

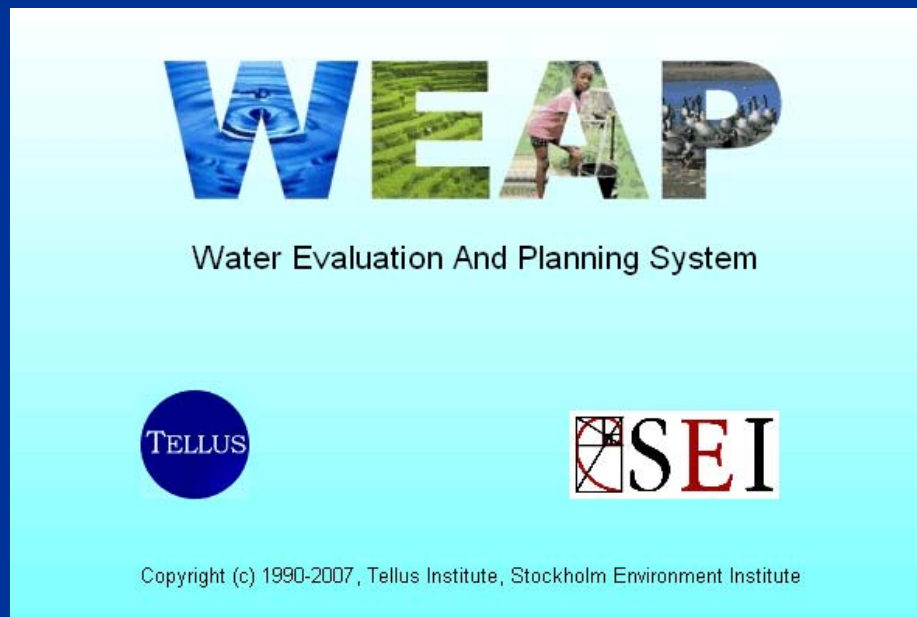


University of  
Massachusetts  
Amherst

## Application of WEAP for Holistic Water Resources Management in MA

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# Application of WEAP for Holistic Water Resources Management in MA



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**David Mitchell - M.Cubed**

**MA Water Resources Conference – April 8, 2008**

# Project Goals

- To demonstrate a holistic approach to water supply, wastewater, and storm water management for Massachusetts municipalities.
- Assist a community working on water resources management planning and decision making.



# WEAP Credits

- WEAP was conceived by Paul Raskin, President of Tellus Institute, and developed under his supervision until 2001. Many have contributed to the development and application of WEAP since its inception. We would like to acknowledge, in particular, Paul Raskin, Eugene Stakhiv, Ken Strzepek, Zhongping Zhu, Bill Johnson, Evan Hansen, Charlie Heaps, Dmitry Stavisky, Mimi Jenkins, Jack Sieber, Paul Kirshen, Tom Votta, David Purkey, Jimmy Henson, Alyssa Holt McClusky, Eric Kemp-Benedict, Annette Huber-Lee, David Yates, Peter Droogers, Pete Loucks, Jeff Rosenblum, Winston Yu, Chris Swartz, Sylvain Hermon, Kate Emans, Dong-Ryul Lee, David Michaud, Chuck Young, Martha Fernandes, Brian Joyce, Daene McKinney, Johannes Wolfer, Markus Huber, Mahmoud Al Sibai and Abdullah Droubi.

# WEAP

- Represents major components of a managed water resources system
- Basic methodology: physical simulation of water demands and supplies
- Allocates water based upon a system of priorities
- Climate driven hydrology module generates stream flow
- Tracks pollution generation, water quality, and wastewater treatment
- Financial module calculates costs and revenues
- Scenarios analysis used to assess water requirements, costs and environmental impacts of proposed management changes
- PC based

# WEAP Capabilities

## Can do

- High level planning and strategic analysis at local, national and regional scales
- Demand management
- Water allocation

