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Streamgaging in the Flathead Basin – Part 1: Fundamentals of Streamgaging

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U.S. Department of the Interior
U.S. Geological Survey

Fundamentals of Streamgaging -

Outline *(from agenda)*

History of streamgaging

Current technology

- **Hardware and sensors**
- **Data metrics and collection**
- **Data management and quality control**

Funding

- **Annual operating expenses for individual gages**
- **Additional expenses for gage networks / programs**
- **Legislative funding and budget constraints**
- **Operators and cooperators**

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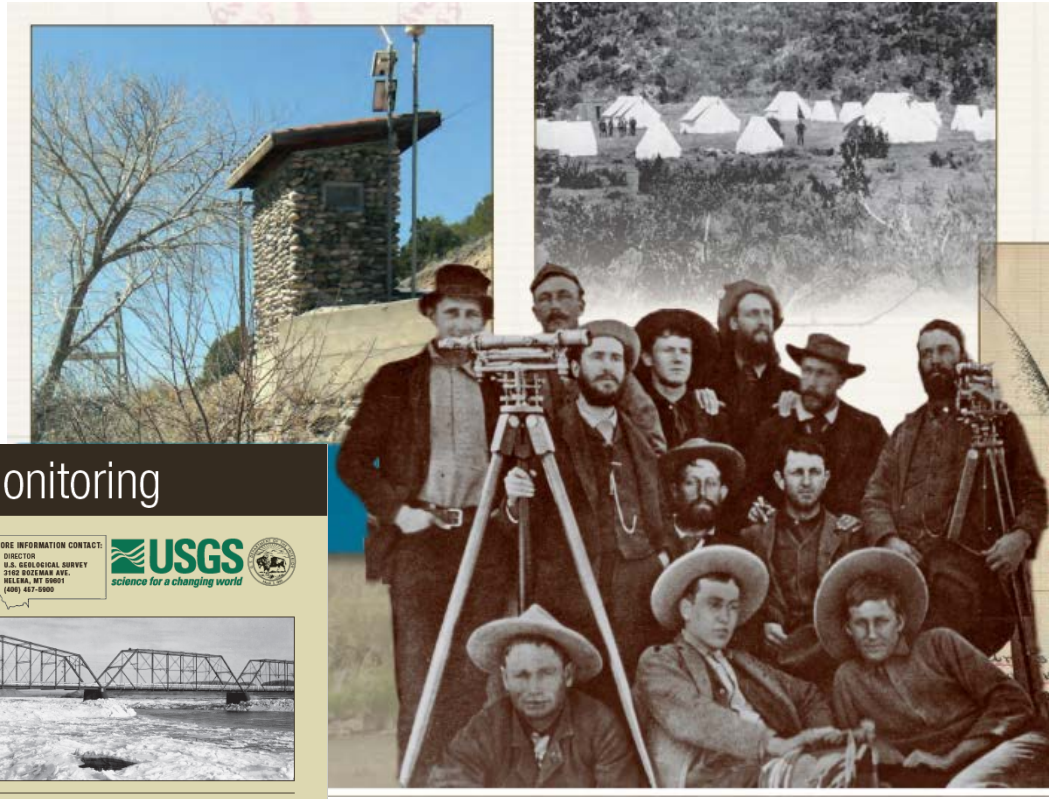
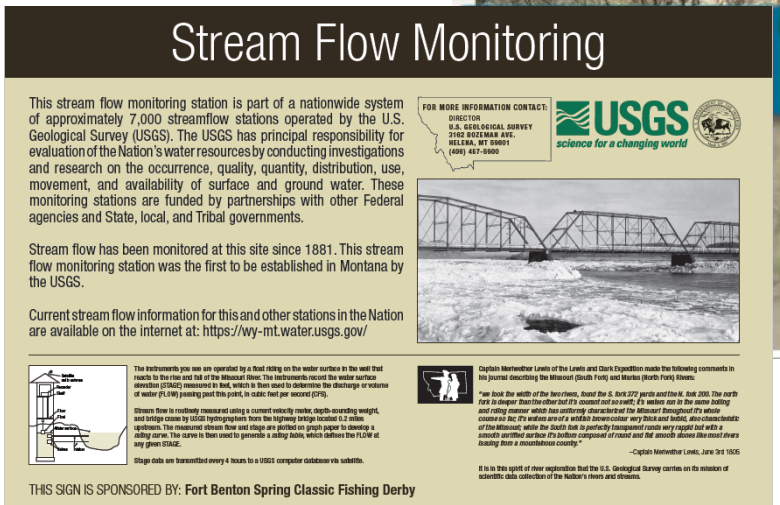
Fundamentals of Streamgaging -

