CHAPTER 2: Management Measures for Agriculture Sources

I. INTRODUCTION

A. What "Management Measures" Are

This chapter specifies management measures to protect coastal waters from agricultural sources of nonpoint pollution. "Management measures" are defined in section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) as economically achievable measures to control the addition of pollutants to our coastal waters, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

These management measures will be incorporated by States into their coastal nonpoint programs, which under CZARA are to provide for the implementation of management measures that are "in conformity" with this guidance. Under CZARA, States are subject to a number of requirements as they develop and implement their Coastal Nonpoint Pollution Control Programs in conformity with this guidance and will have some flexibility in doing so. The application of these management measures by States to activities causing nonpoint pollution is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA).

B. What "Management Practices" Are

In addition to specifying management *measures*, this chapter also lists and describes management *practices* for illustrative purposes only. While State programs are required to specify management *measures* in conformity with this guidance, State programs need not specify or require the implementation of the particular management *practices* described in this document. However, as a practical matter, EPA anticipates that States the management measures generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices listed in this document have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measures. EPA has also used some of these practices, or appropriate combinations of these practices, as a basis for estimating the effectiveness, costs, and economic impacts of achieving the management measures. (Economic impacts of the management measures are addressed in a separate document entitled *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*)

EPA recognizes that there is often site-specific, regional and national variability in the selection of appropriate practices, as well as in the design constraints and pollution control effectiveness of practices. The list of practices for each management measure is not all-inclusive and does not preclude States or local agencies from using other technically sound practices. In all cases, however, the practice or set of practices chosen by a State needs to achieve the management measure.

C. Scope of This Chapter

This chapter addresses six categories of sources of agricultural nonpoint pollution that affect coastal waters:

(1) Erosion from cropland;
(2) Confined animal facilities;
(3) The application of nutrients to cropland;
(4) The application of pesticides to cropland;
(5) Grazing management; and
(6) Irrigation of cropland.

Each category of sources (with the exception of confined animal facilities, which has two management measures) is addressed in a separate section of this guidance. Each section contains (1) the management measure; (2) an applicability statement that describes, when appropriate, specific activities and locations for which the measure is suitable; (3) a description of the management measure's purpose; (4) the basis for the management measure's selection; (5) information on the effectiveness of the management measure and/or of practices to achieve the measure; (6) information on management practices that are suitable, either alone or in combination with other practices, to achieve the management measure; and (7) information on costs of the measure and/or practices to achieve the measure.

D. Relationship of This Chapter to Other Chapters and to Other EPA Documents

1. Chapter 1 of this document contains detailed information on the legislative background for this guidance, the process used by EPA to develop this guidance, and the technical approach used by EPA in the guidance.

2. Chapter 7 of this document contains management measures to protect wetlands and riparian areas that serve a nonpoint source abatement function. These measures apply to a broad variety of sources, including agricultural sources.

3. Chapter 8 of this document contains information on recommended monitoring techniques (1) to ensure proper implementation, operation, and maintenance of the management measures and (2) to assess over time the success of the measures in reducing pollution loads and improving water quality.

4. EPA has separately published a document entitled *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*

5. NOAA and EPA have jointly published guidance entitled *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance.* This guidance contains details on how State Coastal Nonpoint Pollution Control Programs are to be developed by States and approved by NOAA and EPA. It includes guidance on the following:

   - The basis and process for EPA/NOAA approval of state Coastal Nonpoint Pollution Control Programs;

   - How NOAA and EPA expect State programs to provide for the implementation of management measures "in conformity" with this management measures guidance;

   - How States may target sources in implementing their Coastal Nonpoint Pollution Control Programs;

- Changes in State coastal boundaries; and

- Requirements concerning how States are to implement the Coastal Nonpoint Pollution Control Programs.

E. Coordination of Measures

The management measures developed for agriculture are to be used as an overall system of measures to address nonpoint source (NPS) pollution sources on any given site. In most cases, not all of the measures will be needed to address the nonpoint sources at a specific site. For example, many farms or agriculture enterprises do not have animals as part of the enterprise and would not need to be concerned with the management measures that address confined animal facilities or grazing. By the same token, many enterprises do not use irrigation and would not need to use the irrigation water management measure.

Most enterprises will have more than one source to address and may need to employ two or more of the measures to address the multiple sources. Where more than one source exists, the application of the measures is to be coordinated to produce an overall system that adequately addresses all sources for the site in a cost-effective manner.

The agricultural management measures for CZMA are, for the most part, systems of practices that are commonly used and recommended by the U.S. Department of Agriculture (USDA) as components of Resource Management Systems, Water Quality Management Plans, and Agricultural Waste Management Systems. Practices and plans installed under State NPS programs are also included. Many farms and fields, therefore, may already be in compliance with the measures needed to address the nonpoint sources on them. For cases where existing source control is inadequate to achieve conformity with the needed management measures, it may be necessary to add only one or two more practices to achieve conformity. Existing NPS progress must be recognized and appropriate credit given to the accomplishment of our common goal to control NPS pollution. There is no need to spend additional resources for a practice that is already in existence and operational. Existing practices, plans, and systems should be viewed as building blocks for these management measures and may need no additional improvement.

F. Pollutants That Cause Agricultural Nonpoint Source Pollution[1]

The primary agricultural nonpoint source pollutants are nutrients, sediment, animal wastes, salts, and pesticides. Agricultural activities also have the potential to directly impact the habitat of aquatic species through physical disturbances caused by livestock or equipment, or through the management of water. The general pathways for transport of pollutants from agricultural lands to water resources are shown in Figure 2-1 (USDA, 1991). The effects of these pollutants on water quality are discussed below.

1. Nutrients

Nitrogen (N) and phosphorus (P) are the two major nutrients from agricultural land that degrade water quality. Nutrients are applied to agricultural land in several different forms and come from various sources, including;

- Commercial fertilizer in a dry or fluid form, containing nitrogen (N), phosphorus (P), potassium (K), secondary nutrients, and micronutrients;

- Manure from animal production facilities including bedding and other wastes added to the manure, containing N,P,K, secondary nutrients, micronutrients, salts, some metals, and organics;

[1] This section on Pollutants That Cause Agricultural Nonpoint Source Pollution is adapted from USDA-SCS (1983).

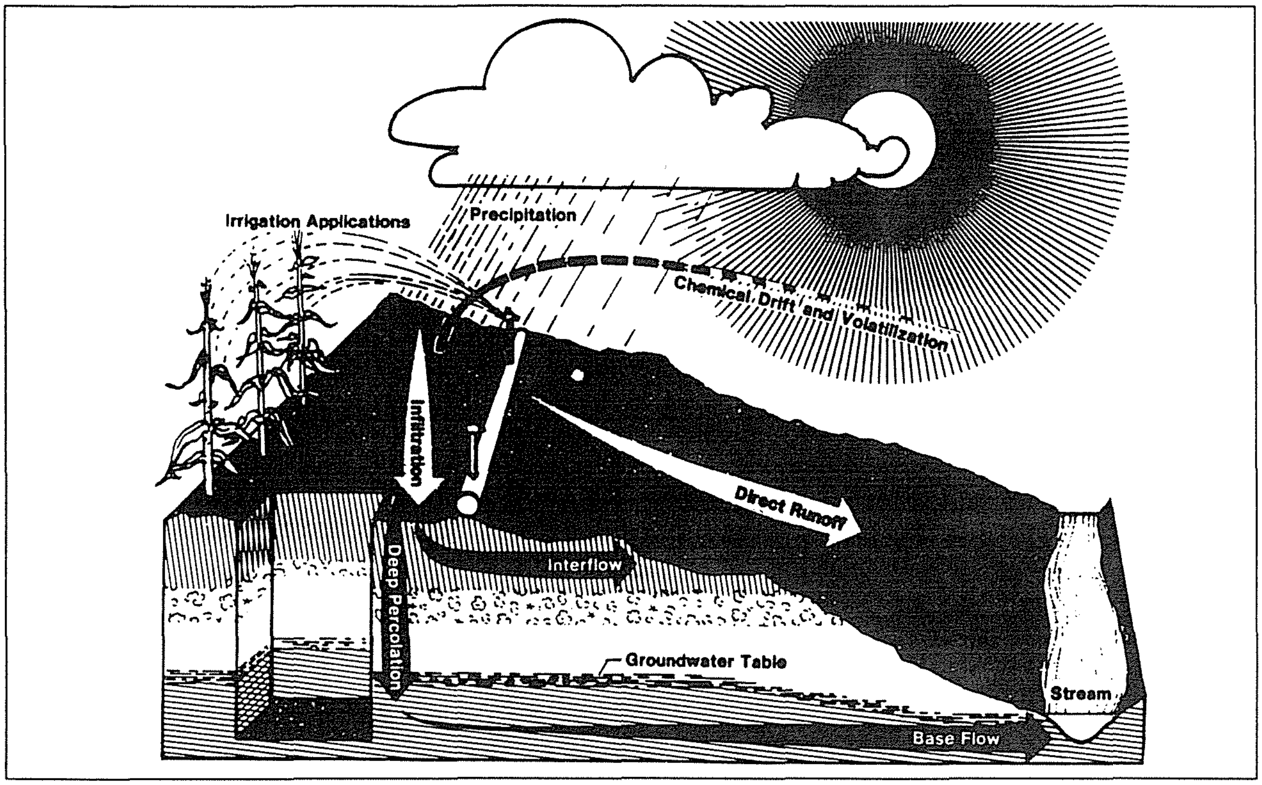

Figure 2-1. Pathways through which substances are transported from agricultural land to become water pollutants (USDA, 1991).

- Municipal and industrial treatment plant sludge, containing N,P,K, secondary nutrients, micronutrients, salts, metals, and organic solids;
- Municipal and industrial treatment plant effluent, containing N,P,K, secondary nutrients, micronutrients, salts, metals, and organics;
- Legumes and crop residues containing N, P, K, secondary nutrients, and micronutrients;
- Irrigation water; and
- Atmospheric deposition of nutrients such as nitrogen and sulphur.

Surface water runoff from agricultural lands to which nutrients have been applied may transport the following pollutants:

- Particulate-bound nutrients, chemicals, and metals, such as phosphorus, organic nitrogen, and metals applied with some organic wastes;
- Soluble nutrients and chemicals, such as nitrogen, phosphorus, metals, and many other major and minor nutrients;
- Sediment, particulate organic solids, and oxygen-demanding material;

- Salts; and
- Bacteria, viruses, and other microorganisms.

Ground-water infiltration from agricultural lands to which nutrients have been applied may transport the following pollutants: soluble nutrients and chemicals, such as nitrogen, phosphorus, metals, and many other major and minor nutrients, and salts.

Surface water and ground-water pollutants from organic matter and crop residue decomposition and from legumes growing on agricultural land may include nitrogen, phosphorus, and other essential nutrients found in the residue of growing crops.

All plants require nutrients for growth. In aquatic environments, nutrient availability usually limits plant growth. Nitrogen and phosphorus generally are present at background or natural levels below 0.3 and 0.05 mg/L, respectively. When these nutrients are introduced into a stream, lake, or estuary at higher rates, aquatic plant productivity may increase dramatically. This process, referred to as cultural eutrophication, may adversely affect the suitability of the water for other uses.

Increased aquatic plant productivity results in the addition to the system of more organic material, which eventually dies and decays. The decaying organic matter produces unpleasant odors and depletes the oxygen supply required by aquatic organisms. Excess plant growth may also interfere with recreational activities such as swimming and boating. Depleted oxygen levels, especially in colder bottom waters where dead organic matter tends to accumulate, can reduce the quality of fish habitat and encourage the propagation of fish that are adapted to less oxygen or to warmer surface waters. Highly enriched waters will stimulate algae production, with consequent increased turbidity and color. Algae growth is also believed to be harmful to coral reefs (e.g., Florida coast). Furthermore, the increased turbidity results in less sunlight penetration and availability to submerged aquatic vegetation (SAV). Since SAV provides habitat for small or juvenile fish, the loss of SAV has severe consequences for the food chain. Chesapeake Bay is an example in which nutrients are believed to have contributed to SAV loss.

a. Nitrogen

All forms of transported nitrogen are potential contributors to eutrophication in lakes, estuaries, and some coastal waters. In general, though not in all cases, nitrogen availability is the limiting factor for plant growth in marine ecosystems. Thus, the addition of nitrogen can have a significant effect on the natural functioning of marine ecosystems.

In addition to eutrophication, excessive nitrogen causes other water quality problems. Dissolved ammonia at concentrations above 0.2 mg/L may be toxic to fish, especially trout. Nitrates in drinking water are potentially dangerous, especially to newborn infants. Nitrate is converted to nitrite in the digestive tract, which reduces the oxygen-carrying capacity of the blood (methemoglobinemia), resulting in brain damage or even death. The U.S. Environmental Protection Agency has set a limit of 10 mg/L nitrate-nitrogen in water used for human consumption (USEPA, 1989).

Nitrogen is naturally present in soils but must be added to increase crop production. Nitrogen is added to the soil primarily by applying commercial fertilizers and manure, but also by growing legumes (biological nitrogen fixation) and incorporating crop residues. Not all nitrogen that is present in or on the soil is available for plant use at any one time. For example, in the eastern Corn Belt, it is normally assumed that about 50 percent of applied N is assimilated by crops during the year of application (Nelson, 1985). Organic nitrogen normally constitutes the majority of the soil nitrogen. It is slowly converted (2 to 3 percent per year) to the more readily plant-available inorganic ammonium or nitrate.

The chemical form of nitrogen affects its impact on water quality. The most biologically important inorganic forms of nitrogen are ammonium (NH_4-N), nitrate (NO_3-N), and nitrite (NO_2-N). Organic nitrogen occurs as particulate matter, in living organisms, and as detritus. It occurs in dissolved form in compounds such as amino acids, amines, purines, and urea.

Nitrate-nitrogen is highly mobile and can move readily below the crop root zone, especially in sandy soils. It can also be transported with surface runoff, but not usually in large quantities. Ammonium, on the other hand, becomes adsorbed to the soil and is lost primarily with eroding sediment. Even if nitrogen is not in a readily available form as it leaves the field, it can be converted to an available form either during transport or after delivery to waterbodies.

b. Phosphorus

Phosphorus can also contribute to the eutrophication of both freshwater and estuarine systems. While phosphorus typically plays the controlling role in freshwater systems, in some estuarine systems both nitrogen and phosphorus can limit plant growth. Algae consume dissolved inorganic phosphorus and convert it to the organic form. Phosphorus is rarely found in concentrations high enough to be toxic to higher organisms.

Although the phosphorus content of most soils in their natural condition is low, between 0.01 and 0.2 percent by weight, recent soil test results show that the phosphorus content of most cropped soils in the Northeast have climbed to the high or very high range (Sims, 1992). Manure and fertilizers increase the level of available phosphorus in the soil to promote plant growth, but many soils now contain higher phosphorus levels than plants need (Killorn, 1980; Novais and Kamprath, 1978). Phosphorus can be found in the soil in dissolved, colloidal, or particulate forms.

Runoff and erosion can carry some of the applied phosphorus to nearby water bodies. Dissolved inorganic phosphorus (orthophosphate phosphorus) is probably the only form directly available to algae. Particulate and organic phosphorus delivered to waterbodies may later be released and made available to algae when the bottom sediment of a stream becomes anaerobic, causing water quality problems.

2. Sediment

Sediment affects the use of water in many ways. Suspended solids reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, smother coral reefs, clog the filtering capacity of filter feeders, and clog and harm the gills of fish. Turbidity interferes with the feeding habits of fish. These effects combine to reduce fish, shellfish, coral, and plant populations and decrease the overall productivity of lakes, streams, estuaries, and coastal waters. In addition, recreation is limited because of the decreased fish population and the water's unappealing, turbid appearance. Turbidity also reduces visibility, making swimming less safe.

Chemicals such as some pesticides, phosphorus, and ammonium are transported with sediment in an adsorbed state. Changes in the aquatic environment, such as a lower concentration in the overlying waters or the development of anaerobic conditions in the bottom sediments, can cause these chemicals to be released from the sediment. Adsorbed phosphorus transported by the sediment may not be immediately available for aquatic plant growth but does serve as a long-term contributor to eutrophication.

Sediment is the result of erosion. It is the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice. The types of erosion associated with agriculture that produce sediment are (1) sheet and rill erosion and (2) gully erosion. Soil erosion can be characterized as the transport of particles that are detached by rainfall, flowing water, or wind (Figure 2-2). Eroded soil is either redeposited on the same field or transported from the field in runoff.

Sediments from different sources vary in the kinds and amounts of pollutants that are adsorbed to the particles. For example, sheet and rill erosion mainly move soil particles from the surface or plow layer of the soil. Sediment that originates from surface soil has a higher pollution potential than that from subsurface soils. The topsoil of a field is usually richer in nutrients and other chemicals because of past fertilizer and pesticide applications, as well as nutrient cycling and biological activity. Topsoil is also more likely to have a greater percentage of organic matter. Sediment from gullies and streambanks usually carries less adsorbed pollutants than sediment from surface soils.

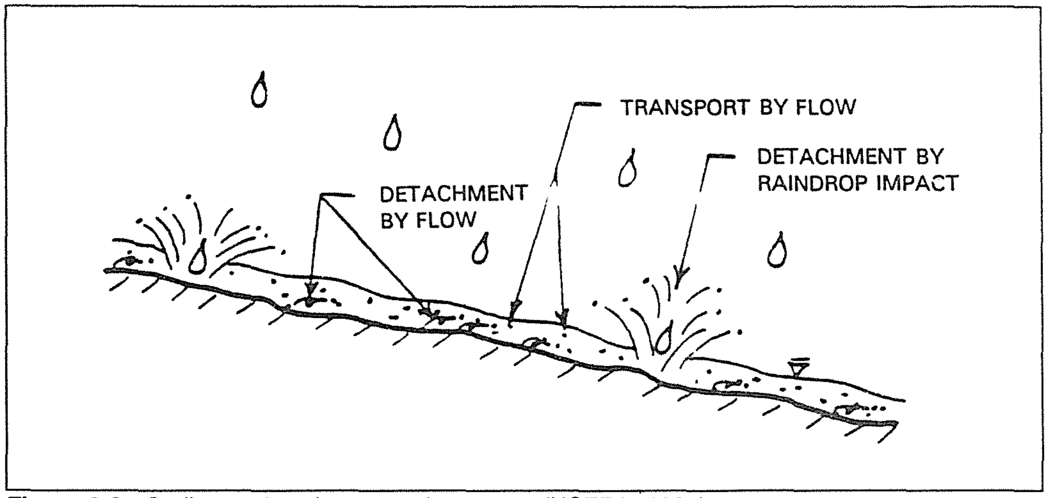

Figure 2-2. Sediment detachment and transport (USEPA, 1981).

Soil eroded and delivered from cropland as sediment usually contains a higher percentage of finer and less dense particles than the parent soil on the cropland. This change in composition of eroded soil is due to the selective nature of the erosion process. For example, larger particles are more readily detached from the soil surface because they are less cohesive, but they also settle out of suspension more quickly because of their size. Organic matter is not easily detached because of its cohesive properties, but once detached it is easily transported because of its low density. Clay particles and organic residues will remain suspended for longer periods and at slower flow velocities than will larger or more dense particles. This selective erosion can increase overall pollutant delivery per ton of sediment delivered because small particles have a much greater adsorption capacity than larger particles. As a result, eroding sediments generally contain higher concentrations of phosphorus, nitrogen, and pesticides than the parent soil (i.e., they are enriched).

3. Animal Wastes

Animal waste (manure) includes the fecal and urinary wastes of livestock and poultry; process water (such as from a milking parlor); and the feed, bedding, litter, and soil with which they become intermixed. The following pollutants may be contained in manure and associated bedding materials and could be transported by runoff water and process wastewater from confined animal facilities:

- Oxygen-demanding substances;
- Nitrogen, phosphorus, and many other major and minor nutrients or other deleterious materials;
- Organic solids;
- Salts;
- Bacteria, viruses, and other microorganisms; and
- Sediments.

Fish kills may result from runoff, wastewater, or manure entering surface waters, due to ammonia or dissolved oxygen depletion. The decomposition of organic materials can deplete dissolved oxygen supplies in water, resulting in anoxic or anaerobic conditions. Methane, amines, and sulfide are produced in anaerobic waters, causing the water to acquire an unpleasant odor, taste, and appearance. Such waters can be unsuitable for drinking, fishing, and other recreational uses.

Solids deposited in waterbodies can accelerate eutrophication through the release of nutrients over extended periods of time. Because of the high nutrient and salt content of manure and runoff from manure-covered areas, contamination of ground water can be a problem if storage structures are not built to minimize seepage.

Animal diseases can be transmitted to humans through contact with animal feces. Runoff from fields receiving manure will contain extremely high numbers of bacteria if the manure has not been incorporated or the bacteria have not been subject to stress. Shellfish closure and beach closure can result from high fecal coliform counts. Although not the only source of pathogens, animal waste has been responsible for shellfish contamination in some coastal waters.

The method, timing, and rate of manure application are significant factors in determining the likelihood that water quality contamination will result. Manure is generally more likely to be transported in runoff when applied to the soil surface than when incorporated into the soil. Spreading manure on frozen ground or snow can result in high concentrations of nutrients being transported from the field during rainfall or snowmelt, especially when the snowmelt or rainfall events occur soon after spreading (Robillard and Walter, 1986). The water quality problems associated with nitrogen and phosphorus are discussed under Section F.1.

When application rates of manure for crop production are based on N, the P and K rates normally exceed plant requirements (Westerman et al., 1985). The soil generally has the capacity to adsorb phosphorus leached from manure applied on land. As previously mentioned, however, nitrates are easily leached through soil into ground water or to return flows, and phosphorus can be transported by eroded soil.

Conditions that cause a rapid die-off of bacteria are low soil moisture, low pH, high temperatures, and direct solar radiation. Manure storage generally promotes die-off, although pathogens can remain dormant at certain temperatures. Composting the wastes can be quite effective in decreasing the number of pathogens.

4. Salts

Salts are a product of the natural weathering process of soil and geologic material. They are present in varying degrees in all soils and in fresh water, coastal waters, estuarine waters, and ground waters.

In soils that have poor subsurface drainage, high salt concentrations are created within the root zone where most water extraction occurs. The accumulation of soluble and exchangeable sodium leads to soil dispersion, structure breakdown, decreased infiltration, and possible toxicity; thus, salts often become a serious problem on irrigated land, both for continued agricultural production and for water quality considerations. High salt concentrations in streams can harm freshwater aquatic plants just as excess soil salinity damages agricultural crops. While salts are generally a more significant pollutant for freshwater ecosystems than for saline ecosystems, they may also adversely affect anadromous fish. Although they live in coastal and estuarine waters most of their lives, anadromous fish depend on freshwater systems near the coast for crucial portions of their life cycles.

The movement and deposition of salts depend on the amount and distribution of rainfall and irrigation, the soil and underlying strata, evapotranspiration rates, and other environmental factors. In humid areas, dissolved mineral salts have been naturally leached from the soil and substrata by rainfall. In arid and semi-arid regions, salts have not been removed by natural leaching and are concentrated in the soil. Soluble salts in saline and sodic soils consist of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, and chloride ions. They are fairly easily leached from the soil. Sparingly soluble gypsum and lime also occur in amounts ranging from traces to more than 50 percent of the soil mass.

Irrigation water, whether from ground or surface water sources, has a natural base load of dissolved mineral salts. As the water is consumed by plants or lost to the atmosphere by evaporation, the salts remain and become concentrated in the soil. This is referred to as the "concentrating effect."

The total salt load carried by irrigation return flow is the sum of the salt remaining in the applied water plus any salt picked up from the irrigated land. Irrigation return flows provide the means for conveying the salts to the receiving streams or ground-water reservoirs. If the amount of salt in the return flow is low in comparison to the total stream flow, water quality may not be degraded to the extent that use is impaired. However, if the process of water diversion for irrigation and the return of saline drainage water is repeated many times along a stream or river, water quality will be progressively degraded for downstream irrigation use as well as for other uses.

5. Pesticides

The term *pesticide* includes any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or intended for use as a plant regulator, defoliant, or desiccant. The principal pesticidal pollutants that may be detected in surface water and in ground water are the active and inert ingredients and any persistent degradation products. Pesticides and their degradation products may enter ground and surface water in solution, in emulsion, or bound to soil colloids. For simplicity, the term *pesticides* will be used to represent "pesticides and their degradation products" in the following sections.

Despite the documented benefits of using pesticides (insecticides, herbicides, fungicides, miticides, nematicides, etc.) to control plant pests and enhance production, these chemicals may, in some instances, cause impairments to the uses of surface water and ground water. Some types of pesticides are resistant to degradation and may persist and accumulate in aquatic ecosystems.

Pesticides may harm the environment by eliminating or reducing populations of desirable organisms, including endangered species. Sublethal effects include the behavioral and structural changes of an organism that jeopardize its survival. For example, certain pesticides have been found to inhibit bone development in young fish or to affect reproduction by inducing abortion.

Herbicides in the aquatic environment can destroy the food source for higher organisms, which may then starve. Herbicides can also reduce the amount of vegetation available for protective cover and the laying of eggs by aquatic species. Also, the decay of plant matter exposed to herbicide-containing water can cause reductions in dissolved oxygen concentration (North Carolina State University, 1984).

Sometimes a pesticide is not toxic by itself but is lethal in the presence of other pesticides. This is referred to as a *synergistic effect*, and it may be difficult to predict or evaluate. *Bioconcentration* is a phenomenon that occurs if an organism ingests more of a pesticide than it excretes. During its lifetime, the organism will accumulate a higher concentration of that pesticide than is present in the surrounding environment. When the organism is eaten by another animal higher in the food chain, the pesticide will then be passed to that animal, and on up the food chain to even higher level animals.

A major source of contamination from pesticide use is the result of normal application of pesticides. Other sources of pesticide contamination are atmospheric deposition, spray drift during the application process, misuse, and spills, leaks, and discharges that may be associated with pesticide storage, handling, and waste disposal.

The primary routes of pesticide transport to aquatic systems are (Maas et al., 1984):

(1) Direct application;
(2) In runoff;
(3) Aerial drift;
(4) Volatilization and subsequent atmospheric deposition; and
(5) Uptake by biota and subsequent movement in the food web.

The amount of field-applied pesticide that leaves a field in the runoff and enters a stream primarily depends on:

(1) The intensity and duration of rainfall or irrigation;
(2) The length of time between pesticide application and rainfall occurrence;
(3) The amount of pesticide applied and its soil/water partition coefficient;
(4) The length and degree of slope and soil composition;
(5) The extent of exposure to bare (vs. residue or crop-covered) soil;

(6) Proximity to streams;
(7) The method of application; and
(8) The extent to which runoff and erosion are controlled with agronomic and structural practices.

Pesticide losses are generally greatest when rainfall is intense and occurs shortly after pesticide application, a condition for which water runoff and erosion losses are also greatest.

The rate of pesticide movement through the soil profile to ground water is inversely proportional to the pesticide adsorption partition coefficient or K_d (a measure of the degree to which a pesticide is partitioned between the soil and water phase). The larger the K_d, the slower the movement and the greater the quantity of water required to leach the pesticide to a given depth.

Pesticides can be transported to receiving waters either in dissolved form or attached to sediment. Dissolved pesticides may be leached to ground-water supplies. Both the degradation and adsorption characteristics of pesticides are highly variable.

6. Habitat Impacts

The functioning condition of riparian-wetland areas is a result of interaction among geology, soil, water, and vegetation. Riparian-wetland areas are functioning properly when adequate vegetation is present to (1) dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality; (2) filter sediment and aid floodplain development; (3) support denitrification of nitrate-contaminated ground water as it is discharged into streams; (4) improve floodwater retention and ground-water recharge; (5) develop root masses that stabilize banks against cutting action; (6) develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and (7) support greater biodiversity.

Improper livestock grazing affects all four components of the water-riparian system: banks/shores, water column, channel, and aquatic and bordering vegetation (Platts, 1990). The potential effects of grazing include:

Shore/banks

- Shear or sloughing of streambank soils by hoof or head action.
- Water, ice, and wind erosion of exposed streambank and channel soils because of loss of vegetative cover.
- Elimination or loss of streambank vegetation.
- Reduction of the quality and quantity of streambank undercuts.
- Increasing streambank angle (laying back of streambanks), which increases water width, decreases stream depth, and alters or eliminates fish habitat.

Water Column

- Withdrawal from streams to irrigate grazing lands.
- Drainage of wet meadows or lowering of the ground-water table to facilitate grazing access.
- Pollutants (e.g., sediments) in return water from grazed lands, which are detrimental to the designated uses such as fisheries.

- Changes in magnitude and timing of organic and inorganic energy (i.e., solar radiation, debris, nutrients) inputs to the stream.
- Increase in fecal contamination.
- Changes in stream morphology, such as increases in stream width and decreases in stream depth, including reduction of stream shore water depth.
- Changes in timing and magnitude of stream flow events from changes in watershed vegetative cover.
- Increase in stream temperature.

Channel

- Changes in channel morphology.
- Altered sediment transport processes.

Riparian Vegetation

- Changes in plant species composition (e.g., shrubs to grass to forbs).
- Reduction of floodplain and streambank vegetation including vegetation hanging over or entering into the water column.
- Decrease in plant vigor.
- Changes in timing and amounts of organic energy leaving the riparian zone.
- Elimination of riparian plant communities (i.e., lowering of the water table allowing xeric plants to replace riparian plants).

II. MANAGEMENT MEASURES FOR AGRICULTURAL SOURCES

A. Erosion and Sediment Control Management Measure

Apply the erosion component of a Conservation Management System (CMS) as defined in the Field Office Technical Guide of the U.S. Department of Agriculture - Soil Conservation Service (see Appendix 2A of this chapter) to minimize the delivery of sediment from agricultural lands to surface waters, *or*

Design and install a combination of management and physical practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to and including a 10-year, 24-hour frequency.

1. Applicability

This management measure is intended to be applied by States to activities that cause erosion on agricultural land and on land that is converted from other land uses to agricultural lands. Agricultural lands include:

- Cropland;
- Irrigated cropland;
- Range and pasture;
- Orchards;
- Permanent hayland;
- Specialty crop production; and
- Nursery crop production.

Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The problems associated with soil erosion are the movement of sediment and associated pollutants by runoff into a waterbody. See Section I.F.2 of this chapter for additional information regarding problems.

Application of this management measure will reduce the mass load of sediment reaching a waterbody and improve water quality and the use of the water resource. The measure can be implemented by using one of two different strategies or a combination of both. The first, and most desirable, strategy would be to implement practices on the field that would prevent erosion and the transport of sediment from the field. Practices that could be used to accomplish this are conservation tillage, contour strip-cropping, terraces, and critical area planting.

The second strategy is to route runoff from fields through practices that remove sediment. Practices that could be used to accomplish this are filter strips, field borders, grade stabilization structures, sediment retention ponds, water and sediment control basins, and terraces. Site conditions will dictate the appropriate combination of practices for any given situation.

Conservation management systems (CMS) include any combination of conservation practices and management that achieves a level of treatment of the five natural resources (i.e., soil, water, air, plants, and animals) that satisfies criteria contained in the Soil Conservation Service (SCS) Field Office Technical Guide (FOTG), such as a resource management system (RMS) or an acceptable management system (AMS). These criteria are developed at the State level, with concurrence by the appropriate SCS National Technical Center (NTC). The criteria are then applied in the provision of field office technical assistance, under the direction of the District Conservationist of SCS. In-state coordination of FOTG use is provided by the Area Conservationist and State Conservationist of SCS.

The erosion component of a CMS addresses sheet and rill erosion, wind erosion, concentrated flow, streambank erosion, soil mass movements, road bank erosion, construction site erosion, and irrigation-induced erosion. National (minimum) criteria pertaining to erosion and sediment control under an RMS will be applied to prevent long-term soil degradation and to resolve existing or potential off-site deposition problems. National criteria pertaining to the water resource will be applied to control sediment movement to minimize contamination of receiving waters. The combined effects of these criteria will be to both reduce upland soil erosion and minimize sediment delivery to receiving waters.

The practical limits of resource protection under a CMS within any given area are determined through the application of national social, cultural, and economic criteria. With respect to economics, landowners will not be required to implement an RMS if the system is generally too costly for landowners. Instead, landowners may be required to implement a less costly, and less protective, AMS. In some cases, landowner constraints may be such that an RMS or AMS cannot be implemented quickly. In these situations, a "progressive planning approach" may be used to ultimately achieve planning and application of an RMS or AMS. Progressive planning is the incremental process of building a plan on part or all of the planning unit over a period of time. For additional details regarding CMS, RMS, and AMS, see Appendix 2A of this chapter.

It is recognized that implementation of this measure may increase the potential for movement of water and soluble pollutants through the soil profile to the ground water. It is not the intent of this measure to address a surface water problem at the expense of ground water. Erosion and sediment control systems can and should be designed to protect against the contamination of ground water. Ground-water protection will also be provided through implementation of the nutrient and pesticide management measures to reduce and control the application of nutrients and pesticides.

Operation and Maintenance

Continued performance of this measure will be ensured through supporting maintenance operations where appropriate. Since practices are designed to control a specific storm frequency, they may suffer damage when larger storms occur. It is expected that damage will be repaired after such storms and that practices will be inspected periodically. To ensure that practices selected to implement this measure will continue to function as designed and installed, some operational functions and maintenance will be necessary over the life of the practices.

Most structural practices for erosion and sediment control are designed to operate without human intervention. Management practices such as conservation tillage, however, do require "operation consideration" each time they are used. Field operations should be conducted with such practices in mind to ensure that they are not damaged or destroyed by the operations. For example, herbicides should not be applied to any practice that uses a permanent vegetative cover, such as waterways and filter strips.

Structural practices such as diversions, grassed waterways, and other practices that require grading and shaping may require repair to maintain the original design; reseeding may also be needed to maintain the original vegetative cover.

Trees and brush should not be allowed to grow on berms, dams, or other structural embankments. Cleaning of sediment retention basins will be needed to maintain their original design capacity and efficiency.

Filter strips and field borders must be maintained to prevent channelization of flow and the resulting short-circuiting of filtering mechanisms. Reseeding of filter strips may be required on a frequent basis.

3. Management Measure Selection

This management measure was selected based on an evaluation of available information that documents the beneficial effects of improved erosion and sediment control (see Section II.A.4 of this chapter). Specifically, the available information shows that erosion control practices can be used to greatly reduce the quantity of eroding soil on agricultural land, and that edge-of-field practices can effectively remove sediment from runoff before it leaves agricultural lands. The benefits of this management measure include significant reductions in the mass load of sediment and associated pollutants (e.g., phosphorus, some pesticides) entering waterbodies. By reducing the load of sediment leaving a field, downstream water uses can be maintained and improved.

Two options are provided under this management measure that represent best available technology for minimizing the delivery of sediment from agricultural lands to receiving waters. Different management strategies, are employed, however, with the options. The most desirable option is "(1)" since it not only minimizes the delivery of sediment to receiving waters, but also reduces erosion to provide an agronomic benefit. Option "(2)" minimizes the delivery of sediment to receiving waters, but does not necessarily provide the agronomic benefits of upland erosion control. By providing these two options, States are given the flexibility to address erosion and sediment problems in a manner that best reflects State and local needs and preferences.

By designing the measure to achieve contaminant load reduction objectives, the necessary mix of structural and management practices for a given site should not result in undue economic impact on the operator. Many of the practices that could be used to implement this measure may already be required by Federal, State, or local rules (e.g., filter strips or field borders along streams) or may otherwise be in use on agricultural fields. Since many producers may already be using systems that satisfy or partly satisfy the intent of this management measure, the only action that may be necessary will be to recognize the effectiveness of the existing practices and add additional practices, if needed. By building upon existing erosion and sediment control efforts, the time, effort, and cost of implementing this measure will be reduced.

4. Effectiveness Information

The effectiveness of management practices depends on several factors, including:

- The contaminant to be controlled;
- The types of practices or controls being considered; and
- Site-specific conditions.

Management practices or systems of practices must be designed for site-specific conditions to achieve desired effectiveness levels. Practice systems include combinations of practices that provide source control of the contaminant(s) as well as control or reductions in edge-of-field losses and delivery to receiving waters. Table 2-1 provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, crop rotation, topography, tillage, and harvesting methods. Even within relatively small watersheds, extreme spatial and temporal variations are common. With this type of variation, the ranges of likely values associated with the reported observations in Table 2-1 are large.

Table 2-1. Relative Gross Effectiveness[a] of Sediment[b] Control Measures (Pennsylvania State University, 1992a)

Practice Category[c]	Runoff[d] Volume	Total[e] Phosphorus (%)	Total[e] Nitrogen (%)	Sediment (%)
Reduced Tillage Systems[f]	—	45	55	75
Diversion Systems[g]	—	30	10	35
Terrace Systems[h]	—	70	20	85
Filter Strips[i]	—	75	70	65

[a] Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.
[b] Includes data where land application of manure has occurred.
[c] Each category includes several specific types of practices.
[d] - indicates reduction; + increase; 0 no change in surface runoff.
[e] Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N.
[f] Includes practices such as conservation tillage, no-till, and crop residue use.
[g] Includes practices such as grassed waterways and grade stabilization structures.
[h] Includes several types of terraces with safe outlet structures where appropriate.
[i] Includes all practices that reduce contaminant losses using vegetative control methods.

The variability in the effectiveness of selected conservation practices that are frequently recommended by SCS in resource planning is illustrated in Table 2-2. This table can be used as a general guide for estimating the effects of these practices on water quality and quantity. The table references include additional site-specific information. Practice effects shown include changes in the water budget, sediment yield, and the movement of pesticides and nutrients. The impacts of variations in climate and soil conditions are accounted for to some extent through the presentation of effectiveness data for different soil-climate combinations. Data were not available for all soils and climates.

Data for the table were obtained from the research literature and include computer model simulation results. Values are reported as the percentage of change in the mass load of a given parameter that can be expected from installing the practice. Changes are determined versus a base condition of a rain-fed, nonleguminous, continuous, row crop (usually corn) that has been cultivated under conventional tillage.

Data from model studies are marked with an "M." For example, *-27M* indicates that the load reduction estimate of 27 percent is derived from a model simulation. Data obtained from plot studies using rainfall simulators are marked with an "S." For example, *+15S* indicates that the estimated load increase of 15 percent is based on a rainfall simulation study.

The range is reported in parentheses, followed by other reported values within the range, set off by commas. For example, *(-32 to +10), -15, +5* denotes a range from a decrease of 32 percent to an increase of 10 percent, with intermediate reported changes of a 15 percent decrease and 5 percent increase. Some practices have a relatively wide range of values because of the variability in climate, soils, and management that occurs with these practices. Although some of the ranges are large, they can usually be attributed to small changes in very small quantities (thus the percentage change is great, yet the magnitude of change is small) or to the variability of site-specific conditions.

Table 2-2 contains the following information:

- Column (a) lists the practice and its SCS reporting code number.
- Column (b) lists the climate and a generalized soil classification for the site under consideration.
- Column (c) is the percentage change in surface runoff and deep percolation, components of the water budget, caused by the applied practice.
- Column (d) is the percentage change in sediment load caused by the applied practice.
- Column (e) is the percentage change in the phosphorus load. Two phases of phosphorus are considered: adsorbed and dissolved.
- Column (f) is the percentage change in the load of nitrogen in the adsorbed phase, nitrate in surface runoff, and nitrate in the leachate.
- Column (g) is the percentage change in the pesticide load. The phases of the pesticide listed are (1) strongly adsorbed in surface water, (2) weakly adsorbed in surface water, and (3) weakly adsorbed in the leachate.

5. Erosion and Sediment Control Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Combinations of the following practices can be used to satisfy the requirements of this management measure. The SCS practice number and definition are provided for each management practice, where available. Also included in italics are SCS statements describing the effect each practice has on water quality (USDA-SCS, 1988).

a. *Conservation cover (327): Establishing and maintaining perennial vegetative cover to protect soil and water resources on land retired from agricultural production.*

Agricultural chemicals are usually not applied to this cover in large quantities and surface and ground water quality may improve where these material are not used. Ground cover and crop residue will be increased with this practice. Erosion and yields of sediment and sediment related stream pollutants should decrease. Temperatures of the soil surface runoff and receiving water may be reduced. Effects will vary during the establishment period and include increases in runoff, erosion and sediment yield. Due to the reduction of deep percolation, the leaching of soluble material will be reduced, as will be the potential for causing saline seeps. Long-term effects of the practice would reduce agricultural nonpoint sources of pollution to all water resources.

b. *Conservation cropping sequence (328): An adapted sequence of crops designed to provide adequate organic residue for maintenance or improvement of soil tilth.*

This practice reduces erosion by increasing organic matter, resulting in a reduction of sediment and associated pollutants to surface waters. Crop rotations that improve soil tilth may also disrupt disease, insect and weed reproduction cycles, reducing the need for pesticides. This removes or reduces the availability of some pollutants in the watershed. Deep percolation may carry soluble nutrients and pesticides to the ground water. Underlying soil

Table 2-2. Effects of Conservation Practices on Water Resource Parameters (USDA-SCS, 1988)

NOTE: Values in the tables are taken from published research, model simulations, and results of simulated rainfall plots. Both the range (in parentheses) and additional values within the range (after parentheses, separated by comma) are presented. The values describe the percentage change in mass loads caused by the use of the practice on a nonirrigated, nonlegume, continuous row crop that has been grown under conventional tillage. Values inside the range are shown behind the range values and are separated by commas (-30,-90), -76. Values from model simulation are marked by an M, e.g., -30M, and values from a rainfall simulator are marked with an S, e.g., -29S. Few data are available for arid conditions and that zone is not included in the table. Not all soil-climate combinations have available reference data. A minus is a decreased value; a plus is an increase.

