Environmental Flow: Linking Water Use and Flow-Ecology Response Relations

Mid-Atlantic Water-Use Workshop

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USGS DE-MD Water Science Center

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Presentation Overview

- Introduction — Environmental Flows
- Hydroecological Integrity Assessment Process (HIP)
- Example — Why Incorporating Water Use information is essential
- Future directions

Human Water Use and Environmental Flows (eFlows) are Intimately Connected

- Brisbane Declaration recognized this…

  eFlows = the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihood and well-being that depend on these ecosystems.

- Growing societal interest in eflows

- http://www.riverfoundation.org.au/

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Global eFlow Efforts

- NGO's --The Nature Conservancy, World Wildlife Fund
- Government's -- EU Water Framework Directive, Australia, South Africa, Tanzania, Vietnam, China, Colombia
- US -- Arizona, Colorado, Connecticut, Georgia, Maine, Massachusetts, Michigan, Missouri, New Jersey, Oklahoma, Pennsylvania, Texas, Virginia, Washington , Mississippi River Basin

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Implementation Challenge

- Regulatory authority over water *quantity* issues as they relate to Clean Water Act authority
- Need supporting science
  - We know:
    - Flow variability influences ecological process and pattern
      - Flow-ecology relations
    - Flow alteration induces ecological change
      - Quantitative relations

  - We also know …

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- Multiple Stressors influence ecological condition
- "Noisy" flow alteration – ecological response relations are the norm
- Need creative approaches
- **Challenge: How to develop "simple" models that account for human WU and supports regulatory implementation?**

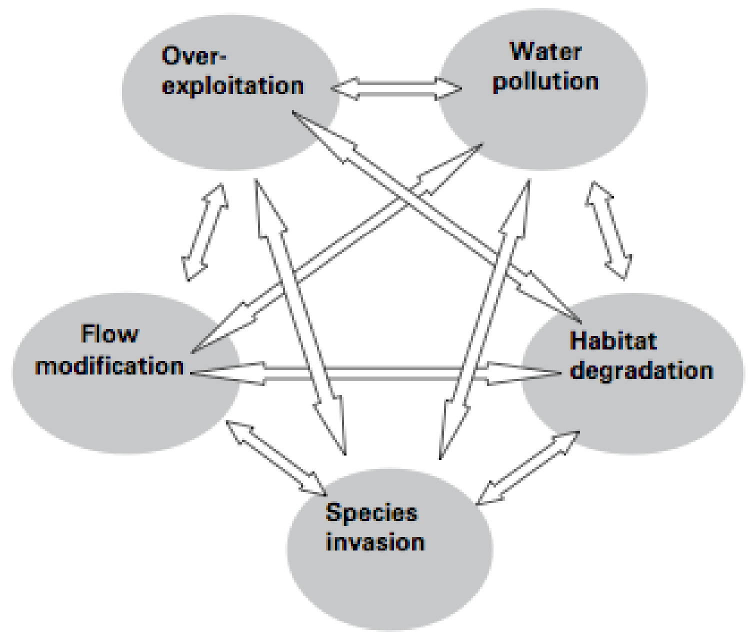

Fig. 1. The five major threat categories and their established or potential interactive impacts on freshwater biodiversity. Environmental changes occurring at the global scale, such as nitrogen deposition, warming, and shifts in precipitation and runoff patterns, are superimposed upon all of these threat categories.

Dudgeon et al., 2006

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Flow variability and the vitality of rivers

- Flow variability shapes the physical, chemical and biological attributes and functioning of riverine systems
  - Channel form and habitat complexity
  - Life-history patterns
  - Lateral and longitudinal connectivity
  - Resistance to species invasions

- At the same time, human societies modify natural flow regimes to provide dependable ecological services and to seek protection from floods and droughts

Major hurdles to linking ecological responses to riverine hydrology

Devising <u>testable hypotheses</u> from general principles

Informing decision <u>support tools</u>

Generating <u>simple models</u> that are realistic, mechanistic and defendable

Accounting for <u>human water use</u>

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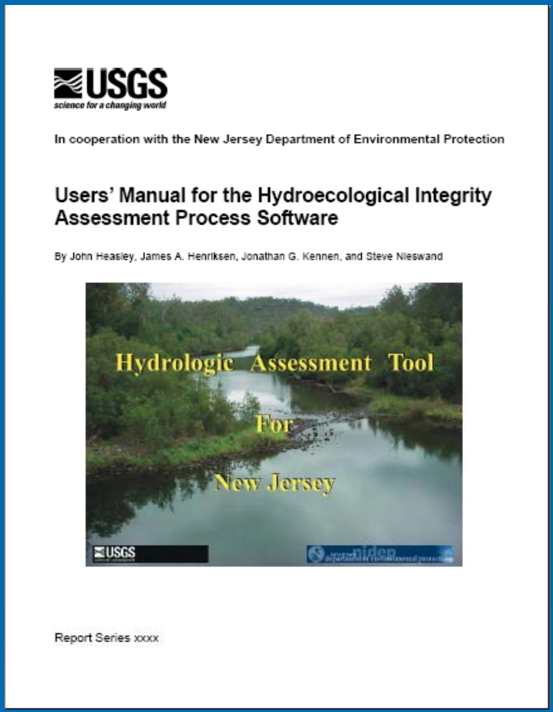
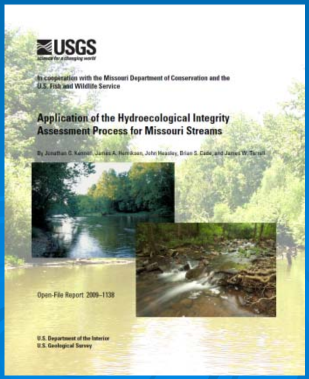
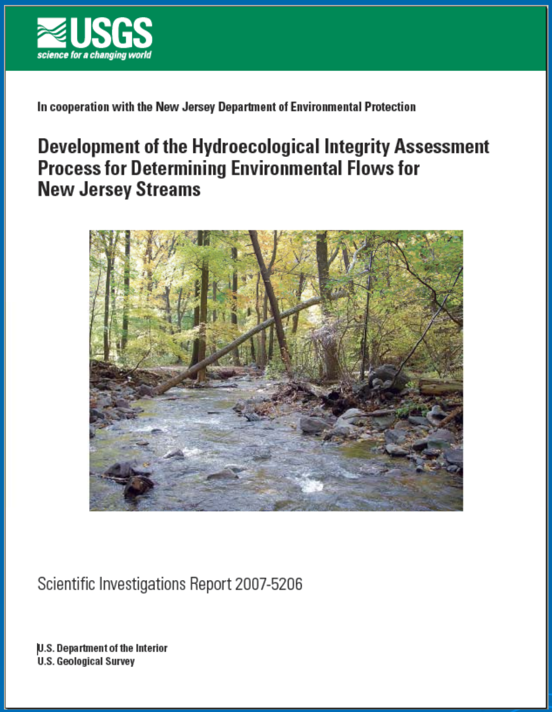
Hydroecological Integrity Assessment Process (HIP)



- ➢http://www.fort.usgs.gov/HIP/

- USGS WRD / BRD-developed HIP as a method to determine the minimum streamflow needed to adequately protect aquatic biota
- Developed in NJ and is currently being applied in several other states, e.g., MO, MA, TX, .





