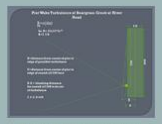
Index Velocity Method V/S Stage Discharge Method

ACOUSTIC DOPPLER VELOCITY METER (ADVM) APPLICATIONS IN KENTUCKY


Measurement to determine Index Velocity rating


Blanking Distance Equation

Kentucky's varied topography and climate leads to unique challenges in the installation and maintenance of surface water stations. Fixed mounted hydroacoustic systems present an even greater challenge. The Kentucky Water Science Center installed its first Acoustic Doppler Velocity Meter in February 2007 and now has 4 ADVM's mounted throughout the state in various applications each with its own special set of spatial and environmental demands.


Canoe expert braves zero velocity water


Sontek SW Unit Installed

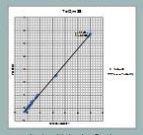
Beargrass Creek at River Road (03293510)

Installed in February of 2007, Beargrass Creek is one of the primary watersheds located in the city of Louisville, KY. The Metropolitan Sewer District (MSD) is required to monitor water quality throughout most of the stream's reach due to the use of CSO's (Combined Sewer Overflows). This particular site is the most downstream , located only 2,000 ft upstream of the confluence with the Ohio River. The site is, at times, backwater affected. The ADVM helps to determine whether the installed QW monitor is reading primarily Beargrass Creek flow or backwater from the Ohio River.


Site Location


ADVM requires bi-annual cleaning


Gage equipment


Index Velocity Rating

Three Mile Creek at Covington (03254695)

Originally installed as stage discharge site in June 2007. The site is 1,500 ft upstream of the confluence with Licking River and backwater is frequently present. Sanitation District #1 is responsible for monitoring water quality at this site. A Sontek SL 1500 was originally installed, but it was later decided to install a Sontek SW up-looker in order to better define vertical velocity profiles.


Lexan protective casing


Uplooker Location


Site Location


Backwater Measurement


Mount and Winch


Gage

Ohio River at Olmsted (03612600)

Resultant Velocity Magnitude Monitoring at the Olmsted Locks and Dam

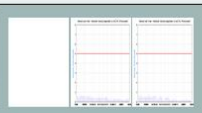
The U.S. Army Corps of Engineers, Louisville District (USACE-LD) has been overseeing the construction of the new Locks and Dam near Olmsted, Illinois, since 1992. The construction phase of the lock chambers is complete and the tainter-gate construction phase currently (2011) is underway. In order to set the tainter gates into place, the gate shells are floated out to their determined location, set in place, and then filled with concrete. To complete this task, a safe-working limit on water velocity was enacted, which permits work to be carried out when the velocity of the Ohio River is flowing at or below 5 feet per second. To monitor the velocities of the Ohio River at this construction site, the USACE partnering with the U.S. Geological Survey--Kentucky Water Science Center (USGS-KY WSC), installed a Sontek SL-500 Acoustic Velocity Meter (SL-500) near the construction site, which is mounted below the water's surface. The unit measures the velocities of the water flowing past the SL-500 at assigned locations on the Ohio River and collects data consisting of an X component (flow perpendicular to the SL-500) and a Y component (flow parallel to the SL-500). These velocities are calculated from volumes of water, referred to as cells, which are centered at specific locations (distances out in the river) that are programmed into the SL-500. Each cell is approximately 46 feet wide and is centered at approximate locations -- 45', 89', 135', 178', and 221'--from the outermost lock wall where the SL-500 currently (2011) is mounted. The velocity data are logged every 15 minutes and relayed via the Geostationary Operational Environmental Satellite (GOES) Data Collection System to the USGS-KY WSC where the data are then processed and displayed on the Center's web site.


Bottom of Protective Mount


Construction


Site Location


Cell Location


Individual Cell Velocities Graph


Lock walls float so ADVM stays a fixed distance from surface


Stage-Discharge Rating Problematic

High Bridge


Gage

Licking River near Alexandria (03254520)

Initially installed as a stage-discharge station in June 2007. Early measurements determined that backwater from Ohio River 18 miles downstream affected the stage-discharge relationship especially at low stages. ADVM installed in August 2010. Licking River has a wide range of stage and gage was installed 75 feet above water surface on bridge railing.


Site Location


Mount retracts for service and repair


Ladder Mount

USGS science for a changing world

USGS

OVERVIEW

What is an Index Velocity site?
Site Selection
Instrument Selection
Types of Installations
Rating Development for Index Velocity
Q/A for Index Velocity

USGS

What is an Index Velocity site?

- Collecting real-time velocity and area to compute discharge.
- Same methodology as a stage/discharge where:
  - Q= V X A
- Differs from separating velocity and area into 2 ratings

USGS

What is an Index Velocity Site Con't?

- Used where a stage/discharge is not able to obtained:
  - Backwater
    - Licking River at 536
  - Slope
    - Ohio River at Louisville
  - Tidal effect
    - Beargrass Creek at River Road
  - Working in conditions where velocity is needed
    - Ohio River at Olmsted

USGS

What is needed for an Index site?

- **Site Selection!!!!**
  - Site is relatively parallel and uniform
  - Near the region of max velocity free from any boundary effects
  - Stream is straight for 300ft or 5-10 channel widths
  - Located 5-10 channel widths US or DS of any tributary
  - Total flow is confined to 1 channel
  - Streambed is not subject to scour and fill
  - Able to measure discharge at all stages
  - Easily accessible for installation and O&M
  - Free from air entrainment

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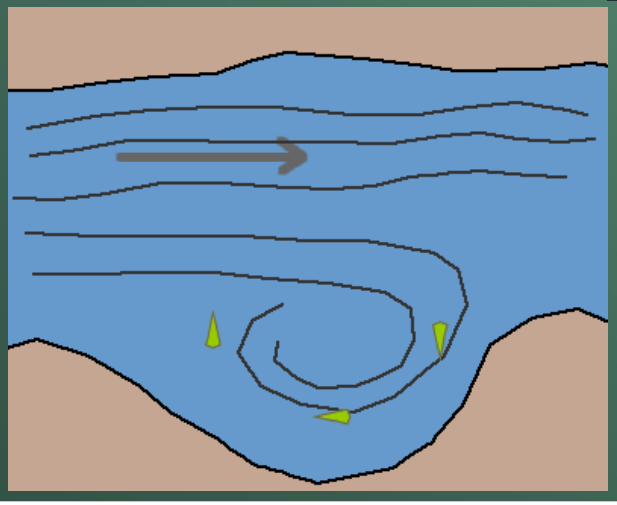
Pier Wakes



Flow Reversals

USGS

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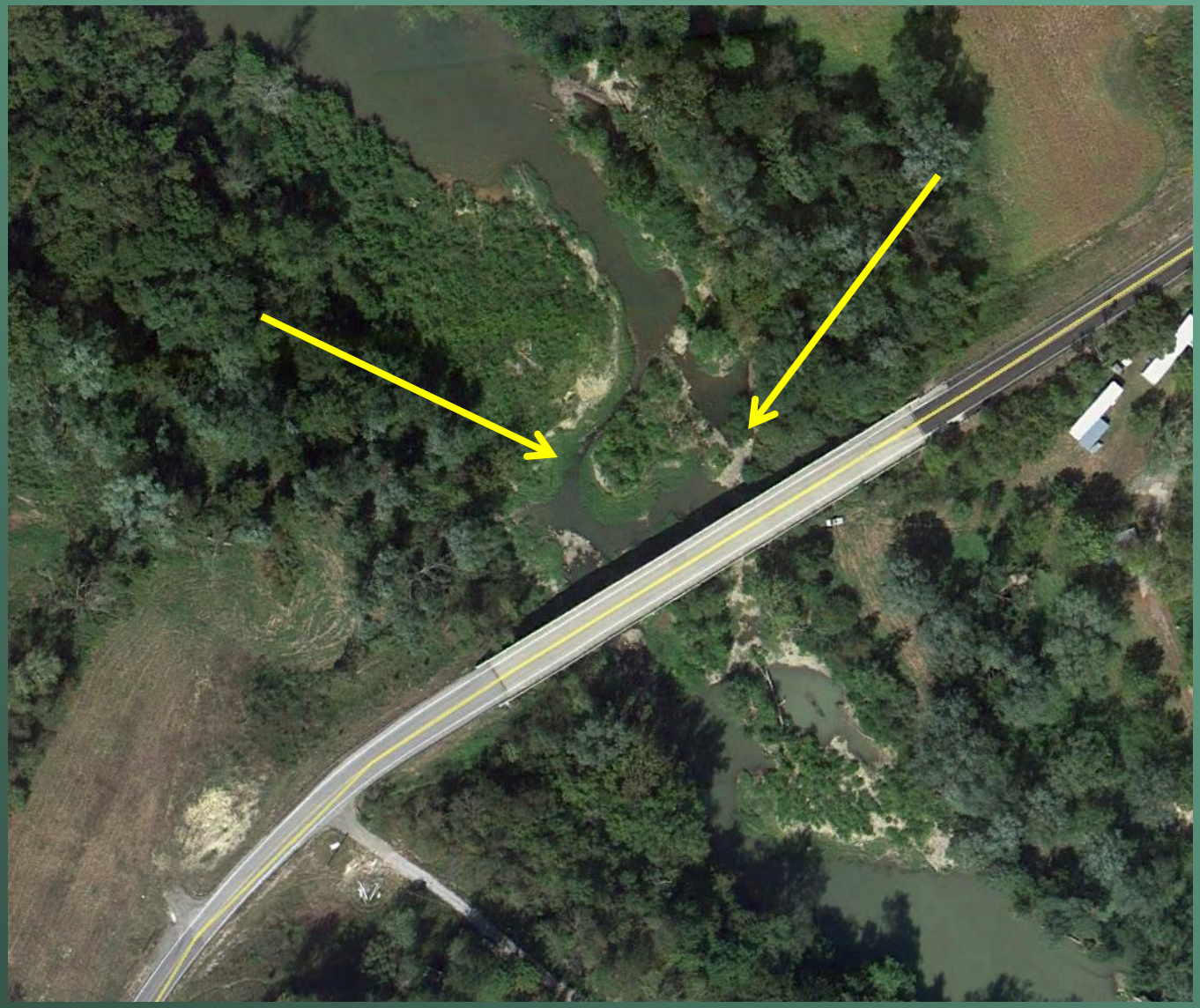

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High

Medium

Wading

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  - **Free from air entrainment**

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What is needed for an Stage/Discharge site?

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  - Able to measure discharge at all stages
  - Easily accessible for installation and O&M
  - Free from air entrainment

USGS

What is needed for an Stage/Discharge site?

- **Site Selection!!!!**
  - Site is relatively parallel and uniform
  - Near the region of max velocity, free from any boundary effects
  - Stream is straight for 2[illegible] or 5-10 channel widths
  - Located 5-10 channel widths US or DS of any tributary
  - Total flow is confined to 1 channel
  - Streambed is not subject to scour and fill
  - Ability to measure discharge at all stages
  - Easily accessible for installation and O&M
  - Free from air entrainment

Exactly the Same

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Instrumentation Selection

- **There are a few types of instruments that can provide velocity:**
  - **Acoustic Doppler Velocity Meters (ADVM) side looking**
    - **Acoustic current meters that use Doppler principle to measure water velocities in a 2-deminsional plane. Sidelooking is mounted so the beams profile out.**
  - **ADVM up looking**
    - **Same as above except up looking is mounted so the beams profile up.**
  - **Acoustic Velocity Meters (AVM)**
    - **Time of travel devices that measure water velocities along an acoustic path**

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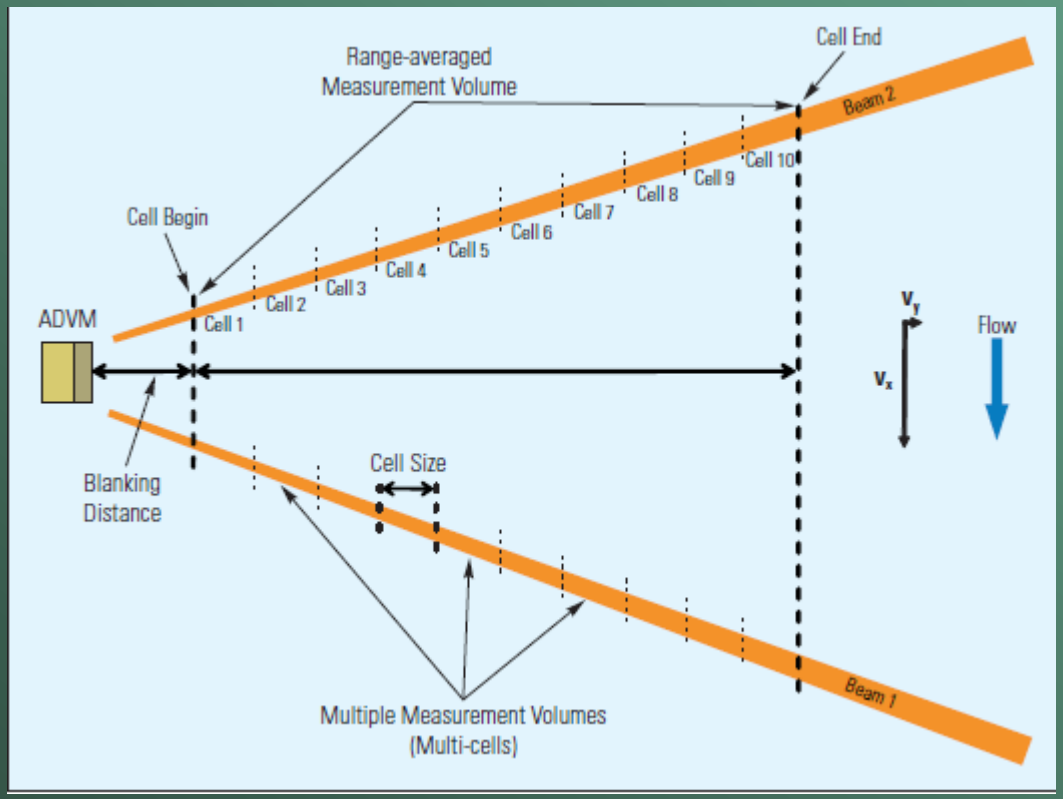
ADVM Side Looking



- Used primarily for larger rivers
- Sediment build-up areas
- Allows for a large or small sample area

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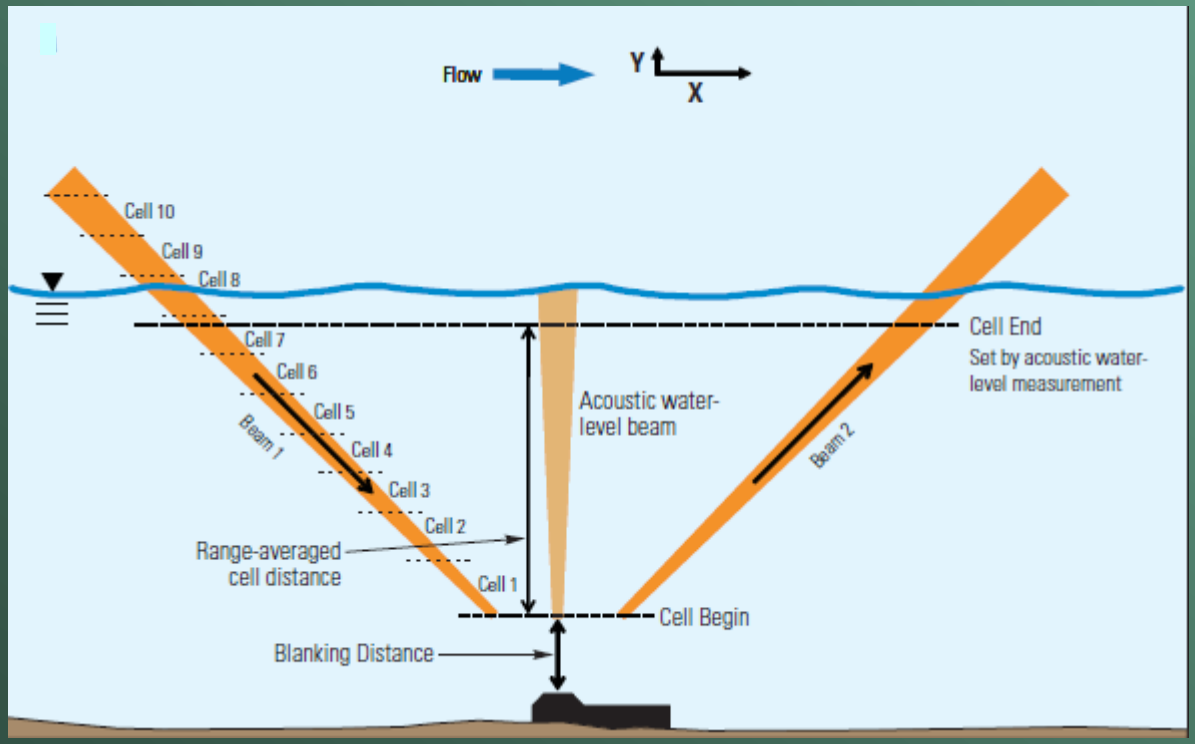
ADVM Up Looking

- Used primarily for smaller streams
- Cells are dynamic to change size on the fly
- Allows for a large or small sample area



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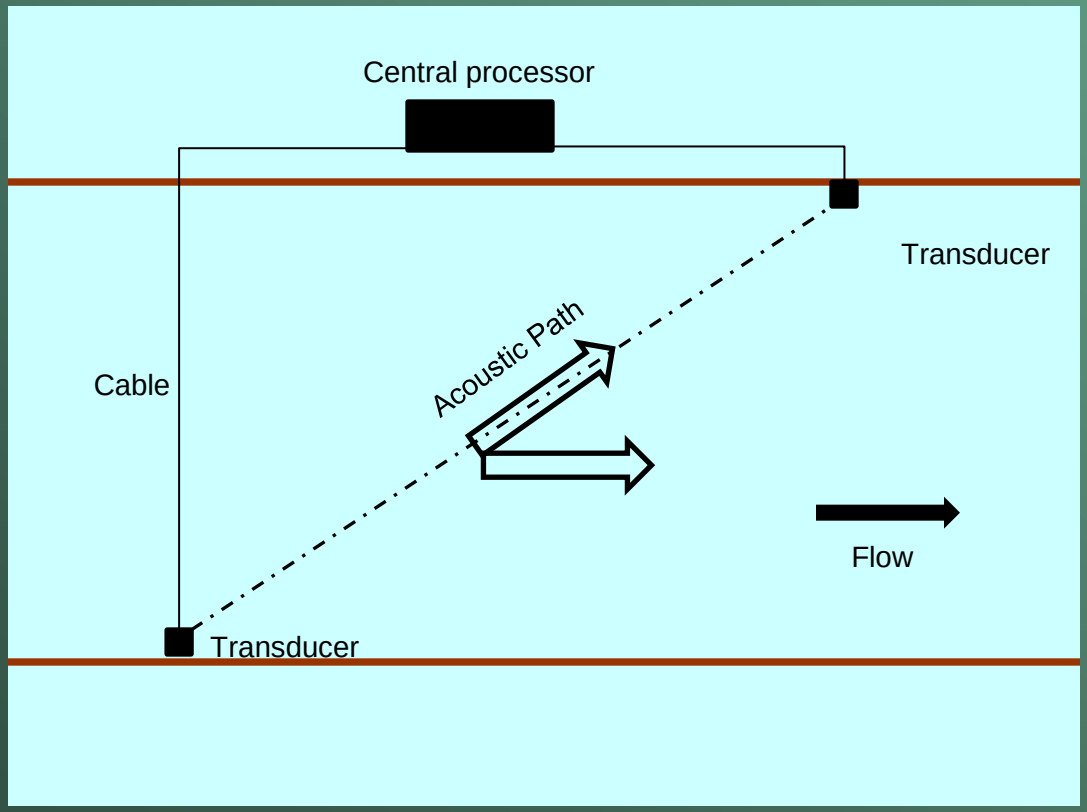
AVM



- Used primarily for smaller streams
- Time of travel devices that measure velocities along an acoustic path
- Allows for a large or small sample area, but only at one depth

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Installations ADVM side looking

