HYDROLOGICAL MODELLING USING HEC-HMS AND HEC-RAS

BY

DR. ANIL KUMAR LOHANI, SCIENTIST G

DR. SANJAY KUMAR JAIN, SCIENTIST G

AMIT KUMAR SHUKLA, JRF

RAJAT AGARWAL, RESEARCH SCIENTIST

National Institute of Hydrology

Roorkee -247 667

Uttrakhand

Exercise 1:

Download the Aster Dem data & Landsat imagery using the shape file (AOI).

GIS Database Preparation

The essential dataset required for training is the terrain data (DEM). Additional datasets that may be useful are aerial photograph (s) and land use information. The small portion of the Uttarkashi is used to demonstrate, how to develop a 1D and 2D model for flood inundation mapping using HEC-RAS, HEC-GeoRAS and ArcGIS.

The **download_rs_data** folder contains the following data as given below:

(i) Aster_DEM
(ii) Landsat 8

(i) Aster DEM Data

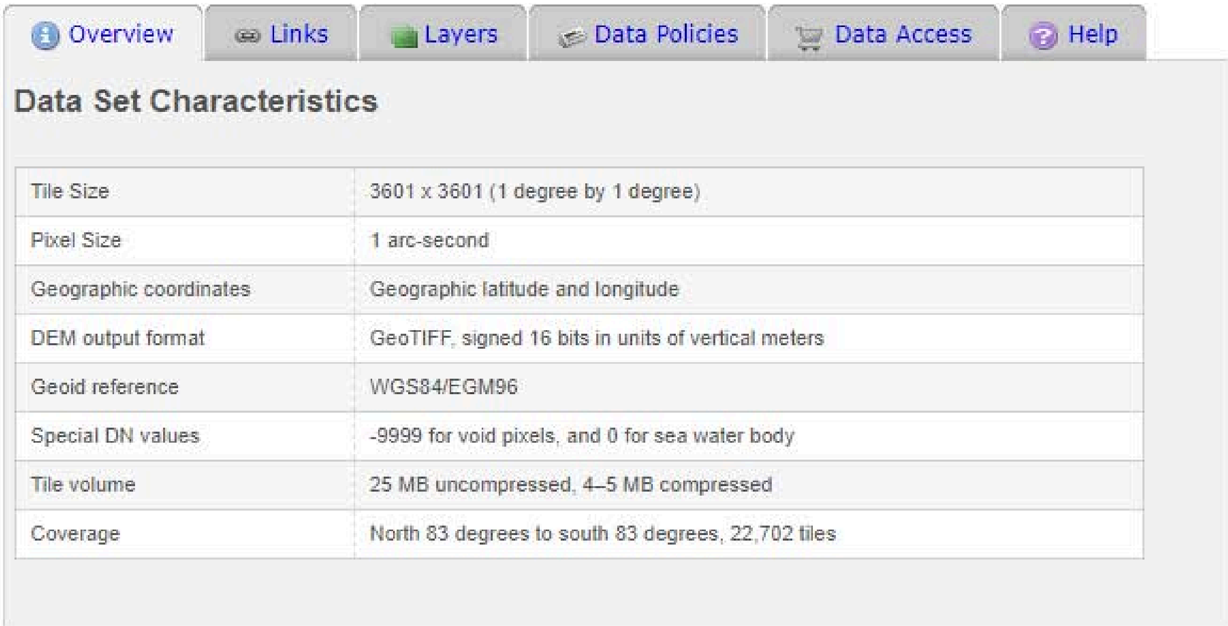
ASTER is capable of collecting in-track stereo using nadir- and aft-looking near infrared cameras. Since 2001, these stereo pairs have been used to produce single-scene (60- x 60-kilomenter (km)) digital elevation models (DEM) having vertical (root-mean-squared-error) accuracies generally between 10- and 25-meters (m).

The methodology used by Japan's Sensor Information Laboratory Corporation (SILC) to produce the ASTER GDEM involves automated processing of the entire ASTER Level-1A archive. Stereo-correlation is used to produce over one million individual scene-based ASTER DEMs, to which cloud masking is applied to remove cloudy pixels. All cloud-screened DEMS are stacked and residual bad values and outliers are removed. Selected data are averaged to create final pixel values, and residual anomalies are corrected before partitioning the data into 1 degree (°) x 1° tiles.

The ASTER GDEM covers land surfaces between 83°N and 83°S and is comprised of 22,702 tiles. Tiles that contain at least 0.01% land area are included. The ASTER GDEM is distributed as Geographic Tagged Image File Format (GeoTIFF) files with geographic coordinates (latitude, longitude). The data are posted on a 1 arc-second (approximately 30–m at the equator) grid and referenced to the 1984 World Geodetic System (WGS84)/ 1996 Earth Gravitational Model (EGM96) geoid.

While the ASTER GDEM 2 benefits from substantial improvements over GDEM 1, users are nonetheless advised that the products still may contain anomalies and artifacts that will reduce its usability for certain applications, because they can introduce large elevation errors on local scales. The data are provided "as is" and neither NASA nor METI/ERSDAC will be responsible for any damages resulting from use of the data.

The generation and basic characteristics of the ASTER GDEM were summarized in a presentation by Tetsushi Tachikawa, et al., at the 2011 Institute of Electrical and Electronics Engineers (IEEE) International Geoscience and Remote Sensing Symposium (IGARSS).



Tile Size	3601 x 3601 (1 degree by 1 degree)
Pixel Size	1 arc-second
Geographic coordinates	Geographic latitude and longitude
DEM output format	GeoTIFF, signed 16 bits in units of vertical meters
Geoid reference	WGS84/EGM96
Special DN values	-9999 for void pixels, and 0 for sea water body
Tile volume	25 MB uncompressed, 4–5 MB compressed
Coverage	North 83 degrees to south 83 degrees, 22,702 tiles

Figure No 1: Overview of Aster Data

Download ASTER DEM of Study area

Open link https://earthexplorer.usgs.gov/. This website user interface is shown in Fig no 2.

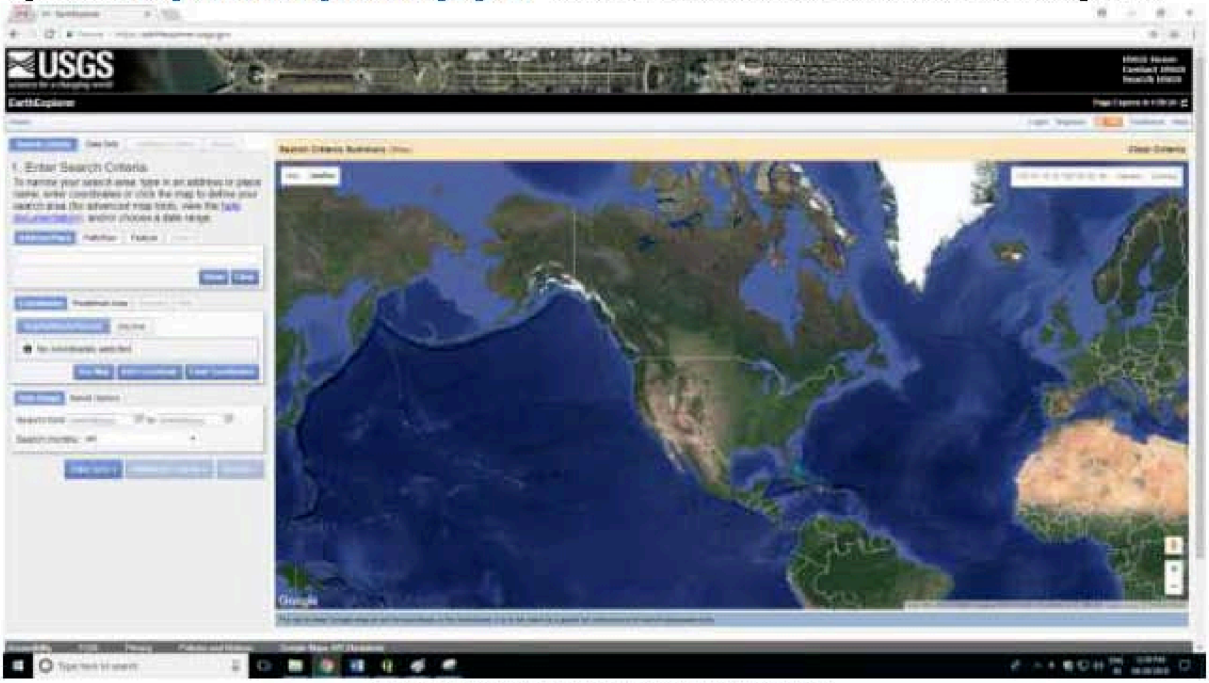


Figure no 2: Earth explorer website

Required Registration

New users must register for their user account in Earth explore website. To register, select Registration (Fig. no 3) button and enter the required information.

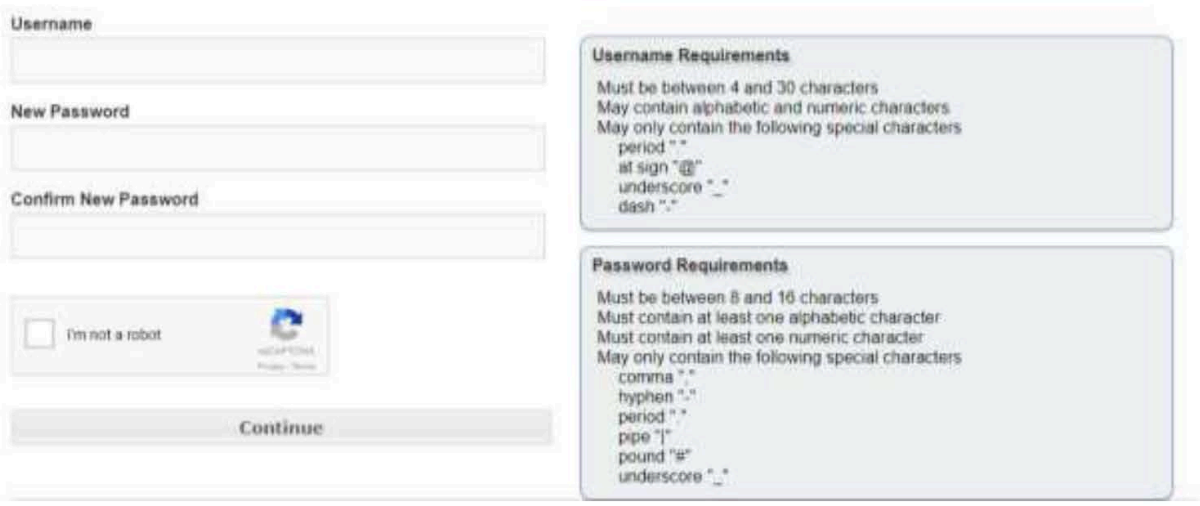


Figure no.3: Registration window

USER Registration

If you have already completed user registration, enter your username and password and click login button (Show in Fig. no 3)

After login, current screen moves to home page.
Step 1: Click on KML
Step 2: Select aoi.kmz from given directory *D:\gisdatabse\dem* and open
Step 3: after that flash a popup window shows the aoi.kmz is uploaded, click on close. Show aoi on MAP window in red color square box
Step 4: Go to data range, select date from 10/01/2011 to 10/30/2011 than go to Data Sets

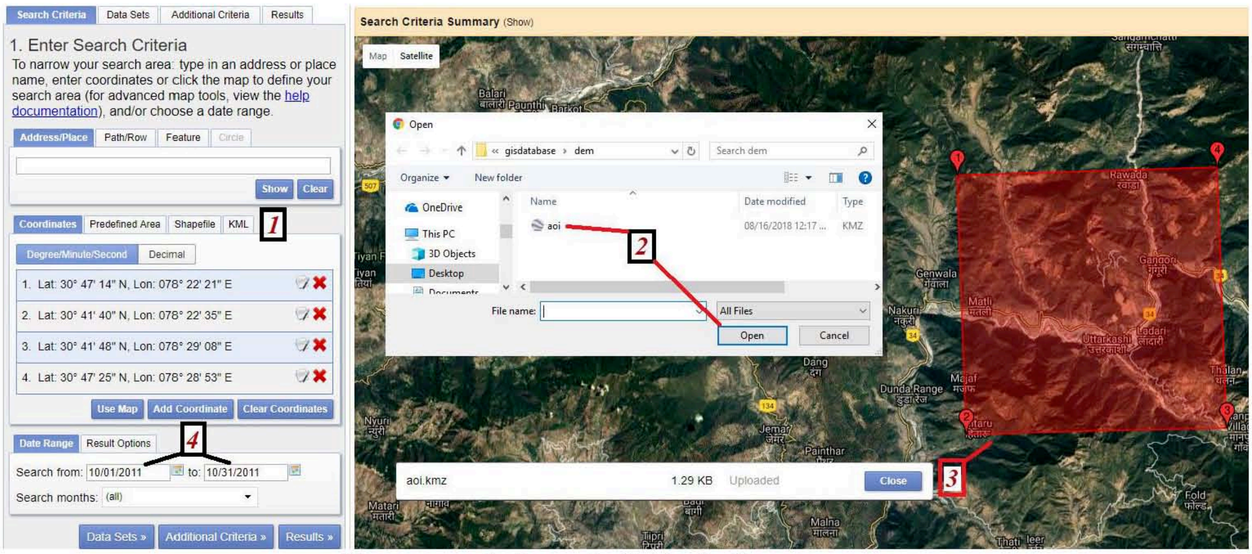


Figure no 4: Search Criteria Summary

Step 1: Click on Data Sets
Step 2: Click on Digital Elevation
Step 3: Click on ASTER Global DEM
Step 4: Click on Result

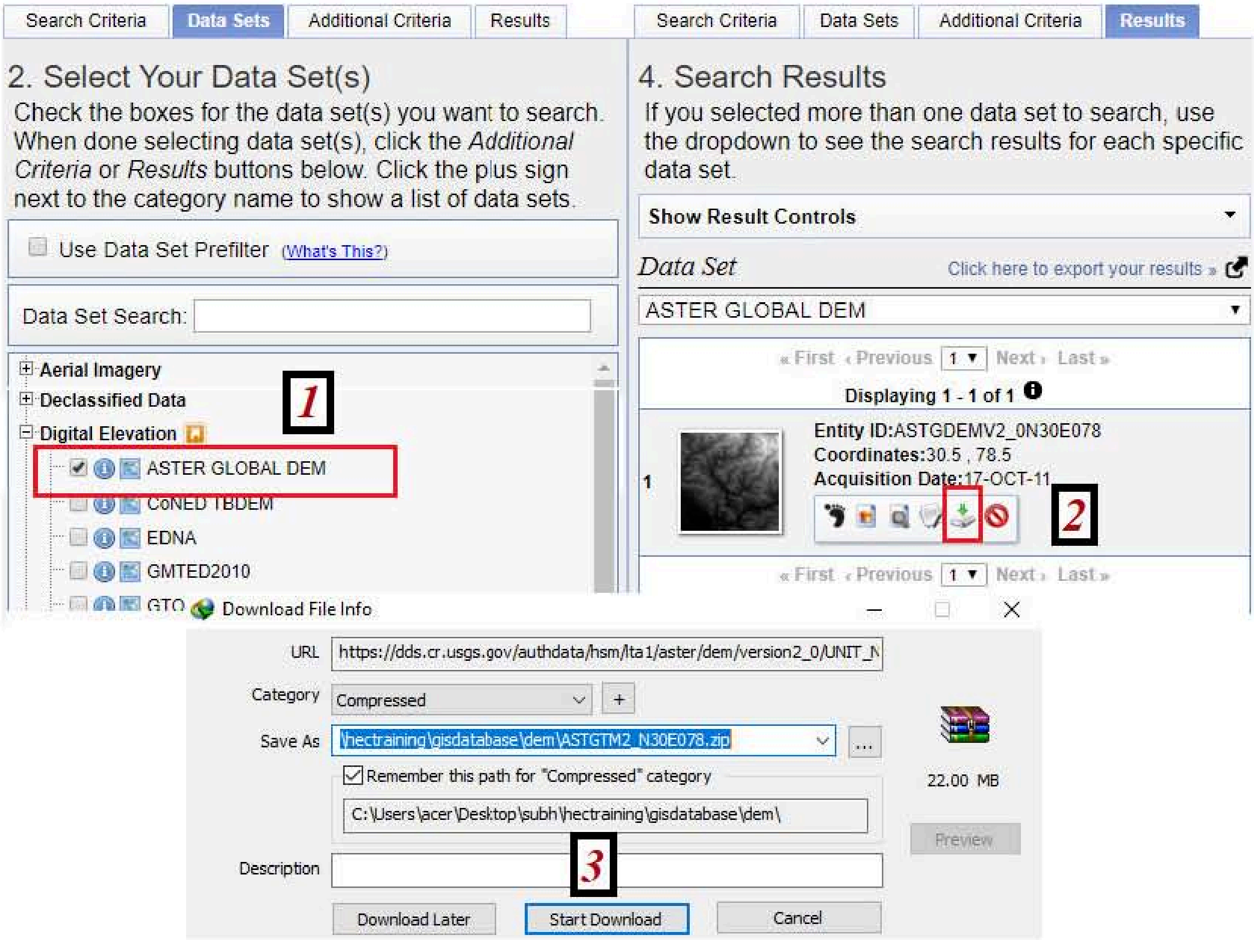


Figure no 5: Information of ASTER Global

ii) Landsat 8

The Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) are instruments onboard the Landsat 8 satellite, which was launched in February of 2013. The satellite collects images of the Earth with a 16-day repeat cycle, referenced to the Worldwide Reference System-2. The satellite's acquisitions are in an 8-day offset to Landsat 7 (see https://landsat.usgs.gov/acquisition). The approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

The spectral bands of the OLI sensor, while similar to Landsat 7's ETM+ sensor, provide enhancement from prior Landsat instruments, with the addition of two new spectral bands: a deep blue visible channel (band 1) specifically designed for water resources and coastal zone investigation, and a new infrared channel (band 9) for the detection of cirrus clouds. Two thermal bands (TIRS) capture data with a minimum of 100 meter resolution, but are registered to and delivered with the 30-meter OLI data product. (See Landsat satellite band designations for more information.) Landsat 8 file sizes are larger than Landsat 7 data, due to additional bands and improved 16-bit data product (see https://landsat.usgs.gov/what-files-are-included-when-i-download-landsat-8-scene).

Landsat 8 Level 1 data products typically include data from both the OLI and TIRS sensor; however, there may be OLI-only and/or TIRS-only scenes in the USGS archive. The first two values of the Landsat 8 scene ID designates the data provided in each scene:

LC08_L1TP_003055_20170207_20170216_01_T1 = Combined (both OLI and TIRS data)
LO08_L1TP_021047_20150304_20170227_01_T1 = OLI data only
LT08_L1GT_137206_20170202_20170215_01_T2 = TIRS data only

A Quality Assurance (QA.tif) band is also included. This file provides bit information regarding conditions that may affect the accuracy and usability of a given pixel – clouds, water or snow, for example. More information about the QA band can be found at https://landsat.usgs.gov/qualityband.

LandsatLook Images (full resolution files) are also available for Landsat 8 scenes, as they are for all previous Landsat scenes. In addition to the Natural Color, Thermal, and Geographic Reference bundle files available, Landsat 8 scenes also include a Quality .png file. This provides a visual representation the QA.tif file. Details about LandsatLook images can be found on https://landsat.usgs.gov/landsatlook-images.

Nearly 10,000 scenes were collected prior to the satellite achieving operational orbit, from launch to April 10, 2013. The earliest images are TIRS data only. These data are included in the **Landsat 8 OLI/TIRS C1 Level-1** data set on EarthExplorer. While these data meet the quality standards and have the same geometric precision as data acquired after achieving operational orbit, the geographic extents of each scene will differ. Most of the scenes will process to full terrain correction, with a pixel size of 30 meters. There may be some differences in the spatial resolution of the early TIRS images due to telescope temperature changes.

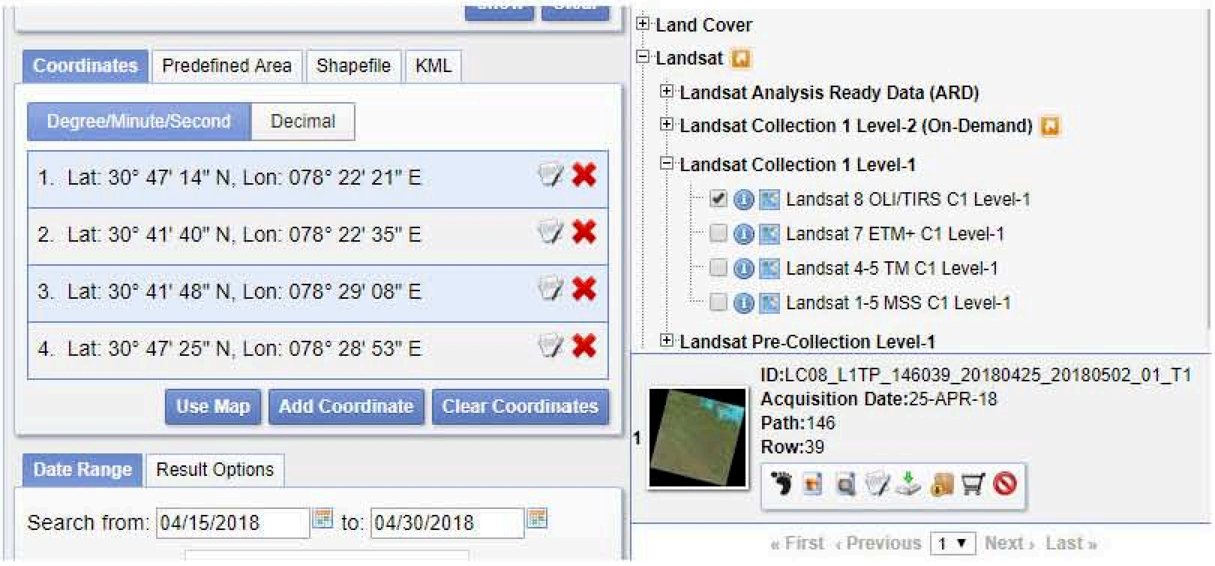


Figure No 6: Download Landsat Image

Exercise 2:
Preprocessing the download data

1. **Re-project Dem Data**
2. **Data Format**
   a) **Tiff for Catchment Delineation**
   b) **Grid for Cross Section**
   c) **Float For Ras Mapper**

3. **Layer Stacking Landsat Imagery**

1. Re-project Dem Data

Step 1: Add data 

D:\HEC_training\dem\ASTGTM2_N30E078\ASTGTM2_N30E078_dem.tiff

Step 2: Go to Arc Tool Box>>Data Management Tools>>Projections and Transformations>>Raster>>Project Raster

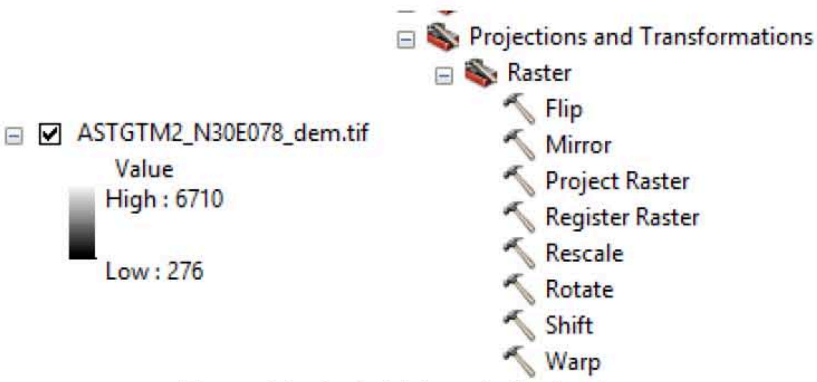


Figure No 1: Add data & Projection

Step 2: Double click on Project Raster than open a pop up window see in fig no 3

Input Raster: ASTGTM2_N30E078\ASTGTM2_N30E078_dem

Output Raster Dataset: reproject

Output Co-ordinate system: WGS_1984_UTM_Zone_44N

If not found projection go Projected>>UTM>>WGS 1984>>Northen Hemisphere>> Select UTM 44 N

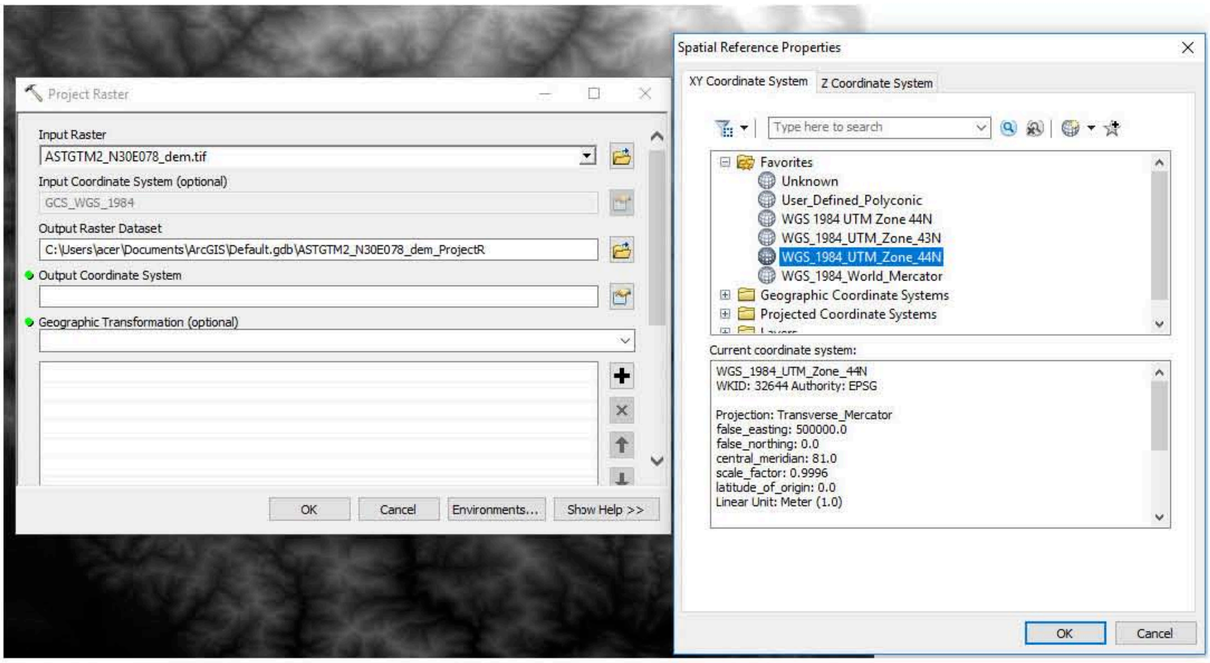


Figure No 2: Spatial Reference System

2. Data Format

a) Tiff for catchment delineation:

Step 1: Right click on reproject dem (show table of content)
Step 2: open a pop up window click on Data>>Export Data
Step 3: Click on Square (put value 30.0)
Step 4: Select Location: D:\HEC_training\pre_processing\dem
Step 5: Name: dem1 (remember this dem use for catchment delineation)
Step 6: Format, select Tiff
Step 7: Save (automatically add in Table of content)

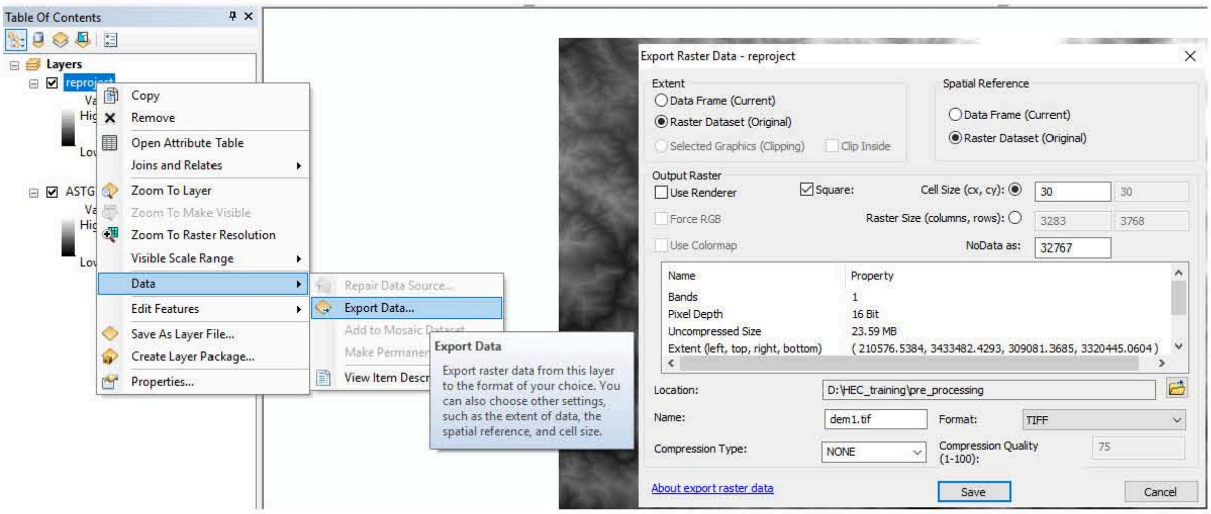


Figure No 3: Tiff Format

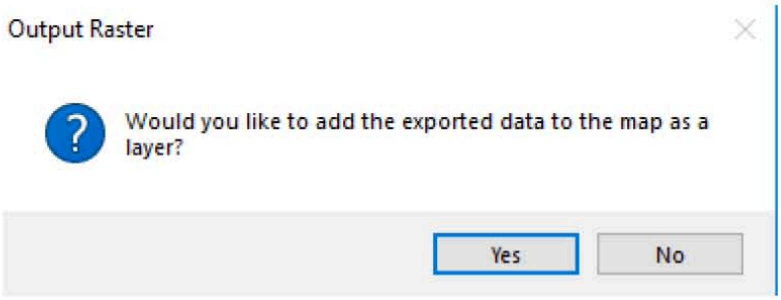


Figure No 4: Output Raster (Tiff Format)

b) Grid for Cross section:

All Step are same, so follow in Tiff format (from 1 to 5)

Step 6: Format, Select Grid (Name: dem2)

Step 7: Save

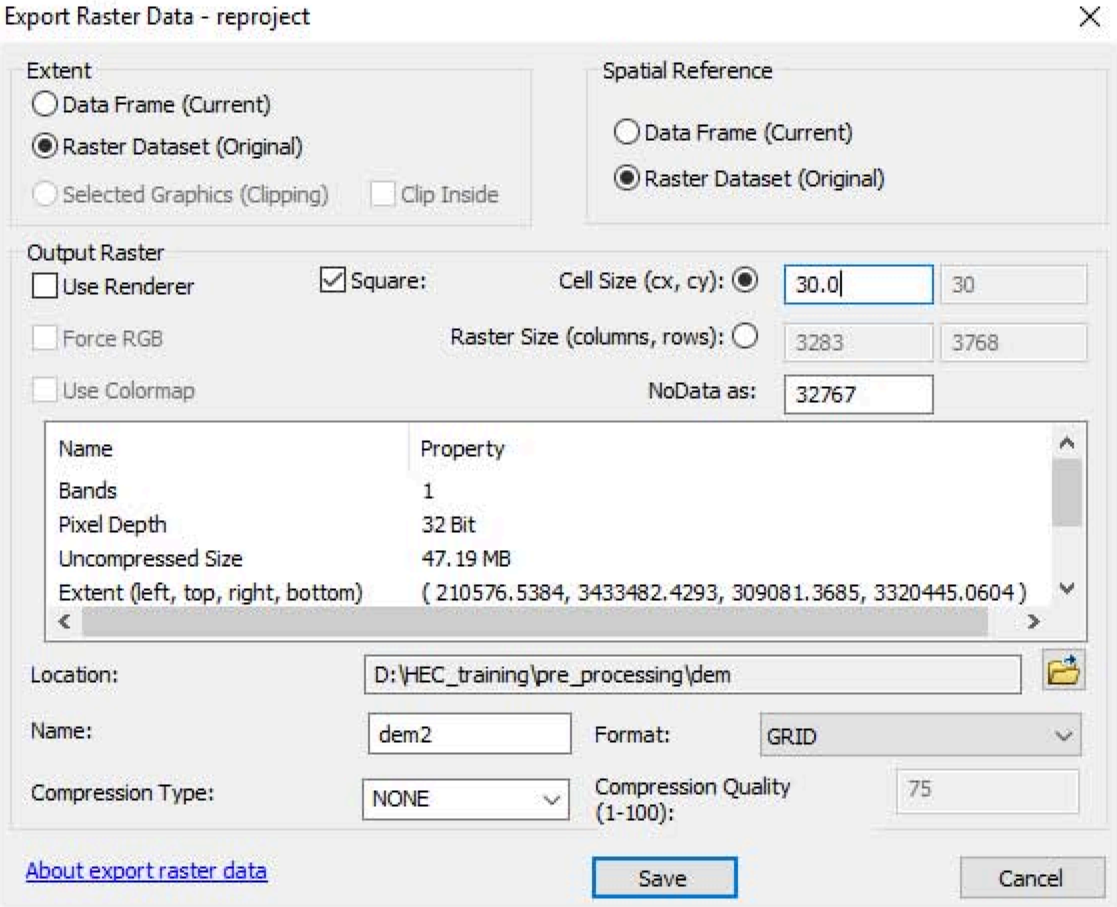


Figure No 5: Grid Format

c) Float for RAS Mapper:

Step 1: Goto Arc Tool Box>>Spatial analyst Tool>>Math>>Trigonometry>>Float

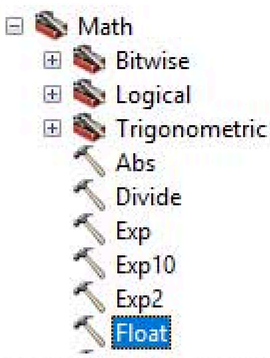


Figure No 6: Trigonometry

Step 2: Double click on float

Input raster or constant values: reproject

Output raster: dem3 (remember this format use for RAS Mapper)

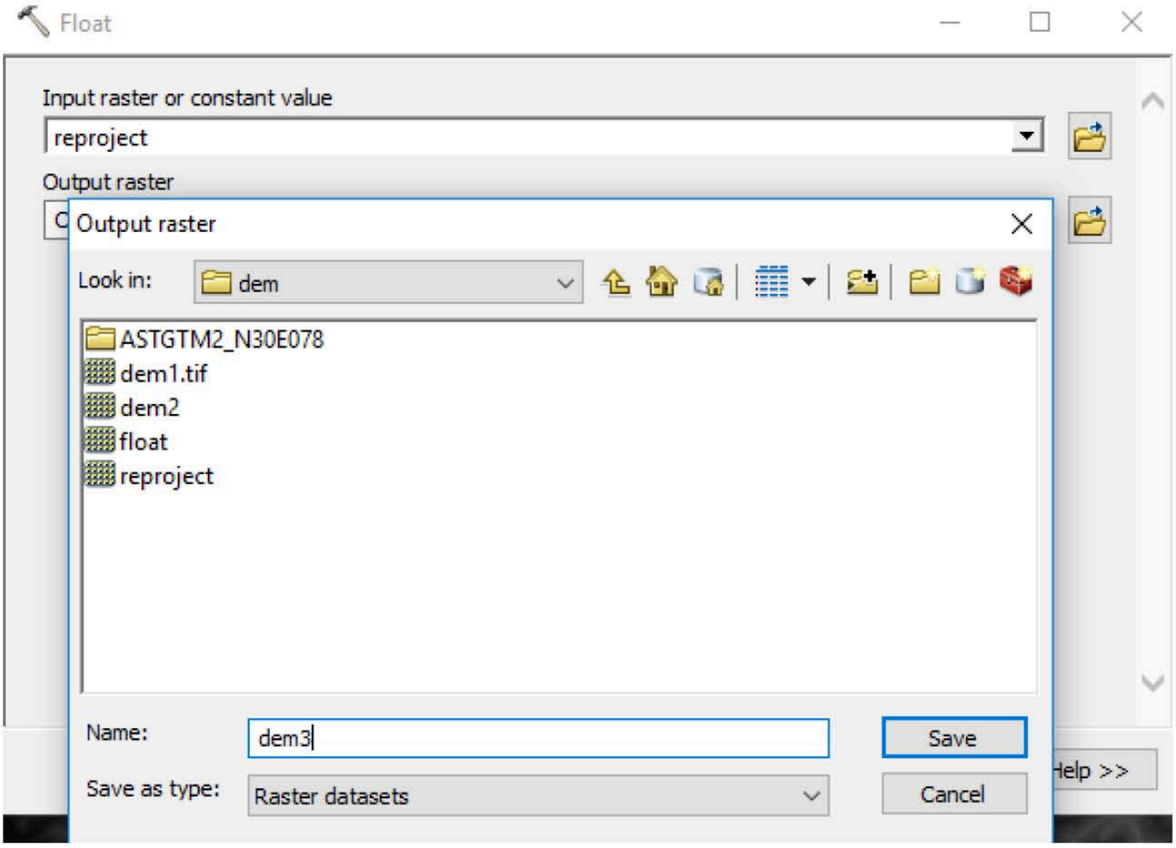


Figure No 7: Float Format

3. Layer Stacking

Step 1: Open ERDAS Imagine 2015

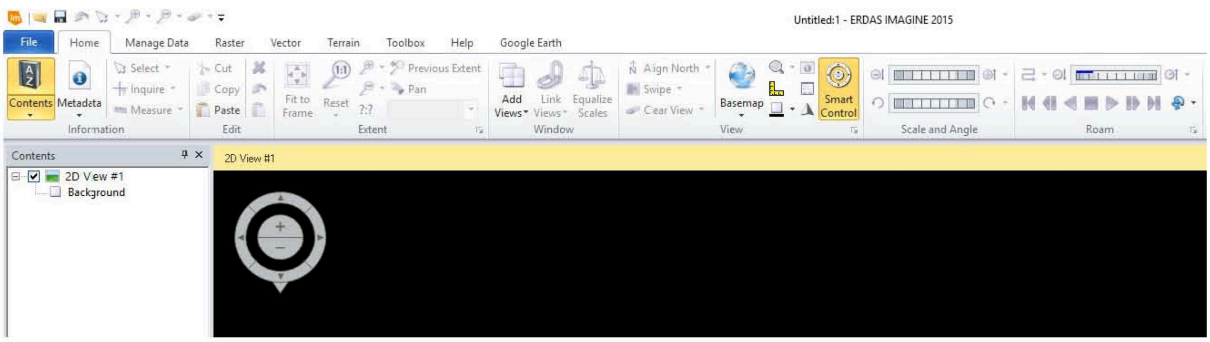


Figure No 8: ERDAS Imagine

Step 2: Click on Raster>>Spectral>>Layer Stack

Step 3: Input File (Click Open), go to directory (D:\HEC_training\pre_processing\landsat\LC08_L1TP_146039_20180425_20180502_01_T1)

File Type: Select Tiff

File Name: lc08_l1tp_146039_20180425_20180502_01_t1_b1.tif

Step 4: Click and open

Step 5: Click on ADD

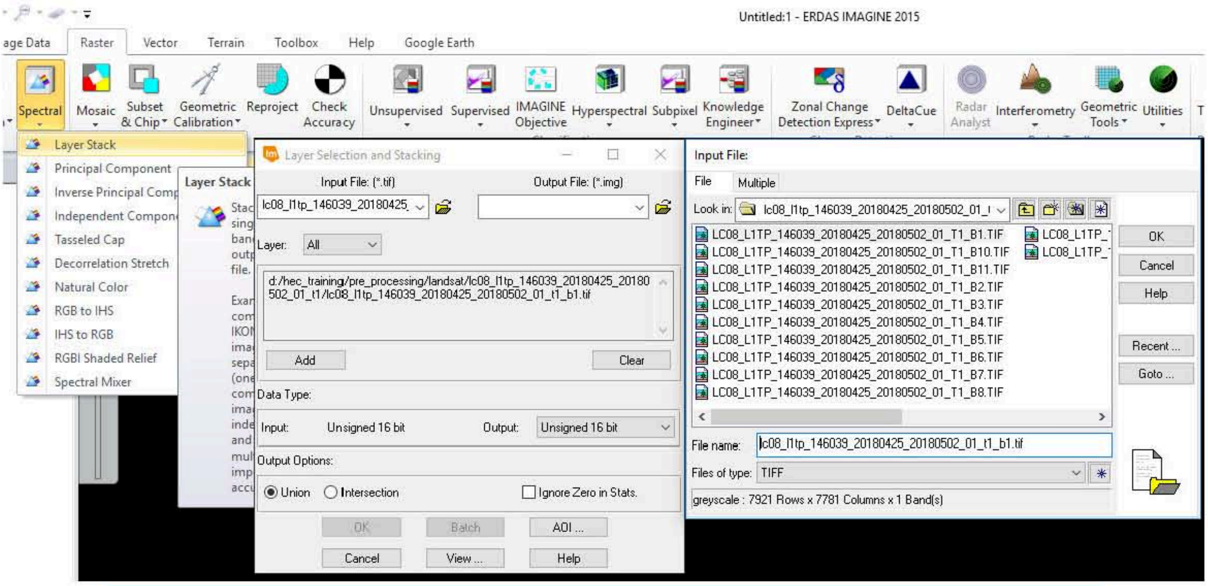
Step 6: Repeat 4 & 5 step for add all bands

Step 7: In Layer Select All

Step 8: Go to output give the name layer_stack

Step 9: OK

Wait 2/3 min (according system configuration)



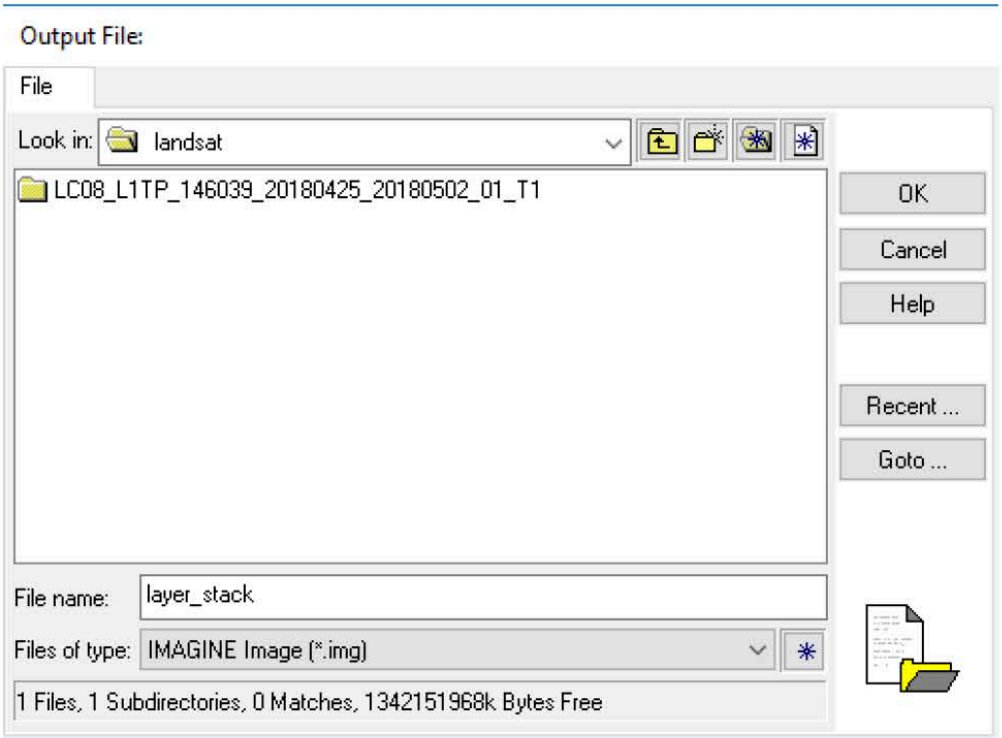


Figure No 9: Layer Stack window

a) Open Raster Layer

Step 1: Right click 2D View #1

Step 2: Open Raster Layer…

Step 3: Select Layer To Add

Location: D:\HEC_training\pre_processing\landsat

File of Type: change in imagine(*.img)

Name: layer_stack.img

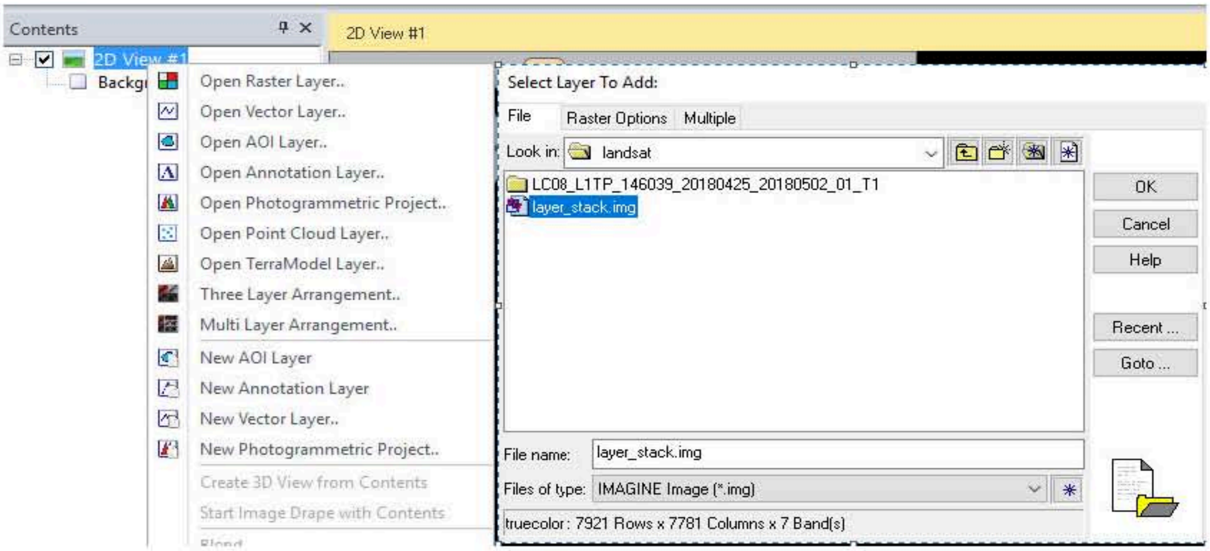


Figure No 10: Open Image

b) Change band combination

Step 1: Go to Raster select multispectral

Step 2: Select layer 5 on 1, Layer 3 on 2, Layer 2 on 3

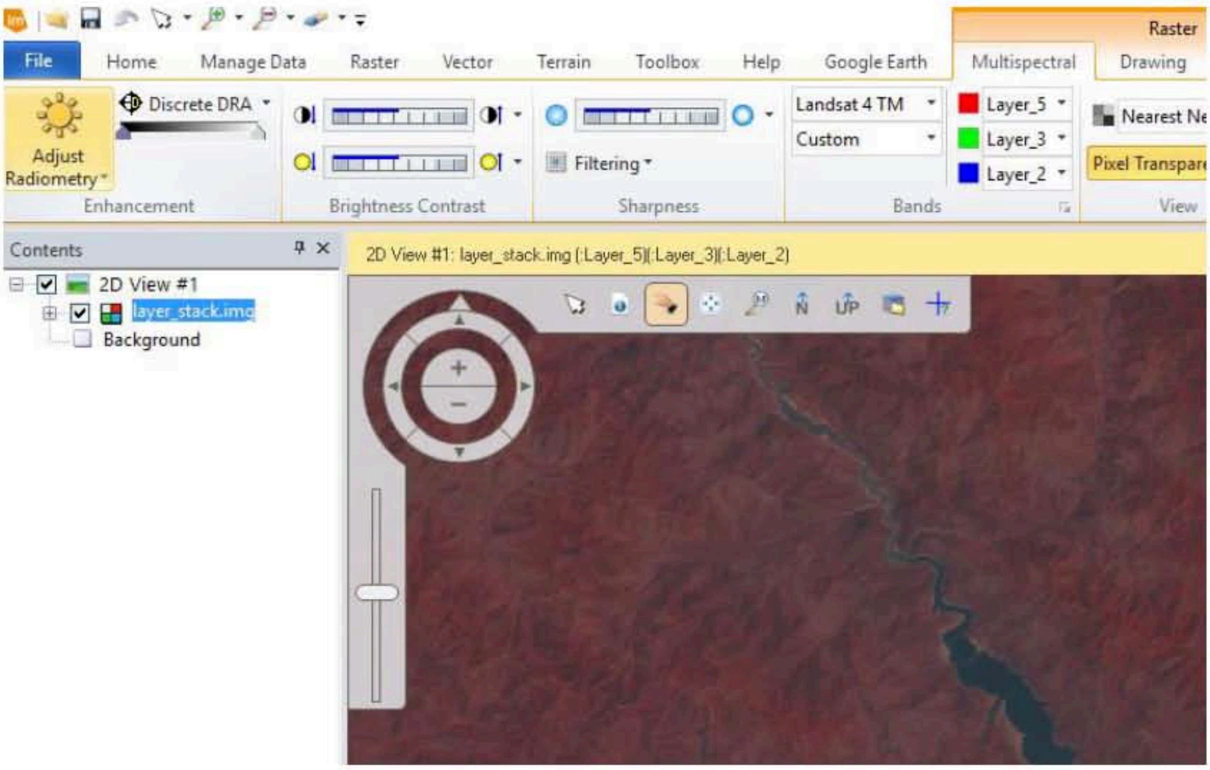


Figure No 11: Change Band Combination

Exercise 3:
Catchment delineation & LULC Classification

1. Catchment Delineation

a) Apply Spatial Tool (Arc-Hydro)
b) Fill
c) Flow Direction
d) Flow Accumulation
e) Stream Network
f) Raster to Polyline (conversion)
g) Define Outlet (Snap Pour Point)
h) Watershed Boundary
i) Convert Raster to Vector (Conversion)
j) Calculate Area

2. LULC Classification

a) Define Signature
b) Supervised Classification

1. Catchment Delineation

a) Apply Spatial tool (Arc-Hydro)

In “Arc Tool box”, click on Spatial Analyst Tools>>Hydrology as shown in Figure 1. Then apply following steps for creating stream network and watershed delineation.

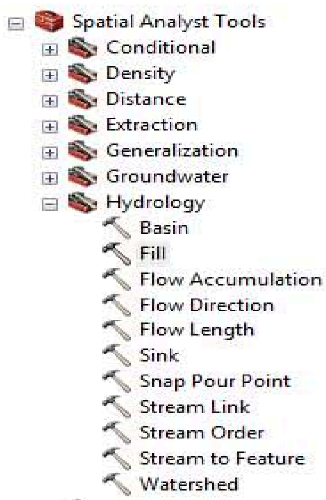


Figure No 1: Spatial Analyst Tool

b) **Fill:** This function fills the sinks in a grid. If cells with higher elevation surround a cell, the water is trapped in that cell and cannot flow. The Fill Sinks function modifies the elevation value to eliminate this problem. The main function of this tool is to remove imperfections in the DEM to enable water flow to the watershed outlet.

Step 1: Double click on “Fill” option.
Step 2: Fill window will appear. Select the dem file (dem1.tiff) in “Input surface raster” option and give the name of output file in “Output surface raster” (eg. Fill_dem1) as shown in Figure 2.
Step 3: Leave the default options for z limit (optional) unchanged. Click OK.
Step 4: After the process is complete a filled DEM (fill_dem1) will be added to the map document.

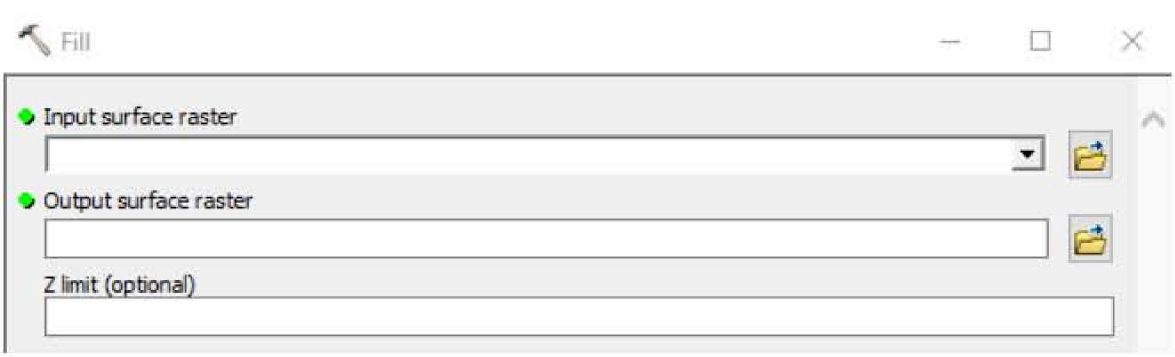


Figure No 2: Fill Dem

c) **Flow Direction:** This function computes the flow direction for a given grid.

Step1: Double click on "Flow Direction" tool.
Step 2: Flow Direction window will appear.
Input Surface Raster: fill_dem1
Output flow direction raster: fdir_dem1
Step 3: Leave the default options for Output drop raster (optional) unchanged. Click OK.

Step 4: After the process is complete a **fdir_dem1** file will be added to the map document (show in figure no 4).