- ➢http://pubs.usgs.gov/sir/2007/5206/

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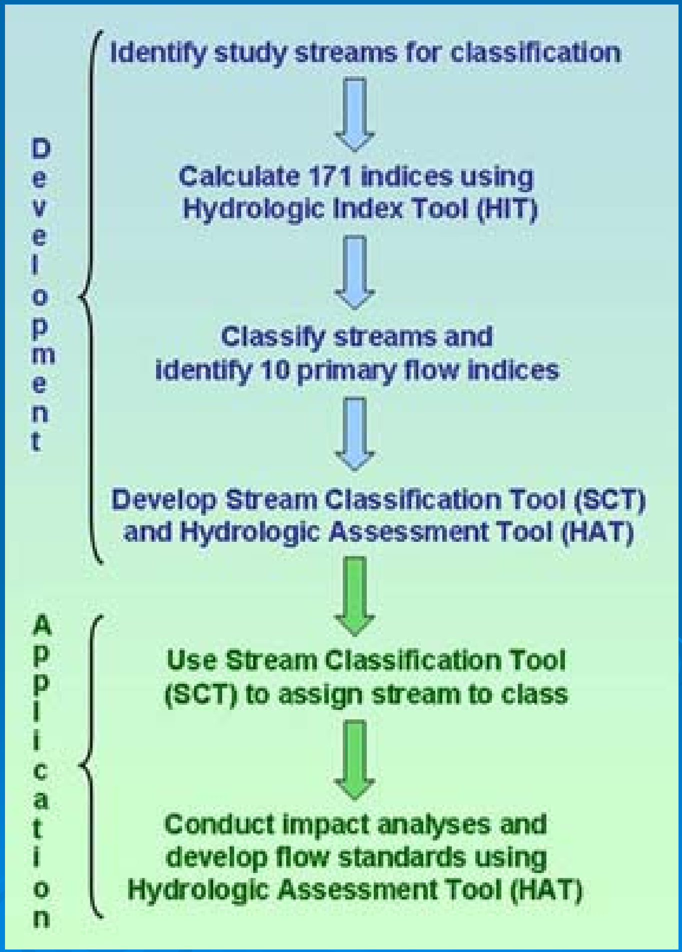
Hydroecological Integrity Assessment Process (HIP)

Process relies on three primary software tools:

- HIT –Hydrologic Index Tool
- SCT –Stream Classification Tool
- NJHAT –New Jersey Hydrologic Assessment Tool



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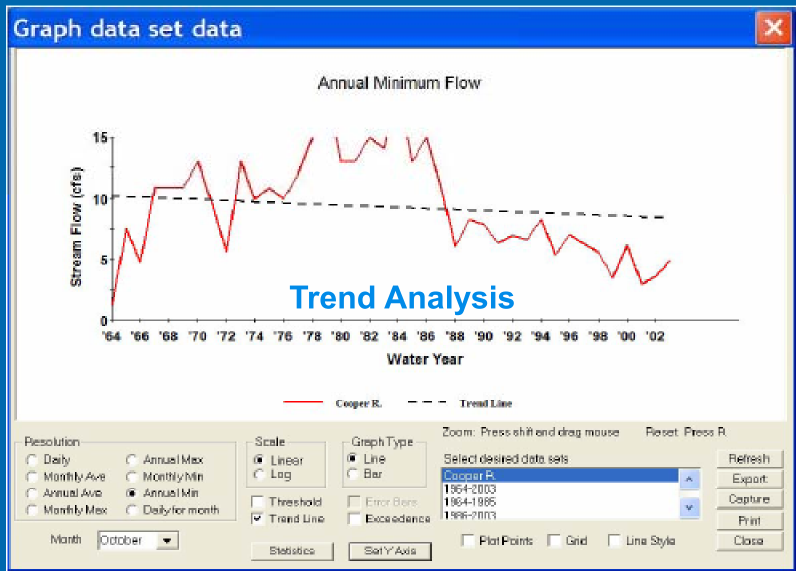
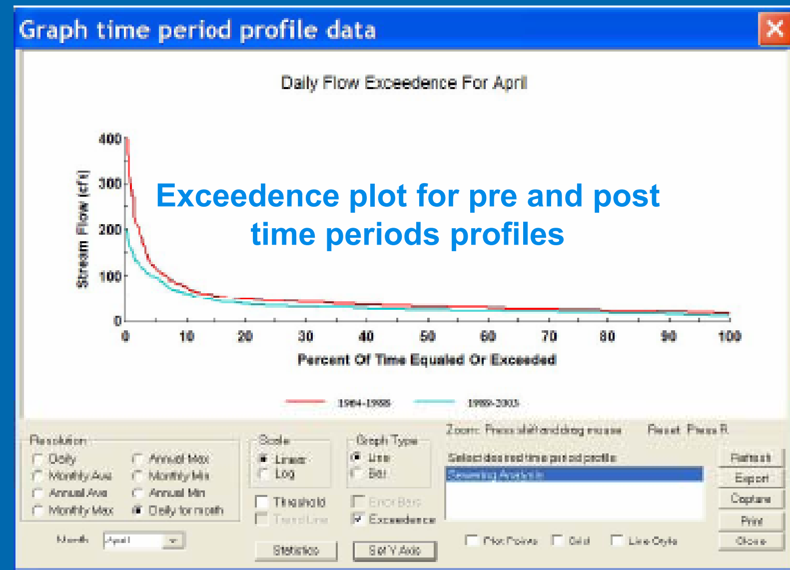
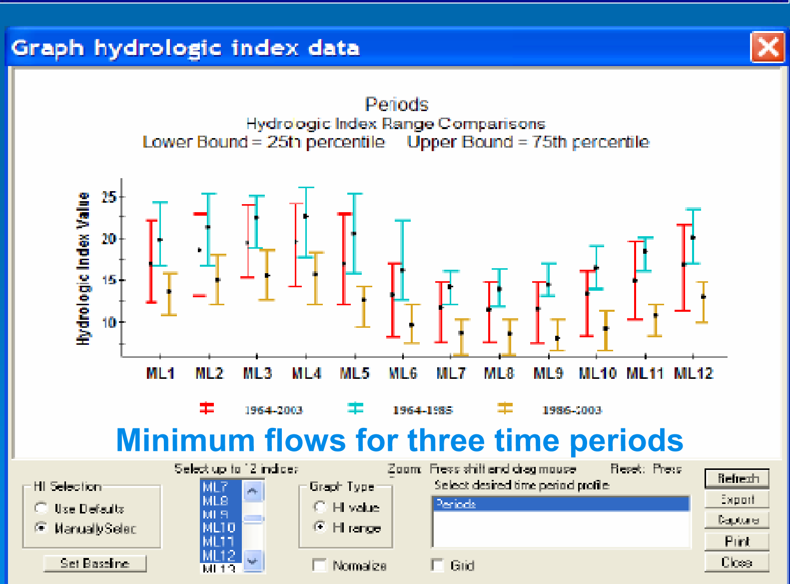
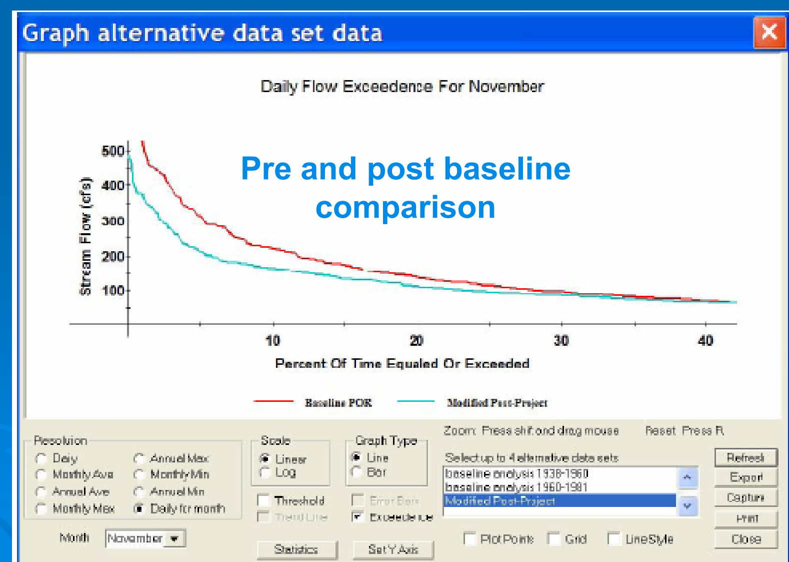
NJHAT Analysis Tools









