The USGS Streamgaging Program

ACWI
Networks Review Team
December 10, 2012

Robert Mason

Surface Water Monitoring Networks

Site Selection/Network Design
- Federal “backbone” (~3,200 gages)
- Non-Federal network (~4,800 gages)

Streamgaging process/standards/QA
- Stage monitoring
- Flow measurements
- Rating/shifts

Network-support infrastructure
- Records processing
- Facilities/Equipment
- Training (for USGS & others)

Furnished Records

The Future

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Streamflow Information is Essential

Uses	
Engineering Design	–Corps, BOR, States, locals
Flood Reservoir Operations	–Corps (2,478 sites), BOR, TVA
Hydroelectric Power Ops	–FERC, Utilities
Steamflow Forecasting	–NWS (3,900 sites)
Water-Quality Regulation	–EPA, States (TMDLs, etc.)
Water/Wastewater Treatment	–Local and State
Irrigation	–BOR, water purveyors
Floodplain Mapping	–FEMA (NFIP)
Evacuation Planning	–FEMA (Hazus)
Recreational boating	–Outfitters, individuals
Research	–NAWQA, NRP, CWP, EPA, NOAA, universities

Streamflow information is essential for many purposes that we can probably categorize as design, operation/management, forecasting, regulatory, recreation, and research

Site Selection

- Purpose/Needs drive site selection
- Purpose/Needs evolve and multiple continually
- Difficult to anticipate new needs
- In addition to the site purpose there is general utility in having the data
- General site selection factors
  - Physical proximity to project/resource or hazard
  - Physical characteristics of the streamgage site
  - Representative sampling/coverage (geography, geology, hydrology, or landuse)

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Federal Needs

- Priority considerations
  - Legal responsibilities
  - Public safety
  - Systematic sampling and monitoring for long-term comparisons
  - Long-term records for reference conditions
- Priority Needs
  - State and international boundaries
  - River forecasting
  - River basin
  - Water-quality monitoring
  - Basin sentential watersheds

http://water.usgs.gov/nsip/pubs/Ries_EWRI_2001.pdf

http://water.usgs.gov/nsip/reviews.html

Prioritization Criteria For Cooperatively Funded USGS Streamgages In Colorado

Goal 1--Quantify Streamflow in Major Colorado Watersheds

Goal 2--Support Colorado Flood and Water-Supply Forecasting

Goal 3--Support Colorado Water Administration and Management

Goal 4--Support Streamflow Gages for Determination of Trends in Flow

Goal 5--Support Water-Quality Networks in Colorado

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Prioritization Criteria For Cooperatively Funded USGS Streamgages In Colorado

Goal 1--Quantify Streamflow in Major Colorado Watersheds

- **3 points--**Gages on major rivers (North Platte, South Platte, Arkansas, Rio Grande, San Juan, Animas, Dolores, Gunnison, Colorado, White, and Yampa) that have a > 20% change in annual flow from downstream gage(s)
- **2 points**—-One gage on small tributaries (tributary flow is > 5% of the mainstem flow upstream from the tributary).
- **1 point**--One gage on small tributaries (tributary flow is > 5% of the mainstem flow upstream from the tributary).
- **0 points**--All other gages**.**

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Prioritization Criteria For Cooperatively Funded USGS Streamgages In Colorado

Goal 2--Support Colorado Flood and Water-Supply Forecasting

- **3 points**--Gage is an NWS, COE, USBR, State, or local flood forecast gage**.**
- **2 points**--Gage is an NRCS or NWS water-supply forecast gage**.**
- **1 point**--Gage is a State or local water-supply forecast gage**.**
- **0 points**--All other gages.

USGS

Final Allocation Ranking

Ranking Scores and Associated FMF Rates--2011 Fiscal Year:

- 0-1 points Very Low Ranking 0% FMFs
- 2-3 points, Low Ranking 12% FMF
- 4-7 points, Medium Ranking 40% FMF
- >7 points, High Ranking 46% FMF

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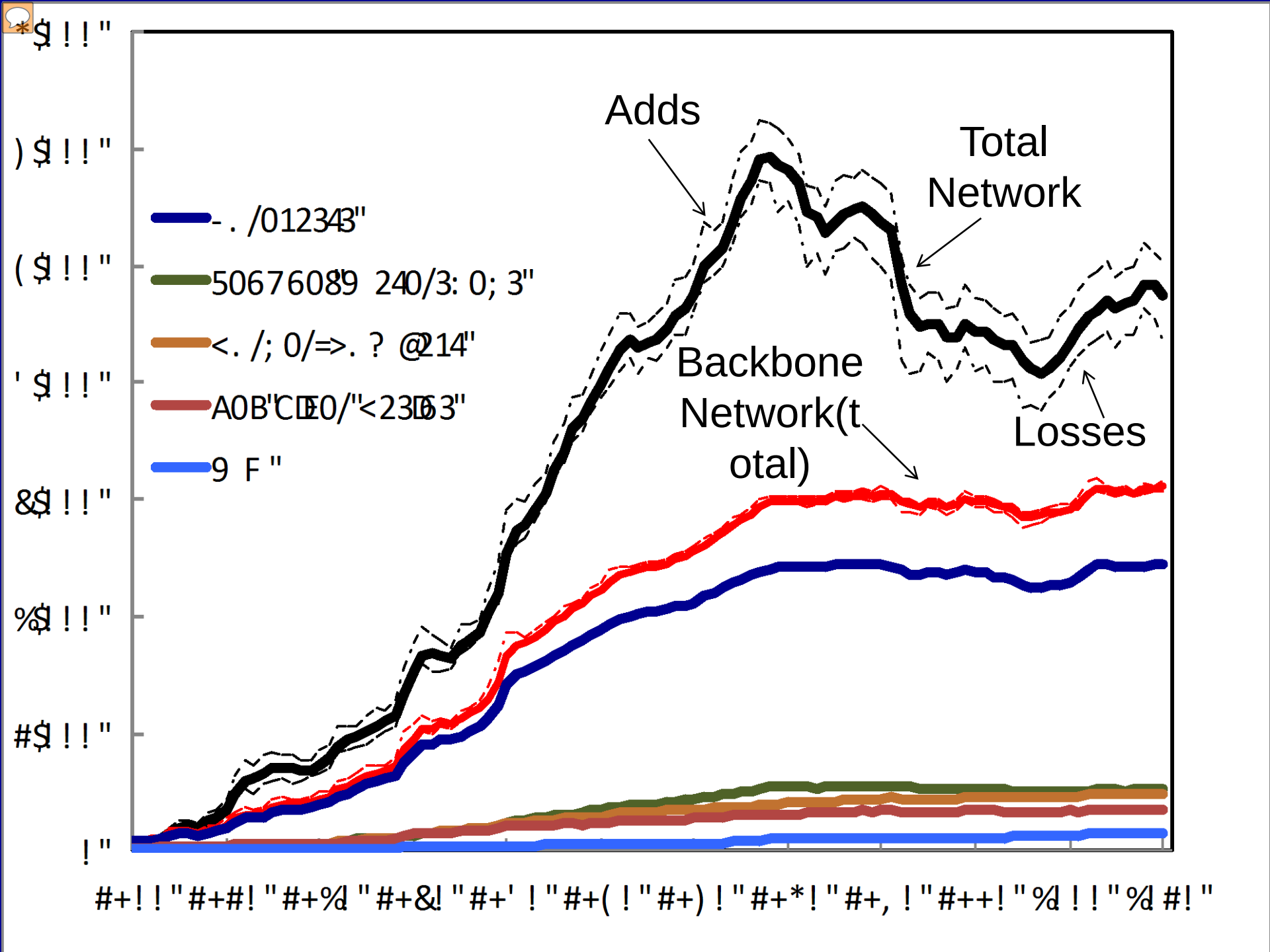
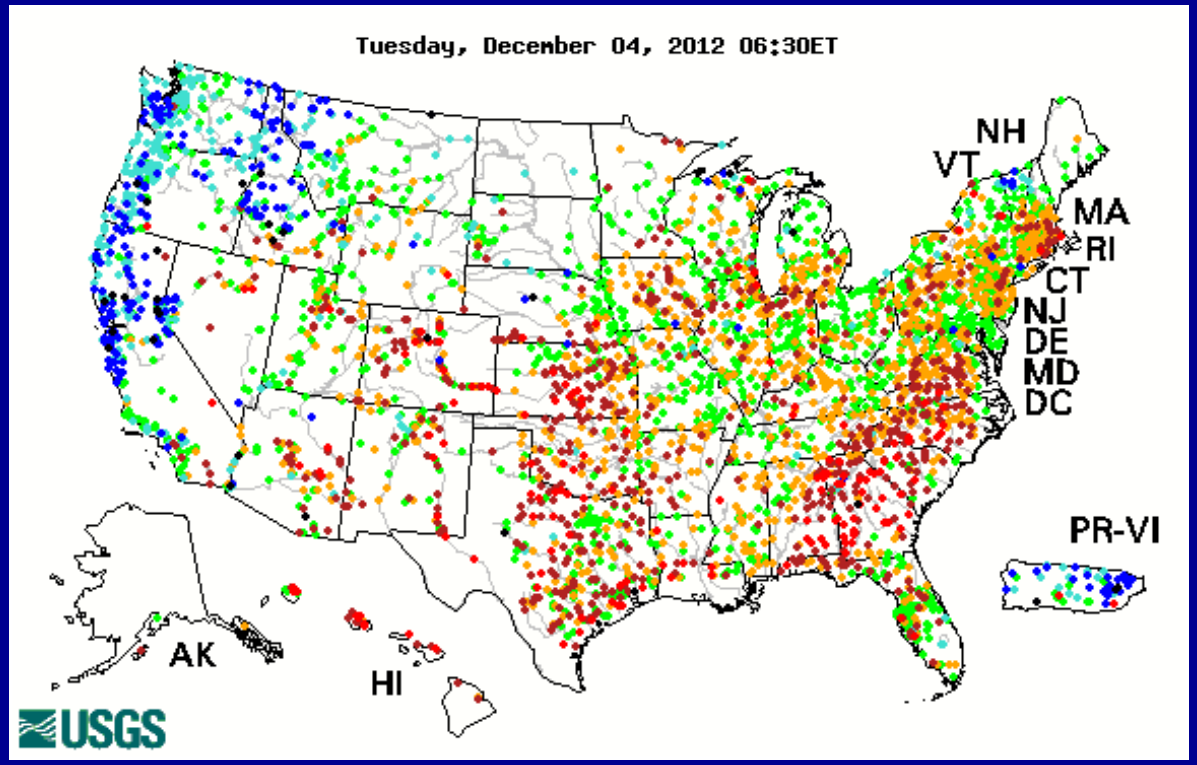

