MUNICIPAL MANAGEMENT IN A CHANGING CLIMATE

31

MUNICIPAL IMPLEMENTATION TOOL #31

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DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION

INTRODUCTION

This brochure is one in a series of Municipal Implementation Tools (MITs) available to local governments and planning partners to assist in implementing the region's long-range plan, *Connections 2045*. Prepared and adopted by the Delaware Valley Regional Planning Commission (DVRPC), the long-range plan provides a sustainable land use and transportation vision for the region's growth and development through the year 2045. *Connections 2045* establishes five key principles that are essential to realizing a sustainable future:

- Sustain the environment.
- Develop livable communities.
- Expand the economy.
- Create an integrated, multimodal transportation network.
- Advance equity and foster diversity.

Municipal governments have the primary authority and responsibility to implement these policies. The series is designed to introduce local officials and citizens to planning techniques that may be useful in their communities. Each covers a different topic and provides an overview of the use of the tool, the benefits, and best practices from within the Greater Philadelphia region. For additional information about *Connections 2045,* please visit www.dvrpc.org/Connections2045. To download additional brochures, visit www.dvrpc.org/MIT.

"The forecast for Philadelphia's future climate can be summed up as 'warmer and wetter,' but much of that warmth and moisture will be concentrated in the form of heat waves and heavy precipitation events (rain or snow)—posing challenges to infrastructure, city services, businesses, and residents."[1]

According to 2017's *Climate Science Special Report*, "Sixteen of the warmest years on record for the globe occurred in the last 17 years (1998 was the exception)."[2] The climate in Greater Philadelphia has also changed, with warmer and wetter weather concentrated in heat waves and heavy rain and snow events. Municipalities have had to bear the burden of this change by responding to the impacts of extreme heat, flooding from heavy rainfall, and clearing heavy snowfall.

This brochure gives a brief overview of the primary ways your municipality can respond to and prepare for the on-going changes in the climate. This short publication does not attempt to address all the issues of this complex topic. Its goal is to introduce municipal leaders to the topic and provide an introduction to how to take climate change into account in municipal management.

This document is organized as follows:

- An overview of climate change, globally and in the region.
- Expected changes in the climate of the Delaware Valley over the rest of the century
    - Temperature
    - Precipitation (rain and snow)
    - Sea Level Rise

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[1] Growing Stronger: Toward a Climate-Ready Philadelphia. Philadelphia Mayor's Office of Sustainability and ICF International. Philadelphia, 2015: p. 9.

[2] Wuebbles, D.J., *et al.*, 2017: Executive summary. In: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* ("*CSSR*") [Wuebbles, D.J., *et al.*(eds.)]. U.S. Global Change Research Program, Washington, DC, USA, p. 13, doi: 10.7930/J0DJ5CTG.

- Expected impacts of these changes on municipal facilities, services, and operations in Greater Philadelphia.
- Basic recommendations for short and long term responses to prepare your community.
- Places to find help and additional information.

Summary Findings

- The climate in our region has changed, is changing, and will continue to change.
- Greater Philadelphia will continue to get warmer, rain will fall in more intense storms, periods of drought may last longer, and the sea level will continue to rise.
- The degree of future change depends on global actions to reduce greenhouse gas emissions, but change is inevitable.
- These unavoidable changes will continue to be incremental – a little warmer and wetter each year; the sea a little higher.
- Slow changes are difficult to address—responses and preparation can always be postponed another year, to the next budget cycle, after the next election.
- Municipalities that base today's decisions with an eye toward tomorrow's conditions will protect and serve their residents better that those that assume tomorrow will be like today.
- To prepare, municipalities need to adjust existing operations:
  - ✓ Prepare municipal facilities for a changing climate, including both buildings and recreation facilities;
  - ✓ Maintain and upgrade stormwater systems to handle more intense rainfall;
  - ✓ Maintain and invest in transportation facilities with an awareness of future climate conditions;
  - ✓ Modify delivery of municipal services (e.g., refuse collection times) appropriately;
  - ✓ Assure employee contracts are suitable for conditions;
  - ✓ Maintain and expand tree cover with species appropriate for a changing climate;
  - ✓ Assure cooling centers are available for residents;
  - ✓ Update regulations to account for climate change;
- Coastal communities face additional risks.
- Guidance and other resources are available.

What is Climate?

The weather changes from day to day and month to month. We can have warm days in January or February, and cool days in July and August, but in general, we know what kind of weather to expect in Greater Philadelphia in the winter, spring, summer, and fall. These expectations we have describe the climate. Weather, on the other hand, is what is happening right now.

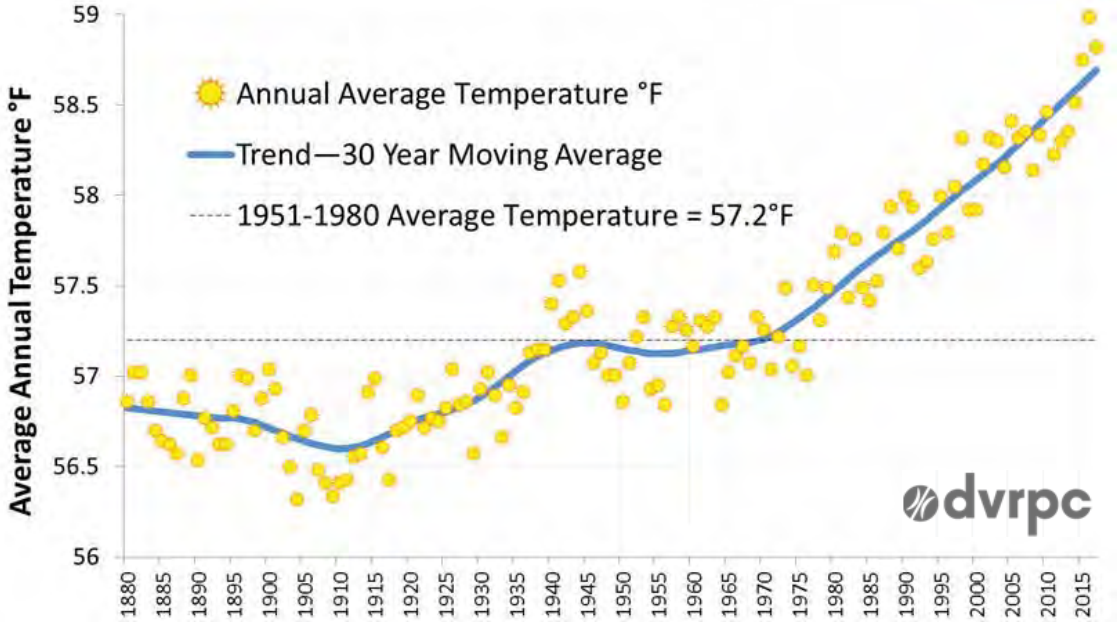
One way to think about it: Weather affects what you choose to wear today, while climate determines the clothes, coats, hats, gloves, and shoes you have in your closet.

What is Climate Change?

Although weather changes from day to day and year to year, the global climate has remained pretty steady over long periods of time, allowing people to know what crops to plant, what livestock to raise, what trees will grow, what weather to expect, and what kind of houses to build.

As Figure 1 below shows, the average global temperature has risen significantly over the 137 year period for which reliable records are available. Temperatures are warmer now than at any time in this period, and the decade from 2008–2017 is the warmest on record.[3]

Figure 1: Global Average Temperature – 1880—2017



Source: DVRPC chart using data accessed 24 May 2018 from www.ncdc.noaa.gov/cag/.

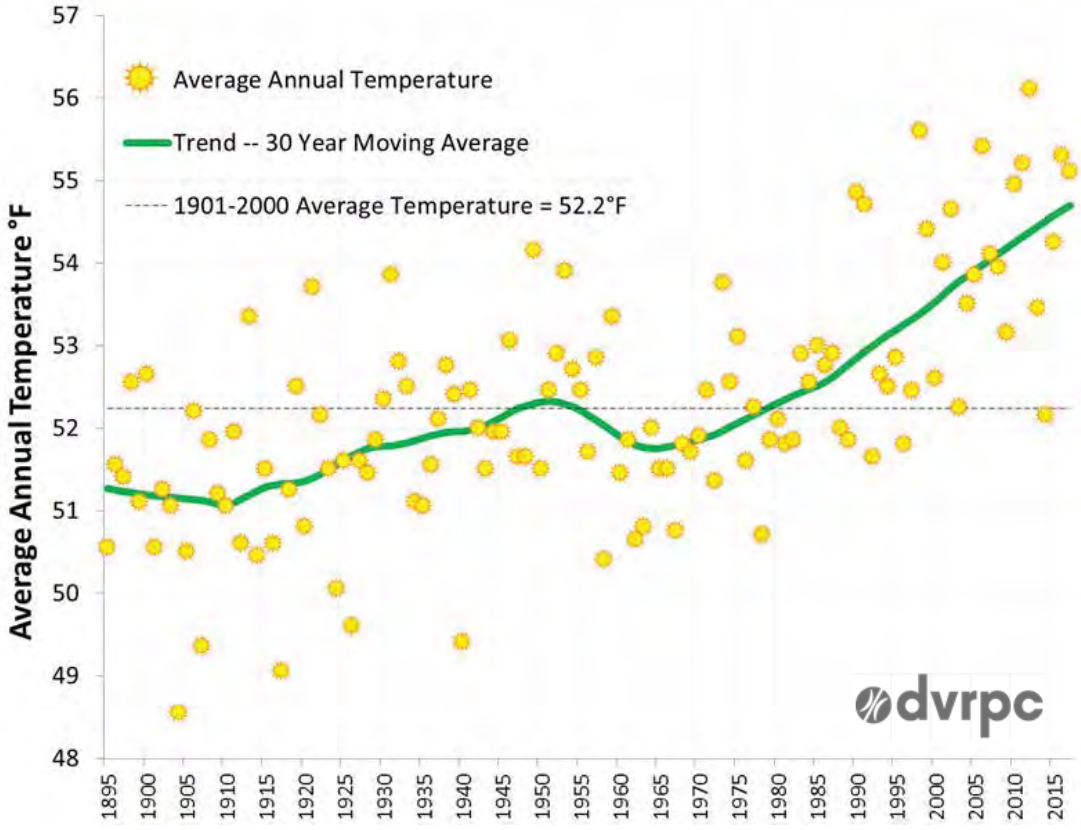
[3] For more on global temperature, see data.giss.nasa.gov/gistemp/faq/abs_temp.html.

