

Alternative Ditch Design and Management Strategies: Lessons Learned



Indiana Watersheds Webinar Series

March 14, 2012

The Need for Drainage



The Need for Drainage



The Extent of Drainage

**80,000+ miles of ditches in
Indiana, Ohio, and
Minnesota**

The Drainage Network as a Source of Pollutants



Streambank Erosion: Mass Failure

Given:

- 100-ft of ditch, 1 side
- 8-ft deep
- 1:1 side slopes

Scenario:

- Flowing water undercuts bank toe making ditch bank too steep leading to mass bank failure.

Bank Erosion:

- ~125-tons



The Drainage Network as a Sink for Pollutants

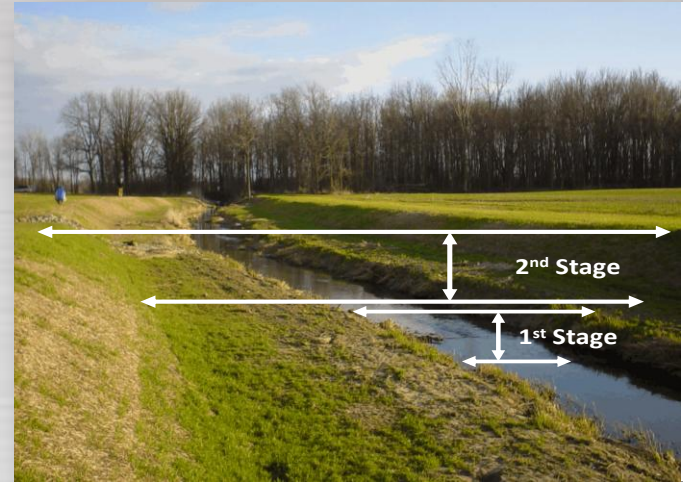


Ditch Design And Maintenance Approaches

Trapezoidal Design



Two-Stage Design



Self-Forming Design



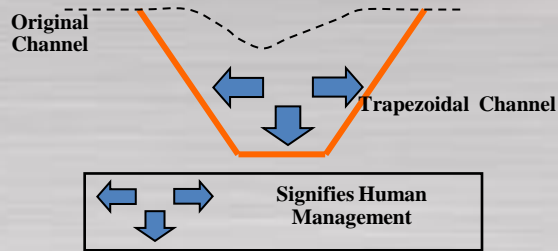
Natural Channel Design



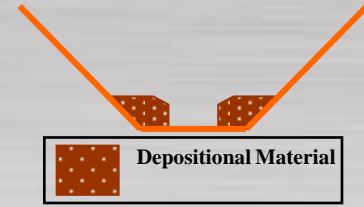
“Do Nothing” or Passive Approaches



A. Trapezoidal Channel

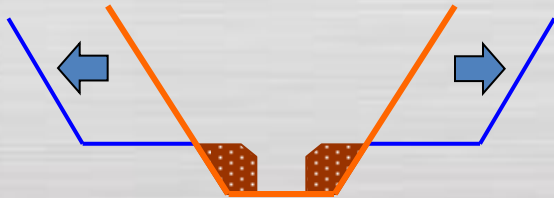


B. Two-Stage Channel (Natural)

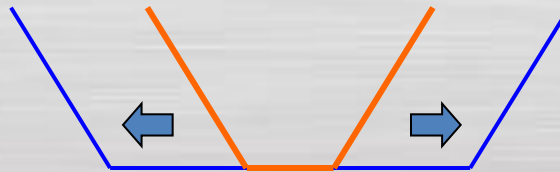


Channel Design and Maintenance Approaches

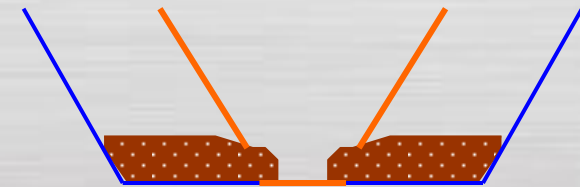
C. Two-Stage Channel (Constructed)



D. Self-Forming Channel (1-month old)



E. Self-Forming Channel (1-year old)



What are the Goals?



Tradeoffs

Elevation (ft)

95

94

93

92

91

36 August 2011

FARM EQUIPMENT



Jon Witter

Applied
Engineering

Considerations for implementing two-stage channels

In the June issue of *Ohio's Country Journal*, the Applied Engineering column focused on an innovative management practice for agricultural drainage channels. In many cases this practice, called the two-stage channel, may have advantages over traditional trapezoidal drainage channels; however, it often comes with additional costs that should be evaluated before making a decision.

