CE-QUAL-W2 MODEL GRID

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CE-QUAL-W2 Workshop

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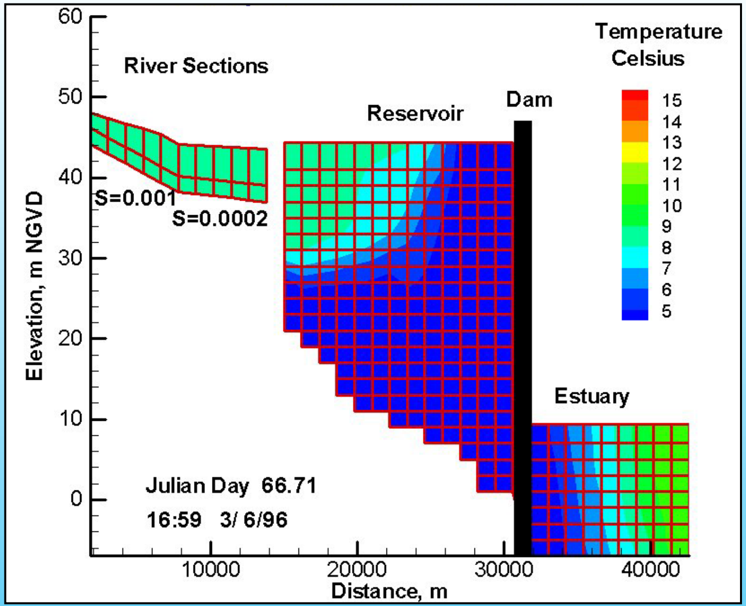
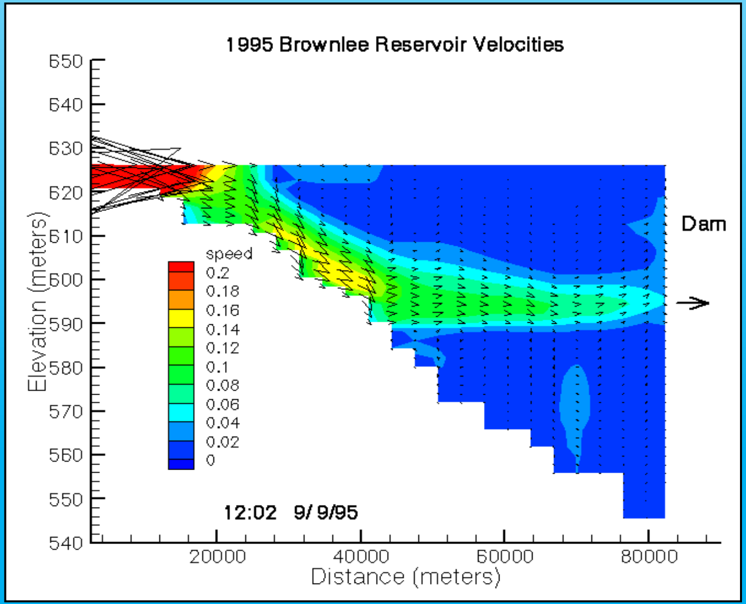
Computational Grid

The computational grid is the finite difference representation of the waterbody. The grid geometry is defined by:

- Longitudinal spacing (segment length): DLX
- Vertical spacing (layer height): H
- Average cross-sectional width (cell width): B
- Waterbody slope: SLOPE

The longitudinal and vertical spacing may vary from segment to segment and layer to layer, but the spacing should vary gradually from one segment or layer to the next to minimize discretization errors.





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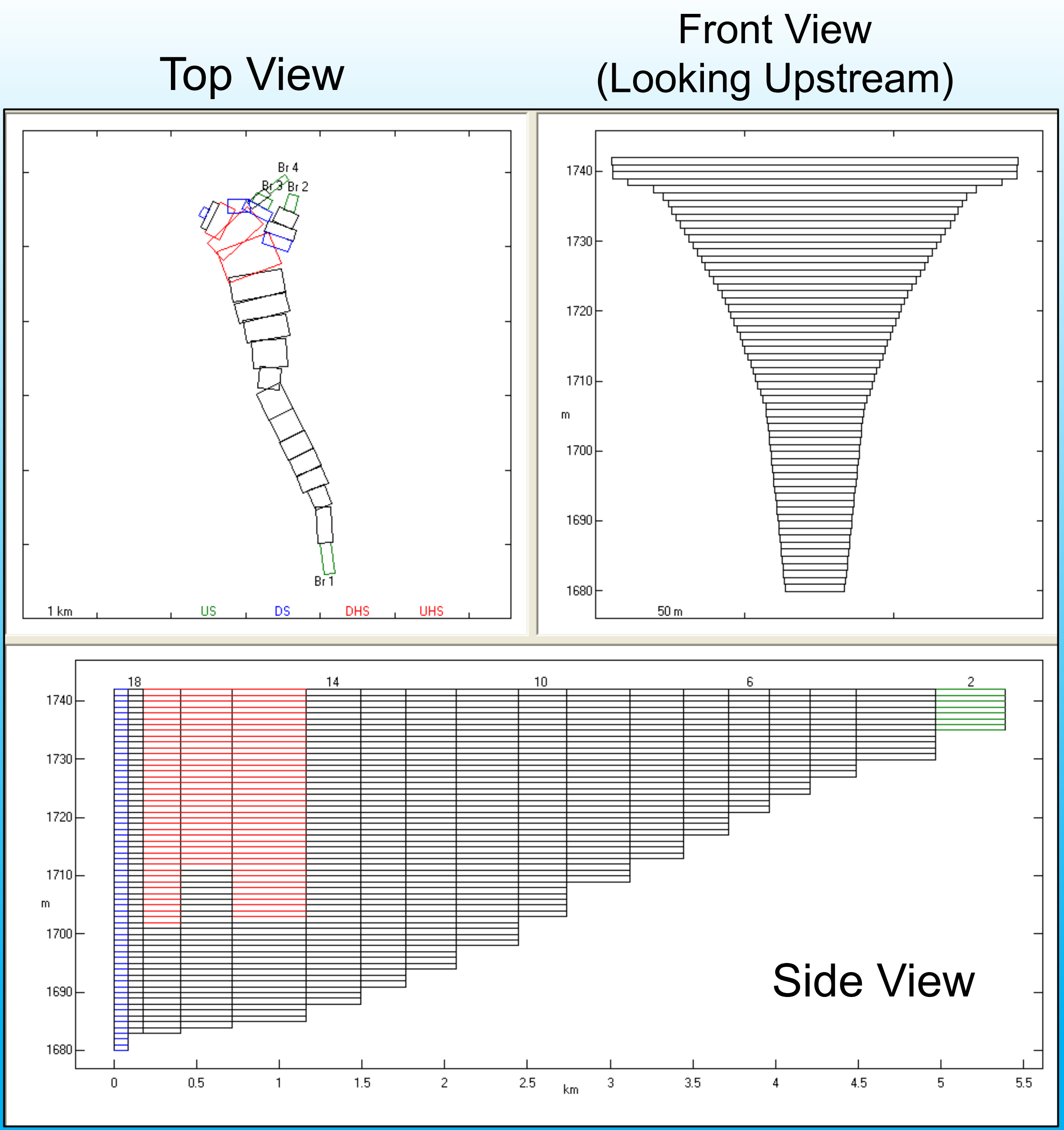