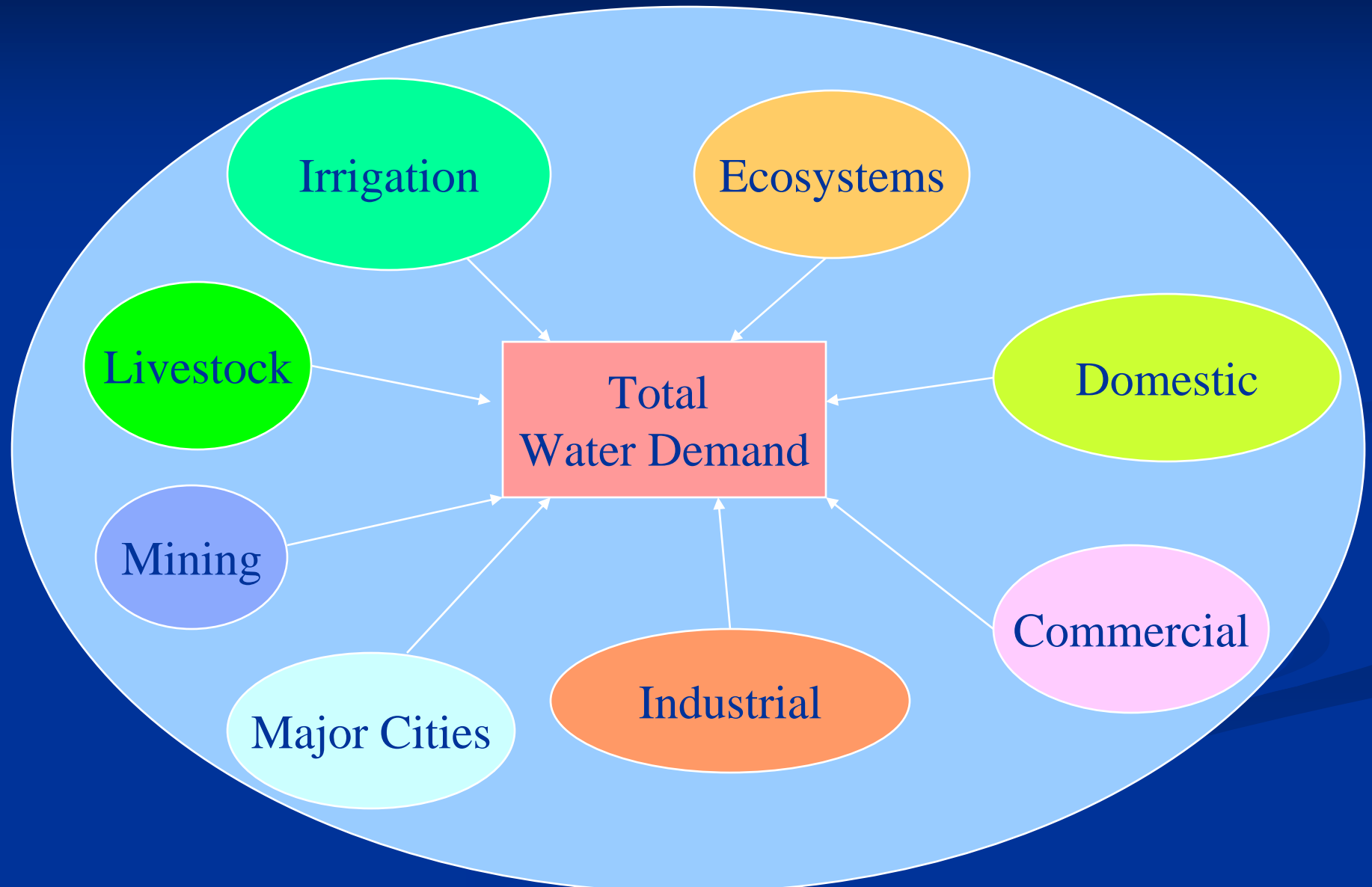
## Cannot do

- Daily operations
- Least-cost optimization of supply and demand

# Supplies

- Rivers
- Groundwater
  - storage capacity
  - maximum monthly withdrawal
  - natural recharge
- Diversions (e.g. canals, pipelines)
- Reservoirs
- Other (e.g. desalination)

