MARICOPA COUNTY
FLOOD CONTROL DISTRICT

DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS

VERSION 6.8.0

TUTORIAL # 2
DEVELOPING A NEW HEC-1 MODEL USING GIS SHAPEFILES

KVL Consultants, Inc.

Table of Contents

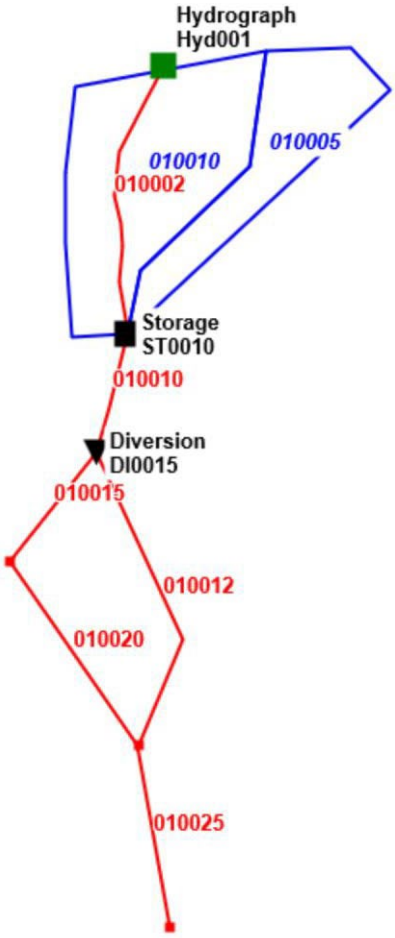
1. Introduction

The application for this example can be imported from the \St\BackupExamples folder. The application is "HEC1TUTORIAL.ZIP".

The HEC-1 modeling will include:

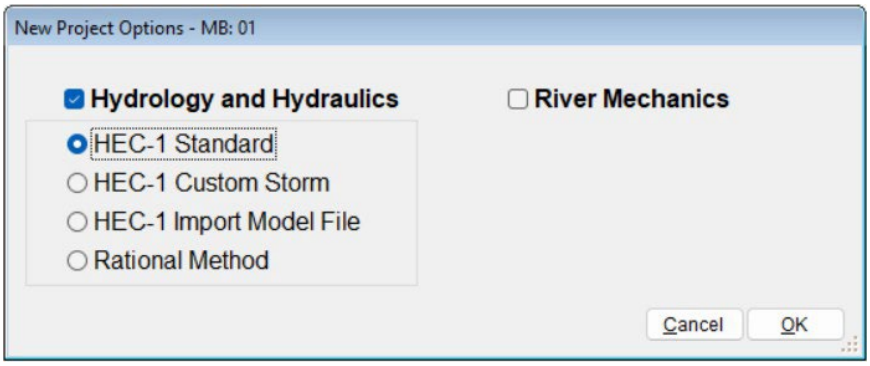
- Sub Basins (***010005***) for example.
- Routing (**010002**) for example.
- Hydrograph (Hyd001)
- Storage Facility (**ST0010**).
- Diversion (**DI0015**).
- Special Code (For 010025 Routing)
- Rainfall (the outline of all Sub Basins).
- Graph Hydrographs

A map of the model is shown below.

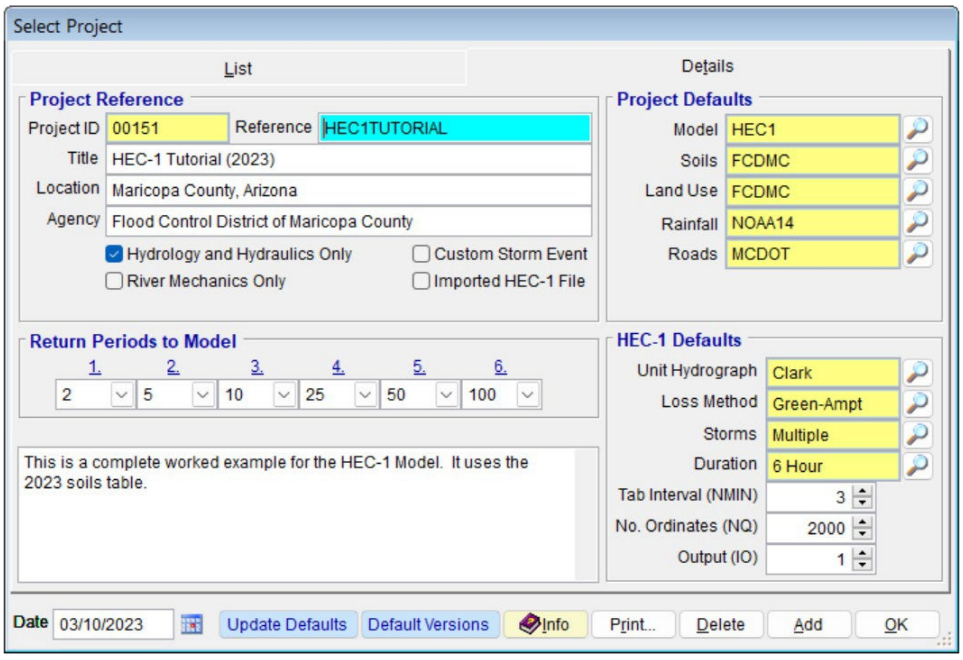


2. Add a New Project

1. Select "*File/New Project*"
2. Check *"Hydrology and Hydraulics" and HEC-1 Standard*".

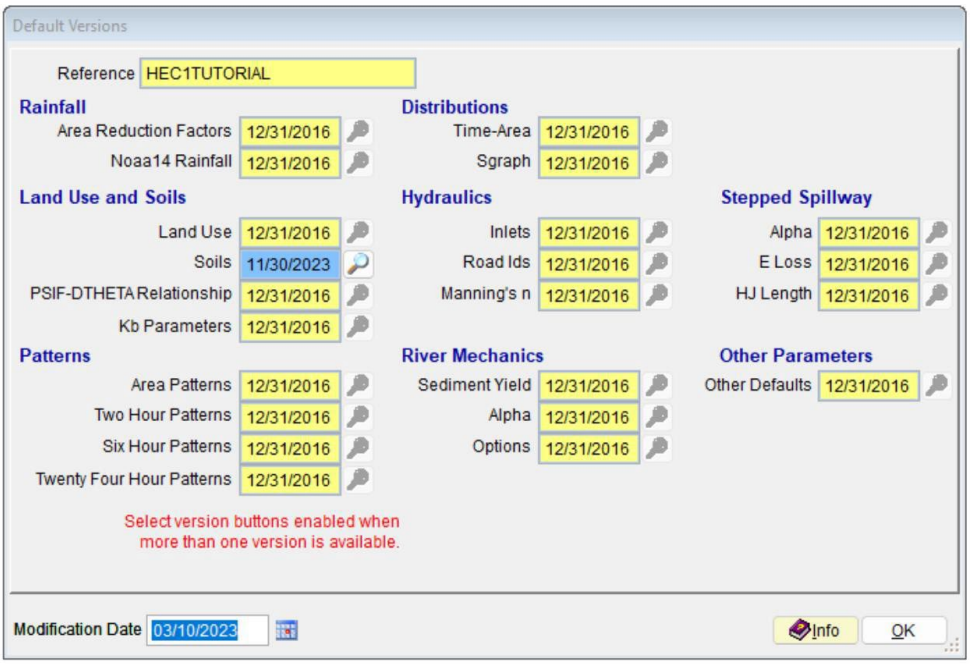


3. Click *"OK"*
4. Enter HEC1TUTORIAL as the Reference.
5. Enter HEC-1 Tutorial for the Title.
6. Enter Maricopa County, Arizona for the Location.
7. Change Tab Interval (NMIN) from 5 to 3.
8. Change Output (IO) to 1 (to get hydrographs).
9. On the *"List"* Tab, select "HEC1 Model*"* for the Group.
10. Click *"OK"*



When a new project is established, the latest versions from Agency data are established for the Project defaults. In this case the new 2023 Soil Defaults is used. If it is necessary to change the default version, then Click "*Default Versions"* to open the following form. Then click on the Hour-Glass adjacent to the required table and select the version. Please note if there is only one version available, the the Hour-Glass is disabled.

For this example leave the Soils version to 11/30/2023.

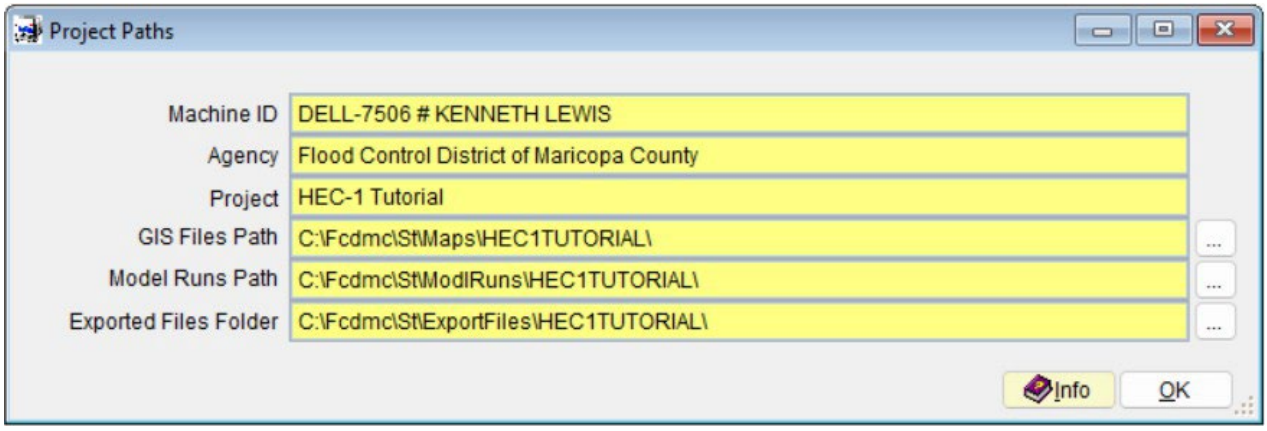


3. Project Paths

1. Select '*File*' => '*Project Paths'*.

For each project, it is necessary to establish folders for: GIS files (if using GIS), Model Runs and Exported Files. When saving a new project, the folders are automatically established using the Project Reference. For example, the Project Reference for this example is "HEC1TUTORIAL", and assuming the application is installed in "C:\FCDMC", then the established folders are shown below.

The folders can be changed by clicking the button ('…') to the right of the folder field and navigate to an appropriate folder.

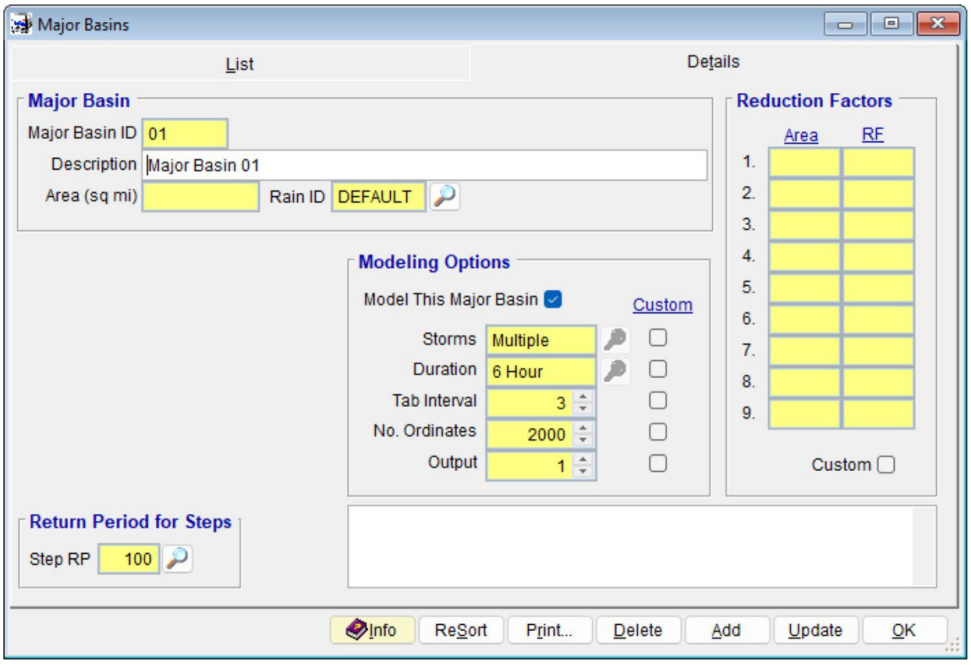


2. Click "*OK"* to exit the form.

4. Establish Major Basin Id's

1. Select Hydrology => *Major Basins* to access the Major Basins data.

The software automatically establishes at least one Major Basin (01) when creating a new project. Since we will only have one major basin in this project, there is no need for further modification at this time. The area will be updated when updating the Sub Basins.



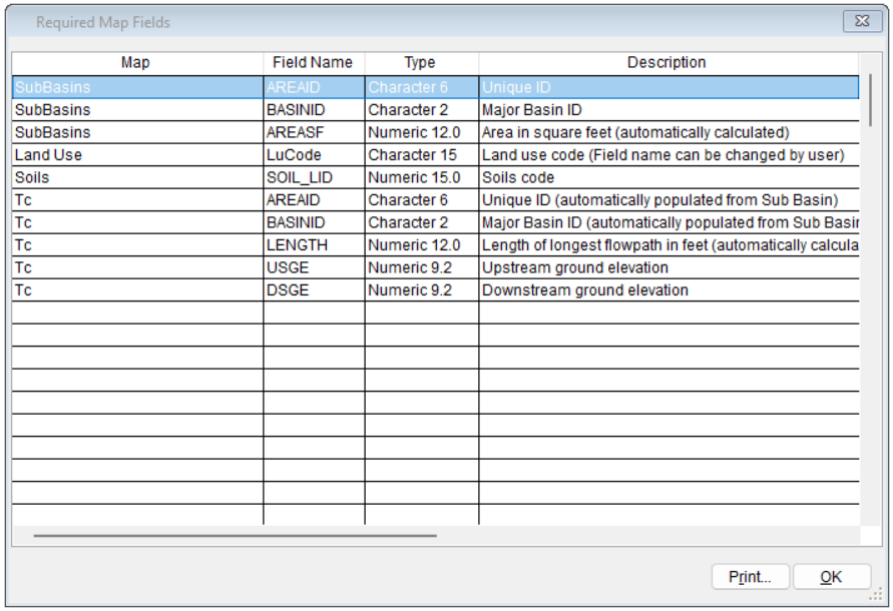
2. Click on the *'OK'* button to close the form.

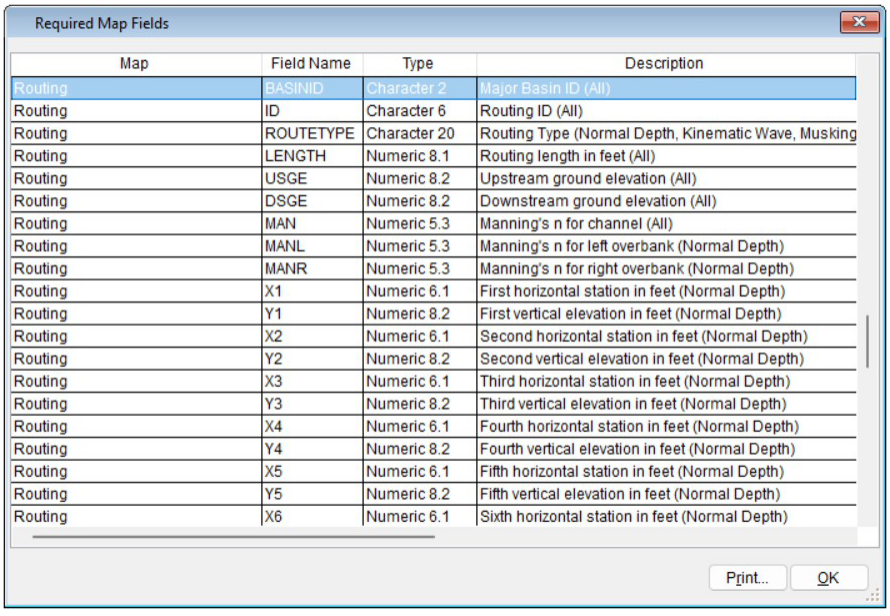
5. Digitize in GIS

All GIS files must be in ESRI Shape file format. For this example, all shapefiles are contained in C:\Fcdmc\St\Maps\HEC1TUTORIAL.

The necessary field structure can be found for the Sub Basins, Land Use, Soils, and Tc by going to Select Maps => *Update Hydrology* and Clicking *"Required Map Fields"*. Note that once the shapefiles have been selected, the Required Map Fields can be automatically established by Clicking *"Check Required Map Fields".*

The necessary field structure can be found for the Routing by going to Select Maps => *Import Routing Data* and Clicking *"Required Map Fields"*. Note that once the shapefiles have been selected, the Required Map Fields can be automatically established by Clicking *"Check Required Map Fields".*

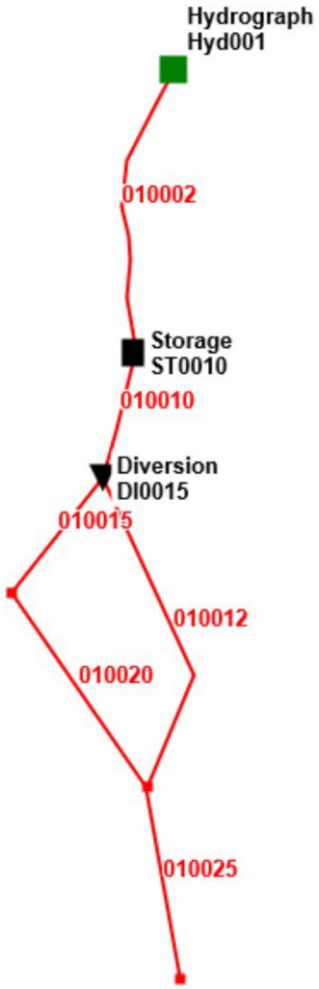




Nodes and Routing

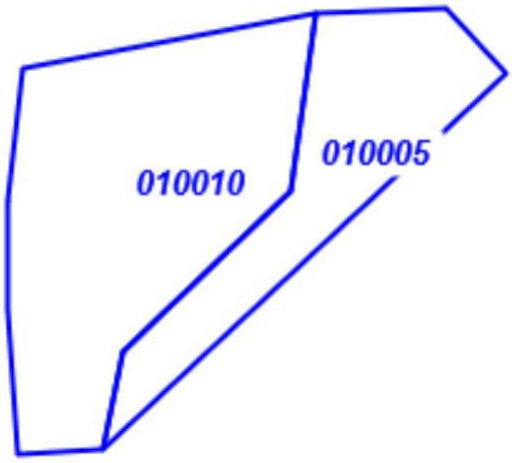
The Nodes include the Hydrograph, Storage, Diversion and points at the beginning and end of Route features. The Nodes are for cosmetic purposes only.