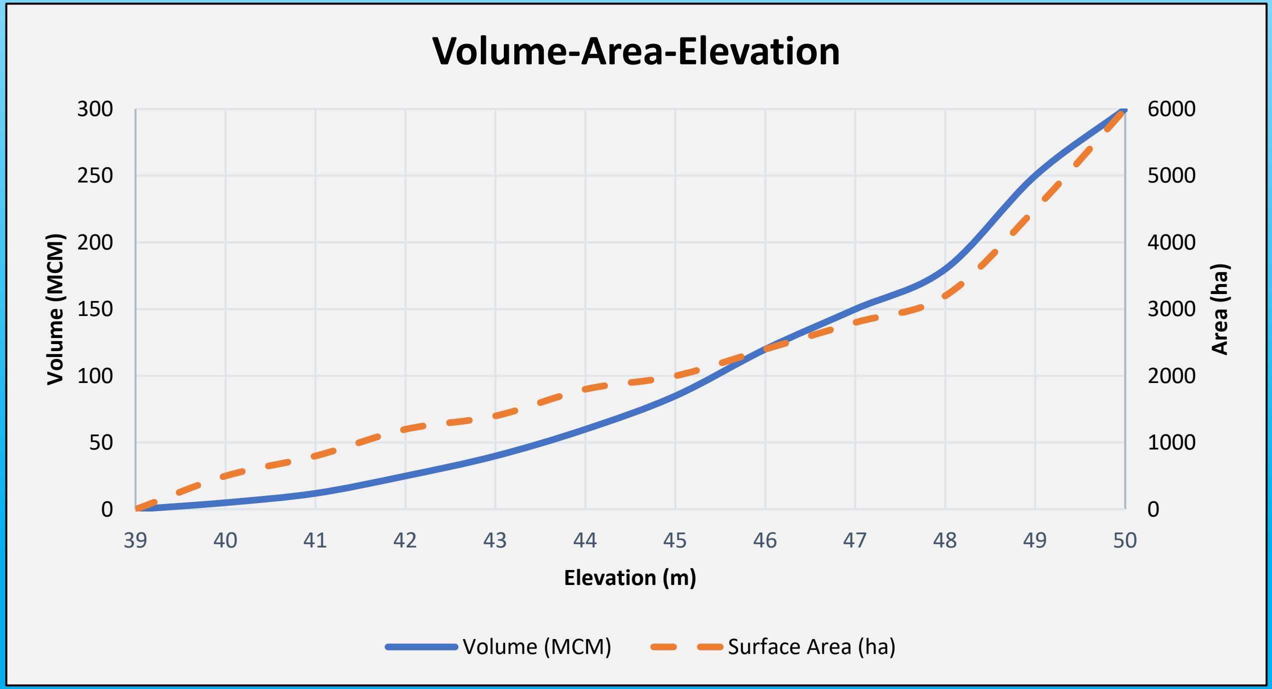
East Canyon Reservoir W2 Bathymetry (plan, profile, and cross section views)

Geometric Data

The following data are needed to set up the Geometry:

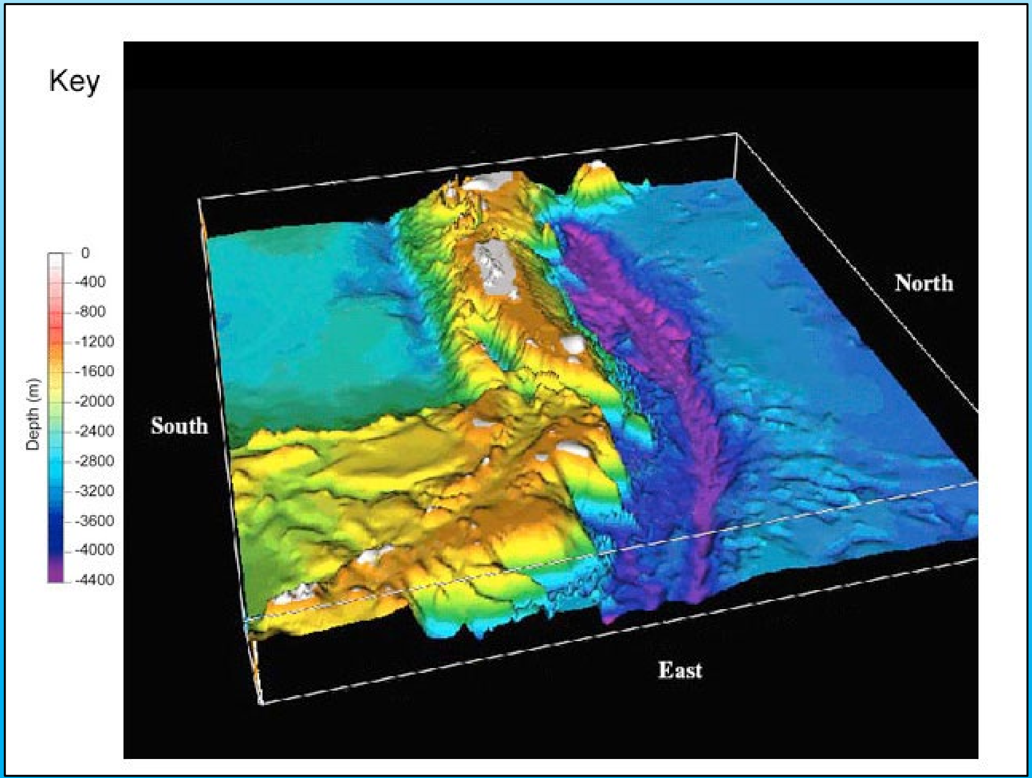
- Elevation Data
  - Topographic map
  - Digital Elevation Map (DEM)
  - Sediment range surveys
- Volume-Area-Elevation Table

Elevation (m)	Volume (MCM)	Surface Area (ha)
39	0	0
40	5	500
41	12	800
42	25	1200
43	40	1400
44	60	1800
45	85	2000
46	120	2400
47	150	2800
48	180	3200
49	250	4500
50	300	6000



