WATER WITHDRAWALS
BALANCING QUANTITY AND QUALITY

Watershed Action Alliance of Southeastern Massachusetts
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Presentation Outline

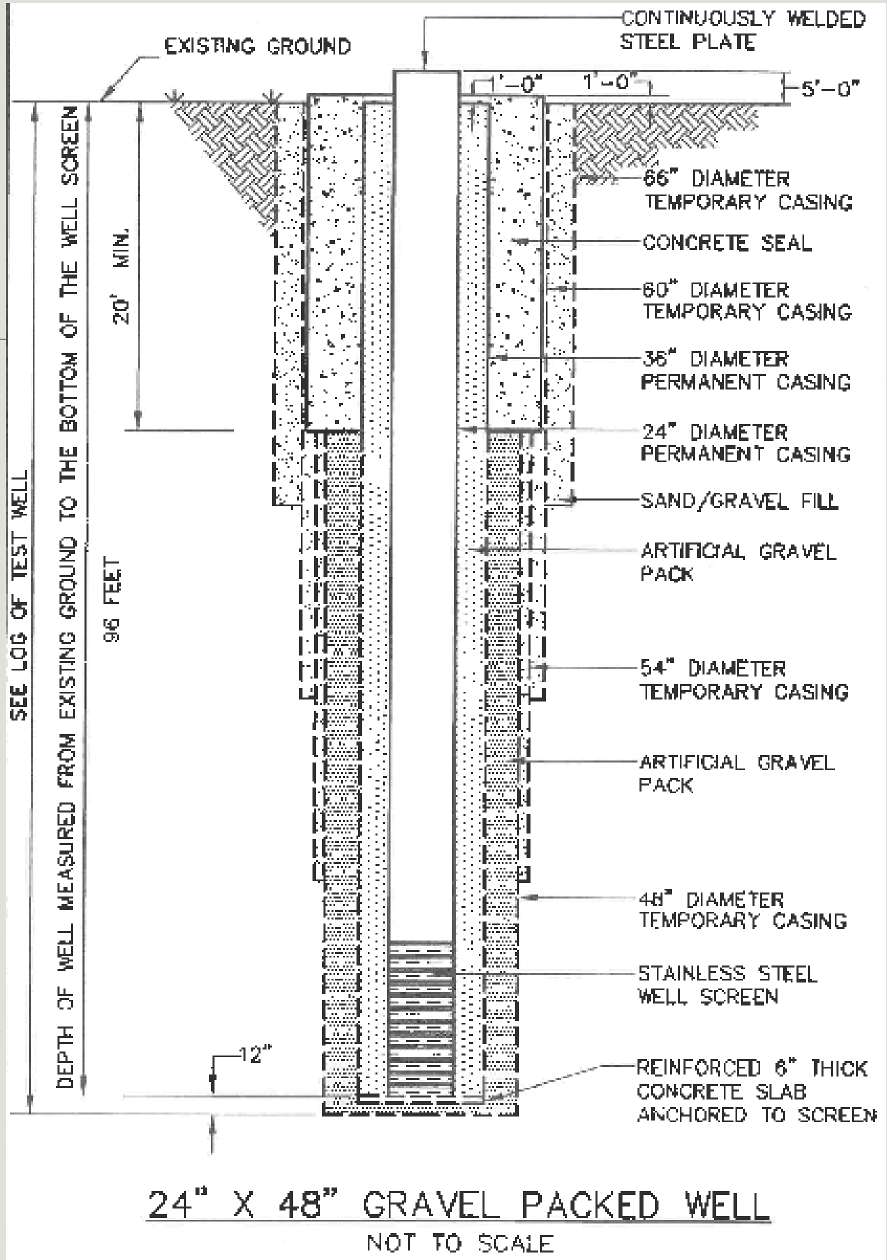
- General Overview of Typical PWS
- Geology in New England and Impacts on Water Quality
- PWS Balancing Act – Quantity and Quality
- Challenges facing Typical PWS

Overview Typical PWS

Sample Overburden
Gravel Packed Well

Variations

- Depth
- Soil Layers and Types
- Size (casing and pack)
- Gravel Pack vs Natural