The Routing data is contained in the Route shapefile for importing into DDMSW.



GIS_LENGTH	GIS_AREA	ID	BASINID	ROUTETYPE	LENGTH	USGE	DSGE	MAN	MANL	MANR	X1	Y1	X2	Y2	X3	Y3	X4	Y4
198	0	010010	01	NORMAL DEPTH	198	998	997	0.035	0.045	0.045	100	100	120	99	140	95	190	94
443.76	0	010002	01	NORMAL DEPTH	444	1000	999	0.035	0.045	0.045	100	100	120	99	140	95	190	94
223.76	0	010015	01	NORMAL DEPTH	224	996	994	0.035	0.045	0.045	100	100	120	99	140	95	190	94
361.75	0	010020	01	NORMAL DEPTH	362	994	993	0.035	0.045	0.045	100	100	120	99	140	95	190	94
296.82	0	010025	01	NORMAL DEPTH	297	992	991	0.035	0.045	0.045	100	100	120	99	140	95	190	94
515.05	0	010012	01	NORMAL DEPTH	515	996	995	0.035	0.045	0.045	100	100	120	99	140	95	190	94

Sub Basins

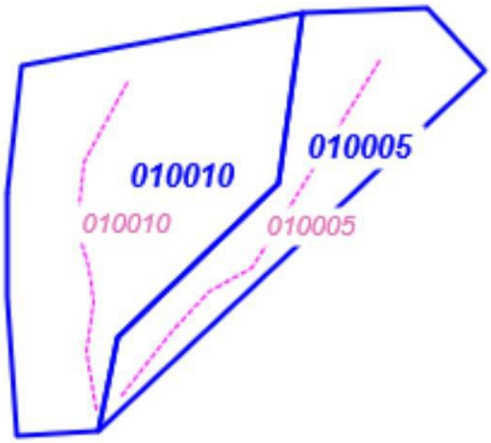


Enter the AREAID and BASINID. The AREASF is automatically calculated when updating the Hydrology from Maps.

AREAID	BASINID	AREASF
010010	01	993441
010005	01	529969

Time of Concentration, Tc

Digitize Time of Concentration. Make sure that the Time of Concentration lines are entirely contained within the sub basin.

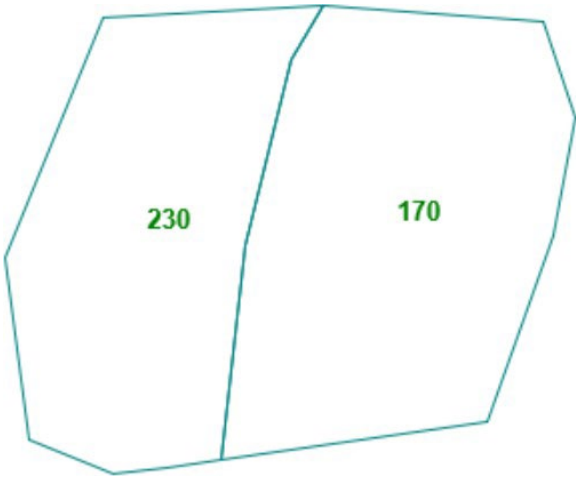


Enter the USGE, DSGE AREAID and BASINID. The LENGTH is automatically calculated when updating the Hydrology from Maps.

USGE	DSGE	LENGTH	AREAID	BASINID
1000	998	1212	010010	01
1000	998	1543	010005	01

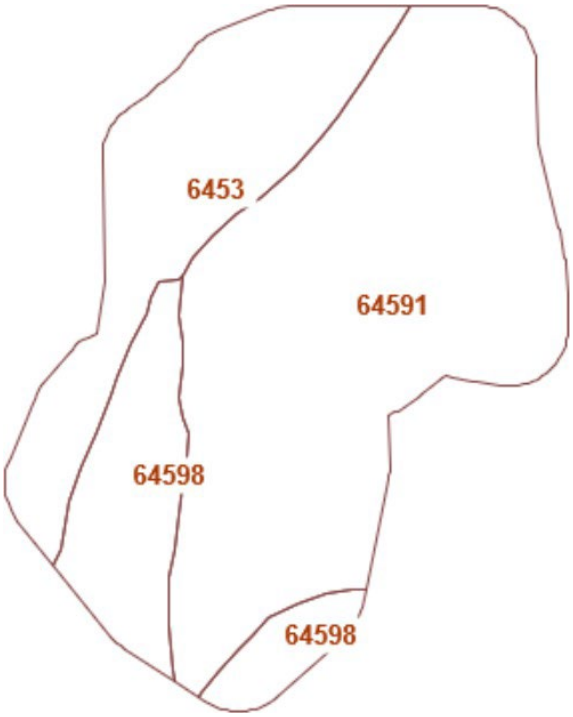
Land Use

Obtain Land Use Map or Digitize. Make sure Land Use codes are included in Land Use Defaults in DDMSW. Also make sure that the land use map extends beyond all sub basin polygons. The only necessary data is the Land Use Code.



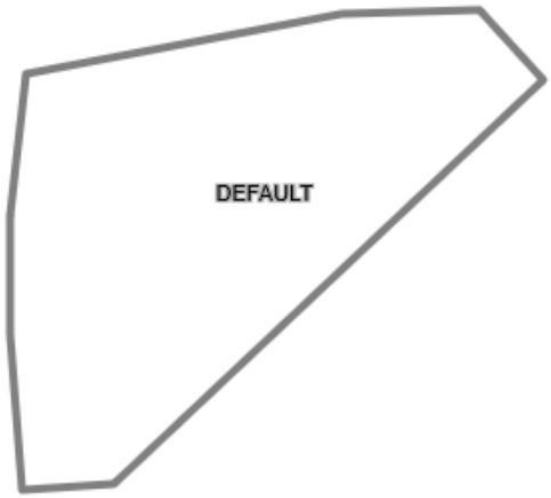
Soils

Obtain Soils map from FCDMC or establish from NRCS file or Digitize. Make sure Soil IDs are included in Soil Defaults in DDMSW. Also make sure that the soils map extends beyond all sub basin polygons. The only necessary data is the Soil ID.



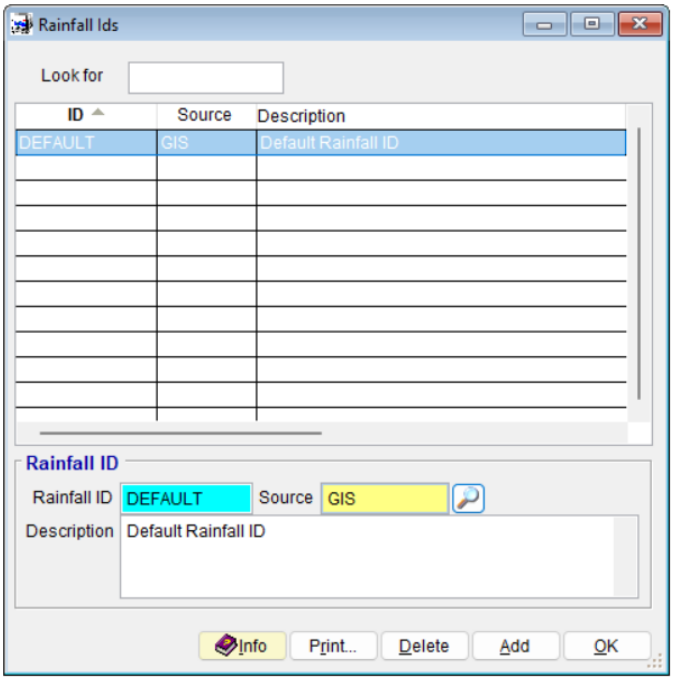
Rainfall

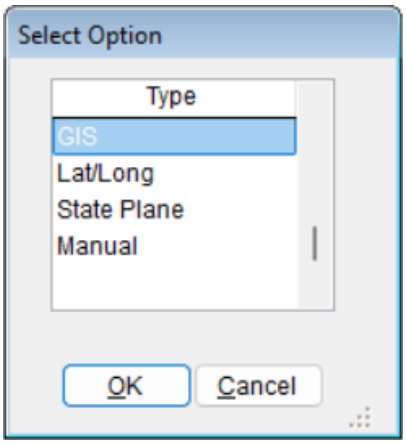
Digitize the Rainfall Map. This can be the outline of all the Sub Basins. The only necessary data is the RAINID and BASINID.



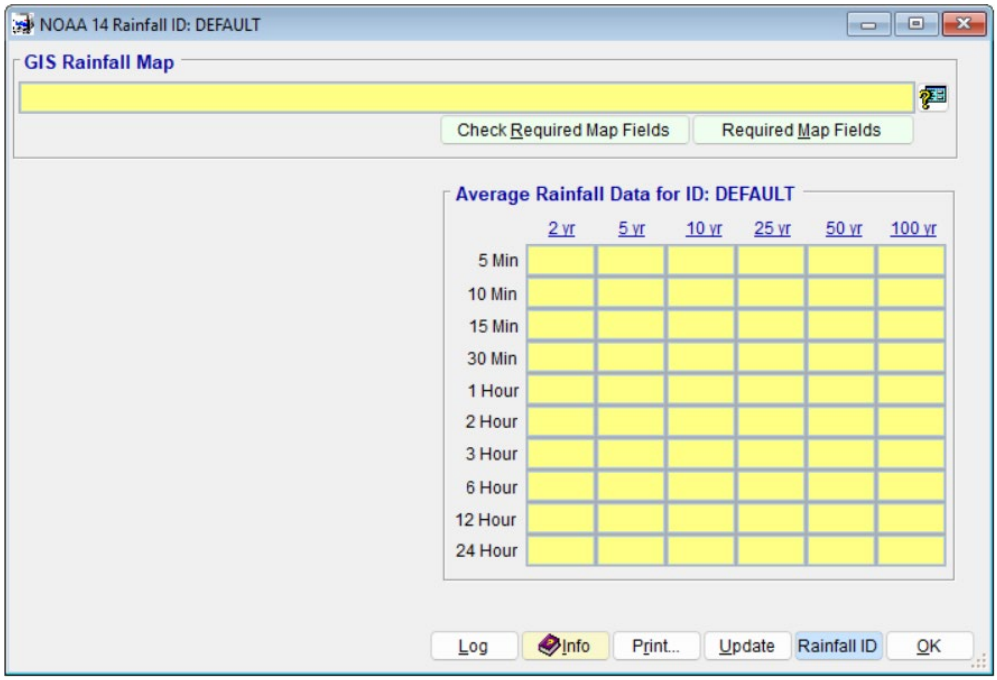
6. Rainfall Data

1. Select Hydrology => *Rainfall IDs*
2. Change *"Source"* to GIS

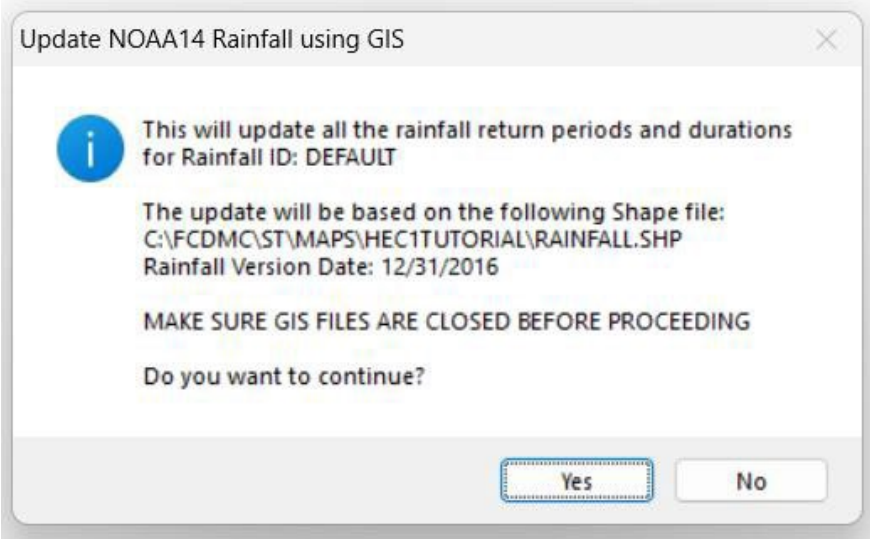




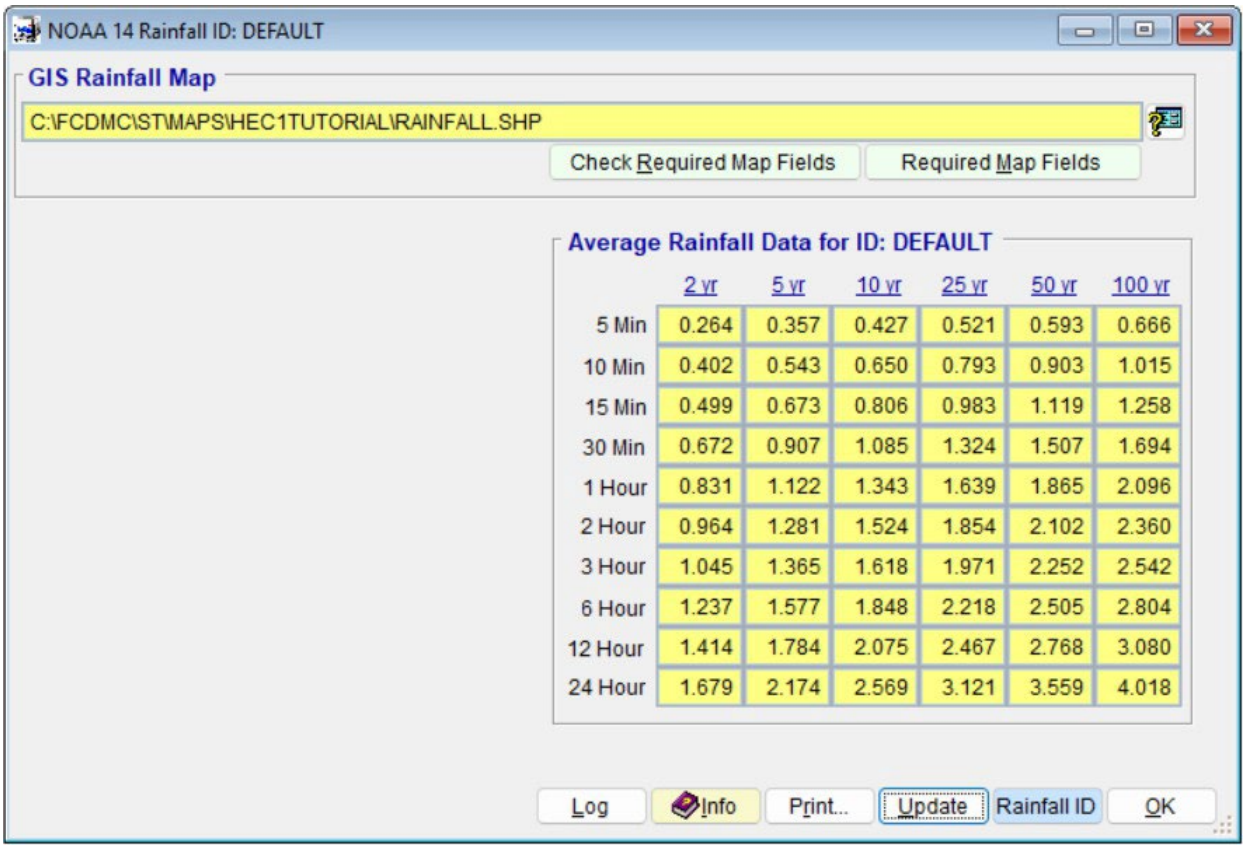
3. Click *"OK"* to continue.
4. Select Hydrology => *Rainfall*



5. Select the Rainfall shapefile.
6. Click *"Save"* to save the data.
7. Click *"Update"* to develop the Rainfall data.



8. Click *"Yes"* to continue.


NOAA 14 Rainfall ID: DEFAULT
GIS Rainfall Map
C:\FCDMC\ST\MAPS\HEC1TUTORIAL\RAINFALL.SHP
Check Required Map Fields
Required Map Fields
Average Rainfall Data for ID: DEFAULT
2 yr 5 yr 10 yr 25 yr 50 yr 100 yr
5 Min 0.264 0.357 0.427 0.521 0.593 0.666
10 Min 0.402 0.543 0.650 0.793 0.903 1.015
15 Min 0.499 0.673 0.806 0.983 1.119 1.258
30 Min 0.672 0.907 1.085 1.324 1.507 1.694
1 Hour 0.831 1.122 1.343 1.639 1.865 2.096
2 Hour 0.964 1.281 1.524 1.854 2.102 2.360
3 Hour 1.045 1.365 1.618 1.971 2.252 2.542
6 Hour 1.237 1.577 1.848 2.218 2.505 2.804
12 Hour 1.414 1.784 2.075 2.467 2.768 3.080
24 Hour 1.679 2.174 2.569 3.121 3.559 4.018
Log
Info
Print...
Update
Rainfall ID
OK

7. Review Land Use Defaults

1. Select *Hydrology => Land Use Defaults* to view or modify land use defaults or add '*Custom*' data. For this example, custom values are not required.

