Federal Interagency Sedimentation Project

USGS science for a changing world | HIF Hydrologic Instrumentation Facility | ars | USDA | FISP

Sediment and Water-Quality Samplers and Research

water.usgs.gov/fisp

Federal Interagency Sedimentation Project
3039 Amwiler Road, Suite 130
Atlanta, GA 30360-2824

(770) 903-9152
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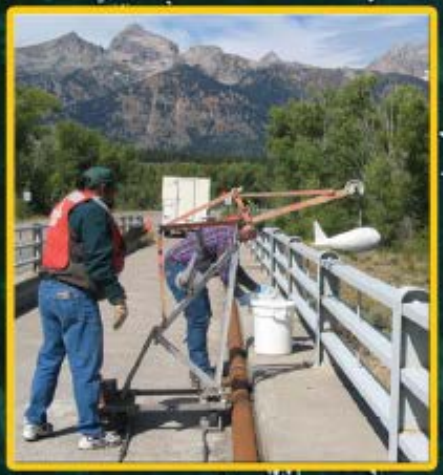
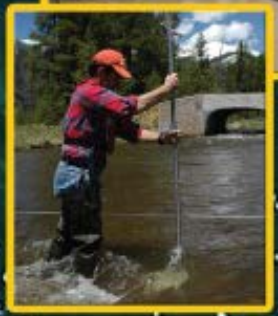
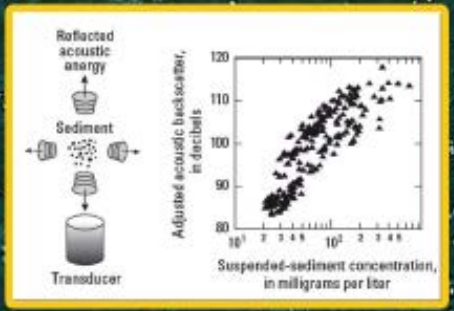


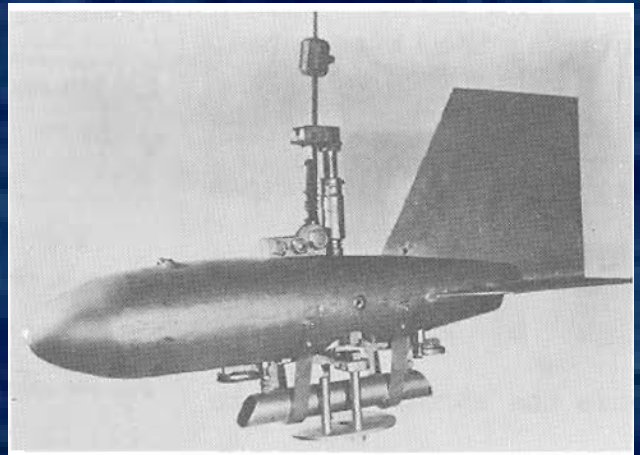




Federal Interagency Sedimentation Project

- Created in 1939 to unify and standardize fluvial sediment data instruments and methods of Federal agencies. Primary focus in 20thc on mechanical and hydraulic aspects of physical samplers to provide consistent, accurate, representative sediment and water-quality samples.

- Early <u>Samplers</u> <u>and</u> <u>Methods</u> for SSC and Bed Load generally collected biased (non-isokinetic), non-comparable results.



ig. 39--Vicksburg District, U.S.E.D. horizontal toggle sampler.

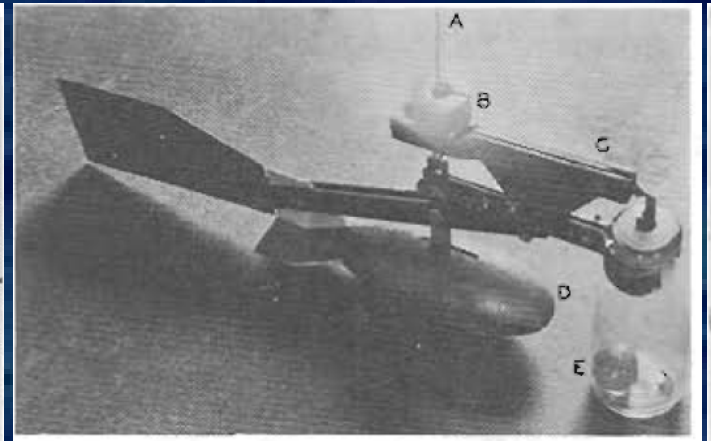


Fig. 54--St. Paul District, U.S.E.D., bottle sampler.

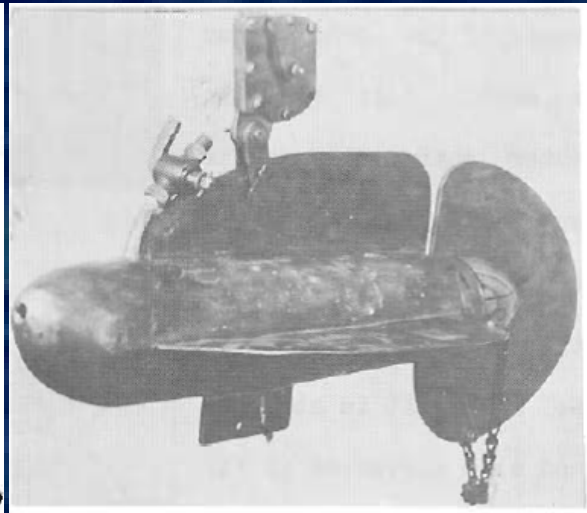


Fig. 66--Rock Island District, U.S.E.D., simplified time-integrating sampler.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

- Early <u>Samplers</u> <u>and</u> <u>Methods</u> for SSC and Bed Load generally collected biased (non-isokinetic), non-comparable results.

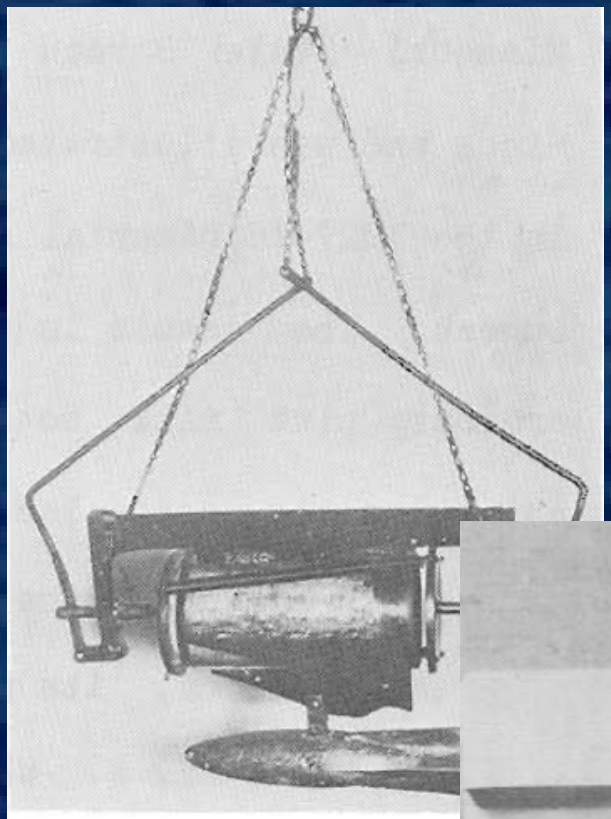
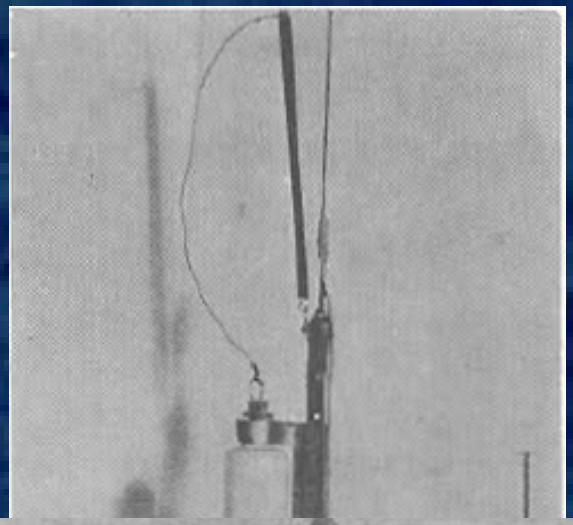
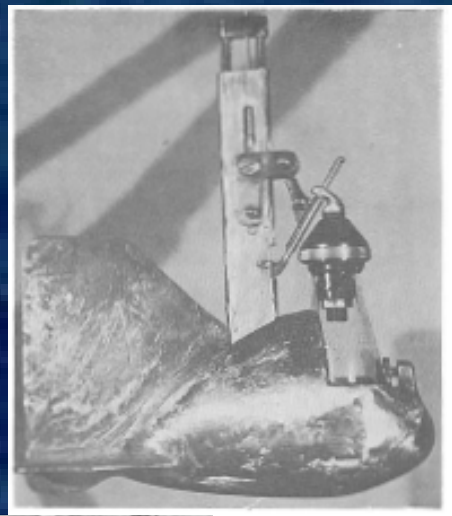
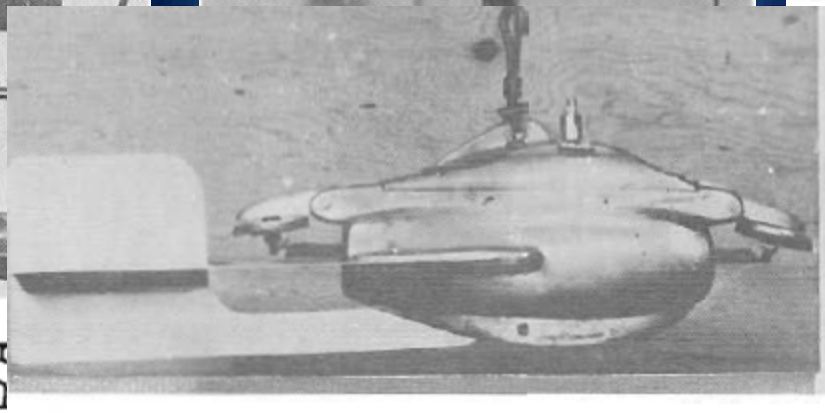