(a)	(b)	(c)		(d)	(e)		(f)			(g)		
		Water Budget (% Change)			Phosphorus (% Change)		Nitrogen (% Change)			Pesticides (% Change)		
Practice and Number	Climate and Soil	Surface Runoff	Deep Percolation	Sediment Yield (% Change)	Sediment	Runoff	Nitrogen Adsorbed Phases	Nitrate in Surface Runoff	Nitrate in Percolate	Strongly Adsorbed SW[b]	Weakly Adsorbed Leachate	Weakly Adsorbed SW[b]
Contour Farming 330	H-S[a] -											
	Sandy	(-65,-75)	#	(-20,-50)	-20	-10	-15	-5	#	#	#	#
	Silty	(-60,-40)	+10	(-65,-30)	(-60,-65)	(-60,-65)	(-45,-54)	(-25,-72),-40	+10,+7	#	#	#
	Clayey	(-19,-20)	+5	(-29,-55)	-55	-20	-55	(-12,-25)	+10	#	#	#
	SA-S[a] -											
	Silty	(-27,-59)	#	(-22,-59)	#	#	#	#	#	#	#	#
	Clayey	-54	#	-26	#	#	#	#	+10	#	#	#
	H[a] -											
	Sandy	-30	+10	-60	-60	-30	-60	-35	+10	#	#	#
	Silty	-16	#	(-30,-48)	#	#	#	(-25,-41)	+6	#	#	#
	Clayey	(-17,-29)	#	#	#	#	#	-12	+7	#	#	#
	SA[a] -											
	Clayey	-15	#	#	#	#	#	#	#	#	#	#
Strip-Cropping Contour 585	H-S[a] -											
	Silty	-5M	+9M	(-37,90M),-49	-80M	-86M	-81M	-43M	+158M	#	#	0,+6
	Clayey	-28M	+366M[c]	-89M	-52M	-89M	-51M	-26M	+220M[c]	#	#	#
	Sandy	No change	No change	-99M	-99M	-99M	-98M	-39M	+12M	#	#	#

Table 2-2. (Continued)

(a) Practice and Number	(b) Climate and Soil	(c) Water Budget (% Change): Surface Runoff	(c) Water Budget (% Change): Deep Percolation	(d) Sediment Yield (% Change)	(e) Phosphorus (% Change): Sediment	(e) Phosphorus (% Change): Runoff	(f) Nitrogen (% Change): Nitrogen Adsorbed Phases	(f) Nitrogen (% Change): Nitrate in Surface Runoff	(f) Nitrogen (% Change): Nitrate in Percolate	(g) Pesticides (% Change): Strongly Adsorbed SW[b]	(g) Pesticides (% Change): Weakly Adsorbed Leachate	(g) Pesticides (% Change): Weakly Adsorbed SW[b]
Cons. Tillage- No Till 329	H[a] -											
	Clayey	(-33,+48)[u]	#	(-73M,-82)	-53M	-30M	-53M	-11	(-49M,+8)	#	#	-51M
	Silty	(-91,+36)[u]	No change	(-75,-99)	(-64,-95)	(+900,-22)[c]	(-60,-94)	(-42,+800) -40,+100	(8M,+16) 1,+8[c]	-78	(+5M,-50)	
	Sandy[d]	(-26M,-88),-61	#	(-66M,-99S)	(-51,-87S)	(0,+155)	(-69s,-90s)	(-67,-80)	0	#	#	#
	SA-S[a] -				[u]-72s,-82		-72,-70	-42s,-45	[e]			
	Silty	+36	#	-96	(-80,-90)	+138	(-50,-90),-60	(0,+45)	+2	#	#	#
	H-S[a] -											
	Silty	(-21,-90)	#	(-88,-99)	(-75,-90)	(+450,+1600)	#	#	#	(-75,-90)	#	+500
Cons. Tillage (Other types) 329	H-S[a] -											
	Silty	(-15,-73) -51,-20	+5	(-43,+95) -85,-55	-90,-84	+1850,+1750[c]	-91,-82	+1800,+950[c]	#	#	#	#
	Clayey	-30	+10	-70	#	#	#	#	#	#	#	#
	SA-S[a] -											
	Silty	-54	#	#	#	#	#	#	#	#	#	#
	Clayey	(-29,-89)	+10	(-70,-42)	#	#	#	#	#	#	#	#
	H[a] -											
	Sandy	(-40,-89)	+5	(-40,-66)	-91	-3	-95	-88	#	#	#	#
	Silty	(-20,-26)	#	(-49,-61)	#	#	#	#	#	(-69,-51)	#	(+15,+27)
	Clayey	(-10,-61),-20	+10	(-29,-86) -34,-41	#	#	#	#	#	(-33M,-2)	#	(+60M,-2[*])

Table 2-2. (Continued)

(a)	(b)	(c)		(d)	(e)		(f)			(g)		
		Water Budget (% Change)			Phosphorus (% Change)		Nitrogen (% Change)			Pesticides (% Change)		
Practice and Number	Climate and Soil	Surface Runoff	Deep Percolation	Sediment Yield (% Change)	Sediment	Runoff	Nitrogen Adsorbed Phases	Nitrate in Surface Runoff	Nitrate in Percolate	Strongly Adsorbed SW[b]	Weakly Adsorbed Leachate	Weakly Adsorbed SW[b]
	SA[a] -											
	Silty	(-16,-25),-	#	(-38,-92),-69	#	#	#	#	#	(-38,-81)	#	+63,+27
	Sandy	20	#	-45	#	#	#	#	#	#	#	#
	Clayey	-31	#	-90M	#	#	#	Not sig.	#	#	#	#
		-88M										
Terraces with Under-ground Outlets 600	H-S[a] -											
	Sandy	-14	#	(-95,-98)	#	#	#	#	#	#	#	#
	Silty	(-24,-60)	(+12,+500)[c]	(-87,-95)	-95	-60	-95	(-70,+55)[u]	+15	#	#	#
	Clayey	(-30,-36)	(+5,+380)[c]	(-90,-95)	#	-30	-95	-30	+10	#	#	#
	SA-S[a] -											
	Sandy	-14M	+67M	(-95,-98)	-99M	-42M	-99M	-42M	+20M	#	#	(-73,-91M)
	Silty	(-73,+43M)	+162M	(-95,-92M)	-97M	-72M	-97M	-78M	+37M	#	#	(-84,-91M)
	Clayey	(-15,-36M)	(+5,+293M)[c]	(-95,-91M)	-96M	-65M	-96M	-91M	(10 to high values)			(-69M,-78M)
WASCOB[f] 638	H[a] -											
	Sandy	-40	+15	(-95,-99)	#	-40	-95	-50	+15	#	#	#
	Silty	(-88,-42)	#	(-95,-50),-86	#	-71	-95	(-86,-44)	+8	#	#	-4
	Clayey	#	#	(-90,-95)	#	#	#	#	#	#	#	#
	SA[a] -											
	Sandy	#	#	(-95,-98)	#	#	#	#	#	#	#	#
	Silty	-73	#	-95	-73	+58[c]	#	-50	#	#	#	#
	Clayey	-30	+5	(-90,-95)	#	#	#	#	#	#	#	#

[a] Climatic conditions: H-S = Humid - Snow; H = Humid; SAS = Semi-Arid - Snow; and SA = Semi-Arid.
[b] SW = Surface Water.
[c] Measured values were small numbers; percentage change may have large values.
[d] Data have scattered values.
[e] Measured values were large numbers.
[f] Water and Sediment Control Basin
[u] = Unknown, site-dependent, or conflicting values.
# = No reported value.

layers, rock and unconsolidated parent material may block, delay, or enhance the delivery of these pollutants to ground water. The fate of these pollutants will be site specific, depending on the crop management, the soil and geologic conditions.

c. Conservation tillage (329): Any tillage or planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water; or, where soil erosion by wind is the primary concern, maintains at least 1,000 pounds of flat, small-grain residue equivalent on the surface during the critical erosion period.

This practice reduces soil erosion, detachment and sediment transport by providing soil cover during critical times in the cropping cycle. Surface residues reduce soil compaction from raindrops, preventing soil sealing and increasing infiltration. This action may increase the leaching of agricultural chemicals into the ground water.

In order to maintain the crop residue on the surface it is difficult to incorporate fertilizers and pesticides. This may increase the amount of these chemicals in the runoff and cause more surface water pollution.

The additional organic material on the surface may increase the bacterial action on and near the soil surface. This may tie-up and then breakdown many pesticides which are surface applied, resulting in less pesticide leaving the field. This practice is more effective in humid regions.

With a no-till operation the only soil disturbance is the planter shoe and the compaction from the wheels. The surface applied fertilizers and chemicals are not incorporated and often are not in direct contact with the soil surface. This condition may result in a high surface runoff of pollutants (nutrient and pesticides). Macropores develop under a no-till system. They permit deep percolation and the transmittal of pollutants, both soluble and insoluble to be carried into the deeper soil horizons and into the ground water.

Reduced tillage systems disrupt or break down the macropores, incidentally incorporate some of the materials applied to the soil surface, and reduce the effects of wheeltrack compaction. The results are less runoff and less pollutants in the runoff.

d. Contour farming (330): Farming sloping land in such a way that preparing land, planting, and cultivating are done on the contour. This includes following established grades of terraces or diversions.

This practice reduces erosion and sediment production. Less sediment and related pollutants may be transported to the receiving waters.

Increased infiltration may increase the transportation potential for soluble substances to the ground water.

e. Contour orchard and other fruit area (331): Planting orchards, vineyards, or small fruits so that all cultural operations are done on the contour.

Contour orchards and fruit areas may reduce erosion, sediment yield, and pesticide concentration in the water lost. Where inward sloping benches are used, the sediment and chemicals will be trapped against the slope. With annual events, the bench may provide 100 percent trap efficiency. Outward sloping benches may allow greater sediment and chemical loss. The amount of retention depends on the slope of the bench and the amount of cover. In addition, outward sloping benches are subject to erosion form runoff from benches immediately above them. Contouring allows better access to rills, permitting maintenance that reduces additional erosion. Immediately after establishment, contour orchards may be subject to erosion and sedimentation in excess of the now contoured orchard. Contour orchards require more fertilization and pesticide application than did the native grasses that frequently covered the slopes before orchards were started. Sediment leaving the site may carry more adsorbed nutrients and pesticides than did the sediment before the benches were established from uncultivated slopes. If contoured orchards *replace other crop or intensive land use, the increase or decrease in chemical transport from the site may be determined by examining the types and amounts of chemicals used on the prior land use as compared to the contour orchard condition.*

Soluble pesticides and nutrients may be delivered to and possibly through the root zone in an amount proportional to the amount of soluble pesticides applied, the increase in infiltration, the chemistry of the pesticides, organic and clay content of the soil, and amounts of surface residues. Percolating water below the root zone may carry excess solutes or may dissolve potential pollutants as they move. In either case, these solutes could reach ground water supplies and/or surface downslope from the contour orchard area. The amount depends on soil type, surface water quality, and the availability of soluble material (natural or applied).

■ f. *Cover and green manure crop (340): A crop of close-growing grasses, legumes, or small grain grown primarily for seasonal protection and soil improvement. It usually is grown for 1 year or less, except where there is permanent cover as in orchards.*

Erosion, sediment and adsorbed chemical yields could be decreased in conventional tillage systems because of the increased period of vegetal cover. Plants will take up available nitrogen and prevent its undesired movement. Organic nutrients may be added to the nutrient budget reducing the need to supply more soluble forms. Overall volume of chemical application may decrease because the vegetation will supply nutrients and there may be allelopathic effects of some of the types of cover vegetation on weeds. Temperatures of ground and surface waters could slightly decrease.

■ g. *Critical area planting (342): Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).*

This practice may reduce soil erosion and sediment delivery to surface waters. Plants may take up more of the nutrients in the soil, reducing the amount that can be washed into surface waters or leached into ground water.

During grading, seedbed preparation, seeding, and mulching, large quantities of sediment and associated chemicals may be washed into surface waters prior to plant establishment.

■ h. *Crop residue use (344): Using plant residues to protect cultivated fields during critical erosion periods.*

When this practice is employed, raindrops are intercepted by the residue reducing detachment, soil dispersion, and soil compaction. Erosion may be reduced and the delivery of sediment and associated pollutants to surface water may be reduced. Reduced soil sealing, crusting and compaction allows more water to infiltrate, resulting in an increased potential for leaching of dissolved pollutants into the ground water.

Crop residues on the surface increase the microbial and bacterial action on or near the surface. Nitrates and surface-applied pesticides may be tied-up and less available to be delivered to surface and ground water. Residues trap sediment and reduce the amount carried to surface water. Crop residues promote soil aggregation and improve soil tilth.

■ i. *Delayed seed bed preparation (354): Any cropping system in which all of the crop residue and volunteer vegetation are maintained on the soil surface until approximately 3 weeks before the succeeding crop is planted, thus shortening the bare seedbed period on fields during critical erosion periods.*

The purpose is to reduce soil erosion by maintaining soil cover as long as practical to minimize raindrop splash and runoff during the spring erosion period. Other purposes include moisture conservation, improved water quality, increased soil infiltration, improved soil tilth, and food and cover for wildlife.

j. *Diversion (362): A channel constructed across the slope with a supporting ridge on the lower side (Figure 2-3).*

This practice will assist in the stabilization of a watershed, resulting in the reduction of sheet and rill erosion by reducing the length of slope. Sediment may be reduced by the elimination of ephemeral and large gullies. This may reduce the amount of sediment and related pollutants delivered to the surface waters.

k. *Field border (386): A strip of perennial vegetation established at the edge of a field by planting or by converting it from trees to herbaceous vegetation or shrubs.*

This practice reduces erosion by having perennial vegetation on an area of the field. Field borders serve as "anchoring points" for contour rows, terraces, diversions, and contour strip cropping. By elimination of the practice of tilling and planting the ends up and down slopes, erosion from concentrated flow in furrows and long rows may be reduced. This use may reduce the quantity of sediment and related pollutants transported to the surface waters.

l. *Filter strip (393): A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater.*

Filter strips for sediment and related pollutants meeting minimum requirements may trap the coarser grained sediment. They may not filter out soluble or suspended fine-grained materials. When a storm causes runoff in excess When the field borders are located such that runoff flows across them in sheet flow, they may cause the deposition of sediment and prevent it from entering the surface water. Where these practice are between cropland and a stream

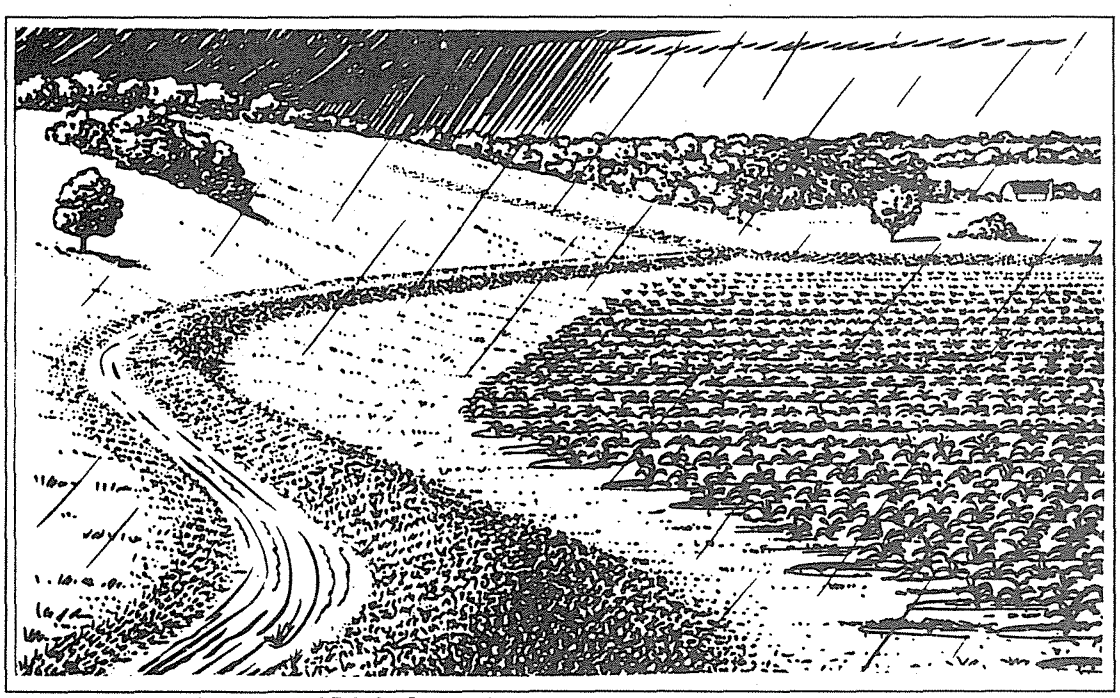

Figure 2-3. Diversion (USDA-SCS, 1984).

or water body, the practice may reduce the amount of pesticide application drift from entering the surface water of the design runoff, the filter may be flooded and may cause large loads of pollutants to be released to the surface water. This type of filter requires high maintenance and has a relatively short service life and is effective only as long as the flow through the filter is shallow sheet flow.

Filter strips for runoff from concentrated livestock areas may trap organic material, solids, materials which become adsorbed to the vegetation or the soil within the filter. Often they will not filter out soluble materials. This type of filter is often wet and is difficult to maintain.

Filter strips for controlled overland flow treatment of liquid wastes may effectively filter out pollutants. The filter must be properly managed and maintained, including the proper resting time. Filter strips on forest land may trap coarse sediment, timbering debris, and other deleterious material being transported by runoff. This may improve the quality of surface water and has little effect on soluble material in runoff or on the quality of ground water.

All types of filters may reduce erosion on the area on which they are constructed.

Filter strips trap solids from the runoff flowing in sheet flow through the filter. Coarse-grained and fibrous materials are filtered more efficiently than fine-grained and soluble substances. Filter strips work for design conditions, but when flooded or overloaded they may release a slug load of pollutants into the surface water.

m. *Grade stabilization structure (410): A structure used to control the grade and head cutting in natural or artificial channels.*

Where reduced stream velocities occur upstream and downstream from the structure, streambank and streambed erosion will be reduced. This will decrease the yield of sediment and sediment-attached substances. Structures that trap sediment will improve downstream water quality. The sediment yield change will be a function of the sediment yield to the structure, reservoir trap efficiency and of velocities of released water. Ground water recharge may affect aquifer quality depending on the quality of the recharging water. If the stored water contains only sediment and chemical with low water solubility, the ground water quality should not be affected.

n. *Grassed waterway (412): A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.*

This practice may reduce the erosion in a concentrated flow area, such as in a gully or in ephemeral gullies. This may result in the reduction of sediment and substances delivered to receiving waters. Vegetation may act as a filter in removing some of the sediment delivered to the waterway, although this is not the primary function of a grassed waterway.

Any chemicals applied to the waterway in the course of treatment of the adjacent cropland may wash directly into the surface waters in the case where there is a runoff event shortly after spraying.

When used as a stable outlet for another practice, waterways may increase the likelihood of dissolved and suspended pollutants being transported to surface waters when these pollutants are delivered to the waterway.

o. *Grasses and legumes in rotation (411): Establishing grasses and legumes or a mixture of them and maintaining the stand for a definite number of years as part of a conservation cropping system.*

Reduced runoff and increased vegetation may lower erosion rates and subsequent yields of sediment and sediment-attached substances. Less applied nitrogen may be required to grow crops because grasses and legumes will supply organic nitrogen. During the period of the rotation when the grasses and legumes are growing, they will take up more phosphorus. Less pesticides may similarly be required with this practice. Downstream water temperatures may be lower depending on the season when this practice is applied. There will be a greater opportunity for animal *waste management on grasslands because manures and other wastes may be applied for a longer part of the crop year.*

p. *Sediment basins (350): Basins constructed to collect and store debris or sediment.*

Sediment basins will remove sediment, sediment associated materials and other debris from the water which is passed on downstream. Due to the detention of the runoff in the basin, there is an increased opportunity for soluble materials to be leached toward the ground water.

q. *Contour stripcropping (585): Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion.*

The crops are arranged so that a strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow or a strip of grass is alternated with a close-growing crop (Figure 2-4).

This practice may reduce erosion and the amount of sediment and related substances delivered to the surface waters. The practice may increase the amount of water which infiltrates into the root zone, and, at the time there is an overabundance of soil water, this water may percolate and leach soluble substances into the ground water.

r. *Field strip-cropping (586): Growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion.*

The crops are arranged so that a strip of grass or a close-growing crop is alternated with a clean-tilled crop or fallow.

This practice may reduce erosion and the delivery of sediment and related substances to the surface waters. The practice may increase infiltration and, when there is sufficient water available, may increase the amount of leachable pollutants moved toward the ground water.

Since this practice is not on the contour there will be areas of concentrated flow, from which detached sediment, adsorbed chemicals and dissolved substances will be delivered more rapidly to the receiving waters. The sod strips will not be efficient filter areas in these areas of concentrated flow.

s. *Terrace (600): An earthen embankment, a channel, or combination ridge and channel constructed across the slope (Figures 2-5 and 2-6).*

This practice reduces the slope length and the amount of surface runoff which passes over the area downslope from an individual terrace. This may reduce the erosion rate and production of sediment within the terrace interval. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water which enhance surface water quality. Terraces may intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thus, reducing the occurrence of ephemeral and classic gullies and the resulting sediment. Increases in infiltration can cause a greater amount of soluble nutrients and pesticides to be leached into the soil. Underground outlets may collect highly soluble nutrient and pesticide leachates and convey runoff and conveying it directly to an outlet, terraces may increase the delivery of pollutants to surface waters. Terraces increase the opportunity to leach salts below the root zone in the soil. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient, salt, and pesticide pollutants to surface or ground waters.

t. *Water and sediment control basin (638): An earthen embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin.*

Contour strip cropping systems can involve up to 10 strips in a field. A strip cropping system could involve the following:

Corn (either for grain and/or silage)

Soybeans

1st year Meadow

Established Meadow (2-4 years)

Oats

Grassed waterway or diversion

Tillage systems may include two kinds in the same year such as chisel plowing for the for crop and moldboard plowing for the oats.

See the following figure showing typical patterns of stripcropping.

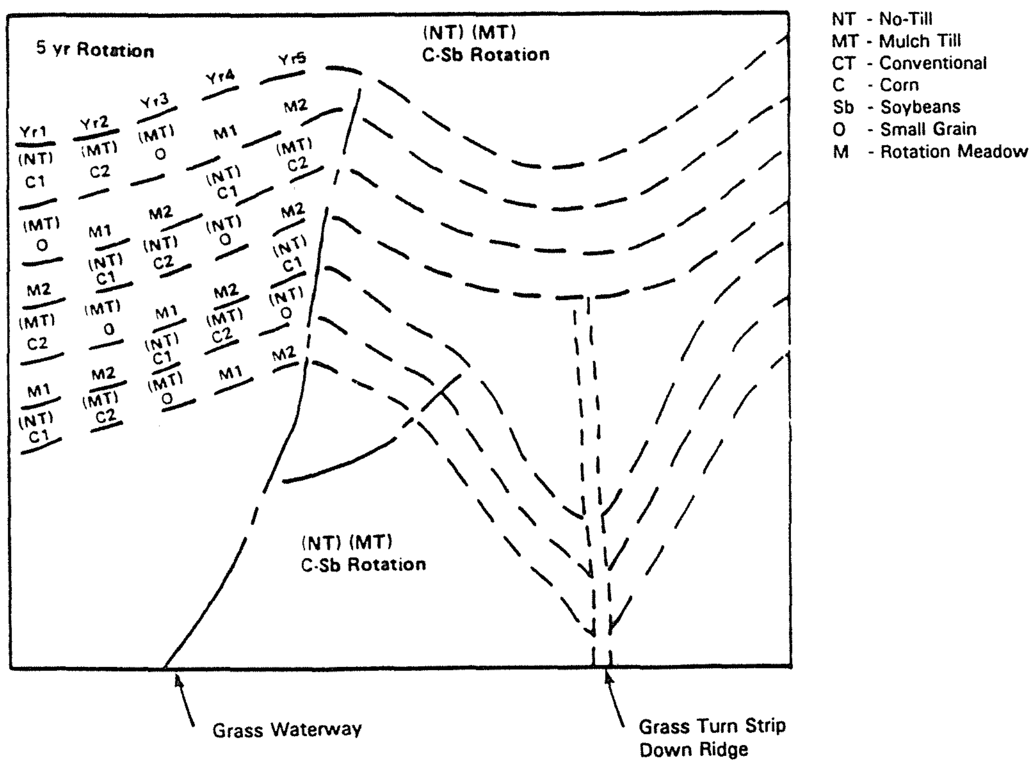

Figure 2-4. Strip-cropping and rotations (USDA-ARS, 1987).

The practice traps and removes sediment and sediment-attached substances from runoff. Trap control efficiencies for sediment and total phosphorus, that are transported by runoff, may exceed 90 percent in silt loam soils. Dissolved substances, such as nitrates, may be removed from discharge to downstream areas because of the increased infiltration. Where geologic condition permit, the practice will lead to increased loadings of dissolved substances toward ground water. Water temperatures of surface runoff, released through underground outlets, may increase slightly because of longer exposure to warming during its impoundment.

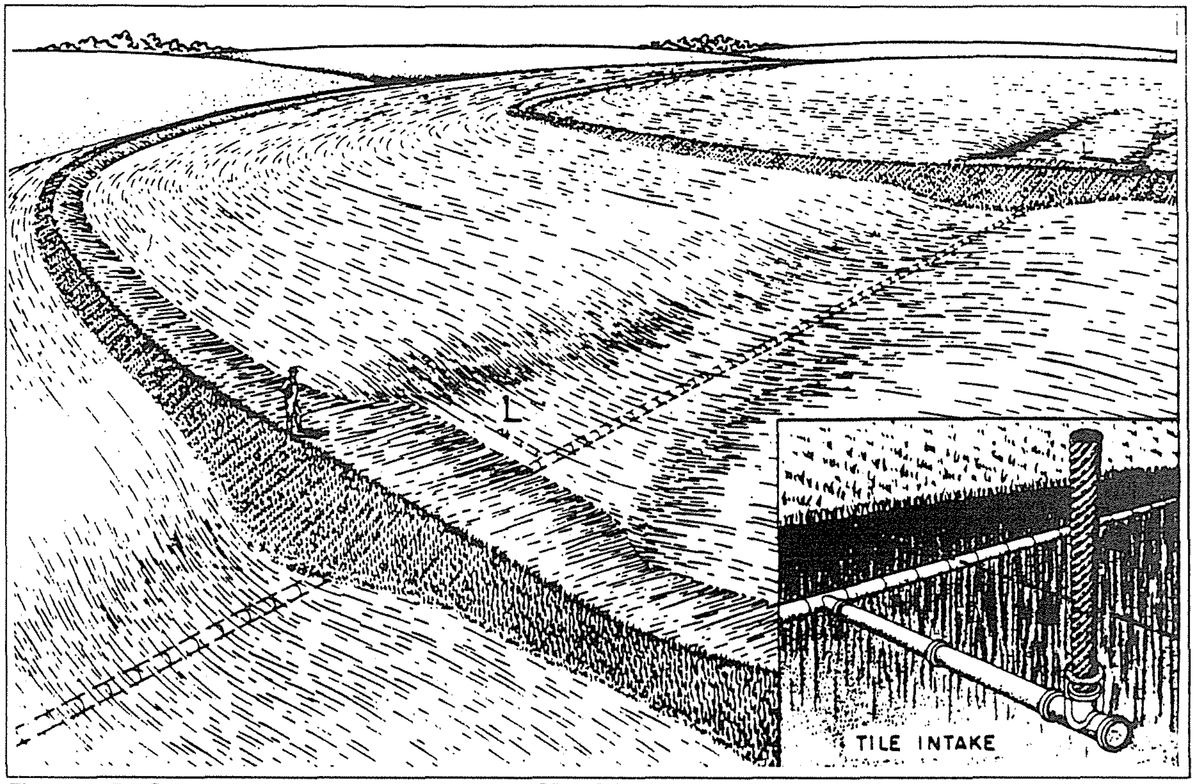

Figure 2-5. Gradient terraces with tile outlets (USDA-SCS, 1984).

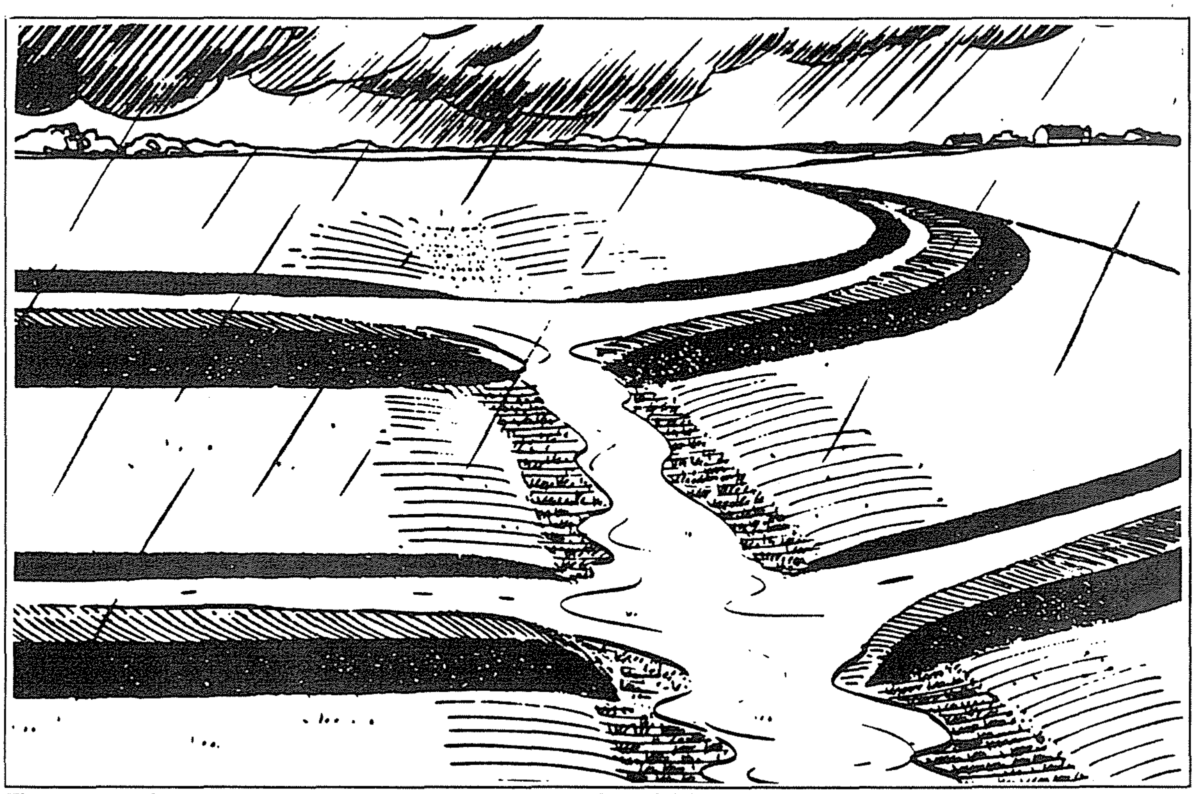

Figure 2-6. Gradient terraces with waterway outlet (USDA-SCS, 1984).

u. *Wetland and riparian zone protection*

Wetland and riparian zone protection practices are described in Chapter 7.

6. Cost Information

Both national and selected State costs for a number of common erosion control practices are presented in Tables 2-3 through 2-7. The variability in costs for practices can be accounted for primarily through differences in site-specific applications and costs, differences in the reporting units used, and differences in the interpretation of reporting units.

The cost estimates for control of erosion and sediment transport from agricultural lands in Table 2-8 are based on experiences in the Chesapeake Bay Program, but are illustrative of the costs that could be incurred in coastal areas across the Nation. It is important to note that for some practices, such as conservation tillage, the net costs often approach zero and in some cases can be negative because of the savings in labor and energy.

The annual cost of operation and maintenance is estimated to range from zero to 10 percent of the investment cost (USDA-SCS-Michigan, 1988).

Table 2-3. Cost of Diversions

Location	Year	Unit	Reported Capital Costs ($/unit)	Constant Dollar Capital Costs ($/unit)[a]	Reference
National	1985	ac	49.45	61.8	Barbarika, 1987.
North Carolina	1980	ac	120.00	164.35	NCAES, 1982
Maryland	1991	ft	3.12	3.12	Sanders et al., 1991.
Maryland	1987	ft	2.25	2.89	Smolen and Humenik, 1989.
Michigan	1981	ft	3.75	4.79	Smolen and Humenik, 1989.
Wisconsin	1987	ft	1.57	2.02	Smolen and Humenik, 1989.
Minnesota	1987	ft	1.43	1.84	Smolen and Humenik, 1989.
Virginia	1987	ft	1.33	1.71	Smolen and Humenik, 1989.

[a] Reported costs inflated to 1991 dollars by the ratio of indices of prices paid by farmers for all production items, 1977=100. Diversion lifetime is expected to be 10 years, but costs are not annualized.

Table 2-4. Cost of Terraces

Location	Year	Unit	Reported Capital Costs ($/unit)	Constant Dollar Capital Costs ($/unit)[a]	Reference
National	1985	ac	91.43	114.44	Barbarika, 1987.
Alabama	1982	a.s.	45.00	55.58	Russell and Christensen, 1984.
Florida	1982	a.s.	40.00	49.41	Russell and Christensen, 1984.
Georgia	1982	a.s.	39.00	48.18	Russell and Christensen, 1984.
North Carolina	1982	a.s.	47.00	58.06	Russell and Christensen, 1984.
South Carolina	1982	a.s.	17.00	21.00	Russell and Christensen, 1984.
Virginia	1982	a.s.	39.00	48.18	Russell and Christensen, 1984.
Wisconsin	1987	ft	10.00	12.86	Smolen and Humenik, 1989.
Minnesota	1987	ft	2.25	2.89	Smolen and Humenik, 1989.

a.s. = acres served

[a] Reported costs inflated to 1991 dollars by the ratio of indices of prices paid by farmers for all production items, 1977=100. Terrace lifetime is expected to be 10 years, but costs are not annualized.

Table 2-5. Cost of Waterways

Location	Year	Unit	Reported Capital Costs ($/unit)	Constant Dollar Capital Costs ($/unit)[a]	Reference
National	1985	ac	94.22	117.93	Barbarika, 1987.
Michigan	1981	ac	150.00	191.55	Smolen and Humenik, 1989.
Wisconsin	1987	ac	2880.00	3702.86	Smolen and Humenik, 1989.
North Carolina	1980	ac	72.00	98.61	NCAES, 1982.
Alabama	1982	a.e.	1088.00	1344.00	Russell and Christensen, 1984.
Florida	1982	a.e.	1026.00	1267.41	Russell and Christensen, 1984.
Georgia	1982	a.e.	880.00	1087.06	Russell and Christensen, 1984.
North Carolina	1982	a.e.	1232.00	1521.88	Russell and Christensen, 1984.
South Carolina	1982	a.e.	1442.00	1781.29	Russell and Christensen, 1984.
Virginia	1982	a.e.	1530.00	1890.00	Russell and Christensen, 1984.
Maryland	1991	ft	5.11	5.11	Sanders et al, 1991.
Maryland	1987	ft	6.00	7.71	Smolen and Humenik, 1989.

a.e. = acres established

[a] Reported costs inflated to 1991 dollars by the ratio of indices of prices paid by farmers for all production items, 1977=100. Waterway lifetime is expected to be 10 years, but costs are not annualized.

Table 2-6. Cost of Permanent Vegetative Cover

Location	Year	Unit	Reported Capital Costs ($/unit)	Constant Dollar Capital Costs ($/unit)[a]	Reference
National	1985	ac	48.10	60.20	Barbarika, 1987.
Maryland	1991	ac	235.48	235.48	Sanders et al., 1991.
Maryland	1987	ac	120.00	154.29	Smolen and Humenik, 1989.
Michigan	1981	ac	62.50	79.81	Smolen and Humenik, 1989.
Wisconsin	1987	ac	70.00	90.00	Smolen and Humenik, 1989.
Minnesota	1987	ac	233.00	299.57	Smolen and Humenik, 1989.
Virginia	1987	ac	133.00	171.00	Smolen and Humenik, 1989.
Alabama	1982	ac	98.78	122.02	Russell and Christensen, 1984.
Florida	1982	ac	98.24	121.36	Russell and Christensen, 1984.
Georgia	1982	ac	98.52	121.70	Russell and Christensen, 1984.
North Carolina	1982	ac	73.74	91.09	Russell and Christensen, 1984.
South Carolina	1982	ac	121.54	150.14	Russell and Christensen, 1984.
Virginia	1982	ac	101.36	125.21	Russell and Christensen, 1984.

[a] Reported costs inflated to 1991 dollars by the ratio of indices of prices paid by farmers for all production items, 1977=100. Permanent vegetative cover lifetime is expected to be 10 years, but costs are not annualized.

Table 2-7. Cost of Conservation Tillage

Location	Year	Unit	Reported Capital Costs ($/unit)	Constant Dollar Capital Costs ($/unit)[a]	Reference
Maryland	1987	ac	18.00	21.99	Smolen and Humenik, 1989.
Michigan	1987	ac	6.75	8.25	Smolen and Humenik, 1989.
Wisconsin	1981	ac	27.55	42.65	Smolen and Humenik, 1989.
Minnesota	1987	ac	13.40	16.37	Smolen and Humenik, 1989.
Virginia	1987	ac	29.30	35.79	Smolen and Humenik, 1989.
North Carolina	1980	ac	10.00	17.12	NCAES, 1982.
Alabama	1982	ac[b]	19.00	26.84	Russell and Christensen, 1984.
Florida	1982	ac[b]	39.00	55.09	Russell and Christensen, 1984.
Georgia	1982	ac[b]	33.00	46.61	Russell and Christensen, 1984.
North Carolina	1982	ac[b]	12.00	16.95	Russell and Christensen, 1984.
South Carolina	1982	ac[b]	27.00	38.14	Russell and Christensen, 1984.
Virginia	1982	ac[b]	16.00	22.60	Russell and Christensen, 1984.

[a] Reported costs inflated to 1991 dollars by the ratio of indices of prices paid by farmers for other machinery, 1977=100. Conservation tillage lifetime is expected to be 10 years, but costs are not annualized.

[b] Per acre of planting and herbicides.

Table 2-8. Annualized Cost Estimates for Selected Management Practices from Chesapeake Bay Installations[a] (Camacho, 1991)

Practice	Practice Life Span (Years)	Median Annual Costs[b] (EAC[c])($/acre/yr)
Nutrient Management	3	2.40
Strip-cropping	5	11.60
Terraces	10	84.53
Diversions	10	52.09
Sediment Retention Water Control Structures	10	89.22
Grassed Filter Strips	5	7.31
Cover Crops	1	10.00
Permanent Vegetative Cover on Critical Areas	5	70.70
Conservation Tillage[d]	1	17.34
Reforestation of Crop and Pasture[d]	10	46.66
Grassed Waterways[e]	10	1.00/LF/yr
Animal Waste System[f]	10	3.76/ton/yr

[a] Median costs (1990 dollars) obtained from the Chesapeake Bay Program Office (CBPO) BMP tracking data base and Chesapeake Bay Agreement Jurisdictions' unit data cost. Costs per acre are for acres benefited by the practice.
[b] Annualized BMP total cost including O&M, planning, and technical assistance costs.
[c] EAC = Equivalent annual cost: annualized total costs for the life span. Interest rate = 10%.
[d] Government incentive costs.
[e] Annualized unit cost per linear foot of constructed waterway.
[f] Units for animal waste are given as $/ton of manure treated.

B1. Management Measure for Facility Wastewater and Runoff from Confined Animal Facility Management (Large Units)

Limit the discharge from the confined animal facility to surface waters by:

(1) Storing both the facility wastewater *and* the runoff from confined animal facilities that is caused by storms up to and including a 25-year, 24-hour frequency storm. Storage structures should:

(a) Have an earthen lining or plastic membrane lining, or
(b) Be constructed with concrete, or
(c) Be a storage tank;

and

(2) Managing stored runoff and accumulated solids from the facility through an appropriate waste utilization system.

1. Applicability

This management measure is intended for application by States to all new facilities regardless of size and to all new or existing confined animal facilities that contain the following number of head or more:

	Head	Animal Units[2]
Beef Feedlots	300	300
Stables (horses)	200	400
Dairies	70	98
Layers	15,000	150[3]
		495[4]
Broilers	15,000	150[3]
		495[4]
Turkeys	13,750	2,475
Swine	200	80

except those facilities that are required by Federal regulation 40 CFR 122.23 to apply for and receive discharge permits. That section applies to "concentrated animal feeding operations," which are defined in 40 CFR Part 122, Appendix B. In addition, 40 CFR 122.23(c) provides that the Director of an NPDES discharge permit program may designate any animal feeding operation as a concentrated animal feeding operation (which has the effect of subjecting

[2] See *animal unit* in Glossary.

[3] If facility has a liquid manure system, as used in 40 CFR Section 122, Appendix B.

[4] If facility has continuous overflow watering, as used in 40 CFR Section 122, Appendix B.

the operation to the NPDES permit program requirements) upon determining that it is a significant contributor of water pollution. In such cases, upon issuance of a permit, the terms of the permit apply and this management measure ceases to apply.

Under the Coastal Zone Act Reauthorization Amendments, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

A *confined animal facility* is a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

- Animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
- Crops, vegetation forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Two or more animal facilities under common ownership are considered, for the purposes of these guidelines, to be a single animal facility if they adjoin each other or if they use a common area or system for the disposal of wastes.

Confined animal facilities, as defined above, include areas used to grow or house the animals, areas used for processing and storage of product, manure and runoff storage areas, and silage storage areas.

Facility wastewater and runoff from confined animal facilities are to be controlled under this management measure (Figure 2-7). Runoff includes any precipitation (rain or snow) that comes into contact with any manure, litter, or bedding. Facility wastewater is water discharged in the operation of an animal facility as a result of any or all of the following: animal or poultry watering; washing, cleaning, or flushing pens, barns, manure pits, or other animal facilities; washing or spray cooling of animals; and dust control.

2. Description

The problems associated with animal facilities result from runoff, facility wastewater, and manure. For additional information regarding problems, see Section I.F.3 of this chapter.

Application of this management measure will greatly reduce the volume of runoff, manure, and facility wastewater reaching a waterbody, thereby improving water quality and the use of the water resource. The measure can be implemented by using practices that divert runoff water from upslope sites and roofs away from the facility, thereby minimizing the amount of water to be stored and managed. Runoff water and facility wastewater should be routed through a settling structure or debris basin to remove solids, and then stored in a pit, pond, or lagoon for application on agricultural land (Figure 2-8). If manure is managed as a liquid, all manure, runoff, and facility wastewater can be stored in the same structure and there is no need for a debris basin.

For new facilities and expansions to existing facilities, consideration should be given to siting the facility:

- Away from surface waters;
- Away from areas with high leaching potential; and
- In areas where adequate land is available to apply animal wastes in accordance with the nutrient management measure.

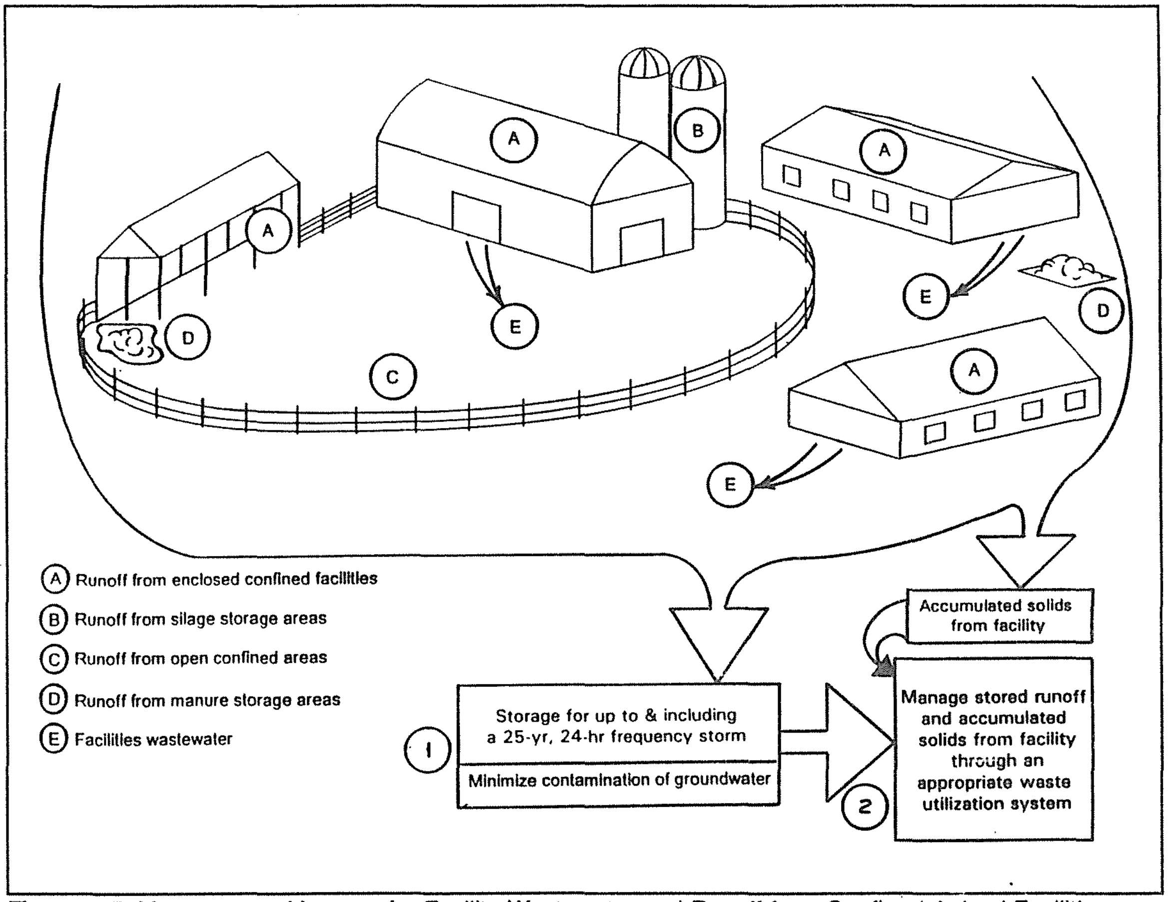

Figure 2-7. Management Measure for Facility Wastewater and Runoff from Confined Animal Facilities (Large Units).

