### Appendix H

## Drainage Ditch Design - Lab

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## Appendix H

### H.1 Ditch Design

#### H.1.1 Introduction

Objective:	Provide the user with a general understanding of how to design and analyze ditches in GEOPAK Drainage.
Goal:	Create a ditch system using GEOPAK Drainage.

The creation of a ditch system in GEOPAK Drainage is similar to the construction of a storm sewer system, with the difference that instead of specifying a pipe for the link connection, the user needs to select the ditch option.

GEOPAK Drainage allows the user to specify a fixed ditch geometry or a ditch extracted from a reference surface.

#### H.1.2 Link/Ditch Configuration

Link options and types are shown in the Option list box on the left side of the dialog. The corresponding fields and items appear on the right. The four options are reviewed below.

- DefinitionDefines the Link's path, connectivity, shape, material,<br/>roughness coefficient, size, and design options.ConditionsDefines or reviews the elevation condition for the Link<br/>including minimum depth, soffit, invert, and slope data. It<br/>also includes the profiling options for holding certain<br/>values constant.ConstraintsDefines the Link constraints including the minimum and<br/>maximum rise (size), slope and velocity used in Link<br/>design.
- Computation Reviews the Link hydraulic computation

### H.2 Lab 19: Ditch Design

#### H.2.1 Introduction

Lab exercise 19 is an excerpt from the 2011 GEOPAK Drainage VDOT Training Manual

- Step 1. Execute C:\data\geo\VDOT\drain1\LAB19\_V8.EXE.
- Step 2. Open the MicroStation file c:\data\geo\VDOT\drain1\h17682.dgn.
- Step 3. Select Drainage from the Applications > GEOPAK Drainage > Drainage pull down menu.
- Step 4. Access the drainage project h17682.gdf by selecting Project > Open from the GEOPAK Drainage pull down menu.

#### H.2.2 Design Ditch Node: ditch1

Step 1. Select from the Drainage Menu: Component > Node > Add.



Step 2. Highlight Properties in the Options group box on the Node Configuration dialog. Select the Node to be used from the Drainage Library and assign its properties as depicted below:

Node Configuratio	n - Properties	
Node ID ┥ ditch1	💌 🕨 🗖 Window Center 频 🍺	🏂 🍃 🍘 🛛 Apply
Details		
Options	Description:	
Properties	Node Type: Other 🔹	
Location	Profile: On Grade 🔽	
Spread Unterna Elevations	Library Item: DITCH NODE	
Junction Loss	· · <u>-</u>	
Discharge Options		
Computations	Node Bottom: None Available	
	Override Library Payitem:	Align

Node ID	Ditch1
Node Type	Other
Library Item	Ditch_Node

Step 3. Highlight Location to describe the inlet's location in the design plane:

SNode Configuration - Location			
Node ID ┥ ditch1	💌 🕨 🗌 Window Center 🍿 🞾 🎢 🍃 🦓 Apply		
Details			
Options	🗹 Chain: MAINLINE 🔽 🗹 Profile: MAINLINE 💌		
Properties	- Coordinates / Stationing		
Location	Align: Tangent to Chain 🔻 🐇 + Angle: 0.000		
Spread Criteria			
Elevations	Station: 209+78.46 X: 2718650.832		
Discharge Options	✓ Offset -171.500 ¥ Y: 339044.128		
Computations	Mirror Node Offset from Gutter to Inlet: 0.000		
1			

Reference Chain	Select Reference chain: MAINLINE
Reference PGL	Select Reference PGL: MAINLINE
Align	Tangent to Ref. Chain
Station	209+78.46
Offset	-171.50

Press Enter to automatically place the node at the specified location.

Step 4. Highlight Elevations to assign the node an elevation and vertical alignment of the ditch node.

Node Configuration - Elevations     □ ×       Node ID ◀ ditch1     ■ ► □ Window Center     ™ № № № № ▲ Apply			
Details			
Options	Reference Surface: TIN File 🔻 survey.tin		
Properties	Elevation Source: Reference TIN 🔽 2015.232		
Location Spread Criteria	Node Elevation Option: Same as Source 💌 2015.232		
Elevations	Vertical Alignment: Match Invert		
Junction Loss Discharge Options	Minimum Depth: 0.000		
Computations	Maximum Depth 10.000		

Elevation Source	Reference TIN
Node Elevation Option	Same as Source
Vertical Alignment Preference	Match Invert
Minimum Depth	0 feet
Maximum Depth	10.00 feet

Step 5. Highlight Junction Losses to use Defined Equations (defaults to Preference > Junction Loss Settings).

