Flood Hazard Modelling using Hydraulic Simulation Model and Satellite Images of the Lower Volta River in Ghana

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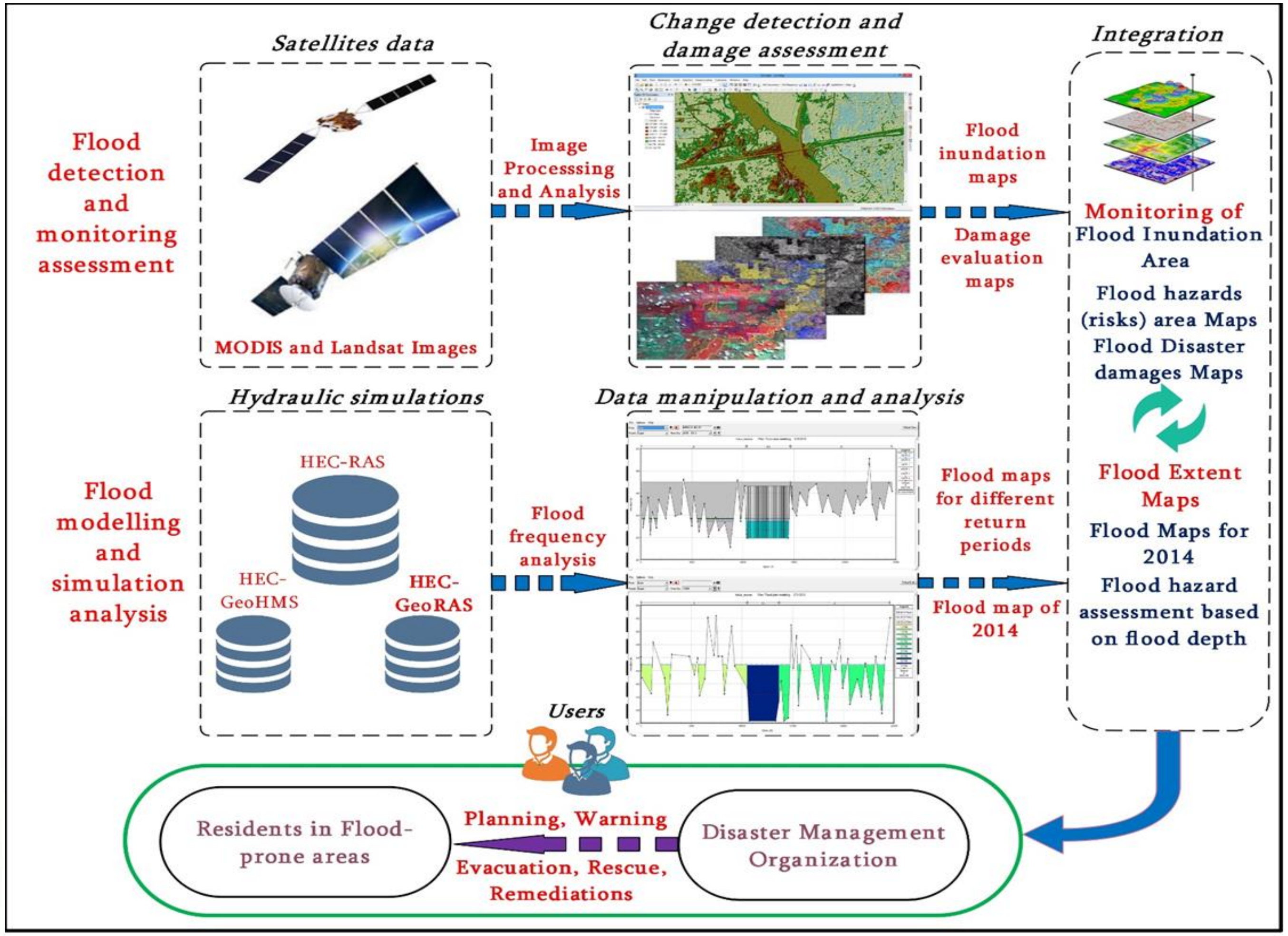
Graphical Abstract



Scientific Introduction

- **HEC-RAS** is a computer based program.
- This program is one-dimensional.
- The program was developed by the US Department of Defense, Army Corps of Engineers
- It was developed in 1995 and has found wide acceptance in hydrologic community since.
- Hydrologic Engineering Center (HEC) in Davis, California developed the River Analysis System (RAS).
- It includes numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities, and graphing and reporting capabilities.

The HEC-RAS Modelling System

- 1D River Hydraulics
- Graphical User Interface
- Steady & Unsteady Flow
- Bridges, Culverts, Dams, weirs, levees, gates, etc…
- Data storage/management
- Graphics, Tabular Output & Reporting
- GeoRas – ArcGIS

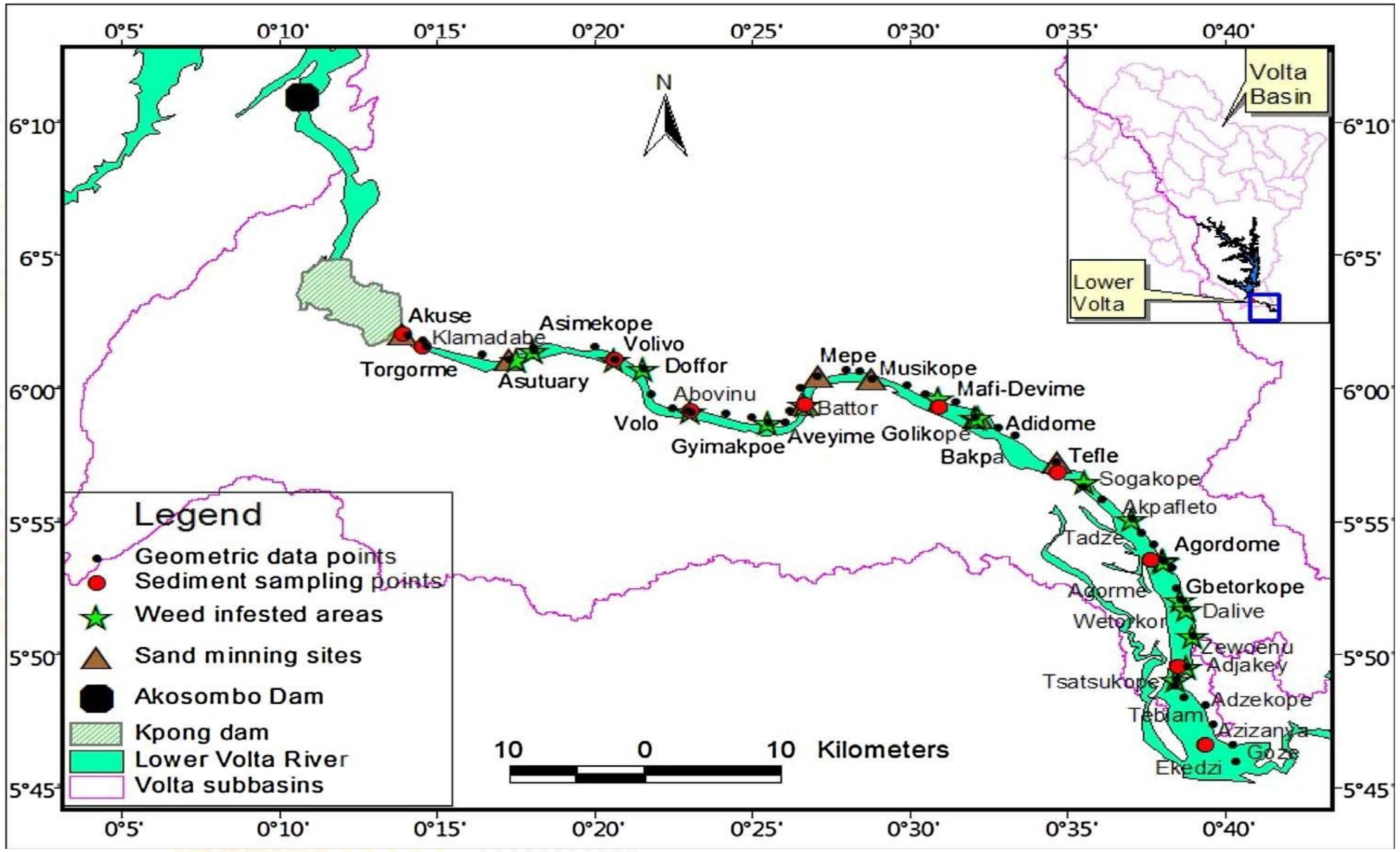
Hydraulic Information and Parameters

- Necessary for planning, flood risk reduction, design, environmental impact assessment and mitigation, restoration

1. Velocity
2. Depth
3. Shear
4. Width
5. Area

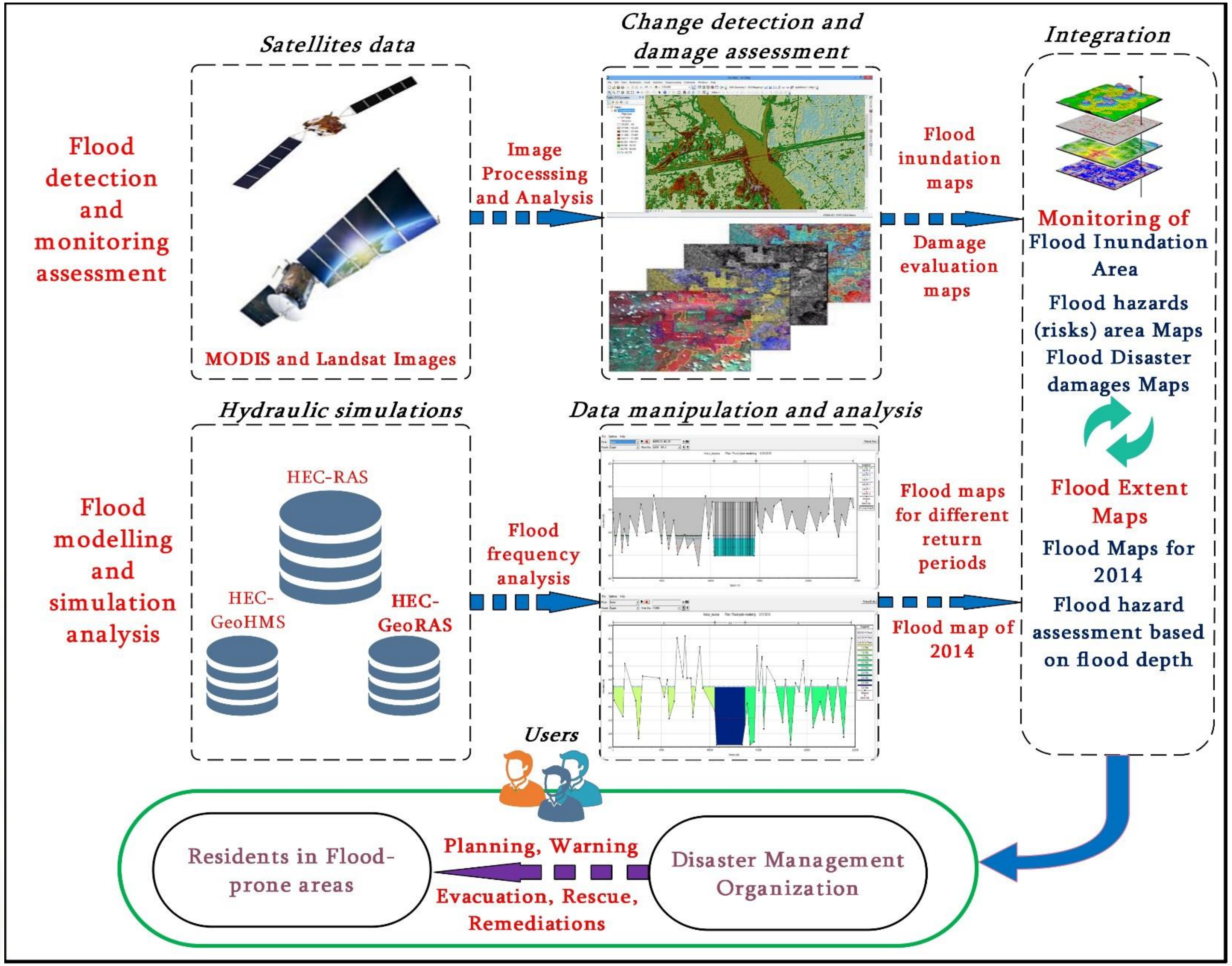
Study area

- The project area (about 9000 km^2) covers the area downstream of the Akosombo and Kpong dams, down to the estuary of the Volta River with relief below 100 m.
- The entire Volta Basin covers a surface area of 409,000 km^2 .



