

# A SURFACE WATER MODEL OF THE MIAMI RIVER



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# BACKGROUND

## Miami River:

- Estuary
- Navigation and storm drainage relief
- 5.5 miles long
- Tamiami Canal
- Comfort Canal

# PROJECT OBJECTIVE

- Predict surface profiles
  - Average flow conditions from 1986 to 1999
  - HEC-RAS
- Hydrologic Engineering Center River Analysis Software
- One-dimensional steady flow analysis

# HEC-RAS

- Applicable to steady gradually varied flow
  - Natural channels
  - Constructed channels
- Supercritical, subcritical, and mixed flow regimes
- Energy or Momentum equations

# HEC-RAS (Cont.)

Software limitations:

1. Flow must be steady
2. Flow must be gradually varied
3. Flow must be one-dimensional
4. River/channel must have small slopes
5. Channel must have a fixed bed
6. Energy losses must be definable by the energy head loss equation

# ENERGY EQUATION

## Standard Step Method

$$Y_2 + Z_2 + \left( \frac{\alpha_2 V_2^2}{2g} \right) = Y_1 + Z_1 + \left( \frac{\alpha_1 V_1^2}{2g} \right) + h_e$$

$$h_e = LS_f + C \left| \frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g} \right|$$

$$S_f = (Q/K)^2$$



# CRITICAL DEPTH

Calculated:

1. Supercritical flow regime
2. Requested by the user
3. User entered boundary condition

# CRITICAL DEPTH (Cont.)

4. Flow regime identification

5. Program cannot balance the energy equation

# CRITICAL DEPTH (Cont.)

Found through iterations of the total energy equation:

$$H = WS + \alpha V^2 / 2g$$

# MOMENTUM EQUATION

Applicable when:

- Water surface at critical depth
- Rapidly varying flow

HEC-RAS applies the momentum equation for the following:

- Hydraulic jumps
- Stream junctions
- Flow obstructions

# STREAM JUNCTIONS

- Analyzed by HEC-RAS using energy or momentum equations
- Cross sections placed close to the stream junction
- Cross sections perpendicular to the flow before and after the junction

# STREAM JUNCTIONS

- Momentum vs. Energy
- Six different possible flow conditions
- Flow combining, subcritical flow



# STREAM JUNCTIONS

Energy equation at a stream junction

$$WS_0 + \frac{\alpha_0 V_0^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + L_{0,1} S_{f0,1} + C \left| \frac{\alpha_1 V_1^2}{2g} - \frac{\alpha_0 V_0^2}{2g} \right|$$

Momentum equation at a stream junction

$$SF_0 = SF_1 \cos \theta_1 - F_{f1,0} + W_{x1,0} + SF_2 \cos \theta_2 - F_{f2,1} + W_{x2,1}$$

# STREAM JUNCTIONS (Cont.)

Friction force equation at a stream junction

$$F_{f0,1} = S_{f0,1} \frac{L_{0,1}}{2} A_0 \cos \theta_1 + S_{f0,1} \frac{L_{0,1}}{2} A_1 \frac{Q_1}{Q_0}$$

Weight force equation at a stream junction

$$W_{x0,1} = S_{o0,1} \frac{L_{0,1}}{2} A_0 \cos \theta_1 + S_{o1,0} \frac{L_{0,1}}{2} A_1 \frac{Q_1}{Q_0}$$



