

# Boundary and Initial Conditions for 2D Modeling

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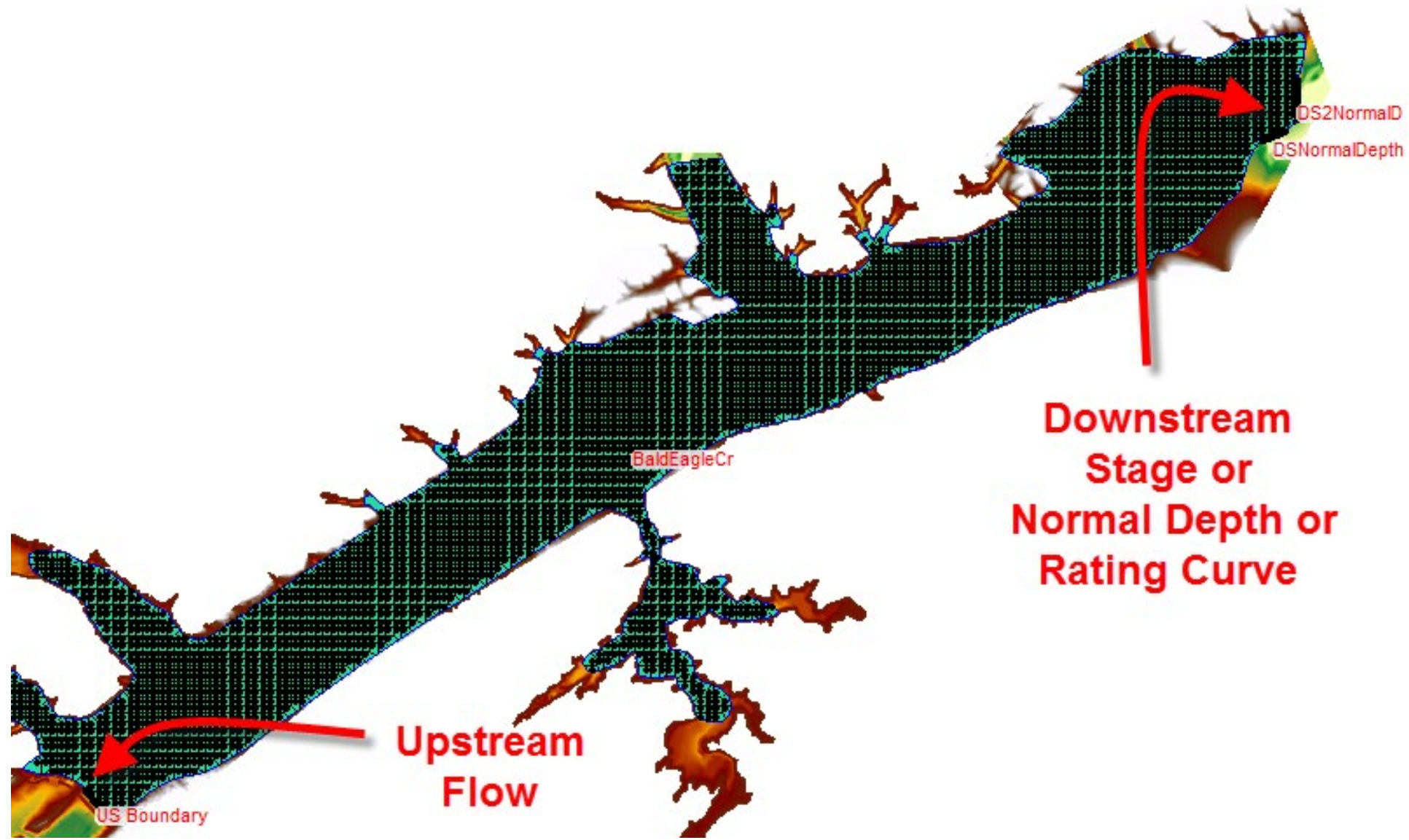


# Overview

- External Boundary conditions
- Internal Boundary conditions
- Initial Conditions



# External Boundary Conditions Overview

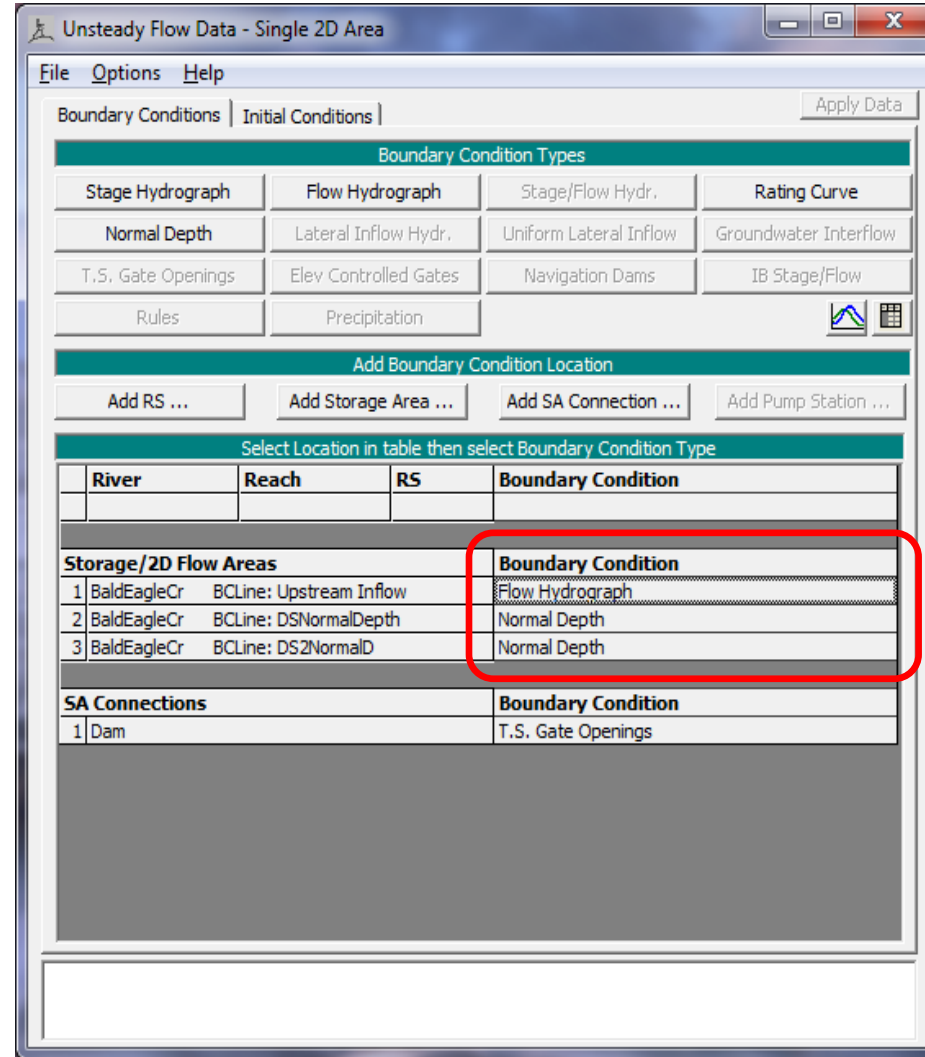
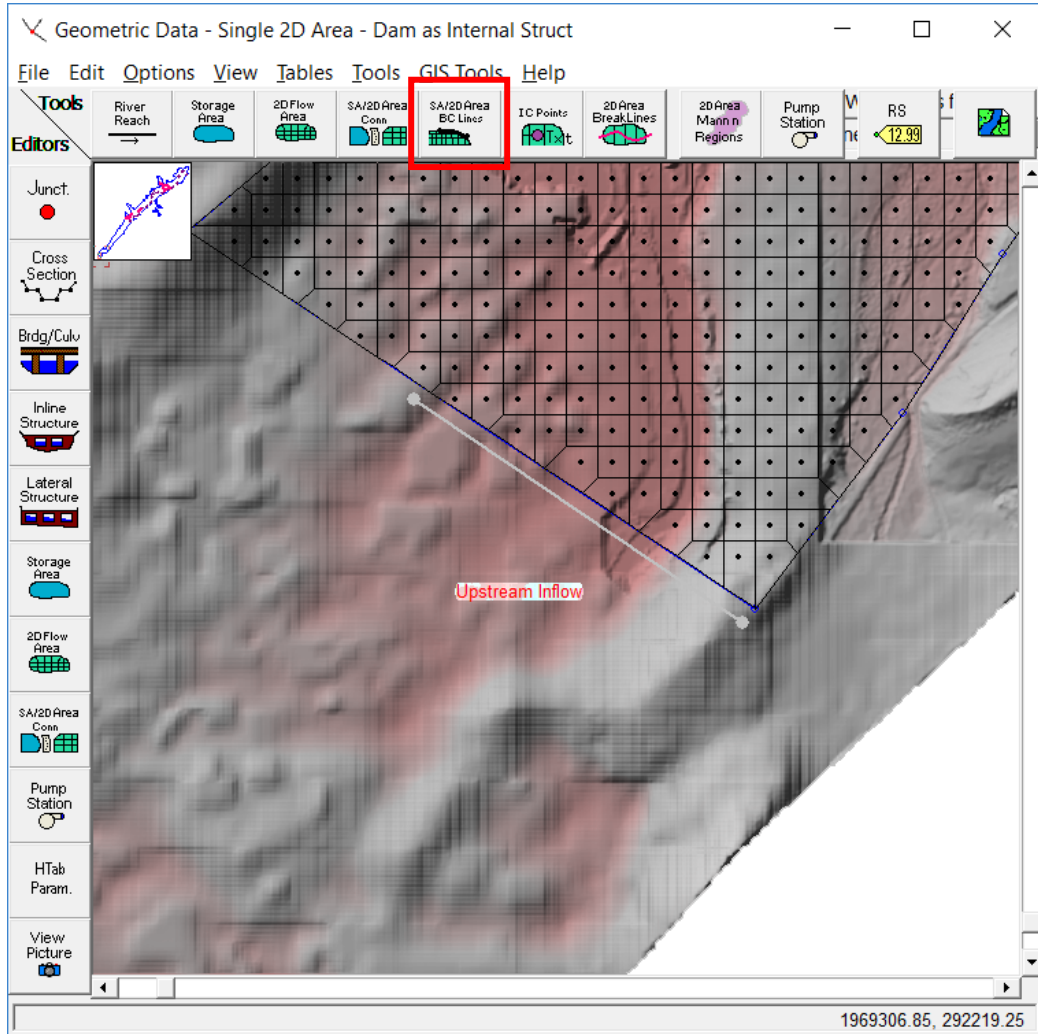