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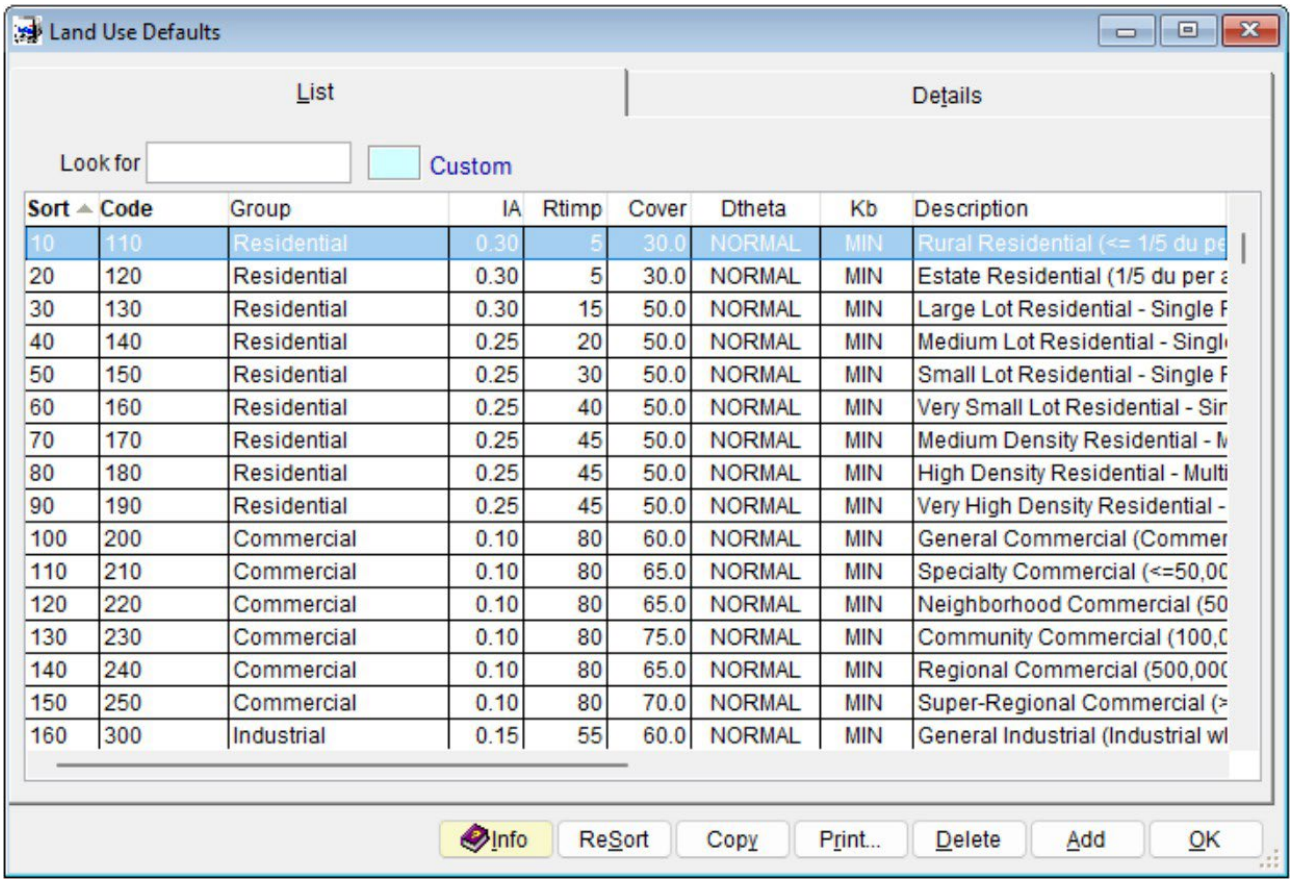
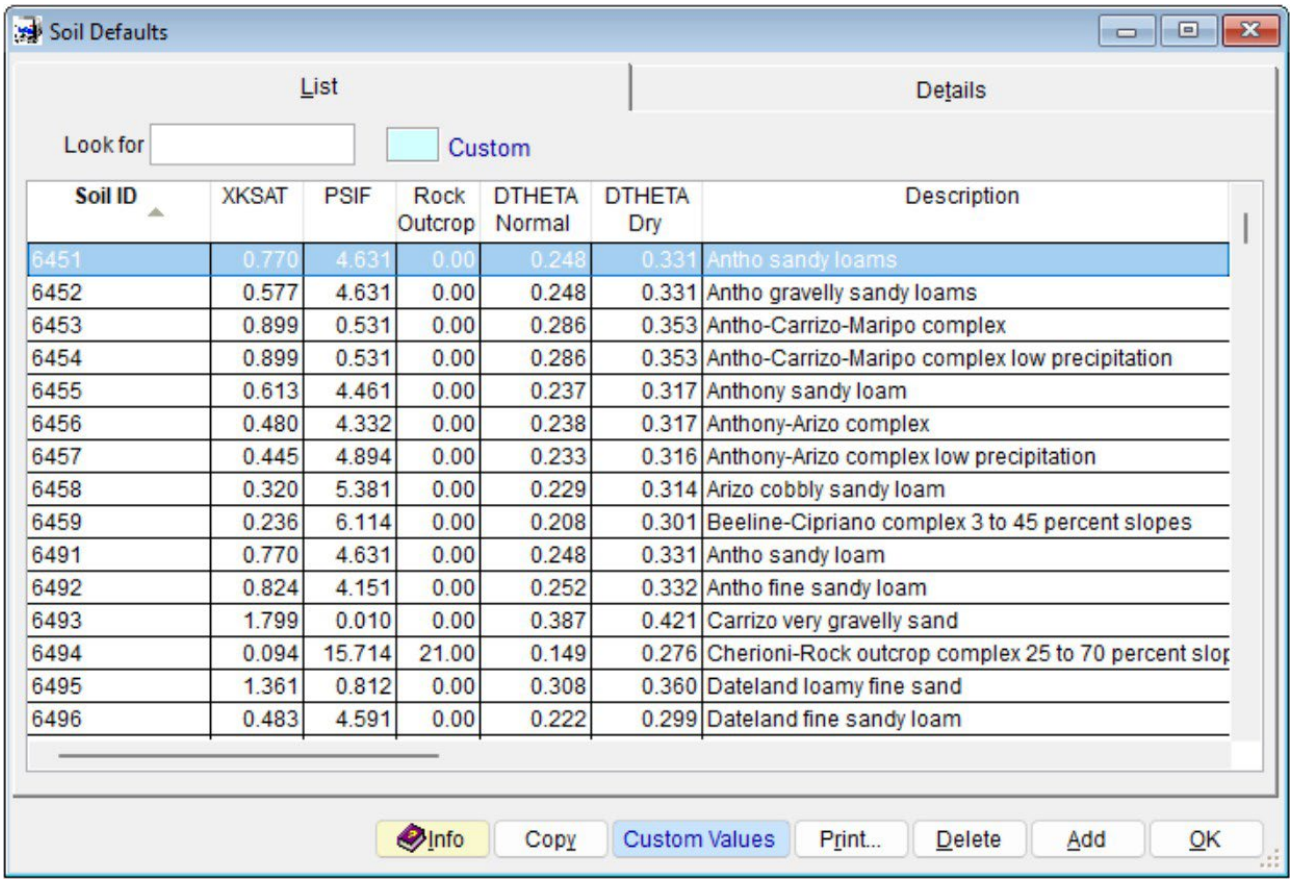


Sort	Code	Group	IA	Rtimp	Cover	Dtheta	Kb	Description
10	110	Residential	0.30	5	30.0	NORMAL	MIN	Rural Residential (<= 1/5 du pe
20	120	Residential	0.30	5	30.0	NORMAL	MIN	Estate Residential (1/5 du per a
30	130	Residential	0.30	15	50.0	NORMAL	MIN	Large Lot Residential - Single F
40	140	Residential	0.25	20	50.0	NORMAL	MIN	Medium Lot Residential - Singl
50	150	Residential	0.25	30	50.0	NORMAL	MIN	Small Lot Residential - Single F
60	160	Residential	0.25	40	50.0	NORMAL	MIN	Very Small Lot Residential - Sir
70	170	Residential	0.25	45	50.0	NORMAL	MIN	Medium Density Residential - M
80	180	Residential	0.25	45	50.0	NORMAL	MIN	High Density Residential - Multi
90	190	Residential	0.25	45	50.0	NORMAL	MIN	Very High Density Residential -
100	200	Commercial	0.10	80	60.0	NORMAL	MIN	General Commercial (Commer
110	210	Commercial	0.10	80	65.0	NORMAL	MIN	Specialty Commercial (<=50,00
120	220	Commercial	0.10	80	65.0	NORMAL	MIN	Neighborhood Commercial (50
130	230	Commercial	0.10	80	75.0	NORMAL	MIN	Community Commercial (100,0
140	240	Commercial	0.10	80	65.0	NORMAL	MIN	Regional Commercial (500,000
150	250	Commercial	0.10	80	70.0	NORMAL	MIN	Super-Regional Commercial (>
160	300	Industrial	0.15	55	60.0	NORMAL	MIN	General Industrial (Industrial wi

2. After *review*, Click *'OK'* to close the form.

8. Review Soil Defaults

1. Select Hydrology => *Soil Defaults* to view or modify soil defaults or add '*Custom*' data. For this example, custom values are not required.

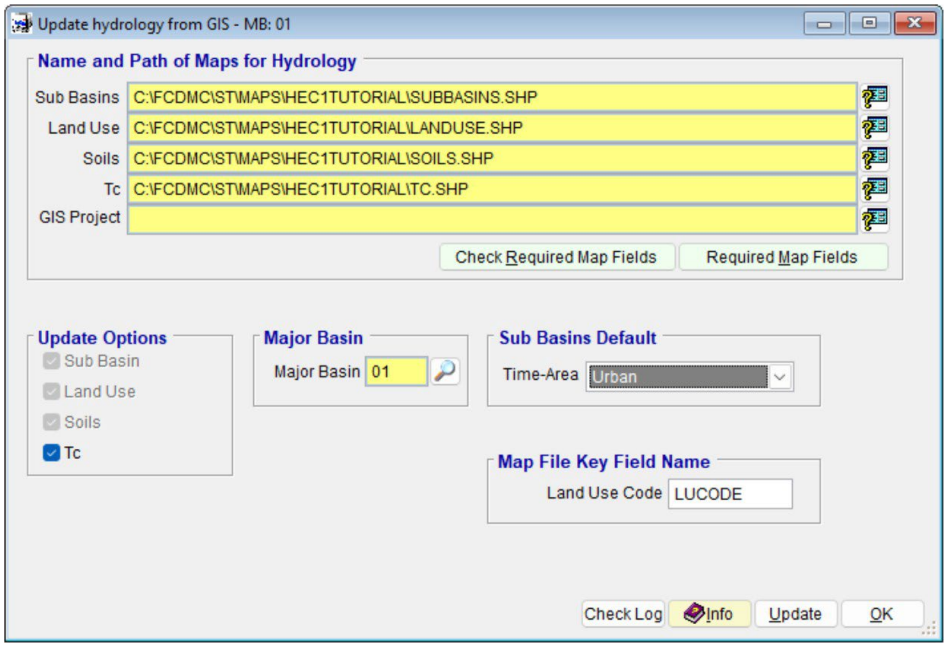


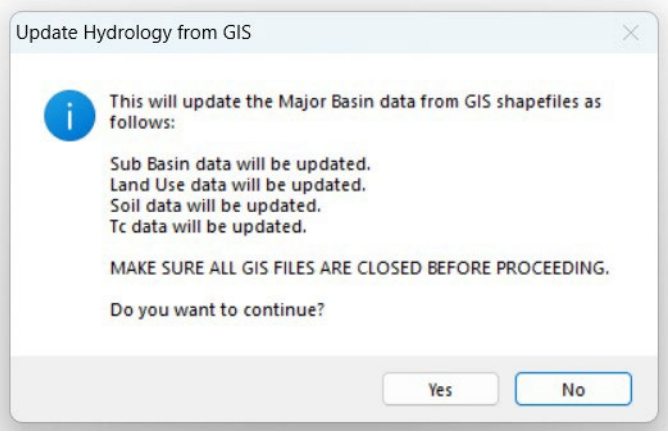
2. After *review*, Click *'OK'* to close the form.

9. Update Hydrology Data

For this example, Sub Basin, Land Use, Soils and Time of Concentration (Tc) data will be developed from the developed GIS files. **The data can also be entered manually**.

1. Select *Maps => Update Hydrology* to access the mapping update.
2. Check *Land Use, Soils* and *Tc* to access the *Name and Path of Maps*
3. Locate the *Sub Basin*, *Land Use, Soils* and *Tc* shape Files.
4. Click *"Save"*
5. Click *'Update'* to update the data.



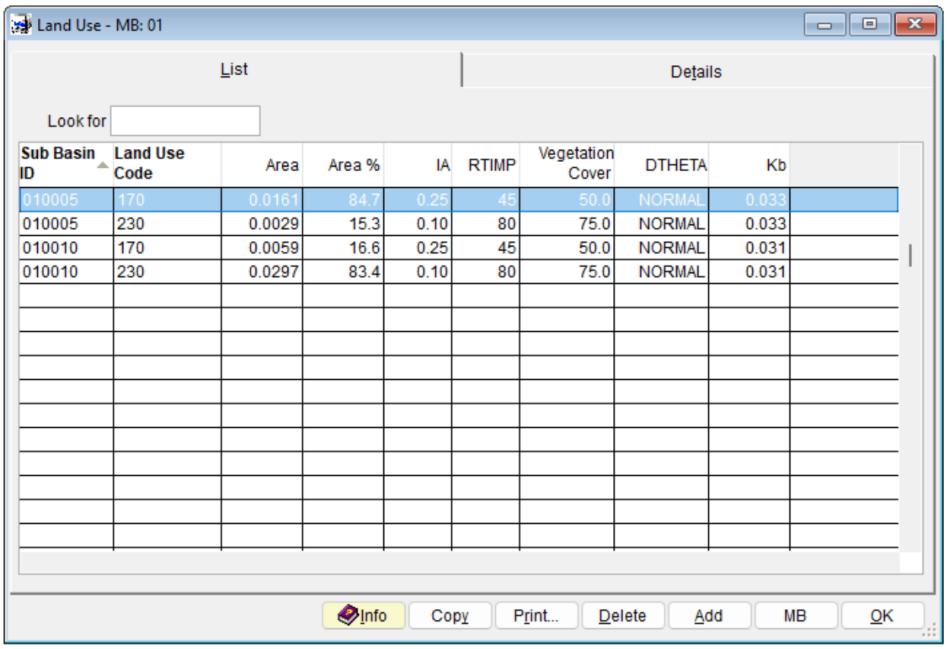


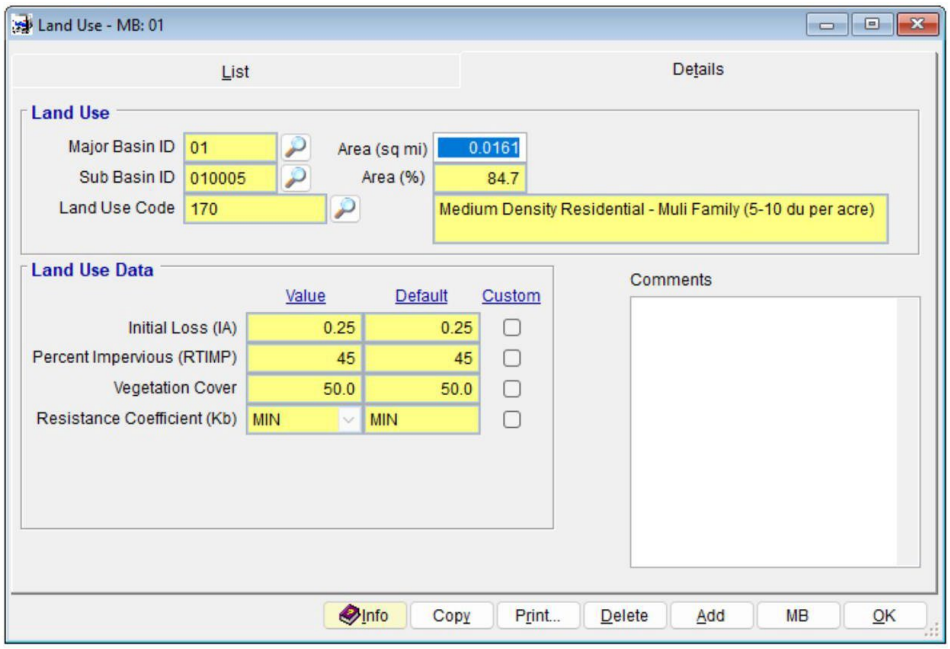
6. Click *'Yes"* to continue.

View Land Use Data

7. Select *Hydrology => Land Use* to view or modify land use data.

.

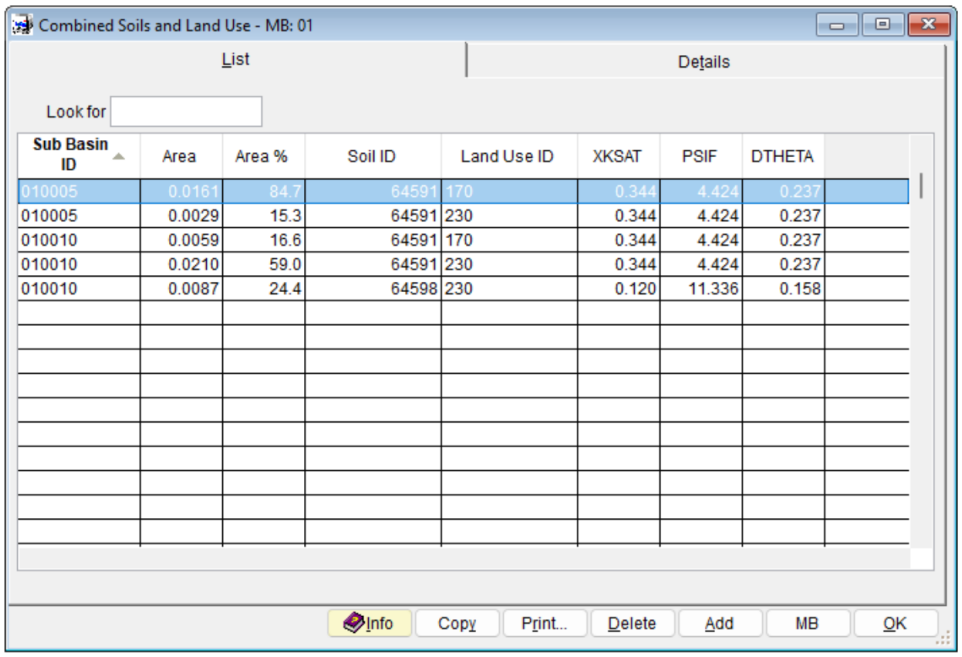




8. After *review*, Click *'OK'* to close the form.

View Soils Data

9. *Select Hydrology* => Soils to view or modify Soils data.



