Developing Irregular Cross-sections for DSM2-Hydro

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Acknowledgements

- Ralph Finch
- Nicky Sandhu
- Parviz Nader-Tehrani

Problem Statement

to describe 3D bathymetry data to hydro, a 1D model

Use CSDP to create model geometry

- Create a minimal representative data set based on the bathymetry data set
- place less emphasis on unreliable or less representative data
- evaluate the effects of proposed changes

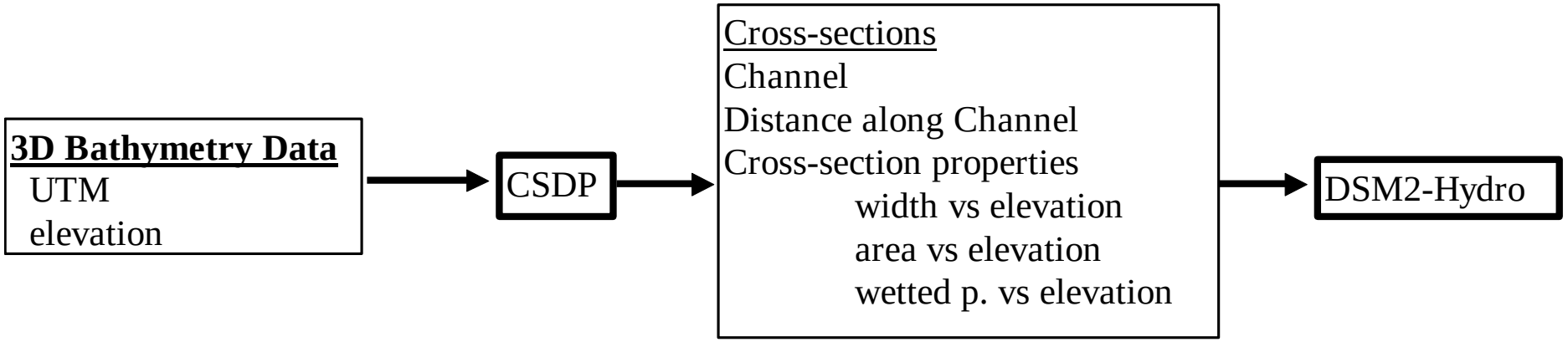
Outline

- Introduction to CSDP
- Problems to avoid
- Demonstration of CSDP
- CSDP Example problem(?)

CSDP

- replaces BDD
- written in Java
  - also an object-oriented language
  - platform independent
  - easier to maintain than C++
- available on DMS web page
  - http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/csdp

Geometry Development

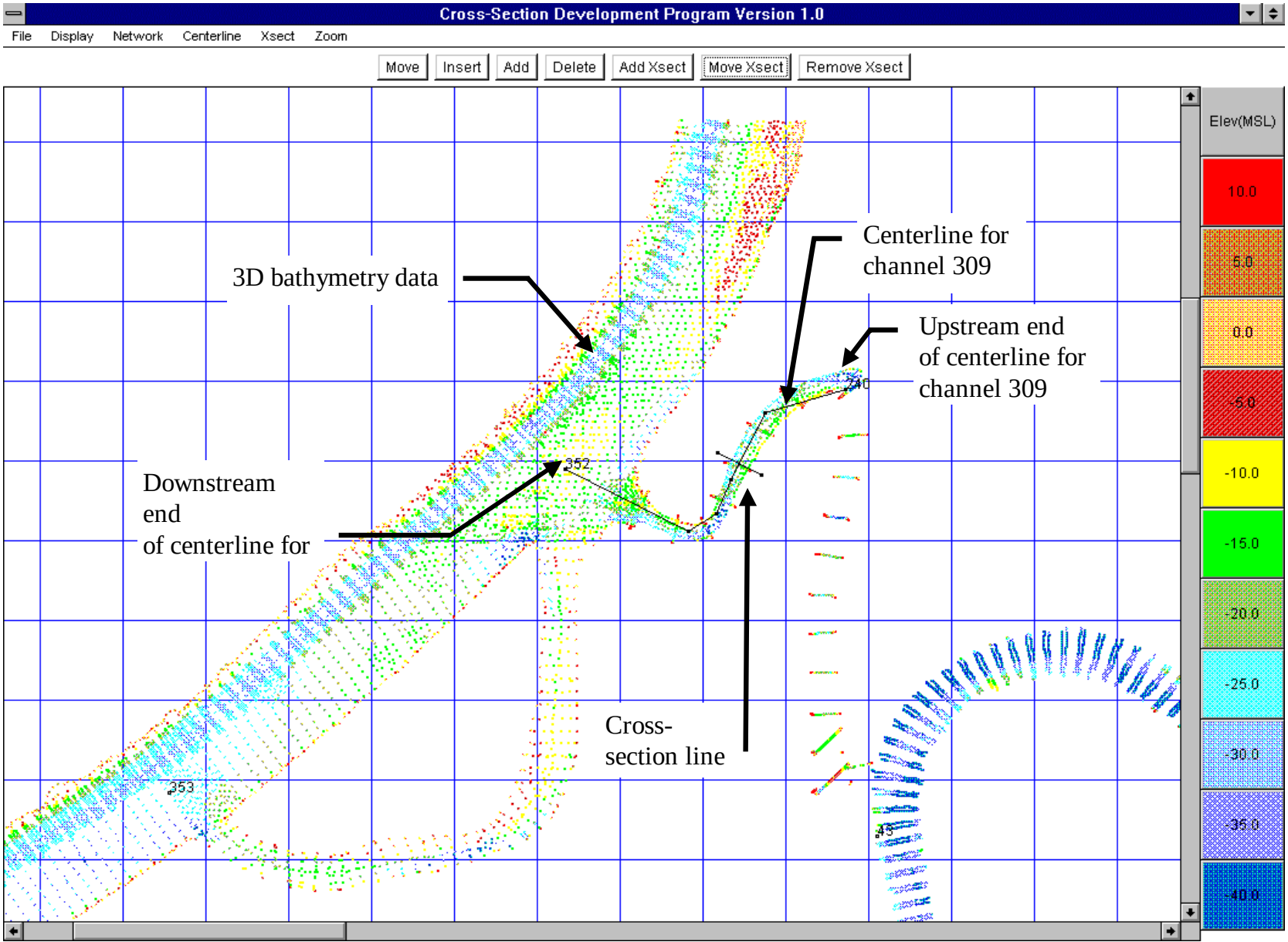


3D Bathymetry Data

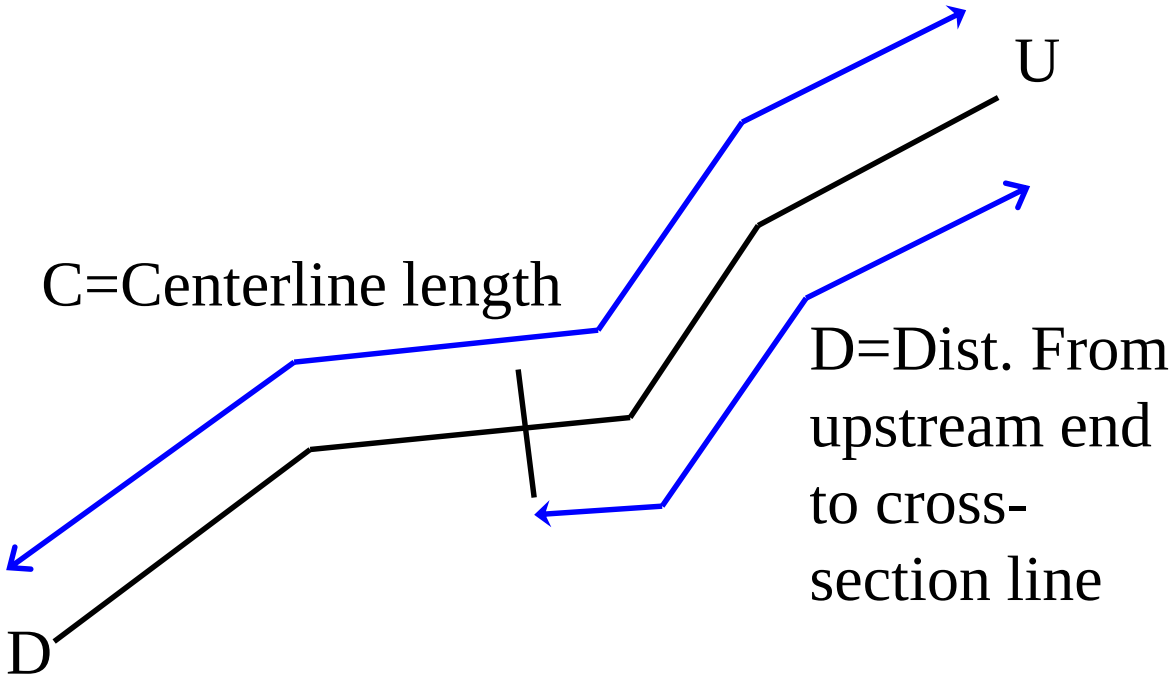
```
;HorizontalDatum:  UTMNAD83
;HorizontalZone:   10
;HorizontalUnits:  Meters
;VerticalDatum:    NGVD29
;VerticalUnits:    USSurveyFeet
;Filetype: bathmetry
;NumElements: 382117
630611.64,4193254.73,-14.54,1934,NOAA,N71-00500
630664.06,4193277.77,-8.53,1934,NOAA,N71-00501
630637.85,4193266.25,-12.54,1934,NOAA,N71-00502
```

