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*Supply and Demand Management of
Greater Boston's Water System
(1600s – the present)*

Joshua Das

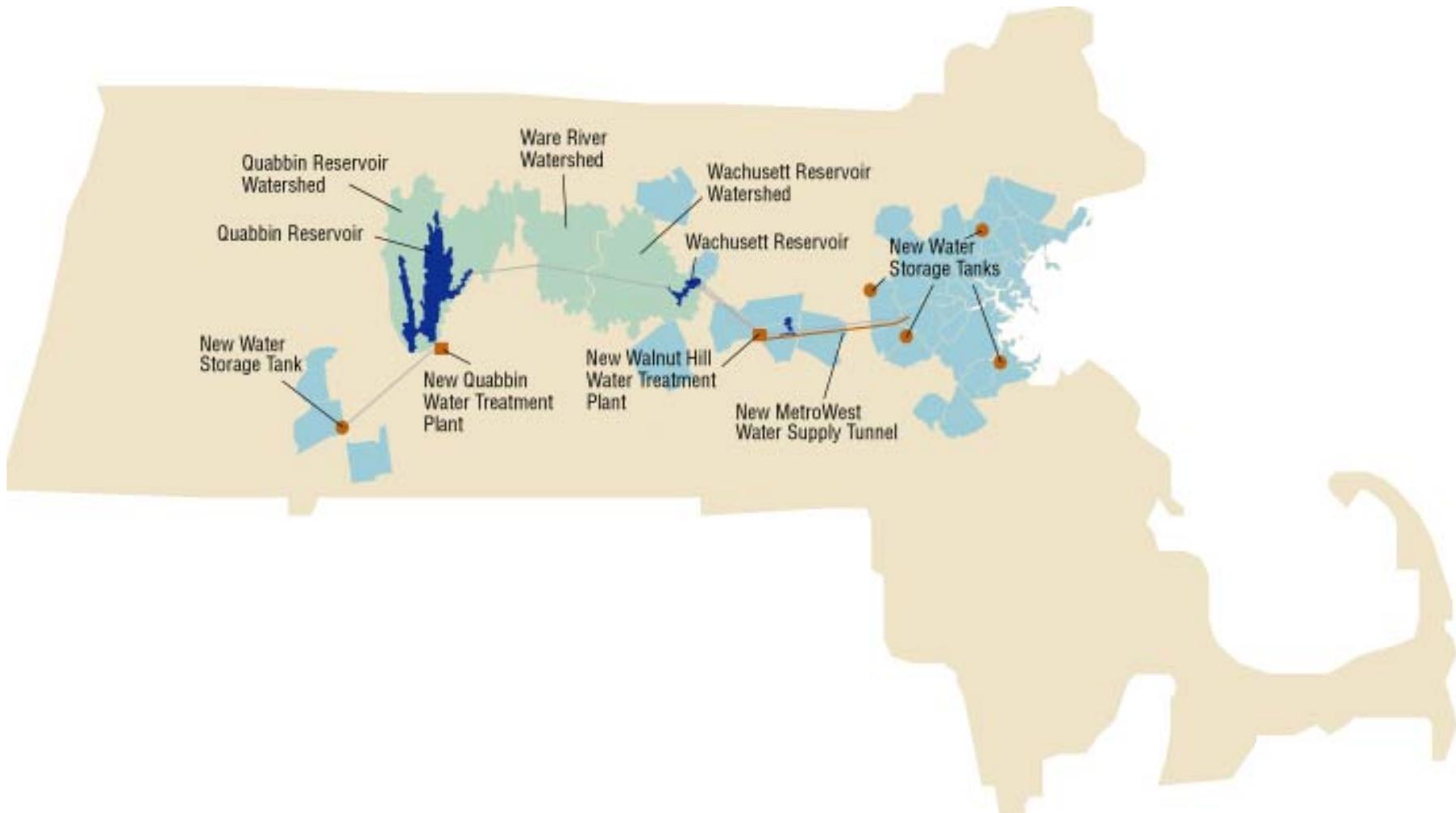
Project Manager, Public Health, MWRA

April 3, 2007



Massachusetts Water Resources Authority (MWRA)

- MWRA created in 1984
- Currently serves 2.5 million people in 61 communities



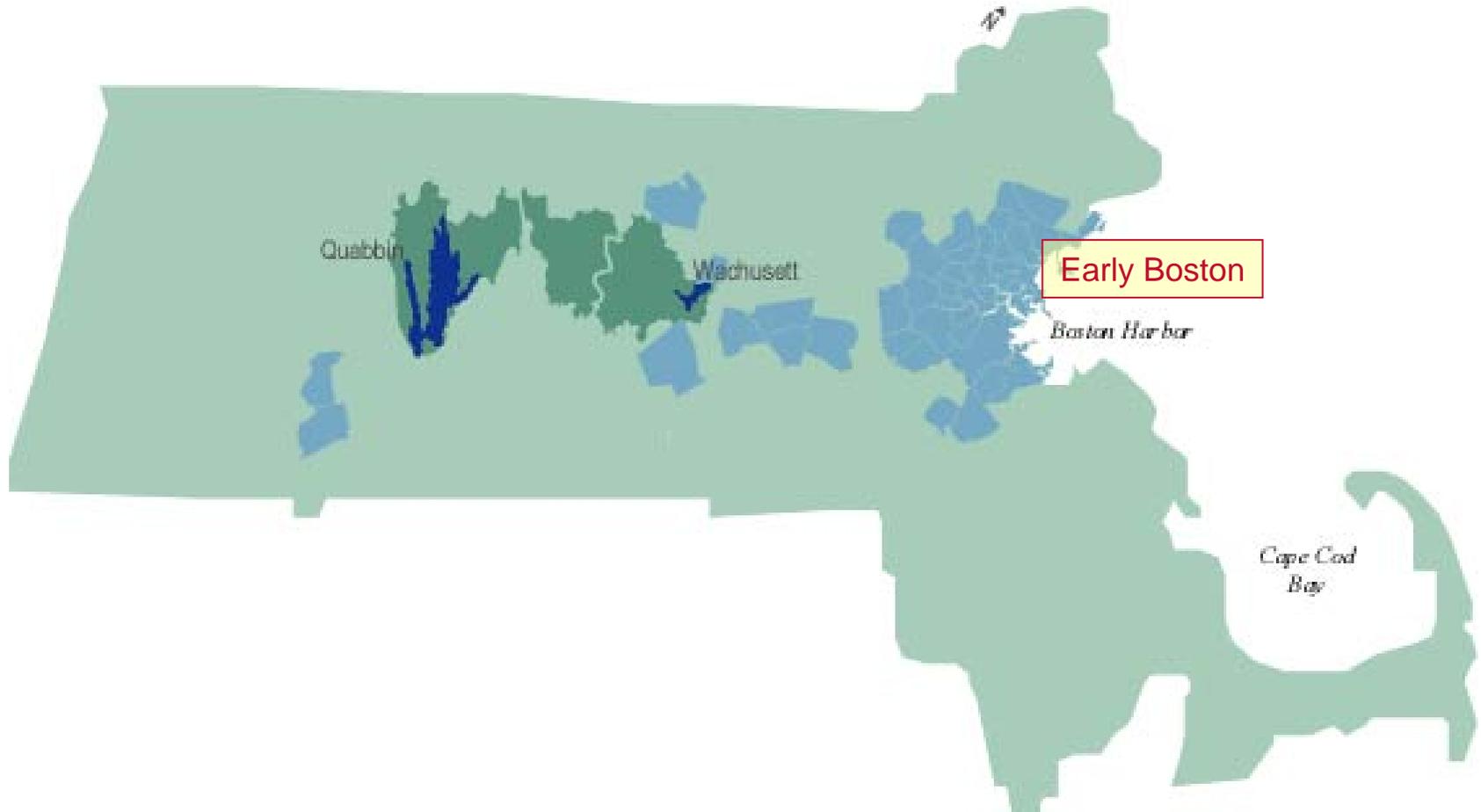


Metro Boston Water Supply History In Brief

- A Journey Westward
- Begin in Boston, then
- Move West Seeking:
 - Larger Quantities of
 - Purer Water, at a
 - Higher Elevation



Water System History - A Journey Westward



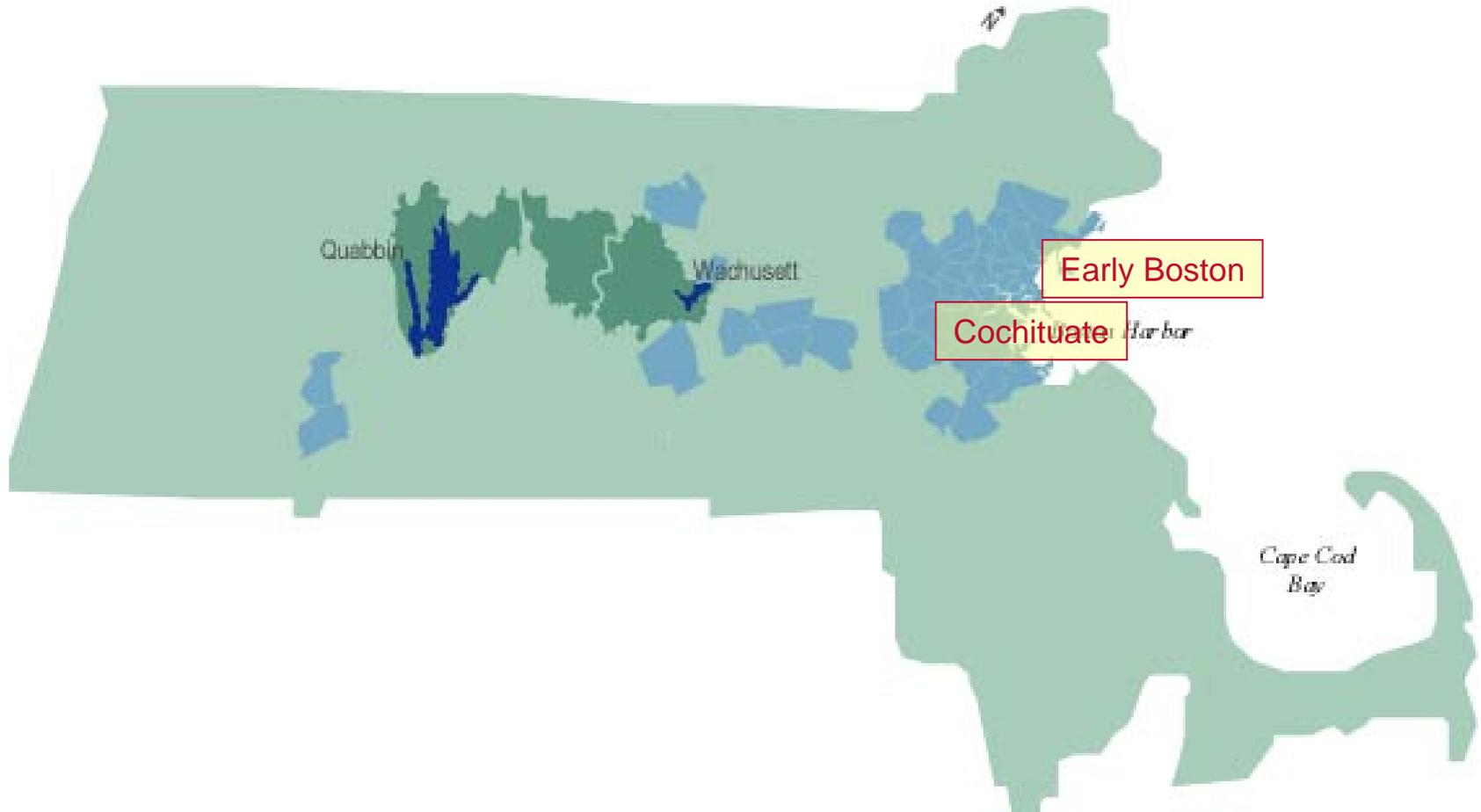


Early Boston Water System

- Early Bostonians relied on local wells, rain barrels and a spring on Boston Common for their water
- In 1795 wooden pipes made from tree trunks delivered water from Jamaica Pond to Boston
- By the 1840s, Jamaica Pond was too small and too polluted to provide water to Boston's 50,000 residents
- A purer and larger source had to be found