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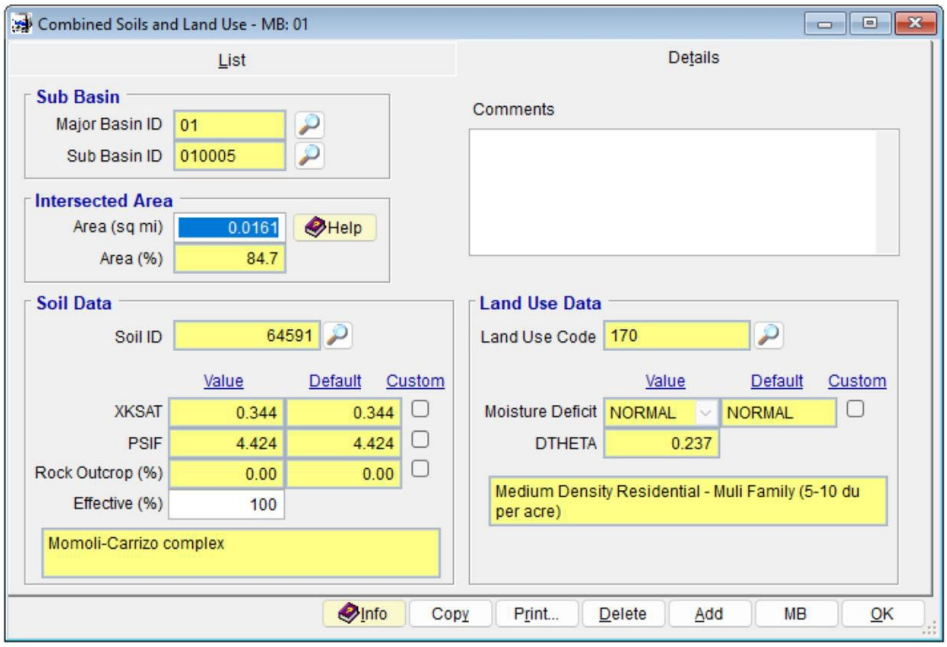
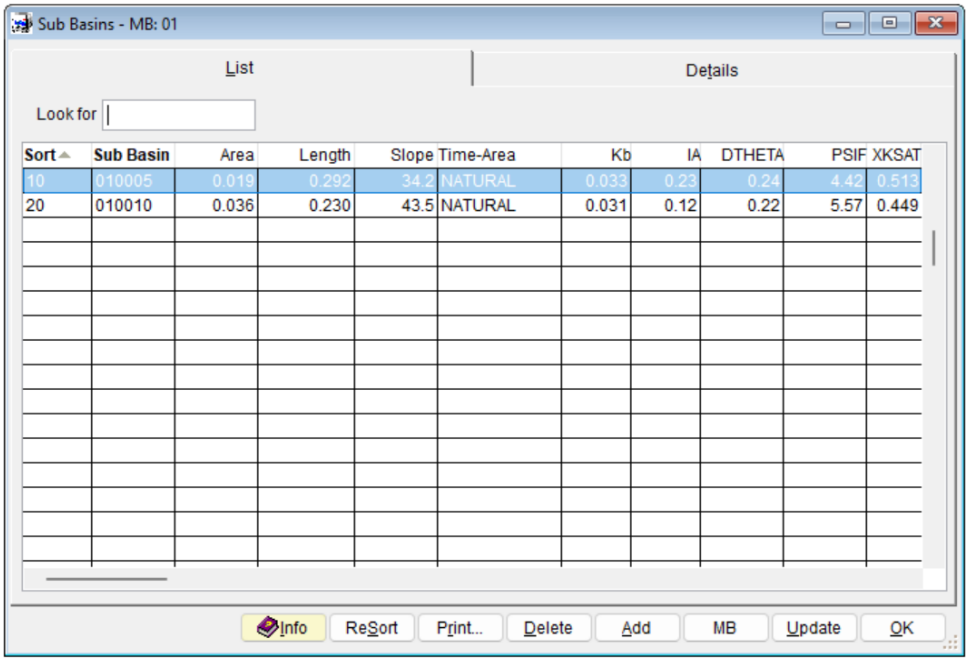


10. After *review*, Click *'OK'* to close the form.

View Sub Basin Data

11. *Select Hydrology* => Sub Basins *to* view or modify Sub Basin data.



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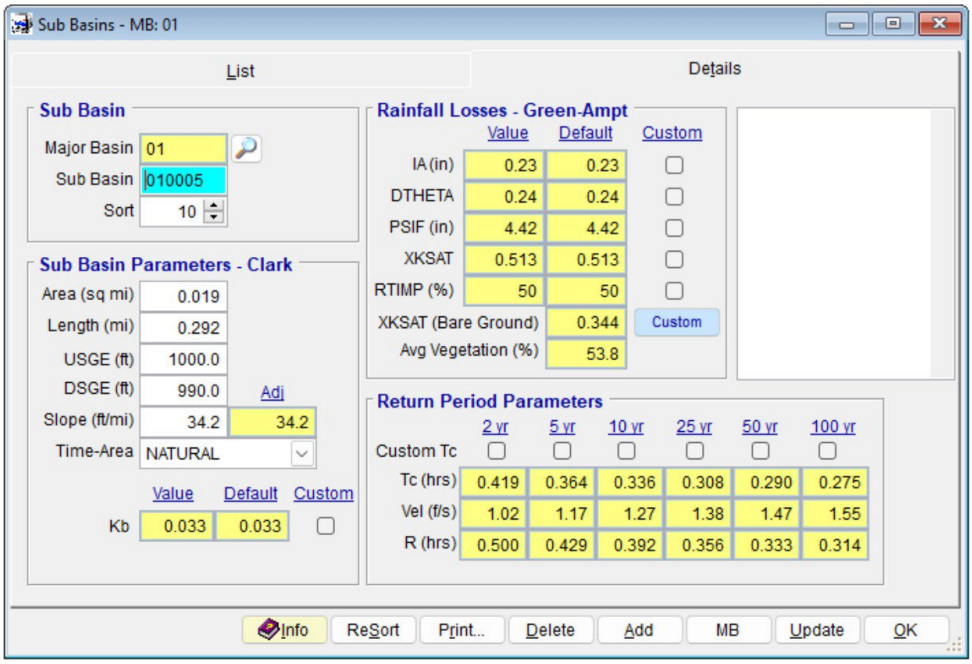


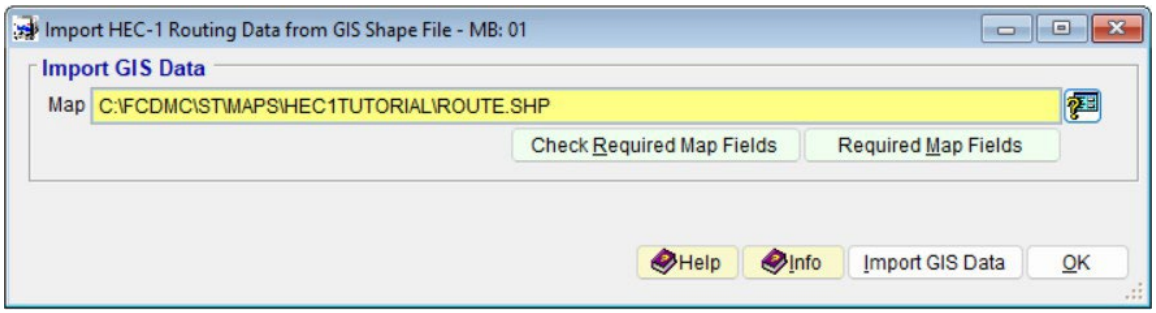
12. After *review*, Click *'OK'* to *close* the form.

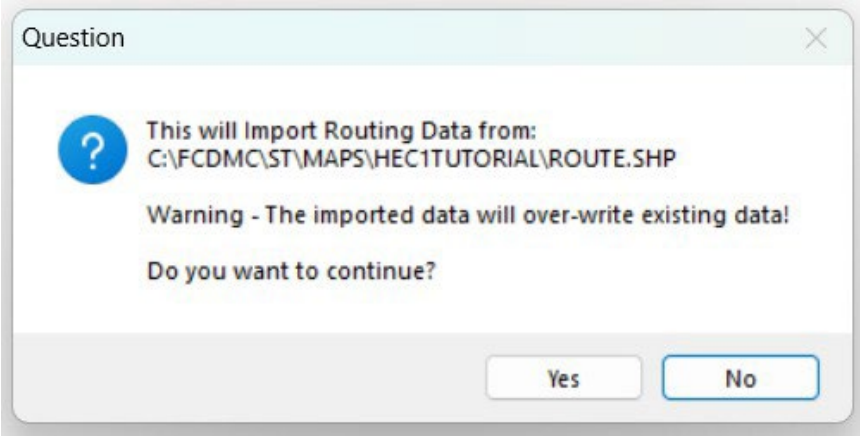
10. Routing Data

Import Routing Data

For this example, the routing data is contained in the Route shapefile. **The data can also be entered manually.**

1. Select *Maps* => Import Routing Data.
2. Click "*Required Map Fields"* to make sure the data structure is correct.
3. Locate the Map shapefile.
4. Click *"Import GIS Data"*

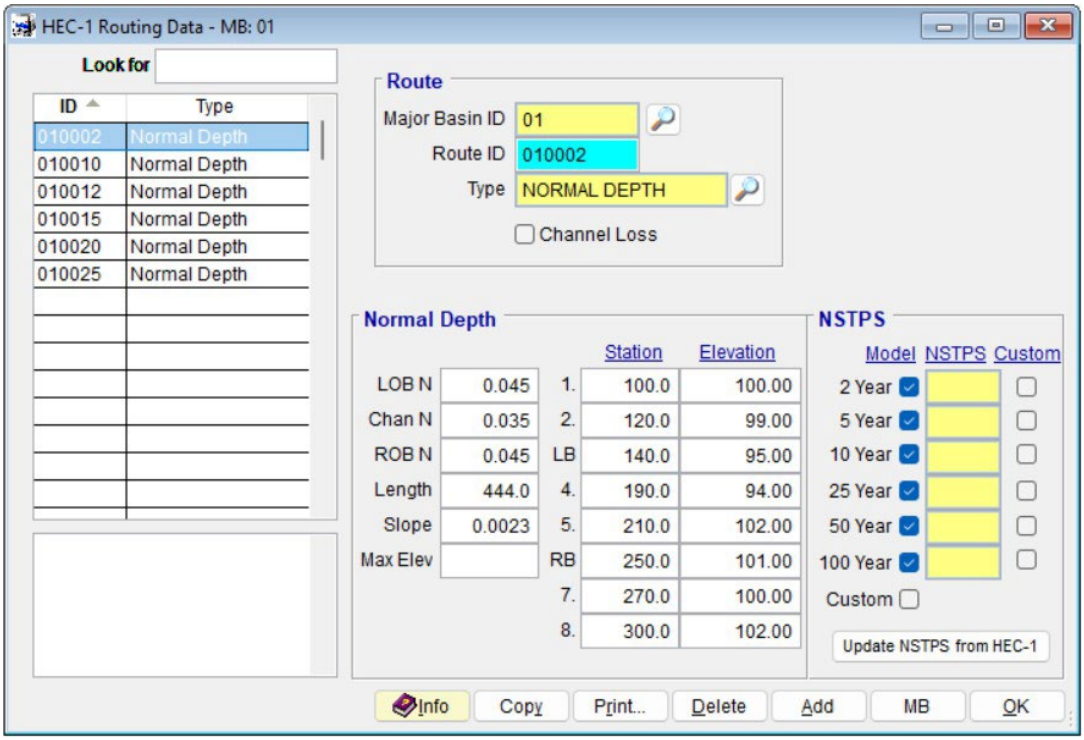




5. Click *"Yes"* to continue.

View Routing Data

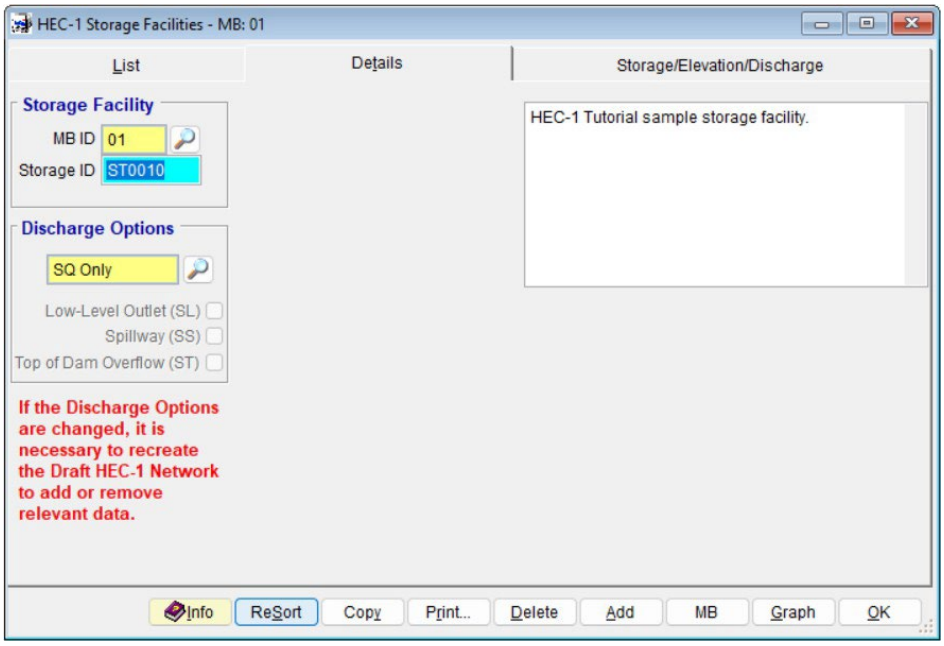
1. Select *Hydrology => HEC-1=> Routing*.



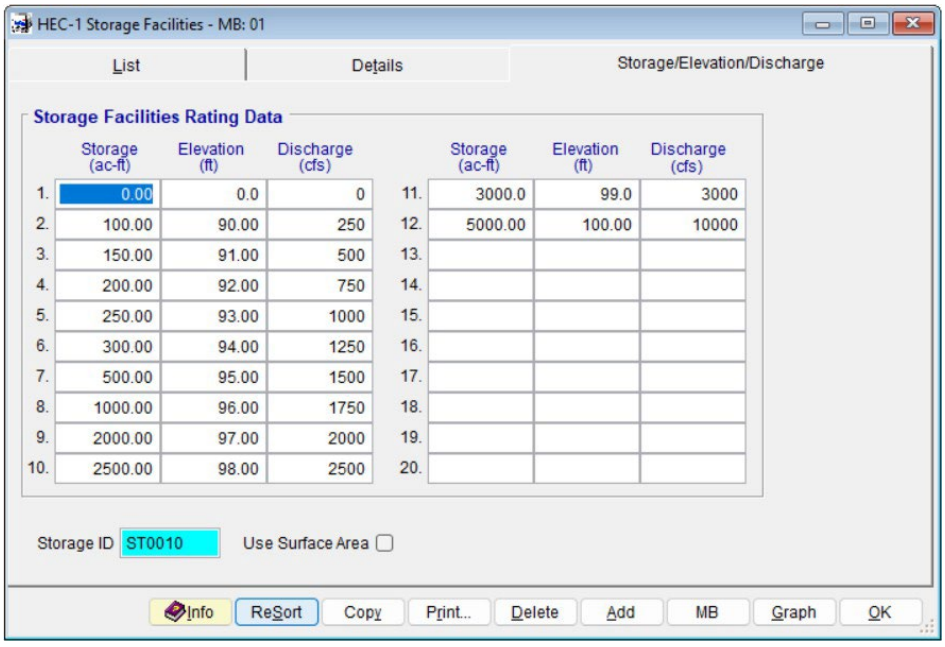
2. Click *"OK"* to close the form.

11. Storage Facility Data

1. Select *"Hydrology=>HEC-1=>Storage*.
2. Click *"Add"* to add a record.
3. Enter ST0010 for the Storage Basin ID.
4. Select SQ Only for the Discharge Option.