Column	Description
1	Easting(west/east UTM zone 10 NAD27 coord.)
2	Northing(north/south UTM zone 10 NAD27 coord.)
3	elevation, ft(NGVD)
4	year of survey
5	source of data or name of survey
6	description of data point(currently not used)

CSDP

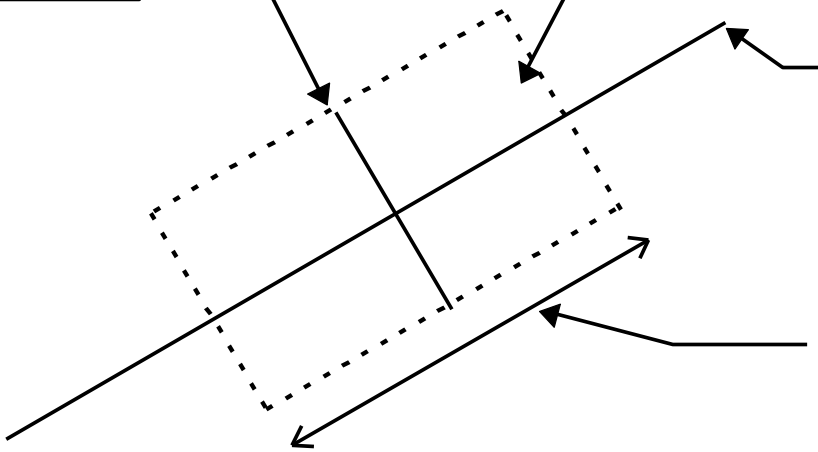

Cross-Section Development Program Version 1.0
File
Display
Network
Centerline
Xsect
Zoom
Move
Insert
Add
Delete
Add Xsect
Move Xsect
Remove Xsect
Elev(MSL)
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
3D bathymetry data
Centerline for channel 309
Upstream end of centerline for channel 309
Downstream end of centerline for
Cross-section line
352
353

Cross-section Normalized Distance



$$N=D/C$$

Data selection



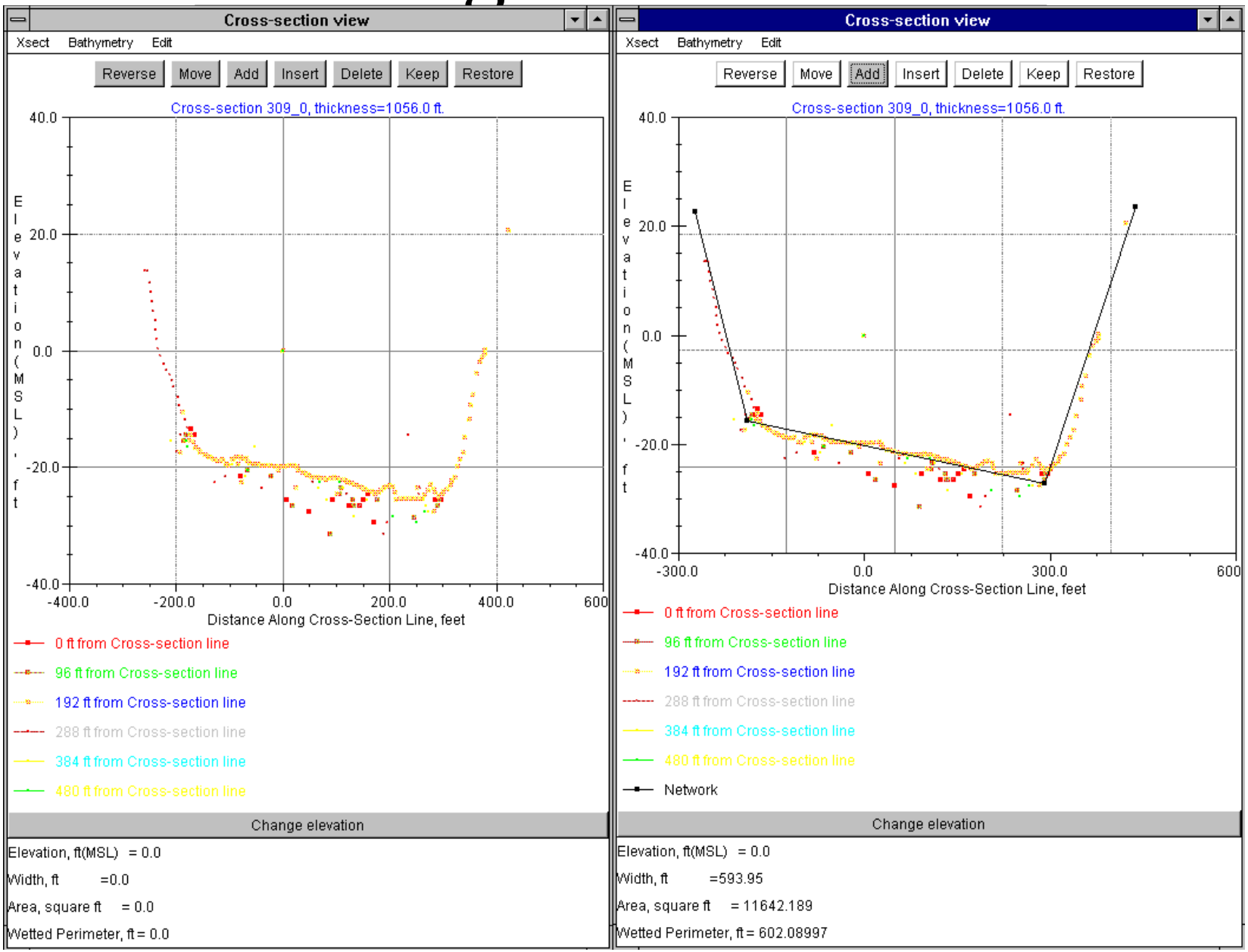
Cross-section line: defines width of region

Rectangular region defined by centerline, cross-section line, and cross-section thickness

Centerline segment

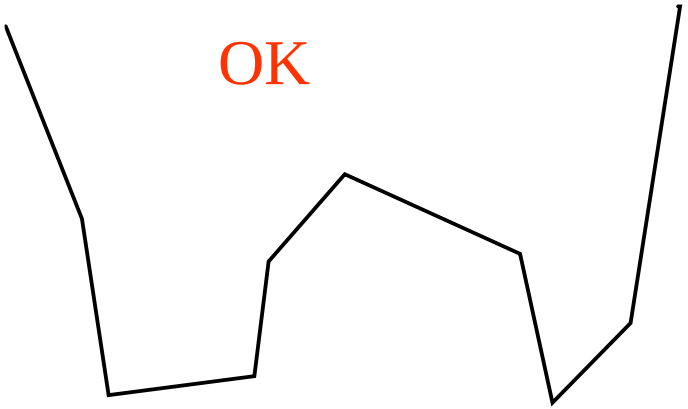
Cross-section thickness: defines length of region; adjusted by Display-Parameters menu item