Fig. 53--U. S. Bur
of Reclamation sl
filling sampler



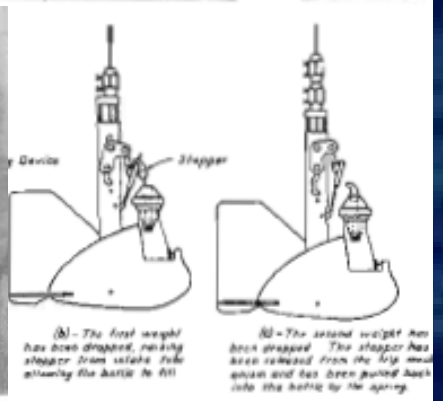




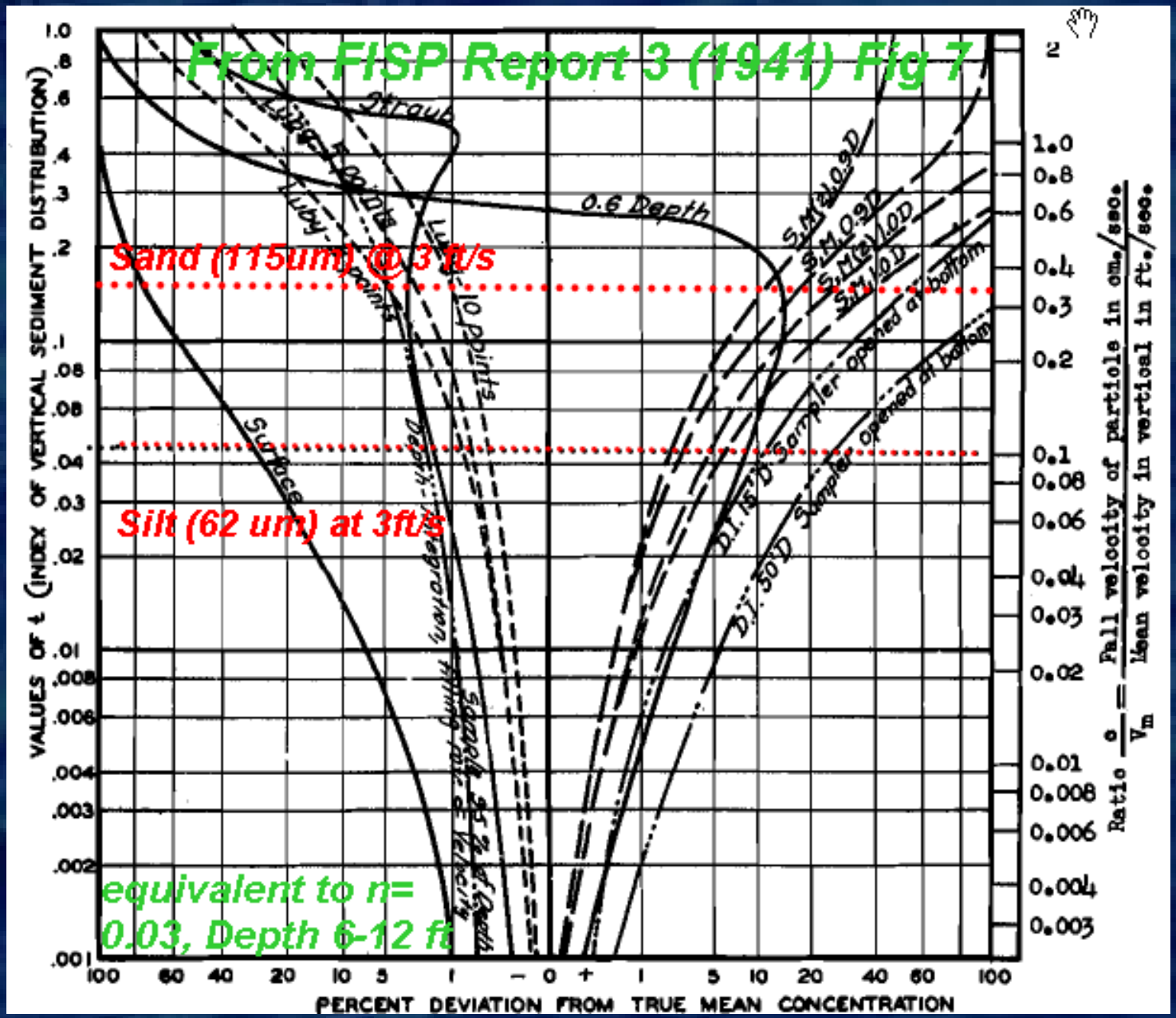
Side view.

Front view.

Fig. 35--T.V.A. sampler, streamlined design.

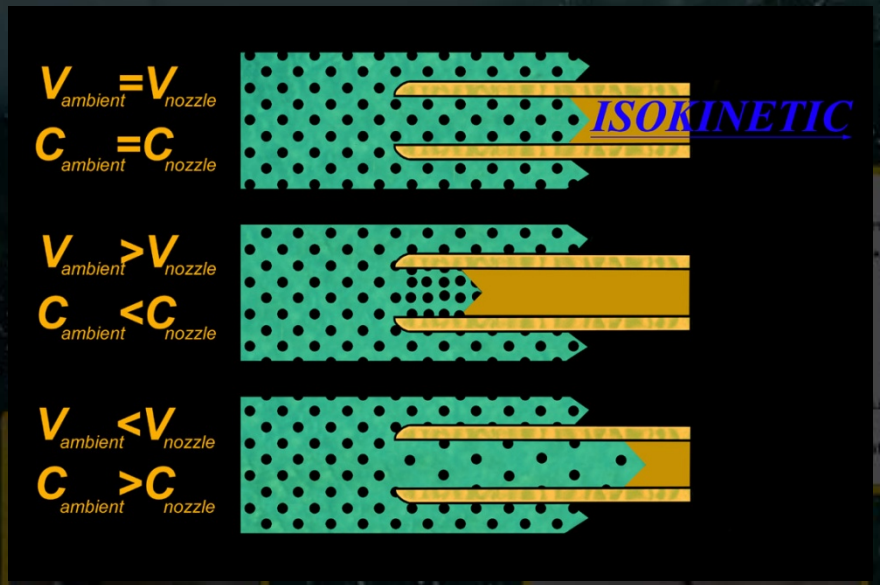


-Frazier, U.S.G.S., time-
ntegrating sampler.


From FISP Report 3 (1941) Fig 7
Sand (115um) @ 3 ft/s
Silt (62 um) at 3ft/s
equivalent to n=
0.03, Depth 6-12 ft
Straub
0.6 Depth
Surface
Depth-Integration, fitting pair of Velocity
Sample 95% of Depth
Lung-10 points
Lung-5 points
Lung-5 points
S.M.(2) 0.9D
S.M. 0.9D
S.M.(2) 1.0D
S.M. 1.0D
D.I. 15'D Sampler opened at bottom
D.I. 50'D Sampler opened at bottom
VALUES OF t (INDEX OF VERTICAL SEDIMENT DISTRIBUTION)
PERCENT DEVIATION FROM TRUE MEAN CONCENTRATION
Ratio c/Vm = Fall velocity of particle in cm./sec. / Mean velocity in vertical in ft./sec.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

- **MISSION:**
- **Conduct and Sponsor applied research to**
- **Design Accurate, Standardized Samplers and Methods for Full Range of Hydrologic, Sedimentologic Conditions**
- **Manufacture and Supply Samplers**
- **Support Sampling with Methods Guidance and Training and Repair**



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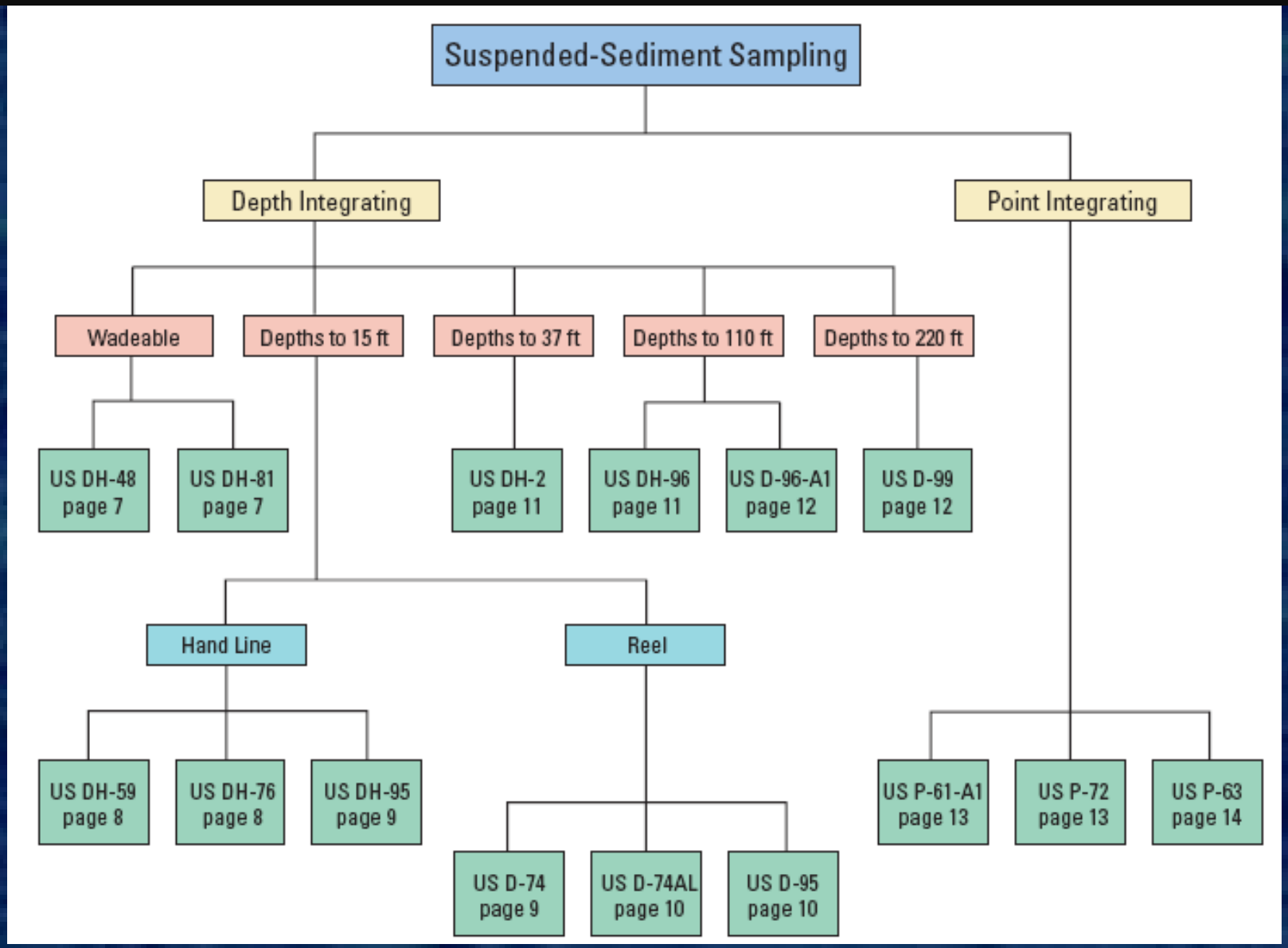

