Fall 2019 Kevin McElroy

FINAL PROJECT ABSTRACT

Project Title: Bathymetry Data Manipulation for Laurance Lake Release Temperature Model

Abstract: In the field of water quality, many environmental factors must be accounted for in order to create a model, including bathymetry. This GIS project aims to create an ArcMap toolset for basic automation of data transformation from bathymetric coordinates into the transect-width format required by the modeling software CE-QUAL-W2. This will allow simplified generation of *bathymetry input files* for CE-QUAL-W2, which also uses many other environmental input files for the target water body including weather, nutrients, contaminants, terrain, flow and more, and uses a laterally averaged application of the Advection Diffusion Equation to determine various water qualities. Laurance Lake near Mt. Hood provides a sufficient example for the process, and model data has been provided by Dr. Scott Wells, who maintains CE-QUAL-W2 at Portland State University. This project attempted to manipulate the data using common TIN, raster, and vector analysis tools and techniques available within ArcMap. Steps involved in the process involve generating aggregating the raw bathymetry points into a shape of the water body, generating TIN and raster data, developing a flow net to identify the water body's thalweg, and generalizing the thalweg vector before creating transects. Further processing to effectively generate transects of a water body, however, require more specialized tools such as ArcHydro toolbox, HEC-GeoRAS toolbar, or customized python scripts, which may not be accessible to common users of ArcMap. All of these tools were discovered too late in the project to be applied to any effect beyond realizing their potential. The ArcHydro toolbox contains many complex tools, and appeared to require more extensive background knowledge to use while also having limited accessibility. While HEC-GeoRAS is intuitive and relevant to the scope of this project, it is not supported beyond ArcMap version 10.2. Further research will explore and likely implement python scripts, which appear to be most suited for this task. Many custom scripts can be downloaded at no cost on https://codesharing.arcgis.com/, which may then be learned from or adapted to accomplish the more challenging tasks of transect building, volume calculation, width derivation, and formatted data export. The data output from this process should be either directly usable in CE-QUAL-W2 or easily manipulated in Excel to achieve the necessary *bth.npt* file. With this properly formatted bathymetry compiled with all other data required for the Laurance Lake temperature model, CE-QUAL-W2 can then pre-process the data for errors and be run.

Bathymetry Data Manipulation

FOR LAURANCE LAKE RELEASE TEMPERATURE MODEL

KEVIN MCELROY

The Problem

Laurance Lake discharges water to the Middle Fork of the Hood River, which violates temperature standards and thus affects fish habitat.

- **How can Laurance Lake be managed or engineered so that the Middle Fork temperatures improve?**
  - Create a temperature model of the discharge!
    - Bathymetry data is a piece of the puzzle

Laurance Lake

Dam discharge

CE-QUAL-W2

- CE-QUAL-W2 is a water quality and hydrodynamic model in 2D (longitudinal-vertical) for:
  - rivers, estuaries, lakes, reservoirs, and river basin systems.
- W2 models basic eutrophication process relationships such as:
  - Temperature - nutrient - algae - dissolved oxygen - organic matter - sediment.

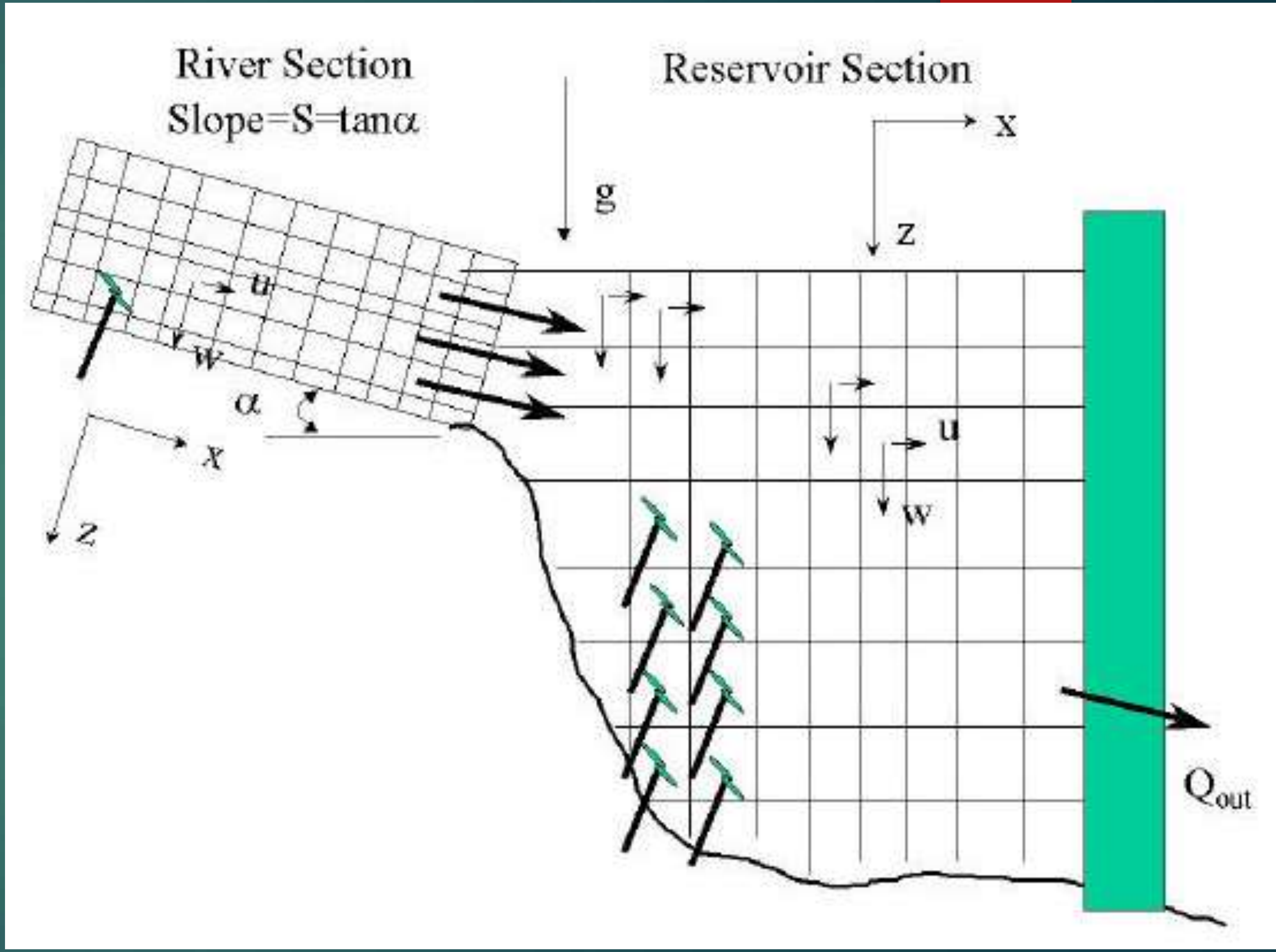
How it works

Incorporates many input files and datasets, not just bathymetry:

- Meterology
  - Solar radiation
  - Cloud cover
  - Wind
  - Air temp.
  - Humidity
  - Sheltering
- Water Level
- Flow Data
  - Inflows
  - Outflows
- Surroundings
  - Stream slope
  - Shading
  - Aeration devices
  - Structures
  - Body shape
- Quality Parameters
  - Water temp.
  - DO
  - pH
  - Nutrients; P-K-N etc.
  - TSS, TDS
  - Algae
  - Organic Matter

And the list goes on …

- Water bodies are considered a collection of water cells
- Individual cells have their own set of values
- Laterally averaged for simplicity and expedited processing

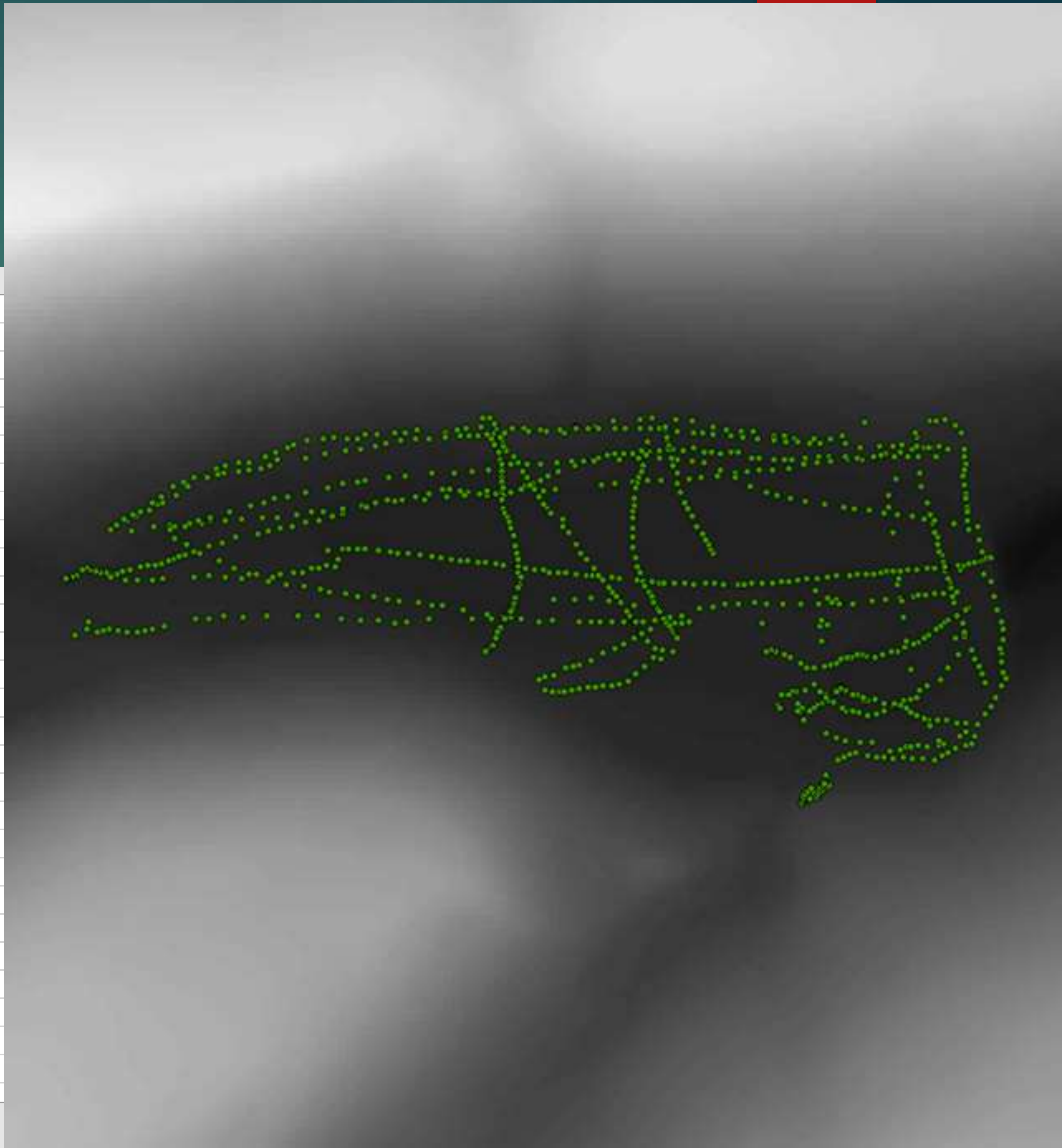


Bathymetry Format

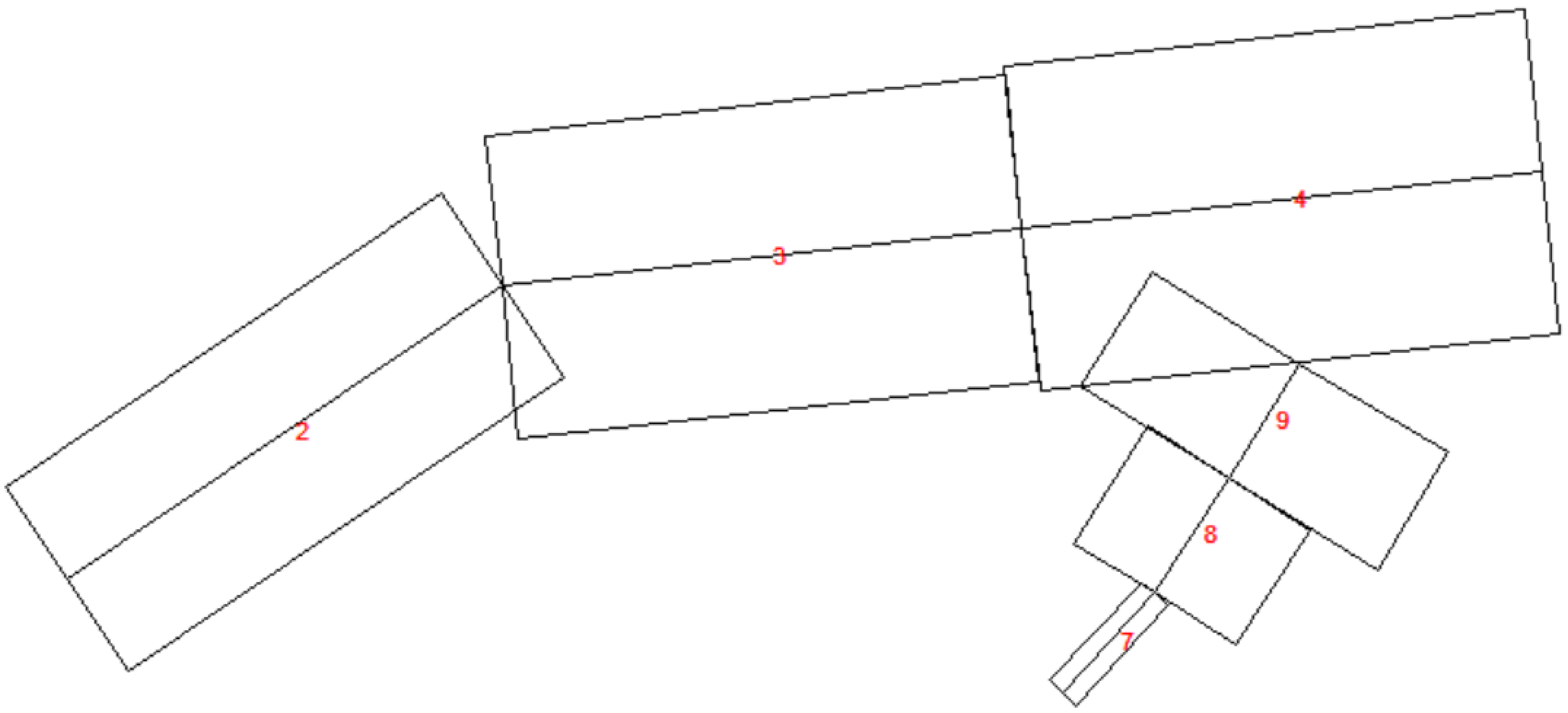
- Have:

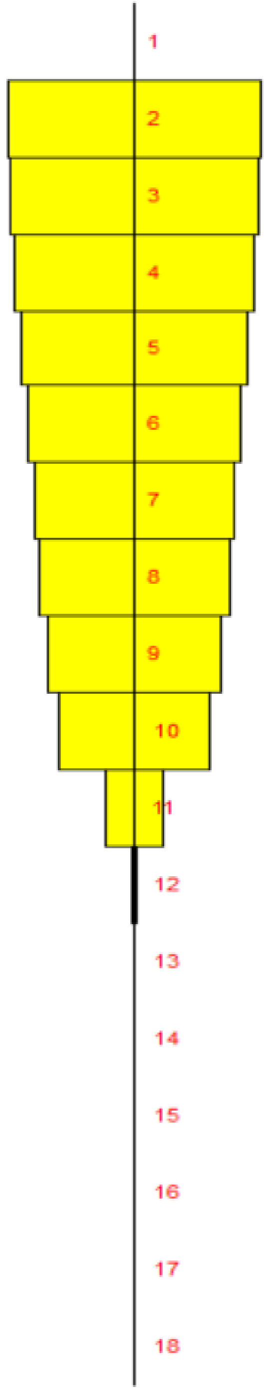
	A	B	C	D	E	F	G	H
1	ID	Page	Latitude	Longitude	Northing	Easting	Elev-ft	Elev-m
2	1	1	45.4571333333	121.6610000000	5034407.95107	604786.60283	2967.050	904.368
3	2	1	45.4573166667	121.6607833333	5034428.60121	604803.20369	2959.590	902.094
4	3	1	45.4573666667	121.6606666667	5034434.30819	604812.23284	2961.490	902.673
5	4	1	45.4574000000	121.6605666667	5034438.14183	604819.98974	2961.390	902.643
6	5	1	45.4574166667	121.6604500000	5034440.14565	604829.08064	2965.990	904.045
7	6	1	45.4573833333	121.6602333333	5034436.72519	604846.08286	2967.490	904.502
8	7	1	45.4573666667	121.6600833333	5034435.06936	604857.84176	2970.290	905.355
9	8	1	45.4573666667	121.6599500000	5034435.24339	604868.26665	2969.390	905.081
10	9	1	45.4573500000	121.6597833333	5034433.60936	604881.32867	2970.690	905.477
