Boundary and Initial Conditions for 2D Modeling

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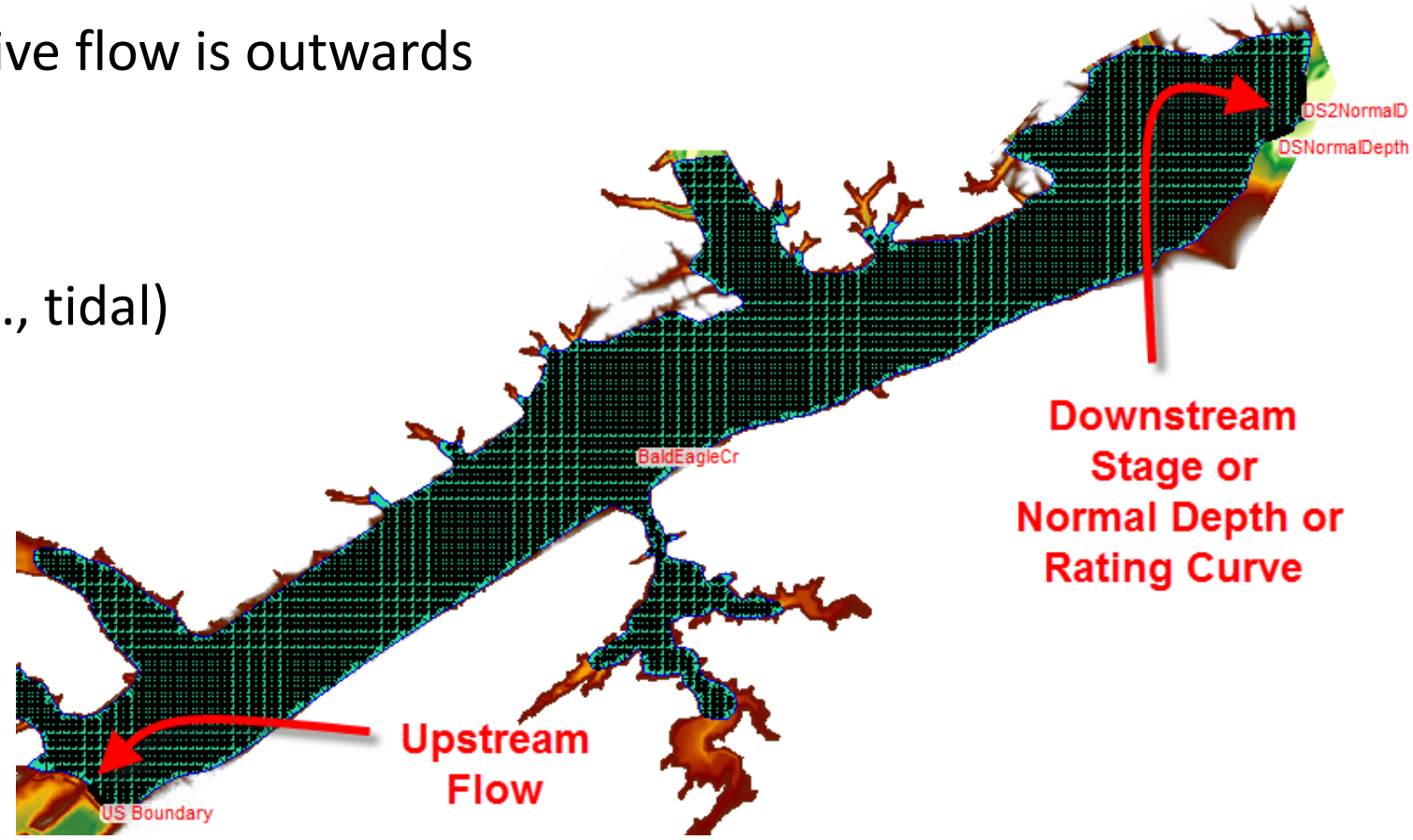
Overview

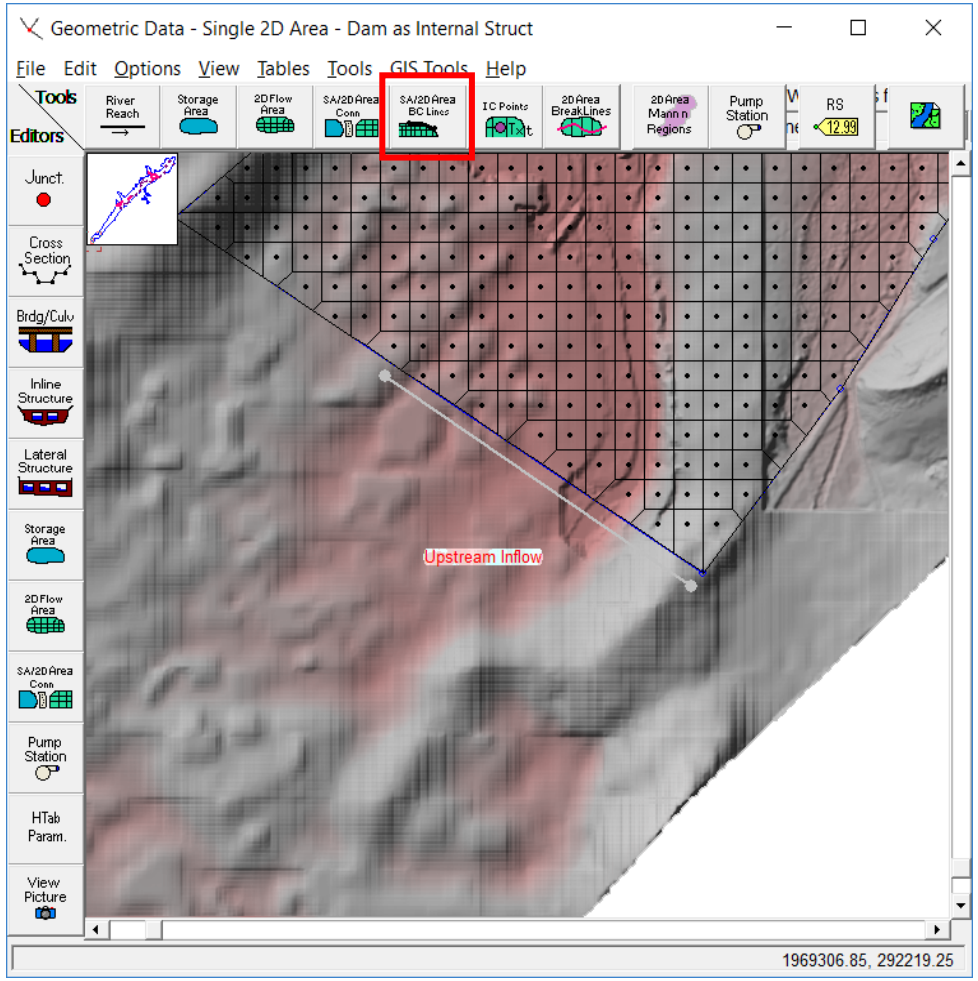
- Boundary Conditions (BC)
  - External
  - Internal
  - Global
- Initial Conditions (IC)
  - User-Specified
  - Ramp Up and Warm Up Periods
  - Restart File
  - Interpolate from Previous Results
- Observed Data

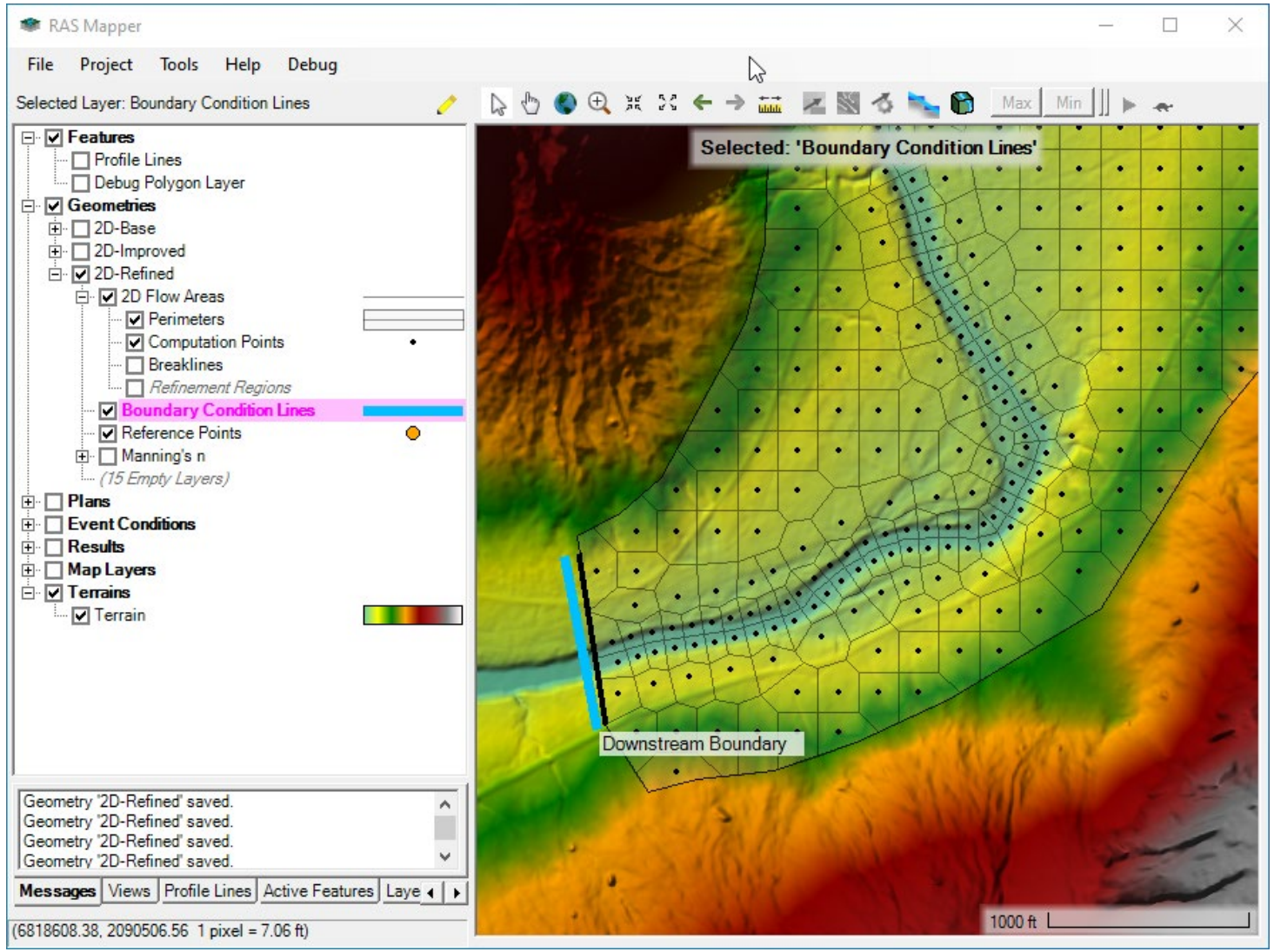
External Boundary Conditions

- **Flow Hydrograph**
  - Usually for inflow (upstream/lateral)
    - Can also be used for outflow
  - Positive flow is inwards; Negative flow is outwards
- **Stage Hydrograph**
  - Usually for outflow
  - Can also be used for inflow (i.e., tidal)
- **Normal Depth** (outflow only)
- **Rating Curve** (outflow only)