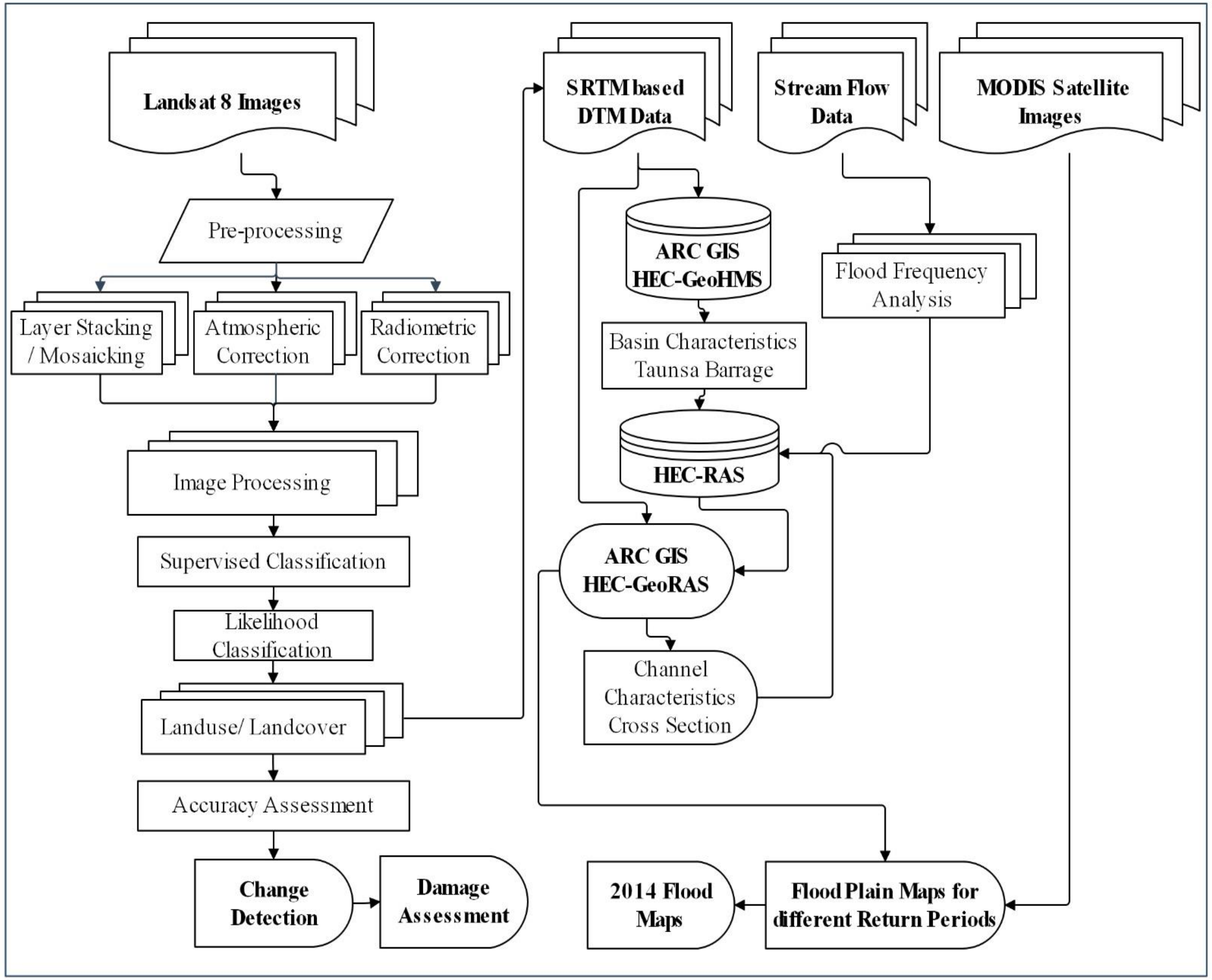
Material

1. Remote Sensing Data for Land-Use/Land-Cover Type Classification
2. The HEC-RAS Model
3. DEM Data
4. Streamflow Data



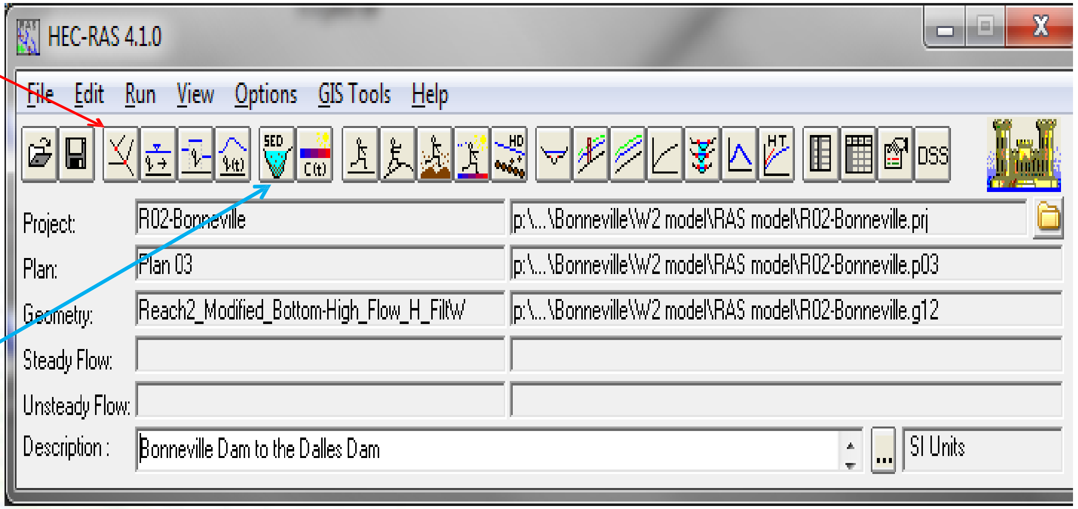
Methodology

1. LULC Classification
2. Satellite-Based Flood Damage Assessment and its Validation
3. Mapping the Spatial Extent of Floods of Different Return Periods and Comparing the Extent of the 2014 Flood with MODIS Imagery



How does it work

- Geometry
  - Cross Section
  - Spacing
  - Structures
  - Manning's n
- Flows
  - Calibration Data



Project: R02-Bonneville p:\...\Bonneville\W2 model\RAS model\R02-Bonneville.prj

Plan: Plan 03 p:\...\Bonneville\W2 model\RAS model\R02-Bonneville.p03

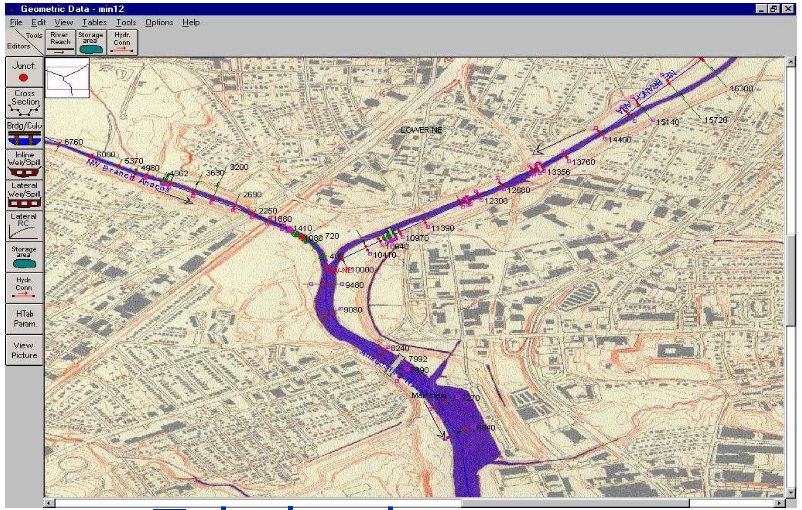
Geometry: Reach2_Modified_Bottom-High_Flow_H_FiltW p:\...\Bonneville\W2 model\RAS model\R02-Bonneville.g12

Steady Flow:

Unsteady Flow:

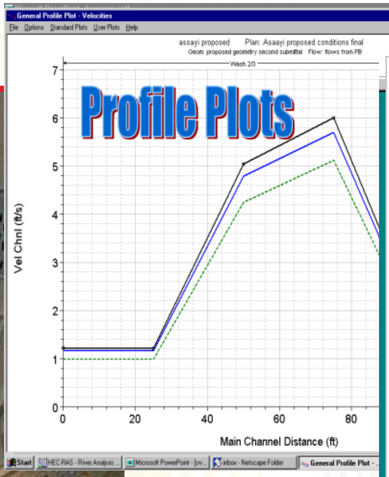
Description : Bonneville Dam to the Dalles Dam SI Units

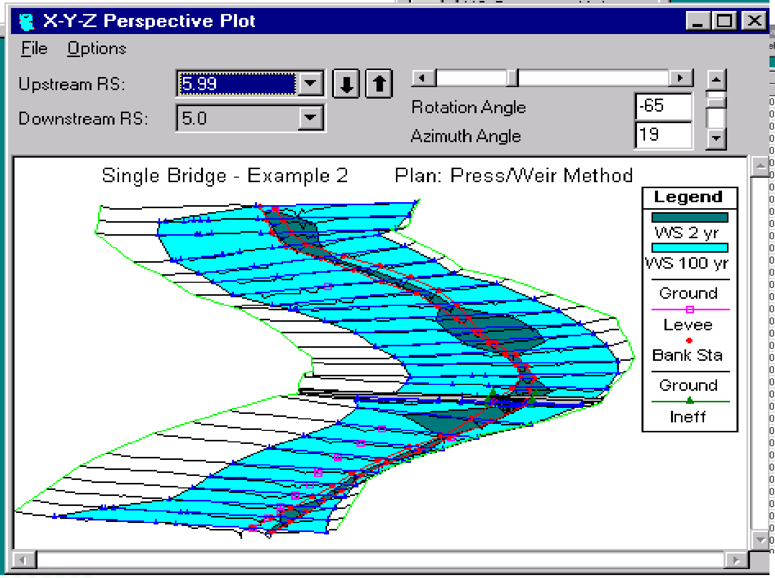
- Back ground picture



Output

- Graphical
- Tabular
- Profile
- Section





Upstream RS: 5.99

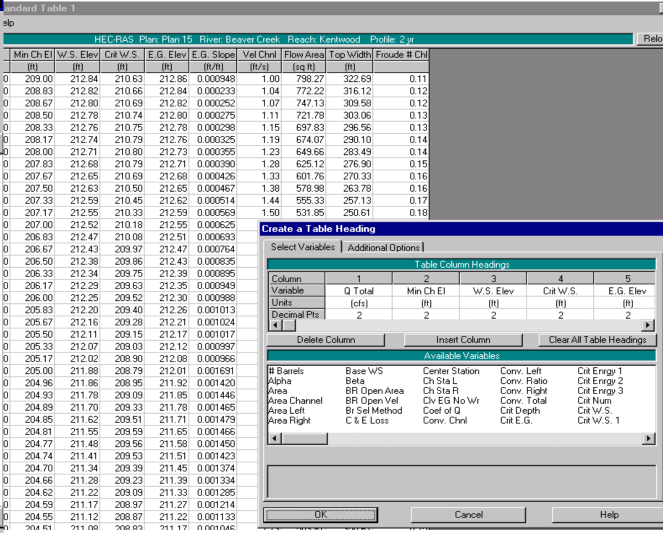
Downstream RS: 5.0

Rotation Angle -65

Azimuth Angle 19

Single Bridge - Example 2 Plan: Press/Weir Method

Tabular data output



HEC-RAS Plan: Plan 15 River: Beaver Creek Reach: Kentwood Profile: 2 yr

	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
0	209.00	212.84	210.63	212.86	0.000948	1.00	798.27	322.69	0.11
0	208.83	212.82	210.66	212.84	0.000233	1.04	772.22	316.12	0.12
0	208.67	212.80	210.69	212.82	0.000252	1.07	747.13	309.58	0.12
0	208.50	212.78	210.74	212.80	0.000275	1.11	721.78	303.06	0.13
0	208.33	212.76	210.75	212.78	0.000298	1.15	697.83	296.56	0.13
0	208.17	212.74	210.79	212.76	0.000325	1.19	674.07	290.10	0.14
0	208.00	212.71	210.80	212.73	0.000355	1.23	649.66	283.49	0.14
0	207.83	212.68	210.79	212.71	0.000390	1.28	625.12	276.90	0.15
0	207.67	212.65	210.69	212.68	0.000426	1.33	601.76	270.33	0.16
0	207.50	212.63	210.50	212.65	0.000467	1.38	578.98	263.78	0.16
0	207.33	212.59	210.45	212.62	0.000514	1.44	555.33	257.13	0.17
0	207.17	212.55	210.33	212.59	0.000569	1.50	531.85	250.61	0.18
0	207.00	212.52	210.18	212.55	0.000625				
0	206.83	212.47	210.08	212.51	0.000693				
0	206.67	212.43	209.97	212.47	0.000764				
0	206.50	212.38	209.86	212.43	0.000835				
0	206.33	212.34	209.75	212.39	0.000895				
0	206.17	212.29	209.63	212.35	0.000949				
0	206.00	212.25	209.52	212.30	0.000988				
0	205.83	212.20	209.40	212.26	0.001013				
0	205.67	212.16	209.28	212.21	0.001024				
0	205.50	212.11	209.15	212.17	0.001017				
0	205.33	212.07	209.03	212.12	0.000997				
0	205.17	212.02	208.90	212.08	0.000966				
0	205.00	211.88	208.79	212.01	0.001691				
0	204.96	211.86	208.95	211.92	0.001420				
0	204.93	211.78	209.09	211.85	0.001446				
0	204.89	211.70	209.33	211.78	0.001465				
0	204.85	211.62	209.51	211.71	0.001479				
0	204.81	211.55	209.59	211.65	0.001466				
0	204.77	211.48	209.56	211.58	0.001450				
0	204.74	211.41	209.53	211.51	0.001423				
0	204.70	211.34	209.39	211.45	0.001374				
0	204.66	211.28	209.23	211.39	0.001334				
0	204.62	211.22	209.09	211.33	0.001285				
0	204.59	211.17	208.97	211.27	0.001214				
0	204.55	211.12	208.87	211.22	0.001133				
0	204.51	211.08	208.83	211.17	0.001046				