Drawing Cross-sections



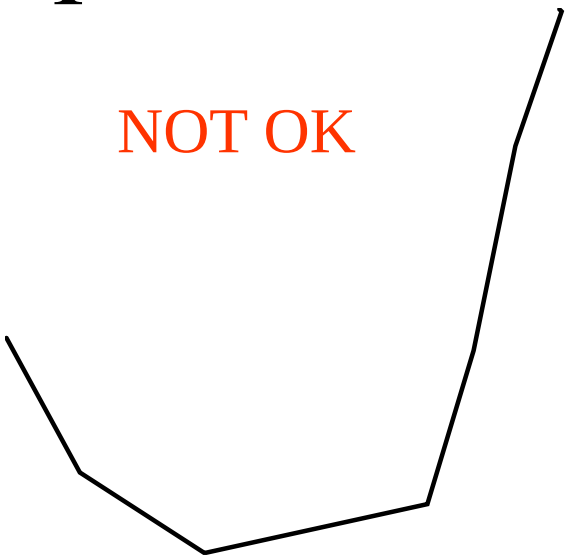
“W” shaped cross-section

OK

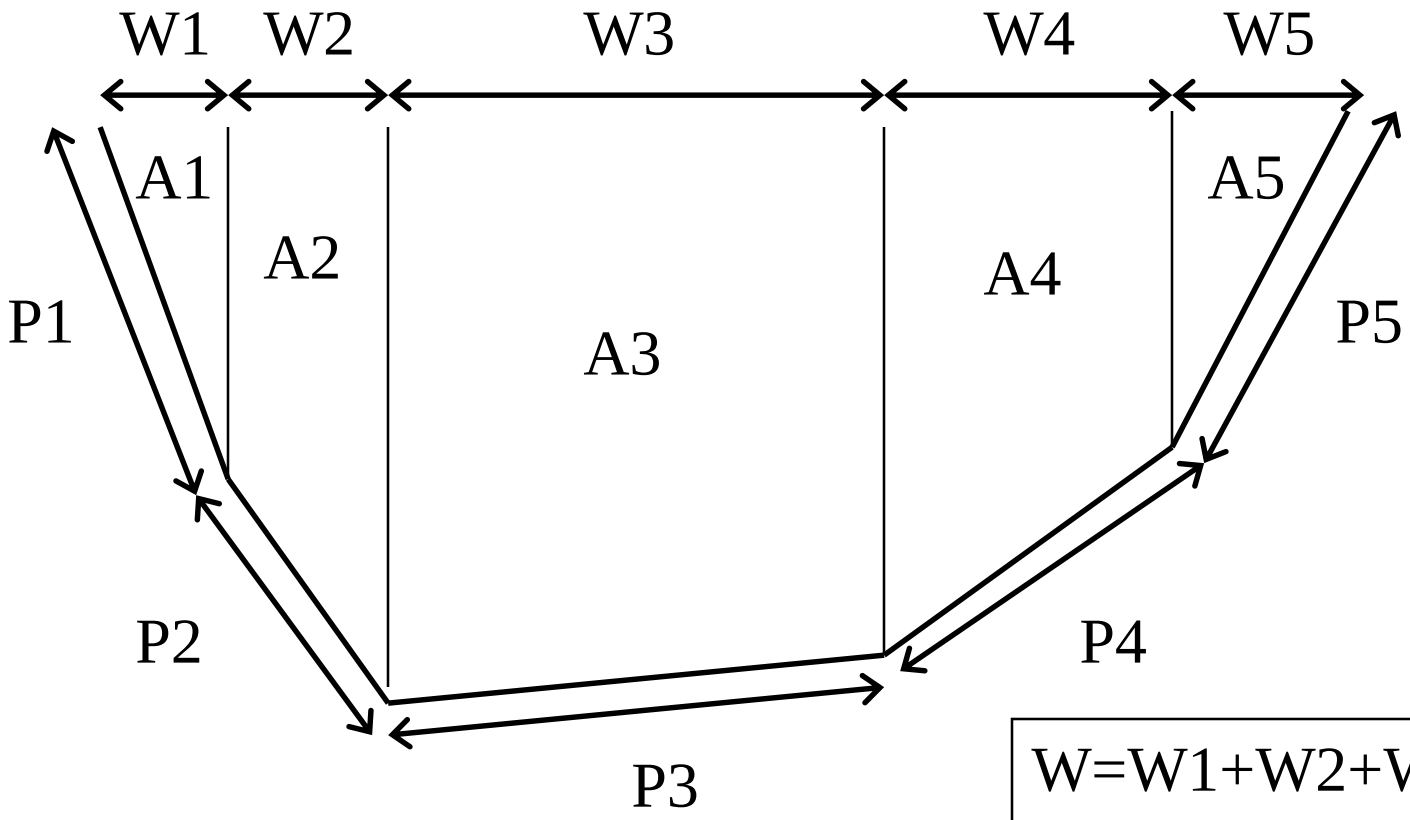


“J” shaped cross-section

NOT OK



Calculation of Conveyance Characteristics

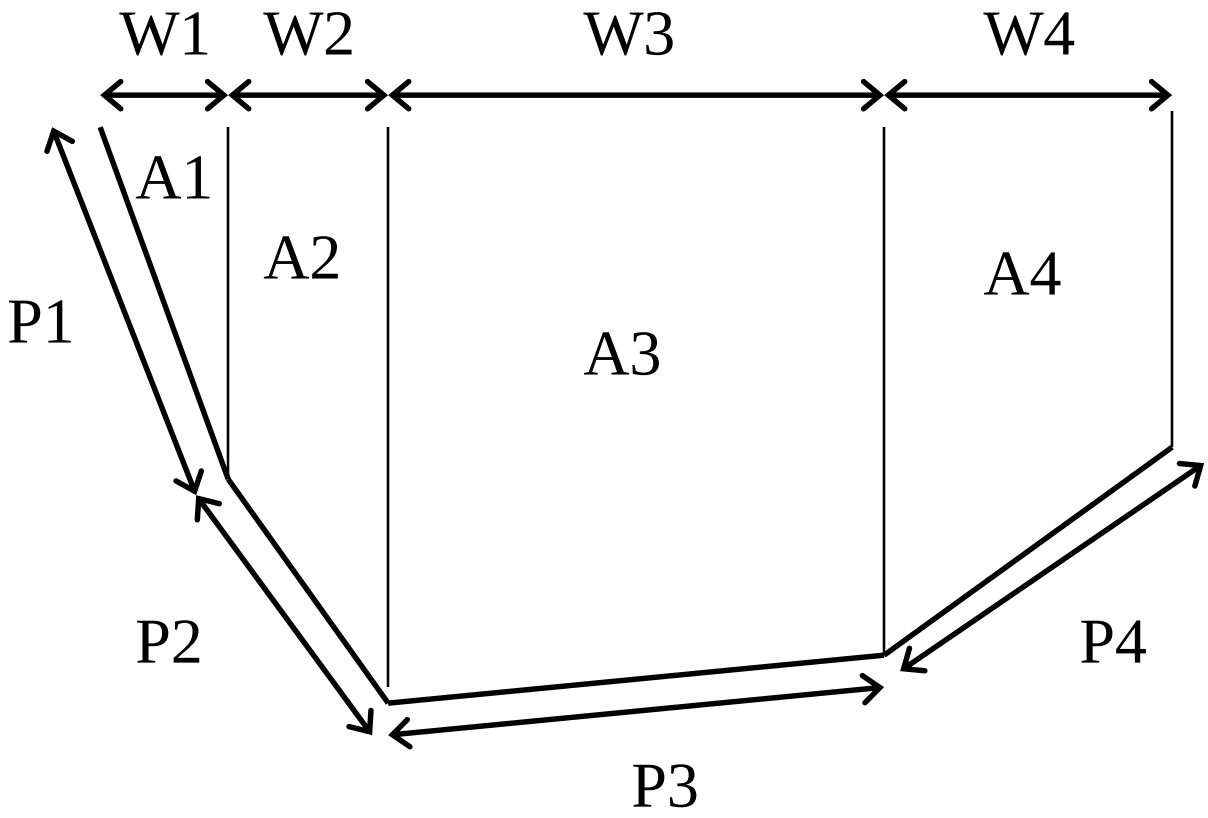


W=W1+W2+W3+W4+W5

A=A1+A2+A3+A4+A5

P=P1+P2+P3+P4+P5

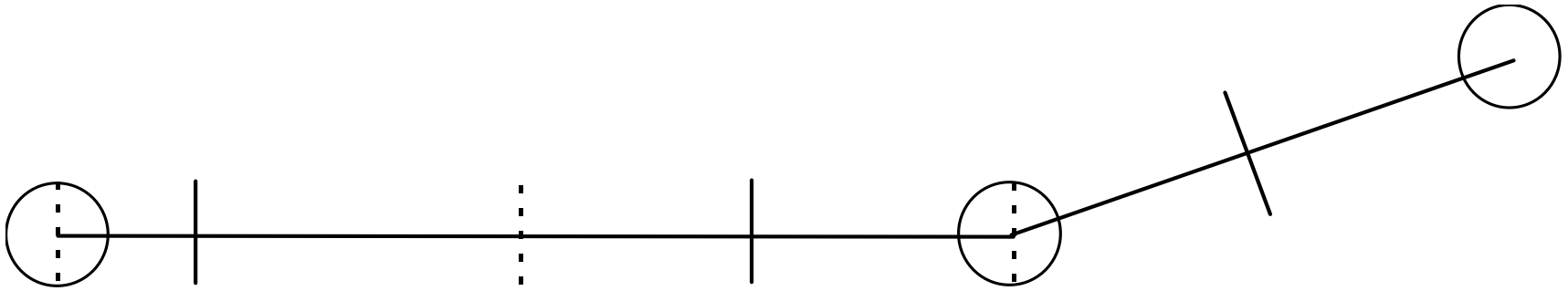
Why J-Shaped cross-section is a bad idea