Global temperature is primarily related to the concentration in the atmosphere of various gases – primarily carbon dioxide – that serve as a blanket that controls how much the sun warms the earth. The variation in global temperature before the late 1800s was due to small changes in the sun's output, and periodic volcanic eruptions blocking out some of the sun. Since about 1870, human activities such as clearing land and burning coal, oil, and natural gas, have increased the concentration of carbon dioxide and other gases ("greenhouse gases" or GHGs), effectively making this blanket thicker, and thus temperatures higher.

Temperature

The global temperature increase has been reflected in temperature changes in Greater Philadelphia. Figure 2 below shows how annual temperature has increased in southeastern Pennsylvania and southern New Jersey over the past 122 years. Although the average temperature varies from year to year, the upward trend since 1895 is clear.

Figure 2: Annual Average Temperature in SE PA and Southern NJ — 1895-2017



Source: DVRPC chart using data accessed 24 May 2018 from www.ncdc.noaa.gov/cag/. Data reflects the average of two regions: Southeastern PA (Climate Div.3) and Southern NJ (Climate Div.2).

Precipitation

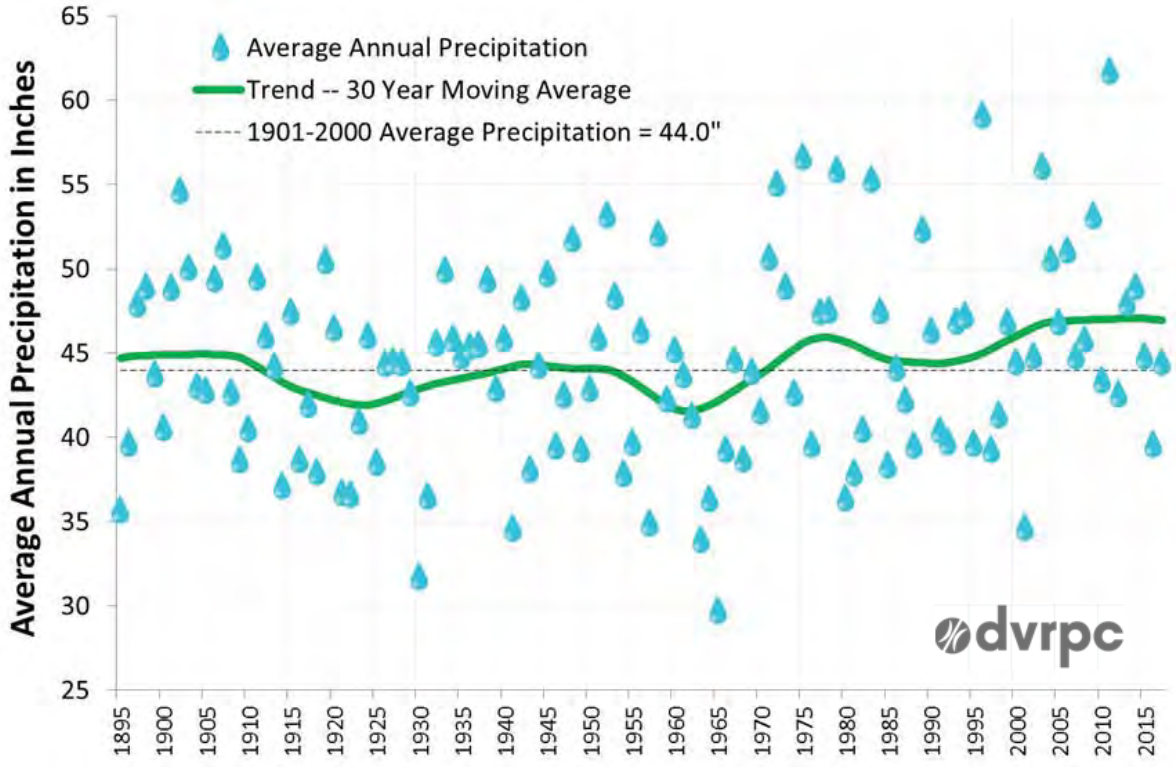
Changes in temperature affect precipitation, because air holds more water as temperature increases.

As Figure 3 shows, annual precipitation in southeastern Pennsylvania and southern NJ over the past century has varied widely, with an average of about 44 inches per year. There has been a slight upward trend of about 2 inches per century.

However, as Figure 4 indicates, over the past century, more of this precipitation has been falling in intense storms.

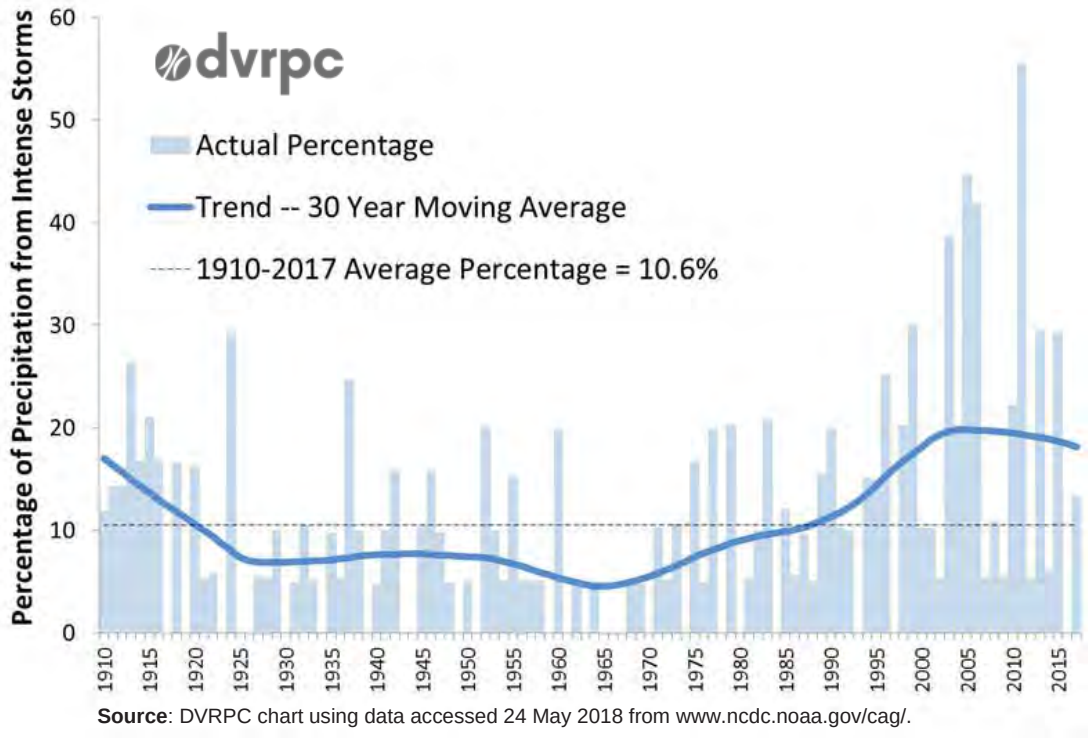
Therefore, although the amount of total rainfall has not changed significantly, there are more intense storms of the kind that overflow storm sewers, flood roads, flood basements, and cause rivers and streams to overflow their banks.

Figure 3: Annual Precipitation in SE PA and Southern NJ — 1895-2017



Source: DVRPC chart using data accessed 24 May 2018 from www.ncdc.noaa.gov/cag/.

Figure 4: Percentage of Precipitation from Intense Storms Northeastern US, 1910-2017



Source: DVRPC chart using data accessed 24 May 2018 from www.ncdc.noaa.gov/cag/.

Sea Level Rise

Increased global temperatures have increased sea levels due to both ocean water expanding as it warms, and additional water from melting glaciers and other land ice (e.g., in Greenland and Antarctica). According to U.S. Global Change Research Program, global sea level has risen 7 to 8 inches since 1900, with over a third of that rise occurring since 1993. The current rate of sea level rise (SLR) is greater than in any century for at least 2,800 years.[4]

Sea level in the Delaware Estuary (the tidal Delaware River and its tributaries) has risen an additional 6 to 8 inches beyond the global rise amount in the 1900 to 2010 period, primarily due to the fact that the land is slowly sinking. This "subsidence" is due to a long-term adjustment of the earth following the melting of the great ice sheets.

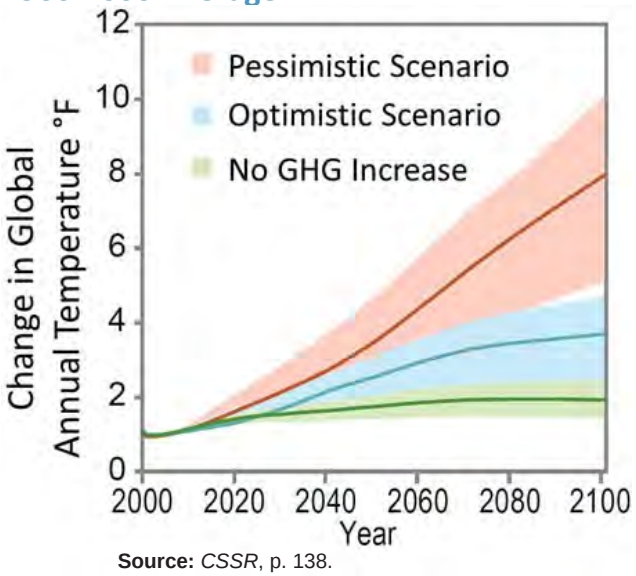
[4] *CSSR*, p. 333.

What is Future Climate Projected to Look Like?

Global Changes

The future average global temperature is expected to continue to rise. How fast and how far depends on how the concentration of GHGs in the atmosphere changes. Figure 5, at right, shows the temperature increases projected for several GHG concentration scenarios, as well as what is projected if GHG emissions were essentially to stop immediately. Note that by 2000, the global temperature was already 1°F above the 1960-2000 Average. If all GHG emissions were to stop today, the current concentration would lead to an additional 1°F increase in temperature by the end of the century.