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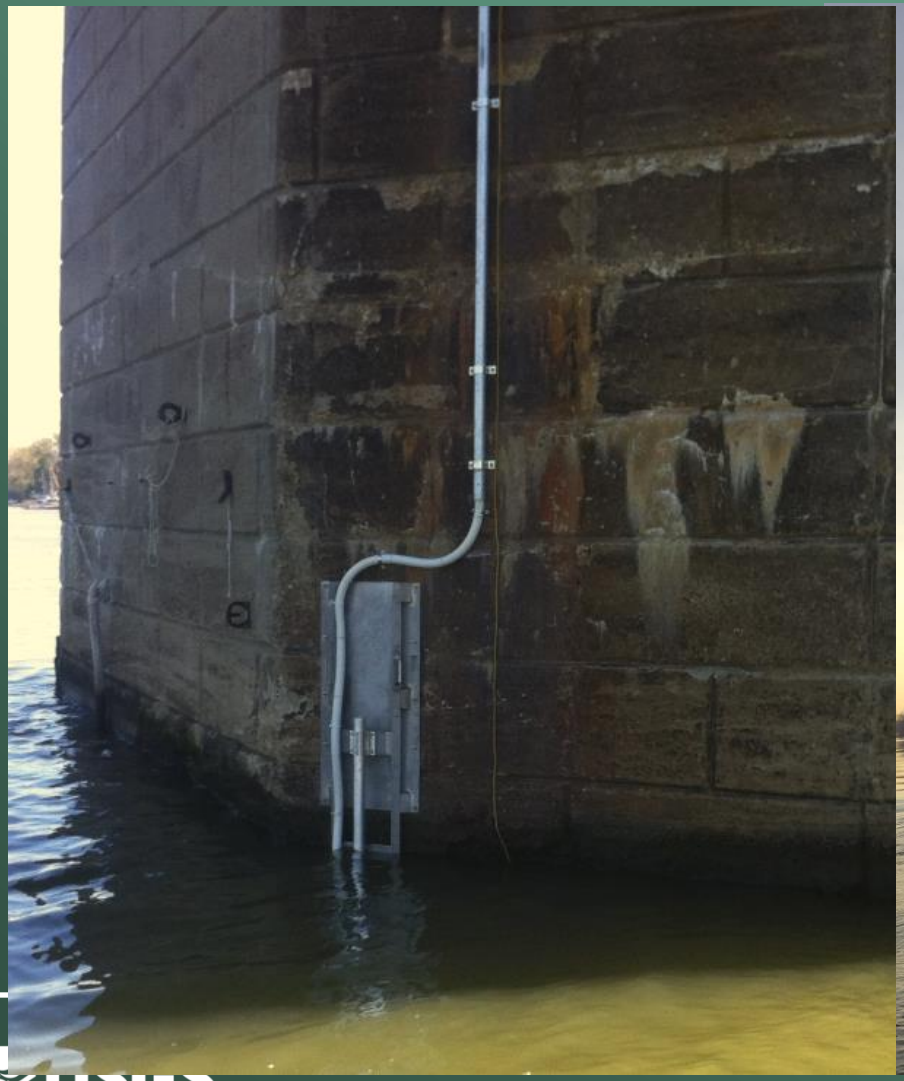
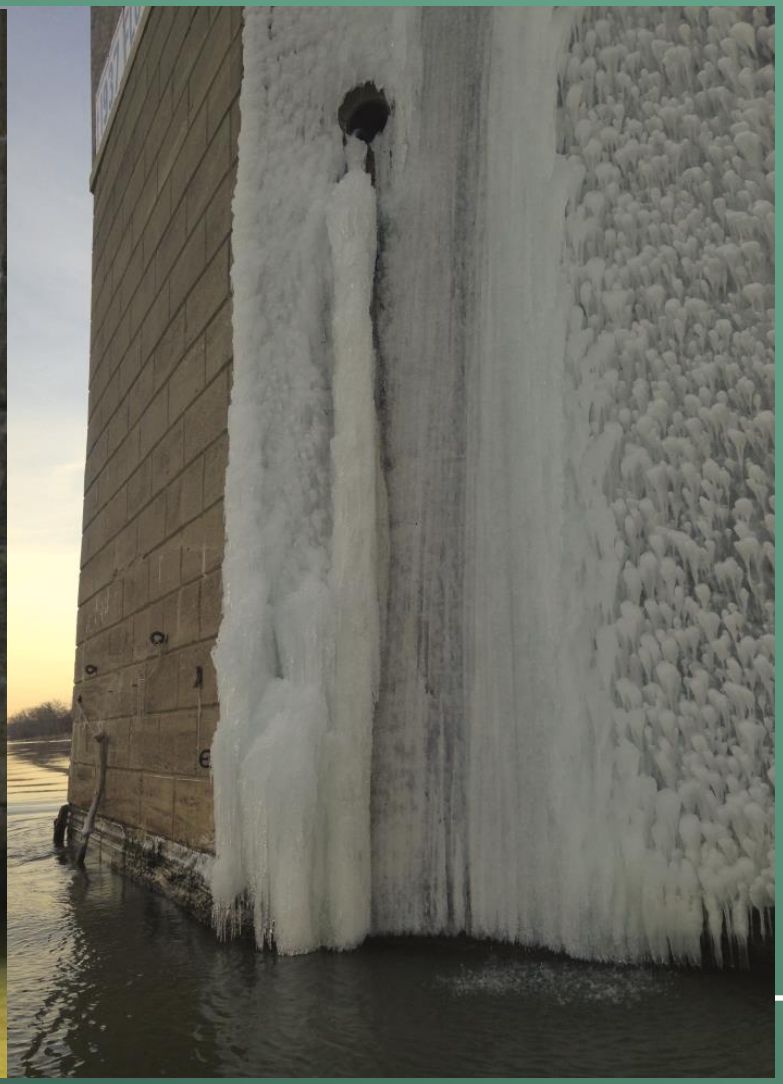
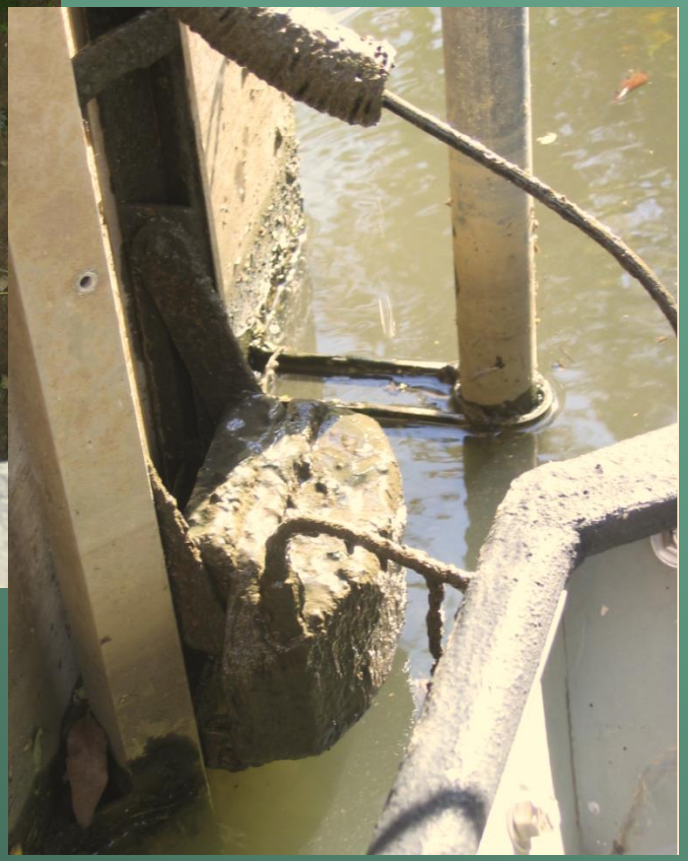




Installations ADVM side looking



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Installations ADVM up looking

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Rating development

Remember our equation to obtain discharge

$$Q = V \times A$$

Rating development

Well we have the “Velocity” installed

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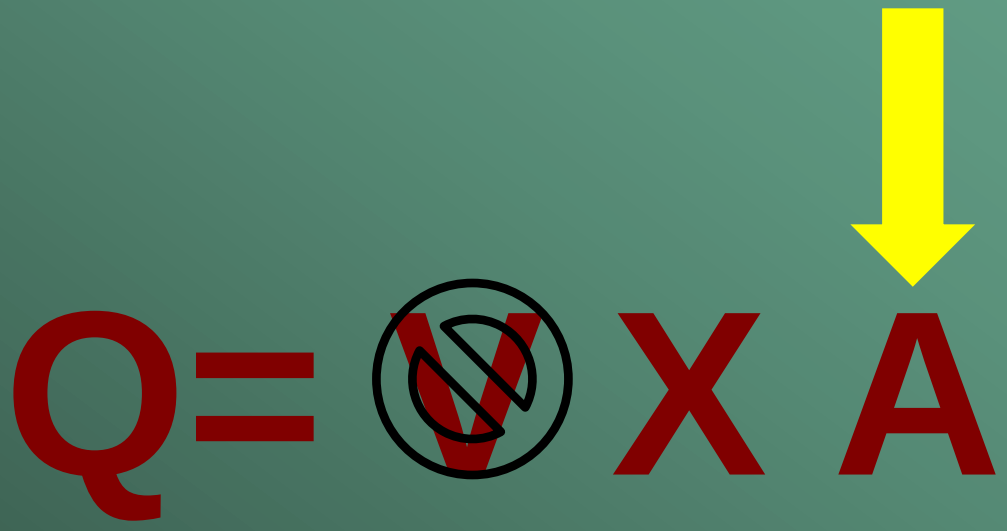
Rating development

How do we get the Area



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Development of Stage-Area Rating

1. Establish a standard cross section
2. Survey the standard cross section
3. Develop stage-area rating and
4. Validate stage-area rating

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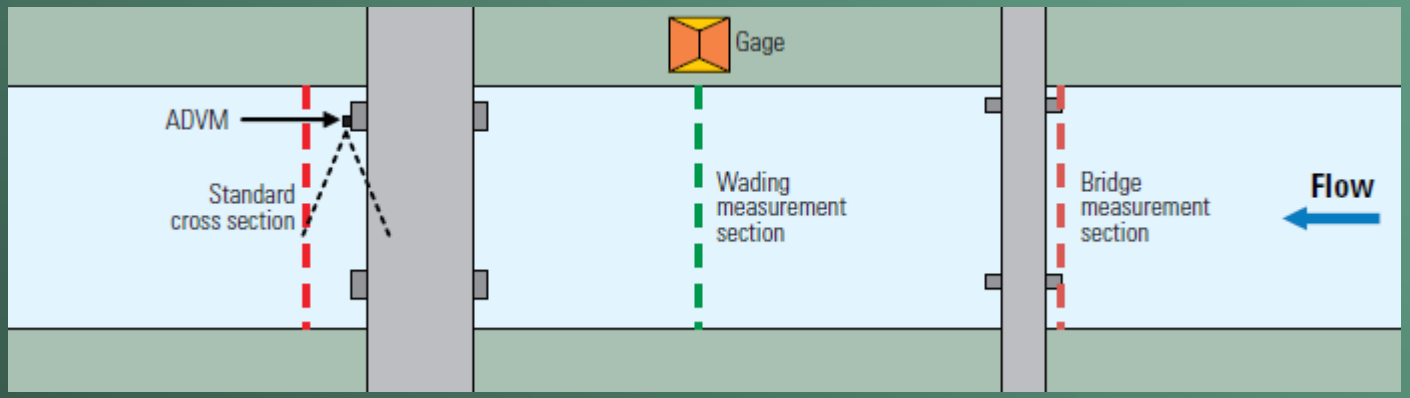
The standard cross section should be located as close to the ADVM as possible so that changes in the cross section can be monitored over time.



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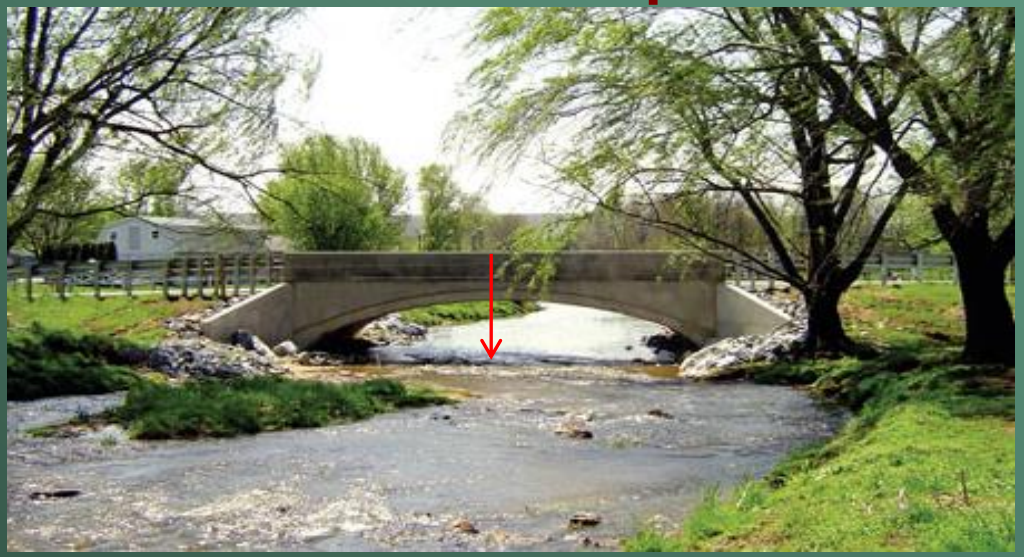
Survey the cross section

- Perpendicular to primary flow
- Survey consist of 2 values
  - Horizontal position
  - Elevation of that horizontal position



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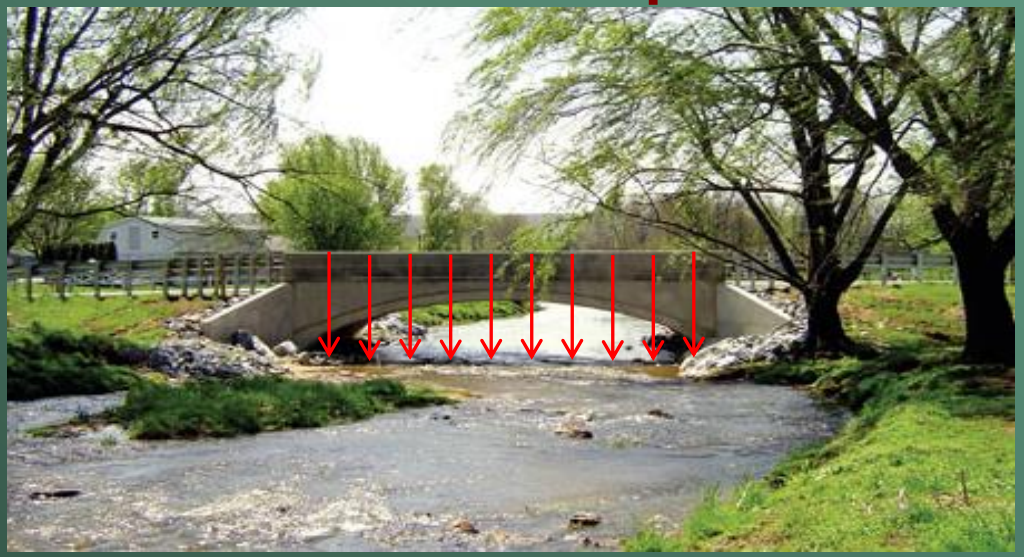

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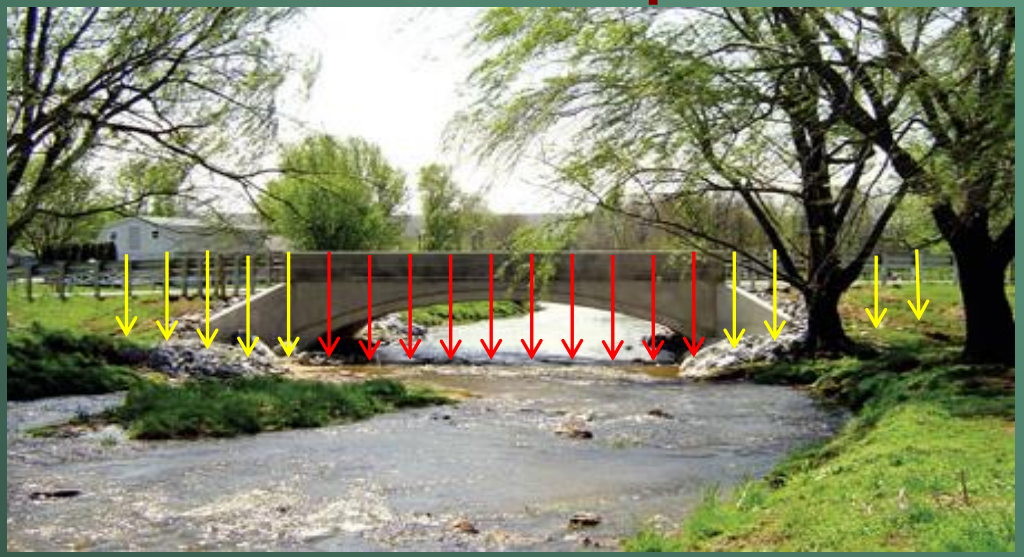

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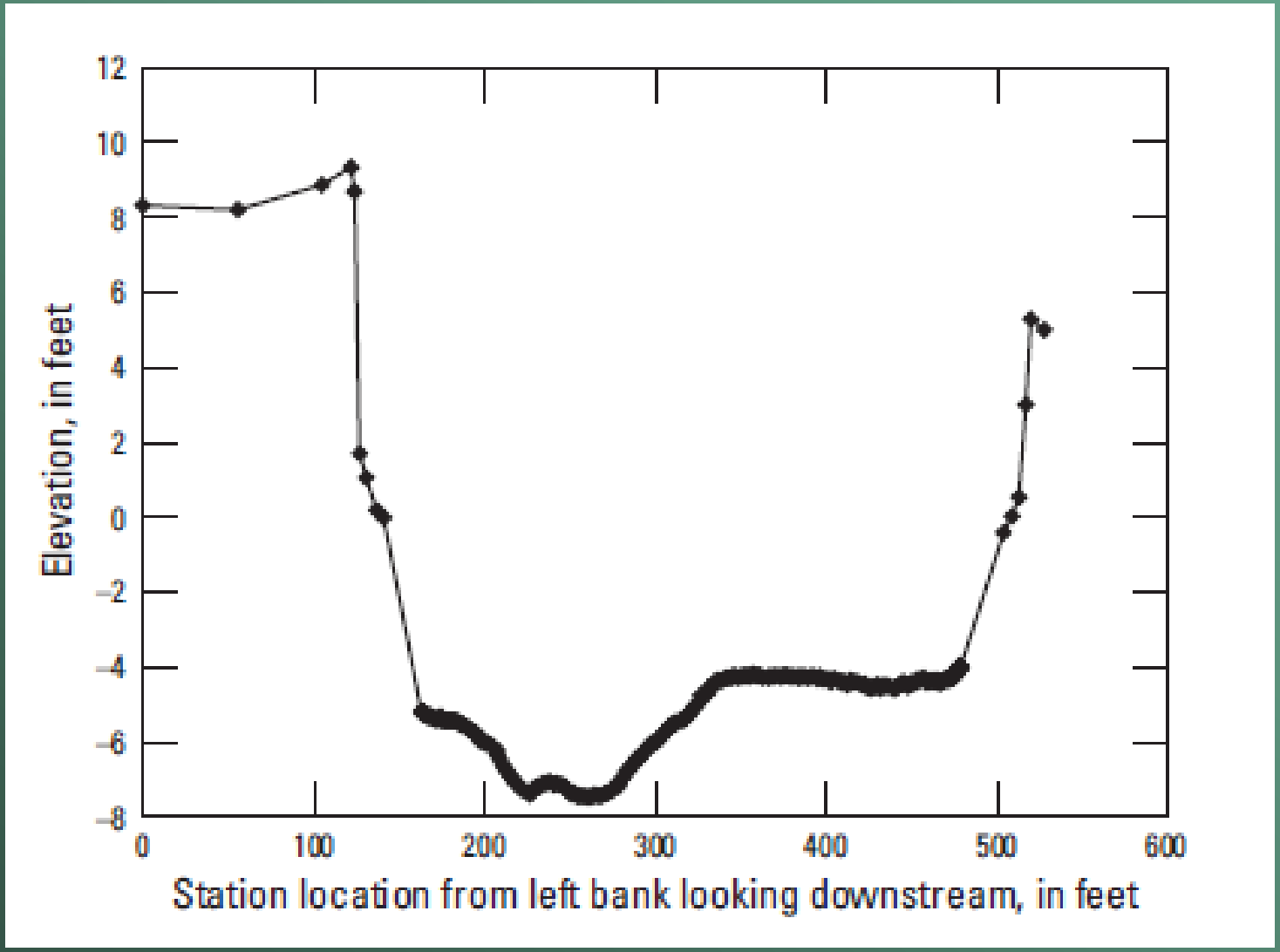
12
10
8
6
4
2
0
–2
–4
–6
–8
Elevation, in feet
0
100
200
300
400
500
600
Station location from left bank looking downstream, in feet

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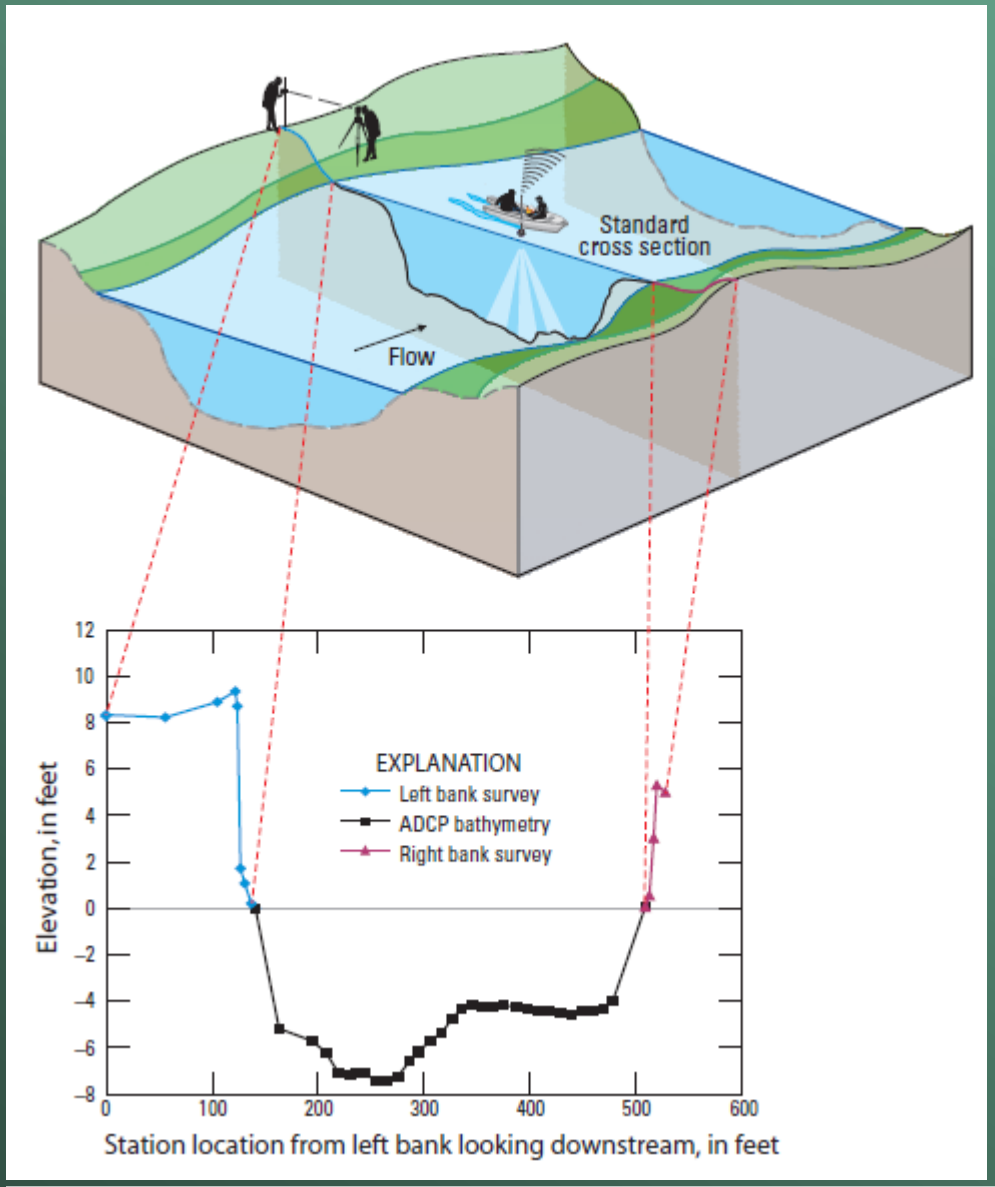

The use of an Acoustic Doppler Current Profiler (ADCP) and leveling equipment can be used for same results