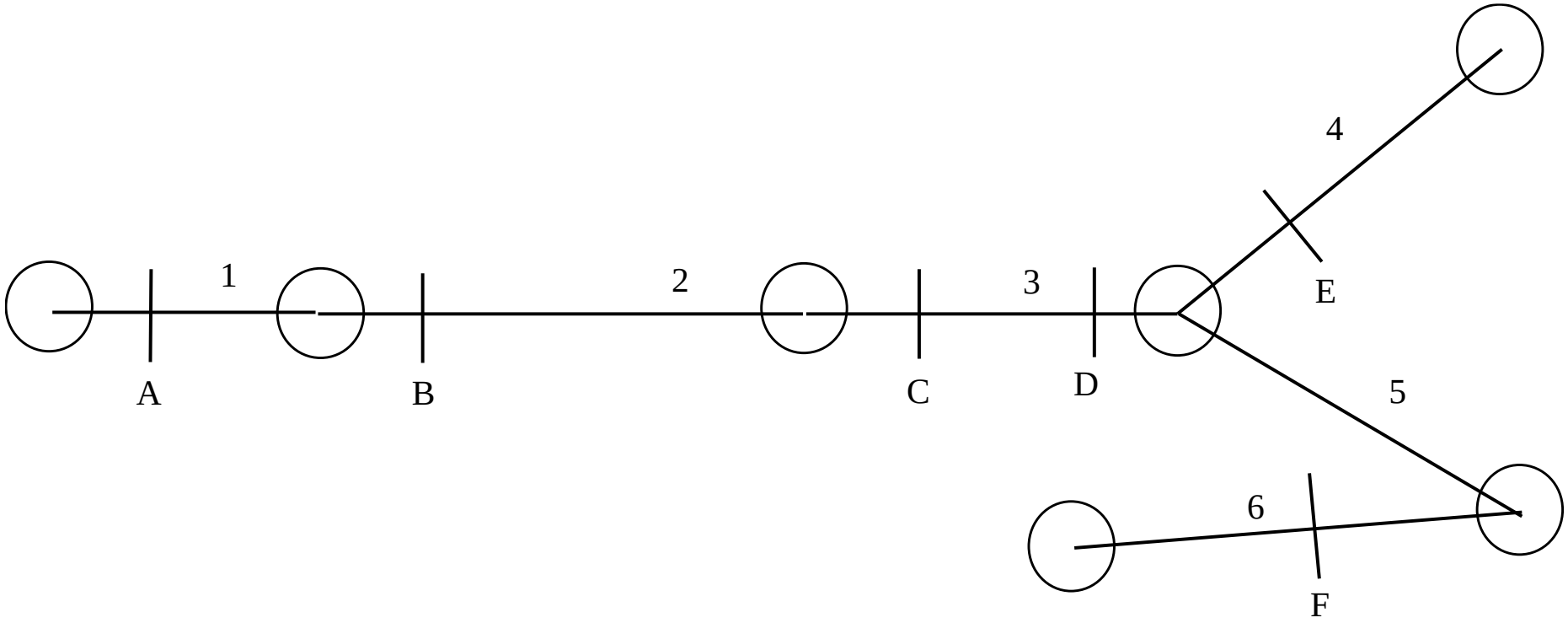
Area is not much smaller,
But wetted perimeter is!
Result:
inaccurate estimation of conveyance characteristics

Cross-section Interpolation

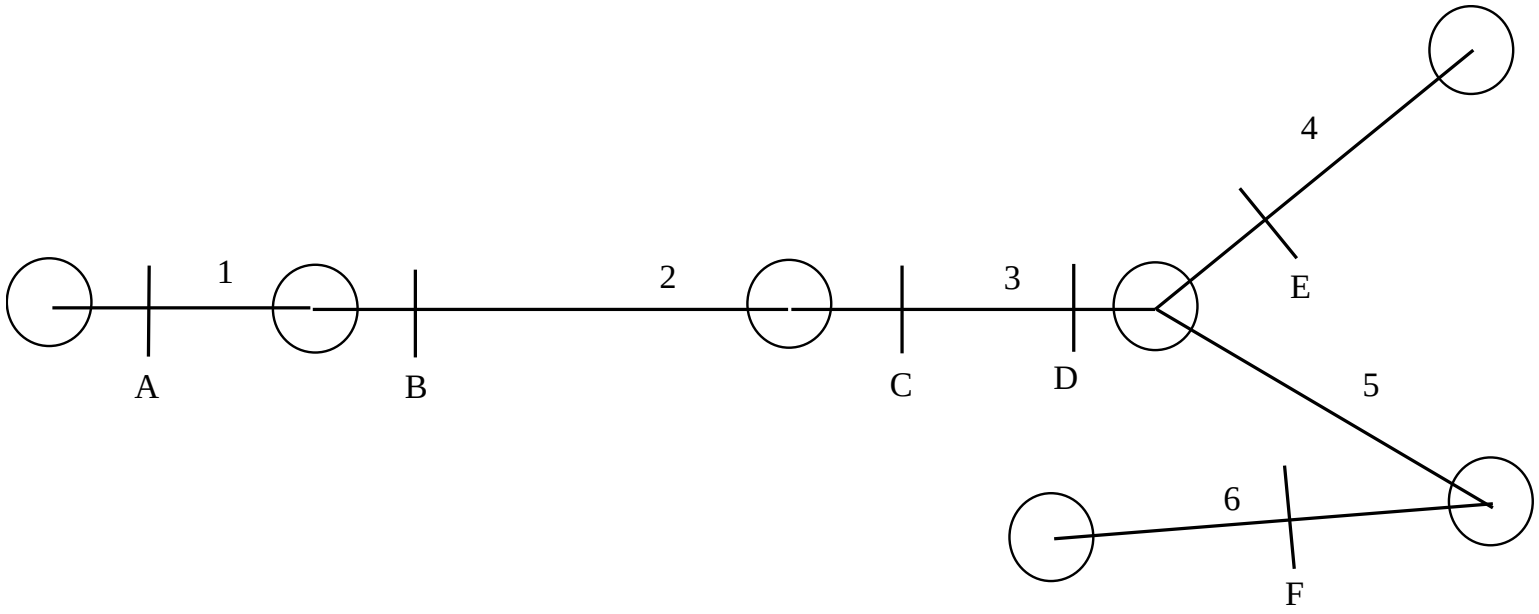
- results in a virtual (interpolated) cross-section at every computational point
- done automatically by Hydro
- limits the use of rectangular cross-sections