Figure 5: Projected Global Temperature vs. 1960-2000 Average



Source: *CSSR*, p. 138.

However, all GHG emissions are not going to stop today. For at least the medium term, fossil fuels will continue to be used to generate electricity, heat our buildings, power our cars, and fuel industry. Future global temperature depends on future GHG emissions, and future GHG emissions depend on human choices, activities, and technological change, all of which are difficult to predict.[5] Climate scientists have developed a set of future emissions pathways to learn the future global temperatures that climate models project for each pathway. Which pathway future emissions will follow depends on humans.

DVRPC focused on two scenarios, which for simplicity are called here the optimistic scenario and the pessimistic scenario.[6] As illustrated in Figure 5, above, by the end of this century, the global average

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[5] *CSSR*, p. 135.

[6] The optimistic scenario is "Representative Concentration Pathway 4.5", or RCP 4.5. The pessimistic scenario is RCP 8.5. The third line on the graph depicts RCP 2.6. For a detailed discussion, see *CSSR*, pp. 135-141.

temperature is projected to rise an additional 1°F to 3°F under the optimistic scenario and an additional 4°F to 9°F under the pessimistic scenario.

Sea level rise (SLR) is projected to continue, with global sea level rising 6 to 7 inches relative to 2000 by 2030, 12 to 17 inches by 2050, and 3 to 5 feet by 2100 under the optimistic and pessimistic scenarios, respectively.[7] SLR in 2100 is significantly affected by GHG emissions. As sea levels have risen, tidal flooding has increased in depth, frequency, and extent. This flooding will continue to increase over the remainder of the century.[8]

[7] *CSSR*, p. 343.
[8] *CSSR*, p. 333.

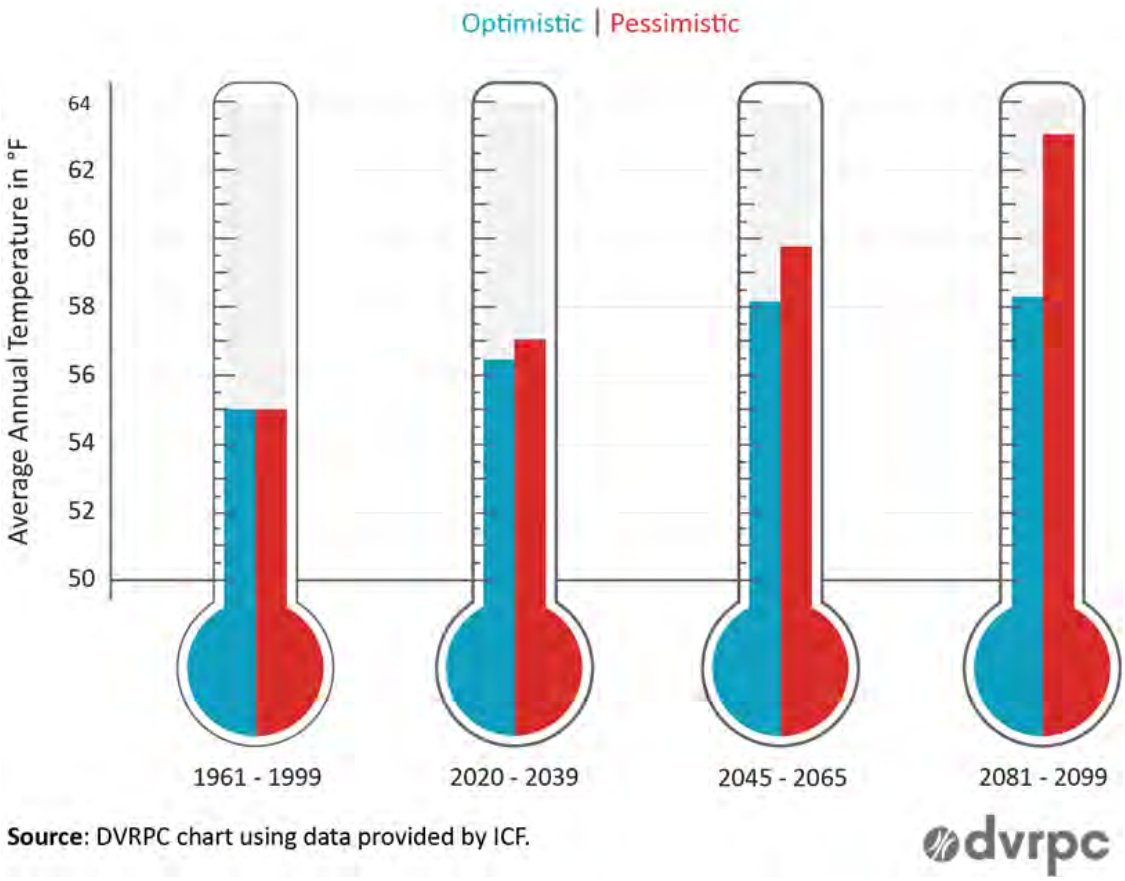
Changes Projected for the DVRPC Region

DVRPC worked with the consulting firm ICF to analyze changes in climate projected for the DVRPC region. These projections are shown and described below.[9]

Temperature

Average annual temperature in the DVRPC region is currently about 55°F. By the end of the century, under the optimistic scenario, average annual temperature is projected to increase by 3°F to 58°F. Under the pessimistic scenario, average annual temperature is projected to increase by 8°F to 63°F. This is shown in Figure 6, below.

Figure 6: Average Annual Temperature in °F — Historic & Projected DVRPC Region



Source: DVRPC chart using data provided by ICF.

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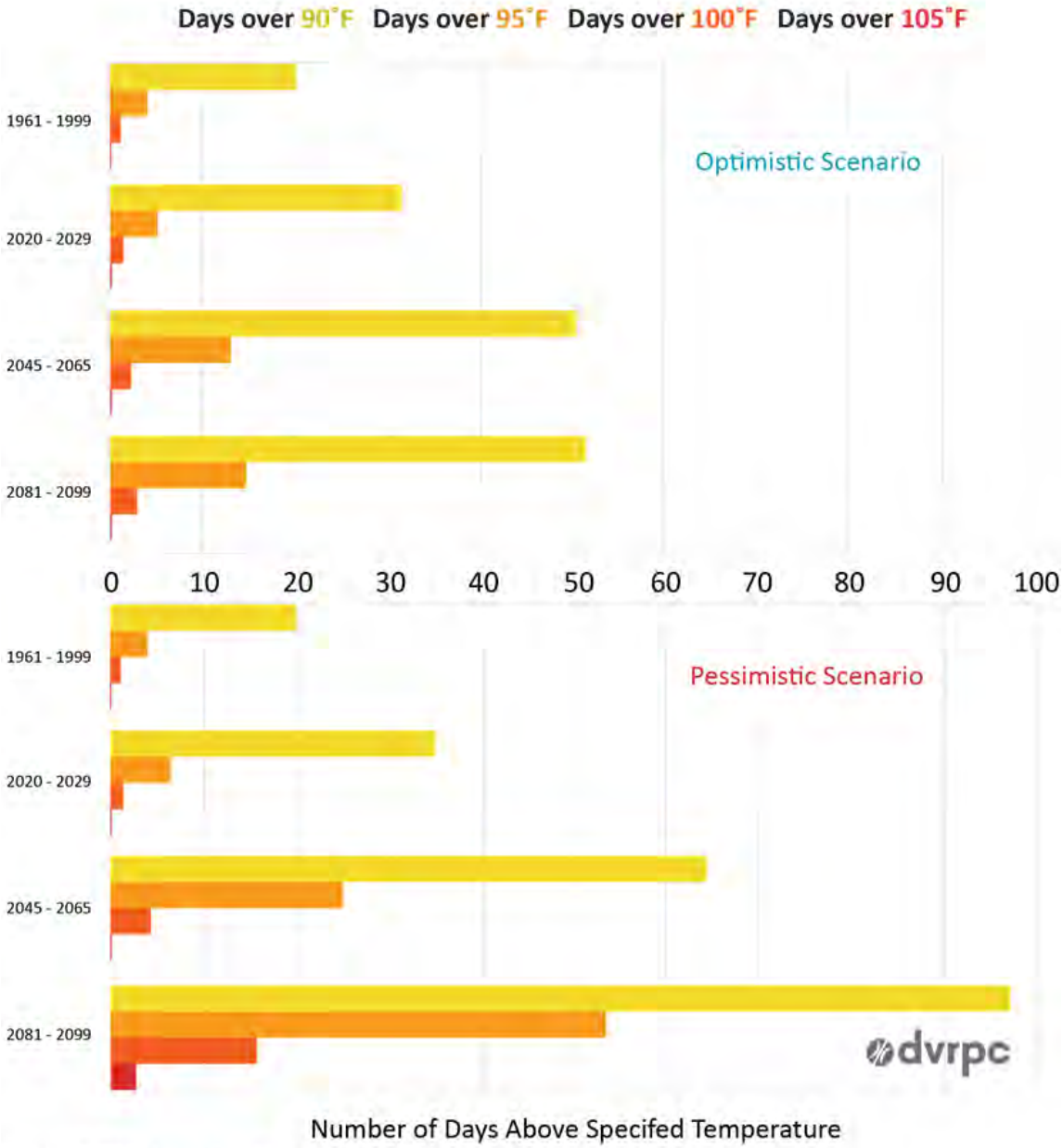
[9] Detailed tables and charts for each county as well as a description of the methodology used are available at www.dvrpc.org/EnergyClimate/CCMIT.

Figure 7: Days per Year above Specified Temperatures — Historic & Projected DVRPC Region



Source: DVRPC chart using data provided by ICF.