# Sectoral Water Demands

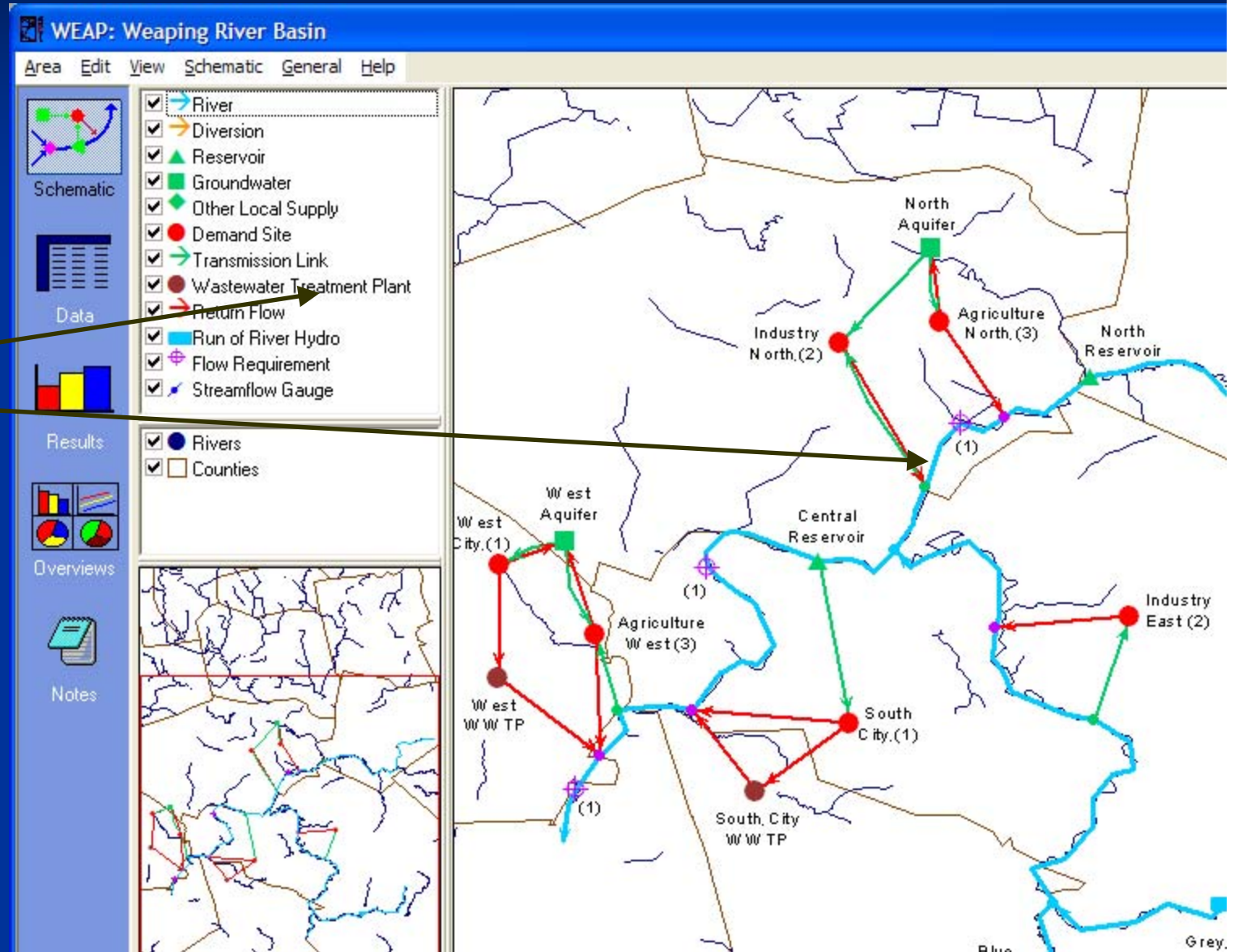


# Examples of Analyses

- Sectoral demand analyses
- Water conservation
- Water rights and allocation priorities
- Groundwater and streamflow simulations
- Reservoir operations
- Hydropower generation
- Pollution tracking
- Ecosystem requirements
- Used Globally

# Schematic View

Click and drag to create a new demand site



# Illustrative Demand Structure

SECTOR	SUBSECTOR	END-USE	DEVICE
Agriculture	Cotton	Irrigation ...	Furrow Sprinkler Drip
	Rice		
	Wheat		
	...		
Industry	Electric Power	Cooling Processing Others	Standard Efficient ...
	Petroleum		
	Paper		
	...		
Municipal	South City	Single Family Multi-family ...	Kitchen Bathing Washer Toilet ...
	West City		
	...		
	...		

# Data View

Data is displayed numerically and graphically

WEAP: Weaping River Basin

Area Edit View General Tree Help

Schematic

- Key Assumptions
- Demand Sites
  - South City
  - West City
  - Industry North
  - Industry East
  - Agriculture North
    - Sprinkler
    - Flood Irrigation
  - Agriculture West
- Hydrology
- Supply and Resources
- Environment
- Other Assumptions

Data

Results

Overviews

Notes

Data for: Reference (1999-2020) Manage Scenarios... Data

Water Use Loss and Reuse Demand

Annual Activity Level Annual Water Use Rate Monthly Variation

**Annual level of activity driving demand, such as agricultural area, population using water for domestic purposes, or industrial output.**

Demand Site	1998	1999-2020	Scale	Unit
Agriculture North	157.5	GrowthAs(Key\Drivers\Built Environment Expansion,-0...	Thousand	ha
Sprinkler	50	Interpl 2020,70	Percent	share of hectares

Chart Table Notes

Annual Activity Level

Area: Weaping River Basin Data View Registered to: tellus institute

- Mass balance equations are the foundation of WEAP's monthly water accounting: total inflows equal total outflows, net of any change in storage (in reservoirs and aquifers). Every node and link in WEAP has a mass balance equation, and some have additional equations which constrain their flows.
- $\text{Inflow } A = \text{Outflow } A - \text{Storage Change } A$

# Overviews

Favorite charts can be selected to give quick overviews

**WEAP21: Weaping River Basin**

Area Edit View Help

Overview Default Manage Overviews 3D Scenario Reference

**Groundwater Storage (end of month)**  
Scenario: Reference, All Months

Million Cubic Meter

1998/01 1999/07 2001/01 2002/07 2004/01 2005/07 2007/01 2008/07

All Years

— North Aquifer  
— West Aquifer

**Inflows to Area**  
Scenario: Reference, All Months

Million Cubic Meter

1998/01 1998/10 2001/08 2004/05 2008/03 2008/12

Selected Years (4/11)

— West Aquifer  
— North Aquifer

**Supply Requirement (Demand + Distribution Losses - Reuse - DSM Savings)**  
Scenario: Reference, All Months

Million Cubic Meter

1998/01 1999/08 2001/03 2002/10 2004/05 2005/12 2007/07

All Years

— West City  
— South City  
— Industry North  
— Industry East  
— Agriculture West  
— Agriculture North

**Unmet Demand**  
Scenario: Reference, All Months

Million Cubic Meter

1998/01 1999/07 2001/02 2002/08 2004/02 2005/09 2007/03 2008/09

All Years

— West City  
— South City  
— Industry North  
— Industry East  
— Agriculture West  
— Agriculture North