# 2D External Boundary Types

- Flow Time Series
  - Usually for inflow (upstream/lateral)
  - Can also be used for outflow
  - Can be inside a 2D area
- Stage Time Series
  - Usually for outflow
  - Can also be used for inflow (i.e., tidal)
- Normal Depth (outflow only)
- Rating Curve (outflow only)
- Precipitation (inflow to cells from above)

# Creating External Boundary Condition Lines





# Flow Hydrograph & EG Slope

## Flow Hydrograph

SA: 2D Area BCLine: BC Upstream (Upstream name)

Read from DSS before simulation Select DSS file and Path

File:

Path:

Enter Table Data time interval: 1 Minute

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 01JAN1999 Time: 1200

Fixed Start Time: Date:  Time:

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data			
	Date	Simulation Time (hours)	Flow (cfs)
1	01Jan1999 1200	00:00	400
2	01Jan1999 1201	00:01	416.67
3	01Jan1999 1202	00:02	833.33
4	01Jan1999 1203	00:03	1250

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step

Max Change in Flow (without changing time step):

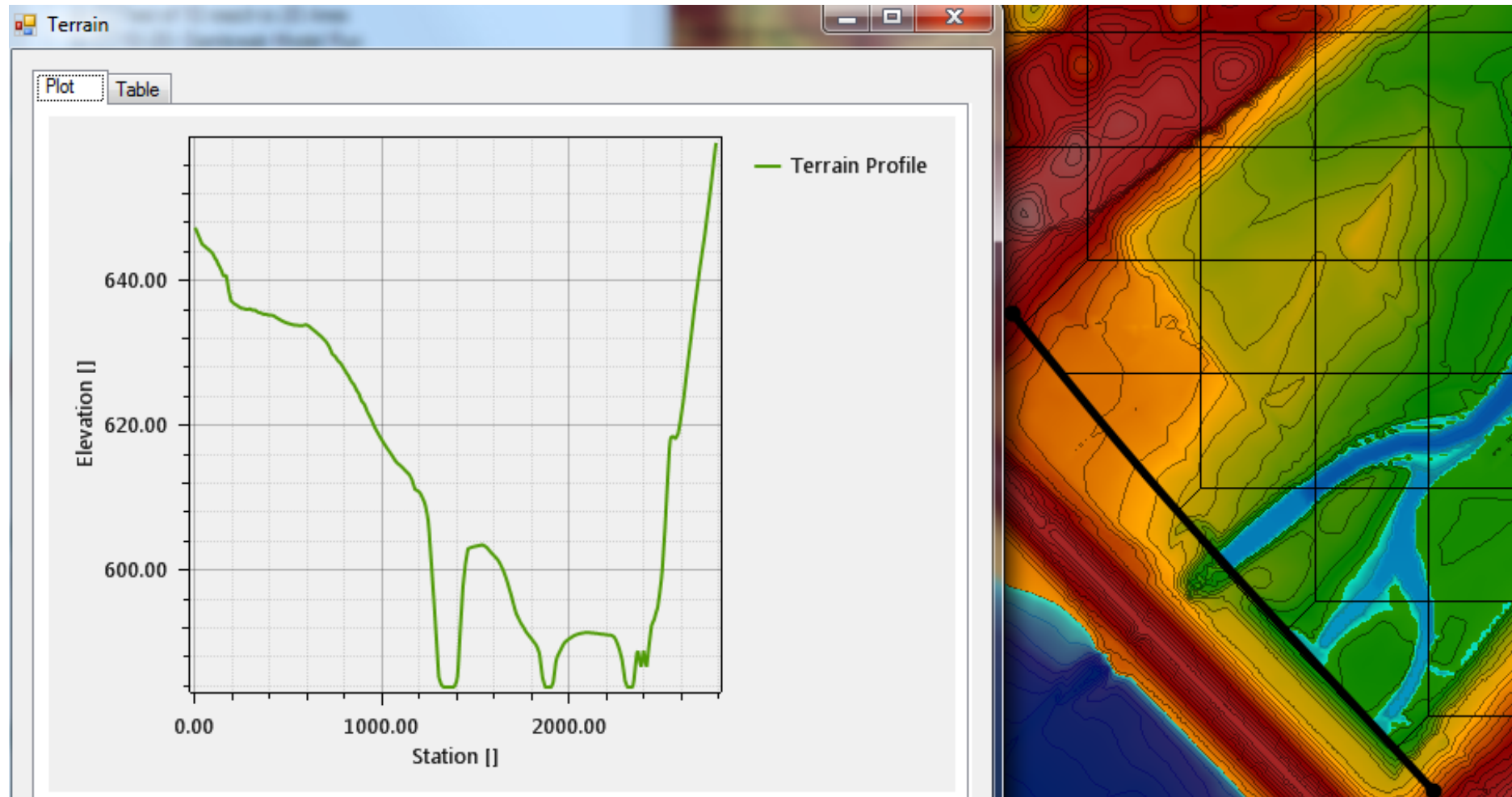
Min Flow:  Multiplier:  **EG Slope for distributing flow along BC Line: 0.1**  TW Check

Plot Data OK Cancel

- EG Slope required to compute normal depth
- TW Check higher of TW and normal depth
- Velocity transferred for full momentum equation



# Flow Distribution along Boundary



- Flow is distributed to the appropriate cells based on EG Slope Conveyance or actual water surface



# Stage Hydrograph

Stage Hydrograph

SA: BaldEagleCr BCLine: DS Stage

Read from DSS before simulation Select D...

File:

Path:

Enter Table Data time interval

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 01JAN1999 Time: 1200

Fixed Start Time: Date:  Time:

No. Ordinates  Interpolate Missing Values  Del Row  Ins Row

Hydrograph Data			
	Date	Simulation Time (hours)	Stage (ft)
1	01Jan1999 1200	00:00	536.13
2	01Jan1999 1300	01:00	537.07
3	01Jan1999 1400	02:00	536.86
4	01Jan1999 1500	03:00	537.53
5	01Jan1999 1600	04:00	538.18
6	01Jan1999 1700	05:00	539.73
7	01Jan1999 1800	06:00	540.38
8	01Jan1999 1900	07:00	540.77

Use Initial Stage (recommended)  Plot Data  OK

Boundary Condition Types

Hydrograph	Stage/Flow Hydr.	Rating Curve
Inflow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
Controlled Gates	Navigation Dams	IB Stage/Flow

Add Boundary Condition Location

Select Location in table then select Boundary Condition Type

River	Reach	RS	Boundary Condition
Storage/2D Flow Areas			Boundary Condition
1	BaldEagleCr BCLine: DS Stage		Stage Hydrograph
2	BaldEagleCr BCLine: US Boundary		Flow Hydrograph
3	BaldEagleCr BCLine: DS Stage 2		Stage Hydrograph





# Normal Depth

The screenshot shows the 'Unsteady Flow Data - 2D Lower' window in HEC-RAS. The 'Boundary Conditions' tab is active, showing a grid of boundary condition types. The 'Normal Depth' button is highlighted. A dialog box titled 'Normal Depth Downstream Boundary' is open, showing the following settings:

- SA: BaldEagleCr BCLine: DS2NormalD
- Friction Slope: 0.0003
- Buttons: OK, Cancel

The background shows a 2D grid of a river reach with a color-coded elevation map. Two boundary lines are labeled: 'DS2NormalD' and 'DSNormalDepth'.

