

Continuous Suspended Sediments Monitoring with SonTek Sidelooker

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Guest Speakers



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House Keeping

- ❑ We are recording!
- ❑ Ask your question at any time in the “question” section of your Zoom screen
- ❑ All questions will be answered at the end of the webinar
- ❑ A link to the recording will be shared in a follow up email

Why Suspended Sediment Monitoring?

Impacts

- Environment
- Water Infrastructure
- Navigation

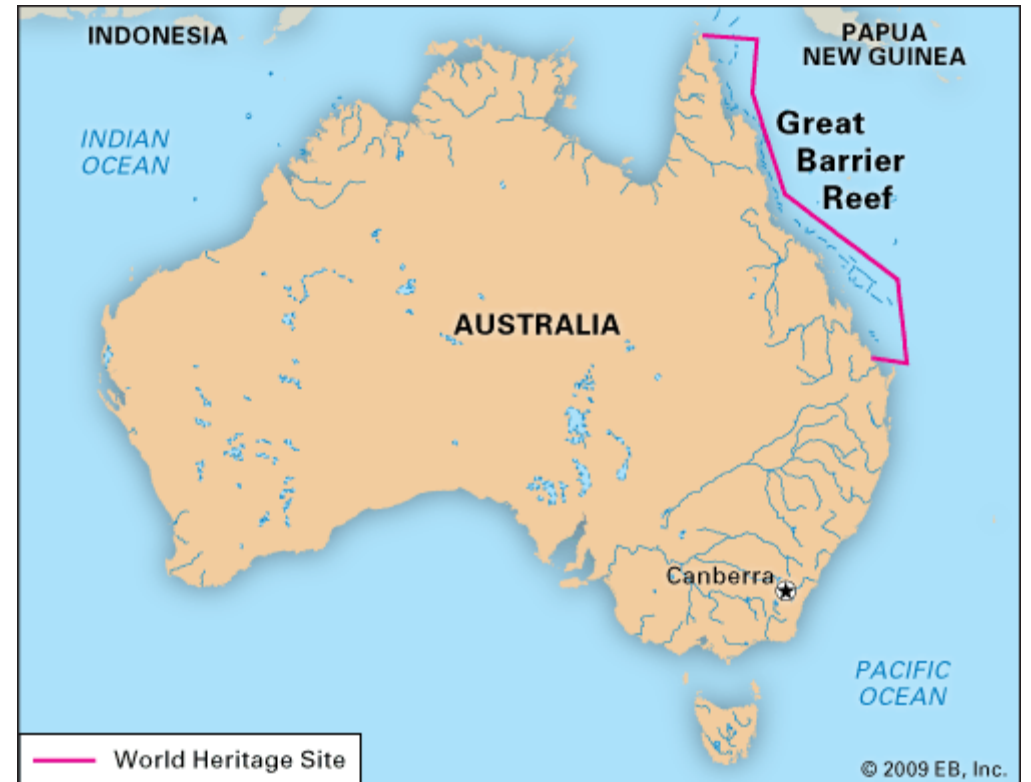
Engagement

- Agriculture

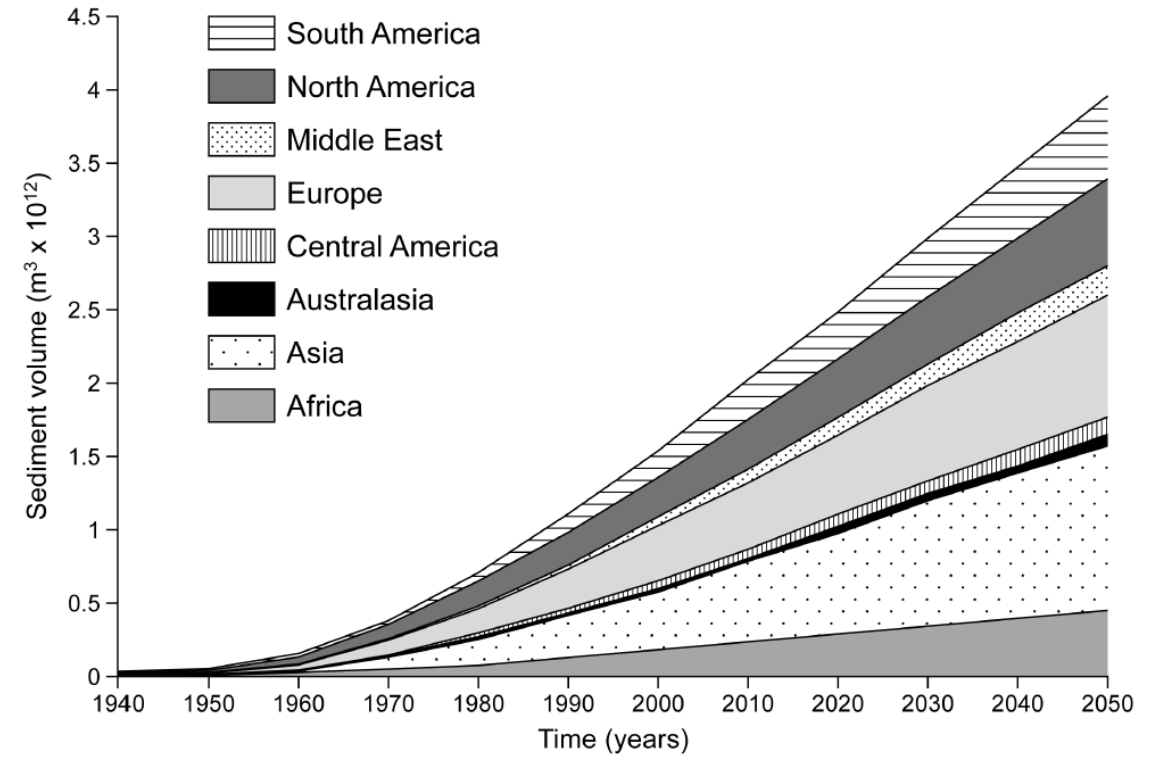
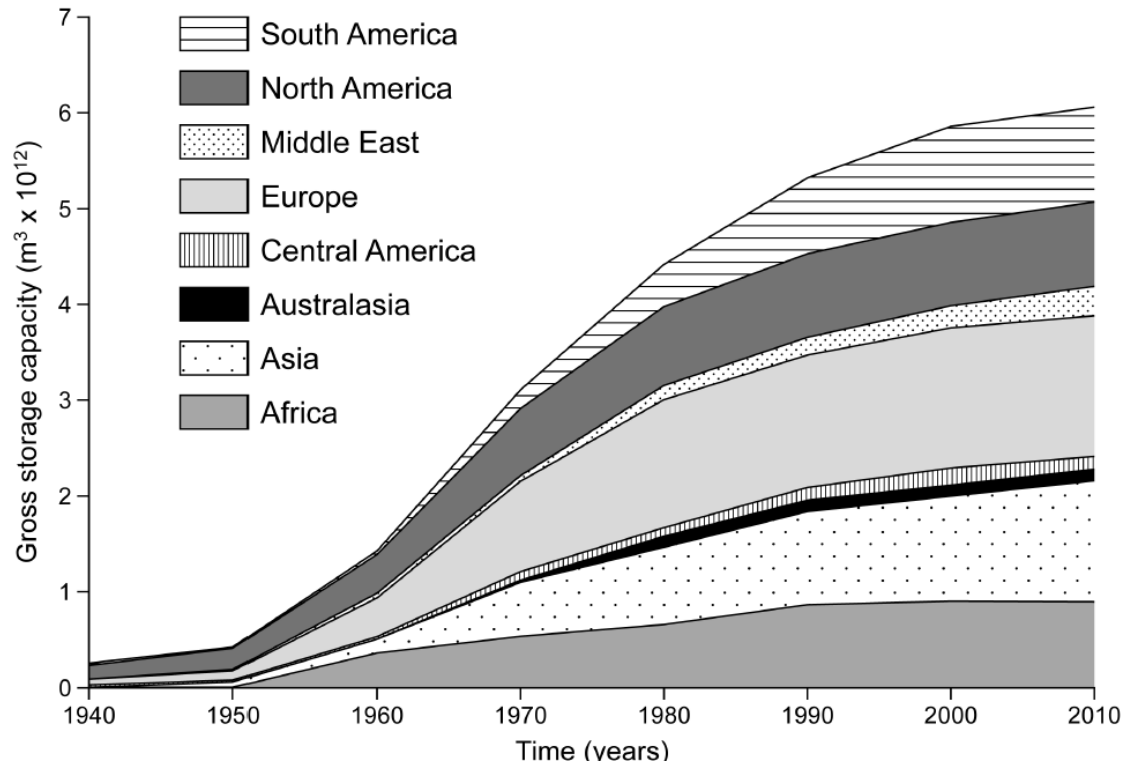


Environment

- Seabed surfaces unsuitable
- Restricting Light
- Reducing the growth rate
- Disease and mortality
- Reducing larval fish



Water Infrastructure



The role of dams in the global sediment budget
DES E. WALLING

Navigation

Dredging

- Removal of sediment from bottom of lakes, rivers, harbours
- Environmental dredging of contaminants

Beneficial Use

- Habitat creation and restoration,
- Beach nourishment,
- Landfill cover
- Land site remediation



Agriculture

- Program
- Engineered structures
- Workshops
- Consultation
- Condition surveys
- Reduce sediment





Why ADVN - SonTek SL?

