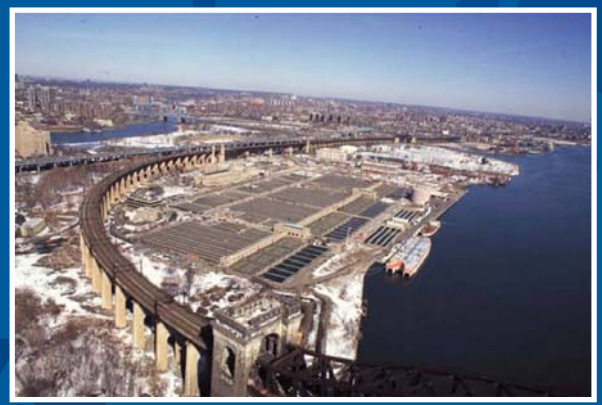
New York City Department of Environmental Protection

Adapting NYC's Water Supply and Wastewater Treatment Systems to Climate Change



Emily Lloyd, Commissioner
New York City Department of Environmental Protection

U.S. Climate Change Science Program Workshop
Water Management: Application of Climate Science
November 15, 2005 • Arlington, Virginia

NYCDEP Climate Change Program

Mission Statement

Ensure that NYCDEP's strategic and capital planning take into account the potential risks posed by climate change—sea level rise, higher temperature, increase in extreme events, and changing precipitation patterns—on the City's water supply and wastewater treatment systems.

Why Should NYCDEP Study and Address Climate Change?

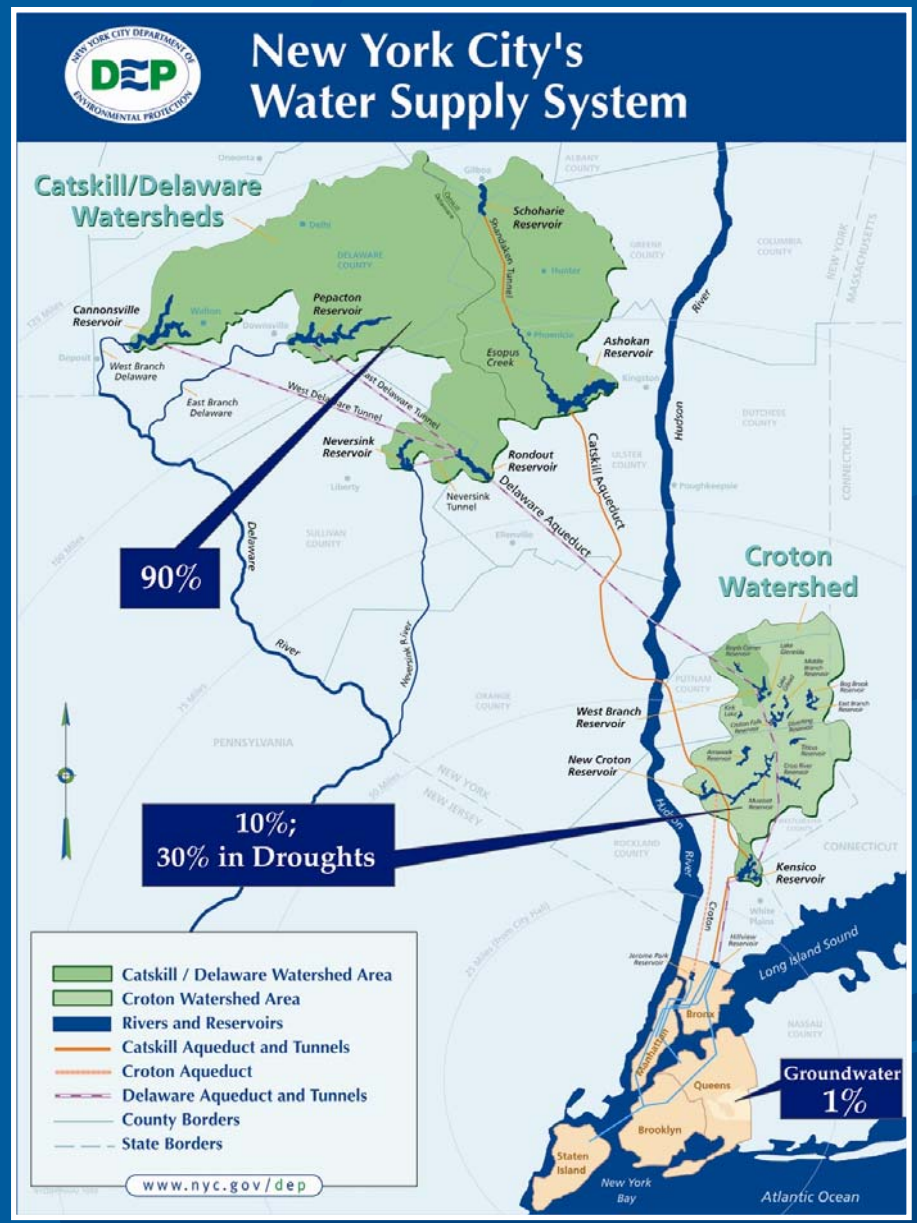
NYCDEP:

- Provides drinking water to 9 million New Yorkers
- Operates NYC's water distribution and sewer systems
- Treats NYC's wastewater: All 14 water pollution control plants (WPCPs) located on waterfront property
- Maintains integrity of local water bodies: Sewage discharge impairs harbor and estuaries

$17 billion capital plan over next decade; responsible capital planning requires consideration of potential impacts of climate change on NYC's water systems: Are we investing wisely?

