Computational Parameters

USACE, Institute for Water Resources, Hydrologic Engineering Center

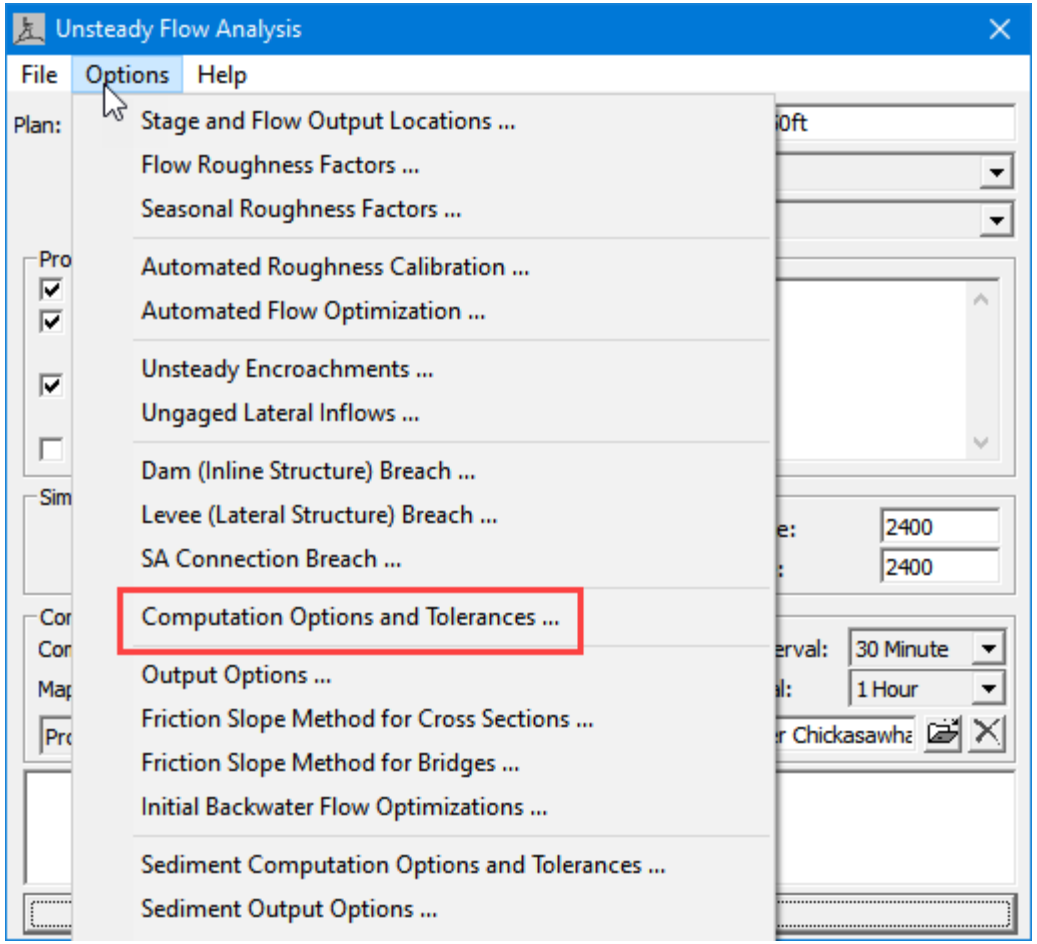
US Army Corps of Engineers

Overview

- Performing Computations
- Computation Options
  - 2D and 1D/2D
- 2D Cell Size Considerations
- Time Step Selection and Options

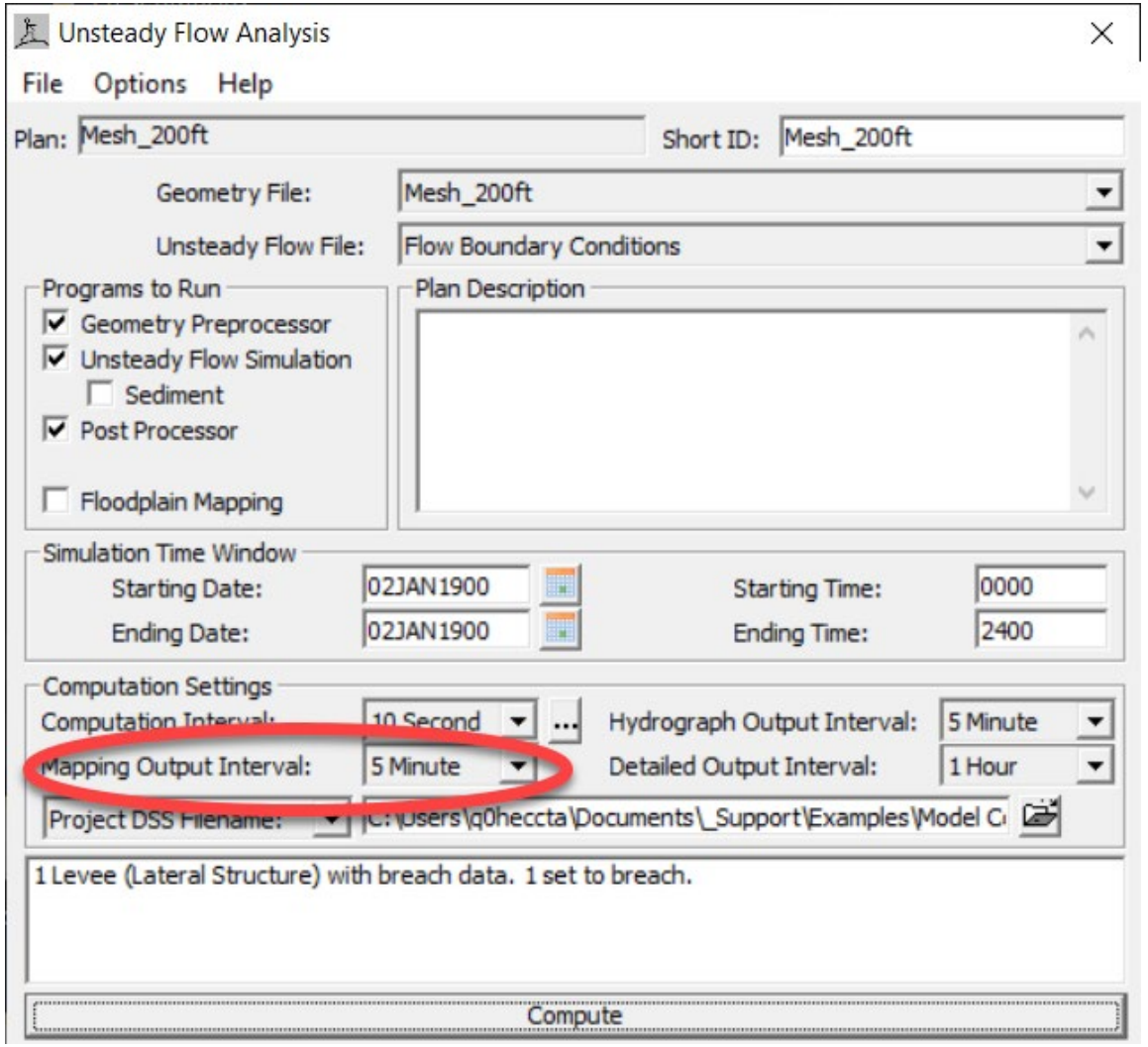
Performing Computations

- Plan Data
- Programs to Run
- Simulation Window
- Computational Settings
  - Computation Timestep
  - Output Intervals
- Computation Options and Tolerances



