MARICOPA COUNTY
FLOOD CONTROL DISTRICT

DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS

VERSION 6.8.0

TUTORIAL # 18

STORMPRO BACKWATER MODELING

KVL Consultants, Inc.

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

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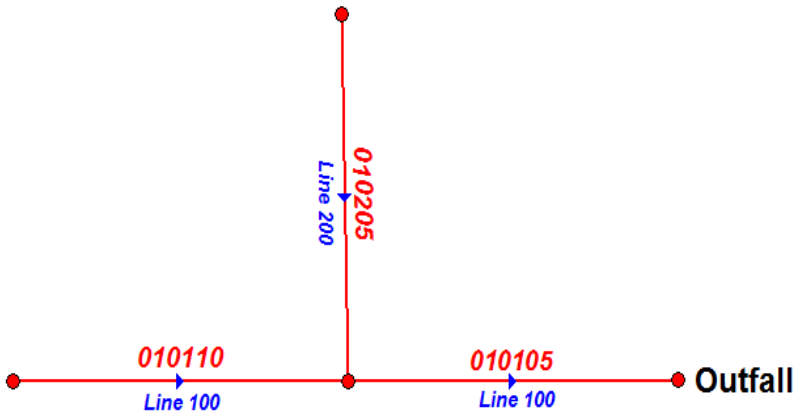
DATE UPDATED: MAY 7, 2024
TUTORIAL TIME: 30 MINUTES

1.0 INTRODUCTION

This tutorial provides a working example (**KVLEXAMPLE7)** 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 pecific 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