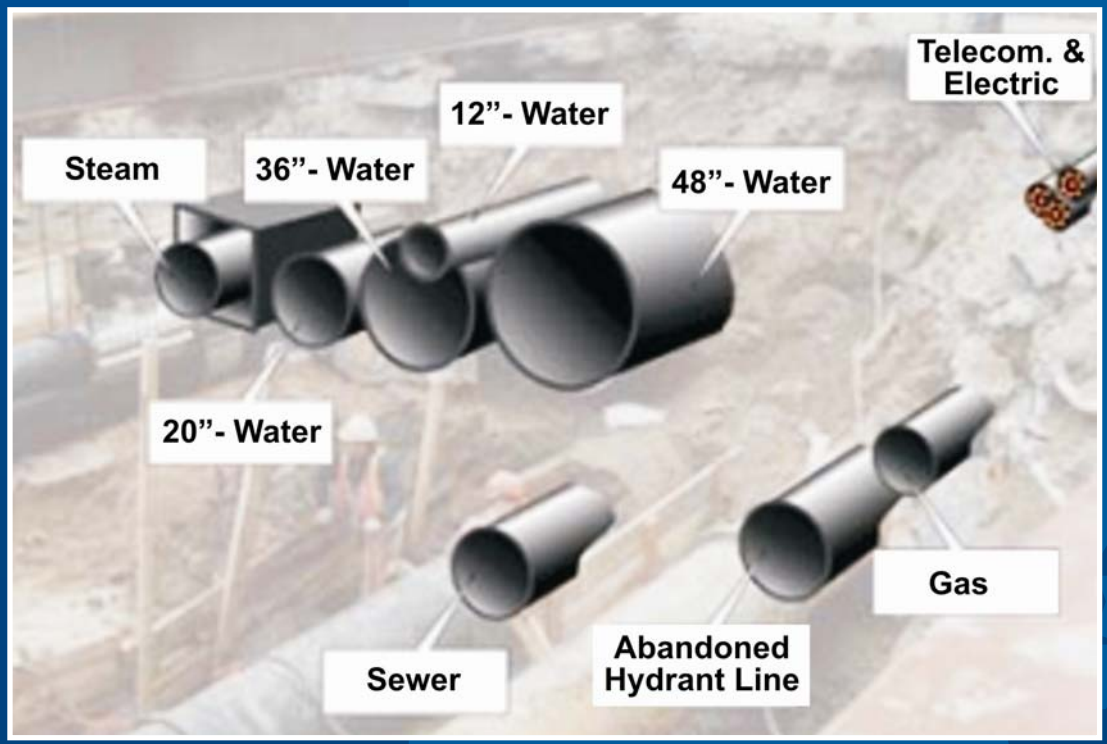
NYCDEP Water Supply System

- 9 million consumers
  - 8 million in NYC, 1 million Upstate
- 1.35 billion gallons/day delivered
- 2 surface water supply systems
  - 580 billion gallon capacity
  - Catskill/Delaware Watershed
    - Unfiltered system – Filtration Avoidance Determination from EPA
  - Croton Watershed
    - Filtration plant under construction (operational 2011)
- 1 groundwater system
  - Brooklyn/Queens Aquifer
    - Provides ~1% of supply
- 18 collecting reservoirs, 3 controlled lakes, 2 balancing reservoirs



NYCDEP Water Distribution and Sewer Systems

- 6,500 miles of water mains
- 6,500 miles of sewer systems
  - sanitary, storm, and combined
- 450 combined sewer outfalls (CSOs)

