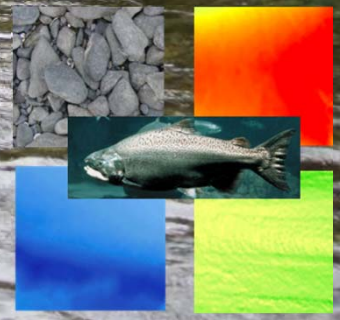
Icicle Creek Instream Flow and Fish Habitat Analysis for the Leavenworth National Fish Hatchery



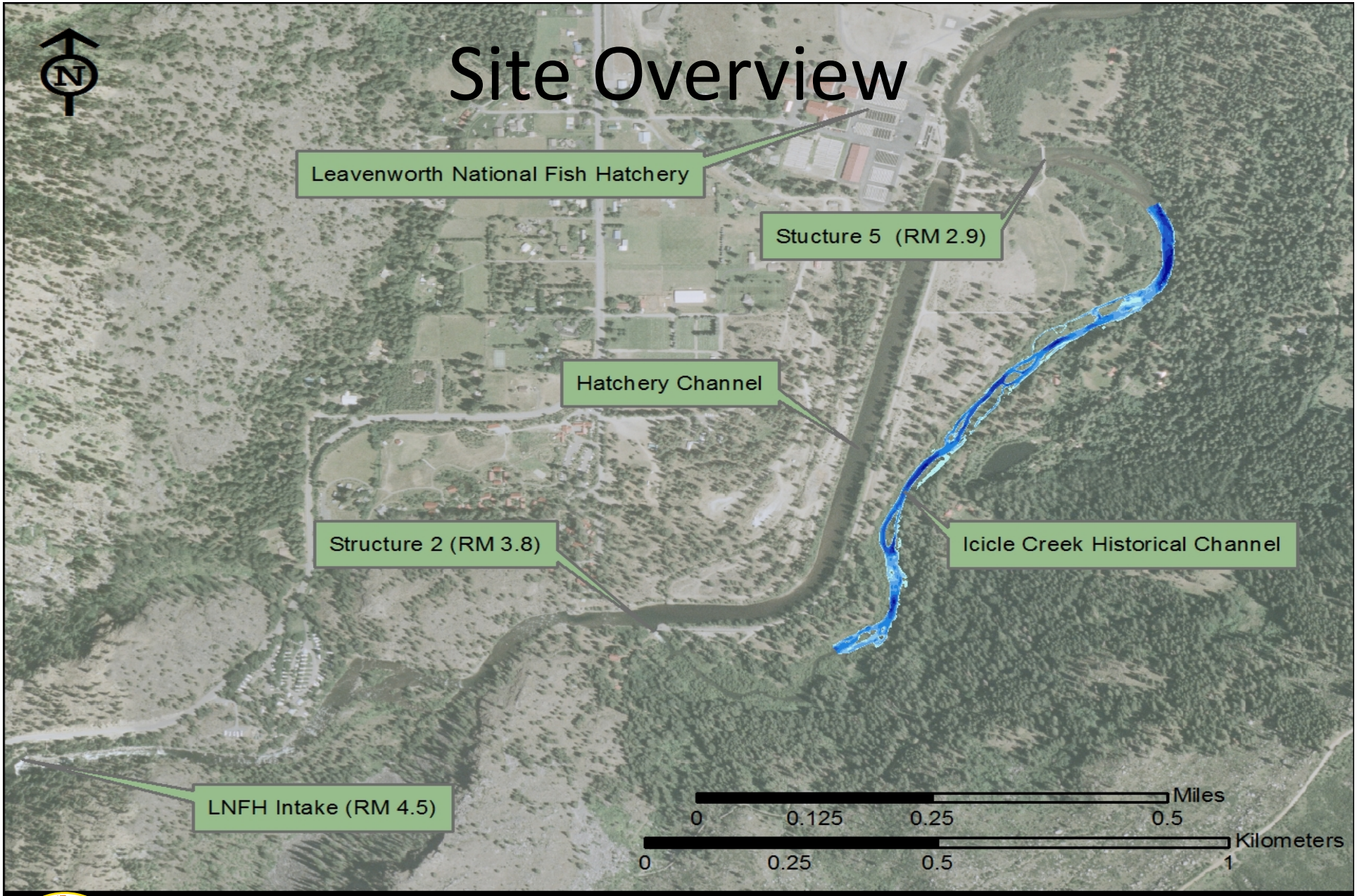
U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office

Conserving America's Fisheries

Presentation Overview

- Goals & Objective
- Hydrodynamic Modeling – Methods & Results
- Habitat Modeling Methods
- Habitat Modeling Results
- Channel Maintenance Flows

Site Overview



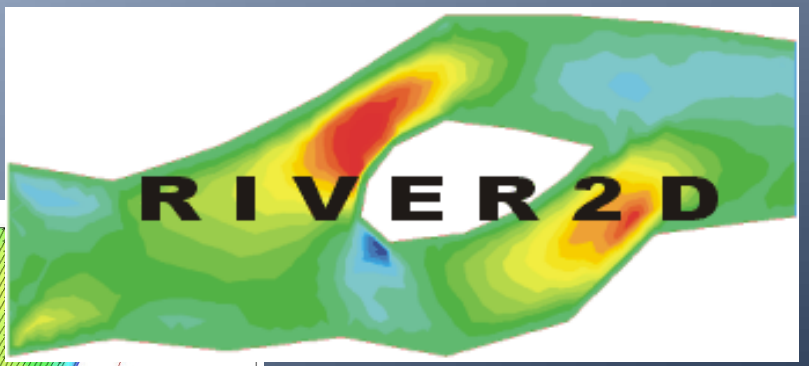
Goals

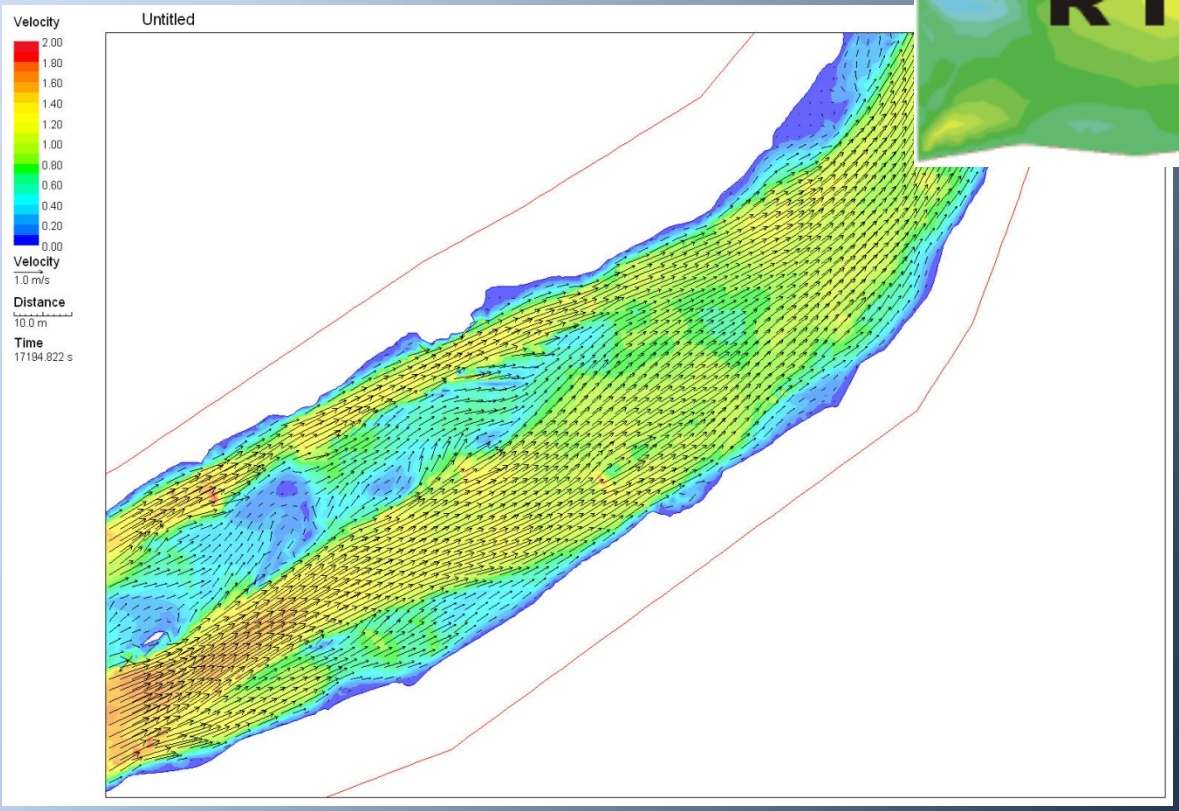
- Quantify fish habitat as a function of streamflow
- Determine streamflows required to maintain channel structure, complexity, and physical habitat
- Provide guidance regarding the integration of the target species habitat needs for the Icicle Creek historical channel