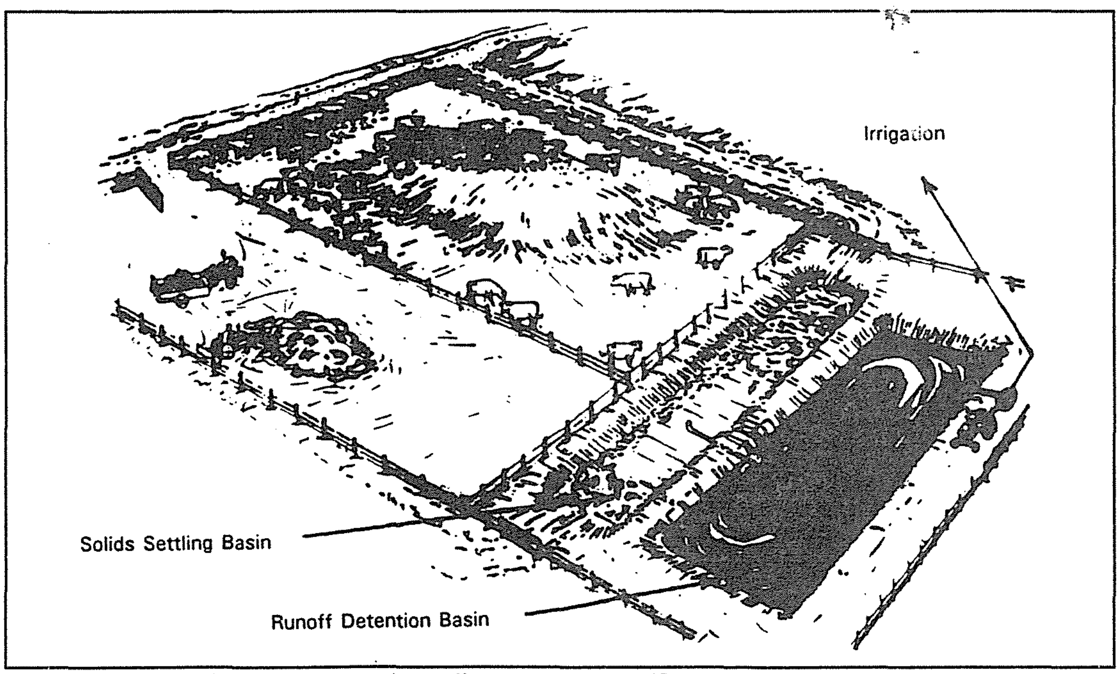

Figure 2-8. Example of manure and runoff storage system (Sutton, 1990).

This management measure does *not* require manure storage structures or areas, nor does it specify required manure management practices. This management measure does, however, address the management of *runoff* from manure storage areas. Manure may be stacked in the confined lot or other appropriate area as long as the storage and management of runoff from the confined lot are in accordance with this management measure. If manure is managed as a solid, any drainage from the storage area or structure area or structure should be routed to the runoff storage system.

When applied to agricultural lands, manure, stored runoff water, stored facility wastewater, and accumulated solids from the facility are to be applied in accordance with the nutrient management measure. An appropriate waste utilization system to minimize impacts to surface water and protect ground water may be achieved through implementation of the SCS Waste Utilization practice (633).

It is recognized that implementation of this measure may increase the potential for movement of water and soluble pollutants through the soil profile to the ground water. It is not the intent of this measure to address a surface water problem at the expense of ground water. Facility wastewater and runoff control systems can and should be designed to protect ground water. Ground-water protection will also be provided by minimizing seepage to ground water, if soil conditions require further protection, and by using the nutrient and pesticide management measures to reduce and control the application of nutrients and pesticides.

Seepage to ground water can be minimized by lining the runoff or manure storage structure with an earthen lining or plastic membrane lining, by constructing with concrete, or by constructing a storage tank. This is not difficult to accomplish and should be achieved in the initial design to reduce costs. For some soils and locations, movement of pollutants to the ground water is not a concern, but site evaluations are needed to determine the appropriate action to take to protect the resources at the site.

Operation and Maintenance of This Measure

Operation

Holding ponds and treatment lagoons should be operated such that the design storm volume is available for storage of runoff. Facilities filled to or near capacity should be drawn down as soon as all site conditions permit the safe removal and appropriate use of stored materials. Solids should be removed from solids separation basins as soon as possible following storm events to ensure that needed solids storage volume is available for subsequent storms.

Maintenance

Diversions will need periodic reshaping and should be free of trees and brush growth. Gutters and downspouts should be inspected annually and repaired when needed. Established grades for lot surfaces and conveyance channels are to be maintained at all times.

Channels should be free of trees and brush growth. Cleaning of debris basins, holding ponds, and lagoons will be needed to ensure that design volumes are maintained. Clean water should be excluded from the storage structure unless it is needed for further dilution in a liquid system.

3. Management Measure Selection

This management measure was selected for larger-sized animal production facilities because it can eliminate the pollutants leaving a facility by storing runoff from storms up to and including the 25-year, 24-hour frequency storm. It also uses practices that reduce the amount of water that comes into contact with animal waste materials. It requires that stored runoff and accumulated solids from the facility are managed through an appropriate waste utilization system. Any stored water, accumulated solids, processed dead animals, or manure are to be applied in accordance with the nutrient management measure.

The size limitations that define a large unit are based on EPA's analysis of the economic achievability of the management measure.

4. Effectiveness Information

The effectiveness of management practices to control contaminant losses from confined livestock facilities depends on several factors including:

- The contaminant(s) to be controlled and their likely pathways in surface, subsurface, and ground-water flows;
- The types of practices (section 5) and how these practices control surface, subsurface, and ground-water contaminant pathways; and
- Site-specific variables such as soil type, topography, precipitation characteristics, type of animal housing and waste storage facilities, method of waste collection, handling and disposal, and seasonal variations. The site-specific conditions must be considered in system design, thus having a large effect on practice effectiveness levels.

The gross effectiveness estimates reported in Table 2-9 simply indicate summary literature values. For specific cases, a wide range of effectiveness can be expected depending on the value and interaction of the site-specific variables cited above.

When runoff from storms up to and including the 24-hour, 25-year frequency storm is stored, there will be no release of pollutants from a confined animal facility via the surface runoff route. Rare storms of a greater magnitude or sequential storms of combined greater magnitude may produce runoff, however. Table 2-10 reflects the occurrence of such storms by indicating less than 100 percent control for runoff control systems.

Table 2-9. Relative Gross Effectiveness[a] of Confined Livestock Control Measures (Pennsylvania State University, 1992a)

Practice[b] Category	Runoff[c] Volume	Total[d] Phosphorus (%)	Total[d] Nitrogen (%)	Sediment (%)	Fecal Coliform (%)
Animal Waste Systems[e]	-	90	80	60	85
Diversion Systems[f]	-	70	45	NA	NA
Filter Strips[g]	-	85	NA	60	55
Terrace System	-	85	55	80	NA
Containment Structures[h]	-	60	65	70	90

NA = not available.
[a] Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.
[b] Each category includes several specific types of practices.
[c] - = reduction; + = increase; 0 = no change in surface runoff.
[d] Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N.
[e] Includes methods for collecting, storing, and disposing of runoff and process-generated wastewater.
[f] Specific practices include diversion of uncontaminated water from confinement facilities.
[g] Includes all practices that reduce contaminant losses using vegetative control measures.
[h] Includes such practices as waste storage ponds, waste storage structures, waste treatment lagoons.

Table 2-10. Effectiveness of Runoff Control Systems (DPRA, 1986)

	Removal Efficiency (%)	
Management Practice	Solids	Phosphorus
Runoff Control System	80 - 90	70 - 95

5. Confined Animal Facility Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Combinations of the following practices can be used to satisfy the requirements of this management measure. The U.S. Soil Conservation Service (SCS) practice number and definition are provided for each management practice, where available. Also included in italics are SCS statements describing the effect each practice has on water quality (USDA-SCS, 1988).

a. Dikes (356): An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Where dikes are used to prevent water from flowing onto the floodplain, the pollution dispersion effect of the temporary wetlands and backwater are decreased. The sediment, sediment-attached, and soluble materials being transported by the water are carried farther downstream. The final fate of these materials must be investigated on site. Where dikes are used to retain runoff on the floodplain or in wetlands the pollution dispersion effects of these areas may be enhanced. Sediment and related materials may be deposited, and the quality of the water flowing into the stream from this area will be improved.

Dikes are used to prevent wetlands and to form wetlands. The formed areas may be fresh, brackish, or saltwater wetlands. In tidal areas dikes are used to stop saltwater intrusion, and to increase the hydraulic head of fresh water which will force intruded salt water out the aquifer. During construction there is a potential of heavy sediment loadings to the surface waters. When pesticides are used to control the brush on the dikes and fertilizers are used for the establishment and maintenance of vegetation there is the possibility for these materials to be washed into the surface waters.

b. Diversions (362): A channel constructed across the slope with a supporting ridge on the lower side.

This practice will assist in the stabilization of a watershed, resulting in the reduction of sheet and rill erosion by reducing the length of slope. Sediment may be reduced by the elimination of ephemeral and large gullies. This may reduce the amount of sediment and related pollutants delivered to the surface waters.

c. Grassed waterway (412): A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

This practice may reduce the erosion in a concentrated flow area, such as in a gully or in ephemeral gullies. This may result in the reduction of sediment and substances delivered to receiving waters. Vegetation may act as a filter *in removing some of the sediment delivered to the waterway, although this is not the primary function of a grassed waterway.*

Any chemicals applied to the waterway in the course of treatment of the adjacent cropland may wash directly into the surface waters in the case where there is a runoff event shortly after spraying.

When used as a stable outlet for another practice, waterways may increase the likelihood of dissolved and suspended pollutants being transported to surface waters when these pollutants are delivered to the waterway.

d. Heavy use area protection (561): Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures.

Protection may result in a general improvement of surface water quality through the reduction of erosion and the resulting sedimentation. Some increase in erosion may occur during and immediately after construction until the disturbed areas are fully stabilized.

Some increase in chemicals in surface water may occur due to the introduction of fertilizers for vegetated areas and oils and chemicals associated with paved areas. Fertilizers and pesticides used during operation and maintenance may be a source of water pollution.

Paved areas installed for livestock use will increase organic, bacteria, and nutrient loading to surface waters. Changes in ground water quality will be minor. Nitrate nitrogen applied as fertilizer in excess of vegetation needs may move with infiltrating waters. The extent of the problem, if any, may depend on the actual amount of water percolating below the root zone.

e. Lined waterway or outlet (468): A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material.

The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

This practice may reduce the erosion in concentrated flow areas resulting in the reduction of sediment and substances delivered to the receiving waters.

When used as a stable outlet for another practice, lined waterways may increase the likelihood of dissolved and suspended substances being transported to surface waters due to high flow velocities.

f. Roof runoff management (558): A facility for controlling and disposing of runoff water from roofs.

This practice may reduce erosion and the delivery of sediment and related substances to surface waters. It will reduce the volume of water polluted by animal wastes. Loadings of organic waste, nutrients, bacteria, and salts to surface water are prevented from flowing across concentrated waste areas, barnyards, roads and alleys will be reduced. Pollution and erosion will be reduced. Flooding may be prevented and drainage may improve.

g. Terrace (600): An earthen embankment, a channel, or combination ridge and channel constructed across the slope.

This practice reduces the slope length and the amount of surface runoff which passes over the area downslope from an individual terrace. This may reduce the erosion rate and production of sediment within the terrace interval. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water which enhances surface water quality. Terraces may intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thus reducing the occurrence of ephemeral and classic gullies and the resulting sediment. Increases in infiltration *can cause a greater amount of soluble nutrients and pesticides to be leached into the soil. Underground outlets may collect highly soluble nutrient and pesticide leachates and convey runoff and conveying it directly to an outlet, terraces may increase the delivery of pollutants to surface waters. Terraces increase the opportunity to leach salts below the root zone in the soil. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient, salt, and pesticide pollutants to surface or ground waters.*

h. Waste storage pond (425): An impoundment made by excavation or earth fill for temporary storage of animal or other agricultural wastes.

This practice reduces the direct delivery of polluted water, which is the runoff from manure stacking areas and feedlots and barnyards, to the surface waters. This practice may reduce the organic, pathogen, and nutrient loading to surface waters. This practice may increase the dissolved pollutant loading to ground water by leakage through the sidewalls and bottom.

i. Waste storage structure (313): A fabricated structure for temporary storage of animal wastes or other organic agricultural wastes.

This practice may reduce the nutrient, pathogen, and organic loading to the surface waters. This is accomplished by intercepting and storing the polluted runoff from manure stacking areas, barnyards and feedlots. This practice will not eliminate the possibility of contaminating surface and ground water; however, it greatly reduces this possibility.

j. Waste treatment lagoon (359): An impoundment made by excavation or earth fill for biological treatment of animal or other agricultural wastes.

This practice may reduce polluted surficial runoff and the loading of organics, pathogens, and nutrients into the surface waters. It decreases the nitrogen content of the surface runoff from feedlots by denitrification. Runoff is retained long enough that the solids and insoluble phosphorus settle and form a sludge in the bottom of the lagoon. There may be some seepage through the sidewalls and the bottom of the lagoon. Usually the long-term seepage rate is low enough, so that the concentration of substances transported into the ground water does not reach an unacceptable level.

k. Application of manure and/or runoff water to agricultural land

Manure and runoff water are applied to agricultural lands and incorporated into the soil in accordance with the management measures for nutrients.

l. Waste utilization (633): Using agricultural wastes or other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources.

Waste utilization helps reduce the transport of sediment and related pollutants to the surface water. Proper site selection, timing of application and rate of application may reduce the potential for degradation of surface and ground water. This practice may increase microbial action in the surface layers of the soil, causing a reaction which assists in controlling pesticides and other pollutants by keeping them in place in the field.

Mortality and other compost, when applied to agricultural land, will be applied in accordance with the nutrient management measure. The composting facility may be subject to State regulations and will have a written operation and management plan if SCS practice 317 (composting facility) is used.

m. Composting facility (317): A facility for the biological stabilization of waste organic material.

The purpose is to treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise utilized in compliance with all laws, rules, and regulations.

n. Commercial rendering or disposal services

o. Incineration

p. Approved burial sites

6. Cost Information

Construction costs for control of runoff and manure from confined animal facilities are provided in Table 2-11. The annual operation and maintenance costs average 4 percent of construction costs for diversions, 3 percent of construction costs for settlement basins, and 5 percent of construction costs for retention ponds (DPRA, 1992). Annual costs for repairs, maintenance, taxes, and insurance are estimated to be 5 percent of investment costs for irrigation systems (DPRA, 1992).

Table 2-11. Costs for Runoff Control Systems (DPRA, 1992)

Practice[a]	Unit	Cost/Unit Construction ($)[b]
Diversion	foot	2.00
Irrigation		
- Piping (4-inch)	foot	1.75
- Piping (6-inch)	foot	2.25
- Pumps (10 hp)	unit	1,750.00
- Pumps (15 hp)	unit	2,000.00
- Pumps (30 hp)	unit	3,000.00
- Pumps (45 hp)	unit	3,500.00
- Sprinkler/gun (150 gpm)	unit	875.00
- Sprinkler/gun (250 gpm)	unit	1,750.00
- Sprinkler/gun (400 gpm)	unit	3,200.00
- Contracted service to empty retention pond	1,000 gallon	3.00
Infiltration[c]	acre	2,500.00
Manure Hauling	mile per 4.5-ton load	2.15
Dead Animal Composting Facility	cubic foot	5.00
Retention Pond		
- 241 cubic feet in size	cubic foot	2.58
- 2,678 cubic feet in size	cubic foot	1.24
- 28,638 cubic feet in size	cubic foot	0.60
- 267,123 cubic feet in size	cubic foot	0.31
Settling Basin		
- 53 cubic feet in size	cubic foot	4.26
- 488 cubic feet in size	cubic foot	2.74
- 5,088 cubic feet in size	cubic foot	1.71
- 49,950 cubic feet in size	cubic foot	1.08

[a] Expected lifetimes of practices are 20 years for diversions, settling basins, retention ponds, and infiltration areas and 15 years for irrigation equipment.
[b] 1990 dollars. This table does not present annualized costs.
[c] Does not include land costs.

B2. Management Measure for Facility Wastewater and Runoff from Confined Animal Facility Mangement (Small Units)

Design and implement systems that collect solids, reduce contaminant concentrations, and reduce runoff to minimize the discharge of contaminants in both facility wastewater and in runoff that is caused by storms up to and including a 25-year, 24-hour frequency storm. Implement these systems to substantially reduce significant increases in pollutant loadings to ground water.

Manage stored runoff and accumulated solids from the facility through an appropriate waste utilization system.

1. Applicability

This management measure is intended for application by States to all existing confined animal facilities that contain the following number of head:

	Head	Animal Units[5]
Beef Feedlots	50-299	50-299
Stables (horses)	100-199	200-399
Dairies	20-69	28-97
Layers	5,000-14,999	50-149[6] 165-494[7]
Broilers	5,000-14,999	50-149[6] 165-494[7]
Turkeys	5,000-13,749	900-2,474
Swine	100-199	40-79

except those facilities that are required by Federal regulation 40 CFR 122.23(c) to apply for and receive discharge permits. 40 CFR 122.23(c) provides that the Director of an NPDES discharge permit program may designate any animal feeding operation as a concentrated animal feeding operation (which has the effect of subjecting the operation to the NPDES permit program requirements) upon determining that it is a significant contributor of water pollution. In such cases, upon issuance of a permit, the terms of the permit apply and this management measure ceases to apply.

Facilities containing fewer than the number of head listed above are not subject to the requirements of this management measure. Existing facilities that meet the requirements of Management Measure B1 for large units are in compliance with the requirements of this management measure. Existing and new facilities that already minimize

[5] See *animal unit* in Glossary.

[6] If facility has a liquid manure system, as used in 40 CFR Section 122, Appendix B.

[7] If facility has continuous overflow watering, as used in 40 CFR Section 122, Appendix B.

the discharge of contaminants to surface waters, protect against contamination of ground water, and have an appropriate waste utilization system may already meet the requirements of this management measure. Such facilities may not need additional controls for the purposes of this management measure.

Under the Coastal Zone Act Reauthorization Amendments, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

A *confined animal facility* is a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

- Animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and

- Crops, vegetation forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Two or more animal facilities under common ownership are considered, for the purposes of these guidelines, to be a single animal facility if they adjoin each other or if they use a common area or system for the disposal of wastes.

Confined animal facilities, as defined above, include areas used to grow or house the animals, areas used for processing and storage of product, manure and runoff storage areas, and silage storage areas.

Facility wastewater and runoff from confined animal facilities are to be controlled under this management measure (Figure 2-9). Runoff includes any precipitation (rain or snow) that comes into contact with any manure, litter, or bedding. Facility wastewater is water discharged in the operation of an animal facility as a result of any or all of the following: animal or poultry watering; washing, cleaning, or flushing pens, barns, manure pits, or other animal facilities; washing or spray cooling of animals; and dust control.

2. Description

The goal of this management measure is to minimize the discharge of contaminants in both facility wastewater and in runoff that is caused by storms up to and including a 25-year, 24-hour frequency storm by using practices such as solids separation basins in combination with vegetative practices and other practices that reduce runoff and are also protective of ground water.

The problems associated with animal facilities are the control of runoff, facility wastewater, and manure. For additional information regarding problems, see Section I.F.3. of this chapter.

Application of this management measure will greatly reduce the volume of runoff, manure, and facility wastewater reaching a waterbody, thereby improving water quality and the use of the water resource. The measure can be implemented by using practices that divert runoff water from upslope sites and roofs away from the facility, thereby minimizing the amount of water that must be managed (Figure 2-10). Runoff water and facility wastewater from the facility should be routed through a settling structure or debris basin to remove solids. If manure is managed as a liquid, all manure, runoff, and facility wastewater can be stored in the same structure and there is no need for a debris basin.

This management measure does *not* require manure storage structures or areas, nor does it specify required manure management practices. This management measure does, however, address the management of *runoff* from manure

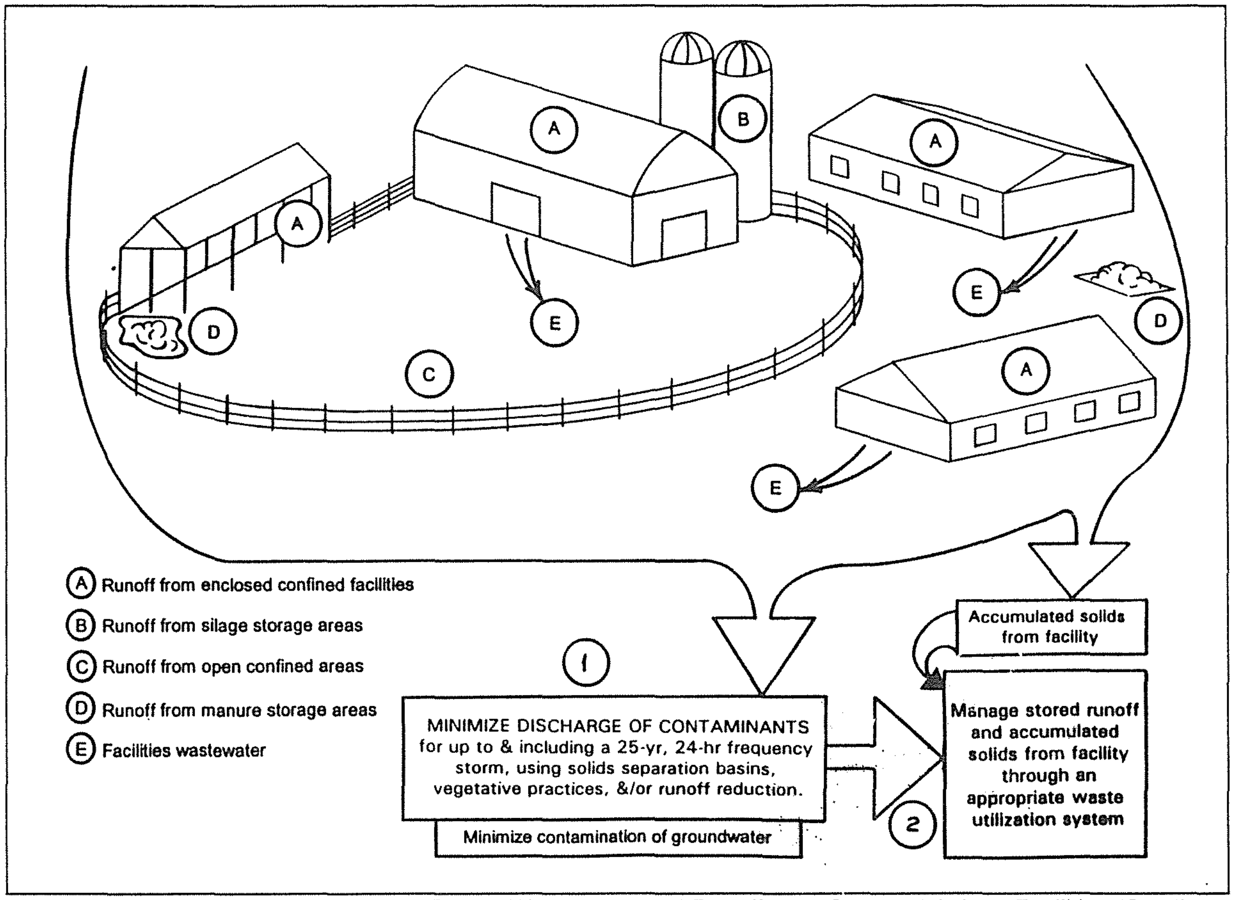

Figure 2-9. Management Measure for Facility Wastewater and Runoff from Confined Animal Facilities (Small Units).

storage areas. Manure may be stacked in the confined lot or other appropriate area as long as the discharge is minimized and any stored runoff is managed in accordance with this management measure. If manure is managed as a solid, any drainage from the storage area or structure should be routed to the runoff control practices.

When applied to agricultural lands, manure, stored runoff water, stored facility wastewater, and accumulated solids from the facility are to be applied in accordance with the nutrient management measure. An appropriate waste utilization system to minimize impacts to surface water and protect ground water may be achieved through implementation of the SCS Waste Utilization practice (633).

It is recognized that implementation of this measure may increase the potential for movement of water and soluble pollutants through the soil profile to the ground water. It is not the intent of this measure to address a surface water problem at the expense of ground water. Facility wastewater and runoff control systems can and should be designed to protect against the contamination of ground water. Ground-water protection will also be provided by minimizing seepage to ground water, if soil conditions require further protection, and by using the nutrient and pesticide management measures to reduce and control the application of nutrients and pesticides. While a nutrient management plan is not required to be implemented on the vegetative control practices themselves, ground water should be protected by taking extreme care to not exceed the capacity of the practices to assimilate nutrients.

When storage structures are used to meet the requirements of this management measure, seepage to ground water can be minimized by lining the runoff or manure storage structure with an earthen lining or plastic membrane lining, by constructing with concrete, or by constructing a storage tank. This is not difficult to accomplish and should be achieved in the initial design to reduce costs. For some soils and locations movement of pollutants to the ground

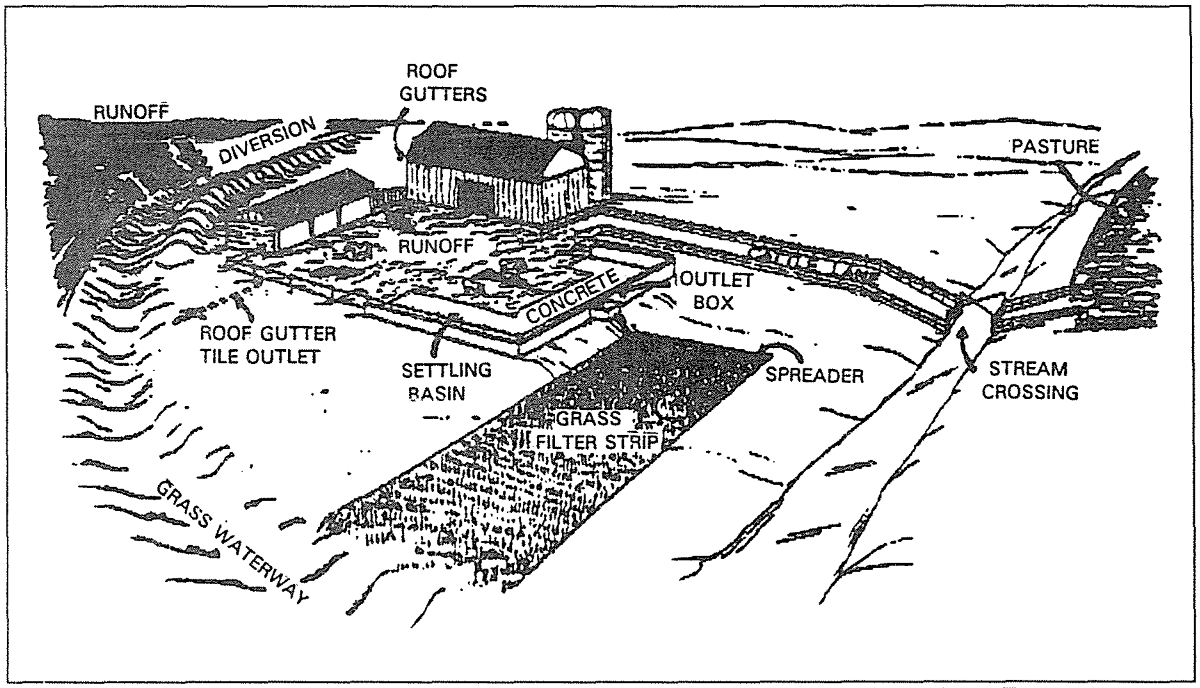

Figure 2-10. Typical barnyard runoff management system (Wisconsin Dept. of Agriculture, Trade and Consumer Protection, 1989).

water is not a concern, but each site must be evaluated and the appropriate action taken to protect the resources at the site.

Operation and Maintenance of This Measure

Operation

Holding ponds and treatment lagoons should be operated such that the design storm volume is available for storage of runoff. Facilities that have filled should be drawn down as soon as all site conditions permit the safe removal and appropriate use of stored materials. Solids should be removed from solids separation basins as soon as possible following storm events to ensure that needed solids storage volume is available for subsequent storms.

Maintenance

Diversions will need periodic reshaping and should be free of trees and brush growth. Gutters and downspouts should be inspected annually and repaired when needed. Established grades for lot surfaces and conveyance channels must be maintained at all times.

Channels must be free of trees and brush growth. Cleaning of debris basins, holding ponds, and lagoons will be needed to ensure that design volumes are maintained. Clean water should be excluded from the storage structure unless it is needed for further dilution in a liquid system.

3. Management Measure Selection

This management measure was selected for smaller-sized animal production facilities based on an evaluation of available information that documents the beneficial effects of improved management of confined livestock facilities. Specifically, the management measure reduces the amount of pollutants leaving a facility by using practices that reduce the amount of water that comes into contact with animal waste materials. It also uses solid removal and filtration of runoff water to remove a significant amount of the pollutants contained in the runoff waters. This can be accomplished without the expense of constructing a runoff storage structure and purchasing the equipment necessary to apply the stored water to the land.

This management measure also requires that stored runoff and accumulated solids from the facility are managed through an appropriate waste utilization system. The size limitations that define a small unit are based on EPA's analysis of the economic achievability of the management measure.

4. Effectiveness Information

The effectiveness information presented for large units (Tables 2-9 and 2-10) also applies to this management measure.

Pollutant loads from runoff caused by storms up to and including the 25-year, 24-hour frequency storm can be reduced by decreasing the potential for runoff contamination (e.g., by keeping accumulations of manure off the open lots), and by removing the contaminants to the fullest extent practicable through vegetative and structural practices (e.g., solids separation devices, sediment basins, filter strips, and constructed wetlands). Pollutant loads can also be reduced by storing and applying the runoff to the land with any manure and facility wastewater in accordance with the nutrient management measure.

Table 2-12 shows reductions in pollutant concentrations that are achievable with solids separation basins that receive runoff from barnyards and feedlots. Concentration reductions may differ from the load reductions presented in Tables 2-9 and 2-10 since loads are determined by both concentration and discharge volume. Solids separation basins combined with drained infiltration beds and vegetated filter strips (VFS) provide additional reductions in contaminant concentrations. The effectiveness of solids separation basins is highly dependent on site variables. Solids separation; basin sizing and management (clean-out); characteristics of VFS areas such as soil type, land slope, length, vegetation type, vegetation quality; and storm amounts and intensities all play important roles in the performance of the system. Appropriate operation and maintenance are critical to success.

Table 2-12. Concentrated Reductions in Barnyard and Feedlot Runoff Treated with Solids Separation

	Constituent Reduction (%)			
Site Location	TS	COD	Nitrogen	TP
Ohio - basin only[a,b]	49-54	51-56	35	21-41
Ohio - basin combined w/infiltration bed[a]	82	85	—	80
VFS[b]	87	89	83	84
Canada - basin only[c]	56	38	14(TKN)	—
Canada - basin w/VFS[c]		(High 90's in fall and spring)		
Illinois - basin w/VFS[d]	73		80(TKN)	78

[a] Edwards et al., 1986.
[b] Edwards et al., 1983.
[c] Adam et al., 1986.
[d] Dickey, 1981.

5. Confined Animal Facility Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Combinations of the following practices can be used to satisfy the requirements of this management measure. The U.S. Soil Conservation Service (SCS) practice number and definition are provided for each management practice, where available. Also included in italics are SCS statements describing the effect each practice has on water quality (USDA-SCS, 1988).

a. Waste storage pond (425): An impoundment made by excavation or earth fill for temporary storage of animal or other agricultural waste.

This practice reduces the direct delivery of polluted water, which is the runoff from manure stacking areas and feedlots and barnyards, to the surface waters. This practice may reduce the organic, pathogen, and nutrient loading to surface waters. This practice may increase the dissolved pollutant loading to ground water by leakage through the sidewalls and bottom.

b. Waste storage structure (313): A fabricated structure for temporary storage of animal waste or other organic agricultural waste.

This practice may reduce the nutrient, pathogen, and organic loading to the surface waters. This is accomplished by intercepting and storing the polluted runoff from manure stacking areas, barnyards and feedlots. This practice will not eliminate the possibility of contaminating surface and ground water; however, it greatly reduces this possibility.

c. Waste treatment lagoon (359): An impoundment made by excavation or earth fill for biological treatment of animal or other agricultural waste.

This practice may reduce polluted surficial runoff and the loading of organics, pathogens, and nutrients into the surface waters. It decreases the nitrogen content of the surface runoff from feedlots by denitrification. Runoff is retained long enough that the solids and insoluble phosphorus settle and form a sludge in the bottom of the lagoon. There may be some seepage through the sidewalls and the bottom of the lagoon. Usually the long-term seepage rate is low enough, so that the concentration of substances transported into the ground water does not reach an unacceptable level.

d. Sediment basin (350): A basin constructed to collect and store debris or sediment.

Sediment basins will remove sediment, sediment associated materials and other debris from the water which is passed on downstream. Due to the detention of the runoff in the basin, there is an increased opportunity for soluble materials to be leached toward the ground water.

e. Water and sediment control basin (638): An earth embankment or a combination ridge and channel generally constructed across the slope and minor water courses to form a sediment trap and a water detention basin.

The practice traps and removes sediment and sediment-attached substances from runoff. Trap control efficiencies for sediment and total phosphorus, that are transported by runoff, may exceed 90 percent in silt loam soils. Dissolved substance, such as nitrates, may be removed from discharge to downstream areas because of the increased infiltration. Where geologic condition permit, the practice will lead to increased loadings of dissolved substances toward ground water. Water temperatures of surface runoff, released through underground outlets, may increase slightly because of longer exposure to warming during its impoundment.

f. Filter strip (393): A strip or area of vegetation for removing sediment, organic matter, and other contaminants from runoff and wastewater.

Filter strips for sediment and related pollutants meeting minimum requirements may trap the coarser grained sediment. They may not filter out soluble or suspended fine-grained materials. When a storm caused runoff in excess of the design runoff, the filter may be flooded and may cause large loads of pollutants to be released to the surface water. This type of filter requires high maintenance and has a relatively short service life and is effective only as long as the flow through the filter is shallow sheet flow.

Filter strips for runoff from concentrated livestock areas may trap organic material, solids, materials which become adsorbed to the vegetation or the soil within the filter. Often they will not filter out soluble materials. This type of filter is often wet and is difficult to maintain.

Filter strips for controlled overland flow treatment of liquid wastes may effectively filter out pollutants. The filter must be properly managed and maintained, including the proper resting time. Filter strips on forest land may trap coarse sediment, timbering debris, and other deleterious material being transported by runoff. This may improve the quality of surface water and has little effect on soluble material in runoff or on the quality of ground water.

All types of filters may reduce erosion on the area on which they are constructed.

Filter strips trap solids from the runoff flowing in sheet flow through the filter. Coarse-grained and fibrous materials are filtered more efficiently than fine-grained and soluble substances. Filter strips work for design conditions, but when flooded or overloaded they may release a slug load of pollutants into the surface water.

g. Grassed waterway (412): A natural or constructed channel that is shaped or graded to required dimensions and established in a suitable vegetation for the stable conveyance of runoff.

This practice may reduce the erosion in a concentrated flow area, such as in a gully or in ephemeral gullies. This may result in the reduction of sediment and substances delivered to receiving waters. Vegetation may act as a filter in removing some of the sediment delivered to the waterway, although this is not the primary function of a grassed waterway.

Any chemicals applied to the waterway in the course of treatment of the adjacent cropland may wash directly into the surface waters in the case where there is a runoff event shortly after spraying.

When used as a stable outlet for another practice, waterways may increase the likelihood of dissolved and suspended pollutants being transported to surface waters when these pollutants are delivered to the waterway.

h. Constructed wetland (ASCS-999): A constructed aquatic ecosystem with rooted emergent hydrophytes designed and managed to treat agricultural wastewater.

This is a conservation practice for which SCS has developed technical requirements under a trial program leading to the development of a conservation practice standard.

i. Dikes (356): An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Where dikes are used to prevent water from flowing onto the floodplain, the pollution dispersion effects of the temporary wetlands and backwater are decreased. The sediment, sediment-attached, and soluble materials being transported by the water are carried farther downstream. The final fate of these materials must be investigated on site. Where dikes are used to retain runoff on the floodplain or in wetlands the pollution dispersion effects of these areas may be enhanced. Sediment and related materials may be deposited, and the quality of the water flowing into the stream from this area will be improved.

Dikes are used to prevent wetlands and to form wetlands. The formed areas may be fresh, brackish, or saltwater wetlands. In tidal areas dikes are used to stop saltwater intrusion, and to increase the hydraulic head of fresh water which will force intruded salt water out the aquifer. During construction there is a potential of heavy sediment loadings to the surface waters. When pesticides are used to control the brush on the dikes and fertilizers are used for the establishment and maintenance of vegetation there is the possibility for these materials to be washed into the surface waters.

j. Diversion (362): A channel constructed across the slope with a supporting ridge on the lower side.

This practice will assist in the stabilization of a watershed, resulting in the reduction of sheet and rill erosion by reducing the length of slope. Sediment may be reduced by the elimination of ephemeral and large gullies. This may reduce the amount of sediment and related pollutants delivered to the surface waters.

k. Heavy use area protection (561): Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures.

Protection may result in a general improvement of surface water quality through the reduction of erosion and the resulting sedimentation. Some increase in erosion may occur during and immediately after construction until the disturbed areas are fully stabilized.

Some increase in chemicals in surface water may occur due to the introduction of fertilizers for vegetated areas and oils and chemicals associated with paved areas. Fertilizers and pesticides used during operation and maintenance may be a source of water pollution.

Paved areas installed for livestock use will increase organic, bacteria, and nutrient loading to surface waters. Changes in ground water quality will be minor. Nitrate nitrogen applied as fertilizer in excess of vegetation needs may move with infiltrating waters. The extent of the problem, if any, may depend on the actual amount of water percolating below the root zone.

l. Lined waterway or outlet (468): A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material.

The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

This practice may reduce the erosion in concentrated flow areas resulting in the reduction of sediment and substances delivered to the receiving waters.

When used as a stable outlet for another practice, lined waterways may increase the likelihood of dissolved and suspended substances being transported to surface waters due to high flow velocities.

m. Roof runoff management (558): A facility for controlling and disposing of runoff water from roofs.

This practice may reduce erosion and the delivery of sediment and related substances to surface waters. It will reduce the volume of water polluted by animal wastes. Loadings of organic waste, nutrients, bacteria, and salts to surface water are prevented from flowing across concentrated waste areas, barnyards, roads and alleys. Pollution and erosion will be reduced. Flooding may be prevented and drainage may improve.

n. Terrace (600): An earthen embankment, a channel, or combination ridge and channel constructed across the slope.

This practice reduces the slope length and the amount of surface runoff which passes over the area downslope from an individual terrace. This may reduce the erosion rate and production of sediment within the terrace interval. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water which enhance surface water quality. Terraces may intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thus reducing the occurrence of ephemeral and classic gullies and the resulting sediment. Increases in infiltration can cause a greater amount of soluble nutrients and pesticides to be leached into the soil. Underground outlets may collect highly soluble nutrient and pesticide leachates and convey runoff and conveying it directly to an outlet, terraces may increase the delivery of pollutants to surface waters. Terraces increase the opportunity to leach salts below the root zone in the soil. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient, salt, and pesticide pollutants to surface or ground waters.

o. Waste utilization (633): Using agricultural wastes or other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources.

Waste utilization helps reduce the transport of sediment and related pollutants to the surface water. Proper site selection, timing of application and rate of application may reduce the potential for degradation of surface and ground water. This practice may increase microbial action in the surface layers of the soil, causing a reaction which assists in controlling pesticides and other pollutants by keeping them in place in the field.

Mortality and other compost, when applied to agricultural land, will be applied in accordance with the nutrient management measure. The composting facility may be subject to State regulations and will have a written operation and management plan if SCS practice 317 (composting facility) is used.

p. Composting facility (317): A facility for the biological stabilization of waste organic material.

The purpose is to treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise used in compliance with all laws, rules, and regulations.

q. Commercial rendering or disposal services

r. Incineration

s. Approved burial site

6. Cost Information

The construction costs for large units (Table 2-11) also apply to this measure. The annual operation and maintenance costs average 4 percent of construction costs for diversions, 3 percent of construction costs for settlement basins, and 5 percent of construction costs for retention ponds (DPRA, 1992). Annual costs for repairs, maintenance, taxes, and insurance are estimated to be 5 percent of investment costs for irrigation systems (DPRA, 1992).

C. Nutrient Management Measure

Develop, implement, and periodically update a nutrient management plan to: (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency. When the source of the nutrients is other than commercial fertilizer, determine the nutrient value and the rate of availability of the nutrients. Determine and credit the nitrogen contribution of any legume crop. Soil and plant tissue testing should be used routinely. Nutrient management plans contain the following core components:

(1) Farm and field maps showing acreage, crops, soils, and waterbodies.

(2) Realistic yield expectations for the crop(s) to be grown, based primarily on the producer's actual yield history, State Land Grant University yield expectations for the soil series, or SCS Soils-5 information for the soil series.

(3) A summary of the nutrient resources available to the producer, which at a minimum include:

- **Soil test results for pH, phosphorus, nitrogen, and potassium;**
- **Nutrient analysis of manure, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable);**
- **Nitrogen contribution to the soil from legumes grown in the rotation (if applicable); and**
- **Other significant nutrient sources (e.g., irrigation water).**

(4) An evaluation of field limitations based on environmental hazards or concerns, such as:

- **Sinkholes, shallow soils over fractured bedrock, and soils with high leaching potential,**
- **Lands near surface water,**
- **Highly erodible soils, and**
- **Shallow aquifers.**

(5) Use of the limiting nutrient concept to establish the mix of nutrient sources and requirements for the crop based on a realistic yield expectation.

(6) Identification of timing and application methods for nutrients to: provide nutrients at rates necessary to achieve realistic crop yields; reduce losses to the environment; and avoid applications as much as possible to frozen soil and during periods of leaching or runoff.

(7) Provisions for the proper calibration and operation of nutrient application equipment.

1. Applicability

This management measure is intended to be applied by States to activities associated with the application of nutrients to agricultural lands. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The goal of this management measure is to minimize edge-of-field delivery of nutrients and minimize leaching of nutrients from the root zone. Nutrient management is pollution prevention achieved by developing a nutrient budget for the crop, applying nutrients at the proper time, applying only the types and amounts of nutrients necessary to produce a crop, and considering the environmental hazards of the site. In cases where manure is used as a nutrient source, manure holding areas may be needed to provide capability to avoid application to frozen soil.

This measure may result in some reduction in the amount of nutrients being applied to the land, thereby reducing the cost of production as well as protecting both ground water and surface water quality. However, application of the measure may in some cases cause more nutrients to be applied where there has not been a balanced use of nutrients in the past. This will usually allow all the nutrients to be used more efficiently, thereby reducing the amount of nutrients that will be available for transport from the field during the non-growing season. While the use of nutrient management should reduce the amount of nutrients lost with surface runoff to some degree, the primary control for the transport of nutrients that are attached to soil particles will be accomplished through the implementation of erosion and sediment control practices (Section II.A of this chapter). For information regarding the potential problems caused by nutrients see Section I.F.1 of this chapter.

Operation and Maintenance for Nutrient Management

The use of a nutrient management plan requires accurate information on the nutrient resources available to the producer. Management practices typically used to obtain this information include periodic soil testing for each field; soil and/or tissue testing during the early growth stages of the crop; and testing of manure, sludge, and irrigation water if they are used. The plan may call for multiple applications of nutrients that require more than one field operation to apply the total nutrients needed by the crop.

A nutrient management plan should be reviewed and updated at least once every 3 years, or whenever the crop rotation is changed or the nutrient source is changed. Application equipment should be calibrated and inspected for wear and damage periodically, and repaired when necessary. Records of nutrient use and sources should be maintained along with other management records for each field. This information will be useful when it is necessary to update or modify the management plan.

3. Management Measure Selection

This management measure was selected as a method (1) to minimize the amount of nutrients entering ground water through root zone leaching and entering surface water from edge-of-field delivery and (2) to promote more efficient use of all sources of nutrients that are available to the producer. The practices and concepts that can be used to implement this measure on a given site are those commonly used and recommended by States and USDA for general use on agricultural lands. By implementing the measure using the necessary mix of practices for a given site there should not be a negative economic impact on the operator, and in most cases the impact will be positive. Many of the practices that can be used to implement this measure may already be required by Federal, State, or local rules (e.g., field borders along streams) or may otherwise be in use on agricultural fields. Since many producers may already be using systems that satisfy or partly satisfy the intent of this management measure, the only action that may be necessary will be to determine the effectiveness of the existing practices and add additional practices, if needed. Use of existing practices will reduce the time, effort, and cost of implementing this measure.

4. Effectiveness Information

Following is a summary of information regarding pollution reductions that can be expected from installation of nutrient management practices.

The State of Maryland estimates that average reductions of 34 pounds of nitrogen and 41 pounds of phosphorus per acre can be achieved through the implementation of nutrient management plans (Maryland Department of Agriculture, 1990). These average reductions may be high because they apply mostly to farms that use animal wastes; average reductions for farms that use only commercial fertilizer may be lower. The reduction in the loading of these nutrients to coastal waters is difficult to measure or predict. Field-scale and watershed models, however, can be used to estimate the reduction in nutrients moving to the edges of fields and to ground water.

As of July 1990, the Chesapeake Bay drainage basin States of Pennsylvania, Maryland, and Virginia reported that approximately 114,300 acres (1.4 percent of eligible cropland in the basin) had nutrient management plans in place (USEPA, 1991a). The average nutrient reductions of total nitrogen and total phosphorus were 31.5 and 37.5 pounds per acre, respectively. The States initially focused nutrient management efforts on animal waste utilization. Because initial planning was focused on animal wastes (which have a relatively high total nitrogen and phosphorus loading factor), estimates of nutrient reductions attributed to nutrient management may decrease as more cropland using only commercial fertilizer is enrolled in the program.