Create a Table Heading

Select Variables | Additional Options

Table Column Headings

Column	1	2	3	4	5
Variable	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev
Units	(cfs)	(ft)	(ft)	(ft)	(ft)
Decimal Pts	2	2	2	2	2

Delete Column | Insert Column | Clear All Table Headings

Available Variables

# Barrels	Base WS	Center Station	Conv. Left	Crit Enrgy 1
Alpha	Beta	Ch Sta L	Conv. Ratio	Crit Enrgy 2
Area	BR Open Area	Ch Sta R	Conv. Right	Crit Enrgy 3
Area Channel	BR Open Vel	Clv EG No Wr	Conv. Total	Crit Num
Area Left	Br Sel Method	Coef of Q	Crit Depth	Crit W.S.
Area Right	C & E Loss	Conv. Chnl	Crit E.G.	Crit W.S. 1

OK | Cancel | Help

How does it work

- Basic computational procedure of **HEC-RAS** for steady flow.
- Energy losses are evaluated by friction and contraction / expansion.
- The momentum equation may be used in situations where the water surface profile is rapidly varied. These situations include hydraulic jumps, hydraulics of bridges, and evaluating profiles at river confluences.
- For unsteady flow, **HEC-RAS** solves the full, dynamic, 1-Dimensional Saint Venant Equation using an implicit, finite difference method.
- HEC-RAS is equipped to model a network.
- Commercial application in **floodplain management** and **flood insurance studies** to evaluate floodway encroachments.

HMS-RAS Integration Overview

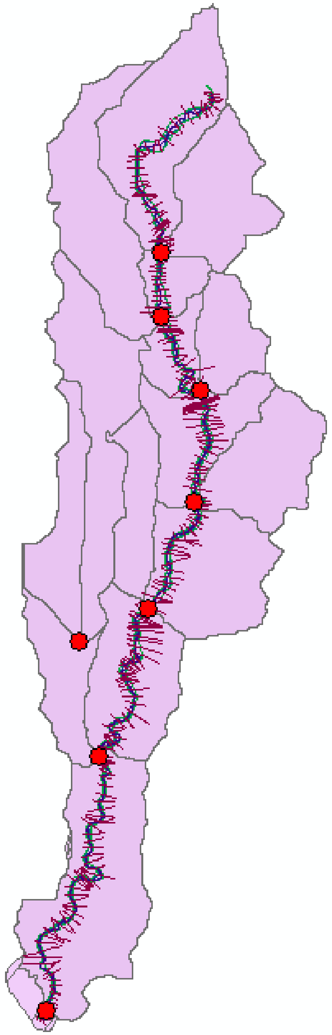
- Mix of planning, GIS, and H&H modeling operations – not a push button operation.
- Types of integration
- Modeling support (preparing data for model input)
  - e.g. land use/soils/CN or rainfall processing – Arc Hydro or general GIS data processing
- Linked
  - GeoHMS
  - GeoRAS
- Integrated
  - DSS

Key Steps

- Plan (roughly) hydrologic and hydraulic model layouts – flow exchange locations
  - e.g. location of HMS modeling elements and RAS cross-sections
- Identify sources of precipitation input into the hydrologic model and techniques for their incorporation into the dataset
  - e.g. Nexrad rainfall
- Develop GeoHMS model (and precipitation sub model)
- Finalize and run HMS model and generate results (DSS)
- Develop GeoRAS model
- Finalize and run RAS taking HMS results as input
- Feedback between HMS and RAS is manual
  - e.g. modification of time of concentration or routing parameters

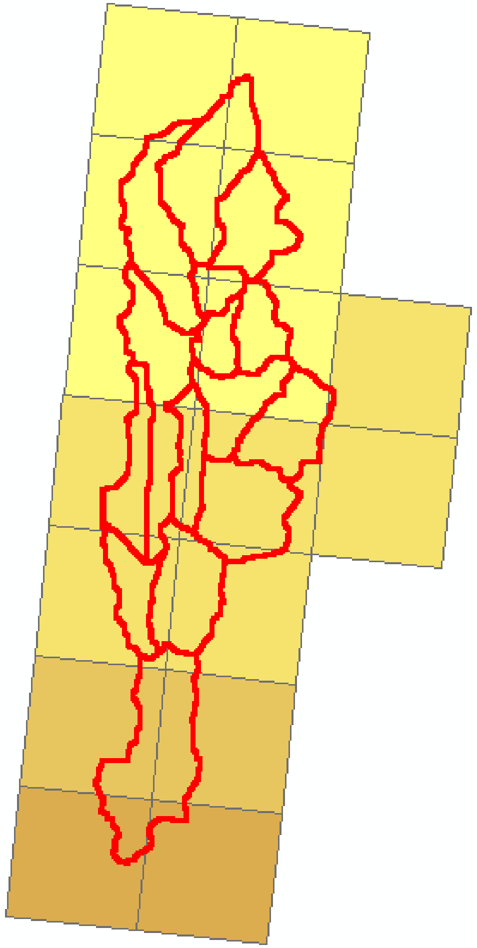
Integration Planning

- Identify where outputs from one model (HMS) become input to the second one (RAS)
- Place hydrologic elements (subbasins, reaches, junctions) to capture flows at points of interest (confluences, structures)
- Place hydraulic elements (cross-sections) at points of interest
- Identify/specify element naming conventions between the two models (persistent or transient names)



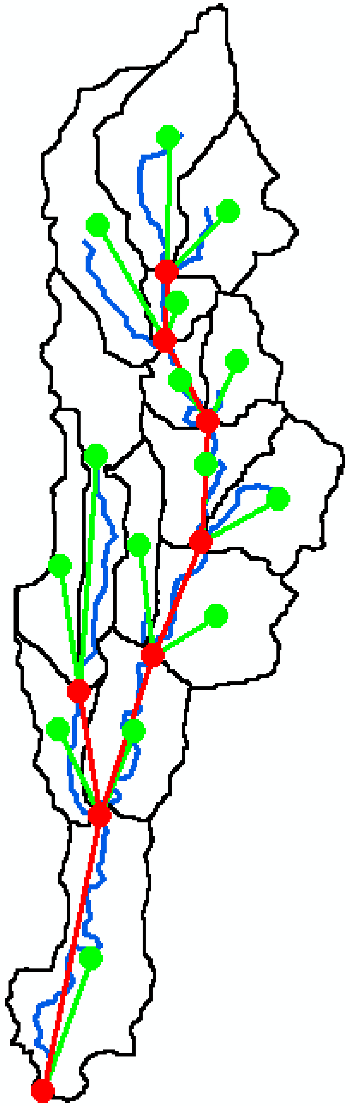
Precipitation Sources

- Identify sources of precipitation input into the hydrologic model and techniques for their incorporation into the dataset
- Point (rain gage)
- Polygon (Nexrad cells)
- Surface (TIN/grid)



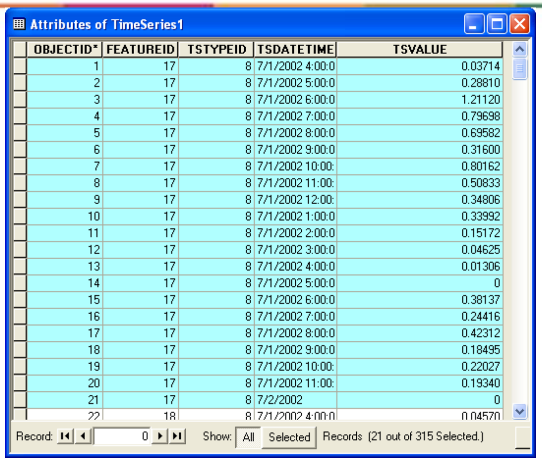
Develop GeoHMS model

- Follow all principles in development of a hydrologic model
- In addition, take into consideration integration planning aspects developed earlier
- Placement of flow exchange points
- Naming conventions
- Incorporate precipitation submodel
- Develop Arc Hydro time series for the final subbasin delineation and export to DSS
- Export to HMS



Meteorological Component

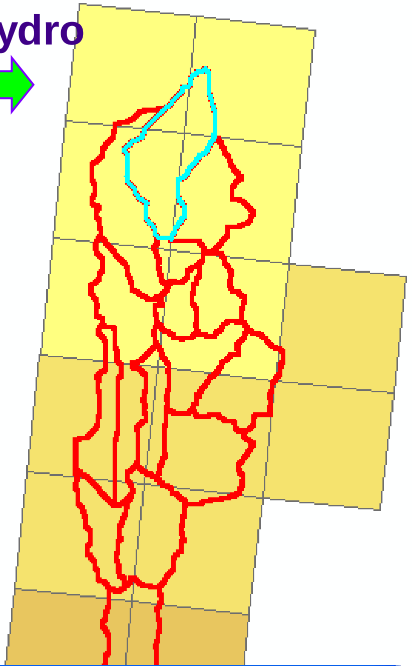
- Develop a custom "gage" for each subbasin or for each rainfall observation element with corresponding weights for subbasins.
- Export the time series for the subbasin "gage" from Arc Hydro time series data structure into DSS



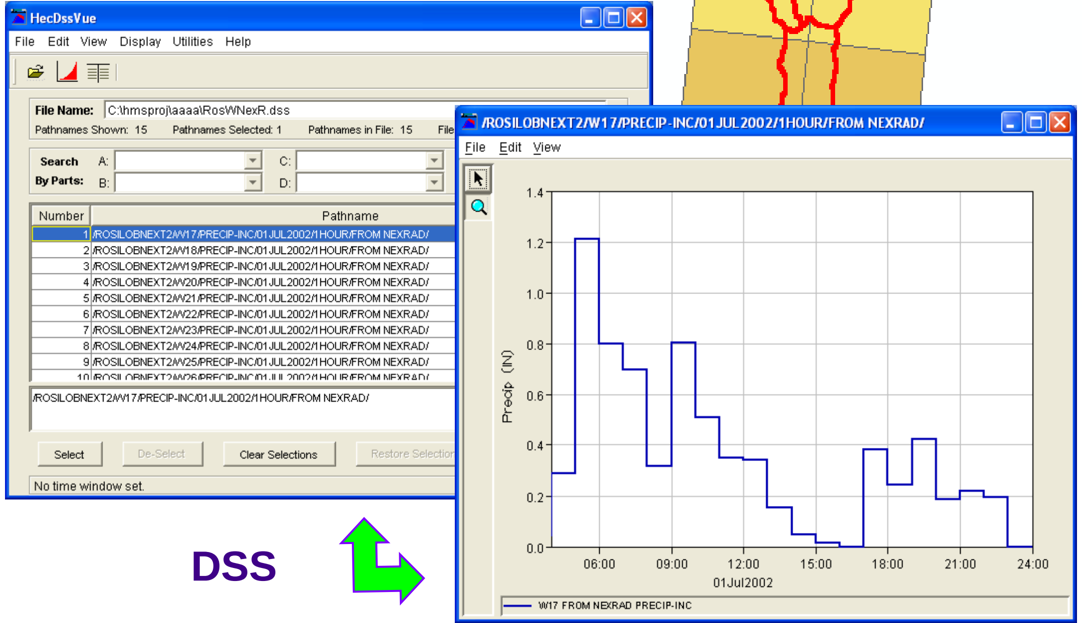
OBJECTID*	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
1	17	8	7/1/2002 4:00:0	0.03714
2	17	8	7/1/2002 5:00:0	0.28810
3	17	8	7/1/2002 6:00:0	1.21120
4	17	8	7/1/2002 7:00:0	0.79698
5	17	8	7/1/2002 8:00:0	0.69582
6	17	8	7/1/2002 9:00:0	0.31600
7	17	8	7/1/2002 10:00:	0.80162
8	17	8	7/1/2002 11:00:	0.50833
9	17	8	7/1/2002 12:00:	0.34806
10	17	8	7/1/2002 1:00:0	0.33992
11	17	8	7/1/2002 2:00:0	0.15172
12	17	8	7/1/2002 3:00:0	0.04625
13	17	8	7/1/2002 4:00:0	0.01306
14	17	8	7/1/2002 5:00:0	0
15	17	8	7/1/2002 6:00:0	0.38137
16	17	8	7/1/2002 7:00:0	0.24416
17	17	8	7/1/2002 8:00:0	0.42312
18	17	8	7/1/2002 9:00:0	0.18495
19	17	8	7/1/2002 10:00:	0.22027
20	17	8	7/1/2002 11:00:	0.19340
21	17	8	7/2/2002	0
22	18	8	7/1/2002 4:00:0	0.04570

Records (21 out of 315 Selected.)

