Sediment Transport Monitoring in the Lower Columbia River

Columbia River Estuary Conference 2023

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In cooperation with the U.S. Army Corps of Engineers – Portland District

Presentation Overview

- Why Sediment Monitoring
- Sediment Monitoring Techniques
- Surrogate Modeling and Methods
- Example Preliminary Observations

Key Benefits of Sediment Transport Monitoring

- Help determine rates and timing of sediment transport events that may impact Navigation and potential need for dredging operations.
- Fish habitat and wildlife Impacts
- Beach and river island erosion and deposition

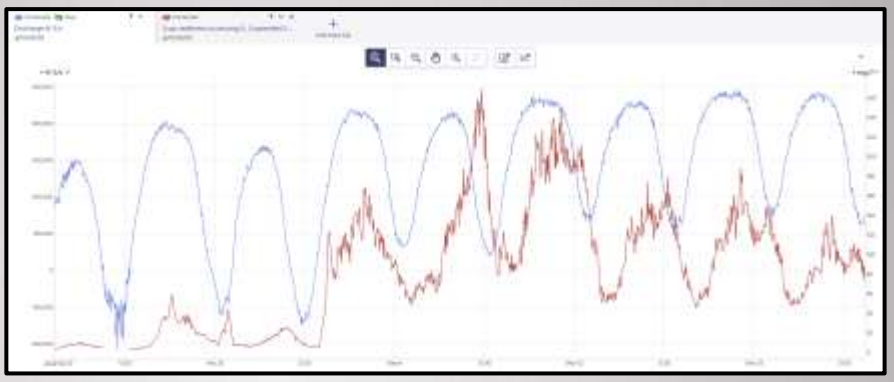
USACE Dredge Essayons at work, date and location unknown.
US Army Corps of Engineers photo by Barrel

Columbia River Shipping Channel

Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

Sediment Transport Monitoring Methods/Technologies

- Discharge Correlation
- Turbidity Meters
- Acoustic Meters
  - Micro Acoustic Meters
  - Profiling Acoustic Meters

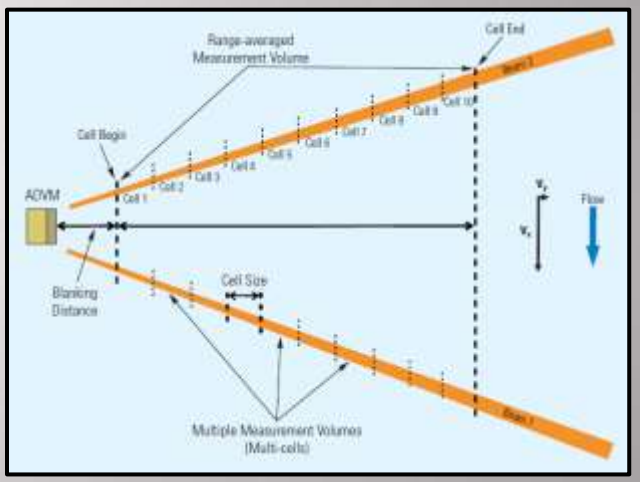


Discharge, cubic feet/second (blue) and sediment concentration, mg/L (red)

DTS12 Turbidity Meter: Forest Technology Systems Ltd.

500kHz ADVM : YSI Sontek

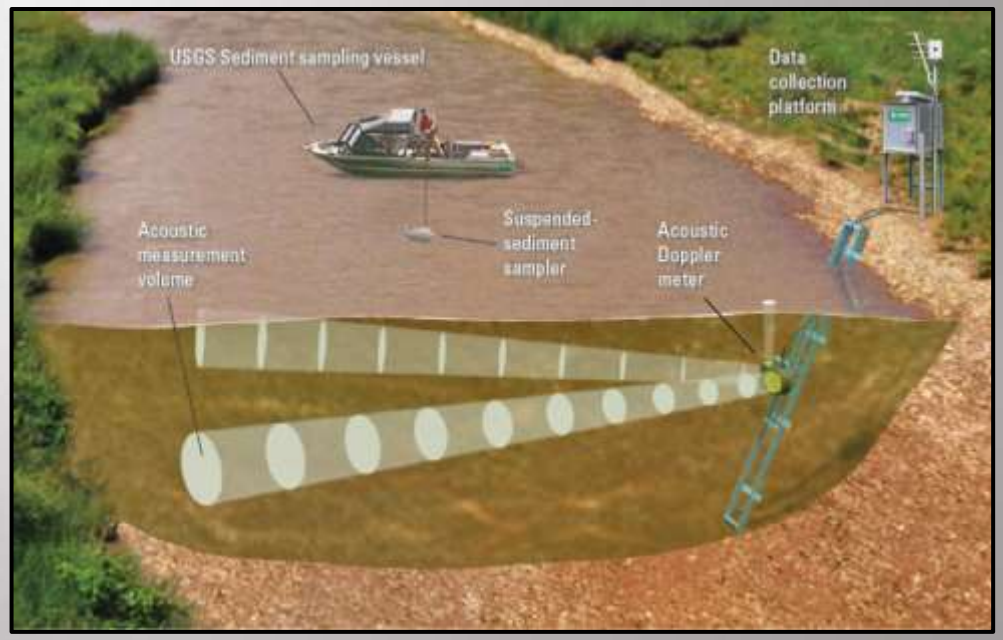
LISST ABS Acoustic Sediment Sensor: Sequoia Scientific