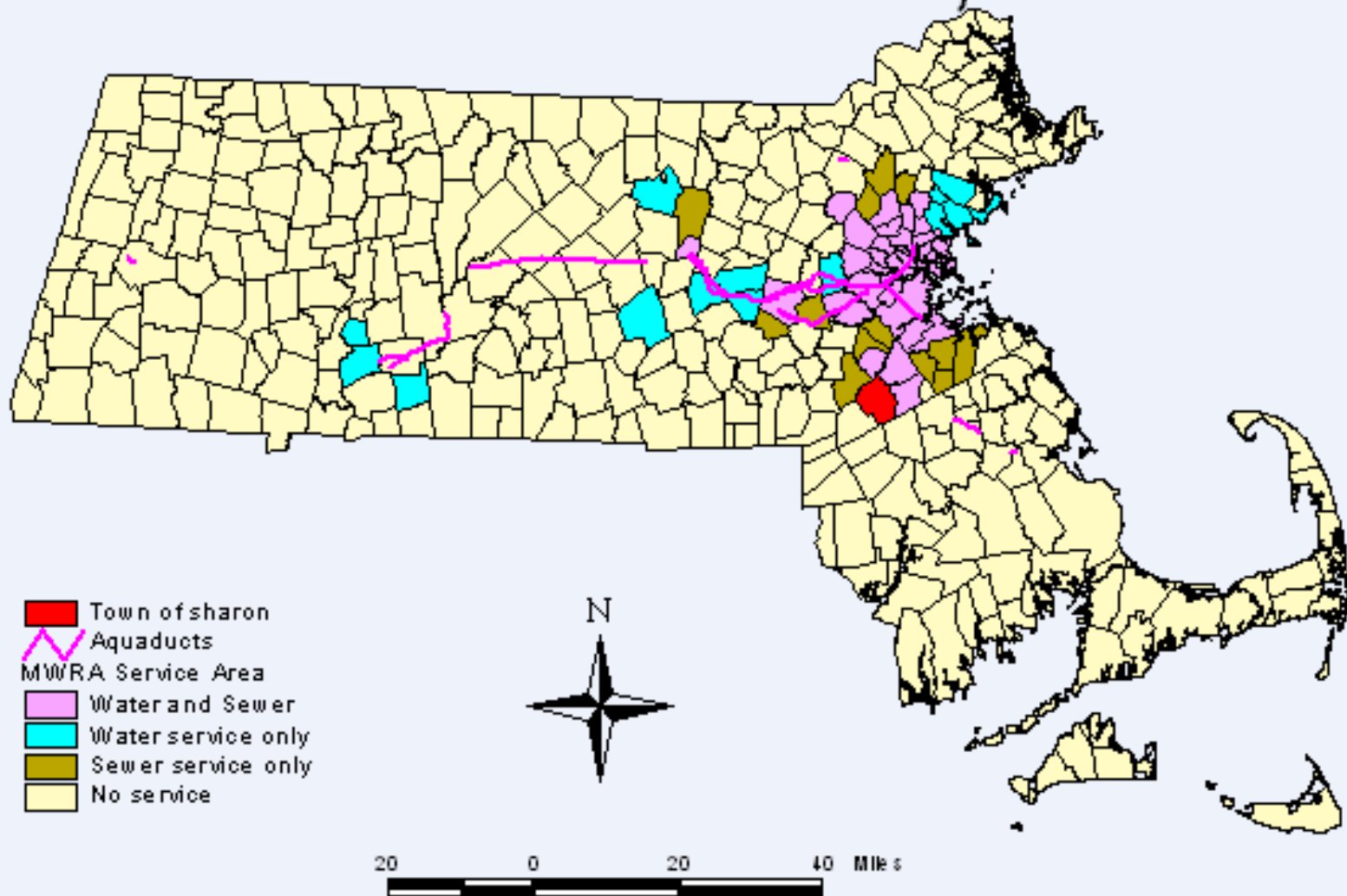
Area: Weaping River Basin | Overviews View | Registered to: Tellus Institute