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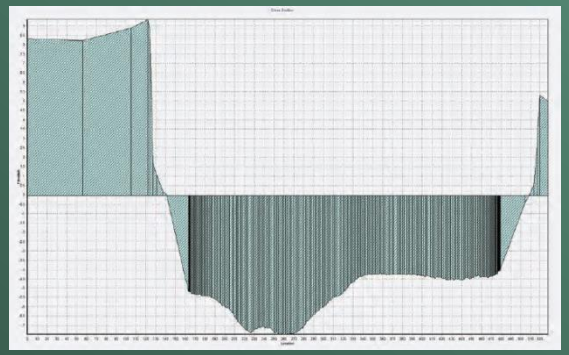
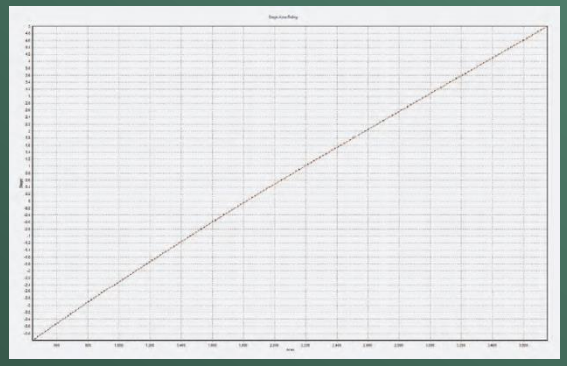
After collecting the cross section information:

- **Software is used to develop the rating and output in graphical and tabular format**





STAGE	AREA	STAGE	AREA	STAGE	AREA	STAGE	AREA
0	154.076	2.68	296.348	15.7	1494.137	27	3544.834
0.01	154.568	2.69	296.915	15.71	1495.653	27.01	3546.79
0.02	155.062	2.7	297.483	15.72	1497.168	27.02	3548.745
0.03	155.555	2.71	298.05	15.73	1498.685	27.03	3550.7
0.04	156.049	2.72	298.618	15.74	1500.201	27.04	3552.655
0.05	156.542	2.73	299.186	15.75	1501.718	27.05	3554.61
0.06	157.037	2.74	299.754	15.76	1503.236	27.06	3556.565
0.07	157.531	2.75	300.323	15.77	1504.754	27.07	3558.521
0.08	158.026	2.76	300.892	15.78	1506.272	27.08	3560.476
0.09	158.521	2.77	301.461	15.79	1507.791	27.09	3562.431
0.1	159.017	2.78	302.03	15.8	1509.31	27.1	3564.386
0.11	159.512	2.79	302.6	15.81	1510.83	27.11	3566.341
0.12	160.008	2.8	303.17	15.82	1512.35	27.12	3568.297
0.13	160.505	2.81	303.74	15.83	1513.871	27.13	3570.252
0.14	161.001	2.82	304.31	15.84	1515.392	27.14	3572.207
0.15	161.498	2.83	304.881	15.85	1516.914	27.15	3574.162
0.16	161.995	2.84	305.452	15.86	1518.436	27.16	3576.118
0.17	162.493	2.85	306.023	15.87	1519.959	27.17	3578.073
0.18	162.991	2.86	306.595	15.88	1521.482	27.18	3580.028
0.19	163.489	2.87	307.166	15.89	1523.005	27.19	3581.984
0.2	163.987	2.88	307.738	15.9	1524.529	27.2	3583.939
0.21	164.486	2.89	308.31	15.91	1526.054	27.21	3585.894
0.22	164.985	2.9	308.883	15.92	1527.578	27.22	3587.85
0.23	165.484	2.91	309.456	15.93	1529.104	27.23	3589.805
0.24	165.984	2.92	310.029	15.94	1530.629	27.24	3591.761
0.25	166.484	2.93	310.602	15.95	1532.156	27.25	3593.716
0.26	166.984	2.94	311.176	15.96	1533.682	27.26	3595.671
0.27	167.485	2.95	311.749	15.97	1535.21	27.27	3597.627
0.28	167.985	2.96	312.324	15.98	1536.737	27.28	3599.582
0.29	168.486	2.97	312.898	15.99	1538.265	27.29	3601.538
0.3	168.988	2.98	313.473	16	1539.794	27.3	3603.493
0.31	169.49	2.99	314.047	16.01	1541.323	27.31	3605.449
0.32	169.992	3	314.623	16.02	1542.852	27.32	3607.404
0.33	170.494	3.01	315.198	16.03	1544.382	27.33	3609.36
0.34	170.996	3.02	315.774	16.04	1545.912	27.34	3611.315
0.35	171.499	3.03	316.35	16.05	1547.443	27.35	3613.271
0.36	172.002	3.04	316.926	16.06	1548.974	27.36	3615.226
0.37	172.506	3.05	317.502	16.07	1550.506	27.37	3617.182
0.38	173.01	3.06	318.079	16.08	1552.038	27.38	3619.137

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Rating development

Now we have both

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Rating development

- **Data Collection**
  - **Discharge Measurements**
  - **Information from Gage**
  - **Data from ADVM**

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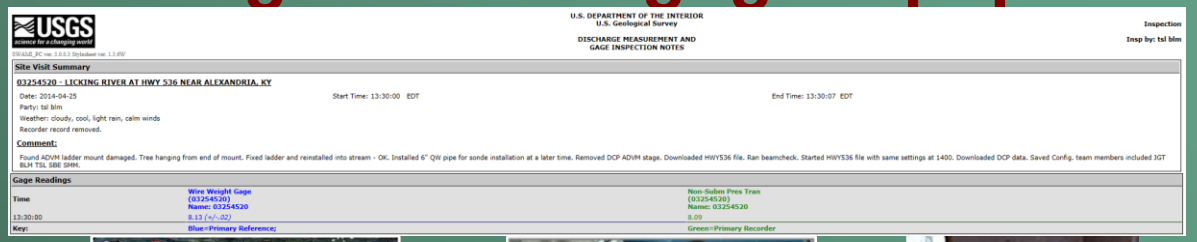
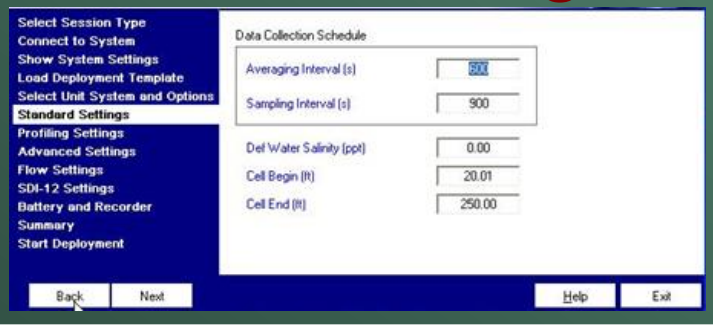
Arrive at the site

- Collect readings from all gage equipment



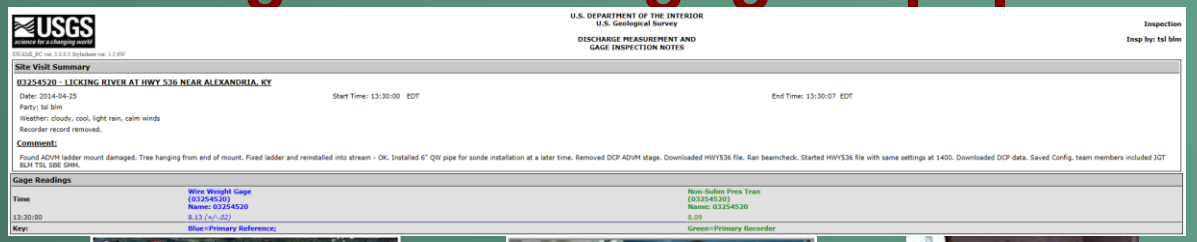
- Set ADVM to log every minute



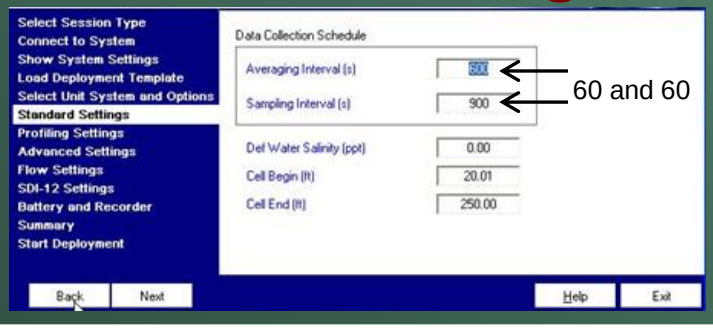
USGS

Arrive at the site

- **Collect readings from all gage equipment**



- **Set ADVM to log every minute**



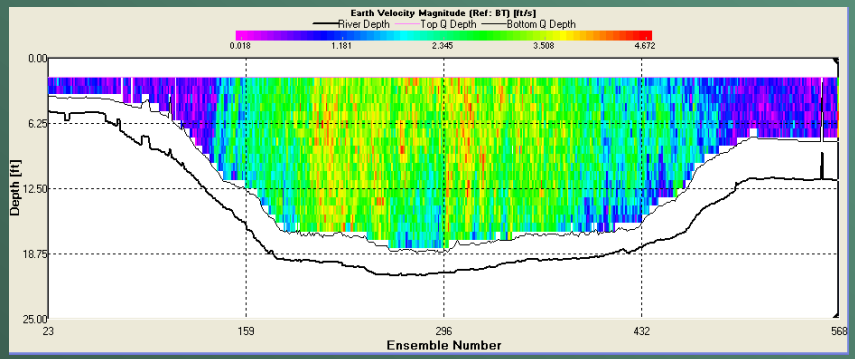
USGS

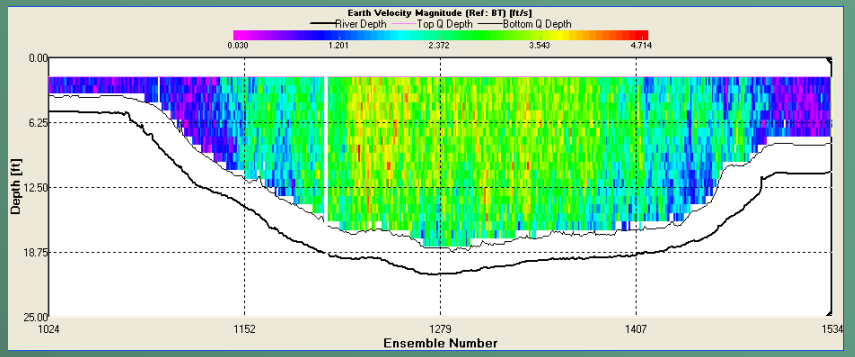
Start measurement

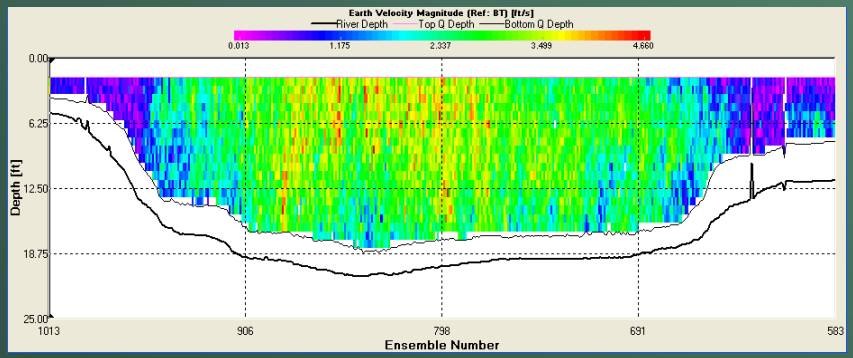
- **Begin the measurement at the beginning of a minute and measure for 12 minutes**

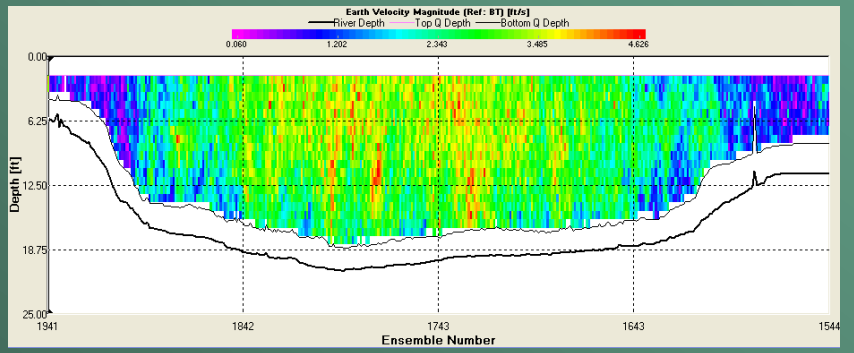
USGS

Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s
licking536_051408000	Left	546	16:24:52	8476.004
licking536_051408001	Right	431	16:28:59	8494.120
licking536_051408002	Left	509	16:32:16	8712.235
licking536_051408003	Right	398	16:36:06	8570.724
Average		471		8563.271
Std Dev.		68		107.461
Std./| Avg.|		0.14		0.01









USGS

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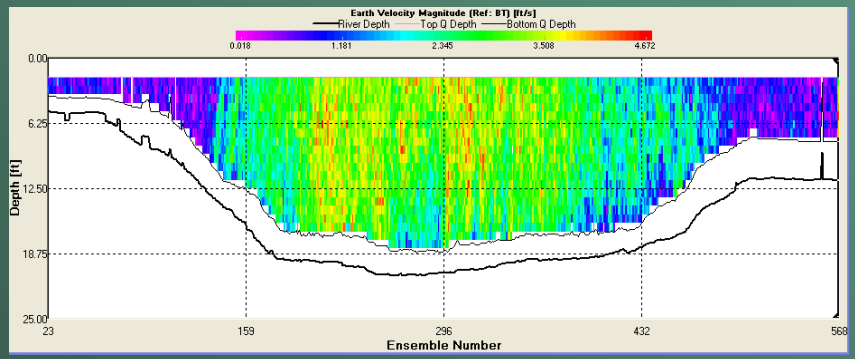

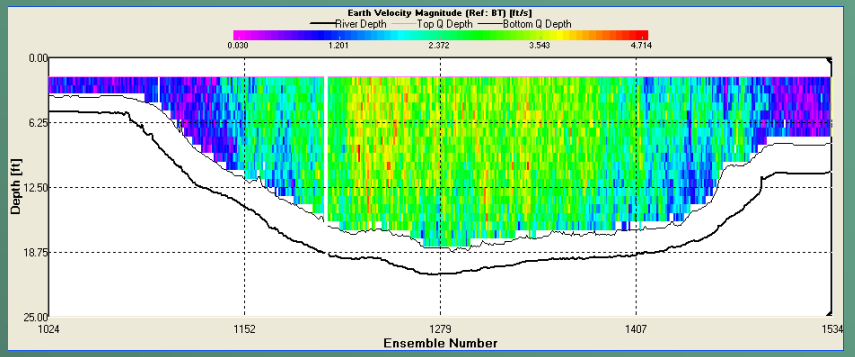

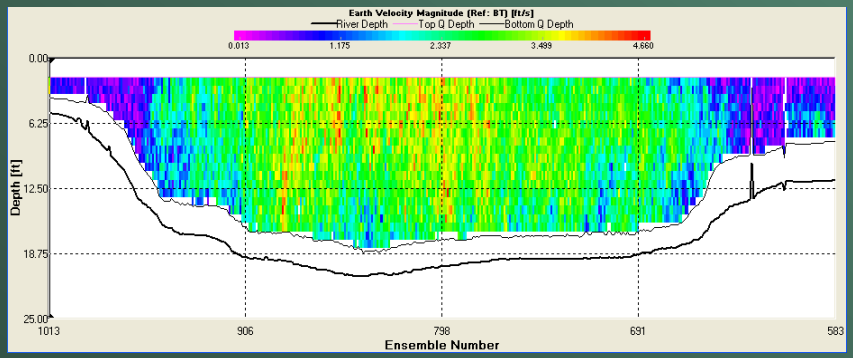

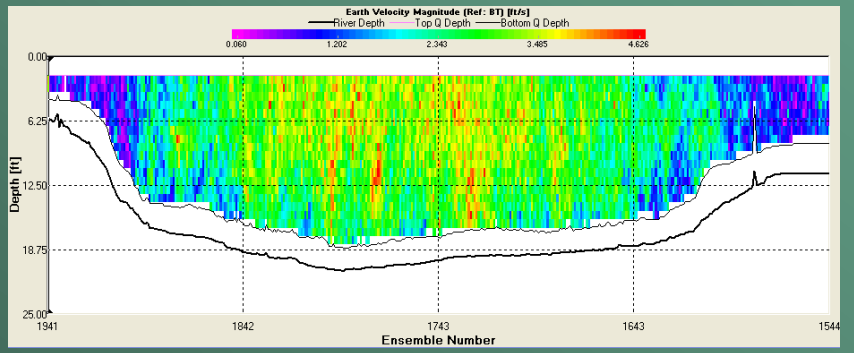

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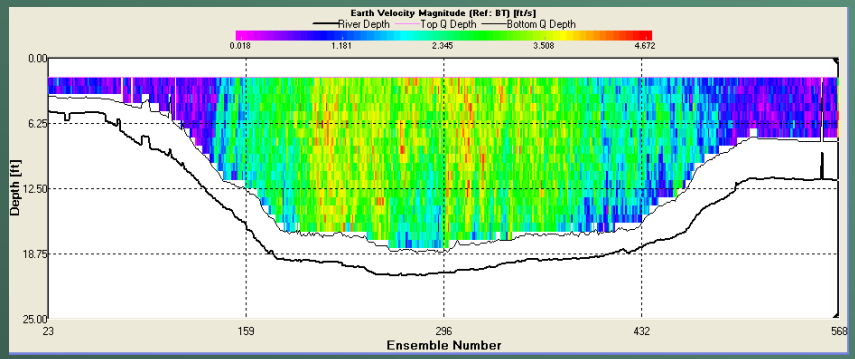

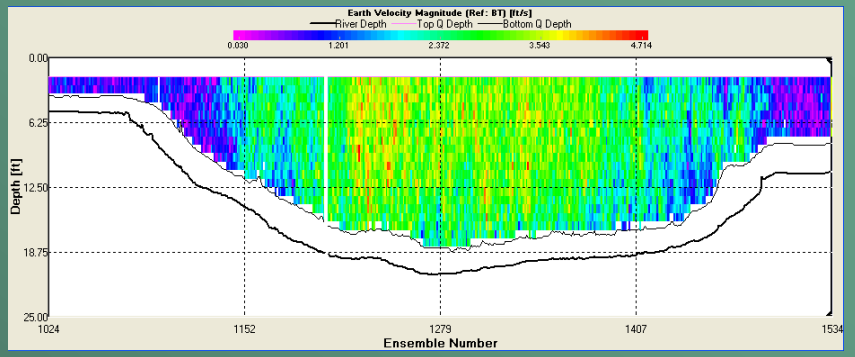

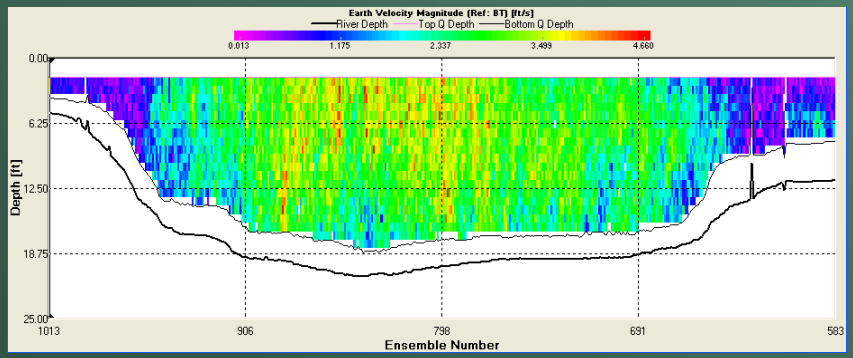

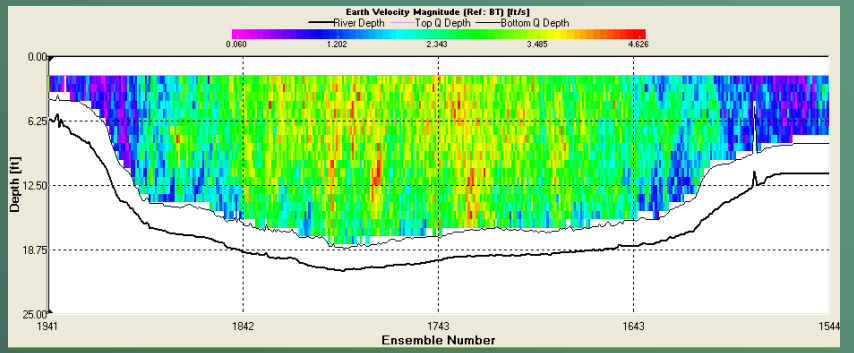

USGS

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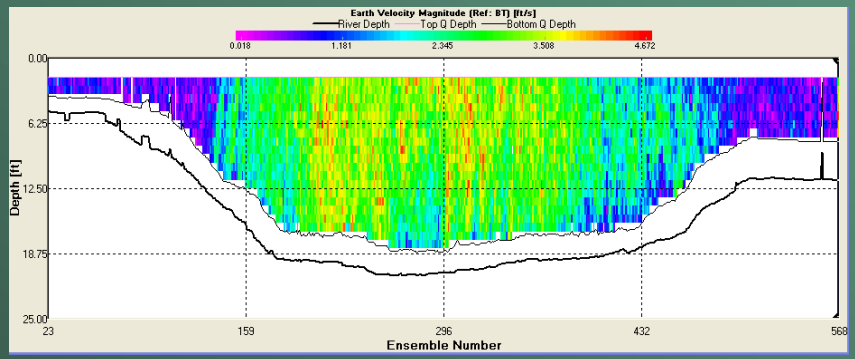
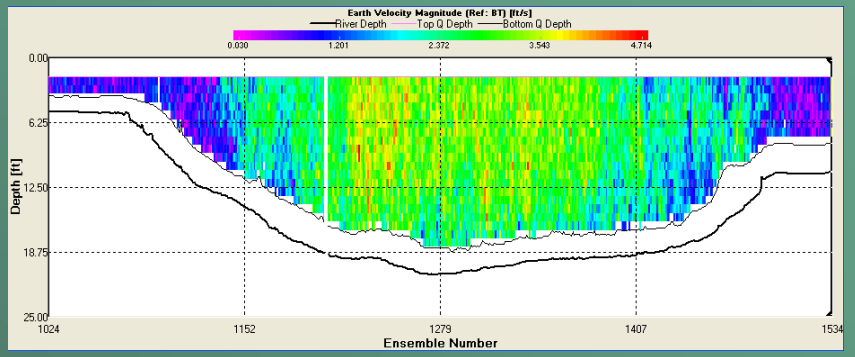
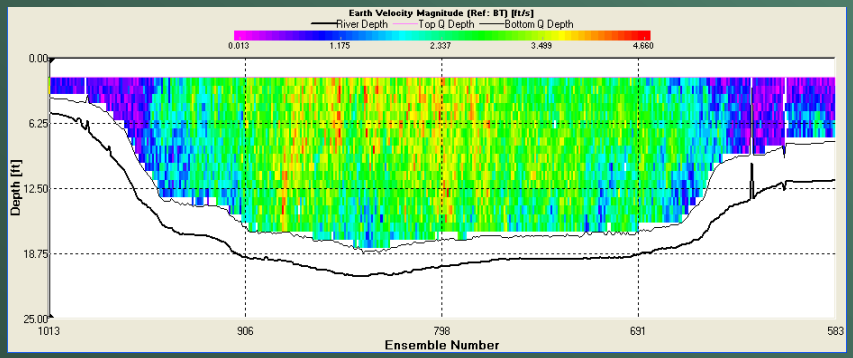
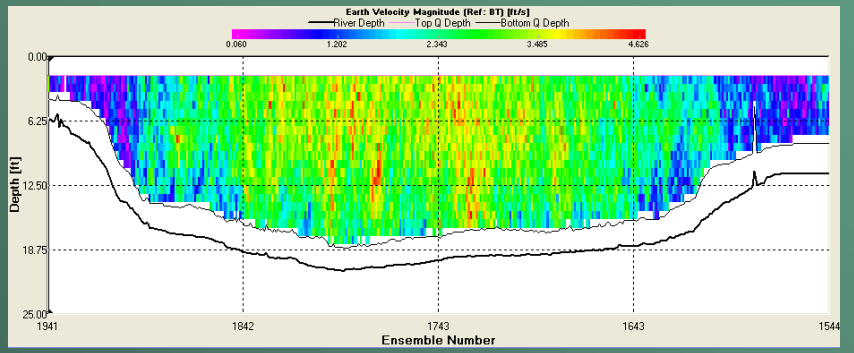








