FLO-2D©

PRO VERSION

TWO-DIMENSIONAL FLOOD ROUTING MODEL

WORKSHOP LESSONS FLO-2D PLUGIN FOR QGIS 2019

FLO-2D Software, Inc.

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INTRODUCTION

This document is organized as step-by-step instructions to create and run a detailed FLO-2D flood routing simulation. The lessons will guide the user through building a spatially variable model with infiltration, channel, levee, building, hydraulic structure, dam breach and street components. The objective is to apply the FLO-2D Plugin for QGIS to create a simple overland flow model that will be expanded with more channel and floodplain details.

Training resources are also available in the FLO-2D Pro Documentation. This folder is installed on the computer under the C:\Users\Public\Documents\FLO-2D PRO Documentation. Training videos can also be downloaded from the FTP site. Email contact@flo-2d.com for more information.

LESSON 1, PART 1 – QGIS FLO-2D PLUGIN GETTING STARTED

Overview

This lesson will outline the process of setting up a FLO-2D project using the Plugin for QGIS. Setting up the computational domain, creating a grid, interpolating elevation data and spatially variable roughness.

Required Data

The lesson makes use of terrain elevation data, project domain, roughness data, and an inflow hydrograph in the Lesson 1 folders.

File	Content	Location*
Elevation.tif	Digital terrain raster	\Example Projects\QGIS Lesson 1 PRO
Project Domain.shp	Polygon for project domain	
Mannings n.shp	Shapefile for spatially variable roughness	
GroverBasinInflow 24hr 100yr.txt	Inflow data file	

**Project Location C:\Users\Public\Documents\FLO-2D PRO Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To setup a FLO-2D flood simulation use these steps.

1. Open the QGIS program;
2. Import the project domain;
3. Set up the project;
4. Create the grid;
5. Save the project
6. Assign the elevation to the grid;
7. Assign Manning's data to the grid;
8. Control variables;
9. Save the project;
10. Export the FLO-2D data files;
11. Run the FLO-2D model.

Step 1: Open QGIS

Search the start menu and run the "QGIS Desktop" program.

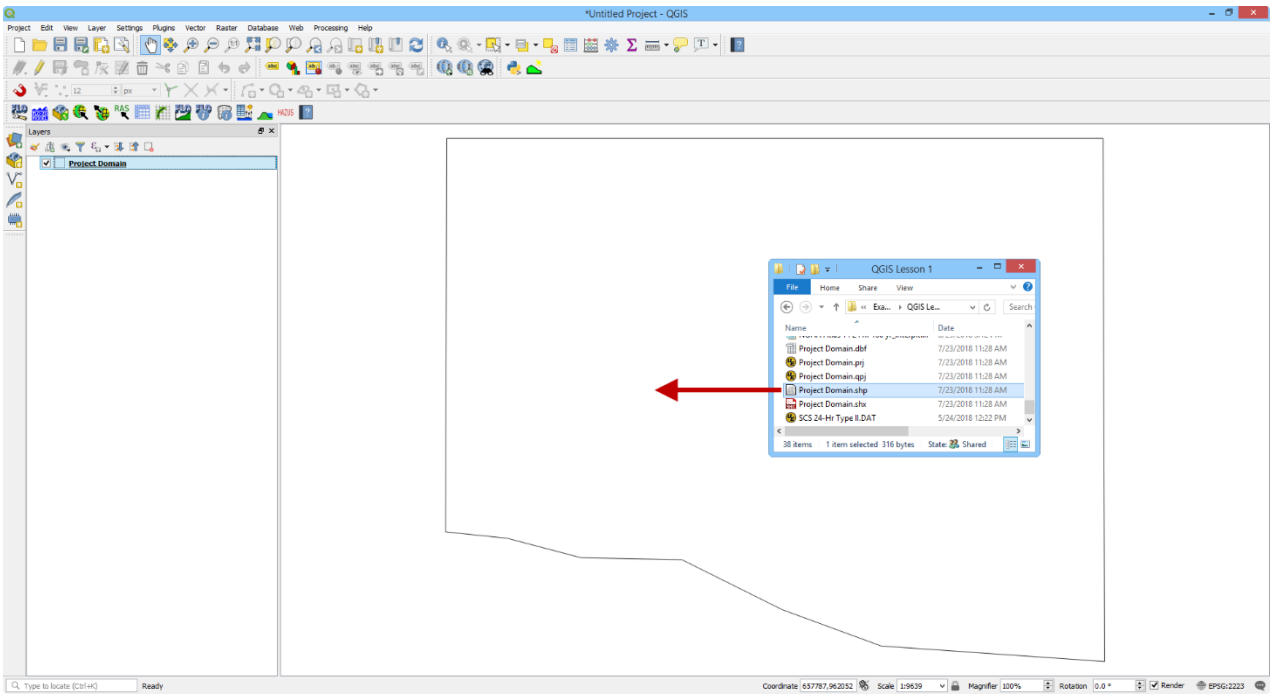
Click the New Project icon to load a new map.

Step 2: Import the project domain

Open the project folder

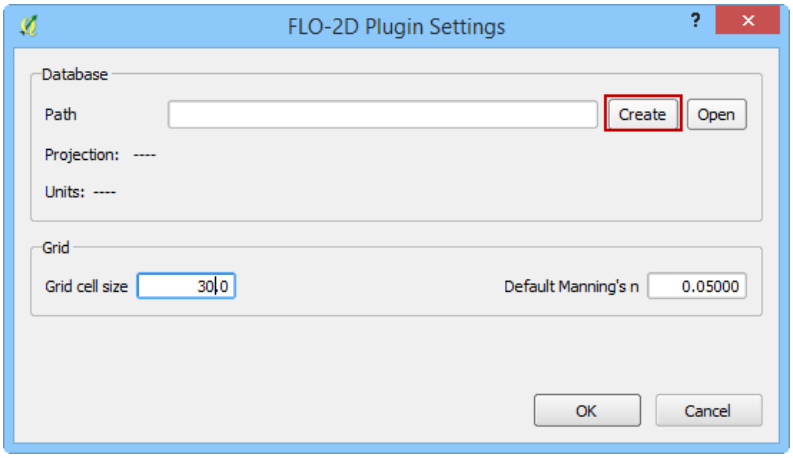
Drag the file **Project Domain.shp** onto the map space. This will set the CRS to the correct EPSG code.

C:\Users\Public\Documents\FLO-2D PRO Documentation \Example Projects\QGIS Lesson 1\Project domain.shp



Step 3: Set up the FLO-2D project

Click the Set-up icon fill out the dialog box as shown below. Set the Grid cell size to 30 ft. Click *Create*.

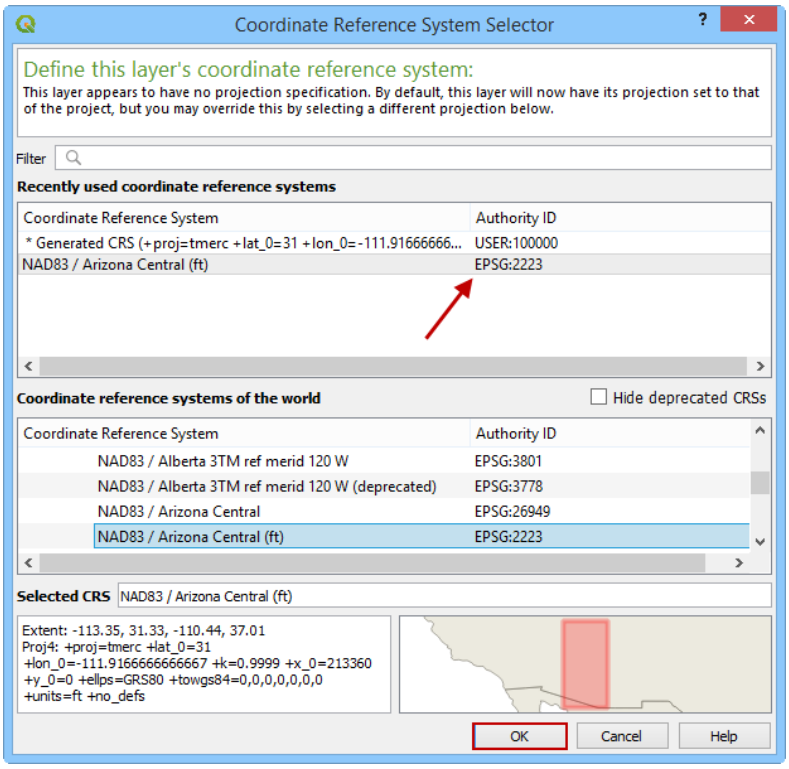


Save the geopackage file to the project folder.

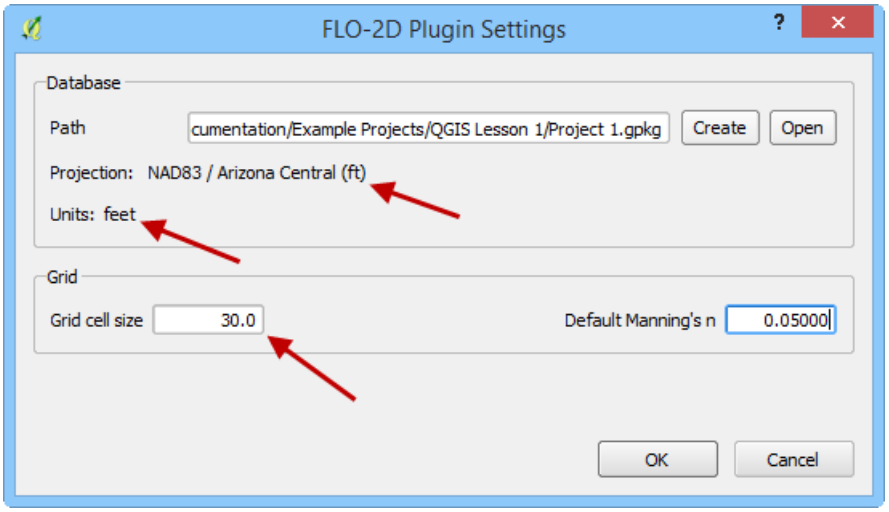
Name the file Lesson 1.gpkg.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1

Set the project CRS to Arizona Central (ft). Filter the list with an EPSG code: 2223. Select EPSG: 2223 and click *OK.*

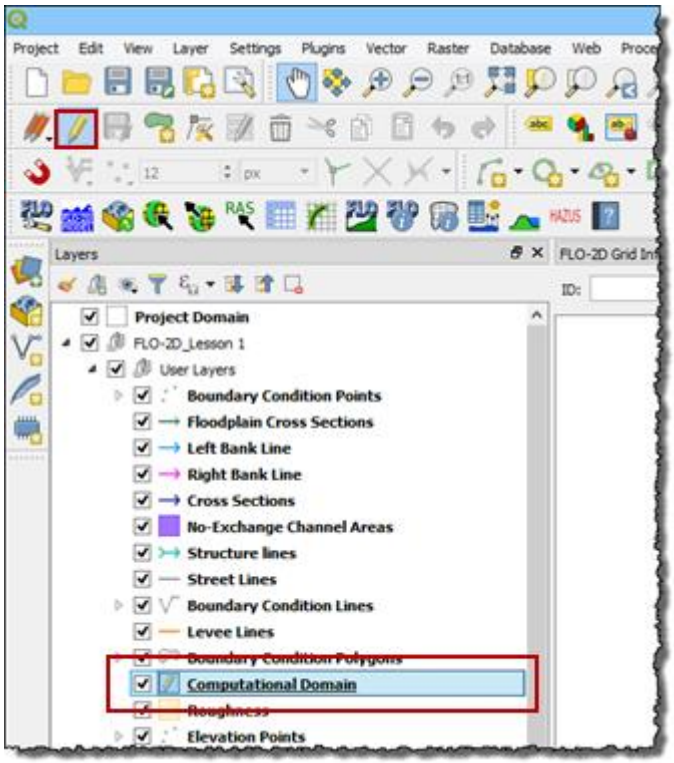


Wait for the geopackage to write and check the accuracy of the project settings and click *OK*.

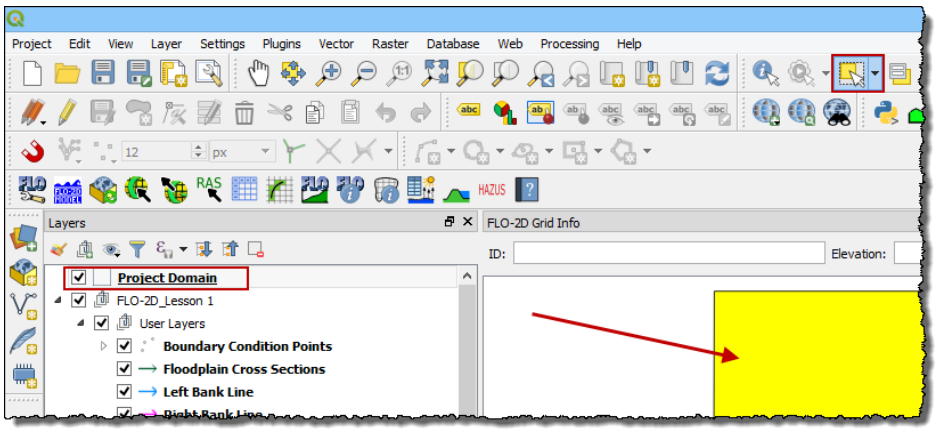


Step 4: Create the grid

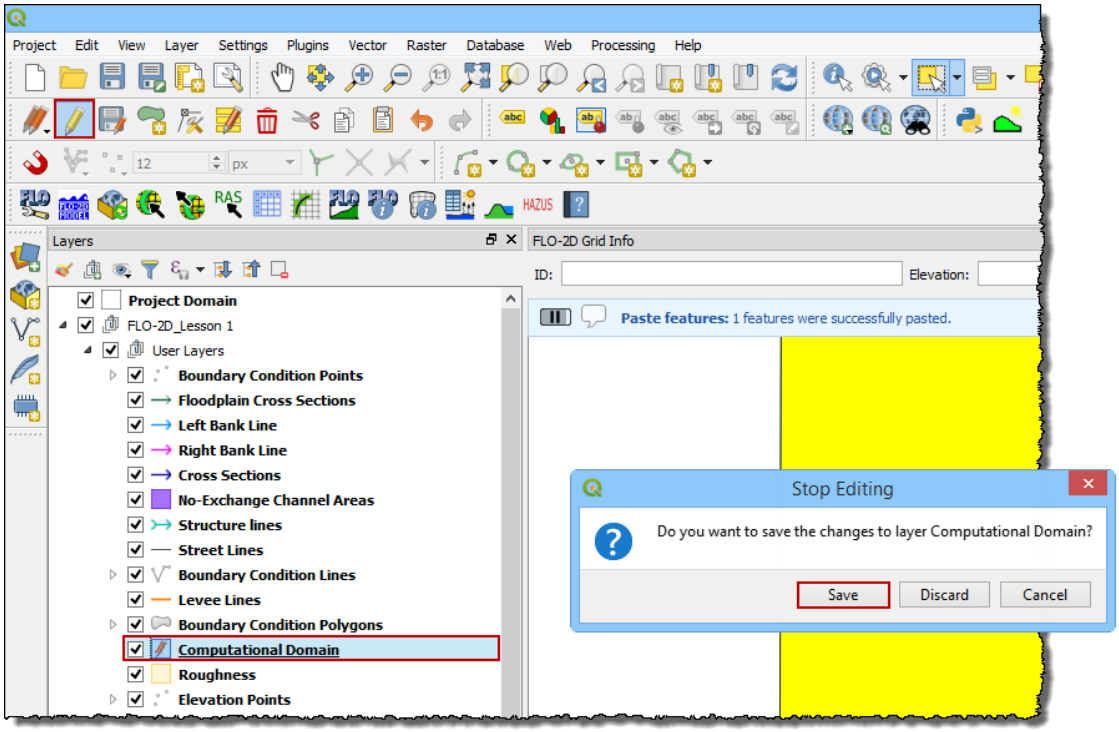
Select the Computational Domain layer by clicking the layer. Toggle the Editor Pencil.



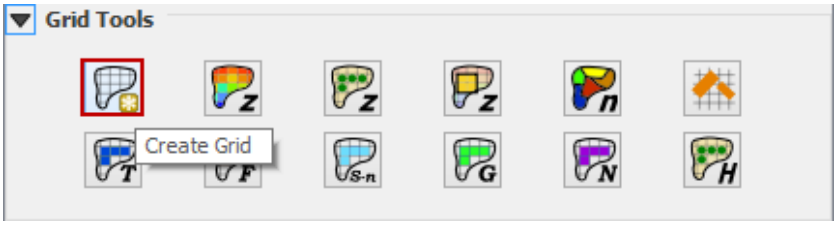
Click the Project Domain layer, click the *Select* icon and click the project polygon. **Ctrl-C** will copy the polygon.



Click the Computational Domain layer. **Ctrl-V** will paste the polygon. Untoggle the **Editor** Pencil and *Save* the edits.

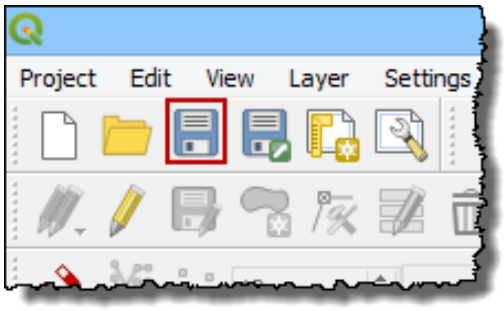


From the Grid Tools widget, select *Create Grid*. When the process is finished, close the window.



Step 5: Save the project

Click the main Save icon on the QGIS toolbar.

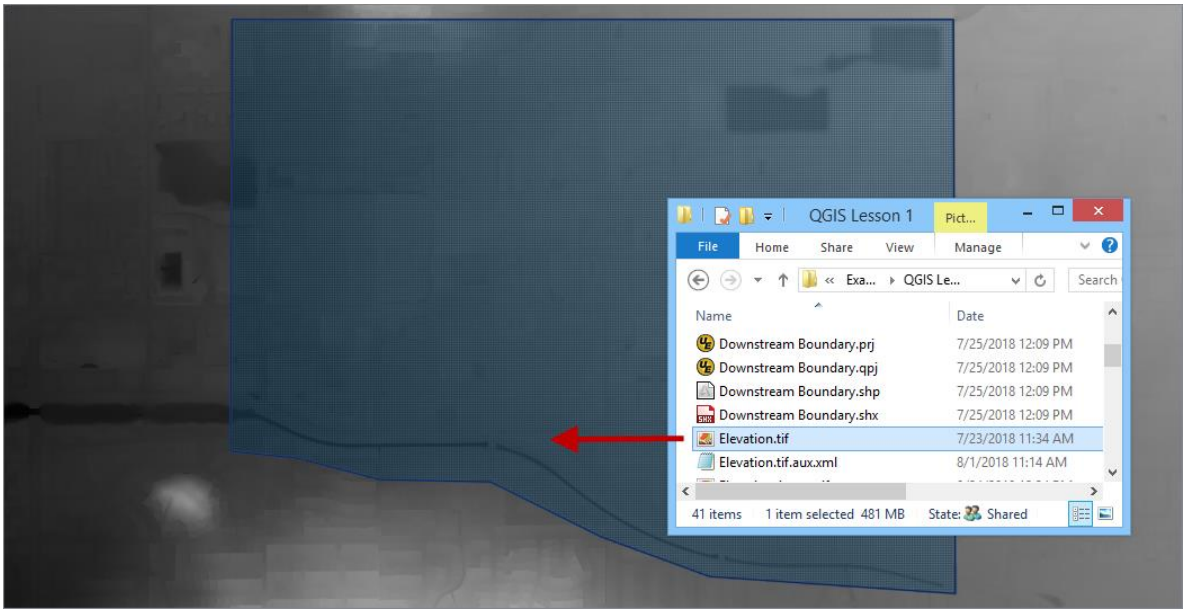


Navigate to the Lesson folder, name the project Lesson 1.qgz and click Save.

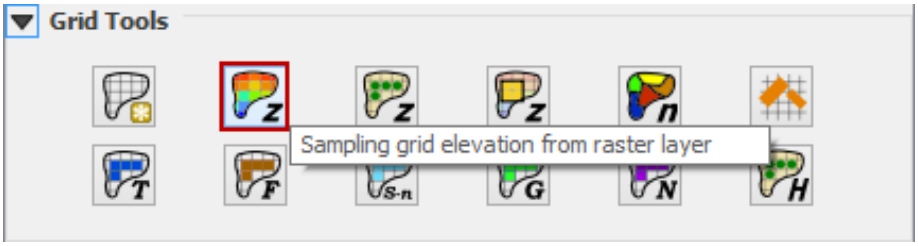
C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\Lesson 1.qgz

Step 6: Assign grid elevation

Import the elevation file. Open the project folder and drag the **Elevation.tif** file onto the map space.



To interpolate the elevation to a grid layer from a raster layer, use the *Sample Grid Elevation* icon.

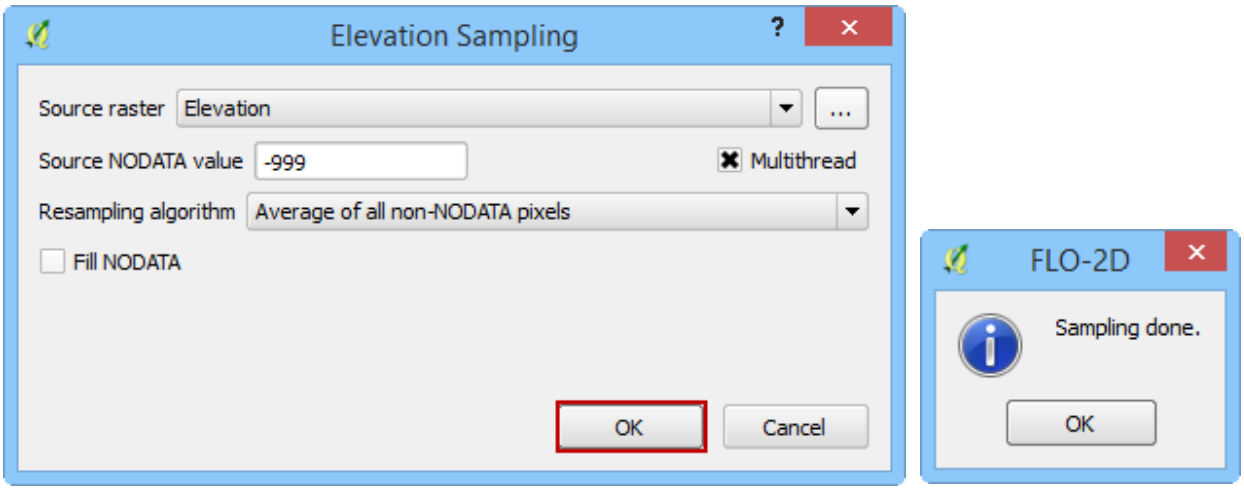


Click on the *Sample Grid Elevation* icon and enter the required data in the dialog fields and click *OK*.

As shown below, when the elevation sample is complete, the

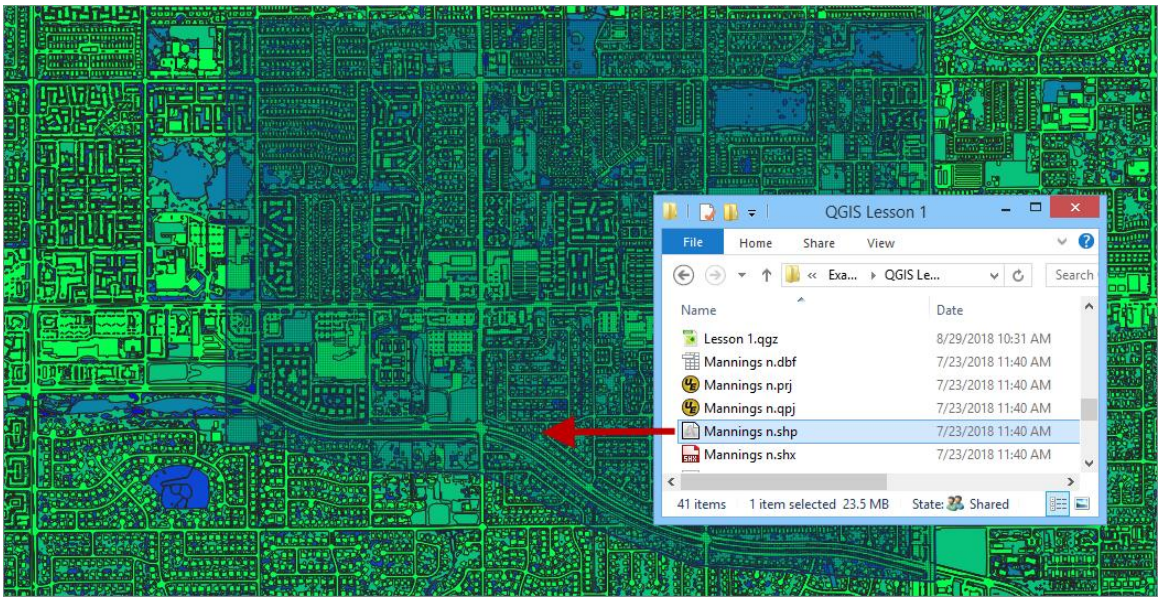
Select the *Fill NoDATA* option to set the elevation of empty grid elements from neighbors.

Sampling Done dialog box will appear. Close it.

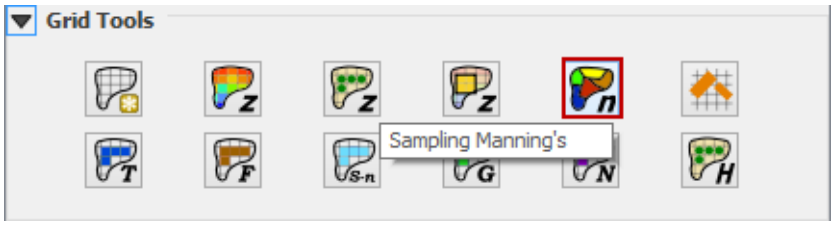


Step 7: Assign Manning's data

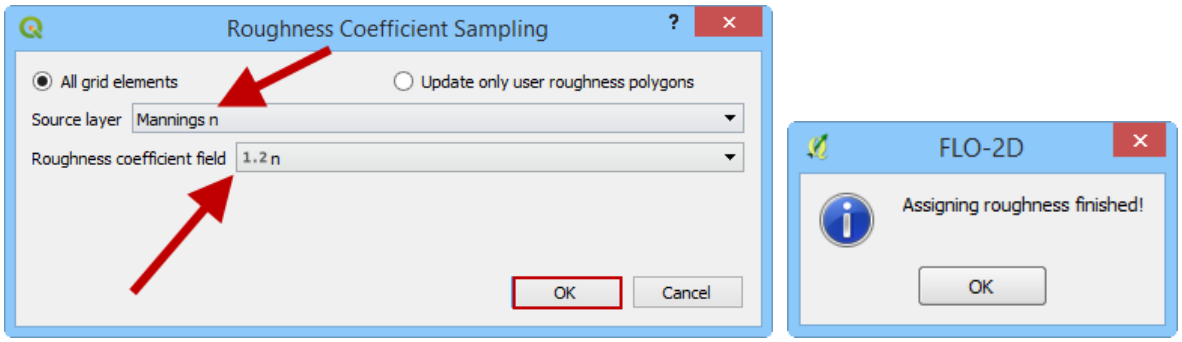
Import the sample roughness file. Open the project folder and drag the Mannings n.shp file onto the map space.



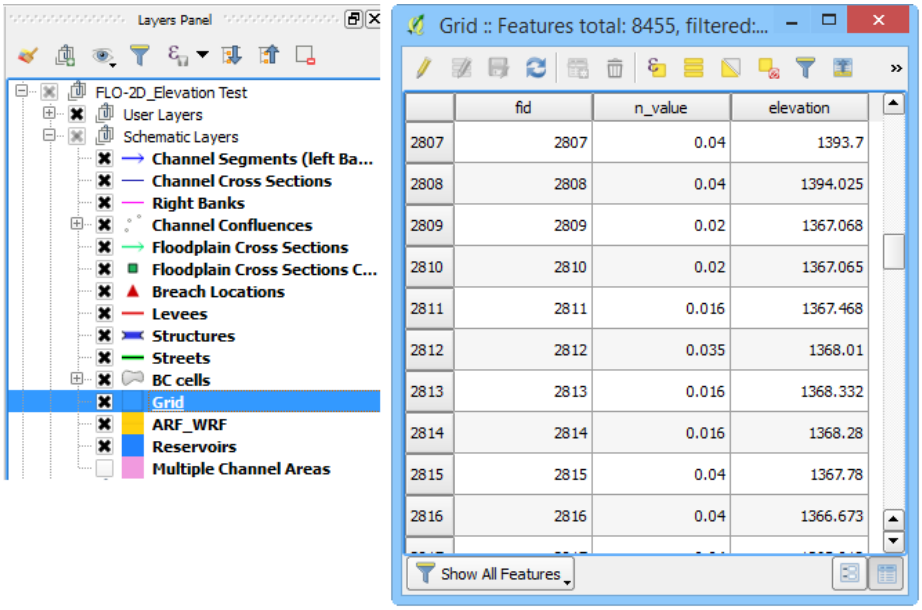
Click the Sample Manning's icon.