Objectives

- Produce species/lifestage specific habitat – flow relationships.
- Produce spatially explicit maps depicting the distribution of the primary habitat variables for representative stream flows.
- Produce tabular and graphic results that quantify species/lifestage specific habitat for streamflows from 20 to 1,500 cfs.
- Estimate flushing flows, channel maintenance flows, and channel forming flows.
- Integrate species-specific habitat-flow relationships to accommodate the habitat needs for multiple target fish species/lifestages that may occur simultaneously in the Icicle Creek historical channel.

Hydrodynamic Modeling





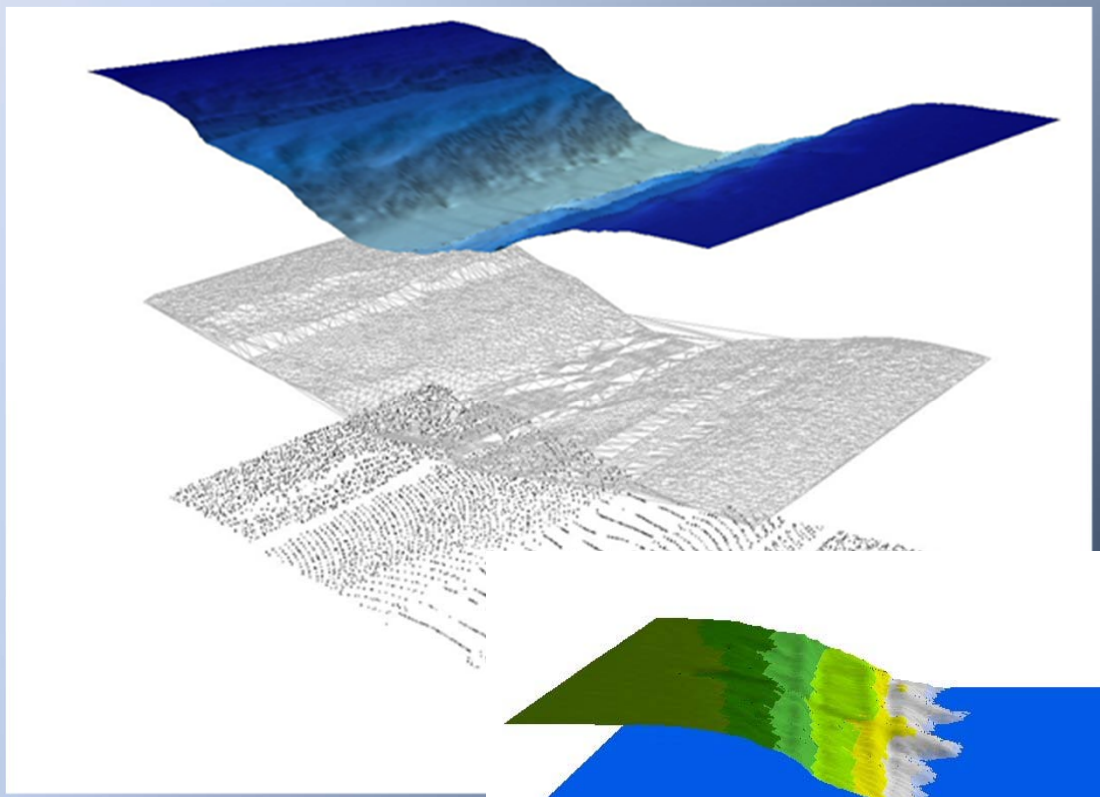
6 Steps

1. ***Develop a digital elevation model (DEM)***
2. ***Collect hydrologic model boundary data***
3. ***Collect representative roughness data***
4. ***Construct Computational Meshes***
5. ***Calibrate and Validate the hydrodynamic model***
6. ***Simulate unmeasured flows***