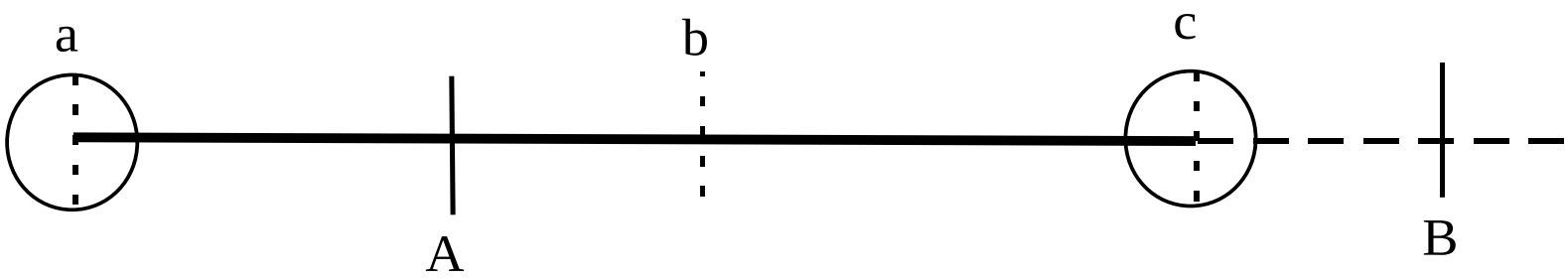


Cross-section Interpolation Example

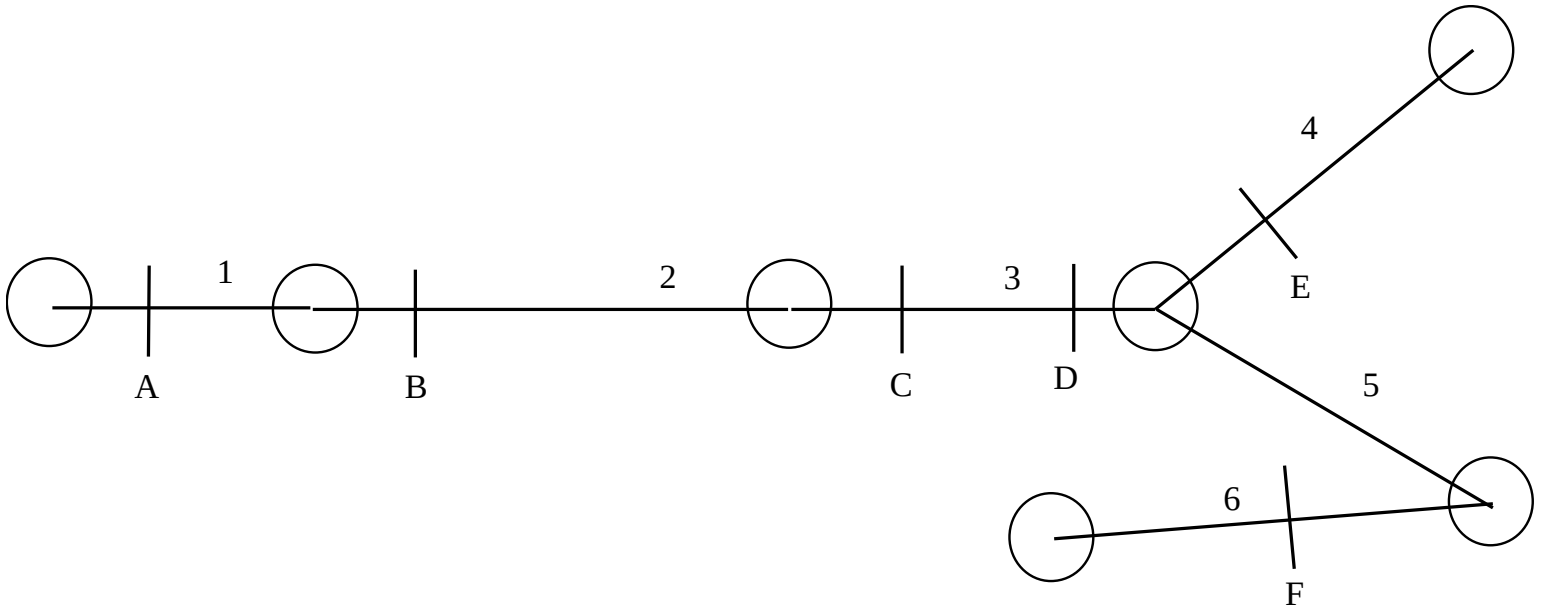


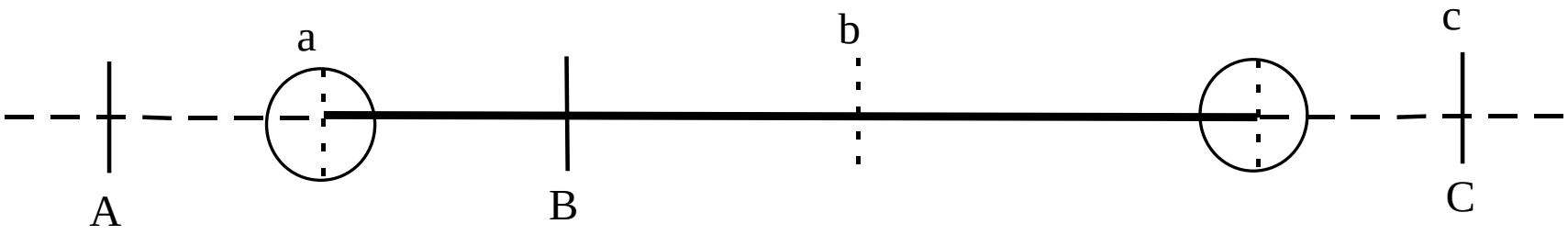
Channel 1



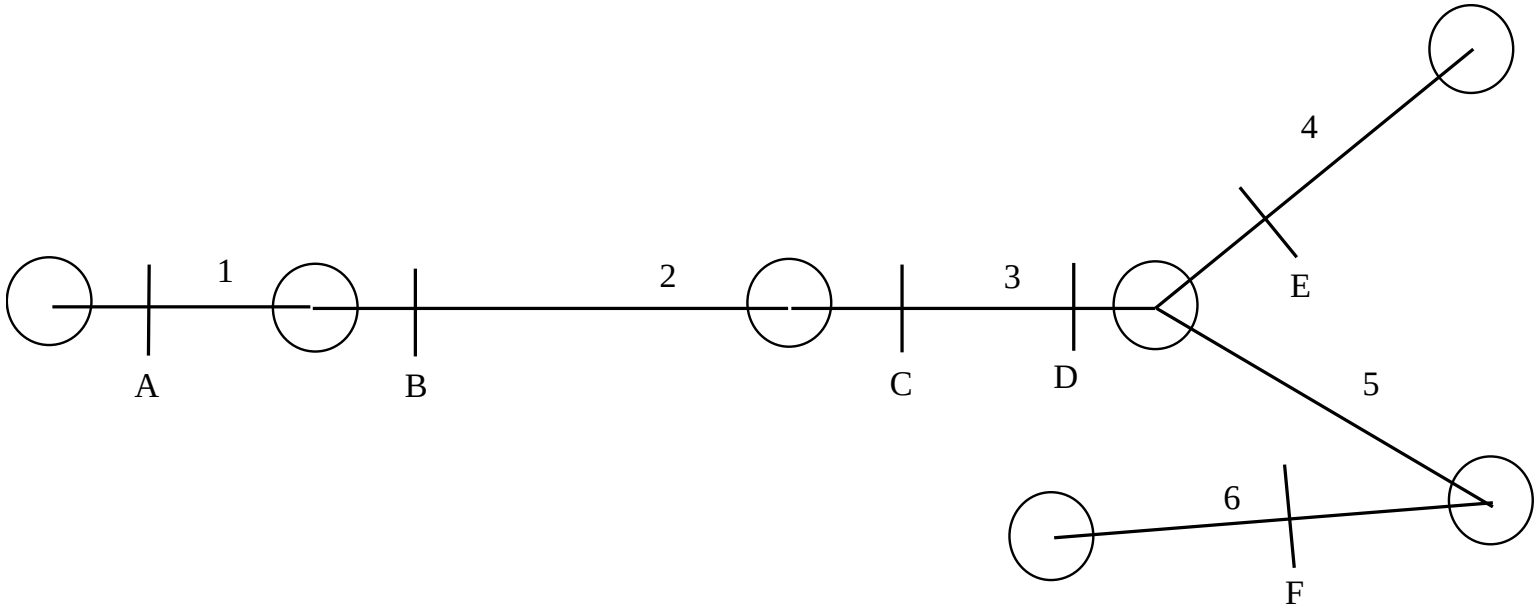


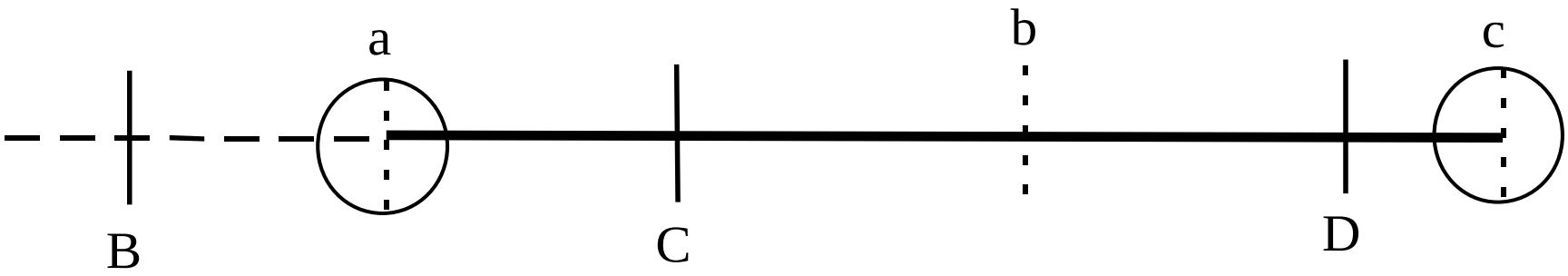
Channel 2



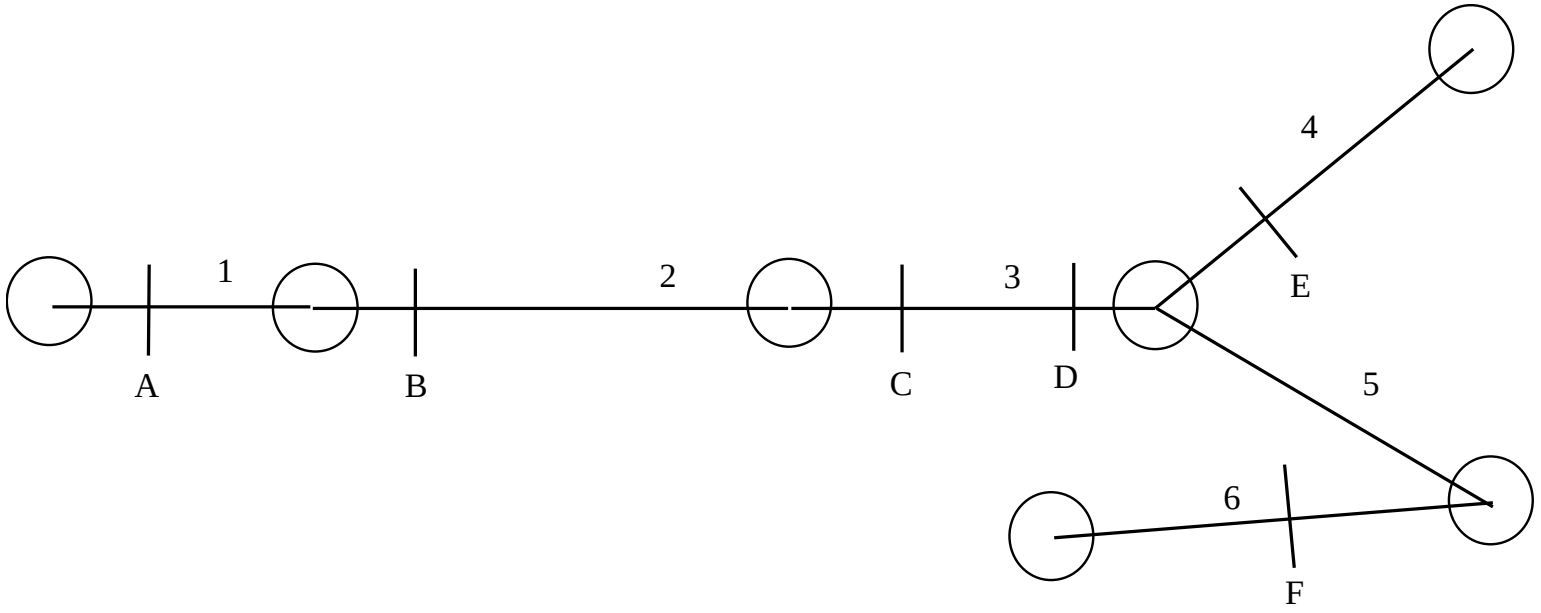


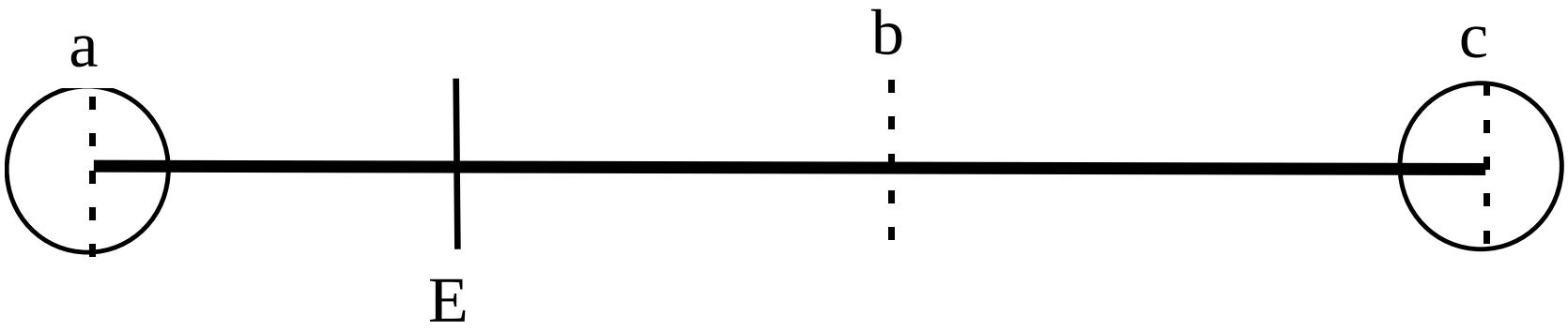
Channel 3



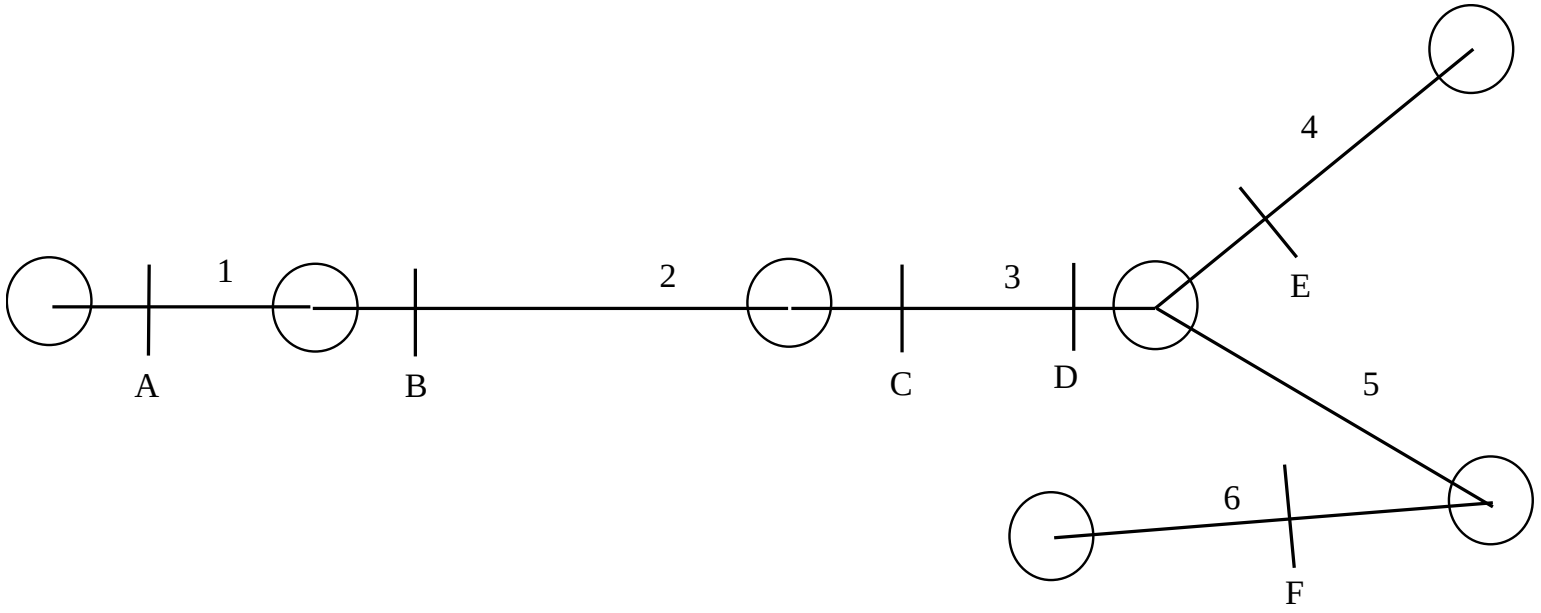


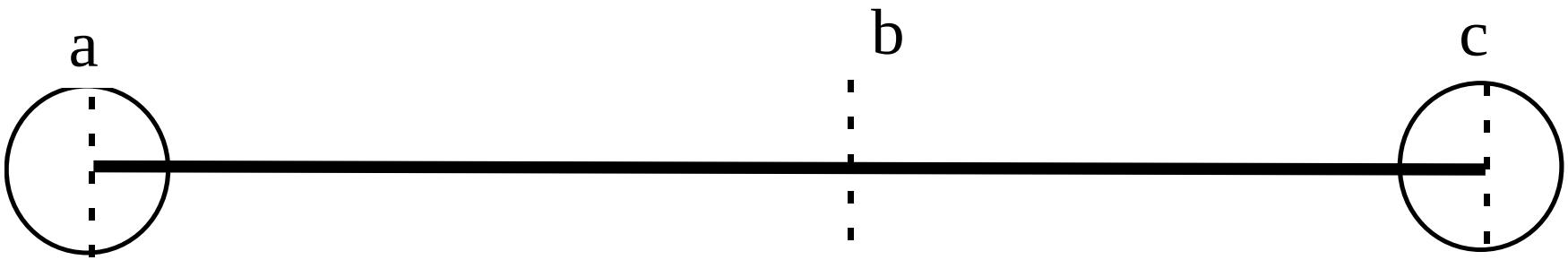
Channel 4



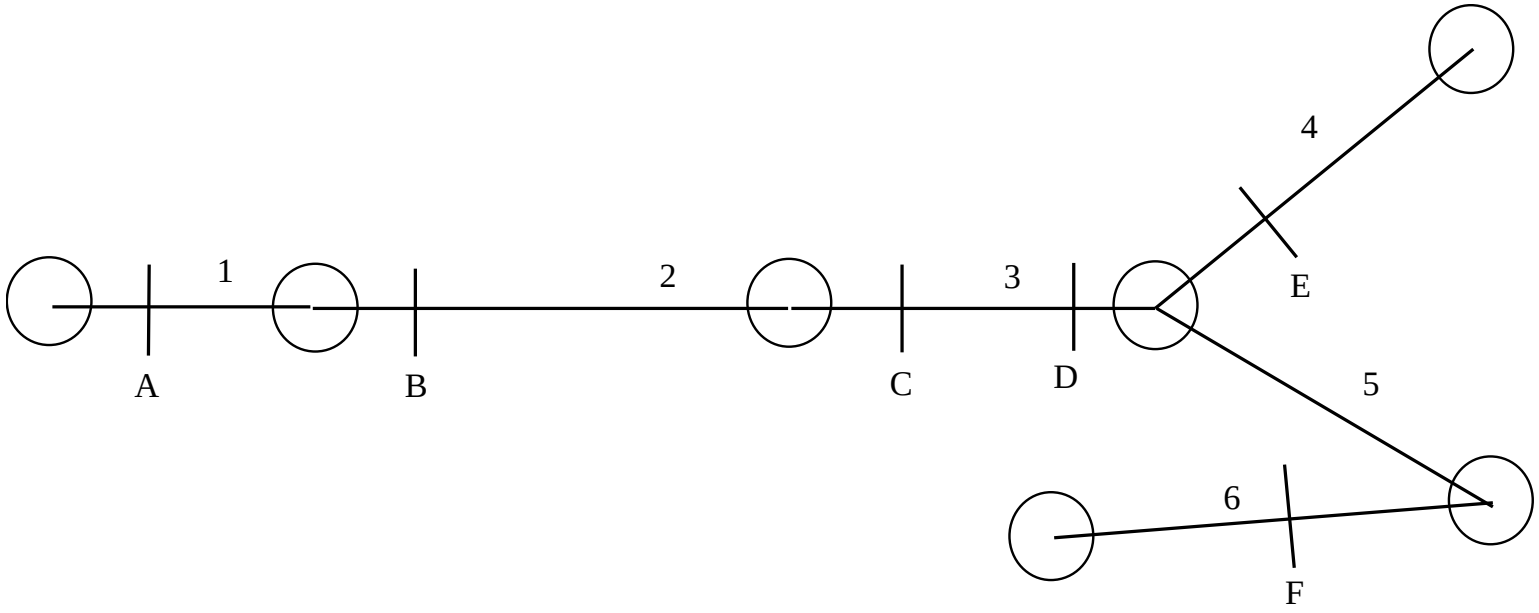


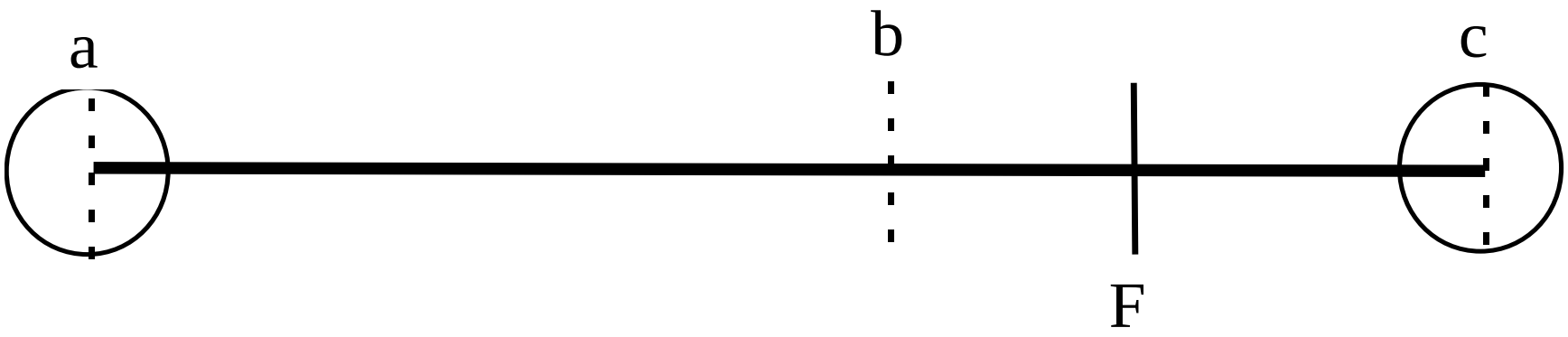
Channel 5





Channel 6





DSM2 Virtual Cross-Sections

VIRTUAL CROSS-SECTION LOOKUP TABLE

Channel 1,Virtual Section 1

Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10

Channel 1,Virtual Section 2

Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10

Channel 1,Virtual Section 3

Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10

Problems to avoid

