INAFSM 2023

Two-Stage Ditches for Flood Reduction and Water Quality Improvements

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INDIANA ASSOCIATION FOR FLOODPLAIN AND STORMWATER MANAGEMENT

Timeless Questions

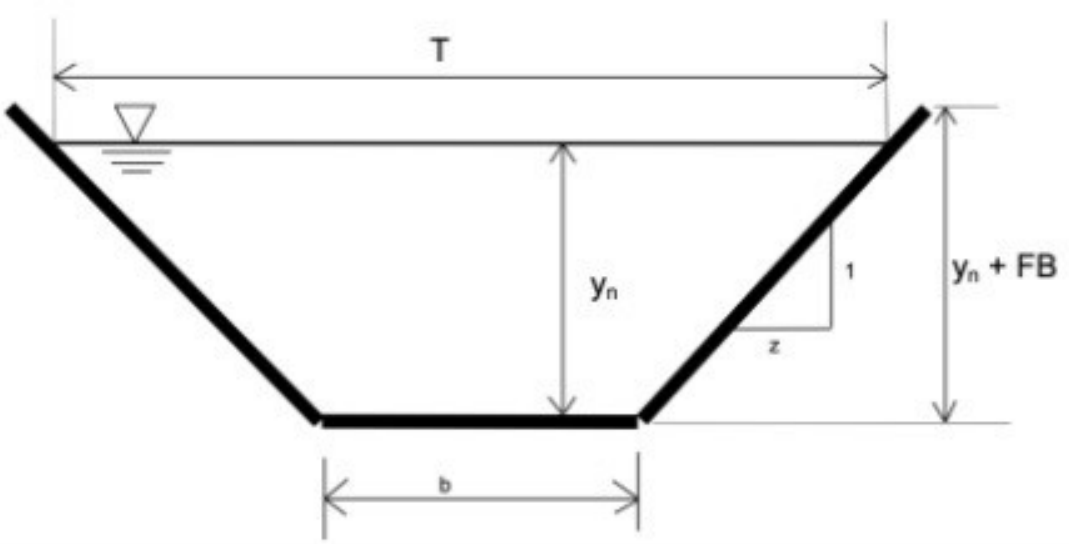
Is there anything in life better than a chocolate chip cookie?

Timeless Questions

YES, Two!

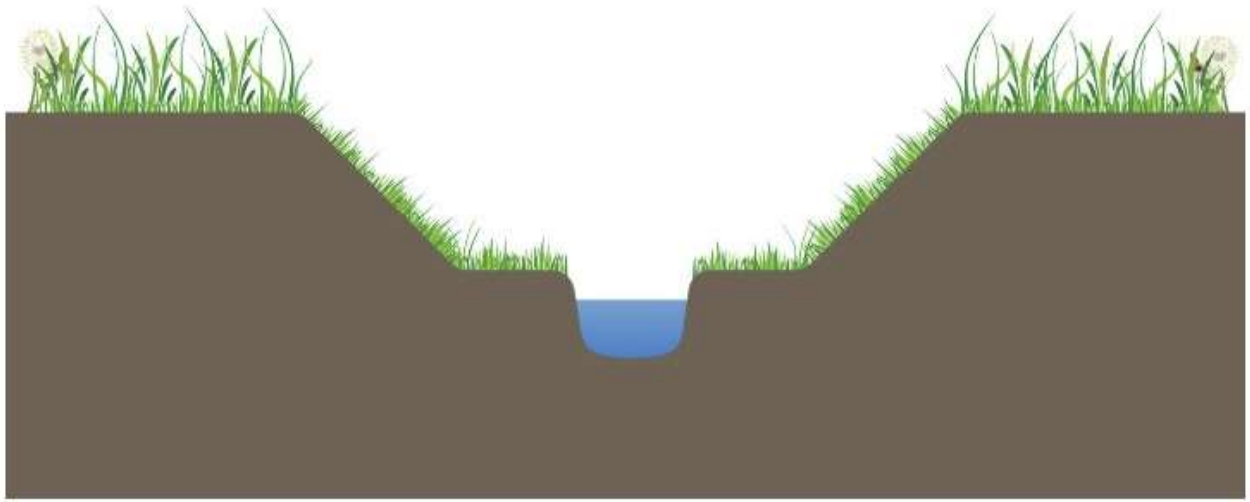
Timeless Questions

Is there anything better than a traditional drainage ditch?



