CLIMATE CHANGE IMPACTS

Actions Needed To Protect The Water Resources of the Delaware River Basin

Carol R. Collier, P.P., AICP
Executive Director
Delaware River Basin Commission

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Topics

- Where We Are – Where We Are Going
- Climate Change Impacts To Water Supply
- Confounding Impacts In The Basin
- Necessary Actions

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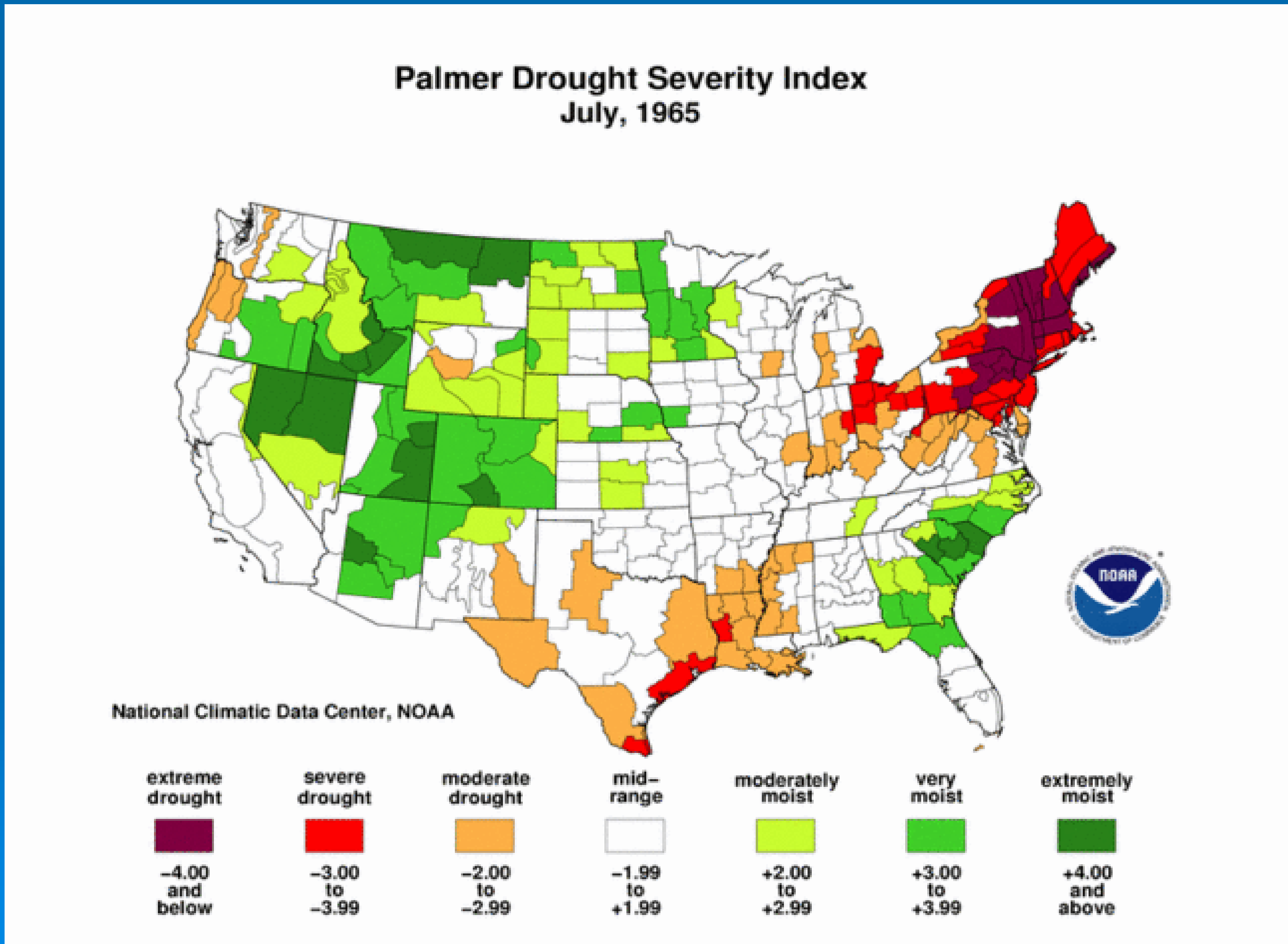
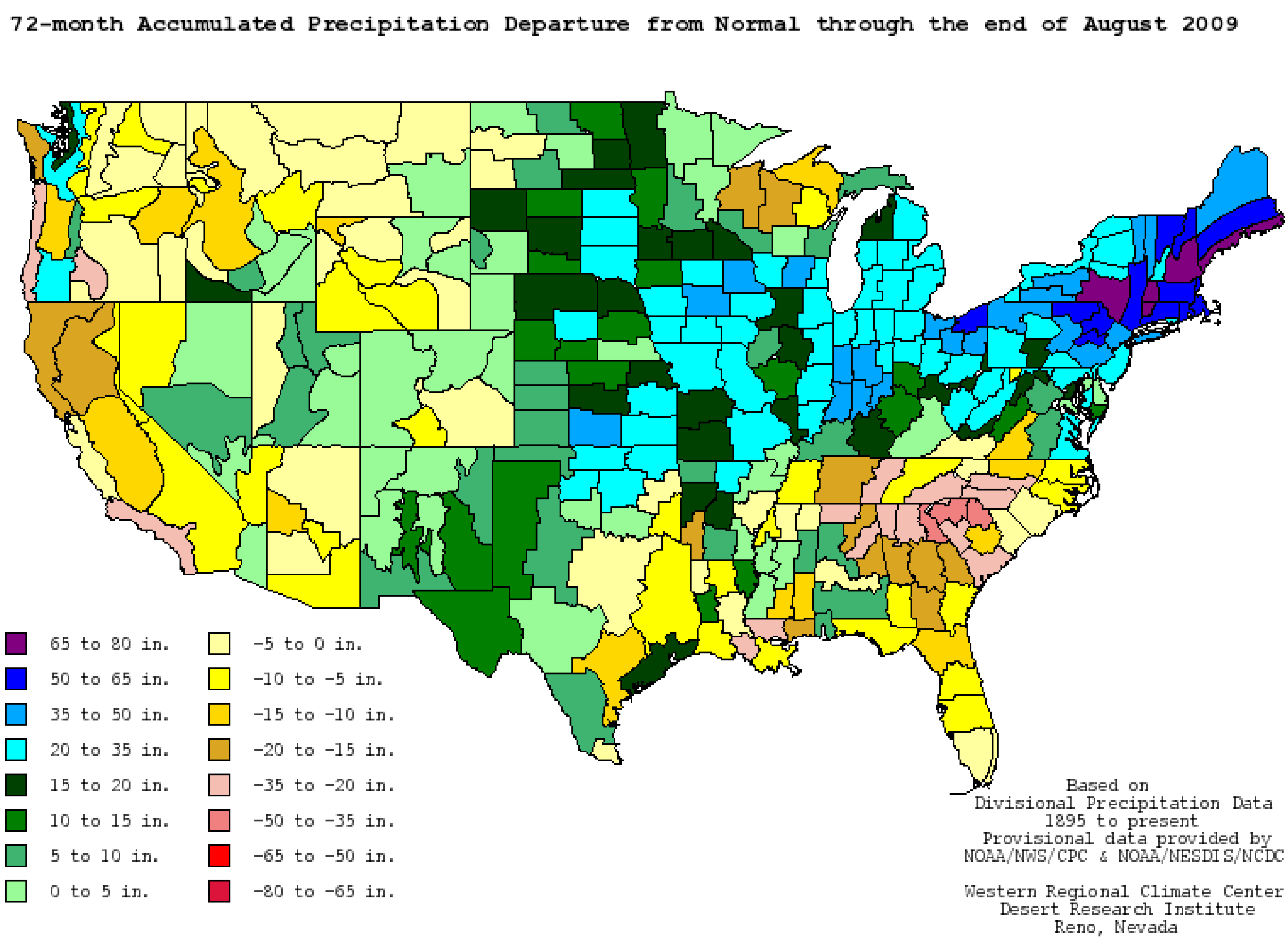
Delaware River Watershed Facts

- Over 15 million people (about 5% of the U.S. population) rely on the waters of the basin
- Drains 13,539 mi² , or 0.4 of 1% of the continental U.S. land area
- Longest undammed river east of the Mississippi

Drought of the 1960's




72-month Accumulated Precipitation Departure from Normal through the end of August 2009
65 to 80 in.
50 to 65 in.
35 to 50 in.
20 to 35 in.
15 to 20 in.
10 to 15 in.
5 to 10 in.
0 to 5 in.
-5 to 0 in.
-10 to -5 in.
-15 to -10 in.
-20 to -15 in.
-35 to -20 in.
-50 to -35 in.
-65 to -50 in.
-80 to -65 in.
Based on
Divisional Precipitation Data
1895 to present
Provisional data provided by
NOAA/NWS/CPC & NOAA/NESDIS/NCDC
Western Regional Climate Center
Desert Research Institute
Reno, Nevada

Flood Mitigation

Assumptions for Future Scenarios

- Increasing Temperatures
- Equal or Increased Precipitation
- Time Shift in Spring High Stream Flows
- Increase in Sea Level Rise