Adds
Total Network
Backbone Network(total)
Losses

The USGS Streamgaging Network

Streamgages
8,000 gages
99 % real-time
All on web

Network Costs
$158M per year
850+ Partners



Funding Sources

State / Local Agencies	$77M	49%
Other Federal Agencies	$28M	18%
USGS Cooperative Program	$26M	16%
USGS Nat Streamflow Info Program	$27M	18%

USGS

2011

USGS Streamgaging

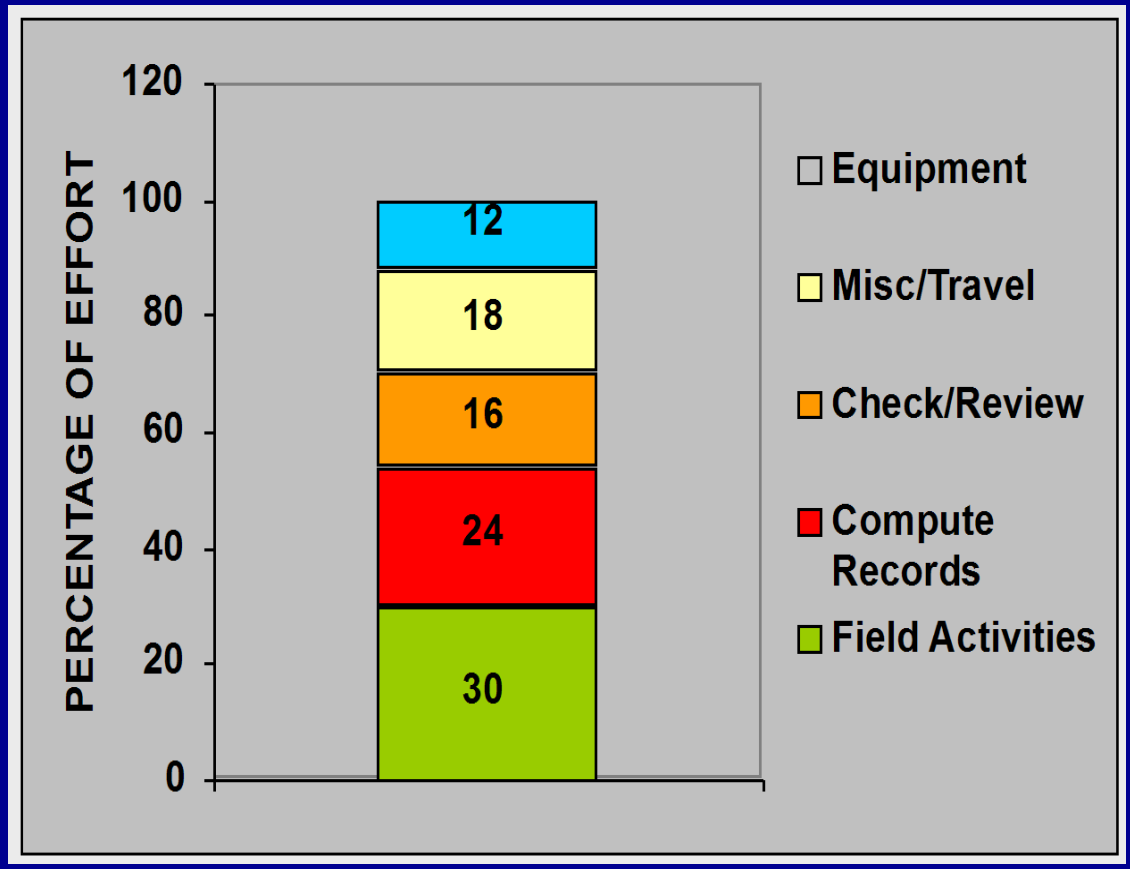
- Consistent, high-quality methodology
- Long--term data collection and archival
- Funded by many partners
- Data freely available
- Field-intensive
- Needs technology infusion

Streamgage Activities And Relative Costs

Field Activities
- -Service Instruments
- -Verify stage
- -Measure Flow
- -Observe “channel”

Records Computations
- -Correct stage data
- -Develop Rating
- -Apply Shifts
- -Document corrections and shifts (extent and timing)

