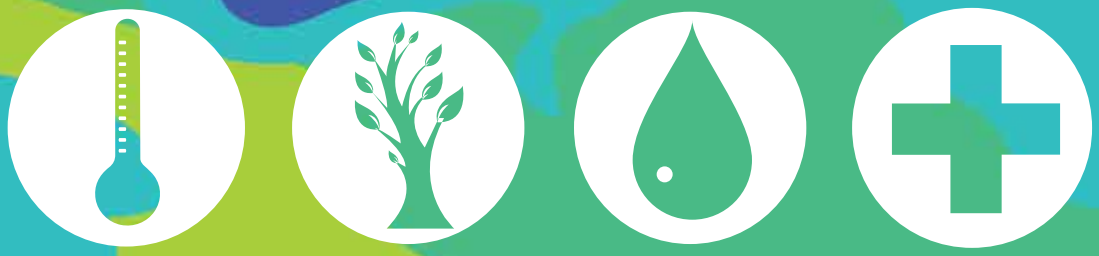
CMAP



Climate Adaptation Guidebook for Municipalities in the Chicago Region

June 2013

Funding Acknowledgement

CMAP would like to thank the U.S. Department of Housing and Urban Development (HUD) for funding the development and production of this document. This project is funded through HUD's Sustainable Communities Regional Planning grant, which supports CMAP's Local Technical Assistance program.

The Chicago Metropolitan Agency for Planning (CMAP) is the region's official comprehensive planning organization. Its GO TO 2040 planning campaign is helping the region's seven counties and 284 communities to implement strategies that address transportation, housing, economic development, open space, the environment, and other quality-of-life issues.

See **www.cmap.illinois.gov** for more information.

Table of Contents

Introduction

Scientific consensus indicates that the climate is changing at a global scale and that greenhouse gas emissions are chiefly responsible for the change.[1] To help mitigate climate change, the northeastern Illinois region's comprehensive plan GO TO 2040 recommends important local steps like improving energy efficiency and encouraging the use of low-carbon transportation alternatives, such as walking, biking, and transit. While it remains critical to reduce emissions to limit climate change, it is wise to prepare for its impacts at the same time.

This guidebook is meant to aid municipalities in the Chicago region that are interested in adapting their planning and investment decisions to a changing climate. Essentially, this means improving resilience to future weather impacts. The central reason for considering climate change is that, in many instances, it will be cheaper and less disruptive to plan for anticipated conditions than to retrofit or rebuild later.

Since it is meant for municipalities, this guidebook concentrates on sectors and services that are typically under their jurisdiction. For instance, municipalities in the region are not directly responsible for deepening port facilities to handle lower water levels or fortifying the electric distribution system to accommodate higher cooling demand as temperature increases. These are issues for the private sector or other levels of government to address. In some cases, the range of solutions available to municipalities is shaped by policies at other levels of government. Where significant, this guidebook calls attention to these policy issues and makes recommendations on the steps needed to address them.

This guidebook and its appendices can be found at **www.cmap.illinois.gov/climate-adaptation**.

Key Impacts

Climate change promises to exacerbate problems already facing the region. While the Chicago area does not face wildfires or sea level rise like more arid or coastal areas do, for example, it can expect heat waves and flooding. The following impacts are anticipated in areas of particular interest to municipalities. For more information, see the regional climate study in Appendix A.[2]

- Heavy rains are likely to fall more frequently, causing flooding more often.
- Light rains are likely to fall less frequently, particularly in the summer, leading to drought.
- Heat waves will probably become more frequent, more intense, and last longer, threatening the health of the old and young and those already ill.
- Hotter summers will lead to cooling demand that may strain the electric grid.
- Hot summer temperatures will make air quality worse while warmer, wetter conditions encourage infectious diseases.
- Weather variability may make operating municipal utilities more difficult and financially risky.