River	Reach	RS	Boundary Condition

Storage/2D Flow Areas	Boundary Condition
1 BaldEagleCr BCLine: US Boundary	Flow Hydrograph
2 BaldEagleCr BCLine: DS2NormalD	Normal Depth
3 BaldEagleCr BCLine: DSNormalDepth	Normal Depth



# Flow/Stage/Normal Depth

- Flow Hydrograph
  - **Cell water surfaces can vary**
- Stage Hydrograph
  - **All of the boundary cells have the same water surface elevation**
- Normal Depth
  - **Normal Depth computation is applied separately to each cell**
  - **Cell water surface elevations can vary**



# Rating Curve

Unsteady Flow Data - 2D Lower

File Options Help

Boundary Conditions | Initial Conditions |

Boundary Condition Types

Stage Hydrograph	Flow Hydrograph	Stage/Flow Hydr.	Rating
Normal Depth	Lateral Inflow Hydr.	Uniform Lateral Inflow	Groundwa
T.S. Gate Openings	Elev Controlled Gates	Navigation Dams	IB Sta

Rules

Add Boundary Condition Location

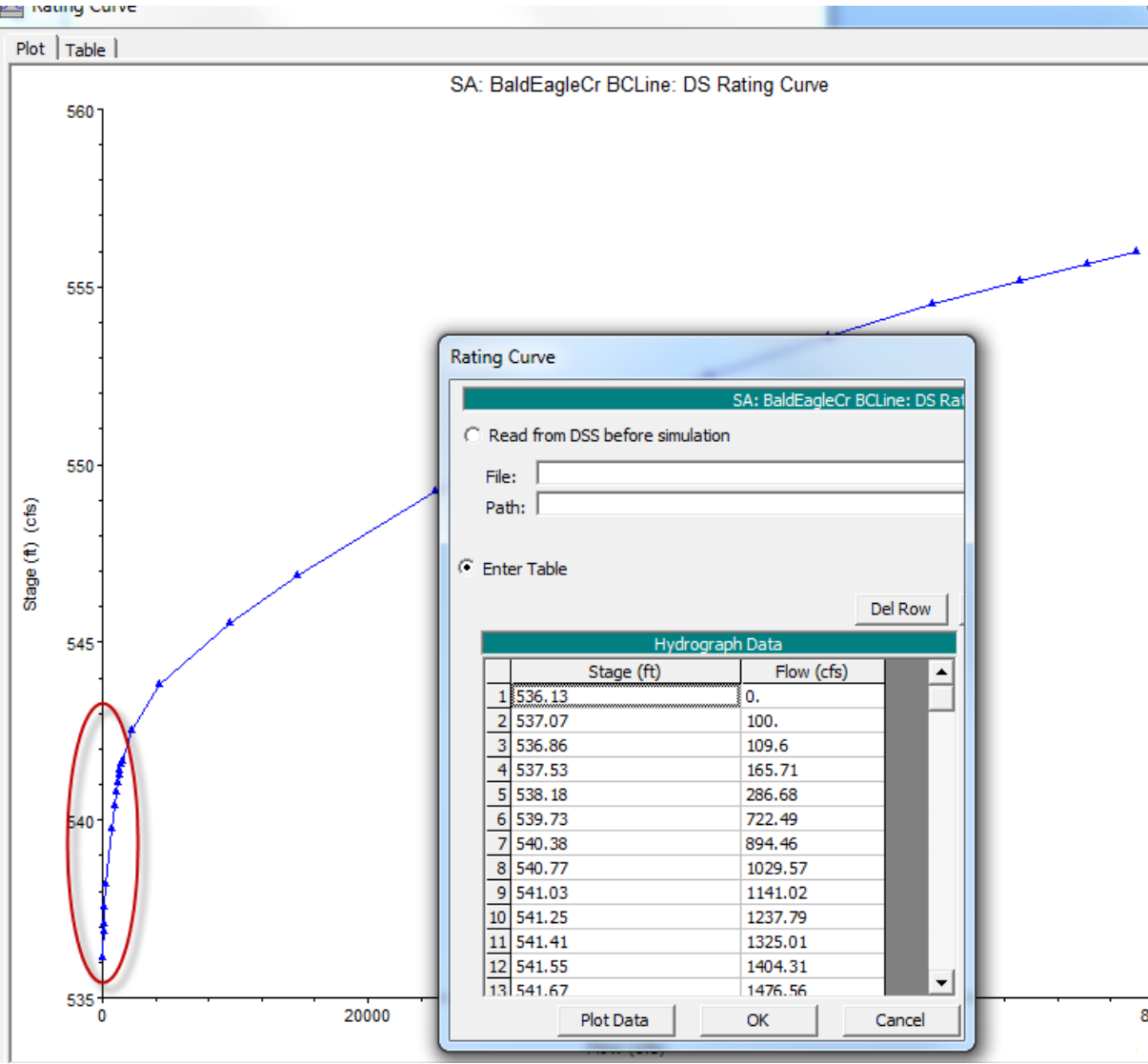
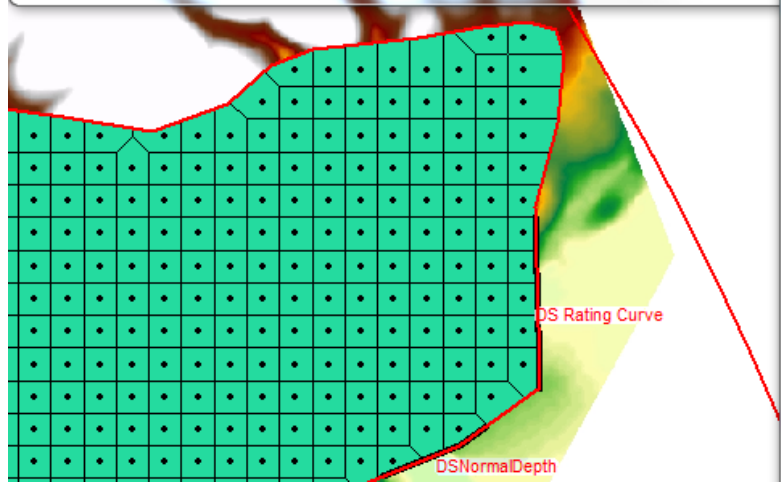
Add RS ... Add Storage Area ... Add SA Connection ... Add Pum

Select Location in table then select Boundary Condition Type

River	Reach	RS	Boundary Condition

Storage/2D Flow Areas

	Boundary Condition
1 BaldEagleCr BCLine: US Boundary	Flow Hydrograph
2 BaldEagleCr BCLine: DS Rating Curve	Rating Curve
3 BaldEagleCr BCLine: DSNormalDepth	Normal Depth





# Rating Curve Considerations

- Flow based on conveyance-averaged WSE
- Flow distribution based on conveyance
- Watch out for a steeply sloped curve and/or sharp transitions in the curve
- Watch out for “bad” low flow curve
- Zero flow point on Rating Curve does **NOT** have to be at invert (could be higher)
- Can have initialization problems (not consistent with cold-start conditions)

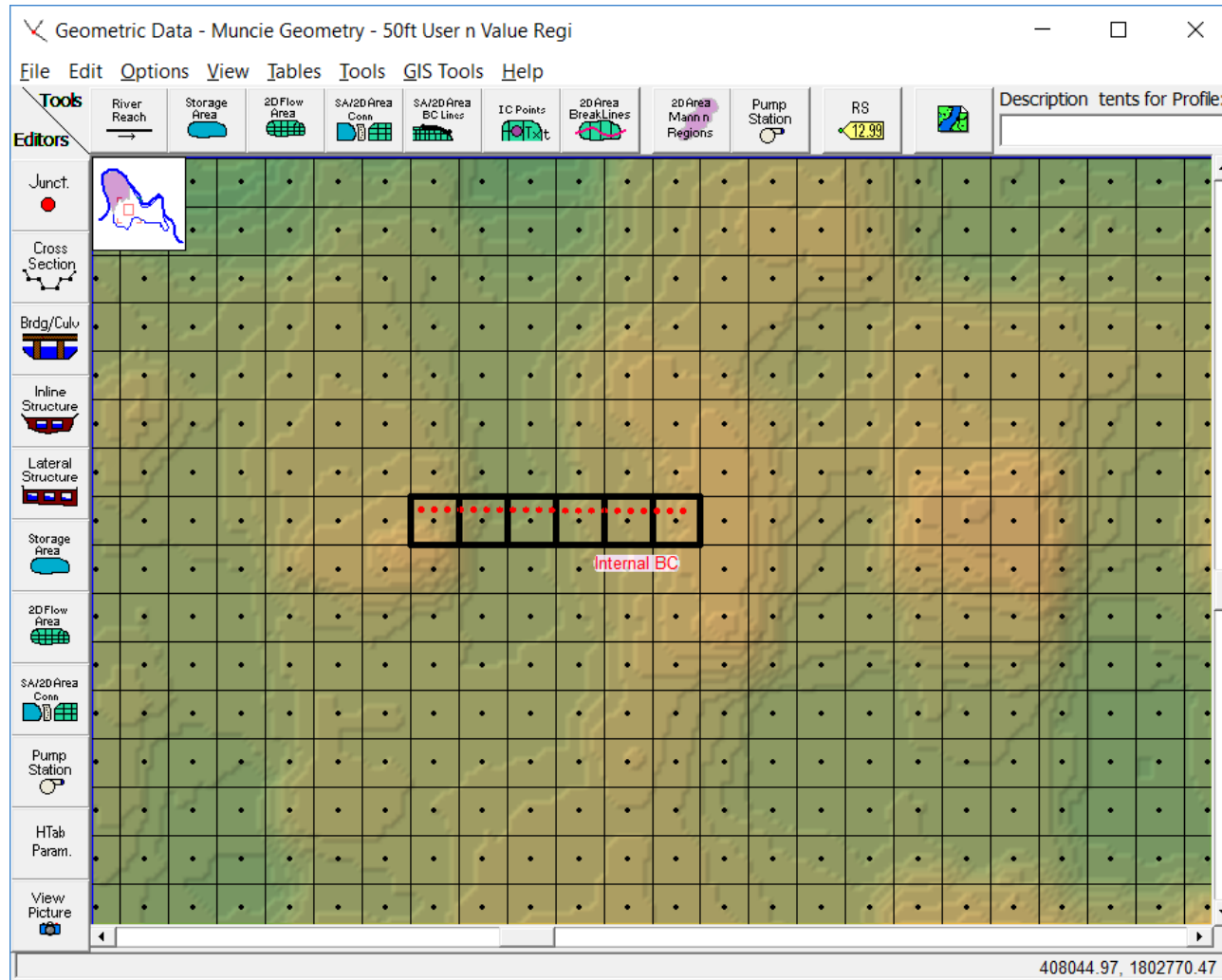


# External Boundary Locations

- Extend boundary condition locations away from study area of interest
  - **Normal Depth is an approximate boundary**
  - **Stage creates a horizontal WSE along the boundary cells**



# Internal Boundary Conditions



- Flow Hydrographs Only
- Must be completely inside of the 2D Flow Area
- Can have positive and/or negative flows



# Boundary Output

The screenshot displays the HEC-RAS 5.0.0 interface. The main window shows a 2D area model with a red boundary line labeled "DS2NormalD". A context menu is open over this boundary, with the option "Plot Stage and Flow Hydrograph ..." selected. To the right, the "Stage and Flow Hydrographs" window is open, showing a plot of Flow (cfs) versus Time (1/3/1999). The plot title is "Plan: Single 2D BCLine: DSNormalDepth". The y-axis ranges from 0 to 250,000 cfs, and the x-axis ranges from 0200 to 1200. The hydrograph shows a sharp initial peak followed by a gradual rise to a steady state of approximately 250,000 cfs.