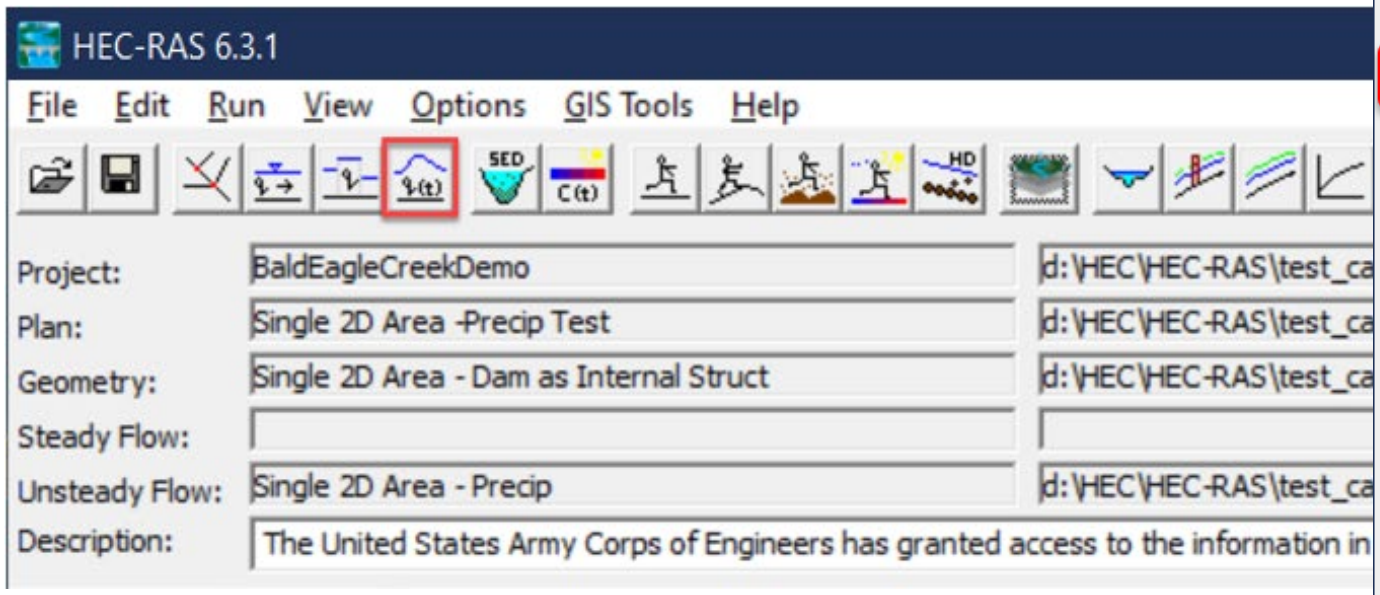


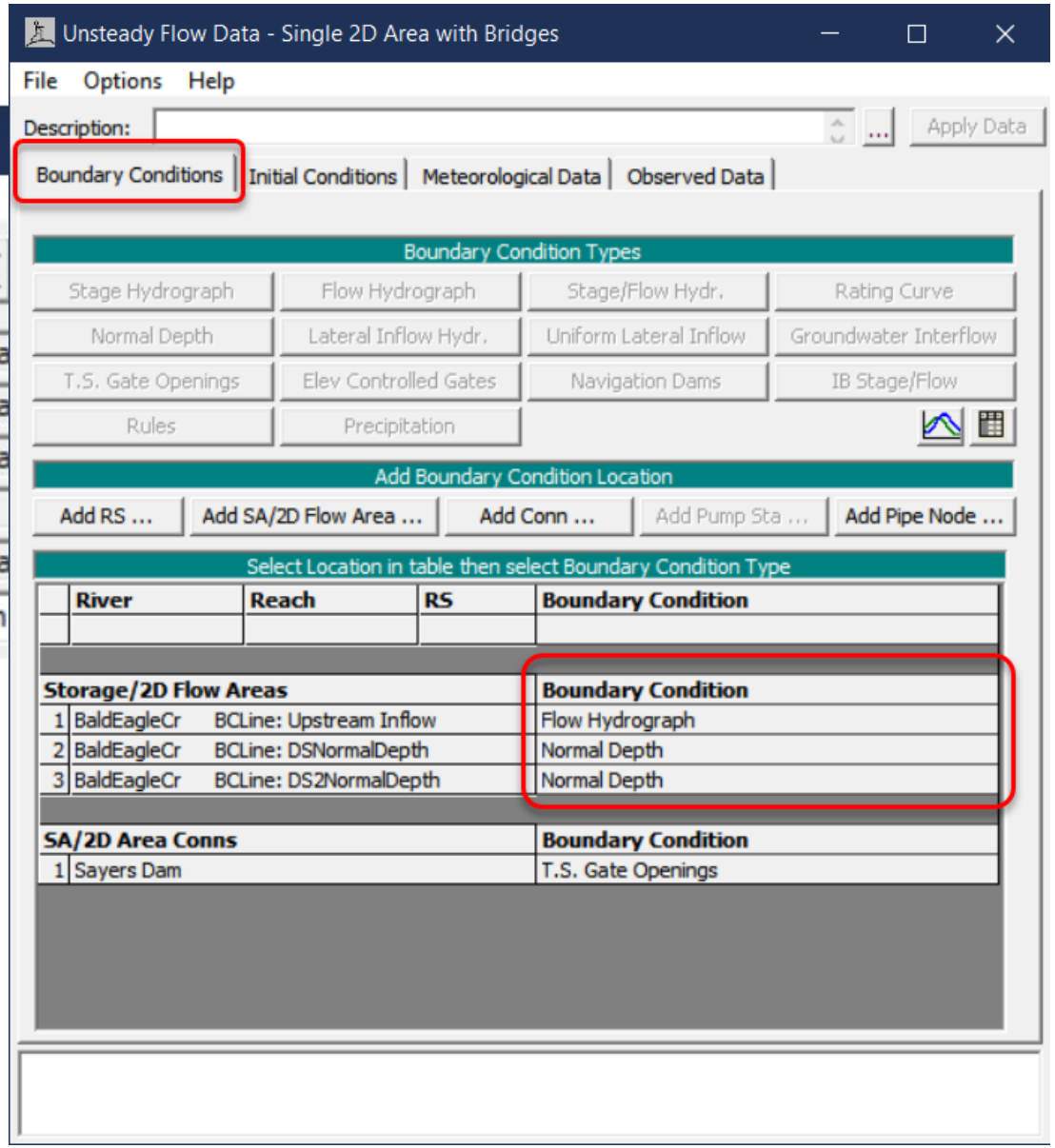
Creating External Boundary Condition Lines





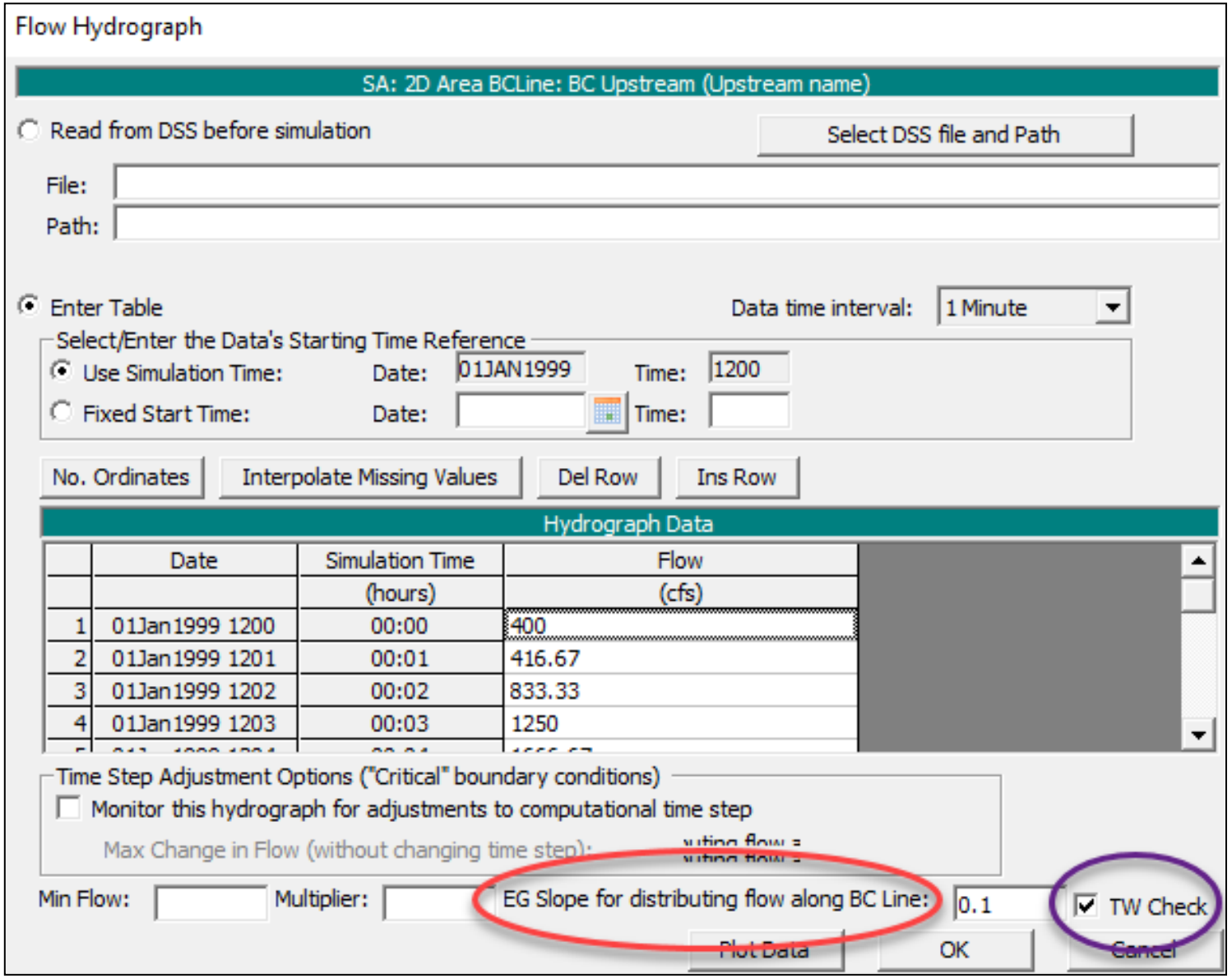
External Boundary Condition Data





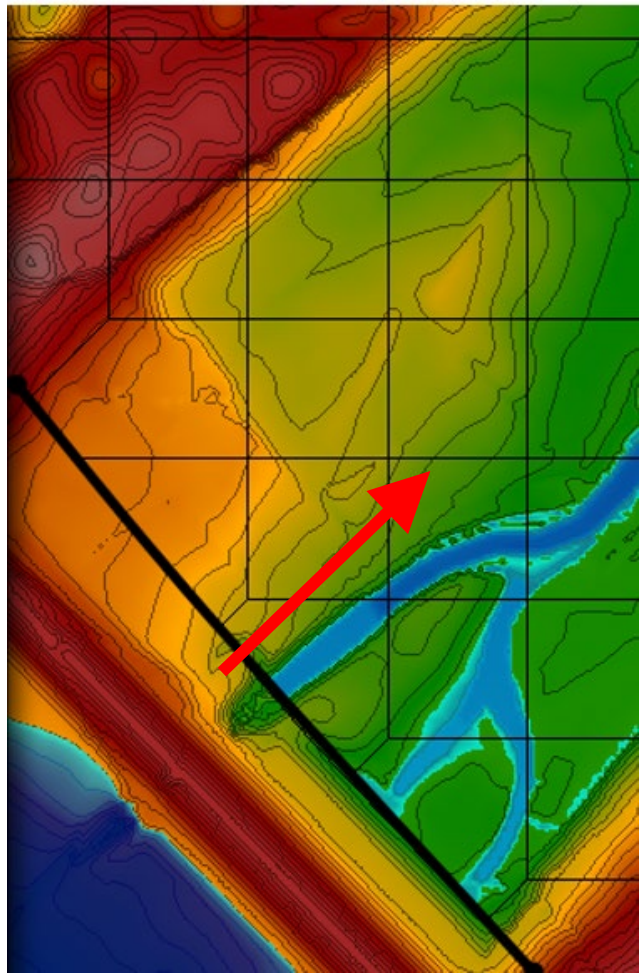
- Open Unsteady Flow Data editor
- Required BC's appear automatically for geometry

Flow Hydrograph & EG Slope



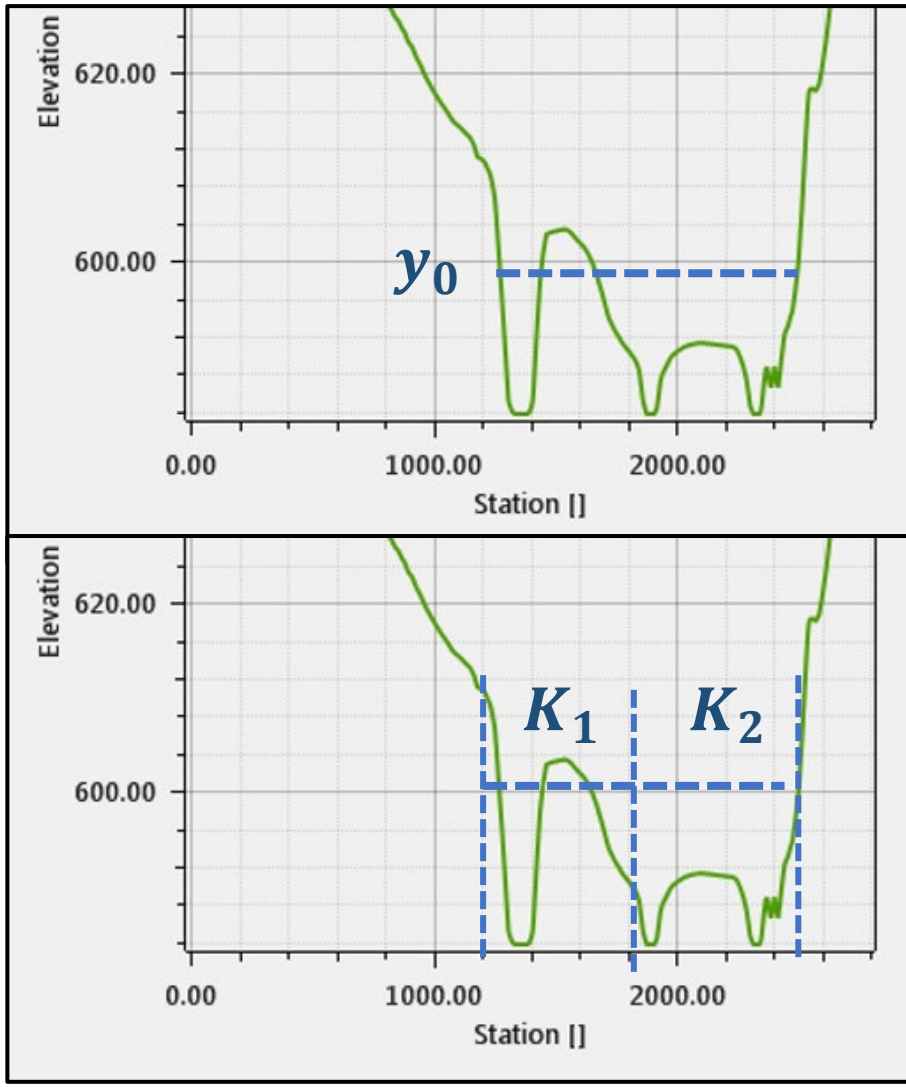
- Time series from DSS or table
- **EG Slope** required to compute normal depth
- Flow distributed to boundary cells based on conveyance
- **TW Check** option uses higher of TW and normal depth
- Face velocities computed for shallow water equations