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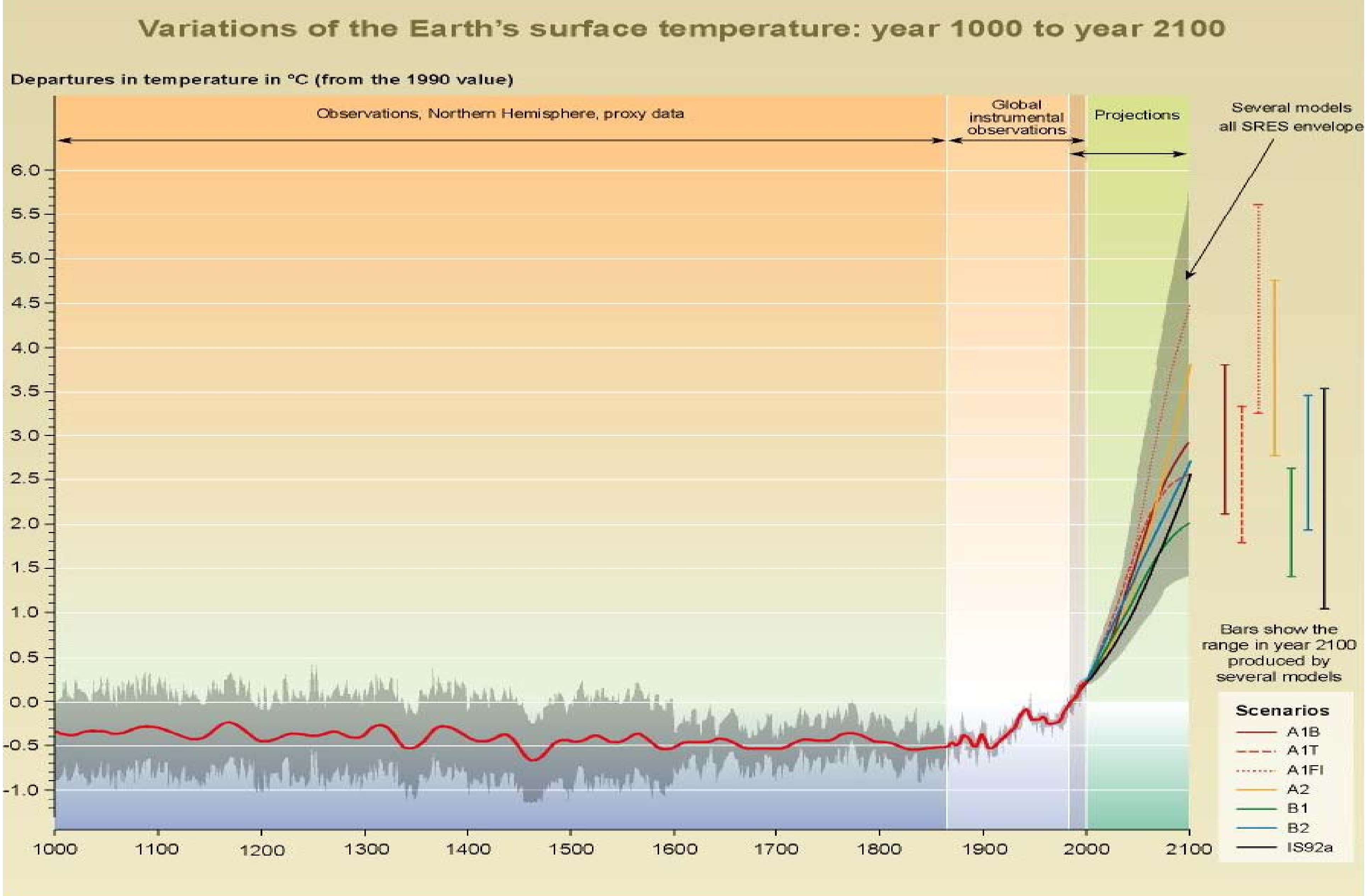
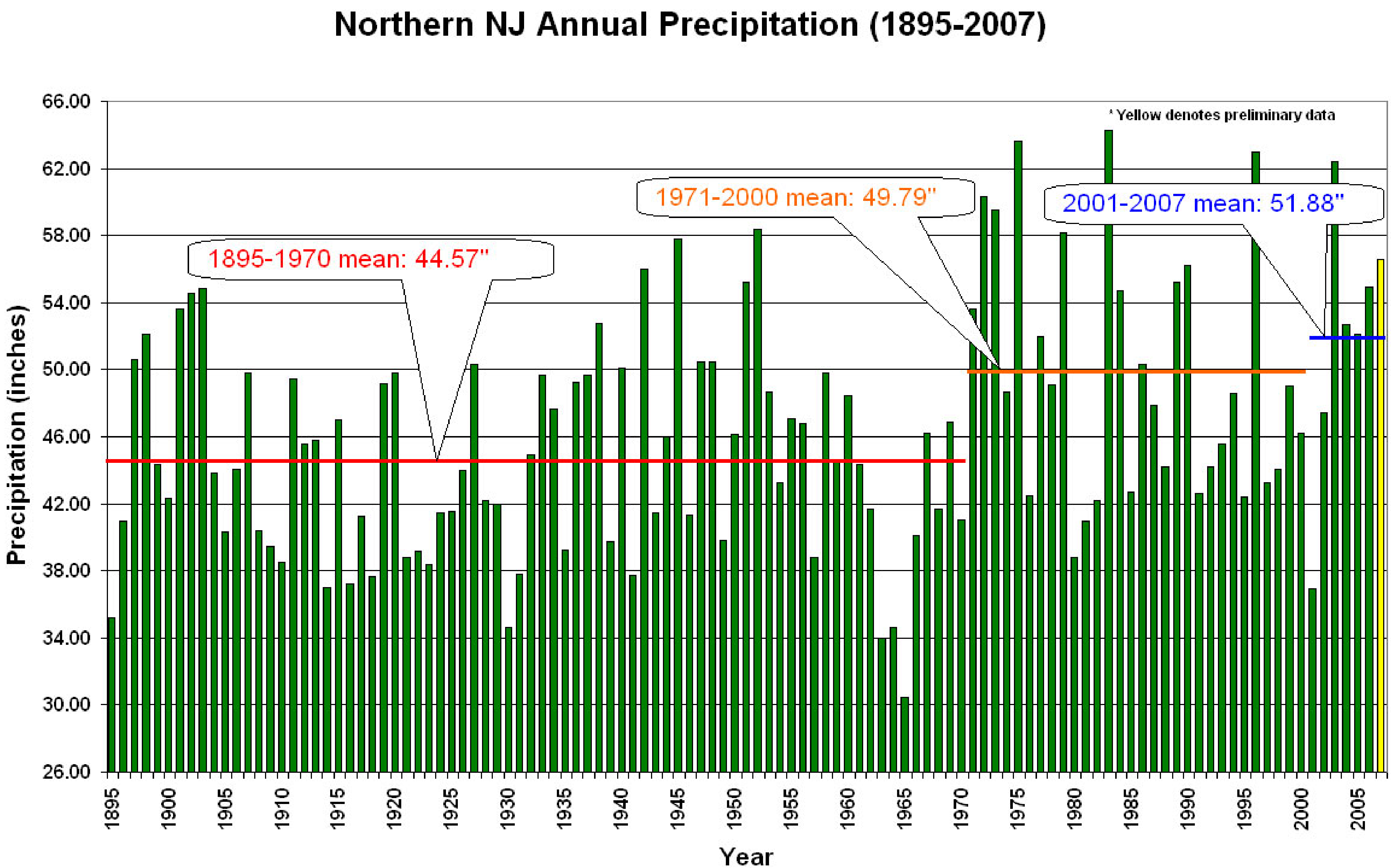
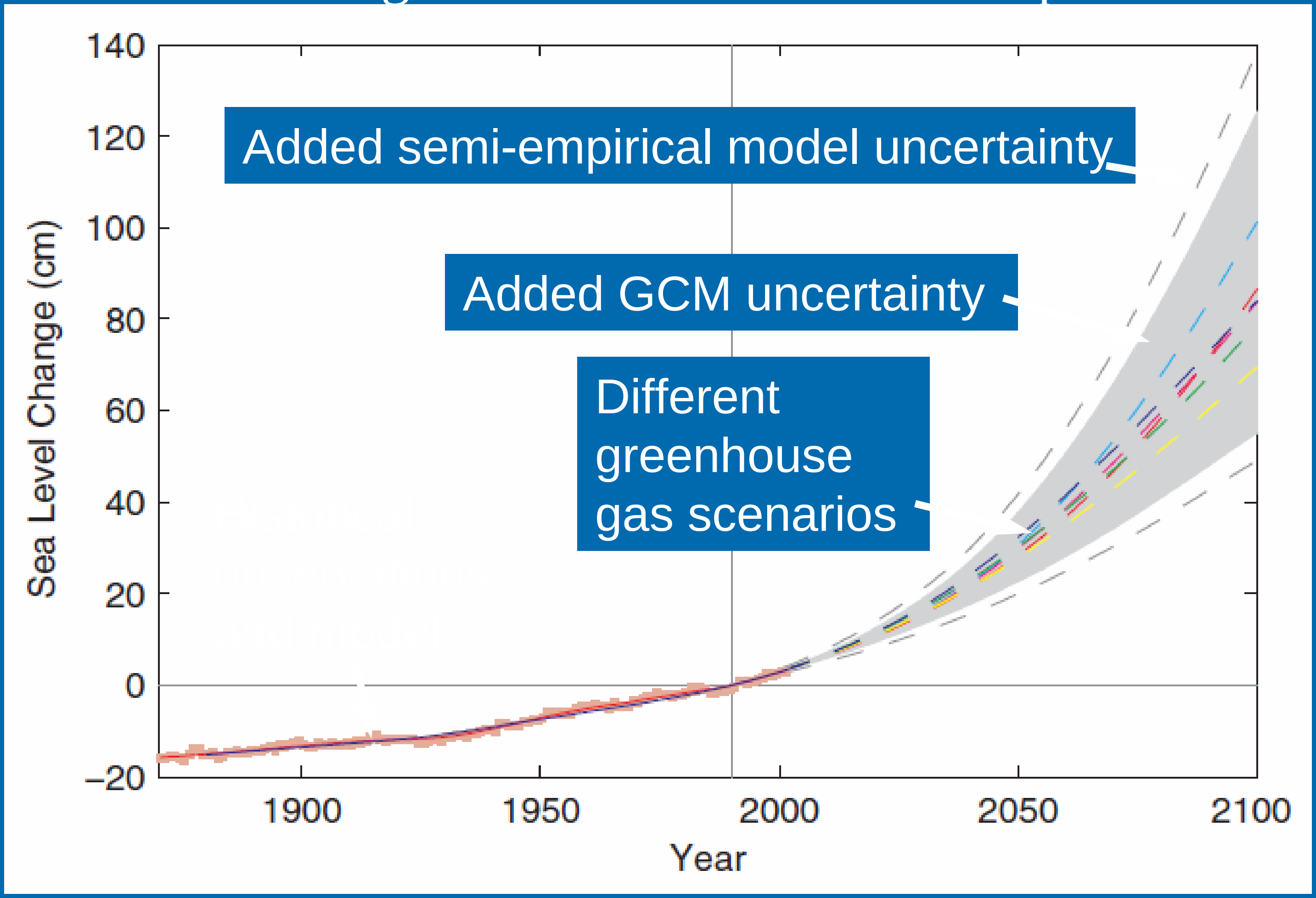


