

Agricultural Drainage Water Management Systems for Improving Water Quality and Increasing Crop Production

Introduction

Drainage water management can improve water quality and increase crop production. The purpose of an agricultural drainage water management system (ADMS) is to allow for the adjustment of the water table, minimize drainage during times of the year when drainage requirements are reduced, and provide for adequate drainage when needed most. Management of drainage water can provide environmental benefits by reducing the quantity of nutrient enriched drainage water leaving fields, and can provide production benefits by extending the period of time when soil water is available to plants. Water management structures are installed in strategic locations on a field drainage system that provide points of management for the operator. This fact sheet identifies published materials describing agricultural drainage and provides some key considerations for planning and designing a surface, subsurface, or combination surface and subsurface ADMS.

Publications

Agricultural drainage guides are published by both the Cooperative State Research, Education, and Extension Service (CSREES) and by Natural Resources Conservation Service (NRCS). Guides published at the national level provide information for the design, operation, and maintenance of various types of drainage systems. State and local guides provide specific information that address local conditions such as unique soils, local agronomic practices, as well as important legal information regarding regulations, easements, necessary permits, and discharge regulations.

Local CSREES offices and NRCS offices should be contacted concerning the availability of local and state drainage guides. Sources and contents of national publications that deal with drainage design and management are listed below.

The National Handbook of Conservation Practices (NHCP) Practice Standard 544, Drainage Water Management, contains information on why and where the practice is applied, and sets forth the minimum technical criteria that must be met during the application of that practice in order to achieve intended purposes. National conservation practice standards are adapted locally to include State and local criteria. The conservation practice standard developed for the county or parish in which you are working should be used to plan, design or install a conservation practice. This standard can be found in Section IV of the Electronic Field Office Technical Guide (eFOTG) at <http://www.nrcs.usda.gov/technical/efotg/>. If this standard is not available in the eFOTG, you should contact the NRCS State Office <http://www.nrcs.usda.gov/about/organization/regions.html#state>, or a local USDA Service Center <http://offices.usda.gov/>. Additional information, such as construction specifications and job sheets, may also be available from the eFOTG web site or the local NRCS office.

National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 14, Water Management (Drainage) provides comprehensive guidance for the planning and implementation of surface and subsurface drainage systems for agricultural land. Chapter 14 may be found at ftp://ftp.wcc.nrcs.usda.gov/water_mgt/EFH&NEH_Drainage_Chapters/EFH14.pdf.

National Engineering Handbook, Part 624, Chapter 10, Water Table Control is a guide for the evaluation of potential sites and the design, installation, and management of water table control in humid areas. It is similar to Part 650 Chapter 14, but with a greater emphasis on water table control. Chapter 10 may be found at ftp://ftp.wcc.nrcs.usda.gov/water_mgt/EFH&NEH_Drainage_Chapters/neh624_10.pdf.

Where to Apply the Practice

Agricultural drainage is accomplished by a system of surface ditches, subsurface conduits, or by a combination of surface and subsurface components. Drainage systems collect and convey water from fields. Drainage water management can be applied on drained fields where outflows from the drains can be controlled. Some older systems and many newer systems can be adapted to allow for the management of drainage water. Management of drainage water is most effective on systems with pattern drainage, but some systems with random drains can also achieve benefits. If the existing drainage system needs extensive repair or is otherwise not functioning properly it may be necessary to install a new drainage system. When replacing an older drainage system with a new system, make the older system inoperable or incorporate its operation into the new system to avoid undesirable interactions between the two systems. Even where drainage water management is not a goal for new systems, consider planning for future conversion to a managed system.

The topography should be relatively uniform, and flat to gently sloping within a management unit or zone. Non-uniform water table depths can lead to non-uniform crop growth that complicates management decisions. Slopes of 1% or less are recommended. Water management structures should be placed every 1' to 1.5' change in elevation along the drainage ditch or conduit. As the slope increases, more water management structures are required and economic factors and erosion concerns begin to detract from the benefits of the ADMS. A way to minimize the number of water management structures is to install the drains along the contour. Structures should be located on main lines that serve a number of laterals in order to minimize the total number of structures required.

Some agricultural drainage systems are part of a network involving multiple landowners. In such situations, managing a drain on one field can have an adverse impact on operations of adjoining properties. Even without interconnected drainage systems, the impacts of ADMS should be evaluated with respect to adjoining fields.

Water Management Structures

Retro-fitting an existing subsurface drainage system involves the installation of water management structures. The management mechanism on the structures may be flash boards, gates, valves, risers, and pipes. Flash board risers allow flexibility in manual management of the drainage water. Flashboard type risers can be full-round pipe risers or half-round pipe risers. The full-round risers are used when the control structure is located within the field, while half-round risers are used at the outlet. Gates or valves can be used to temporally stop the flow through the drain, or may be used in such a way that there is a low water table when the gate is opened, and a raised water table when the gate is closed. Gate or valve structures are sometimes automated.