11	10	1	45.4573666667	121.6595833333	5034435.72206	604896.93511	2971.290	905.660
12	11	1	45.4573666667	121.6594333333	5034435.91792	604908.66312	2971.990	905.874
13	12	1	45.4573500000	121.6592500000	5034434.30574	604923.02826	2967.690	904.563
14	13	1	45.4573500000	121.6590333333	5034434.58872	604939.96872	2964.090	903.466
15	14	1	45.4574000000	121.6588833333	5034440.33944	604951.60396	2961.890	902.795
16	15	1	45.4574333333	121.6587833333	5034444.17326	604959.36078	2961.590	902.704
17	16	1	45.4575000000	121.6586333333	5034451.77560	604970.96506	2963.090	903.161
18	17	1	45.4575333333	121.6584666667	5034455.69656	604983.93428	2966.990	904.350
19	18	1	45.4575500000	121.6583500000	5034457.70062	604993.02511	2972.190	905.935
20	19	1	45.4576500000	121.6583000000	5034468.87552	604996.74882	2973.090	906.209
21	20	1	45.4578166667	121.6582333333	5034487.47858	605001.65187	2969.090	904.990
22	21	2	45.4579500000	121.6581166667	5034502.44381	605010.52606	2969.090	904.990
23	22	2	45.4580333333	121.6580166667	5034511.83248	605018.18994	2968.790	904.898
24	23	2	45.4581500000	121.6579166667	5034524.92436	605025.79191	2965.990	904.045
25	24	2	45.4583166667	121.6578166667	5034543.57102	605033.30101	2962.690	903.039
26	25	2	45.4584000000	121.6577500000	5034552.91615	605038.35863	2961.390	902.643
27	26	2	45.4584833333	121.6578000000	5034562.10874	605034.29463	2960.890	902.490
28	27	2	45.4586166667	121.6578333333	5034576.87791	605031.44089	2951.390	899.595
29	28	2	45.4587166667	121.6578333333	5034587.98747	605031.25521	2945.990	897.949