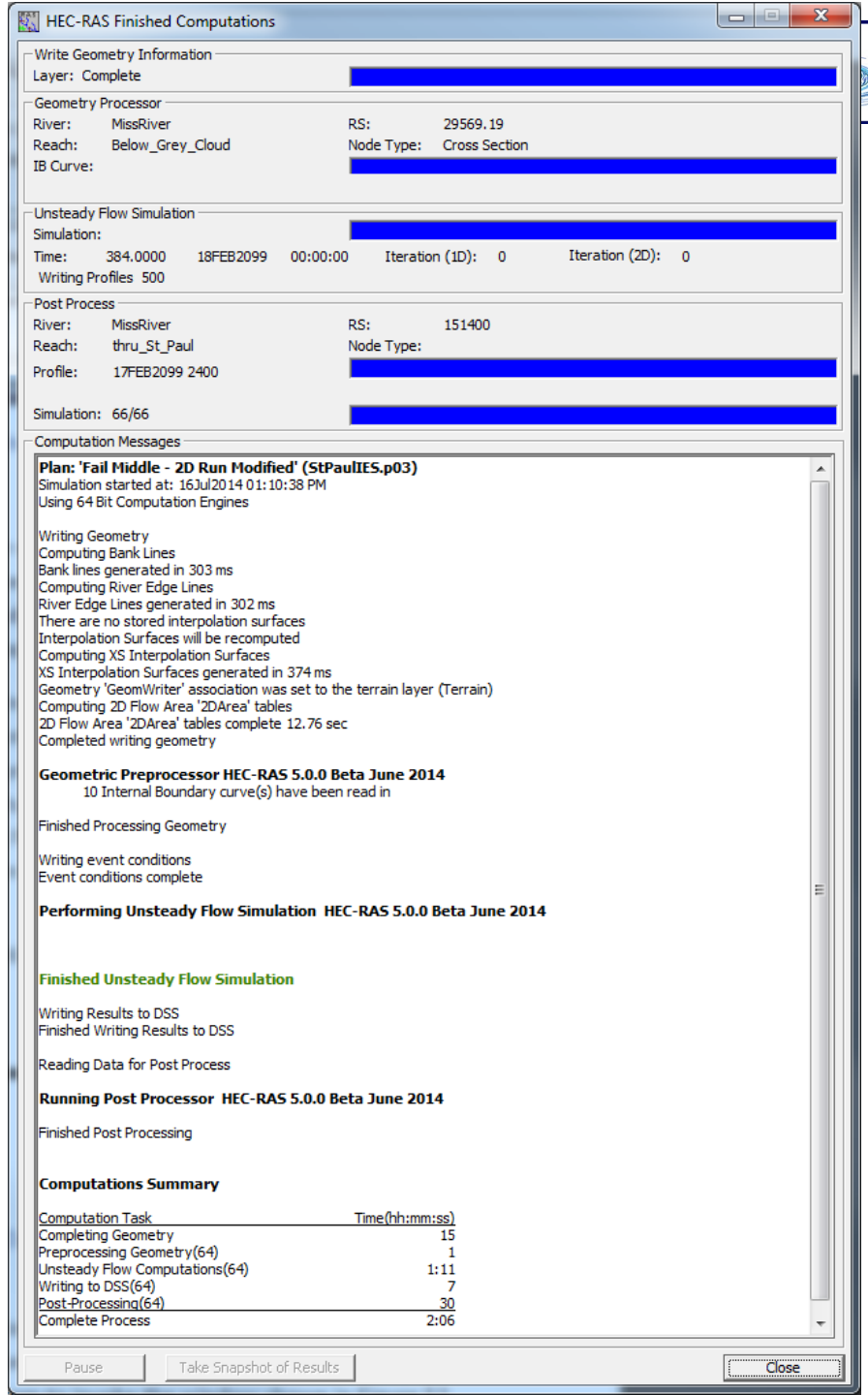
Performing Computations

- Floodplain Mapping
  - Creates a stored map
  - Must set up map in RAS Mapper prior to run
- Mapping Output Interval
  - Time Series Data written to HDF file at Cross Sections, Storage Areas, and 2D Cells
  - XS
    - WSE, Flow, Velocity
  - Cells
    - WSE, Depth cell center
    - Velocity at cell faces



Order of Operations

1. Writing 1D Geometry
   - Bank Lines, Edge Lines (1D)
   - Interpolation Surface (1D)
2. 2D Geometry Preprocessor
   - Process 2D Cells and Faces
3. 1D Geometry Preprocessor
   - Hydraulic Tables for Cross Sections
4. Unsteady Flow Simulation
5. Post Processor (1D only)

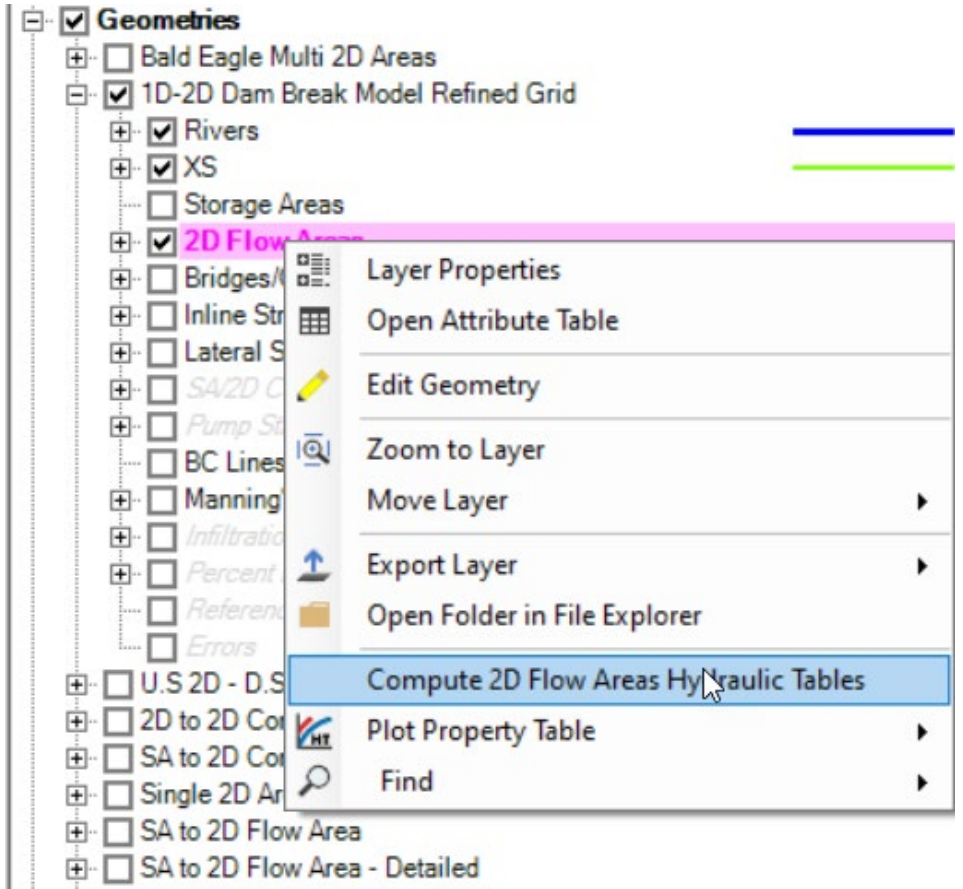


2D Pre-processor to compute cell information

Unsteady-flow Simulation

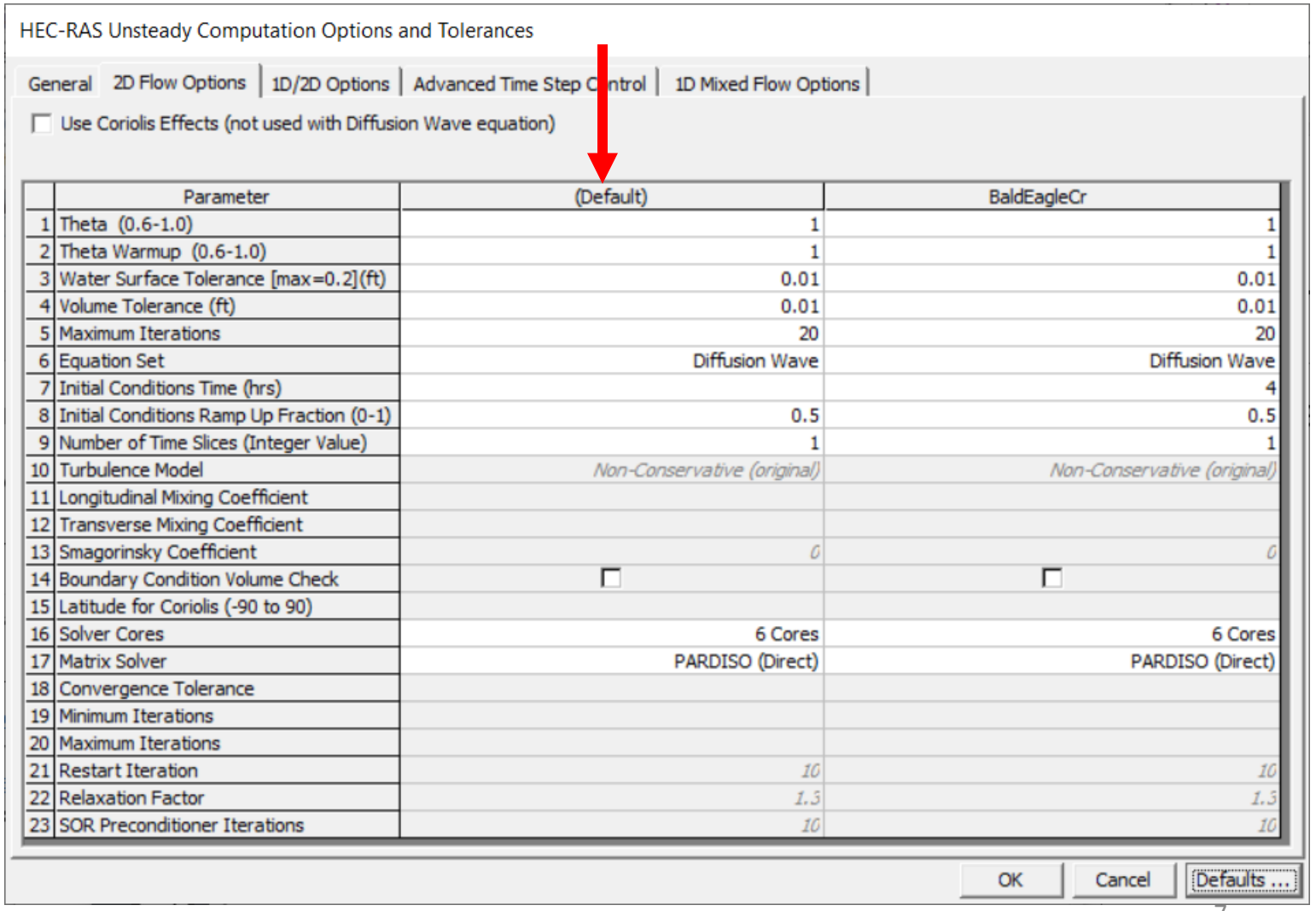
```
Writing Geometry
Computing Bank Lines
Bank lines generated in 303 ms
Computing River Edge Lines
River Edge Lines generated in 302 ms
There are no stored interpolation surfaces
Interpolation Surfaces will be recomputed
Computing XS Interpolation Surfaces
XS Interpolation Surfaces generated in 374 ms
Geometry 'GeomWriter' association was set to the terrain layer (Terrain)
Computing 2D Flow Area '2DArea' tables
2D Flow Area '2DArea' tables complete 12.76 sec
Completed writing geometry
```

