

Storage Areas and Storage Area Connections

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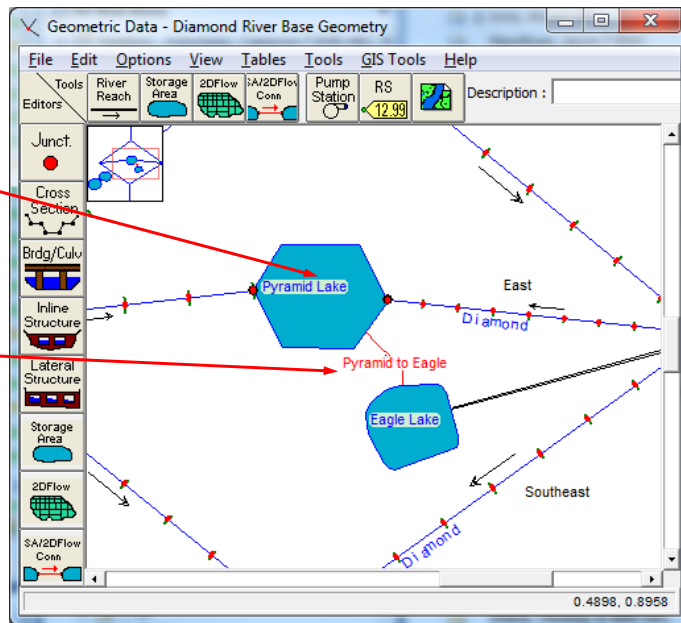
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Introduction

- Storage Areas
 - Purpose
 - Data Entry
 - Output
- SA Connections
 - Purpose
 - Data Entry
 - Output



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- The output from an unsteady flow run are stage hydrographs, flow hydrographs, and basic stage profiles.
- These hydrographs and profiles are stored in DSS.
- For more detailed output you must run the post-processor.
- The post-processor reads the hydrograph and profile information in the DSS file and creates detailed output data for the maximum stage computed and series of snap shots in time on a selected “Detailed Output Interval”.



Storage Areas - Purpose

- Good for areas that are either inline or off line storage areas where the water surface is horizontal
- Stabilizing influence on computations
- Continuity equation is used to account for volume of storage areas
- Momentum is not computed
- Can be connected to:
 - Lateral structures
 - Top or bottom of a reach
 - Another storage area (with a SA Connection)

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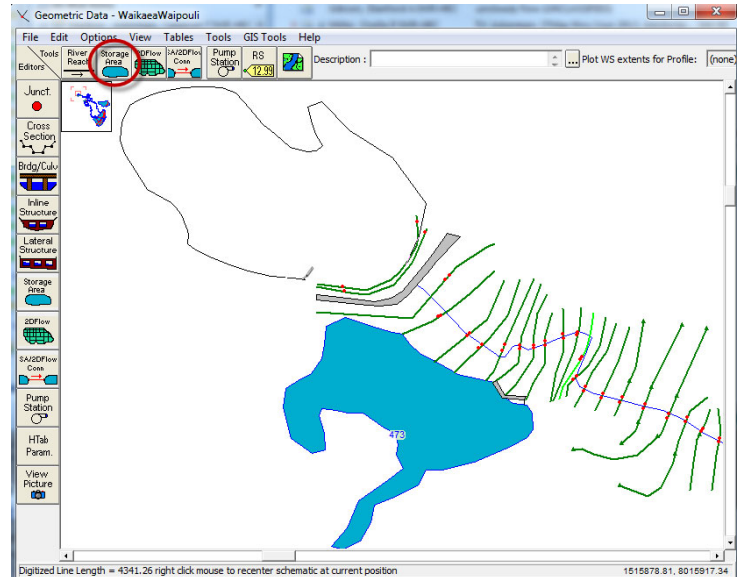
- Storage areas are more stable in computations (and faster) than representing a region with cross sections.



Storage Area - Creating



- Created on the geometry schematic using the Storage Area editor



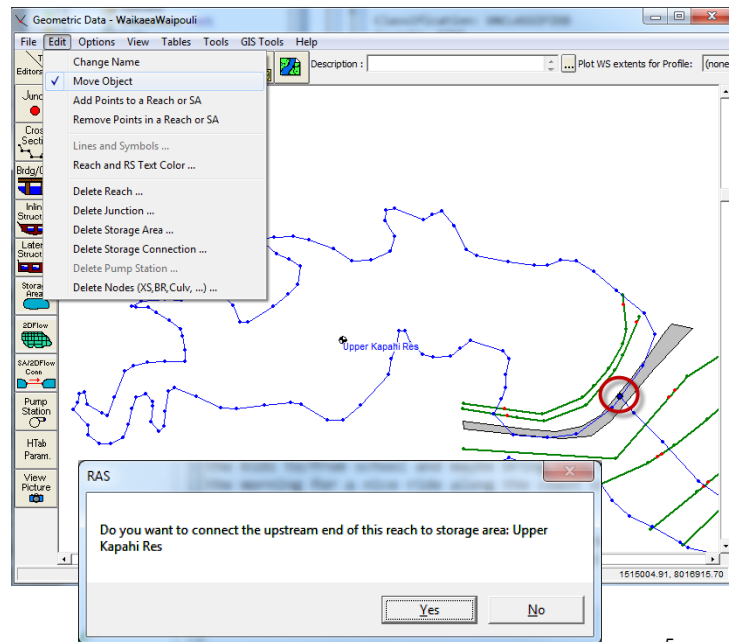
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- Storage Areas are created on the geometry schematic with the “Storage Area” tool. Press the button and the mouse cursor changes to a pen, draw the storage area and double click to end drawing.



