



New Features of HEC-RAS 4.0

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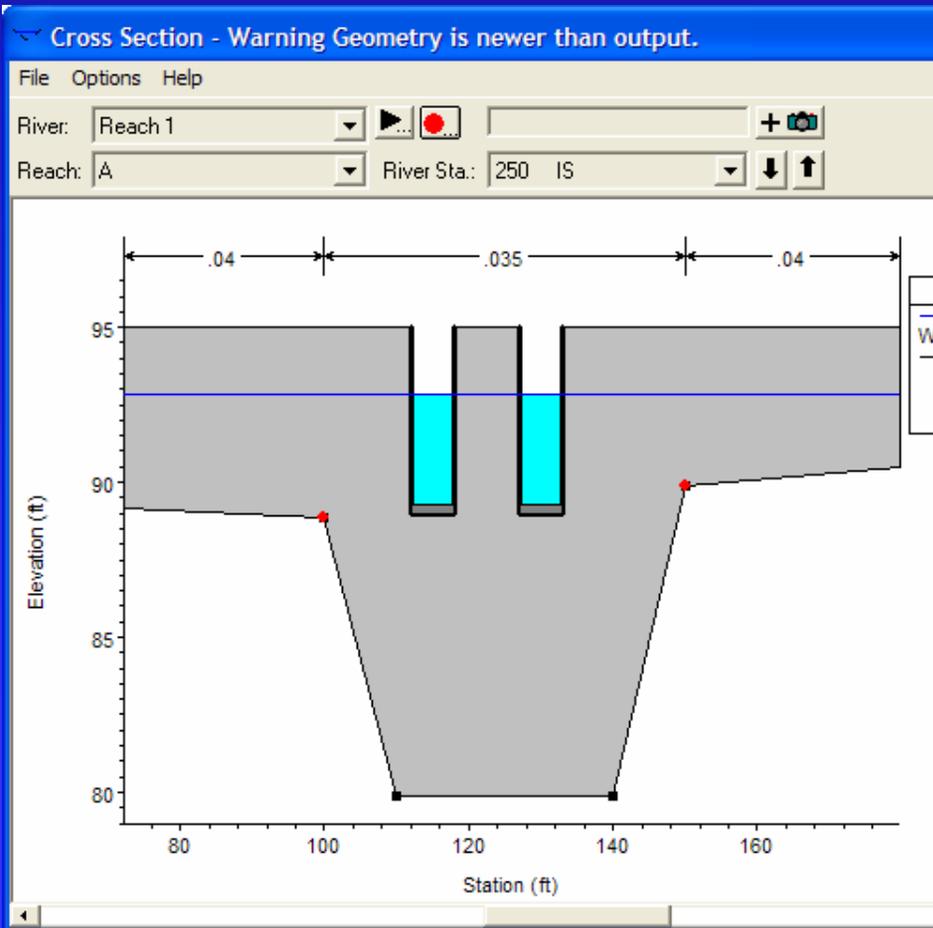
New Features in HEC-RAS 4.0

- **Overflow Gates**
- **User Defined Rules for Gate Operations**
- **Pressure Flow in Pipes**
- **Pump Station Rules**
- **Hager's Lateral Weir Equation**
- **Geo-referencing Tools**
- **Water Quality – Temperature Modeling**
- **Sediment Transport (erosion and deposition)**



Overflow Gates

- Open Air



Inline Gate Editor

Gate Group: Gate #1

Gate type (or methodology): Overflow (open air)

Geometric Properties

Height: 6

Width: 6

Invert: 89

Openings: 2

Centerline Stations

Station
1 115.
2 130.
3
4
5
6
7
8
9
10
11
12

Weir Flow Over Gate

Weir Shape: Sharp Crested

Weir Method: User entered coefficient

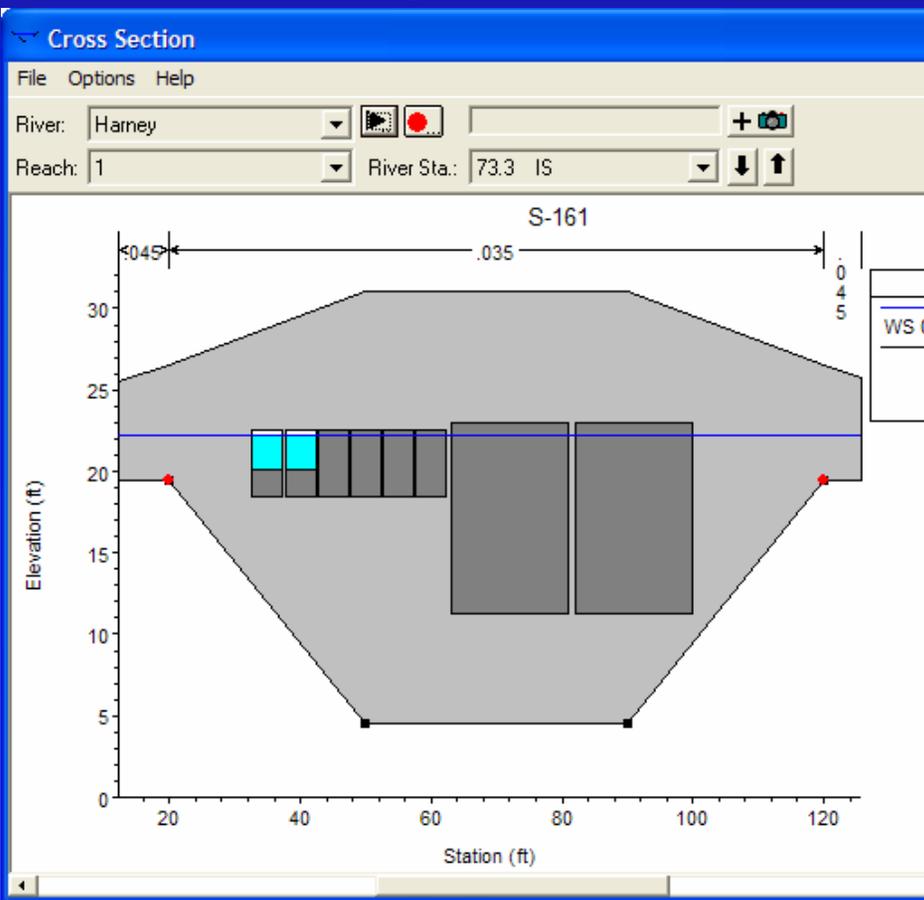
Weir Coefficient: 3.2

OK Cancel Help



Overflow Gates

- Closed Top



Inline Gate Editor

Gate Group: Gate #1

Gate type (or methodology): Overflow (closed top)

Geometric Properties

Height: 4

Width: 4.7

Invert: 18.5

Openings: 1

Centerline Stations

	Station
1	35.
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Gate Flow

Sluice Gate Flow

Sluice Discharge Coefficient (0.5-0.7): 0.7

Submerged Orifice Flow

Orifice Coefficient (typically 0.8): 0.8

Head Reference: Sill (Invert)

Weir Flow Over Gate

Weir Shape: Sharp Crested

Weir Method: User entered coefficient

Weir Coefficient: 3.27

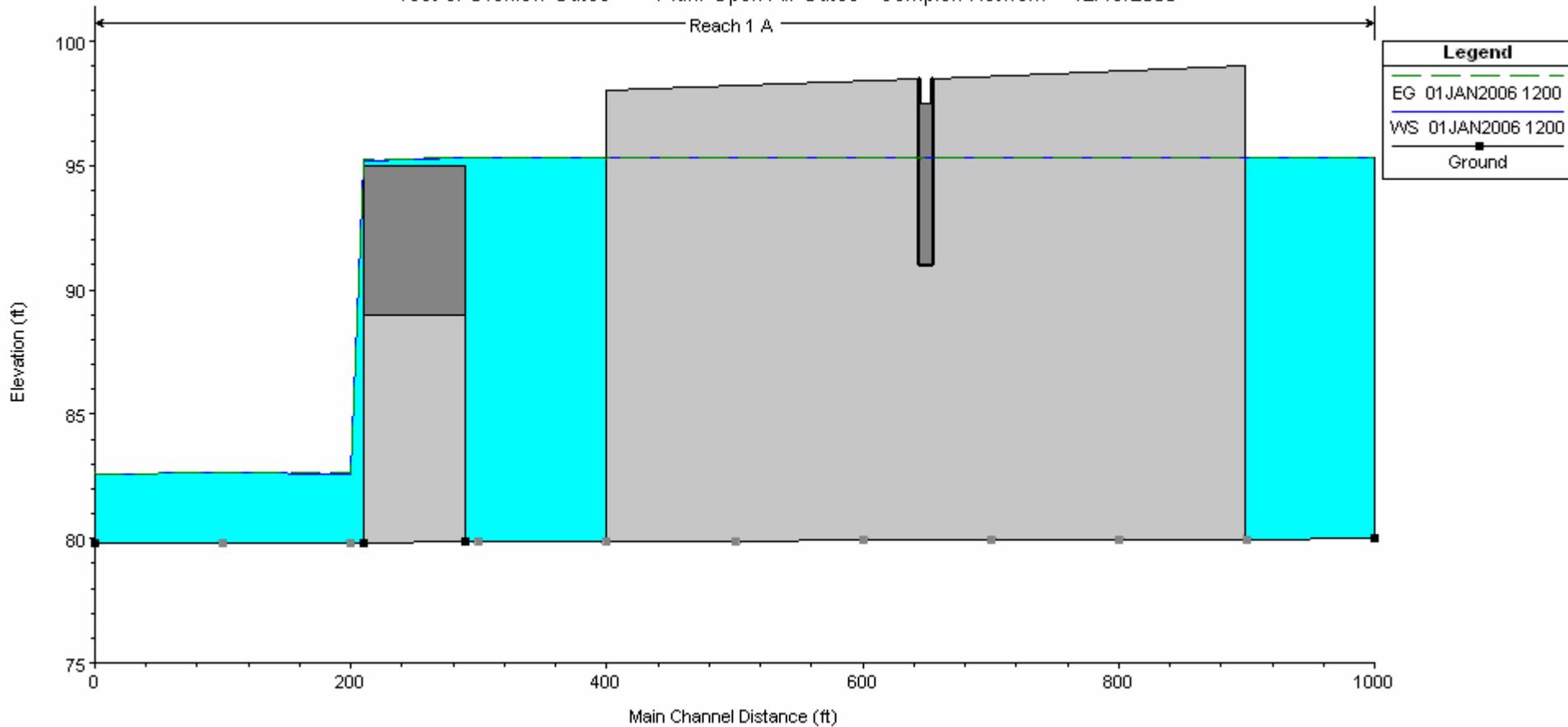
OK Cancel Help



Overflow Gates Example

Test of Overflow Gates Plan: Open Air Gates - Complex Network 12/19/2005

Reach 1 A



Legend

- EG 01 JAN 2006 1200
- WS 01 JAN 2006 1200
- Ground



Operation Rules for Gated Structures

- Unsteady Flow Editor
“Rules” boundary condition
- Inline/Lateral Structures
- Storage Area Connections
- Controls
 - ◆ Gates
 - ◆ Weir Coefficients
 - ◆ Min/Max Flow
- Rules are evaluated at every time step

Unsteady Flow Data - Unsteady Flow with ND target 22.65 wro

File Options Help

Boundary Conditions | Initial Conditions | Apply Data

Select Location for Boundary Condition

River:

Reach: River Sta.: Add a Boundary Condition Location

Boundary Condition Types

Rules

River	Reach	RS	Boundary Condition Type
1 CowHouseCk	1	12500	Flow Hydrograph
2 Harney	1	73.3 IS	Rules
3 Hillsborough	1	605400	Flow Hydrograph
4 Hillsborough	1	605101.*	Lateral Inflow Hydr.
5 Hillsborough	1	605100	Lateral Inflow Hydr.
6 Hillsborough	1	604999 IS	T.S. Gate Openings
7 Hillsborough	1	602447.*	Lateral Inflow Hydr.
8 Hillsborough	1	602400	Lateral Inflow Hydr.
9 Hillsborough	1b	601300	Lateral Inflow Hydr.
10 Hillsborough	1h	601050	Lateral Inflow Hydr.