04142003 | 04152003 | 05012003 | Processed

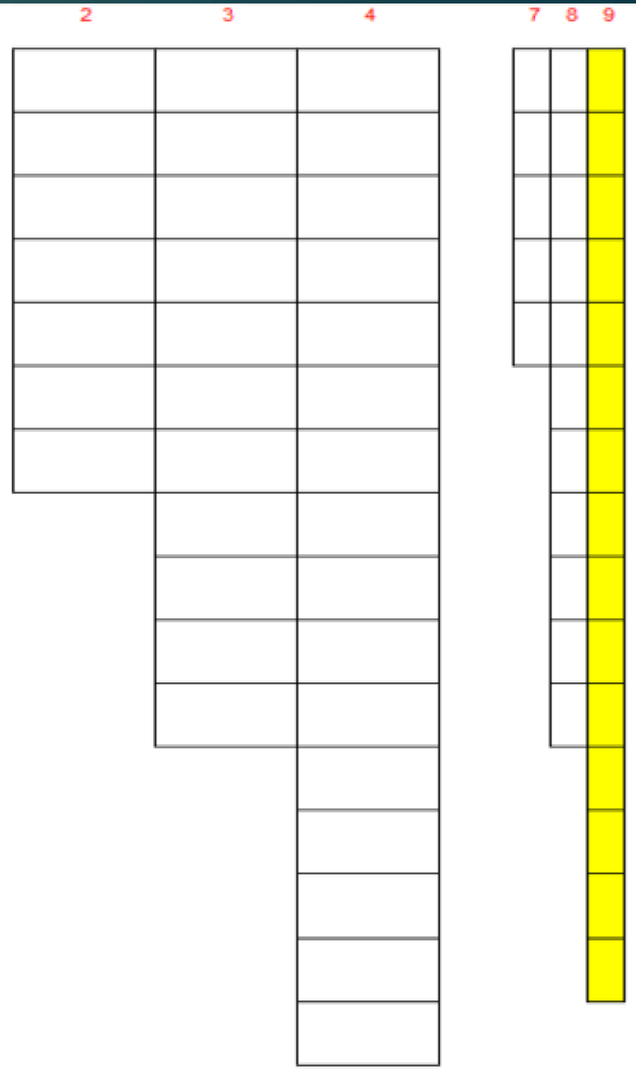


- Want





	A	B	C	D	E	F	G	H	I	J	K	L	M
1	$ Bathymetry file for waterbody 1												
2	SEG#	1	2	3	4	5	6	7	8	9	10		
3	DLX	0	638.4	638.4	638.4	0	0	166.32	166.32	166.32	0		
4	ELWS	903.528	903.528	903.528	903.528	903.528	903.528	903.528	903.528	903.528	903.528		
5	PHI0	0	4.1216	4.6016	4.6016	0	0	3.8916	3.7116	3.6916	0		
6	FRIC	70	70	70	70	70	70	70	70	70	70		
7	LAYERH	1	2	3	4	5	6	7	8	9	10	K	ELEV
8	3	0	0	0	0	0	0	0	0	0	0	1	
9	3	0	270.25	372.75	399.25	0	0	44.5	233.5	423.67	0	2	
10	3	0	263.75	367.25	395.75	0	0	35.17	231.5	422	0	3	
11	3	0	240.75	351.75	383	0	0	8.34	225.5	414.67	0	4	
12	3	0	213.25	334.5	367.25	0	0	5	219.5	407.84	0	5	
13	3	0	168.75	315.25	343.75	0	0	5	191.5	398.17	0	6	
14	3	0	104.75	296.5	324	0	0	0	95.5	376	0	7	
15	3	0	39.25	278.25	278.5	0	0	0	21.5	350.17	0	8	
16	3	0	0	258	248.5	0	0	0	15	290.5	0	9	
17	3	0	0	223.5	202.5	0	0	0	12	193.34	0	10	
18	3	0	0	88	172	0	0	0	10	129.67	0	11	
19	3	0	0	3.75	146.5	0	0	0	5	75	0	12	
20	3	0	0	0	122	0	0	0	0	36.83	0	13	
21	3	0	0	0	79.75	0	0	0	0	16.17	0	14	
22	3	0	0	0	34	0	0	0	0	10	0	15	
23	3	0	0	0	13.5	0	0	0	0	5	0	16	
24	3	0	0	0	5	0	0	0	0	0	0	17	
25	3	0	0	0	0	0	0	0	0	0	0	18	