Node ID ┥ ditch1	💌 🕨 🗖 Window Center 📁 🝺 🎢 🍃 🦓 🗕 Apply
Details	
Options Properties Location Spread Criteria Elevations Junction Loss Discharge Options Computations	<ul> <li>Defined Equations</li> <li>Equations x Loss Reduction: 0.000</li> <li>Absolute Loss: 0.000</li> <li>Supplied K - Outlet Velocity: 0.000</li> <li>Supplied K - Change in Velocity: 0.000</li> <li>None</li> </ul>

Step 6 Highlight Discharge Options to specify the discharge getting into the ditch. The actual flow was previously calculated. Therefore, keyin 10 cfs at the Supplied Discharge field and activate the toggle.

8 Node Configuration	SNode Configuration - Discharge Options		
Node ID ┥ ditch1	💌 🕨 🔽 Window Center 📁 🕫 🏂 🍃 🐴 🖉 Apply		
- Details			
Options Properties Location Spread Criteria Elevations Junction Loss Discharge Options Computations	<ul> <li>Use Computed Discharge</li> <li>Supplied Discharge: 10.000</li> <li>Disable Inlet Calculations</li> <li>Capacity: 0.0000</li> <li>Link Drainage Area: 3-1</li> </ul>		

- Step 7. Click Apply to add this node to the project.
- Step 8. Close the Node Configuration dialog.

#### H.2.3 Design Ditch Node: ditch2

Step 1. Select from the Drainage Menu: Component > Node > Add.

Add a New Node			
Node ID: ditc	h2		
Description:			
OK	Cancel		

Step 2. Highlight Properties in the Options group box on the Node Configuration dialog. Select the Node to be used from the Drainage Library and assign its properties as depicted below:

<b>Node Configuratio</b>	n - Properties	_ 🗆 ×
Node ID ┥ ditch2	💌 🕨 🗖 Window Center 🐄 🍺 🏂 👘 🤗	Apply
Details		
Options	Description:	
Properties	Node Type: Other 🔹	
Location	Profile: On Grade 🔽	
Elevations	Library Item: DITCH NODE	/
Junction Loss		_
Discharge Options		
Computations	Node Bottom: None Available	
	Override Library Payitem:	Align

Node ID	Ditch2
Node Type	Other
Library Item	Ditch_Node

Step 3. Highlight Location to describe the inlet's location in the design plane:



Reference Chain	Select Reference chain: MAINLINE
Reference PGL	Select Reference PGL: MAINLINE
Align	Tangent to Ref. Chain
Station	208+67.91
Offset	-151.86

Press Enter to automatically place the node at the specified location.

Step 4. Highlight Elevations to assign the node an elevation and vertical alignment of the ditch node.

Node Configuration	n - Elevations	
Node ID ┥ 🕅 ditch2	💌 🕨 🗖 Window Center 🝿 🝺 🏂 🎲 🐔 🔄 App	ly
Details ———		
Options	Reference Surface: TIN File 🔻 survey.tin	
Properties	Elevation Source: Reference TIN 💌 2012.561	
Spread Criteria	Node Elevation Option: Same as Source 🔹 2012.561	
Elevations	Vertical Alignment: Match Invert 🔹 0,000	
Junction Loss Discharge Options	Minimum Depth: 0.000	
Computations	Maximum Depth: 10.000	

Elevation Source	Reference TIN
Node Elevation Option	Same as Source
Vertical Alignment Preference	Match Invert
Minimum Depth	0 feet
Maximum Depth	10.00 feet

Step 5. Highlight Junction Losses to use Defined Equations (defaults to Preference > Junction Loss Settings).



Step 6. Highlight Discharge Options to specify the discharge getting into the ditch. This node will not receive any direct discharge other than the one coming from the previous node. Therefore keyin 0 cfs at the Supplied Discharge field and activate the toggle.