Arc Hydro



Arc Hydro to DSS transfer



File Name: C:\hmsproj\aaaa\RosWNexR.dss

Pathnames Shown: 15　Pathnames Selected: 1　Pathnames in File: 15

Number	Pathname
1	/ROSILOBNEXT2/W17/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
2	/ROSILOBNEXT2/W18/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
3	/ROSILOBNEXT2/W19/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
4	/ROSILOBNEXT2/W20/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
5	/ROSILOBNEXT2/W21/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
6	/ROSILOBNEXT2/W22/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
7	/ROSILOBNEXT2/W23/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
8	/ROSILOBNEXT2/W24/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
9	/ROSILOBNEXT2/W25/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
10	/ROSILOBNEXT2/W26/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/

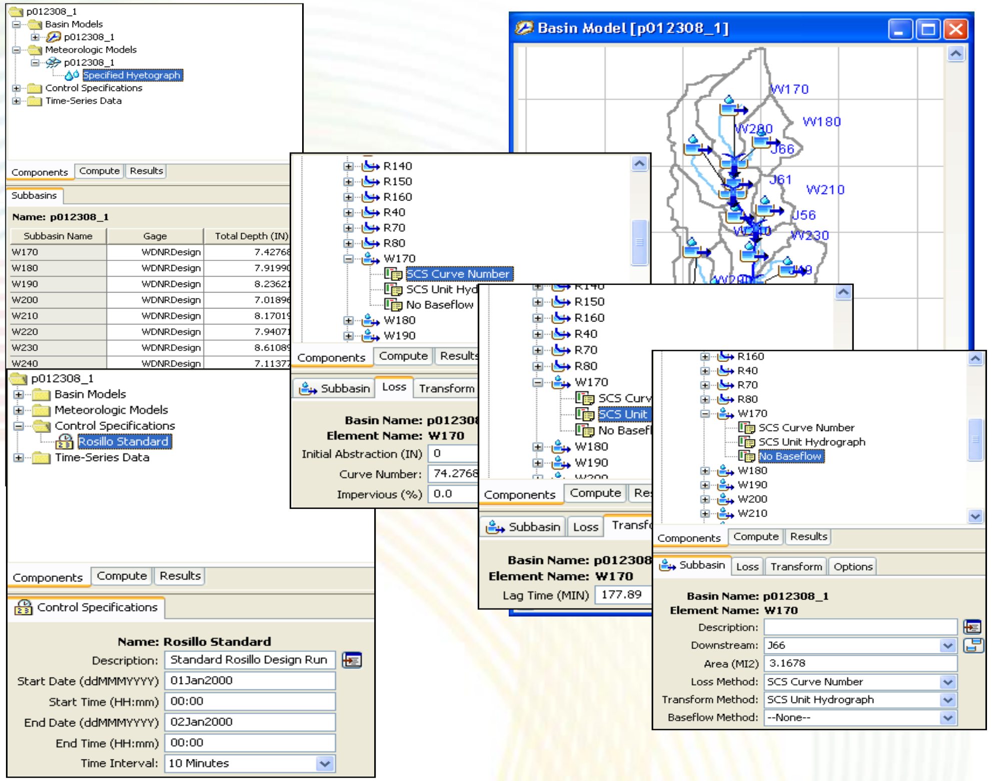
/ROSILOBNEXT2/W17/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/

No time window set.

DSS

Finalize and Run HMS

- Complete HMS model with any additional parameters including meteorological model and control specifications
- Follow all principles in HMS model development (calibration, etc.)
- Do the final run and generate results (DSS)



Name: p012308_1

Subbasin Name	Gage	Total Depth (IN)
W170	WDNRDesign	7.4276
W180	WDNRDesign	7.9199
W190	WDNRDesign	8.2362
W200	WDNRDesign	7.0189
W210	WDNRDesign	8.1701
W220	WDNRDesign	7.9407
W230	WDNRDesign	8.6108
W240	WDNRDesign	7.1137

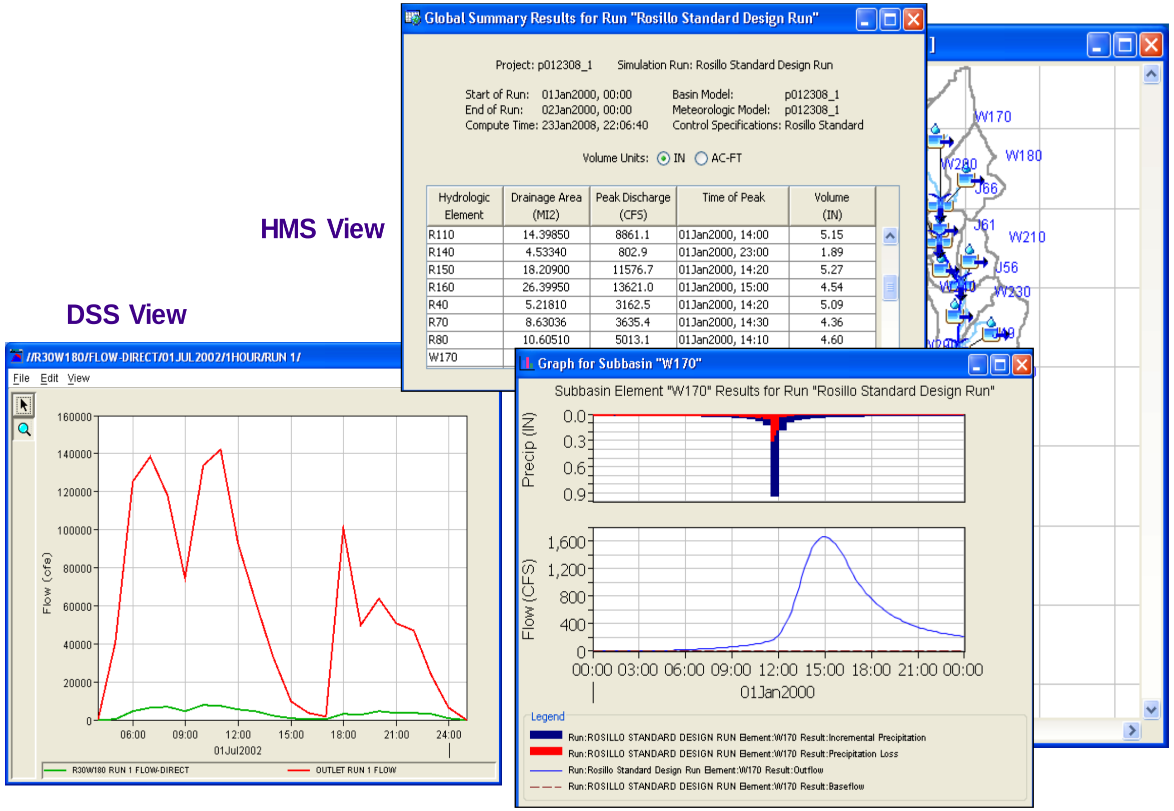
Control Specifications

Name: Rosillo Standard
Description: Standard Rosillo Design Run
Start Date (ddMMMYYYY) 01Jan2000
Start Time (HH:mm) 00:00
End Date (ddMMMYYYY) 02Jan2000
End Time (HH:mm) 00:00
Time Interval: 10 Minutes

Basin Name: p012308
Element Name: W170
Initial Abstraction (IN) 0
Curve Number: 74.2768
Impervious (%) 0.0

Basin Name: p012308
Element Name: W170
Lag Time (MIN) 177.89

Basin Name: p012308_1
Element Name: W170
Description:
Downstream: J66
Area (MI2) 3.1678
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Baseflow Method: --None--



HMS View

DSS View

Global Summary Results for Run "Rosillo Standard Design Run"

Project: p012308_1 Simulation Run: Rosillo Standard Design Run

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: 23Jan2008, 22:06:40
Basin Model: p012308_1
Meteorologic Model: p012308_1
Control Specifications: Rosillo Standard

Volume Units: ● IN ○ AC-FT

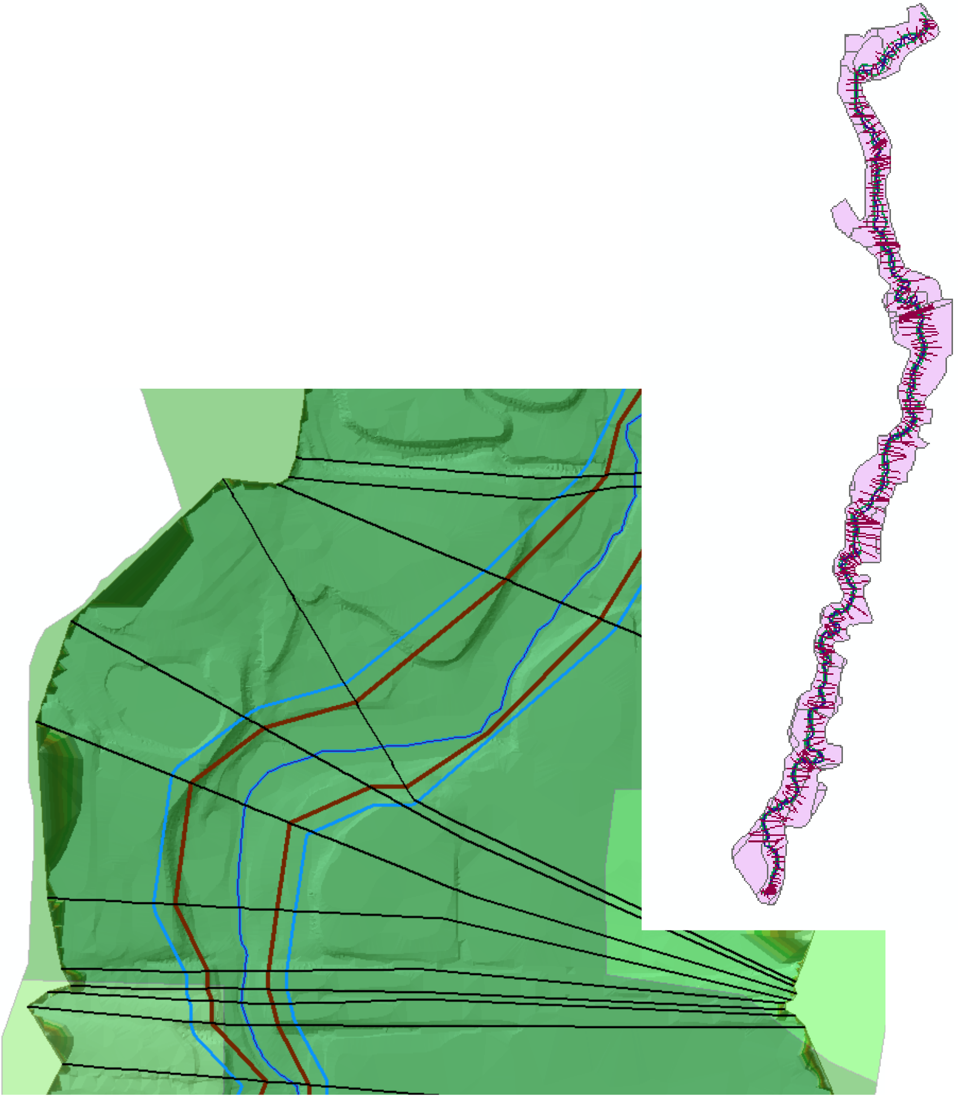
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
R110	14.39850	8861.1	01Jan2000, 14:00	5.15
R140	4.53340	802.9	01Jan2000, 23:00	1.89
R150	18.20900	11576.7	01Jan2000, 14:20	5.27
R160	26.39950	13621.0	01Jan2000, 15:00	4.54
R40	5.21810	3162.5	01Jan2000, 14:20	5.09
R70	8.63036	3635.4	01Jan2000, 14:30	4.36
R80	10.60510	5013.1	01Jan2000, 14:10	4.60
W170				