RAS Mapper – 2D Flow Areas



2D Computation Options Tab

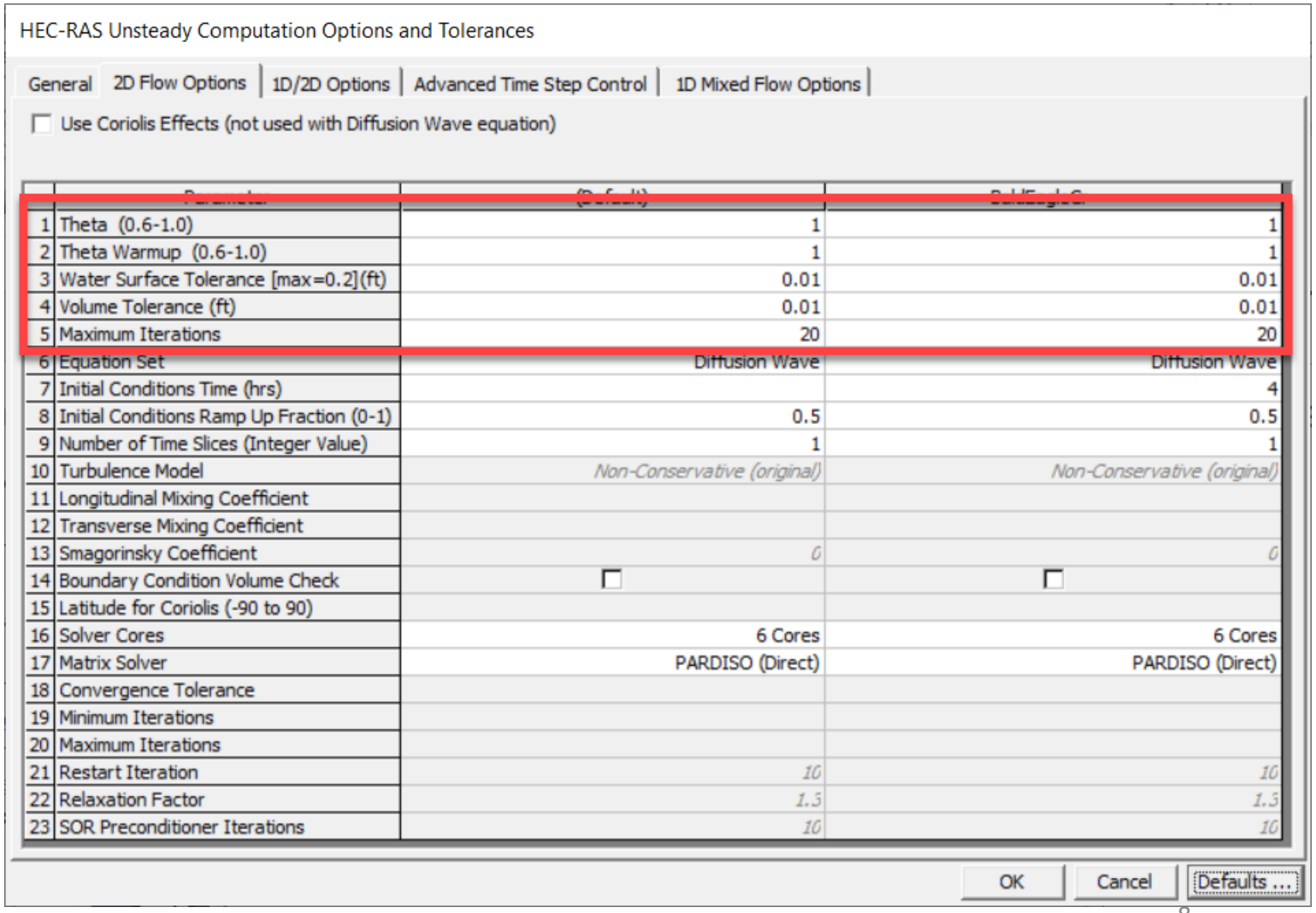
- Defaults
- Column Per 2D Flow Area



	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)		4
8	Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	*Non-Conservative (original)*	*Non-Conservative (original)*
11	Longitudinal Mixing Coefficient		
12	Transverse Mixing Coefficient		
13	Smagorinsky Coefficient	*0*	*0*
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	6 Cores	6 Cores
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations		
20	Maximum Iterations		
21	Restart Iteration	*10*	*10*
22	Relaxation Factor	*1.3*	*1.3*
23	SOR Preconditioner Iterations	*10*	*10*