Source – Ben Horton


Northern NJ Annual Precipitation (1895-2007)
* Yellow denotes preliminary data
1895-1970 mean: 44.57"
1971-2000 mean: 49.79"
2001-2007 mean: 51.88"
Precipitation (inches)
Year
66.00
62.00
58.00
54.00
50.00
46.00
42.00
38.00
34.00
30.00
26.00
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Global changes—future

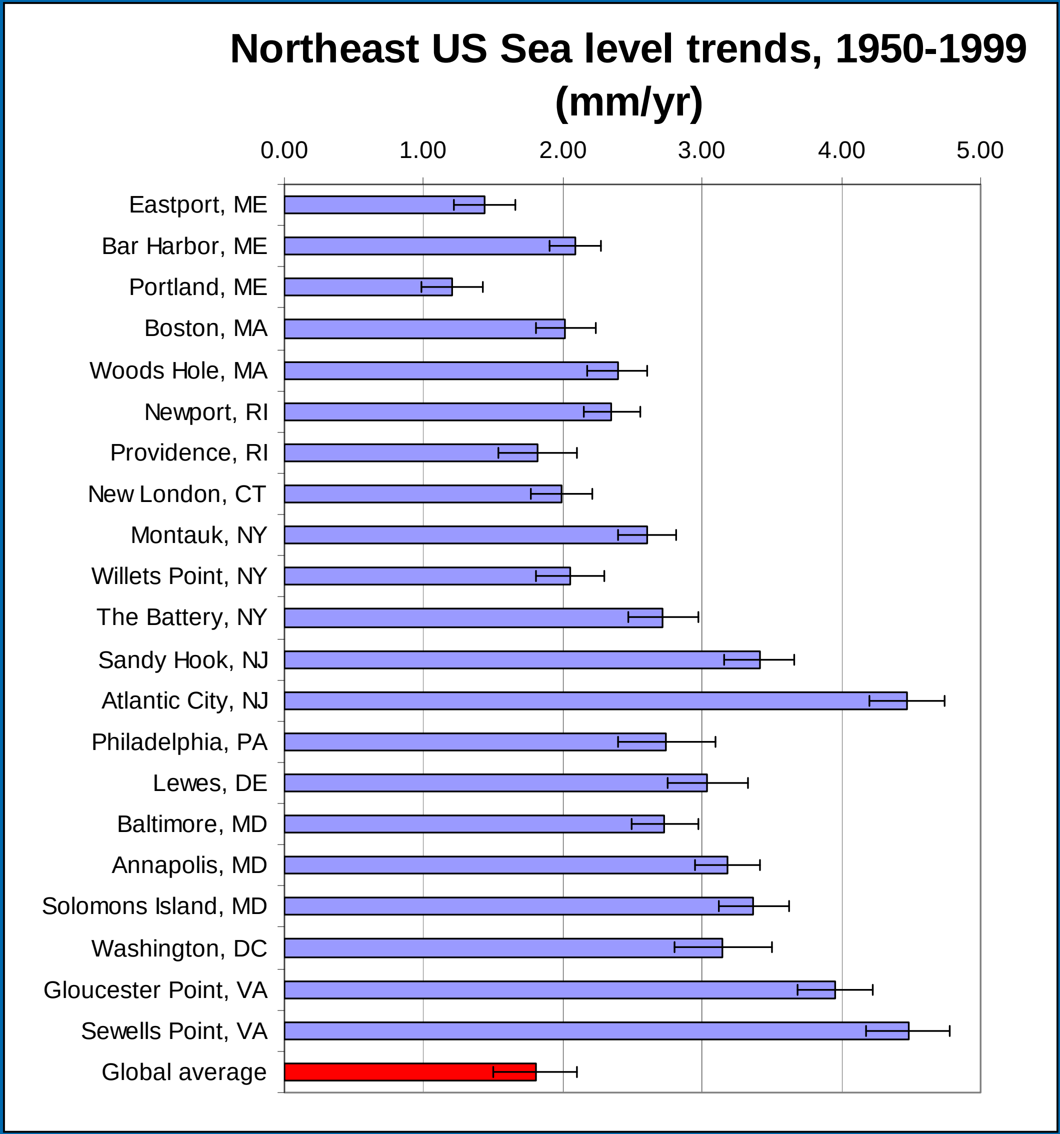
Semi-empirical model of global-mean sea level based on global-mean surface air temperature



Source – Ray Najjar

Source: Rahmstorf (2007)

Regional changes—Northeast U.S.



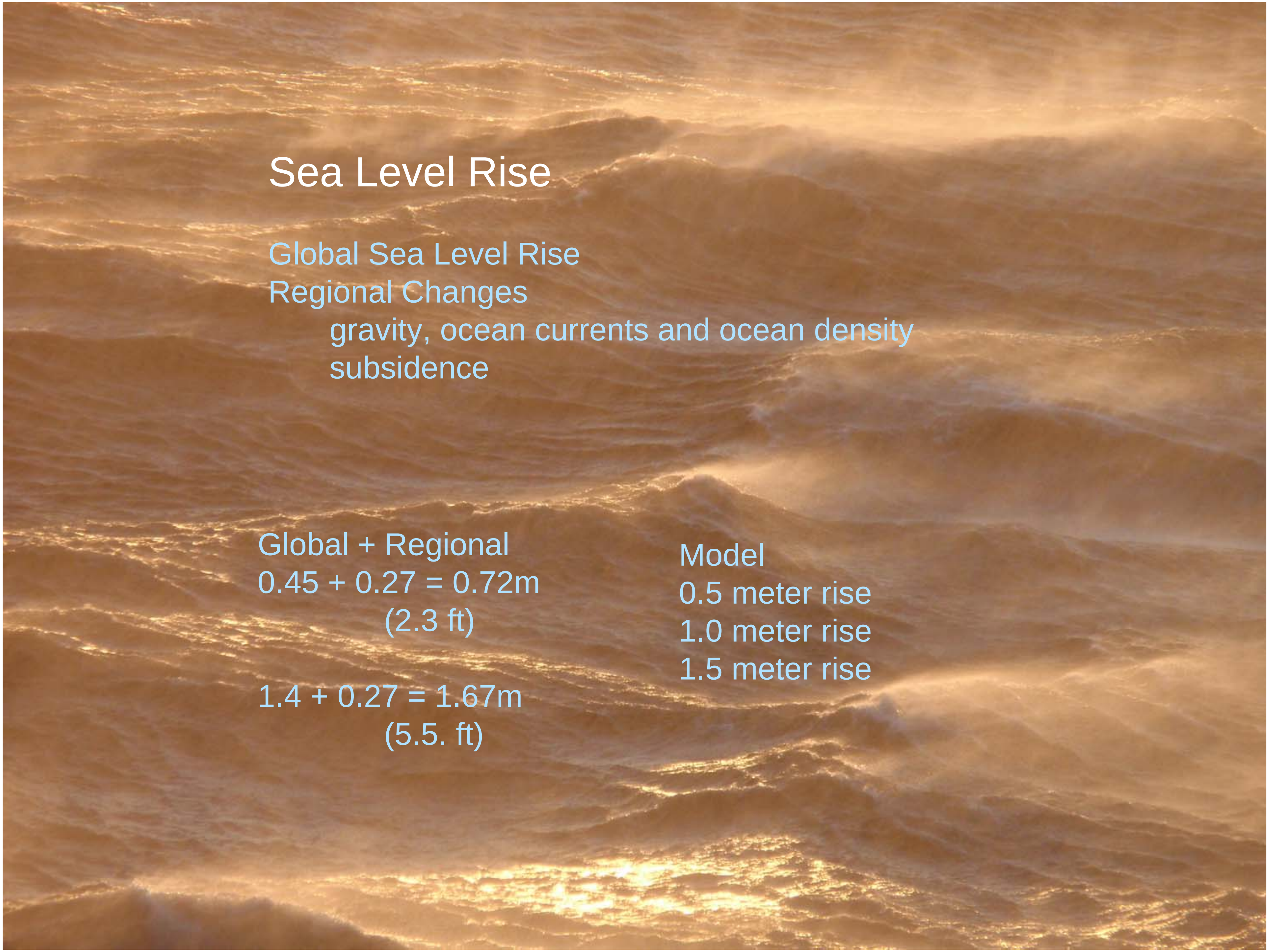
In the Northeast U.S., sea level is rising much faster than the global average, most likely due to local land subsidence.

Inferred subsidence rates are -0.6 to 2.7 mm yr^{-1}.

Over the 21st Century, this is an additional sea-level rise of -6 to 27 cm.