# MODEL ASSUMPTIONS

## Data

- **Average flow data**
- **Cross sectional data**

## Assumption

- **No tidal flow contributions**
- **Five foot freeboard for the river**

# MODEL ASSUMPTIONS



# MODEL ASSUMPTIONS

## Data

- No cross sections for the South Fork

## Assumption

- Comfort connects directly to the River



# MODEL ASSUMPTIONS (Cont.)

## Data

- No cross sections for areas with marinas

## Assumption

- River does not have any marinas



# MODEL ASSUMPTIONS (Cont.)

## Data

- No cross sections for bridge crossings

## Assumption

- River does not have any bridges



# MODEL ASSUMPTIONS



# MODEL ASSUMPTIONS (Cont.)

## Assumption

- Manning's value of 0.07



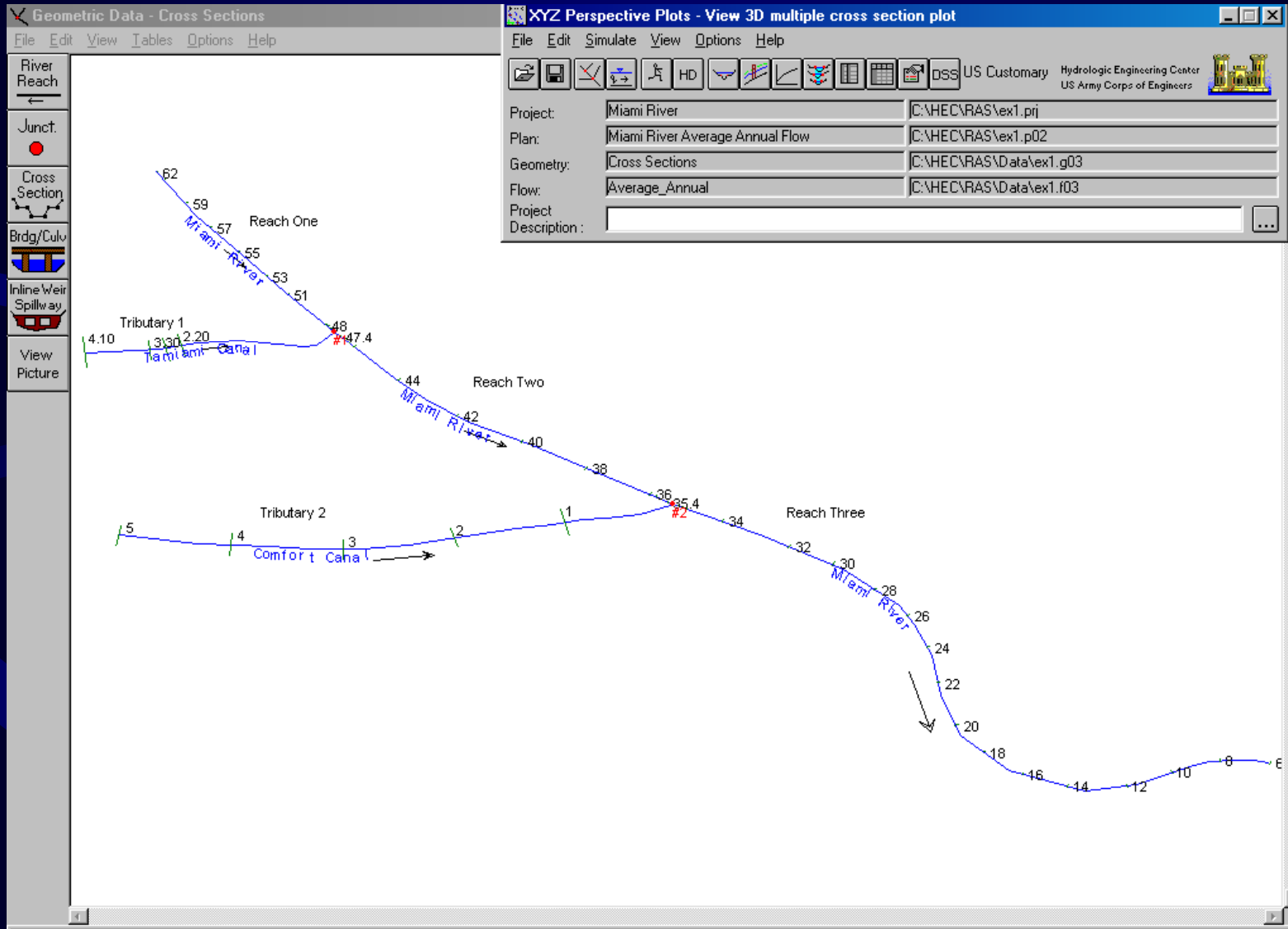
# MODEL ASSUMPTIONS (Cont.)

- River's flow = S-26 + S25B + S25
  - Drainage basins were not considered