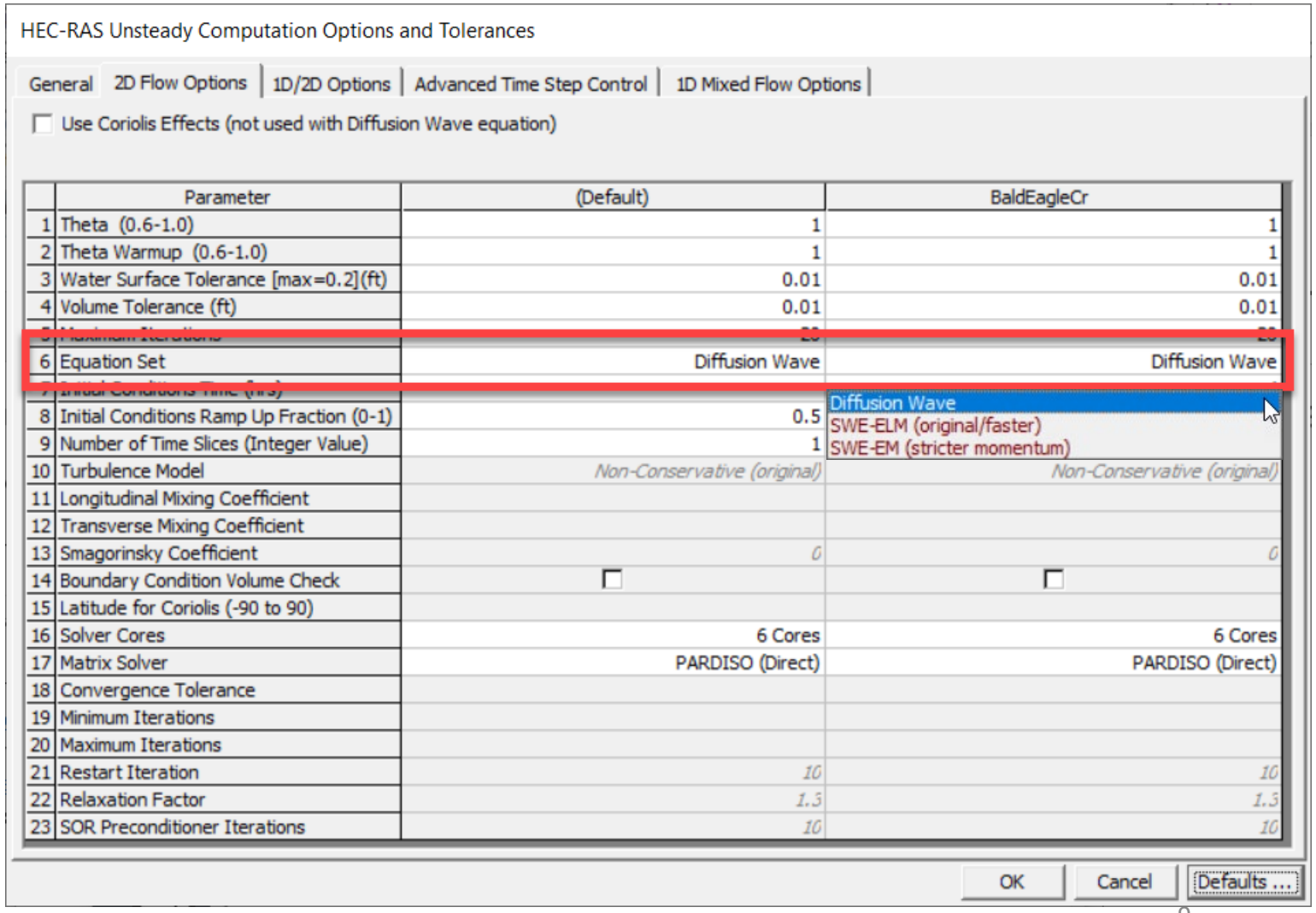
General 2D Computation Options

- Theta
- Theta Warmup
- Water Surface Tol
- Volume Tolerance
- Max Iterations



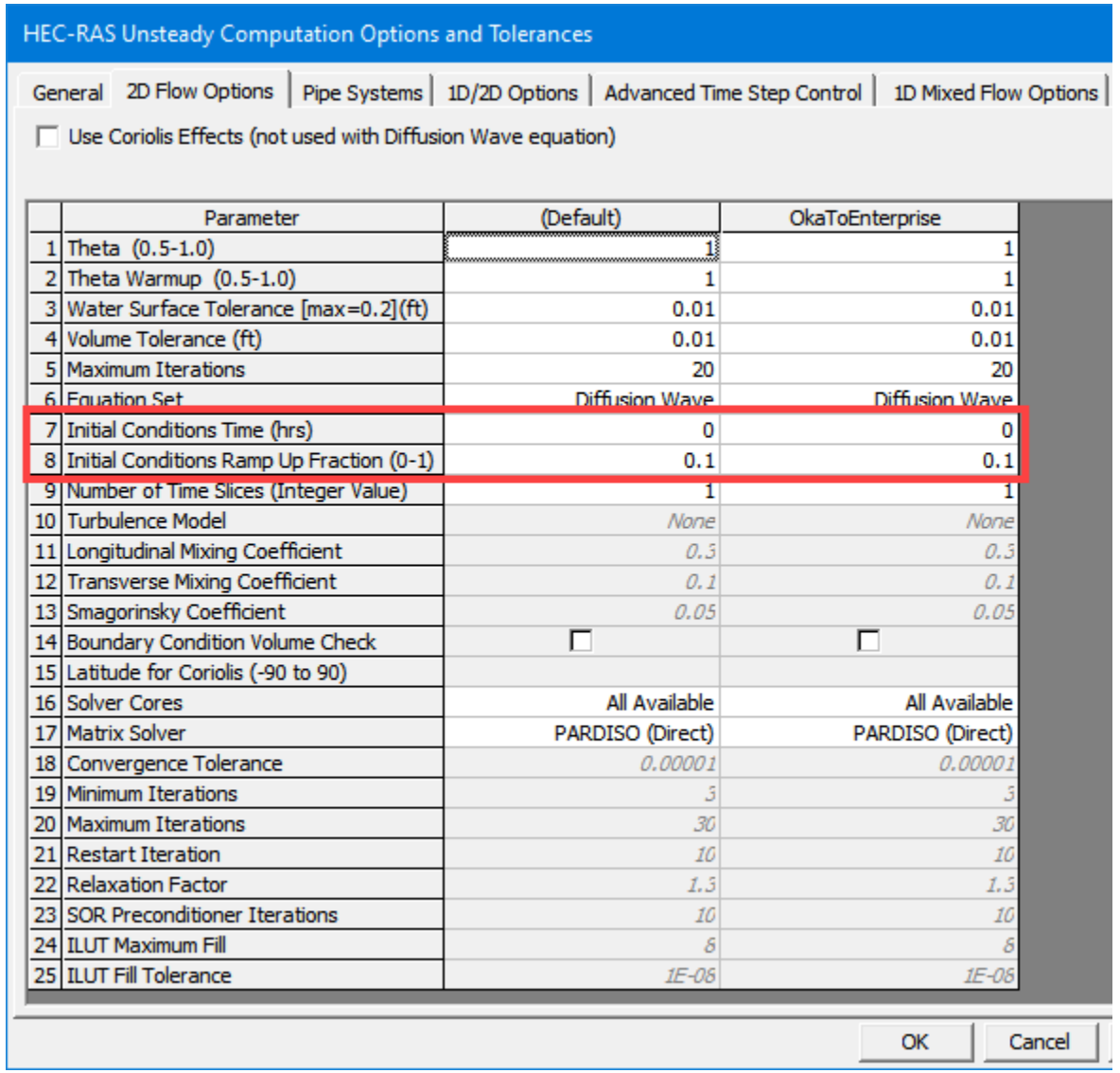
2D Equation Set

- Diffusion Wave
- Shallow Water Eqn (faster)
- Shallow Water Eqn (conservative)
- Local Inertial Approx (LIA)

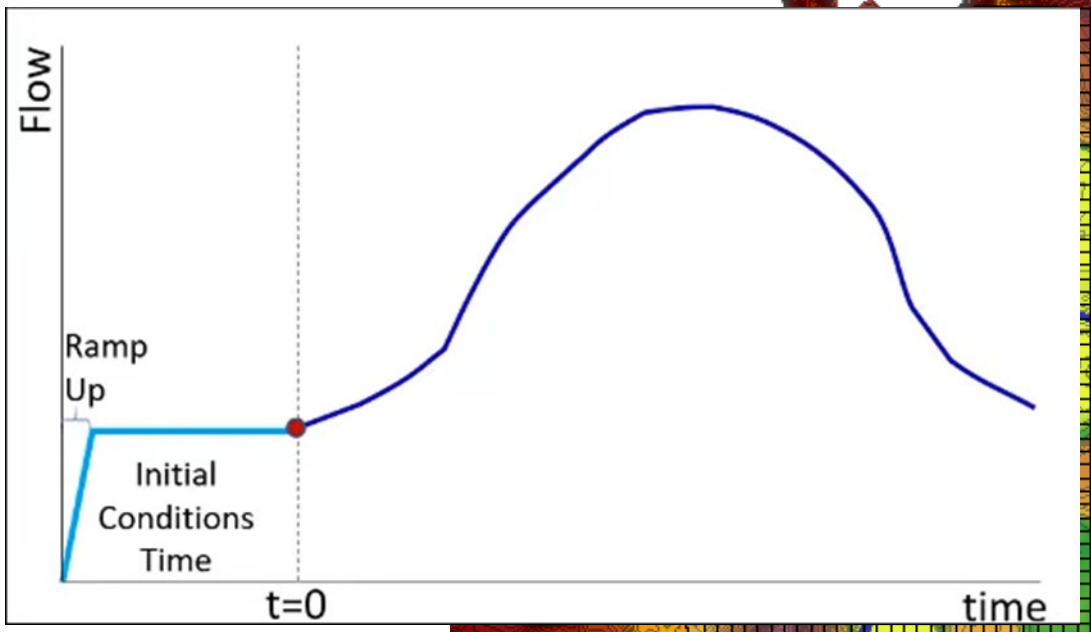


2D Initial Conditions

- Time allowed for each 2D area to compute an initial water surface
- Initial flows and stages can be ramped up during initial conditions