Sources: Zervas (2001), Church et al. (2004)

Source – Ray Najjar


Sea Level Rise
Global Sea Level Rise
Regional Changes
gravity, ocean currents and ocean density
subsidence
Global + Regional
0.45 + 0.27 = 0.72m
(2.3 ft)
1.4 + 0.27 = 1.67m
(5.5. ft)
Model
0.5 meter rise
1.0 meter rise
1.5 meter rise

Assumptions for Future Scenarios

- Increasing Temperatures - > 2- 4^{o} C
- Equal or Increased Precipitation- > 7 – 9%
- Greater Intensity of Storms/Hurricanes
- More Precip. In Winter Months
- Warmer Summers
- Working at the Extremes
  - Floods and Droughts
- Increase in Sea Level Rise
  - Inundation (height + tidal range change)
    - 15-20% range increase at Balt. For 1m rise (Zhong et al., 2008)
  - Storm Surge
  - Salinity Increases

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Water Supply & Infrastructure

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Potential Impacts – Water Supply and Infrastruture

- Loss Of Snow Pack
- Prolonged Droughts
- Increased Evapotransporation
- Fewer But More Intense Storms
- Salinity Pushing Inland– Sea Level Rise
- Infrastructure - Water Lines, Sewer Lines, Wastewater Treatment

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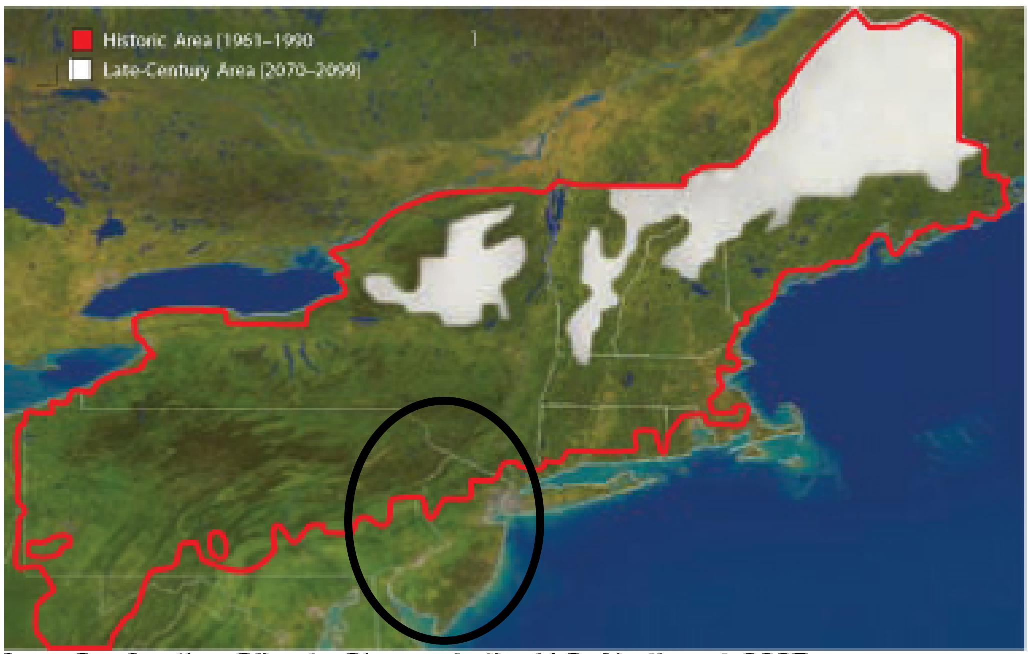
Changes in Snowpack and Timing of Snowmelt

- There will be less snow in the winter; this affects water supply for many who depend on the melting of snowpack as a water source. The timing of snowmelt may also change, prompting water resource managers to change how water supply reservoirs are managed.

The Changing Face of Winter



If higher emissions prevail, a typical snow season may become increasingly rare in much of the Northeast toward the end of the century. The red line in the map captures the area of the northeastern United States that, historically, has had at least a dusting of snow on the ground for at least 30 days in the average year. The white area shows the projected retreat of this snow cover by late-century to higher altitudes and latitudes, suggesting a significant change in the character of a Northeast winter.

from *Confronting Climate Change in the U.S. Northeast*, 2007
Northeast Climate Impacts Assessment

Wastewater System Impacts

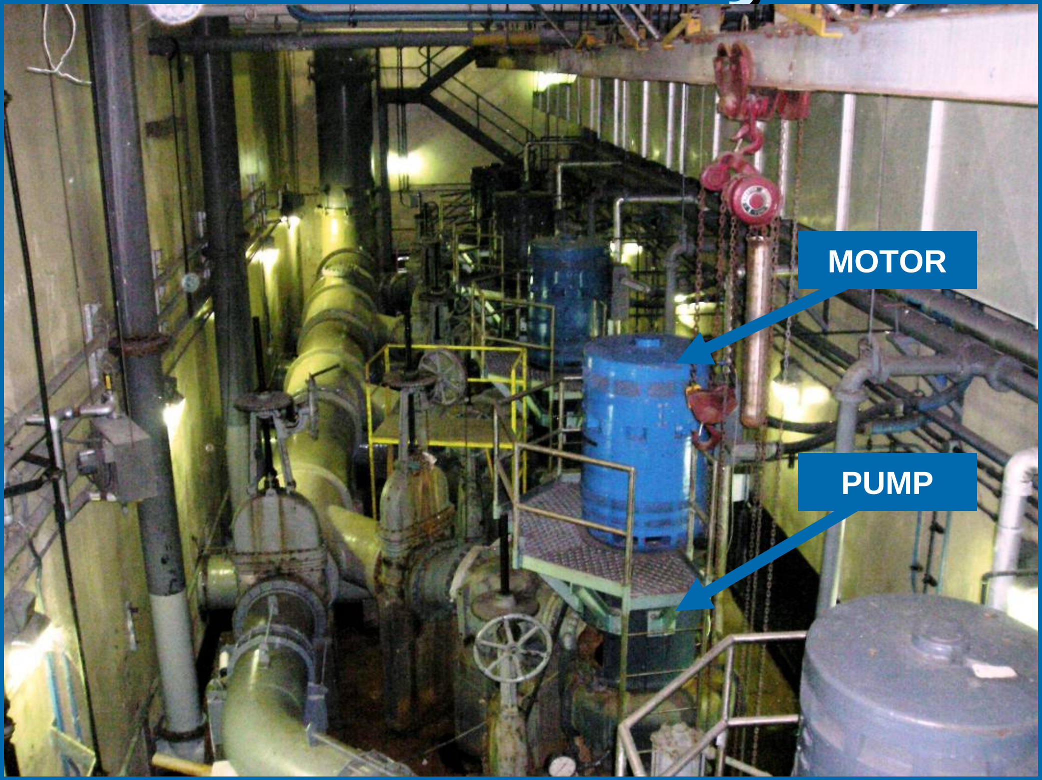
Sea level rise compounding seasonal storm events to overwhelm water pollution control plants