This article outlines some important issues that should be considered when deciding how to maintain a drainage channel.

Channel management practices

For nearly 150 years, drainage channels have been constructed by digging deep, straight channels with a trapezoidal cross section (Figure 1). While this approach is easy to construct and can effectively convey runoff, this is not a design that nature would create. Therefore, maintenance often is needed to retain the trapezoidal shape.

Consider a clean natural stream that hasn't been channelized. The stream most likely meanders, avulsed and floods out frequently onto a floodplain several times or more per year. Once a stream is channelized into the trapezoidal form, nature will constantly try to erode the channel or deposit sediments in an effort to move it to a more natural state. In some drainage channels the trapezoidal channel may be quite stable, rarely "silt up," and require infrequent maintenance; however, in some drainage channels this cycle of erosion

and sedimentation may require frequent and costly maintenance to sustain drainage capacity and outlets for subsurface drainage systems.

If you have a drainage channel that is unstable, has inadequate drainage capacity, floods crop fields regularly and/or requires sediments to be removed rather frequently, you may want to consider a two-stage channel. The two-stage approach uses knowledge of what nature would like to create (i.e., a channel with a floodplain) and incorporates that into the existing agricultural drainage channel.

In the two-stage design (Figure 2) the first stage is the most channel that nature would create and the second stage is a floodplain, consisting of low grassed benches that should be used to stabilize the channel and convey larger storm events so that adjacent fields are not flooded. By designing with natural processes in mind we can generate a drainage system that not only performs well for drainage, but also functions more sustainably and requires little ongoing maintenance compared to traditional trapezoidal channels.

Key issues to consider

Decisions to construct a two-stage channel should be supported by an evaluation of the risks and benefits associated with implementing the design. Local conservation professionals, OSU Extension educators or drainage engineers may be able to help with an evaluation of various management alternatives. The most important issues to consider are:

The two-stage design may take some land out of production. In one example an additional 15 feet of width was needed for the two-stage design. Over a 5-mile long channel an additional 15 acres of land was needed to implement the design. The loss of land is typically minimal in shallow channels with small drainage areas and greater in deep channels with large drainage areas.



Traditional trapezoidal drainage ditch

The two-stage design will likely improve conveyance capacity leading to lower water stages and less frequent on-bank flooding. The two-stage channel provides a larger cross-sectional area compared to the traditional trapezoidal channel it replaces. In most cases, this will translate to lower water elevations of flows compared to the trapezoidal channel. Maintaining a lower water surface elevation should lead to improved performance of the subsurface drainage systems installed in the adjacent fields and better soil conditions for field operations and crop growth.

Construction of two-stage channels may impact existing cost-share best management practices. As discussed earlier, the construction of a two-stage channel may require additional land. If that land is enrolled in a cost-share program, such as the Conservation Reserve Program (CRP), the loss of land through two-stage channel construction may constitute a breach of contract and lead to loss of cost-share payments and possible fines. Consultation with the local agencies (e.g., NRCS, SRCD, FSA, etc.) is recommended before installing a two-stage channel that may impact any cost-share best management practices.

Two-stage channels may be eligible for cost-share or grant programs that provide funding to offset costs of construction for environmental benefits. In several states various agencies have recognized the two-stage channel as a conservation best management practice, and cost-share or grant funding is available for implementation. Sources of funding for this type of work vary from state to state. In Indiana, cost-share payments have been made through the USACE's Environmental Quality Incentives Program (EQIP). In Ohio, funding has previously been available through various environmental and mitigation programs. In the future, water quality trading programs may be an additional source of funding to support this work. Upfront costs of two-stage channel construction will likely be higher than traditional maintenance approaches. Two-stage construction often requires additional resources for earthwork and



Two-stage channel

disposal, reconstruction of the outlets, and erosion control that will probably require more initial investment.

Long-term maintenance costs will likely be lower for two-stage channels as they form a self-flushing system that is self-maintaining. Two-stage channels have an inset channel that is self-maintaining. It is less likely to fill up over time resulting in a channel that requires little or less frequent maintenance. Reductions in long-term maintenance needs may outweigh the additional initial construction costs.

Water quality treatment from vegetation on the floodplain bench represents a side-benefit based on the prevention of downstream water pollution. The small floodplain benches within the two-stage channel provide water quality benefits. Research suggests that nitrogen, phosphorus and sediment pollution is retained or muted by the channel, which can help protect streams, lakes and public drinking water supplies.

