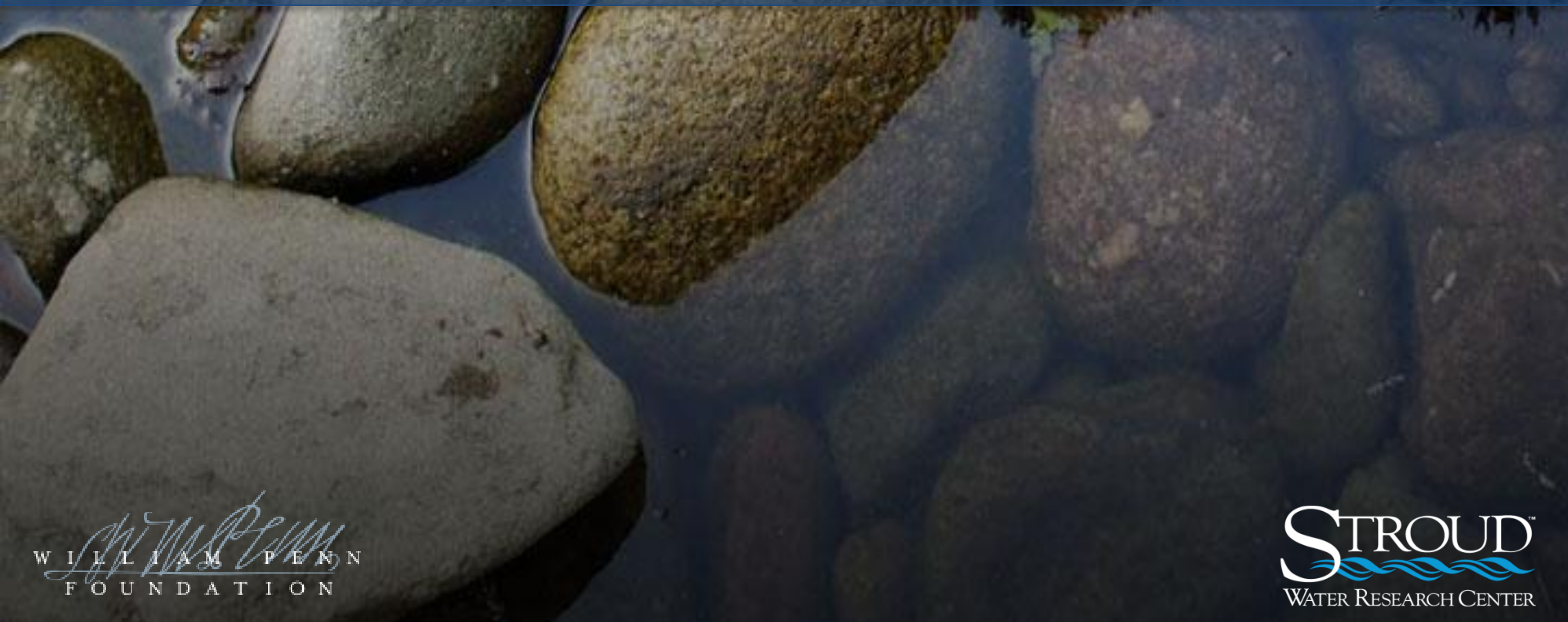
Watershed 201, Discharge and Total Suspended Solids

Measuring discharge, collecting TSS samples, measuring TSS, and setting up a low-cost TSS lab

June 7, 2019, 9:00a-4:00p, at Willistown Conservation Trust, Rushton Conservation Center, 915 Delchester Rd, Newtown Square, PA 19073



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Overview for the day

Agenda

- 9:00-9:15 – Welcome, refreshments, light breakfast
- 9:15-9:30 – Introductions, overview for the day
- 9:30-10:00 – Presentation on discharge, suspended sediment, rating curves, and loads
- 10:00-10:15 – Break and prep for group work
- 10:15-12:30 – Lab and Field, two groups
    - Lab – Review of two low-cost TSS lab setups; measuring TSS
    - Field – Measuring discharge and collecting grab samples for TSS
- 12:30-1:00 – Lunch (attendees bring bagged lunches)
- 1:00-3:15 – Lab and Field, two groups switch
- 3:15-4:00 – Overflow, discussion, rating curves
- 4:00-6:00 – 1:1 meetings

***Everyone does everything, working in pairs**

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Today

- **Everyone does everything, working in pairs. We will be using attendee lab and field results in comparison study**

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Today

- With Lauren McGrath and Marion Waggoner in Lab
  - Demonstration of methods
  - In pairs
    - Filter samples (already prepared with known concentrations, to be dried and weighed later)
    - Weigh samples (already dried)
- With Dave Bressler, Regan Dohm (plus Maddy and Kacy), and Dave Yake in Field
  - Demonstration of methods
  - In pairs
    - Discharge measurements, flow meter
    - Discharge measurements, orange float
    - Collect and label grab samples

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Stream Discharge and TSS

- **Discharge (or flow)** is the volumetric flow rate of water that is transported through a given cross-sectional area
  - Cubic feet per second
  - Cubic feet per meter

- **Total suspended solids (TSS)** is the dry-weight of suspended particles, *that are not dissolved*, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus
  - Milligrams per liter

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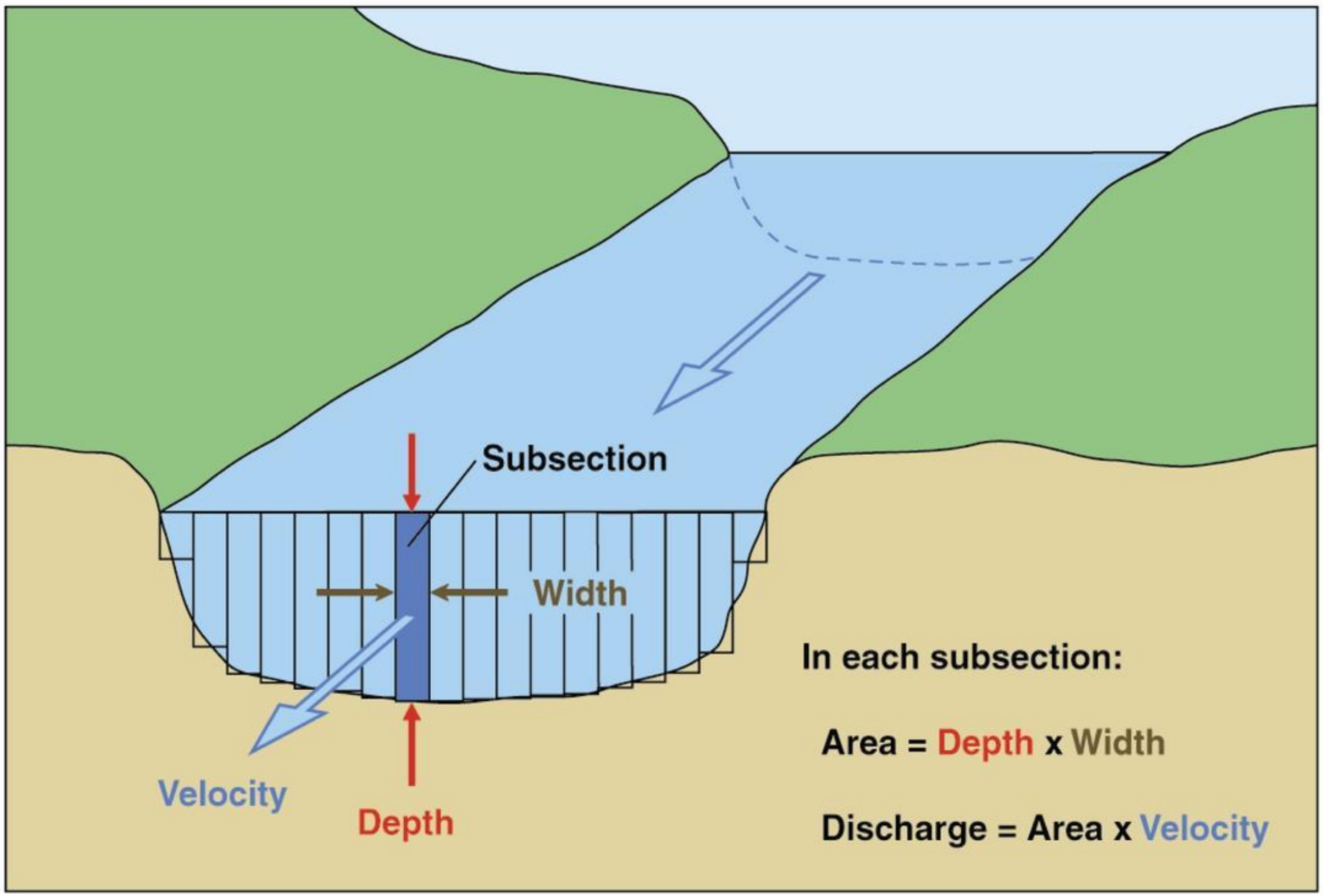
Discharge


Subsection
Width
Velocity
Depth
In each subsection:
Area = Depth x Width
Discharge = Area x Velocity

Sediment

φ scale	Size range (metric)	Size range (approx. inches)	Aggregate name (Wentworth Class)	Other names
< −8	> 256 mm	> 10.1 in	Boulder	
−6 to −8	64–256 mm	2.5–10.1 in	Cobble	
−5 to −6	32–64 mm	1.26–2.5 in	Very coarse gravel	Pebble
−4 to −5	16–32 mm	0.63–1.26 in	Coarse gravel	Pebble
−3 to −4	8–16 mm	0.31–0.63 in	Medium gravel	Pebble
−2 to −3	4–8 mm	0.157–0.31 in	Fine gravel	Pebble
−1 to −2	2–4 mm	0.079–0.157 in	Very fine gravel	Granule
0 to −1	1–2 mm	0.039–0.079 in	Very coarse sand	
1 to 0	½–1 mm	0.020–0.039 in	Coarse sand	
2 to 1	¼–½ mm	0.010–0.020 in	Medium sand	
3 to 2	125–250 µm	0.0049–0.010 in	Fine sand	
4 to 3	62.5–125 µm	0.0025–0.0049 in	Very fine sand	
8 to 4	3.90625–62.5 µm	0.00015–0.0025 in	Silt	Mud
> 8	< 3.90625 µm	< 0.00015 in	Clay	Mud
>10	< 1 µm	< 0.000039 in	Colloid	Mud

http://www.horiba.com/?id=2780

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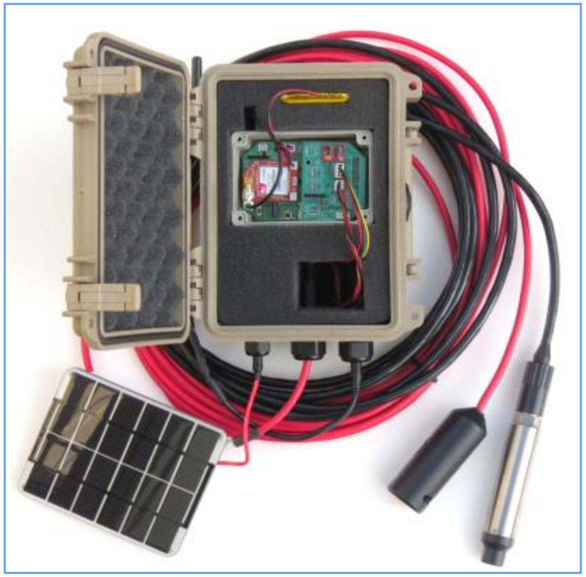
Context

- Delaware River Watershed Initiative, William Penn Foundation
- Citizen Science, Stroud Center facilitation of continuous monitoring using EnviroDIY Mayfly sensor stations
  - ~70 sensor stations deployed across Delaware River Basin
    - Conductivity, Temperature, **Depth** (CTD) and **Turbidity**
    - Solar powered
    - Logging data every 5 minutes
    - Some online, always log to microSD card on-site
  - Stroud Center facilitating use of stations among watershed groups in Delaware Basin (next slide)



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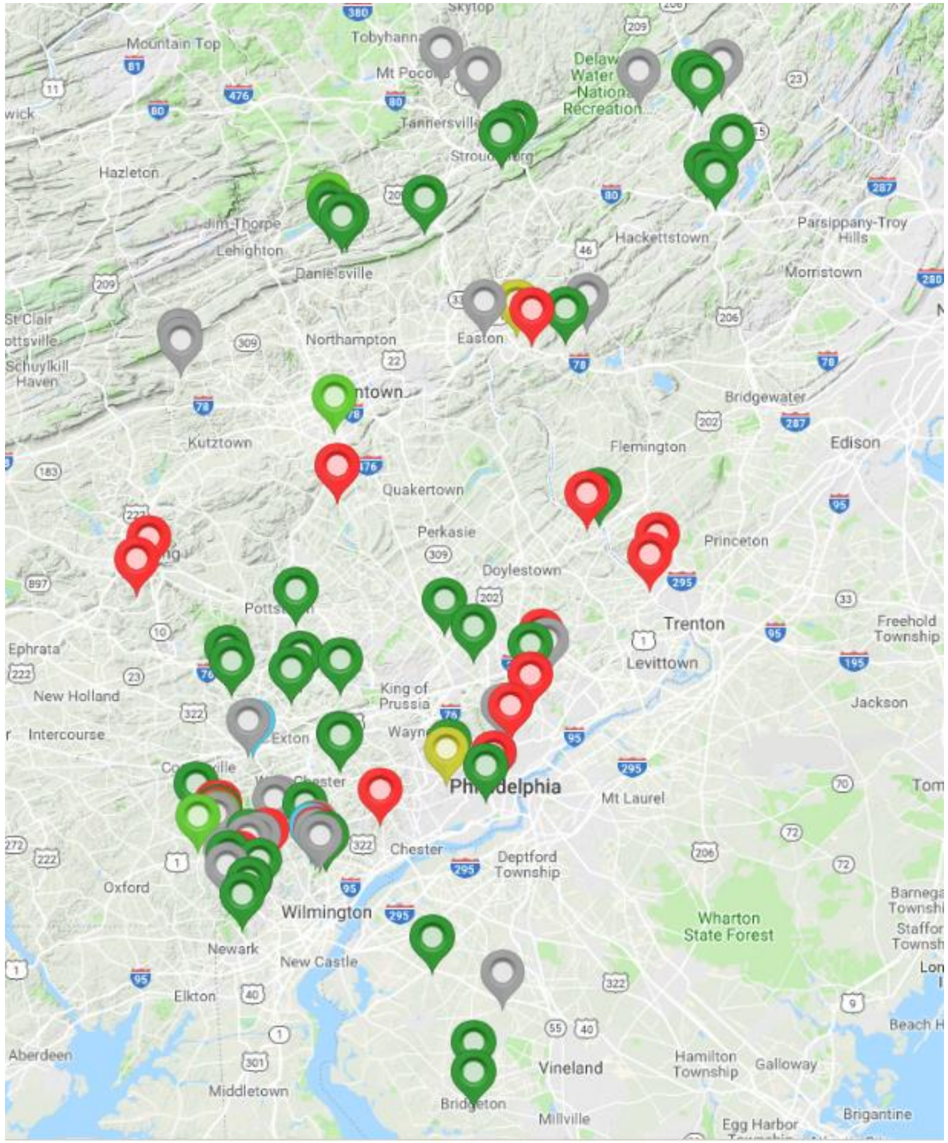
Distribution



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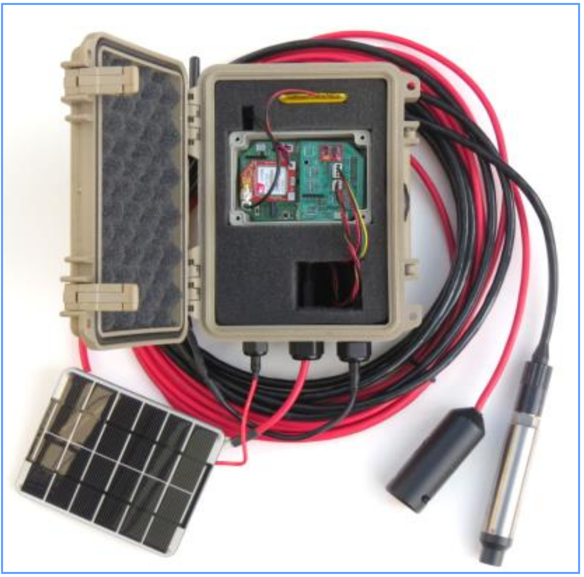


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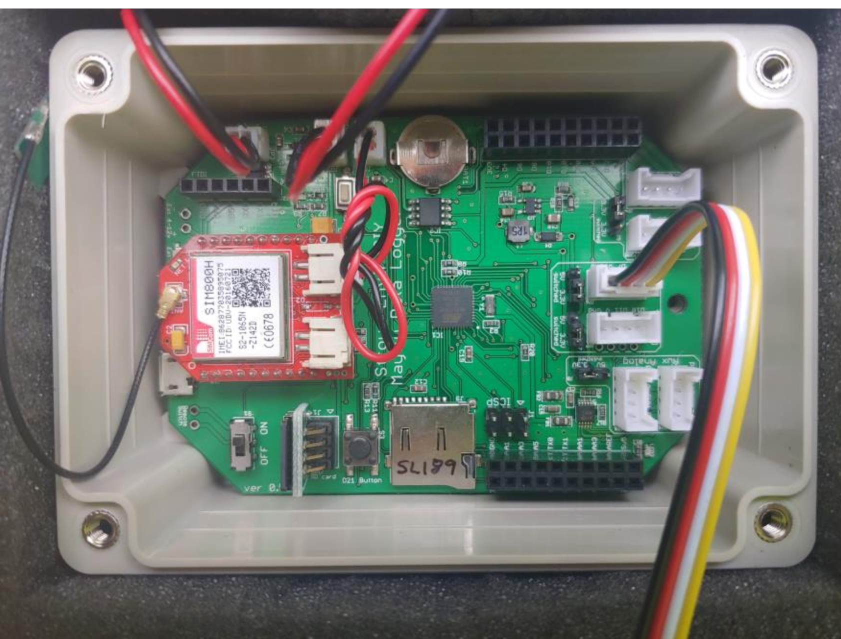

SIM800H
SL189

Ridley Creek SL155

http://drwisensors.dreamhosters.com/

http://drwisensors.dreamhosters.com/charts_main_SL155.php

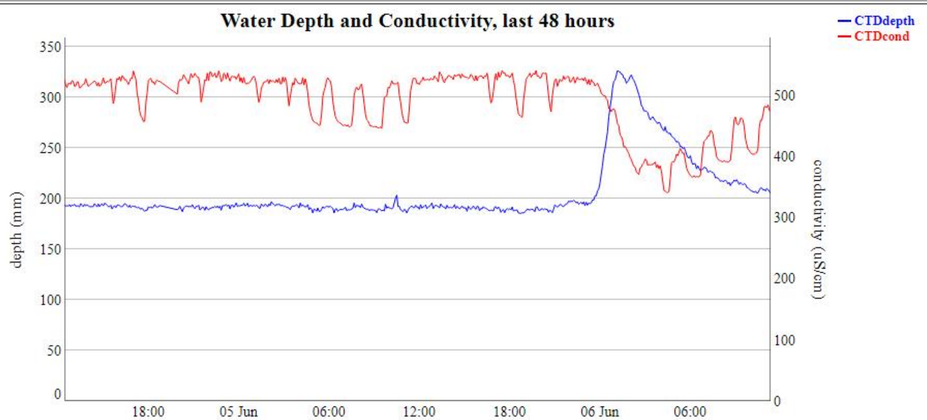
SL155 Turbidity/CTD Logger

This is data from logger SL155.
The logger is equipped with a Decagon CTD which measures water conductivity, temperature, and depth;
and a Campbell Scientific OBS3+ which measures turbidity in two ranges.