1. Digital Elevation Model Development

DEM Results: 4,988 points

DEM

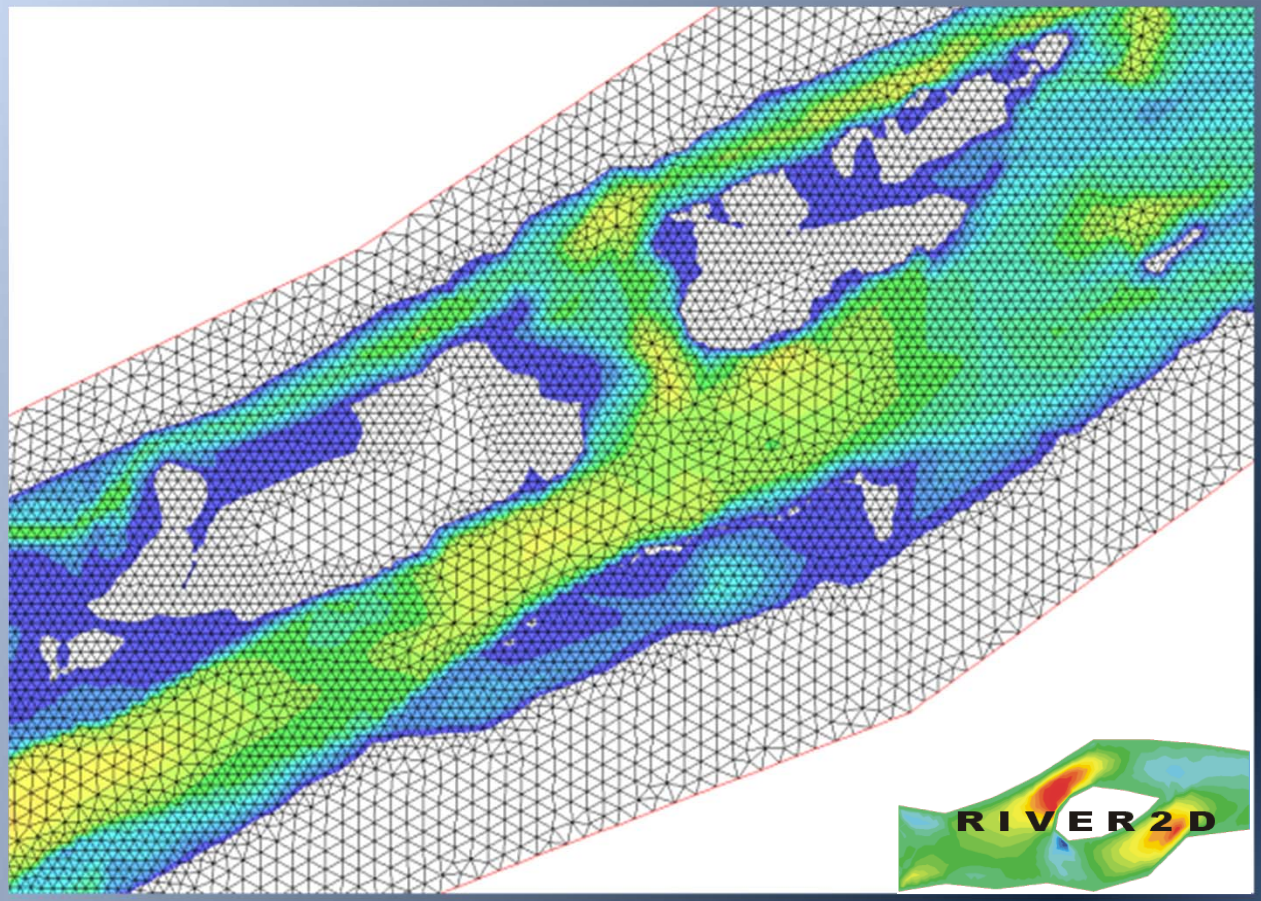


2. Collect Boundary Data (Paired inflow and outflow WSE's)

Discharge		Water Surface Elevations (m)	
cfs	cms	Downstream Boundary	Upstream Boundary
20	0.566	340.331	342.475
30	0.850	340.361	342.492
40	1.133	340.385	342.509
50	1.416	340.406	342.526
60	1.699	340.425	342.543
70	1.982	340.443	342.559
80	2.265	340.461	342.576
90	2.549	340.477	342.592
100	2.832	340.493	342.608
120	3.398	340.525	342.640
140	3.964	340.553	342.671
160	4.531	340.579	342.702
180	5.097	340.606	342.732
200	5.663	340.631	342.762
250	7.079	340.690	342.833
300	8.495	340.746	342.901
350	9.911	340.798	342.965
400	11.327	340.848	343.026
450	12.743	340.895	343.083
500	14.158	340.942	343.136
550	15.574	340.986	343.186
600	16.990	341.030	343.232
650	18.406	341.070	343.274
700	19.822	341.112	343.313
750	21.238	341.151	343.349
800	22.653	341.190	343.380
850	24.069	341.228	343.408
900	25.485	341.265	343.433
950	26.901	341.302	343.454
1000	28.317	341.339	343.471
1050	29.733	341.372	343.485
1100	31.148	341.410	343.495
1150	32.564	341.442	343.501
1200	33.980	341.476	343.504
1250	35.396	341.509	343.503
1300	36.812	341.540	343.499
1350	38.228	341.573	343.491
1400	39.644	341.602	343.479
1450	41.059	341.637	343.464
1500	42.475	341.668	343.445

3. Collect Representative Roughness Data

4. Computational Mesh Construction



5. Model Calibration and Validation

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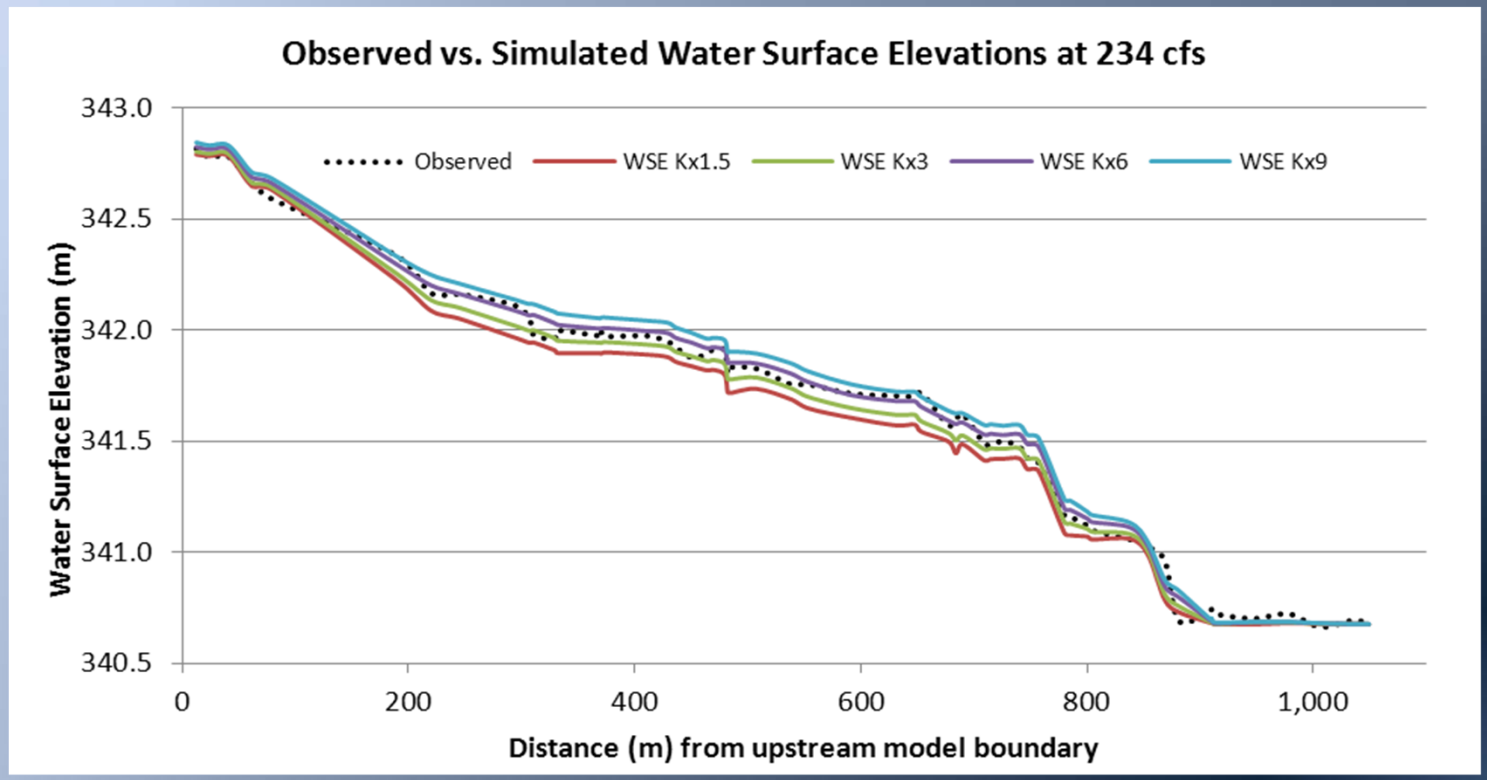
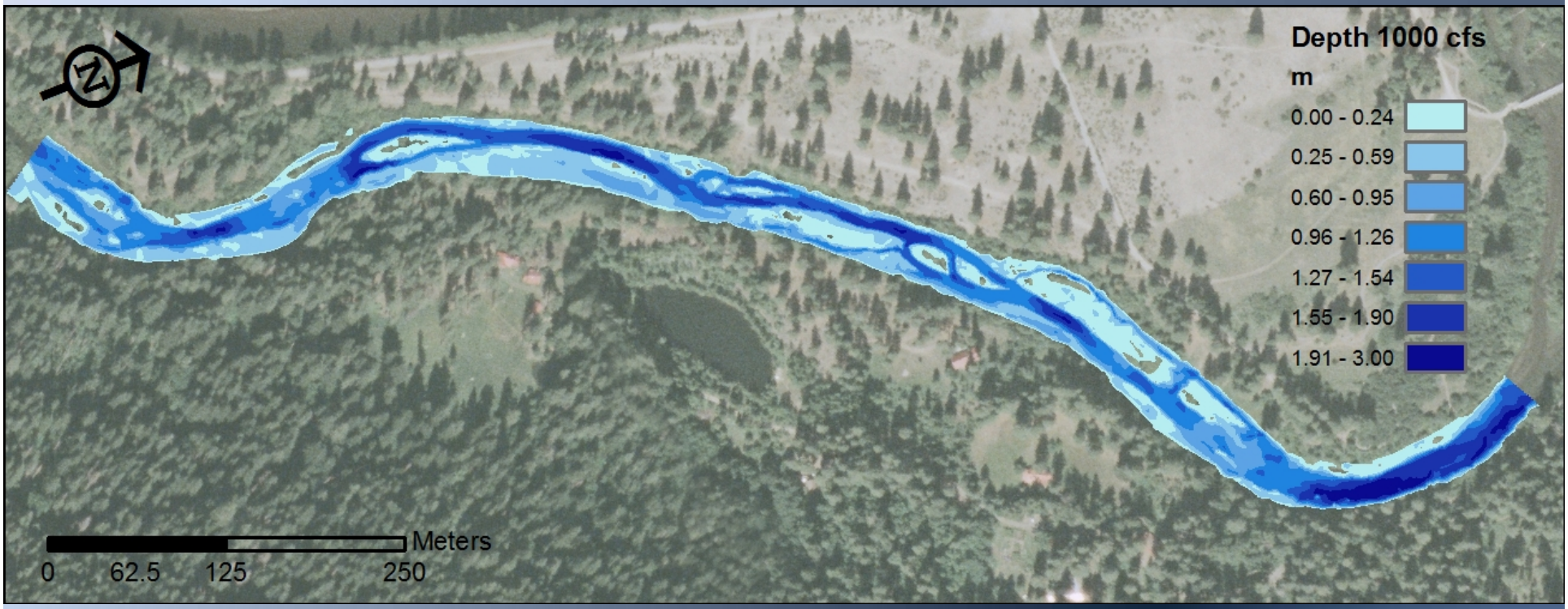