Generalized Measurement Volume of an ADVM : Levesque, V.A., and Oberg, K.A., 2012, Computing discharge using the index velocity method: U.S. Geological Survey Techniques and Methods 3–A23,

Benefits and Requirements of using ADVM Profilers for use in Monitoring Suspended Sediment Concentration in Large Rivers

- Can be used as a surrogate for Sediment Concentration Measurements
- Benefit from limited bio fouling
- Sample a significantly greater volume of water
- Models can be implemented to compute concentrations Real-Time
- Acoustic Parameter configuration at each site
  - Raw Measured Acoustic Backscatter needs to be corrected for the effects of:
    - Beam Spreading
    - Water Absorption
  - Normalized Acoustic Parameters
    - SCB (sediment corrected backscatter)
    - SAC (sediment attenuation coefficient)
  - Data Transformations
  - Regression Models
  - Model Implementation into NWIS Database

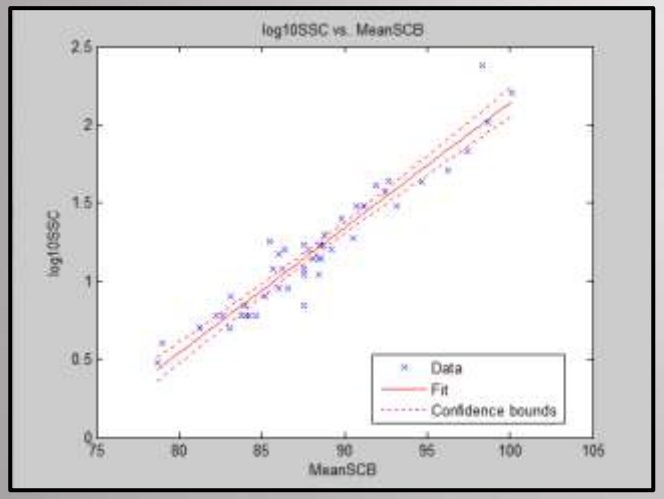


Example of a sediment acoustic surrogate streamgage (adapted from image provided by SonTek® / Xylem.

Sediment Surrogate Modeling

- Method for estimating continuous sediment concentration data.
- Calibration data (samples) are collected to relate the mean channel concentration to data collected from fixed mounted surrogate instrument.
  - Cross Section Samples
  - Representative of the range in expected sediment concentration at site
  - Representative of seasonality at site
  - Statistically significant number of samples
- In the case of ADVM surrogate modeling, several corrections to the raw data are required to account for signal losses (beam spreading, absorption, and other losses).

D-96 depth integrated sediment sampler on the Columbia River, photo credit: P. Diaz