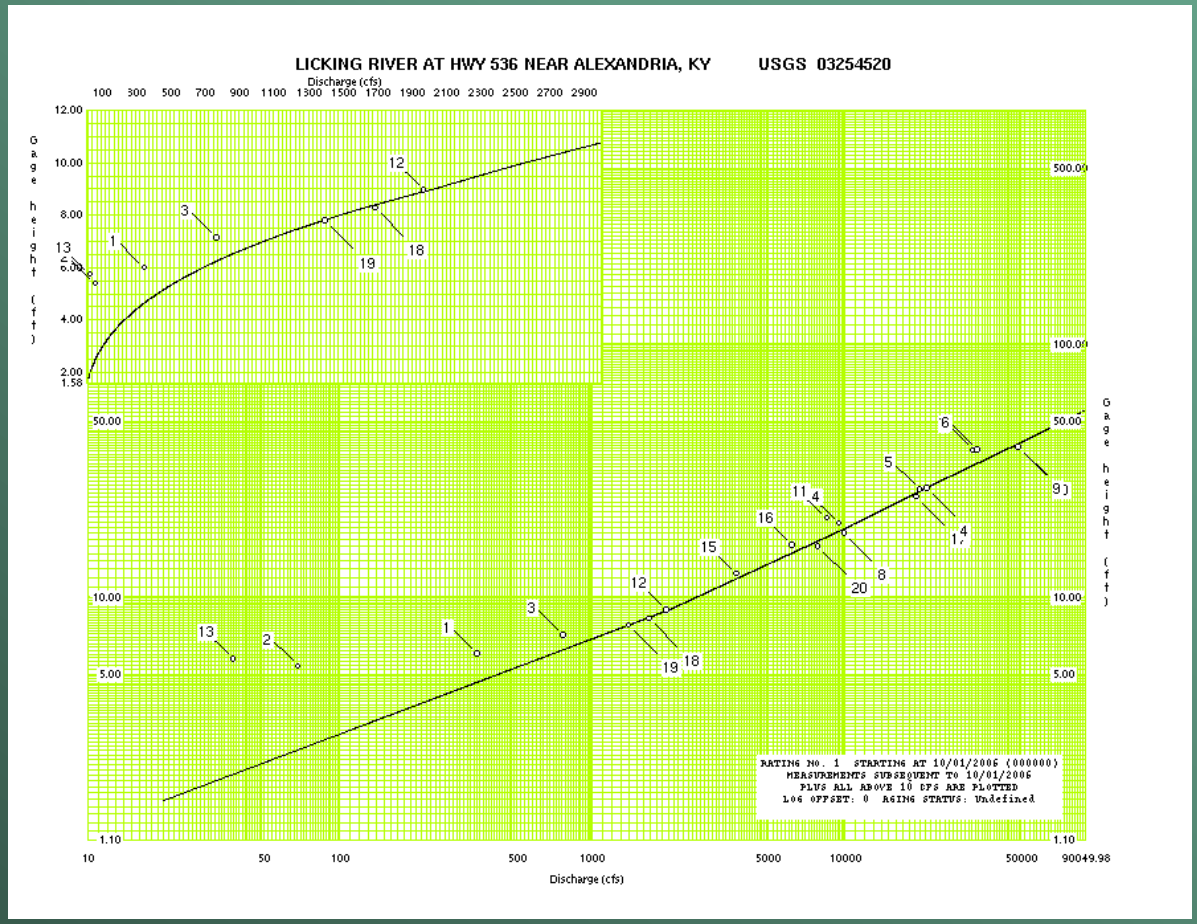
USGS

After measurement

- Retrieve data from ADVM
- Collect a final set of gage readings
- Scribe the discharge with other measurements made at the site
- After enough measurements are made, a rating can be established

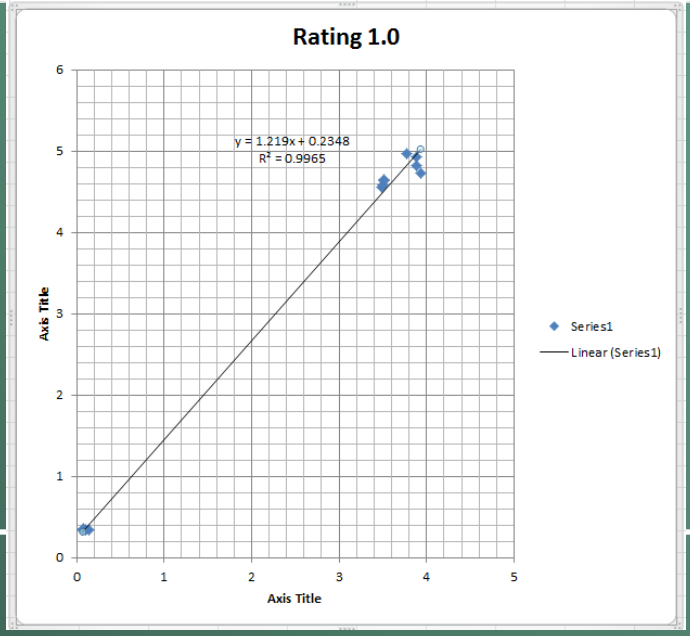
USGS

With a stage/discharge relationship a logarithmic curve can be used:



Index/velocity uses a liner line to calculate discharge:

QM #	DATE	TIME	STAGE	DISCHARGE	AREA	SL1500 VELOCITY	MEAN VELOCITY	SL1500 VELOCITY	STAGE*VELOCITY
22	8/12/2010	1315-1325	5.9	209	605.7	0.07	0.345055308	0.07	0.413
23	8/12/2010	1330-1340	5.9	213	605.7	0.08	0.351659237	0.08	0.472
24	8/12/2010	1345-1355	5.93	208	610	0.14	0.340983607	0.14	0.8302
25	8/12/2010	1400-1410	5.9	206	605.7	0.11	0.340102361	0.11	0.649
30	2/2/2011	1015-1025	21.73	16504	3627	3.49	4.550317066	3.49	75.8377
31	2/2/2011	1030-1040	21.87	16755	3660.4	3.5	4.577331079	3.5	76.545
32	2/2/2011	1045-1055	22.01	17159	3693.9	3.51	4.645263639	3.51	77.2551
33	2/2/2011	1100-1010	22.15	17297	3727.4	3.51	4.64052498	3.51	77.7465
34	2/25/2011	1645-1655	37.49	40000	8458.8	3.93	4.72880314	3.93	147.3357
35	2/25/2011	1700-1710	37.56	42200	8487	3.77	4.972328169	3.77	141.6012
36	2/25/2011	1715-1725	37.65	41100	8523.3	3.89	4.822092929	3.89	146.4585
37	2/25/2011	1730-1740	37.71	42100	8547.5	3.88	4.925405264	3.88	146.3148



USGS

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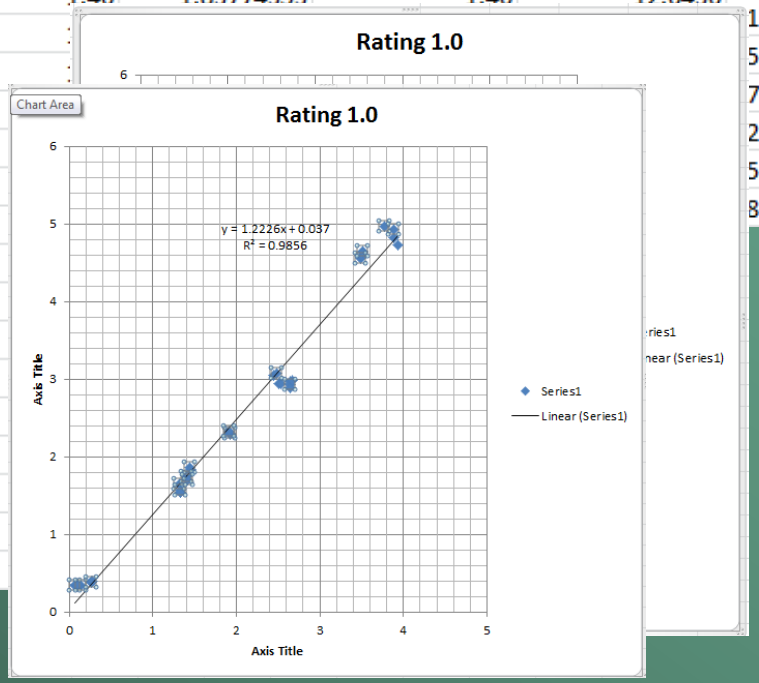
25	8/12/2010	1400-1410	5.9	206	605.7	0.11	0.340102361	0.11	0.649
42	7/28/2011	1045-1055	8.68	1924	1034.9	1.44	1.859098859	1.44	12.4992
43	7/28/2011	1100-1110	8.66	1896	1031.7	1.46	1.83774353	1.46	12.6436
44	7/28/2011	1145-1155	8.63	1792	1026.9				
45	7/28/2011	1200-1210	8.62	1818	1025.3				
46	7/28/2011	1215-1225	8.61	1746	1023.7				
47	10/12/2011	845-855	5.9	235	605.7				
48	10/12/2011	900-910	5.89	239	604.3				
49	10/12/2011	915-925	5.88	231	602.9				
50	10/12/2011	930-940	5.87	236	601.4				
51	1/10/2012	1100-1110	9.16	1830	1112.4				
52	1/10/2012	1115-1125	9.16	1720	1112.4				
53	1/10/2012	1130-1140	9.15	1740	1110.8				
54	1/10/2012	1145-1155	9.15	1710	1110.8				
55	3/27/2012	1600-1610	13.27	4204	1818.1				
56	3/27/2012	1615-1625	13.26	4174	1816.3				
57	3/27/2012	1630-1640	13.25	4160	1814.4				
58	3/27/2012	1645-1655	13.25	4225	1814.4				



USGS

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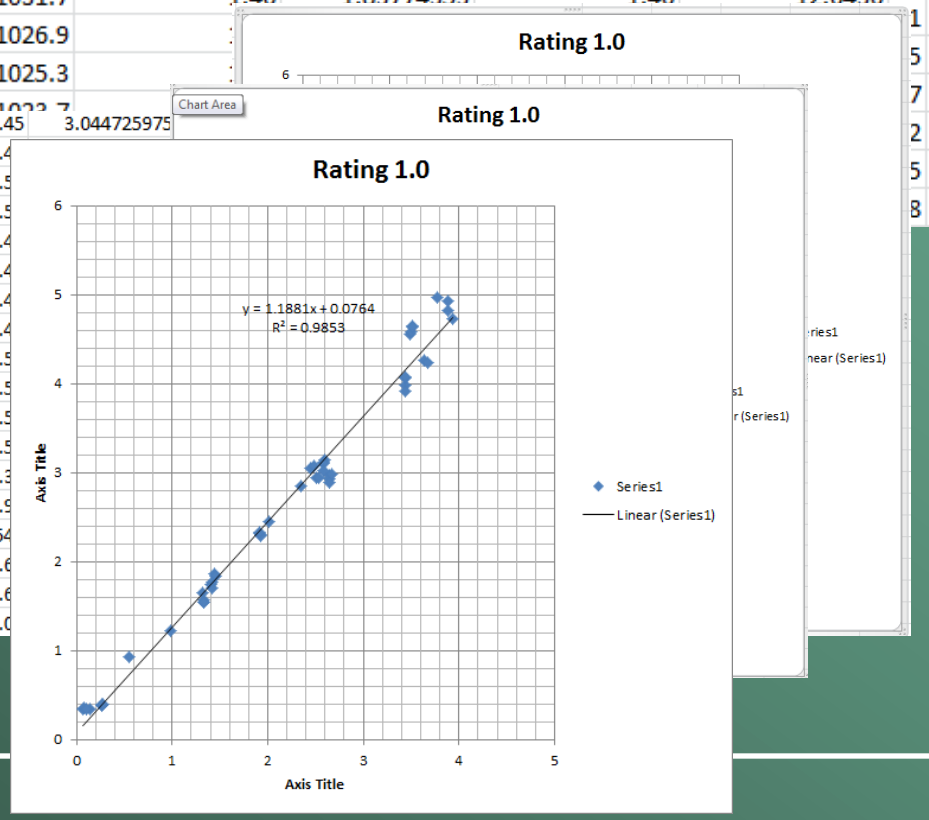
43	7/28/2011	1100-1110	8.66	1896	1031.7	1.46	1.83774353	1.46	12.6436
44	7/28/2011	1145-1155	8.63	1792	1026.9				
45	7/28/2011	1200-1210	8.62	1818	1025.3				
59	5/8/2012	1300-1310	19.66	9570	3143.1	2.45	3.044725975		
60	5/8/2012	1315-1325	19.66	9650	3143.1	2.4			
61	5/8/2012	1330-1340	19.68	9282	3147.7	2.5			
62	5/8/2012	1345-1355	19.71	9293	3154.6	2.5			
63	1/31/2013	815-825	22.19	14900	3737	3.4			
64	1/31/2013	830-840	22.22	15200	3744.2	3.4			
65	1/31/2013	845-855	22.25	14700	3751.4	3.4			
66	1/31/2013	900-910	22.28	15300	3758.6	3.4			
67	4/30/2013	800-810	14.64	6528	2081.4	2.5			
68	4/30/2013	815-825	14.6	6466	2073.6	2.5			
69	4/30/2013	830-840	14.56	6419	2065.8	2.5			
70	4/30/2013	915-925	14.45	6170	2044.3	2.5			
71	7/18/2013	1045	12.24	4647	1631.1	2.3			
72	8/20/2013	1100	7.82	1098	898	0.9			
73	10/29/2013	1145	6.7	672	724.1	0.54			
74	11/18/2013	1000	22.4	16155	3787.4	3.6			
75	11/18/2013	1100	22.4	16055	3787.4	3.6			
76	2/28/2014	1000	18.88	7280	2966.4	2.0			



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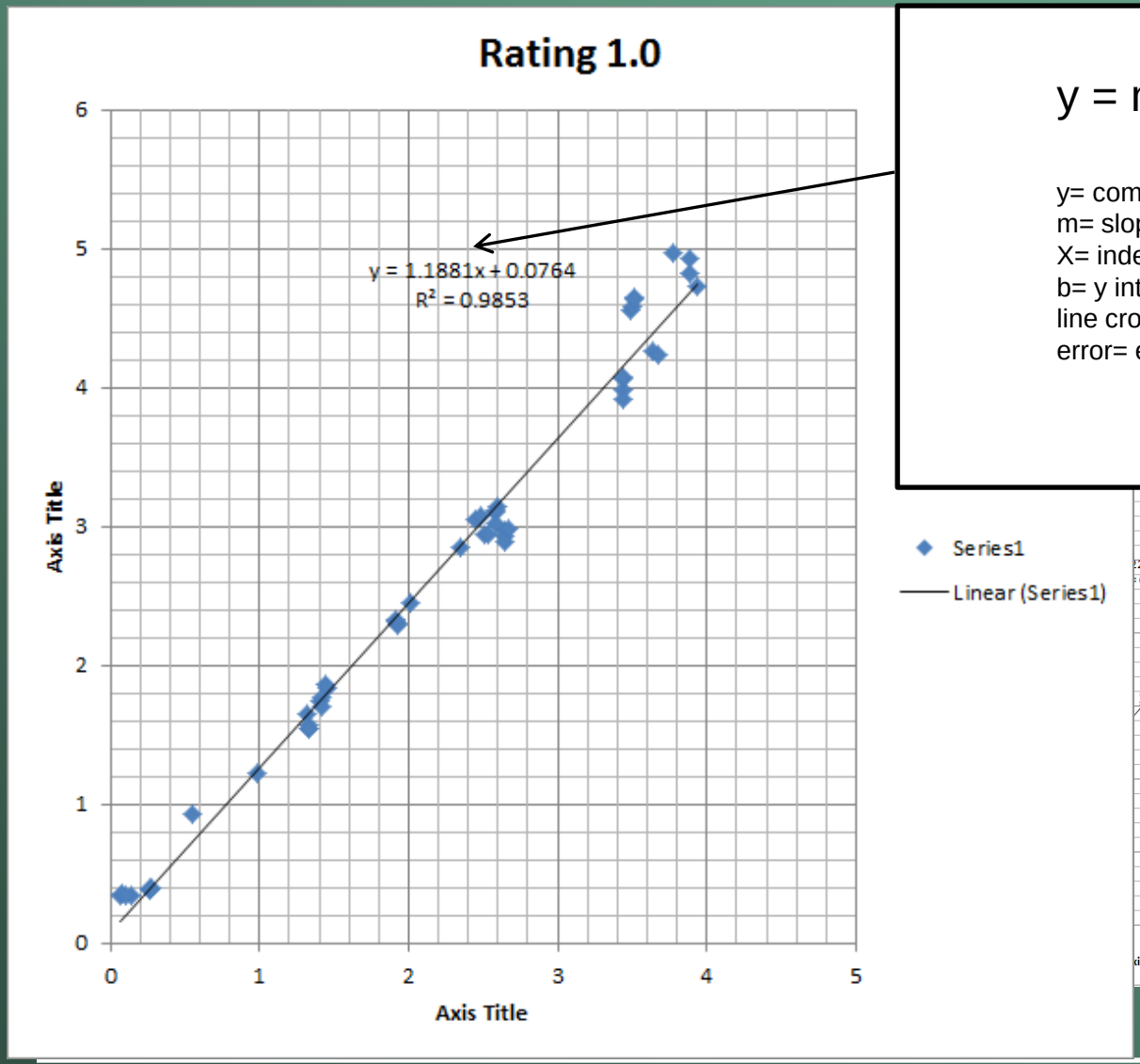


$$y = mX + b + error$$

y= computed mean velocity
m= slope of line
X= index velocity
b= y intercept (where the regression line crosses the y=axis when x=0)
error= error around regression line

Is the Rating Complete?

- **No we still need to make sure that the rating is statistically valid, through regression**

Regression statistics	
Multiple R	0.997162
R-square	0.994332
Adjusted R-square	0.994242
Standard error	0.048462
Observations	65

ANOVA

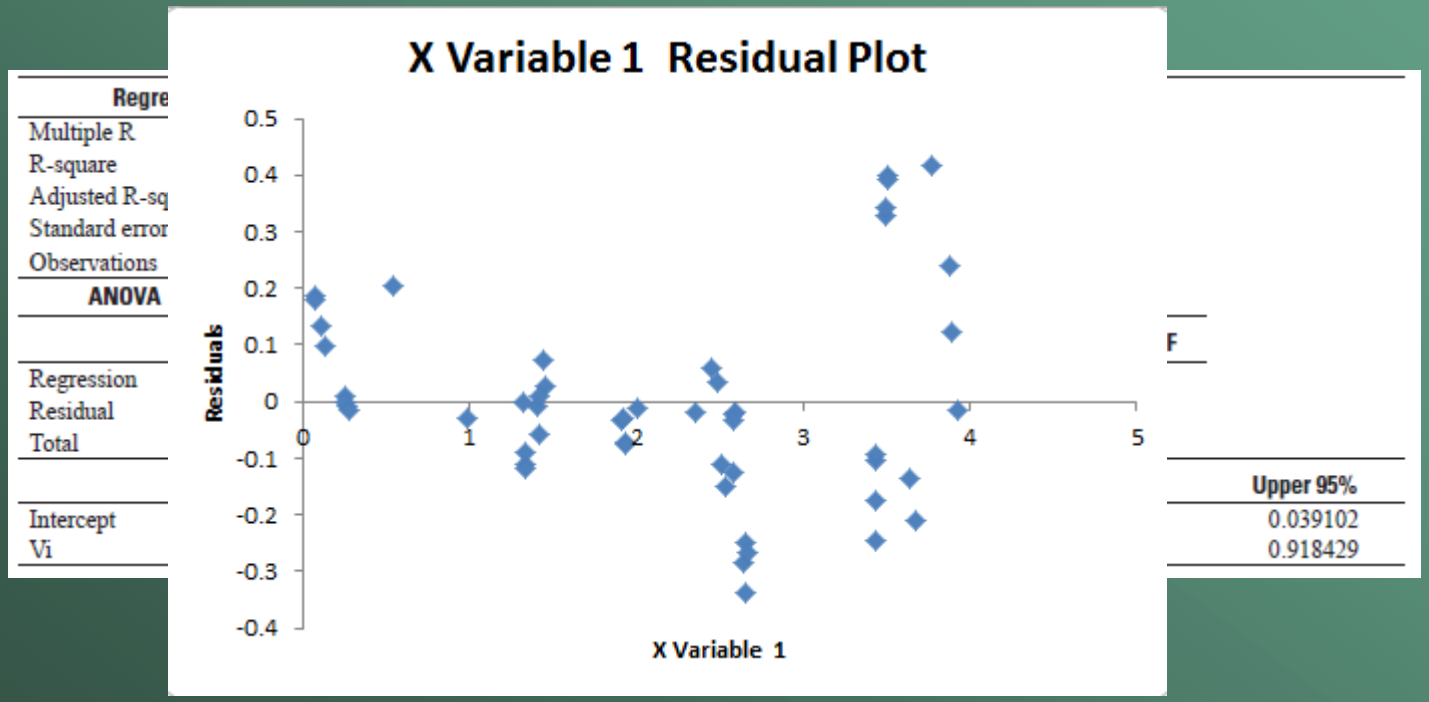
	df	SS	MS	F	Significance F
Regression	1	25.95845	25.95845	11052.69	1.71E-72
Residual	63	0.147962	0.002349		
Total	64	26.10641			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.01768	0.01072	1.649276	0.104069	–0.00374	0.039102
Vi	0.901298	0.008573	105.1318	1.71E-72	0.884166	0.918429