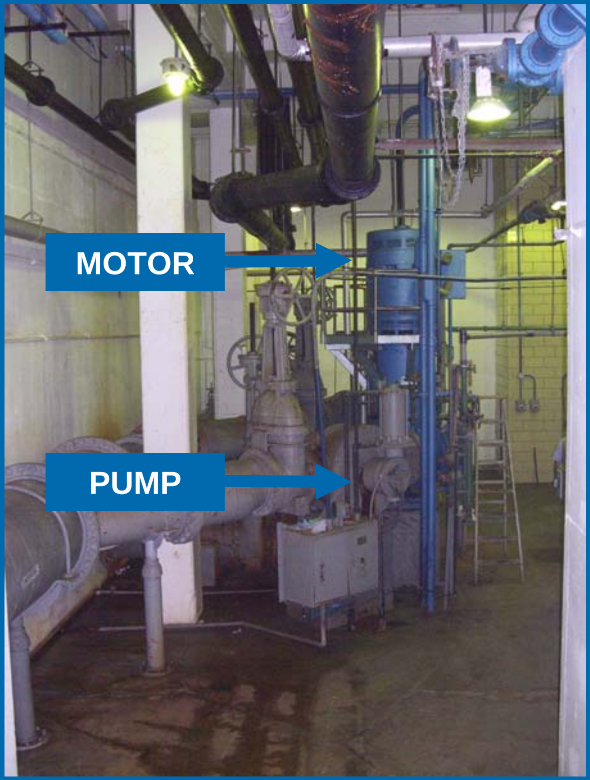
planyc 2030
www.nyc.gov/html/planyc2030

Flood Gates at Facility Entryways

Flood Gate at Tallman Island WPCP

Critical Equipment at Rockaway WPCP





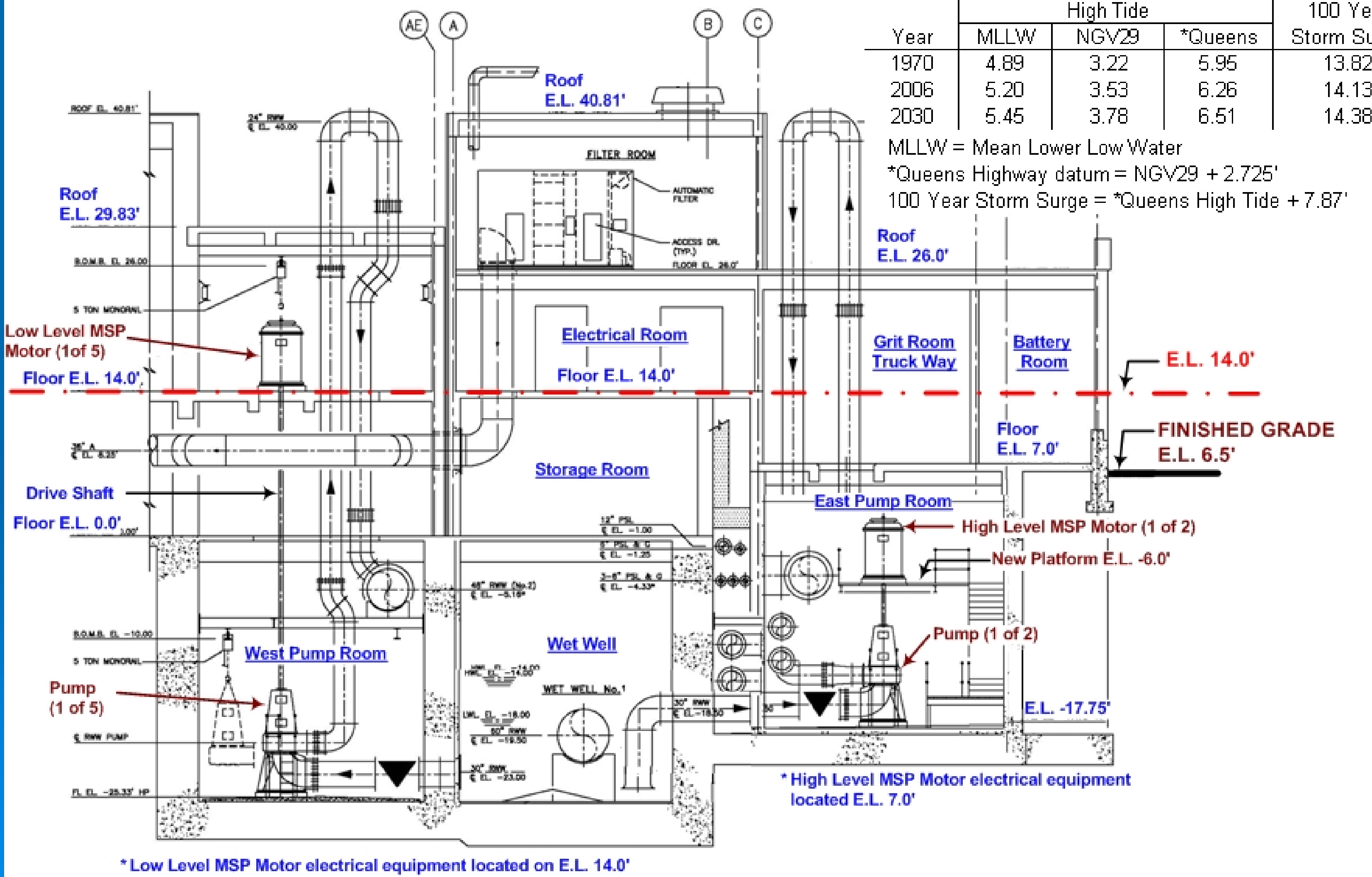
West pump room: 25.33' below sea level

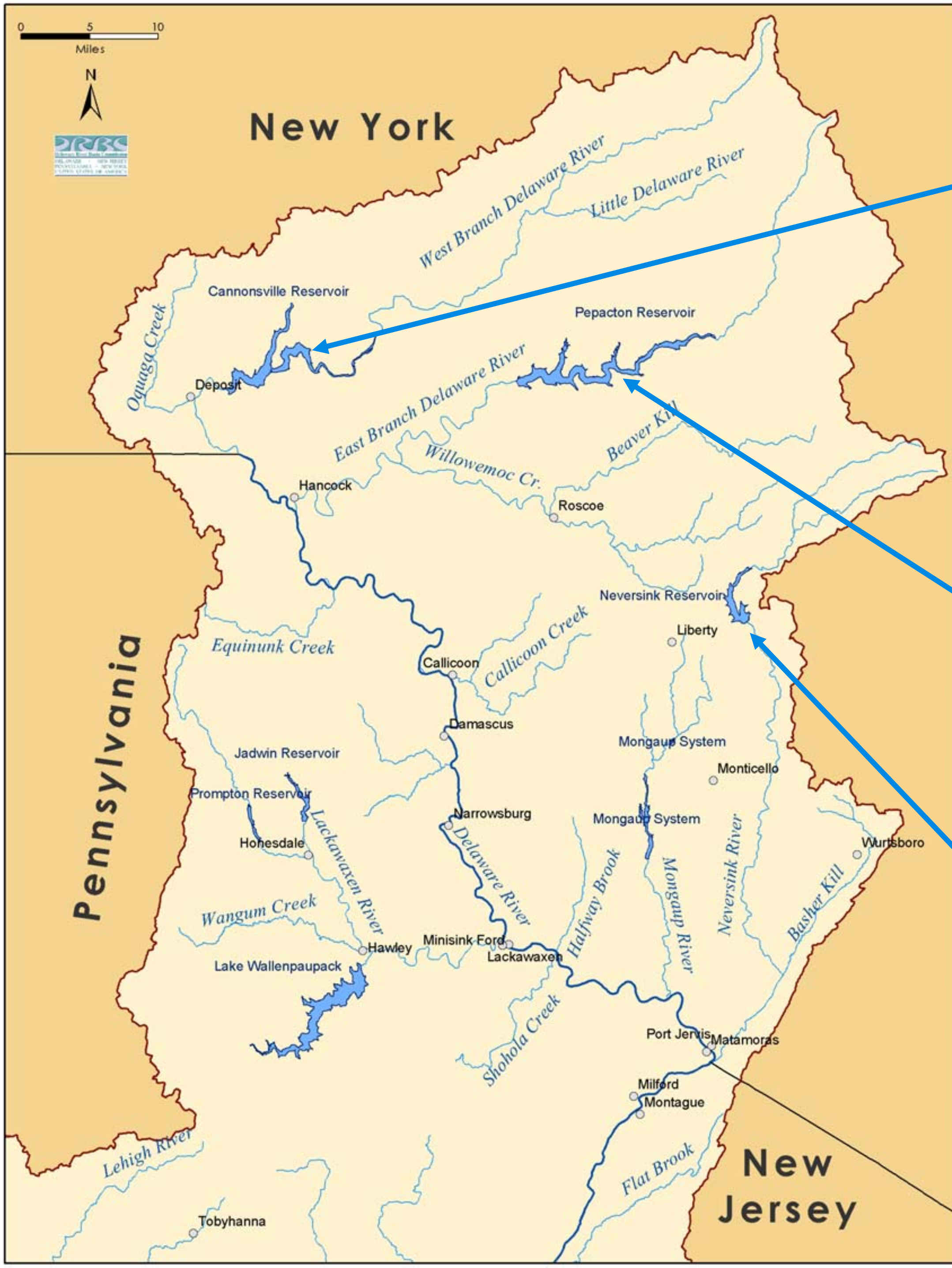
East pump room: 17.75' below sea level

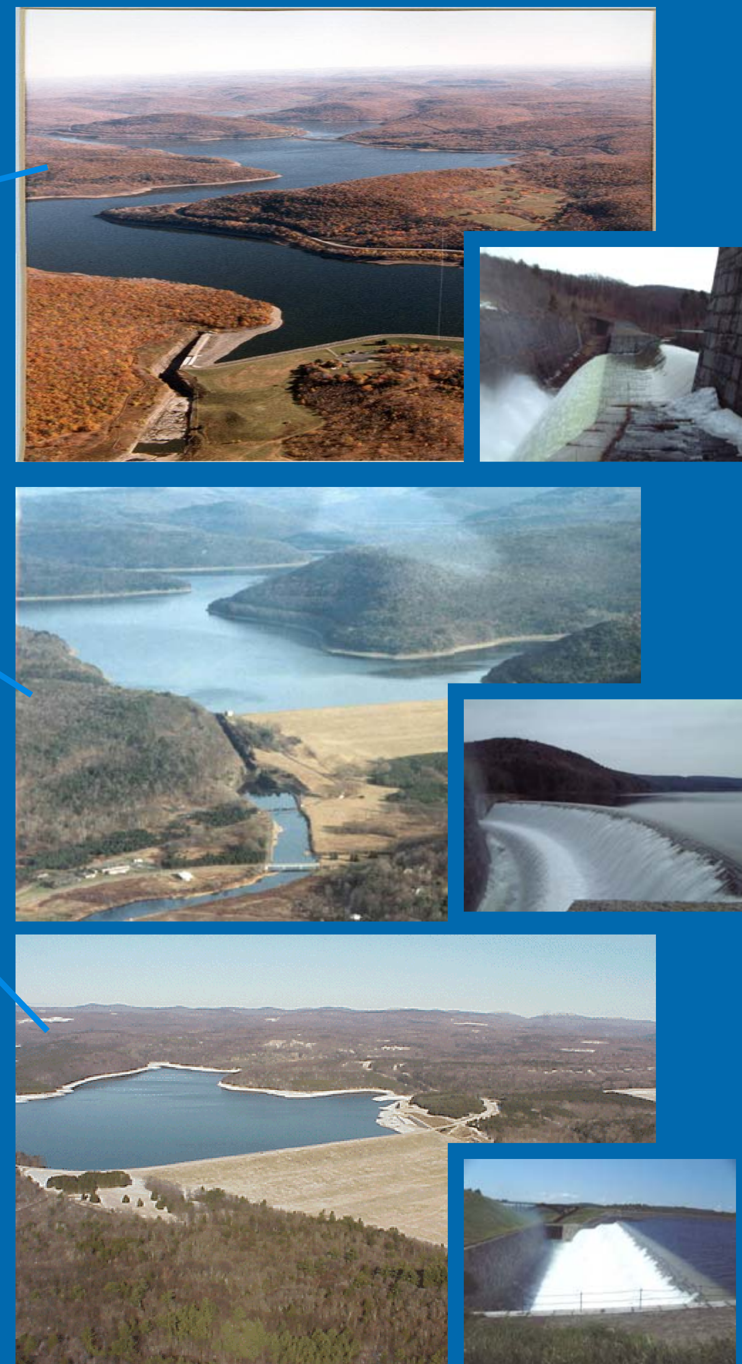
Proposed Equipment Locations

Year	High Tide MLLW	High Tide NGV29	High Tide *Queens	100 Year Storm Surge
1970	4.89	3.22	5.95	13.82
2006	5.20	3.53	6.26	14.13
2030	5.45	3.78	6.51	14.38