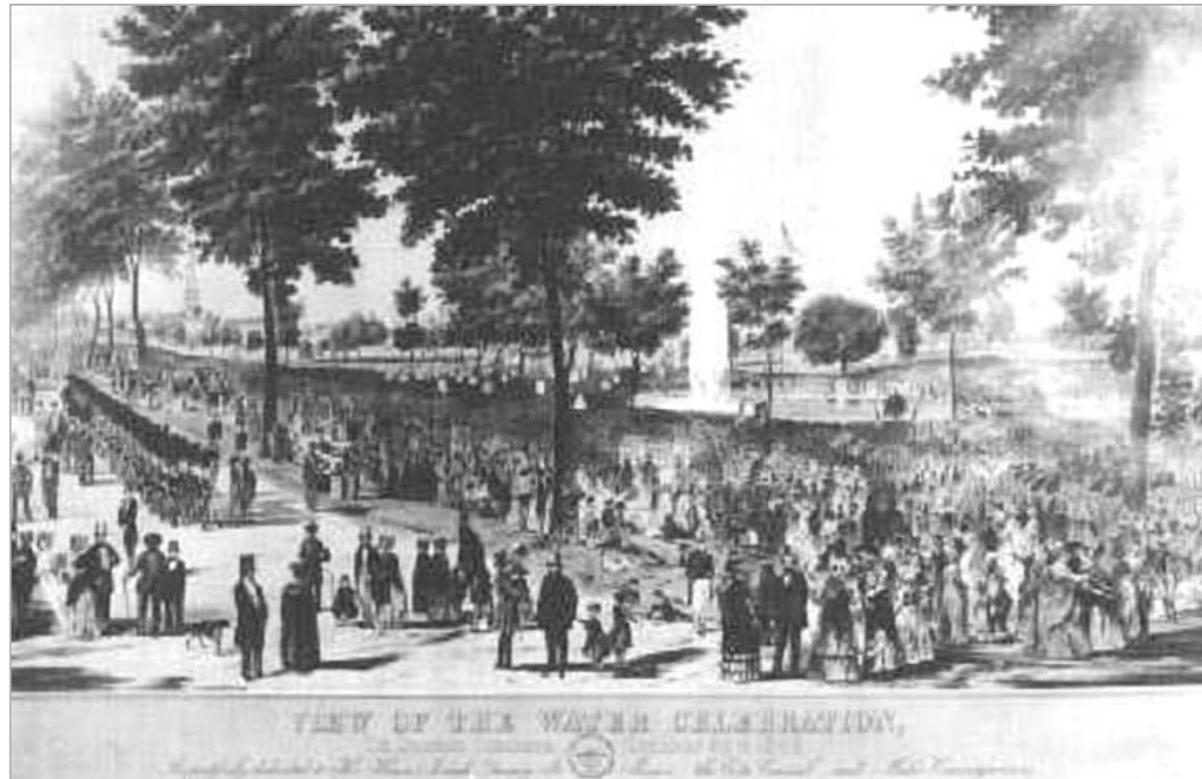
Water System History - A Journey Westward





The Cochituate System

- After 20 years of study, the Cochituate System was chosen, and construction began in 1845
- The Sudbury River was impounded and Lake Cochituate was formed 14.5 miles from Boston. It provided 2 billion gallons of storage and 10 million gallons per day
- Water flowed into the Frog Pond on Boston Common in 1848 at a dedication ceremony that drew 100,000





The Mystic Lakes System

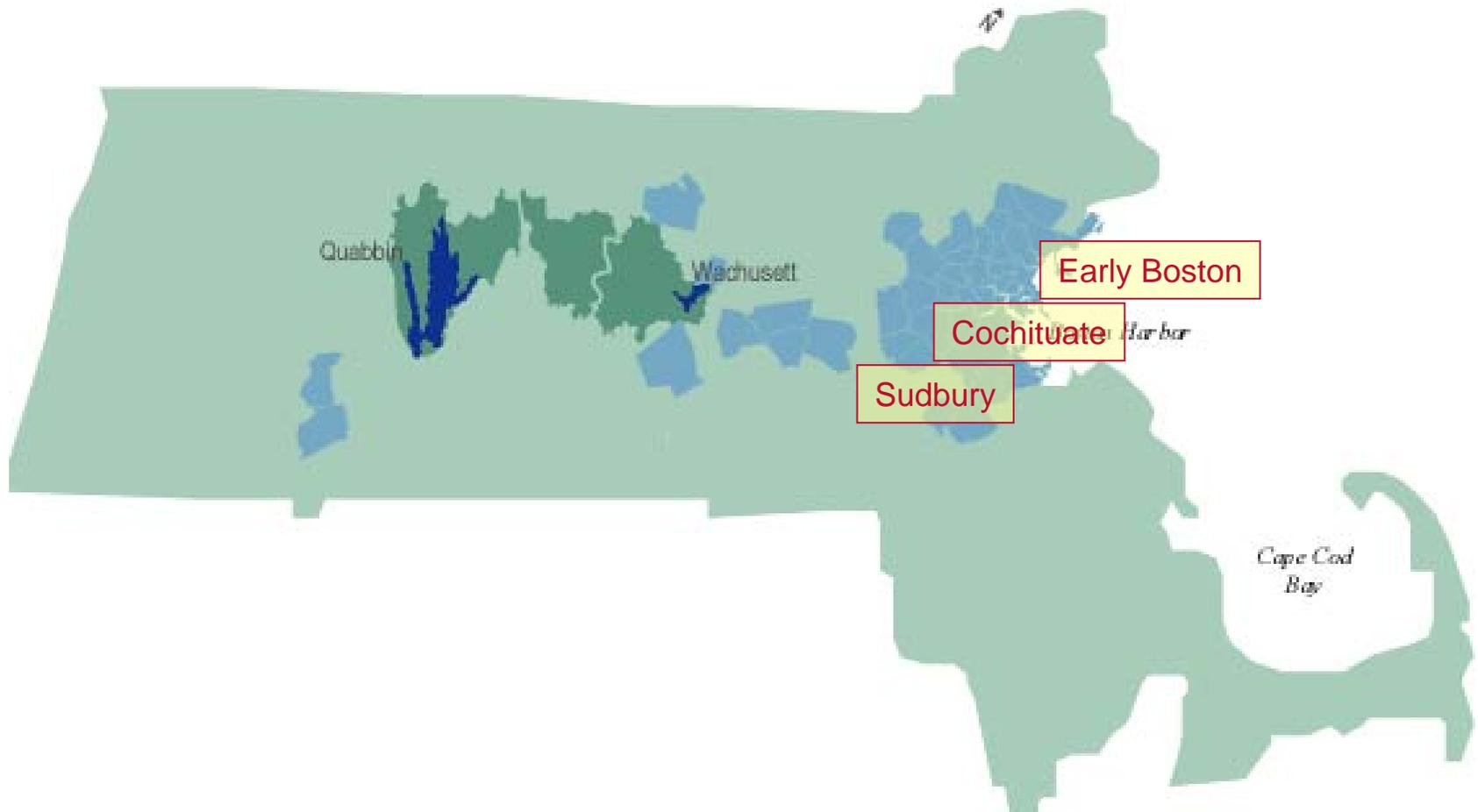
- By 1870, Boston's population soared to 200,000
- In 1870 the Mystic Lakes System in Winchester, Medford and Arlington was added to the Boston System
- But engineers soon looked west for a larger source



Mystic Reservoir at Tufts College



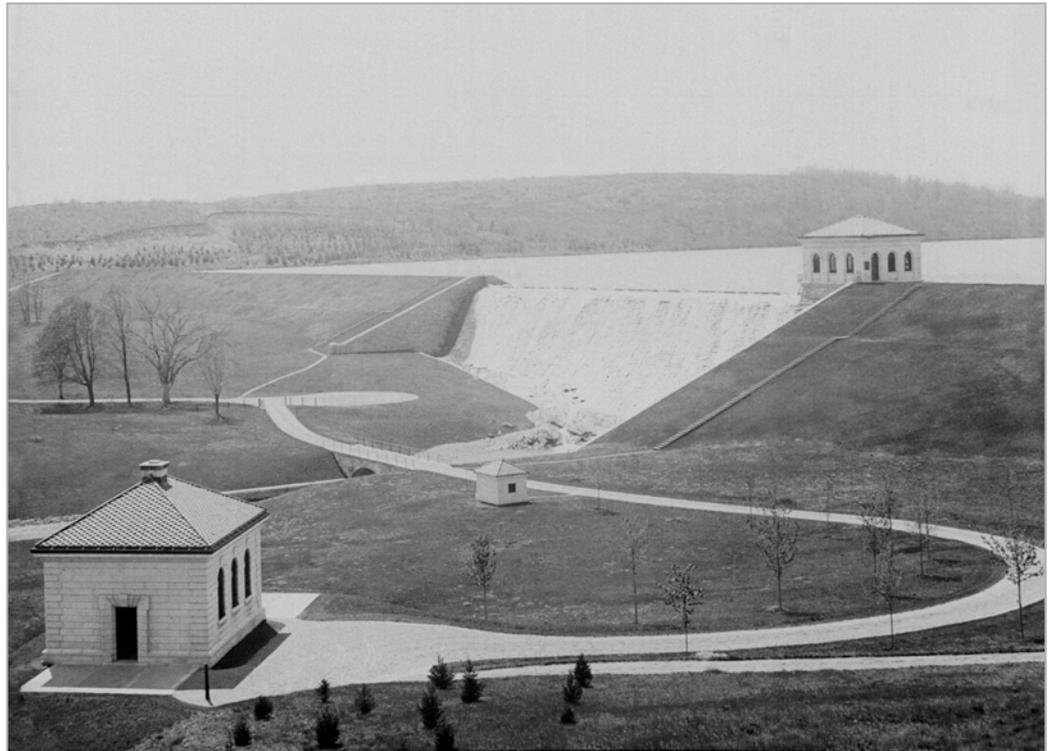
Water System History - A Journey Westward





The Sudbury System

- In 1878, the Sudbury River, 18 miles from Boston, was diverted through the Sudbury Aqueduct to the Chestnut Hill Reservoir
- By 1898, the Fayville Dam and the Sudbury Reservoir were completed