- Assumed water surface elevation at last cross section: -0.6 ft NGVD





# METHODOLOGY



# METHODOLOGY

Geometric Data - Cross Sections

File Edit View Tables Options Help

River Reach  
Junct.  
Cross Section  
Brdg/Culv  
Inline Weir Spillway  
View Picture

**Cross Section Data - Cross Sections**

Exit Edit Options Plot Help

River: Miami River Apply Data

Reach: Reach Two River Sta.: 47.4

Description: Joint Crosssection #3

Cross Section X-Y Coordinates		Downstream Reach Lengths		
Station	Elevation	LOB	Channel	ROB
1	0	100	100	100
2	5			
3	10			
4	20			
5	25	0.07	0.07	0.07
6	30			
7	40			
8	50	0		100
9	60			
10	70			
11	80			
12	90			

Manning's n Values		
LOB	Channel	ROB
0.07	0.07	0.07

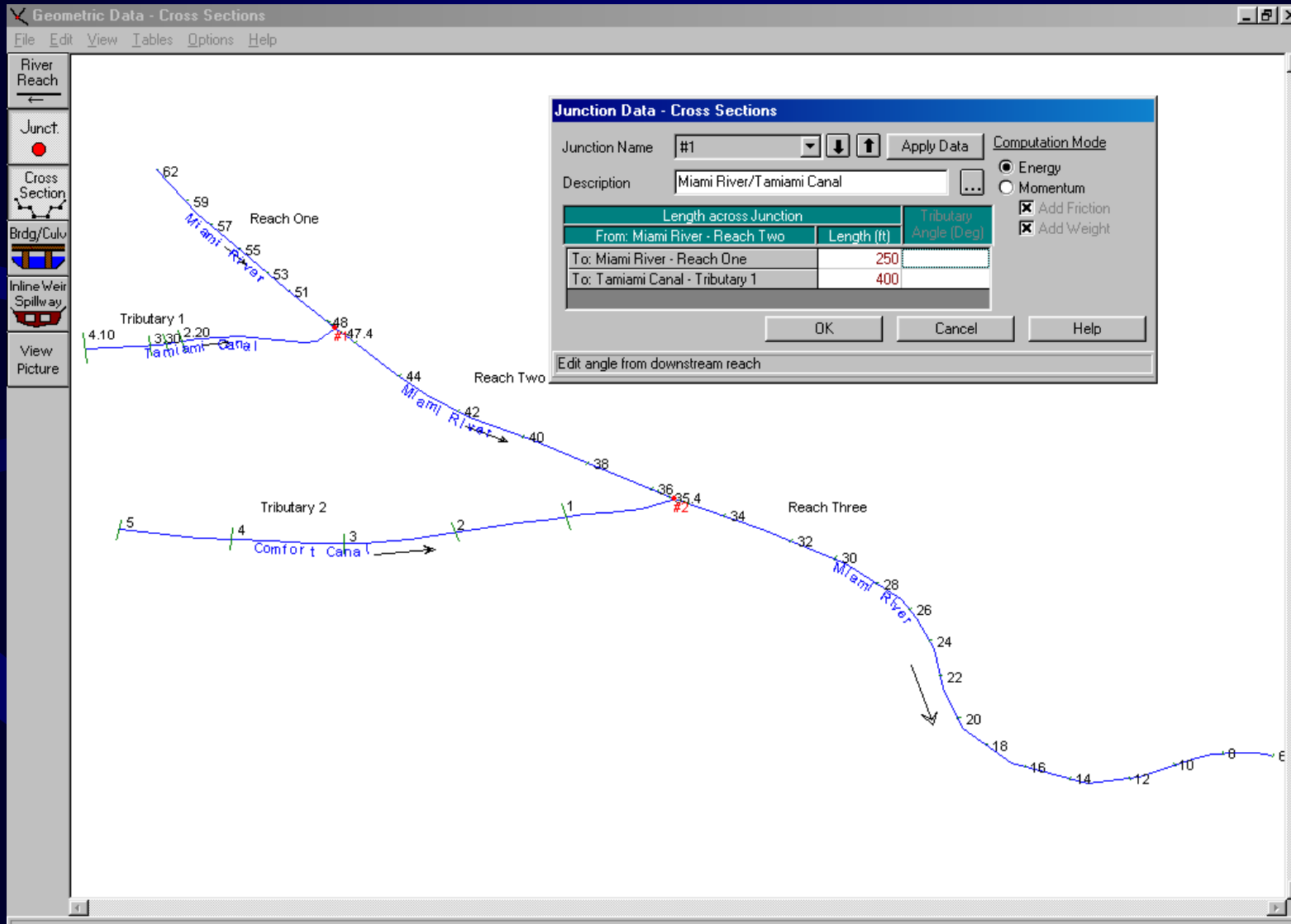
Main Channel Bank Stations	
Left Bank	Right Bank
0	100