Check/Review/Archive
- -Document/Explain adjustments



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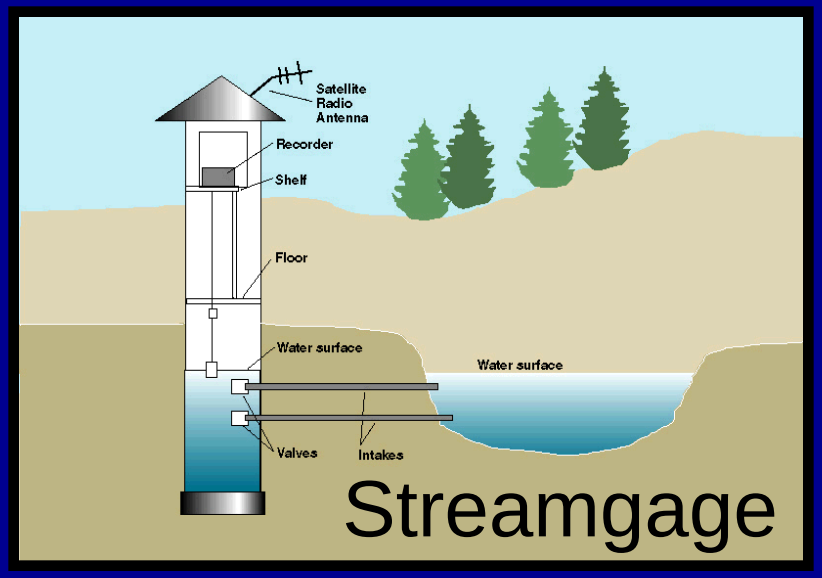
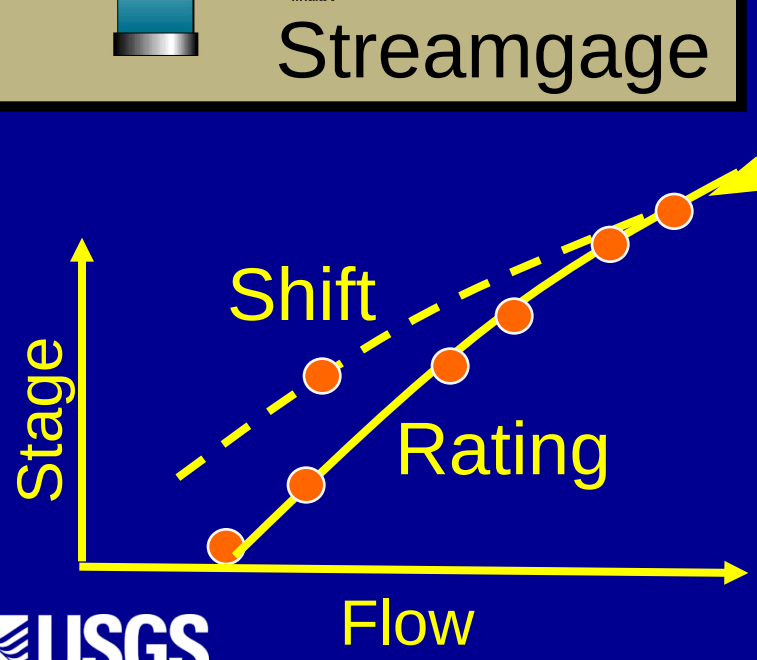
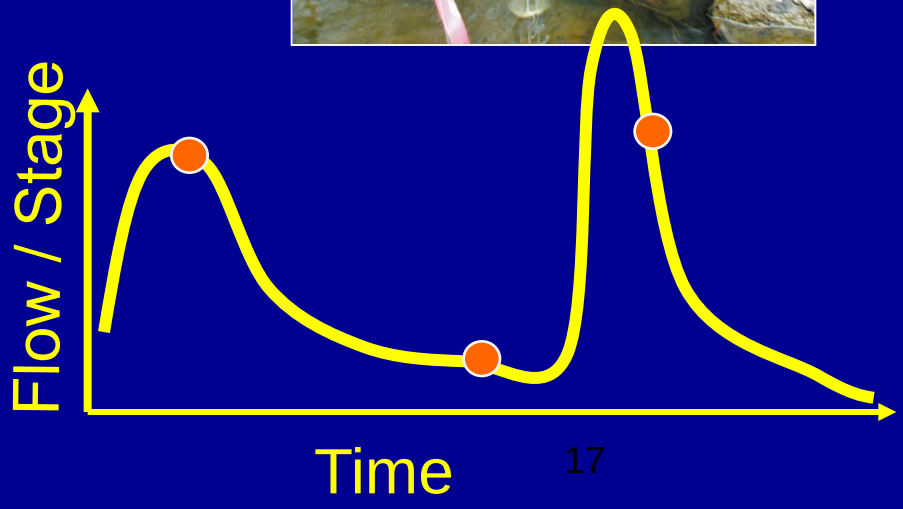
The Streamgaging Process



Flow Measurements





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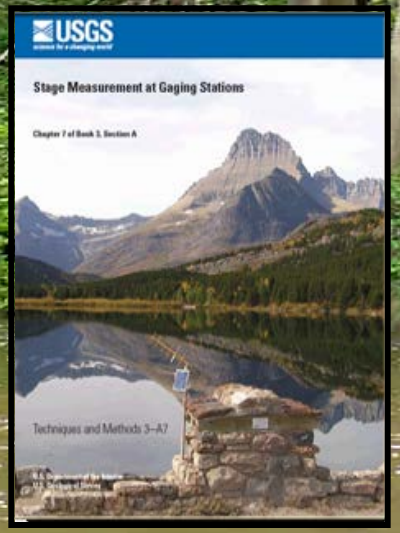
Monitoring Stage

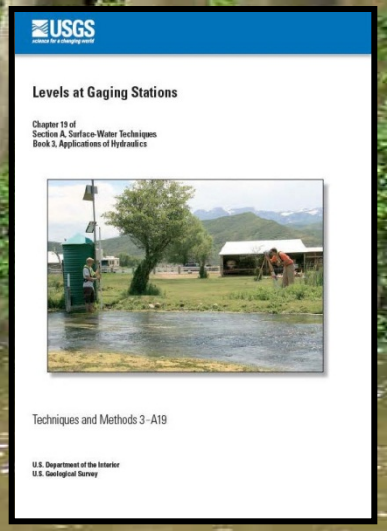
+/- 0.02 ft. or 2% of range

Monitoring Stage

- Verified by direct readings
- Record adjusted accordingly
- New technologies reduced costs

Monitoring Stage





Flow Measurements

Before Acoustics (1991)

-52 flood measurements
-10 days
-Staff of 11
-Average time -- 96 min.

With Acoustics (2012)

-62 flood measurements
-10 days
-Staff of 6
-Average time -- 18 min.

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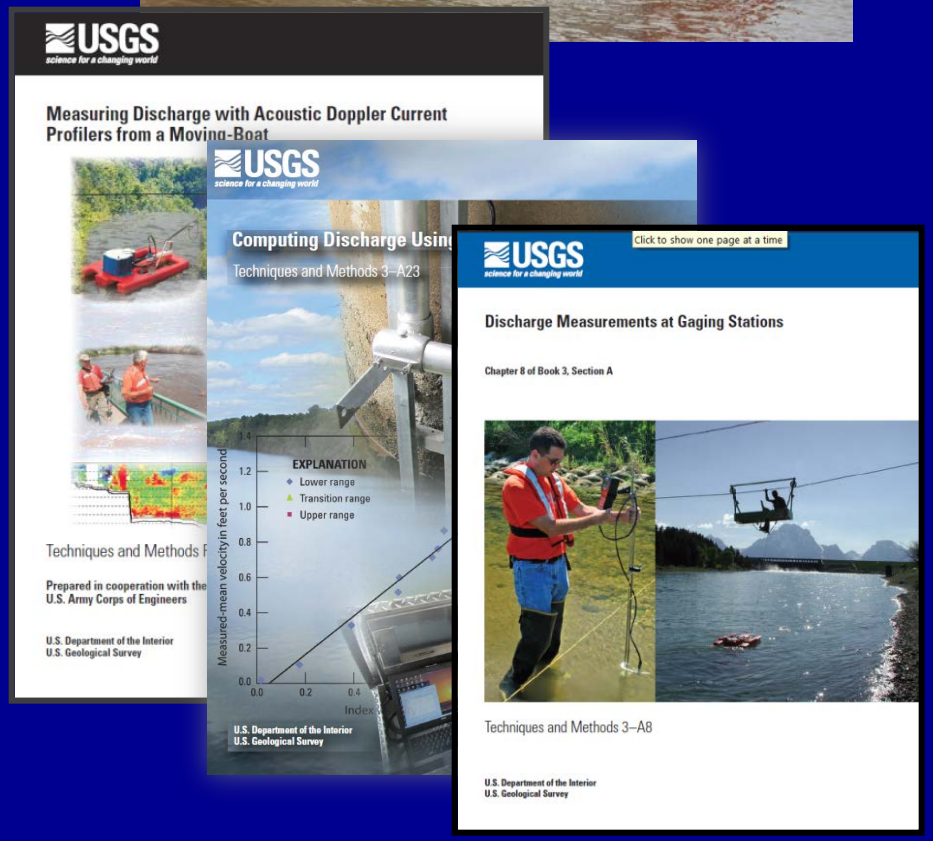
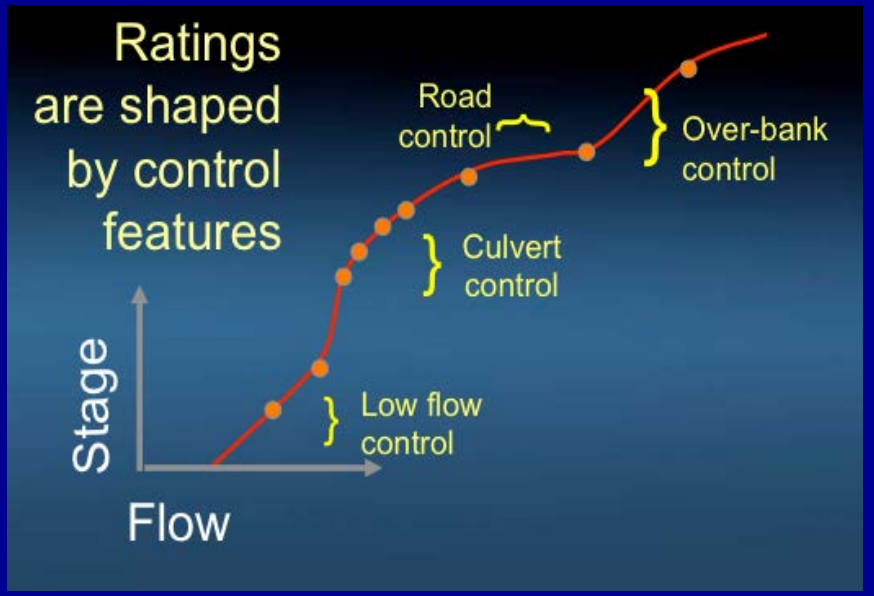
Standards for Flow Measurements