- Convergence Failures-big changes within channel
- negative dConveyance
- interpolated negative dConveyance

Convergence Failures

- model will not converge if large changes in NGVD area within a channel
  max NGVD area >= 2 * min NGVD area
- If a channel dries up or overflows, could be the result of a convergence failure
- to find channels with potential convergence problems, run Hydro with printlevel 5
- to correct: adjust cross-sectional areas or assign cross-sections to ends of channels to prevent interpolation

Negative dConveyance

$$K = \left(\frac{1.486}{n}\right) A R^{\frac{2}{3}}$$

since $R = \frac{A}{P}$

$$K = \left(\frac{1.486}{n}\right) \frac{A^{\frac{2}{3}}}{P^{\frac{2}{3}}}$$

$$\frac{\partial K}{\partial Z} = \left(\frac{\partial K}{\partial A}\frac{\partial A}{\partial Z} + \frac{\partial K}{\partial P}\frac{\partial P}{\partial Z}\right)$$

$$\frac{\partial K}{\partial Z} = \left(\frac{1.486}{n}\right)\left(\frac{5}{3}\frac{A^{\frac{2}{3}}}{P^{\frac{2}{3}}}\frac{\partial A}{\partial Z} + \left(-\frac{2}{3}\right)\frac{A^{\frac{5}{3}}}{P^{\frac{5}{3}}}\frac{\partial P}{\partial Z}\right)$$

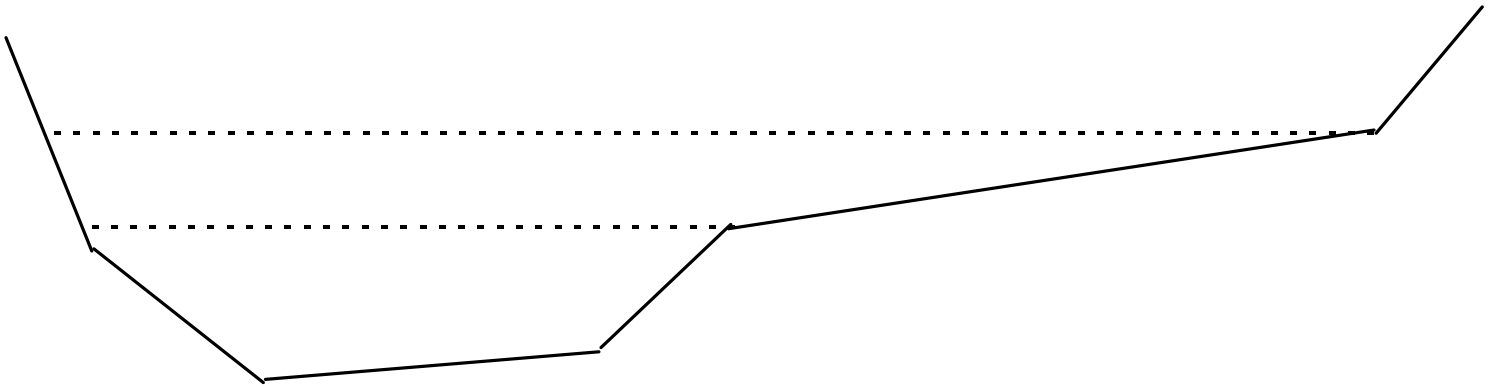
If $\frac{\partial K}{\partial Z} < 0$, then

$$\frac{5}{3}\frac{A^{\frac{2}{3}}}{P^{\frac{2}{3}}}\frac{\partial A}{\partial Z} + \left(-\frac{2}{3}\right)\frac{A^{\frac{5}{3}}}{P^{\frac{5}{3}}}\frac{\partial P}{\partial Z} < 0$$

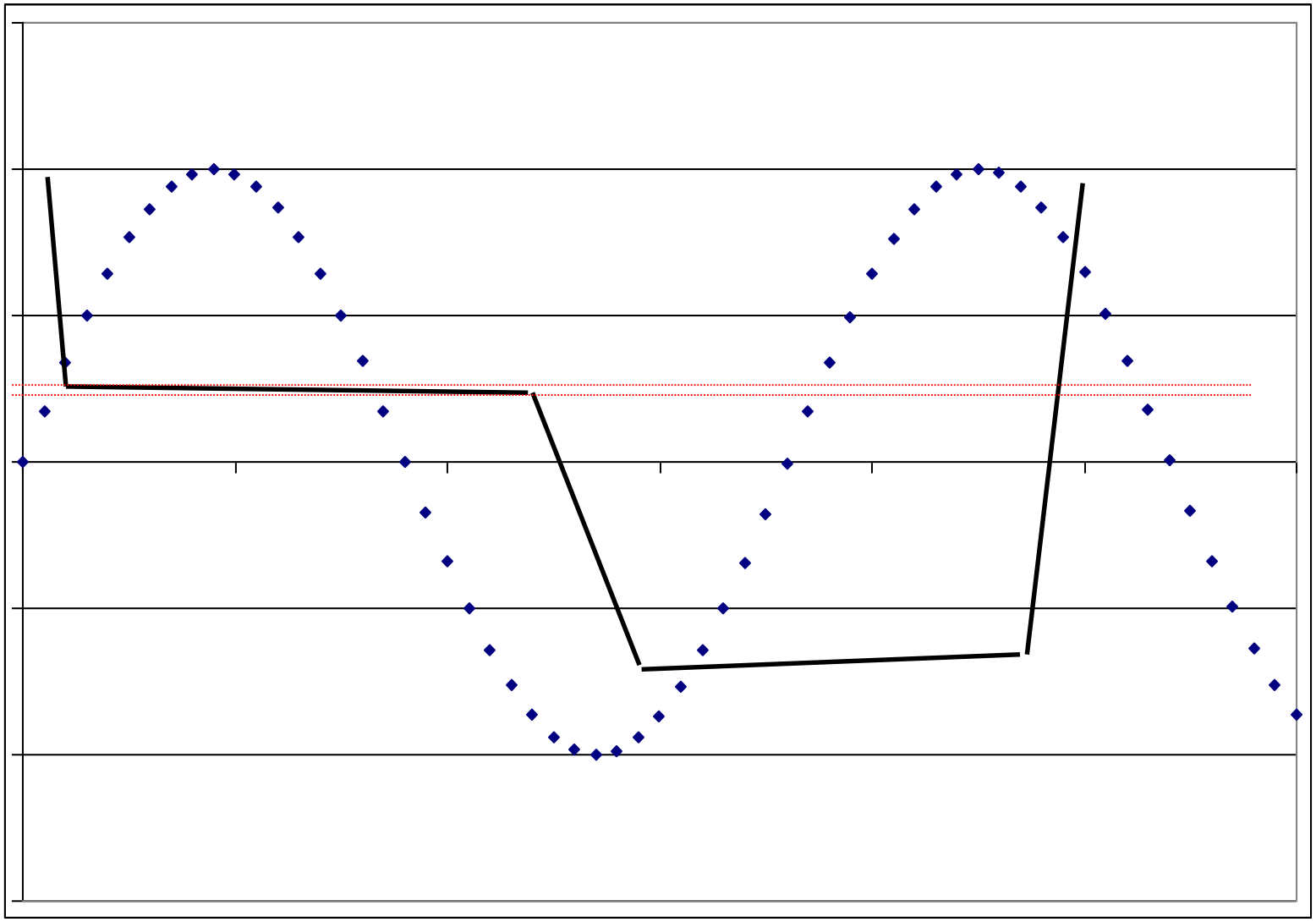
Or $5\frac{\partial A}{\partial Z} < 2R\frac{\partial P}{\partial Z}$

Negative dConveyance

- derivative of conveyance wrt height
- caused by small line segment slopes
- model run will fail if water level enters a portion of any cross-section with –dk
- identify by running Hydro with printlevel 5
- try to remove -dk in -5 ft < Z > 15 ft NGVD
- A convergence failure could cause water level to go outside of its normal range, cause a –dk error.
- eliminate by changing slope