The number of hot days per year increases as annual average temperature increases. From 1961 to 1999, the region averaged

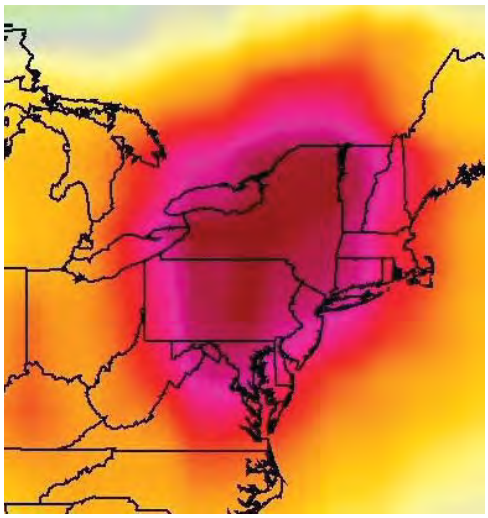
- 20 days per year over 90°F
- 4 days per year over 95°F
- 1 day per 4 years over 100°F

As Figure 7 indicates, in the optimistic scenario, by the end of the century, the region will average

- 51 days per year over 90°F
- 15 days per year over 95°F
- 2½ days per year over 100°F
- 1 day per 3 years over 105°F

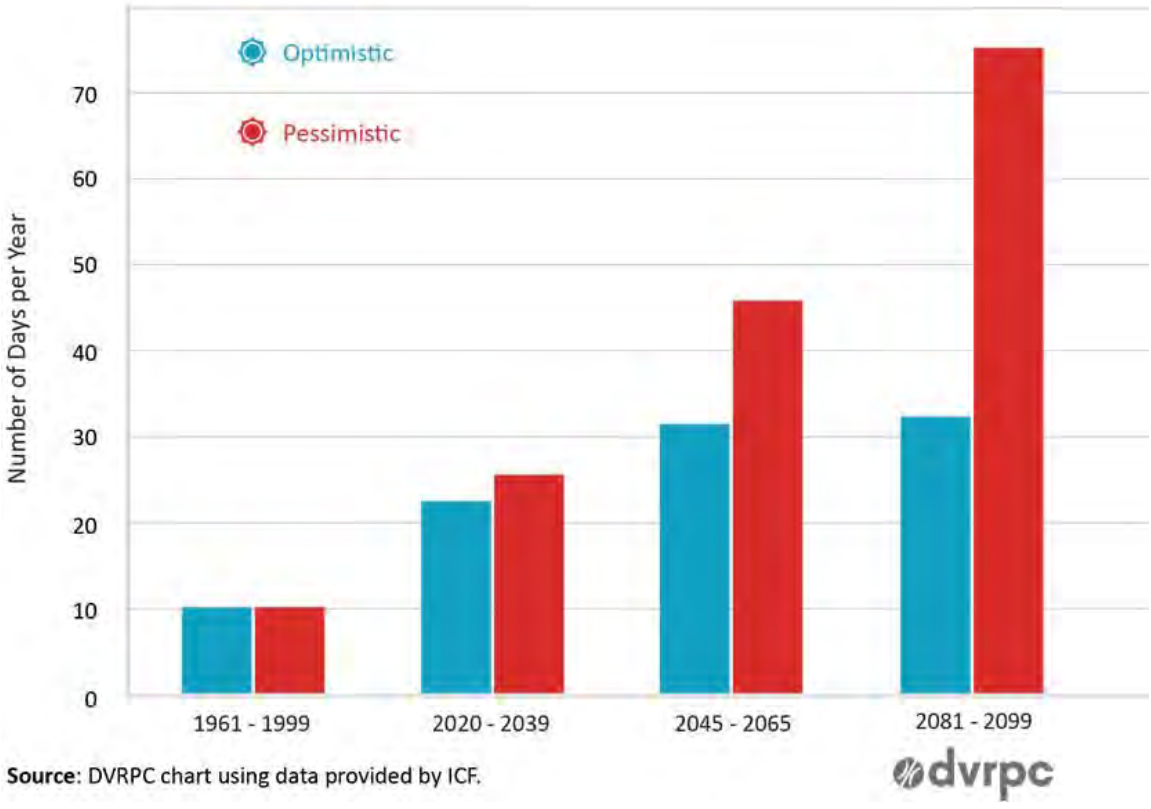
In the pessimistic scenario, by the end of the century, the region will average

- 98 days per year over 90°F
- 54 days per year over 95°F
- 16 days per year over 100°F
- 3 days per year over 105°F



Source: NASA/JPL July 24 2011 heat wave. Image cropped.

Figure 8: Days per Year When Temperature Never Falls below 70°F Historic & Projected — DVRPC Region



Source: DVRPC chart using data provided by ICF.

The number of days when the temperature never falls below 70°F—generally recognized as needed for a good night's sleep—is projected to increase. Nights where the temperature doesn't fall below 70°F are

problematic, allowing no downtime for air conditioning systems, and great discomfort for those without air conditioning, including the homeless. As illustrated in Figure 8, from 1961 to 1999, the region averaged 10 days when the low remained above 70°F. In the optimistic scenario, this will increase to 33 days by the end of the century; in the pessimistic scenario, it will increase to 75 days.

Precipitation

As shown in Figure 9, in both the optimistic and pessimistic scenarios, total annual precipitation is projected to increase slightly—by 5 to 7 inches—between now and the end of the century.

Figure 10 shows that by the end of the century, most of the increased precipitation is projected to take place in the winter and summer, with increases of about 20 percent in the summer, and 50 percent or more in some parts of the winter. Monthly precipitation totals in the spring and fall are projected to be largely unchanged. Note that, perhaps counterintuitively, February rainfall is projected to be higher under the optimistic scenario than under the pessimistic scenario.

Extreme precipitation events are projected to continue to increase as well, with more of the region's precipitation coming in intense storms. Historically, the expected maximum 24-hour rainfall in a five year period for Philadelphia has been 4¼ inches.[10] By the end of the century, a 4¼ inch rainfall in 24 hours will be expected twice as often under the optimistic scenario (every 2½ years) and four times as often under the pessimistic scenario (every 16 months).[11]

Although the region is warming, there will still be many cold winter days. Thus, some of this precipitation will fall as snow instead of rain, which may—somewhat counterintuitively—lead to extremely heavy snowfalls as our climate warms. Four of the ten largest snowfalls in Philadelphia history have occurred since 1996.[12]

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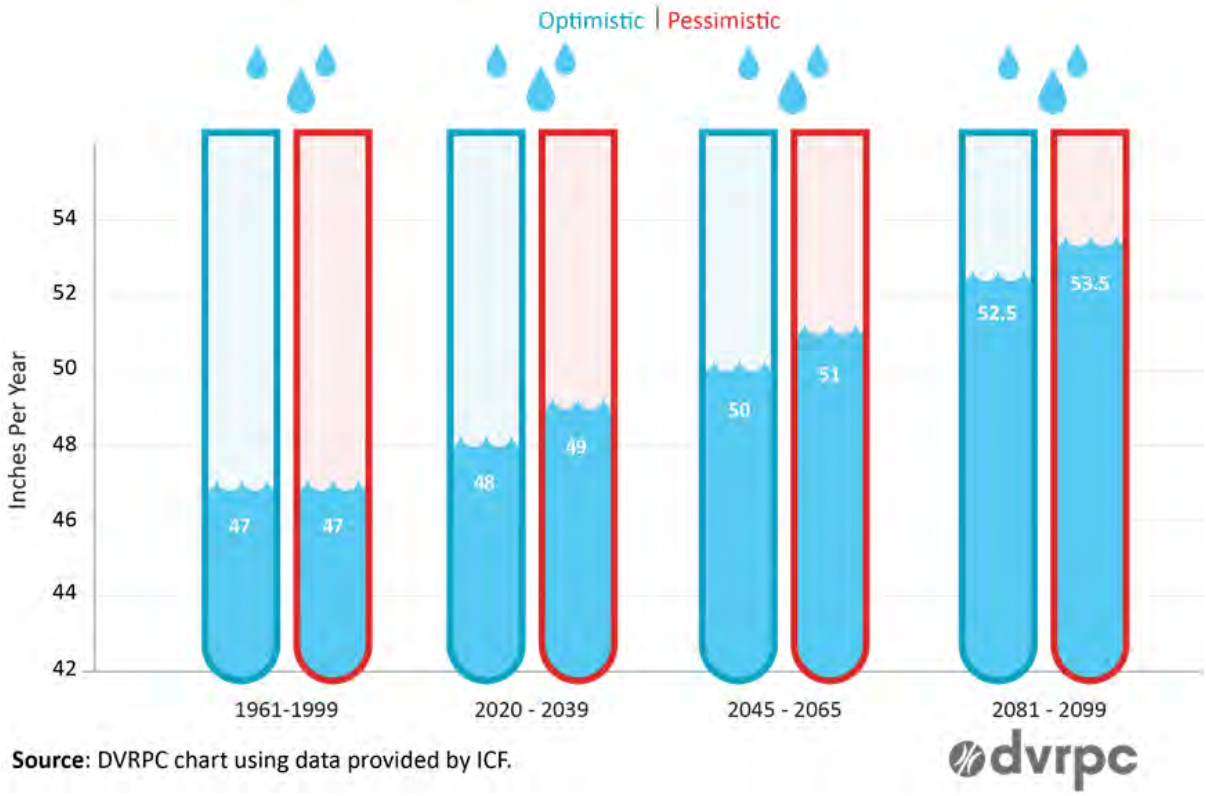
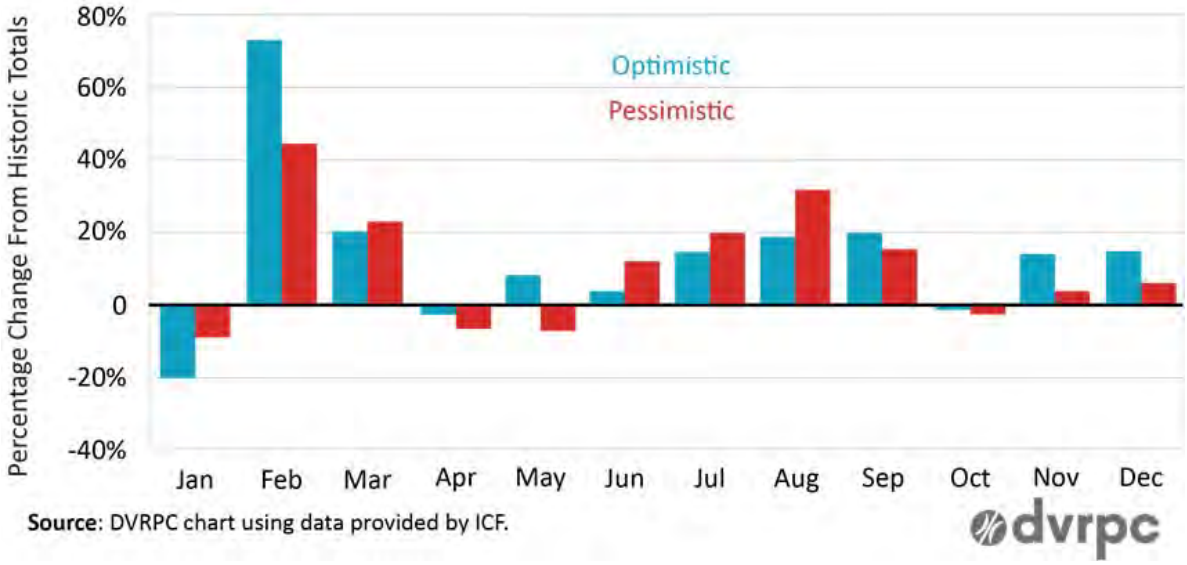
[10] Philadelphia Water Department *Stormwater Management Guidance Manual, Version 3.0*. July 2015. Appendix F (F.6.1.8).
[11] *CSSR*, p.219. Estimate of frequency is for the Northeast US Region.
[12] Philadelphia *Inquirer*, March 13, 2017. Viewed at: www.philly.com/philly/blogs/real-time/Top-10-snowfalls-in-Philadelphia-History.html on June 13, 2018.