Storage Area - Connecting

- When you connect the river to the SA a “node” is formed
- Upstream
 - Inline Structure with 2 cross sections u/s of structure
- Downstream

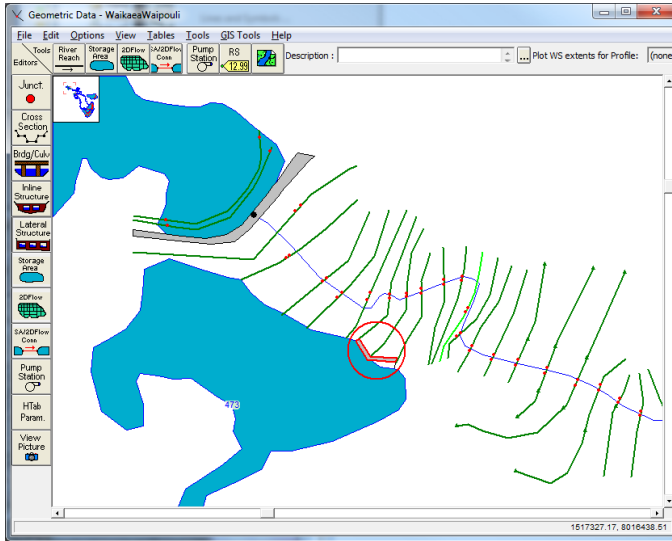


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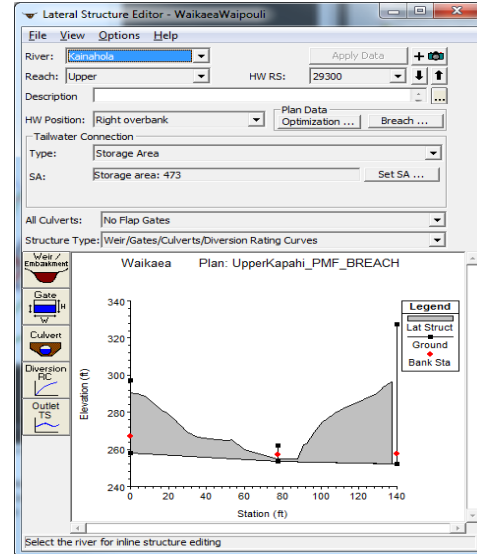
- In order to connect a storage area to the upstream or downstream end of a river reach, select the Edit | Move Object menu item. Then grab the end of the river reach and move it into the storage area. RAS will ask you if you want to connect the river reach and storage area. If you accept Yes, then a node will be formed at the boundary of the storage area and the river line.
- When using a storage area for an upstream boundary, there must be 2 cross sections placed upstream of an inline structure.



Storage Area - Connecting



• Lateral Structure



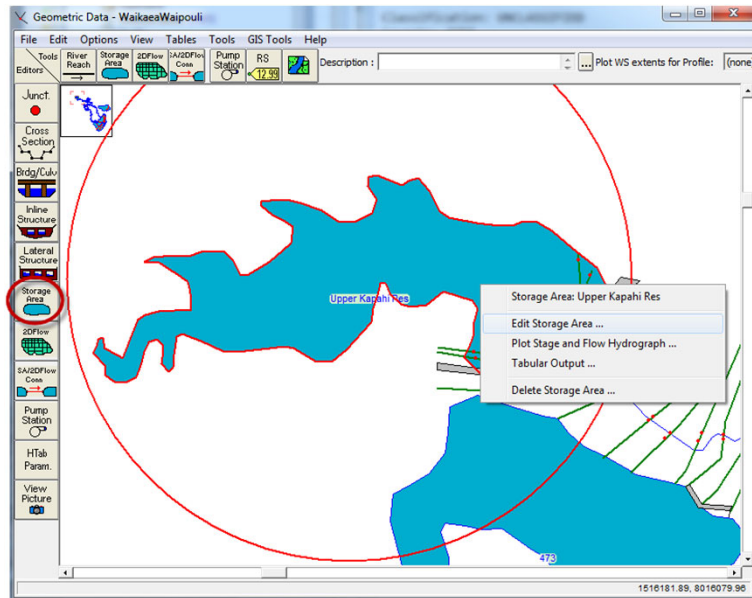
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- To connect a storage area to a river, you do so using a lateral structure.
- A new lateral structure is added similar to adding a bridge, by selecting a river and reach and specifying a river station.
- The lateral structure has several options, but for a storage area you are connecting from the river (Headwater) on the right or left side to the storage area (Tailwater)!



Storage Area - Geometry Data

- Open editor
 - Floating menu from left mouse click
 - Button



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- The data editor for storage areas can be accessed by clicking on the “Storage Area” button on the schematic editor or clicking on the storage area with left mouse button, this will display an popup menu with the option to edit .



Storage Area - Geometry Data

Storage Area Editor

Storage Area: Reservoir Pool

Connections and References to this Storage Area

Conn: Dam

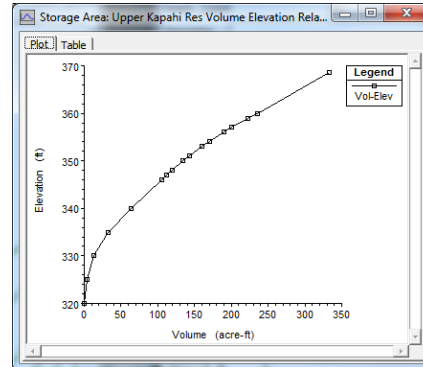
Area times depth method Area (acres): 280210300
Min Elev: 0

Elevation versus Volume Curve **Compute E-V table from Terrain**

Elevation Volume Curve		
First elevation must have zero volume Filter...		
	Elevation	Volume (acre-ft)
1	583	0
2	588	0.01
3	590	20
4	592	80
5	594	180
6	596	360
7	598	760
8	600	1390
9	602	2160
10	604	3030
11	606	4010
12	608	5100
13	610	6300
14	612	7640
15	614	9150

GIS Outline... Plot Vol-Elev... OK Cancel

- Volume Methods
 - Area times depth
 - Elevation - Volume Curve (cut from terrain)
- Edit outline
- Plot Curve



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- The only data needed for storage areas is a method of computing storage verses elevation.
- Two methods are available, a surface area times a depth or interpolation from a rating curve.