USGS

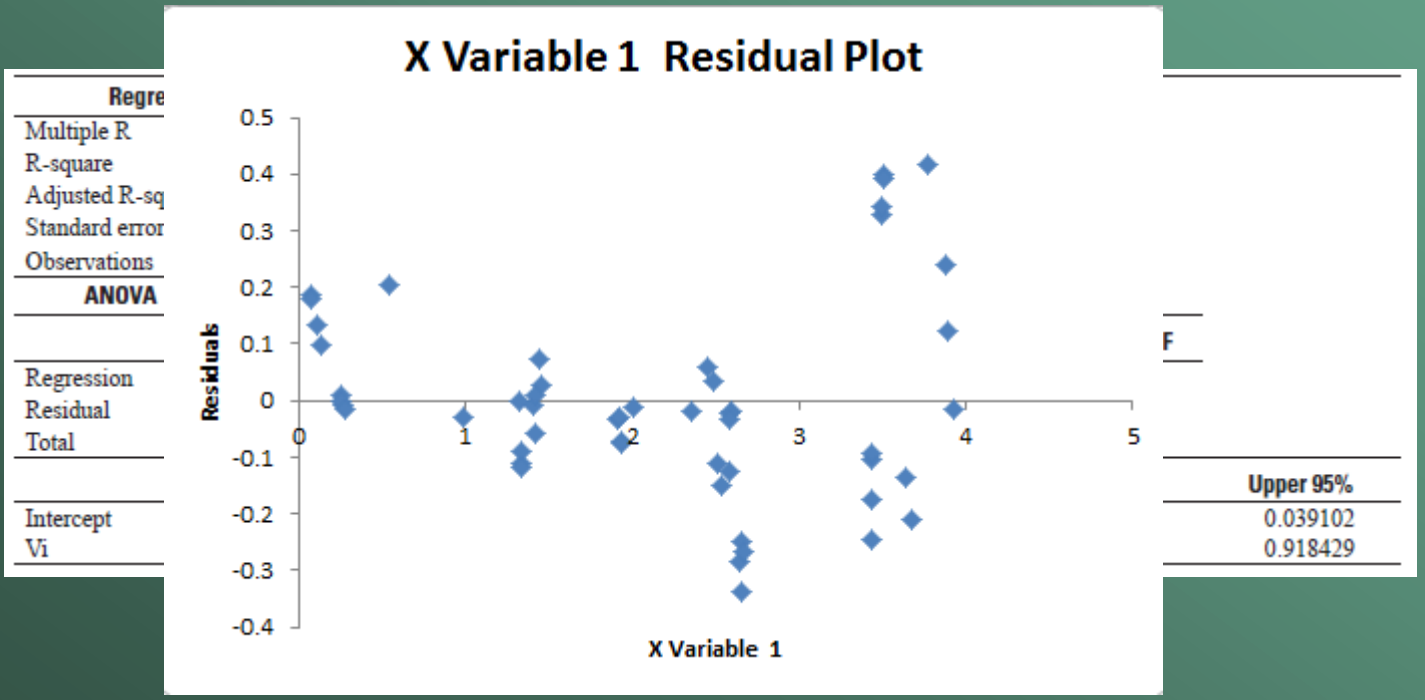
Is the Rating Complete?

- **No we still need to make sure that the rating is statistically valid, through regression**



Is the Rating Complete?

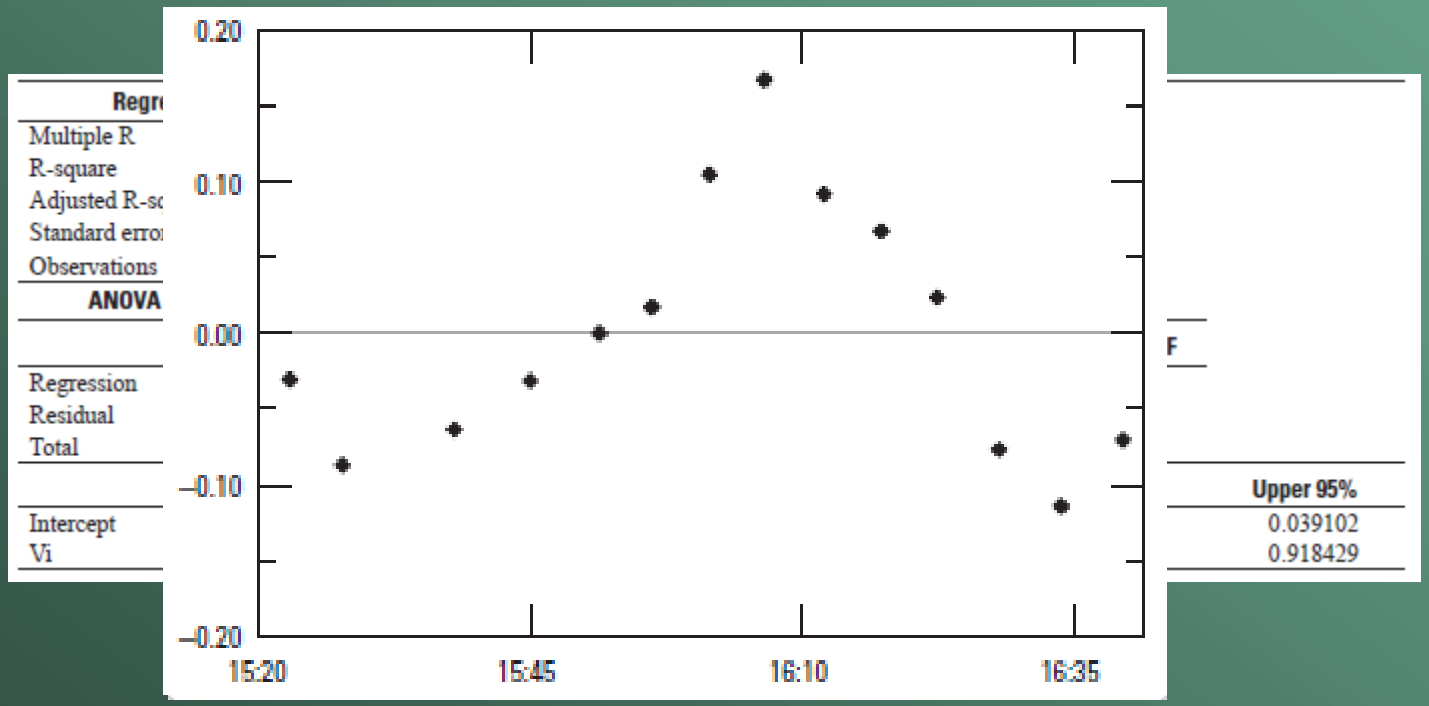
- **NO TREND, that's good**



USGS

Is the Rating Complete?

- **TREND, that's not good**



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NO TREND

- Indicates that the index velocity is an appropriate estimator for the mean channel velocity

TREND

- Indicates that one or more other variables affect the relation to mean channel velocity

USGS

Discharge Rating Analysis (DRA)

- The Discharge Rating Analysis shows how the measurements plot on the rating
- After a rating is established the DRA verifies or validates if the rating is changing

USGS

Qm Rating Analysis

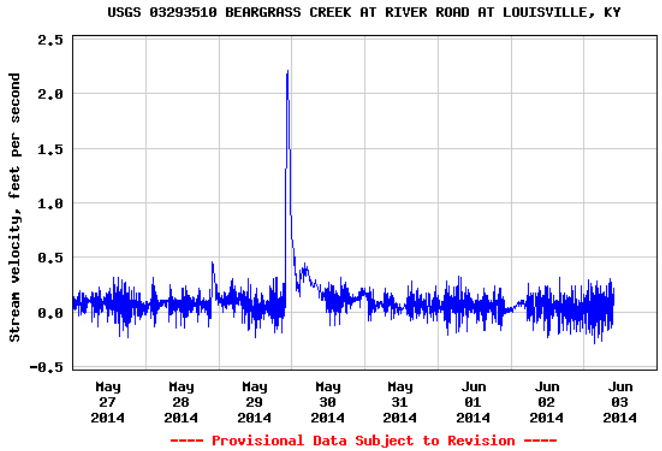
Discharge Measurements			Index Velocity Rating			Computational	
QM #	Rated	Q	Rated Q	% Difference	Rating #	Index Vel	Area
34	Good	40000	40142.4	0.4	1.0	3.93	8458.8
35	Good	42200	38662.7	-9.1	1.0	3.77	8486.97
36	Good	41100	40043.3	-2.6	1.0	3.89	8523.27
37	Good	42100	40055.6	-5.1	1.0	3.88	8547.52
38	Fair	26502	28726.6	7.7	1.0	2.65	8907.85
39	Fair	26002	28514.4	8.8	1.0	2.64	8874.73
40	Fair	25571	28553.1	10.4	1.0	2.65	8854.06
41	Fair	26402	28549.3	7.5	1.0	2.67	8788.12
42	Good	1924	1849.7	-4.0	1.0	1.44	1034.91
43	Good	1896	1868.4	-1.5	1.0	1.46	1031.7
44	Good	1791	1798.7	0.4	1.0	1.41	1026.9
45	Good	1818	1808.1	-0.5	1.0	1.42	1025.3
46	Good	1746	1805.3	3.3	1.0	1.42	1023.7
47	Fair	235	240.6	2.3	1.0	0.27	605.7
48	Fair	239	232.8	-2.6	1.0	0.26	604.3
49	Fair	231	232.3	0.6	1.0	0.26	602.9
50	Fair	236	246.0	4.1	1.0	0.28	601.4
51	Fair	1830	1829.6	0.0	1.0	1.32	1112.4
52	Fair	1720	1842.8	6.7	1.0	1.33	1112.41
53	Fair	1740	1840.1	5.4	1.0	1.33	1110.8
54	Fair	1710	1840.1	7.1	1.0	1.33	1110.79
55	Fair	4204	4264.7	1.4	1.0	1.91	1818.13
56	Fair	4174	4303.5	3.0	1.0	1.93	1816.25
57	Fair	4160	4299.0	3.2	1.0	1.93	1814.37
58	Fair	4225	4277.5	1.2	1.0	1.92	1814.4
59	Fair	9570	9389.3	-1.9	1.0	2.45	3143.14

USGS

Finally the discharge is ready for the internet

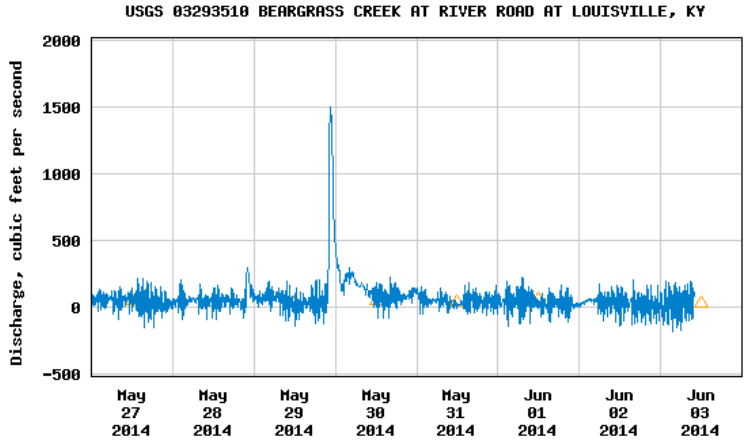
Stream velocity, feet per second

Most recent instantaneous value: 0.12 06-03-2014 09:50 EDT



Discharge, cubic feet per second

Most recent instantaneous value: 79 06-03-2014 09:50 EDT



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Question and Answers for Index Velocity

- **Does index velocity work at every site?**
  - **In most backwater, tidal effected, slope stations; Yes they do. The installation and section location is the most challenging. There are some instances where index velocity will not work in backwater conditions.**
    - **SUCH AS:**

USGS

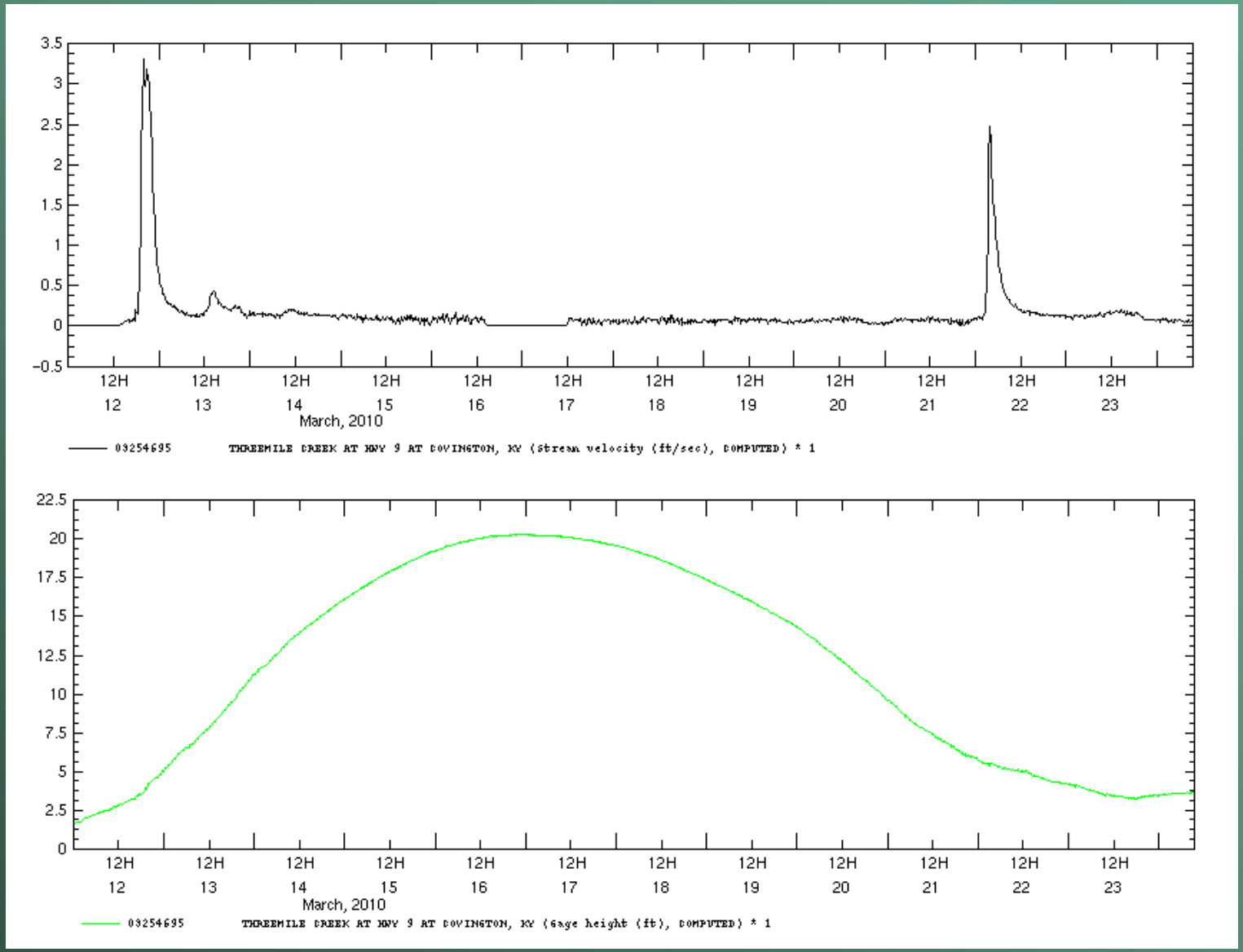
Regular Stream Flow

Backwater from Licking River

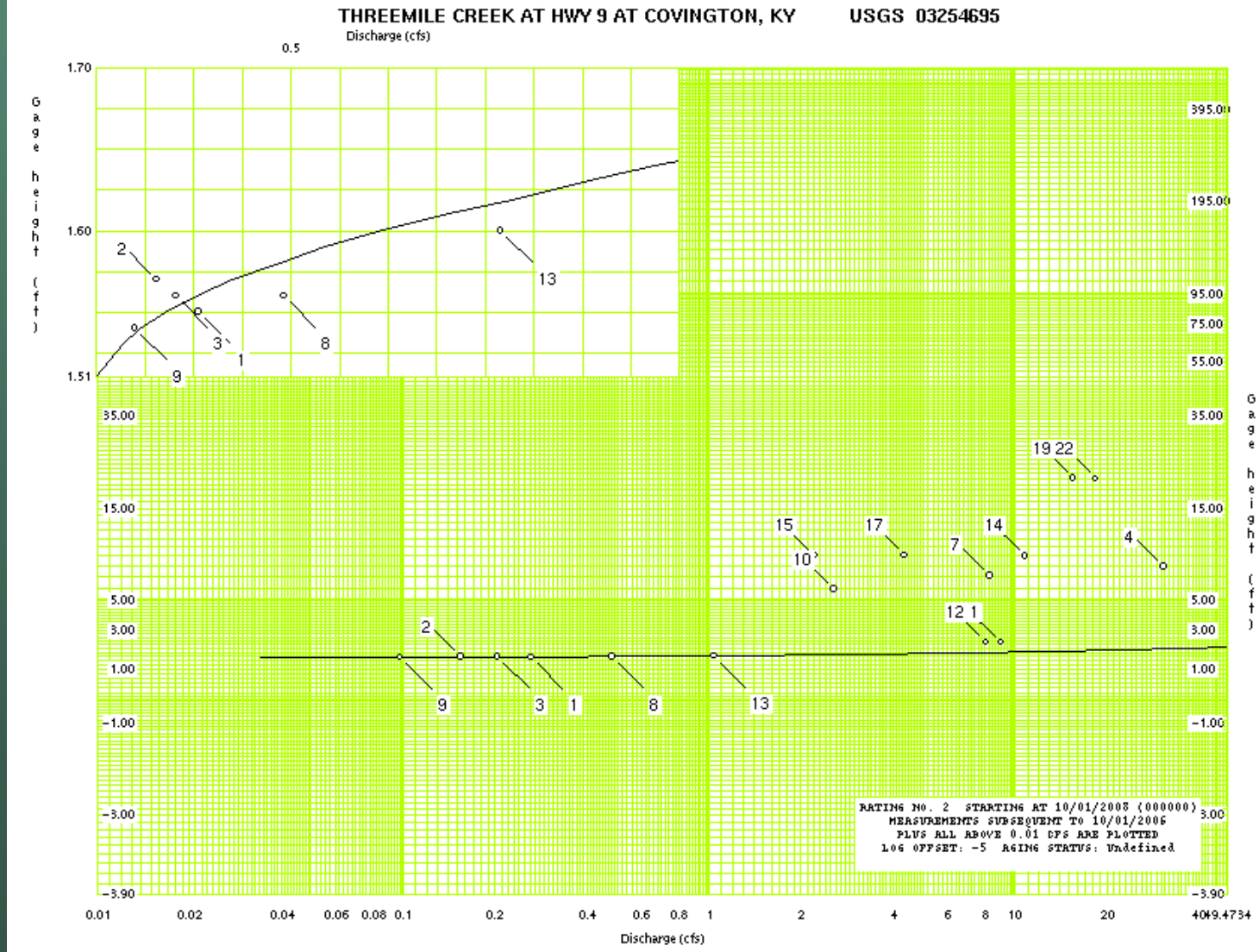
USGS

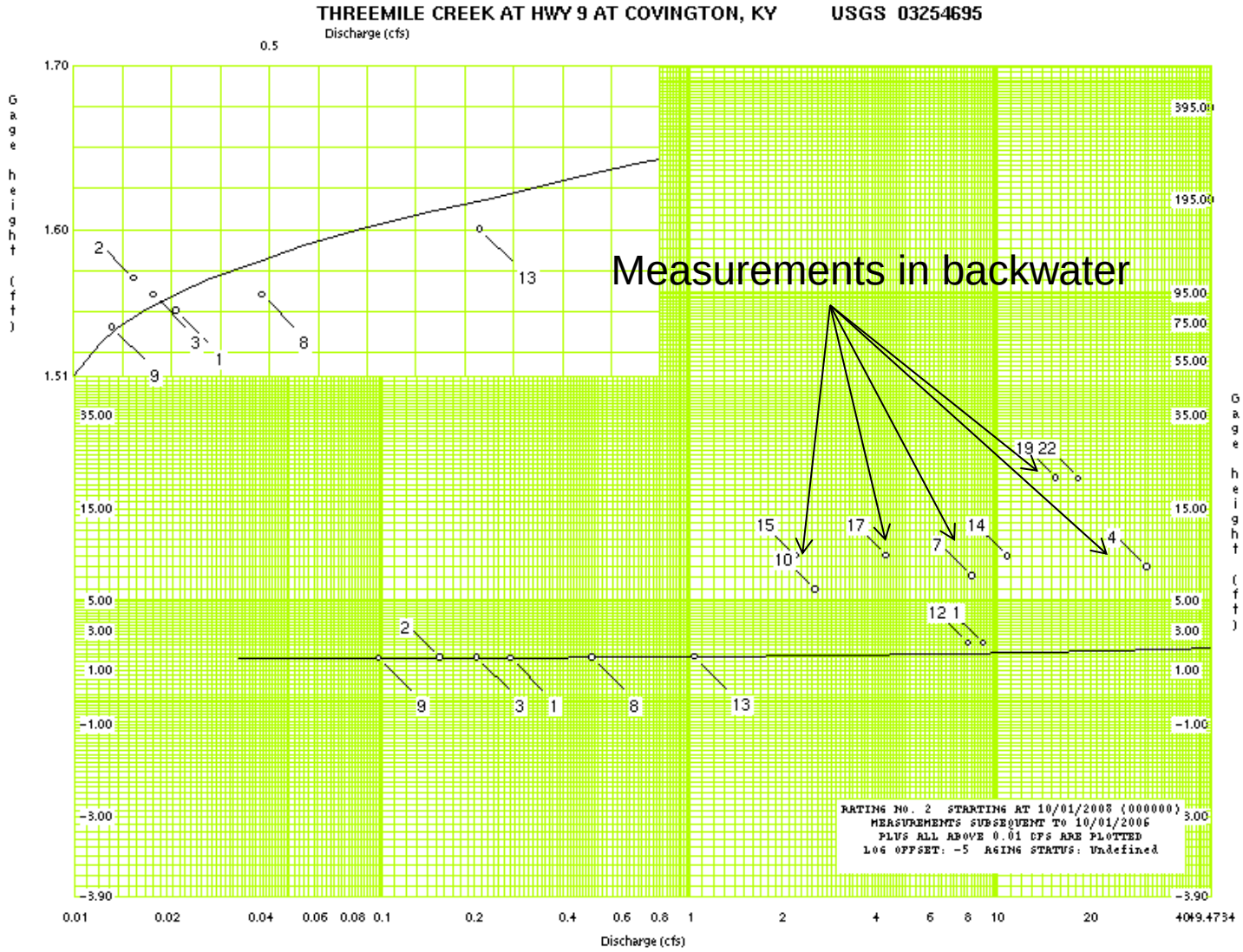

12/12/2007


03/16/2010


3.5
3
2.5
2
1.5
1
0.5
0
-0.5
12H 12
12H 13
12H 14
12H 15
12H 16
12H 17
12H 18
12H 19
12H 20
12H 21
12H 22
12H 23
March, 2010
03254695 THREEMILE CREEK AT HWY 9 AT COVINGTON, KY (Stream velocity (ft/sec), COMPUTED) * 1
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
12H 12
12H 13
12H 14
12H 15
12H 16
12H 17
12H 18
12H 19
12H 20
12H 21
12H 22
12H 23
March, 2010
03254695 THREEMILE CREEK AT HWY 9 AT COVINGTON, KY (Gage height (ft), COMPUTED) * 1