Overview

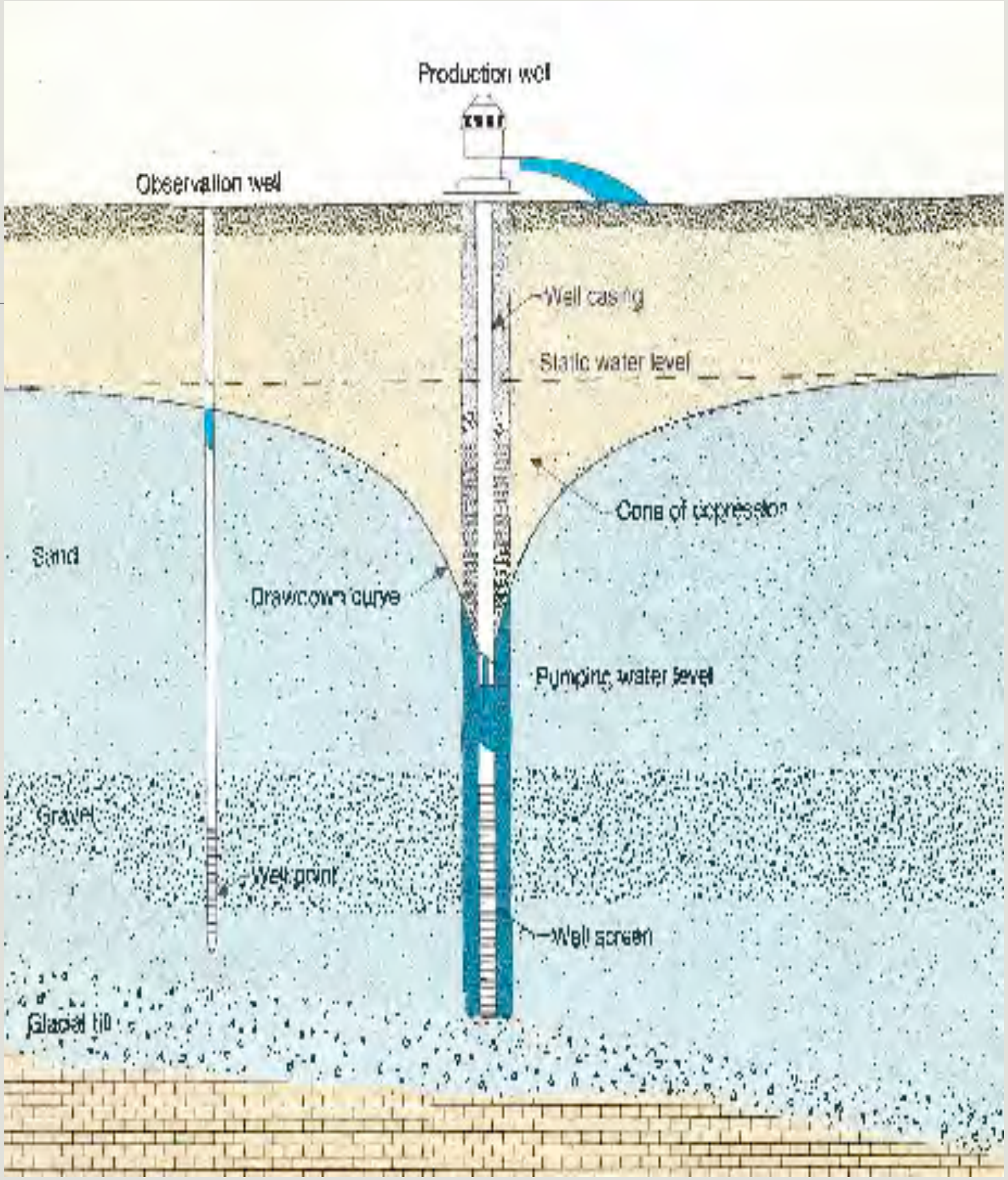
Sample Drawdown Curve

Image from "Groundwater and Wells"

by Fletcher G. Driscoll

1986

Johnson Division, Minnesota



Overview - Typical PWS MassDEP Protective Zones

Zone 1	400 foot radius around well (varies if less than 100,000 gpd) Must be owned or controlled by PWS
Zone 2	Modelled extent of drawdown 180 days of pumping at approved yield, no precipitation
Zone 3	Extent of watershed in which well is located Excludes downgradient portions that do not contribute