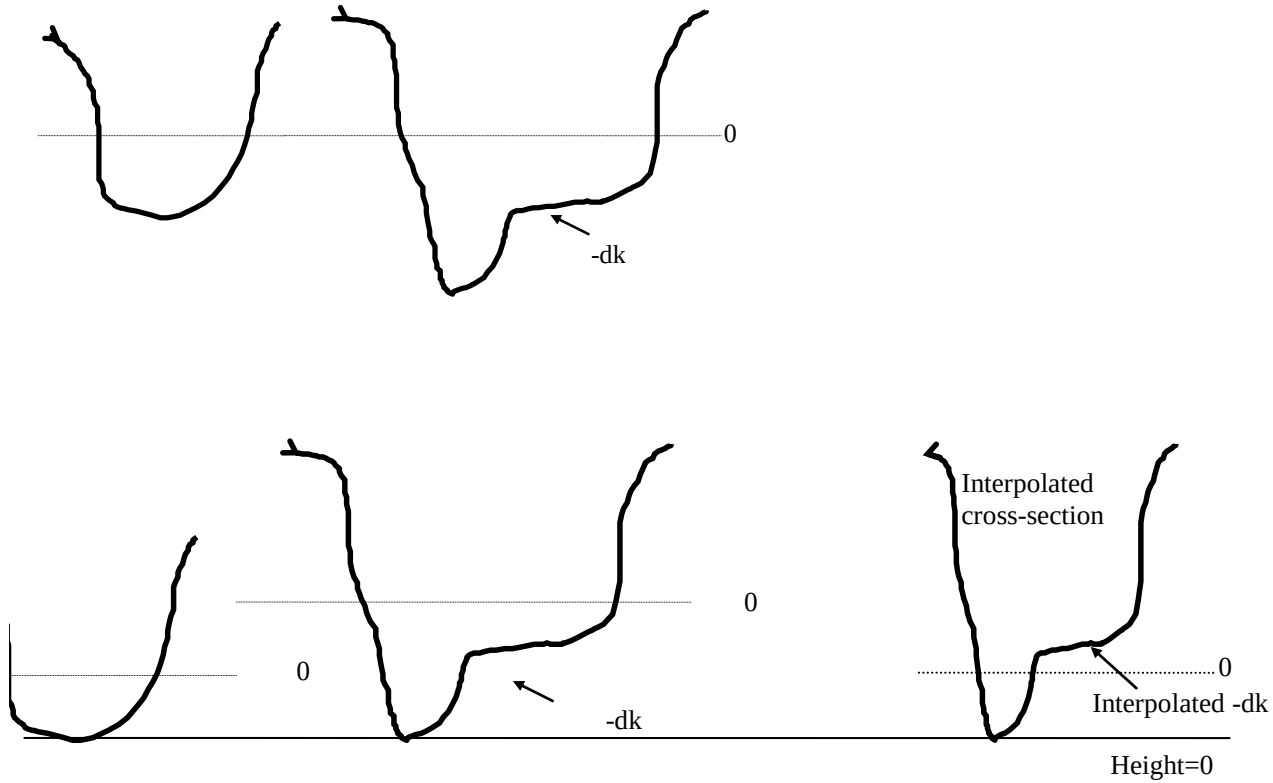
Negative dConveyance



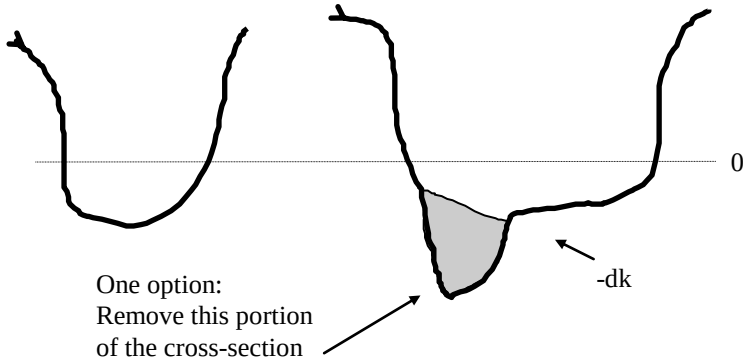
Interpolated Negative dConveyance

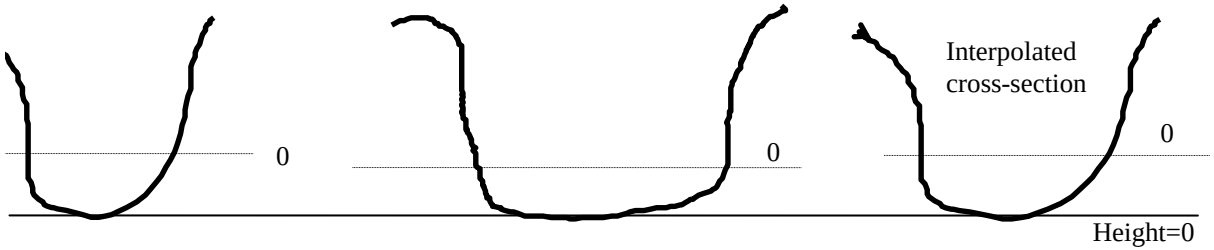
- occurs in virtual(interpolated) cross-sections
- usually caused by differences in bottom elevation
- to correct:
  - change bottom elevation(s)
  - assign cross-section to end(s) of channel to prevent interpolation from adjacent channel(s)

Interpolated Negative dConveyance



Correcting Interpolated Negative dConveyance





CSDP Output files--DSM2 irregular cross-section input

irregular_xsects.inp

```
IRREG_GEOM
CHAN      DIST       FILENAME
   6      0.62093    ./6_0.62093.txt
   7      0.25863    ./7_0.25863.txt
   7      0.86019    ./7_0.86019.txt
   8      0.13301    ./8_0.13301.txt
   9      0.18331    ./9_0.18331.txt
   9      0.89620    ./9_0.89620.txt
  11      0.05921    ./11_0.05921.txt
END
```

Don't edit this file!

---

irregular_xsects_copy.inp

```
IRREG_GEOM
CHAN     DIST     FILENAME
327      0        ./327_0.44122.txt
1        0        ./1u.txt
309      LENGTH   ./tmsred.txt
END
```

DSM2 irregular cross-section input

Cross-section: 105_0.75640

Elev(MSL)	A	P	W	Rh	Xc	Zc
100.00	108887.6	1164.4	1026.1	93.5	86.6	47.7
-1.43	9631.0	939.9	931.0	10.2	-1.4	-6.7
-8.86	3481.9	728.5	724.1	4.8	-94.7	-11.7
-12.13	1451.9	519.6	517.5	2.8	-182.9	-14.4
-13.05	1003.7	458.6	456.7	2.2	-227.6	-15.6
-13.75	706.3	394.9	393.2	1.8	-275.8	-16.7
-14.00	636.5	167.0	165.3	3.8	-288.8	-17.1
-14.68	541.1	116.6	115.1	4.6	-300.5	-17.6
-21.64	0.0	40.4	40.4	0.0	-308.7	-21.6

X: -421.68 -360.62 -328.87 -288.44 -232.02 -20.80 98.01 162.39 247.35 564.60 604.42

Y: 100.00 -12.13 -21.64 -21.64 -14.00 -13.75 -8.86 -14.68 -13.05 -1.43 100.00

What to do if you get a –dk error

- Use the “H” value and bottom elevation to calculate the elevation of the –dk
- Do any of the irregular cross-sections have –dk at this elevation? If no, it’s interpolated –dk.
- If it’s not interpolated –dk: should the water be entering this part of the cross-section?
  - If yes, then determine which cross-section(s) are used to create the virtual cross-section, and edit cross-section(s).
  - If no, then it’s really a convergence failure

What to do if a channel dries up

- Check all input for errors (fixed and time-varying)
- What is the H value?
  - If large negative value, it's definitely a convergence problem.
  - If small, possibilities are:
    - Is it early in the run? May need to adjust initial conditions. An initial stage that is too high or too low can cause a channel to dry up.
- Does this channel dry up in reality?
  - If yes, then options are:
    - remove channel from grid
    - Make cross-section(s) deeper, either by removing irregular cross-sections or by editing them
  - If no:
    - Does the channel almost dry up in reality? Consider making the cross-sections deeper.
    - Does the channel never come close to drying up in reality? If initial conditions are ok, consider modifying geometry to remove large cross-sectional area changes.

What to do if a channel overflows

- Check all input (fixed and time-varying)
- Check virtual cross-sections for large changes in cross-sectional area and adjust.

CSDP Installation

- Download and execute the csdpsetup.exe file from http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/csdp/index.html
- The setup program creates c:\semms.env and c:\semmsconLib\. Do not rename or remove these.

Cross-Section Development Program Version 2.53
---------- Semmscon Test Results ----------
Input: utm27x, utm27y=629355.0,4199384.0
NOTE: the following values should be
629258.5972470464 and 4199579.604951745
If they are not, there may be a problem
with the installation of the coordinate
conversion routines
result of utm27ToUtm83:

utm83x, utm83y=629258.5972470464,4199579.604951745

These numbers should match these numbers

CSDP Demonstration

- Add bathymetry data to database
- select data
  - centerline
  - cross-section line
- draw and edit cross-sections
- create DSM2 input files
- run Hydro
- -dConveyance & convergence failures