History of streamgaging

“Oldest” *USGS* streamgages

- **Rio Grande at Embudo, NM**
  - **January 1889 to present**
- **Missouri River at Fort Benton, MT**
  - **October 1890* to present**





Stream Flow Monitoring

This stream flow monitoring station is part of a nationwide system of approximately 7,000 streamflow stations operated by the U.S. Geological Survey (USGS). The USGS has principal responsibility for evaluation of the Nation's water resources by conducting investigations and research on the occurrence, quality, quantity, distribution, use, movement, and availability of surface and ground water. These monitoring stations are funded by partnerships with other Federal agencies and State, local, and Tribal governments.

Stream flow has been monitored at this site since 1881. This stream flow monitoring station was the first to be established in Montana by the USGS.

Current stream flow information for this and other stations in the Nation are available on the internet at: https://wy-mt.water.usgs.gov/

FOR MORE INFORMATION CONTACT:
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The instruments you see are operated by a float riding on the water surface in the well that reacts to the rise and fall of the Missouri River. The instruments record the water surface elevation (STAGE) measured in feet, which is then used to determine the discharge or volume of water (FLOW) passing past this point, in cubic feet per second (CFS).

Stream flow is routinely measured using a current velocity meter, depth-sounding weight, and bridge cranes by USGS hydrographers from the highway bridge located 0.2 miles upstream. The measured stream flow and stage are plotted on graph paper to develop a *rating curve*. The curve is then used to generate a *rating table*, which defines the FLOW at any given STAGE.

Stage data are transmitted every 4 hours to a USGS computer database via satellite.

Captain Meriwether Lewis of the Lewis and Clark Expedition made the following comments in his journal describing the Missouri (South Fork) and Marias (North Fork) Rivers:

"we took the width of the two rivers, found the S. fork 372 yards and the N. fork 200. The north fork is deeper than the other but it's current not so swift; it's waves ran in the same boiling and rolling manner which has uniformly characterized the Missouri throughout it's whole course so far. It's waters are of a reddish brown colour very thick and turbid, also characteristic of the Missouri; while the South fork is perfectly transparent runs very rapidd but with a smooth unrifled surface it's bottom composed of round and flat smooth stones like most rivers leading from a mountainous country."

–Captain Meriwether Lewis, June 3rd 1805

It is in this spirit of river exploration that the U.S. Geological Survey carries on its mission of scientific data collection of the Nation's rivers and streams.

THIS SIGN IS SPONSORED BY: **Fort Benton Spring Classic Fishing Derby**

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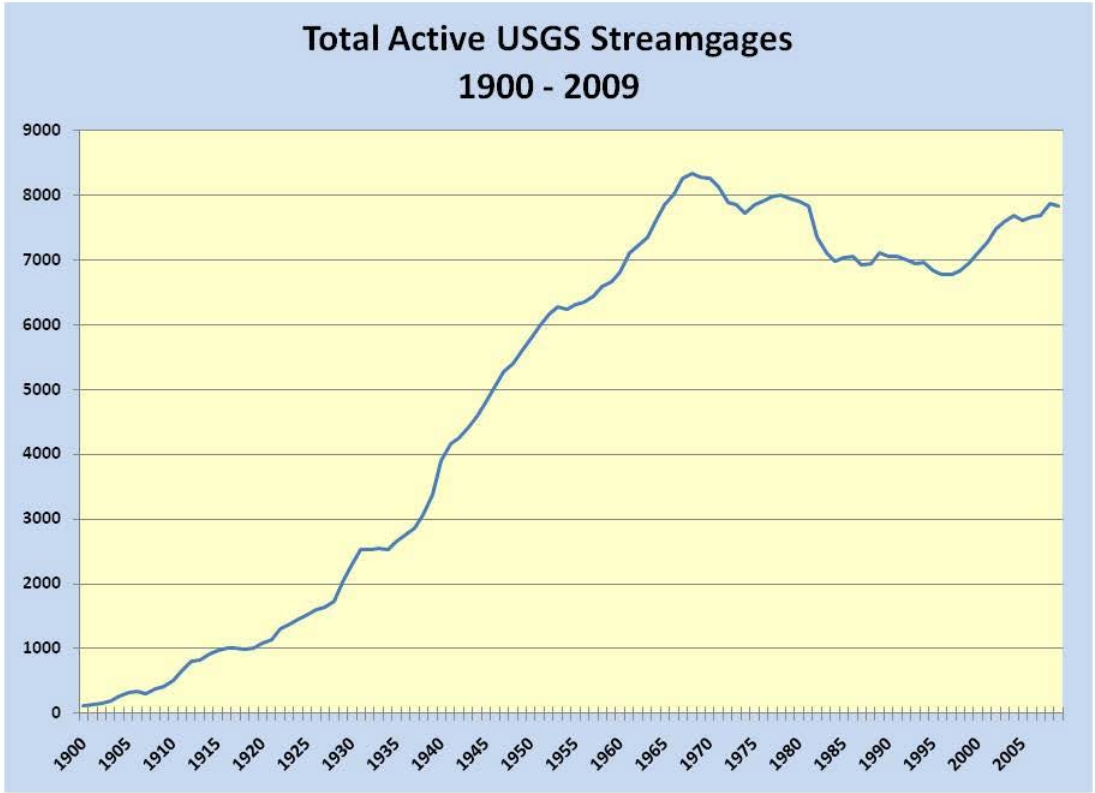
Fundamentals of Streamgaging -