MLLW = Mean Lower Low Water
*Queens Highway datum = NGV29 + 2.725'
100 Year Storm Surge = *Queens High Tide + 7.87'







Photos Courtesy NYC DEP

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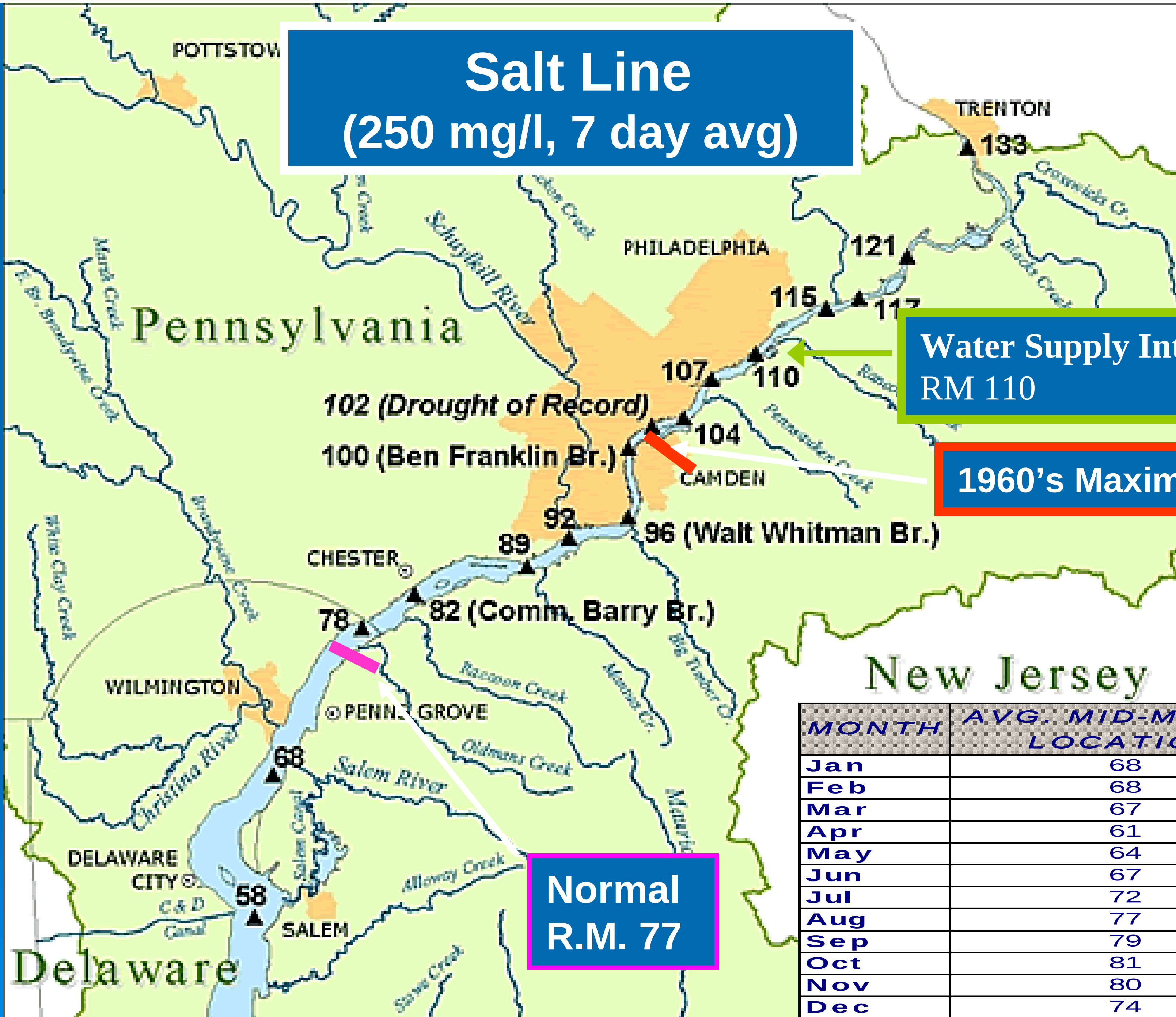
Salt Line
(250 mg/l, 7 day avg)



MONTH	AVG. MID-MONTH LOCATION
Jan	68
Feb	68
Mar	67
Apr	61
May	64
Jun	67
Jul	72
Aug	77
Sep	79
Oct	81
Nov	80
Dec	74

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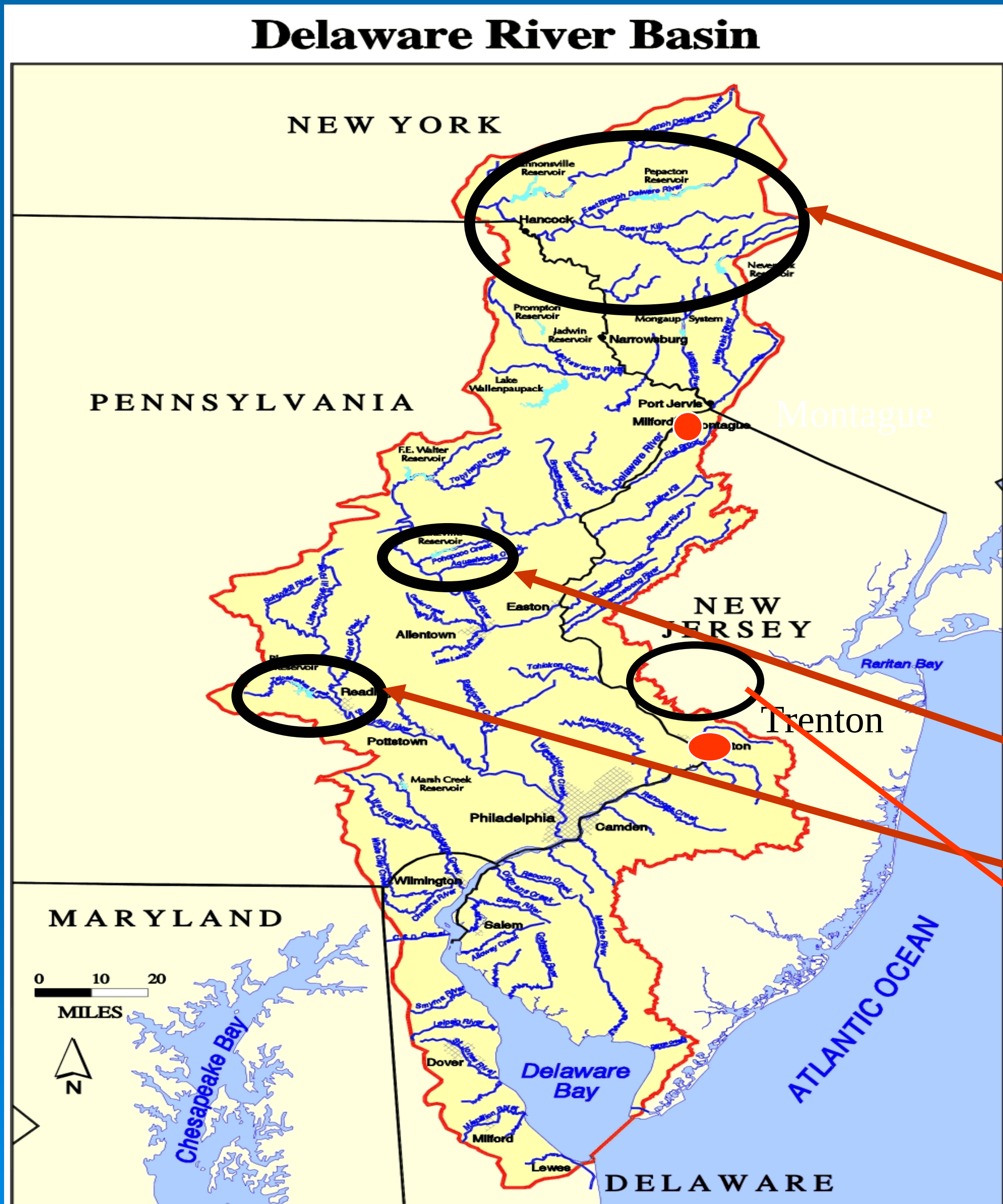
Data for determination provided by the U.S. Geological Survey and Kimberly Clark Corp.