HEC-RAS 5.0.0

File Edit Run View Options GIS Tools Help Debug

Geometric Data - Single 2D Area - D...

File Edit Options View Tables Tools GIS Tools Help

Tools: River Reach, Storage Area, 2D Flow Area, SA/2D Area Conn, SA/2D Area BC Lines, 2D Area BreakLine

Editors: Junct., Cross Section, Brgd/Culv, Inline Structure, Lateral Structure, Storage Area, 2D Flow Area, SA/2D Area Conn

BC Line: DS2NormalD

- Edit BC Line Name ...
- Plot Stage and Flow Hydrograph ...
- Delete BC Line ...

Stage and Flow Hydrographs

File Type Options Help

BC Line: DSNormalDepth

Plot Stage  Plot Flow  Obs Stage  Obs Flow  Use Ref Stage

Stage Flow | Table | Rating Curve |

Plan: Single 2D BCLine: DSNormalDepth

Flow (cfs)

Time

Time (1/3/1999)	Flow (cfs)
0200	0
0300	50,000
0400	150,000
0500	200,000
0600	230,000
0700	245,000
0800	250,000
0900	250,000
1000	250,000
1100	250,000
1200	250,000



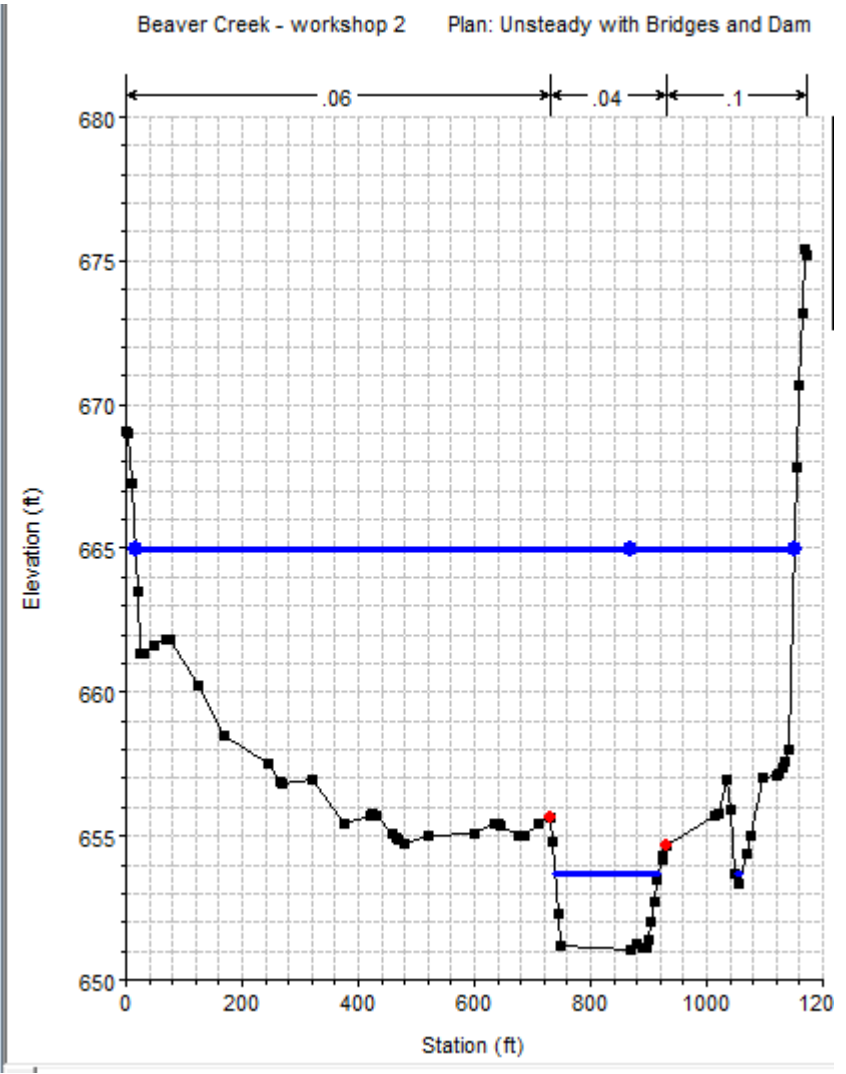
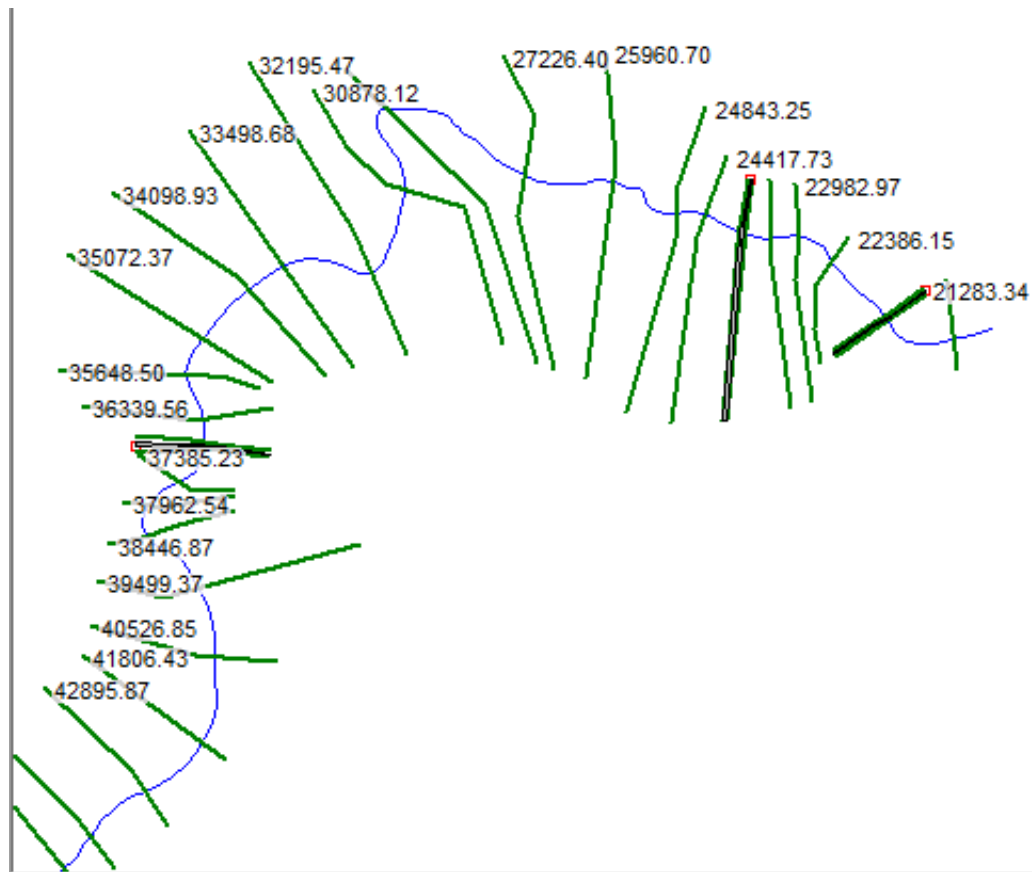
# 2D Starting Options Overview

- User Specified Initial Conditions
  - 2D starts dry
  - Horizontal WSE
  - **2D Initial Condition Time** (Optional)
    - **Allows each 2D area to compute an initial profile**
    - **Somewhat similar to 1D initial backwater**
  - Optional entire model **Warm Up** period to settle simulation
- Use **Restart File**
  - Restart File created by previous run