Sediment corrected backscatter dB vs calibration samples mg/l; from Sediment Acoustics Index Developer developer tool.

```
Linear regression model:
log10SSC = -3.94 + 3.94e-06Q - 0.359VELX + 0.0563MeanSCB

Estimated Model Coefficients
                Estimate        SE          tStat       pValue      Lower95%      Upper95%         VIF
(Intercept)      -3.9361      0.35455      -11.101     2.6437e-20      -4.6378       -3.2344
Q              3.9375e-06    8.0169e-07     4.9111     2.7913e-06    2.6089e-06    5.2661e-06     41.577
VELX             -0.3594      0.084268     -4.2659     3.6133e-05      -0.5262       -0.1926     59.961
MeanSCB          0.05632     0.0041853      13.456     5.2592e-26      0.04803       0.06461     1.5122

Number of observations: 128, Error degrees of freedom: 124
Root Mean Squared Error (Standard Error of Regression): 0.19667
R-squared: 0.783,  Adjusted R-Squared 0.778
F-statistic vs. constant model: 149, p-value = 3.33e-42

RMSE(%): 45.0459

Non-parametric smearing bias correction factor: 1.1036

Probability plot correlation coefficient: 0.98722

High leverage:                                  0.09375
Extreme outlier (Standardized residual): 3 (absolute value)
High influence (Cook's D):                      1.5914
High influence (DFFITS):                        0.35355
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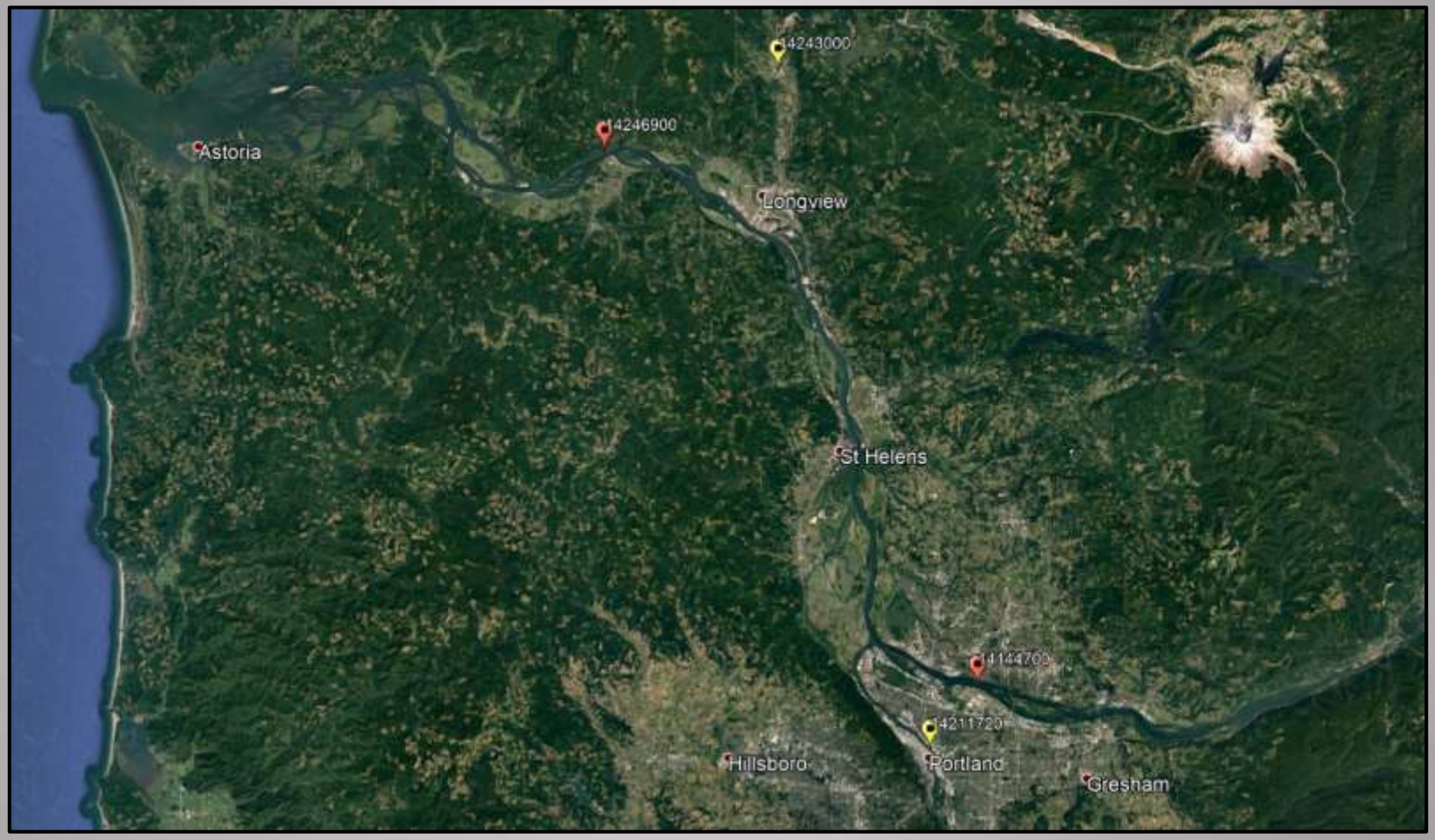
Model output statistics; from Sediment Acoustics Index Developer tool.

USGS Sediment Monitoring Locations



Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

USGS Sediment Monitoring Stations

Installed Summer 2015

14246900 Columbia River nr Port Westward, OR

Installed Summer 2015

14211720 Willamette River at Portland, OR

Installed Winter 2015

14144700 Columbia River at Vancouver, WA

Installed Fall 2020

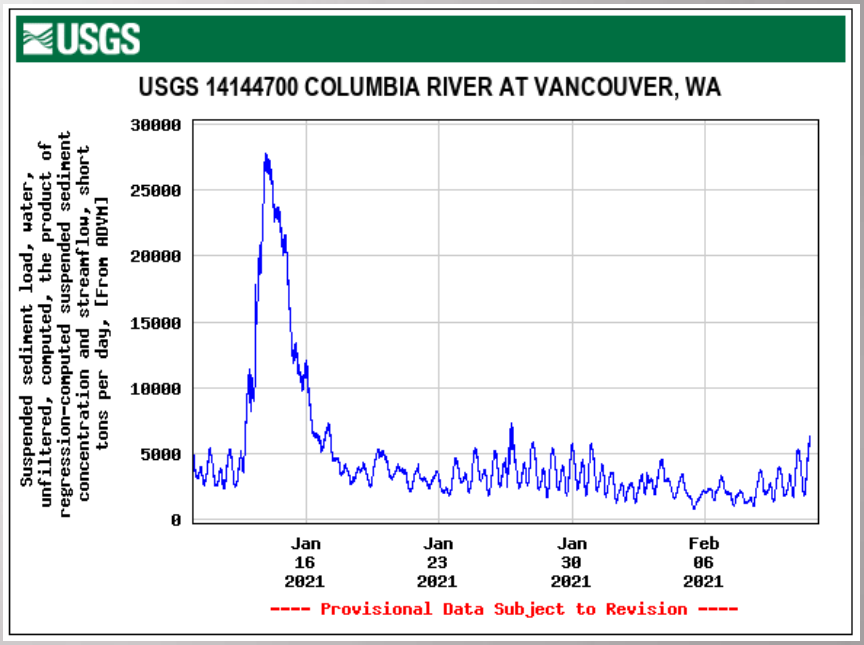
14243000 Cowlitz River at Castle Rock, WA

Operational Sediment Acoustic Models and Real-Time Concentration Data

- 14246900 Columbia at Port Westward (BAT), OR
- 14144700 Columbia at Vancouver, WA
- 14211720 Willamette River at Portland, OR