Flow Distribution along Boundary



$$Q = \frac{1.49}{n} * AR^{2/3} S_f^{1/2}$$

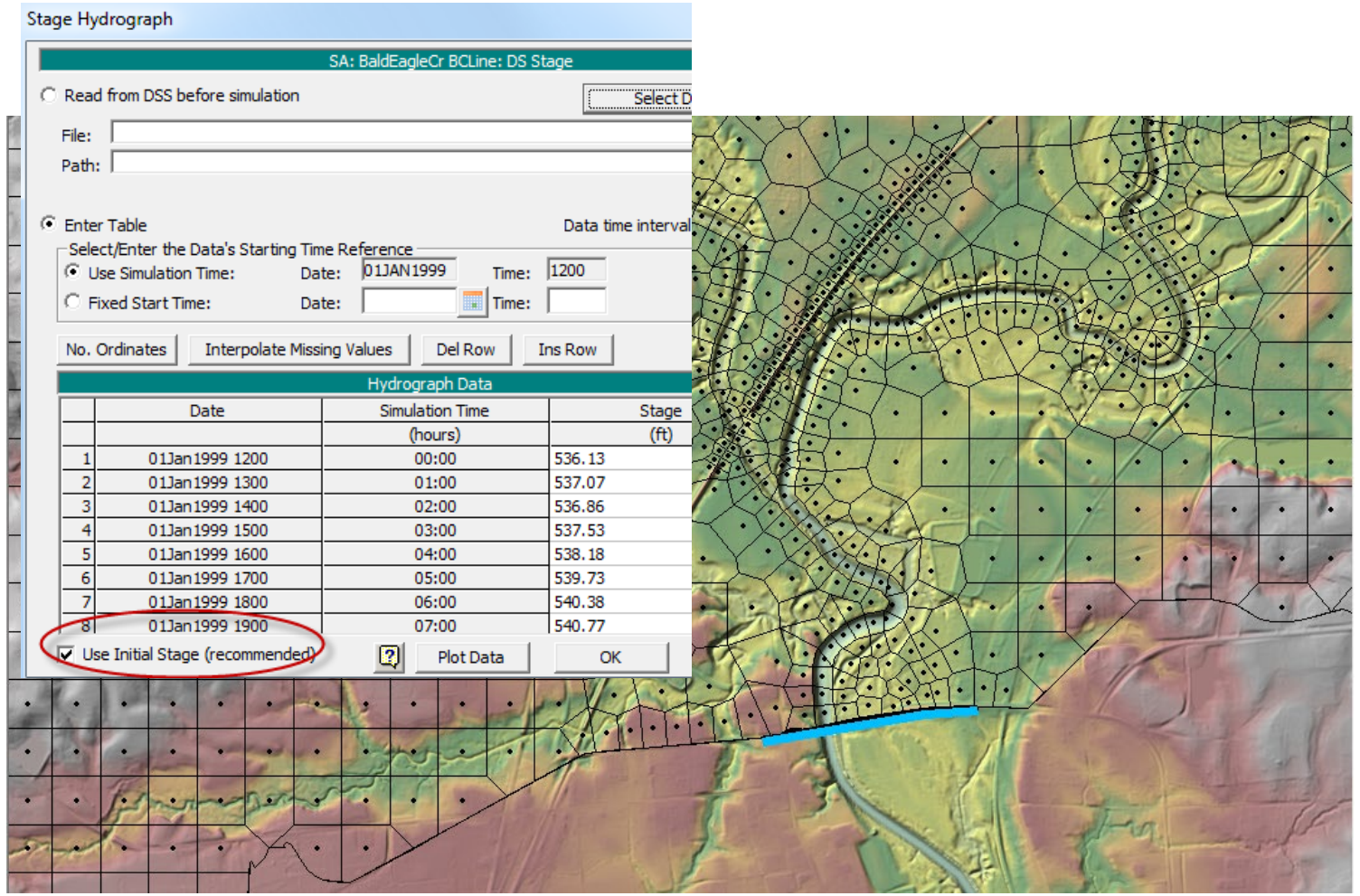
$$K = \frac{1.49}{n} * AR^{2/3}$$



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

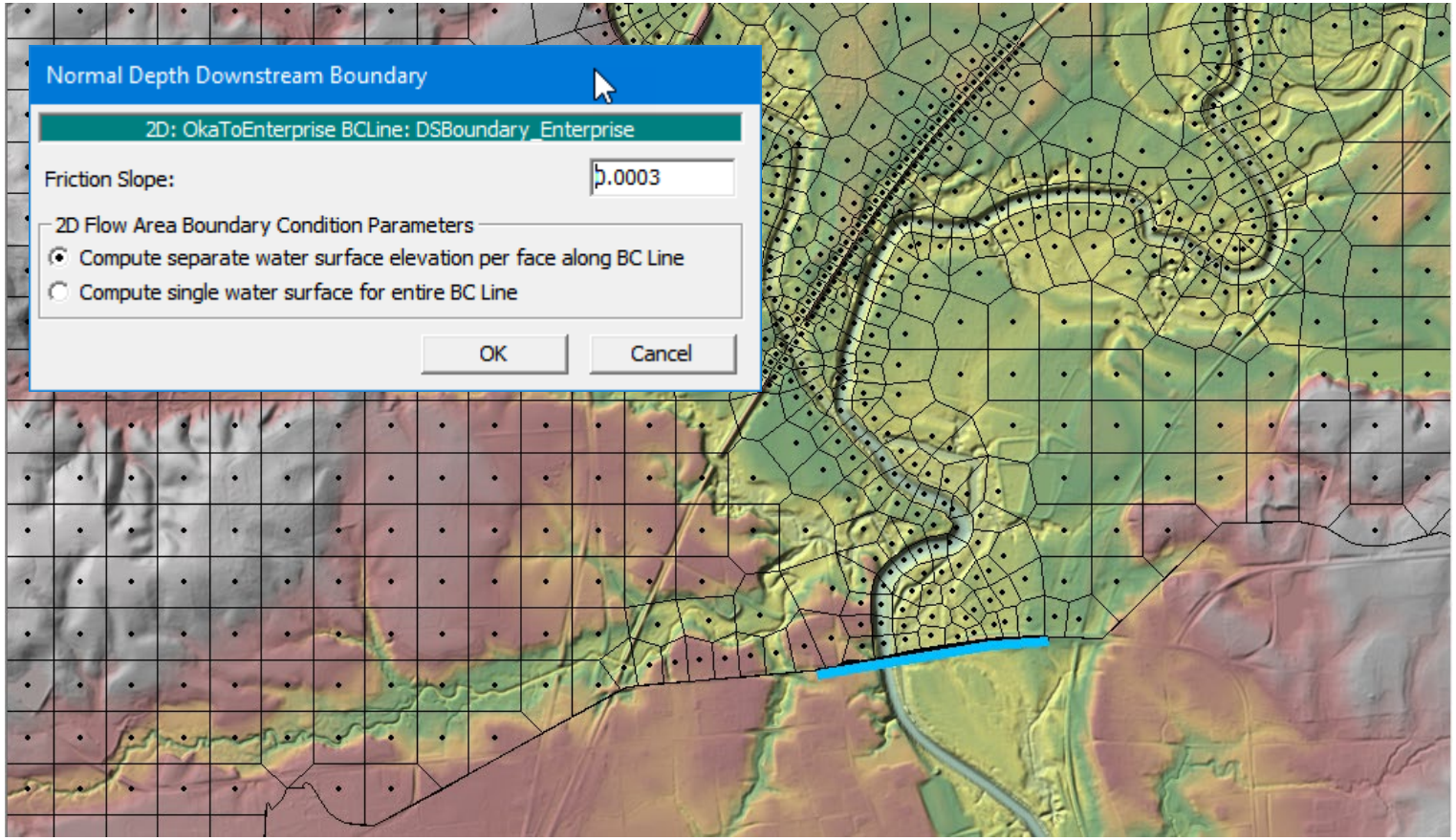
Stage Hydrograph

- Inflow or outflow
- All wet faces at the boundary assigned the same stage
- Flow computed per wet face
- **Use Initial Stage** option applies a horizontal water level from the boundary inwards

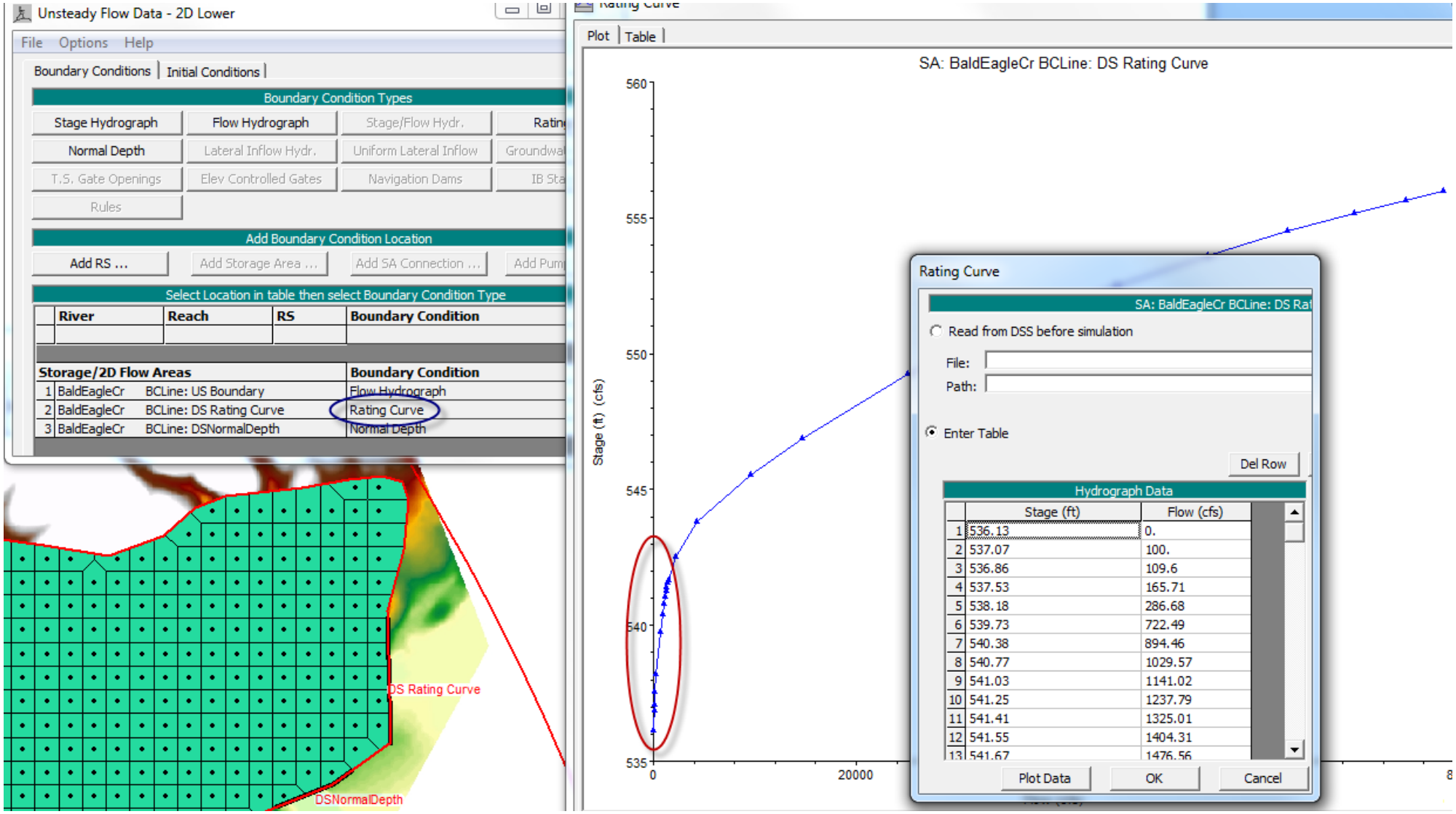


Normal Depth

- Only for **outflow**
- $Q = \frac{1.49}{n} * AR^{2/3} \boldsymbol{S_f^{1/2}}$
- Manning's Eq. used to compute **flow per face**
- Boundary stage can vary
- Should be reserved for situations where no other data is available



Rating Curve



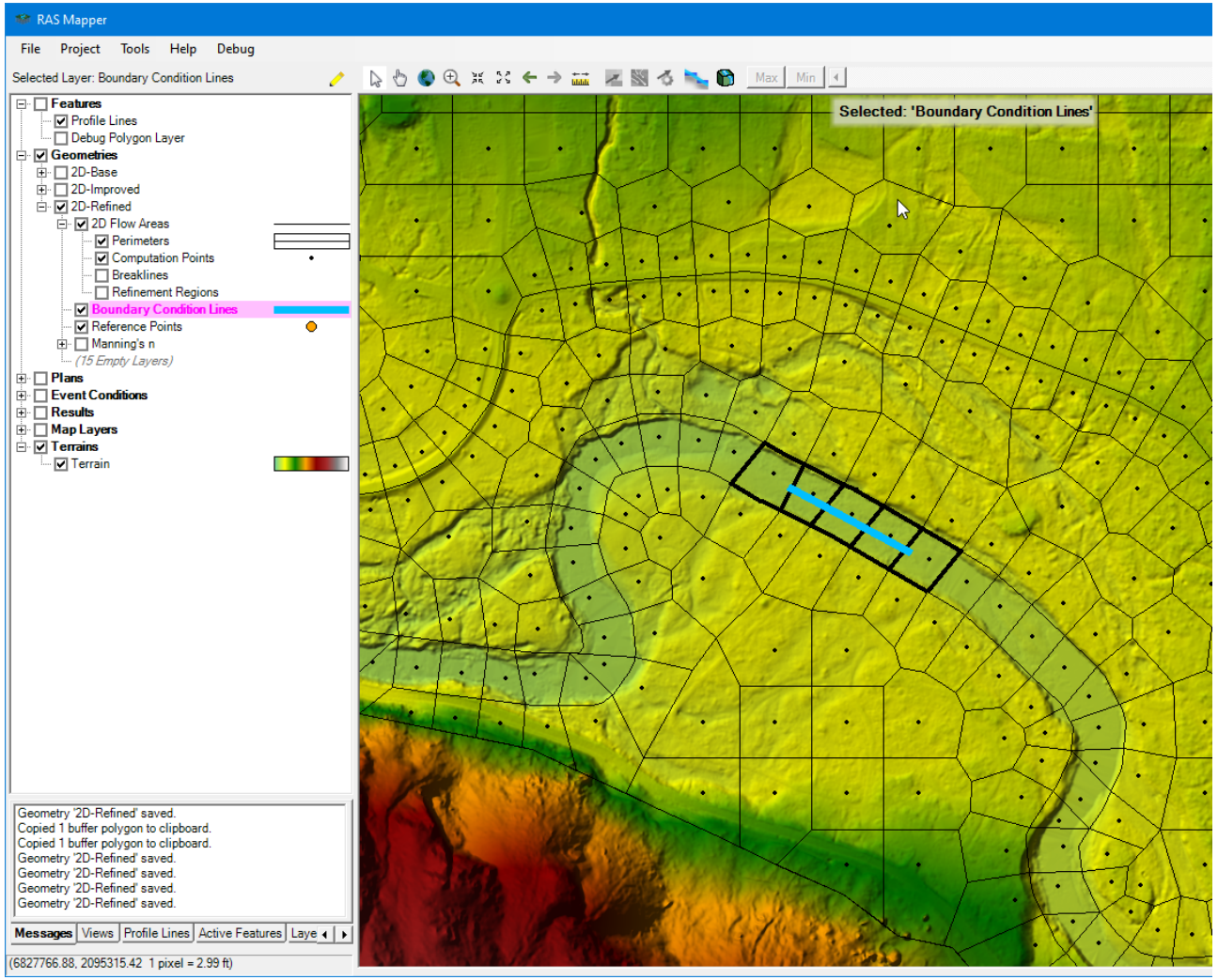
Rating Curve Considerations

- 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 (when RC is not consistent with cold-start conditions)

External Boundaries Summary

- 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 (place normal to flow)
- Rating curve does not account for changes in flow for rising and falling-limbs of hydrograph