8Node Configuratio	n - Discharge Options
Node ID ┥ ditch2	💌 🕨 🗌 Window Center 🝿 🕼 🎢 🎁 🐴 🛛 Apply
Details	
Options Properties Location Spread Criteria Elevations Junction Loss Discharge Options Computations	Use Computed Discharge     Supplied Discharge: 0.000     Disable Inlet Calculations     Capacity: 0.0000     Link Drainage Area: 31

- Step 7. Click Apply to add this node to the project.
- Step 8. Close the Node Configuration dialog.

#### H.2.4 Design Ditch Outlet Node: ditch-outlet

Step 1. Select from the Drainage Menu: Component > Node > Add.

Add a New Node		
Node ID: ditch_outlet		
Description:		
OK Cancel		

Step 2. Highlight Properties in the Options group box on the Node Configuration dialog. Select the Node to be used from the Drainage Library and assign its properties as depicted below:

8 Node Configuratio	n - Properties	
Node ID 4 ditch-out	let 💽 🕨 🔲 Window Center 📁 📁 🏂 👘 🐔	Apply
Details		
Options	Description	
Properties Location	Node Type: Outlet	
Spread Criteria	Profile: On Grade 🔽	
Elevations	Library Item: DITCH_OUTLET 🔽	
Junction Loss Discharge Options	● Fix Tailwater at: Critical Depth ▼	
Computations	O Tailwater Elevation: 0.000	
	Node Bottom: None Available	Align

Node ID	Ditch_outlet
Node Type	Outlet
Library Item	Ditch_Outlet
Fix Tailwater	Critical Depth

Step 3. Highlight Location to describe the inlet's location in the design plane:

Node Configuration	n - Location
Node ID ┥ ditch-out	et 💌 🕨 🗌 Window Center 📁 📁 🏂 🎲 🐔 🗛 Apply
Details	
Options	🗹 Chain: MAINLINE 💌 🗹 Profile: MAINLINE 💌
Properties	Coordinates / Stationing
Location	Align: Tangent to Chain 🔽 🚿 + Angle: 0.000
Spread Criteria	
Elevations	X: 2/18472.635
Discharge Options	✓ Offset: -113.570 ¥ Y: 339200.070
Computations	Mirror Node Offset from Gutter to Inlet: 0.000
Discharge Options Computations	Mirror Node Offset from Gutter to Inlet: 0.000

Reference Chain	Select Reference chain: MAINLINE
Reference PGL	Select Reference PGL: MAINLINE
Align	Tangent to Ref. Chain
Station	207+72.29
Offset	-113.57

Press Enter to automatically place the node at the specified location.

Step 4. Highlight Elevations to assign the node an elevation and vertical alignment of the ditch outlet node.



- Step 5. Click Apply to add this node to the project.
- Step 6. Close the Node Configuration dialog.

#### H.2.5 Design Ditch Links

Step 1. Select from the Drainage Menu : Component > Link > Add.

Add a New Link		
Link ID: ditch1-2		
ΠΚ	Cancel	
OK		

Step 2. Highlight Definition to Set the ditch spatial characteristics including From and To Nodes ID's, and geometry.

Graphically select the Nodes by clicking the ID button for each and identifying the Nodes. Dtich1-2 traverses From Node <u>ditch1</u> to Node <u>ditch2</u>

ion Definition 📃 🗆 🔀
1-2 💌 🕨 📙 Window Center 🦅 🏏 💥 🥢 Apply
Description:
From Node: ditch1 💌 🍿 To Node: ditch2 💌 🍿
Length: 0.0000 🔲 Use MS Element (1)
Configuration
Ditch Type: Fixed Geometry TRoughness: 0.012
Ditch Width: 3.0000
Ditab Depthy 2 0000
Side Slope Ratio Left (H:1): 3.0000 Right (H:1): 3.0000

Туре	Ditch
Geometry	Fixed Geometry
Manning's n	0.012
Ditch Width	3.00
Design Width	Toggle OFF
Ditch Depth	3.00
Design Depth	Toggle OFF
Side Slope Ratio	3:1 Left and 3:1 Right

Step 3. Highlight Conditions. The elevations shown are based on the From-Node and To-Node elevation minus the min/max depth, as specified in the Node Definition Dialog Box for Nodes ditch1 and ditch2 respectively.

In this case, no entries are necessary; GEOPAK Drainage will design all the profiles for this project.