Fill the dialog box and click *OK*. Once the sample is complete, the following window will appear. Close the window.



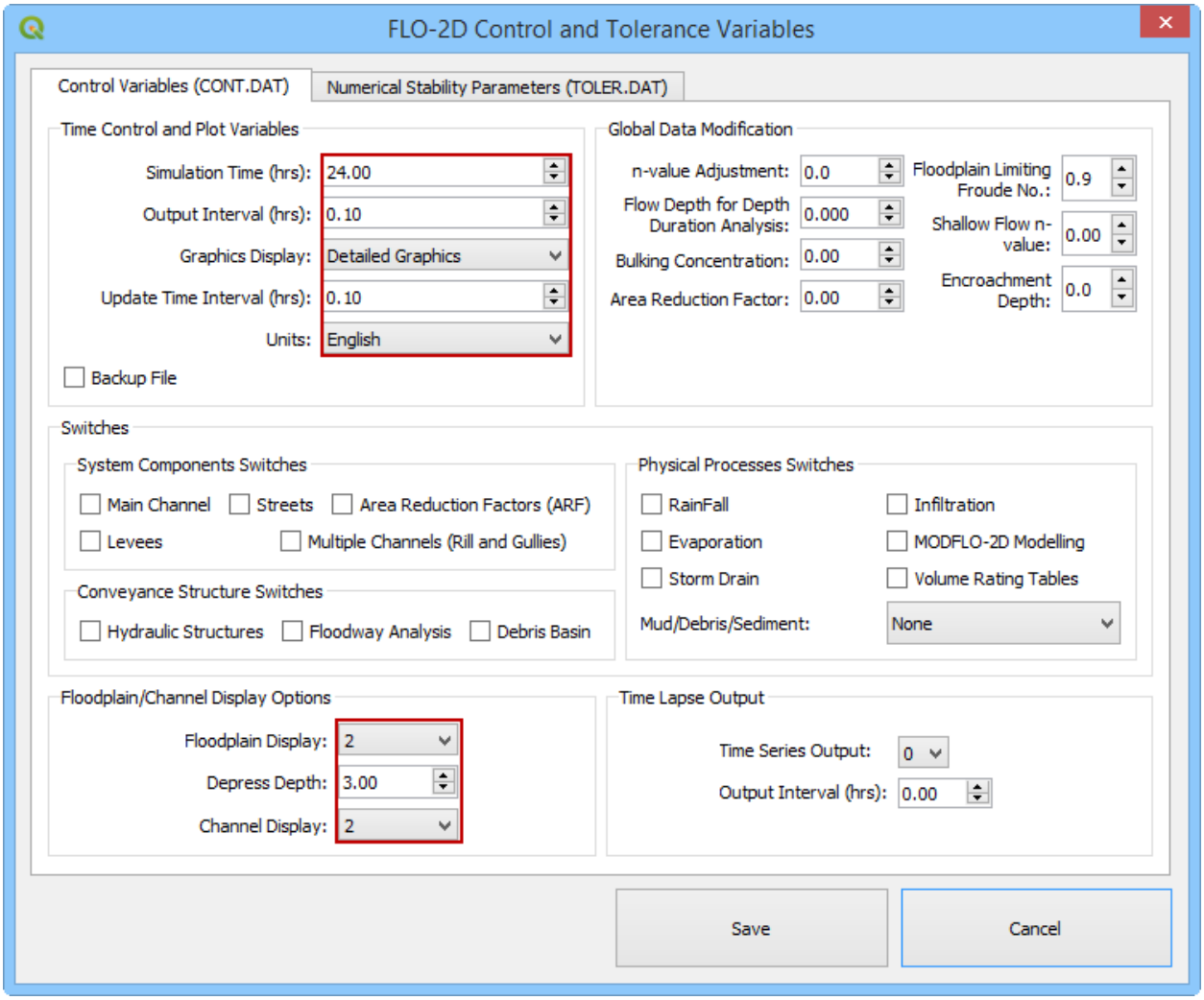
The roughness values and elevations are assigned to the grid layer in the Schematized Layers group.

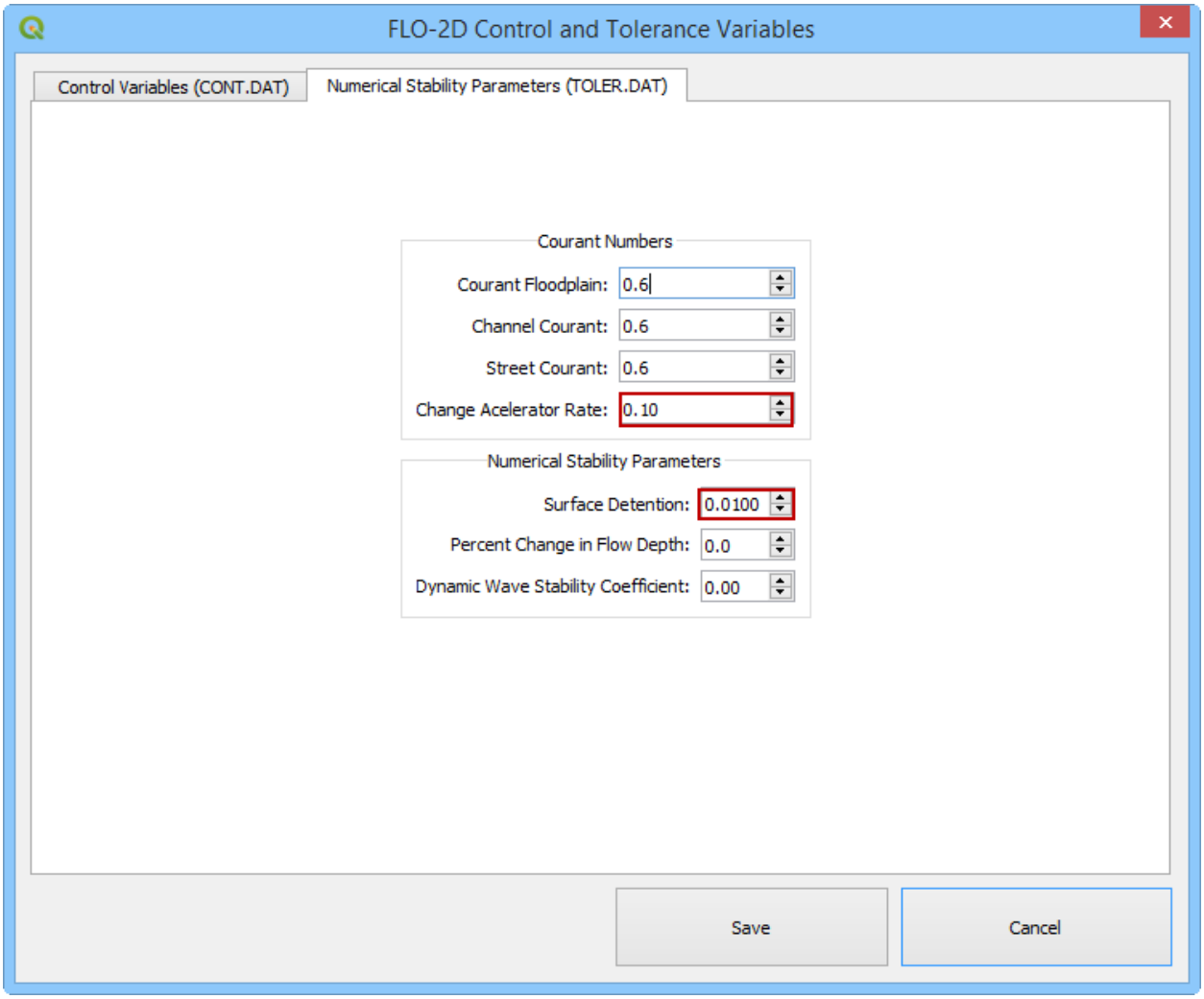


	fid	n_value	elevation
2807	2807	0.04	1393.7
2808	2808	0.04	1394.025
2809	2809	0.02	1367.068
2810	2810	0.02	1367.065
2811	2811	0.016	1367.468
2812	2812	0.035	1368.01
2813	2813	0.016	1368.332
2814	2814	0.016	1368.28
2815	2815	0.04	1367.78
2816	2816	0.04	1366.673

Step 8: Control variables

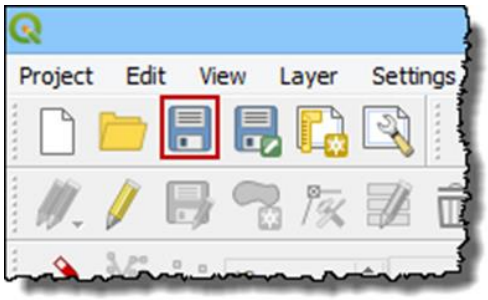
Click the *Set Control Parameters* Icon. Fill the dialog box using the two figures below. Save the data to the GeoPackage with the *Save* icon. The variable descriptions and instructions are presented in the Data Input Manual.




FLO-2D Control and Tolerance Variables
Control Variables (CONT.DAT)
Numerical Stability Parameters (TOLER.DAT)
Courant Numbers
Courant Floodplain: 0.6
Channel Courant: 0.6
Street Courant: 0.6
Change Acelerator Rate: 0.10
Numerical Stability Parameters
Surface Detention: 0.0100
Percent Change in Flow Depth: 0.0
Dynamic Wave Stability Coefficient: 0.00
Save
Cancel

Step 9: Save the project

Click the main *Save* icon on the QGIS toolbar.



Step 10: Export the project

Save project, then continue to export the project data into the FLO-2D format. Click the *GDS Export* icon. Navigate to the project folder and click *Select* Folder.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\Project Export

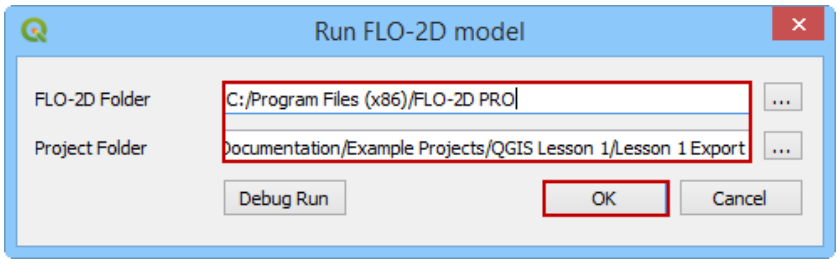
Step 11: Run the simulation

Click on the *Run FLO-2D* icon.

Set the FLO-2D Pro folder. **C:\program files (x86)\flo-2d pro**

Set the Project folder. **C:\users\public\documents\flo-2d pro documentation\example projects\QGIS Lesson 1**

Click *OK* to Run the simulation.



LESSON 1, PART 2 – PROJECT AND DATA SAFEGUARDING

Overview

Lesson 1, Part 2 is a practical study of managing a FLO-2D project that was constructed using QGIS and the FLO-2D Plugin.

Required Data

The lesson has a QGIS project file, Geopackage file, FLO-2D Data Export files and FLO-2D Project Run files.

File	Content	Location*
Lesson 1.qgz	Digital terrain raster	\Example Projects\QGIS Lesson 1 PRO
Lesson 1.gpkg	Polygon for project domain	
*.DAT files	Shapefile for spatially variable roughness	

**Project Location C:\Users\Public\Documents\FLO-2D Documentation*

Check these folders to ensure the data is available before starting the lesson. Lesson 1, Part 1 should be completed first.

Step-by-Step Procedure

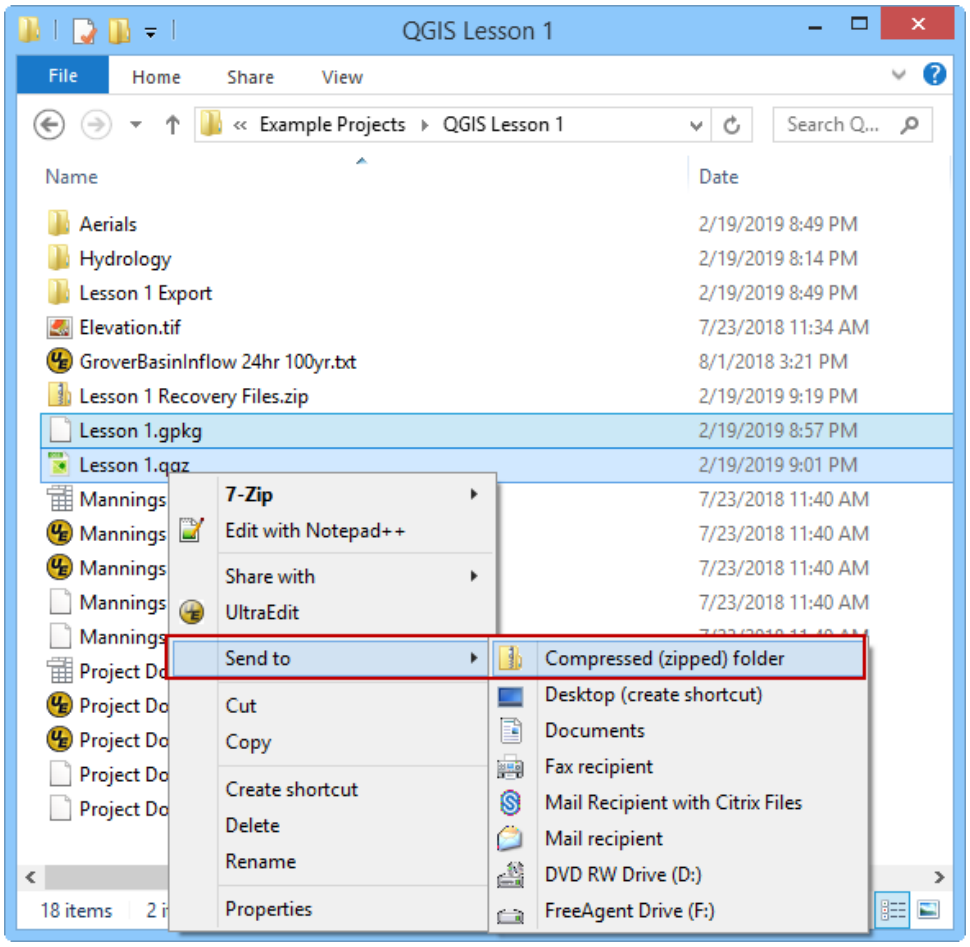
To create recovery backup system, follow these steps:

1. Create a recovery file;
2. Recover a project;
3. Open project;
4. Load a GeoPackage from previous FLO-2D Plugins build;
5. Recover data from a corrupt GeoPackage file;

Step 1: Create a recovery file

Open QGIS Lesson 1 in a File Browser. Select the **Lesson 1.gpkg** and **Lesson 1.qgz** files and zip them. This will create a recovery file.

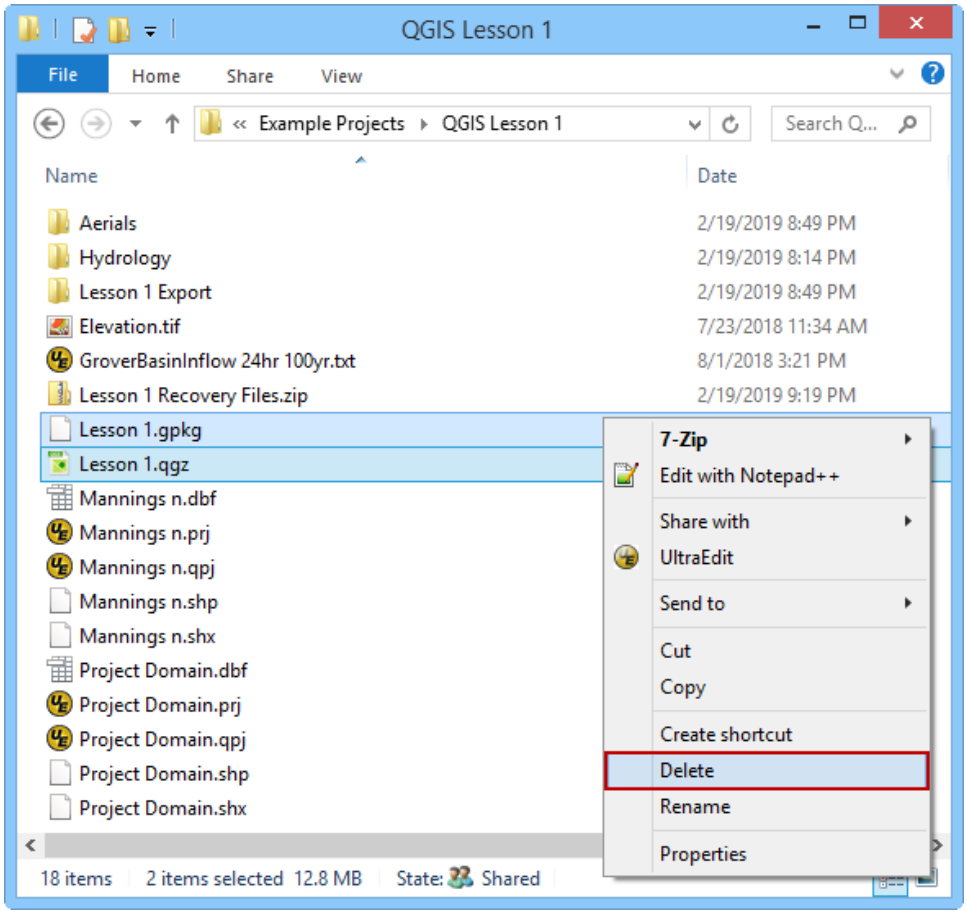
Name the zipped file. It is good to choose a name that identifies project progress. For Example: **Lesson 1 n-value OK.zip**.



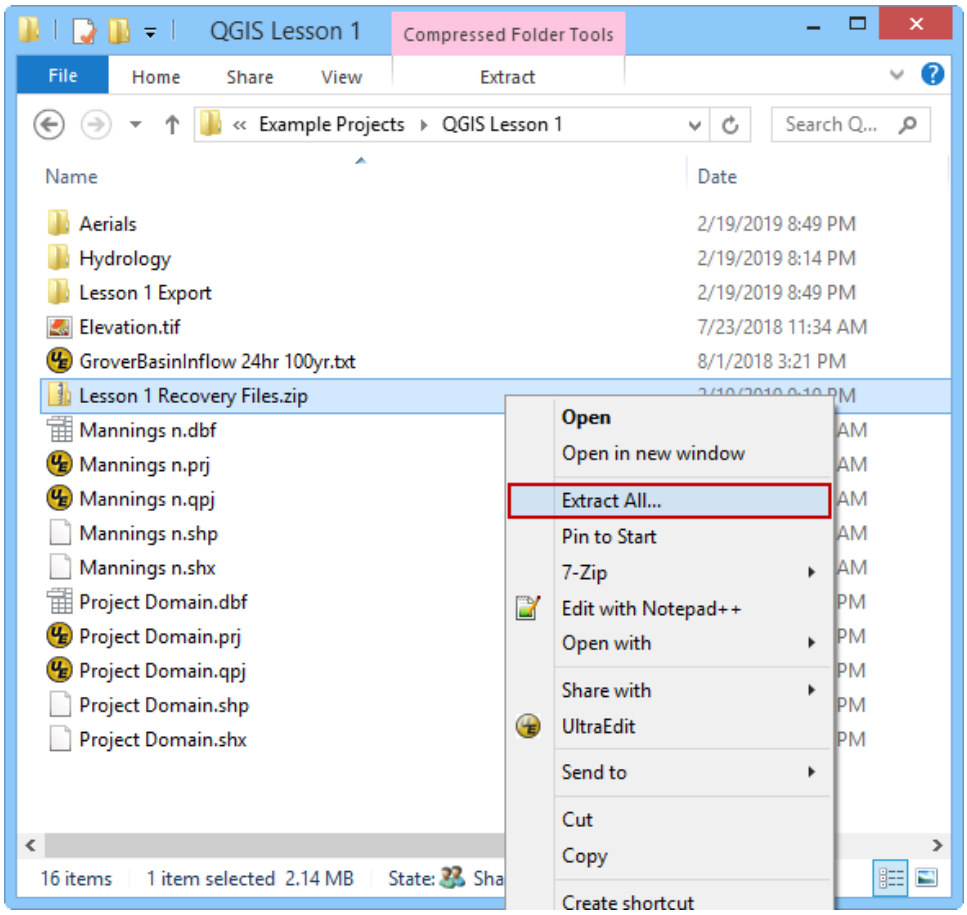
Step 2: Recover a project

This step is used when project data is corrupt. If a project is not exporting data correctly or a corruptive mistake is made, use this method.

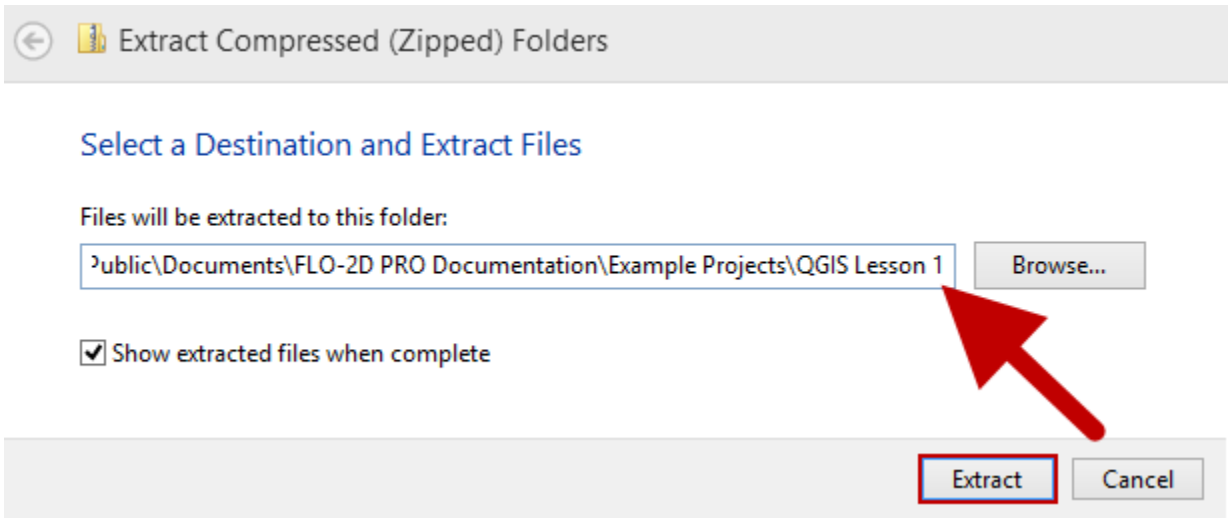
In the Lesson 1 Folder, select **Lesson 1.gpkg** and **Lesson 1.qgz** and delete them both.



Extract the recovery files. The example below uses **Lesson 1 Recovery Files.zip.** Either use this file or the file created in **Step 1**.

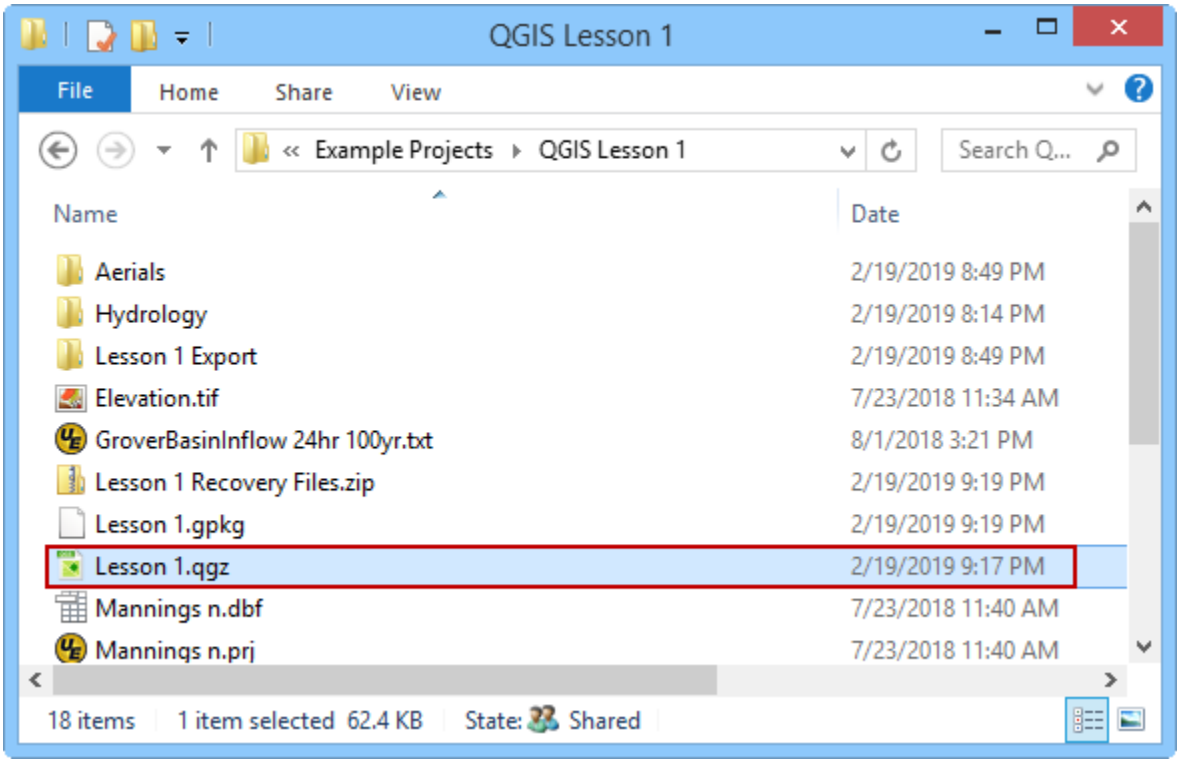


Change the name of the path so the file can be extracted directly to the Lesson 1 folder.

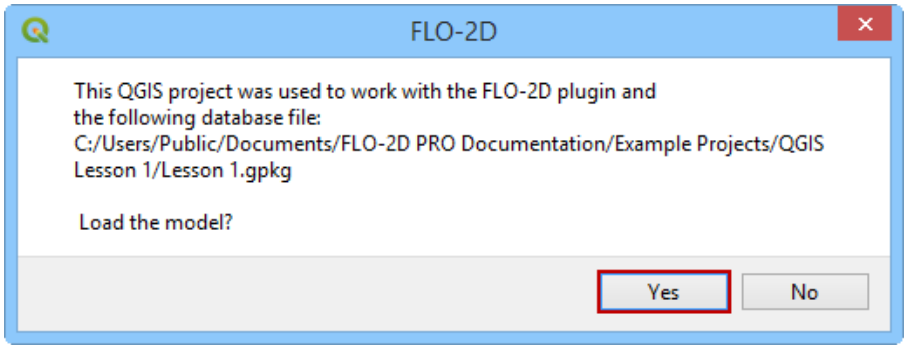


Step 3: Open the project

Double click Lesson 1.qgz to open the file in QGIS and Load the Project into the FLO-2D Plugin.



Click Yes to load the plugin.



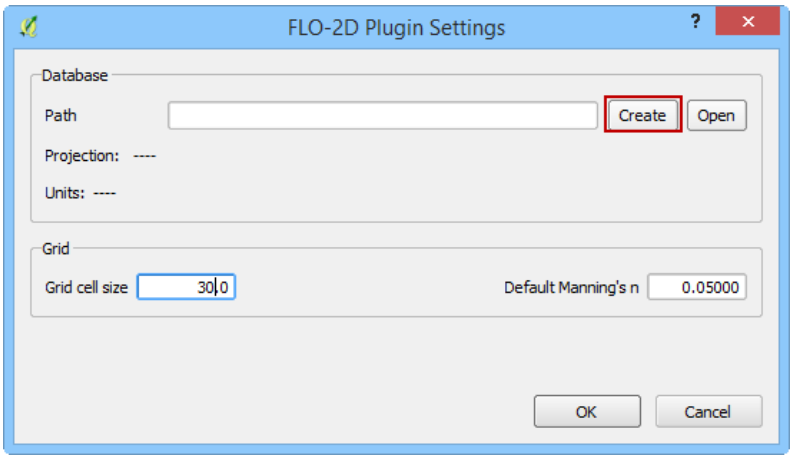
Step 4: Load a GeoPackage from a previous build

Use this procedure when the FLO-2D Plugin has an update.