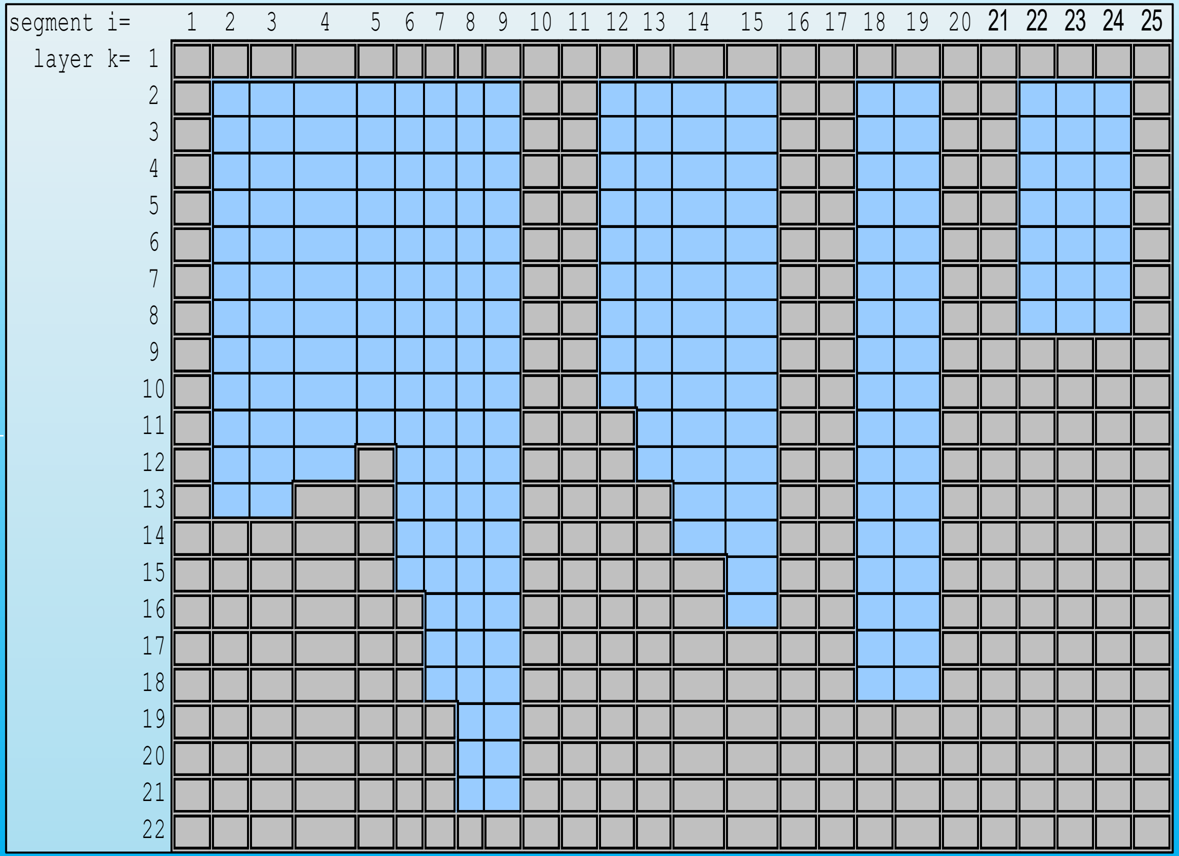
Factors Affecting the Computational Grid

- Areas of strongest gradients
- Computational and memory requirements
- Bottom slope
- Results



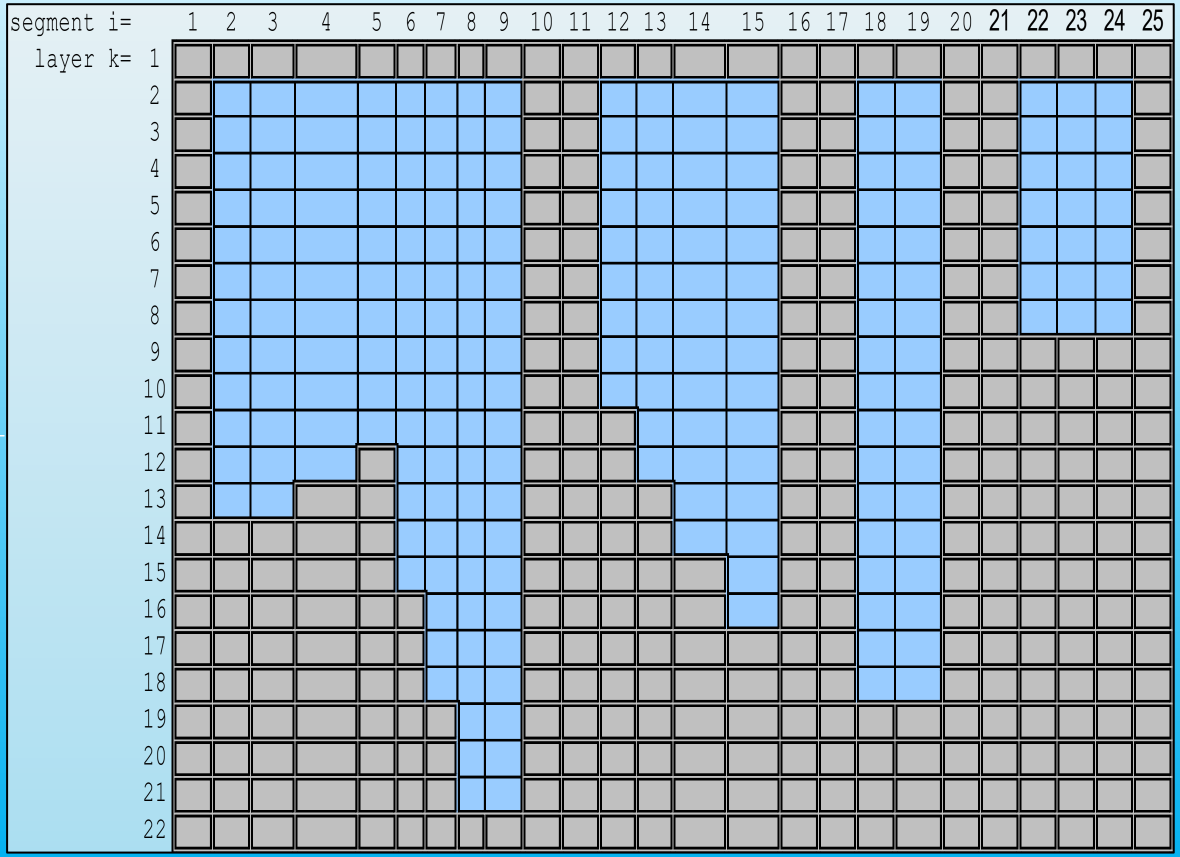
Sample Computational Grid

- A sample computational grid in the longitudinal/vertical plane with four branches is shown here.
- The grid consists of 25 longitudinal segments [IMX] and 22 vertical layers [KMX].
- They constitute the total number of cells in the computational grid.
- This is exactly how the model sees the grid layout even though this is not the correct physical representation of the system.
- Branch 2 and Branch 3 join Branch 1.