Figure 9: Annual Precipitation in Inches — Historic & Projected DVRPC Region



Source: DVRPC chart using data provided by ICF.

Figure 10: Projected Percentage Change in Monthly Rainfall Totals from Baseline to 2081–2099 — DVRPC Region



Source: DVRPC chart using data provided by ICF.

Sea Level Rise

The direct impact of sea level rise on the DVRPC region is projected to be limited to coastal areas along the tidal portions of the Delaware River and its tributaries (the Delaware River Estuary). The following chart summarizes projected sea level rise in the Delaware River Estuary.

Figure 11: Projected Sea Level Rise in the Delaware River Estuary[13]

	Central Estimate	Likely Range	1-in-20 Chance	1-in-200 Chance	1-in-1000 Chance
Year	*50% probability SLR meets or exceeds…*	*67% probability SLR is between…*	*5% probability SLR meets or exceeds…*	*0.5% probability SLR meets or exceeds…*	*0.1% probability SLR meets or exceeds…*
2030	0.8 ft	0.6 – 1.0 ft	1.1 ft	1.3 ft	1.5 ft
2050	1.4 ft	1.0 – 1.8 ft	2.0 ft	2.4 ft	2.8 ft
2100 No GHG Increase	2.3 ft	1.7 – 3.1 ft	3.8 ft	5.9 ft	8.3 ft
2100 Pessimistic	3.4 ft	2.4 – 4.5 ft	5.3 ft	7.2 ft	10 ft

The maps on the following page show the areas along the Delaware River Estuary near Philadelphia International Airport and The Navy Yard, first with current sea level, and then showing the inundation with 2 and 4 feet of sea level rise, which correspond roughly to the sea level rise expected by 2100 under the no GHG increase and pessimistic scenarios.[14] In addition, increased sea levels result in the storm surge associated with coastal storms going further inland. Significant areas of the Navy Yard and Airport are vulnerable, as are large areas in New Jersey.

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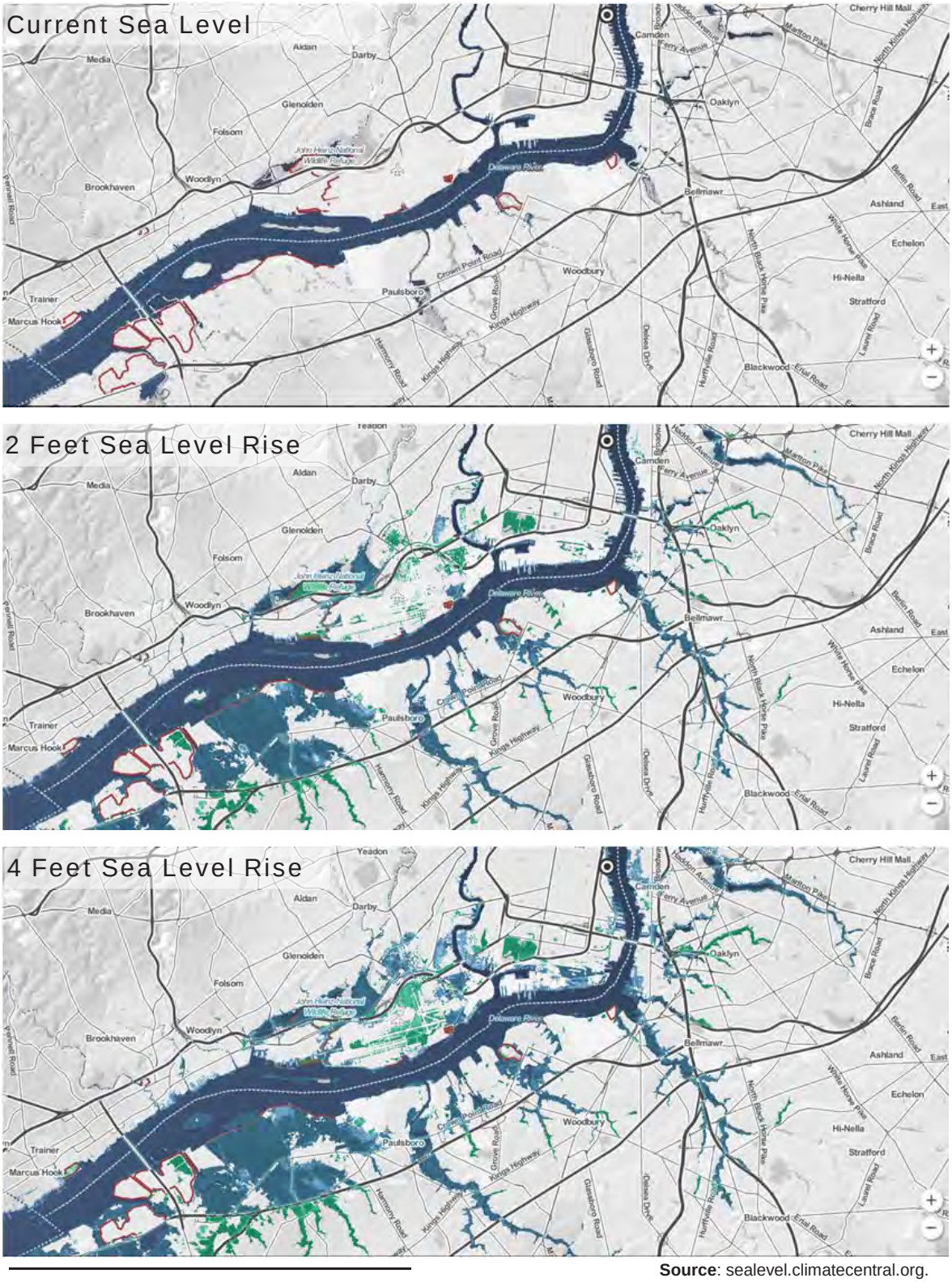
[13] Based on Kopp, R.E., *et al*. 2016. *Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel*. Page 2. Downloaded 04/06/2018 from njadapt.rutgers.edu/resources/nj-sea-level-rise-reports. The "No GHG Increase" scenario is RCP 2.6, and the "Pessimistic" scenario is RCP 8.5. Source did not include DVPRC's "Optimistic" scenario (RCP 4.5).

[14] To explore inundation under other sea level rise scenarios, please see Climate Central's Surging Seas: Risk Zone Map at sealevel.climatecentral.org.

Figure 12: Inundated Land (in Blue) Near Philadelphia International Airport and The Navy Yard Under Various Sea Level Rise Scenarios[15]



Source: sealevel.climatecentral.org.

[15] Areas in green are below sea level, but are isolated by land features or structures.

Summary

The future climate of the DVRPC region is projected to be significantly warmer, with many more very hot days. Annual precipitation is projected to increase slightly overall, with the additional precipitation coming mostly in winter and summer. The trend for precipitation to be concentrated in intense storms is projected to continue. Sea level rise will be a concern for those 83 municipalities in the DVRPC region located in the Delaware River Estuary, listed below.

Delaware County
Chester City
Darby Township
Eddystone Borough
Folcroft Borough
Lower Chichester Township
Marcus Hook Borough
Middletown Township
Nether Providence Township
Norwood Borough
Prospect Park Borough
Ridley Park Borough
Ridley Township
Sharon Hill Borough
Tinicum Township
Trainer Borough
Upland Borough
Upper Chichester Township

Philadelphia City

Bucks County
Bensalem Township
Bristol Borough
Bristol Township
Falls Township
Hulmeville Borough
Langhorne Borough
Langhorne Manor Borough
Lower Southampton Twp
Middletown Township
Morrisville Borough
Penndel Borough
Tullytown Borough

Burlington County
Bass River Township
Beverly City
Bordentown City
Bordentown Township
Burlington City
Burlington Township
Chesterfield Township
Cinnaminson Township
Delanco Township
Delran Township
Edgewater Park Township
Fieldsboro Borough
Florence Township
Hainesport Township
Lumberton Township
Mansfield Township
Maple Shade Township
Moorestown Township
Mount Holly Township
Mount Laurel Township
Palmyra Borough
Riverside Township
Riverton Borough
Springfield Township
Washington Township
Westampton Township
Willingboro Township

Camden County
Bellmawr Borough
Brooklawn Borough
Camden City
Cherry Hill Township
Gloucester City
Gloucester Township
Mount Ephraim Borough
Pennsauken Township
Runnemede Borough
Woodlynne Borough
Haddon Township

Gloucester County
Deptford Township
East Greenwich Township
Greenwich Township
Logan Township
Mantua Township
National Park Borough
Paulsboro Borough
Swedesboro Borough
Wenonah Borough
West Deptford Township
Woodbury City
Woolwich Township
Westville Borough

Mercer County
Hamilton Township
Trenton City

How is Climate Change Expected to Affect Municipal Operations?

