**Urban Utilities Planning: Water Supply, Sanitation and Drainage**
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**Module - 12**
**Drainage and Recharge**
**Lecture - 59**
**Urban Flood Management and Drainage Plans Part II**

In lecture 59 Urban Flood Management and Drainage Plans – Part II will be covered.

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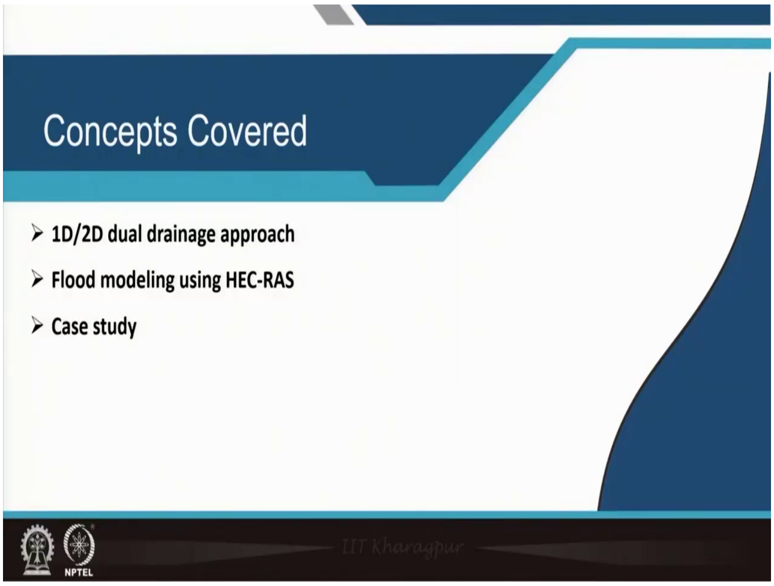


The concepts to be covered includes:

- 1D and 2D dual drainage approach
- Flood modeling using HEC RAS and a Case study

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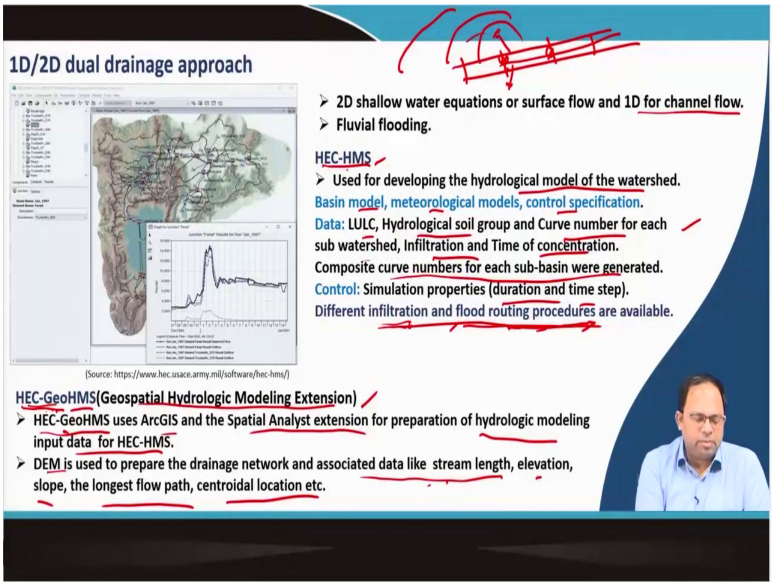
**1D/2D Dual drainage approach**




This approach uses 2D shallow water equations for surface flow and 1D for channel flow. Fluvial flooding can also be modelled. HES-HMS and HEC-RAS software will be addressed. If the cross sections of a river for certain locations and the flow is considered, water may flow beyond the sides of the stream that can lead to overland flow and eventually flooding. This can be modelled using software. This can be applied for natural streams as well as for storm water sewers.

This modeling system involves four software, but nowadays, using two can address the requirements.

**HEC-HMS Software**

This is used for developing the hydrological model of the watershed. Using this, the basin model, the meteorological models and the control specifications can be developed.

Data required to run this model involves land use, land cover, hydrological soil group, curve number for each watershed infiltration and time of concentration then composite curve number for each sub watershed, infiltration and time of concentration. The simulation properties in the model can be controlled by changing the duration and the time step.