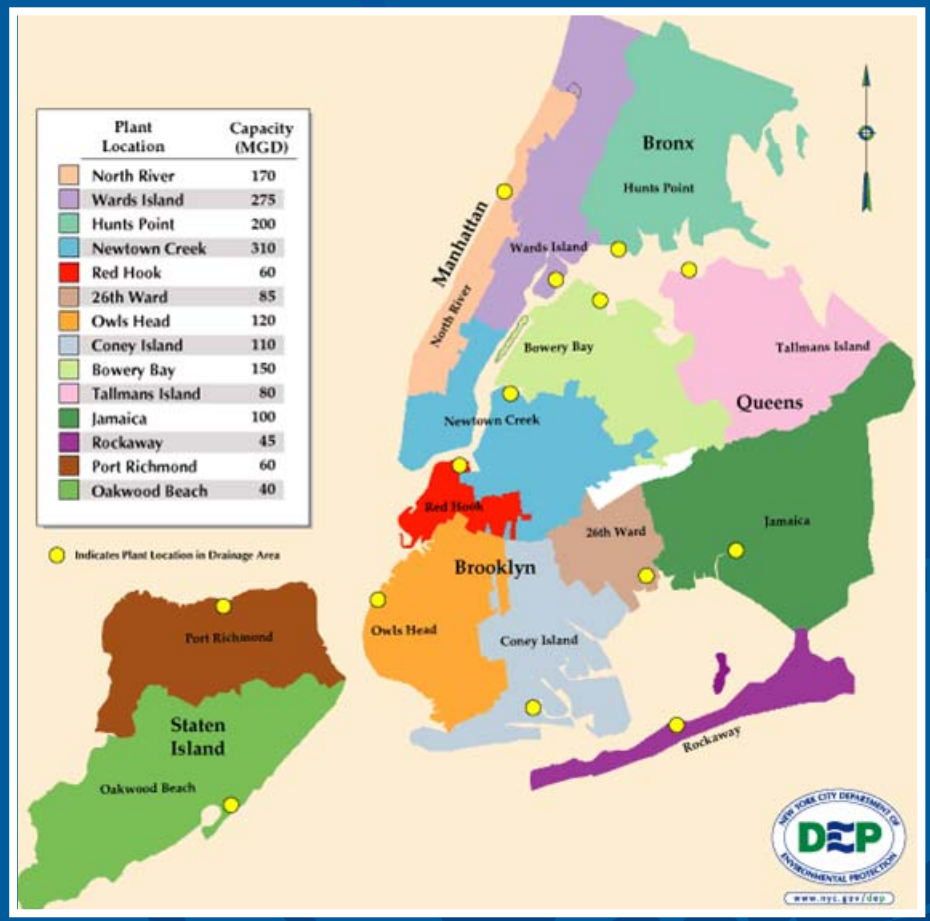


Cross Section of NYC Street Showing Utilities

- Staten Island Bluebelt Program
  - Restores and preserves wetlands that are then used as a natural alternative to storm sewers
  - Drains over 14,000 acres

NYCDEP Wastewater Treatment System

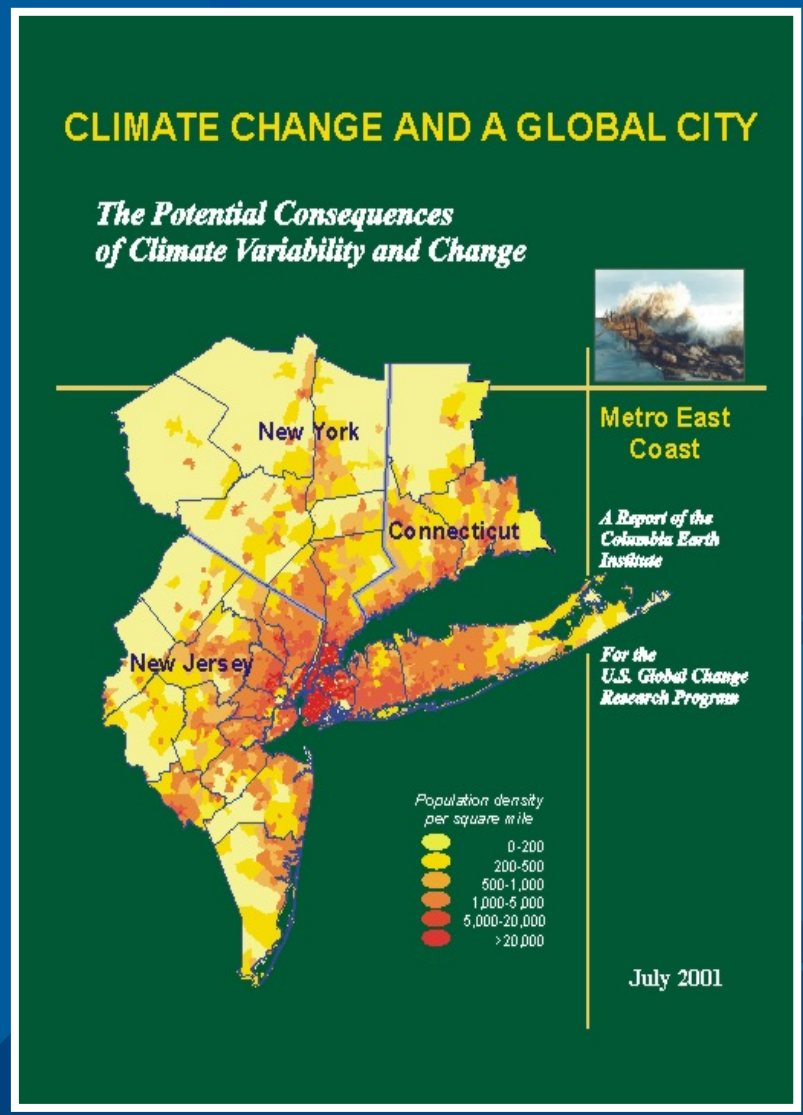
- 1.5 billion gallons of wastewater treated per day
- 14 water pollution control plants (WPCPs)
  - 1 combined sewer overflow treatment plant
  - 8 sludge dewatering facilities
  - 93 pumping stations
  - 490 sewer regulators
  - 553 tide gates



WPCP Locations

Institutionalizing Climate Change

- 2001: Metro East Coast Assessment, prepared by scientists at the Columbia Univ. Earth Institute, and funded by the National Science Foundation, **determined the risks to NYC's water infrastructure posed by climate change** required more comprehensive analysis
- 2003: **Formed partnership with Columbia University** Center for Climate Systems Research and NASA's Goddard Institute for Space Studies (GISS)
- 2004: **Developed agency-wide NYCDEP Climate Change Task Force** in collaboration with Columbia/GISS
- June 2006: **Draft Guidelines Report**



