



DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS VERSION 6.0.5

TUTORIAL # 18 STORMPRO BACKWATER MODELING



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This document contains step-by-step tutorials for the Storm Drainage Hydraulics module of DDMSW for evaluating the hydraulic grade line.

STORMPRO BACKWATER MODELING

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STORMPRO BACKWATER MODELING

DATE UPDATED: APRIL 20, 2022

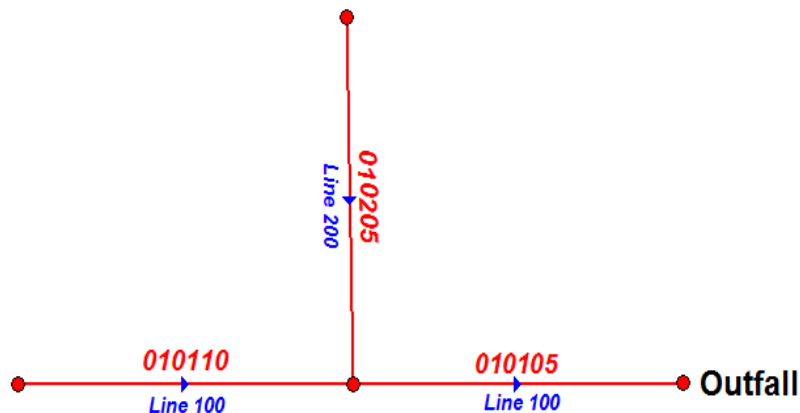
TUTORIAL TIME: 30 MINUTES

1.0 INTRODUCTION

This tutorial provides a working example (**KVLEEXAMPLE7**) in the use of the **STORMPRO** Backwater Model. Prior to developing the backwater model, it was necessary to develop the hydrology for the Rational Method and to enter the data for all the conveyance facilities. The detailed procedures for employing the Rational Method and for analyzing the Conveyance Facilities included in the network were already covered in **TUTORIAL #3 – DEVELOPING A NEW PROJECT USING RATIONAL METHOD**. **TUTORIAL #18** starts after **TUTORIAL #3** was concluded.

The specific requirements for running **STORMPRO** using the Pipe Network shown below include:

1. Establishing a folder for the model runs
2. Modifying the Conveyance Facilities
3. Establish the details for the Line IDs
4. Run Model



KvExample7 Pipe Network

2.0 SET THE FOLDER FOR MODEL RUNS (FILE → PROJECT PATHS)

- (1) Start **DDMSW**
- (2) Open the **SELECT PROJECT** form and select the **List** tab (**File → Select Project → List tab**)
- (3) From the list of **Rational Method** projects, select **KVLEEXAMPLE7**.
- (4) Create a copy of the project and name it as **V605_KVLEEXAMPLE7**.
- (4) With the new project selected, switch to the **Details** tab. Take note on the project defaults already made and adjust the **Modification Date** to reflect the current Date. Click **Save** to save the changes entered and press **OK** to close the window.

Select Project

List Details Default Table Versions

Project Reference

Project ID 00151 Reference V605_KVLEEXAMPLE7

Title StormPro Backwater Modeling

Location Maricopa County, Arizona

Agency Flood Control District of Maricopa County

Hydrology and Hydraulics Only

River Mechanics Only

Project Defaults

Model Rational

Land Use FCDMC

Rainfall NOAA14

Roads MCDOT

Inlets MAG

Min/Max Tc (minutes)

Minimum Tc 10

Maximum Tc 90

This tutorial project is set up to showcase the use of StormPRO program in DDMSW. A previous project that was built using Rational Method (KVLEexample7) was used.

Modification Date 03/29/2022 Update Project Defaults Info Print... Delete Add OK

- (5) Set the **Model Runs Path** of the project (**File → Project Paths**) to **C:\FCDMC\DDMSW605\Modlruns\ V605_KVLEEXAMPLE7**.