- Real-Time Suspended Sediment data available on NWISWEB
- LISST ABS and Turbidity Data also available

- 14246900 Columbia at Port Westward (BAT), OR
https://waterdata.usgs.gov/monitoring-location/14246900
- 14144700 Columbia at Vancouver, WA
https://waterdata.usgs.gov/monitoring-location/14144700
- 14211720 Willamette River at Portland, OR
https://waterdata.usgs.gov/monitoring-location/14211720

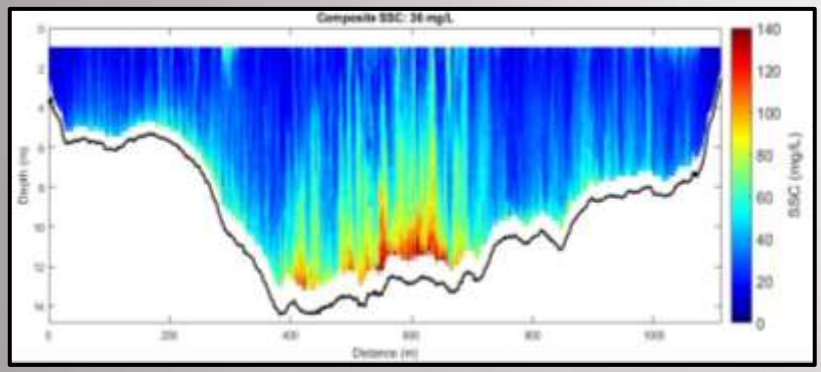
- 14243000 Cowlitz River at Castle Rock, WA
https://waterdata.usgs.gov/monitoring-location/14243000



Suspended Sediment load tons/day; 14144700 Columbia River at Vancouver, WA
https://waterdata.usgs.gov/

Down-looking Acoustic SSC Measurement

- ADCP (down-looking acoustic meters) can be used to estimate SSC and its spatial distribution in the cross section.
- ADCP's are widely used to make routine discharge measurements
- Can provide more information about "unsampled zone".
- ADCP's calibrated to measured SSC using Stationary Transect Acoustics (STA) software
- USGS is making progress on refinement of technique and software development