- Large water bodies can become much more complex and slower to process

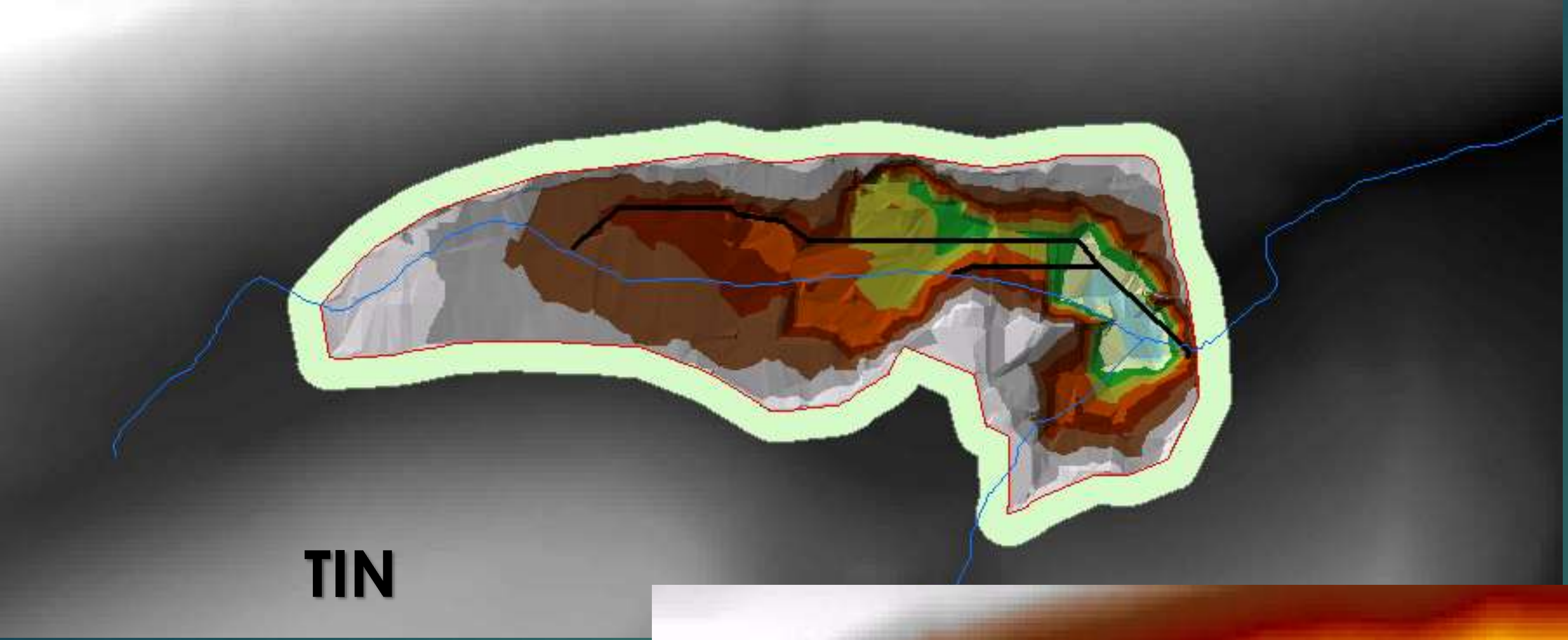
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	$															
2		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3	DLX	1046.4	1046.4	1046.4	965.9	965.9	764.7	764.7	1046.4	1046.4	1073.2	1073.2	1073.2	1126.9	1126.9	1180.5
4	ELWS	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1
5	PHI0	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
6	FRIC	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
7	LAYERH															
8	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0.5	0	335	335	335	335	364	364	362	362	327	327	327	423	423	438
10	0.5	0	231	231	231	231	254	254	255	255	312	312	312	406	406	426
11	0.5	0	228	228	228	228	243	243	248	248	298	298	298	388	388	413
12	0.5	0	224	224	224	224	231	231	241	241	285	285	285	370	370	400
13	0.5	0	220	220	220	220	219	219	233	233	272	272	272	351	351	387
14	0.5	0	215	215	215	215	206	206	225	225	259	259	259	332	332	373
15	0.5	0	202	202	202	202	188	188	208	208	247	247	247	324	324	359
16	0.5	0	192	192	192	192	161	161	199	199	234	234	234	291	291	345
17	0.5	0	173	173	173	173	142	142	189	189	222	222	222	269	269	330
18	0.5	0	0	0	130	130	130	130	178	178	208	208	208	247	247	315
19	0.5	0	0	0	0	125	125	125	166	166	195	195	195	223	223	298
20	0.5	0	0	0	0	0	120	120	153	153	181	181	181	199	199	282
21	0.5	0	0	0	0	0	0	110	139	139	167	167	167	173	173	265
22	0.5	0	0	0	0	0	0	0	135	135	151	151	151	145	145	246
23	0.5	0	0	0	0	0	0	0	0	130	134	134	134	116	116	227
24	0.5	0	0	0	0	0	0	0	0	0	114	114	114	100	110	209
25	0.5	0	0	0	0	0	0	0	0	0	0	40	100	90	100	184
26	0.5	0	0	0	0	0	0	0	0	0	0	0	40	80	90	160
27	0.5	0	0	0	0	0	0	0	0	0	0	0	0	40	80	134
28	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	75	104
29	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
30	0.5	0	0	0	0	0	0	0	0	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
32	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0.5	0	0	0	0	0	0	0	0	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
36	0.5	0	0	0	0	0	0	0	0	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
38	0.5	0	0	0	0	0	0	0	0	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