- Single Instrument
- Velocity, Back Scatter
- Model Development
- Discharge, SSC, Total Nitrogen, Total Phosphorus, E.coli

J.M. Bell

Acoustic Data as Surrogates for Concentrations of
Suspended Sediment, Nutrients, and Bacteria
U.S. Geological Survey

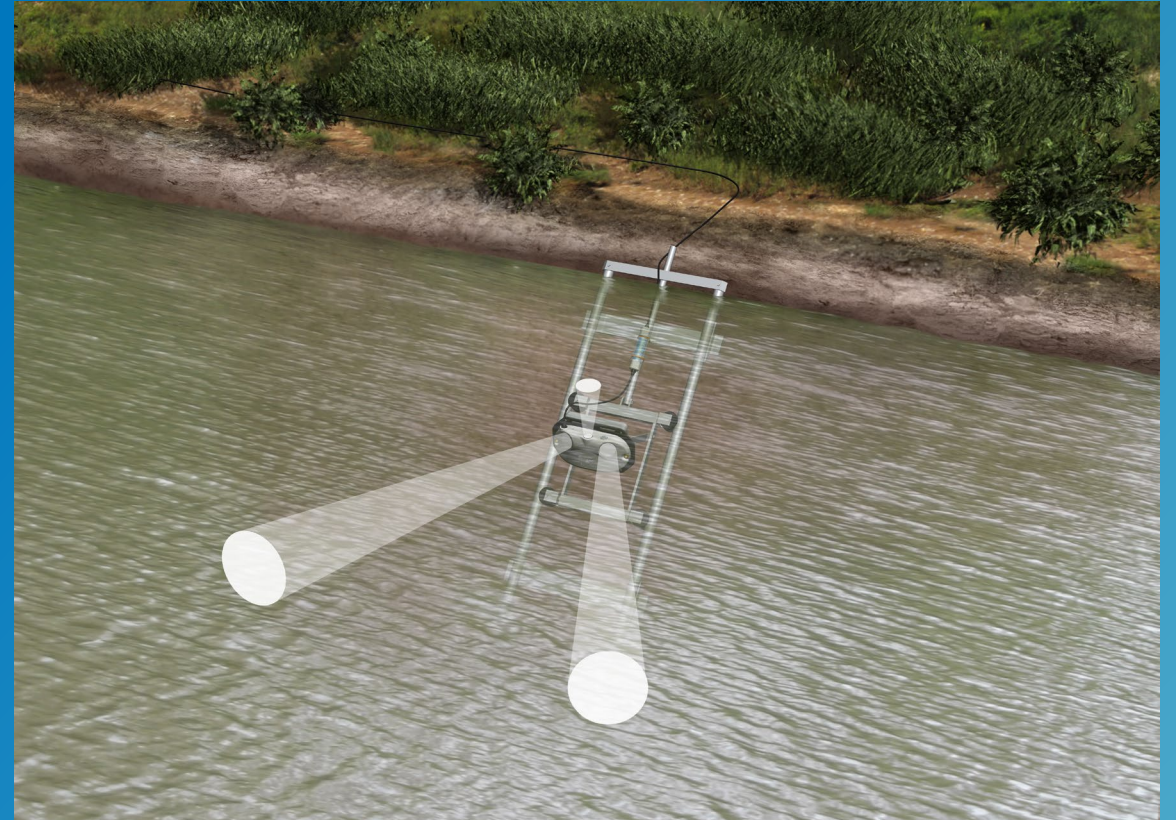
Acoustic Backscatter and Suspended Sediments Theory

- Diagnostic Data
- Acoustic Principles
- Correlation
- Acoustic Surrogates
- Acoustic Attenuation by Sediment

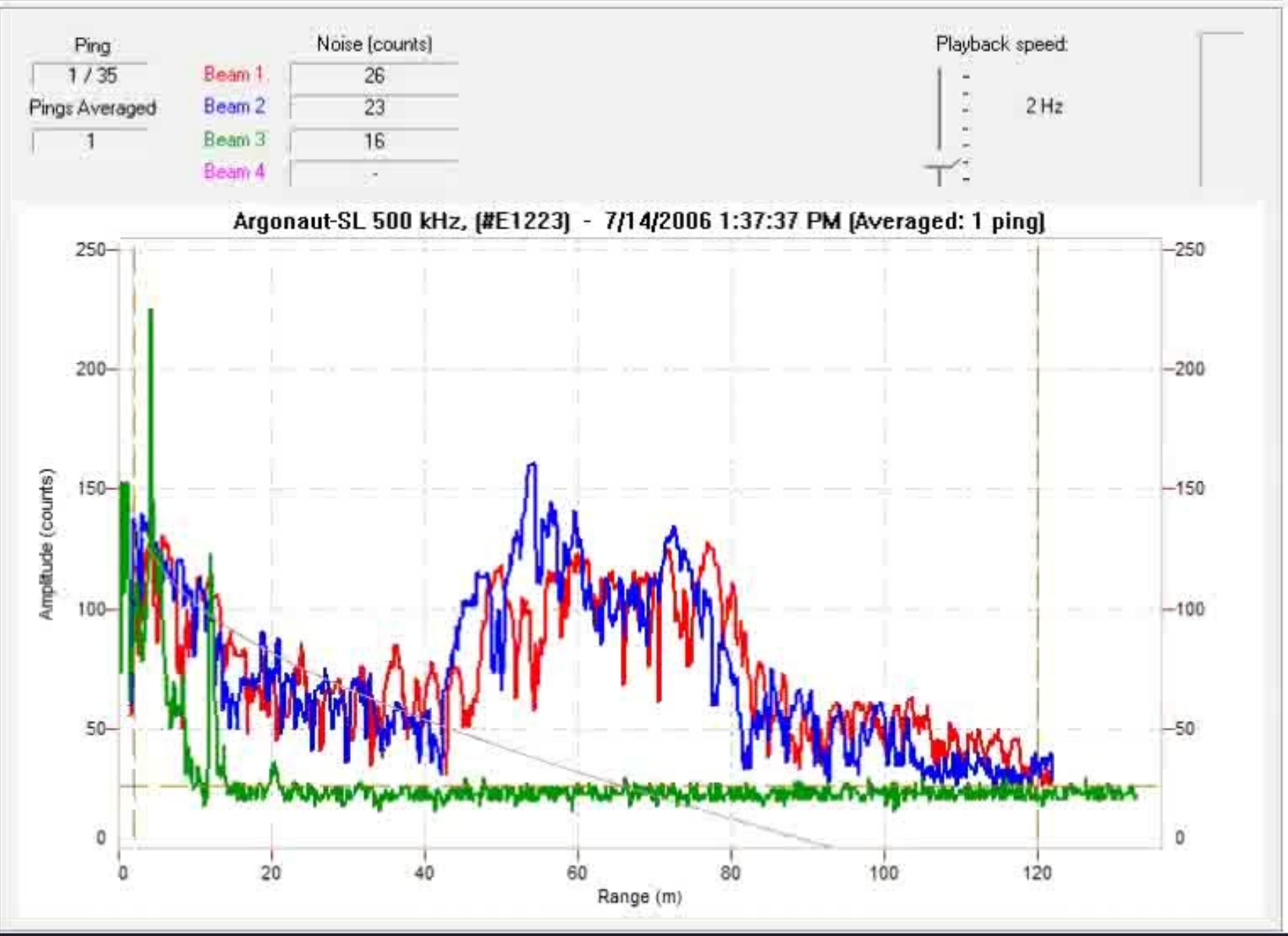
Office of Surface Water

Sediment Acoustic Leadership Team

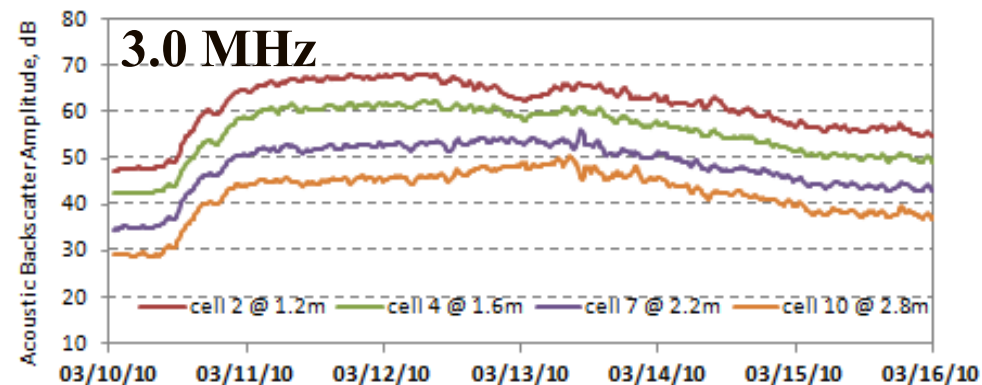
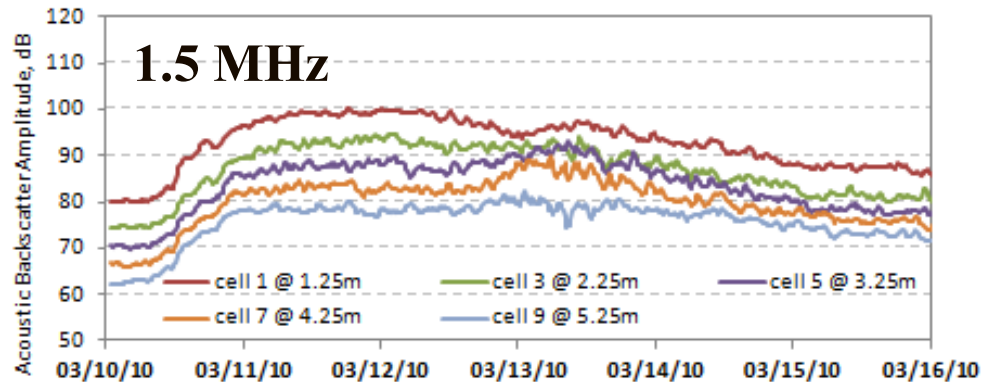
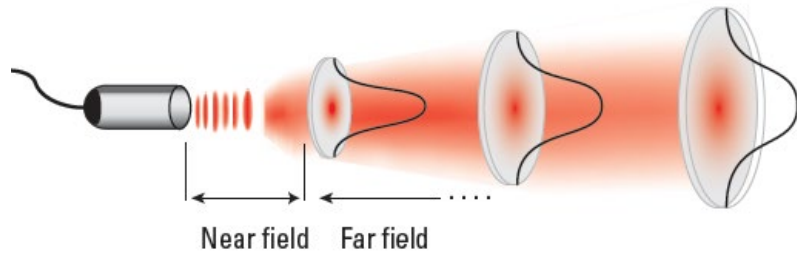
U.S. Geological Survey



