CLIMATE CHANGE – Increasing Uncertainty in Water Resources Management

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Executive Director

Delaware River Basin Commission

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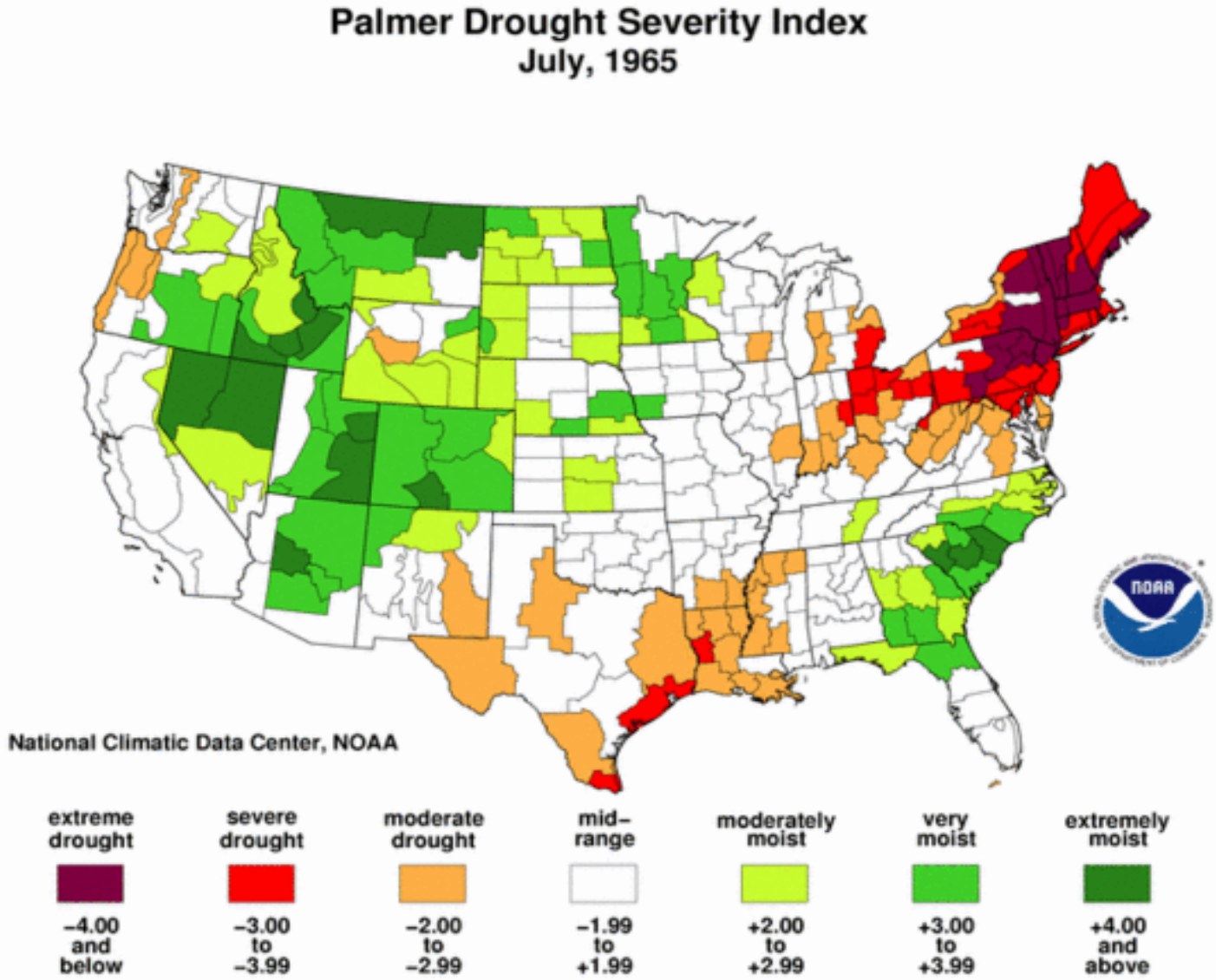
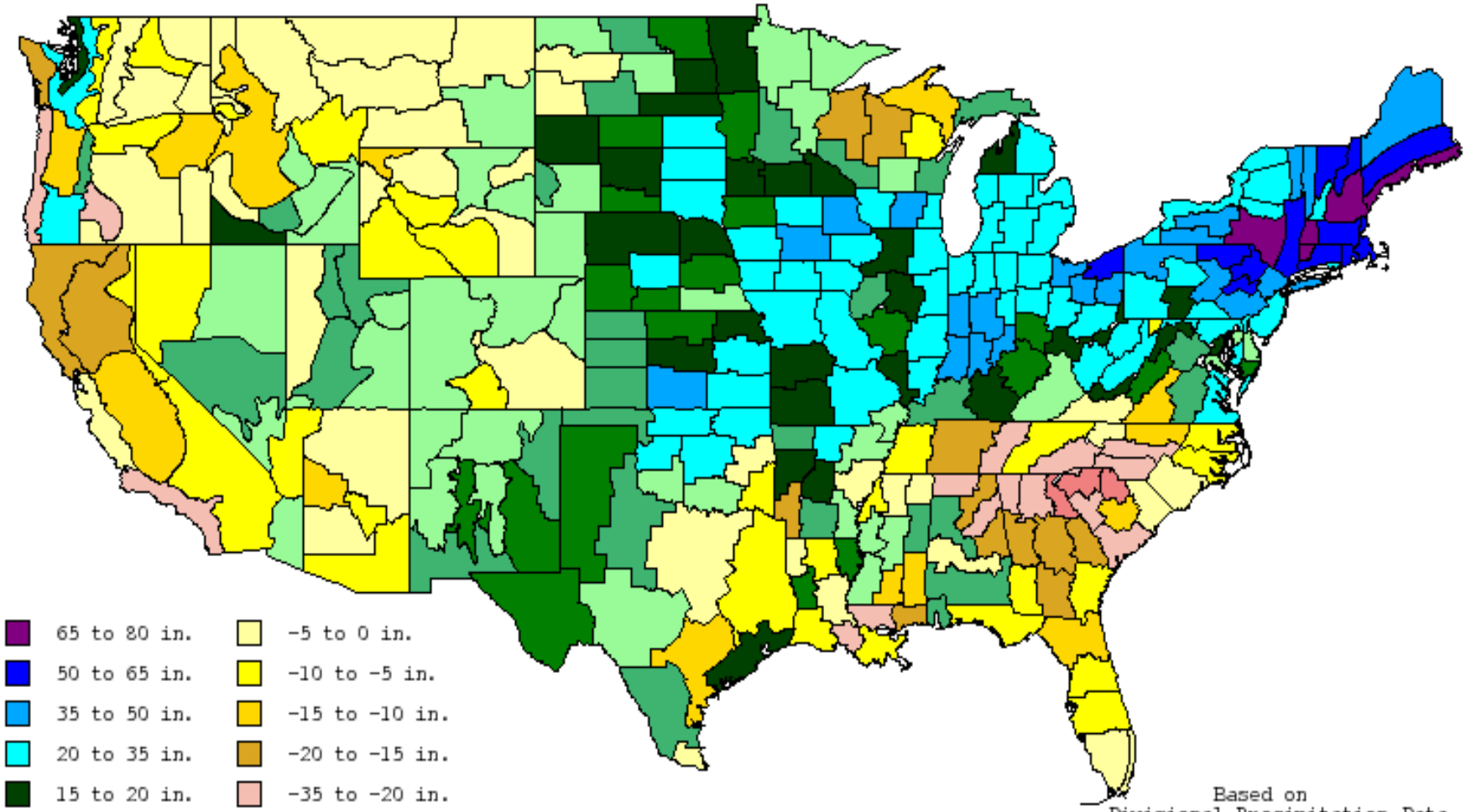
Delaware River Watershed Facts