Storage Area and SA Connections: Add a Boundary Condition Location

Storage Area or SA Connection	Boundary Condition Type
1	

Initial internal water surface elevations set
Observed DSS data set



User Defined Rules Editor for Operating Gated Structures

Operation Rules

Rule Based Operations

row	Operation	True	False
1	Real 'Tampa Dam Vol since midnight' (Initial Value = 0)	2	2
2	Real 'S-161 Vol since midnight' (Initial Value = 0)	3	3
3	Real 'S-161 Vol Diversion'	4	4
4	'Tampa Dam 4 Hour Ave Flow' = Inline Structures:Structure - Total Flow (Fixed)(Hillsborough,2,600042,Average over previous time window,4,0)	5	5
5	'Time Step hours' = Solution:Time Step(Value at current time step)	6	6
6	'Time Step seconds' = 3600 * 'Time Step hours'	7	7
7	'Tampa Dam Flow' = Inline Structures:Structure - Total Flow (Fixed)(Hillsborough,2,600042,Value at current time step)	8	8
8	'S-161 Flow' = Inline Structures:Structure - Total Flow (Fixed)(Harney,1,73.3,Value at current time step)	9	9
9	'Tampa Dam Vol since midnight' = 'Tampa Dam Flow' * 'Time Step seconds' + 'Tampa Dam Vol since midnight'	10	10
10	'S-161 Vol since midnight' = 'S-161 Flow' * 'Time Step seconds' + 'S-161 Vol since midnight'	11	11
11	'Day Beg time step' = Time:Day of Month(Beginning of time step)	12	12
12	'Day End time step' = Time:Day of Month(End of time step)	13	13
13	If ('Day Beg time step' <> 'Day End time step') Then	14	50
14	'HR 24hour ave Flow' = 'Tampa Dam Vol since midnight' + 'S-161 Vol since midnight' / 86400	15	15
15	'Tampa Dam Vol since midnight' = 0	16	16
16	'S-161 Vol since midnight' = 0	17	17

Insert New Operation

Current Operation Changes

Disable

Get Simulation Value

Assign Result

Existing Variable
 New Variable

S-161 Flow =

Inline Structures
 Structure - Total Flow (Fixed)
Structure - Total Flow (Desired)
Structure - Flow Additional
Structure - Flow Maximum
Structure - Flow Minimum
 Structure - Total Gate Flow
Structure - Total Gate Flow Maxi
Structure - Total Gate Flow Mini
 Structure - Gate Master Setting

Set Node Location

River: Harney
 Reach: 1
 RS: 73.3 IS

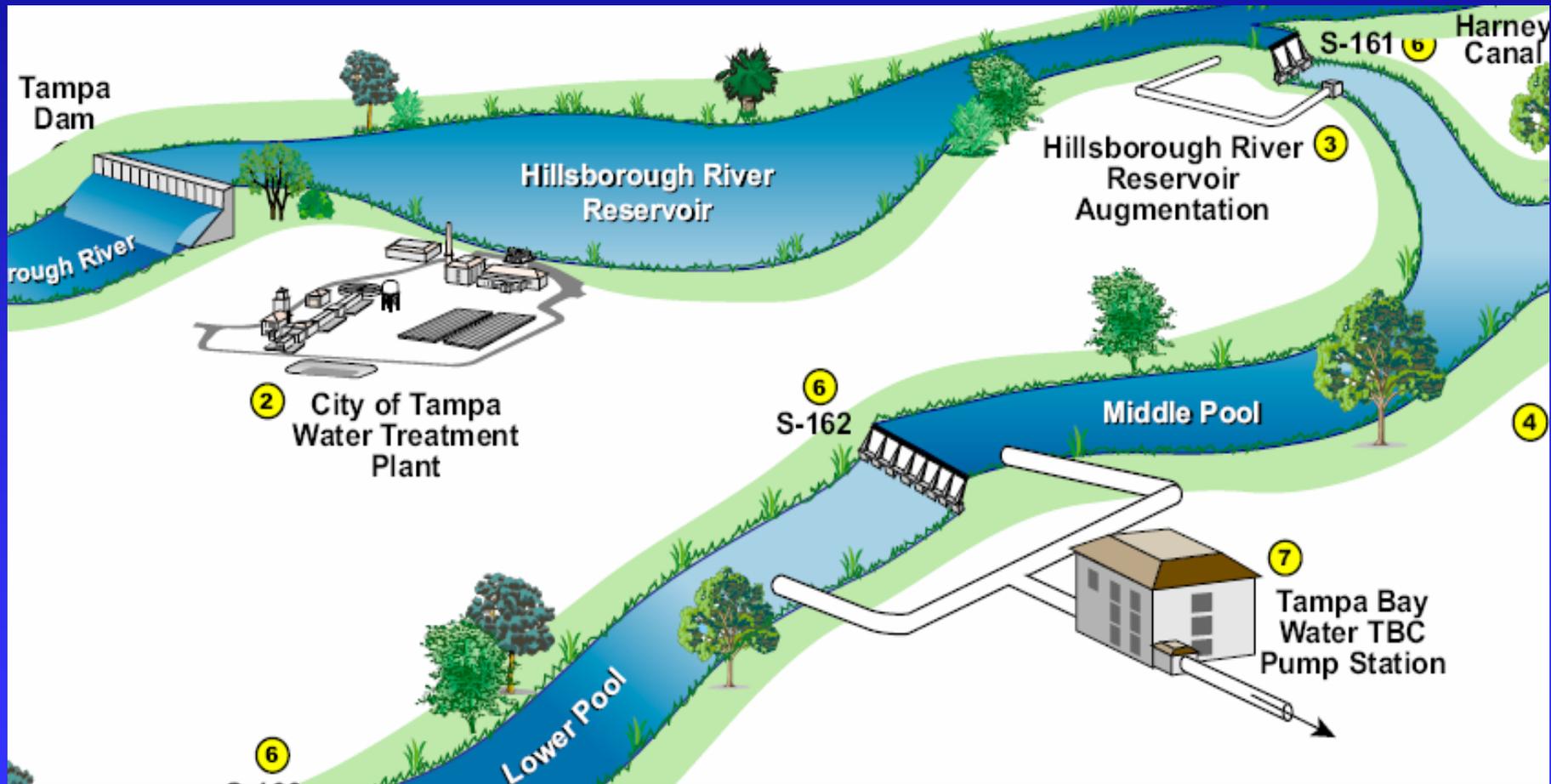
Value at current time step

(Simulation variables in bold are only available for the current structure)

OK Cancel



Tampa Bay Water System Overview





TBW S-161 Diversion Structure Rules

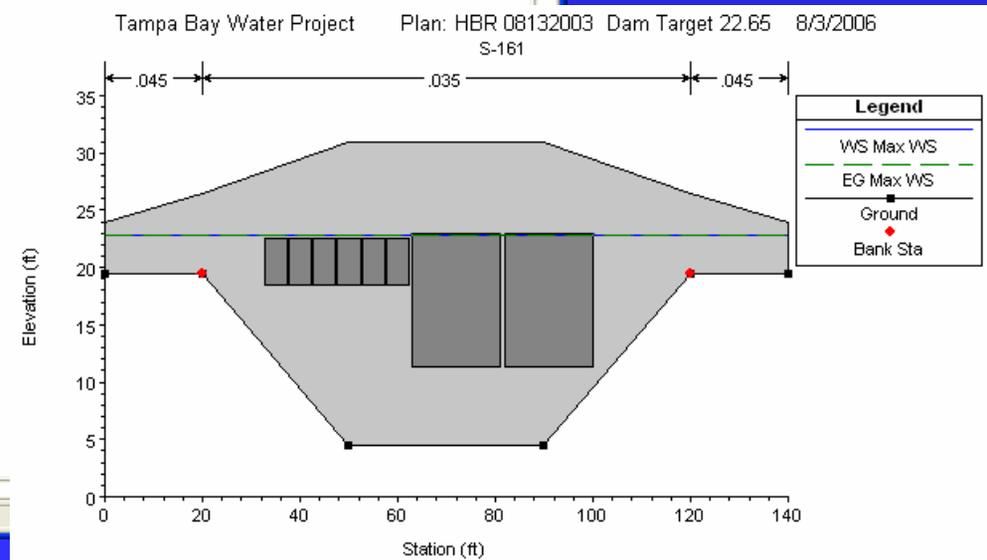
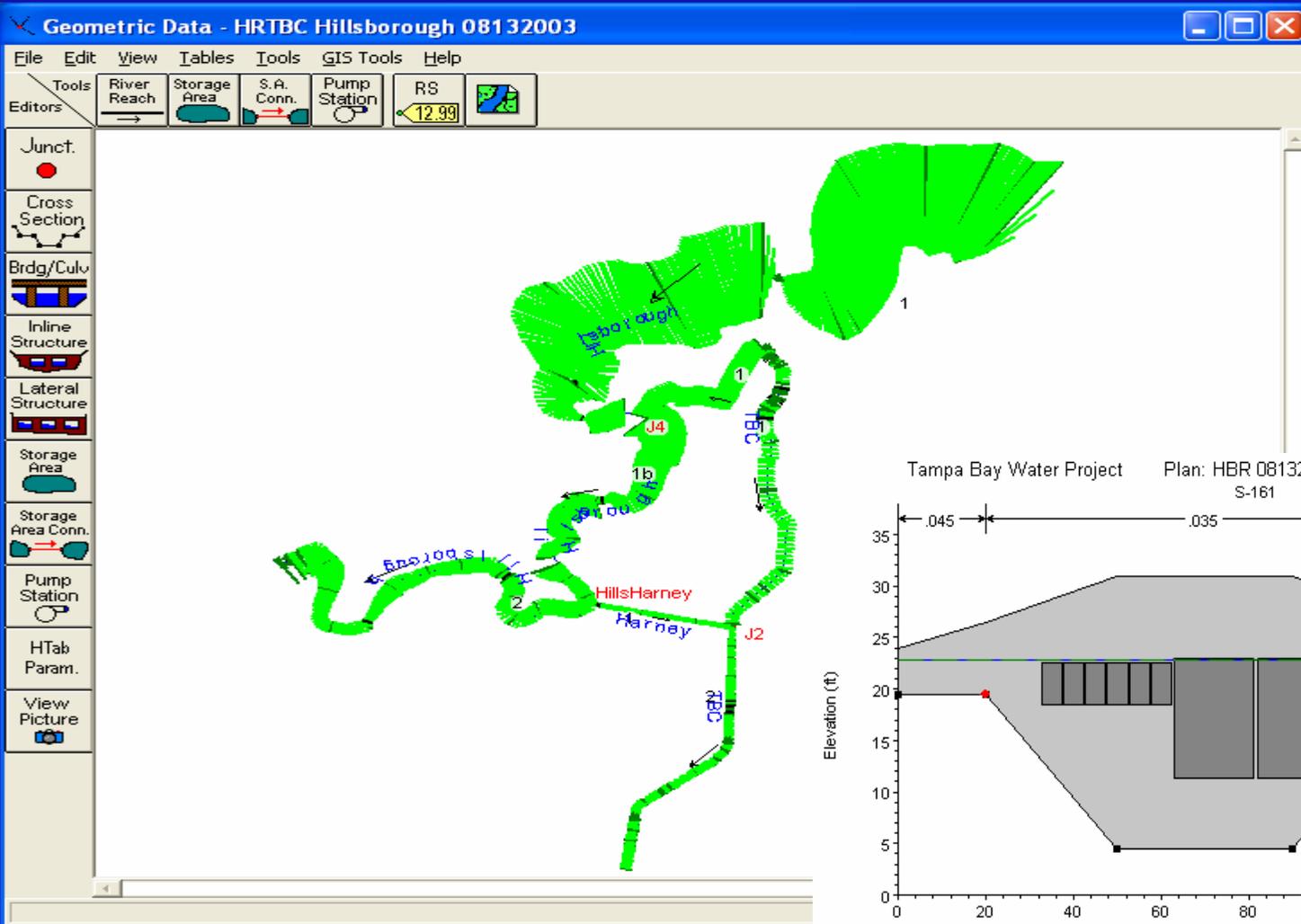
- **Get previous 24 hour outflow**
 - ♦ **Outflow includes Tampa Dam & S-161**
- **Determine allowable diversion:**