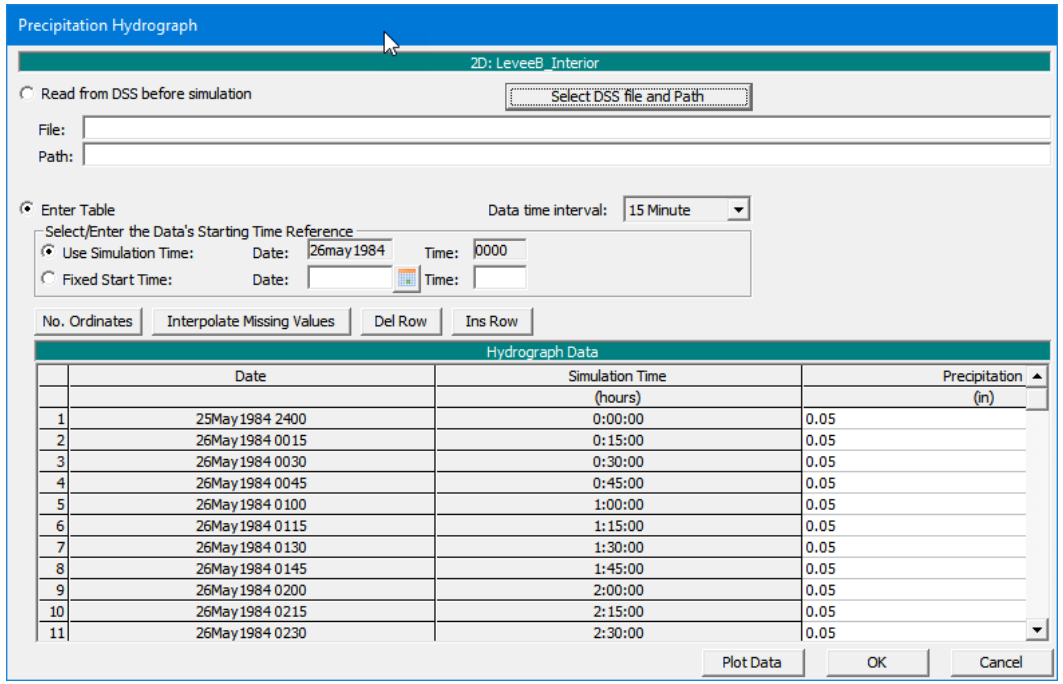
Internal Flow Hydrographs

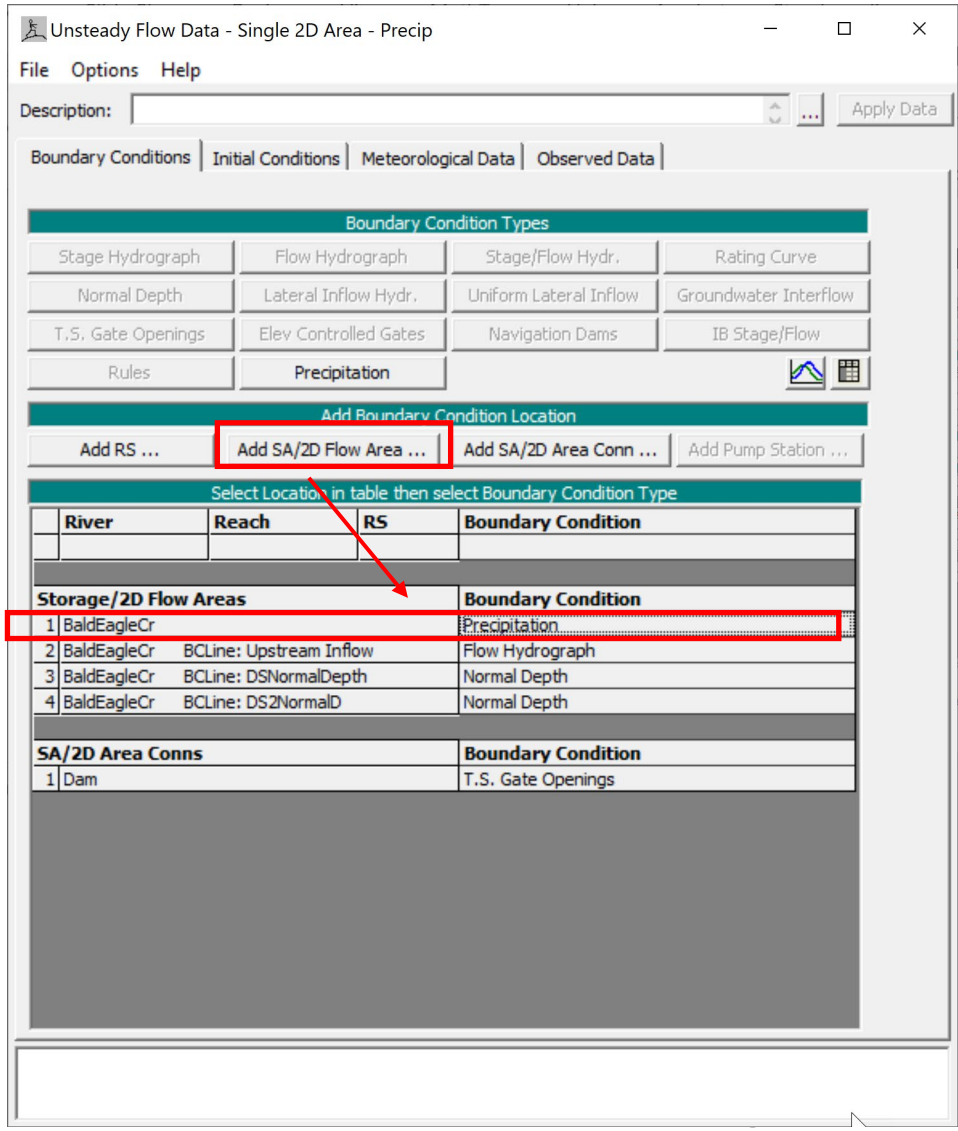


- Must be **inside** of the 2D Flow Area
- Can have positive or negative flows
- No flow direction; volume added only
- Flow is distributed to cells based on **length** of line in each cell

Internal (2D Area) Precipitation BC

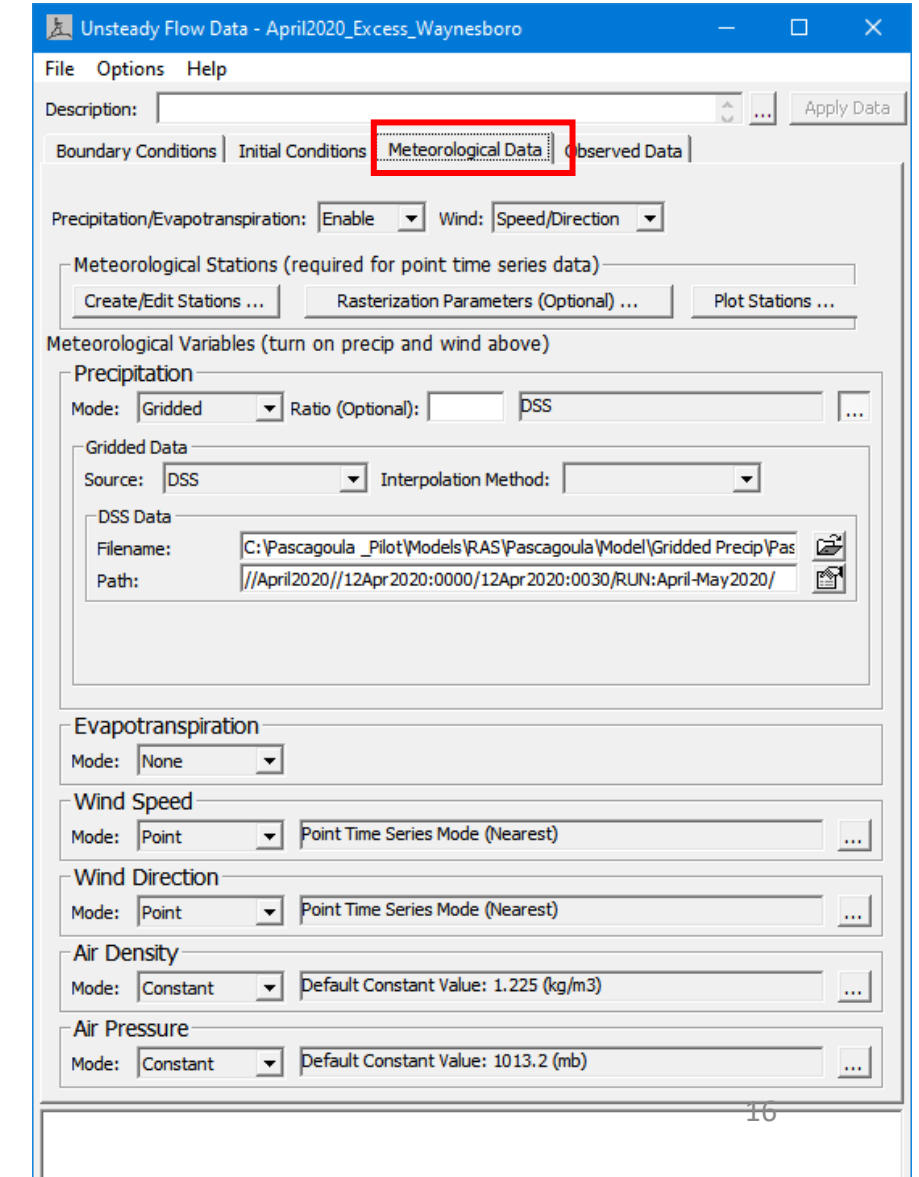
- Time-series applied to individual 2D areas
- Precipitation rates spatially uniform
- Specified as period cumulative depths



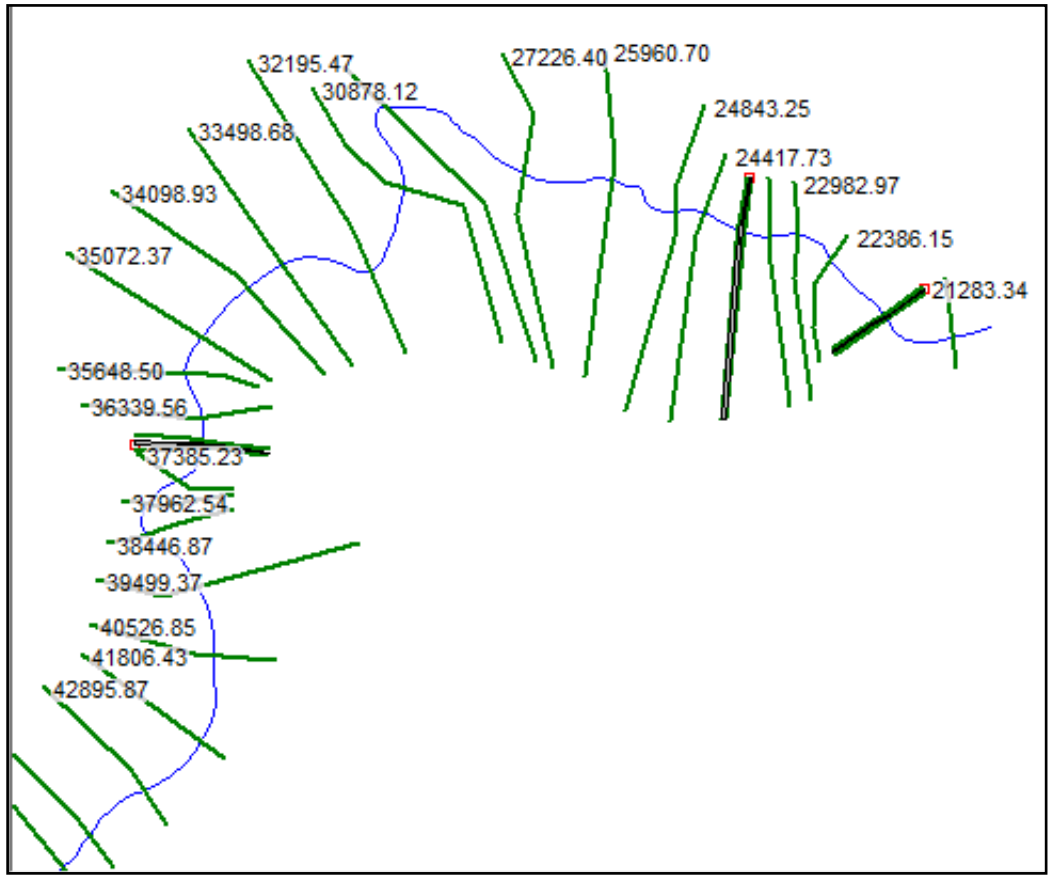


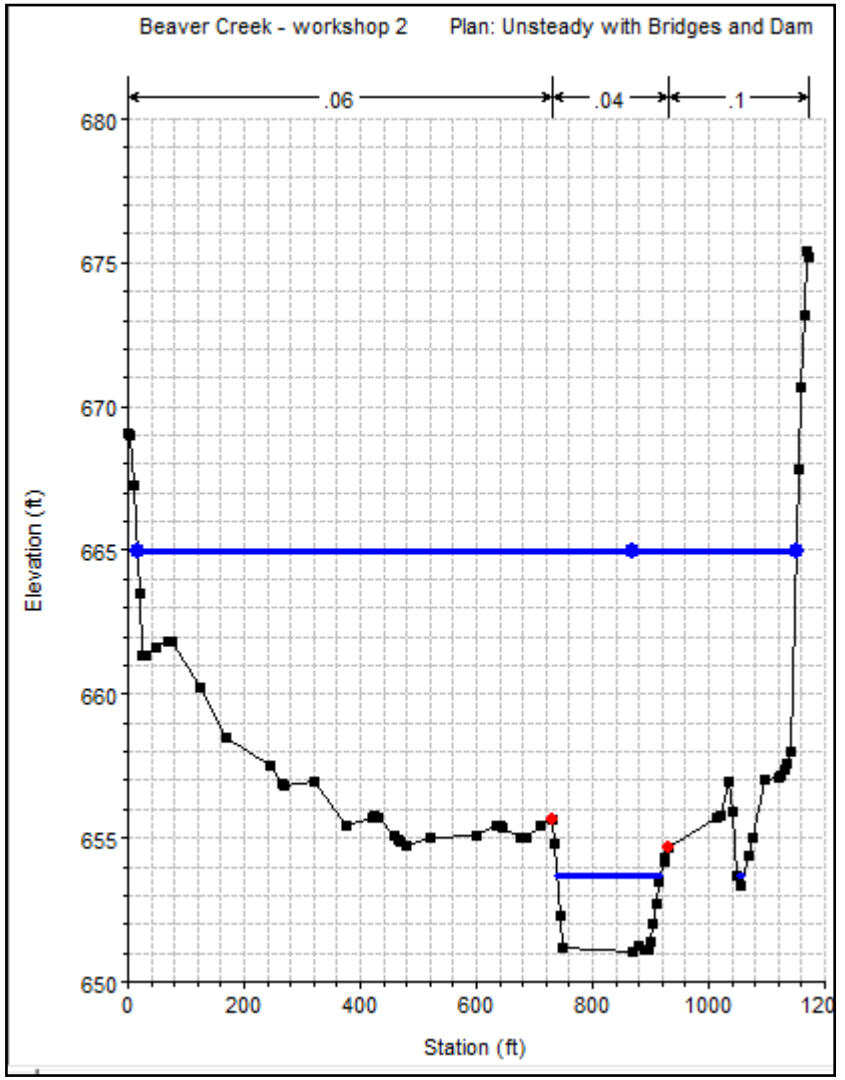
Global Boundary Conditions

- Applied to the **entire domain**
- Specified in **Meteorologic Data** tab
- Types of Boundaries:
  1. Precipitation
  2. Evapotranspiration Potential
  3. Wind
  4. Air Density
  5. Air Pressure
- Types of Data
  1. Point
  2. Constant
  3. Gridded