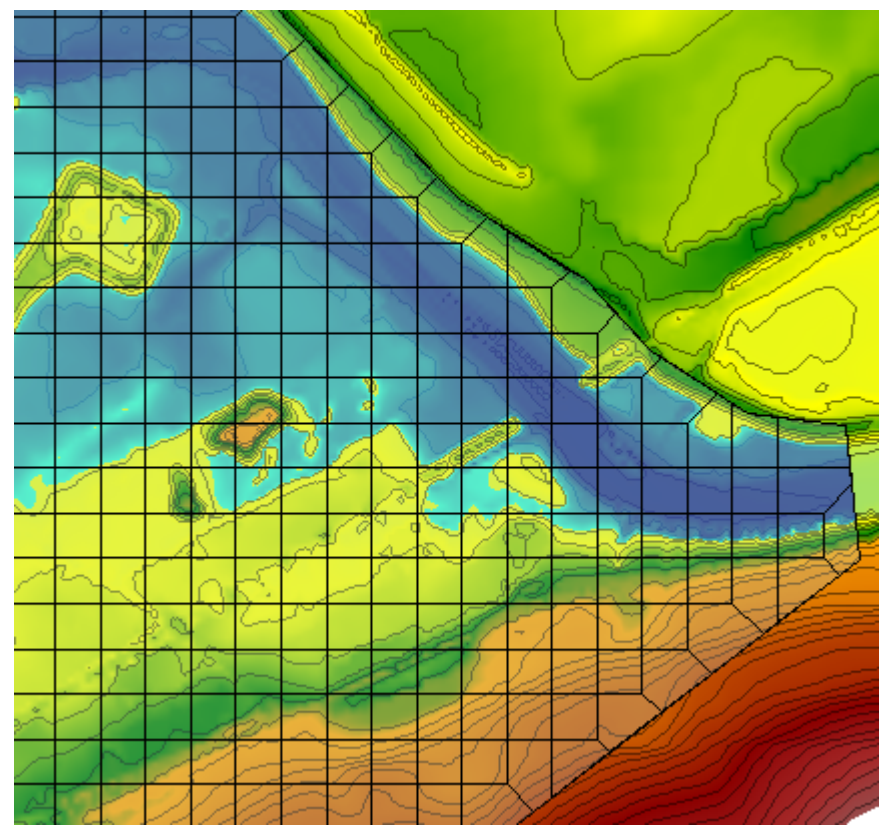
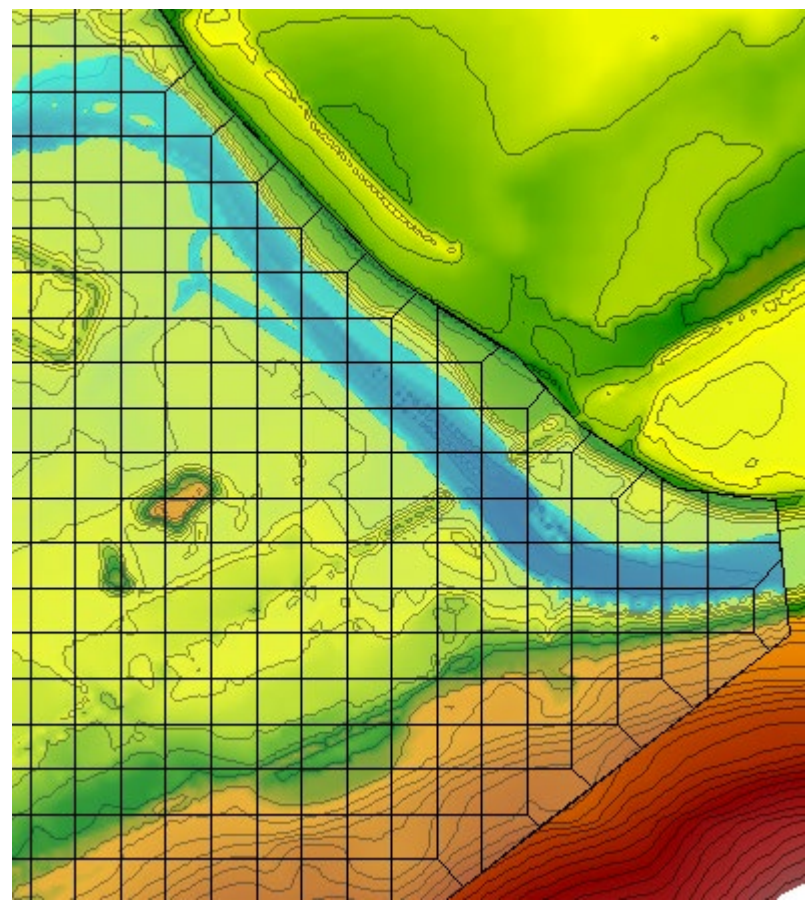


# 1D Stays Wet





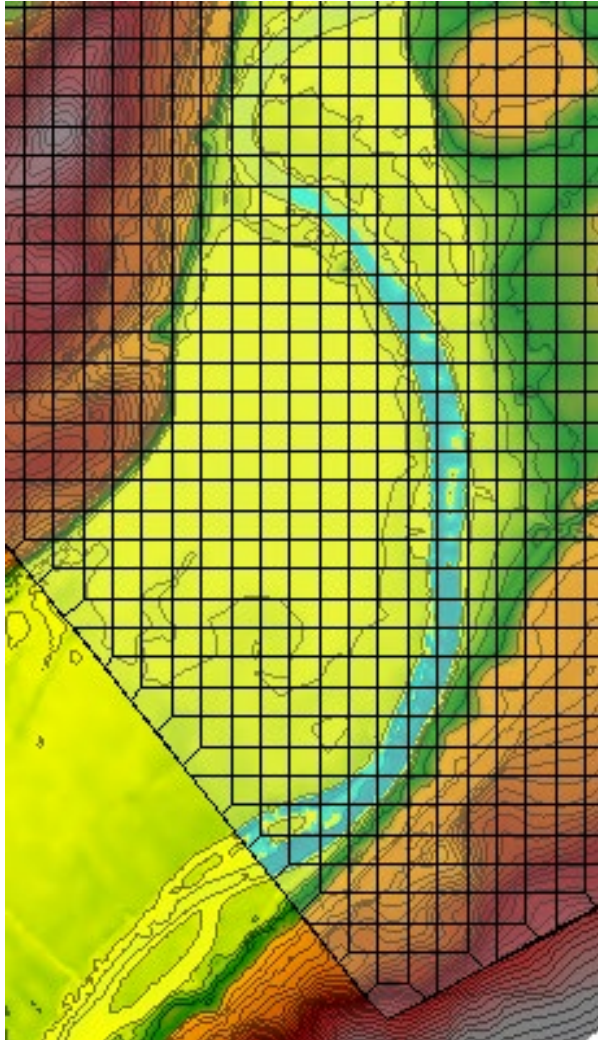
# 2D Wetting/Drying





# Filling 2D Channel

- Use Initial Conditions Time to fill channel



- Upstream flow will eventually fill channel
- May take a long time to fill, especially reservoirs
- Initial [horizontal] WSE can be used to speed things up
- A Restart File can save time



# Initial Conditions Ramp Up

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)	2D Area
1	Theta (0.6-1.0):	1	1
2	Theta Warmup (0.6-1.0):	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		2
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	<input type="checkbox"/>	<input type="checkbox"/>
12	Latitude for Coriolis (-90 to 90)		

Simulation Time Window  
Starting Date:  
Ending Date:

Computation Settings  
Computation Interval: 1 Minute  
Mapping Output Interval: 5 Minute  
DSS Output Filename: C:\Users\q0hecsp\Documents\IRAS Data\Other\unsteady\2D

Hydrograph Output Interval: 1 Minute  
Detailed Output Interval: Max Profile

OK Cancel Defaults ...

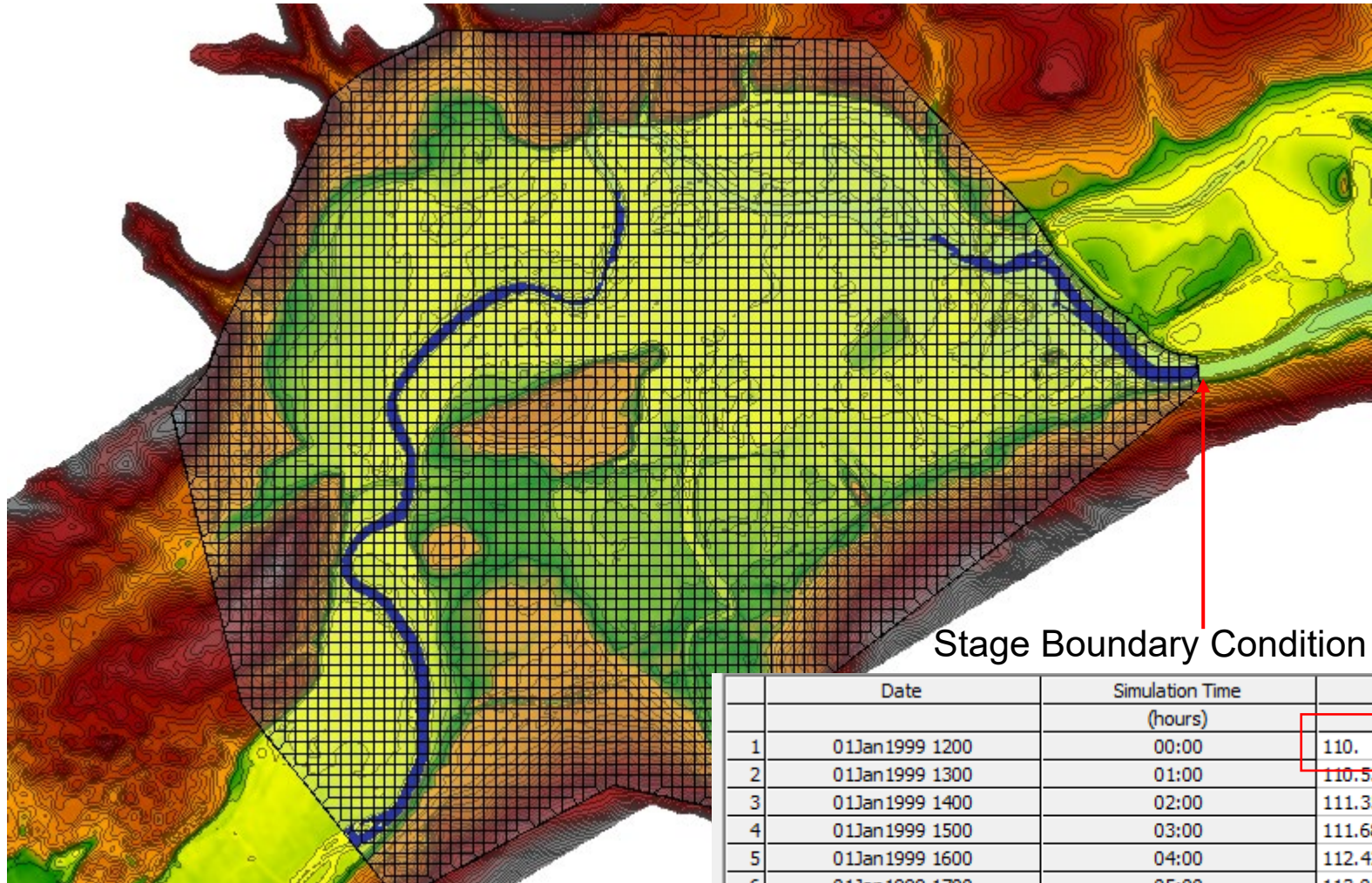


# 2D Initial Conditions

- Separate Initial Conditions computed for each 2D area, one at a time
- All external flows go from zero to starting value during Ramp Up and are then held constant
- Initial WSE (from Unsteady flow data file) applies to all cells
- Starting WSE at a Stage boundary condition uses smart projection
- Model Warm Up period (General tab from computational settings and options) is for entire model
  - **For a single 2D area Initial Conditions and Warm Up do mostly the same thing**