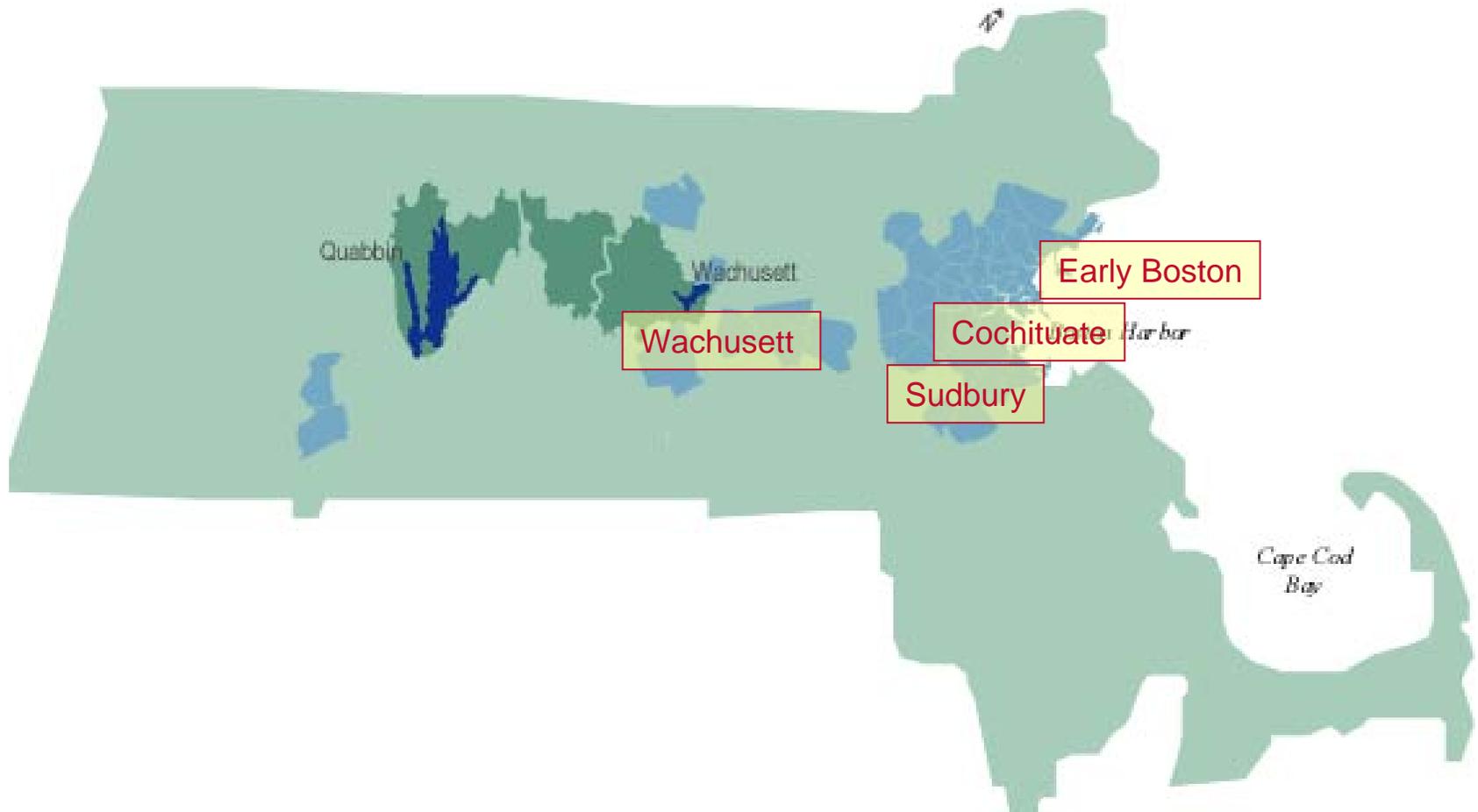


Soon - A Regional Solution Was Needed

- Boston continued to grow rapidly in the 1880s and 1890s
- And planners had not foreseen the advent of **indoor plumbing**
- In 1895 the Metropolitan Water District was formed to serve 11 cities and towns with a population of 750,000 and a water demand of 70 million gallons per day
- New water sources were considered: the Nashua River, the Merrimack River, Lake Winnepesaukee and Sebago Lake



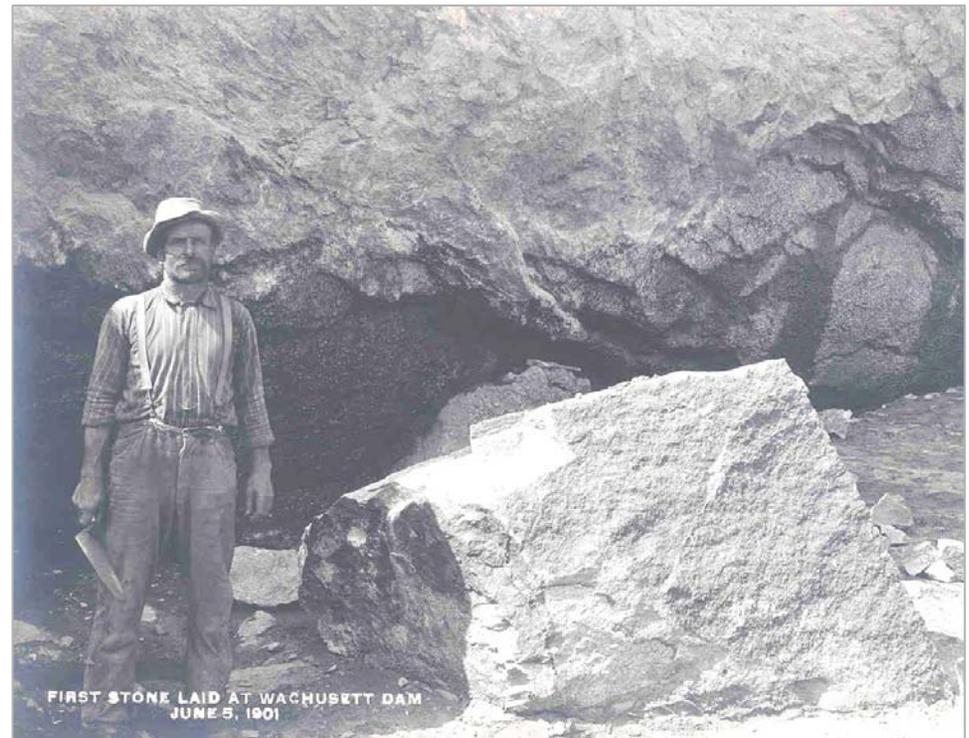
Water System History - A Journey Westward





The Wachusett Reservoir

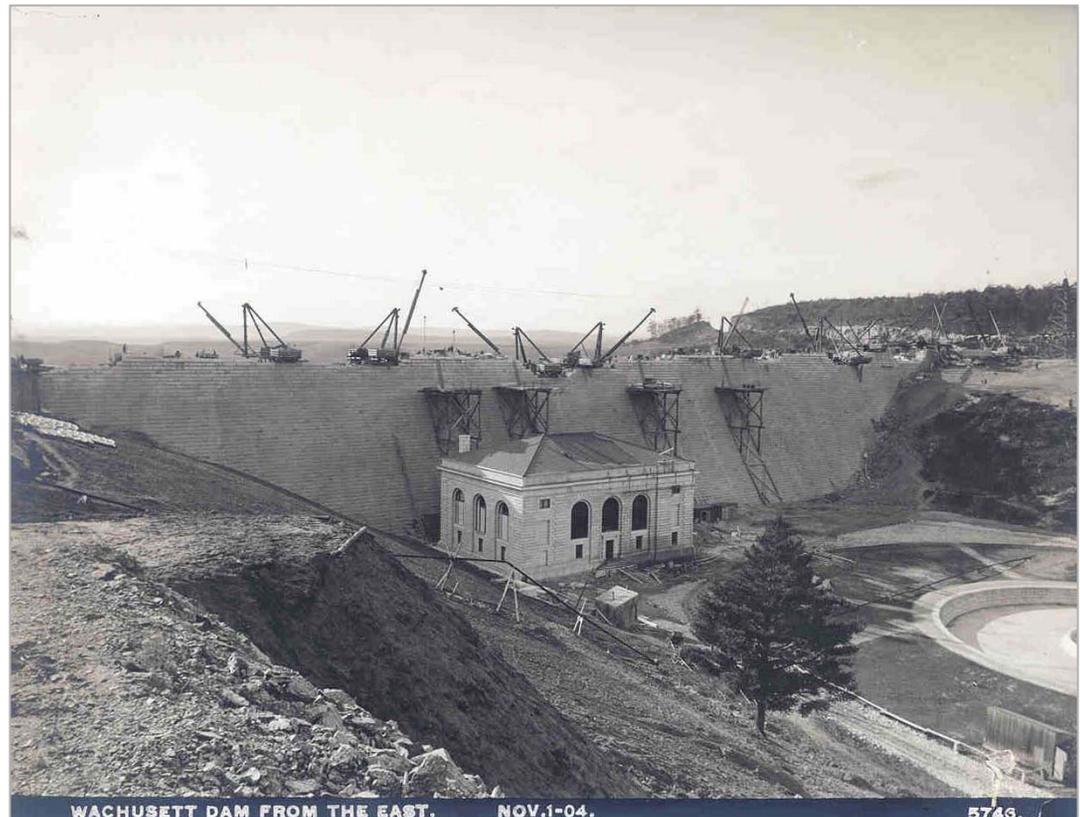
- Chief Engineer Frederick Stearns planned a water source that would be gravity-operated and not require filtration
- In 1897, the site was chosen - the Nashua River was impounded by the Wachusett Dam, 38 miles from Boston
- 6.5 square miles were flooded in the towns of Boylston, West Boylston, Clinton and Sterling