Storage Area - Unsteady Flow Data

- Initial Conditions (Optional)
 - Starting WSE

River	Reach	RS	Initial Flow	
1	Kanahola	Upper	30192	120
2	Kanahola	Lower	11897	450
3	Konohiki	Upper	35990	200
4	Konohiki	Lower	4138	850
5	Mokikeha Canal	outlet	2000	50
6	TwinAltBreak	Alt	3980	100
7	Waipouli	CanalUpper	5483	70
8	Waipouli	CanalLower	1660	150
9	WaipouliLocal	Wetland	174	80

Storage Area/2D Flow Area	Initial Elevation	
1	1772	1.83
2	464	107
3	465	2.3
4	466	0.03
5	467	0.39
6	468	1.05
7	469	0.73
8	470	4.2
9	471	0.89
10	472	1.7

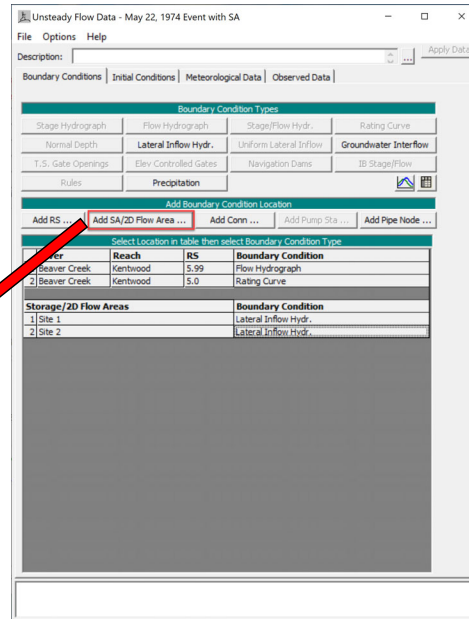
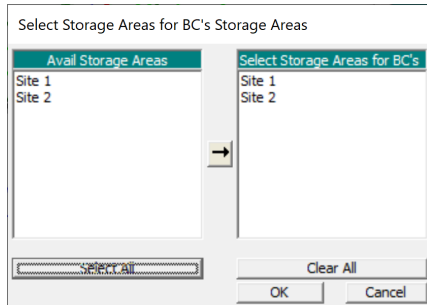
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- The initial elevation of the storage area is required for simulation, this is specified on the unsteady flow data window on the “Initial Conditions” tab.



Storage Area - Unsteady Flow Data

- Boundary Conditions (Optional)
 - Lateral Inflow Hydrograph



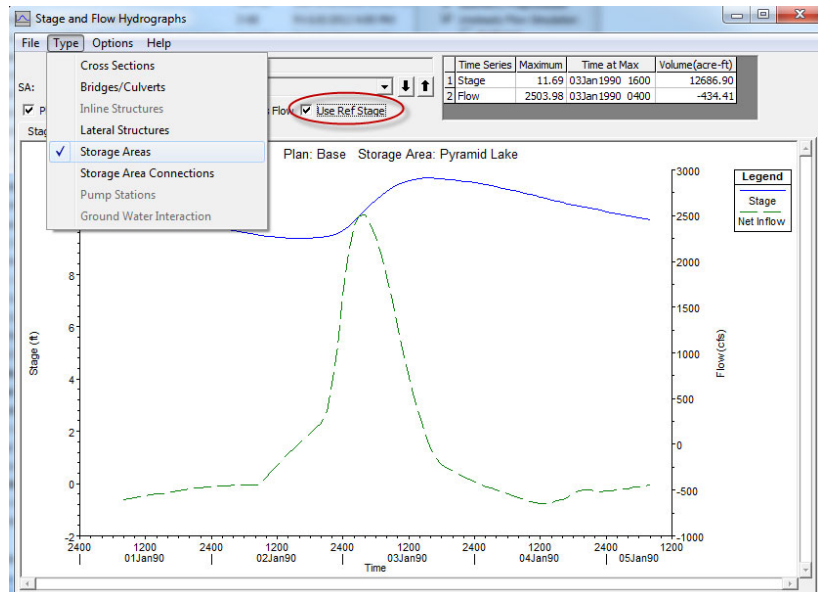
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- A time series of lateral inflows can also be entered for a storage area, this would be entered on the same window, but on the “Boundary Conditions” tab.



Storage Area - Output

- Stage Flow Plot
 - Stage
 - Net Flow



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- Stage and flow hydrographs are available for storage areas if storage areas are selected as the node type in the hydrograph output window.
- From this window you have the option to view computed stage, computed flow, observed stage, and observed flow (or none of the above).
- There is also a checkbox that allows you to use a reference stage for the hydrograph.
- When this option is selected, it changes the scale along the y axis to include the entire range of values from the user input storage-elevation curve for that storage area. Otherwise, the y axis scale is set to the range of stages computed.



Storage Area - Output

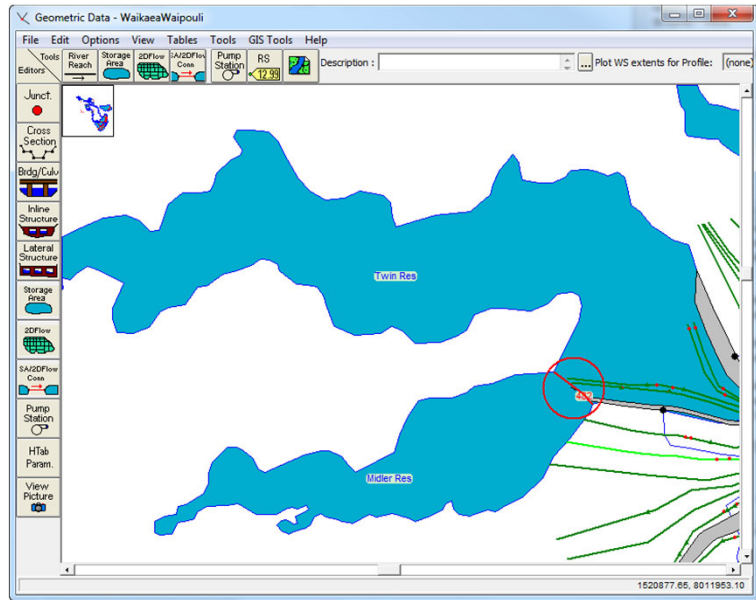
- Profile Output Table

Storage Area	Profile	W.S. Elev (ft)	SA Min El (ft)	Net Flux (cfs)	SA Area (acres)	SA Volume (acre-ft)
Eagle Lake	Max WS	10.19	0.00	122.79	1500.00	10281.38
Lower Angora	Max WS	11.99	0.00	-20.96	1000.00	11991.28
Pyramid Lake	Max WS	11.69	-1.00	21.86	1000.00	12686.90
Upper Angora	Max WS	10.64	0.00	250.15	1000.00	10640.82