Cont\Exp Coefficients	
Contraction	Expansion
0.2	0

Select Reach for cross section editing

25, 71

# METHODOLOGY



# METHODOLOGY (Cont.)

The screenshot displays the HEC-RAS software interface. The main window is titled "Geometric Data - Cross Sections" and shows a plan view of a river system. The river is labeled "Miami River" and is divided into "Reach One" and "Reach Two". Tributaries include "Tributary 1" (Tamiami Canal) and "Tributary 2" (Comfort Canal). Stationing points are marked along the river, such as 62, 59, 57, 55, 53, 51, 48, 47, 4, 3, 2, 1, 5, and 4. The left sidebar contains tool icons for River Reach, Junct., Cross Section, Brgd/Culv, Inline Weir Spillway, and View Picture.

The "Steady Flow Data - Average\_Annual" dialog box is open, showing the following configuration:

- File | Options | Help
- Enter/Edit Number of Profiles (100 max): 11
- Reach Boundary Conditions: [Apply Data]
- Locations of Flow Data Changes: [Green bar]
- River: Miami River
- Reach: Reach One
- River Sta.: 62
- Add A Flow Change Location: [Button]

Flow Change Location			Profile Names and Flow Rates	
River	Reach	RS	PF 1	
1	Tamiami Canal	Tributary 1	4.10	200
2	Tamiami Canal	Tributary 1	3	200
3	Tamiami Canal	Tributary 1	1	200
4	Miami River	Reach One	62	167.2
5	Miami River	Reach Two	47.4	368
6	Miami River	Reach Two	46	368
7	Miami River	Reach Three	35.3	375

At the bottom of the dialog box, it says "Edit Steady flow data for the profiles (cfs)".

# METHODOLOGY (Cont.)

The screenshot displays the HEC-RAS software interface. The main window is titled "Geometric Data - Cross Sections" and shows a map of a river reach with stationing from 57 to 62. A "Steady Flow Data - Average\_Annual" dialog box is open, showing the "Locations of Flow Data Changes" section with a table of flow change locations. A "Steady Flow Boundary Conditions" dialog box is also open, showing the "Set boundary for all profiles" option selected and a table of boundary conditions for various river reaches.

**Steady Flow Data - Average\_Annual**

Enter/Edit Number of Profiles (100 max): 1    Reach Boundary Conditions    Apply Data

Locations of Flow Data Changes

River: Miami River    Reach: Reach One    River Sta.: 62    Add A Flow Change Location

Flow Change Location			Profile Names and Flow Rates	
River	Reach	RS	PF 1	
1	Tamiami Canal	Tributary 1	4.10	200
2	Tamiami Canal	Tributary 1	3	200
3	Tamiami Canal	Tributary 1	1	200
4	Miami River	Reach One	62	167.2
5	Miami River	Reach Two	47.4	368
6	Miami River	Reach Two	46	368
7	Miami River	Reach Three	35.3	375

**Steady Flow Boundary Conditions**

Set boundary for all profiles     Set boundary for one profile at a time

Known W.S.    Critical Depth    Normal Depth    Rating Curve    Delete

River	Reach	Profile	Upstream	Downstream
Tamiami Canal	Tributary 1	all		Junction=#1
Miami River	Reach One	all		Junction=#1
Miami River	Reach Two	all	Junction=#1	Junction=#2
Miami River	Reach Three	all	Junction=#2	Known WS
Comfort Canal	Tributary 2	all		Junction=#2

Enter to accept data changes.

# METHODOLOGY (Cont.)

The image displays the HEC-RAS software interface. The main window is titled "Geometric Data - Cross Sections" and shows a plan view of a river channel. The channel is divided into "Reach One" and "Reach Two". The river is labeled "Miami River". A tributary labeled "Tributary 1" joins the main channel. The channel is defined by a series of cross-sections, with stationing numbers ranging from 4.10 to 62. The "Steady Flow Analysis" dialog box is open, showing the following settings:

- Plan: Miami River Average Annual Flow
- Short ID: aveq
- Geometry File: Cross Sections
- Steady Flow File: Average\_Annual
- Flow Regime:  Subcritical,  Supercritical,  Mixed
- Plan Description: Average Annual Flow Conditions

The "COMPUTE" button is visible at the bottom of the dialog box. The background of the slide features a blue and black wavy pattern.