KvlExample7 Pipe Network

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

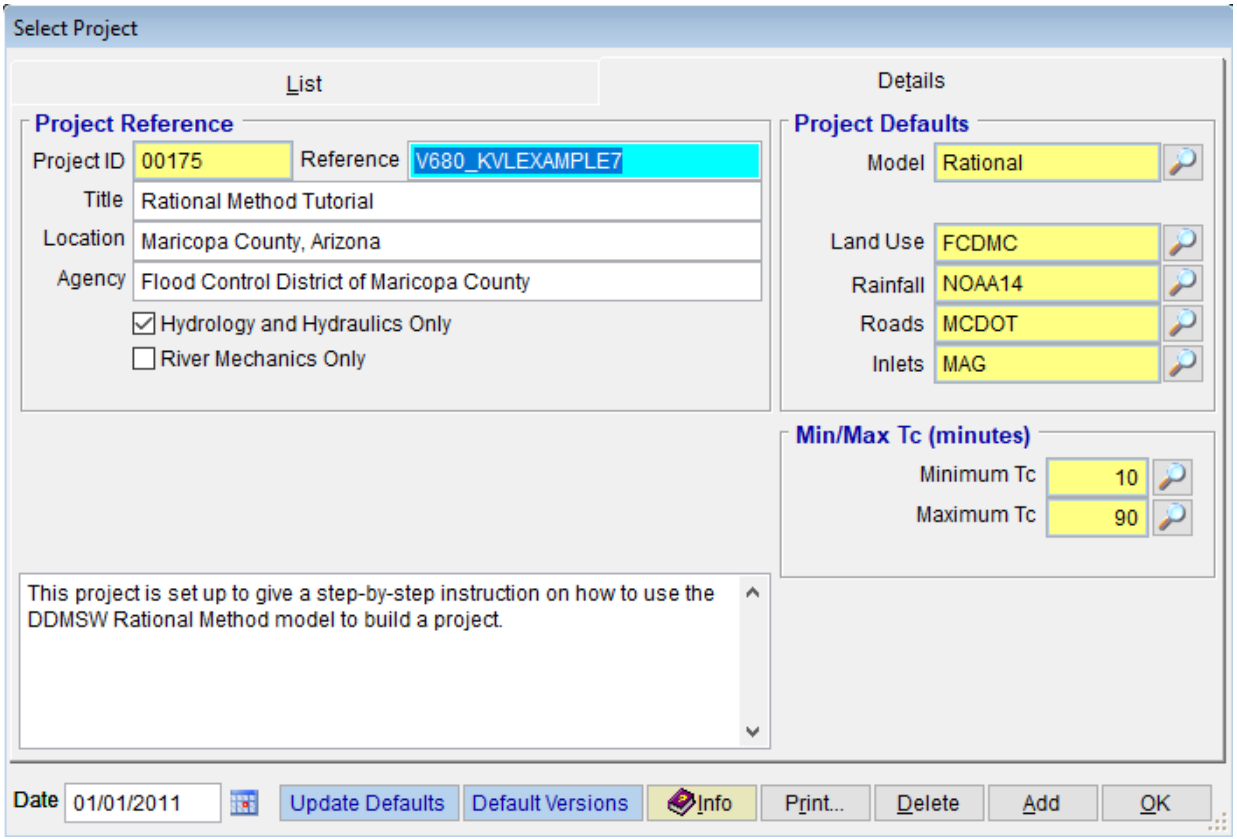
(1) Start **DDMSW**

(2) Open the **SELECT PROJECT** form and select the ***List*** tab (***File ➔ Select Project ➔ List tab***)

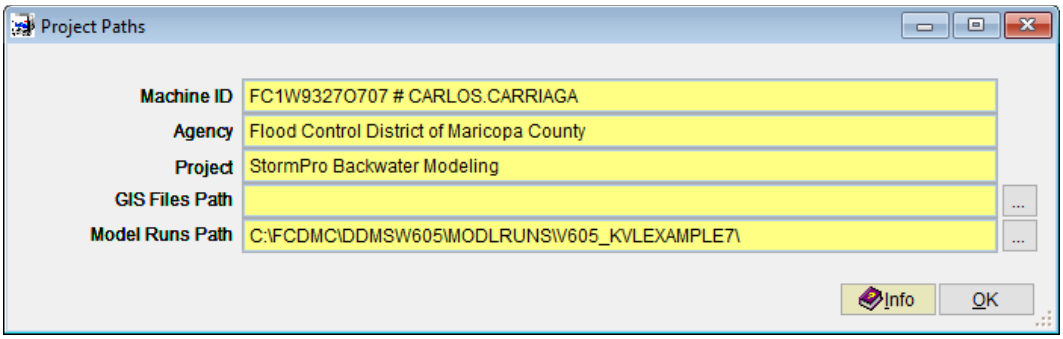
(3) From the list of **Rational Method** projects**,** select **KVLEXAMPLE7**.

(4) Create a copy of the project and name it as **V680_KVLEXAMPLE7**.

(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.



(5) Set the **Model Runs Path** of the project (***File ➔ Project Paths***) to *C:\FCDMC\DDMSW605\Modlruns\ V680_KVLEXAMPLE7*.



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.