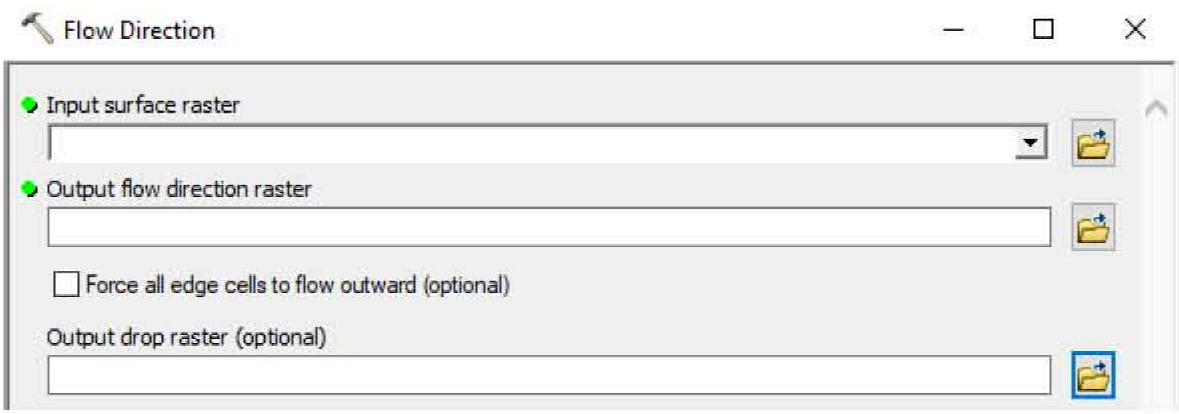


Figure No 3: Flow Direction

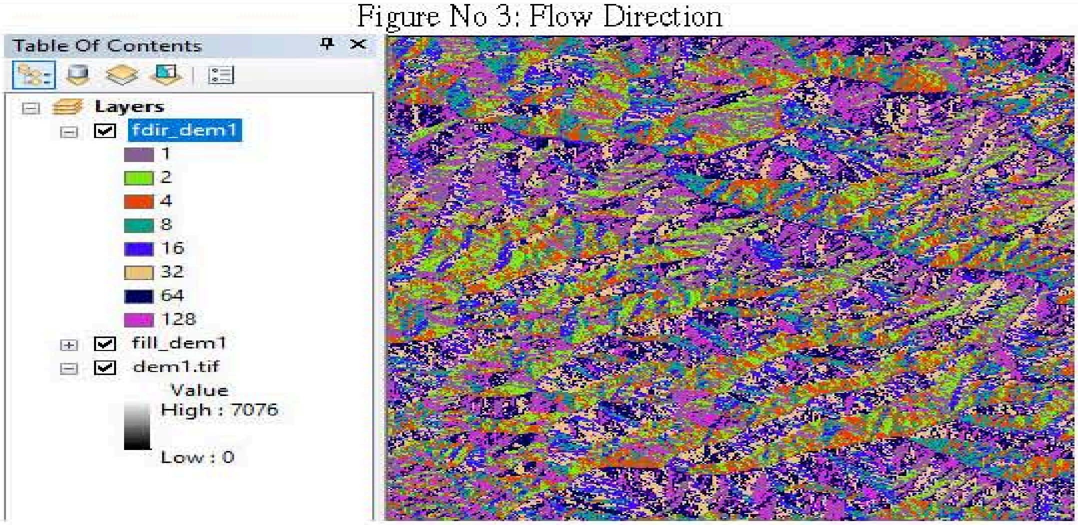


Figure No 4: Output fdir_dem1

d) **Flow Accumulation:** The function uses the flow direction grid to compute the accumulated number of cells that are draining to any particular cell in the DEM.

Step 1: Double click on "Flow Accumulation" tool.
Step 2: Flow Accumulation" window will appear.
Input flow direction raster: fdir_dem1

Output accumulation raster: facc_dem1

Step 3: Leave the default options for input weight raster and output data type (float) unchanged. Click OK.

Step 4: After the process is complete a **facc_dem1** file will be added to the map document.

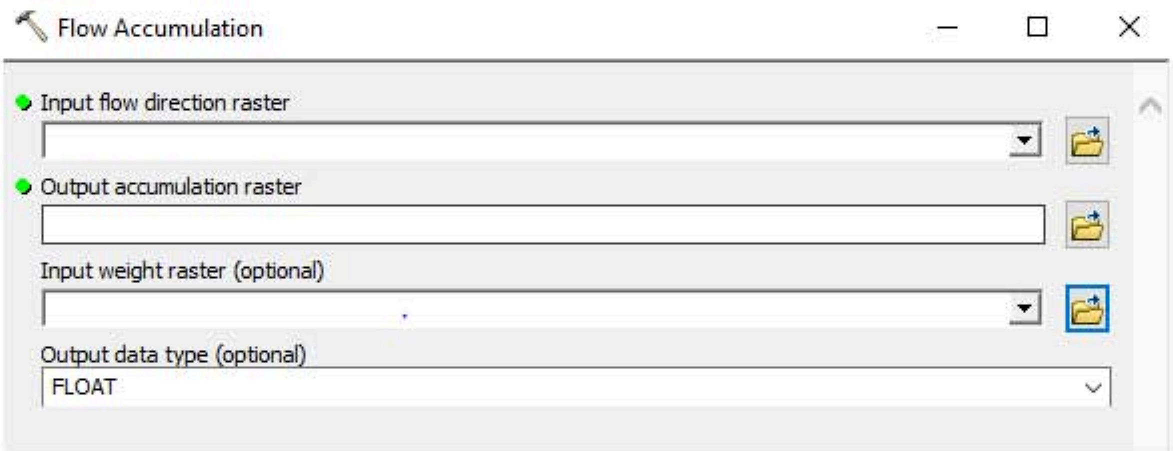


Figure No 5: Flow Accumulation

e) **Stream Network:** Because the flow accumulation gives the number of cells (or area) that drain to a particular cell, it can be used to define a stream. It is assumed that a stream is formed when a certain area (threshold) drains to a point. This threshold can be defined by using the number of cells in the flow accumulation grid. If we assume an area of $1km^2$ as the threshold to create a stream, the number of cells corresponding to this threshold area is 1111 (1000000/(30*30)) as the resolution of ASTER DEM is 30m.

Step 1: Select **Spatial Analyst>> Map Elgebra>>Raster Calculator**

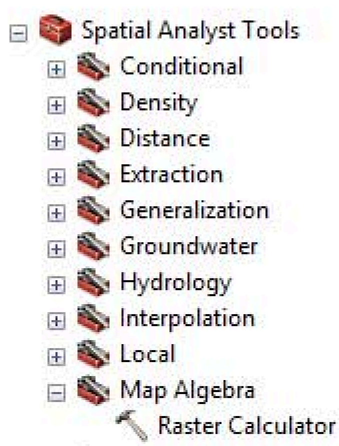


Figure No 6: Map Algebra

Step 2: “Raster Calculator” window will appear. Write the function in Raster Calculator as given below

Give formula in expression **Setnull ([facc_dem1] < 1111, 1)**

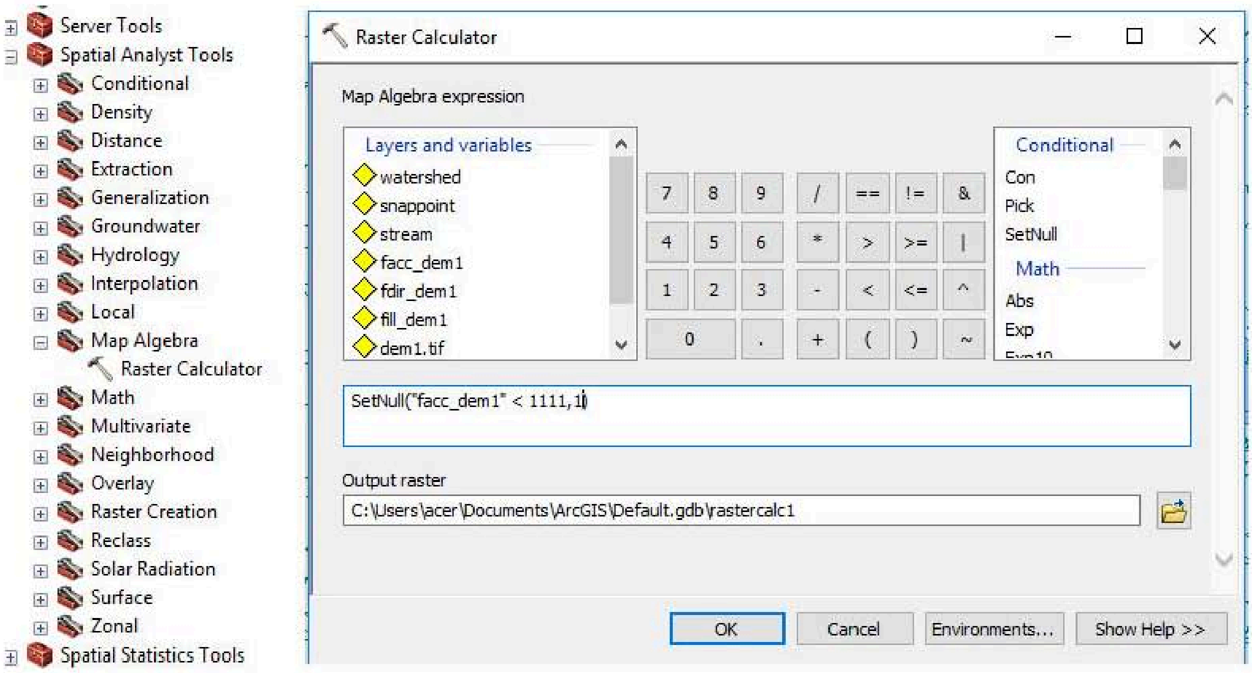


Figure No 7: Raster Calculator

Step 3: Output Name: Stream

f) Raster to Polyline (conversion):

Step 1: Go to Arc Tool Box Conversions Tools>>From raster>>Raster to Polyline

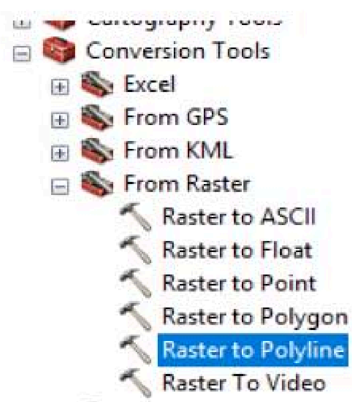


Figure 8: Conversion Tool

Step 2: "Raster to Polyline" window will appear. Select the **stream** file (output file of previous function) in "Input raster" option and give the name of output file in "Output polyline features".

Input Raster: Stream

Output Polyline Line Feature: Drainage

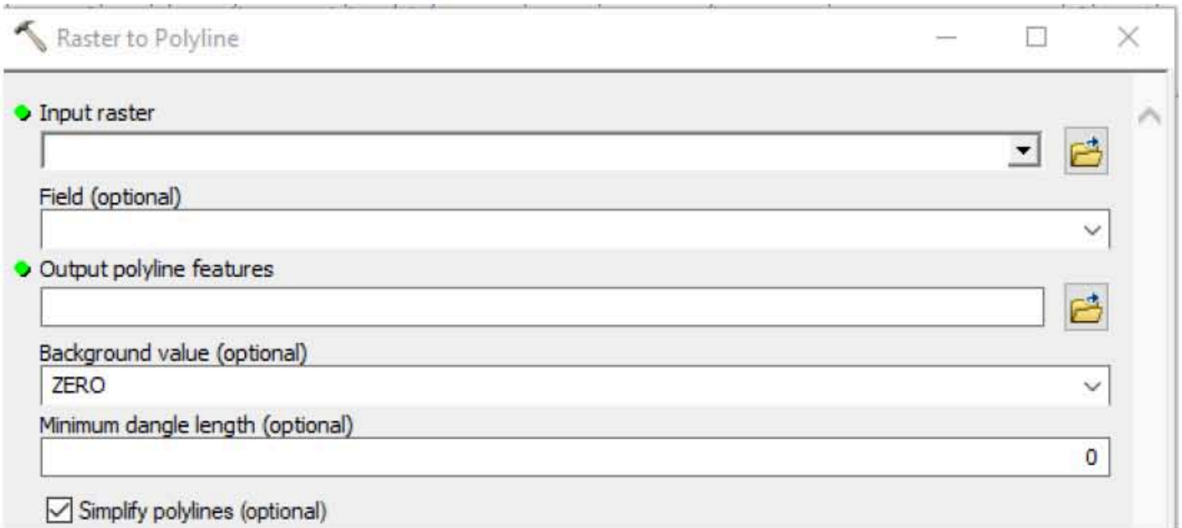


Figure No 9: Raster to Polyline

After the process is complete a **drainage.shp** file will be added to the map document.

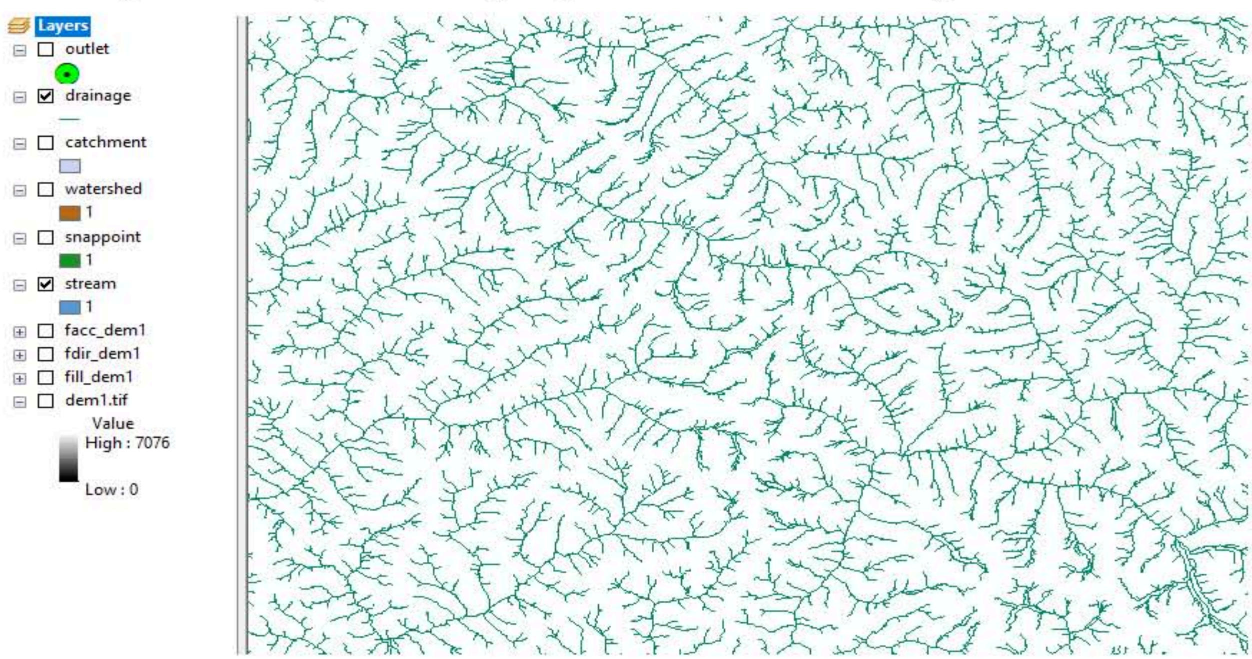


Figure No 10: Drainage Network

g) Define Outlet:

Step 1: Add Point shape file (Name: outlet.shp)

Step 2: Open Snap Pour Point

Input raster or feature pour point data: outlet.shp

Input accumulation raster: facc_dem1

Output raster: Snappoint

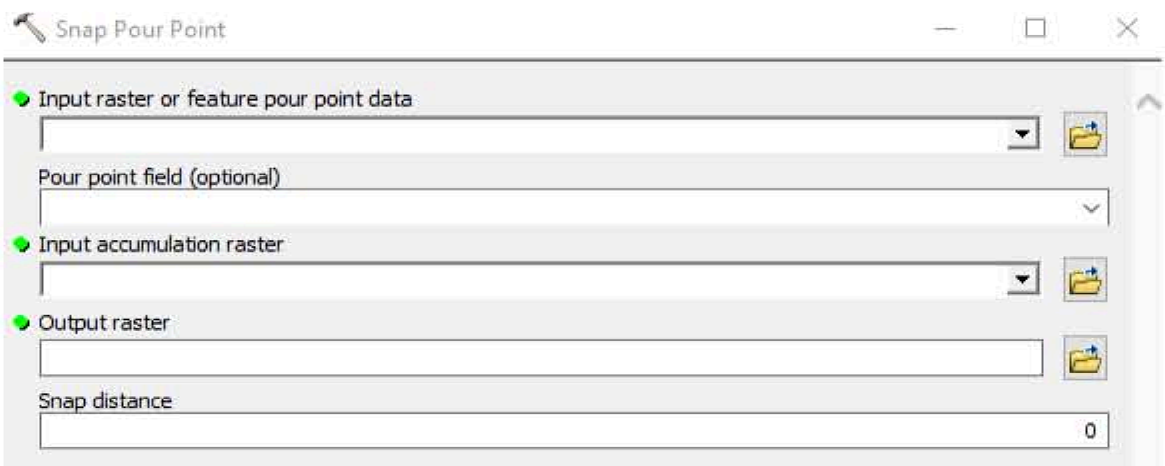


Figure No 11: Snap Pour Point

h) Watershed:

Step 1: Double click on Watershed

Input flow direction raster: fdir_dem1

Input raster or feature pour point data: SnapPoint

Output raster: Watershed

Step 2: Ok

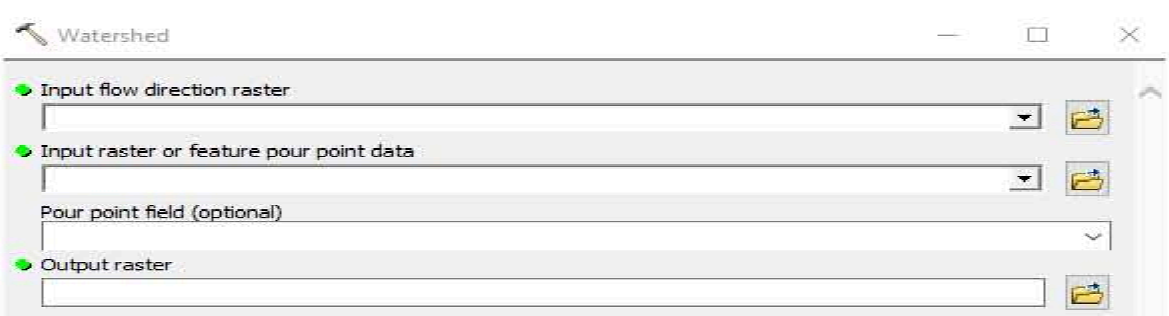


Figure 12: Watershed

i) Raster to polygon (Conversion):

Step 1: Click on Conversion>>From Raster>>Raster to Polygon

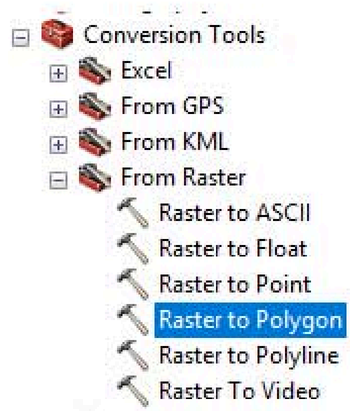


Figure 12: Conversion (raster to polygon)

Step 2: Raster to polygon

Input raster: watershed

Output polygon feature: Catchment

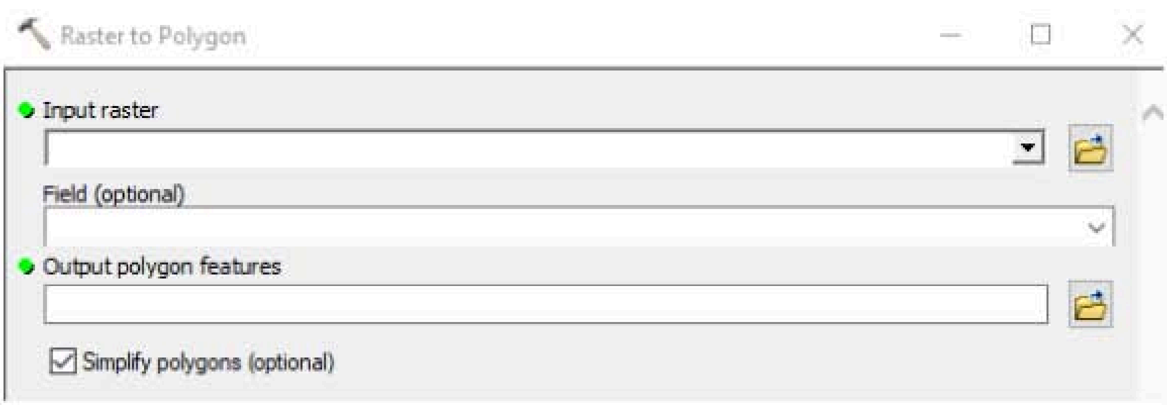


Figure No 13: Raster to Polygon

j) Calculate Area:

Step 1: Right Click on Catchment and open Attribute table

Step 2: go to menu bar and click (show a column window)

Step 3: Click on Add field (Name: area, Type: float)

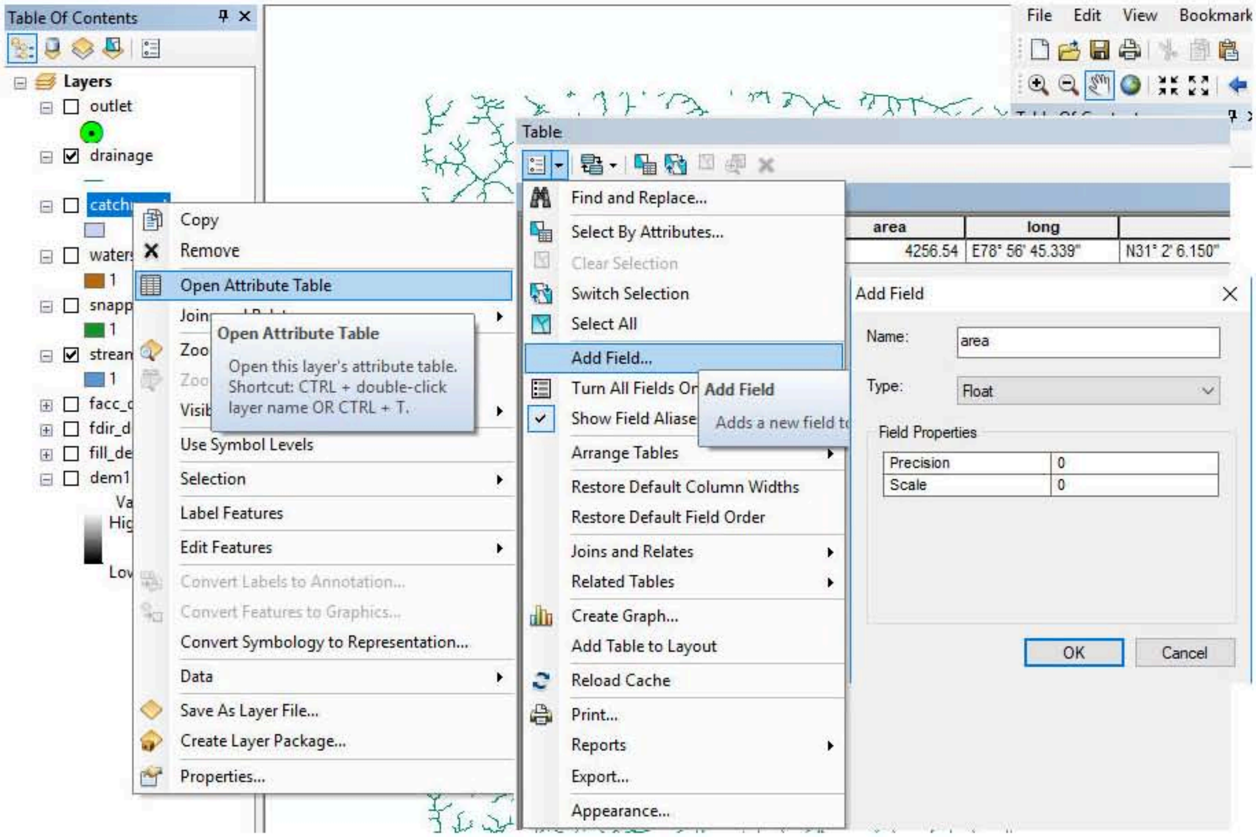


Figure No 14: Catchment Attribute Table

Step 4: Right click on area (open a pop up window)>>select calculate geometry than click on Yes

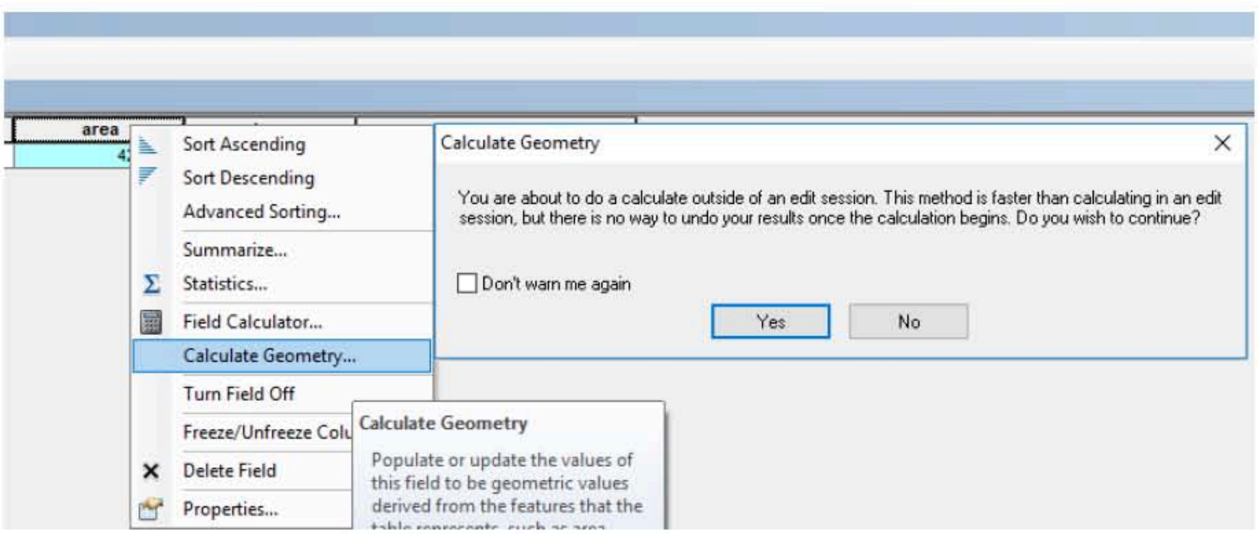


Figure No 14: Calculate geometry

Step 5: Open automatically pop up window Calculate geometry window

Property: Area

Units: Square Kilometers [sq km]

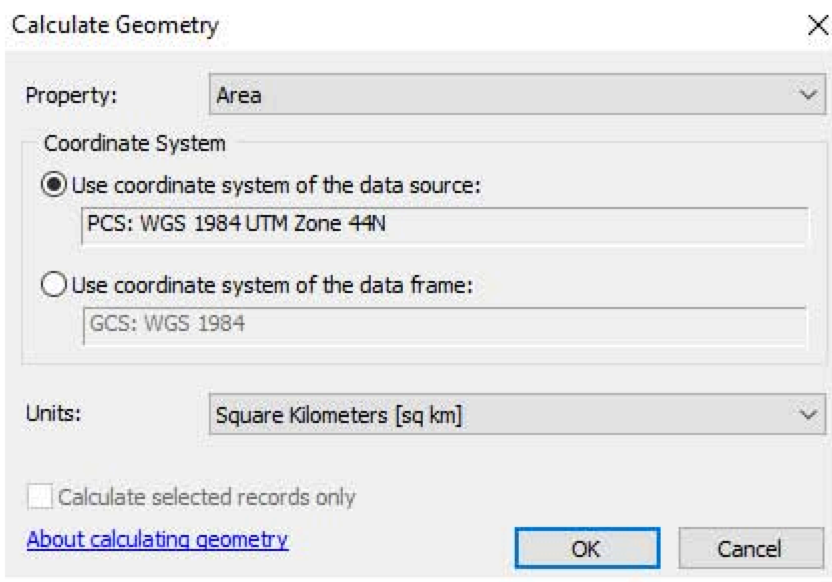


Figure No 15: Area Calculate

2. LULC Classification

Erdas Imagine 2015 software is used for preparing Landuse/ cover map. For this, supervised classification of Landsat 8 OLI/TIRS image will be carried out to classify the image in to classes, namely forest, urban, fallow, barren etc.
Right click on 2 D view# and select add raster data *D:\HEC_traininglanduse*

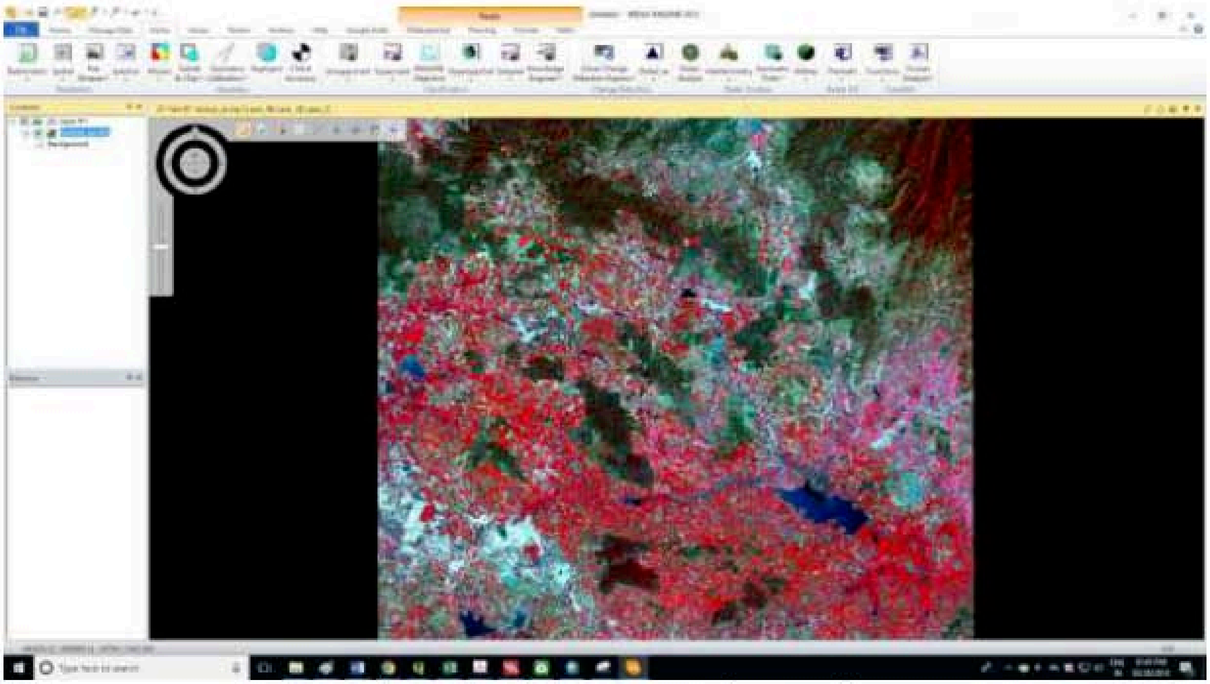


Figure No 16: ERDAS Imagine Interface

Define Signature
Step 1: Goto Raster>>Supervised classification>>Signature Editor

Step 2: Select aoi toolbar and select  polygon create feature (water signature at least 10 to 25 class create.
In Viewer #1 use Zoom icon to zoom to a theme

Step 3: create new signature from aoi 
Add more signatures for same class for others part of image using procedure described in steps
Select all signature of same class as shown in Fig18 and click on **Merge Selected Signature**  option. After that delete selected signatures and give the class name Water.

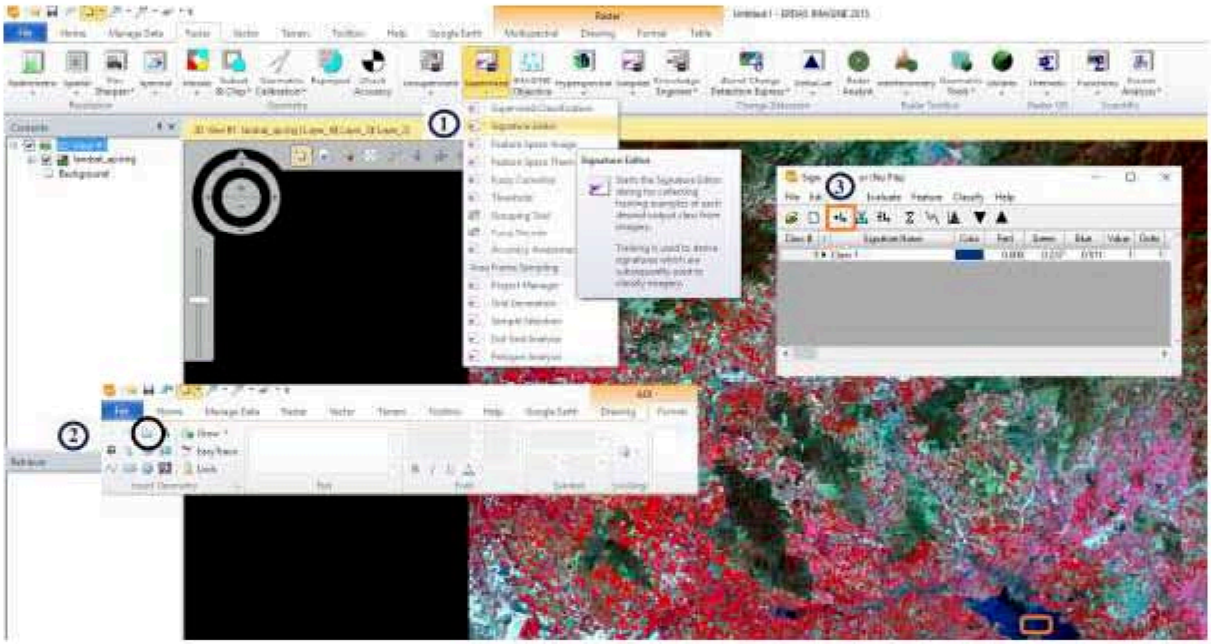


Figure No 17: Signature mapping

Add atleast 10 class for each (ex-forest, water etc)
Step 1: Select all Classes
Step 2: Click on merge
Step 3: Give the class name (Ex-Water)
Step 4: Save signature file as D:\HEC_training\Classifiaction\sign1

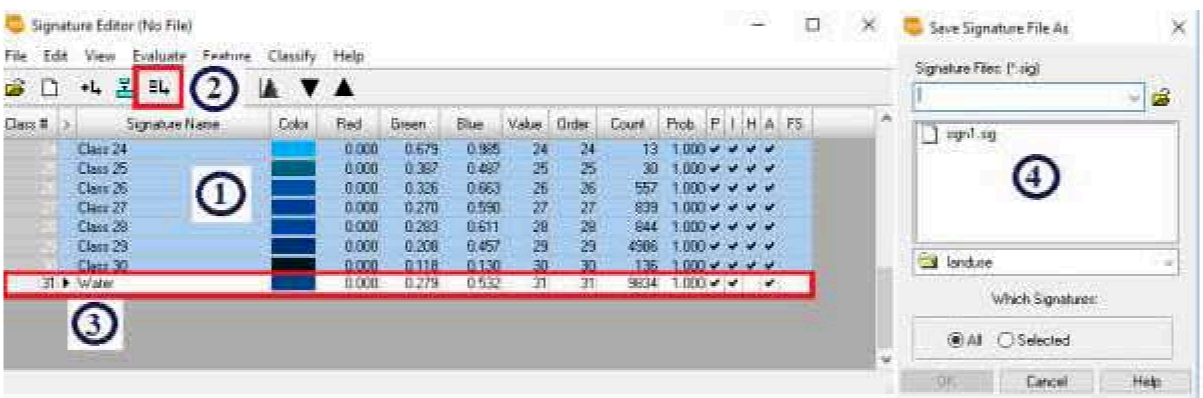


Figure No 18: Signature Editor

Supervised classification

Click **Classify-Supervised** menu to open **Supervised Classification** dialog box.
Step 1: Select Raster in main tool box
Step 2: Select supervised classification
Step 3: Input raster, input Signature and give classified File supervised (output)

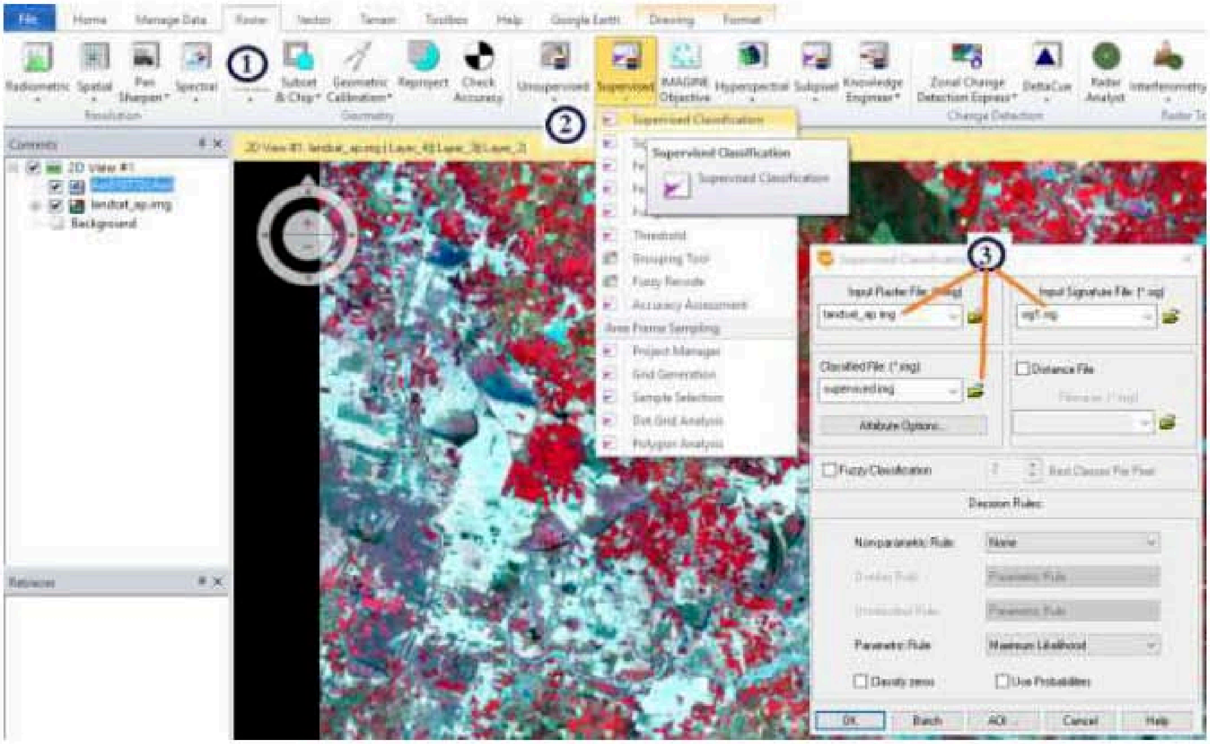


Figure NO 10: Supervised classification

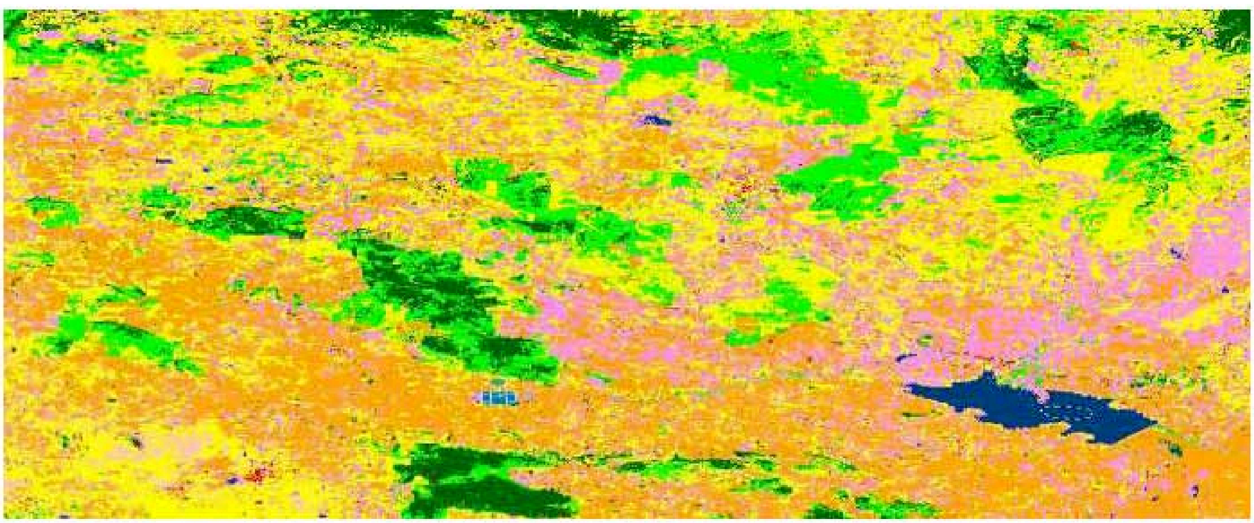


Figure no 11: Classified Image

Exercise 4:
Delineate Cross Section from DEM Data

1) Save Arc Map Document
   Step 1: Click on File>>Save As
   Step 2: Save As x_section

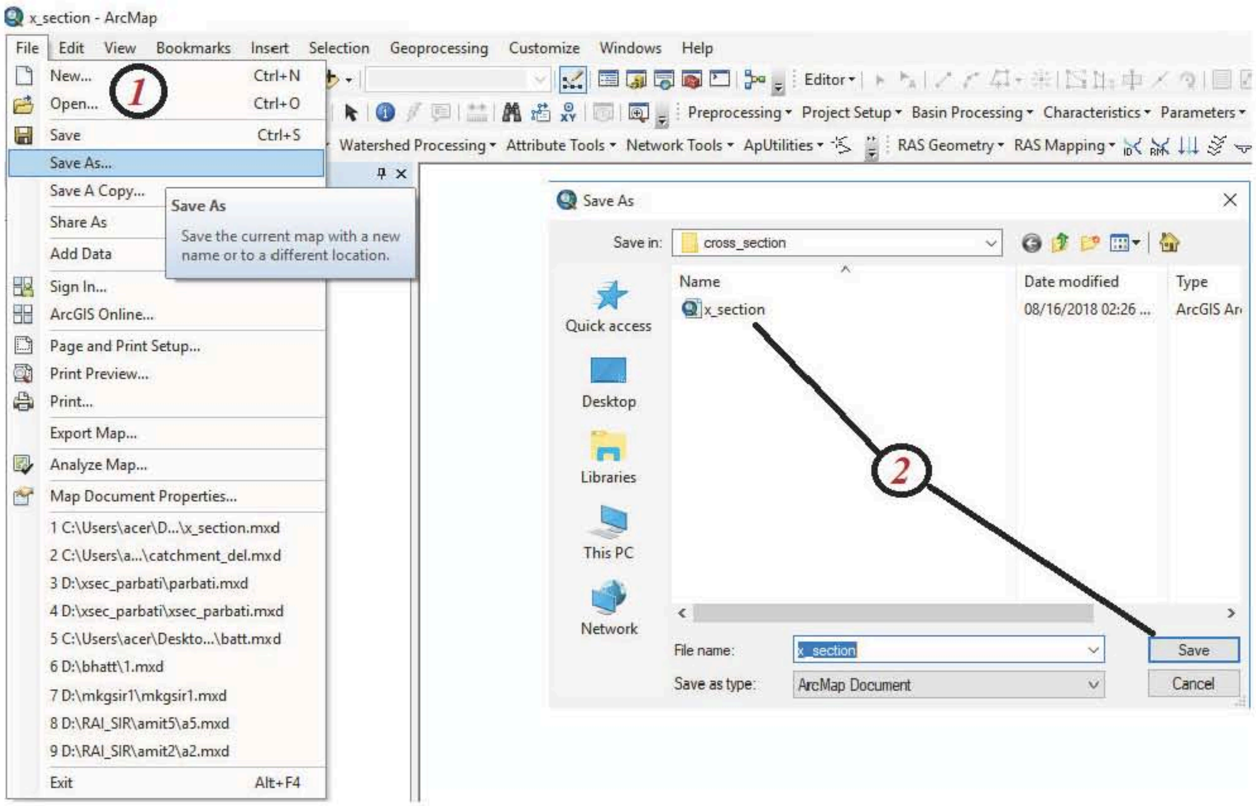


Figure No 1: create X Section

Note: Since Hec-GeoRAS uses functions associated with ArcGIS Spatial Analyst and 3D Analyst extensions, make sure these extensions are available, and are enabled

Clicking on Customize →Extensions and checking the boxes (if they are unchecked) next to 3D Analyst and Spatial Analyst as shown below (Fig. 2 & 3). Close the Extensions window

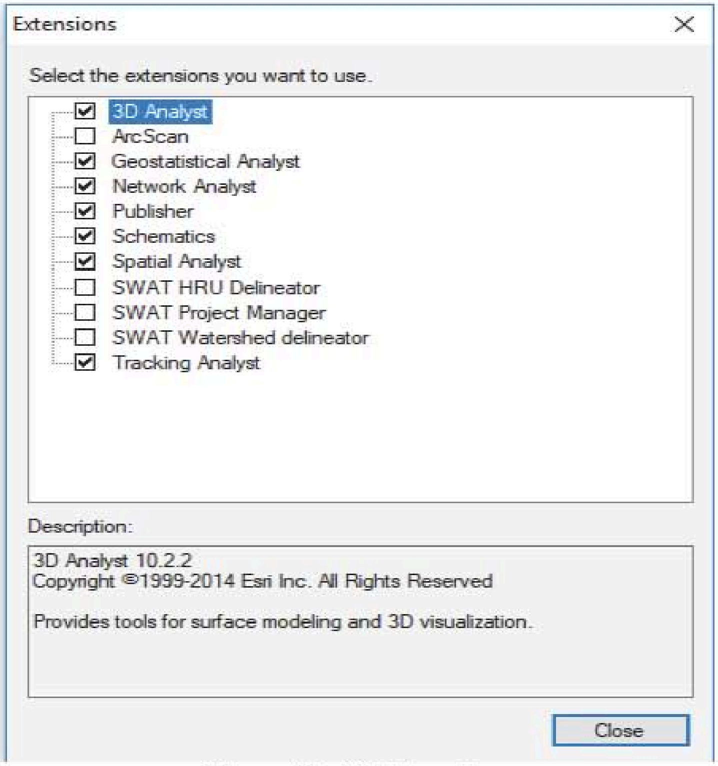


Figure No 2: Extension

Load the HEC-GeoRAS toolbar into ArcGIS by clicking on Customize→ Toolbars and click on check box of HEC-GeoRAS option as shown below (Fig.3):

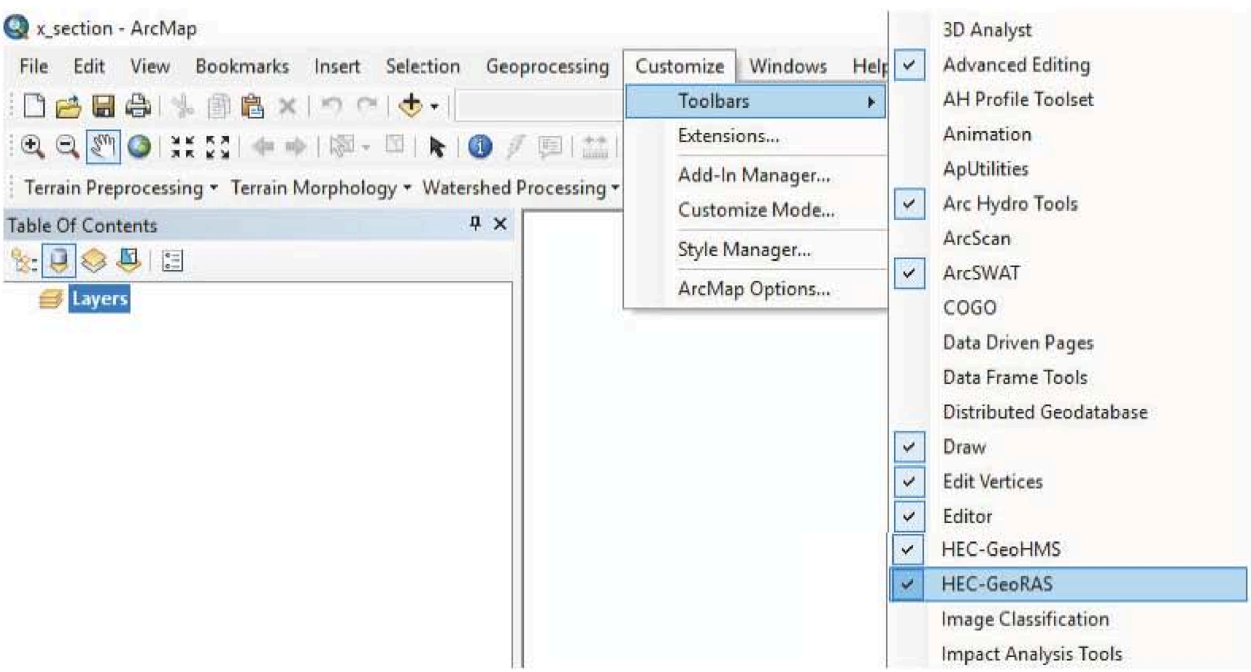


Figure No 3: Add tool bar

Note : The HEC-GeoRAS toolbar has four menus (RAS Geometry, RAS Mapping, ApUtilities, Help) and seven tools/buttons (Assign RiverCode/ReachCode, Assign FromStation/ToStation, Assign Line Type, Construct XS Cutlines, Plot Cross Section, and Assign Levee Elevation) as shown in circles and boxes, respectively in the Fig.5.

a) Setting up Analysis Environment for HEC-GeoRAS

Click on Add button  in ArcMap and browse to dem2 to add the DEM to the map document as shown in Fig. 4. You must have the same coordinate system for all the data and data frames used for Geo-RAS project. Because dem2 already has a projected coordinate system, it is applied to the data frame

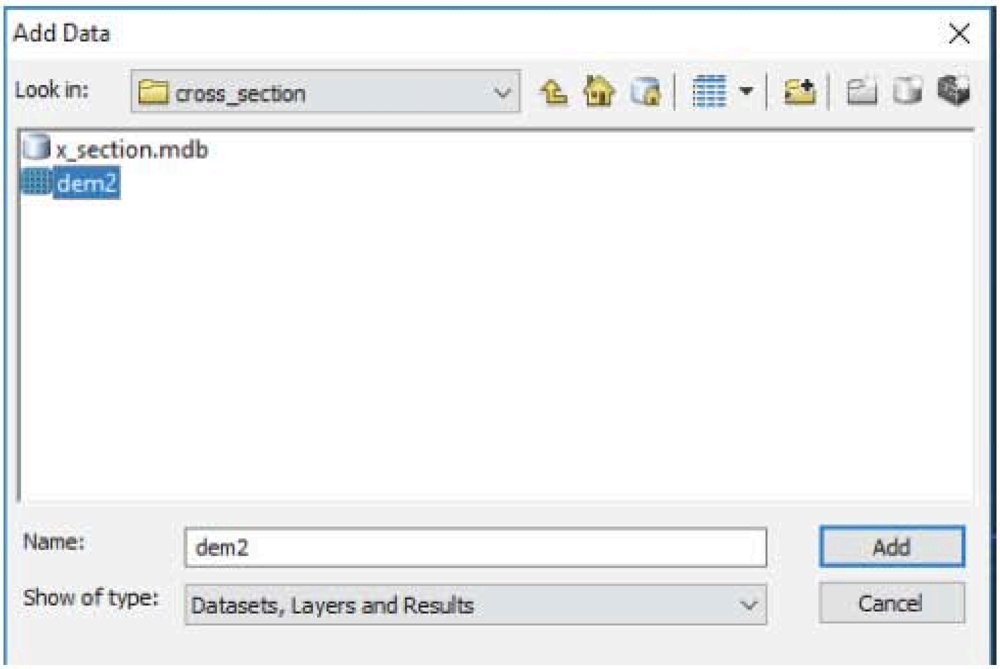


Figure no 4: Add Data

Click on RAS Geometry>>Layer Setup. Select dem2 as the single Grid in the Required Surface tab, and click OK.(see in figure no 5)

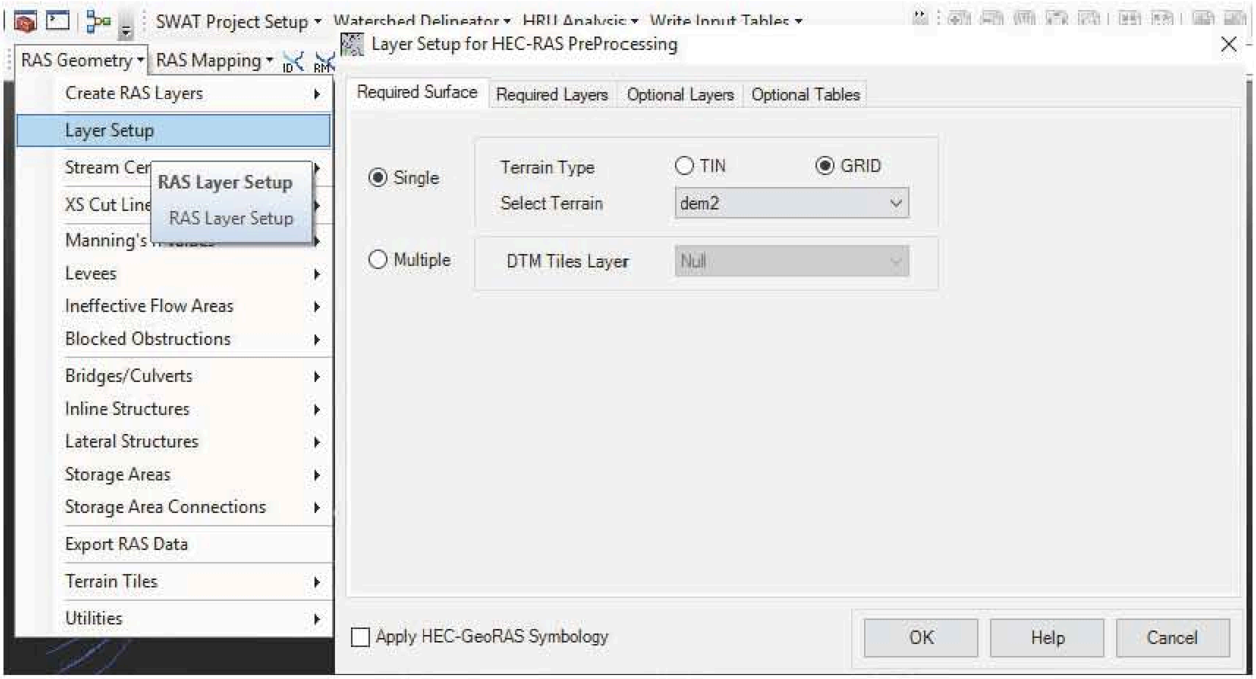


Figure No 5: Layer Setup

In HEC-GeoRAS, each attribute is stored in a separate feature class called as RAS Layer. So before creating river attributes in GIS, let us first create empty GIS layers using the RAS Geometry menu on the HEC-GeoRAS toolbar.

b) Create Stream Centre line

Click on **RAS Geometry →Create RAS Layers** (**Fig.6**). You will see a list of all the possible attributes that you can have in the HEC-RAS geometry file. Click on individual attribute to create a single layer at a time.