Different infiltration (CN method / Horton methods etc.) and flood routing procedures (kinematic wave / diffusion wave) can be set in this model. The modeling is similar to SWMM and can be called as an alternative to SWMM.

**HEC-GeoHMS (Geospatial hydrologic modeling extension)**

This software uses ArcGIS and the spatial analyst extension for preparation of hydrologic modeling input data such as the catchment sizes, proportion of pervious and impervious surfaces for HEC-HMS.

Nowadays, RAS mapper, a component of the HEC-GeoHMS software can be used to get the same task done instead of using the separate extension.

DEM (digital elevation model) is used to prepare the drainage network and associated data like stream length, elevation, slope and the longest flow path, centroidal location etc.

To model open channels, 1D Saint Venant equations can be used. The data on the profile of the channel at different sections is required.

**HEC-GeoRAS**

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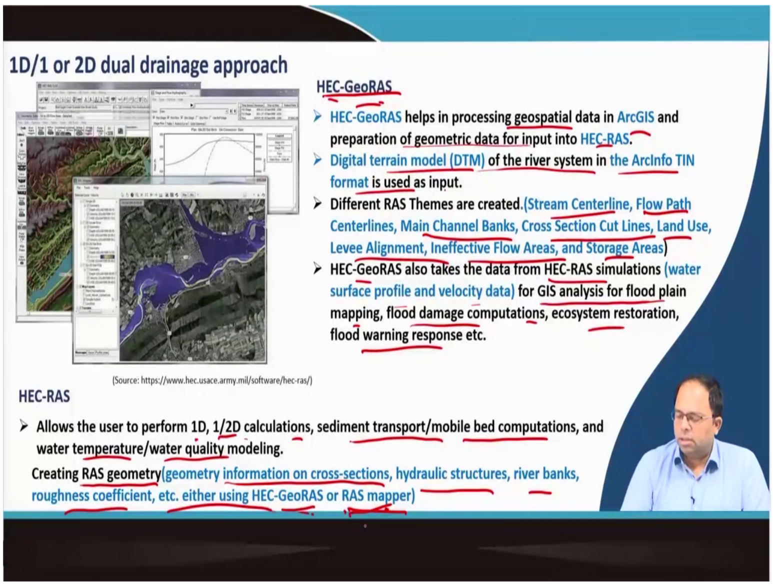

This is a GIS extension for the HEC RAS software which is employed in processing geospatial data. This helps in preparation of geometric data for input into HEC RAS. GeoRAS is used for preparing data for HEC RAS. The digital terrain model of the river system is prepared in the Arcinfo TIN format. Different RAS themes are created which includes the stream center line, flow path center lines, main channel banks, cross section cut lines, land use, levee arrangement, ineffective flow areas and storage areas. The entire channel profile and the surrounding area is being modeled along with the digital terrain model.

HEC-GeoRAS can obtain data from the HEC RAS simulations (water surface profile and velocity data) for GIS analysis for flood plain mapping, flood damage computations, ecosystem restoration, flood warning response etc. Thus it can be used both for processing the data for input into the HEC RAS software and also take input from the HEC RAS software to display the data. HEC RAS allows the user to perform this 1D or 1D/2D calculations. Sediment transport/mobile bed computations and then water temperature/water quality modeling can also be done using the software.

So, it is required to create RAS geometry involving geometry information on cross sections, hydraulic structures, river banks, roughness coefficient etc. either using HEC-GeoRAS or RAS mapper.

**Flood modelling using HEC-GeoRAS**

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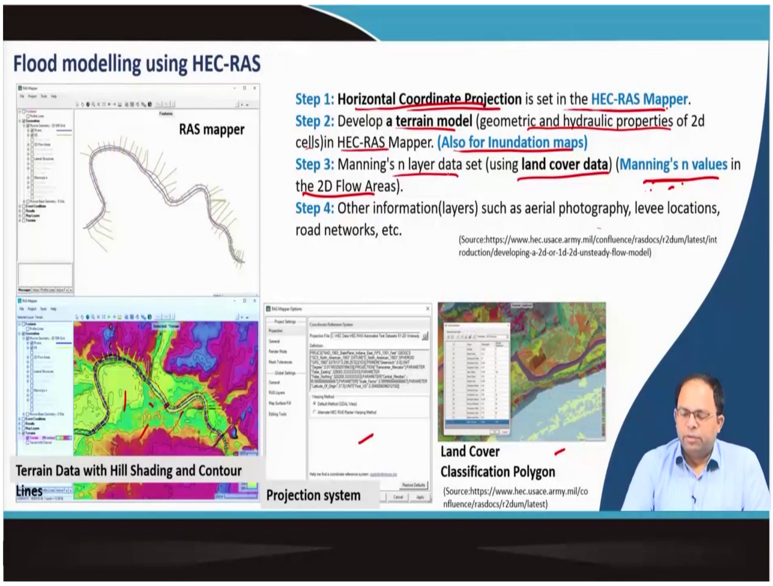


