Modification of Indiana’s Hydrologic Cycle

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Indiana’s Physical Setting

Tipton Till Plain
Recently Deglaciated
(<20,000 yrs)

Glacial Maximums

Older Glacial Terrain (and non-glaciated)

(Source Data: USGS DEM)
Indiana’s Hydrologic Cycle

P: 38 in/yr
E / T: 26 in/yr
I: 3.0 - 3.6 in/yr
R: 8.4 - 9.0 in/yr
Henry H. Gray, 2001, Map of Indiana Showing Physiographic Divisions, IGS Misc. Map 69
Indiana Ground Water Resources

Legend

- Pink: 10 gallons per minute
- Yellow: 200 gallons per minute
- Light Pink: 50 gallons per minute
- Green: 400 gallons per minute
- Brown: 100 gallons per minute
- Dark Green: 600 gallons per minute
- Blue: > 1000 gallons per minute
Approximate location of virgin old-growth forest.

Meyer, 1995
“On the Banks of Fall Creek”
C. Deam, 1922, Clark State Forest
IDNR
Wetland Loss from Time of European Settlement

Percentage of wetland loss

0 - 11
12 - 24
25 - 29
30 - 35
36 - 39
40 - 45
46 - 49
50 - 65
66 - 69
70 - 75
76 - 79
80 - 85
86 - 89
90 - 100

Source - U.S. Environmental Protection Agency
Indiana Wetland Loss

Historic

Circa 1986

Wetland Acres
- 1 Dot = 1000

Counts

3.5% of surface area
813,000 acres

24.1% of surface area
5.6 million acres

James Robb
IDEM 2002
Agricultural Drainage System

- 75-80% of the agricultural areas on the till plain are tile drained
- Tile drains function much like urban storm water drains
  - Effect is the same
    > peak flows,
    < base flow
- Riparian buffer strips are short-circuited by tile drains
- Results in relatively high chemical loading to streams

Kovacic, 2005
The Urban Hydrologic System

infrastructure driven pathways

Impervious Surfaces

Septic Systems

Ground water Flow Paths

Storm drains

Wastewater Conduits

Artificial Channels

Miller, BES
Historic Land Use, Cheeney Creek Watershed 1956
Land Use, Cheeney Creek Watershed, 2005
Change in Hydrology after Urbanization

- **Urban**: Decreased lag time and increased peak discharge.
- **Suburban**: Reduced lag time and increased peak discharge compared to rural areas.
- **Rural**: Lower peak discharge and longer lag time due to natural vegetation and permeable soil.

The diagram illustrates how urbanization affects the hydrological cycle, leading to faster and more pronounced discharge events.
Indiana Land Use/Cover

US EPA 1994
Alteration of Hydrologic Cycle

- Extensive Alteration of Hydrologic Processes Has Led to the Degradation of Water Resources
  - Increased Peak Flows and Decreased Base Flows in Streams
  - Increased Flooding and Increased Overall Discharge
  - Decrease in Water and Sediment Storage Upstream
  - Sediment, Nutrient, and Pathogen Loading Downstream
- High and Variable Contaminant Loads Impacting Both Recreational and Drinking Water Uses of Surface Water
Climate Change

“The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer will lead to more Global Climate Change Impacts in the United States - periods of both floods and water deficits.”

Global Climate Change Impacts in the United States, 2009
Precipitation Trends from 1900 – 2000

Trends per 100 years

- + 20 %
- + 10 %
- + 5 %
- - 5 %
- - 10 %
- - 20 %

Source: Karl et al. (1996)
Increases in Average # of Days with Very Heavy Precipitation (>2”), 1958-2007
Weather Patterns

• Extreme heat will be more common, and the frequency of heavy rainstorms will increase.

• Winter and spring rainfall events are expected to increase in quantity and intensity, resulting in flooding and more municipal and farm runoff.

• The frequency of heavy rainstorms, both 24-hour and multiday, is projected to increase over the next century. These trends are already evident in the region.
Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water-resource region. Colors indicate percentage changes in runoff.
Union of Concerned Scientists (2003)
Restoration of Indiana’s Hydrologic Cycle

• Naturalizing Flow Patterns
  – Increase Upland Storage
    • Increase Groundwater Recharge
    • Stabilize Base Flow
  – Reduction of Overland Flows — or Interception Prior to Reaching Stream Network

• Reestablish Ecosystem Functions
  – Reconnect Floodplains
  – Restore Streams and Riparian Corridors
  – Reestablish Wetland Complexes
Reestablish Upland Water Storage

• Focus on Premise that Agricultural and Storm Water Management should NOT be Water Disposal

• Improve Agricultural Water Management Practices

• Improve Storm Water Management Practices (LID Practices)
Reestablish Stream Functions

• Stream naturalization that combines flood storage with flow naturalization

• Requires upland storage and enhanced infiltration

• Link urban LID stormwater practices with stream mitigation

(Pleasant Run G.C., Indianapolis, IN)
Utilizing Natural Storage

• 80-day flood of 1993 on the Mississippi River generated 39 million acre-feet of floodwaters (at St Louis)

• Conservative estimate of available flood storage in the watershed indicates that approximately 40 million acre-feet of water could be stored within the existing levees and outside the levees on existing or drained wetlands.

• Spent >$55 million in levee repair

Hey and others, 2004
Identifying Potential Storage Areas

– GIS-based Tool
– Utilizes
  • Land Use/Land Cover
  • Soil Drainage Class
  • Digital Elevation Models
  • Flow Path Modeling
Potential Upland Water Storage Sites:
Eagle Creek Watershed

On a large scale this indicates that we could potentially moderate runoff in 29% of the watershed area by using only 1.5% of the land!

M. Babbar-Sebens

Total Wetland Area = 1.5% of Watershed Area
Wetland Drainage Area = 29% of Watershed Area
Challenges for Improving Water Resources

• Agricultural and Urban Storm Water Management Must Go Beyond Water Disposal

• Recognize that Water Resources are All Part of the Same Cycle and Manage Them Together

• Water Cycle Needs to be Managed for both Quality AND Quantity