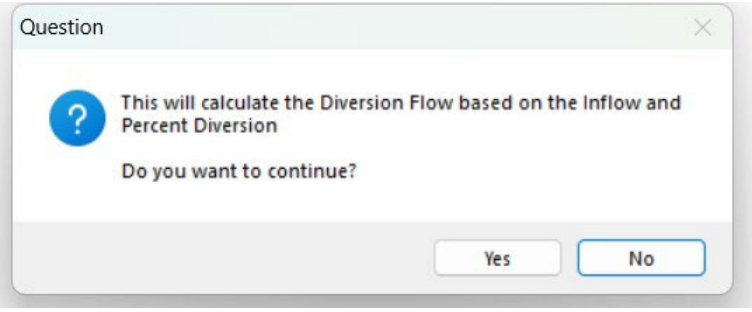
5. Click *"Save"*
6. Click the Tab *"Storage/Discharge/Elevation"* and enter the data shown below:



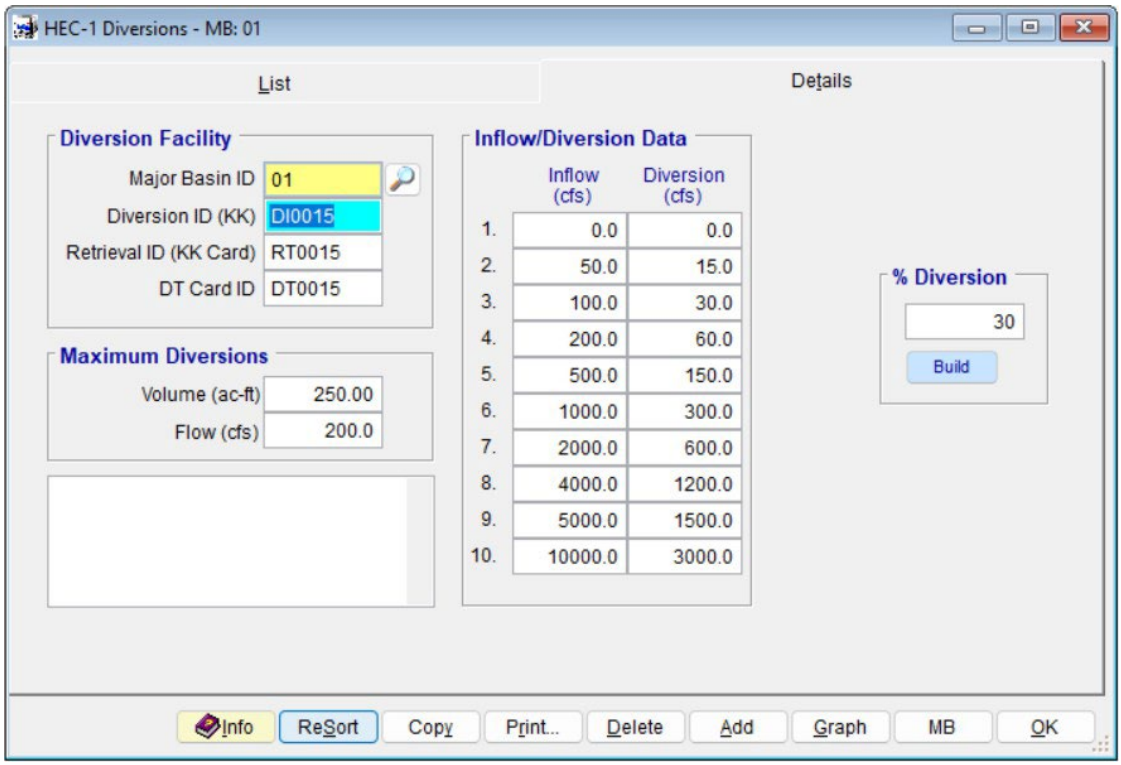
7. Click *"Save"* to save the data and *"OK"* to exit.

12. Diversion Data

1. Select *"Hydrology=>HEC-1=>Diversions*.
2. Click *"Add"* to add a record.
3. Enter DI0015 for the Diversion ID.
4. Click *"Save"*. This will establish the Retrieval and DT IDs.
5. Enter 250 for the Maximum Volume.
6. Enter 200 for the Maximum Flow.
7. Click *"Save"*
8. Enter the Inflow Data shown below (Diversion data will be calculated)
9. Enter 30 for the *"Percent Diversion"*
10. Click *"Build Diversion"*



11. Click *"Yes"*



12. Click *"OK"* to exit.

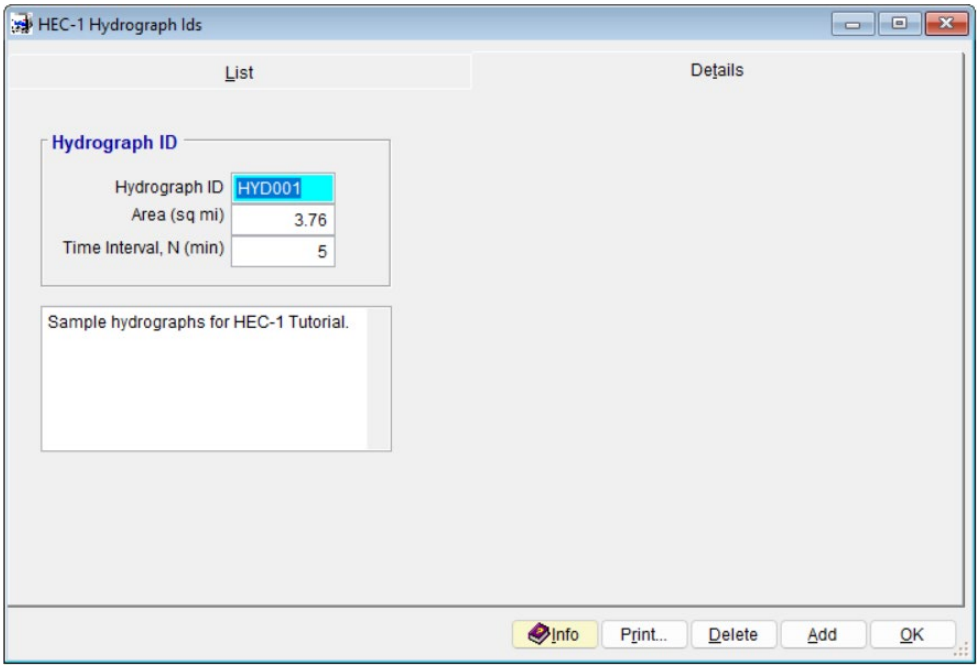
13. Hydrographs

For this model, hydrograph data from a previous HEC-1 model will be inserted at the beginning of the model. The data for the hydrographs for all return periods are available in folder C:\Fcdmc\ST\Modlruns\HEC1TUTORIAL. They are:

- Hyd001-2
- Hyd001-5
- Hyd001-10
- Hyd001-25
- Hyd001-50
- Hyd001-100

Hydrograph IDs

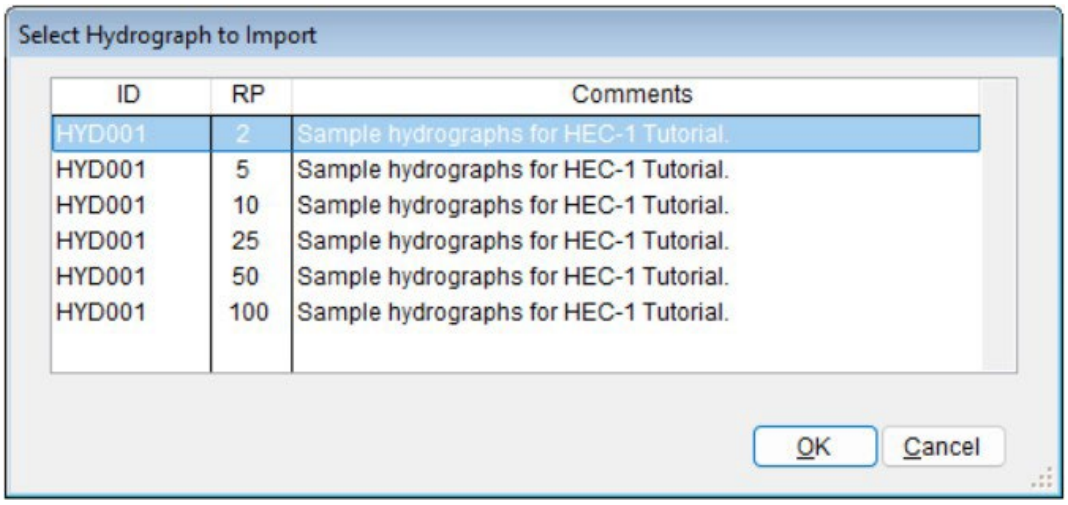
1. Select *"Hydrology=>HEC-1=>Hydrograph IDs*.
2. Click *"Add"* to add a record.
3. Enter HYD001 for the Hydrograph ID and enter the data shown below.



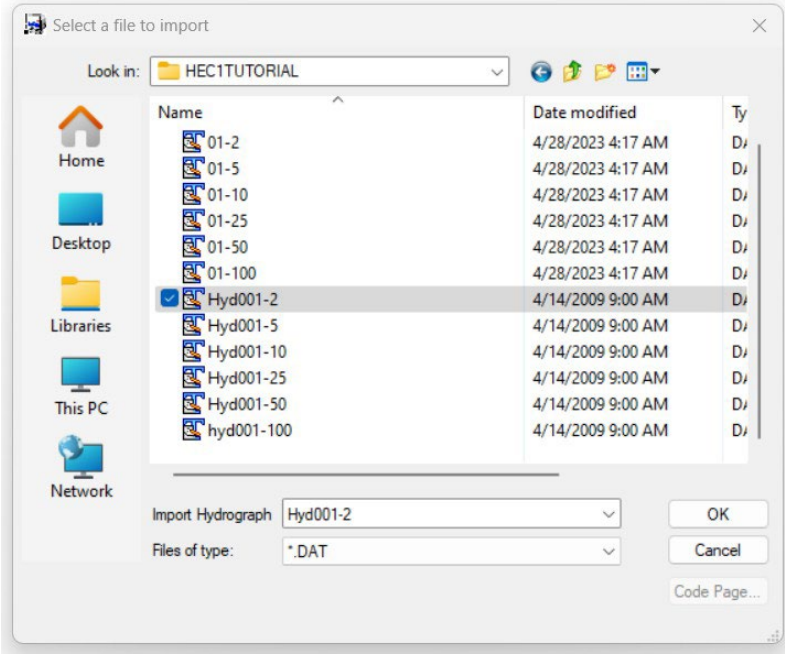
4. Click *"Save"*.
5. Click *"OK"*. To exit the form.

Hydrograph Data

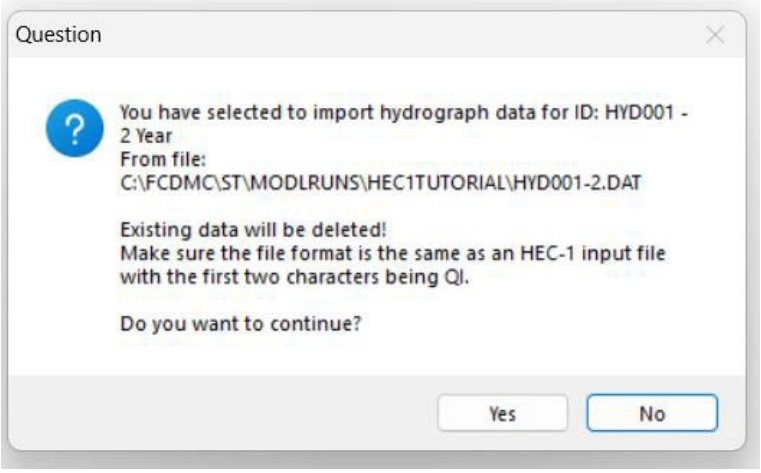
1. Select *"Hydrology=>HEC-1=>Hydrograph Data*.
2. Click *"Import Hydrograph"* to add a hydrograph data.
3. Select the 2-Year return period.



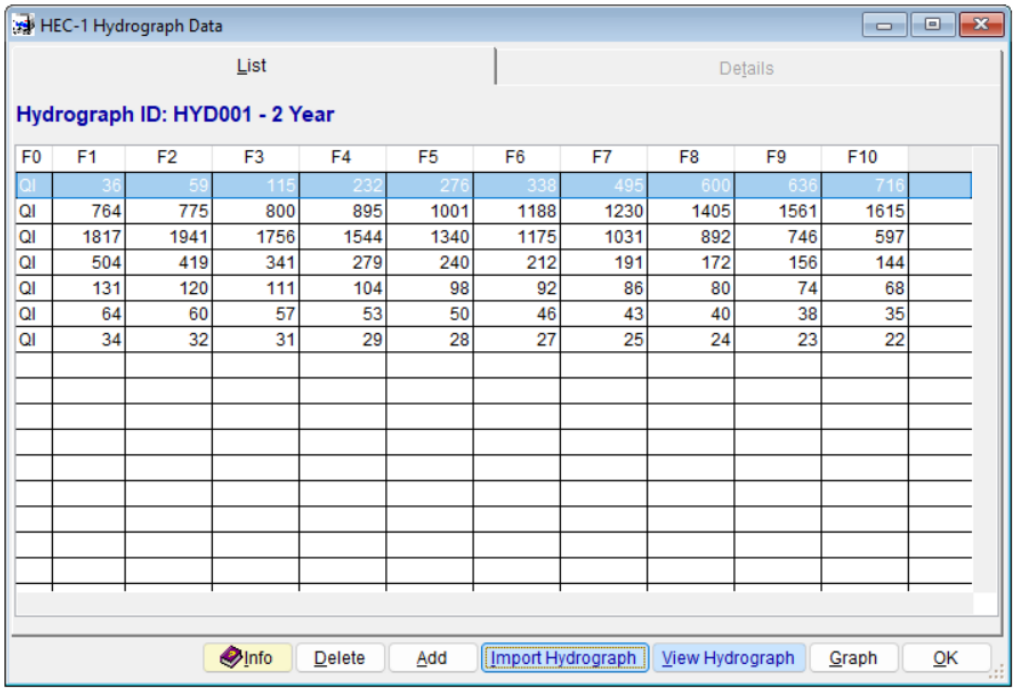
4. Click *"OK"*.
5. Select DAT as the extension and Click *"OK"*.
6. Migrate to the C:\Fcdmc\ST\Modlruns\HEC1TUTORIAL folder and select Hyd001-2



7. Click *"OK"*.



8. Click *"Yes"*.



F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
QI	36	59	115	232	276	338	495	600	636	716
QI	764	775	800	895	1001	1188	1230	1405	1561	1615
QI	1817	1941	1756	1544	1340	1175	1031	892	746	597
QI	504	419	341	279	240	212	191	172	156	144
QI	131	120	111	104	98	92	86	80	74	68
QI	64	60	57	53	50	46	43	40	38	35
QI	34	32	31	29	28	27	25	24	23	22

9. Import the remaining hydrographs (5, 10, 25, 50 and 100) using the same procedure.
10. After all hydrographs have been imported, Click *"OK"* to exit the form.

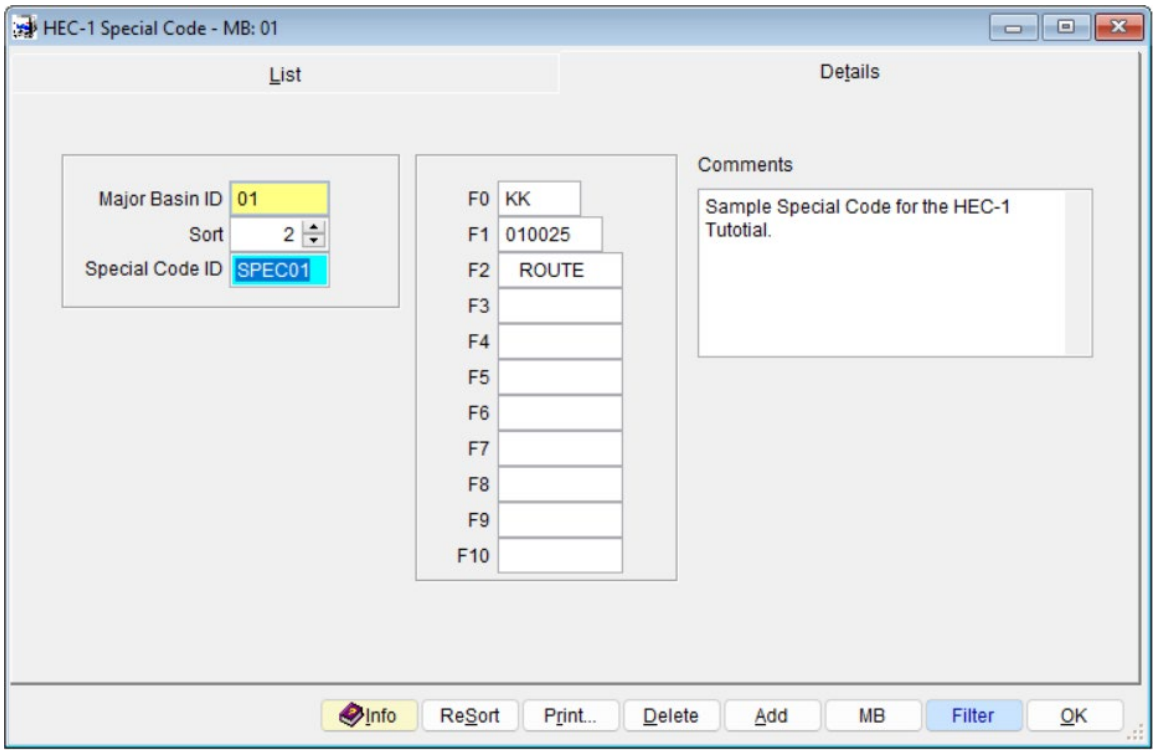
14. Special Code

"Special Code" has been established in DDMSW to manage HEC-1 features that are available in the HEC-1 model but are not included in DDMSW.

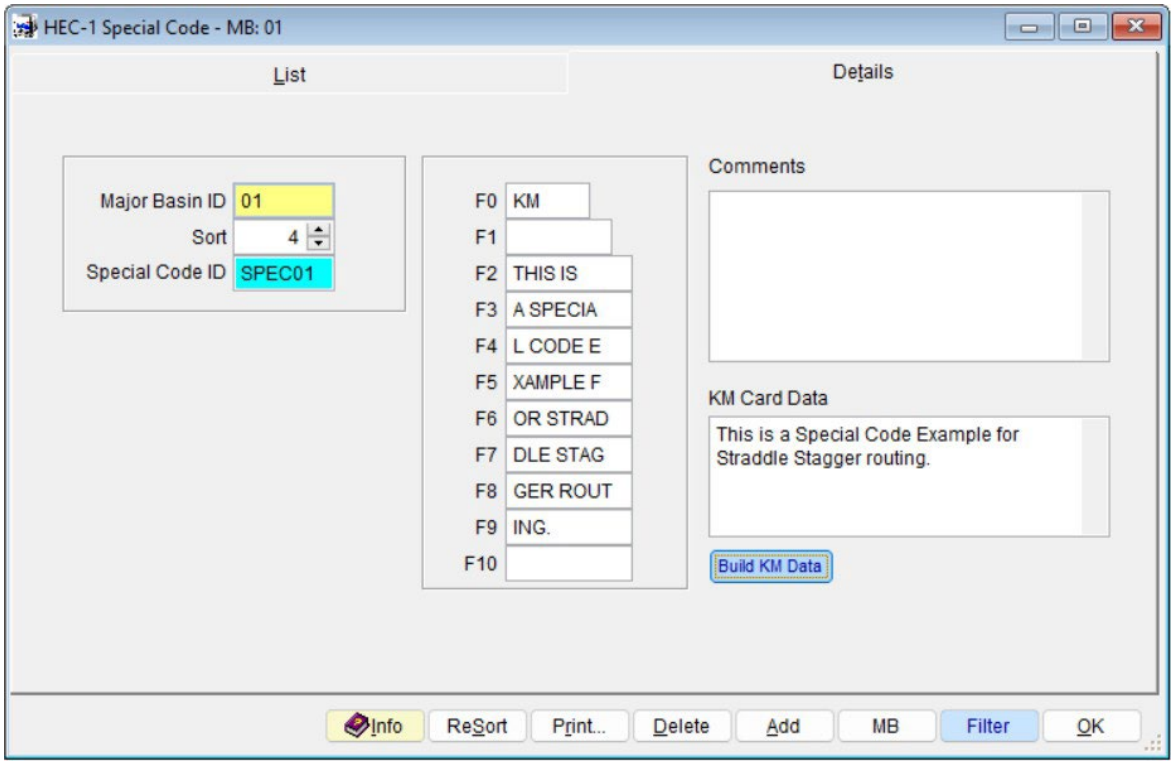
For this example, the Straddle/Stagger Routing data will be used for Route ID 010025.