Diagnostic Data



Acoustic Principles

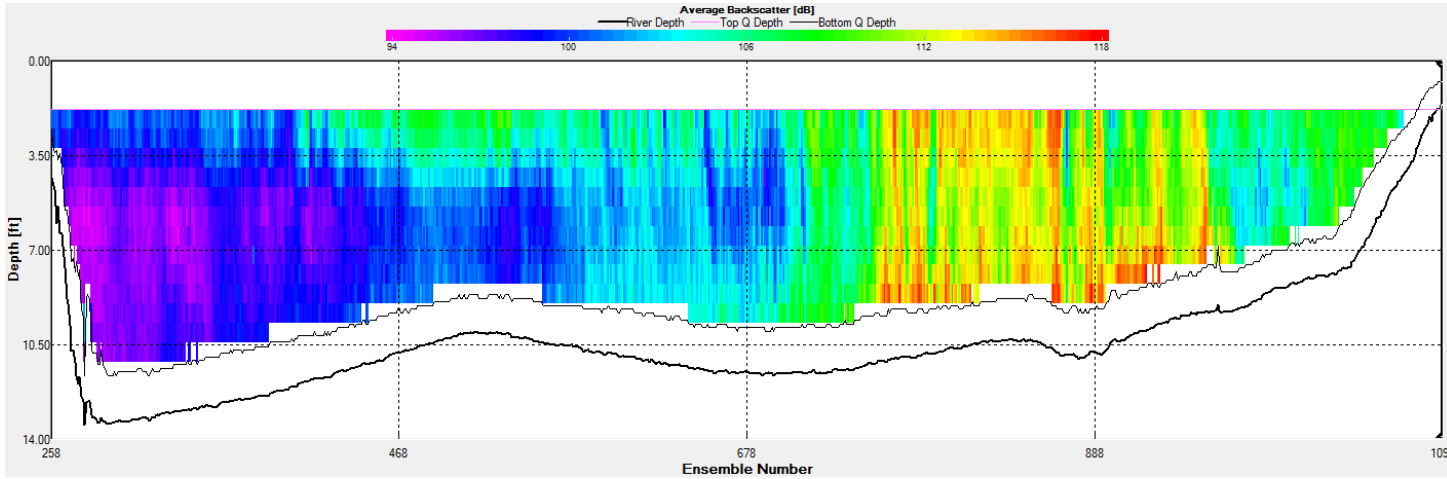


Backscatter Intensity = Function of:

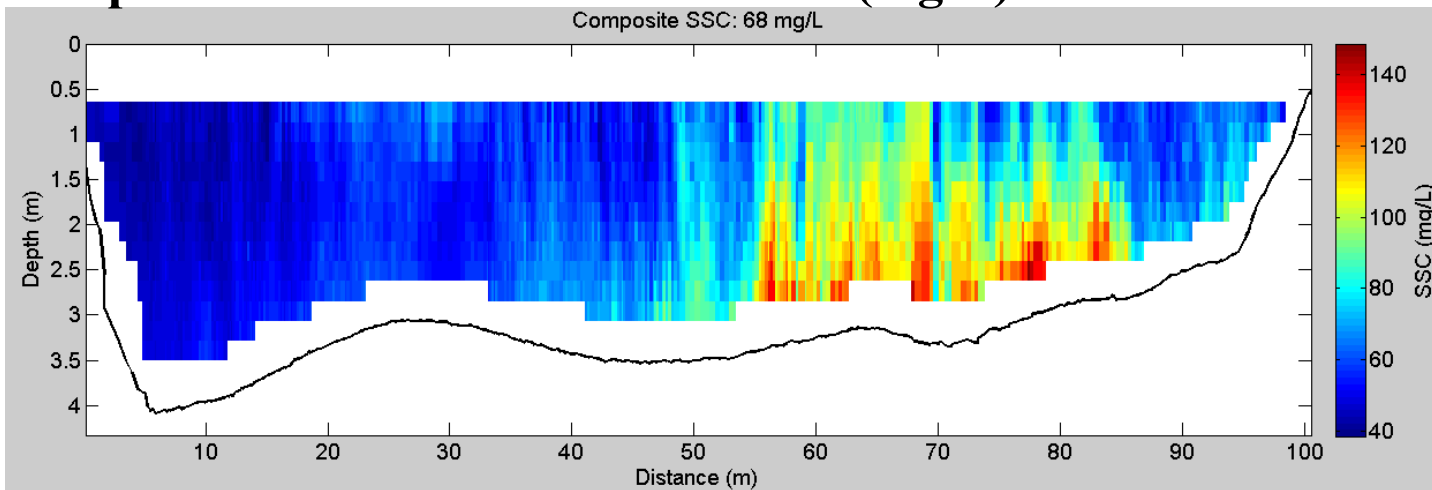
- Range from transducer (signal spreading)
- Near Field Effects
- Acoustic Energy
- Transducer Properties
- Power Supply Amplitude
- Water Temperature (viscosity)
- Dissolved Solids (sound velocity)
- Pressure (Depth, if > 100ft)
- Sediment Properties (Size, Shape, Density)
- Sediment Concentration (SSC)

Correlation

Measured Backscatter (dB)