Timeless Questions

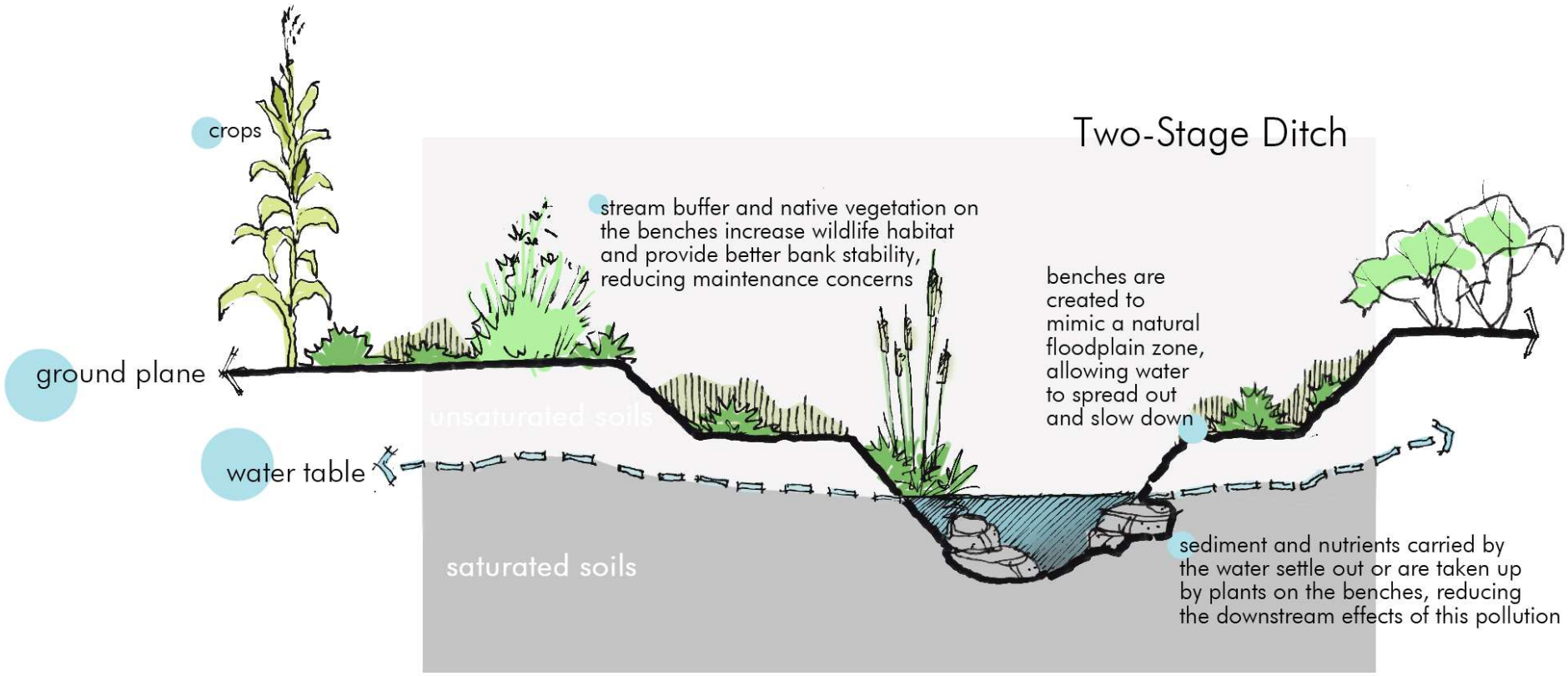
YES, the Two-Stage Ditch



Introduction – Two Stage Ditches

- Historically drainage channels have been designed for the primary purpose of conveyance which has resulted in large trapezoidal shaped channels.
  - Typically accommodates 5-year to 100-year recurrence intervals

What is a two-stage ditch?



Source: Greenwood, Indiana

Introduction – Agenda

- Advantages of the two-stage ditch
  - Water Volume Storage
  - Water Quality
  - Permitting Advantages
- Pre-project Planning
- Design of a two-stage ditch
- Project examples
- Additional resources

Advantages of the Two-Stage Ditch

Advantages of the Two-Stage Ditch

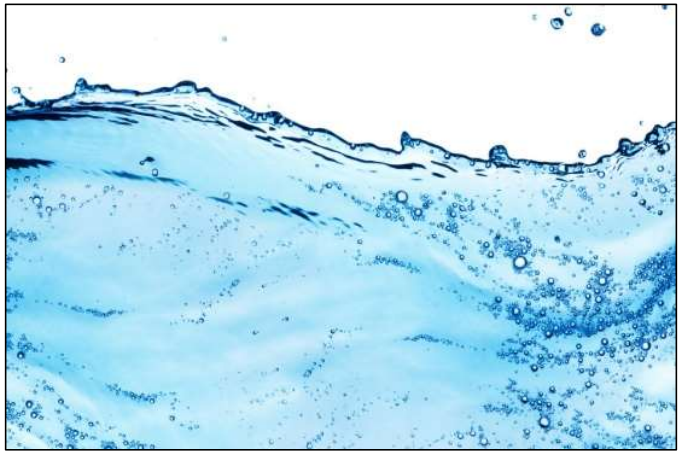
- Water Volume Storage
- Water Quality
- Increased Channel Stability
- Reduced Maintenance
- Permitting Advantages

Water Volume Storage

- Additional watershed storage volume in channel to provide regional detention.
- Reduces downstream flooding risk.
- Slow and reduce peak discharges downstream.

Water Quality

- Reduction in nutrient load.
  - There was a great presentation at last years conference that studied the effect of two-stage ditches on agricultural waterways, showed increased biological nitrate removal, dissolved phosphorus retention, and reduced suspended sediments.



Increase Channel Stability

- The cross-sectional area of the channel flow is wider and more shallow.
- Channel geometry reduces the erosive potential of larger flows
- Sheer stress on the toe of the bank is reduced
- Bench not exposed to low flow, resulting in a dryer surface better for vegetative growth.