Show all data in the database as table or as CSV text
Get raw CSV text file

Latest readings:

At 2019-06-06 11:21:05 EST:
CTD Depth= 205.3mm, CTD Temp= 20.1 degreesC, CTD Conductivity= 474.3 uS/cm
Turbidity Low= 2.4 NTU, Turbidity High= 1.8 NTU, Board Temp= 27.8 degreesC; Battery= 4.02 volts



Historic Data

Water depth

Conductivity

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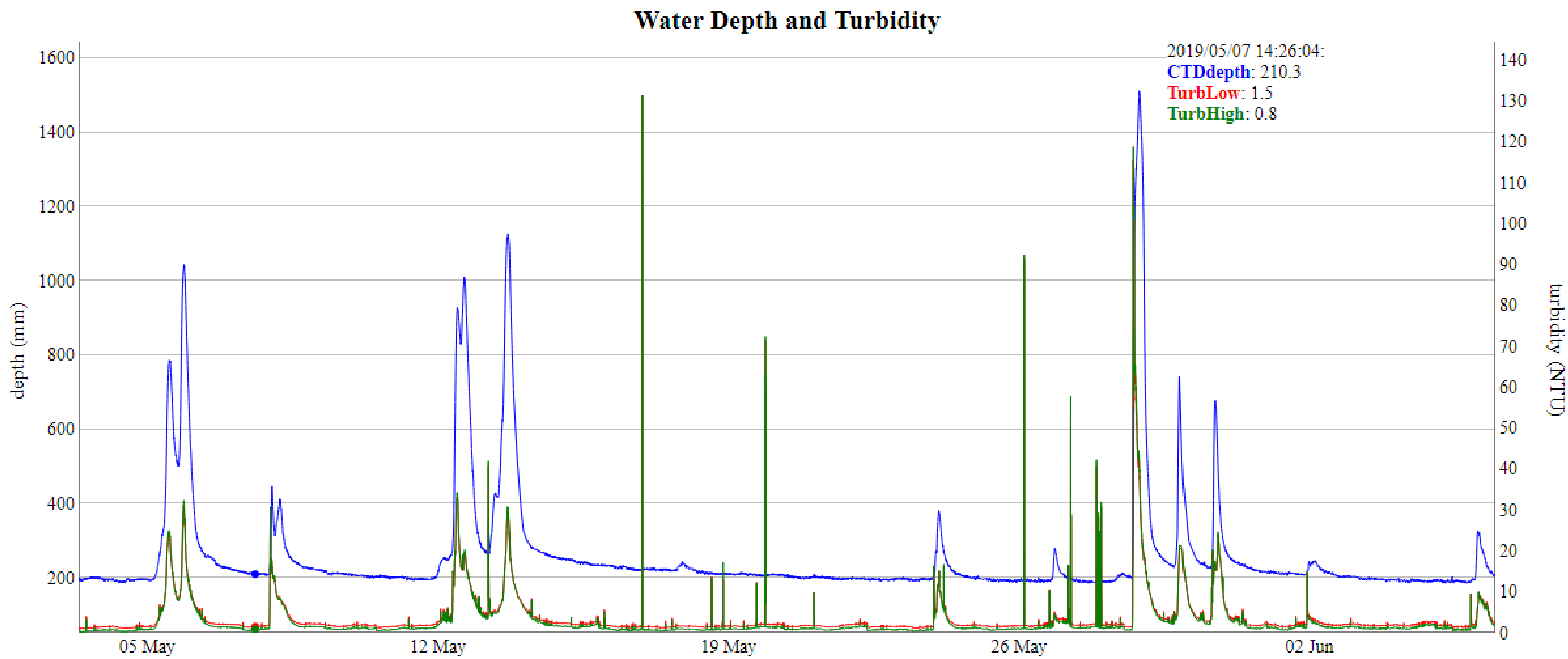
Ridley Creek SL155

http://drwisensors.dreamhosters.com/

http://drwisensors.dreamhosters.com/charts_turb_SL155.php



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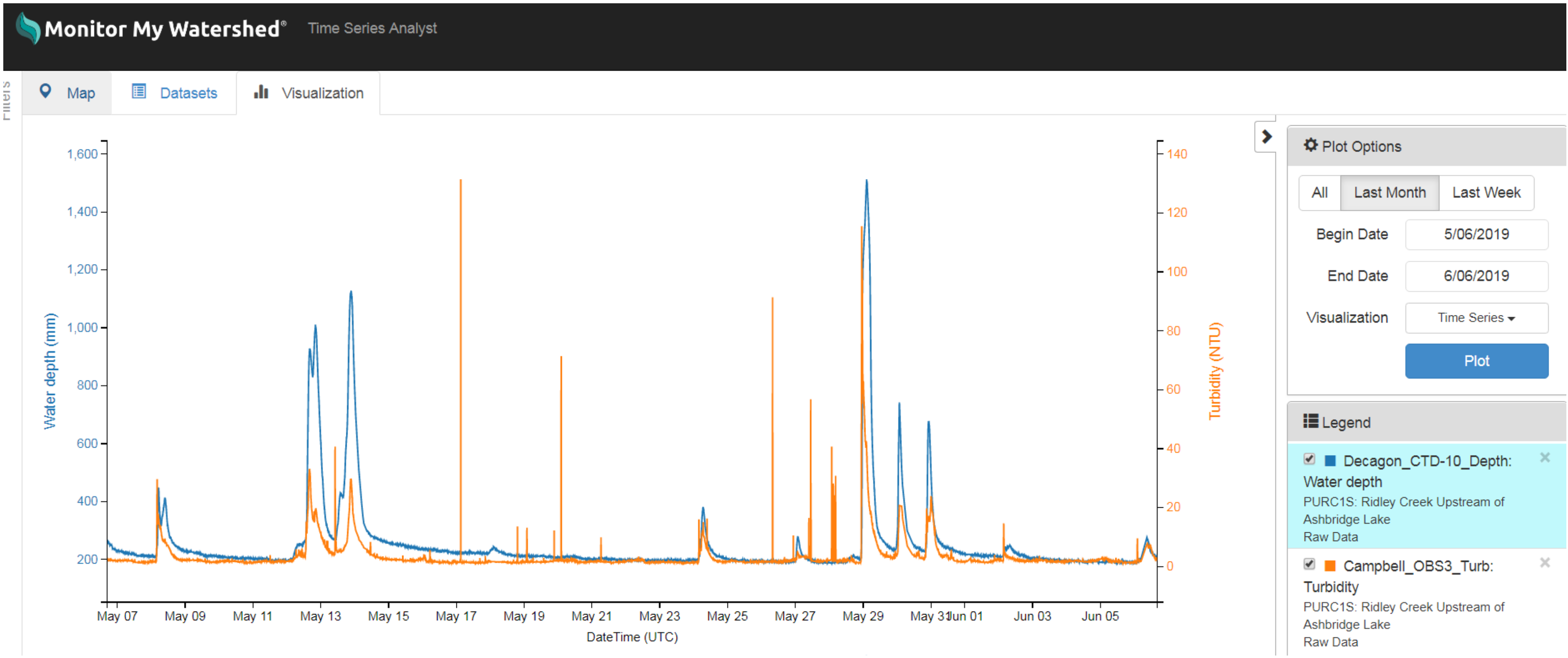
Ridley Creek SL155



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What do the stations have to do with today?

- Developing rating curves to enhance sensor station data – make data more useful
  - Converting **Depth** (mm) to **Discharge** (m^3/s)
  - Converting **Turbidity** (NTU) to **Total Suspended Solids** (mg/L)

*Once rating curves developed you can start to talk about concentrations and quantities of material moving in stream (e.g., “sediment loads”)

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Hydrologic rating curve

- Depth (“stage”) to Discharge

Add A New Discharge Measurement

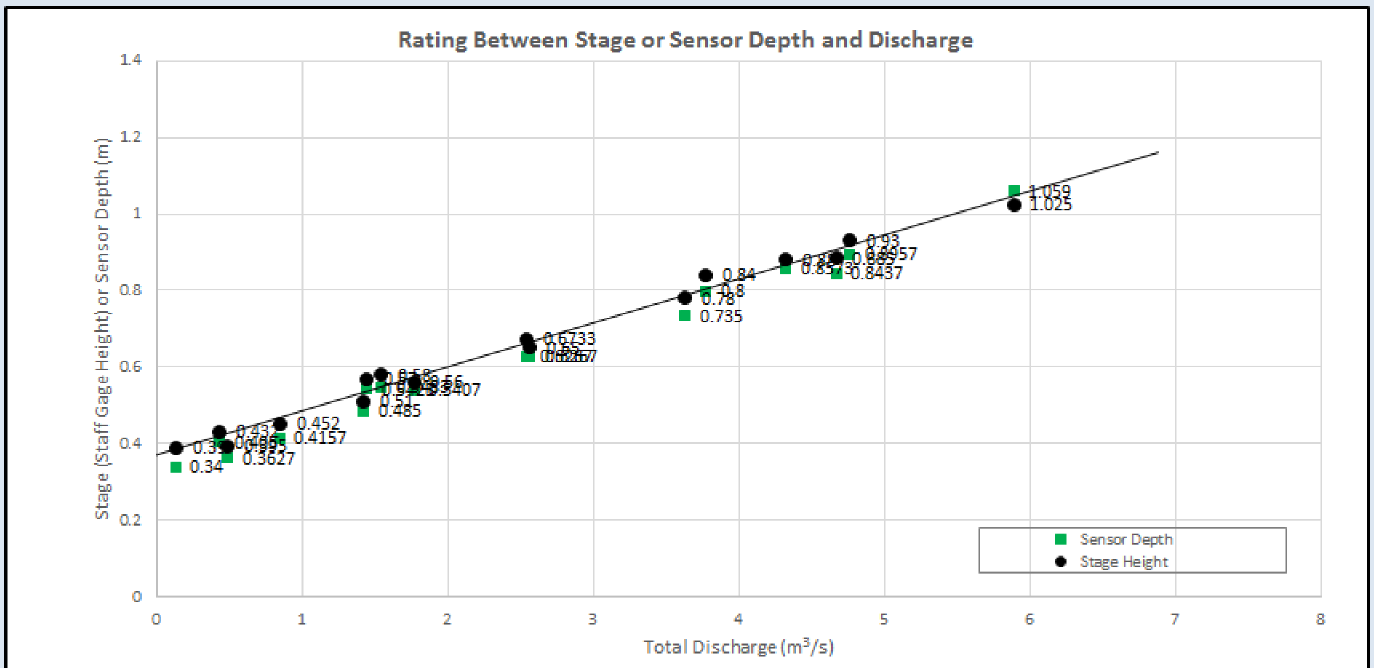
Average Offset between Sensor Depth and Stage: *0.032*

Rating Equation - Discharge to Stage

Total Discharge = (8.624 x Stage) -3.175

Rating Equation - Discharge to Stage plus Sensor Depth Offset

Total Discharge = (8.624 x SensorDepth) -3.143



Data from Pickering Creek at Montgomery School (SHPK5S, SL135)

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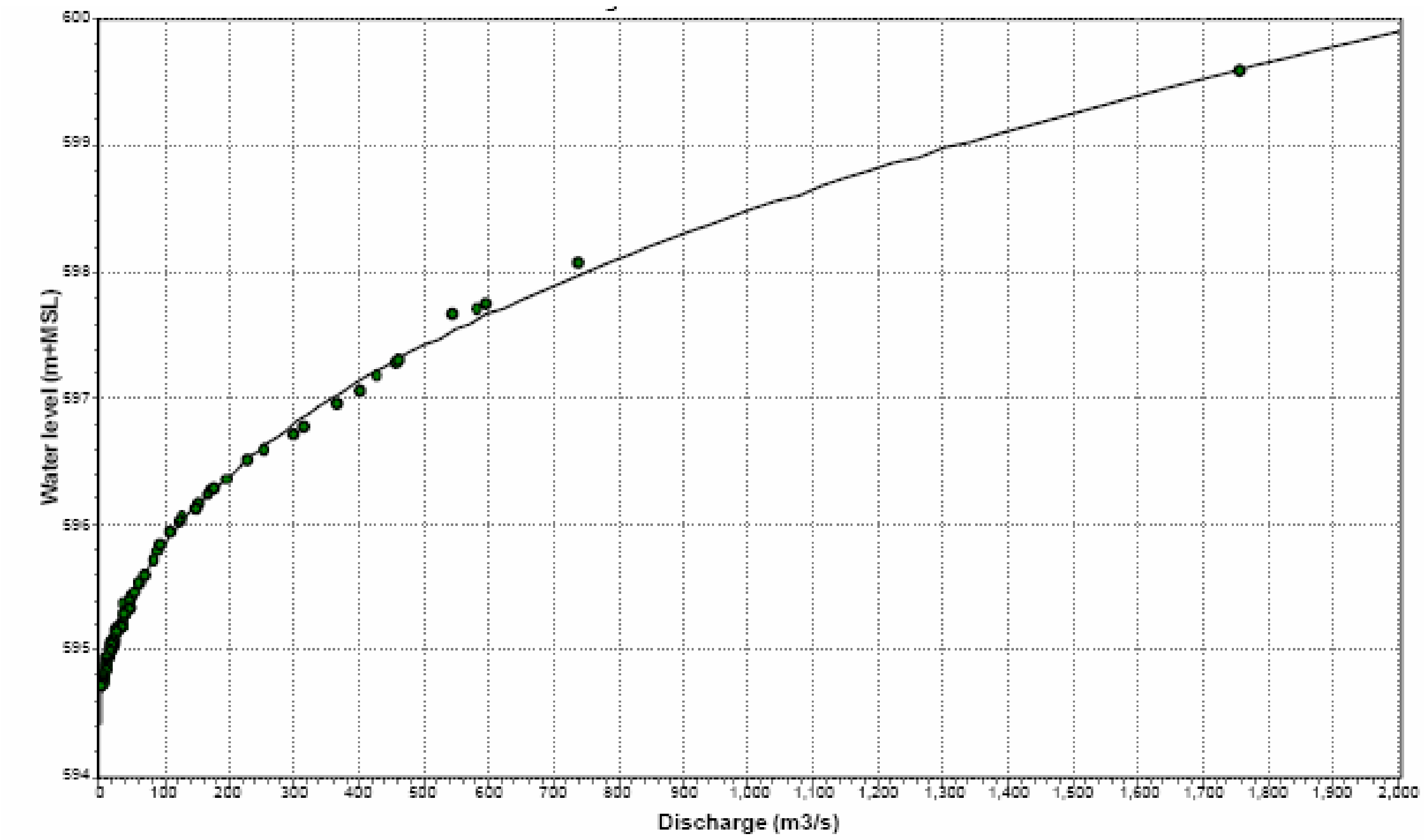
Hydrologic rating curve



Braca, Giovanni. (2019). STAGE-DISCHARGE RELATIONSHIPS IN OPEN CHANNELS: PRACTICES AND PROBLEMS.

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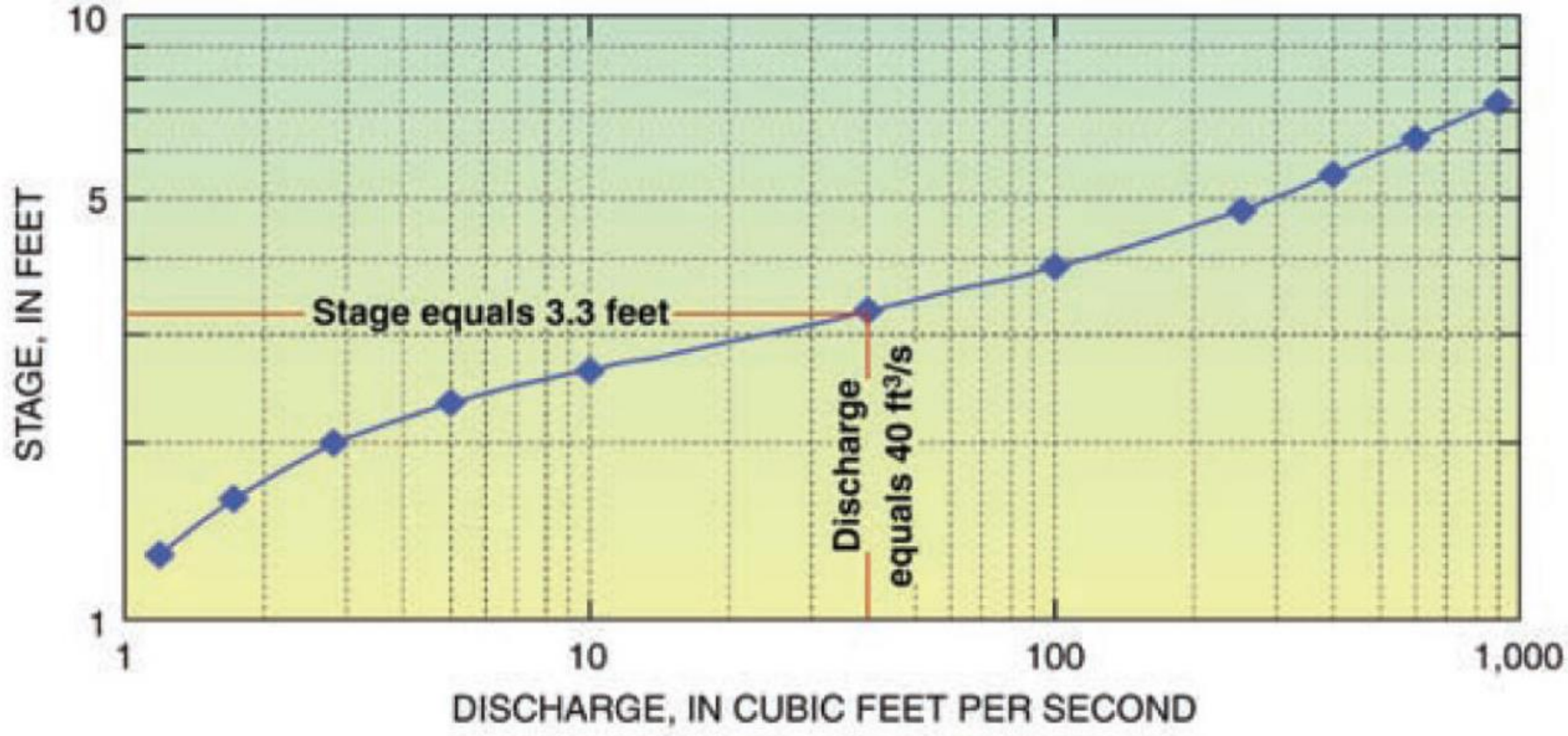
Hydrologic rating curve



https://www.usgs.gov/media/images/usgs-stage-discharge-relation-example

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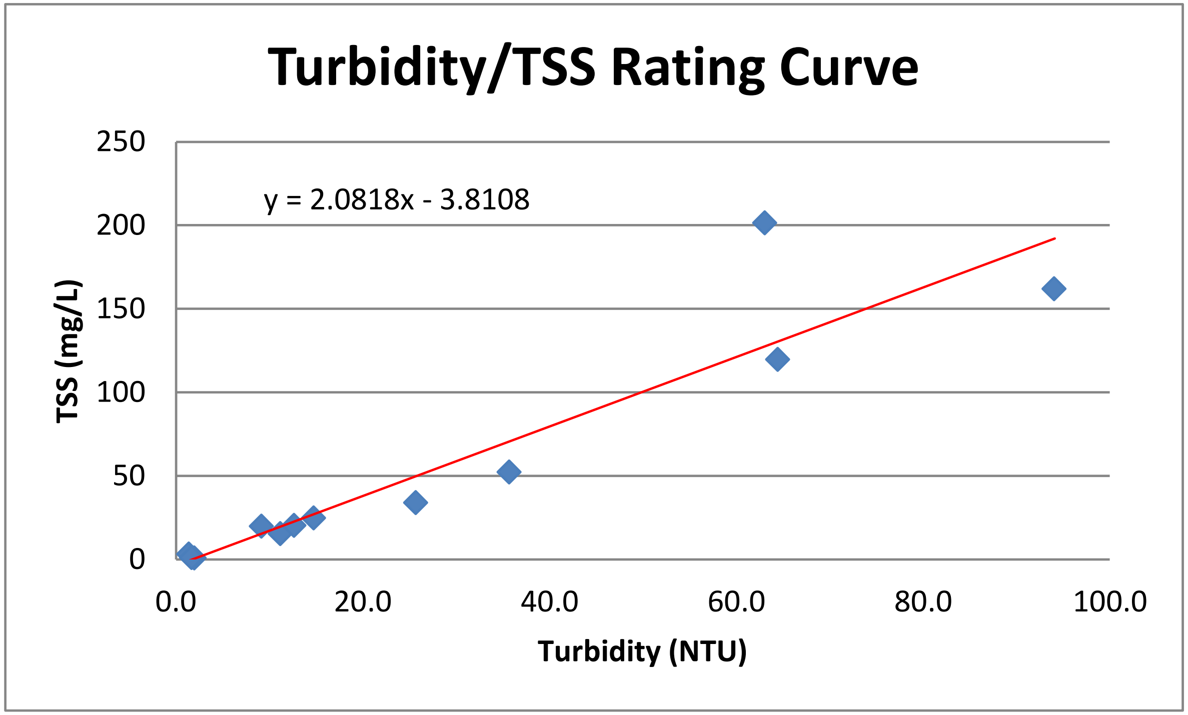
Sediment rating curve

- TSS to Turbidity



Data from Pickering Creek at Montgomery School (SHPK5S, SL135)

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Sediment rating curve

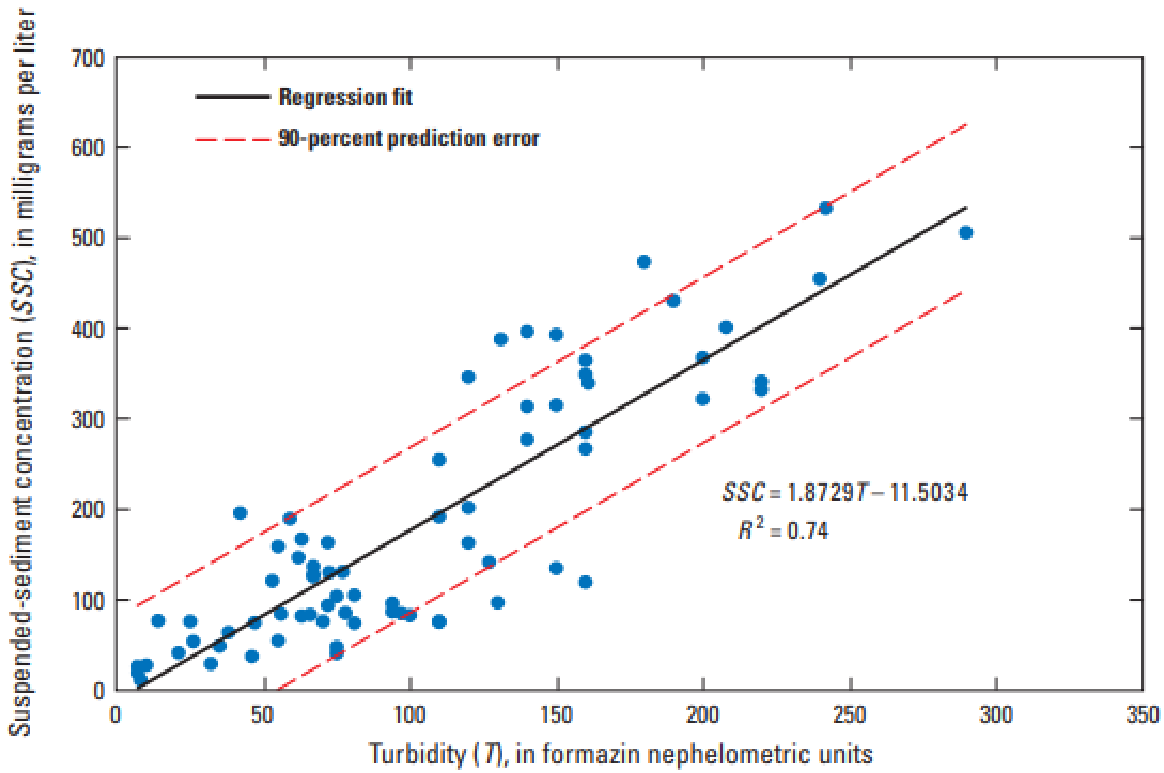

Figure 4. Regression relations of turbidity to suspended-sediment concentration for West Branch Brandywine Creek near Honey Brook, Pennsylvania.