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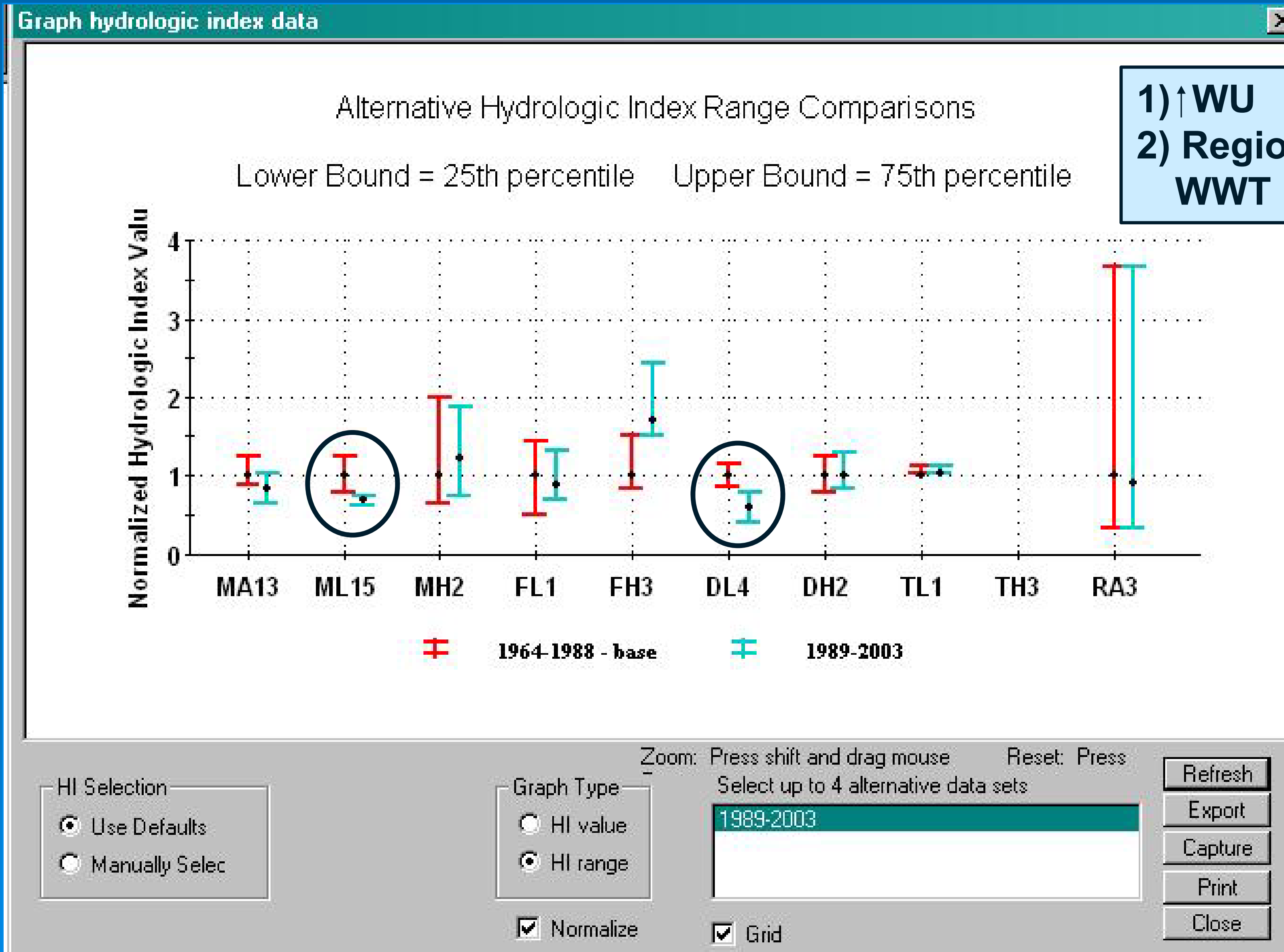
Cooper River



1) ↑WU
2) Regionalized WWT

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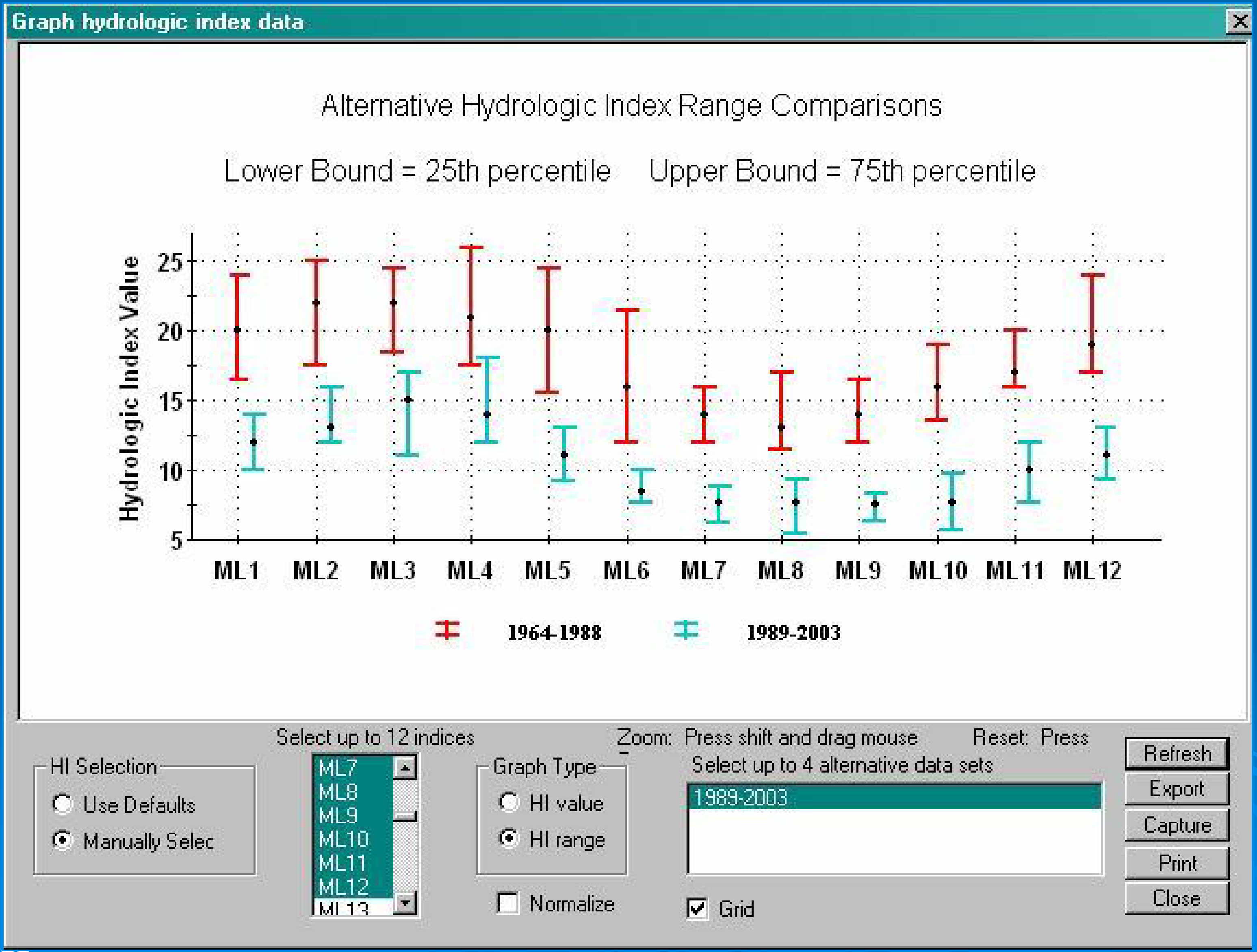
Cooper River