SA Connection - Purpose

- Convey water from storage area to storage area

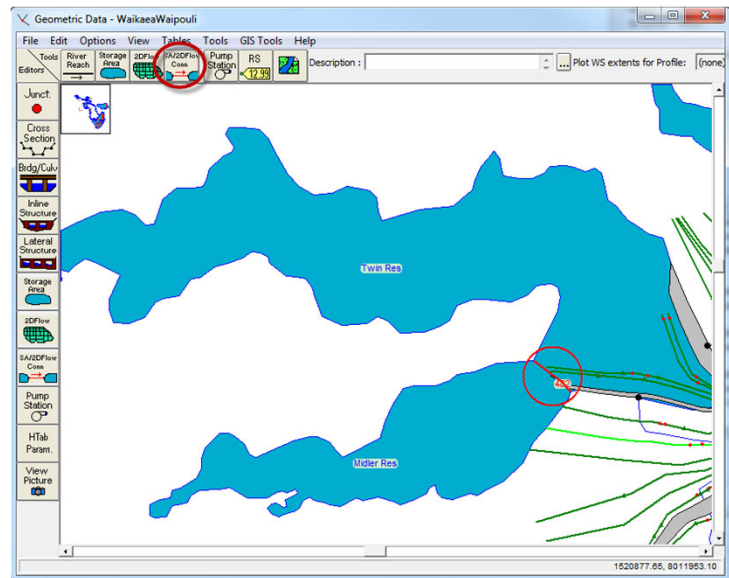


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SA Connection - Geometry

- Created on the geometry schematic
- Ends snap to the nearest Storage Area



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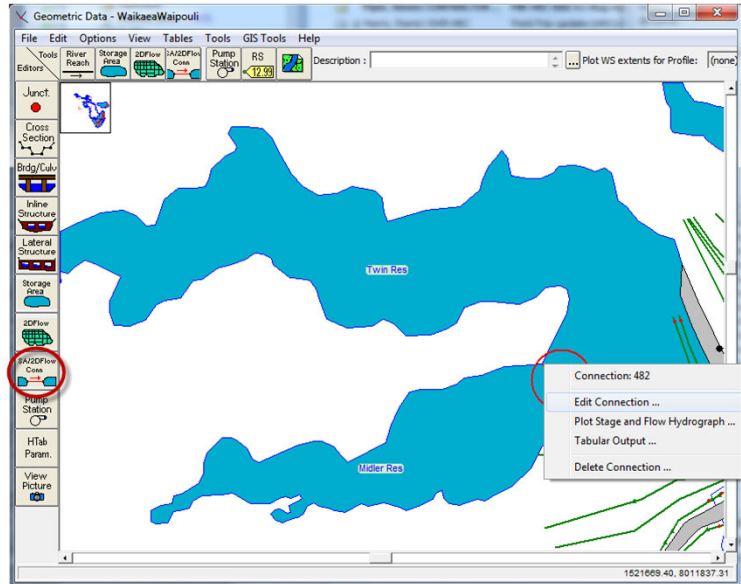
- Press the SA Conn tool button on the top row of the schematic editor, and the mouse pointer will change to a pen.
- Draw the connection and double click to finish the polyline.
- SA connections snap to the nearest possible end point so start and end the connection near the desired storage area.



SA Connection - Geometry



- Open editor
 - Floating menu from left mouse click
 - Button

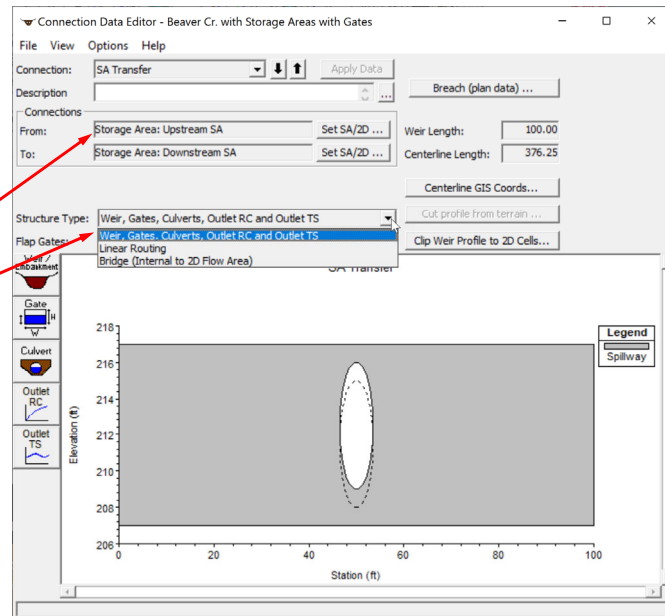


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SA Connection - Geometry

- Connection Selection drop down list
- Description
- Editor Shows connections “From” and “To”
- Structure Types:
 1. Weir, Gates, & Culverts, etc
 2. Linear Routing Method
 3. Bridge (Internal to 2D Areas)



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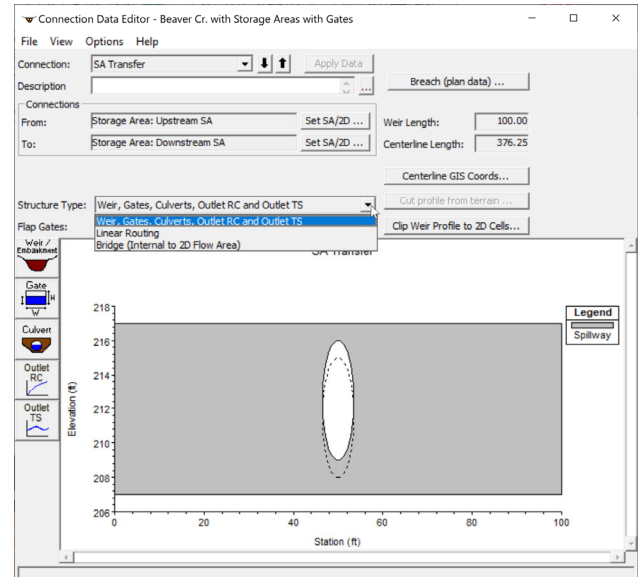
- When the SA Connection editor is opened the plot will initially be blank.
- The description can be entered and the “From” and “To” ends of the connection.
- The buttons on the left, load sub-editors for the components of the connection.