6. Simulation of Unmeasured Flows

Simulated depths (m) at 20 cfs.

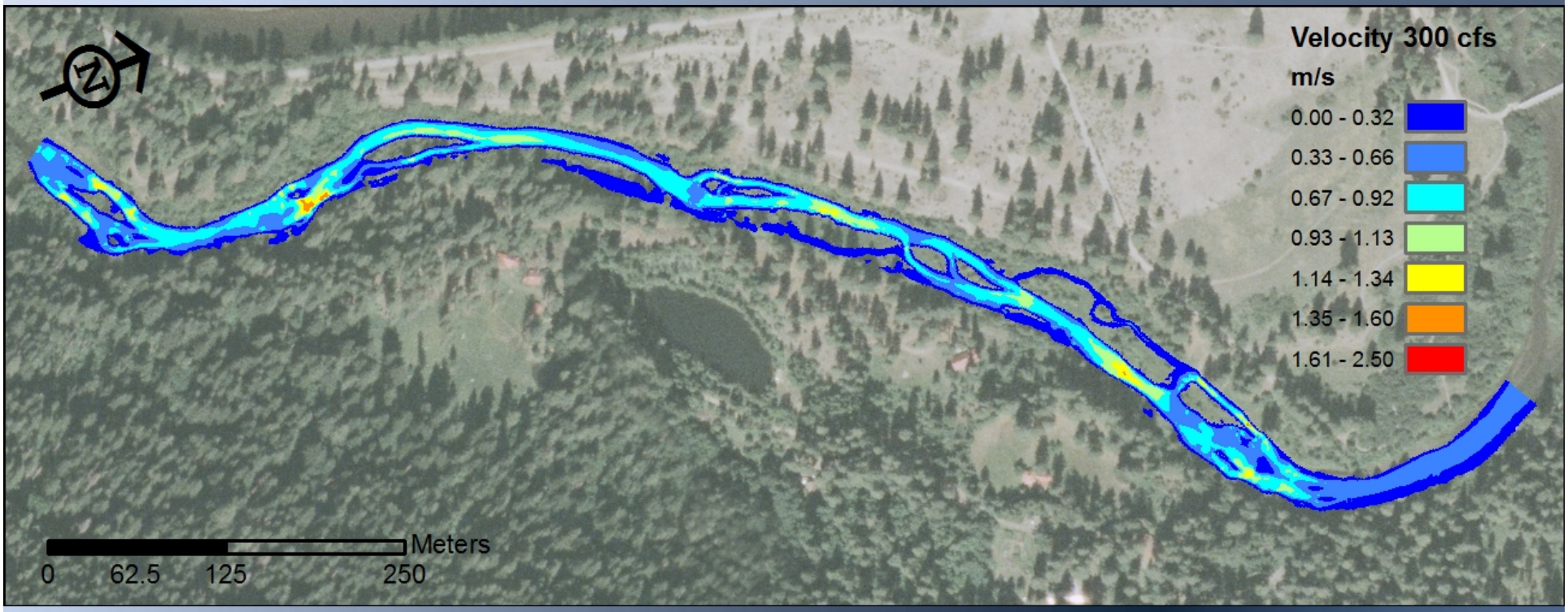
Simulated depths (m) at 300 cfs.

Simulated depths (m) at 1000 cfs.

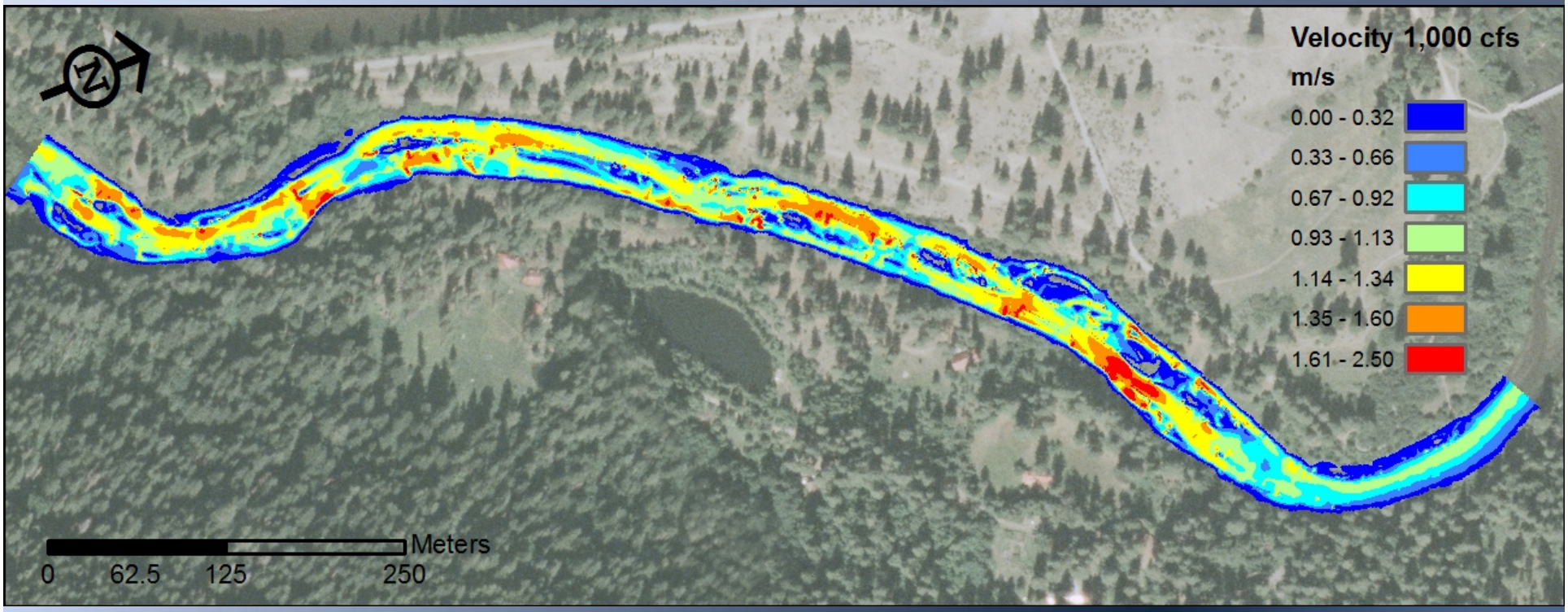


Simulated velocities (m/s) at 20 cfs.