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Recent Application of the HIP Approach

- NJ Pinelands -- Evaluating natural and human-induced changes in stream flow regime on fish and aquatic invertebrate assemblages in the New Jersey Pinelands.
- Primary Question -- Can we evaluate ecosystem response to hydrologic stress based on water use scenarios and develop simple statistical models that can be used in a management context?

(Poff et al. 1997)

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Kirkwood-Cohansey Project

A hydroecological investigation in the New Jersey Pinelands

New Jersey Pinelands Commission

U.S. Geological Survey

Rutgers University

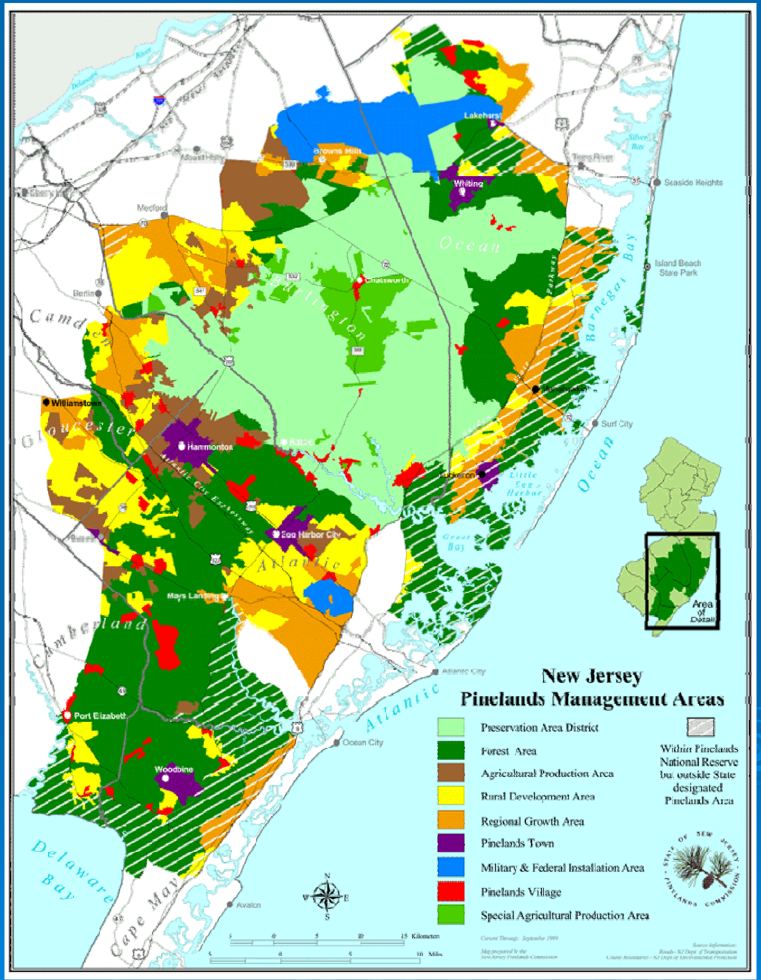
U.S. Fish and Wildlife Service

NJ Department of Environmental Protection

Problem

- Human demand for water from the aquifer system is increasing as planned growth occurs within & around the Pinelands area

- The effects of changes in ground water use on the ecology of the Pinelands are poorly understood



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Legislation

P.L. 2001, ch. 165 directs named partners to:

"assess and prepare a report on the key hydrologic and ecological information necessary to determine how the current and future water supply needs within the Pinelands area may be met while protecting the Kirkwood-Cohansey aquifer system and while avoiding any adverse ecological impact on the Pinelands area."

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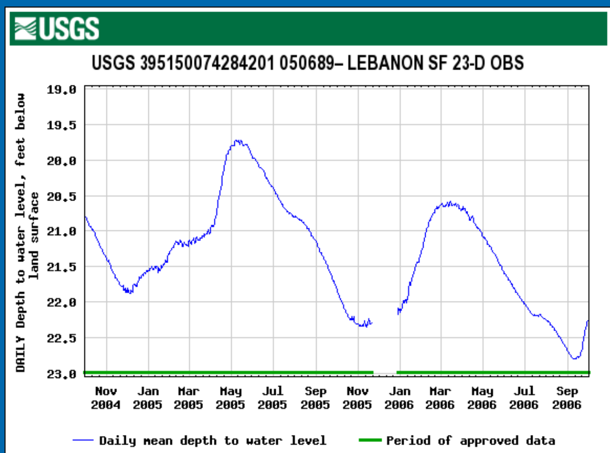
Hydrologic Assessment / Infrastructure