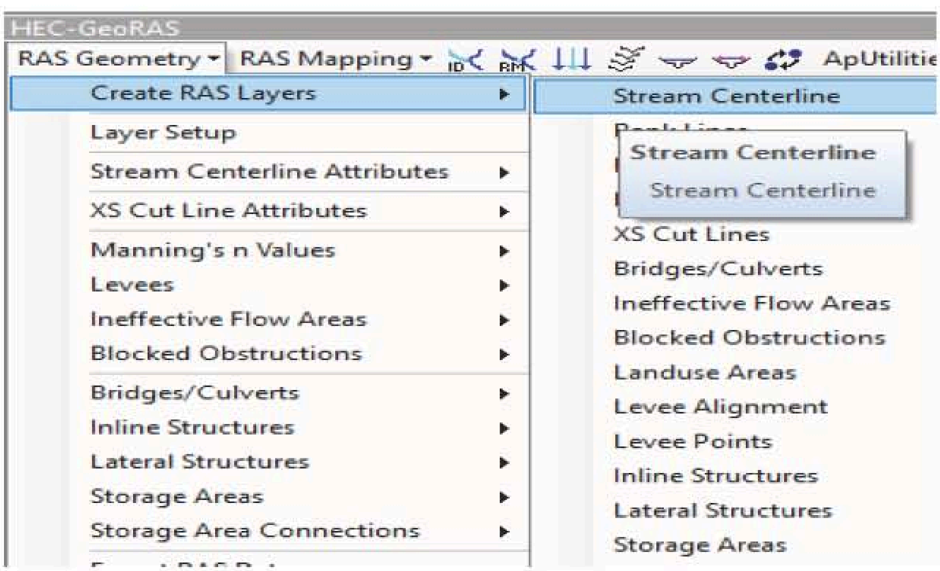


Figure No 6: Stream Line creation

Click on ***RAS Geometry >>Create RAS Layers>> double click on Stream Centerline***. Create Stream Centerline Layer window will appear (Fig 7), accept the default names (eg. River), and click OK.

Create Stream Centerline Layer acknowledge window will appear (Fig.7). Click OK

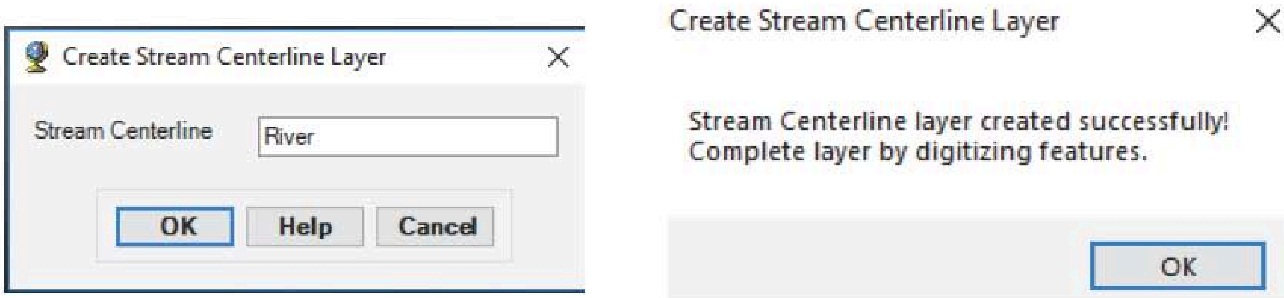


Figure No 7: Stream Centre line Name (Feature Name)

c) Bank Line

Click on RAS Geometry →Create RAS Layers→ double click on **Bank Lines**. Create bank lines window (Fig.8) will appear, accept the default names (eg. Banks), and click OK.

Create Bank Lines acknowledge window will appear (Fig.8). Click **OK**

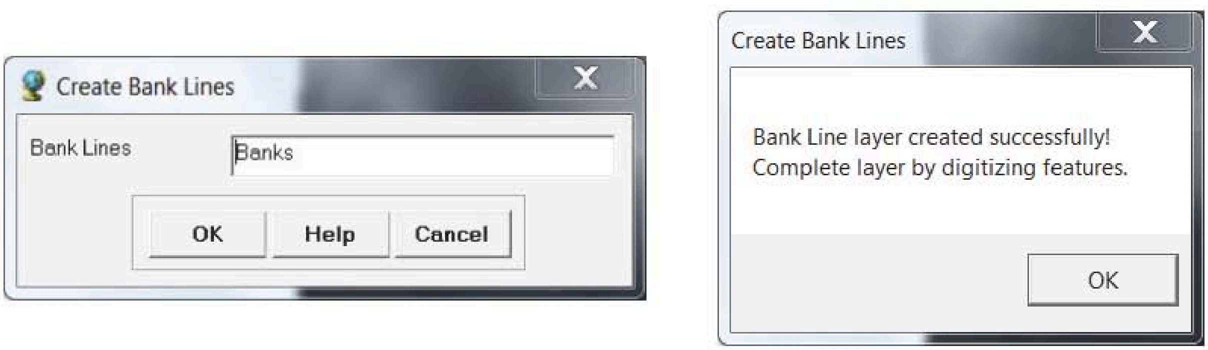


Figure No 8: Bank Name

After creating RAS layers, these are added to the map document with a pre-assigned symbology. Since these layers are empty, our task is to populate some or all of these layers depending on our project needs, and then create a HEC-RAS geometry file.

d) Creating River Centerline

- Let us first start with river centerline. The river centerline is used to establish the river reach network for HEC-RAS. The Bhagirathi River flowing from east to west.

- Click on  button to add the satellite image (e.g layer_stack.img) in ArcMap interface.
- Right click on layer_stack.img file and click on Properties (Fig.9).
- Layer properties window will open. In Symbology tab, select band combination as 4 3 2. Click OK.
- We will create/digitize the center of the river, and aligned in the direction of flow. Zoom-in to the most upstream part of the Bhagirathi reach to see the main channel.

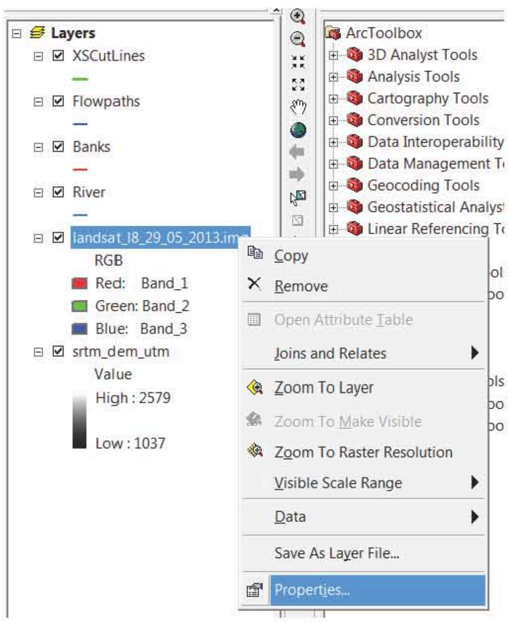
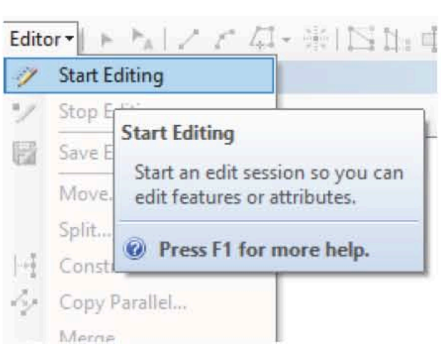


Figure No 9: Band Combination Image

- Create the river centerline (in River feature class), Go to Editor →Start Editing (Fig. 10). In editor menu select  create features tool, select **River** as shown in Fig. 11. for dizitization.

(<u>Note</u>: While digitizing the centerline, make sure that you leave some space between the boundary of the dataset and the beginning/ending of your centerline.)



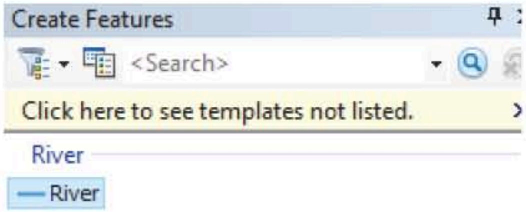


Figure no 10: Start Editing

Start digitizing the river centerline from the upstream end towards the downstream. When you reach on the end point, double click to complete the centerline for the reach. After finishing digitizing the Bhagirathi Reach, Go to Editor → save the edits. Then click on **Stop Editing.**

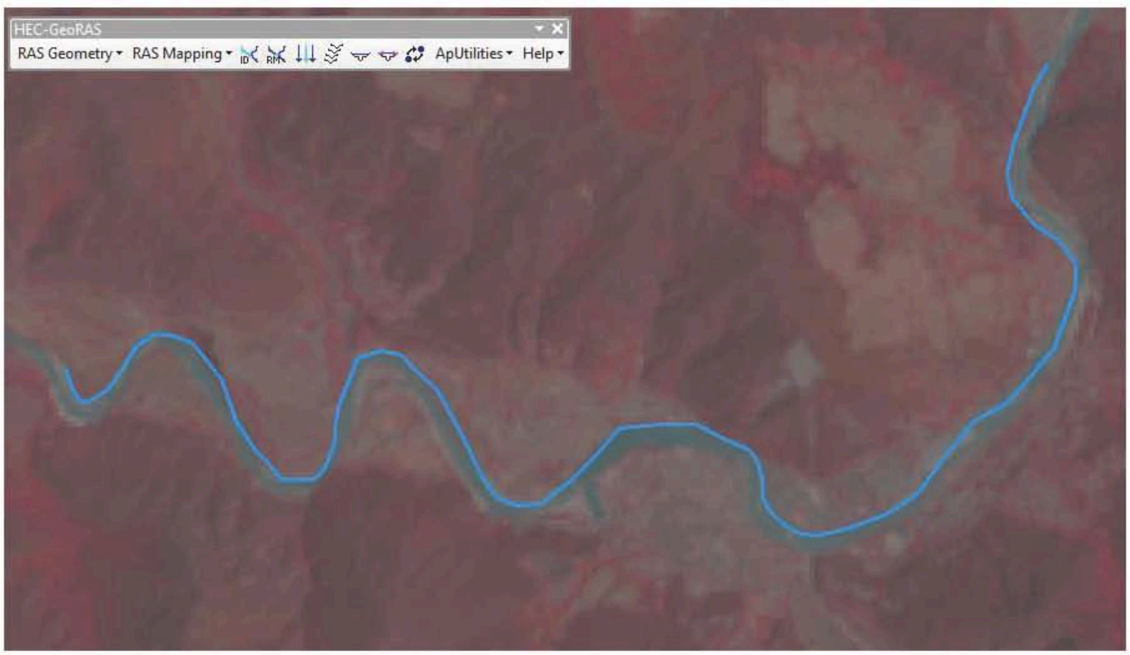


Figure No 11: Mapping

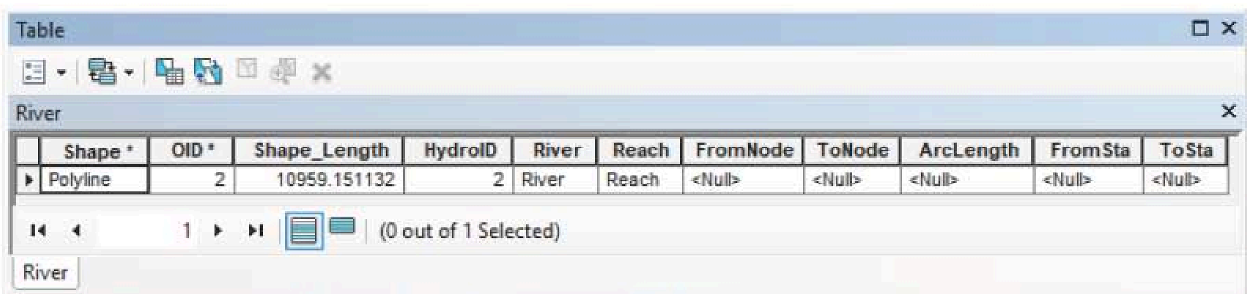
After the reach is digitized, the next task is to name them. Each river in HEC-RAS must have a unique river name, and each reach within a river must have a unique reach name. To assign names to reaches, click on Assign RiverCode/ReachCode button to activate it as shown below in Fig. 12

Figure No 12: River ID Name

With the button active, click on the Bhagirathi River reach. Assign River and Reach code window will open, Assign the River and Reach name as River and Reach (Fig. 13), respectively, and click OK

Figure No 13: River Name & Reach Name

Now open the attribute table of the River and you will see that the information you just provided on river and reach names is entered as feature attributes as shown below (Fig 14)



Table

River

Shape *	OID *	Shape_Length	HydroID	River	Reach	FromNode	ToNode	ArcLength	FromSta	ToSta
Polyline	2	10959.151132	2	River	Reach	<Null>	<Null>	<Null>	<Null>	<Null>

1 (0 out of 1 Selected)

River

Figure No 14: Attribute Table (River)

- Also note that there are still some unpopulated attributes in the River feature class (FromNode, ToNode, etc.).

Before we move forward let us make sure that the reaches we just created are connected, and populate the remaining attributes of the River feature class. Click on RAS.

e) Create Stream Centerline Topology, Length and Elevation profile (Fig.15)

Geometry→ Stream Centerline Attributes→All

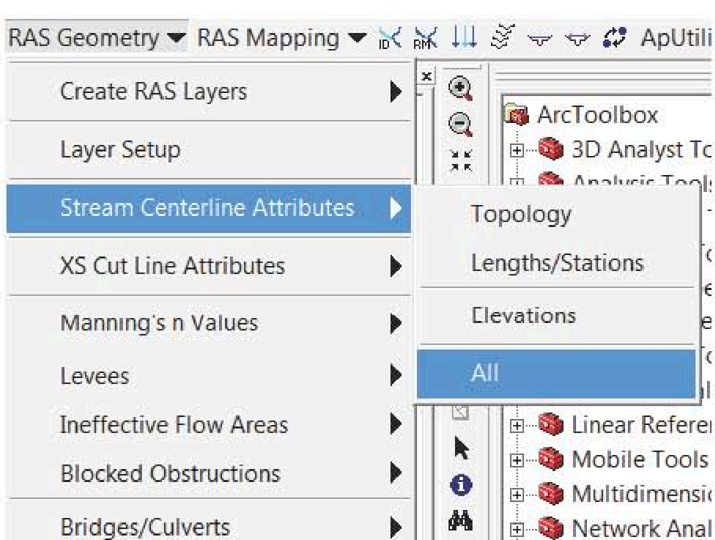


Figure No 15: Create Topology. Length & Elevation

All Steam Tools dialogue window (Fig. 16) will appear. Confirm **River** for Stream Centerline and **dem2** (Give name) for Terrian, River3D for Stream Profiles, and click OK

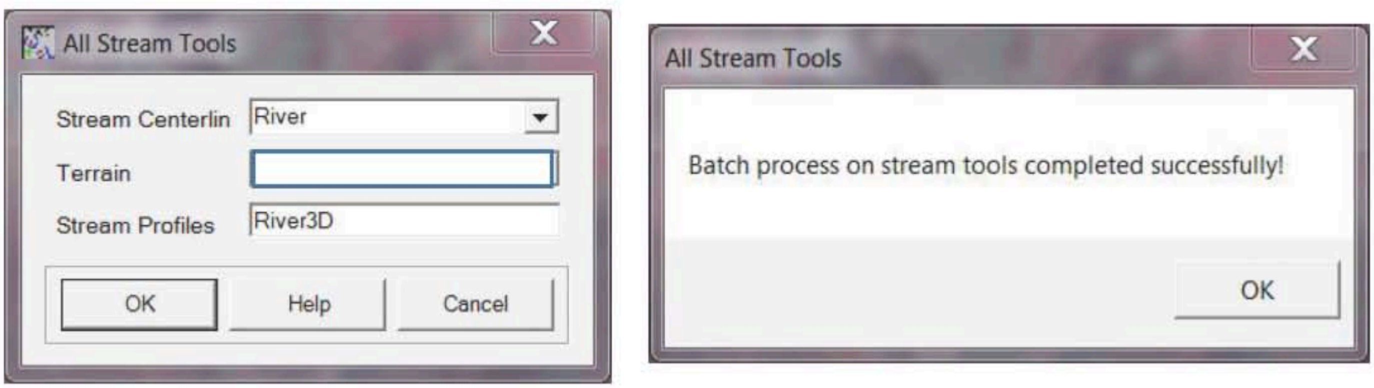


Figure No 16: All Stream Data set

This function will populate the FromNode and ToNode attribute of the River feature class. This will populate all attributes in River, and will also create 3D version (new feature class) of River centerline called River3D. Now open the attribute table for River (Fig. 17), and understand the meaning of each attribute

Figure No 17: Attribute Table

Note: HydroID is a unique number for a given feature in a geodatabase. The River and Reach attributes contain unique names for rivers and reaches, respectively. The FromNode and ToNode attributes define the connectivity between reaches. ArcLength is the actual length of the reach in map units, and is equal to Shape_Length. In HEC-RAS, distances are represented using station numbers measured from downstream to upstream. For example, each river has a station number of zero at the downstream end, and is equal to the length of the river at the upstream end.
Close the attribute table, and save the map document

f) Creating River Banks

Bank lines are used to distinguish the main channel from the overbank floodplain areas. Information related to bank locations is used to assign different properties for cross-sections. For example, compared to the main channel, overbank areas are assigned higher values of Manning's n to account for more roughness caused by vegetation. Creating bank lines is similar to creating the channel centerline, but there are no specific guideless with regard to line orientation and connectivity - they can be digitized either along the flow direction or against the flow direction, or may be continuous or broken.

- To create a bank line (in Banks feature class), follow the same digitization procedure by selecting bank feature in Target and straight segment tool. You can have a single bank for the whole reach. One the right hand side, however, you cannot cross the stream so you will need two separate lines for the right bank of the Bhagirathi River. Digitize banks for Bhagirathi reach (Fig. 18) and save the edits and the map document.

Figure No 18: Channel Mapping

g) Creating Flowpaths

The flow path layer contains three types of lines: centerline, left overbank, and right over bank. The flow path lines are used to determine the downstream reach lengths between cross-sections in the main channel and over bank areas. If the river centerline that we created earlier lie approximately in the center of the main channel (which it does), it can be used as the flow path centerline

- Click on RAS Geometry →Create RAS Layers→ double click on Flow Path Cenerlines. Create Flow path Layer window (Fig. 19) will appear. Click Yes.

- Create Flow paths window (Fig. 19) will appear, accept the default names (eg. River in Stream Centerline and Flow paths in Flow paths). Click OK.

- Create Flow paths acknowledge window (Fig. 19) will appear. Click OK

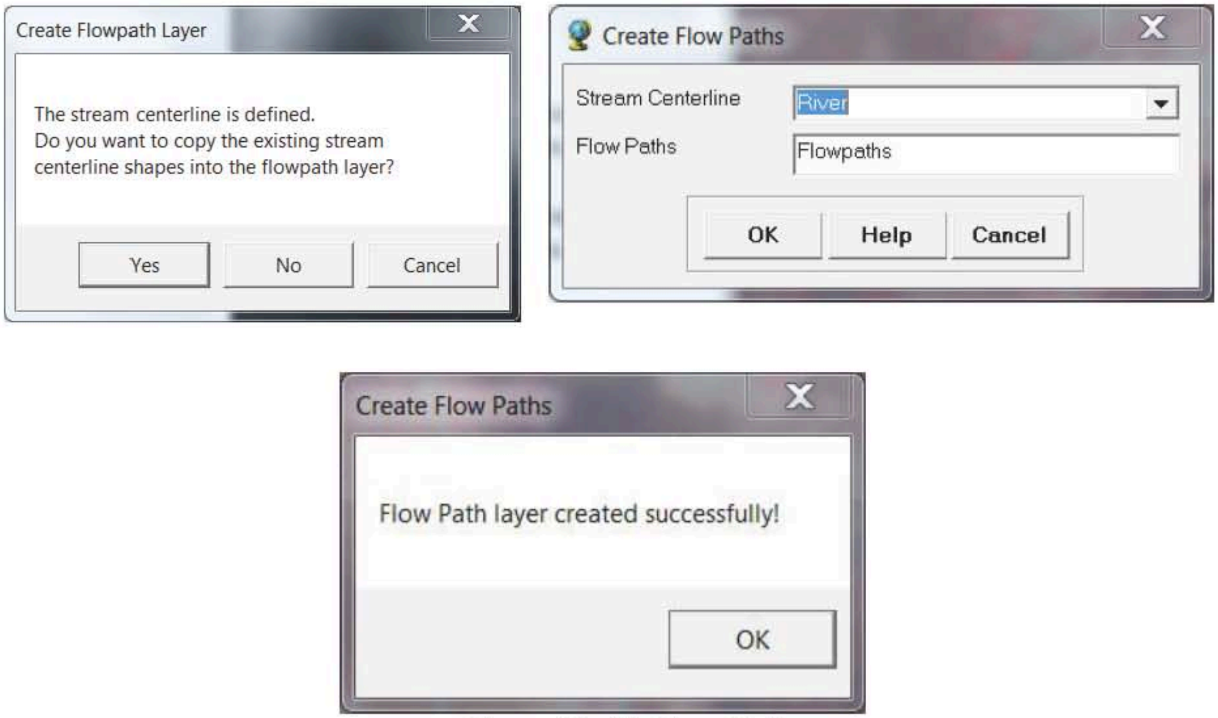
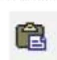
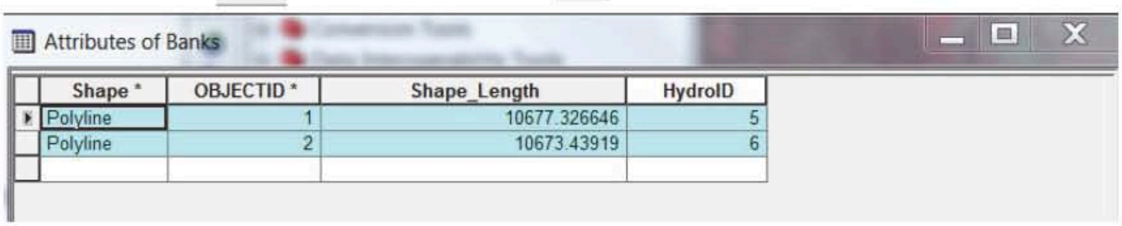


Figure No 19: Flow Path

To create the left and right flow paths in Flowpaths feature class, start editing. Set Flowpaths feature class in Target. Open attribute table of Banks feature class (Fig.48). Select both banks lines. Click on **Copy**  tool then click on  Paste tool


Attributes of Banks

Shape *	OBJECTID *	Shape_Length	HydroID
Polyline	1	10677.326646	5
Polyline	2	10673.43919	6

Figure No 20: Attribute table of Banks

- Go to Editor save the edits and stop editing.
- Open attribute table of Flow paths feature class. You can see that left and right banks are added in flow paths feature class as shown in Fig. 21.

Now label the flowpaths by using the Assign LineType  button

Click on the button (notice the change in cursor), and then click on one of the flow paths (left or right, looking downstream), and name the flow path accordingly as shown in Fig 49

Figure No 21: Define Channel

.

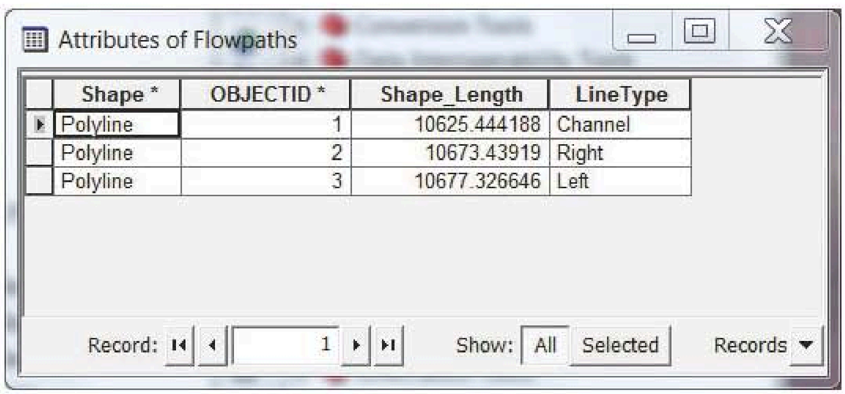


Figure No 22: Flow path attribute table

Label all flow paths, and confirm this by opening the attribute table of the Flowpaths feature class. The Line Type field must have data for each row if all flowpaths are labeled as shown below in Fig. 22

h) Creating Cross-sections

Cross-sections are one of the key inputs to HEC-RAS. Cross-section cutlines are used to extract the elevation data from the terrain to create a ground profile across channel flow. The intersection of cutlines with other RAS layers such as centerline and flow path lines are used to compute HEC-RAS attributes such as bank stations (locations that separate main channel from the floodplain), downstream reach lengths (distance between cross-sections) and Manning's n. Therefore, creating adequate number of cross-sections to produce a good representation of channel bed and floodplain is critical. Certain guidelines must be followed in creating cross-section cutlines: (1) they are digitized perpendicular to the direction of flow; (2) must span over the entire flood extent to be modeled; and (3) always digitized from left to right (looking downstream). Even though it is not required, but it is a good practice to maintain a consistent spacing between cross-sections. In this exercise, let's use an approximate spacing of 1000 meters for all cross-sections.

1. Click on RAS Geometry →Create RAS Layers→ double click on XS Cut Lines. Create Create XS Cut Lines window (Fig.23) will appear, accept the default names (eg. XSCutLInes), and click OK.

Figure No 23: Create XS Cut Lines

Create XS Cut Lines acknowledge window (Fig.24) will appear. Click OK

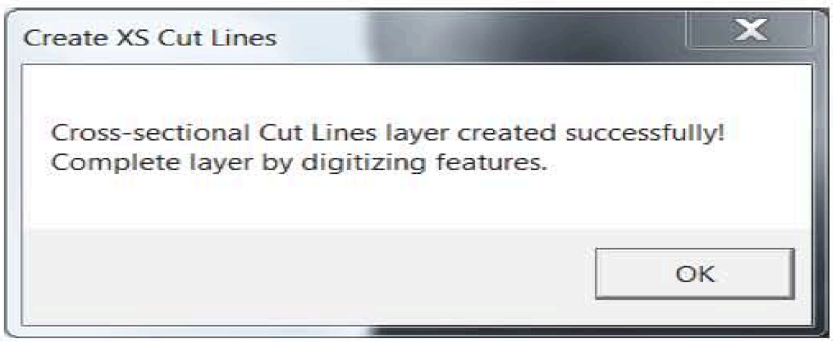


Figure No 24: Create XS Cut Lines Successfull

2. To create cross-section cutlines in XSCutlines feature class. Click on Construct XS cutlines button.
3. Create cross section window (Fig. 25) will appear. Give interval (eg 1000) & width (eg 1000). Click OK.

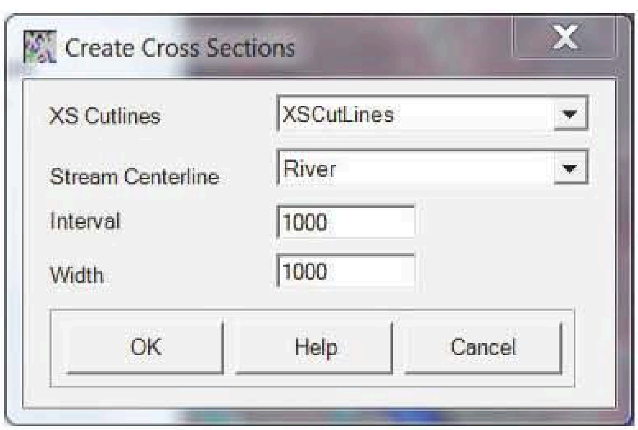


Figure No 25: Create Cross Sections

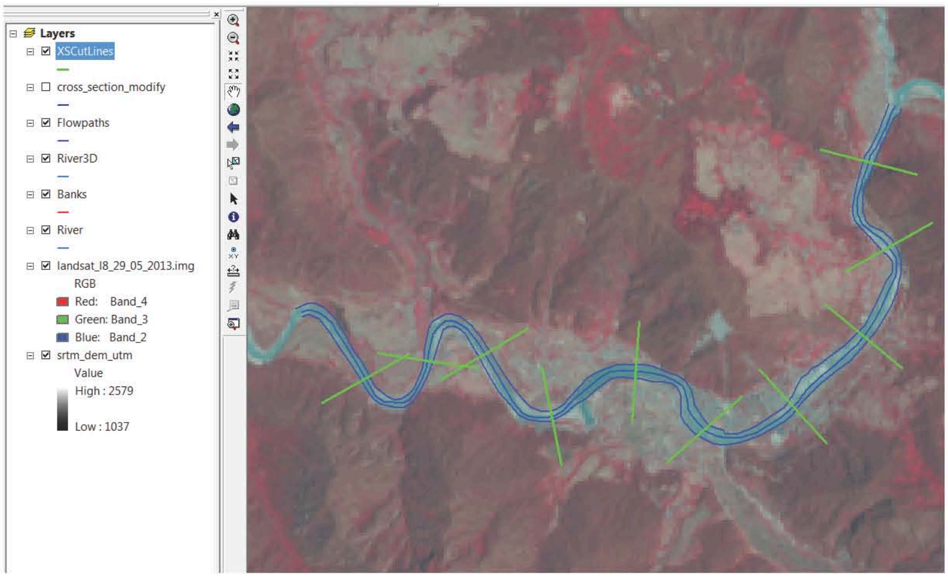
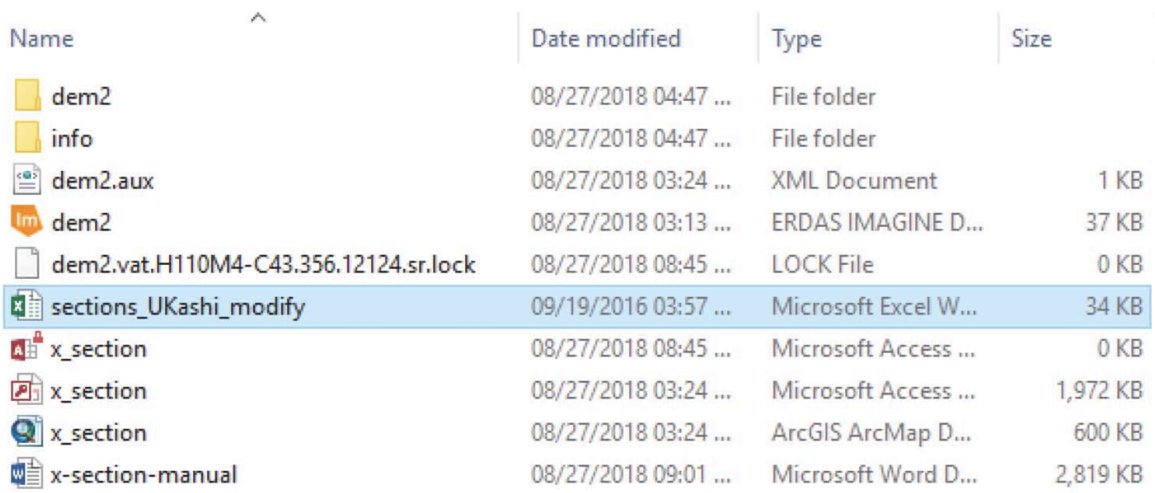


Figure No 26: Cross Section window

Note: We have surveyed cross section. So we replace automatically creates cross section with survey cross section line.

Click on Add button. Go to working directory and select **cross_section_modify.shp** file



Name	Date modified	Type	Size
dem2	08/27/2018 04:47 ...	File folder	
info	08/27/2018 04:47 ...	File folder	
dem2.aux	08/27/2018 03:24 ...	XML Document	1 KB
dem2	08/27/2018 03:13 ...	ERDAS IMAGINE D...	37 KB
dem2.vat.H110M4-C43.356.12124.sr.lock	08/27/2018 08:45 ...	LOCK File	0 KB
sections_UKashi_modify	09/19/2016 03:57 ...	Microsoft Excel W...	34 KB
x_section	08/27/2018 08:45 ...	Microsoft Access ...	0 KB
x_section	08/27/2018 03:24 ...	Microsoft Access ...	1,972 KB
x_section	08/27/2018 03:24 ...	ArcGIS ArcMap D...	600 KB
x-section-manual	08/27/2018 09:01 ...	Microsoft Word D...	2,819 KB

Figure No 27: Modify cross section

2 Cross_section_modify.shp will be added in Layer.

Go to Editor → Start editing. Select **XSCutLines** in **Target**.

Right click on XSCutLines file and open attribute table.

Select all the attributes and right click and select **Delete Selected** (Fig. 28). It will delete the

entire cross lines.
Go to Editor → Save Edits.
Close the attribute table

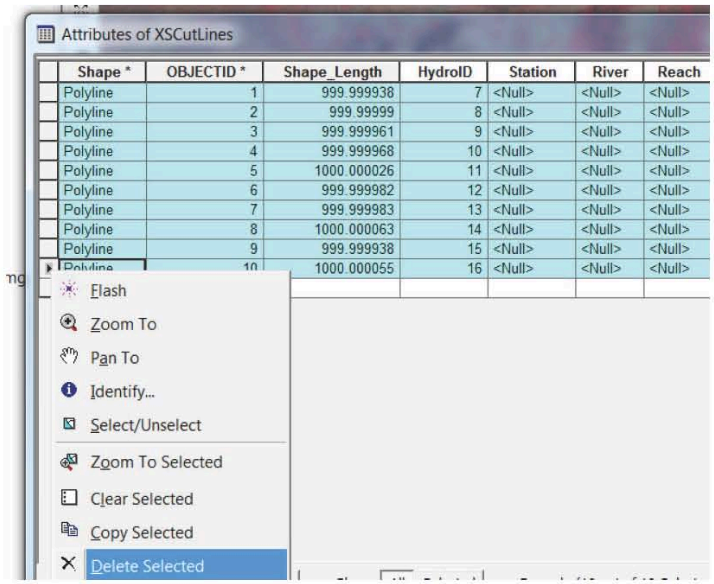


Figure No 28: Delete XS Cut Lines

Now Right click on Cross_section_modify.shp file and open attribute table. In attribute table select all the cross sections. Click copy  button, then click on paste  button. It will paste all the cross section of **Cross_section_modify.shp** file into XSCutLines file.

To verify this, open the attribute table of XSCutLines file as shown in Fig. 29

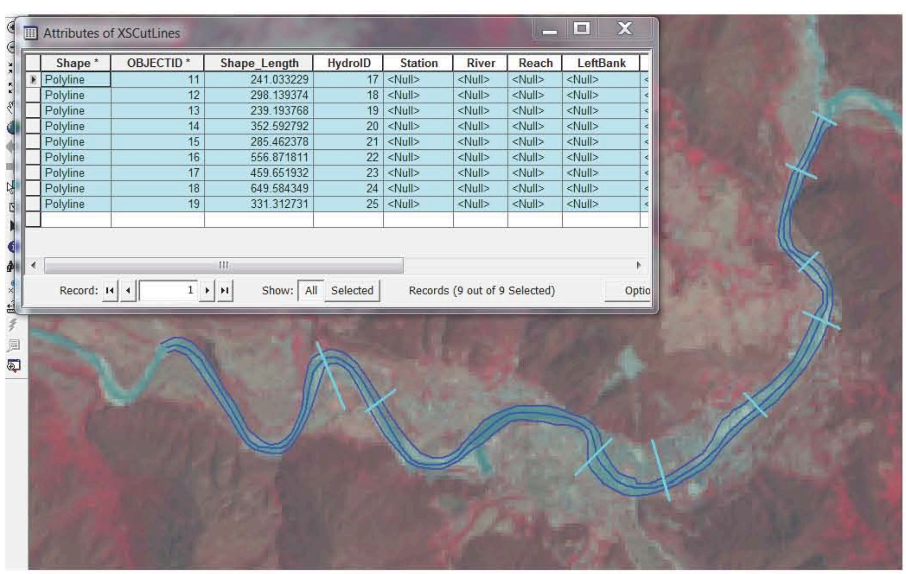


Figure No 29: Update X Section

Go to Editor→ Save Edits → Stop Edits

a) Add HEC-RAS attributes to these cutlines

We will add Reach/River name, station number along the centerline, bank stations and downstream reach lengths. Since all these attributes are based on the intersection of cross-sections with other layers, make sure each cross-section intersects with the centerline and overbank flow paths to avoid error messages.

- Click on RAS Geometry→ XS Cut Line Attributes→All.

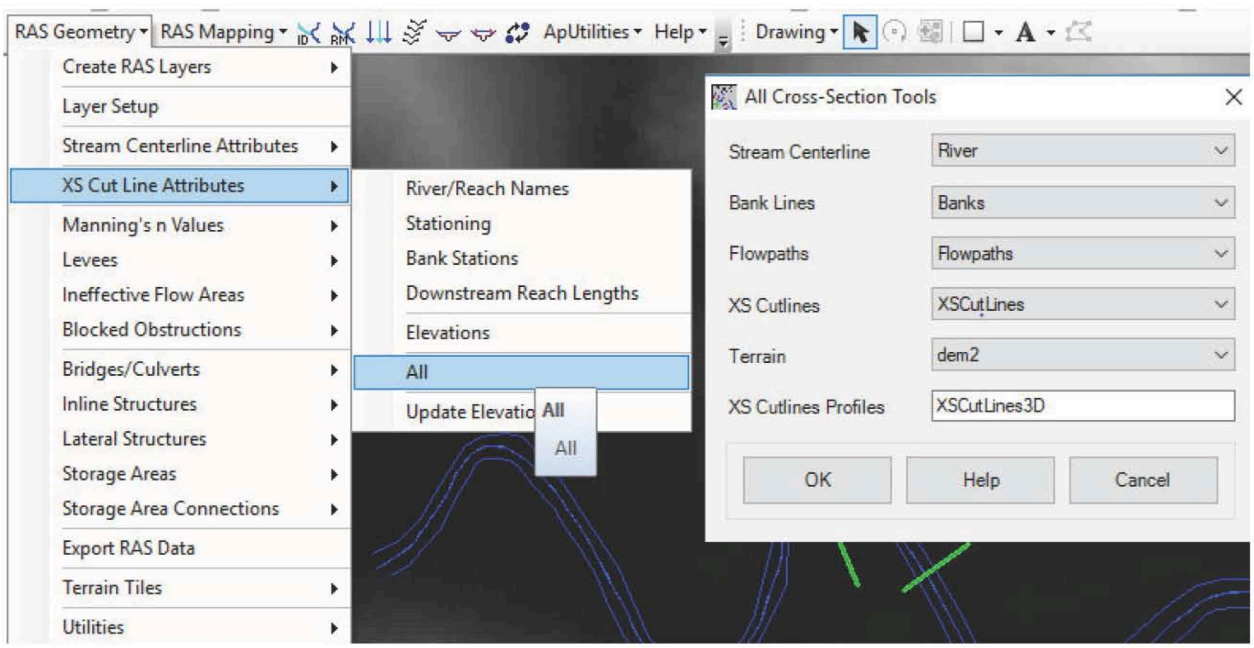


Figure No 30:XS Cut lines

After click ok

- After this process is finished, open the attribute table of XSCutLines3D feature class and see that the shape of this feature class is now PolylineZ (Fig. 67).

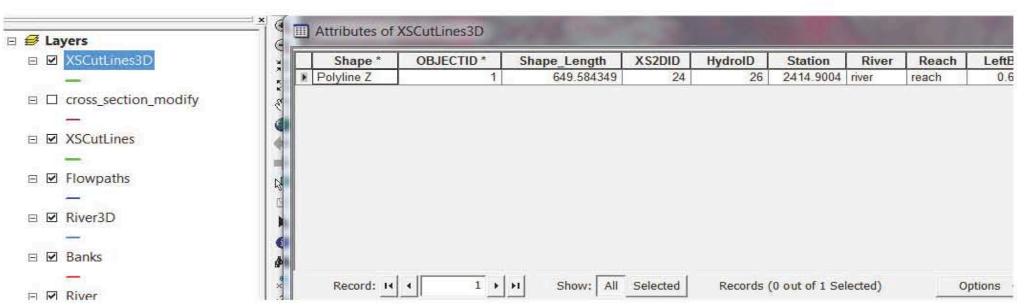


Figure no 31: XS Cut line 3D

Note: final and most important step before proceeding further is the data check, we will manually check the following feature classes:

River: Open the attribute table of River, and make sure all the attributes are correctly populated. Check the connectivity of the centerlines and make sure there are no negative or invalid numbers for any fields.

Flowpaths: Open the attribute table for Flowpath, and make sure that that the Line Type field is populated and that the line types are correct. For example, left should represent the left flowpath and Right should represent the right flowpath for each reach.

XSCutlines: Open the attribute table for XSCutline, and make sure that all the attributes are populated. Make sure that all numbers are positive for StationNo, RLenth, LLength and ChLength fields. If any number for RLength or LLength is negative for any cross section, that cross-section was most likely digitized in the wrong direction. Go back and flip that cross-section, and re-assign the attributes. Do this for all cross-sections that have negative numbers for RLength or Length.

After verifying all layers and tables, click on RAS Geometry→Export RAS data (Fig. 31). Confirm the location and the name of the export file (GIS2RAS in this case), and click OK. During the export, you will see a series of messages as shown in Fig. 31.

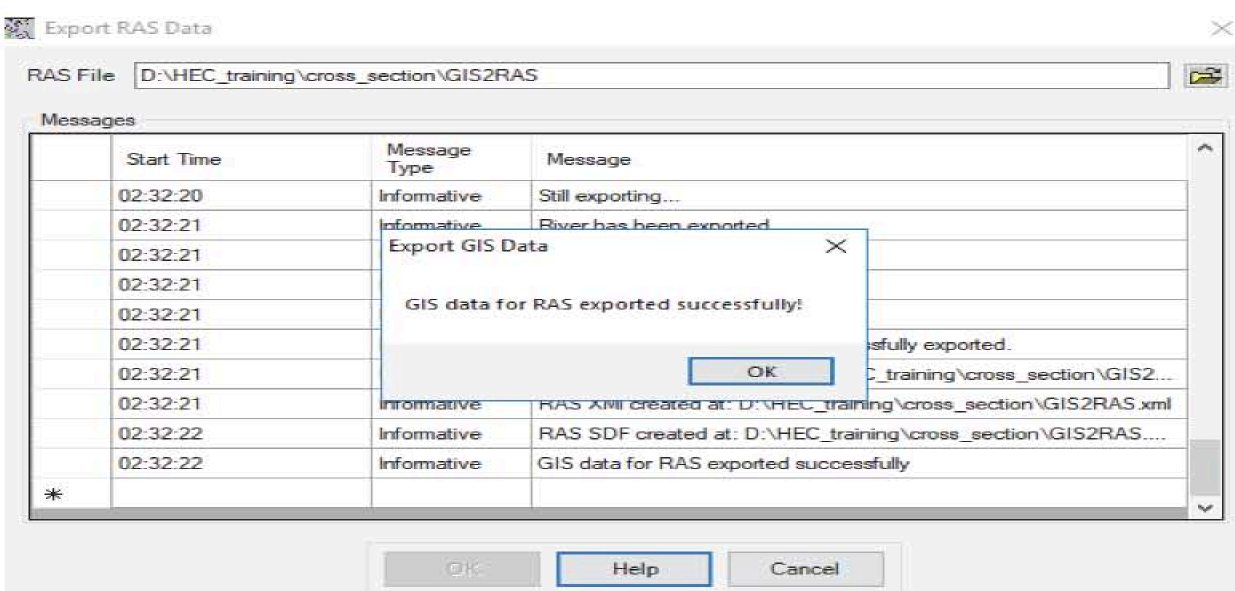


Figure No 31: Export RAS data

- After the export is complete, close the window. This process will create two files:
  GIS2RAS.xml
  GIS2RAS.RASImport.sdf.
  Import these data into a HEC-RAS model.

Importing Geometry data into HEC-RAS

1. Open HEC-RAS software (Fig. 32).

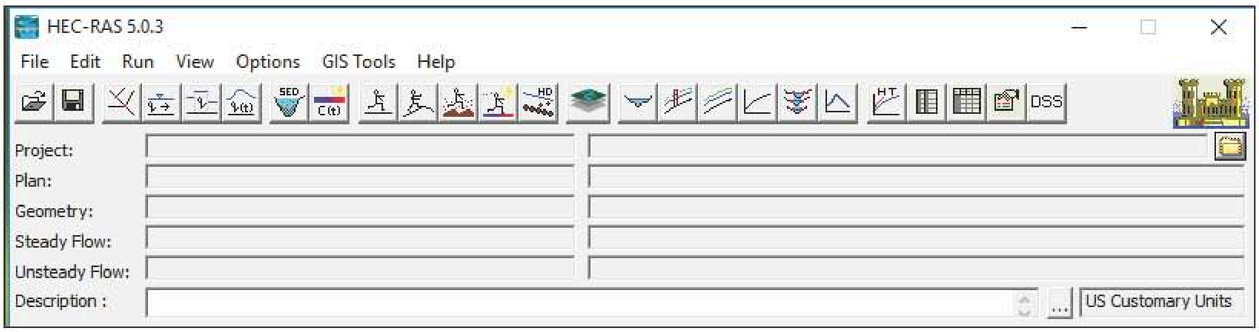


Fig. 32

2. Go to HEC-RAS 5.0.3 → Options→ Unit System (US Customary/SI)… (Fig. 52)

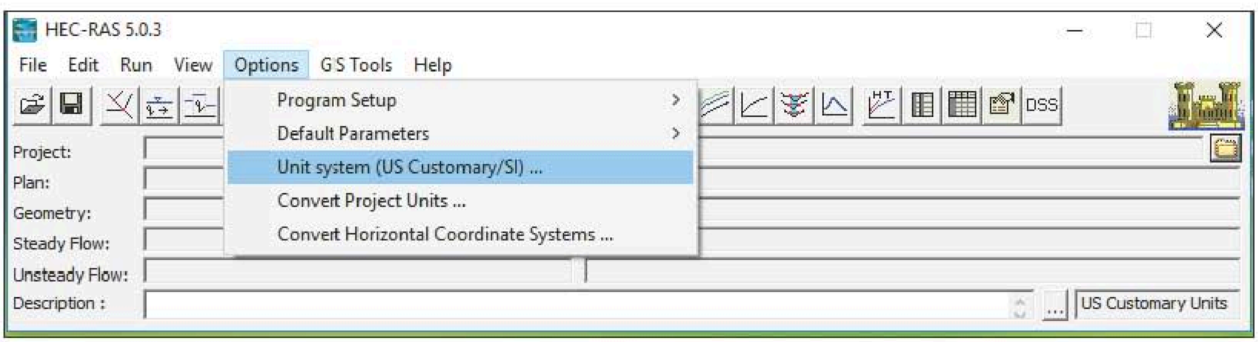


Fig. 52

3. HEC-RAS window (Fig. 53) will appear. Select System International (Metric System). Click Ok.
4. RAS acknowledge window will appear. Click Yes.

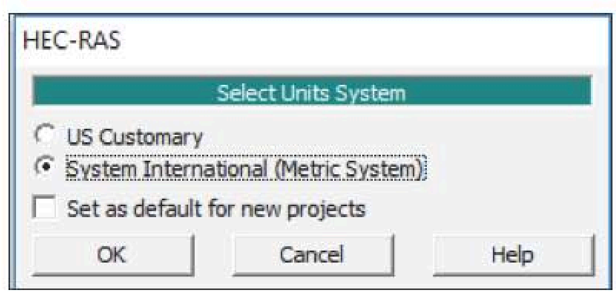


Fig. 53

5. Save the new project by going to File→Save Project As. Select working directory and save as Ukashi.prj as shown in fig. Fig. 54. Click OK

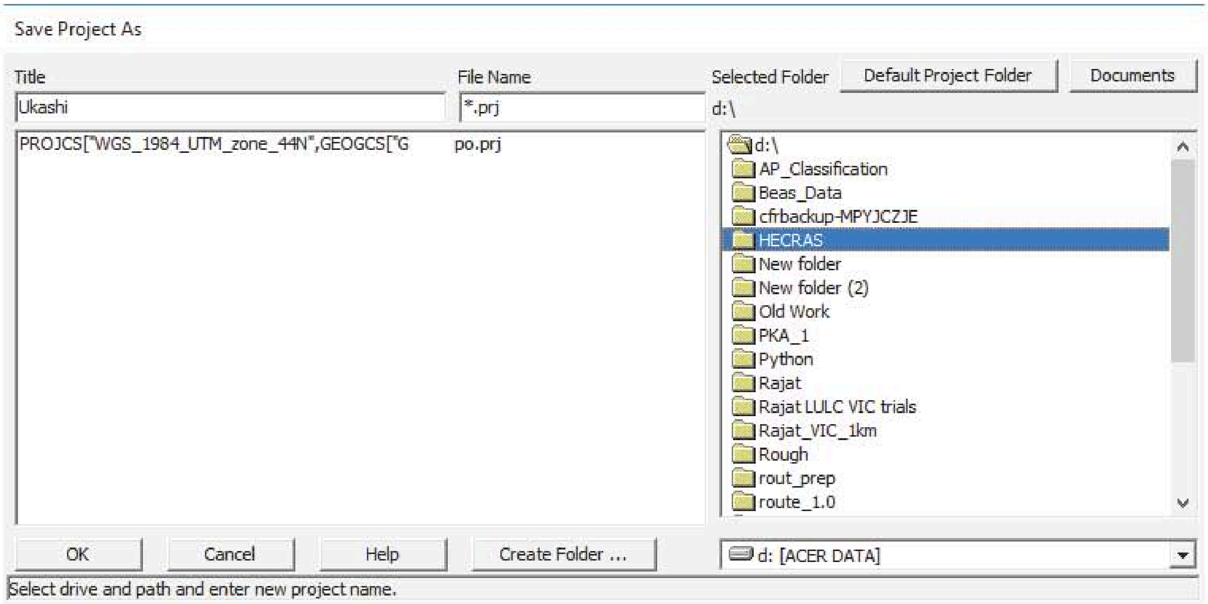


Fig. 54

6. To import the GIS data into HEC-RAS, Click on View/Edit Geometric Data . Geometric Data window (Fig. 55) will appear.

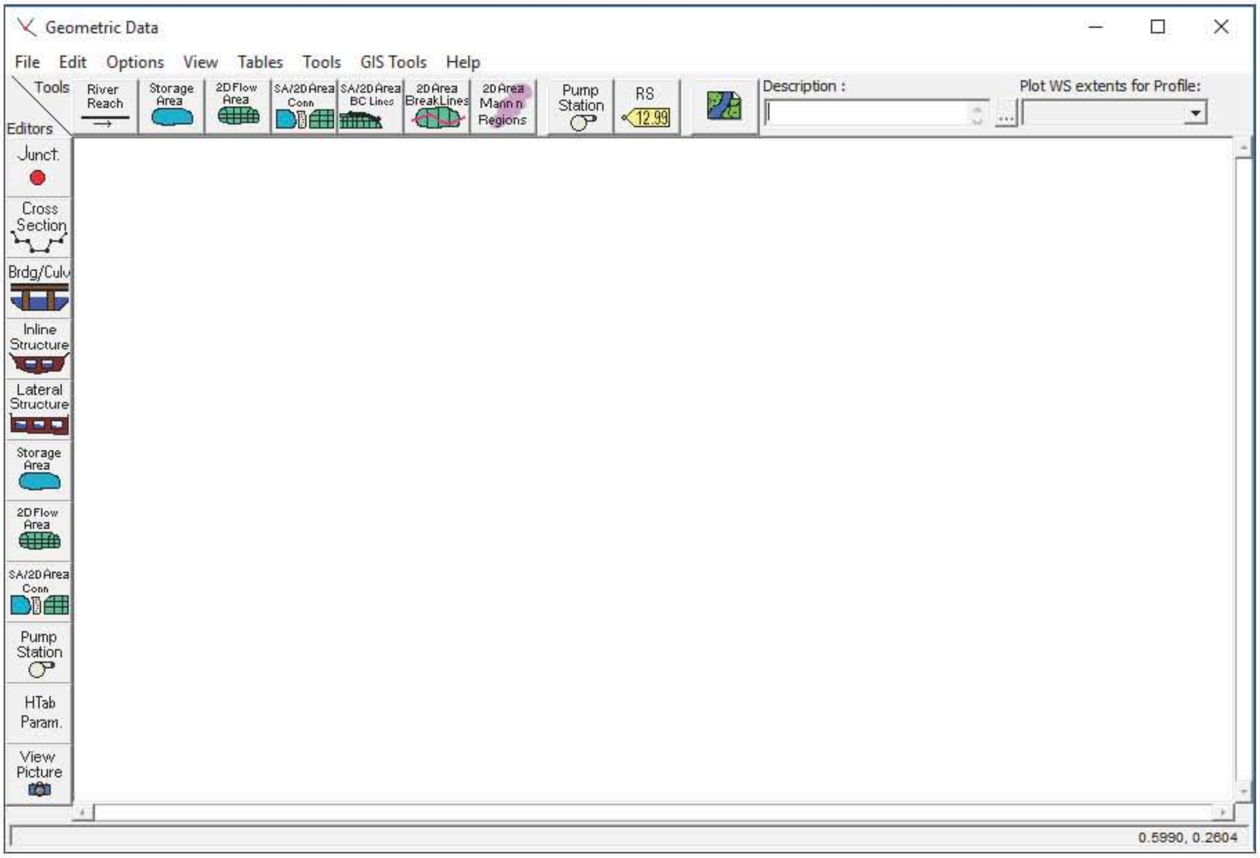


Fig. 55

7. Click on File→Import Geometry Data→ GIS Format (Fig. 56).

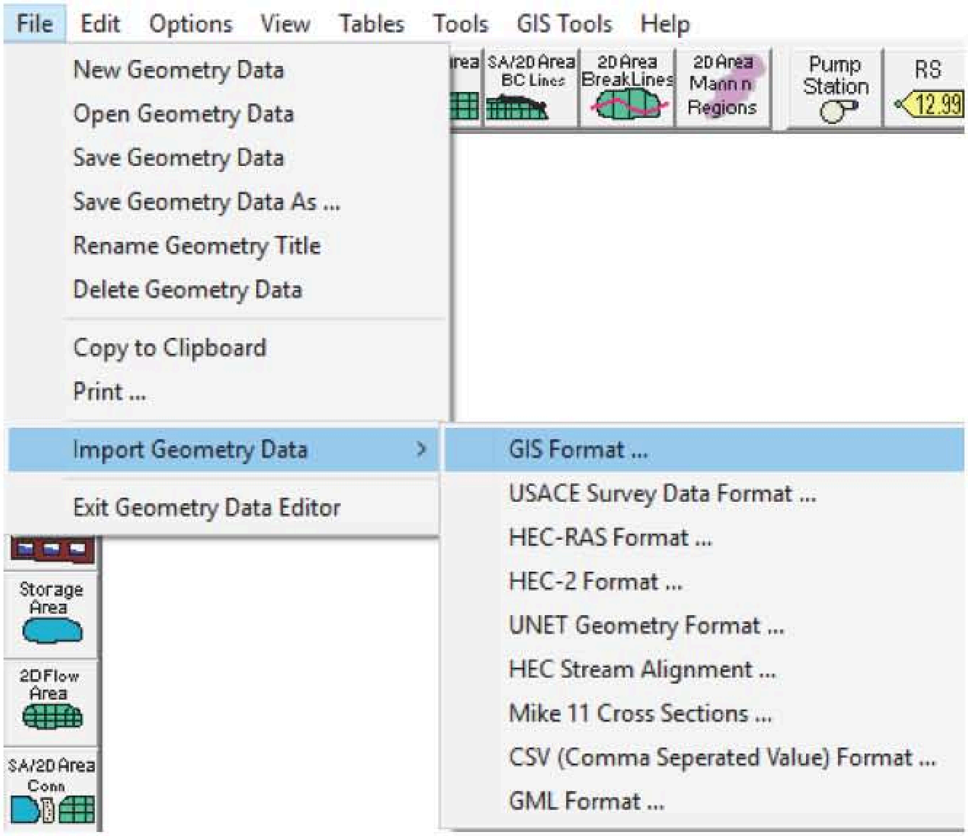


Fig. 56

8. **Import #GIS Format data** file (Fig. 57) will appear. Browse to **GIS2RAS.RASImport.sdf** file created in GIS, and click OK.