- Nearly 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



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

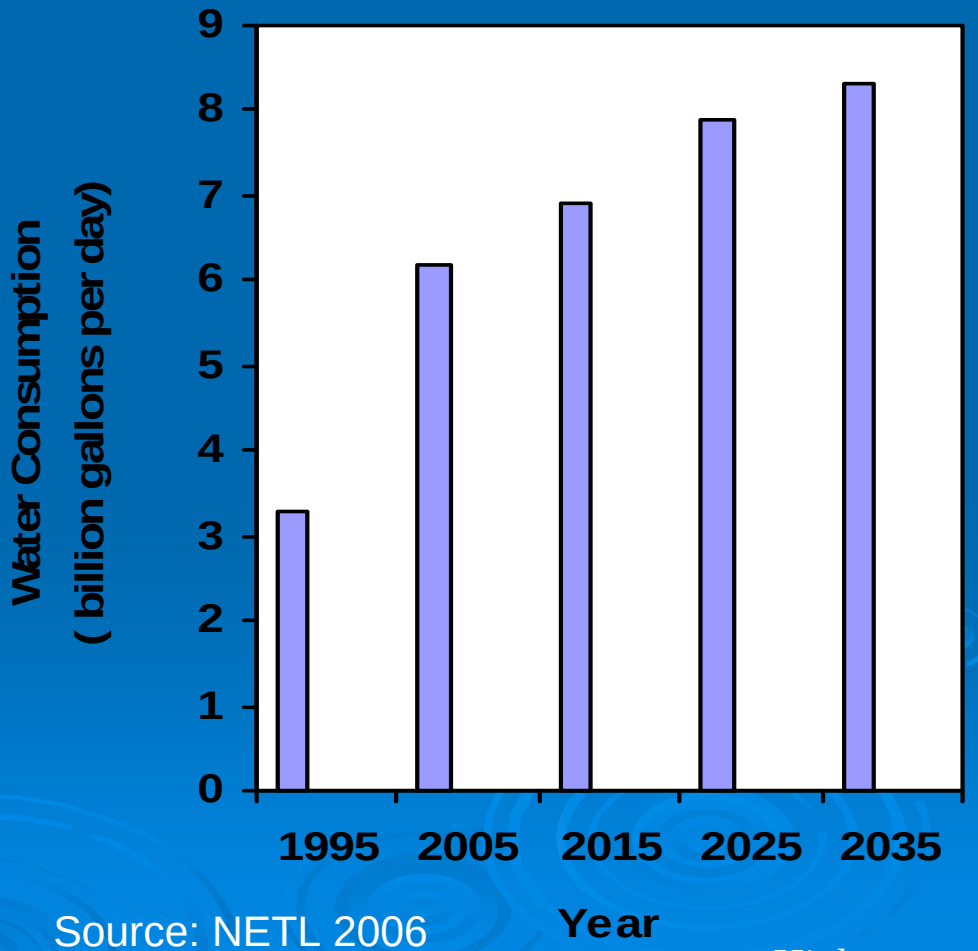
- Increasing Temperatures
- Equal or Increased Precipitation
- Greater Intensity of Storms
- More Precip. In Winter Months
- Potential for Extended Droughts
- Time Shift in Spring High Stream Flows
- Increase in Sea Level Rise

Potential Impacts

- Energy - Water Nexus
- Flooding
- Biological
- Water Quality
- Water Supply

Water Demands for Future Electric Power Development

- Water demands could almost triple from 1995 consumption for projected mix of plants and cooling
- Carbon emission requirements will increase water consumption by an additional 1-2

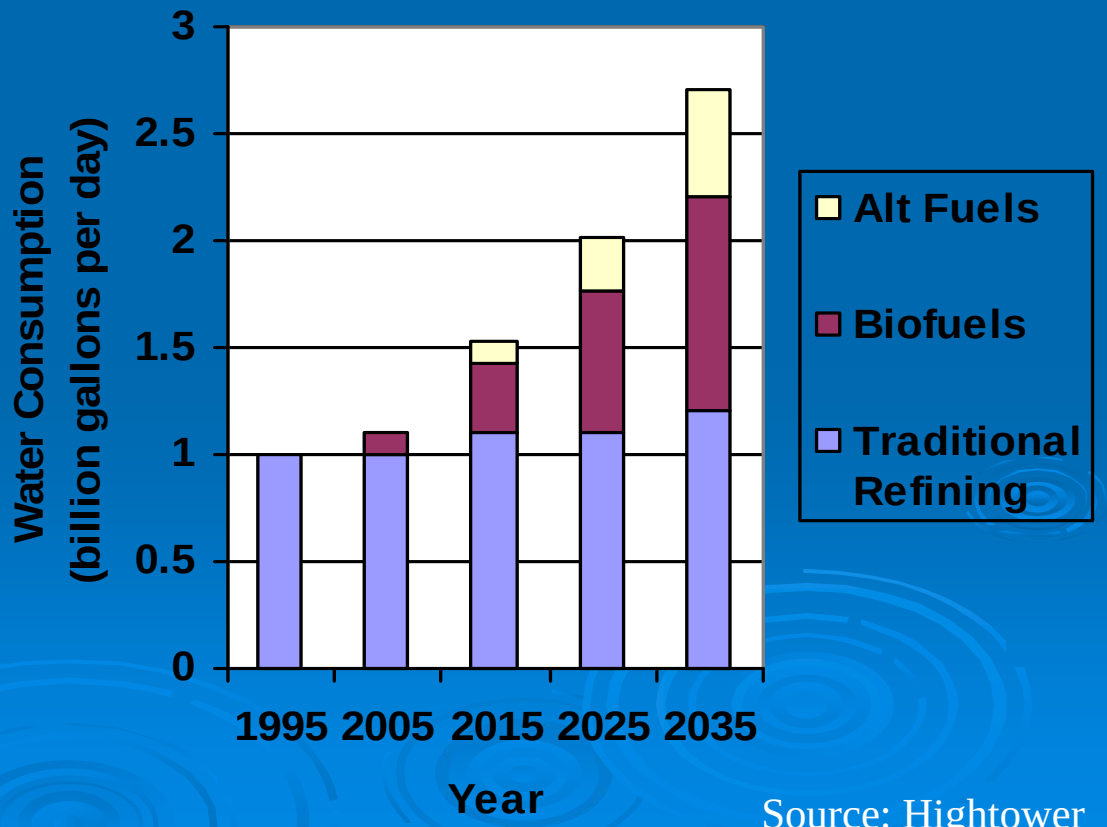


Source: NETL 2006

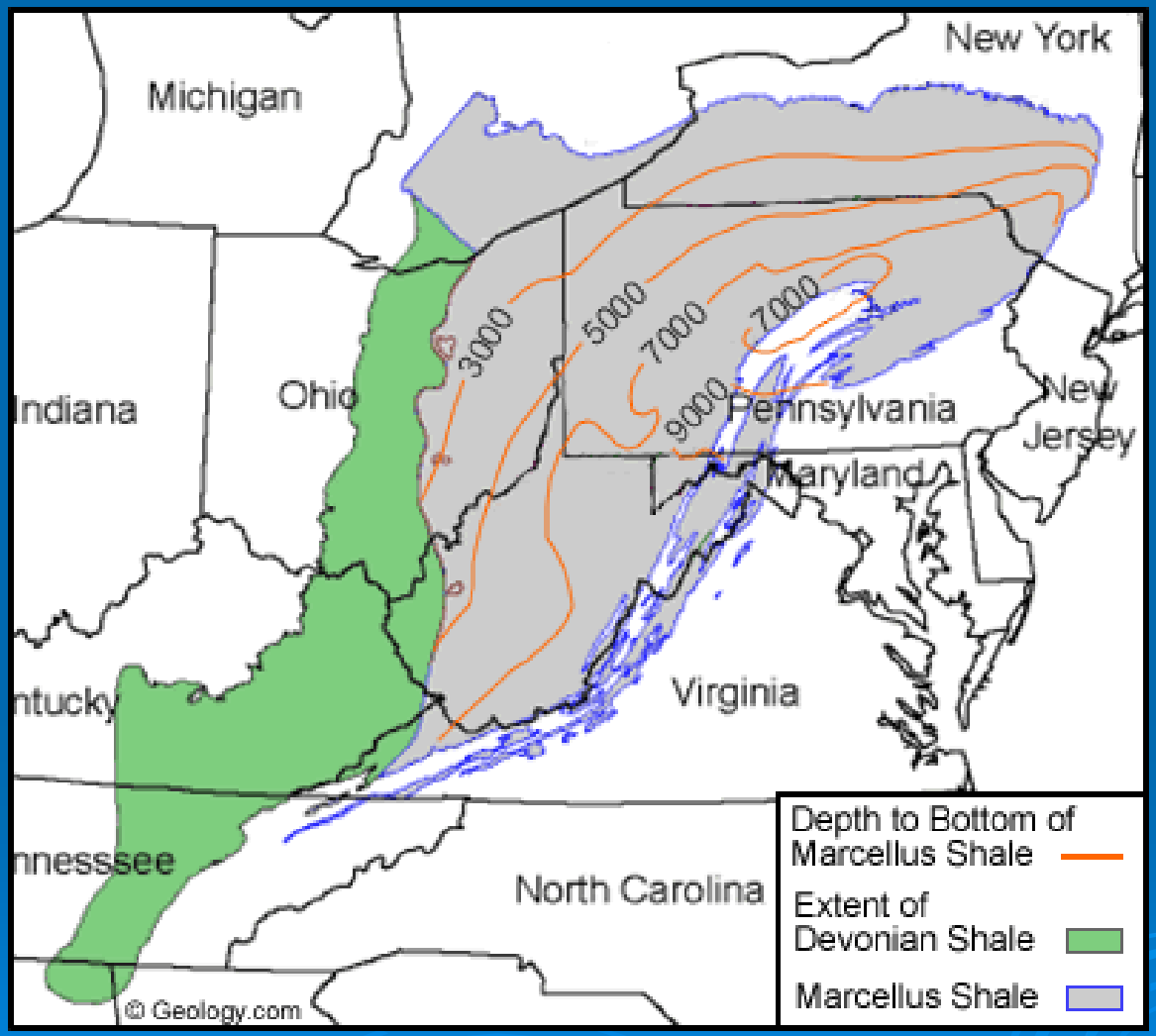
Hightower

Emerging Water Demands for Alternative Fuels Development

- Irrigation of even small percentage of biofuel acreage will increase water consumption by an additional 3-5 Bgal/day