Reduced Maintenance

- Side slopes and floodplain bench do not need to be mowed.
- Vegetative growth on the bench helps stabilize the channel while provide water quality benefits.
- Increased side slope stability reducing the probability of slopes needing to be reconstructed.

Permit Advantages

- Avoid disturbance to existing channel below the OHWM for Waters of the US.
- Vegetative plantings on the floodplain bench could potentially be accepted as mitigation.
- Converting a trapezoidal ditch to a two-stage ditch is looked at favorably by the permitting agencies.

Pre-Project Planning

What locations are good candidates for a 2-stage ditch?

- Channels upstream of flood prone areas
- Channels that receive a high nutrient load
- Steep unstable banks/erosion
- Areas with most impact on water quality
- Undersized field tiles/daylighting opportunities
- Watersheds preparing for future development
- Existing channel with a heavy maintenance requirement

Site Assessment

- **Topography and landuse:** Understand the lay of the land to determine if a two-stage ditch is feasible.
  - ROW Concerns, roads, developments, wooded areas
- **Proximity to Built Environment:** Consider how close the stream is to roads, homes, or other infrastructure that could be impacted.
- **Soil Type:** Different soils have different infiltration rates and erosion risks.

Site Assessment

- **Flow Patterns:** Streams with highly variable flow patterns may benefit from a two-stage ditch to manage both low and high flows.
- **Flood Frequency:** If the area is prone to frequent flooding, a two-stage ditch can help in floodplain management.
- **Water Quality:** Streams with poor water quality due to sedimentation or nutrient loading may be improved with a two-stage ditch.
- **Ecosystem Impact:** Consider how the ditch will affect local flora and fauna. The project should aim for a net positive or neutral impact.

Considerations

- **Legal Restrictions/Easements:** Make sure there are no legal impediments to modifying the stream.
- **Access:** How with the site be accessed during construction?
- **Permitting:** Understand what permits will be required and how difficult they will be to obtain.
  - IDNR Construction in the Floodway?
  - IDEM Water Quality Certification?
  - IDEM General Construction Stormwater Permit (yes)
- **Budget:** Construction cost considerations, Purchase of easements
- **Schedule:** How the site will be accessed, Will tree removal be required

How to Design a Two-Stage Ditch

Design Overview

1. Evaluate site
   - Easement limits
   - Topography
   - Access
2. Complete a topographical survey of the channel
3. Perform Wetland Delineation
4. Perform geotechnical analysis/soil borings
5. Evaluate the Hydrology of the watershed
6. Calculate Channel Geometry
7. Prepare Construction Documents
8. Public Outreach

Field Investigations

- Topographical Field Survey
  - Channel slopes and geometry
  - Utilities
  - Property and easement limits
  - Large trees (larger than 4”)
- Geotechnical Investigation/Soil Borings
  - Especially if rock is believed to be encountered
- Wetland Investigations/Waters Report
  - Know where your wetlands are and plan your design around them.