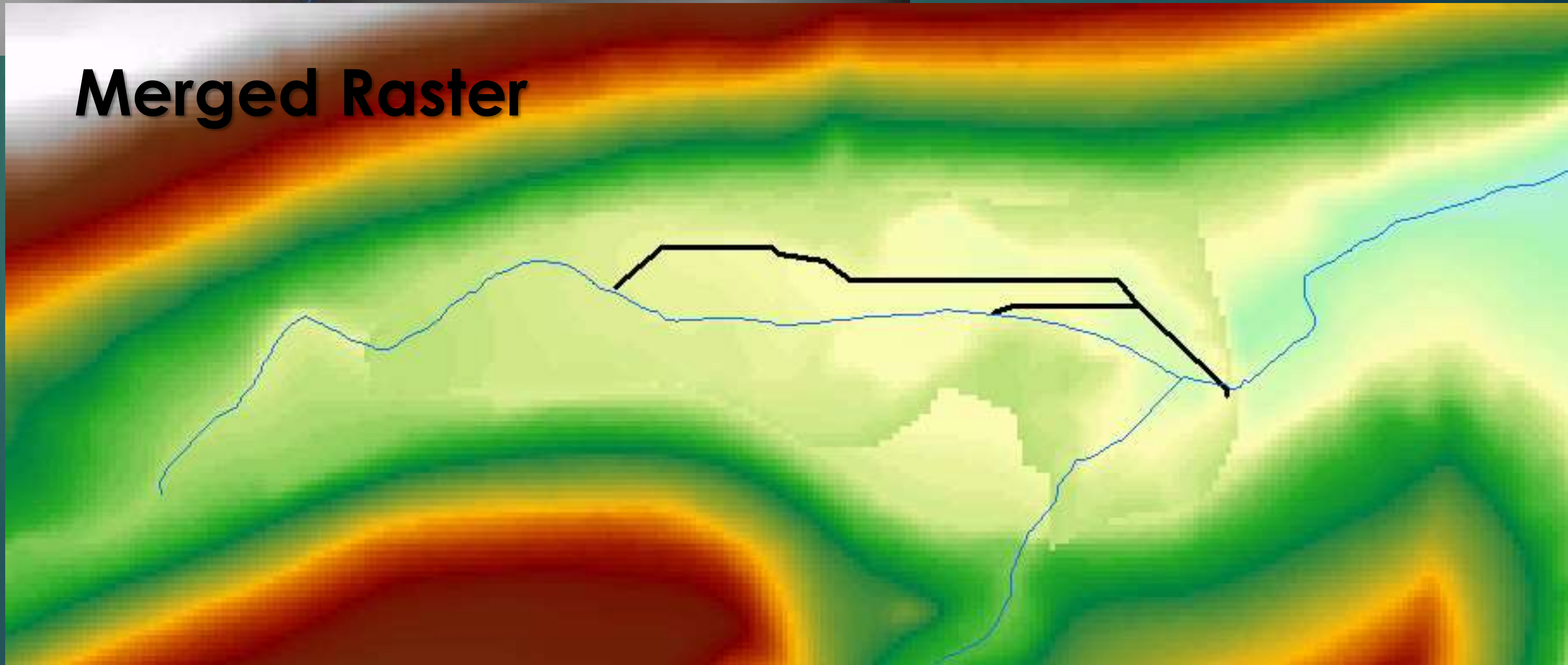
	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1																
2	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
3	1180.5	1180.5	912.2	912.2	912.2	804.9	804.9	804.9	804.9	804.9	858.5	858.5	858.5	1006.1	1006.1	457.3
4	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1	430.1
5	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
6	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
7																
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	438	438	472	472	472	490	490	457	457	457	501	501	501	516	516	487
10	426	426	466	466	466	486	486	453	453	453	498	498	498	509	509	483
11	413	413	460	460	460	482	482	449	449	449	494	494	494	502	502	480
12	400	400	453	453	453	477	477	444	444	444	491	491	491	495	495	476
13	387	387	446	446	446	472	472	440	440	440	487	487	487	488	488	473
14	373	373	439	439	439	467	467	435	435	435	484	484	484	481	481	467
15	359	359	431	431	431	462	462	430	430	430	480	480	480	473	473	465
16	345	345	422	422	422	457	457	425	425	425	476	476	476	465	465	461
17	330	330	414	414	414	451	451	420	420	420	472	472	472	458	458	457
18	315	315	404	404	404	445	445	415	415	415	468	468	468	450	450	453
19	298	298	395	395	395	440	440	409	409	409	465	465	465	442	442	449
20	282	282	384	384	384	433	433	404	404	404	460	460	460	434	434	445
21	265	265	372	372	372	427	427	397	397	397	456	456	456	426	426	440
22	246	246	360	360	360	419	419	391	391	391	451	451	451	417	417	436
23	227	227	346	346	346	412	412	384	384	384	447	447	447	408	408	431
24	209	209	330	330	330	404	404	377	377	377	442	442	442	400	400	426
25	184	184	311	311	311	396	396	369	369	369	436	436	436	391	391	422
26	160	160	288	288	288	386	386	361	361	361	431	431	431	381	381	417
27	134	134	258	258	258	376	376	352	352	352	426	426	426	372	372	411
28	104	104	215	215	215	364	364	342	342	342	420	420	420	362	362	406
29	100	90	146	146	146	351	351	330	330	330	413	413	413	352	352	401
30	90	80	83	83	83	334	334	317	317	317	407	407	407	342	342	394
31	0	0	44	44	44	313	313	302	302	302	400	400	400	331	331	388
32	0	0	0	30	40	279	279	282	282	282	392	392	392	320	320	382
33	0	0	0	0	30	68	68	251	251	251	384	384	384	308	308	375
34	0	0	0	0	0	39	39	72	72	72	375	375	375	297	297	368
35	0	0	0	0	0	0	30	34	34	54	365	365	365	284	284	360
36	0	0	0	0	0	0	0	30	30	40	353	353	353	271	271	352
37	0	0	0	0	0	0	0	0	20	30	340	340	340	257	257	344
38	0	0	0	0	0	0	0	0	0	20	322	322	322	243	243	334
39	0	0	0	0	0	0	0	0	0	0	296	296	296	227	227	324

Geoprocessing

XYZ-Coordinate Bathymetry
- TIN
  - Buffers
  - Raster
    - Contours
    - Flow net
      - Thalweg
        - Appropriate shape?

Oregon 10m DEM
- Clip
  - Merge
    - Streamlines
      - Appropriate shape?
    - Need Transects


TIN


Merged Raster

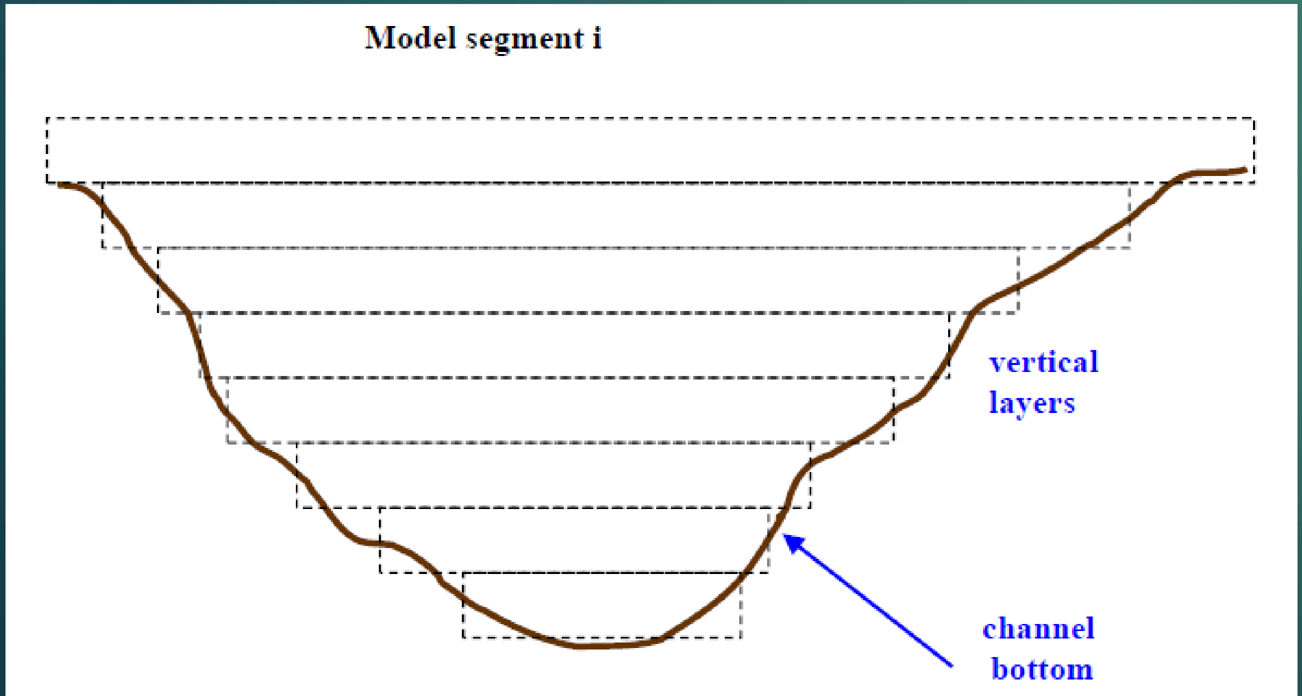
Geoprocessing

Incremental nodes along chosen thalweg

Generate shapes with z value from individual contours

Generate perpendicular lines (via python script or other tool)