USGS


THREEMILE CREEK AT HWY 9 AT COVINGTON, KY USGS 03254695
Discharge (cfs)
0.5
Gage height (ft)
1.70
1.60
1.51
35.00
15.00
5.00
3.00
1.00
-1.00
-3.00
-3.90
395.00
195.00
95.00
75.00
55.00
35.00
15.00
5.00
3.00
1.00
-1.00
-3.00
-3.90
0.01
0.02
0.04
0.06
0.08
0.1
0.2
0.4
0.6
0.8
1
2
4
6
8
10
20
4049.4734
Discharge (cfs)
RATING No. 2 STARTING AT 10/01/2008 (000000)
MEASUREMENTS SUBSEQUENT TO 10/01/2006
PLUS ALL ABOVE 0.01 CFS ARE PLOTTED
LOG OFFSET: -5 AGING STATUS: Undefined


THREEMILE CREEK AT HWY 9 AT COVINGTON, KY
USGS 03254695
Discharge (cfs)
0.5
Gage height (ft)
1.70
1.60
1.51
Measurements in backwater
395.00
195.00
95.00
75.00
55.00
35.00
15.00
5.00
3.00
1.00
-1.00
-3.00
-3.90
0.01
0.02
0.04
0.06
0.08
0.1
0.2
0.4
0.6
0.8
1
2
4
6
8
10
20
4049.4734
Discharge (cfs)
RATING No. 2 STARTING AT 10/01/2008 (000000)
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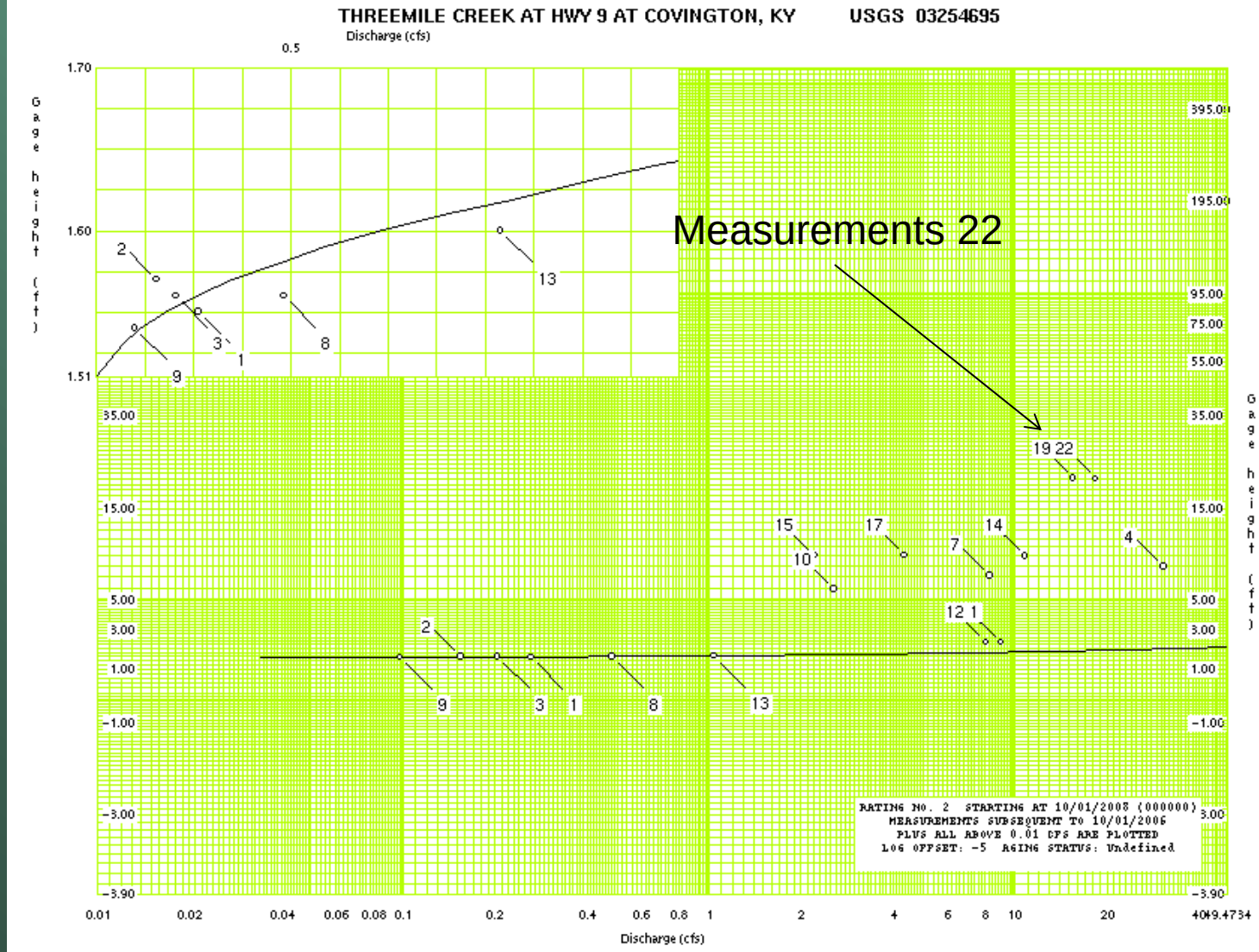
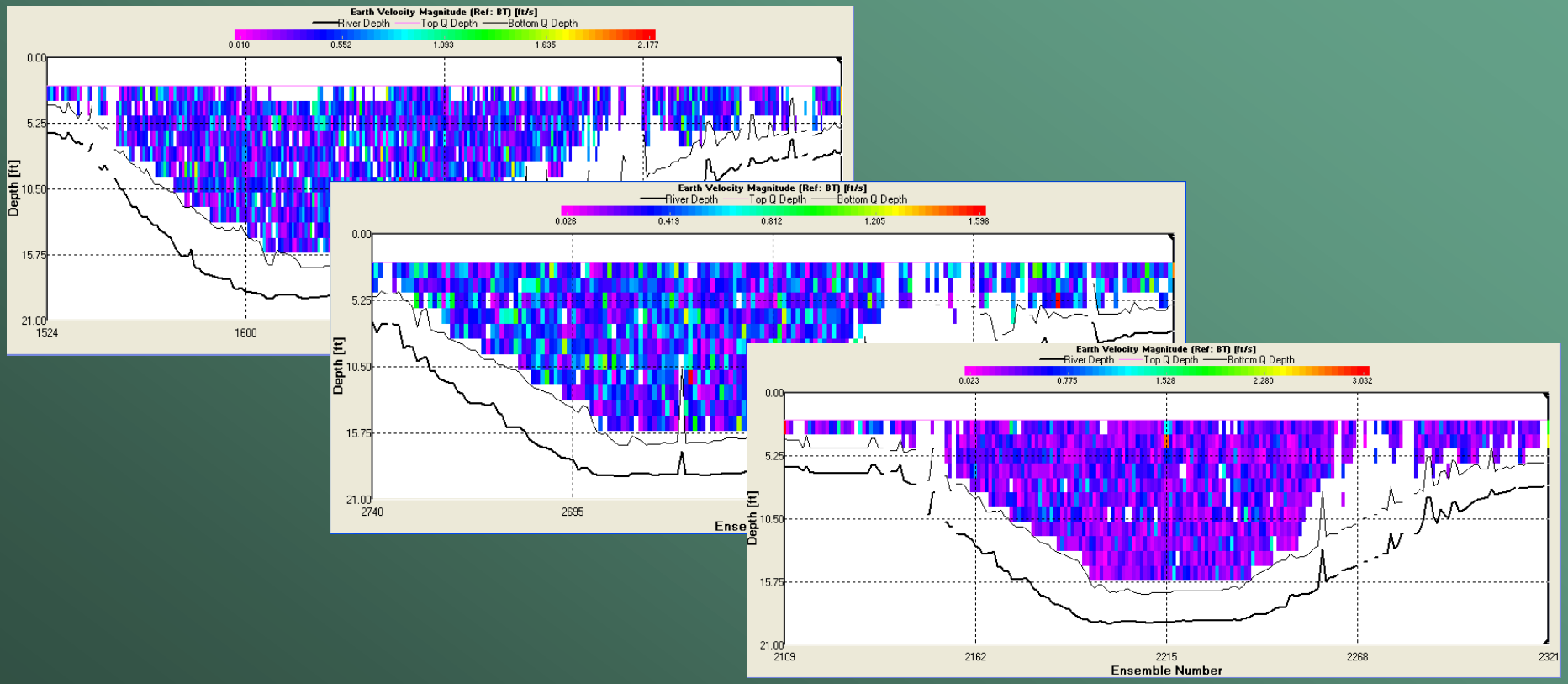

THREEMILE CREEK AT HWY 9 AT COVINGTON, KY USGS 03254695
Discharge (cfs)
0.5
Gage height (ft)
1.70
1.60
1.51
Measurements 22
2
13
3
1
8
9
395.00
195.00
95.00
75.00
55.00
35.00
15.00
5.00
3.00
1.00
-1.00
-3.00
-3.90
19 22
15
10
17
7
14
4
12 1
2
9
3
1
8
13
RATING No. 2 STARTING AT 10/01/2008 (000000)
MEASUREMENTS SUBSEQUENT TO 10/01/2006
PLUS ALL ABOVE 0.01 CFS ARE PLOTTED
LOG OFFSET: -5 AGING STATUS: Undefined
0.01
0.02
0.04
0.06
0.08
0.1
0.2
0.4
0.6
0.8
1
2
4
6
8
10
20
4049.4734
Discharge (cfs)

USGS

Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s
ThreeMile_031710003	Left	305	12:45:00	22.637
ThreeMile_031710004	Right	237	12:49:33	6.639
ThreeMile_031710005	Left	213	12:53:35	-45.132
Average		251		-5.285
Std Dev.		48		35.423
Std./| Avg.|		0.19		6.70



USGS

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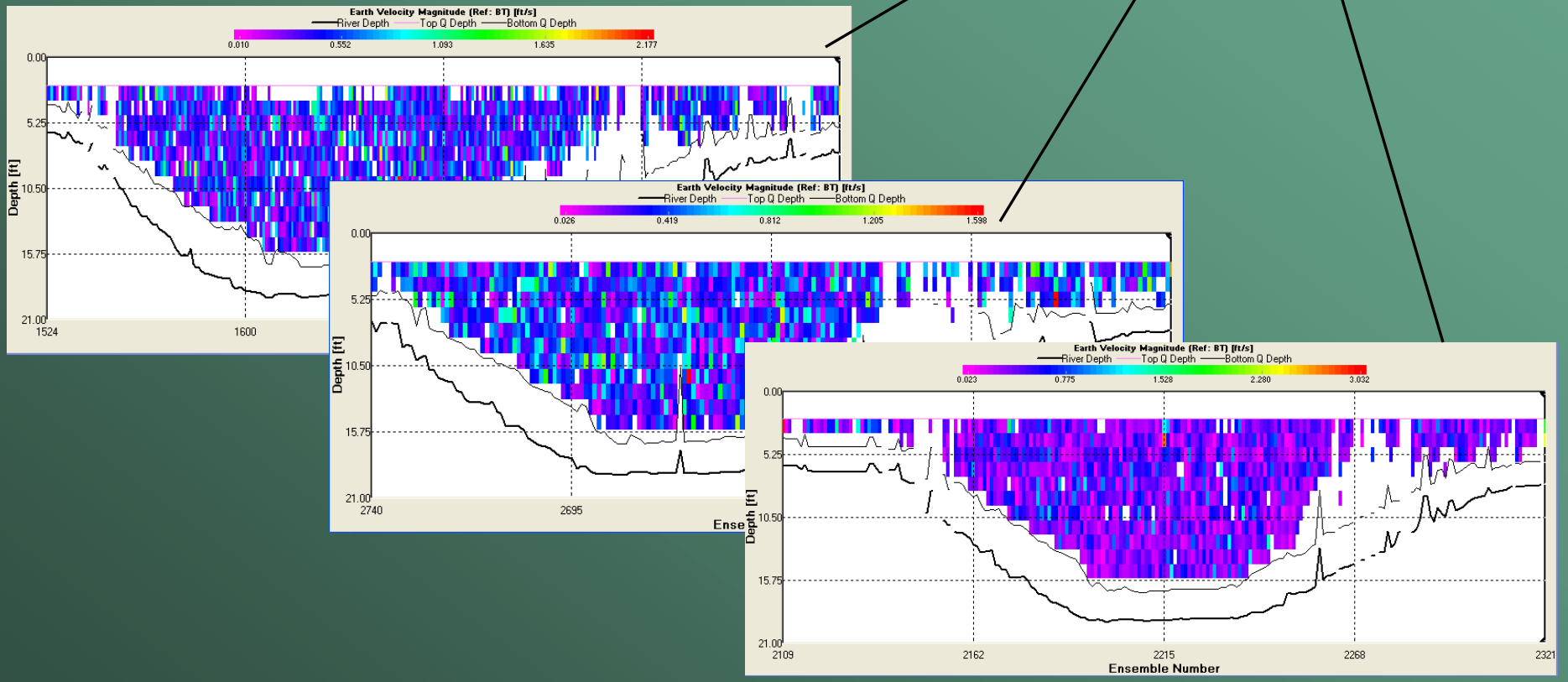
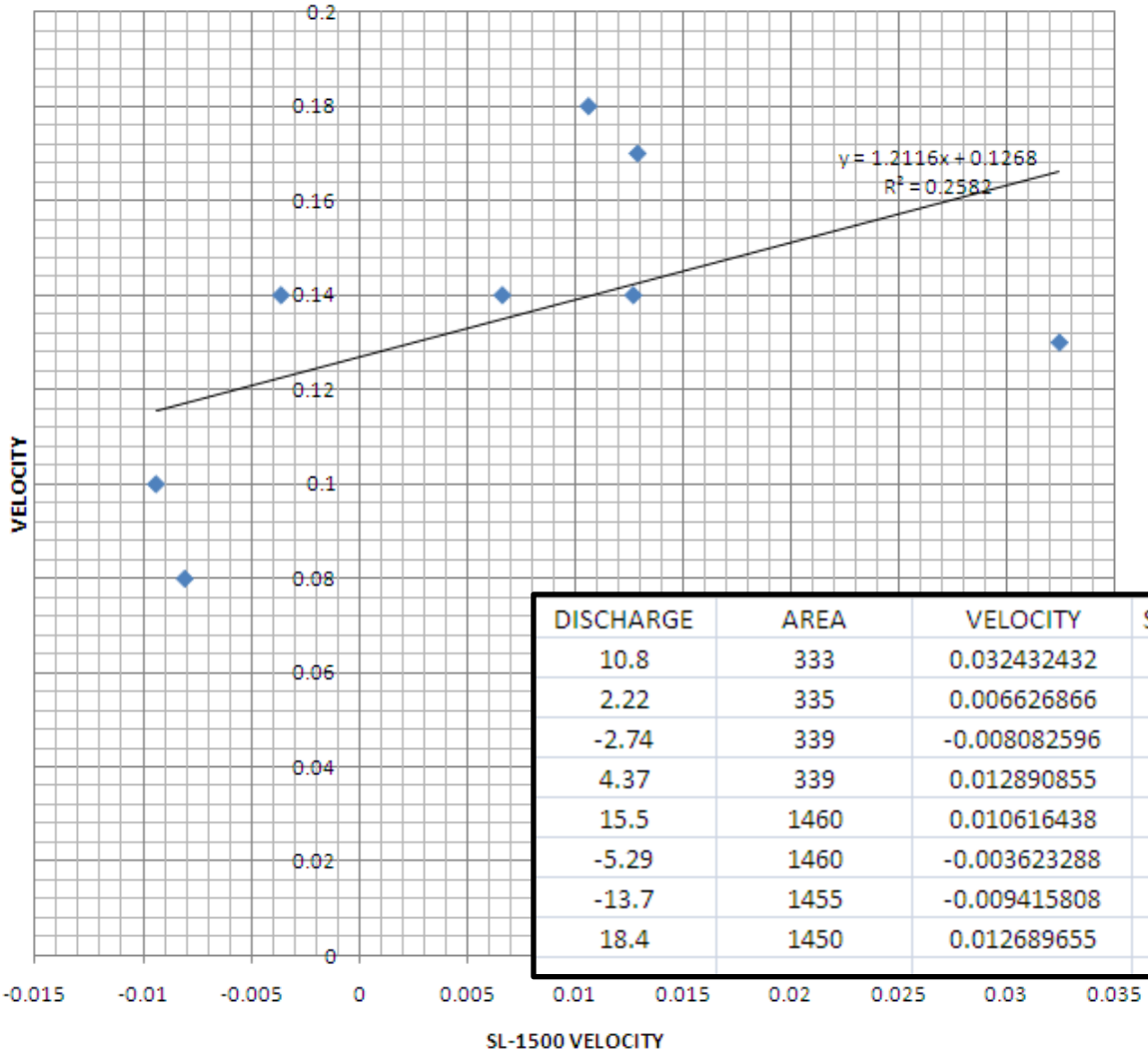
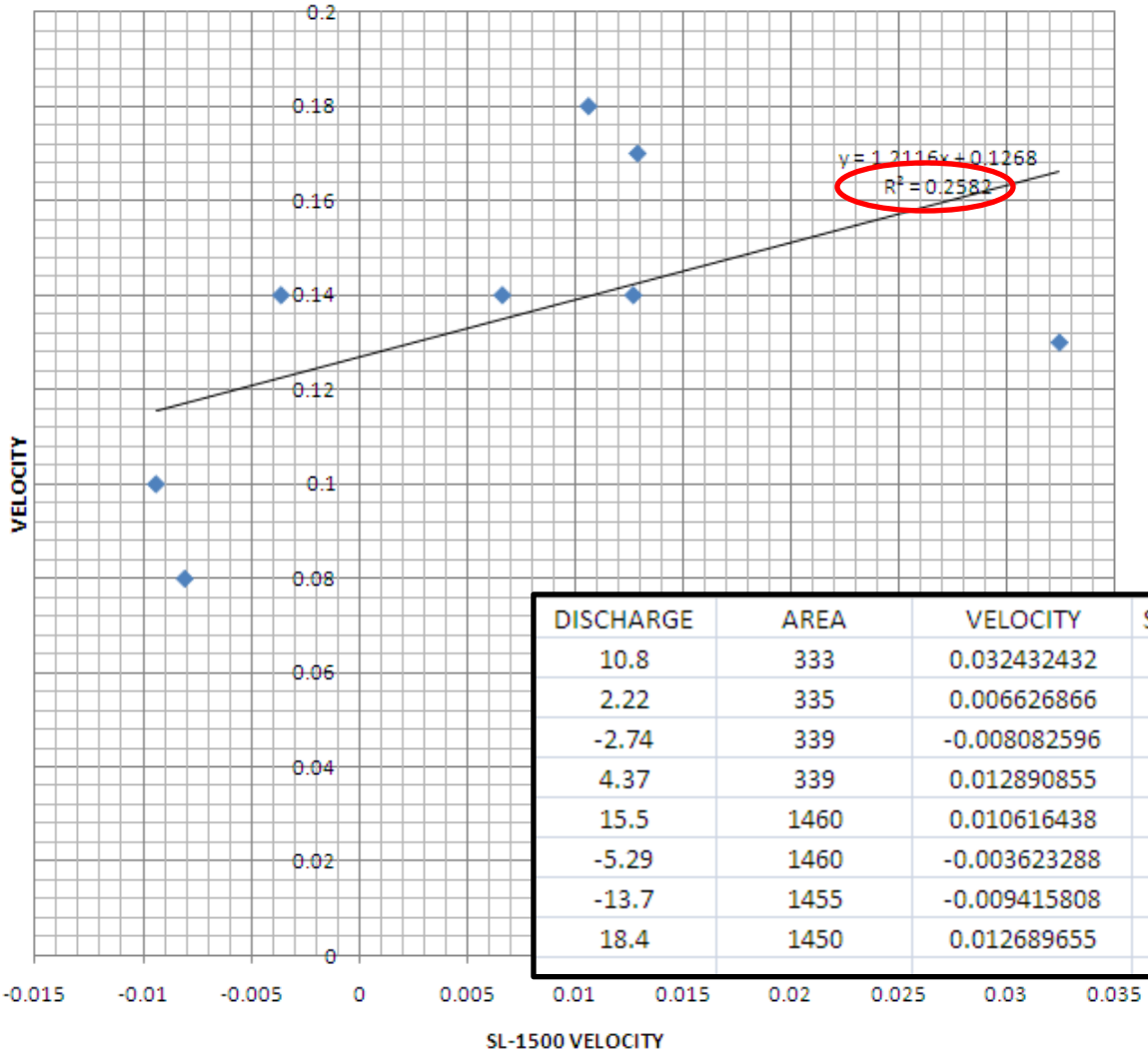
ThreeMile_031710003	Left	305	12:45:00	22.637
ThreeMile_031710004	Right	237	12:49:33	6.639
ThreeMile_031710005	Left	213	12:53:35	-45.132
Average		251		-5.285
Std Dev.		48		35.423
Std./| Avg.|		0.19		6.70