Operating Plans

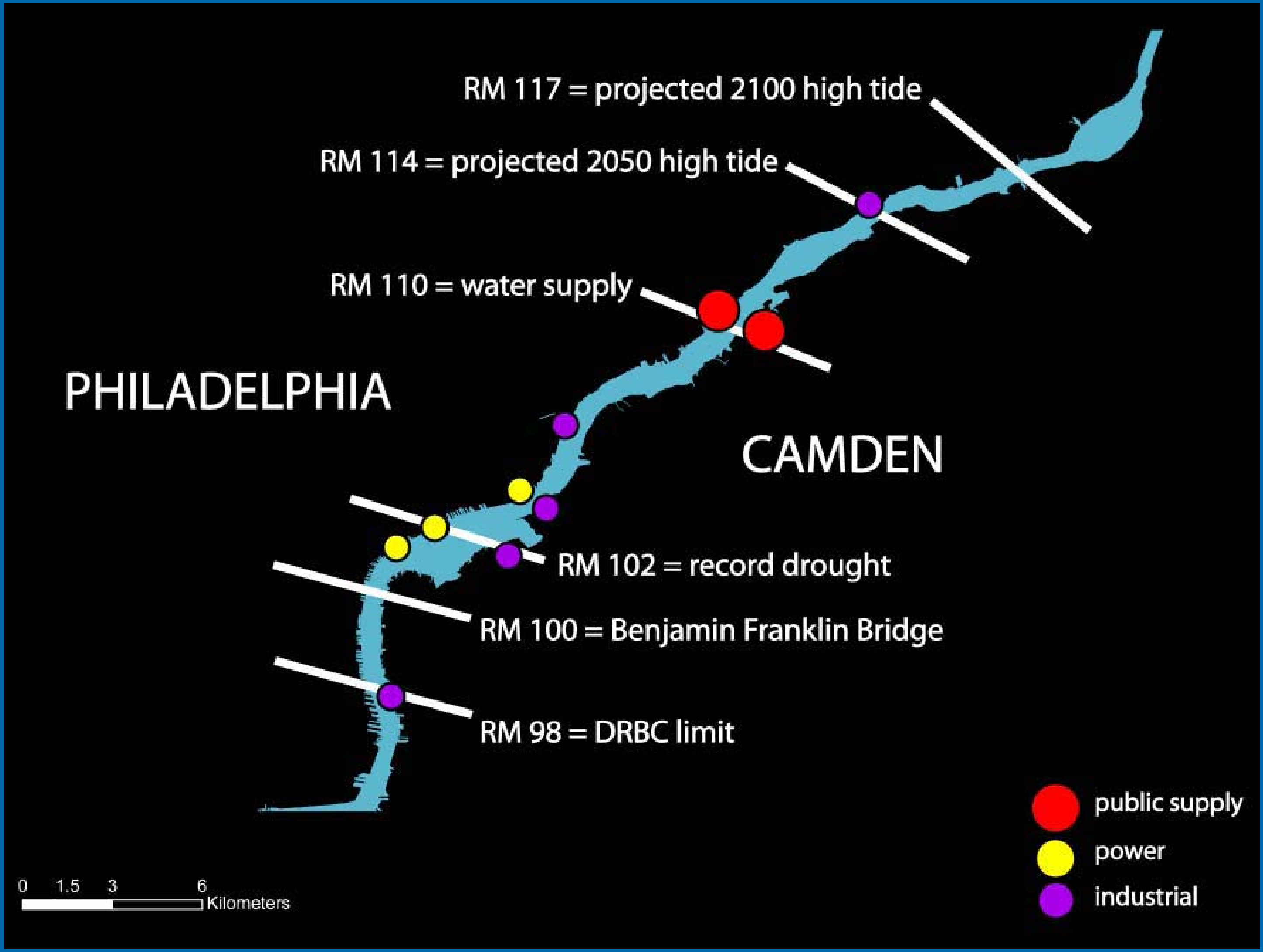
- New York City Delaware Basin Reservoirs drive the Basin wide Operating Plan.
  - Cannonsville
  - Pepacton
  - Neversink
- Two Corps of Engineers Reservoirs drive Lower Basin Operating Plan
  - Beltzville
  - Blue Marsh
- Merrell Creek Reservoir

Water Intakes at Risk from Drought and Sea Level Rise: *location of the salt line at high tide during drought*

Power
- Exelon Delaware Generating Station
- Exelon Richmond Generating Station
- Philadelphia Gas Works Richmond

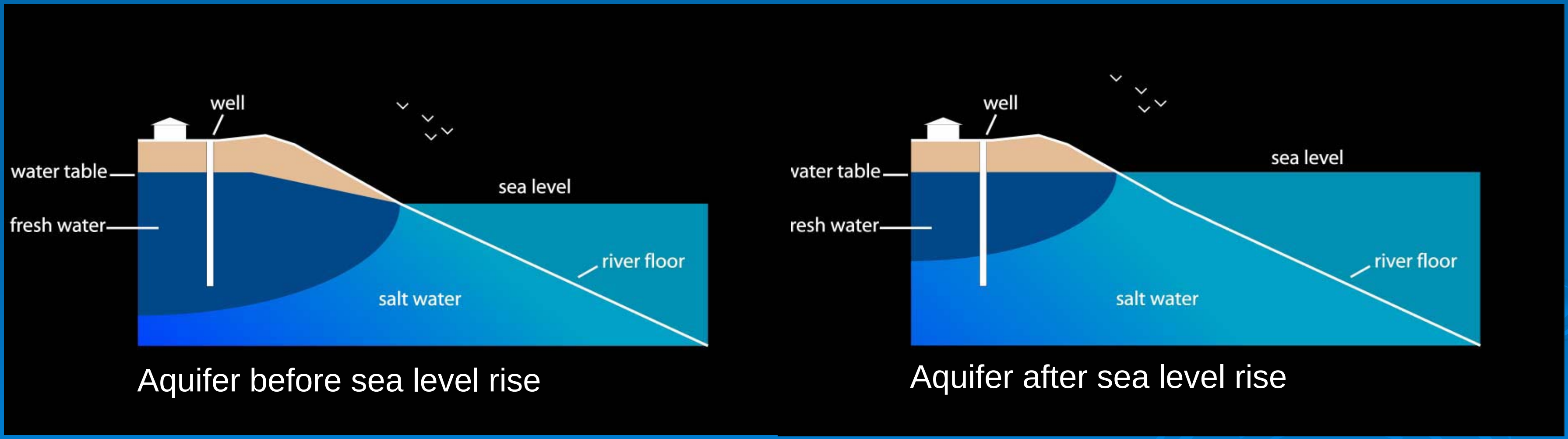
Industrial
- Koch Material Co.
- NGC Industries
- Rohm and Haas Philadelphia
- MacAndrew and Forbes Co.
- Pennwalt Corporation
- Sunoco

Public Supply
- Torresdale Water Intake (provides
- almost 60% of Philadelphia's water supply)
- New Jersey American Water Co. Tri-County Water Treatment Plant



Effect of Sea Level Rise on Aquifers

- Increased water consumption combined with sea level rise can compromise coastal aquifers
- As the ground water table falls below sea-level, intrusion of salt water into hydraulically connected coastal aquifers increases.
- New Jersey’s coastal communities are particularly vulnerable: “sole source aquifers” provide 50% or more of their drinking water.



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Other Impacts in the Basin

- Increased impervious surfaces
- Changing demographics/ water demand –
  - Population size and location
- Threats to the Headwaters
  - Quantity and Quality

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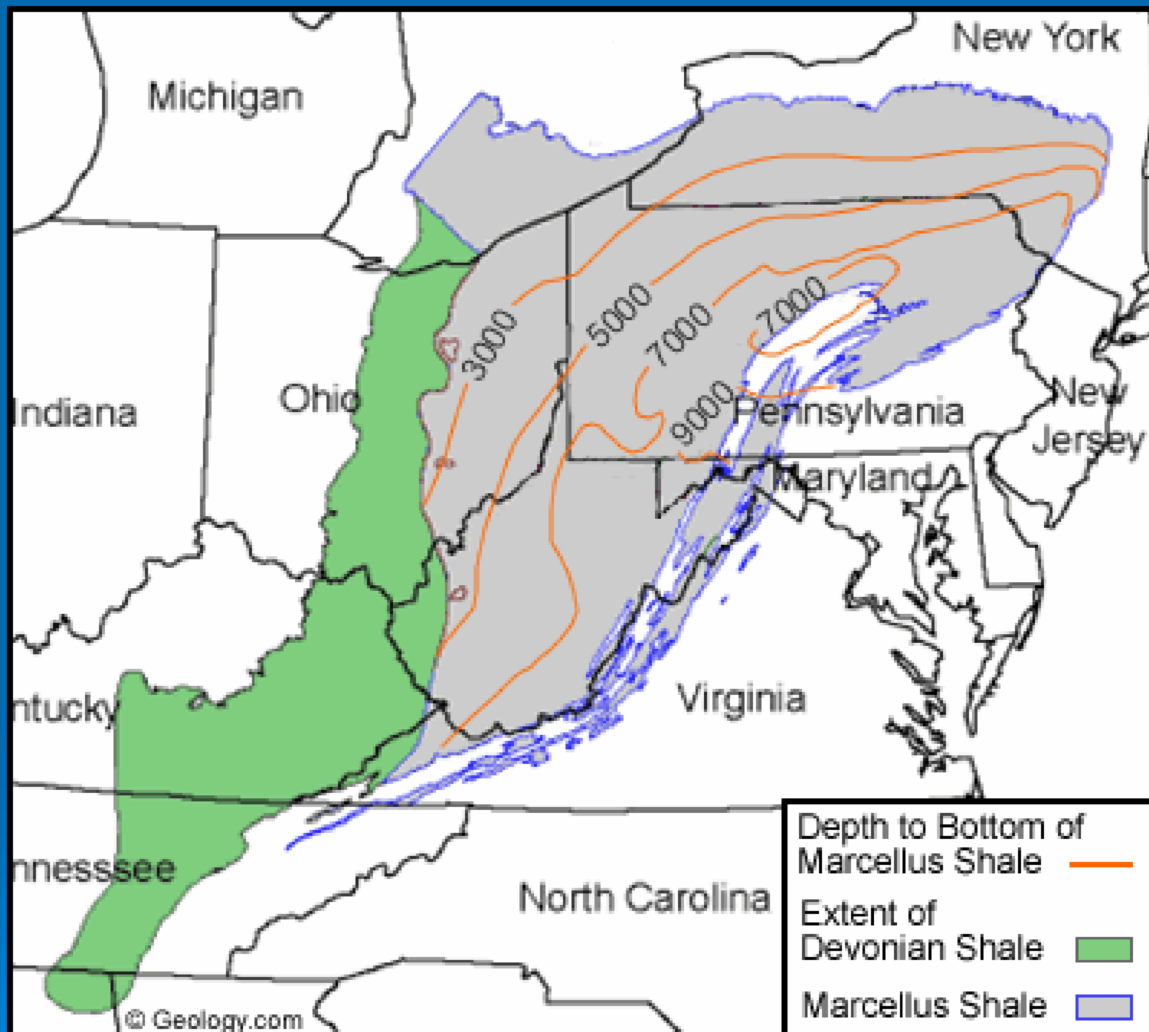

