Two-Stage Drainage Ditch Fact Sheet

Characteristics of a Two-Stage Ditch

A two-stage ditch is either naturally formed (Figure 1) or constructed with an inset channel in the bottom of a larger, typically trapezoidal ditch (Figure 2). Channelized alluvial streams and ditches with perennial flow often form a 2-stage channel based on the hydrology and sediment supply of their watershed and the soils in the channel banks and bed. Two-stage ditches typically have a meandering 1st stage channel and the following beneficial 2-stage channel characteristics:

- the ability to transport bed load sediment more effectively than a wide, shallow ditch, reducing ditch maintenance;
- well-vegetated 2nd stage "benches" that can buttress the channel side slopes, improving side slope stability and reducing erosion and associated maintenance;
- a relatively narrow and deep inset channel often shaded by adjacent vegetation, helping to maintain cooler water temperatures for enhanced aquatic habitat and biota;
- varying degrees of riffles and pools (typically not visible) in the inset channel, including varying depths and diverse substrates such as sand, gravel or cobble that provide valuable aquatic habitat; and
- increased surface area of vegetation, and associated soil microbes that help denitrify drainage waters.

Figure 1. Wilkin CD-44, S. Br. Buffalo River

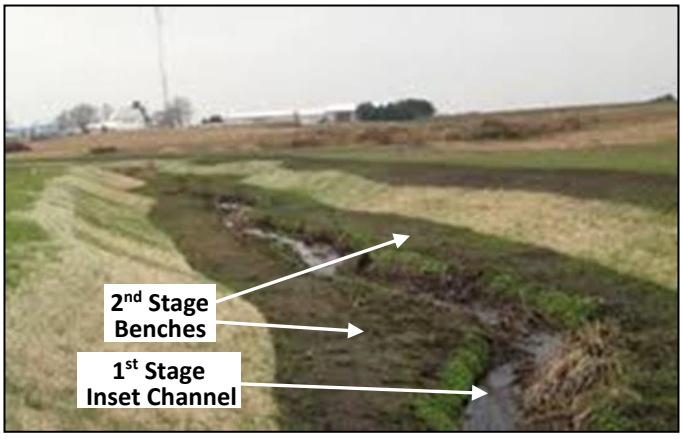

Figure 2. Constructed Two-Stage Ditch

Multipurpose Water Management

Two-stage ditches are one of the Best Management Practices (BMPs) that drainage authorities, local water planning authorities, drainage engineers and others should consider for multipurpose water management. This BMP is most applicable where there is perennial flow, ditch side slopes are slumping and eroding, and/or a ditch requires frequent maintenance due to sediment deposition. There are many channels in Minnesota where a 2-stage channel has naturally started to reform. In those situations, a 2-stage ditch repair with the same flow capacity as the original ditch can be more stable than a single-stage trapezoidal ditch, while providing multipurpose benefits. A 2-stage channel or ditch can be a component of a stream restoration, which often involves re-meandering a channel within a floodplain and sometimes involves set-back levees. See the DNR River Ecology Unit webpage for information about stream restoration.

Watershed plans, including plans developed via the **One Watershed, One Plan Program,** often include strategies for drainage management. Protection and use of 2-stage drainage ditches in priority locations can be a component of these plans to better achieve multiple benefits, including adequate drainage capacity, reduced channel erosion and sedimentation, reduced ditch maintenance, improved aquatic habitat and improved water quality. Examples of 2-stage ditches in Minnesota to date include:

Whisky Creek Tributary, Buffalo-Red River Watershed District

Mullenbach Ditch, Mower County

Judicial Ditch 8, Swift County

Blue Earth County Ditch 57

Guiding Principles and Considerations for Two-Stage Ditches

1. Two-stage ditches are most applicable for channelized alluvial streams or ditches with perennial flow and a significant sediment load where a 2-stage channel has already formed. Another priority application is where there is substantial seepage from ditch banks and/or other soil conditions that make the ditch side slopes unstable.
2. Channelized alluvial streams and ditches in Minnesota that have formed 2 stages are expected to have 1st stage channel dimensions and bankfull flow capacity similar to natural streams in the associated hydrogeomorphic region. The 1st stage typically ranges from the 1-2 year return period, however resources must be consulted during design in order to choose the best dimensions. Existing dimensions, meander pattern, and profile of a naturally formed inset channel within a ditch are often the best way to "design" the 1st stage channel. First-stage channel dimension reference information can also be obtained from regional hydrogeomorphic data available from the DNR River Ecology Unit and other literature (See Resources Section). Because existing inset channels are often deeper than they may appear, it's important to include the 1st stage channel capacity in the analysis and design of the overall hydraulic capacity of a 2-stage ditch.
3. The potential to change conveyance capacity, and the associated affects downstream, must be considered when designing a 2-stage ditch. Design factors affecting hydraulic conveyance capacity of ditches include changes in cross-sectional area, roughness (e.g., vegetation type, height and density), and 1st and 2nd stage channel lengths and slopes. These can be off-setting factors to varying extents depending on flows, depths of flow (channel versus overbank), varied vegetation, increased sinuosity (decrease slope), and backwater effects from downstream. Two-stage ditches can be modeled and designed to have the same bankfull hydraulic capacity as a single-stage trapezoidal ditch and/or combined with other runoff reduction and detention BMPs to avoid increasing downstream peak flows. This is particularly important for runoff events at or near 2nd stage channel capacity.
4. Two-stage ditches can involve additional costs for 2nd stage bench excavation and associated right-of-way compared to a single-stage ditch. This BMP should be targeted to where it is most needed, beneficial and cost-effective.
5. Erosion control during construction and timely establishment of vegetation for erosion control are very important considerations for any project involving construction or modification of a drainage ditch.

Connection to Minnesota Statutes, Chapter 103E DRAINAGE

Minnesota drainage law enables the use of a two-stage ditch design for a "drainage project" (i.e., drainage system establishment, improvement, improvement of an outlet, or a lateral). The drainage engineer appointed by a Chapter 103E drainage authority (county board, joint county board, or watershed district board) can propose whatever channel design is considered best for a "drainage project", including a 2-stage ditch.

Based on stakeholder Drainage Work Group recommendations in 2013, Chapter 103E was revised to enable the use of a 2-stage ditch for a repair petitioned by "an individual or entity interested in or affected by a drainage system", including the drainage authority. (Section 103E.715 **Repair by Petition.**, Subd. 6. **Repair by resloping ditches, incorporating multistage ditch cross-section, leveling spoil banks, installing erosion control, or removing trees.**)

Resources

1. See the MnDNR River Ecology Unit Website or contact Neil Haugerud (neil.haugerud@state.mn.us), Natural Resources Specialist, for regional curves
2. Open Channel/Two-Stage Ditch Design, Ohio State University Extension (see "**Technical Information**" for additional resources)
3. Guidelines for Sizing Southern Minnesota Agricultural Ditches (Two-Stage), Great Lakes Regional Water Program, 2013
4. Improvements in Fluvial Stability Associated with Two-Stage Ditch Construction in Mower County, Minnesota, University of Minnesota, JAWRA, 2017
5. Multipurpose Drainage Management (MDM) Fact Sheet, MN BWSR 3-16-20
6. Chapter 10. Two-Stage Channel Design, USDA-NRCS NEH, Part 654 **Stream Restoration Design**, 2007

Fact sheet provided by the interagency and university Drainage Management Team including:
BWSR, MDA, MDNR, MPCA, USDA NRCS, USDA ARS, USFWS, UMN-EXT, UMN-WRC