Sloto, R.A., and Olson, L.E., Estimated suspended-sediment loads and yields in the French and Brandywine Creek Basins, Chester County, Pennsylvania, water years 2008–09: U.S. Geological Survey Scientific Investigations Report 2011–5109, 31 p.

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Sediment rating curve

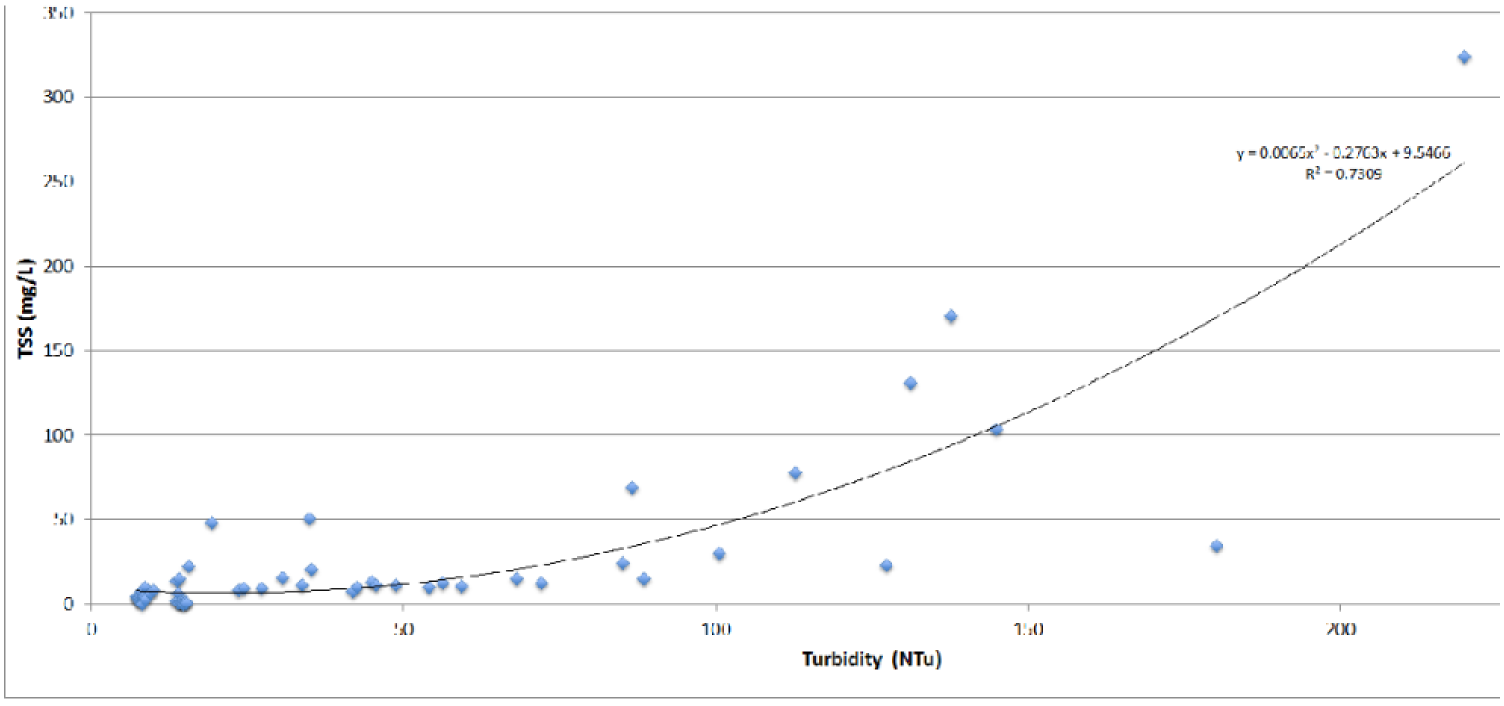

Figure 1. Relationship curve between turbidity and total suspended solids at the Duke Forest site.

Blatt, Ethan et al. "Influences of Windthrow in Forested Stream Buffers." (2015).

What to do with rating curves?

USE THE EQUATION

Apply depth/discharge rating curve equation to Depth data to transform it to Discharge data

Date, time	CTDepth (mm)	Discharge (m^3/s) *Sensor Depth (x) into Discharge Rating Curve*
6/7/19, 8:00a	465.3	0.286
6/7/19, 8:05a	480.4	0.299
6/7/19, 8:10a	491.4	0.308
6/7/19, 8:15a	503.5	0.318
6/7/19, 8:20a	515.3	0.328

**Example only*

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What to do with rating curves?

Apply turb/tss rating curve equation to Turbidity data to transform it to TSS data

Convert L to m3

Multiply by discharge to get sediment amount per second ("flux")

Multiply flux by cumulative time between observations to get sediment load for each block of time

Date, time	Turbidity (NTU)	TSS (mg/L) *Input Turb (x) into TSS Rating Curve*	TSS (mg/m3) *TSS (mg/L) x 1000*	Sediment Flux (mg/s) *Discharge x TSS*	Sediment Load (mg) *Sediment Flux x Time*
6/7/##, 8:00a	8.56	7.95	7953	2280	688579
6/7/##, 8:05a	9.7	10.42	10425	3121	930158
6/7/##, 8:10a	10.79	12.78	12788	3947	1196090
6/7/##, 8:15a	11.27	13.82	13829	4409	1309710
6/7/##, 8:20a	11.74	14.84	14848	4882	1459852

Sum to get individual storm, daily, monthly, seasonal loads, etc.

**Example only*

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Context

- Citizen Science, Stroud Center facilitation of usage of EnviroDIY sensor stations
  - Technical support, troubleshooting, etc.
  - Coordinating efforts among managers, volunteers/citizen scientists, professional scientists, teachers, students
  - Online tools
    - **Sensor station data: Monitor My Watershed (**http://monitormywatershed.org/)
    - **Sensor station data:** http://drwisensors.dreamhosters.com/ **- SL155 for today**
    - Delaware Basin Sensor Stations online group (private group via https://wikiwatershed.org/)
    - EnviroDIY (https://www.envirodiy.org/)
  - Manuals and guidance materials – all posted to online group and available from Stroud Center
  - Data sheets - Field Visit Data sheet, **Stream Discharge Data sheet**
  - Data analysis tools – **Stage to Area predictor, discharge rating curve calculator, load calculator**
  - Workshops, trainings, user group meetings, 1:1 work
  - Presentations and articles

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Stroud support

- Citsci support personnel
  - **David Bressler**, Stroud – main contact
  - **Shannon Hicks**, Stroud – high level technical support
  - **Rachel Johnson**, Stroud – technical support, field assistance, small workshop facilitation
  - **Matt Gisondi**, Stroud – data analysis (rating curves, loads), field assistance, 1:1 training
  - **Christa Reeves**, Stroud/Musconetcong WA – regional assistance, northern Delaware Basin
  - **Carol Armstrong**, Stroud/PSU Master Watershed Stewards – citizen science volunteer assistance, field maintenance and storm sampling, PSU Master Watershed Stewards mentor
  - **WHAT (Yake/Waggoner/Ward)** – Watershed Hydrological Assessment Team, technical support on hydrology and sediment
  - **Dave Arscott** (ex dir), **John Jackson** (senior sci), and **Matt Ehrhart** (dir of restoration) – original citsci project designers

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Important Field Work

- **Maintenance – every two weeks**
  - Clean sensors
  - Clean around logger
  - Complete Field Visit Data sheet
  - Other site observations, upkeep, photos, etc.
  - Enter data online - https://wikiwatershed.org/drwi/; pass: drwi

- **Quality Control – quarterly**
  - Clean sensors
  - QC Depth
  - QC Chemistry
  - SD card swapping (data download)

Biweekly – Maintenance and sensor cleaning

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EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):

Site ID:	LoggerID:
Stream Name:	Location:
GPS (Lat/Long):	Date: Arrival Time: AM/PM? *EST/EDT?
Photos? Yes/No	*EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)
Precipitation last 24 Hours? Yes/No Amount:	Water Clarity (Clear, Cloudy, Muddy):

General Notes/ Photo Descriptions:

SENSOR CLEANING (*Recommended frequency: weekly or biweekly; monthly if only CTD sensor*)

*Cleaned Sensors? Yes/No If Yes, exact time: AM/PM? EST/EDT? **Clean >5 min. before grab sampling*

GRAB SAMPLES (*Rec frequency: Situational; for rating curves, collect when water is high/turbid or higher than normal conductivity*)

Grab Sample Taken? Yes/No	Time collected (to minute): AM/PM? EST/EDT?
Sample Number:	Volume:
Bottle Type:	Date Shipped:
Lab Sent To:	Notes:

*SENSOR STATION DATA TO MATCH WITH GRAB SAMPLE LAB RESULTS (*Complete in field or office*)

Sensor station Conductivity (uS/cm):	Time (military):	Not applicable	Always EST
Sensor station Turbidity (NTU):	Time (military):	Not applicable	Always EST

**For use in Turbidity/TSS and Conductivity/Chloride rating curve development. Record sensor station Cond and Turb data at time nearest to grab sample collection time. Can be completed in field (by accessing online data) or in office (online or download from microSD card). Acquire final grab sample lab results from Stroud Center (or lab that processed sample).*

QUALITY CONTROL - WATER LEVEL DATA (*Rec frequency: quarterly and/or more frequently as needed*)

[a]Staff Gauge Height (m):	Time:	AM/PM?	EST/EDT?
[a]Sensor Station Water Depth (mm):	Time (military):	Not applicable	Always EST
[b]QC Sensor Station Water Depth (mm):	Time:	AM/PM?	EST/EDT?

Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):

a - Staff Gauge Height and Sensor Station Water Depth readings should be from about the same time (+/- 5 minutes).
b - Use metric ruler to measure from pressure transducer (white disc in CTD sensor) to water surface. Note - this depth measure may be slightly different from the sensor-measured depth but should be consistent over time.

QUALITY CONTROL - CHEMISTRY DATA (*Rec frequency: quarterly and/or more frequently as needed*)

Parameter	QC Hand-held Meter Result	QC Time	QC AM/PM?	QC EST/EDT?	Sensor Station Result	Sensor Station-Time (Military, EST)
Conductivity (uS/cm):			AM/PM	EST/EDT		
Temperature (degC):			AM/PM	EST/EDT		
Turbidity (NTU):			AM/PM	EST/EDT		
Dissolved Oxygen (mg/L):			AM/PM	EST/EDT		

QUALITY CONTROL CHEMISTRY FIELD METER INFORMATION

Parameter	Field Meter Brand/Model/Serial # or unique ID	Meter calibrated?	Standard	Calibration
Conductivity (uS/cm):		Yes/No		
Temperature (degC):		Yes/No		
Turbidity (NTU):		Yes/No		
Dissolved Oxygen (mg/L):		Yes/No		

SENSOR STATION MAINTENANCE

Sensors Submerged? Yes/No
If no or partially, describe in Notes.

Location of Sensors Changed? Yes/No
If yes, explain in notes. **Please consult Stroud Center before changing location of sensors.*

Retrieved Memory Card? Yes/No
(Rec frequency for QC: quarterly if online; biweekly-monthly if not online)

Changed Batteries? Yes/No

Cleaned Solar Panel? Yes/No

Other sensor station maintenance? Yes/No
(If Yes, describe in Notes)

Notes (Describe specific sensor station management actions and any other issues):

OTHER IN-SITU PARAMETERS (e.g., Nitrate, Phosphate, Chloride, pH, Dissolved Oxygen)

Parameter	Result	Brand/Model

OTHER INFORMATION

Field Duplicate Taken of Grab Sample? Yes/No	Flow Measurement w/ Neutrally Buoyant Object? Yes/No
Performed Cross Section Survey? Yes/No	Flow Measurement w/ another method? Yes/No
Flow Measurement w/ Flow Meter? Yes/No	If Yes, explain in Notes

Quarterly – Quality Control

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EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):

Site ID: | LoggerID:
Stream Name: | Location:
GPS (Lat/Long): | Date: Arrival Time: AM/PM? *EST/EDT?
Photos? Yes/No | *EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)
Precipitation last 24 Hours? Yes/No Amount: | Water Clarity (Clear, Cloudy, Muddy):

General Notes/ Photo Descriptions:

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*Cleaned Sensors? Yes/No If Yes, exact time: AM/PM? EST/EDT? *Clean >5 min. before grab sampling*

GRAB SAMPLES (*Rec frequency: Situational; for rating curves, collect when water is high/turbid or higher than normal conductivity*)

Grab Sample Taken? Yes/No | Time collected (to minute): AM/PM? EST/EDT?
Sample Number: | Volume:
Bottle Type: | Date Shipped:
Lab Sent To: | Notes:

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[a]Staff Gauge Height (m):	Time:	AM/PM?	EST/EDT?
[a]Sensor Station Water Depth (mm):	Time (military):	Not applicable	Always EST
[b]QC Sensor Station Water Depth (mm):	Time:	AM/PM?	EST/EDT?
Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):			

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Conductivity (uS/cm):			AM/PM	EST/EDT		
Temperature (degC):			AM/PM	EST/EDT		
Turbidity (NTU):			AM/PM	EST/EDT		
Dissolved Oxygen (mg/L):			AM/PM	EST/EDT		

QUALITY CONTROL CHEMISTRY FIELD METER INFORMATION

Parameter	Field Meter Brand/Model/Serial # or unique ID	Meter calibrated?	Standard	Calibration
Conductivity (uS/cm):		Yes/No		
Temperature (degC):		Yes/No		
Turbidity (NTU):		Yes/No		
Dissolved Oxygen (mg/L):		Yes/No		

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Parameter	Result	Brand/Model

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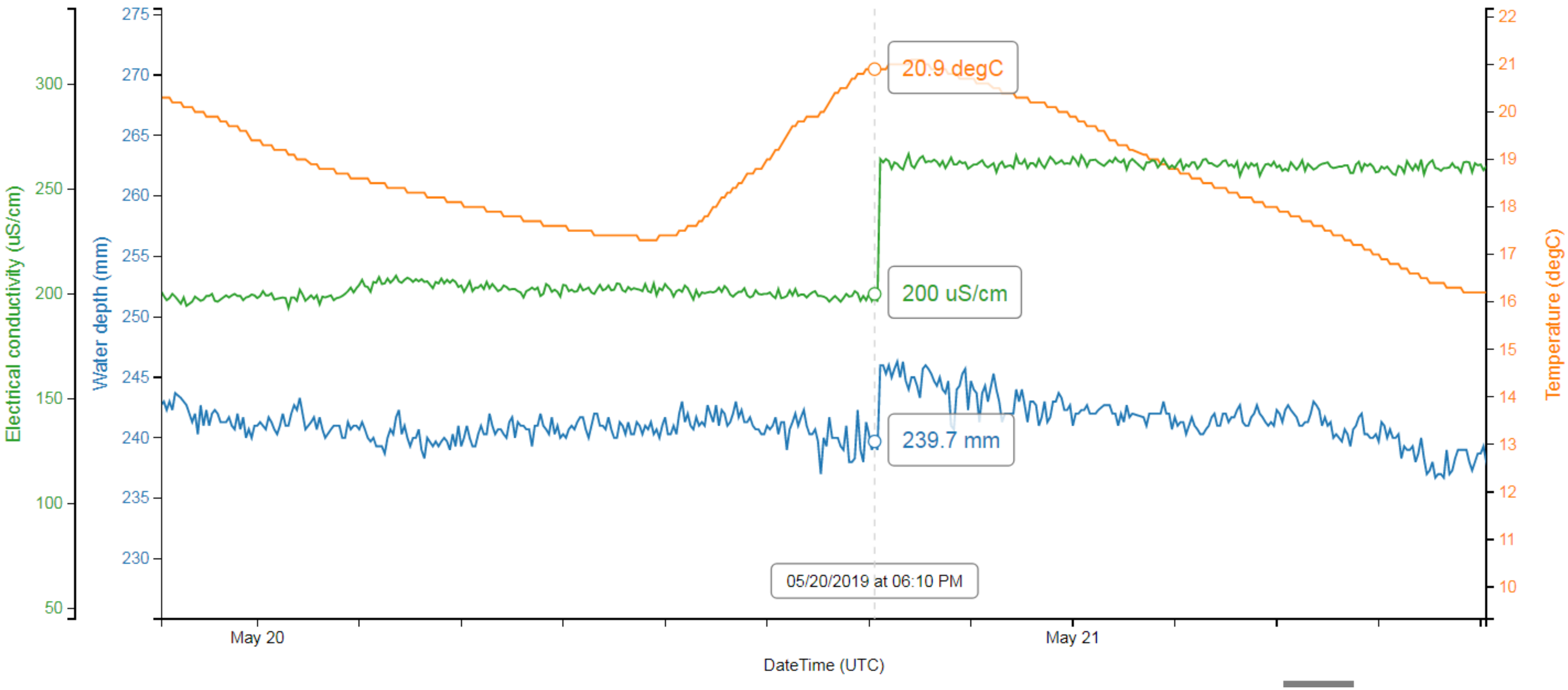
Performed Cross Section Survey? Yes/No
Flow Measurement w/ Flow Meter? Yes/No
Flow Measurement w/ Neutrally Buoyant Object? Yes/No
Flow Measurement w/ another method? Yes/No
If Yes, explain in Notes

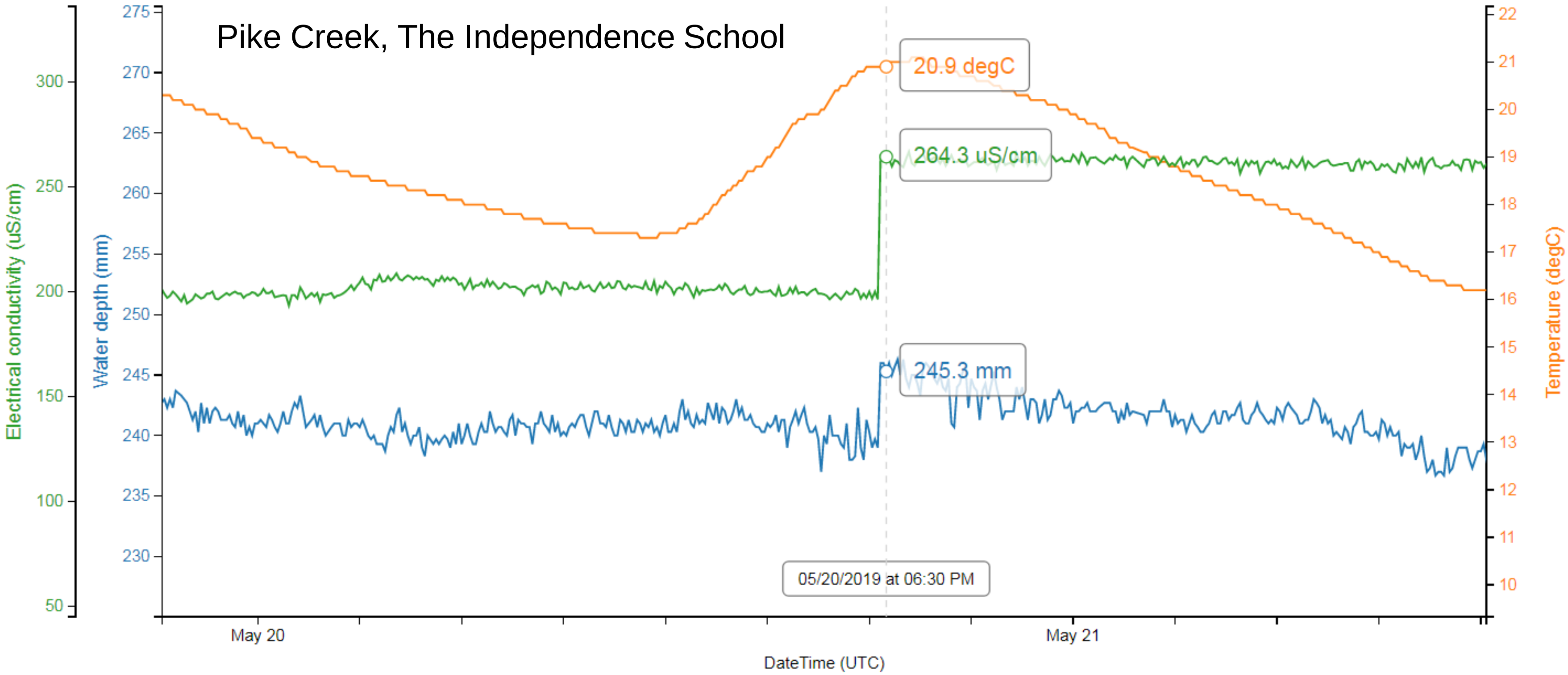
Importance of sensor cleaning and QC

Pike Creek, The Independence School



Conductivity, temperature and depth readings _before_ cleaning

Importance of sensor cleaning and QC



Conductivity, temperature and depth readings *<u>after</u>* cleaning

<u>Conductivity</u> change of ~60 uS/cm
<u>Depth</u> change of ~5mm;
<u>Temp</u> change of 0 deg C