Source: Hightower


New York
Michigan
Indiana
Ohio
Pennsylvania
New Jersey
Maryland
Virginia
ntucky
nnesssee
North Carolina
3000
5000
7000
7000
9000
Depth to Bottom of Marcellus Shale
Extent of Devonian Shale
Marcellus Shale
© Geology.com

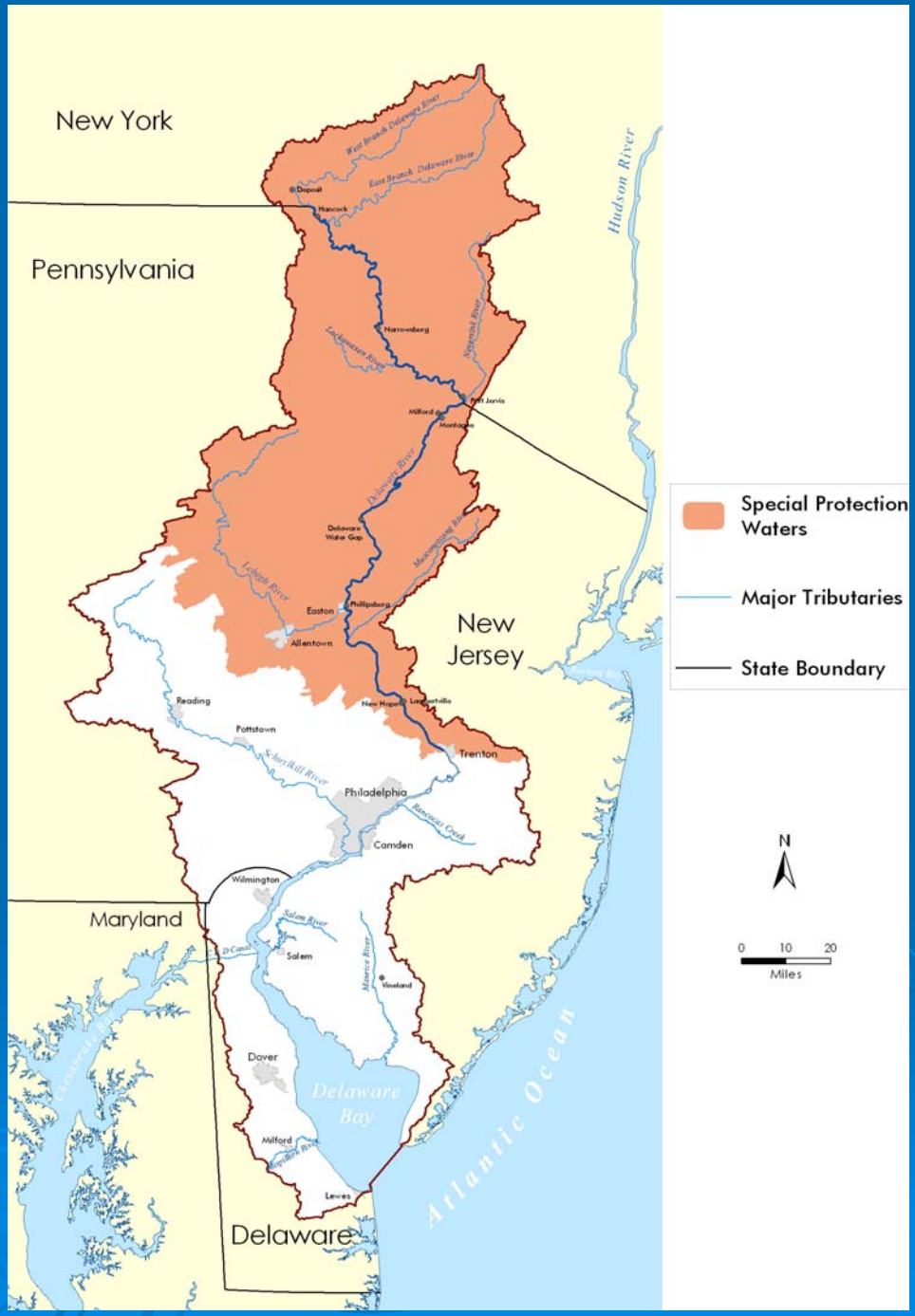
Extent of Marcellus Shale Formation within the Delaware River Basin

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

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

- Multiple Factors
  - Increasing Impervious Cover – development (5000 units)
  - Road cuts, pipeline connections,
  - Ozone Increases
- Forest Fragmentation

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

Flood Inundation

- Increased Precipitation
- More Intense Storms
- River Corridors – Old Towns
- Coastal Surge
- Siting of Water and Wastewater Plants

Biological Impacts

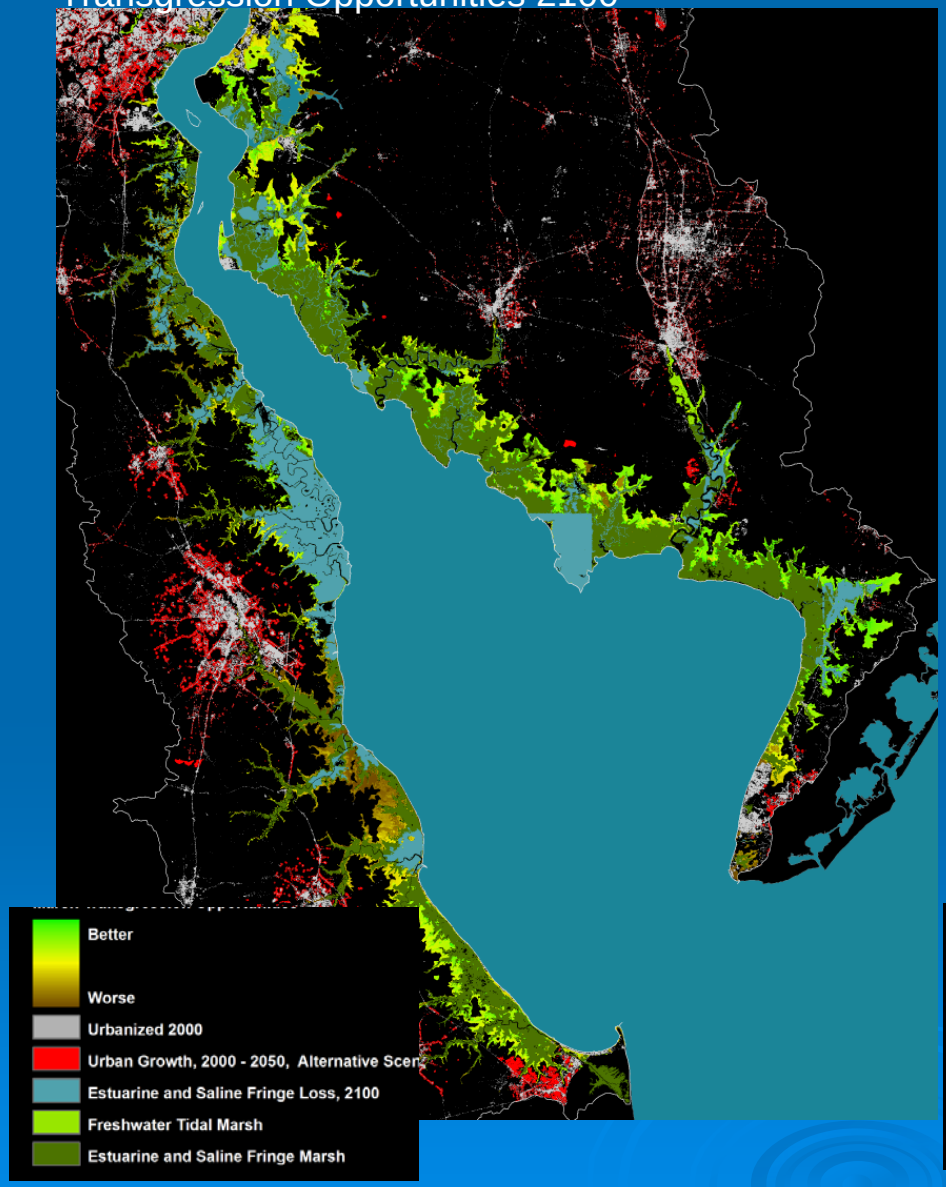
- Wetlands Inundation/Loss
- Vegetation Changes
- Invasive Species
- Change in Spring Thaw Flows
  - Migratory Patterns
- Disruption of Symbiotic Relationships