History of streamgaging (continued)

USGS Streamgaging in the Nation – 1900-2009

- 1954 ~6,400 streamgages[1]
- 1996 6,593[2]
- **2007 >7,400[3]**
- **2018 8,046[4]**



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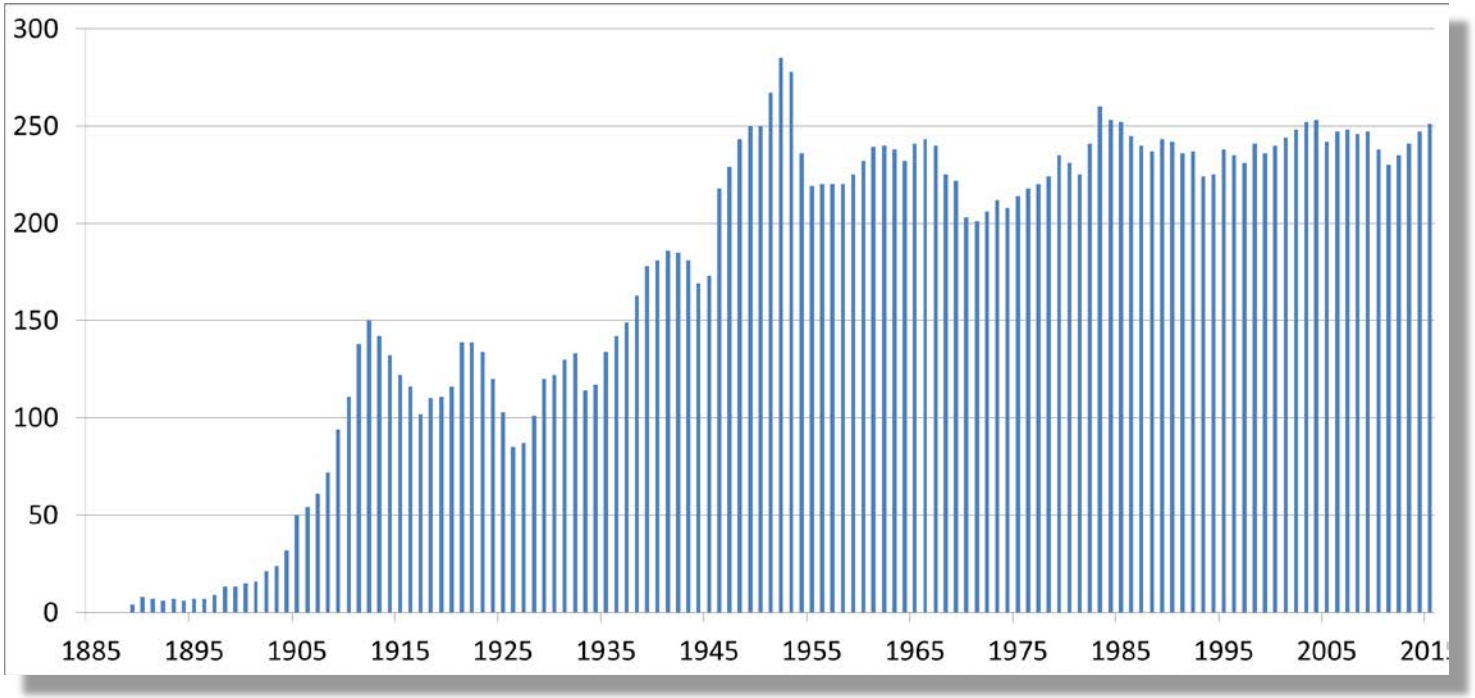
Fundamentals of Streamgaging -