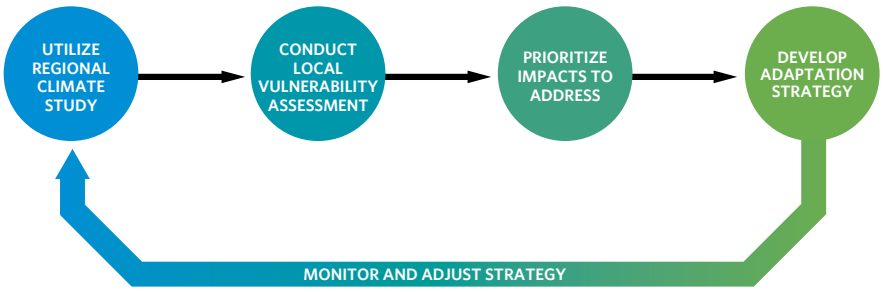
1 The most recent assessment report in 2007 from the Intergovernmental Panel on Climate Change concluded that climate change, especially increases in temperature, has already been observed on all continents. The draft National Climate Assessment for 2013 reaffirms that, in the continental U.S., temperatures are increasing, extreme weather events are becoming more frequent, sea levels have risen and are continuing to rise, and frost-free periods are lengthening each year, among other effects. See Chapter 2, *Our Changing Climate* (**http://ncadac.globalchange.gov/**).

2 Available online at **www.cmap.illinois.gov/climate-adaptation**.

Developing a Municipal Climate Adaptation Strategy

This guidebook surveys climate change impacts in the Chicago area and suggests potential adaptation measures for municipalities to address them. Yet communities will still need to establish a process to study their particular vulnerabilities and to implement adaptation measures that work for their individual circumstances. Each community's situation is different, from the vulnerabilities they face to the resources at their disposal. In very general terms, an approach to developing a municipal climate adaptation strategy is shown below. This approach can also be adapted readily for municipalities developing a more general hazard mitigation plan.

Steps for developing a municipal climate adaptation strategy



Source: Chicago Metropolitan Agency for Planning.

Utilize the Regional Climate Study

Understanding the ways the climate is expected to change is a critical basis for decision-making. Appendix A is meant to provide this foundation for northeastern Illinois. Individual communities within the region are expected to face similar future weather patterns. With estimates of air temperature, humidity, precipitation, vegetation, and Lake Michigan levels, the regional climate study (included as Appendix A to this guidebook) can serve as a useful resource describing altered climatic conditions in northeastern Illinois.

Conduct a Local Vulnerability Assessment

While communities in the Chicago area are likely to face similar climatic conditions, their vulnerability to the resulting weather impacts will vary. In some places, many homes and businesses may be exposed to flooding, while in other places the risk is much lower. A risk and asset vulnerability assessment allows municipal leaders to understand the implications of changed weather patterns. The following chapter discusses a set of likely effects on municipal assets and operations, but localities could benefit from more detailed study.

A straightforward way to conduct a local vulnerability assessment is to use a "checklist" approach. A simple checklist called *Self-Assessment to Address Climate Change Readiness in Your Community* from Illinois-Indiana Sea Grant is available as Appendix B. At the other end of the complexity spectrum is the version used by New York City Climate Change Panel.[3] Municipalities will probably need to budget for a vulnerability assessment and use outside professional services, but these two approaches provide bookends for the level of effort required.

Prioritize Impacts to Address

With a grasp of the ways that climate change will likely affect their communities, local leaders need to determine which issues to address and when. The process for prioritization will depend on factors specific to each community, but some considerations include:

- ***Results of the risk and asset assessment:*** Which assets are most vulnerable? Are there issues that are more urgent than others to address?
- ***"No-regrets" strategies:*** Are there current problems that need to be addressed and are expected to grow worse with climate change? A "no-regrets" approach means tackling issues in a way that benefits the municipality regardless of how a particular climate forecast pans out.
- ***Upcoming plans:*** Are there any upcoming infrastructure upgrades? Planned infrastructure improvement projects provide opportunities to incorporate adaptation measures that can make infrastructure more resilient to future changes and that often require relatively small changes in design.
- ***"Low-hanging fruit":*** Would it be more beneficial to first tackle issues that are least costly or fastest to implement?
- ***Budget:*** How much funding is required for different adaptation measures? Which of those measures can piggyback onto existing program funds? It is almost certainly easier to fold adaptation strategies into existing programs rather than create new institutions to fund and oversee them.

Because adaptation measures involve a range of institutions and people, input from key stakeholders in this step can provide valuable insight into how to best sequence and implement climate adaptation strategies.