1. Observe and document control conditions
2. Require at least 12 minutes
3. At least 4 transits
4. Compute flow on-site
5. Verify ADCP compass, GPS
6. Perform moving-Bed Tests
7. Check for air entrainment
8. Measure reference depth
9. Evaluate Edge Discharges
10. Evaluate Extrapolation Methods
11. Check measurements
    a. 5% departure from rating
    b. Departures from trend
    c. Obvious channel change

Ratings and Controls



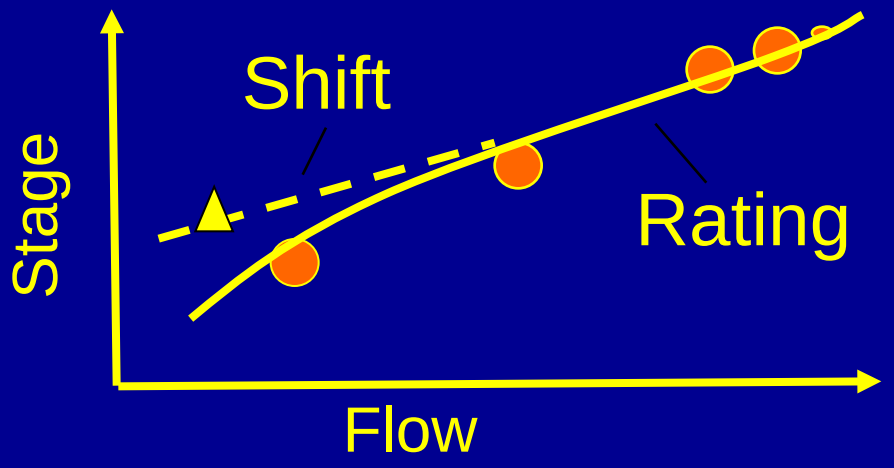
Records Processing

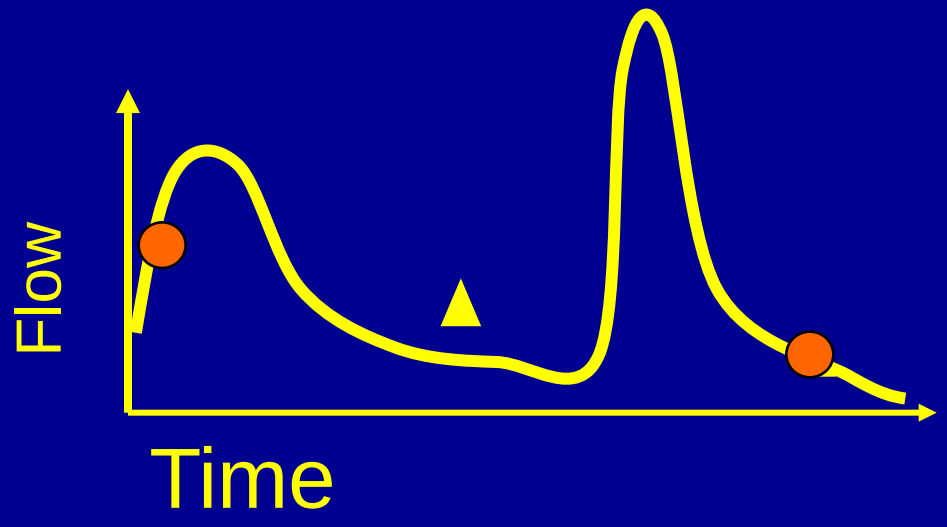
Examine stage records
- -Retrieve missing data
- -Apply corrections

Update Rating
- -Plot flow meas on rating
- -Plot shift curve
- -Develop shift diagram
- -Examine stage hydrograph for date/time
- Manually enter shifts

Run computations

Check/Review/Archive
- -Develop shift diagram
- -Check against nearby gages
- -Write station analysis
- -Approve records





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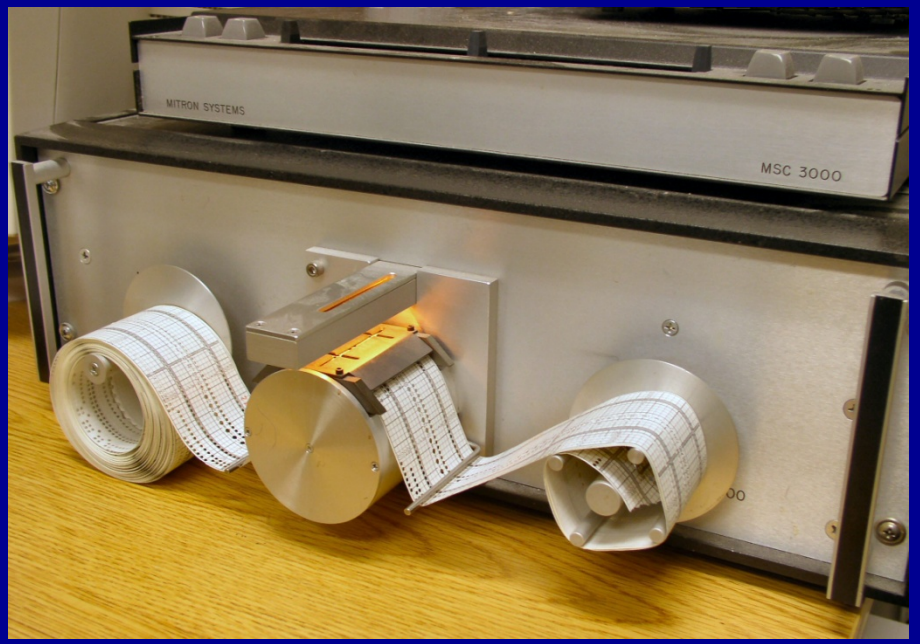
Infrastructure -Records Processing

- Automated Data Processing System (ADAPS)
  - Data edits
  - Data corrections
  - Ratings and shifts
  - Data estimates



