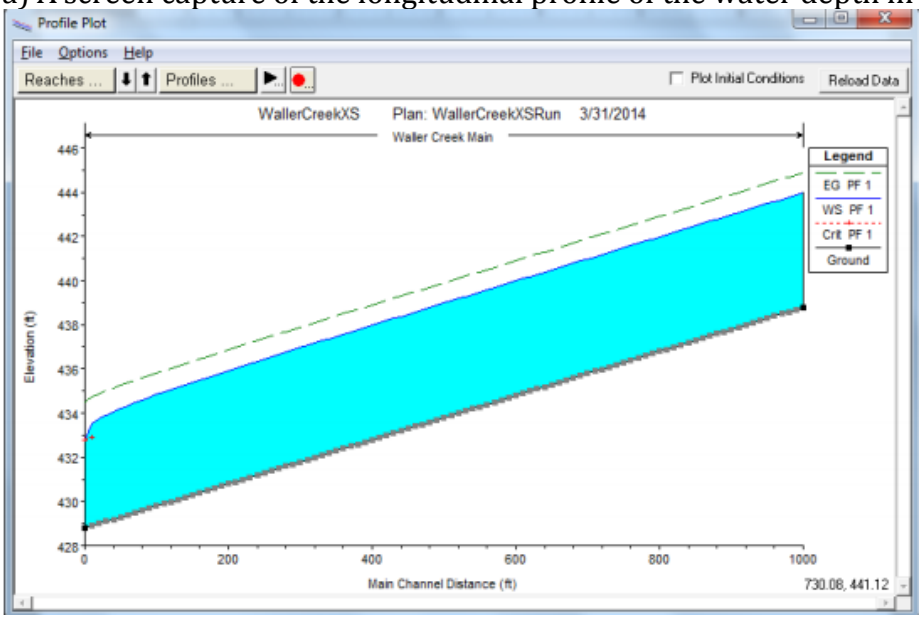
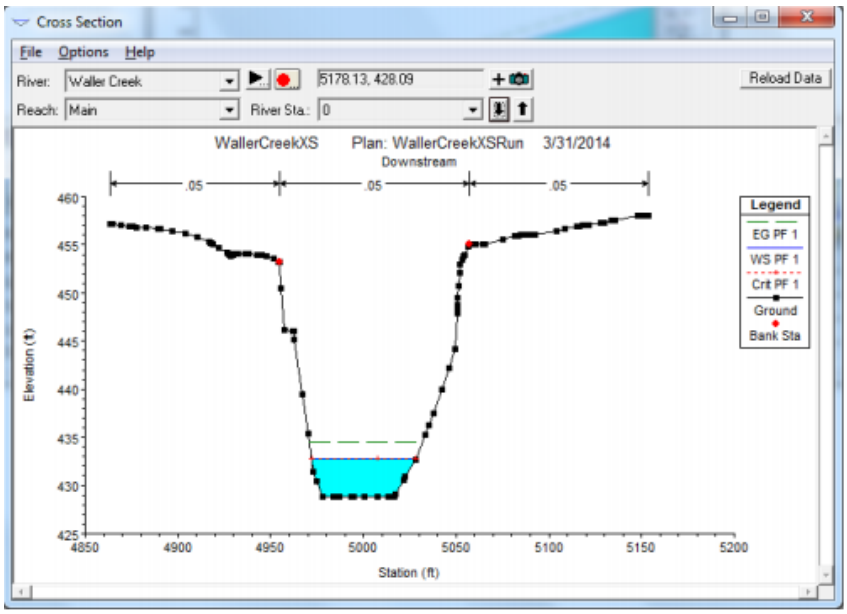
Solution to Homework 6
Hydraulic Engineering Design
Spring 2014
Prepared by Carlos Galdeano and David Maidment