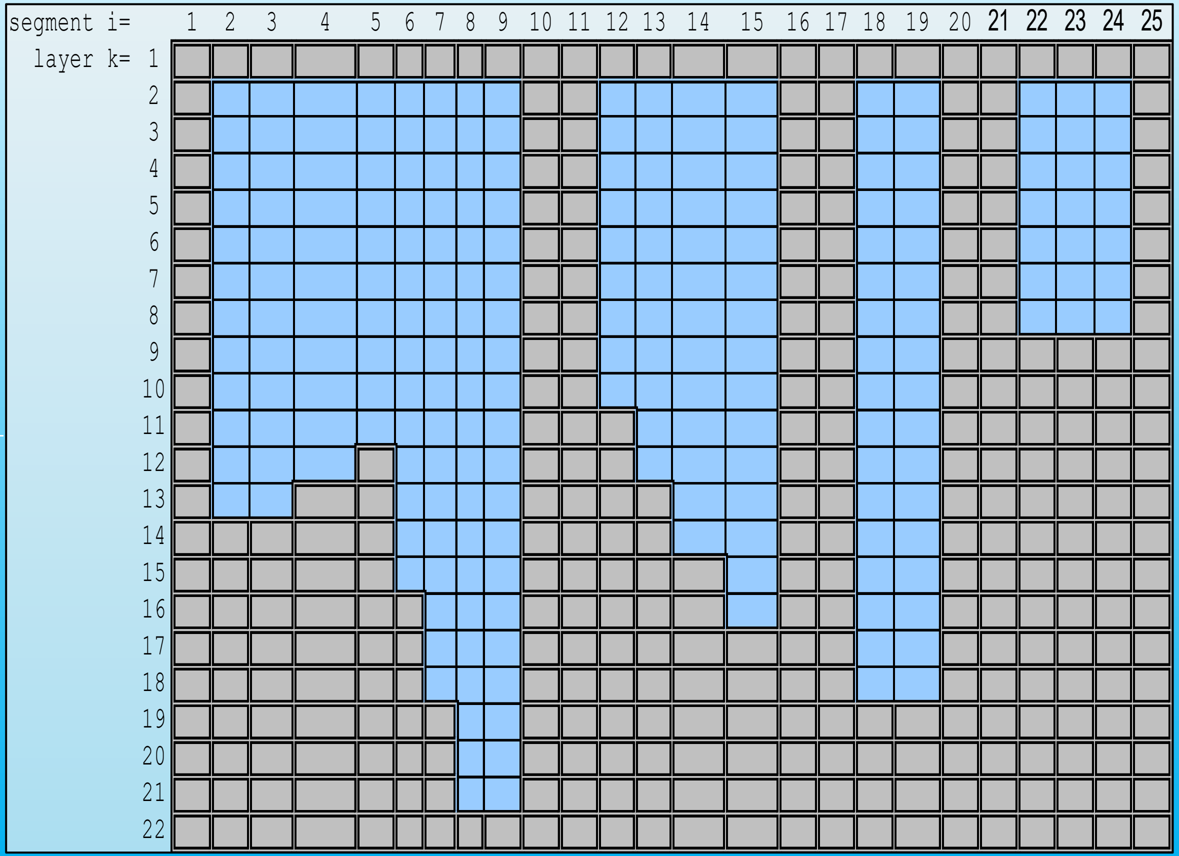
Grid Cell Types

- Grid cell types. This grid contains two kinds of cells: ones with either a single or a double line border.
- Cells with a single line border represent cells that may contain water during the simulation.
- The active cells are defined in the bathymetry input as having non-zero widths.
- Cells with a double border represent boundary cells located at or beyond the waterbody boundaries. The boundary cells are defined in the bathymetry input as having zero widths.