History of streamgaging *(continued)*

USGS Streamgaging in Montana – Number of streamgages by year



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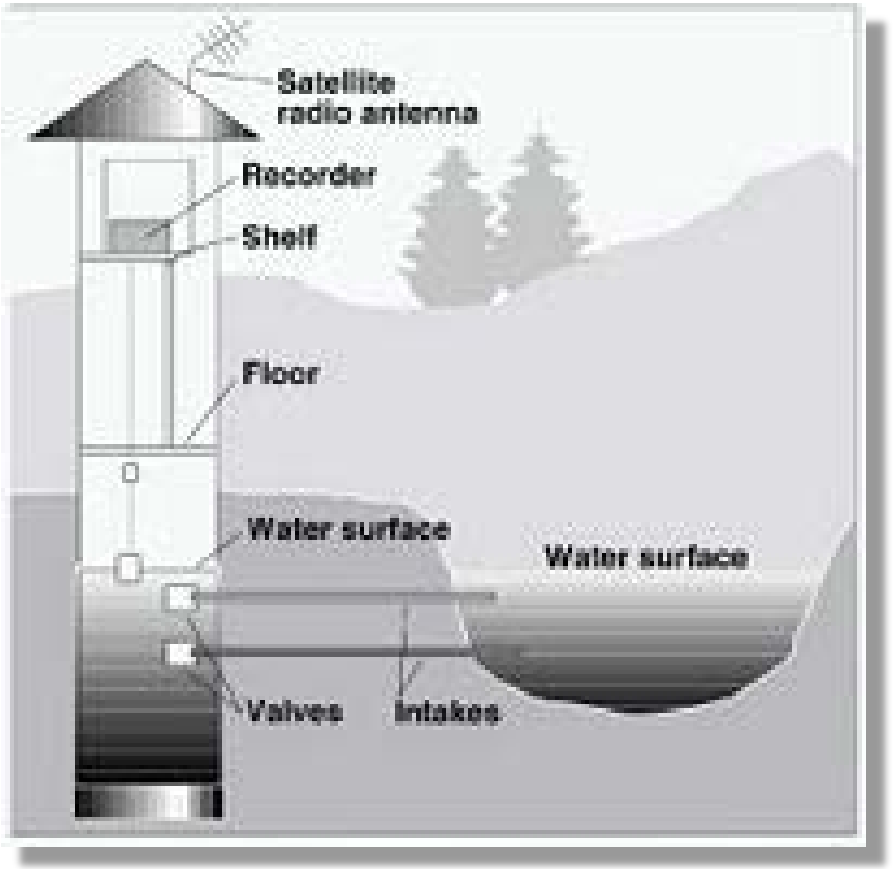
Fundamentals of Streamgaging -
History of streamgaging (continued)

What is a streamgage?

- ***"streamgage" is an active, continuously functioning measuring device in the field…***
- **Measures river stage → reported as gage height in feet above a local datum**
  - **Float + encoder**
  - **Transducer**
  - **Non-contact**
- **For the purpose of computing discharge → reported as streamflow in cubic feet per second**