SA Connection - Computations



- **Inline Weir Type**
 - Can use the weir equation in computations
 - Can use a family of curves
- **Inline Weir Type with Gates or Culverts**
 - Uses the weir and gate equations in computations
 - Cannot use curves because the gates change the properties over time
 - Outlet Time Series
 - Outlet Rating Curve
 - Culverts need HTab Parameters



- The data for storage area connections is a combination of things that are available elsewhere in the program.
- For example, the culvert data for a storage area connection is similar to the normal culvert data at a bridge/culvert crossing.



SA Connection - Computations



- Linear Routing Type

$$Q = kS : \text{Flow}$$

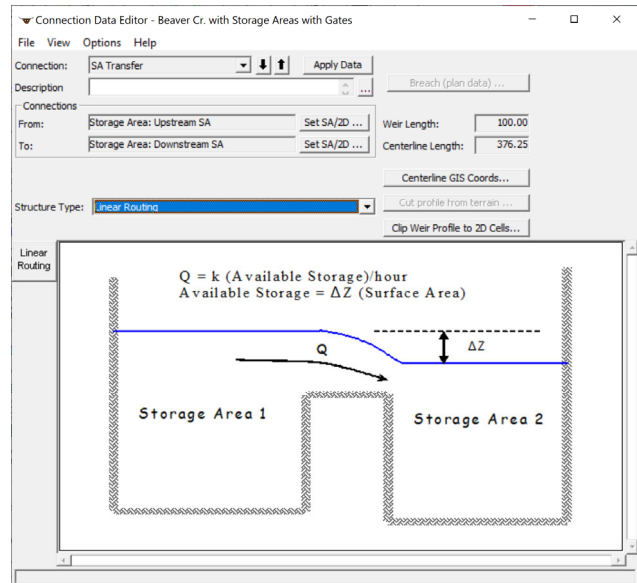
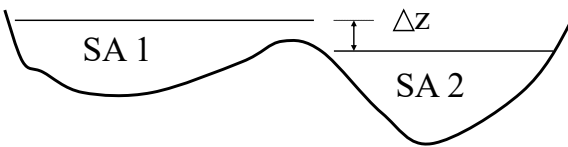
$$S = A\Delta z : \text{Available storage}$$

A : Surface area

k : Linear routing coefficient (1/hr)

Range of k : 0–1

Typical k value: 0.05



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- Another method of computing flow between storage areas is with linear routing.
- Linear routing computes the flow between storage areas by a simple fraction of the available storage difference between each storage area for each time step.
- The coefficients k has units of 1/hours.



SA Connection - Geometry Data

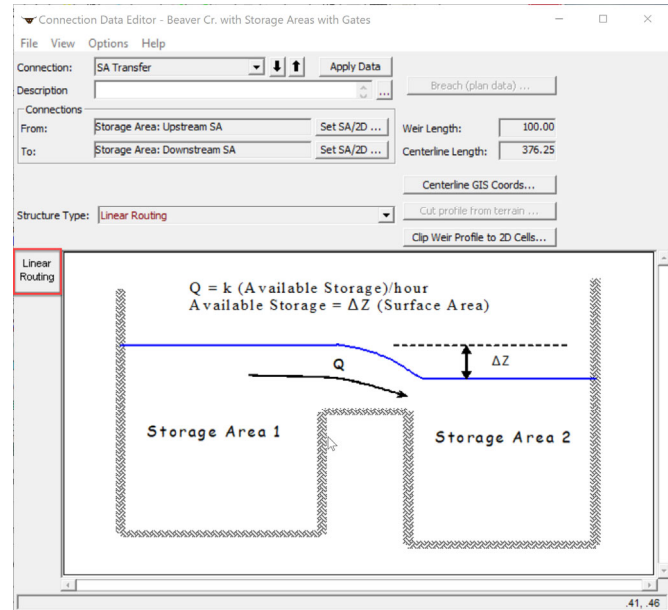
- Linear routing
 - Separate linear routing coefficients selected for each flow direction
 - Optional Spillway Crest Elevation

SA Connection Linear Routing Editor

Linear Routing Coef for flow from Storage Area: Upstream SA to Storage Area: Downstream SA

Linear Routing Coef for flow from Storage Area: Downstream SA to Storage Area: Upstream SA

Elevation of spillway crest:



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The linear routing coefficient is direction dependent, so one for each flow direction must be entered. The “elevation of crest” is a reference that determines when water will start flowing from one storage area to the next.



SA Connection - Geometry Data



- Weir/Embankment
 - Weir Width (Optional)
 - Flow Reference
 - Weir Coefficient
 - Range 0 - 4
 - Default = 3 (maybe 2.6 would be better)
 - Weir Crest Shape
 - Broad Crested
 - Ogee
 - Weir Profile

Storage Area Connection Weir Data

Weir Data
Weir Width: 10.

Weir Computations:
Standard Weir Equation Parameters
Weir Coefficient (Cd): 3.82

Weir Crest Shape: Ogee

Spillway Approach Height: 12.
Design Energy Head: 20. Cd ...

HW Connections ... TW Connections ...

Embankment Station/Elevation Table

	Station	Elevation
1	0	683
2	420.24	683
3	2233.24	683
4	2233.24	657
5	2833.24	657
6	2833.24	683
7	7400.24	683
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		

OK Cancel

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Weir Coefficients range from 0 to 4.