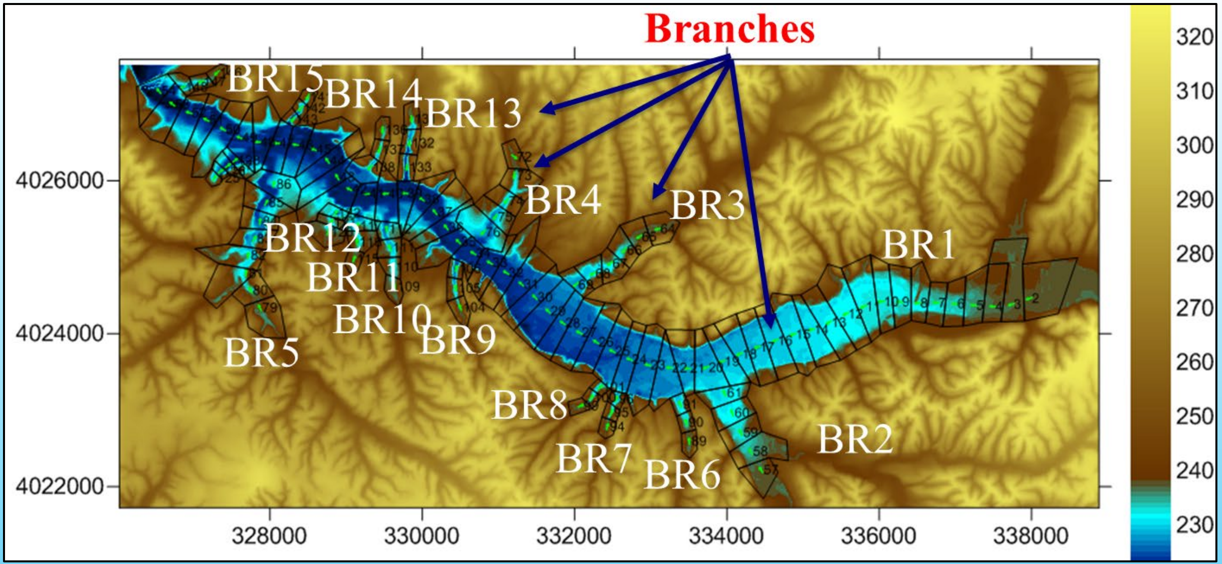
Grid Cell Types

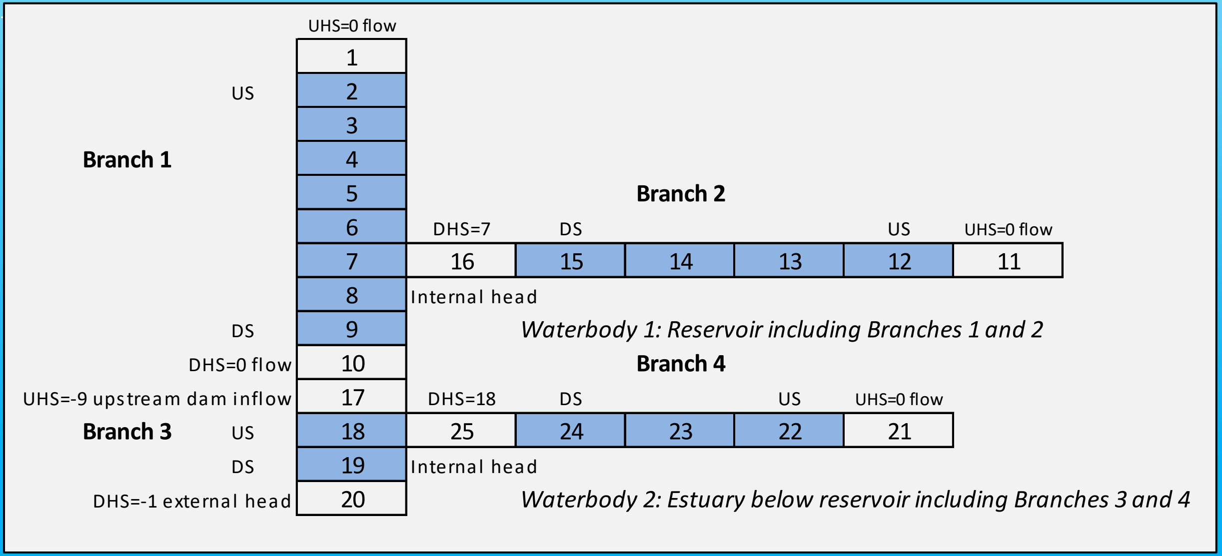
- There are four types of boundary cells:
  1. Top
  2. Bottom
  3. Upstream
  4. Downstream
- Each segment must have a zero width for the cell in layer 1 and a zero width for every cell located below the bottom active cell.
  - For example, cells 1 and 12-22 in Segment 5 would have zero widths.
  - Each branch must have zero widths for upstream boundary and downstream boundary segments. This results in two segments of boundary cells between each branch (segments 10-11 and 16-17).



Branches

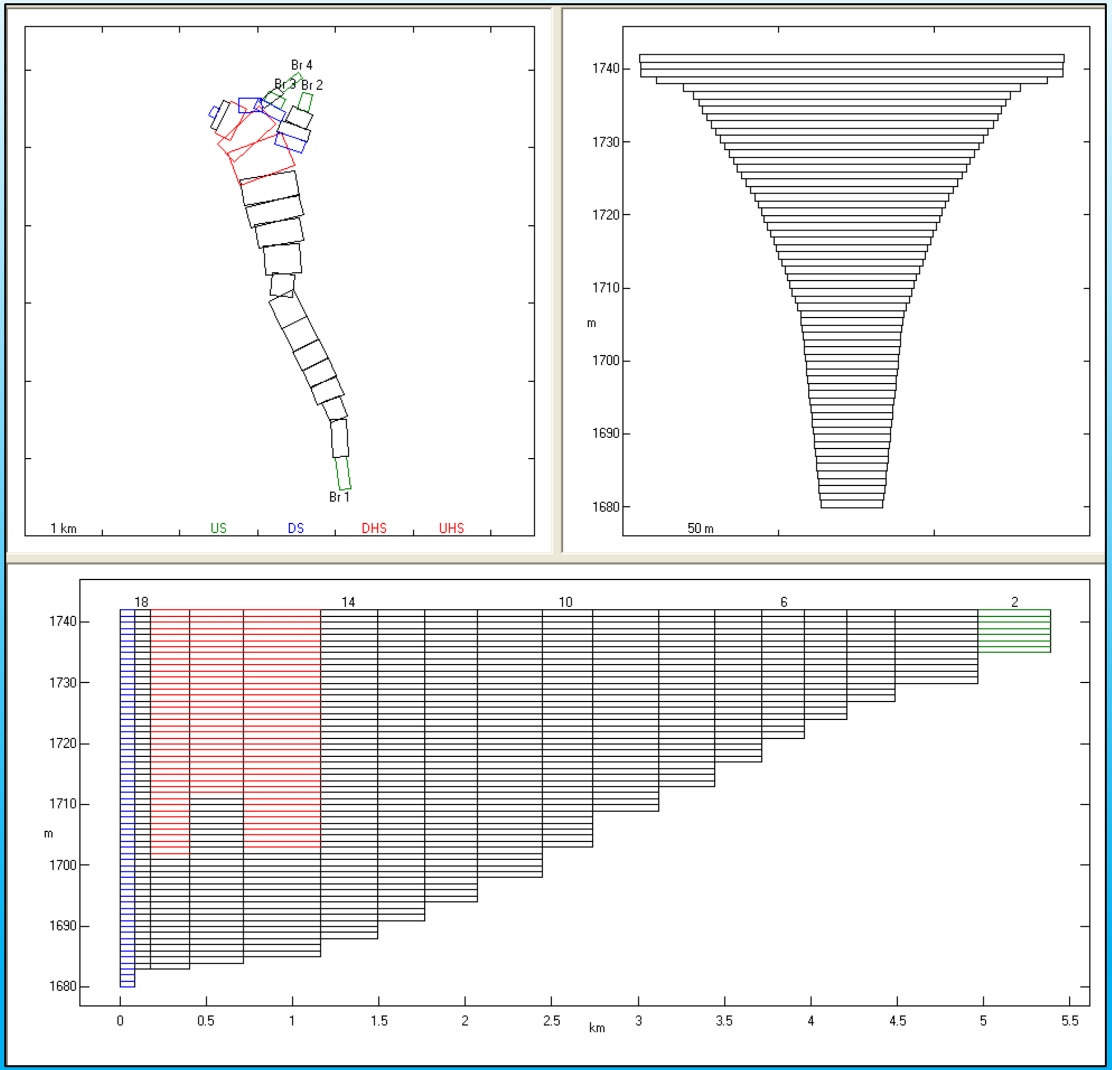
- CE-QUAL-W2 can simulate a system with any number of waterbodies containing any number of branches.
- This figure shows a plan view of the same three branch grid shown in the previous slides.
- For each branch, the upstream segment [US] and the downstream segment [DS] must be defined.
- The current upstream segment [CUS] is calculated by the model and may vary over time to meet restrictions imposed by the solution scheme.
- Typically segment numbers increase going from upstream to downstream in the branch.
- A branch may connect to other branches at its upstream [UHS] and/or downstream segment [DHS].
- The downstream segment of branch 2 ([DS]=15) connects to branch 1 at segment 7 ([DHS]=7).





