Flash Flood Water Sampling in Remote Areas: Application of MiniSippers for Automated, High-Resolution, Long Duration Water Quality Monitoring during Extreme Events in Grand Canyon NP

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In 2012, the Department of Interior closed ~1 million acres of Federal land in the Grand Canyon watershed to new mining claims. USGS and other federal agencies tasked with researching the potential effects of uranium mining on the natural resources in the Grand Canyon National Park (GCNP) and surrounding areas. Both natural uranium sources and abandoned mine uranium sources are found in tributaries to the Colorado River in Grand Canyon NP.
Water sampling of potential U source tributaries to CO River in GCNP

- Episodic summer monsoon rains can lead to extreme flash floods in tributaries:
  - Kanab Creek can go from 5 cfs to >10,000 cfs in <60 minutes, 14’ depth change
  - Some of the highest sediment loads ever recorded by USGS (>1,000,000 mg/L sand)
  - Travertine (CaCO$_3$) precipitation clogs submerged instruments at Havasu & LCR
- Extremely difficult and expensive to access tributary sampling sites
  - 10-25 mile hike (one way), 5000’ vertical, dangerous in summer (110°F, no water)
- River: 18 day raft trip, 2 times a year, only ~10-12 hours work time at each site
- Cost: >$10,000 to get a single sample at each site (raft trip, equip, salaries, etc.)
- 2 WQ samples/year, rarely at sampling site during flash flood events
- Power is a problem: very limited solar recharge so need large batteries
Havasu Creek-July 11, 2018, 19:00
Flow = 75 cfs
Havasu Creek-July 11, 2018, 19:30
Flow = 3700 cfs
Water depth increase by 9 ft
Very turbid, high sediment water
How do we automatically collect water samples in Grand Canyon NP?

**ISCO Sampler**
- $4,500
- Reliable, easy to use
- 1000 mL samples (24)
- Out of stream
- **Can pull water up 25’**
- Large, Heavy
  - (>120 lbs)
  - not very portable
- Large batteries + solar
- Works well for sediment samples
- WQ samples:
  - No filtration
  - Acid preservation
- Can’t operate in freezing conditions

**MiniSipper**
- $2,000
- Not easy to use
- 5 mL samples (~240)
- Small, light, portable
- Runs 12 months
- Small batteries
- **Filters and acid preserve samples**
- Submerged, works in
  - Acidic water
  - Under ice
MiniSipper (mini segmented water sampler)

- ~240 5 mL samples (discrete, integrated, event trigger)
- Small (12” x 10”), lightweight, submerged (2-3’ max)
- Battery powered, for remote or difficult to access areas
- Samples separated by inert gas bubble, <5% carryover
- ICP-MS provides sub ppb detection of >50 elements
- 6-12 month deployments (operates under snow/ice)
- Low cost (~$2000), fewer site visits, lower field costs
- 10 μm inlet filter + 0.45 μm filter + acid preservation
- Excellent agreement grab samples (usually ± 10%)
- Not simple and easy to use, a lot of things can go wrong
- MiniSipper cost/sample ~10-200x less than grab sampling


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FlashFlood MiniSipper Modifications

- Place MiniSipper above expected flood stage
- Lift Pump pulls water through inlet filter and pumps up to MiniSipper
- Robust 7 stage inlet filtration
  - Handles high sediment events
- Initial MiniSipper deployments failed badly
  - Inlet and 0.45 μm capsule filters clogged
  - Sample trigger problems
  - Only discover failure 6 months later
ISCOs for long duration Water Quality sampling?
• 24 sample bottles can sit for 6 months
  • uncovered, unfiltered, un-acidified
• Experiments to evaluate evaporation losses
• Experiments to evaluate changes in chemistry

MiniSipper provides:
• ~240 samples (filtered and preserved)
• Able to capture multiple flash flood events
Havasu Creek-2016

Dry summer, only a few small flash flood events

Havasu Baseflow = 75 cfs
U ~ 3 μg/L
Se ~ 2 μg/L
As ~ 11 μg/L

Primarily seeing a dilution signal at Havasu during these 2016 events

Drinking water STD
U = 30 μg/L
Se = 50 μg/L
As = 10 μg/L
Kanab Creek-2016

Dry summer, only a few small flash flood events

Kanab Baseflow, 4 cfs
U = 4 μg/L
Se = 3 μg/L
As = <1 μg/L

Primarily seeing a dilution signal at Kanab during these 2016 events

Drinking water STD
U = 30 μg/L
Se = 50 μg/L
As = 10 μg/L
Little CO River (LCR) 2016

More monsoon storms than Kanab or Havasu with a few bigger events

LCR Baseflow ~200 cfs
U ~ 7 µg/L
Se ~2 µg/L
As ~3 µg/L

Drinking water STD
U = 30 µg/L
Se = 50 µg/L
As = 10 µg/L
Little CO River large dynamic watershed with numerous tributaries (some with abandoned mines, some without).

MiniSipper collected filtered and preserved 120 samples

Pulse on Oct 1 had high levels of U, Se and As

Pulse on Oct 3 had very low levels of Se and As

Drinking water STD
U = 30 µg/L
Se = 50 µg/L
As = 10 µg/L
CA-Post Wildfire MiniSippers
Flash Flood MiniSippers deployed mid Dec 2018 at Iron Mountain EPA Superfund site.
• Post wildfire acid mine drainage signal
Flash Flood MiniSippers deployed mid Dec 2018 at Camp Fire sites near Paradise, CA
• Post wildfire urban pollution signal
Not going well:
• Huge winter rains and flood events
• Much higher floods than predicted
• 4 MiniSippers flooded, 2 lost, 1 stolen
Lucky find: Iron Mtn Sipper, deployed 12+’ above baseflow. Washed 200m+ downstream & completely buried in sand

Flash Flood MiniSippers
- Provides low-cost, high-resolution, long duration water sampling
- Operates in remote and/or dangerous sampling areas
- Can handle very high sediment waters with massive inlet filtration
- Collect up to 240 5 mL 0.45 μm filtered and acid preserved samples
- Only used for metals so far (may work for organics, pesticides, or other pollutants)
- Rapid emergency response (wildfires, mine blowout (Gold King), big river floods? hurricanes?)
- MiniSipper cost/sample can be >100x less than grab sampling
- Questions?

Difficult sampling problem? Contact: tchapin@usgs.gov 303-236-5795