Overview - Typical PWS MassDEP Protective Zones II

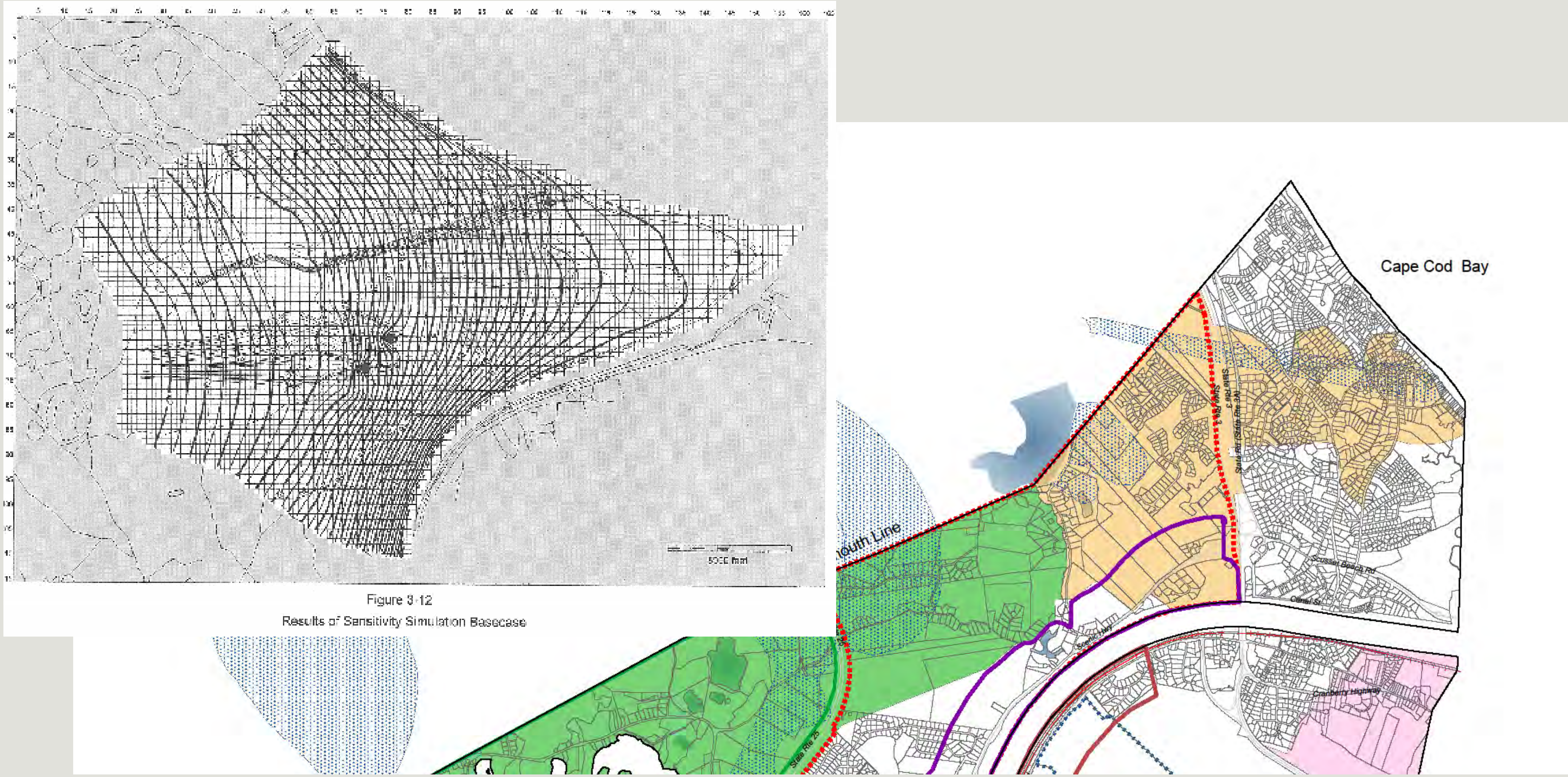


Figure 3-12
Results of Sensitivity Simulation Basecase

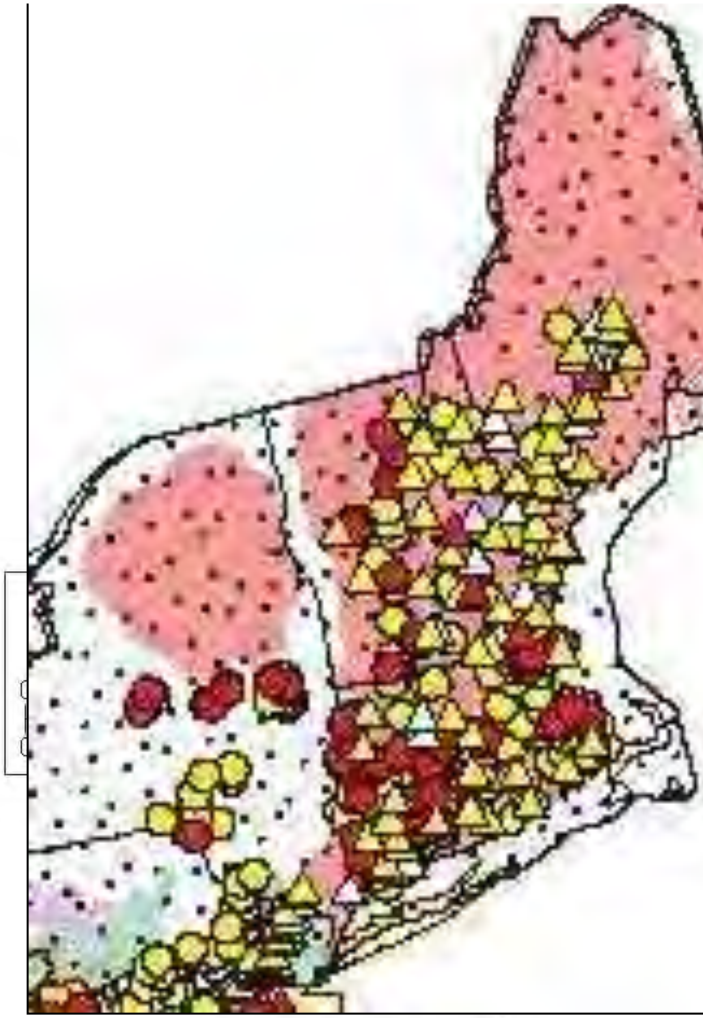
Geology in New England Impact on Water Quality