1. Search the start menu and run the “QGIS Desktop” program.

2. Click the New Project icon to load a new map.

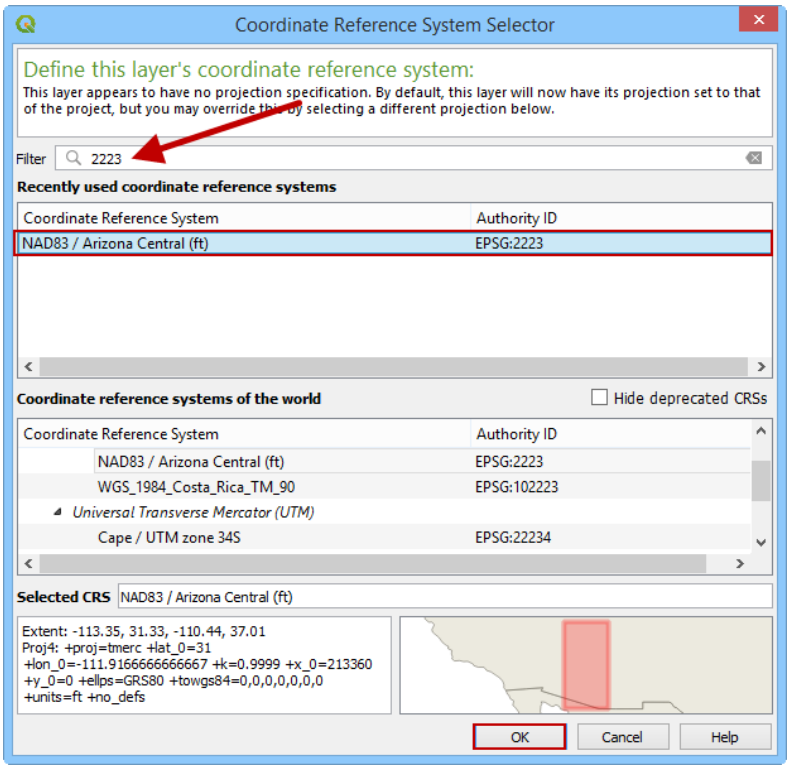
3. Click the Set-up icon fill out the dialog box as shown below. Set the Grid cell size to 30 ft. Click *Create*.



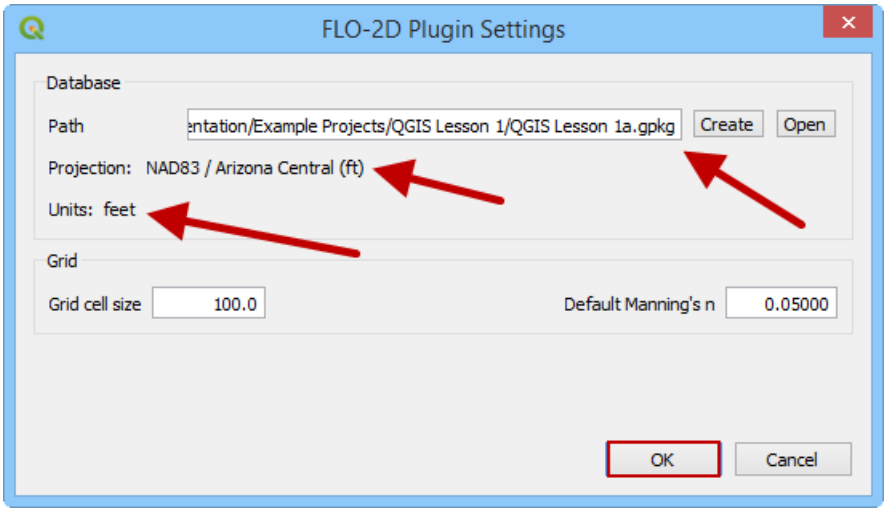
4. Save the geopackage file to the project folder. Name the file Lesson 1a.gpkg.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1

5. Set the project CRS to Arizona Central (ft). Filter the list with an EPSG code: 2223. Select EPSG: 2223 and click *OK.*

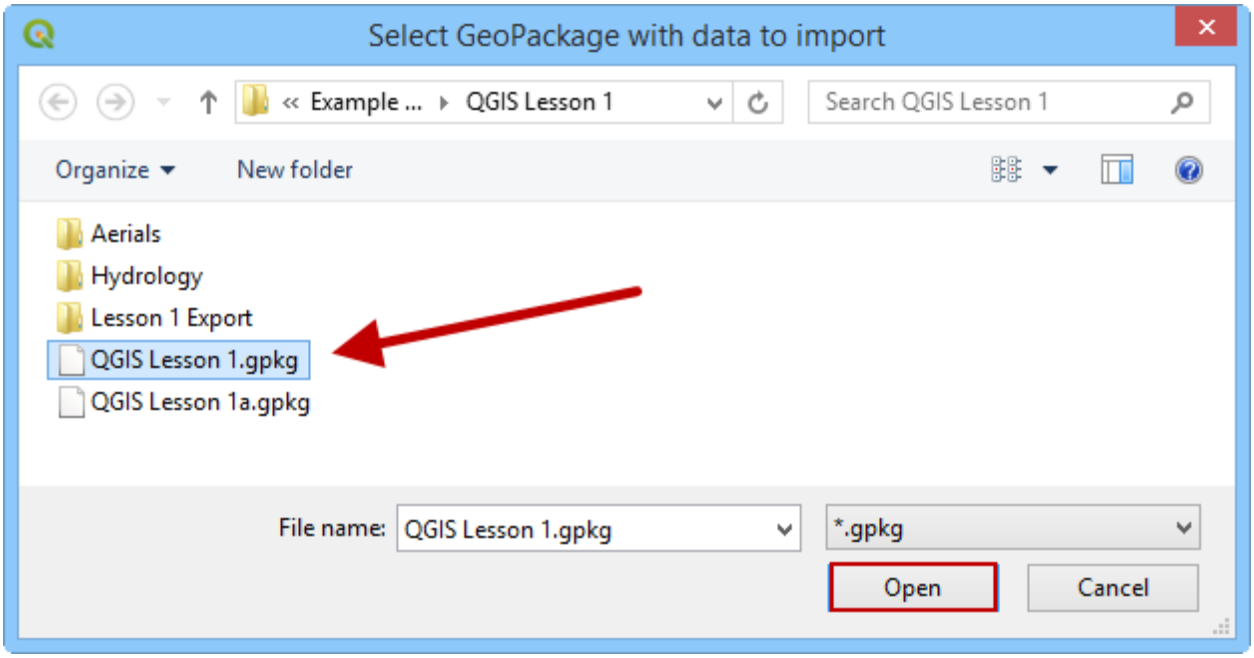


6. Wait for the geopackage to write and check the accuracy of the project settings and click *OK*.



7. Click the *Import from GeoPackage* icon to import the original **QGIS Lesson 1** project file. This will load the GeoPackage and all layers into the plugin but it will not load external data layers such as **Elevation.tif** or **Mannings.shp**.

   Select **QGIS Lesson 1.gpkg** and click *Open*.



8. Once the old data is loaded Save the project using the process in Lesson 1, Part 1, Step 5.

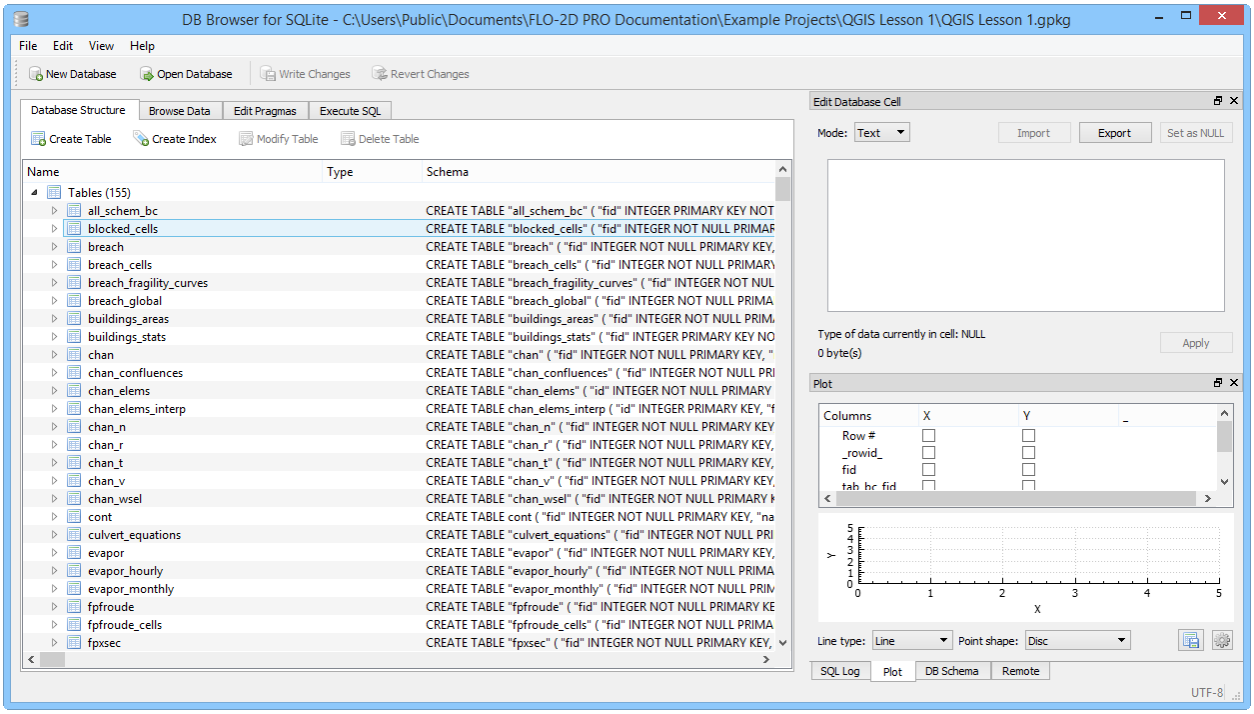
Now the old GeoPackage is configured in the new format and saved to the new GeoPackage file name **QGIS Lesson 1a.gpkg**.

Step 5: Recover data from a corrupt GeoPackage

Use this procedure when the GeoPackage or QGZ file will not load into the Plugin or the data has been corrupted.

The database browser program **DB Browser for SQLite** can be installed for free from here. https://sqlitebrowser.org/

This browser can read and edit GeoPackage data. It is an excellent resource for adding tabular data like dozens of rating tables or inflow hydrographs.



This program can also be used to fix broken GeoPackage files by eliminating bad data tables and bad records.

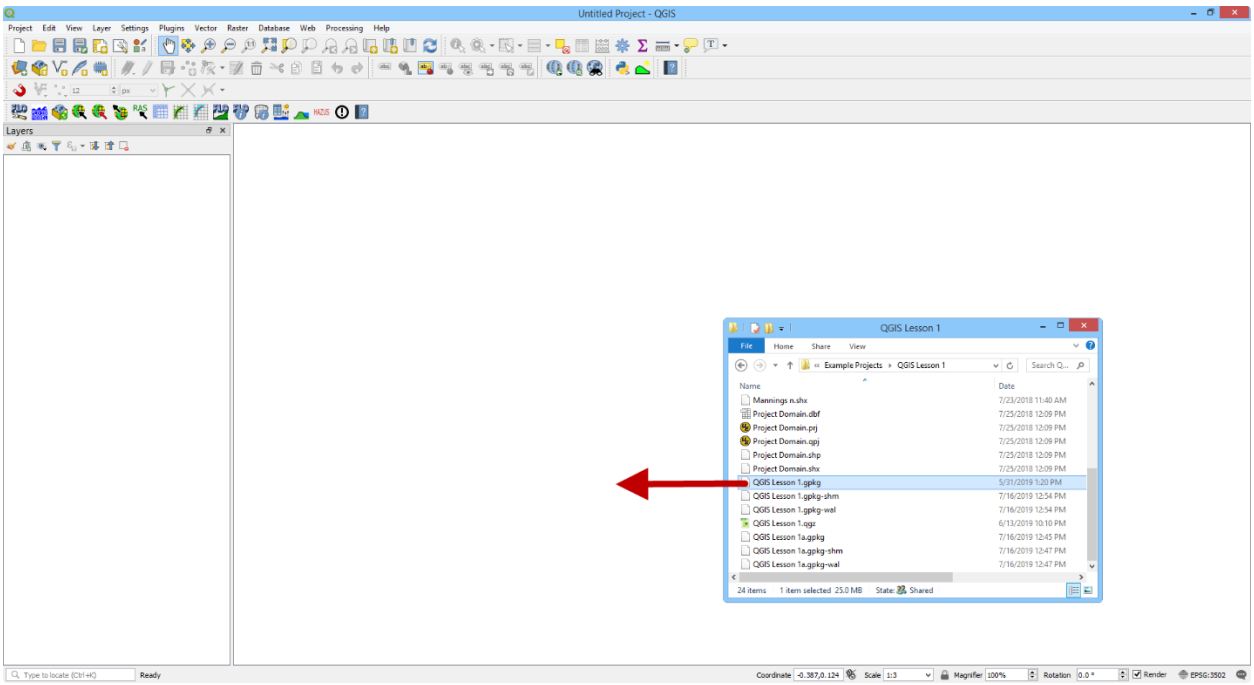
It also stores data sequencing triggers that the FLO-2D Plugin uses to build and fill the table data.

The user manual and tutoirals for **DB Browser for SQLite** are available on its website.

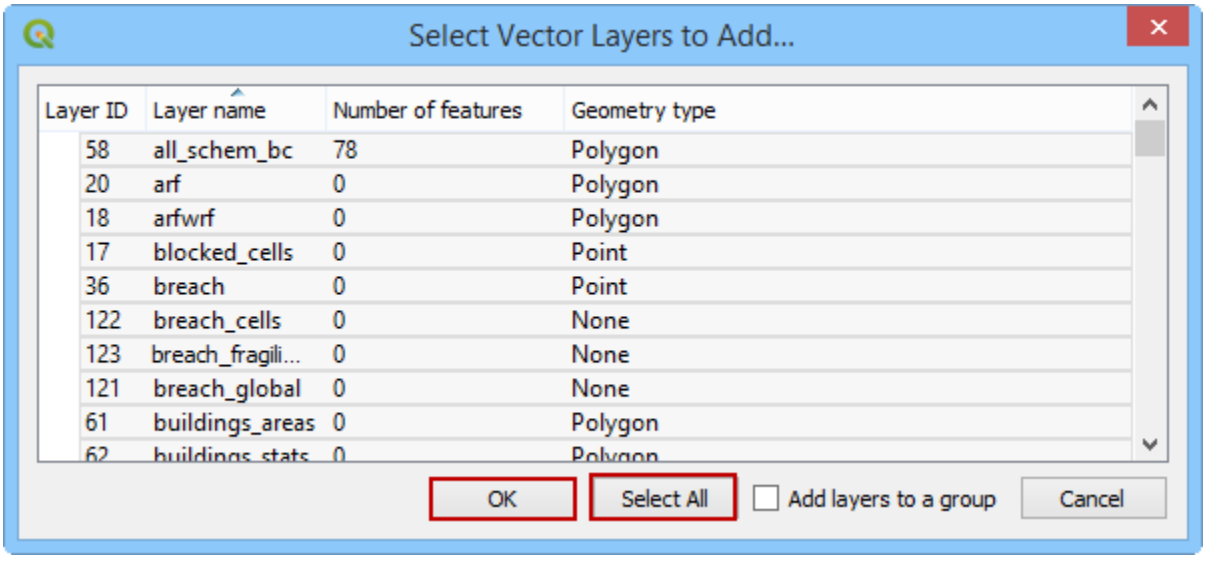
A GeoPackage file can also be loaded directly into QGIS for Data Recovery porposes.

Drag the QGIS Lesson 1.gpkg file onto a blank map space from the QGIS Lesson 1 folder.

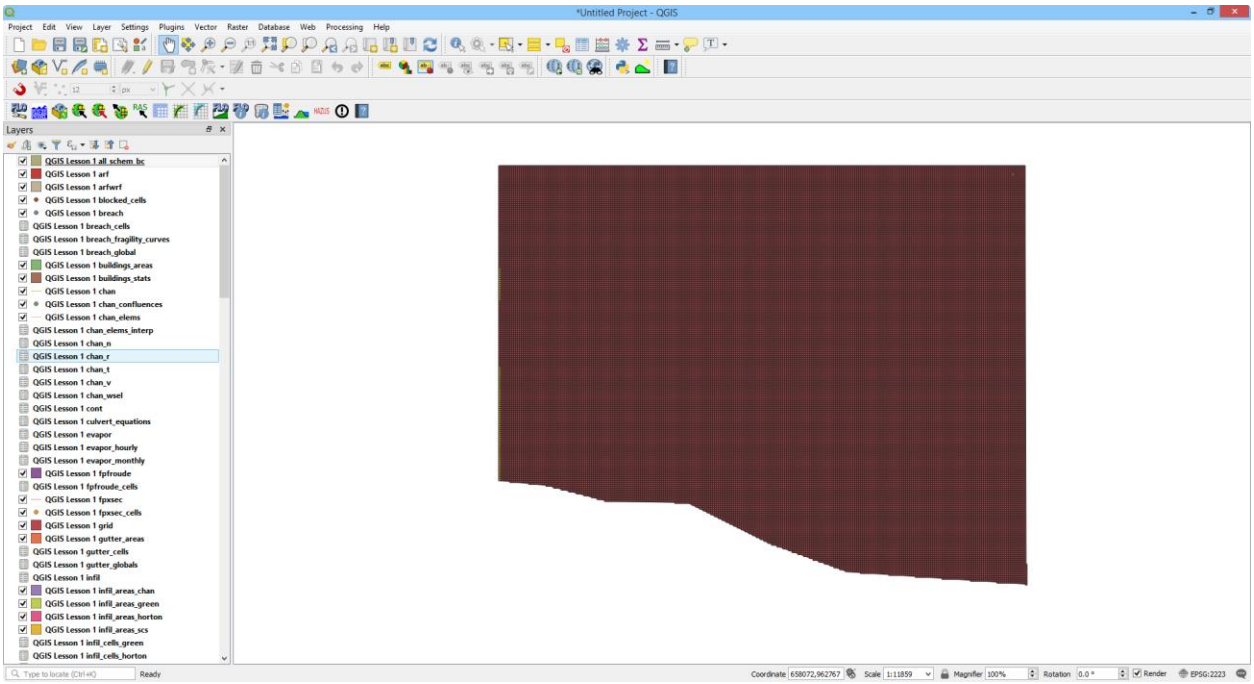
C:\Users\Public\Documents\FLO-2D PRO Documentation \Example Projects\QGIS Lesson 1\QGIS Lesson 1.gpkg



The layers can be selected, or the user can *Select All* and click *OK*.



The layers and tables are loaded in alphabetical order and the plugin is not loaded. This method allows the end user to extract data directly from the geometric layers (point, polyline and polygon) and the data tables.



To extract the data from any layer, right click the layer and Export that data as a shapefile or csv file.

LESSON 1, PART 3 – HYDROLOGY, RAINFALL, AND INFILTRATION

Overview

This lesson will outline the process for setting up a rainfall runoff model using a 24-hour 100yr storm and rainfall data and spatially variable infiltration data. This lesson is a continuation Lesson 1. If Lesson 1 cannot be loaded, it can be recovered from the Lesson 1 Recovery Files.zip.

Required Data

The lesson makes use of rainfall distribution, rain arf, landuse and soil data.

File	Content	Location*
SCS 24-Hr Type II	Rainfall Distribution Curve	\Example Projects\QGIS Lesson 1 PRO\Hydrology
NOAA Atlas 14	Rainfall depth reduction	
Land use.shp	Shapefile for land use	
Soil.shp	Shapefile for soil type	

**Project Location C:\Users\Public\Documents\FLO-2D PRO Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To setup a FLO-2D flood simulation use these steps.

1. Open the QGIS program;
2. Load Lesson 1;
3. Import aerial images;
4. Assign inflow;
5. Assign rainfall;
6. Assign infiltration
7. Check control variables;
8. Save the project;
9. Export the FLO-2D data files;
10. Run the FLO-2D model.

Step 1: Open QGIS

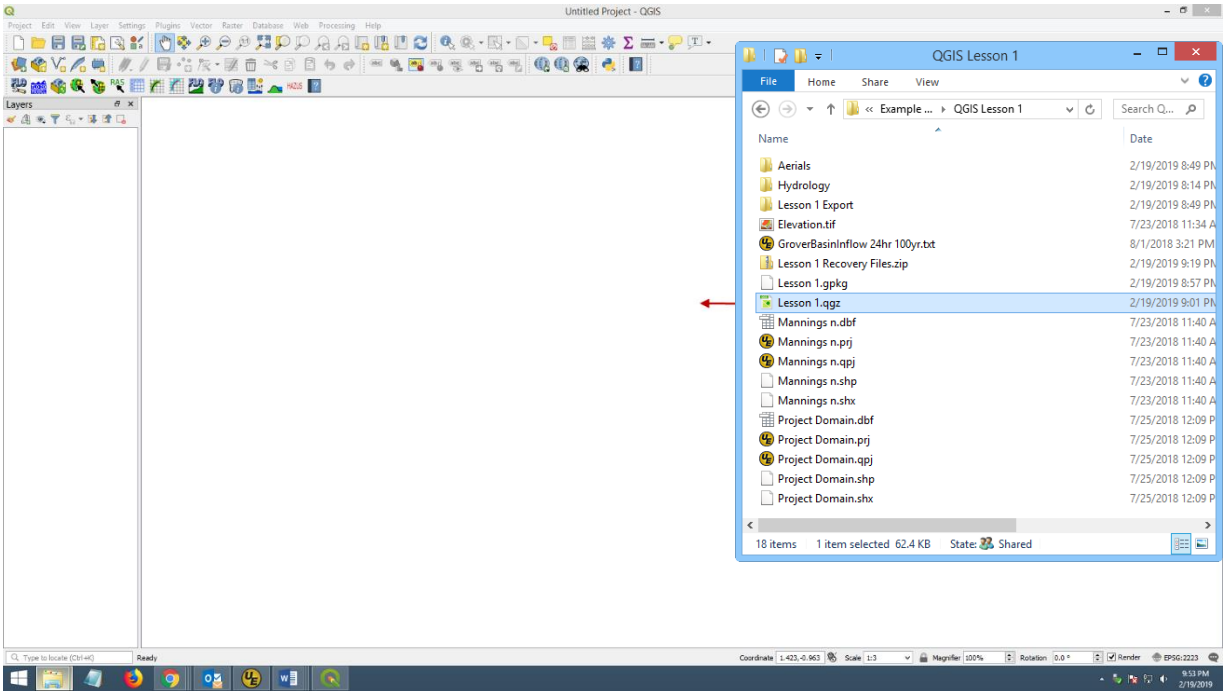
Search the start menu and run the “QGIS Desktop” program.

Step 2: Load Lesson 1

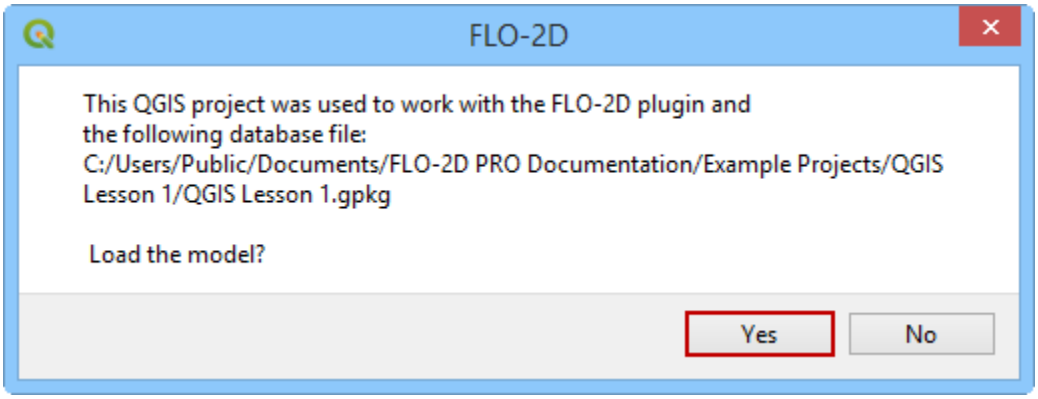
Open the project folder.

Drag the file **Lesson 1.qgz** onto the map space. If the file is missing. Extract it from the zipped recovery file.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\Lesson 1.qgz

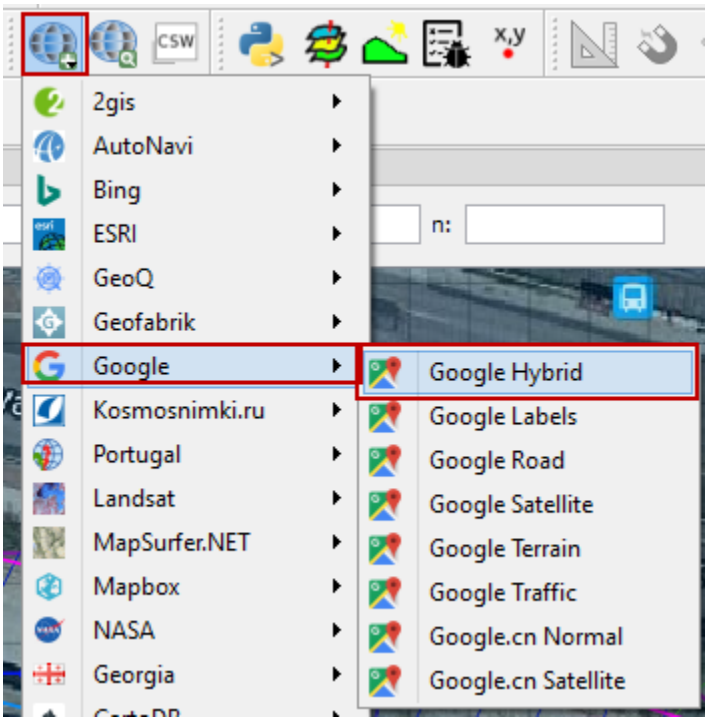


Click *Yes* to load the model.



Step 3: Import aerial images

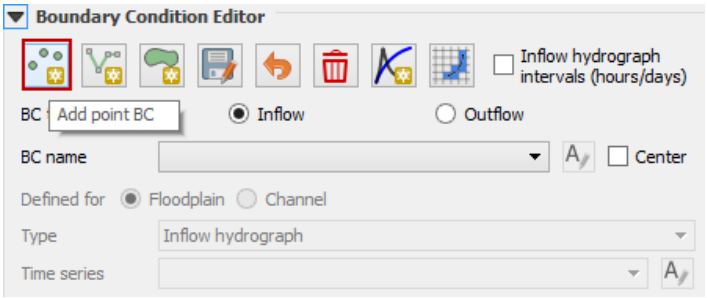
Inflow nodes are set up using the Boundary Condition Editor widget. Load an aerial image to help with placement. Use *Quick Map Services Plugin* with the *Contributed Pack* to load aerial images into the layer.



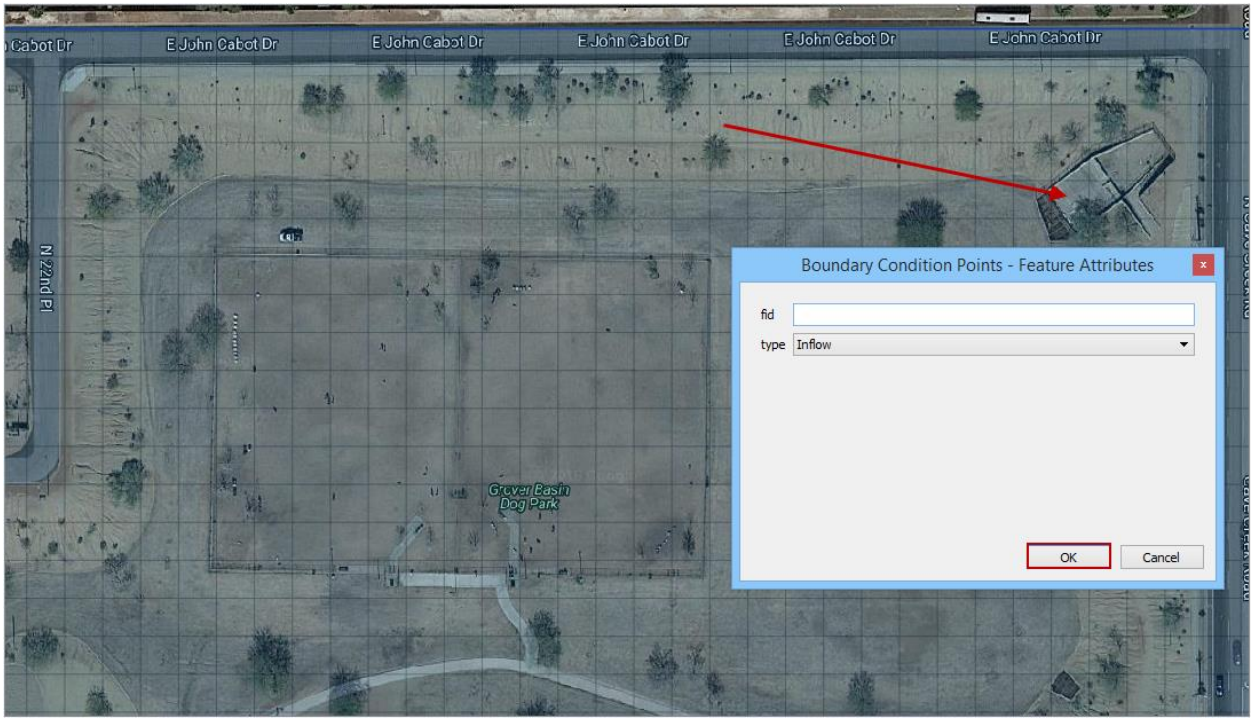
Note: If this plugin is not available, aerial images are saved to Lesson 1 folder.