2D Initial Conditions Warm Up in Progress



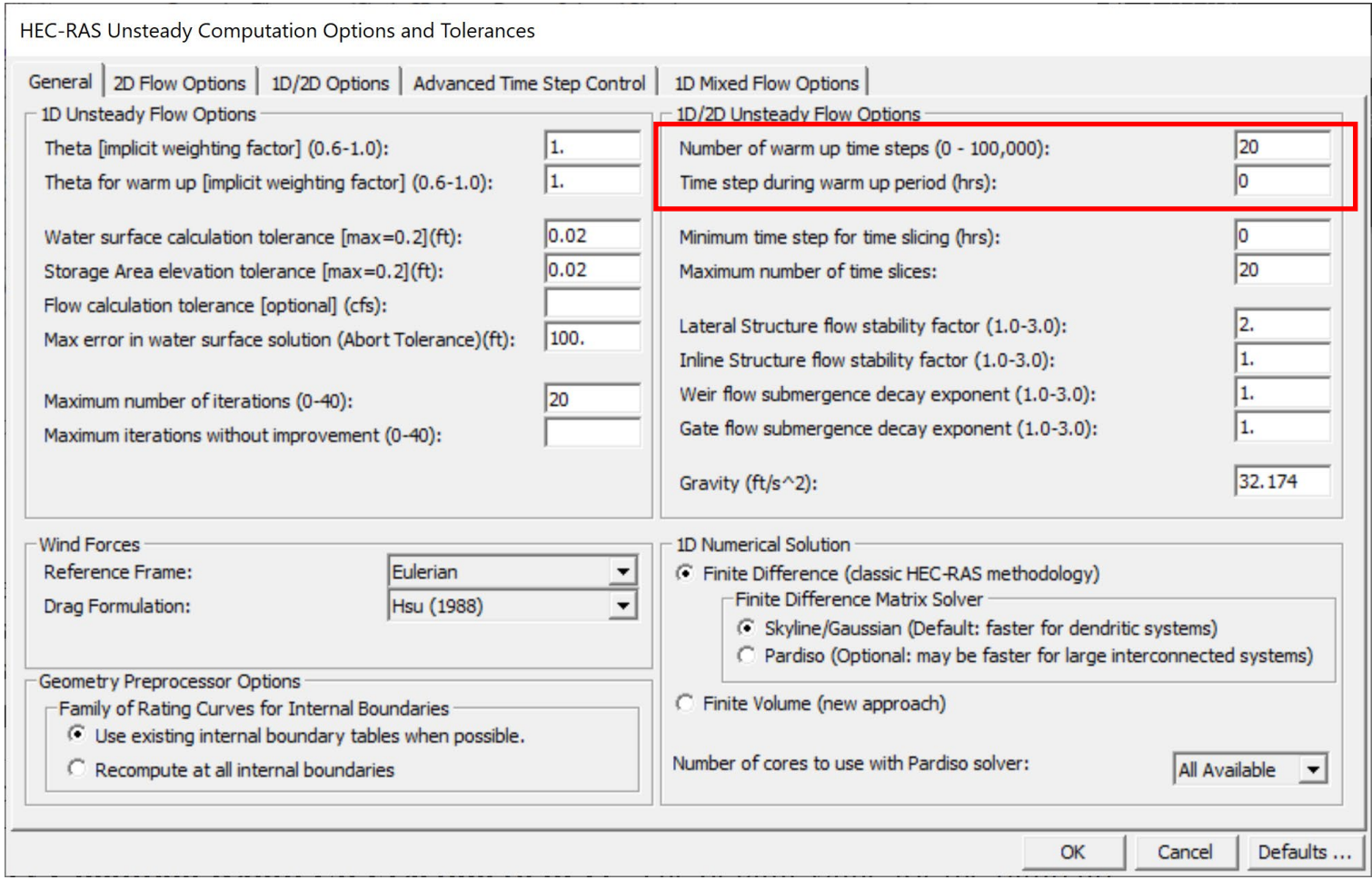
Stage Boundary Condition

	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

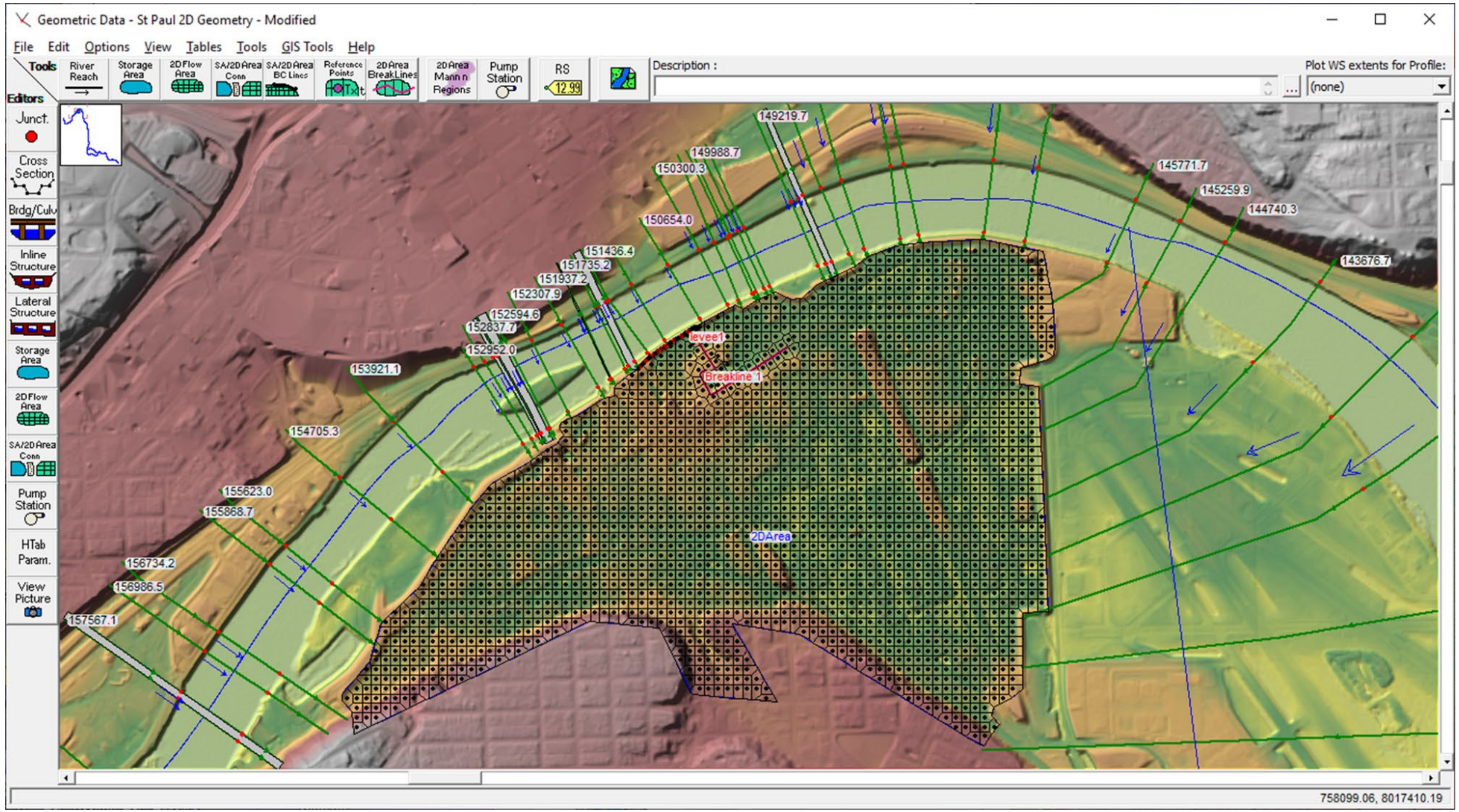
Use Initial Stage (recommended) | t Data | OK

1D/2D Warm Up Period

- Hold all the BC's constant, allow the model to stabilize
- Runs after 2D Initial Conditions Period
- Duration specified as number of time steps
- Time step is optional

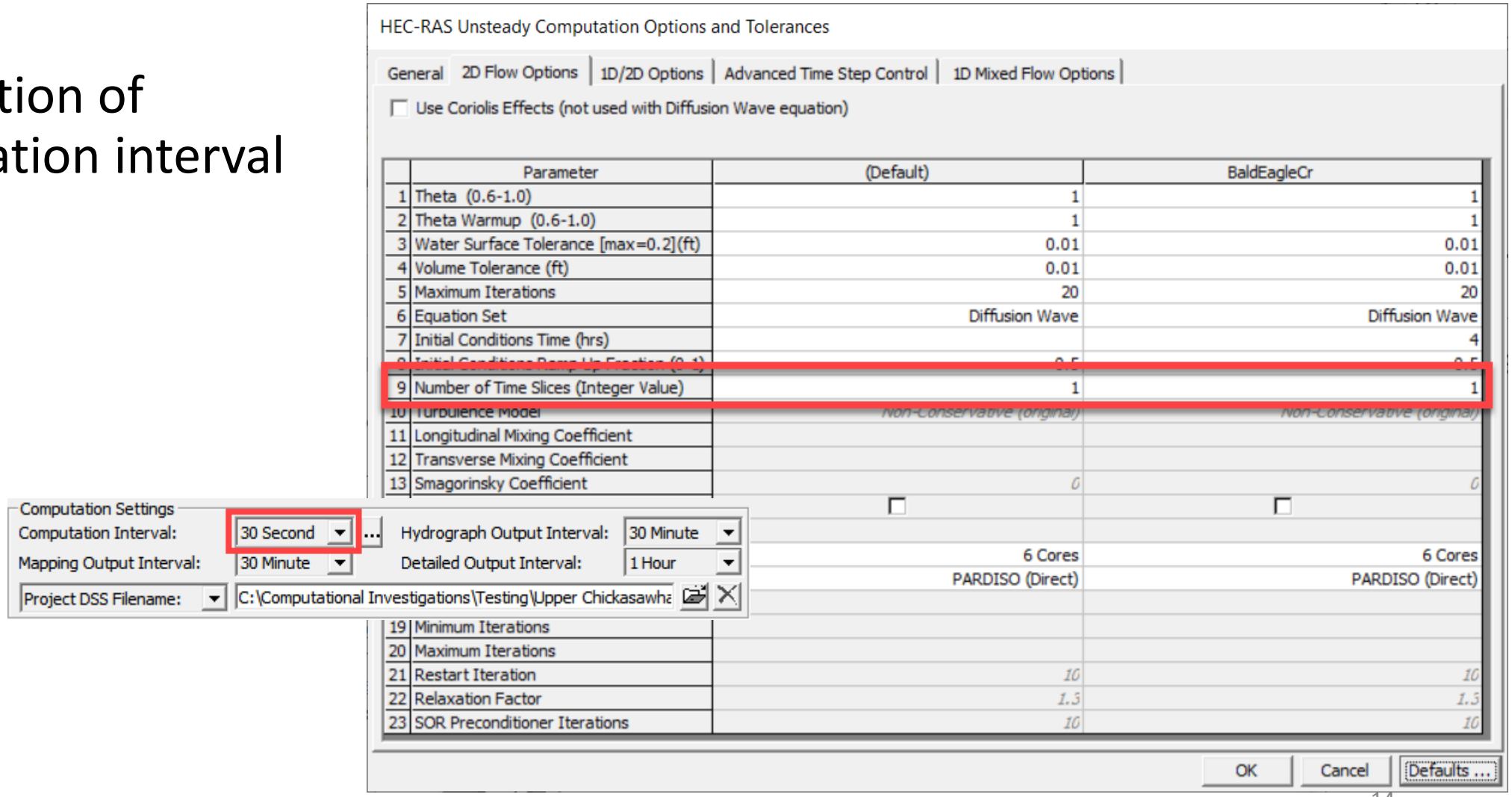


1D/2D Modeling Computational Time Step



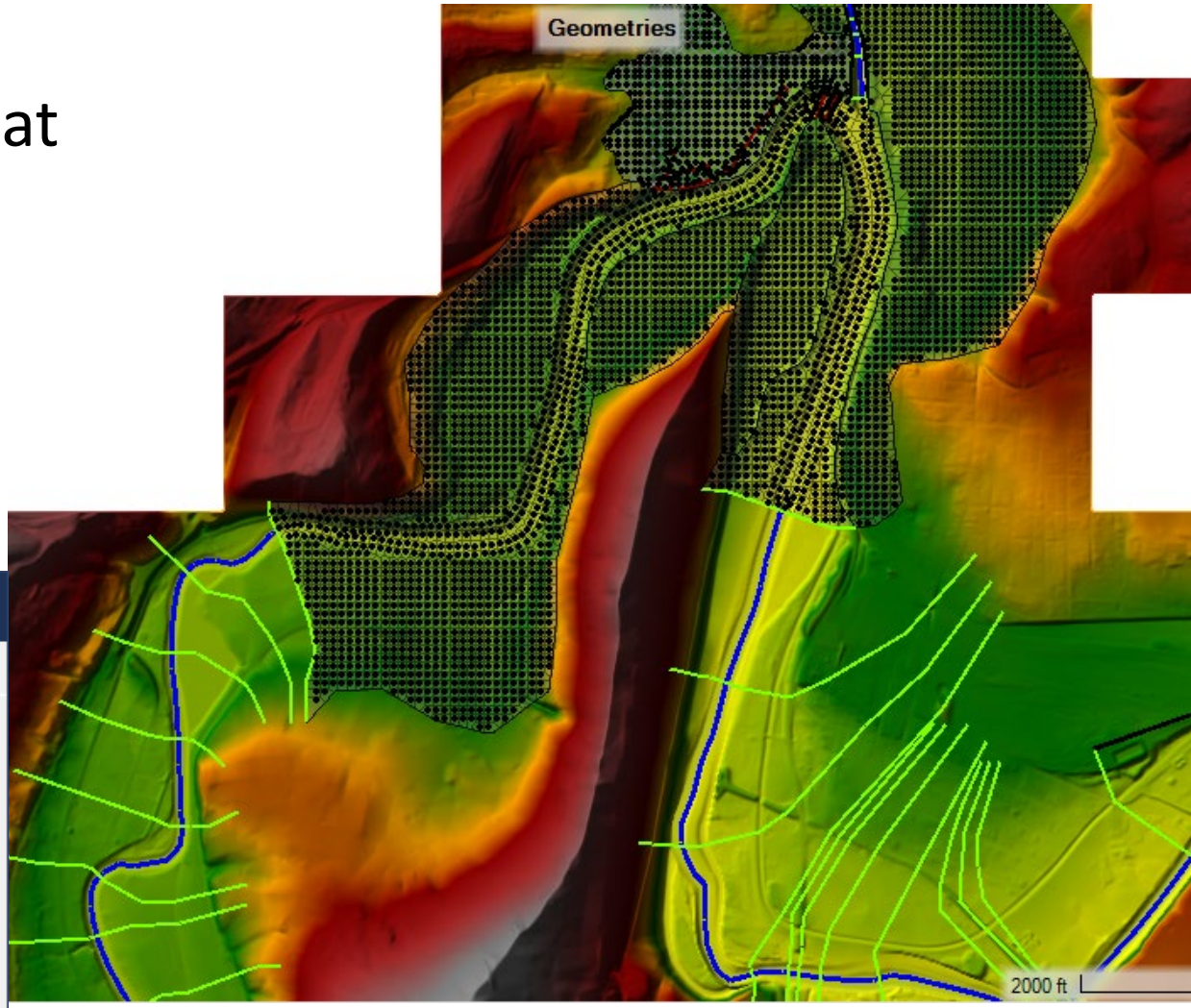
2D Time Slicing

- Use fraction of computation interval



1D/2D Iterations Option

- Monitors WSEL and Flow Tolerance at boundaries
- Iterates the 1D and 2D domain until tolerances are met
- Off by default (0 iterations)