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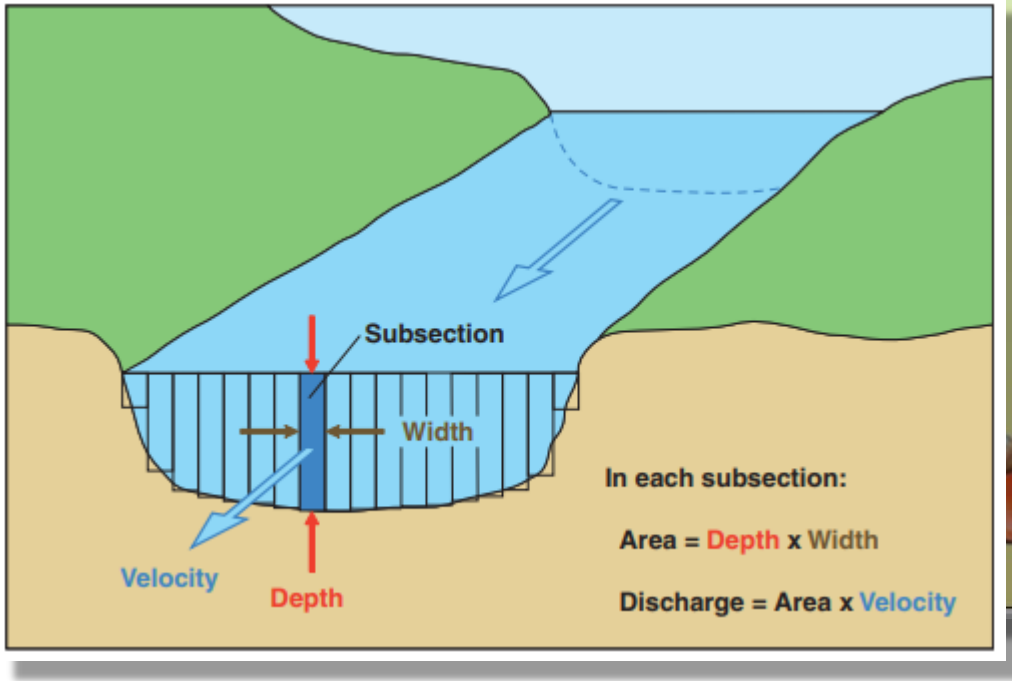
Fundamentals of Streamgaging -
History of streamgaging (continued)

How do you compute discharge?

- ***Discharge Measurements***



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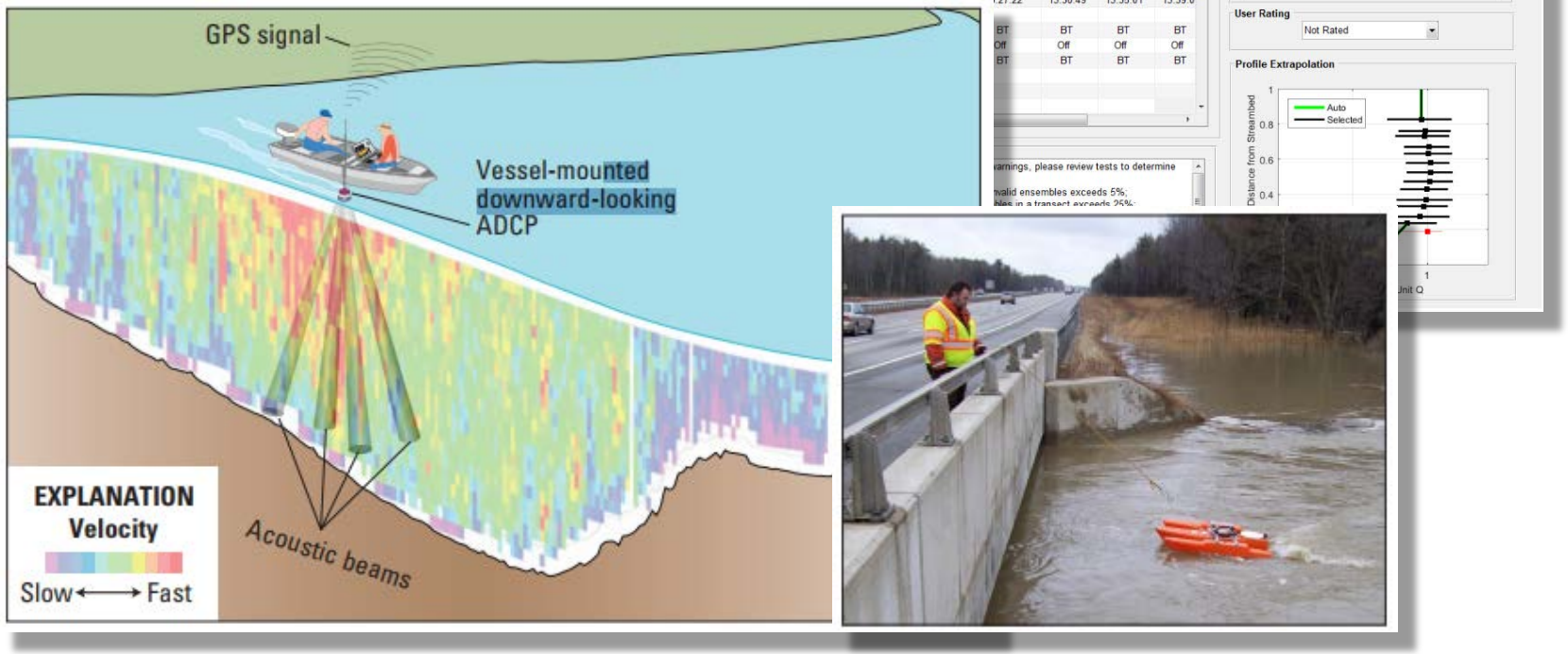
Fundamentals of Streamgaging -

History of streamgaging *(continued)*

How do you compute discharge?