The **Straddle Stagger** method uses empirical representations of translation and attenuation processes to route water through a reach. Inflow is delayed a specified amount of time. The delayed flows are averaged over a specified amount of time to produce the final outflow.

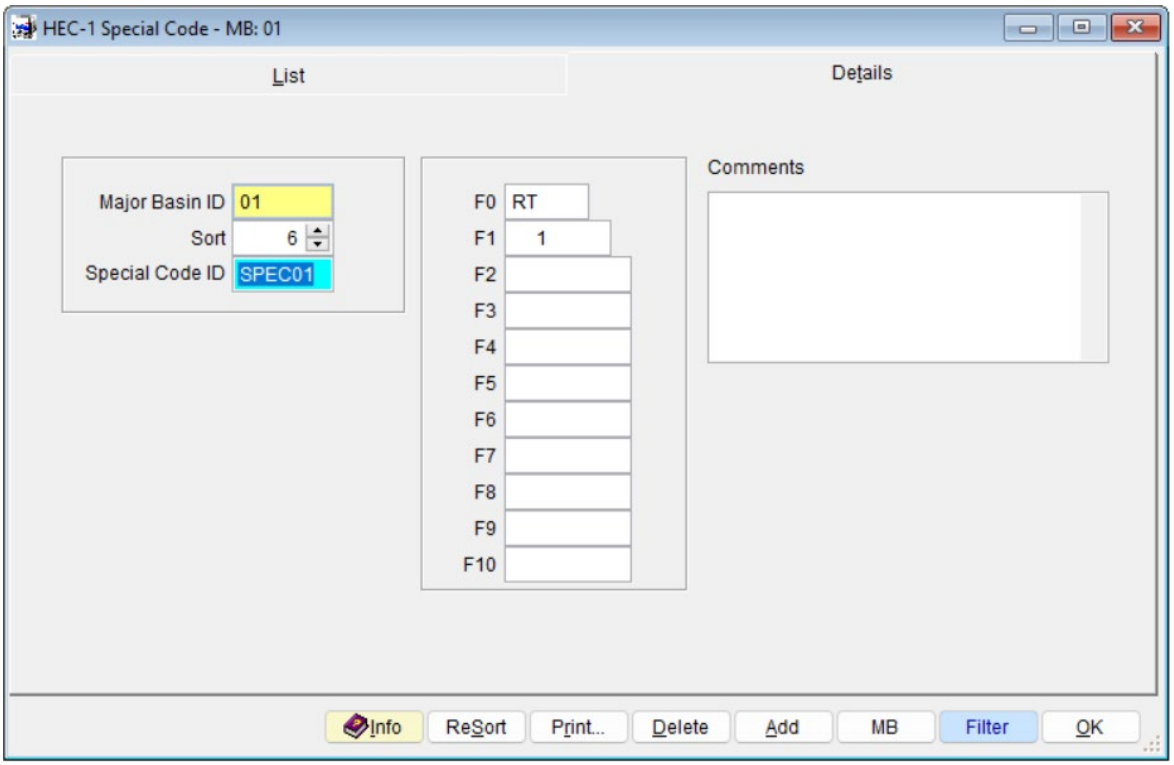
1. Select *Hydrology => HEC-1 => Special Code*.
2. Click 'Add' to add the first record.
3. Enter the data shown below and Click *"Save"*.

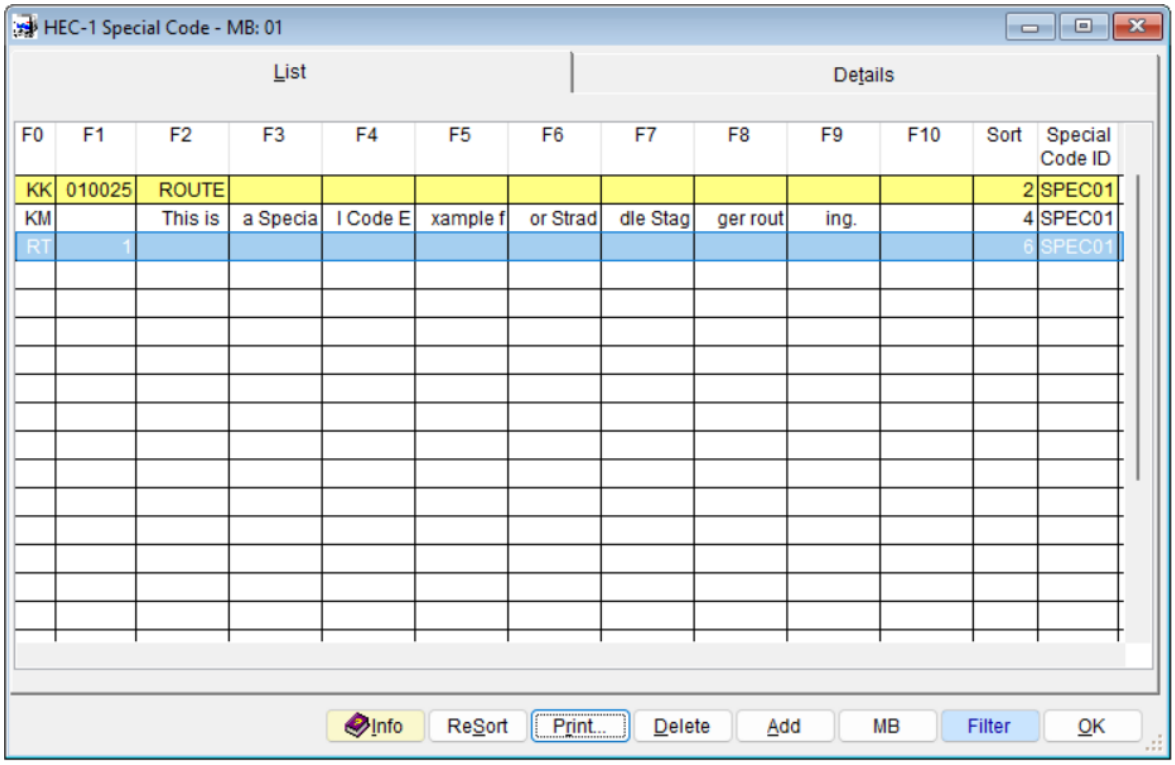


4. Click *"Add"*. To add a new record.
5. Enter KM for F0.
6. Enter the KM comment in the KM Card Data
7. Click *"Save"*.
8. Click *"Build KM data"*.

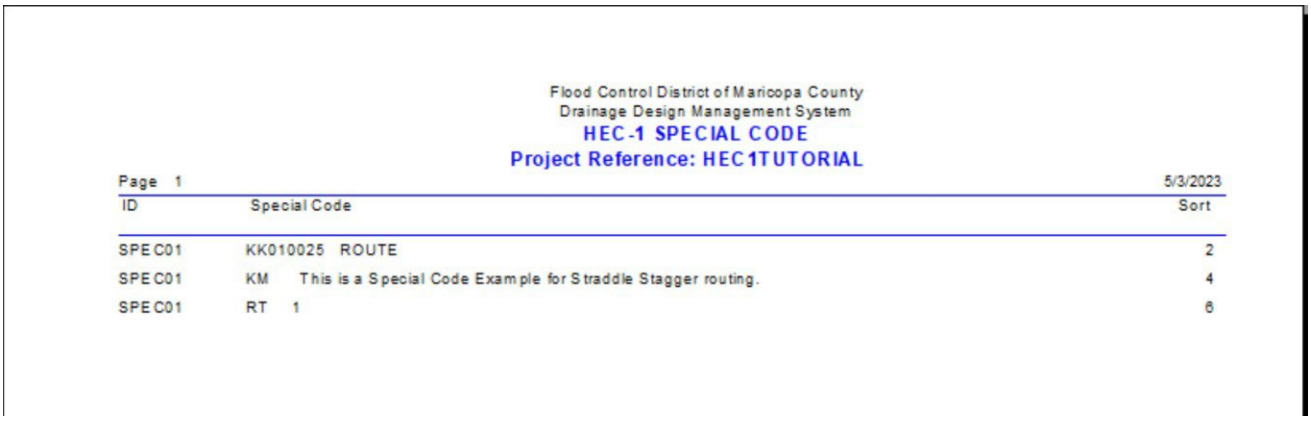


9. Click *"Add"*. To add a new record.
10. Enter the data shown below.





11. Click *"Print"* to print the data.



Flood Control District of Maricopa County
Drainage Design Management System
HEC-1 SPECIAL CODE
Project Reference: HEC1TUTORIAL

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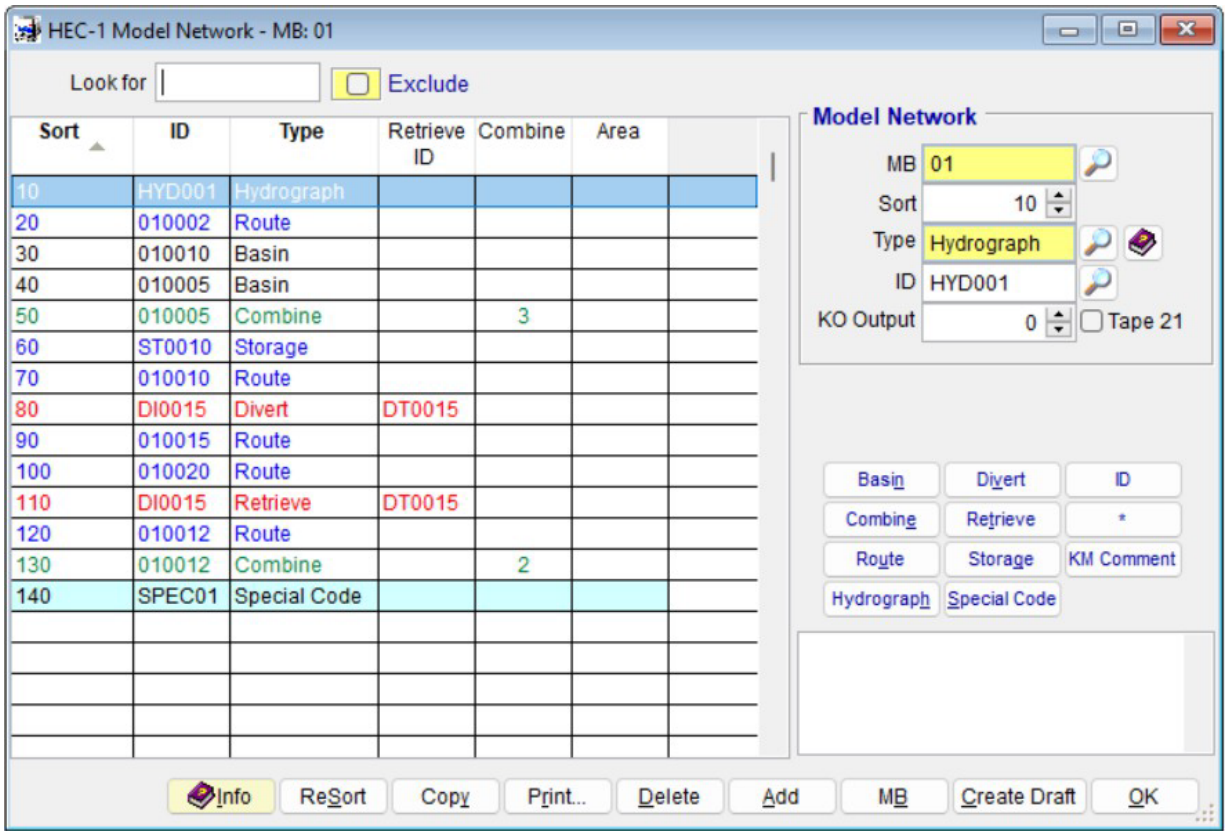
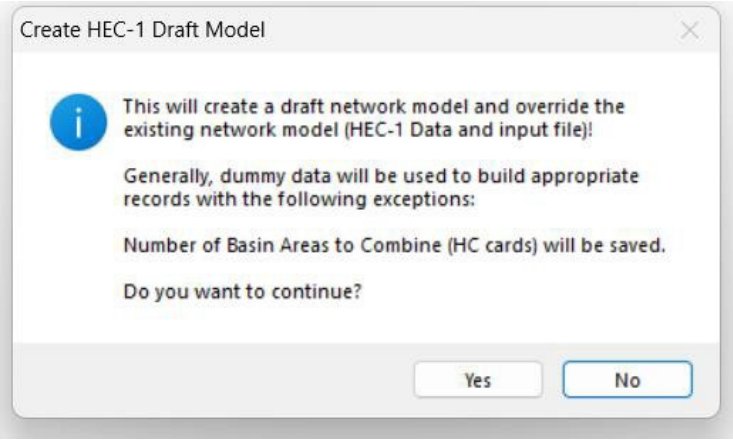
ID	Special Code	Sort
SPEC01	KK010025 ROUTE	2
SPEC01	KM This is a Special Code Example for Straddle Stagger routing.	4
SPEC01	RT 1	6

12. Click *"OK"* to exit.

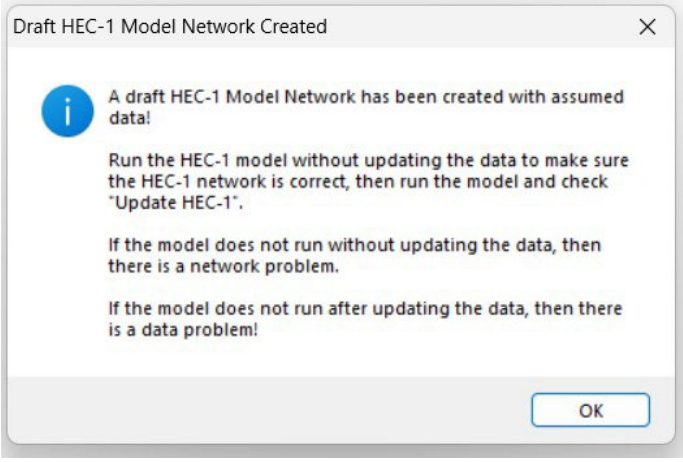
15. HEC-1 Model Network

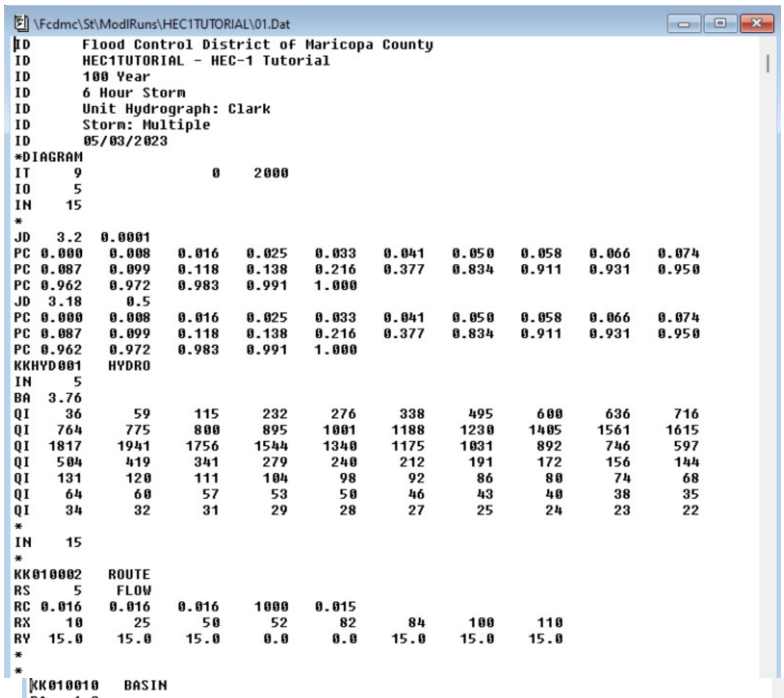
1. Select *Hydrology => HEC-1 => Network* to access the model network.
2. *Click 'Add' to add the first record and select Hydrograph.*
3. *Click the button next to ID and select HYD001, then Click "Save".*
4. *Click 'Route' and select 010002.*
5. *Click 'Basin' and select 010010.*
6. *Click "Basin" and select 010005.*
7. *Click "Combine" and change Combine to 3. Then Click "Save".*
8. *Click 'Storage' and select ST0010.*
9. *Click 'Route' and select 010010.*
10. *Click 'Divert' and select DI0015.*
11. *Click 'Route' and select 010015.*
12. *Click 'Route' and select 010012.*
13. *Click 'Retrieve' and select DI0015.*
14. *Click 'Route' and select 010012.*
15. *Click 'Combine.*
16. *Click 'Special Code' and select SPEC01.*
17. Click '*Create Draft' to create the daft network model.*

