50 Years of Watershed Modeling

Critical Gaps in Operational Watershed Modeling (or, more aptly, ***Potpourri***)

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Outline

- Who am I?
- Observations on modeling, based on my experiences
  - Simple models can be very useful.
  - Complex, models can also be useful, often leave out critical features and processes.
- Monitoring-based compliance (TMDL)
- Floodplain management

Who Am I?

- Use models in teaching, research, and public service
- Have conducted many investigations of small watersheds, mostly in Wisconsin.
- Have participated in NRC studies on the Everglades, Katrina, and the American River
- Prepared this talk after hearing all of the previous talks

Examples of Good Simple Models

- TR-55
  - Used to design storage required to reduce post-development to pre-development levels for events of prescribed recurrence intervals
  - Based on runoff “curve number”
  - In its most *appropriate* use, it is a quantile-quantile model, not a model of actual events.
  - It would be nice, however, to see some testing of the method.

Examples of Good Simple Models

- WinSLAMM
  - Empirical model of non-point pollution (with physically-based modeling of mitigation practices)
  - Very effective for planning and design
- SNAP+
  - Empirical model of average annual phosphorus delivery from a farm field based on soil phosphorus, soil type, slope, and detailed information on crops and management practices
  - Can easily be used by individual farmers

Advantages of Simple Empirical Models

- Easy to use
- Based on extensive local data
- Developers known and trusted

Research questions:

– How do stakeholders evaluate models?

Details that Challenge Watershed Modeling
(and must be considered in a national model)

- Closed watersheds
- Discordant surface and ground water drainage divides
- Perched water tables
- Sediment/phosphorus transport
- Impervious surfaces
- Urban soils

Closed Watersheds

- Ubiquitous in glaciated regions
- Most runoff does not leave watershed, except in very wet years
- DEMs commonly eliminate them
- Landowners often drain, either temporarily or permanently
- Hence require careful field checking

Groundwater Divides

- In areas of modest topographic relief, surface and ground water divides may not correspond.
- Can be due to closed depressions, where P-ET becomes recharge
- Can also occur in areas that don't have closed depressions
- For a 10 km^2 watershed, can account for 50% of annual baseflow.

Perched Water Tables

- In the Driftless Area of WI, IA, MN, and IL, high springs are fed by groundwater perched on a clay derived from the dolomite that supports the ridge tops.
- Streams with drainage areas of 10 km^2 can have mean unit area baseflows greater than those of the larger stream into which they flow.

Sediment/Phosphorus Transport-Channel Storage

- Monitored sediment and phosphorus upstream and downstream of a flat stream reach running through a small wetland for one runoff season (Mar.-Sept).

Sediment/Phosphorus Transport-Channel Storage

- For 7 of 10 storms, there was very little sediment transport in or out of the reach.
- For the 3 largest events, there was more than twice as much sediment leaving the reach as entered.
- Discrepancy due to temporary sediment storage in the channel

Sediment/Phosphorus Transport-Channel Storage

- For the runoff season, the channel and wetland sequestered 30% of the dissolved phosphorus.
- But 34% more sediment-bound phosphorus left the wetland than entered.

Channel Avulsion- Dorn Creek Wetland

- Wetland just above Lake Mendota
- In the very wet 1993 the stream changed course due to backwater from the lake.

Channel Avulsion- Dorn Creek Wetland

- The channel flowed into a linear excavation and sheet flowed back to the main channel.
- In the sheet flow area, most of the sediment and phosphorus has been trapped for the past 19 years.
- But this is only temporary, as a new channel is forming.

Urban Areas

- The connectivity of impervious surfaces to drainage conveyances is not easily quantified.
- Available soil data bears little resemblance to the actual soil conditions, given modern construction practices.

Monitoring-based Compliance

- TMDL for phosphorus in Rock River (WI)
- Allocation process was not done well:
  - Limited stakeholder participation in urban areas
  - Large uncertainties in modeling
  - Municipalities would need to construct expensive, but inefficient practices.
  - Contested by municipalities, with no formal response (Lawsuit potential!)
  - Ag is major source, but requires cost-sharing

Monitoring-based Compliance

- Nutrient trading is an obvious solution, but historically not effective due to high trading coefficients.
- With EPA approval, the DNR authorized an "adaptive watershed management" approach.
- Compliance to be based on monitoring
- MMSD taking lead, beginning with a pilot project
- *Adaptation to policy implementation*

Floodplain Management: Can Policy Adapt?

- Current national floodplain policy was developed when watershed modeling and statistical hydrology was in its infancy.
- As a result we have levees built to provide 100-year protection. (Much too low!)
- Those behind levees are generally unaware of their high risks and do not have insurance.

Floodplain Management: Can Policy Adapt?

- Any degradation in levee protection puts these folks in the regulatory floodplain, and subject to its requirements.
- Hurricane Katrina resulted in much greater scrutiny of levee integrity, resulting in decertification of many major levee systems.
- This resulted in political protests!

Floodplain Management: Can Policy Adapt?

- But we currently have the modeling capacity to support a fully risk-based approach that would enable setting actuarially based rates that account for uncertainty for areas vulnerable to up to the 500-year event.
- Will this capacity drive changes in national floodplain management policy?

Has federal environmental policy ever changed as a result of scientific and technological innovations?

(For TMDLs, federal policy was far ahead of scientific and technological capacity)

Lagniappe

CUAHSI Survey on Science and Practice

- As Rick Hooper pointed out, CUAHSI is very interested in the use of hydrologic innovations in practice.
- One activity is a national survey of water professionals and scientists.
- The survey will be announced in the October AWRA email newsletter.
- Please participate!

C' est too!

Laissez les bons temps rouler!