# “Urban” WEAP Enhancements

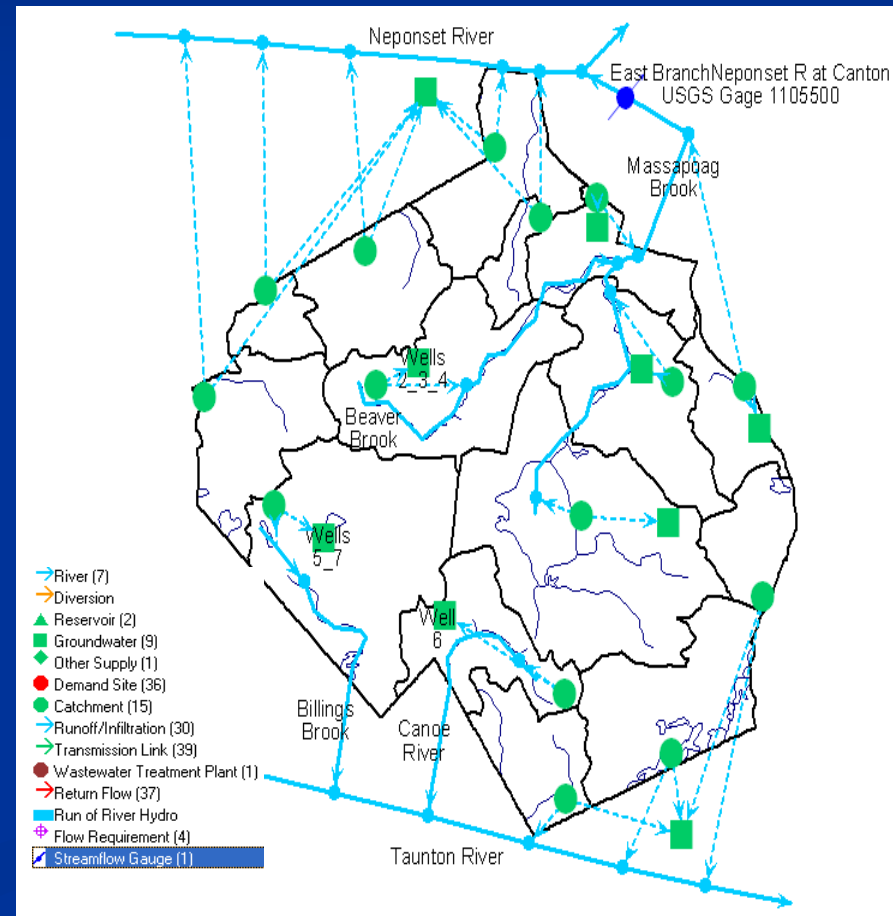
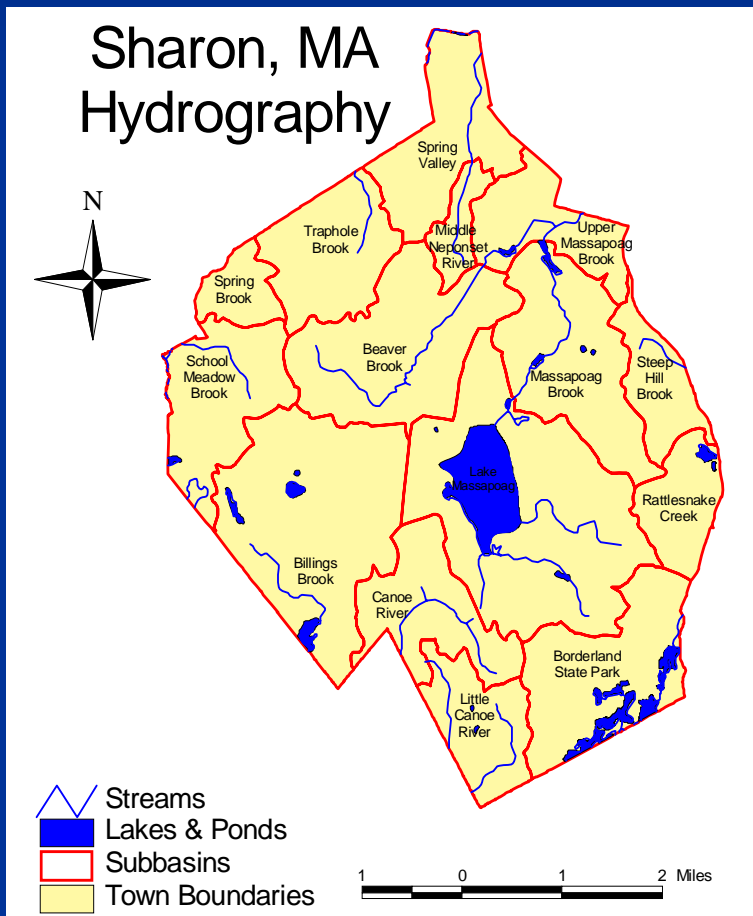
New features allow the user to include the following:

- **Infiltration and Inflow** from groundwater to sewage collection systems.
- **Infiltration Basins & Retention Ponds** as management practices.
- **Display of User-Defined Performance Measures as Results.**
- **Tiered Water Pricing** policies as a means of promoting demand management.
- **Combined Sewer Overflows (CSOs)** that pose potential risks to public health and aquatic life, because they discharge chemicals and disease-causing pathogens directly into waterways.

# Where is Sharon, MA?

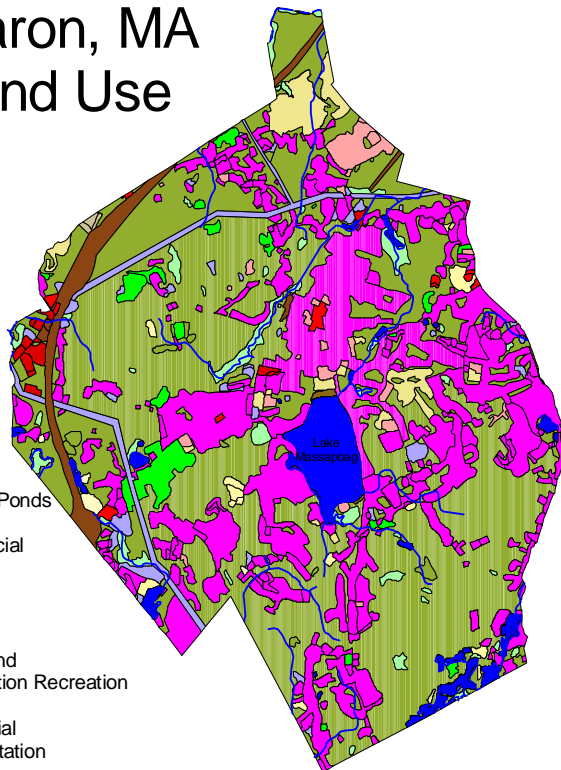


# Study Definition: *Hydrography*



# Current Accounts: *Land Use*

## Sharon, MA Land Use



- Streams
- Lakes & Ponds
- Land use**
- Commercial
- Cropland
- Forest
- Industrial
- Mining
- Open Land
- Participation Recreation
- Pasture
- Residential
- Transportation
- Urban Open
- Water
- Water Based Recreation
- Wetland
- Woody Perennial