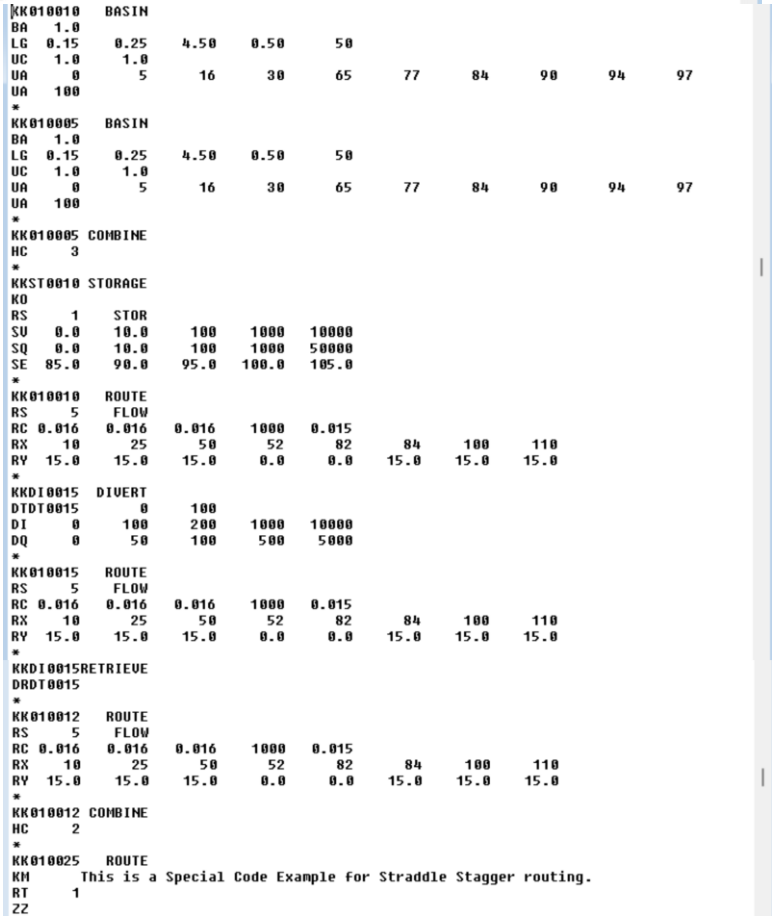




18. Click 'Yes' *to continue.*



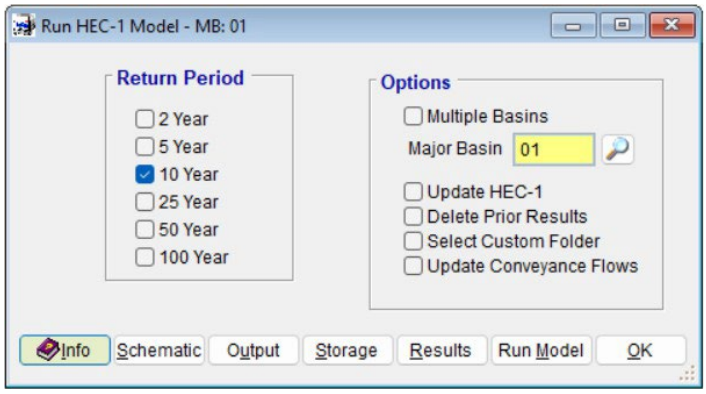

\Fcdmc\St\ModlRuns\HEC1TUTORIAL\01.Dat
ID Flood Control District of Maricopa County
ID HEC1TUTORIAL - HEC-1 Tutorial
ID 100 Year
ID 6 Hour Storm
ID Unit Hydrograph: Clark
ID Storm: Multiple
ID 05/03/2023
*DIAGRAM
IT 9 0 2000
IO 5
IN 15
*
JD 3.2 0.0001
PC 0.000 0.008 0.016 0.025 0.033 0.041 0.050 0.058 0.066 0.074
PC 0.087 0.099 0.118 0.138 0.216 0.377 0.834 0.911 0.931 0.950
PC 0.962 0.972 0.983 0.991 1.000
JD 3.18 0.5
PC 0.000 0.008 0.016 0.025 0.033 0.041 0.050 0.058 0.066 0.074
PC 0.087 0.099 0.118 0.138 0.216 0.377 0.834 0.911 0.931 0.950
PC 0.962 0.972 0.983 0.991 1.000
KKHYD001 HYDRO
IN 5
BA 3.76
QI 36 59 115 232 276 338 495 600 636 716
QI 764 775 800 895 1001 1188 1230 1405 1561 1615
QI 1817 1941 1756 1544 1340 1175 1031 892 746 597
QI 504 419 341 279 240 212 191 172 156 144
QI 131 120 111 104 98 92 86 80 74 68
QI 64 60 57 53 50 46 43 40 38 35
QI 34 32 31 29 28 27 25 24 23 22
*
IN 15
*
KK010002 ROUTE
RS 5 FLOW
RC 0.016 0.016 0.016 1000 0.015
RX 10 25 50 52 82 84 100 110
RY 15.0 15.0 15.0 0.0 0.0 15.0 15.0 15.0
*
*


KK010010 BASIN
BA 1.0
LG 0.15 0.25 4.50 0.50 50
UC 1.0 1.0
UA 0 5 16 30 65 77 84 90 94 97
UA 100
*
KK010005 BASIN
BA 1.0
LG 0.15 0.25 4.50 0.50 50
UC 1.0 1.0
UA 0 5 16 30 65 77 84 90 94 97
UA 100
*
KK010005 COMBINE
HC 3
*
KKST0010 STORAGE
KO
RS 1 STOR
SV 0.0 10.0 100 1000 10000
SQ 0.0 10.0 100 1000 50000
SE 85.0 90.0 95.0 100.0 105.0
*
KK010010 ROUTE
RS 5 FLOW
RC 0.016 0.016 0.016 1000 0.015
RX 10 25 50 52 82 84 100 110
RY 15.0 15.0 15.0 0.0 0.0 15.0 15.0 15.0
*
KKDI0015 DIVERT
DTDT0015 0 100
DI 0 100 200 1000 10000
DQ 0 50 100 500 5000
*
KK010015 ROUTE
RS 5 FLOW
RC 0.016 0.016 0.016 1000 0.015
RX 10 25 50 52 82 84 100 110
RY 15.0 15.0 15.0 0.0 0.0 15.0 15.0 15.0
*
KKDI0015RETRIEVE
DRDT0015
*
KK010012 ROUTE
RS 5 FLOW
RC 0.016 0.016 0.016 1000 0.015
RX 10 25 50 52 82 84 100 110
RY 15.0 15.0 15.0 0.0 0.0 15.0 15.0 15.0
*
KK010012 COMBINE
HC 2
*
KK010025 ROUTE
KM This is a Special Code Example for Straddle Stagger routing.
RT 1
ZZ

16. Run HEC-1 Model

1. Select *Hydrology => HEC-1 => Model* to access the HEC-1 model.

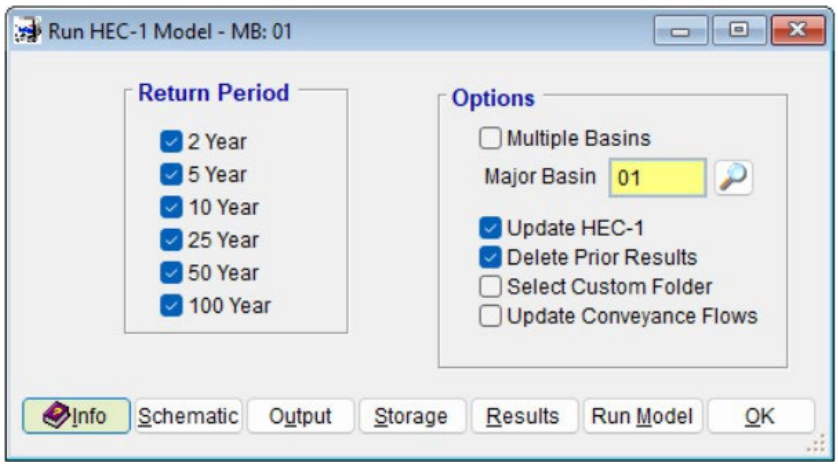
2. Check the '*10 Year*' Return Period and the *'Delete Prior Results*' option. Uncheck all other return periods and options.

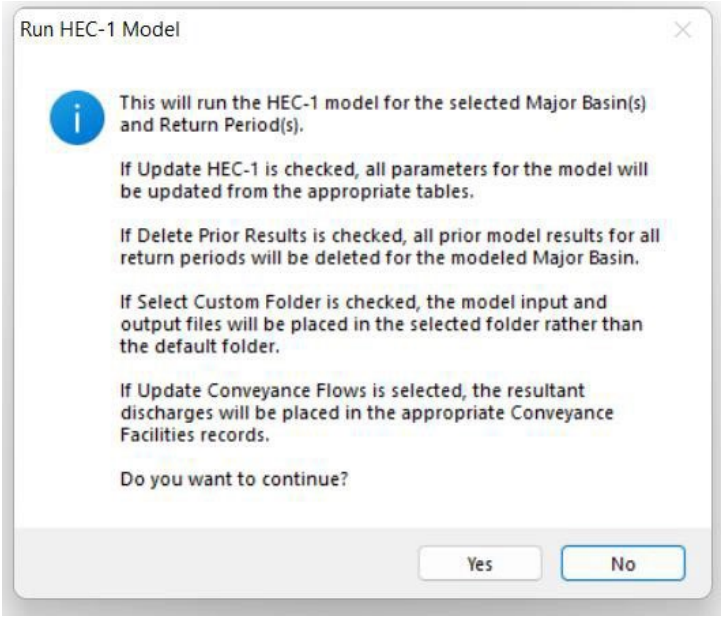


1. Click '*Save'*, then Click *'Run Model'* to run the Draft HEC-1 Model. If the model runs correctly, it means the HEC-1 Network is fine.

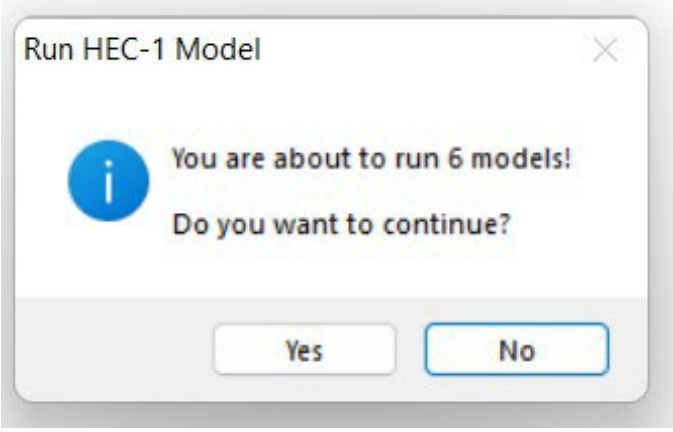
2. If no errors, Check all the Return Periods, Update HEC-1 and Delete Prior Results.

3. Click *"Save"* and then Click *"Run Model"*.





4. Click '*Yes'* to continue.

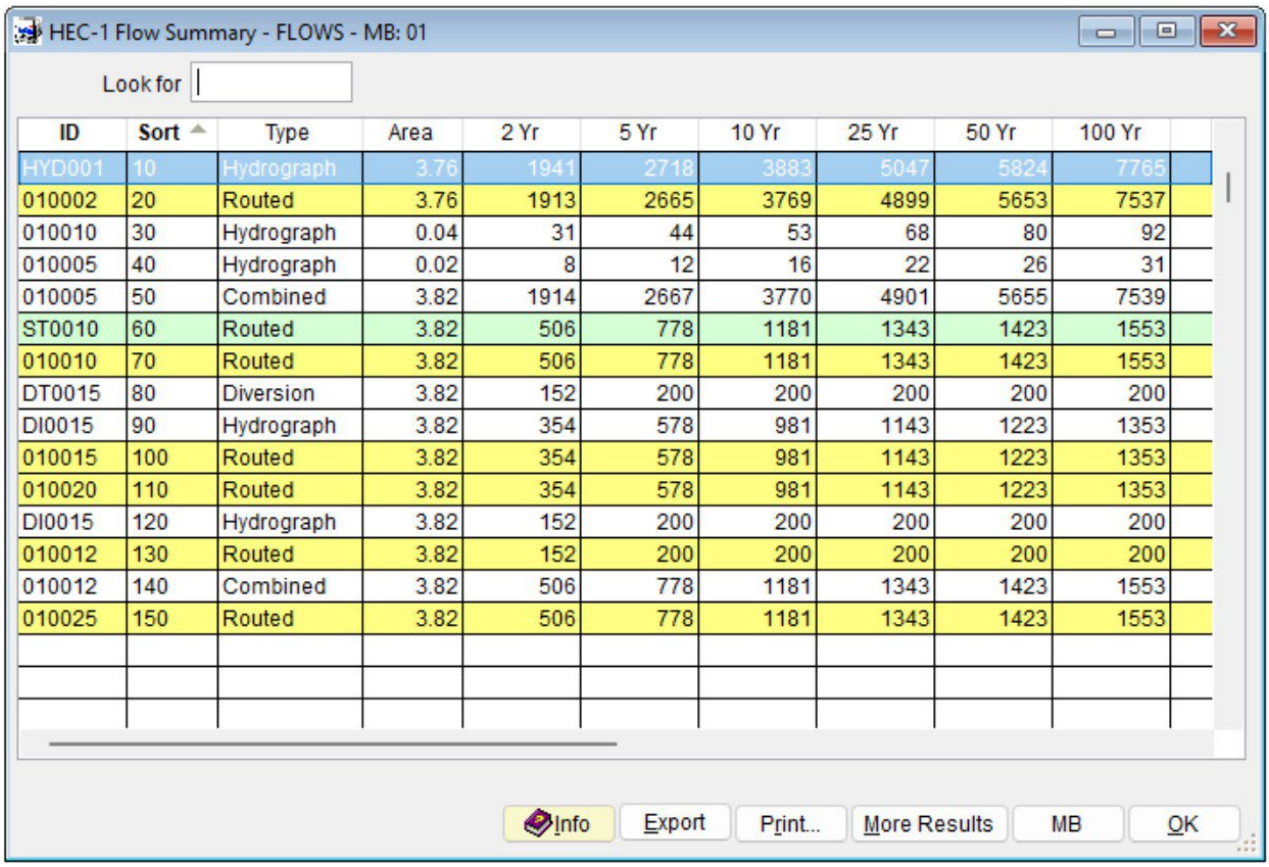


5. Click '*Yes'* to run the models.
6. Click *"Results"* to view the results.

1. Click *"Yes"* to continue.
2. Click *"OK"* to close the form.

17. Flow Summary

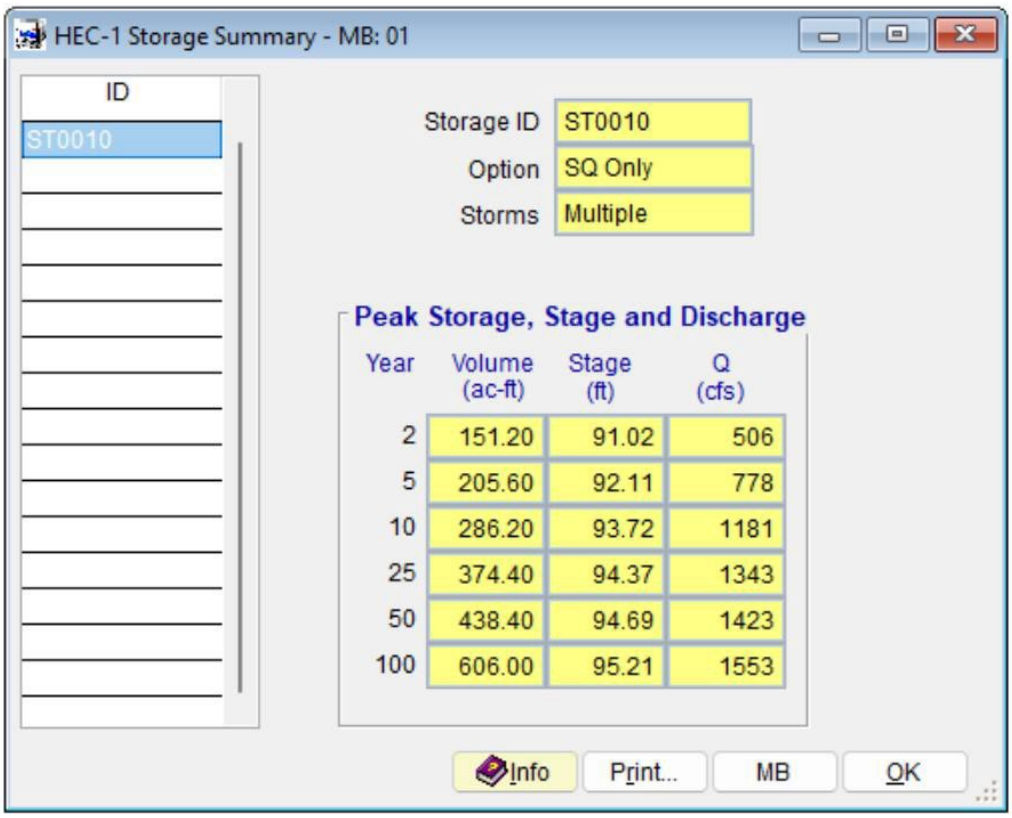
1. Select *Hydrology => HEC-1 => Flow Summary*



ID	Sort	Type	Area	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
HYD001	10	Hydrograph	3.76	1941	2718	3883	5047	5824	7765
010002	20	Routed	3.76	1913	2665	3769	4899	5653	7537
010010	30	Hydrograph	0.04	31	44	53	68	80	92
010005	40	Hydrograph	0.02	8	12	16	22	26	31
010005	50	Combined	3.82	1914	2667	3770	4901	5655	7539
ST0010	60	Routed	3.82	506	778	1181	1343	1423	1553
010010	70	Routed	3.82	506	778	1181	1343	1423	1553
DT0015	80	Diversion	3.82	152	200	200	200	200	200
DI0015	90	Hydrograph	3.82	354	578	981	1143	1223	1353
010015	100	Routed	3.82	354	578	981	1143	1223	1353
010020	110	Routed	3.82	354	578	981	1143	1223	1353
DI0015	120	Hydrograph	3.82	152	200	200	200	200	200
010012	130	Routed	3.82	152	200	200	200	200	200
010012	140	Combined	3.82	506	778	1181	1343	1423	1553
010025	150	Routed	3.82	506	778	1181	1343	1423	1553

18. Storage Summary

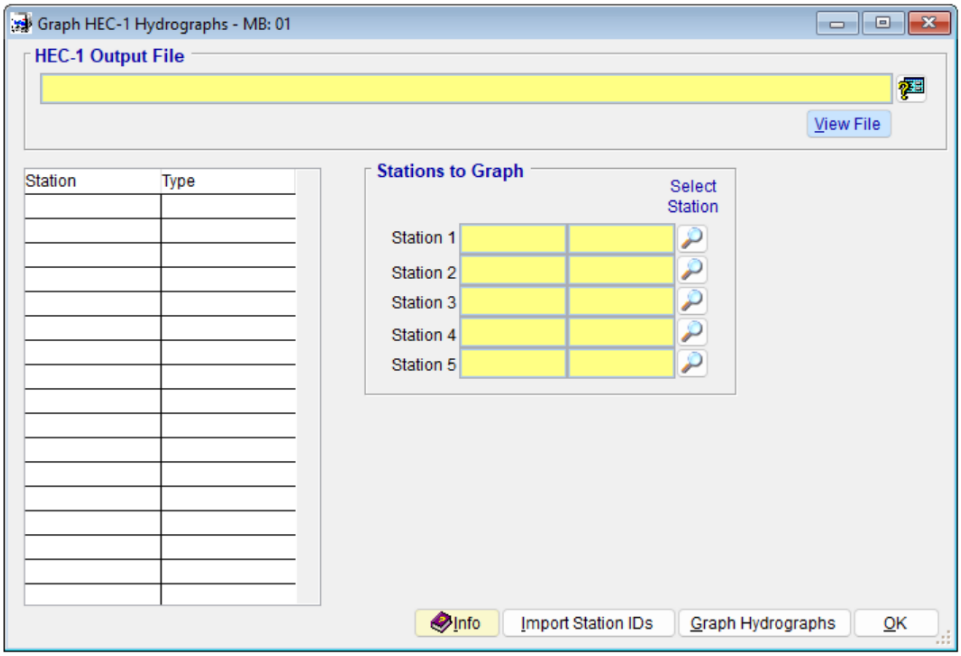
1. Select *Hydrology => HEC-1 => Storage Summary*



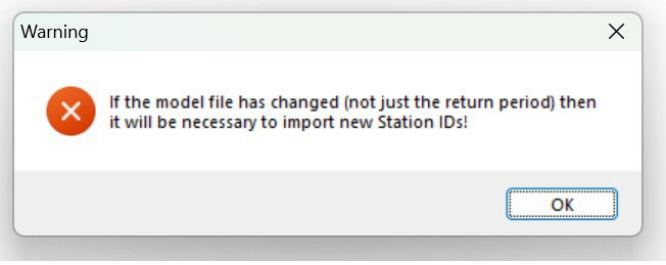
2. Click *"OK"* to close the form.