Climate Change Variables Important to NYCDEP

Surface Air Temperature	Long-term warming trend with **annual mean temperature of region rising 0.014 °C/ year;** temperature increased approximately 1.4 °C over last century
Precipitation	**Annual precipitation in region increased by ~2.5 cm (1 in)** over last century
Extreme Weather Events (storms, floods, droughts)	Stronger and more frequent **hurricanes and Nor'easters threaten system infrastructure and quality of the water supply**
Sea Level Rise	**Sea level in NY Metro Region rising at ~2.6 mm/year (.1 in/year)** (combined effect of local subsidence and thermal expansion), while global sea level is rising at rate of ~1.7mm/year

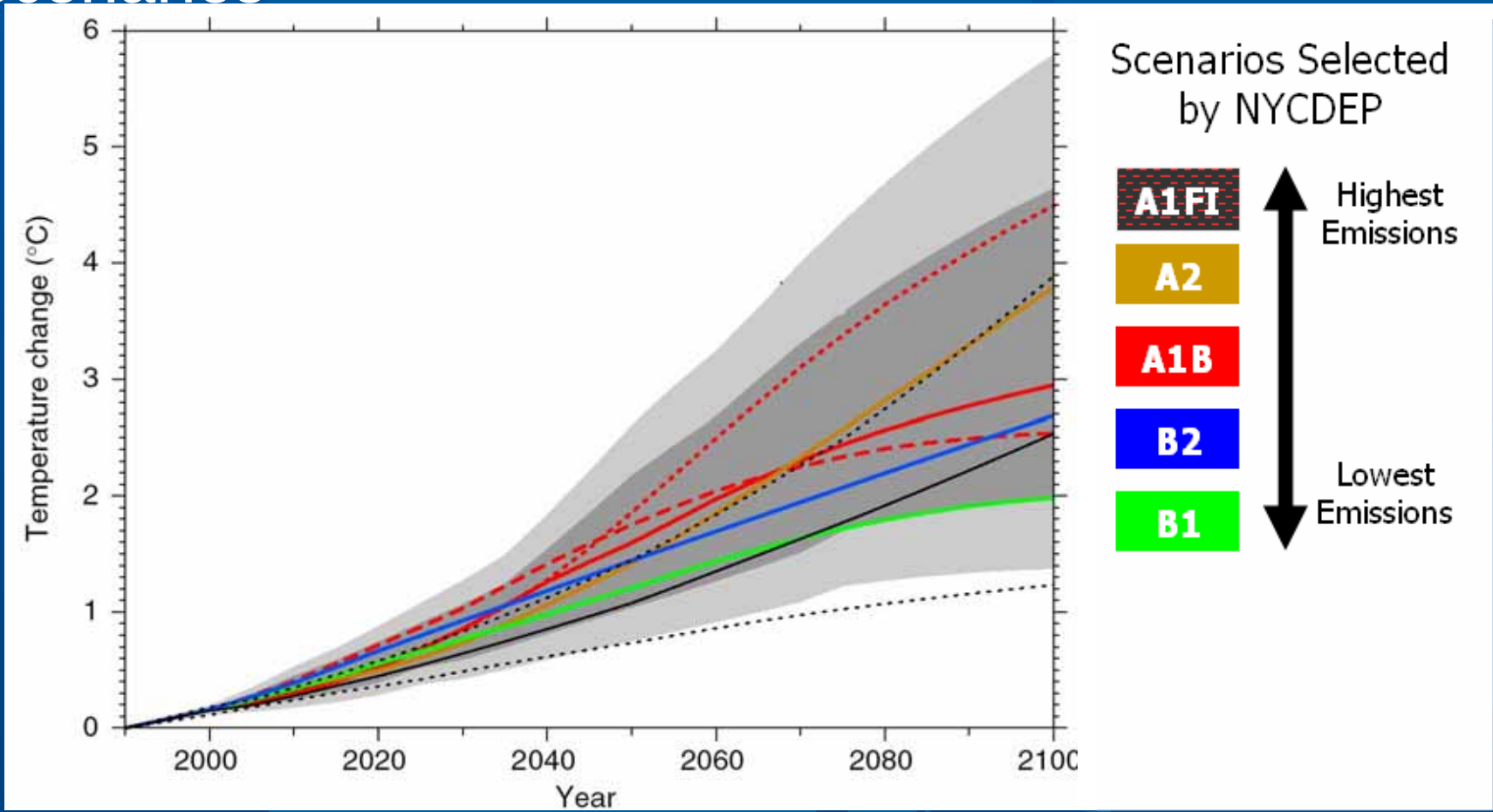
Climate Science: Scenarios & Models

NYCDEP is:

- Using Five Intergovernmental Panel on Climate Change (IPCC) Greenhouse Gas (GHG) Emissions Scenarios
- Taking a global issue and looking at it on a regional level
  - Using various methods to assess climate impacts on NYC region, including:
    - Interpolation from Global Climate Model (GCM) grids
    - Regional Climate Models (RCMs)
- Using GCM and RCM output to forecast local impacts
  - Sea Level Rise Models
  - Storm Surge Models
  - Watershed & Terrestrial Models

Projected Global Temperature Change

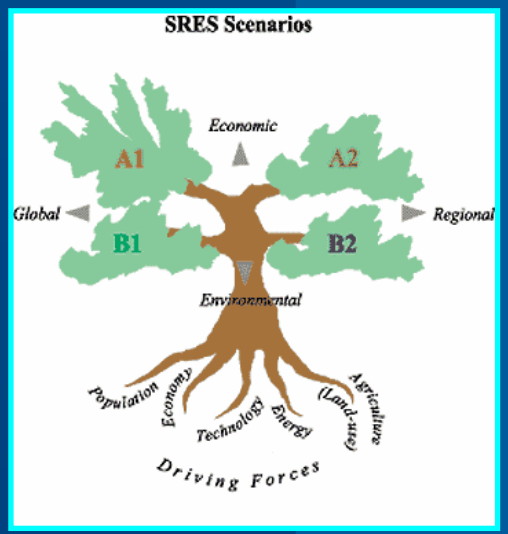
Upward Trend for All GHG Emissions Scenarios