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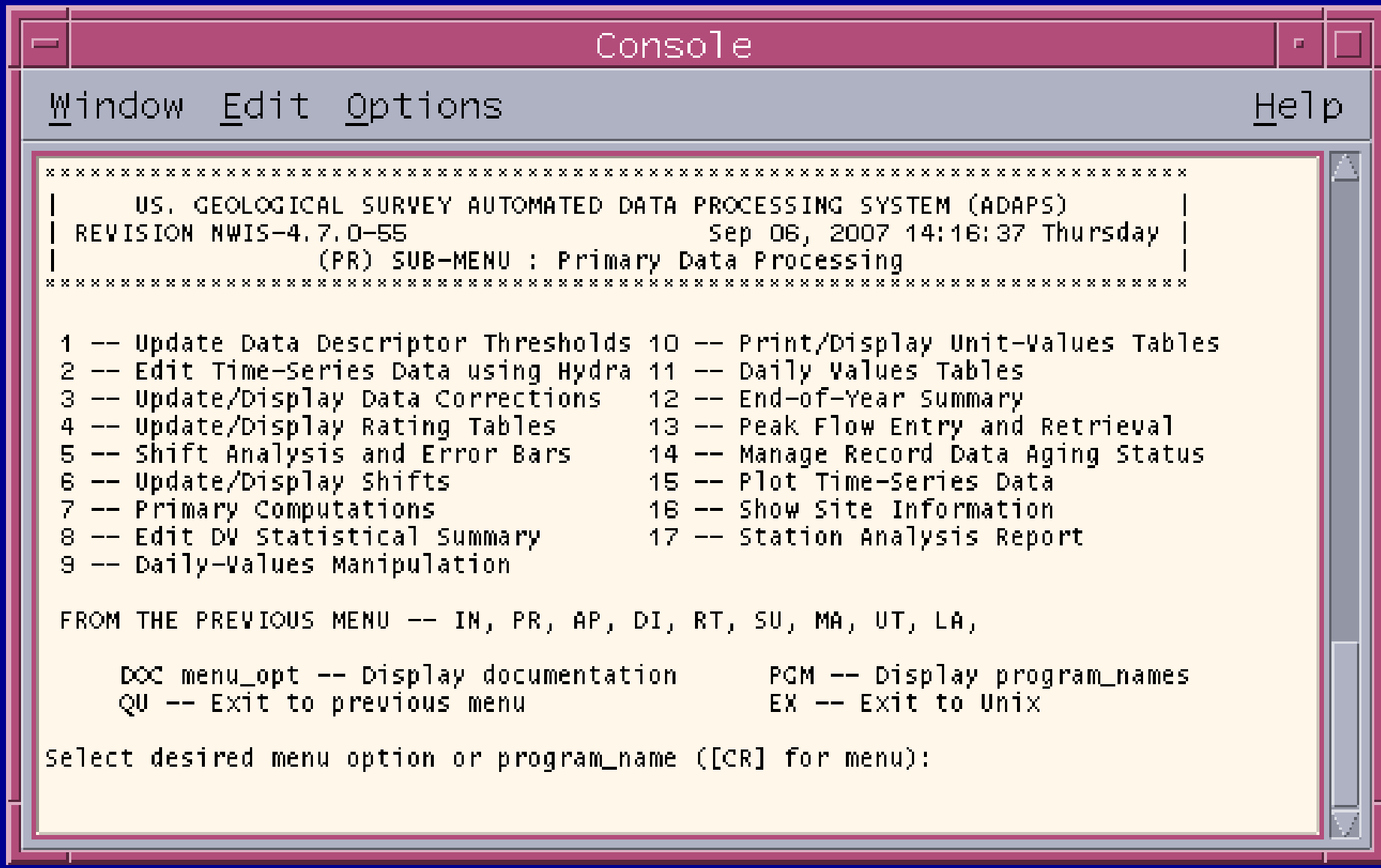
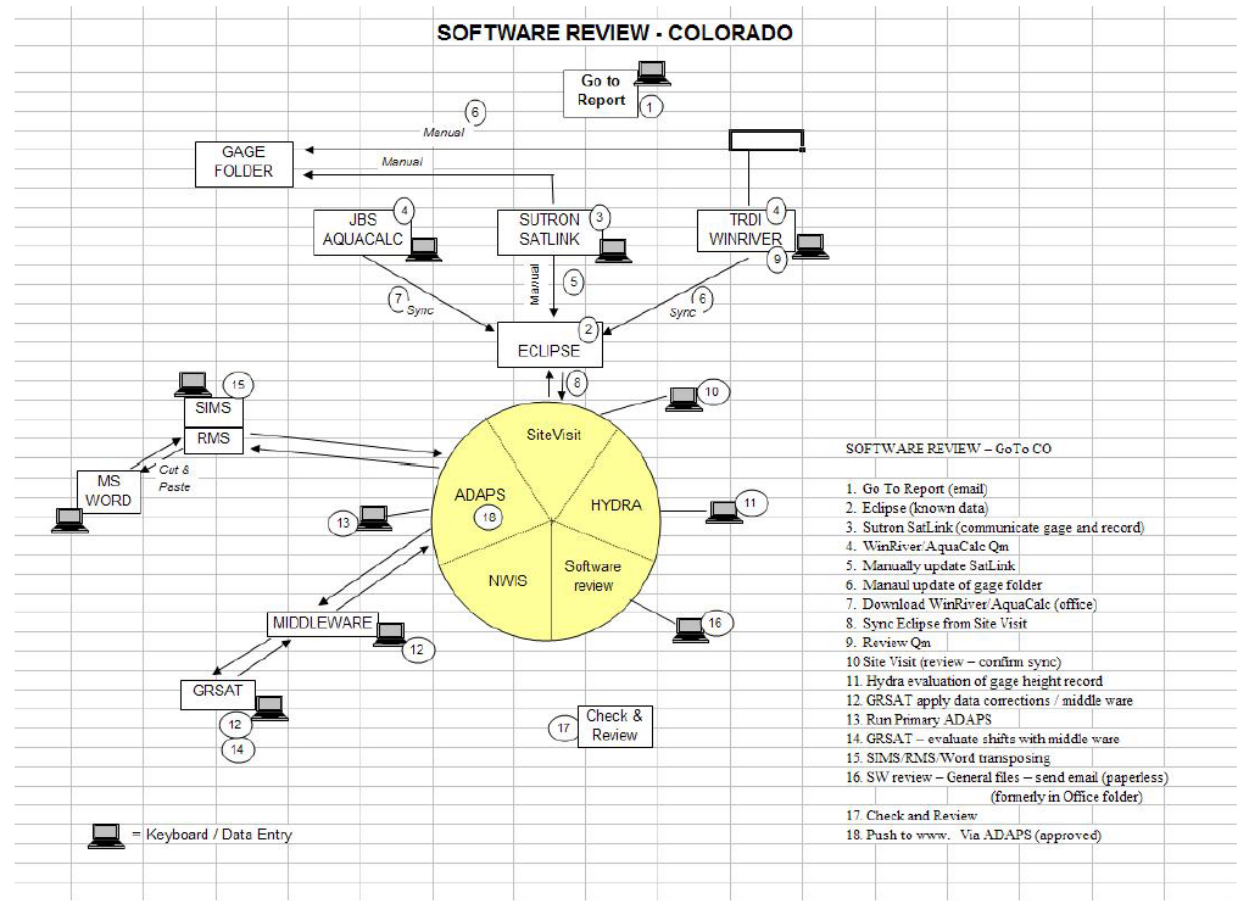

Console
Window Edit Options Help
US. GEOLOGICAL SURVEY AUTOMATED DATA PROCESSING SYSTEM (ADAPS)
REVISION NWIS-4.7.0-55 Sep 06, 2007 14:16:37 Thursday
(PR) SUB-MENU : Primary Data Processing
1 -- Update Data Descriptor Thresholds
2 -- Edit Time-Series Data using Hydra
3 -- Update/Display Data Corrections
4 -- Update/Display Rating Tables
5 -- Shift Analysis and Error Bars
6 -- Update/Display Shifts
7 -- Primary Computations
8 -- Edit DV Statistical Summary
9 -- Daily-Values Manipulation
10 -- Print/Display Unit-Values Tables
11 -- Daily Values Tables
12 -- End-of-Year Summary
13 -- Peak Flow Entry and Retrieval
14 -- Manage Record Data Aging Status
15 -- Plot Time-Series Data
16 -- Show Site Information
17 -- Station Analysis Report
FROM THE PREVIOUS MENU -- IN, PR, AP, DI, RT, SU, MA, UT, LA,
DOC menu_opt -- Display documentation
QU -- Exit to previous menu
PGM -- Display program_names
EX -- Exit to Unix
Select desired menu option or program_name ([CR] for menu):

"… to the outside observer, the process that the technicians had to go through was *astonishing*. An attempt to diagram the movement of data processes at each site we observed can be found in Appendix D." – Streamflow data value engineering study

"Consolidate functionalities of multiple software programs into one solution … Nine different software programs currently being used for data processing" – Water-quality data value engineering study