Hydrologic Assessment

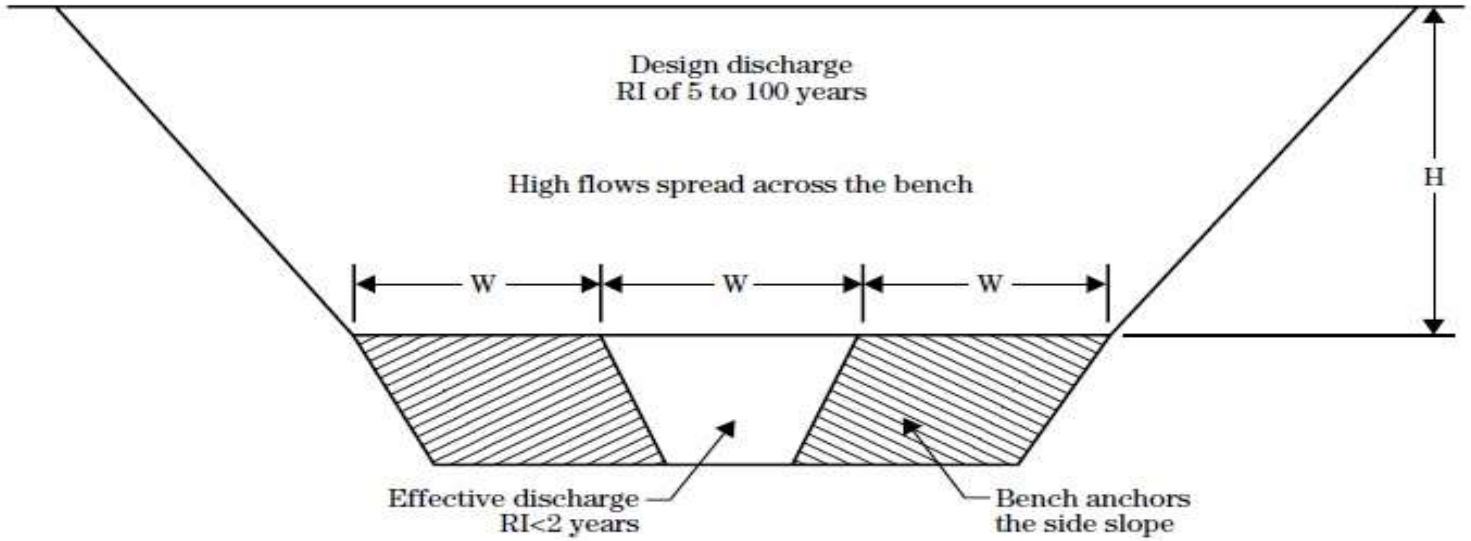
- Indiana Design Manual

Facility Description	Methodology					
	Rational Method*	TR-20 or HEC-HMS	IDNR Coordinated Curves	USGS Gaging Information	Stream Stats	Purdue Regression Equations
Culvert	2	2	1	--	3	--
Bridge or Channel, < 5 sq mi drainage area	--	2	1	3	3	3
Bridge or Channel, ≥ 5 sq mi drainage area	--	3	1	2	3	3
Storm Drain and Inlets	1	4	--	--	--	--
Storage Facility	5	1	--	--	--	--
Pumping Station **	--	1	--	--	--	--

Notes: Must use IDNR Discharge Letter if IDNR Permit is required.

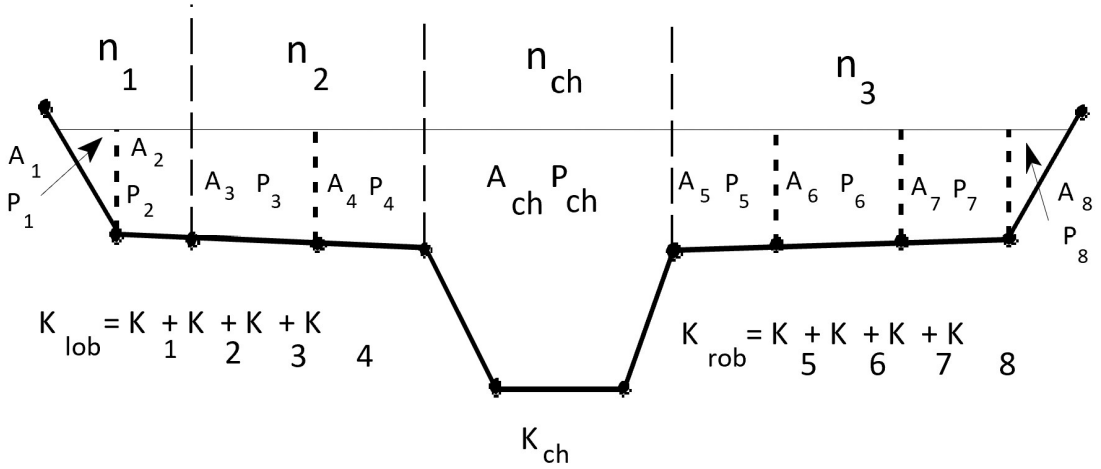
Design of a Two-Stage Ditch

1. Low flow channel (recurrence interval <2 years)
2. Floodplain bench channel (recurrence interval 5 year to 100 year)



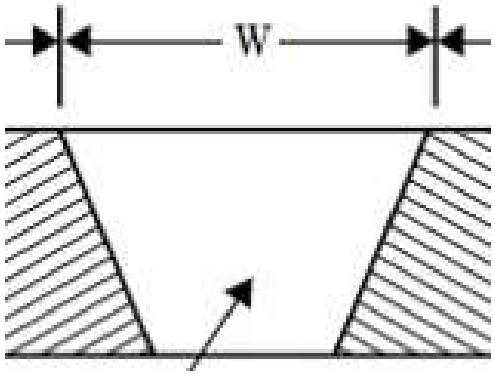
Design Tools and Calculations

- Design tools typically used
  - USACE HEC-RAS
  - Other software packages (SWMM, HY8, etc…)
  - Spreadsheets and calculations
- Information needed
  - Peak flow values (2-yr, 10-yr, 100-yr)
  - Slopes of the channel
  - Land use (existing and proposed)
  - Cross section geometry



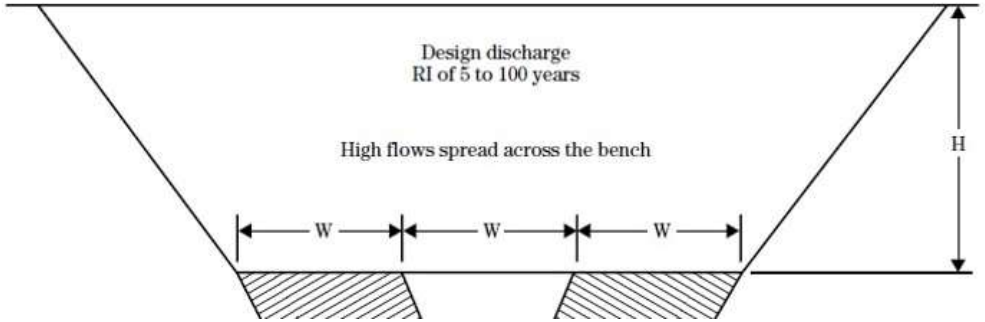
Low Flow Channel Design

- Determine the dimensions of the low flow channel
  - The low flow channel will have alluvial properties, carry most of the sediment
  - Define the recurrence interval (typically 1 to 2 year event)
  - Calculate the required cross-sectional area
  - Height and width will be determined in the next step