Summary

Much of Ohio depends on improved surface and subsurface drainage for reliable and profitable crop production. Effective management of drainage channels is needed to ensure that drainage systems function efficiently while providing important conservation benefits. In areas where surface in fields with subsurface drainage is a problem and/or channel systems require frequent maintenance the two-stage channel approach may be a good alternative. It is also a useful approach where land use activities are causing downstream water quality problems.

For more research and/or assistance, Department of Food, Agricultural and Biological Engineering, can be contacted at 614-292-5126 or info@fabe.osu.edu. This column is provided by the Ohio State University Department of Food, Agricultural and Biological Engineering (FABE) Extension, Ohio Agricultural Research and Development Center, and the College of Food, Agricultural and Environmental Sciences, Professor Andy Ward and Jessica D. Anderson contributed to this article.

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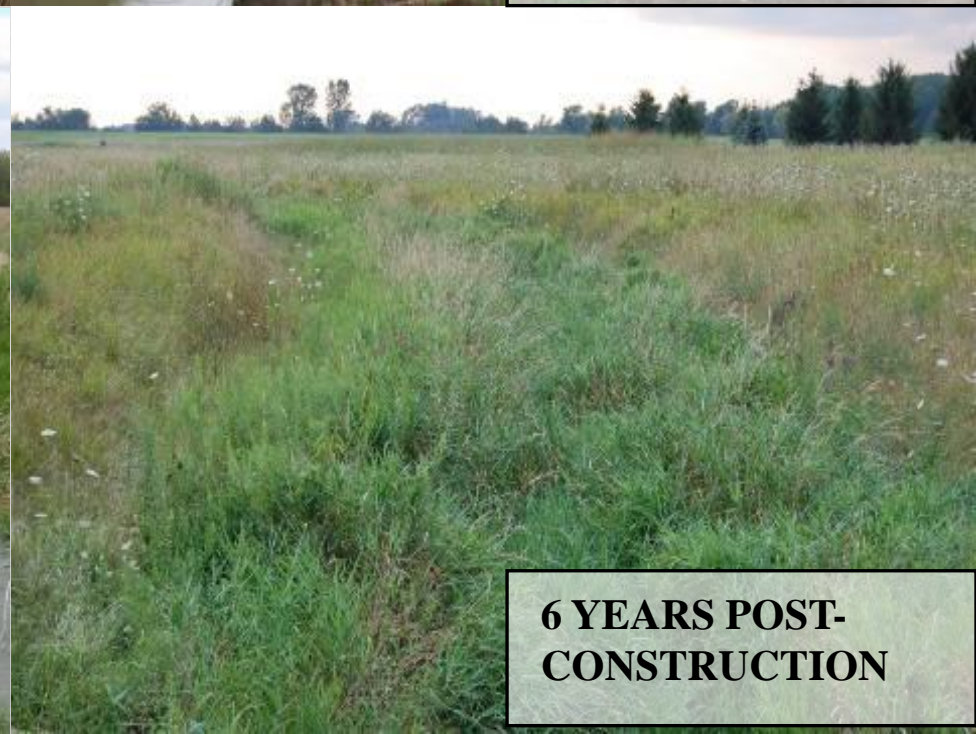
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20

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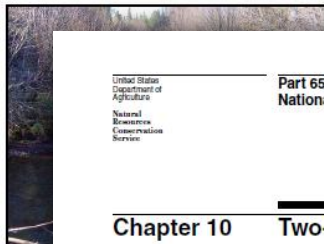
Bull Creek Tributary, Wood County, OH



United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Stream Restoration Design



Chapter 10

Two-Stage Channel Design



1210

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G.E. Powell, A.D. Ward, D.E. Mecklenburg, and A.D. Jayaraman

Abstract: Outlined is a practical approach to size and modify agricultural drainage channels to two-stage geometry to maintain drainage function and capacity while increasing channel stability. Two-stage channel systems consist of an inset channel and small floodplain (benches) within the ditch confines. The two-stage channel sizing procedure includes nine steps: (1) project identification; (2) data collection; (3) data analysis; (4) hydrologic evaluation; (5) conceptual channel system sizing; (6) project assessment; (7) design and/or final design; (8) construction; and (9) monitoring and assessment of performance. Channel width

Key words: bankfull—best management practice—drainage—flood

Rural watersheds in the Midwest region of the United States are dominated by agricultural land uses that often incorporate subsurface drainage improvements. Subsurface drainage systems discharge into headwater channels that have been deepened and straightened to facilitate the flow of water from drainage outlets and to increase

of water from drainage outlets and to lessen flooding of agricultural fields (figure 1A). Often, these modified headwater systems exhibit geomorphic features such as a main channel with a series of bars and benches (Landwehr and Rhoads 2003; Jayakaran et al. 2005). However, rarely do these systems exhibit out-of-bank flows onto a broad floodplain and, in many cases, when stable benches form they are periodically removed by human maintenance activities (figure 1B).