Manuals

- EnviroDIY Sensor Station Operation Manual V1, DRWI
  - Operation manual for CTD/Turbidity EnviroDIY sensor stations (Delaware River Watershed Initiative context)
  - Access web link via Delaware Basin Sensor Station online group, Uploaded Files tab, “Guidance docs” category; link: https://docs.google.com/document/d/17iWKFOjD6tSFT6-a5mItXlgO8uhXjsA_voGDVRxEBTI/edit?usp=sharing

- EnviroDIY Mayfly Sensor Station Manual
  - Comprehensive – building, coding, installation, management
    - Does not contain DRWI specific info, e.g., online EnviroDIY Field Visit Data sheet
    - Access via EnviroDIY.org: https://www.envirodiy.org/mayfly-sensor-station-manual/

Videos

- Stroud sensor station video tutorials:
  - Installation
    - https://www.envirodiy.org/videos/
    - Youtube: https://www.youtube.com/results?search_query=envirodiy+mayfly+data+logger+steps+1-5
    - Link also on Delaware Basin Sensor Stations online group forum
  - Sensor cleaning
  - Data download
  - Sensor bundle removal
  - Discharge calculator, Stage-to-Area predictor, Load calculator

Delaware Basin Sensor Station online group

- Weekly reports from Carol Armstrong
- General updates from Bressler
- **Uploading lab results, rating curves, etc.**
- Uploaded Files tab – multiple categories – lots of files here
- Guidance docs for use of the site and the forum
- Forum topics – important ones pinned to the top

Stroud Water Research Center

Stream Discharge Data sheet

Names of all individuals involved on-site

Decimal degrees

Information on specific flow meter used for measurements

SiteID = specific site identifier

Identifier for specific data logger (depth and/or turbidity)

General locational info, e.g., ~100m upstream of Rte 1 bridge

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Stream Discharge Data

Name(s):

Site ID:	GPS (Lat/Long):		Velocity Meter Type:
Logger ID:	Date:	Staff Gage Height at start (m):	Serial Number:
Stream Name:	Start Time: AM / PM	Staff Gage Height at end (m):	
	StopTime: AM / PM	Sensor-Reported Water Depth at start (mm):	Calibration Date:
Location:	Time Zone: EST / EDT	Sensor-Reported Water Depth at end (mm):	

CROSS SECTION AND VELOCITY

When safely wadeable, take a wetted cross section measurement, recording the distance along the measuring tape (tagline) and the water depth across the stream. The tagline should be strung between the bank pins. If a velocity meter is available, record the water velocity at each interval. Make note of the RPIN/LPIN (right/left bank pin) and REW/LEW (right/left edge of water). Right and left are determined when facing downstream. If wadeable, whether using a flow meter or neutrally buoyant object, always record Points to Note, Distance Along Tagline, and Water Depth. If not wadeable, use Predicted Wetted Cross Sectional Area estimate (from StagetoAreaPredictor spreadsheet) and measure/record velocity data in Neutrally Buoyant Object section (right) or Unwadeable Flow Meter Velocity section (back).

Point	Points to Note LPIN/RPIN LEW/REW	Distance Along Tagline (m)	Water Depth (m)	Velocity (m/s) (Using Flow Meter)	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

NEUTRALLY BUOYANT OBJECT

Float object through main path of the stream. The measured transect should be halfway between the start and stop point. The total distance should be enough to ensure a travel time of >5 seconds.

TOTAL Travel Distance (m):

Start-to-Transect Distance (m):

Transect-to-End Distance (m):

Float #	Travel Time (seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Stream Discharge Data sheet

Exact time when measurements started

Exact time when measurements ended

EST = Eastern Standard Time - for 2017/2018 EST was from November 5, 2017 to March 11, 2018

EDT = Eastern Daylight Time – for 2018 EST is from Sunday, March 11, 2:00am to Sunday, November 4, 2:00am

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Stream Discharge Data

Name(s):

Site ID:	GPS (Lat/Long):		Velocity Meter Type:
Logger ID:	Date:	Staff Gage Height at start (m):	Serial Number:
Stream Name:	Start Time: AM / PM	Staff Gage Height at end (m):	
Location:	StopTime: AM / PM	Sensor-Reported Water Depth at start (mm):	Calibration Date:
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Float #	Travel Time (seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Stream Discharge Data sheet

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Stream Discharge Data

Name(s):

Site ID:

GPS (Lat/Long):

...eter Type:

Logger ID:

Date:

Staff Gage Height at start (m):

Staff Gage Height at end (m):

Serial Number:

Stream Name:

Start Time: AM / PM

StopTime: AM / PM

Sensor-Reported Water Depth at start (mm):

Sensor-Reported Water Depth at end (mm):

Calibration Date:

Location:

Time Zone: EST / EDT

CROSS SECTION AND VELOCITY

When safely wadeable, take a wetted cross section measurement, recording the distance along the measuring tape (tagline) and the water depth across the stream. The tagline should be strung between the bank pins. If a velocity meter is available, record the water velocity at each interval. Make note of the RPIN/LPIN (right/left bank pin) and REW/LEW (right/left edge of water). Right and left are determined when facing downstream. If wadeable, whether using a flow meter or neutrally buoyant object, always record Points to Note, Distance Along Tagline, and Water Depth. If not wadeable, use Predicted Wetted Cross Sectional Area estimate (from StagetoAreaPredictor spreadsheet) and measure/record velocity data in Neutrally Buoyant Object section (right) or Unwadeable Flow Meter Velocity section (back).

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Start-to-Transect Distance (m):

Transect-to-End Distance (m):

Float #	Travel Time (seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Water level as measured by staff gauge at time when flow measurements started and when flow measurements finished

Water level as measured depth sensor at time when flow measurements started and when flow measurements finished

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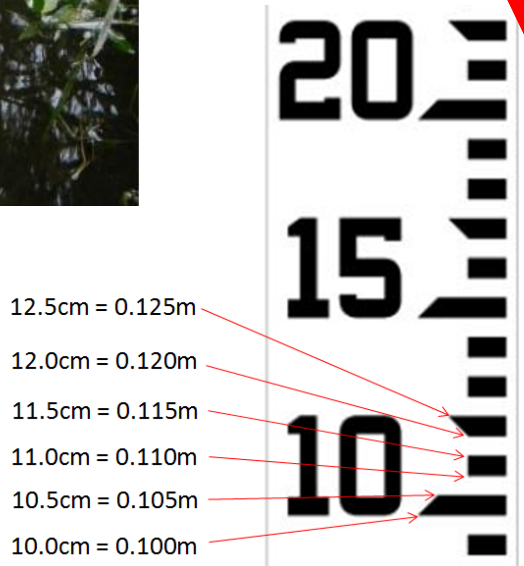
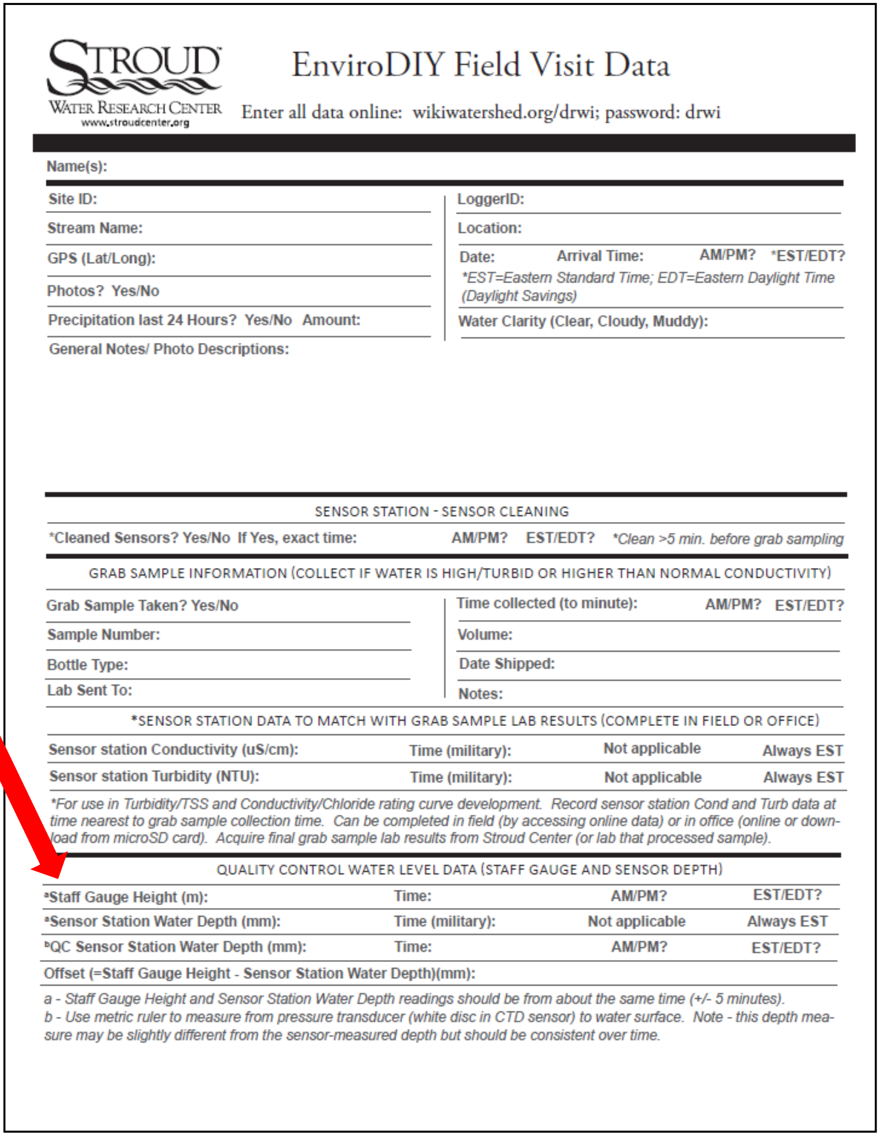
QUALITY CONTROL WATER LEVEL DATA

Staff Gauge Height:
On-site visual measure of water depth; this is used for QC of sensor depth and also used for discharge/depth rating curve





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EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):

Site ID:	LoggerID:
Stream Name:	Location:
GPS (Lat/Long):	Date: Arrival Time: AM/PM? *EST/EDT?
Photos? Yes/No	*EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)
Precipitation last 24 Hours? Yes/No Amount:	Water Clarity (Clear, Cloudy, Muddy):

General Notes/ Photo Descriptions:

SENSOR STATION - SENSOR CLEANING

*Cleaned Sensors? Yes/No If Yes, exact time: AM/PM? EST/EDT? *Clean >5 min. before grab sampling

GRAB SAMPLE INFORMATION (COLLECT IF WATER IS HIGH/TURBID OR HIGHER THAN NORMAL CONDUCTIVITY)

Grab Sample Taken? Yes/No	Time collected (to minute): AM/PM? EST/EDT?
Sample Number:	Volume:
Bottle Type:	Date Shipped:
Lab Sent To:	Notes:

*SENSOR STATION DATA TO MATCH WITH GRAB SAMPLE LAB RESULTS (COMPLETE IN FIELD OR OFFICE)

Sensor station Conductivity (uS/cm):	Time (military):	Not applicable	Always EST
Sensor station Turbidity (NTU):	Time (military):	Not applicable	Always EST

*For use in Turbidity/TSS and Conductivity/Chloride rating curve development. Record sensor station Cond and Turb data at time nearest to grab sample collection time. Can be completed in field (by accessing online data) or in office (online or download from microSD card). Acquire final grab sample lab results from Stroud Center (or lab that processed sample).

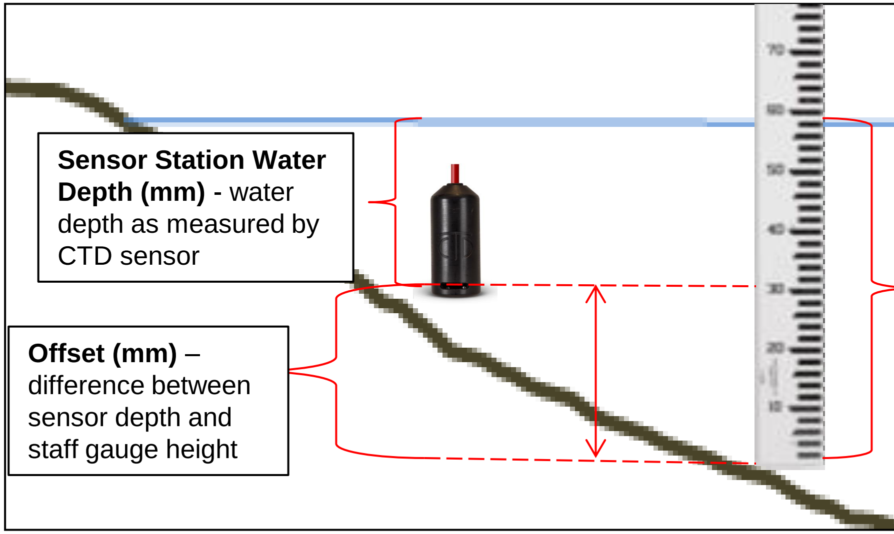
QUALITY CONTROL WATER LEVEL DATA (STAFF GAUGE AND SENSOR DEPTH)

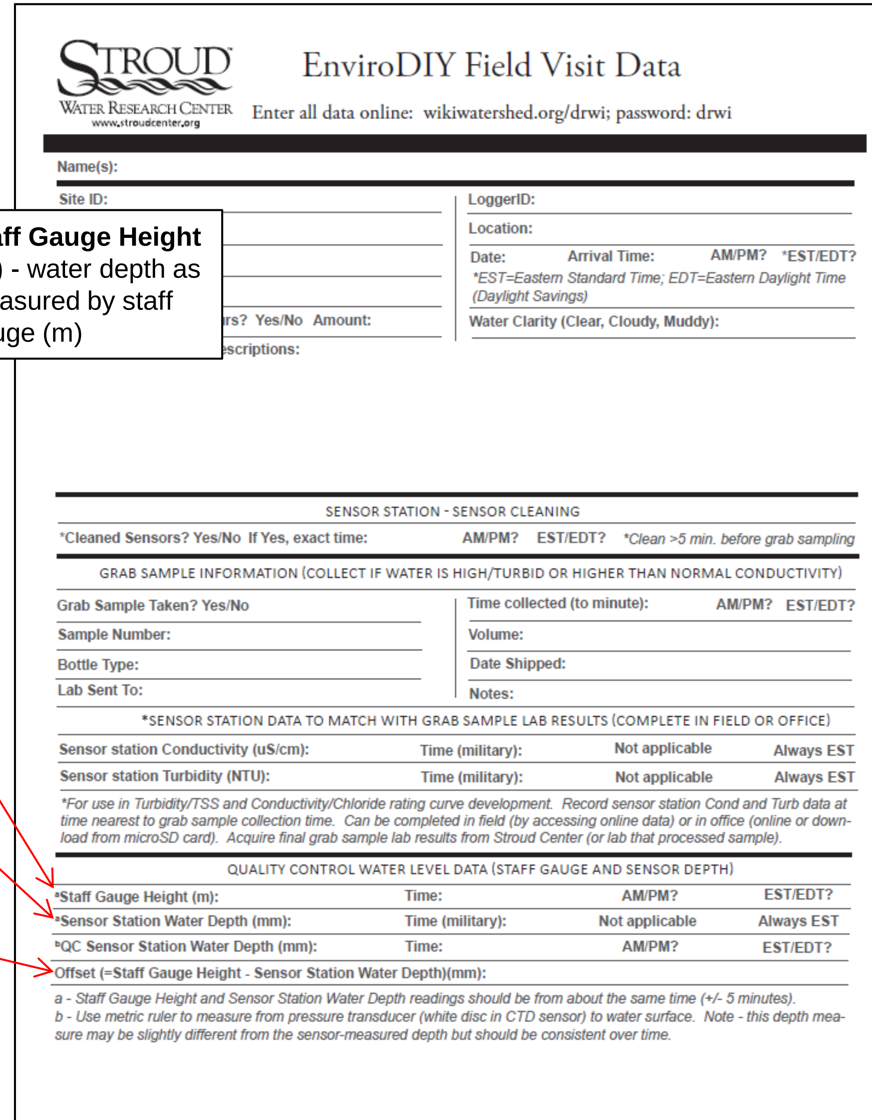
aStaff Gauge Height (m):	Time:	AM/PM?	EST/EDT?
aSensor Station Water Depth (mm):	Time (military):	Not applicable	Always EST
bQC Sensor Station Water Depth (mm):	Time:	AM/PM?	EST/EDT?

Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):

a - Staff Gauge Height and Sensor Station Water Depth readings should be from about the same time (+/- 5 minutes).
b - Use metric ruler to measure from pressure transducer (white disc in CTD sensor) to water surface. Note - this depth measure may be slightly different from the sensor-measured depth but should be consistent over time.

QUALITY CONTROL WATER LEVEL DATA

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EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):

Site ID:

LoggerID:

Location:

Date: Arrival Time: AM/PM? *EST/EDT?

*EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)

rs? Yes/No Amount:

Water Clarity (Clear, Cloudy, Muddy):

escriptions:

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*Cleaned Sensors? Yes/No If Yes, exact time: AM/PM? EST/EDT? *Clean >5 min. before grab sampling

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Grab Sample Taken? Yes/No

Time collected (to minute): AM/PM? EST/EDT?

Sample Number:

Volume:

Bottle Type:

Date Shipped:

Lab Sent To:

Notes:

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Sensor station Conductivity (uS/cm): Time (military): Not applicable Always EST

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QUALITY CONTROL WATER LEVEL DATA (STAFF GAUGE AND SENSOR DEPTH)

[a]Staff Gauge Height (m): Time: AM/PM? EST/EDT?

[a]Sensor Station Water Depth (mm): Time (military): Not applicable Always EST

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Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):

a - Staff Gauge Height and Sensor Station Water Depth readings should be from about the same time (+/- 5 minutes).
b - Use metric ruler to measure from pressure transducer (white disc in CTD sensor) to water surface. Note - this depth measure may be slightly different from the sensor-measured depth but should be consistent over time.

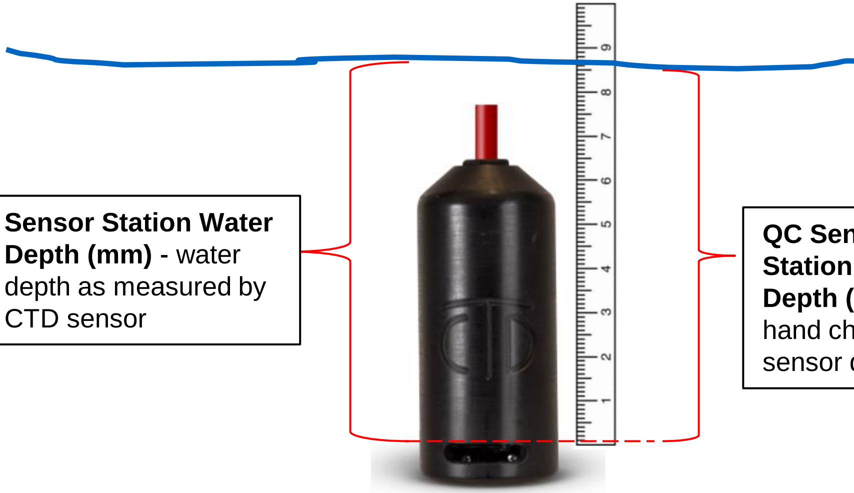
Staff Gauge Height – on-site visual measure of water depth; this is used for QC of sensor depth and also used for discharge/depth rating curve

Sensor Station Water Depth – water depth as measured by the CTD sensor

Offset – difference between water depth as measured by staff gauge and water depth as measured by CTD sensor (*see above diagram)*

NOTE – RECOMMENDATION IS TO DO QUALITY CONTROL ON AT LEAST A QUARTERLY BASIS (EVERY 3 MONTHS)

QUALITY CONTROL WATER LEVEL DATA



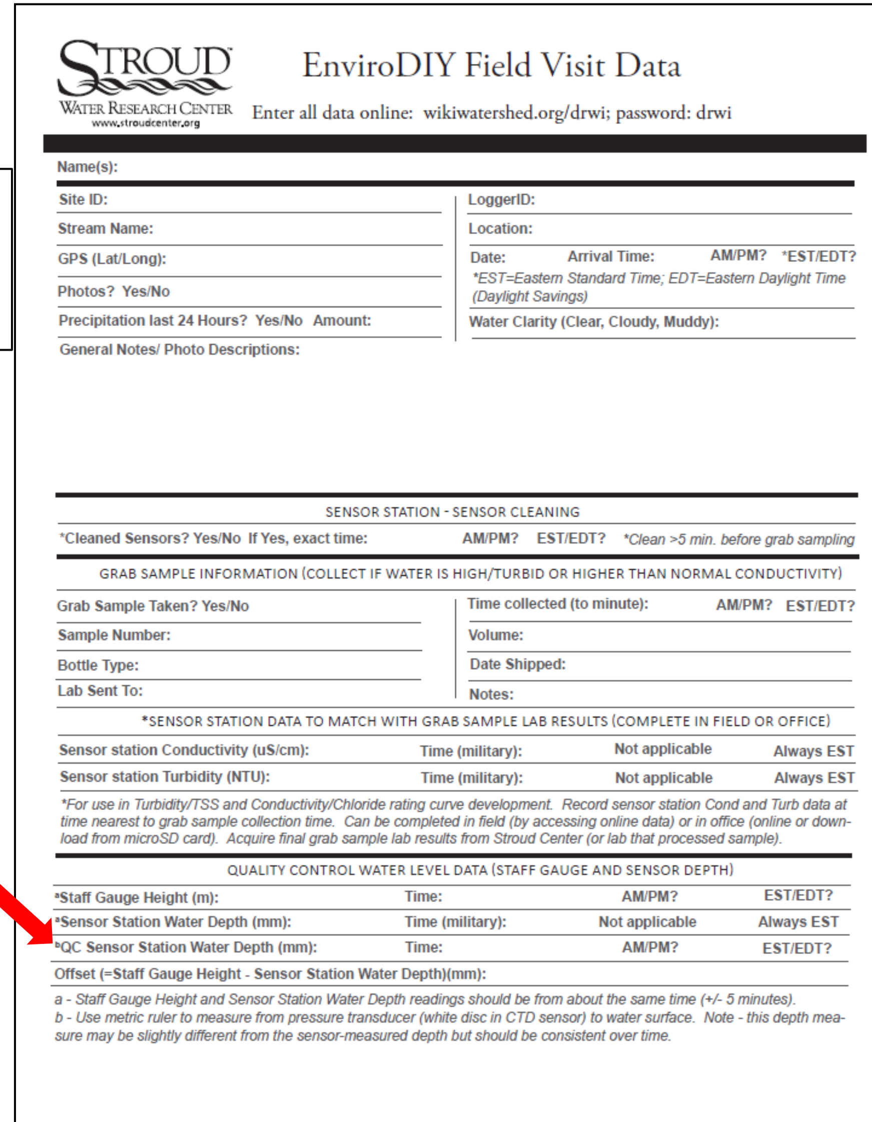
Sensor Station Water Depth (mm) - water depth as measured by CTD sensor

QC Sensor Station Water Depth (mm) – hand check of sensor depth

Pressure transducer (white disc)

QC Sensor Station Water Depth – hand check of sensor depth – use metric ruler to measure from top of sensor window (where pressure transducer [white disc] is located) to water surface. Compare this number to the depth produced by CTD sensor.