Project Paths

Machine ID FC1W93270707 # CARLOS.CARRIAGA

Agency Flood Control District of Maricopa County

Project StormPro Backwater Modeling

GIS Files Path

Model Runs Path C:\FCDMC\DDMSW605\MODLRUNS\V605_KVLEEXAMPLE7\

Info OK

3.0 MODIFY CONVEYANCE FACILITIES (HYDRAULICS → CONVEYANCE FACILITIES)

In addition to the data previously entered in **TUTORIAL #3 (DEVELOPING A NEW PROJECT USING RATIONAL METHOD)** for the Conveyance Facilities, the following additional data needs to be entered:

Line ID: **STORMPRO** models each line separately starting with the lowest **Line ID**. It is important to enter the **Line ID's** in the order that the model should run. This is to establish the starting water surface elevation for Lines entering another Line. In the above network, all conveyance facilities in the **Main Line** (that goes to an *Outfall*) are labeled **Line ID 100**. The upstream Line in this example is labeled **Line ID 200**.

Sort: For **STORMPRO** to run correctly, the **Facility ID's** must be sorted in the order from Downstream to Upstream. Use the **Sort** field to force the correct order. This is critical.

Outfall: If a **Facility ID** is an outfall, then check the **Outfall** checkbox. In this case, there are two outfalls. They are **Facility IDs 010105** and **010205** for **Line IDs 100** and **200**, respectively.

D/S Pipe ID: If a **Facility ID** enters a downstream Line, then enter the **D/S Pipe ID**. In the case of **Facility ID 010205** for **Line ID 200**, enter **Pipe ID 010105** (of **Line ID 100**) as the **D/S Pipe ID**.

Manholes: *Enter the number of manholes in each Facility ID.*

Screen Captures for **Facility IDs 010105, 010110** and **010205** are shown below.

Facility ID 010105:

Click to navigate all records

MB ID 01
 Facility ID 010105
 Line ID 100
 Sort 10

Section Type
 Section Pipe
 Length (ft) 1323.00
 Manning's n 0.013
 Diameter (in) 54
 No. of Barrels 1
 No. of Manholes 1

Calculations
 Capacity (cfs) 107.6
 Slope (ft/ft) 0.0030
 Velocity (fps) 11.3
 Normal Depth (ft) 4.50
 Critical Depth (ft) 3.88

Model Options
 RP (yrs) 10 All RP
 Custom Q
 Model Road
 First Pipe
 Outfall
 D/S Pipe ID

Elevations

| | U/S (ft) | D/S (ft) |
|--------|----------|----------|
| Ground | 993.00 | 988.00 |
| Invert | 988.00 | 984.00 |

| | Q (cfs) | Upstream HGL (ft) |
|--------|---------|-------------------|
| 2 Yr | 94.7 | 991.26 |
| 5 Yr | 144.9 | 995.20 |
| 10 Yr | 179.2 | 999.30 |
| 25 Yr | 253.6 | 1010.6 |
| 50 Yr | 318.8 | 1023.5 |
| 100 Yr | 383.9 | 1043.8 |

Info ReSort Print... Delete Add Graph MB Update OK

Facility ID 010110:

MB ID 01
 Facility ID 010110
 Line ID 100
 Sort 20

Section Type
 Section Pipe
 Length (ft) 1348.00
 Manning's n 0.013
 Diameter (in) 48
 No. of Barrels 1
 Road ID MC-RMAR
 No. of Manholes 1

Calculations
 Capacity (cfs) 55.6
 Slope (ft/ft) 0.0015
 Velocity (fps) 5.0
 Normal Depth (ft) 4.00
 Critical Depth (ft) 2.40

Model Options
 RP (yrs) 10 All RP
 Custom Q
 Model Road
 First Pipe
 Outfall

Elevations

| | U/S (ft) | D/S (ft) |
|--------|----------|----------|
| Ground | 997.00 | 993.00 |
| Invert | 990.00 | 988.00 |

| | Q (cfs) | Road Depth (ft) | Upstream HGL (ft) |
|--------|---------|-----------------|-------------------|
| 2 Yr | 34.4 | | 993.59 |
| 5 Yr | 51.8 | | 999.39 |
| 10 Yr | 63.0 | 0.55 | 1005.6 |
| 25 Yr | 89.6 | 0.94 | 1023.3 |
| 50 Yr | 110.6 | 1.08 | 1043.4 |
| 100 Yr | 134.8 | 1.19 | 1073.0 |

Info ReSort Print... Delete Add Graph MB Update OK

Facility ID 010205:

The screenshot shows the 'Conveyance Facilities - MB: 01' window with the 'Details' tab selected. The interface is divided into several sections:

- ID:** MB ID (01), Facility ID (010205), Line ID (200), Sort (30).
- Section Type:** Section (Pipe), Length (ft) (1318.00), Manning's n (0.013), Diameter (in) (42), No. of Barrels (1), Road ID (MC-RMAR), No. of Manholes (1).
- Model Options:** RP (yrs) (10), Custom Q (unchecked), Model Road (checked), First Pipe (checked), Outfall (checked), D/S Pipe ID (010105).
- Elevations:** U/S (ft) and D/S (ft) for Ground (996.00, 993.00) and Invert (992.00, 988.50).
- Calculations:** Capacity (cfs) (52.2), Slope (ft/ft) (0.0027), Velocity (fps) (7.0), Normal Depth (ft) (3.50), Critical Depth (ft) (2.57).
- Table:** A table showing Road Q (cfs), Road Depth (ft), and Upstream HGL (ft) for various return periods (2 Yr to 100 Yr).

| | Road Q (cfs) | Road Depth (ft) | Upstream HGL (ft) |
|--------|--------------|-----------------|-------------------|
| 2 Yr | 34.1 | | 994.07 |
| 5 Yr | 53.3 | 0.27 | 996.72 |
| 10 Yr | 66.9 | 0.73 | 998.87 |
| 25 Yr | 96.2 | 1.05 | 1005.1 |
| 50 Yr | 120.3 | 1.18 | 1011.9 |
| 100 Yr | 144.0 | 1.28 | 1020.1 |

4.0 ESTABLISH LINE IDS (HYDRAULICS → STORMPRO BACKWATER → LINES)

When first going into this form, there will be no data and there will not be an **Add** button. The data for the Lines are established when clicking the **Update** button. In this case a warning will be given that there is no **Downstream ID** for **Line ID 100** (because it is an **Outfall**). For this **Line ID 100**, check **Main Line**. It is important to note that if the Conveyance Facilities are modified, then the **STORMPRO** Lines should be updated before running a **STORMPRO** Model.

For a **Main Line**, the **Starting HGL** (Hydraulic Grade Line) for each return period can be entered. If left blank, the model uses the formula $(D_c + D)/2$, where D_c is the critical depth and D is the height of the **Facility ID**.

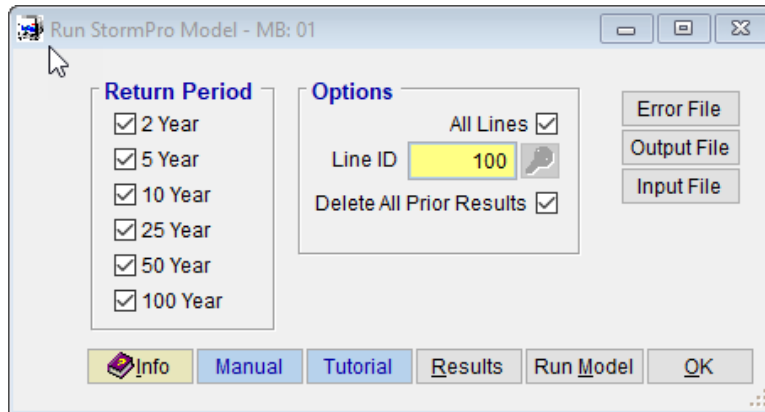
For Lines that are not a Main Line, a **Starting HGL** can be entered by checking the appropriate **Custom** checkbox for each return period. If left blank, the model establishes the value from the modeled Line that this Line enters.

Line ID 100:

These are the screenshots for the two Lines (**Line ID 100** and **Line ID 200**) where the Starting HGL are automatically loaded from analysis results.

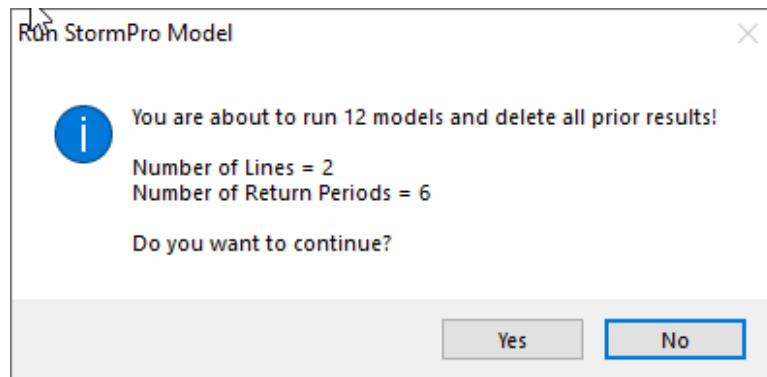
5.0 RUN MODEL (HYDRAULICS → STORMPRO BACKWATER → MODEL)

On the **RUN STORMPRO MODEL** form (*Hydraulics → StormPro Backwater → Model*), click the **Run Model** button.