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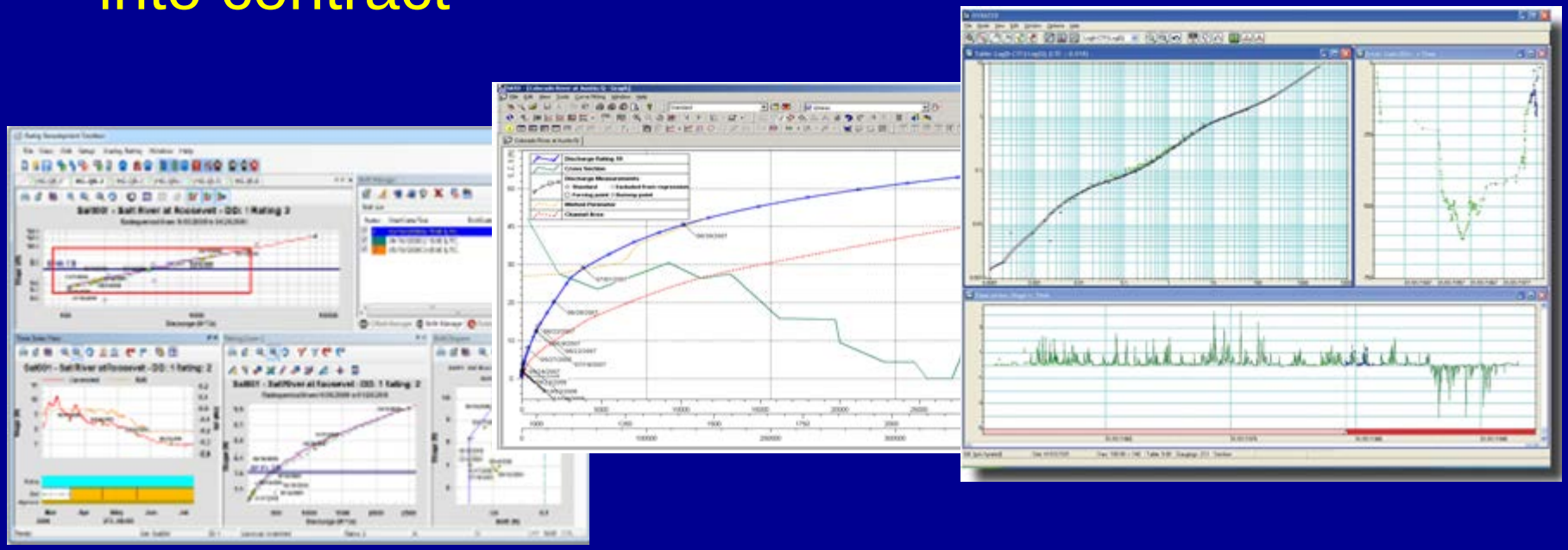
Replace ADAPS with Commercial Software

Aquarius

- Smallest of 3 major commercial systems used worldwide
- Off the shelf product
- Extensive expansion and tailoring capabilities built into contract



Procurement/Training Costs for New System

- $3.2M initial base package delivery
- Up to $5M build out and support (5-year)
- Up to $5M internal project costs (customization, testing, training, rollout)

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Efficiency/Savings

- $22M annually from streamgaging
  - From 2008 Committee on gage costs projecting 50% reduction in office processing time
- $8M annually from all data types
  - From 2011 Time-series processing future committee survey of selected USGS Water-Science Centers

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Quality-Assurance Practices

- Written National standards (T&Ms)
- Technical memos
- QA plans for each state and office
- Work/Check/Review cycle
- Standardized software and databases
- Hydrologic Instrumentation Facility for testing, procuring equipment
- National and regional training
- Technical reviews and ongoing records screening

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Published Standards of Practice

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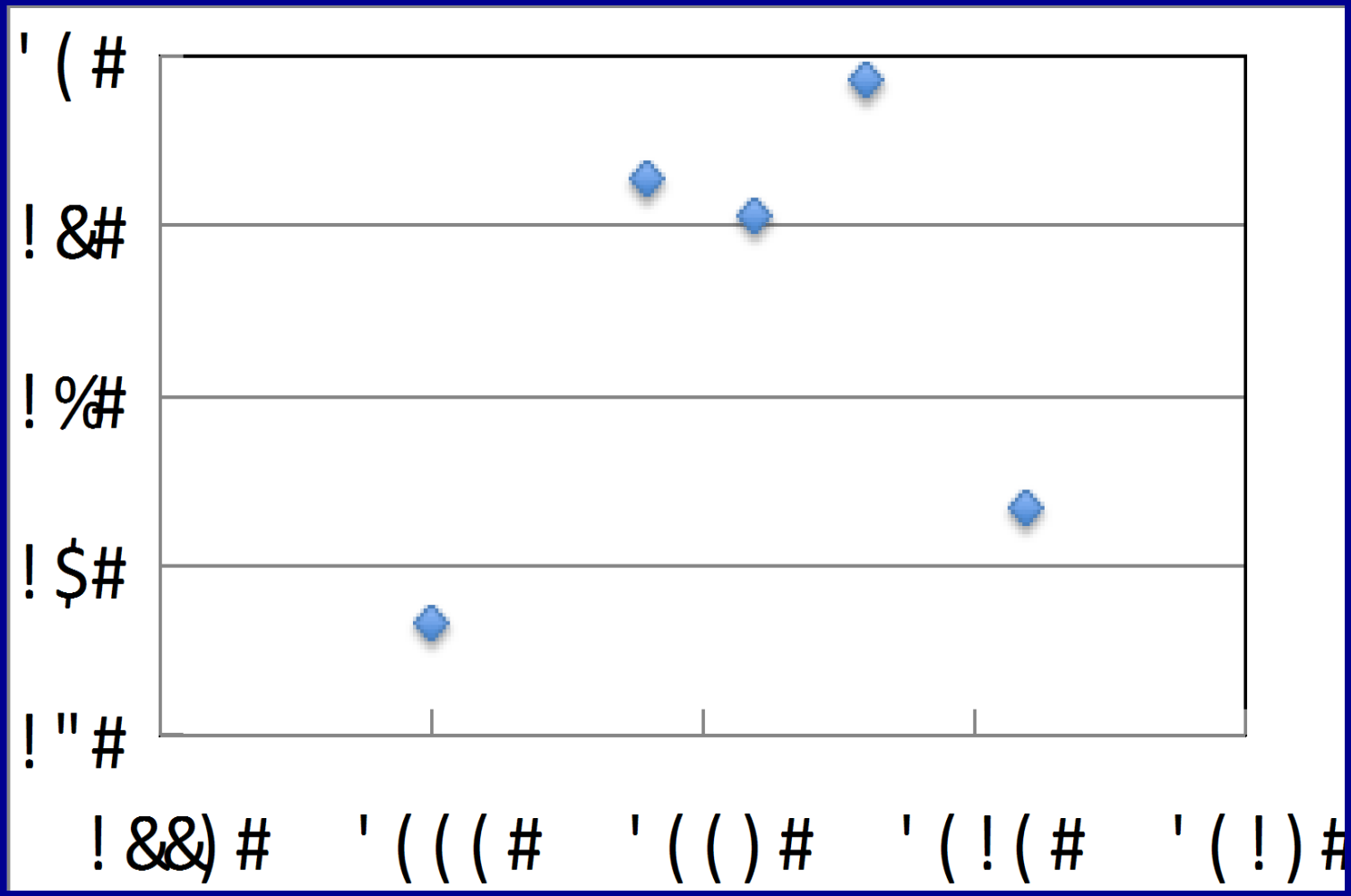
USGS HydoAcoustics Training

- Over 1,000 trained on basic ADCP use
  - Approx. 120 NEW users trained per year
  - Current course includes latest ADCPs (TRDI RiverRay and SonTek M9/S5)
- Developing material for two day local refresher class to help keep everyone up-to-date
- Scheduled webinars (since 2007)
- On Demand (new in 2011)
  - Video podcasts (short, focused)
- Hydroacoustics Forum (since 2008)
  - Online community for discussions/questions
  - Almost 1000 members

Change in Streamgage/FTE Workload



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Furnished Records

- About 8% of USGS streamflow records are furnished
- Mostly by CA FERC licensees, VA DEQ
- Current policy requires only that record be based on USGS standards and “indistinguishable” in quality from those of USGS

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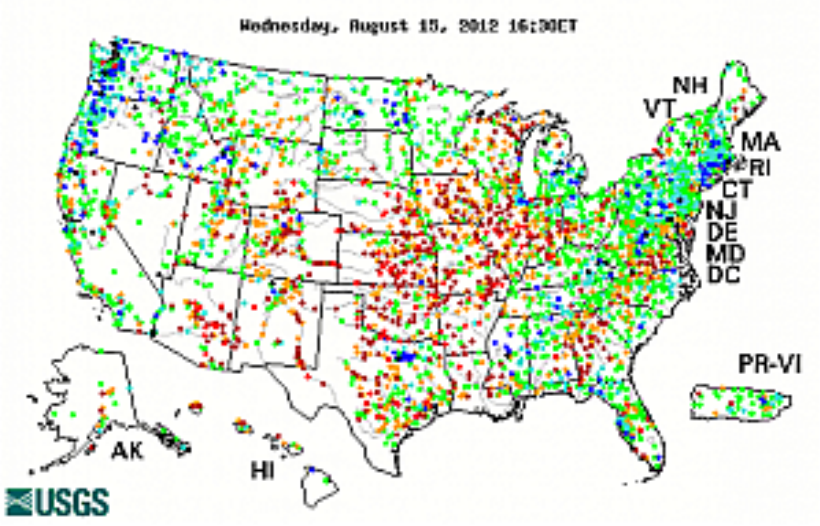
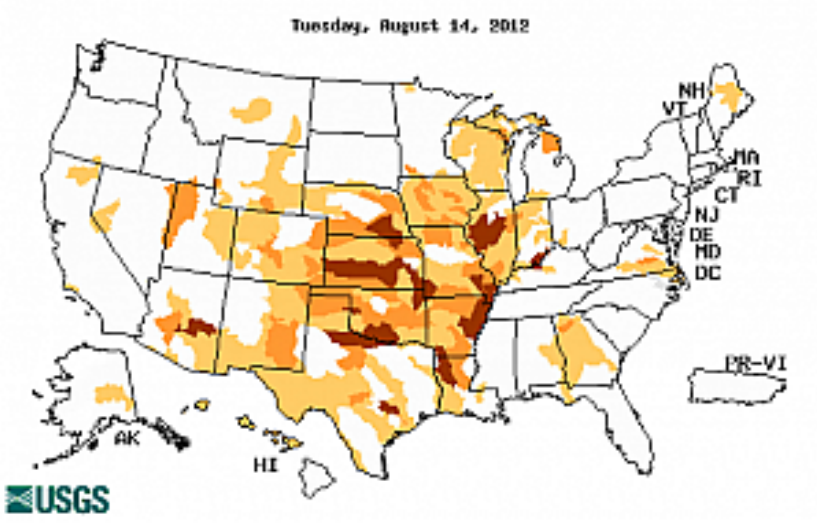
Delivering the Data -WaterWatch