Step 4: Add inflow node

Zoom in on the top right corner of the project. Find the Basin Inlet feature. Click the *Add point BC* icon.

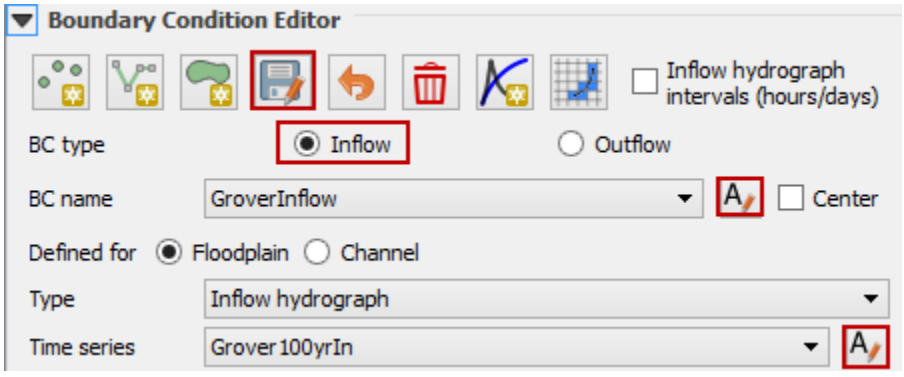


Click the cell indicated on the map in the following image and click *OK* to close the window.



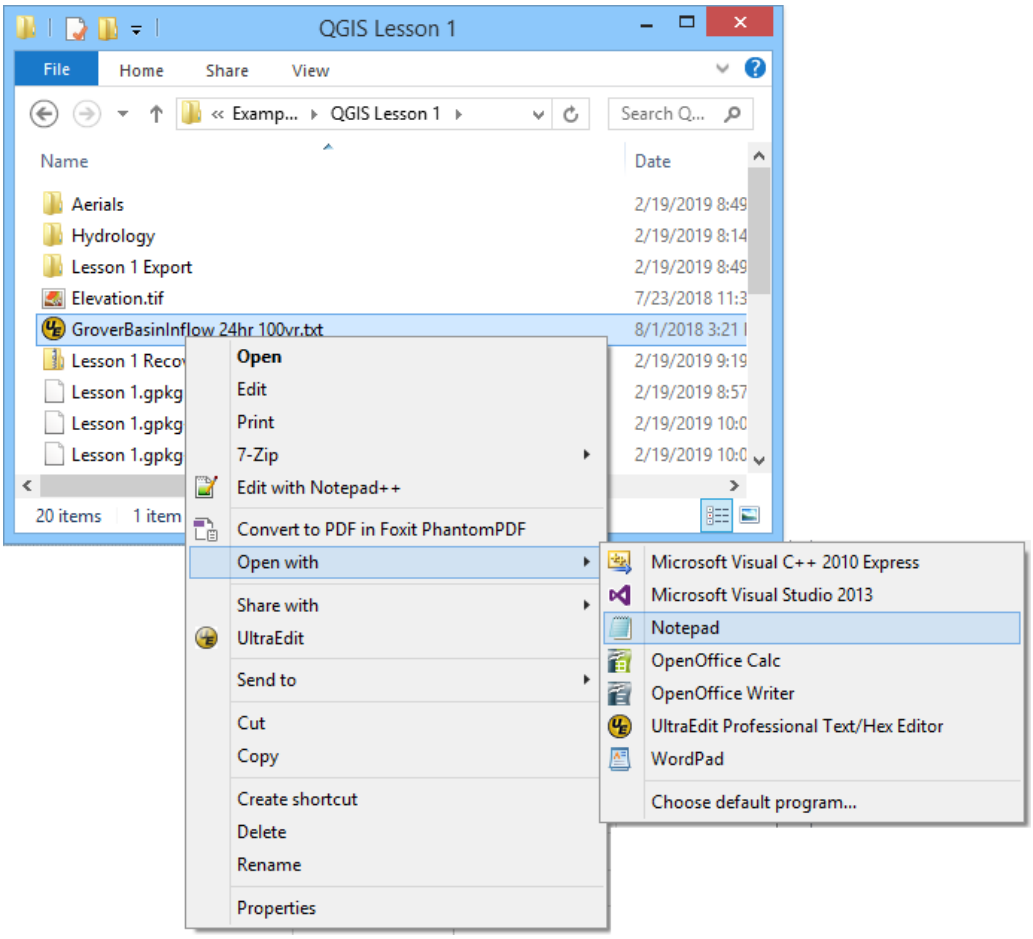
Click *Save* to load the data into the editor.

Updated the BC name and the Time series name.



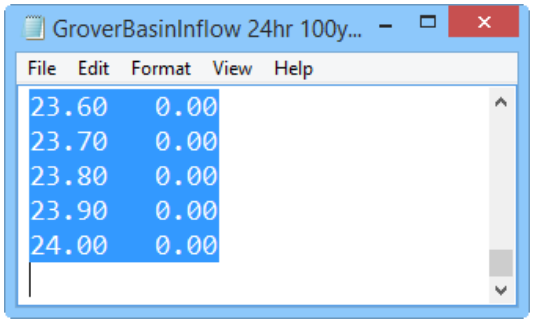
The inflow hydrograph is stored in a text file in the project folder. Open this file in Notepad.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\GroverBasinIfnlow 24hr 100yr.txt

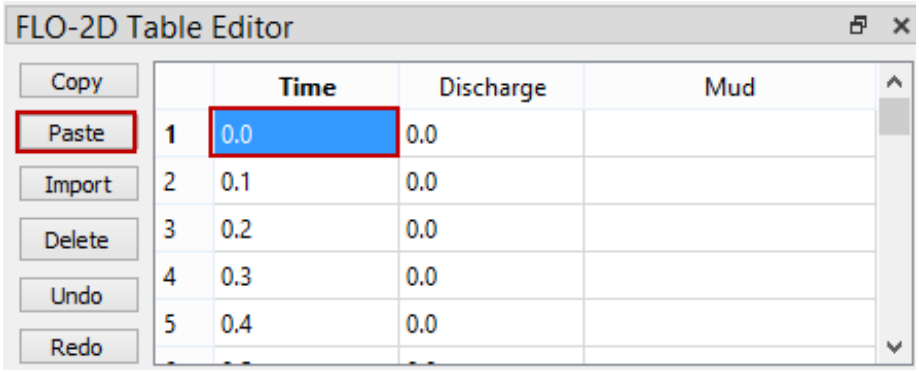


CTRL – A will select all data.

CTRL – C will copy the data.

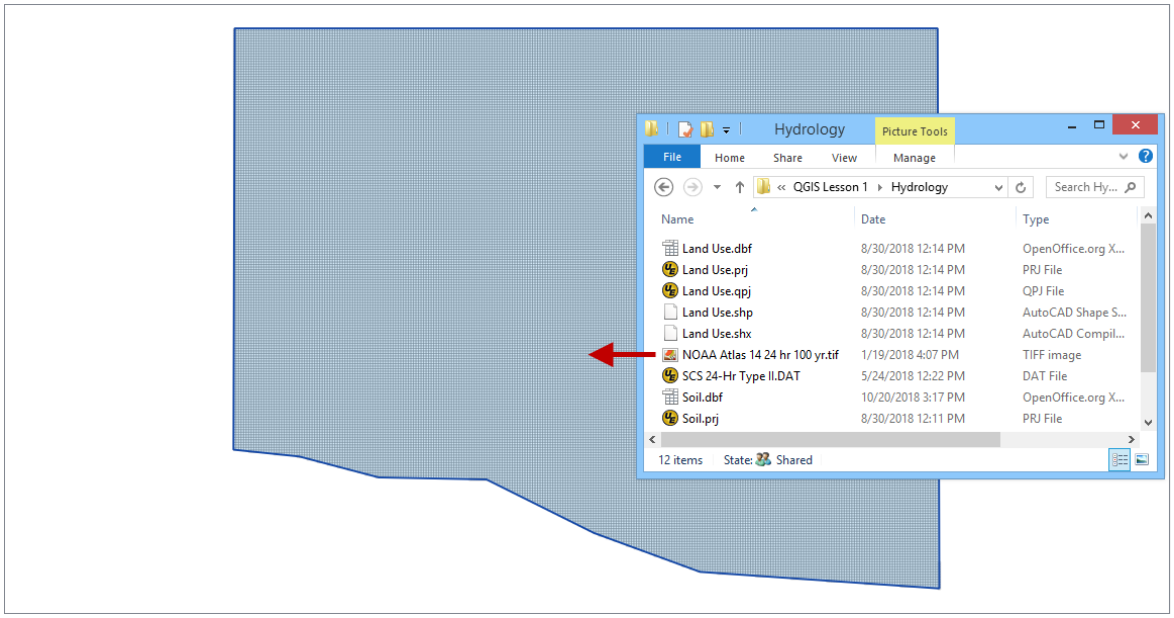


Select the first cell of the FLO-2D Table Editor Table and click *Paste*.



Step 5: Assign rainfall

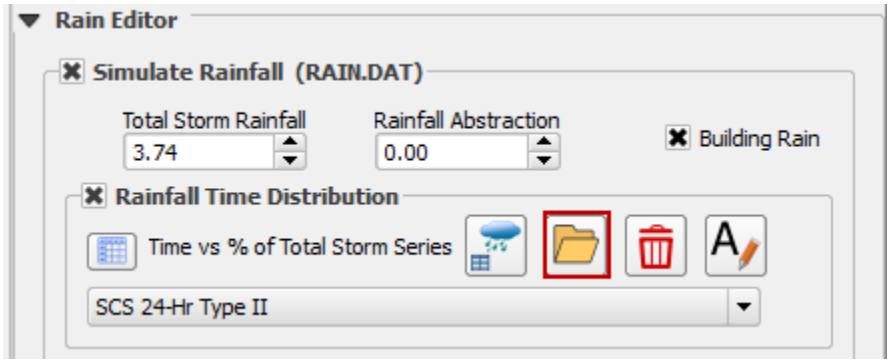
Import the NOAA Atlas rainfall map. Open the project folder and drag the **NOAA Atlas 14 24hr 100yr.tif** file onto the map space.

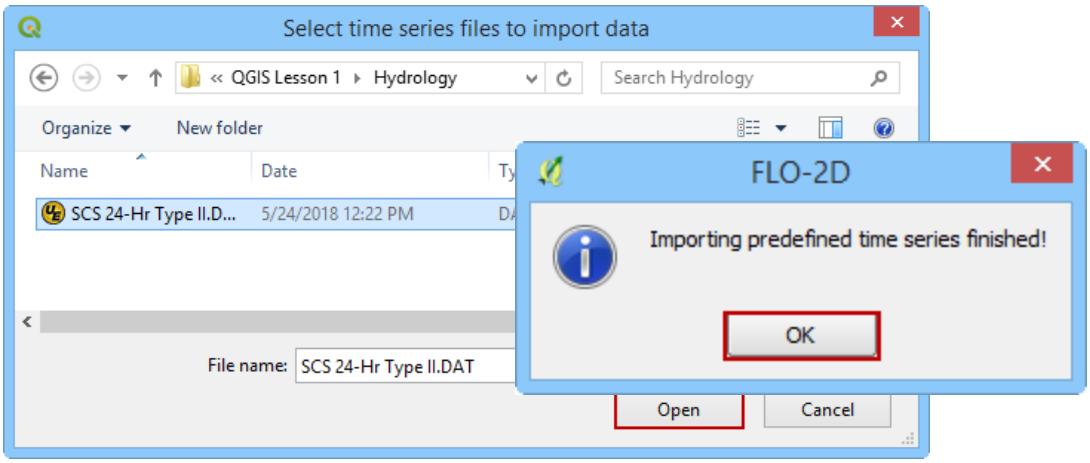


Uniform rainfall requires the total rain in inches or millimeters and a rainfall distribution.

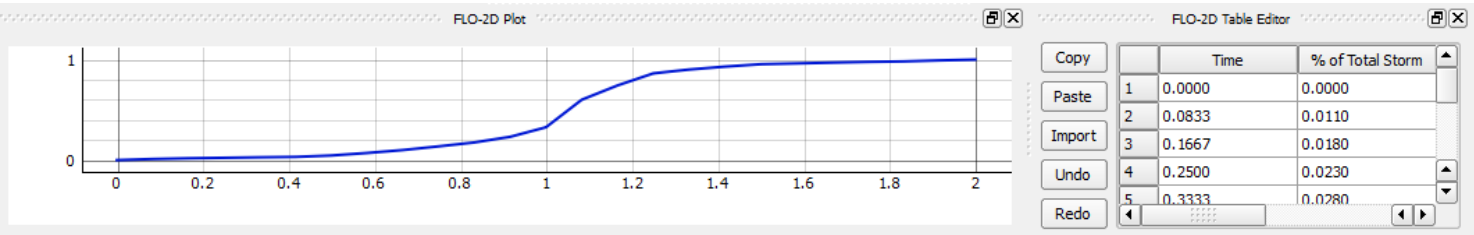
The rainfall distribution is in a rainfall distribution data file. Click the *Import* icon and load the data file from QGIS Lesson 1.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\Hydrology\SCS 24-Hr Type II.DAT

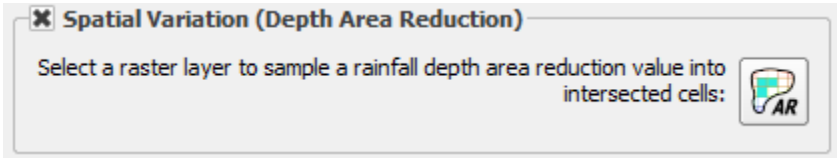




The rainfall data is imported into the FLO-2D Table Editor.

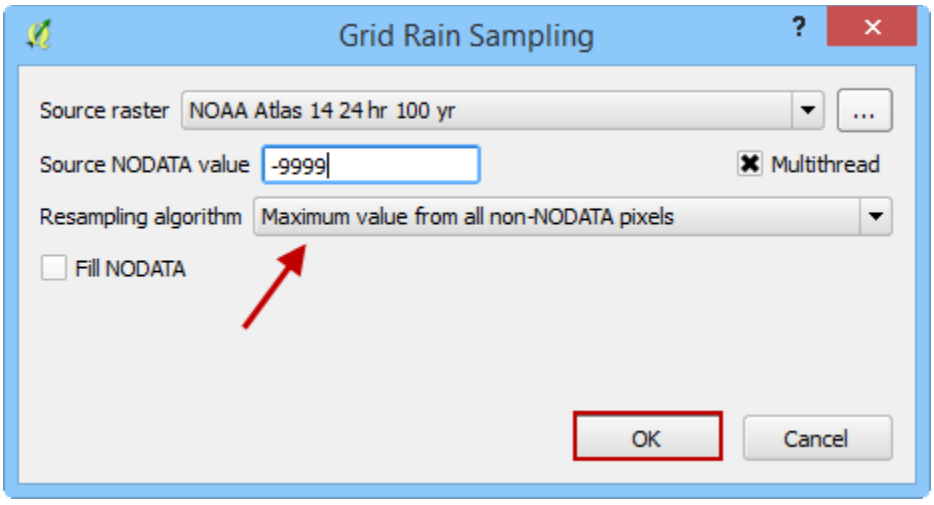


To perform the depth area reduction calculation, use the Area Reduction calculator.



1. Click the *Area Reduction* icon.
2. Fill the form and click OK.

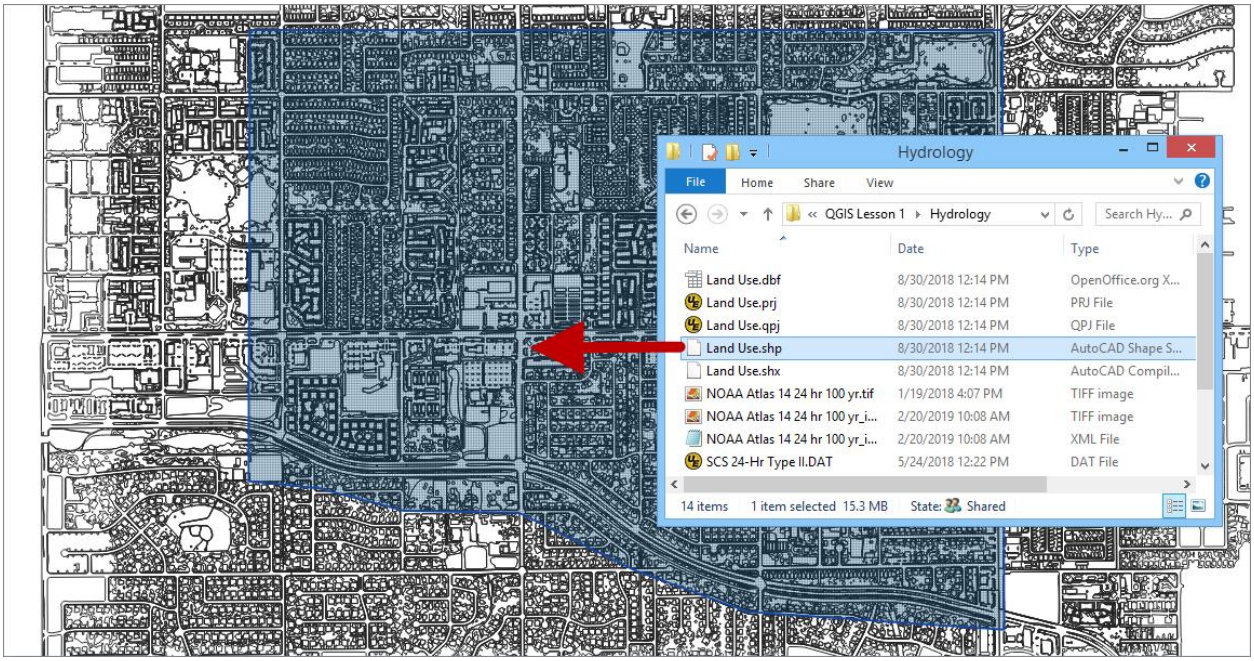
The raster pixels are typically 1000 by 1000 ft or larger. It is not necessary to average the data. Select the maximum value to set the cell value.



Step 6: Assign infiltration

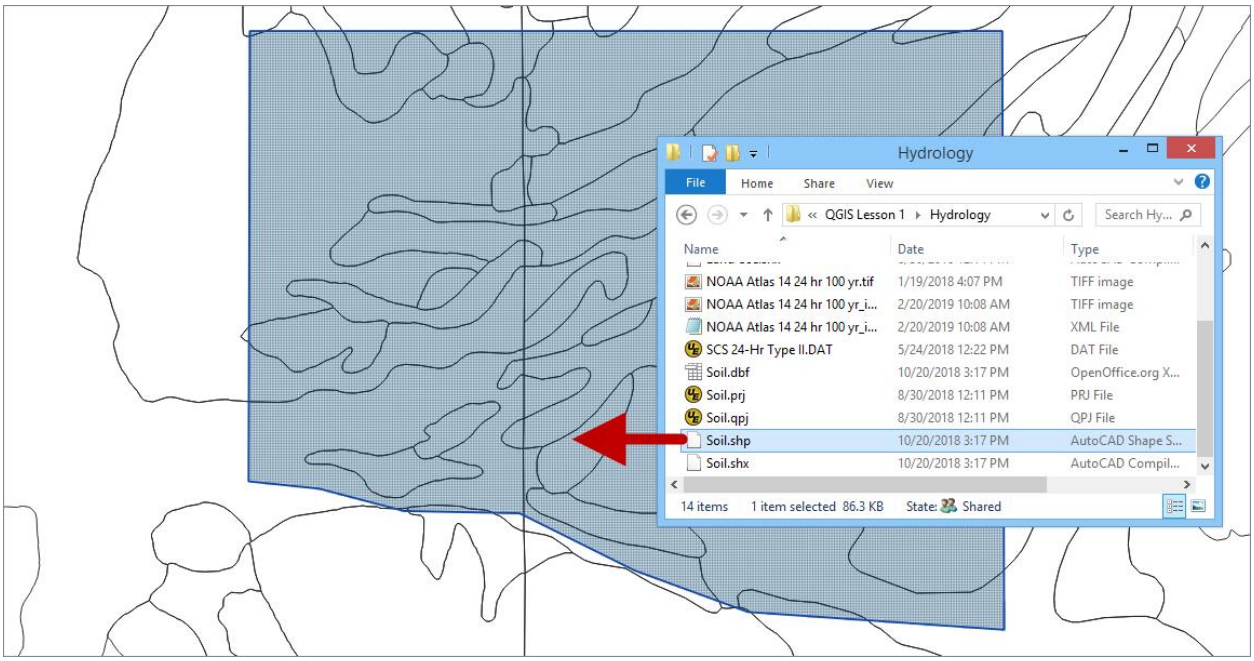
Drag the file **Land Use.shp** onto the map space.

C:\Users\Public\Documents\FLO-2D PRO Documentation\FLO-2D Pro Documentation\Example Projects\QGIS Lesson 1\Hydrology\Land Use.shp



Drag the file **Soil.shp** onto the map space.

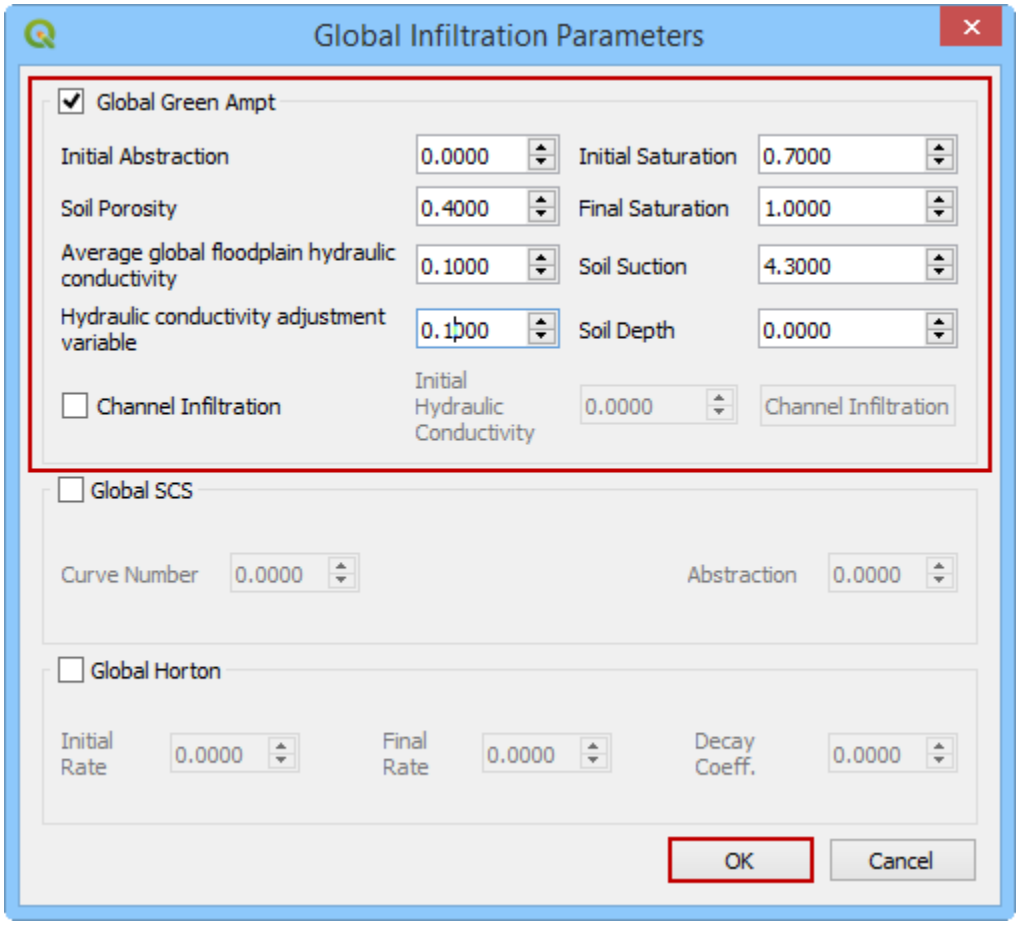
C:\Users\Public\Documents\FLO-2D PRO Documentation\FLO-2D Pro Documentation\Example Projects\QGIS Lesson 1\Hydrology\Soil.shp



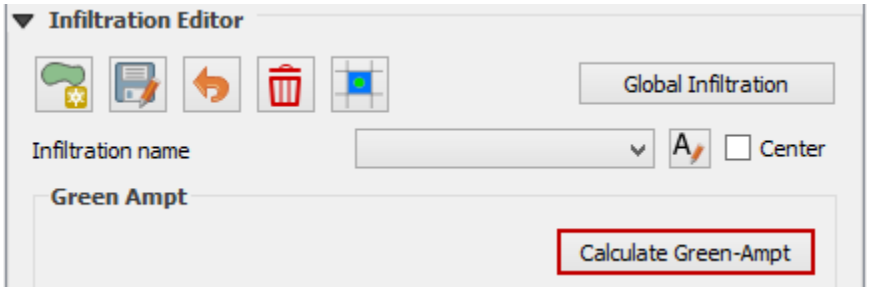
From the **Infiltration Editor** click the **Global Infiltration** icon.

Check the **Global Green Ampt** switch and fill the global variables. The Global variables will be used for any cell that is not defined by the F lines in the spatially variable data assigned to INFIL.DAT.

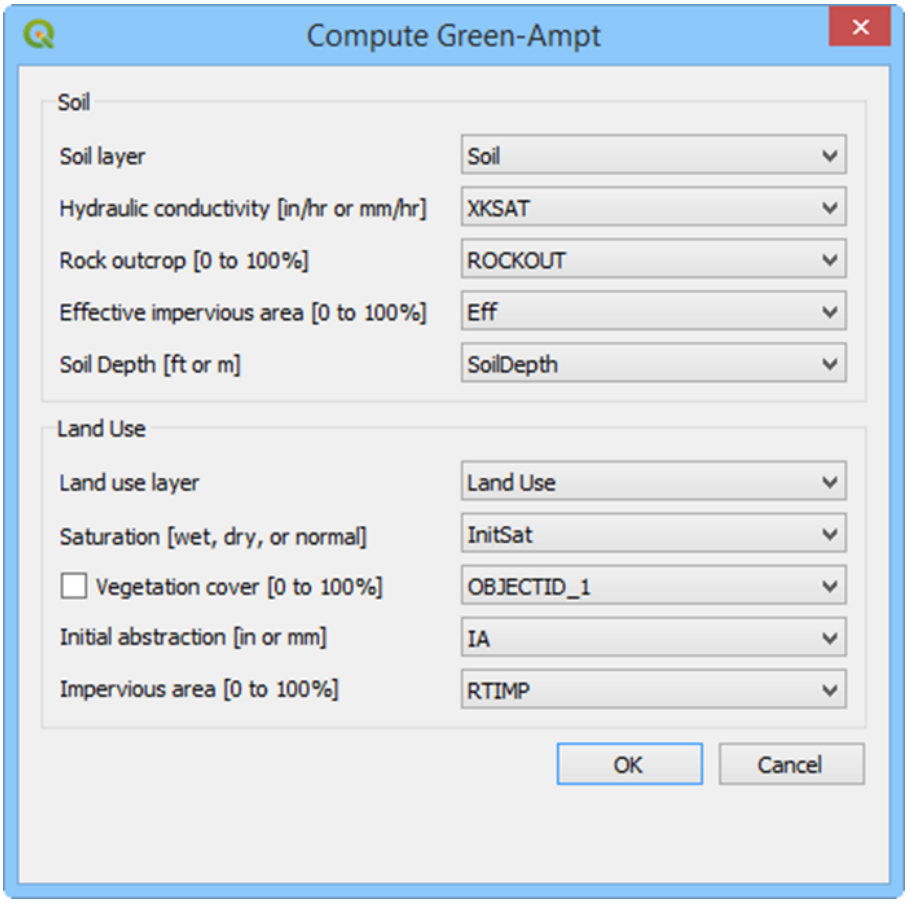
Click **OK** to close.



On the **Infiltration Editor** click **Calculate Green-Ampt**.