- ***Discharge Measurements – ADCP***



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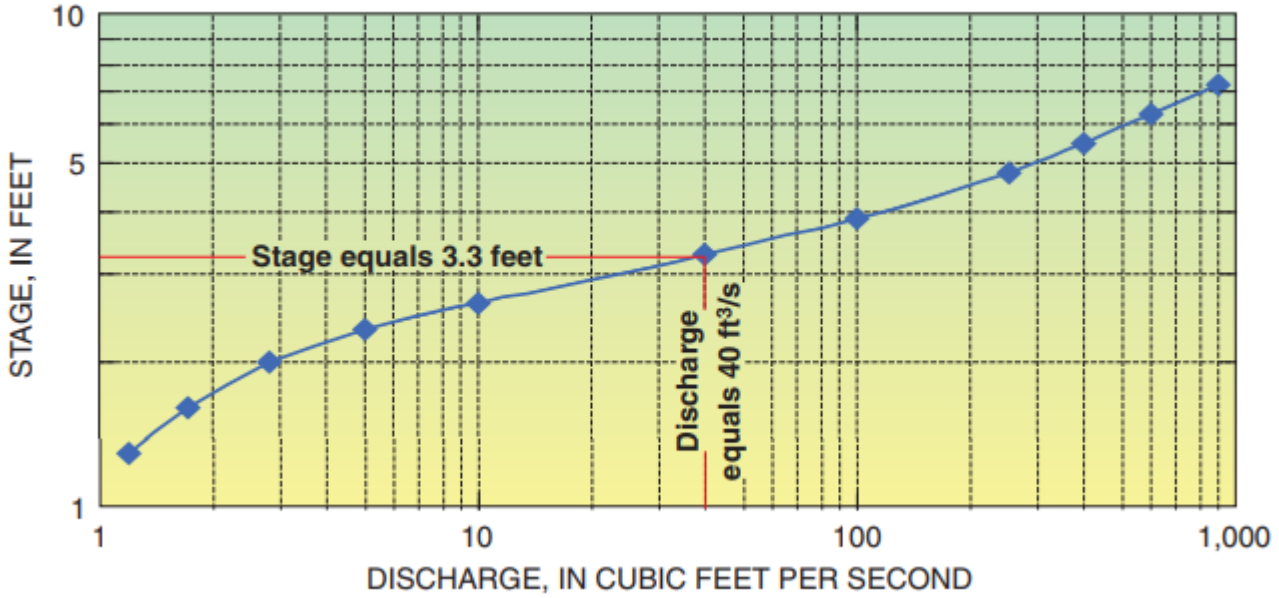
Fundamentals of Streamgaging -
History of streamgaging (continued)

How do you compute discharge? *(continued)*

- ***Stage-Discharge Rating***
- **Multiple discharge measurements over range in stage**
- **Define "break points"**
  - **Channel morphology**
  - **Hydraulic factors**
- ***All stage-discharge ratings change***



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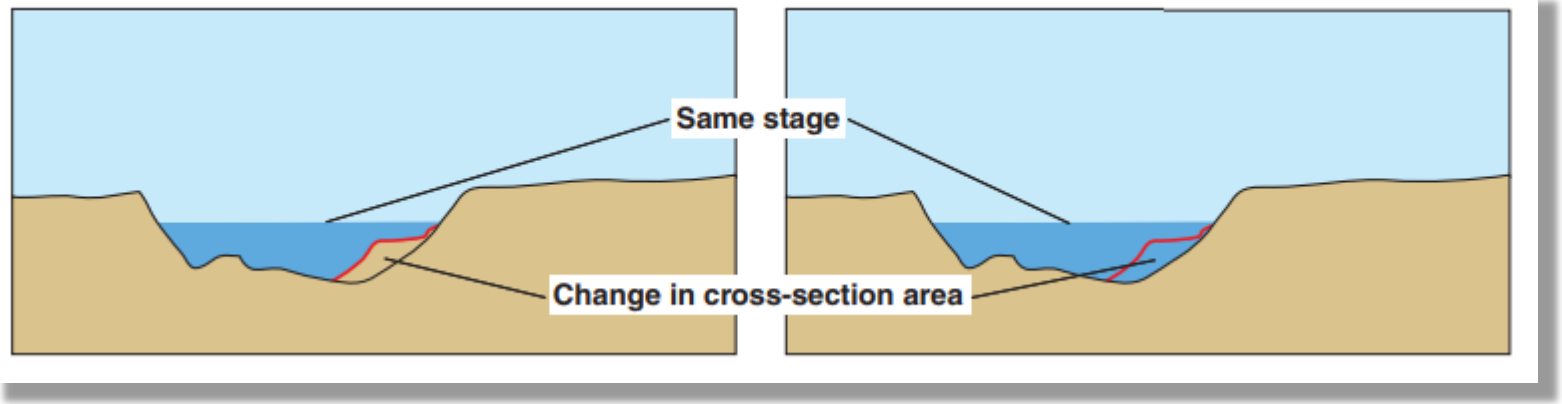
Fundamentals of Streamgaging -
History of streamgaging (continued)