This is intended as a coarse check of sensor function and also is a calibration to the individual sensor function (i.e., it may not be exactly the same as the ruler measurement but the difference should be consistent over time).



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EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):

Site ID: | LoggerID:

Stream Name: | Location:

GPS (Lat/Long): | Date: Arrival Time: AM/PM? *EST/EDT?

*EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)

Photos? Yes/No

Precipitation last 24 Hours? Yes/No Amount: | Water Clarity (Clear, Cloudy, Muddy):

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*Cleaned Sensors? Yes/No If Yes, exact time: AM/PM? EST/EDT? *Clean >5 min. before grab sampling

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Grab Sample Taken? Yes/No | Time collected (to minute): AM/PM? EST/EDT?

Sample Number: | Volume:

Bottle Type: | Date Shipped:

Lab Sent To: | Notes:

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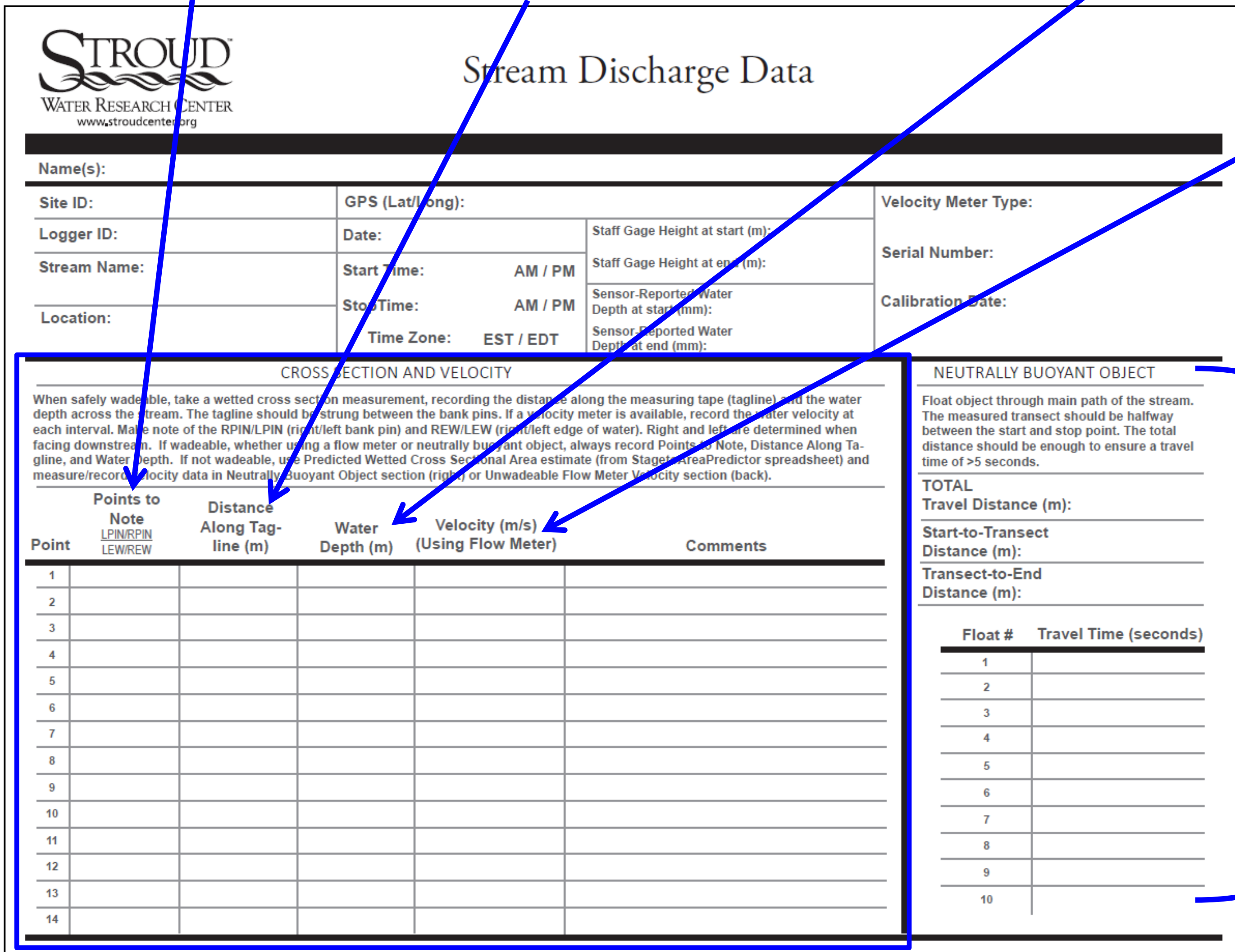
Stream Discharge Data sheet

Left and Right Bank Pins, Left and Right Edge of Water

Measuring tape strung between bank pins across stream

Depth of water at points along measuring tape

Velocity measured with meter at points along measuring tape – velocity at 60% total depth…



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Stream Discharge Data

Name(s):

Site ID:	GPS (Lat/Long):		Velocity Meter Type:
Logger ID:	Date:	Staff Gage Height at start (m):	
Stream Name:	Start Time: AM / PM	Staff Gage Height at end (m):	Serial Number:
Location:	Stop Time: AM / PM	Sensor-Reported Water Depth at start (mm):	Calibration Date:
	Time Zone: EST / EDT	Sensor-Reported Water Depth at end (mm):	

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NEUTRALLY BUOYANT OBJECT

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TOTAL Travel Distance (m):

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Transect-to-End Distance (m):

Float #	Travel Time (seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Or… measure Velocity by timing a floated object over a defined distance (*use this method if a flow meter isn't available OR if water is too high to use flow meter*)

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Stream Discharge Data sheet

CROSS SECTION AND VELOCITY

Point	Points to Note LPIN/RPIN LEW/REW	Distance Along Tag-line (m)	Water Depth (m)	Velocity (m/s) (Using Fow Meter)	Comments
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
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40					

UNWADEABLE FLOW METER VELOCITY

Take 1-10 flow meter velocity measurements near the cross section that appear to be representative of the velocity of the main flow of the stream. These velocity measurements should taken wherever is accessible considering unwadeable conditions.

Measurement #	Flow meter velocity (m/s)	Location in stream channel
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Notes:

Or… measure Velocity by using flow meter where possible, i.e., if water is not wadeable (visually *assess velocity across channel and use flow meter in a spot that seems representative of overall flow*)

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Q = Area x Velocity

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Stream Discharge Data

Name(s):

Site ID:	GPS (Lat/Long):	Velocity Meter Type:
Logger ID:	Date: / Staff Gage Height at start (m): / Staff Gage Height at end (m):	Serial Number:
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7					
8					
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10					
11					
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13					
14					

Discharge (m^3/s) = Wetted Area (m^2) x Velocity (m/s)

NEUTRALLY BUOYANT OBJECT

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8	
9	
10	

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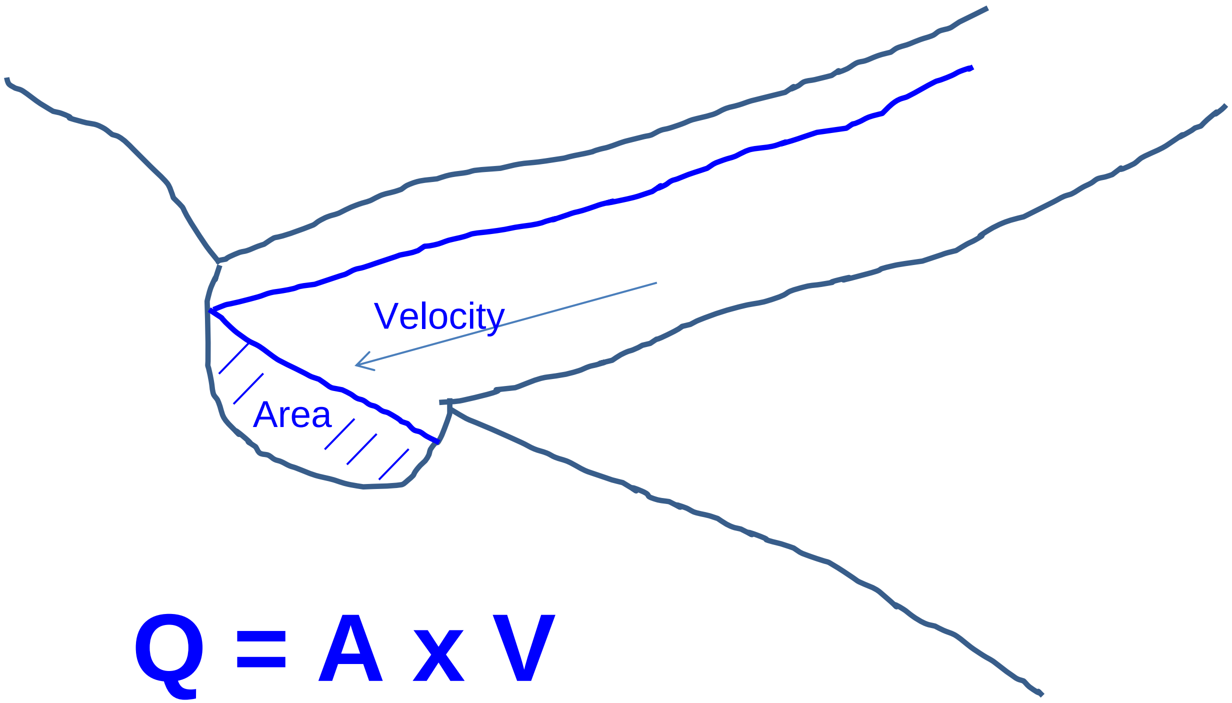
Discharge

- Amount of water flowing in stream as a measure of time
  - Cubic feet per second, cfs
  - Cubic meters per second
- "Q" = Discharge

Q = Area x Velocity

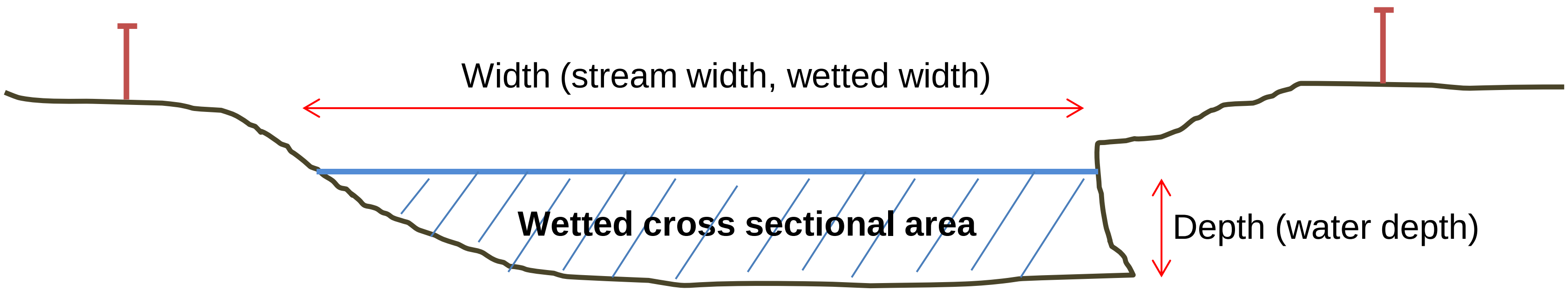
Discharge

Q = Area (of wetted stream cross section) x Velocity (of flowing water)



Q = A x V

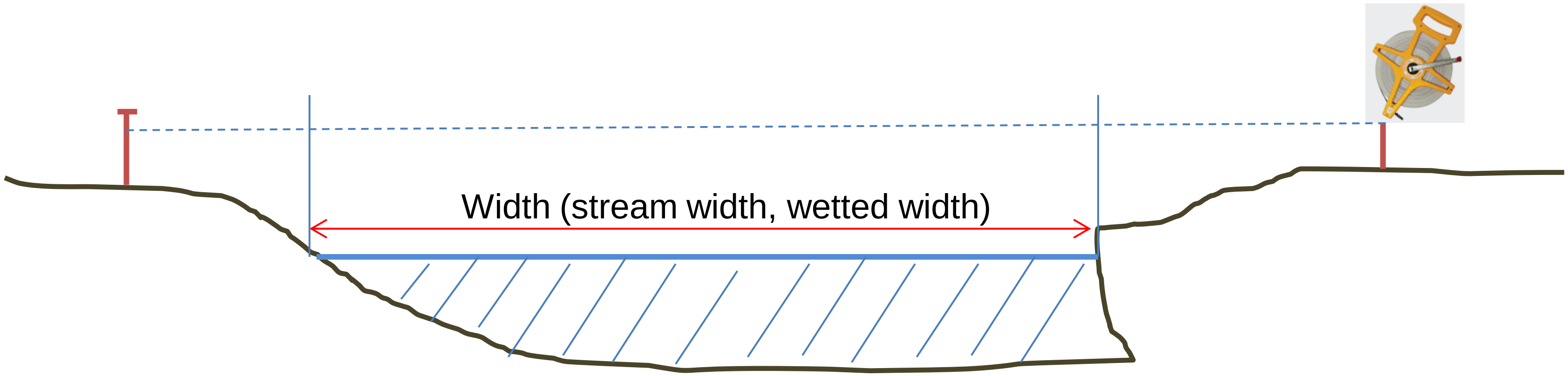
Q = Area x Velocity



Area = Width x Depth

Q = Area x Velocity

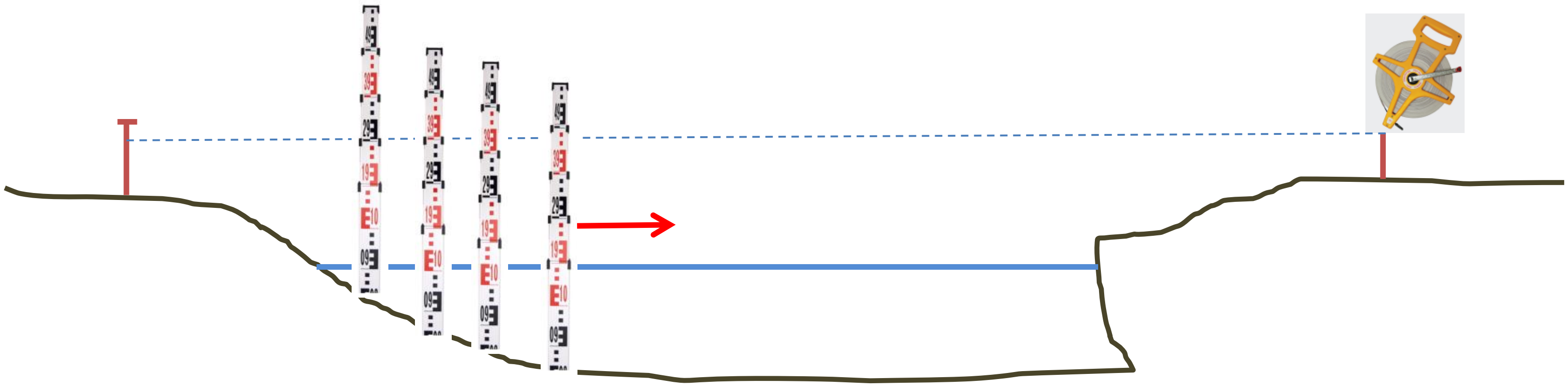
Measure stream width with measuring tape – wetted edge to wetted edge



Width x Depth = Area

Q = Area x Velocity

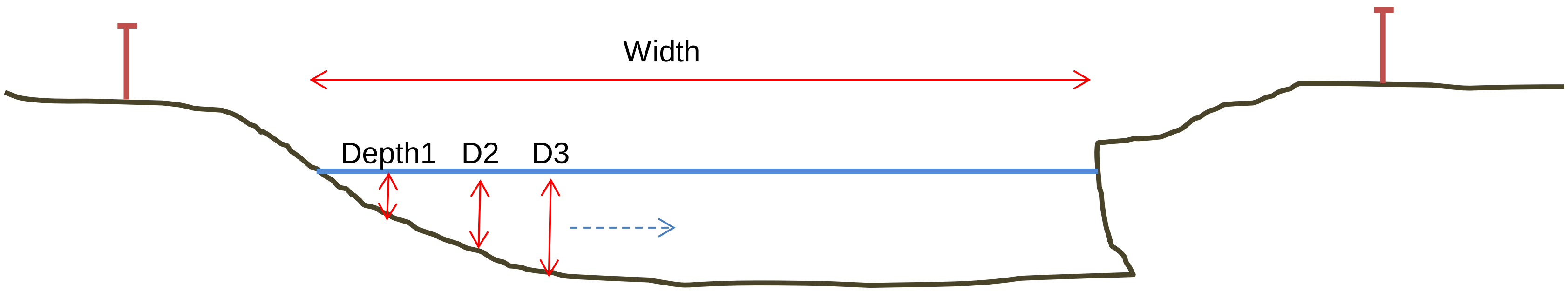
Measure stream depth across the channel



Width x **Depth** = Area

Q = Area x Velocity

Coarse by-hand calculation of Area



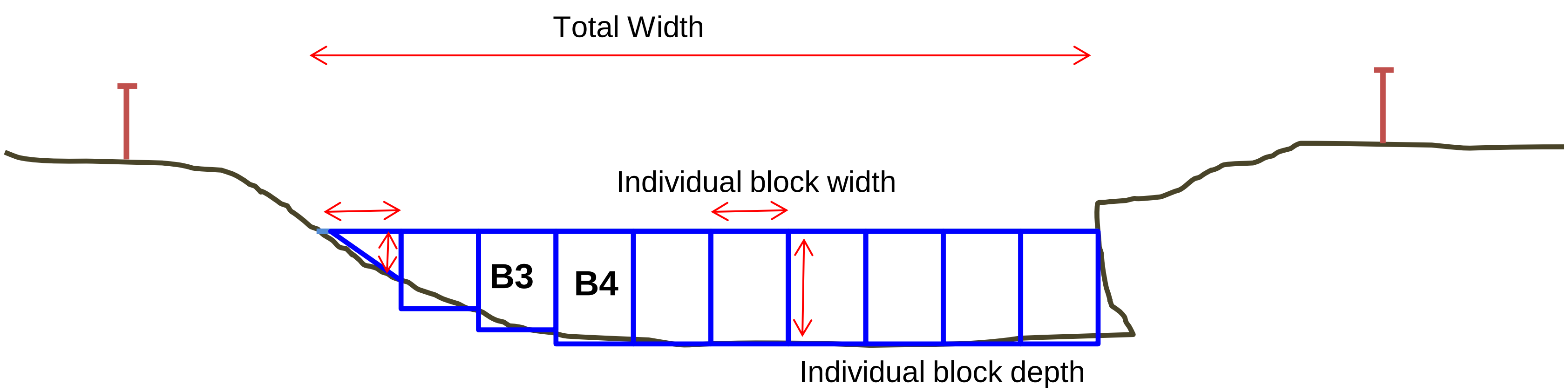
Get *Coarse* Depth by averaging your different depth measurements