- Collecting and processing point sample data is labor and time intensive, but should pay dividends after instrument is calibrated.



Example Cross Section Plot

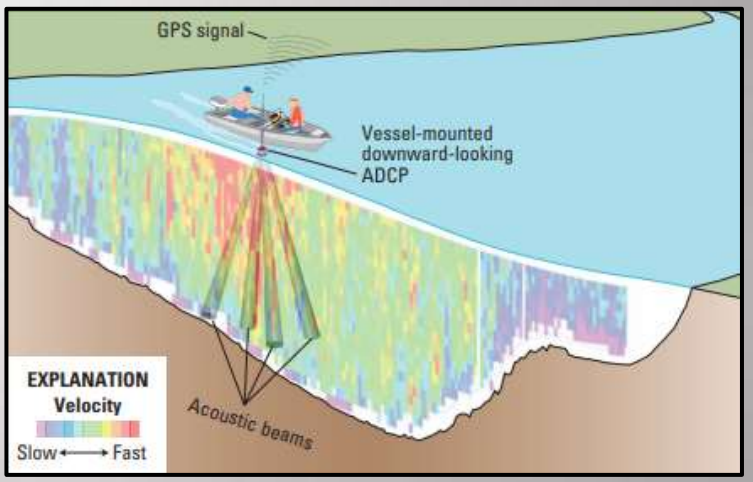


Illustration of a boat-mounted acoustic Doppler current profiler (ADCP) measuring discharge using the moving-boat technique. From Mueller, D.S., Wagner, C.R., Rehmel, M.S., Oberg, K.A,, and Rainville, Francois, 2013, Measuring discharge with acoustic Doppler current profilers from a moving boat (ver. 2.0, December 2013): U.S. Geological Survey Techniques and Methods, book 3, chap. A22.

Observations

Lower Columbia River is a Complex System

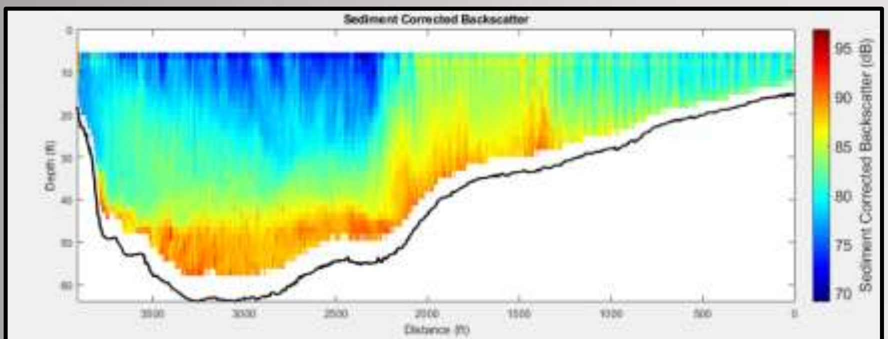
Mouth of Willamette River

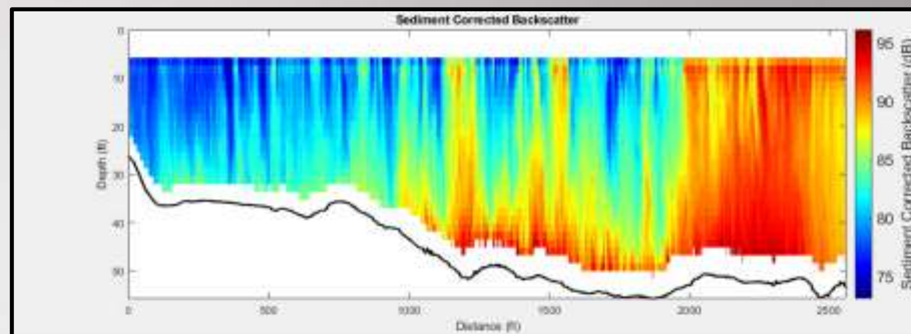
Mouth of Cowlitz River

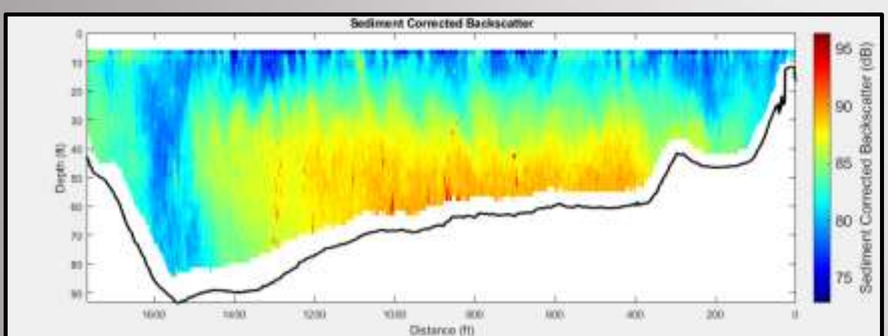
Mouth of Cowlitz River Downstream

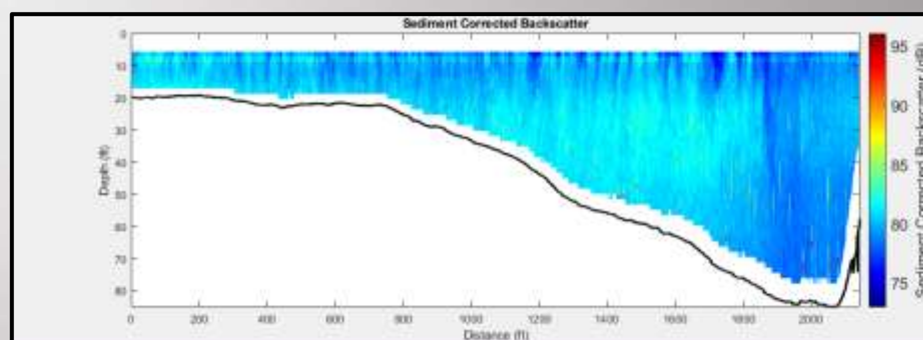
Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

Examples of Cross Sectional Concentration Plots