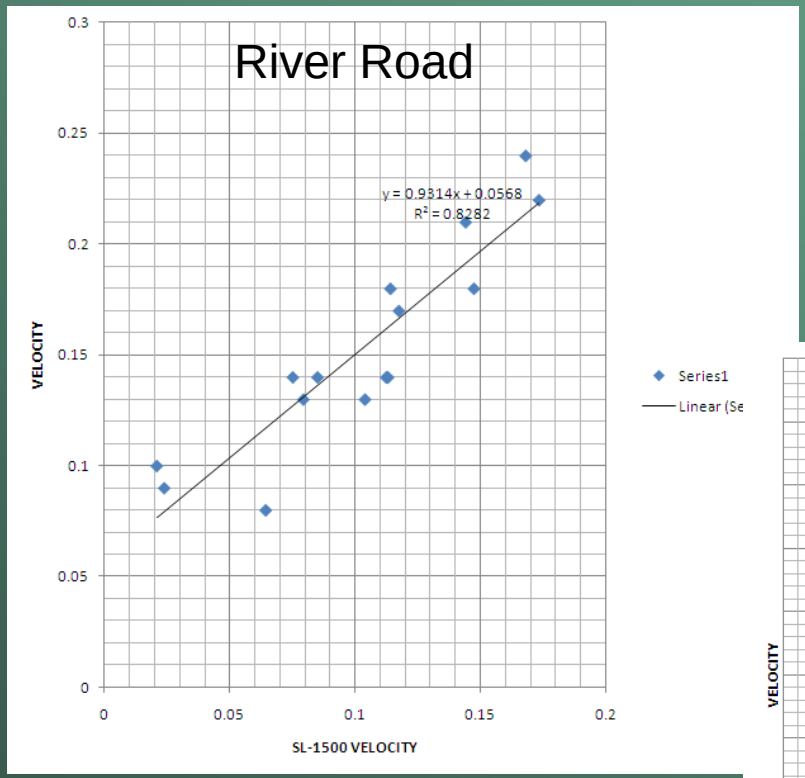
DISCHARGE	AREA	VELOCITY	SL-1500 VELOCITY	STAGE*VELOCITY
10.8	333	0.032432432	0.13	1.17
2.22	335	0.006626866	0.14	1.2656
-2.74	339	-0.008082596	0.08	0.728
4.37	339	0.012890855	0.17	1.547
15.5	1460	0.010616438	0.18	3.6126
-5.29	1460	-0.003623288	0.14	2.8084
-13.7	1455	-0.009415808	0.1	2.005
18.4	1450	0.012689655	0.14	2.8056

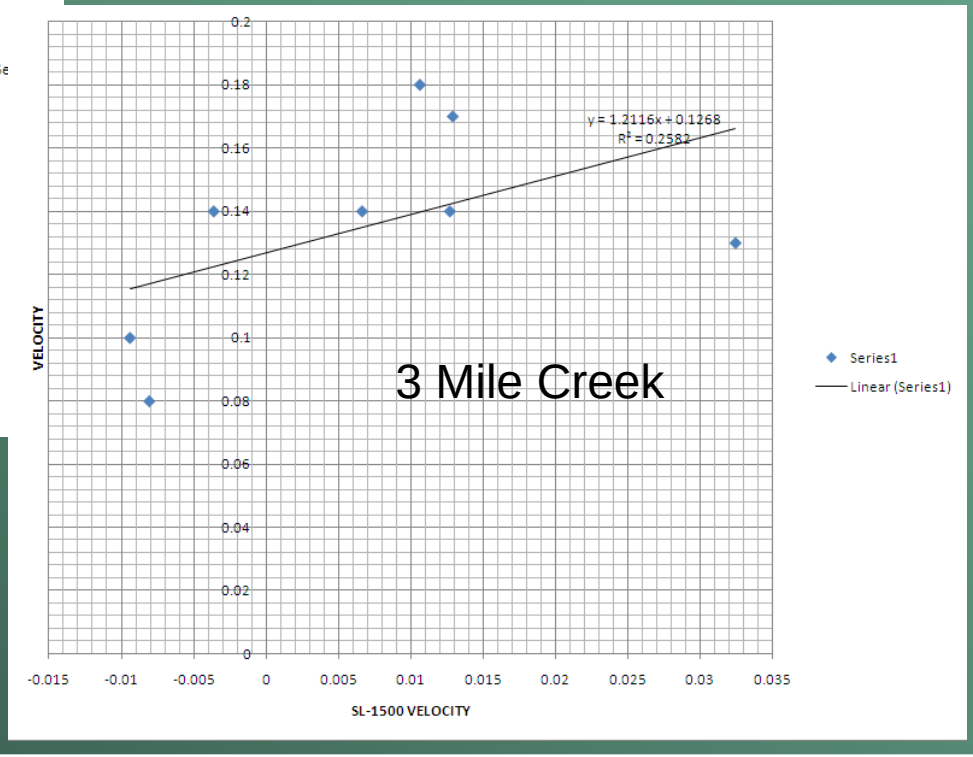
USGS



DISCHARGE	AREA	VELOCITY	SL-1500 VELOCITY	STAGE*VELOCITY
10.8	333	0.032432432	0.13	1.17
2.22	335	0.006626866	0.14	1.2656
-2.74	339	-0.008082596	0.08	0.728
4.37	339	0.012890855	0.17	1.547
15.5	1460	0.010616438	0.18	3.6126
-5.29	1460	-0.003623288	0.14	2.8084
-13.7	1455	-0.009415808	0.1	2.005
18.4	1450	0.012689655	0.14	2.8056

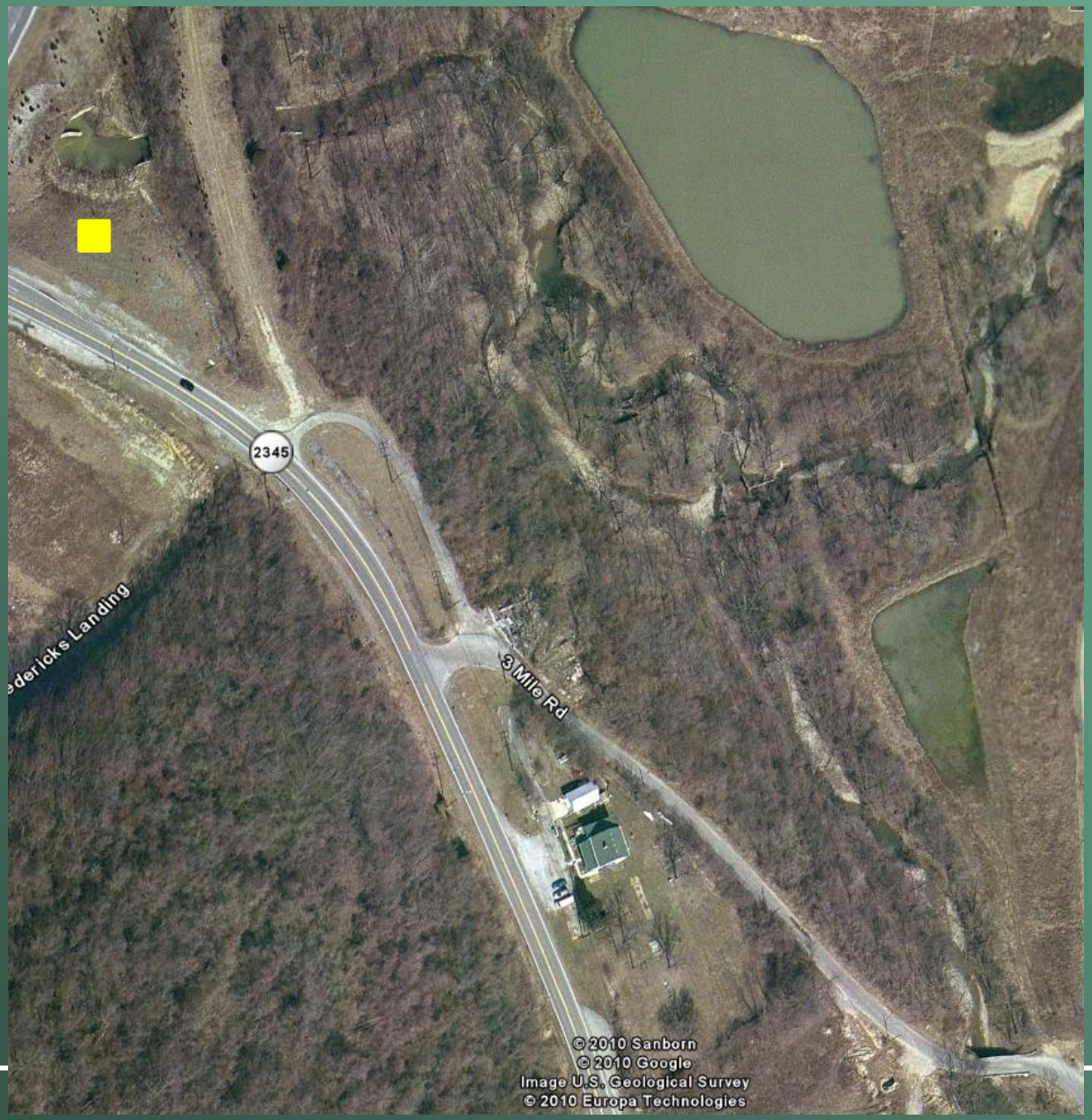
USGS


River Road
y = 0.9314x + 0.0568
R² = 0.8282
VELOCITY
SL-1500 VELOCITY
Series1
Linear (Se

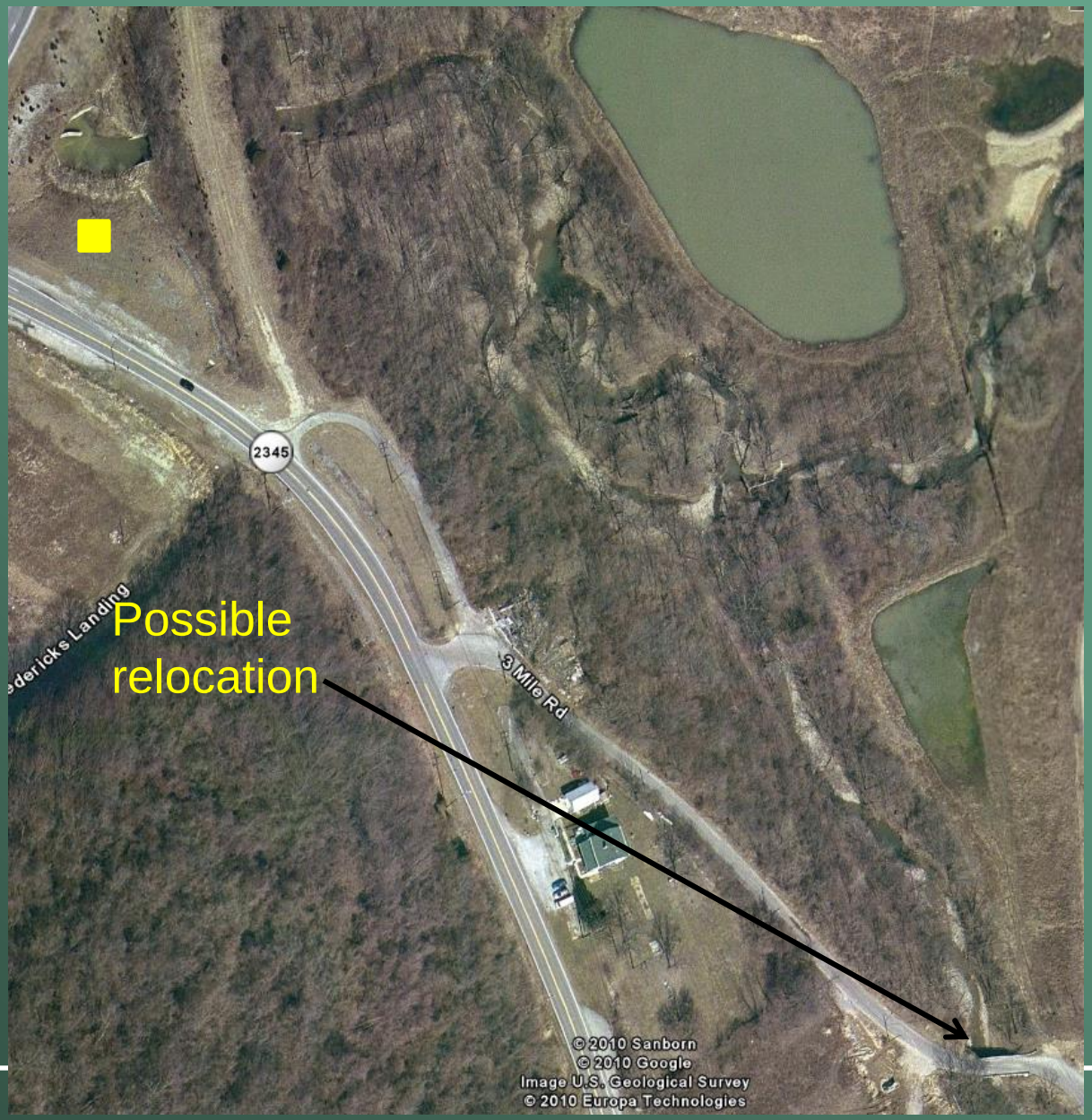

3 Mile Creek
y = 1.2116x + 0.1268
R² = 0.2582
VELOCITY
SL-1500 VELOCITY
Series1
Linear (Series1)

USGS

USGS


2345
edericks Landing
3 Mile Rd
© 2010 Sanborn
© 2010 Google
Image U.S. Geological Survey
© 2010 Europa Technologies

USGS

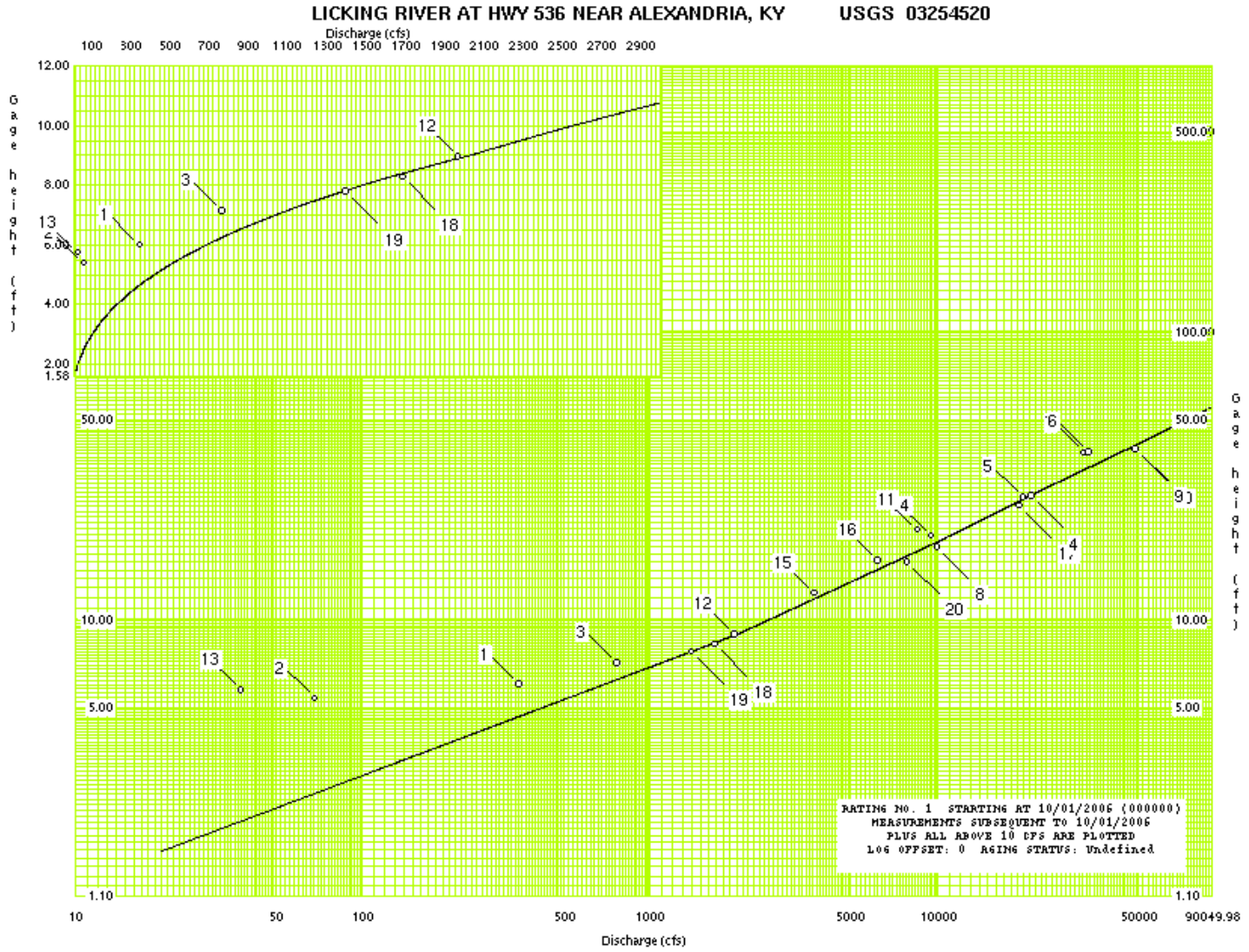

2345
Possible relocation
3 Mile Rd
© 2010 Sanborn
© 2010 Google
Image U.S. Geological Survey
© 2010 Europa Technologies

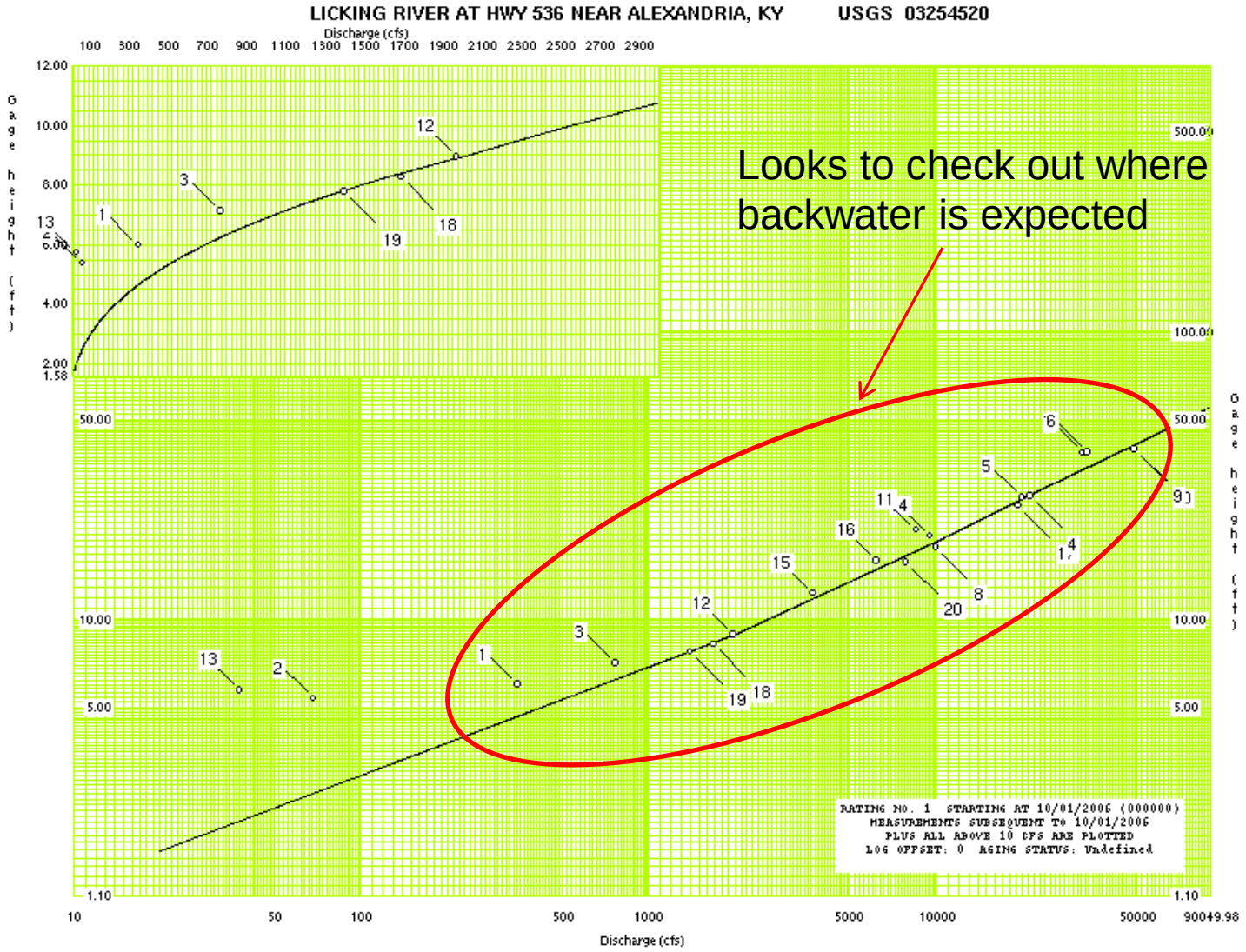
USGS

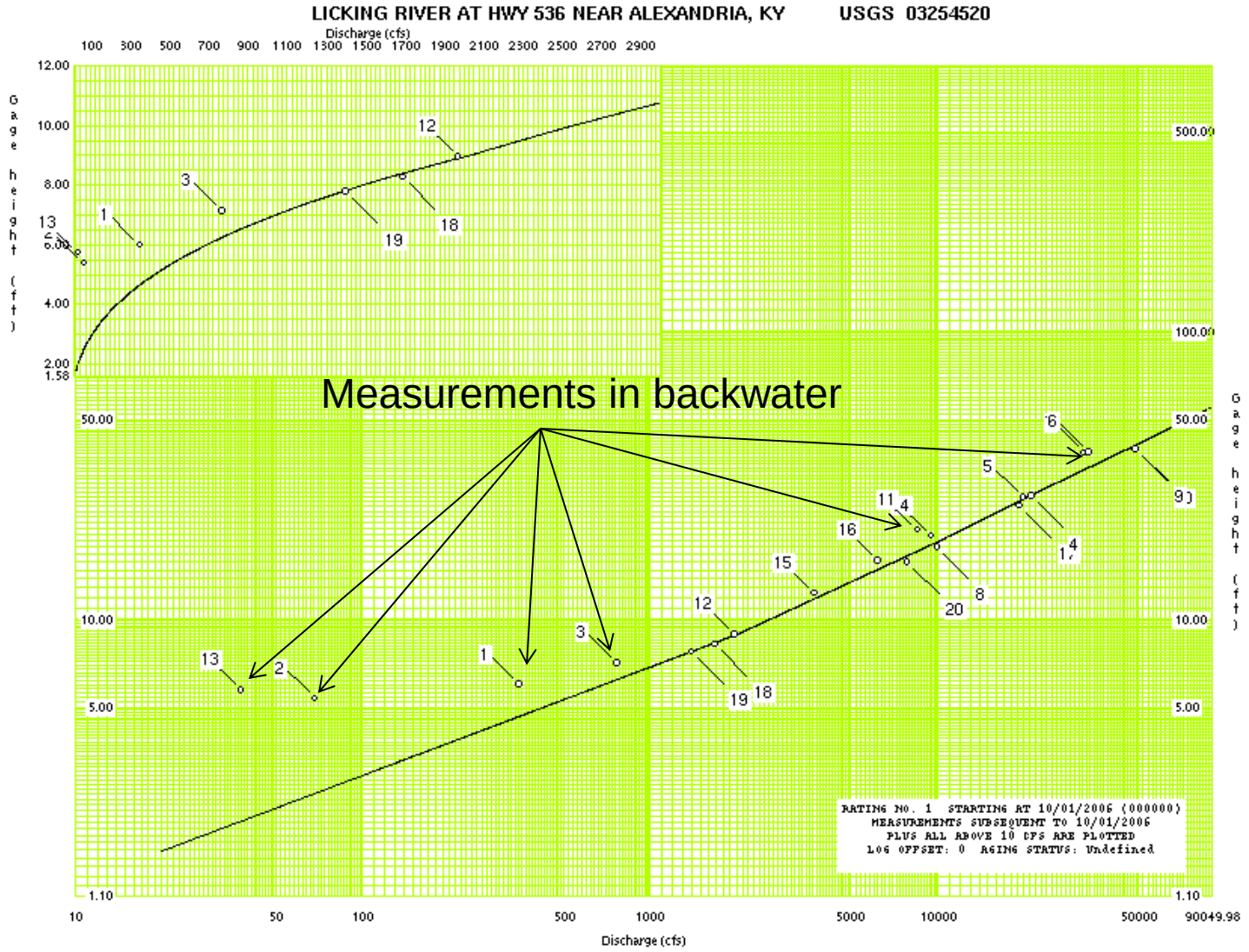
What happens when you don’t see any effects from backwater and a stage discharge relationship looks fine?