In contrast to agricultural ditches and modified rural headwater channels, natural streams and rivers in the region often have a main channel and an active floodplain that is flooded several times or more annually.

Bankfull dimensions of these natural streams are sized and maintained by fluvial processes.

to conceive that subsurface drainage function is diminished due to a reduction in outlet depth or conveyance capacity. This work includes removal of woody vegetation, weeds, and deposited sediment, and channel erosion stabilization associated with bank failures and toe scour (Fausney et al. 1982). Rather than removing stable benches to improve conveyance capacity, an approach has been developed that widens the top portion of the cross-section to provide larger benches. The approach for sizing two-stage systems (figure 2) consists of: (1) an inner channel to convey the bankfull discharge; (2) a flood plain to store the excess flow; and (3) sufficient capacity above the benches to reduce the likelihood that flow will overtop the ditch banks and flood surrounding land. The primary intent for establishing a two-stage geometry is to have a stable ditch system working in harmony with natural

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²⁴⁴ G.E. Powell, A.D. Ward, D.E. Mecklenburg, J. Draper, and W. Word

Abstract: This paper presents case studies with two-stage channel groin structures that were based on geomorphic principles. Geomorphic data were collected at the project site and throughout the watershed. Watershed specific regional curves were developed for each project. Factors considered in sizing each system were the width and depth of the inner channels that were associated with the channel forming discharge, bench widths, and the side slopes of the banks of the second stage. The channel-forming discharges for the inner channels were based on the design of the second stage. The second stage was designed to provide the preconstruction inner channel intact and constructs, or widens, benches, or elevations consistent with channel-forming and regional curve concepts. Two-stage channel inner system construction was discovered to be easier than clean out operations for traditional trapezoidal channel maintenance. Overall, two-stage channel projects cost more than traditional channel maintenance, but they are an anticipated improved grade life. Since construction, construction cost savings have been realized. No erosion changes were observed. No changes were found in the benches, but the inner channels have narrowed.

Key words: bankfull discharge—best management practice—channel-forming discharge—drainage ditch—geomorphology

Headwater streams throughout the United States have been highly modified

Midwest states have been highly motivated to enhance drainage and capacity. In the Midwest, agricultural channels (ditches) are often deepened and straightened to facilitate the flow of water from subsurface drainage outlets and maximize conveyance for a design event discharge. Urban channels are often enlarged to accommodate discharge increases from development and to reduce

The authors have developed detailed procedures for sizing two-stage channels using measured data collected at the project site, the surrounding watershed, and similar stable channels if available (Powell et al. 2007). These procedures were used to size two-stage systems for the case studies presented in this paper.

Case Studies

The case studies are located in Indiana, Michigan, and Ohio (figure 1). The sizing procedure for each case study was based on