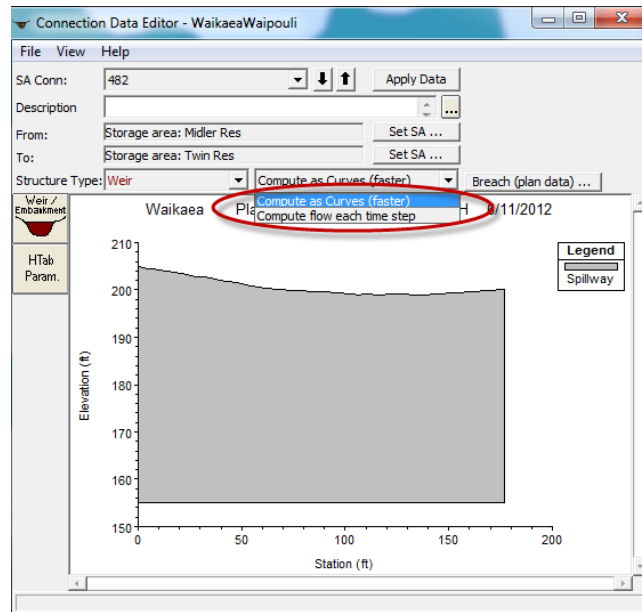
<u>Application</u>	<u>Weir Coefficient</u>
For a levee	2.6
Broad Crested Weir	2.6
Natural ground	<2



SA Connection - Geometry Data



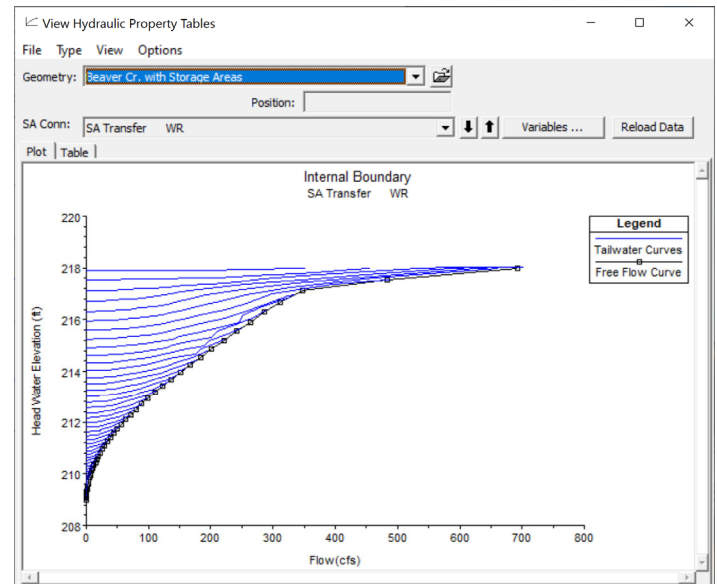
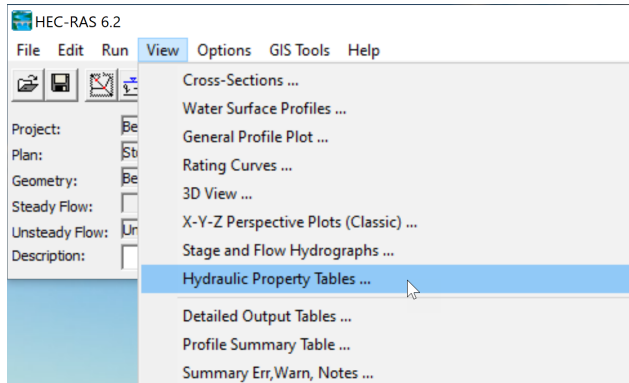
- Inline Weir
 - “On the fly” computations
 - Family of Curves
 - Cannot change curves
 - Can produce errors if stage goes beyond curves



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SA Connection - Computations



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The family of rating curves can be viewed from the “View Hydraulic Properties” window. Select “SA Connections” under the “Type” menu option.



SA Connection - Geometry Data



- Gate Editor
 - Same editor for Inline and Lateral Structures

Connection Gate Editor

Gate Group: Gate #1

Gate type (or methodology): Sluice

Gate Flow

Sluice Gate Flow

Sluice Discharge Coefficient (0.5-0.7): 0.6

Submerged Orifice Flow

Orifice Coefficient (typically 0.8): 0.8

Head Reference: Sill (Invert)

Weir Flow Over Gate Sill (gate out of water)

Weir Shape: Broad Crested

Weir Coefficient: 3

Geometric Properties

Height: 4 Width: 10 Invert: 83

Opening Centerline Stations # Openings: 0

	Opening Name	Station	GIS Sta
1	Gate 1	25	
2			
3			
4			
5			
6			
7			

Opening GIS Data: Length:

	X	Y
1		
2		
3		
4		
5		
6		
7		

Individual Gate Centerlines ...

OK Cancel Help

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- The data for a gate editor is the same as for an inline weir.
- Refer to the inline weir section of the HEC-RAS Users Manual.



SA Connection - Geometry Data

- Culvert Editor
 - Same editor for Bridge/Culverts and Lateral Structures

Culvert Data Editor

Culvert Group:

Solution Criteria:

Shape: Span: Diameter:

Chart #:

Scale #:

Culvert Length: Depth to use Bottom n:

Entrance Loss Coeff: Depth Blocked:

Exit Loss Coeff: Upstream Invert Elev:

Manning's n for Top: Downstream Invert Elev:

Manning's n for Bottom:

Culvert Barrel Data

Barrel Centerline Stations				# Barrels :
	Barrel Name	US Sta	DS Sta	GIS Sta
1	Barrel #1	50	50	
2				
3				
4				
5				

Barrel GIS Data: Barrel #1
Length: 0

	X	Y
1		
2		
3		
4		
5		

Select culvert to edit

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- The data for a gate editor is the same as for an inline weir.
- Refer to the inline weir section of the HEC-RAS Users Manual.



SA Connection - Geometry Data

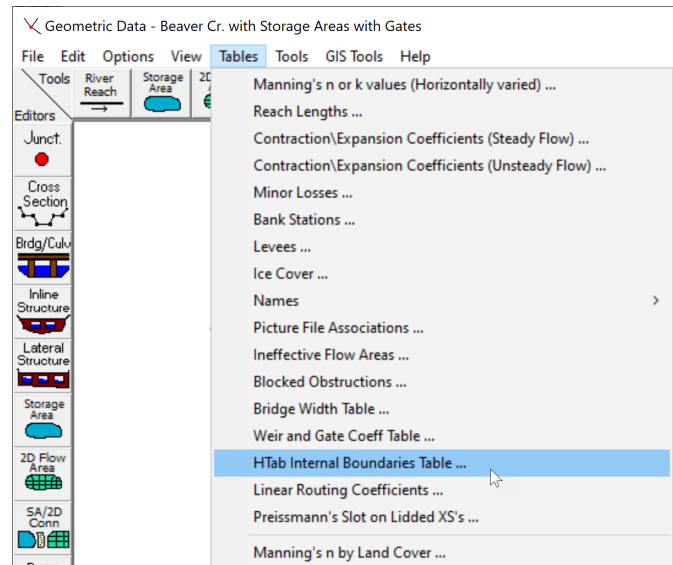
- HTab Parameters
 - Headwater maximum (required)
 - Tailwater maximum (optional)
 - Maximum Flow (Optional)

HTab Parameters for Internal Boundaries

Selected Area Edit Options
 Add Constant ... Multiply Factor ... Set Values ... Replace Values ...