*<u>Step 1:</u>* Horizontal coordinate projection is set in the HEC-RAS mapper.

*<u>Step 2:</u>* to develop a terrain model (geometric and hydraulic properties of 2D cells) in HES-RAS mapper. This is also required for generating the inundation map. Based on the terrain data including the hill shading and contour, the profile can be developed for a stream channel. The entire area can be divided into multiple cells with specific geometry and hydraulic properties based on the DEM. This helps determining the direction in which water will flow.

*<u>Step 3</u>*: is input Manning's n layer data set data (using land cover data) (Manning's n values in the 2D flow areas)

*<u>Step 4:</u>* Other information layers such as the aerial photography, levee locations road networks, etc also are input in the software.

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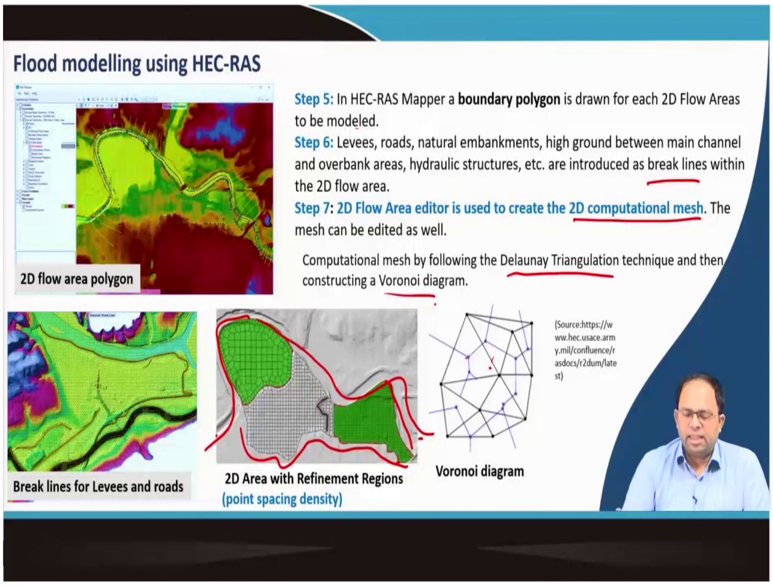


*Step 5:* In HEC-RAS mapper, a boundary polygon is drawn for each 2D flow areas that has to be modeled ie, the extent of the flood spread is determined.

*Step 6:* levees, roads natural embankments high ground between main channel and overbank areas, hydraulic structure etc. are introduced as break lines within the 2D flow area. These represent the areas across which water cannot pass.

*Step 7:* 2D flow area editor is used to create 2D computational mesh. The mesh can be edited. It can be computed by Delaunay triangulation technique and enables the creation of Voronoi diagrams or Thiessen polygons. Each cell of the mesh will have its specific digital elevation or slope. Water flow on the overland surface from one cell and the other will depend on the slope.

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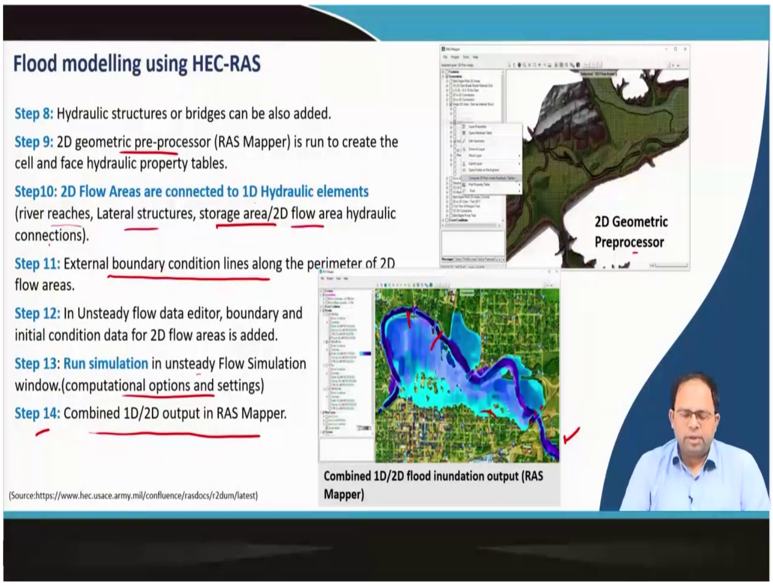


