PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2011
Two-Stage Ditch Design

Agricultural & Biological ENGINEERING

Emily Stein (ANRE) Brice Brown (ASM)

Problem Statement

This project is sponsored by Natural Resources Conservation Service (NRCS) and is intended to convert an existing tile drainage system that is cracked in several places to a two-stage ditch. In addition to cracked tile, there is water standing in the field and depressions in the grass waterway where the water has already begun to form a ditch.

This project is funded by Section 319 of the Clean Water Act. Section 319 provides federal funding to mitigate nonpoint source pollution.

Broken Clay Tile

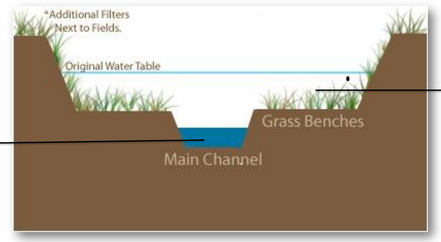
The Current Grass Waterway

Standing Water in the Field

Background

A two-stage ditch is a intended to mimic natural stream behavior. Benefits to this design practice include increased bank stability by reducing the stresses on the banks which reduces erosion and maintenance. The benches of the ditch are between 2 to 4 times the width of the bottom channel.

The first stage is designed for the 0.5 to 1 year 24 hour storm and generally is filled with water.

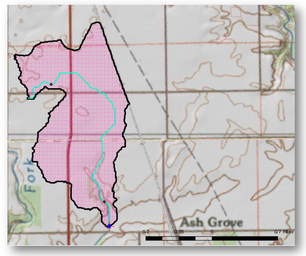


The second stage is designed for the 100 year 24 hour storm in urban areas while in agricultural areas the 10 year 24 hour storm is generally used for design purposes.

Alternative Solution

Replacing the cracked tile is the alternative to a two stage ditch. The existing 18 inch tile would be replaced with 18 inch plastic tile. The rough estimate of replacing the tile is over $30,000 which does not include the cost of excavation. A two-stage ditch was chosen because the landowner secured federal funding for its construction.

The existing grass waterway (above) and the watershed (below)



Preliminary Design

- **TR-55 to estimate peak flows**
  - **Drainage Area= 941.1 Acres**
  - **CN=78.6**
- **Flow**
  - **1st Stage: 100 cfs**
  - **2nd Stage: 431 cfs**
- **Time of Concentration**

$$t_c = \frac{t_L}{0.6} \qquad t_L = \frac{L^{0.8}(S+1)^{0.7}}{1900Y^{0.5}}$$

L=hydraulic length
S=max soil water retention
Y=average land slope (%)

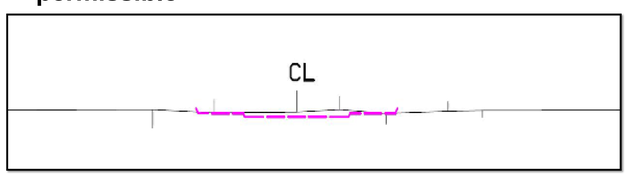
- **INDR Rainfall Maps**
  - **0.5 year 24 hour storm**
  - **10 year 24 hour storm**
- **Manning's Equation**
  - **Comparison to TR -55**
  - **L-THIA & Stream Stats**

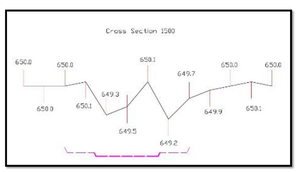
Final Design

- **Final dimensions**
  - **1st Stage**
    - **Depth 0.9 feet**
    - **Width 30 feet**
  - **2nd Stage**
    - **Depth 1 foot**
    - **Width 13 feet benches on either side**
  - **Slope 0.32%**

Final Two-Stage Ditch Design

- **Final velocity is 3.6 fps in the first stage and 5.3 fps. This exceeds maximum allowable design velocity of 2 fps without stability checks, but is permissible**



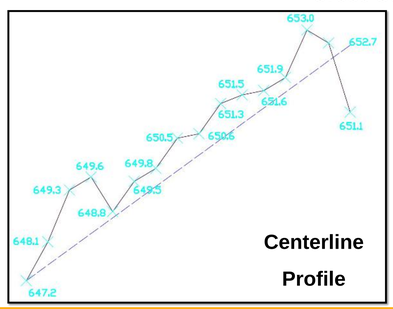


Cross Section 15+00 unskewed and skewed

Construction Costs

- **Cross Sectional Area = 283,813 ft²**
- **Length of Channel = 2389 ft**
- **Excavation Cost = $2.00 yd²**
- **Total Excavation Cost = $21,000**

- **Note this cost does not include equipment, labor, or soil removal from the site**



References

The NRCS Open Channel Design Standard Technical Release-55 (TR 55)
IDNR 1,10,100 year 24 hour Rainfall Maps
L-THIA
USGS Stream Stats
NRCS Web Soil Survey
Haan, C.T., et all. *Design Hydrology and Sedimentology for Small Catchments.*

Sponsor:
Jeff Cannaday, P.E.
NW Area Engineer

Technical Advisor :
Christina Murphy, P.E.

NRCS Natural Resources Conservation Service

PURDUE AGRICULTURE
PURDUE UNIVERSITY

PURDUE ENGINEERING
Think impact.