<i>Discharge at Tampa Dam (mgd)</i>	<i>Withdrawal from Middle Pool (mgd)</i>
Less than 65	0
65-97	10% of the discharge at Tampa Dam
97-139	10-30% of the discharge
139-647	30% of the discharge
More than 647	194

- **Adjust S-161 gates to get allowable diversion in ~20 hours**
- **Close gates when/if:**
 - ♦ **Maximum volume diverted**
 - ♦ **4 hour running average at Tampa Dam < 10cfs**



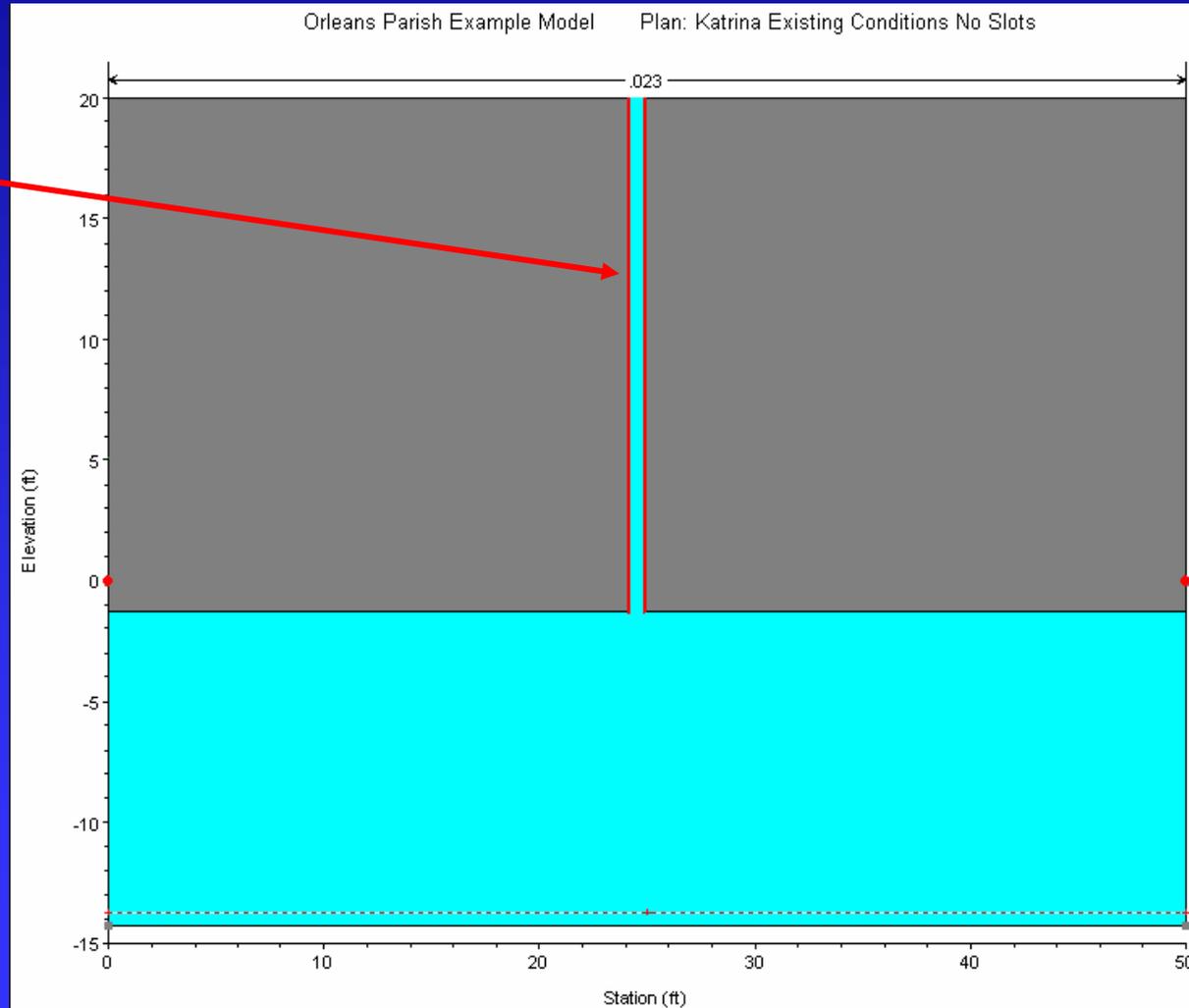
Animation of Gate Operations Tampa Bay Water Project Hillsborough River – Harney Canal





Pressurized Pipe Flow

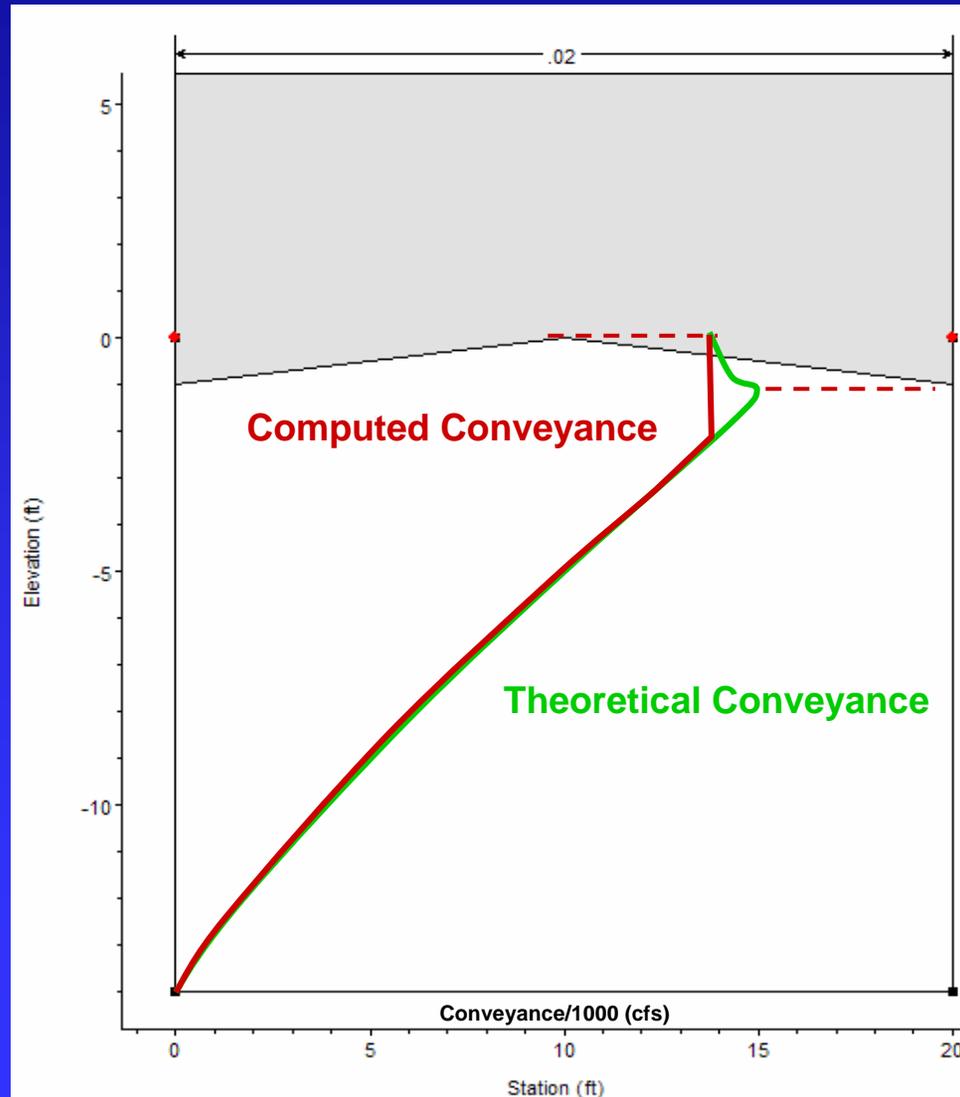
- **Priessman Slot** – insertion of an infinitesimal slot into the XS lid
- Any Pipe Shape
- Allows the water surface to rise to the pressure head (hydraulic grade line)





Pressurized Pipe Flow

- Conveyance and wetted perimeter are cut off at top of pipe
- Area is added, but it is negligible
- Conveyance curve is truncated to local minimum to increase stability





Pump Station Override Rules

Pump Station Data Editor

Pump Station Name: Pump15

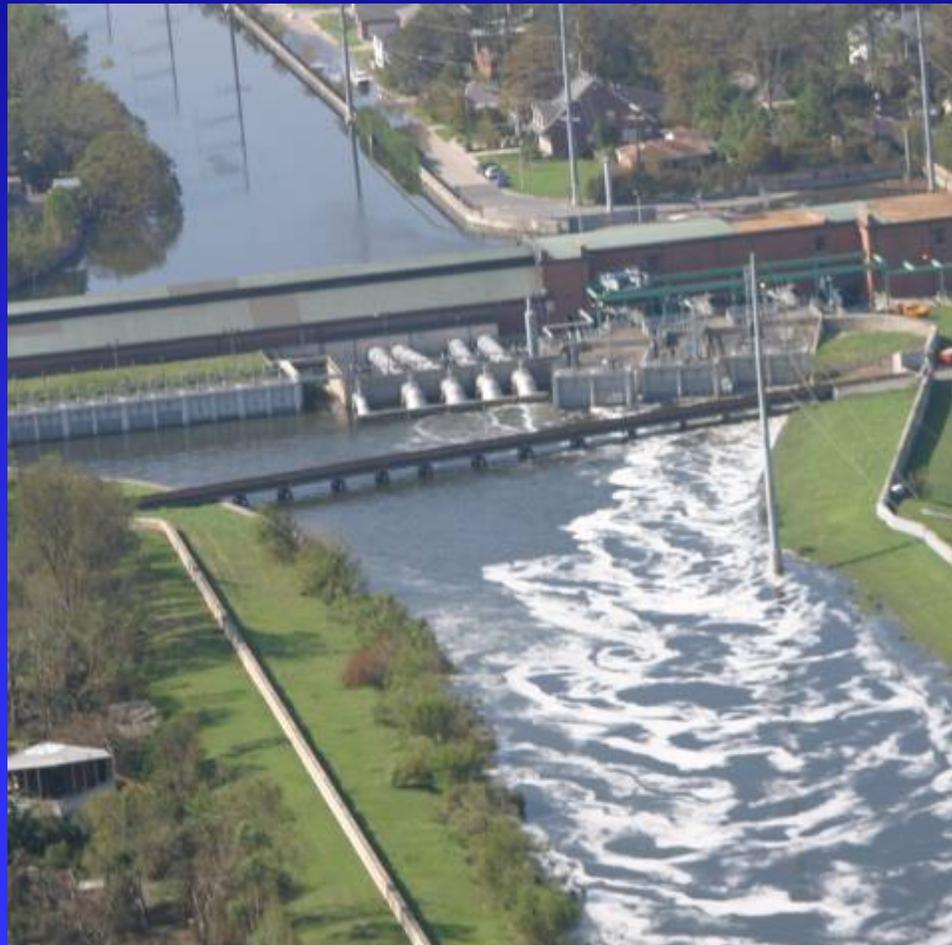
Pump Connection Data | Pump Group Data | **Advanced Control Rules**