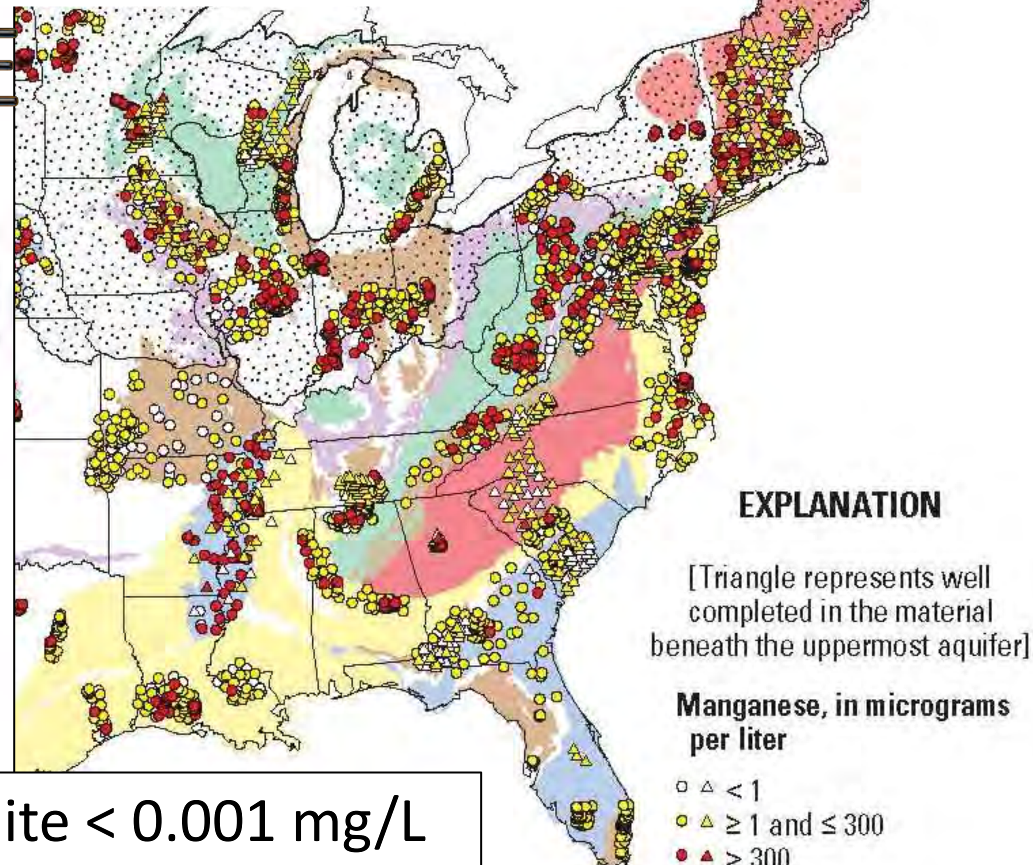
Overburden Materials (aka Surficial Geology)

Elements typically impacting Massachusetts PWS

- Iron (discoloration and potential buildup/clogging)
- Manganese (discoloration and health impacts)
- Arsenic (health impacts)

Manganese Levels in Wells in NE





White < 0.001 mg/L
Yellow 0.001-0.3 mg/L
Red > 0.3 mg/L

Shading is Aquifer Group defined for study

Source: USGS, Trace Elements and Radon in Groundwater Across the United States, 1992–2003, Scientific Investigations Report 2011–5059, 2011

Intellectual Impairment in School-Age Children Exposed to Manganese from Drinking Water

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"The findings from our study support the hypothesis that low-level, chronic exposure to manganese from drinking water is associated with significant intellectual impairments in children."

BACKGROUND: Man…
Despite the commo…
of exposure are large…

OBJECTIVES: Our fir…
ing water and child…
manganese exposure…
concentration.