Simulated velocities (m/s) at 300 cfs.



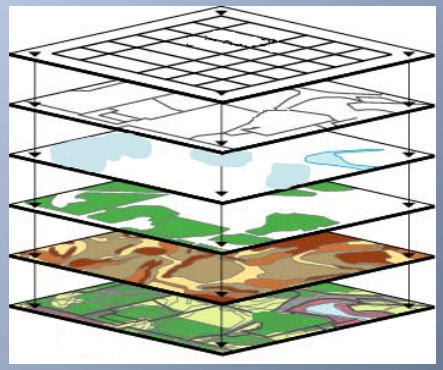
Simulated velocities (m/s) at 1000 cfs.

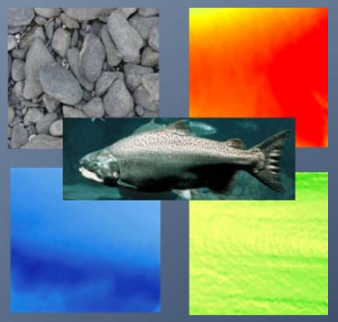


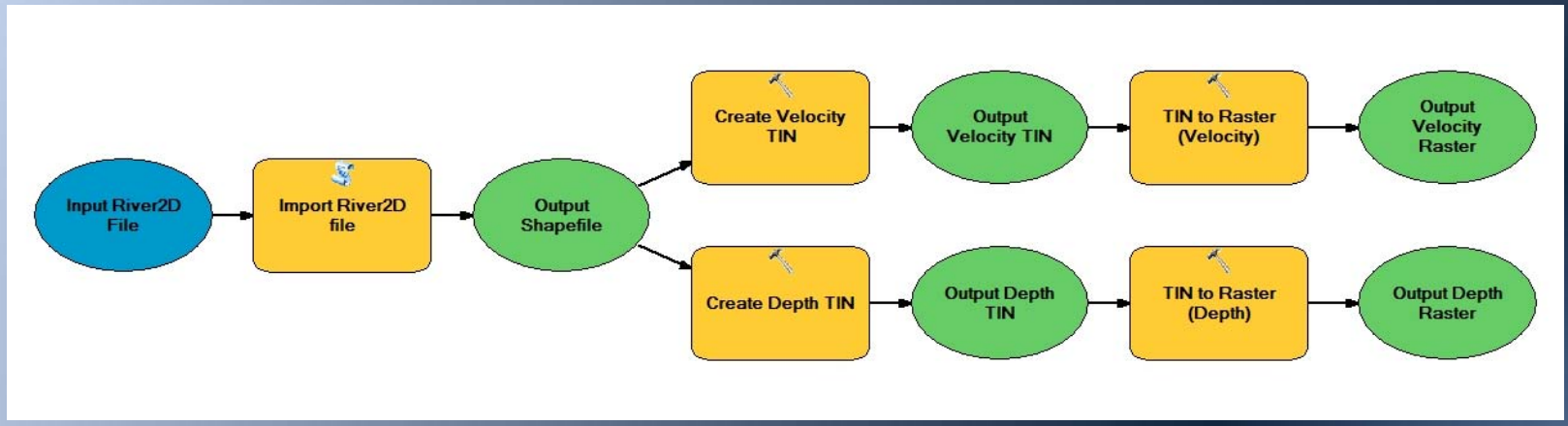
Habitat Modeling Methods

- Habitat Suitability Criteria
- Physical Parameters (depth, velocity & substrate)
- GIS Cell-Based Habitat Modeling