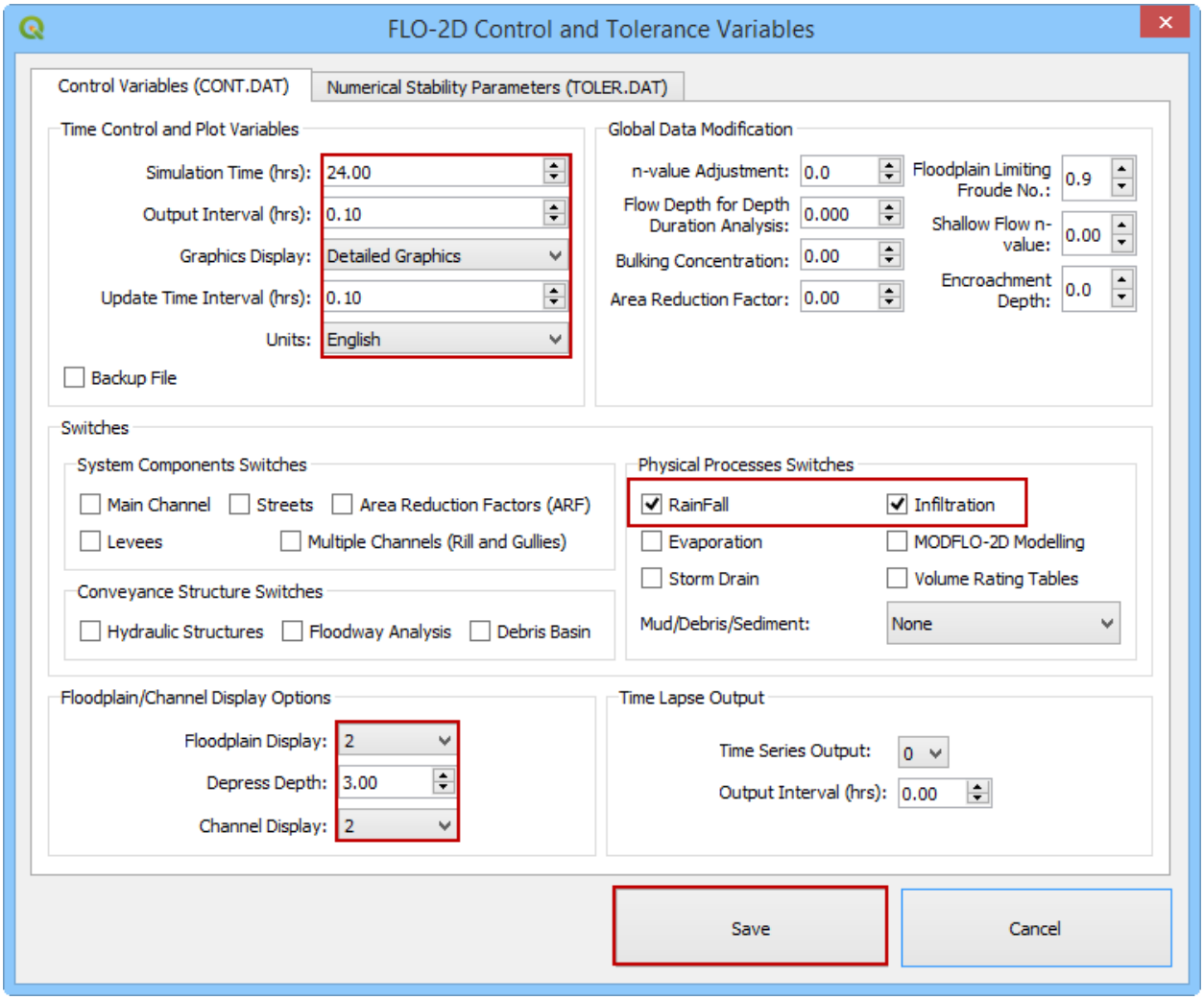


Specify the attributes as shown in the following image and click OK. The calculation process will take 3 to 5 min for this project.



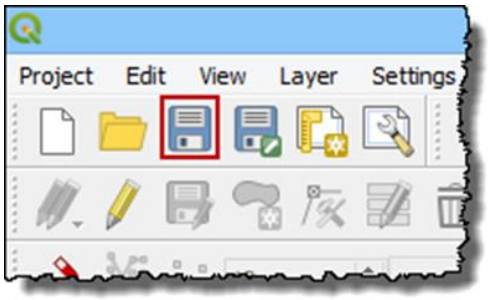
Step 7: Check control variables

Click the **Control Parameters Icon**. Make sure the **Rain** and **Infiltration** switches are turned on. Click **Save** to **Close**.



Step 8: Save the project

Click the main Save icon on the QGIS toolbar.



Step 9: Export the project

Save project, then continue to export the project data into the FLO-2D format. Click the GDS Export icon. Navigate to the project folder and click Select Folder.

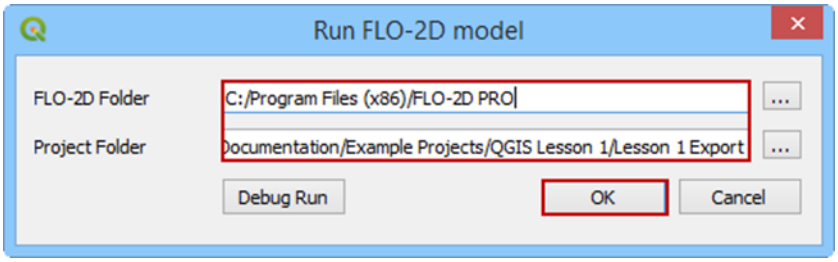
C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\Project Export

Step 10: Run the simulation

Click on the *Run FLO-2D* icon.

Set the FLO-2D Pro folder. **C:\program files (x86)\flo-2d pro**

Set the Project folder. **C:\users\public\documents\flo-2d pro documentation\example projects\QGIS Lesson 1\Lesson 1 Export**



This project can be opened in the GDS and tested for accuracy.

LESSON 2 – CHANNELS

Overview

Complete QGIS Lesson 1 before starting this lesson. Use Lesson 2 to build an urban drainage channel and add culverts to the channel.

Required Data

The lesson makes use of the original data from Lesson 1, left bank, right bank, and cross section data, and culvert rating tables. Start from the end of Lesson 1. All data is provided in the Lesson folders.

File	Content	Location*
QGIS Lesson 1.gpkg		\Example Projects\QGIS Lesson 1
QGIS Lesson 1.qgz		
Grnway Inflow 24 hr 100yr.txt	Inflow hydrograph	\Example Projects\QGIS Lesson 2
Culvert rating tables.txt	Culvert rating tables	
Greenway.g01	Channel GeoRAS file	

**Project Location C:\Users\Public\Documents\FLO-2D PRO Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To setup a FLO-2D flood simulation use these steps.

1. Open Lesson 1;
2. Import GeoRAS Channel Features.;
3. Cross-Section Roughness;
4. Schemetize Channel;
5. Channel In/Out Condition;
6. Create Culverts;
7. Set up Control Parameters Export Project;
8. Interpolate the Channel;
9. Import the new data;
10. Run the FLO-2D model.

Step 1: Open Lesson 1 in QGIS and load the FLO-2D Plugin data

Search the start menu and run the "QGIS Desktop" program.

Click *Open Project* and navigate to **QGIS Lesson 1**. Select **QGIS Lesson 1.qgz** and click *Open*.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 1\QGIS Lesson 1.qgz

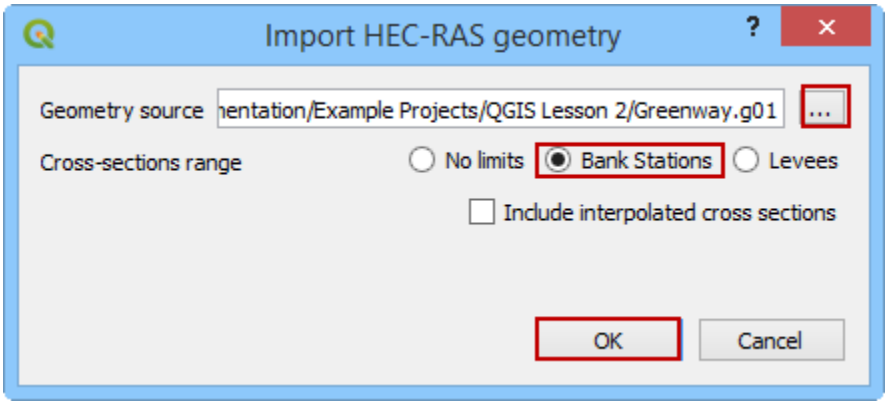
Use *Quick Map Services* to load an aerial image onto the map. See **Lesson 1 - Part 2 - Step 3** for instructions.

Step 2: Import GeoRAS channel features

Click the *Import RAS* icon. Open the **Greenway.g01** file.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 2\Greenway.g01

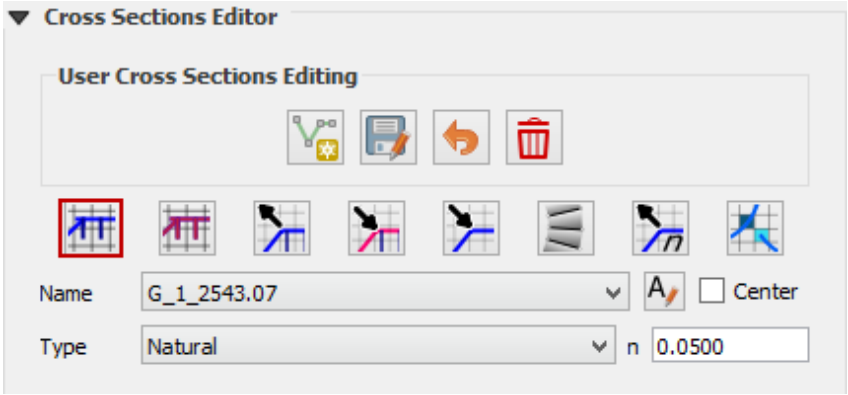
Check the *Bank Station* icon and click *OK*.



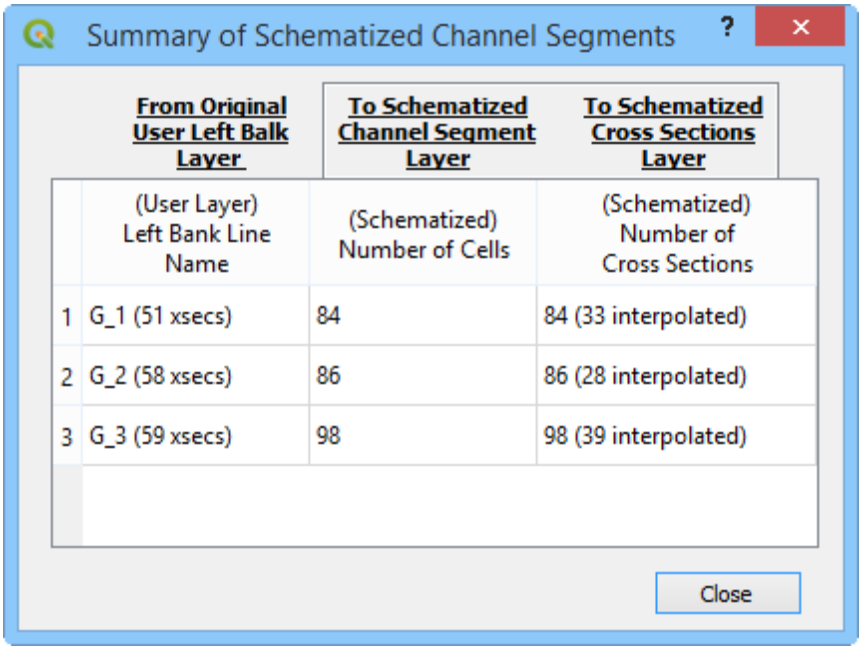
The channel left bank and cross sections are imported into the *User Layers*. The cross section data is imported into the cross section data tables.

Step 3: Schematize channel

Click Schematize left banks and cross sections.



If the channel schematization process was successful, the following message will appear. Click *Close*.

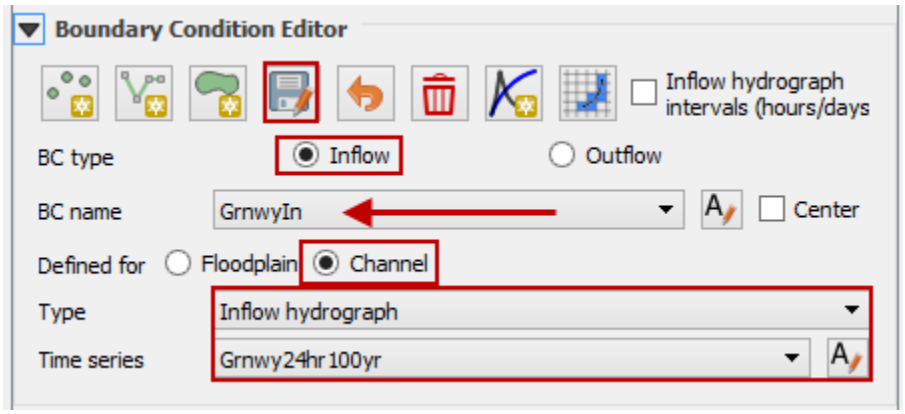


Step 4: Channel in/out condtion

Inlet

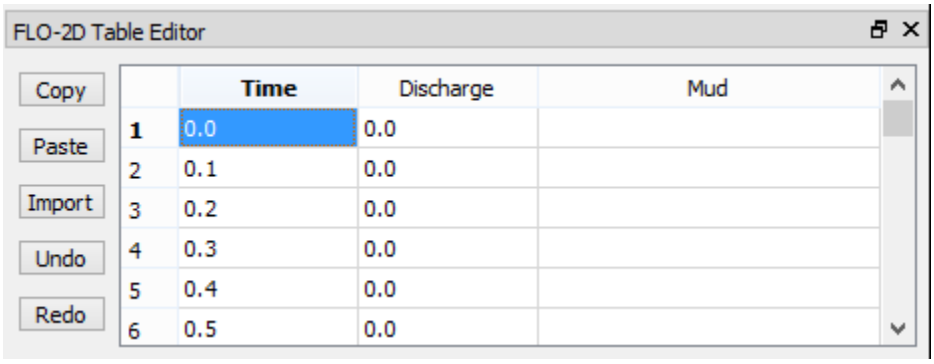
Zoom to the first channel element on the southwest corner of the map. Use the Boundary Condition Editor to create the Inflow point.

This process is outlined in Lesson 1, Part 3, Step 4.



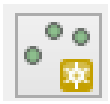
Add a time series the new BC node. Copy the inflow hydrograph data from the Grnwy inflow file to the table editor.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 2\Greenway Inflow 100yr 24hr.txt

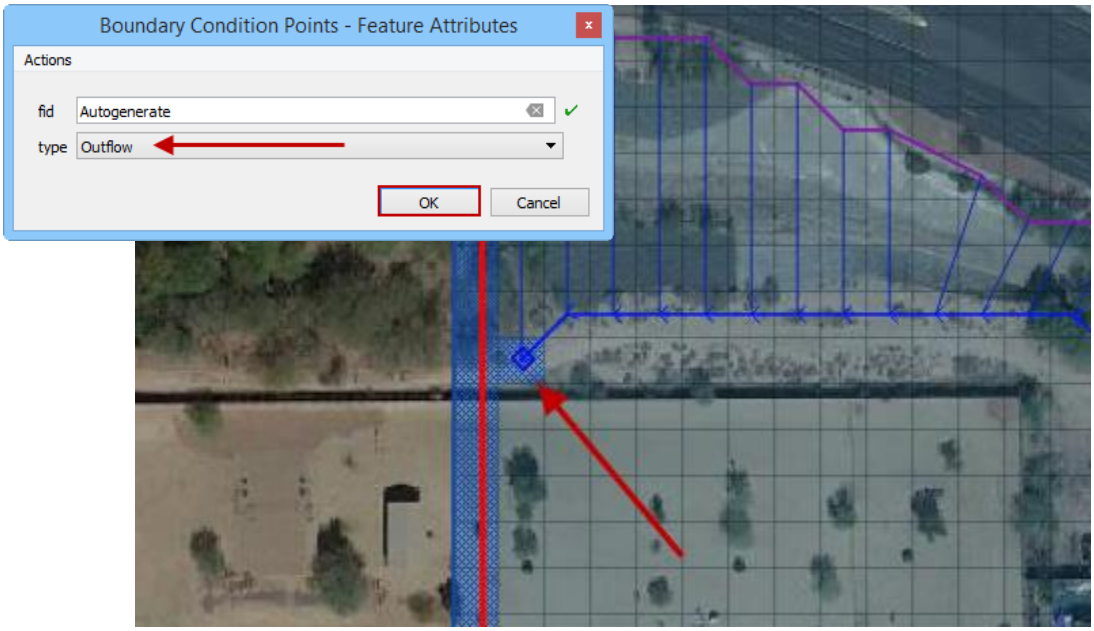


	Time	Discharge	Mud
1	0.0	0.0	
2	0.1	0.0	
3	0.2	0.0	
4	0.3	0.0	
5	0.4	0.0	
6	0.5	0.0	

Outlet



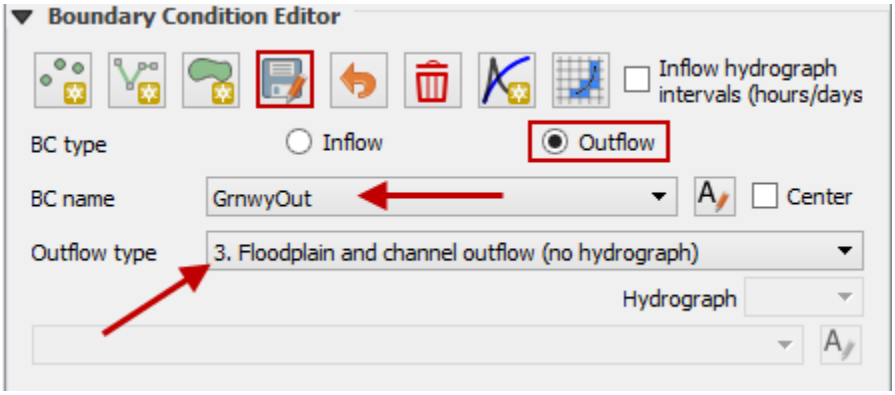
Zoom to the end of the channel. Add a BC Point to the last element of the channel.

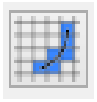


Save the form and set the BC type to Outflow

Name the BC to GrnwyOutCh

Set the type to 3.

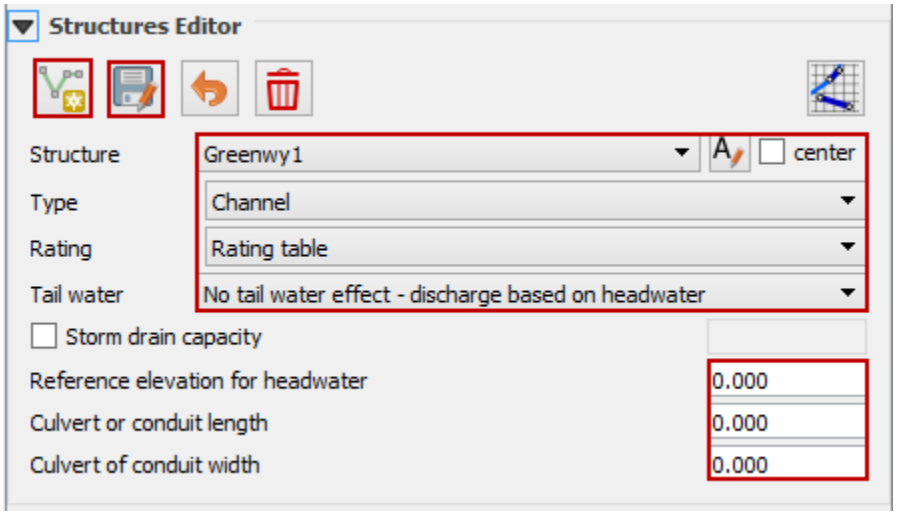




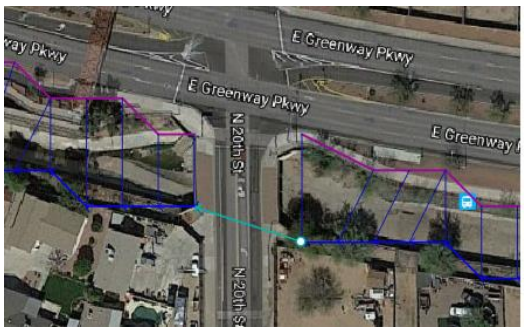
Shematize the outflow conditions.

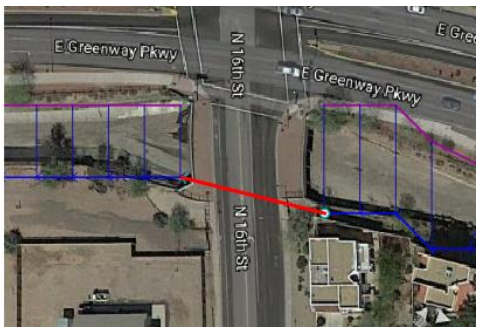
Step 5: Culverts

This structure will calculate discharge through a box culvert. This example has a box culvert that is longer than the grid element. The channel segments are split up to allow for the width of the roadway.



1. Open the *Stuctures Editor* drop down. Click the *Add Structure* icon.
2. Digitize two culverts by clicking on the blue left bank elements that represent the beginning and end of the hydraulic structure. Both structures are between the channel segments.

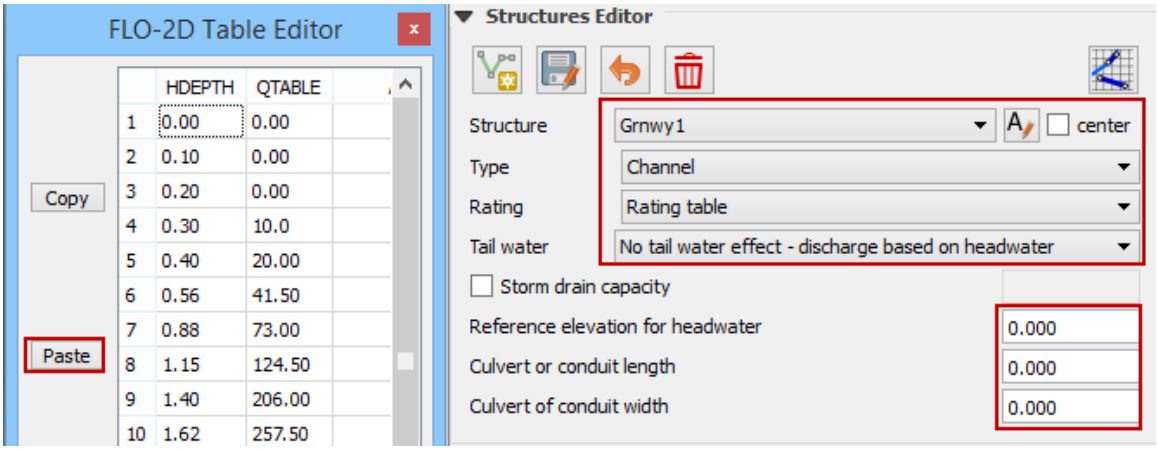




3. Click *Save*.
4. Fill in the data on the Structure Editor and the Table Editor.

a. Name the culverts
b. Channel to Channel
c. Rating table
d. Tailwater condition is none.
e. Head Reference elevation is not needed 0.00 will default to the channel inverts.
f. Conduit length is default 0.00. Not needed for standard box culvert.
g. Conduit width is default 0.00. Not needed for standard box culvert.
h. Open ***Culvert Rating Tables.txt*** from *Lesson 2*. Copy the text and paste the text into the *FLO-2D Table Editor*.

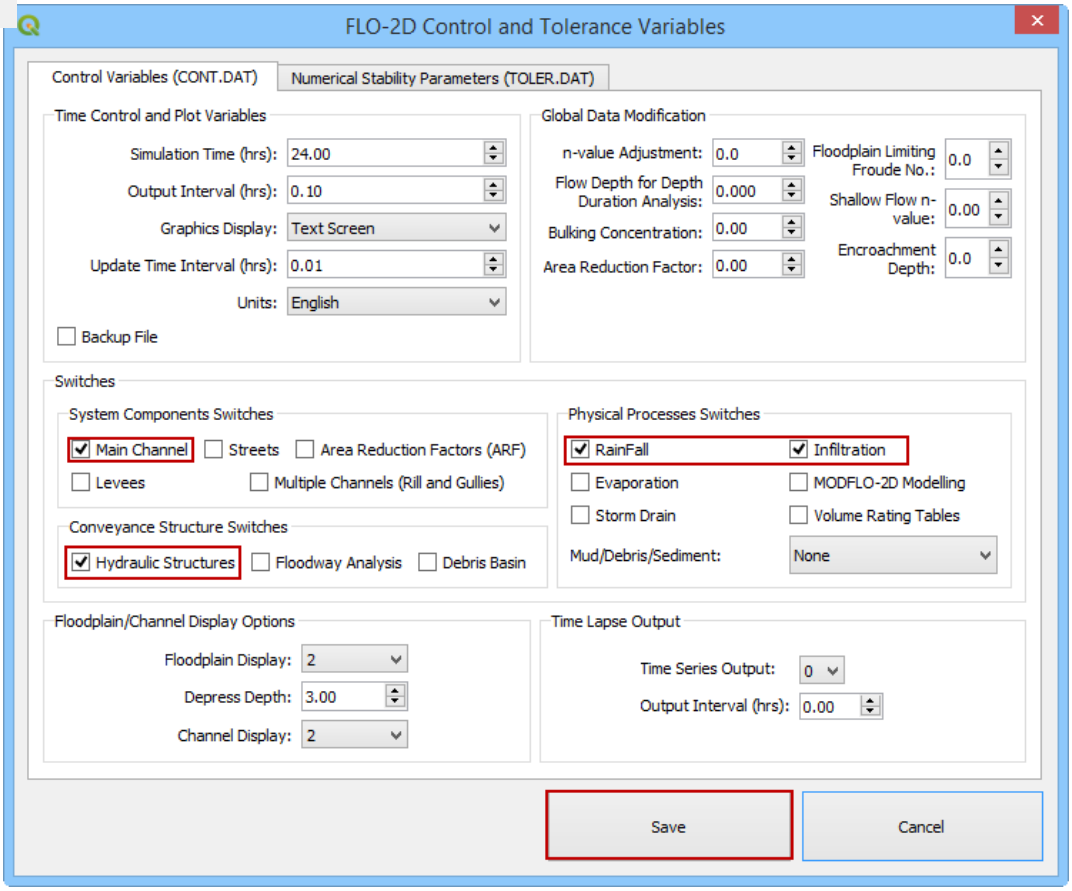
C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 2\Culvert Rating Tables.txt

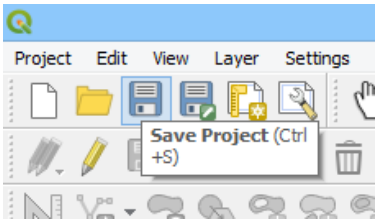


5. Important **Click select each field even if it is already set to the default.**
6. Repeat the process for the second culvert Grnwy2.
7. Click *Schematize* to write the data to the schematic layers and *Save* the project.

Step 6: Export the project

Click the *Setup Control Parameters* icon.





Select set control parameters. Check the boxes for Main Channel and Hydraulic structures if needed. Click *Save*.

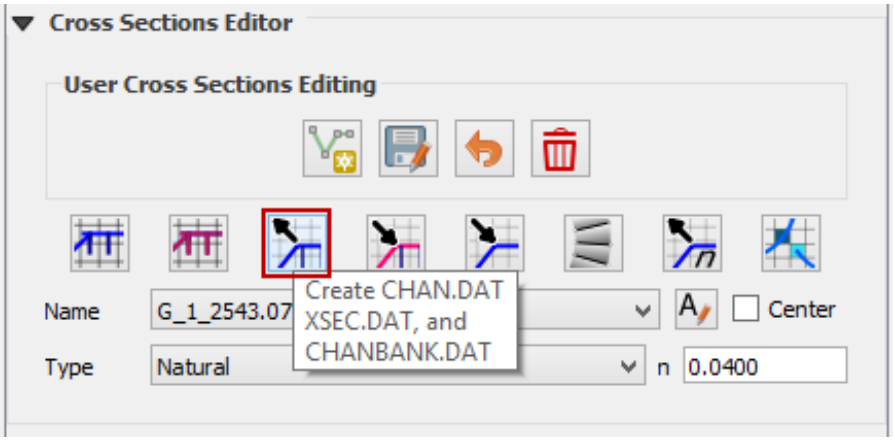
This is a good point to save project. Refer to Steps 9 in Lesson 1.