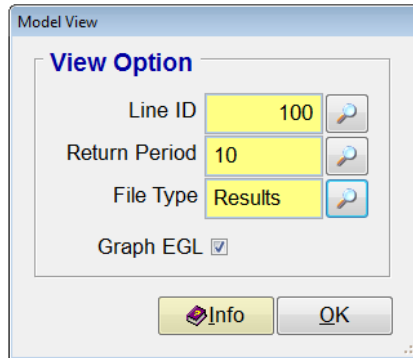


Options when running a **STORMPRO** Model include **Return Period**, **Line ID** and **Delete Prior Results**. If **All Lines** check box is checked, then **STORMPRO** will model all the selected return periods for **Line 100** then model all the selected return periods for **Line 200** (in that order).

Click **Save** to accept the analysis settings entered on the form and click **Run Model** to execute the model. Click **Yes** to continue.



To view another line and/or return period, click the **View** button.



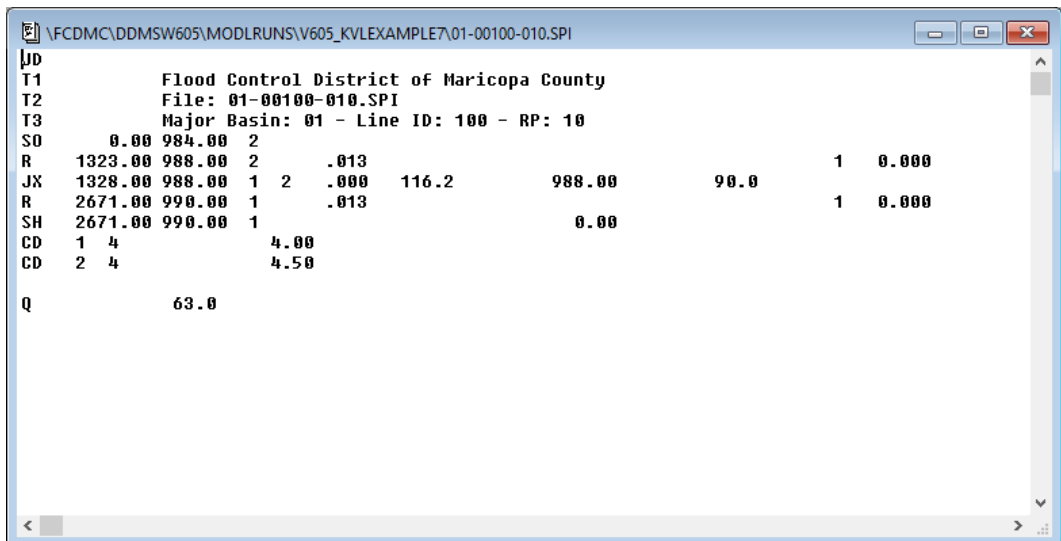
Options include selecting the **Line ID**, **Return Period**, **File Type** and an option to graph the Energy Grade Line (**Graph EGL**). When selecting a **File Type** the following options are available:

Results will select the data from the **STORMPRO RESULTS** filtered for the selected **Line ID** and **Return Period**.

HGL>GE will select the data from the **STORMPRO RESULTS** filtered for the selected **Line ID**, **Return Period** and sections where the hydraulic grade line is above the ground elevation.

Input, *Output* or *Warning* will open the model Input, Output and Warning files, respectively (See below for examples of the Input File, Output File, and Warning File).