Aquatic Problems

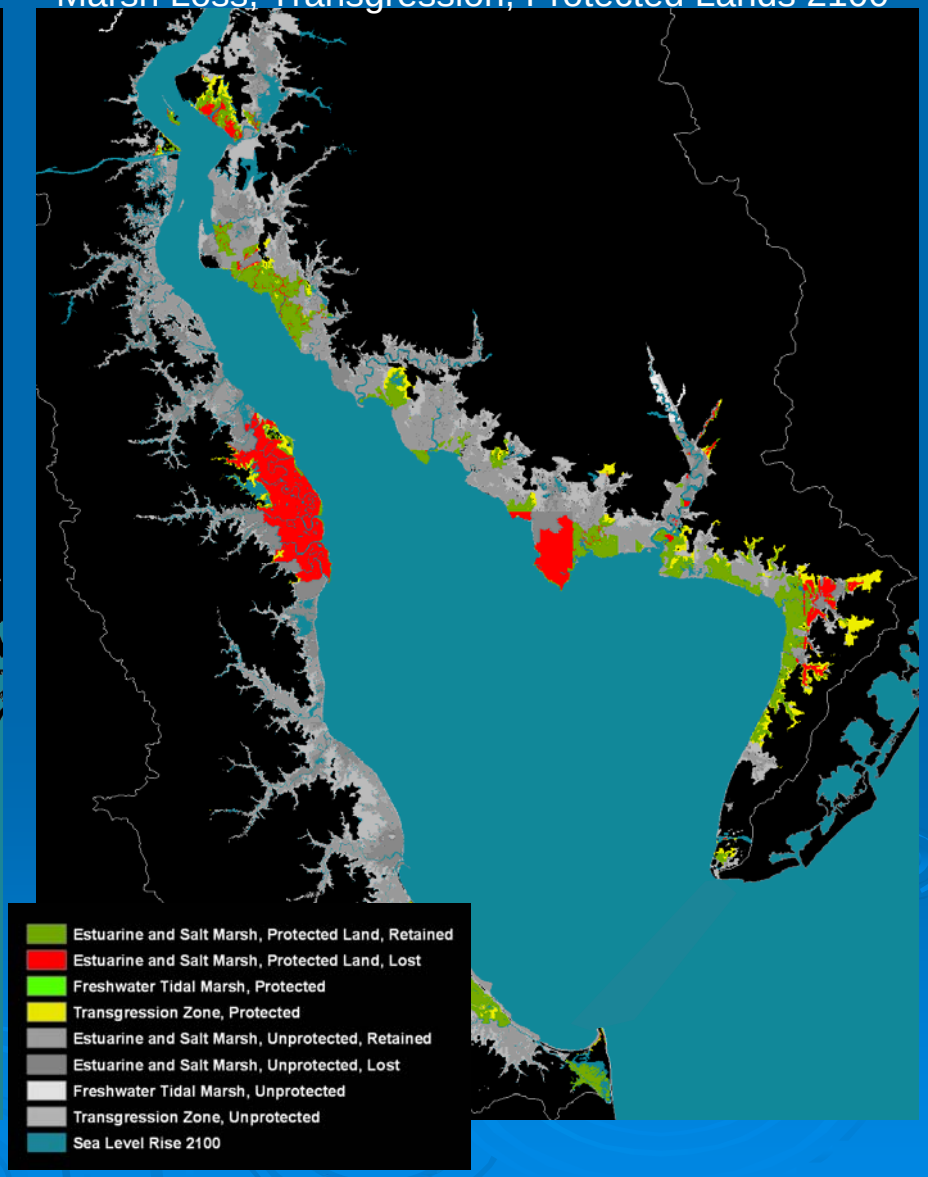
- Coldwater Fisheries
- Endangered Species (Dwarf Wedgemussel)
- Terrestrial/aquatic interactions
- Seasonal migrations (shad, salmon, etc.)
- Easier for Invasive Species to move in

Wetlands - Analysis: Marsh Transgression

Transgression Opportunities 2100



Marsh Loss, Transgression, Protected Lands 2100



- The animals, plants, and forests of the region may shift their habitat and ranges northward due to increased temperatures and potential decrease in water.
- Biodiversity among species may also decrease, which can also lead to an increase in invasive species.

Changes in Forest Diversity for the MARA Region

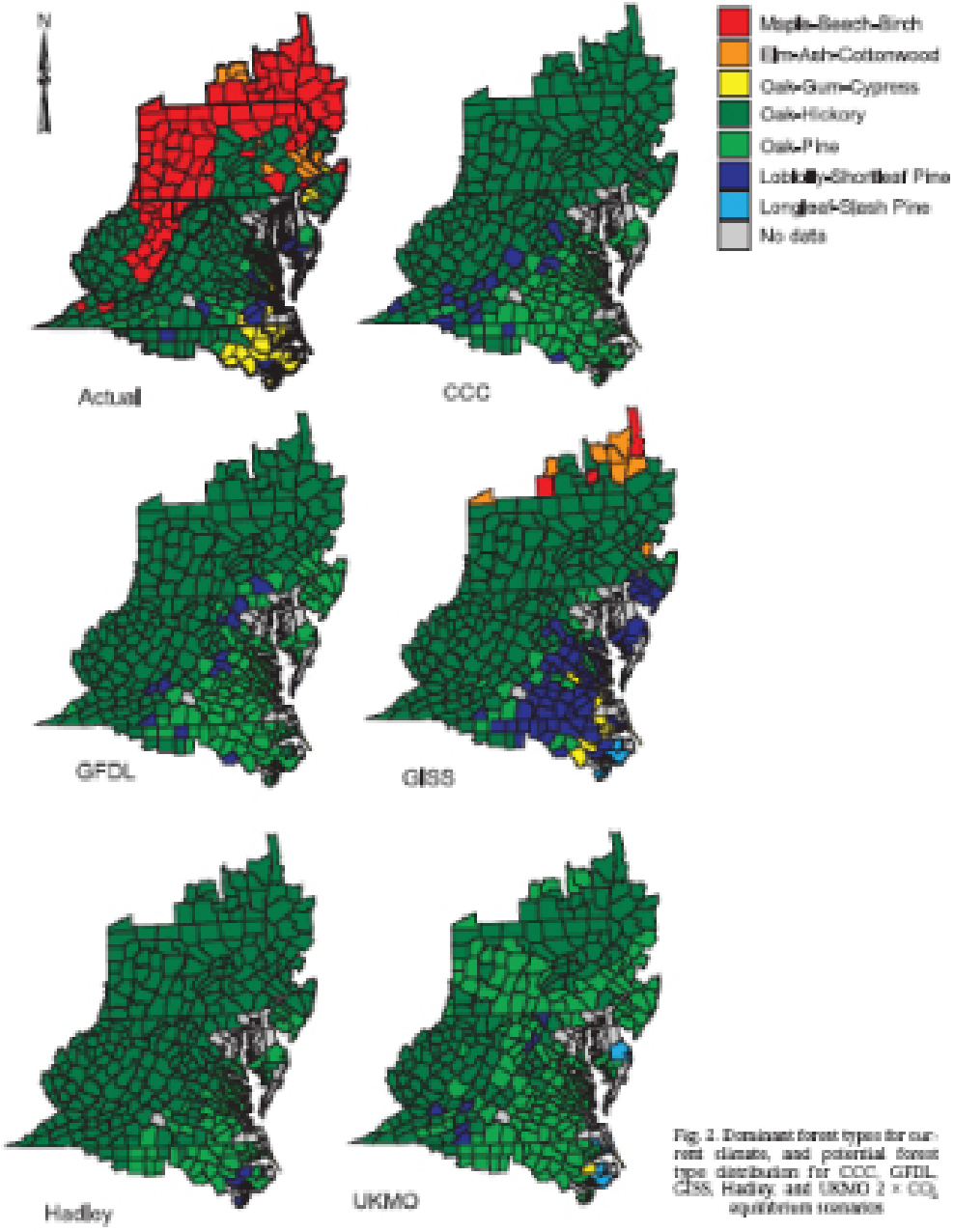


Fig. 2. Dominant forest types for current climate, and potential forest type distribution for CCC, GFDL, GISS, Hadley, and UKMO 2 × CO_2 equilibrium scenarios

http://www.cira.psu.edu/mara/index.html

Water Quality

- Temperature
- Dissolved Oxygen
- Suspended Sediment
- Lower $_{7}Q_{10}$ for Wastewater Assimilation/ TMDLs/ Increased Residence Time
- Potential Increase in Waterborne Pathogens/ Phytoplankton Blooms
- Impact on Regulatory Policies – drinking water and wastewater, antibacksliding