Floodplain Bench Channel Design

- Determine the dimensions of the bankfull channel
  - Bench will act as a floodplain within the ditch
  - Establishment of dense grass cover
  - Side slopes and depths that satisfy geotechnical requirements
  - Bench width 3 X bankfull channel top width
  - Design dimensions for the calculated discharge (5 year to 100 year recurrence interval)



Prepare Grading Plan

- Prepare construction documents based on proposed geometry
  - Layout per designed geometry
  - Best done with AutoDesk Civil 3d or similar type program
  - Plan views, profile views, and misc. details
- Keep in mind changes during design and update model if needed:
  - Changes in channel geometry
  - Changes to slopes/elevations
  - If there is obstructions that restrict flow
- Evaluate changes that occur during design/const. and update calculations accordingly

Plan Vegetative Plantings

- Dense grass cover on the bench and side slopes
- Work with stakeholders to determine plantings preferred

Public Outreach

- Keep stakeholders informed
- Regular progress meetings with owner and engineer
- Other Stakeholders that may be interested:
  - Elected officials
  - Other municipalities
    - Local parks department
  - Watershed residents and rate payers
    - Emphasis adjacent and affected property owners
  - Contractors

Permitting

Typical Agency Permitting Times

Agency	Permit Type	Month for Review of Application
USACE	404 Individual Permit*	12-18 months
USACE	404 Nationwide Permit	3 months
USACE	404 Regional General Permit (RGP)*	4-6 months
IDEM	401 with more than 0.1 acre or >300’ of impacts	7 months
IDEM	401 with less than 0.1 acre or >300’ of impacts	4 months
IDEM	Construction General Stormwater Permit (CSGP)	1-2 months
IDEM	Isolated Wetlands*	7 months
DNR	All permits types by DNR*	7-9 months

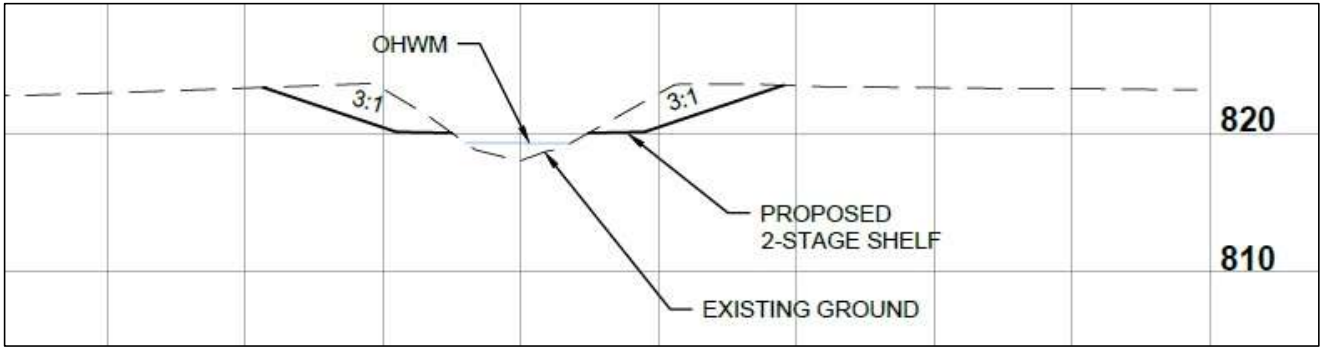
*Mitigation may be needed for permit application.

Application of Two-Stage Ditches

Johnson County Indiana

- Scott-Highbridge Legal Drain in Greenwood Indiana
  - Reconstructed 1,300 feet of channel
  - 245 acre watershed
  - 600 feet of channel classified as wetland
  - Goal to address maintenance issues and increase floodplain storage