Pump Rules

- Day/Hour based rule - flow max = 0 start at: 28AUG 0000 end at: 28AUG 1330
- Day/Hour based rule - flow max = 250 start at: 28AUG 1330 end at: 28AUG 1530**
- Day/Hour based rule - flow max = 750 start at: 28AUG 1530 end at: 28AUG 1545
- Day/Hour based rule - flow max = 500 start at: 28aug 1545 end at: 2aug 1600
- Day/Hour based rule - flow max = 0 flow min = 0 start at: 28AUG 1600 end at: 13SEP 0900

Edit Current Selected Rule

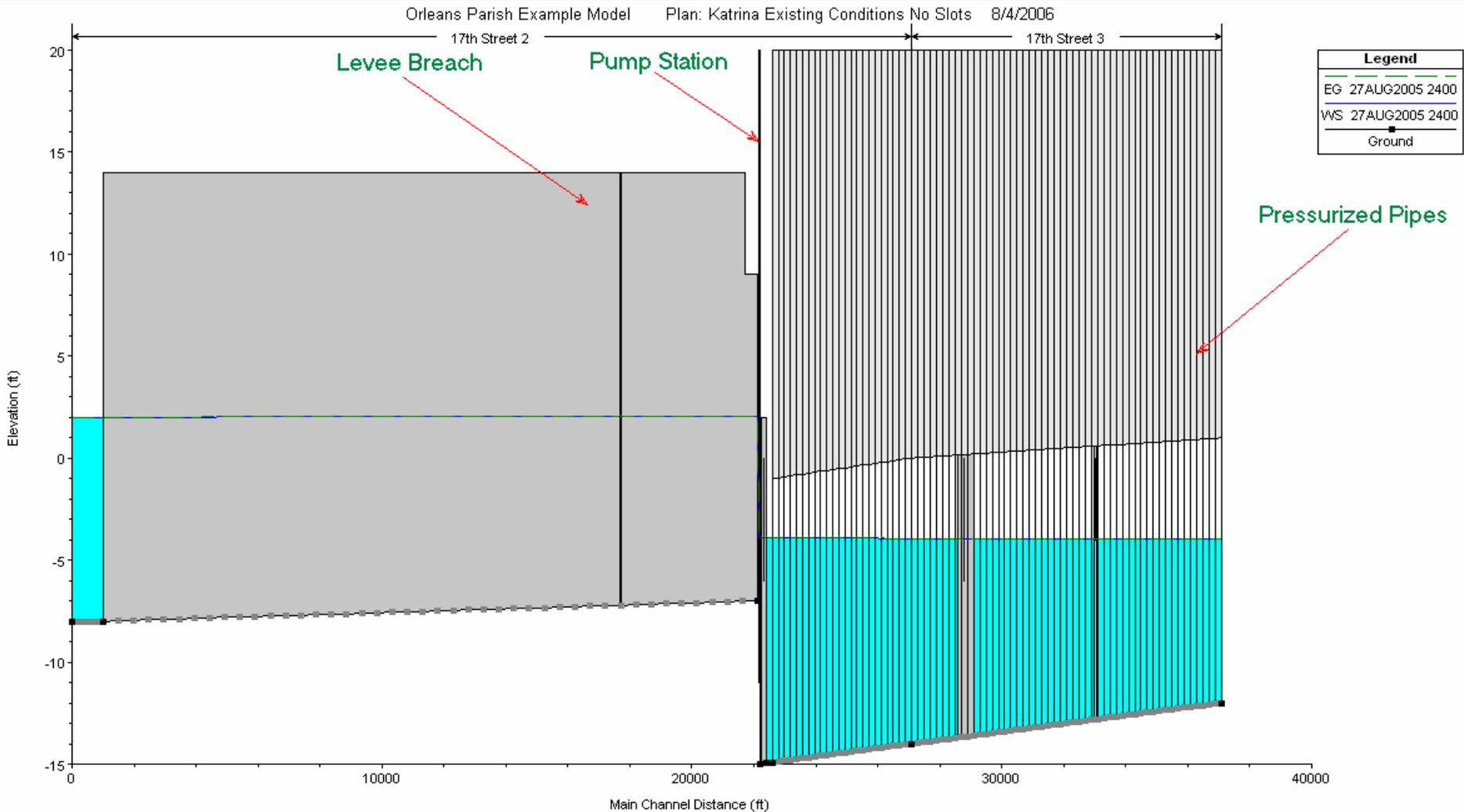
Rule Flow Maximum:	<input type="text" value="250"/>	Rule Flow Minimum:	<input type="text"/>
Transition (min):	<input type="text" value="5"/>	Transition (min):	<input type="text" value="5"/>
Rule Start Day:	<input type="text" value="28AUG"/>	Rule Start Hour:	<input type="text" value="1330"/>
Rule End Day:	<input type="text" value="28AUG"/>	Rule End Hour:	<input type="text" value="1530"/>



New Orleans - 17th Street Pump Station



Pressurized Pipes, Pump Station, And Levee Breach Animation



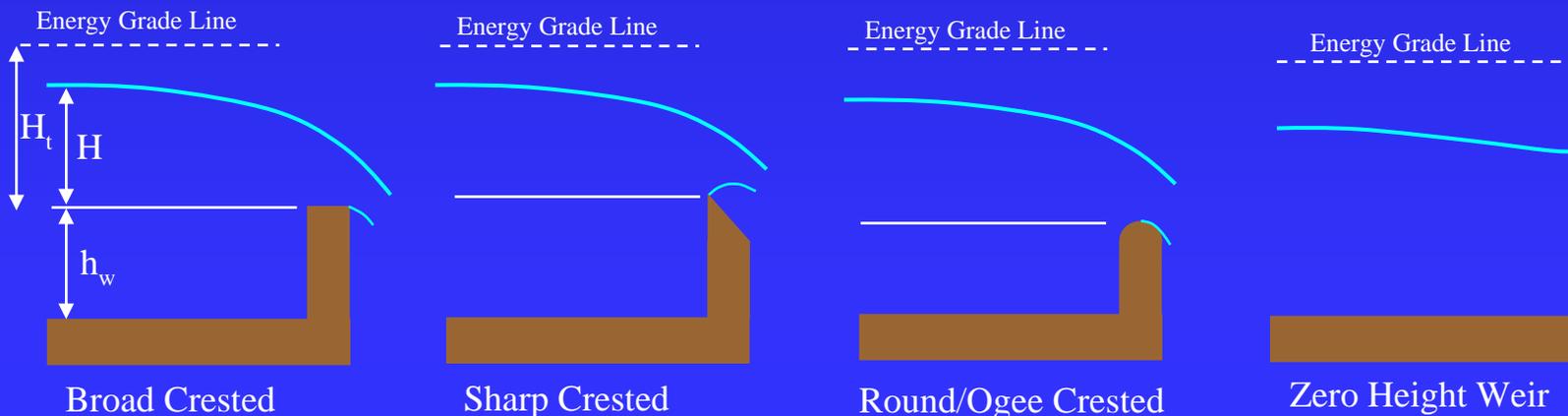


Hager's Lateral Weir Equation

$$Q = CLH^{3/2}$$

$$C = \frac{3}{5} C_0 \sqrt{g} \left[\frac{1-W}{3-2y-W} \right]^{0.5} \left\{ 1 - (\beta + S_0) \left[\frac{3(1-y)}{y-W} \right]^{0.5} \right\}$$

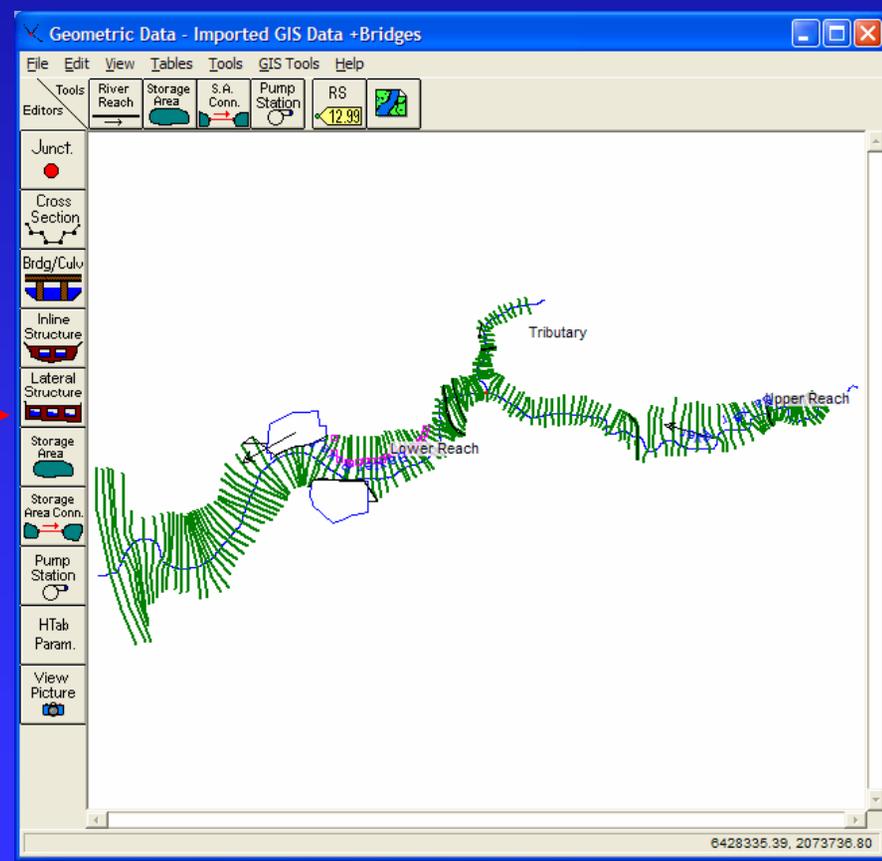
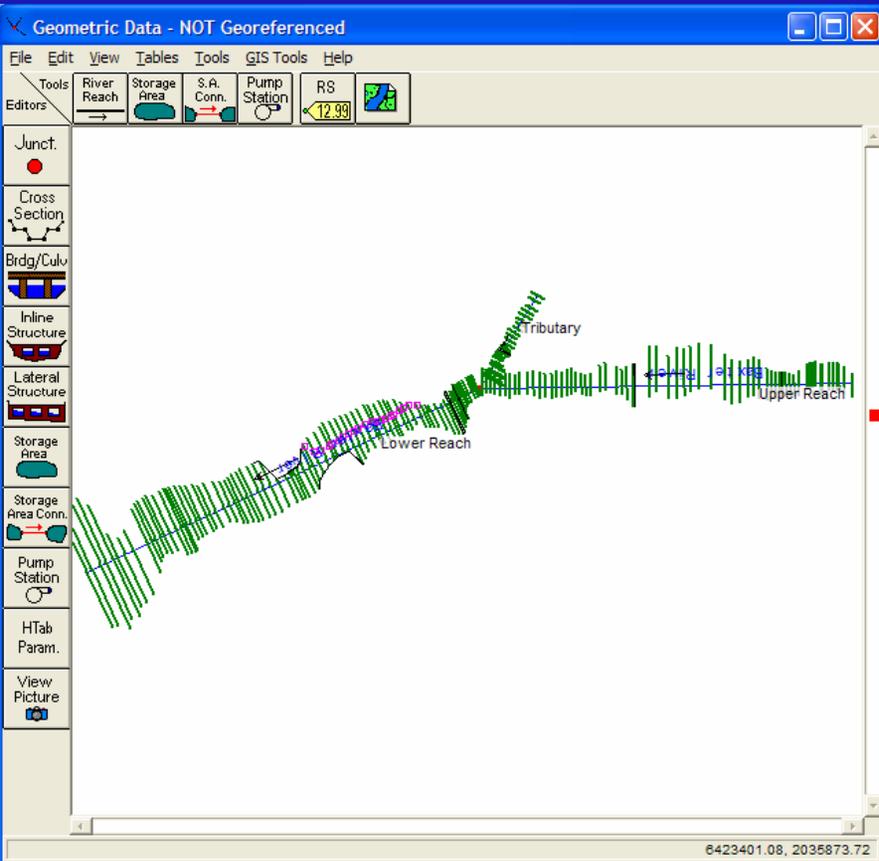
$$W = \frac{h_w}{H_t + h_w} \quad y = \frac{H + h_w}{H_t + h_w} \quad C_0 = \text{Function}(\text{weir shape})$$