Cut all contour shapes at all elevations with perpendicular lines



Number all transect polygons

Calc volume below all polygons

Move to excel for further calcs

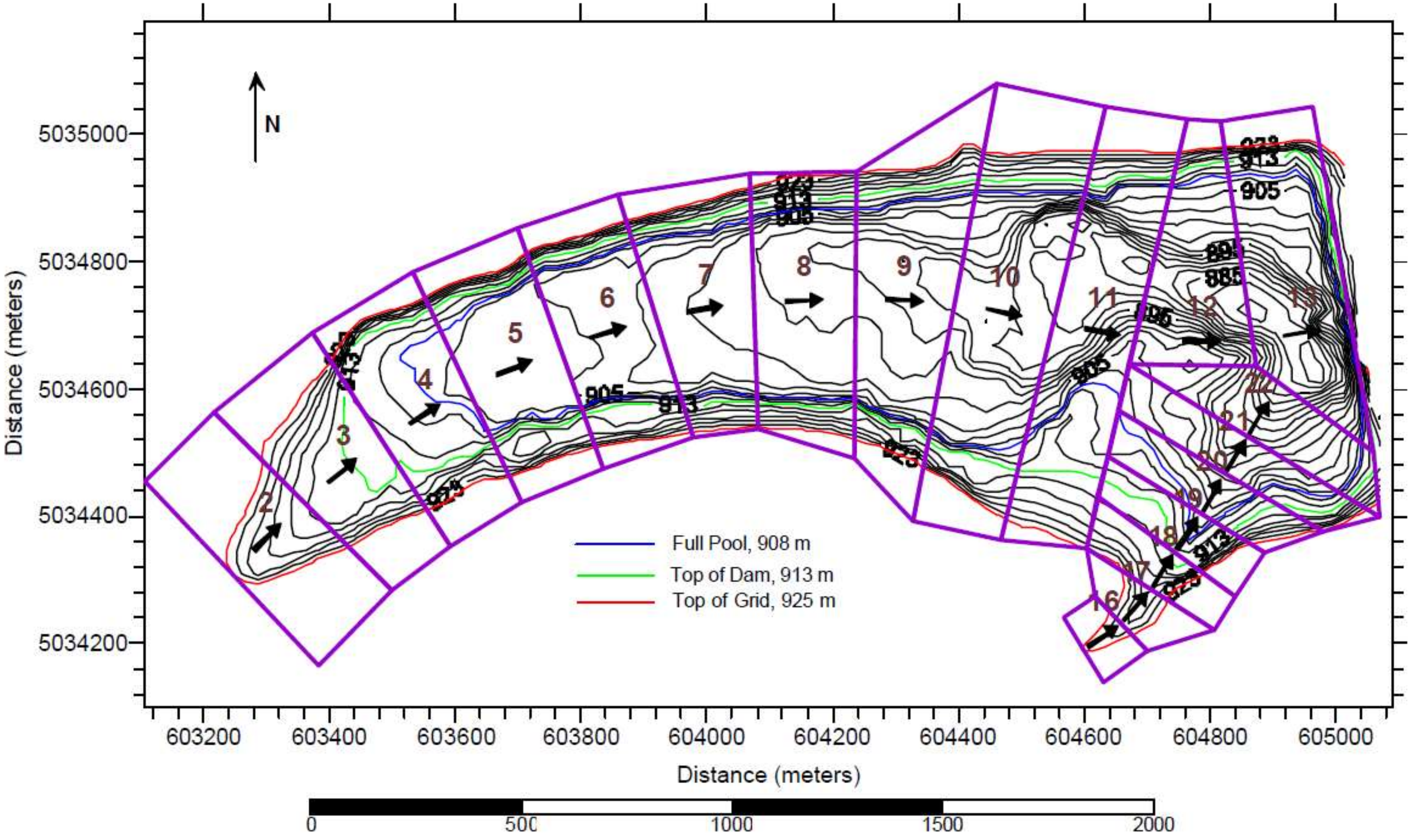
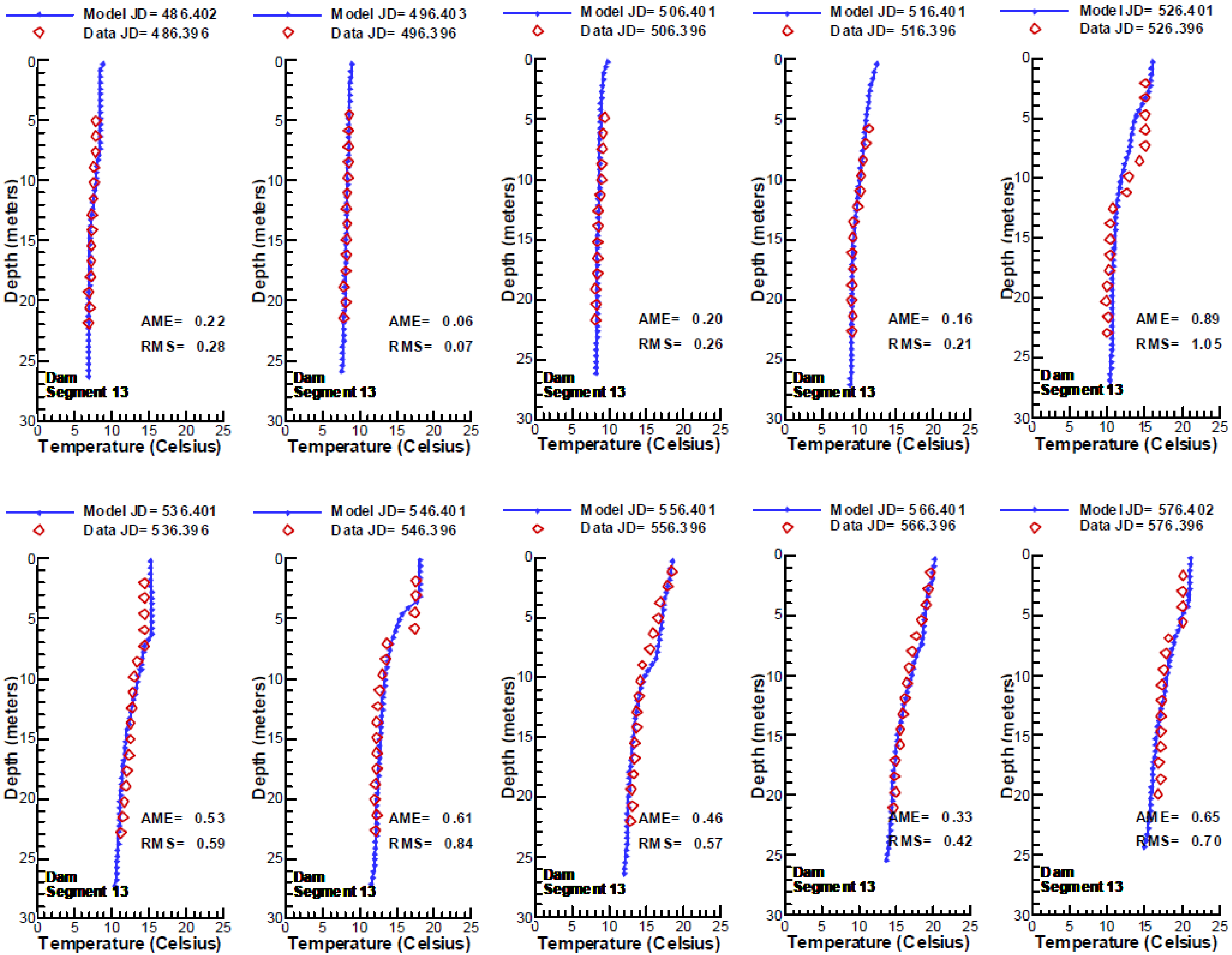