(D1+D2+…D10)/10 = **Average Depth**

Average Depth x Width = Area

Q = Area x Velocity

More precise calculation of Area



Width of individual block x Depth individual block = **Area of single block**

**triangles at edges (1/2base x height)*

Area of Block 1 + A_{B2}+A_{B3}…+ A_{B10} = Total Area

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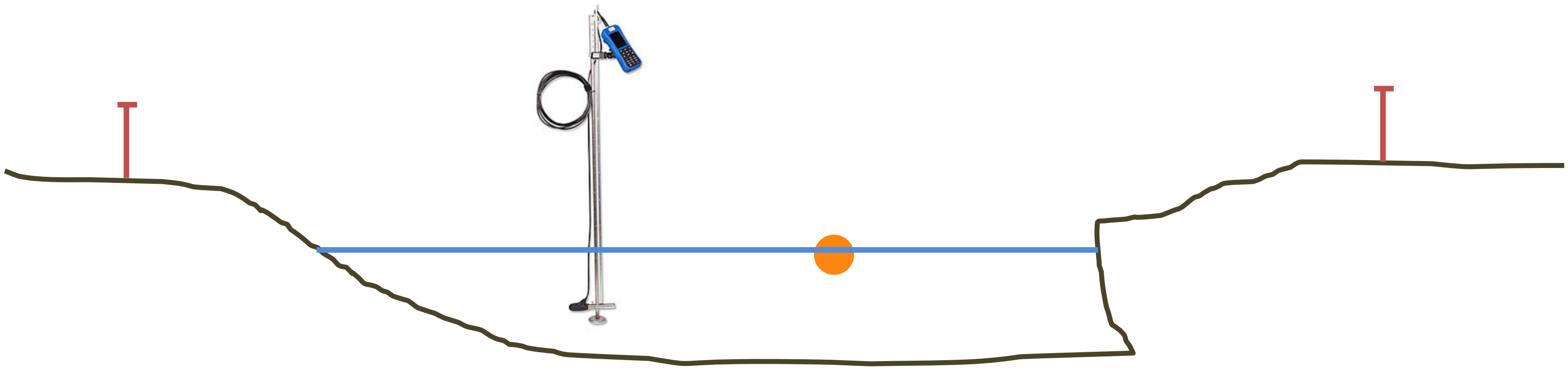
Q = Area x Velocity

Measure **Velocity** with:

- **Flow Meter** - measure velocity at the same place where depth measurements were made

OR

- **Neutral Buoyant Object** (e.g., an orange) – measure velocity in main flow of stream multiple times



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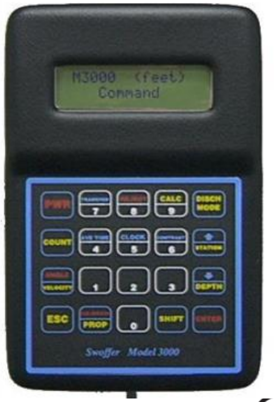
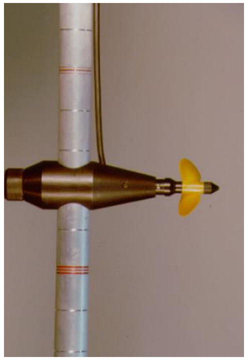
Flow meters

Hach

OTT

Swoffer





Hach/Marsh-McBirney

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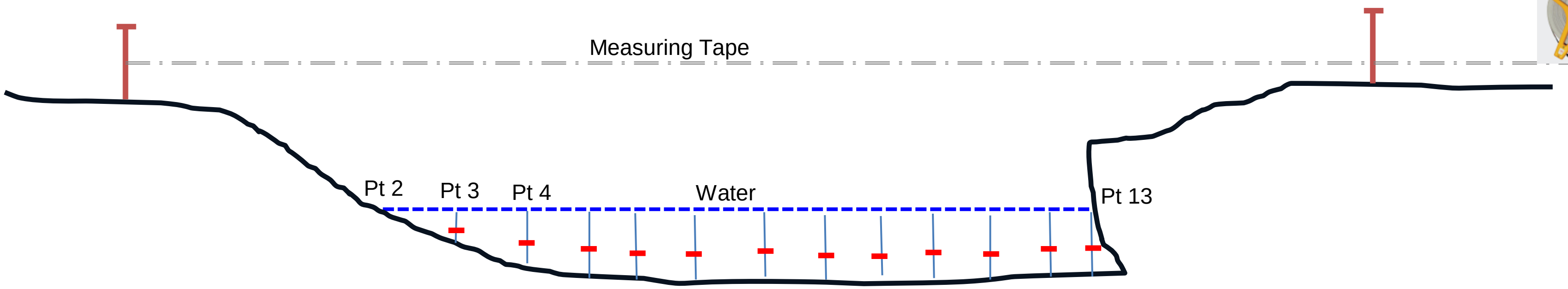
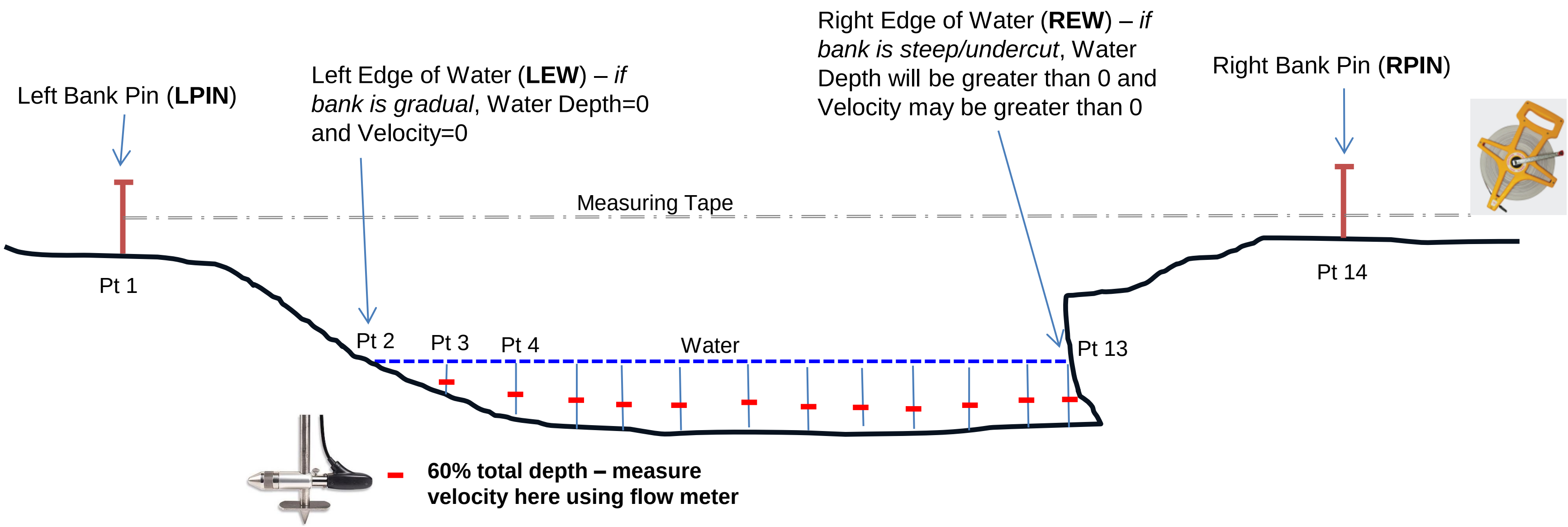
WATER RESEARCH CENTER

Q = Area x Velocity



Flow meter – measure **Velocity** at 60% of total depth (a little over half way down in the water column)

Q = Area x Velocity



CROSS SECTION AND VELOCITY

When safely wadable, take a wetted cross section measurement, recording the distance along the measuring tape (tagline) and the water depth across the stream. The tagline should be strung between the bank pins. If a velocity meter is available, record the water velocity at each interval. Make note of the REW/LEW (right/left edge of water) and RPIN/LPIN (right/left bank pin). Right and left are determined when facing downstream. If wadable, whether using flow meter or neutrally buoyant object, always record Points to Note, Distance Along Tagline, and Water Depth. If not wadable, use predicted wetted area (from StagetoAreaPredictor spreadsheet) and measure velocity using Neutrally Buoyant Object section OR take at least one velocity measurement using flow meter from bank (better option).

Point	Points to Note LPIN/RPIN LEW/REW	Distance Along Tagline (m)	Water Depth (m)	Velocity (m/s) (Using Flow Meter)	Comments
1	LPIN	0	0	0	
2	LEW	2.1	0	0	
3		2.6	0.2	0.24	
4		3.2	0.38	0.26	
5		3.8	0.39	0.35	
6		4.3	0.40	0.36	
7		4.8	0.40	0.36	
8		5.3	0.40	0.36	
9		5.7	0.40	0.36	
10		6.1	0.40	0.36	
11		6.5	0.40	0.26	
12		7.0	0.40	0.26	
13	REW	7.4	0.4	0.1	
14	RPIN	8.7	0	0	

NEUTRALLY BUOYANT OBJECT

Float object through main path of the stream. The measured transect should be halfway between the start and stop point. The total distance should be enough to ensure a travel time of >5 seconds.

TOTAL Travel Distance (m):

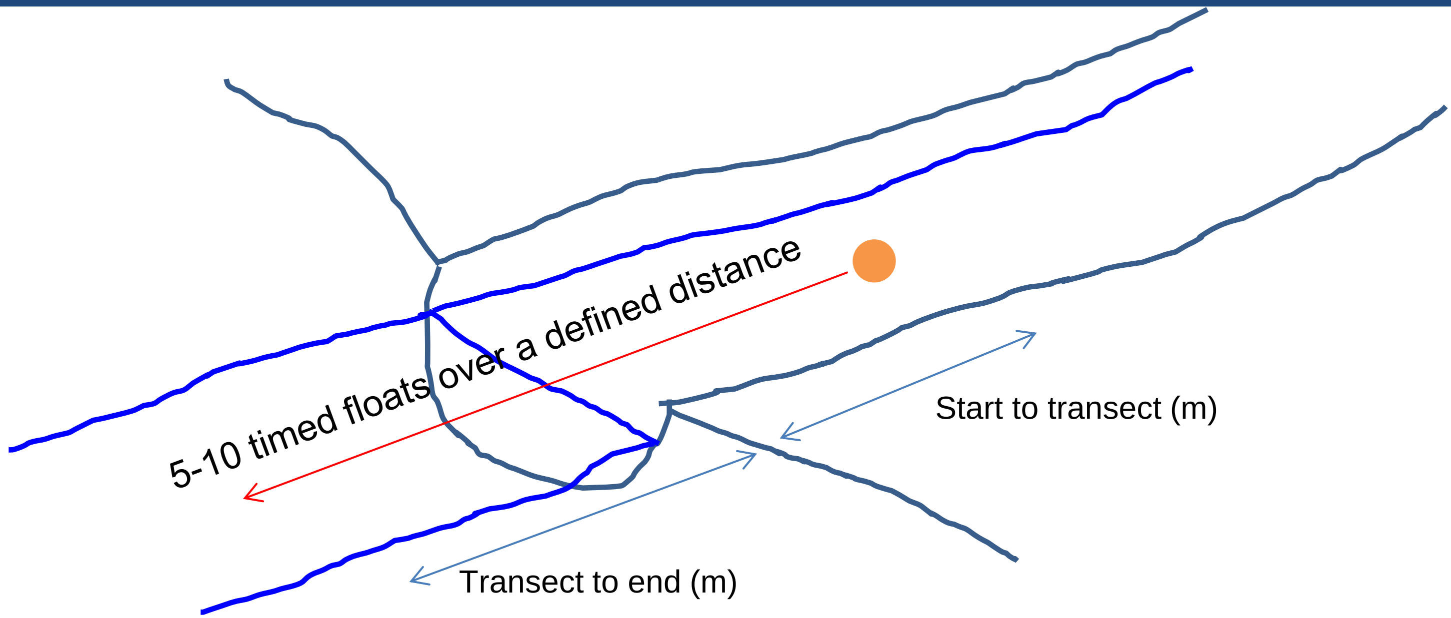
Start-to-Transect Distance (m):

Transect-to-End Distance (m):

Travel Time (seconds) (record at least 5)	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

STROUD™ WATER RESEARCH CENTER

Q = Area x Velocity



CROSS SECTION AND VELOCITY

When safely wadable, take a wetted cross section measurement, recording the distance along the measuring tape (tagline) and the water depth across the stream. The tagline should be strung between the bank pins. If a velocity meter is available, record the water velocity at each interval. Make note of the REW/LEW (right/left edge of water) and RPIN/LPIN (right/left bank pin). Right and left are determined when facing downstream. If wadable, whether using flow meter or neutrally buoyant object, always record Points to Note, Distance Along Tagline, and Water Depth. If not wadable, use predicted wetted area (from StagetoAreaPredictor spreadsheet) and measure velocity using Neutrally Buoyant Object section OR take at least one velocity measurement using flow meter from bank (better option).

Point	Points to Note LPIN/RPIN LEW/REW	Distance Along Tagline (m)	Water Depth (m)	Velocity (m/s) (Using Flow Meter)	Comments
1	LPIN	0	0		
2	LEW	2.1	0		
3		2.6	0.2		
4		3.2	0.38		
5		3.8	0.39		
6		4.3	0.40		
7		4.8	0.40		
8		5.3	0.40		
9		5.7	0.40		
10		6.1	0.40		
11		6.5	0.40		
12		7.0	0.40		
13	REW	7.4	0.4		
14	RPIN	8.7	0		

NEUTRALLY BUOYANT OBJECT

Float object through main path of the stream. The measured transect should be halfway between the start and stop point. The total distance should be enough to ensure a travel time of >5 seconds.

TOTAL Travel Distance (m): 5

Start-to-Transect Distance (m): 2.5

Transect-to-End Distance (m): 2.5

Travel Time (seconds) (record at least 5)	
1	15
2	16
3	16
4	18
5	14
6	17
7	16
8	
9	
10	

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Q = Velocity x Area

Calculate Q coarsely by hand:

Q = (Width x Average Depth) x Average Velocity (by flow meter or by NBO float)

CROSS SECTION AND VELOCITY

When safely wadable, take a wetted cross section measurement, recording the distance along the measuring tape (tagline) and the water depth across the stream. The tagline should be strung between the bank pins. If a velocity meter is available, record the water velocity at each interval. Make note of the REW/LEW (right/left edge of water) and RPIN/LPIN (right/left bank pin). Right and left are determined when facing downstream. If wadable, whether using flow meter or neutrally buoyant object, always record Points to Note, Distance Along Tagline, and Water Depth. If not wadable, use predicted wetted area (from StagetoAreaPredictor spreadsheet) and measure velocity using Neutrally Buoyant Object section OR take at least one velocity measurement using flow meter from bank (better option).

Point	Points to Note LPIN/RPIN LEW/REW	Distance Along Tagline (m)	Water Depth (m)	Velocity (m/s) (Using Flow Meter)	Comments
1	LPIN	0	0	0	
2	LEW	2.1	0	0	
3		2.6	0.2	0.24	
4		3.2	0.38	0.26	
5		3.8	0.39	0.35	
6		4.3	0.40	0.36	
7		4.8	0.40	0.36	
8		5.3	0.40	0.36	
9		5.7	0.40	0.36	
10		6.1	0.40	0.36	
11		6.5	0.40	0.26	
12		7.0	0.40	0.26	
13	REW	7.4	0.4	0.1	
14	RPIN	8.7	0	0	

NEUTRALLY BUOYANT OBJECT

Float object through main path of the stream. The measured transect should be halfway between the start and stop point. The total distance should be enough to ensure a travel time of >5 seconds.

TOTAL Travel Distance (m): 5

Start-to-Transect Distance (m): 2.5

Transect-to-End Distance (m): 2.5

Travel Time (seconds) (record at least 5)	
1	15
2	16
3	16
4	18
5	14
6	17
7	16
8	
9	
10	

Avg water depth = 0.35m

Avg velocity w NBO = 0.31m/s

Width=7.4-2.1=5.3m **Avg velocity w flow meter = 0.27m/s**

Qflowmeter = (5.3x.35)x<u>0.27</u> = <u>0.5m3/s</u>

Qneutralbuoyobj = (5.3x.35)x<u>0.31</u> = <u>0.58m3/s</u>

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Q = Velocity x Area

OR…Use Discharge Rating Curve Calculator spreadsheet (or other spreadsheet)

Basic Metadata

Measurement Completed By:	ler, Hicks, Johnson, Muenz, Armstrong, Bullard, Hughes, S
Stream Name:	Pickering Creek
Location:	Phoenixville YMCA
SiteID:	SHPK6S
Station Latitude / Longitude:	40.10799, -75.51938
Date:	12/12/2017
Start Time in EST:	3:10 PM
Stop Time in EST:	3:45 PM
Staff Gauge Height (m):	0.22
Recorded Sensor Depth (mm):	261
Staff Gage/Sensor Offset (m):	-0.041
Velocity Meter (if applicable):	
Calibration Date of Velocity Meter:	
Other Notes:	Installed station and cross section

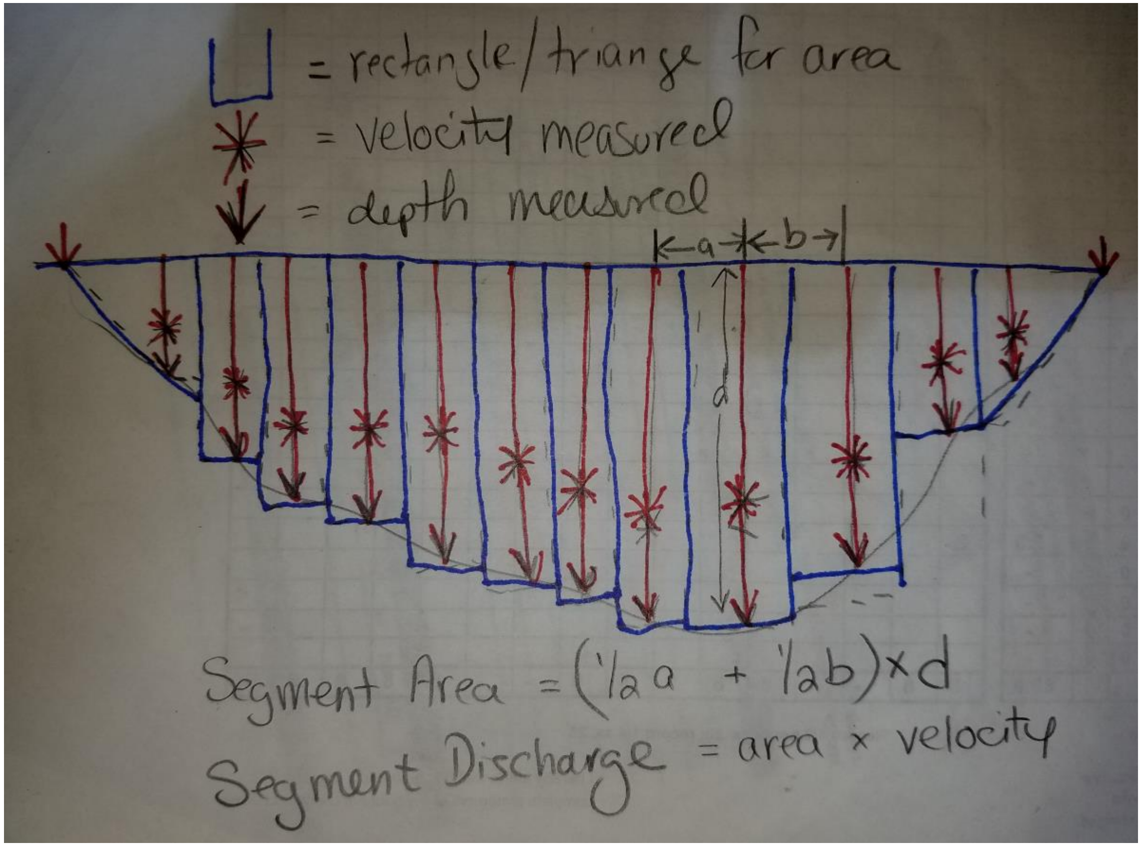
Results

Calculated Total Discharge (m^3/s):	*0.48*
Stream Wetted Width (m):	*17.64*
Stream Cross Sectional Area (m^2):	*5.45*

Cross Section and Velocity Measurements

Point	Points of note:	Distance (m)	Water Depth (m)	Velocity (m/s)	Comment
1	REW	2.41	0	0	
2		2.85	0.16	0.01	
3		3.4	0.25	0.05	
4		3.95	0.29	0.05	
5		4.6	0.37	0.06	
6		5.4	0.41	0.08	
7		6.1	0.51	0.08	
8		6.8	0.5	0.06	
9		7.4	0.42	0.06	
10		8	0.34	0.08	
11		8.9	0.33	0.08	
12		9.9	0.25	0.12	
13		10.6	0.26	0.13	
14		11.5	0.27	0.14	
15		12.3	0.3	0.11	
16		13.1	0.36	0.13	
17		13.9	0.4	0.14	
18		14.7	0.42	0.11	
19		15.5	0.4	0.12	
20		16.3	0.38	0.1	
21		17	0.28	0.07	
22		17.8	0.22	0.03	
23		18.6	0.14	0.01	
24	LEW	20.05	0	0	
25					
26					
27					
28					
29					
30					
31					