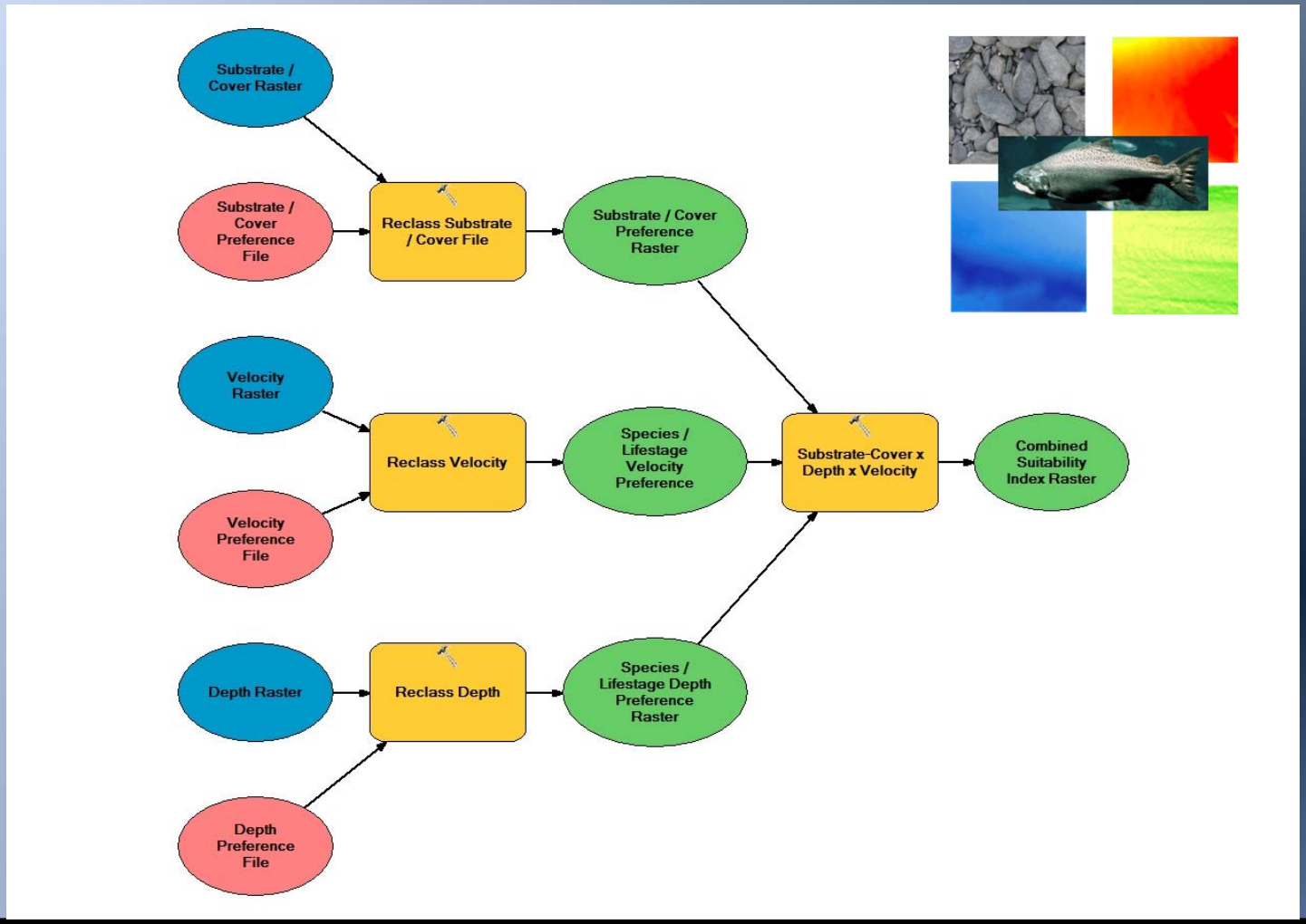
GIS Cell-Based Habitat Modeling



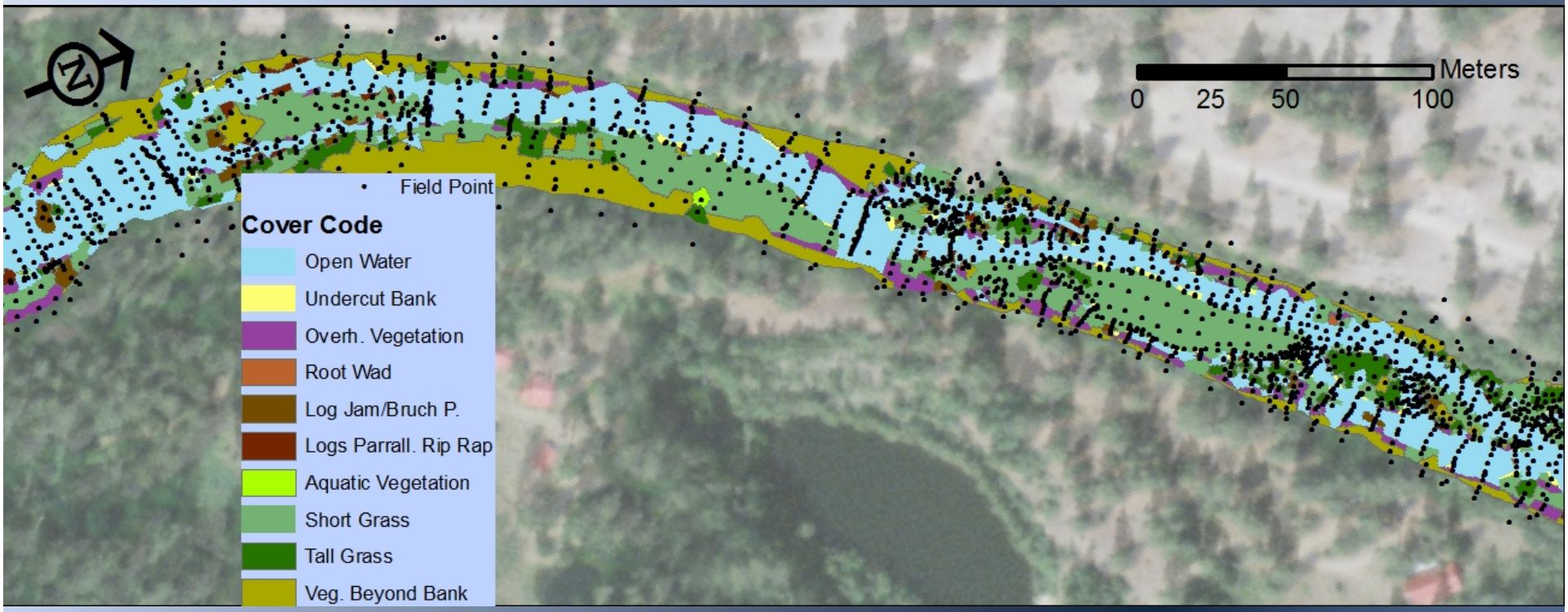




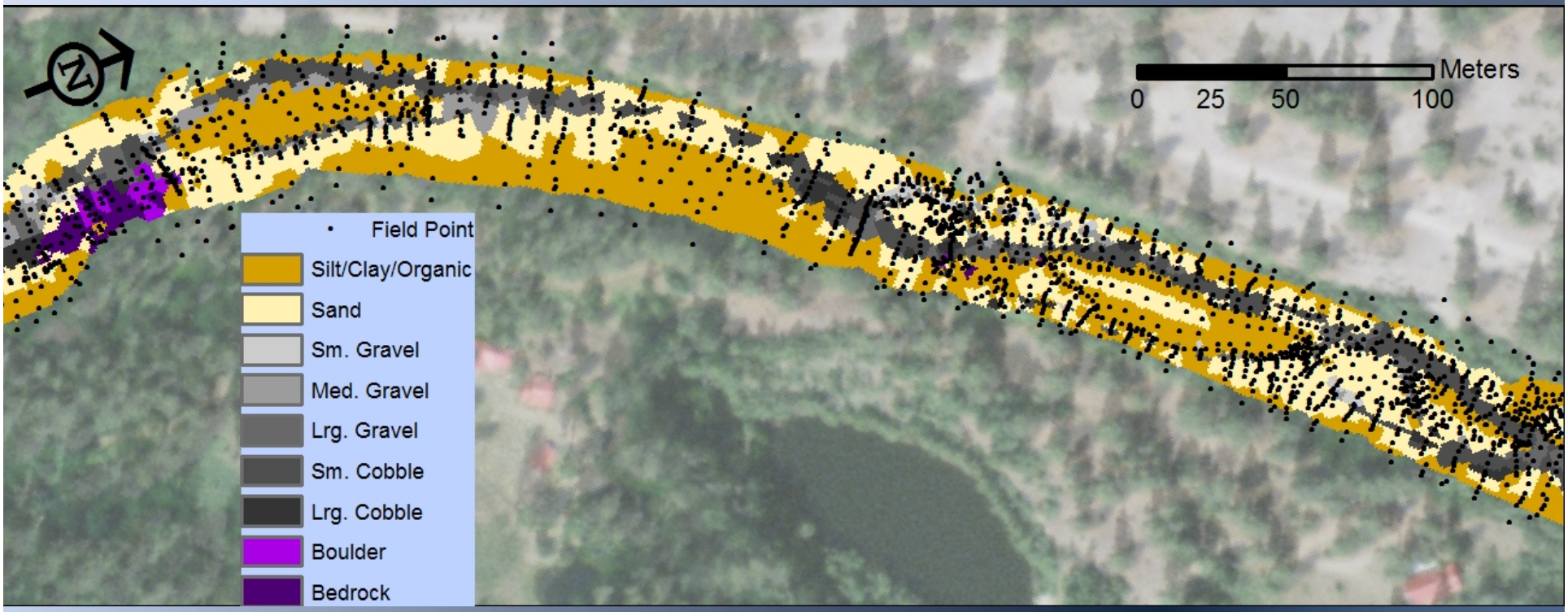
GIS Cell-Based Habitat Modeling

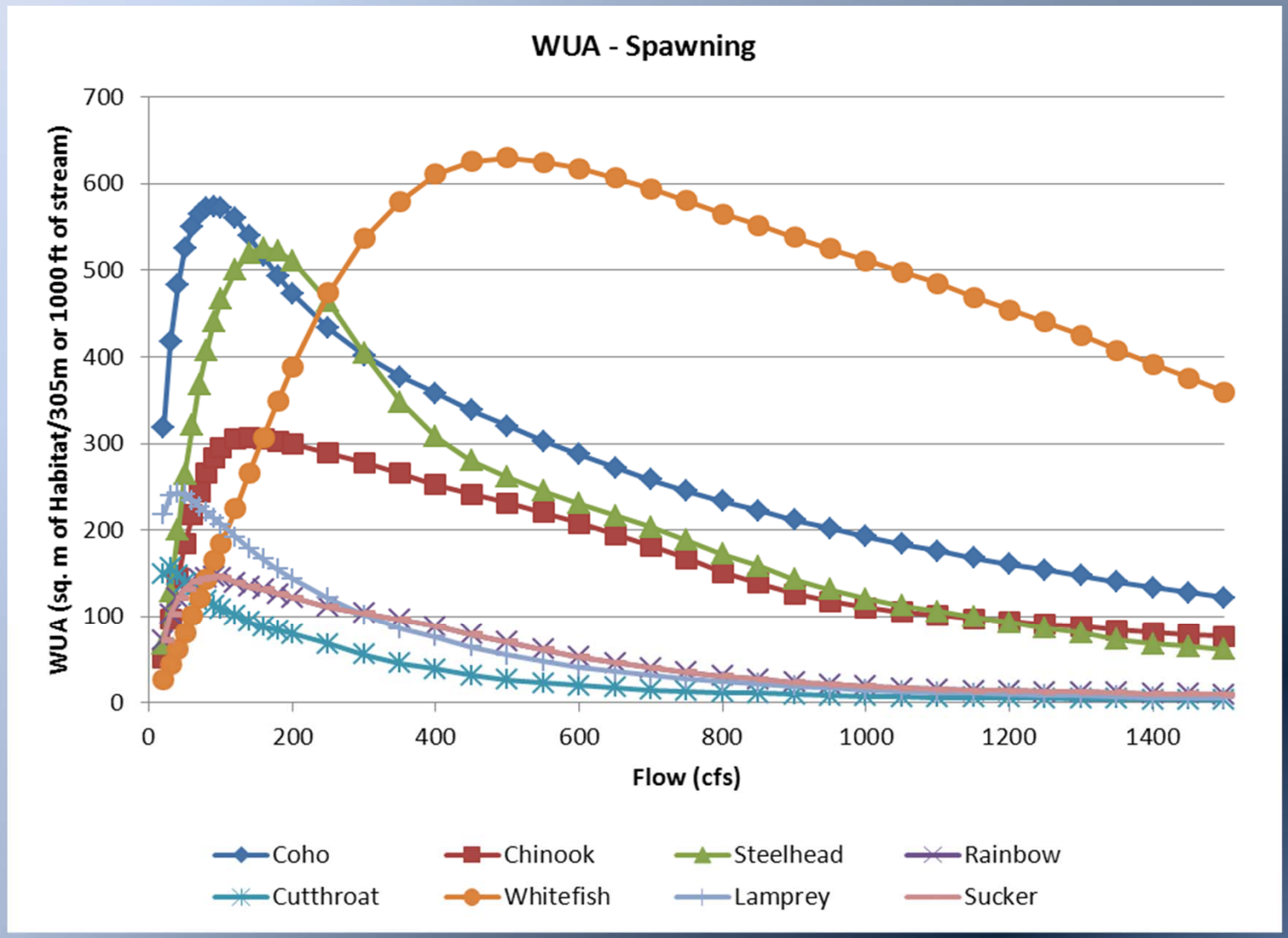


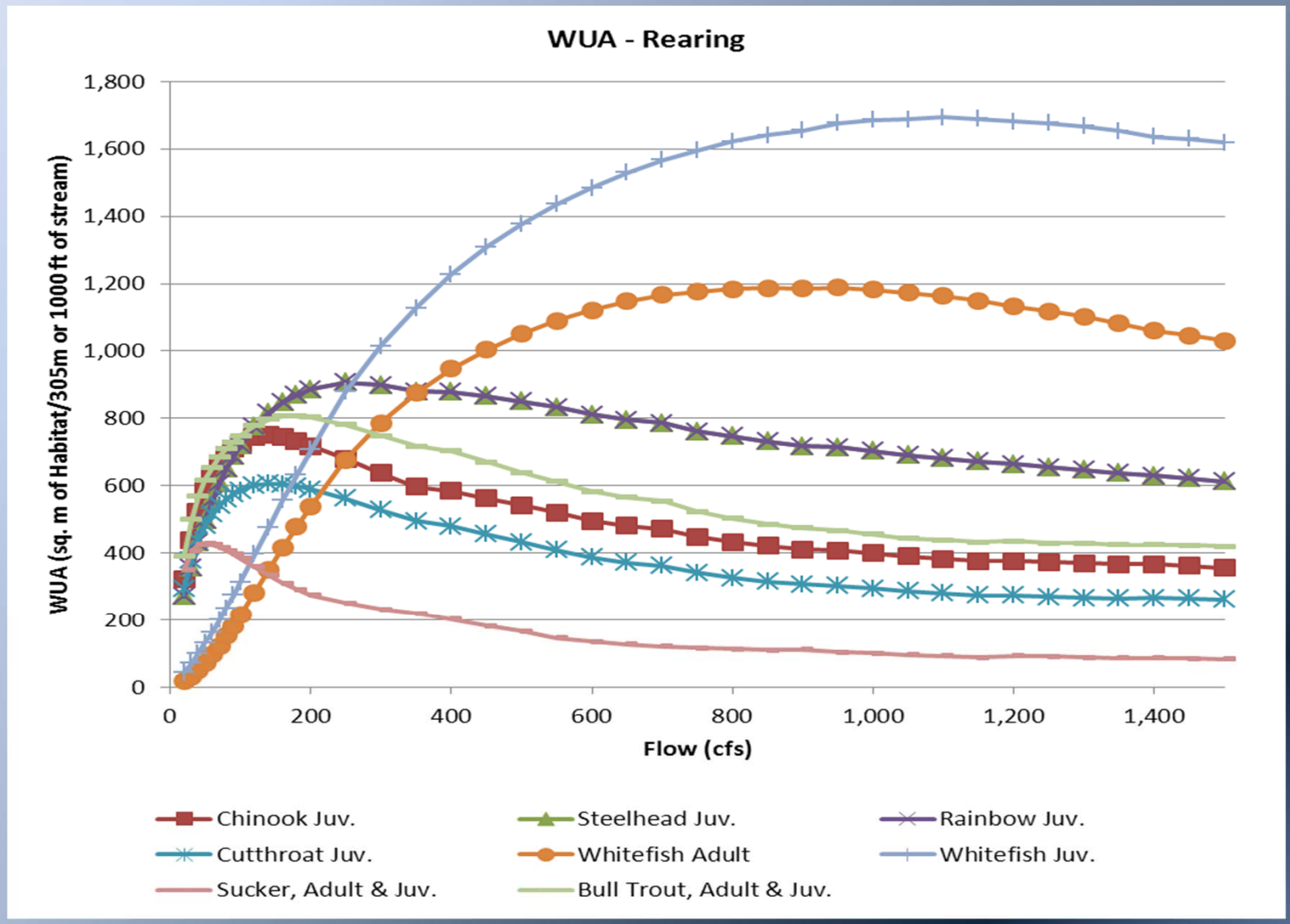
Cell-Based Cover Layer



Cell-Based Substrate Layer




WUA - Spawning
WUA (sq. m of Habitat/305m or 1000 ft of stream)
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
Flow (cfs)
Coho
Chinook
Steelhead
Rainbow
Cutthroat
Whitefish
Lamprey
Sucker


WUA - Rearing
WUA (sq. m of Habitat/305m or 1000 ft of stream)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0
200
400
600
800
1,000
1,200
1,400
Flow (cfs)
Chinook Juv.
Steelhead Juv.
Rainbow Juv.
Cutthroat Juv.
Whitefish Adult
Whitefish Juv.
Sucker, Adult & Juv.
Bull Trout, Adult & Juv.