Municipal responsibilities and operations will be affected by the higher temperatures, changes in precipitation patterns, and more intense precipitation that climate change will bring. This section discusses key impacts, provides basic guidance on addressing them, and includes resources for additional guidance. We have organized this discussion into the following categories, although several issues—such as public trees—are discussed in more than one category.

- Municipal facilities
- Stormwater systems
- Transportation infrastructure
- Municipal services
- Public employee and contractor work rules
- Public trees
- Public health
- Municipal regulations

A final section touches on special issues faced by coastal municipalities.

The impact of climate change on each of these issues has been studied and written about extensively. The purpose of this brochure is to introduce the major concerns and activities, and provide direction—where DVRPC is aware—for further information and action. Municipalities are encouraged to contact DVRPC for additional guidance.

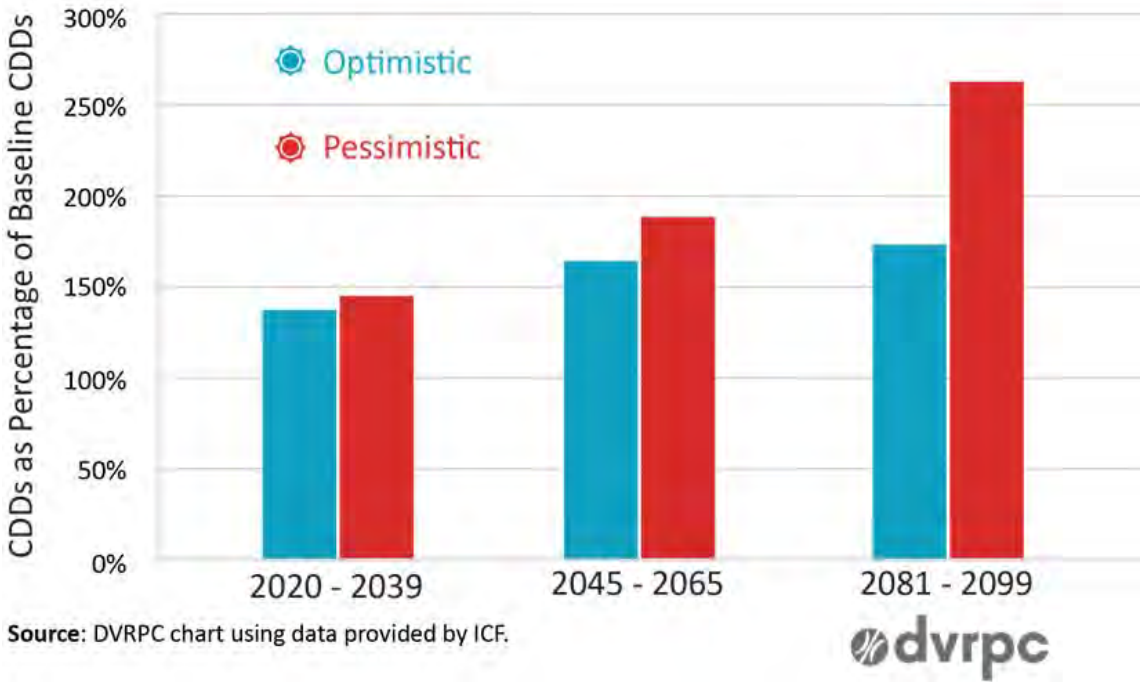
Municipal Facilities

Municipal facilities, including administration buildings, police and fire facilities, public works facilities, recreation facilities, and libraries are likely to be affected by the increased temperatures and more frequent intense storms and heavy rain events expected as our region's climate changes.

The most direct effect of projected increased temperatures is changes in cooling and heating needs of buildings. Increases in temperature projected for the region are expected to result in somewhat lower heating requirements and significantly greater cooling requirements for buildings. The impact of temperature change on building energy

demand can be projected by looking at *heating degree days* (HDDs) and *cooling degree days* (CDDs). These are a standard measure of how much heating or cooling is needed to be considered comfortable by building occupants.[16] As Figure 13 indicates, by the end of the century, cooling needs are projected to be more than 1½ times what they were in 1961-1999, under the optimistic scenario. Under the pessimistic scenario, cooling needs are projected to be more than 2½ times than in the baseline period.

Figure 13: Projected Change in Cooling Degree Days From 1961-1999 Baseline — DVRPC Region



Similarly, as Figure 14 indicates, heating requirements are projected to decrease. By the end of the century, the Philadelphia region is projected to feel more like southern Georgia does today.[17]

When buildings are designed or renovated, or heating, ventilation, and air conditioning (HVAC) systems are replaced or updated, the heating and cooling requirements for the full design life of the building need to

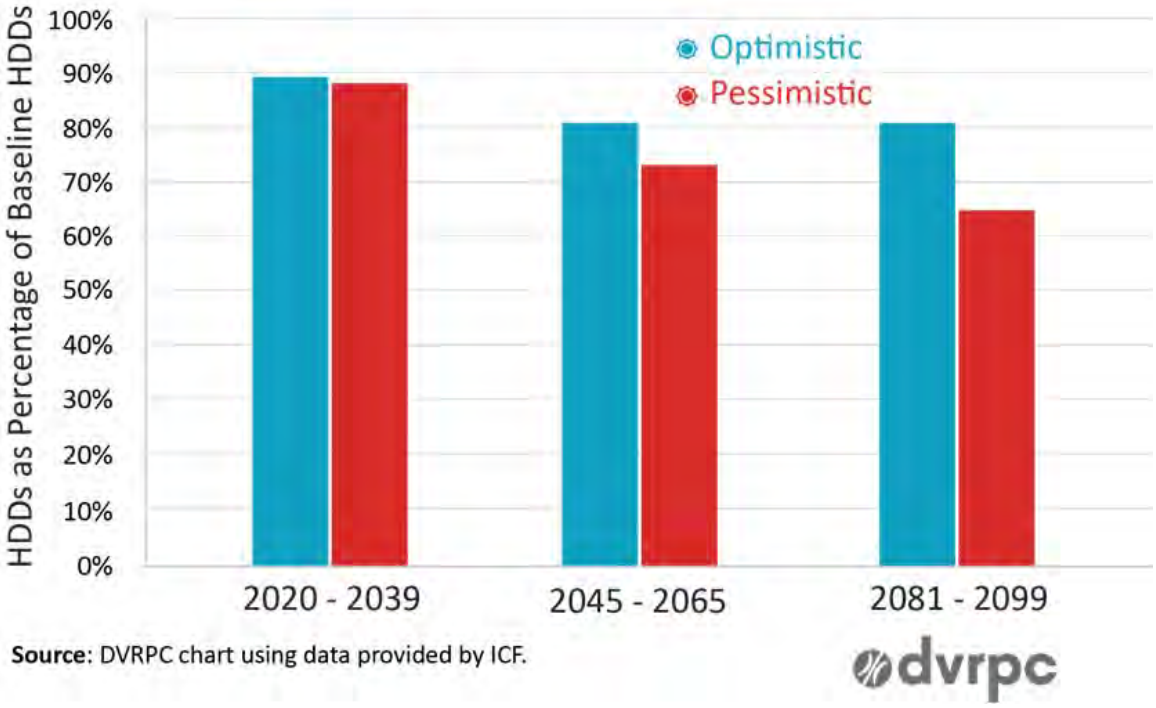
[16] For more information on degree days, see: www.eia.gov/energyexplained/index.cfm?page=about_degree_days.
[17] Union of Concerned Scientists, *Climate Change in Pennsylvania*, 2008. p. 9.

be kept in mind in order that the building will be comfortable throughout the life of the building and HVAC system.

Building energy demand can be reduced in the design phase in many ways, including proper building orientation, placement of trees to provide heat-reducing shade and windbreaks, and use of white or vegetated roofs. New or modified plantings and roofing materials can also greatly reduce the energy demands of existing buildings.

New heating and cooling equipment should be selected taking into account the projected changes in HDDs and CDDs in the coming century, which may result in lower upfront cost and reduce the operational cost of that equipment over time. In addition to right-sizing HVAC equipment, investments in reducing air leaks and increasing insulation will become even more important in the future as a result of the significant increase in cooling requirements projected. A thorough energy audit for municipal buildings with an eye to lowering costs both now and in the future should be considered (see *Resources* on page 24).

Figure 14: Projected Change in Heating Degree Days From 1961-1999 Baseline — DVRPC Region



In addition to investments in building upgrades, municipalities should consider educating building users on the impact that warmer days will

have on their day-to-day activities. Fire station employees, for example will need to pay particular attention to their doors in the summer, as when these are left open, energy costs for cooling can increase greatly.

Higher temperatures will not only affect indoor building comfort, but will also impact how municipalities operate outdoor facilities, such as sport fields, and basketball and tennis courts. These facilities may need to be planned to assure there are shaded (or even cooled) areas for players to cool off and for spectators. Playing surfaces—whether paved or turf—may need to be selected and designed to withstand increased high temperatures and changes in precipitation patterns. Playing hours may need to be adjusted to cooler times of day, which may require lights.

HVAC: Design for the Future

When the municipal building's HVAC system in Towamencin Township (Montgomery County) caused trouble and repair costs began to rise, officials knew it was time for a replacement. They reached out to Practical Energy Solutions (PES)—a privately-owned energy consulting group headquartered in West Chester, Pennsylvania—for help. Rather than simply swap out the old system for a new "in-kind" system, the PES team performed an energy assessment and recommended changes that will reduce energy consumption by nearly 60 percent and prepare the Township for the future.

PES designed a durable and efficient geothermal HVAC system, using existing water piping and air-handling units, while eliminating the Township's reliance on natural gas. The new system also includes air cleaning technology to reduce outside air ventilation loads by about two-thirds, allowing a smaller and less expensive geothermal well field while producing superior indoor air quality. Because the air cleaners allow more conditioned air to be recirculated, rather than rely on outside air that requires cooling and heating, the system will be capable of meeting the unpredictable needs of the future climate.[18]

The increased frequency of heavy-rain events and intense storms is another effect of climate change that municipalities should consider for their facilities. In general, facilities that have problems with heavy rainfall today—such as flooded parking lots or access roads or water in buildings—are projected to have

[18] Communication with PES President Paul Spiegel, PSpiegel@practicalenergy.net.

increased problems in the future as intense storms become more common. Facility managers are advised to assure local drainage and properly-sized gutters and downspouts are in place, and that future rainfall projections are taken into account in any facility design. Trees, rain gardens, and other green stormwater infrastructure, discussed below, are essential tools in stormwater management.