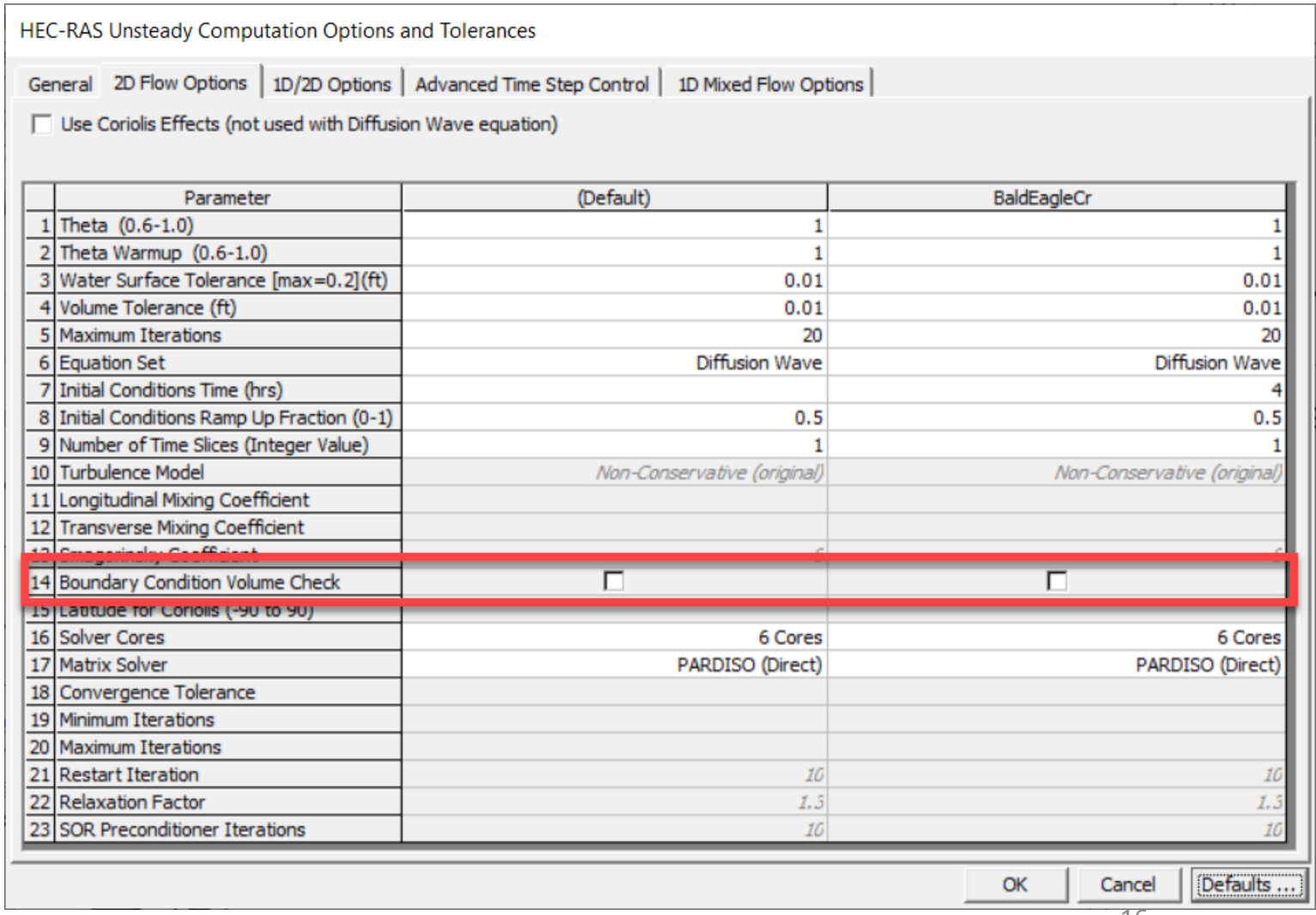
HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

Maximum iterations between 1D and 2D (0=off, 1 to 20):	0
Water surface tolerance (ft):	0.01
Flow Tolerance (%)	0.1
Minimum flow tolerance (cfs):	1.

2D Boundary Condition Volume Check

- Boundary Condition Volume Check
- Checks if enough volume is available to satisfy flow rate leaving



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12	Transverse Mixing Coefficient		
13	Stagnancy Coefficient	6	6
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
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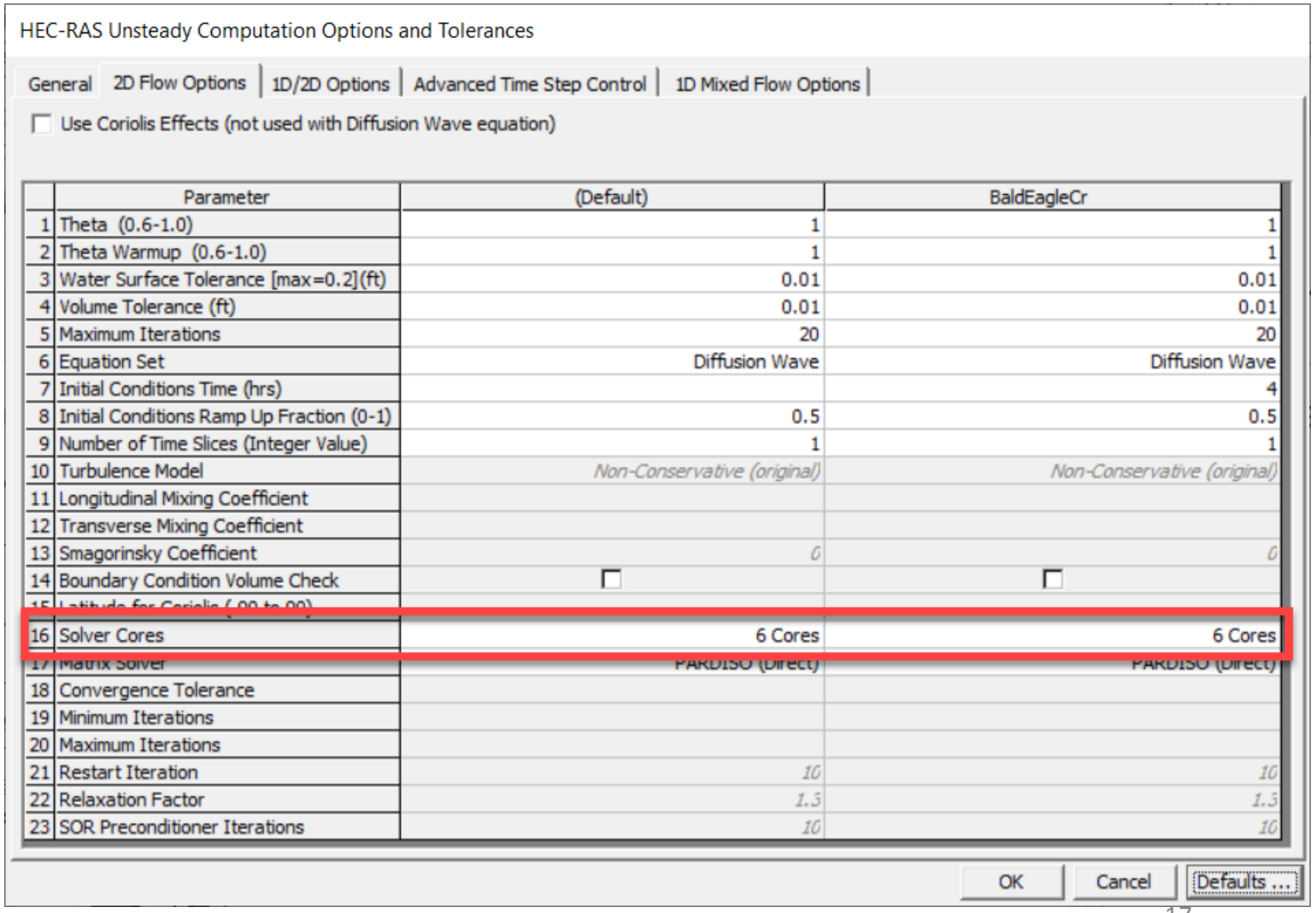
2D Solver Cores

