CLIMATE CHANGE IMPACTS

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

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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
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

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
Northern NJ Annual Precipitation (1895-2007)

1895-1970 mean: 44.57”

1971-2000 mean: 49.79”

2001-2007 mean: 51.88”

Yellow denotes preliminary data.
Global changes—future

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

Source: Rahmstorf (2007)
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)
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- 4º 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
Water Supply & Infrastructure
Potential Impacts – Water Supply and Infrastructure

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

<table>
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<tr>
<th>Year</th>
<th>MLLW</th>
<th>NGV29</th>
<th>&quot;Queens&quot; High Tide</th>
<th>100 Year Storm Surge</th>
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<tr>
<td>1970</td>
<td>4.89</td>
<td>3.22</td>
<td>5.96</td>
<td>13.82</td>
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<td>2006</td>
<td>5.20</td>
<td>3.53</td>
<td>6.26</td>
<td>14.13</td>
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<td>2030</td>
<td>5.45</td>
<td>3.78</td>
<td>6.51</td>
<td>14.38</td>
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</table>

MLLW = Mean Lower Low Water
"Queens Highway datum = NGV29 + 2.725′
100 Year Storm Surge = "Queens High Tide + 7.87′"
Delaware River Basin
Salt Line
(250 mg/l, 7 day avg)

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.
Other Impacts in the Basin

- Increased impervious surfaces
- Changing demographics/ water demand –
  - Population size and location
- Threats to the Headwaters
  - Quantity and Quality
Extent of Marcellus Shale Formation within the Delaware River Basin

36% (4,937 mi²) 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
- Forest Fragmentation
- Philadelphia Source Water Protection Analysis
  - #1 – Change in Delaware River Headwaters most critical
“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
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
GOAL: Determine basin-wide concerns, identify location and magnitude of deficits for vulnerable watersheds and river points

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
Time for Action!