<u>*Step 8*</u>: Hydraulic structures or bridges can also be added.

<u>*Step 9:*</u> is 2D geometric pre-processor (RAS mapper) is run to create the cells and face hydraulic property tables because from the geometric processor, the relevant parameters determining the overland flow can be modelled.

<u>*Step 10*</u>: 2D flow areas are connected to 1D hydraulic elements. The 2D areas where overland flow occurs is connected with the hydraulic elements. The different nodes from where the flood will be spreading can be understood. Hydraulic elements includes the river reaches, lateral structures, storage area/2D flow area, hydraulic connections.

<u>*Step 11*</u>: External boundary condition lines along the perimeter of 2D flow areas are introduced

<u>*Step 12*</u>: In unsteady flow data editor, boundary and initial condition data for 2D flow areas are added.

<u>*Step 13:*</u> The stimulation is run in unsteady flow simulation window. The required computational settings and options can be set.

<u>*Step 14:*</u> Combined1D-2D output is produced in the RAS mapper.

In standard models, 1D modeling of the channels (both surface and underground) can be considered. The spread of the flood can be modelled using inundation algorithm and using GIS approaches.

**Casestudy:**

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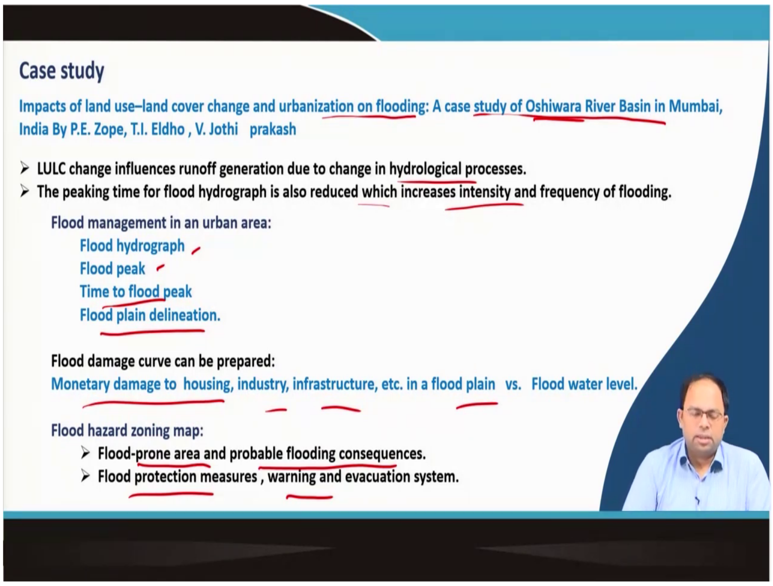


Impacts of land use–land cover change and urbanization on flooding: A case study of Oshiwara River Basin in Mumbai, India By *P.E. Zope, T.I. Eldho, V. Jothi Prakash.*

The study analyses how a rainfall event will cause overflow of the banks and how the water will spread. LULC (land use land cover) changes or influences the runoff generation due to change in the hydrological processes. The peak time of flood hydrograph is also reduced which increases intensity and frequency of flooding.

Flood management urban areas requires:

- The flood hydrograph.
- The flood peak (total flow during that time)
- Time to flood peak
- Flood plain delineation

The flood damage curve can be determined based on the spread of the flood water which involves the monetary damage to housing, industry, infrastructure etc. in the flood plain based on the flood water level.

Flood hazard zoning maps can be prepared based on inundation map produced after the analysis considering the parameters such as flood prone area, probable flooding consequences in that area, flood protection measures, warning and evacuation systems etc.