Export the Project to the Project Folder in QGIS Lesson 2

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 2\Lesson 2 Export

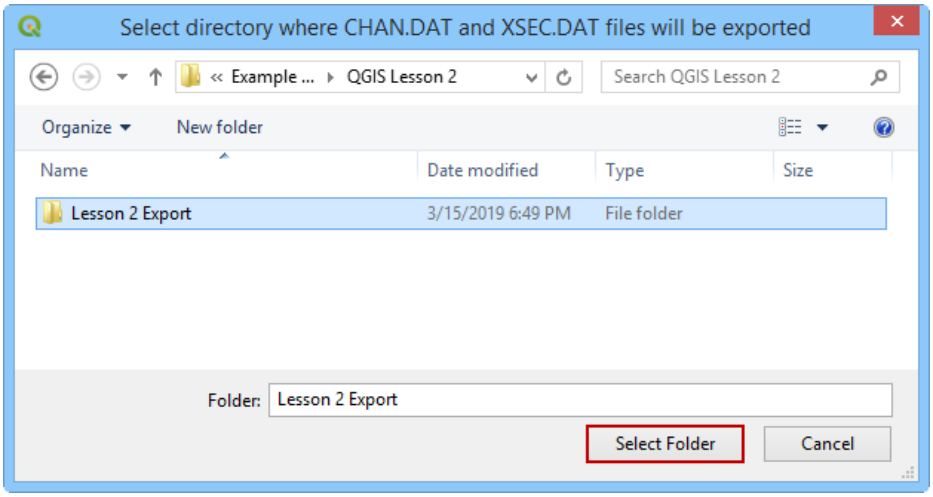
Step 7: Interpolate the channel

To interpolate the channel segments, export the channel data and run the interpotator. In the *Cross Sections Editor* widget, click the *Create CHAN.DAT, XSEC.DAT, and CHANBANK.DAT* icon.

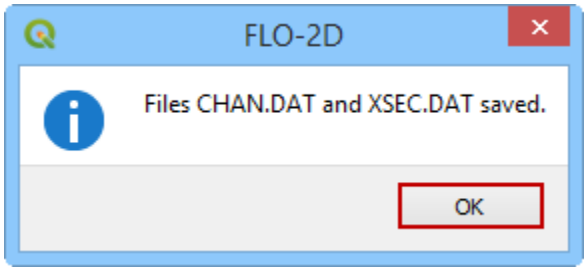


Select the folder where the *.DAT files will be saved.

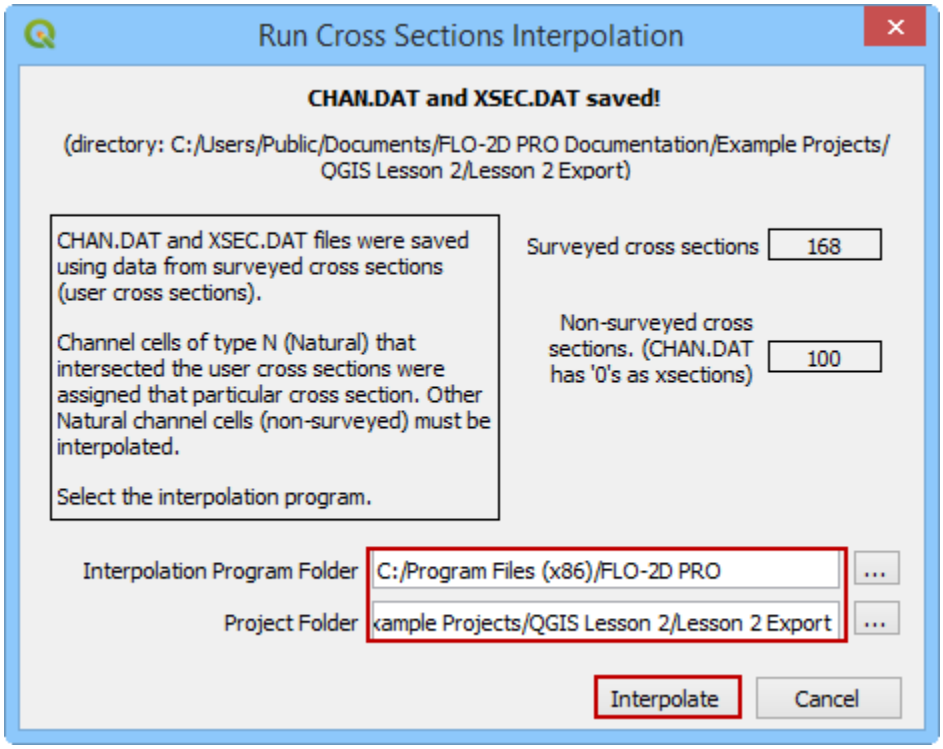
C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 2\Lesson 2 Export



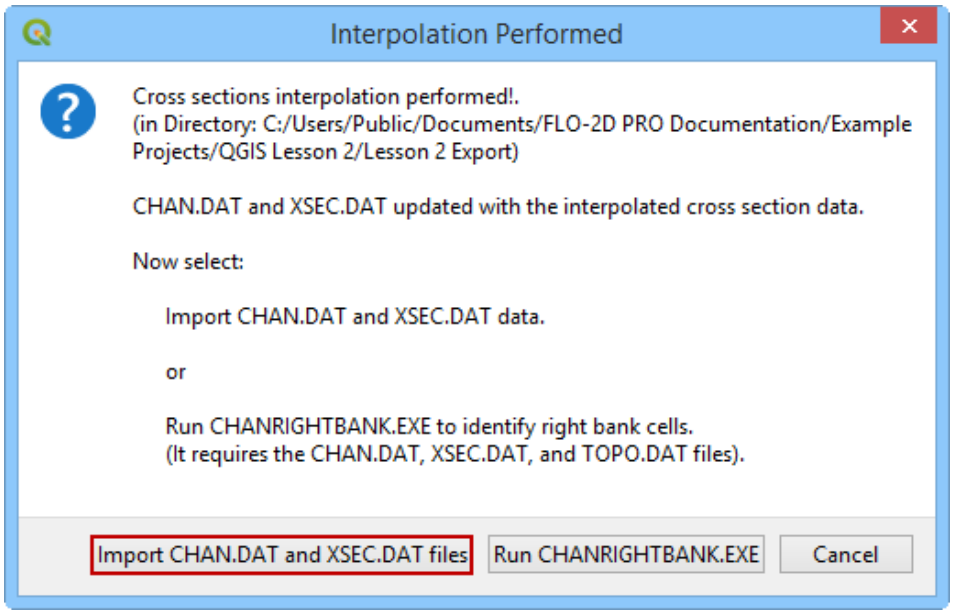
The first action saves the channel data.



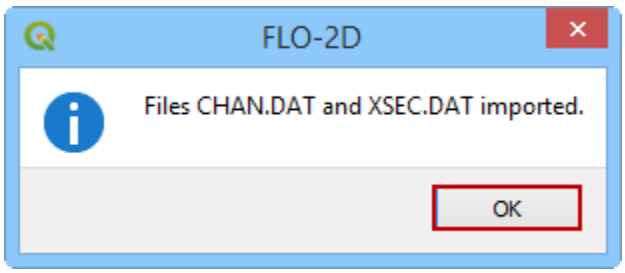
The second action calls the Interpolate.exe program from the FLO-2D Pro folder. If this process results in an Interpolate.exe error, it is possible to move that file to another location and make sure it is named correctly.



If the interpolation is performed correctly the following message will appear. Click *Import CHAN.DAT and XSEC.DAT* to update the channel data in QGIS.



Click the OK icon when the process is finished.



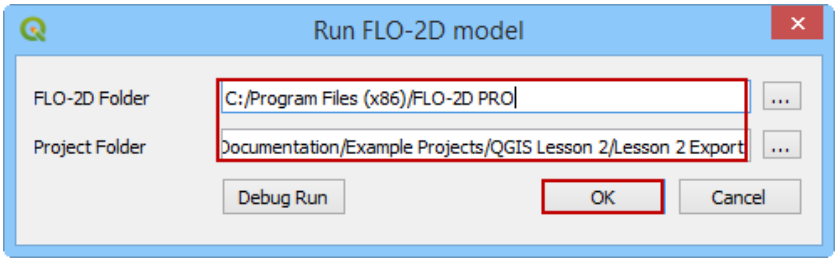
Step 8: Run the simulation

Click the *Run FLO-2D* Icon.

Set the *FLO-2D Folder*. **C:\program files (x86)\flo-2d pro**

Set the *Project Folder*. **C:\users\public\public documents\flo-2d pro documentation\example projects\QGIS Lesson 2\Lesson 2 Export**

Click *OK*.



Summary

This lesson was a simple channel import. It used a Georeferenced HEC-RAS geometry file. These files can be made with HEC-RAS version 5.0 or HEC GEORAS plugin for ArcGIS. There are many ways to build channels with QGIS for FLO-2D and the other possibilities are outlined in the User's Manual.

To add more detail and components to the project such as channels, hydraulic structures, buildings, levees and stormdrains, complete the following lessons.

LESSON 3 – CREATE A STORM DRAIN SYSTEM USING SHAPEFILES

Overview

This lesson will outline the process of importing some shapefiles for a stormdrain system and create the INP file and associated storm drain data files.

Required Data

The lesson makes use of the original data from Lesson 2, with the urban components overlaying a storm drain system on the grid. All data is provided in the Lesson folders.

File	Content	Location*
QGIS Lesson 3.gpkg		\Example Projects\QGIS Lesson 3
QGIS Lesson 3.qgz		
Shapefiles	Inlets/Junctions, Outfalls and Conduits	

**Project Location C:\Users\Public\Documents\FLO-2D Pro Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To setup a FLO-2D flood simulation use these steps.

1. Create Lesson 3 GeoPackage and QGZ file;
2. Import shapefiles for storm drain;
3. Select components from storm drain shapefiles;
4. Review storm drain data;
5. Build type 4 tables
6. Schematize storm drain data;
7. Export swmm.inp file;
8. Export project data;
9. Run the simulation.

Step 1: Open Lesson 3 in QGIS and load the FLO-2D Plugin data

Search the start menu and run the "QGIS Desktop" program.

Complete Lesson 2 prior to starting this lesson. Click the FLO-2D Settings buggon and create a Lesson 3 Geopackage.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\QGIS Lesson 3.gpkg

Click the Import icon to import the GeoPackage from Lesson 2.

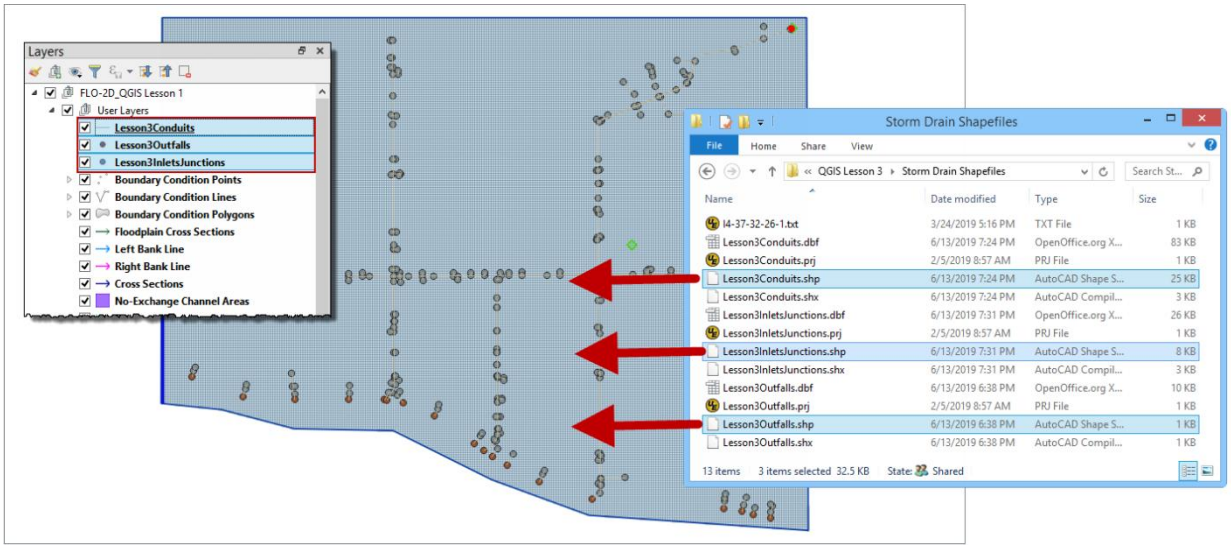
Save the project

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\QGIS Lesson 3.qgz

Step 2: Import shapefiles for storm drain features

Grab the *.SHP files from QGIS Lesson 3 and drop the files in the map space. The shapefiles should be located inside the project layer in the layer panel.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\Storm Drain Shapefiles



The shapefiles can be described as follow:

- **Lesson3Outfalls.shp** is a point shapefile that contains the outfalls.
- **Lesson3Conduits.shp** is a line shapefile that contains the pipes.
- **Lesson3InletsJunctions.shp** is a point shapefile that contains the Inlets and Junctions. Inlets collect flow from the surface and their name should start with "I", this is a requirement for all inlets from type 1 to 5, including manholes.

Check the Atribute Tables radio button and review them for conduits, inlets/junctions and outfalls.

The following data must be available in the shapefile to create the **SWMM.INP** files and the associated storm drain data files: **SWMMFLO.DAT**, **SWMMOUTF.DAT** and **SWMMFLORT.DAT**.

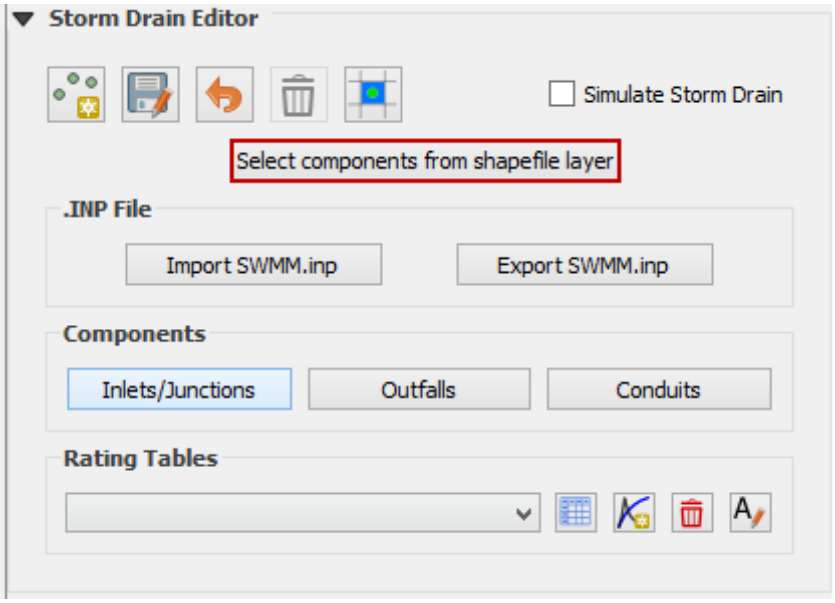
CONDUITS	Name
	Upstream Inlet/Junction
	Downstream Inlet/Junction
	Inlet/Outlet Offset (not required)
	Shape
	No of Barrels
	Max Depth (Diameter for circular)
	Geom 2 (Width for rectangle)
	Geom 3
	Geom 4
	Length
	Manning's N
	Initial Flow (Not required)
	Maximum Flow (Not required)
	Entry Loss Coef (Not required)
	Exit Loss Coef (Not required)
	Average Loss Coef (Not required)
	Flap Gate

INLETS/JUNCTIONS	Name
	Invert Elevation
	Maximum Depth
	Initial Depth (Not required)
	Surcharge Depth (Not required)
	Length/Perimeter
	Width/Area
	Height/Sag/Surcharge Depth
	Weir Coefficient
	Feature (Not required)
	Curb Height (Not required)
	Clogging Factor (Not required)
	Time for Clogging (Not required)

OUTFALLS	Name
	Invert Elevation
	Flap Gate
	Allow Discharge Switch
	Outfall Type
	Water Depth (Not required)
	Tide Curve (Not required)
	Time Series (Not required)

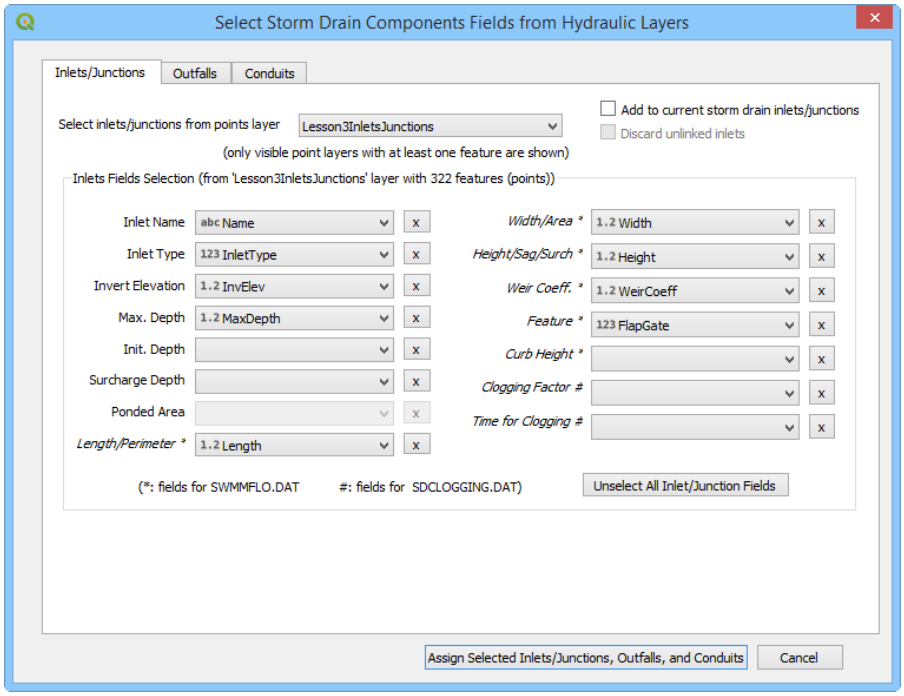
Step 3: Select components from shapefile layer

Display the *Storm Drain Editor* widget and click the *Select components from shapefile layer* button.

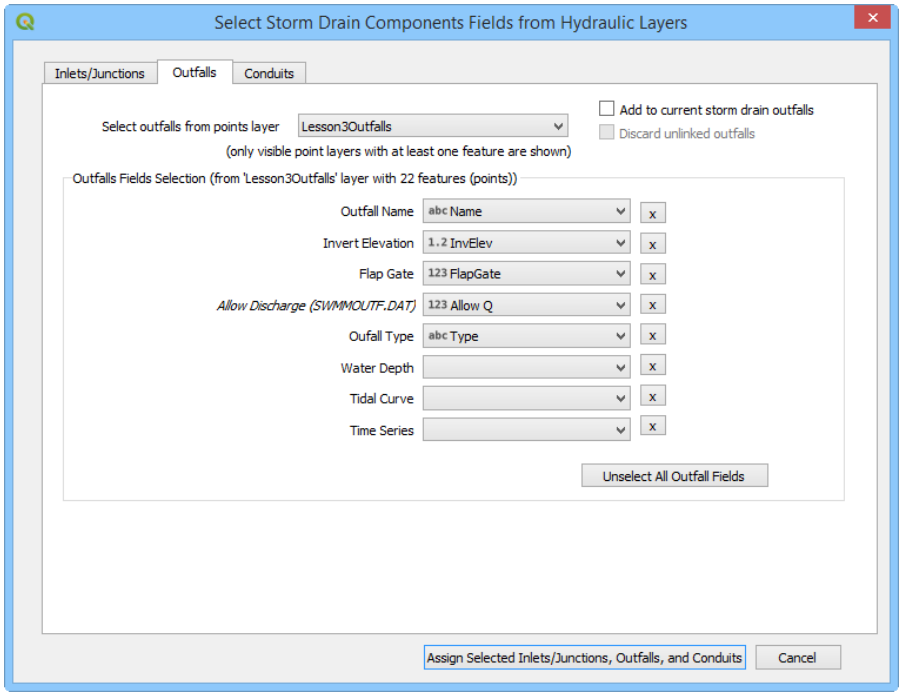


Use the Editor to assign the Inlets/Junctions parameters from the shapefile to the attribute table.

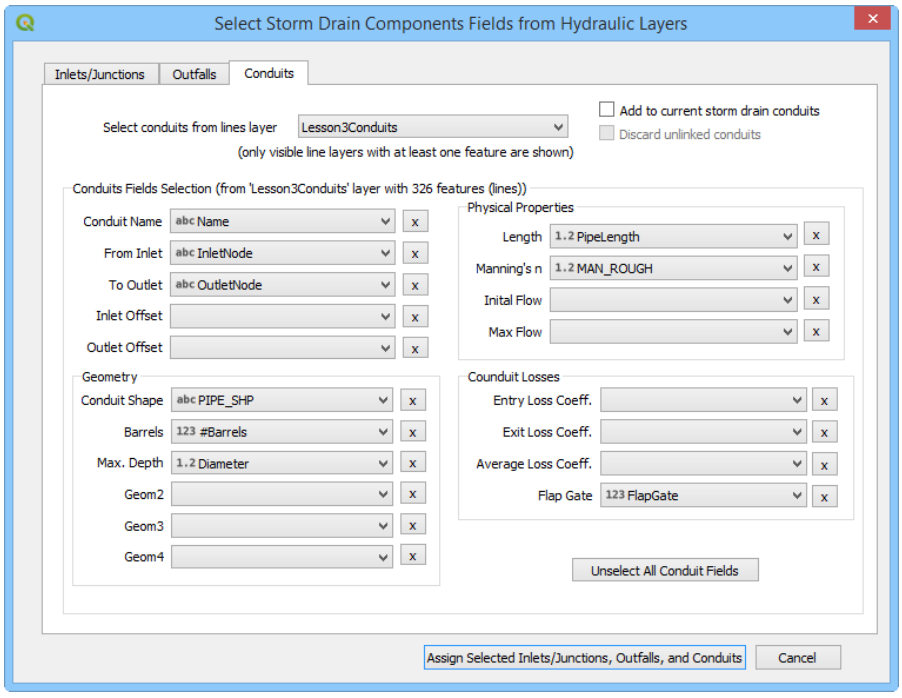
Use the Editor to assign the I*nlet/Junction* fields.



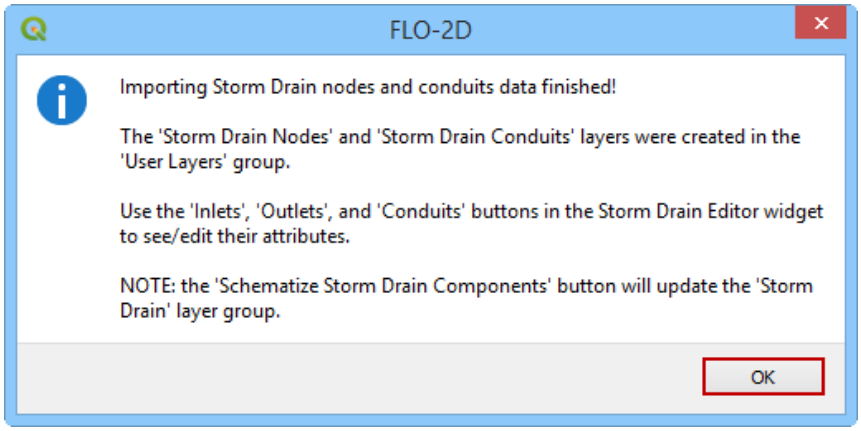
Use the Editor to assign the O*utfall* parameters from the shapefile to the attribute table.



Use the Editor to assign the C*onduits* parameters from the shape-file to the attribute table.

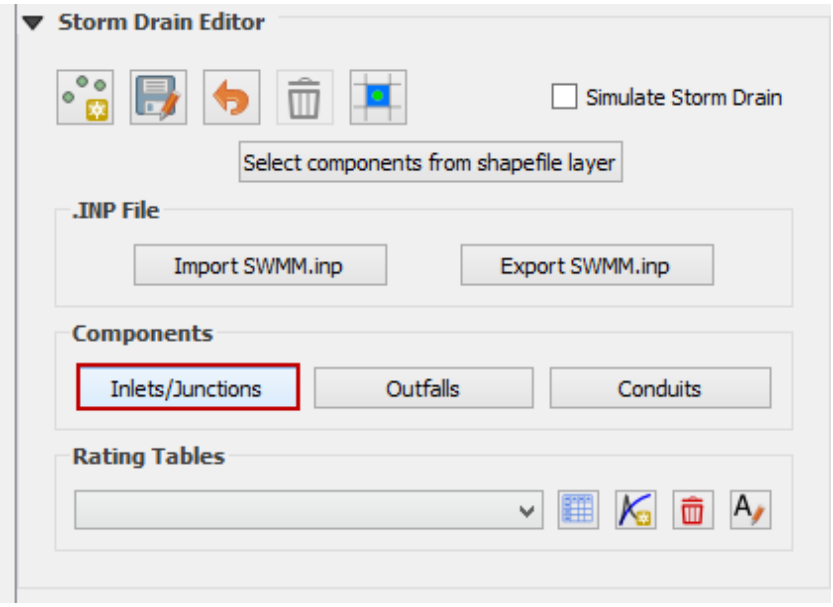


Once all features are assigned in the drop-down menu, then click on *Assign Selected Inlets/Junctions, Outfalls and Conduits* to create the data structures of the Storm Drain Components. The following message will be displayed. Click *OK*.

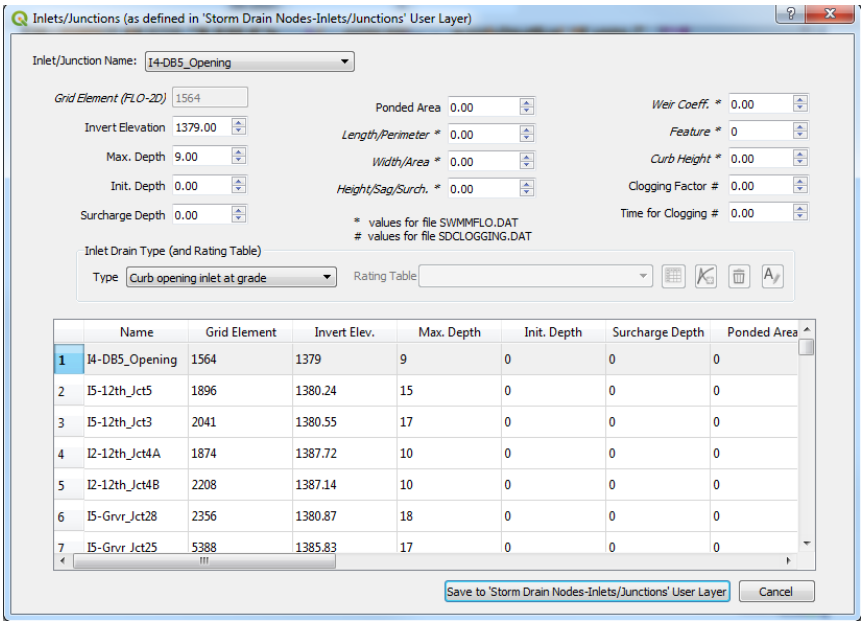


Step 4: Review tables for storm drain components

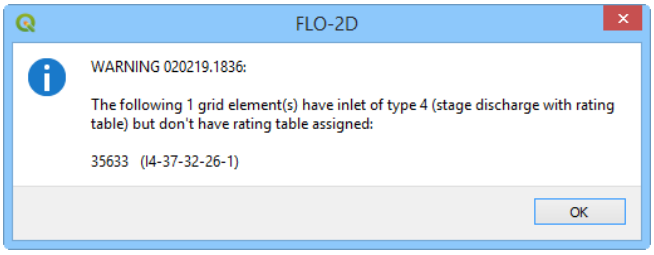
Display the Storm Drain Editor widget and click on *Inlets/Junctions.*



The table for *Inlets/Junctions* that was filled up using the shapefile attributes is displayed. The user can review the data and make sure all parameter was correctly imported. Data can be directly modified in this table. Once the data has been reviewed, click on *Save to 'Storm Drain Nodes-Inlets/Junctions' User Layer* Button.

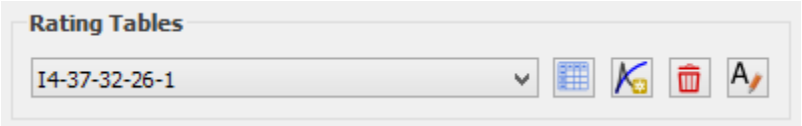


If there are Type 4 inlets, the following message will appear. Click *OK*.