Geo-referencing Tools in HEC-RAS

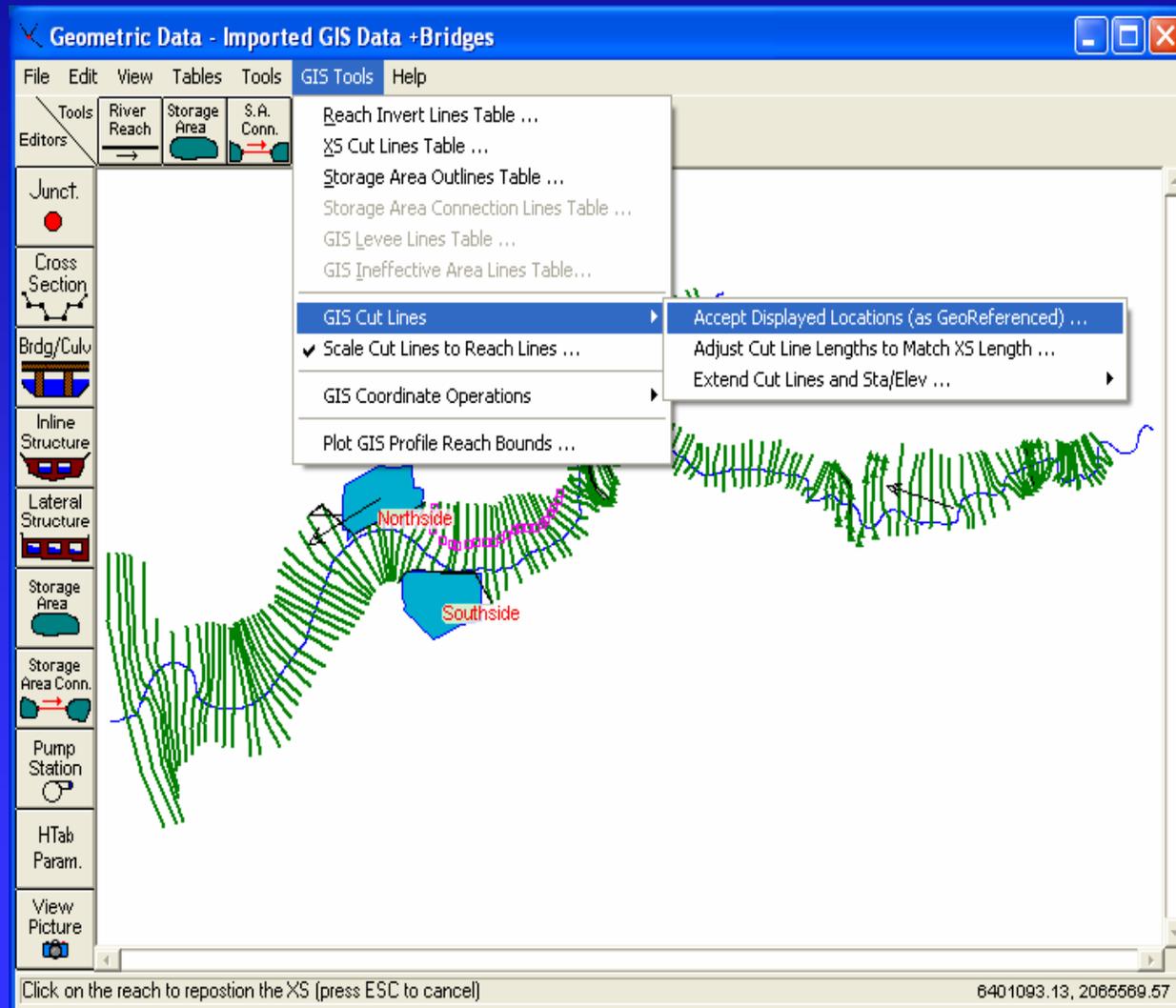
- From “stick figure” to real locations





Geo-referencing Tools in HEC-RAS

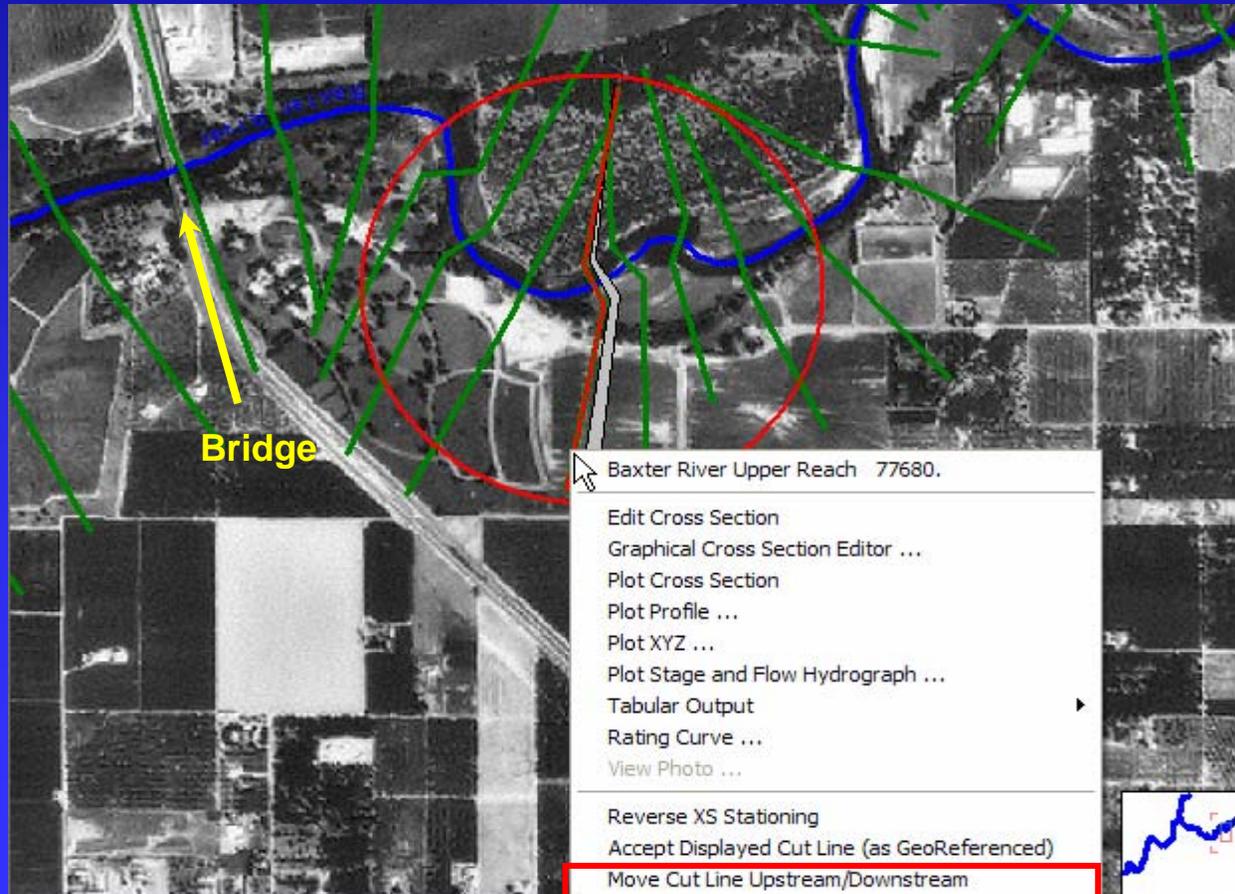
- Fix the cross sections at “known” locations
- RAS will help move the rest of the sections





Geo-referencing

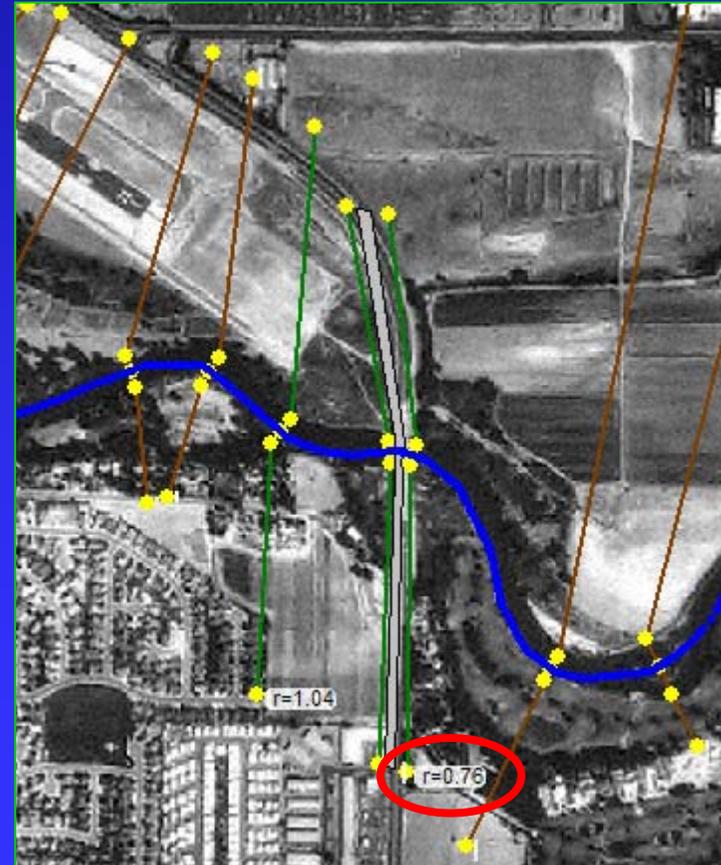
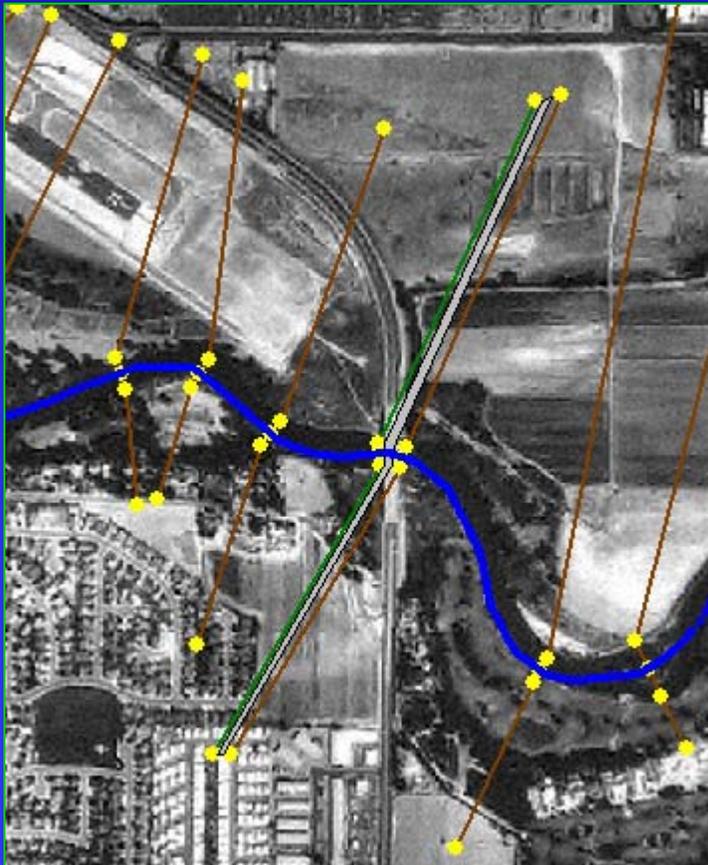
- Move Cut Line Upstream/Downstream