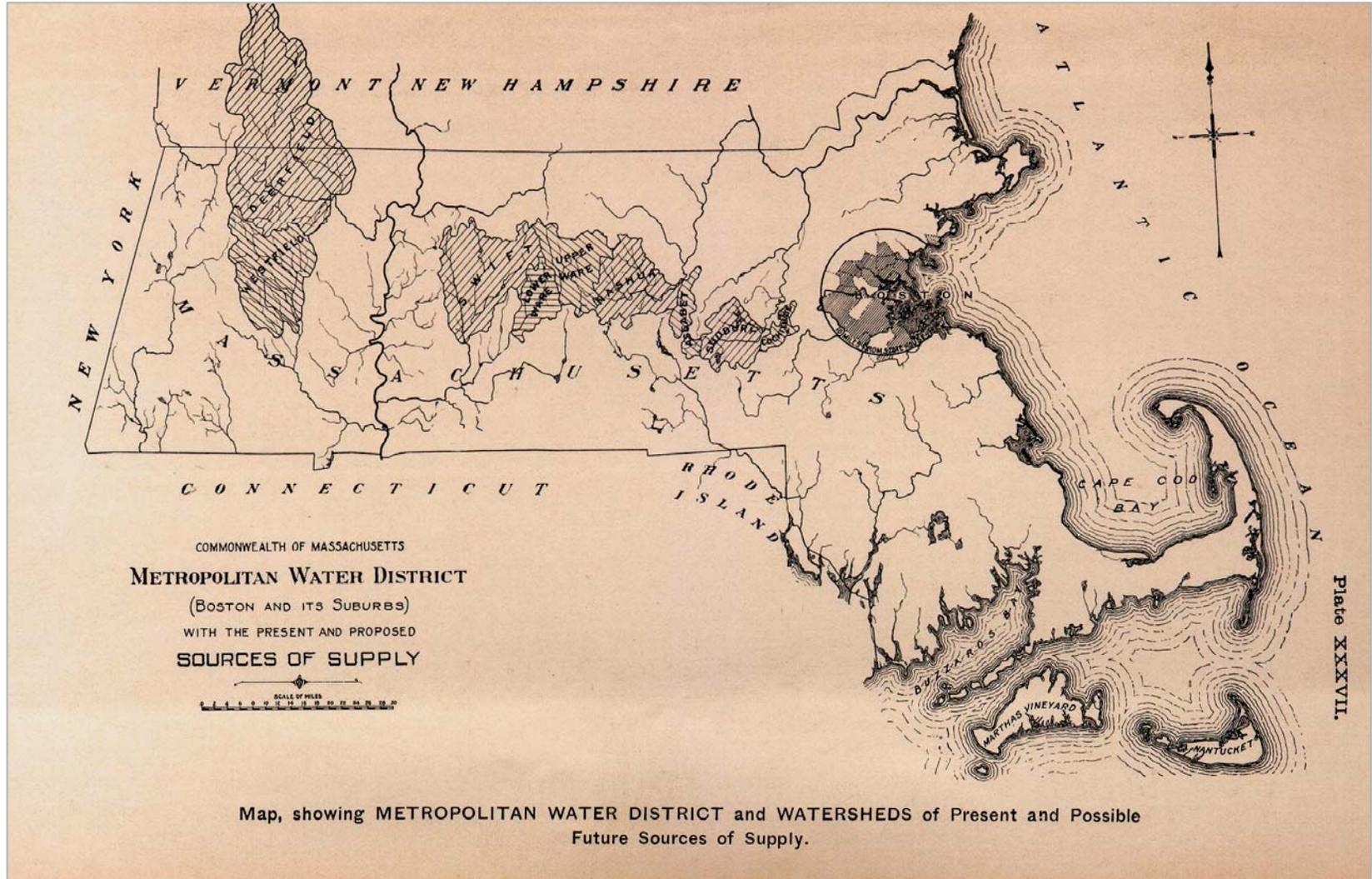
The Wachusett Reservoir

- At the time it was constructed, the Wachusett Reservoir was the largest man-made water supply reservoir in the world
- Its 65 billion gallons supplied 118 million gallons per day
- Work was completed in 1905 and the reservoir filled in May 1908





But Even In 1895, Engineers Set Their Sites Further West



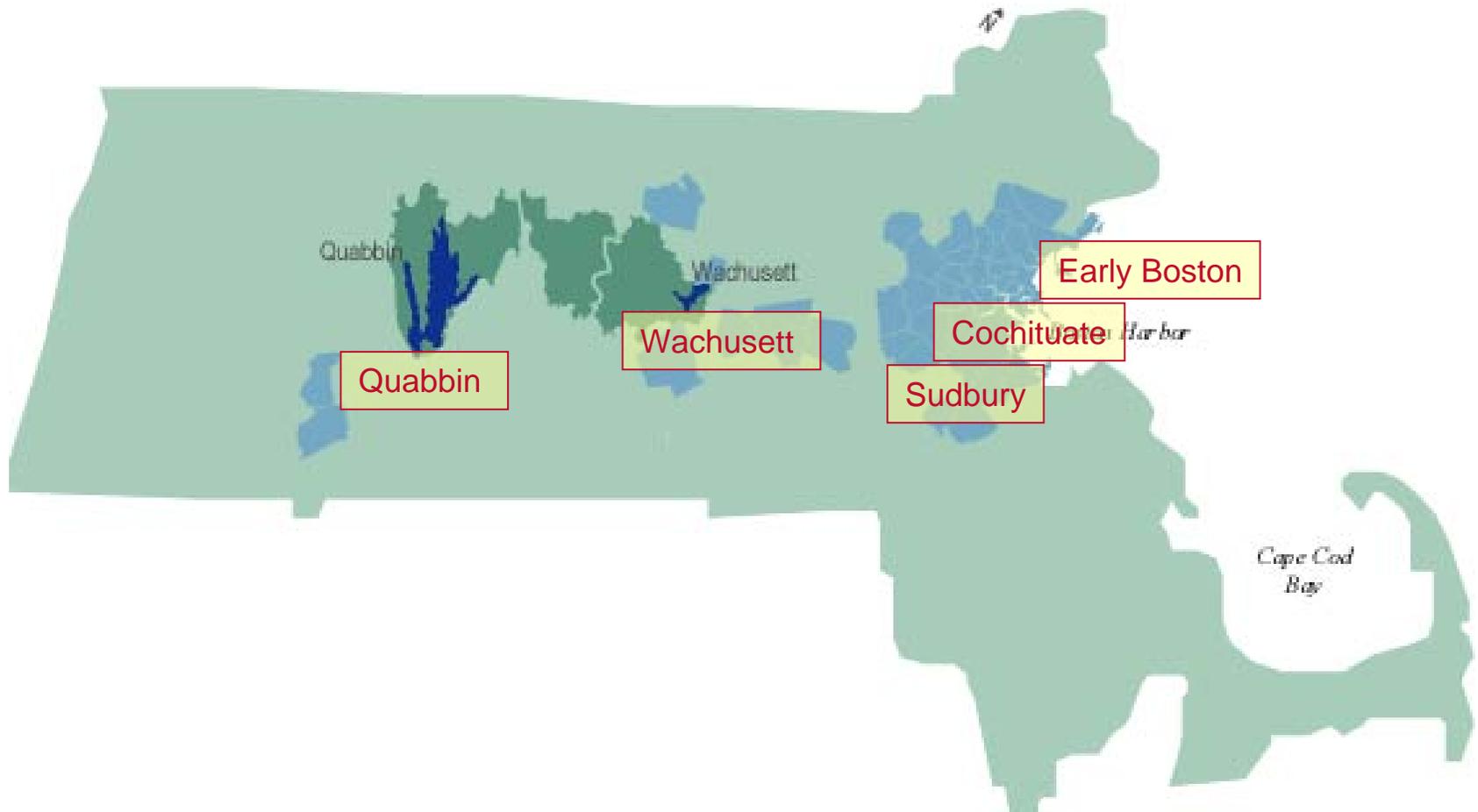


And Planning Was Soon Underway

- In 1919, the Metropolitan District Commission was created consolidating responsibility for water, sewage and parks
- The MDC and the Department of Public Health were appointed to a Joint Board by the legislature to study water supply needs
- The Joint Board made projections to 1970 and determined current water supply would be inadequate by 1930
- In 1922, the Joint Board recommended the addition of the Ware River and the Quabbin Reservoir to the MDC water supply system
- The Quabbin Reservoir, 60 miles from Boston, could be gravity-operated and not require filtration



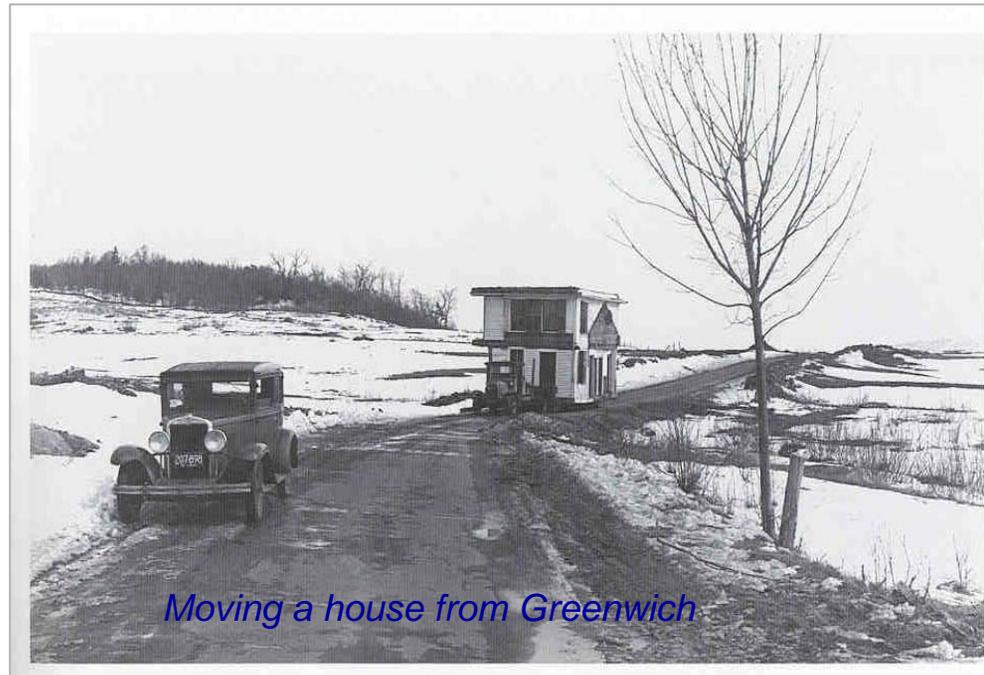
Water System History - A Journey Westward





The Quabbin Reservoir

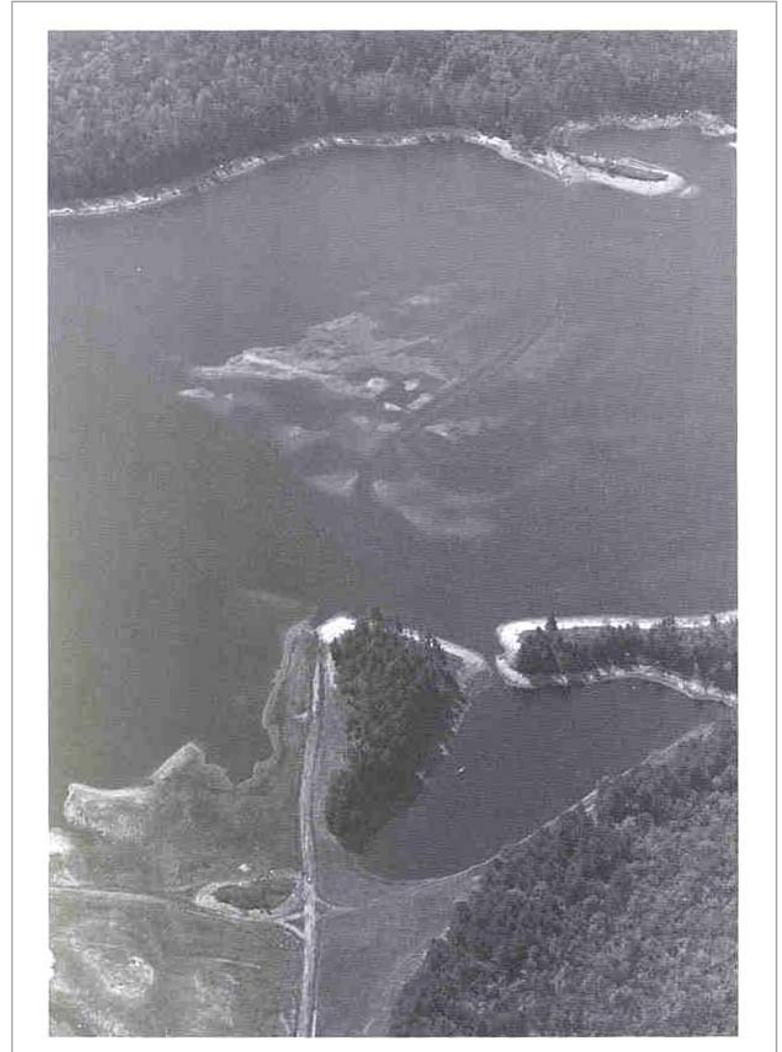
- Construction of the Wachusett-Colebrook Tunnel (now the Quabbin Tunnel) began in 1926, carrying flow from the Ware River to the Wachusett Reservoir.
- In the 1930s, the Tunnel was extended to the Swift River.
- This two-way tunnel carries flows east and west.
- In 1936, construction of the reservoir began.
- Construction of the Quabbin required the impoundment of the Swift River and the takings of four towns.