Initial Conditions in 1D



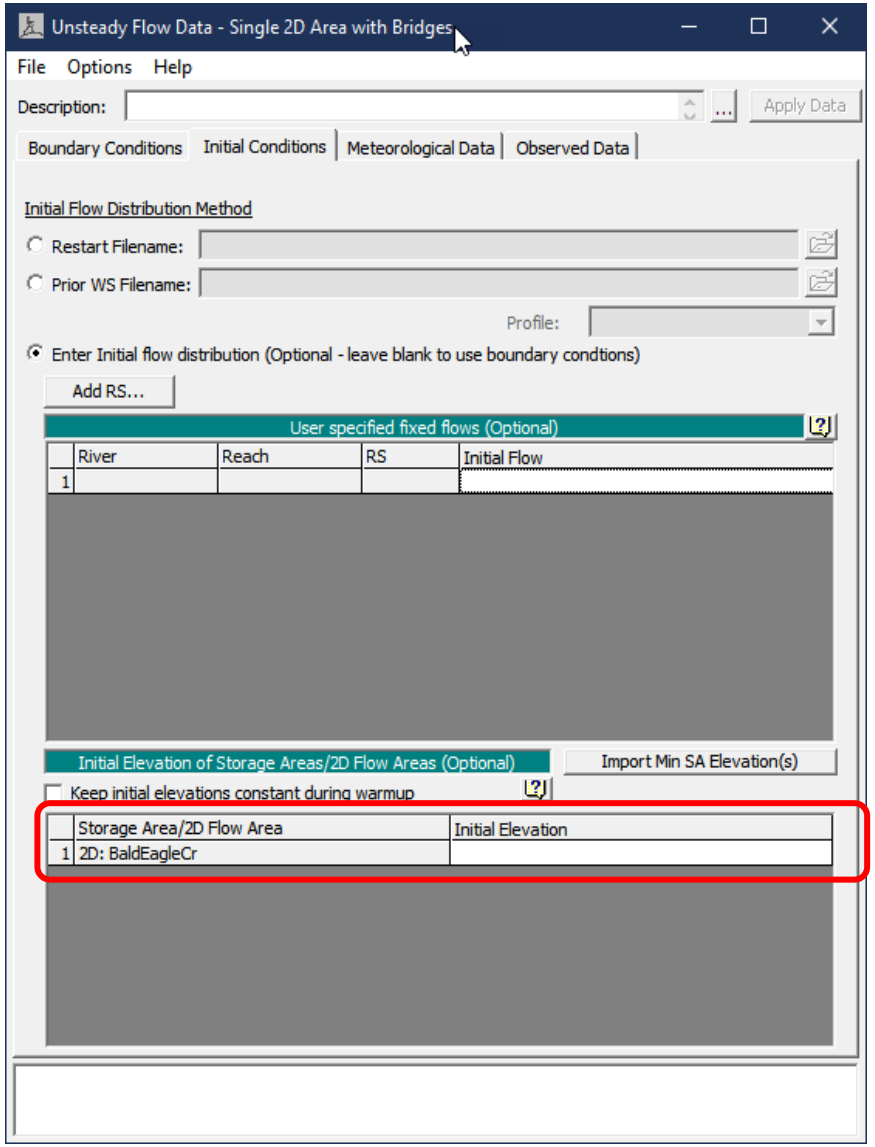


2D Initial Conditions Overview

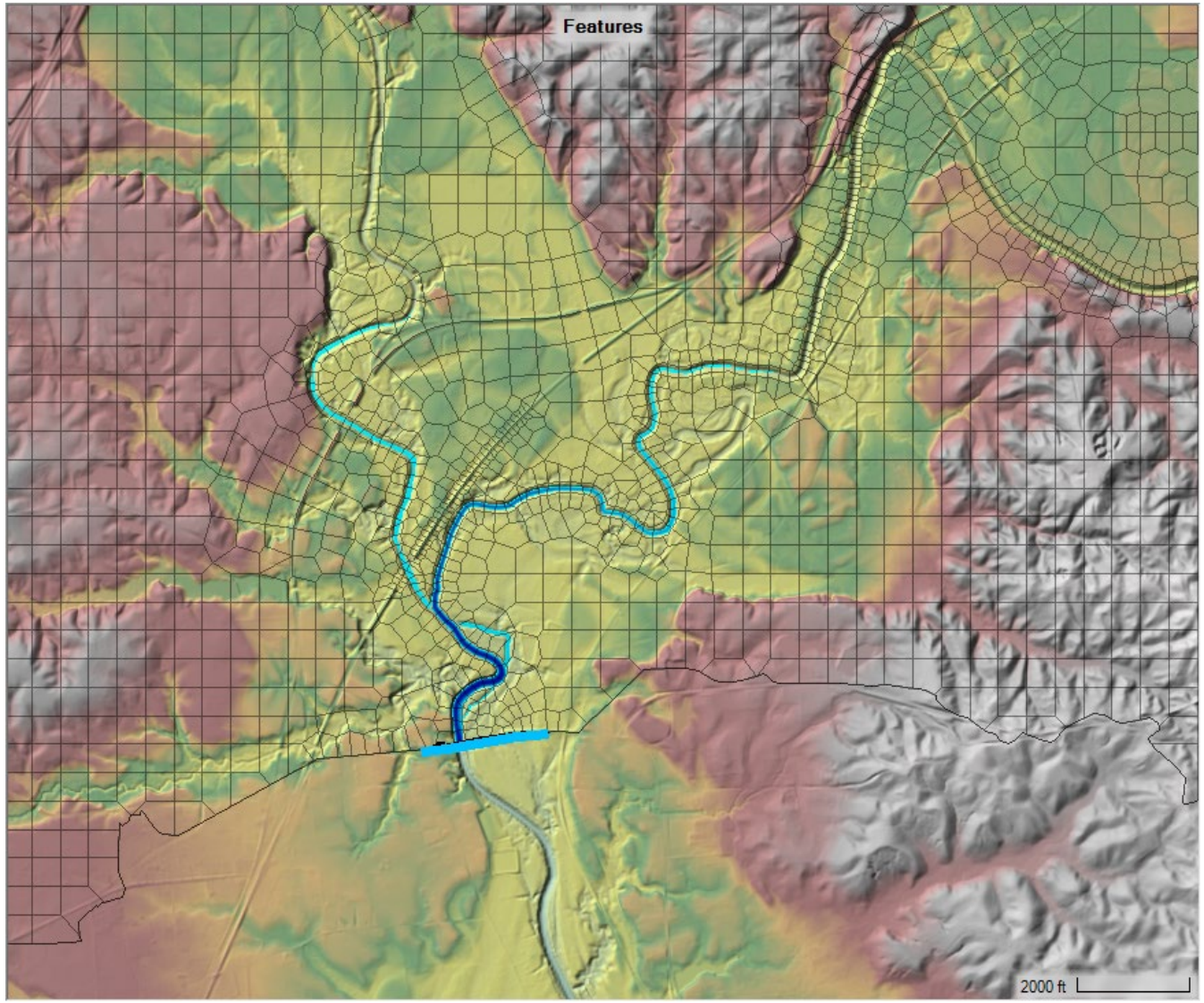
- **User Specified Initial Conditions**
  - Single horizontal WSE
  - Project initial stage boundary values
  - Initial Conditions Points
- **Initial Conditions/ Warm Up**
  - 2D Initial Conditions
  - 1D/2D Warm Up Period
- **Use Restart File**
  - Restart File created by previous run
- **Interpolate from Previous Results**
  - Interpolates wse, velocity, and flows for 1D and 2D
  - Geometries do not have to be the same

2D Horizontal Initial Elev

- Single WSEL per 2D area
- Not so useful…by itself



2D Initial Stage Hydrograph



Stage Hydrograph

2D: OkaToEnterprise BCLine: DSBoundary_Enterprise

Read from DSS before simulation — Select DSS file and Path

File:

Path:

Enter Table — Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 13APR2020 Time: 2400

Fixed Start Time: Date: Time:

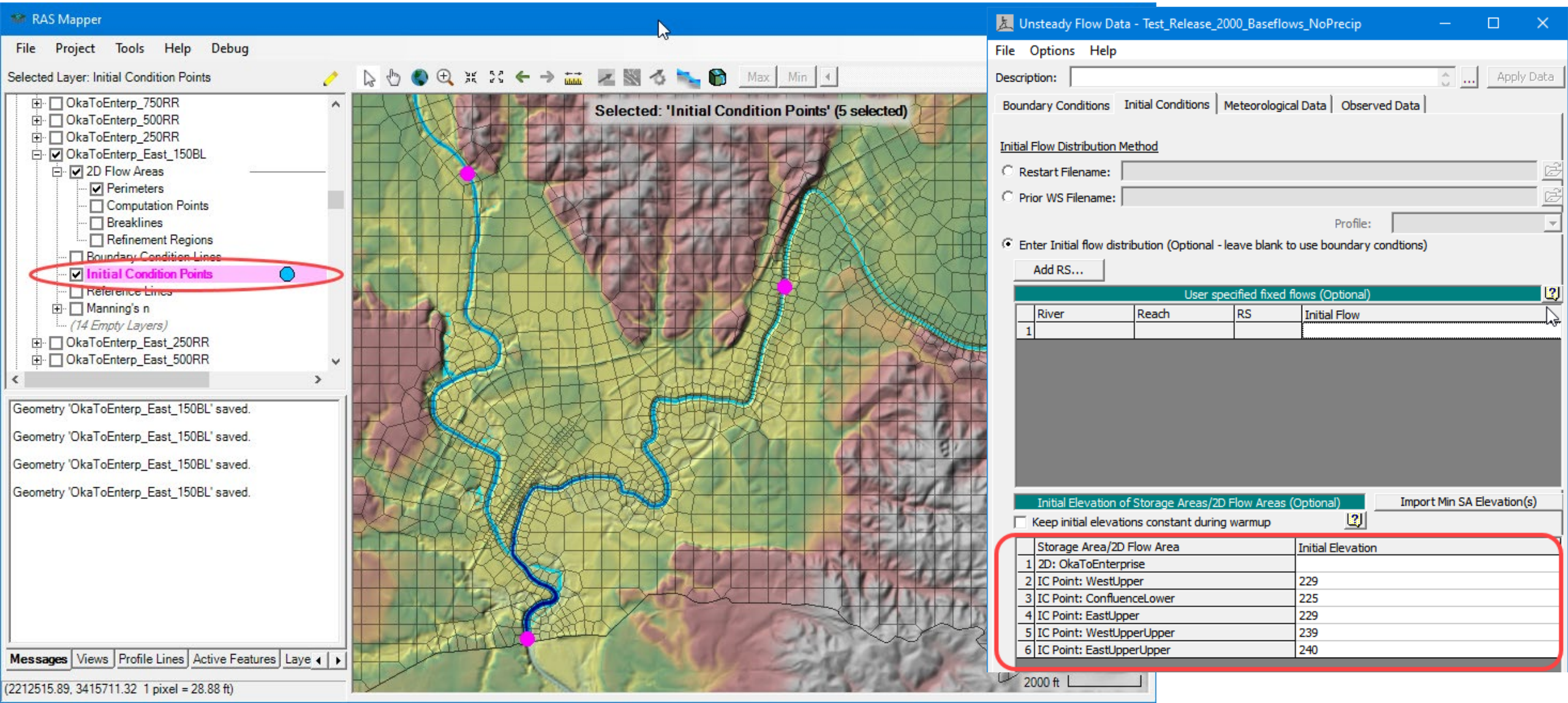
No. Ordinates | Interpolate Missing Values | Del Row | Ins Row

Hydrograph Data

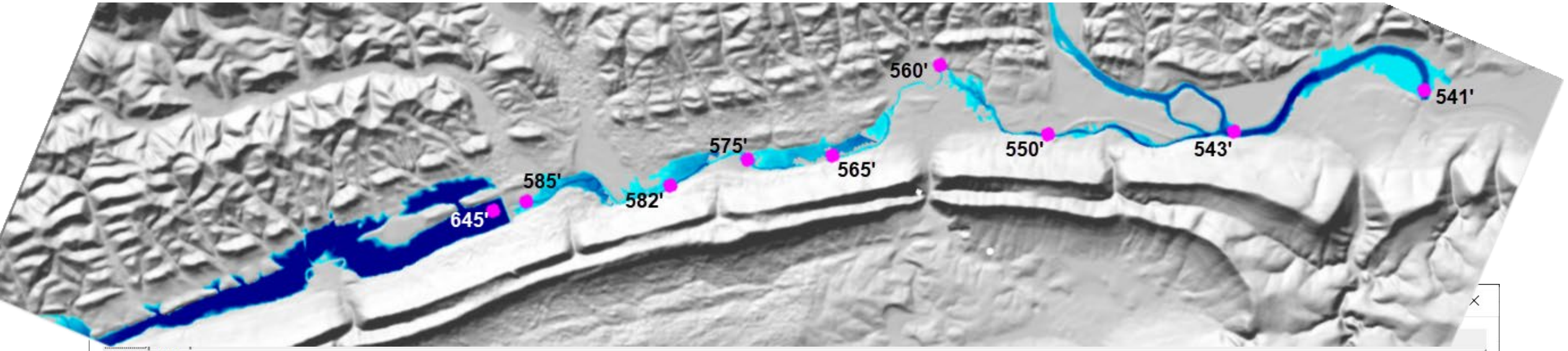
	Date	Simulation Time (hours)	
1	13Apr2020 2400	0:00:00	221.1
2	14Apr2020 0100	1:00:00	221.204
3	14Apr2020 0200	2:00:00	221.309
4	14Apr2020 0300	3:00:00	221.413
5	14Apr2020 0400	4:00:00	221.517
6	14Apr2020 0500	5:00:00	221.621
7	14Apr2020 0600	6:00:00	221.726

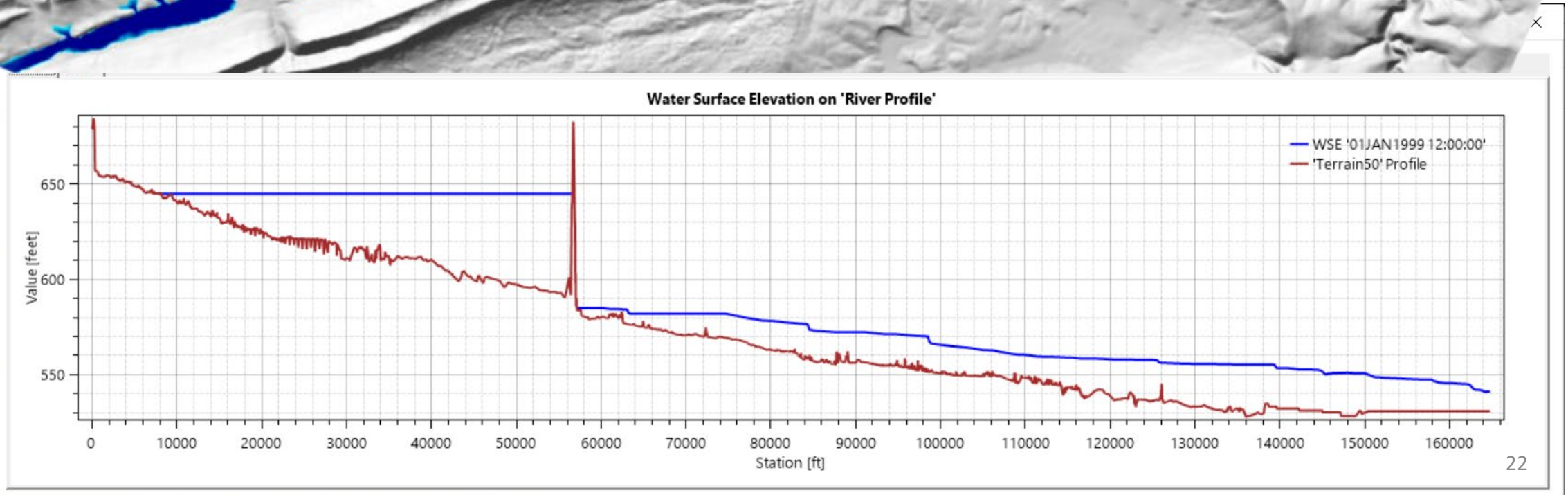
Use Initial Stage (recommended) | Plot Data | OK