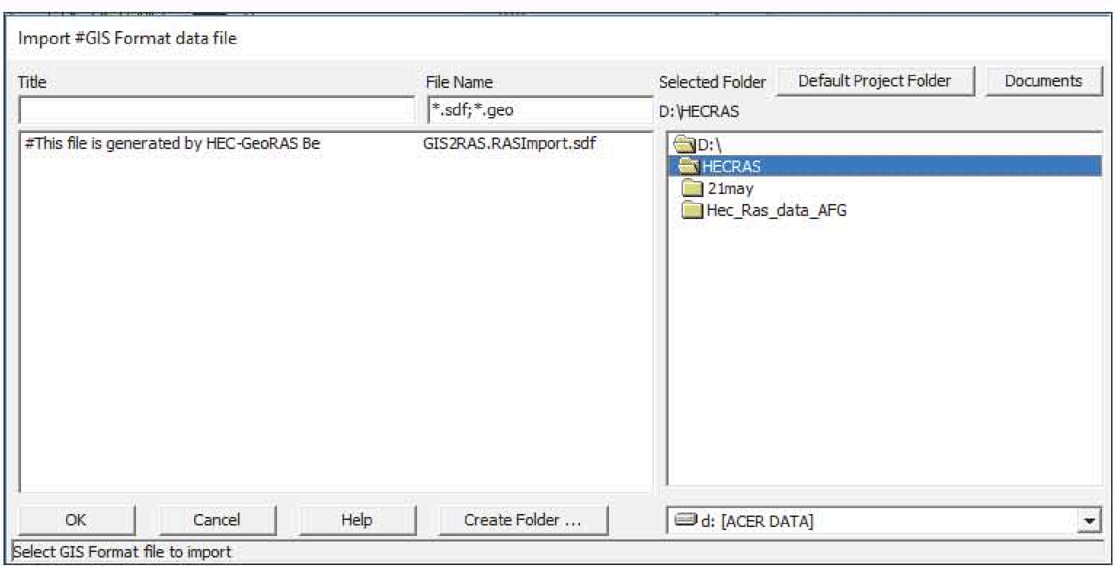


Fig. 57

9. Import Geometry Data window (Fig. 58) will appear. In the Intro tab, select SI (metric) Units for Import data as and click Next.

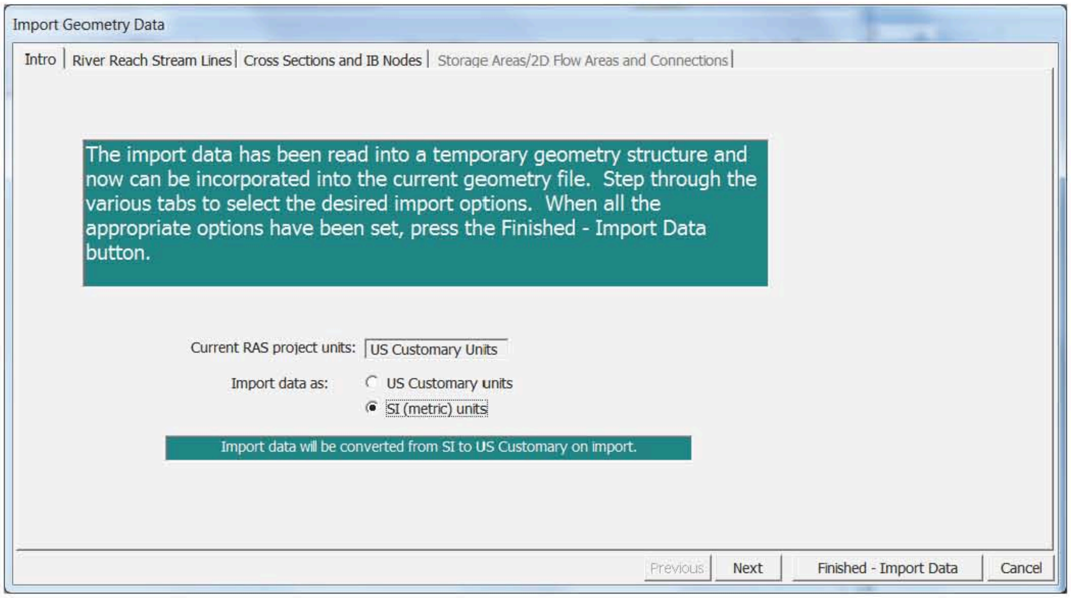


Fig. 58

10. Confirm the River/Reach data, make sure **Import stream lines** box is checked, and click **Next** as shown in Fig. 59.

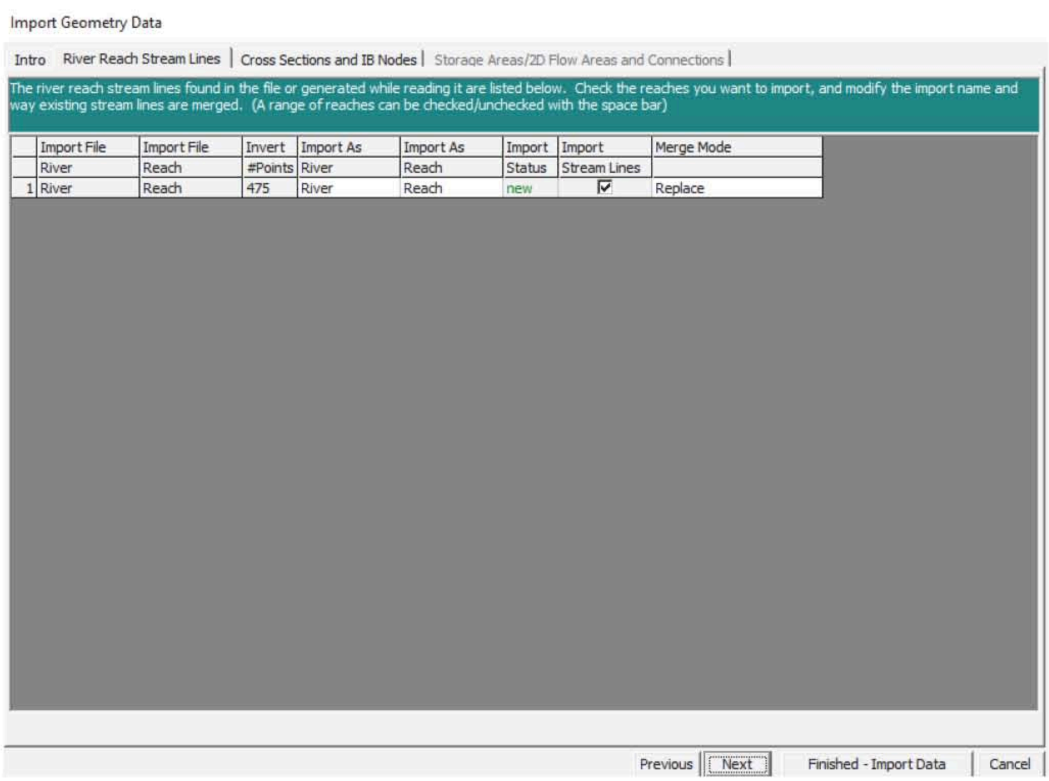
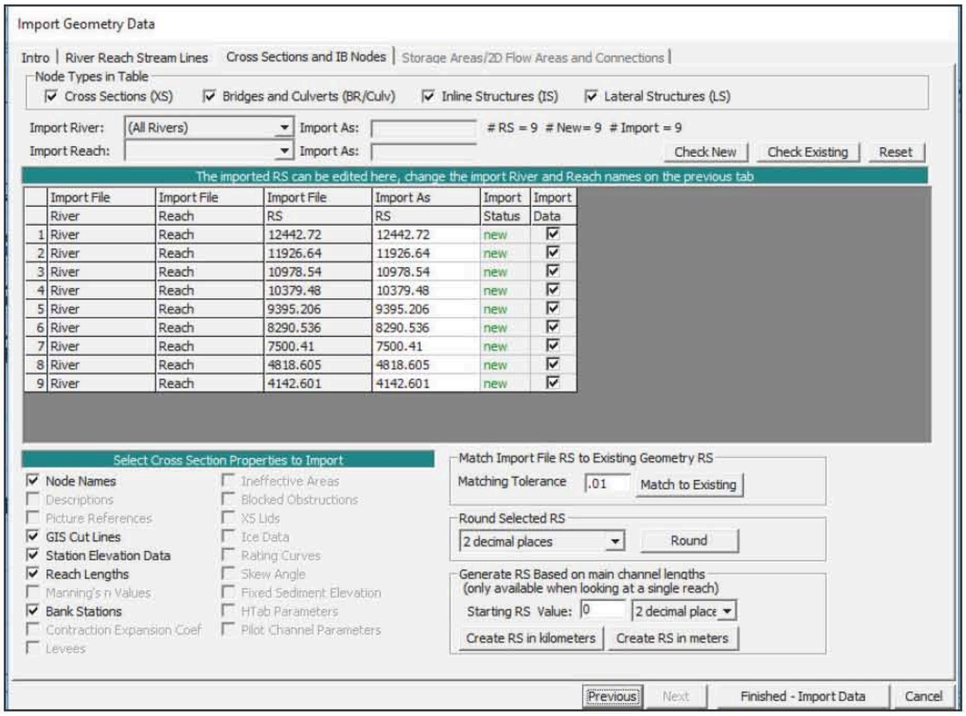


Fig. 59

11. Confirm cross-sections data; make sure all Import Data boxes are **checked** for cross-sections (Fig. 60), and **click Finished- Import Data** (accept default values for matching tolerance, round places, etc).



	Import File River	Import File Reach	Import File RS	Import As RS	Import Status	Import Data
1	River	Reach	12442.72	12442.72	new	☑
2	River	Reach	11926.64	11926.64	new	☑
3	River	Reach	10978.54	10978.54	new	☑
4	River	Reach	10379.48	10379.48	new	☑
5	River	Reach	9395.206	9395.206	new	☑
6	River	Reach	8290.536	8290.536	new	☑
7	River	Reach	7500.41	7500.41	new	☑
8	River	Reach	4818.605	4818.605	new	☑
9	River	Reach	4142.601	4142.601	new	☑

Fig. 60

12. The data will then be imported to the HEC-RAS geometric editor as shown in Fig. 61.

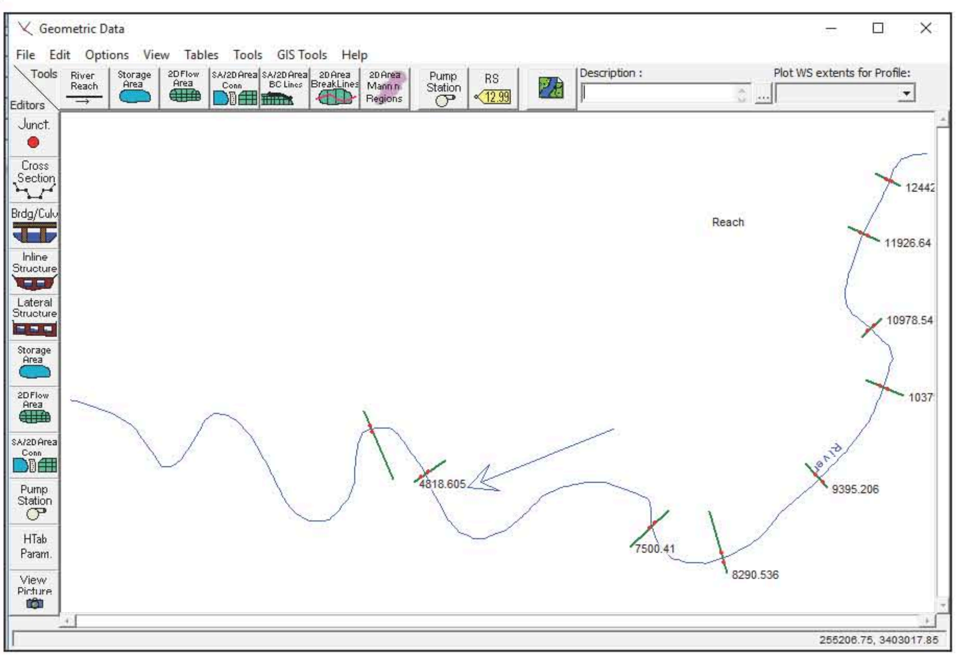


Fig. 61

13. Save the geometry file by clicking File→Save Geometry Data as Ukashi. Click OK.

14. Next, click on the Geometry editor and select Edit and /or create cross-sections tool.

15. You should see the cross-section window as shown in Fig. 62.

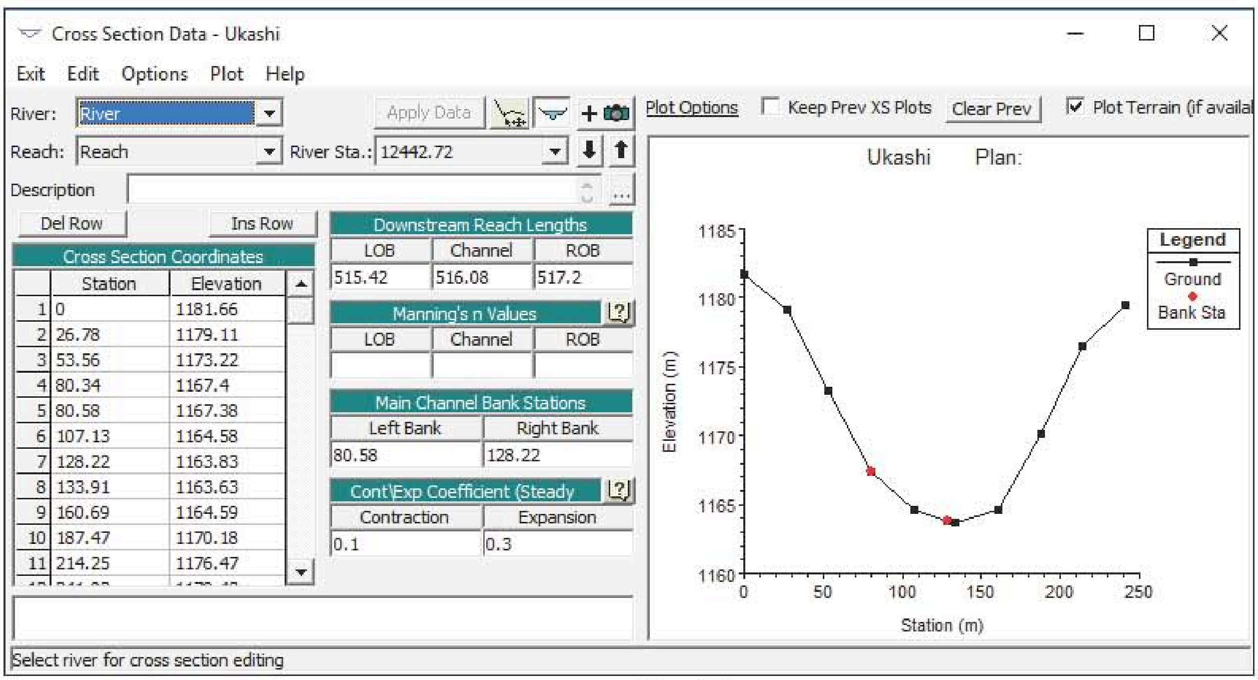


Fig. 62

Note: Each cross-section in HEC-RAS has the following information:

Location: This is described by using three pieces of information: River, Reach and River Station.

Elevation Profile: This is the profile view that you see on the right hand side in the cross-section window. This profile is created by using the information from the station and elevation columns in the Cross Section Coordinates table on the left. The numbers in the station column shows the distance along the cross-section from left to right (looking downstream along the flow direction), and the elevation column shows the elevation at each station point. You can think of Station and Elevation as the (x,z) attributes for the cross-section line. Each station/elevation point is represented by a black dot on the cross-section profile.

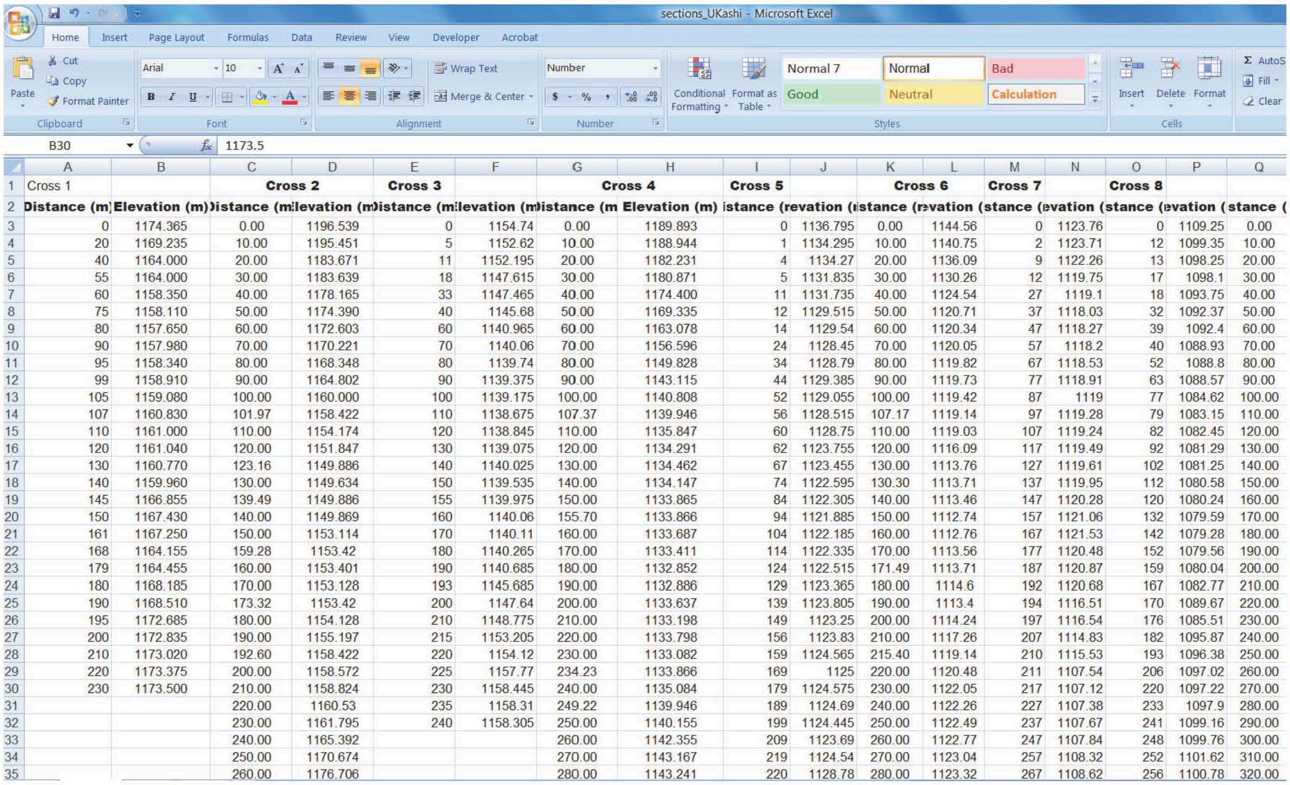
Bank locations: These are represented by two red dots on the cross-section profile. The location of these red dots is dictated by the station numbers for Left and Right Banks in the "Main Channel Bank Stations" table in the cross-section window.

Roughness (Manning's n Values): The horizontal line at the top of the cross-section profile shows the distribution of Manning'n value along the cross-section. This distribution is defined in the n Val column in the Cross Section Coordinates table. You will see that the n Val column is not populated for each row. The values are only reported at stations points where there is a change in the Manning's n.

Distance to the next downstream cross-section: This information is presented in the Downstream Reach Lengths table. The numbers for LOB, ROB and Channel represent the distances to the next downstream cross-section along the left over bank, right over bank and channel, respectively. These distances are computed by using the flow path features that are digitized in HEC-GeoRAS.

Note: ***As we have the surveyed value of elevations on cross section lines, so we replace the Station value and corresponding elevation value.***

16. Go to working directory open **sections_UKashi.xls** file (Fig. 63) which consist the value of distance (location) along with elevation values for each cross section lines.

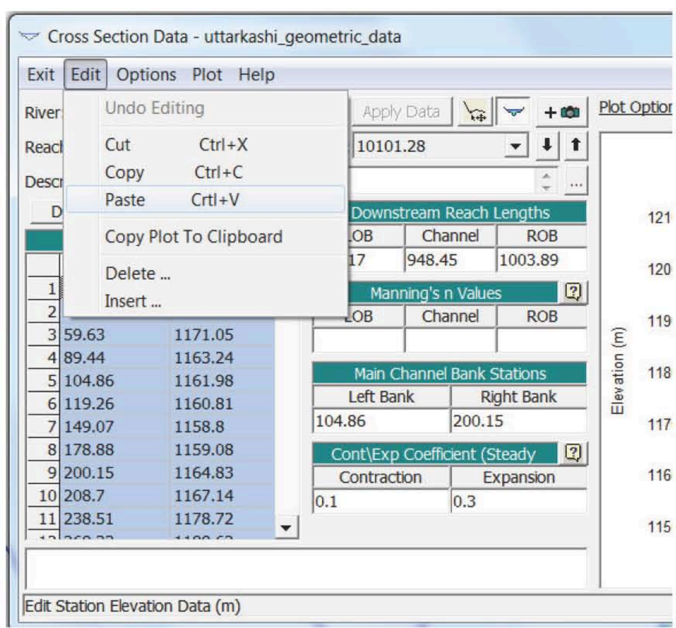


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Cross 1		**Cross 2**		**Cross 3**		**Cross 4**		**Cross 5**		**Cross 6**		**Cross 7**		**Cross 8**		
2	**Distance (m**	**Elevation (m)**	**)istance (m**	**levation (m**	**)istance (m**	**levation (m**	**)istance (m**	**Elevation (m)**	**istance (**	**evation (**	**istance (**	**evation (**	**stance (**	**evation (**	**stance (**	**evation (**	**stance (**
3	0	1174.365	0.00	1196.539	0	1154.74	0.00	1189.893	0	1136.795	0.00	1144.56	0	1123.76	0	1109.25	0.00
4	20	1169.235	10.00	1195.451	5	1152.62	10.00	1188.944	1	1134.295	10.00	1140.75	2	1123.71	12	1099.35	10.00
5	40	1164.000	20.00	1183.671	11	1152.195	20.00	1182.231	4	1134.27	20.00	1136.09	9	1122.26	13	1098.25	20.00
6	55	1164.000	30.00	1183.639	18	1147.615	30.00	1180.871	5	1131.835	30.00	1130.26	12	1119.75	17	1098.1	30.00
7	60	1158.350	40.00	1178.165	33	1147.465	40.00	1174.400	11	1131.735	40.00	1124.54	27	1119.1	18	1093.75	40.00
8	75	1158.110	50.00	1174.390	40	1145.68	50.00	1169.335	12	1129.515	50.00	1120.71	37	1118.03	32	1092.37	50.00
9	80	1157.650	60.00	1172.603	60	1140.965	60.00	1163.078	14	1129.54	60.00	1120.34	47	1118.27	39	1092.4	60.00
10	90	1157.980	70.00	1170.221	70	1140.06	70.00	1156.596	24	1128.45	70.00	1120.05	57	1118.2	40	1088.93	70.00
11	95	1158.340	80.00	1168.348	80	1139.74	80.00	1149.828	34	1128.79	80.00	1119.82	67	1118.53	52	1088.8	80.00
12	99	1158.910	90.00	1164.802	90	1139.375	90.00	1143.115	44	1129.385	90.00	1119.73	77	1118.91	63	1088.57	90.00
13	105	1159.080	100.00	1160.000	100	1139.175	100.00	1140.808	52	1129.055	100.00	1119.42	87	1119	77	1084.62	100.00
14	107	1160.830	101.97	1158.422	110	1138.675	107.37	1139.946	56	1128.515	107.17	1119.14	97	1119.28	79	1083.15	110.00
15	110	1161.000	110.00	1154.174	120	1138.845	110.00	1135.847	60	1128.75	110.00	1119.03	107	1119.24	82	1082.45	120.00
16	120	1161.040	120.00	1151.847	130	1139.075	120.00	1134.291	62	1123.755	120.00	1116.09	117	1119.49	92	1081.29	130.00
17	130	1160.770	123.16	1149.886	140	1140.025	130.00	1134.462	67	1123.455	130.00	1113.76	127	1119.61	102	1081.25	140.00
18	140	1159.960	130.00	1149.634	150	1139.535	140.00	1134.147	74	1122.595	130.30	1113.71	137	1119.95	112	1080.58	150.00
19	145	1166.855	139.49	1149.886	155	1139.975	150.00	1133.865	84	1122.305	140.00	1113.46	147	1120.28	120	1080.24	160.00
20	150	1167.430	140.00	1149.869	160	1140.06	155.70	1133.866	94	1121.885	150.00	1112.74	157	1121.06	132	1079.59	170.00
21	161	1167.250	150.00	1153.114	170	1140.11	160.00	1133.687	104	1122.185	160.00	1112.76	167	1121.53	142	1079.28	180.00
22	168	1164.155	159.28	1153.42	180	1140.265	170.00	1133.411	114	1122.335	170.00	1113.56	177	1120.48	152	1079.56	190.00
23	179	1164.455	160.00	1153.401	190	1140.685	180.00	1132.852	124	1122.515	171.49	1113.71	187	1120.87	159	1080.04	200.00
24	180	1168.185	170.00	1153.128	193	1145.685	190.00	1132.886	129	1123.365	180.00	1114.6	192	1120.68	167	1082.77	210.00
25	190	1168.510	173.32	1153.42	200	1147.64	200.00	1133.637	139	1123.805	190.00	1113.4	194	1116.51	170	1089.67	220.00
26	195	1172.685	180.00	1154.128	210	1148.775	210.00	1133.198	149	1123.25	200.00	1114.24	197	1116.54	176	1085.51	230.00
27	200	1172.835	190.00	1155.197	215	1153.205	220.00	1133.798	156	1123.83	210.00	1117.26	207	1114.83	182	1095.87	240.00
28	210	1173.020	192.60	1158.422	220	1154.12	230.00	1133.082	159	1124.565	215.40	1119.14	210	1115.53	193	1096.38	250.00
29	220	1173.375	200.00	1158.572	225	1157.77	234.23	1133.866	169	1125	220.00	1120.48	211	1107.54	206	1097.02	260.00
30	230	1173.500	210.00	1158.824	230	1158.445	240.00	1135.084	179	1124.575	230.00	1122.05	217	1107.12	220	1097.22	270.00
31			220.00	1160.53	235	1158.31	249.22	1139.946	189	1124.69	240.00	1122.26	227	1107.38	233	1097.9	280.00
32			230.00	1161.795	240	1158.305	250.00	1140.155	199	1124.445	250.00	1122.49	237	1107.67	241	1099.16	290.00
33			240.00	1165.392			260.00	1142.355	209	1123.69	260.00	1122.77	247	1107.84	248	1099.76	300.00
34			250.00	1170.674			270.00	1143.167	219	1124.54	270.00	1123.04	257	1108.32	252	1101.62	310.00
35			260.00	1176.706			280.00	1143.241	220	1128.78	280.00	1123.32	267	1108.62	256	1100.78	320.00

Fig. 63

17. Copy Distance (location) and elevation of each cross section lines from excel file and go to HEC-RAS's Cross Section data window. Click on cross section coordinate sub window. It will select all station and elevation values.

18. Go to edit and click on Paste (Fig. 64). It will replace automatic geometric data



value with survey geometric data.

Fig. 64

19. In Manning's n Values option assign **0.04** for LOB, Channel and ROB.

20. In main Channel bank Stations option, replace the value of Left Bank and Right Bank by the nearest values using data in excel file eg. First cross section replaces 44.28 by 40 and 176.79 by 179.

21. Click on ⬇ arrow tool for going to next cross section.
22. Cut Line Extension Option window will (Fig. 65) appear. Click on **Accept edits and adjust cut line** option.

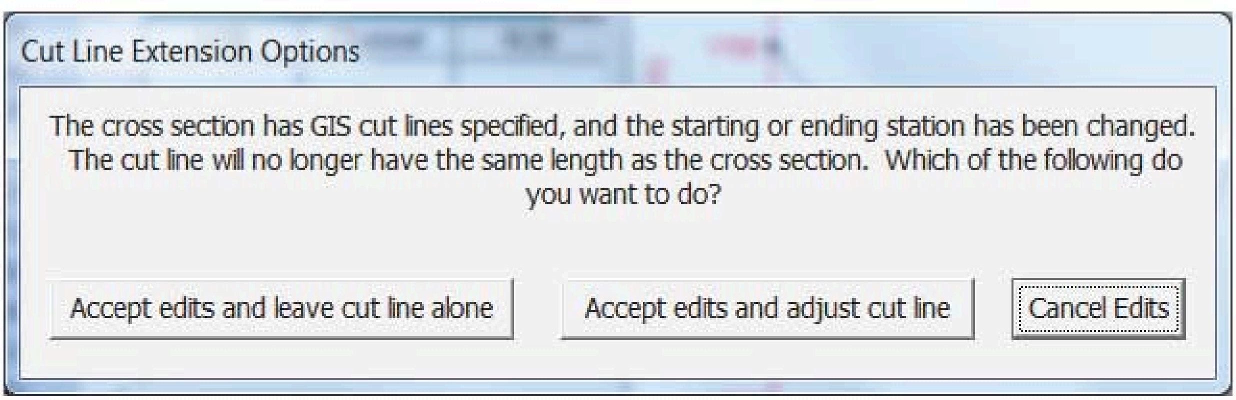


Fig. 65

23. Now window for next cross section elevation will come. Apply similar steps for others cross

section.

24. Close Cross Section Data window.

25. Go to **Geometric Data window → File**. Click on **Save Geometric Data**. Close Geometric Data window.

EXERCISE 5:

HYDROLOGICAL MODELLING USING HEC-HMS

Rainfall Runoff Analysis through given input data (see in table no 1)

S no	Item (content Type)	Value
1	Area of Basin 1	4285 sq km
2	Loss Method	SCS Curve Number
3	Transform Method	SCS Unit Hydrograph
4	Base flow Method	None
5	Curve Number	75
6	Impervious (%)	0.0
7	Graph Type	Standard (PRF484)
8	Log Time	00:00
9	Precipitation Time	01 Jan 1979 to 31 Aug 2017
10	Data Source	Manually Entry
11	Unit	Incremental Millimetre
12	Time Interval	1 Day

Table No 1: Input Data

1. **Step by step procedure for Creating a Single Basin HEC-HMS Model**

   Open HEC-HMS software from file menu
   Click on start and select HEC-HMS
   Automatically HEC-HMS window open (see in fig no 1)

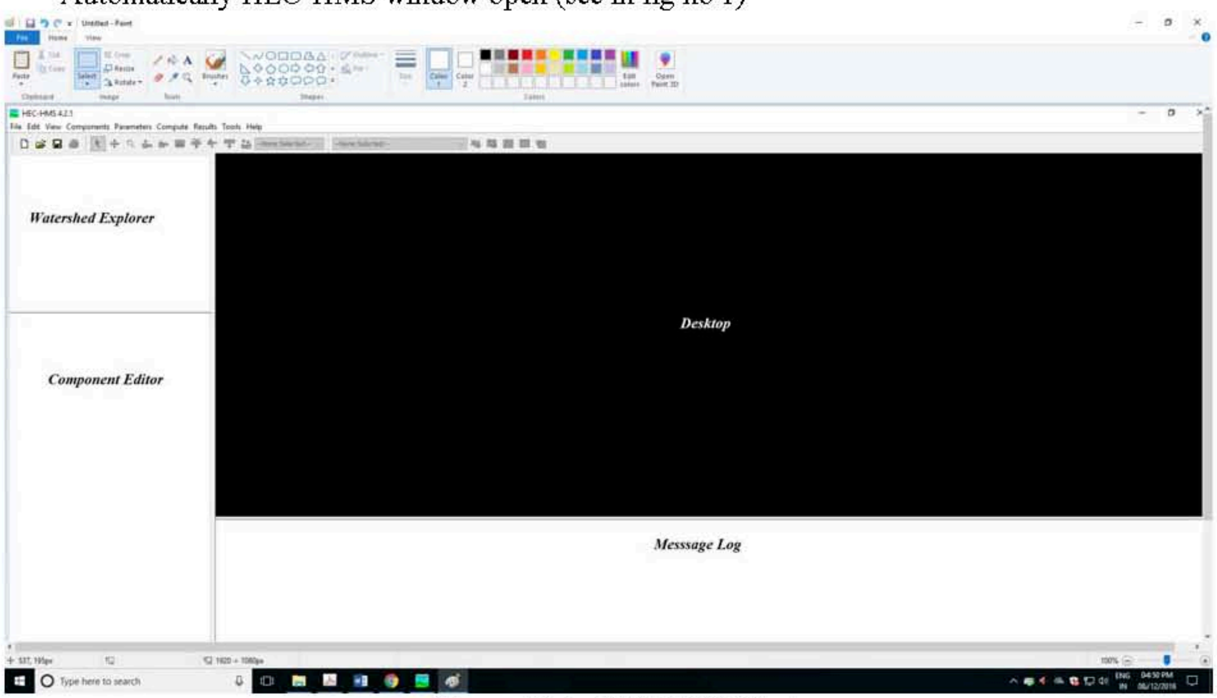


Figure No 1: HEC-HMS Window

2. Description of Tool

S No.	Name	Image	Description
1	New		Create a New Project
2	Open		Open A project
3	Save		Save A Project
4	Print		Print current selection
5	Arrow Tool		Object selection
6	Pan Tool		Moving Object (Manually)
7	Zoom tool		Magnifier
8	Sub basin	 #	Sub basin creation tool
9	Reach	 #	Reach creation Tool
10	Reservoir	 #	Reservoir Creation tool
11	Junction	 #	Junction creation tool
12	Diversion	 #	Diversion Creation Tool
13	Point source	 #	Source Creation tool
14	Outlet	 #	Sink creation tool

Table No 2: Description of Tool Bar

3. Create a New Project (demo1): On the main Menu, click on File>>New. First specify the location of where you want to save your project, give a name (demo11), accept the default unit system (Metric), and click on Create. Note that the unit system may be different for different projects (see in fig no 2).

Step1: Click on File and select new (Ctrl+N)
Step2: Write project Name (demo1)
Step 3: Description of project
Step4.1: Browse project location (HEC-HMS for single basin
Step4.2: Select directory where save the project (*D:\hechms)*
Step5: Click on Create

After that automatically demo1 project show in HEC-HMS window

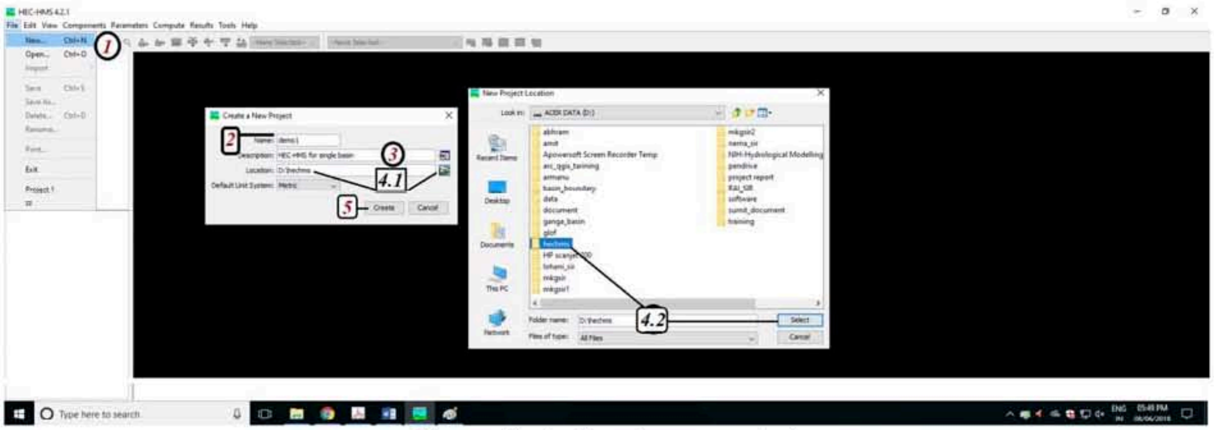


Figure No 2: Create new project

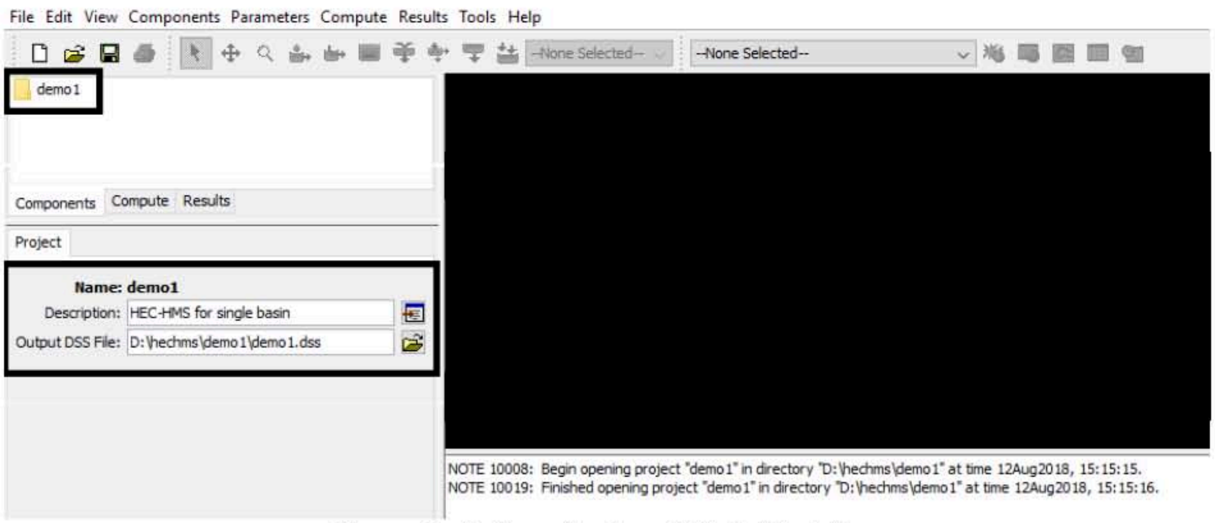
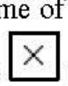


Figure No 3: Show the demo1 file in black box

4. **Create Basin Model:** A basin model represents the physical description of the watershed in a HEC-HMS project. First an empty basin model is created, and then it is populated with all the necessary information needed to create the complete description of a watershed. In addition to including the physical description, a basin model also includes information on the mathematical methods (or equations) that will be used in simulating the hydrology of the basin, and the values for all the variables in those equations. The variables in all the equations are called parameters because by changing the values for these parameters we can change the output from the model.

   See in fig no 4
   Step1: Click on Component and select Basin Model Manager
   Step2: Click on New
   Step3: Give name of basin (Basin1) than click on create
   After that close  the window

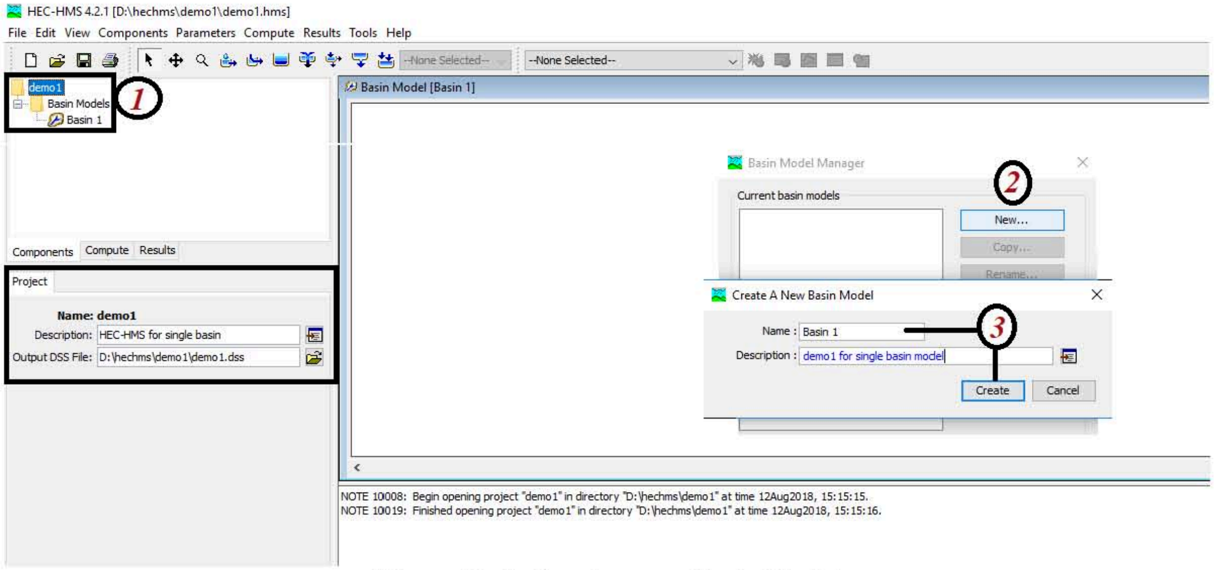


Figure No 4: Create a new Basin Model

5. **Create sub-basin**: This is done by using the create sub-basin tool ( ). Select the sub-basin tool, and click on the basin model (white window in the desktop pane). You will be prompted to enter the name and description of the new sub-basin as shown below.

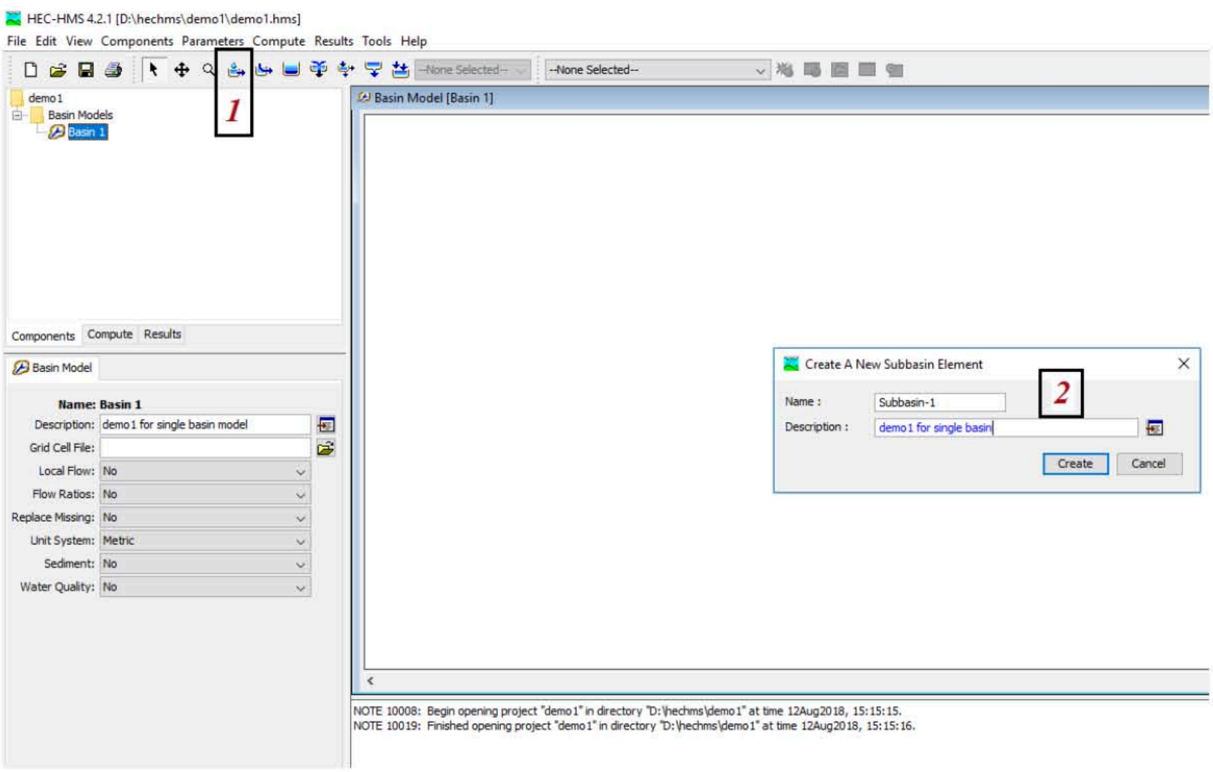


Figure No 5: Create sub-basin

Click Create. You will see that your basin model now has a sub-basin and all the information related to this sub-basin can be entered in the component editor. A sub-basin is just one of the components of your basin model.

Expand Basin 1 and Sub-basin 1 in the watershed explorer, and you will see the following (or a variation of it).

Step 1: Simple click on sub basin after that click on window

Step 2: Type name of Sub basin (Subbasin-1) click create than close sub basin window

This information can be edited by using the component editor, and each label above is related to a "method" in the basin model. You can think of a method as a hydrologic process, and then you have to choose which equation you want to use to simulate this hydrologic process. The Canopy method allows users to model the interception and evapotranspiration in the watershed. For this demo, we will ignore this method. The surface method allows users to represent depression storage in the watershed. Again, we will ignore surface method for this lab. The next method allows users to represent losses in the rainfall. We know that not all rainfall becomes runoff because some of it is lost to infiltration. The loss method lets users to model this infiltration by using various equations. We have not covered this topic in the class yet, but for completing this lab, just change the loss method to SCS Curve Number for now by using the component editor. The transform method allows users to convert the rainfall (after subtracting losses) to streamflow hydrograph. Change the transform method to SCS Unit Hydrograph. Base flow method allows users to account for existing flow conditions in the outlet stream. Again, we will ignore base flow for this lab.
Finally, enter the area of the watershed (4285 km2) in the area box of the component editor. If you see input for latitude, longitude, etc., simply ignore those for now. The exact placement of this sub-basin is not important for this demonstration.

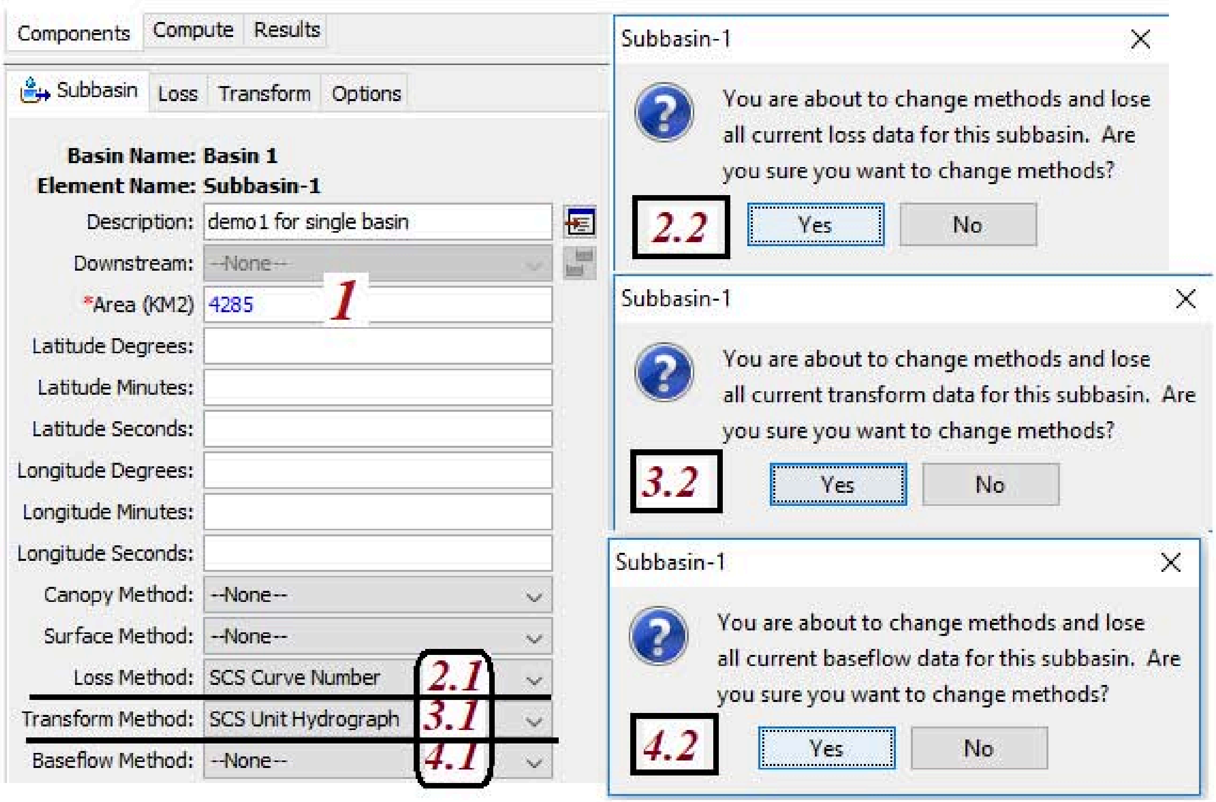


Figure No 6: Basin Description

By specifying names for each method, we are basically telling the program which equation to use. To execute these equations, we need to also specify values for all the variables (parameters) needed.