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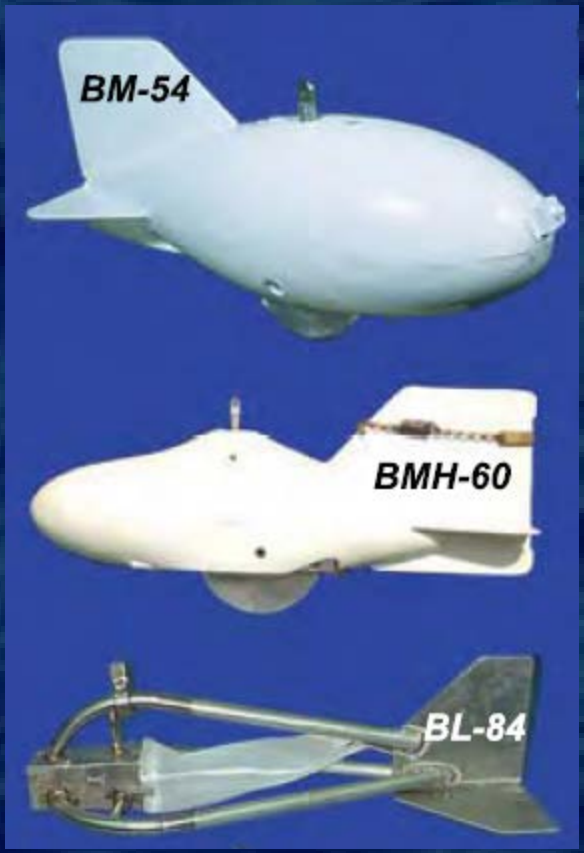
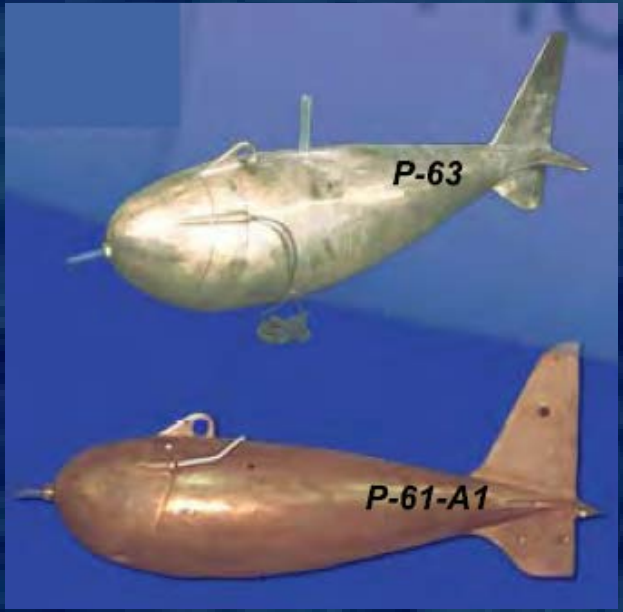




Federal Interagency Sedimentation Project

Transitions:

- **Develop Water-Quality Samplers Capable of Sampling for Trace Constituents without conamination (DH-81, D-95, DH-95, DH-02, D-96, D-99)**

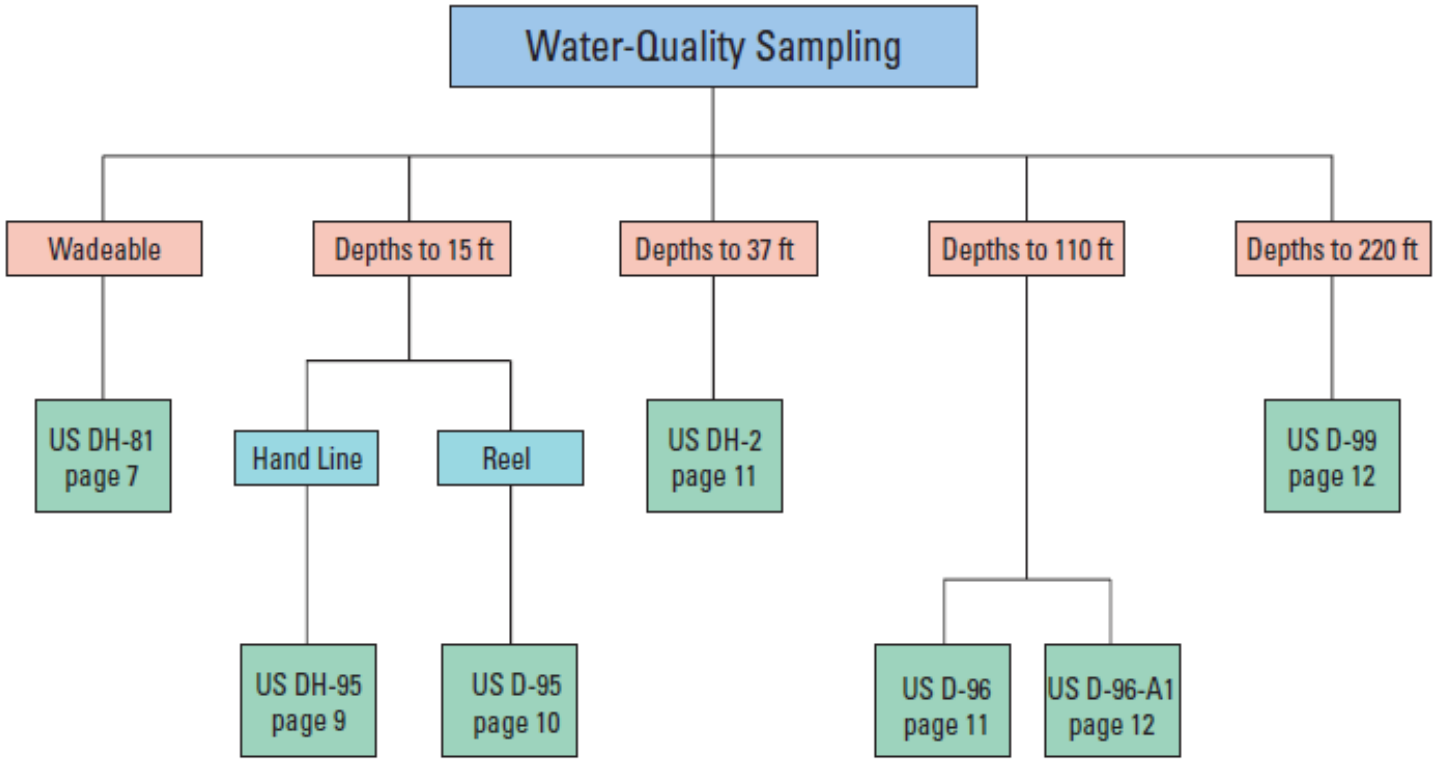


Figure 2. Flow chart for the selection of water-quality sampling equipment.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

Transitions:

- **Develop Water-Quality Samplers Capable of Sampling for Trace Constituents without conamination (DH-81, D-95, DH-95, DH-02, D-96, D-99)**

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

Transitions:

- **Develop Water-Quality Samplers Capable of Sampling for Trace Constituents without contamination (DH-81, D-95, DH-95, DH-02, D-96, D-99)**

- **<u>Logistical Transition</u>: Move Sampler Supply, Testing, and Maintenance to USGS Hydrologic Instrumentation Facility (2005)**
  - **Manage all contracts with manufacturers**
  - **Manage Inventory, Orders, and Shipping**
  - **100% of all equipment is tested prior to shipping**
  - **Repairs Conducted**

Top Selling Items FY11

$$$

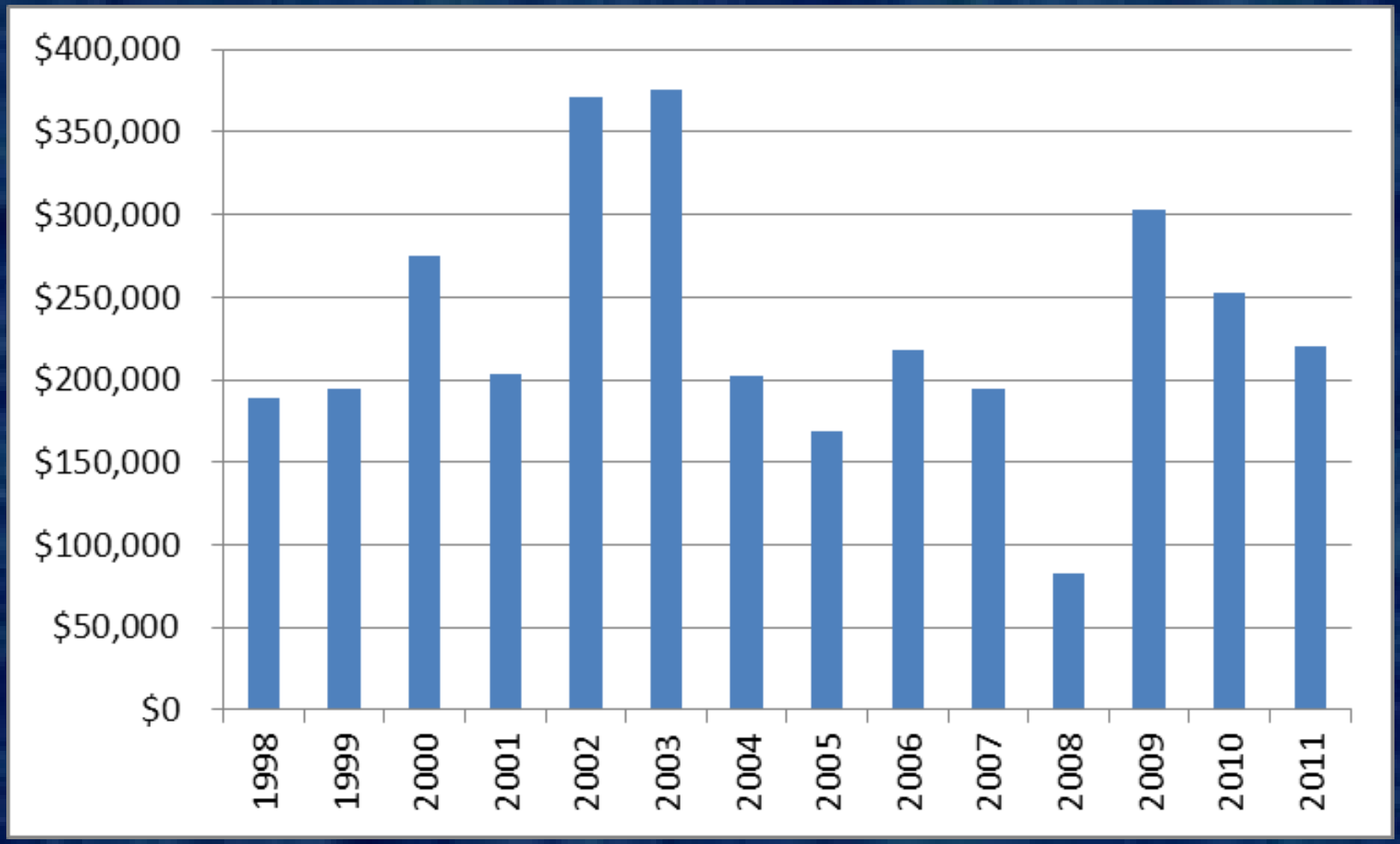
- *DH-95 Samplers* *$29,965*
- *Poly Churn Sample Splitters* *$19,776*
- *DH-2 Samplers* *$18,065*
- *BL-84* *$15,370*
- *D-96 Samplers* *$11,744*
- *D-95 Samplers* *$11,344*