Subbasin Element "W170" Results for Run "Rosillo Standard Design Run"

Legend
Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Incremental Precipitation
Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Precipitation Loss
Run:Rosillo Standard Design Run Element:W170 Result:Outflow
Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Baseflow

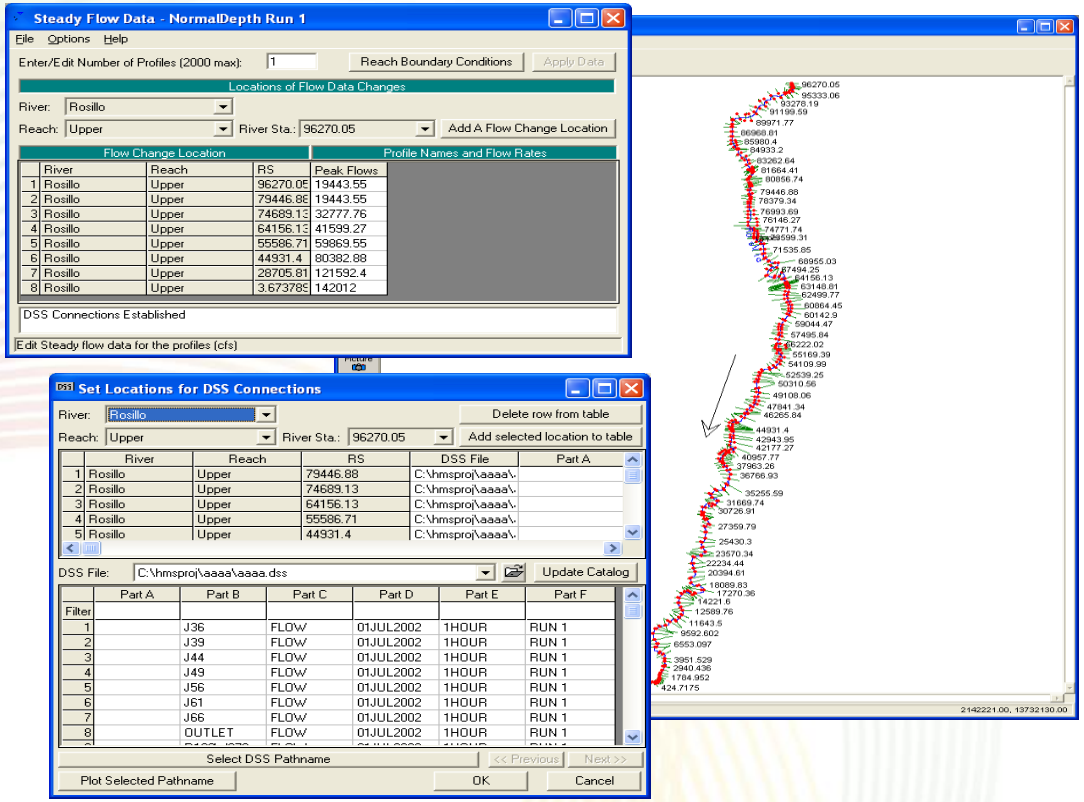
Develop GeoRAS model (pre-processing)

- Follow all principles in development of a hydraulic model for element placement (confluences, structures, …)
- In addition, take into consideration integration planning aspects developed earlier
- Naming conventions (add name of the HMS element to the cross-section that will get the element’s flows)
- Export to RAS



Finalize and Run RAS

- Complete RAS model with any additional parameters including initial and boundary conditions
- Follow all principles in RAS model development (calibration, etc.)



Steady Flow Data - NormalDepth Run 1

Enter/Edit Number of Profiles (2000 max): 1

Locations of Flow Data Changes

River: Rosillo

Reach: Upper River Sta.: 96270.05

	Flow Change Location			Profile Names and Flow Rates
	River	Reach	RS	Peak Flows
1	Rosillo	Upper	96270.0	19443.55
2	Rosillo	Upper	79446.8	19443.55
3	Rosillo	Upper	74689.1	32777.76
4	Rosillo	Upper	64156.1	41599.27
5	Rosillo	Upper	55586.71	59869.55
6	Rosillo	Upper	44931.4	80382.88
7	Rosillo	Upper	28705.81	121592.4
8	Rosillo	Upper	3.67378	142012

DSS Connections Established

Edit Steady flow data for the profiles (cfs)

Set Locations for DSS Connections

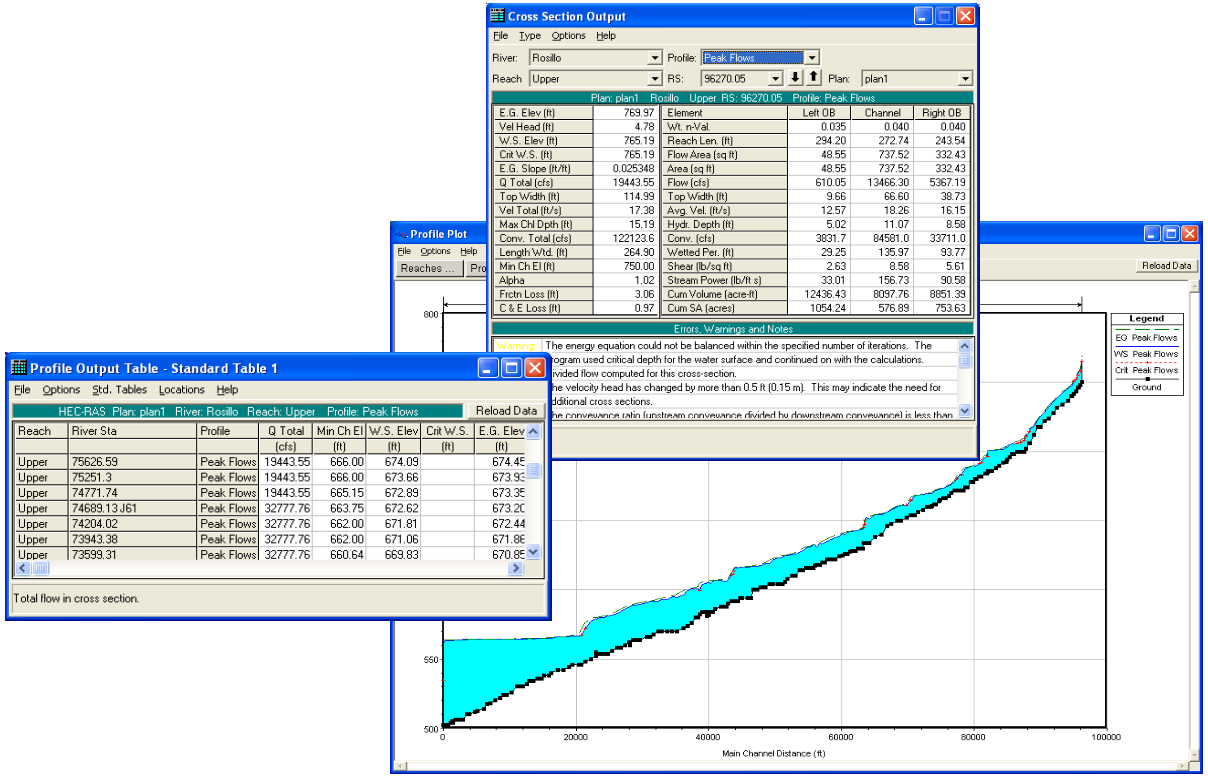
River: Rosillo

Reach: Upper River Sta.: 96270.05

	River	Reach	RS	DSS File	Part A
1	Rosillo	Upper	79446.88	C:\hmsproj\aaaa\.	
2	Rosillo	Upper	74689.13	C:\hmsproj\aaaa\.	
3	Rosillo	Upper	64156.13	C:\hmsproj\aaaa\.	
4	Rosillo	Upper	55586.71	C:\hmsproj\aaaa\.	
5	Rosillo	Upper	44931.4	C:\hmsproj\aaaa\.	

DSS File: C:\hmsproj\aaaa\aaaa.dss

	Part A	Part B	Part C	Part D	Part E	Part F
Filter						
1		J36	FLOW	01JUL2002	1HOUR	RUN 1
2		J39	FLOW	01JUL2002	1HOUR	RUN 1
3		J44	FLOW	01JUL2002	1HOUR	RUN 1
4		J49	FLOW	01JUL2002	1HOUR	RUN 1
5		J56	FLOW	01JUL2002	1HOUR	RUN 1
6		J61	FLOW	01JUL2002	1HOUR	RUN 1
7		J66	FLOW	01JUL2002	1HOUR	RUN 1
8		OUTLET	FLOW	01JUL2002	1HOUR	RUN 1



Cross Section Output

River: Rosillo Profile: Peak Flows

Reach Upper RS: 96270.05 Plan: plan1

Plan: plan1 Rosillo Upper RS: 96270.05 Profile: Peak Flows

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	769.97	Wt. n-Val.	0.035	0.040	0.040
Vel Head (ft)	4.78	Reach Len. (ft)	294.20	272.74	243.54
W.S. Elev (ft)	765.19	Flow Area (sq ft)	48.55	737.52	332.43
Crit W.S. (ft)	765.19	Area (sq ft)	48.55	737.52	332.43
E.G. Slope (ft/ft)	0.025348	Flow (cfs)	610.05	13466.30	5367.19
Q Total (cfs)	19443.55	Top Width (ft)	9.66	66.60	38.73
Top Width (ft)	114.99	Avg. Vel. (ft/s)	12.57	18.26	16.15
Vel Total (ft/s)	17.38	Hydr. Depth (ft)	5.02	11.07	8.58
Max Chl Dpth (ft)	15.19	Conv. (cfs)	3831.7	84581.0	33711.0
Conv. Total (cfs)	122123.6	Wetted Per. (ft)	29.25	135.97	93.77
Length Wtd. (ft)	264.90	Shear (lb/sq ft)	2.63	8.58	5.61
Min Ch El (ft)	750.00	Stream Power (lb/ft s)	33.01	156.73	90.58
Alpha	1.02	Cum Volume (acre-ft)	12436.43	8097.76	8851.39
Frctn Loss (ft)	3.06	Cum SA (acres)	1054.24	576.89	753.63
C & E Loss (ft)	0.97				

Errors, Warnings and Notes

Warning: The energy equation could not be balanced within the specified number of iterations. The rogram used critical depth for the water surface and continued on with the calculations.

ivided flow computed for this cross-section.

he velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for dditional cross sections.

he convevance ratio (upstream convevance divided bv downstream convevance) is less than