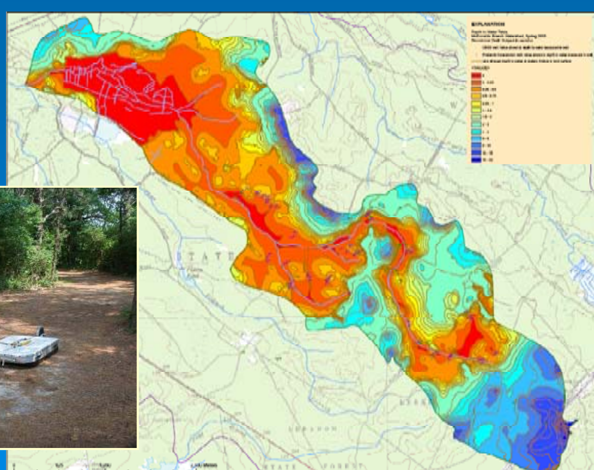
Depth of water

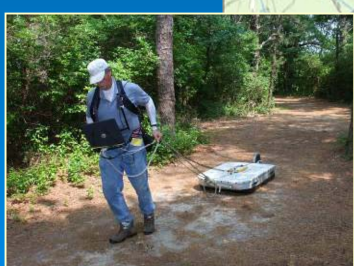


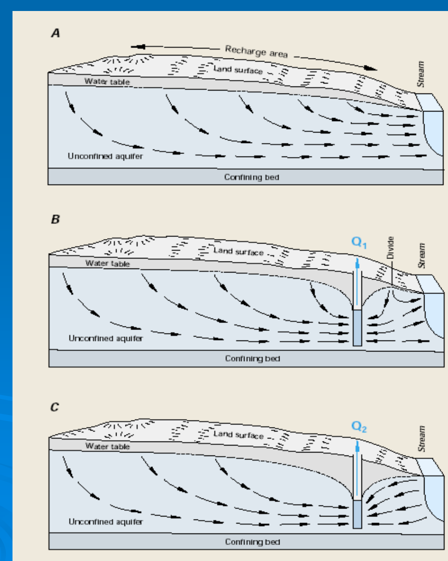
Water Budget

Stream Gaging

Water-level maps







Wetland/ aquifer interactions

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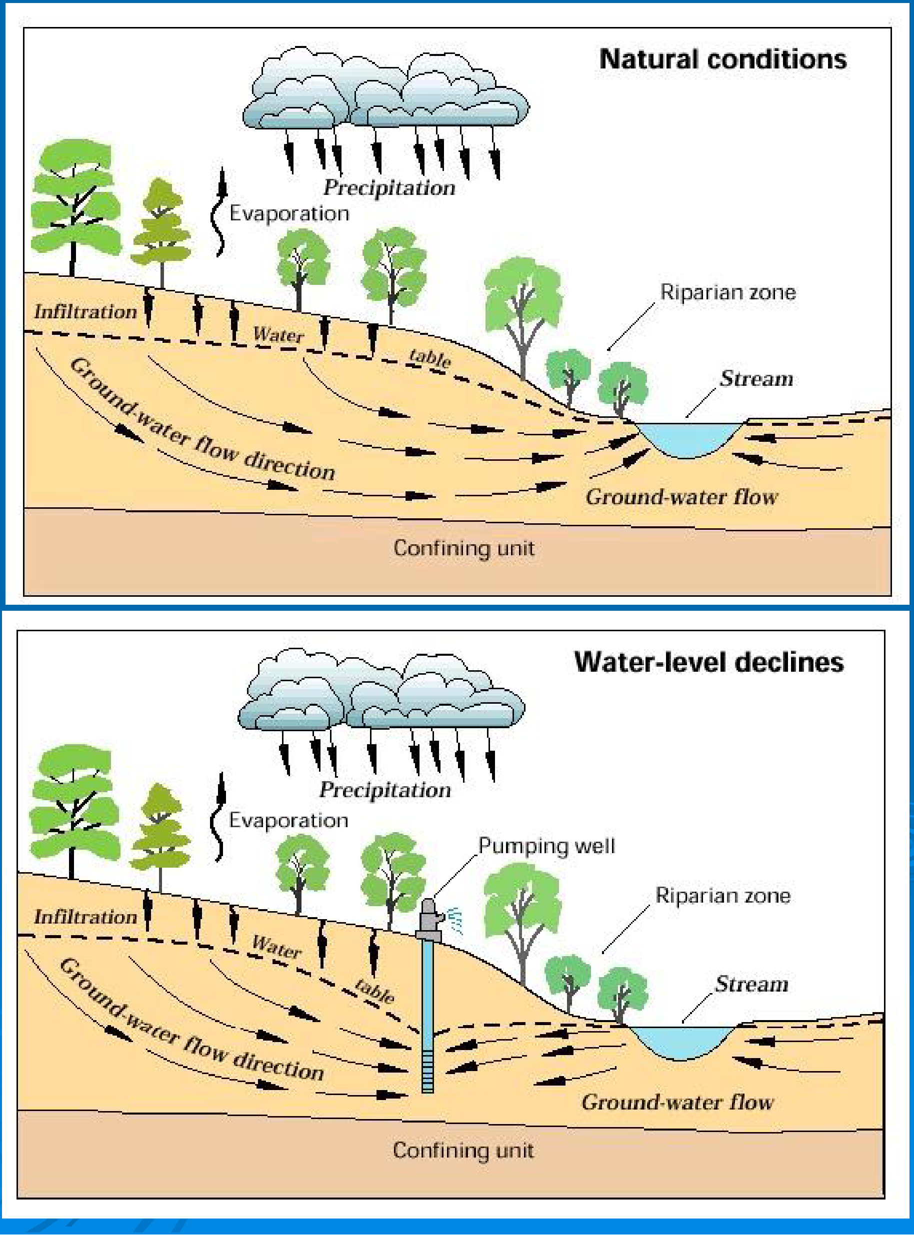
Human Water Use – GW Pumping

- Pumping lowers the water table in the surrounding area, including wetlands
- Drawdown magnitude and extent are concerns
- Pumping for human use will also divert discharge or induce changes in flow.



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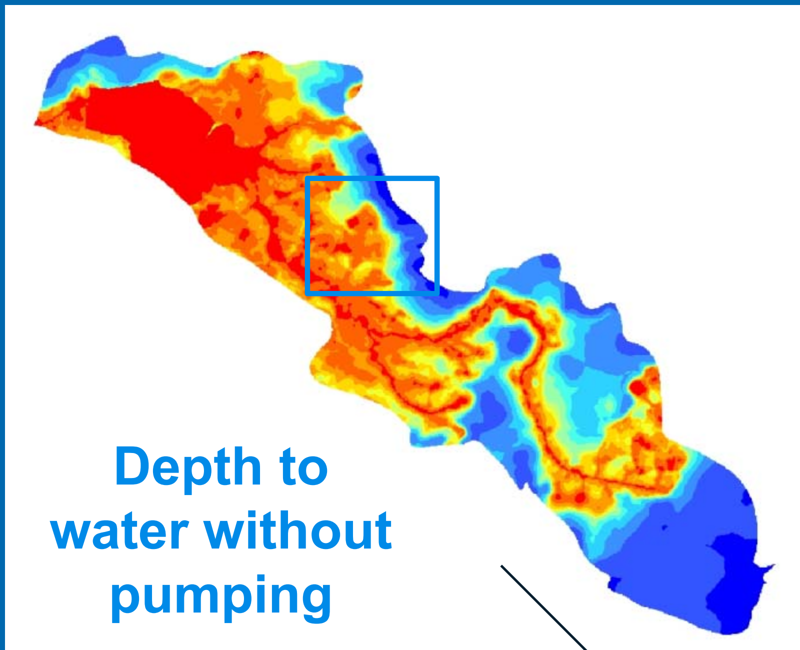
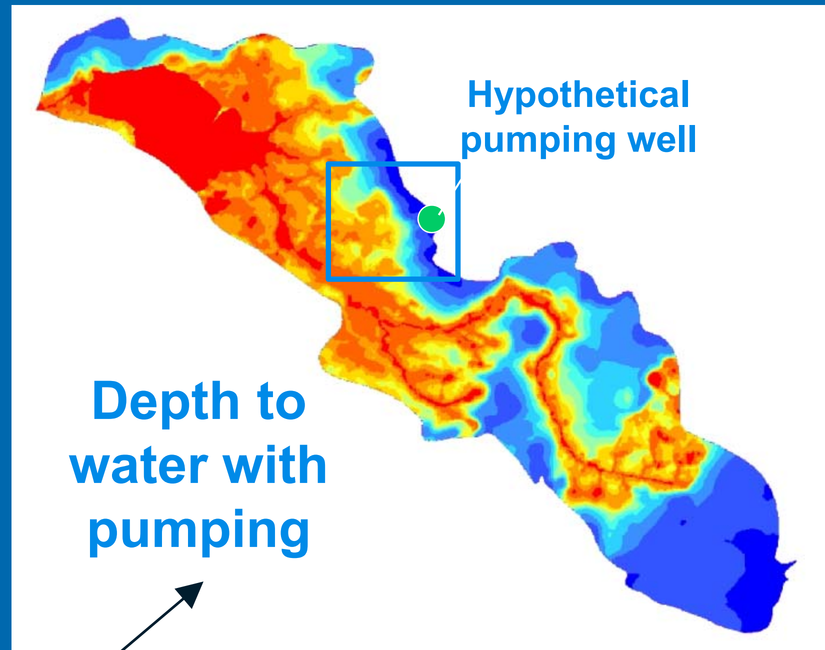
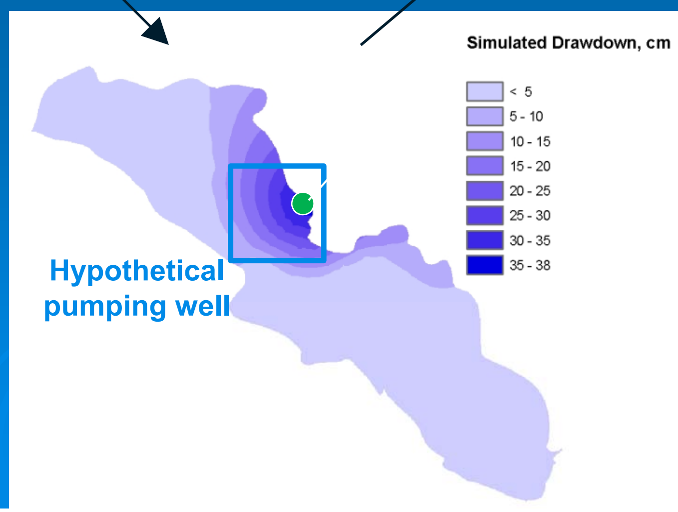
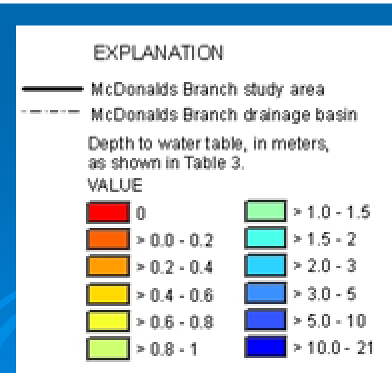
Simulate Changes in Depth to Water Table









