

Appendix M

Drinking Water Survey Results

Paula Conolly, Philadelphia Water Department Consultant

Priscilla Cole, Partnership for the Delaware Estuary

July, 2010

The Drinking Water Work Group polled experts on the relative vulnerability of Drinking Water to climate change parameters that are expected to change in the Delaware Estuary watershed. See Chapter 4 more of the Drinking Water Workgroup findings. This appendix includes all major survey data collected and the survey questions.

M.1 Identifying Vulnerabilities & Climate Drivers– Ten vulnerabilities to drinker water supply were identified by the Drinking water workgroup as they appear in table M.1.1. These vulnerabilities were thought to be the result of the six umbrella climate drivers, identified in Table M.1.2. The climate drivers were broken out in detail and matched with their corresponding drinking water vulnerabilities in Table M.1.2.

Table M.1.1

Vulnerabilities of Drinking Water Supply	
1	erosion of infrastructure
2	overflowing reservoir capacity
3	decreased supply in reservoirs
4	flooding of treatment plants and pump stations
5	inoperable treatment plants
6	degraded water quality of source water and finished water (turbidity, dissolved oxygen, dissolved organic carbon, taste and odor compounds, dbp formation etc.)
7	upward salt line movement
8	saltwater intrusion in coastal aquifers and freshwater habitats
9	increased demand for supply
10	power outages and issues with customer supply

Table M.1.2

Climate Drivers	Specific climate drivers could cause the following vulnerabilities:				
increased precipitation (rainfall expected to increase mainly in the Northern and Eastern parts of the country)	increased river discharge and stream flow				
		1	2	6	
	increased runoff				
		1	2	6	
	increased groundwater levels				
		1	2	6	
	extreme flooding				
decreased precipitation (rainfall expected to decrease mainly in the Southwest, but could be short-term periods in the East)		1	2	4	6
	changes in watershed vegetation and forest cover				
			1	6	
	decreased river discharge and stream flow				
		3	6	7	9
	decreased groundwater levels				
		3	6	7	9
increased frequency and magnitude of storms	increased frequency of short-term drought				
		3	6	8	9
	increased number and intensity of wild fires				
		1	6	9	10
	changes in watershed vegetation and forest cover				
			1	6	
	lightening and electrical disturbances				
warmer water temperatures			5	10	
	storm surge				
		1	2	4	5
thawing permafrost, reduced ice cover and snow pack, and reduction in freezing season			6	7	8
	sea level rise				
		1	4	5	6
flooding					
		1	2	4	6
	sea level rise				
		1	4	5	6
	decreased river discharge and stream flow (spring and summer)				
		3	6	7	9
changes in watershed vegetation and forest cover					
			1	6	

M.2 Drinking Water Survey – The inventories found in Tables M.1.1 and M.1.2 served as the starting point from which the survey was constructed. Local drinking water experts were asked to assess the relative impacts of the vulnerabilities to drinking water supply systems in Philadelphia. In addition, survey respondents were asked to report their confidence levels in the amount of information available to make this assessment.

Table. M.2.1. Survey guide.

Impact from Climate Change	Confidence Level in the Climate Info Available to Determine an Impact
1 = below detectable limit 2 = minimal impact 3 = moderate impact 4 = high impact 5 = maximum impact	L = low confidence M = medium confidence H = high confidence

Table M.2.2. Example of the Drinking Water Survey.

Erosion of Infrastructure	Impact Ranking (1 -5)	Confidence Level (L,M,H)
increased river discharge and stream flow		
increased runoff		
increased groundwater levels		
extreme flooding		
changes in watershed vegetation and forest cover		
increased number and intensity of wild fires		
storm surge		
sea level rise		
flooding		

Overflowing Reservoir Capacity	Impact Ranking (1 -5)	Confidence Level (L,M,H)
increased river discharge and stream flow		
increased runoff		
increased groundwater levels		
extreme flooding		
storm surge		
flooding		

Decreased Supply in Reservoirs	Impact Ranking (1 -5)	Confidence Level (L,M,H)
decreased river discharge and stream flow		
decreased groundwater levels		
increased frequency of short-term drought		

Flooding of Treatment Plants & Pumping Stations	Impact Ranking (1-5)	Confidence Level (L,M,H)
extreme flooding		
storm surge		
sea level rise		
flooding		

Inoperable Treatment Plants	Impact Ranking (1 -5)	Confidence Level (L,M,H)
lightening and electrical disturbances		
storm surge		
sea level rise		

Degraded Water Quality for Source & Finished	Impact Ranking (1 -5)	Confidence Level (L,M,H)
increased river discharge and stream flow		
increased runoff		
increased groundwater levels		
extreme flooding		
changes in watershed vegetation and forest cover		
decreased river discharge and stream flow		
decreased groundwater levels		
increased frequency of short-term drought		
increased number and intensity of wild fires		
storm surge		
disruptions to aquatic ecosystems		
sea level rise		
Flooding		

Upward Salt Line Movement	Impact Ranking (1 -5)	Confidence Level (L,M,H)
decreased river discharge and stream flow		
decreased groundwater levels		
disruptions to aquatic ecosystems		
sea level rise		

Saltwater Intrusion in Aquifers and Habitats	Impact Ranking (1 -5)	Confidence Level (L,M,H)
increased frequency of short-term drought		
storm surge		
disruptions to aquatic ecosystems		
sea level rise		

Increased Demand for Supply	Impact Ranking (1 -5)	Confidence Level (L,M,H)
decreased river discharge and stream flow		
decreased groundwater levels		
increased frequency of short-term drought		
increased number and intensity of wild fires		
storm surge		

Power Outages & Customer Supply Issues	Impact Ranking (1 -5)	Confidence Level (L,M,H)
extreme flooding		
increased number and intensity of wild fires		
lightening and electrical disturbances		
storm surge		
flooding		

M.3. Survey Results – After compiling the result of the surveys, the scores were averaged in the categories of relative impact and confidence levels. These scores are found in columns two and three of tables M.3.1 – M.3.10.