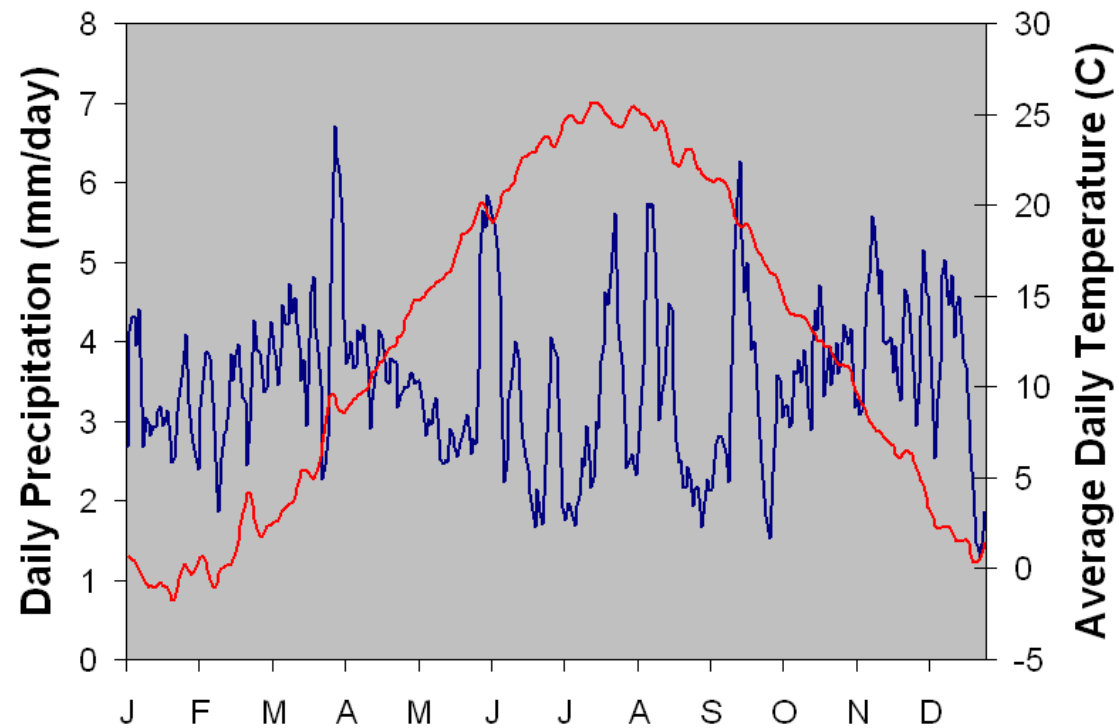
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### Land Use Areas for WEAP Sub-Basins (acres)