In Iowa, average corn yields remained constant while nitrogen use dropped from 145 pounds per acre in 1985 to less than 130 pounds per acre in 1989 and 1990 as a result of improved nutrient management (Iowa State University, 1991b). In addition, data supplied from nitrate soil tests indicated that at least 32 percent of the soils sampled did not need additional nitrogen for optimal yields (Iowa State University, 1991b).

In a pilot program in Butler County, Iowa, 48 farms operating 25,000 acres reduced fertilizer nitrogen use by 240,000 pounds through setting realistic yield goals by soils, giving appropriate crop rotation and manure credits, and some use of the pre-sidedress soil nitrate test (Hallberg et al., 1991). Other data from Iowa showed that in some areas fields have enough potassium and phosphorus to last for at least another decade (Iowa State University, 1991b).

In Garvin Brook, Minnesota, fertilizer management on corn resulted in nitrogen savings of 29 to 49 pounds per acre from 1985 to 1988 (Wall et al., 1989). In this Rural Clean Water Program (RCWP) project, fertilizer management consisted of split applications and rates based upon previous yields, manure application, previous crops, and soil test results.

Berry and Hargett (1984) showed a 40 percent reduction in statewide nitrogen use over 8 years following introduction of improved fertilizer recommendations in Pennsylvania. Findings from the RCWP project in Pennsylvania indicate that, for 340 nutrient management plans, overall recommended reductions (corn, hay, and other crops) were 27 percent for nitrogen, 14 percent for phosphorus, and 12 percent for potash (USDA-ASCS, 1992a). Producers achieved 79 percent of the recommended nitrogen reductions and 45 percent of the recommended phosphorus reductions.

In Vermont, research suggests that a newly introduced, late spring soil test results in about a 50 percent reduction in the nitrogen recommendation compared to conventional technologies (Magdoff et al., 1984). Research in New York and other areas of the Nation documents fertilizer use reductions of 30 to 50 percent for late spring versus preplant and fall applications, with yields comparable to those of the preplant and fall applications (Bouldin et al., 1971).

USDA reports that improved nutrient management has resulted in nitrogen application reductions of 33.1 pounds/acre treated for surface water protection, 28.4 pounds/acre treated for ground water protection, and 62.1 pounds of phosphorus per acre treated for water quality protection in its 16 Water Quality Demonstration Projects and 74 Hydrologic Unit Areas (USDA, 1992). The Hydrologic Unit Areas begun in 1990 show the greatest reductions in fertilizer use per acre (Table 2-13).

A summary of the effectiveness of nutrient management in controlling nitrogen and phosphorus is given in Table 2-14. This summary is based on an extensive search of the published literature.

Table 2-13. Nutrient Reductions Achieved Under USDA's Water Quality Program (USDA, 1992)

	Cumulative				
	Pounds Reduced		Acres Treated		Average Reduction in Pounds/Acre Treated
Projects	N	P	N	P	
1990 Demos (8 projects)	284,339 SW 556,437 GW	178,204	5,980 SW 18,771 GW	5,184	47.5 N-SW 29.6 N-GW 34.4 P
1991 Demos (8 projects)	34,672 SW	38,060	788 SW	692	44 N-SW 55 P
1990 HUAs (37 areas)	656,374 SW 601,646 GW	1,344,260	13,761 SW 16,808 GW	15,962	47.7 N-SW 35.8 N-GW 84.2 P
1991 HUAs (37 areas)	156,552 SW 366,890 GW	118,037	13,658 SW 18,115 GW	5,188	11.5 N-SW 20.2 N-GW 22.8 P
1990/1991 Demo/HUA Overall	1,131,937 SW 1,524,973 GW	1,678,561	34,187 SW 53,694 GW	27,026	33.1 N-SW 28.4 N-GW 62.1 P

SW = surface water
GW = ground water

Table 2-14. Relative Effectiveness[a] of Nutrient Management (Pennsylvania State University, 1992a)

Practice	Percent Change in Total Phosphorus Loads	Percent Change in Total Nitrogen Loads
Nutrient Management[b]	-35	-15

[a] Most observations from reported computer modeling studies.
[b] An agronomic practice related to source management; actual change in contaminant load to surface and ground water is highly variable.

5. Nutrient Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Following are practices, components, and sources of information that should be considered in the development of a nutrient management plan:

(1) Use of soil surveys in determining soil productivity and identifying environmentally sensitive sites.

(2) Use of producer-documented yield history and other relevant information to determine realistic crop yield expectations. Appropriate methods include averaging the three highest yields in five consecutive crop years for the planning site, or other methods based on criteria used in developing the State Land Grant University's nutrient recommendations. In lieu of producer yield histories, university recommendations based on interpretation of SCS Soils-5 data may be used. Increased yields due to the use of new and improved varieties and hybrids should be considered when yield goals are set for a specific site.

(3) Soil testing for pH, phosphorus (Figure 2-11), potassium, and nitrogen (Figure 2-12).

(4) Plant tissue testing.

(5) Manure (Figure 2-13), sludge, mortality compost, and effluent testing.

(6) Use of proper timing, formulation, and application methods for nutrients that maximize plant utilization of nutrients and minimize the loss to the environment, including split applications and banding of the nutrients, use of nitrification inhibitors and slow-release fertilizers, and incorporation or injection of fertilizers, manures, and other organic sources.

(7) Use of small grain cover crops to scavenge nutrients remaining in the soil after harvest of the principal crop, particularly on highly leachable soils. Consideration should be given to establishing a cover crop on land receiving sludge or animal waste if there is a high leaching potential. Sludge and animal waste should be incorporated.

(8) Use of buffer areas or intensive nutrient management practices to manage field limitations based on environmentally high risk areas such as:

- Karst topographic areas containing sinkholes and shallow soils over fractured bedrock;
- Lands near surface water;
- High leaching index soils;
- Irrigated land in humid regions;
- Highly erodible soils;
- Lands prone to surface loss of nutrients; and
- Shallow aquifers.

(9) Control of phosphorus losses from fields through a combination of the Erosion and Sediment Control Measure (Section II.A of this chapter) and the Nutrient Management Measure. Limit manure and sludge applications to phosphorus crop needs when possible, supplying any additional nitrogen needs with nitrogen fertilizers or legumes. If this is not practical, route excess phosphorus in manures or sludge to

07/31/84	0004	700234	SOMERSET	25	NPBUU1	READINGTON
DATE	LAB NO.	SERIAL NO.	COUNTY	ACRES	FIELD	SOIL

THE PENNSYLVANIA STATE UNIVERSITY
COLLEGE OF AGRICULTURE
MERKLE LABORATORY - SOIL & FORAGE TESTING
UNIVERSITY PARK, PA 16802

SOIL TEST REPORT FOR:

P.A. PENN
RD1
ANYTOWN, PA 10000

COPY SENT TO:

ACME FERTILIZER CO.
MAIN STREET
ANYTOWN, PA 10000

SOIL NUTRIENT LEVELS:

				LOW	OPTIMUM	HIGH	EXCESSIVE
Soil pH		6.2		XXXXXXXXXXXXXXX			
Phosphate	(P_2O_5)	114	lb/A	XXXXXXXXXXXX			
Potash	(K_2O)	178	lb/A	XXXXXXXXXXX			
Magnesium	(MgO)	230	lb/A	XXXXXXXXXXXXXXX			

RECOMMENDATIONS FOR: *PLANTING CORN FOR GRAIN* (For other crops see ST 2 column 1) — See Back For Comments

YIELD GOAL 125.0 BUSHELS (PER ACRE) — 1,2

LIMESTONE: 3400 lb/A Calcium Carbonate Equivalent — 3,4

PLANT NUTRIENT NEEDS:

NITROGEN (N)	PHOSPHATE (P_2O_5)	POTASH (K_2O)	MAGNESIUM (MgO)	
130 lb/A	70 lb/A	90 lb/A	10 lb/A	5,11

MESSAGES:

- USE A STARTER FERTILIZER — 6,7
- LIMESTONE RECOMMENDATION, IF ANY, IS TO BRING THE SOIL PH TO 6.0 - 6.5. MULTIPLY THE EXCHANGABLE ACIDITY BY 1000 TO ESTIMATE THE LIME REQUIREMENT FOR PH 6.5 - 7.0.
- RECOMMENDED LIMESTONE CONTAINING .2% MGO WILL MEET THE MG REQUIREMENT.
- IF MANURE WILL BE APPLIED, SEE ST-10 "USE OF MANURE" — 9

LABORATORY RESULTS

6.2	50	4.1	0.19	0.6	7.8	12.6	1.5	4.7	61.5
SOIL pH	P lb/A	ACIDITY	K	Mg	Ca	CEC	K	Mg	Ca
		EXCHANGEABLE CATIONS (meq/100 g)					% SATURATION		

OTHER TESTS: ORGANIC MATTER - 2.2 %

Figure 2-11. Example of soil test report (Pennsylvania State University, 1992b).

PENNSTATE

1855

PRE-SIDEDRESS SOIL NITROGEN TEST FOR CORN QUICKTEST EVALUATION PROJECT

- SOIL TEST INFORMATION AND REPORT FORM -

GROWER (PLEASE PRINT)

↑ NAME ↑

↑ STREET OR R. D. NO. ↑

↑ CITY, STATE, AND ZIP↑

↑ COUNTY ↑

DATE:

ANALYZED BY:

☐☐☐ - ☐☐☐ - ☐☐☐☐

↑ AREA CODE ↑ ↑ TELEPHONE NO. ↑

Best time to call (8 am - 4:30 pm): ________

Please answer all of the following questions about this field:

1. What is the field ID (name or number)? ____________ Corn Height ________in.
2. What is the expected yield of the corn crop (bu/A or ton/A) in this field? ________
3. What was the previous crop? ________________

   If this was a forage legume what was the % stand?

   (check one): ☐ 0-25% ☐ 25-50 % ☐ 50-100%
4. Was manure applied to this field? ☐ Yes ☐ No If "yes" answer the following questions:

   When? ☐ Fall ☐ Spring ☐ Both ☐ Daily

   Type? ☐ Cattle ☐ Poultry ☐ Swine ☐ Horse ☐ Sheep

   Estimate manure rate: _____ tons/acre - OR - _____ gallons/acre

   If incorporated how many days were there between spreading and incorporation? _____
5. What is the tillage program on this field? ☐ Conventional Tillage ☐ Minimum Tillage ☐ No-till
6. What would be your normal N fertilizer application rate for this field? _____ lbs. N/acre

Do not write below this line (to be completed by the analyst)

Quicktest Analysis Result & Recommendation

Individual Meter Readings	**Average meter reading**		**Conversion factor**		**Average standard reading**		**Soil Nitrate-N (ppm)**
☐ ☐ ☐ →	☐	x	**20**	÷	☐	=	☐

Sidedress N Fertilizer Recommendation ☐ **lbs. N/acre**

(See table and guidelines on back of form)

If you have any questions about this test contact your Penn State Cooperative Extension Office

White copy- Grower
Yellow copy- Analyst
Pink copy- Agronomy Extension

5/91

Figure 2-12. Example of Penn State's soil quicktest form (Pennsylvania State University, 1992b).

WORKSHEET FOR CALCULATING
APPLICATION RATES OF
ANIMAL MANURE ON CROPLAND

Prepared by:
JOE CONSULTANT
Nut. Mgt. Consult.
CECIL
County

****

Name.............		*	LIST FERTILIZER PRICES
Address..........		*	
....		*	
Field Number.....	G-1	*	
Field Location...	____________	*	N.... $0.25 /lb
Acres in Field...	14.0	*	P2O5. $0.25 /lb
Manure Source....	BROILER	*	K2O.. $0.12 /lb
Date/Time........	03/07/90 *** 04:08 PM	*	

****

ENTER MANURE ANALYSIS DATA AND SOIL TEST INFORMATION.

MANURE COMPOSITION			SOIL TEST INFORMATION	
Total N...........	3.70 %	**	Texture........SILT	
Ammonium N........	0.43 %	**	pH.............	5.8
P2O5..............	3.70 %	**	Mg.............	278.0 lb/A
K2O...............	3.10 %	**	P2O5...........	112.0 lb/A
Calcium...........	1.40 %	**	K2O............	123.0 lb/A
Magnesium.........	0.56 %	**	Calcium........	1328.0 lb/A
Sulfur............	0.59 %	**	Sulfur.........	6.8 lb/A
Manganese.........	361.50 ppm	**	Manganese......	18.0 lb/A
Zinc..............	380.60 ppm	**	Zinc...........	4.4 lb/A
Copper............	352.80 ppm	**	Copper.........	1.3 lb/A
Moisture..........	13.10 %	**	Org. Matter....	2.5 %
Liquid Wt.........	________lb/100gal		(Leave blank if not liquid.)	

****

IF MANURE WAS APPLIED PREVIOUSLY TO THIS FIELD, ENTER DATA REQUESTED FOR PRIOR YEARS. IF NONE APPLIED, LEAVE BLANK.

	Yr. 1-2	Yr. 2-3	Yr. 3-4
Total N...........	________%	________%	________%
Ammonium N........	________%	________%	________%
Rate..............	________T/A	________T/A	________T/A

****

**** PHOSPHORUS NOTE ****

Soil tests indicate that phosphorus levels are NOT EXCESSIVE. Additional phosphorus may be applied in animal manure. For maximum economic and environmental benefits, phosphorus levels should be monitored regularly by soil test and manure applications made ONLY to fields less than VERY HIGH in PHOSPHATE.

****

Figure 2-13. Example of work sheet for applying manure to cropland (University of Maryland, 1990).

fields that will be rotated into legumes, to other fields that will not receive manure applications the following year, or to sites with low runoff and low soil erosion potential.

(10) A narrative accounting of the nutrient management plan that explains the plan and its use.

6. Cost Information

In general, most of the costs are associated with providing additional technical assistance to landowners to develop nutrient management plans. In many instances landowners can actually save money by implementing nutrient management plans. For example, Maryland has estimated (based on the over 750 nutrient management plans that were completed prior to September 30, 1990) that if plan recommendations are followed, the landowners will save an average of $23 per acre per year (Maryland Dept. of Agriculture, 1990). The average savings may be high because most plans were for farms using animal waste. Future savings may be reduced as more farms using commercial fertilizer are included in the program.

In the South Dakota RCWP project, the total cost (1982-1991) for implementing fertilizer management on 46,571 acres was $50,109, or $1.08 per acre (USDA-ASCS, 1991a). In the Minnesota RCWP project, the average cost for fertilizer management for 1982-1988 was $20 per acre (Wall et al., 1989). Assuming a cost of $0.15 per pound of nitrogen, the savings in fertilizer cost due to improved nutrient management on Iowa corn was about $2.25 per acre as rates dropped from 145 pounds per acre in 1985 to about 130 pounds per acre in 1989 and 1990 (Iowa State University, 1991a).

D. Pesticide Management Measure

To reduce contamination of surface water and ground water from pesticides:

(1) Evaluate the pest problems, previous pest control measures, and cropping history;

(2) Evaluate the soil and physical characteristics of the site including mixing, loading, and storage areas for potential leaching or runoff of pesticides. If leaching or runoff is found to occur, steps should be taken to prevent further contamination;

(3) Use integrated pest management (IPM) strategies that:

(a) Apply pesticides only when an economic benefit to the producer will be achieved (i.e., applications based on economic thresholds); and

(b) Apply pesticides efficiently and at times when runoff losses are unlikely;

(4) When pesticide applications are necessary and a choice of registered materials exists, consider the persistence, toxicity, runoff potential, and leaching potential of products in making a selection;

(5) Periodically calibrate pesticide spray equipment; and

(6) Use anti-backflow devices on hoses used for filling tank mixtures.

1. Applicability

This management measure is intended to be applied by States to activities associated with the application of pesticides to agricultural lands. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The goal of this management measure is to reduce contamination of surface water and ground water from pesticides. The basic concept of the pesticide management measure is to foster effective and safe use of pesticides without causing degradation to the environment. The most effective approach to reducing pesticide pollution of waters is, first, to release fewer pesticides and/or less toxic pesticides into the environment and, second, to use practices that minimize the movement of pesticides to surface water and ground water (Figure 2-14). In addition, pesticides should

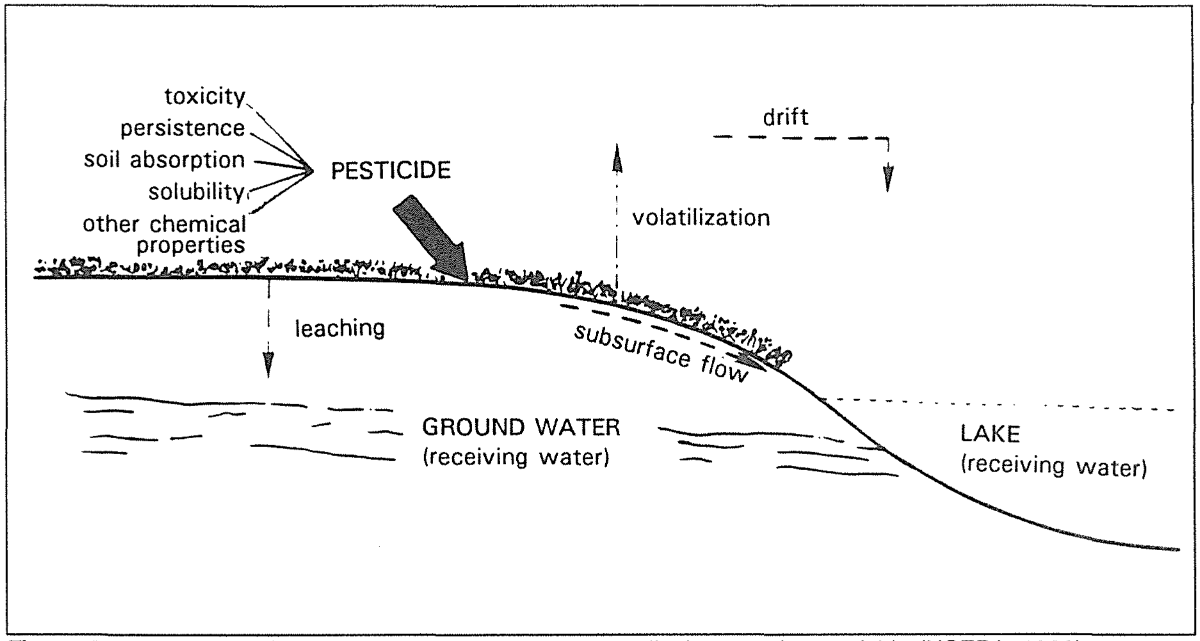

Figure 2-14. Factors affecting the transport and water quality impact of a pesticide (USEPA, 1982).

be applied only when an economic benefit to the producer will be achieved. Such an approach emphasizes using pesticides only when, and to the extent, necessary to control the target pest. This usually results in some reduction in the amount of pesticides being applied to the land, plants, or animals, thereby enhancing the protection of water quality and possibly reducing production costs as well.

The pesticide management measures identify a series of steps or thought processes that producers should use in managing pesticides. First, the pest problems, previous pest control measures, and cropping history should be evaluated. Then the physical characteristics of the soil and the site—including mixing, loading, and storage areas—should be evaluated for potential leaching and/or runoff potential. Integrated pest management (IPM) strategies should be used to minimize the amount of pesticides applied. It is understood that IPM practices are not available for some commodities or in certain regions. An effective IPM strategy should call for pesticide applications only when an economic benefit to the producer will be achieved. In addition, pesticides should be applied efficiently and at times when runoff losses are unlikely.

When pesticide applications are necessary and a choice of materials exists, producers are encouraged to choose the most environmentally benign pesticide products. Users must apply pesticides in accordance with the instructions on the label of each pesticide product. Labels include a number of requirements including allowable use rates; whether the pesticide is classified as "restricted use" for application only by certified and trained applicators; safe handling, storage, and disposal requirements; whether the pesticide can be used only under the provisions of an approved Pesticide State Management Plan; and other requirements. If label requirements include use only under an approved Pesticide State Management Plan, pesticide management measures and practices under the State Coastal Nonpoint Pollution Control Program should be consistent with and/or complement those in EPA-approved Pesticide State Management Plans.

Section 1491 of the 1990 Farm Bill requires users to maintain records of application of restricted use pesticides for a 2-year period after such use. Section 1491 of the 1990 Farm Bill also includes provisions for access to such pesticide records by Federal and State agency staff.

Operation and Maintenance for Pesticide Management

At a minimum, effective pest management requires evaluating past and current pest problems and cropping history; evaluating the physical characteristics of the site; applying pesticides only when an economic benefit to the producer will be achieved; applying pesticides efficiently and at times when runoff losses are unlikely; selecting pesticides (when a choice exists) that are the most environmentally benign; using anti-backflow devices on hoses used for filling tank mixtures; and providing suitable mixing, loading, and storage areas.

Pest management practices should be updated whenever the crop rotation is changed, pest problems change, or the type of pesticide used is changed. Application equipment should be calibrated and inspected for wear and damage each spray season, and repaired when necessary. Anti-backflow devices should also be inspected each spray season and repaired when necessary.

3. Management Measure Selection

This management measure was selected as a method to reduce the amount of pesticides entering ground water and surface water, and to foster effective and safe use of pesticides. The practices and concepts that can be used to implement this measure on a given site are those commonly used and recommended by States and USDA for general use on agricultural lands. When this measure is implemented by using the necessary mix of practices for a given site, there should be a relatively small negative economic impact on the operator's net costs and farm income, and in some cases the impact will be positive (U.S. Environmental Protection Agency, 1992). Many of the practices that can be used to implement this measure may already be required by Federal, State, or local rules, or may otherwise be in use on agricultural fields. Since many producers may already be using systems that satisfy or partly satisfy the intent of this management measure, the only action that may be necessary will be to determine the effectiveness of the existing practices and implement additional practices, if needed. Use of existing practices will reduce the time, effort, and cost of implementing this measure.

4. Effectiveness Information

Following is a summary of available information regarding pollution reductions that can be expected from using various pesticide management practices.

Use of IPM strategies is a key element of the pesticide management measures. Table 2-15 summarizes the findings of several empirical IPM studies on a variety of crops (Virginia Cooperative Extension Service et al., 1987). The summary table indicates that many studies have found IPM to reduce pesticide use. While all these studies indicate a reduction or no change in pesticide use, it is understood that in a small percentage of cases IPM can result in an increased use of pesticides as producers become more aware of what pests are present in the field and then take action to control problems.

Table 2-16 summarizes estimates of reductions in pesticide loss using various management practices and combinations of practices for cotton (North Carolina State University, 1984). These estimates are made at the field level as compared with a hypothetical field using cropping practices that were typical until the late 1970s. The uncertainty of the estimates is a function of the rapid transitions in production methods coupled with the variance among regions and seasons. Traditional sediment and erosion control practices are not as effective on cotton as on corn and soybeans because much cotton is grown on relatively flat land with little or no water erosion problem (Heimlich and Bills, 1984).

Table 2-17 summarizes the estimates of pesticide loss reductions from various management practices and combinations of practices for corn (North Carolina State University, 1984). These estimates are also made at the field level as compared with a hypothetical field using conventional, traditional, or typical cropping practices, realizing that these practices may vary considerably between geographic regions.

Banding of herbicide applications is one of the more recent and promising methods of reducing herbicide applications to corn (NRDC, 1991). Instead of applying herbicides to the entire row, herbicides are applied in a band near to the corn plant. One 3-year study conducted in Iowa on two fields of corn and one of soybeans monitored the effect of different herbicide treatments on yields and herbicide concentrations in tile-drainage water. Over the 3-year period, corn acreage with banded treatments produced equal or slightly higher yields than acreage receiving broadcast herbicides (Baker, 1988). Analysis of water samples for herbicide residues in water beneath herbicide-treated areas revealed that, during this 3-year period, atrazine was detected more often and at higher concentrations in the areas where atrazine was broadcast. Banding of herbicides means, however, that farmers have to rely more extensively on mechanical tillage and cultivation to control weeds.

Table 2-15. Results of IPM Evaluation Studies (Virginia Cooperative Extension Service et al., 1987)

Author	Study Object[a]	Pesticide Use and/or Cost of Production with IPM[b]	Yield with IPM[c]	Net Return with IPM[d]	Level of Risk with IPM[e]
Sprott et al., 1976	C	D	I	I	-
Condra et al., 1977	C	D	D	I	-
Lacewell et al., 1977	C	-	-	I	-
Clarke et al., 1980	C	-	I	I	-
Von Rumker et al., 1975	T	D	-	I	-
Von Rumker et al., 1975	P	D	I	I	-
Burrows, 1983	C,Ci	D,D	-,-	-,-	-,-
Rajotte et al., 1984	S	D	-	I	-
Thompson et al., 1980	A	D	C	-	-
Larson et al., 1975	C	D	-	I	-
Masud et al., 1981	C	D	I	I	-
Huffaker and Croft, 1978	C,A	D,D	I,-	-,-	-,-
Teage and Schulstad, 1981	C	D	-	-	-
Weathers, 1979-1980	Co,S,P	D,D,D	I,I,D	I,I,I	-,-,-
Lacewell et al., 1974	C	D	I	I	-
Lacewell et al., 1976	C	D	-	-	-
Casey et al., 1975	C	D	I	I	-
Allen and Roberts, 1974	S	D	-	I	-
Greene et al., 1985	S	D	-	-	-
Lindsey et al., 1976	C	-	-	I	-
Frisbie et al., 1974	C	D	I	I	-
Frisbie, 1976	C	D	-	I	-
Hoyt and Callagirone, 1971	M	D	-	-	-

Table 2-15. (Continued)

Author	Study Object[a]	Pesticide Use and/or Cost of Production with IPM[b]	Yield with IPM[c]	Net Return with IPM[d]	Level of Risk with IPM[e]
Croft et al., 1975	M	D	-	-	-
Howitt et al., 1966	A	D	-	-	-
Batiste et al., 1973	A	D	-	-	-
Eves et al., 1975	A	D	-	-	-
Hall, 1977	C	D	N	N	D
Prokopy et al., 1973	A	-	-	I	-
McGuckin, 1983	Al	D	-	I	D
King and O'Rourke, 1977	A	D	-	-	-
Cammell and Way, 1977	F	-	-	I	D
Liapis and Moffit, 1983	C	-	-	-	D
Miranowski, 1974	C	D	-	-	-
Huffaker, 1980	C	D	-	-	-
Reichelderfer, 1979	Pe	D	-	I	-
Carlson, 1969	Pc	-	-	-	D
Carlson, 1979	C	-	-	-	D
Lazarus and Swanson, 1983	Co,S	-,-	-,-	-,-	I,I
Moffitt et al., 1982	S	-	-	-	D
Hatcher et al., 1984	C,P,S	-,-,-	I,I,I	N,I,I	-,-,-
White and Thompson, 1982	A	D	-	-	-

[a] C = cotton; T = tobacco; P = peanut; Ci = citrus; S = soybean; A = apple; Co = corn; M = mite; Al = alfalfa; F = field bean; Pe = pecan; Pc = peach.
[b,c,d,e] C = constant; D = decreased; I = increased; N = no impact; - = no information.

Table 2-16. Estimates of Potential Reductions in Field Losses of Pesticides for Cotton Compared to a Conventionally and/or Traditionally Cropped Field[a] (North Carolina State University, 1984)

Management Practice	Transport Route(s)	Range of Pesticide Loss Reduction (%)[b]
SWCPs		
Terracing	SR and SL	0 - (20)[c]
Contouring	SR and SL	0 - (20)[c]
Reduced Tillage	SR and SL	-40 - +20 AB
Grassed Waterways	SR and SL	0 - 10 AB
Sediment Basins	SR	0 - 10 AB
Filter Strips	SR	0 - 10 A
Cover Crops	SR and SL	-20 - +10 B
Optimal Application Techniques[d]	All Routes[e]	40 - 80 A
Nonchemical Methods	All Routes	
Scouting Economic Thresholds	All Routes	40 - 65 A 0 - 30 B
Crop Rotations	All Routes	0 - 20 A 10 - 30 B
Pest-Resistant Varieties	All Routes	0 - 60 A 0 - 30 B
Alternative Pesticides	All Routes	60 - 95 A 0 - 20 B

SR = surface runoff
SL = soil leaching
[a] The hypothetical traditionally cropped comparison field uses the following management system:
(1) conventional tillage without other soil and water conservation practices;
(2) aerial application of all pesticides with timing based only on field operation convenience;
(3) ten insecticide treatments annually with a total application of 12 kg/ha based on a prescribed schedule;
(4) cotton grown in 3 out of 4 years; and
(5) long-season cotton varieties.
[b] Assumes field loss reductions are proportional to application rate reductions.
A = insecticides (toxaphene, methylparathion, synthetic pyrethroids).
B = herbicides (trifluralin, fluometron).
Ranges allow for variation in production region, climate, slope and soils.
[c] Refers to estimated increases in movement through soil profile.
[d] Defined for cotton as ground application using optimal droplet or granular size ranges with spraying restricted to calm periods in late afternoon or at night when precipitation is not imminent.
[e] Particularly drift and volatilization.

Table 2-17. Estimates of Potential Reductions in Field Losses of Pesticides for Corn Compared to a Conventionally and/or Traditionally Cropped Field[a] (North Carolina State University, 1984)

Management Practice	Transport Route(s) Affected	Range of Pesticide Loss Reduction (%)[b]
SWCPs	SR and/or SL(#)	
Terracing	SR and/or SL	40 - 75 AB (25[c])
Contouring	SR and/or SL	15 - 55 AB (20[c])
No-till	SR and/or SL	-10 - +40 B 60 - +10 A (10[c])
Other Reduced Tillage	SR and/or SL	-10 - +60 B -40 - +20 A (15[c])
Grassed Waterways	SR	-10 - 20 AB
Sediment Basins	SR	0 - 10 AB
Filter Strips	SR	0 - 10 AB
Cover Crops	SR and/or SL	0 - 20 B[d]
Optimal Application Techniques[e]	All Routes[f]	10 - 20 20 - 40 B
Nonchemical Methods	All Routes	
Adequate Monitoring	All Routes	40 - 65 A
Crop Rotations	All Routes	40 - 70 A 10 - 30 B

SR = surface runoff
SL = soil leaching
[a] The hypothetical field used as the basis for comparison uses the following management system:
(1) conventional tillage without other soil and water conservation practices;
(2) ground application with timing based only on field operation convenience;
(3) little or no pest monitoring; spraying on prescribed schedule; and
(4) corn grown in 3 out of 4 years.
[b] Assumes field loss reductions are proportional to application rate reductions.
A = insecticides (carbofuran and organophosphates)
B = herbicides (Triazine, Alachlor, Butylate, Parquat)
Ranges allow for variation in climate, slope, soils, and types of pesticides used. Ranges for no-till and reduced-till are derived from a combination of increased application rates and decreased runoff losses.
[c] Refers to estimated increases in movement through soil profile.
[d] Cover crops will affect runoff and leaching losses only for pesticides persistent enough to be available over the non-growing season. In the case of pesticides used on corn only the triazine and anilide herbicides will generally meet this criterion.
[e] Defined here for corn as ground application using optimal droplet or granular size ranges, with spraying restricted to calm periods in late afternoon or evening.
[f] Particularly drift and volatilization.

5. Pesticide Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above. The U.S. Soil Conservation Service practice number and definition are provided for management practices, where available.

a. Inventory current and historical pest problems, cropping patterns, and use of pesticides for each field.

This can be accomplished by using a farm and field map, and by compiling the following information for each field:

- Crops to be grown and a history of crop production;
- Information on soils types;
- The exact number of acres within each field; and
- Records on past pest problems, pesticide use, and other information for each field.

b. Consider the soil and physical characteristics of the site including mixing, loading and storage areas for potential for the leaching and/or runoff of pesticides.

In situations where the potential for loss is high, emphasis should be given to practices and/or management practices that will minimize these potential losses. The physical characteristics to be considered should include limitations based on environmental hazards or concerns such as:

- Sinkholes, wells, and other areas of direct access to ground water such as karst topography;
- Proximity to surface water;
- Runoff potential;
- Wind erosion and prevailing wind direction;
- Highly erodible soils;
- Soils with poor adsorptive capacity;
- Highly permeable soils;
- Shallow aquifers; and
- Wellhead protection areas.

c. Use IPM strategies to minimize the amount of pesticides applied.

Following is a list of IPM strategies:

- Use of biological controls:
  - introduction and fostering of natural enemies;
  - preservation of predator habitats; and
  - release of sterilized male insects;
- Use of pheromones:
  - for monitoring populations;
  - for mass trapping;
  - for disrupting mating or other behaviors of pests; and
  - to attract predators/parasites;
- Use of crop rotations to reduce pest problems;
- Use of improved tillage practices such as ridge tillage;

- Use of cover crops in the system to promote water use and reduce deep percolation of water that contributes to leaching of pesticides into ground water;
- Destruction of pest breeding, refuge, and overwintering sites (this may result in loss of crop residue cover and an increased potential for erosion);[8]
- Use of mechanical destruction of weed seed;[8]
- Habitat diversification;
- Use of allelopathy characteristics of crops;
- Use of resistant crop strains;
- Pesticide application based on economic thresholds, i.e., apply pesticides when an economic threshold level has been reached as opposed to applying pesticides in anticipation of pest problems;
- Use of periodic scouting to determine when pest problems reach the economic threshold on each field;
- Use of less environmentally persistent, toxic, and/or mobile pesticides;
- Use of timing of field operations (planting, cultivating, irrigation, and harvesting) to minimize application and/or runoff of pesticides; and
- Use of more efficient application methods, e.g., spot spraying and banding of pesticides.

d. When pesticide applications are necessary and a choice of materials exists, consider the persistence, toxicity, and runoff and leaching potential of products along with other factors, including current label requirements, in making a selection.

Users must apply pesticides in accordance with the instructions on the label of each pesticide product and, when required, must be trained and certified in the proper use of the pesticide. Labels include a number of requirements including allowable use rates; classification of pesticides as "restricted use" for application only by certified applicators; safe handling, storage, and disposal requirements; restrictions required by State Pesticide Management Plans to protect ground water; and other requirements. If label requirements include use only under an approved State Pesticide Management Plan, pesticide management measures and practices under the State Coastal Nonpoint Program should be consistent with and/or complement those in approved State Pesticide Management Plans.

e. Maintain records of application of restricted use pesticides (product name, amount, approximate date of application, and location of application of each such pesticide used) for a 2-year period after such use, pursuant to the requirements in section 1491 of the 1990 Farm Bill.

Section 1491 requires that such pesticide records shall be made available to any Federal or State agency that deals with pesticide use or any health or environmental issue related to the use of pesticides, on the request of such agency. Section 1491 also provides that Federal or State agencies may conduct surveys and record the data from individual applicators to facilitate statistical analysis for environmental and agronomic purposes, but in no case may a government agency release data, including the location from which the data was derived, that would directly or indirectly reveal the identity of individual producers. Section 1491 provides that in the case of Federal agencies, access to records maintained under section 1491 shall be through the Secretary of Agriculture, or the Secretary's designee. This section also provides that State agency requests for access to records maintained under section 1491 shall be through the lead State agency so designated by the State.

Section 1491 includes special access provisions for health care personnel. Specifically, when a health professional determines that pesticide information maintained under this section is necessary to provide medical treatment or first aid to an individual who may have been exposed to pesticides for which the information is maintained, upon request persons required to maintain records under section 1491 shall promptly provide record and available label information to that health professional. In the case of an emergency, such record information shall be provided immediately.

[8] Several IPM strategies listed above emphasize the use of mechanical tillage and removal of crop residue cover. Such IPM strategies may result in some producers being out of compliance with the U.S. Department of Agriculture's requirements for highly erodible land, and such producers may need to consider other IPM strategies on such highly erodible land.

Operators may consider maintaining records beyond those required by section 1491 of the 1990 Farm Bill. For example, operators may want to maintain records of *all* pesticides used for each field, i.e., not just restricted use pesticides. In addition, operators may want to maintain records of other pesticide management activities such as scouting records or other IPM techniques used and procedures used for disposal of remaining pesticides after application.

f. Use lower pesticide application rates than those called for by the label when the pest problem can be adequately controlled using such lower rates.

g. Consider the use of organic farming techniques that do not rely on the use of synthetically compounded pesticides.

h. Recalibrate spray equipment each spray season and use anti-backflow devices on hoses used for filling tank mixtures.

Purchase new, more precise application equipment and other related farm equipment (including improved nozzles, computer sensing to control flow rates, radar speed determination, electrostatic applicators, and precision equipment for banding and cultivating) as replacement equipment is needed.

i. Integrated crop management system (Pest Management 595): A total crop management system that promotes the efficient use of pesticide and nutrients in an environmentally sound and economically efficient manner.

6. Cost Information

In general, most of the costs of implementing the pesticide management measure are program costs associated with providing additional educational programs and technical assistance to producers to evaluate pest management needs and for field scouting during the growing season. Producers may actually save money by implementing IPM strategies as indicated by the data in Table 2-15.

Table 2-15 summarizes the findings of several IPM studies on a variety of crops (Virginia Cooperative Extension Service et al., 1987). This summary table indicates that, in general, IPM reduces pesticide use, increases yields, increases net returns, and decreases economic risk.

Table 2-18 shows that IPM scouting costs vary by crop type and by region (USEPA, 1992). High and low scouting costs are given for major crops in each of the coastal regions. These costs reflect variations in the level of service provided by various crop consultants. For example, in the Great Lakes region, the relatively low cost of $4.95 per acre is based on five visits per season at the request of the producer. Higher cost services include scouting and weekly written reports during the growing seasons. Cost differences may also reflect differences in the size of farms (i.e., number of acres) and distance between farms.

The variations in scouting costs between regions and within regions also occur because of differences in the provider of the service. For example, in some States the Cooperative Extension Service provides scouting services at no cost or for a nominal fee. In other areas of the coastal zone, farmer cooperatives have formed crop management associations to provide scouting and crop fertility/pest management recommendations.

Scouting costs also vary by crop type. For example, the data in Table 2-18 indicate that scouting costs for fresh market vegetables are higher than for all other crop types. Scouting services for high-value cash crops, such as fruits and vegetables, must be very intensive given that pest damage is permanent and may make the crop unmarketable.

Costs for erosion and sediment control and for irrigation management are discussed in Sections II.A and II.F, respectively, of this chapter.

Table 2-18. Estimated Scouting Costs (dollars/acre) by Coastal Region and Crop in the Coastal Zone in 1992 (USEPA, 1992)

	Crop						
Coastal Region	Corn	Soybean	Wheat	Rice	Cotton	Fresh Market Vegetables[a]	Hay[b]
Northeast							
Low	5.50	NA	3.75	—	—	25.00	2.50
High	6.25	NA	4.50	—	—	28.00	2.75
Southeast							
Low	5.00	3.25	3.00	8.00	6.00	30.00	2.00
High	6.00	4.00	3.50	12.00	8.00	35.00	3.00
Gulf Coast							
Low	6.00	4.50	—	5.00	6.00	35.00	—
High	8.00	6.50	—	9.00	9.00	40.00	—
Great Lakes							
Low	4.95	4.25	3.75	—	—	—	4.75
High	5.50	5.00	4.00	—	—	—	5.25
West Coast							
Low	NA	NA	3.50	NA	6.75	32.00	NA
High	NA	NA	5.50	NA	9.30	38.00	NA

NA = not available
— = not applicable
[a] Most fresh market vegetables are produced under a regular spraying schedule.
[b] Scouting costs for hay are based on alfalfa insect inspection. The higher cost in the Great Lakes region includes pesticide and soil sampling.

7. Relationship of Pesticide Management Measure to Other Programs

Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), EPA registers pesticides on the basis of evaluation of test data showing whether a pesticide has the potential to cause unreasonable adverse effects on humans, animals, or the environment. Data requirements include environmental fate data showing how the pesticide behaves in the environment, which are used to determine whether the pesticide poses a threat to ground water or surface water. If the pesticide is registered, EPA imposes enforceable label requirements, which can include, among other things, maximum rates of application, classification of the pesticide as a "restricted use" pesticide (which restricts use to certified applicators trained to handle toxic chemicals), or restrictions on use practices, including requiring compliance with EPA-approved Pesticide State Management Plans (described below). EPA and the U.S. Department of Agriculture Cooperative Extension Service provide assistance for pesticide applicator and certification training in each State.

FIFRA allows States to develop more stringent pesticide requirements than those required under FIFRA, and some States have chosen to do this. At a minimum, management measures and practices under State Coastal Nonpoint Source Programs must not be less stringent than FIFRA label requirements or any applicable State requirements.

EPA's *Pesticides and Groundwater Strategy* (USEPA, 1991b) describes the policies and regulatory approaches EPA will use to protect the Nation's ground-water resources from risks of contamination by pesticides under FIFRA. The objective of the strategy is the prevention of ground-water contamination by regulating the use of certain pesticides (i.e., use according to EPA-approved labeling) in order to reduce and, if necessary, eliminate releases of the pesticide in areas vulnerable to contamination. Priority for protection will be based on currently used and reasonably expected sources of drinking water supplies, and ground water that is closely hydrogeologically connected to surface waters. EPA will use Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act as "reference points" for water resource protection efforts when the ground water in question is a current or reasonably expected source of drinking water.

The Strategy describes a significant new role for States in managing the use of pesticides to protect ground water from pesticides. In certain cases, when there is sufficient evidence that a particular use of a pesticide has the potential for ground-water contamination to the extent that it might cause unreasonable adverse effects, EPA may (through the use of existing statutory authority and regulations) limit legal use of the product to those States with an acceptable Pesticide State

Management Plan, approved by EPA. Plans would tailor use to local hydrologic conditions and would address:

- State philosophy;
- Roles and responsibilities of State and local agencies;
- Legal and enforcement authority;
- Basis for assessment and planning;
- Prevention measures;
- Ground-water monitoring;
- Response to detections;
- Information dissemination; and
- Public participation.

In the absence of such an approved plan, affected pesticides could not be legally used in the State.

Since areas to be managed under Pesticide State Management Plans and Coastal Nonpoint Pollution Control Programs can overlap, State coastal zone and nonpoint source agencies should work with the State lead agency for pesticides (or the State agency that has a lead role in developing and implementing the Pesticide State Management Plan) in the development of pesticide management measures and practices under both programs. This is necessary to avoid duplication of effort and conflicting pesticide requirements between programs. Further, ongoing coordination will be necessary since both programs and management measures will evolve and change with increasing technology and data.

Section 1491 of the 1990 Farm Bill requires recordkeeping for restricted use pesticides for a 2-year period after such use. Specifically, records of pesticide applications are to include product name, amount, approximate date of application, and location of application of each pesticide used. Section 1491 also specifies the limitations on access to these records by governmental agencies and health care personnel (see practice "e" under "Pesticide Management Practices" for additional information regarding access to such records).

E. Grazing Management Measure

Protect range, pasture and other grazing lands:

(1) By implementing one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, and riparian zones):

(a) Exclude livestock,
(b) Provide stream crossings or hardened watering access for drinking,
(c) Provide alternative drinking water locations,
(d) Locate salt and additional shade, if needed, away from sensitive areas, or
(e) Use improved grazing management (e.g., herding)

to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock; *and*

(2) By achieving either of the following on all range, pasture, and other grazing lands not addressed under (1):

(a) Implement the range and pasture components of a Conservation Management System (CMS) as defined in the Field Office Technical Guide of the USDA-SCS (see Appendix 2A of this chapter) by applying the progressive planning approach of the USDA-Soil Conservation Service (SCS) to reduce erosion, or
(b) Maintain range, pasture, and other grazing lands in accordance with activity plans established by either the Bureau of Land Management of the U.S. Department of the Interior or the Forest Service of USDA.

1. Applicability

The management measure is intended to be applied by States to activities on range, irrigated and nonirrigated pasture, and other grazing lands used by domestic livestock. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

Range is those lands on which the native vegetation (climax or natural potential plant community) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing use. Range includes natural grassland, savannas, many wetlands, some deserts, tundra, and certain forb and shrub communities. Pastures are those lands that are primarily used for the production of adapted, domesticated forage plants for livestock. Other grazing lands include woodlands, native pastures, and croplands producing forages.

The major differences between range and pasture are the kind of vegetation and level of management that each land area receives. In most cases, range supports native vegetation that is extensively managed through the control of livestock rather than by agronomy practices, such as fertilization, mowing, irrigation, etc. Range also includes areas that have been seeded to introduced species (e.g., crested wheatgrass), but which are extensively managed like native range. Pastures are represented by those lands that have been seeded, usually to introduced species (e.g., tall fescue) or in some cases to native plants (e.g., switchgrass), and which are intensively managed using agronomy practices and control of livestock.