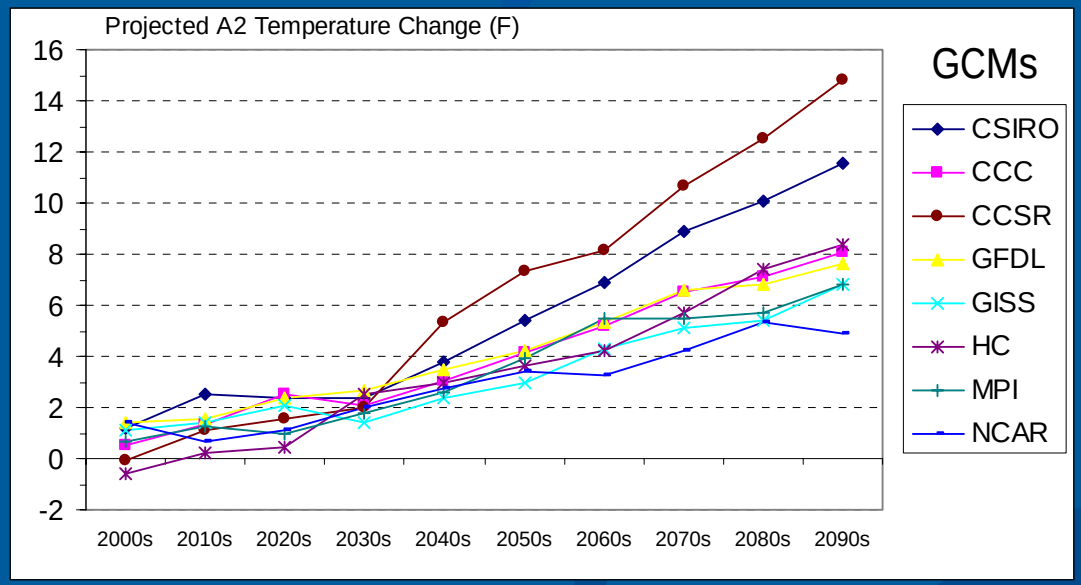


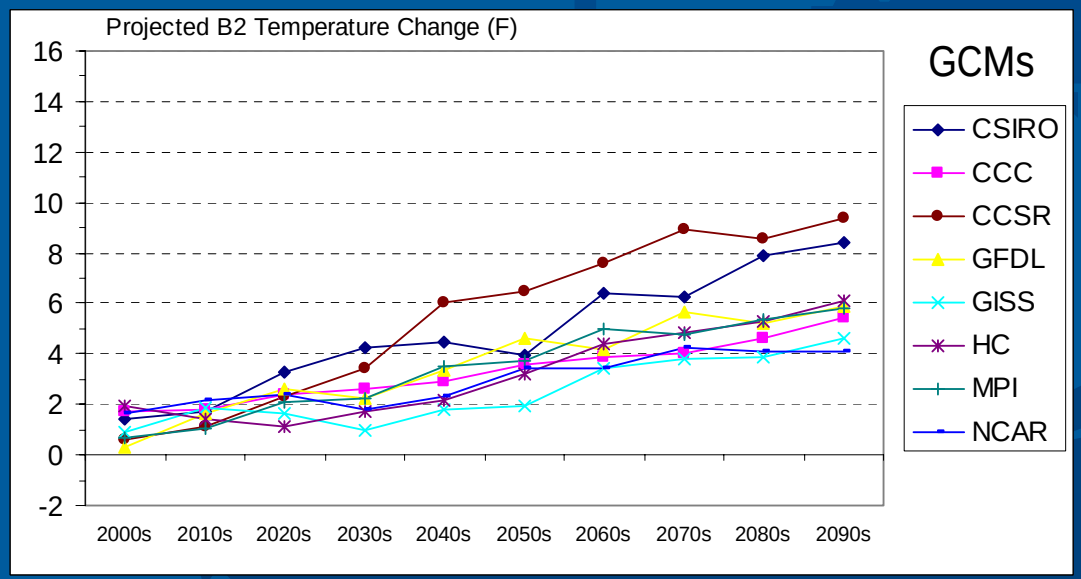
Source: IPCC Special Report on Emission Scenarios (SRES)

Temperature Projections for NYCDEP

- Change in NYC Annual Temperature
  - For 8 GCMs
  - Using 2 Emissions Scenarios
- Range in 2050s is ~1 - 4°C (~2 - 7° F)