The Quabbin Reservoir

- The reservoir was filled with water from the Swift River and the Ware River
- Filling began in 1939 and was completed in 1946
- At the time, the 412 billion gallon reservoir was the largest man-made reservoir in the world



Road still visible beneath surface of water



Current Reservoir Capacity

Quabbin Reservoir

Storage: 412 billion gallons

Depth: 150 feet

Length: 17.9 miles

Width: 3 miles



Wachusett Reservoir

Storage: 65 billion gallons

Depth: 129 feet

Length: 8.5 miles

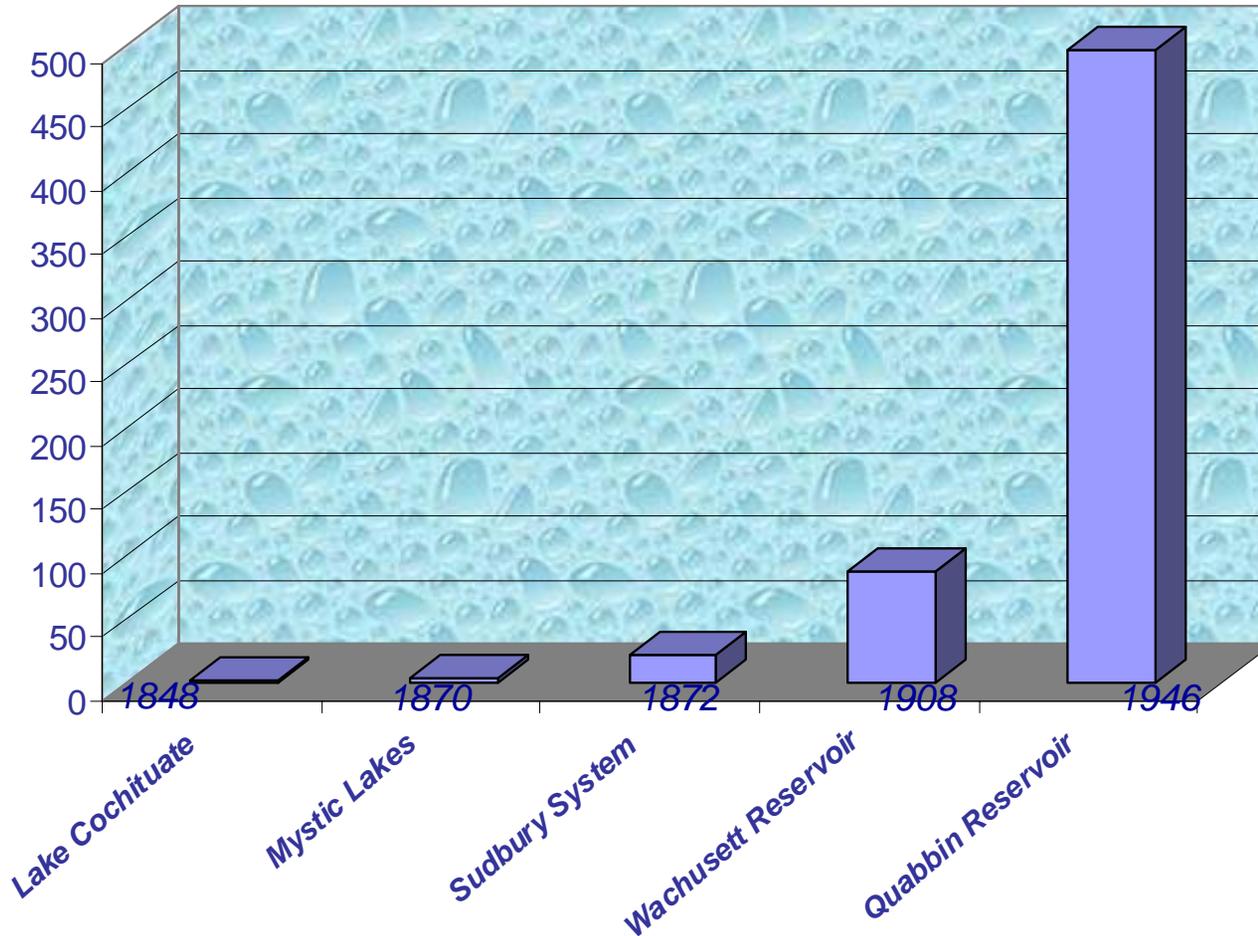
Width: 1 mile





Cumulative Water Supply Capacity

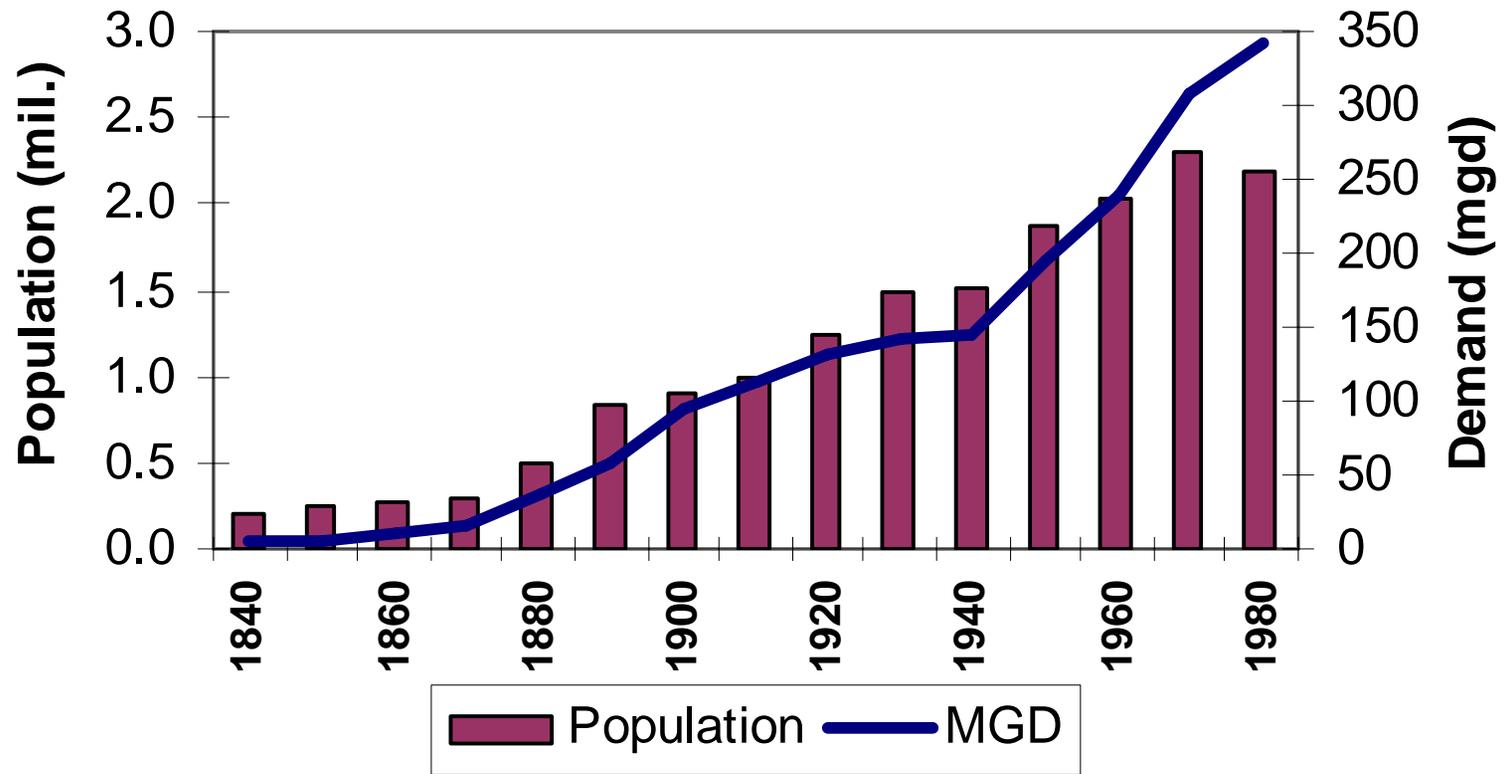
Billion Gallons





Population Growth & Water Usage Kept Growing

MWRA System Water Demand vs. Population





Demand Exceeded Safe Yield

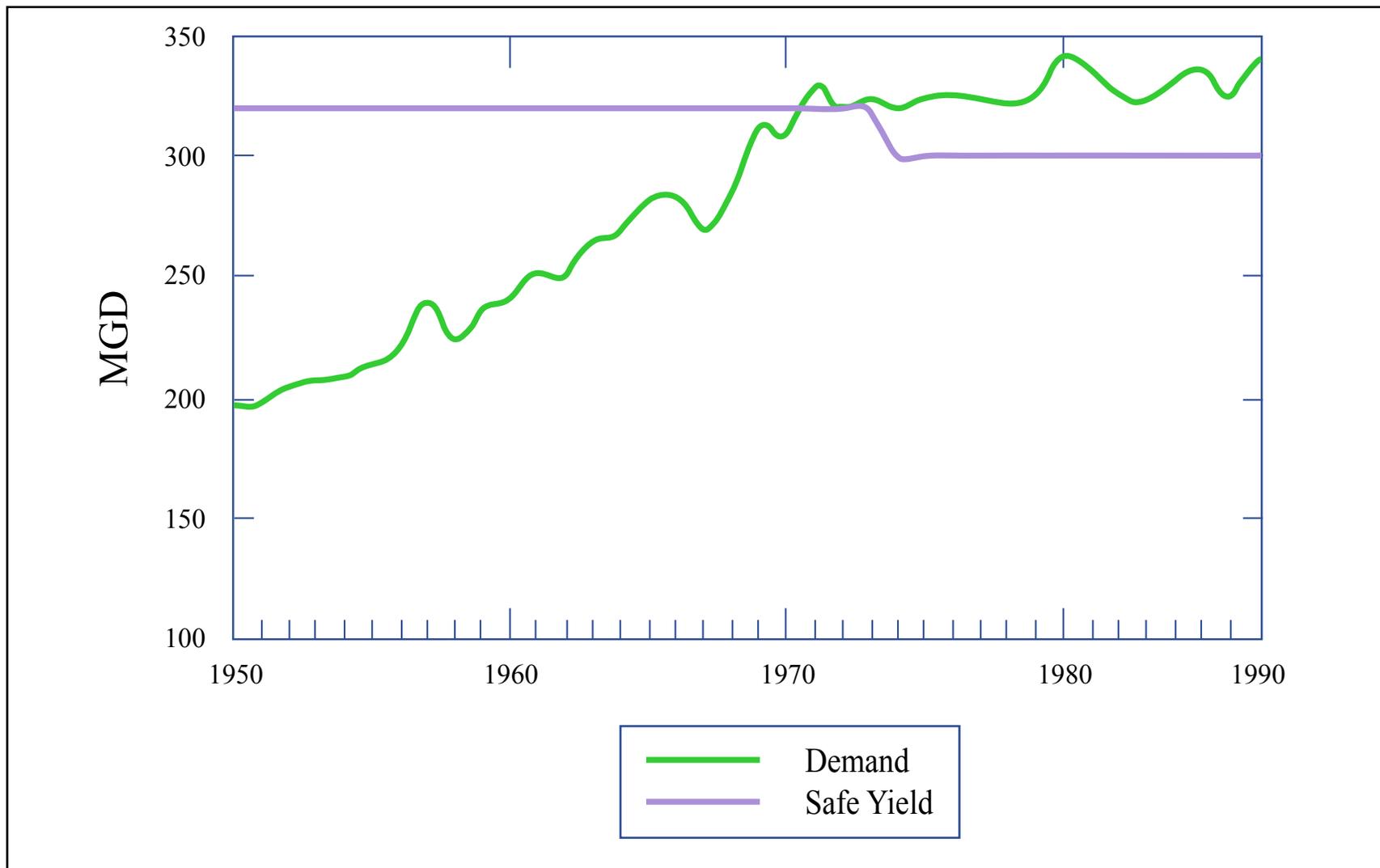


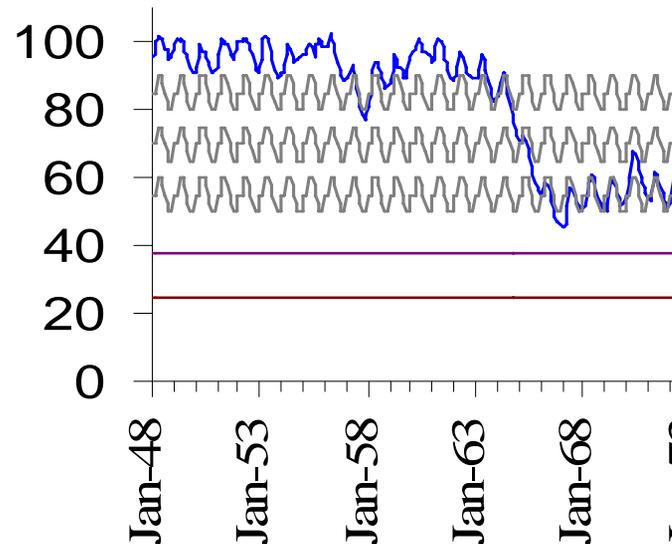
Figure by MIT OCW.

1987



Northeast Drought

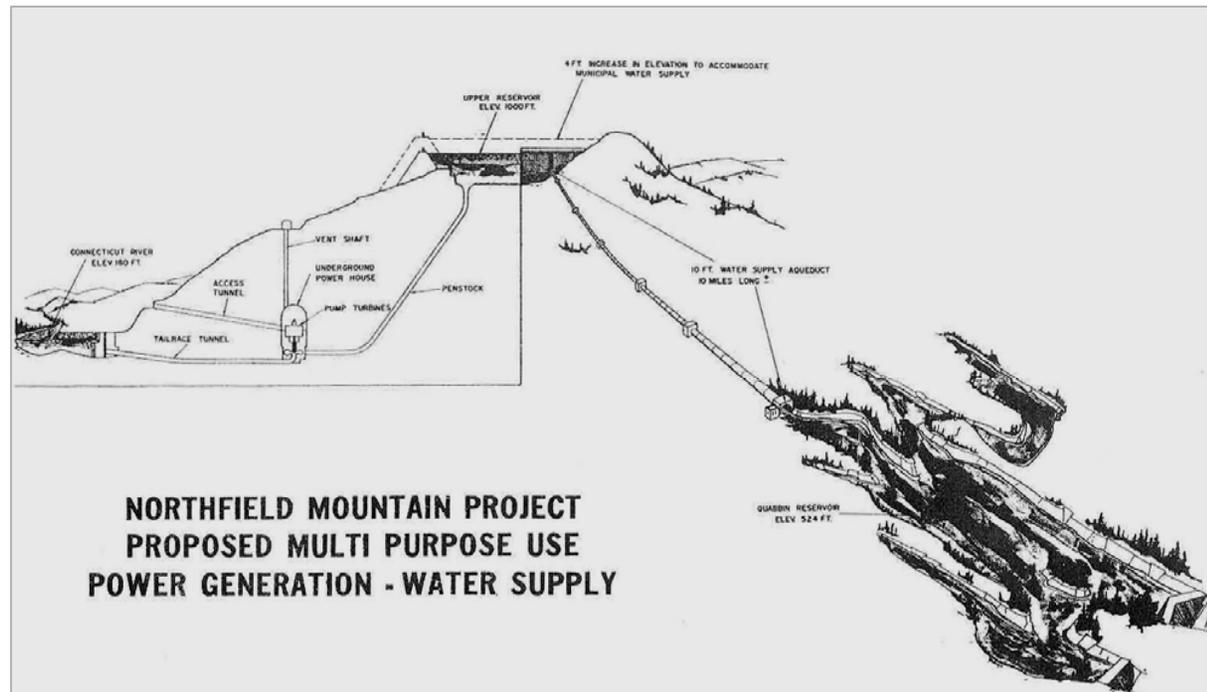
- Just 20 years after Quabbin was completed, the drought of the 1960s led some to believe that the source might not be sufficient to serve water needs in the decades to come
- Capacity of the Quabbin Reservoir reached a historic low of 44% in May 1967





Studies For Northfield Mountain Project

- The Northfield Project was a proposal for skimming Connecticut River spring flood flows and diverting them into the Quabbin Reservoir, using a pumped-storage facility
- The measure was authorized by the legislature in both 1967 and 1970
- The storage was built into the Northfield Mountain power reservoir.





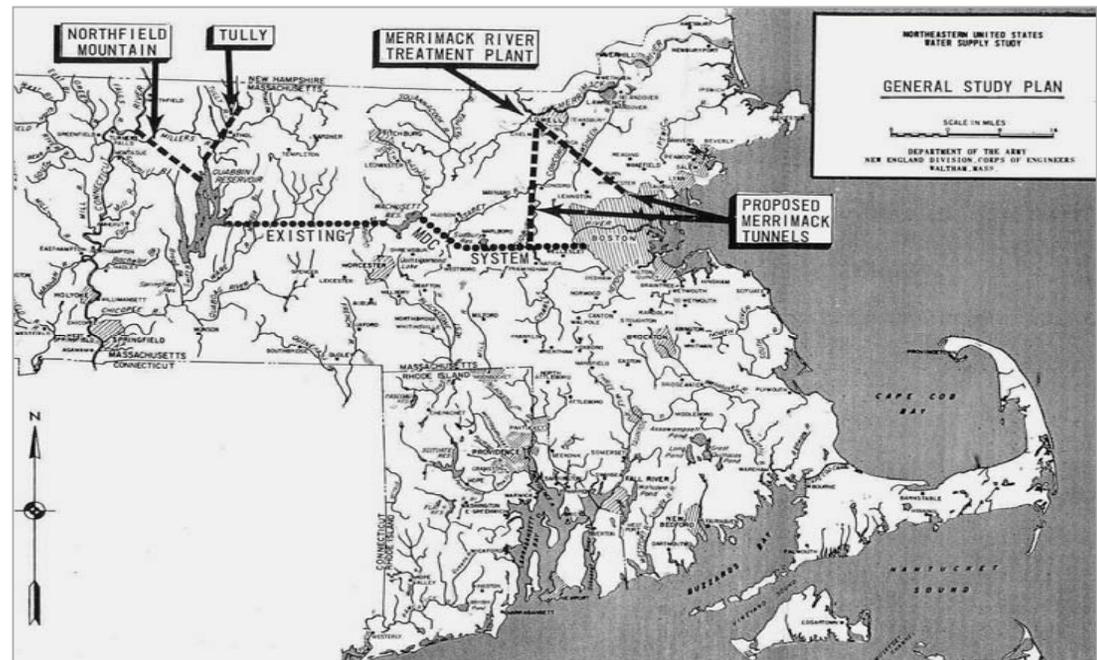
Water Management Era Begins

- Earth Day and the rise of the environmental movement
- Citizen awareness and participation increased
- Founded as the Northfield Citizens Advisory Committee in 1977, the Water Supply Citizens Advisory Committee continues today
- MEPA established to open up decision-making
- Coalition forms against Connecticut River diversion and exploits Western Massachusetts resentment toward Boston
- State of Connecticut fights plan and threatens lawsuit



Nine Alternatives To Be Considered

- Demand Management
- No Action
- Connecticut River