Suspended Sediment Concentration (mg/L) EDI = 71.4 mg/L



Acoustic Surrogates

$$WCB = MB + 20\log_{10}(\psi r) + 2r(\alpha_w)$$

$$SCB = WCB + 2r\alpha_s$$

$$SCB = MB + 20\log_{10}(\psi r) + 2r(\alpha_w) + 2r\alpha_s$$

↑
Measured
Backscatter

↑
Beam
Spreading

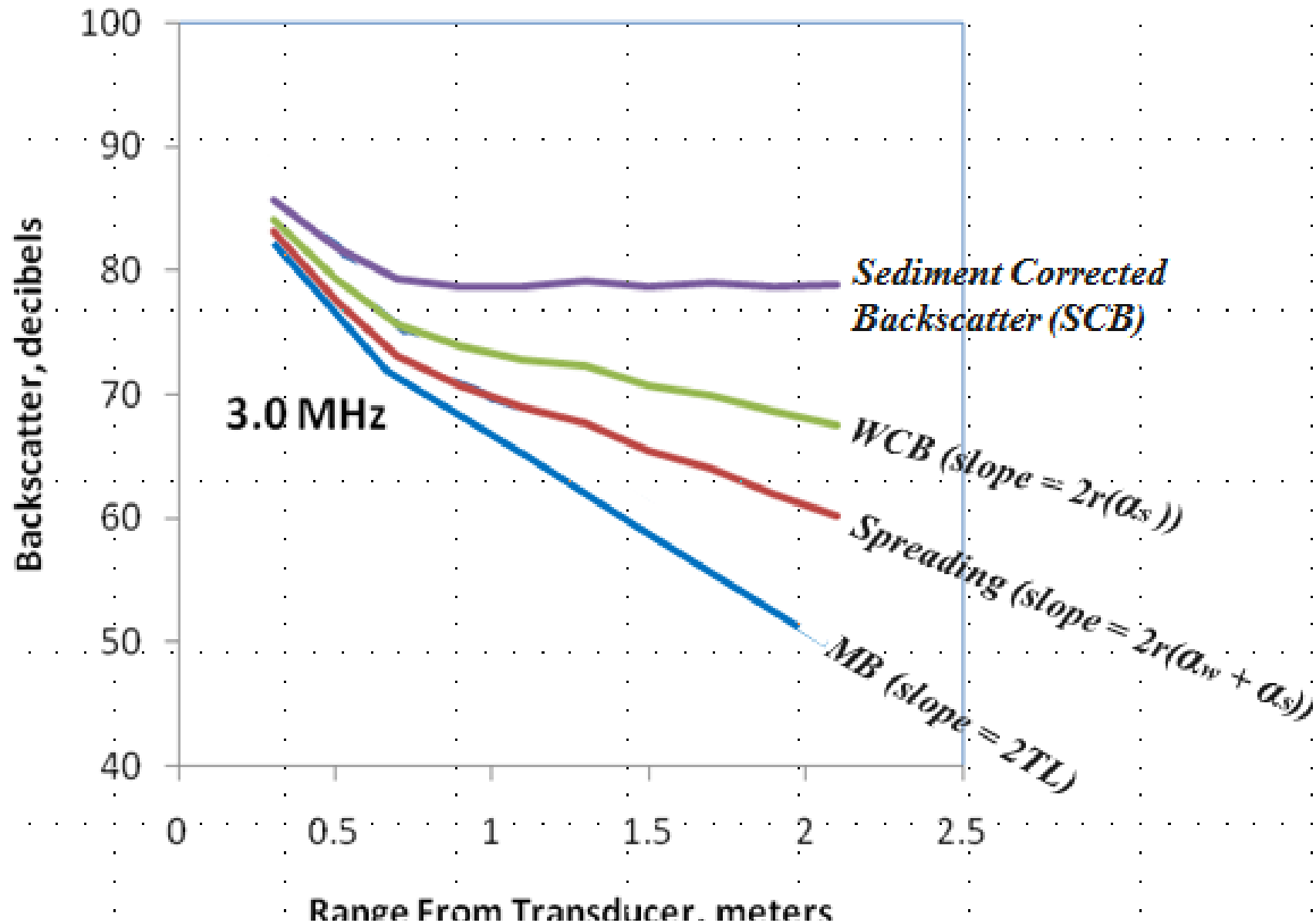
↑
Water
Absorption

↑
Sediment
Attenuation

$\alpha_s = \text{SAC}$

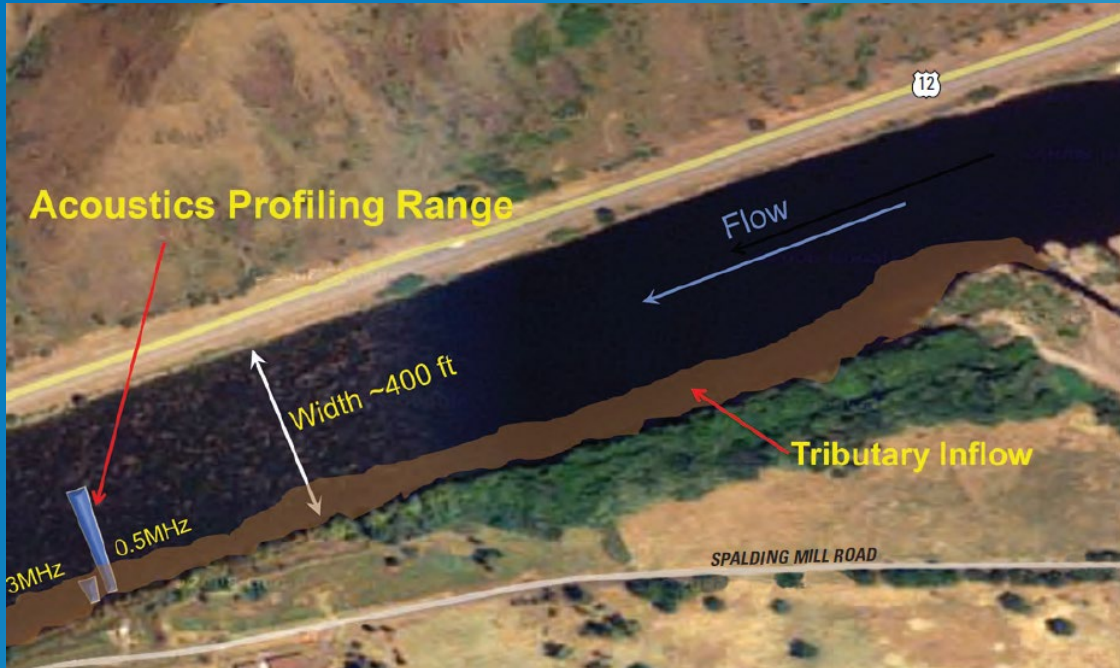
2-Way Transmission Losses

Acoustic Attenuation by Sediment



Site Selection

- Sediment correlate well
- Sediment homogeneous
- Changes in distribution systematic
- Sampling location
- Accessible
- Protection
- Adequate depth
- Straight reach
- Sediment mixing

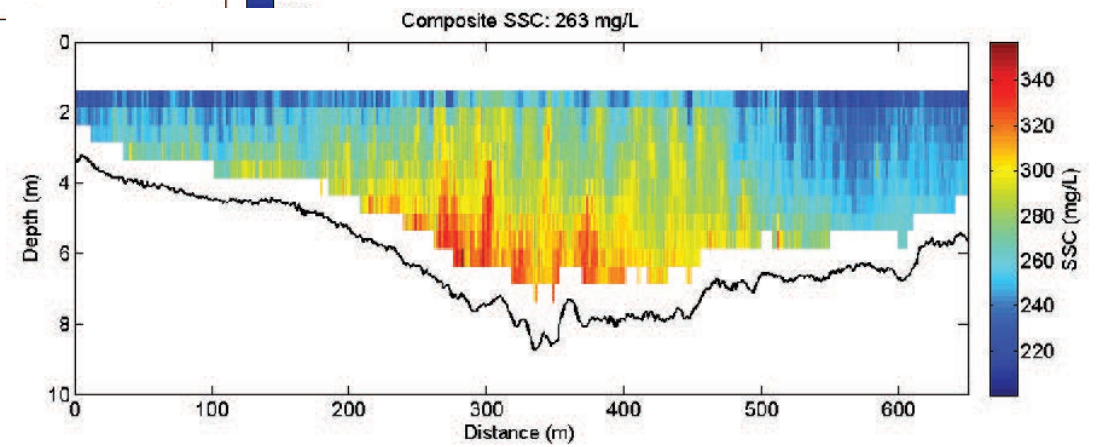
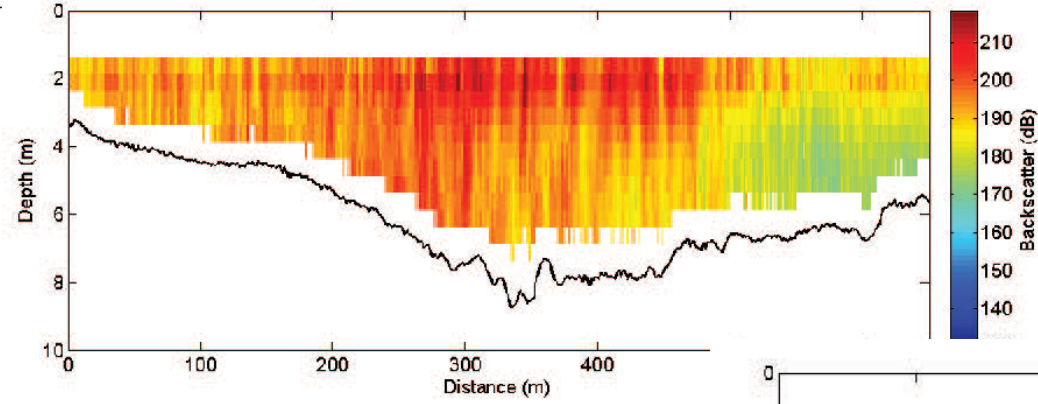
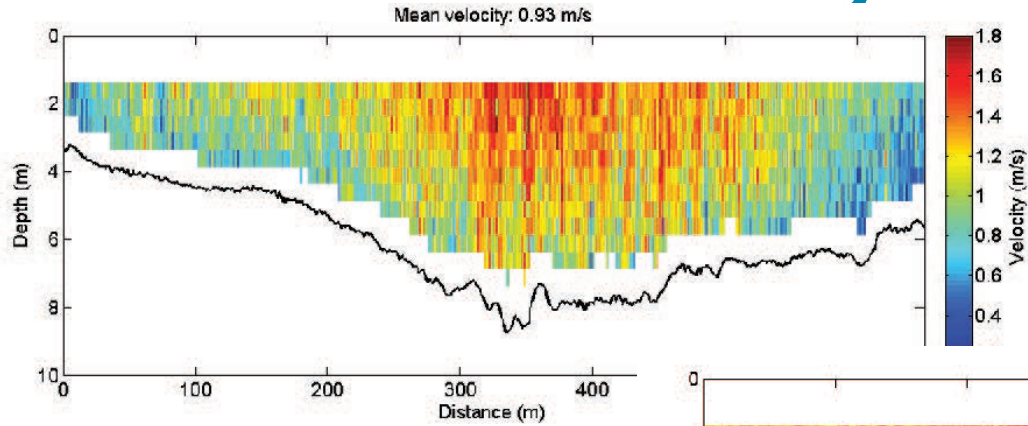


Techniques and Methods 3–C5

Sediment Acoustic Index Method for Computing
Continuous Suspended-Sediment Concentrations

U.S. Geological Survey

Evaluate Site Suitability



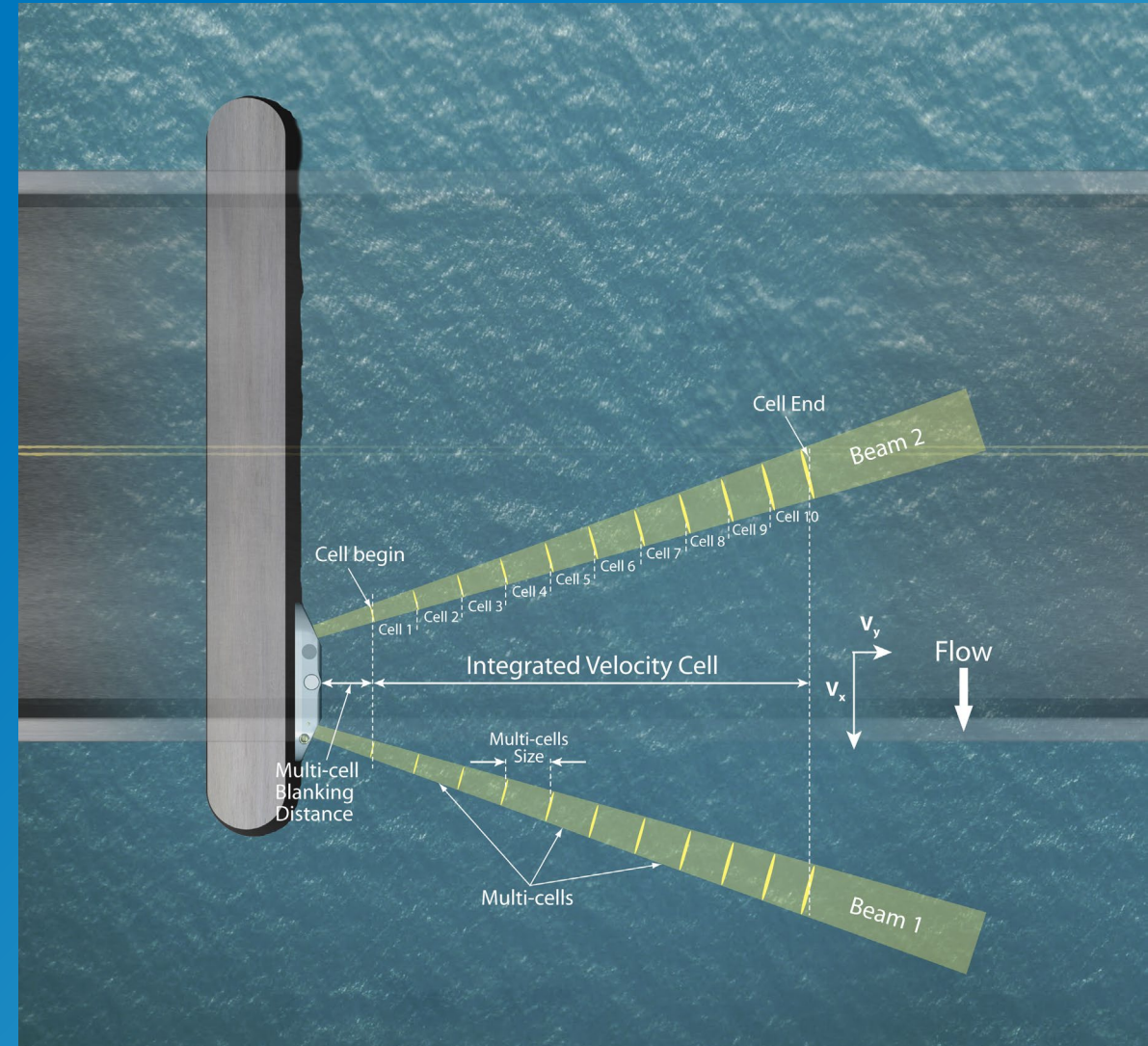
SonTek SL Configuration

- Evaluate backscatter
- Blanking distance
- Optimize configuration
- Sampling interval and averaging period
- Beam check