2. Description

The focus of the grazing management measure is on the riparian zone, yet the control of erosion from range, pasture, and other grazing lands above the riparian zone is also encouraged. Application of this management measure will reduce the physical disturbance to sensitive areas and reduce the discharge of sediment, animal waste, nutrients, and chemicals to surface waters. For information regarding potential problems caused by grazing, see Sections I.F.2 and I.F.6 of this chapter.

The key options to consider (all are not required by this management measure) when developing a comprehensive grazing management approach at a particular location include the development of one or more of the following:

- Grazing management systems. These systems ensure proper grazing use through:
  - Grazing frequency (includes complete rest);
  - Livestock stocking rates;
  - Livestock distribution;
  - Timing (season of forage use) and duration of each rest and grazing period;
  - Livestock kind and class; and
  - Forage use allocation for livestock and wildlife.
- Proper water and salt supplement facilities.
- Livestock access control.
- Range or pasture rehabilitation.

For any grazing management system to work, it must be tailored to fit the needs of the vegetation, terrain, class or kind of livestock, and particular operation involved.

For both pasture and range, areas should be provided for livestock watering, salting, and shade that are located away from streambanks and riparian zones where necessary and practical. This will be accomplished by managing livestock grazing and providing facilities for water, salt, and shade as needed.

Special attention must be given to grazing management in riparian and wetland areas if management measure objectives are to be met. For purposes of this guidance, riparian areas are defined (Mitsch and Gosselink, 1986; Lowrance et al., 1988) as:

> Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody.

The health of the riparian system, and thus the quality of water, is dependent on the use, management, and condition of the related uplands. Therefore, the proper management of riparian and wetland ecosystems will involve the correct management of livestock grazing and other land uses in the total watershed.

Conservation management systems (CMS) include any combination of conservation practices and management that achieves a level of treatment of the five natural resources (i.e., soil, water, air, plants, and animals) that satisfies criteria contained in the Soil Conservation Service (SCS) Field Office Technical Guide (FOTG), such as a resource management system (RMS) or an acceptable management system (AMS). These criteria are developed at the State level, with concurrence by the appropriate SCS National Technical Center (NTC). The criteria are then applied in the provision of field office technical assistance, under the direction of the District Conservationist of SCS. In-state coordination of FOTG use is provided by the Area Conservationist and State Conservationist of SCS.

The range and pasture components of a CMS address erosion control, proper grazing, adequate pasture stand density, and range condition. National (minimum) criteria pertaining to range and pasture under an RMS are applied to achieve environmental objectives, conserve natural resources, and prevent soil degradation.

The practical limits of resource protection under a CMS within any given area are determined through the application of national social, cultural, and economic criteria. With respect to economics, landowners will not be required to implement an RMS if the system is generally too costly for landowners. Instead, landowners may be required to implement a less costly, and less protective, AMS. In some cases, landowner constraints may be such that an RMS or AMS cannot be implemented quickly. In these situations, a "progressive planning approach" may be used to ultimately achieve planning and application of an RMS or AMS. Progressive planning is the incremental process of building a plan on part or all of the planning unit over a period of time. For additional details regarding CMS, RMS, and AMS, see Appendix 2A of this chapter.

3. Management Measure Selection

This management measure was selected based on an evaluation of available information that documents the beneficial effects of improved grazing management (see "Effectiveness Information" below). Specifically, the available information shows that (1) aquatic habitat conditions are improved with proper livestock management; (2) pollution from livestock is decreased by reducing the amount of time spent in the stream through the provision of supplemental water; and (3) sediment delivery is reduced through the proper use of vegetation, streambank protection, planned grazing systems, and livestock management.

4. Effectiveness Information

Hubert et al. (1985) showed in plot studies in Wyoming that livestock exclusion and reductions in stocking rates can result in improved habitat conditions for brook trout (Table 2-19) . In this study, the primary vegetation was willows, Pete Creek stocking density was 7.88 ac/AUM (acres per animal unit month), and Cherry Creek stocking density was 10 cows per acre.

Platts and Nelson (1989) used plot studies in Utah to evaluate the effects of livestock exclusion on riparian plant communities and streambanks. Several streambank characteristics that are related to the quality of fish habitat were measured, including bank stability, stream shore depth, streambank angle, undercut, overhang, and streambank alteration. The results clearly show better fish habitat in the areas where livestock were excluded (Table 2-20).

Kauffman et al. (1983) showed that fall cattle grazing decreases the standing phytomass of some riparian plant communities by as much as 21 percent versus areas where cattle are excluded, while causing increases for other plant communities. This study, conducted in Oregon from 1978 to 1980, incorporated stocking rates of 3.2 to 4.2 ac/AUM.

Eckert and Spencer (1987) studied the effects of a three-pasture, rest-rotation management plan on the growth and reproduction of heavily grazed native bunchgrasses in Wyoming. The results indicated that range improvement under this otherwise appropriate rotation grazing system is hindered by heavy grazing. Stocking rates on the study plots ranged from 525 to 742 cow-calf AUMs.

Table 2-19. Grazing Management Influences on Two Brook Trout Streams in Wyoming (Hubert et al., 1985)

	Pete Creek (n=3)		Cherry Creek (n=4)	
Parameter	Heavily Grazed (mean)	Lightly Grazed (mean)	Outside Exclosure (mean)	Inside Exclosure (mean)
Width	2.9	2.2[a]	2.9	2.5[a]
Depth	0.07	0.11[a]	0.08	0.09[a]
Width/depth ratio	43	21	37	28[a]
Coefficient of variation in depth	47.3	66.6[a]	57	71
Percent greater than 22 cm deep	9.0	22.3[b]	6.7	21.0[a]
Percent overhanging bank cover	2.7	30.0[a]	24.0	15.3
Percent overhanging vegetation	0	11.7[a]	8.5	18.0
Percent shaded area	0.7	18.3[a]	23.5	28.0
Percent silt substrate	35	52	22	13[a]
Percent bare soil along banks	19.7	13.3	22.8	12.3[a]
Percent litter along banks	7.0	6.0	10.0	6.8[a]

[a] Indicates statistical significance at p<=0.05.
[b] Indicates statistical significance at p<=0.1.

In a literature review, Van Poollen and Lacey (1979) showed that herbage production was greater for managed grazing versus continuous grazing, greater for moderate versus heavy intensity grazing, and greater for light- versus moderate-intensity grazing.

McDougald et al. (1989) tested the effects of moving supplemental feeding locations on riparian areas of hardwood range in California. With stocking rates of approximately 1 ac/AUM, they found that moving supplemental feeding locations away from water sources into areas with high amounts of forage greatly reduces the impacts of cattle on riparian areas (Table 2-21).

Table 2-20. Streambank Characteristics for Grazed Versus Rested Riparian Areas (Platts and Nelson, 1989)

Streambank Characteristic (unit)	Grazed	Rested
Extent (m)	4.1	2.5
Bank stability (%)	32.0	88.5
Stream-short depth (cm)	6.4	14.9
Bank angle (°)	127.0	81.0
Undercut (cm)	6.4	16.5
Overhang (cm)	1.8	18.3
Streambank alteration (%)	72.0	19.0

Table 2-21. The Effects of Supplemental Feeding Location on Riparian Area Vegetation (McDougald et al., 1989)

	Percentage of riparian area with the following levels of residual dry matter in early October		
Practice	Low	Moderate	High
Supplemental feeding located close to riparian areas:			
1982-85 Range Unit 1	48	39	13
1982-85 Range Unit 8	59	29	12
1986-87 Range Unit 8	54	33	13
Supplemental feeding moved away from riparian area:			
1986-87 Range Unit 1	1	27	72

Miner et al. (1991) showed that the provision of supplemental water facilities reduced the time each cow spent in the stream within 4 hours of feeding from 14.5 minutes to 0.17 minutes (8-day average). This pasture study in Oregon showed that the 90 cows without supplemental water spent a daily average of 25.6 minutes per cow in the stream. For the 60 cows that were provided a supplemental water tank, the average daily time in the stream was 1.6 minutes per cow, while 11.6 minutes were spent at the water tank. Based on this study, the authors expect that decreased time spent in the stream will decrease bacterial loading from the cows.

Tiedemann et al. (1988) studied the effects of four grazing strategies on bacteria levels in 13 Oregon watersheds in the summer of 1984. Results indicate that lower fecal coliform levels can be achieved at stocking rates of about 20 ac/AUM if management for livestock distribution, fencing, and water developments are used (Table 2-22). The study also indicates that, even with various management practices, the highest fecal coliform levels were associated with the higher stocking rates (6.9 ac/AUM) employed in strategy D.

Lugbill (1990) estimates that stream protection in the Potomac River Basin will reduce total nitrogen (TN) and total phosphorus (TP) loads by 15 percent, while grazing land protection and permanent vegetation improvement will reduce TN and TP loads by 60 percent. Owens et al. (1982) measured nitrogen losses from an Ohio pasture under a medium-fertility, 12-month pasture program from 1974 to 1979. The results included no measurable soil loss from three watersheds under summer grazing only, and increased average TN concentrations and total soluble N loads from watersheds under summer grazing and winter feeding versus watersheds under summer grazing only (Table 2-23).

Table 2-22. Bacterial Water Quality Response to Four Grazing Strategies (Tiedemann et al., 1988)

Practice	Geometric Mean Fecal Coliform Count
Strategy A: Ungrazed.	40/L
Strategy B: Grazing without management for livestock distribution; 20.3 ac/AUM.	150/L
Strategy C: Grazing with management for livestock distribution: fencing and water developments; 19.0 ac/AUM.	90/L
Strategy D: Intensive grazing management, including practices to attain uniform livestock distribution and improve forage production with cultural practices such as seeding, fertilizing, and forest thinning; 6.9 ac/AUM.	920/L

Table 2-23. Nitrogen Losses from Medium-Fertility, 12-Month Pasture Program (Owens et al., 1982)

Practice	Soil Loss (kg/ha)	Total Sediment N Transport (kg/ha)	Total N Concentration (mg/l)[a]	Total Soluble N Transport (kg/ha)[a]
Summer Grazing Only				
Growing season	—	—	3.7	0.4
Dormant season	—	—	1.8	0.1
Year	—	—	3.0	0.5
Summer Grazing - Winter Feeding				
Growing season	251	1.4	4.9	2.5
Dormant season	1,104	6.6	14.6	11.3
Year	1,355	8.0	10.7	13.8

[a] Five-year average (1974-1979)

Data from a comparison of the expected effectiveness of various grazing and streambank practices in controlling sedimentation in the Molar Flats Pilot Study Area in Fresno County, California indicate that planned grazing systems are the most effective single practice for reducing sheet and rill erosion (Fresno Field Office, 1979). Streambank protection is expected to be the most effective single practice for reducing streambank erosion. Other practices evaluated are proper grazing use, deferred grazing, emergency seeding, and livestock exclusion.

5. Range and Pasture Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

The U.S. Soil Conservation Service practice number and definition are provided for each management practice, where available. Also included in italics are SCS statements describing the effect each practice has on water quality (USDA-SCS, 1988.)

Grazing Management System Practices

Appropriate grazing management systems ensure proper grazing use by adjusting grazing intensity and duration to reflect the availability of forage and feed designated for livestock uses, and by controlling animal movement through the operating unit of range or pasture. 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:

■ *a. Deferred grazing (352): Postponing grazing or resting grazing land for prescribed period.*

In areas with bare ground or low percent ground cover, deferred grazing will reduce sediment yield because of increased ground cover, less ground surface disturbance, improved soil bulk density characteristics, and greater infiltration rates. Areas mechanically treated will have less sediment yield when deferred to encourage re-vegetation. Animal waste would not be available to the area during the time of deferred grazing and there would be less opportunity for adverse runoff effects on surface or aquifer water quality. As vegetative cover increases, the filtering processes are enhanced, thus trapping more silt and nutrients as well as snow if climatic conditions for snow exist. Increased plant cover results in a greater uptake and utilization of plant nutrients.

b. *Planned grazing system (556): A practice in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years, and rest periods may be throughout the year or during the growing season of key plants.*

Planned grazing systems normally reduce the system time livestock spend in each pasture. This increases quality and quantity of vegetation. As vegetation quality increases, fiber content in manure decreases which speeds manure decomposition and reduces pollution potential. Freeze-thaw, shrink-swell, and other natural soil mechanisms can reduce compacted layers during the absence of grazing animals. This increases infiltration, increases vegetative growth, slows runoff, and improves the nutrient and moisture filtering and trapping ability of the area.

Decreased runoff will reduce the rate of erosion and movement of sediment and dissolved and sediment-attached substances to downstream water courses. No increase in ground water pollution hazard would be anticipated from the use of this practice.

c. *Proper grazing use (528): Grazing at an intensity that will maintain enough cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation.*

Increased vegetation slows runoff and acts as a sediment filter for sediments and sediment attached substances, uses more nutrients, and reduces raindrop splash. Adverse chemical effects should not be anticipated from the use of this practice.

d. *Proper woodland grazing (530): Grazing wooded areas at an intensity that will maintain adequate cover for soil protection and maintain or improve the quantity and quality of trees and forage vegetation.*

This practice is applicable on wooded areas producing a significant amount of forage that can be harvested without damage to other values. In these areas there should be no detrimental effects on the quality of surface and ground water. Any time this practice is applied there must be a detailed management and grazing plan.

e. *Pasture and hayland management (510): Proper treatment and use of pasture or hayland.*

With the reduced runoff there will be less erosion, less sediment and substances transported to the surface waters. The increased infiltration increases the possibility of soluble substances leaching into the ground water.

Alternate Water Supply Practices

Providing water and salt supplement facilities away from streams will help keep livestock away from streambanks and riparian zones. The establishment of alternate water supplies for livestock is an essential component of this measure when problems related to the distribution of livestock occur in a grazing unit. In most western states, securing water rights may be necessary. Access to a developed or natural water supply that is protective of streambank and riparian zones can be provided by using the stream crossing (interim) technology to build a watering site. In some locations, artificial shade may be constructed to encourage use of upland sites for shading and loafing. Providing water can be accomplished through the following Soil Conservation Service practices and the stream crossing (interim) practice (practice "m") of the following section. Descriptions have been modified to meet CZM needs:

f. *Pipeline (516): Pipeline installed for conveying water for livestock or for recreation.*

Pipelines may decrease sediment, nutrient, organic, and bacteria pollution from livestock. Pipelines may afford the opportunity for alternative water sources other than streams and lakes, possibly keeping the animals away from the stream or impoundment. This will prevent bank destruction with resulting sedimentation, and will reduce animal *waste deposition directly in the water. The reduction of concentrated livestock areas will reduce manure solids, nutrients, and bacteria that accompany surface runoff.*

g. *Pond (378): A water impoundment made by constructing a dam or an embankment or by excavation of a pit or dugout.*

Ponds may trap nutrients and sediment which wash into the basin. This removes these substances from downstream. Chemical concentrations in the pond may be higher during the summer months. By reducing the amount of water that flows in the channel downstream, the frequency of flushing of the stream is reduced and there is a collection of substances held temporarily within the channel. A pond may cause more leachable substance to be carried into the ground water.

h. *Trough or tank (614): A trough or tank, with needed devices for water control and waste water disposal, installed to provide drinking water for livestock.*

By the installation of a trough or tank, livestock may be better distributed over the pasture, grazing can be better controlled, and surface runoff reduced, thus reducing erosion. By itself this practice will have only a minor effect on water quality; however when coupled with other conservation practices, the beneficial effects of the combined practices may be large. Each site and application should be evaluated on their own merits.

i. *Well (642): A well constructed or improved to provide water for irrigation, livestock, wildlife, or recreation.*

When water is obtained, if it has poor quality because of dissolved substances, its use in the surface environment or its discharge to downstream water courses the surface water will be degraded. The location of the well must consider the natural water quality and the hazards of its use in the potential contamination of the environment. Hazard exists during well development and its operation and maintenance to prevent aquifer quality damage from the pollutants through the well itself by back flushing, or accident, or flow down the annular spacing between the well casing and the bore hole.

j. *Spring development (574): Improving springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities.*

There will be negligible long-term water quality impacts with spring developments. Erosion and sedimentation may occur from any disturbed areas during and immediately after construction, but should be short-lived. These sediments will have minor amounts of adsorbed nutrients from soil organic matter.

Livestock Access Limitation Practices

It may be necessary to minimize livestock access to streambanks, ponds or lakeshores, and riparian zones to protect these areas from physical disturbance. This could also be accomplished by establishing special use pastures to manage livestock in areas of concentration. Practices include:

k. *Fencing (382): Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people (does not include temporary fences).*

Fencing is a practice that can be on the contour or up and down slope. Often a fence line has grass and some shrubs in it. When a fence is built across the slope it will slow down runoff, and cause deposition of coarser grained materials reducing the amount of sediment delivered downslope. Fencing may protect riparian areas which act as sediment traps and filters along water channels and impoundments.

Livestock have a tendency to walk along fences. The paths become bare channels which concentrate and accelerate runoff causing a greater amount of erosion within the path and where the path/channel outlets into another channel. This can deliver more sediment and associated pollutants to surface waters. Fencing can have the effect of concentrating livestock in small areas, causing a concentration of manure which may wash off into the stream, thus causing surface water pollution.

■ *l. Livestock exclusion (472): Excluding livestock from an area not intended for grazing.*

Livestock exclusion may improve water quality by preventing livestock from being in the water or walking down the banks, and by preventing manure deposition in the stream. The amount of sediment and manure may be reduced in the surface water. This practice prevents compaction of the soil by livestock and prevents losses of vegetation and undergrowth. This may maintain or increase evapotranspiration. Increased permeability may reduce erosion and lower sediment and substance transportation to the surface waters. Shading along streams and channels resulting from the application of this practice may reduce surface water temperature.

■ *m. Stream crossing (interim): A stabilized area to provide access across a stream for livestock and farm machinery.*

The purpose is to provide a controlled crossing or watering access point for livestock along with access for farm equipment, control bank and streambed erosion, reduce sediment and enhance water quality, and maintain or improve wildlife habitat.

Vegetative Stabilization Practices

It may be necessary to improve or reestablish the vegetative cover on range and pastures to reduce erosion rates. The following practices can be used to reestablish vegetation:

■ *n. Pasture and hayland planting (512): Establishing and reestablishing long-term stands of adapted species of perennial, biannual, or reseeding forage plants. (Includes pasture and hayland renovation. Does not include grassed waterways or outlets or cropland.)*

The long-term effect will be an increase in the quality of the surface water due to reduced erosion and sediment delivery. Increased infiltration and subsequent percolation may cause more soluble substances to be carried to ground water.

■ *o. Range seeding (550): Establishing adapted plants by seeding on native grazing land. (Range does not include pasture and hayland planting.)*

Increased erosion and sediment yield may occur during the establishment of this practice. This is a temporary situation and sediment yields decrease when reseeded area becomes established. If chemicals are used in the reestablishment process, chances of chemical runoff into downstream water courses are reduced if application is applied according to label instructions. After establishment of the grass cover, grass sod slows runoff, acts as a filter to trap sediment, sediment attached substances, increases infiltration, and decreases sediment yields.

■ *p. Critical area planting (342): Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas. (Does not include tree planting mainly for wood products.)*

This practice may reduce soil erosion and sediment delivery to surface waters. Plants may take up more of the nutrients in the soil, reducing the amount that can be washed into surface waters or leached into ground water.

During grading, seedbed preparation, seeding, and mulching, large quantities of sediment and associated chemicals may be washed into surface waters prior to plant establishment.

q. *Brush (and weed) management (314): Managing and manipulating stands of brush (and weeds) on range, pasture, and recreation and wildlife areas by mechanical, chemical, or biological means or by prescribed burning. (Includes reducing excess brush (and weeds) to restore natural plant community balance and manipulating stands of undesirable plants through selective and patterned treatments to meet specific needs of the land and objectives of the land user.)*

Improved vegetation quality and the decrease in runoff from the practice will reduce the amount of erosion and sediment yield. Improved vegetative cover acts as a filter strip to trap the movement of dissolved and sediment attached substances, such as nutrients and chemicals from entering downstream water courses. Mechanical brush management may initially increase sediment yields because of soil disturbances and reduced vegetative cover. This is temporary until revegetation occurs.

r. *Prescribed burning (338): Applying fire to predetermined areas under conditions under which the intensity and spread of the fire are controlled.*

When the area is burned in accordance with the specifications of this practice the nitrates with the burned vegetation will be released to the atmosphere. The ash will contain phosphorous and potassium which will be in a relatively highly soluble form. If a runoff event occurs soon after the burn there is a probability that these two materials may be transported into the ground water or into the surface water. When in a soluble state the phosphorous and potassium will be more difficult to trap and hold in place. When done on range grasses the growth of the grasses is increased and there will be an increased tie-up of plant nutrients as the grasses' growth is accelerated.

Selection of Practices

The selection of management practices for this measure should be based on an evaluation of current conditions, problems identified, quality criteria, and management goals. Successful resource management on range and pasture includes appropriate application of a combination of practices that will meet the needs of the range and pasture ecosystem (i.e., the soil, water, air, plant, and animal (including fish and shellfish) resources) and the objectives of the land user.

For a sound grazing land management system to function properly and to provide for a sustained level of productivity, the following should be considered:

- Know the key factors of plant species management, their growth habits, and their response to different seasons and degrees of use by various kinds and classes of livestock.
- Know the demand for, and seasons of use of, forage and browse by wildlife species.
- Know the amount of plant residue or grazing height that should be left to protect grazing land soils from wind and water erosion, provide for plant regrowth, and provide the riparian vegetation height desired to trap sediment or other pollutants.
- Know the range site production capabilities and the pasture suitability group capabilities so an initial stocking rate can be established.
- Know how to use livestock as a tool in the management of the range ecosystems and pastures to ensure the health and vigor of the plants, soil tilth, proper nutrient cycling, erosion control, and riparian area management, while at the same time meeting livestock nutritional requirements.

- Establish grazing unit sizes, watering, shade and salt locations, etc. to secure optimum livestock distribution and proper vegetation use.

- Provide for livestock herding, as needed, to protect sensitive areas from excessive use at critical times.

- Encourage proper wildlife harvesting to ensure proper population densities and forage balances.

- Know the livestock diet requirements in terms of quantity and quality to ensure that there are enough grazing units to provide adequate livestock nutrition for the season and the kind and classes of animals on the farm/ranch.
- Maintain a flexible grazing system to adjust for unexpected environmentally and economically generated problems.

- Special requirements to protect threatened or endangered species.

6. Cost Information

Much of the cost associated with implementing grazing management practices is due to fencing installation, water development, and system maintenance. Costs vary according to region and type of practice. Generally, the more components or structures a practice requires, the more expensive it is. However, cost-share is usually available from the USDA and other Federal agencies for most of these practices.

a. Grazing Facilities

Principal direct costs of providing grazing facilities vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by herding or strategically locating grazing facilities to draw cattle away from streamside areas can result in improved utilization of existing forage.

The availability and feasibility of supplementary water development varies considerably between arid western areas and humid eastern areas, but costs for water development, including spring development and pipeline watering, are similar (Table 2-24).

b. Livestock Exclusion

Principal direct costs of livestock exclusion are the capital and maintenance costs for fencing to restrict access to streamside areas or the cost of herders to achieve the same results. In addition, there may be an indirect cost of the forage that is removed from grazing by exclusion.

There is considerable difference between multistrand barbed wire, chiefly used for perimeter fencing and permanent stream exclusion and diversions, and single- or double-strand smoothwire electrified fencing used for stream exclusion and temporary divisions within permanent pastures. The latter may be all that is needed to accomplish most livestock exclusion in smaller, managed pastures in the East (Table 2-25).

c. Improvement/Reestablishment

Principal direct costs of improving or reestablishing grazing land include the costs of seed, fertilizer, and herbicides needed to establish the new forage stand and the labor and machinery costs required for preparation, planting, cultivation, and weed control (Table 2-26). An indirect cost may be the forage that is removed from grazing during the reestablishment work and rest for seeding establishment.

Table 2-24. Cost of Water Development for Grazing Management

Location	Year	Type	Unit	Reported Capital Costs $/Unit	Constant Dollar[a] Capital Costs 1991 $/Unit	Constant Dollar[a] Annualized Costs 1991 $/Unit
California[b]	1979	pipeline	foot	0.28	0.35	0.05
Kansas[c]	1989	spring	each	1,239.00	1,282.94	191.20
		spring	each	1,389.00	1,438.26	214.34
Maine[d]	1988	pipeline	each	831.00	879.17	131.02
Alabama[e]	1990	spring	each	1,500.00	1,520.83	226.65
		pipeline	foot	1.60	1.62	0.24
		trough	each	1,000.00	1,013.89	151.10
Nebraska[f]	1991	pipeline	foot	1.31	1.31	0.20
		tank	each	370.00	370.00	55.14
Utah[g]	1968	spring	each	200.00	389.33	58.02
Oregon[h]	1991	pipeline	foot	0.20	0.20	0.03
		tank	each	183.00	183.00	27.27

[a] Reported costs inflated to 1991 constant dollars by the ratio of indices of prices paid by farmers for building and fencing, 1977=100. Capital costs are annualized at 8 percent interest for 10 years.
[b] Fresno Field Office, 1979.
[c] Northup et al., 1989.
[d] Cumberland County Soil and Water Conservation District, undated.
[e] Alabama Soil Conservation Service, 1990.
[f] Hermsmeyer, 1991.
[g] Workman and Hooper, 1968.
[h] ASCS/SCS, 1991.

d. Overall Costs of the Grazing Management Measure

Since the exact combination of practices needed to implement the management measure depends on site-specific conditions that are highly variable, the overall cost of the measure is best estimated from similar combinations of practices applied under the Agricultural Conservation Program (ACP), Rural Clean Water Program (RCWP), and similar activities. Cost data from the ACP programs are summarized in Table 2-27.

Table 2-25. Cost of Livestock Exclusion for Grazing Management

Location	Year	Type	Unit	Reported Capital Costs $/Unit	Constant Dollar[a] Capital Costs 1991 $/Unit	Constant Dollar[a] Annualized Costs 1991 $/Unit
California[b]	1979	permanent	mile	2,000	2,474.58	368.78
Alabama[c]	1990	permanent	mile	3,960	4,015.00	598.35
		net wire	mile	5,808	5,888.67	877.58
		electric	mile	2,640	2,676.67	398.90
Nebraska[d]	1991	permanent	mile	2,478	2,478.00	369.30
Great Lakes[e]	1989	permanent	mile	2,100 - 2,400	2,174.47 - 2,485.11	324.06 - 370.35
Oregon[f]	1991	permanent	mile	2,640	2,640.00	393.44

[a] Reported costs inflated to 1991 constant dollars by the ratio of indices of prices paid by farmers for building and fencing, 1977=100. Capital costs are annualized at 8 percent interest for 10 years.
[b] Fresno Field Office, 1979.
[c] Alabama Soil Conservation Service, 1990.
[d] Hermsmeyer, 1991.
[e] DPRA, 1989.
[f] ASCS/SCS, 1991.

Table 2-26. Cost of Forage Improvement/Reestablishment for Grazing Management

Location	Year	Type	Unit	Reported Capital Costs $/Unit	Constant Dollar[a] Capital Costs 1991 $/Unit	Constant Dollar[a] Annualized Costs 1991 $/Unit
Alabama[b]	1990	planting (seed, lime & fertilizer)	acre	84 - 197	83 - 195	12.37 - 29.00
Nebraska[c]	1991	establishment	acre	47	47	7.00
		seeding	acre	45	45	6.71
Oregon[d]	1991	establishment	acre	27	27	4.02

[a] Reported costs inflated to 1991 constant dollars by the ratio of indices of prices paid by farmers for seed, 1977=100. Capital costs are annualized at 8 percent interest for 10 years.
[b] Alabama Soil Conservation Service, 1990.
[c] Hermsmeyer, 1991.
[d] ASCS/SCS, 1991.

Table 2-27. Summary of ACP Grazing Management Practice Costs, 1989 (US and 1990 (USDA-ASCS, 1990; USDA-ASCS, 1991)[a]

Region[b]	ASCS Practice Code[c]	Adjusted Cost/Acre Treated[d] ($/acre)		
		Average	Low	High
GL	SL1	17.34	13.01	49.80
GL	SL2	16.18	11.53	24.82
GL	SL6	27.76	17.32	37.92
GL	SL11	31.63	11.95	66.50
GL	SP10	19.13	13.50	52.03
GL	WP2	31.78	16.09	165.37
Gulf	SL1	12.67	9.95	19.19
Gulf	SL2	4.44	4.26	13.43
Gulf	SL6-range	1.81	0.81	12.55
Gulf	SL6-pasture	24.00	9.68	219.45
Gulf	SL11	47.92	27.53	109.98
Gulf	WC3	0.78	0.69	0.98
Gulf	WP2	58.44	38.14	72.84
NE	SL1	23.92	17.18	45.76
NE	SL2	21.06	5.08	45.98
NE	SL6	34.70	19.38	42.20
NE	SL11	109.11	17.62	374.48
NE	SP10	106.53	52.03	1,023.61
NE	WP2	72.75	31.08	1,543.97
Pacific	SL1	9.75	7.92	24.39
Pacific	SL2	3.62	0.61	7.32
Pacific	SL6	1.06	0.51	2.22
Pacific	SL11	12.61	7.20	20.86
Pacific	SP10	100.19	19.59	132.36
Pacific	WP2	14.22	7.53	190.51
SE	SL1	19.54	15.49	24.05
SE	SL2	10.68	5.20	15.81
SE	SL6	10.14	9.49	262.77
SE	SL11	55.20	15.70	116.40
SE	WP2	75.90	13.21	224.73

Table 2-27 Notes:

[a] Acreage-weighted average of 1989 and 1990 costs.
[b] GL=Great Lakes Region (IL, IN, MI, NY, OH, WI)
GULF=Gulf States Region (AL, FL, LA, MS, TX)
NE=Northeast Region (CT, DE, MA, MD, ME, NH, NY, PA, RI)
Pacific=Pacific Region (CA, OR, WA)
SE=Southeast Region (FL, GA, NC, SC, VA)
[c] ASCS practices with description title and technical practice code:

SL1 - Permanent vegetative cover establishment

Conservation tillage	329
Pasture and hayland planting	512
Range seeding	550
Cover and green manure crop (orchard and vineyard only)	340
Field borders	386
Filter strips	393

SL2 - Permanent vegetative cover improvement

Conservation tillage	329
Pasture and hayland management	510
Pasture and hayland Planting	512
Fencing	382
Range seeding	550
Deferred grazing	352
Firebreak	394
Brush management	314

SL6 - Grazing land protection

Critical area planting	342
Pond	378
Fencing	382
Pipeline	516
Spring development	574
Stock trails and walkways	575
Trough or tank	614
Water-harvesting catchment	636
Wells	642

SL11 - Permanent vegetative cover on critical areas

Cover and green manure crop	340
Critical area planting	342
Fencing	382
Field borders	386
Filter strip	393
Forest land erosion control system	408
Mulching	484
Streambank and shoreline protection	580
Tree planting	612

SP10 - Streambank stabilization

Critical area planting	342
Livestock exclusion	472
Mulching	484
Streambank and shoreline protection	580
Tree planting	612

WC3 - Rangeland moisture conservation

Grazing land mechanical treatment	548

WP2 - Stream protection

Filter strip	393
Channel vegetation	322
Fencing	382
Pipeline	516
Streambank and shoreline protection	580
Field border	386
Tree planting	612
Trough or tank	614
Stock trails or walkways	575

[d] Average annual cost, adjusted to 1990 constant dollars using ratio of index of prices paid for production items 1989 to 1990 (171/165). Source: USDA-ERS, 1991.

F. Irrigation Water Management

To reduce nonpoint source pollution of surface waters caused by irrigation:

(1) Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This will require, as a minimum: (a) the accurate measurement of soil-water depletion volume and the volume of irrigation water applied, and (b) uniform application of water.

(2) When chemigation is used, include backflow preventers for wells, minimize the harmful amounts of chemigated waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system may be needed.

The following limitations and special conditions apply:

(1) In some locations, irrigation return flows are subject to other water rights or are required to maintain stream flow. In these special cases, on-site reuse could be precluded and would not be considered part of the management measure for such locations.

(2) By increasing the water use efficiency, the discharge volume from the system will usually be reduced. While the total pollutant load may be reduced somewhat, there is the potential for an increase in the concentration of pollutants in the discharge. In these special cases, where living resources or human health may be adversely affected and where other management measures (nutrients and pesticides) do not reduce concentrations in the discharge, increasing water use efficiency would not be considered part of the management measure.

(3) In some irrigation districts, the time interval between the order for and the delivery of irrigation water to the farm may limit the irrigator's ability to achieve the maximum on-farm application efficiencies that are otherwise possible.

(4) In some locations, leaching is necessary to control salt in the soil profile. Leaching for salt control should be limited to the leaching requirement for the root zone.

(5) Where leakage from delivery systems or return flows supports wetlands or wildlife refuges, it may be preferable to modify the system to achieve a high level of efficiency and then divert the "saved water" to the wetland or wildlife refuge. This will improve the quality of water delivered to wetlands or wildlife refuges by preventing the introduction of pollutants from irrigated lands to such diverted water.

(6) In some locations, sprinkler irrigation is used for frost or freeze protection, or for crop cooling. In these special cases, applications should be limited to the amount necessary for crop protection, and applied water should remain on-site.

1. Applicability

This management measure is intended to be applied by States to activities on irrigated lands, including agricultural crop and pasture land (except for isolated fields of less than 10 acres in size that are not contiguous to other irrigated lands); orchard land; specialty cropland; and nursery cropland. Those landowners already practicing effective irrigation management in conformity with the irrigation water management measure may not need to purchase additional devices to measure soil-water depletion or the volume of irrigation water applied, and may not need to expend additional labor resources to manage the irrigation system. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The goal of this management measure is to reduce nonpoint source pollution of surface waters caused by irrigation. For the purposes of this management measure, "harmful amounts" are those amounts that pose a significant risk to aquatic plant or animal life, ecosystem health, human health, or agricultural or industrial uses of the water.

A problem associated with irrigation is the movement of pollutants from the land into ground or surface water. This movement of pollutants is affected by the pathways taken by applied water and precipitation (Figure 2-15); the physical, chemical, and biological characteristics of the irrigated land; the type of irrigation system used; crop type; the degree to which erosion and sediment control, nutrient management, and pesticide management are employed; and the management of the irrigation system (Figure 2-16).

Return flows, runoff, and leachate from irrigated lands may transport the following types of pollutants:

- Sediment and particulate organic solids;
- Particulate-bound nutrients, chemicals, and metals, such as phosphorus, organic nitrogen, a portion of applied pesticides, and a portion of the metals applied with some organic wastes;
- Soluble nutrients, such as nitrogen, soluble phosphorus, a portion of the applied pesticides, soluble metals, salts, and many other major and minor nutrients; and
- Bacteria, viruses, and other microorganisms.

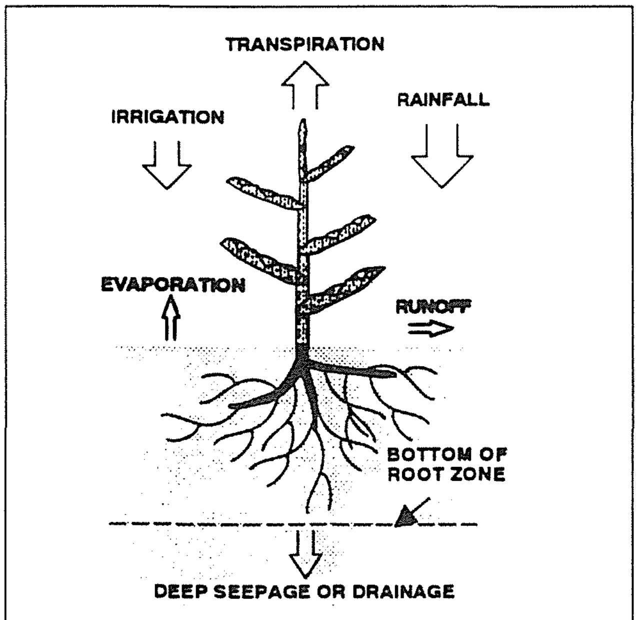

Figure 2-15. Source and fate of water added to a soil system (Evans et al., 1991c).

Transport of irrigation water from the source of supply to the irrigated field via open canals and laterals can be a source of water loss if the canals and laterals are not lined. Water is also transported through the lower ends of canals and laterals because of the flow-through requirements to maintain water levels in them. In many soils, unlined canals and laterals lose water via seepage in bottom and side walls. Seepage water either moves into the ground water through infiltration or forms wet areas near the canal or lateral. This water

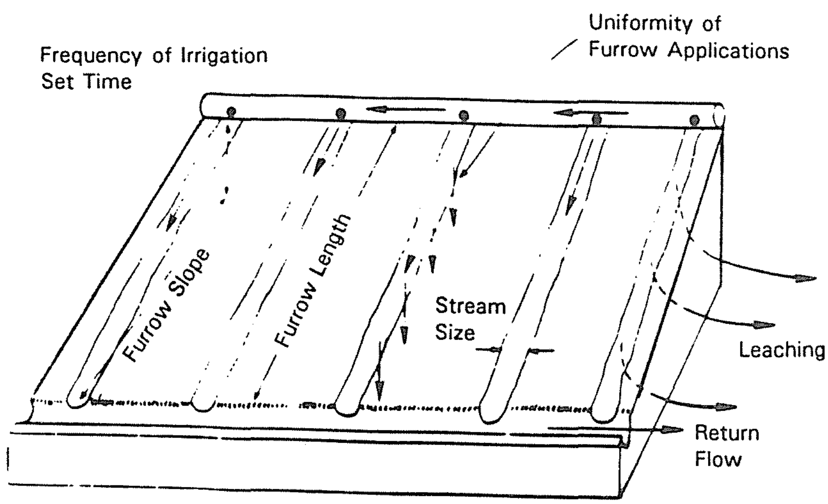

Figure 2-16. Variables influencing pollutant losses from irrigated fields (USEPA, 1982).

will carry with it any soluble pollutants in the soil, thereby creating the potential for pollution of ground or surface water.

Since irrigation is a consumptive use of water, any pollutants in the source waters that are not consumed by the crop (e g., salts, pesticides, nutrients) can be concentrated in the soil, concentrated in the leachate or seepage, or concentrated in the runoff or return flow from the system. Salts that concentrate in the soil profile must be removed for sustained crop production.

For additional information regarding the problems caused by these pollutants, see Section I.F of this chapter.

Application of this management measure will reduce the waste of irrigation water, improve the water use efficiency, and reduce the total pollutant discharge from an irrigation system. It is not the intent of this management measure to require the replacement of major components of an irrigation system. Instead, the expectation is that components to manage the timing and amount of water applied will be provided where needed, and that special precautions (i.e., backflow preventers, prevent tailwater, and control deep percolation) will be taken when chemigation is used.

Irrigation scheduling is the use of water management strategies to prevent over-application of water while minimizing yield loss due to water shortage or drought stress (Evans et al., 1991d). Irrigation scheduling will ensure that water is applied to the crop when needed and in the amount needed. Effective scheduling requires knowledge of the following factors (Evans et al., 1991c; Evans et al., 1991d):

- Soil properties;
- Soil-water relationships and status;
- Type of crop and its sensitivity to drought stress;
- The stage of crop development;
- The status of crop stress;
- The potential yield reduction if the crop remains in a stressed condition;
- Availability of a water supply; and
- Climatic factors such as rainfall and temperature.

Much of the above information can be found in Soil Conservation Service soil surveys and Extension Service literature. However, all information should be site-specific and verified in the field.

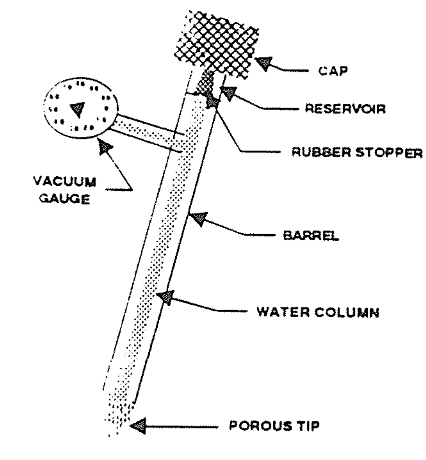

Figure 2-17. Diagram of a tensiometer (Evans et al., 1991b).

There are three ways to determine when irrigation is needed (Evans et al., 1991d):

- Measuring soil water;
- Estimating soil water using an accounting approach; and
- Measuring crop stress.

Soil water can be measured using a range of devices (Evans et al., 1991b), including tensiometers, which measure soil water suction (Figure 2-17); electrical resistance blocks (also called gypsum blocks or moisture blocks), which measure electrical resistance that is related to soil water by a calibration curve (Figure 2-18); neutron probes, which directly measure soil water; Phene cells, which are used to estimate soil water based on the relationship of heat conductance to soil water content; and time domain reflectometers, which can be used to estimate soil water based on the time it takes for an electromagnetic pulse to pass through the soil. The appropriate device for any given situation is a function of the acreage of irrigated land, soils, cost, and other site-specific factors.

Accounting approaches estimate the quantity of soil water remaining in the effective root zone and can be simple or complex. In essence, daily water inputs and outputs are measured or estimated to determine the depletion volume. Irrigation is typically scheduled when the allowable depletion volume is nearly reached.

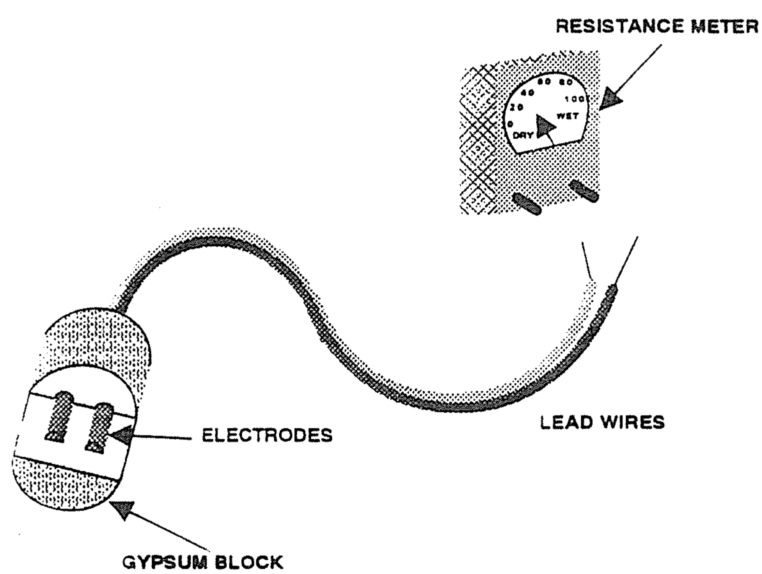

Figure 2-18. Schematic of an electrical resistance block and meter (Evans et al., 1991b).

Once the decision to irrigate has been made, it is important to determine the amount of water to apply. Irrigation needs are a function of the soil water depletion volume in the effective root zone, the rate at which the crop uses water (Figure 2-19), and climatic factors. Accurate measurements of the amount of water applied are essential to maximizing irrigation efficiency. The quantity of water applied

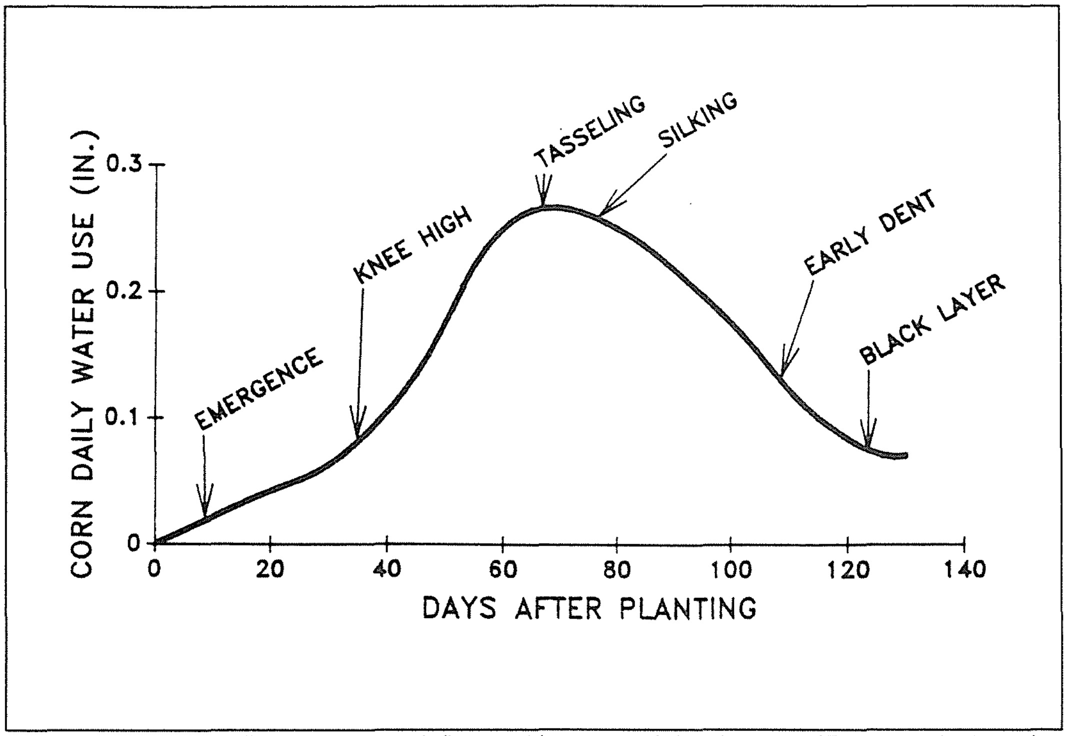

Figure 2-19. Corn daily water use as influenced by stage of development (Evans et al., 1991c).

can be measured by such devices as a totalizing flow meter that is installed in the delivery pipe. If water is supplied by ditch or canal, weirs or flumes in the ditch can be used to measure the rate of flow.