Flows (cfs)		Adult Spawning							
USGS	Structure 2	Coho	Chinook	Steelhead	Rainbow	Cutthroat	Whitefish	Lamprey	Sucker
na	20	319	51	68	72	149	27	218	72
na	30	417	97	130	103	156	44	240	103
na	40	483	144	200	121	148	62	243	121
na	50	525	184	265	133	139	80	241	133
88	60	550	217	321	140	130	101	234	140
101	70	564	243	368	143	124	122	227	143
115	80	572	265	408	145	119	144	220	145
129	90	574	283	440	146	113	165	213	146
142	100	572	294	466	145	109	185	206	145
168	120	560	305	500	139	101	224	192	139
193	140	539	307	520	135	94	265	179	135
218	160	516	305	525	131	88	307	166	131
243	180	493	303	522	126	84	348	155	126
266	200	473	300	511	122	79	388	144	122
325	250	433	289	463	111	68	474	121	111
382	300	402	278	404	104	56	536	102	104
437	350	377	265	348	96	46	579	86	96
491	400	358	253	308	88	39	611	76	88
544	450	338	242	280	79	32	625	65	79
596	500	320	231	261	70	26	629	55	70
648	550	303	220	245	62	23	625	48	62
699	600	287	208	231	53	20	617	41	53
749	650	272	195	217	46	18	606	36	46
799	700	259	182	203	40	15	594	32	40
848	750	245	167	189	35	13	580	28	35
896	800	233	151	172	31	12	564	24	31
944	850	223	138	158	28	11	552	22	28
1,024	900	212	126	143	24	10	538	20	24
1,115	950	202	118	131	22	9	525	17	22
1,215	1,000	192	111	121	19	7	511	15	19
1,315	1,050	184	105	112	17	7	498	13	17
1,425	1,100	176	101	106	16	6	485	12	16
1,525	1,150	168	97	99	14	6	469	11	14
1,640	1,200	161	94	93	14	6	454	10	14
1,760	1,250	154	90	86	13	5	440	9	13
1,890	1,300	148	88	81	13	5	425	9	13
2,020	1,350	140	84	73	12	4	407	7	12
2,150	1,400	134	81	68	11	4	391	6	11
2,300	1,450	128	79	65	11	4	375	6	11
2,440	1,500	122	77	62	10	3	359	5	10

Flows (cfs)		Chinook	Steelhead	Rainbow	Cutthroat	Whitefish	Whitefish	Sucker	Bull Trout
USGS	Structure 2	Juvenile	Juvenile	Juvenile	Juvenile	Juvenile	Adult	Adult & Juv.	Adult & Juv.
na	20	323	271	271	295	17	45	349	390
na	30	438	358	358	380	32	72	406	499
na	40	523	433	433	438	51	100	425	569
na	50	584	498	498	481	72	131	428	617
88	60	631	556	556	515	96	164	425	655
101	70	666	606	606	540	123	199	417	686
115	80	691	649	649	560	152	236	407	710
129	90	710	687	687	574	183	274	396	730
142	100	726	720	720	586	215	314	384	749
168	120	745	774	774	601	283	396	359	778
193	140	751	816	816	607	350	477	334	797
218	160	745	847	847	604	416	556	310	806
243	180	733	870	870	598	478	632	292	807
266	200	718	887	887	590	538	706	275	803
325	250	680	906	906	562	677	879	251	782
382	300	637	898	898	528	786	1,015	231	749
437	350	597	880	880	494	875	1,127	220	718
491	400	585	879	879	480	948	1,228	202	703
544	450	563	866	866	456	1,004	1,309	183	670
596	500	542	850	850	432	1,050	1,376	167	640
648	550	520	833	833	410	1,090	1,435	147	612
699	600	495	811	811	387	1,122	1,485	135	583
749	650	480	795	795	372	1,147	1,529	127	565
799	700	472	786	786	362	1,166	1,567	121	554
848	750	449	762	762	341	1,177	1,595	116	523
896	800	433	747	747	327	1,184	1,622	113	502
944	850	421	731	731	316	1,187	1,641	109	485
1,024	900	411	718	718	307	1,185	1,654	111	474
1,115	950	408	714	714	303	1,188	1,677	104	467
1,215	1,000	400	702	702	295	1,182	1,686	101	456
1,315	1,050	390	690	690	286	1,172	1,687	96	444
1,425	1,100	383	681	681	280	1,164	1,694	92	439
1,525	1,150	376	671	671	274	1,149	1,689	88	433
1,640	1,200	376	665	665	274	1,132	1,681	92	435
1,760	1,250	373	655	655	269	1,118	1,678	91	430
1,890	1,300	370	647	647	267	1,102	1,668	88	429
2,020	1,350	367	637	637	266	1,082	1,653	87	424
2,150	1,400	366	629	629	266	1,061	1,636	87	425
2,300	1,450	362	622	622	264	1,046	1,629	85	423
2,440	1,500	356	613	613	262	1,031	1,620	83	420

Steelhead Rearing Habitat – 20 cfs

Steelhead Rearing Habitat – 300 cfs

Steelhead Rearing Habitat – 1000 cfs

Steelhead Spawning Habitat – 20 cfs

Steelhead Spawning Habitat – 300 cfs

Steelhead Spawning Habitat – 1,000 cfs

WUA Percent of Peak, for April Spawners

Flows (cfs)		April Spawners			
USGS	Structure 2	Steelhead	Rainbow	Cutthroat	Lamprey
na	20	13%	49%	95%	90%
na	30	25%	70%	100%	99%
na	40	38%	83%	95%	100%
na	50	50%	91%	89%	99%
88	60	61%	96%	83%	96%
101	70	70%	98%	79%	93%
115	80	78%	99%	76%	91%
129	90	84%	100%	73%	88%
142	100	89%	99%	70%	85%
168	120	95%	95%	65%	79%
193	140	99%	92%	60%	74%
218	160	100%	90%	56%	68%
243	180	99%	86%	54%	64%
266	200	97%	83%	51%	59%
325	250	88%	76%	44%	50%
382	300	77%	71%	36%	42%
437	350	66%	66%	29%	35%
491	400	59%	60%	25%	31%
544	450	53%	54%	20%	27%
596	500	50%	48%	17%	23%
648	550	47%	42%	15%	20%
699	600	44%	36%	13%	17%
749	650	41%	32%	11%	15%
799	700	39%	28%	10%	13%
848	750	36%	24%	9%	11%
896	800	33%	21%	8%	10%
944	850	30%	19%	7%	9%
1,024	900	27%	16%	6%	8%
1,115	950	25%	15%	5%	7%
1,215	1,000	23%	13%	5%	6%
1,315	1,050	21%	12%	4%	5%
1,425	1,100	20%	11%	4%	5%
1,525	1,150	19%	10%	4%	4%
1,640	1,200	18%	10%	4%	4%
1,760	1,250	16%	9%	3%	4%
1,890	1,300	15%	9%	3%	4%
2,020	1,350	14%	8%	3%	3%
2,150	1,400	13%	7%	3%	3%
2,300	1,450	12%	7%	2%	2%
2,440	1,500	12%	7%	2%	2%

April Exceedance flows at Structure 2 (90-10%) 270 to 873 cfs and are highlighted in the shaded area

Channel Maintenance Flows

	Icicle Creek Historical Channel (Structure 2) Flow (cfs)	Supporting USGS 12458000 Gage Flow (cfs)
Flushing	624	720
Maintenance	1,248	1,760
Forming	7,930	NA

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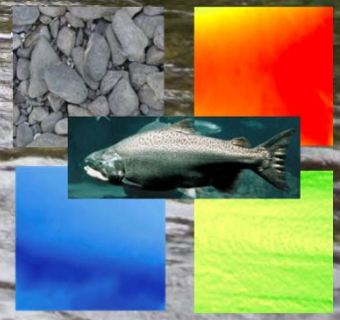

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