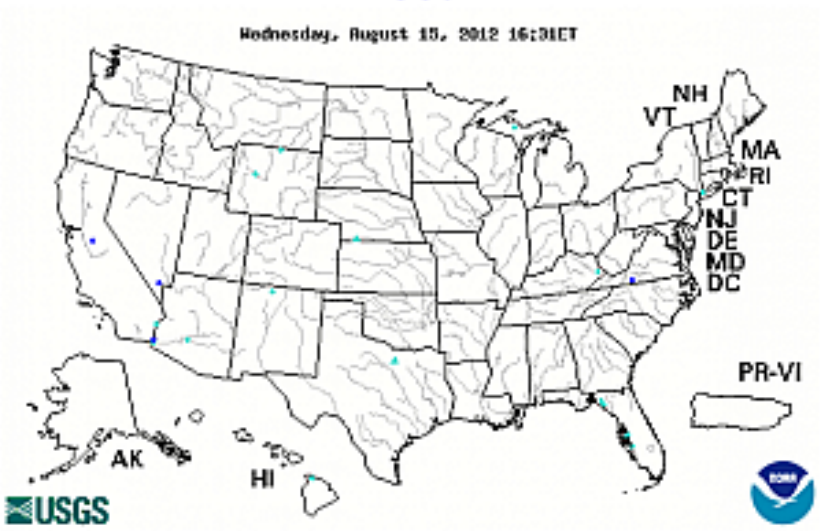
Current Streamflow



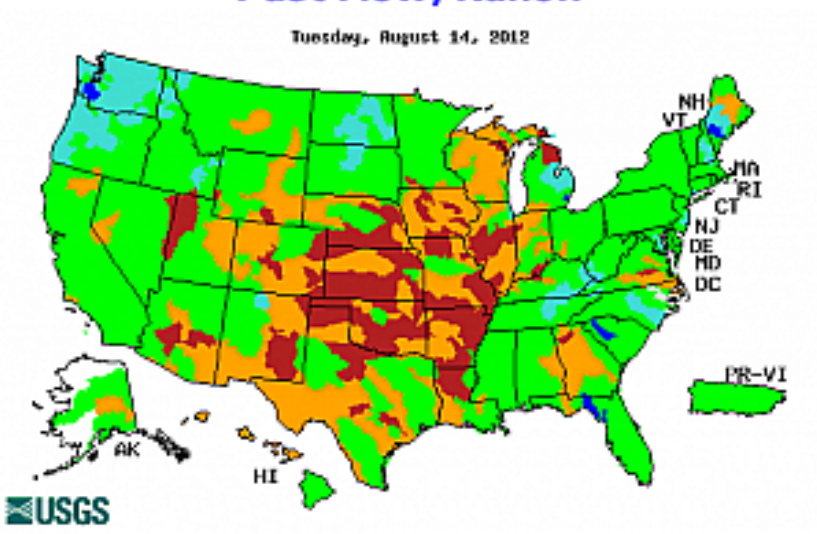
Drought



Flood

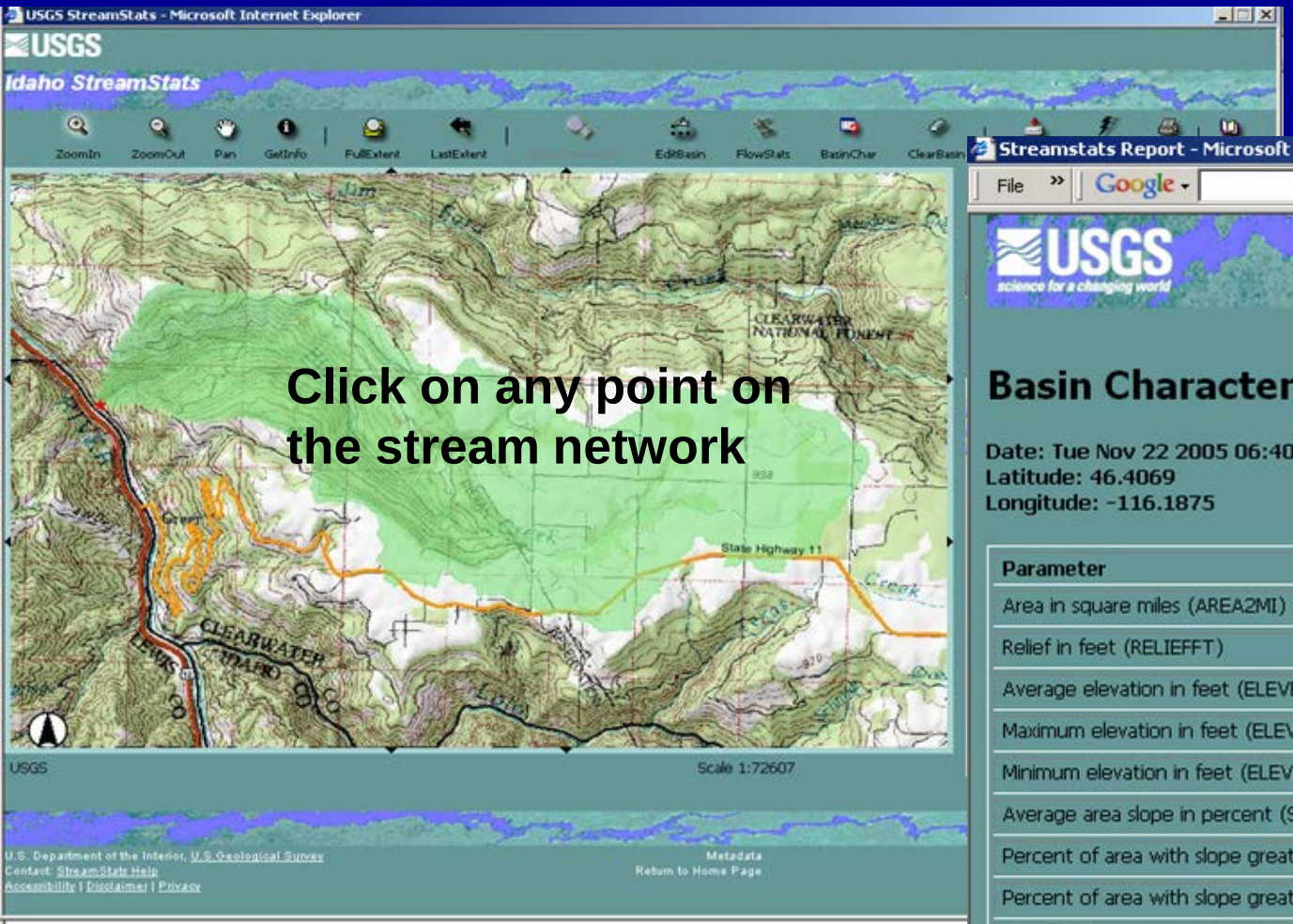


Past Flow/Runoff

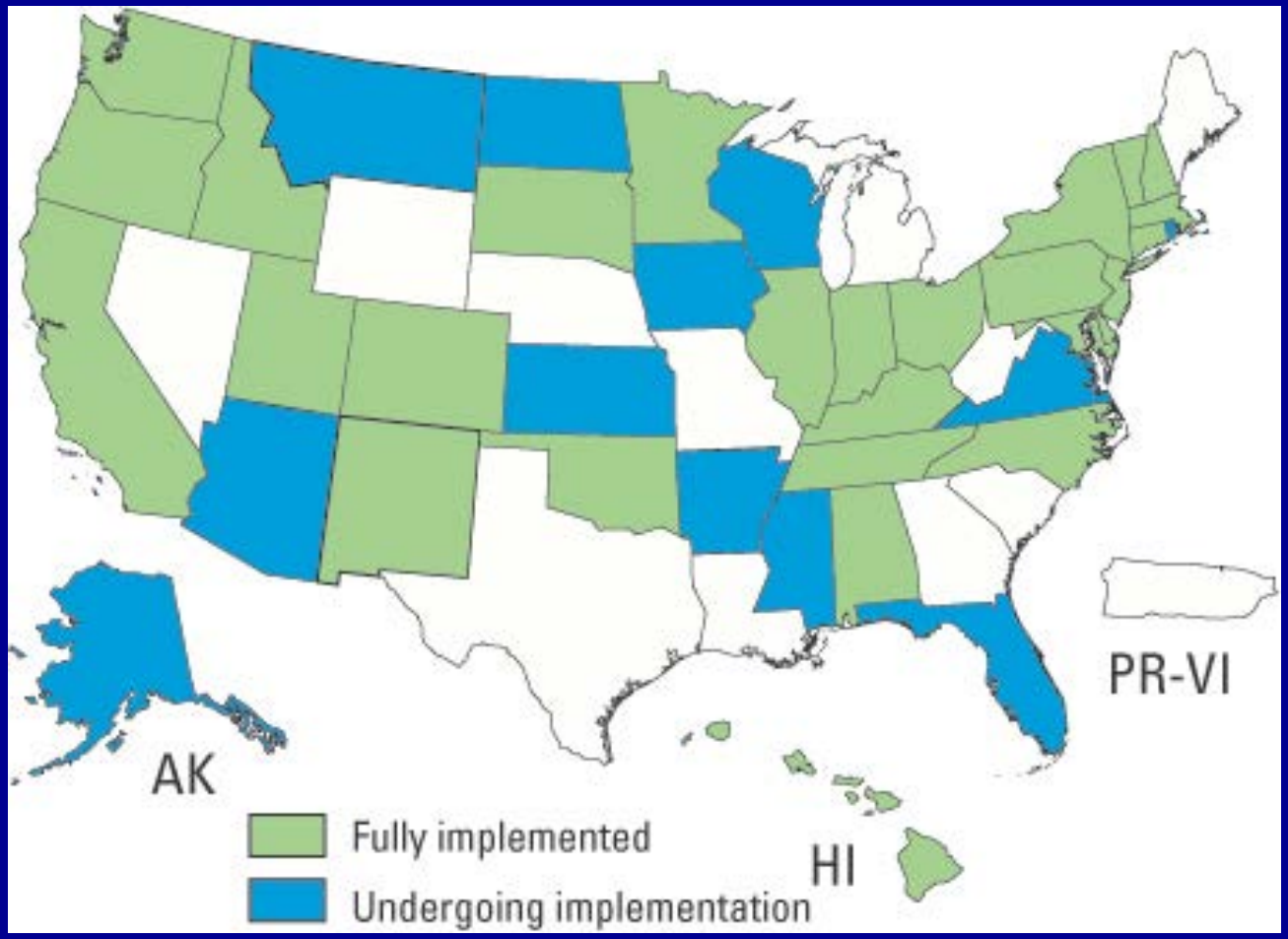


Delivering the Data -StreamStats

- Web-based application
- Provides GIS-piloting to site of interest
- Automatically measures basin and climatic characteristics using GIS
- Provides at-site streamflow statistics for gaged sites
- Solves regional regression equations to estimate statistics for ungaged sites
- GIS DEM and other measurement tools



StreamStats – Implementation Status



- 27 states fully implemented, including network navigation
- 10 states in implementation process
- SC and GA start in fall of 2012

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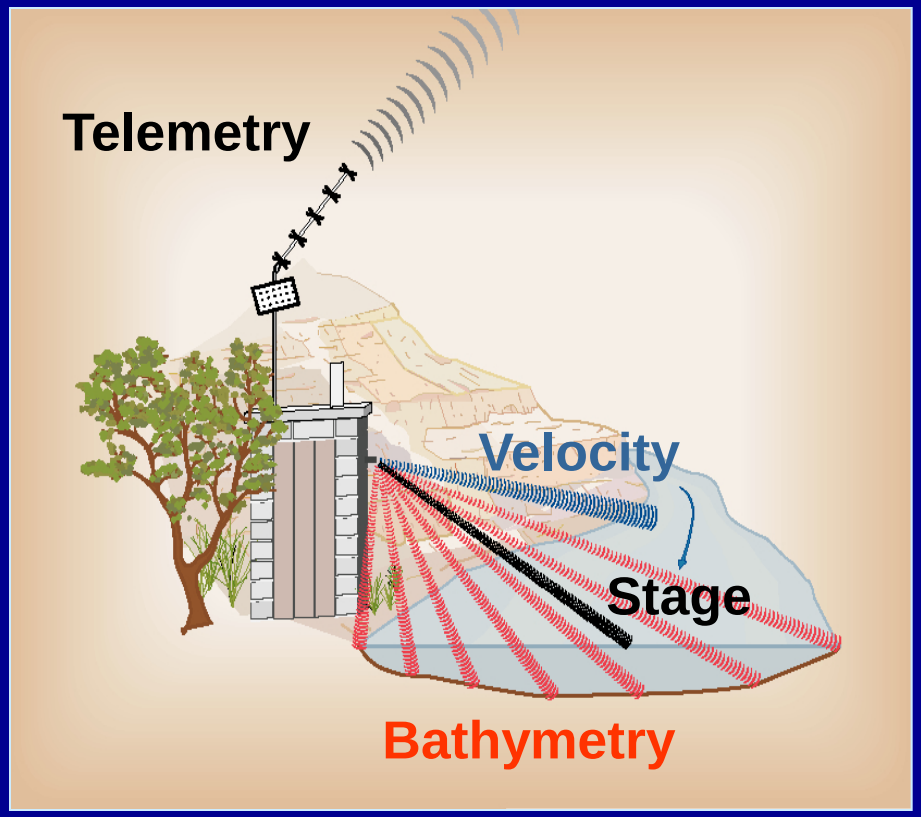
Measurement Method Improvements

The Future? - Non-Contact Radar-Derived Discharge



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Emerging Technologies

detectable signal whenever there is a surface heat flux, as is typically the case in streams and rivers (Webb & Zhang 1999), as well as extending the capability to night-time collections. This paper presents a summary of our efforts to exploit the IR signal for airborne current retrievals by modifying the original AROSS camera system (Dugan et al 2001a) to include a sensitive mid-wave IR camera.

IMAGING SYSTEM

