GIS and Water Sustainability
A Taunton River Basin Case Study

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Water Sustainability A Growing Concern

- Water Not Always Available Where it is Needed
- Interbasin Transfers More Common – Not Always Realized
- Climate Change Will Only Exacerbate These Issues
Understanding the Hydrologic Balance of a Watershed is Key to Climate Change Adaptation

- Needed to Understand Water Withdrawal and Wastewater Disposal Impacts
- Important for Wetland Protection
- Important for Stream Baseflow Management
Baseflow Alterations
The Taunton River Watershed

- Taunton River
  - Longest New England coastal river unimpaired by dams
  - Flat river system: 20 ft elevation over 40 miles

- 562 mile² watershed

- 108 sub-watersheds

- Relatively healthy

- Diverse habitat

- Low permeability soils

- Large wetland systems
Development and Stress

- Developed land increased over 60% in 30 yrs
- Water quality impairments
  - Algal blooms
  - Sediments/siltation
  - Pathogens
- 43 municipalities
- Many with comprehensive water/wastewater planning

BUT

Need for regional solution
A Watershed-Wide Model

- Methodology
- Assumptions
- Inputs
- Data needs
- Platform
- Results
Key Model Assumption

- “Stream base flow during periods of average groundwater storage can be used to estimate recharge” (Hansen & Lapham, 1992)

- Groundwater recharge = primary source of base flow to streams

- Declines in recharge =
  - Reduced base flow
  - Potential ecological Impacts including habitat loss
Model Inputs

\[ BF = (GW_{nat} + WW_{GDP} + WW_{septic}) - (WS_{WMA} + WS_{prvt} + SW_{EIA}) \]

- BF = average annual base flow
- \( GW_{nat} \) = natural groundwater (gw) recharge
- \( WW_{GDP} \) = Groundwater Discharge Permit inflows
- \( WW_{septic} \) = private septic system inflows
- \( WS_{WMA} \) = WMA permitted withdrawals
- \( WS_{prvt} \) = private gw withdrawals
- \( SW_{EIA} \) = stormwater runoff from effective impervious areas
Model Inputs

Technically Speaking.....

Goesinta = Goesouta
Stream Base Flow

- USGS stream gage data
- If record too short to estimate base flow, determine closest index stream based on:
  - Drainage area
  - Mean basin slope
  - Stratified drift per stream length
- Calculate average mean of minimum monthly flows for reference stream
- Extrapolate base flow for stream of interest
Natural Recharge

Is a Function of Precipitation and

Geology and Hydrology
Water Withdrawal Data

- Public groundwater wells
- Surface water withdrawals (intake location)
- Private groundwater withdrawals
Private Groundwater Withdrawals

- Water service areas
- Land use data
  - Residential
  - Commercial
  - Industrial
  - Agricultural
- Additional data
  - Density
  - Per capita water use
Wastewater Recharge

- Mass. Groundwater Discharge Permits
- NPDES Permits
- Private Septic Systems
Stormwater Runoff from Effective Impervious Area (EIA)

- Total Impervious Area
  - rooftops
  - roads
  - parking lots
  - other (sidewalks, patios)

- EIA accounts for small, disconnected areas draining to infiltrating surfaces
Validating Key Assumptions

Rattlesnake Watershed
Modeling Platform

- For Taunton watershed, or single sub-watershed:
  - GIS geo-processing and
  - Spreadsheet calculations to combine assumptions with GIS results
- For 108 sub-watersheds?
- For running future scenarios?
  - Sewering?
  - Land use policies / regulations?
  - Population growth?
- Need automated process
Model – Geo-processing Engine

- Build automated geo-processing model using embedded Model Builder
Model – Water Budget Engine

- Build a “calculator” to read data from GIS layers and calculate water budget automatically for each of 108 sub-watersheds.
Model Verification

- Confirm results for two watersheds:
  - Rattlesnake Brook
  - Coweesset
Results - Current Water Balance

Entire Watershed

Water Balance

-10% (withdrawals > recharge)
-10% to -5%
-5% to 0%
0% to 5%
> 5% (recharge > withdrawals)
Results - Current Water Balance

Hockomock Swamp Subwatershed

Water Balance:
- < -10% (withdrawals > recharge)
- -10% to -5%
- -5% to 0%
- 0% to 5%
- > 5% (recharge > withdrawals)
Taunton watershed results

- Excluding surface water withdrawals or discharge (left)
- Including surface water withdrawals or discharge (right)
Use for Broader Audience

Questions

- Use of GIS as a modeling platform?
- Availability of GIS Data?
- Technical proficiency of potential users?
Use for Broader Audience Opportunities

- Adaptability to New Inputs
  - Future Changes in Precipitation and Recharge
  - Land use changes and impervious cover changes
  - Water or Sewer System Improvements