The values for these parameters are provided in the additional tabs that you see in the component editor for each method. Because we only chose two methods (Loss and Transform), you will see that there is a tab for each method in the component editor. Click on the Loss tab, and enter a value of zero for initial abstraction, 75 for curve number and zero for impervious cover. We will learn about these variables later in the semester. In the transform tab, enter a value of 60 min for lag time

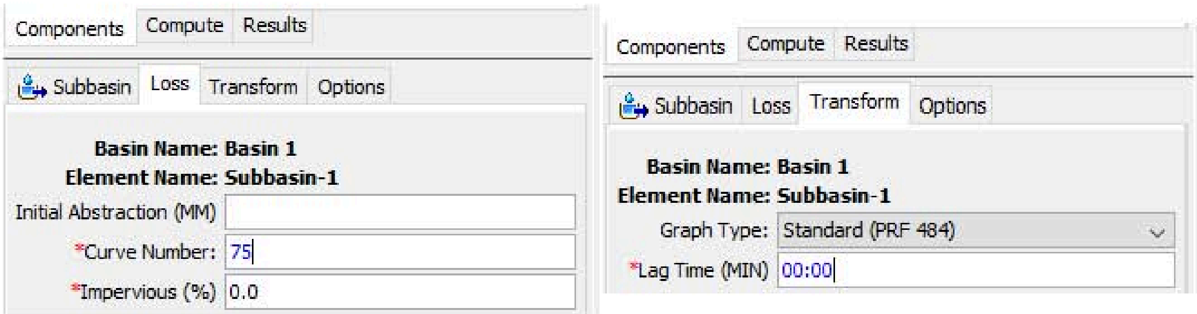


Figure No 7: Basin Loss & Transform Information

Do not input any information for options. Select "None" for Canopy, Surface and Base flow methods. Save your project. You have now entered all the necessary information needed to represent a watershed in the basin model.

Go back to windows explorer, and open the Basin1.basin file in notepad to see how all the information in the basin model is stored in a simple text file. Now that we have a basin model, we need some input to drive the simulation. The primary driver of a hydrologic event is precipitation. Note that precipitation/rainfall are typically recorded using weather stations or rainfall gauges. So to provide rainfall input, we first have to create a precipitation gage.

6. **Create a Precipitation Gage station:** To create a precipitation gage, go to Components Editor>>Time Series Data Manager. Select Data Types as precipitation gages, and click on New. Use the default name and provide some basic description for the gage. Click Create.

   In the watershed explorer, you will see that a new folder called Time Series is created. Expand this folder to see another folder called Precipitation Gages, and then gage1 is created inside the Precipitation Gages folder. We will populate this gage with the information presented in the table below. What we have here is daily rainfall data in mm from Jan 01, 1979 to 31 August 2017. Note that this information is hypothetical!

   Step1: Click on component
   Step2: select time series data manager
   Step3: Click on new
   Step4: Type gage name and description

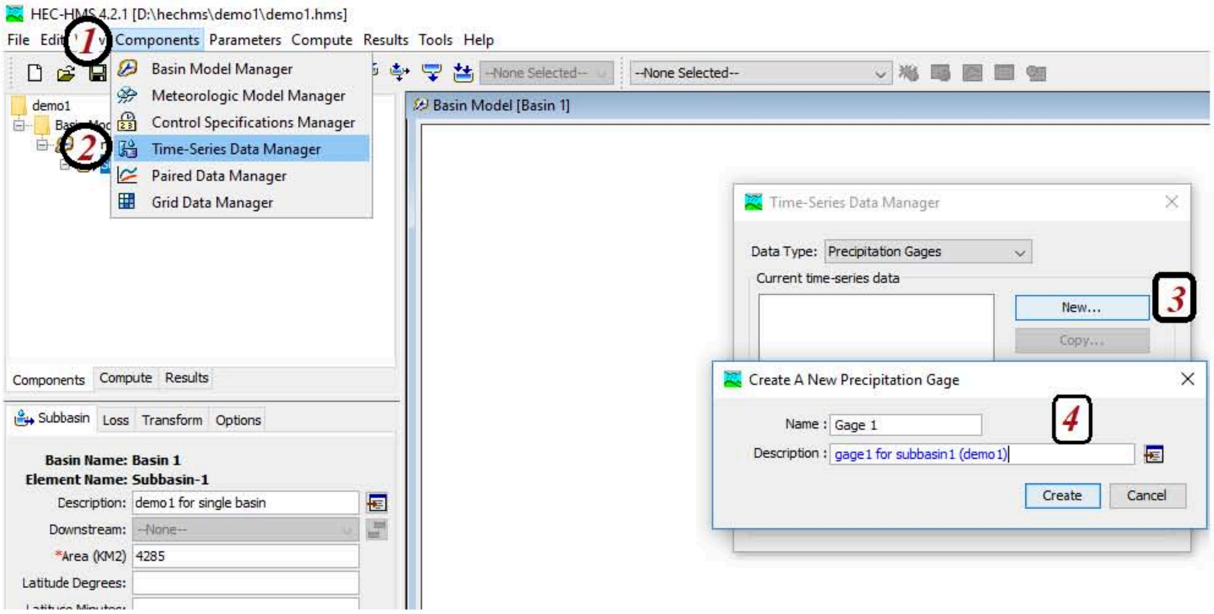


Figure No 8: Component Analysis

The gage that we just created has the input that we need, but the program does not know that this gage is located in the sub-basin we have created. To link this precipitation to the sub-basin, we need to create a meteorologic model. Before you proceed, check that the units for rainfall are correct.

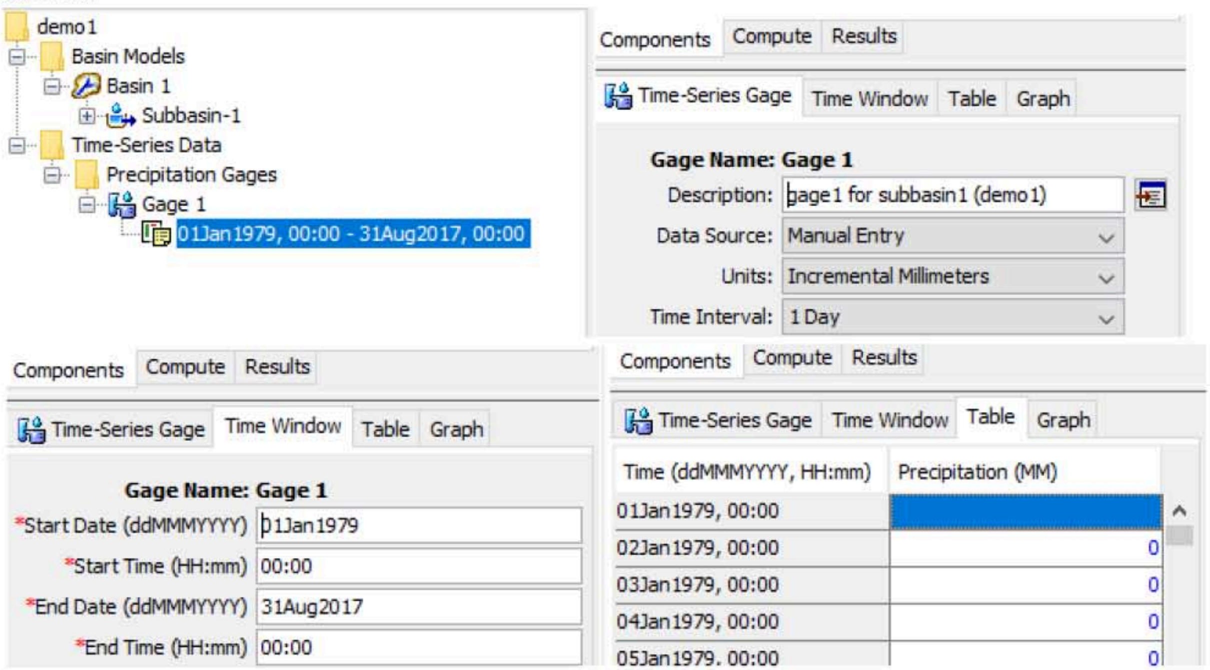


Figure No 9: Gage 1 Data

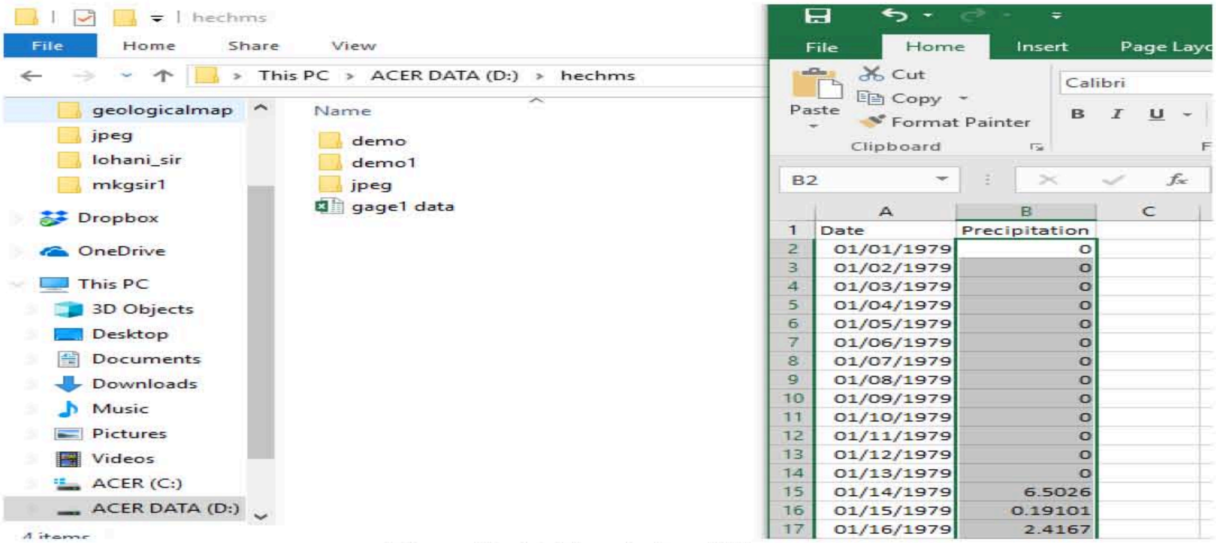


Figure No 10: Data in Excel Sheet

7. **Create new metrological model:** A meteorologic model or file contains meteorologic information to drive the hydrologic simulation. You cannot run a HEC-HMS simulation without a meteorologic model/file. To create a meteorologic model, go to Components>>Meterologic Model Manager, and create New. Use the default name and provide some basis description and click Create.
   Step1: Click on Component
   Step2: Click on Metrologic Model Manager
   Step3: Click on new
   Step4: Type Name and description

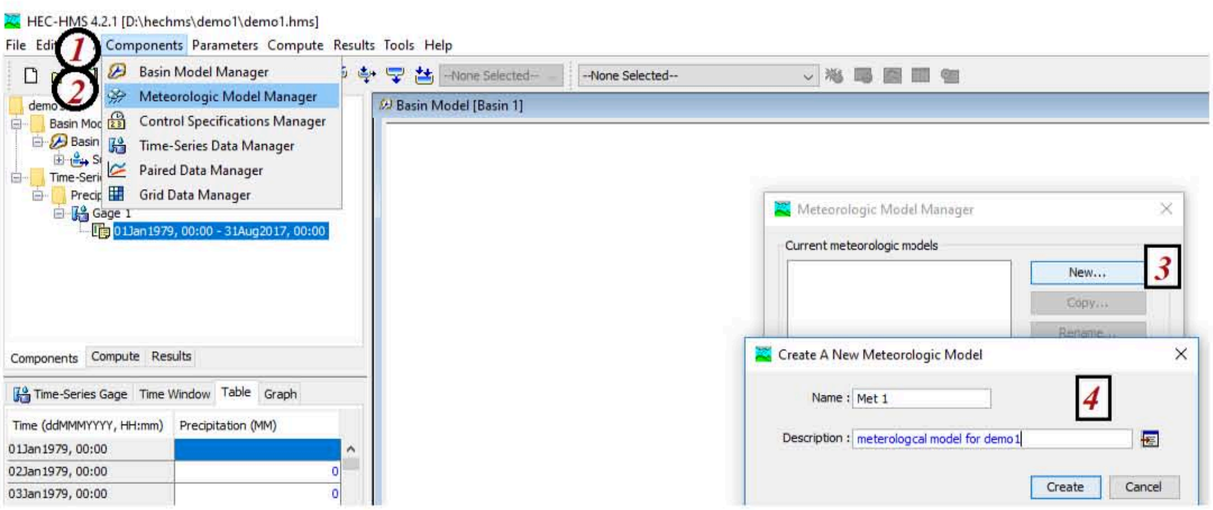
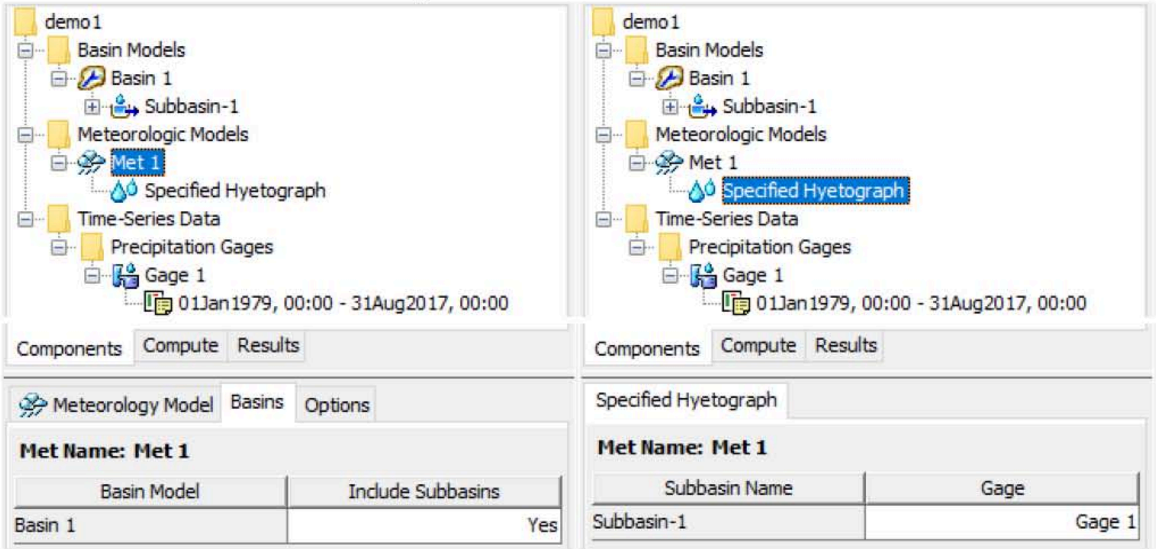


Figure No 11: Metrologic Model Manager

You will see a new folder called Meteorologic Models in the watershed explorer, and if you expand this folder, you will see the Met 1 file that you just created. Under Met 1 label, you will see Specified Hyetograph label. Click on Met 1 in the watershed explorer and then click on the Basins tab in the Component editor, and then click Yes on Include sub-basins. This will link gage 1 to sub-basin1.

Next, select the specified hyetograph label in watershed explorer, and then select Gage1 for sub-basin 1 in the component editor as shown below.#



#

Figure No 12: Specified Hydrograph

Next, select the Met 1 and then change the Replace Missing to "Set to Default" as shown below. The earlier option (abort) will not let the model run if the simulation time is longer than the rainfall duration.

Save your project. Now we have the watershed description and the input information. The next thing is to provide some basic information on the time-step to run the model and the duration because we know that the rainfall occurred from 00:00 to 00:00.

8. Creating a Control Specification Model

Step 1: Click on Component

Step 2: Click on control Specification Manager

Step 3: Select new

Step 4: Create (Name: Control 1, Description: Control Specification for demo1)

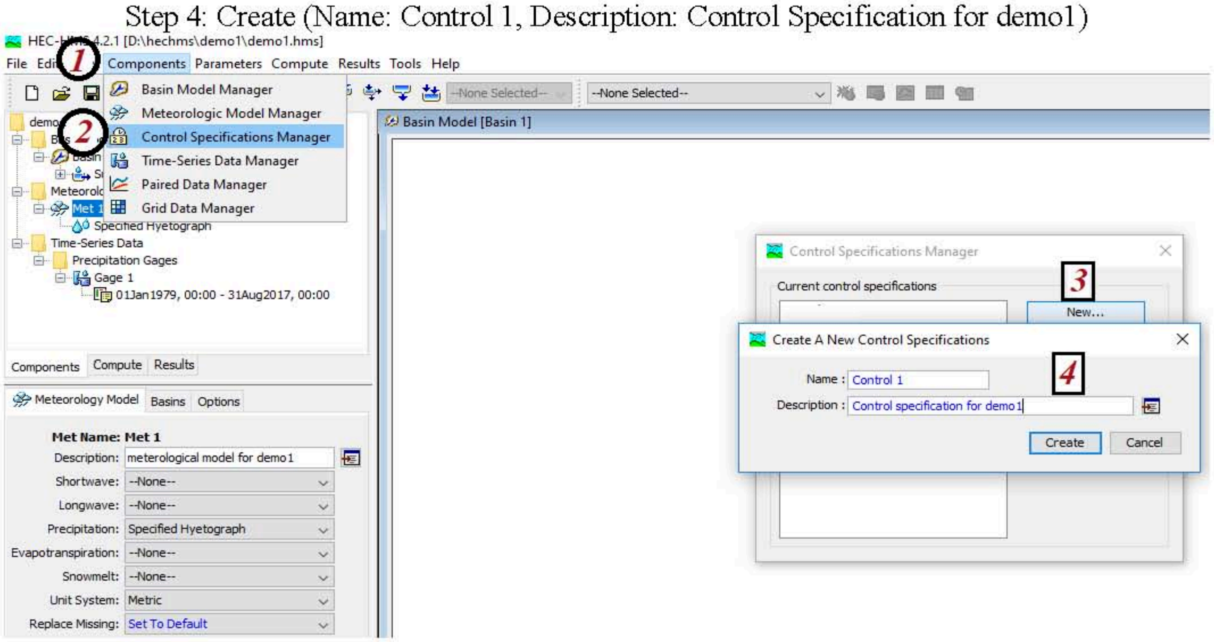


Figure No 13: Control Specification Manager#

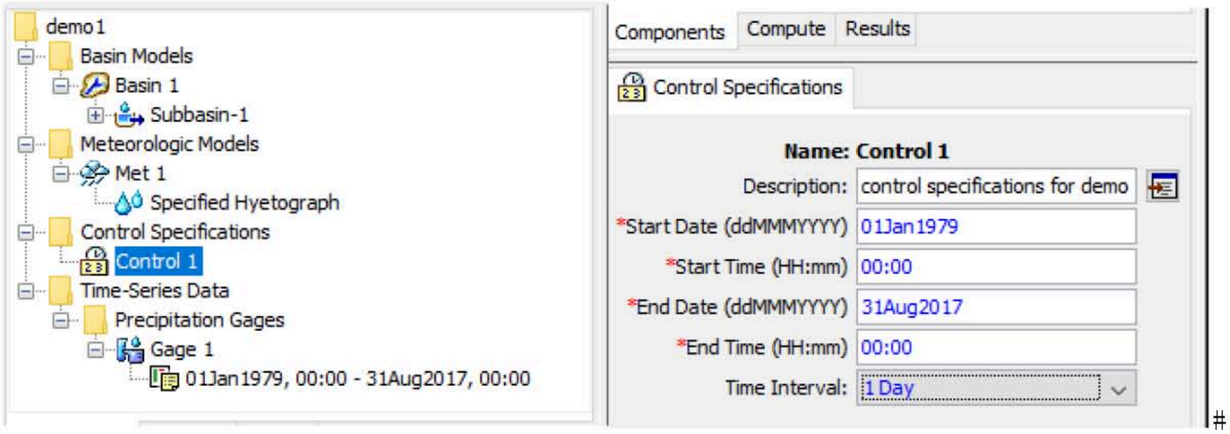


Figure No 14: Control Specification

9. Creating a Simulation Run

To create a simulation Run go to Compute>>Create Compute>>Simulation Run. Accept the default name Run 1 and then accept all the default models and finish creating the run. If you had more than one model for Basin, Meteorology and Control specification, you get to select them during this step. Because we have only one model for each, the process is straight forward. Save the project.

Running a Simulation

Once a simulation run is created, select the simulation by going to the Compute tab in the watershed explorer and select the run as shown below (see result in figure no 16).

Step 1: Click on Compute
Step 2: Create Compute>>Simulation Run
Step 3: Name- Run1
Step 4: Select Basin 1
Step 5: Select Metrological data (Met1)
Step 6: Select Control Configuration (control 1)

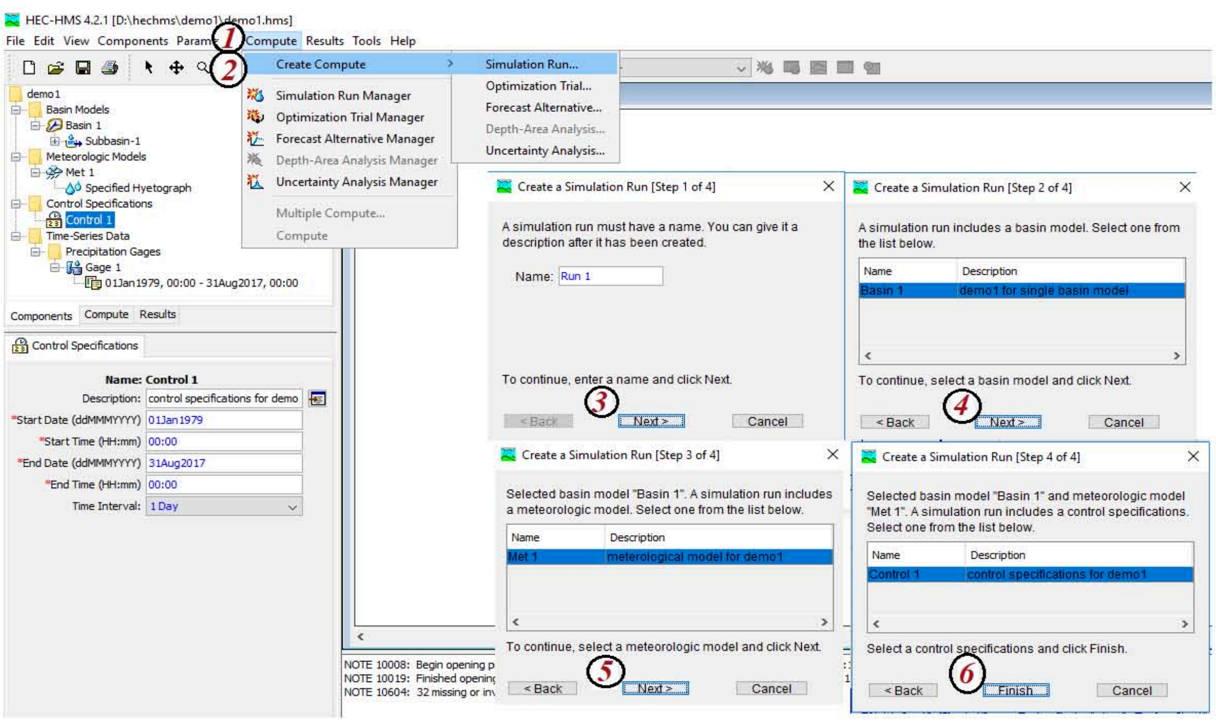


Figure No 15: Run Method

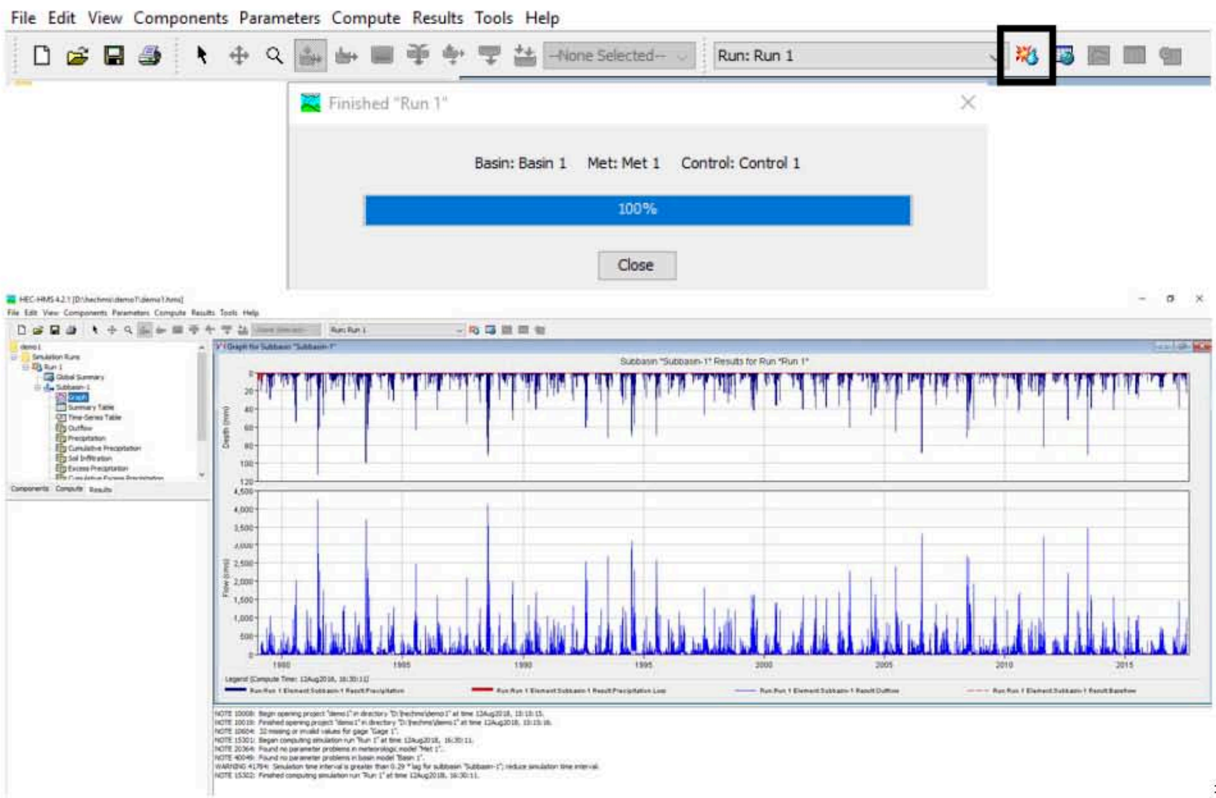


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Figure No 16: Result

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EXERCISE 6:

HYDROLOGICAL MODELLING USING HEC-HMS

Rainfall Runoff Analysis through given input data (see in table no 1)

S no	Item (content Type)	Value
1	Area of Basin 1 Area of Basin 2	4285 sq km 195 sq km
2	Reach Length	300 m
3	Loss Method	SCS Curve Number
4	Transform Method	SCS Unit Hydrograph
5	Base flow Method	None
6	Curve Number	75
7	Impervious (%)	0.0
8	Graph Type	Standard (PRF484)
9	Lag Time	10, 60
10	Precipitation Time	01 Jan 1979 to 31 July 2017
11	Data Source	Manually Entry
12	Unit	Incremental Millimetre
13	Time Interval	1 Day
14	Routing Method	Muskingum
15	Muskingum K (HR)	1
16	Muskingum X	0.22

Table No 1: Data input

1. **Create a New Project (demo2):**
   Step 1: Click on File>>New
   Step 2: Give details of project
   Step 3: Create, after that show in dialog box (red box)

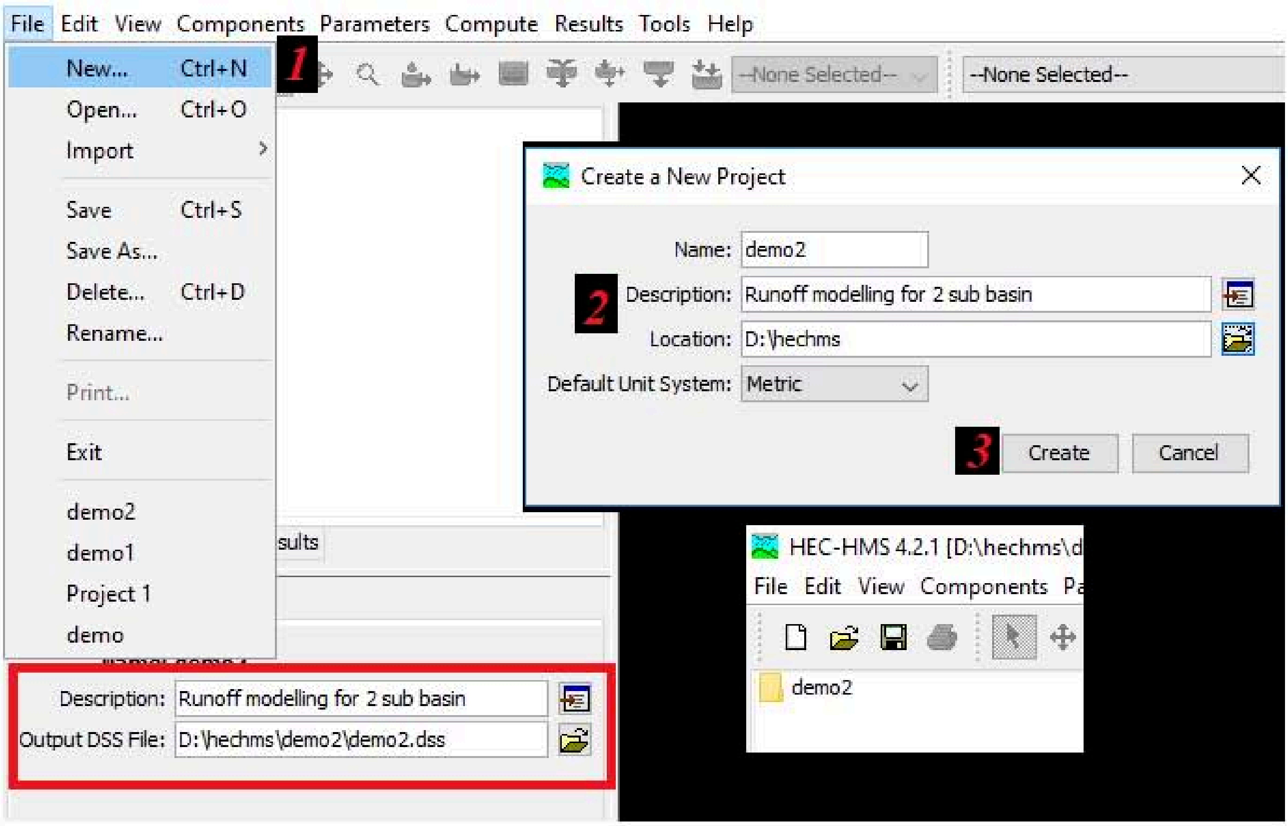


Figure No 1: Create New Project

2. **Basin Model Manager**

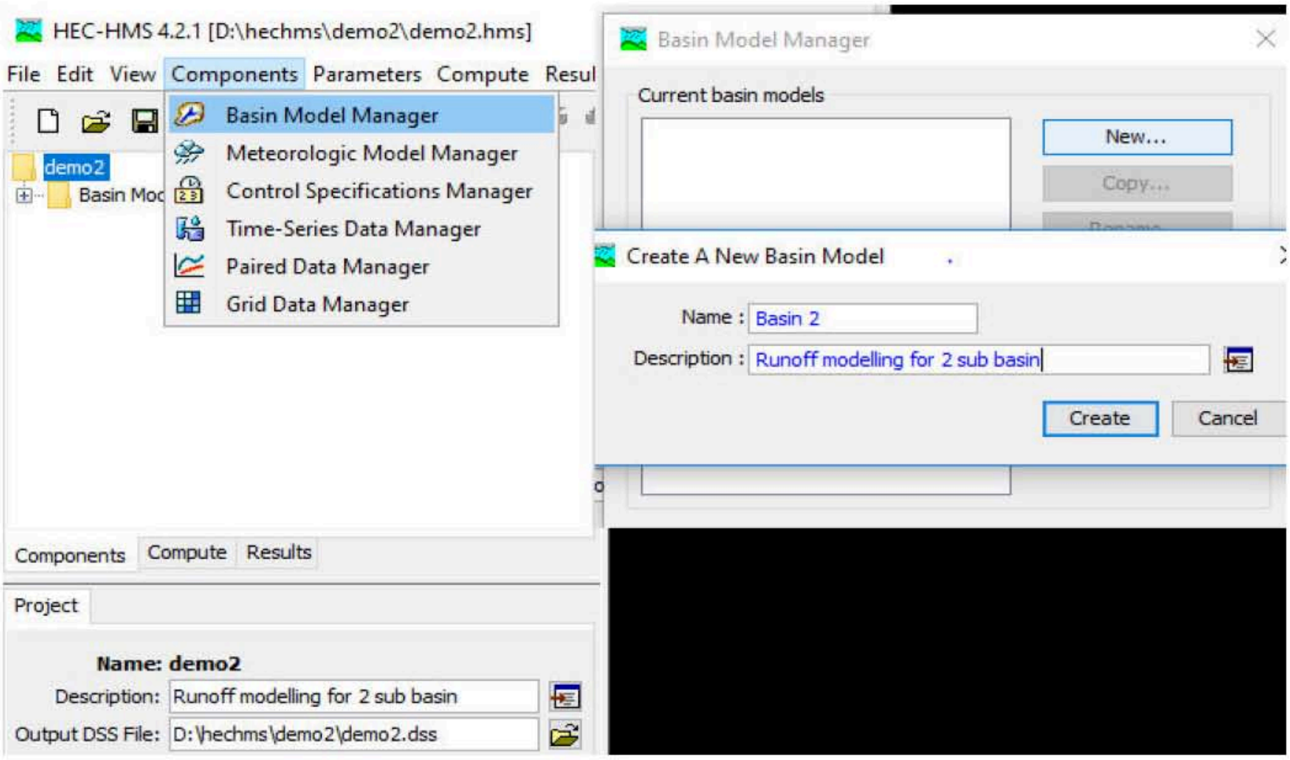


Figure No 2: Create new Basin Model

3. **Create Basin: same input as exercise 5**

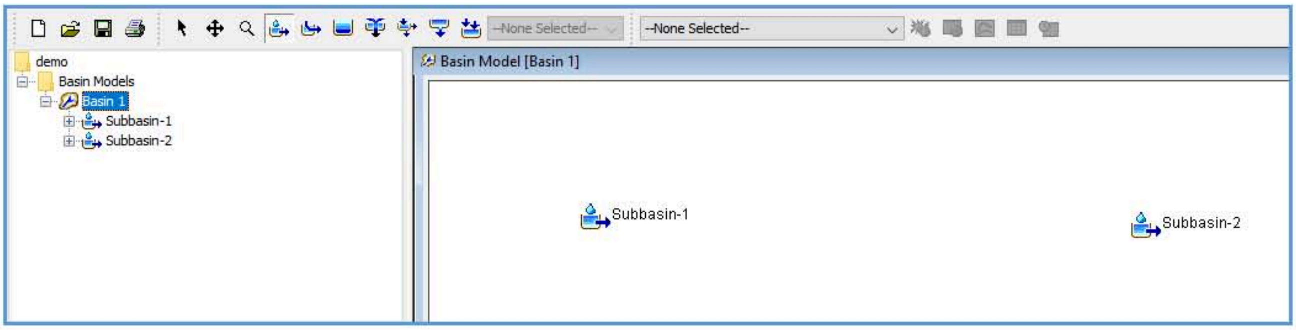


Figure No 3: Sub basin

4. **Create outlet:** Simple click on sink creation tool  after that click on window

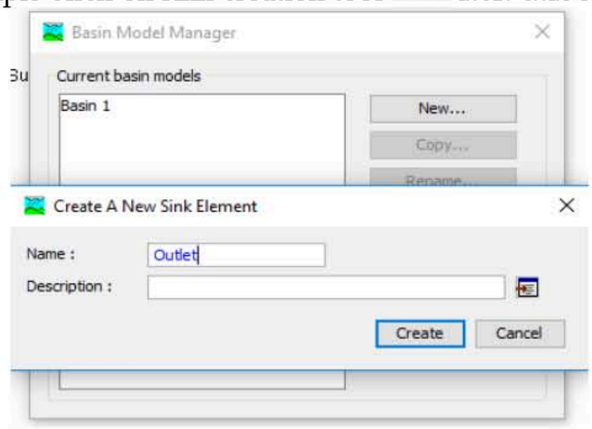


Figure No 4: Outlet

Give the name of sink element (Outlet)

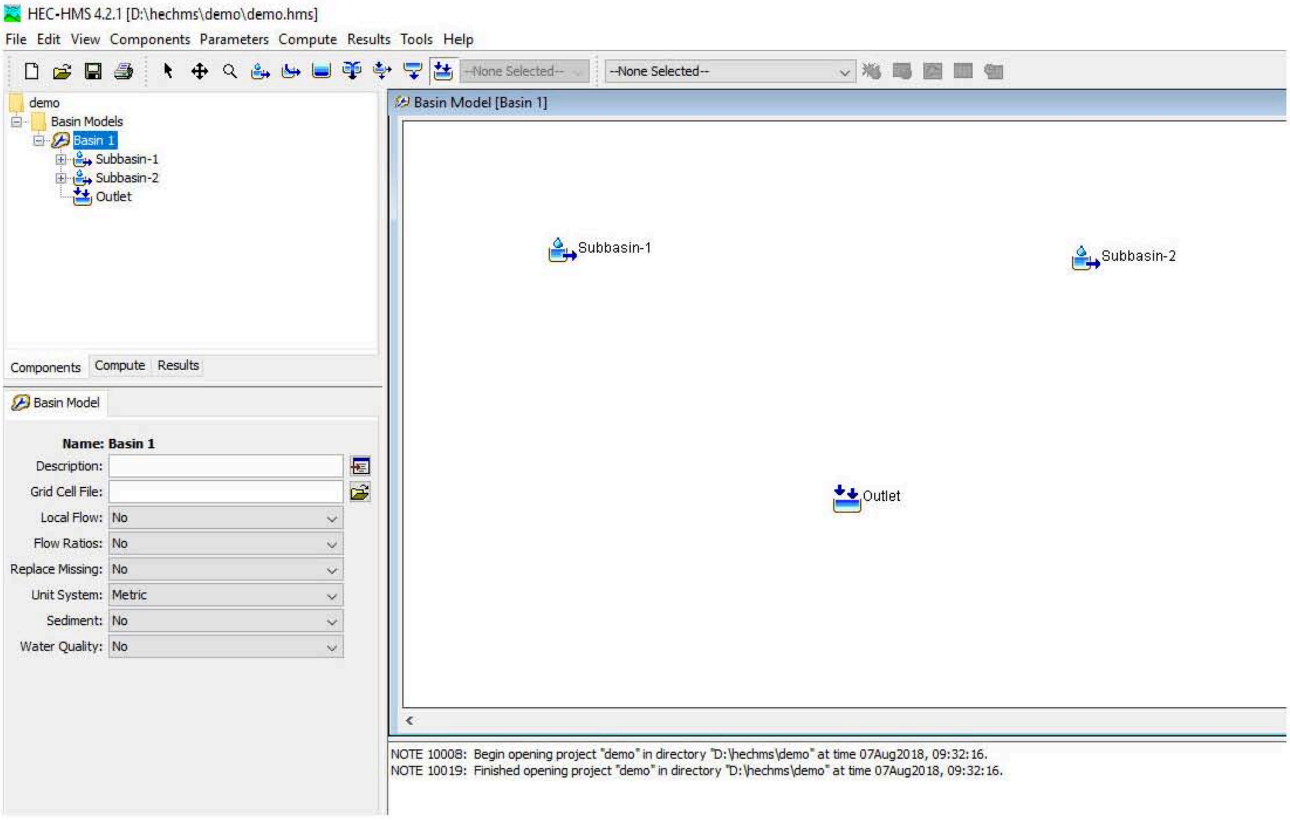


Figure No 5: Basin & Outlet

5. Create reach

Simple click on reach creation tool after that click on window

Give the name of reach element (Reach-1)

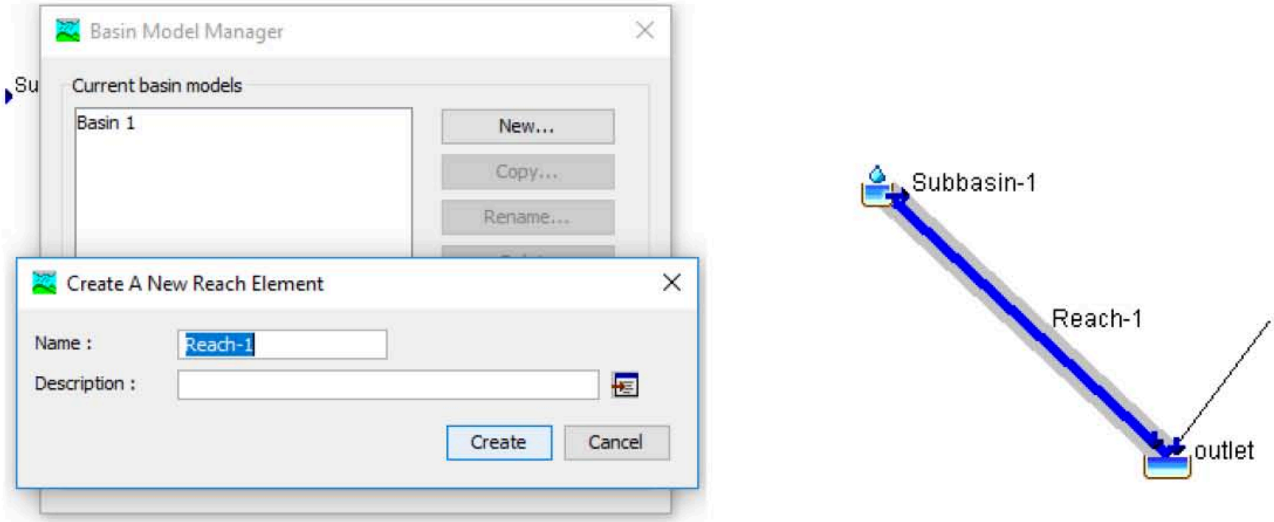


Figure No 6: Create Reach

6. **Fill all input in sub basin1**

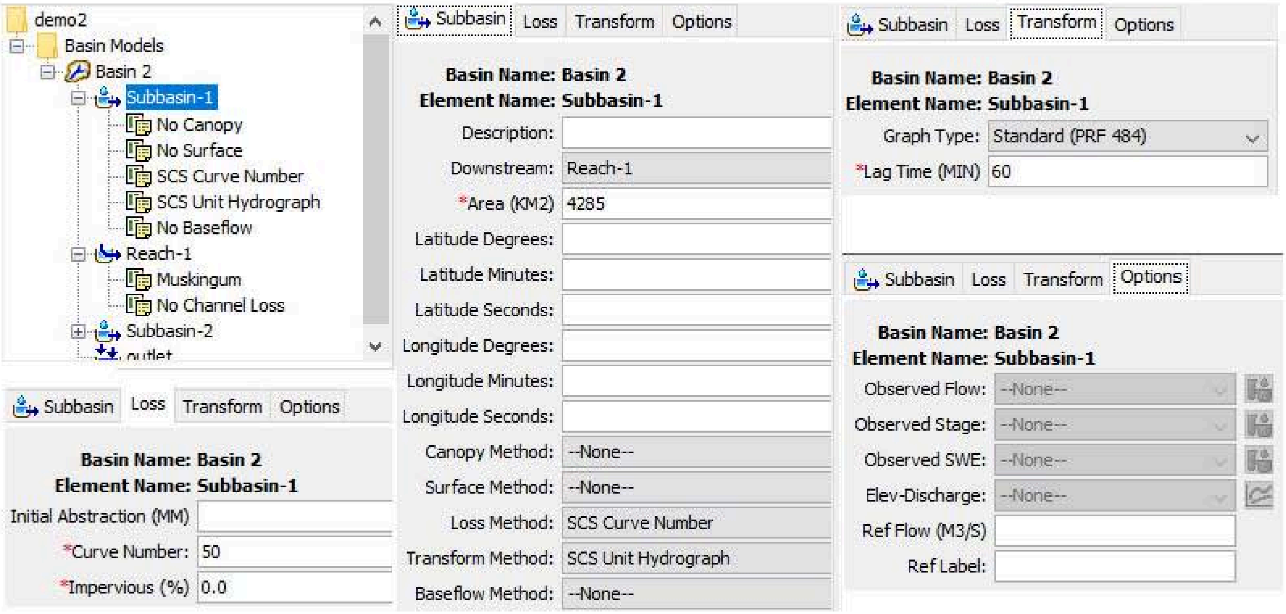


Figure No 7: Sub basin 1 Input

7. **Fill all input sub basin 2**

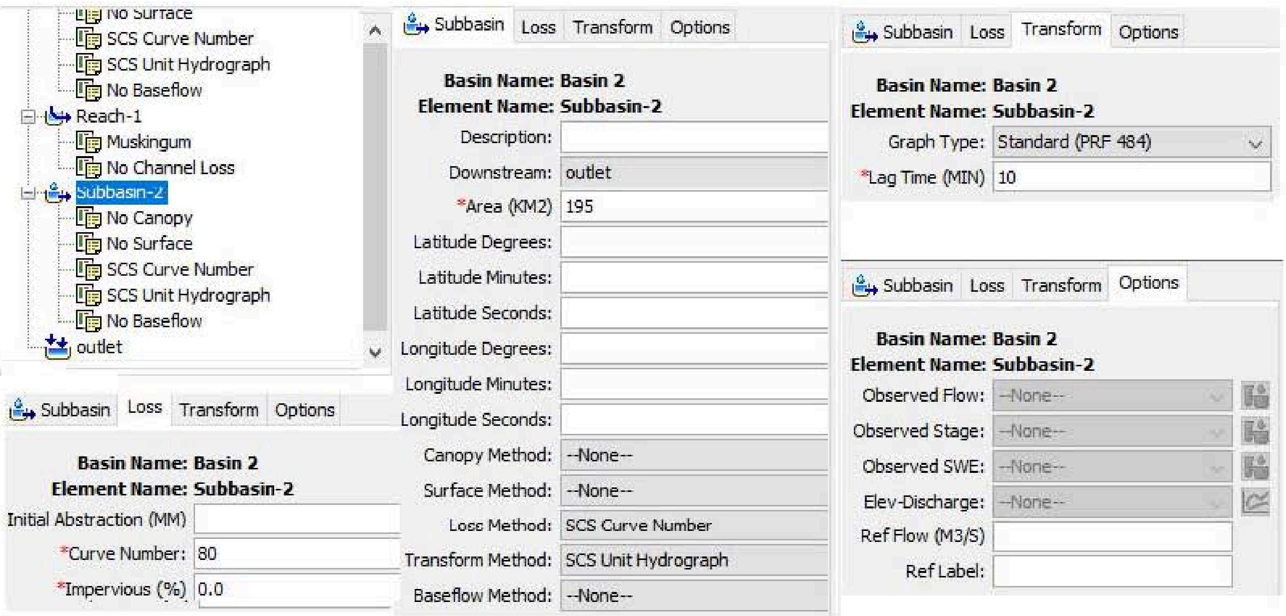
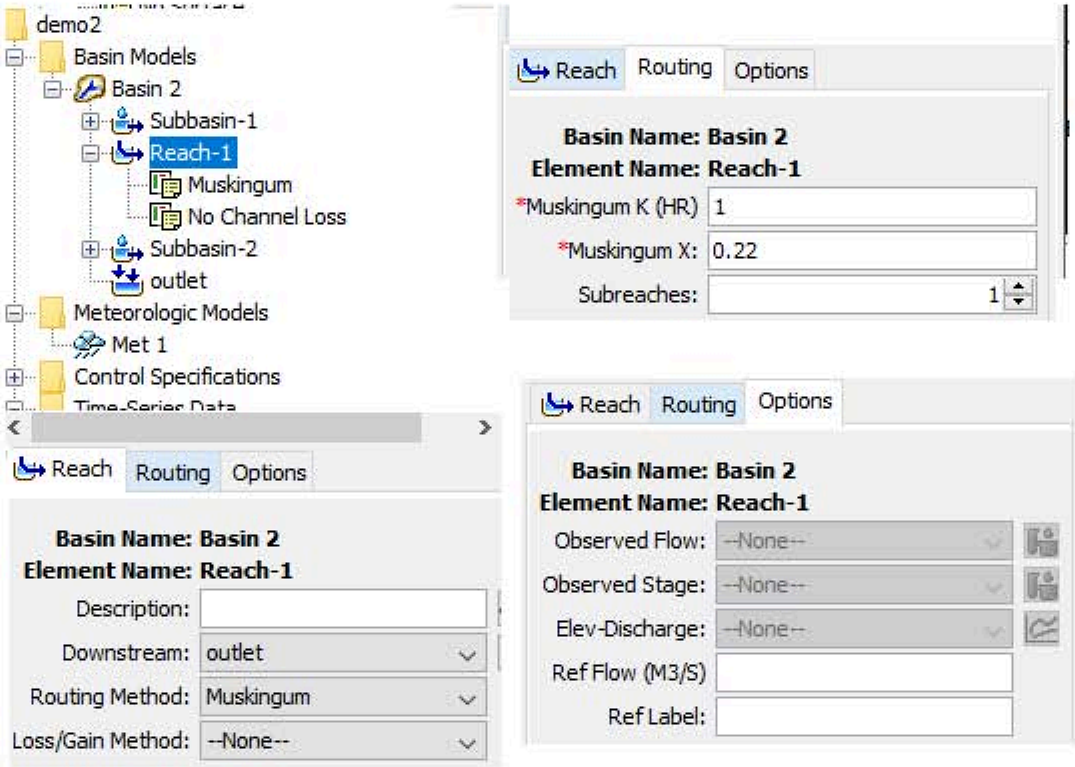


Figure No 8: Sub basin 2 input

8. Reach Input:



Repeat all process for Metrological, Gauge & Run from exercise 5

You are also give more gauge site

For Gauge site: You can also give more gauge site

Exercise 7-10: HEC-RAS 1D-2D Modelling & Flood Inundation mapping

Importing Geometry data into HEC-RAS

1. Open HEC-RAS software (Fig. 1).

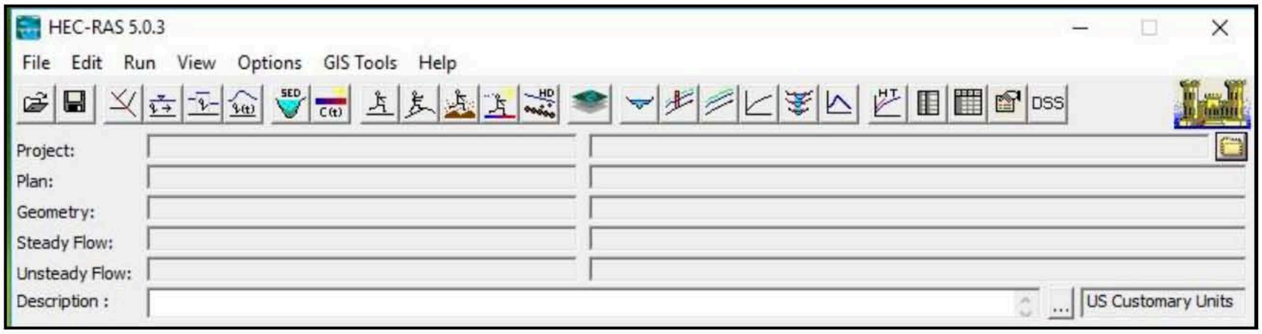


Fig. 1

2. Go to HEC-RAS 5.0.3 → Options→ Unit System (US Customary/SI)… (Fig. 2)

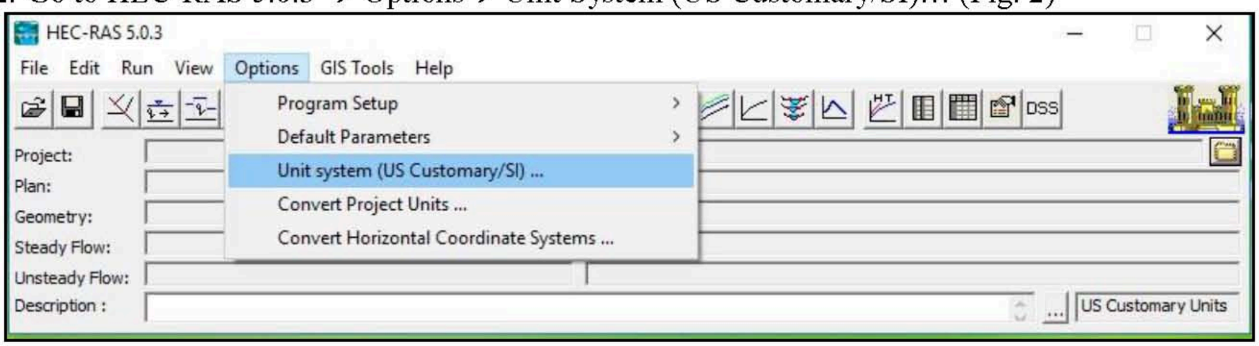


Fig. 2

3. HEC-RAS window (Fig. 3) will appear. Select System International (Metric System). Click Ok.

4. RAS acknowledge window will appear. Click Yes.

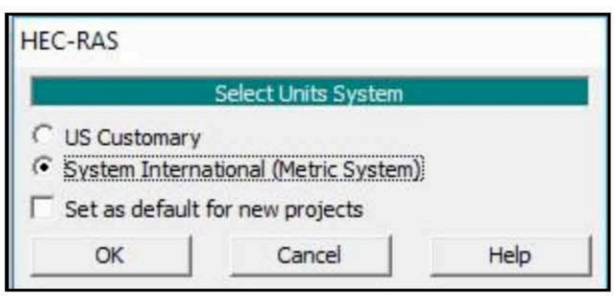


Fig. 3

5. Save the new project by going to File→Save Project As. Select working directory and save as name.prj as shown in fig. Fig. 4. Click OK