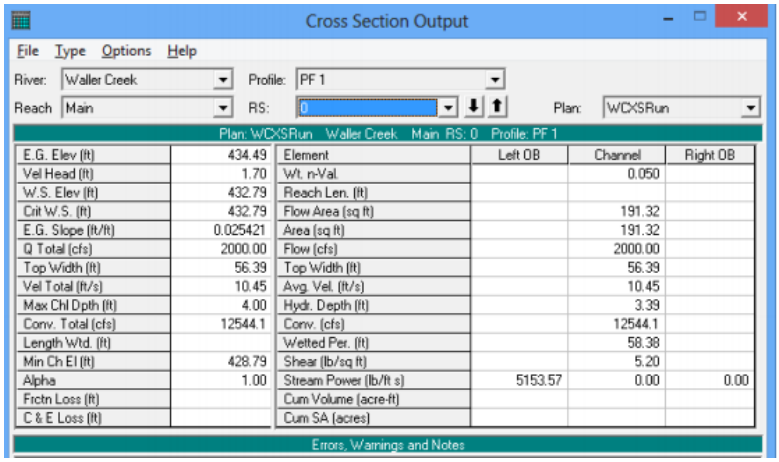
1.
a) A screen capture of the longitudinal profile of the water depth in the channel.



b) Screen captures of the Cross-sections at the upstream and downstream ends of the channel. Document the velocity, depth and top Width of the flow at these two cross-sections.