Deep percolation can be greatly reduced by limiting the amount of applied water to the amount that can be stored in the plant root zone. The deep percolation that is necessary for salt management can be accomplished with a sprinkler system by using longer sets or very slow pivot speeds or by applying water during the non-growing season.

Reducing overall water use in irrigation will allow more water for stream flow control and will increase flow for diversion to marshes, wetlands, or other environmental uses. If the source is ground water, reducing overall use will maintain higher ground-water levels, which could be important for maintaining base flow in nearby streams. Reduced water diversion will reduce the salt or pollutant load brought into the irrigation system, thereby reducing the volume of these pollutants that must be managed or discharged from the system.

Although this management measure does not require the replacement of major components of an irrigation system, such changes can sometimes result in greater pollution prevention. Consequently, the following is a broader discussion of the types of design and operational aspects of the overall irrigation system that could be addressed to provide additional control of nonpoint source pollution beyond that which is required by this management measure. Overall, five basic aspects of the irrigation system can be addressed:

(1) Irrigation scheduling;
(2) Efficient application of irrigation water;
(3) Efficient transport of irrigation water;
(4) Use of runoff or tailwater; and
(5) Management of drainage water.

This management measure addresses irrigation scheduling, efficient application, and the control of tailwater when chemigation is used. The efficient transport of irrigation water, the use of runoff or tailwater, and the management of drainage water are additional considerations.

Although not a required element of this management measure, the seepage losses associated with canals and laterals can be reduced by lining the canals and laterals, or can be eliminated by conversion from open canals and laterals to pipelines. Flow-through losses will not be changed by canal or lateral lining, but can be eliminated or greatly reduced by conversion to pipelines.

Surface irrigation systems are usually designed to have a percentage (up to 30 percent) of the applied water lost as tailwater. This tailwater should be managed with a tailwater recovery system, but such a system is not required as a component of this management measure unless chemigation is practiced. Tailwater recovery systems usually include a system of ditches or berms to direct water from the end of the field to a small storage structure. Tailwater is stored until it can be either pumped back to the head end of the field and reused or delivered to additional irrigated land. In some locations, there may be downstream water rights that are dependent upon tailwater, or tailwater may be used to maintain flow in streams. These requirements may take legal precedence over the reuse of tailwater.

Well-designed and managed irrigation systems remove runoff and leachate efficiently; control deep percolation; and minimize erosion from applied water, thereby reducing adverse impacts on surface water and ground water. If a tailwater recovery system is used, it should be designed to allow storm runoff to flow through the system without damage. Additional surface drainage structures such as filter strips, field drainage ditches, subsurface drains, and water table control may also be used to control runoff and leachate if site conditions warrant their use. Sprinkler systems will usually require design and installation of a system to remove and manage storm runoff.

A properly designed and operated sprinkler irrigation system should have a uniform distribution pattern. The volume of water applied can be changed by changing the total time the sprinkler runs; by changing the pressure at which the sprinkler operates; or, in the case of a center pivot, by adjusting the speed of travel of the system. There should be no irrigation runoff or tailwater from most well-designed and well-operated sprinkler systems.

The type of irrigation system used will dictate which practices can be employed to improve water use efficiency and to obtain the most benefit from scheduling. Flood systems will generally infiltrate more water at the upper end of the field than at the lower end because water is applied to the upper end of the field first and remains on that portion of the field longer. This will cause the upper end of the field to have greater deep percolation losses than the lower end. Although not required as a component of this management measure, this situation can sometimes be improved by changing slope throughout the length of the field. This type of change may not be practical or affordable in many cases. For example, furrow length can be reduced by cutting the field in half and applying water in the middle of the field. This will require more pipe or ditches to distribute the water across the middle of the field.

3. Management Measure Selection

This management measure was selected based on an evaluation of available information that documents the beneficial effects of improved irrigation management (see Section II.F.4 of this chapter). Specifically, the available information shows that irrigation efficiencies can be improved with scheduling that is based on knowledge of water needs and measurement of applied water. Improved irrigation efficiency can result in the reduction or elimination of runoff and return flows, as well as the control of deep percolation. Secondly, backflow preventers can be used to protect wells from chemicals used in chemigation. In addition, tailwater prevention, or tailwater management where necessary, is effective in reducing the discharge of soluble and particulate pollutants to receiving waters.

By reducing the volume of water applied to agricultural lands, pollutant loads are also reduced. Less interaction between irrigation water and agricultural land will generally result in less pollutant transport from the land and less leaching of pollutants to ground water.

The practices that can be used to implement this measure on a given site are commonly used and are recommended by SCS for general use on irrigated lands. By designing the measure using the appropriate mix of structural and management practices for a given site, there is no undue economic impact on the operator. Many of the practices that can be used to implement this measure (e.g., water-measuring devices, tailwater recovery systems, and backflow preventers) may already be required by State or local rules or may otherwise be in use on irrigated fields. Since many irrigators may already be using systems that satisfy or partly satisfy the intent of the management measure, the only action that may be necessary will be to determine the effectiveness of the existing practices and add additional practices, if needed.

4. Effectiveness Information

Following is information on pollution reductions that can be expected from installation of the management practices outlined within this management measure.

In a review of a wide range of agricultural control practices, EPA (1982) determined that increased use of call periods, on-demand water ordering, irrigation scheduling, and flow measurement and control would all result in decreased losses of salts, sediment, and nutrients (Table 2-28). Various alterations to existing furrow irrigation systems were also determined to be beneficial to water quality, as were tailwater management and seepage control.

Logan (1990) reported that chemical backsiphon devices are highly effective at preventing the introduction of pesticides and nitrogen to ground water. The American Society of Agricultural Engineers (ASAE) specifies safety devices for chemigation that will prevent the pollution of a water supply used solely for irrigation (ASAE, 1989).

Properly designed sprinkler irrigation systems will have little runoff (Boyle Engineering Corp., 1986). Furrow irrigation and border check or border strip irrigation systems typically produce tailwater, and tailwater recovery systems may be needed to manage tailwater losses (Boyle Engineering Corp., 1986). Tailwater can be managed by applying the water to additional fields, by treating and releasing the tailwater, or by reapplying the tailwater to upslope cropland.

The Rock Creek Rural Clean Water Program (RCWP) project in Idaho is the source of much information regarding the benefits of irrigation water management (USDA, 1991). All crops in the Rock Creek watershed are irrigated with water diverted from the Snake River and delivered through a network of canals and laterals. The combined implementation of irrigation management practices, sediment control practices, and conservation tillage has resulted in measured reductions in suspended sediment loadings ranging from 61 percent to 95 percent at six stations in Rock Creek (1981-1988). Similarly, 8 of 10 sub-basins showed reductions in suspended sediment loadings over the same time period. The sediment removal efficiencies of selected practices used in the project are given in Table 2-29.

In California it is expected that drip irrigation will have the greatest irrigation efficiency of those irrigation systems evaluated, whereas conventional furrow irrigation will have the lowest irrigation efficiency and greatest runoff fraction (Table 2-30). Tailwater recovery irrigation systems are expected to have the greatest percolation rate. Plot studies in California have shown that in-season irrigation efficiencies for drip irrigation and Low Energy Precision Application (LEPA) are greater than those for improved furrow and conventional furrow systems (Table 2-31). LEPA is a linear move sprinkler system in which the sprinkler heads have been removed and replaced with tubes that supply water to individual furrows (Univ. Calif., 1988). Dikes are placed in the furrows to prevent water flow and reduce soil effects on infiltrated water uniformity.

Mielke et al. (1981) studied the effects of tillage practice and type of center pivot irrigation on herbicide (atrazine and alachlor) losses in runoff and sediment. Study results clearly show that, for each of three tillage practices studied, low-pressure spray nozzles result in much greater herbicide loss in runoff than either high-pressure or low-pressure impact heads.

5. Irrigation Water Management Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully apply to achieve the management measure described above.

Table 2-28. Summary of Pollutant Impacts of Selected Irrigation Practices[a] (USEPA, 1982)

Practice	Description	T-P[b]	NA-P[c]	T-N[d]	NA-N[e]	A-Pes[f]	NA-Pes[g]	Salts[h]	Sed[i]
Call Period	A minimum length of time allowed to place an order.	–	–	–	–	–	–	–	–
On-Demand Water Ordering	Maximizes scheduling flexibility; however, this encourages less planning.	–/0	–/0	–/0	–/0	–/0	–/0	–/0	–/0
Irrigation Scheduling	Uses meteorological information with soil moisture levels to forecast future irrigations.		–	–	–	–	–	–	–
Conveyance Channel Improvements and Maintenance	Keep canals free of silt deposits and vegetation to maintain capacity. Repair damaged canal banks.	–	–	–	–	–	–	–	–
Improved Management of System Storage	System water storage provides flexibility and efficiency, but it should be minimized to reduce seepage and evaporation.	–	–	–	–	–	–	–	–
Improved Management of Return Flows	Canals should not be operated at capacity at all times with unneeded water spilled into return flows.				–			–	
Seepage Control	Lining canals, ditches, laterals, and watercourses that have high seepage losses with some impermeable material.				–			–	
Flow Measurement and Control	Measure and control flow to ensure adequate application of water while preventing unnecessary and wasteful diversions. To control the flow of water in canals and ditches, structures such as checks, drops, culverts, and field inlet devices are used. Notched weirs or small fiberglass flumes are used to measure the flow of water.	–	–	–	–	–	–	–	–
Cutback Irrigation	Flow volume is adjusted by using a head ditch or delivery pipe, which is adjusted so that a flow is quickly introduced to the end of the furrow and then "cut back" to a "soaking" flow rate. Increases uniformity of application and reduces tailwater, but is only applicable if there is sufficient cross slope.	–	–	–	–	–	–	–	–
Gated Pipe System	Combines features of improved furrow and cutback systems, and can be automatically controlled and coupled with on-demand water availability.	–	–	–	–	–	–	–	–

Table 2-28. (continued)

Practice	Description	T-P[b]	NA-P[c]	T-N[d]	NA-N[e]	A-Pes[f]	NA-Pes[g]	Salts[h]	Sed[i]
Multi-set Irrigation System	Combines features of improved furrow with a shorter length of run by using lateral supply pipes across each field.	–	–	–	–	–	–	–	–
Tailwater Reuse System/Subsurface Drainage	Tile drainage allows collection of surface flows into a water drainage system for control.	–	–	–	–	–	–	–	–
Sprinkler Irrigation	This system includes side-roll, center-pivot, tow-line, and solid-set sprinklers. Sprinkler systems are more efficient than surface irrigation.	–	–	–	–	–	–	–	–
Trickle Irrigation	Water is delivered to individual plants through lines or emitters in order to provide crop plants with nearly optimal soil moisture.	–	–	–	–	–	–	–	–

[a] + = increases in application of control will increase pollutant losses; – = increases in application of control will decrease pollutant losses; 0 = no appreciable effect. Blanks indicate no information presented.
[b] Absorbed phosphorus (total and labile).
[c] Nonabsorbed phosphorus (soluble forms).
[d] Absorbed nitrogen (total N and ammonium).
[e] Nonabsorbed nitrogen (nitrate).
[f] Absorbed pesticide.
[g] Nonabsorbed pesticide.
[h] Salts.
[i] Sediment.

Table 2-29. Sediment Removal Efficiencies and Comments on BMPs Evaluated (USDA, 1991)

Practice	Sediment Removal Efficiency (%)		Comment
	Average	Range	
Sediment basins: field, farm, subbasin	87	75-95	Cleaning costly.
Mini-basins	86[a]	0-95	Controlled outlets essential. Many failed. Careful management required.
Buried pipe systems (incorporating mini-basins with individual outlets into a buried drain)	83	75-95	High installation cost. Potential for increased production to offset costs. Eliminates tailwater ditch. Good control of tailwater.
Vegetative filters	50[a]	35-70	Simple. Proper installation and management needed.
Placing straw in furrows	50	40-80	Labor-intensive without special equipment. Careful management required.

[a] Mean of those that did not fail.

Table 2-30. Expected Irrigation Efficiencies of Selected Irrigation Systems in California (California SWRCB, 1987)

Irrigation System	Irrigation Efficiency (%)	Percolation Fraction (%)	Runoff Fraction (%)
Conventional Furrow	60	17.5	22.5
Gated Pipe	67.5	14.2	18.3
Shorter Run	70	13.3	16.7
Tail Water Recovery	73.2	21.3	5.5
Hand Move Sprinkler	80	8.75	11.3
Lateral Move Sprinkler	87.5	5.5	7.0
Drip	95	4.0	1.0

Table 2-31. Irrigation Efficiencies of Selected Irrigation Systems for Cotton (California SWRCB, 1991)

System	Year	Seasonal Irrigation (in.)	In-Season Distribution Uniformity (%)	In-Season Irrigation Efficiency (%)	In-Season Deep Percolation (in.)
Drip Irrigation	1989	17.82	87	99	2.43
	1990	19.24	81	82	3.98
LEPA (Low Energy Precision Application)	1989	14.21	92	97	2.88
	1990	23.19	92	78.6	6.13
Improved Furrow	1989	20.89	57.5	36	18.9
	1990	16.35	86.5	75.3	6.15
Conventional Furrow	1989	21.26	59.3	36	19.4
	1990	20.00	74	74	9.85

The U.S. Soil Conservation Service practice number and definition are provided for each management practice, where available. Also included in italics are SCS statements describing the effect each practice has on water quality (USDA-SCS, 1988).

Irrigation Scheduling Practices

Proper irrigation scheduling is a key element in irrigation water management. Irrigation scheduling should be based on knowing the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil, and measuring the amount of water applied to the field. Also, natural precipitation should be considered and adjustments made in the scheduled irrigations.

Practices that may be used to accomplish proper irrigation scheduling are:

a. *Irrigation water management (449): Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner.*

Management of the irrigation system should provide the control needed to minimize losses of water, and yields of sediment and sediment attached and dissolved substances, such as plant nutrients and herbicides, from the system. Poor management may allow the loss of dissolved substances from the irrigation system to surface or ground water. Good management may reduce saline percolation from geologic origins. Returns to the surface water system would increase downstream water temperature.

The purpose is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response, to minimize soil erosion and loss of plant nutrients, to control undesirable water loss, and to protect water quality.

To achieve this purpose the irrigator must have knowledge of (1) how to determine when irrigation water should be applied, based on the rate of water used by crops and on the stages of plant growth; (2) how to measure or estimate the amount of water required for each irrigation, including the leaching needs; (3) the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rate; (4) how to adjust water stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of irrigation runoff from an area; (5) how to recognize erosion caused by irrigation; (6) how to estimate the amount of irrigation runoff from an area; and (7) how to evaluate the uniformity of water application.

Tools to assist in achieving proper irrigation scheduling:

b. Water-measuring device: An irrigation water meter, flume, weir, or other water-measuring device installed in a pipeline or ditch.

The measuring device must be installed between the point of diversion and water distribution system used on the field. The device should provide a means to measure the rate of flow. Total water volume used may then be calculated using rate of flow and time, or read directly, if a totalizing meter is used.

The purpose is to provide the irrigator the rate of flow and/or application of water, and the total amount of water applied to the field with each irrigation.

c. Soil and crop water use data: From soils information the available water-holding capacity of the soil can be determined along with the amount of water that the plant can extract from the soil before additional irrigation is needed.

Water use information for various crops can be obtained from various USDA publications.

The purpose is to allow the water user to estimate the amount of available water remaining in the root zone at any time, thereby indicating when the next irrigation should be scheduled and the amount of water needed. Methods to measure or estimate the soil moisture should be employed, especially for high-value crops or where the water-holding capacity of the soil is low.

Practices for Efficient Irrigation Water Application

Irrigation water should be applied in a manner that ensures efficient use and distribution, minimizes runoff or deep percolation, and eliminates soil erosion.

The method of irrigation employed will vary with the type of crop grown, the topography, and soils. There are several systems that, when properly designed and operated, can be used as follows:

d. Irrigation system, drip or trickle (441): A planned irrigation system in which all necessary facilities are installed for efficiently applying water directly to the root zone of plants by means of applicators *(orifices, emitters, porous tubing, or perforated pipe) operated under low pressure (Figure 2-20). The applicators can be placed on or below the surface of the ground (Figure 2-21).*

Surface water quality may not be significantly affected by transported substances because runoff is largely controlled by the system components (practices). Chemical applications may be applied through the system. Reduction of runoff will result in less sediment and chemical losses from the field during irrigation. If excessive, local, deep percolation should occur, a chemical hazard may exist to shallow ground water or to areas where geologic materials provide easy access to the aquifer.

e. *Irrigation system, sprinkler (442): A planned irrigation system in which all necessary facilities are installed for efficiently applying water by means of perforated pipes or nozzles operated under pressure.*

Proper irrigation management controls runoff and prevents downstream surface water deterioration from sediment and sediment attached substances. Over irrigation through poor management can produce impaired water quality in runoff as well as ground water through increased percolation. Chemigation with this system allows the operator the opportunity to mange nutrients, wastewater and pesticides. For example, nutrients applied in several incremental applications based on the plant needs may reduce ground water contamination considerably, compared to one application during planting. Poor management may cause pollution of surface and ground water. Pesticide drift from chemigation may also be hazardous to vegetation, animals, and surface water resources. Appropriate safety equipment, operation and maintenance of the system is needed with chemigation to prevent accidental environmental pollution or backflows to water sources.

f. *Irrigation system, surface and subsurface (443): A planned irrigation system in which all necessary water control structures have been installed for efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.*

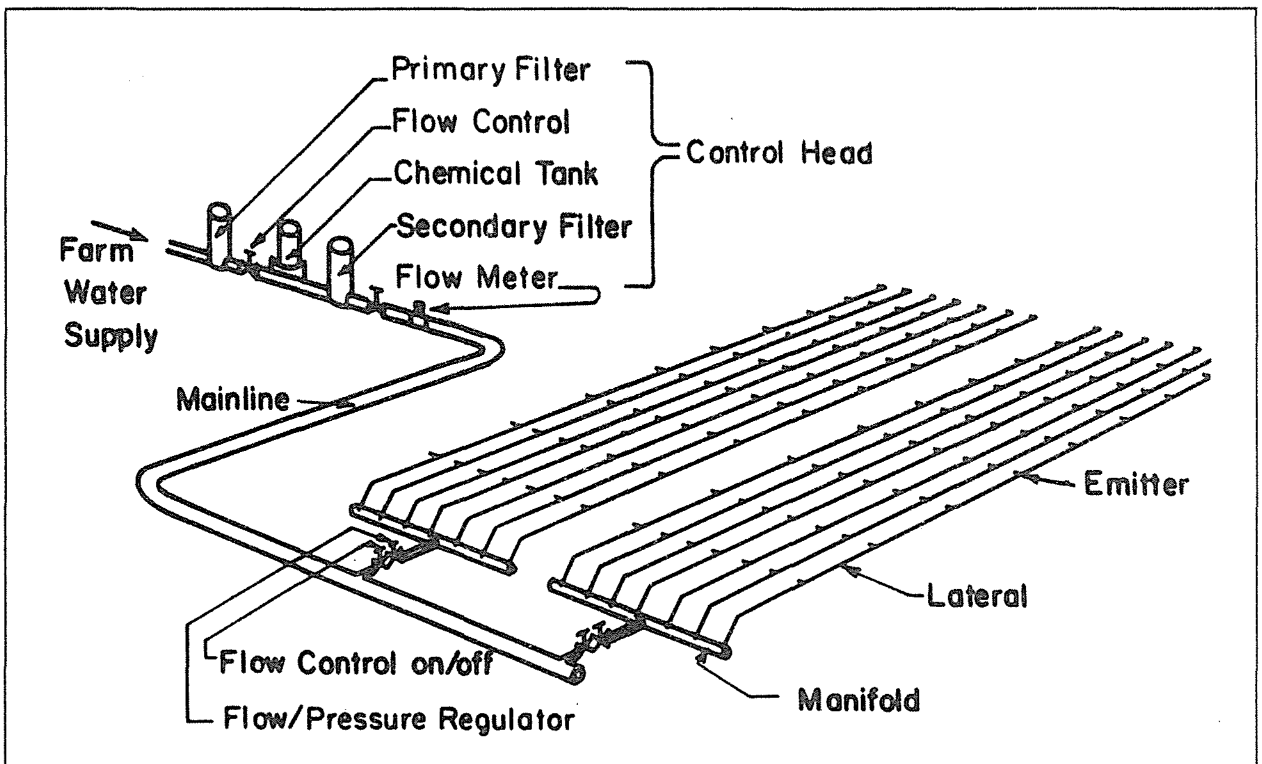

Figure 2-20. Basic components of a trickle irrigation system (USDA-SCS, 1984).

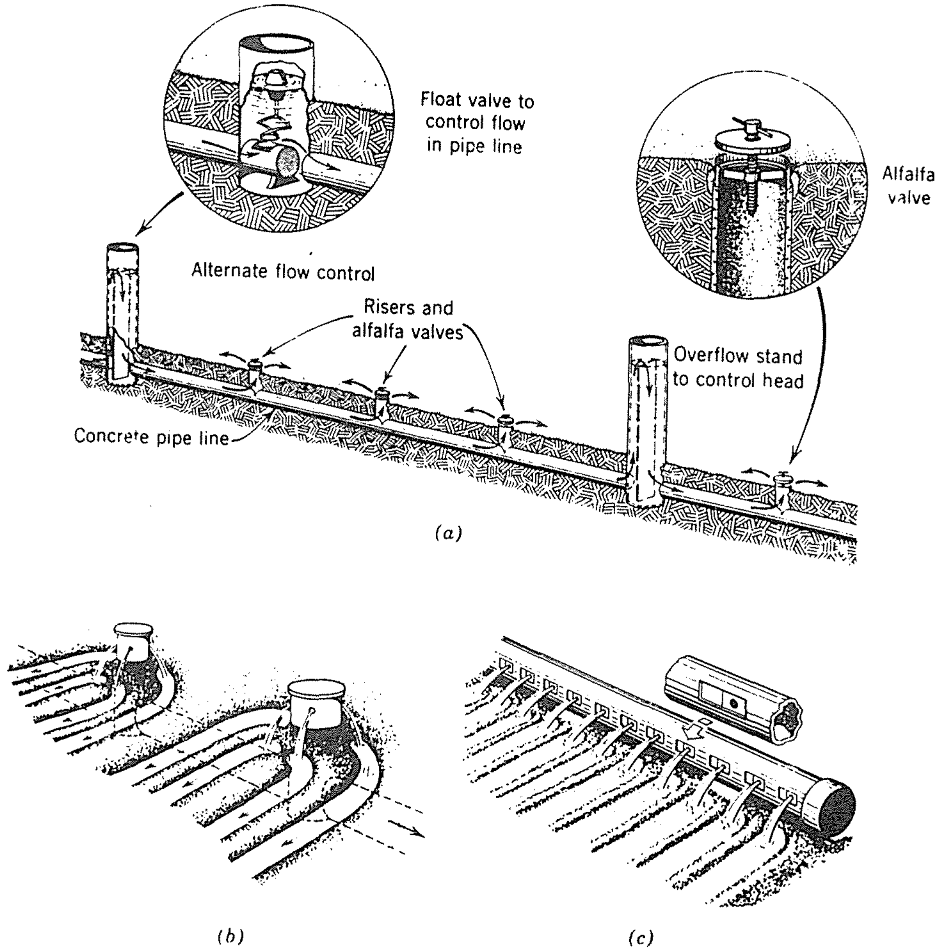

Figure 2-21. Methods of distribution of irrigation water from (a) low-pressure underground pipe, (b) multiple-outlet risers, and (c) portable gated pipe (Schwab et al., 1981).

Operation and management of the irrigation system in a manner which allows little or no runoff may allow small yields of sediment or sediment-attached substances to downstream waters. Pollutants may increase if irrigation water management is not adequate. Ground water quality from mobile, dissolved chemicals may also be a hazard if irrigation water management does not prevent deep percolation. Subsurface irrigation that requires the drainage and removal of excess water from the field may discharge increased amounts of dissolved substances such as nutrients or other salts to surface water. Temperatures of downstream water courses that receive runoff waters may be increased. Temperatures of downstream waters might be decreased with subsurface systems when excess water is being pumped from the field to lower the water table. Downstream temperatures should not be affected by subsurface irrigation during summer months if lowering the water table is not required. Improved aquatic habitat may occur if runoff or seepage occurs from surface systems or from pumping to lower the water table in subsurface systems.

g. Irrigation field ditch (388): A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields in a farm distribution system.

The standard for this practice applies to open channels and elevated ditches of 25 ft^3/second or less capacity formed in and with earth materials.

Irrigation field ditches typically carry irrigation water from the source of supplying to a field or fields. Salinity changes may occur in both the soil and water. This will depend on the irrigation water quality, the level of water management, and the geologic materials of the area. The quality of ground and surface water may be altered depending on environmental conditions. Water lost from the irrigation system to downstream runoff may contain dissolved substances, sediment, and sediment-attached substances that may degrade water quality and increase water temperature. This practice may make water available for wildlife, but may not significantly increase habitat.

■ h. *Irrigation land leveling (464): Reshaping the surface of land to be irrigated to planned grades.*

The effects of this practice depend on the level of irrigation water management. If plant root zone soil water is properly managed, then quality decreases of surface and ground water may be avoided. Under poor management, ground and surface water quality may deteriorate. Deep percolation and recharge with poor quality water may lower aquifer quality. Land leveling may minimize erosion and when runoff occurs concurrent sediment yield reduction. Poor management may cause an increase in salinity of soil, ground and surface waters. High efficiency surface irrigation is more probable when earth moving elevations are laser controlled.

Practices for Efficient Irrigation Water Transport

Irrigation water transportation systems that move water from the source of supply to the irrigation system should be designed and managed in a manner that minimizes evaporation, seepage, and flow-through water losses from canals and ditches. Delivery and timing need to be flexible enough to meet varying plant water needs throughout the growing season.

Transporting irrigation water from the source of supply to the field irrigation system can be a significant source of water loss and cause of degradation of both surface water and ground water. Losses during transmission include seepage from canals and ditches, evaporation from canals and ditches, and flow-through water.[9] The primary water quality concern is the development of saline seeps below the canals and ditches and the discharge of saline waters. Another water quality concern is the potential for erosion caused by the discharge of flow-through water. Practices that are used to ensure proper transportation of irrigation water from the source of supply to the field irrigation system *can be found in the USDA-SCS Handbook of Practices, and include: irrigation water conveyance, ditch and canal lining (428); irrigation water conveyance, pipeline (430); and structure for water control (587).*

Practices for Utilization of Runoff Water or Tailwater

The utilization of runoff water to provide additional irrigation or to reduce the amount of water diverted increases the efficiency of use of irrigation water. For surface irrigation systems that require runoff or tailwater as part of the design and operation, a tailwater management practice needs to be installed and used. The practice is described as follows:

■ i. *Irrigation system, tailwater recovery (447): A facility to collect, store, and transport irrigation tailwater for reuse in the farm irrigation distribution system.*

The reservoir will trap sediment and sediment attached substances from runoff waters. Sediment and chemicals will accumulate in the collection facility by entrapping which would decrease downstream yields of these substances.

[9] Flow-through water is water that is never applied to the land but is needed to maintain hydraulic head in the ditch. Flow-through water is also water transported in excess of delivery requirements, carried to reduce the level of management necessary to adjust flows in the ditch for changed delivery locations and amounts. Typically this water (10 - 35 percent of delivery requirements) is applied to fields as excess flow above the requested or billed amount, or returned to the supply stream as delivery system tailwater. Often credit is given by the regulatory agency for this returned water.

Salts, soluble nutrients, and soluble pesticides will be collected with the runoff and will not be released to surface waters. Recovered irrigation water with high salt and/or metal content will ultimately have to be disposed of in an environmentally safe manner and location. Disposal of these waters should be part of the overall management plan. Although some ground water recharge may occur, little if any pollution hazard is usually expected.

Practices for Drainage Water Management

Drainage water from an irrigation system should be managed to reduce deep percolation, move tailwater to the reuse system, reduce erosion, and help control adverse impacts on surface water and groundwater. A total drainage system should be an integral part of the planning and design of an efficient irrigation system. This may not be necessary for those soils that have sufficient natural drainage abilities.

There are several practices to accomplish this:

■ j. *Filter strip (393): A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and waste water.*

Filter strips for sediment and related pollutants meeting minimum requirements may trap the coarser grained sediment. They may not filter out soluble or suspended fine-grained materials. When a storm causes runoff in excess of the design runoff, the filter may be flooded and may cause large loads of pollutants to be released to the surface water. This type of filter requires high maintenance and has a relative short service life and is effective only as long as the flow through the filter is shallow sheet flow.

Filter strips for runoff form concentrated livestock areas may trap organic material, solids, materials which become adsorbed to the vegetation or the soil within the filter. Often they will not filter out soluble materials. This type of filter is often wet and is difficult to maintain.

Filter strips for controlled overland flow treatment of liquid wastes may effectively filter out pollutants. The filter must be properly managed and maintained, including the proper resting time. Filter strips on forest land may trap coarse sediment, timbering debris, and other deleterious material being transported by runoff. This may improve the quality of surface water and has little effect on soluble material in runoff or on the quality of ground water.

All types of filters may reduce erosion on the area on which they are constructed. Filter strips trap solids from the runoff flowing in sheet flow through the filter. Coarse-grained and fibrous materials are filtered more efficiently than fine-grained and soluble substances. Filter strips work for design conditions, but when flooded or overloaded they may release a slug load of pollutants into the surface water.

■ k. *Surface drainage field ditch (607): A graded ditch for collecting excess water in a field.*

From erosive fields, this practice may increase the yields of sediment and sediment-attached substances to downstream water courses because of an increase in runoff. In other fields, the location of the ditches may cause a reduction in sheet and rill erosion and ephemeral gully erosion. Drainage of high salinity areas may raise salinity levels temporarily in receiving waters. Areas of soils with high salinity that are drained by the ditches may increase receiving waters. Phosphorus loads, resulting from this practice may increase eutrophication problems in ponded receiving waters. Water temperature changes will probably not be significant. Upland wildlife habitat may be improved or increased although the habitat formed by standing water and wet areas may be decreased.

■ l. *Subsurface drain (606): A conduit, such as corrugated plastic tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.*

Soil water outletted to surface water courses by this practice may be low in concentrations of sediment and sediment-adsorbed substances and that may improve stream water quality. Sometimes the drained soil water is high in the *concentration of nitrates and other dissolved substances and drinking water standards may be exceeded. If drainage water that is high in dissolved substances is able to recharge ground water, the aquifer quality may become impaired. Stream water temperatures may be reduced by water drainage discharge. Aquatic habitat may be altered or enhanced with the increased cooler water temperatures.*

m. Water table control (641): Water table control through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water.

The water table control practice reduces runoff, therefore downstream sediment and sediment-attached substances yields will be reduced. When drainage is increased, the dissolved substances in the soil water will be discharged to receiving water and the quality of water reduced. Maintaining a high water table, especially during the nongrowing season, will allow denitrification to occur and reduce the nitrate content of surface and ground by as much as 75 percent. The use of this practice for salinity control can increase the dissolved substance loading of downstream waters while decreasing the salinity of the soil. Installation of this practice may create temporary erosion and sediment yield hazards but the completed practice will lower erosion and sedimentation levels. The effect of the water table control of this practice on downstream wildlife communities may vary with the purpose and management of the water in the system.

n. Controlled drainage (335): Control of surface and subsurface water through use of drainage facilities and water control structures.

The purpose is to conserve water and maintain optimum soil moisture to (1) store and manage infiltrated rainfall for more efficient crop production; (2) improve surface water quality by increasing infiltration, thereby reducing runoff, which may carry sediment and undesirable chemicals; (3) reduce nitrates in the drainage water by enhancing conditions for denitrification; (4) reduce subsidence and wind erosion of organic soils; (5) hold water in channels in forest areas to act as ground fire breaks; and (6) provide water for wildlife and a resting and feeding place for waterfowl.

Practices for Backflow Prevention

o. The American Society of Agricultural Engineers recommends, in standard EP409, safety devices to prevent backflow when injecting liquid chemicals into irrigation systems (ASAE Standards, 1989).

The process of supplying fertilizers, herbicides, insecticides, fungicides, nematicides, and other chemicals through irrigation systems is known as chemigation. A backflow prevention system will "prevent chemical backflow to the water source" in cases when the irrigation pump shuts down (ASAE, 1989).

Three factors an operator must take into account when selecting a backflow prevention system are the characteristics of the chemical that can backflow, the water source, and the geometry of the irrigation system. Areas of concern include whether injected material is toxic and whether there can be backpressure or backsiphonage (ASAE, 1989; USEPA, 1989b).

Several different systems used as backflow preventers are:

(1) **Air gap.** A physical separation in the pipeline resulting in a loss of water pressure. Effective at end of line service where reservoirs or storage tanks are desired.

(2) **Check valve with vacuum relief and low pressure drain.** Primarily used as an antisiphon device (Figure 2-22).

(3) **Double check valve.** Consists of two single check valves coupled within one body and can handle both backsiphonage and backpressure.

(4) **Reduced pressure principle backflow preventer.** This device can be used for both backsiphonage and backpressure. It consists of a pressure differential relief valve located between two independently acting check valves.

(5) **Atmospheric vacuum breaker.** Used mainly in lawn and turf irrigation systems that are connected to potable water supplies. This system cannot be installed where backpressure persists and can be used only to prevent backsiphonage.

6. Cost Information

A cost of $10 per irrigated acre is estimated to cover investments in flow meters, tensiometers, and soil moisture probes (USEPA, 1992; Evans, 1992). Information from North Carolina indicates that the cost of devices to measure soil water ranges from $3 to $4,500 (Table 2-32). Gypsum blocks and tensiometers are the two most commonly used devices.

For quarter-section center pivot systems, backflow prevention devices cost about $416 per well (Stolzenburg, 1992). This cost (1992 dollars) is for (1) an 8-inch, 2-foot-long unit with a check valve inside ($386) and (2) a one-way injection point valve ($30). Assuming that each well will provide about 800-1,000 gallons per minute, approximately 130 acres will be served by each well. The cost for backflow prevention for center pivot systems then becomes approximately $3.20 per acre. In South Dakota, the cost for an 8-inch standard check valve is about $300, while an 8-inch check valve with inspection points and vacuum release costs about $800 (Goodman, 1992). The latter are required by State law. For quarter-section center pivot systems, the cost for standard check valves ranges from about $1.88 per acre (corners irrigated, covering 160 acres) to $2.31 per acre (circular pattern, covering about 130 acres).

Tailwater can be prevented in sprinkler irrigation systems through effective irrigation scheduling, but may need to be managed in furrow systems. The reuse of tailwater downslope on adjacent fields is a low-cost alternative to tailwater recovery and upslope reuse (Boyle Engineering Corp., 1986). Tailwater recovery systems require a suitable

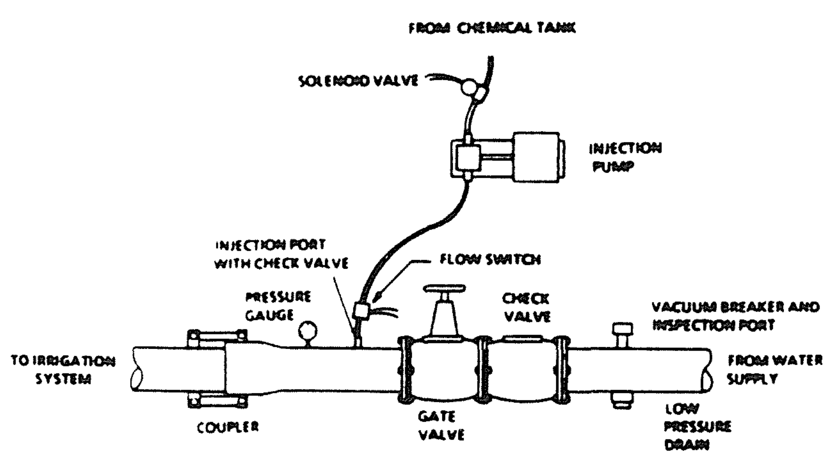

Figure 2-22. Backflow prevention device using check valve with vacuum relief and low pressure drain (ASAE, 1989).

Table 2-32. Cost of Soil Water Measuring Devices

Device	Approximate Cost
Flow meters[a]	$35 to $300, depending on size
Tensiometers[a]	$35 and up, depending on size
Gypsum blocks[a]	$3-4, $200-400 for meter
Neutron Probe[a]	$4,000-4,500
Phene Cell[a]	$4,000-4,500
Flow meters, tensiometers, and soil moisture probes[b]	$10 per irrigated acre

[a] Sneed, 1992.
[b] Evans, 1992.

drainage water receiving facility such as a sump or a holding pond, and a pump and pipelines to return the tailwater for reapplication (Boyle Engineering Corp., 1986). The cost to install a tailwater recovery system was about $125/acre in California (California State Water Resources Control Board, 1987) and $97.00/acre in the Long Pine Creek, Nebraska, RCWP (Hermsmeyer, 1991).

The cost to install irrigation water conservation systems (ASCS practice WC4) for the primary purpose of water conservation in the 33 States that used the practice was about $86.00 per acre served in 1991 (USDA-ASCS, 1992b). Practice WC4 increased the average irrigation system efficiency from 48 percent to 64 percent at an amortized cost of $9.47 per acre foot of water conserved. The components of practice WC4 are critical area planting, canal or lateral, structure for water control, field ditch, sediment basin, grassed waterway or outlet, land leveling, water conveyance ditch and canal lining, water conveyance pipeline, trickle (drip) system, sprinkler system, surface and subsurface system, tailwater recovery, land smoothing, pit or regulation reservoir, subsurface drainage for salinity, and toxic salt reduction. When installed for the primary purpose of water quality, the average installation cost for WC4 was about $52 per acre served. For erosion control, practice WC4 averaged approximately $57 per acre served. Specific cost data for each component of WC4 are not available.

Water management systems for pollution control, practice SP35, cost about $26 per acre served when installed for the primary purpose of water quality (USDA-ASCS, 1992b). When installed for erosion control, SP35 costs about $19 per acre served. The components of SP35 are grass and legumes in rotation, underground outlets, land smoothing, structures for water control, subsurface drains, field ditches, mains or laterals, and toxic salt reduction.

The design lifetimes for a range of salt load reduction measures are presented in Table 2-33 (USDA-ASCS, 1988).

Table 2-33. Design Lifetime for Selected Salt Load Reduction Measures (USDA-ASCS, 1988)

Practice/Structure	Design Life (years)
Irrigation Land Leveling	10
Irrigation Pipelines - Aluminum Pipe	20
Irrigation Pipelines - Rigid Gated Pipe	15
Irrigation Canal and Ditch Lining	20
Irrigation Field Ditches	1
Water Control Structure	20
Trickle Irrigation System	10
Sprinkler Irrigation System	15
Surface Irrigation System	15
Irrigation Pit or Regulation Reservoir	20
Subsurface Drain	20
Toxic Salt Reduction	1
Irrigation Tailwater Recovery System	20
Irrigation Water Management	1
Underground Outlet	20
Pump Plant for Water Control	15

III. GLOSSARY

10-year, 24-hour storm: A rainfall event of 24-hour duration and 10-year frequency that is used to calculate the runoff volume and peak discharge rate to a BMP.

25-year, 24-hour storm: A rainfall event of 24-hour duration and 25-year frequency that is used to calculate the runoff volume and peak discharge rate to a BMP.

Acceptable Management System (AMS): A combination of conservation practices and management that meets resource quality criteria established in the FOTG by the State Conservationist that is feasible within the social, cultural, or economic constraints identified for the resource conditions. It is expected that some degradation may continue to occur for the resource after the AMS is applied (Part 506, Glossary, SCS General Manual).

Adsorption: The adhesion of one substance to the surface of another.

Agronomic practices: Soil and crop activities employed in the production of farm crops, such as selecting seed, seedbed preparation, fertilizing, liming, manuring, seeding, cultivation, harvesting, curing, crop sequence, crop rotations, cover crops, strip-cropping, pasture development, and others (Soil Conservation Society of America, 1982).

Aquifer: A geologic formation or structure that transmits water in sufficient quantity to supply the needs for a water development; usually saturated sands, gravel, fractures, and cavernous and vesicular rock (Soil Conservation Society of America, 1982).

ASCS: Agricultural Stabilization and Conservation Service of USDA.

Animal unit: A unit of measurement for any animal feeding operation calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 25 kilograms (approximately 55 pounds) multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0 (40 CFR Part 122, Appendix B).

AUM: Animal unit month. A measure of average monthly stocking rate that is the tenure of one animal unit for a period of 1 month. With respect to the literature reviewed for the grazing management measure, an animal unit is a mature, 1,000-pound cow or the equivalent based on average daily forage consumption of 26 pounds of dry matter per day (Platts, 1990). Alternatively, an AUM is the amount of forage that is required to maintain a mature, 1,000-pound cow or the equivalent for a one-month period. See *animal unit* for the NPDES definition.

Backflow prevention device: A safety device used to prevent water pollution or contamination by preventing flow of water and/or chemicals in the opposite direction of that intended (ASAE, 1989).

Best Management Practice (BMP): A practice or combination of practices that are determined to be the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals (Soil Conservation Society of America, 1982).

Broiler: Bird that is raised for its meat production; usually produced in a 7-week period.

Center pivot: Automated sprinkler irrigation achieved by automatically rotating the sprinkler pipe or boom, supplying water to the sprinkler head or nozzle, as a radius from the center of the field to be irrigated (Soil Conservation Society of America, 1982).

Chemigation: The addition of one or more chemicals to the irrigation water.

Chemigated water: Water to which fertilizers or pesticides have been added.

Check valve: A device to provide positive closure that effectively prohibits the flow of material in the opposite direction of normal flow when operation of the irrigation system pumping plant or injection unit fails or is shut down (ASAE, 1989).

Composting: A controlled process of degrading organic matter by microorganisms (Soil Conservation Society of America, 1982).

Conservation management system (CMS): A generic term that includes any combination of conservation practices and management that achieves a level of treatment of the five natural resources that satisfies criteria contained in the Field Office Training Guide (FOTG), such as a resource management system or an acceptable management system (Part 506, Glossary, SCS General Manual).

Cover crop: A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production or between trees and vines in orchards and vineyards (Soil Conservation Society of America, 1982).

Crop residue: The portion of a plant or crop left in the field after harvest (Soil Conservation Society of America, 1982).

Crop rotation: The growing of different crops in recurring succession on the same land (Soil Conservation Society of America, 1982).

Defoliant: A herbicide that removes leaves from trees and growing plants (USEPA, 1989a).

Denitrification: The chemical or biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen (Soil Conservation Society of America, 1982).

Deposition: The accumulation of material dropped because of a slackening movement of the transporting material—water or wind (Soil Conservation Society of America, 1982).

Desiccant: A chemical agent used to remove moisture from a material or object (Soil Conservation Society of America, 1982).

Dike: An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee (Soil Conservation Society of America, 1982).

Diversion: A channel, embankment, or other man-made structure constructed to divert water from one area to another (Soil Conservation Society of America, 1982).

Effluent: Solid, liquid, or gaseous wastes that enter the environment as a by-product of man-oriented processes (Soil Conservation Society of America, 1982).

Empirical: Originating in or relying or based on factual information, observation, or direct sense experience.

EPA: United States Environmental Protection Agency.

Erosion: Wearing away of the land surface by running water, glaciers, winds, and waves. The term erosion is usually preceded by a definitive term denoting the type or source of erosion such as gully erosion, sheet erosion, or bank erosion (Brakensiek et al., 1979).

ES: Extension Service of USDA.

Evaporation: The process by which a liquid is changed to a vapor or gas (Soil Conservation Society of America, 1982).