Response to Potential WQ Changes

Issues –

- Should We adapt to CC-caused WQ Changes?
- How to Handle Natural Changes – Regulation of Dischargers?
- Existing Water Quality Standards
- Anti-Backsliding Rules

➢ Modeling of Scenarios / Impacts

Water Supply

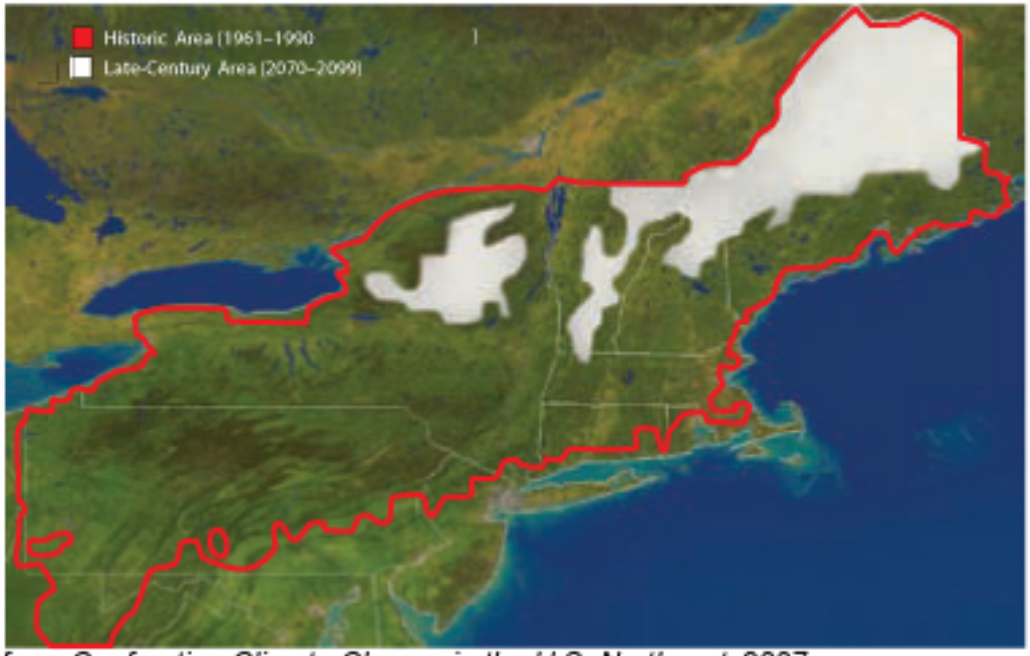
Potential Impacts – Water Supply and Infrastruture

- Prolonged Droughts
- Increased Evapotransporation
- Loss of Snow Pack
- Salinity Pushing Inland– Sea Level Rise
- Infrastructure - wastewater treatment, sewer lines, transportation

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

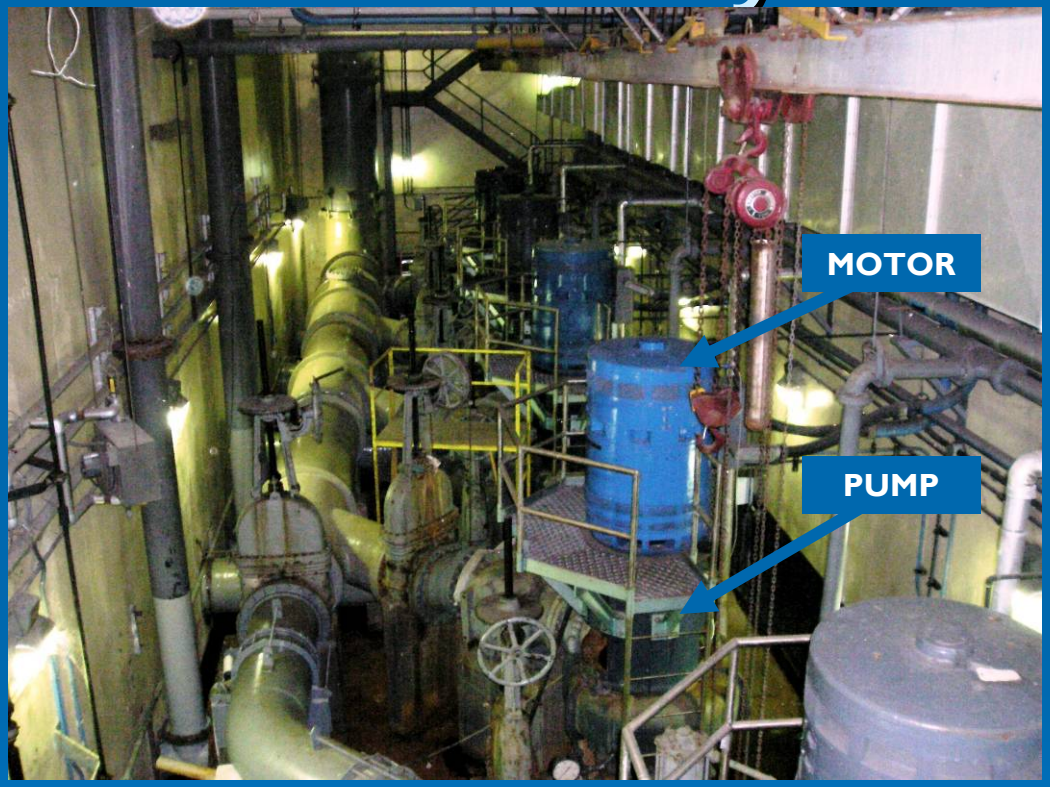
Sea level rise compounding seasonal storm events to overwhelm water pollution control plants