Geo-referencing

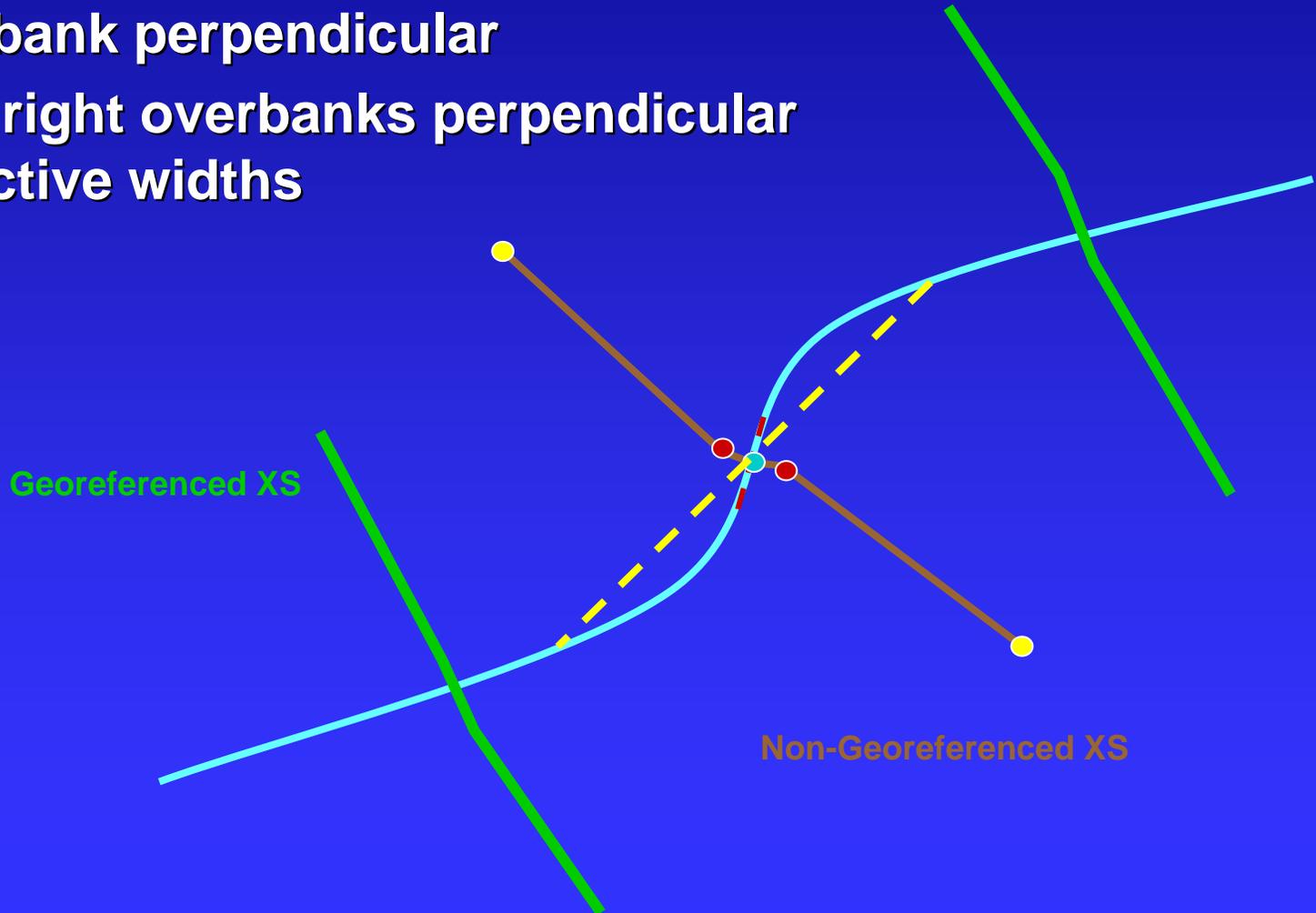
- Edit | Move Object





Geo-referencing: New XS Interpolation

- Bank to bank perpendicular
- Left and right overbanks perpendicular to respective widths



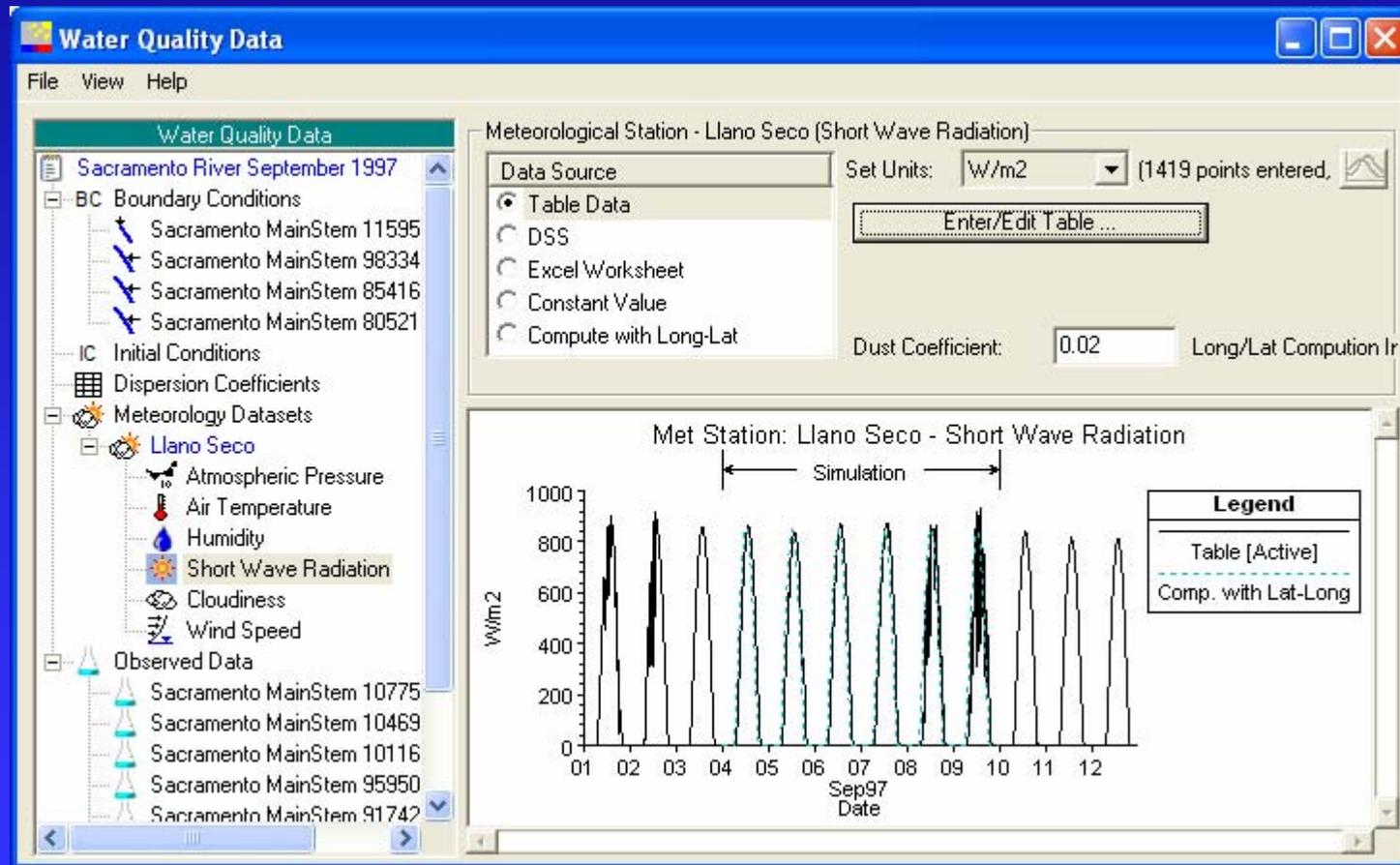


Water Quality (Temperature) Model

- **Based on unreleased version of CE-QUAL-RIV1**
- **Numerical Scheme**
 - ♦ **Finite Volume**
 - ♦ **Variable grid size**
 - ♦ **Automatic time step selection**
- **Full energy budget**

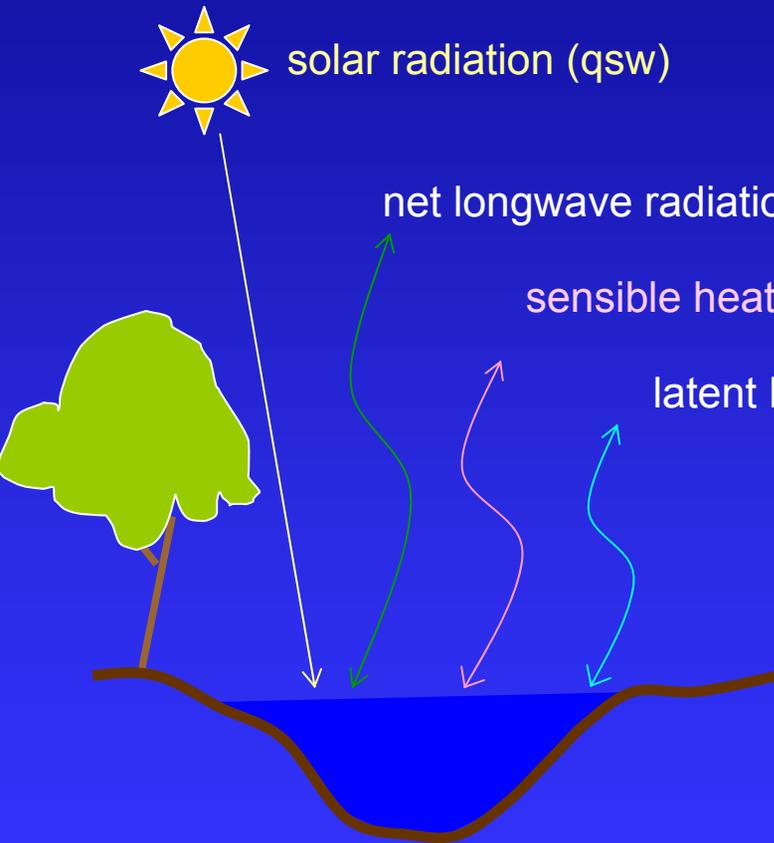


Meteorological Data Editor – Solar Radiation





Source/Sink Term for Temperature (Energy Budget)



solar radiation (q_{sw})

f (site location, time of day, day of year, atmospheric turbidity, cloud cover)

net longwave radiation (q_{lw})

f (air temperature, water temperature)

sensible heat (q_h)

f (temperature gradient, wind, a&b)

latent heat (q_e)

f (vapor pressure gradient, wind, a&b)

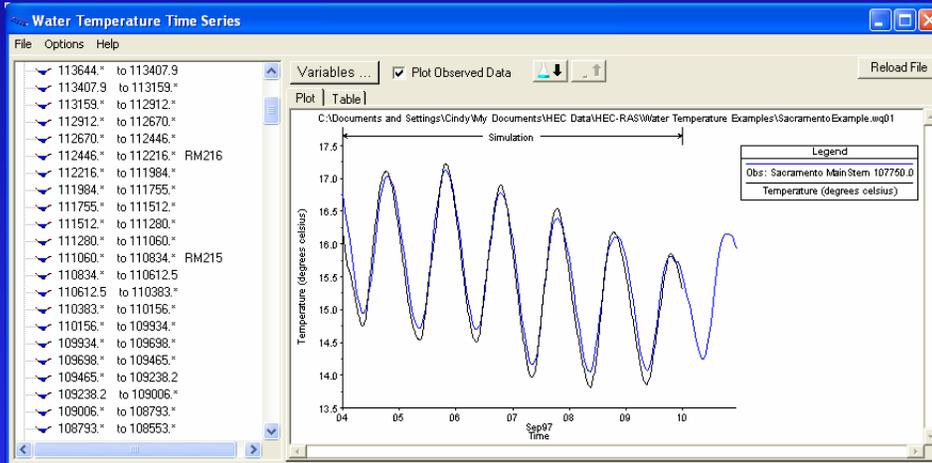
$$q_{net} = q_{sw} + q_{lwn} + q_h + q_e$$