Q = Area x Velocity



Pickering Creek, Phoenixville YMCA

	dist	depth	vel
REW	2.44	0.15	0.01
	3	0.28	0.06
	3.5	0.35	0.16
	4	0.42	0.19
	4.5	0.49	0.17
	5	0.52	0.15
	5.5	0.54	0.17
	6	0.62	0.10
	6.5	0.62	0.10
	7	0.60	0.16
	7.5	0.53	0.20
	8	0.49	0.28
	8.5	0.50	0.33
	9	0.44	0.26
	9.5	0.35	0.31
	10	0.35	0.22
	10.5	0.34	0.29
	11	0.35	0.25
	11.5	0.37	0.27
	12	0.40	0.31
	12.5	0.43	0.39
	13	0.44	0.37
	13.5	0.50	0.28
	14	0.51	0.30
	14.5	0.48	0.25
	15	0.48	0.23
	15.5	0.50	0.25
	16	0.46	0.22
	16.5	0.46	0.20
	17	0.38	0.21
	17.5	0.35	0.21
	18	0.30	0.15
	18.5	0.28	0.17
	19	0.20	0.15
	19.5	0.17	0.17
	20	0.13	0.07
	20.2	0.10	0.08
LEW	20.46	0.00	0.00
	Width	Avg Depth	Avg Vel
	18.02	0.39	0.20

1.43 Q via coarse average
1.62 Q via individual blocks

	dist	depth	vel
REW	2.41	0.00	0.00
	2.85	0.16	0.01
	3.4	0.25	0.05
	3.95	0.29	0.05
	4.6	0.37	0.06
	5.4	0.41	0.08
	6.1	0.51	0.08
	6.8	0.50	0.06
	7.4	0.42	0.06
	8	0.34	0.08
	8.9	0.33	0.08
	9.9	0.25	0.12
	10.6	0.26	0.13
	11.5	0.27	0.14
	12.3	0.30	0.11
	13.1	0.36	0.13
	13.9	0.40	0.14
	14.7	0.42	0.11
	15.5	0.40	0.12
	16.3	0.38	0.10
	17	0.28	0.07
	17.8	0.22	0.03
	18.6	0.14	0.01
LEW	20.05	0.00	0.00
	Width	Avg Depth	Avg Vel
	17.64	0.30	0.08

0.40 Q via coarse average
0.48 Q via individual blocks

STROUD™ WATER RESEARCH CENTER

Grab samples

- Storm grab samples analyzed at Stroud only for:
  - **Total Suspended Solids**
  - Chloride

- Collect samples from the range of observed turbidity values at site – i.e., **collect samples from dirty water!**

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Grab samples

- Labeling samples is super important
  - Site identifier
  - Date
  - **Time – to the minute**
    - Very important so that grab sample results can be matched up with sensor reading at the specific time grab was collected
  - Collector

Stroud Water Research Center

Developing rating curves across the Delaware Basin

- Stroud (Matt Gisondi and interns) to facilitate rating curve development this summer, *as time and storms allow*
  - Discharge and grab samples
  - Matt will be in touch with groups if he’s in the area
    - Assistance welcomed, opportunity for on-site training
    - Spur of the moment because of the nature of storms and field sampling

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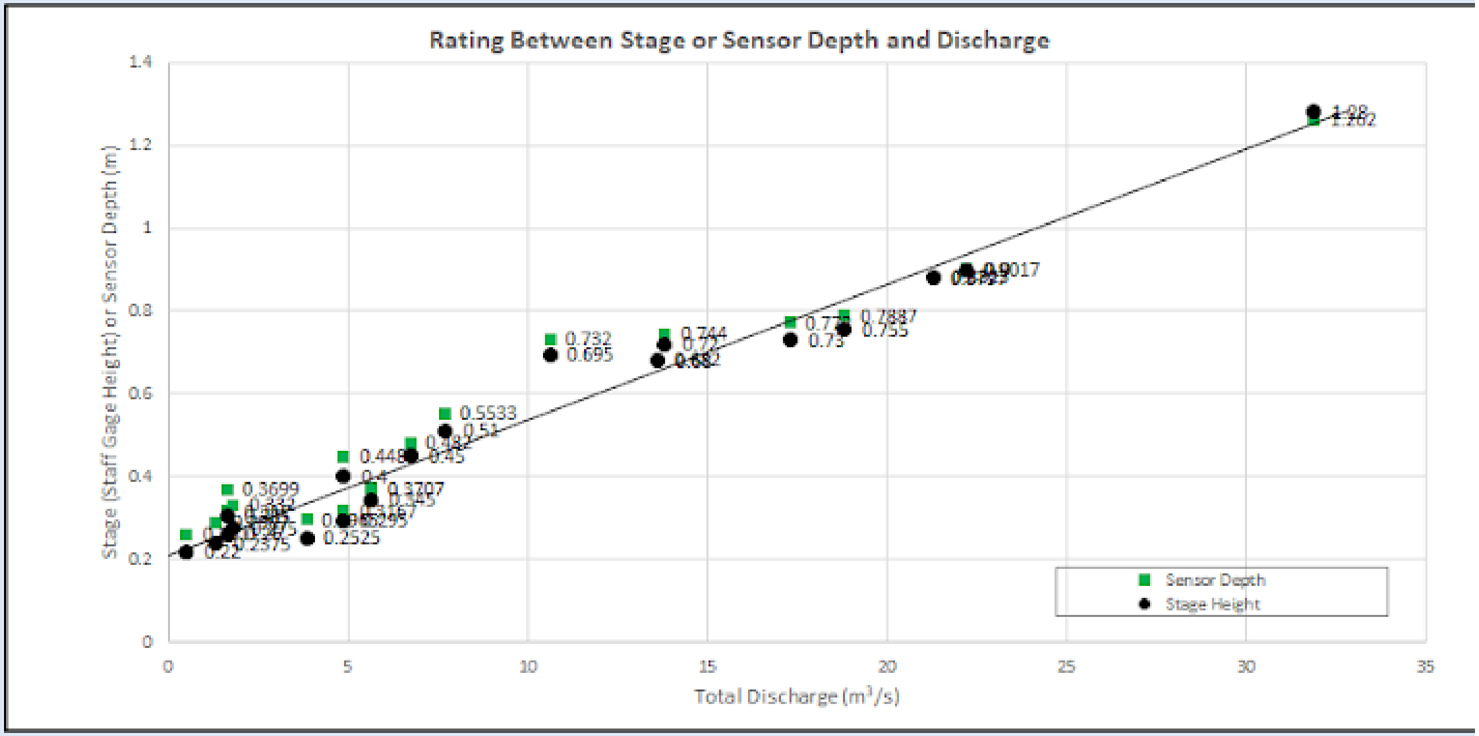
Rating curves



Data from Ridley Creek at Ashbridge Preserve (PURC1S, SL155), Willistown Conservation Trust, Lauren McGrath

Rating curves

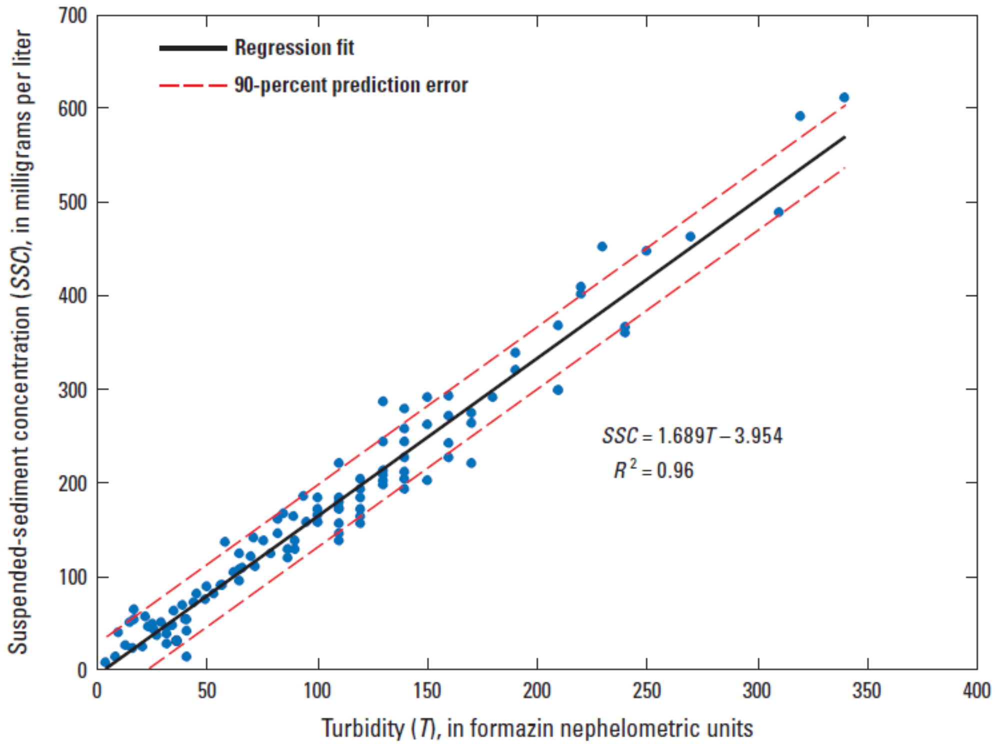


Figure 3. Regression relations of turbidity and suspended-sediment concentration for French Creek near Phoenixville, Pennsylvania.

Sloto, R.A., and Olson, L.E., Estimated suspended-sediment loads and yields in the French and Brandywine Creek Basins, Chester County, Pennsylvania, water years 2008–09: U.S. Geological Survey Scientific Investigations Report 2011–5109, 31 p.

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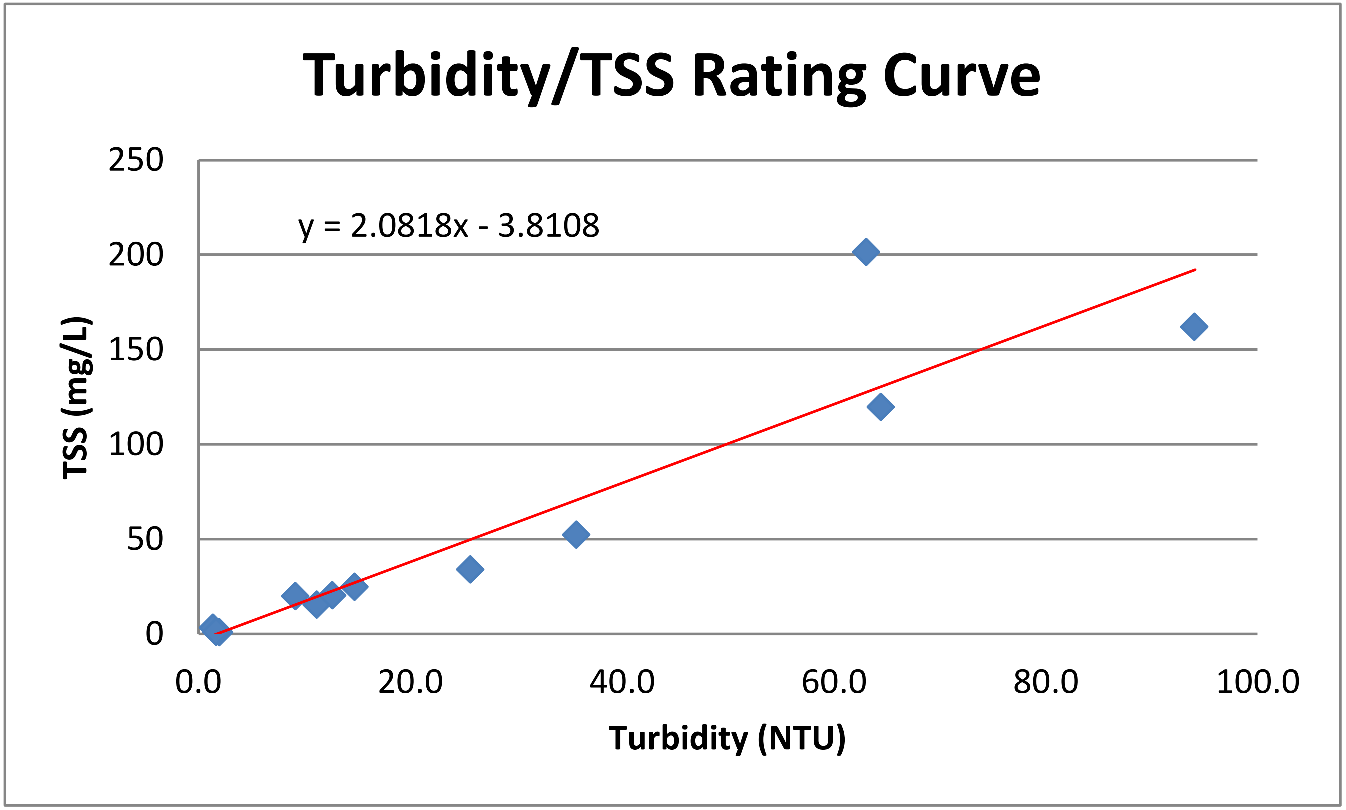
Rating curves

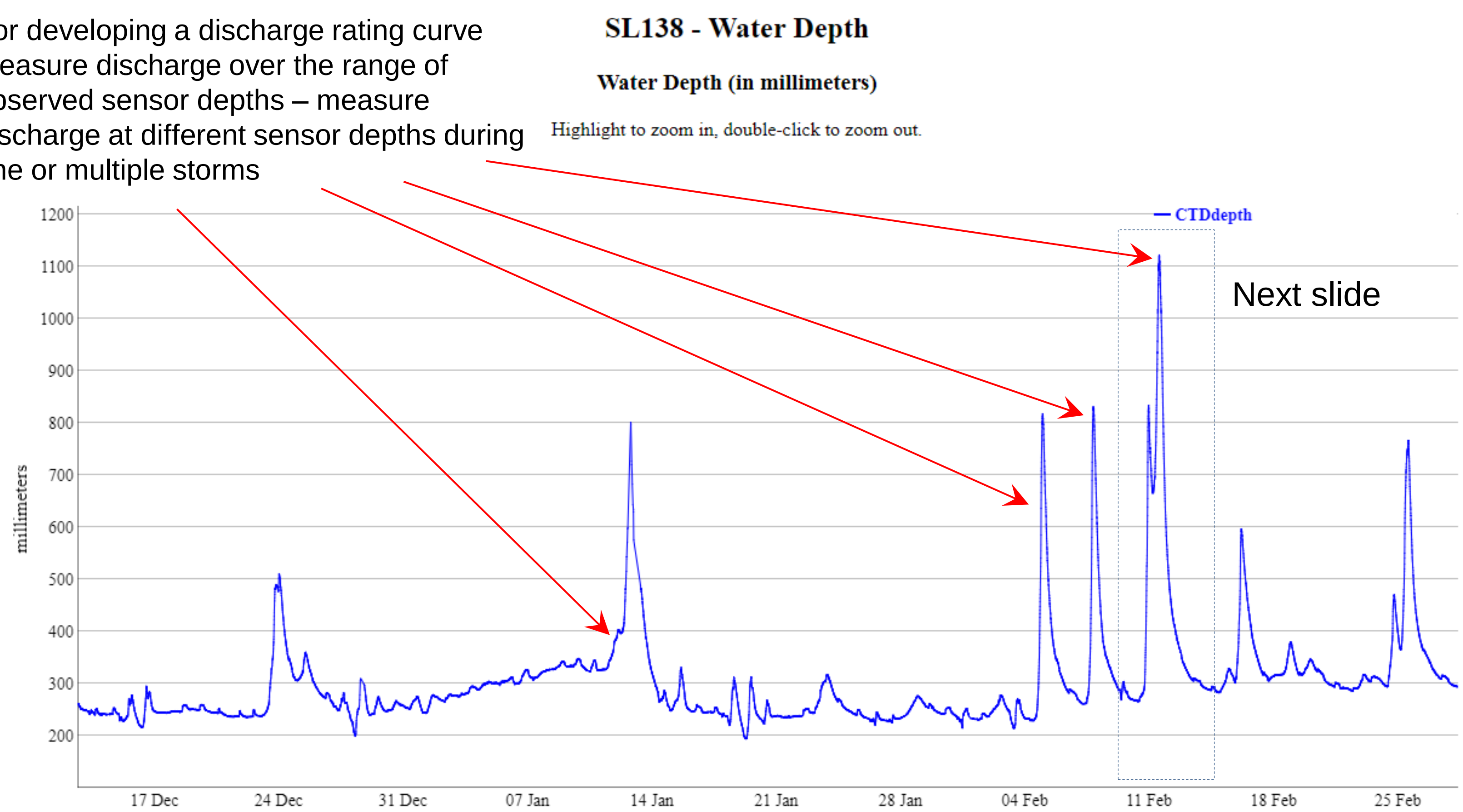


Data from Pickering Creek at Montgomery School (SHPK5S, SL135), Carol Armstrong, George Seeds, and David Kline (and students)

Stroud Water Research Center

Measuring discharge for rating curve

For developing a discharge rating curve measure discharge over the range of observed sensor depths – measure discharge at different sensor depths during one or multiple storms



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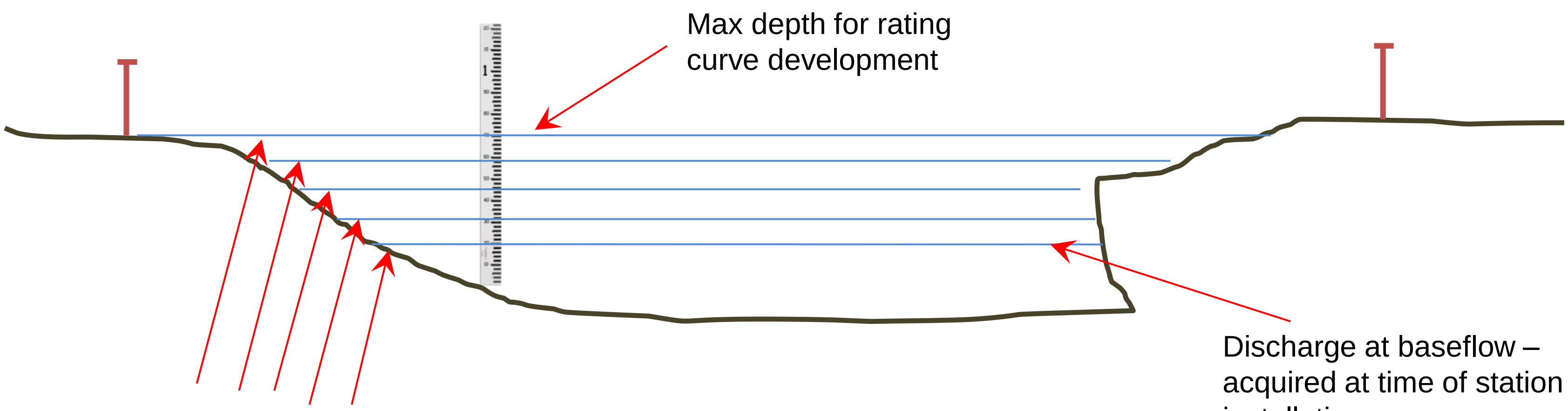
Measuring discharge for rating curve

If possible, measure discharge multiple times over the course of one storm – this allows you to develop rating curve quickly

Measuring discharge for rating curve



- Take discharge measurements at different water levels – these are then related to the staff gauge levels and sensor depths associated with these discharges
- Discharge (m^3/s) = Wetted area (m^2) x Velocity of water (m/s)

STROUD WATER RESEARCH CENTER

Collecting grab samples for rating curve

- How to know when to collect grab samples
    - Observe your stream on-site and watch sensor data to know when water gets muddy (see next slide)
    - Collect samples from **a range of turbidity values, especially trying to get very muddy water**
        - **Collect multiple samples ranging in turbidity from a single storm (see next slide) or several storms**

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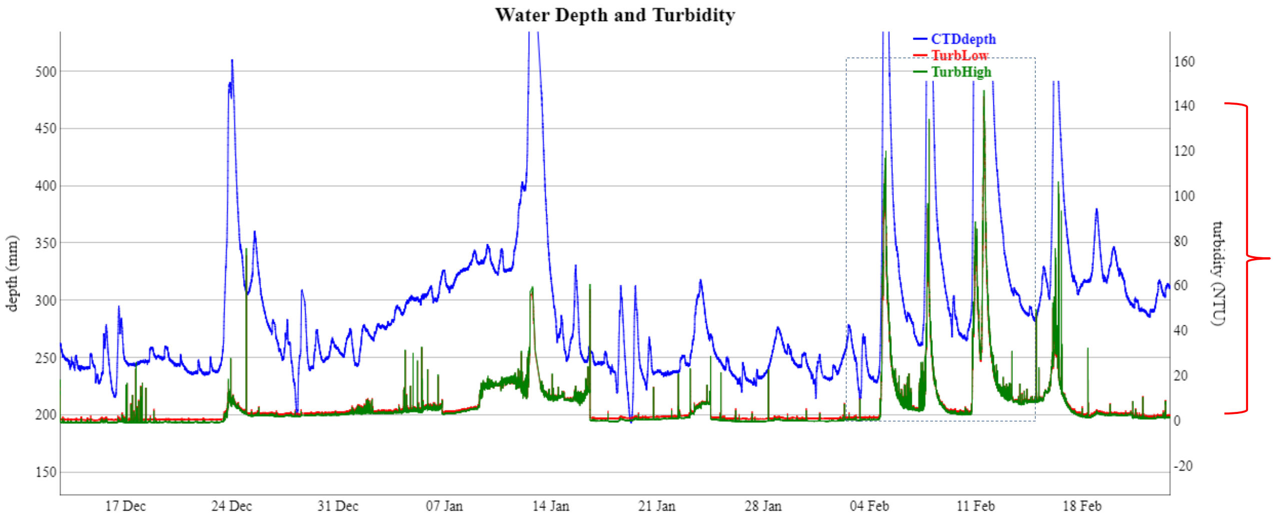
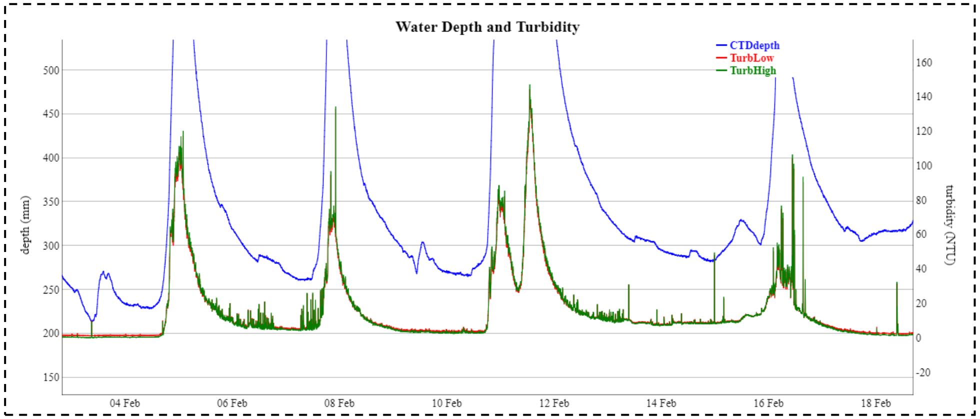
Collecting grab samples for rating curve