Top Selling Items FY11

quantity

- *1-Liter Heavy Grade Bottles* *344*
- *Bag-retention Straps* *182*
- *D-96 & D96-A1 PFA Bags* *159*
- *Plastic Nozzle Holder Caps* *122*
- *DH-81A Adapters* *108*
- *3-Liter Plastic Bottles* *94*

Sediment Equipment Sales
FY98 — FY11



FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Transitions:

- **Develop Water-Quality Samplers Capable of Sampling for Trace Constituents without contamination (DH-81, D-95, DH-95, DH-02, D-96, D-99)**

- **Logistical Transition: Move Sampler Supply, Testing, and Maintenance to USGS Hydrologic Instrumentation Facility (2005)**

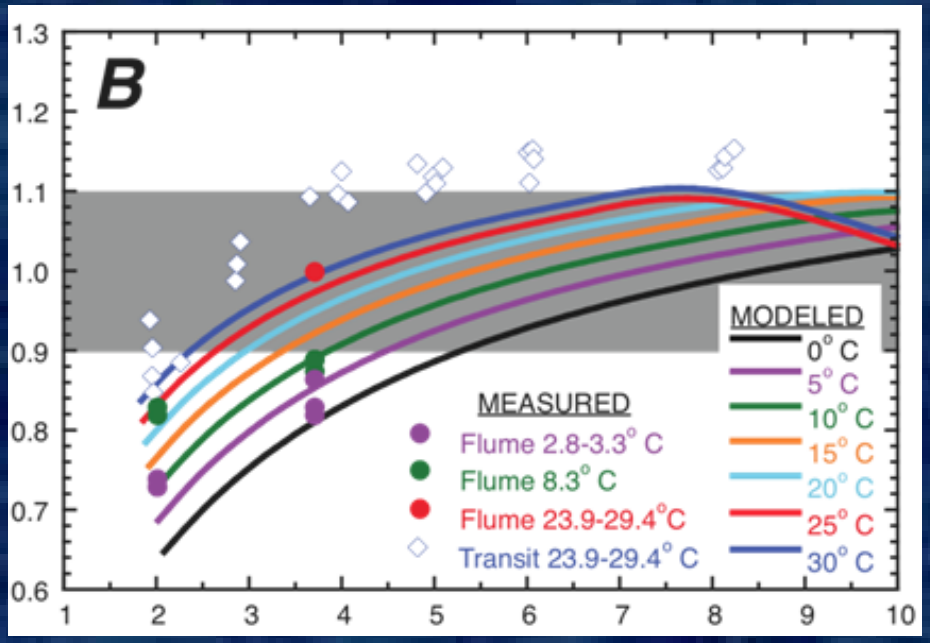
- **<u>Mission Expansion</u>: Major Focus on Sediment Surrogate Instrumentation and Methods**
  - **Always been an element of FISP Research (Flammer 1962)**
  - **Technology Focus on Laser-Diffraction and Hydroacoustics**

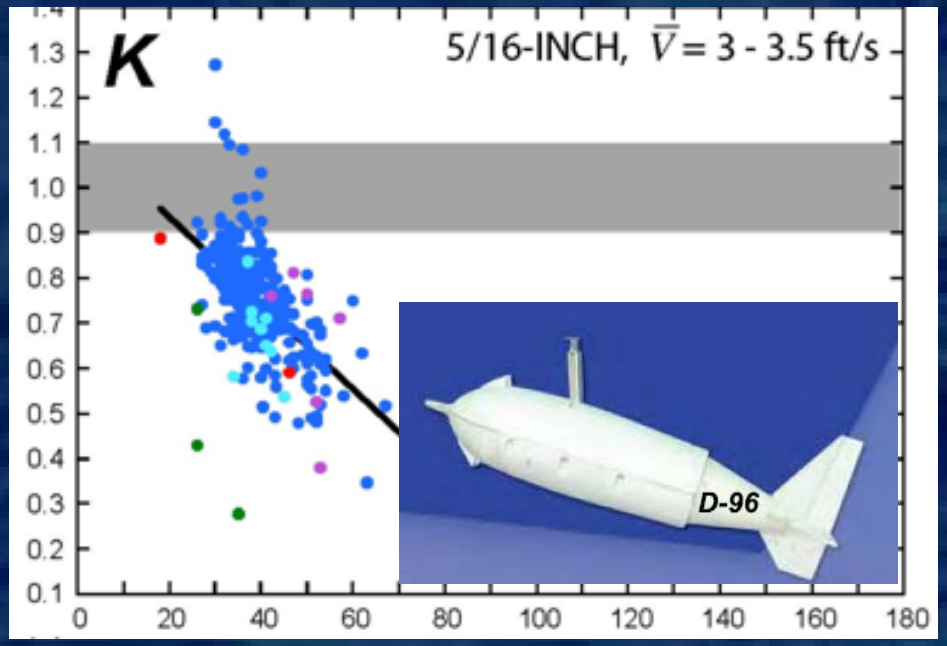
FEDERAL INTERAGENCY SEDIMENTATION PROJECT

Current Research Activities:

Bag Sampler Evaluation: Research on Colorado River in AZ has found US D-96 Bag Sampler to operate non-isokinetically, particularly in colder, lower velocity conditions; conflicting with other laboratory and field tests. The researchers hypothesize that as the sample chamber does not remain in equilibrium with ambient pressure as the bag fills.

Approach: field and laboratory testing, field guidance, proposed CFD modeling, proposed pressure monitoring





FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Current Research Activities:

Acoustic Surrogates of Suspended Sediment Properties:

A technology that is ubiquitous in streamflow velocity monitoring is already collecting data that infers sediment characteristics

Advantages

- High Temporal Resolution (Fixed)
- High Spatial Resolution (Mobile)
- Improved Accuracy & Reduced Cost
- Concurrent Velocity Measurement → Discharge
- Highly Robust in Environment
- Ubiquitous in Streamflow Monitoring
- Large Sample Volume
- Multi-frequency may indicate Sediment Size

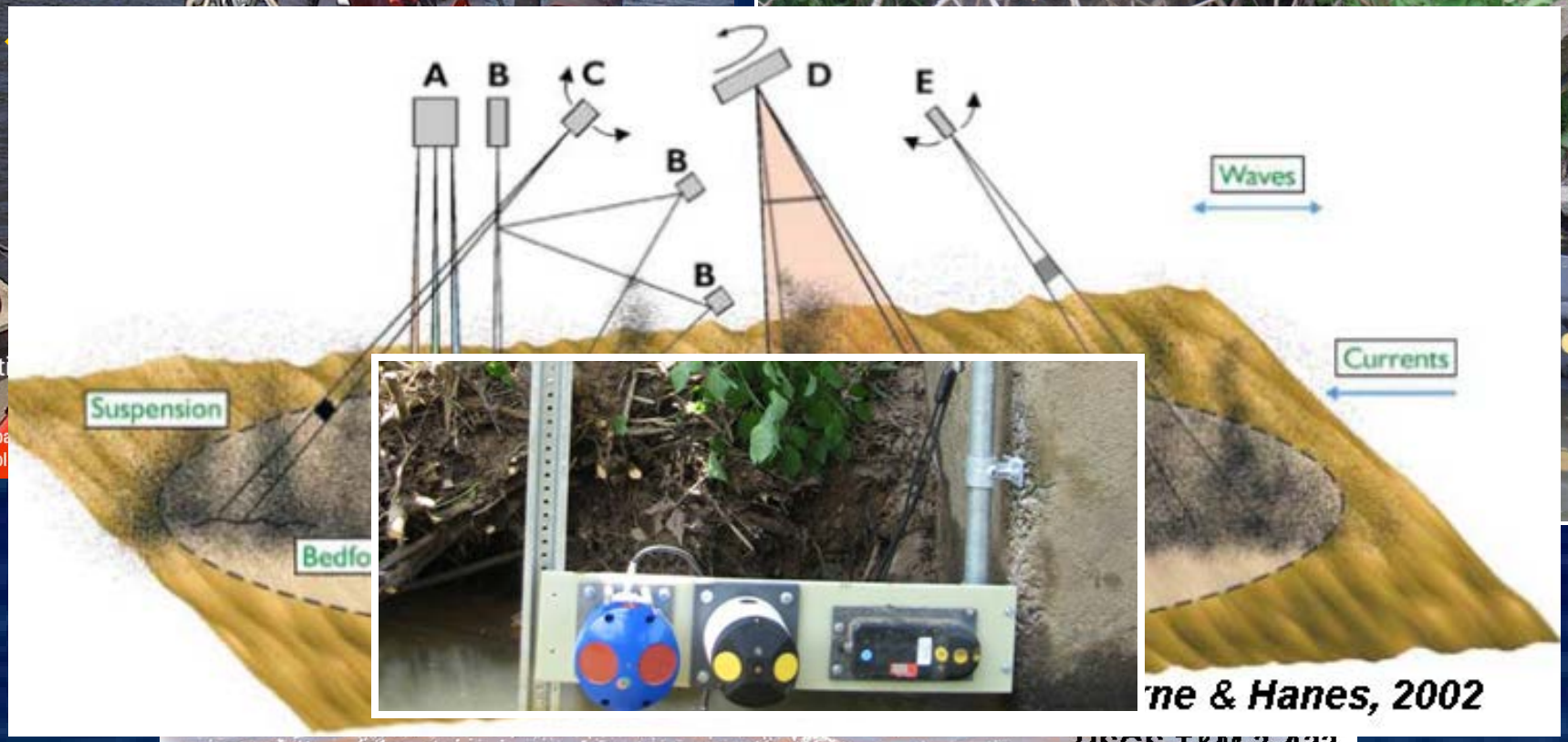
Disadvantages

- Complexity of Signal Processing
- Variety of Signal Processing Among Manufacturers
- Inconsistent Data by Different Instruments
- Low Concentration Limit at Typical Frequencies