As general guidance, don't build things today that are not designed for the conditions they are expected to face in their lifetimes.

Resources

- Municipalities are encouraged to contact county planning offices for assistance.
- See www.epa.gov/green-infrastructure/lower-building-energy-demands for additional information and links to resources for lowering building energy demand with trees and other green infrastructure.
- DVRPC carried out a direct technical assistance program for energy management in municipal operations. This work is summarized in *Municipal Energy Management: Best Practices from DVRPC's Direct Technical Assistance Program*.[19]
- Municipalities in Pennsylvania are encouraged to contact the Pennsylvania Department of Environmental Protection's energy office which has services specifically for local governments.[20] Pennsylvania municipalities are also encouraged to contact their electric distribution company (EDC)—PECO Energy, PPL Utilities, or Met-Ed—to learn what they offer their commercial customers under their energy efficiency and conservation programs, as mandated under PA Act 129. These programs vary by EDC, but generally include rebates for installing energy efficient equipment, as well as for energy efficient lighting.
- New Jersey municipalities are encouraged to contact Sustainable Jersey, a non-profit organization that combines the forces of the College of New Jersey, the New Jersey League of Municipalities, the New Jersey Department of Environmental

[19] www.dvrpc.org/Products/15020.
[20] www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/Pages/default.aspx.

Protection, and the New Jersey Board of Public Utilities to deliver a range of services and certifications related to preparing municipal facilities for a changing climate.[21]

Stormwater Systems

While total annual precipitation is projected to increase only slightly as our climate changes, more precipitation is projected to occur in intense storms. Stormwater systems will be challenged to handle this more intense rainfall. This makes it particularly important to assure that system inlets and outfalls are kept clear of debris.

Green stormwater infrastructure (GSI)—which handles the first inch or so of stormwater before it has a chance to enter storm sewers—is instituted primarily for water quality benefits. However, it has the added benefit—together with other stormwater mitigation systems, such as retention basins and riparian corridor protection—of slowing the short, intense, bursts of rainfall that can cause nuisance flooding and overwhelm stormwater systems, effectively increasing the capacity of a stormwater system. This can help limit nuisance flooding during rainfall events.

When reviewing stormwater plans for new development or redevelopment, future rainfall projections should be kept in mind.

[21] www.sustainablejersey.com.

Resources

- Municipalities are encouraged to contact county planning offices for assistance.
- The US EPA has a section on their website addressing *Climate Adaptation and Stormwater Runoff*.[22]
- The City of Philadelphia's *Green City, Clean Waters* program is a national model for using green stormwater infrastructure (GSI). Their website has many resources useful to municipalities interested in GSI.[23]
- DVRPC worked with the City of Chester to create a *Green Stormwater Infrastructure Plan*. This is available on DVRPC's website.[24]
- For New Jersey municipalities, Sustainable Jersey offers information on green infrastructure planning and implementation as part of their Land Use and Transportation Actions guidance.[25]

Transportation Infrastructure

Several aspects of transportation infrastructure are vulnerable to climate change.

Intense storms cause waterways to flow faster and with greater volume. Bridges, culverts, and other infrastructure were designed for historic storms, and thus are in many cases no longer adequate for current and future storms. In addition to assuring that culverts and passages under bridges are kept clear of debris, municipalities should—at time of replacement—assure bridges, culverts, and other infrastructure are designed for future storms, rather than simply replacing in kind. DVRPC provided comments to NJDOT recommending that future flooding be considered in the redesign of the two Route 130 bridges over Assiscunk Creek in Burlington City. DVRPC also recommended bioswales be added

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[22] www.epa.gov/arc-x/climate-adaptation-and-stormwater-runoff
[23] Information may be found at: www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan.
[24] www.dvrpc.org/Products/15066.
[25] See www.sustainablejersey.com.

to an intersection improvement project in Northampton Township, Bucks County to reduce roadway flooding.

Pavement surface temperature can be much higher than air temperature, and can buckle and soften in very high temperatures. As climate change proceeds, municipalities need to select appropriate pavements. For instance, higher temperatures may require raising high-temperature asphalt binder grade and/or increasing the use of binder polymerization and/or improved aggregate structure in asphalt mixes.[26]

Waiting for public transit in hot weather is projected to become increasingly uncomfortable. Stations and bus stops should all be provided with shade, either trees or a transit shelter. In Southeastern Pennsylvania, bus shelters are typically provided by the municipality or property owner (often with the involvement of an advertising vendor). New Jersey Transit has an ongoing program to install bus shelters at agreed-upon locations at no cost to municipalities, if the municipality agrees to assume maintenance responsibilities for the shelter. Please contact your relevant transit operator or Transportation Management Association (TMA) to learn more about options for shelters.

Hotter weather presents a challenge to bicyclists and pedestrians as well. Maintaining street trees will help shade sidewalks and bike lanes. Trees shading dedicated trails are also important.

Resources

- The Sustainable Transportation section of US Department of Transportation Federal Highway Administration's website has many resources for addressing resilience of transportation as the climate changes.[27] These include tools for assessing how components of a municipal transportation system may be vulnerable to climate stressors.
- The topic for DVRPC's Climate Adaptation Forum in October 2017 was *Preparing Transit Systems for Extreme Weather*. The

[26] See, for instance, the Federal Highway Administration's 2015 publication *Climate Change Adaptation for Pavements*, available to download at: www.fhwa.dot.gov/pavement/sustainability/hif15015.pdf.
[27] www.fhwa.dot.gov/environment/sustainability/resilience/.

DVRPC website archives that Forum, and contains a number of useful resources.[28] Key insights include that many of the steps taken to respond to climate change can be made using the standard capital improvement process.

- The Pennsylvania Department of Transportation's comprehensive *Extreme Weather Vulnerability Study* discusses a wide range of impacts of extreme weather on the transportation system.[29]

Municipal Services

The delivery of some municipal services may need to change as the climate changes. For instance, higher summer temperature may lead to a demand for more frequent trash collection, to reduce odor and pests. The time of day for collection may need to be earlier in summer months in order to assure the health of trash collectors. Timing of leaf collection operations may need to be adjusted. Police foot patrols may need to be adjusted to cooler times of day as temperatures increase, or cooling stations may need to be established. Organized summer programs for children may need to include indoor activities in the hottest portions of the day.

Public Employee and Contractor Work Rules

Municipal managers need to be aware that—over time— the increase in temperatures is expected to result in more time when temperatures are too high for outdoor work to be conducted safely. Managers may wish to review work rules and working hours to assure municipal employees and contractors can complete work in work periods.

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[28] www.dvrpc.org/Resiliency/CAF/Transit/.

[29] Available at pennshare.maps.arcgis.com/apps/MapSeries/index.html?appid=29bf9f06045f47feb9888193674f8a95.

Public Trees

Public trees will be increasingly important to municipalities in addressing the impacts of climate change on their communities. Street trees help keep sidewalks cool, encouraging walking within the community. Trees provide shade to residences and businesses, lowering their cooling demand. Trees in parks and at recreational fields will also be increasingly important in keeping users of these facilities comfortable. Street trees, when installed with tree trenches, can be an important part of a green stormwater infrastructure system.

It is critical that municipalities select tree species that are suited for expected climate conditions over the tree's expected lifetime. This may require selecting trees that differ from species that have historically populated streets and parks. A first step would be to create an inventory of street trees and trees in parks.

In addition, municipalities should consider policies that support homeowners and businesses to select and maintain trees and other plantings on their properties. This might include community trainings on tree selection and maintenance, as well as scheduled brush collections.

Resources

- The Climate Change Response Framework has created a series of brief documents summarizing climate change projections for tree species across the Mid-Atlantic region. The DVRPC region is covered by the Piedmont[30] (subregion 5), and Coastal Plains[31] (subregion 6) handouts.
- Mount Holly, NJ, has carried out a street tree assessment. Their report provides an excellent example for other municipalities.[32]
- Information on conducting a community tree inventory is available from PennState Extension.[33]

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[30] forestadaptation.org/sites/default/files/PA5_Piedmont_summary_041018.pdf.
[31] forestadaptation.org/sites/default/files/pictures/MAR_coastal_species_handout_6_0.pdf.
[32] http://sj-site-persistent-prod.s3.amazonaws.com/fileadmin/cicbase/documents/2015/6/5/14335153916003.pdf.
[33] extension.psu.edu/conducting-a-community-tree-inventory.

- The New Jersey Urban and Community Forestry program website has information on grant opportunities and links to tree management tools.[34]
- Sustainable Jersey has information on conducting an assessment of municipal trees.[35]
- Pennsylvania municipalities are encouraged to contact the Pennsylvania Horticultural Society, which offers information on street trees through their Tree Tenders program, as well as other resources for supporting community trees.[36]
- The topic for DVRPC's Climate Adaptation Forum in October 2016 was *Forests, Urban Trees, and Climate Change*. The DVRPC website archives that Forum, and contains a number of useful resources.[37]

Public Health

According to the Centers for Disease Control and Prevention (CDC), climate change impacts a wide-range of health outcomes. Figure 15 illustrates the most significant climate change impacts (rising temperatures, more extreme weather, rising sea levels, and increasing carbon dioxide levels), their effect on exposures, and the subsequent health outcomes that can result from these changes in exposures.[38]

Many of these impacts are outside of the direct influence of most municipalities. However, it is important for municipalities to coordinate with county and state public health officials to address these impacts. In particular, to address extreme heat, municipalities can be sure they have an effective network of cooling centers, and provide pre-season community workshops about extreme heat preparedness, targeted to vulnerable populations, including the poor, those living alone, the elderly, and those without air conditioning. Municipalities can also initiate and participate in coordinated public information campaigns,