Planned:

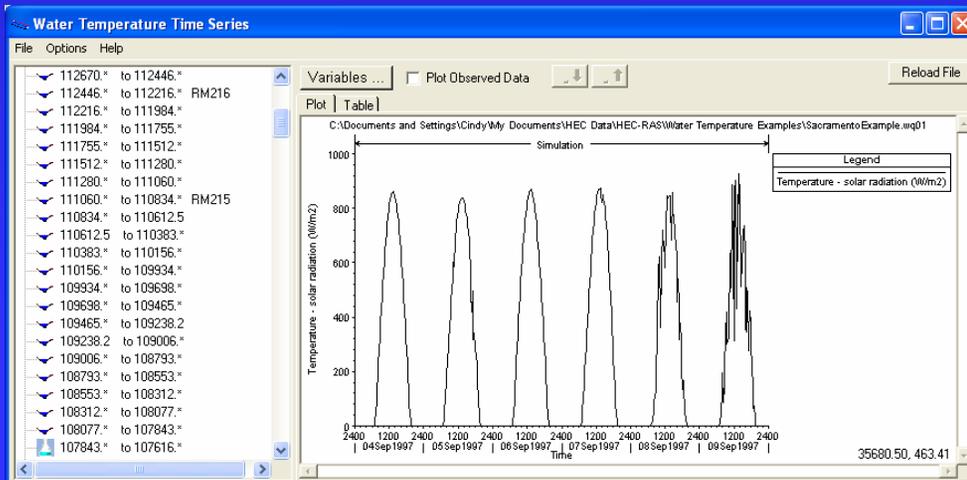
- ground heat conduction
- shading (topographic, riparian)



Time Series Plots



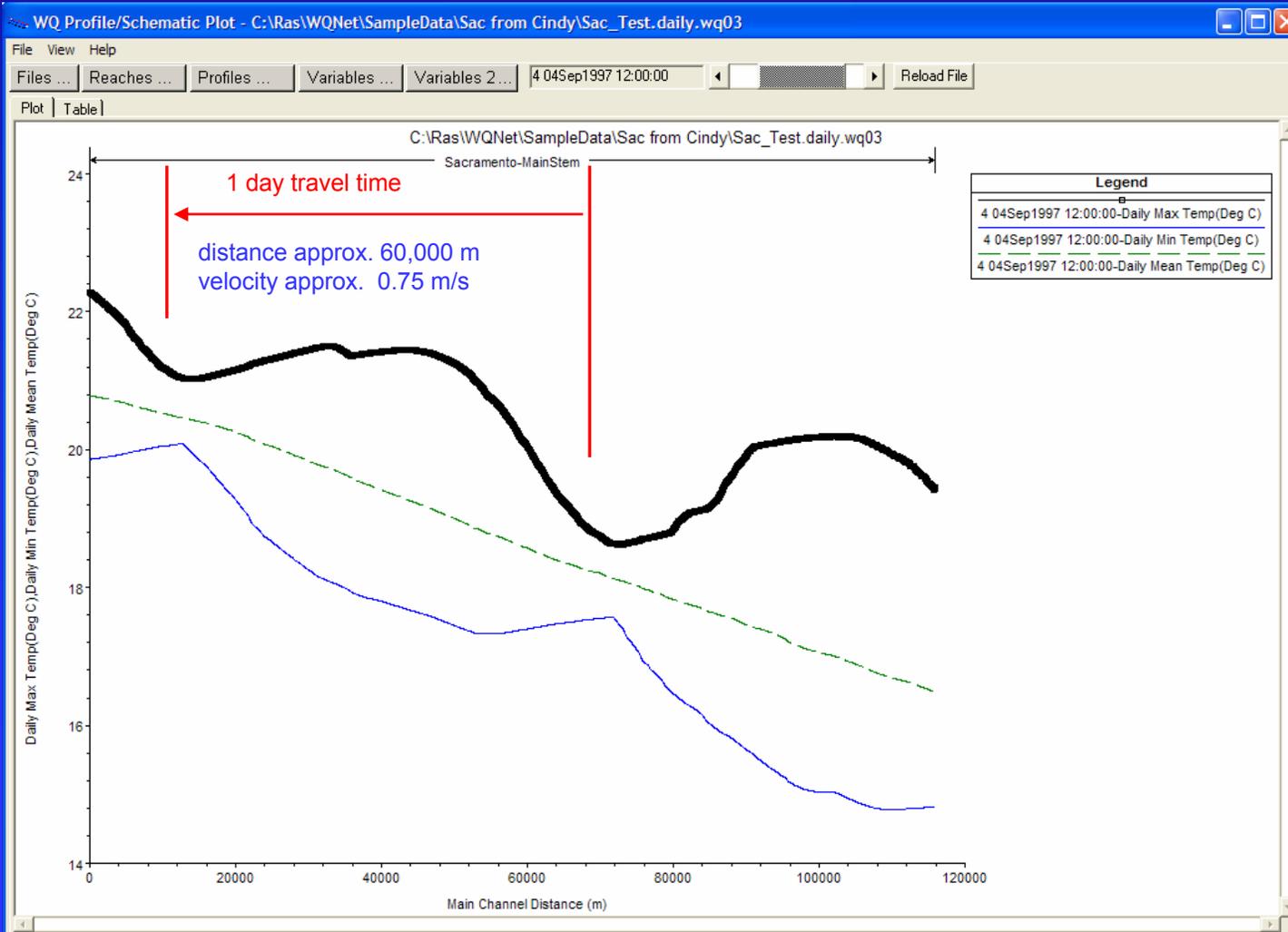
Water temperature



Solar Radiation

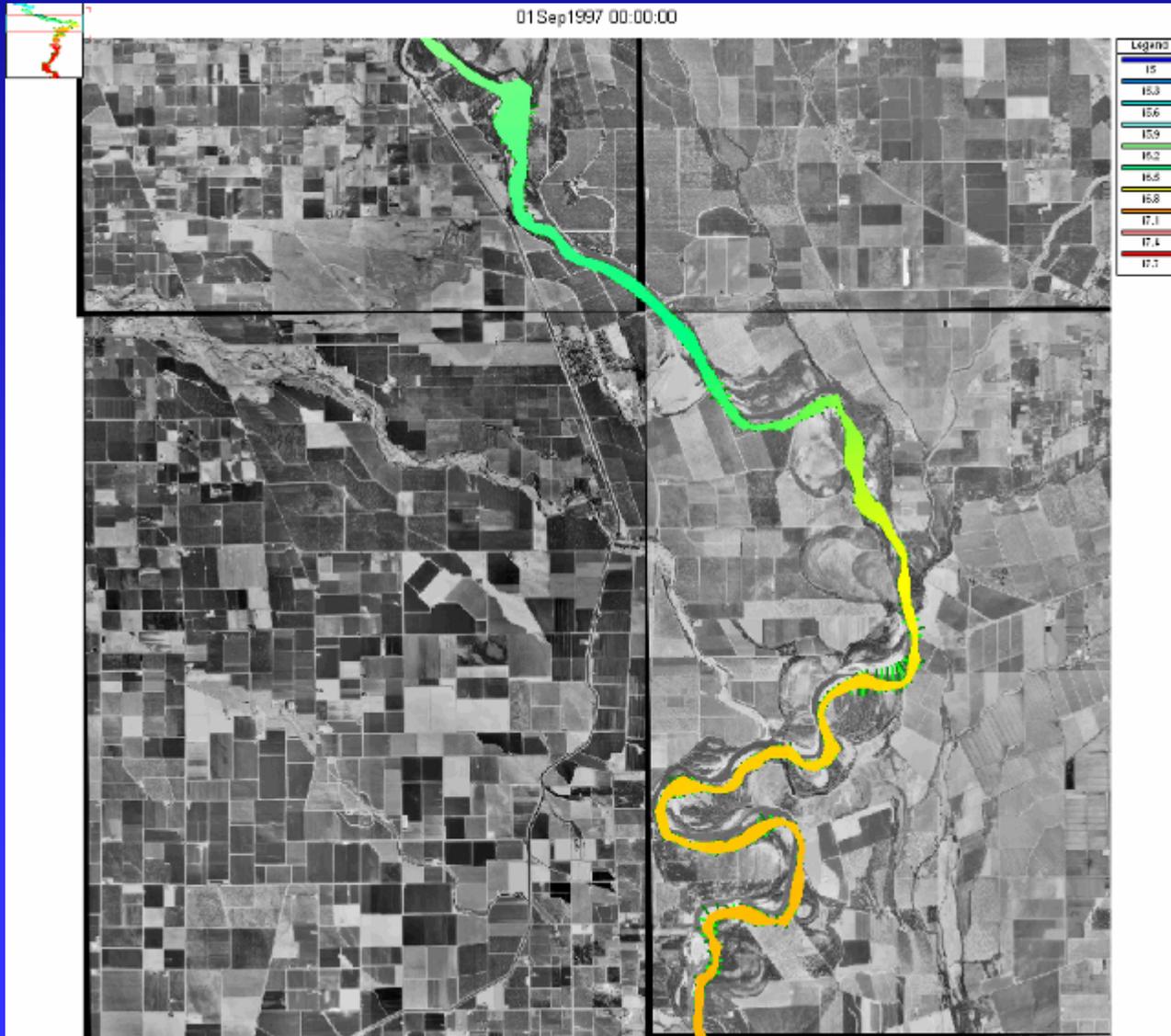


Profile Plot of Temperature





Map View





Mobile Bed Sediment Transport

- **Quasi-Steady Hydrodynamics**
- **Transport Capacity**
- **Sediment continuity**
- **Sorting and Armoring**
- **Erosion and Deposition**
- **Graphical User Design**



Transport Potential Functions

- Ackers-White
- Englund-Hansen
- Laursen (Copland)
- Myer-Peter-Meuler
- Toffaleti
- Yang (Sand and Gravel)
- Wilcock



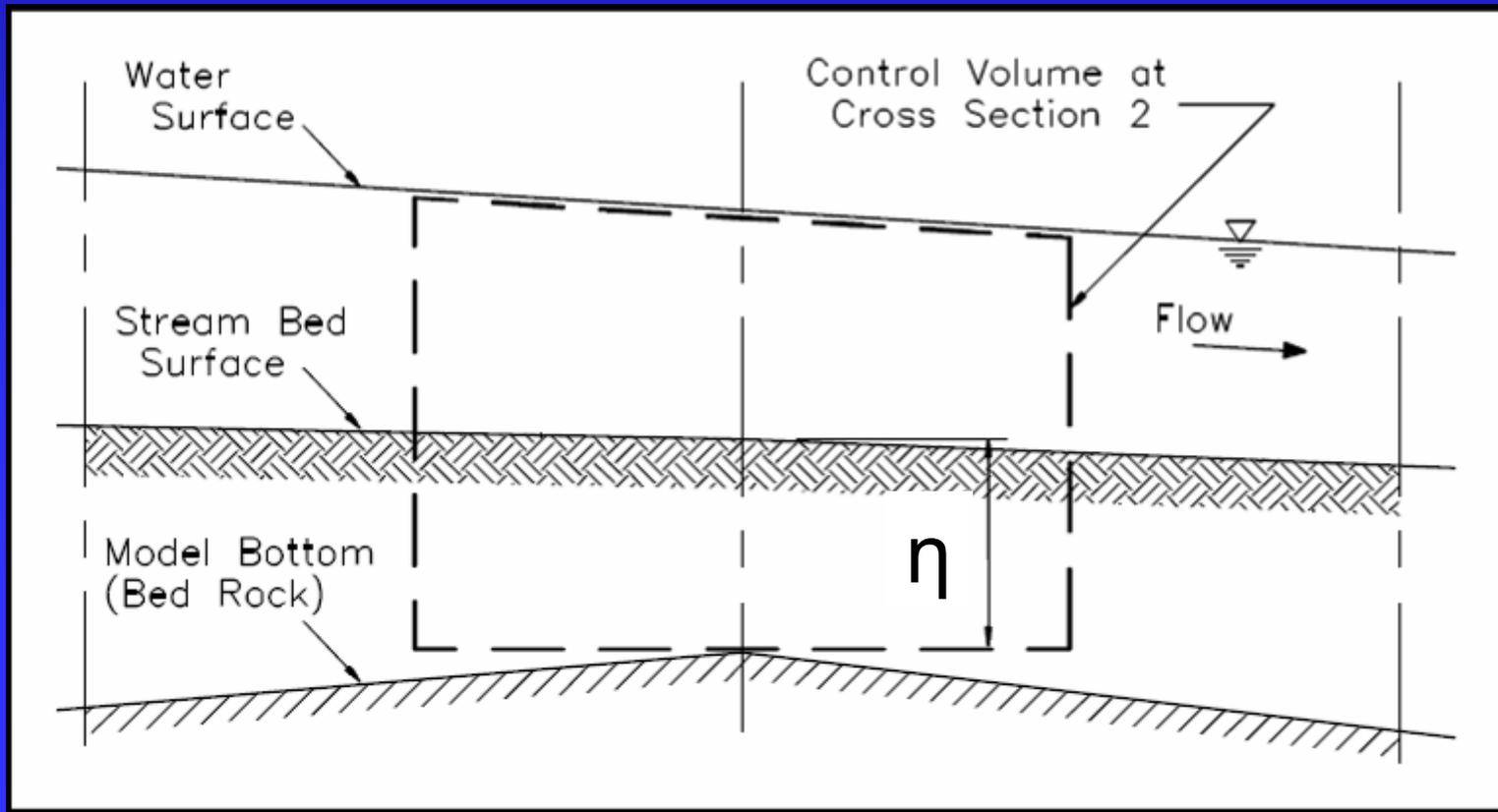
Transport Capacity by Multiple Grain Sizes