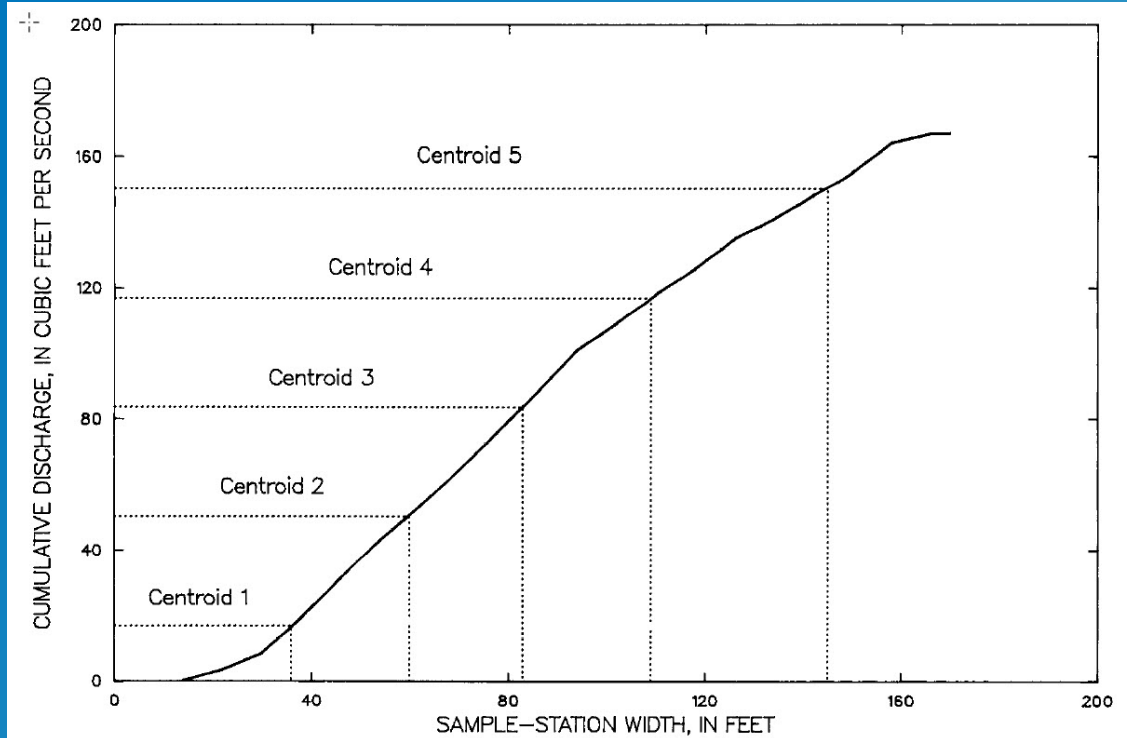
Techniques and Methods 3–C5

Sediment Acoustic Index Method for Computing Continuous Suspended-Sediment Concentrations

U.S. Geological Survey



Sediment Sampling Program



- Sample-Collection Methods
- Depth Integrated Techniques
- Equal-Width-Increment (EWI) method
- Equal-Discharge-Increment (EDI) Method
- Single-Vertical Sample

Techniques and Methods 3–C2

Field Methods for Measurement of Fluvial Sediment

U.S. Geological Survey

Sample-Collection Methods

- **Depth-integrated sampling**
- Point-integrated sampling
- Non-discharge integrated sampling
 - **Single vertical (WBH-96)**
 - Gray or dip sampling with an open-mouth bottle
- Pumped samples
- Single-stage samples

Equal-Width-Increment (EWI) method

- 8-20 equal-width sections
- Sample collected at centroid
- Single transit rate
- Transit rate at max-Q
- Transit rate never > 0.4
- Single composite analysis


Equal-Width-Increment (EWI) method

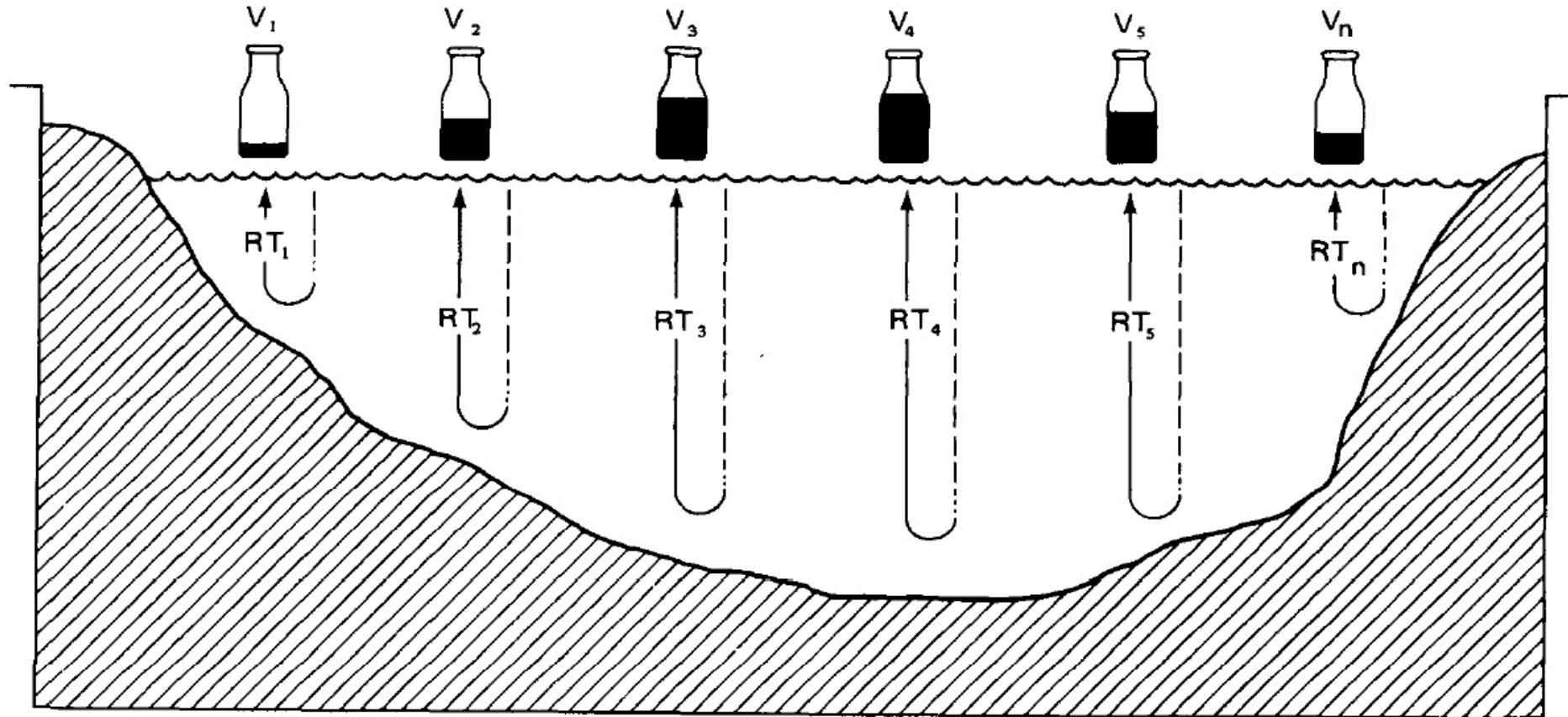
EXPLANATION



RT Transit rate at each vertical (equal)

V Volume collected at each vertical (not equal, but proportional to the discharge at each increment)

 Vertical in each increment (samples collected)



Equal-Discharge-Increment (EDI) Method

- 4-10 equal discharge
- Sample collected at centroid
- Transit rate not equal
- Transit rate never > 0.4
- Analyse sub-samples