Initial Conditions Points



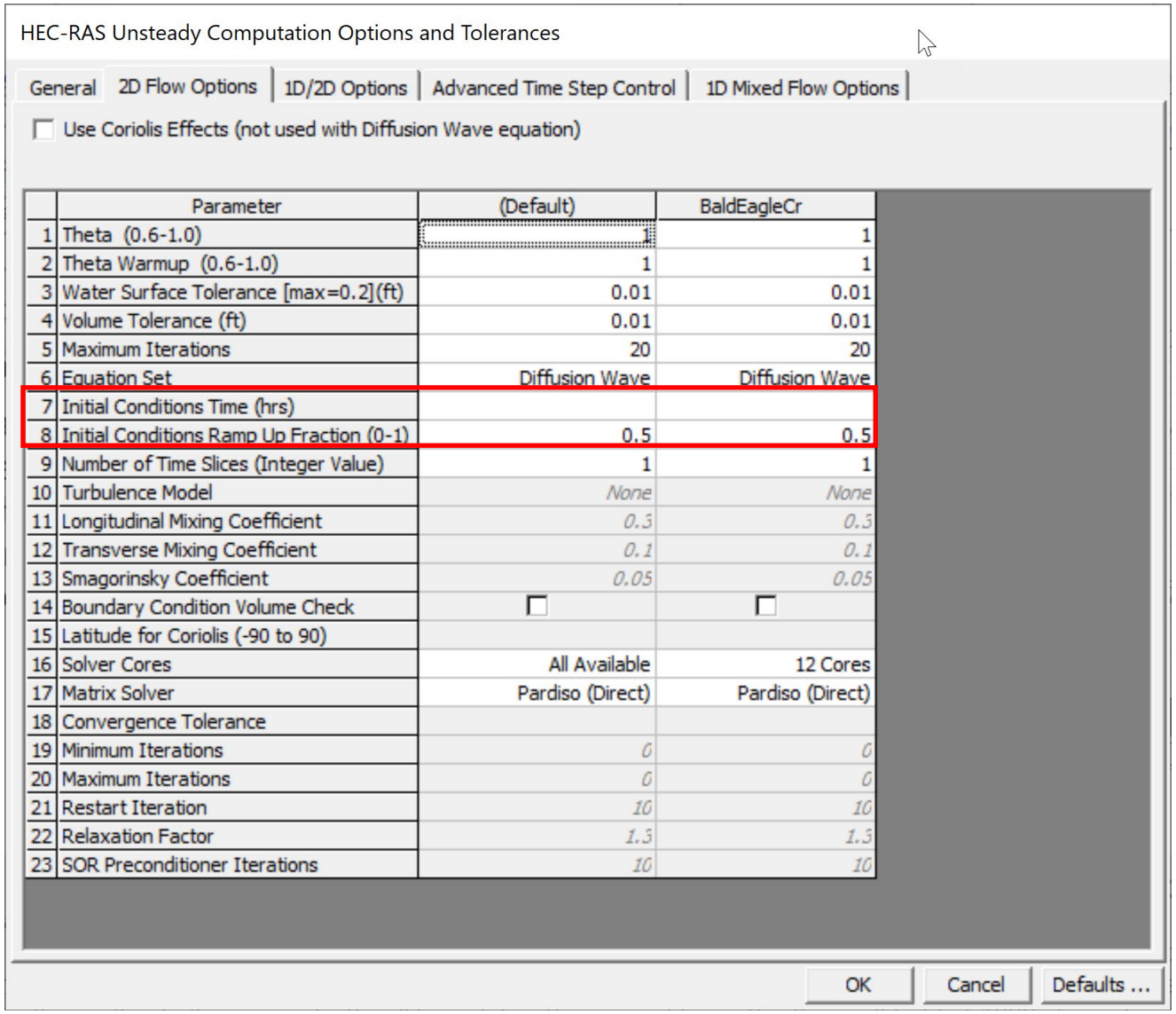
Initial Conditions Backwater Profile





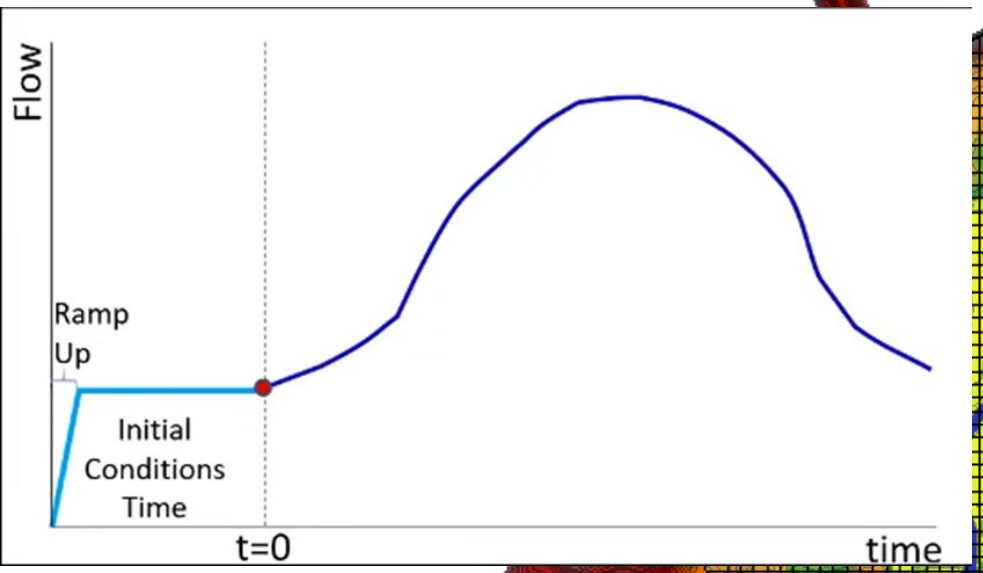
2D Initial Conditions Time

- Each 2D Area warms up individually
- **Initial Condition Time:**
  - Time allowed to run
- **Ramp Up Fraction:**
  - Period over which flow & stage are ramped up to the initial condition
  - Flows & stages then held constant



	Parameter	(Default)	BaldEagleCr
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)		
8	Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	*None*	*None*
11	Longitudinal Mixing Coefficient	*0.3*	*0.3*
12	Transverse Mixing Coefficient	*0.1*	*0.1*
13	Smagorinsky Coefficient	*0.05*	*0.05*
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	All Available	12 Cores
17	Matrix Solver	Pardiso (Direct)	Pardiso (Direct)
18	Convergence Tolerance		
19	Minimum Iterations	*0*	*0*
20	Maximum Iterations	*0*	*0*
21	Restart Iteration	*10*	*10*
22	Relaxation Factor	*1.3*	*1.3*
23	SOR Preconditioner Iterations	*10*	*10*

2D Initial Conditions in Progress

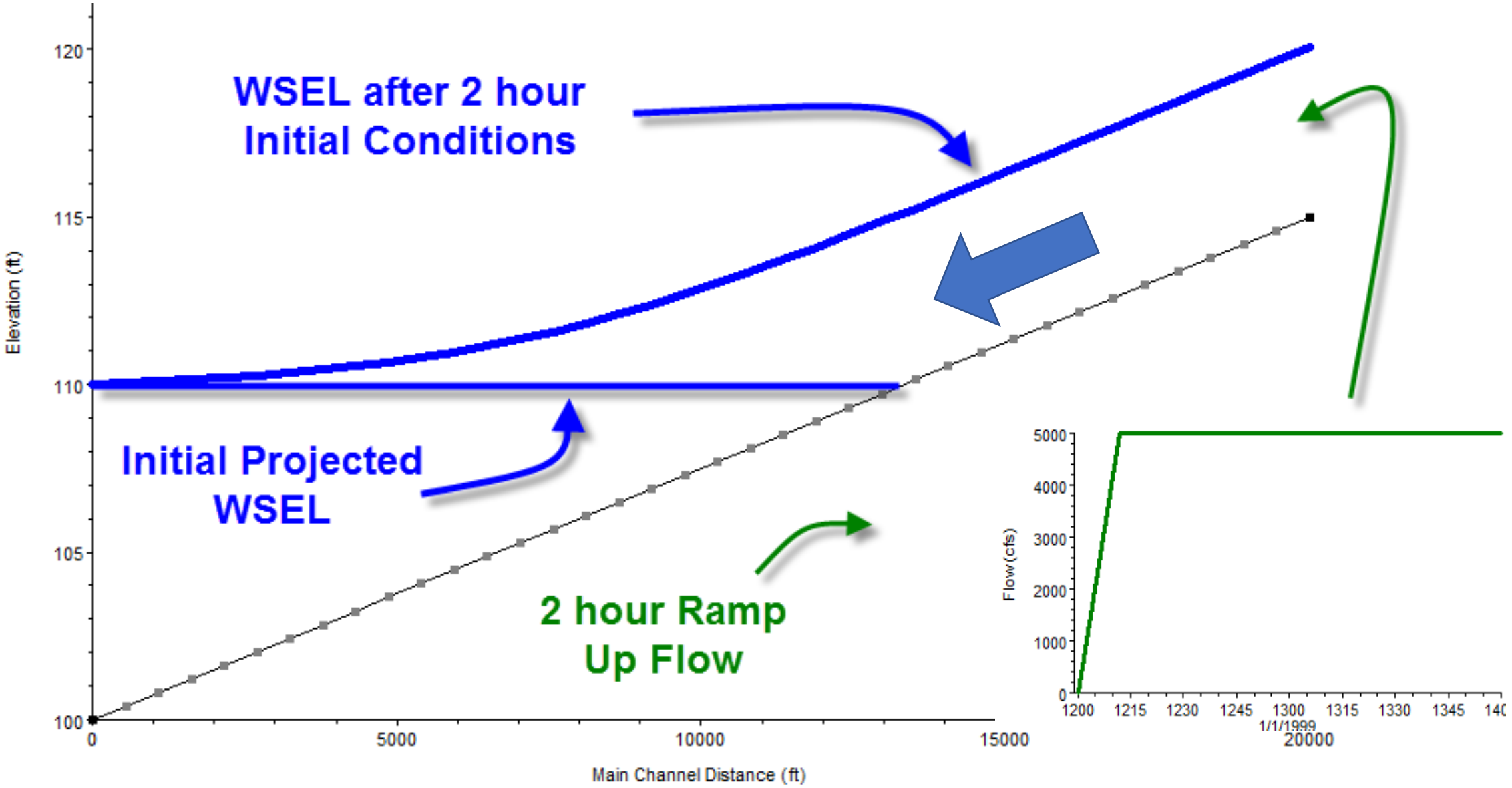


Stage Boundary Condition

	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

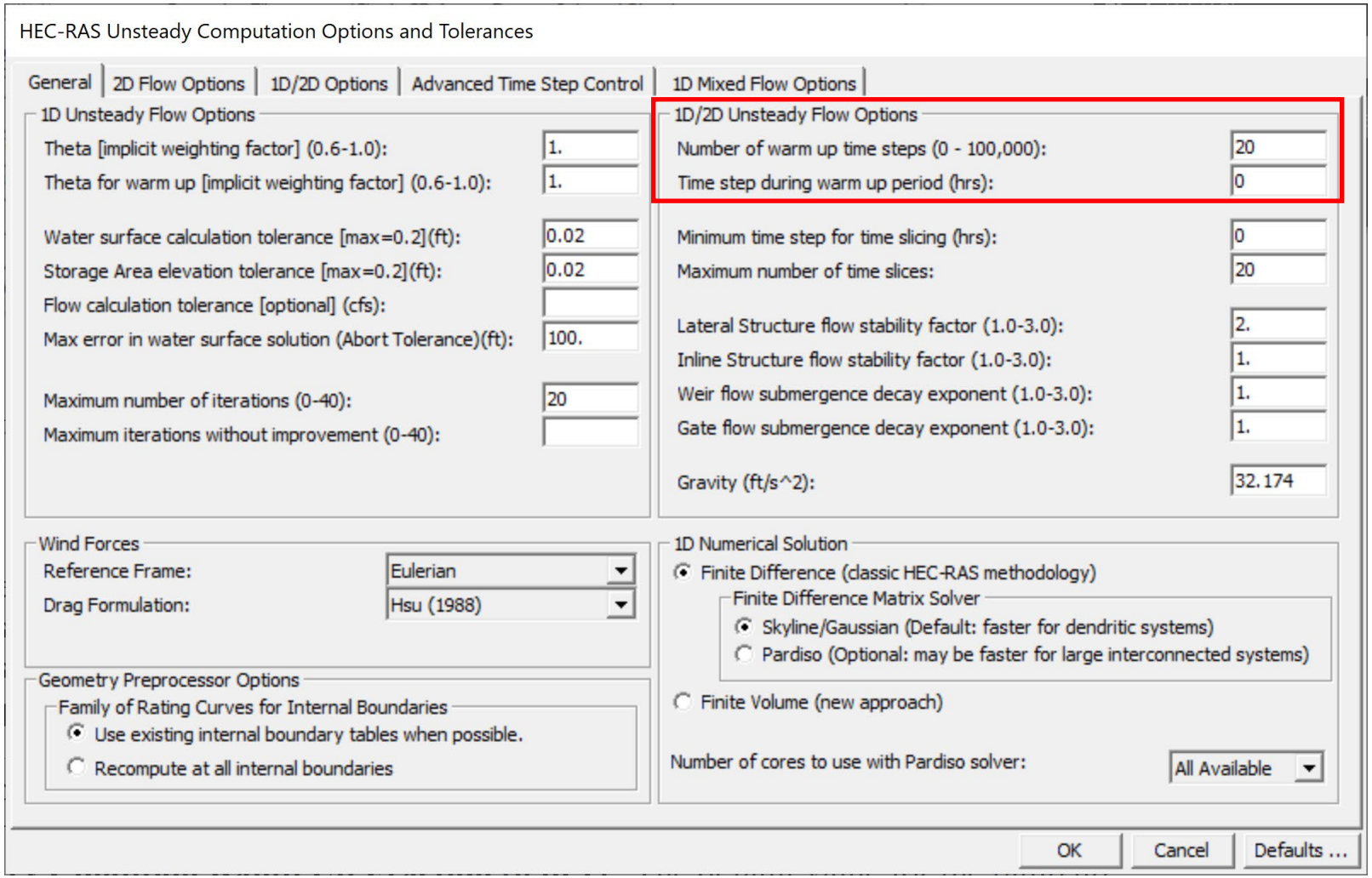
Use Initial Stage (recommended) | t Data | OK

2D Initial Conditions Profile



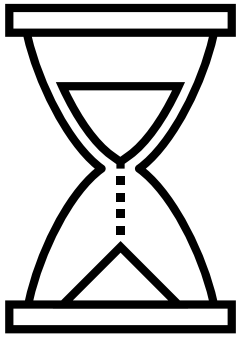
1D/2D Warm Up Period

- Runs **whole model domain**
- Holds all the BC's constant and allows the model to stabilize
- Runs after 2D Initial Conditions
- Timestep optional