Cink Configuratio	n Conditions					×
Link ID: 🔺 ditch1-	2 💌	▶ 🗖 Window ☐ Highligh	) Center 🦅	> >	🛠 🥜 🛛 Apply	
Details Definition Conditions Constraints Computation Type O Pipe O Ditch	Profile Conditi Min Cover: Soffit: Invert: Max Depth:	ons From Node 2015.23; 0.000 0.000 2005.23;	Slope 0.000 0.000 0.000		To Node 2012.56° 0.000 0.000 2002.56°	

Step 4. Highlight Constraints. Establish the min/max design criteria for Links as follows:

8 Link Configuration	Constraints			_ 🗆 ×
Link ID:    ditch1-2	💌 🕨 🗖 Window Center 🦅 🗦	/ *	1	Apply
Details Definition Conditions Constraints Computation Type O Pipe O Ditch	Design Constraints Minimum Maximum Rise: 0.100 6.000 Slope: 0.100 10.000 Velocity: 1.000 10.000			

Rise min/max	0.1 / 6.0 (feet)					
% Slope min/max	0.10 / 10.00 (%)					
Velocity min/max	1.00 / 10.00 (fps)					

Step 5. Highlight Computations to display the computed hydraulic properties of the ditch.



Note: Ditch hydraulics are not available for review until a Network has been established and designed or analyzed successfully. Check back here for computations after the Network has been added and designed or analyzed.

- Step 6. Press Apply to incorporate the link to the project.
- Step 7. Add the remainder of the ditch system from Node <u>ditch2</u> to Node <u>ditch-outlet</u> using the Drainage Menu Component > Link > Add.
- Step 8. After adding the last portion of the ditch, close the Link configuration dialog.

#### H.2.6 Ditch Network Design

Step 1. Select Network > Add from the Drainage menu.

Add a New Network								
Network ID:	ditch							
Description:								
Outlet Node:	ditch-ou	utlet	-					
OK		Cancel						

Step 2. In the Network Configuration dialog, enter the following information:

SNetwork Configuration - [ditch]	
Network ID: 4 ditch	😽 🧏 💓 🎒 🛛 Apply
Details Description:	Outlet Node: ditch-outlet 💌 🔩
Validation Computations	Lock Sizes Unlock Sizes
<b>T</b> +	Lock Elevations Unlock Elevations

Network ID:	DITCH
Description:	(Optional)
Outlet Node	Click the ID button and select the DITCH- OUTLET node.

Step 3. Click the Build Network button. This feature verifies the nodal topology and link connectivity. The Highlight Network feature highlights all components (ditch nodes and ditch links) connected to the active Network.

8 Network Configuration - [System 1]	_
Network ID: 4 ditch	😽 🧏 🧊 📥 🗛 Apply
Details	
Description:	Outlet Node: ditch-outlet 💽 📩
Validation Computations Build Network	Lock Sizes Unlock Sizes Lock Elevations Unlock Elevations

- Step 4. Click the Apply button. Network "DITCH" has been added to the project.
- Step 5. Click the Design button. This command initiates the hydraulic design of the components contained in the Network.
- Step 6. Then GEOPAK will design the network and issue the pertinent Warning messages, if necessary.

Informat	ion
1	Network ditch Hydraulics Successfully Computed Total Node in Network = 3 Total Links in Network = 2
	<u>O</u> K

- Step 7. Set the Active Network to Ditch so we can review some of the provided reports.
- Step 8. We can now review some of the GEOPAK provided reports. Drainage > Reports > Storm Drain Links.

名 Storm Drai	in Hydraulic	Calculation Sun	nmary for N	etwork ditch	- Errors in I	letwork Ca	lculatio	ns				_ 🗆 ×
	Upstream	Downstream	Upstream	Downstream					Unif	orm	Actua	l .
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocit	Depth	Velociț	Depth
ditch2-outle	ditch2	ditch-outlet	2010.136	2006.404	10.000	1093.952	3.120	0.000	8.460	0.302	8.410	0.304
ditch1-2	ditch1	ditch2	2012.807	2009.900	10.000	894.122	2.083	0.000	7.360	0.338	7.345	0.339
ASCII File:			ן א <u>ר</u>	dit	I_ Wind ∏ Highl	low Center ight	App	oly				

#### Step 9. Exit MicroStation.