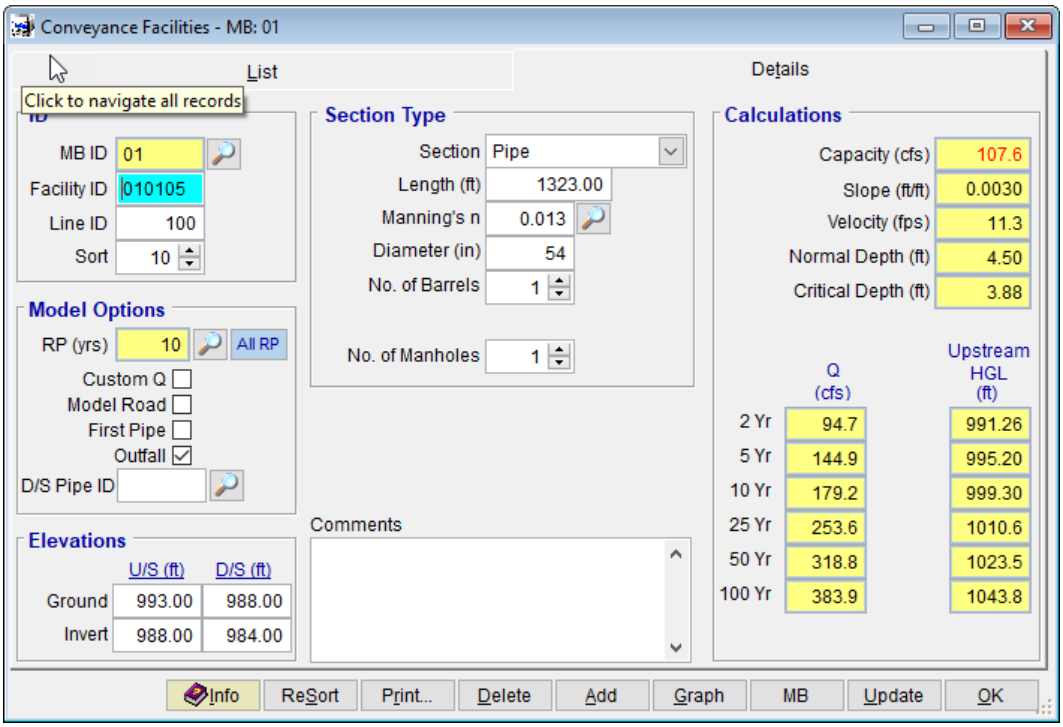
Outfall: If a **Facility ID** is an outfall, then check the **Outfall** checkbox. In this case, there are two outfalls. They are **Facility IDs** *010105* and *010205* for **Line IDs** *100* and *200*, respectively.

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**.

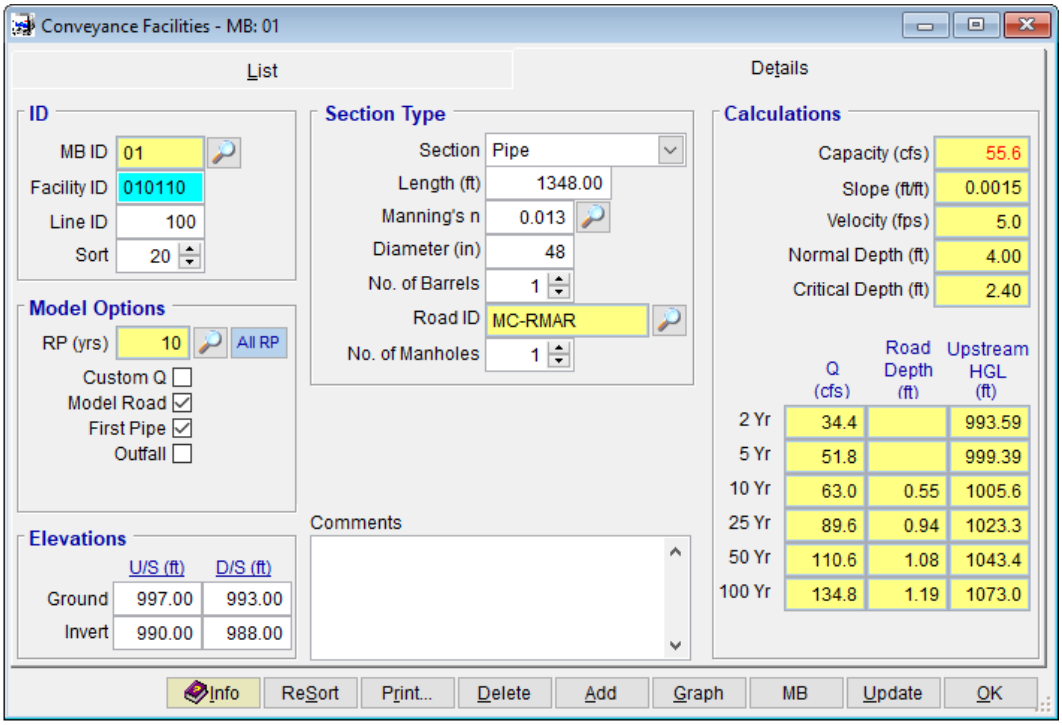
Manholes: ***Enter the number of manholes in each*** **Facility ID.**