Profile Output Table - Standard Table 1

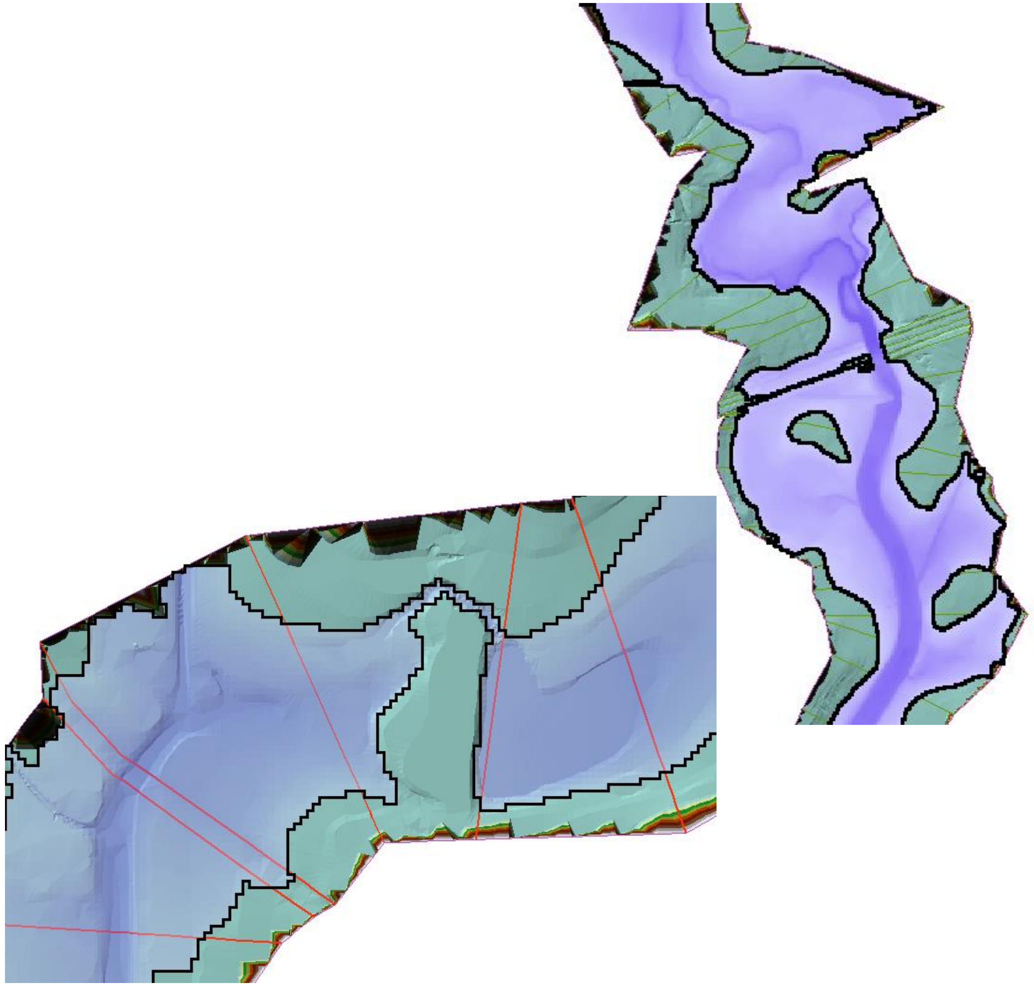
HEC-RAS Plan: plan1 River: Rosillo Reach: Upper Profile: Peak Flows

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev
			(cfs)	(ft)	(ft)	(ft)	(ft)
Upper	75626.59	Peak Flows	19443.55	666.00	674.09		674.45
Upper	75251.3	Peak Flows	19443.55	666.00	673.66		673.93
Upper	74771.74	Peak Flows	19443.55	665.15	672.89		673.35
Upper	74689.13 J61	Peak Flows	32777.76	663.75	672.62		673.20
Upper	74204.02	Peak Flows	32777.76	662.00	671.81		672.44
Upper	73943.38	Peak Flows	32777.76	662.00	671.06		671.86
Upper	73599.31	Peak Flows	32777.76	660.64	669.83		670.85

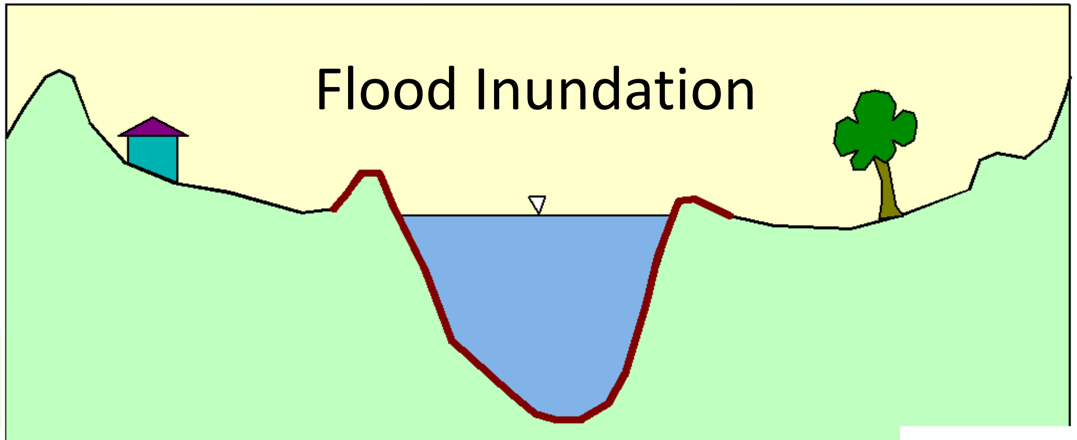
Total flow in cross section.

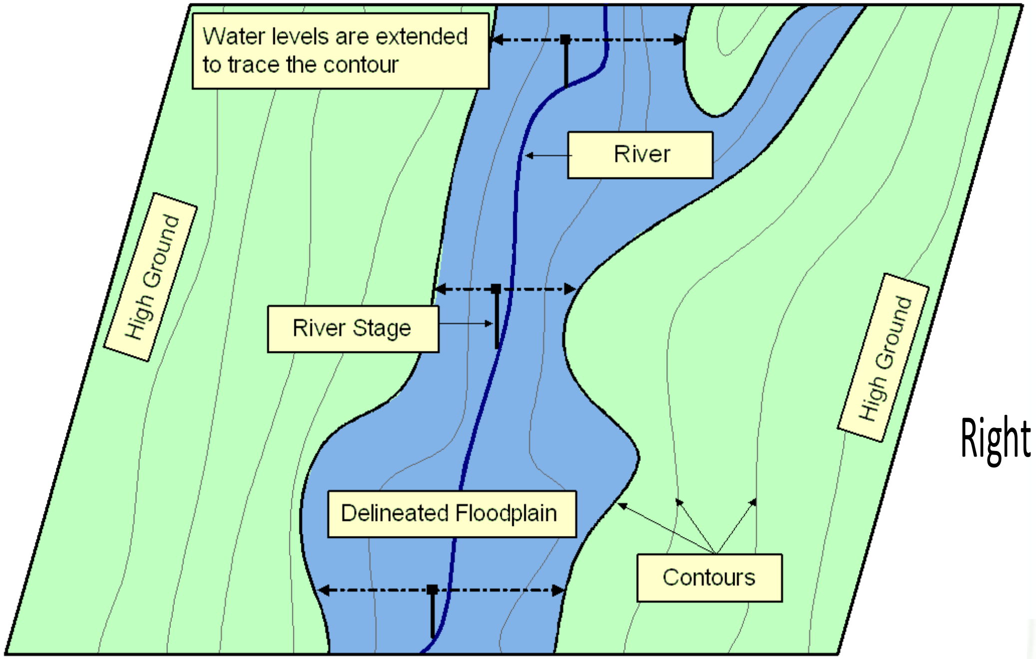
Process RAS results in GeoRAS

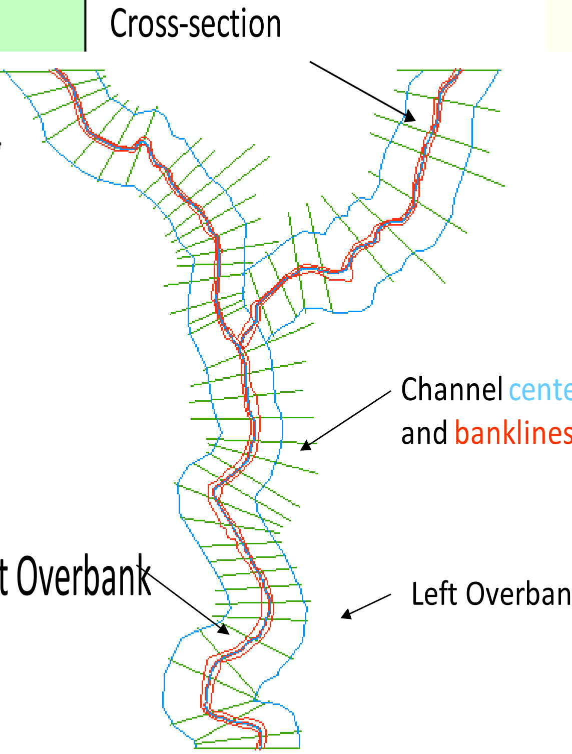
- Construct the floodplain based on the results in the sdf
- Review the results with respect to spatial integrity (extents of cross-sections, ineffective flow areas, disconnected flood areas, …)
- Clean results
- Revisit RAS