planyc 2030
www.nyc.gov/html/planyc2030

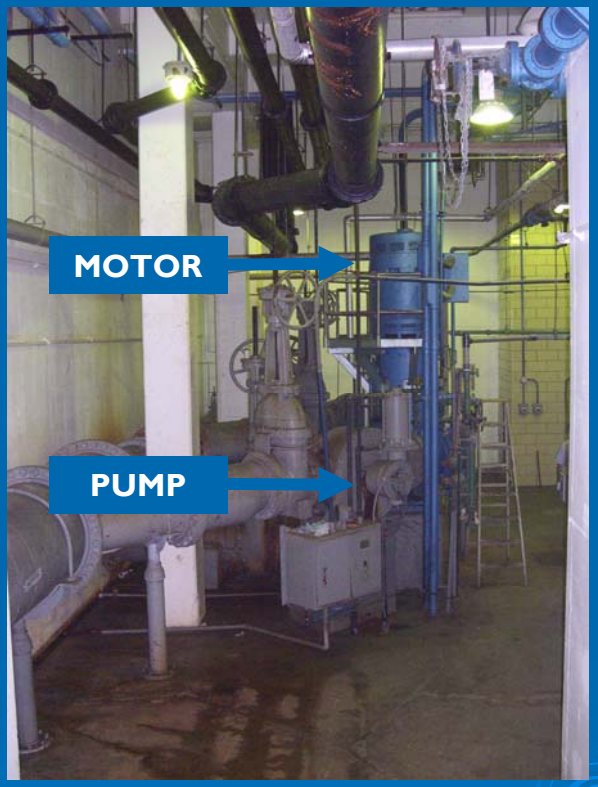
Flood Gates at Facility Entryways

Flood Gate at Tallman Island WPCP

Critical Equipment at Rockaway WPCP

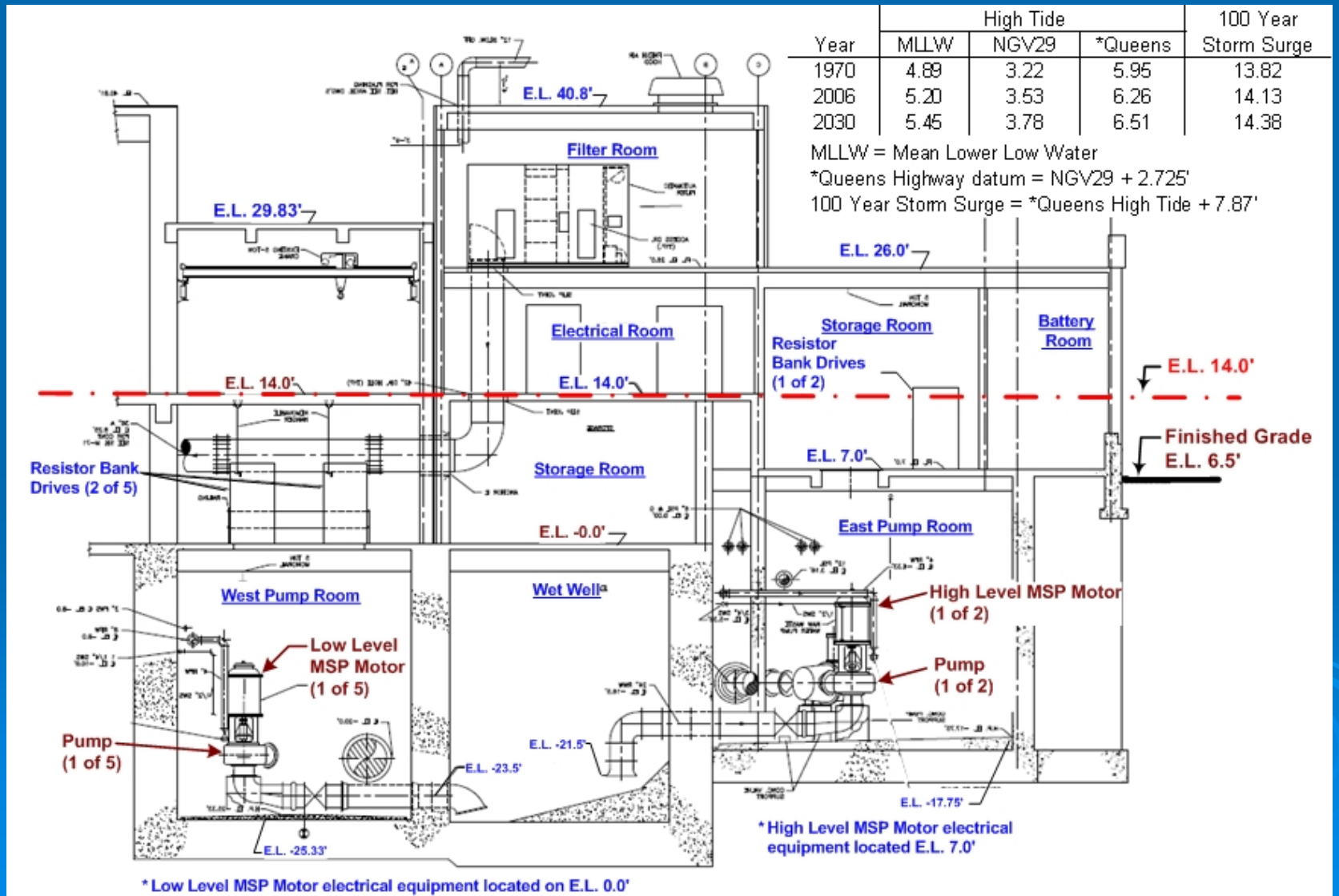


West pump room: 25.33’ below sea level



East pump room: 17.75’ below sea level

Existing Equipment Locations



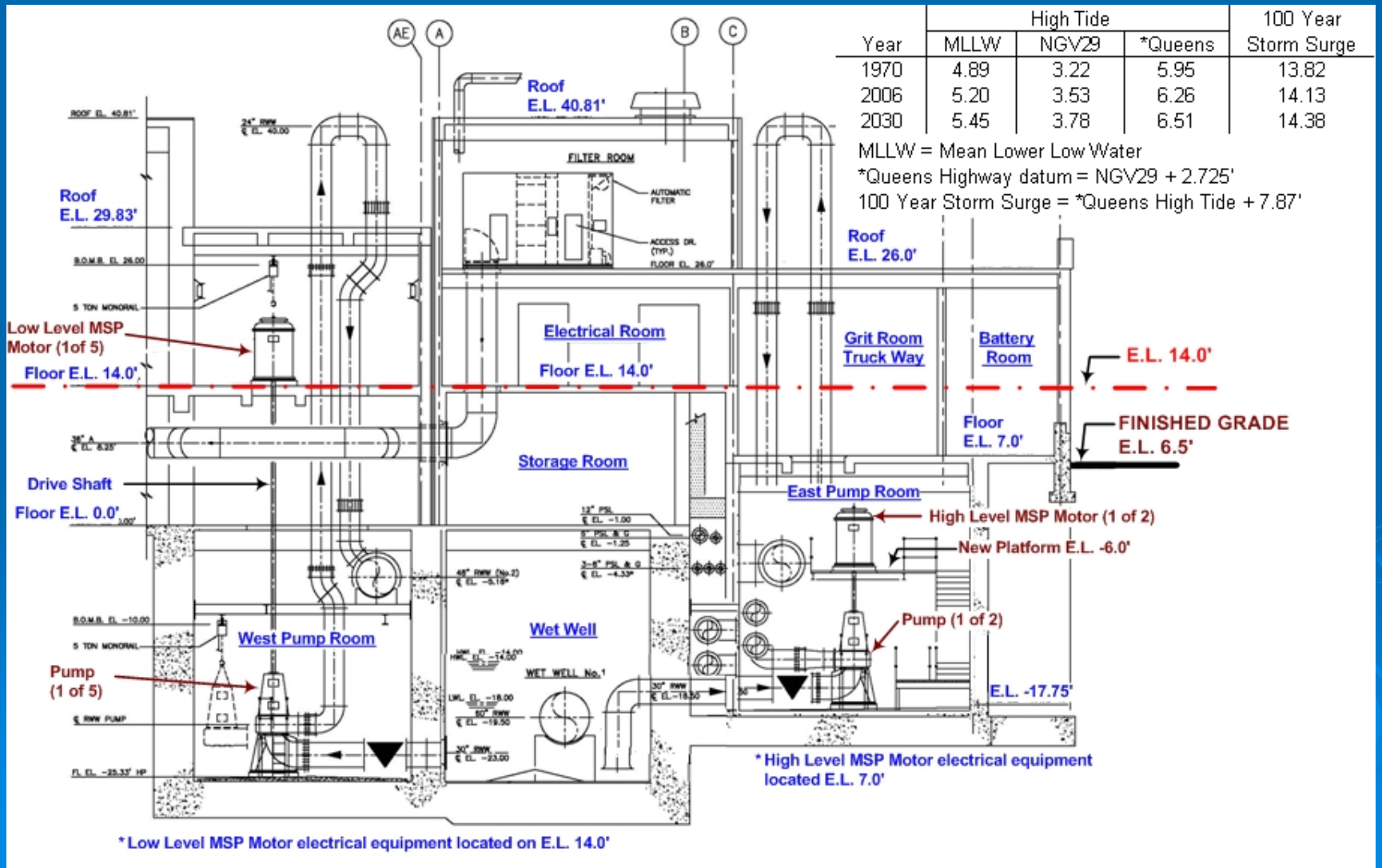
Year	High Tide			100 Year
	MLLW	NGV29	*Queens	Storm Surge
1970	4.89	3.22	5.95	13.82
2006	5.20	3.53	6.26	14.13
2030	5.45	3.78	6.51	14.38

MLLW = Mean Lower Low Water

*Queens Highway datum = NGV29 + 2.725'