- Number of Cores



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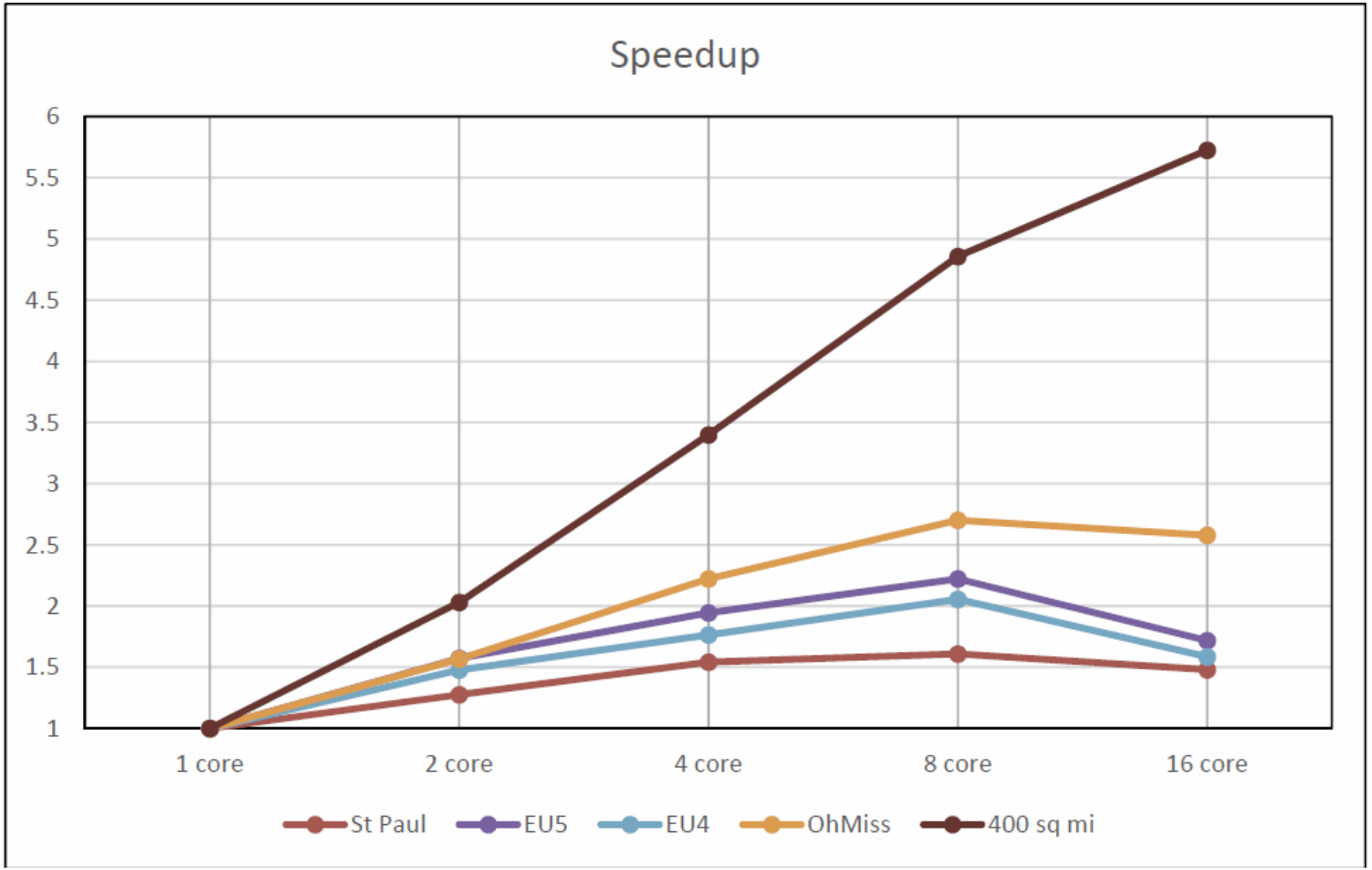
Processing Time vs Number of Cores



Mesh Cell Size

- Mesh Cell size determination is based on
  - Land surface features of the Terrain
    - Faces control water movement
  - Water Surface Slope
    - Capturing localized effects in model requires smaller cell sizes (analogous to cross section spacing for rapidly varied flow).
  - Velocity
- Start with a “large” cell size and refine the model through iteration
- Always test different cell sizes to see what affect they have on water surfaces and velocities

Time Step Selection

- Time Step selection will be based on the size of the grid cells and velocity of water in the cells.
- Dependent on Equation Set selected
  - Diffusion Wave approximation
  - Full Shallow Water Equations

$$\underbrace{\frac{\partial \boldsymbol{V}}{\partial t}}_{\text{Temporal}} + \underbrace{(\boldsymbol{V}\cdot\nabla)\boldsymbol{V}}_{\text{Advection}} + \underbrace{f_c \boldsymbol{k}\times\boldsymbol{V}}_{\text{Coriolis}} = \underbrace{-g\nabla z_s}_{\text{Pressure gradient}} + \underbrace{\frac{1}{h}\nabla\cdot(\nu_t h\nabla\boldsymbol{V})}_{\text{Diffusion}} - \underbrace{\frac{\boldsymbol{\tau}_b}{\rho R}}_{\text{Bottom Friction}} + \underbrace{\frac{\boldsymbol{\tau}_s}{\rho h}}_{\text{Wind Stress}}$$

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Courant Number and Timestep

- Full Shallow Water Equations
  - Experience shows, max C = 3.0

$$C = \frac{V * \Delta T}{\Delta X} \leq 1.0$$

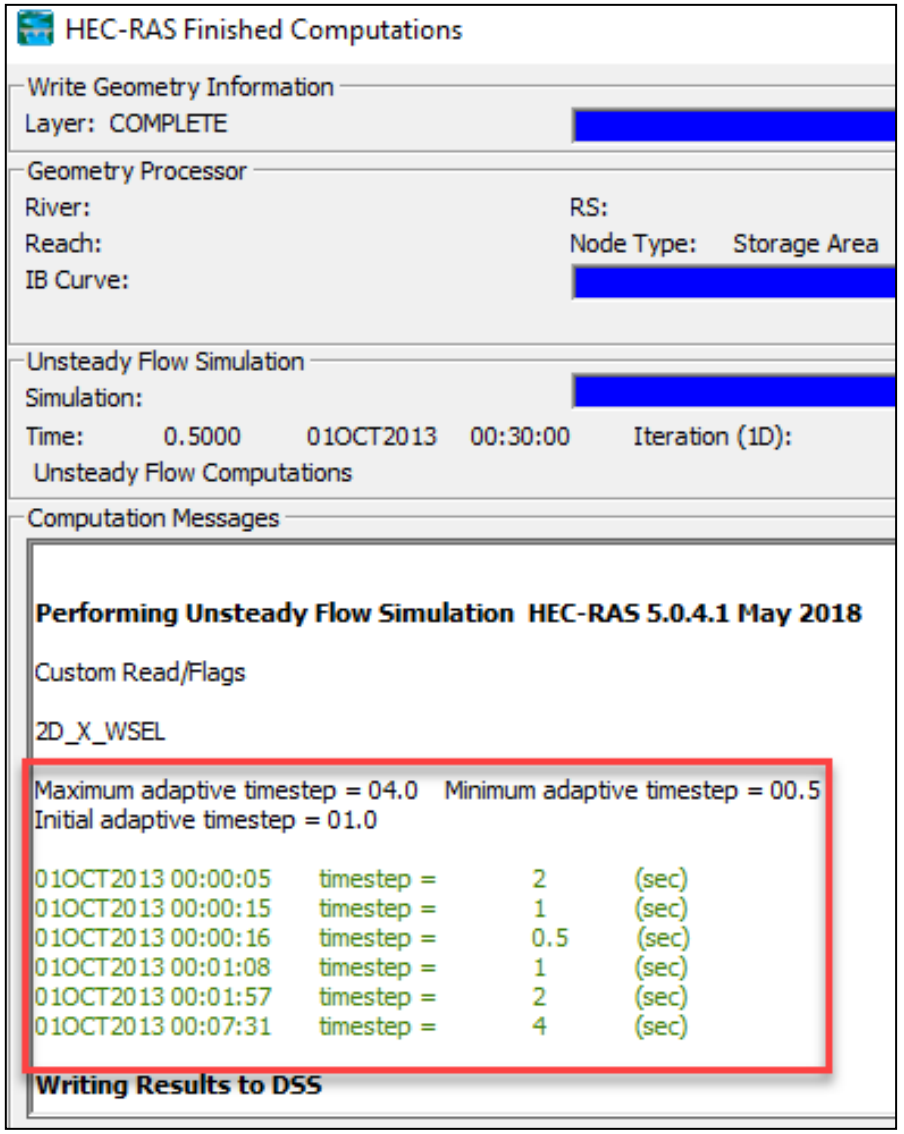
- Diffusion Wave Approximation
  - Experience shows, max C = 5.0

$$C = \frac{V * \Delta T}{\Delta X} \leq 2.0$$

C	=	Courant Number
V	=	Velocity of the Flood Wave (ft/s)
ΔT	=	Computational Time Step (seconds)
ΔX	=	The average Cell size (ft)