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

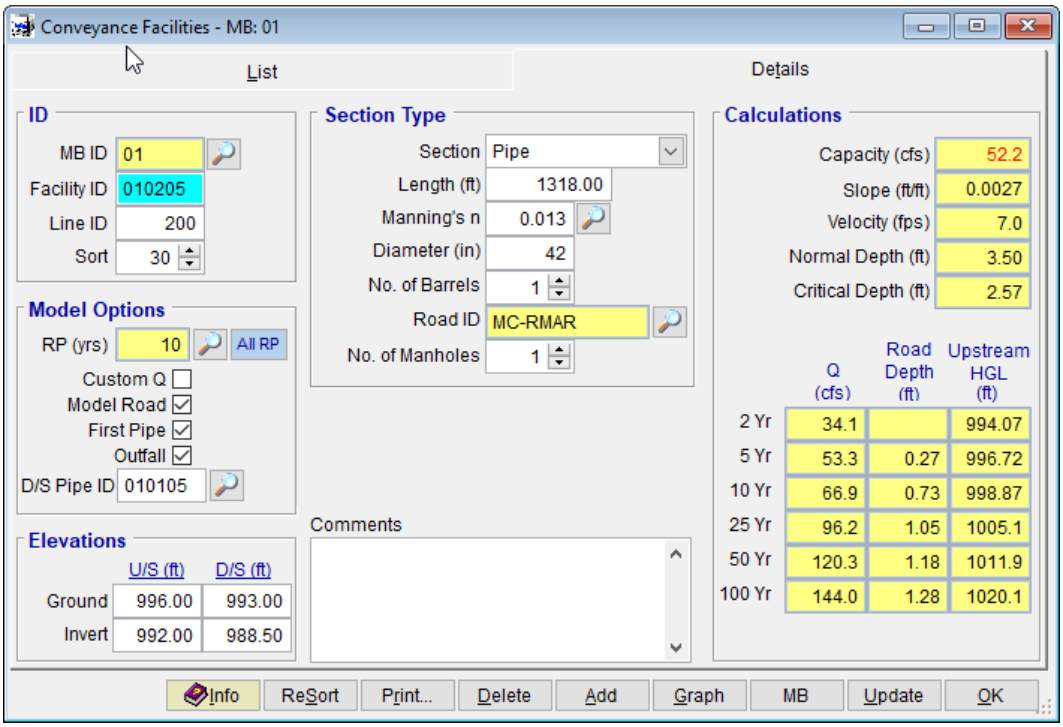
Facility ID *010105:*



Facility ID *010110:*



Facility ID *010205:*



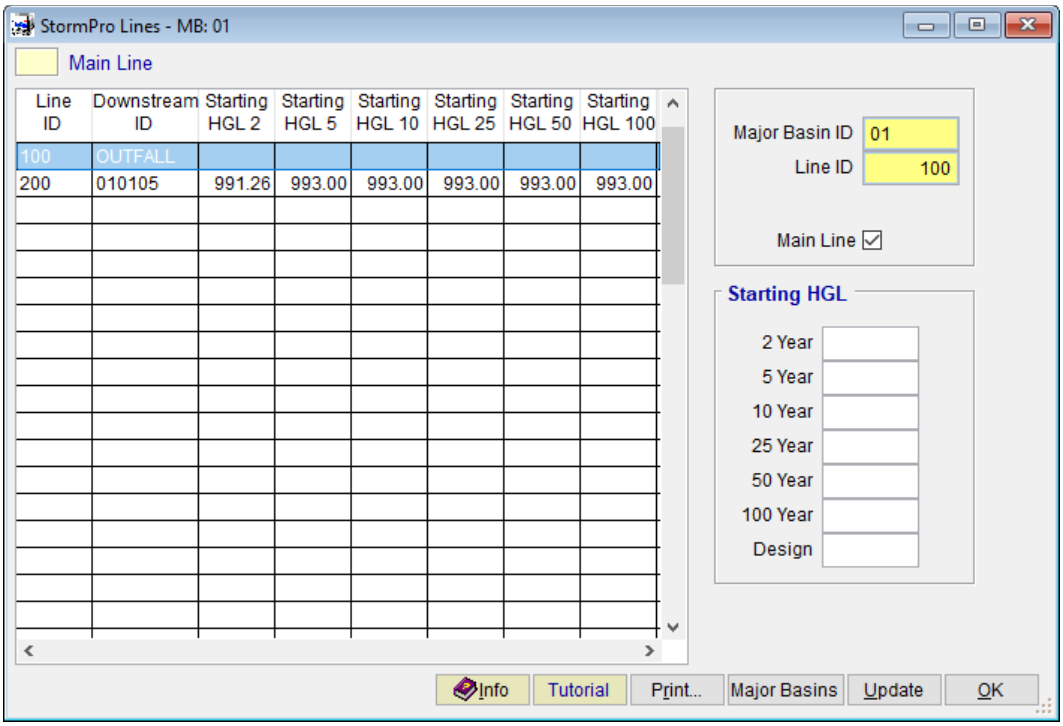
4.0 ESTABLISH LINE IDS (HYDRAULICS ➔ STORMPRO BACKWATER ➔ LINES)