- Watershed Management
- Millers/Tully Rivers
- Merrimack River
- Upper Sudbury
- User Sources
- Plymouth Aquifer





MWRA Formed

- MWRA began operations in 1985
- MDC retains watershed and reservoir management
- MWRA reviews Long Range Water Supply Study begun by MDC that included diversion options of Connecticut, Merrimack and Sudbury Rivers
- Extensive briefing and consultation process
- In November 1986, the Board of Directors voted to try water conservation for a 3-year period to curb demand



25 Separate Short and Long Term Policies

- Leak Detection, Repair and Metering
- Conservation and Demand Management
- Improved Use of Sources
- Water Supply Protection
- Management and Planning for the Future
- Outreach and Reporting

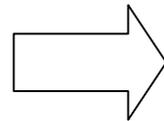


Demand Management Strategy

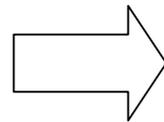
WATER USE

Residential Toilet Shower Laundry Kitchen Tub & Sink Outdoor
Industrial Commercial Institutional Process Cooling Sanitary
Unaccounted For Water Leakage Meter Errors Public Use Other

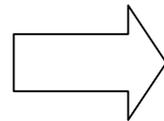
Problem



Inefficient Fixtures
Poor Water Habits

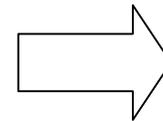


Inefficient Fixtures
Once Through Cooling
Inefficient Process Use

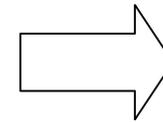


Leakage
Meter Errors

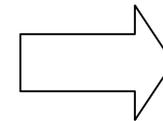
Response



Retrofit Fixtures
Public Education
School Education
Efficient Technology



Technical Assistance
Water Audits
Technology Transfer
Training & Education



Leak Survey & Repair
Test/Replace Meters

Multimedia Approach

<u>Purpose</u>	<u>Technique</u>	<u>Distribution</u>
Make consumers Aware	Bill Stuffers Messages on Water Bills Brochures Displays Public Service Announcements Press Releases	Utilities direct mail Community centers Town halls, Libraries Special events Radio, TV, Cable Local Media
Respond to Questions Facilitate Decisions	Fact Sheets FAQ's Newsletters Speakers Bureau Resources Network Customer Service Training Personal contact Independent, credible sources Partnerships Newsletters	On Request Workshops Community Meetings WEB site Employee Workshops Community Meetings Customer hotline