Johnson County Indiana



Channel Cross Section

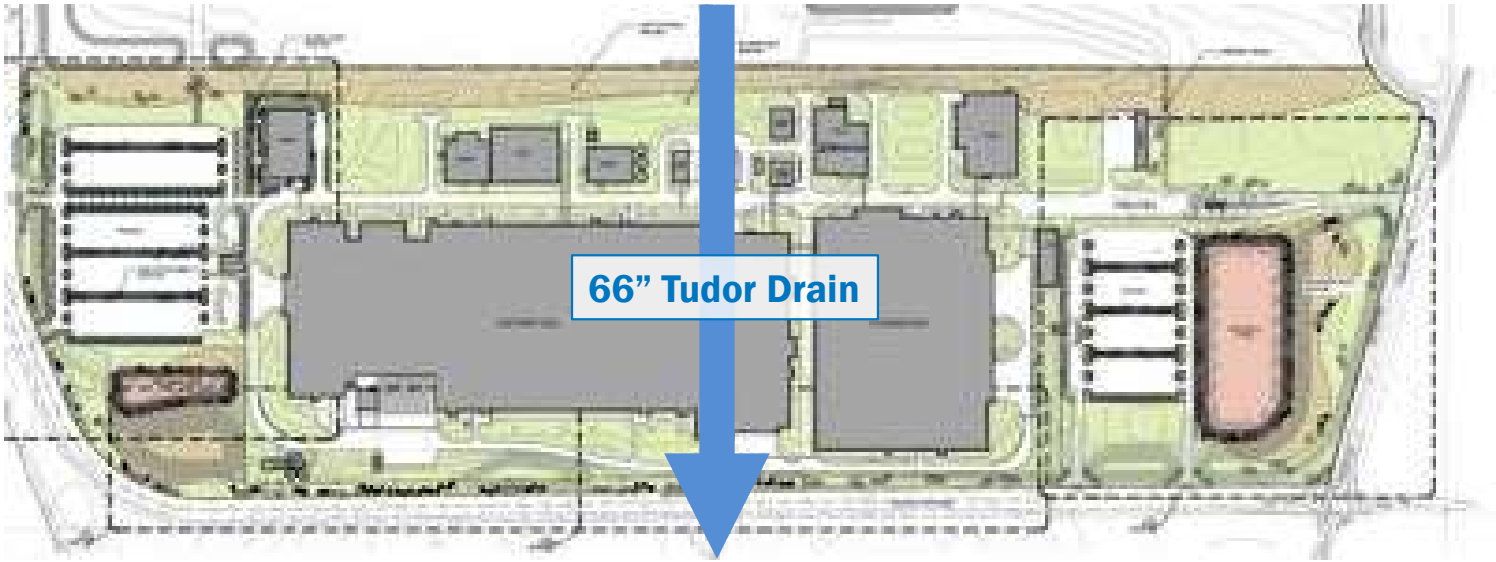
Existing Wetland

Johnson County Indiana

Post-Construction

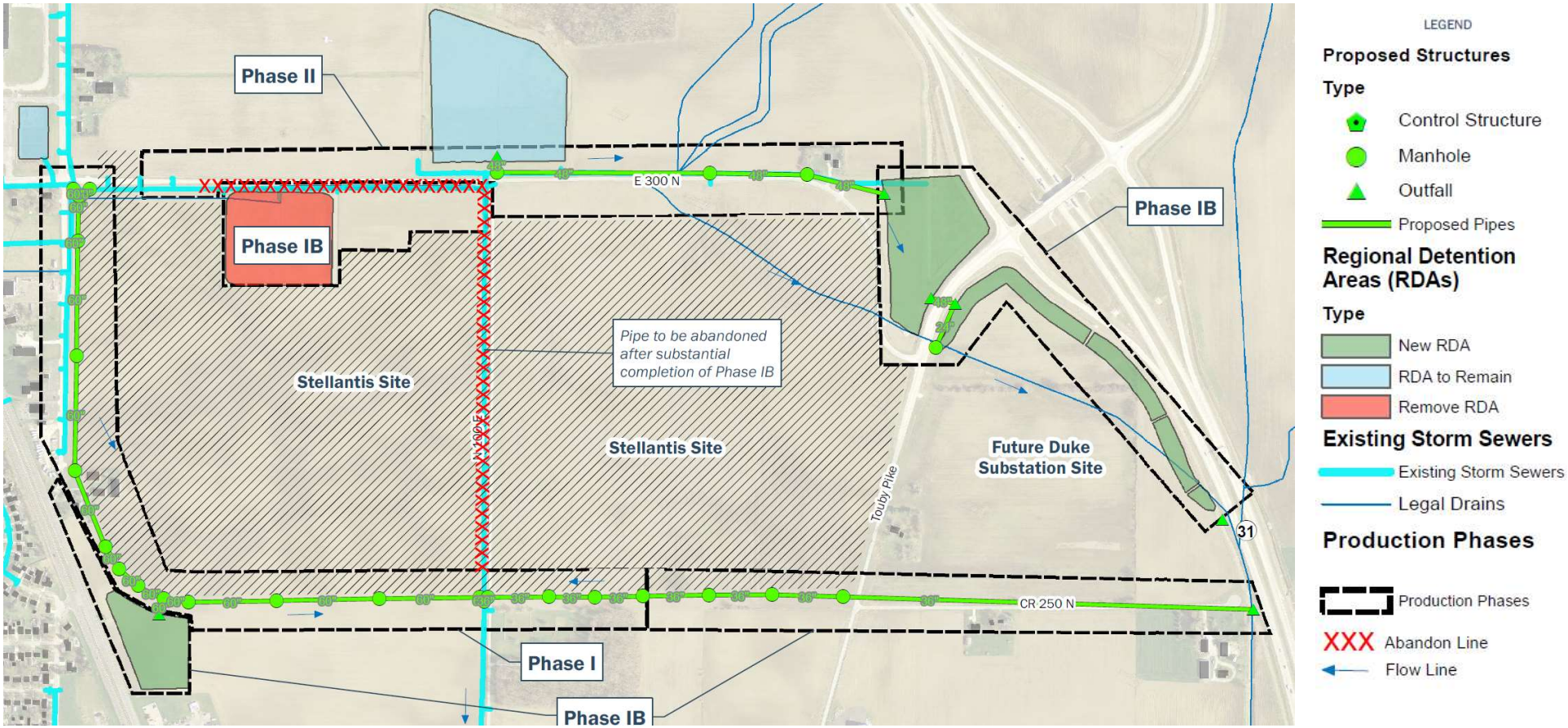
Tudor Drain Relocation

- EV battery factory in Kokomo, Howard County, Indiana
- Joint-venture company created by Stellantis and Samsung SDI