- A good example of this is a site 13 miles from the Ohio River and measurements checked out well to a stage discharge rating:

USGS


LICKING RIVER AT HWY 536 NEAR ALEXANDRIA, KY USGS 03254520
Discharge (cfs)
100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300 2500 2700 2900
Gage height (ft)
12.00
10.00
8.00
6.00
4.00
2.00
1.58
500.00
100.00
50.00
10.00
5.00
1.10
10 50 100 500 1000 5000 10000 50000 90049.98
Discharge (cfs)
RATING No. 1 STARTING AT 10/01/2006 (000000)
MEASUREMENTS SUBSEQUENT TO 10/01/2006
PLUS ALL ABOVE 10 CFS ARE PLOTTED
LOG OFFSET: 0 AGING STATUS: Undefined

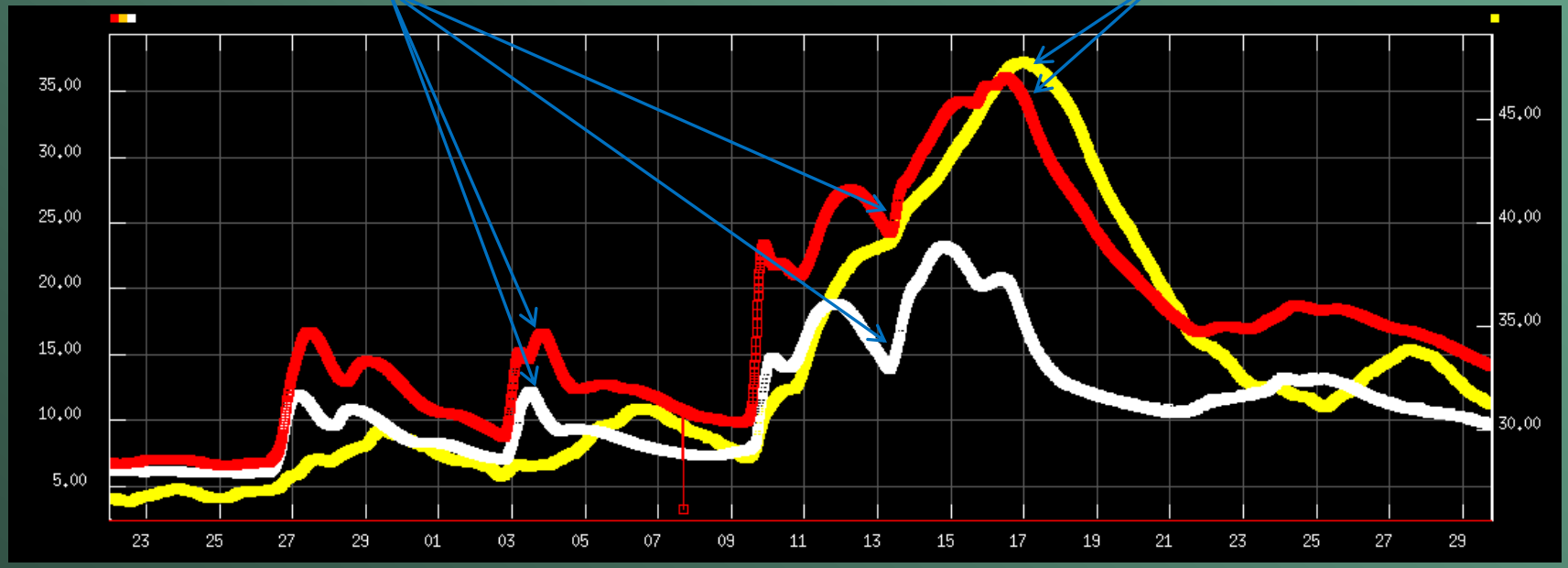

LICKING RIVER AT HWY 536 NEAR ALEXANDRIA, KY
USGS 03254520
Discharge (cfs)
100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300 2500 2700 2900
Gage height (ft)
12.00
10.00
8.00
6.00
4.00
2.00
1.58
Looks to check out where backwater is expected
50.00
10.00
5.00
1.10
10 50 100 500 1000 5000 10000 50000 90049.98
Discharge (cfs)
RATING No. 1 STARTING AT 10/01/2006 (000000)
MEASUREMENTS SUBSEQUENT TO 10/01/2006
PLUS ALL ABOVE 10 CFS ARE PLOTTED
LOG OFFSET: 0 AGING STATUS: Undefined


LICKING RIVER AT HWY 536 NEAR ALEXANDRIA, KY
USGS 03254520
Discharge (cfs)
100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300 2500 2700 2900
Gage height (ft)
12.00
10.00
8.00
6.00
4.00
2.00
1.58
Measurements in backwater
50.00
10.00
5.00
1.10
500.00
100.00
50.00
10.00
5.00
1.10
10
50
100
500
1000
5000
10000
50000
90049.98
Discharge (cfs)
RATING No. 1 STARTING AT 10/01/2006 (000000)
MEASUREMENTS SUBSEQUENT TO 10/01/2006
PLUS ALL ABOVE 10 CFS ARE PLOTTED
LOG OFFSET: 0 AGING STATUS: Undefined

Licking River at 536 Issue

Licking River at 536 and
Licking River at Catawba

Licking River at 536 and
Ohio River at Cincinnati



USGS

STATION:03254520 LICKING RIVER AT HWY 536 NEAR ALEXANDRIA, KY TYPE:STREAM AGENCY:USGS STATE:21 COUNTY:037
LATITUDE: 385513 LONGITUDE: 0842653 NAD27 DRAINAGE AREA:3593* CONTRIBUTING DRAINAGE AREA: DATUM:480 NGVD29
Date Processed: 2010-03-11 07:29 By aruby
Lowest aging status in period is WORKING
DD #2
Discharge, cubic feet per second
WATER YEAR OCTOBER 2008 TO SEPTEMBER 2009
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	e81	e247	e302	e3150	13100	5040	4170	1810	4140	1400	9360	e225
2	e76	e233	e283	e2030	8950	5430	3550	2560	3250	1400	13700	e189
3	e73	e229	e303	e1320	8790	4190	4920	3350	3170	2200	7830	e160
4	e72	e241	e340	e1280	9350	3570	11600	3810	3890	1990	5330	e147
5	e71	e250	e344	e1990	6980	2940	15500	6730	8170	5670	15700	e135
6	e72	e235	e334	1630	5250	2440	11700	13300	8520	7100	20100	e125
7	e73	e230	e325	2990	5460	2220	9390	19100	6300	3610	17300	e1140
8	e78	e231	e312	7250	17400	2090	8840	19200	4230	2450	9530	1810
9	e74	e249	e323	12500	20300	1700	7670	28100	2830	1580	5450	2270
10	e71	e265	e355	14300	14000	e1820	6170	26300	4320	1270	4310	1360
11	e70	e256	e387	15200	16800	e1710	12200	23000	11500	1260	4770	1080
12	e66	e253	e516	12100	20500	e1600	19900	16000	11100	1180	4510	1010
13	e66	e267	e618	10500	19500	e1520	18000	9800	8840	1030	4220	e774
14	e69	e274	e1220	8350	16400	e1440	13200	6760	6740	980	3380	e511
15	e69	e291	e1830	6120	14300	e1440	12100	5380	5580	e728	2070	e361
16	e66	e293	e1730	4740	11500	e1600	10100	4090	5300	e623	1480	e233
17	e66	e275	e1680	3470	7870	e1940	8690	3010	7570	e562	1200	e192
18	e65	e288	e1810	2190	5650	e2540	7160	3420	5650	e457	1020	e165
19	e65	e328	e2250	1520	4430	e3510	5860	2840	3830	e435	967	e147
20	e73	e307	e2770	1370	3920	3310	7240	3420	3780	e467	e724	e180
21	e191	e291	e2820	1850	3380	2950	11400	3530	3530	e383	e699	e812
22	e242	e290	e2540	1910	3100	2270	12600	3370	2580	e367	e996	2610
23	e227	e311	e2250	1720	2660	1770	9680	3270	e2060	e541	e990	5340
24	e241	e307	e4830	1130	2180	1500	7110	3220	e1610	e579	e766	4060
25	e279	e338	e15000	976	1790	1320	5410	3160	e1310	e842	e642	3810
26	e264	e316	e16000	1190	1540	2570	4220	3720	e1870	1300	e469	7080
27	e242	e320	e9240	956	3920	5140	3280	5080	2610	1030	e352	20700
28	e231	e344	e4610	e3270	4330	4660	e2950	e7770	2950	958	e291	27100
29	e222	e338	e4290	15000	---	5920	e2500	e7220	2210	7560	e253	15500
30	e238	e314	e4220	32900	---	5470	e2150	6190	1780	8510	e227	6580
31	e258	---	e3830	26800	---	4760	---	4960	---	12300	e238	---
MEAN	131	280	2828	6507	9048	2915	8642	8176	4707	2283	4480	3527
MAX	279	344	16000	32900	20500	5920	19900	28100	11500	12300	20100	27100
MIN	65	229	283	956	1540	1320	2150	1810	1310	367	227	125

USGS

STATION:03254520 LICKING RIVER AT HWY 536 NEAR ALEXANDRIA, KY TYPE:STREAM AGENCY:USGS STATE:21 COUNTY:037
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Date Processed: 2010-03-11 07:29 By aruby
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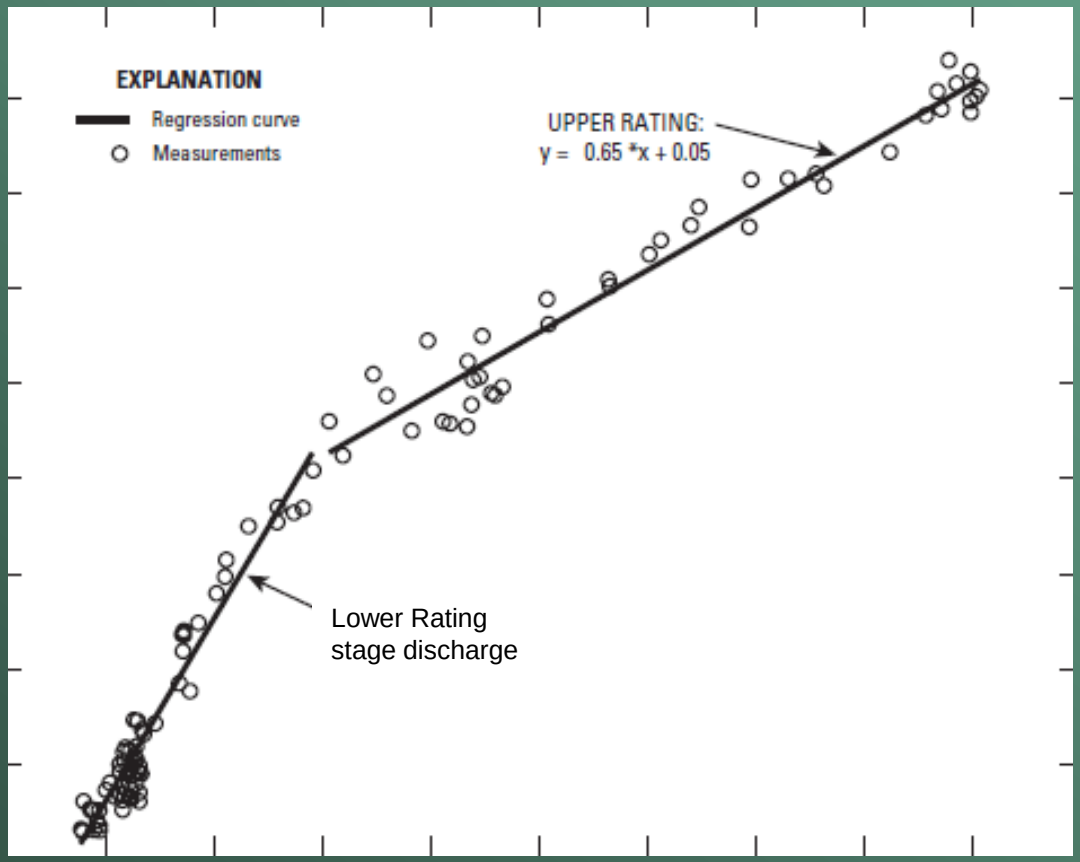
2	e76	e233	e283	e2030	8950	5430	3550	2560	3250	1400	13700	e189
3	e73	e229	e303	e1320	8790	4190	4920	3350	3170	2200	7830	e160
4	e72	e241	e340	e1280	9350	3570	11600	3810	3890	1990	5330	e147
5	e71	e250	e344	e1990	6980	2940	15500	6730	8170	5670	15700	e135
6	e72	e235	e334	1630	5250	2440	11700	13300	8520	7100	20100	e125
7	e73	e230	e325	2990	5460	2220	9390	19100	6300	3610	17300	e1140
8	e78	e231	e312	7250	17400	2090	8840	19200	4230	2450	9530	1810
9	e74	e249	e323	12500	20300	1700	7670	28100	2830	1580	5450	2270
10	e71	e265	e355	14300	14000	e1820	6170	26300	4320	1270	4310	1360
11	e70	e256	e387	15200	16800	e1710	12200	23000	11500	1260	4770	1080
12	e66	e253	e516	12100	20500	e1600	19900	16000	11100	1180	4510	1010
13	e66	e267	e618	10500	19500	e1520	18000	9800	8840	1030	4220	e774
14	e69	e274	e1220	8350	16400	e1440	13200	6760	6740	980	3380	e511
15	e69	e291	e1830	6120	14300	e1440	12100	5380	5580	e728	2070	e361
16	e66	e293	e1730	4740	11500	e1600	10100	4090	5300	e623	1480	e233
17	e66	e275	e1680	3470	7870	e1940	8690	3010	7570	e562	1200	e192
18	e65	e288	e1810	2190	5650	e2540	7160	3420	5650	e457	1020	e165
19	e65	e328	e2250	1520	4430	e3510	5860	2840	3830	e435	967	e147
20	e73	e307	e2770	1370	3920	3310	7240	3420	3780	e467	e724	e180
21	e191	e291	e2820	1850	3380	2950	11400	3530	3530	e383	e699	e812
22	e242	e290	e2540	1910	3100	2270	12600	3370	2580	e367	e996	2610
23	e227	e311	e2250	1720	2660	1770	9680	3270	e2060	e541	e990	5340
24	e241	e307	e4830	1130	2180	1500	7110	3220	e1610	e579	e766	4060
25	e279	e338	e15000	976	1790	1320	5410	3160	e1310	e842	e642	3810
26	e264	e316	e16000	1190	1540	2570	4220	3720	e1870	1300	e469	7080
27	e242	e320	e9240	956	3920	5140	3280	5080	2610	1030	e352	20700
28	e231	e344	e4610	e3270	4330	4660	e2950	e7770	2950	958	e291	27100
29	e222	e338	e4290	15000	---	5920	e2500	e7220	2210	7560	e253	15500
30	e238	e314	e4220	32900	---	5470	e2150	6190	1780	8510	e227	6580
31	e258	---	e3830	26800	---	4760	---	4960	---	12300	e238	---
MEAN	131	280	2828	6507	9048	2915	8642	8176	4707	2283	4480	3527
MAX	279	344	16000	32900	20500	5920	19900	28100	11500	12300	20100	27100
MIN	65	229	283	956	1540	1320	2150	1810	1310	367	227	125

USGS

Can you have a stage discharge and index velocity rating at the same site?

- Yes compound ratings are possible
- The lower end of the rating may be represented very well by a stage discharge, while the upper end, such as a slope site may need an index velocity.
- The result will look similar to:

USGS



There may be a small imperfection within the transition point
If the point of transition is right before it goes into slope the point is almost seamless

USGS

Can this technology be used for anything other than providing discharge?

- Yes. Estimating suspended sediment in rivers and streams.
- High sediment concentrations can reduce:
  - Water quality
  - Flood protection capacity
  - Waterway navigation
  - Reservoir storage capacity

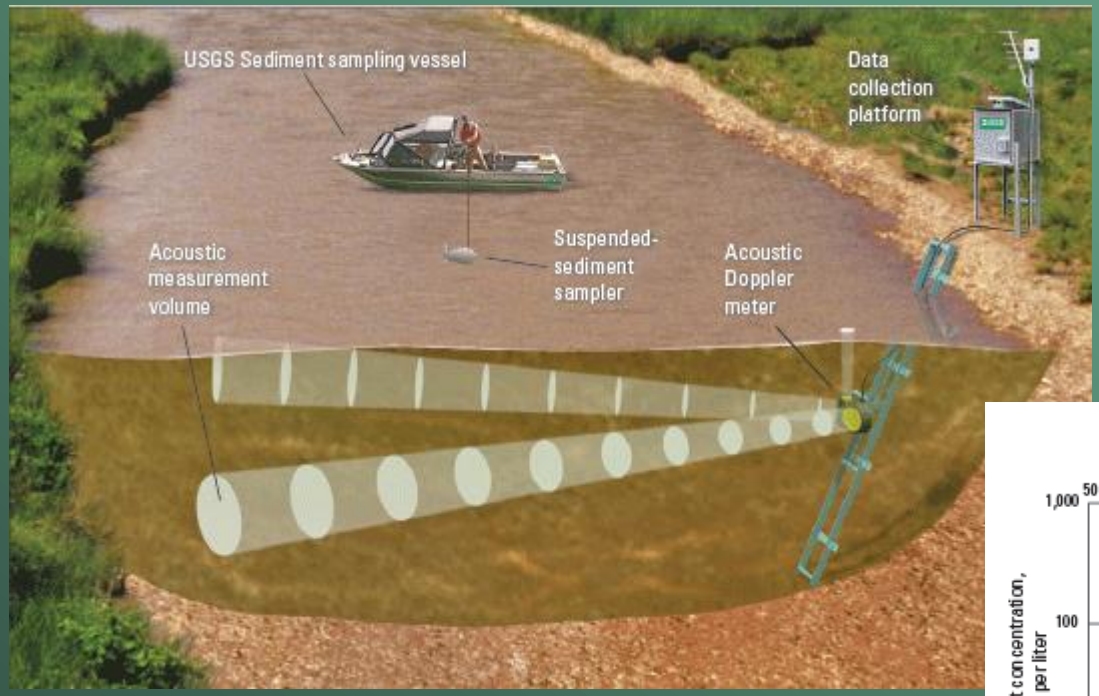
USGS

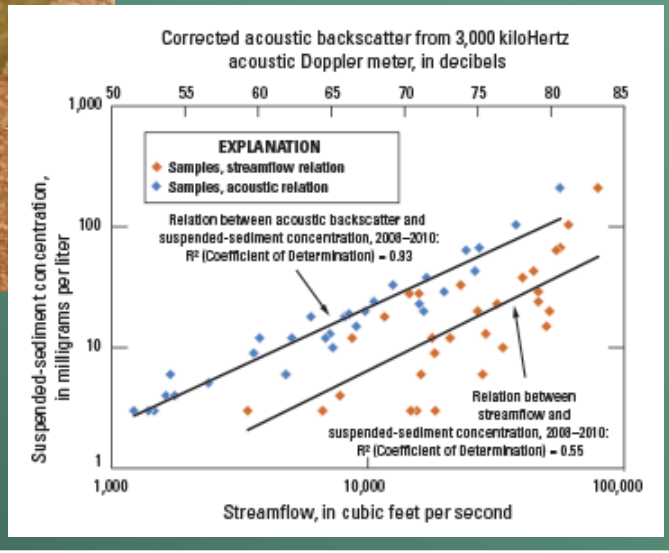
Can this technology be used for anything other than providing discharge?

- The use of Acoustic technology for sediment surrogate is:
  - Provide more direct measure of sediment concentrations
  - Not susceptible to biofouling like turbidity sensors
  - Measure larger sampling volume
  - Potentially provide information on sediment size

USGS

Can this technology be used for anything other than providing discharge?





USGS

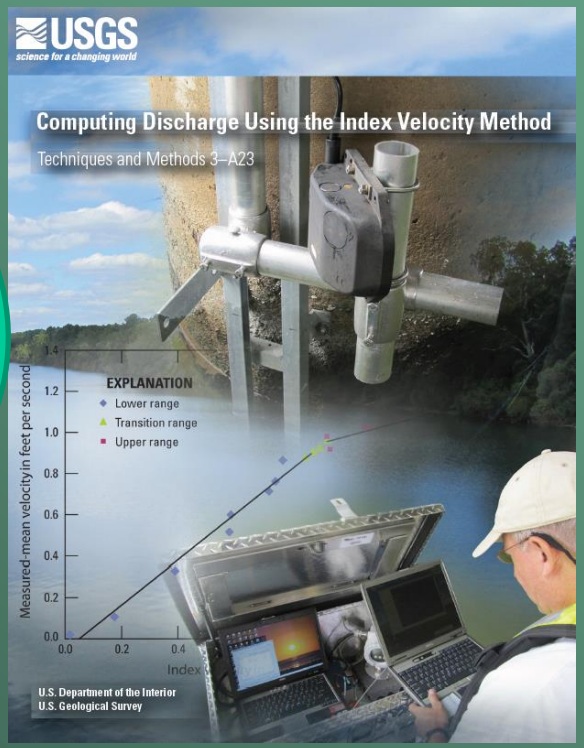
Is there a cost difference for an index velocity?

- Because the site requires more equipment and more measurements at all velocities, the site increases for the first 2 years.
- The site then goes to regular O&M costs after the rating is established.

USGS

Questions?

I feel I always look sideways.



Don't worry things are starting to look up!

USGS