Step 5: Set up rating table for type 4 inlet

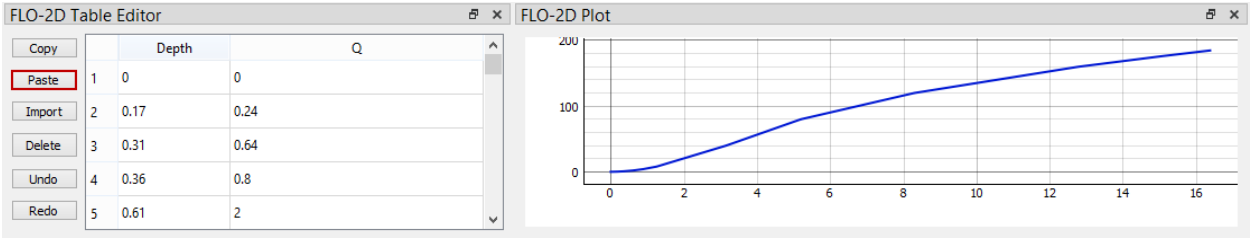
Add a new table for the Type 4 Inlet I4-37-32-26-1



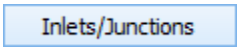
The table data is saved in the text file

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\Storm Drain Shapefiles\I4-37-32-26-1.txt

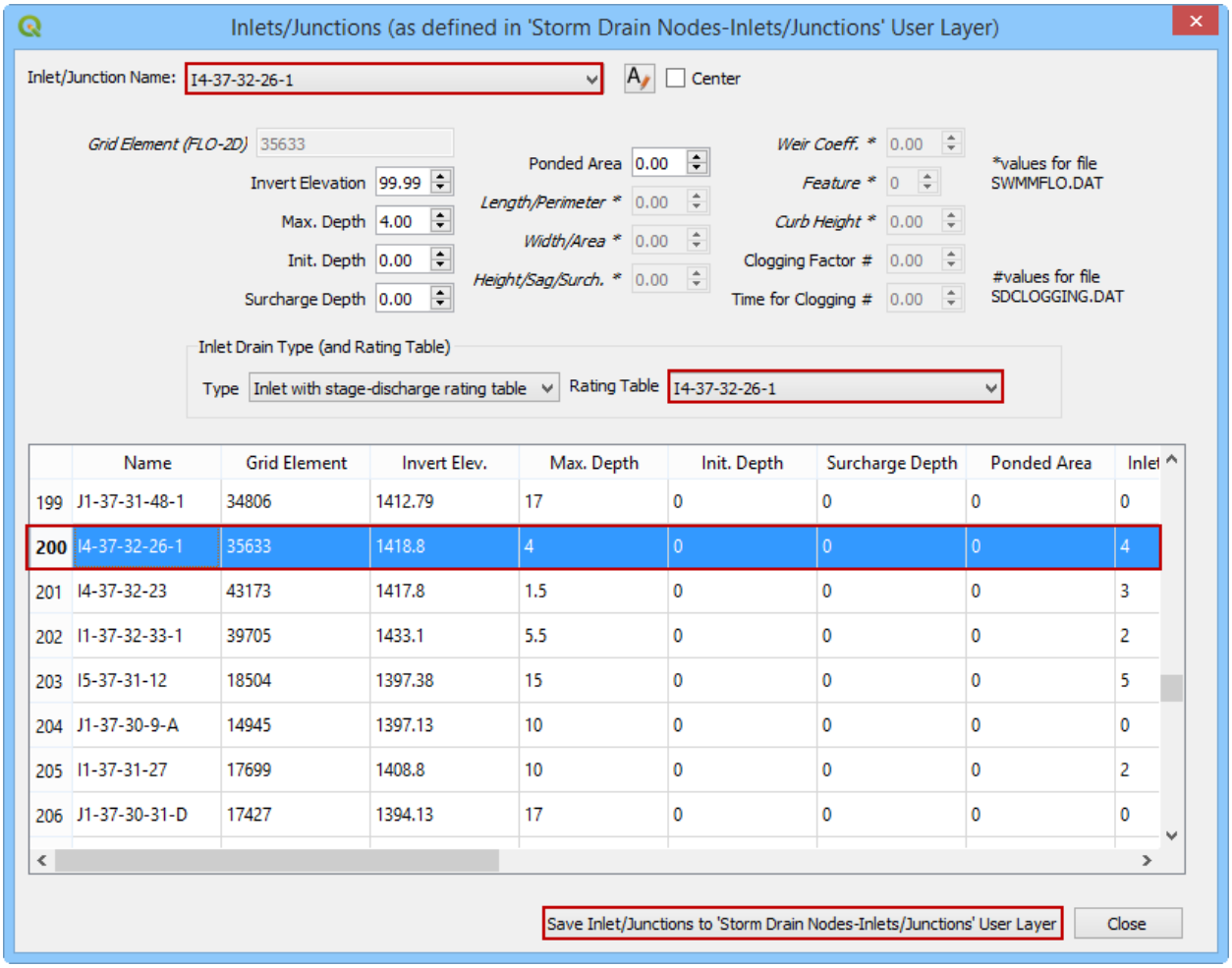
Copy the data and paste it into the *FLO-2D Table Editor*.



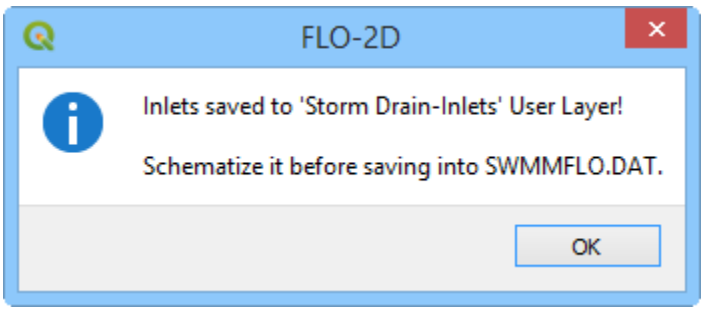
Use the *Components Inlets/Junctio*ns button to assign the table to the inlet.



Select the *Type 4,* assign the rating table and click the *Save Inlet* button.

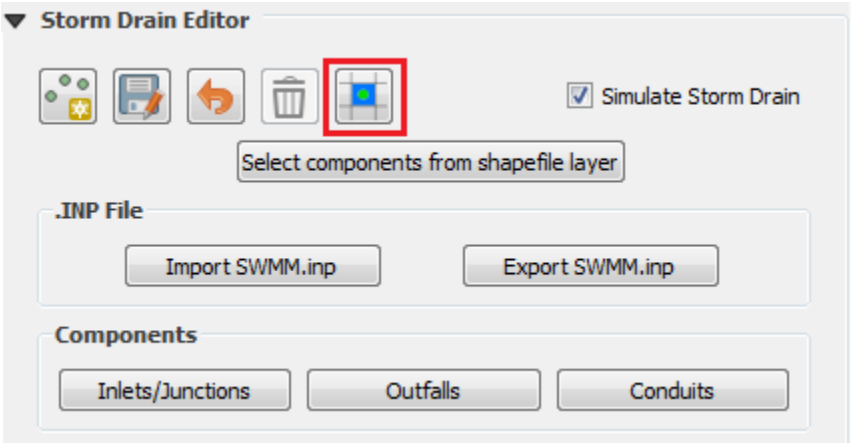


If the data is saved correctly, click *OK* on the following message.

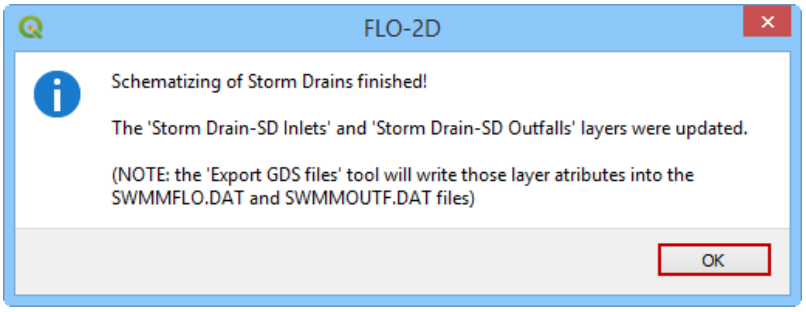


Step 6: Schematize storm drain components

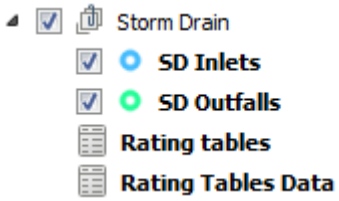
Click on *Schematize Storm Drain Components* in the *Storm Drain Editor* widget.



Once the storm drain components are schematized, the following dialog will appear. Click *OK* to close.

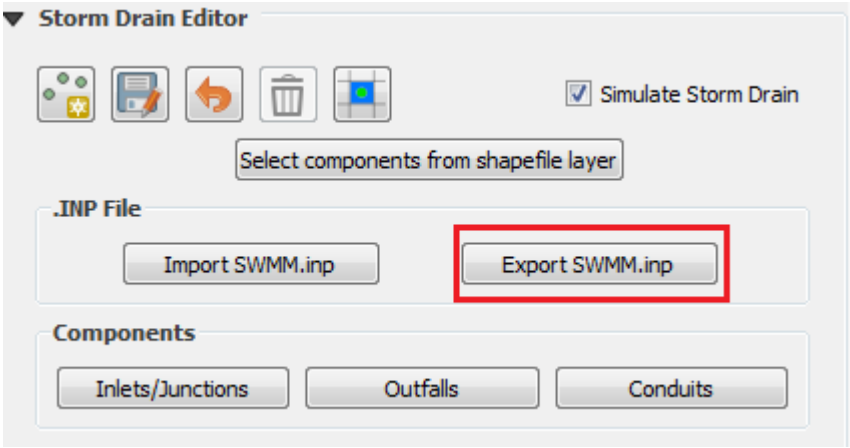


The storm drain schematized data layers have been completed and the atribute tables can be reviewed in the *Storm Drain* layers: *Inlets* and *Outfalls*. The storm drain components are now part of the s*hematized layers* in the project.

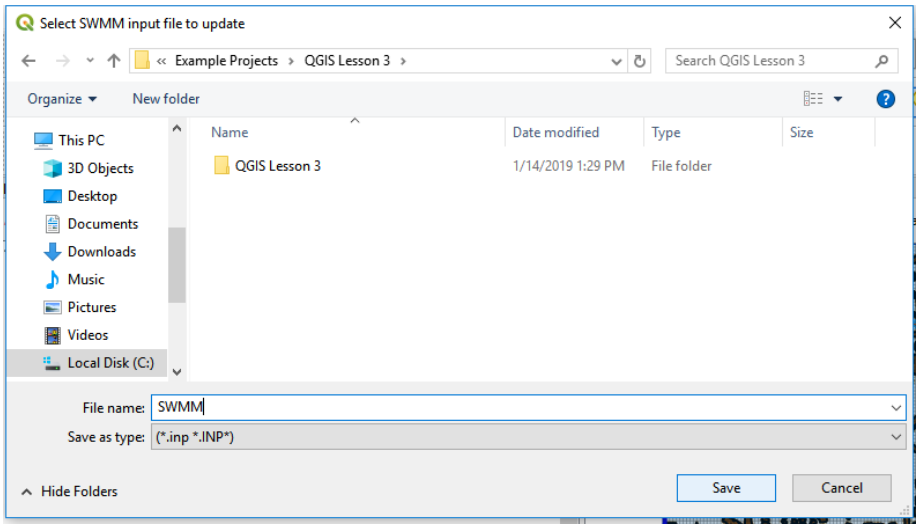


Step 7: Export SWMM.INP file

Make sure the switch *Simulate Storm Drain* is selected. Click on *Export SWMM.INP* button in the **Storm Drain Editor** widget.

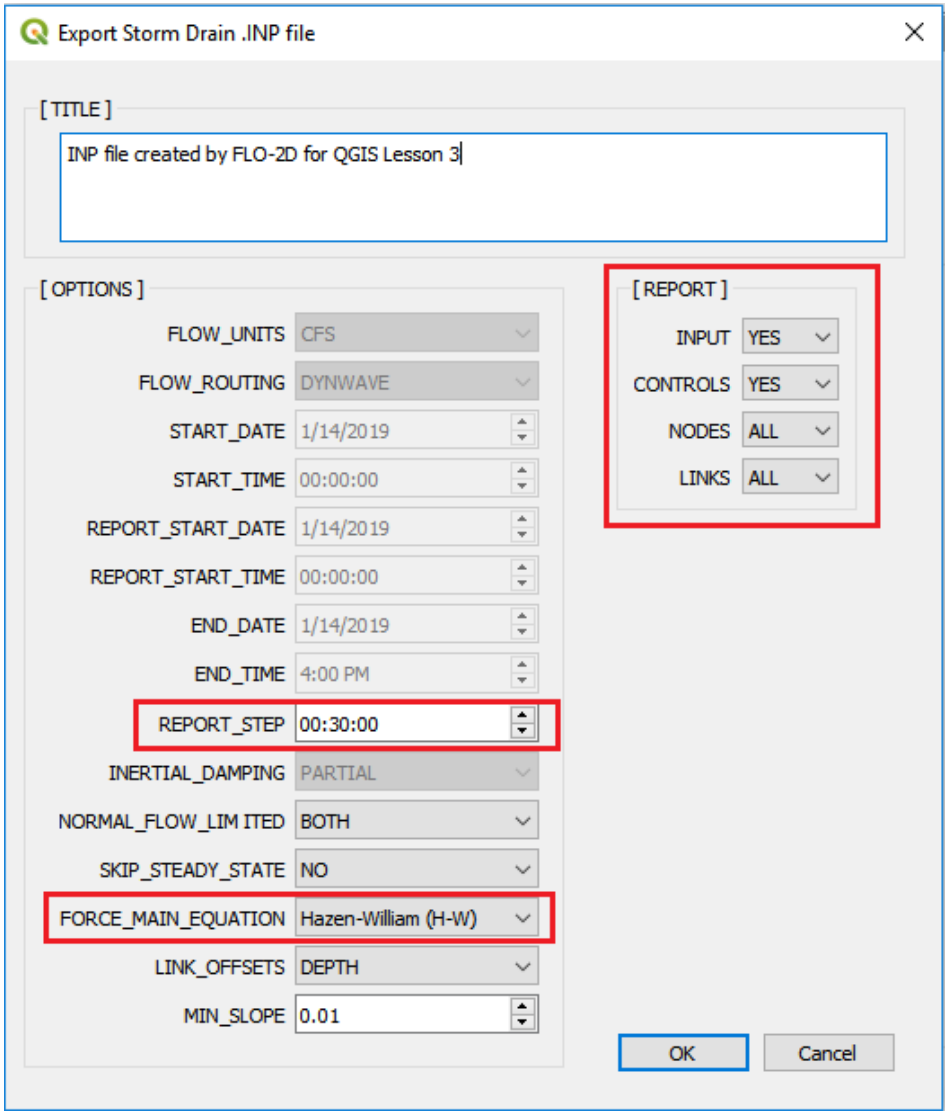


Browse to the Project Folder and Save the **SWMM.INP** file. The *.INP file should be named as 'SWMM.INP', no other names will be read by FLO-2D model. Click *Save*.

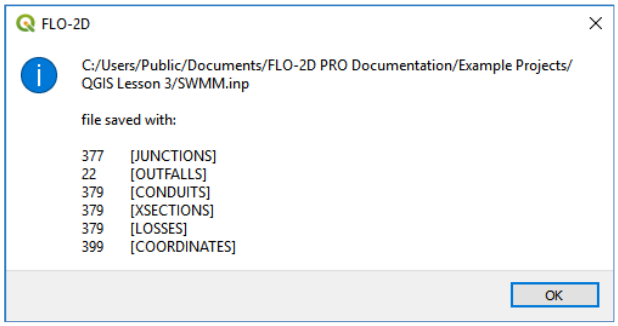


The *Storm Drain Control Dialog* is displayed. The control parameters must be entered. The time, date, flow units and other data are hardwired from the FLO-2D surface Control Dialog. All gray out data in the control dialog is hardwired.

The red boxes in the image below show the data that is required.



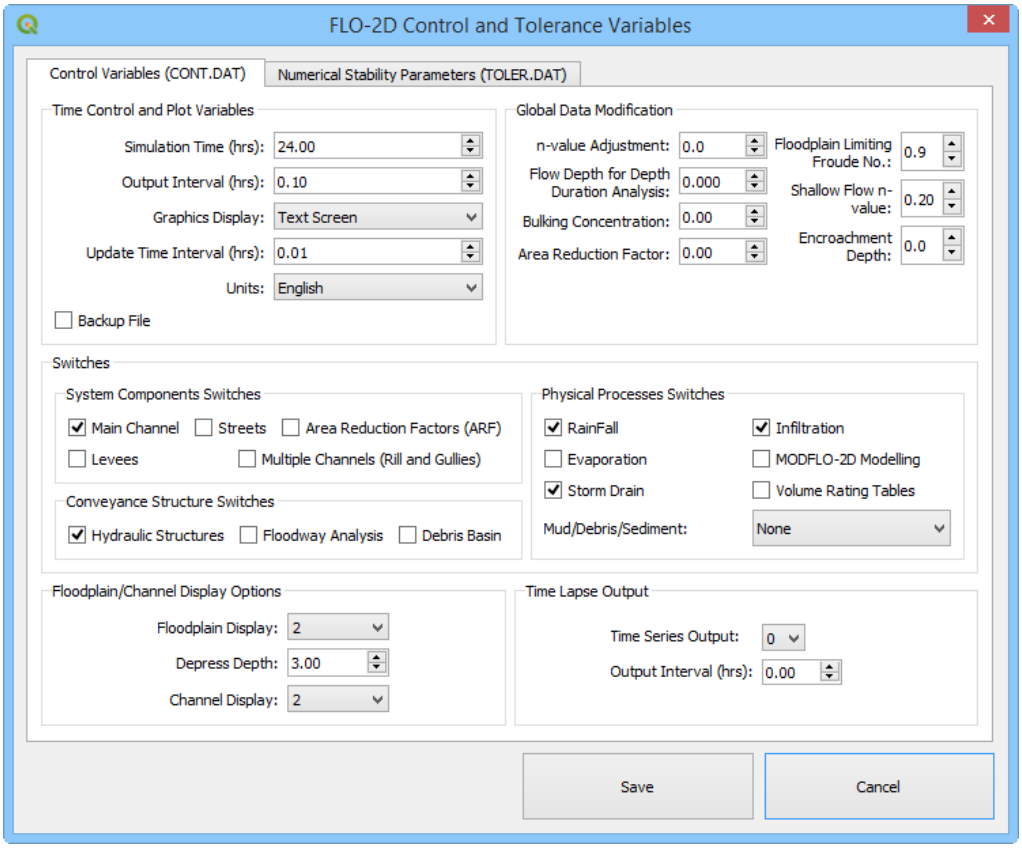
A dialog displays presenting the features that were written to the *.INP file. Click *OK*.

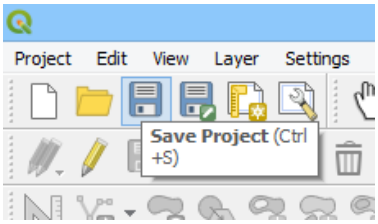


Step 8: Export the project

The files that connect inlets and outfalls with the FLO-2D surface layer are created when the GDS Data Files are exported.

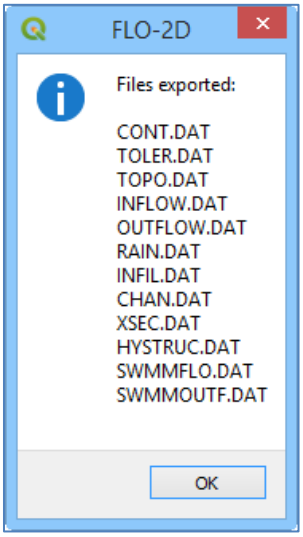
Click the *Set Control Variable* icon and enter the data in the FLO-2D Toolbar. The following dialog will be displayed, make sure the *Storm Drain* component switch is selected. Click *Save*.





This is a good point to save project. Refer to Steps 9 in Lesson 1.

Export the data files to the Project Folder in QGIS Lesson 3



C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\Lesson 3 Export

All GDS Data files will be created in the selected project folder, including **SWMMFLO.DAT** and **SWMMOUTF.DAT** files.

The following dialog will be displayed, associated storm drain data files are created when the storm drain switch has been turned ON.

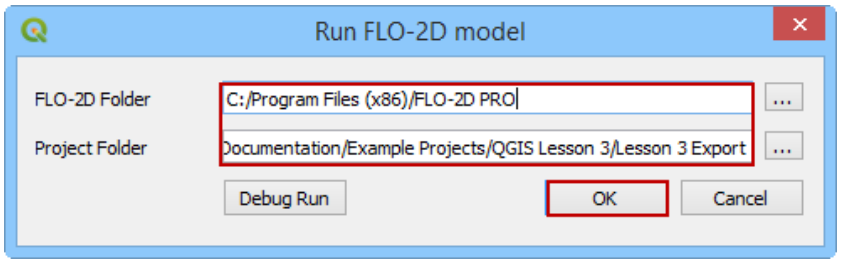
Step 9: Run the simulation

Click the *Run FLO-2D* Icon.

Set the Project path and the FLO-2D Engine Path and click OK to start the simulation.

Set the *FLO-2D Folder*. **C:\program files (x86)\flo-2d pro**

Set the *Project Folder*. **C:\users\public\public documents\flo-2d pro documentation\example projects\QGIS Lesson 3\Lesson 3 Export**



After the storm drain model is complete, review FLO-2D Storm Drain Manual Chapter 6 for more details about reviewing results.

Summary

This is the completion of a full storm drain model using the FLO-2D model along with digital terrain elevation data and an inflow hydrograph, rain and boundary conditions from Lesson 1 and 2. This lesson has demonstrated how to create the storm drain system by using shapefiles for conduits, inlets/junctions and outfalls.

LESSON 4 – QGIS FLO-2D PLUGIN BUILDINGS AND WALLS

Overview

Lesson 4 will outline the process of setting up buildings and walls in a FLO-2D project using the Plugin for QGIS. This lesson can be completed after Lesson 1 is finished. Apply these instructions after Lesson 1, 2 or 3 are completed.

Required Data

The lesson makes use of buildings and walls shapefiles.

File	Content	Location*
Buildings.shp	Building shapefile	\Example Projects\QGIS Lesson 4 PRO
Walls.shp	Walls shapefile	

**Project Location C:\Users\Public\Documents\FLO-2D Pro Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To setup a FLO-2D flood simulation use these steps.

1. Open Lesson 1, 2 or 3 completed project.;
2. Assign buildings;
3. Assign walls;
4. Save and export;
5. Run the simulation.

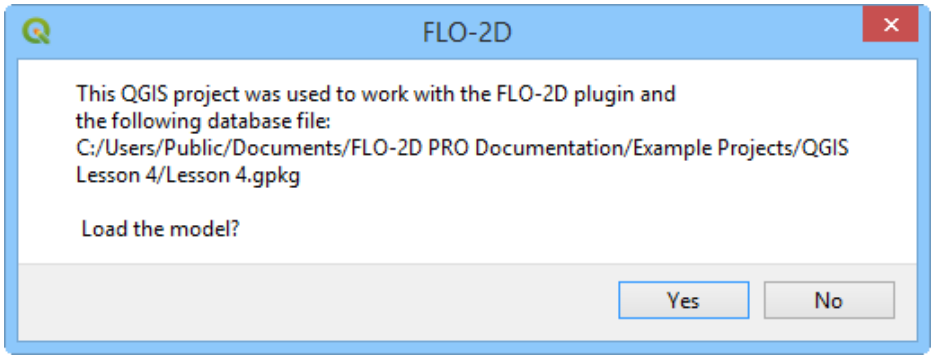
Step 1: Open project QGIS and load the FLO-2D Plugin data

Search the start menu and run the "QGIS Desktop" program.

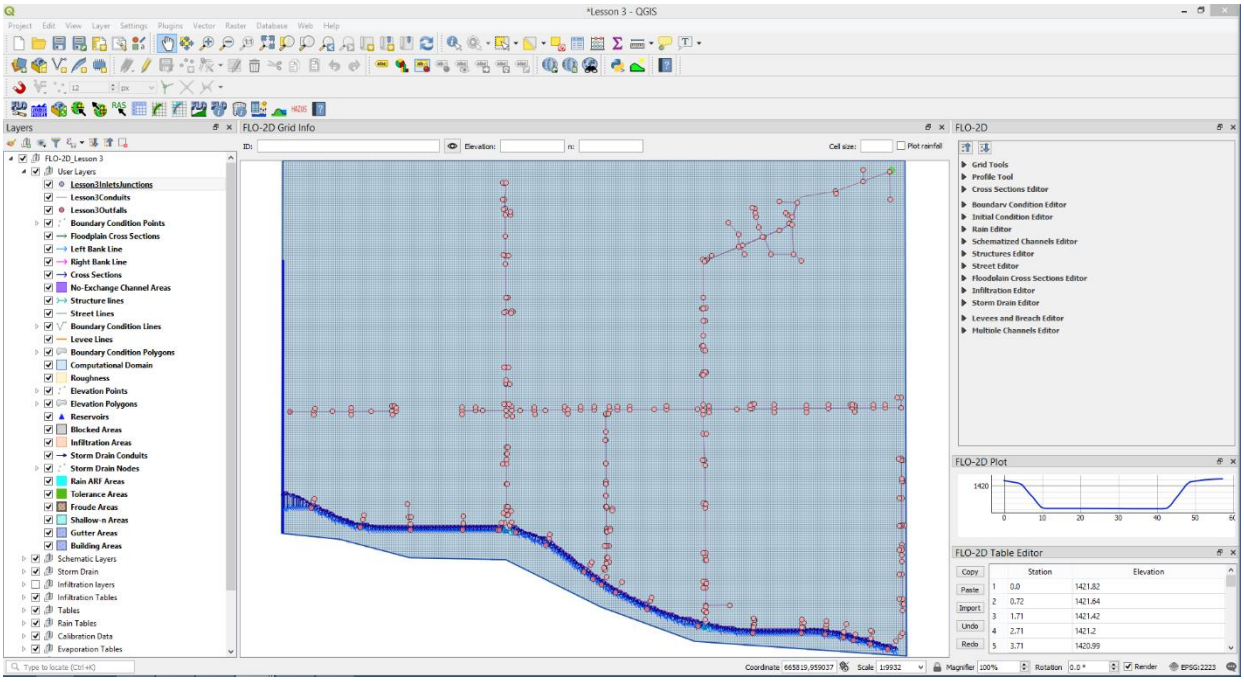
QGIS Lesson 1, 2 or 3 can be used to for this project. Click Open Project and navigate to Example Projects. If QGIS Lesson 1, 2 or 3 are complete, choose any of these files to continue with Lesson 4. This tutorial will continue from Lesson 3.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 3\QGIS Lesson 3.gpkg

Click Yes in the FLO-2D window to Load the model.