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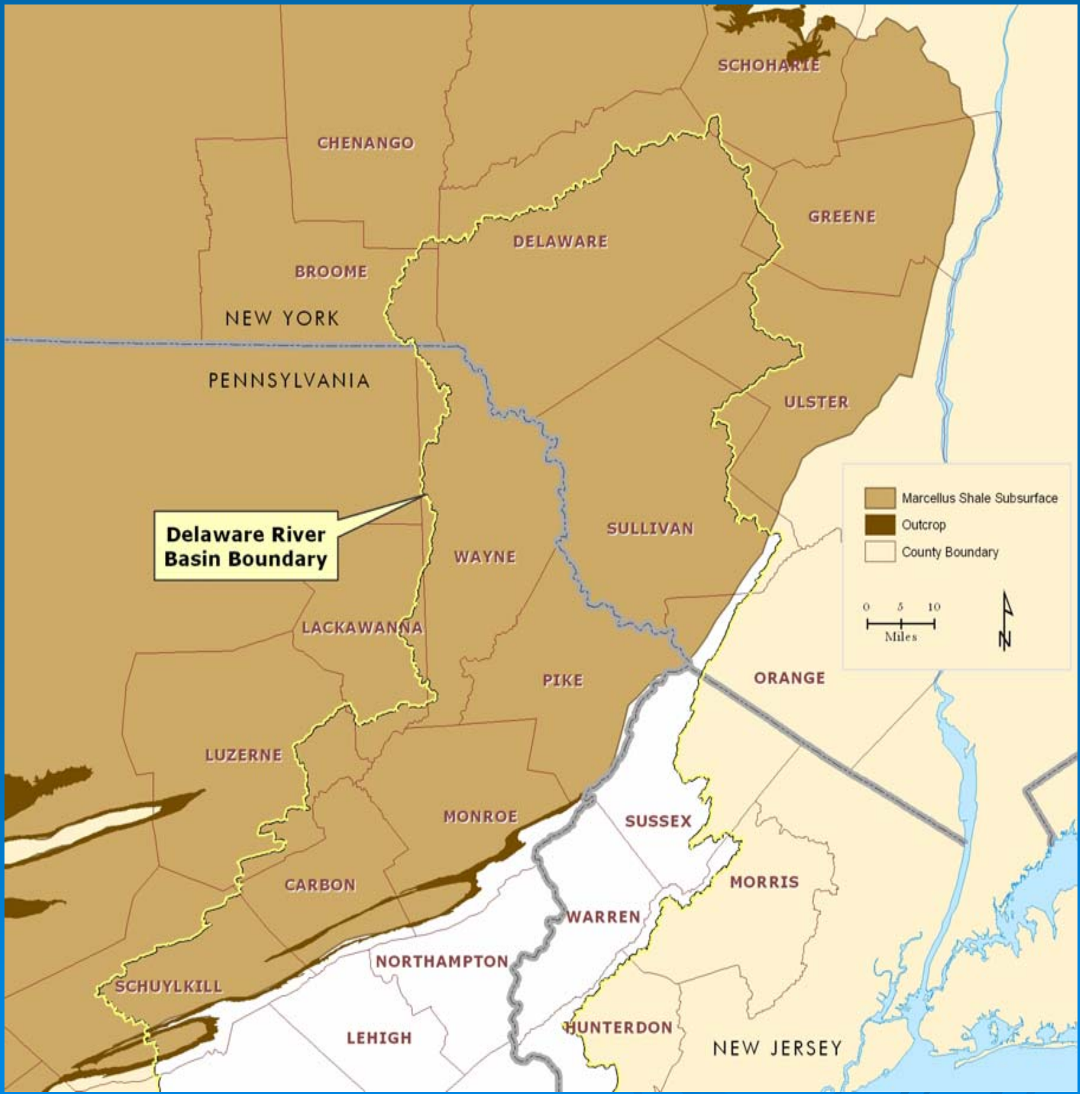
Extent of Marcellus Shale Formation within the Delaware River Basin



36% (4,937 mi^2) of the Delaware Basin is underlain by the Marcellus Shale

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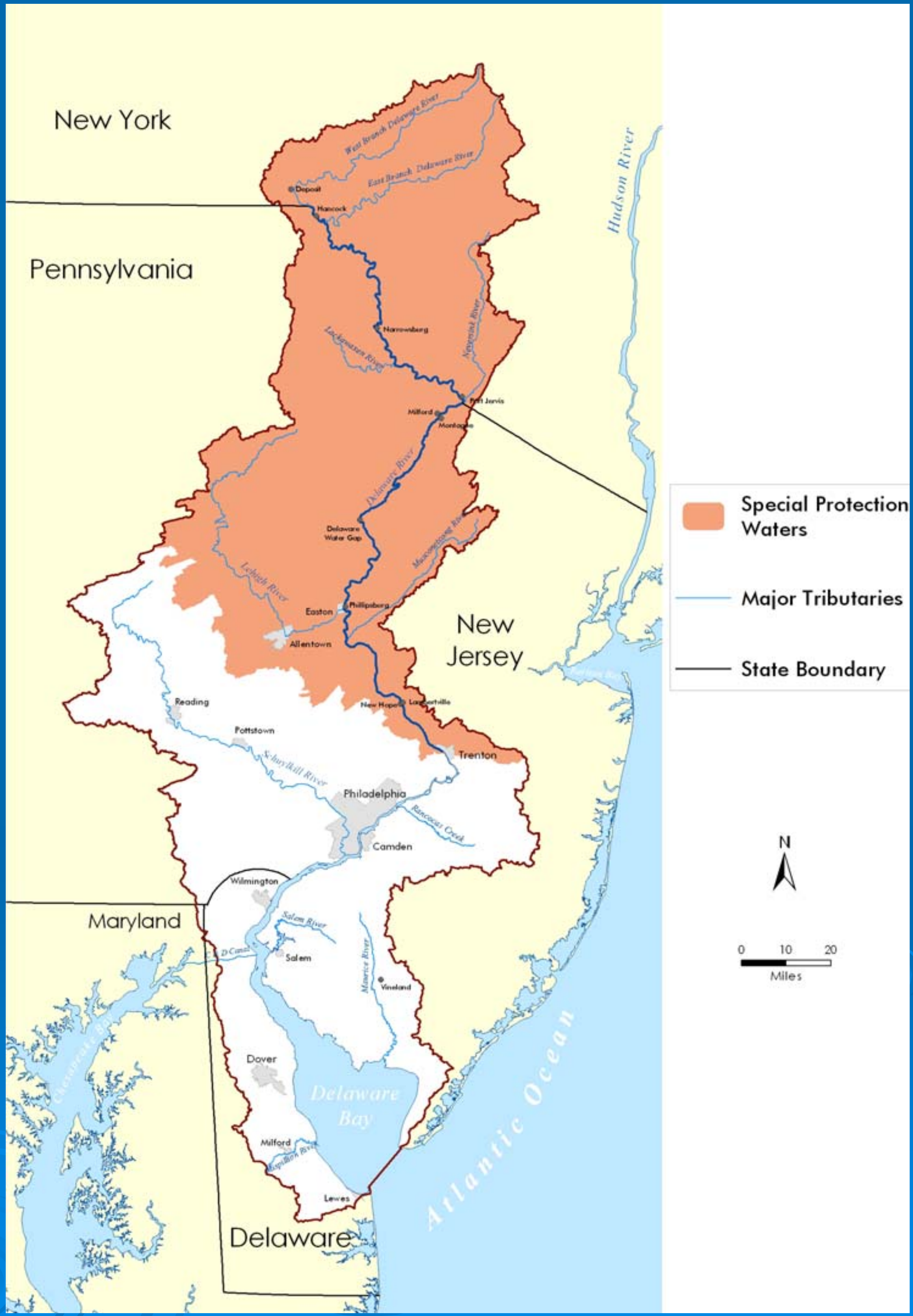
Hydro-fracking Phase –
(a week or two)

Injection pumps, supplies, and many frack tanks for fresh and flowback waters

Special Protection Waters (SPW)



Vulnerability of the Headwaters

- Headwaters are the most sensitive areas of a watershed
- Existing contiguous forest is critical to water quantity and quality

- Forest Fragmentation

- Philadelphia Source Water Protection Analysis
  - #1 – Change in Delaware River Headwaters most critical

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“Adaptation to climate change is now inevitable… The only question is will it be by plan or by chaos?”

Roger Jones, CSIRO, Australia; Co-author of IPCC

Needs

- Partnerships, multiple agencies and stakeholders
- Holistic Analysis –
  - Geography – basinwide
  - Water quality, quantity, biological/habitat, human needs
- Inform decision makers – risks and options

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Needs

- Sophisticated Models - Test Different Scenarios
  - Drought and Flood of Record (?)
- Analysis based on Potential Risk
- Overlay Climate Change on other Water Resources Impacts
  - Increasing demand, increased impervious cover, loss of forests, water quality impacts with land use changes
- Evaluation of Adaptation Options
  - Reduce Demand – Water Conservation
  - Better Stormwater Management
  - Need for Increased Upstream Storage (?)
  - Flood Mitigation

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ASSESSMENT

Water Availability

2030 Withdrawal Demand

Instream Flow Needs (ecological / salinity)

Drought Vulnerability

Flood Vulnerability

<u>GOAL</u>: Determine basin-wide concerns, identify location and magnitude of deficits for vulnerable watersheds and river points

STRATEGIES

Reduction of Demand by Conservation Measures

Conservation pricing, drip irrigation, residential irrigation alternatives, water loss control, plumbing requirements, water reuse, education, etc.

Increasing Instream Flow / Mitigating Flood Loss

Local solutions, LID, riverine buffers, protection of headwaters, stormwater infiltration, storage in old quarries/ mine rec., ASR

New / Modified Storage & Infrastructure

Water storage / flood mitigation / Interconnections

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Time for Action !

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