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To Build a Better Ditch

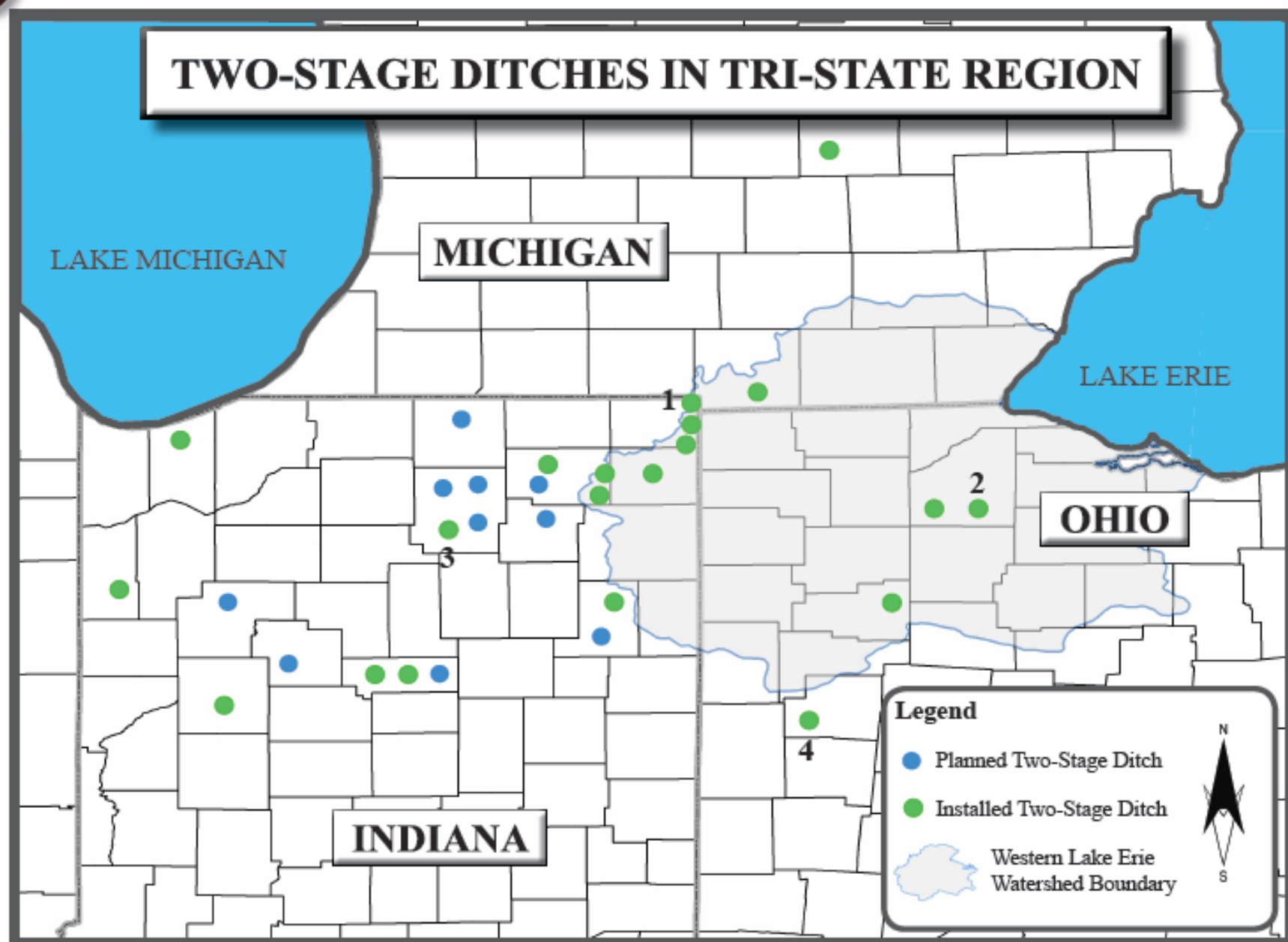


<http://vimeo.com/7901535>

1

(Click and hold on numbers in corners to see examples of two stage ditch projects)

2



3

(Click and hold on numbers in corners to see examples of two stage ditch projects)

4

Bench Formation Issues



May have difficulty maintaining two-stage form if 1) the ditch is very narrow, 2) small drainage area, 3) very low energy

Weak Bench Formation in a Wide Ditch with Good Baseflow

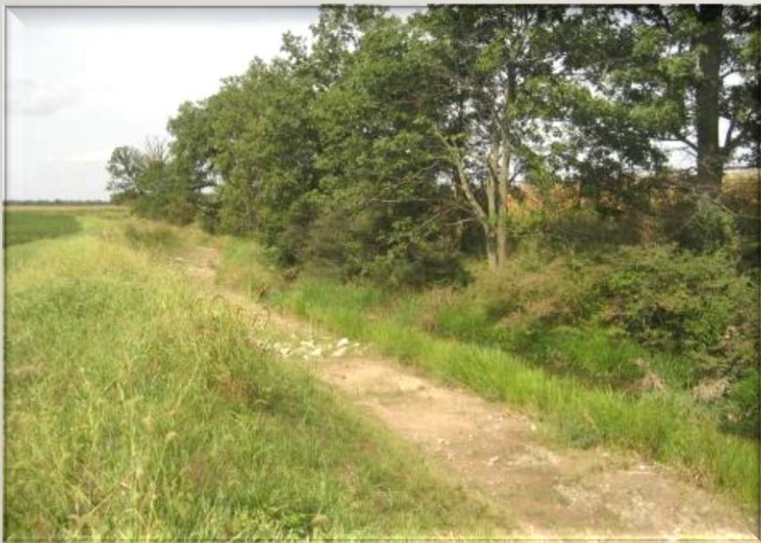


Spoil Distribution



5/8/2002

Compacted or Poor Bench Soils



Establishing Vegetation



One Side Construction & Shading



Surface Runoff Control



Velocity Around Bends



Sizing Bench Widths



Bench Heights and Tile Outlets



Tile Outlet Design



Education, Outreach, Demonstration, and Communication



08/26/2004

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