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.

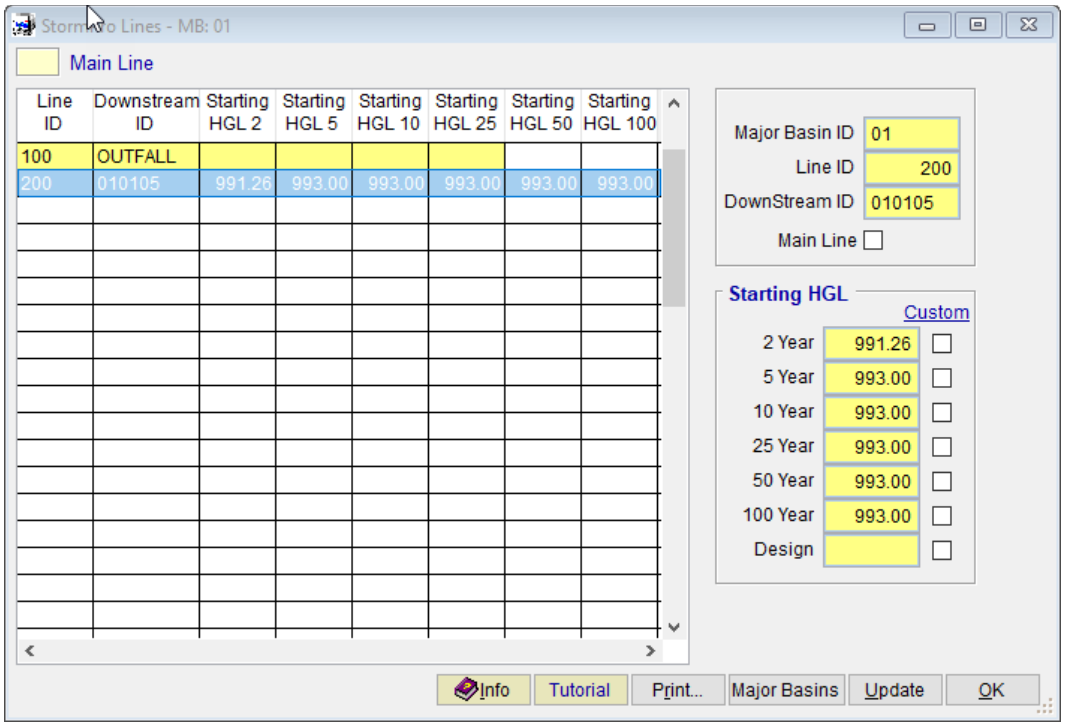
For a **Main Line**, the **Starting HGL** (Hydraulic Grade Line) for each return period can be entered. If left blank, the model uses the formula *(Dc + D)/2*, where Dc is the critical depth and D is the height of the **Facility ID**.