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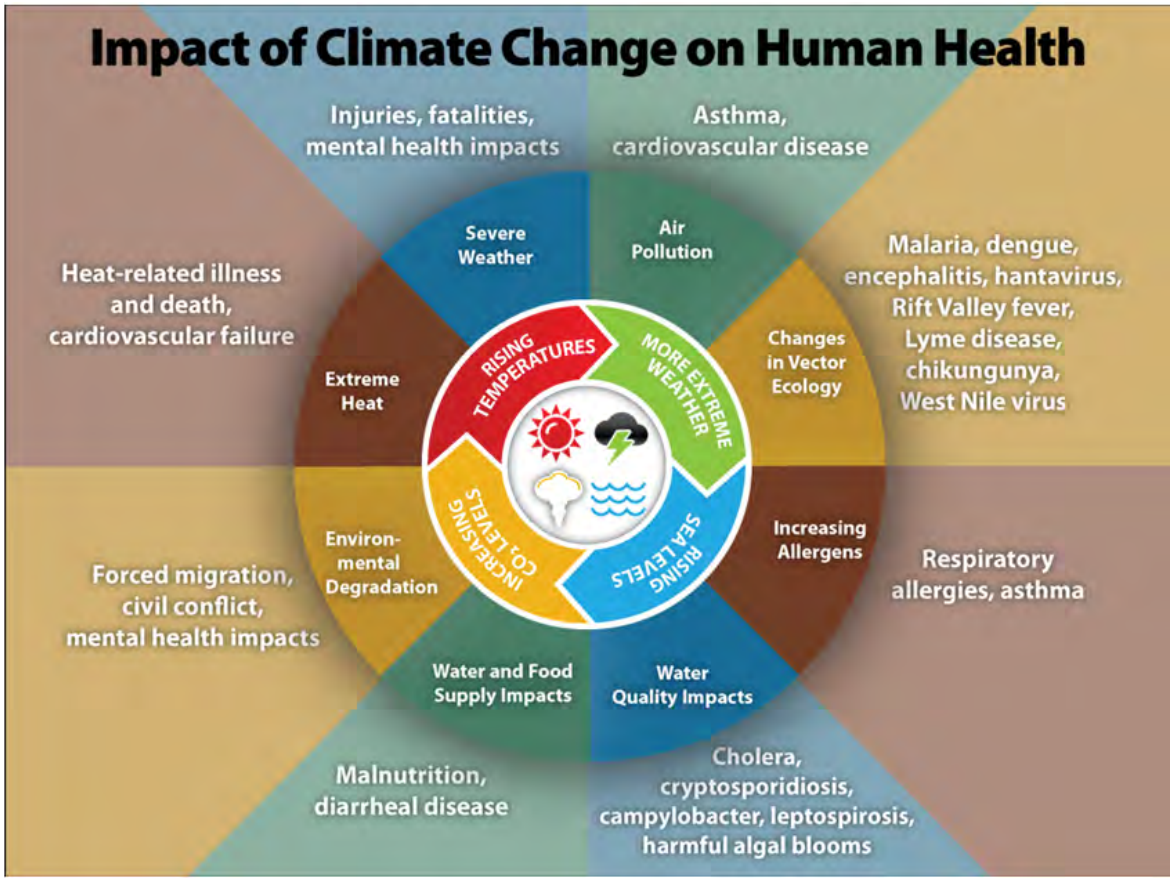
[34] https://www.state.nj.us/dep/parksandforests/forest/community/Information_for_Municipalities.html.
[35] www.sustainablejersey.com/actions-certification/actions/#open/action/70.
[36] phsonline.org/programs/tree-tenders/.
[37] www.dvrpc.org/Resiliency/CAF/ForestsTrees/.
[38] From www.cdc.gov/climateandhealth/effects/default.htm. Image downloaded 12/31/2017.

and use neighborhood networks to visit vulnerable populations prior to extreme heat events to assure those who wish are able to get to cooling centers.

Additionally, municipalities can help their communities prepare for the increase in vector-borne disease. A recent CDC report found that disease cases from mosquito, tick, and flea bites—such as Lyme disease and West Nile virus—tripled in the US from 2004 to 2016.[39] According to the CDC, it is particularly important to protect children from such insect bites and control the spread of these insects. Local programs to educate residents on avoiding risks from mosquitos and ticks, what to do if you find a tick on your child, as well as on the early symptoms of Lyme disease and other illnesses can be very effective.

Figure 15: Impact of Climate Change on Human Health



Source: CDC.

[39] www.cdc.gov/vitalsigns/vector-borne.

Resources

- The Centers for Disease Control and Prevention is the nation's public health agency. Its website provides information on its *Climate-Ready States & Cities Initiative*, including links to data, tools, webinars, trainings, and publications.[40]
- The topic for DVRPC's Climate Adaptation Forum in February 2017 was *Public Health and Climate Change*. The DVRPC website archives that Forum, and contains a number of useful resources, including user-friendly handouts and posters addressing topics including heat, allergies, and heart health.[41]

- The Philadelphia Department of Public Health is one of 12 local health departments participating in a national Climate and Health Learning Collaborative for Urban Health Departments.[42]
- The New Jersey Climate Adaptation Alliance has produced a video describing how climate change is and will continue to affect public health in New Jersey.[43]

Regulations

Floodplain Ordinances

As precipitation increases, land near surface water is increasingly vulnerable to flooding. This vulnerability is expected to increase over time. Thus it is advisable for municipalities to review their floodplain ordinances, and strengthen them to be prepared for future conditions. This can include incorporating additional freeboard requirements, and

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[40] www.cdc.gov/climateandhealth/climate_ready.htm.
[41] www.dvrpc.org/Resiliency/CAF/PublicHealth.
[42] usclimateandhealthalliance.org/philadelphia-department-public-health.
[43] njadapt.rutgers.edu/resources/videos/climate-change-and-public-health-implications-for-new-jersey.

extending existing floodplains to include land expected to be inundated in the future.

Municipalities may also consider acquiring flood-prone properties, removing improvements, and restricting future development.

Zoning Strategies

Zoning ordinances can be a powerful tool for protecting community assets against flooding. For example, zoning ordinances can regulate setbacks from rivers and streams, increase base flood elevations for buildings, and establish requirements for stormwater management. In particular, a community can create a zoning overlay in floodplain areas, or update the existing zoning code, to require new construction, renovations, and/or flood-sensitive building systems to be elevated above projected flood heights over the expected life of an asset.

Building Codes

Updated building codes that regulate the design, construction, and landscaping of new construction and renovation can improve the ability of structures in hazard-prone areas to withstand hazard events. Although code requirements are established at the state level, municipalities may impose additional requirements for building in a flood zone.

Resources

- DVRPC's website has sample natural resource protection and open space preservation ordinances that can be used to keep development out of floodplains.[44]
- Many county planning offices are able to provide municipalities with model floodplain ordinances.
- Many of the resources for the following section, *Planning for Coastal Hazards*, are relevant to non-coastal municipalities.

Planning for Coastal Hazards

Coastal municipalities face special risks not faced by inland municipalities. In the DVRPC region, municipalities located along the tidal Delaware River or its tributaries may face increased coastal

[44] www.dvrpc.org/MuniToolsServices/NaturalResourceProtectionTools/Ordinances.

flooding threats due to both sea level rise and the prospect of more intense storms. Together, these two factors raise the flood heights likely to occur during storm events, and the consequent damage to or loss of property, loss of coastal land, or stress to vulnerable coastal populations.

Municipal plans and regulations can serve as tools to prepare for coastal hazards before they occur. Municipalities can use—but are not limited to—the municipal master plan, all hazards mitigation plan, emergency response plan, zoning ordinance, subdivision and land development ordinance, and stormwater management ordinance to protect themselves from future coastal floods. These tools will help municipalities make better decisions about where to invest their time and funding to make themselves more resilient to the effects of current and projected coastal flooding.

Planning efforts require understanding and commitment from local residents and businesses. Coastal municipalities should begin a community-wide planning process to prepare for the long-term effects of storm surge and sea level rise beyond the standard 20- or 25-year planning horizon. This will help the community prepare for the gradual, but steadily increasing, rates of sea level rise and storm surge expected in the ensuing decades.

Resources

- DVRPC has worked with New Jersey and Pennsylvania municipalities in the Delaware Estuary.
  - In New Jersey, this work was carried out through the Resilient Coastal Communities Initiative, a partnership funded by NOAA and managed by the NJ Department of Environmental Protection. DVPRC assisted six municipalities, all (coincidentally) in Burlington County: Beverly City, Bordentown Township, Burlington City, Burlington Township, Delran Township, and Moorestown Township. Detailed reports for each these municipalities that DVRPC assisted are available on DVRPC's website.
  - Similar work in Pennsylvania is being carried out in Bucks and Delaware counties with funding through the Coastal

Zone Management Program, run by the PA Department of Environmental Protection. Information on this work, and additional resources for municipalities, is available on DVRPC's website.[45]

- DVRPC's website has specific resources for plans, regulations, and ordinances for coastal municipalities.[46]
- The Georgetown Climate Center has extensive resources for municipalities at risk from sea-level rise.[47]

Additional Information

This brochure provides only a brief overview of the issues related to climate change in the DVRPC region, and of the resources available to municipalities. Please visit the climate change section of DVRPC's web site at www.dvrpc.org/EnergyClimate for additional information and resources, and for contact information to consult with DVRPC's staff.

[45] www.dvrpc.org/Resiliency/Coastal/.
[46] www.dvrpc.org/resiliency/Coastal/pdfs/Plans_Regulations_Ordinances.pdf and www.dvrpc.org/resiliency/Coastal/pdfs/Municipal_Operations.pdf.
[47] www.georgetownclimate.org.

ABOUT DVRPC

The Delaware Valley Regional Planning Commission is the federally designated Metropolitan Planning Organization for a diverse nine-county region in two states: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey.

DVRPC's vision for the Greater Philadelphia Region is a prosperous, innovative, equitable, resilient, and sustainable region that increases mobility choices by investing in a safe and modern transportation system; that protects and preserves our natural resources while creating healthy communities; and that fosters greater opportunities for all.

DVRPC's mission is to achieve this vision by convening the widest array of partners to inform and facilitate data-driven decision-making. We are engaged across the region, and strive to be leaders and innovators, exploring new ideas and creating best practices.

DVRPC fully complies with Title VI of the Civil Rights Act of 1964 and related nondiscrimination statutes in all activities. For more information, visit www.dvrpc.org/GetInvolved/TitleVI.

The authors are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

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