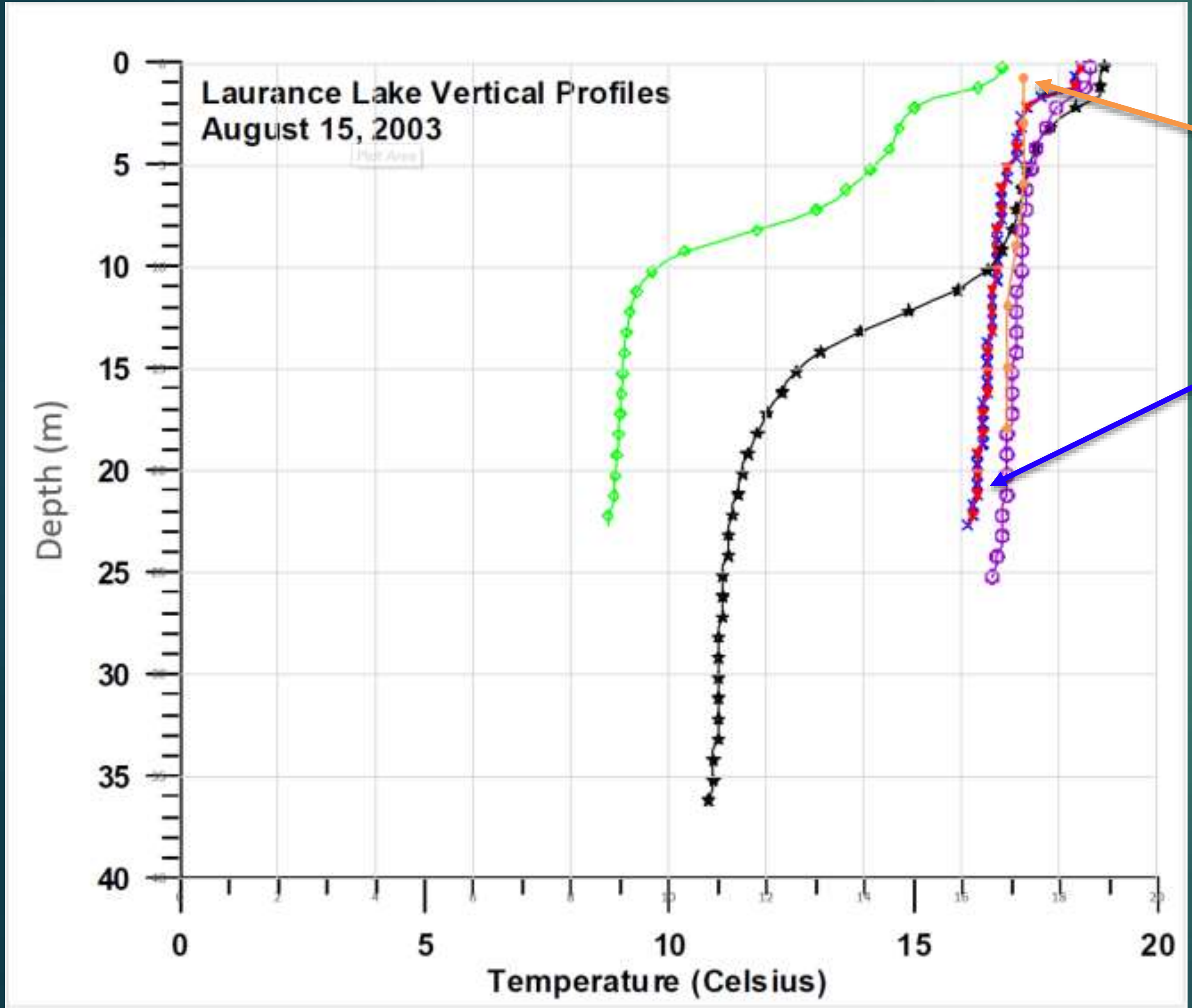
Figure 8. Plan view of the Laurance Lake grid. The arrows show the segment orientation.



Comparison of model predicted vertical temperature profiles and data collected at dam (Julian Day 486 to Julian Day 586).

'AME' is absolute mean error and 'RMS' is root mean square error.

Model Comparisons



My Uncalibrated model

Calibrated model

Other lines are management scenarios

Not much to compare to, I only have a working model from JDay 135 – 457.

Most calibration data is JDay 486 – beyond.

Sources

- Berger, Christopher J.; Wells, Scott A.; and Annear, Robert, "Laurance Lake Temperature Model" (2005).
- Laser Cut Lake photos: ScrimshawGallery.com
- USGS NHD HU8 - 17070105 (published 20191207)
- ArcGIS scripts, codes, etc.: https://codesharing.arcgis.com/
- Oregon Saptial