METHODS: This cros…
supplied by ground…
children's hair (Mn…
food frequency quest…

RESULTS: The medi…
MnH increased with manganese intake from water consumption, but not with dietary manganese intake. Higher MnW and MnH were significantly associated with lower IQ scores. A 10-fold increase in MnW was associated with a decrease of 2.4 IQ points (95% confidence interval: –3.9 to –0.9; $p < 0.01$), adjusting for maternal intelligence, family income, and other potential confounders. There was a 6.2-point difference in IQ between children in the lowest and highest MnW quintiles. MnW was more strongly associated with Performance IQ than Verbal IQ.

CONCLUSIONS: The findings of this cross-sectional study suggest that exposure to manganese at levels common in groundwater is associated with intellectual impairment in children.

KEYWORDS: children, intellectual quotient, manganese, neurotoxicity, water. *Environ Health Perspect* 119:138–143 (2011). doi:10.1289/ehp.1002321 [Online 20 September 2010]

…from water containing …L, one presenting with …impairments (Woolf …ther with neurologic …a repetitive stuttered …coordination, and fine …. 2007).

…ntration in drinking … in the United States …sed guidelines for the …anganese in drink…00 μg/L by the U.S. …ction Agency (EPA) (2004) and at 400 μg/L by the World Health Organization (WHO) (2008).

To date, no epidemiologic study has examined possible neurotoxic effects at manganese concentrations common in North American aquifers. In the present study, we assessed the relationship between exposure to manganese from drinking water and IQ of school-age children living in communities relying on groundwater. In addition, we