# 2D Initial Conditions in Progress



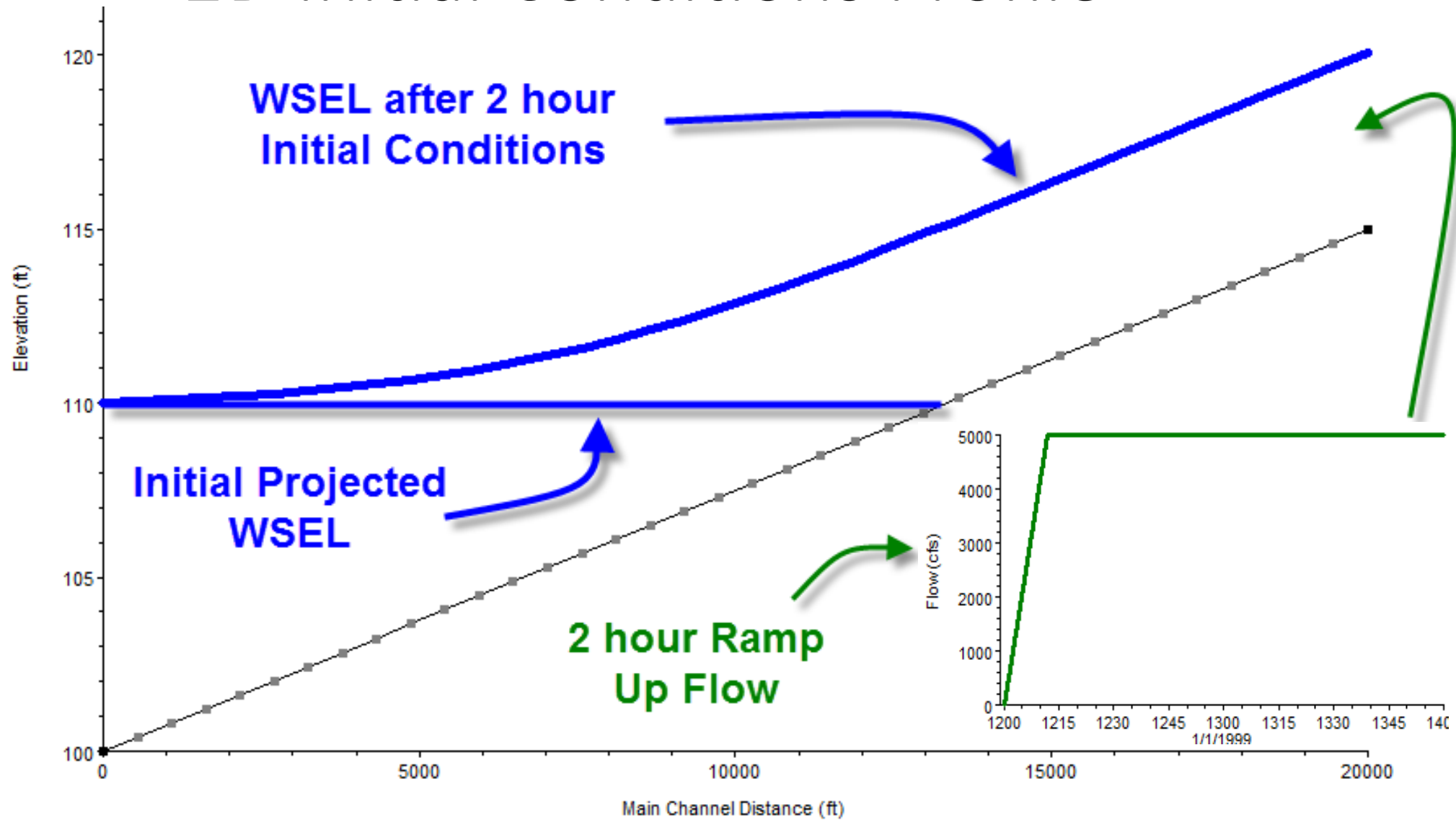
Stage Boundary Condition

	Date	Simulation Time (hours)	
1	01Jan1999 1200	00:00	110.
2	01Jan1999 1300	01:00	110.53
3	01Jan1999 1400	02:00	111.35
4	01Jan1999 1500	03:00	111.68
5	01Jan1999 1600	04:00	112.42
6	01Jan1999 1700	05:00	113.05
-	---	---	---

Use Initial Stage (recommended)    ? t Data    OK

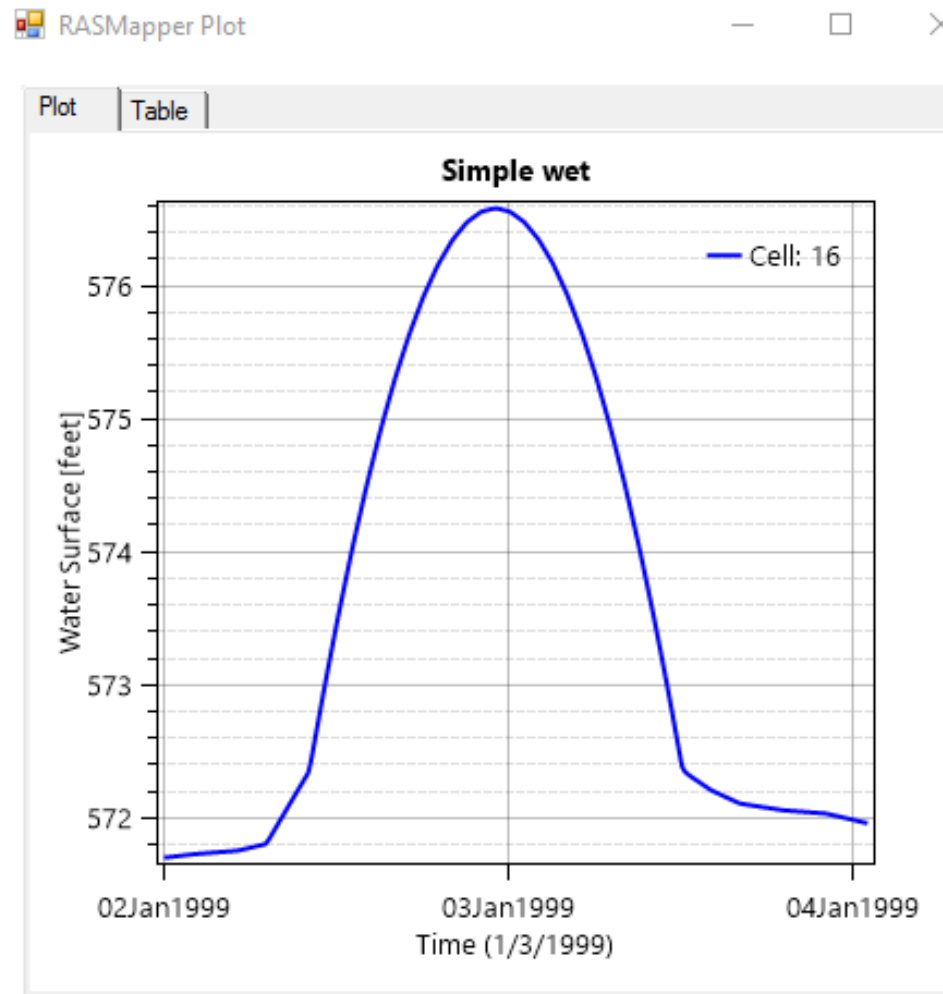
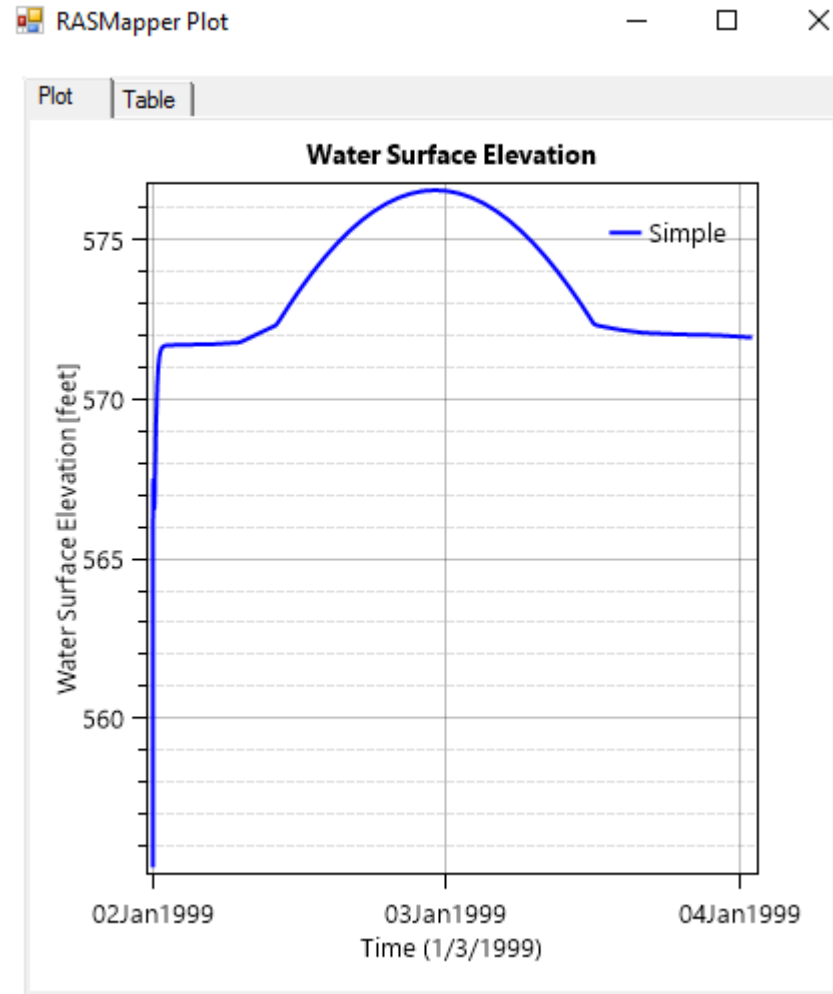