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:*


StormPro Lines - MB: 01
Main Line
Line ID
Downstream ID
Starting HGL 2
Starting HGL 5
Starting HGL 10
Starting HGL 25
Starting HGL 50
Starting HGL 100
100 OUTFALL
200 010105 991.26 993.00 993.00 993.00 993.00 993.00
Major Basin ID 01
Line ID 100
Main Line
Starting HGL
2 Year
5 Year
10 Year
25 Year
50 Year
100 Year
Design
Info
Tutorial
Print...
Major Basins
Update
OK

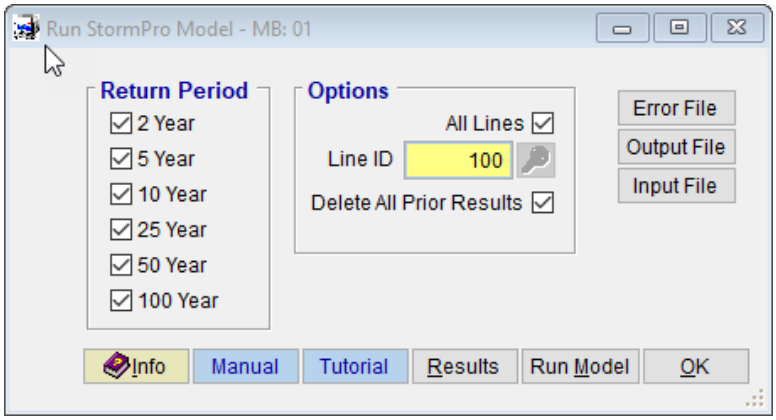
Line ID *200:*


Main Line
Line ID
Downstream ID
Starting HGL 2
Starting HGL 5
Starting HGL 10
Starting HGL 25
Starting HGL 50
Starting HGL 100
100 OUTFALL
200 010105 991.26 993.00 993.00 993.00 993.00 993.00
Major Basin ID 01
Line ID 200
DownStream ID 010105
Main Line
Starting HGL
Custom
2 Year 991.26
5 Year 993.00
10 Year 993.00
25 Year 993.00
50 Year 993.00
100 Year 993.00
Design
Info
Tutorial
Print...
Major Basins
Update
OK

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.

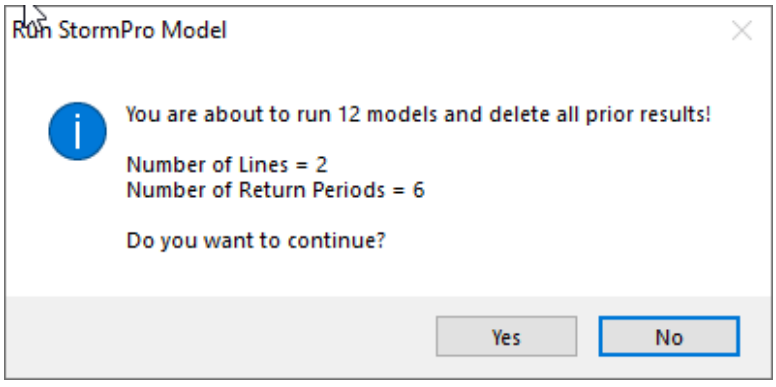
5.0 RUN MODEL (HYDRAULICS ➔ STORMPRO BACKWATER ➔ MODEL)

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.