Example: McDonalds Branch

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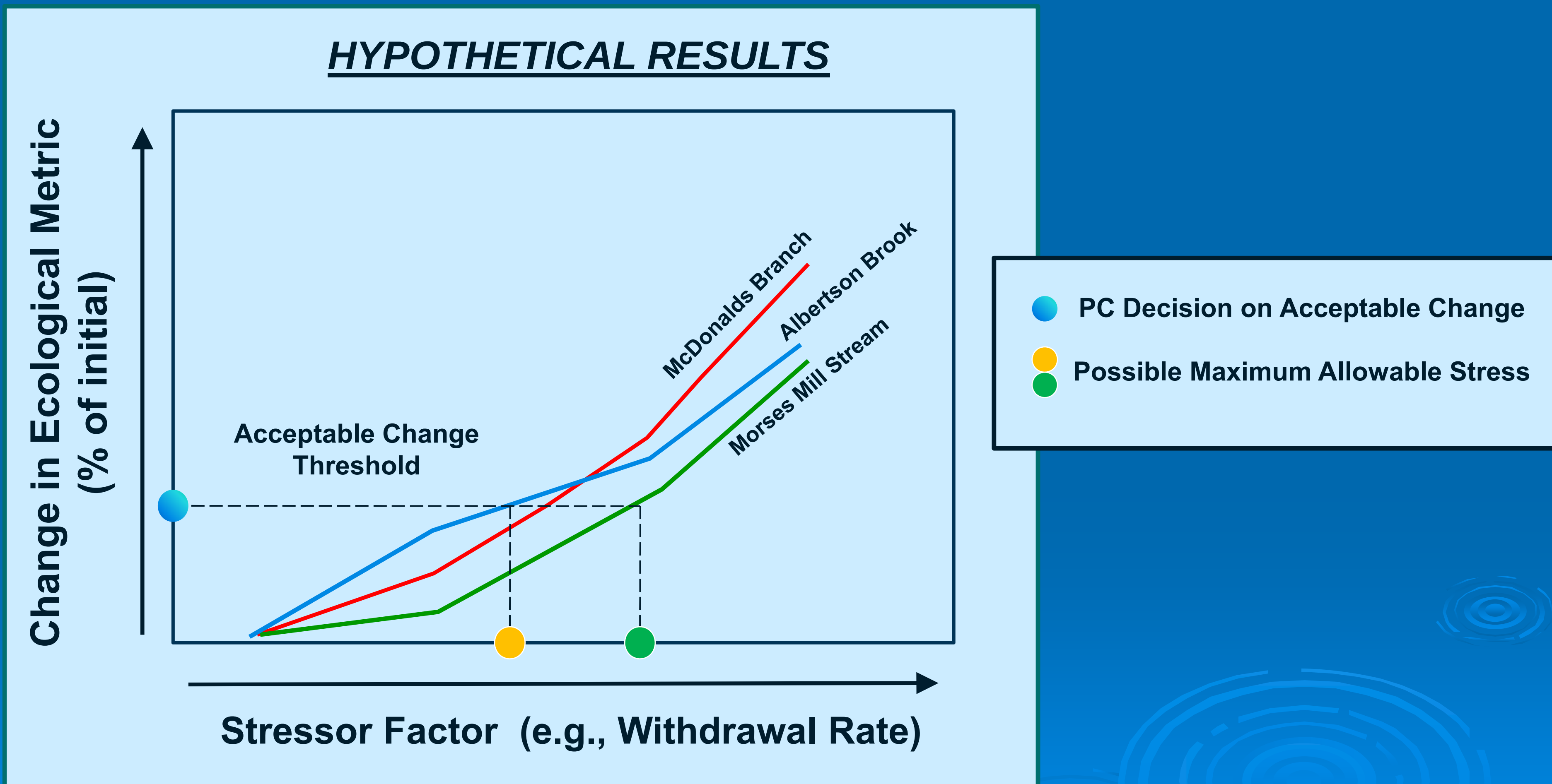
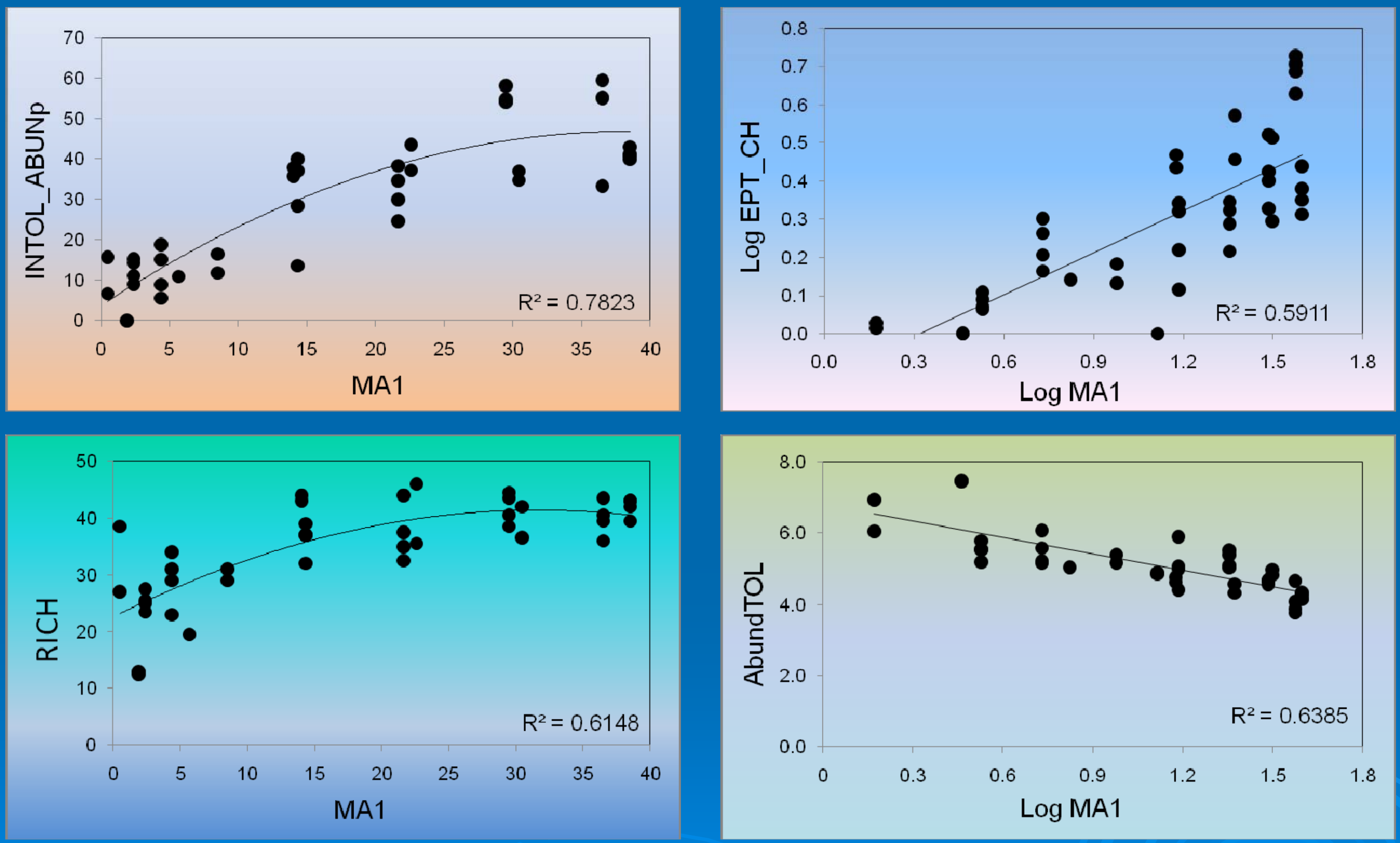
Invertebrate & Fish Assessments