# 2D Initial Conditions Profile





# Dry vs Wet Start





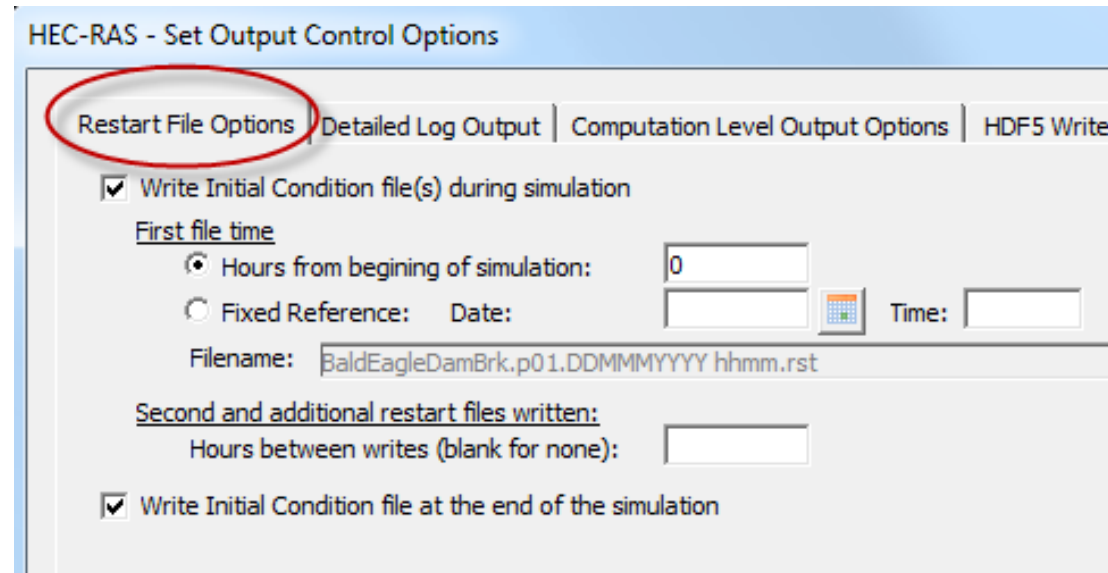
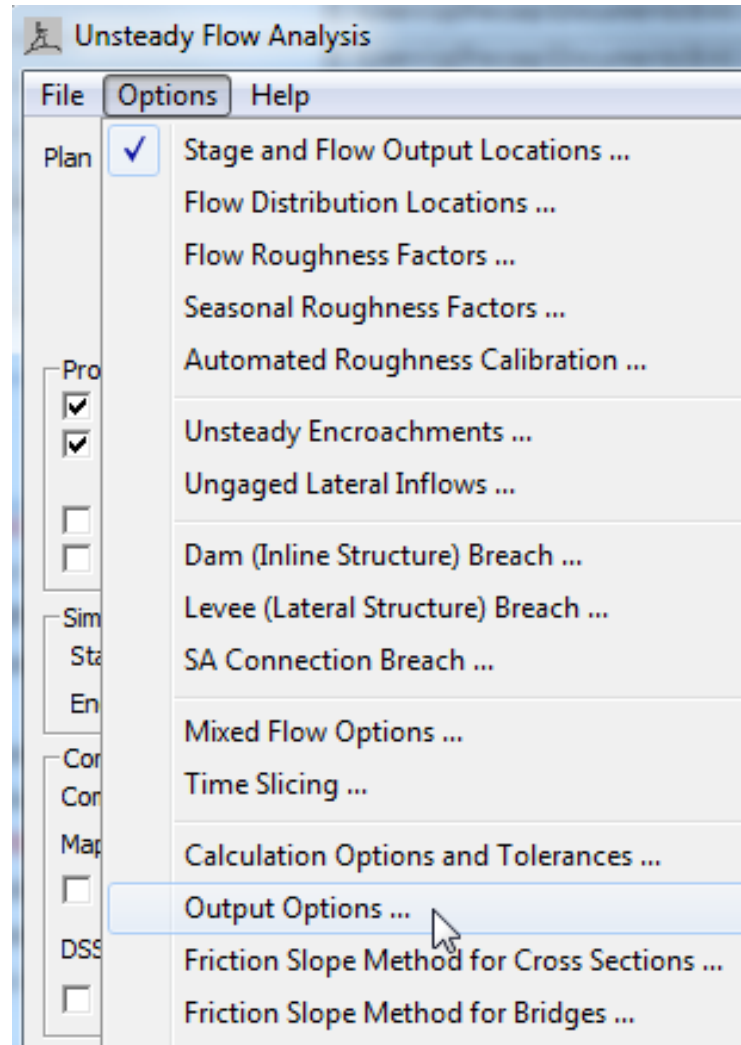


# Using a Restart File

- Write Initial Condition file out at time zero [or at the desired time(s)] from a previous run.
- Create a new Unsteady Flow file and Plan (“Save As...”)
- Select Use a Restart File option in Unsteady Flow Initial Conditions Tab
- Adjust starting date, and any hydrographs, if needed (if you start model later than previous run).

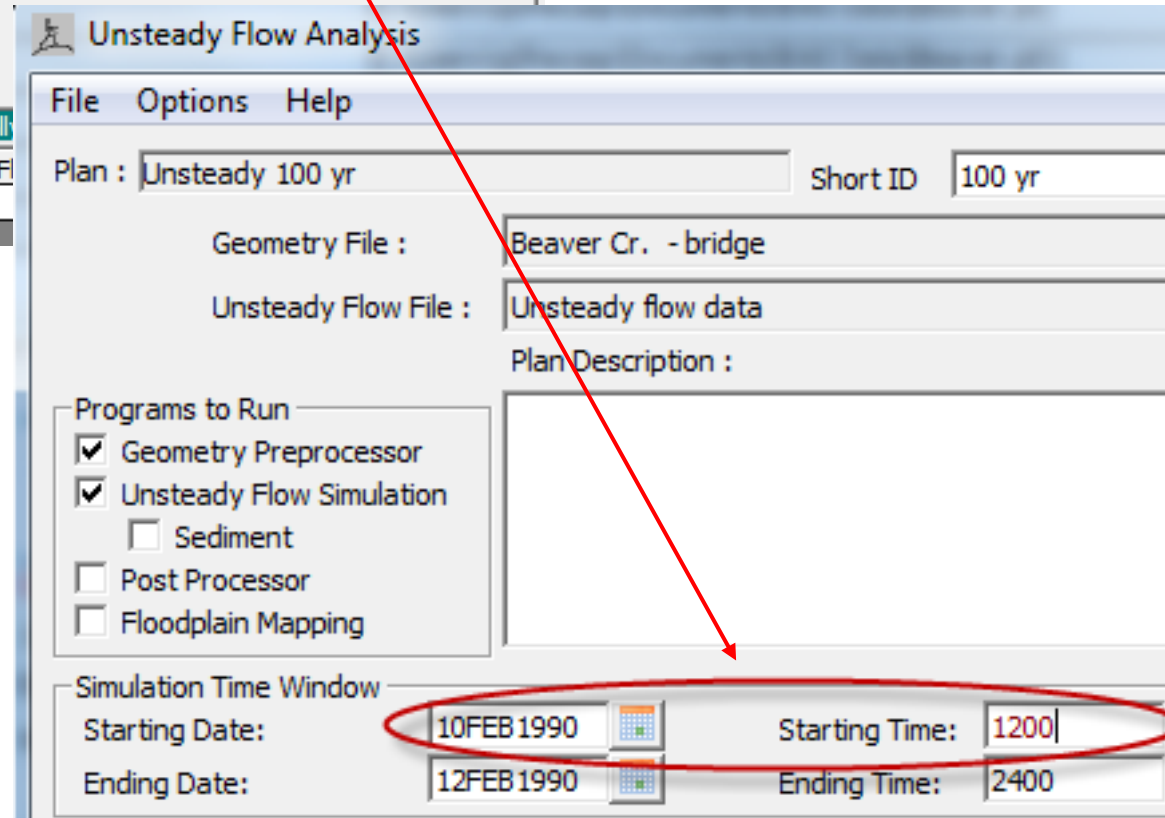
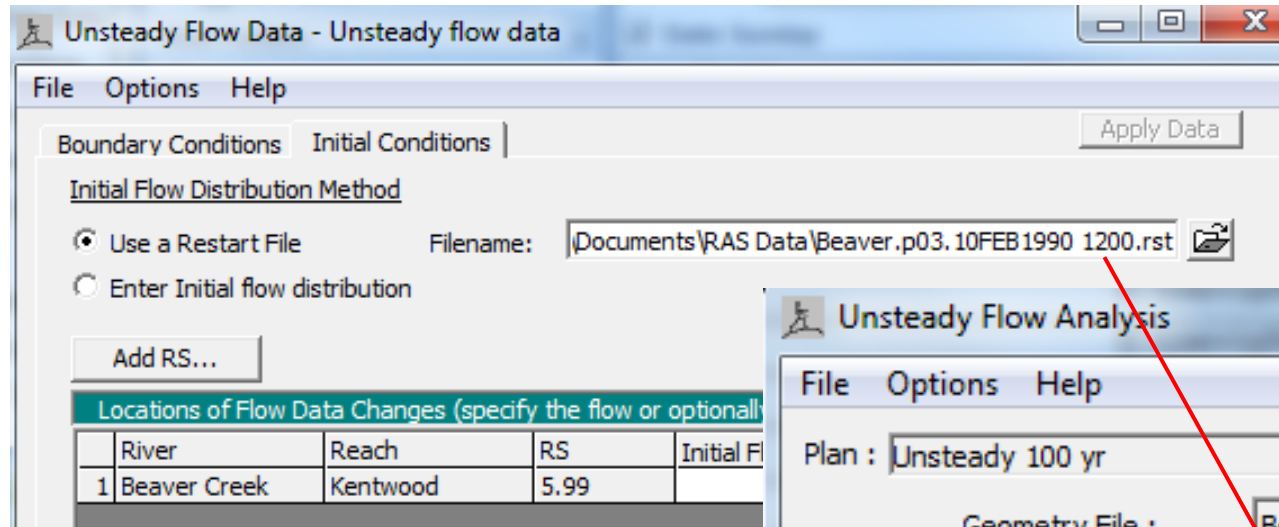