3 See **http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/pdf**.

Develop Adaptation Strategy

Once impacts have been a clearly prioritized, specific adaptation measures are needed. The following section of this guidebook provides a selected list of potential adaptation measures for municipalities to consider. However, these should be considered within the context of an overall strategy. Some principles to keep in mind in developing this strategy include:

- Identifying clear objectives and measurable targets is critical to guiding the overall direction of an adaptation strategy. Some examples can include establishing a target number of cooling centers or repaving a certain percentage of roads with a climate-resilient paver over a defined timeframe.
- Identifying parties that will be responsible for implementation and oversight helps to organize the plan of action. Some strategies may be best suited to implementation by private citizens, the business community, or another unit of government.
- Identifying available funding sources early ensures that recommendations can actually be implemented. Often, adaptation measures can be folded into existing operations and may require only slightly more financing to execute. Sometimes, however, adaptation activities require more dedicated funds. Appendix C provides some examples of potential funding sources for adaptation.
- Identifying any relevant existing plans, codes, and policies allows local leaders to dovetail adaptation with existing operations. It also brings to light any codes or regulations that may hinder the process and changes that may need to be in place before it is possible to proceed.
- Implementation can be streamlined if the mechanism to carry out the measure can be clearly identified. Improving infrastructure, for example, may be implemented by a public works department, while strengthening floodplain management standards may require changes to local ordinances.
- Communicating with the public about the measures that are being undertaken can educate residents about the importance of adaptation to their public infrastructure and services, as well as provide examples of actions that residents and business owners can undertake on their own properties.

Monitor and Adjust Strategy

Tracking progress allows local leaders to understand whether their actions are effective and how they can be improved. Local governments should determine the type of data that is most appropriate to collect given the adaptation strategy and the performance measures against which to track implementation. It is important to decide the frequency of monitoring and the department responsible for conducting the monitoring. To the extent possible, it can also be useful to identify ahead of time the potential policies that may need to be adjusted as new information is collected.

Selected Climate Impacts and Adaptation Measures

Climate change has the potential to affect many different assets and services typically provided by municipalities. This section surveys the likely impacts of climate change on these areas of interest and suggests potential adaptation measures — that is, ways municipalities can protect themselves and their residents. Most of the expected impacts are on infrastructure systems maintained by municipalities, but future weather conditions may have implications for public health, building design, and natural resources as well. The range of impacts and adaptation measures discussed here is not exhaustive. However, the most significant expected impacts and most likely adaptation approaches are covered. A vulnerability assessment and adaptation planning process, such as discussed in the previous chapter, will be needed at the local level.

Drainage and Flood Protection

Background

Municipalities in Illinois have numerous duties related to stormwater management and flood risk reduction. First, municipalities generally regulate development to protect property from flood damage. They enforce floodplain management standards, which apply within flood-prone areas to minimize the threat that floodwaters will damage buildings. They also typically enforce stormwater detention standards, which are meant to reduce impacts on downstream property owners by decreasing the rate of runoff from new developments upstream.

The same basic issue confronts municipalities with both kinds of standard. Since flood-prone areas are determined based on historical patterns, floodplain management standards may not be in place for areas that will have higher flood risk in the future. Likewise, sizes or capacities for stormwater infrastructure calculated using historical rainfall may not be large enough to provide the same level of protection in the future that they do today.

Besides these regulatory responsibilities, municipalities own and operate much of the drainage system — the storm sewers, ditches, and so forth. With heavier rain events occurring more frequently over time, more demands will be placed on this system. It may not perform to the level that residents expect. Thus, it is important for communities to consider the improvements they may need to maintain a level of flood risk they are comfortable with in the face of climate change.

Flooding along Illinois 53 in Lisle in April 2013.
Photo courtesy of Antonio Perez, Chicago Tribune, April 18, 2013.