INPUT FILE:



OUTPUT FILE:

```

\FCDM\C\DDMSW605\MODLRUNS\V605_KVLEXAMPLE7\01-00100-010.SPO
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWRKS, W.S.ELEV = INU + DC
1
WATER SURFACE PROFILE LISTING
Flood Control District of Maricopa County
File: 01-00100-010.SPI
Major Basin: 01 - Line ID: 100 - RP: 10
PAGE 1
0 STATION      INVERT      DEPTH      W.S.      Q      VEL      VEL      ENERGY      SUPER      CRITICAL      HGT/      BASE/      ZL      NO      AUBPR
0 L/ELEM      SO          OF FLOW    ELEV      Q      SF AVE    HEAD    GRO.EL.     ELEV      DEPTH      DIA      ID NO.  PIER
0 0.00  984.00    3.88    987.88    179.2    12.29    2.35    990.23    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 8.98  0.00302    4.13    988.16    179.2    11.72    0.00744    0.07    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 8.98  984.03    4.13    988.16    179.2    11.72    2.13    990.29    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 44.06 0.00302    4.50    988.66    179.2    11.27    0.00771    0.34    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 53.04 984.16    4.50    988.66    179.2    11.27    1.97    990.63    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 1269.96 0.00302    11.30    999.30    179.2    11.27    0.00825    10.48    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 1323.00 988.00    11.30    999.30    179.2    11.27    1.97    1001.27    0.00    3.88    4.50    4.50    0.00    0.00    0 0.00
0 JUNCT STR 0.00000    15.05    1003.05    63.0    5.01    0.00593    0.03    1003.44    0.00    2.39    4.00    4.00    0.00    0.00    0 0.00
0 1328.00 988.00    15.05    1003.05    63.0    5.01    0.39    1003.44    0.00    2.39    4.00    4.00    0.00    0.00    0 0.00
0 1343.00 0.00149    15.65    1005.65    63.0    5.01    0.00192    2.58    0.00    2.39    4.00    4.00    0.00    0.00    0 0.00
0 2671.00 990.00    15.65    1005.65    63.0    5.01    0.39    1006.04    0.00    2.39    4.00    4.00    0.00    0.00    0 0.00
1

```

WARNING FILE:

```

\FCDM\C\DDMSW605\MODLRUNS\V605_KVLEXAMPLE7\01-00100-010.SPW
INPUT FILE LISTING
T1 Flood Control District of Maricopa County
T2 File: 01-00100-010.SPI
T3 Major Basin: 01 - Line ID: 100 - RP: 10
SD 0.00 984.00 2
R 1323.00 988.00 2 .013
JX 1328.00 988.00 1 2 .000 116.2 988.00 90.0 1 0.000
R 2671.00 990.00 1 .013
SH 2671.00 990.00 1 0.00
1
WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING
PAGE 1
0 CARD SECT CHN NO OF AVE PIER HEIGHT 1 BASE ZL ZR INU V(1) V(2) V(3) V(4) V(5) V(6) V(7) V(8) V(9) V(10)
CODE NO TYPE PIERS WIDTH DIAMETER WIDTH DROP
CD 1 4 4.00
CD 2 4 4.50
HEADING LINE NO 1 IS -
Flood Control District of Maricopa County
HEADING LINE NO 2 IS -
File: 01-00100-010.SPI
HEADING LINE NO 3 IS -
Major Basin: 01 - Line ID: 100 - RP: 10
ELEMENT NO 1 IS A SYSTEM OUTLET
U/S DATA STATION INVERT SECT W S ELEV
0.00 984.00 2 0.00
ELEMENT NO 2 IS A REACH
U/S DATA STATION INVERT SECT N RADIUS ANGLE ANG_PT MAN_H ININORL CHINORL
1323.00 988.00 2 0.013 0.00 0.00 0.00 1 0 0.00
ELEMENT NO 3 IS A JUNCTION
U/S DATA STATION INVERT SECT LAT-1 LAT-2 N Q3 Q4 INVERT-3 INVERT-4 PHI 3 PHI 4
1328.00 988.00 1 2 0 0.014 116.2 0.0 988.00 0.00 90.00 0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
ELEMENT NO 4 IS A REACH
U/S DATA STATION INVERT SECT N RADIUS ANGLE ANG_PT MAN_H ININORL CHINORL
2671.00 990.00 1 0.013 0.00 0.00 0.00 1 0 0.00
ELEMENT NO 5 IS A SYSTEM HEADWORKS
U/S DATA STATION INVERT SECT W S ELEV
2671.00 990.00 1 0.00

```

This concludes TUTORIAL # 18.