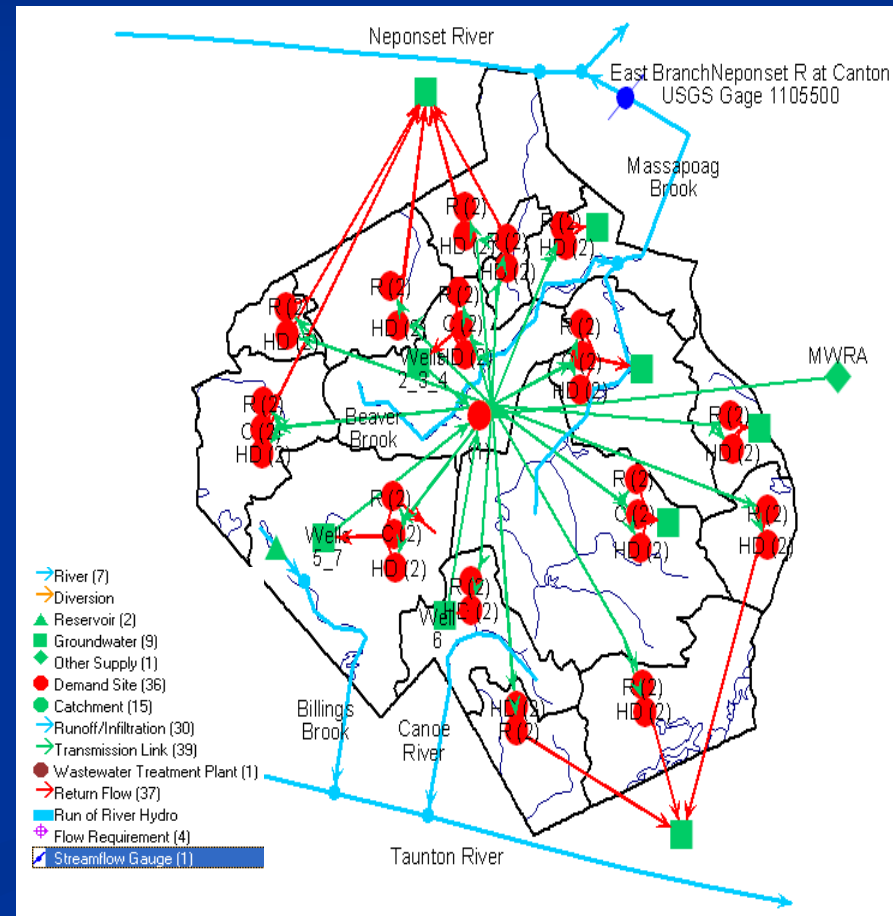
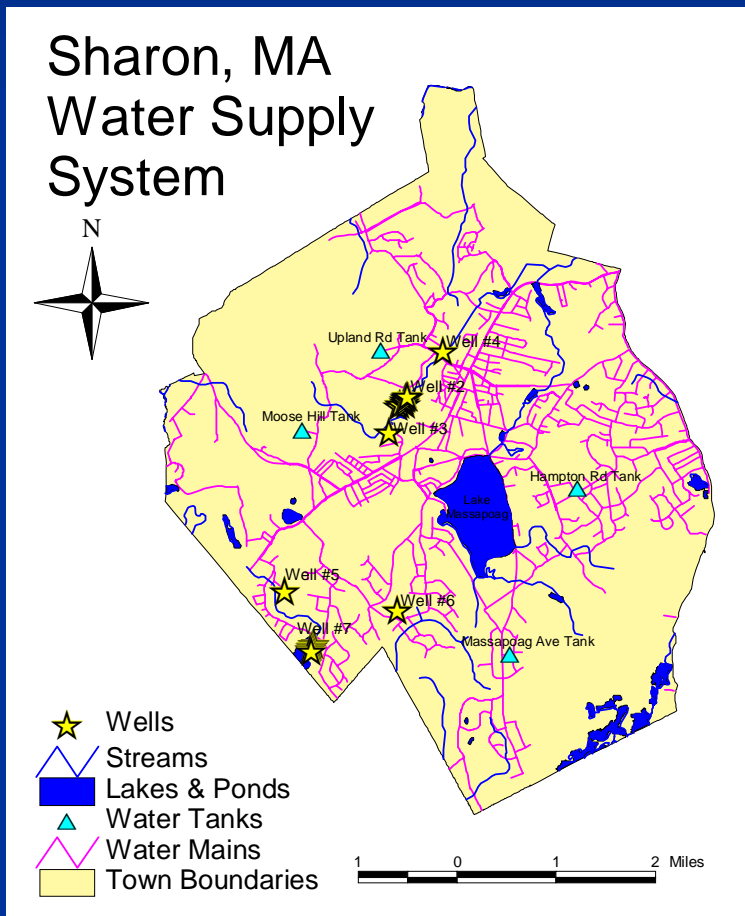
	Cropland	Forest	Parks	Pasture	Residential	Shrub	Transportation	Urban	Water	Wetland	Grand Total
BEAVER BROOK	24	987	40	8	403		9	15		69	1,554
BILLINGS BROOK	154	875	168	36	670	23	78	15	50	42	2,111
BORDERLAND STATE PARK	8	974	1	13	133				110	25	1,264
CANOE RIVER		520	10	2	352	3					889
DEVIL'S BROOK	11	513	78	8	635			6	18	54	1,324
LITTLE CANOE RIVER	8	374	7	5	267				3	3	667
MASSAPOAG BROOK	10	1,143	158	10	942			17	378	59	2,717
MIDDLE NEPONSET	1	127	25		92					7	251
RATTLESNAKE CREEK		295	1		207				13		516
SCHOOL MEADOW BROOK	6	618	53		95	3	95	80	5	38	994
SPRING BROOK	8	163	41		7		85				305
SPRING VALLEY	18	437	271		160		30		1	25	942
STEEP HILL BROOK	0	97	29	12	334			7			481
TRAPHOLE BROOK	52	634	66		62		66	2		22	903
UPPER MASSAPOAG BROOK	4	279	126	10	237		10	12	5	12	695
<b>Grand Total</b>	<b>303</b>	<b>8,035</b>	<b>1,072</b>	<b>105</b>	<b>4,597</b>	<b>29</b>	<b>373</b>	<b>154</b>	<b>582</b>	<b>360</b>	<b>15,610</b>

# Current Accounts: *Climate*

Average Daily Precipitation and Temperature  
(1980 – 2003)