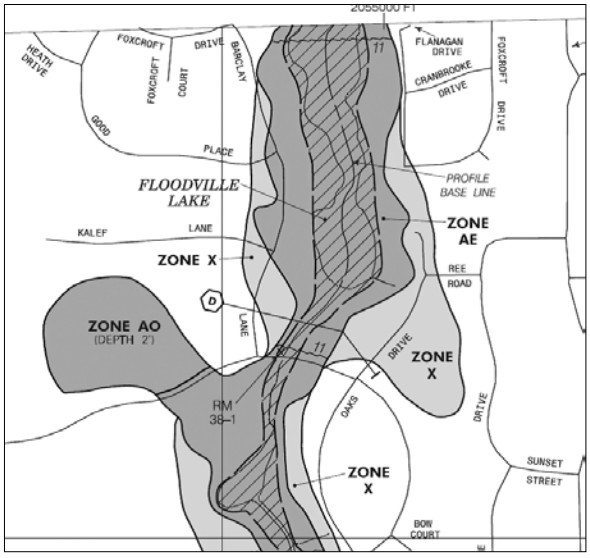
ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
More frequent occurrence of heavy rainfall	**Increased flood damage because area of significant flood risk and elevation of floodwaters are underestimated on flood maps**
	Increased downstream flood damage because detention is inadequate

Potential Adaptation Measures

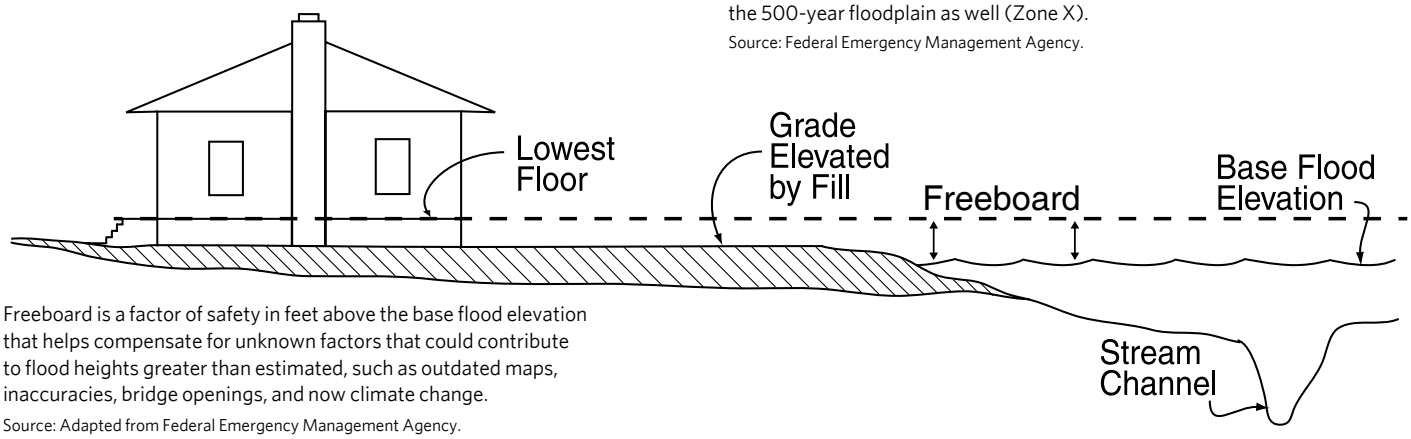
Increase flood protection elevation.
Most local floodplain management ordinances in the Chicago region require the lowest occupied level of a building located within a regulatory floodplain to be at least one foot higher than the predicted height of floodwaters. The regulatory floodplain is the area estimated to be inundated during a 100-year flood, also called a Special Flood Hazard Area (SFHA). To accommodate the possibility that the height of the 100-year flood in the future will be higher than it is now, new construction could be required to have additional separation, or "freeboard," perhaps two to three feet. Aside from protecting against climate change, having additional freeboard helps prevent structures from damage in case flood studies underestimate the height of floodwaters. For participants in the Federal Emergency Management Agency (FEMA Community Rating System, higher freeboard can help reduce flood insurance premiums for residents. Higher freeboard requirements are the primary adaptation measure.

Additional freeboard can be implemented through an ordinance amendment. While adding a foot or two of additional elevation to a building may be relatively inexpensive, raising a building may change its "look" and fit with neighboring properties, which may be a concern for infill development. This can be addressed through the use of design treatments or landscaping that disguises the change in elevation.