How do you compute discharge? *(continued)*

- ***Stage-Discharge Rating – Shifts happen***
  - **Event-based changes in channel morphology**
    - **Scour → results in lower stage for same discharge**
    - **Fill → results in higher stage for same discharge**
  - **Progressive changes in channel morphology**



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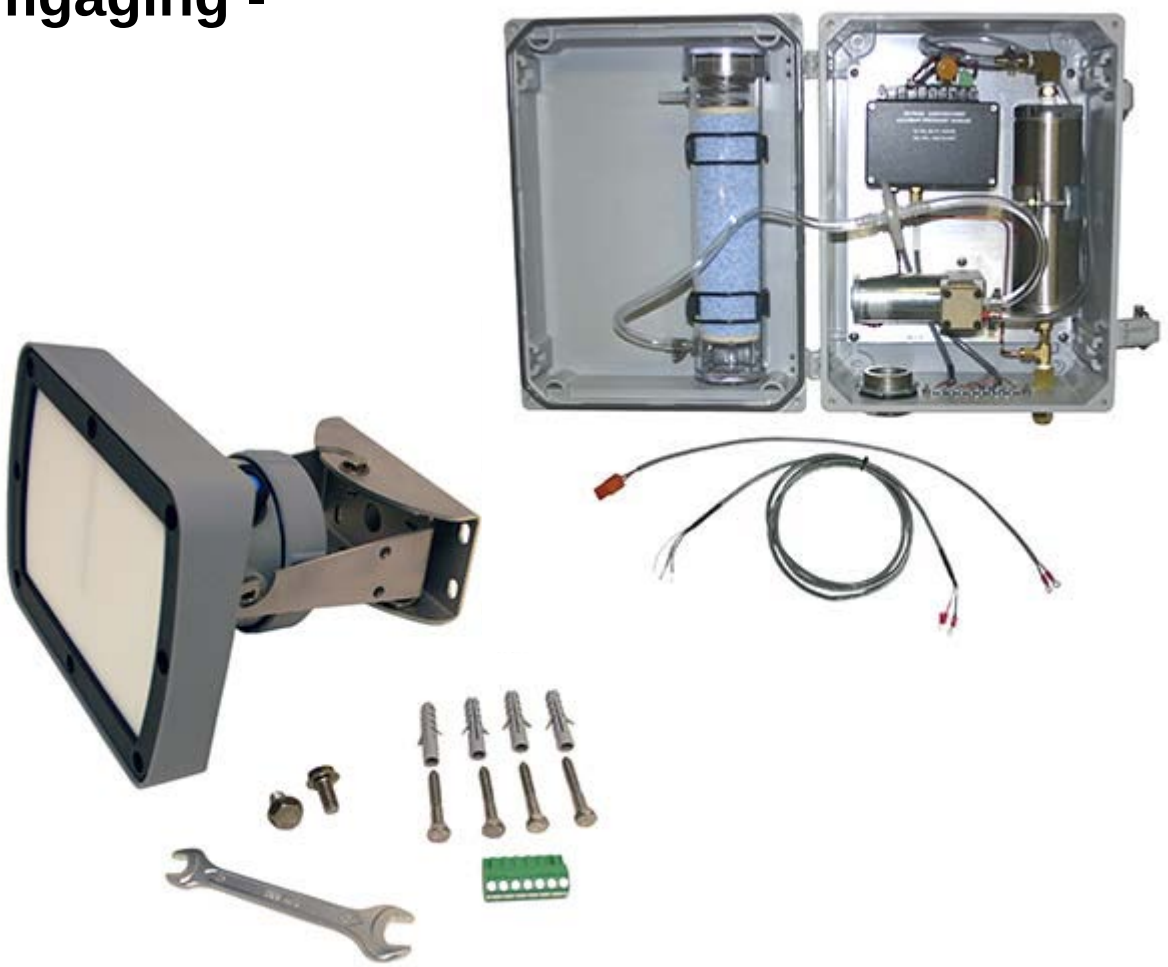
Fundamentals of Streamgaging -
Current technology