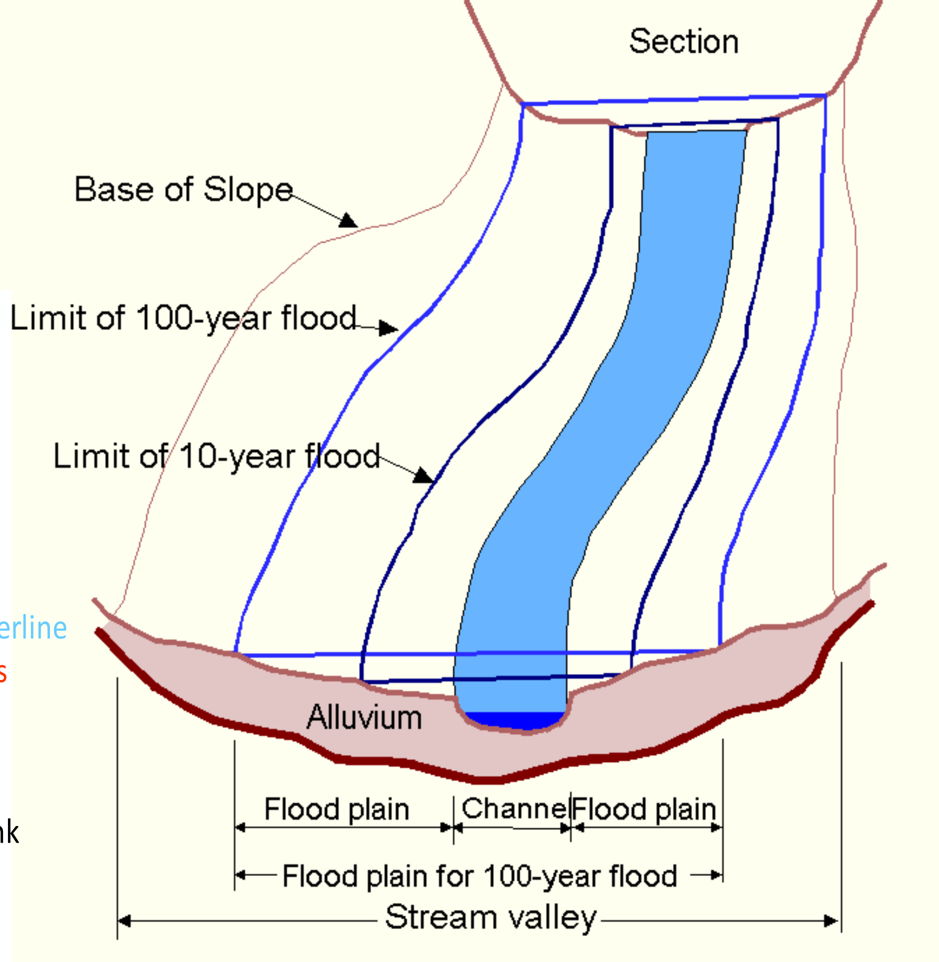
Flood Inundation







Floodplain Delineation

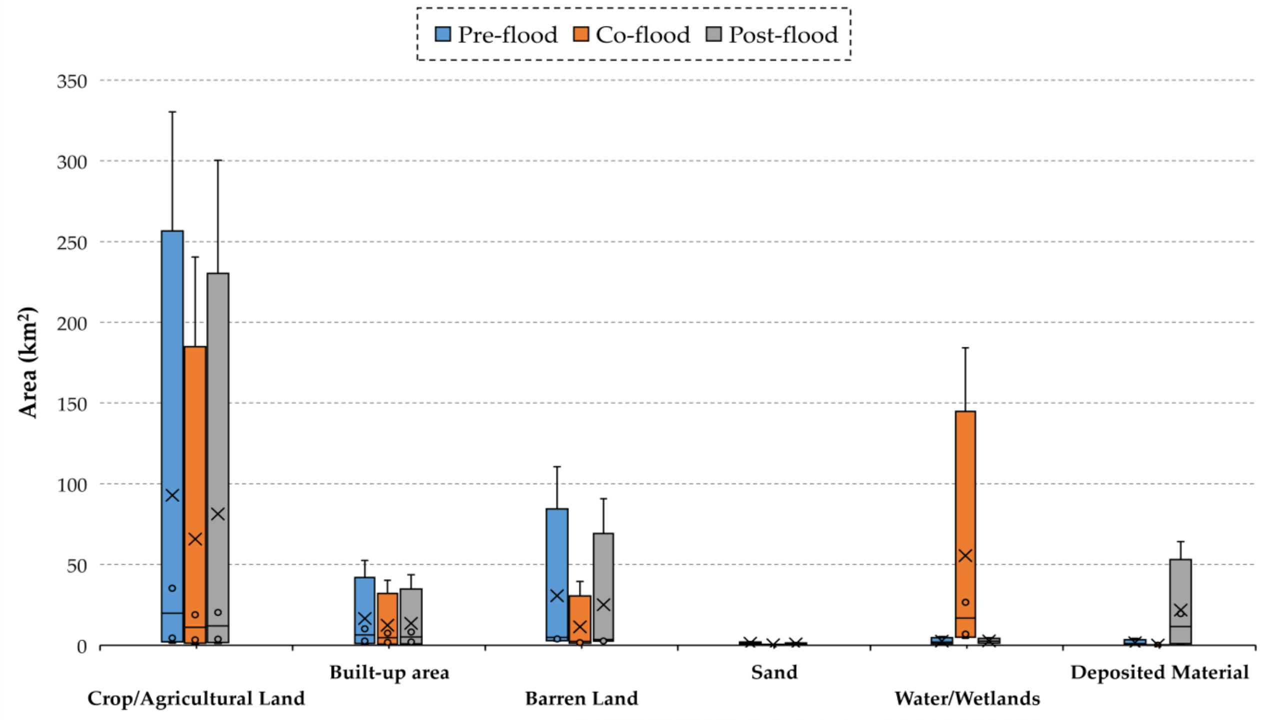


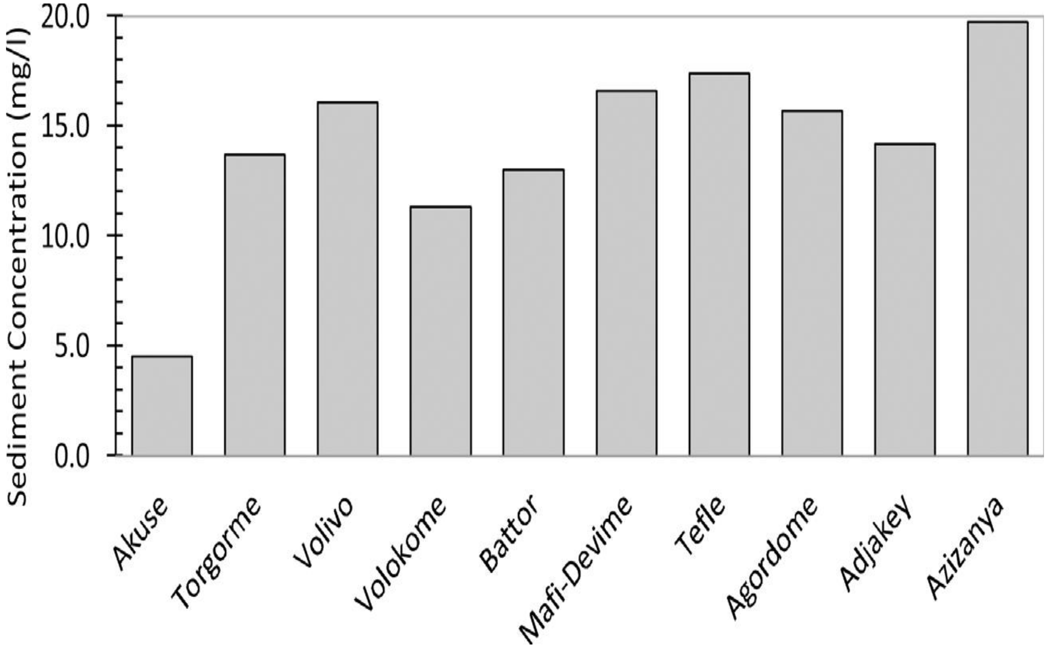
Results

- Changes in LULC After the Flood
- Accuracy Assessment
- Damage Assessment
- Frequency Analysis
- Flood Plain Mapping

Changes in LULC After the Flood

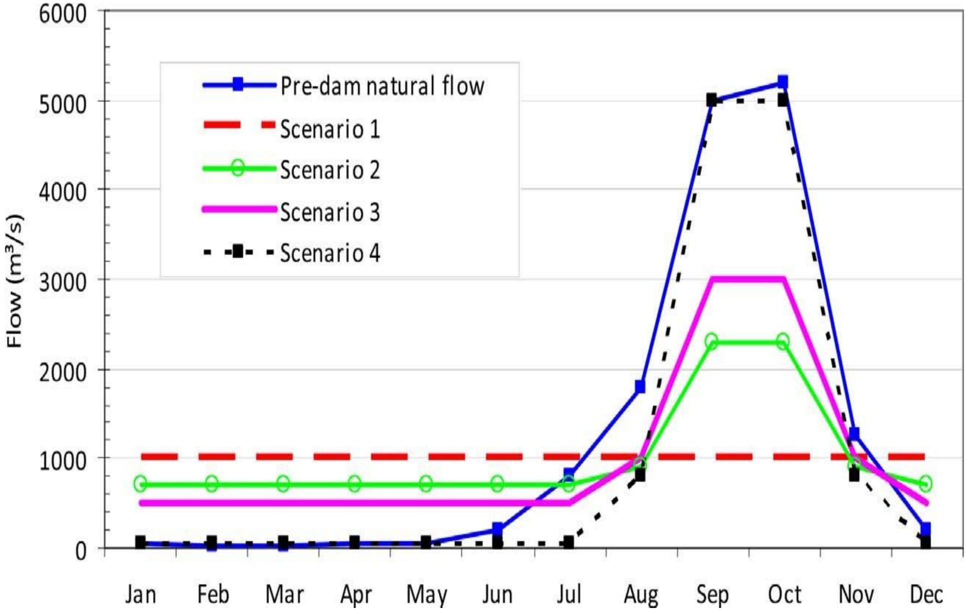
Before the flood, the watershed, covering a surface area of approximately 581.8 km2, consisted of 63.8% crop/agricultural land, 11.3% built-up area, 21.1% barren land, 0.9% sand, and 1.1% deposited material (left side). The ‘Water/Wetlands’ category covered only 1.1% of the watershed area, but, as expected, this increased dramatically to 38% during the flood, there-fore affecting other LULC types.





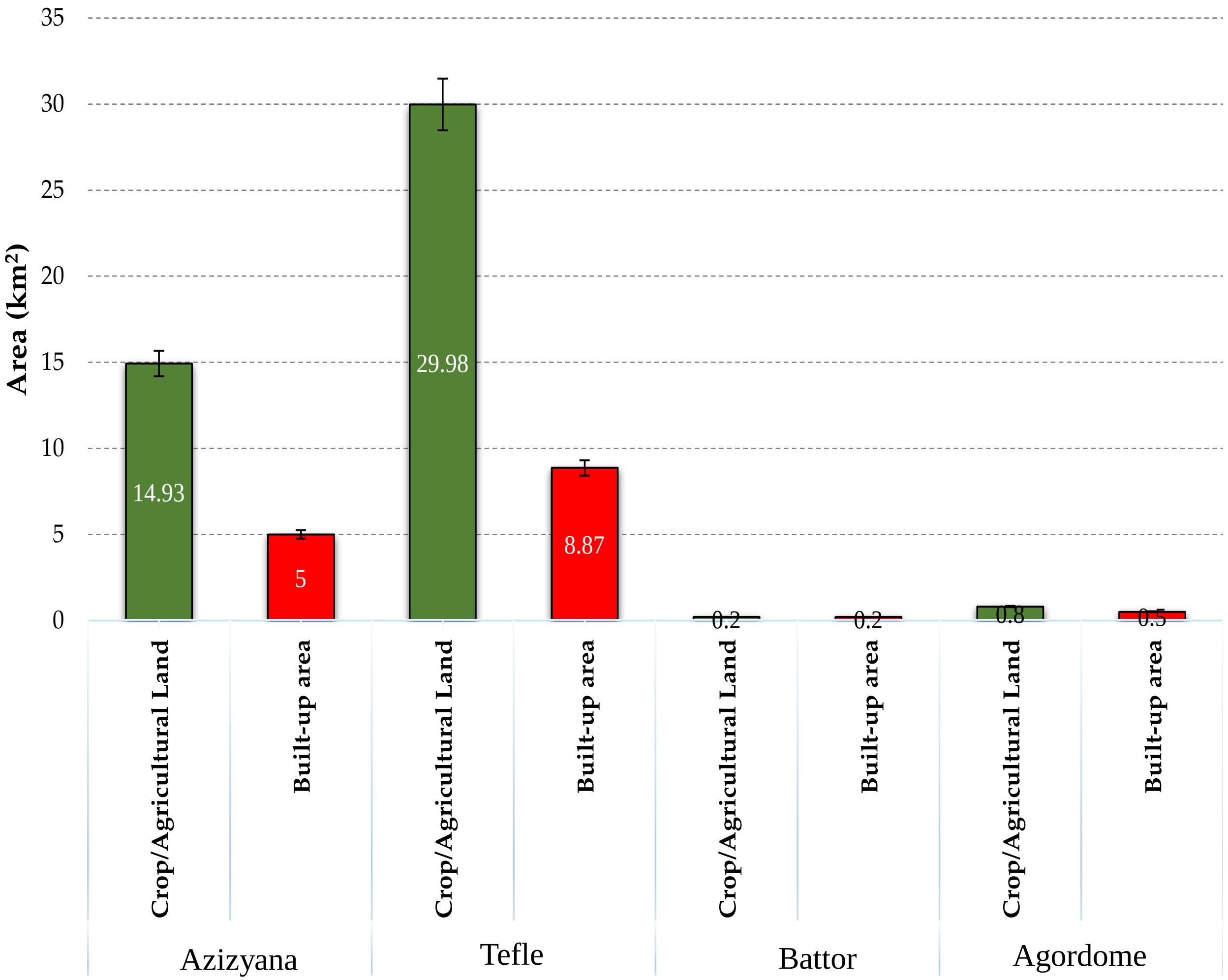
Accuracy Assessment

- The highest overall accuracy (OA) value, i.e., 96%, was obtained from the pre-flood image (July 22), while the post-flood image (September 24) had the lowest OA of 90%.
- The highest UA of the 'built-up' area class was attained for the pre-flood image, with a value of 98.98%, while the lowest was 80.11% for 'water/wetland' class for the image taken during the flood (August 8).
- The OA and K for study area as a whole are 0.96 and 0.94 (corrected samples, 576), 0.93 and 0.91 (corrected samples, 545), 0.90 and 0.85 (corrected samples, 560) for the pre-flood, during the flood, and post-flood image, respectively.