Apply floodplain management requirements to area larger than the historic Special Flood Hazard Area.
Increasing freeboard requirements within the SFHA helps to correct for underestimates in the extent of floodplains and height of floodwaters. Increasing freeboard is the primary option for addressing climate change. However, some areas outside the SFHA may be subject to additional flood risk with climate change, especially because buildings outside the SFHA are not typically elevated or floodproofed. Thus, it is worth considering whether the SFHA shown on Flood Insurance Rate Maps (FIRMs) is an adequate predictor of flood risk given climate change.[4]



Flood insurance rate maps typically show the Special Flood Hazard Area (the 100-year floodplain, Zones AE and AO) and often show the 500-year floodplain as well (Zone X).
Source: Federal Emergency Management Agency.



Freeboard is a factor of safety in feet above the base flood elevation that helps compensate for unknown factors that could contribute to flood heights greater than estimated, such as outdated maps, inaccuracies, bridge openings, and now climate change.
Source: Adapted from Federal Emergency Management Agency.

4 While FIRMs in Illinois have been modernized in recent years by making them compatible with geographic information systems (GIS) and improving their topographic base, the underlying models have not been updated for the most part. These models were generally run in the 1970s using rainfall data older than that. In addition, significant development has occurred in many watersheds since floodplains were delineated, increasing runoff during storm events. Thus, in some places the maps underestimate the area that would be inundated in a major flood given today's level of risk and may perform worse in the future.

Short of remapping the floodplain,[5] a municipality could amend its ordinances to require that floodplain management standards be met for all new construction within the 500-year floodplain (where it is shown on the FIRM). Alternatively, an interval between the mapped 100- and 500-year floodplains could be selected, or the 100-year floodplain could be expanded in area by a set percentage.

Expand outreach and technical assistance to reduce flood risk.
Property owners must ultimately make their own decisions about whether to invest in floodproofing and sometimes whether to purchase flood insurance. Municipalities often provide information to residents and builders on floodproof construction, the National Flood Insurance Program, and other flooding topics. Municipalities with capacity should consider encouraging staff to attend neighborhood group meetings to promote flood damage risk reduction and provide technical assistance to property owners seeking to limit their exposure to flood hazards. Direct outreach and technical assistance would be needed to reduce flood damage risk to already-developed areas that were not built to adequate floodplain management standards.

Develop stormwater master plan to identify needed drainage improvements.
Studies reviewed in Appendix A suggest that intense rainstorms may become more frequent in the upcoming decades. The region could see an increase in large storms with high rainfall totals that lead to overbank flooding, but it could also see more short, localized, intense bursts of rainfall that overwhelm local drainage and cause yard and street flooding. In the latter case, a number of smaller-scale capital projects may be needed. The ideal approach would be to develop a stormwater master plan to understand resident needs and prioritize capital projects to address them. The engineering for drainage projects should incorporate assumptions about future climate conditions.

An innovative approach is to use site-scale green infrastructure projects, such as rain gardens and swales, to capture more runoff. This approach mimics natural drainage, allowing water to infiltrate into the ground or be taken up by plants rather than piping it away. Green infrastructure projects also enhance neighborhood aesthetics. Nonetheless, conveyance improvements such as additional inlets to storm sewers may still be needed, depending on conditions.

Design can be used to disguise a changed elevation for the lowest occupied floor resulting from higher freeboard requirements. In this example from Oregon, planters are used to disguise higher foundation walls. Other designs could be applied to houses elevated on fill.
Source: Architects Without Borders, **http://www.awboregon.org/documents/vernonia_final.pdf**.

5 In July 2012, Congress reauthorized and revised the National Flood Insurance Program. Among the changes to the program, a federal panel is required to study how to incorporate future climate factors into the flood insurance program, including updates to floodplain maps. It is not clear when or if this change in federal law will lead to wholesale updates in floodplain maps. See **http://www.govtrack.us/congress/bills/112/hr4348/text**, Section 100215(d) Future Conditions Risk Assessment and Modeling Report.

Green infrastructure, like this rain garden, can be used to capture runoff.
Photo courtesy of Chicago Metropolitan Agency for Planning.

Detention basins, like this one in South Barrington, are designed to handle a certain design rainfall. These standards may need review to make sure they will provide adequate protection in the future.
Photo courtesy of Chicago Metropolitan Agency for Planning.