Our current retrieval approach uses time series imagery from visible band and MWIR cameras mounted on a Twin Otter aircraft, a system called the Airborne Remote Optical Spotlight System (AROSS). The spotlight terminology indicates a capability to continuously point the cameras to a spot on the water, thereby obtaining a temporal sequence of image data. Image sequences
configurations, labeled AROSS-IR and AR
configuration consists of a dual camera system

Figure 4. Potomac River Currents. Current extractions are from 16x16m grid cells. A mosaic of 10 orbits is shown and the river is ~250-300 m wide.

either moored or towed by a small boat. An example of such a comparison on the Connecticut River is shown in Figure 3. The majority (68%) of individual current speed differences were within 10 cm/s. The RMS differences were 10.3 cm s^{-1} and 10° for speed and direction respectively with no significant bias. There were occasions during daylight hours when the emissive IR signature was not strong enough for current retrievals. However, we were consistently able to retrieve currents at nighttime except for a few very shallow (<2m) and slow moving locations.

Source: Steven Anderson, Cindy Piotrowski, John Duganr, Robert DiMarcor and Seth Zuckerma, 2011, “Airborne Passive Remote Sensing of Surface Currents in Rivers and Estuaries”

The Future?

- Continue to implement a “continuous records computations” process
- Develop new techniques for “continuous flow measurements”
- Automate first cut shift detection and analysis
- Improve data handling with better processing software
- Focus on interpretation/check/review
- Improve furnished records review and use
- Develop “network extension techniques”

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