Grid Restrictions

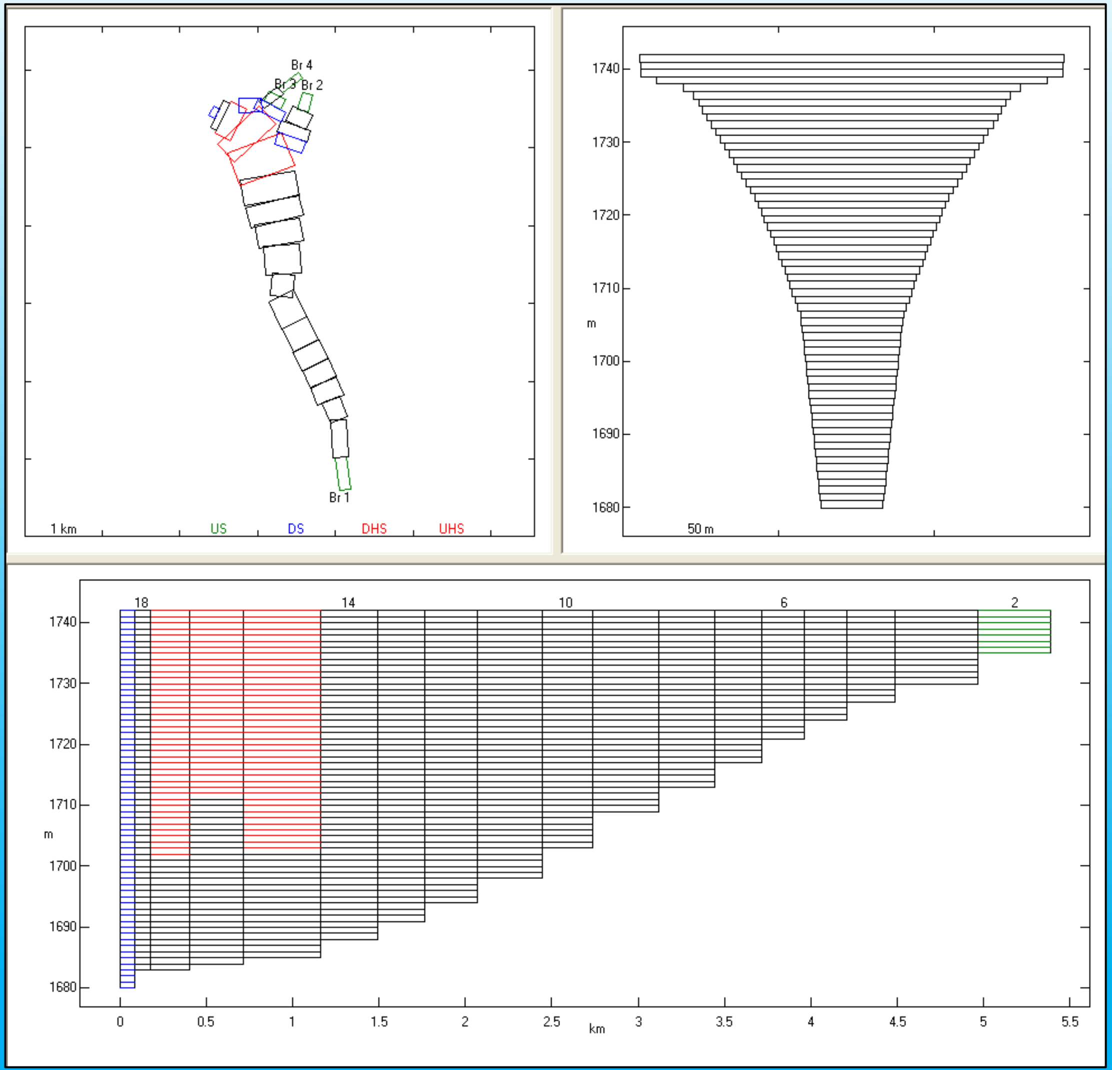
- The grid must satisfy the conditions:
  1. Cell widths cannot increase with depth.
  2. A branch may connect to other branches at its upstream or downstream segment, but a branch may not enter or leave itself.
  3. Two branches may not connect at the same segment of another branch.
- The bathymetry input file contains the longitudinal grid spacing [DLX], initial water surface elevation [WSEL], segment orientations [PHI0], vertical grid spacing [H], bottom friction [FRICT], and average cell widths [B].



East Canyon Reservoir W2 Bathymetry (plan, profile, and cross section views)

Grid Restrictions

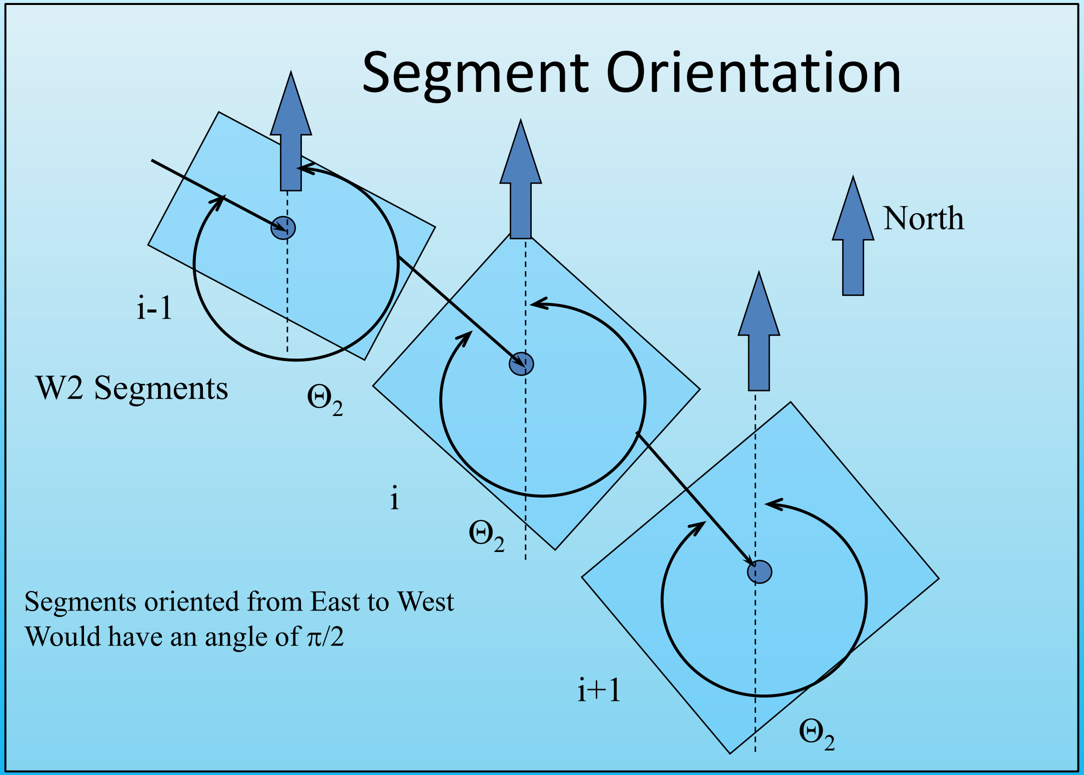
- After the bathymetry is generated, it should be checked to ensure the bottom elevation varies smoothly and represents the average slope over appropriate portions of the waterbody for reservoirs and estuaries.
- Minimum bottom widths are often set at 5-15 m.
    - This helps increase timesteps with minimal impact on the volume-area-elevation curves.
    - However, increasing widths in the bottom layers can affect water quality since sediment oxygen demand and nutrient fluxes are dependent on bottom surface areas.
- Refer to the bathymetry file and preprocessor output in the sample applications for additional guidance in setting up the bathymetry.