Other Considerations

While local ordinances define the allowed release rate from detention basins, the volume is typically calculated based on a 100-year, 24-hour design rainfall from the Illinois State Climatologist's Bulletin 70 publication. However, future rainfall may depart from historical rainfall pattern. When Bulletin 70 is updated — design storms may currently be somewhat larger than estimated in that publication — it should include consideration of likely future rainfall patterns to ensure that detention basins provide the same level of protection into the future. The Illinois State Climatologist is encouraged to update Bulletin 70.

In many communities, flood control measures are needed to reduce current threats to life and property. Such projects are also typically designed to handle events of a certain size as determined by the historical record, an approach which may underestimate future events. Although municipalities are not generally the lead agencies responsible for building major flood control projects — typical lead agencies in the region are the Army Corps of Engineers, the Illinois Department of Natural Resources, the Metropolitan Water Reclamation District, and the Counties — they often participate in design and financing and can encourage the consideration of future hydrology in design engineering. Lead agencies should strongly consider the effect of climate change in designing flood control projects.

Flooding in a subdivision in unincorporated McHenry Township in April 2013.
Photo courtesy of Chuck Berman/Chicago Tribune, April 21, 2013.

Drinking Water

Background

Since municipalities are widely responsible for providing drinking water to residents in northeastern Illinois, they are the front line in responding to the effects of climate change on water supply. For water utility planning and operations, the primary consequence of climate change is likely to be higher variability in weather conditions and customer demand.[6] Because the construction of water treatment plants is usually financed by borrowing against future water sales, this increased variability in demand may have financial implications. Similarly, increased variability in weather conditions may affect the design needed for water treatment plant processes.

Secondarily, some water utilities could experience an increase in per capita demand due to warmer temperatures and longer periods without rain. Previous regional demand projections done for CMAP's Water 2050 plan considered the potential effects of climate change by estimating future per capita demand under a combination of temperature and precipitation changes. The study found that, independent of changes due to other factors, annual average per capita demand could increase 7-12 percent by 2050 due to climate change, at least on a region-wide basis.[7] This suggests that planning by local utilities should consider changes in demand due to longer-term weather conditions.

To many people, the most significant question of water supply planning in the face of climate change may be, "will there be 'enough' water?" The Illinois State Water Survey has addressed this question,[8] concluding that projected demand can be met, but with some consequences. For instance, groundwater users may have to rely on deeper, more brackish water since upper aquifers would probably be dewatered by mid-century at current rates of use.

The Survey noted that availability is not really a fixed value, but is actually a function of costs that ratepayers and the public are willing to bear. This would include higher water prices because of increased costs for pumping and treatment, but it also includes the costs of environmental damage and costs imposed on other users.

Local drinking water distribution systems and water treatment plants, like this plant in Elgin, are major municipal assets.

Photo courtesy of Google Earth.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in climate variability	**Increases challenge of planning for demand**
Increase in average summer temperature	**Increases drinking water demand**
Increased occurrence of drought	**Increases drinking water demand**
More frequent occurrence of heavy rainfall	**Higher chance of microbial contamination from flooding**

6 National Drinking Water Advisory Council. December 2010. Climate Ready Water Utilities. Available at **http://water.epa.gov/drink/ndwac/climatechange/upload/CRWU-NDWAC-Final-Report-12-09-10-2.pdf**.

7 See **http://www.cmap.illinois.gov/water-2050/**.

8 Northeastern Illinois Water Supply Planning Investigations: Opportunities and Challenges of Meeting Water Demand in Northeastern Illinois--Executive Summary. Meyer, Scott, H. Allen Wehrmann, H. Vernon Knapp, Yu-Feng Lin, Edward Glatfelter, James R. Angel, Jason Thomason, Daniel Injerd, 2012 Illinois State Water Survey, Champaign, IL. ISWS CR 2012-03. See **http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2012-03sum.pdf**.