- **Bed Material and Inflowing Load divided into separate grain classes (up to 20)**
- **Transport potential is calculated for each grain size**
- **Transport Capacity = (Transport Potential for each grain size) X (fraction of that material in active layer of bed)**



Sediment Continuity: Exner Equation

$$(1 - \lambda_p) B \frac{\partial \eta}{\partial t} = - \frac{\partial Q_s}{\partial x}$$





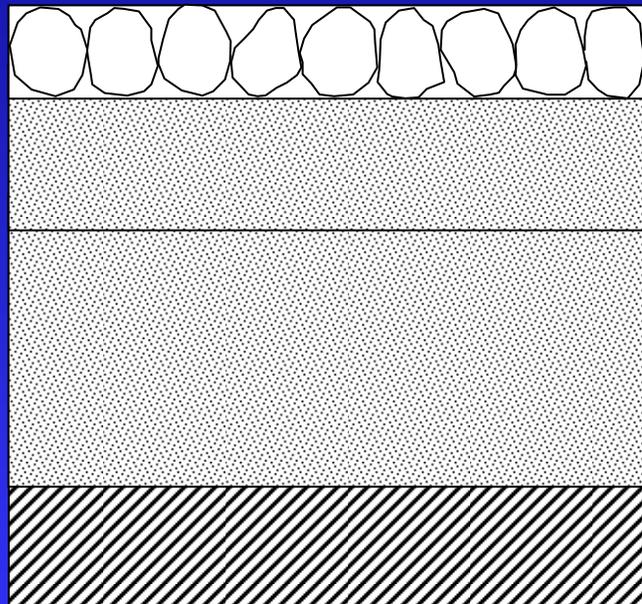
Temporal Constraints on Eroding and Depositing

- Erosion and deposition does not occur instantaneously.
- Deposition is based on settling velocity:
 - ♦ Deposition efficiency coefficient =
$$\frac{V_s(i) \cdot \Delta t}{D_e(i)}$$
- Erosion is based on “Characteristic Flow Length”
 - ♦ Erosion = $(G_s - Q_s) \times C_e$ Entrainment Coefficient
 - ♦ Where:

$$C_e = 1.368 - e^{-\frac{L}{30 \cdot D}}$$



Sorting and Armoring



Cover Layer

Subsurface Layer

Inactive Layer

Bedrock Layer

Active Layer

Diagramed and Conceptualized HEC 6 Code

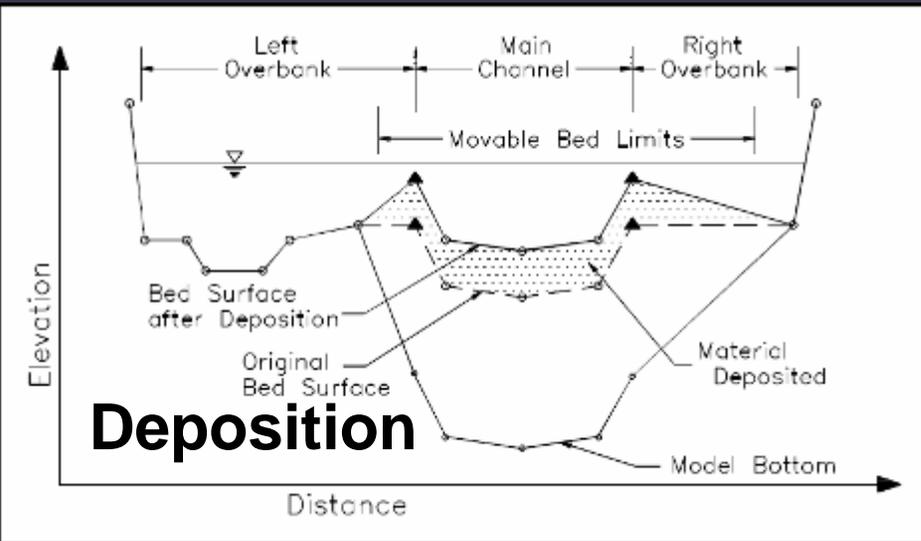
Exner 5 implemented Currently in RAS

Also Simple Active Layer Method

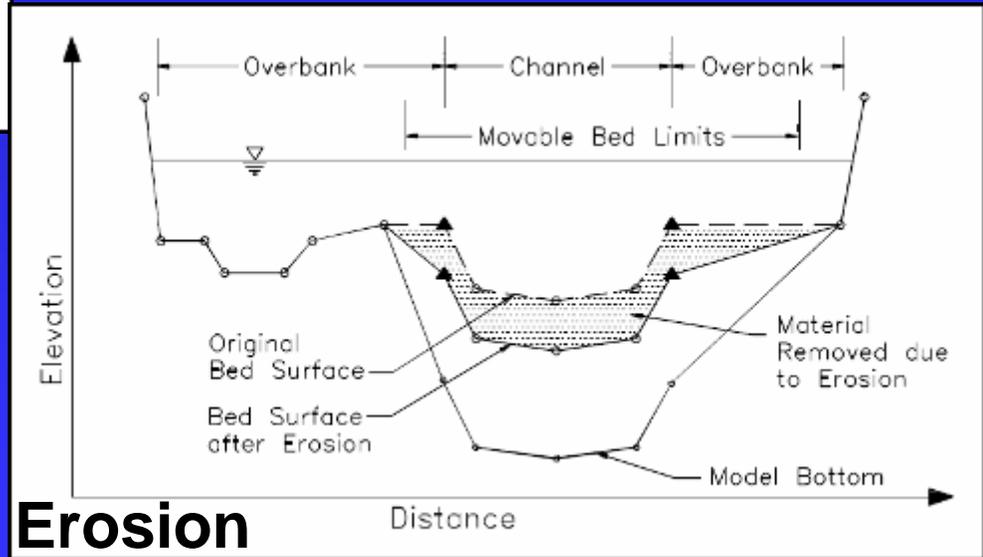
* Erosion can be further constrained by the cover Layer



Erosion and Deposition to RAS Cross Sections



RAS computations modified to compute bed changes and modify cross sections before each time step



- Cross Sections
- Bridges



Case Study: Euclid Creek





Case Study: Euclid Creek



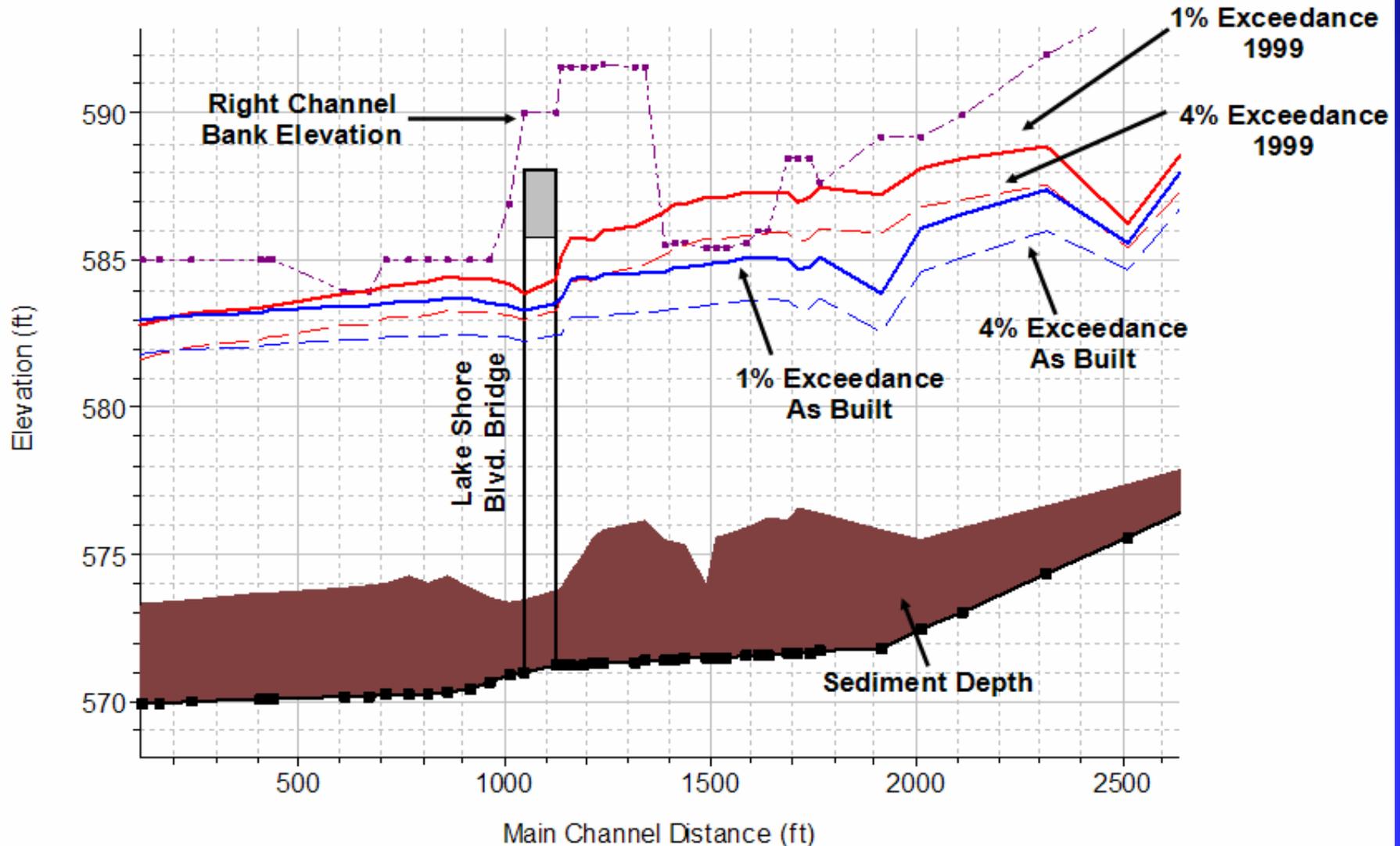


Case Study: Euclid Creek





Case Study: Euclid Creek





Animation of Bed Movement