# Write Initial Condition File





# Select Restart





# Hydrograph Starting Time

Flow Hydrograph

River: Bald Eagle Reach: Loc Hav RS: 138154.4

Read from DSS before simulation

File:

Path:

Enter Table Data time in

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 10FEB1990 Time: 1200

Fixed Start Time: Date:  Time:

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data			
	Date	Simulation Time (hours)	Flow (cfs)
1	10Feb1990 1200	00:00	1075.53
2	10Feb1990 1300	01:00	1301.64
3	10Feb1990 1400	02:00	1676.94
4	10Feb1990 1500	03:00	2199.12
5	10Feb1990 1600	04:00	2864.95
6	10Feb1990 1700	05:00	3670.34
7	10Feb1990 1800	06:00	4610.32
8	10Feb1990 1900	07:00	5679.08
9	10Feb1990 2000	08:00	6870.05

Time Step Adjustment Options ("Critical" boundary conditions)

in Flow: this hydrograph for adjustments to computational time step

Max Change in Flow (without changing time step):

Min Flow:  Multiplier:

Plot Data OK Cancel

Flow Hydrograph

River: Bald Eagle Reach: Loc Hav RS: 138154.4

Read from DSS before simulation

File:

Path:

Enter Table Data time in

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 10FEB1990 Time: 1200

Fixed Start Time: Date: 01Jan1990 Time: 0000

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data			
	Date	Simulation Time (hours)	Flow (cfs)
1	31Dec1989 2400	00:00	1075.53
2	01Jan1990 0100	01:00	1301.64
3	01Jan1990 0200	02:00	1676.94
4	01Jan1990 0300	03:00	2199.12
5	01Jan1990 0400	04:00	2864.95
6	01Jan1990 0500	05:00	3670.34
7	01Jan1990 0600	06:00	4610.32
8	01Jan1990 0700	07:00	5679.08
9	01Jan1990 0800	08:00	6870.05

Time Step Adjustment Options ("Critical" boundary conditions)

in Flow: this hydrograph for adjustments to computational time step

Max Change in Flow (without changing time step):

Min Flow:  Multiplier:

Plot Data OK Cancel



# Restart File

- Geometry must be the same
- Switch equation Momentum/Diffusion if desired
  - **Can use Diffusion Wave run as restart for Full Eqns**
- Can change the time step
- Can change the output interval
- Can (generally) change flow and plan data



# Interpolate From Previous Results

- New for Version 6.0
- User selects a previous plan results file (ProjectName.p##.hdf)
- Geometry does not have to be the same
- Interpolates water levels, velocities, and flows
- Works for 1D and 2D

Unsteady Flow Data - Interpolated Initial Conditions

File Options Help

Description:

Boundary Conditions Initial Conditions Meteorological Data

Initial Flow Distribution Method

Restart Filename:

Results Filename:

Results Profile:

Enter Initial flow distribution (Optional - leave blank to use boundary conditions)

User specified fixed flows (Optional)

	River	Reach	RS	Initial Flow
1				

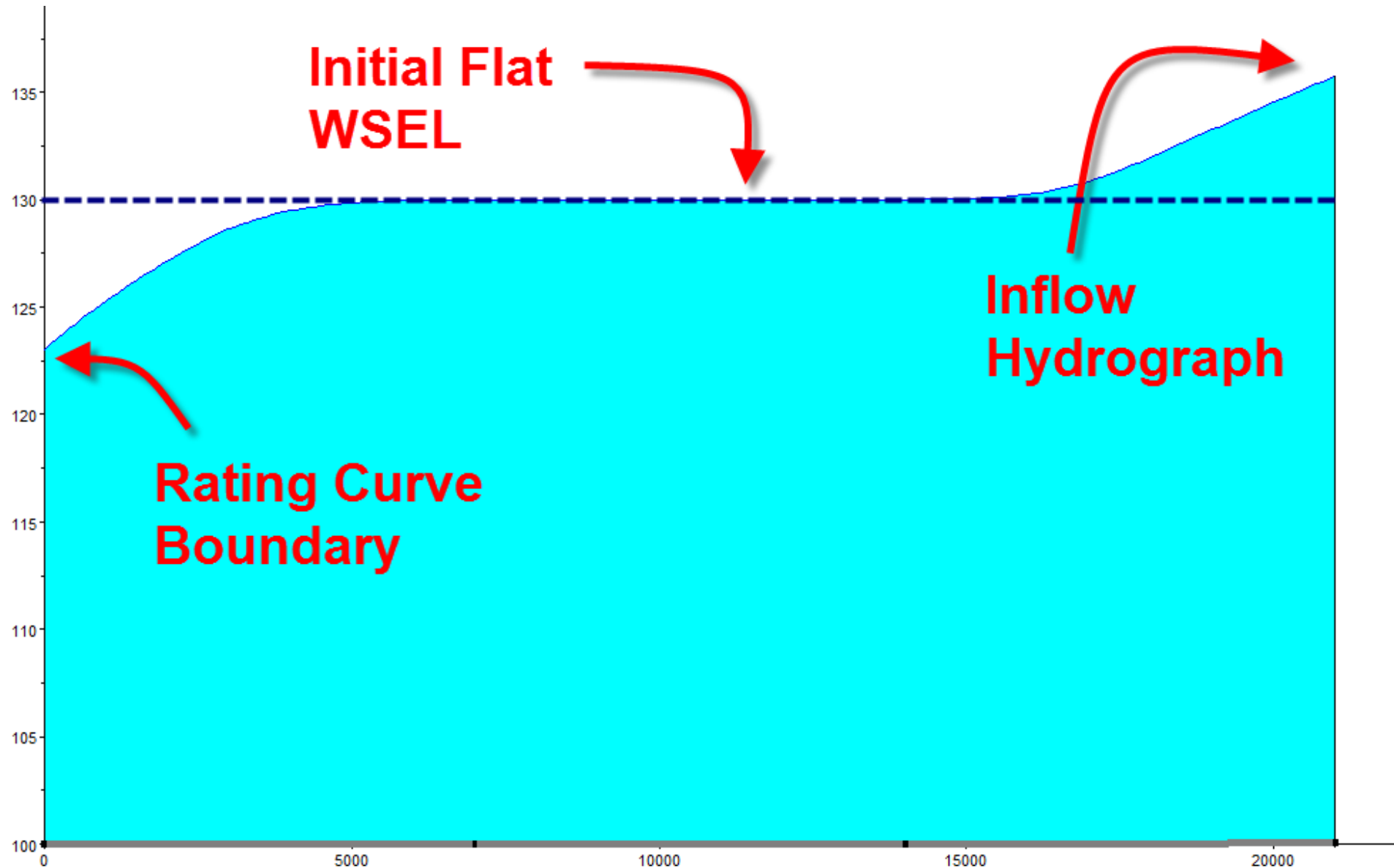
Initial Elevation of Storage Areas/2D Flow Areas (Optional)

Keep initial elevations constant during warmup

	Storage Area/2D Flow Area	Initial Elevation
1	2D: BaldEagleCr	



# Flat WSEL vs Momentum



# Questions?