# Study Definition: *Water Supply & Delivery System*



# Current Accounts: *Annual Demands*

## Average Water Use Rates

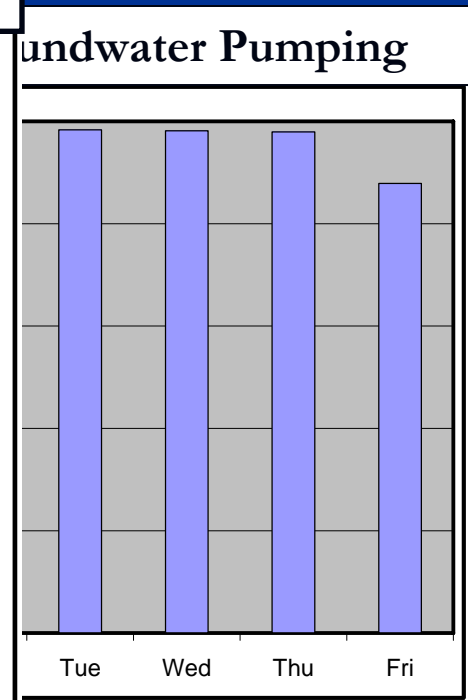
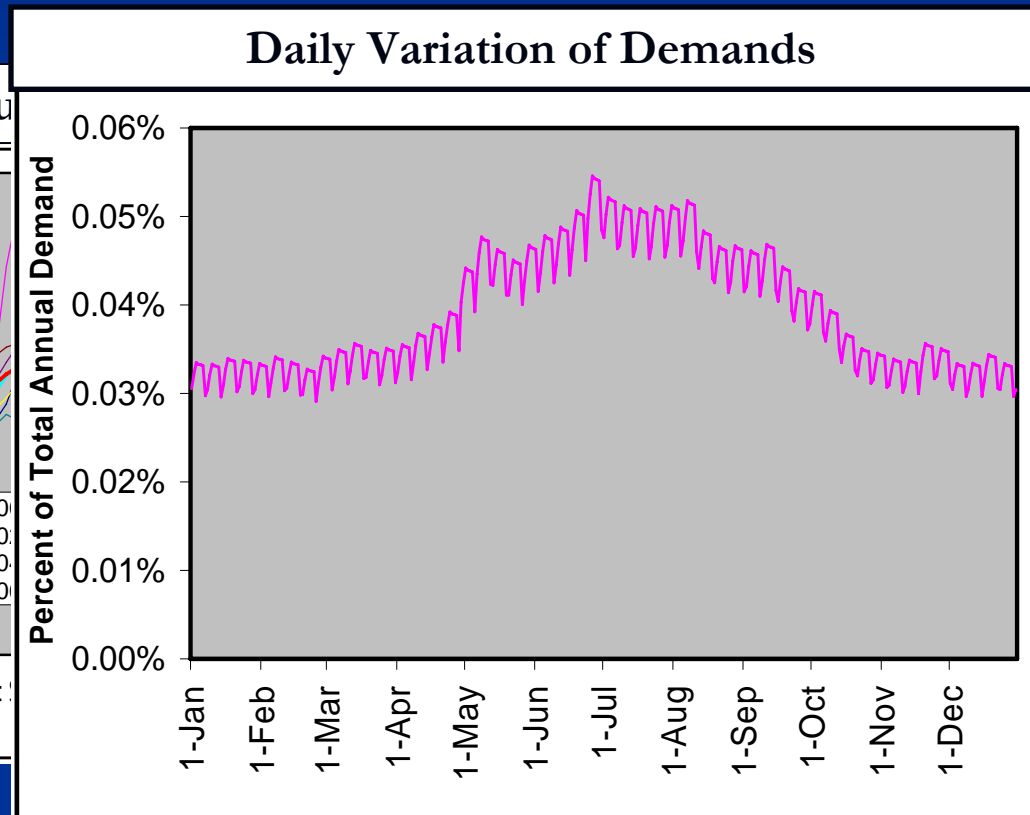
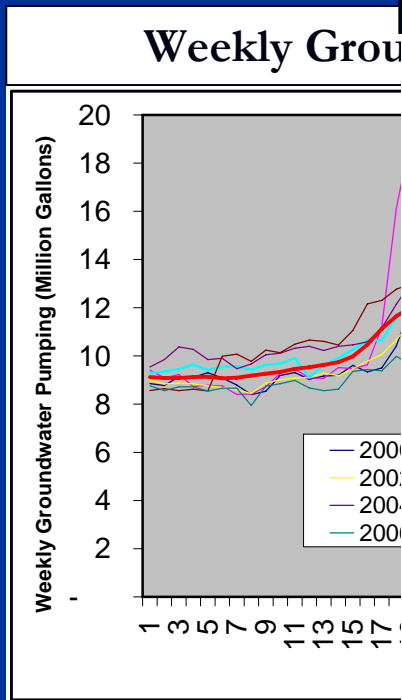
- Residential = 61 gallons/day/person, with 3.25 people/household
- High Density = 130 gallons/day/housing unit
- Commercial = 500 gallons/day/building

	Residential (Households)	High-Density (Housing Units)	Commercial (Buildings)
Beaver Brook	614	8	7
Billings Brook	1065		8
Borderland State Park	99		
Canoe River	397		
Devils Brook	889	8	4
Little Canoe	242		
Massapoag Brook	1104	16	43
Middle Neponset	72		
Rattlesnake Creek	232		
School Meadow Brook	93		15
Spring Brook	4		
Spring Valley	146		
Steep Hill	415		
Traphole Brook	64		
Upper Massapoag	215	50	
Grand Total	5651	82	77

\*Source: Parcels Database, Town of Sharon Department of Public Works

- System Losses = 8 %
- Total Annual Demands = 465 Million Gallons

# Current Accounts: *Demand Variation*



# Scenarios

## ■ Issues to explore:

- Impacts on water supply, runoff and wastewater from proposed high density developments and continued commercial and residential growth.
- Possible use of emergency water supply from the Massachusetts Water Resources Authority.
- The use of stormwater harvesting to facilitate groundwater recharge into the aquifer used for water supply.
- Replacing the Cedar Swamp drainage ditch

# Protection of Cedar Swamp



Important for aquifer recharge, and habitat

- Drainage ditch to prevent basin flooding and protect septic systems
- Plan
  - replace ditch by drainage culvert
- Redirect Return Flows to a farm to WWTP and Irrigation
  - sewer area, provide package WWTP, effluent

**Table 5. Benefits of Cedar Swamp Ecosystem Services (\$/Yr; 2006 dollars)**

	Cedar Swamp Area	
<b>Value/Acre/Year</b>	<b>211 acres</b>	<b>600 acres</b>
Low	\$1,899	\$5,400
Medium	\$253,200	\$720,000
High	\$1,793,500	\$5,100,000

Values in Table 5 can be directly compared to the annualized cost of \$130,000/year for the septic conversion project. Such a comparison indicates the project would generate

# Summary

- Enhanced WEAP model can be used to evaluate “with” and “without” development scenarios to determine the physical impacts to streamflow and associated opportunity costs in terms of forgone amenity recreation and fish and wildlife habitat
- WEAP can be used to calculate the costs of projects that could physically mitigate streamflow impacts.

# Availability

- Evaluation version available from <http://www.weap21.org>
- No-cost license to many organizations, eg ,all MA municipalities.
- Training is available from SEI-Boston.