Fallow: Allowing cropland to lie idle, either tilled or untilled, during the whole or greater portion of the growing season (Soil Conservation Society of America, 1982).

Fertilizer: Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth (Soil Conservation Society of America, 1982).

Field capacity: The soil-water content after the force of gravity has drained or removed all the water it can, usually 1 to 3 days after rainfall (Evans et al., 1991c).

Flume: An open conduit on a prepared grade, trestle, or bridge for the purpose of carrying water across creeks, gullies, ravines, or other obstructions; also used in reference to calibrated devices used to measure the flow of water in open conduits (Soil Conservation Society of America, 1982).

Forb: A broad-leaf herbaceous plant that is not a grass, sedge, or rush.

FOTG: USDA-SCS's Field Office Technical Guide.

Grade: (1) The slope of a road, channel, or natural ground. (2) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation (Soil Conservation Society of America).

Grazing unit: An area of public or private pasture, range, grazed woodland, or other land that is grazed as an entity.

Herbaceous: A vascular plant that does not develop woody tissue (Soil Conservation Society of America, 1982).

Herbicide: A chemical substance designed to kill or inhibit the growth of plants, especially weeds (Soil Conservation Society of America, 1982).

Herding: The guiding of a livestock herd to desired areas or density of distribution.

Holding pond: A reservoir, pit, or pond, usually made of earth, used to retain polluted runoff water for disposal on land (Soil Conservation Society of America, 1982).

Hybrid: A plant resulting from a cross between parents of different species, subspecies, or cultivar (Soil Conservation Society of America, 1982).

Hydrophyte: A plant that grows in water or in wet or saturated soils (Soil Conservation Society of America, 1982).

Incineration: The controlled process by which solids, liquid, or gaseous combustible wastes are burned and changed into gases; the residue produced contains little or no combustible material (Soil Conservation Society of America, 1982).

Inert: A substance that does not react with other substances under ordinary conditions.

Infiltration: The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls (USEPA, 1989a).

Insecticide: A pesticide compound specifically used to kill or control the growth of insects (USEPA, 1989a).

Integrated Pest Management (IPM): A pest population management system that anticipates and prevents pests from reaching damaging levels by using all suitable tactics including natural enemies, pest-resistant plants, cultural management, and the judicious use of pesticides, leading to an economically sound and environmentally safe agriculture.

Irrigation: Application of water to lands for agricultural purposes (Soil Conservation Society of America, 1982).

Irrigation scheduling: The time and amount of irrigation water to be applied to an area.

Karst: A type of topography characterized by closed depressions, sinkholes, underground caverns, and solution channels. See *sinkhole* (Soil Conservation Society of America, 1982).

Lagoon: A reservoir or pond built to contain water and animal wastes until they can be decomposed either by aerobic or anaerobic action (Soil Conservation Society of America, 1982).

Lateral: Secondary or side channel, ditch, or conduit (Soil Conservation Society of America, 1982).

Layer: Bird that is used to produce eggs for broilers, new layers, or consumption.

Leachate: Liquids that have percolated through a soil and that contain substances in solution or suspension (Soil Conservation Society of America, 1982).

Leaching: The removal from the soil in solution of the more soluble materials by percolating waters (Soil Conservation Society of America, 1982).

Legume: A member of a large family that includes many valuable food and forage species, such as peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudzu (Soil Conservation Society of America, 1982).

Levee: See *dike*.

Limiting nutrient concept: The application of nutrient sources such that no nutrient (e.g., N, P, K) is applied at greater than the recommended rate.

Livestock: Domestic animals.

Load: The quantity (i.e., mass) of a material that enters a waterbody over a given time interval (Soil Conservation Society of America, 1982).

Manure: The fecal and urinary defecations of livestock and poultry; may include spilled feed, bedding litter, or soil (Soil Conservation Society of America, 1982).

Micronutrient: A chemical element necessary in only extremely small amounts (less than 1 part per million) for the growth of plants (Soil Conservation Society of America, 1982).

NOAA: United States Department of Commerce, National Oceanic and Atmospheric Administration.

Nutrients: Elements, or compounds, essential as raw materials for organism growth and development, such as carbon, nitrogen, phosphorus, etc. (Soil Conservation Society of America, 1982).

Parasites: An organism that lives on or in a host organism during all or part of its existence. Nourishment is obtained at the expense of the host (Soil Conservation Society of America, 1982).

Pasture: Grazing lands planted primarily to introduced or domesticated native forage species that receives periodic renovation and/or cultural treatments such as tillage, fertilization, mowing, weed control, and irrigation. Not in rotation with crops.

Percolation: The downward movement of water through the soil (Soil Conservation Society of America, 1982).

Perennial plant: A plant that has a life span of 3 or more years (Soil Conservation Society of America, 1982).

Permanent wilting point: The soil water content at which healthy plants can no longer extract water from the soil at a rate fast enough to recover from wilting. The permanent wilting point is considered the lower limit of plant-available water (Evans et al., 1991c).

Permeability: The quality of a soil horizon that enables water or air to move through it; may be limited by the presence of one nearly impermeable horizon even though the others are permeable (Soil Conservation Society of America, 1982).

Pesticide: Any chemical agent used for control of plant or animal pests. Pesticides include insecticides, herbicides, fungicides, nematocides, and rodenticides.

Pheromone: A substance secreted by an insect or an animal that influences the behavior or morphological development, or both, of other insects or animals of the same species (Soil Conservation Society of America, 1982).

Plant-available water: The amount of water held in the soil that is available to plants; the difference between field capacity and the permanent wilting point (Evans et al., 1991c).

Pollutant: Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (Section 502(6) of The Clean Water Act as amended by the Water Quality Act of 1987, Pub. L. 100-4).

Range: Land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs. Includes lands revegetated naturally or artificially when routine management of that vegetation is accomplished mainly through manipulation of grazing. Range includes natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, wet meadows, and riparian areas.

Reduced-till: A system in which the primary tillage operation is performed in conjunction with special planting procedures to reduce or eliminate secondary tillage operations (Soil Conservation Society of America, 1982).

Residue: See *crop residue.*

Resource Management System (RMS): A combination of conservation practices and management identified by land or water uses that, when installed, will prevent resource degradation and permit sustained use by meeting criteria established in the FOTG for treatment of soil, water, air, plant, and animal resources (Part 506, Glossary, SCS General Manual).

Return flow: That portion of the water diverted from a stream that finds its way back to the stream channel either as surface or underground flow (Soil Conservation Society of America, 1982).

Riparian area: Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody.

Root zone: The part of the soil that is, or can be, penetrated by plant roots (Soil Conservation Society of America, 1982).

Runoff: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters (USEPA, 1989a).

Salinity: The concentration of dissolved solids or salt in water (Soil Conservation Society of America, 1982).

Savannas: A grassland with scattered trees, either as individuals or clumps; often a transitional type between true grasslands and woodland.

SCS: Soil Conservation Service of USDA.

SCS Soils-5 Information: SCS Soil Interpretation Records data base, which contains a wide variety of soil characteristics and interpretations. Available through the Statistical Laboratory, Iowa State University, Ames, Iowa.

Sediment: The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice (USDA-SCS, 1991).

Sedimentation: The process or act of depositing sediment (Soil Conservation Society of America, 1982).

Seepage: Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring, where the water emerges from a localized spot (Soil Conservation Society of America, 1982).

Settleable solids: Solids in a liquid that can be removed by stilling a liquid. Settling times of 1 hour (APHA/AWWA/WPFC, 1975) or more are generally used (Soil Conservation Society of America, 1982).

Sheet flow: Water, usually storm runoff, flowing in a thin layer over the ground surface (Soil Conservation Society of America, 1982).

Silage: A fodder crop that has been preserved in a moist, succulent condition by partial fermentation; such crops include corn, sorghums, legumes, and grasses (Soil Conservation Society of America, 1982).

Sinkhole: A depression in the earth's surface caused by dissolving of underlying limestone, salt, or gypsum; drainage is through underground channels; may be enlarged by collapse of a cavern roof (Soil Conservation Society of America, 1982).

Slope: The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees (Soil Conservation Society of America, 1982).

Sludge: The material resulting from chemical treatment of water, coagulation, or sedimentation (Soil Conservation Society of America, 1982).

Soil profile: A vertical section of the soil from the surface through all its horizons, including C horizons (Soil Conservation Society of America, 1982).

Soil survey: A general term for the systematic examination of soils in the field and in laboratories; their description and classification; the mapping of kinds of soil; the interpretation of soils according to their adaptability for various crops, grasses, and trees; their behavior under use or treatment for plant production or for other purposes; and their productivity under different management systems (Soil Conservation Society of America, 1982).

Soil water depletion volume: The amount of plant-available water removed from the soil by plants and evaporation from the soil surface (Evans et al., 1991c).

Surface water: All water whose surface is exposed to the atmosphere (Soil Conservation Society of America, 1982).

Suspended sediment: The very fine soil particles that remain in suspension in water for a considerable period of time (Soil Conservation Society of America, 1982).

Tailwater: Irrigation water that reaches the lower end of a field (Soil Conservation Society of America, 1982).

Tillage: The operation of implements through the soil to prepare seedbeds and rootbeds, control weeds and brush, aerate the soil, and cause faster breakdown of organic matter and minerals to release plant foods (Soil Conservation Society of America, 1982).

Tilth: The physical condition of the soil as related to its ease of tillage, its fitness as a seedbed, and its impedance to seedling emergence and root penetration (Soil Conservation Society of America, 1982).

Topography: The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface (Soil Conservation Society of America, 1982).

USDA: United States Department of Agriculture.

Waste: Material that has no original value or no value for the ordinary or main purpose of manufacture or use; damaged or defective articles of manufacture; or superfluous or rejected matter or refuse (Soil Conservation Society of America, 1982).

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Water table: The upper surface of the ground water or that level below which the soil is saturated with water; locus of points in soil water at which the hydraulic pressure is equal to atmospheric pressure (Soil Conservation Society of America, 1982).

Weir: Device for measuring or regulating the flow of water (Soil Conservation Society of America, 1982).

IV. REFERENCES

Adam, Real, et al. 1986. *Evaluation of Beef Feedlot Runoff Treatment by a Vegetative Filter Strip*. ASAE North Atlantic Regional Meeting. Paper No. NAR 86-208.

USDA. 1990. Soil and Water Conservation Practices: Special ACP Water Quality Project, Sand Mountain/Lake Guntersville. In *USDA Technical Guide, Section V.* U.S. Department of Agriculture, Alabama Soil Conservation Service.

APHA, AWWA, and WPCF. 1975. *Standard Methods for the Examination of Water and Wastewater.* American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, DC, pp. 95-96.

ASAE. 1989. *Standards, Engineering Practices and Data Developed and Adopted by the American Society of Agricultural Engineers.* Standard EP409. American Society of Agricultural Engineers, St. Joseph, MI.

USDA, ASCS/SCS, Oregon Dept. of Environmental Quality, and Oregon State University. 1991. *Tillamook Bay Rural Clean Water Project, 10-year Progress Report.* U.S. Department of Agriculture; Agricultural Stabilization and Conservation Service, and Soil Conservation Service, Washington, DC.

Baker, J.L. 1988. Potential Water Quality and Production Efficiency Benefits from Reduced Herbicide Inputs through Banding. In *Integrated Farm Management Demonstration Program: 1988 progress report.* Iowa State University, Ames.

Barbarika, A. Jr. 1987. Costs of Soil Conservation Practices. In *Optimum Erosion Control at Least Cost: Proceedings of the National Symposium on Conservation Systems.* American Society of Agricultural Engineers St. Joseph, MI, pp. 187-195.

Berry, J.T., and N. Hargett. 1984. *Fertilizer Summary Data.* Tennessee Valley Authority, National Fertilizer Development Center, Mussel Shoals, AL.

Bouldin, D., W. Reid, and D. Lathwell. 1971. Fertilizer Practices Which Minimize Nutrient Loss. In *Proceedings of Cornell University Conference on Agricultural Waste ManagementAgricultural Wastes: Principles and Guidelines for Practical Solutions*, Syracuse, NY.

Boyle Engineering Corp. 1986. *Evaluation of On-Farm Management Alternatives.* Prepared for the San Joaquin Valley Drainage Program, Sacramento, CA.

Brakensiek, D.L., H.B. Osborn, and W.J. Rawls. 1979. *Field Manual for Research in Agricultural Hydrology.* Agriculture Handbook No. 224. U.S. Department of Agriculture, Science and Education Administration, Beltsville, MD.

California SWRCB 1987. *Regulation of Agricultural Drainage to the San Joaquin River: Executive Summary.* California State Water Resources Control Board. Doc. No. WQ-85-1.

California State Water Resources Control Board. 1991. *Demonstration of Emerging Technologies.* California State Water Resources Control Board. Doc. No. 91-20-WQ.

Camacho, R. 1991. *Financial Cost Effectiveness of Point and Nonpoint Source Nutrient Reduction Technologies in the Chesapeake Bay Basin.* Interstate Commission on the Potomac River Basin, Rockville, Maryland. Unpublished draft.

Cumberland County (Maine) Soil and Water Conservation District. undated. *Innovative Livestock Watering System and Improving Pasture Profits.*

Dickey, E.C. 1981. Performance and Design of Vegetative Filters for Feedlot Runoff Treatment. In *Proceedings of the Fourth International Symposium on Livestock Wastes, Livestock Waste: A Renewable Resource.*

DPRA. 1986. *An Evaluation of the Cost Effectiveness of Agricultural Best Management Practices and Publicly Owned Treatment Works is Controlling Phosphorus Pollution in the Great Lakes Basin.* Prepared by DPRA Inc. for U.S. Environmental Protection Agency, Washington, DC.

DPRA. 1989. *Evaluation of the Cost Effectiveness of Agricultural Best Management Practices and Publicly Owned Treatment Works in Controlling Phosphorus Pollution in the Great Lakes Basin.* Prepared by DPRA Inc. for U.S. Environmental Protection Agency under contract no. 68-01-7947, Manhattan, KS.

DPRA. 1992. *Draft Economic Impact Analysis of Coastal Zone Management Measures Affecting Confined Animal Facilities.* Prepared by DPRA Inc. for U.S. Environmental Protection Agency under contract no. 68-C99-0009, Manhattan, KS.

Eckert, R.E., and J.S. Spencer. 1987. Growth and Reproduction of Grasses Heavily Grazed under Rest-Rotation Management. *Journal of Range Management*, 40(2):156-159.

Edwards, W.M., L.B. Owens, R.K. White, and N.R. Fausey. 1986. Managing Feedlot Runoff with a Settling Basin Plus Tiled Infiltration Bed. *Transactions of the ASAE*, 29(1):243-247.

Edwards, W.M., L.B. Owens, and R.K. White. 1983. Managing Runoff from a Small, Paved Beef Feedlot. *Journal of Environmental Quality*, 12(2).

Evans, R.O. 1992. Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, personal communication.

Evans, R.O., D.K. Cassel, and R.E. Sneed. 1991a. *Calibrating Soil-Water Measuring Devices.* North Csarolina Cooperative Extension Service, Raleigh, NC. AG-452-3.

Evans, R.O., D.K. Cassel, and R.E. Sneed. 1991b. *Measuring Soil Water for Irrigation Scheduling: Monitoring Methods and Devices.* North Carolina Cooperative Extension Service, Raleigh, NC. AG-452-2.

Evans, R.O., D.K. Cassel, and R.E. Sneed. 1991c. *Soil, Water and Crop Characteristics Important to Irrigation Scheduling.* North Carolina Cooperative Extension Service, Raleigh, NC. AG-452-1.

Evans, R.O., R.E. Sneed, and D.K. Cassel. 1991d. *Irrigation Scheduling to Improve Water- and Energy-Use Efficiencies.* North Carolina Cooperative Extension Service, Raleigh, NC. AG-452-4.

Fresno Field Office and River Basin Planning Staff. 1979. *Comparison of Alternative Management Practices, Molar Flats Pilot Study Area, Fresno County, California*, Mini-Report. U.S. Department of Agriculture, Soil Conservation Service, Davis, CA.

Goodman, J. 1992. South Dakota Department of Environment and Natural Resources, Pierre, SD, personal communication.

Hallberg, G.R., et al. 1991. *A Progress Review of Iowa's Agricultural-Energy-Environmental Initiatives: Nitrogen Management in Iowa*, Technical Information Series 22, Iowa Department of Natural Resources, Iowa City, IA.

Heimlich, R.E., and N.L. Bills. 1984. An improved soil erosion classification for conservation policy. *Journal of Soil and Water Conservation*, 39(4):261-267.

Hermsmeyer, B. 1991a. *Nebraska Long Pine Creek Rural Clean Water Program 10-year Report 1981-1991.* Brown County Agricultural Stabilization and Conservation Service, Ainsworth, NE.

Hermsmeyer, B. 1991b. *Pre-publication Charts for the Long Pine RCWP 10-year Report.* Agricultural Stabilization and Conservation Service, Ainsworth, NE.

Hubert, W.A., R.P. Lanka, T.A. Wesch, and F. Stabler. 1985. Grazing Management Influences on Two Brook Trout Streams in Wyoming. In *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses.* U.S.Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-120, pp.290-294.

Iowa State University. 1991a. Ag Programs Bring Economic, Environmental Benefits. In *Extension News.* Extension Communications, Ames, IA.

Iowa State University. 1991b. *Nitrogen Use in Iowa.* Prepared for the nitrogen use press conference Dec. 5, 1991, University Extension, Ames, IA.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Effects of Late Season Cattle Grazing on Riparian Plant Communities. *Journal of Range Management*, 36(6):685-691.

Killorn, R. 1990. *Trends in Soil Test P and K in Iowa*, Paper Presented at the 20th North Central Extension-Industry Soil Fertility Workshop, 14-15 November, Bridgeton, MO.

Logan, T.J. 1990. Agricultural Best Management Practices and Groundwater Protection. *Journal of Soil and Water Conservation.* 45(2):201-206.

Lowrance, R.R., S. McIntyre, and C. Lance. 1988. Erosion and Deposition in a Field/Forest System Estimated Using Cesium-137 Activity, *Journal of Soil and Water Conservation*, 43(2):195-199.

Lugbill, J. 1990. *Potomac River Basin Nutrient Inventory.* Metropolitan Washington Council of Governments, Washington, DC.

Magdoff, F.R., D. Ross, and J. Amadon. 1984. A Soil Test for Nitrogen Availability to Corn. *Soil Science Society of America Journal*, 48:1301-1304.

Maryland Department of Agriculture. 1990. *Nutrient Management Program.* Maryland Department of Agriculture, Annapolis, MD.

McDougald, N.K., W.E. Frost, and D.E. Jones. 1989. *Use of Supplemental Feeding Locations to Manage Cattle Use on Riparian Areas of Hardwood Rangelands.* U.S. Department of Agriculture Forest Service. General Technical Report PSW-110, pp 124-126.

Mielke, L.N., and J.R.C. Leavitt. 1981. *Herbicide Loss in Runoff Water and Sediment as Affected by Center Pivot Irrigation and Tillage Treatments.* U.S. Department of the Interior, Office of Water Research and Technology. Report A-062-NEB.

Miner, J.R., J.C. Buckhouse, and J.A. Moore. 1991. Evaluation of Off-Stream Water Source to Reduce Impact of Winter Fed Range Cattle on Stream Water Quality. In *Nonpoint Source Pollution: The Unfinished Agenda for the Protection of Our Water Quality*, 20-21 March, 1991, Tacoma, WA. Washington Water Research Center, Report 78, pp. 65-75.

Mitsch, W.J., and J.G. Gosselink. 1986. *Wetlands.* Van Nostrand Reinhold, New York.

NRDC. 1991. *Harvest of Hope: The Potential for Alternative Agriculture to Reduce Pesticide Use.* Natural Resources Defense Council, New York.

Nelson, D. 1985. Minimizing Nitrogen Losses in Non-irrigated Eastern Areas. In *Proceedings of the Plant Nutrient Use and the Environment Symposium, Plant Nutrient Use and the Environment*, 21-23 October, 1985, Kansas City, MO, pp. 173-209. The Fertilizer Institute.

North Carolina State University. 1984. *Best Management Practices for Agricultural Nonpoint Source Control: IV. Pesticides.* North Carolina State University, National Water Quality Evaluation Project, Raleigh, NC.

North Carolina Agricultural Extension Service. 1982. *Best Management Practices for Agricultural Nonpoint Source Control III: Sediment.* In cooperation with USEPA and USDA. Raleigh, North Carolina.

Northup, B.K., D.T. Goerend, D.M Hays, and R.A. Nicholson. 1989. Low Volume Spring Developments. *Rangelands*, 11(1):39-41.

Novais, R., and E.J. Kamprath. 1978. Phosphorus Supplying Capacities of Previously Heavily Fertilized Soils. *Soil Science Society of America Journal*, 42:931-935.

Owens, L.B., R.W. Van Keuren, and W.M. Edwards. 1982. Environmental Effects of a Medium-Fertility 12-Month Pasture Program: II. Nitrogen. *Journal of Environmental Quality*, 11(2):241-246.

Pennsylvania State University. 1992a. Nonpoint Source Database. Pennsylvania State University, Dept. of Agricultural and Biological Engineering, University Park, PA. (see Appendix 2-B for list of references.)

Pennsylvania State University. 1992b. College of Ariculture, Merkle Laboratory - Soil & Forage Testing, University Park, PA.

Platts, W.S. 1990. *Managing Fisheries and Wildlife on Rangelands Grazed by Livestock, A Guidance and Reference Document for Biologists.* Nevada Department of Wildlife, Reno, NV.

Platts, W.S., and R.L. Nelson. 1989. Characteristics of Riparian Plant Communities and Streambanks with Respect to Grazing in Northeastern Utah. In *Practical Approaches to Riparian Resource Management - An Educational Workshop*, ed. R.E. Gressell, B.A. Barton, and J.L. Kershner, pp.73-81. U.S. Department of the Interior, Bureau of Land Management.

Reed, A.D., J.L. Meyer, F.K. Aljibury, and A.W. Marsh. 1980. *Irrigation Costs.* University of California, Division of Agricultural Sciences, Leaflet 2875 (as reported by Boyle Engineering Corp., 1986).

Robillard, P.D., and M.F. Walter. 1986. *Nonpoint Source Control of Phosphorus - A Watershed Evaluation. Vol. 2. Development of Manure Spreading Schedules to Decrease Delivery of Phosphorus to Surface Waters.* U.S. Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, Ada, OK. Internal report.

Russell, J.R., and L. A. Christensen. 1984. *Use and Cost of Soil Conservation and Water Quality Practices in the Southeast.* U.S. Dept. of Agriculture, Economic Research Service, Washington, DC.

Sanders, J.H., D. Valentine, E. Schaeffer, D. Greene, and J. McCoy. 1991. *Double Pipe Creek RCWP: Ten Year Report.* U.S. Department of Agriculture, University of Maryland Cooperative Extension Service, Maryland Department of the Environment, and Carroll County Soil Conservation District.

Schwab, G.O., R.K. Frevert, T.W. Edminster and K.K. Barnes. 1981. *Soil and Water Conservation Engineering.* 3rd ed. John Wiley & Sons, New York.

Sims, J.T. 1992. Environmental management of phosphorus in agricultural and municipal wastes. In *Future Directions for Agricultural Pollution Research*, ed. F.J. Sikora. Tennessee Valley Authority, Muscle Shoals, AL. Bulletin Y-224.

Smolen, M.D., and F.J. Humenik. 1989. *National Water Quality Evaluation Project 1988 Annual Report: Status of Agricultural Nonpoint Source Projects.* U.S. Environmental Protection Agency and U.S. Department of Agriculture, Washington, DC. EPA-506/9-89/002.

Sneed, R. 1992. Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, personal communication.

Soil Conservation Society of America. 1982. *Resource Conservation Glossary,* 3rd ed.

Stolzenburg, B. 1992. University of Nebraska, Cherry County Cooperative Extension Service, Valentine, NE, personal communication.

Sutton, A.L. 1990. *Animal Agriculture's Effect on Water Quality: Pastures & Feedlots.* Purdue University Cooperative Extension Service, West Lafayette, IN. Doc. No. WQ7.

Tiedemann, A.R., D.A. Higgins, T.M. Quigley, H.R. Sanderson, and C.C. Bohn. 1988. *Bacterial Water Quality Responses to Four Grazing Strategies - Comparison with Oregon Standards.*

USDA. 1991. *An Interagency Report: Rock Creek Rural Clean Water Program Final Report 1981-1991.* U.S.Department of Agriculture, Twin Falls, ID.

USDA. 1992. *Educational, Technical, and Financial Assistance for Water Quality, Report of Fiscal Year 1991 Operations.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Extension Service, and Soil Conservation Service. Washington, DC.

USDA-ARS. 1987. *User Requirements. USDA-Water Erosion Prediction Project (WEPP). Draft 6.3.* U.S. Deptartment of Agriculture, Agricultural Research Service, Beltsville, MD.

USDA-ASCS. 1988. *Moapa Valley, Colorado River Salinity Control Program, Project Implementation Plan (PIP).* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Washington, DC.

USDA-ASCS. 1990. *Agricultural Conservation Program - 1989 Fiscal Year Statistical Summary.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Washington, DC.

USDA-ASCS. 1991a. *Oakwood Lakes-Poinsett Project 20 Rural Clean Water Program Ten Year Report.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Brookings, SD.

USDA-ASCS. 1991b. *Agricultural Conservation Program - 1990 Fiscal Year Statistical Summary.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Washington, DC.

USDA-ASCS. 1992a. *Conestoga Headwaters Project Pennsylvania Rural Clean Water Program 10-Year Report 1981-1991.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Harrisburg, PA.

USDA-ASCS. 1992b. *Agricultural Conservation Program - 1991 Fiscal Year Statistical Summary.* U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Washington, DC.

USDA-ERS. 1991. *Agricultural Outlook*, AO-183, March 1991. U.S. Department of Agriculture, Economic Research Service, Washington, DC.

USDA-SCS. 1983. *Water Quality Field Guide.* U.S. Department of Agriculture, Soil Conservation Service, Washington, DC. SCS-TP-160.

USDA-SCS. 1984. *Engineering Field Manual.* U.S. Department of Agriculture, Soil Conservation Service, Washington, DC.

USDA-SCS. 1988. I-4 Effects of Conservation Practices on Water Quantity and Quality. In *Water Quality Workshop, Integrating Water Quality and Quantity into Conservation Planning.* U.S. Department of Agriculture, Soil Conservation Service, Washington, DC.

USDA-SCS, Michigan. 1988. Flat Rate Schedule - Costs of Conservation Practices. In *Technical Guide Section V-A-3.* U.S. Department of Agriculture, Soil Conservation Service, MI.

USDA-SCS. 1991. *Water Quality Field Guide.* U.S. Department of Agriculture, Soil Conservation Service, Washington, DC. SCS-TP-160.

USEPA. 1981. *ANSWERS - Users Manual.* U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL. EPA-905/9-82-001.

USEPA. 1982. *Planning Guide for Evaluating Agricultural Nonpoint Source Water Quality Controls.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Athens, GA. EPA-600/3-82-021.

USEPA. 1989a. U.S. Environmental Protection Agency. National Primary and Secondary Drinking Water Standards; Proposed Rule. 40 CFR Parts 141, 142, and 143.

USEPA. 1989b. *Glossary of Environmental Terms And Acronym List.* U.S. Environmental Protection Agency, Office of Communications and Public Policy. Washington, DC. 19K-1002.

USEPA. 1989c. *Cross-Connection Control Manual.* U.S. Environmental Protection Agency, Office of Water. Washington, DC.

USEPA. 1991a. *1990 Annual Progress Report for the Baywide Nutrient Reduction Strategy.* U.S. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD.

USEPA. 1991b. *Pesticides and Groundwater Strategy.* U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Washington, DC.

USEPA. 1992. *Preliminary Economic Achievability Analysis: Agricultural Management Measures.* U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, Washington, DC.

University of California Committee of Consultants on Drainage Water Reduction. 1988. *Associated Costs of Drainage Water Reduction.*

University of Maryland. 1990. *Example Nutrient Management Plan.* University of Maryland, Cooperative Extension Service, University Park, MD.

Van Poollen, H.W., and J.R. Lacey. 1979. Herbage Response to Grazing Systems and Stocking Intensities. *Journal of Range Management*, 32(4):250-253.

Virginia Cooperative Extension Service, Virginia Tech Virginia State, and U.S. Department of Agriculture - Extension Service. 1987. *The National Evaluation of Extension's Integrated Pest Management (IPM) Programs.* Virginia Cooperative Extension Service, Virginia Tech, Virginia State University, and U.S. Department of Agriculture, Cooperative Extension Service. Virginia Cooperative Extension Publication 491-010.

Wall, D.B., S.A. McGuire, and J.A. Magner. 1989. *Water Quality Monitoring and Assessment in the Garvin Brook Rural Clean Water Project Area.* Minnesota Pollution Control Agency, St. Paul, MN.

Westerman, P.W., L.M. Safley, J.C. Barker, and G.M. Chescheir. 1985. Available Nutrients in Livestock Waste. In *Proceedings of the Fifth International Symposium on Agricultural Wastes, Agricultural Waste Utilization and Management,* American Society of Agricultural Engineers, St. Joseph, MI, pp. 295-307.

Wisconsin Department of Agriculture, Trade and Consumer Protection. 1989. *Nutrient and Pesticide Best Management Practices for Wisconsin Farms.* Prepared by University of Wisconsin-Extension and Wisconsin Department of Agriculture, Trade and Consumer Protection.

Workman, J.P., and J.F. Hooper. 1968. Preliminary Economic Evaluation of Cattle Distribution Practices on Mountain Rangelands. *Journal of Range Management,* 21(3):301-304.

Appendix 2A

SCS Field Office Technical Guide Policy

United States Department of Agriculture
Soil Conservation Service
P.O. Box 2890
Washington, D.C.
20013

February 12, 1990

GENERAL MANUAL
450-TCH
AMENDMENT - 4 (PART 401)

SUBJECT: TCH - SCS TECHNICAL GUIDE POLICY

Purpose. To transmit revised Soil Conservation Service (SCS) Field Office Technical Guide (FOTG) policy.

Effective Date. This policy is effective when received.

Background. SCS Field Office Technical Guide policy was revised by 450-GM, Amendment 3, February 1987. As a result of numerous comments received on that policy, the National Technical Guide Committee (NTGC) prepared a draft revision for review by selected states and by technical guide committees at the National Technical Centers. Amendment 4 is the result of comments on the draft.

Explanation. Policy transmitted by this amendment contains guidance by which FOTG are established, changed and maintained. Following are the more important changes from Amendment 3:

1. State and NTC responsibilities in Section 401.01 for maintaining up-to-date information in technical guides have been amplified.

2. The descriptions of the six resource concerns in Section 401.03(b)(3)(iii) have been replaced with descriptions of the five resources: soil, water, air, plants, and animals.

3. Criteria for treatment required to achieve an RMS for each of the five resources have been clearly stated in Section 401.03(b)(iv).

4. The process for developing criteria for treatment required to achieve an Acceptable Management System (AMS), a new concept, has been stated in section 401.03(b)(3)(v).

5. Explanation of the content of the National Handbook for Conservation Practices (NHCP) in Subpart B has been revised to remove redundant statements and clearly states responsibilities for changes in NHCP and for issuance and review of interim standards.

6. Section V of the FOTG, described in section 401.03(b)(5), has been totally revised and is now named "Conservation Effects." Guidance on effects is provided to aid in conservation planning activities.

DIST: GM

Filing Instructions:

1. Remove and discard existing GM 450, Part 401, dated February 1987. (Amendment 3)

2. Replace with the enclosed GM 450, Part 401, dated January 1990.

Directives Cancelled:

1. Remove and discard National Instruction No. 450-301, dated October 5, 1979.

WILSON SCALING
Chief

Enclosures

PART 401 - TECHNICAL GUIDES

SUBPART A - POLICY AND RESPONSIBILITIES

401.00 General.

(a) This part states policy for establishing, changing, and maintaining technical guides. It also establishes supporting committees for maintaining those guides.

(b) The Soil Conservation Service (SCS) is responsible for providing national leadership and administration of programs to conserve soil, water, and related resources on the private lands of the Nation. A primary goal is to provide technical assistance to decision-makers for the planning and implementation of a system of conservation practices and management which achieves a level of natural resource protection that prevents degradation and permits sustainable use. In cases where degradation has already occurred, the goal is to restore the resource to the degree practical to permit sustainable use. Technical guides provide procedures and criteria for the formulation and evaluation of resource management systems which achieve these goals and, when needed, for the formulation and evaluation of acceptable management systems which achieve these goals to the extent feasible.

(c) Technical guides are primary technical references for SCS. They contain technical information about conservation of soil, water, air, and related plant and animal resources. Technical guides used in any office are to be localized so that they apply specifically to the geographic area for which they are prepared. These documents are referred to as Field Office Technical Guides (FOTGs). Appropriate parts of FOTG will be systematically automated as data bases, computer programs, and other electronic-based materials compatible with the Computer Assisted Management and Planning System (CAMPS) are developed.

(d) Technical guides provide:

(1) Soil interpretations and potential productivity within alternative levels of management intensity and conservation treatment;

(2) Technical information for achieving SCS's and the decisionmaker's objectives;

(3) Information for interdisciplinary planning for the conservation of soil, water, and related resources;

(4) A basis for identifying resource management system (RMS) options and, when needed, acceptable management system (AMS) options and components thereof;

(5) Information on effects of resource management systems, acceptable management

systems, and their component practices;

(6) Criteria to evaluate the quality of RMS options, AMS options, and components thereof;

(7) Standards and specifications for conservation practices;

(8) Information for evaluating the economic feasibility of conservation practices and resource management system options;

(9) Information for locating and identifying cultural resources and methods to account for their significance; and

(10) Technical material for training employees.

401.01 Responsibilities.

(a) National Headquarters (NHQ).

(1) The Deputy Chief for Technology has national leadership for policy and procedures for developing and using the FOTG.

(2) The Director, Ecological Sciences Division (ECS), chairs the National Technical Guide Committee (NTGC).

(3) The NTGC makes recommendations to the Deputy Chief for Technology regarding technical guide policy and procedure.

(b) National Technical Centers (NTCs).

(1) NTC directors are responsible for establishing a Technical Guide Committee (TGC) at each NTC.

(2) The TGC provides guidance to states in developing FOTGs.

(3) NTC directors establish procedures to coordinate NTC technical review and concurrence of state developed material that affect either policy or technical aspects in all sections of the FOTG.

(4) The TGC coordinates NTC technical review and concurrence of state developed material as described in (3). The NTC director will inform the state conservationist (STC) of NTC action and comments.

(5) The TGC refers proposed changes in the National Handbook of Conservation Practices (NHCP) to NTGC for action.

(6) NTC provide states with examples of guidance documents for RMS and AMS options, displays of conservation effects, and guidance documents developed to meet specific program requirements. NTC has primary technical oversight.

(7) NTC directors are responsible for coordination and consistency among NTC regions.

(c) State offices.

(1) The state conservationist (STC) is responsible for the development, quality, coordination, use, and maintenance of FOTG in his/her state.

(2) The STC will:

(i) Coordinate FOTG contents across state lines where Major Land Resource Areas are shared to achieve reasonable uniformity between and among states;

(ii) Request appropriate assistance from the NTC director to prepare, revise, and maintain the FOTG and to correlate FOTG contents with adjoining states;

(iii) Submit to the NTC for review and concurrence all state developed materials that affect either policy or technical aspects in all FOTG sections prior to issuance;

(iv) Propose interim standards, variances, or changes in national standards to the NTC director for action;

(v) Establish a state TGC and appoint membership;

(vi) Establish criteria for RMS and AMS with concurrence by the NTC; and

(vii) Establish procedures for maintaining up-to-date data in FOTG. All FOTG material is to be reviewed by the designated state discipline specialist at least once every two years. Material is to be updated as necessary to maintain technical adequacy. Each technical guide subsection described in section 401.03(b) is to contain a table of contents showing the issue date and the date of the last review.

(d) Area offices.

(1) The area conservationist (AC) will:

(i) Coordinate the development, use, and maintenance of FOTG in the field offices supervised;

(ii) Work with the specialists in the state offices to achieve high-quality FOTG; and

(iii) Establish an area-level TGC if necessary.

(e) **Field offices.**

(1) District conservationists (DC) will:

(i) Take the lead to develop and assemble the FOTG;

(ii) Use and maintain the FOTG in the office(s) they supervise;

(iii) Ensure that all field office technical assistance is based on FOTG contents;

(iv) Identify needed changes and/or additions; and

(v) Request specialist help to make improvements.

(2) All field office employees are responsible for identifying the need for improvements and for informing the DC of those needs.

401.02 National Technical Guide Committee (NTGC).

(a) **Membership. The members of the NTGC are:**

(1) Director, Ecological Sciences Division (chairperson);
(2) Director, Engineering Division;
(3) Director, Economics and Social Sciences Division;
(4) Director, Soil Survey Division;
(5) Director, Land Treatment Program Division;
(6) Director, Conservation Planning Division;
(7) Director, Watershed Projects Division;
(8) Director, Basin and Area Planning Division;
(9) Director of an NTC (on a 1-year rotation);
(10) Executive Secretary (appointed by the chairperson); and
(11) Chair of National Conservation Practice Standards Subcommittee (NCPSS) (appointed by the NTGC chairperson).
(12) A representative from the Extension Service will be invited to participate in all NTGC meetings.

(b) **Responsibilities.**

(1) Keep national FOTG policy and procedures current by recommending policy changes to the Deputy Chief for Technology.

(2) Respond to requests for FOTG policy and procedure clarification.
(3) Designate members of the National Conservation Practice Standards Subcommittee.
(4) Act upon recommendations from NCPSS.
(5) Coordinate policy and procedures established to automate FOTG contents and functions in SCS operations.
(6) Create ad hoc subcommittees as necessary.
(7) Receive and act upon requests, recommendations, referrals, and suggestions from the NTC TGC.

(c) NTGC operation.

(1) NTGC will meet quarterly and otherwise as convened by the chairperson.
(2) Materials for consideration by the NTGC will be sent to the chairperson.
(3) Minutes of each meeting will be sent to each member, the Deputy Chiefs for Technology and Programs, and NTC directors.
(4) Matters requiring action will be acted upon within 45 days of receipt.

401.03 Content of technical guides.

(a) Technical guides contain Sections I through V and appropriate subsections. Those sections are:

(1) Section I - General Resource References;

(2) Section II - Soil and Site Information;

(3) Section III - Conservation Management Systems;

(4) Section IV - Practice Standards and Specifications; and

(5) Section V - Conservation Effects.

(b) The following are descriptions of technical guide sections and subsections:

(1) Section I - General Resource References.

This section lists references and other information for use in understanding the field office working area or in making decisions about resource use and management systems. The actual references listed are to be filed to the extent possible in the same location as the FOTG. References kept in other locations will be cross-referenced. The following are subsections of Section I of the FOTG.

(i) **Reference lists.** These include handbooks, manuals, and reports commonly used in resource conservation planning and implementation activities such as irrigation and drainage guides; the *National List of Scientific Plant Names* (NLSPN); the *National Register of*

Historic Places; published soil surveys; basic water resources information on ground water quality, surface water quality, and water quantity; recreation potential appraisals; natural resource inventories; reports that identify such items as areas susceptible to flooding; river basin reports; seismic zones; and documentation of useful computer models.

(ii) **Cost data.** General reference data on costs, such as cost lists for practice components.

(iii) **Maps.** The SCS National Planning Manual (NPM), Part 507, Exhibits 507.09, contains a list of resource maps that should be included. Water quality problem areas and areas with a potential water quality problem are to be included here.

(iv) **Erosion prediction.** Guidance, data, and SCS approved techniques for predicting soil erosion are to be included here, or appropriately referenced.

(v) **Climatic data.** This subsection contains local climatic data needed for planning conservation management systems and installing conservation practices, such as record low and high temperatures; averages for such items as rainfall, length of growing season, temperatures, wind velocities, hail incidence, and snowfall; water supply data; probability of receiving selected amounts of precipitation by months; and frost-free periods. References should be made to other climatic data in other field office documents.

(vi) **Cultural (archaeological and historic) resource information.** This subsection contains general locational data and documentation suitable for inventory, checking and recording, and conservation planning. The law states that specific locational information, such as site maps, is not to be available to the general public; therefore they should only be referenced in this subsection.

(vii) **Threatened and endangered species list.** This subsection contains information on species of plants and animals that are threatened and endangered and are to be accounted for in conservation planning.

(viii) **Laws.** List of state and local laws, ordinances, or regulations that impact Conservation Management System development and other technical applications such as conservation practice application.

(2) Section II - Soil and Site Information.

Information from the State Soil Survey Database (3SD) will be used as the basis of this section. The 3SD contains current information on soils and their basic interpretations as tailored from the Soil Interpretations Records (SCS-SOI-5). Detailed interpretations of soils will be provided in Section II by state and area specialists.

Interpretations are specific to the soils identified and mapped in the area. Map units to which the interpretations apply are clearly identified by name, symbol(s), or both. New map unit names and symbols resulting from reclassification of soils are cross-referenced to old names and symbols and shown on a list.

Soils are to be described and interpreted to help make decisions about use and management of land. Soil characteristics that limit or affect land use and management are to be identified, and soils are to be rated according to limitations, capability, suitability, and/or potential.

This information may be available in published soil surveys or in the State Soil Survey Database (3SD). A copy of the appropriate sections of soil surveys can be included in the applicable subsections, or reference can be made to the source document maintained in the field office.

The following are subsections of Section II of the FOTG.

(i) **Soils legend.** This list includes the names of the soil map units and, for each unit, the identification of interpretive groups (if any) of importance in the field office. For map units having two or more soils in their name, interpretive groups are identified for each soil. Where appropriate, the map unit is placed in a group that generally controls the use and management of the area.

If soil surveys of more than one vintage are used, the symbols used in each are to be identified along with appropriate interpretive groups. For remapped areas, only the legend for the most recent mapping is to be used.

(ii) **Soil descriptions.**

(A) **Nontechnical** soil descriptions for use with individuals, groups, and units of government are included. Brief references to major limitations e.g., erosion or wetness, and soil potential are a part of each description. Basic information needed to develop these descriptions is in the soil map unit descriptions and in the State Soil Survey Database (3SD).

(B) **Technical** descriptions of each soil series and of each soil map unit are provided in this section or available in the field office. If such descriptions are maintained as separate material, the source document should be listed here as a reference.

(iii) **Detailed soil interpretations.** These will be supplied by appropriate technical specialists for all land uses in the field office area. Examples follow:

(A) **Cropland interpretations.** These include soil interpretive information needed for plant adaptations, yield estimates, and the lists of soil map units that meet the soil requirements for prime farmland and highly erodible land. Interpretations are presented by land capability units, erodibility index, and soil map units in narrative or tabular form as appropriate. Where land capability unit or erodibility index is used, a list of all soil map units in each capability unit or erodibility index is included.

(B) **Rangeland, grazed forest land, and native pasture interpretations.** The required content of range and native pasture interpretive groupings is outlined in the National Range Handbook. All soils used as rangeland are to be placed in appropriate range sites. Range site descriptions and condition guides for rangeland are included. Grazed forest land and native pasture groupings include references to individual soils, grazing groups, or woodland suitability groups. Interpretations may be presented by individual soil map units or by groups of soil map units.

(C) **Forest land interpretations.** These are presented by individual soils or by woodland suitability groups (WSG). These interpretations include the woodland class symbol that denotes potential productivity for the indicator species in wood per cubic meters per hectare. Site index and annual productivity estimates in cubic feet per acre, board feet per acre, and/or cords per acre may also be provided for important tree species. The subclass indicates the primary soil or physiographic characteristic that contributes to important hazards or limitations in management. Site index information is also provided for important tree species.

(D) **Nonagricultural interpretations.** Nonagricultural uses include commercial development, subdivision development, industrial related development, roads and other transportation and transmission systems, and other land uses important to the area.

(E) **Recreation interpretations.** These include the ratings of soils for recreation uses.

(F) **Wildlife interpretations.** These are presented by wildlife habitat elements with descriptions of each element.

(G) **Pastureland and hayland interpretations.** These are arranged by pastureland and hayland suitability groups, capability units, other groupings, or soil map units.

(H) **Mined land interpretations.** These include interpretations which dictate the limitation to reclamation, revegetation, and maintenance for the different types of mined land.

(I) **Windbreak interpretations.** These interpretations are made by individual soils or by windbreak suitability groups (WISG). Interpretations provided by the WISG include the soil-adapted species recommended, the predicted height growth in 20 years, and the soil-related limitations.

(J) **Engineering interpretations.** These include engineering properties, indices, and soil interpretations for engineering uses and practices.
(K) **Waste disposal interpretations.** These are interpretations related to the suitability of soils for disposal of organic and inorganic wastes.