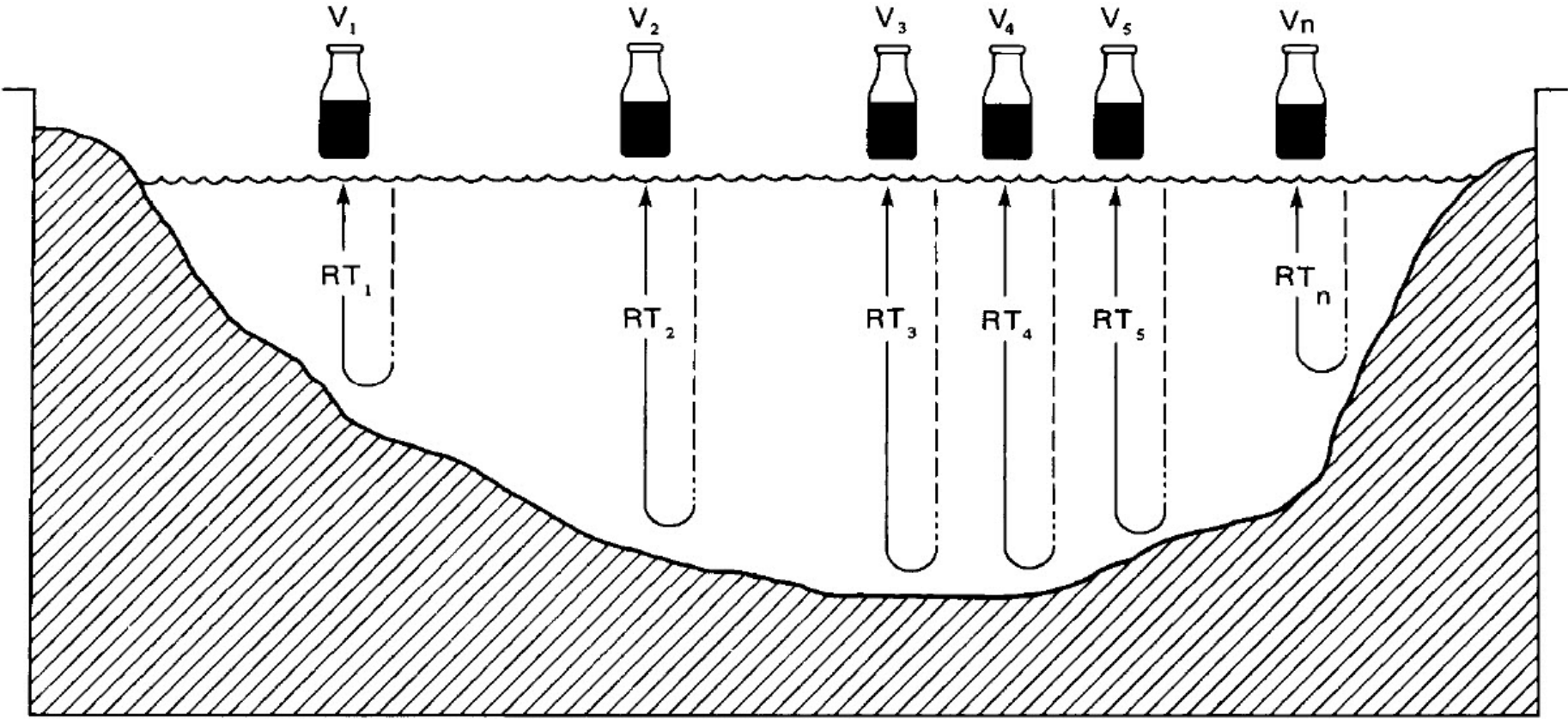
Equal-Discharge-Increment (EDI) Method

EXPLANATION

RT Transit rate at each centroid (not equal)

V Volume collected at each centroid (equal)

Centroid in each increment (samples collected)



Equal-Discharge-Increment (EDI) Method

Nav Reference: BT GGA VTG Comp Tracks: ON OFF

Main SysTest Compass/P/R Temp/Sal MovBedTst BT GPS Depth WT Extrap Edges EDI Adv. Graph MAP

Select Transect

Select Transect	Start	Bank	End	Duration (sec)	Total Q(m3/s)	Top Q(m3/s)	Meas Q(m3/s)	Bottom Q(m3/s)	Left Q(m3/s)	Right Q(m3/s)
<input checked="" type="checkbox"/> 20240827134539	13:45:38	R	13:52:36	418.0	570.0	73.4	427.0	66.8	1.48	1.78

Zero Distance Offset(m) From Right Bank Export PDF Report Create TopoQuad File

Percent Q	Target Q (m3/s)	Actual Q (m3/s)	Distance (m)	Depth (m)	Velocity (m/s)	Latitude (D M.M)	Longitude (D M.M)
10	57.01	58.02	42.5	3.9	0.6	-25 10.3056681	152 35.5588293
30	171.04	172.07	91.6	4.7	0.5	-25 10.3321970	152 35.5606510
50	285.06	285.86	139.5	4.1	0.6	-25 10.3580938	152 35.5622491
70	399.09	400.38	186.0	4.3	0.6	-25 10.3832527	152 35.5637189
90	513.12	513.58	236.4	3.8	0.5	-25 10.4105682	152 35.5646708

Add Row Compute Stations

Single-Vertical Sample

- EDI method
- Mean sediment concentration
- Slowest transit rate w/o overflowing
- Duplicate + samples

Sediment Sampling Hardware

- Suspended Sediment Samplers
- Selection of Suspended Sediment Sampler

Techniques and Methods 3–C2

Field Methods for Measurement of Fluvial Sediment

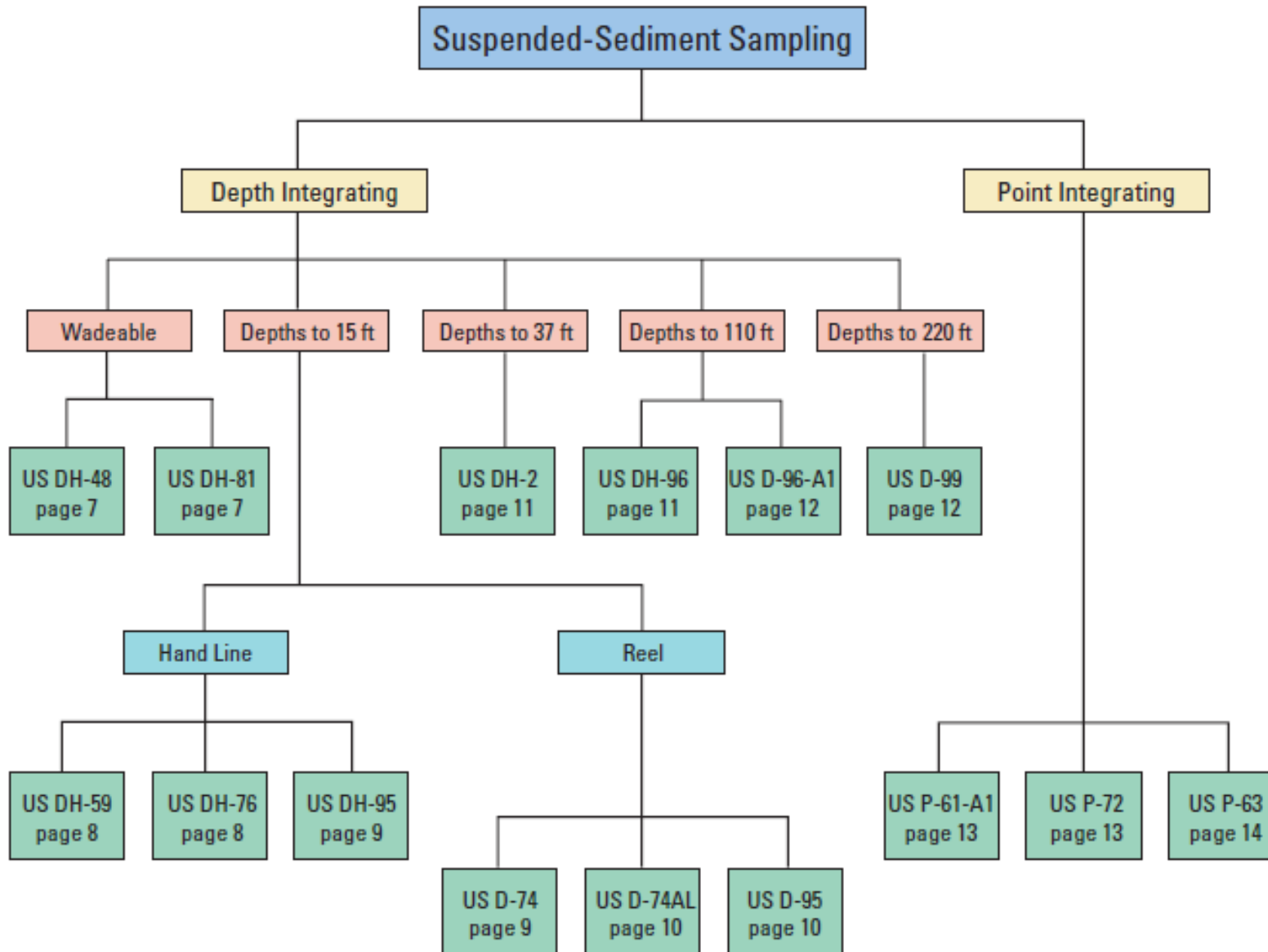
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Suspended Sediment Samplers