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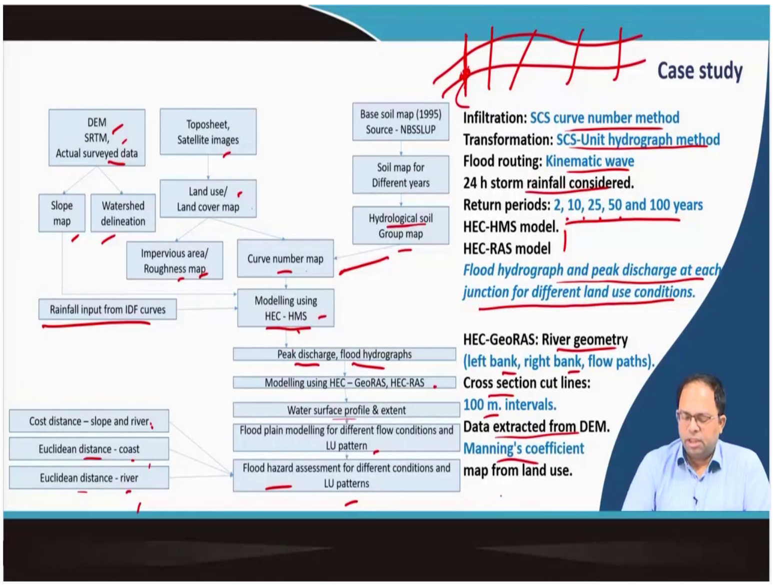


The data required involves the DEM, SRTM data, and the surveyed data. This is used to create the slope map and the watershed delineation. Toposheet satellite images are used to generate land use/land cover map. This is used to determine the impervious area/the roughness map and the curve number map. The base soil maps and the soil map for different years is used to generate the hydrological soil group map. Rainfall input from IDF curves is also involved. All these are used for modelling using HFC-HMS. The peak discharges and the flood hydrographs are determined. Modelling is done using HEC GeoRAS and HEC RAS. The water surface profile and extent, flood plain modeling for different flow conditions and LU patterns, and flood hazard assessment for different conditions and LU patterns is determined.

- The cost distance-slope and the Euclidean distance from the coast/river are considered. All these parameters were utilized to determine the overall hazard of flood in the area.
- The curve number method is utilized for infiltration.
- SCS unit hydrograph method is utilized for determining the hydrograph of the area.
- The routing was done using kinematic wave
- 24 hours storm rainfall was considered
- Return period was considered for 2, 10, 25, 50 and 100 years separately. For each return period the flood inundation was estimated and then overall map was prepared.
- HEC HMS and HEC RAS models were used.
- Flood hydrographs and peak discharge at each junction for different land use conditions were determined. This was modeled using this HEC RAS model.
- HEC GeoRAS created was used to create the river geometry (left bank right bank flow paths)
- Cross section cut lines at 100 meter intervals.
- Data extracted also from DEM
- Manning's coefficient was used.

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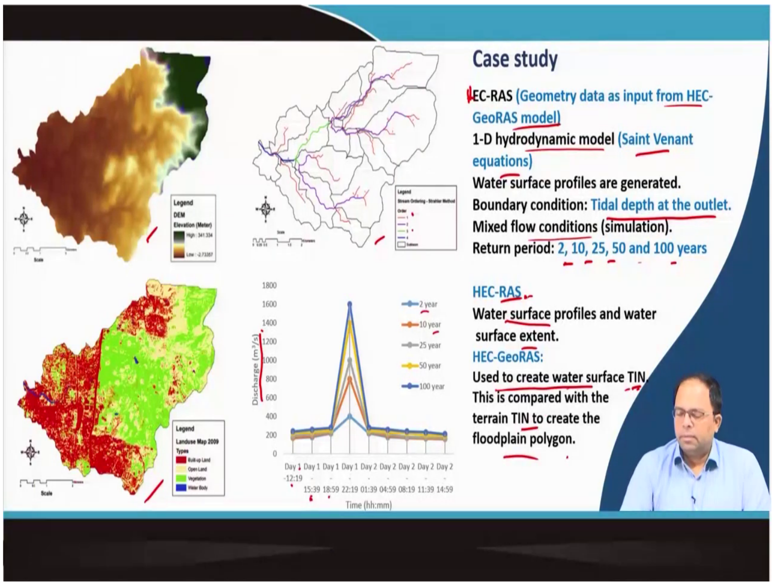


- HEC RAS (geometry data as input from HEC GeoRAS model) was introduced

- 1D hydrodynamic model was utilized using Saint Venant’s equations.
- Water surface profiles are generated on Oshiwara stream or river
- Boundary conditions - the title depth
- Mixed flow condition at the outlet was simulated
- Return periods of 2, 10, 25, 50 and 100 years.
- Using HEC RAS, the water surface profile and water surface extent was determined and HEC GeoRAS was used to create water surface
- This is compared with the terrain TIN to create the flood plain polygon.