(L) **Water quality and quantity interpretations.** These are interpretations related to soil properties affecting water quantity and quality problems and treatments. Included are soil-pesticide interactive ratings and soil ratings for nitrates and soluble nutrients.

(M) **Hydric soils interpretations.** These are interpretations related to the identification and use of wetlands.

(3) Section III - Conservation Management Systems.

The function of SCS is to provide technical assistance to decisionmakers to protect, maintain, and improve soil, water, air, and related plant and animal resources. This section provides guidance for developing resource management systems (RMS) and acceptable management systems (AMS) for a resource area to prevent or treat problems and take advantage of opportunities associated with these resources. This section includes a description of considerations important in conservation planning of soil, water, air, and related plant and animal resources.

(i) **An RMS achieves the goal of preventing resource degradation and permitting sustainable use as stated in 401.00 (b).** An RMS is achieved if criteria for soil, water, air, and related plant and animal resources are met as defined in Section 401.03(b)(3)(iv). This section describes either national criteria or considerations that must be addressed in developing state criteria for achieving an RMS that solve identified onsite and offsite resource problems using best available technology. The concept and use of RMS is defined in the SCS National Planning Manual (NPM). RMS are not to be confused with "conservation systems," as defined in 7 CFR Section 12.2 for treatment of highly erodible land. A conservation system for Food Security Act purposes is an erosion reduction component of an RMS for cropland.

(ii) **SCS helps decisionmakers plan and apply conservation management systems to prevent and/or solve identified onsite and offsite resource problems or conditions and to achieve the decisionmaker's and public objectives.** SCS identifies and documents decisionmaker's objectives, consistent with land capability and sound environmental principles, as part of element 3 (Determining objectives) of the planning process (reference: National Planning Manual). SCS identifies and documents resource problems or conditions as part of element 4 (Providing resource inventory data) of the planning process. As part of element 6 (Developing and evaluating conservation alternatives), information on conservation effects is used to provide suitable options for addressing the decisionmaker's and public objectives.

(iii) **The five resources are soil, water, air, plants, and animals.** Each resource has several considerations important in conservation planning. Additional considerations in a specific state may need to be added to account for wide variations in soils, climate, or topography. A description of the main considerations for each resource follows:

(A) **Soil.** Considerations for the soil resource are erosion, condition, and deposition.

[1] **Erosion.** This consideration deals with one or more of the following types or locations of erosion: sheet and rill, wind, concentrated flow (ephemeral gully and classic gully), streambank, soil mass movement (land slips or slides), road bank, construction site, and irrigation-induced. All of these forms of erosion that are identified on the site to be planned need to be dealt with in developing treatment options.

[2] **Condition.** This consideration deals with the chemical and physical characteristics of soil as related to its ease of tillage, fitness as a seedbed, and ability to absorb, store, and release water and nutrients for plants. Aspects of this consideration will improve soil tilth, which reduces soil crusting and compacting; optimize water infiltration; optimize soil organic material; enhance beneficial soil organisms and biological activity; reduce subsidence; and minimize effects of excess natural and applied chemicals and elements such as salt, selenium, boron, and heavy metals. This consideration also deals with the proper and safe land application and utilization of animal wastes, other organics, nutrients, and pesticides.

[3] **Deposition.** This consideration deals with onsite or offsite deposition of products of erosion, which includes sediment causing damages to land, crops, and property, such as structures and machinery. This consideration also deals with safety hazards and decreased long-term productivity.

(B) **Water.** Considerations for the water resource are quantity and quality.

[1] **Quantity includes:**

- proper disposal of water from overland flows or seeps, both natural and man-made;
- management of water accumulations on soil surfaces or in soil profiles and vadose zones;
- optimization of irrigation and precipitation water use;
- dealing with other problems relating to irrigation — water mounding, water supply and distribution, increasing or decreasing water tables;
- management of deep percolation, runoff, and evaporation;
- water storage;
- management of water for wetland protection; and
- sediment deposition in lakes, ponds, streams and reservoirs, and restricted water conveyance capacity.

[2] **Quality includes:**

- reducing the effects of salinity and sodicity;
- minimizing deep percolation of contaminated water which will lead to unacceptable levels of pollutants in the underlying ground water;
- maintaining acceptable water quality;
- minimizing offsite effects including ground water contamination by pesticides, nutrients, salts, organics, metals and other inorganics, and pathogens; contamination of surface water (streams and lakes) by sediment, pesticides, nutrients, salts, organics, metals and other inorganics; pathogens; fecal coliform; and high temperature;
- reducing the quantity of sediment;
- improving the quality of sediment;
- ensuring that all waters will be free from substances attributable to man-caused nonpoint source discharges in concentrations that:
    - *settle to form objectionable deposits;
    - *float as debris, scum, oil or other matter to form nuisances;

*produce objectionable color, odor, taste, or turbidity;
*injure, are toxic to, or produce adverse physiological or behavior responses in humans, animals, or plants; or
*produce undesirable aquatic life or result in the dominance of nuisance species.

(C) **Air.** This resource deals with onsite and offsite airborne effects of undesirable odors, windblown particulates, chemical drift, temperature, and wind.

(D) **Plants.** The considerations for the plant resource are suitability, condition, and management.

[1] **Suitability includes:**
- plant adaptation to site; and
- plant suitability for intended use.

[2] **Condition includes:**
- productivity, kinds, amounts, and distribution of plants; and
- health and vigor of plants.

[3] **Management includes:**
- establishment, growth, and harvest (including grazing) of plants;
- agricultural chemical management (pesticides and nutrients); and
- pest management (brush, weeds, insects, and diseases).

(E) **Animals.** This includes wild and domestic animals, both terrestrial and aquatic. The considerations for the animal resource are habitat and management.

[1] **Habitat includes:**
- food;
- cover or shelter; and
- water.

[2] **Management includes:**
- population and resource balance; and
- animal health.

(iv) **Criteria for treatment required to achieve an RMS will be established by SCS.** They are to be stated in either qualitative or quantitative terms for each resource consideration. Where national criteria have not been established, the state conservationist will establish criteria with concurrence by the NTC. Where state and/or local regulations establish more restrictive criteria, these must be used in developing criteria for state and local programs. For example, some state and/or local regulations have established criteria for offsite control of water quality.

(A) **Soil.** Following are the criteria for this resource:

[1] **Erosion.**

• Estimated sheet and rill or wind erosion rates are reduced to the level that long term soil degradation is prevented and a high level of crop productivity can be sustained economically and indefinitely.

• Erosion from ephemeral or similar gullies is reduced to a level which permits efficient farming operations and sustains long term productivity.

• Irrigation-induced erosion is reduced to a level that sustains long term productivity.

• Other forms of erosion, such as classic gullies, streambank, roadbank, and landslides, that are identified as needing treatment (and are within the ability of the decisionmaker to treat), are reduced to the degree necessary to protect the resources or threatened man-made improvements.

[2] **Condition.**

• Soil tilth is maintained or improved;

• Crop production practices return adequate residue within the rotation cycle;

• Soil compaction by machinery, livestock, or other traffic is minimized:

• Water infiltration is optimized so as not to increase sheet and rill erosion;

• Wind forces and soil blowing are controlled below the crop tolerance level of young seedlings;

• Toxic chemicals affecting soil and plants are controlled to levels sufficient to prevent soil degradation and are below the tolerance of adapted crops;

• Application and utilization of animal wastes and other organics are at a rate that the soil, soil microbes and bacteria, and the plant community can assimilate, degrade, or retain the various materials.

[3] **Deposition.**

• Where existing or potential onsite or offsite deposition problem(s) are identified, the practices applied to the contributing land resolve the identified deposition problem(s).

• State and/or local governments may establish criteria in response to identified deposition problems. These criteria will be used to determine the adequacy of an RMS with regard to offsite effects. This may require the establishment of more restrictive criteria for one or more of the resources to alleviate the problem. Local public perception of an acceptable level could be used where no standards have been established.

- When disposal of animal wastes and other organics is needed, it shall be done in a manner that maintains or enhances the natural resources.

(B) Water. In developing criteria for this resource, the state conservationist is to address:

[1] Quantity.

- Overland flows and subsurface water conveyed by conservation practices are safely conducted and disposed of through acceptable outlets.

- Water system discharges going from one ownership to another ownership are not changed from natural flow pathways unless needed land and/or water rights have been obtained consistent with local, state, and Federal regulations.

- Water quality aspects associated with outlets are accounted for.

- Appropriate water storage requirements are in accordance with the needs of the planned use.

- Drainage activities are consistent with SCS policy regarding wetland protection.

- For irrigated land, a minimum percentage level of efficiency is achieved or exceeded for each type of irrigation system and management, as stated in the SCS state irrigation guide.

- For land under supplemental irrigation where adequate water supplies exist, or for land under partial irrigation because of water deficiency or lack of seasonal availability or frequency of availability of water, water is applied in the most effective manner, so that the infiltration rate of the soil, the plant needs, and the soil water-holding capacity are not exceeded.

- Vegetation, cropping sequences, and cultural operations are managed for efficient use of precipitation by minimizing water losses to runoff and evaporation, thereby inducing positive effects on the plant-soil moisture relationship, on ground water recharge, and on water yield downstream.

[2] Quality.

- Sediment movement is controlled to minimize contamination of receiving waters.

• Percolation below the root zone is managed to minimize contamination of the percolating water and to minimize the negative effects on production.

• Water used for salt leaching and plant temperature modification is applied to minimize adverse effects.

• Acceptable water temperature is maintained.

• Irrigation water and natural precipitation are managed to minimize the movement of nutrients, pesticides, sediment, salts, and animal wastes to offsite surface and ground water.

• Water-based uses, such as aquaculture enterprises and water-based recreation facilities maintain or improve environmental quality.

• Where surface or ground water nutrient and/or pesticide problems or potential problems exist, the selection of appropriate nutrients or pesticides and the timing, chemical forms, and rate and method of application reduce adverse effects. The use of pesticides and nutrients with high potential for polluting water are avoided where site limitations, such as slope, depth to ground water, soil, and material in the vadose zone or aquifer could allow that potential to be realized. Soil-pesticide interactive ratings to identify potential problem situations from surface runoff and/or leaching are used according to FOTG guidelines. Alternative practices or other pest control methods (mechanical, cultural, or biological) or integrated methods are recommended where site limitations exist that increase the probability of degrading water supplies, either below the surface or downstream.

• Agricultural chemical containers and chemicals (including waste oil, fuel, and detergents) are used, handled, and disposed of in compliance with Federal, state, and local laws.

(C) **Air.** Criteria established by the state conservationist are to address the following onsite and offsite considerations:

• Airborne particulates from agricultural sources do not cause safety, health, machinery, vehicular, or structure problems.

• Local and state regulations are followed in minimizing undesirable odors from agricultural sources.

• Air movement and temperatures are modified when necessary using appropriate vegetative or mechanical means.

• Chemical drift from the application of agricultural chemicals is controlled by adherence to local and state application recommendations and product labels.

(D) Plants. Criteria established by the state conservationist are to address the following considerations:

- Plants on all land uses are used, maintained and improved to achieve acceptable production levels to meet conservation, environmental, decisionmaker, and public objectives.

- Nutrient applications for any land use are based on plant nutrient requirements, production requirements, soil test recommendations, soil fertility, soil potential limitations, water budget, and the types of practices planned. Nutrients from all sources (animal waste, crop residue, soil residual, commercial fertilizer, atmospheric-fixed) are considered when calculating the amount of nutrients to apply. Timing, method, and rate of application, and chemical forms of nutrients to be applied are taken into consideration in planning practices.

- Pesticide applications for any land use are applied according to the label recommendation and federal, state, and local regulations.

- On Cropland, crops are grown in a planned sequence that meets conservation, production, and decisionmaker objectives; and weeds, insects, other pests, and diseases are adequately treated.

- On Hayland, dominant native or introduced plant species are appropriate for the forage, agronomic, or commercial use; well adapted to the site; and their stand density is maintained or improved.

- On Native Pasture, herbaceous plants are properly grazed, forage value rating is medium or better, vigor is strong and is commensurate with overstory canopy.

- On Pastureland, dominant plant species are appropriate for the use, adapted to the site, and their stand density is adequate and productivity is maintained or improved.

- On Rangeland, the plant community is managed to meet the needs of the plants and animals in a manner to conserve the natural resources and meet the objectives of the decisionmaker. As a general rule, rangeland in poor or fair ecological range condition is managed for an upward range trend, and rangeland in good or excellent ecological range condition will be managed for a static or upward range trend. In some special situations, poor or fair ecological range condition could be managed for a static range trend to meet special objectives of the decisionmaker as long as there is no degradation of the soil resource.

- On Forest Land, trees are well distributed, vigorous, relatively free of insects, disease, and other damage, and the density of the stand is within 25% of forest stand density guide spacing on a stems-per-acre basis for the particular forest types. Forest Land shall be protected from wildfires and erosion. Forest Land that is grazed shall also be managed to meet the needs of the forage plants, the animals, and the objectives of the decisionmaker.

• On Wildlife Land, Recreation Land, and Other Land, adapted or native plants are of sufficient quantity and quality to improve or protect the defined resource.

• On Urban Land uses, soil cover is maintained using suitable plants or other cover to keep soil erosion within acceptable limits, minimize runoff, and manage infiltration.

(E) Animals. Criteria established by the state conservationist are to address the following considerations:

• The adaptation, kinds, amounts, distribution, health, and vigor of livestock and wildlife are appropriate for the site.

• Adequate quality, quantity and distribution of food are provided for the species of concern.

• Adequate quantity, quality and distribution of wildlife cover for the species of concern are provided. Domestic animals are provided adequate shelter as needed.

• Adequate quantity, quality and distribution of water are provided for the species of concern.

• The decisionmaker's enterprise and the balance between forage production and livestock needs are appropriate.

• Domestic livestock are managed in a manner that meets the needs of the ecosystem, the animal, and that accomplishes the goals and objectives of the decisionmaker.

• Animal wastes and other organic wastes are managed according to an animal waste management plan developed according to SCS standards. Minimum quality criteria are met when the animal waste management plan is applied. Where surface and ground water problems exist from organic waste, bacteria, pathogens, microorganisms, or nutrients, special design considerations for each component will be necessary to eliminate further contamination of runoff or leachates.

(v) **An AMS will be established for a resource area in the event that social, cultural, or economic characteristics of the area prevent the feasible achievement of an RMS.** An AMS is achieved when soil, water, air, and related plant and animal criteria for the related resource use are established at the level which is achievable in view of the social, cultural, and economic characteristics of the resource area involved.

(A) Social, cultural, and economic considerations are used to establish the level of natural resource protection obtainable and may constrain the resource criteria used in formulating an

RMS. Criteria for treatment required to achieve an AMS will be established by SCS. They are to be stated in either qualitative or quantitative terms for each resource consideration . The state conservationist will establish criteria with concurrence by the NTC. Some of these criteria are prescribed by law or statute; e.g., the National Historic Preservation Act. Others are developed through an onsite assessment of social, cultural, and economic factors which define the reasonable and practical degree to which the resource criteria can be achieved. Where regional, state and/or local regulations establish more restrictive criteria, these must be used.

(B) The following criteria are applied to determine the practical limits of resource protection within a resource area and temper the resource criteria to be used in the formulation of an AMS.

(1) Social
- Public health is maintained or improved.
- Treatment level is compatible with community characteristics.
- Treatment level is compatible with clientele characteristics.

(2) Cultural
- Protection of cultural resources is consistent with GM 420, Part 401.

(3) Economic
- Treatment level reflects the ability to pay that is representative of the area.
- Inputs required for conservation treatment are readily available.
- Conservation treatment is consistent with government program participation.

(vi) **Additional considerations useful in the planning process to screen or select suitable conservation treatments for individual decisionmakers may include legal, social, cultural, economic, aesthetic, management, and other factors.** These are integral to the planning process and are discussed in the National Planning Manual and are displayed in Section V.

(vii) **Applications of RMS and AMS Criteria**

(A) Several factors may affect the actual level or degree of treatment achieved at a point in time or that is required to be achieved by the decisionmaker. Without legal constraints, the differing cultural, social or economic situation of a decisionmaker usually determines the degree of treatment planned or attained at any point in time. Where an RMS or AMS is not attainable during the present planning effort, the progressive planning approach in NPM 501.04 (d) may be used to ultimately achieve planning and application of an RMS or AMS. Progressive planning is the incremental process of building a plan on part or all of the planning unit consistent with the decisionmaker's ability to make decisions over a period of time. The progression on individual planning units is always toward the planning and implementation of an RMS.

(B) Legislated programs usually have varying authorities and qualifying criteria that may require more or less treatment than RMS or AMS criteria. An example is legislated practices for improving water quality. In this case, the related program manual will establish the criteria to be achieved. These applications must be coordinated across county and state lines and should be for the period of time specified in the law or in the related policies and procedures.

(C) The opportunity for establishing an RMS to achieve the non-degradation and sustainable use goal should be evaluated when ownership, land use, or cropping system changes, or when new technology becomes available.

(D) Decisionmakers may desire to plan treatment in addition to that required to meet RMS or AMS criteria to enhance resource conditions or to serve secondary or tertiary uses or objectives. This additional treatment may include conservation practices or management that contribute to further improvement of water quality; increased production, drainage, or irrigation; enhancement of cultural and environmental values, wildlife habitat, or aesthetics; or improved health and safety.

(viii) RMS, AMS, or other guidance documents will be developed by major land use in the field office area and placed in Section III of each FOTG.

(A) Only enough guidance documents to show examples of the RMS and AMS options to treat the most common identified resource problems for each locally applicable major land use will be developed. NTC will provide specific examples of format for guidance to states in the preparation of guidance documents. Guidance documents are to be developed by states for each FOTG using the NTC format. Guidance documents are to have concurrence of the NTC. NTC directors are to coordinate formats across NTC boundaries.

(B) Guidance documents will present a reasonable number of alternative combinations of practices and management that will meet the criteria for solving resource problems common to that land use.

(C) In developing guidance documents, the effects that alternative practices and combinations of practices and management have on the five resources and on the social, economic, and cultural considerations are to be used. For each guidance document developed, a display of effects of the conservation system should be included in Section V. Guidance on the development and display of effects is provided in Section 401.03(b)(5).

(D) Guidance documents may need to be developed to meet specific program requirements, in which case they are to be clearly labeled to show the program(s) or provision(s) of law to which they apply. These guidance documents may describe management actions in addition to conservation practices that can be carried out to achieve these program purposes.

(ix) Conservation practices are to be installed according to SCS practice standards and specifications. Practice standards and specifications are the same for both RMS and AMS.

(4) Section IV - Practice Standards and Specifications

(i) This section of FOTG contains conservation practice standards and specifications.

(ii) The first item of Section IV is an alphabetical list of conservation practices used by the field office, followed by the practice standards and specifications in the same order. This list will include the date of preparation or revision of each standard, supplement, specification, and interim standard in effect. This list will also show the date of the last review. This list will be revised and reissued each time a change is made in a conservation practice standard, supplement, or specification. See section 401.01(c)(2)(vii).

(iii) Practice standards establish the minimum level of acceptable quality for planning, designing, installing, operating, and maintaining conservation practices. Standards from the National Handbook of Conservation Practices (NHCP) and interim standards are to be used, and will be supplemented by states as needed.

(iv) Practice specifications describe requirements necessary to install a conservation practice so that it functions properly. For most practices in the NHCP, it is necessary to prepare state specifications to fit local soil and climatic conditions. Specifications include some or all of the following: major elements of work to be done; kind, quality, and quantity of materials to be used; essential details of installation; and other technical instructions necessary for installing and maintaining the practice.

(v) See **Part 401 - Subpart B** for policy and procedural details for standards and specifications.

(5) Section V - Conservation Effects

(i) The purpose of this section is twofold:

(A) The first purpose is to provide a repository of data on the effects of conservation activities. Such data are an important part of technical reference material used by SCS and decisionmakers in planning conservation actions. SCS determines the effects of conservation treatments in order to help formulate and facilitate the identification of suitable conservation management systems to protect the resource base and to address the decisionmaker's and society's social, cultural, and economic objectives. The concept of using conservation effects in the decisionmaking process (CED) is elaborated in the National Planning Manual.

(B) The second purpose of this section is to serve as a source of appropriate procedures and methods for collecting, analyzing, and displaying conservation effects data.

(ii) Conservation effects information will typically include the resource setting (i.e., soil, slope, etc.), the specific conservation treatments applied, the kinds, amounts, and timing of actions undertaken by decisionmakers in their operations, and the expected outcome in terms of solving resource problems and meeting social, cultural, and economic objectives.

(A) Effects of conservation may be expressed in either narrative or quantitative terms that represent factual data on experienced or expected results of the specified conservation treatment as applied to the resource setting. Effects of conservation will normally be expressed as a condition or stage of the factors associated with a specified conservation action. For example, typical effects could be: a corn yield of 110 bushels per acre; a USLE erosion rate of 4 tons per acre; irrigation efficiency of 60%; or "a significant reduction in ephemeral gully erosion will occur with this treatment." "Impacts" is a closely related term. An impact is a measure of the change between the stage or condition of one treatment alternative to another. Guidance on the use of effects information in the conservation planning process is contained in the National Planning Manual.

(B) To the extent possible, conservation effects information will include conservation treatments on the five resources and their considerations as described in Section III above.

[1] Examples of effects of conservation treatment on the five resources include but are not limited to:

- Expected effect on sheet and rill, wind, or ephemeral gully erosion.
- Indicators or measures of soil conditions, such as tilth, compaction, and infiltration.
- Where applicable, indicators of soil deposition.
- Measures or indicators of effects on quality and quantity of surface or subsurface waters, such as chemical runoff as influenced by the conservation system.
- Effects on plant conditions and management, such as expected status of range conditions with the indicated range conservation actions.
- Measures of conservation effects on wild and domestic animals, including animal waste uses and effects on the resource base.
- Indicators of effects on air, such as airborne particulates, odors, and chemical drift.

[2] Effects information will also include management, social, cultural, and economic information. Factors such as cost, client acceptability, and physical changes to cultural resource sites associated with the specific conservation treatment component are to be identified. Included, for example, would be:

- Tillage requirements, labor inputs, quantity and costs of inputs, net economic returns, experienced yields, risk management requirements, operation and maintenance requirements, time requirements, cultural resources (archaeological and historic properties), length of life of practices, health and safety, aesthetics, and community effects.

(C) Information developed on conservation effects will vary significantly in scope and detail depending on the resource conditions in the local area as well as upon the needs for technical reference materials to carry out conservation activities in that location.

(iii) Section V of the FOTG should contain summaries of effects data relevant to the field office area. As a minimum, Section V should contain a display of the important effects for decisionmaking for each of the RMS and AMS developed and inserted in Section III. The display should be cross referenced with cropping system, soil map units, and other descriptions of the resource setting and conditions (e.g., precipitation, slope, etc.) that the RMS or AMS was formulated to address in that field office. The format of the display should be easily understandable so as to make the information valuable as ready reference material for the conservation planner and decisionmaker to facilitate planning and decisionmaking. The display will show the degree of resource protection achieved.

(A) Options may be evaluated by simply comparing the differences in the effects of the options.

(B) NTC will provide specific examples of format guidance to states for recording and displaying conservation effects data.

(C) Collection of data on conservation effects is a long term effort to be undertaken as part of the followup element in the planning process. Initial efforts may provide effect information for only the most common situations. Over time, additional resource situations and treatment alternatives will be examined to add depth and breadth to the available conservation effect information.

(D) Information on conservation effects may be refined or updated over time as needed in the local area. The data on conservation effects should be useful to field office personnel in identifying suitable conservation treatment applicable to the area, and serves as technical reference materials when working with decisionmakers in the conservation planning process. (See National Planning Manual Section 508.01).

(iv) Data on conservation effects may be developed by following two general approaches:

(A) The observation and documentation of the experiences of cooperators. Typically, conservationists will make observations of conservation treatments applied by one or more decisionmakers in the first or second year following the application and record the effects experienced. This data can be recorded in conservation field notes and be entered into CAMPS databases. Effects information may also be available from conservation field trials, university research plots, or other trials in the area.

(B) Models of processes impacted by conservation actions can be used to simulate the physical, agronomic, or other effects of treatment systems. Actual results or graphs summarizing results could be developed by state staffs and provided to field offices for inclusion in FOTG. Appropriate models or references to the appropriate models may be stored in FOTG Section V to facilitate use in collecting and analyzing conservation effects data.

(v) Data relating effects of conservation practices on the five resources may be displayed in tabular, narrative, or matrix form. This will be useful in developing RMS or AMS for inclusion in FOTG Section III.

SUBPART B — NATIONAL HANDBOOK OF CONSERVATION PRACTICES

401.10 Purpose.

This subpart sets forth SCS policy for establishing and maintaining a National Handbook of Conservation Practices (NHCP). It also includes directions for variances, changes, interim standards, and adaptations of standards to state and local conditions.

401.11 Content.

(a) The NHCP establishes a national standard for each conservation practice, including:

(1) The official name, definition, code identity, and unit of measurement for the practice;

(2) A concise statement of the scope, purposes (including secondary purposes), conditions where the practice applies, and planning considerations for the practice; and

(3) Criteria for the practice.

(b) For some conservation practices, the NHCP also establishes items for inclusion in state-developed specifications.

(c) The NHCP contains an index of national standards, including:

(1) The practice name and unit.

(2) The SCS technical discipline leader responsible for each practice.

(3) The date of the current standard.

(4) The code number of the standard.

401.12 National Conservation Practice Standards Subcommittee (NCPSS) of National Technical Guide Committee (NTGC).

The National Conservation Practice Standards Subcommittee (NCPSS) of NTGC coordinates and updates the NHCP. The NTGC designates subcommittee members and acts on recommendations from NCPSS.

401.13 Practice standards and specifications.

(a) Practice standards establish the minimum level of acceptable quality of planning, designing, installing, operating and maintaining conservation practices.

(1) NHCP standards are to be used directly within a state, or state supplements can be added as necessary. Because of wide variations in soils, climate, and topography, state conservationists may need to add special provisions or provide more detail in the standards. State laws and local ordinances or regulations may dictate more stringent criteria.

(2) The official practice name, definition, code identity, and unit of measurement are established nationally and are not to be changed. Generally, the statement of scope, purpose, and conditions where a practice applies can be used directly.

(b) Practice specifications establish the technical details and workmanship for the various operations required to install the practice and the quality and extent of the materials to be used.

(1) Specifications enumerate items that apply when adapting the standard to site specific locations, such as considerations of site preparation and protection; instructions for use of materials described in the standard; or guidance for performing installation operations not directly addressed in the standard. Statements in the specifications are not to conflict with the requirements of the standard.

(2) Items to be included in state-developed specifications for a limited number of conservation practices are contained in the NHCP. Specifications for practices are to be developed by states or NTCs and are to consider the wide variations in soils, climate, and topography present in the various states. State developed specifications must be approved by the appropriate discipline specialist and the state conservationist. Specifications are to meet the requirements of state laws and local ordinances or regulations.

(c) National Technical Centers (NTCs) review and concur in supplements to NHCP standards and specifications prepared by a state for use within that state to ensure conformance with NHCP and consistency among states.

401.14 Variances.

Only the directors of the Engineering and/or Ecological Sciences Divisions can approve variances from requirements stated in the NHCP except that approval authority for variations in channel stability requirements has been delegated to the heads of engineering staffs at the NTC (see NEM 210 Section 501.32). Any other request for a variance is to be submitted to the NTGC and is to include recommendations of the appropriate NTC Director. The NTGC will refer the request to the appropriate division for action. Variances, when granted, are for a specific period of time or until the practice standard to which they pertain is revised, whichever is shorter. Variances will include any requirements for monitoring, evaluation, and reporting needed to determine whether or not changes in practice standards are necessary.

401.15 Changes in the National Handbook of Conservation Practices (NHCP).

(a) The NTGC will consider and recommend proposed changes in the NHCP to the Deputy Chief for Technology. Changes will be made by numbered handbook notices issued by the Deputy Chief for Technology.

(b) Each NHCP standard is to be formally reviewed by the NCPSS at least once every five years from the date of issuance or revision to determine if the standard is needed and up-to-date. If revisions are needed, the revised standard will establish the current minimum level of acceptable quality for planning, designing, installing, operating, and maintaining conservation practices.

(c) The NTC reviews all state proposed changes to NHCP and sends recommendations for approval or disapproval to NTGC. Review and approval of technical content of proposed changes is to be made by the Director, Engineering Division, or the Director, Ecological Sciences Division. Review and approval of format with respect to inclusion of items listed in Section 401.11 are to be performed by NTGC.

401.16 Interim standards.

(a) Interim standards are prepared by states or NTC to address problems for which there is no existing standard.

(b) Interim standards are to be approved by the NTC Director.

(c) Interim standards are to be issued for a period not to exceed 3 years. The NTC director can extend the period for further evaluation at the end of this period, and after an analysis of practice performance using the interim standard.

(d) Interim standards will be evaluated by NTC Technical Guide Committees at the end of the 3-year period and, if appropriate, recommendations made to the NTGC for inclusion in the National Handbook of Conservation Practices.

(e) The notice of approval of each interim standard will provide instructions to states regarding evaluation of practice performance.

(f) NTC directors are to send information copies of all interim standards and evaluation reports to NTGC.

Appendix 2B

List of References for Nonpoint Source Database - Pennsylvania State University

Articles Entered into NPSDB Listed in Order by SAN

Current as of 05/27/92

SAN	Applic. Class	First Authors	Article Title
2	Confined Livestock	Dickey, E.C.	Performance and Design of Vegetable Filters for Feedlot Runoff Treatment, Livestock Waste, A Renewable Resource
3	Confined Livestock		Livestock in Confinement - Section 10.0
10	Confined Livestock Manure Spreading	Westerman, P.W., et al.	Swine Manure and Lagoon Effluent Applied to a Temperate Forage Mixture: II Rainfall Runoff and Soil Chemical Properties, Journal of Environmental Quality, Vol. 16, No. 2, 1987
13	Conf. Livstk Manure Spreading.	Quisenberry, V.L., et al.	Management Aspects of Applying Poultry or Dairy Manures to Grassland in the Piedmant Region, Livestock Waste, A Renewable Resource
15	Manure Spreading	Doyle, R.C., et al	Effectiveness of Forest Buffer Strip in Improving the Water Quality of Manure Polluted Runoff
16	Manure Spreading	Mueller, D.H., et al.	Phosphorus Losses as Affected by Tillage and Manure Application, Soil Science Society Journal, Vol. 48, 1984
21	Manure Spreading	Gerhart, James M.,	Ground Water Recharge and Its Effects on Nitrate Concentration Beneath a Manured Field Site in Pennsylvania, Ground Water, Vol. 24, No. 4, 1986
22	Manure Spreading	Hubbard, R.K., et al.	Surface Runoff and Shallow Ground Water Quality as Affects by Center Pivot Applied Dairy Cattle Wastes, Transactions of the ASAE, 1987
23	Manure Spreading	Watters, S.P.	Water Quality Impacts on Animal Waste Application in a Northeastern Oklahoma Watershed
25	Manure Spreading	Clausen, John C.	Water Quality Achievable with Agricultural Best Management Practices, Journal of Soil and Water Conservation, 1989
26	Manure Spreading	Deiyman, Marcia M., Saied Mostaghimi	A Model for Evaluating the Impact of Land Application of Organic Wastes on Runoff Water Quality, Research Journal of the Water Pollution Control Federation, 1991
30	Cropland Erosion	Naderman, George C.	Surface Water Management for Crop Production on Highly Erodible Land
32	Cropland Erosion		Impact of Land Treatment on the Restoration of Skinner Lake Noble County Indiana

34	Cropland Erosion	McGregor, K.C., et al.	Effects of Tillage with Different Crop Residues on Runoff and Soil Loss
36	Cropland Erosion	Spomer, R.G. (duplicate)	Concentrated Flow Erosion on Conventional and Conservation Tilled Watershed
41	Cropland Erosion	Smith, S.J.	Water Quality Impacts Associated with Wheat Culture in the Southern Plains Journal of Environmental Quality, Vol. 20, No. 1, 1991
42	Cropland Erosion	Rayavian, Daryoush	Hydrologic Responses of an Agricultural Watershed to Various Hydrologic and Management Conditions
45	Cropland Erosion	Baldwin, P.L., et al.	Effects of Tillage on Quality of Runoff Water
46	Cropland Erosion	Mutchler, C.K., et al.	Erosion from Reduced-Till Cotton
51	Cropland Erosion	Unger, P.W.	Conservation Tillage Systems
53	Cropland Erosion	Mostaghimi, S., et al.	Influence of Tillage Systems and Residue Levels on Runoff, Sediment and Phosphorus Losses Transactions of the ASAE, Vol. 31, No. 1, 1988
54	Cropland Erosion	McDowell, L. L.	Nitrogen and Phosphorus Losses in Runoff from No-Till Soybeans
56	Cropland Erosion	Meek, B.D.	Infiltration Rate as Affected by an Alfalfa and No-Till Cotton Cropping System
58	Cropland Erosion	Cogo, N.P.	Soil Loss Reductions from Conservation Tillage Practices
59	Cropland Erosion	Zhu, J.C.	Runoff Soil and Dissolved Nutrients Losses from No-Till Soybeans with Winter Cover Crops
60	Cropland Erosion	Berg, W.A.	Management Effects on Runoff, Soil and Nutrient Losses from Highly Erodible Soils in the Southern Plains
62	Cropland Erosion	Dick, W.A., et al.	Surface Hydrologic Response of Soils to No-Till
63	Cropland Erosion	Beasley, D.B., et al.	Using Simulation to Assess the Impacts of Conservation Tillage on Movement of Sediment and Phosphorus into Lake Erie, Winter Meeting of the ASAE, 1986
64	Cropland Erosion	Baker, J.L.	Water Quality Consequences of Conservation Tillage
67	Confined LIvestock	Lorimor, J.C., et al.	Nitrate Concentration in Groundwater Beneath a Beef Cattle Feedlot Water Resource Bulletin, Vol. 8, No. 5, 1972
68	Cropland Erosion	Rousseau, A., et al.	Evaluation of Best Management Practices to Control Phosphorus Nonpoint Source Pollution
69	Cropland Erosion	Scott, R., Alfredo B. Granillo	Sediment and Water Yields from Managed Forests on Flat Coastal Plain Sites

70	Cropland Erosion	Landale, G.W.	Conservation Practice Effects on Phosphorus Losses from Southern Piedmont Watersheds, Journal of Soil and Water Conservation, 1985
84	Cropland Erosion	Dillaha, T.A., et al.	Vegetative Filter Strips for Agricultural Nonpoint Source Pollution Control, Transactions of the ASAE, Vol. 32, No. 2, 1989
93	Nutrient Management	Gold, Arthur J., et al.	Runoff Water Quality from Conservation and Conventional Tillage
94	Nutrient Management	Staver, K. Set al.	Nitrogen Export from Atlantic Coastal Plain Soils, International Summer Meeting of the ASAE, 1988
96	Nutrient Management	Baker, J.L. et al	Effect of Tillage on Infiltration and Anion Leaching, Winter Meeting of the ASAE, 1986
98	Nutrient Management	Mueller, D.H., et al.	Effect of Conservation Tillage on Runoff Water Quality: Total, Dissolved and Algal-Available Phosphorus Losses, Winter Meeting of the ASAE, 1983
100	Nutrient Management	Alberts, E.E., R.G. Spomer	Dissolved Nitrogen and Phosphorus in Runoff from Watersheds in Conservation and Conventional Tillage, Journal of Soil and Water Conservation, 1985
106	Nutrient Management	Angle, J.S., et al.	Nutrient Losses in Runoff from Conventional and No-Till Corn Watersheds, Journal of Environmental Quality, Vol. 13, No. 3
107	Nutrient Management	Mostaghimi, Saied, et al.	Phosphorus Losses from Cropland as Affected by Tillage System and Fertilizer Application Method, Water Resources Bulletin, Vol. 24, No. 4, 1988
110	Nutrient Management	Kanwar, R.S., et al.	Tillage and N-Fertilizer Management Effects on Groundwater Quality, Summer Meeting of the ASAE, 1987
167	Cropland Erosion	Edwards, W.M., et al.	Contribution of Macroporosity to Infiltration into a Continuous Corn No-Till Watershed: Implications for Contaminant Movement
183	Cropland Erosion	Deizman, M.M., et al.	Size Distribution of Eroded Sediment from Two Tillage Systems
184	Cropland Erosion	Khan, M.J., et al.	Mulch Cover and Canopy Effect of Soil Loss
185	Cropland Erosion	McGregor, K.C., et al.	Effect of Incorporating Straw Residues on Interrill Soil Erosion
212	Cropland Erosion	Mostaghimi, S., T.A. Dillaha, V.O. Shanholtz	Runoff, Sediment and Phosphorus Losses from Agricultural Lands as Affected by Tillage and Residue Levels

221	Cropland Erosion	Logan, Terry J.	Overview of Conservation Tillage, from Effects of Conservation Tillage on Groundwater Quality Nitrates and Pesticides -
226	Conf. Lvstk.	Texas Tech Univ.	Characteristics of Water from Southeastern Cattle Feedlots
235	Confined Livestock		Livestock Waste Management with Pollution Control North Central Regional Research Publication 222, June 1975
236	Manure Spreading	Gilbertson, C.B., et al.	Animal Waste Utilization on Cropland and Pastureland A Manual for Evaluating Agronomic and Environmental Effects, USDA, USEPA; EPA-600/2-79-059, 1979
238	Manure Spreading	Klausner, S.D., et al.	Nitrogen and Phosphorus Losses from Winter Disposal of Dairy Manure Journal of Environmental Quality, V. 5, No. 1, 1976
239	Manure Spreading	Fleming, R.J.	Impact of Agricultural Practices on Tile Water Quality ASAE Summer Meeting, 1990
240	Confined Livestock	Elliott, L.F., et al.	Ammonia, Nitrate, and Total Nitrogen in the Soil Water of Feedlot and Field Soil Profiles Applied Microbiology, April 1972, V. 28, No. 9
242	Confined Livestock	Coote, D.R. F.R. Hore	Runoff from Feedlots and Manure Storage in Southern Ohio Canadian Agricultural Engineering, V. 19, No. 2 1977
243	Confined Livestock	Gilberson, C.B., et al.	Physical and Chemical Properties of Outdoor Beef Cattle Feedlot Runoff,
245	Confined Livestock	Westerman, Philip W.; Michael R. Overcash	Dairy Open Lot and Lagoon Irrigation Pasture Runoff Quantity and Quality Transactions of the ASAE, Vol. 23, No. 5, 1980
246	Manure Spreading	Phillips, P.A., et al.	Pollution Potential and Corn Yields from Selected Rates and Timing of Liquid Manure Application 1979 Summer Meeting of ASAE and CSAE
248	Manure Spreading Confined Livestock	Adam, Real, et al.	Evaluation of Beef Feedlot Runoff Treatment by a Vegetative Filter Strip ASAE North Atlantic Regional Meeting, 1986
249	Confined Livestock Manure Spreading	Evans, R.O., et al.	Drainage Water Quality from Land Application of Swine Lagoon Effluent ASAE Summer Meeting, 1981
250	Manure Spreading	Mueller, D.H., et al.	Soil and Water Loss as Affected by Tillage and Manure Application Soil Science Society of America Journal, Vol 48, 1984

252	Manure Spreading	Long, F.L., et al.	Effects of Soil Incorporated Dairy Cattle Manure on Runoff Water Quality and Soil Properties Journal of Environmental Quality, Vol. 4, No. 2, 1975
253	Confined Livestock	Koelliker, J.K., et al.	Performance of Feedlot Runoff Control Facilities in Kansas ASAE Summer Meeting, 1974
254	Confined Livestock	Larson, C.L., et al.	Performance of Feedlot Runoff Control Systems in Minnesota ASAE Summer Meeting, 1974
255	Manure Spreading	Mather, A.C., et al.	Manure Effec_ on Water Intake and Runoff Quality from Irrigated Grain Sorghum Plots Soil Science Society of America Journal, Vol. 41, 1977
257	Manure Spreading	Walter, Jack N.	Phosphate and Nitrate Removal by a Grass Filtration System for Final Treatment of Municipal Waste M.S. Thesis, Agricultural Engineering Dept, The Pennsylvania State University, 1974
258	Manure Spreading	Converse, J.C., et al.	Nutrient Losses in Surface Runoff from Winter Spread Manure Transactions of the ASAE, 1976
259	Manure Spreading Confined Livestock	Thompson, D.B., et al.	Winter and Spring Runoff from Manure Application Plots ASAE Summer Meeting, 1978
260	Manure Spreading	McCaskey, T.A.	Water Quality of Runoff from Grassland Applied with Liquid, Semi Liquid, and Dry Dairy Waste Livestock Waste Management, 1971
261	Manure Spreading	Steenhuis, T., et al..	Winter Spread Manure Nitrogen Loss ASAE Summer Meeting, 1979
262	Manure Spreading	Keeney, D.R., L.W. Walsh	Sources and Fate of Available Nitrogen in Rural Ecosystems
263	Manure Spreading	Westerman, P.W., et al.	Erosion of Soil and Manure After Surface Application of Manure North Carolina Agricultural Research Service, 1980
264	Irrigation	Stewart, B.A., et. al.	Yield and Water Use Efficiency of Grain Sorghum in a Limited Irrigation Dairyland Farming System Agronomy Journal, 1983
266	Irrigation	Michelson, R.H., et al.	Till-Plant Systems for Reducing Runoff under Low-Pressure, Center Pivot Irrigation Journal of Soil and Water Conservation, 1987
268	Irrigation	DeBoer, D.W., et al.	Primary and Secondary Tillage for Surface Runoff Control Under Sprinkler Irrigation ASAE, 1987

292	Irrigation	King, J. Phillip, Julie Wright	Interim Report: Irrigation Water Management Systems, Draft, November 15, 1991 Department of Civil, Agricultural and Geological Engineering, New Mexico State University Prepared for USEPA, NPSCB, Contract No. 68-C9-0013
293	Cropland Erosion	King, J. Phillip, Julie Wright	Interim Report: Sediment Delivery Estimation Methods, Draft, November 15, 1991, Department of Civil, Agricultural and Geological Engineering, New Mexico State University Prepared for USEPA, NPSCB, Contract No. 68-C9-0013
294	Manure Spreading	Steenhuis, T.S., et al.	Ammonia Volitilization of Winter Spread Manure Transactions of the ASAE, Vol. 22, No. 1, pp. 152-157, 1979
310	Cropland Erosion	Arcieri, W.R., et al.	Tillage and Winter Cover Effects on Runoff and Soil Loss in Silage Corn Atlantic Regional Meeting of the ASAE, August, 1986
311	Nutrient Managemtn	Romkens, M.J.M., et al.	Nitrogen and Phosphorus Composition of Surface Runoff as Affected by Tillage Method Journal of Environmental Quality, Vol.2, No. 2, 1973
313	Manure Spreading	Long, F. Leslie,	Runoff Water Quality as Affected by Surface-applied Dairy Cattle Manure Journal of Environmental Quality, Vol. 8, No. 2, 1979
330	Cropland Erosion	Mueller, Dwight H.	Effect of Selected Conservation Tillage Practices on The Quality of Runoff Water M.S. Thesis, University of Wisconsin, 1979
331	Cropland Erosion	Schwab, G.O., et al.	Sediment and Chemical Content of Drainage Water Joint Meeting of ASAE and CSAE, 1979
333	Cropland Erosion	Yoo, K.H., et al.	Surface Runoff and its Quality from Conservation Tillage Systems of Cotton
335	Cropland Erosion	Spomer, R.G., et al.	Soil and Water Conservation with Western Iowa Tillage Systems Transactions of the ASAE, Vol. 19, No. 1, 1976
340	Nutrient Management	Spooner, J., et al.	Nonpoint Sources: NPS Policy, Economics, and Planning Research Journal WPCF, Vol. 62, No. 4, June 1990
347	Irrigation	Yonts, C.D., et al.	Furrow Irrigation Performance in Reduced-Tillage Systems Transactions of the ASAE, Vol. 34, No. 1, 1991
348	Cropland Erosion	Roy, B.L., A. R. Jarreet	The Role of Coarse Fragments and Surface Compaction in Reducing Interrill Erosion Transactions of the ASAE, Vol. 34, No. 1, 1991
352	Cropland Erosion	Younos, T.M., et al.	Fate and Effects of Pollutants: Nonpoint Sources (literature review), Journal WPCF, Vol. 59, No. 6, 1987
353	Cropland Erosion	JHayes, .C., J.E. Hairston	Modeling Long-Term Effectiveness of Vegetative Filters as On-Site Sediment Controls ASAE Paper No. 83-2081, 1983