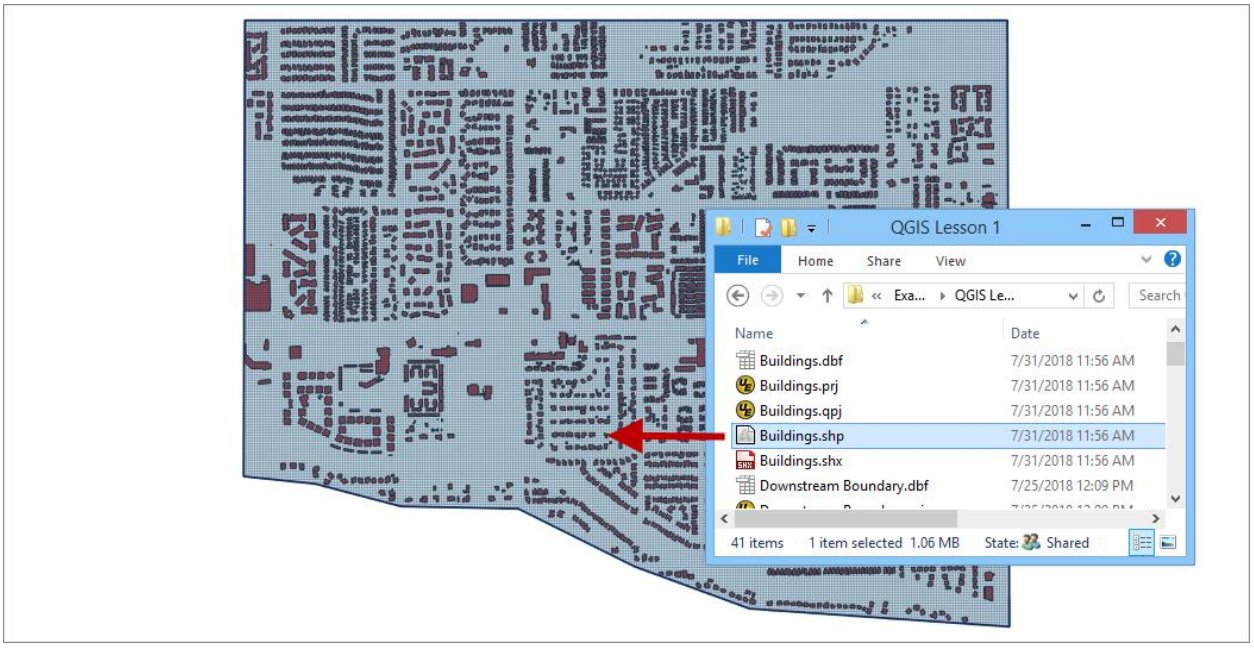


The model will look as follows:

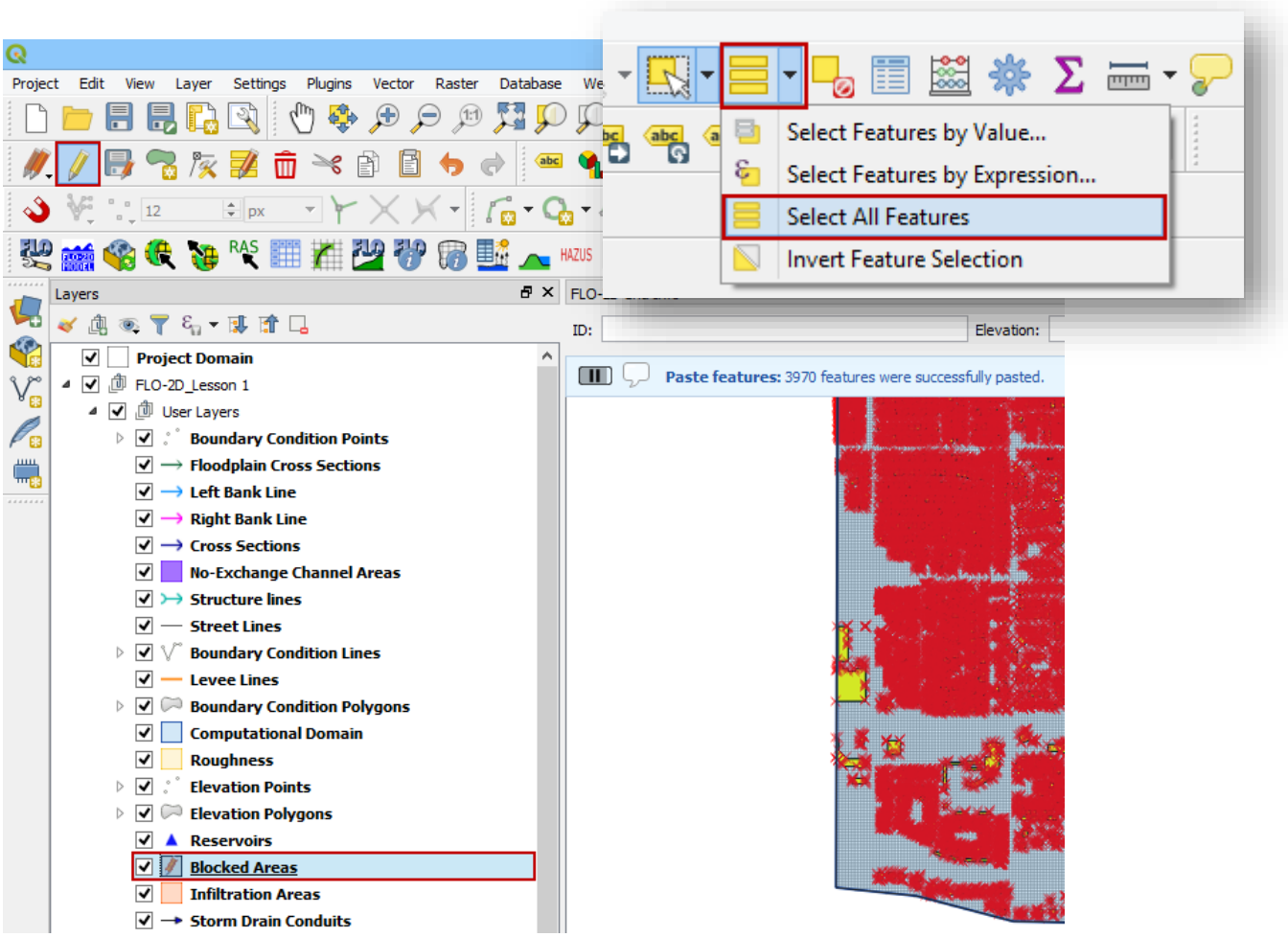


Step 2: Assign buildings

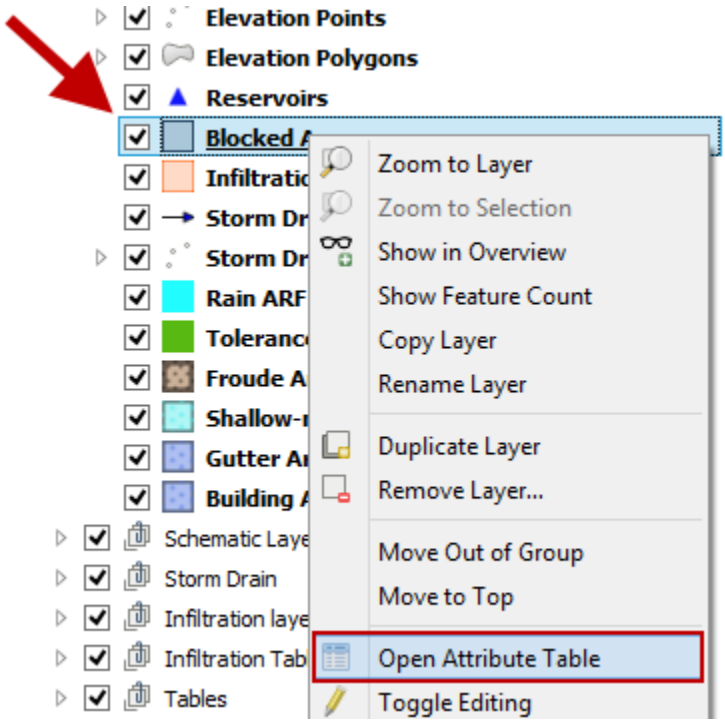
Drag the **Buildings.shp** shapefile onto the map space.



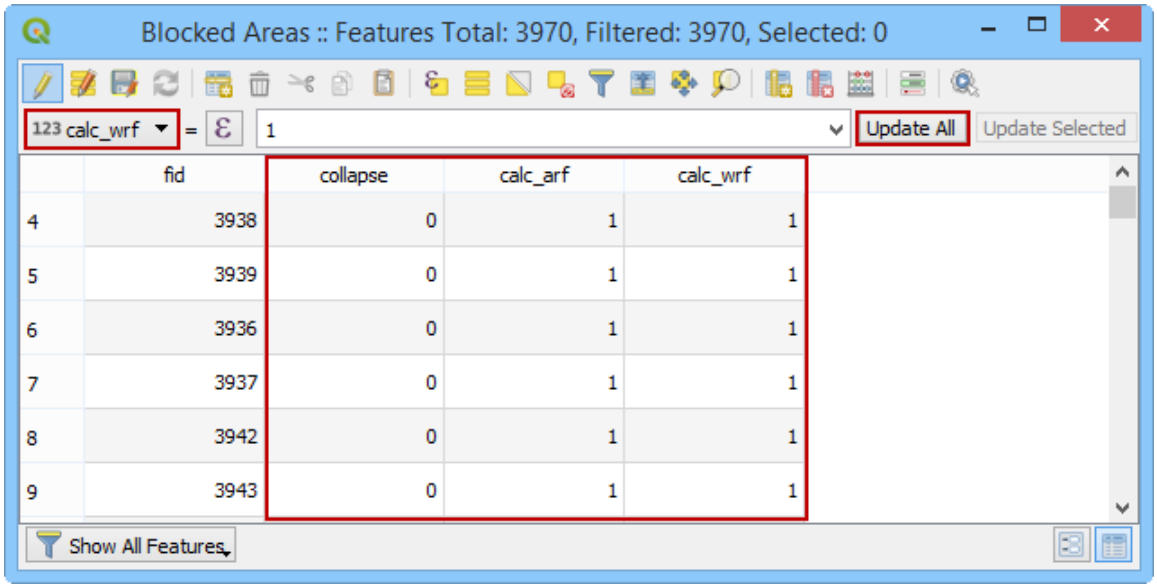
Click the *Buildings* layer and *Select* all the building with the select tool. **CTRL-C** will copy the building features. Select the *Blocked Areas* layer and click the *Editor Pencil*. **CTRL-V** will paste the buildings into the layer.



It is necessary to add some data to the blocked areas polygons. *Right click* the *Blocked Areas* layer and click *Open Attribute Table*.

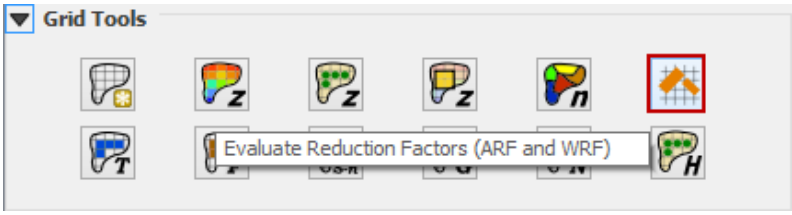


Edit the *calc_arf* and *calc_wrf* fields by assigning a zero to each file using the *Update All* button. Click the *Editor Pencil* to save and close.

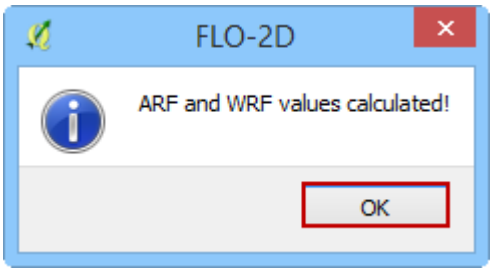


	fid	collapse	calc_arf	calc_wrf
4	3938	0	1	1
5	3939	0	1	1
6	3936	0	1	1
7	3937	0	1	1
8	3942	0	1	1
9	3943	0	1	1

Click the Evaluate Reduction Factors (ARF and WRF) icon.



Close *OK* the window.

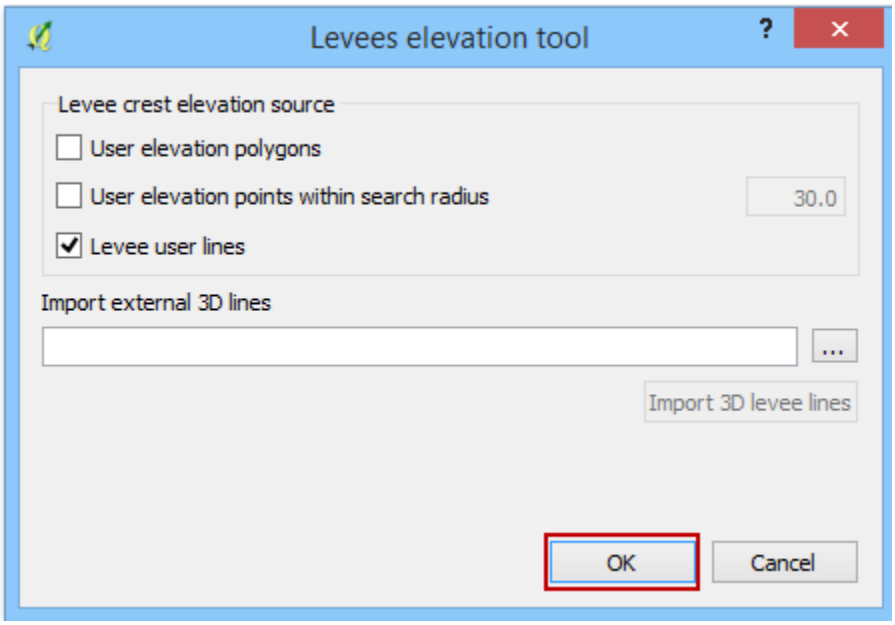


Step 3: Assign walls

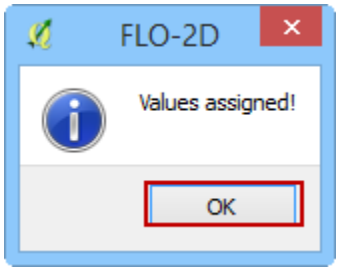
Drag the file ***Walls.shp*** into the map space. Select Walls in the Layers Panel and copy the features using the *Select Features by Area Tool*. **Ctrl-C** to copy the walls.

Select *Levee Lines Layer* in the User Layers, open *Toggle Editing*. **Crtl-V** to paste the walls into the layer. Save the edits and close the editor.

Select the *Levee Elevation Tool* from the *FLO-2D Toolbar*. Check only *Levee user lines* and select *OK*.



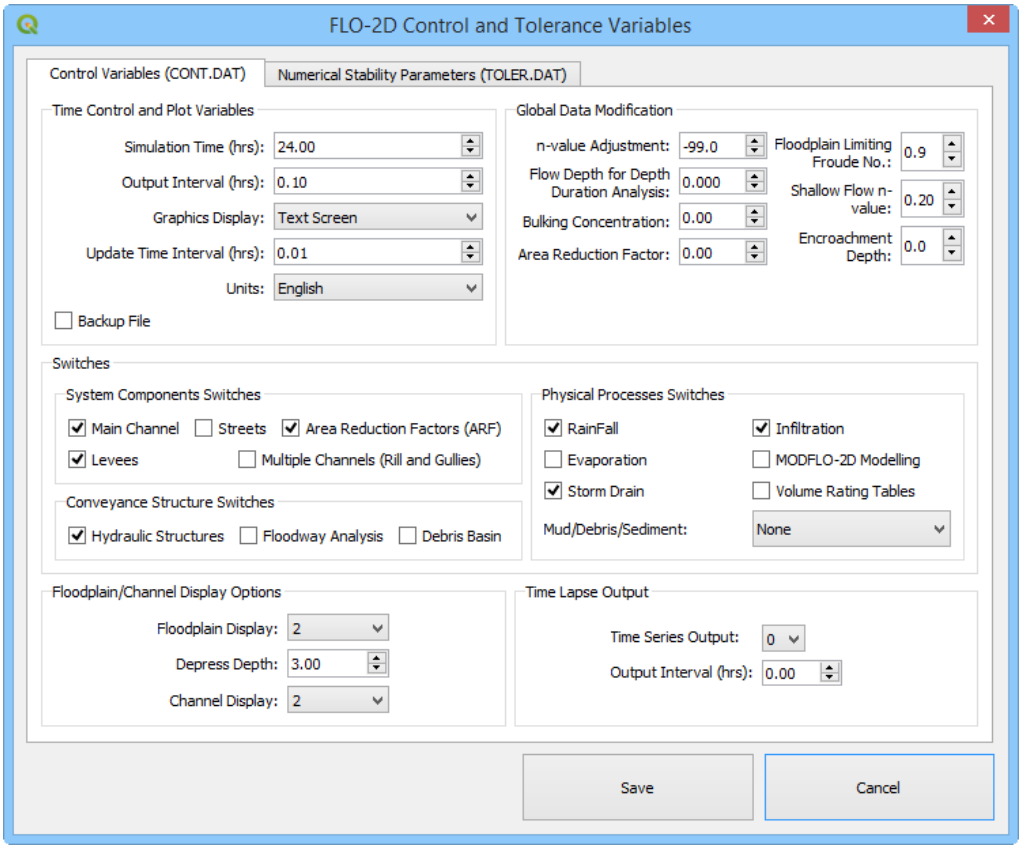
Once the levee elevation is assigned the following icon will appear. Select *OK* to close.

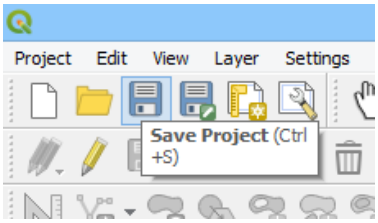


Step 4: Export the project

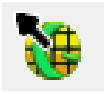
The files that connect inlets and outfalls with the FLO-2D surface layer are created when the GDS Data Files are exported.

Click the *Set Control Parameters* icon and enter the data in the FLO-2D Toolbar. The following dialog will be displayed, make sure the ***Area Reduction Factors*** and *Levees* component switches are selected. Click *Save*.





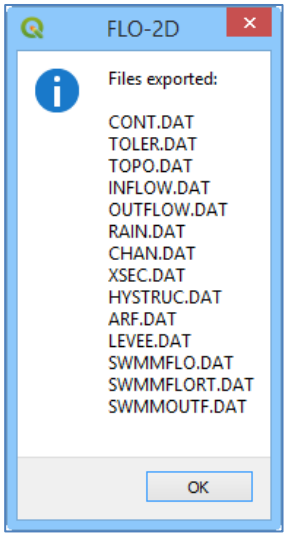
This is a good point to save project. Refer to Steps 9 in Lesson 1.



Export the data files to the project folder in QGIS Lesson 4.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 4\QGIS Lesson 4 Export

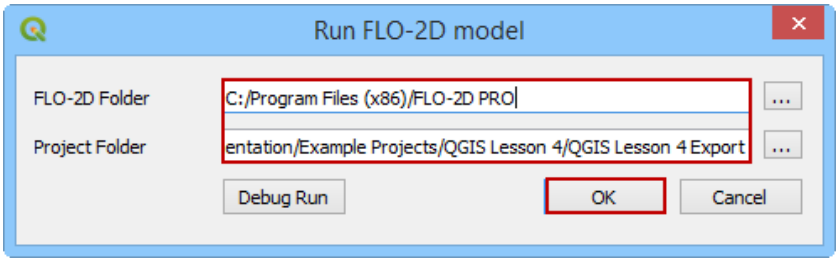
All GDS Data files will be created in the selected project folder, including **ARF.DAT** and **LEVEE.DAT** files.



Step 5: Run the simulation

Click the *Run FLO-2D* Icon.

Set the Project path and the FLO-2D Engine Path and click *OK* to start the simulation.



Summary

This is the completion of a tutorial for adding buildings and walls to a model that is ready to run. This tutorial can be applied to any project once the grid and elevation is assigned.

LESSON 5 – REALTIME RAINFALL DATA

Overview

Lesson 5 outlines the process of setting up realtime rainfall data in the raincell.dat file. It is important to perform this tutorial on a Lesson 1 skeleton project. Finish Lesson 1 through Step 5 before performing the following steps.

Required Data

The lesson makes use of QGIS Lesson 1 and rainfall data *.ASC files in QGIS Lesson 5.

File	Content	Location*
*.asc	ASCII Grid File	\Example Projects\QGIS Lesson 5 PRO
*.rfc	Rainfall Catalog File	

**Project Location C:\Users\Public\Documents\FLO-2D Pro Documentation*

Check these folders to ensure the data is available before starting the lesson.

Step-by-Step Procedure

To build **RAIN.DAT** and **RAINCELL.DAT** following these steps.

1. Complete QGIS Lesson 1 to Step 5;
2. Set up the rain editor;
3. Import the rainfall data;
4. Export the project;
5. Transfer RAIN.DAT and RAINCELL.DAT files;
6. Run the simulation.

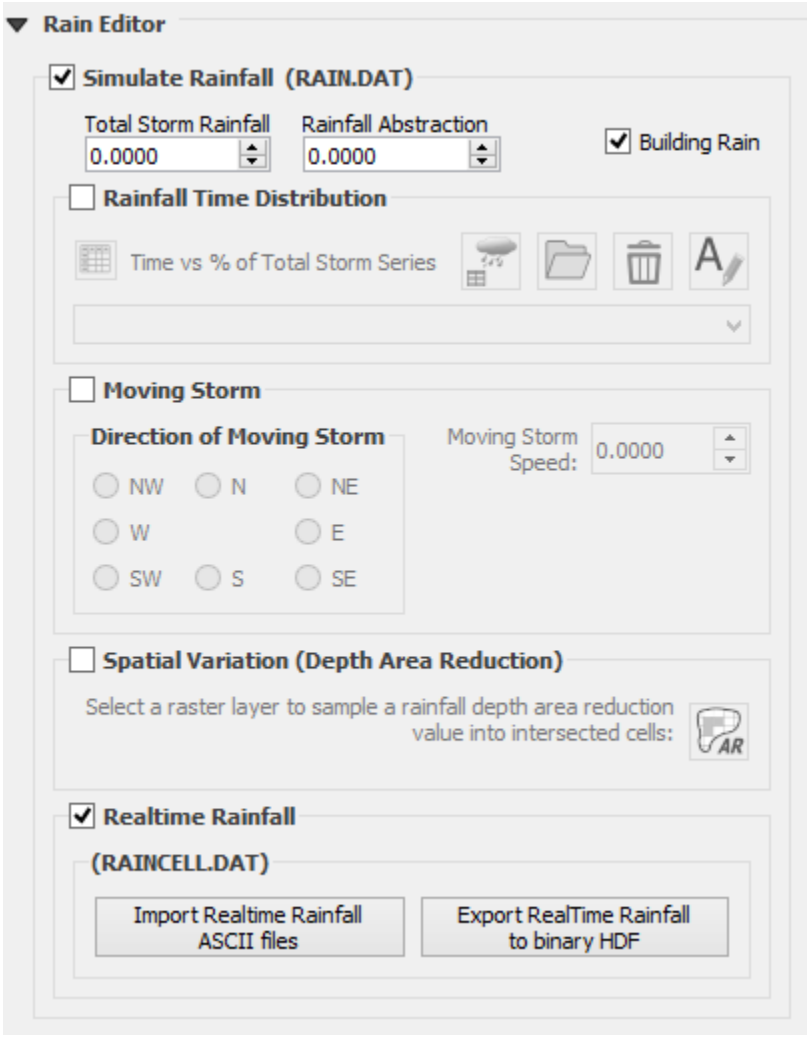
Step 1: Setup the project

Set up a "Skeleton Project". **RAINCELL.DAT** is a large file and it is not necessary to keep it in the regular project GeoPackage. It will slow the model down and the **RAINCELL.DAT** is not a file that needs to be regenerated.

Follow the QGIS Lesson 1 steps up to Step 5.

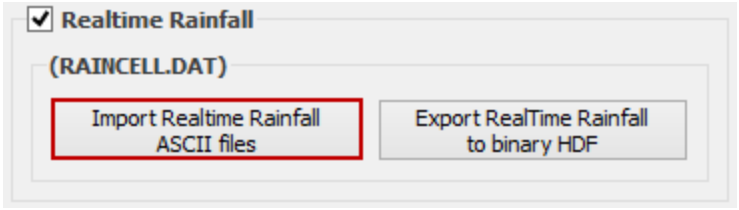
Step 2: Rain editor

Set up the *Rain Editor* widget by checking the *Simulate Rainfall*, *Building Rain* and *Realtime Rainfall* check boxes.



Step 3: Import rainfall data

Click the *Import Realtime Rainfall ASCII files* button.

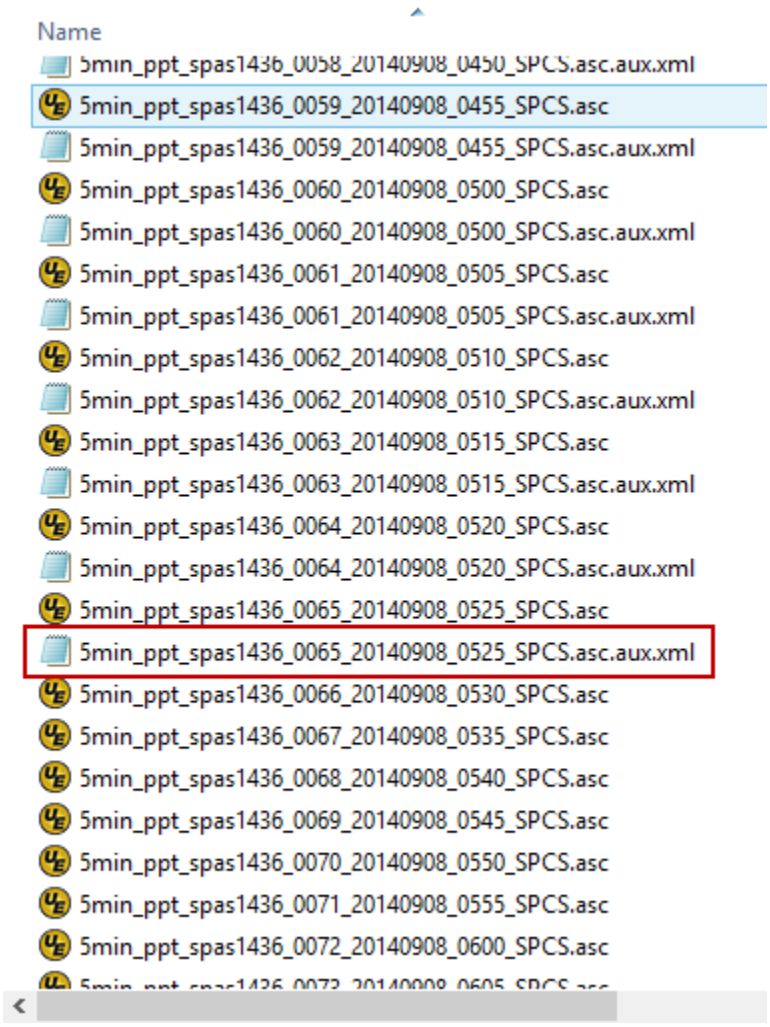


Select the folder to import the data.

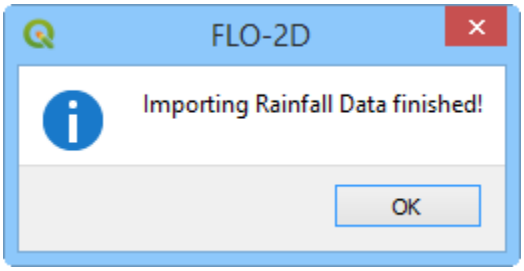
C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 5

The plugin will read the catalog file and the ASCII grid files and interpolate the realtime rainfall data to the grid.

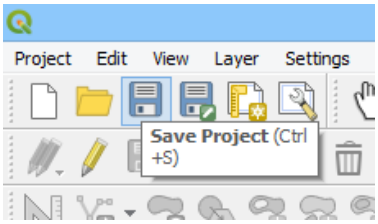
The data processing takes time. Track the the progress by the processor by how many auxillary files exist.

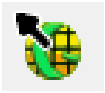


Once the processing is complete, click *OK* to close the dialog box.



Step 4: Export the project



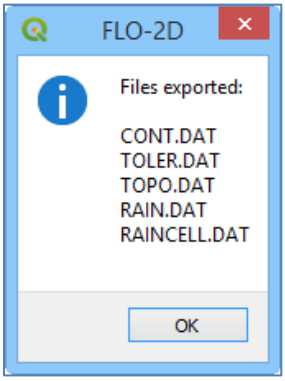


This is a good point to save project. Refer to Step 9 in Lesson 1.

Export the data files to the Project Folder in QGIS Lesson 5.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 5\Lesson 5 Export

All GDS data files will be created in the selected project folder, including RAIN.DAT and RAINCELL.DAT files.

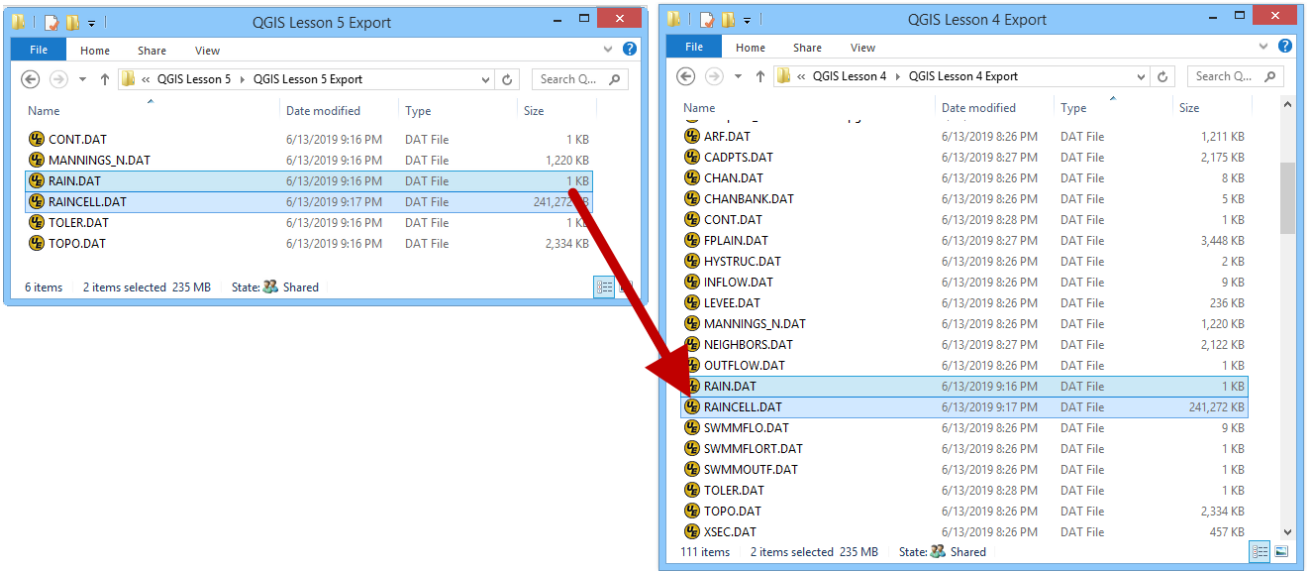


Step 5: Transfer the RAIN.DAT and RAINCELL.DAT files

To use the new Rainfall data it needs to be transferred to a project folder. This project can be started by adding the **FLOPRO.EXE** Engine to the folder or by calling it from the Plugin.

Copy the **RAIN.DAT** and **RAINCELL.DAT** files to the Lesson 4 Export folder. Replace the original **RAIN.DAT** file.

C:\Users\Public\Documents\FLO-2D PRO Documentation\Example Projects\QGIS Lesson 4\QGIS Lesson 4 Export



Step 6: Run the simulation

Click the *Run FLO-2D* Icon.

Set the Project path and the FLO-2D Engine Path and click *OK* to start the simulation.