Water Savings at Home

- MWRA's Operation WaterSense in 1990s installed 1.3 million water saving fixtures in approximately 350,000 households.
- Public Education Outreach
- School Education program promotes water conservation awareness
- Code Changes Locally and Nationally



Promote Water Efficient Technologies

- Ultra Low Flow Toilets
- Energy Efficient Appliances



Water Savings In Businesses and Institutions

- Identify Possible Efficiency Improvements with Audits
- Demonstrate Their Effectiveness through Implementation
- Reach Out and Publicize Success

- Increasing Cost of Water and Sewer Service No Small Incentive

- Market Forces and Private Firms Keep it going



Source Protection and Development

- 1970's Saw Many Sources Lost Due to Newly Identified Contaminants
- MWRA Concern:
 - MWRA Partially Supplied Communities Will Lose Their Sources
 - Adjacent Communities will Need MWRA Water
- MWRA Program:
 - 40 Local Community Source Protection Studies
- Potential New or Rehabilitated Sources Identified



Management and Planning for the Future

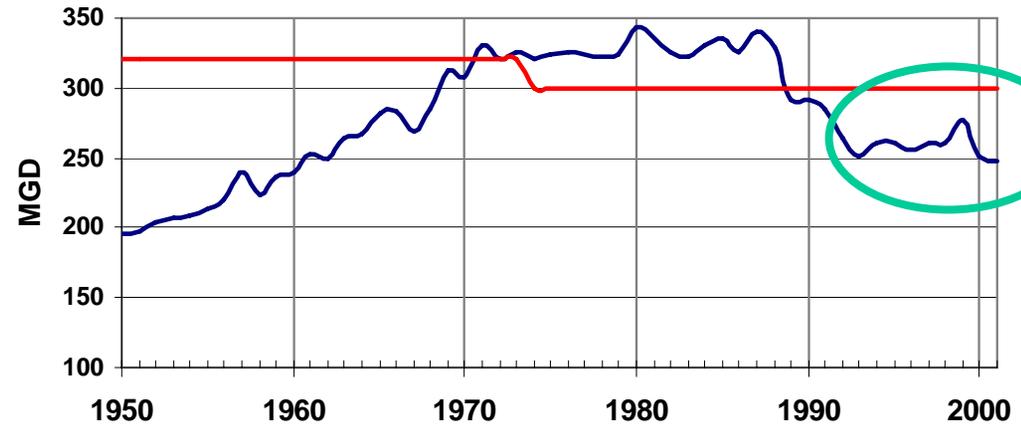
- Drought Preparedness Planning
- Redundancy Studies
- Conservation Policies For Contract Users and New Communities
- Routine Review of Leading Indicators on Demand
- Better Source Performance Indicators to Evaluate New Users
 - Not Just Safe Yield, but a Whole Suite of Tools



Conservation Worked!

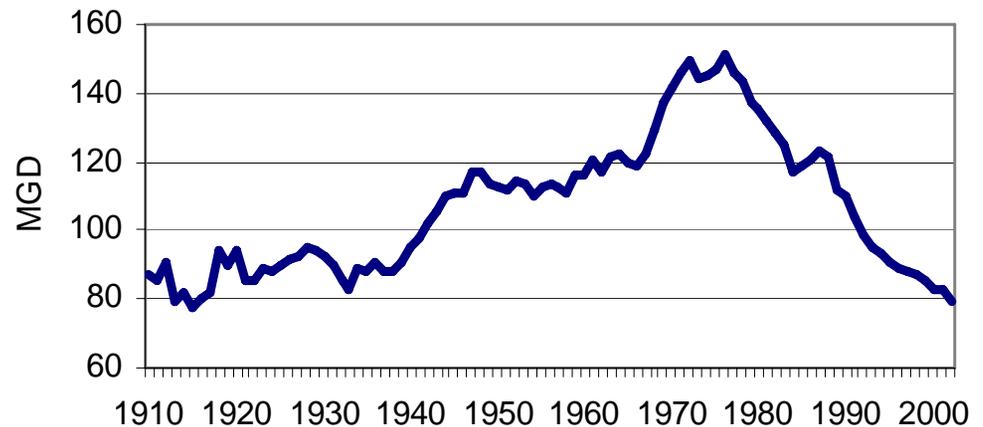
- Total System Demand was reduced from 336 in 1987 to 256 mgd in 1997

MWRA Annual Average System Demand



- Boston's Demand is the Lowest Since 1915

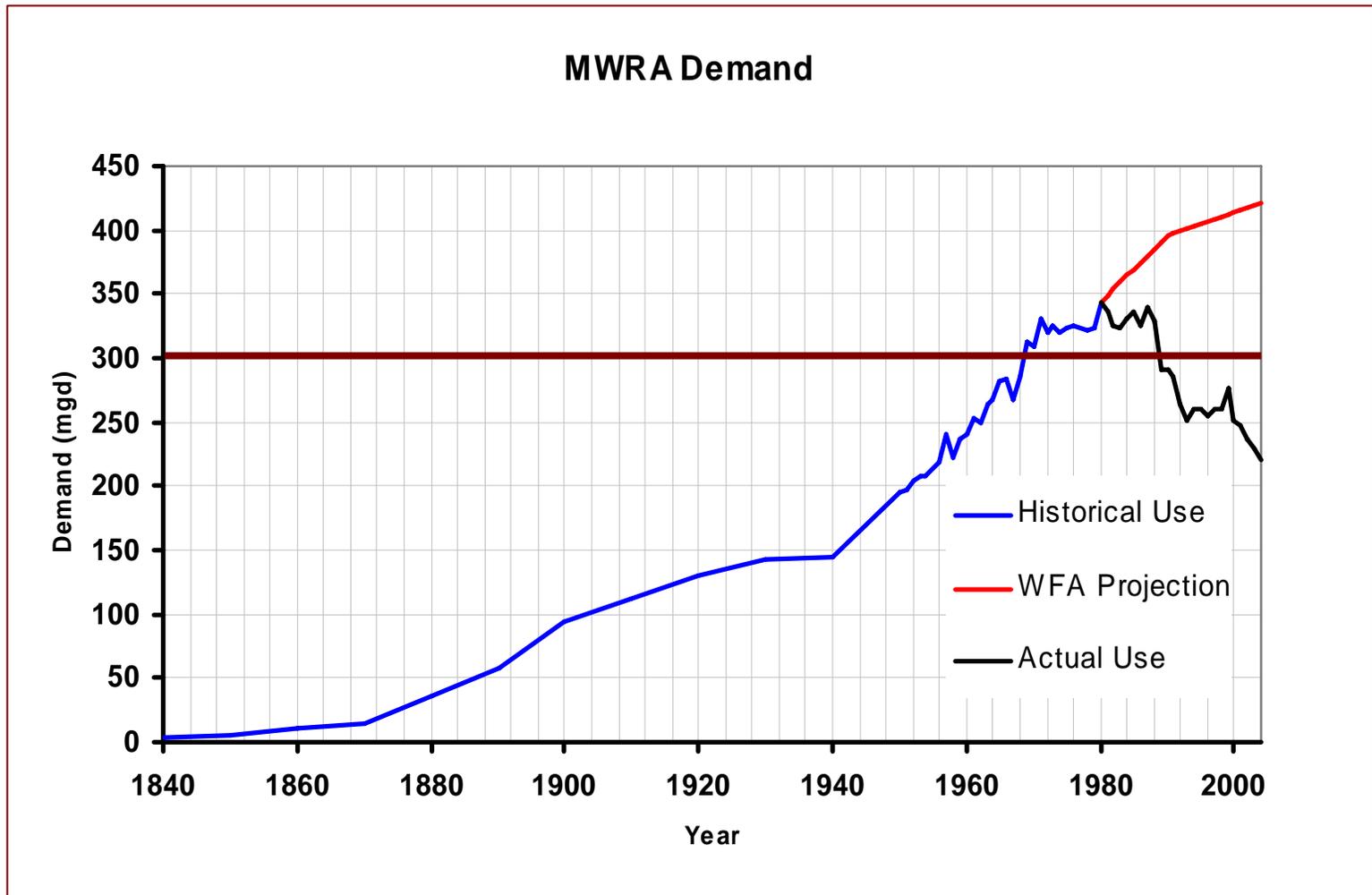
City of Boston Water Demand
1910 - 2002





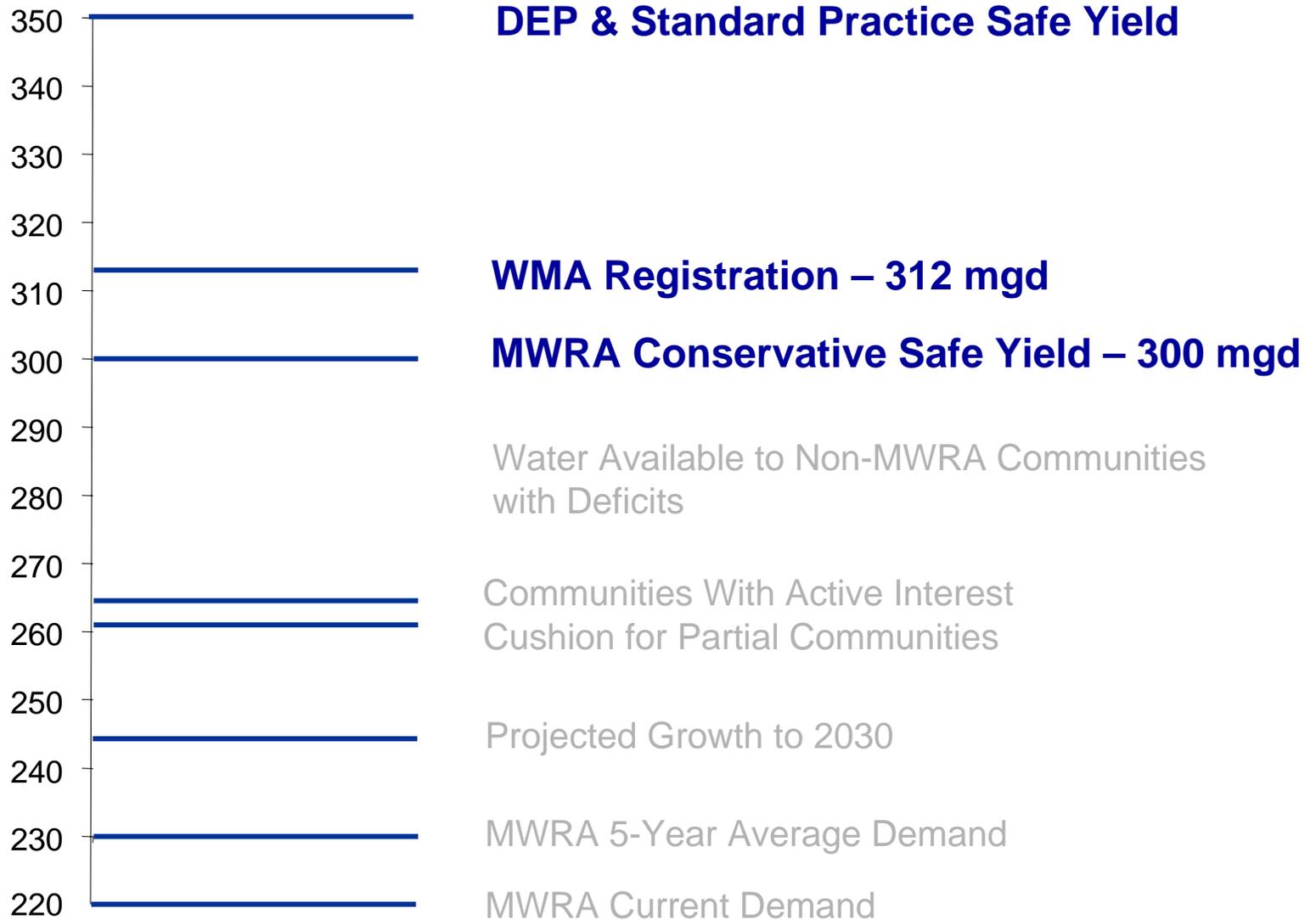
What Happened to Demand?