100 Year Storm Surge = *Queens High Tide + 7.87'

Proposed Equipment Locations



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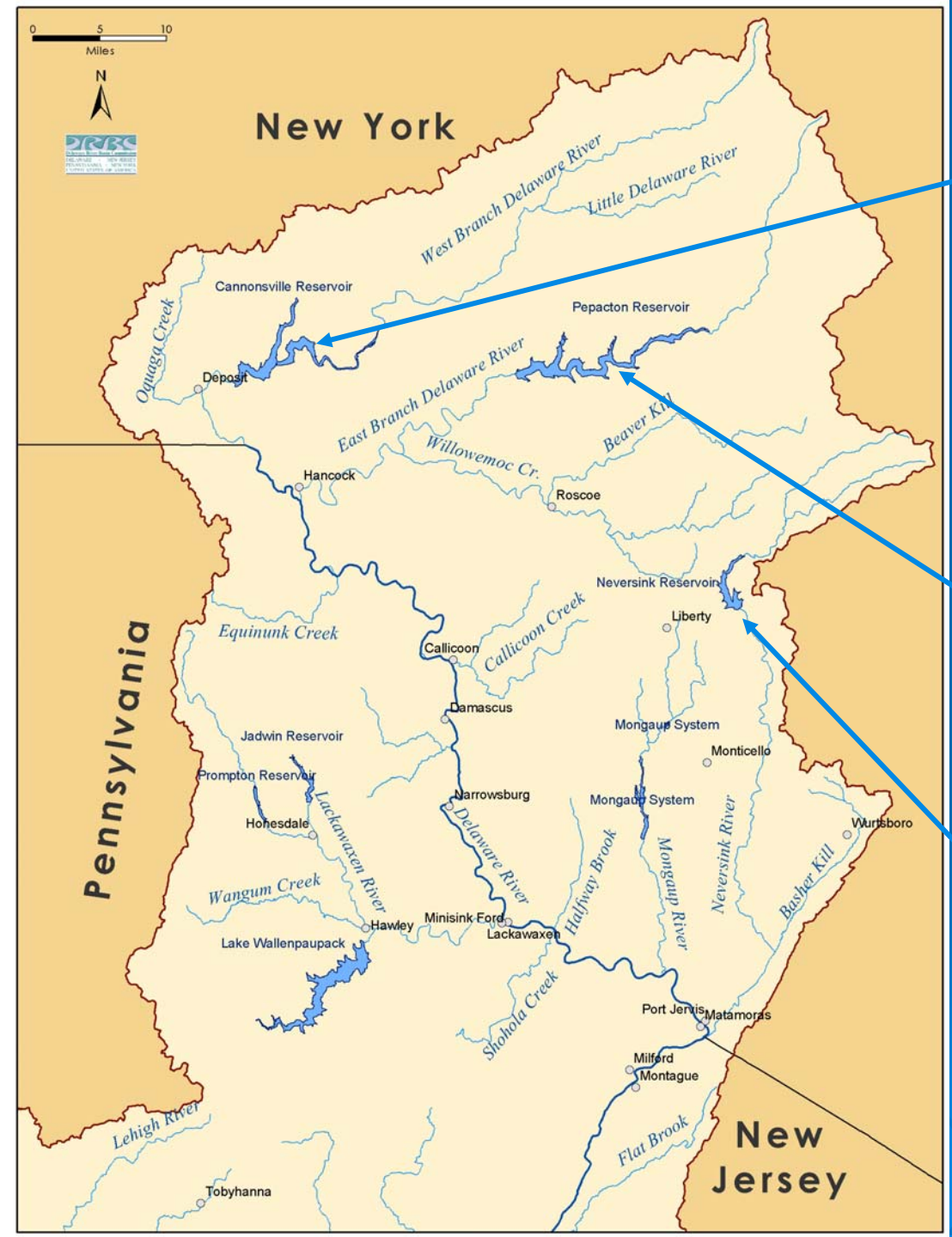
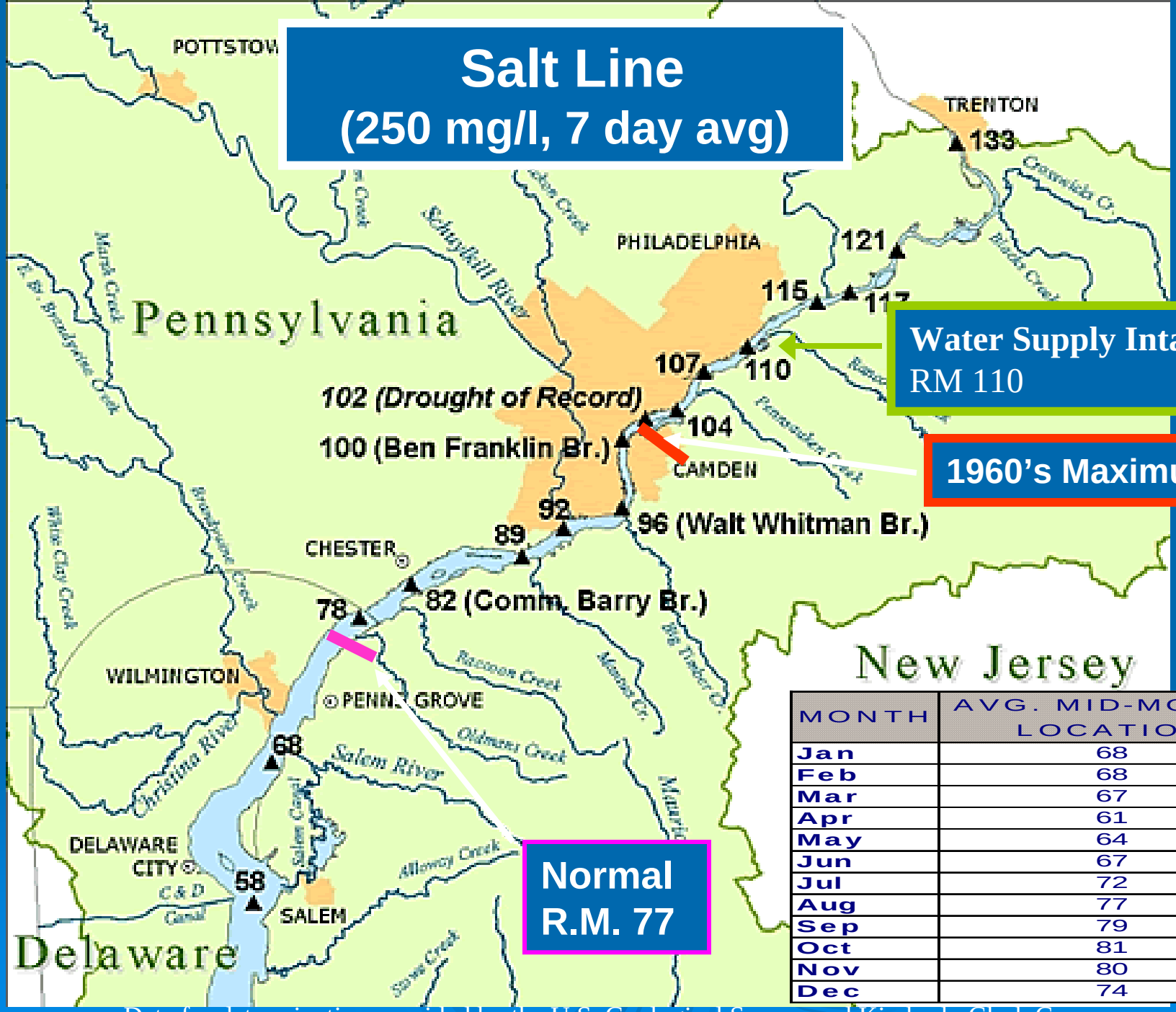
Sea Level Rise
1 meter by 2100
Greater with rapid ice melt
Global sea level rise
And local subsidence


0 5 10
Miles
N
New York
Pennsylvania
New Jersey
West Branch Delaware River
Little Delaware River
Cannonsville Reservoir
Pepacton Reservoir
Oquaga Creek
Deposit
East Branch Delaware River
Willowemoc Cr.
Beaver Kill
Hancock
Roscoe
Neversink Reservoir
Liberty
Equinunk Creek
Callicoon
Callicoon Creek
Damascus
Mongaup System
Jadwin Reservoir
Monticello
Prompton Reservoir
Narrowsburg
Mongaup System
Lackawaxen River
Delaware River
Neversink River
Wurtsboro
Honesdale
Wangum Creek
Halfway Brook
Mongaup River
Basher Kill
Hawley
Minisink Ford
Lackawaxen
Lake Wallenpaupack
Shohola Creek
Port Jervis
Matamoras
Milford
Montague
Lehigh River
Flat Brook
Tobyhanna