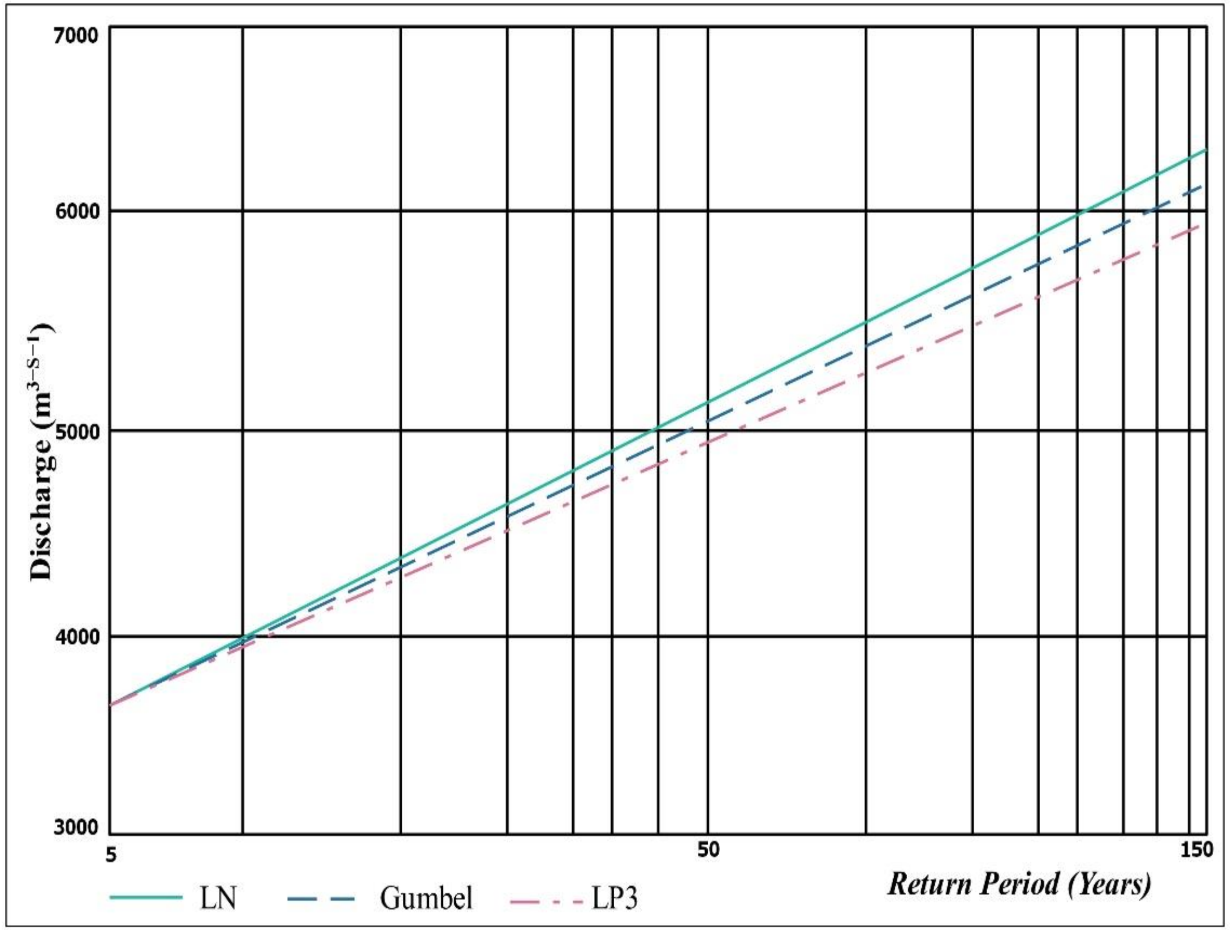
Damage Assessment

- This study shows that the 'crop/agricultural land' was the most damaged LULC class because of the 2014 flood.
- Approximately 371.2 km^2 of crop/agricultural land was inundated compared to 65.98 km^2 for the built-up area.
- Furthermore, the results highlight that deposited material damaged about 45.91 km^2 of agricultural/cropland and 11.57 km^2 of built-up area.



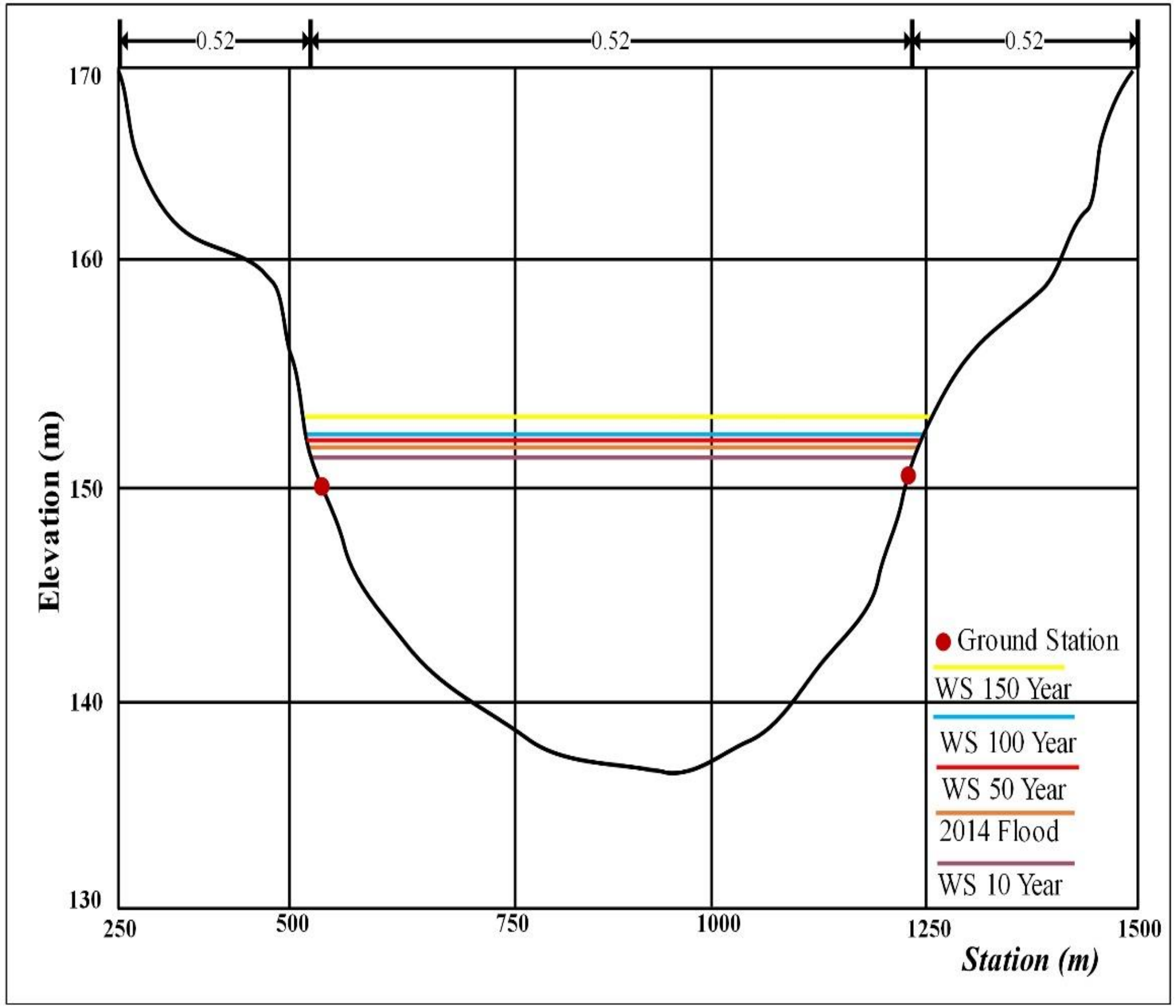
Frequency Analysis

- The maximal instantaneous discharges at **Lower Volta River** in **Ghana** for floods of different return periods are indicated using the LN, Gumbel, and LP3 distributions
- Figure depicts the discharge for each of those distributions.
- For the three distributions, the recorded discharge values are higher
- The expected flood peaks using the LN distribution are larger than those obtained using the LP3 and Gumbel distributions for all return periods greater than 50 years.

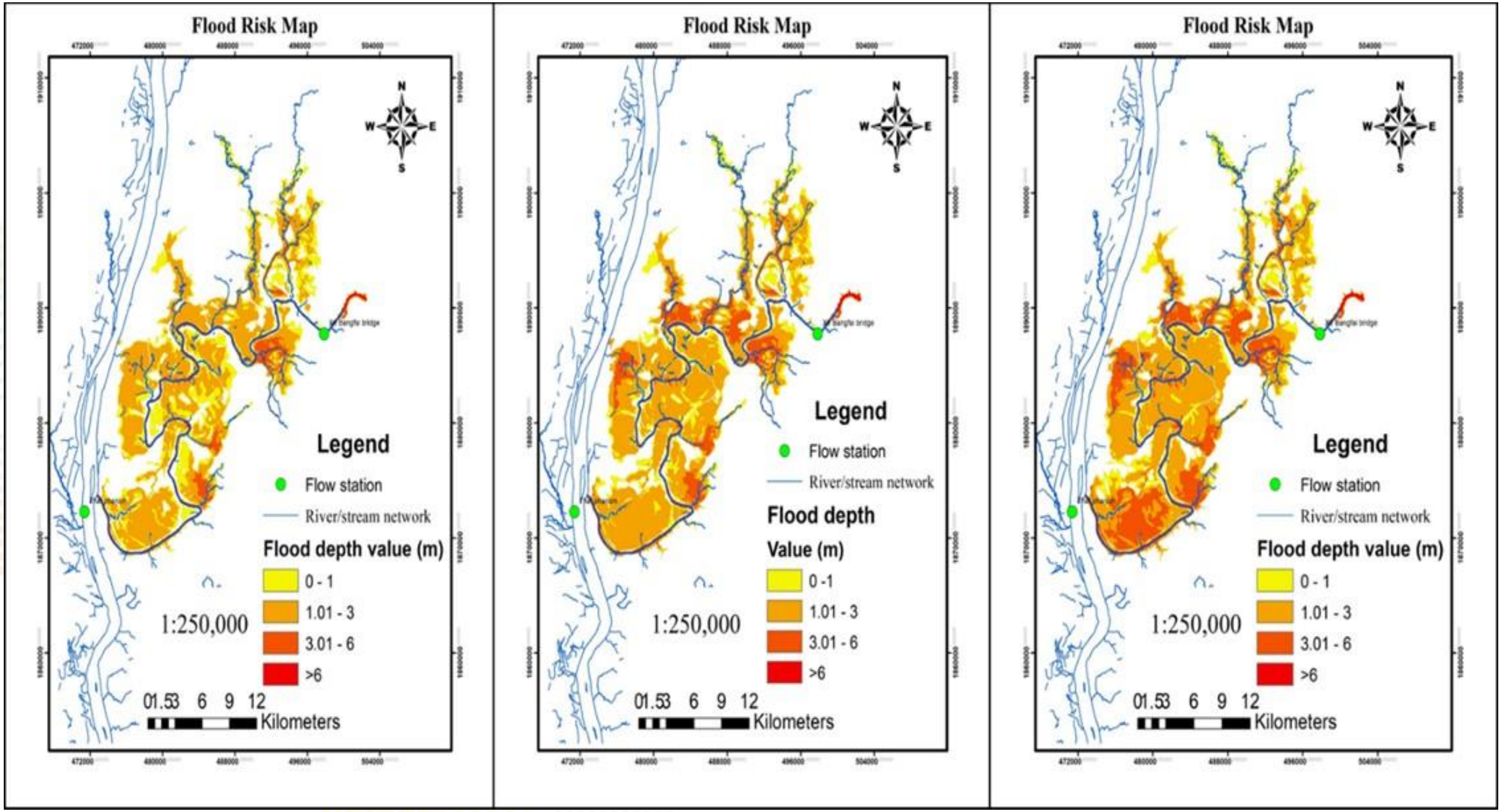


Frequency Analysis

- The LP3 distribution was used to predict flood peaks at **Lower Volta River** in **Ghana** based on the value of the K-S statistical test.
- For the return periods of 5-, 10-, 50-, 100-, and 150-year as well as for the 2014 flood, the instantaneous flows derived from the LP3 distribution were used as steady flow inputs into the HEC-RAS model.
- The first segment was downstream from **Lower Volta River** in **Ghana** at some distance. The topography was comparatively precise compared to the upstream parts, while the second part was at the intersection of the Indus River.
- Both floods with 100- and 150-year return periods show higher water levels than the water levels that occurred during the 2014 flood



Flood Plain Mapping



Discussion

- **Ghana** is a country highly vulnerable to floods
- In 2014, heavy monsoon rains resulted in a high discharge of the **Lower Volta River** in
- **Ghana**, which exceeded the channel capacity, causing a major flood in study area.
- This paper also shows that sediment build-up can also be detected with good accuracy over crop/agricultural fields and built-up areas
- This analysis identified ‘sand’ with an accurate accuracy, however, wet sand has often been mistaken with water and vegetation/agricultural land in some instances. This is also observed in some situations where blurred pixels, crop/agricultural land, and built-up areas are also misclassified in transition areas.
- To evaluate the suitability of the HEC-RAS model to simulate the water surface profiles and determine the spatial extent of floods of different return periods. It was found that the HEC-RAS model was able to replicate the magnitude of the 2014 flood. The floodplain map showed that the flood levels were about four times higher for a flood with a 50-year return period than those under typical flow conditions.

Conclusion

- Using GIS and RS to depict the spatial extent of the 2014 flood of the **Lower Volta River** in **Ghana**, comparing the model output with MODIS satellite imagery, and determining the extent of floods of different return periods for the basin.
- Landsat images to identify the various LULC types over the watershed and the approach was subsequently evaluated using Google Earth images and field data with an overall classification accuracy of 85% obtained.
- Evaluated the HEC-RAS model to simulate the 2014 flood and using the model to simulate floods of different return periods.
- The K-S statistical test identified the LP3 probability distribution to be best at simulating the flow regime of the **Lower Volta River** in **Ghana**, and this distribution was then used to identify the peak river discharge for floods with a 5-, 10-, 50-, 100-, and 150-year return period, which was then used as input into the HEC-RAC model to estimate the areas of the watershed at risk of flooding for each return period.

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Thanks

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