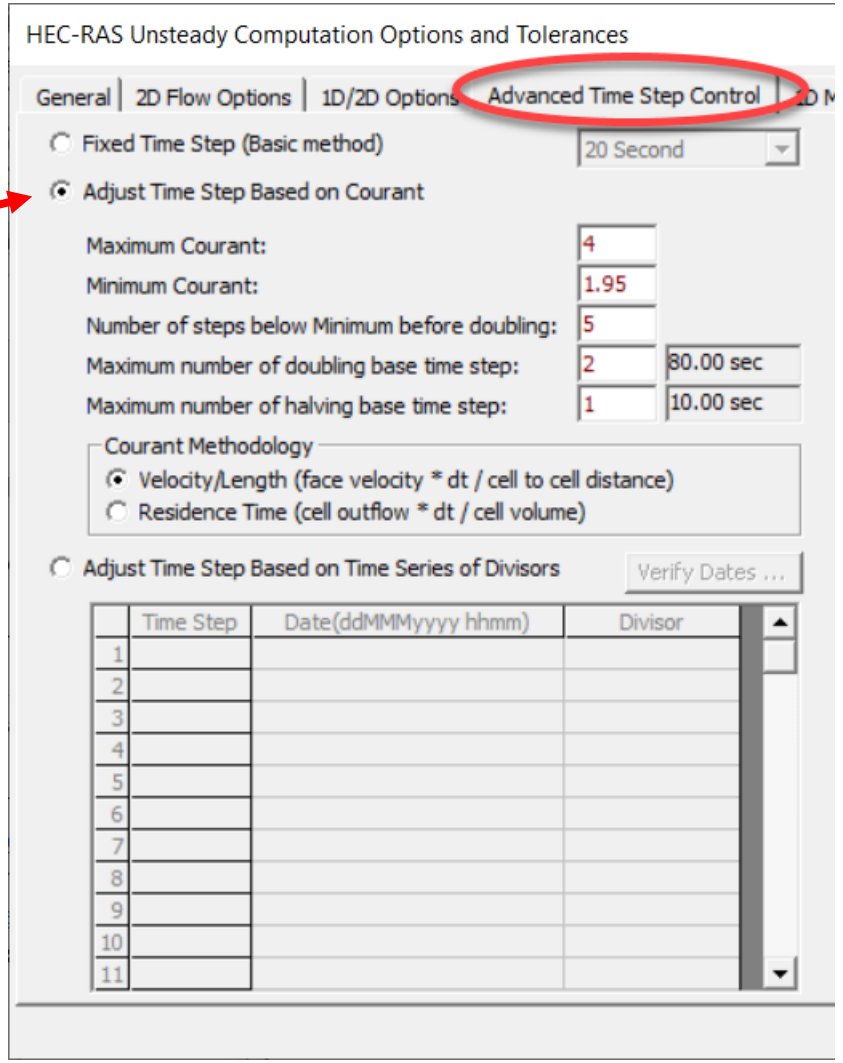
Variable Time Step

- Reduce time step to improve accuracy
- Increase time step to reduce computation times



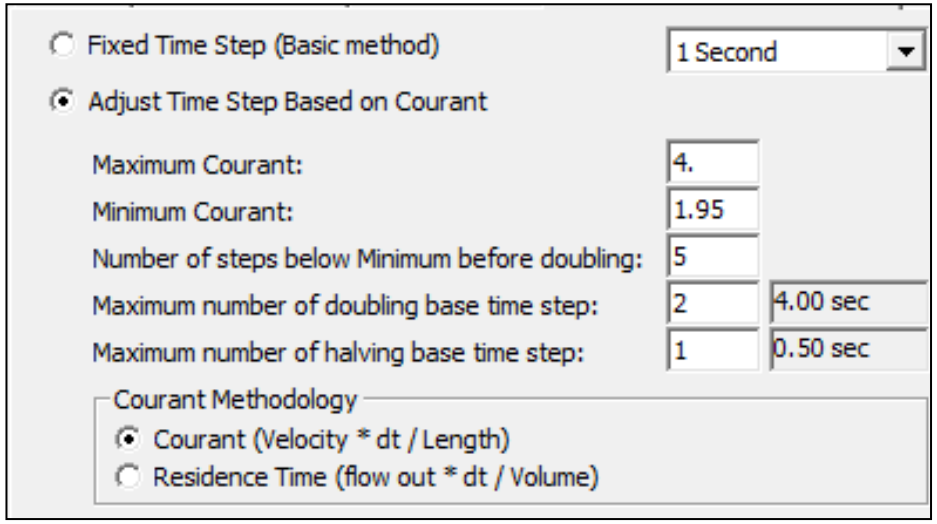
Variable Time Step Options

- Fixed Time Step (default)
- Adjust Time Step Based on
  - Courant Number (adaptive)
  - Date/Time and a Time step divisor



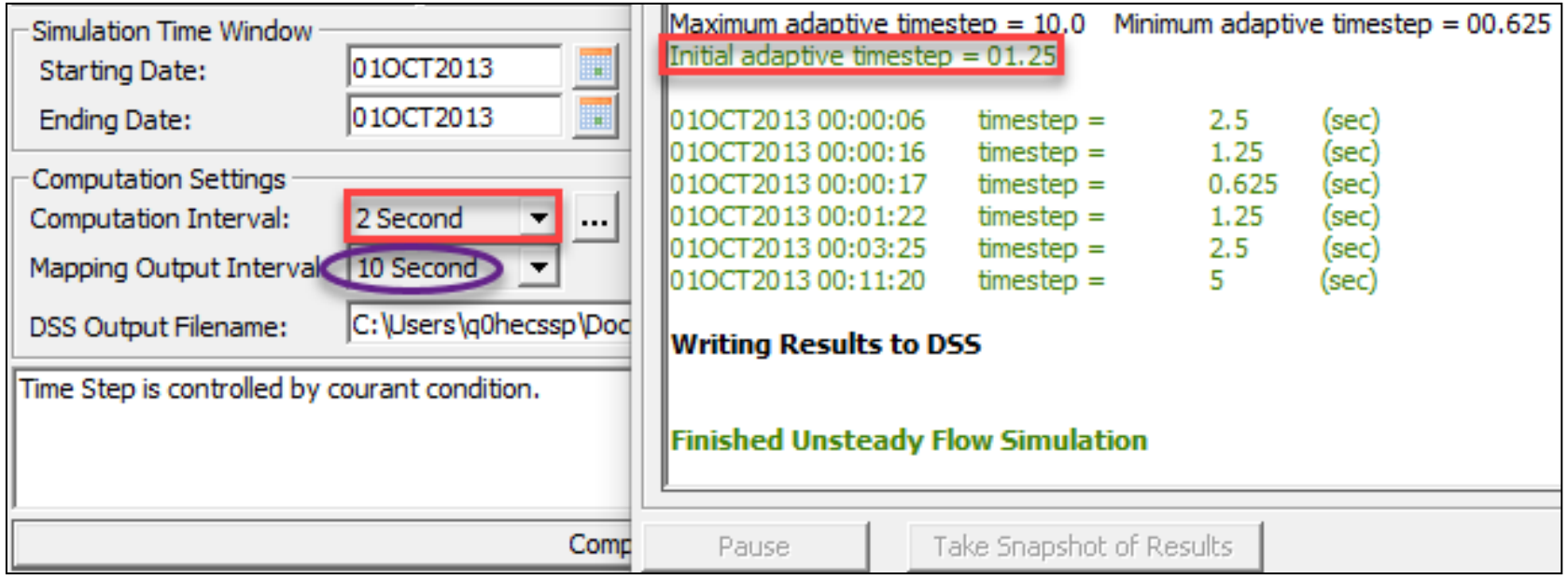
Adaptive Time Step

- Maximum Courant before halving time step
- Minimum Courant before doubling time step
  - **Min < ½ Max !**
- Number of steps before doubling
- Maximum number of doubling
- Maximum number of halving
- Courant (default) or Residence Time



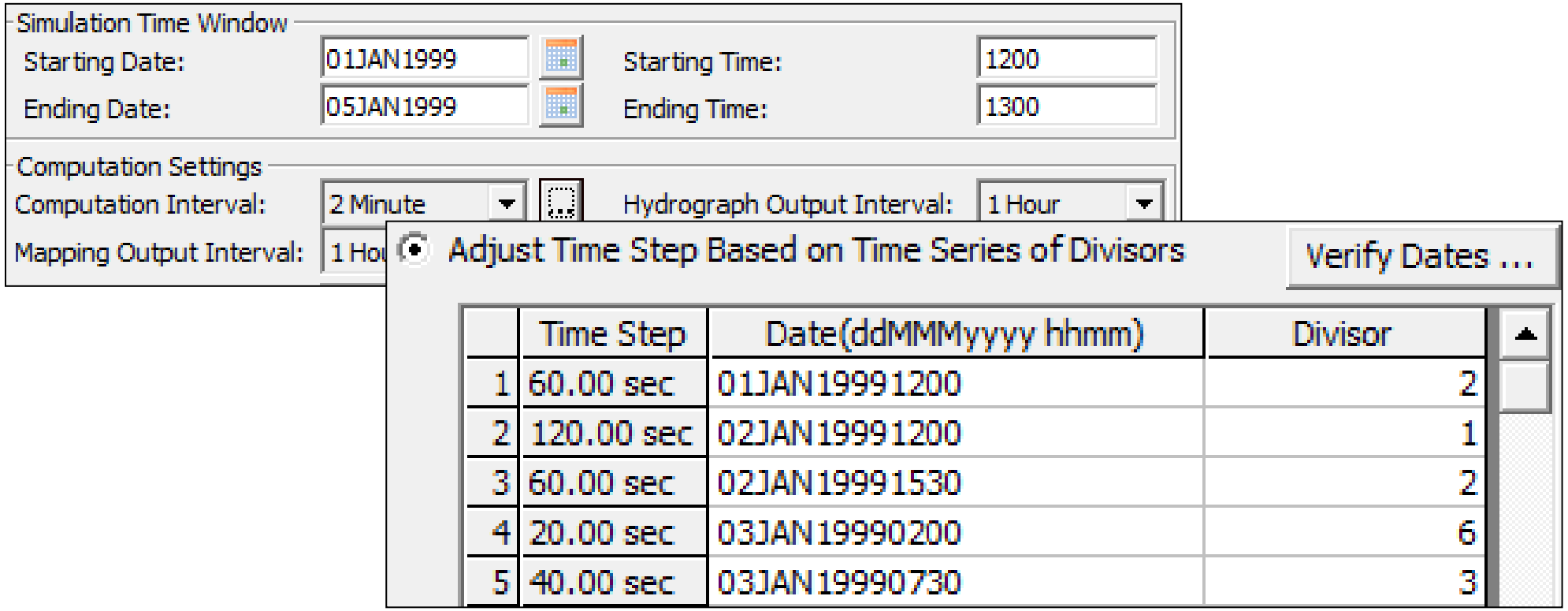
Mapping Output Interval

- Adaptive time step is always integer interval of Mapping Output Interval, so Unsteady may need to adjust base Computation Interval



Time Series of Divisors

- Control time step length by date
- Enter integer halving divisor to reduce time step



Questions?

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