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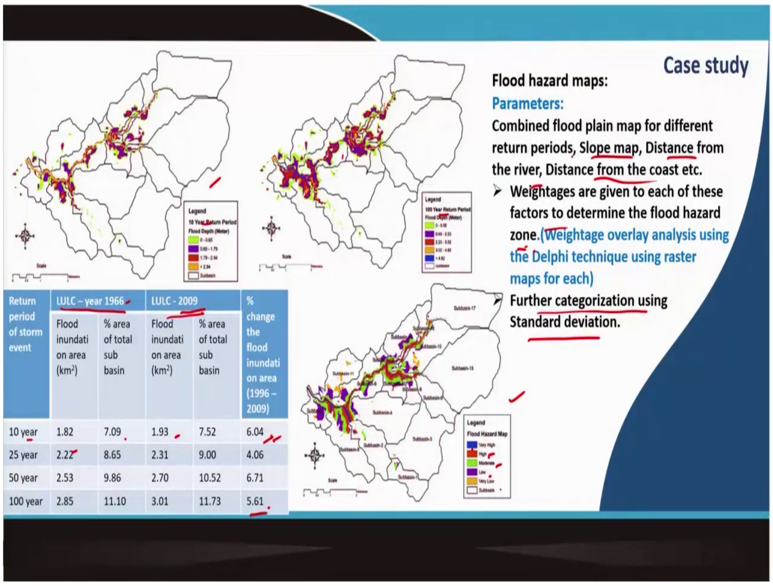


Flood inundation area is determined considering the different parameters as listed in the table. The weightages are given to each of these factors to determine the flood hazard zone.

**Conclusion:**

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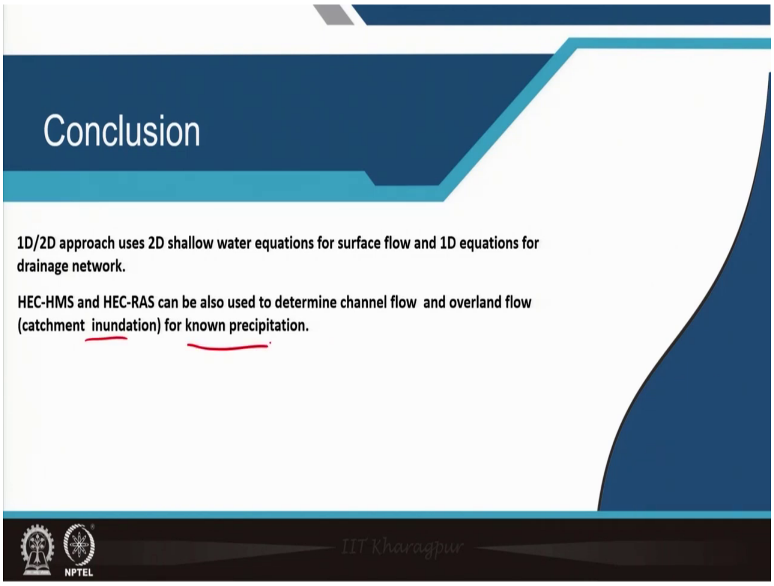


- 1D 2D approach uses 2D shallow water equations for surface flow and 1D equations for drainage network.
- HEC HMS and HEC-RAS can also be used to determine channel flow and overland flow catchment inundation for known precipitation events.

**References:**

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# References


- Zope, P. E., Eldho, T. I., Jothiprakash, V. 2016. *Impacts of land use–land cover change and urbanization on flooding: A case study of Oshiwara River Basin in Mumbai, India.* CATENA. Volume 145. pp. 142-154. https://doi.org/10.1016/j.catena.2016.06.009.
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