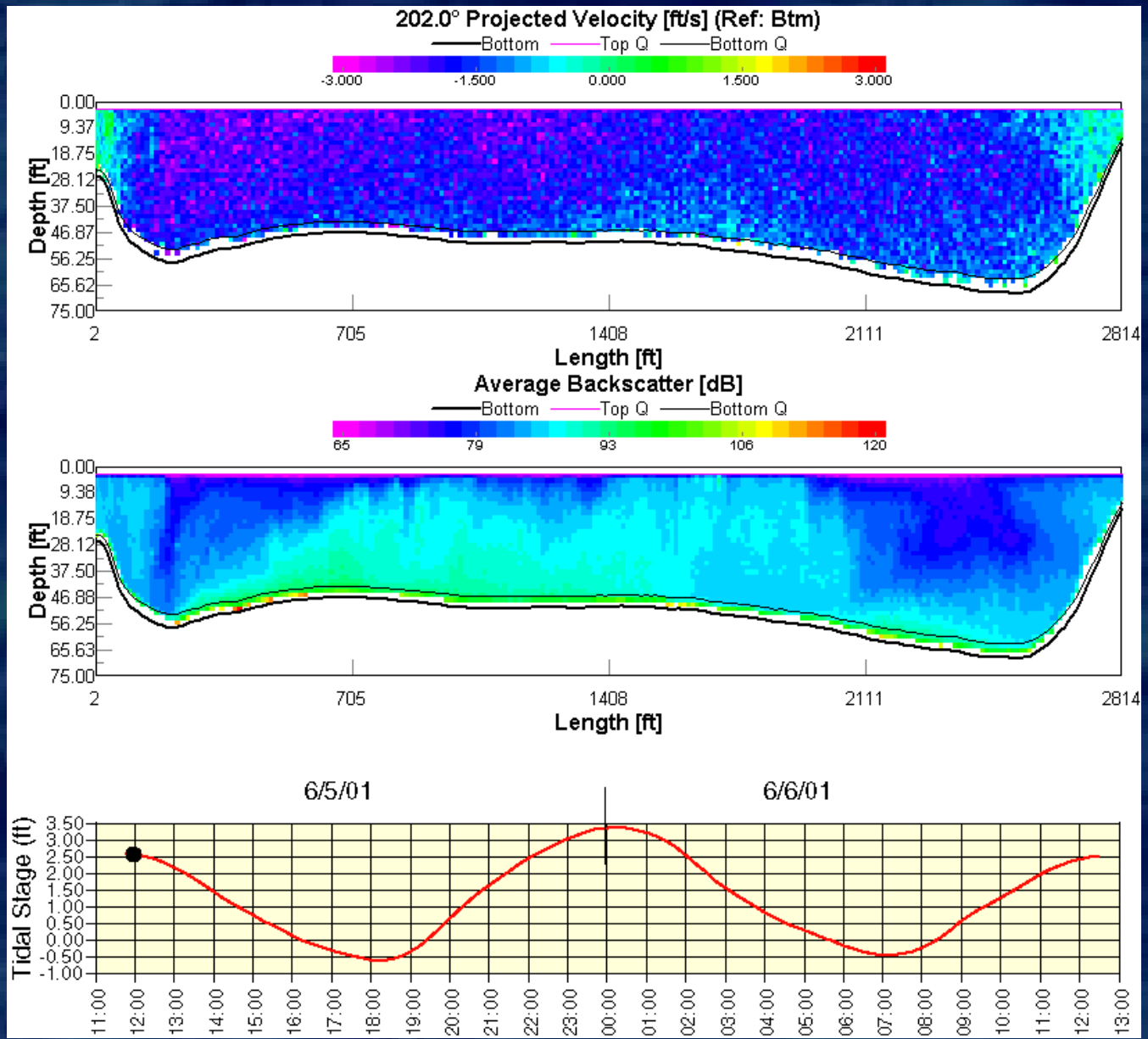
Sediment-Acoustic Monitoring

Many Differences in Instruments, Deployments, Signal Processing

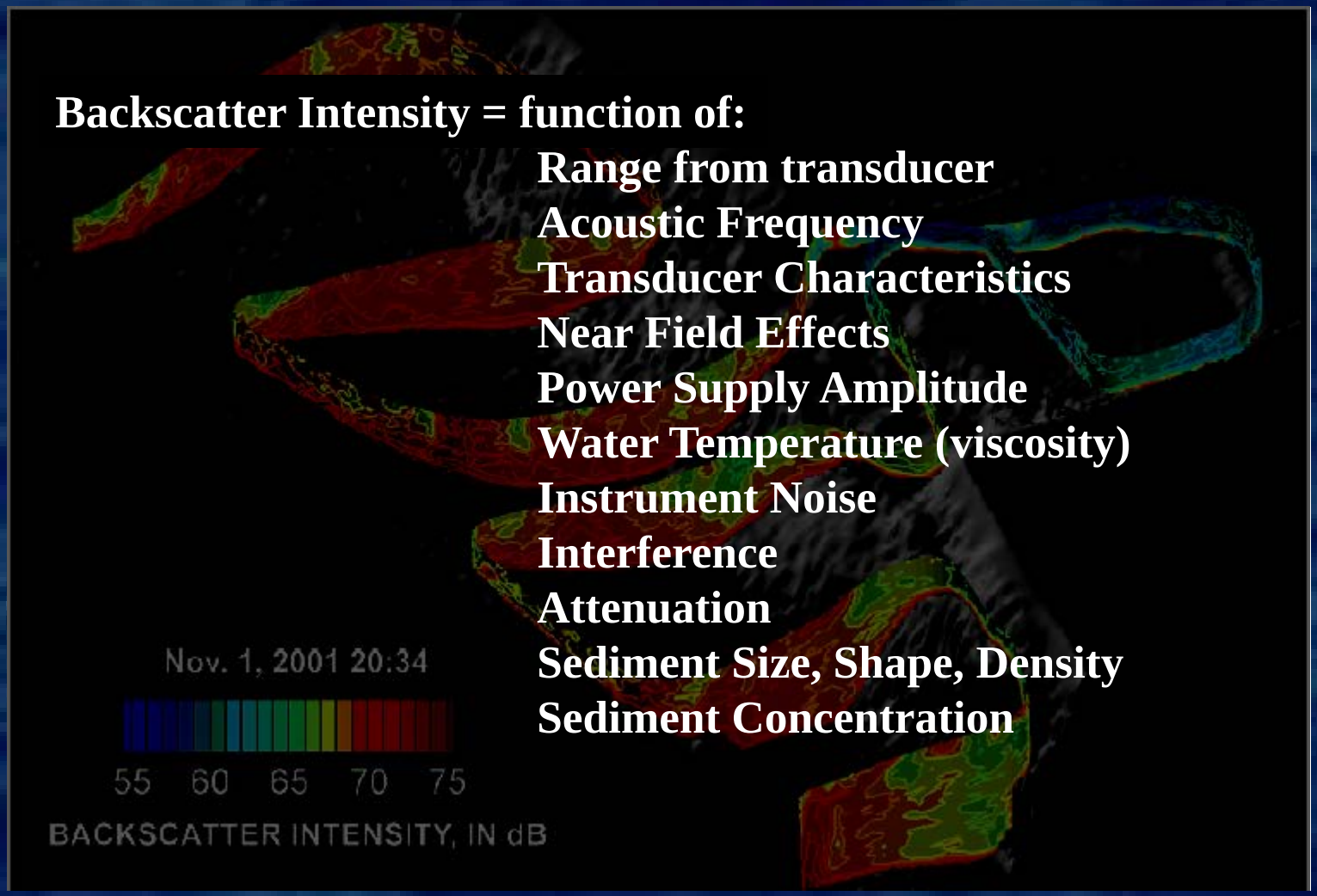
- Multiple Frequencies (~ 0.5 to ~25MHz)
- Broadband, Narrowband
- Profiling & Non-Profiling
- Fixed Installations for Continuous Monitoring of Fluvial Sediment
- Mounted & Moored Systems for Marine Sediment Characterization