Geology in New England Impact on Water Quality

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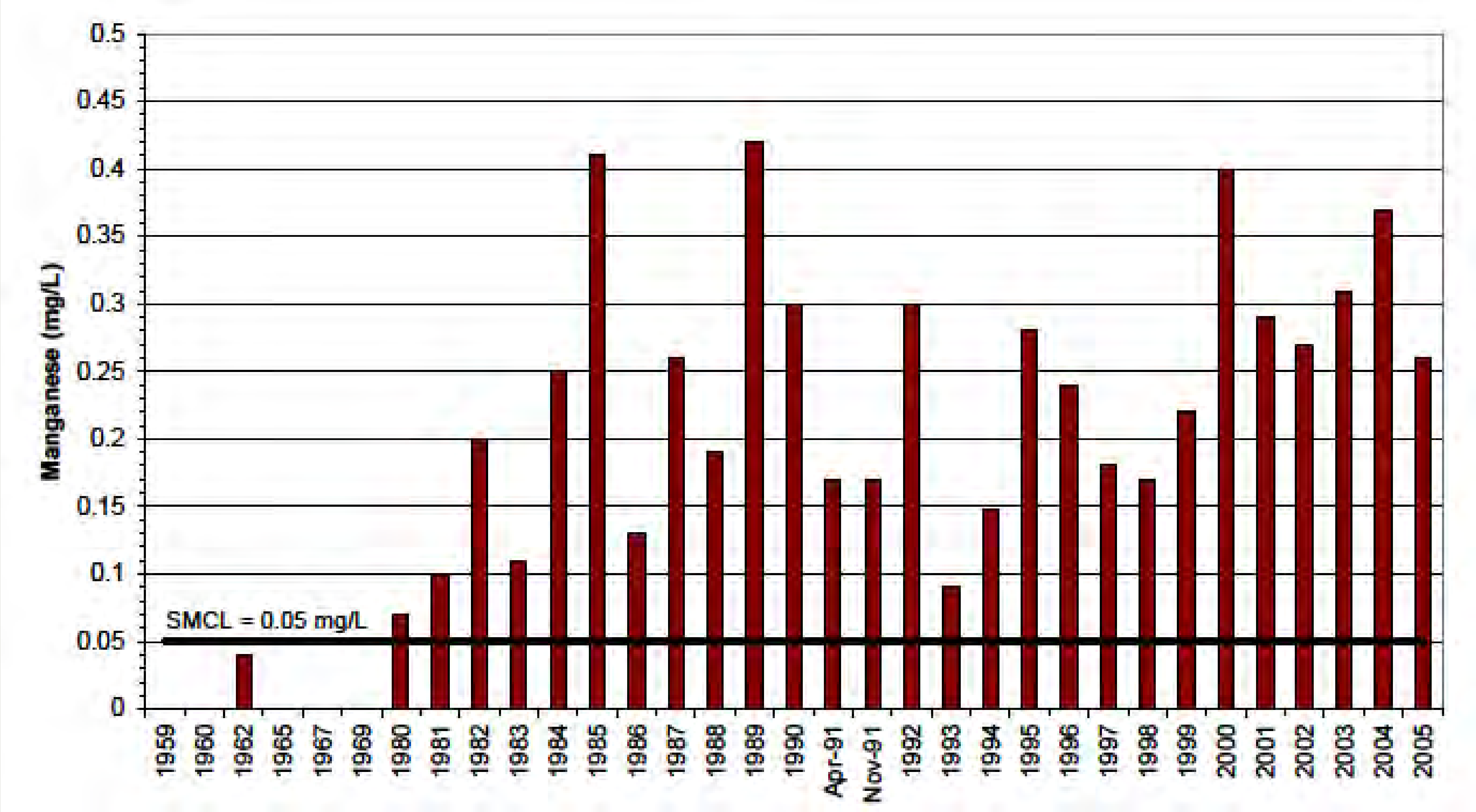
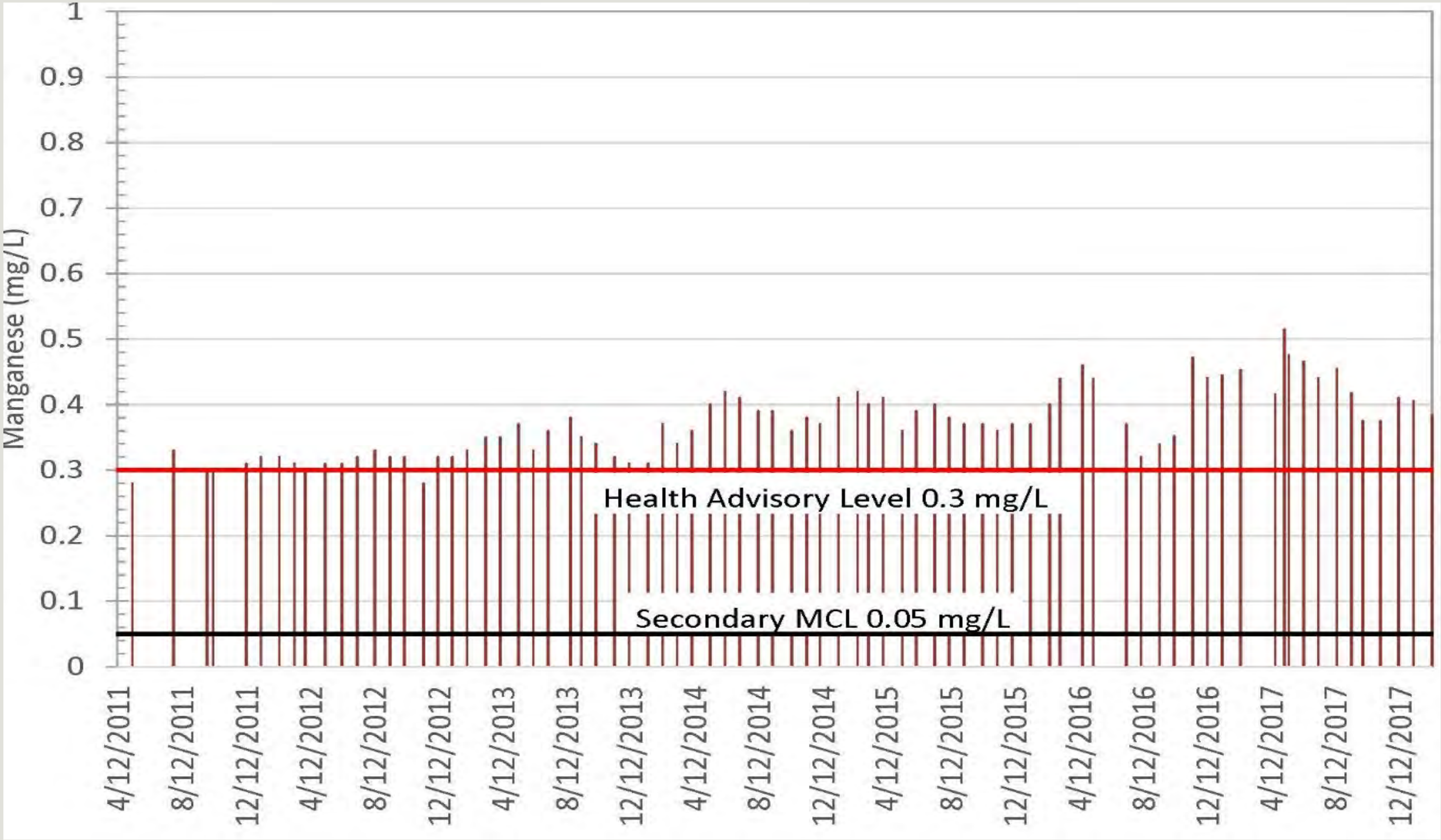


Geology in New England Impact on Water Quality



PWS Balancing Act
Water Quantity and Quality

Well/Source Management

- Ideally limit to 16 hours daily, allows recovery and avoid "stressing" well
- Weekly rotation of multiple sources

