Monitoring and Responding to Flooding Applications Using Acoustic Instruments

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SonTek History

• Founded in 1992 in San Diego, California
• Manufacturer of acoustic Doppler current meters
• Our Products measure water speed and direction in various environments, including rivers/streams, pipes, and the ocean
FLOODING: Why monitor flow?

During a flood, we need to know discharge: how much water and how fast?

- for knowing when banks will overflow
- Warning systems for residents in area
- Wildlife/habitat impacts
- Information for containment/overflow systems downstream (reservoirs, catchments, storm drains, etc.)
1) Traditional stage-discharge relationships

2) Indexing versus traditional stage-discharge
   Improved accuracy of discharge in complex conditions (near tributaries, backwater/eddies, changes in vegetation/sediment)

3) Velocity leading stage, giving you time to respond
   Many flooding systems exhibit hysteresis
1) Stage-Discharge Relationships

(Hydrology 101)

‘Rating Curve’

(Marion Muste, 2013)
Assumptions:
- Steady flow
- Uniform flow

1) Stage-Discharge Relationships

- Used most widely at US gaging sites
- Cheapest, simplest to install, maintain, and process data

(Marion Muste, 2013)
1) Stage-Discharge Relationships

Requirements:

- Continuous stage measurement (stilling well/shaft encoder, radar/laser level, bubbler or pressure transducer, etc.)
- **Instantaneous** discharge measurements spanning a wide range of stages

FlowTracker2

(Marion Muste, 2013)
2) Using Acoustics and Velocity Indexing

**Complications:**
- Non-uniform flow
- Backwater and eddies
- Flashy events (flooding, storms, tidal cycles)
- Vegetation and tributaries
- Dams or other structures

Data from Site in Yuma, Arizona
Hurricane Irma (September 2017)

- Category 5, 185 MPH maximum winds
- 134 lives lost
- Extensive flooding
2) Using Acoustics and Velocity Indexing

Data from Kissimmee, Florida during Hurricane Irma

Located near Good Samaritan Retirement Community, where many elderly residents struggled to evacuate and save their homes.
2) Using Acoustics and Velocity Indexing

Data from Kissimmee, Florida during Hurricane Irma
2) Using Acoustics and Velocity Indexing

Data from Kissimmee, Florida during Hurricane Irma

BEFORE

AFTER

RiverSurveyor M9 Measurements
2) Using Acoustics and Velocity Indexing

Data from Kissimmee, Florida during Hurricane Irma
2) Using Acoustics and Velocity Indexing

SonTek systems **measure** velocity and depth, then **calculate** area, flow/discharge, and total volume.
2) Using Acoustics and Velocity Indexing

• Requires direct measurements of velocity, discharge, area, and stage
• Greater accuracy at complex sites
• Measures channel geometry and velocity very precisely

\[ Q = v \times A \]

“Instantaneous” discharge measurement

“Continuous” discharge measurement

“FlowPack” velocity indexing software
Hysteresis often occurs during flooding.

What is hysteresis?

(Marion Muste, 2013)
3) Velocity Leading Stage - Hysteresis

- Nashville, TN
- Historic flooding event in 2010 (peaked at 59ft!)

- Operated in Cooperation with the USACE
- Side-looking instruments mounted to bridge pilons
3) Velocity Leading Stage - Hysteresis

Flood Data – Nashville, TN (USGS)

Peak 1:
V: 5/3 1:45
S: 5/3 12:30
Delta: ~12 hrs

[Graph showing stage and velocity data with highlighted peak and time differences]
3) Velocity Leading Stage - Hysteresis

- Texas Flooding 2006 (Lower Neches Valley)
- Long-range, low-frequency side-looker (500kHz)
- Cell Begin 10ft / Cell End 240ft
- Tidally influenced
- Upstream diversions for municipal use, flow regulated by reservoir upstream
3) Velocity Leading Stage - Hysteresis

Flood Lower Neches Valley - Texas (USGS)

Peak 1:
V: 10/19 6:15
S: 10/22 11:30
Delta: 2.5 days
3) Velocity Leading Stage - Hysteresis

**Velocity data:**
- Measure flow directly – most accurate
- can be valuable early-warning parameter in flooding events

Peak 1:
- V: 10/19 6:15
- S: 10/22 11:30
- Delta: 2.5 days

Flood Lower Neches Valley - Texas (USGS)
3) Velocity Leading Stage - Hysteresis

More accurate flood stage peaks levels and timing
Summary: Methods for Measuring Discharge During Flooding

1) Traditional stage-discharge relationships
   • Simplest, cheapest solution
   • Won’t give most accurate results all the time, especially during flooding events

2) Indexing versus traditional stage-discharge
   • More involved measurements and data processing
   • Get more accurate results during flooding events

3) Velocity leading stage, giving you time to respond
   • Velocity data can provide real-time accurate discharge during big events
   • Due to hysteresis during a flood, velocity peak leads stage, and can be used as early warning indicator
Thank you for listening. Questions?

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