19. Graph Hydrographs

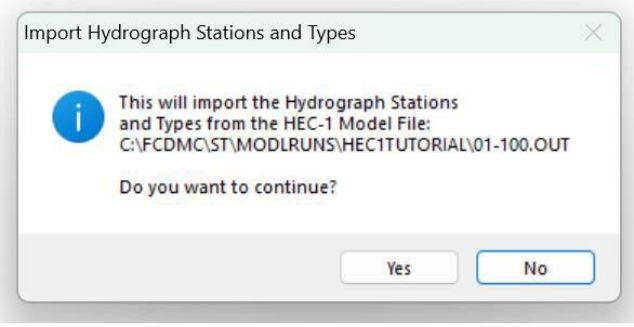
1. Select Hydrology => *HEC-1* => *Graph Hydrographs*



2. Select the HEC-1 output file.

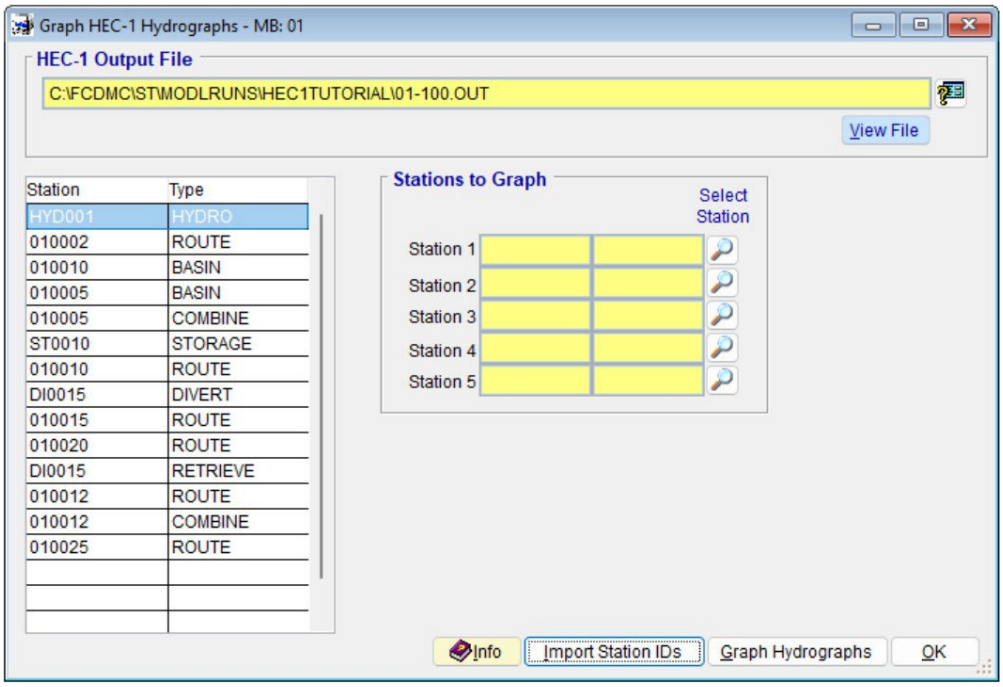


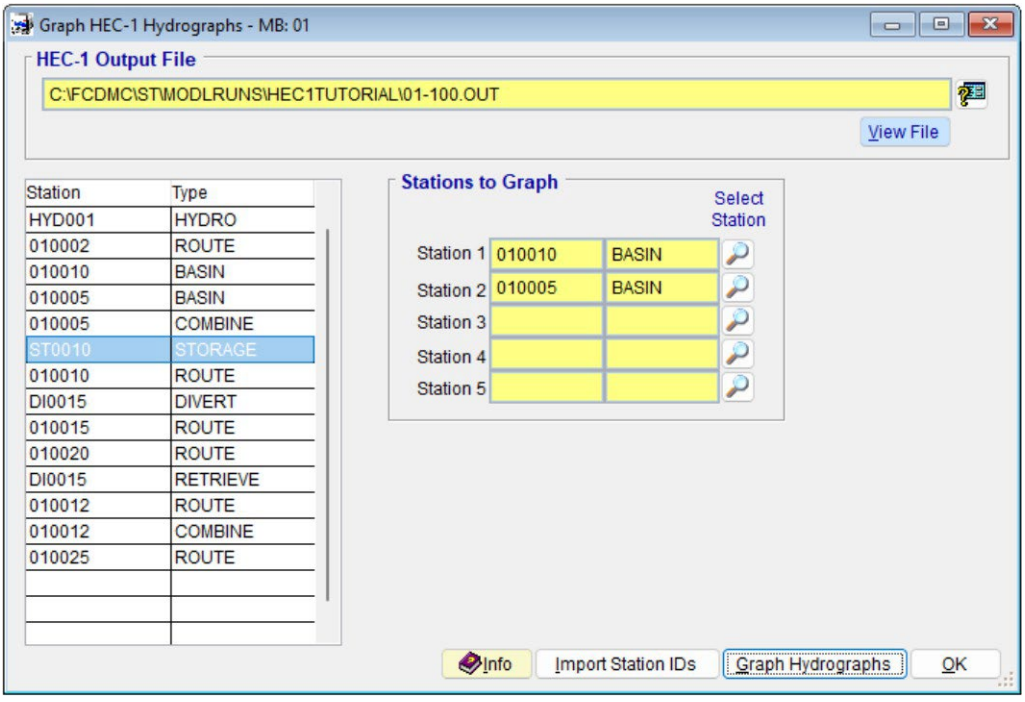
3. Since the model file has not changed, this is not necessary. Click OK.
4. Click *"Import Station IDs"*.



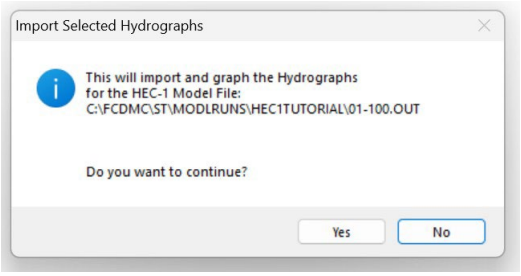
5. Click *"OK"* to continue.

6. Now that all available hydrographs are shown, up to 5 hydrographs can be selected for graphing. Select the hydrographs by highlighting it on the left and clicking the appropriate hour-glass on the right as show below.

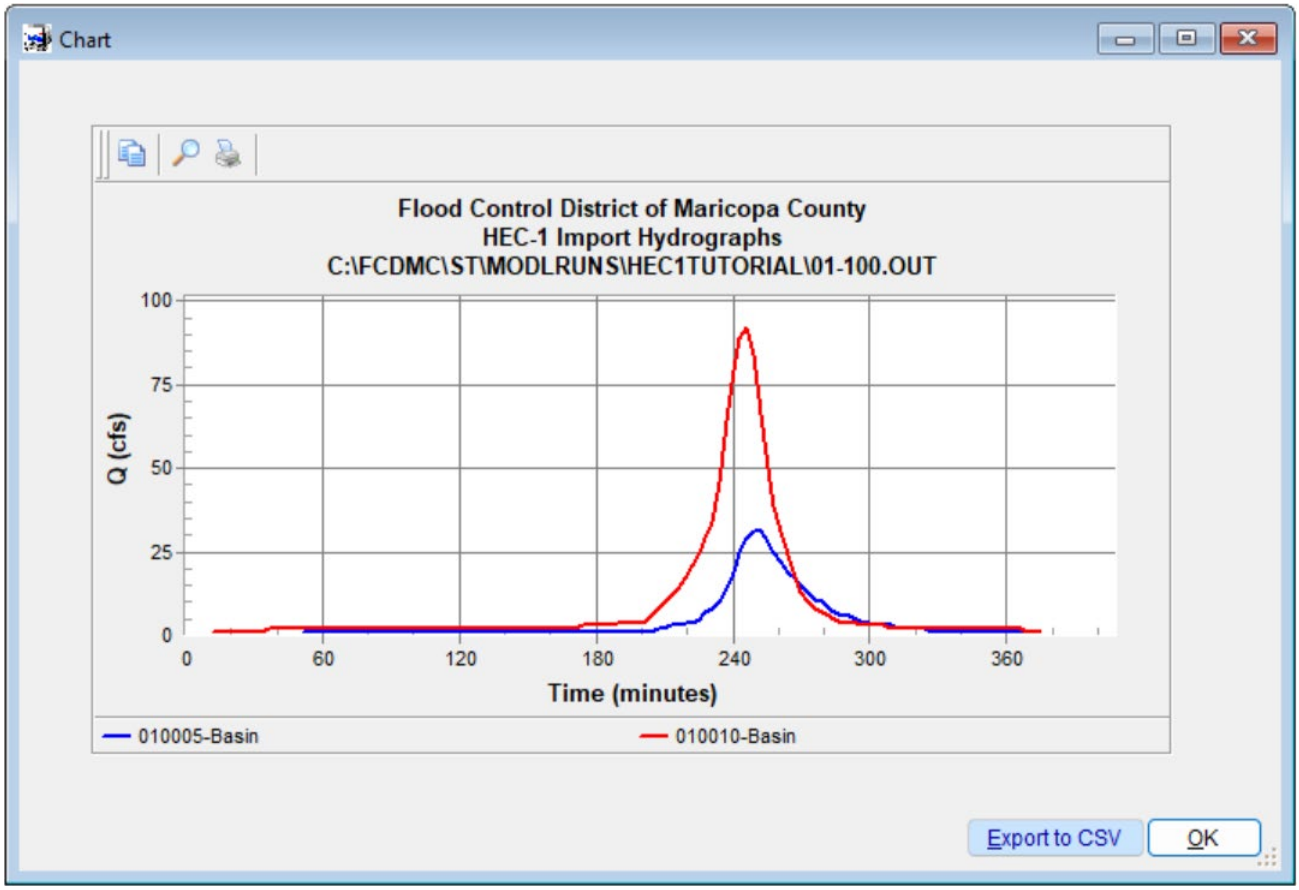




7. Click *"Graph Hydrographs"* to graph the selected hydrographs.

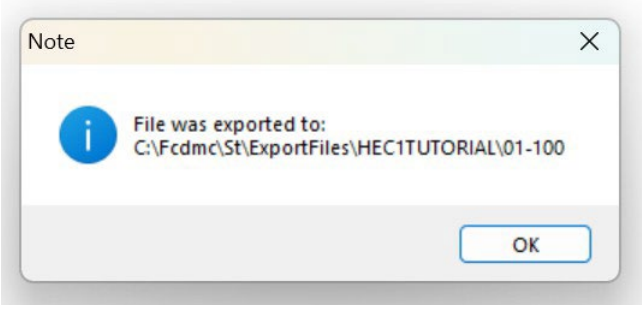


8. Click *"Yes"* to continue.

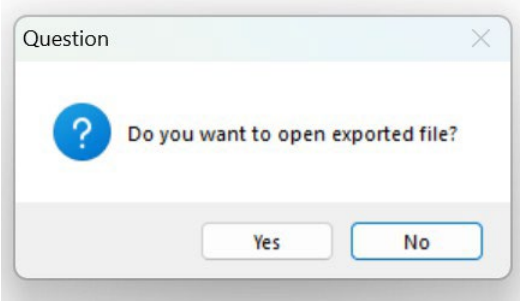


Export Hydrographs

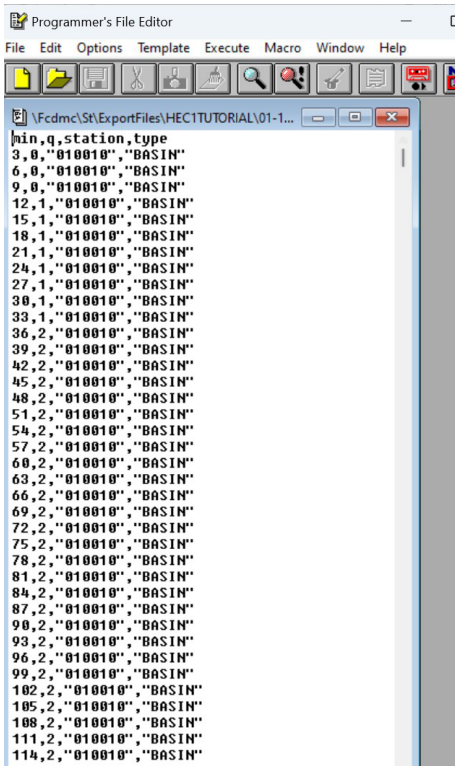
9. Click *"Export to CSV"* to export the hydrograph data to a CSV file.



10. Click *"OK"* to continue.



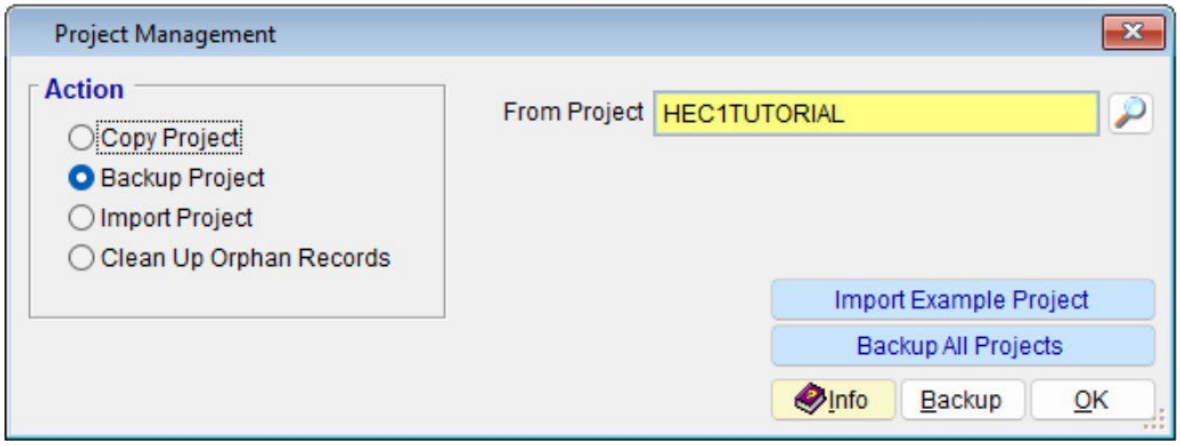
11. Click *"Yes" to open CSV file.*



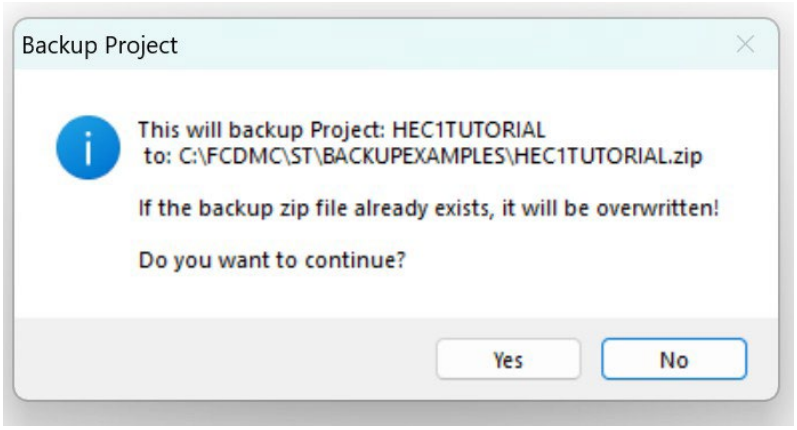
Note, each hydrograph's data continues after the first hydrograph's data.

20. Backup Project

1. Select *File => Project Management* to access the *Project Management* module.
2. Select *'Backup Project'* as the *Action* and HEC1TUTORIAL as the project (use the adjacent icon to select).
3. Click *'Backup'* and select the folder where your backup file should go.



4. Click *"OK"* when the folder has been selected.



5. Click *"Yes"* to continue.
6. Click "*OK"* to close the form.