Real Versus Projected Demand Shows the Dramatic Change



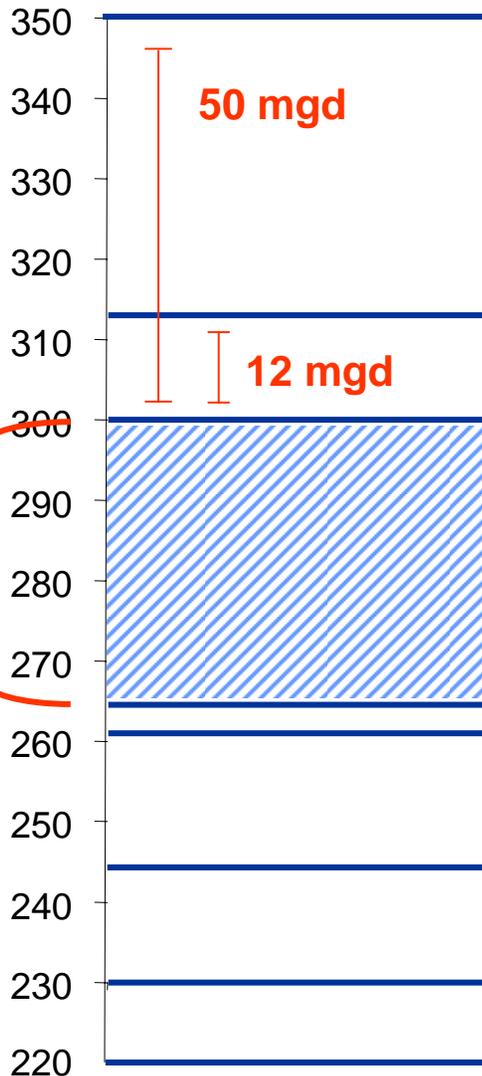


MWRA Current Demand





Conservatively, We Have 36 MGD Available



DEP & Standard Practice Safe Yield

WMA Registration

MWRA Conservative Safe Yield Estimate

Water Available to Non-MWRA Communities with Deficits

Communities With Active Interest
Cushion for Partial Communities

Projected Growth to 2030

MWRA 5-Year Average Demand

MWRA Current Demand

36 mgd

50 mgd

12 mgd



“Safe Yield”

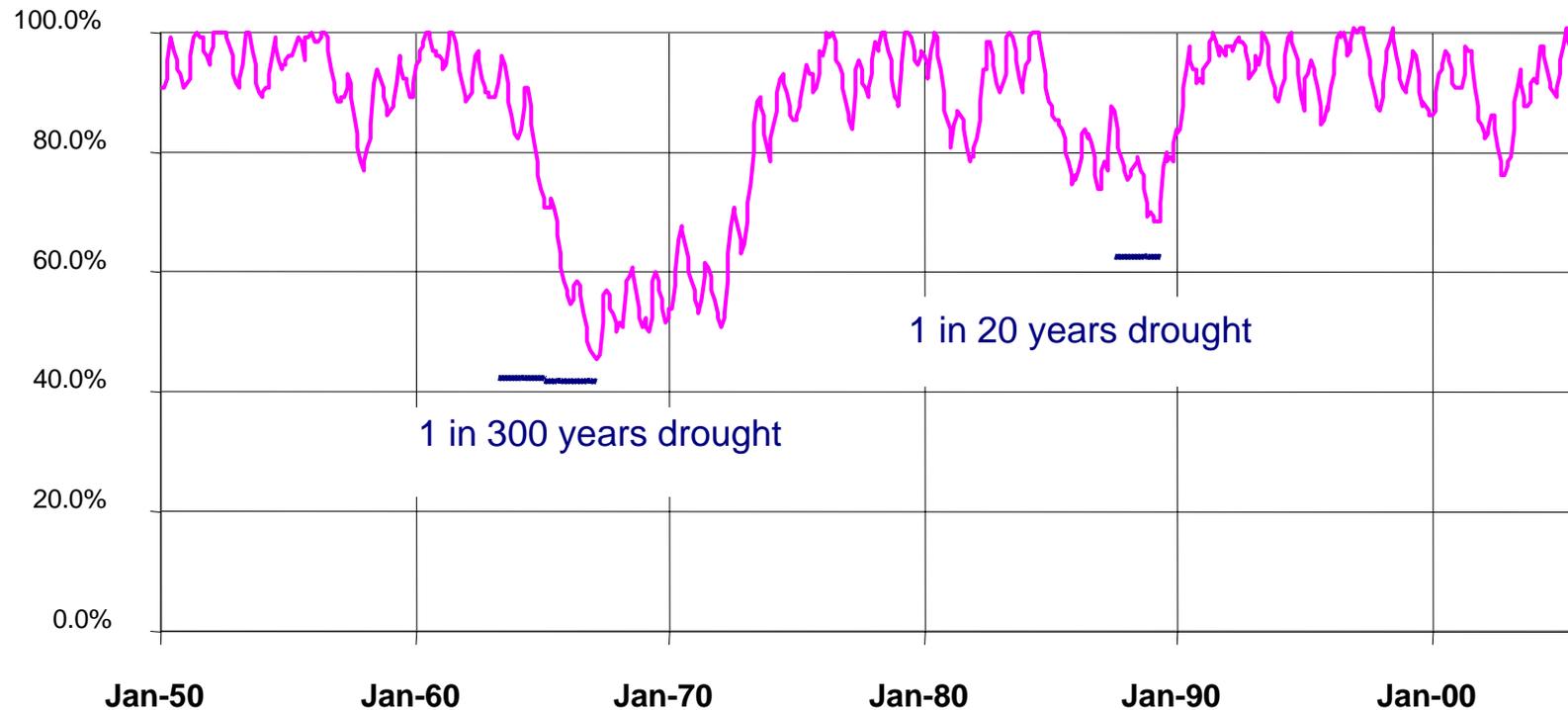
- DEP Safe Yield & Standard Engineering 355 mgd
- All Time Highest Usage 1980 342 mgd
- WSCAC 1984 318 mgd
- WMA Registration 312 mgd
- MWRA Conservative Estimate 300 mgd

Net of 31 million gallons of required releases



Conservative Estimate Available Safe Yield

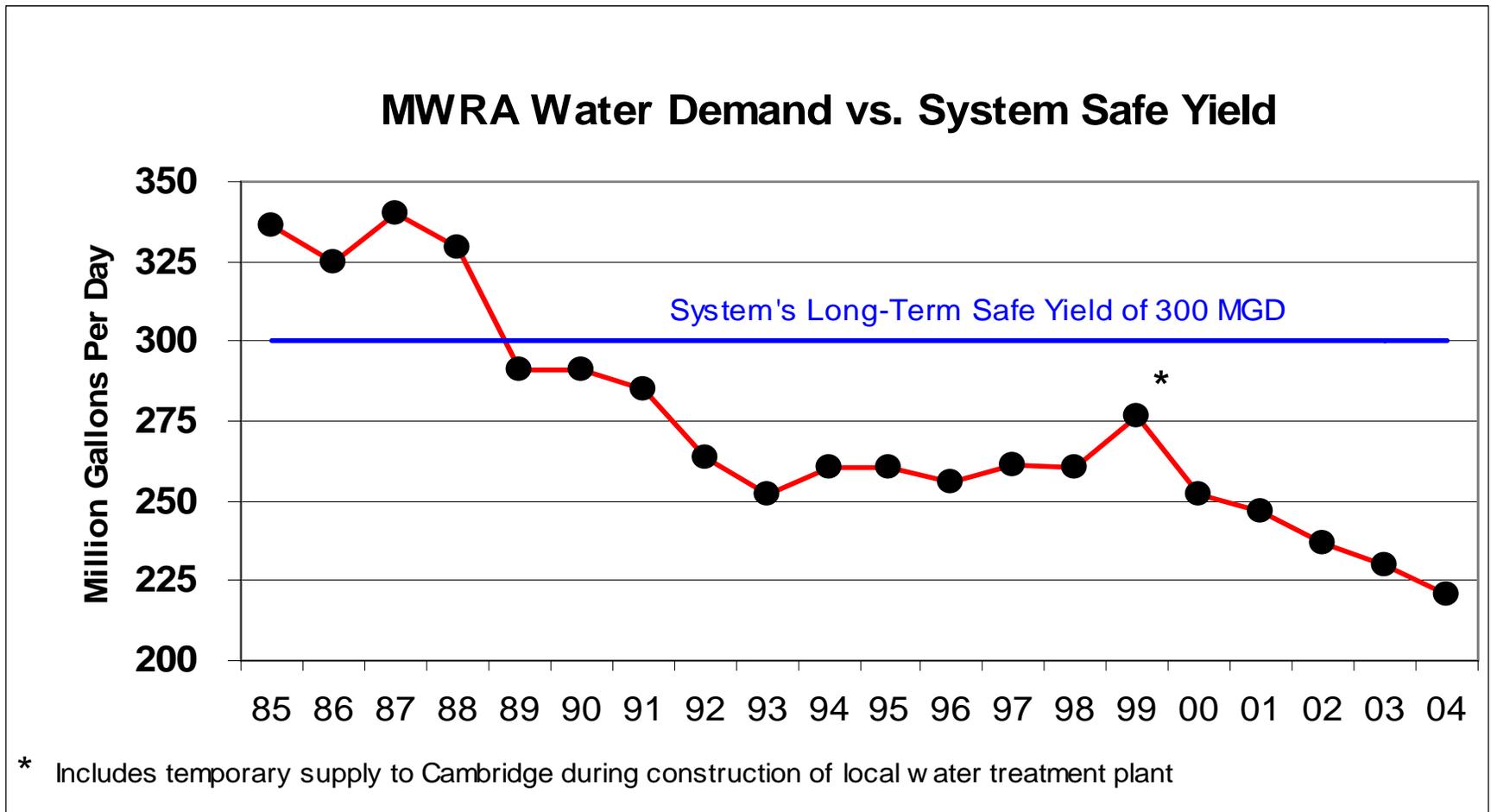
- MWRA Uses the 1960's Drought:
 - a One in 300+ Year Event





MWRA Current Demand

- Current 5-Year Running Average – 225 mgd





Summary of Demand Assumptions

Build-Out Analysis	High Estimate	Medium Estimate	Low Estimate
Indeterminate Timeframe	2030 MAPC Population and Employment	2030 MAPC Population and Employment	2030 MAPC Population and Employment
Every Lot in Region is Developed	No Demand Reductions by Current Users	Continued Efficiency Changes Small Decrease in Local Source Availability	More Aggressive conservation