The riser should be large enough to maintain the cross-sectional area of flow from the drain and the length of the flashboard should compensate for the transition from pipe flow to weir flow. It has been a common practice to make the length of the weir a minimum of 1.3 times the diameter of the drain in rectangular risers and 1.7 times the diameter of the drain in circular risers. It is important to size the riser large enough for the easy removal and placement of flash boards. Flashboards made of wood can swell when wet and become difficult to remove. It may be more convenient to remove these boards with a chainsaw and replace them with new flashboards.

Water management structures that are not automated must be easily accessible and clearly visible for safety purposes so they are not damaged during field operations. The drainage conduit should be non-perforated within 20 feet of a control structure. Small amounts of seepage at the control structure are usually not a problem. Providing the materials are resistant to damage from ultraviolet light, plastic risers are acceptable except where there is danger of fire, or where they may be damaged by freezing of water surrounding the riser.

Impacts of Drainage Water Management

Drainage water management can have a significant impact on the transport of nitrogen, phosphorous and sediment to surface waters and on crop production. Lowering the water table increases the amount of water passing through the soil. Nitrates and soluble phosphorous move with the drainage water and are transported to the drainage outlets. A lower water table also reduces the frequency and magnitude of surface runoff, and thereby reduces the erosion potential, sediment transport, and the transport of sediment-adsorbed phosphorus. The aerobic conditions created in drained soils decrease the occurrence of denitrification.

Raising the water table decreases the amount of water passing through the soil, and proportionally decreases the transport of nitrates and soluble phosphorous from the field. Raising the water table during the non-growing season can result in a 30% reduction in the discharge of nitrates, but reductions of 50% or greater have often been accomplished. Raising the water table can also increase the amount of surface runoff, leading to increased erosion, sediment transport and transport of sediment-adsorbed phosphorous. Erosion and sediment transport can be controlled with residue management, buffers, grassed waterways, and other conservation practices. Anaerobic conditions created in saturated soils increases the occurrence of denitrification, further reducing nitrate-nitrogen in the drainage water

Lowering the water table improves field trafficability and timeliness of crop management operations such as field preparation, planting, and harvesting, and can extend the growing season by allowing earlier access to the field. With a low water table, ponding is less likely to occur or to be sustained when it does occur. A lower water table results in aerobic soil conditions and an increased depth of the root zone. Partially raising the water table after crops are established can conserve soil moisture and may enable a crop to be more productive in the years where there is an extended dry period during the growing season.

A Basic Recommended Strategy

A drainage system infrastructure that enables the operator to manage the water table provides an opportunity to take advantage of the benefits of both high and low water tables. Deciding when to raise or lower a water table can be a difficult decision, particularly when rainfall is uncertain. As with many other practices, more intensive and careful management creates a potential for achieving greater advantages from the system.

In absence of a detailed analysis, there are some basic strategies that can be employed to greatly improve the functionality and benefits of the system. A high water table in the winter months will decrease the transport of nitrates and soluble phosphorus to surface waters. The water table should be lowered in the spring early enough for the field to be accessible for seedbed preparation, planting, and other field operations. Lowering the water table two weeks before field operations in the spring is generally sufficient.

After planting, the water table can be raised to conserve soil moisture for use by the crop during extended dry periods. Once the crop is established, evapotranspiration will often be sufficient to remove excess water from the root zone. It may be necessary to lower the water table during extended wet periods. Careful attention to drainage water management for water conservation may increase yields, particularly in dry years.

In addition to drainage water management, soil, crop, and nutrient management should be a part of a plan to improve water quality in agricultural areas. Nutrient management practices should follow state and local recommendations and NRCS practice standards. Nutrient management applied in conjunction with drainage management can help maximize the effectiveness of both practices.

Field Scale Monitoring

Monitoring of water table elevations can be accomplished by observing water depths in the water management structures, but in many instances it is better to monitor the water table by establishing monitoring wells in the field. A monitoring well can consist of a perforated PVC pipe that extends below the water table with a measuring rod attached to a float. Other methods for reading water depths include a chalked tape or a string and bobber. Monitoring wells can be located near the edge of the field, where they are easier to monitor and where they are protected from agricultural equipment, but for more representative readings, they should be located farther within the field. Monitoring wells placed between drain lines are more representative of the entire field than those placed directly over a drain line. When they are located in the field they need to be clearly marked and protected from damage by farming operations and livestock. The top of the riser and the measuring rod should be higher than the anticipated crop height during the monitoring periods. In colder climates the monitoring wells may not function over the winter months due to freezing. It may not be necessary to maintain the monitoring wells once the relationship between the water table elevation in the field and the depth of water in the control structure is understood.