Multiple sources

- Reduced flow and reduced drawdown
- Reduced Water Quality Deterioration (or delayed impact)
- Side benefit of supply redundancy is increased system resiliency
- Preferential use of sources in different (less stressed) river basins
- Problem - difficult to locate new "clean" sources

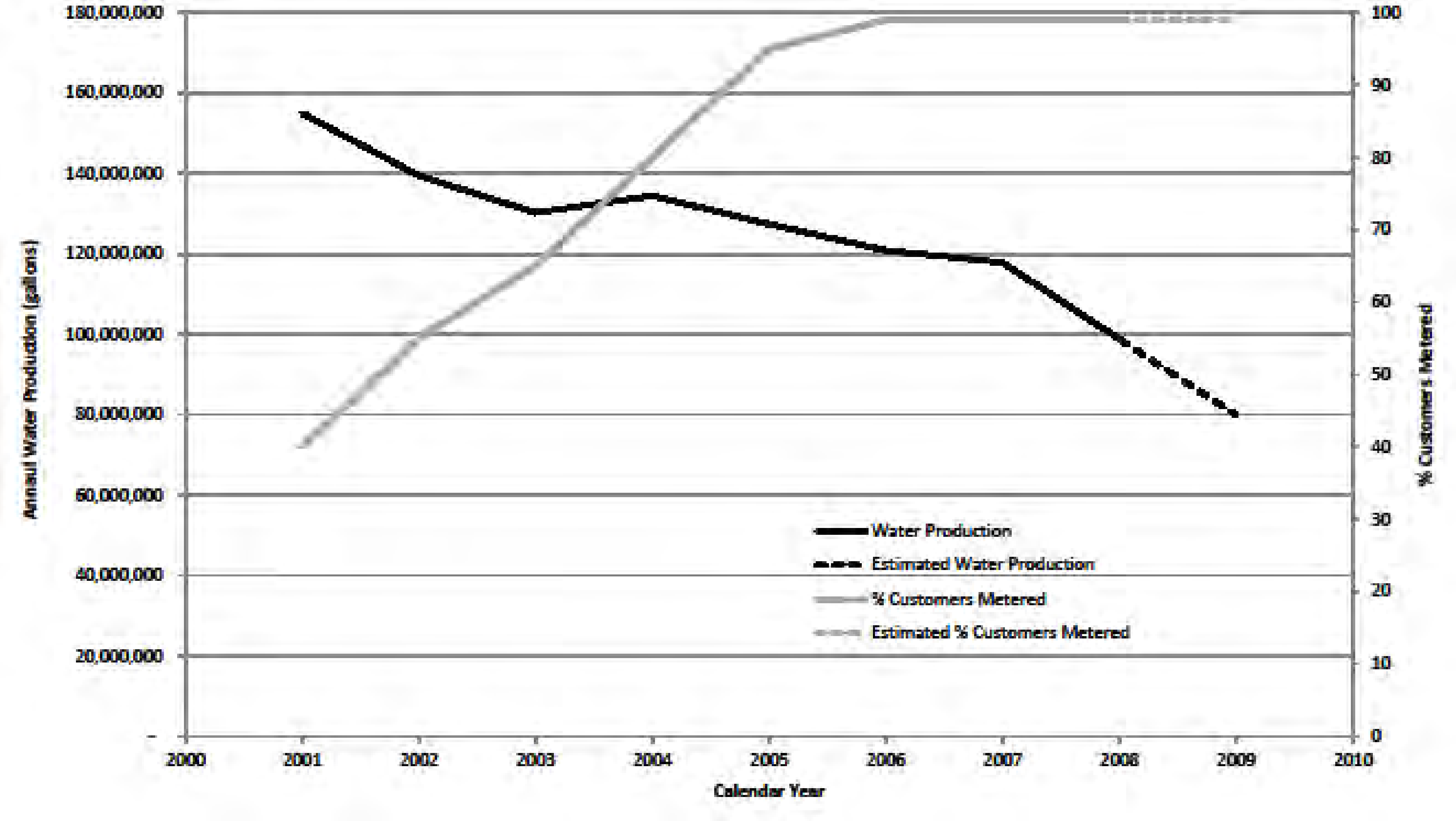
Promote conservation

- Banning of lawn irrigation system or separate irrigation meters/rates
- Adherence to MassDEP Conservation goals of 65 gpcd and 10% UAW