Acoustic Surrogates

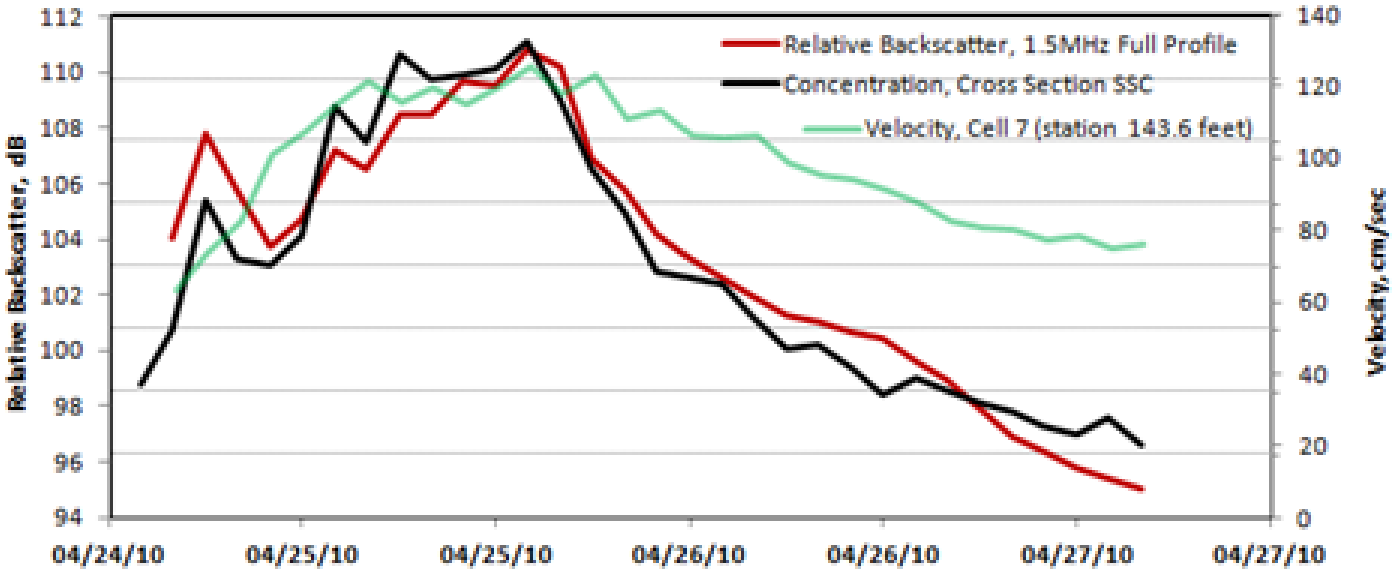


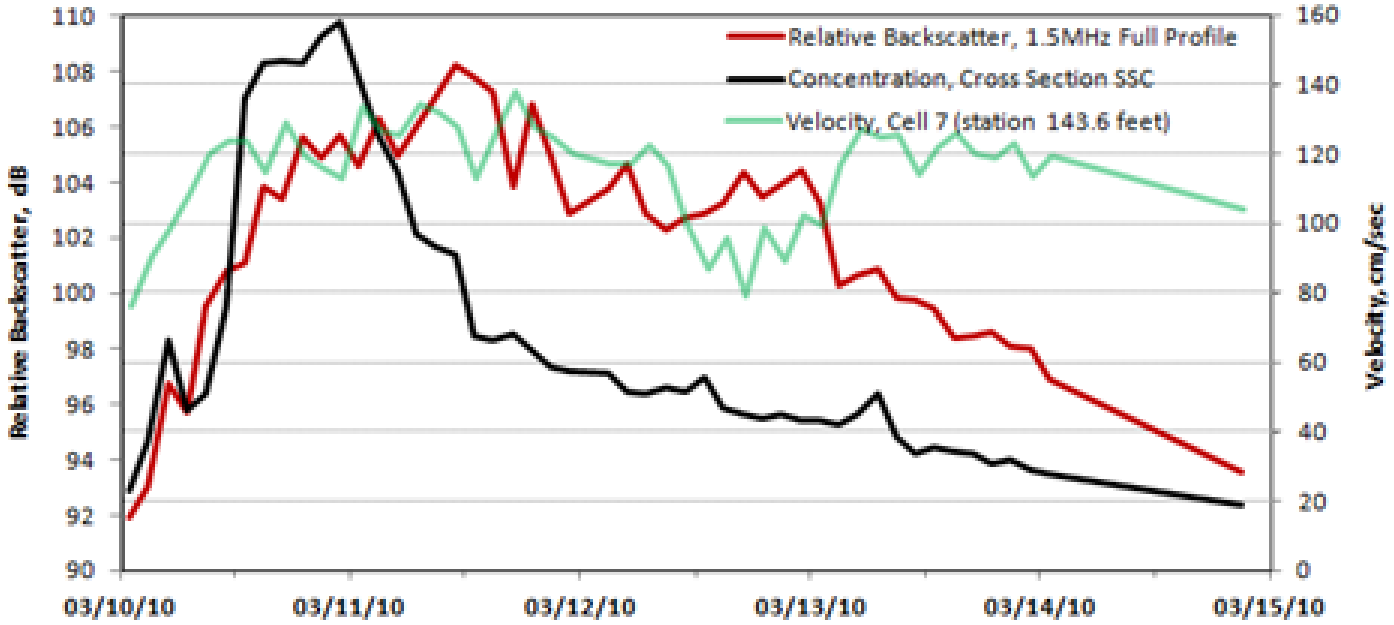
Acoustic Surrogates of SSC



Backscatter Intensity = function of:

- **Range from transducer**
- **Acoustic Frequency**
- **Transducer Characteristics**
- **Near Field Effects**
- **Power Supply Amplitude**
- **Water Temperature (viscosity)**
- **Instrument Noise**
- **Interference**
- **Attenuation**
- **Sediment Size, Shape, Density**
- **Sediment Concentration**

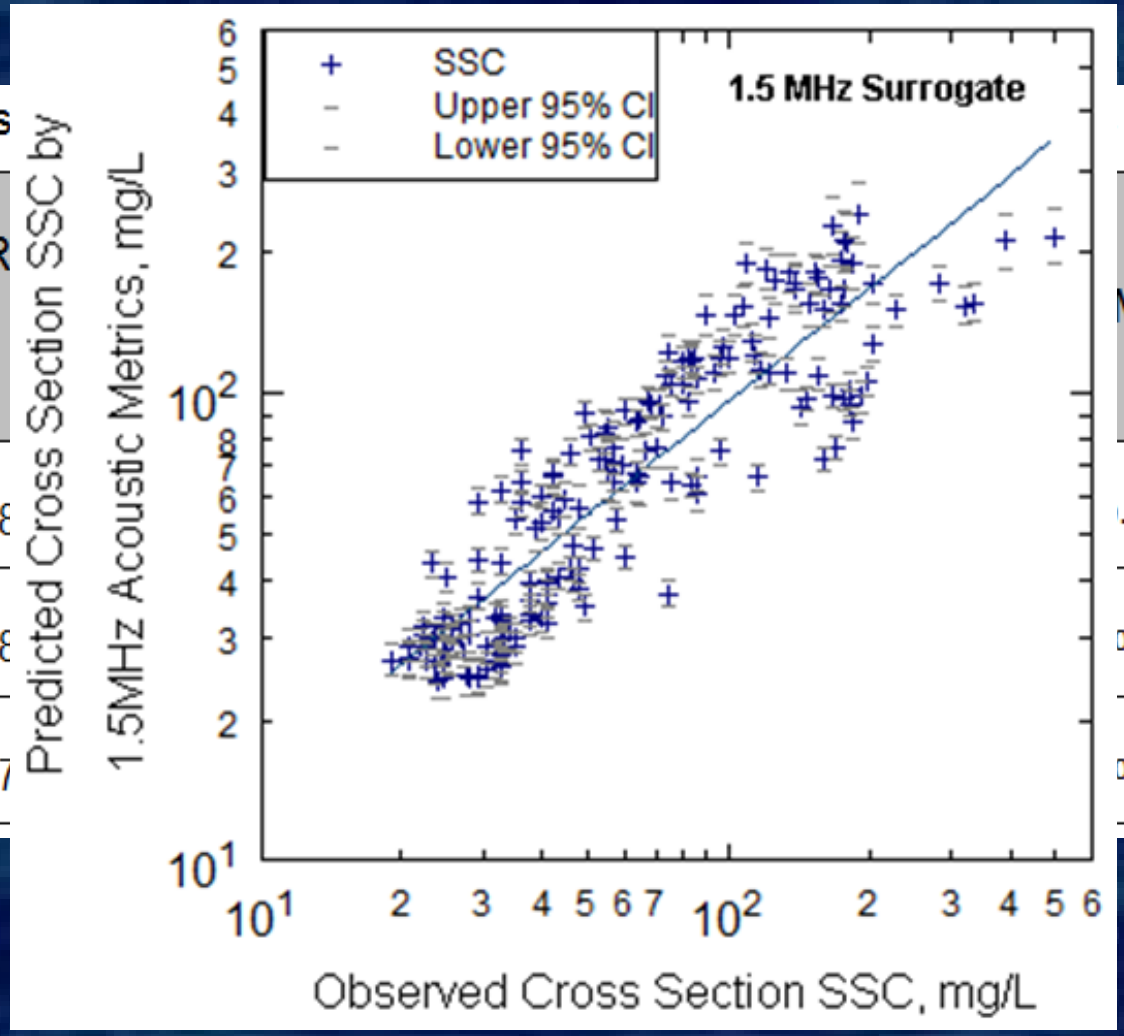

Relative Backscatter, 1.5MHz Full Profile
Concentration, Cross Section SSC
Velocity, Cell 7 (station 143.6 feet)
Relative Backscatter, dB
Velocity, cm/sec
112
110
108
106
104
102
100
98
96
94
140
120
100
80
60
40
20
0
04/24/10
04/25/10
04/25/10
04/26/10
04/26/10
04/27/10
04/27/10


Relative Backscatter, 1.5MHz Full Profile
Concentration, Cross Section SSC
Velocity, Cell 7 (station 143.6 feet)
Relative Backscatter, dB
Velocity, cm/sec
110
108
106
104
102
100
98
96
94
92
90
160
140
120
100
80
60
40
20
0
03/10/10
03/11/10
03/12/10
03/13/10
03/14/10
03/15/10