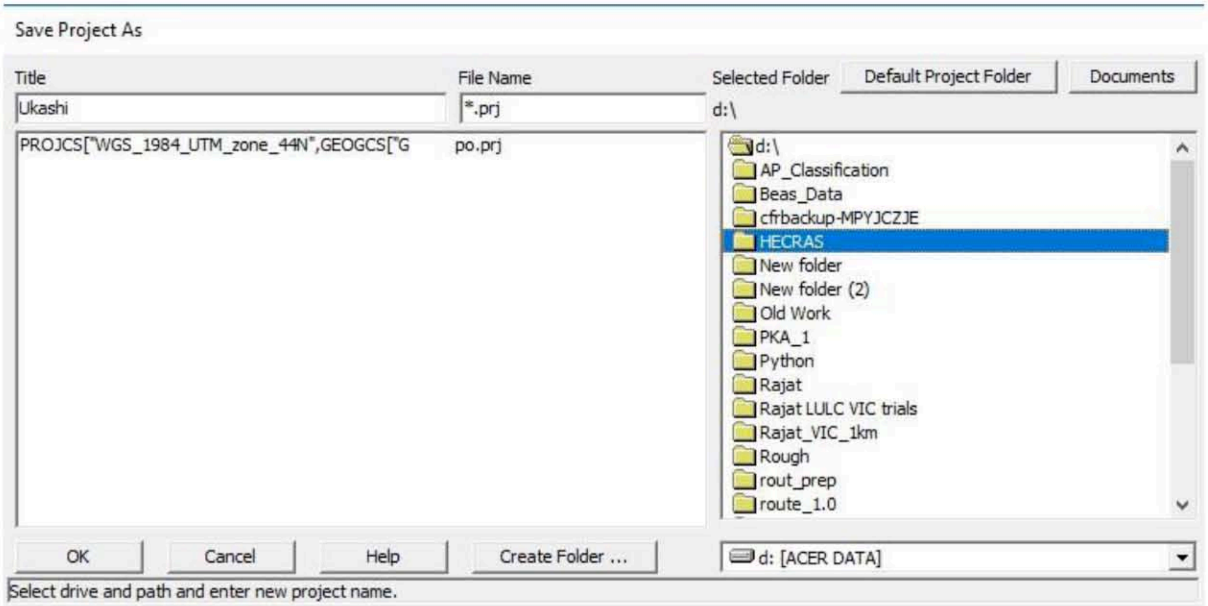


Fig. 4

6. To import the GIS data into HEC-RAS, Click on View/Edit Geometric Data  . Geometric Data window (Fig. 5) will appear.

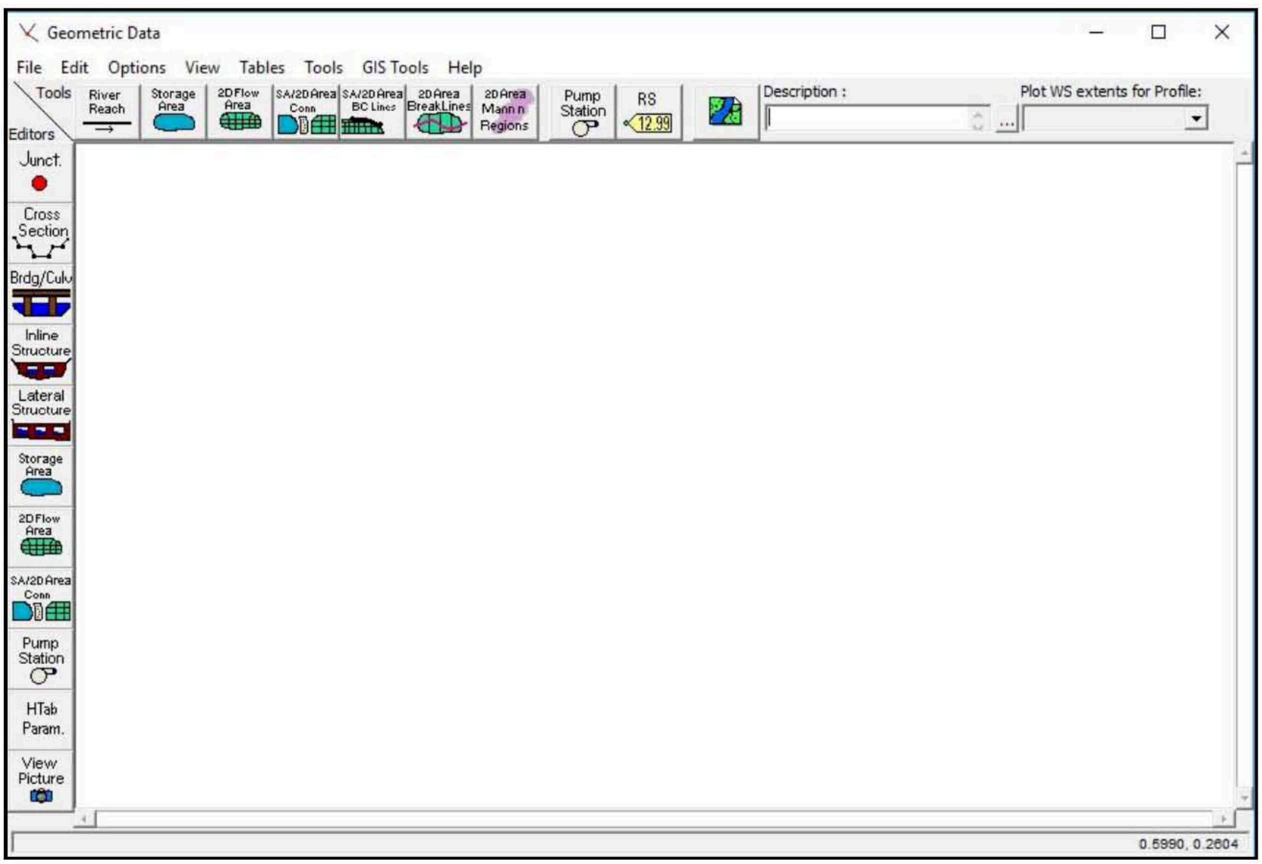


Fig. 5

7. Click on File→Import Geometry Data→ GIS Format (Fig. 6).

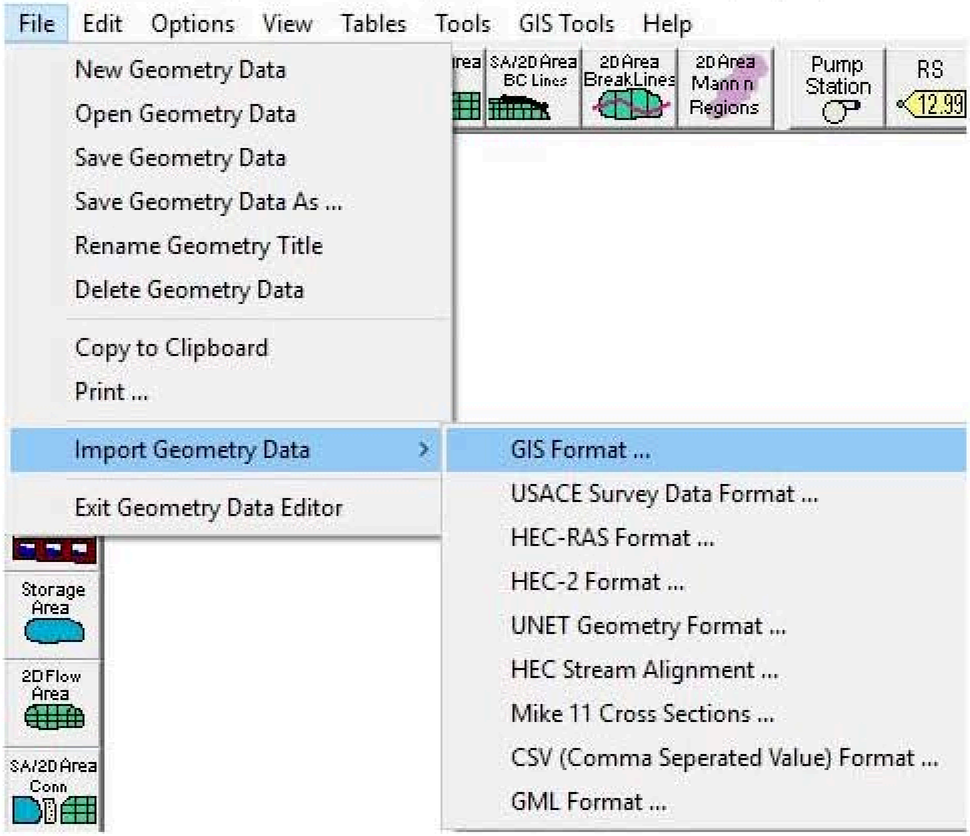


Fig. 6

8. **Import #GIS Format data** file (Fig. 7) will appear. Browse to **GIS2RAS.RASImport.sdf** file created in GIS, and click OK.

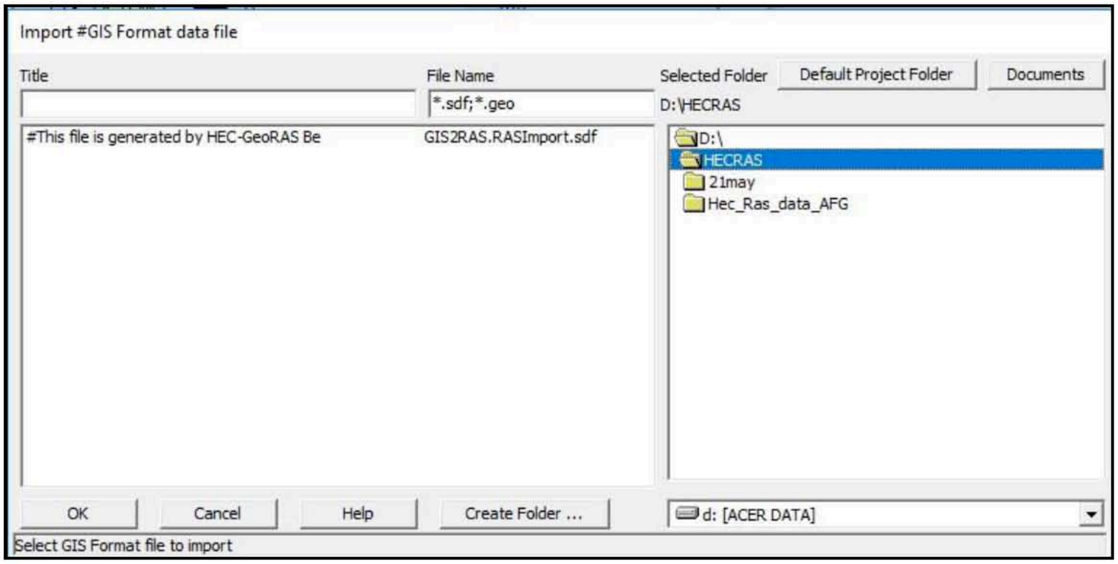


Fig. 7

9. Import Geometry Data window (Fig. 8) will appear. In the Intro tab, select SI (metric) Units for Import data as and click Next.

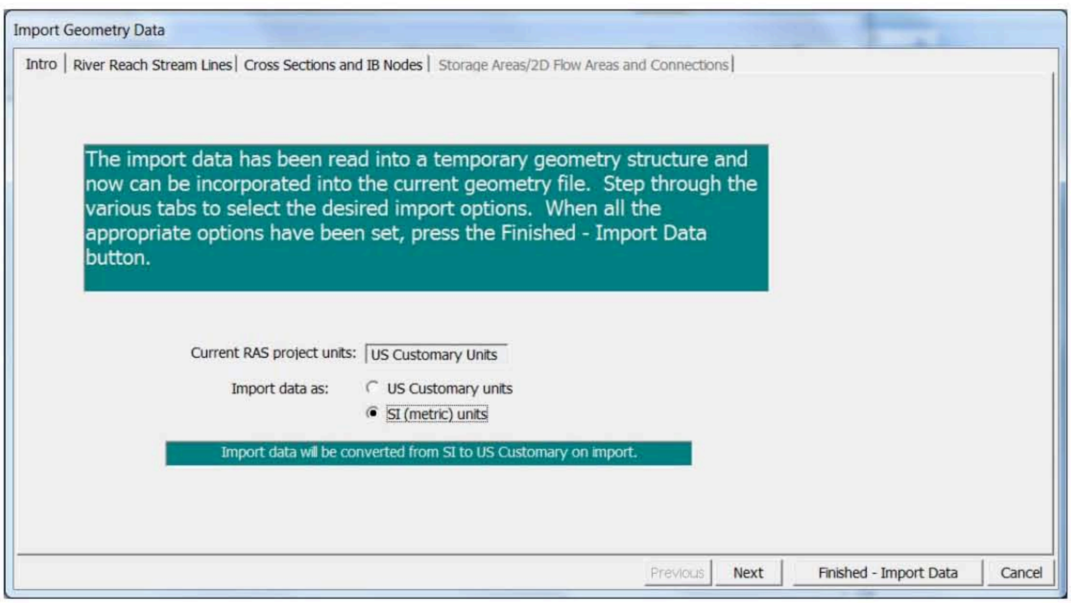


Fig. 8

10. Confirm the River/Reach data, make sure **Import stream lines** box is checked, and click **Next** as shown in Fig. 9.

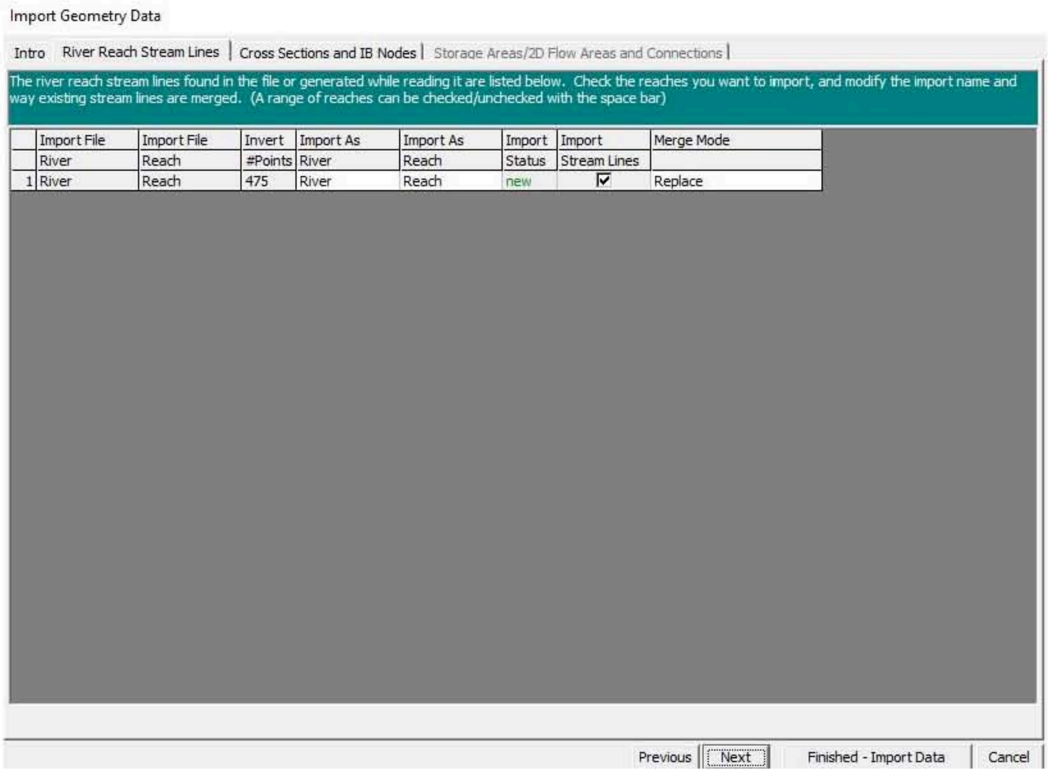


Fig. 9

11. Confirm cross-sections data; make sure all Import Data boxes are checked for cross-sections (Fig. 10), and click Finished- Import Data (accept default values for matching tolerance, round places, etc).

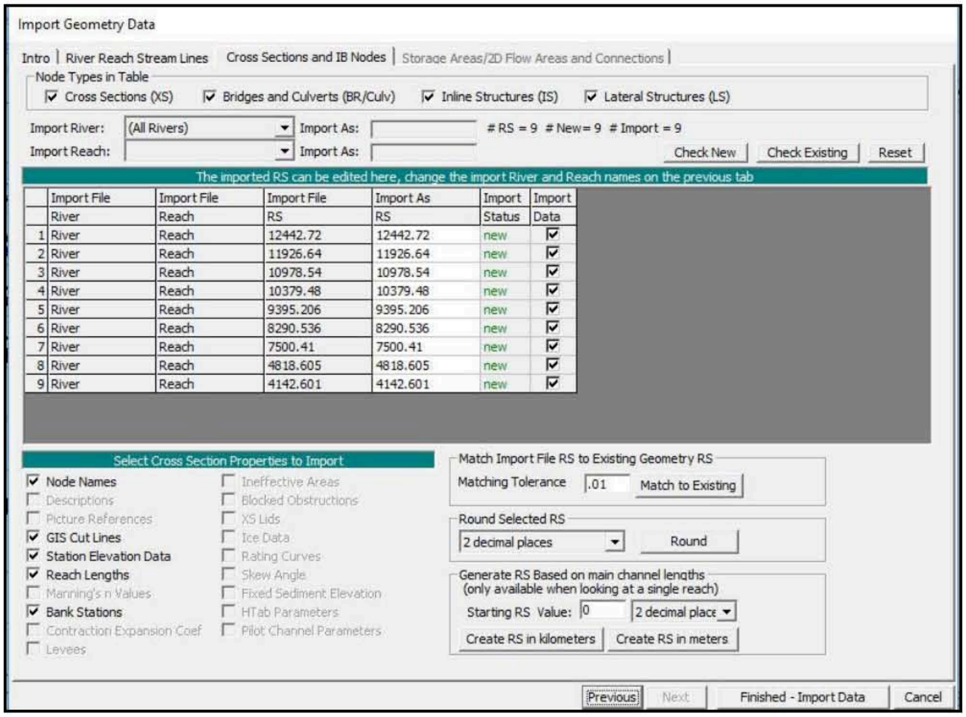


Fig. 10

12. The data will then be imported to the HEC-RAS geometric editor as shown in Fig. 11.

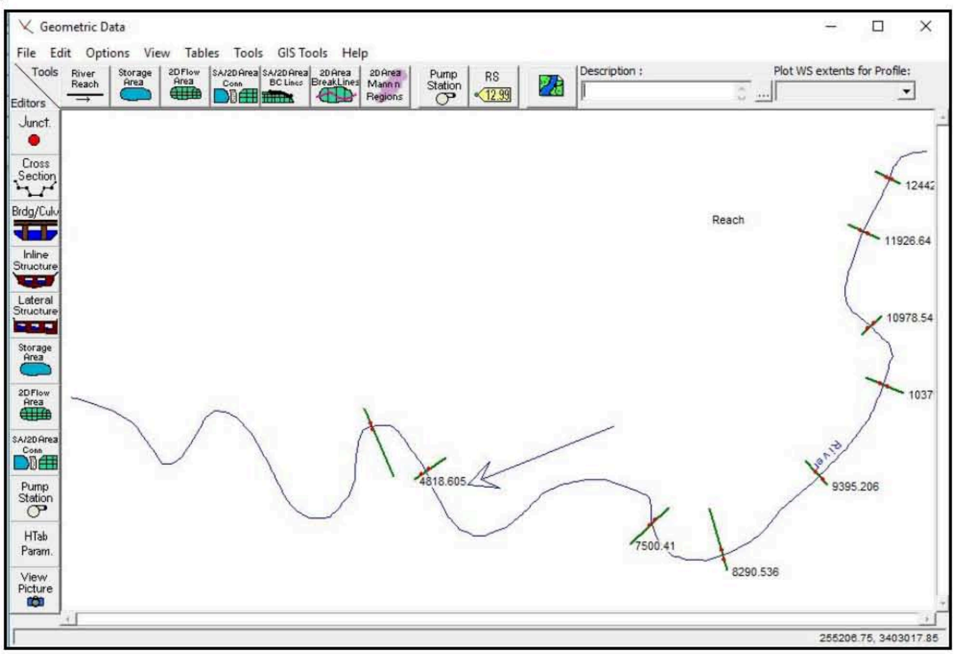
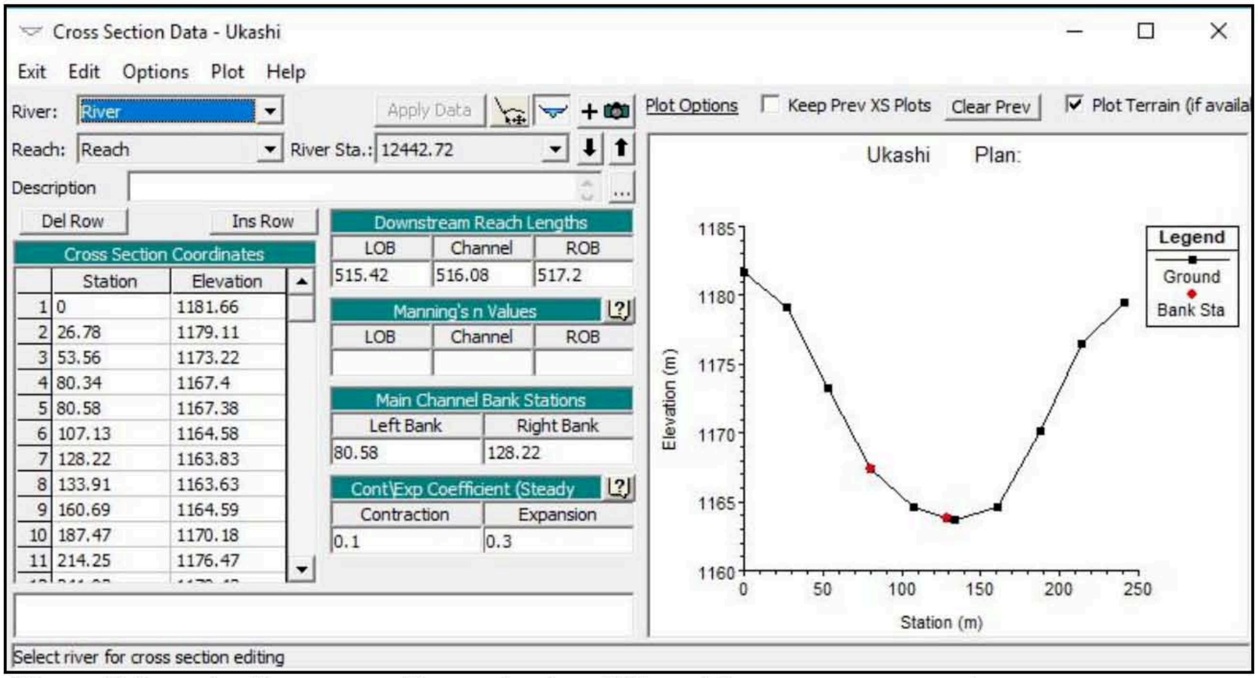


Fig. 11

13. Save the geometry file by clicking File→Save Geometry Data as Ukashi. Click OK.

tool.

15. You should see the cross-section window as shown in Fig. 12.



14. Next, click on the Geometry editor and select Edit and /or create cross-sections

Fig. 12

Note: Each cross-section in HEC-RAS has the following information:

Location: This is described by using three pieces of information: River, Reach and River Station.

Elevation Profile: This is the profile view that you see on the right hand side in the cross-section window. This profile is created by using the information from the station and elevation columns in the Cross Section Coordinates table on the left. The numbers in the station column shows the distance along the cross-section from left to right (looking downstream along the flow direction), and the elevation column shows the elevation at each station point. You can think of Station and Elevation as the (x,z) attributes for the cross-section line. Each station/elevation point is represented by a black dot on the cross- section profile.

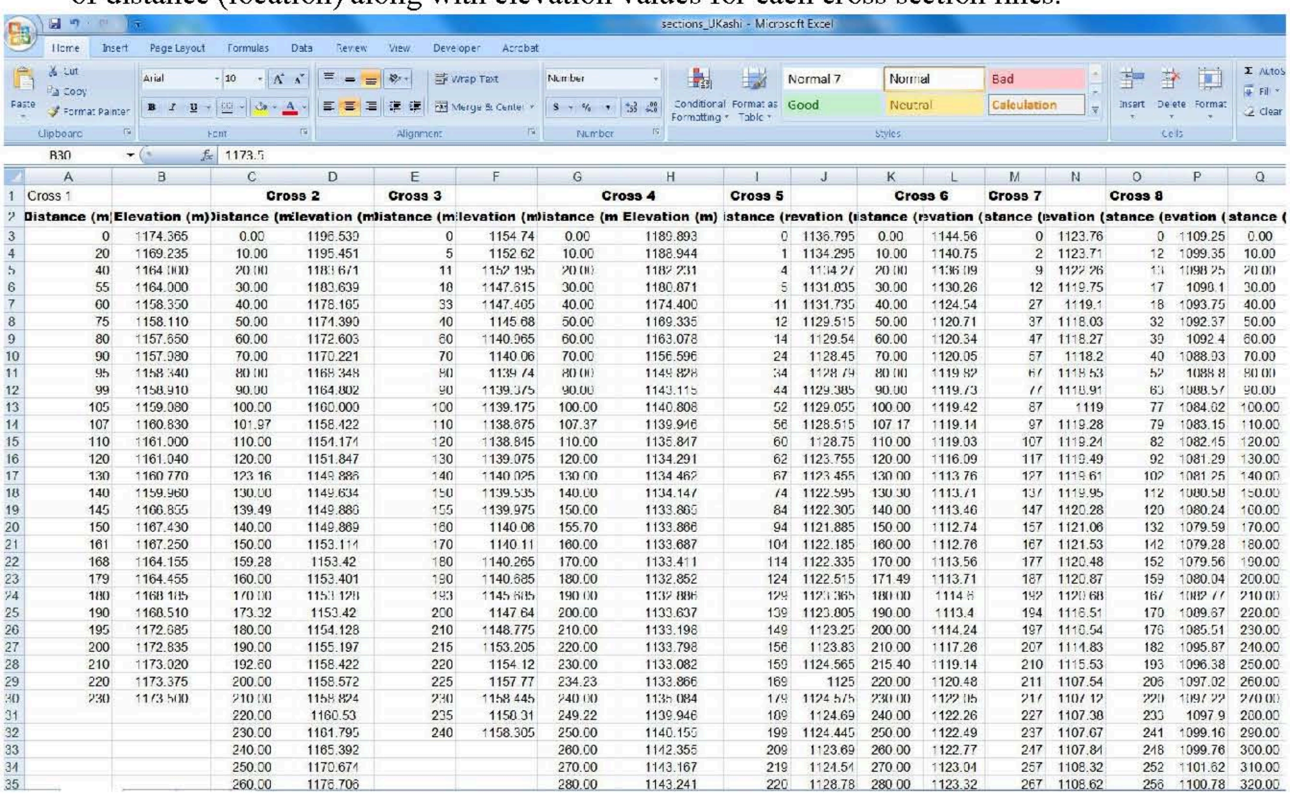
Bank locations: These are represented by two red dots on the cross-section profile. The location of these red dots is dictated by the station numbers for Left and Right Banks in the "Main Channel Bank Stations" table in the cross-section window.

Roughness (Manning's n Values): The horizontal line at the top of the cross-section profile shows the distribution of Manning'n value along the cross-section. This distribution is defined in the n Val column in the Cross Section Coordinates table. You will see that the n Val column is not populated for each row. The values are only reported at stations points where there is a change in the Manning's n.

Distance to the next downstream cross-section: This information is presented in the Downstream Reach Lengths table. The numbers for LOB, ROB and Channel represent the distances to the next downstream cross-section along the left over bank, right over bank and channel, respectively. These distances are computed by using the flow path features that are digitized in HEC-GeoRAS.

Note: ***As we have the surveyed value of elevations on cross section lines, so we replace the Station value and corresponding elevation value.***

16. Go to working directory open **sections_UKashi.xls** file (Fig. 13) which consist the value of distance (location) along with elevation values for each cross section lines.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Cross 1		Cross 2		Cross 3		Cross 4		Cross 5		Cross 6		Cross 7		Cross 8		
2	Distance (m	Elevation (m)	)istance (m	:levation (m	)istance (m	:levation (m	)istance (m	Elevation (m)	istance (	revation (	istance (	revation (	stance (	evation (	stance (	evation (	stance (
3	0	1174.365	0.00	1196.539	0	1154.74	0.00	1189.893	0	1136.795	0.00	1144.56	0	1123.76	0	1109.25	0.00
4	20	1169.235	10.00	1195.451	5	1152.62	10.00	1188.944	1	1134.295	10.00	1140.75	2	1123.71	12	1099.35	10.00
5	40	1164.000	20.00	1183.671	11	1152.195	20.00	1182.231	4	1134.27	20.00	1136.09	9	1122.26	13	1098.25	20.00
6	55	1164.000	30.00	1183.639	18	1147.615	30.00	1180.871	5	1131.835	30.00	1130.26	12	1119.75	17	1090.1	30.00
7	60	1158.350	40.00	1178.165	33	1147.405	40.00	1174.400	11	1131.735	40.00	1124.54	27	1119.1	18	1093.75	40.00
8	75	1158.110	50.00	1174.390	40	1145.68	50.00	1169.335	12	1129.515	50.00	1120.71	37	1118.03	32	1092.37	50.00
9	80	1157.650	60.00	1172.603	60	1140.965	60.00	1163.078	14	1129.54	60.00	1120.34	47	1118.27	39	1092.4	60.00
10	90	1157.980	70.00	1170.221	70	1140.06	70.00	1156.596	24	1128.45	70.00	1120.05	57	1118.2	40	1088.93	70.00
11	95	1158.340	80.00	1168.348	80	1139.74	80.00	1149.828	34	1128.79	80.00	1119.82	67	1118.53	52	1088.8	80.00
12	99	1158.910	90.00	1164.802	90	1139.375	90.00	1143.115	44	1129.385	90.00	1119.73	77	1118.91	63	1088.57	90.00
13	105	1159.080	100.00	1160.000	100	1139.175	100.00	1140.808	52	1129.055	100.00	1119.42	87	1119	77	1084.02	100.00
14	107	1160.830	101.97	1158.422	110	1138.875	107.37	1139.946	56	1128.515	107.17	1119.14	97	1119.28	79	1083.15	110.00
15	110	1161.000	110.00	1154.174	120	1138.845	110.00	1135.847	60	1128.75	110.00	1119.03	107	1119.24	82	1082.45	120.00
16	120	1161.040	120.00	1151.847	130	1139.075	120.00	1134.291	62	1123.755	120.00	1116.09	117	1119.49	92	1081.29	130.00
17	130	1160.770	123.16	1149.886	140	1140.025	130.00	1134.462	67	1123.455	130.00	1113.76	127	1119.61	102	1081.25	140.00
18	140	1159.960	130.00	1149.634	150	1139.535	140.00	1134.147	74	1122.595	130.30	1113.71	137	1119.95	112	1080.58	150.00
19	145	1166.855	139.49	1149.886	155	1139.975	150.00	1133.865	84	1122.305	140.00	1113.46	147	1120.28	120	1080.24	160.00
20	150	1167.430	140.00	1149.869	160	1140.06	155.70	1133.866	94	1121.885	150.00	1112.74	157	1121.06	132	1079.59	170.00
21	161	1167.250	150.00	1153.114	170	1140.11	160.00	1133.687	104	1122.185	160.00	1112.76	167	1121.53	142	1079.28	180.00
22	168	1164.155	159.28	1153.42	180	1140.265	170.00	1133.411	114	1122.335	170.00	1113.56	177	1120.48	152	1079.56	190.00
23	179	1164.455	160.00	1153.401	190	1140.685	180.00	1132.852	124	1122.515	171.49	1113.71	187	1120.87	159	1080.04	200.00
24	180	1168.185	170.00	1153.128	193	1145.685	190.00	1132.886	129	1123.365	180.00	1114.6	192	1120.68	167	1082.77	210.00
25	190	1168.510	173.32	1153.42	200	1147.64	200.00	1133.637	139	1123.805	190.00	1113.4	194	1116.51	170	1089.67	220.00
26	195	1172.685	180.00	1154.128	210	1148.775	210.00	1133.198	149	1123.25	200.00	1114.24	197	1116.54	176	1085.51	230.00
27	200	1172.835	190.00	1155.197	215	1153.205	220.00	1133.798	156	1123.83	210.00	1117.26	207	1114.83	182	1095.87	240.00
28	210	1173.020	192.60	1158.422	220	1154.12	230.00	1133.082	159	1124.565	215.40	1119.14	210	1115.53	193	1096.38	250.00
29	220	1173.375	200.00	1158.572	225	1157.77	234.23	1133.866	169	1125	220.00	1120.48	211	1107.54	206	1097.02	260.00
30	230	1173.500	210.00	1158.824	230	1158.445	240.00	1135.084	179	1124.575	230.00	1122.05	217	1107.12	220	1097.22	270.00
31			220.00	1160.53	235	1150.31	249.22	1139.946	189	1124.69	240.00	1122.26	227	1107.38	233	1097.9	280.00
32			230.00	1161.795	240	1158.305	250.00	1140.155	199	1124.445	250.00	1122.49	237	1107.67	241	1099.16	290.00
33			240.00	1165.392			260.00	1142.355	209	1123.69	260.00	1122.77	247	1107.84	248	1099.76	300.00
34			250.00	1170.674			270.00	1143.167	219	1124.54	270.00	1123.04	257	1108.32	252	1101.62	310.00
35			260.00	1176.706			280.00	1143.241	220	1128.78	280.00	1123.32	267	1108.62	256	1100.78	320.00

Fig. 13

17. Copy Distance (location) and elevation of each cross section lines from excel file and go to HEC-RAS's Cross Section data window. Click on cross section coordinate sub window. It will select all station and elevation values.

18. Go to edit and click on Paste (Fig. 14). It will replace automatic geometric data value with survey geometric data.

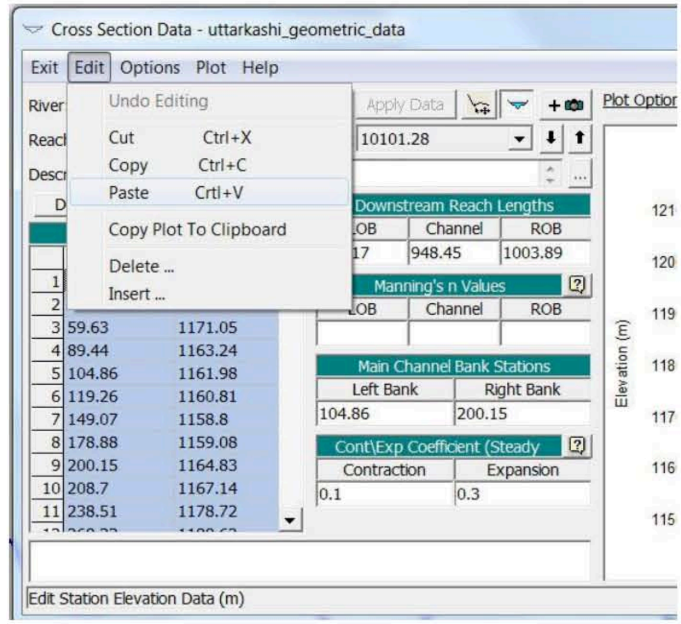


Fig. 14

19. In Manning's n Values option assign **0.04** for LOB, Channel and ROB.

20. In main Channel bank Stations option, replace the value of Left Bank and Right Bank by the nearest values using data in excel file eg. First cross section replaces 44.28 by 40 and 176.79 by 179.

21. Click on  arrow tool for going to next cross section.
22. Cut Line Extension Option window will (Fig. 15) appear. Click on **Accept edits and adjust cut line** option.

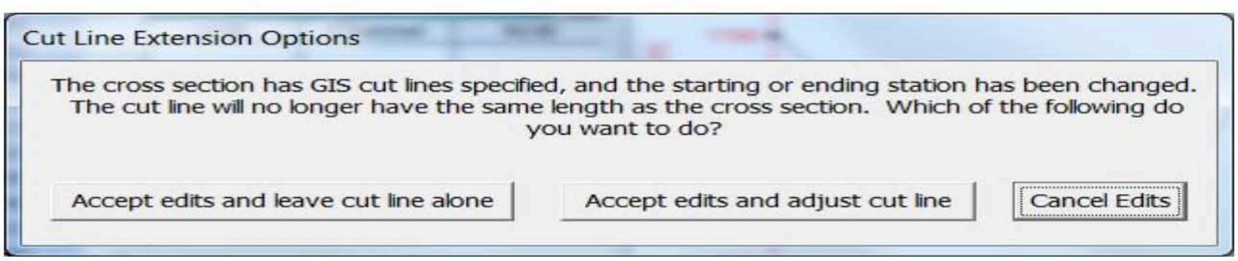


Fig. 15

23. Now window for next cross section elevation will come. Apply similar steps for others cross section.

24. Close Cross Section Data window.

25. Go to **Geometric Data window → File**. Click on **Save Geometric Data**. Close Geometric Data window.

Steady Flow

Entering Flow Data and Boundary Conditions

Flows are typically defined at the most upstream location of each river/tributary. Each flow that needs to be simulated is called a profile in HEC-RAS. For this exercise, we will create one hypothetical profile.

1. In the main HEC-RAS window, click on Edit →Steady Flow Data (Fig. 16).

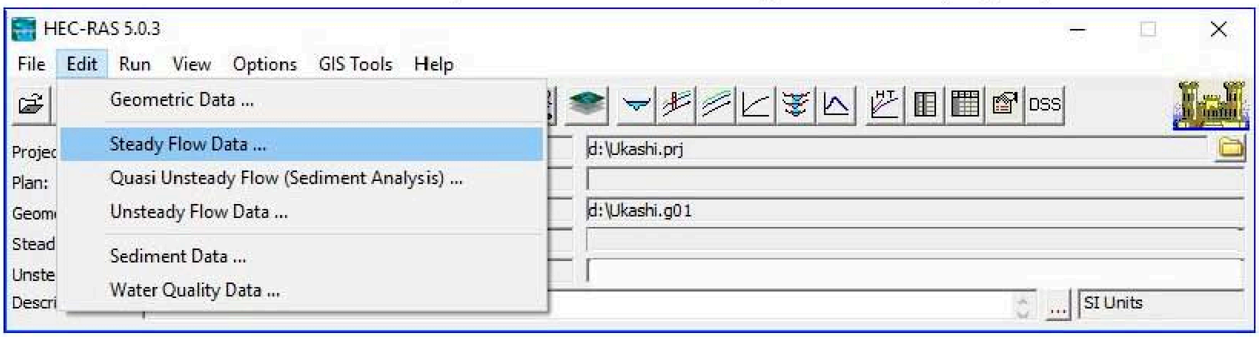


Fig. 16

2. Steady Flow Data window will appear. Enter hypothetical flow conditions for this profiles enter 1 for number of profiles and **1396** in PF1 option as shown in Fig. 17, and click on **Apply Data**.

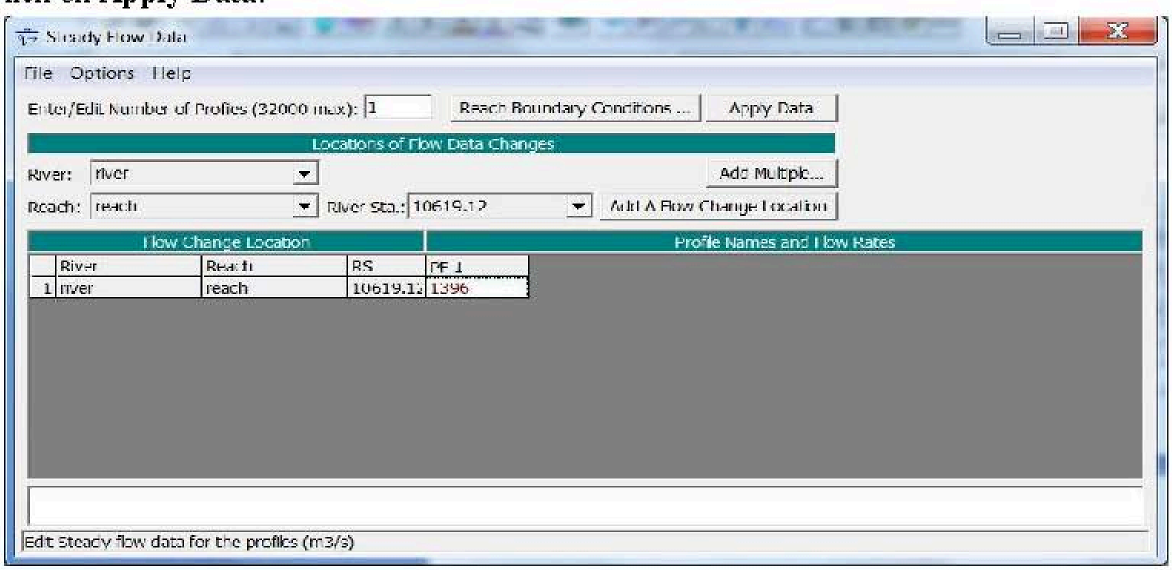


Fig. 17

The flow conditions defined in the above window are upstream conditions.

3. To define downstream boundary, click on **Reach Boundary Conditions**. Then select Downstream for uttarkashi Reach, click on **Normal Depth**, and enter **0.0002** (Fig. 18). Click OK.

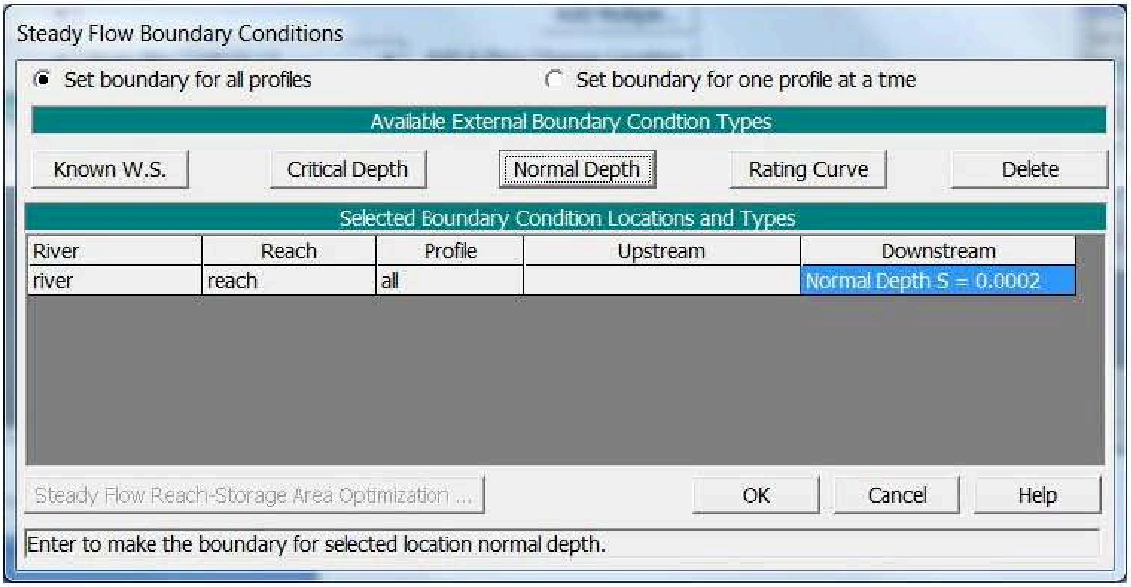


Fig. 18

4. Now come to Steady Flow Data window. Go to File →Save Flow Data.
5. Save Flow Data As window will appear. Select working directory and give the title (eg. uttarkashi_steady_flow_data). Click OK. Close the Steady Flow Data window. Now we are ready to run HEC-RAS!

Step 10: Running HECRAS

1. In the main HEC-RAS window, click on Run→Steady Flow Analysis (Fig. 19).

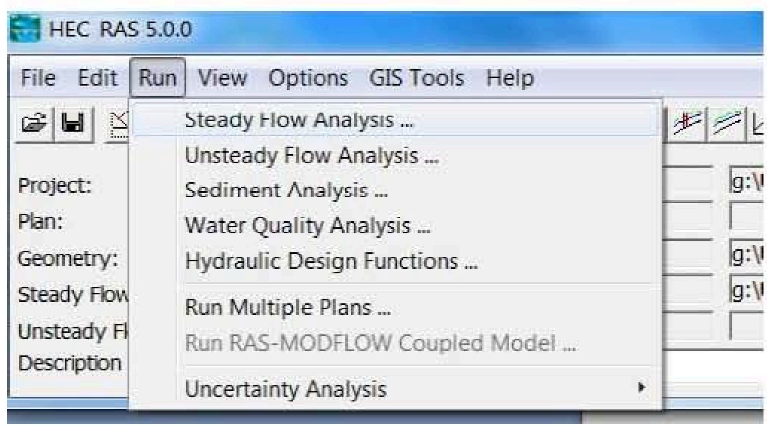


Fig. 19

2. Steady Flow Analysis window (Fig. 20) will appear. Give Short ID (eg. Uk). Select Subcritical Flow Regime. Click on Floodplain mapping check box. Click on Compute button. The model will run.

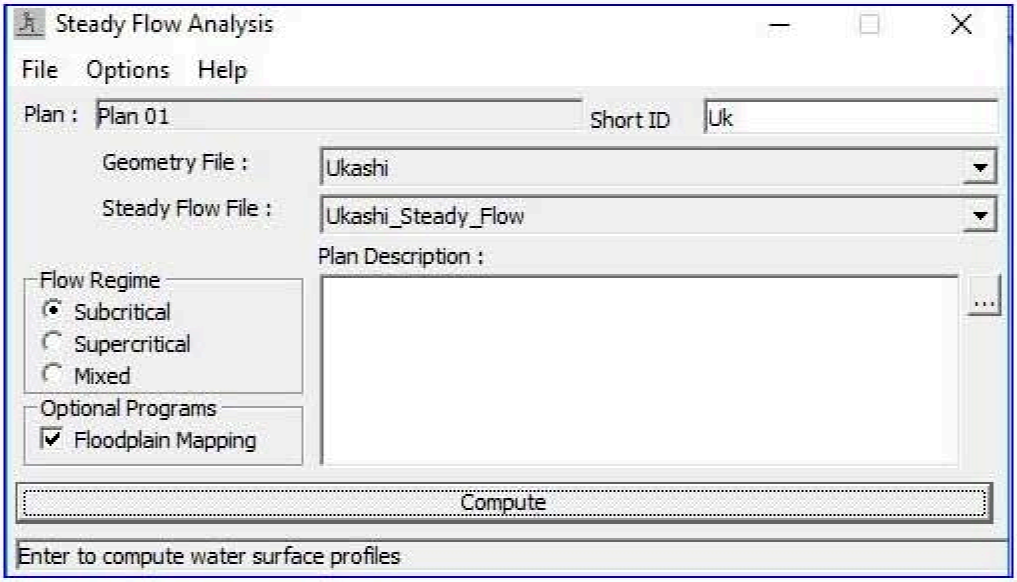


Fig. 20

3. HEC_RAS Finishes Computations window (Fig. 21) will open. After successful simulation, close the computation window and the steady flow Analysis window.

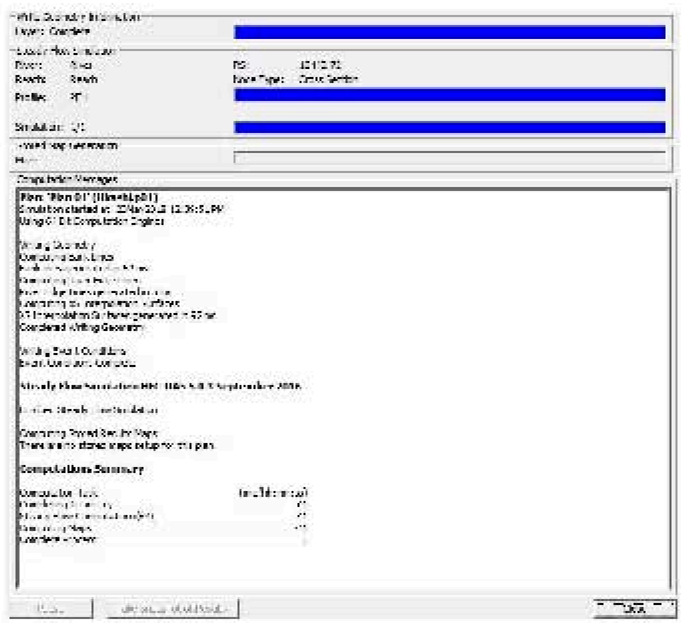
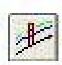


Fig. 21

4. Save work plan as Plan 01 on **View profiles** button  on HEC-RAS interface. Profile Plot window (Fig. 22) will appear. Check longitudinal profiles for the stream sections. Close window.

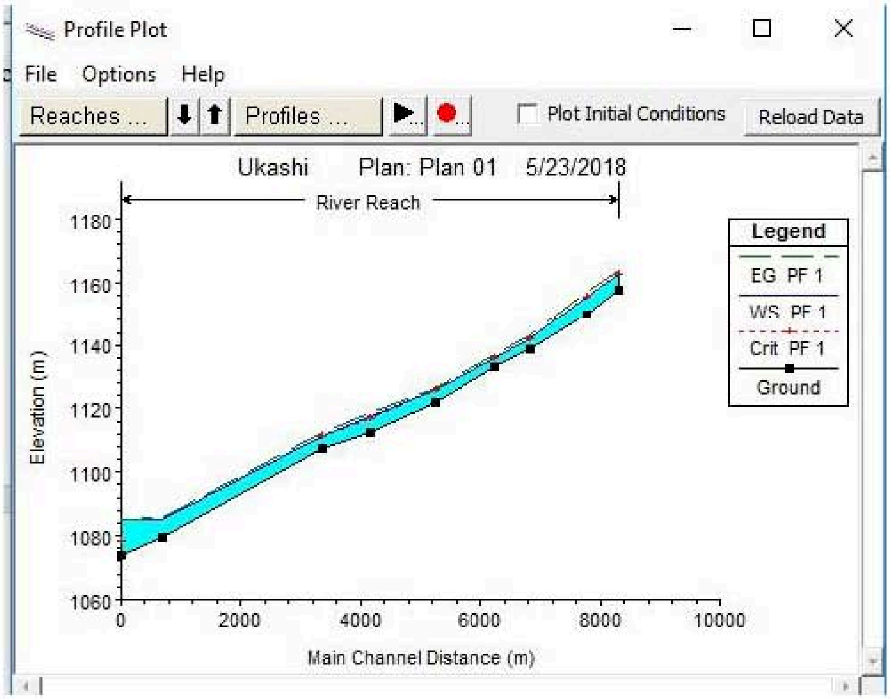


Fig. 22

5. Click on **View cross sections** button  on HEC-RAS interface. Cross Section window (Fig. 23) will appear. Review cross-sections and water surface elevations at cross-sections. Close window.

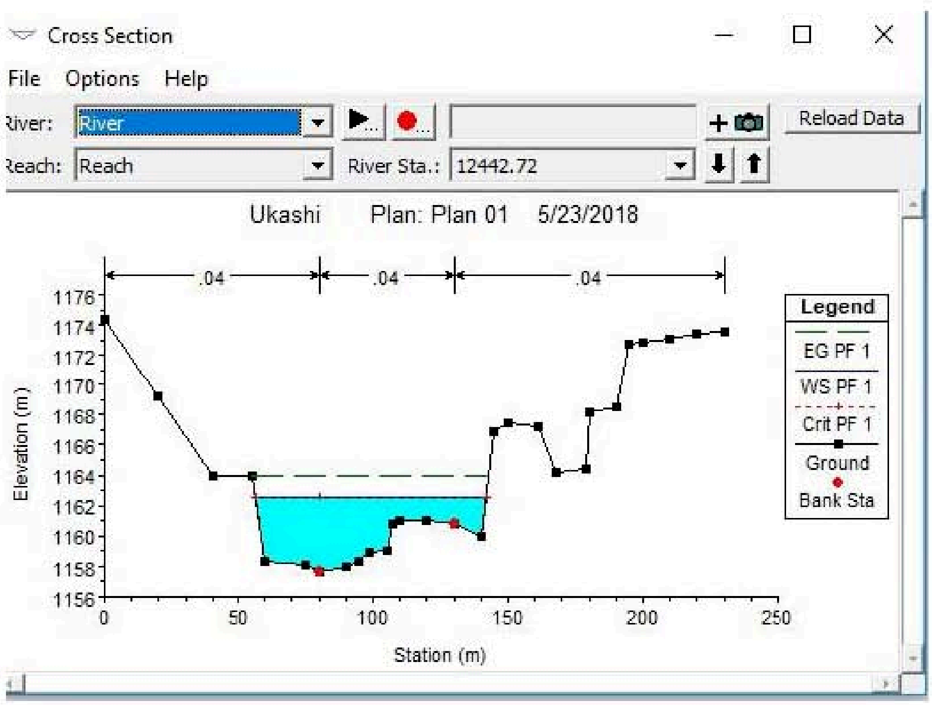
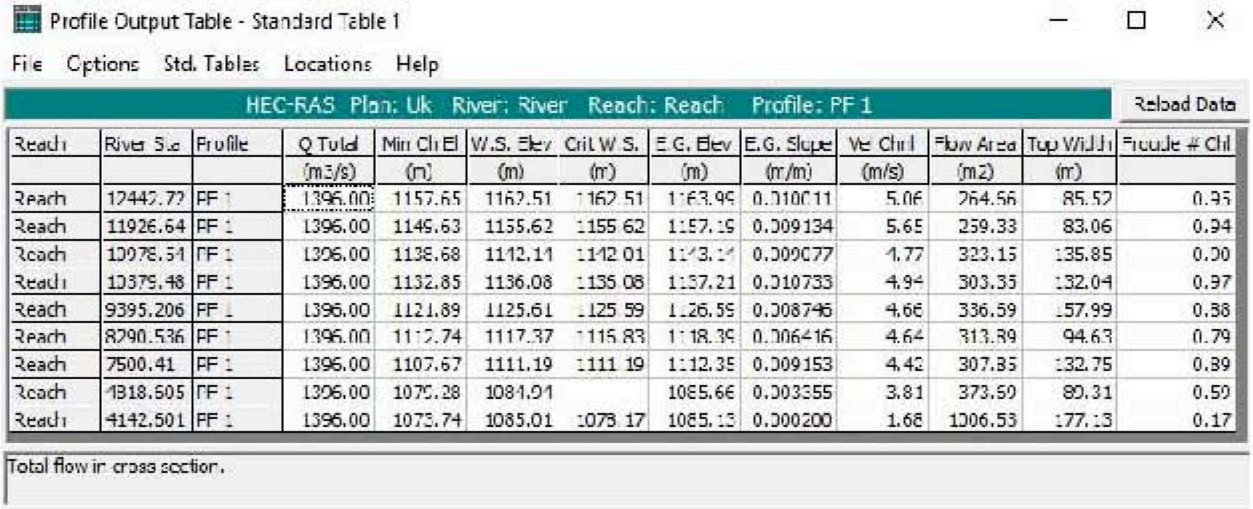


Fig. 23

6. Click on **View summary output tables by profile** button on HEC-RAS interface. Profile Output Table window will show as Fig 24. Review results.



Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Reach	12442.72	PF 1	1396.00	1157.65	1162.51	1162.51	1163.99	0.010011	5.06	264.56	85.52	0.95
Reach	11926.64	PF 1	1396.00	1149.63	1155.62	1155.62	1157.19	0.009134	5.65	259.33	83.06	0.94
Reach	10978.54	PF 1	1396.00	1138.68	1142.11	1142.01	1143.14	0.009077	4.77	323.15	135.85	0.90
Reach	10379.48	PF 1	1396.00	1132.85	1136.08	1136.08	1137.21	0.010733	4.94	303.35	132.04	0.97
Reach	9395.206	PF 1	1396.00	1121.89	1125.61	1125.59	1126.59	0.008746	4.66	336.59	157.99	0.88
Reach	8290.536	PF 1	1396.00	1112.74	1117.37	1115.83	1118.39	0.006416	4.64	313.89	94.63	0.79
Reach	7500.41	PF 1	1396.00	1107.67	1111.19	1111.19	1112.35	0.009153	4.42	307.85	132.75	0.89
Reach	4818.505	PF 1	1396.00	1075.28	1084.94		1085.66	0.003355	3.81	373.59	80.31	0.59
Reach	4142.501	PF 1	1396.00	1073.74	1085.01	1078.17	1085.13	0.000200	1.68	1006.53	177.13	0.17

Total flow in cross section.

Fig 24

Exporting HEC-RAS Output to HEC GeoRAS

1. To export the data to ArcGIS. Click on File →Export GIS Data… (Fig. 25) in the main HEC-RAS window.

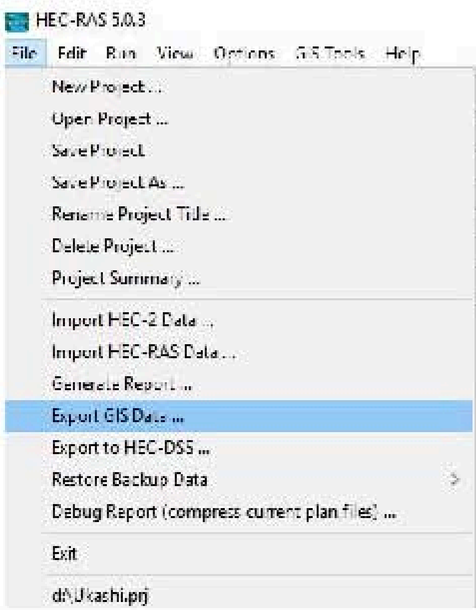


Fig. 75

2. **GIS Export** window will open. Click on options which you want to export as show in Fig.

26.

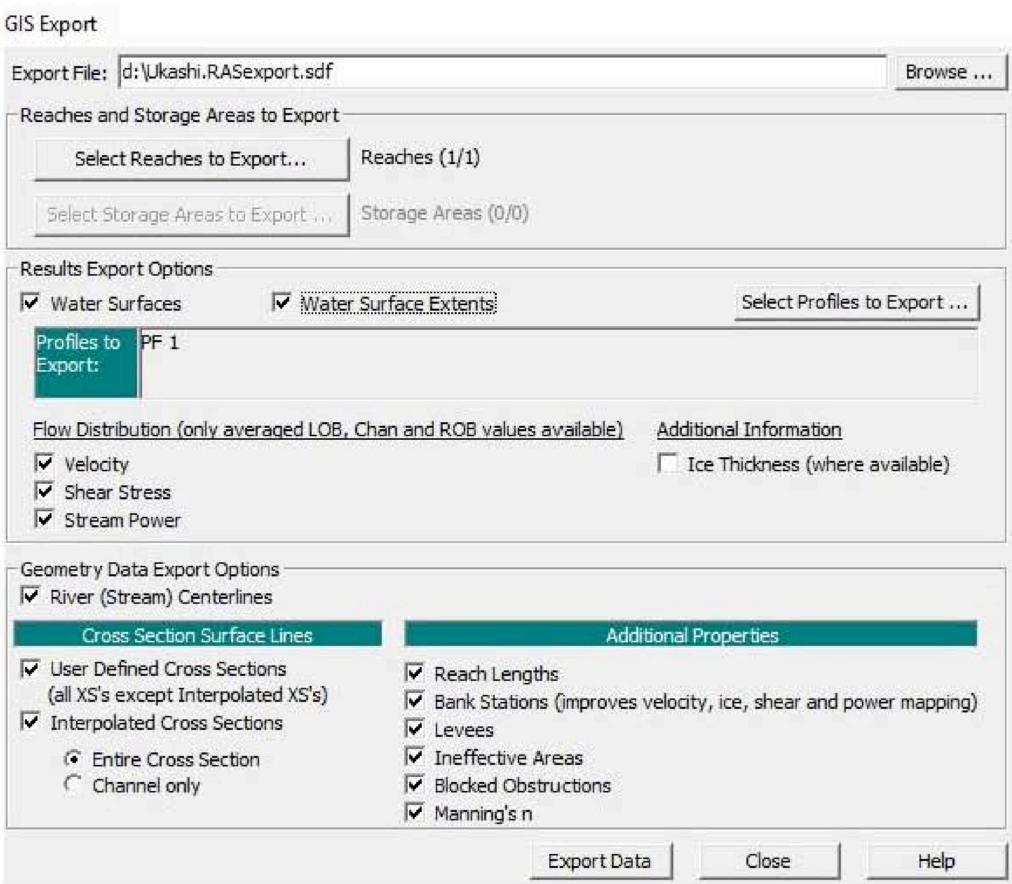


Fig. 26

3. **Click** on **Export Data** button. RAS acknowledge window will appear. Click OK. (It will create a SDF file in your working directory).

4. **Save** the HEC-RAS project and **exit**. We will now return to ArcMap to create a flood inundation map.

Unsteady Flow Analysis:

Flows are typically defined at the most upstream location of each river/tributary. Each flow that needs to be simulated is called a profile in HEC-RAS. For this exercise, we will create one hypothetical profile.

1. In the main HEC-RAS window, click on Edit →Unsteady Flow Data (Fig. 27).

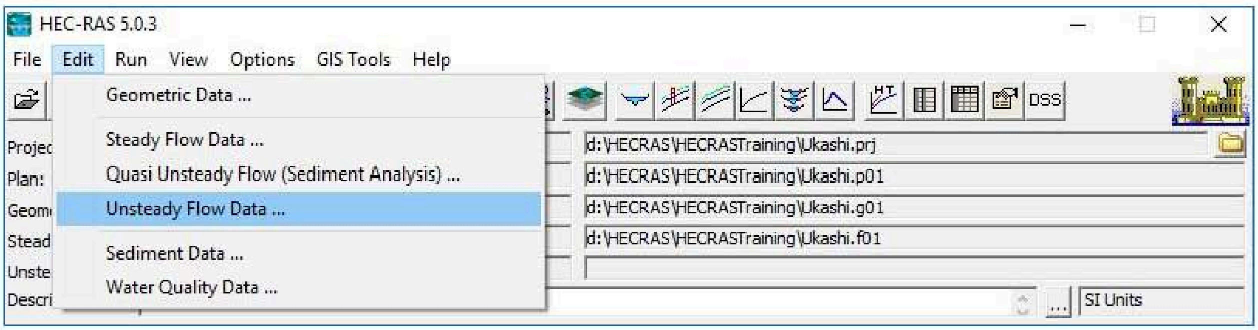
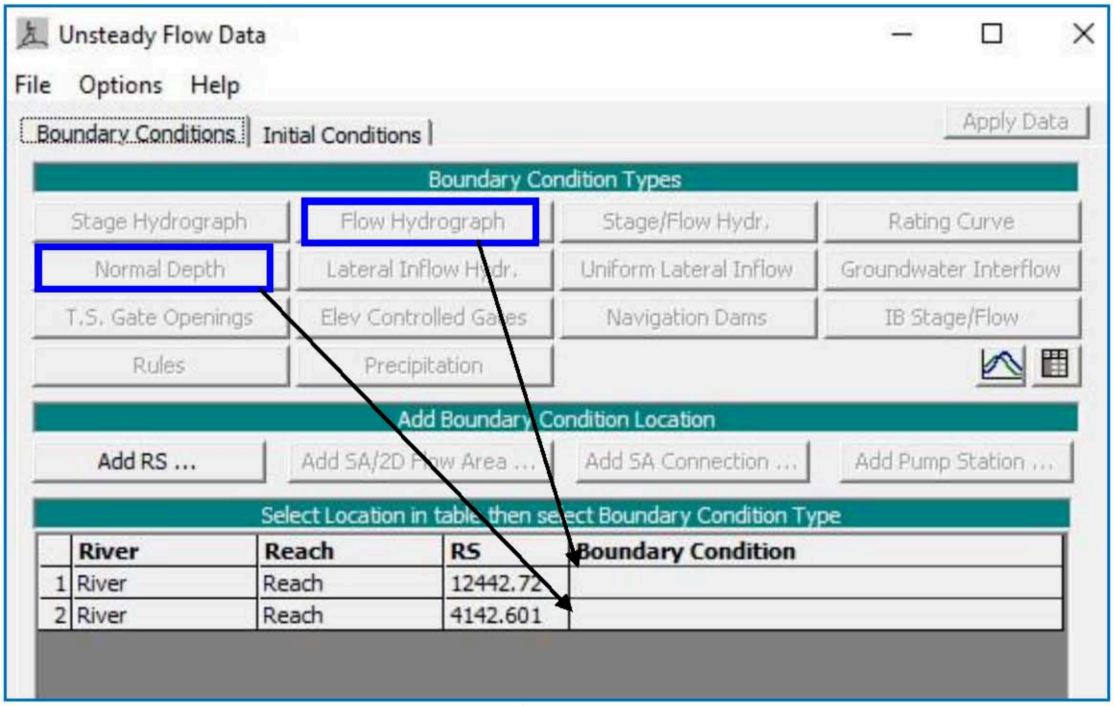


Fig. 27

2. Unsteady Flow Data window will appear as shown in Fig. 28. Select the boundary condition for river. Randomly we select flow hydrograph as upper boundary condition and normal depth as downstream boundary condition.


Unsteady Flow Data
File Options Help
Boundary Conditions
Initial Conditions
Apply Data
Boundary Condition Types
Stage Hydrograph
Flow Hydrograph
Stage/Flow Hydr.
Rating Curve
Normal Depth
Lateral Inflow Hydr.
Uniform Lateral Inflow
Groundwater Interflow
T.S. Gate Openings
Elev Controlled Gates
Navigation Dams
IB Stage/Flow
Rules
Precipitation
Add Boundary Condition Location
Add RS ...
Add SA/2D Flow Area ...
Add SA Connection ...
Add Pump Station ...
Select Location in table then select Boundary Condition Type
River
Reach
RS
Boundary Condition
1 River Reach 12442.72
2 River Reach 4142.601
i
Fig. 28

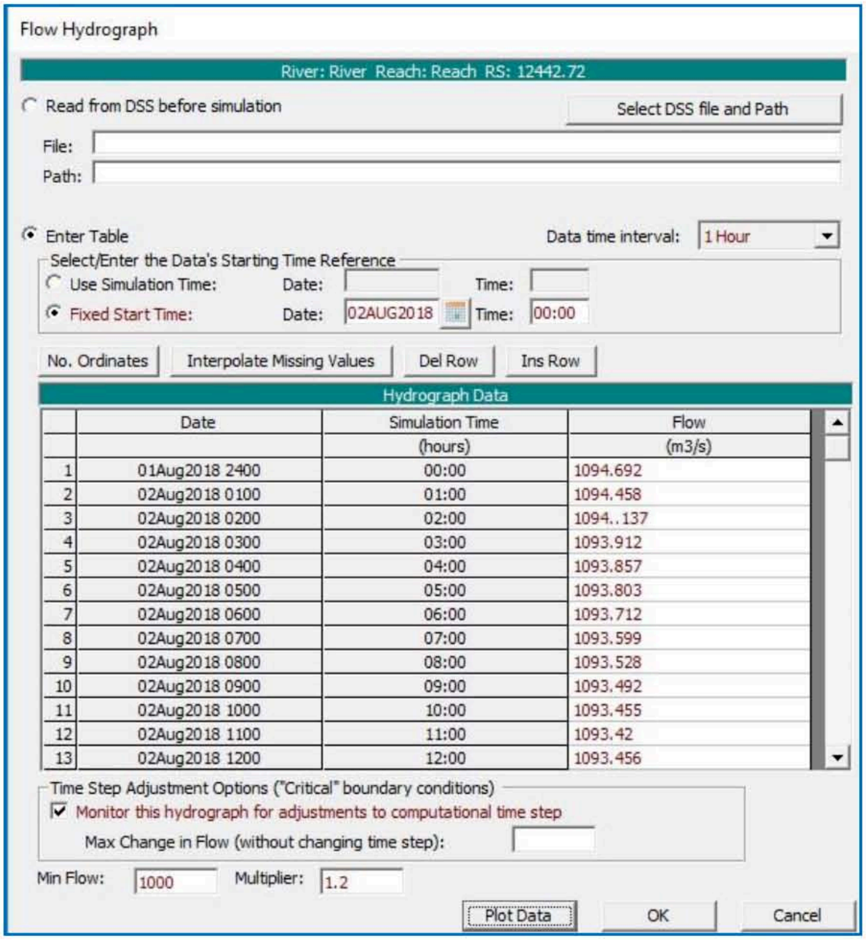


Fig. 29

3. Now come to Unsteady Flow Data window. Go to File →Save Flow Data.
4. Save Flow Data As window will appear. Select working directory and give the title (eg. Unsteady_Ukashi). Click OK. Close the Unsteady Flow Data window. Now we are ready to run HEC-RAS.

Step 10: Running HEC-RAS

In the main HEC-RAS window, click on Run→Unsteady Flow Analysis (Fig. 30).

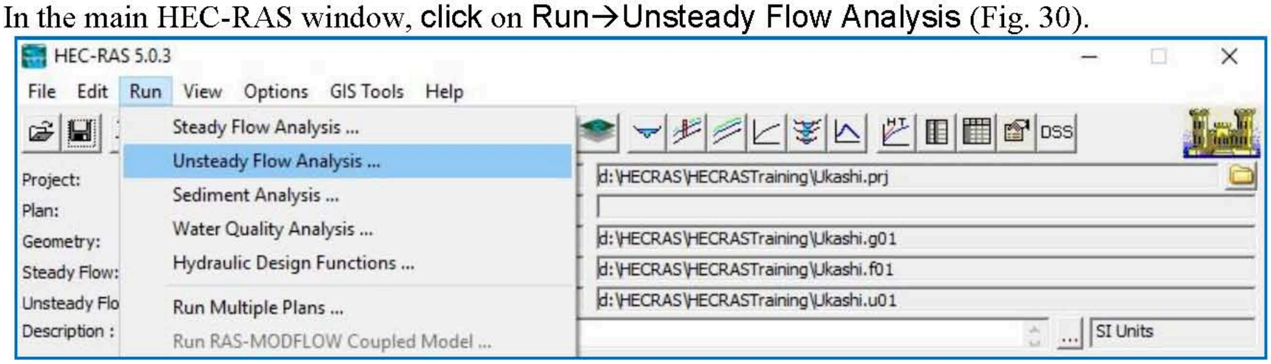


Fig. 30

16 5. Unsteady Flow Analysis window (Fig. 31) will appear. Give Short ID (eg. UK_Un_p). Select Subcritical Flow Regime. Click on Floodplain mapping check box. Click on Compute button. The model will run.

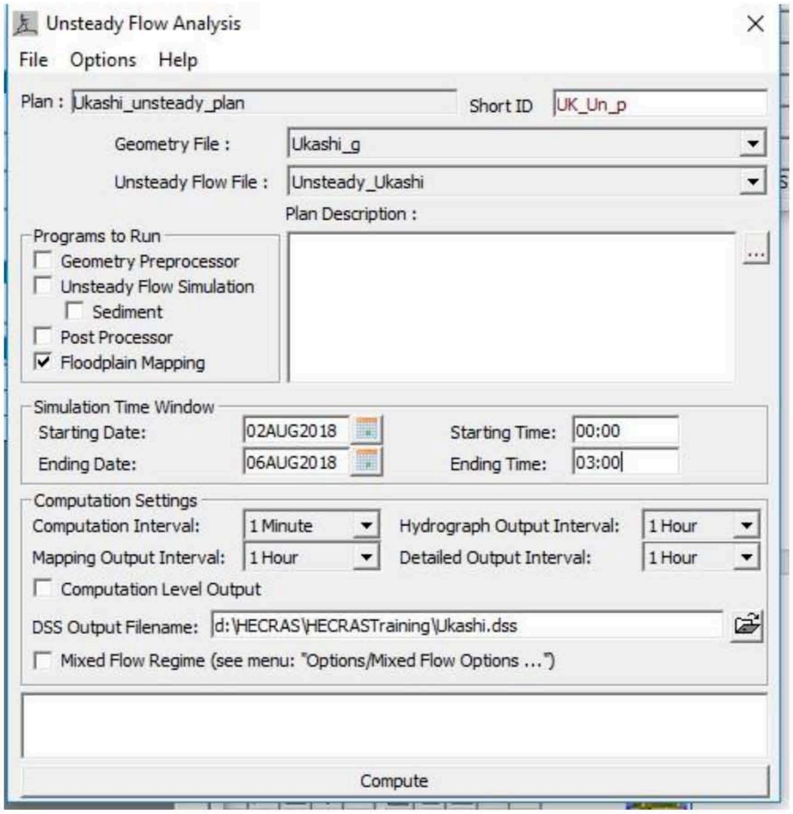


Fig. 31

6. HEC_RAS Finishes Computations window (Fig. 32) will open. After successful simulation, close the computation window and the unsteady flow Analysis window.

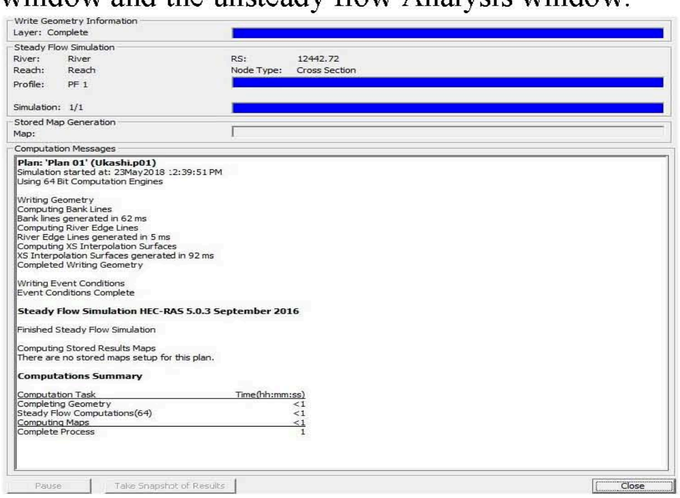


Fig. 32

1 D Flood inundation mapping

1. In ArcMap (if you closed **Uttarkashi.mxd** earlier, open it).
2. Click on **Import RAS SDF file** button to convert the SDF file into an XML file.

   Convert RAS Export SDF to XML window will appear.

3. In RAS SDF File option, browse to Flood_study_uttarka.RASexport.sdf . The XML file will be saved with the input file name in the same folder with an xml extension as shown in Fig. 33. Click OK.

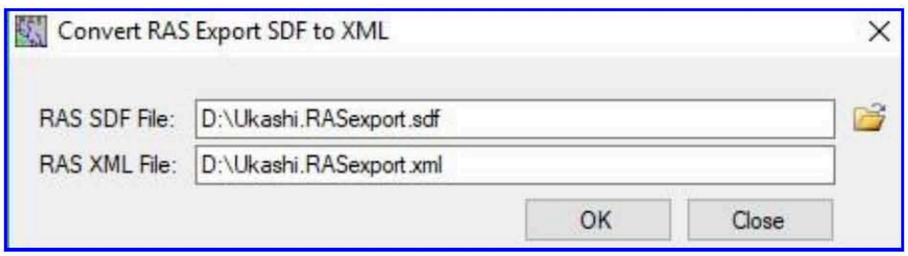


Fig. 33

4. SDF2XML acknowledge window will appear. Click OK. 5. Now click on RAS

   Mapping→Layer Setup to open the post processing layer menu.

6. In the **Layer Setup** for post-processing, first select the **New Analysis** option, and name the new analysis as ***Uttarkashi_Steady_Flow2***. Browse to ***UkashiRASexport.xml*** for **RAS GIS Export** File. Select the **Single**, in Terrain Type select **GRID** and browse to ***srtm_dem_utm***. Browse to your working folder for **Output Directory** as shown in Fig. 78.

   HEC-GeoRAS will create a geodatabase with the analysis name (**Uttarkasi_Steady_Flow2**) in your output directory. Accept the default **30** map units for Rasterization Cell Size. Click OK.

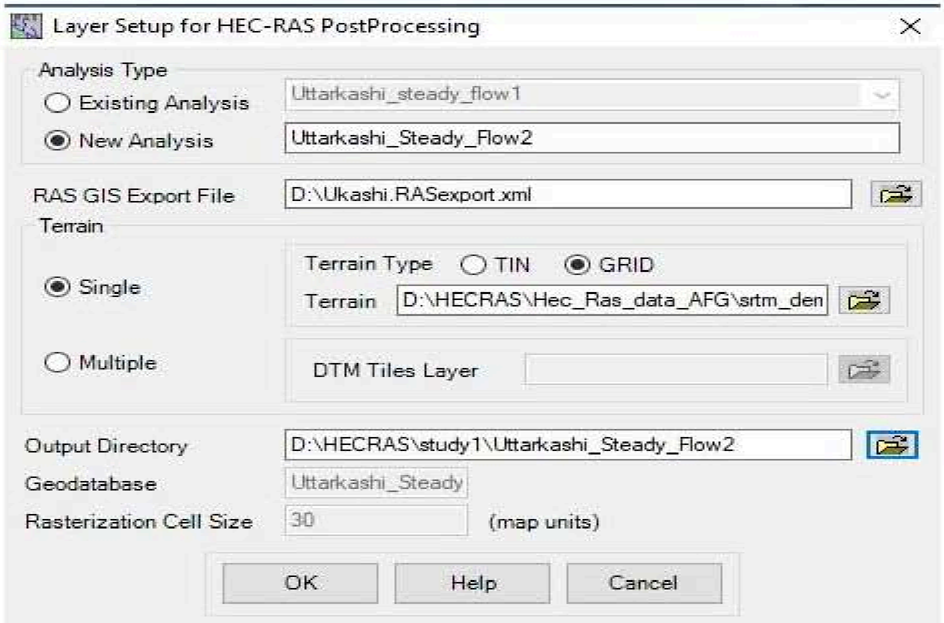


Fig. 34

7. A new map (data frame) with the analysis name (Uttarkasi_steady_flow) will be added to ArcMap with the terrain data.

8. Next click on RAS Mapping →Import RAS Data.

9. Import RAS Data window (Fig. 35) will appear. Click OK.

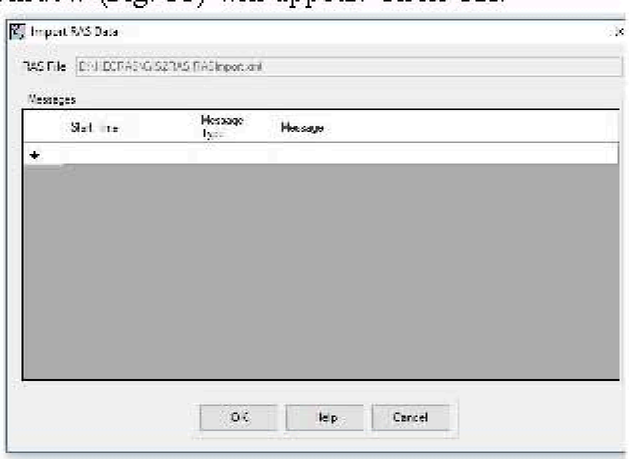


Fig. 35

10. Similar to during export, you will see a series of messages during the import as shown in Fig. 36.

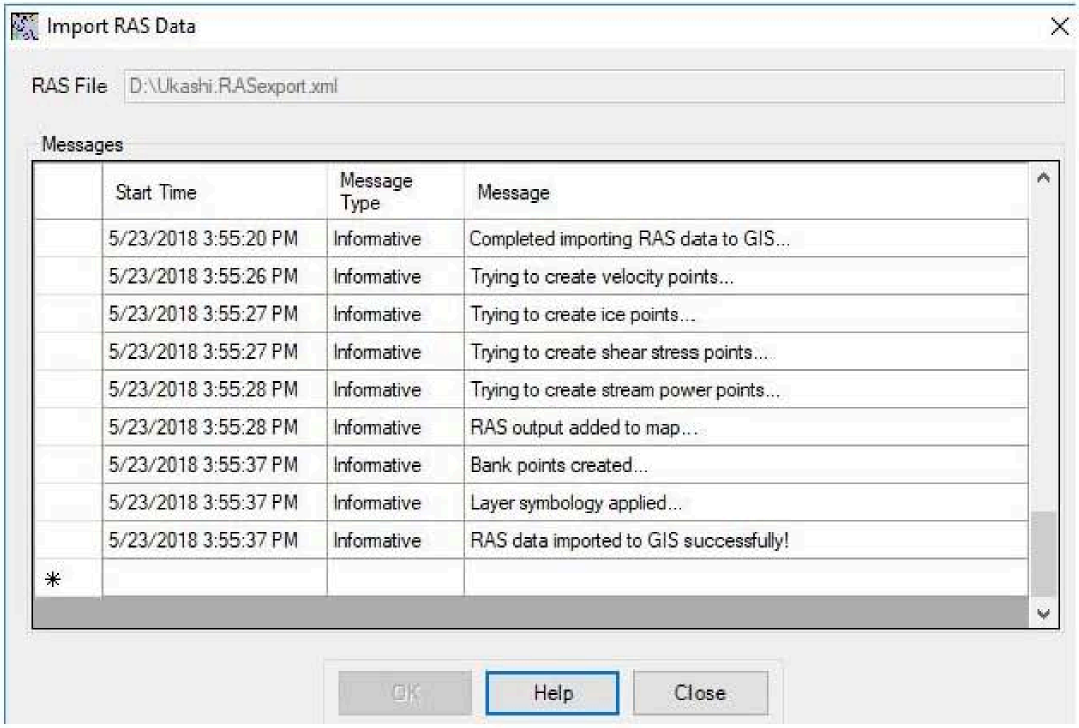


Fig. 36

11. This will create a bounding polygon, which basically defines the analysis extent for inundation mapping, by connecting the endpoints of XS Cut Lines (Fig. 36).

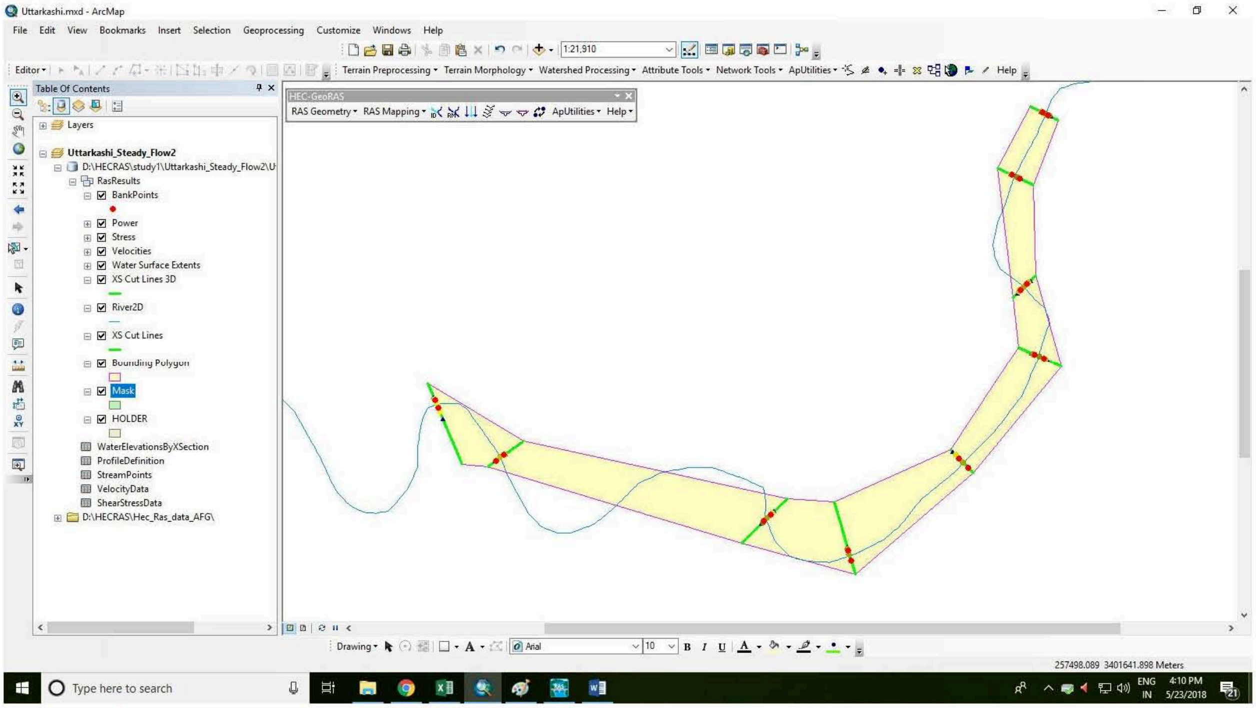


Fig. 36

12. After the analysis extent is defined, we are ready to map the inundation extent. Click on **RAS Mapping→Inundation Mapping→ Water Surface Generation** (Fig. 37).

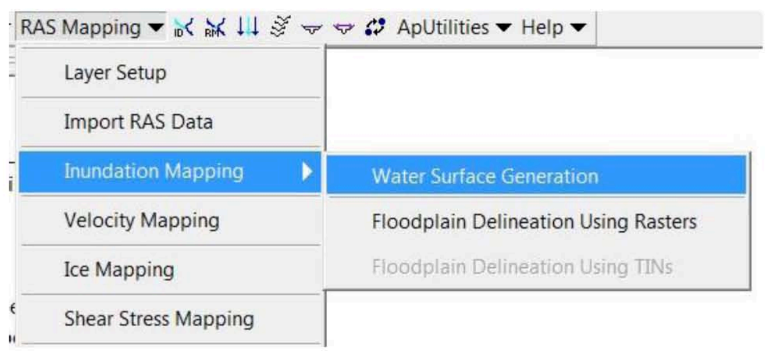


Fig. 37

13. Water Surface TIN window (Fig. 38) will appear. Select **PF1**, and Click **OK**.

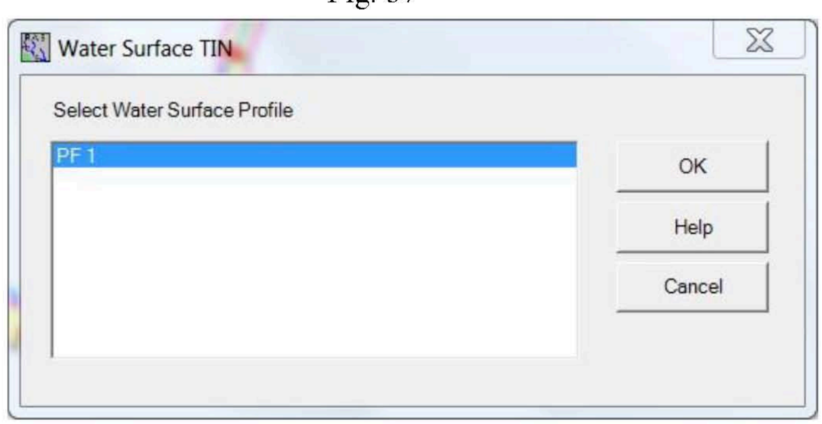


Fig. 38

14. This will create a surface with water surface elevation for the selected profile. The TIN (t PF1) that is created in this step will define a zone that will connect the outer points of the bounding polygon, which means the TIN will include area outside the possible inundation as shown in Fig. 39.

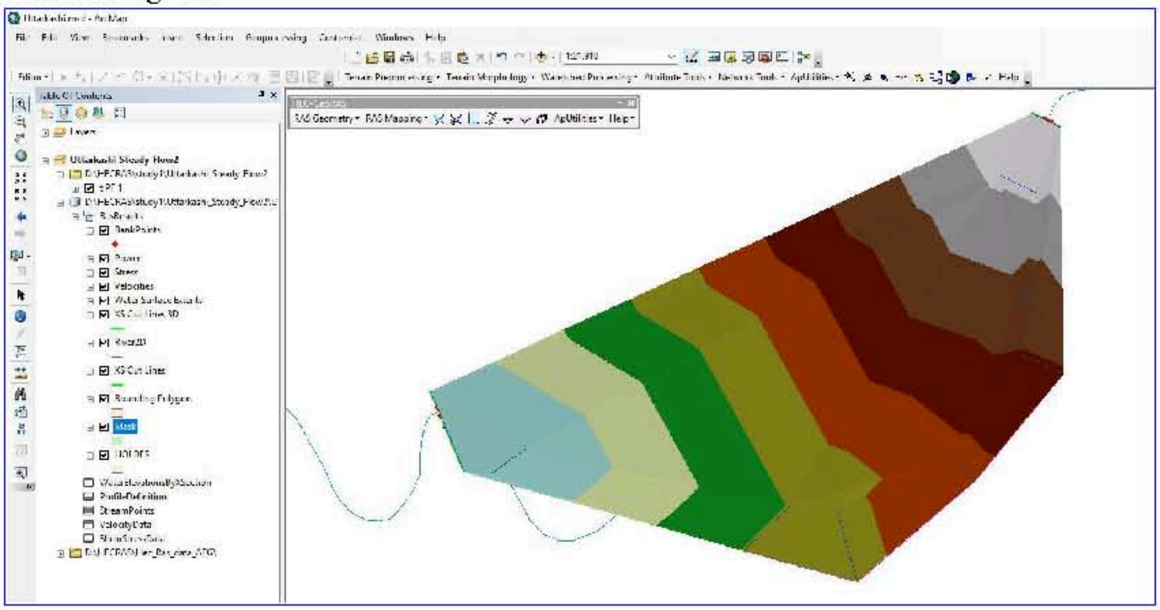


Fig. 39

Note: At this point we have a water surface (t PF1) TIN, and we have an underlying terrain (srtm_dem_utm). Now we will subtract the terrain (srtm_dem_utm) from the water surface TIN, by first converting the water surface TIN to a grid.

15. Click on **RAS Mapping->Inundation Mapping→ Floodplain Delineation using Rasters** (Fig. 85).

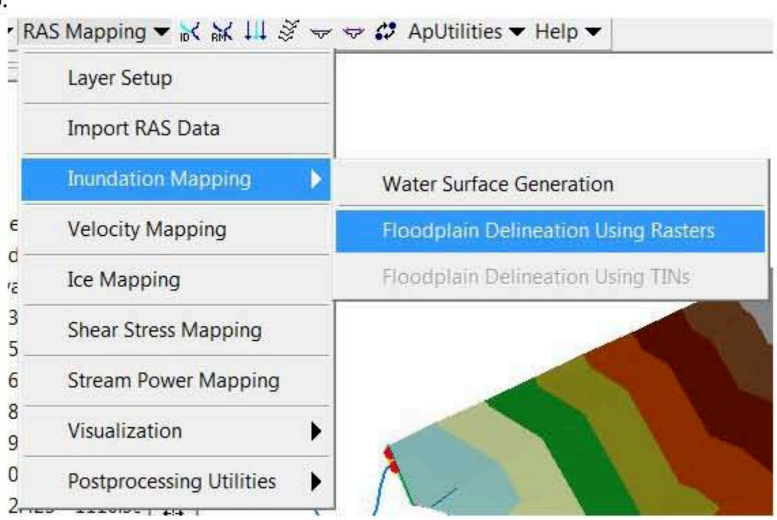


Fig. 40

16. Floodplain Delineation (Fig. 40) will appear. Again, select PF1 and click OK.

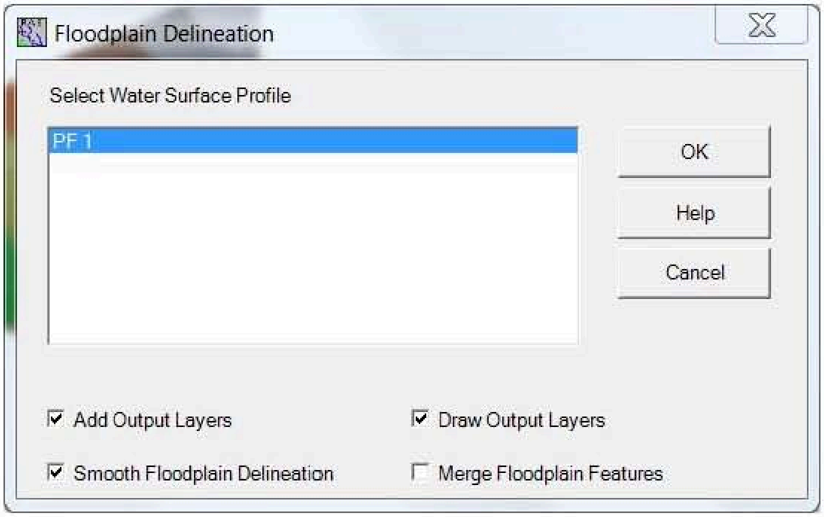


Fig. 41

17. HEC-GeoRAS acknowledge window will appear. Click OK.

18. **srtm_dem_utm** is subtracted from the water surface grid. The area with positive results (meaning water surface is higher than the terrain) is flood area, and the area with negative results is dry. All the cells in water surface grid that result in positive values after subtraction are converted to a polygon, which is the final flood inundation polygon as shown in Fig. 87.

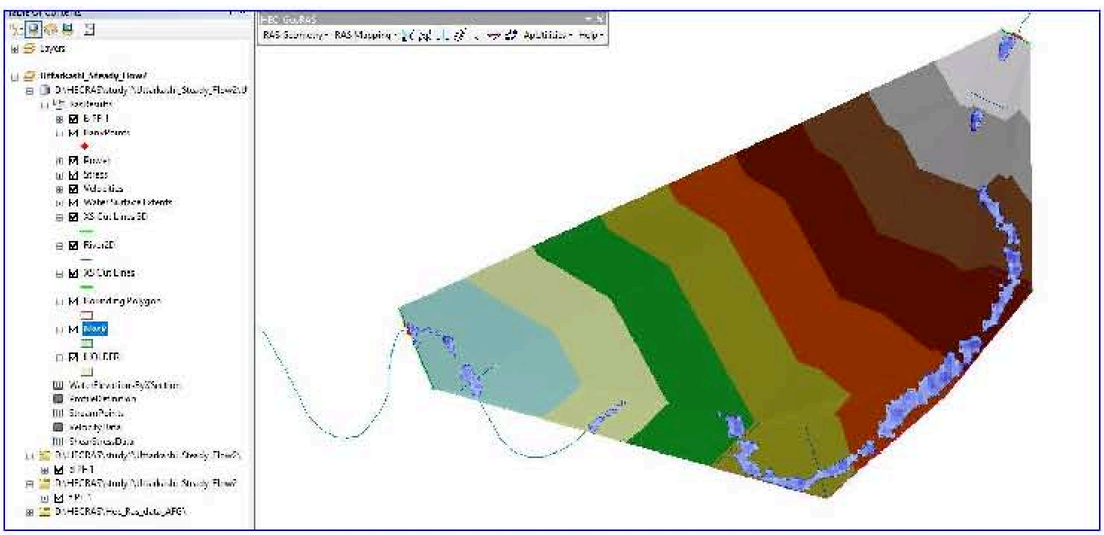


Fig. 41

19. Save the ArcMap document.

2D Flood Inundation Modeling

HECRAS version 5 and later includes functionality to analyses water flows moving across a surface. this is known as 2D flood modelling and provides more accurate modelling of water movement across a surface. For 2D flow modeling followings steps are accomplished.

1. Convert DEM to Float in ArcGIS using the following command Raster to Float (In ArcToolbox goto 3D Analyst Tool/Raster Math/Float) as shown in figure 42. In input raster "srtm_dem_utm" and Output raster "dem.flt" as shown in figure 88.

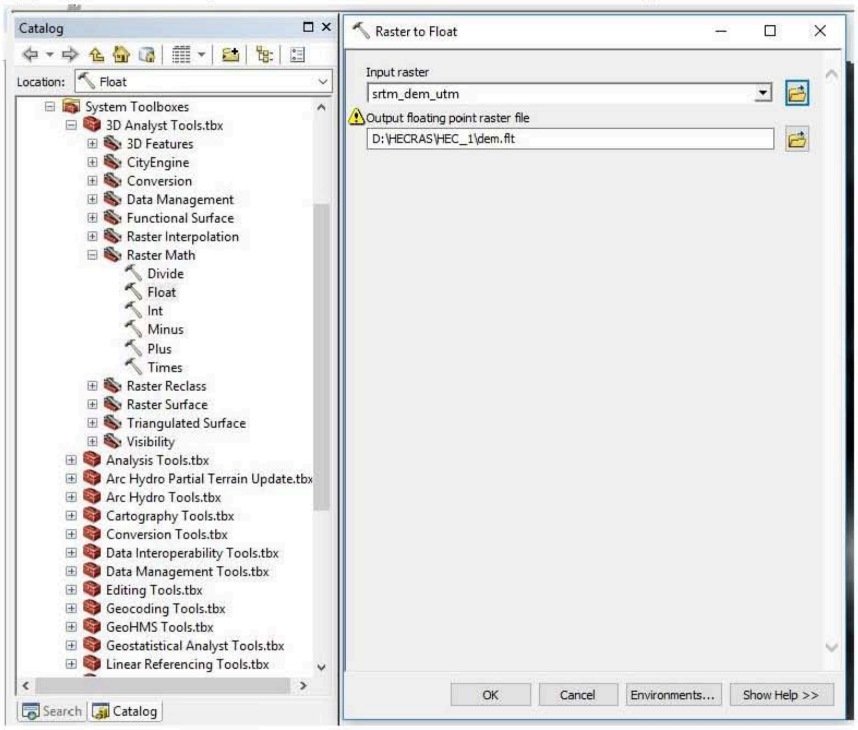


Fig. 42

2. Open HEC-RAS and create a new project and defines the unit system:

   - Click on **File > New**. Select a location and name for the new project
   - Click on **Options > Unit System** to confirm the units (this example is using **Metric units**).

3. The first step in developing a terrain data set is to open RAS Mapper. This is accomplished by selecting GIS Tools from the HEC-RAS main window, then selecting RAS Mapper, or by pressing the RAS Mapper button on the HEC-RAS main window. When this is done, the window shown in figure 43 will appear.

4. In RAS Mapper firstly set the projection for the project. In Tools menu select "Set Projection for Project" and defines the projection parameters or import from the file as shown in figure 44.

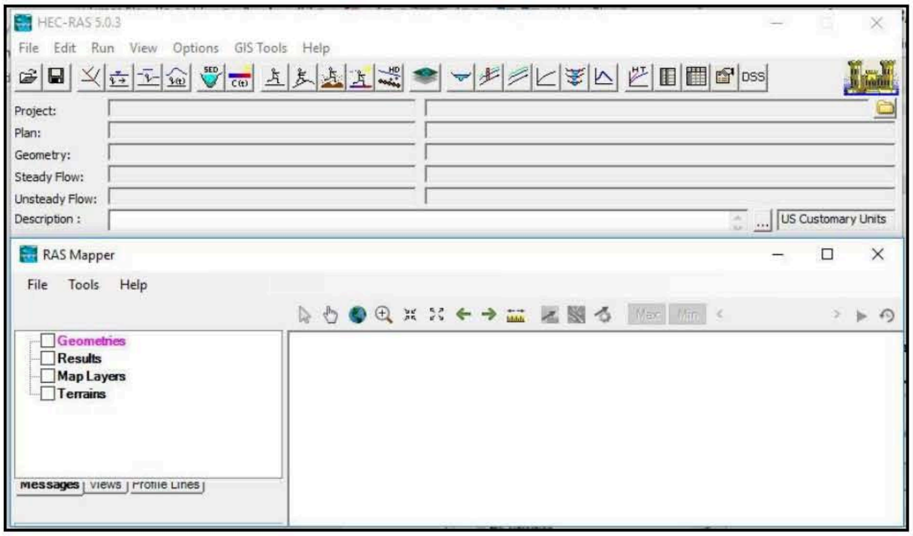


Fig 43

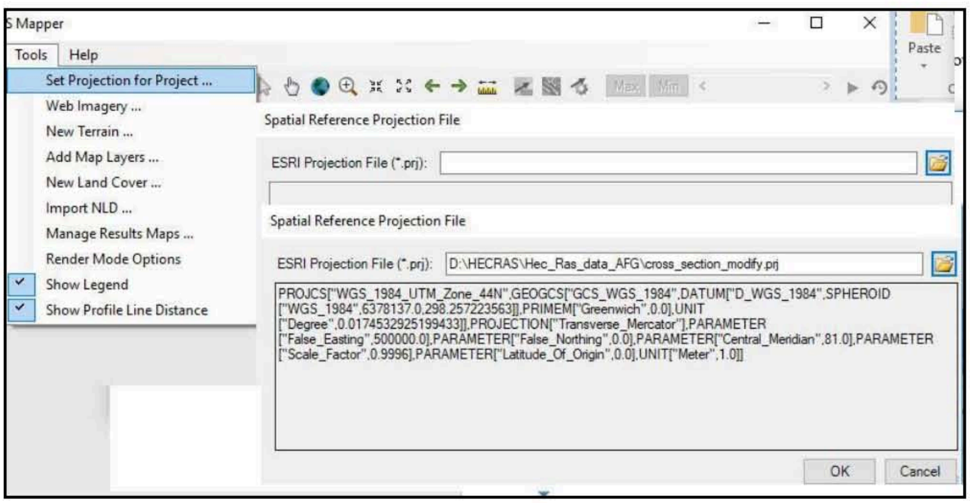


Fig 44

5. In RAS Mapper to add a terrain, **Click on Tools > New Terrain**

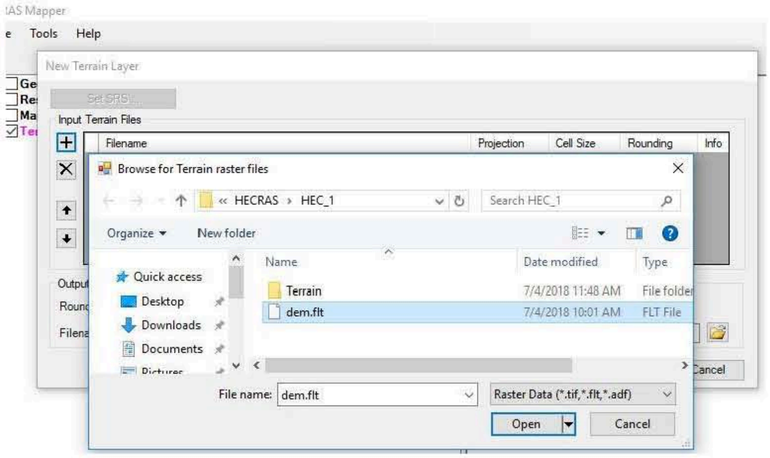


Fig 45

This data will be used to create a Terrain – in HECRAS the terrain is saved as a file with extension .hdf.

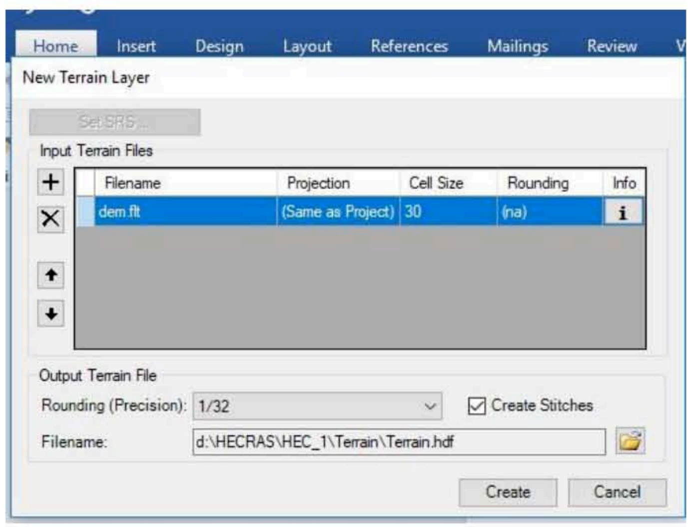


Fig 46

Click on Create to import the Terrain. Note under the Terrains layer is a new layer. Make sure that Terrains is ticked on, then right click on Terrain and choose Zoom to Extents to see the full extents of the terrain model in RAS Mapper. Terrain data is exported in jpg format.(named terrain.jpg)

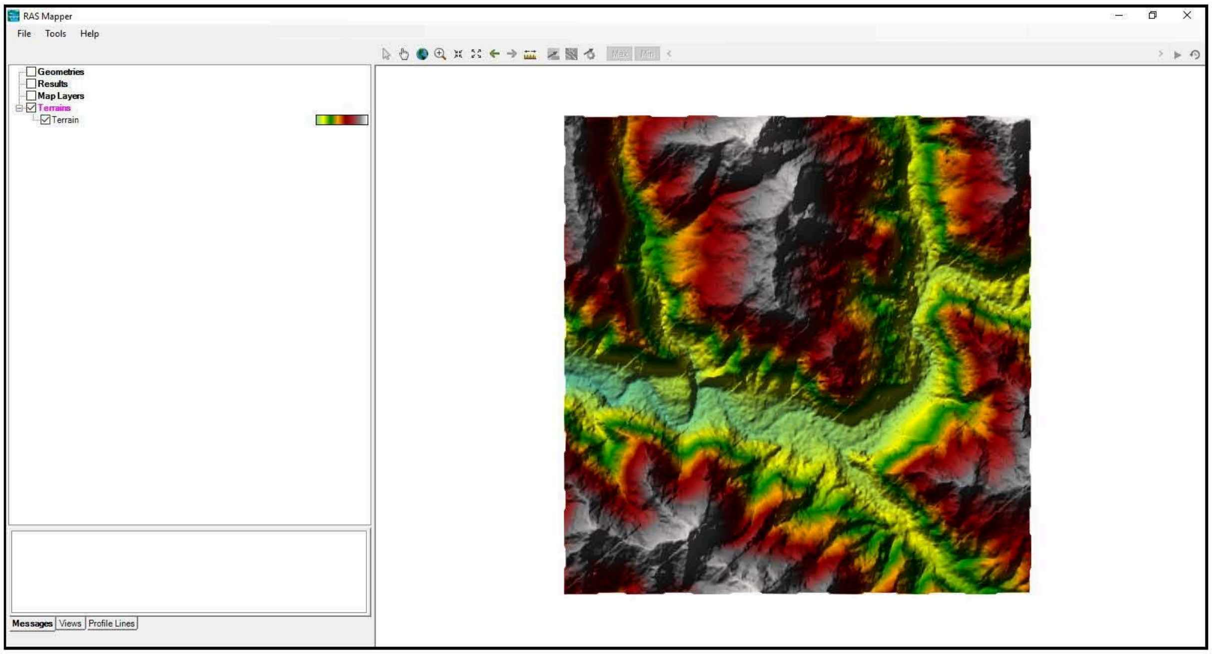


Fig 47

6. In RAS Mapper to add a Map Layer, **Right click on Map Layers and select Add map data layers, (*Using this option we can add exported terrain image as well as Google satellite etc*).**

When prompted to select a file, use the file type dropdown bottom right to select images.

Tick on the image to display it in RAS Mapper. Right click on the image name to edit the Image Display Properties – a transparency can be assigned here as shown in Figure 48. Then close RAS Mapper.