Hardware and sensors

- **Measuring stage**
  - **Bubbler systems**
    - **Self-contained**
  - **RADAR**
    - **Non-contact**



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Fundamentals of Streamgaging - *Current technology* ***(continued)***

Hardware and sensors

- **Measuring discharge**
  - Acoustic Doppler Current Profiler (ADCP)
    - Auto-adjust frequency / mode
  - Acoustic Velocimeter (AVM)
  - Index-velocity
- **Transmitting data**
  - Geostationary Operational Environmental Satellite (GOES)
  - Cell and Iridium Modems
    - Not in WY-MT WSC … not yet!

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Fundamentals of Streamgaging - *Current technology* *(continued)*

Data metrics and collection

- Maintaining datum
  - Ensure rating tied to reference
  - Frequent station levels
- Validating rating
  - *All stage-discharge ratings change*
  - Frequent discharge measurements
- Site visits
  - Complete observations on-site
  - Measurements processed on-site
- Hydroacoustics checks
  - Beam check
  - Thermistor check
  - Moving bed test
- Additional fieldwork
  - Discharge check measurements
    - Quality assurance
  - Indirect discharge measurements
    - Large streamflows not measured directly

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Fundamentals of Streamgaging -
Current technology ***(continued)***

"right data right now"

Data management and quality control

- Transmitted data → Automated and hydrographer reviews
- Field measurements → QC and efficiency goals
  - Electronic field forms
  - Uploaded ASAP
- New time-series software → AQUARIUS
- Timely analyses → QA for transmitted data
  - Corrections and preliminary shifts applied
  - Additional automated reviews
- Approvals and Audits
  - Multiple and different "sets of eyes"
  - One- to three-year external audits
- Meter QC program → Periodic testing
  - Retiring cat-whisker contacts
- Training
  - National Training Center
  - Center-sponsored courses
- Techniques and Methods
  - USGS "TWRI" series → Revised and updated

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Fundamentals of Streamgaging - *Funding*

Annual operating expenses for individual gages

- **Cooperators not eligible for USGS-CMF**
  - **FY18 - $18,100**
- **Cooperators eligible for USGS-CMF**
  - **FY18 example: 40% matching funds**
    - **Partner - $9,970**
    - **USGS - $6,650***
- **Year-round, “full-service” streamgage**
- **Other agreement-related considerations:**
  - **Federal v. State fiscal years**
  - **Multiple year commitments**

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Fundamentals of Streamgaging -
Funding *(continued)*

Additional expenses for gage networks / programs

- Cableways
  - Design ← Safety
  - Substantial excavation and concrete
  - A-frames – Specialized construction
  - Example: Clark Fork above Missoula
    - ~$110,000
- Discontinued Sites
  - O&M funding ceases – No funds to remediate site infrastructure (e.g. WCF)

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Fundamentals of Streamgaging -
Funding *(continued)*

Legislative funding and budget constraints –
USGS Groundwater and Streamflow Information Program (GWSIP)

- **USGS Cooperative Matching Funds (CMF)**
  - **Appropriation contingent**
  - **Center allocation**
  - **Multiple uses**
  - **Capped ratio**
- **USGS Federal Priority Streamgages (FPS)**
  - **FKA NSIP – Fixed network**
  - **Appropriation contingent**
  - **Federal goal**

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Fundamentals of Streamgaging -
Funding *(continued)*

Operators and Cooperators – Flathead Basin

- **Energy Keepers, Inc.**
- **Confederated Salish & Kootenai Tribes**
- **U.S. Bureau of Reclamation**
- **Bonneville Power Administration**
- **Montana Fish, Wildlife & Parks**
- **Montana Department of Natural Resources and Conservation**
- **Glacier National Park**
- **Flathead Conservation District**
- **U.S. Geological Survey Groundwater and Streamflow Information Program**

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