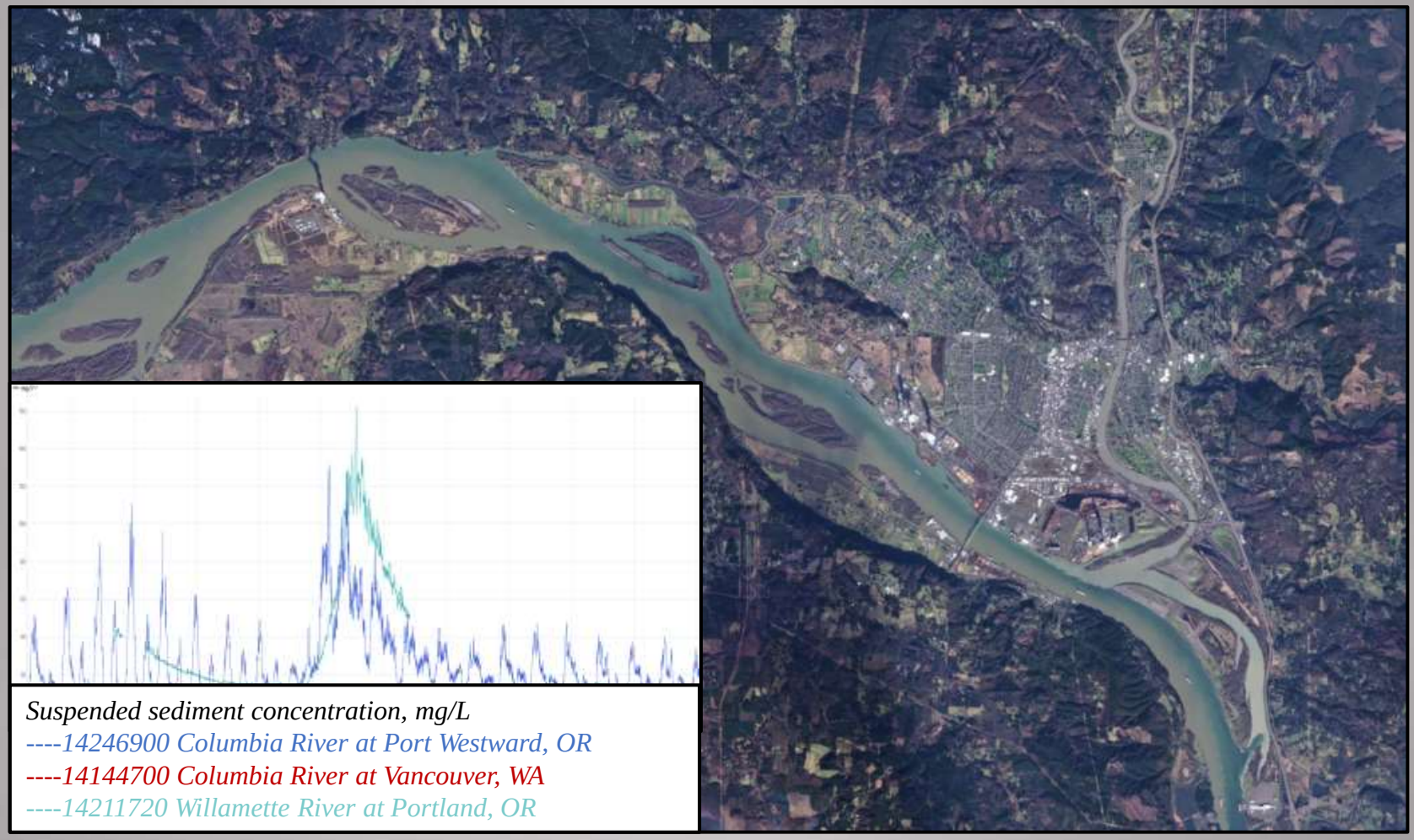






Observations/Example Data

January 23, 2017 Regional Event



Suspended sediment concentration, mg/L
----14246900 Columbia River at Port Westward, OR
----14144700 Columbia River at Vancouver, WA
----14211720 Willamette River at Portland, OR

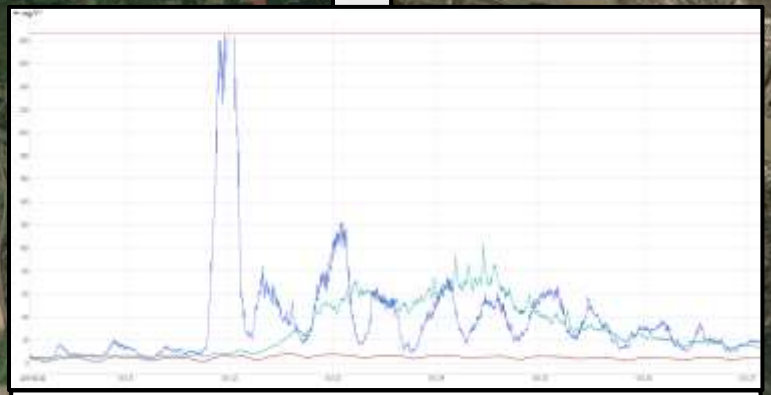
Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

Observations/Example Data

October 22, 2017 Regional Event

October 23, 2017

October 27, 2017



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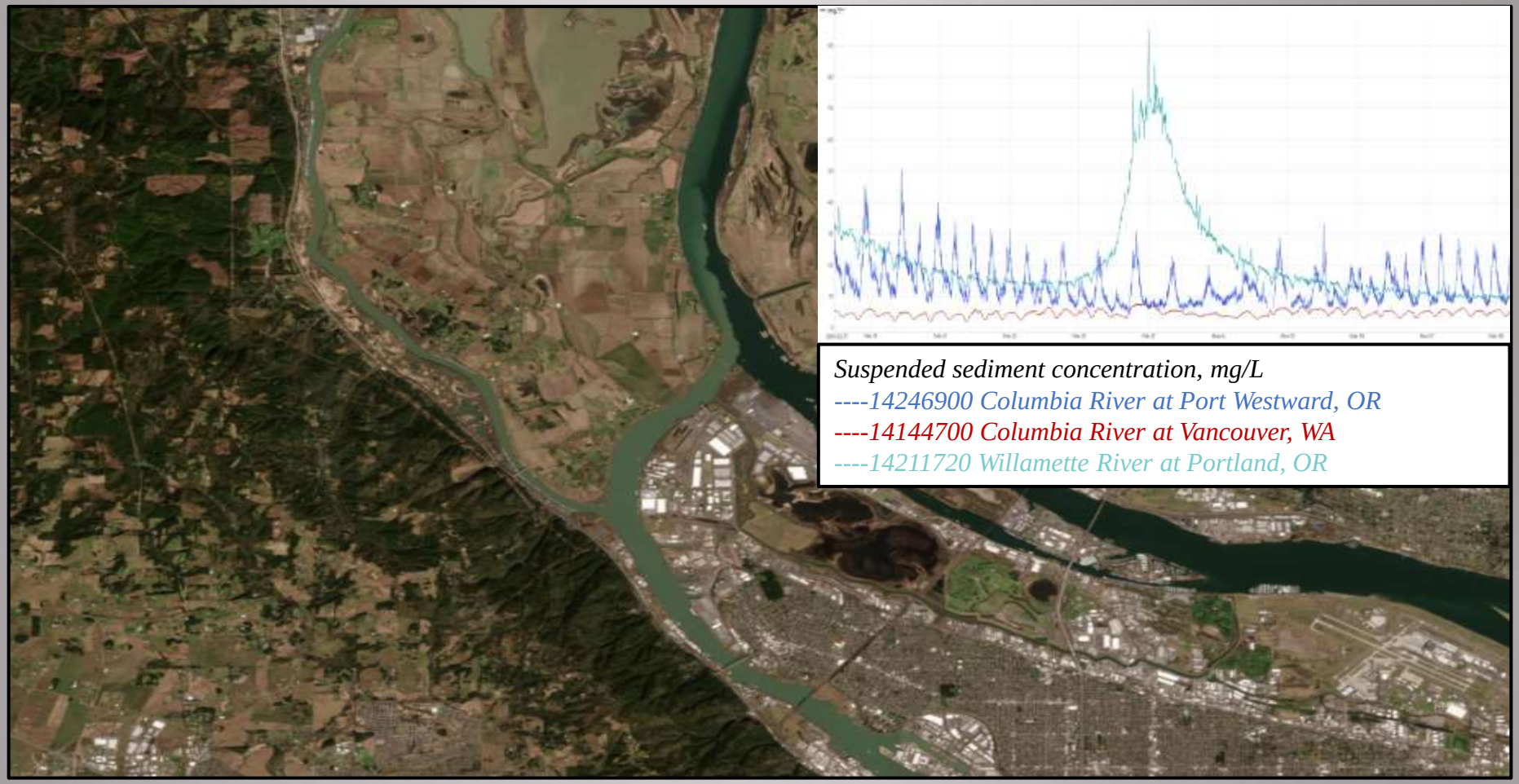
Observations/Example Data

February 27, 2019 Event on the Willamette River



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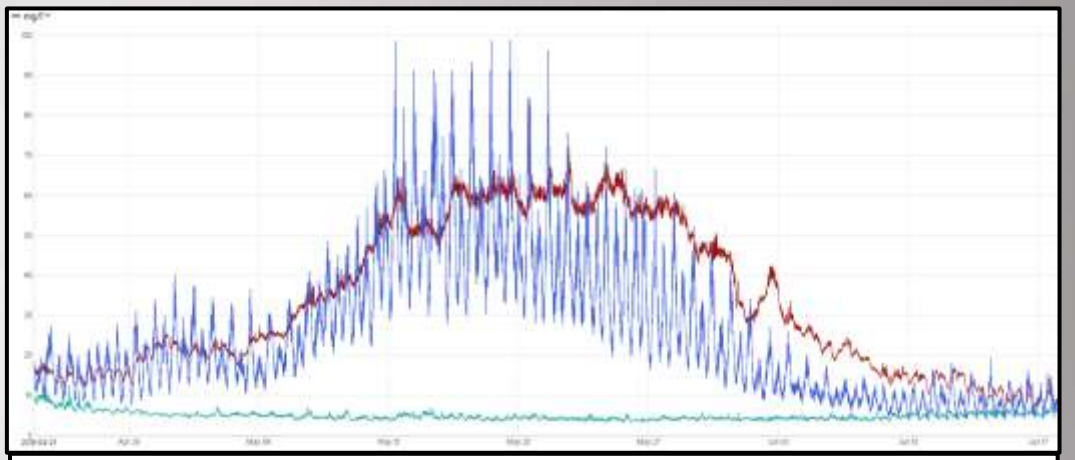
Observations/Example Data

May 2022 Freshet

Mouth of Cowlitz River

Mouth of Willamette River



Suspended sediment concentration, mg/L

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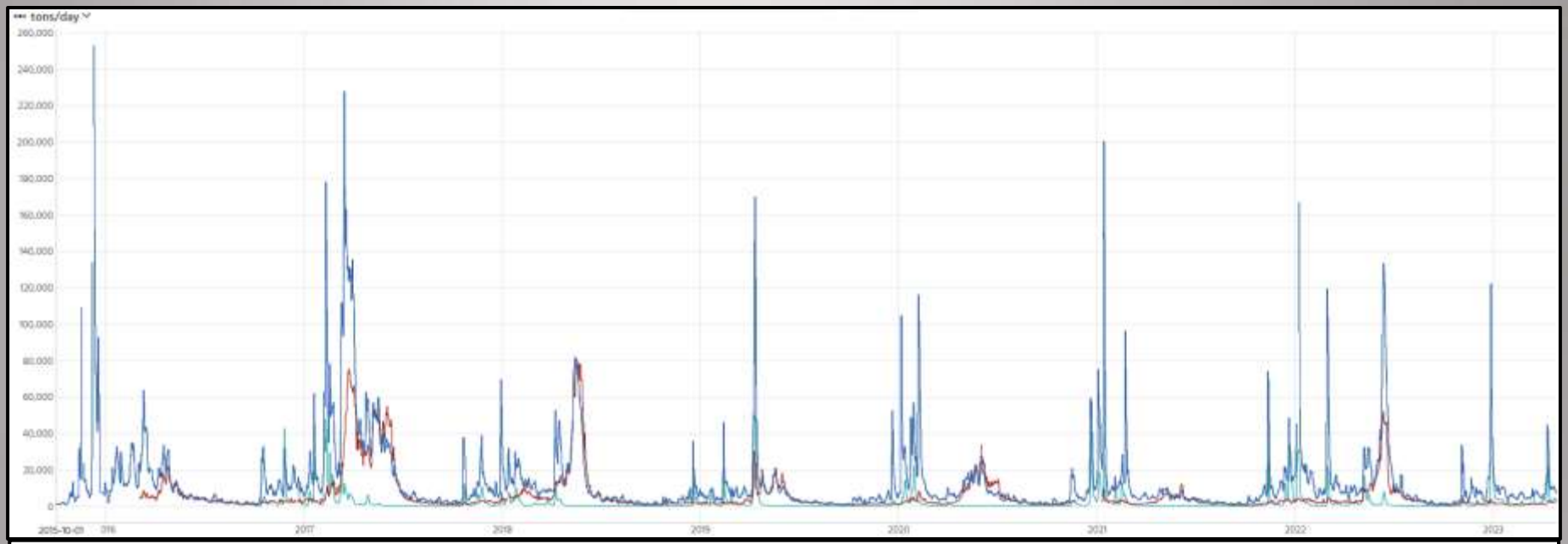
Preliminary Information-Subject to Revision. Not for Citation or Distribution.