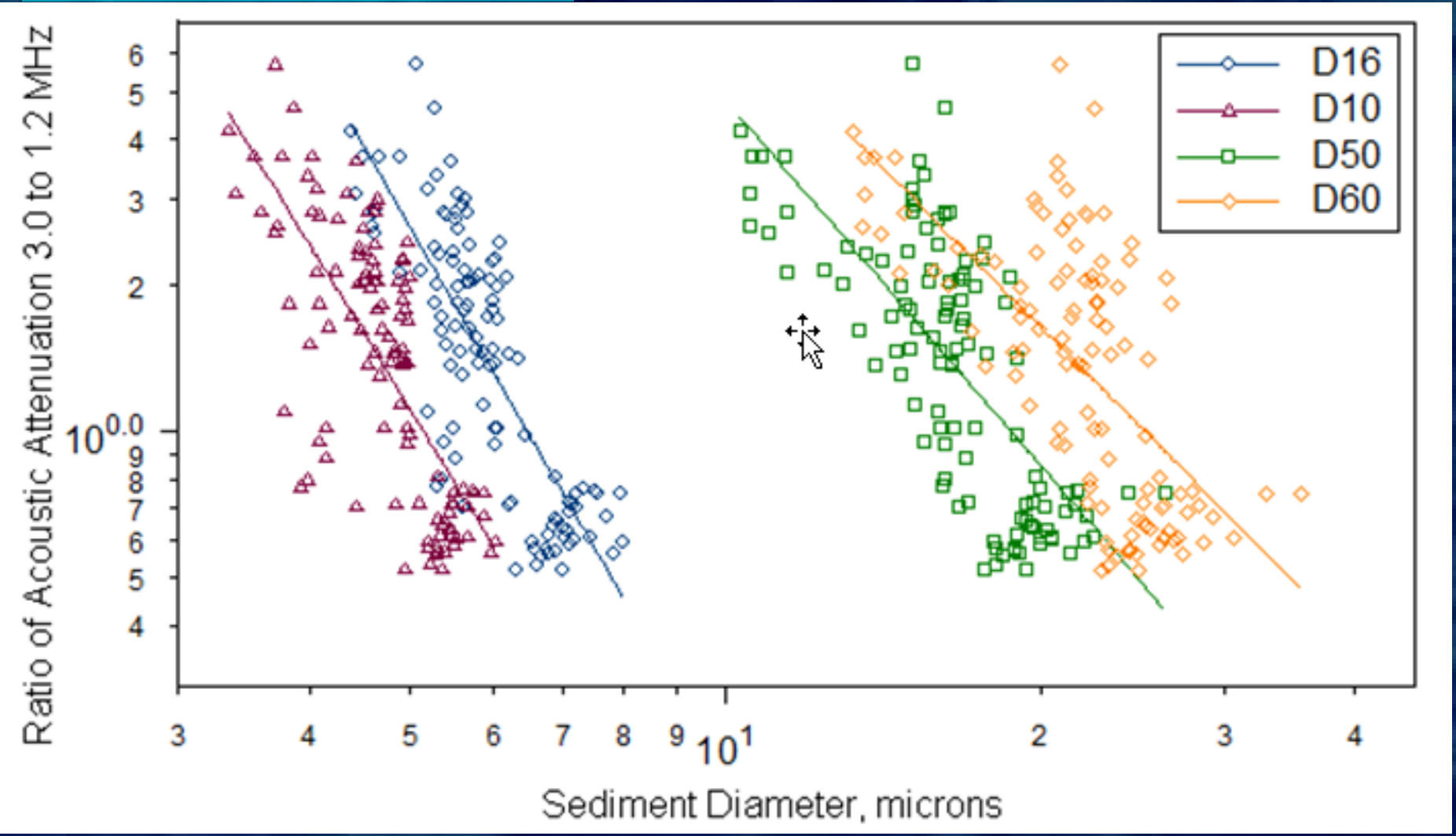
Acoustic Surrogates of SSC

Table 9.2—Res surrogate metrics

Explan-atory Variables	R	Model
$RB_{1.5MHz}$ $\alpha_{s\ 1.5MHz}$	0.8	.0543 $\alpha s_{1.5MHz}$
$RB_{3.0MHz}$ $\alpha_{s\ 3.0MHz}$	0.8	0.0611 $\alpha s_{3.0MHz}$
$RB_{1.2MHz}$ $\alpha_{s\ 1.2MHz}$	0.7	0.0476 $\alpha s_{1.2MHz}$



Sediment Size from Acoustic Attenuation



FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Current Research Activities:

Acoustic Surrogates of Suspended Sediment Properties:

Problem:

- Several studies within and across federal agencies are applying highly inconsistent, often wrong, incomplete methods using this technology.
- Most studies report, at best, model error. Uncertainty and bias are typically unknown for these methods.
- The technology and methods are highly complex. Minor changes in instrument set up, which may be automatic, will alter ratings. Instrument to instrument differences are known to occur.

- Sediment Acoustics methods will advance in the next few years to much broader use. Without specific, recognized federal guidance, the results will often be non-comparable, and of unknown accuracy.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

Current Research Activities:

Acoustic Surrogates of Suspended Sediment Properties:

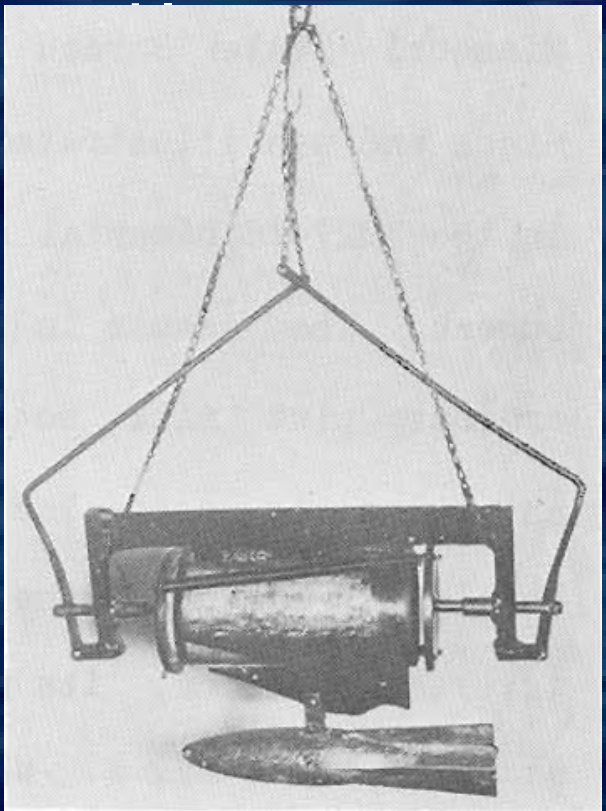


Fig. 53--U. S. Bureau of Reclamation slow filling sampler.

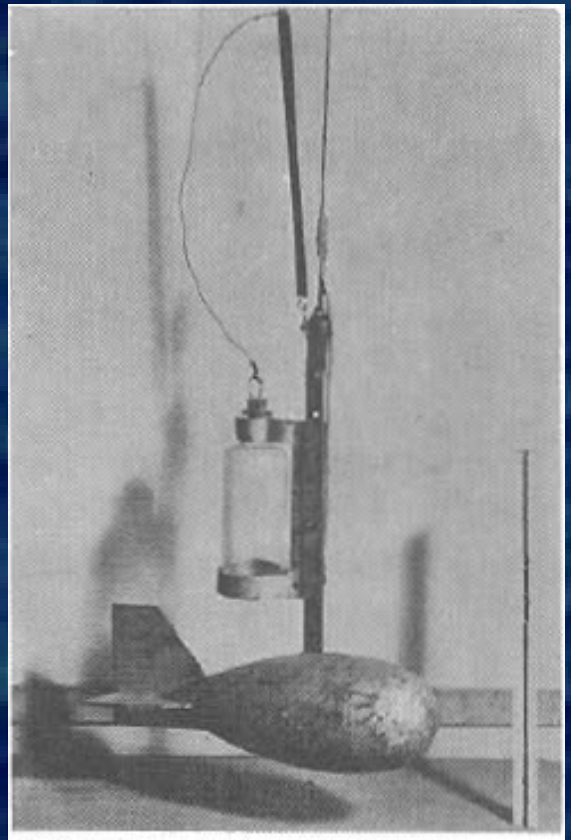


Fig. 56--U.S.D.A. bottle sampler.

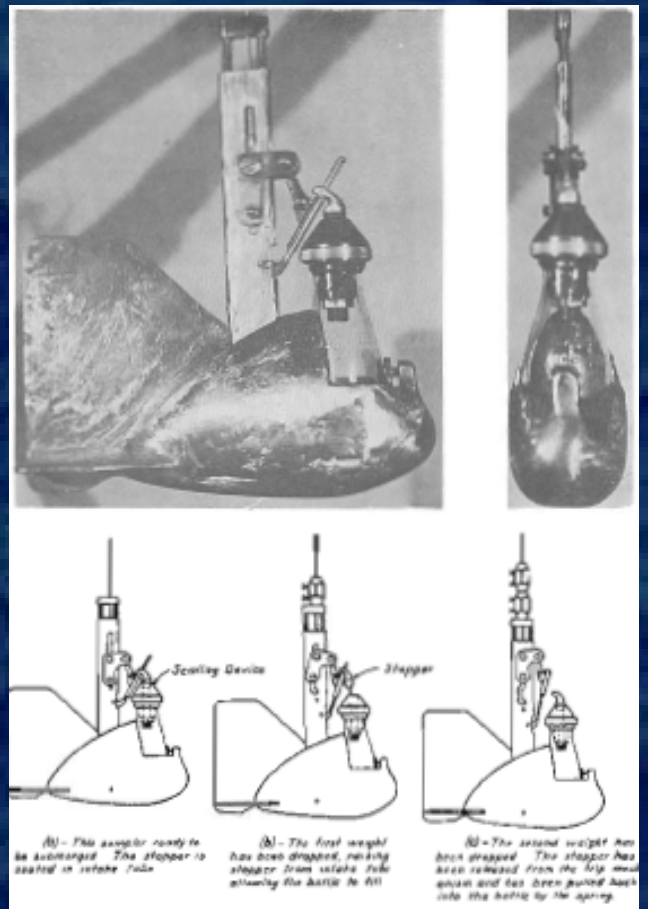


Fig. 67--Frazier, U.S.G.S., time-integrating sampler.

FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Current Research Activities:

Acoustic Surrogates of Suspended Sediment Properties:

- **Fund Research Projects Last ~ 5 years**
- **Coordinate among Federal Partners**
- **Meet with Manufacturers**
- **Form Sediment Acoustic Leadership Team (SALT)**
- **Co-Sponsor CUAHSI Workshop March 2012**

Goals:

- **Provide Preliminary Guidance and Training**
- **Conduct / Sponsor / Obtain Results from Basic Research to Address Key Questions** *(instrument precision and accuracy; how to treat attenuation; sensitivity to changing instrument set-up and transducer properties; sensitivity to changes in PSD; low-concentration limit; multi-frequency methods for PSD; near-field effects; temperature sensitivity; input power sensitivity;)*
- **Work with manufacturers to obtain: Standard data formats for backscatter, transmit pulse length, instrument noise, input voltage, and other metadata**

FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Current Research Activities:

Acoustic Surrogates of Suspended Sediment Properties:

Goals (Continued):

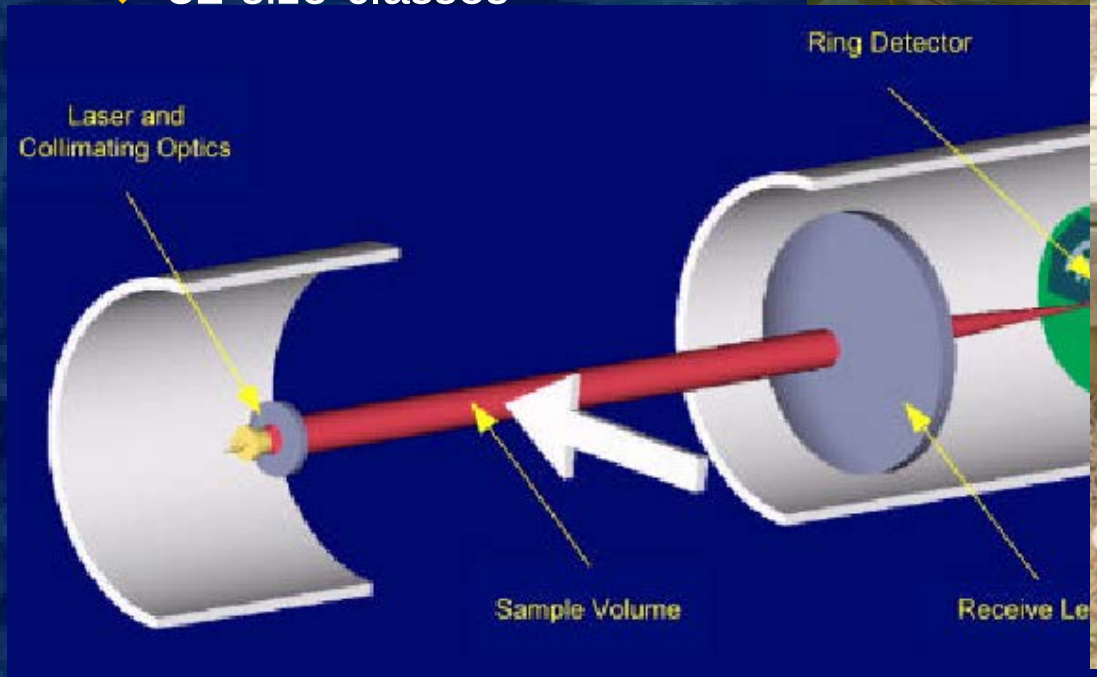
- **Work with manufacturers to obtain sediment-specific data collection mode for single and multi-frequency devices**
- **Promote software for Signal Processing and Calibration and Time Series SSC / PSD development**
- **Promote software for real-time data transmission, analysis and reporting**
- **Develop Accuracy Assessment and Criteria**
- **Provide Standardized, Generalized Guidance for Federal Agencies**

FEDERAL INTERAGENCY SEDIMENTATION PROJECT

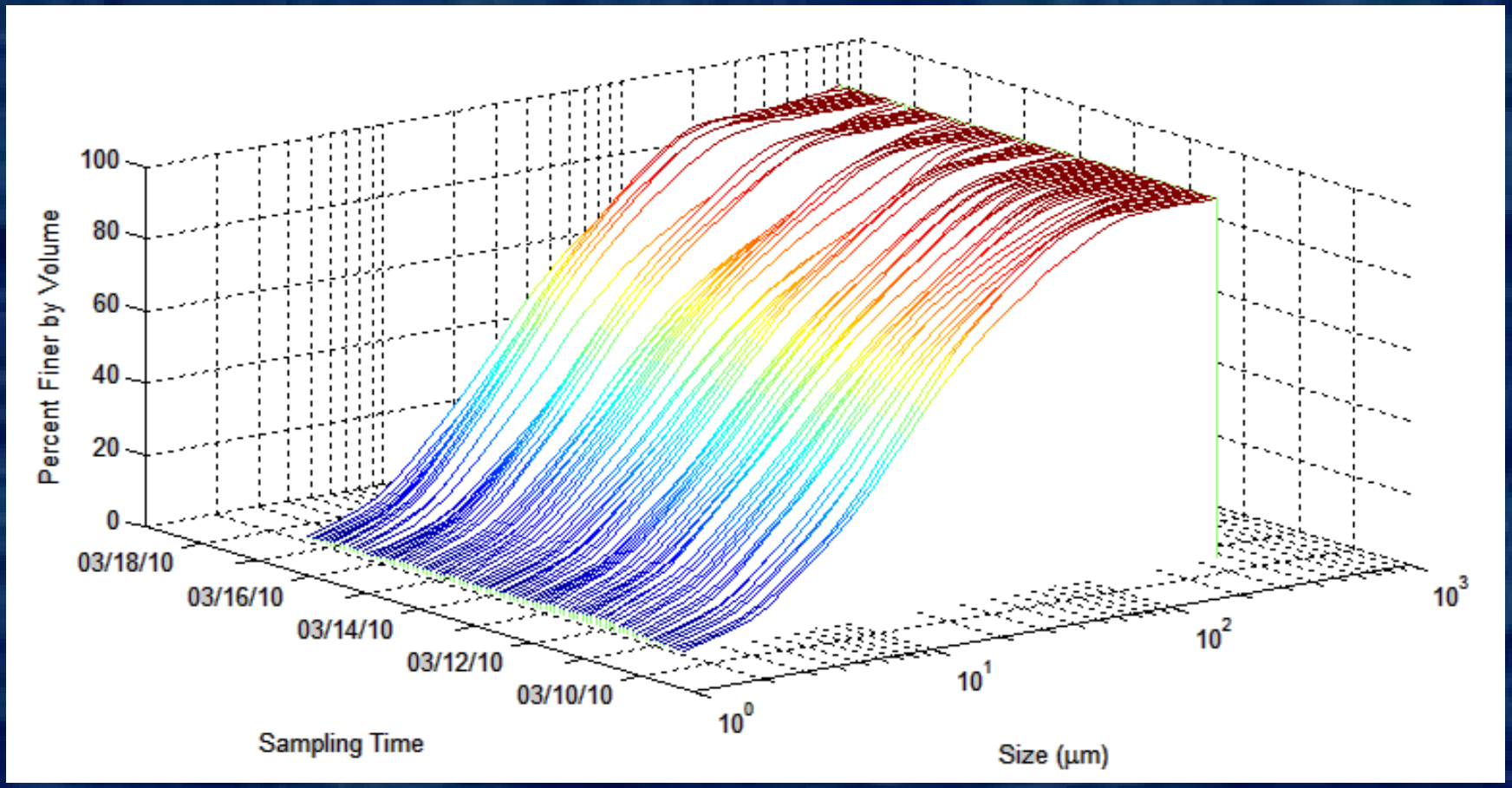
Current Research Activities:

Laser Diffraction Sediment Surrogate Instr

- Properties Measured:
  - Volumetric concentration and particle si
- Instrument Technology
  - Laser Diffraction
  - LISST Streamside
  - Sampling Volume, few cm^3
  - 32 size classes



Laser-Diffraction Surrogates of SSC Particle Size Distribution Time Series



Limitations of LISST instruments

- Comparability of Volumetric to Mass SSC and PSD
- Concentration limits
  - Limits exists in the field
  - For –SL: upper limit (mg/l) = 300*d[µm]
  - For –SS: 200*d[µm]
  - Lower limit limited by signal-to-noise ratio
- Size range may not cover all particles in suspension
- Clogging of intakes for pumped instruments
- Velocity limits for isokinetic sampling and general operation (-SL only)

FEDERAL INTERAGENCY SEDIMENTATION PROJECT
Current Research Activities:

Bed Load and Bed Material Load

- By Repeat Bathymetric Survey and Bottom Ping Acoustic Results (Abraham and McElroy, 2010-2011); (Wood, 2012)

Digital Imaging for Partical Size Analysis (CVO, 2012)

Depth Integrating Sampler Arm for Urban Environments (2011)

Federal Interagency Sedimentation Project

- **STATUS:**
- **FISP Funded Research had continued to Benefit Federal Agencies**
- **FISP Equipment Sales and Support and Training have been good**
- **FISP Transitions have been successful**
- **FISP Relevance Has (potentially) increased with surrogate techs**
- **FISP engagement with Federal Partners has increased last 1.5 years**
- **BUT….**
- **Federal Participation and Funding has Dwindled over Last Decade**
- **Funding had declined amidst tighter Federal Budgets**
- **Terms of Reference for 2012 and forward is not yet signed by Federal Partners**

Federal Interagency Sedimentation Project

USGS science for a changing world | HIF Hydrologic Instrumentation Facility | ars | USDA | FISP

Sediment and Water-Quality Samplers and Research

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3039 Amwiler Road, Suite 130
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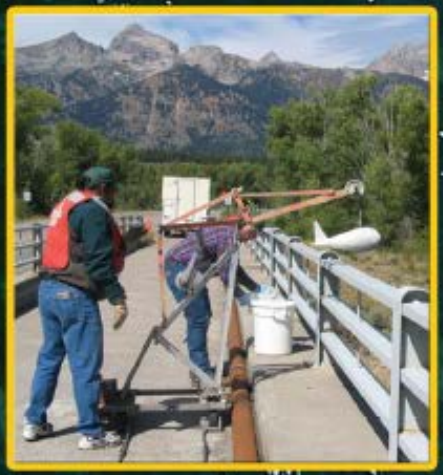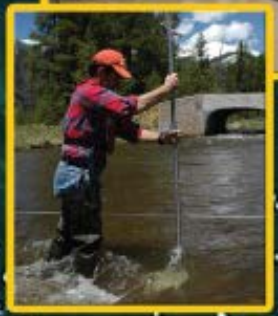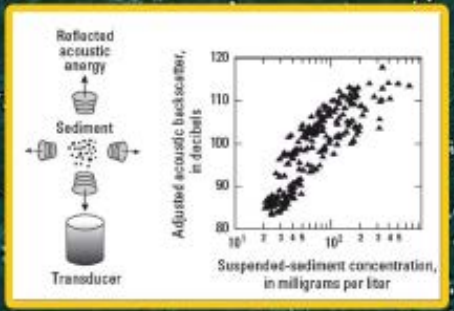
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