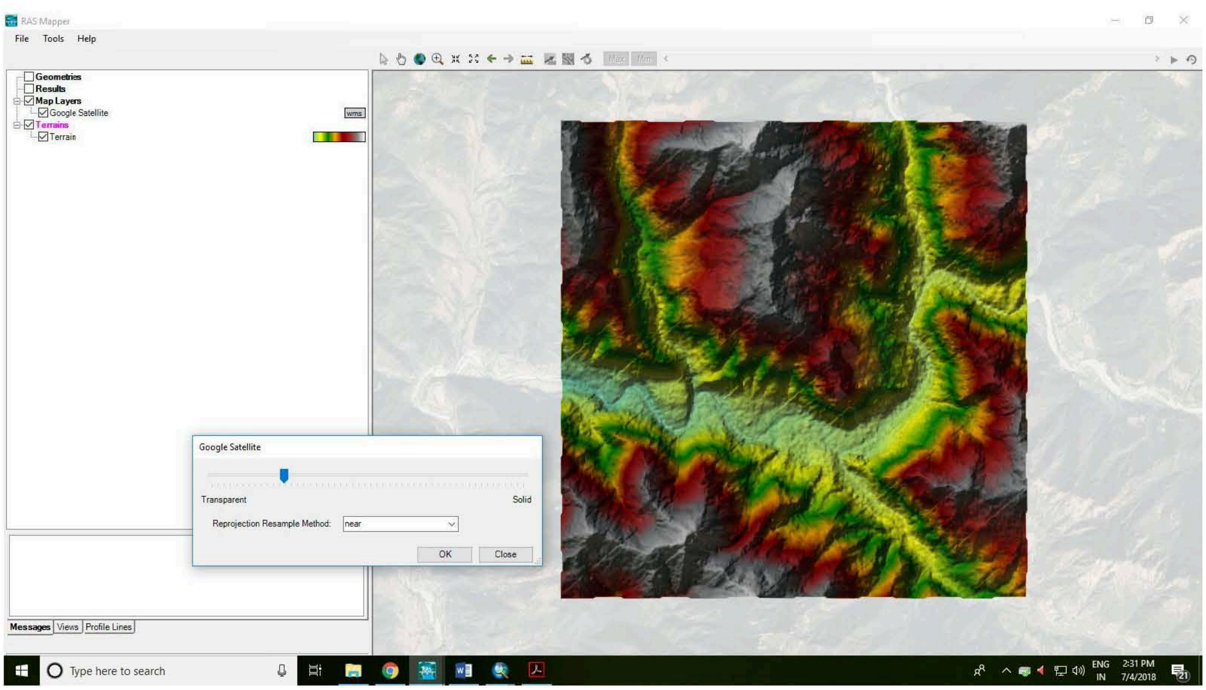


Fig 48

7. Creating the 2D Flow Area

From the HEC-RAS interface, click on View/Edit Geometric Data  A new form will display entitled Geometric Data. The surface will initially display with the colours representing elevations. To show the aerial photo, click on  and tick on to display the Map Layer you added.

- ➢ The linework (Create in 1D model) in your original drawing can be included in the Geometric data as a layer, after exporting it out from the drawing in an appropriate format for HECRAS. Now to create a 2D flow area for analysis. To keep it simple, select the extents of the terrain as the boundary.
- ➢ Click on the 2D Flow  Area button. Use the left mouse button to sketch the boundaries of a flow area. Double click on the start of the first line drawn to close the area.
- ➢ At the prompt, name the area **2DArea** and click OK.

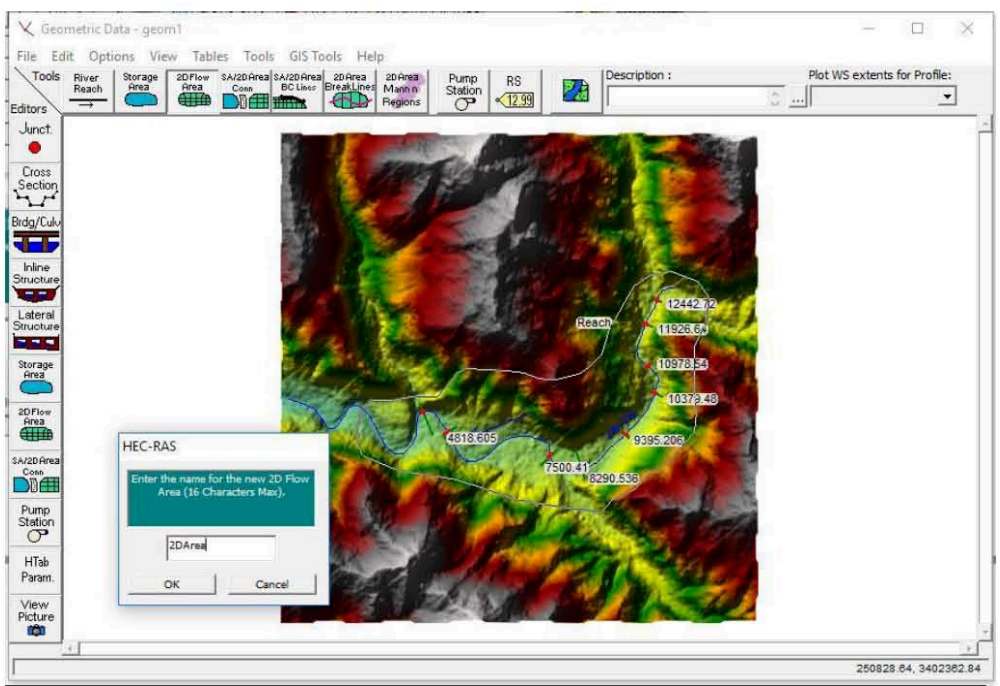


Fig 49

- Left click on the new area and select Edit 2D Flow Area.
- In the 2D Flow Areas form you apply a computational mesh across the surface, as well as establish Manning's 'n' values to apply for the default area and for any other Land Cover areas added. Click on Generate Computation Points on Regular Interval with All Breaklines. Set DX and DY both to 50 and click Generate Points in 2D Flow Area.

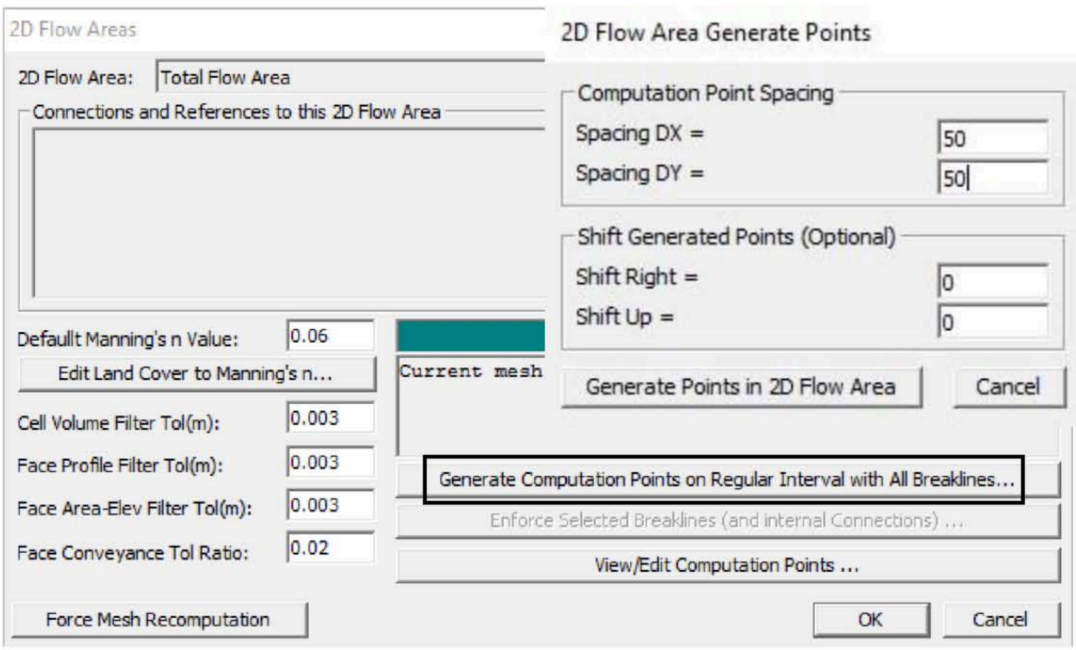


Fig 50

- Click OK to close the 2D Flow Areas form. The pattern on the 2D flow area in the Geometric Editor will change – zooming in will expose the individual mesh areas. Zoom in to view the mesh shape. If any are red in colour then you will need to use the Edit > Add Points command to add more mesh point or else adjust the boundary shape.

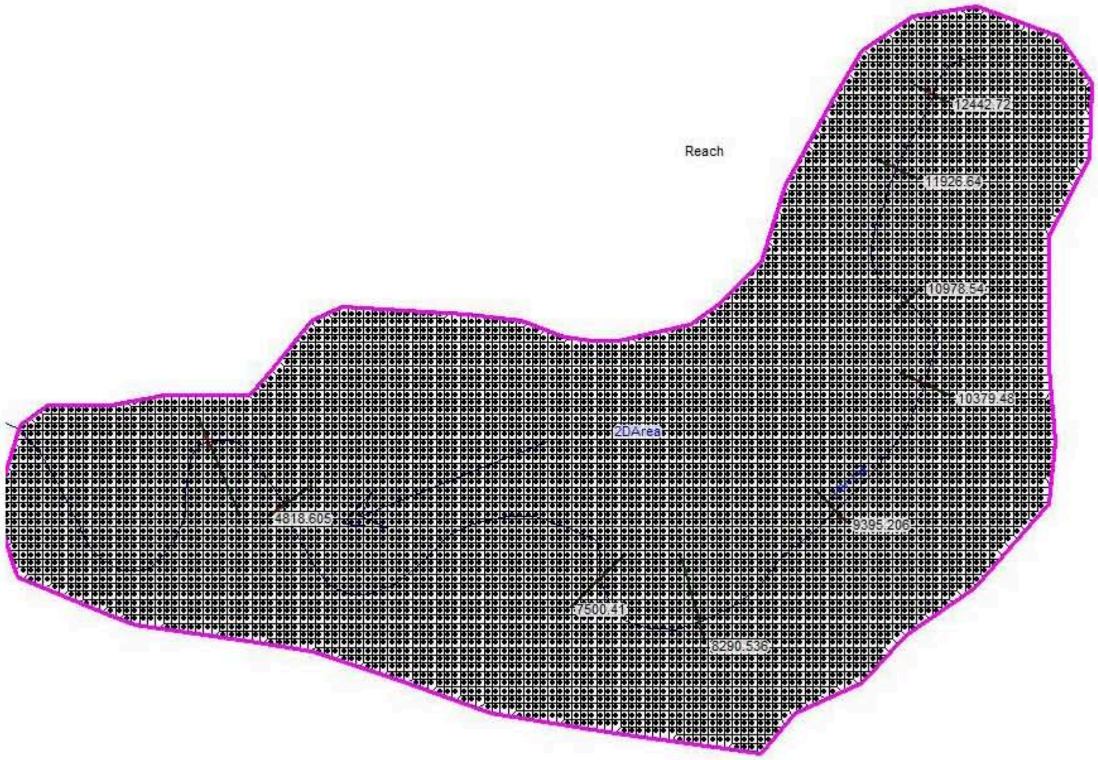


Fig 51

8. Setting Boundary Conditions (for Incoming and Outgoing flows)

Flow comes from northeast side, so inflow boundary condition has been set on this side and outflow boundary is set on western side. To set the boundary condtion we use the following steps:

- Click on the SA/2D Area BC Lines  button

- Click along the northeastern boundary to set an incoming flow line. Double click to finish the boundary.

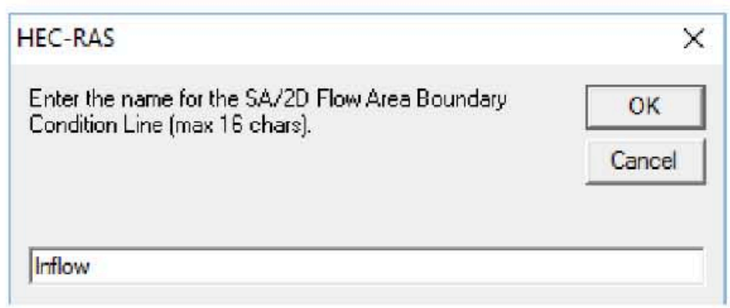


Fig 52

- Name the boundary Inflow and click OK to create.
- Repeat the above 3 steps to create an 'outflow' boundary. Run the boundary along the western boundary where the properties are and name the flow area boundary Outflow. Outputs should look similar to below:

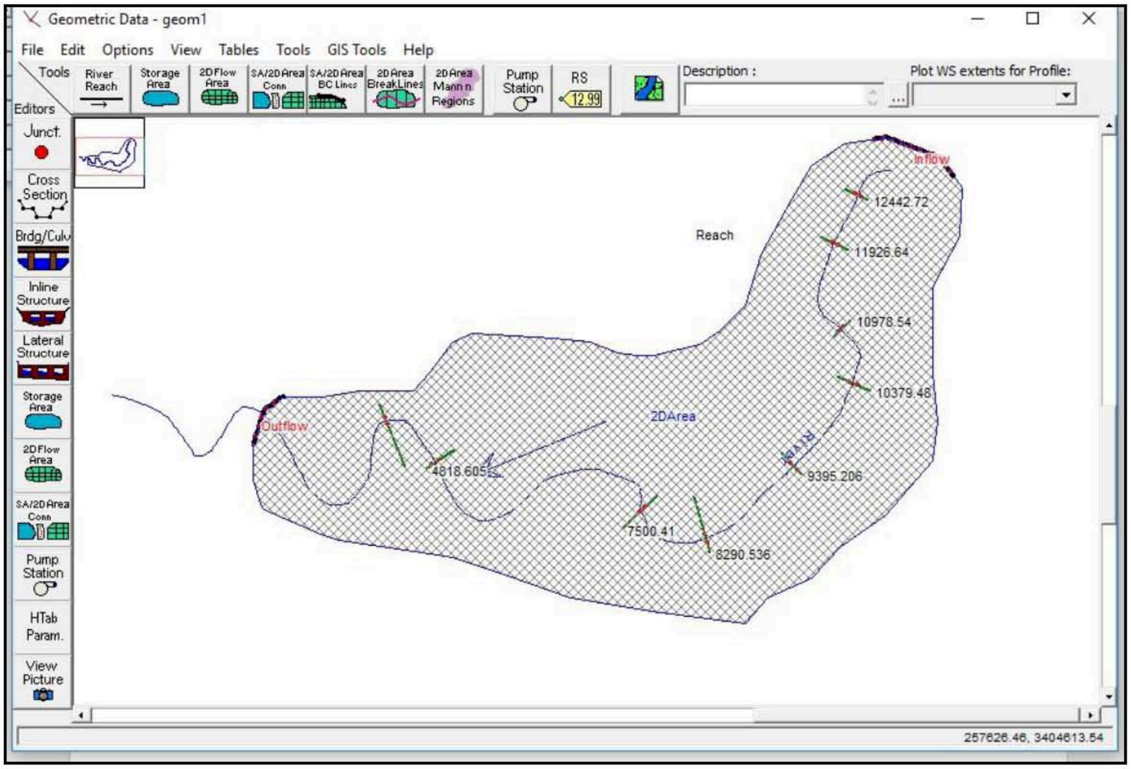
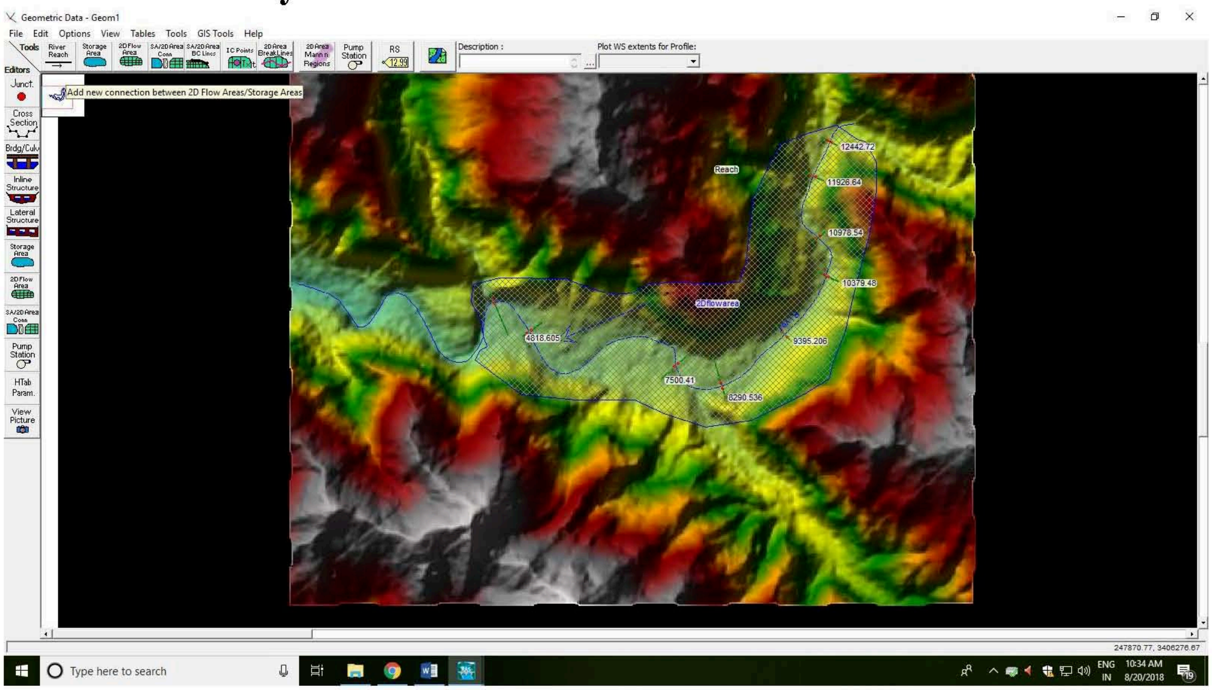


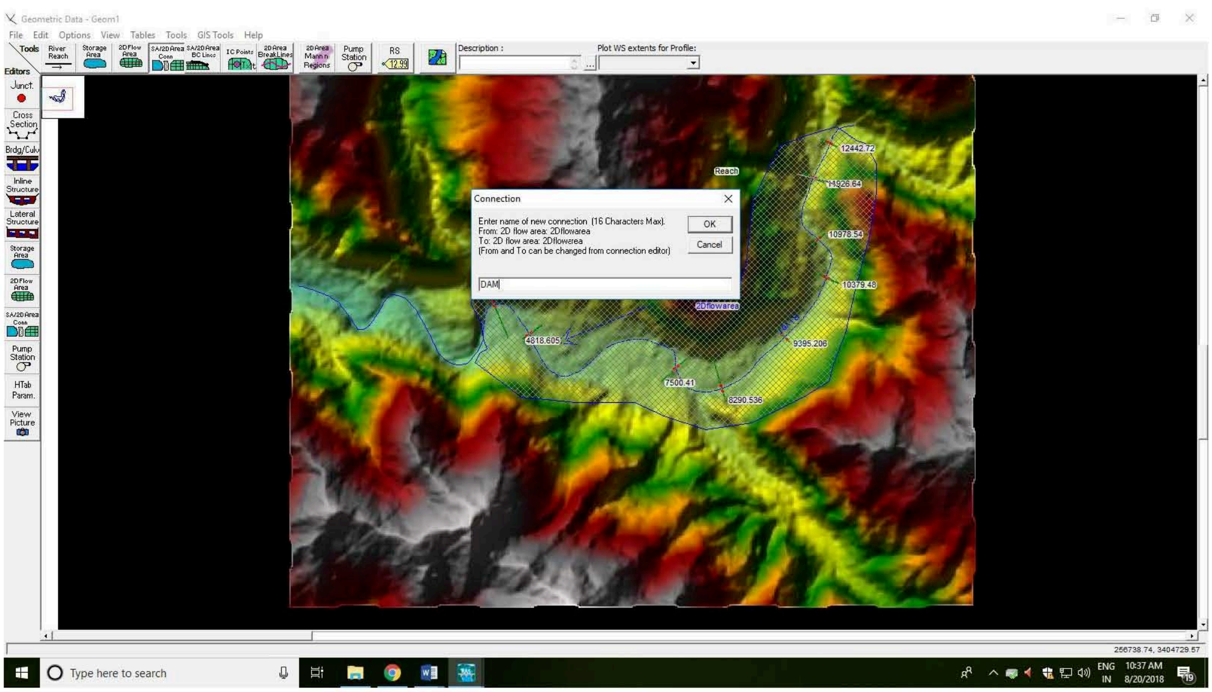
Fig 53

- Click on File > Save Geometry Data.
- Name the file Existing Conditions and click OK

9. Edit unsteady flow data and assign boundary condition data. In our case we use daily flow hydrograph data (for inlet the water from upstream) and normal depth is used for downstream flow data. Save unsteady flow data.
10. In HecRAS go to run command and then click on Unsteady flow analysis option and save the plan. In this case assigned the time period of model to run.
11. In RasMapper computes 2D flow area. If any error is occurred to set the time parameter in unsteady flow analysis option of run command.

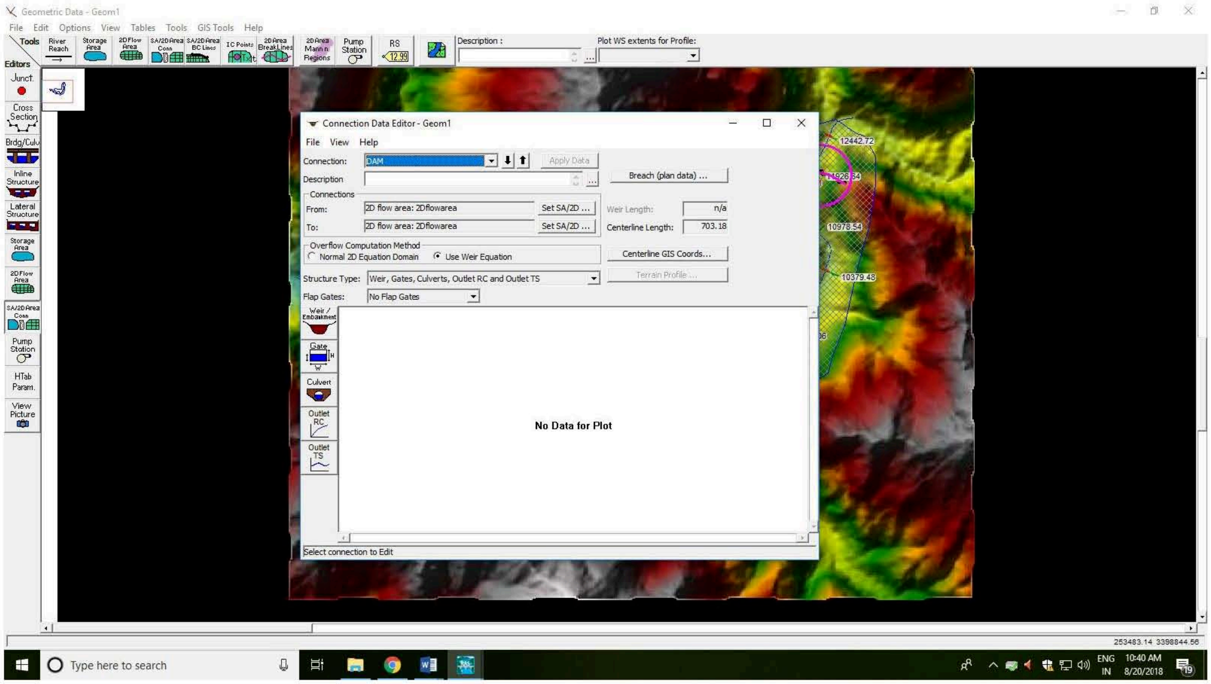
DAM Break Analysis



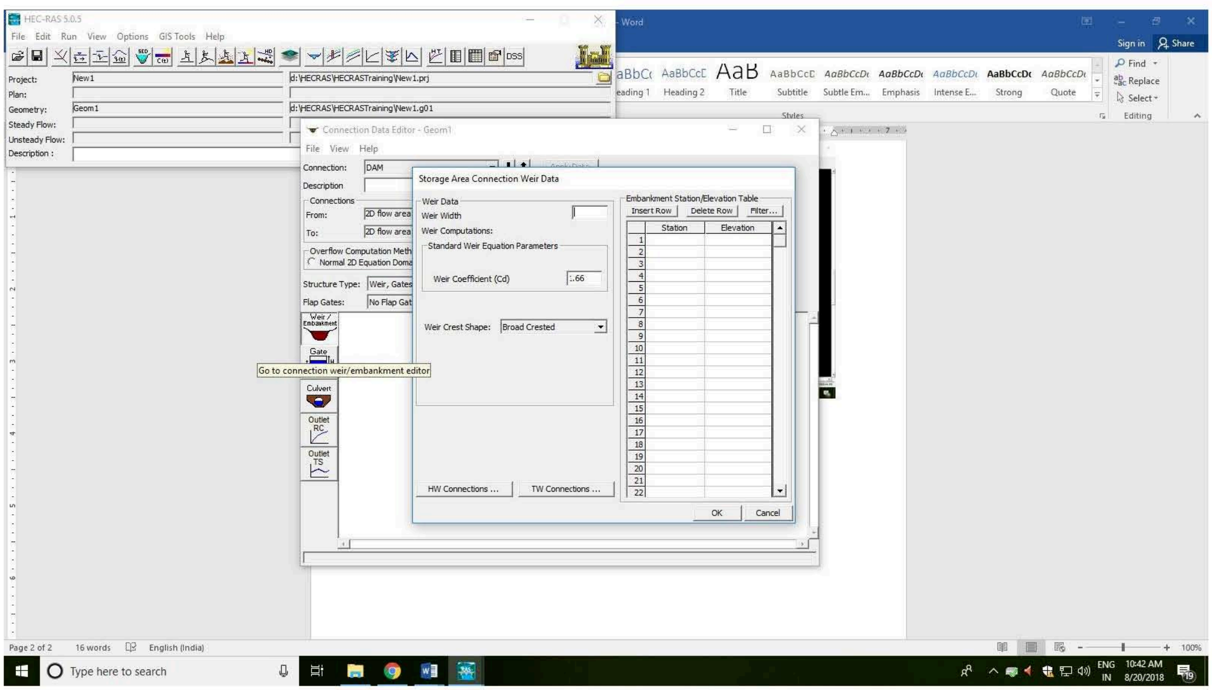


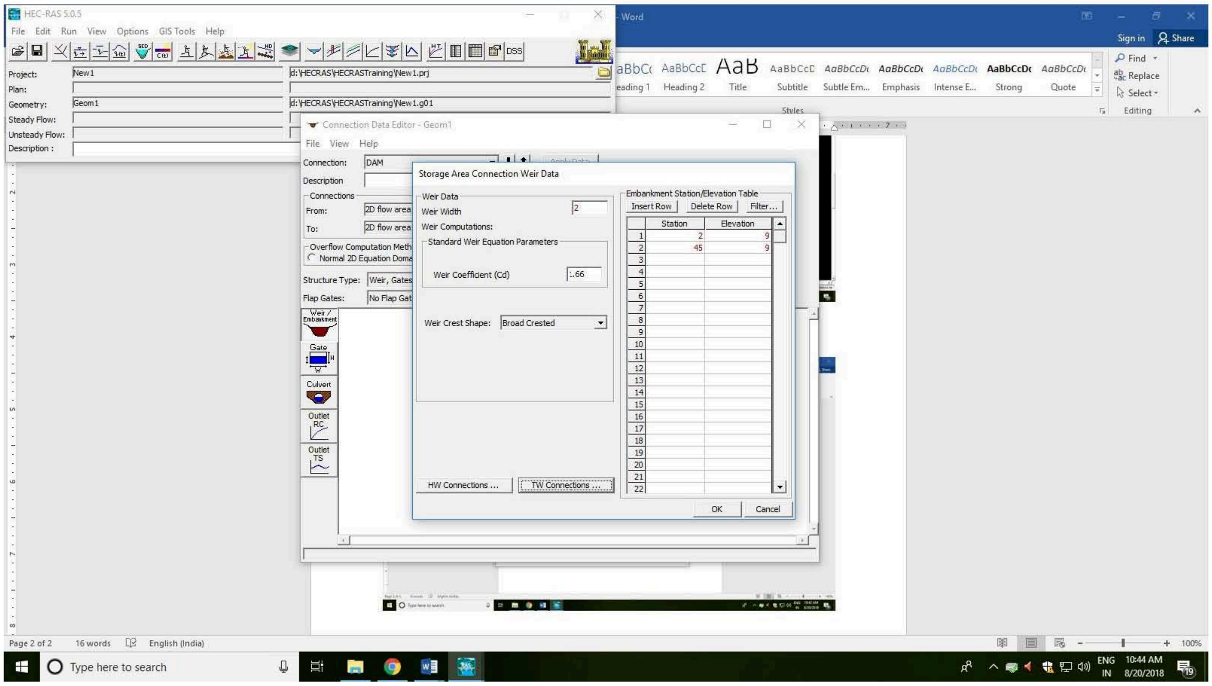
Ok

Click on edit connection, Connection Data Editor window is open



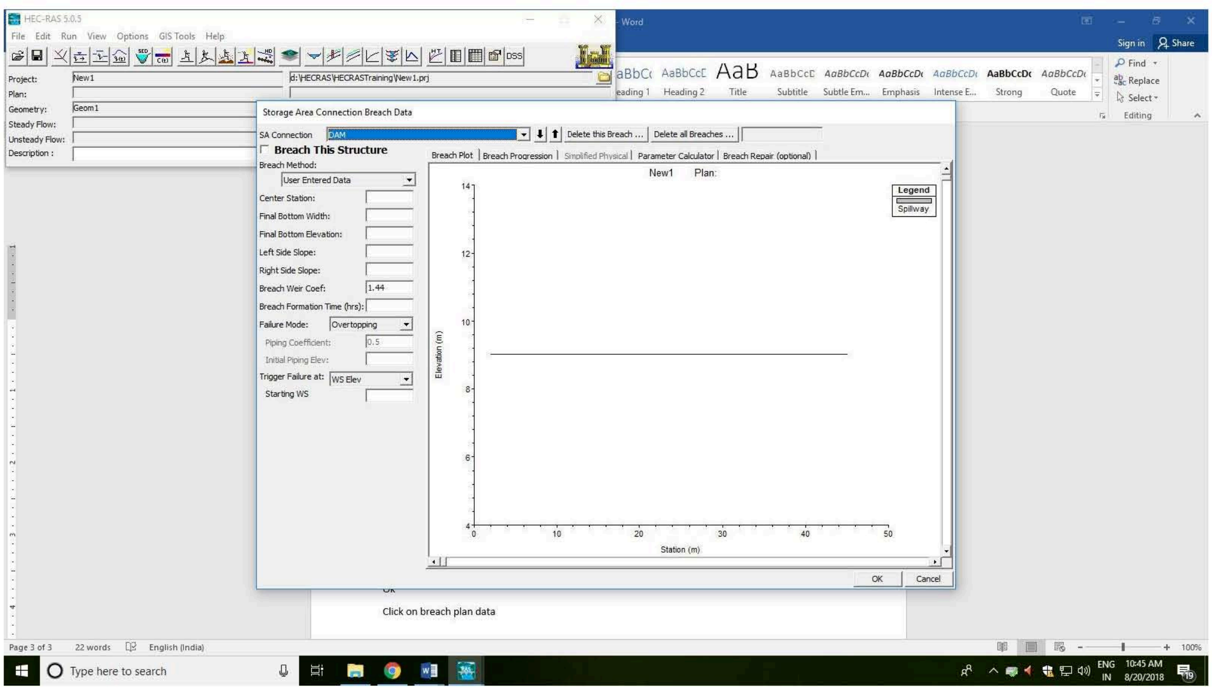
Click on weir and embankment

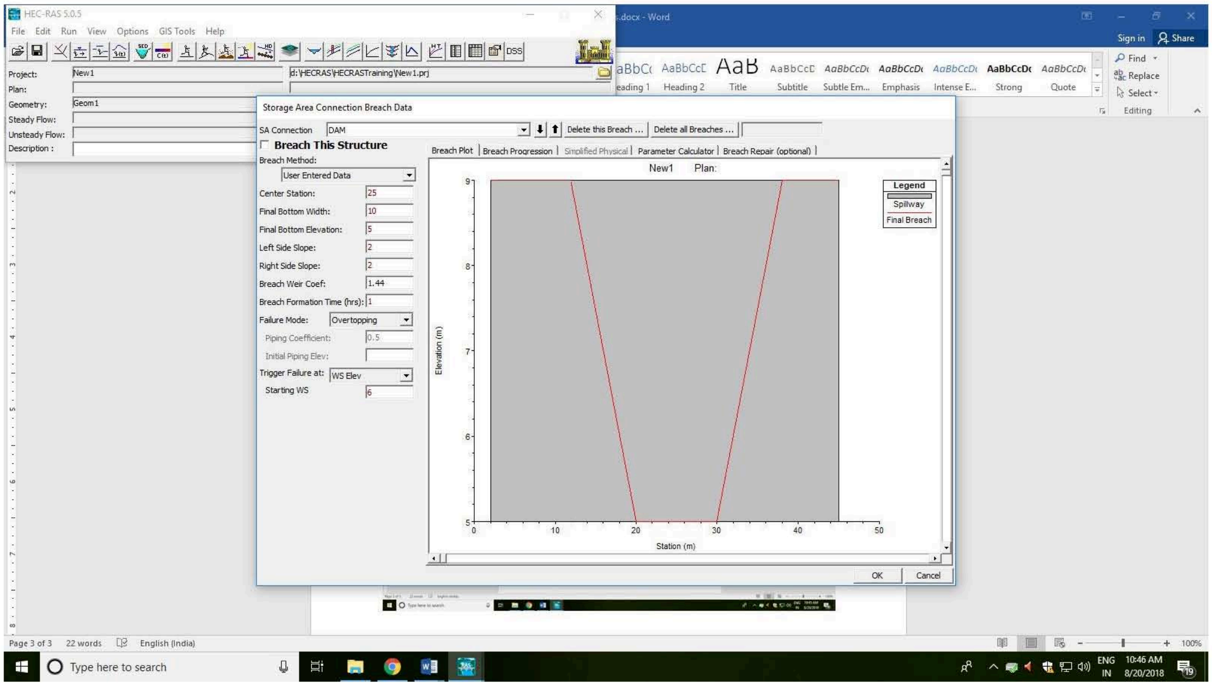




Ok

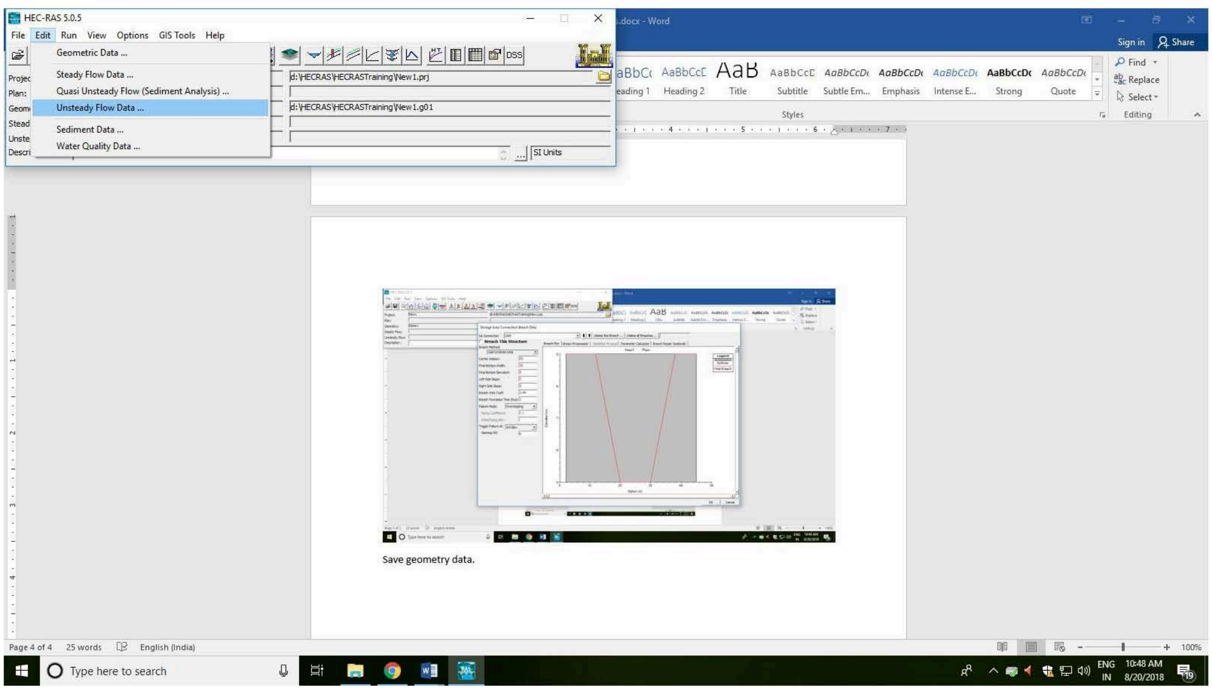
Click on breach plan data

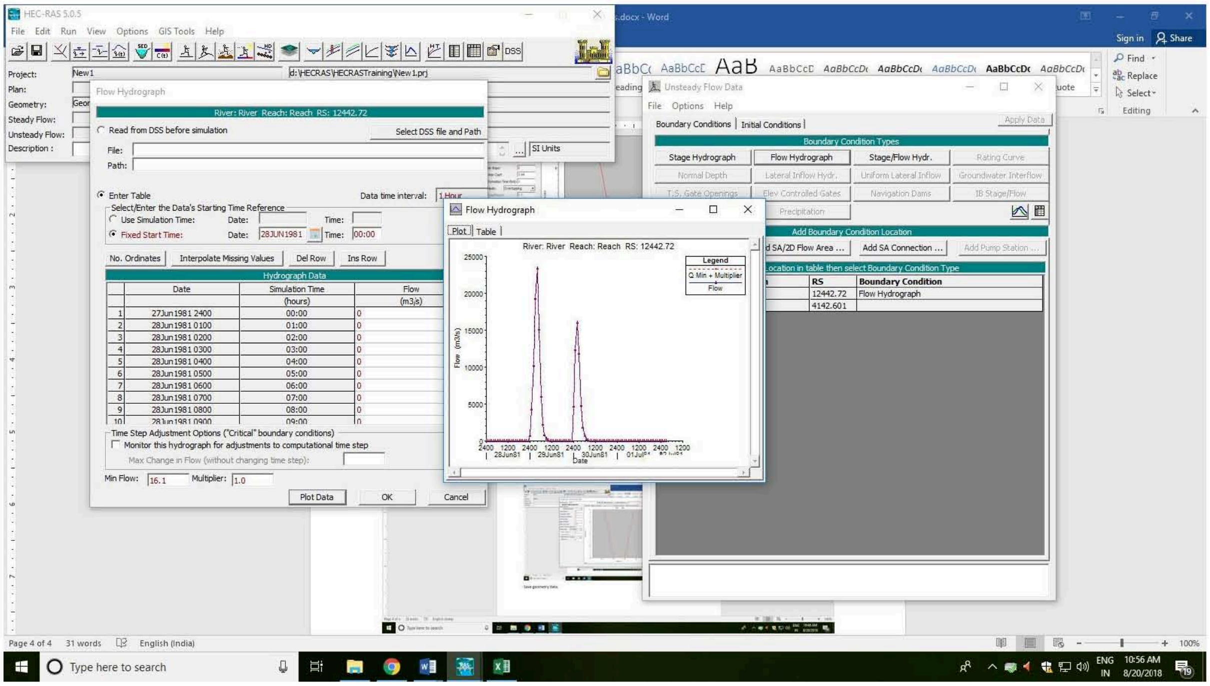




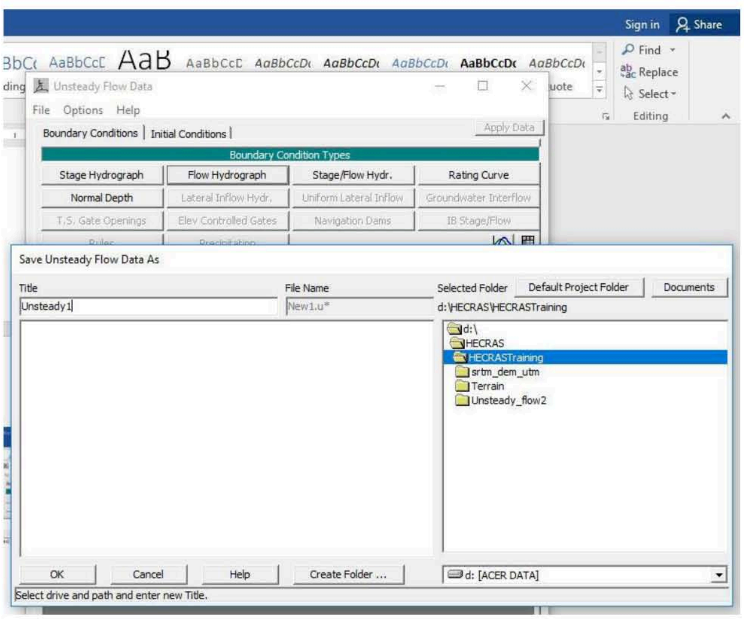
Save geometry data.

Open unsteady editor input the flow

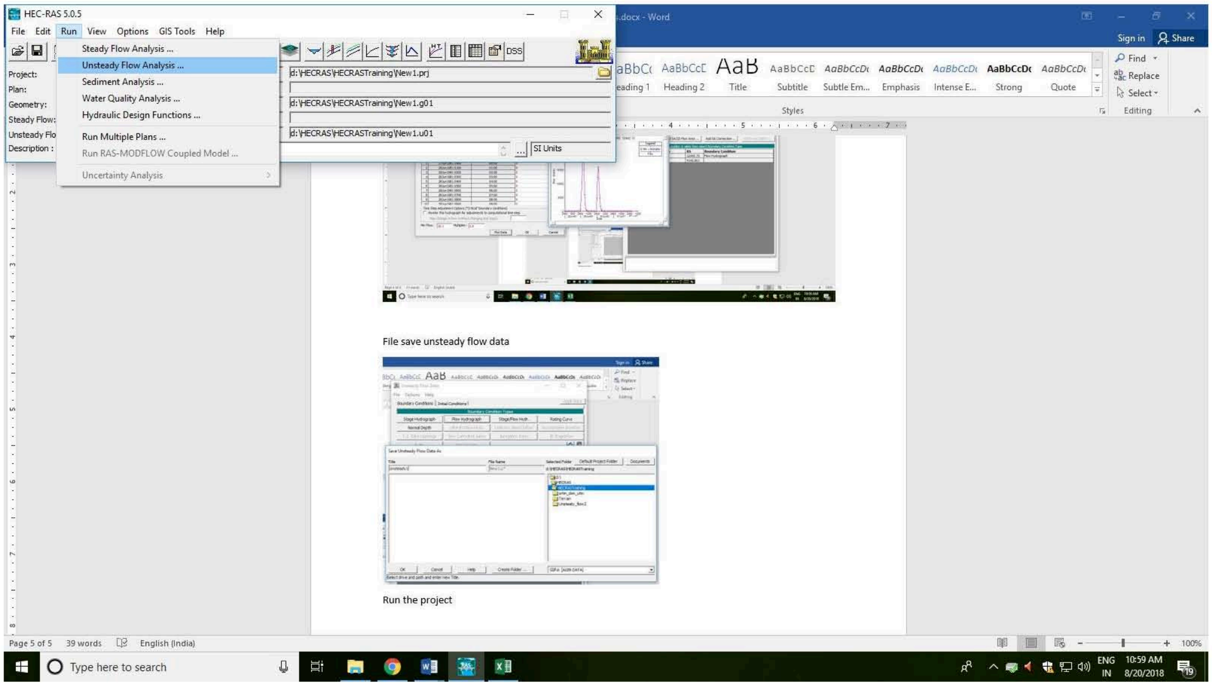


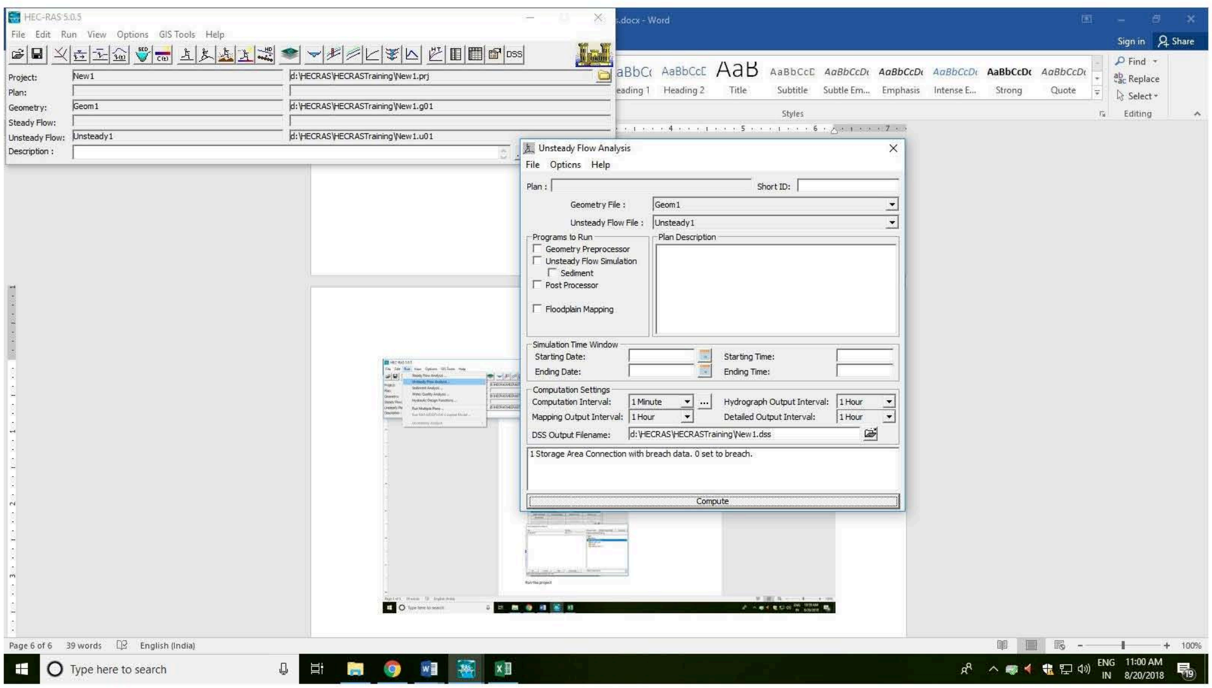


File save unsteady flow data

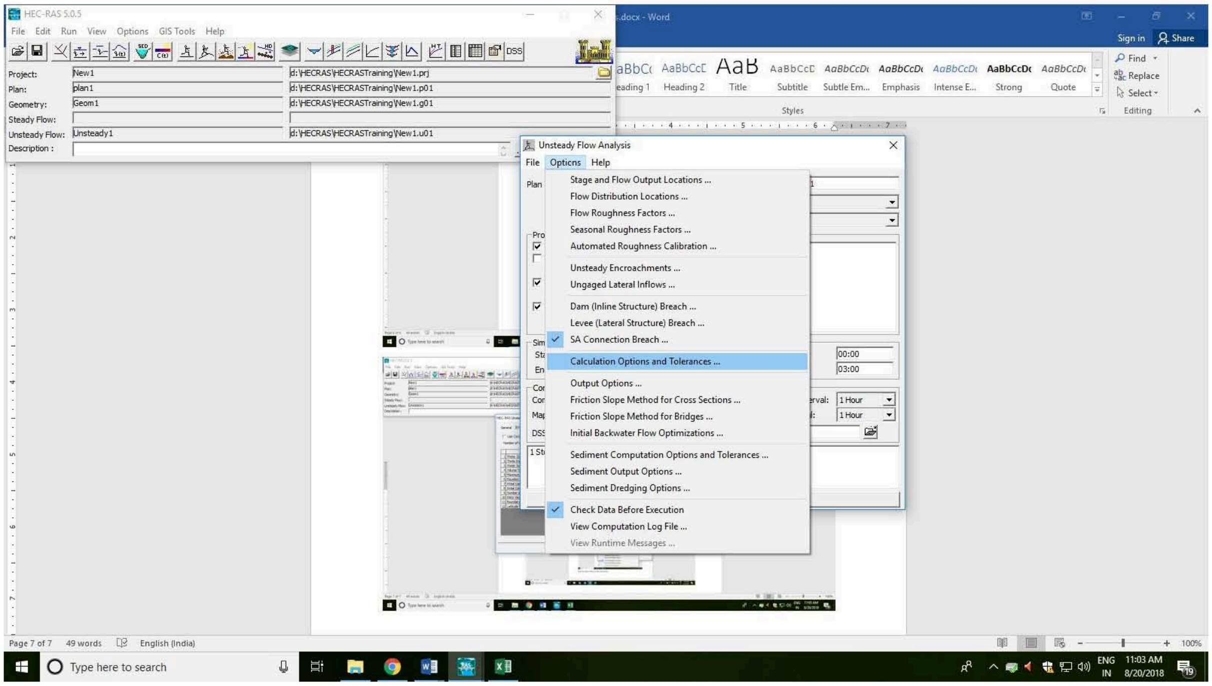


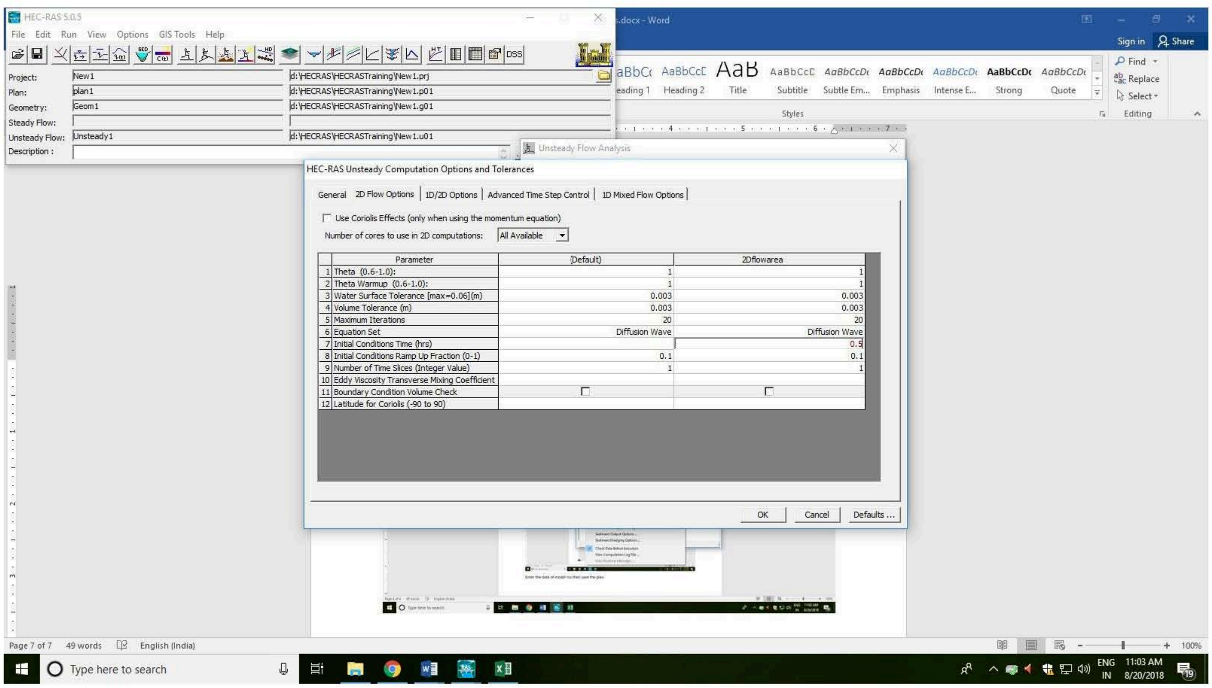
Run the project





Enter the date of model run then save the plan


HEC-RAS 5.0.5
File Edit Run View Options GIS Tools Help
Project: New1 d:\HECRAS\HECRASTraining\New1.prj
Plan: plan1 d:\HECRAS\HECRASTraining\New1.p01
Geometry: Geom1 d:\HECRAS\HECRASTraining\New1.g01
Steady Flow:
Unsteady Flow: Unsteady1 d:\HECRAS\HECRASTraining\New1.u01
Description :
Unsteady Flow Analysis
File Options Help
Stage and Flow Output Locations ...
Flow Distribution Locations ...
Flow Roughness Factors ...
Seasonal Roughness Factors ...
Automated Roughness Calibration ...
Unsteady Encroachments ...
Ungaged Lateral Inflows ...
Dam (Inline Structure) Breach ...
Levee (Lateral Structure) Breach ...
SA Connection Breach ...
Calculation Options and Tolerances ...
Output Options ...
Friction Slope Method for Cross Sections ...
Friction Slope Method for Bridges ...
Initial Backwater Flow Optimizations ...
Sediment Computation Options and Tolerances ...
Sediment Output Options ...
Sediment Dredging Options ...
Check Data Before Execution
View Computation Log File ...
View Runtime Messages ...
Page 7 of 7 49 words English (India)
Type here to search
11:03 AM 8/20/2018


HEC-RAS Unsteady Computation Options and Tolerances
General 2D Flow Options 1D/2D Options Advanced Time Step Control 1D Mixed Flow Options
Use Coriolis Effects (only when using the momentum equation)
Number of cores to use in 2D computations: All Available
Parameter (Default) 2Dflowarea
1 Theta (0.6-1.0): 1 1
2 Theta Warmup (0.6-1.0): 1 1
3 Water Surface Tolerance [max=0.06](m) 0.003 0.003
4 Volume Tolerance (m) 0.003 0.003
5 Maximum Iterations 20 20
6 Equation Set Diffusion Wave Diffusion Wave
7 Initial Conditions Time (hrs) 0.5
8 Initial Conditions Ramp Up Fraction (0-1) 0.1 0.1
9 Number of Time Slices (Integer Value) 1 1
10 Eddy Viscosity Transverse Mixing Coefficient
11 Boundary Condition Volume Check
12 Latitude for Coriolis (-90 to 90)
OK Cancel Defaults ...
Page 7 of 7 49 words English (India)
Type here to search
11:03 AM 8/20/2018