East Canyon Reservoir W2 Bathymetry (plan, profile, and cross section views)

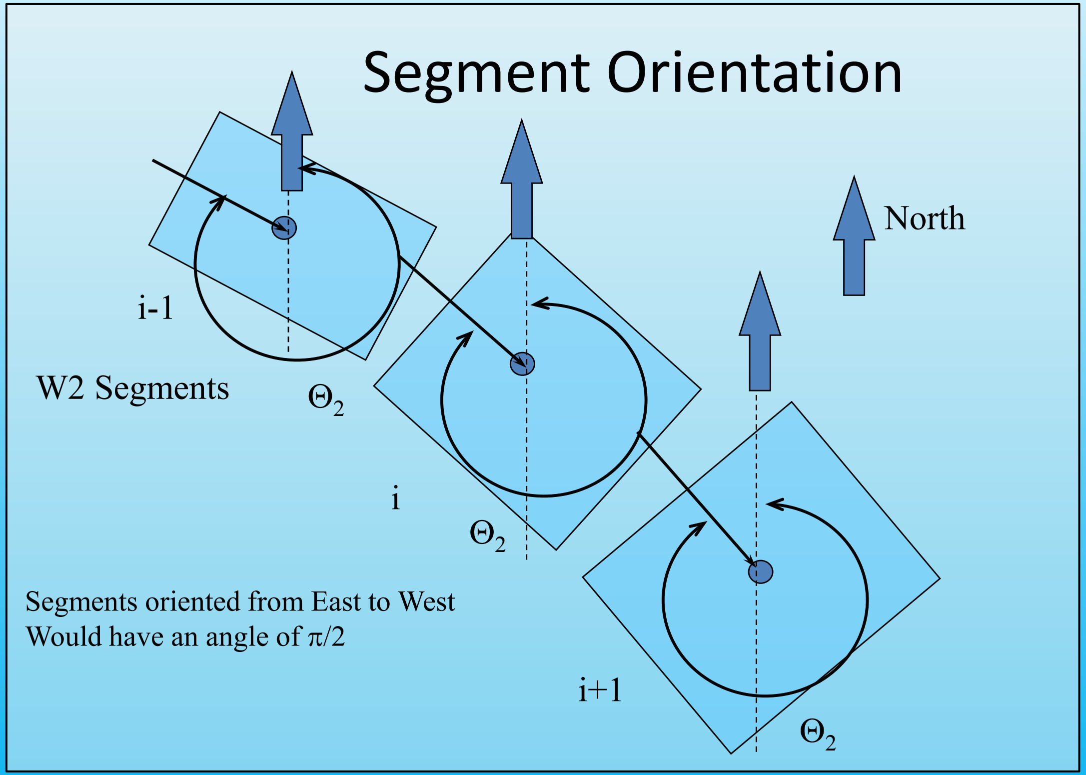
Bathymetry File

- The bathymetry file(s) contains information specifying the:
  - Segment lengths
  - Water surface elevations
  - Segment orientations
  - Bottom friction
  - Layer heights for each segment
  - Average widths for each grid cell.



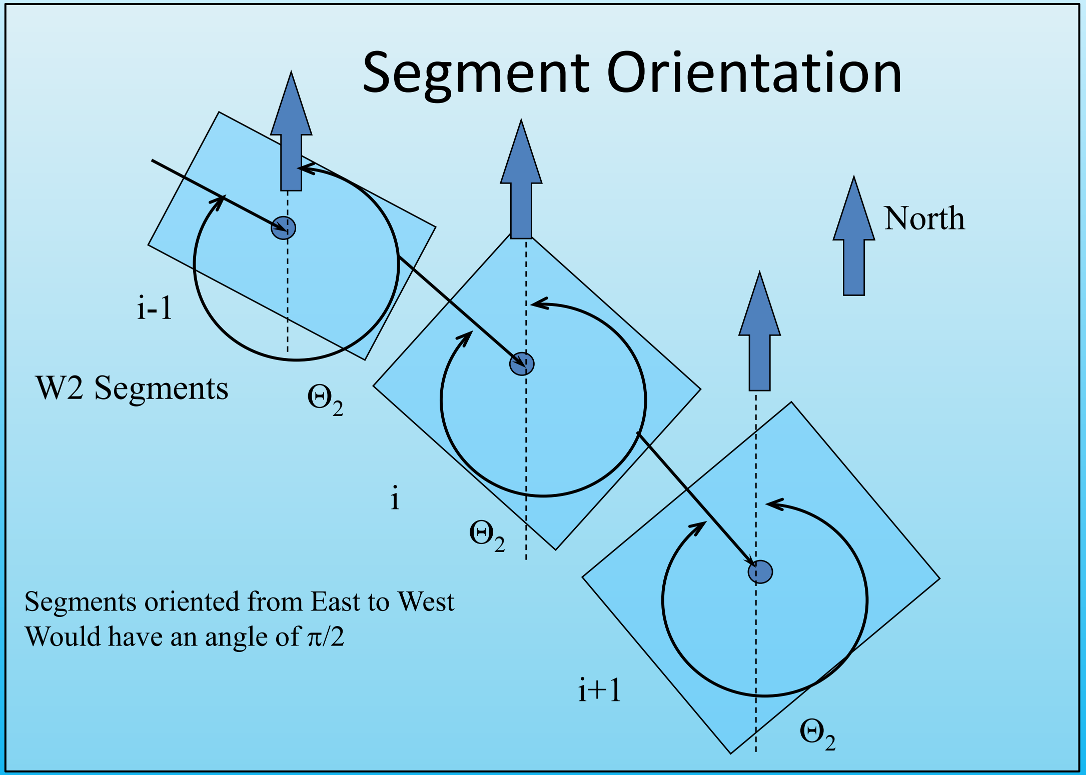
Bathymetry File Guidelines

1. It is recommended that the user numbers the branches starting with the mainstem as branch 1. The remaining branch numbers should be numbered consecutively starting with the most upstream branch and followed by the remaining branches as one moves down-stream.
2. Each branch is surrounded by a segment of boundary cells (cells with zero widths) on both the upstream and downstream ends. Note that this requirement results in two segments of zero widths between each branch.
3. Boundary cells must also be included at the top and bottom of each segment.