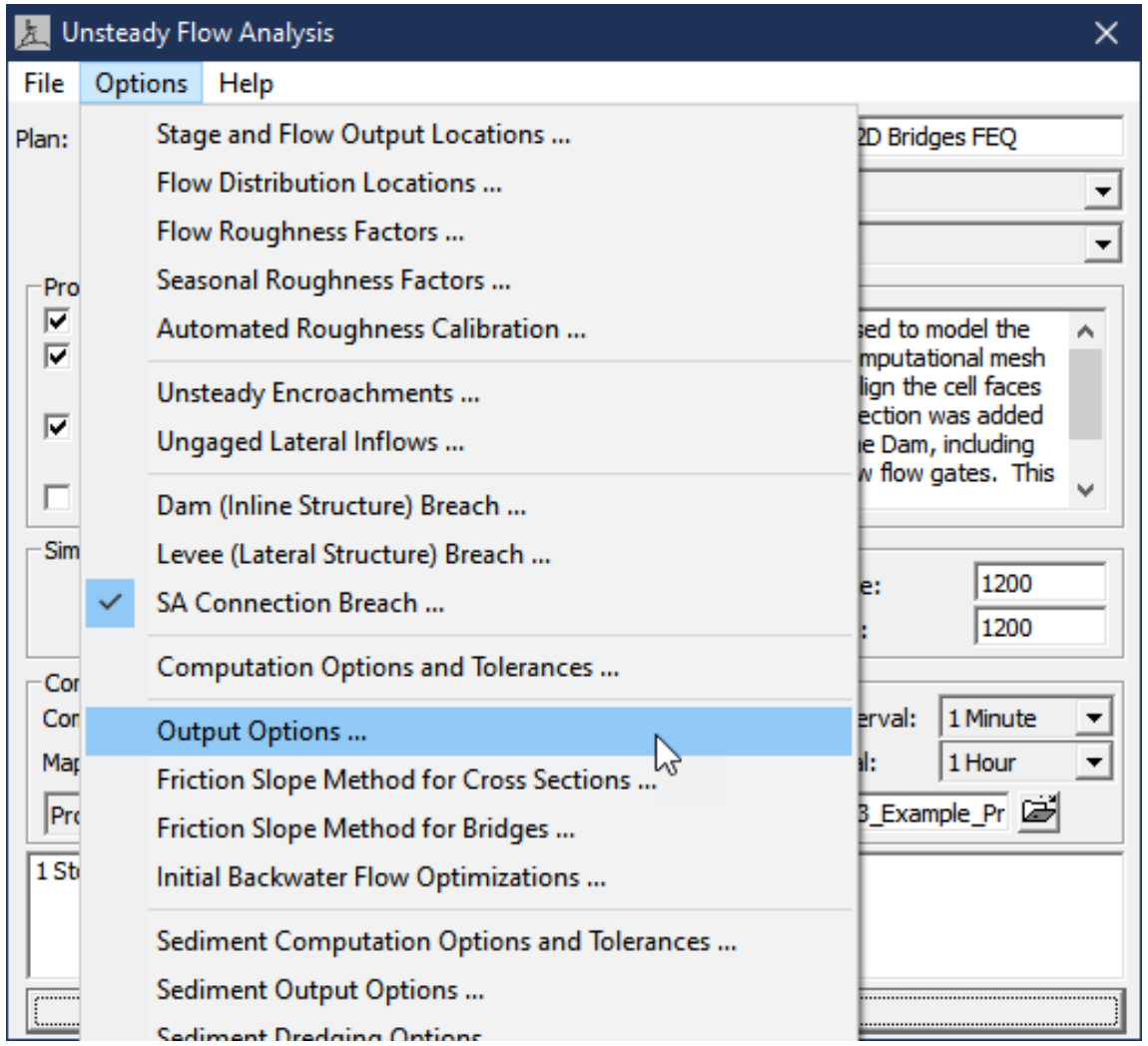
Using a Restart File

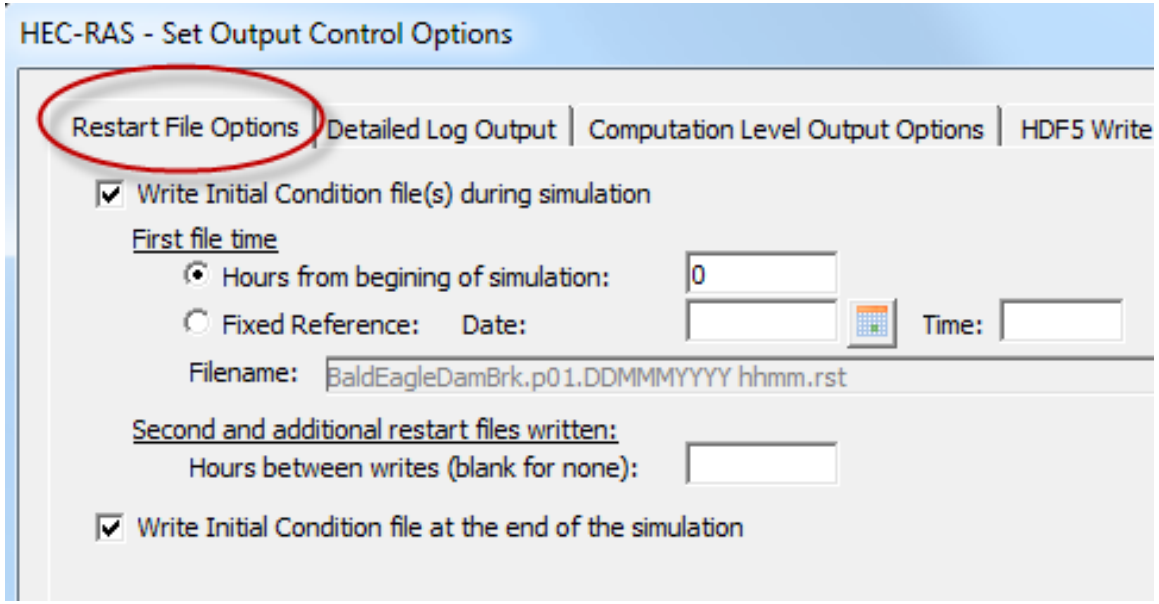
Avoid Ramp Up / Warm Up Compute Time!



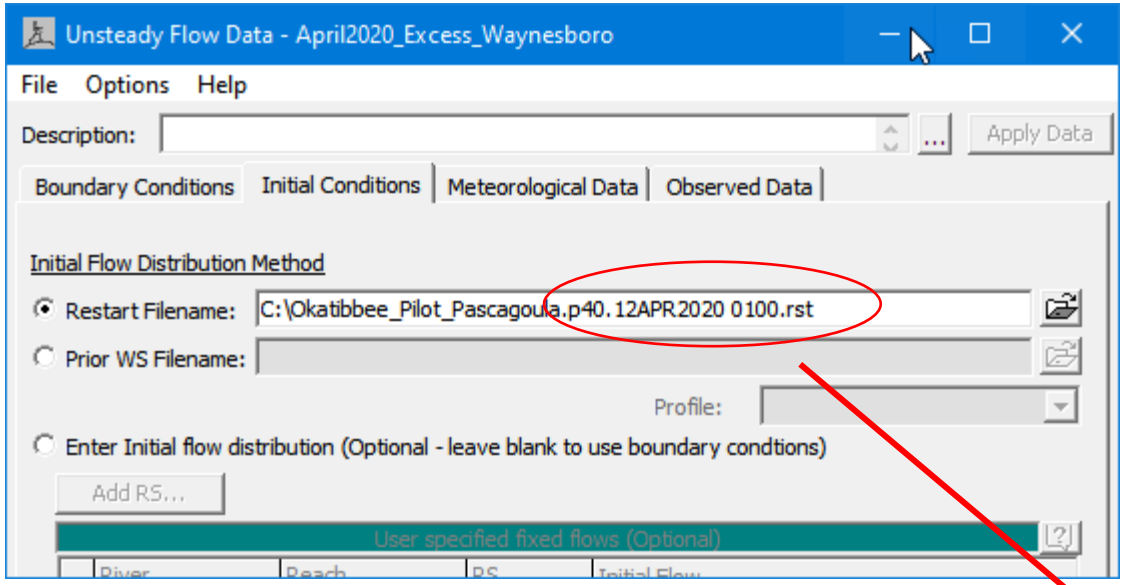
1. Run initial conditions once
2. Write **Initial Condition File** out
3. Create a new **Unsteady Flow Plan**
4. Select **Use a Restart File**
5. Adjust starting date, and any hydrographs, if needed (if you start model later than previous run).

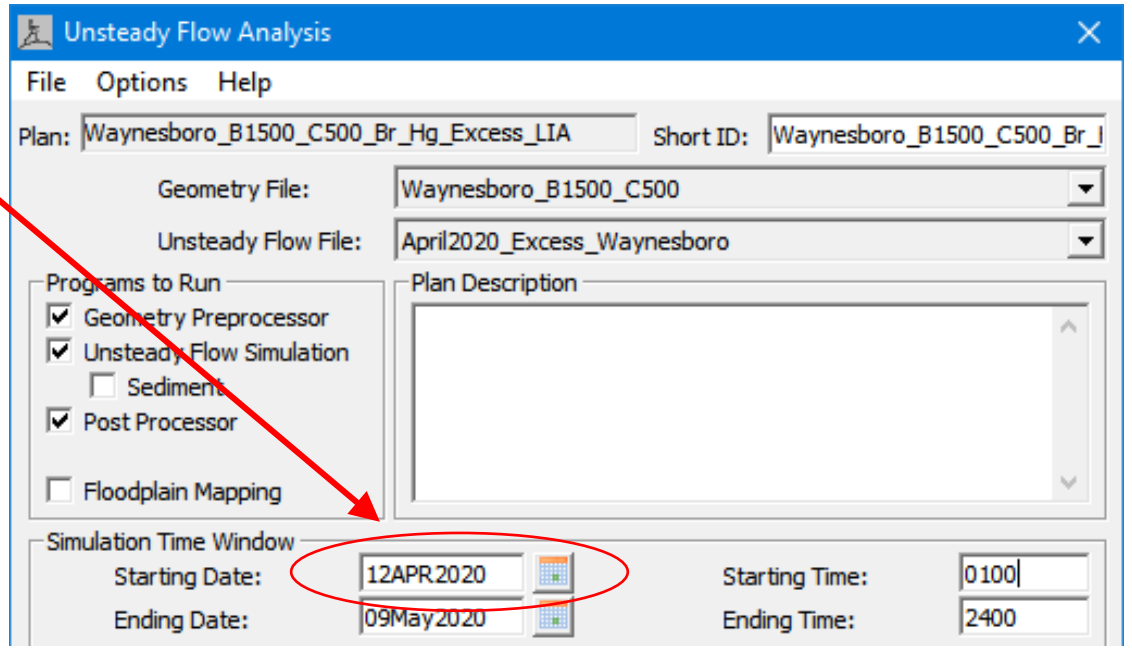
Write Initial Condition File





Select Restart File



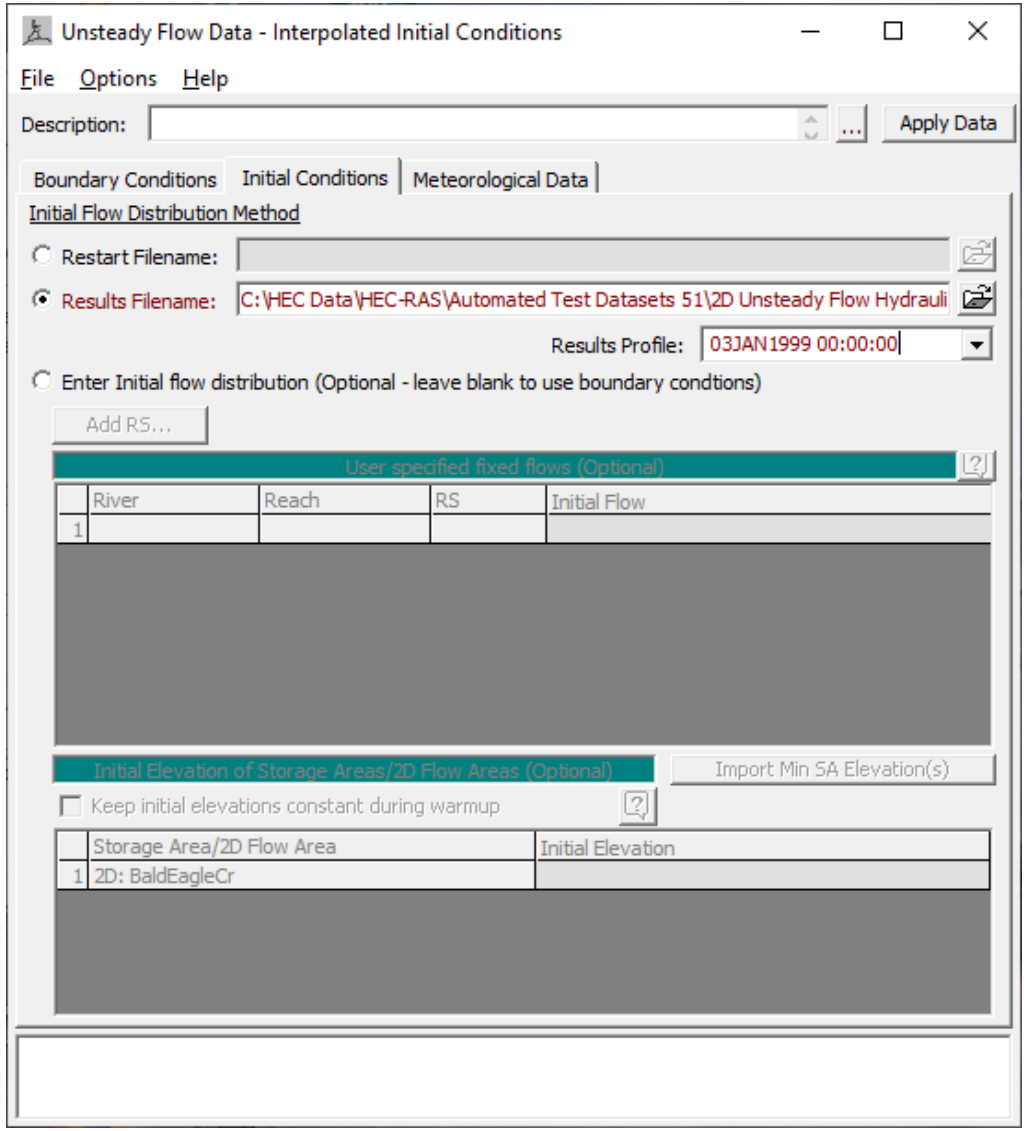


Restart File Notes

- Geometry must be the same
- Version must be the same
- Can switch 2D equation if desired
  - Use to run DWE to create Restart for SWE
- Can change the time step
- Can change the output interval
- Can change flow and plan data