- Comprehensive aquatic invertebrate sampling – mod. MACS Protocol
- Electrofished & seined100 m sampling reaches.
  - High & low flow periods
  - Identified to species, TL, Wt.
- Water Quality and Staff measurements
- Habitat assessment (stream and riparian)

Generalized Application

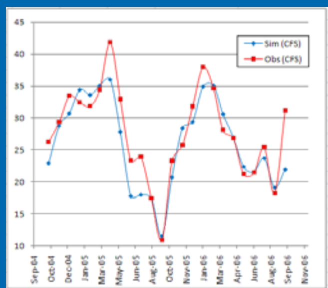


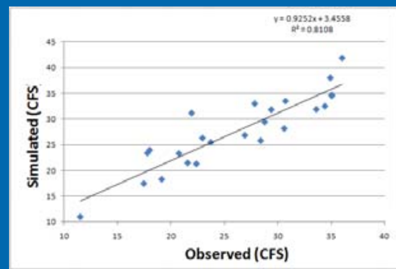
Flow-ecology Response Relations

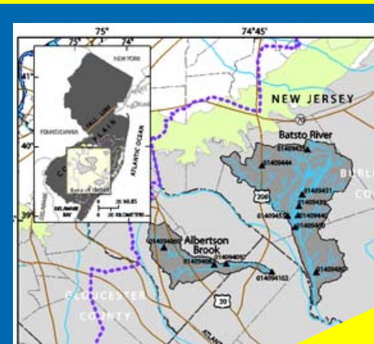


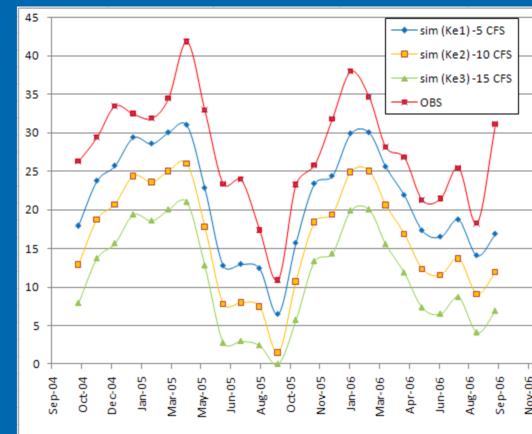
Invertebrates

General Flow Chart of hydrologic analysis



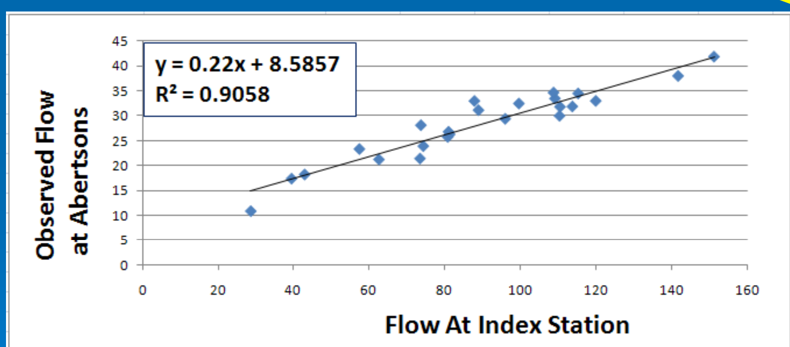


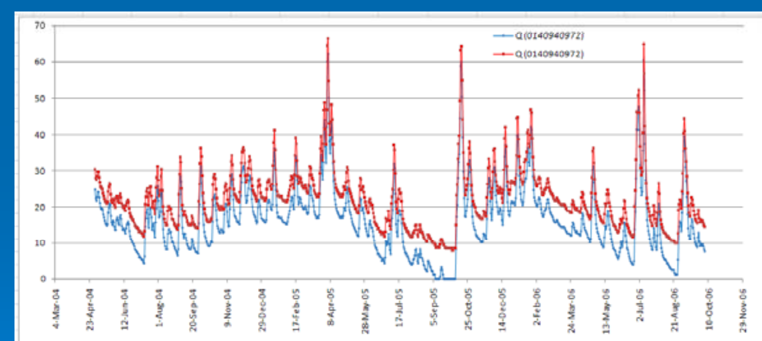




(A) MODFLOW Sim vs Obs for Alberson's Brook

(B) 3 GW withdrawal scenarios at -5, -10, & -15 CFS





(C) Predict potential change in flow at "Index Gage"

(D) MOVE 1 at Sites X, Y, Z…

(E) Predict potential change in flow at other gaging locations w/in index basin, e.g., Batsto Basin