# MODEL'S RESULTS

## Tabular Results

Profile Output Table - Standard Table 1

File Options Std. Tables Help

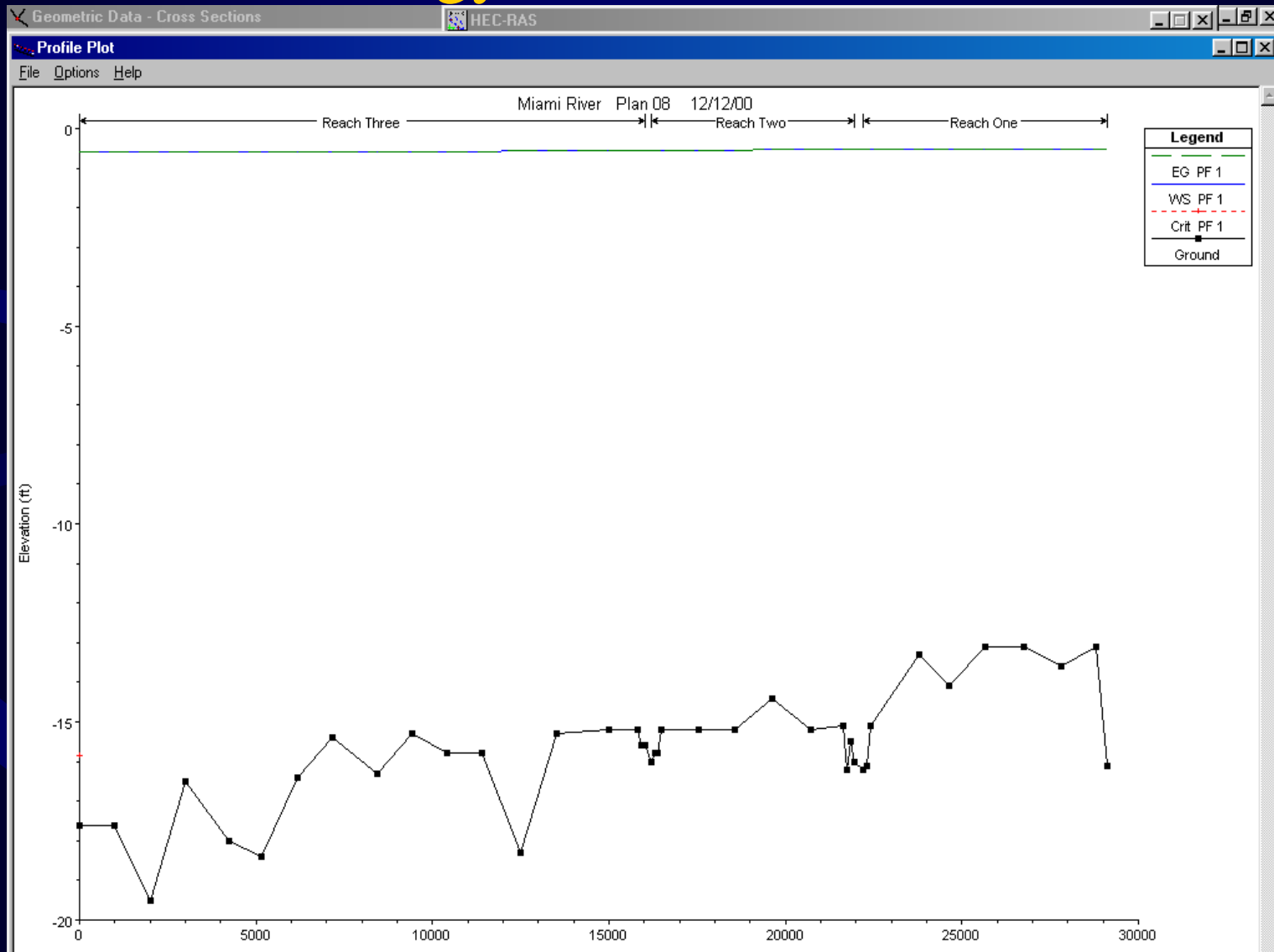
HEC-RAS Plan: aveq Reload Data

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude #	Chl
Reach One	62	168.00	-16.10	-0.51		-0.51	0.000002	0.15	1129.34	107.10	0.01	
Reach One	61	168.00	-13.10	-0.51		-0.51	0.000004	0.18	956.30	100.92	0.01	
Reach One	59	168.00	-13.60	-0.51		-0.51	0.000002	0.12	1395.63	155.58	0.01	
Reach One	57	168.00	-13.10	-0.52		-0.51	0.000005	0.17	1005.95	136.15	0.01	
Reach One	55	168.00	-13.10	-0.52		-0.52	0.000003	0.14	1198.84	145.72	0.01	
Reach One	53	168.00	-14.10	-0.52		-0.52	0.000001	0.12	1409.33	120.32	0.01	
Reach One	51	168.00	-13.30	-0.52		-0.52	0.000002	0.14	1193.12	112.52	0.01	
Reach One	48	168.00	-15.10	-0.52		-0.52	0.000001	0.09	1897.05	149.38	0.00	
Reach One	47.5	168.00	-16.10	-0.52		-0.52	0.000001	0.13	1309.52	96.47	0.01	
Reach One	47.4	168.00	-16.20	-0.52		-0.52	0.000002	0.13	1285.80	96.11	0.01	
Reach Two	47.4	368.00	-16.00	-0.53		-0.53	0.000013	0.37	999.06	73.56	0.02	
Reach Two	47.3	368.00	-15.50	-0.53		-0.53	0.000008	0.29	1249.15	95.50	0.01	
Reach Two	47.2	368.00	-16.20	-0.53		-0.53	0.000009	0.31	1187.19	94.91	0.02	
Reach Two	46	368.00	-15.10	-0.53		-0.53	0.000005	0.22	1641.41	148.39	0.01	
Reach Two	44	368.00	-15.20	-0.53		-0.53	0.000005	0.23	1596.69	129.86	0.01	
Reach Two	42	368.00	-14.40	-0.54		-0.54	0.000005	0.23	1603.35	136.89	0.01	
Reach Two	40	368.00	-15.20	-0.54		-0.54	0.000004	0.21	1789.61	166.80	0.01	
Reach Two	38	368.00	-15.20	-0.55		-0.55	0.000004	0.21	1745.92	159.54	0.01	
Reach Two	36	368.00	-15.20	-0.55		-0.55	0.000004	0.21	1786.70	172.74	0.01	
Reach Two	35.6	368.00	-15.80	-0.55		-0.55	0.000008	0.29	1276.27	100.29	0.01	
Reach Two	35.5	368.00	-15.80	-0.55		-0.55	0.000008	0.29	1276.19	100.29	0.01	
Reach Two	35.4	368.00	-16.00	-0.56		-0.55	0.000007	0.26	1392.04	120.02	0.01	
Reach Three	35.3	375.00	-15.60	-0.56		-0.56	0.000006	0.25	1483.15	120.13	0.01	
Reach Three	35.2	375.00	-15.60	-0.56		-0.56	0.000006	0.25	1486.55	120.23	0.01	
Reach Three	35.1	375.00	-15.20	-0.56		-0.56	0.000010	0.30	1264.33	119.74	0.02	
Reach Three	34	375.00	-15.20	-0.56		-0.56	0.000003	0.17	2147.40	209.60	0.01	
Reach Three	32	375.00	-15.30	-0.57		-0.57	0.000003	0.16	2394.40	263.29	0.01	
Reach Three	30	375.00	-18.30	-0.57		-0.57	0.000003	0.15	2524.77	277.98	0.01	
Reach Three	28	375.00	-15.80	-0.57		-0.57	0.000003	0.18	2126.22	181.70	0.01	
Reach Three	26	375.00	-15.80	-0.58		-0.58	0.000003	0.18	2114.47	184.31	0.01	
Reach Three	24	375.00	-15.30	-0.58		-0.58	0.000004	0.20	1972.35	163.71	0.01	
Reach Three	22	375.00	-16.30	-0.58		-0.58	0.000003	0.18	2074.38	167.58	0.01	
Reach Three	20	375.00	-15.40	-0.59		-0.59	0.000003	0.18	2033.53	171.94	0.01	
Reach Three	18	375.00	-16.40	-0.59		-0.59	0.000004	0.20	1883.12	165.21	0.01	
Reach Three	16	375.00	-18.40	-0.59		-0.59	0.000002	0.15	2501.90	188.08	0.01	
Reach Three	14	375.00	-18.00	-0.59		-0.59	0.000002	0.17	2252.10	189.97	0.01	
Reach Three	12	375.00	-16.50	-0.60		-0.60	0.000001	0.14	2764.43	206.94	0.01	
Reach Three	10	375.00	-19.50	-0.60		-0.60	0.000001	0.11	3425.18	237.35	0.01	

Total flow in cross section.