To create a relative vulnerability index, the scores from impacts and confidence were then combined, and ranked: Highest, High, Med-High, Med-Low, and Low. High rankings indicate issues which require immediate attention since both their impacts and confidence levels are high. These rankings were used to develop the recommendations found in Chapter 4. The Drinking Water Workgroup also used the scores to determine research need areas. If an issue got a high impact score and a low confidence rating, this was considered a research need area. The confidence scores were used to reflect the confidence of the information available to set the impact level, so a low confidence score indicates vulnerabilities which are largely unknown.

Table M.3.1

	Erosion of Drinking Water Infrastructure	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	increased river discharge and stream flow	2.5	2.3	5.8	Med-Low
	increased runoff	2.7	3.0	8.0	Med-High
	increased groundwater levels	2.0	1.0	2.0	Low
	extreme flooding	3.0	4.0	12.0	High
	changes in watershed vegetation and forest cover	2.0	3.0	6.0	Med-Low
	increased number and intensity of wild fires	1.3	1.0	1.3	Low
	storm surge	2.7	3.5	9.3	Med-High
	sea level rise	2.3	5.0	11.7	High
	flooding	2.7	3.5	9.3	Med-High

Table M.3.2

	Decreased Supply in Reservoirs	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	decreased river discharge and stream flow	3.7	1.0	3.7	Low
	decreased groundwater levels	3.3	1.0	3.3	Low
	increased frequency of short-term drought	3.7	2.0	7.3	Med-Low

Table M.3.3

	Overflowing Reservoir Capacity	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	increased river discharge and stream flow	3.0	1.0	3.0	Low
	increased runoff	4.0	1.7	6.7	Med-Low
	increased groundwater levels	3.0	1.0	3.0	Low
	extreme flooding	1.0	1.0	1.0	Low
	storm surge	1.0	1.0	1.0	Low
	flooding	1.3	1.0	1.3	Low

Table M.3.4

	Flooding of Treatment Plants & Pumping Stations	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	extreme flooding	4.0	3.0	12.0	High
	storm surge	4.0	3.0	12.0	High
	sea level rise	4.0	3.0	12.0	High
	flooding	4.0	3.0	12.0	High

Table M.3.5

	Inoperable Treatment Plants	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	lightening and electrical disturbances	3.0	2.5	7.5	Med-Low
	storm surge	3.0	3.0	9.0	Med-High
	sea level rise	1.3	3.0	4.0	Low

Table M.3.6

	Degraded Water Quality for Source & Finished	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	increased river discharge and stream flow	3.0	3.0	9.0	Med-High
	increased runoff	4.0	3.0	12.0	High
	increased groundwater levels	2.0	1.0	2.0	Low
	extreme flooding	2.3	3.0	7.0	Med-Low
	changes in watershed vegetation and forest cover	4.7	3.0	14.0	High
	decreased river discharge and stream flow	3.0	3.0	9.0	Med-High
	decreased groundwater levels	2.0	1.0	2.0	Low
	increased frequency of short-term drought	2.0	3.0	6.0	Med-Low
	increased number and intensity of wild fires	1.0	3.0	3.0	Low
	storm surge	2.3	3.0	7.0	Med-Low
	disruptions to aquatic ecosystems	3.5	2.5	8.8	Med-High
	disruptions to distribution systems	3.5	3.0	10.5	Med-High
	sea level rise	3.5	5.0	17.5	Highest
	floodings	2.3	3.7	8.6	Med-High

Table M.3.7

	Upward Salt Line Movement	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	decreased river discharge and stream flow	4.0	3.0	12.0	High
	decreased groundwater levels	3.0	1.0	3.0	Low
	disruptions to aquatic ecosystems	2.0	1.0	2.0	Low
	sea level rise	4.0	4.3	17.3	Highest

Table M.3.8

	Saltwater Intrusion in Aquifers and Habitats	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	increased frequency of short-term drought	1.0	1.0	1.0	Low
	storm surge	3.0	3.7	11.0	High
	disruptions to aquatic ecosystems	2.5	1.3	3.3	Low
	sea level rise	4.0	3.7	14.7	Highest

Table M.3.9

	Increased Stress on Supply Availability	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	decreased river discharge and stream flow	2.3	3.0	7.0	Med-Low
	decreased groundwater levels	2.0	3.0	6.0	Med-Low
	increased frequency of short-term drought	3.0	3.0	9.0	Med-High
	increased number and intensity of wild fires	1.0	1.0	1.0	Low
	storm surge	2.0	1.7	3.3	Low
	Increases in demand	4.0	1.7	6.7	Med-Low

Table M.3.10

	Power Outages & Customer Supply Issues	Average Impact Score	Average Confidence Score	Combined Score	Ranking
Drivers	extreme flooding	4.0	3.0	12.0	High
	increased number and intensity of wild fires	1.0	3.0	3.0	Low
	lightening and electrical disturbances	3.0	3.0	9.0	Med-High
	storm surge	3.0	3.7	11.0	High
	flooding	3.0	3.0	9.0	Med-High