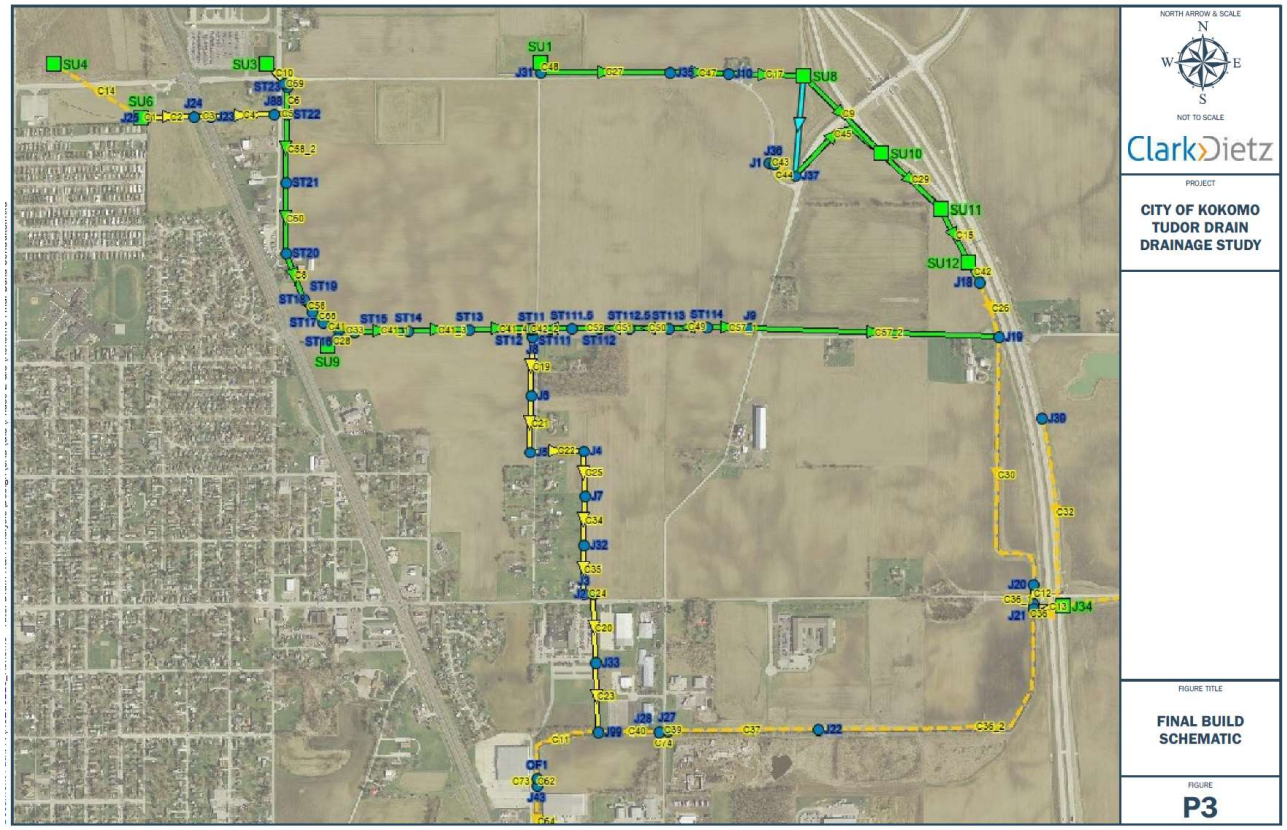
Source: Kokomo Tribune

Tudor Drain Relocation



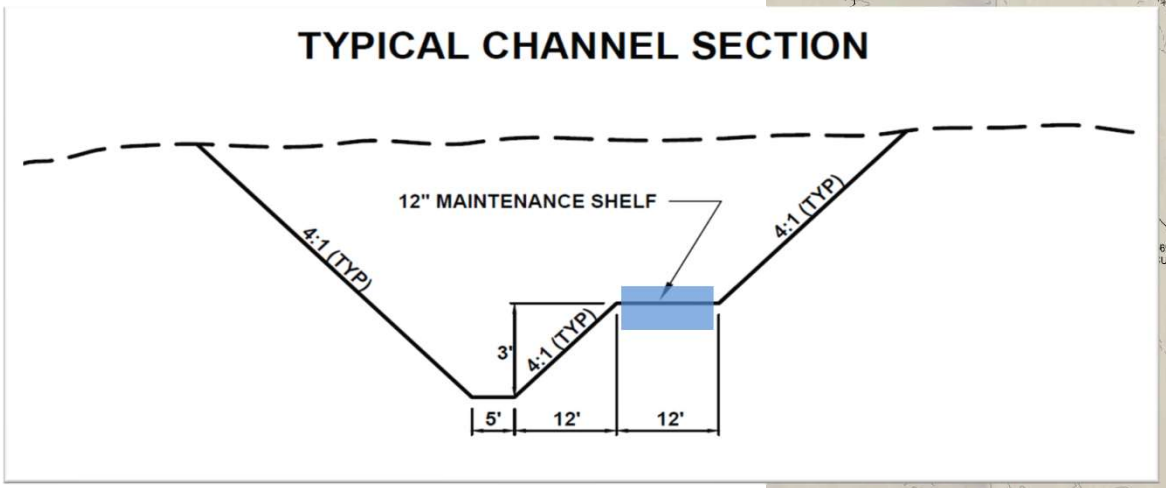
Tudor Drain Relocation

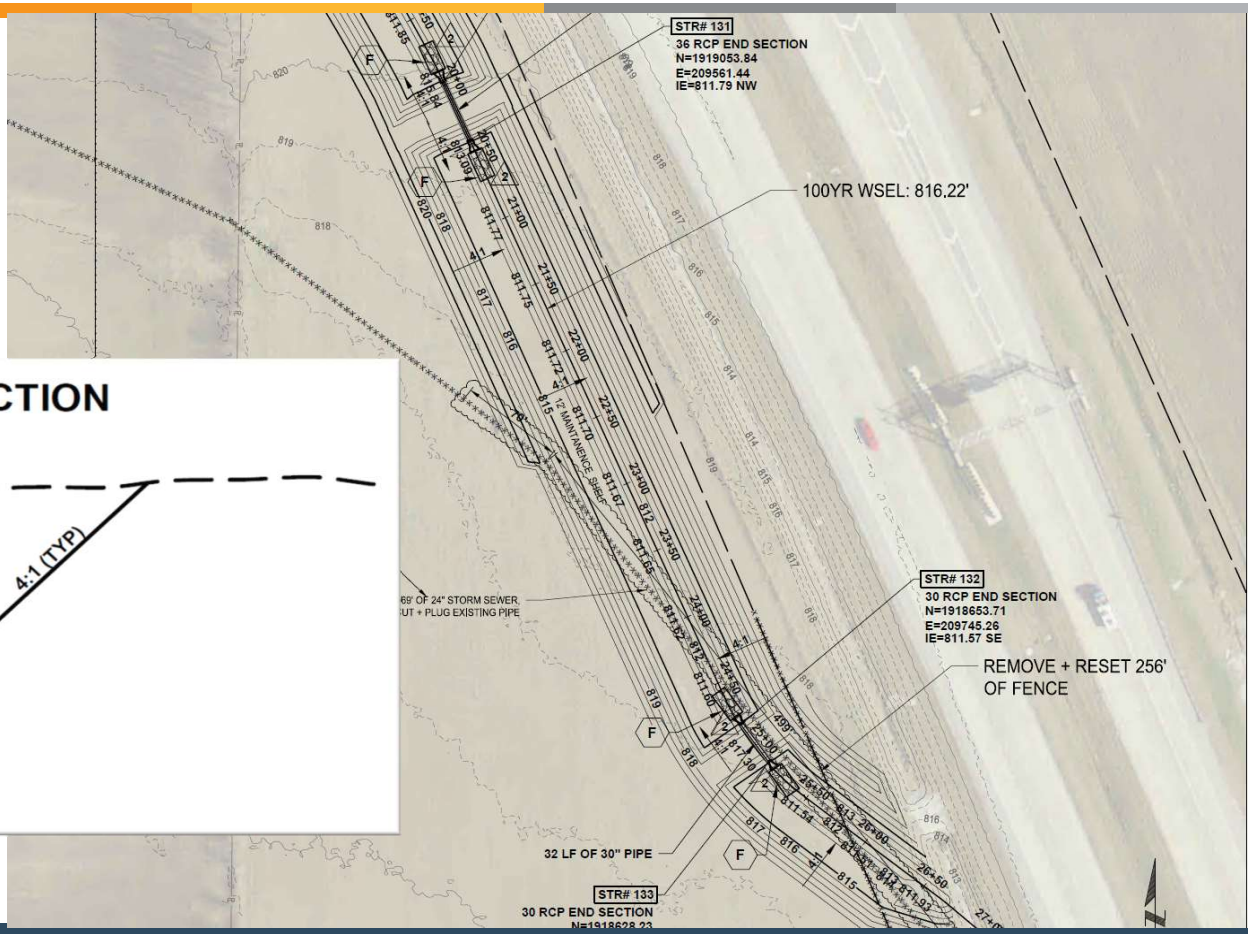
- Watershed hydraulic model identified three locations for regional detention needed.
- One of those locations utilized two a two-stage ditch approach along with inline storage.



Tudor Drain Relocation

- In-Line Storage
  - Low flow channel
  - Maintenance shelf/flood storage





Additional Resources

Additional Resources

- Two-Stage Agricultural Drainage Ditches – Ohio Department of Natural Resources and Ohio State University have developed a two-stage ditch design
- Impact of two-stage ditch on water quality – The Agriculture Water Management publication has online resources available
- Journal of the America Water Resources Association (JAWRA) has multiple articles on the benefits of two-stage ditches

Questions?

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