PWS Balancing Act

Month	Average Demand (mgd)[2]		Week 1	Week 2	Week 3	Week 4
	Low Zone	High Zone				
January	0.98	0.13	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St	South St Millgate Soules Pond 1-86	Grassy Hole Soules Pond Millgate South St
February	0.98	0.14	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St	South St Millgate Soules Pond 1-86	Grassy Hole Soules Pond Millgate South St
March	0.99	0.13	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St
April	1.02	0.16	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St	South St Millgate Soules Pond Grassy Hole	1-86 Soules Pond Millgate South St
May	1.16	0.20	HZ Transfer[3] 1-86 Soules Pond Millgate	HZ Transfer South St Millgate Soules Pond	HZ Transfer Grassy Hole Soules Pond Millgate	HZ Transfer 1-86 Soules Pond Millgate
June	1.33	0.33	HZ Transfer South St Millgate Soules Pond	HZ Transfer Grassy Hole Soules Pond Millgate	HZ Transfer 1-86 Soules Pond Millgate	HZ Transfer South St Millgate Soules Pond

PWS Balancing Act



PWS CHALLENGES
Treatment Impacts (Mn Example)

Mitigation Methods for Manganese

- Flushing Water Mains
- Cleaning Wells
- New Source Development
- Blending Source Waters
- Resting Wells
- Reduced Pumping Rates
- Sequestering through chemical addition
- Fe & Mn Removal through Treatment Facility

PWS CHALLENGES
Treatment Impacts (Mn Example)

Sequestering through chemical addition

- Addition of chemical (phosphate)
- Binds Mn in solution to prevent oxidizing by air or chlorine, preventing color/staining
- Common approach for managing Mn
- Limitations
  - Only effective for Mn up to approximately 0.1 mg/L
  - Ineffective at higher temps (hot water heaters)
  - Mn is not removed (potential health impacts remain!)

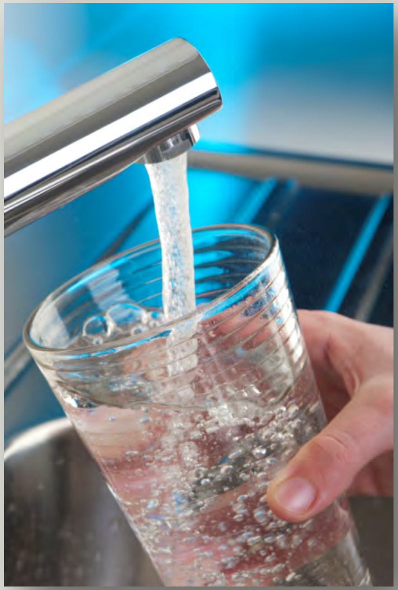
PWS CHALLENGES
Treatment Impacts (Mn Example)

Manganese Removal Options

(through new Treatment Facility)

- Oxidation
- Adsorption
- Filtration
  - Pressure Filtration
  - Traditional Filtration
  - Membrane Filtration
- Biological
- Ion Exchange

PWS CHALLENGES
Treatment Impacts (Mn Example)

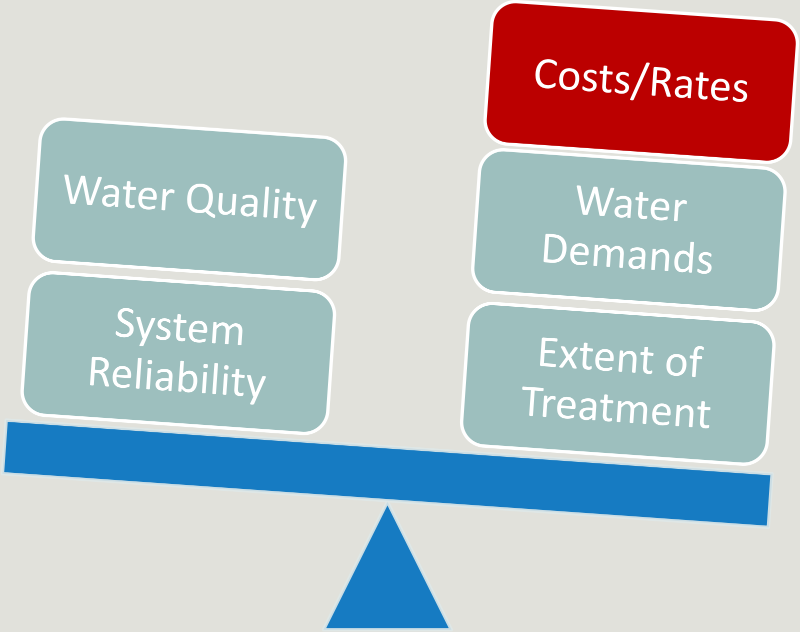


PWS CHALLENGES
Treatment Impacts (Mn Example)

Pump Station (low Mn)
Estimated Cost $1M

Manganese Removal Treatment Facility
Estimated Cost $5M

Ultimate PWS Challenge



Many PWS are (or strive to be) financially self-sufficient.

Increased costs (or reduced water use) leads to increased rates.

Questions?

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