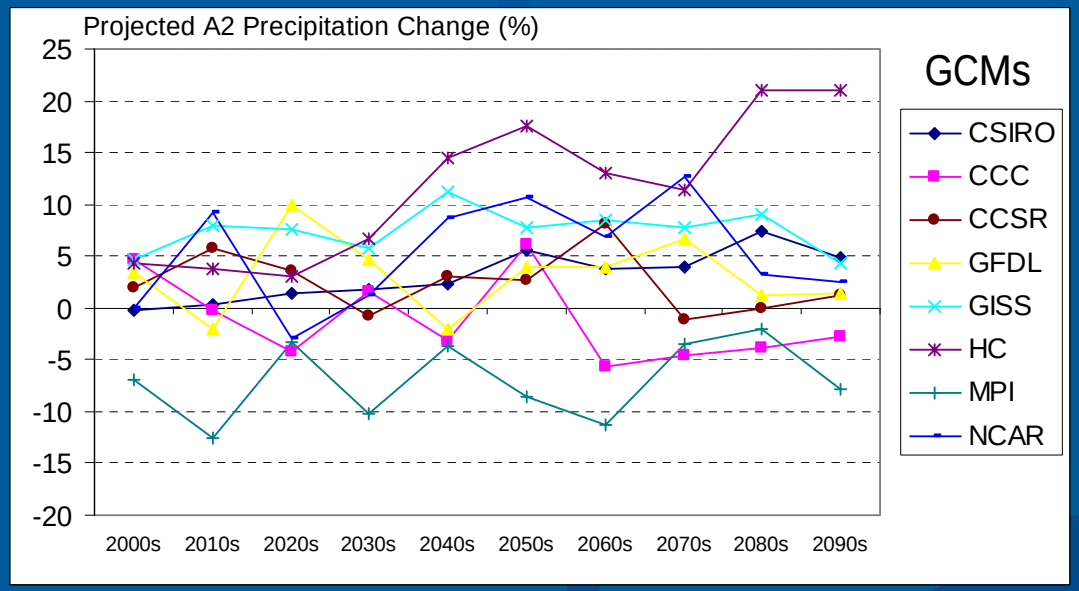


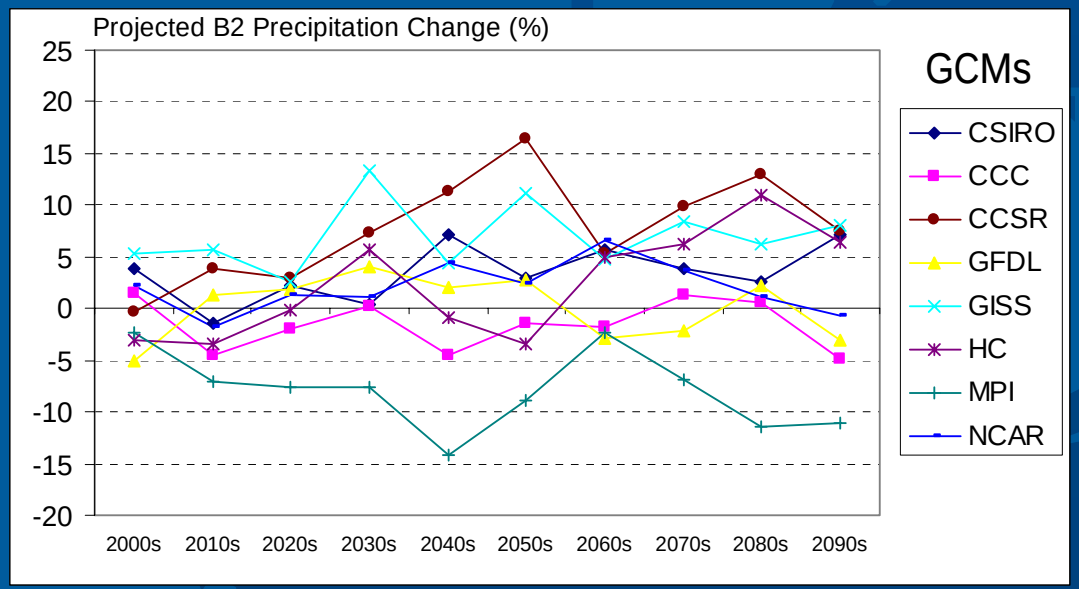




Precipitation Projections for NYCDEP

- Change in NYC Annual Precipitation
  - For 8 GCMs
  - Using 2 Emissions Scenarios
- Range in 2050s is -8 to +17%





Integrated Climate Science

NYCDEP is collaborating with many institutions:

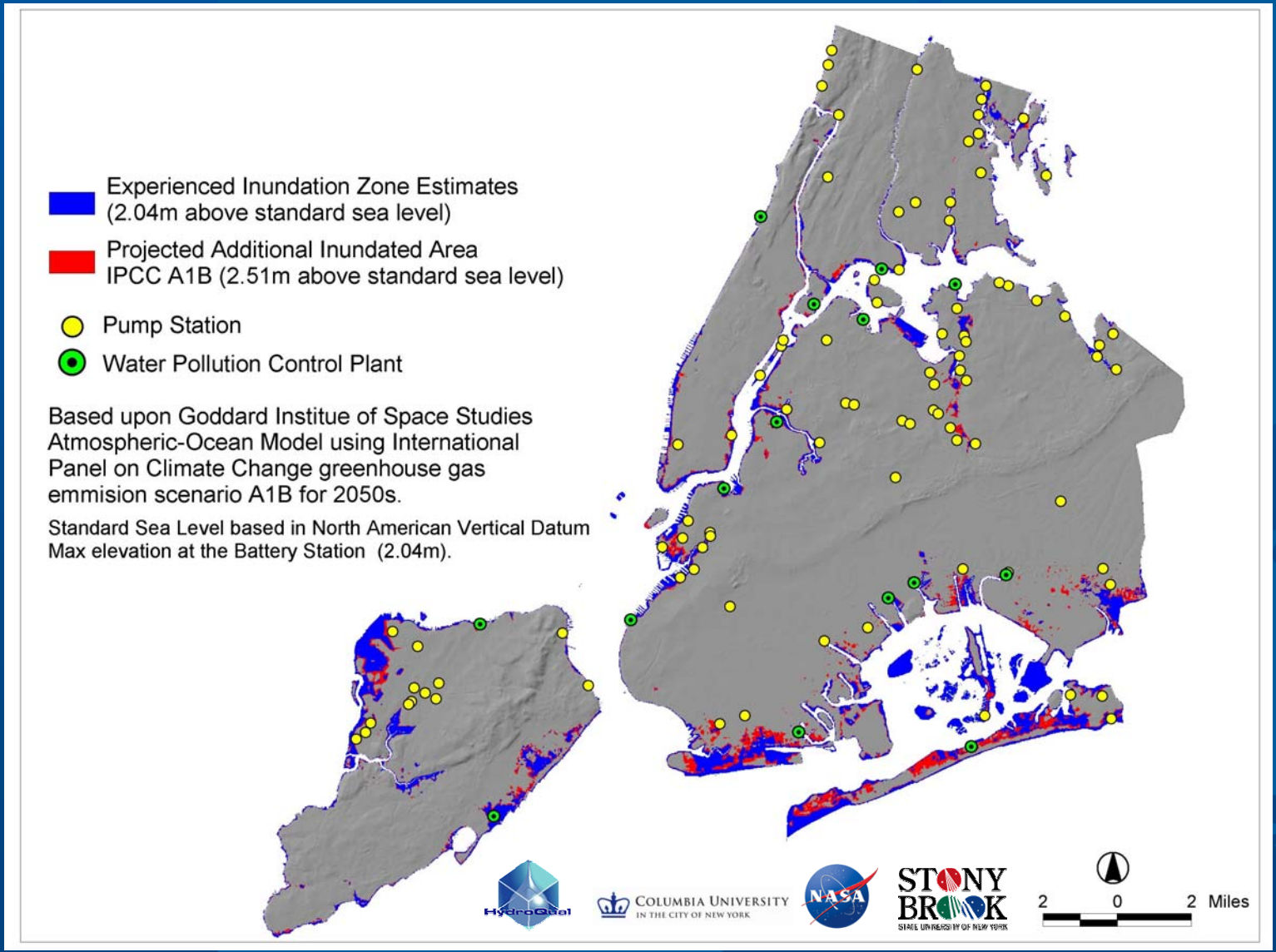
- Columbia University's Center for Climate Systems Research
- NASA's Goddard Institute for Space Studies
- SUNY Stony Brook Marine Sciences Research Center
- Hunter College CUNY Geography Department
- European Union CLIME program (Climate & Lake Impacts in Europe)
- HydroQual, Inc. Environmental Engineers & Scientists

Example of a collaborative project:

- Using sea level rise forecasts as input to storm surge and elevation models to analyze impact of flooding on NYCDEP coastal facilities
- Initial runs with IPCC low-level (B1) and mid-level (A1B) GHG emissions scenarios suggest local sea level may increase from 16.6 to 47.2 cm (6.1 to 18.8 in) by 2050s over 1990s decadal mean

Collaborative Project: Comparing Inundation with Current and Projected (2050s) Sea Level Estimates

Case Study: December 1992 Nor'easter



Assessing Climate Impacts on Water Systems & Adaptive Strategies

Recent weather events have highlighted adverse ways climate change could impact:

- quality and quantity of NYC's water supply
- NYC's water supply & wastewater infrastructure

Hurricane Floyd, September 1999

Climate Impacts & Adaptation

Water Supply System

Impact: Water Quality Impairment from Extreme Events and Temperature Rise

- Heavy rains can increase pathogen levels and turbidity
  - Effects can be magnified by "first-flush" storms: heavy rains after weeks of dry weather
- Examples:
  - DOH issued advisory to immune-suppressed New Yorkers after June 2005 storm caused turbid water to enter distribution system
  - Treated turbidity with aluminum sulfate (alum) twice in 2005: Required emergency permits, and now NYCDEP must dredge alum from reservoir

Challenge:

- Maintaining Filtration Avoidance
  - Filtering Catskill/Delaware water supply would cost $5 – $10 billion for a plant, plus $300 – $500 million for annual operation/maintenance

Possible Adaptations:

- Acquiring more watershed land (increase $250 million cap)
- Managing forests so they remain healthy in changing climatic conditions
- Adapting Waterfowl Management Program as bird migrations shift

Turbidity After Hurricane Floyd

Climate Impacts & Adaptation
Water Supply System

Impact: Flood Damage from Extreme Events

- Watershed communities experiencing increased flooding

Challenges:

- NYC reservoirs not designed for rapid releases
- Developing measures to limit future damage requires coordination with communities/officials
- Flood control measures reduce water supply for NYC

Possible Adaptations:

- Dual Use of Reservoirs for Water Supply and Flood Control
  - Modify dam infrastructure
  - Modify operations
    - Pilot Reservoir Spill Reduction Program: Releases made to maintain void in reservoir

Flooding downstream of a Delaware Basin Reservoir

Climate Impacts & Adaptation

Water Supply System

Impact: More Frequent / Prolonged Droughts

Challenges:

- Maintaining dependability of water supply in changing climatic conditions, as well as:
  - Increased demand from upstate communities that get water from NYC system by right
  - Demand for increased releases to provide < 70°F water to sustain fish populations
  - Aging infrastructure

Possible Adaptations:

- Water dependability through:
  - Demand reduction
  - System flexibility
  - New sources

A Reservoir During 2001-2002 Drought

Climate Impacts & Adaptation

Water Distribution and Sewer Systems

Impact: Water Quality Impairment from Extreme Events & Warmer Water

- Intense rain events of short duration (NYC average of .5 in/hr) can create CSO condition
- Combined sewer discharge can decrease dissolved oxygen and increase total Coliform in NY harbor. Water quality in the harbor is most challenged during summer months (warm water holds less dissolved oxygen and can stimulate plant and algae growth)

Challenges:

- 70% of NYC land is on combined system
- CSO Long Term Control Plan projected to cost $1.9 billion through 2017; huge investment with diminishing returns as capture rate will decrease with increased precipitation intensity
- Health of Jamaica Bay: wetlands abate storm surge intensity; ~45 acres currently lost per year; wetlands also at risk from sea level rise

Possible Adaptations:

- Increase expenditure for CSO program
  - Estimated cost of increasing wet weather capture from 75% to 95%: $12-$40 billion ($1,500-$5,000 per capita)

Climate Impacts & Adaptation

Water Distribution and Sewer Systems

Impact: Flood Damage from Sea Level Rise and Extreme Events

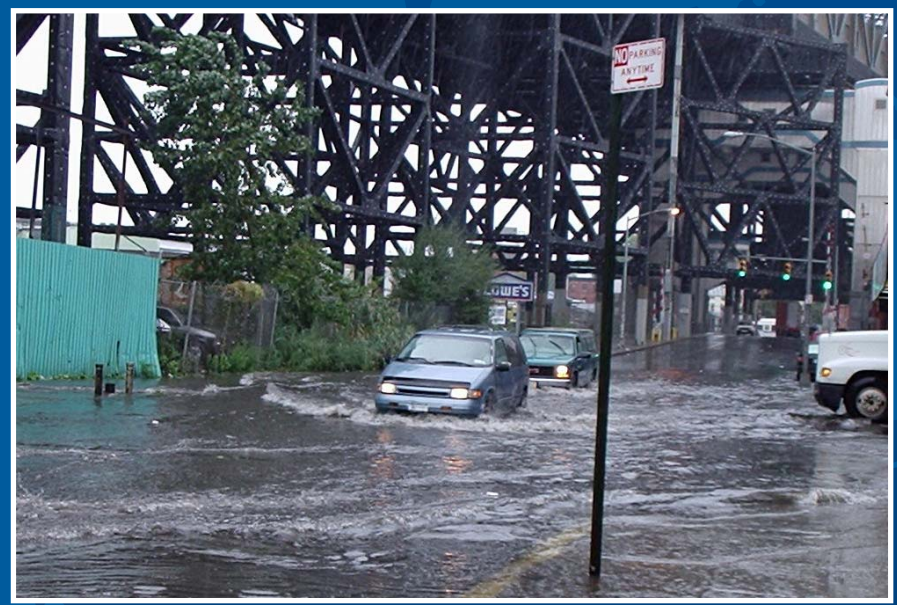
- High sea levels and heavy rains can cause sewer back-up and extensive flooding of streets and basements

Challenges:

- Precipitation increase (volume/intensity) will acutely affect drainage system
- Sea level rise will cause street flooding, particularly during high tides
- Record rainfall (~13 in) over 8 days in October 2005
  - Number of complaints an all-time high: ~1,850 for sewer back-up, ~2,000 for street flooding

Possible Adaptations:

- Modify design criteria to reflect changing hydrologic processes (study being scoped)
- Reconfigure outfalls to prevent sediment build-up and surging – How? (study being scoped)
- Expand Bluebelt project and other urban greening programs



Street Flooding in Brooklyn

Climate Impacts & Adaptation

Wastewater Treatment System

Impact: Water Quality Impairment and Flood Damage from Extreme Events and Sea Level Rise

- Treatment tanks overflowed at a Bronx WPCP during March 2001 storm; unusually high tidal elevations blocked discharge of treated sewage into East River and caused back-up
- Dewatering/chlorination building flooded at a Queens WPCP during December 1992 Nor'easter; electrical equipment and instrumentation suffered tens of millions in damage

Challenges:

- Prevention
- Fuel for generators and chlorine supply if there is a multi-day power outage

Possible Adaptations:

- Infrastructure: Relocate critical control systems to higher floors/ground (done at the Queens WPCP after 1992 storm)
- Infrastructure: Flood walls

Treated Sewage Backed-Up at a Bronx WPCP

Looking Forward

- Executive Policy Decisions
  - What should NYCDEP study?
  - What actions should NYCDEP take? When?
- Continued Collaboration with Scientific Research Institutions
  - How does NYCDEP determine that evolving science is “good enough” for influencing decision making and design of multi-billion-dollar infrastructure?
- Designing Infrastructure in the Face of Uncertainty
  - How do we make infrastructure more robust and adaptable to changing climate, regulatory mandates, zoning, and population distribution?
- Mitigation
  - Develop greenhouse gas inventory and management program in-line with City-wide initiatives
- Leadership
  - We have an opportunity and responsibility to share with other agencies and operators our methods and lessons learned.

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