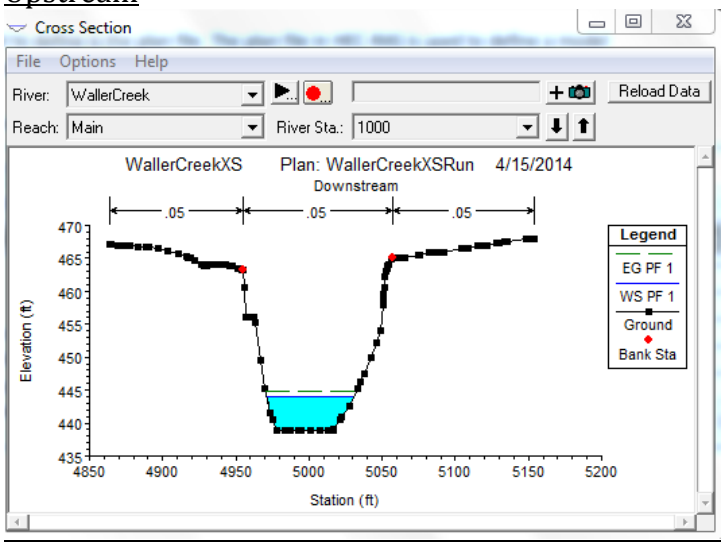
<u>Downstream</u>

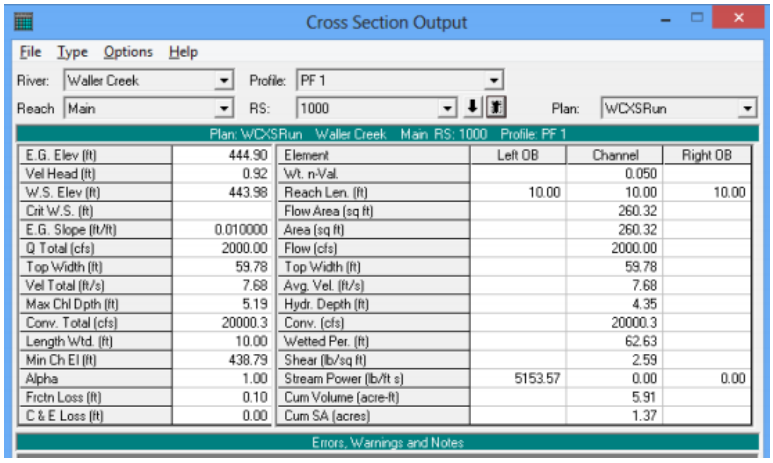




Velocity = 10.45 ft/s
Water Depth = Max Chl Dpth= 4 ft
Top Width = 56.39 ft

<u>Upstream</u>

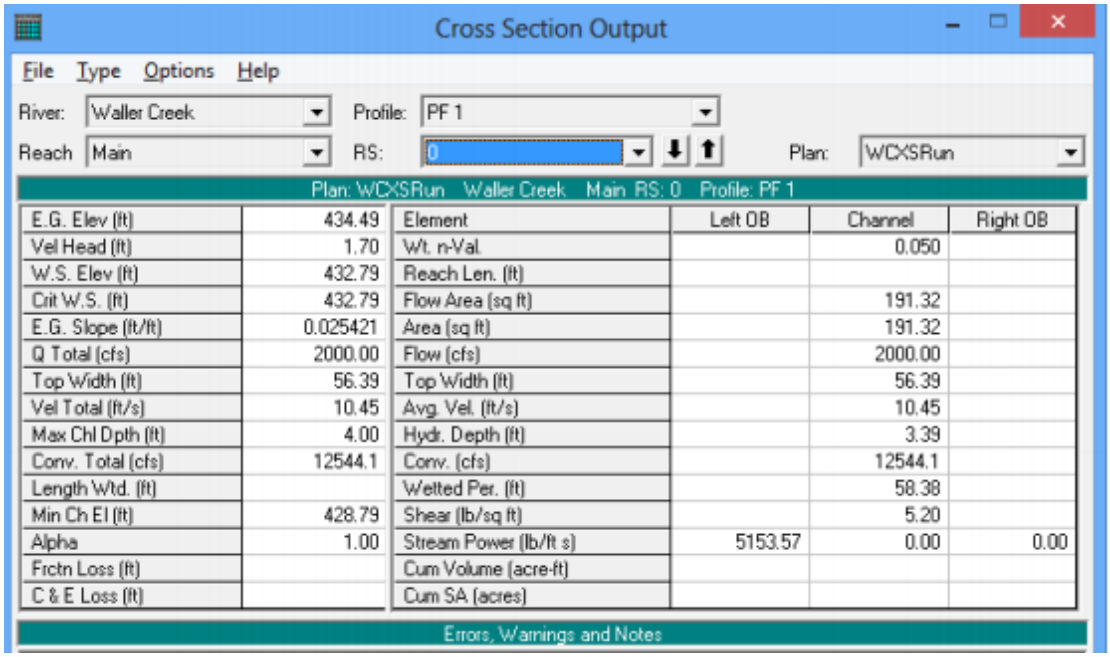




Velocity = 7.68 ft/s
Water Depth = Max Chl Dpth= 5.19 ft
Top Width = 59.78 ft

c) Use the data provided by the HEC-RAS program to verify uniform flow conditions at the upstream end of the channel and critical flow conditions at the downstream end of the channel.

Downstream



		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	434.49				
Vel Head (ft)	1.70	Wt. n-Val.		0.050	
W.S. Elev (ft)	432.79	Reach Len. (ft)			
Crit W.S. (ft)	432.79	Flow Area (sq ft)		191.32	
E.G. Slope (ft/ft)	0.025421	Area (sq ft)		191.32	
Q Total (cfs)	2000.00	Flow (cfs)		2000.00	
Top Width (ft)	56.39	Top Width (ft)		56.39	
Vel Total (ft/s)	10.45	Avg. Vel. (ft/s)		10.45	
Max Chl Dpth (ft)	4.00	Hydr. Depth (ft)		3.39	
Conv. Total (cfs)	12544.1	Conv. (cfs)		12544.1	
Length Wtd. (ft)		Wetted Per. (ft)		58.38	
Min Ch El (ft)	428.79	Shear (lb/sq ft)		5.20	
Alpha	1.00	Stream Power (lb/ft s)	5153.57	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

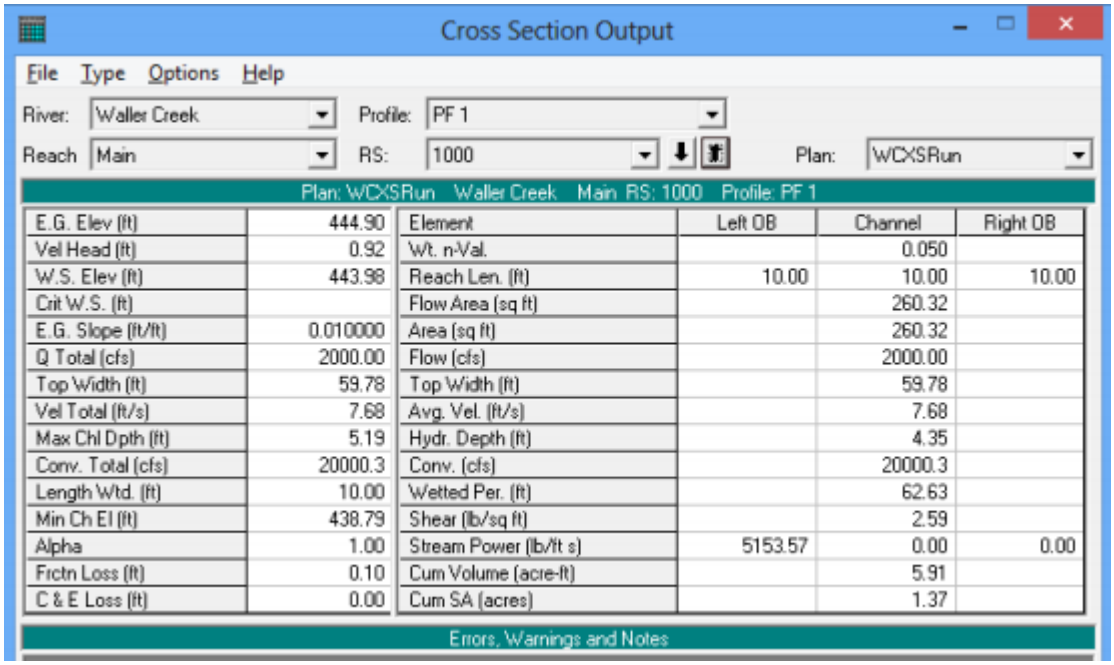
As we can see from the table above, the Water Surface Elevation and the Critical Water surface is the same (432.79 ft), which indicates that the flow downstream is Critical Flow. This can be verified using the formula for critical conditions:

$$\frac{Q^2T}{gA^3} = 1$$

From the display above, Q = 2000 cfs, T = 56.39 ft, A = 191.32 ft^2, and g = 32.2 ft/sec^2. Hence

$$\frac{\boldsymbol{Q^2T}}{\boldsymbol{gA^3}} = \frac{\boldsymbol{2000^2 * 56.39}}{\boldsymbol{32.2 * 191.32^3}} = \boldsymbol{1\ as\ required\ for\ critical\ flow}$$

Upstream



As we can see from the table above, the Energy Gradient Elevation is equal to the bed slope (0.01), which indicate that the flow upstream is uniform. Let's verify this using Mannings Equation. In general, for any flow condition:

$$Q = \frac{1.486}{n} A R^{2/3} S_f^{1/2}$$

So if we solve for the slope of the energy grade line, S_f, we obtain

$$S_f = \left(\frac{Qn}{1.486 A R^{2/3}} \right)^2$$

From the table above for upstream flow conditions, we have Q = 2000 cfs, n = 0.050, A = 260.32 ft^2, and P = 62.63 ft. Hence R = A/P = 260.32/62.63 = 4.15 ft and the resulting friction slope is

$$S_f = \left(\frac{2000 * 0.050}{1.486 * 260.32 * 4.156^{2/3}} \right)^2 = 0.01$$

Which is labeled as E.G. Slope (ft/ft) = 0.01 in the Upstream conditions given above. This is the same as the bed slope of S_o = 0.01 given as a part of the problem statement. Hence **$S_o = S_f$ and the requirement for uniform flow is satisfied**.

2. Using the web site http://fris.nc.gov/fris/ compute the expected annual damage from flood losses at 115 London St, Asheville NC. What is the value of this property? Describe the mitigation strategies that the owners of this property have to reduce their losses in the event of a flood. Which one would you choose?

<u>Value of the property</u>

Value Property = $ 415,709

115 London Rd, Asheville, NC

Google Street View

Property	
Building Value ($):	415709
Stories:	1
Square Feet (ft):	6524
Foundation:	Slab on Grade
Occupancy Type:	Retail Trade

Recalculate

The river flooding hazard is rated **High** for this location.

This year you have a **50%** chance of flooding.
Over the next 15 years you have a **100%** chance.
Over the next 30 years you have a **100%** chance.