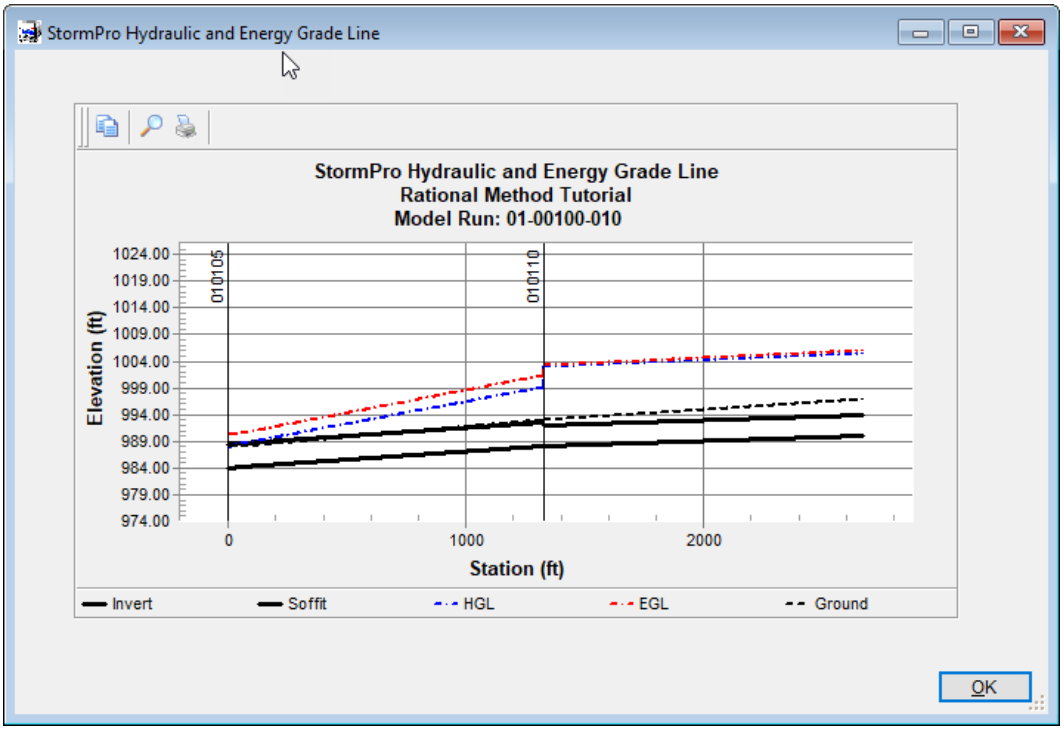


After successful model run, click ***Results*** to view the analysis results.

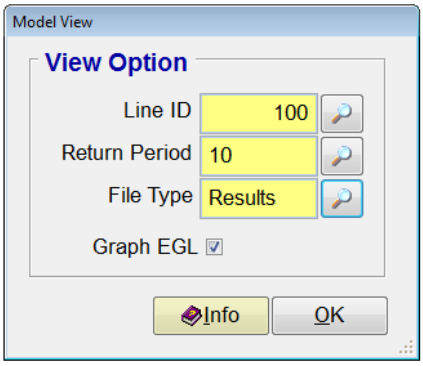
Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
100	10	010105	54" Dia Pipe	0.00	179.2	12.29	984.00	987.88	988.00	
100	10	010105	54" Dia Pipe	8.98	179.2	11.72	984.03	988.16	988.03	0.13
100	10	010105	54" Dia Pipe	53.04	179.2	11.27	984.16	988.66	988.20	0.46
100	10	010105	54" Dia Pipe	1323.00	179.2	11.27	988.00	999.30	993.00	6.30
100	10	010110	48" Dia Pipe	1328.00	63.0	5.01	988.00	1003.05	993.01	10.04
100	10	010110	48" Dia Pipe	2671.00	63.0	5.01	990.00	1005.65	997.00	8.65

Click ***Graph*** to view the graph of the model results.