Bathymetry File Guidelines

4. Cell widths start at layer 1 and continue to the maximum number of layers [KMX]. The number of layers specified in this file must match the value of [KMX] in the control file.
5. Only cells that are potentially active have non-zero widths. The first layer, boundary segment cells, and cells below the reservoir bottom elevation at a given segment have zero widths.
6. A separate bathymetry file is required for each waterbody.
7. The segment angles are relative to N. Figure 31 shows an example of segment orientation.



Bathymetry Files: CSV Format

- We recommend developing the bathymetry in Microsoft Excel and then saving as a Comma-Separated Value (CSV) file, with the values delimited by commas.
- This requires inserting the “$” character as the first character of the first line.

$1981 Bluestone Reservoir Bathymetry																																							
SEG: I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	
DLX	1046.4	1046.4	1046.4	965.9	965.9	764.7	764.7	1046.4	1046.4	1073.2	1073.2	1073.2	1126.9	1126.9	1180.5	1180.5	1180.5	912.2	912.2	912.2	804.9	804.9	804.9	804.9	804.9	858.5	858.5	858.5	1006.1	1006.1	457.3	457.3	724.4	724.4	724.4	804.9	804.9	804.9	
ELWS	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	
PHIO	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	3.142	4.7	4.7	4.7	4.7	4.7	4.7	
FRICT	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	
LAYERH		BR1																																BR2					K
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0.5	0	335	335	335	335	364	364	362	362	327	327	327	423	423	438	438	438	472	472	472	490	490	457	457	457	501	501	501	516	516	487	0	0	242	242	320	320	0	2
0.5	0	231	231	231	231	254	254	255	255	312	312	312	406	406	426	426	426	466	466	466	486	486	453	453	453	498	498	498	509	509	483	0	0	234	234	318	318	0	3
0.5	0	228	228	228	228	243	243	248	248	298	298	298	388	388	413	413	413	460	460	460	482	482	449	449	449	494	494	494	502	502	480	0	0	226	226	316	316	0	4
0.5	0	224	224	224	224	231	231	241	241	285	285	285	370	370	400	400	400	453	453	453	477	477	444	444	444	491	491	491	495	495	476	0	0	219	219	314	314	0	5
0.5	0	220	220	220	220	219	219	233	233	272	272	272	351	351	387	387	387	446	446	446	472	472	440	440	440	487	487	487	488	488	473	0	0	211	211	312	312	0	6
0.5	0	215	215	215	215	206	206	225	225	259	259	259	332	332	373	373	373	439	439	439	467	467	435	435	435	484	484	484	481	481	467	0	0	202	202	309	309	0	7
0.5	0	202	202	202	202	188	188	208	208	247	247	247	324	324	359	359	359	431	431	431	462	462	430	430	430	480	480	480	473	473	465	0	0	185	185	305	305	0	8
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0.5	0	0	0	0	0	0	110	139	139	167	167	167	173	173	265	265	265	372	372	372	427	427	397	397	397	456	456	456	426	426	440	0	0	125	125	291	291	0	14
0.5	0	0	0	0	0	0	0	135	135	151	151	151	145	145	246	246	246	360	360	360	419	419	391	391	391	451	451	451	417	417	436	0	0	113	113	290	290	0	15
0.5	0	0	0	0	0	0	0	0	130	134	134	134	116	116	227	227	227	346	346	346	412	412	384	384	384	447	447	447	408	408	431	0	0	101	101	287	287	0	16
0.5	0	0	0	0	0	0	0	0	0	114	114	114	100	110	209	209	209	330	330	330	404	404	377	377	377	442	442	442	400	400	426	0	0	87	87	285	285	0	17
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0.5	0	0	0	0	0	0	0	0	0	0	0	40	80	90	160	160	160	288	288	288	386	386	361	361	361	431	431	431	381	381	417	0	0	58	58	281	281	0	19
0.5	0	0	0	0	0	0	0	0	0	0	0	0	40	80	134	134	134	258	258	258	376	376	352	352	352	426	426	426	372	372	411	0	0	41	41	278	278	0	20
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	75	104	104	104	215	215	215	364	364	342	342	342	420	420	420	362	362	406	0	0	20	30	276	276	0	21
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	90	146	146	146	351	351	330	330	330	413	413	413	352	352	401	0	0	0	20	132	132	0	22
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	80	83	83	83	334	334	317	317	317	407	407	407	342	342	394	0	0	0	0	66	66	0	23
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0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	68	68	251	251	251	384	384	384	308	308	375	0	0	0	0	0	0	0	26
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	39	72	72	72	375	375	375	297	297	368	0	0	0	0	0	0	0	27
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	34	34	54	365	365	365	284	284	360	0	0	0	0	0	0	0	28
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0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	30	340	340	340	257	257	344	0	0	0	0	0	0	0	30
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	322	322	322	243	243	334	0	0	0	0	0	0	0	31
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	296	296	296	227	227	324	0	0	0	0	0	0	0	32
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	134	134	210	210	312	0	0	0	0	0	0	0	33
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0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	171	171	285	0	0	0	0	0	0	0	35
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	147	147	266	0	0	0	0	0	0	0	36
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	117	117	241	0	0	0	0	0	0	0	37
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	197	0	0	0	0	0	0	0	38
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	50	0	0	0	0	0	0	0	39
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40

Bathymetry: CSV Format

1st line: Include the '$' character as the first character in line 1. The rest of this line is ignored and can be used for

$1981 Bluestone Reservoir Bathymetry

2nd line: Title: Seg, followed by a header for each model segment. This is ignored.

SEG: I	1	2	3	4	5	6	7

3rd line: Title: DLX, followed by DLX in m for each segment.

DLX	1046.4	1046.4	1046.4	965.9	965.9	764.7	764.7

4th line: Title: ELWS, followed by ELWS in m for each segment (initial water surface elevation).

ELWS	430.1	430.1	430.1	430.1	430.1	430.1	430.1

5th line: Title: PHIO, followed by PHIO for each segment (orientation angle in radians).

PHIO	3.142	3.142	3.142	3.142	3.142	3.142	3.142

6th line: Title: FRICT, followed by FRICT for each segment (Mannings or Chezy friction factor).
Typical values for friction factors are 0.035 for Mannings and 70 for Chezy.

FRICT	70	70	70	70	70	70	70

7th line: Titles that are ignored by the model.

LAYERH		BR1						K

8th line to end of file: 1st column is layer height in m; 2nd column is segment widths in m for segment 1; 3rd column is s

0.5	0	0	0	0	0	0	0	1
0.5	0	335	335	335	335	364	0	2
0.5	0	231	231	231	231	254	0	3
0.5	0	228	228	228	228	243	0	4
0.5	0	224	224	224	224	231	0	5
0.5	0	220	220	220	220	219	0	6
0.5	0	215	215	215	215	206	0	7

Bathymetry: Questions?