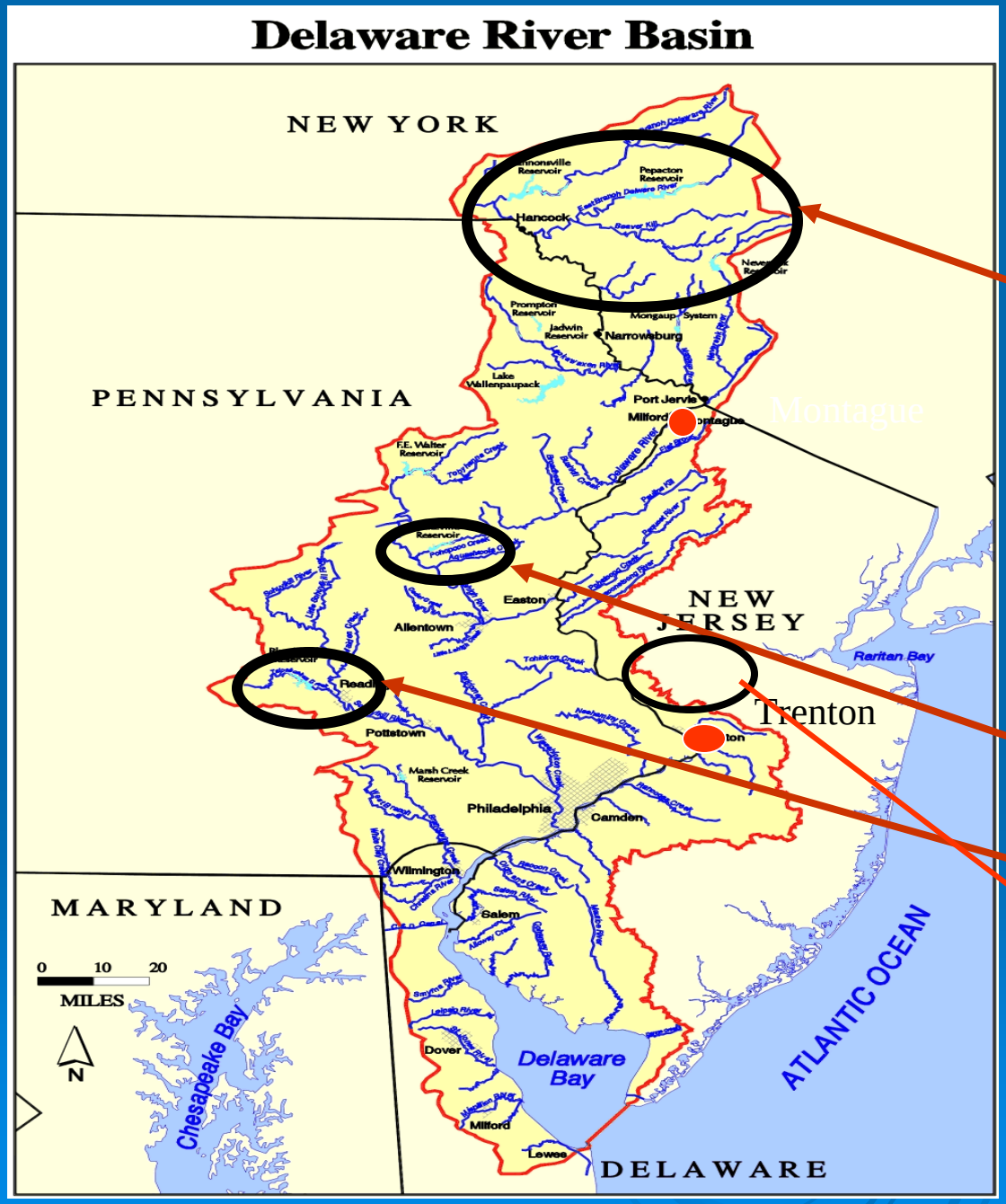
Delaware River Basin

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

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

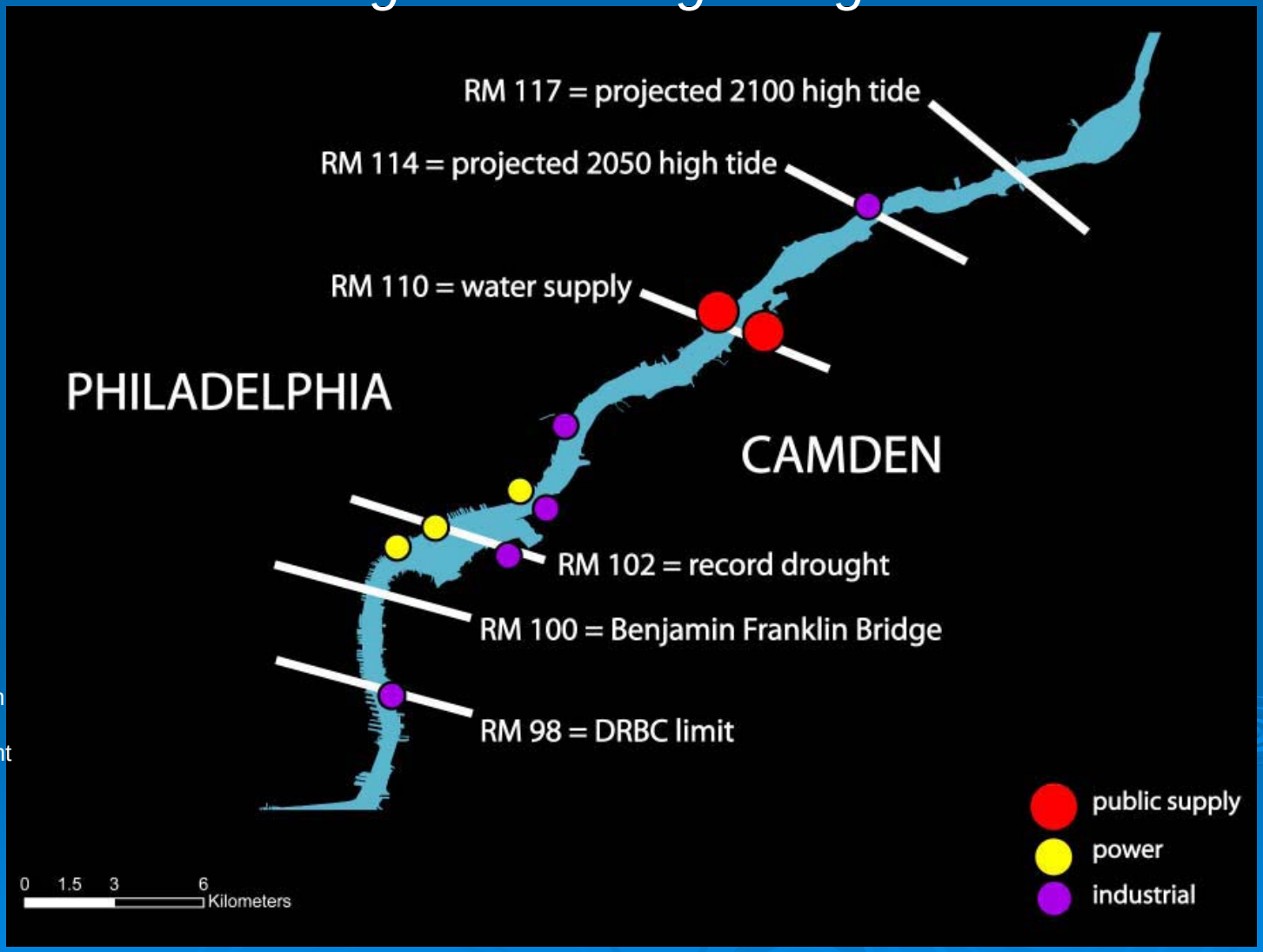
Delaware River Basin Commission

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

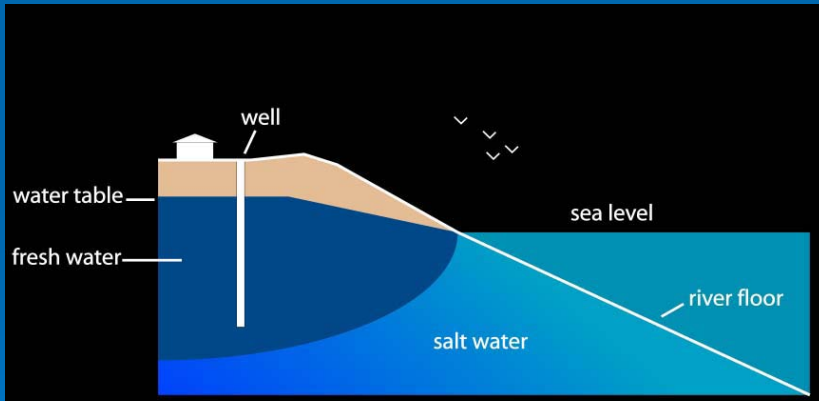
Industrial
- Koch Material Co.
- NGC Industries
- Rohm and Haas Philadelphia
- MacAndrew and Forbes Co.
- Pennwalt Corporation

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

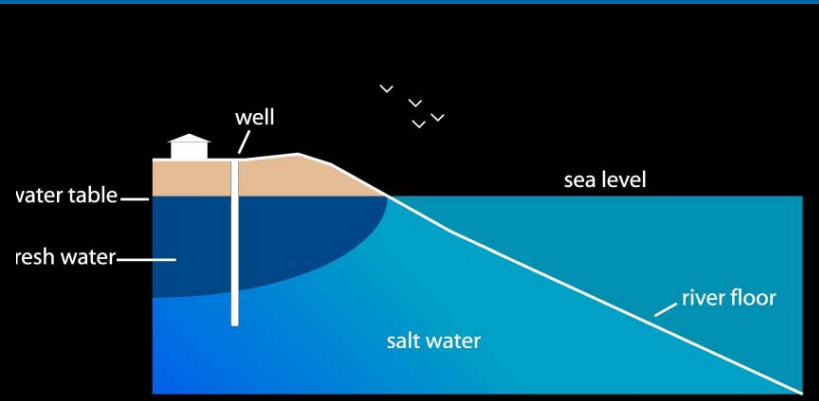


Effect of Sea Level Rise on Aquifers

- 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.



Aquifer before sea level rise



Aquifer after sea level rise

“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

- Models with Uncertainty Factors
  - 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

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