# MODEL'S RESULTS (Cont.)

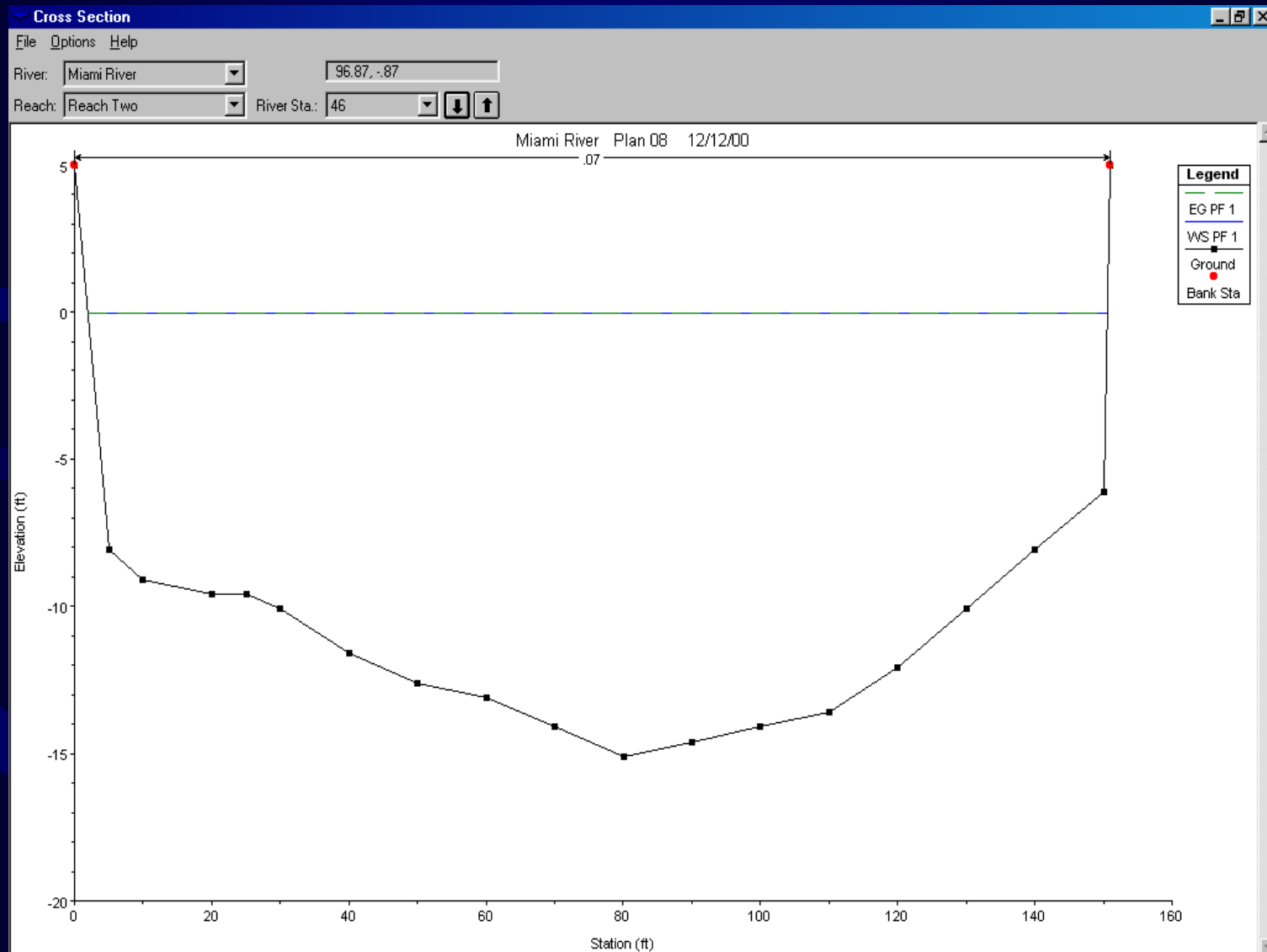
## Energy Method Results





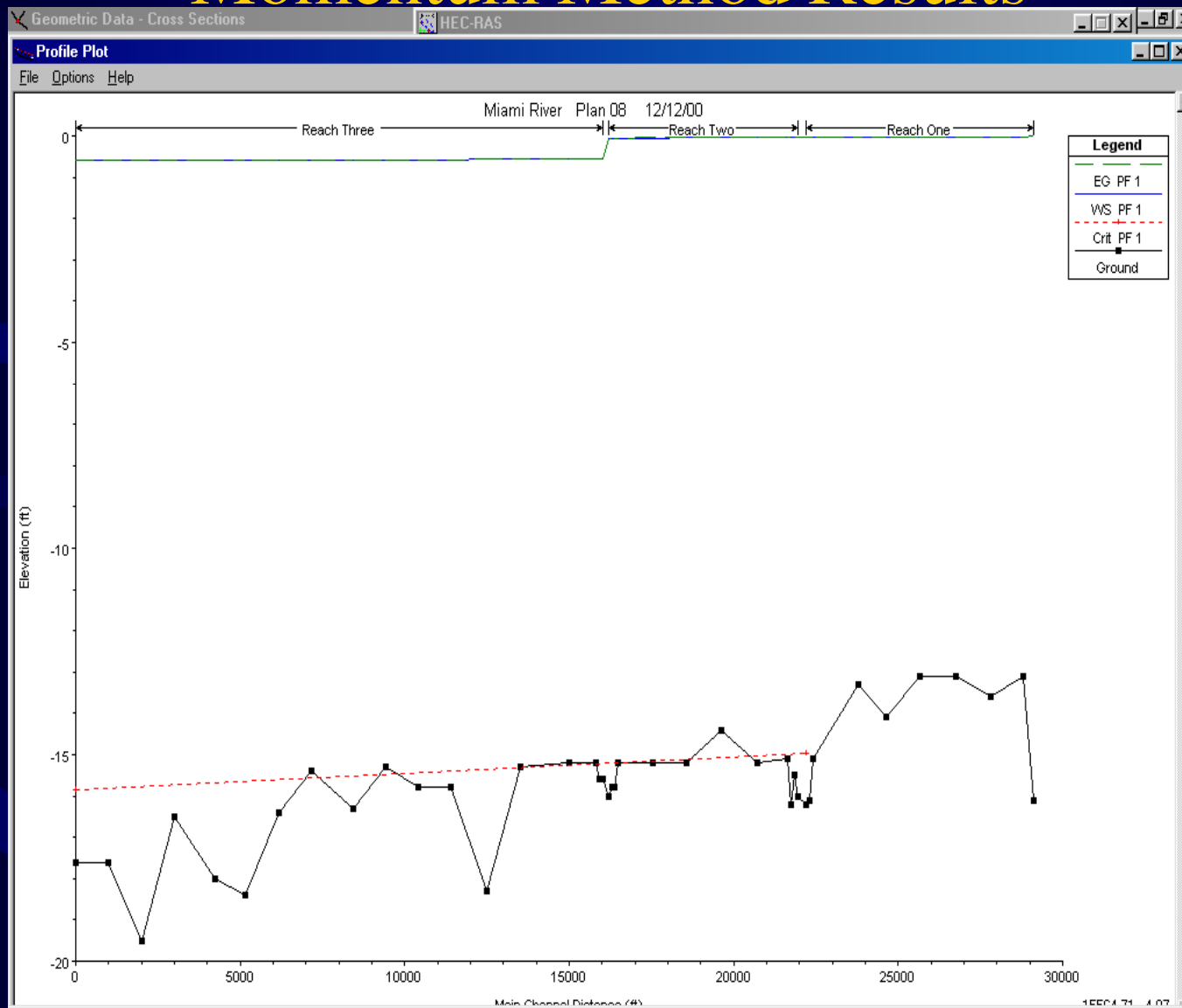
# MODEL'S RESULTS (Cont.)