Suspended Sediment Samplers



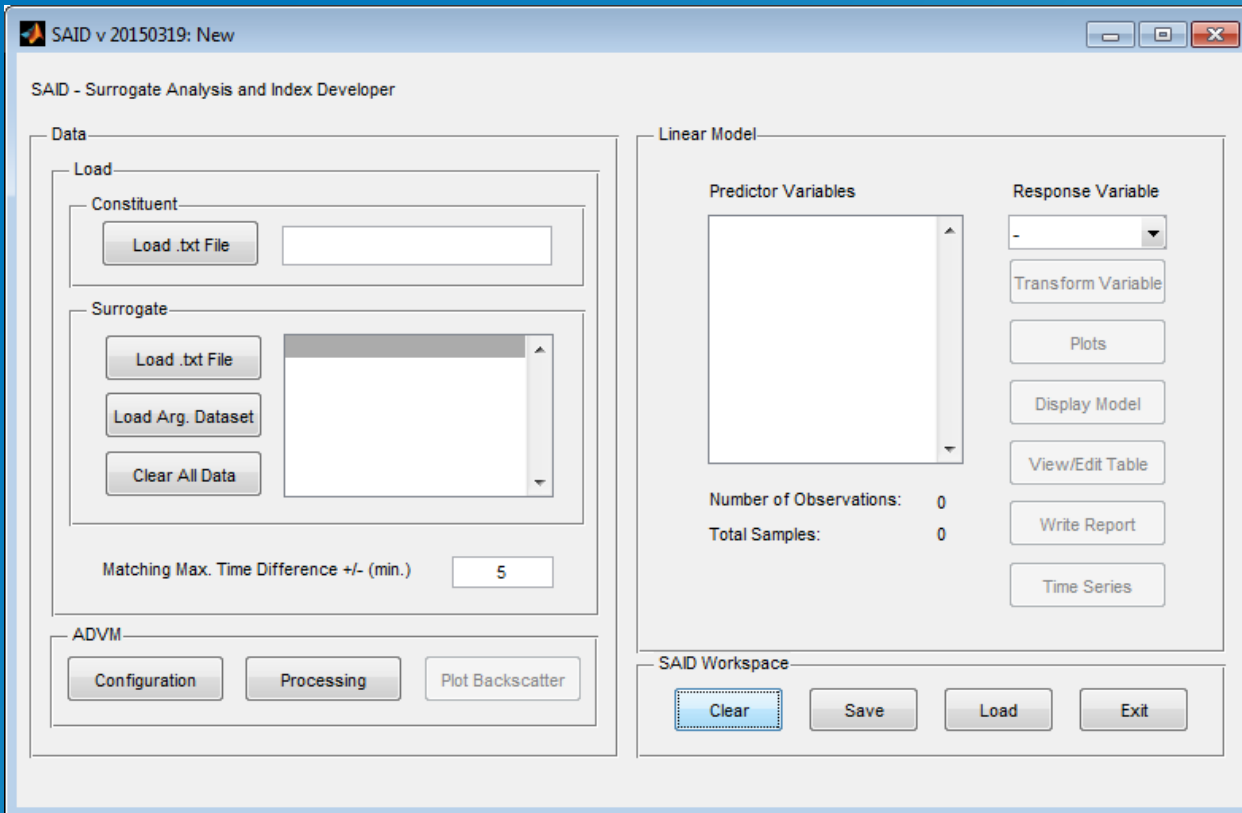
Laboratory Analysis

Analysis required to develop the sediment acoustic index rating is the SSC of the composite cross-section sample.

- Each sample should be analysed
 - SSC
 - % finer than 62.5 microns
- Composition of SSC
 - sediment-corrected backscatter is more responsive to sand-sized particles
 - sediment attenuation coefficient is more responsive to fine-sized materials

Development Suspended Sediment Index Rating

- Constituent – SSC
- Surrogate - SNR
- ADVM Deployment Configuration
- ADVM Processing Options
- Backscatter Profiles
- Linear Model
- Plots



SAID
U.S. Geological Survey

Constituent / Surrogate

SAID v 1.1: New

SAID - Surrogate Analysis and Index Developer

Data

Load

Constituent

Load .txt File

spoonSSC.txt

Surrogate

Load .txt File

Load Arg. Dataset

Clear All Data

SPOON001 (Arg)

SPOON002 (Arg)

Matching Max. Time Difference +/- (min.)

5

ADVM

Configuration

Processing

Plot Backscatter

Linear Model

Explanatory Variables

ADVMTemp

Vbeam

alphaS

MeanSCB

Response Variable

SampleMethod

Transform Variable

Plots

Display Model

View/Edit Table

Write Report

Time Series

Number of Observations: 0

Total Samples: 0

SAID Workspace

Clear

Save

Load

Exit

ADVM Configuration

ADVM deployment configuration

Configuration

Frequency (kHz)	1500
Effective Transducer Diameter (m)	0.03
Beam Orientation	Horizontal
Slant Angle (deg)	25
Number of Beams	
Blanking Distance (m)	1
Cell Size (m)	1.75
Number of Cells	10