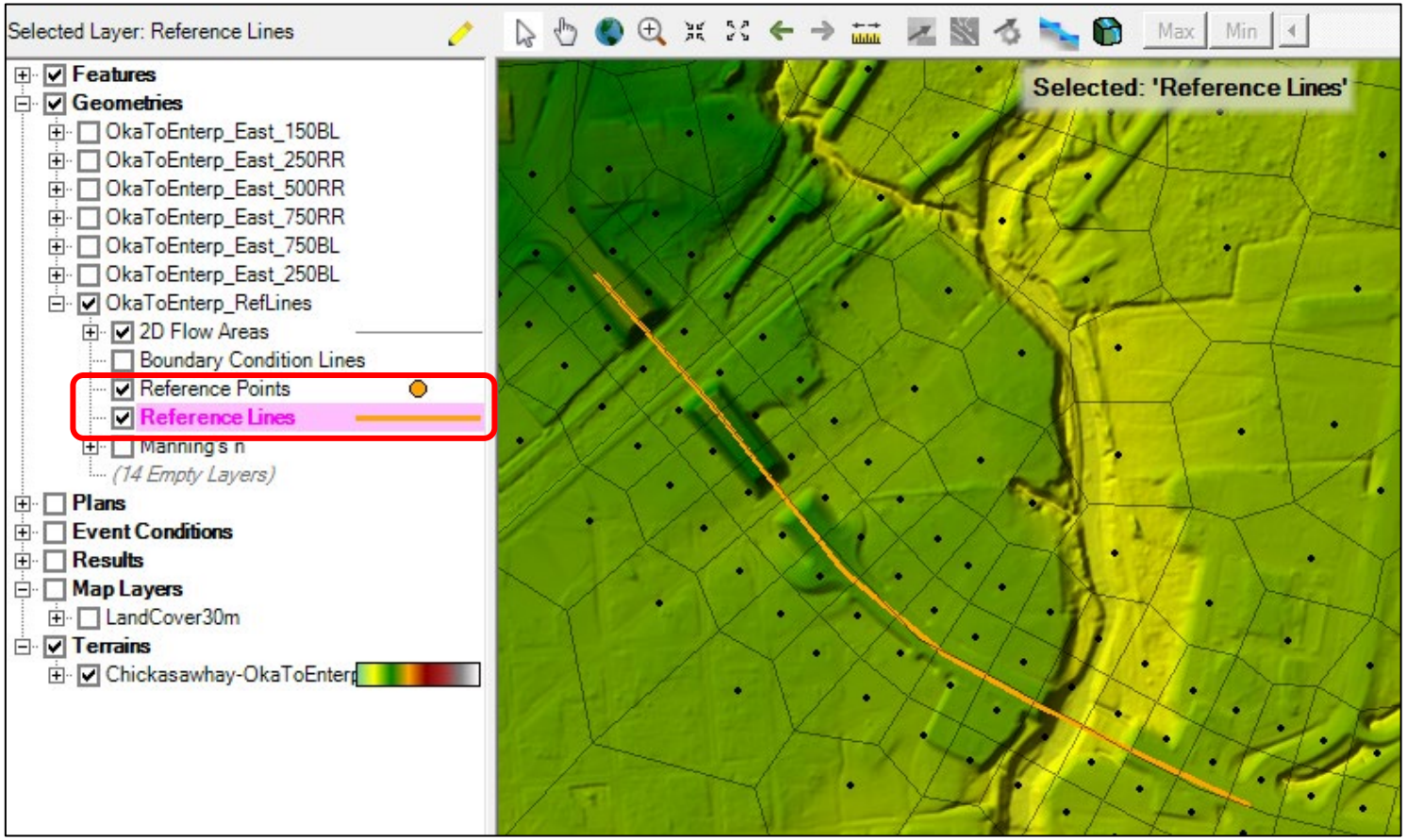
Initializing From Previous Results

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



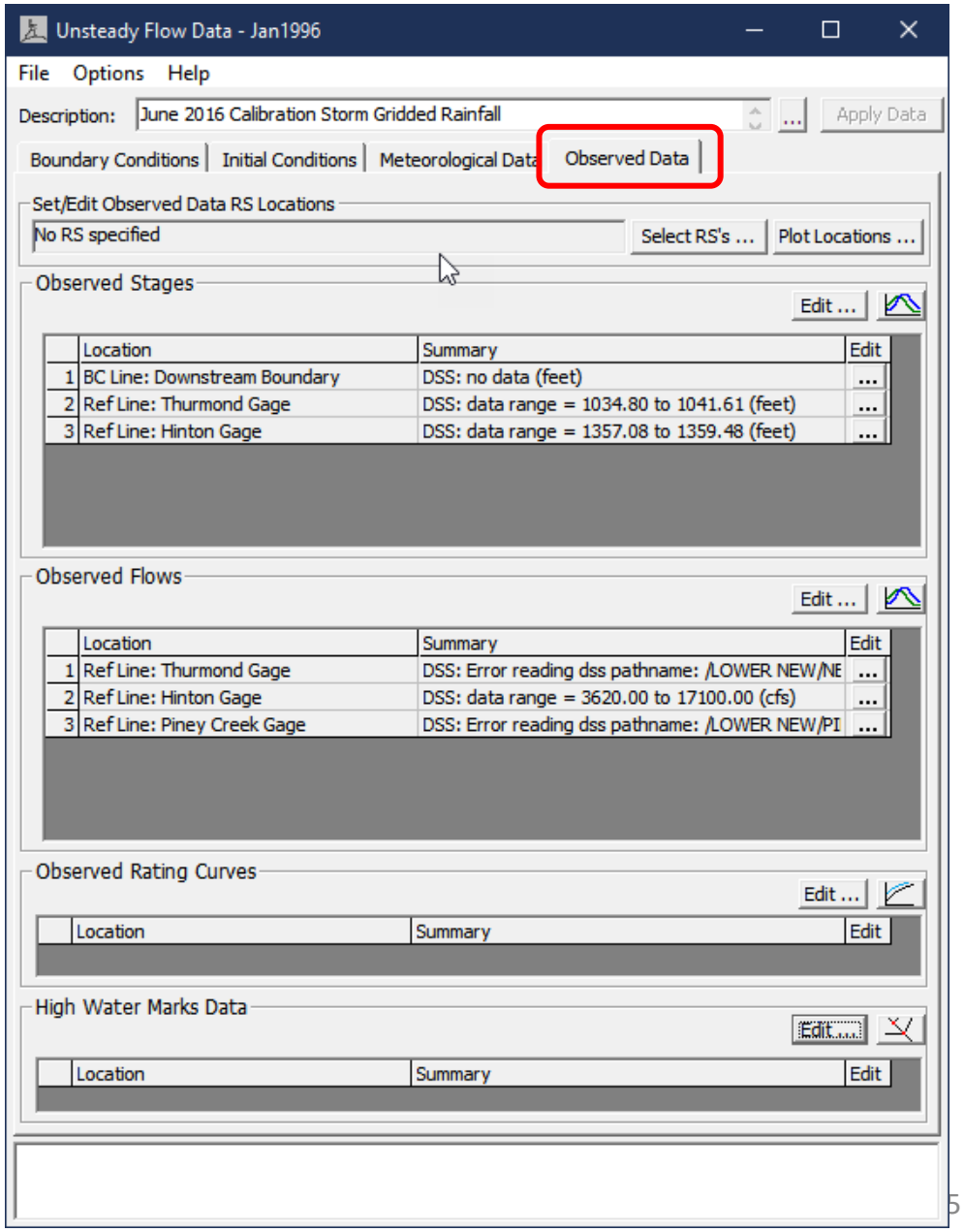
Observed Data Locations

- Reference Lines
  - Stage
  - Flow
  - Rating
  - HWM
- Reference Points
  - Stage
  - HWM

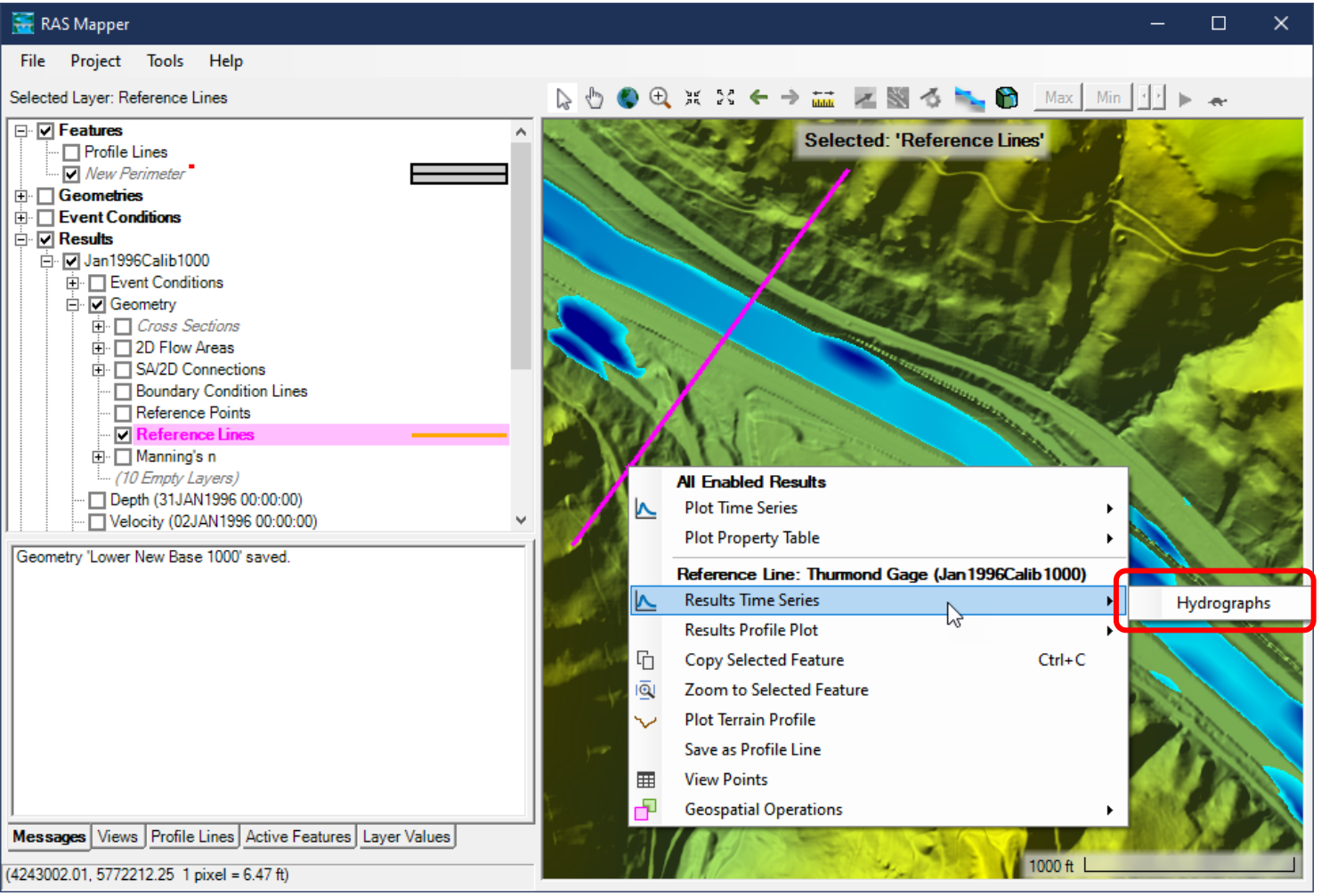


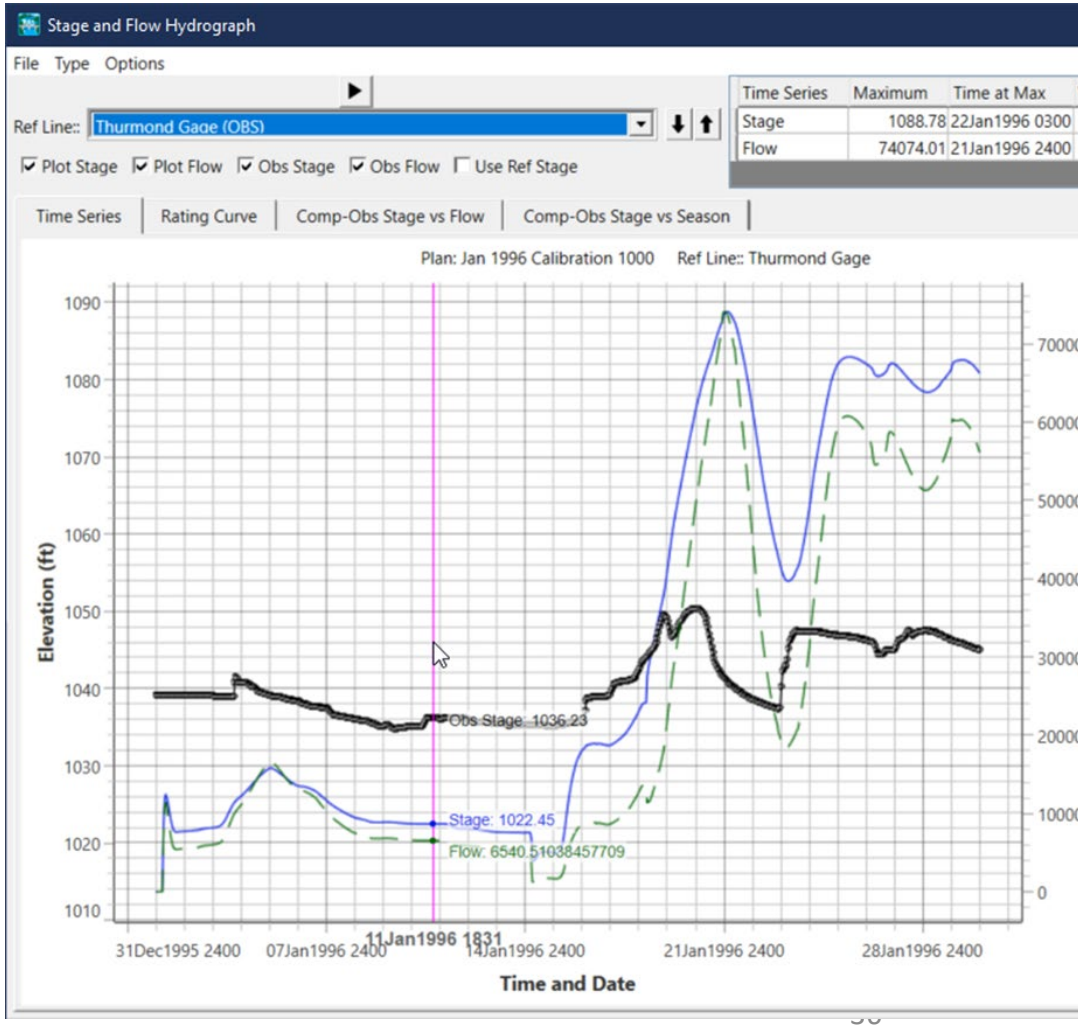
Observed Data Entry

- Observed data locations defined in geometry
- Observed data set in the Unsteady Flow File



Accessing Observed Data Locations





Questions?

US Army Corps of Engineers