## Energy Method Results



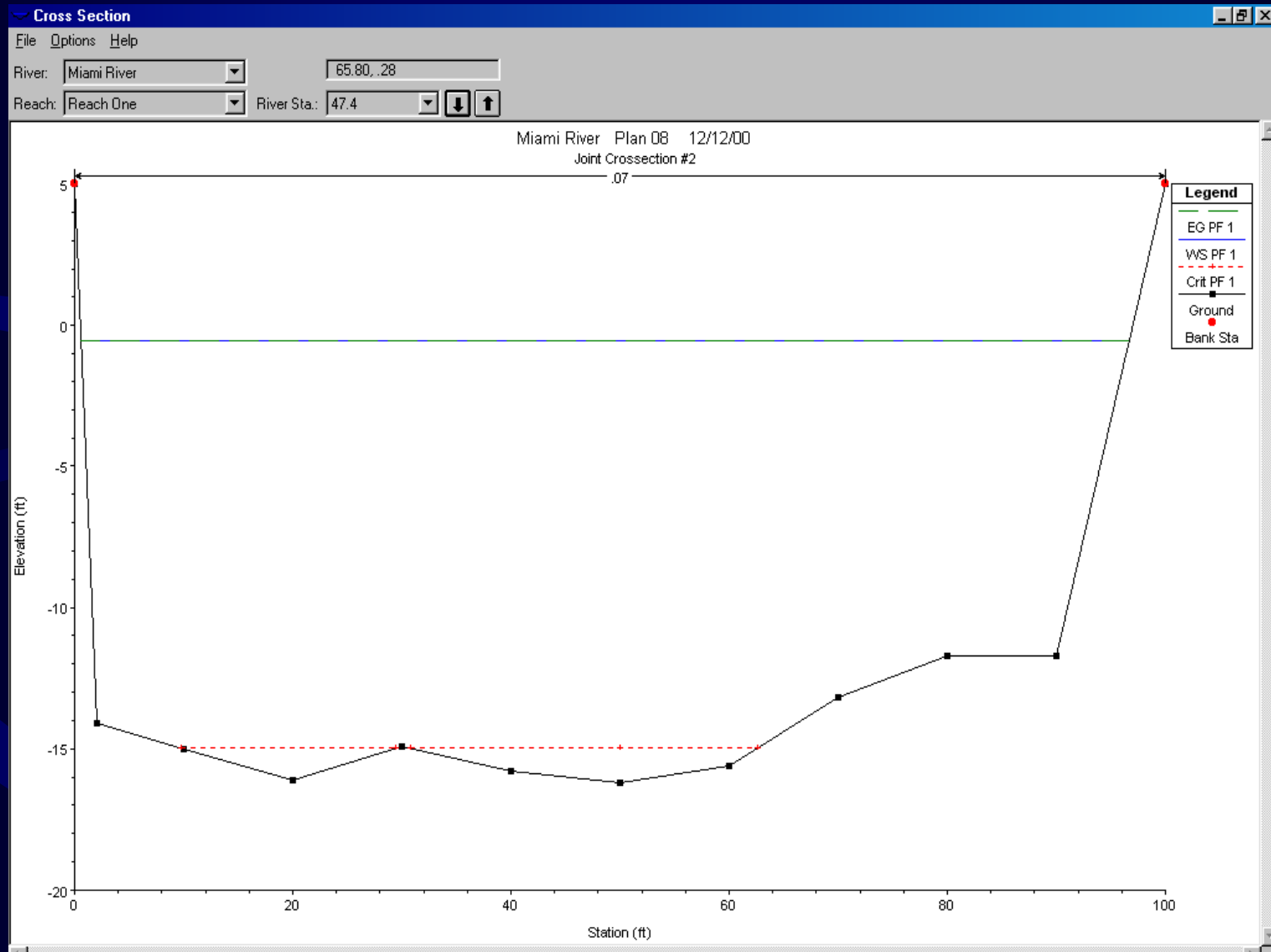
# MODEL'S RESULTS (Cont.)

## Momentum Method Results



# MODEL'S RESULTS

## Momentum Method Results

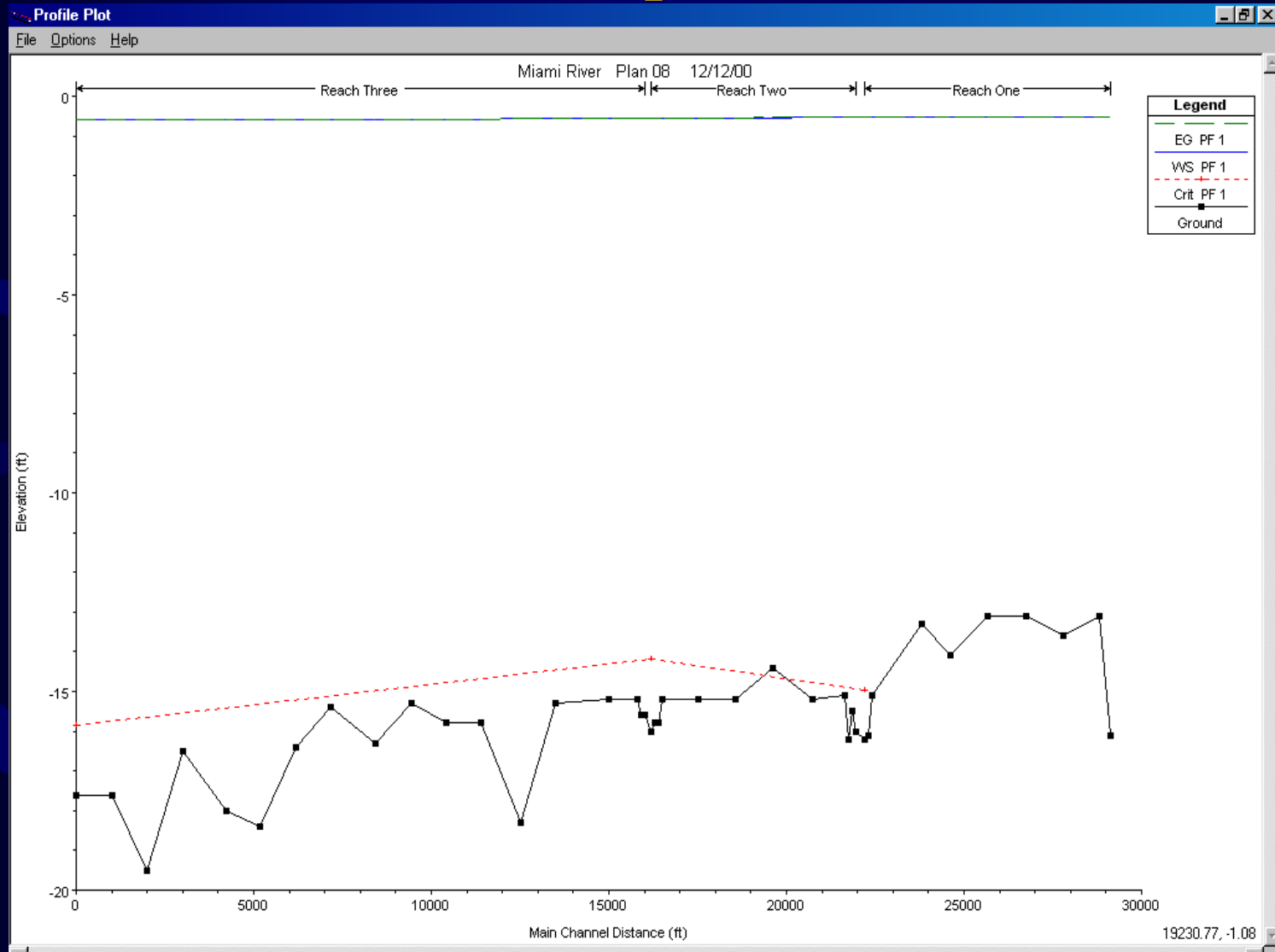


# MODEL'S RESULTS (Cont.)

- Test cross section added downstream of Comfort
- Steady flow analysis was performed