Summary of the parameters for internal boundary rating curves								
	Location		#Pt FF Curve	# RC	#Pt on RC	HW Max	TW Max(Opt.)	Max Flow(Rec.)
1	Beaver Creek Kentwood	5.4 BR	50	50	20	225	220	50000
2	SA Conn:SA Transfer		50	50	20	218		

OK Cancel



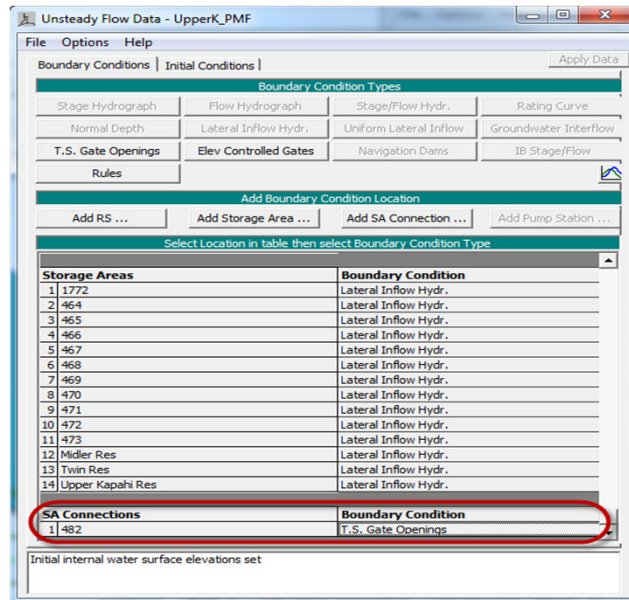
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- The HTab data is only needed for the culvert type connections.
- The data required here is the same as covered for bridges and culverts, covered earlier in this course.
- The maximum swell head parameter is the largest difference between head water and tailwater.
- All four parameters maximum headwater, tailwater, and maximum flow are used to limit the range of the family of rating curves.
- It's important to keep the curves in the possible flow and stage ranges to minimize the errors in interpolation
- The only parameter required for connections is the headwater maximum, the program computes default values for the others.



SA Connection - Unsteady Flow Data

- Gated Connections
 - Time series of Gate Openings
 - Elevation Controlled Gates



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- If a SA Connection has gates, then boundary condition data will need to be entered on the unsteady flow data editor.
- The lower portion of the boundary condition editor is where the connection is added to the table.
- Two types are possible, a time-series of gate openings and elevation-controlled gates.
- The data for these boundary conditions are the same as for the gates on inline and lateral weirs.



SA Connection - Tabular Output



- Culvert Type

The screenshot shows the 'Storage Area Connection Output' window. The 'Conn:' dropdown is set to 'Pyramid to Eagle', 'Profile:' is 'Max WS', and 'Culv Group:' is 'Culvert #1'. The table below displays various culvert parameters and their values.

Plan: Base, Pyramid to Eagle, Culv Group: Culvert #1, Profile: Max WS			
Q Culv Group (cfs)	0.17	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	0.71
Q Barrel (cfs)	0.17	Culv Vel DS (ft/s)	1.54
E.G. US. (ft)	11.70	Culv Inv El Up (ft)	11.50
W.S. US. (ft)	11.70	Culv Inv El Dn (ft)	11.40
E.G. DS (ft)	10.19	Culv Frctn Ls (ft)	1.00
W.S. DS (ft)	10.19	Culv Exit Loss (ft)	1.36
Delta EG (ft)	1.51	Culv Entr Loss (ft)	0.00
Delta WS (ft)	1.51	Q Weir (cfs)	
E.G. IC (ft)	11.64	Weir Sta Lft (ft)	
E.G. OC (ft)	11.70	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	11.69	Weir Max Depth (ft)	
Culv WS Outlet (ft)	11.51	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	0.19	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	0.11	Min El Weir Flow (ft)	16.51

Errors, Warnings and Notes

Note: During subcritical analysis, the culvert direct step method, the solution went to normal depth.

Select River Station

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SA Connection - Tabular Output

- Inline Weir with Gates

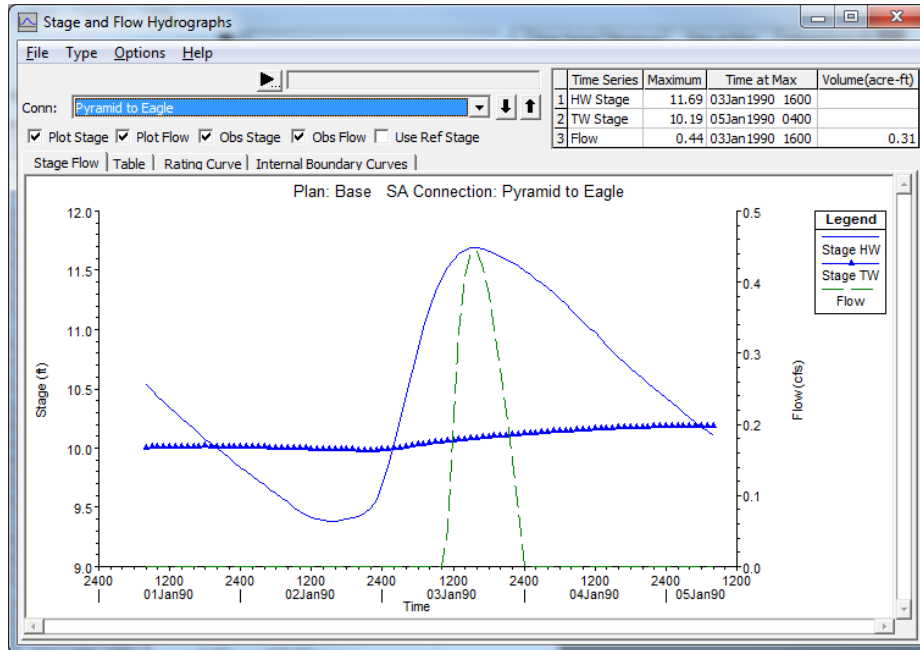
The screenshot shows a software window titled "Storage Area Connection Output". It contains a table with the following data:

Plan: SA_Conn	RS: Gated Conn	Gate Group: Gate #1	Profile: Max WS
E.G. Elev (ft)	84.90	Q Gates (cfs)	78.76
W.S. Elev (ft)	84.90	Q Gate Group (cfs)	78.76
Q Total (cfs)	78.76	Gate Open Ht (ft)	2.00
Q Weir (cfs)		Gate #Open	1
Weir Flow Area (sq ft)		Gate Area (sq ft)	19.03
Weir Sta Lit (ft)		Gate Submerg	0.02
Weir Sta Rgt (ft)		Gate Invert (ft)	83.00
Weir Max Depth (ft)			
Weir Avg Depth (ft)			
Weir Submerg			
Min El Weir Flow (ft)	90.01		
Wt Top Width (ft)			

Below the table is a section titled "Errors, Warnings and Notes" which is currently empty. At the bottom of the window, there is a "Select Profile" button.



SA Connection - Stage Flow Plots



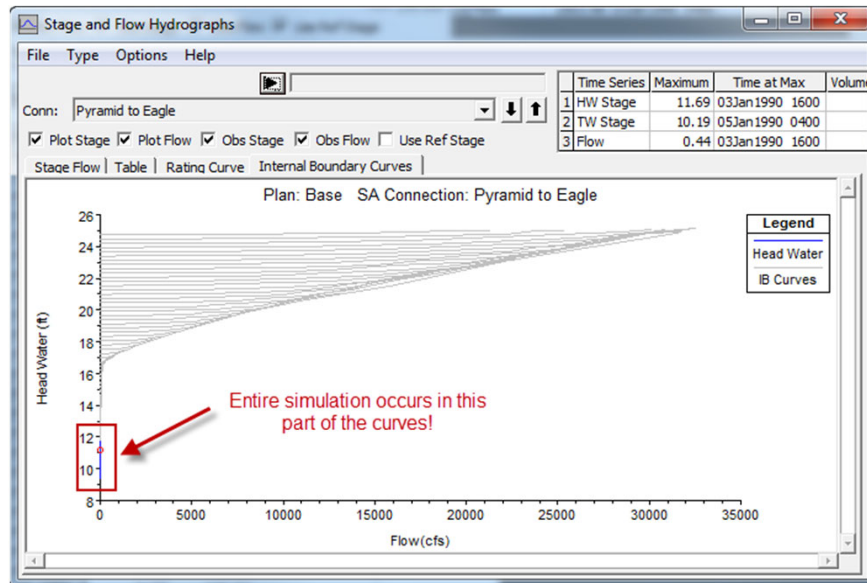
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SA Connection - Stage Flow Plots



- Limit hydraulic properties

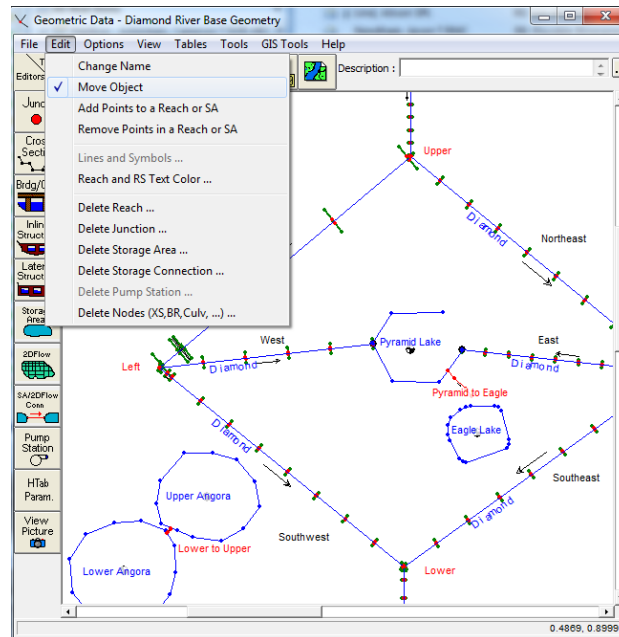


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Schematic Editing

- Select “Move Object” under “Edit”
- Move individual points
- Move whole SA with centroid
- Move Text
- SA Conn snap to nearest point



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Once the outline is created, it can be edited by selecting the “Move Object” menu item under “Edit”. The schematic will change its appearance and allow features to be moved.



Editing GIS Data in Table

Connection Data Editor - SA to 2D Conn - Test 2017

File View Help

Connection: Dam [Apply Data] [Breach (plan data) ...]

Description: [Breach (plan data) ...]

Connections

From: Storage area: Reservoir Pool [Set SA/ZD ...] Weir Length: 7400.24

To: 2D flow area: BaldEagleCr [Set SA/ZD ...] Centerline Length: 7400.24

Centerline GIS Coords...

Structure Type: Weir, Gates, Culverts, Outlet RC and Outlet TS [Terrain Profile ...]

Flap Gates: No Flap Gates

Dam

Legend

- Spillway
- TW Cell Min Elev

SA Connections Centerlines GIS Coordinates

Names (Select one or Many) [Add] [Multiply] [Set Values] [Replace] [Round]

BacksideLevee

Levee

	X (ft)	Y (ft)
1	2002386.54900304	323626.166724332
2	2002597.66	323437.29
3	2002717.13	323336.19
4	2003158.26	323115.63
5	2003332.87	323106.44
6	2003406.4	323078.87
7	2003571.82	323134.01
8	2003764.82	323207.53
9	2003930.24	323299.43
10	2004086.47	323317.81
11	2004261.09	323317.81
12	2004481.65	323271.86
13	2004876.84	323179.96
14	2005373.11	323042.11
15	2005529.34	322977.77
16	2005869.38	322738.83
17	2006466.75	322150.65
18	2008369.13	320174.75

Import Lines Filter Line(s) Lengths [OK] [Cancel]

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