https://www.usgs.gov/about/organization/science-support/office-science-quality-and-integrity/fundamental-science-5#12

Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

Observations/Example Data

Sediment Transport Events
(October 2015 - April 2023)
Tons/day



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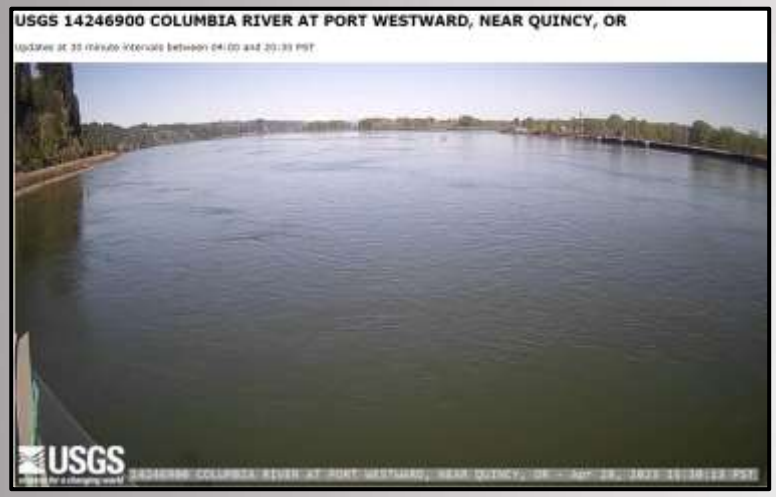
Real-Time Cameras added to USGS LCR Sediment Monitoring Sites



- Available on the Next Gen Pages
- Ability to go back in time, download images.
- Can be used to confirm events and/or other.
- Port Westward is Online
- Cowlitz and Vancouver installed and collecting data, service request in for addition to Next Gen pages.

NWIS WEB: Access to Real-Time Sediment Concentration Data

- 14246900 Columbia at Port Westward (BAT), OR
  https://waterdata.usgs.gov/monitoring-location/14246900
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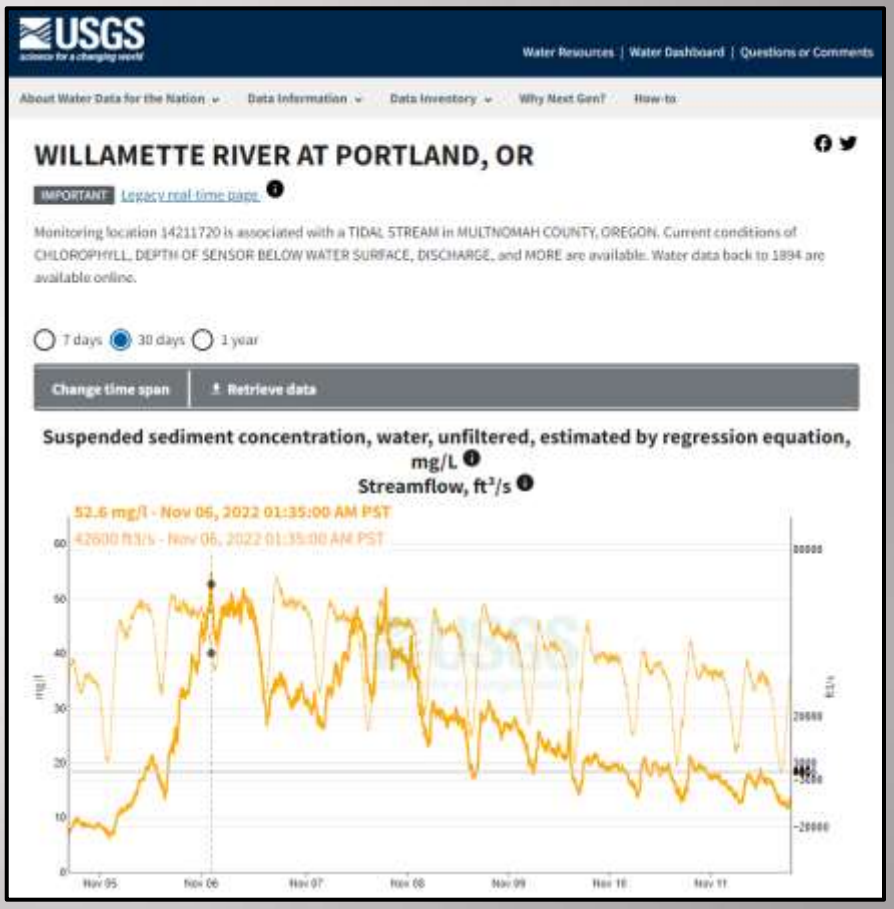

Next Generation NWIS WEB Pages,
https://waterdata.usgs.gov/

Questions?

14246900 Columbia River at Port Westward, OR, 12/10/2015, 238mg/L