HGL and EGL generated for **Line ID** *100*:



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



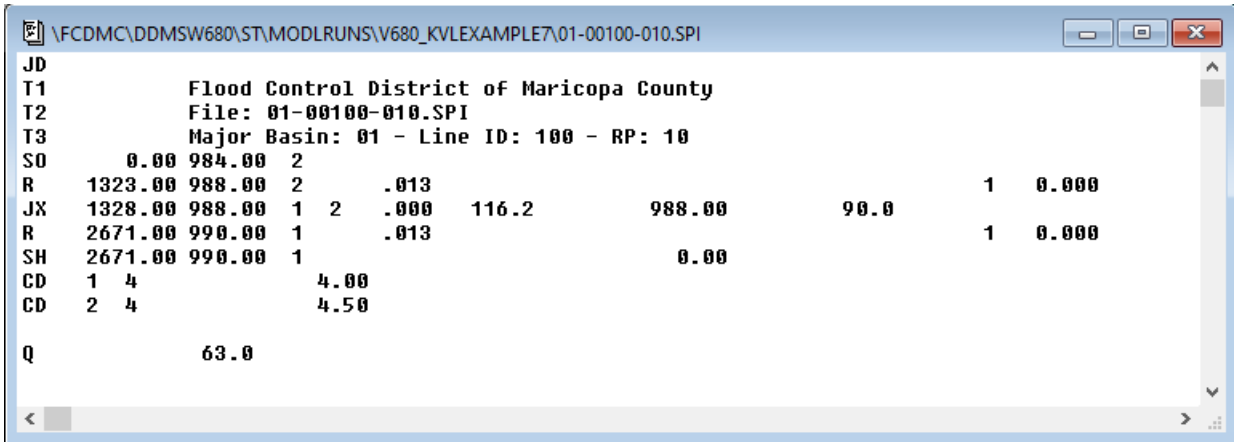
Options include selecting the **Line ID**, **Return Period**, **File Type** and an option to graph the Energy Grade Line (**Graph EGL**). When selecting a **File Type** the following options are available:

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:

\FCDMC\DDMSW680\ST\MODLRUNS\V680_KVLEXAMPLE7\01-00100-010.SPO

```
 ** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
1                                                                                                                         PAGE    1
                                                      WATER SURFACE PROFILE LISTING
                                        Flood Control District of Maricopa County
                                        File: 01-00100-010.SPI
                                        Major Basin: 01 - Line ID: 100 - RP: 10
0 STATION     INVERT    DEPTH      W.S.         Q      VEL      VEL    ENERGY  SUPER  CRITICAL            HGT/   BASE/     ZL  NO  AVBPR
              ELEV    OF FLOW     ELEV                          HEAD   GRD.EL.  ELEV    DEPTH              DIA    ID NO.       PIER
0 L/ELEM       SO                                              SF AVE    HF                      NORM DEPTH                    ZR
*****************************************************************************************************************************************
0      0.00   984.00     3.88    987.88     179.2    12.29     2.35    990.23   0.00     3.88            4.50     0.00  0.00   0   0.00
0      8.98  0.00302                                         0.00744    0.07                     4.50                  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     0.00  0.00   0   0.00
0     44.06  0.00302                                         0.00771    0.34                     4.50                  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     0.00  0.00   0   0.00
0   1269.96  0.00302                                         0.00825   10.48                     4.50                  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     0.00  0.00   0   0.00
0JUNCT STR   0.00000                                         0.00593    0.03                                           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     0.00  0.00   0   0.00
0   1343.00  0.00149                                         0.00192    2.58                     4.00                  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     0.00  0.00   0   0.00
1
```

WARNING FILE:

\FCDMC\DDMSW680\ST\MODLRUNS\V680_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
 SO       0.00 984.00  2
 R     1323.00 988.00  2      .013                                      1   0.000
 JX    1328.00 988.00  1  2   .000    116.2         988.00         90.0
 R     2671.00 990.00  1      .013                                      1   0.000
 SH    2671.00 990.00  1                           0.00
1                                                            SP
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                         PAGE    1
0 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(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  IMINORL  CMINORL
                                1323.00  988.00    2             0.013                                            0.00   0.00    0.00     1       0     0.000
 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  IMINORL  CMINORL
                                2671.00  990.00    1             0.013                                            0.00   0.00    0.00     1       0     0.000
 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.