SL138, Pickering Creek

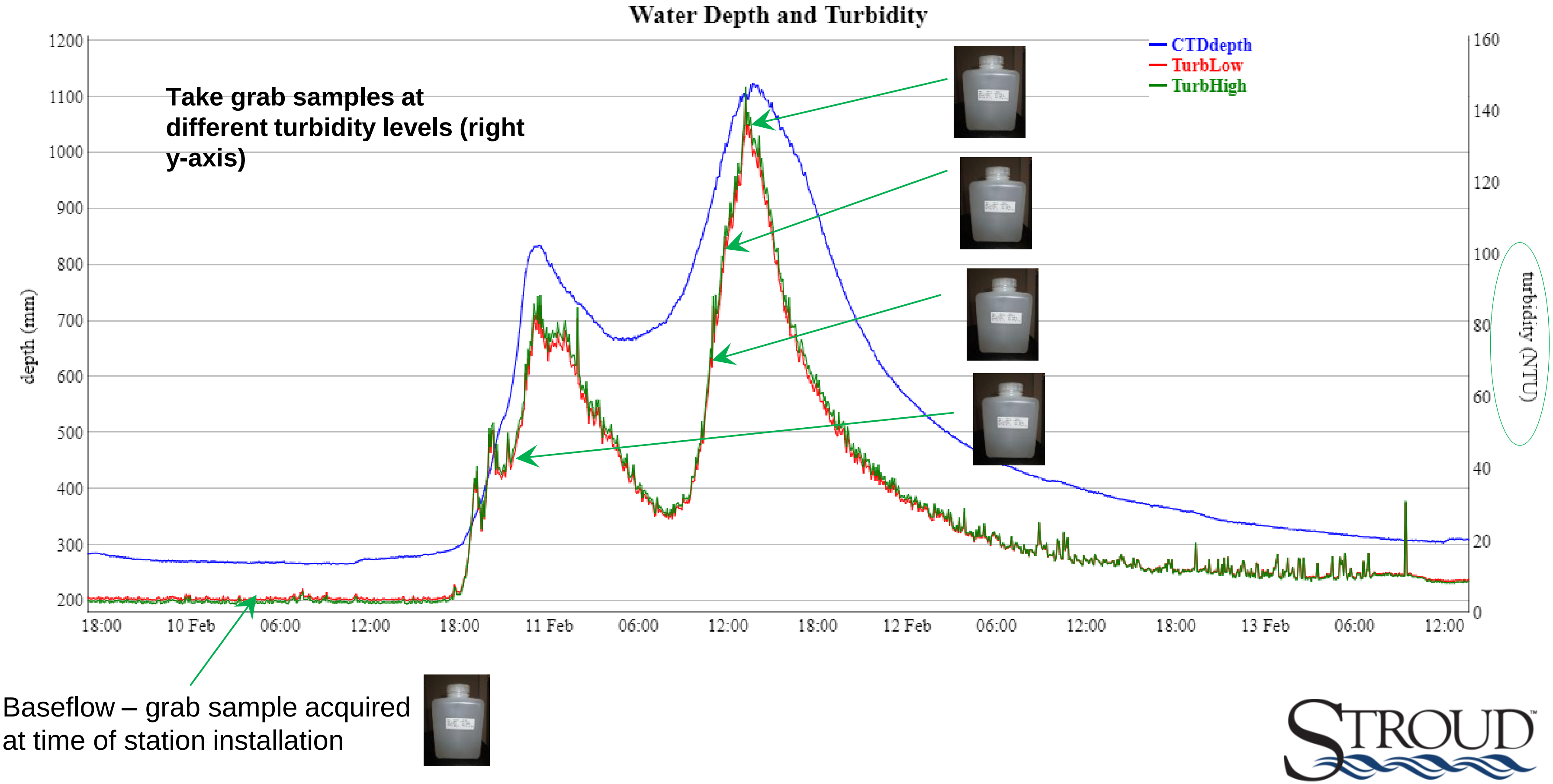




- Understand range of turbidity values observed at the site, so that you know when to collect grab samples – distribute grabs across the observed range (here 0-140 NTU)
- Understand what amount of rainfall and sensor depth increases cause what levels of turbidity – use this to focus the timing of your grab sampling efforts
- Turbidity sensor must be kept clean through the storm to ensure accurate data

Collecting grab samples for rating curve

SL138, Pickering Creek



Baseflow – grab sample acquired at time of station installation

STROUD WATER RESEARCH CENTER

Spreadsheet Calculators

- Discharge Rating Curve Calculator
- Stage to Area Predictor
- Load Calculator

Discharge Rating Curve Calculator

Basic Metadata

Measurement Completed By: ler, Hicks, Johnson, Muenz, Armstrong, Bullard, Hughes, S

Stream Name:	Pickering Creek
Location:	Phoenixville YMCA
SiteID:	SHPK6S
Station Latitude / Longitude:	40.10799, -75.51938
Date:	12/12/2017
Start Time in EST:	3:10 PM
Stop Time in EST:	3:45 PM
Staff Gauge Height (m):	0.22
Recorded Sensor Depth (mm):	261
Staff Gage/Sensor Offset (m):	-0.041
Velocity Meter (if applicable):	
Calibration Date of Velocity Meter:	
Other Notes:	Installed station and cross section

Results

Calculated Total Discharge (m^3/s):	*0.48*
Stream Wetted Width (m):	*17.64*
Stream Cross Sectional Area (m^2):	*5.45*

Cross Section and Velocity Measurements

Point	Points of note:	Distance (m)	Water Depth (m)	Velocity (m/s)	Comment
1	REW	2.41	0	0	
2		2.85	0.16	0.01	
3		3.4	0.25	0.05	
4		3.95	0.29	0.05	
5		4.6	0.37	0.06	
6		5.4	0.41	0.08	
7		6.1	0.51	0.08	
8		6.8	0.5	0.06	
9		7.4	0.42	0.06	
10		8	0.34	0.08	
11		8.9	0.33	0.08	
12		9.9	0.25	0.12	
13		10.6	0.26	0.13	
14		11.5	0.27	0.14	
15		12.3	0.3	0.11	
16		13.1	0.36	0.13	
17		13.9	0.4	0.14	
18		14.7	0.42	0.11	
19		15.5	0.4	0.12	
20		16.3	0.38	0.1	
21		17	0.28	0.07	
22		17.8	0.22	0.03	
23		18.6	0.14	0.01	
24	LEW	20.05	0	0	
25					
26					
27					
28					
29					
30					
31					

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t

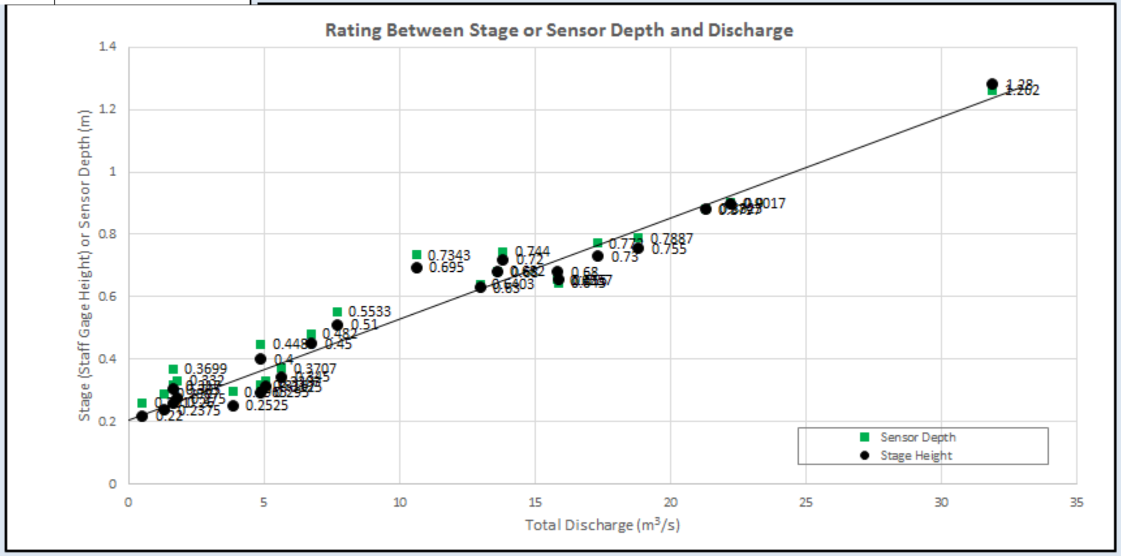
Average Offset between Sensor Depth and Stage: *-0.038*

Rating Equation - Discharge to Stage

Total Discharge = (29.673 x Stage) -5.664

Rating Equation - Discharge to Stage plus Sensor Depth Offset

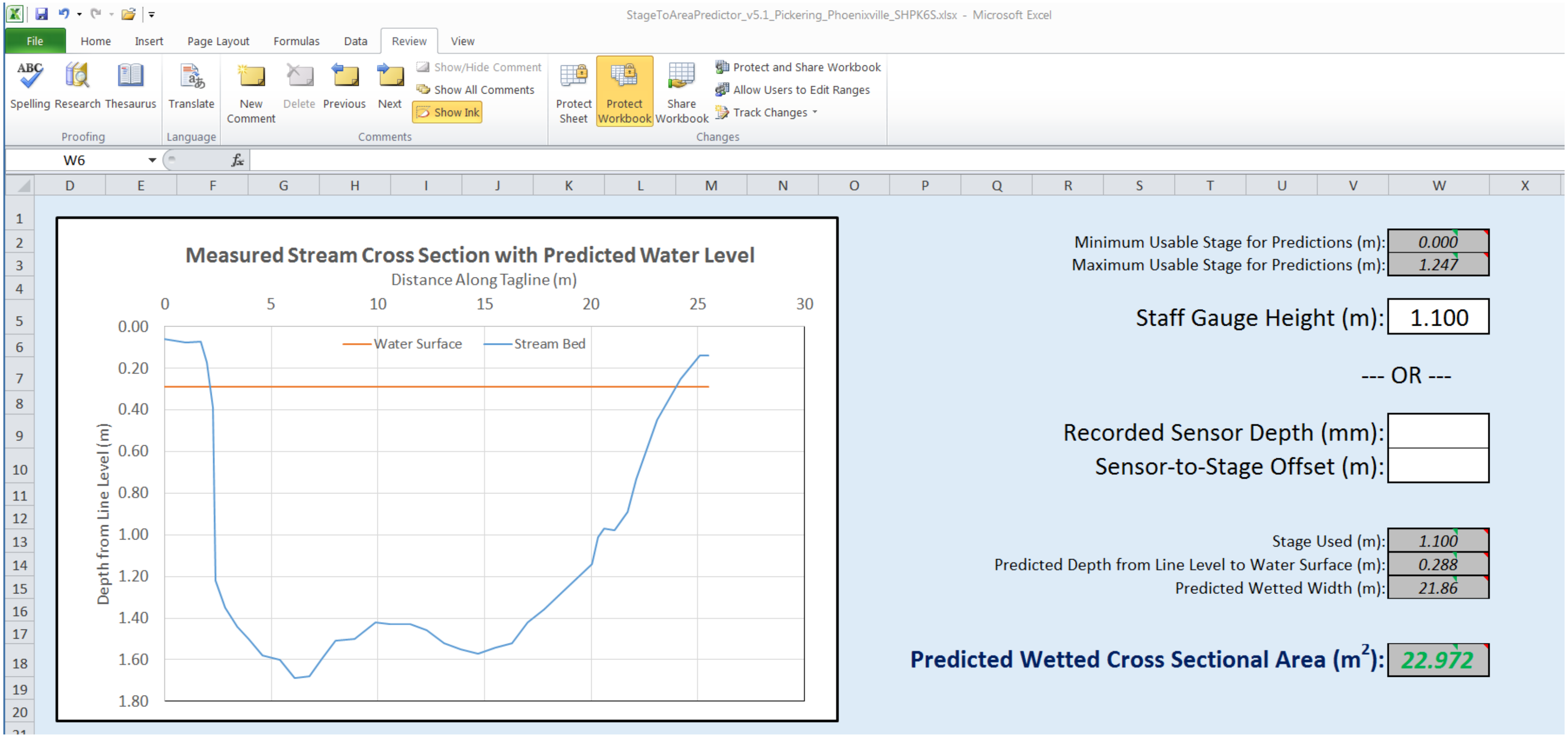
Total Discharge = (29.673 x SensorDepth) -5.702



Stage to Area Predictor

- **Predict Area ("predicted wetted cross sectional area")** – for use when water is too high to measure width and depth across the channel
- Use predicted Area with measured Velocity (via NBO or point flow meter measurements) to calculate Discharge

Stage to Area Predictor



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Load Calculator

Load Calculator v1.3_example.xlsx - Microsoft Excel

B12 ='Data Import'!B12

	A	B	K	L	M	N	O	P	Q	R	S
1	Discharge Calculator Rating Curve Equation		Load Calculations								
2	y = mx + b	y = 0.843x - 0.2	**Cond (µS/cm)**	**TSS (mg/L)**	**TSS (mg/m3)**	**Chloride (mg/L)**	**Chloride (mg/m3)**	**Sediment Flux (mg/s)**	**Chloride Flux (mg/s)**	**Sediment Load (mg)**	**Chloride Load (mg)**
3	m (slope)	0.843	CTDcond Data from Webpage	Input Turb (x) into TSS Rating Curve	TSS (mg/L) x 1000	Input Cond (x) into Chloride Rating Curve	Chloride x 1000	Discharge x TSS	Discharge x Chloride	Sediment Flux x Time	Flux x Time
4	b (y-axis intercept)	-0.2	263.8	0.34341	343.41	0	0	70.2754224	0	#VALUE!	#VALUE!
5	TSS/Turbidity Rating Curve Equation		258.7	2.012924	2012.924	0	0	419.5607946	0	128385.6031	0
6	y = mx + b	y = 2.1682x - 10.606	249.3	2.034606	2034.606	0	0	436.4292943	0	128746.6417	0
7	m (slope)	2.1682	246.8	2.338154	2338.154	0	0	514.5503025	0	154365.0909	0
8	b (y-axis intercept)	-10.606	241.2	4.506354	4506.354	0	0	1018.671236	0	308657.3842	0
9	Chloride/Conductivity Rating Curve Equation		238	2.793476	2793.476	0	0	635.0037458	0	189231.1162	0
10	y = mx + b	0	234	3.031978	3031.978	0	0	687.685659	0	209744.1262	0
11	m (slope)	0	227.7	1.774422	1774.422	0	0	398.1203213	0	117445.4947	0
12	b (y-axis intercept)	0	225.6	3.097024	3097.024	0	0	692.7788732	0	207140.8832	0
13	Average Offset Between Sensor Depth and Stage		216.7	2.83684	2836.84	0	0	630.9906617	0	191190.1704	0
14	Offset (m)	0.112	212.7	3.59571	3595.71	0	0	794.9341732	0	236890.384	0
15	Load Totals		213.2	3.443936	3443.936	0	0	763.7027954	0	231401.9469	0
16	**Sediment Load (mg)**	254,447,241.51	213.4	4.614764	4614.764	0	0	1023.726324	0	303022.9921	0
17	**Chloride Load (mg)**	-	213.3	3.335526	3335.526	0	0	746.1298149	0	224585.0742	0
18	Sediment Load (kg)	**254.45**	212.4	5.156814	5156.814	0	0	1159.623078	0	351365.7923	0
19	Chloride Load (kg)	-	211.6	4.35458	4354.58	0	0	984.7294802	0	292464.6559	0
20	Sediment Load (lb)	**559.78**	210.4	3.747484	3747.484	0	0	853.7611736	0	258689.6354	0
21	Chloride Load (lb)	-	209.3	4.658128	4658.128	0	0	1079.289655	0	320549.0278	0
22	**Notes**		208.5	4.13776	4137.76	0	0	983.4859683	0	295045.7902	0
23	**1)** All values on this page will be filled once		207	5.00504	5005.04	0	0	1224.223775	0	369715.5803	0
24	every value and equation found on the "Data		210.5	6.52278	6522.78	0	0	1647.14806	0	490850.1218	0
25	Import" worksheet is appropriately filled out.		206	9.66667	9666.67	0	0	2500.538429	0	757663.1434	0
26	____		197.9	6.175868	6175.868	0	0	1640.762614	0	487306.4969	0
27	**2)** Data under the "Load Calculations" section		186.7	6.782964	6782.964	0	0	1847.796061	0	554338.8177	0
28	will correspond to how many lines of data you		179.6	7.953792	7953.792	0	0	2280.065035	0	688579.6409	0
29	copied over from the logger station webpage		173.8	10.42554	10425.54	0	0	3121.335782	0	930158.0628	0
30	table which is why choosing a specific time		172	12.788878	12788.878	0	0	3947.494375	0	1196090.797	0
31	range is inportant, prevents oversaturation.		164.1	13.829614	13829.614	0	0	4409.800613	0	1309710.78	0
32	____		157.4	14.848668	14848.668	0	0	4882.448435	0	1459852.083	0
33	**3)** The main values that will be used for analysis		148.8	16.084542	16084.542	0	0	5389.159575	0	1632915.35	0
34	are the "Sediment Load" and "Chloride Load"		144.5	17.298734	17298.734	0	0	5836.809086	0	1733532.3	0
35	values since they calculate the amount of		142.9	22.437368	22437.368	0	0	7774.927204	0	2363577.87	0
36	particles passing the sensor station when		135.8	27.576002	27576.002	0	0	9790.341081	0	2907731.298	0
37	automatic data logging occurred.		138.5	32.736318	32736.318	0	0	11807.31226	0	3542193.682	0
38	____		131.5	27.597684	27597.684	0	0	10286.60067	0	3116840	0
39	**4)** This table will only be able to read up to 1000		128.7	26.513584	26513.584	0	0	10106.02903	0	2991384.595	0
40	data entries. If including more than 1000, scroll		125.4	30.04775	30047.75	0	0	11729.22635	0	3565684.811	0

Discharge and TSS literature

- Sloto, R.A., and Olson, L.E., Estimated suspended-sediment loads and yields in the French and Brandywine Creek Basins, Chester County, Pennsylvania, water years 2008–09: U.S. Geological Survey Scientific Investigations Report 2011–5109, 31 p., https://pubs.usgs.gov/sir/2011/5109/
- Sloto, R.A., Gellis, A.C., and Galeone, D.G., 2012, Total nitrogen and suspended-sediment loads and identification of suspended-sediment sources in the Laurel Hill Creek watershed, Somerset County, Pennsylvania, water years 2010–11: U.S. Geological Survey Scientific Investigations Report 2012–5250, 44 p., https://pubs.usgs.gov/sir/2012/5250/support/sir2012-5250.pdf
- MGlysson, G & Gray, John & Schwarz, Gregory. (2001). A Comparison of Load Estimates Using Total Suspended Solids and Suspended-Sediment Concentration Data. 10.1061/40569(2001)123. https://www.researchgate.net/publication/237815051_A_Comparison_of_Load_Estimates_Using_Total_Suspended_Solids_and_Suspended-Sediment_Concentration_Data
- Gray, John R, G. Douglas Glysson, Lisa M. Turcios, and Gregory E. Schwarz. Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data. U.S. GEOLOGICAL SURVEY, Water-Resources Investigations Report 00-4191, Reston, Virginia 2000. https://water.usgs.gov/osw/pubs/WRIR00-4191.pdf
- Lewis, Jack, Rand Eads, Randy Klein. Comparisons of Turbidity Data Collected with Different Instruments. Report on a Cooperative Agreement Between the California Department of Forestry and Fire Protection and USDA Forest Service--Pacific Southwest Research Station (PSW Agreement # 06-CO-11272133-041). https://water.usgs.gov/fisp/docs/Tprobe_final_report.pdf

STROUD™
WATER RESEARCH CENTER

Today

- With Lauren McGrath and Marion Waggoner in Lab
  - Demonstration of methods
  - In pairs
    - Filter samples (already prepared with known concentrations, to be dried and weighed later)
    - Weigh samples (already dried)
- With Dave Bressler and Dave Yake in Field
  - Demonstration of methods
  - In pairs
    - Discharge measurements, flow meter
    - Discharge measurements, orange float
    - Collect and label grab samples

STROUD WATER RESEARCH CENTER

Preparing for the rest of the day

- Get into pairs
- Half stay at Lab, half go in field
  - Field
    - “Ashbridge Preserve” – put this into GPS
    - Carpool as you’d like
    - **Everyone bring waders**
    - **Everyone bring your grab bottle, data sheet, clipboard, pencil**
    - Bring other supplies as needed

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