Save Cancel

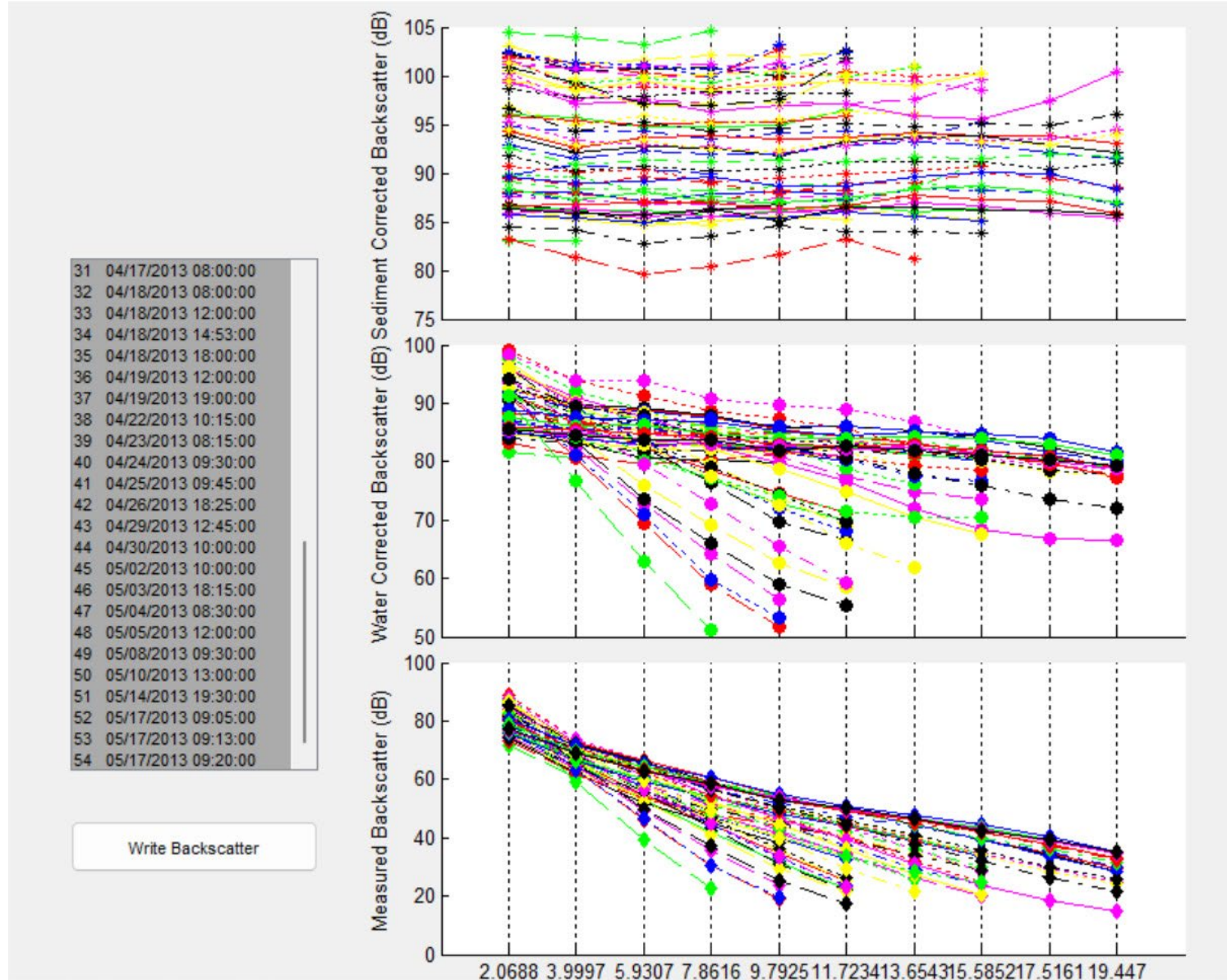
ADVM Processing

Processing

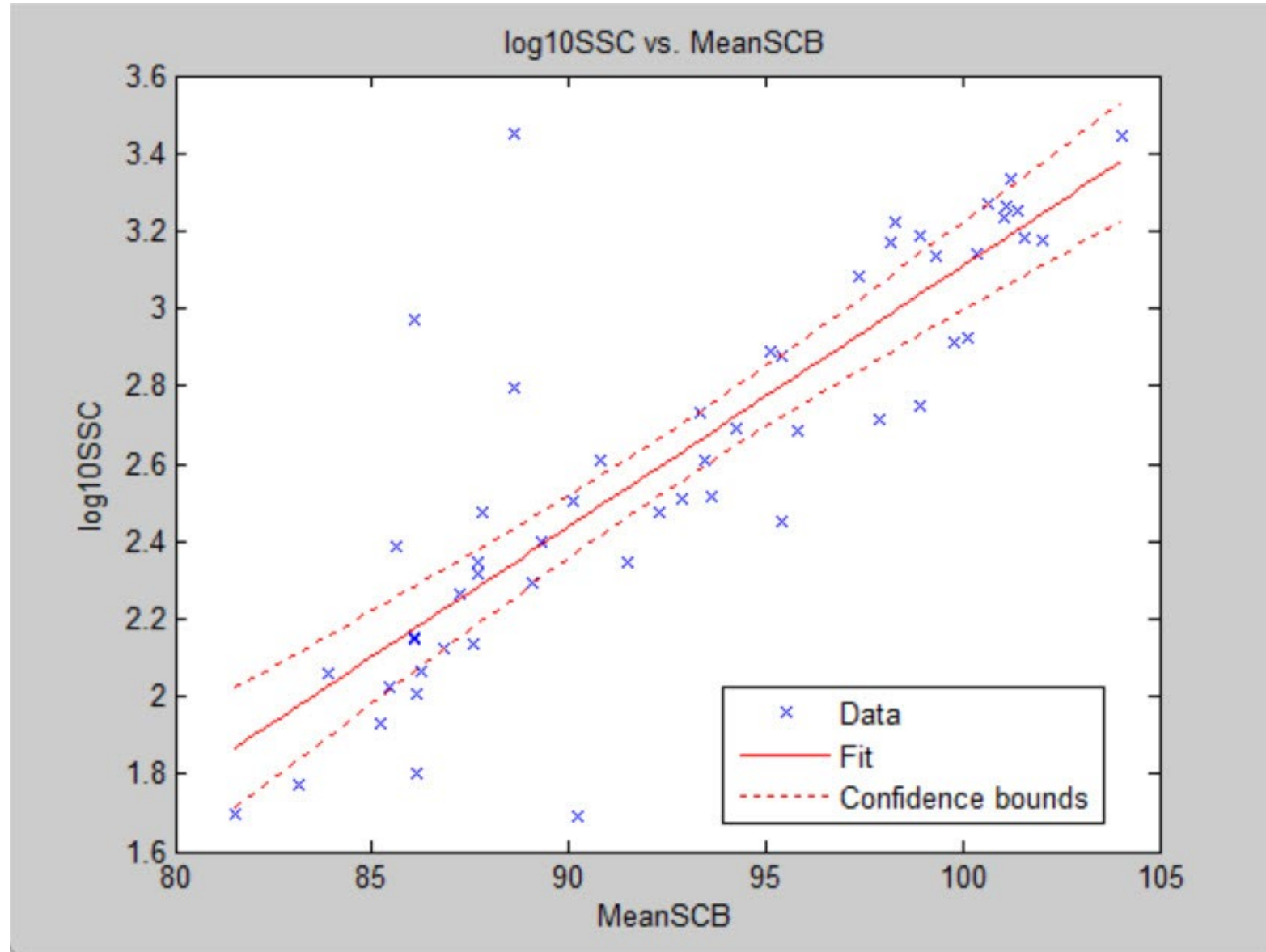
Beam	Avg
Moving Average Span (# of observations)	1
Backscatter Values	Amp
Intensity Scale Factor	0.43
Minimum Cell Mid-Point Distance (m)	-Inf
Maximum Cell Mid-Point Distance (m)	Inf
Minimum Number of Cells	2
Minimum Vbeam (m)	-Inf
Near Field Correction	<input checked="" type="checkbox"/>
Water Corrected Backscatter (WCB) Profile Adjustment	<input checked="" type="checkbox"/>

Save Cancel

Plot Backscatter



SSC Model Plot



SSC Model Parameters

Linear regression model:

$$\log_{10}SSC = -3.6 + 0.0671\text{MeanSCB}$$

Estimated Model Coefficients

	Estimate	SE	tStat	pValue	Lower90%	Upper90%
(Intercept)	-3.6037	0.55525	-6.4902	3.2134e-08	-4.53358	-2.67384
MeanSCB	0.067119	0.0059733	11.236	1.5931e-15	0.0571154	0.0771221

Number of observations: 54, Error degrees of freedom: 52

Root Mean Squared Error (Standard Error of Regression): 0.26924

R-squared: 0.708, Adjusted R-Squared 0.703

F-statistic vs. constant model: 126, p-value = 1.59e-15

Linear correlation coefficient: 0.8416

RMSE (%): 68.4566

Non-parametric smearing bias correction factor: 1.3164

Probability plot correlation coefficient: 0.91188

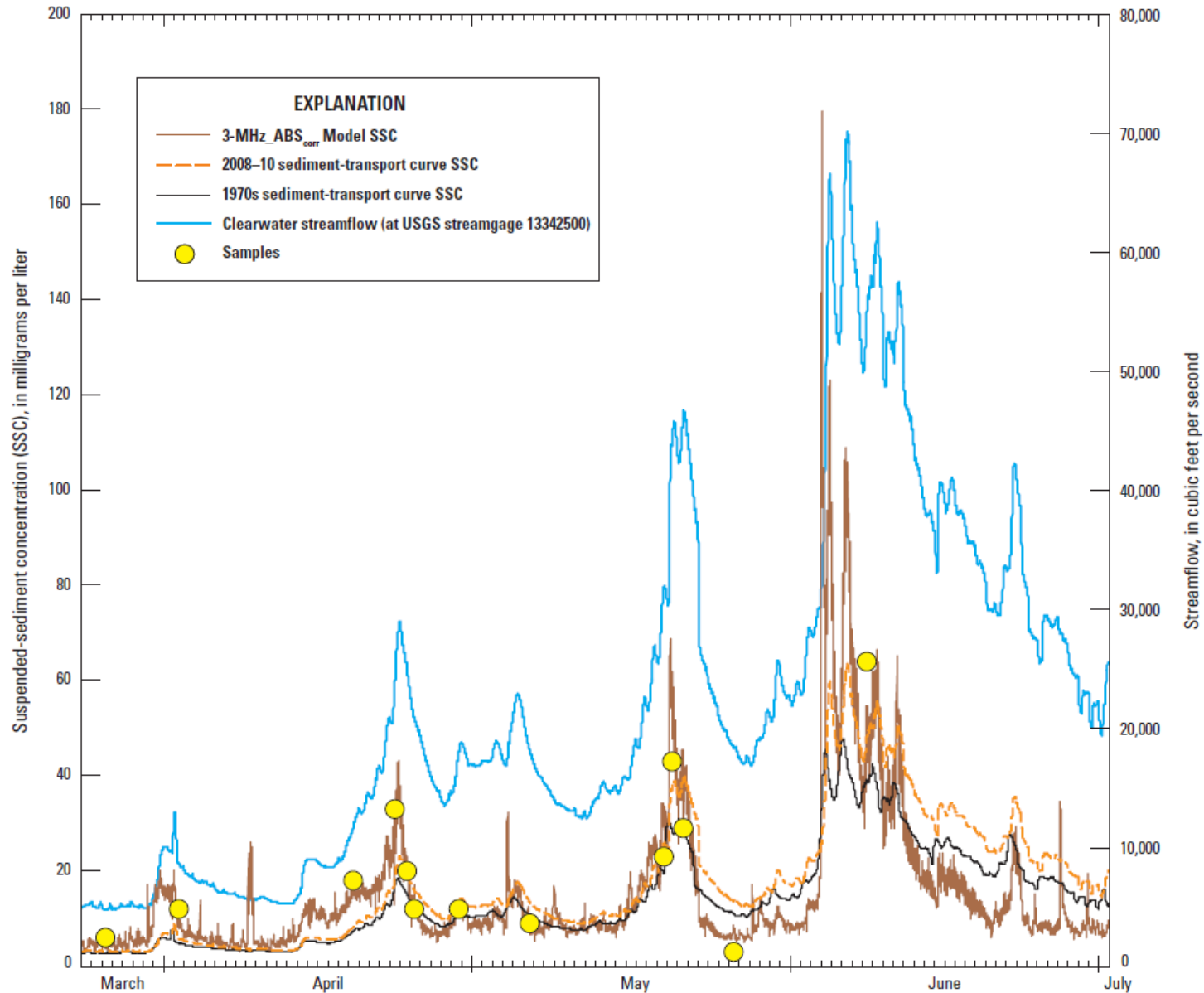
High leverage: 0.11111

Extreme outlier (Standardized residual): 3 (absolute value)

High influence (Cook's D): 2.1843

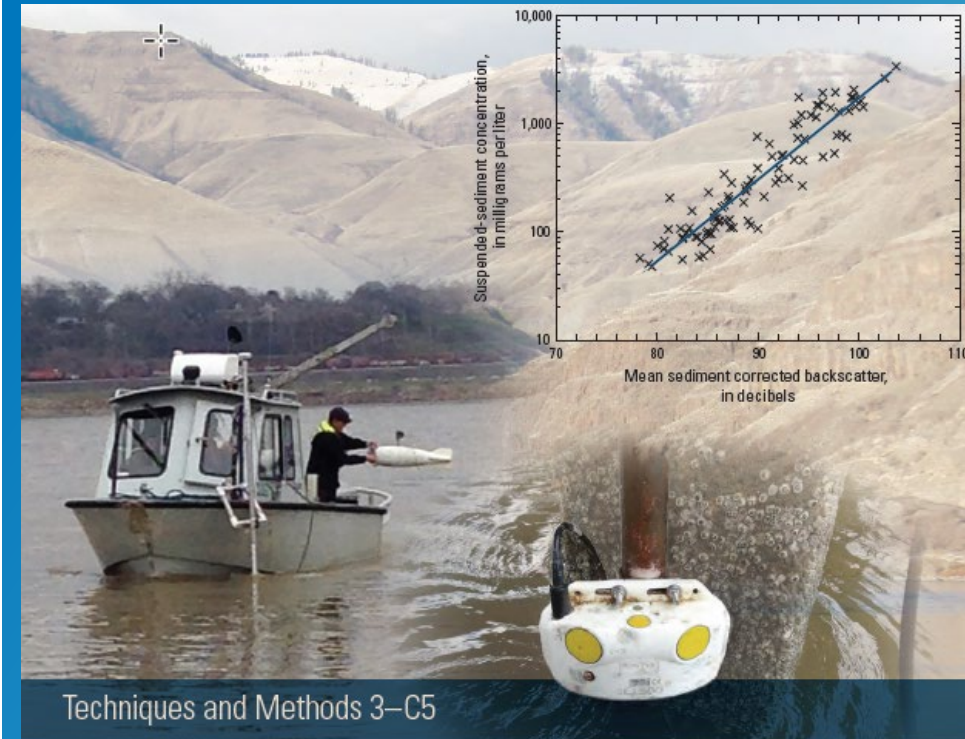
High influence (DFFITS): 0.3849

Suspended Sediment Concentration



Resources

- Techniques and Methods 3–C2, Field Methods for Measurement of Fluvial Sediment, USGS
- Techniques and Methods 3–C5, Sediment Acoustic Index Method for Computing Continuous Suspended-Sediment Concentrations, USGS
- Surrogate Analysis and Index Developer (SAID) Tool, USGS



Questions?

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