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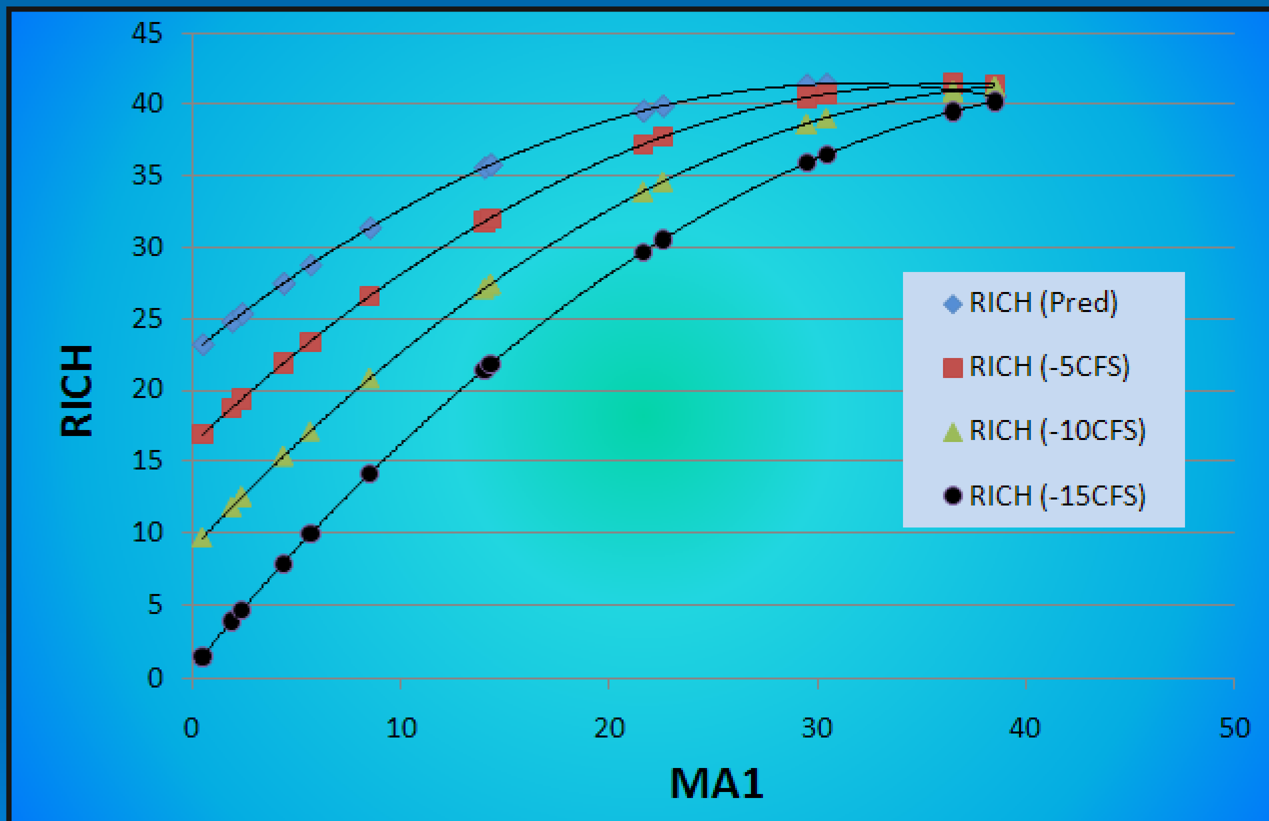
Flow-Alteration Ecological Response Relations



Invertebrates

Other Directions. . . .

- *TMDL's?*
- Linkages with SW & GW flow models?
- Climate Change?
- National Water Census—CR, DR & ACF

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Water Availability for Human and Ecological Needs

- It’s not necessarily a question of how much water a river needs, but how much can flow regimes be altered before having an appreciable affect on ecosystem integrity.

- Ultimately, a balance needs to be established between water supply intended to meet human needs and conservation of biological integrity.

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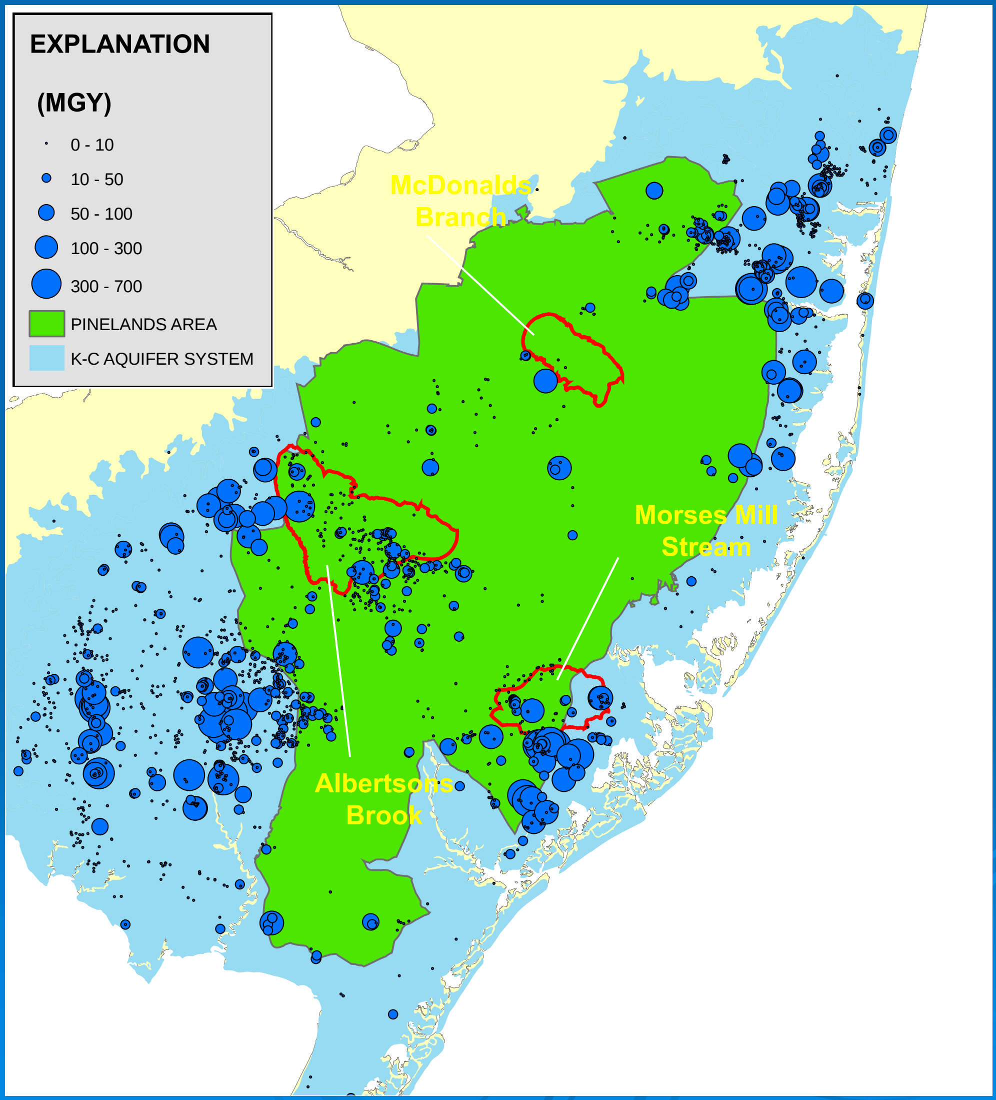
(Poff et al. 1997)

(Poff et al. 1997)

KIRKWOOD-COHANSEY AQUIFER SYSTEM WITHDRAWALS, 2005



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