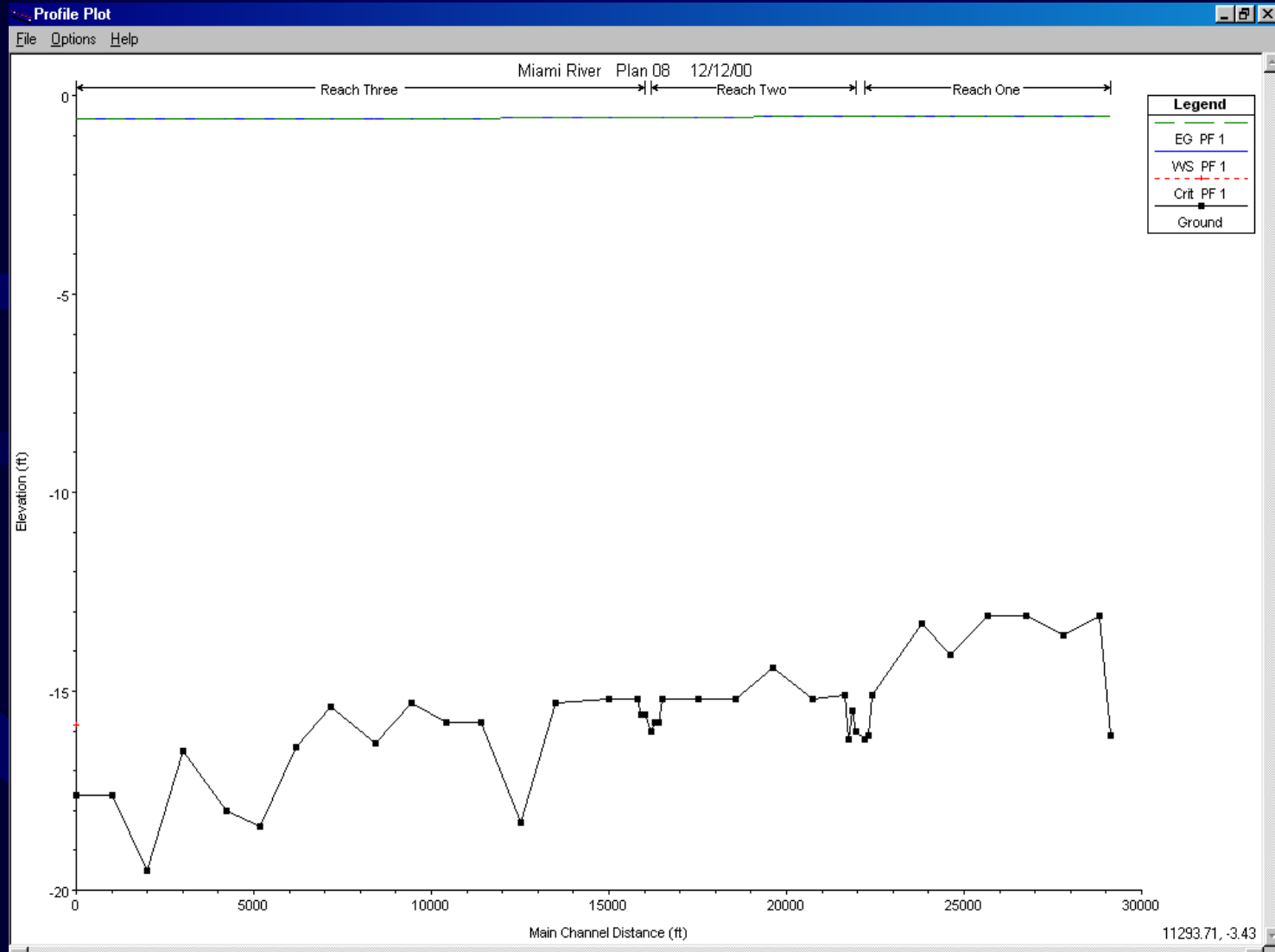
# MODEL'S RESULTS (Cont.)

## Momentum Equation Results



# MODEL'S RESULTS (Cont.)

## Energy Equation Results



# CONCLUSION

- Results obtained were expected
- Reach Three similar to the mean low water elevations
- Depth, slope, and bed roughness changed by sediments

# RECOMMENDATIONS

- Match model to existing conditions
  - Flow data and corresponding water surface elevations
  - Sensitivity analysis
- Inclusion of the flow from drainage basins



# RECOMMENDATIONS (Cont.)

- More recent cross sectional data
  - Marinas and bridges
- Operation of control structures S-26, S-25, and S-25B

# REFERENCES

Fernandez, Nahum D. *A Basic Study on the Hydraulics of the Miami River, Miami-Dade County, Florida*. Miami: Florida International University, August 2000.

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US Army Corps of Engineers. *HEC-RAS River Analysis System: User Manual, Version 2.2*. Davis: US Army Corps of Engineers, September 1998.

US Army Corps of Engineers. *HEC-RAS River Analysis System: Hydraulic Reference Manual, Version 2.2*. Davis: US Army Corps of Engineers, August 1998.

**THE END**

**ANY QUESTIONS?**