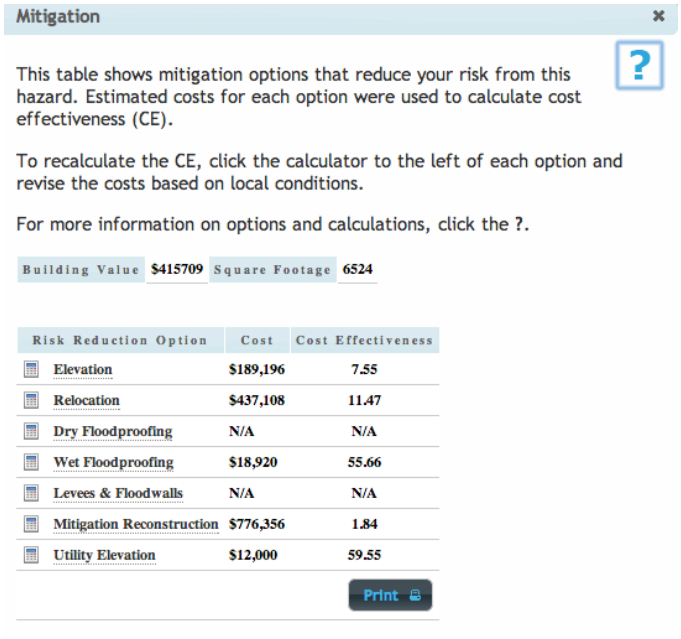
Annual Chance of Flood	Depth Above Finished Floor (in feet)	Damage	Building Losses
10 %	7.1	26%	$109,082
4 %	7.2	27%	$110,745
2 %	7.4	27%	$114,071
1 %	7.4	27%	$114,071
.2 %	7.6	28%	$117,396

(Microsoft Excel Worksheet Object)

Annual chance of Flood	Building losses	Average losses	ΔP	Expected Losses
0.1	$109,082	$109,082	0.100	$ 10,908.20
0.04	$110,745	$109,914	0.060	$ 6,594.81
0.02	$114,071	$112,408	0.020	$ 2,248.16
0.01	$114,071	$114,071	0.010	$ 1,140.71
0.002	$117,396	$115,734	0.008	$ 925.87
	Sum of Expected Losses			**$ 21,817.75**

This means that the average annual flood losses at this location are nearly $22,000 per year. About half of these losses are for 10 year return period events or less, so that means that this is a "Repetitively Loss Property" which is anticipated to have losses at fairly frequent intervals.

Mitigation Strategies



Mitigation

This table shows mitigation options that reduce your risk from this hazard. Estimated costs for each option were used to calculate cost effectiveness (CE).

To recalculate the CE, click the calculator to the left of each option and revise the costs based on local conditions.

For more information on options and calculations, click the ?.

Building Value $415709 Square Footage 6524

Risk Reduction Option	Cost	Cost Effectiveness
Elevation	$189,196	7.55
Relocation	$437,108	11.47
Dry Floodproofing	N/A	N/A
Wet Floodproofing	$18,920	55.66
Levees & Floodwalls	N/A	N/A
Mitigation Reconstruction	$776,356	1.84
Utility Elevation	$12,000	59.55

Print

Utility Elevation costs $12,000 and given that the property floods frequently, it is clear that this is worthwhile (Benefit/Cost Ratio = 59.55).

Wet Flood Proofing costs $18, 920, and again since the property floods frequently, this is also worthwhile (Benefit/Cost Ratio = 55.66).

Relocation costs $437,108, and although it is much more expense, the Benefit/Cost ratio = 11.47

Elevating the Building costs $189,196 and it also has a very positive Benefit/Cost ratio = 7.55

If only a small amount of capital is available than elevating the utilities and wet flood proofing should be done.

If more capital is available, it is probably best just to relocate the whole activity in this building.

a) Elevation

Elevating your home above the potential floodwater height can significantly reduce your risk, but knowing just how high you need to go is essential for this strategy to be effective. Elevation height should be at least one foot above Base Flood Elevation (BFE), though extra height is recommended.

b) Relocation

Relocation is moving a structure out of a flood hazard area.

c) Dry flood Proofing

Dry floodproofing can be used where flooding is expected to be less than three feet deep. It makes a house watertight below the level that needs flood protection so that floodwaters cannot enter.

d) Wet flood Proofing

Wet floodproofing applies measures to prevent and resist structural damage to your home while allowing floodwaters to enter. Wet floodproofing is not practical for portions of the home used for living space; therefore, it is usually used to limit damages to basements, crawlspaces, or attached garages.

e) Levees & Floodwalls

Levees and floodwalls are types of constructed flood protection barriers.

f) Mitigation Reconstruction

Mitigation reconstruction projects include demolition of an existing home and rebuilding it according to the local building code, floodplain management, and zoning requirements. It is only permitted if traditional structure elevation cannot be implemented.

g) Utility Elevation

Utility elevation raises utilities and electrical panels above Base Flood Elevation (BFE). Costs associated with utility elevation include relocation of HVAC equipment, duct work, and all connections. Utility elevation does not include construction of new storage closets or replacement utility systems.