Potential Adaptation Measures

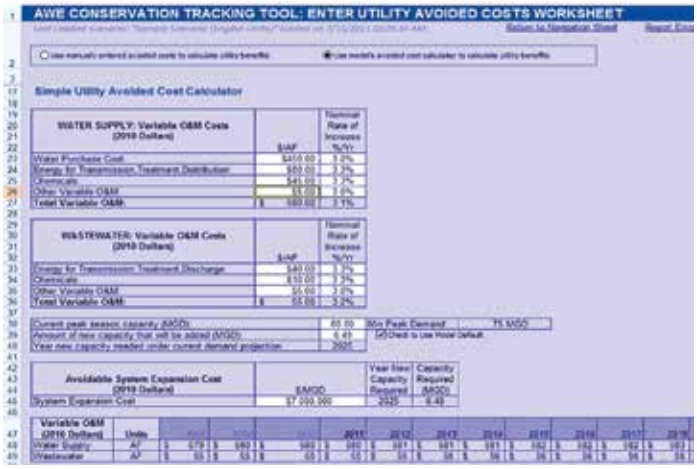
Prepare for increased frequency/severity of droughts and other emergencies.
Utilities may develop a drought preparedness plan that specifies the actions that should be taken in response to a drought,[9] such as irrigation or car washing restrictions. It could define droughts by severity and specify the priority of uses in advance so that decisions do not have to be made on an ad hoc basis during a drought. Ideally this would be done in coordination with neighboring water systems. They may also establish interconnections with neighboring water systems to open in emergencies, with agreements on how and when they may be used. Having these kinds of interconnections may be critical during emergency situations.

Take climate into consideration in utility forecasting and planning.
Utilities will need to consider significant variations in demand and the possibility of greater departures from normal in relevant weather variables. Utility forecasting in the region often uses service population as the only variable in projecting demand. Such planning practices will need to grow more sophisticated to make utilities more resilient to climate change.

Furthermore, municipalities may specifically consider climate change in the operating conditions assumed for treatment plants and other components. They may also consider engineering solutions such as flexible treatment technologies and water supply diversification. A number of tradeoffs will be encountered which engineers should be attuned to. Consultants should be specifically asked about their experience in these areas as part of a request for qualifications or proposals.

Implement conservation measures.
Numerous conservation measures are available to utilities, from reducing utility system leakage to assisting with conservation efforts in homes or businesses. The Alliance for Water Efficiency, based in Chicago, has developed a spreadsheet tool[10] to help water utilities design a cost-effective conservation program. CMAP has developed a model ordinance[11] that municipalities can use as a menu from which to draw conservation measures.

Utilities are often reluctant to pursue conservation if it deprives them of revenue needed for operations and debt service.[12] From an economic standpoint, the appropriate course of action is to raise water rates and use the increased revenue to fund cost-effective conservation. This returns the cost of the rate hikes to customers by lowering their water usage while protecting the revenue needed to pay for the water system.[13] Setting rates to support conservation is ultimately in the public interest, but it requires strong local leadership.



The Alliance for Water Efficiency, based in Chicago, has developed a spreadsheet tool to help water utilities design a cost-effective conservation program. Source: Alliance for Water Efficiency.

Consider targeted shifts to alternative water sources.
The most drought-resistant sources of water in the region, the deep aquifer system and Lake Michigan, are already over-used or nearly so. Water from the deep aquifer is being pumped faster than it is being replenished. While some capacity remains in Lake Michigan, it is mostly allocated and cannot accommodate a wholesale shift. On the other hand, the Fox and the Kankakee Rivers are underutilized and may represent an attractive option for additional supply for some communities. For some communities, seeking Lake Michigan[14] water is still the best option, but for communities in the Fox and Kankakee River valleys, the rivers should be seen as a viable alternative to groundwater. However, it should be noted that inland surface water generally has higher treatment costs which may increase as warmer temperatures and heavier rainfall alter raw water quality.

9 See for example National Drought Mitigation Center, the Oklahoma Climatological Survey, the Illinois State Water Survey, and the Lower Platte River Corridor Alliance. 2011. Drought-Ready Communities: A Guide to Community Drought Preparedness. See **http://www.drought.unl.edu/portals/0/docs/DRC_Guide.pdf**.

10 See **http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx**.

11 See **http://www.cmap.illinois.gov/water-2050/model-ordinance**.

12 Utilities also sometimes are concerned about conservation measures eliminating discretionary uses of water because this is thought to limit the ability to respond to drought. If the water system has been planned assuming significant conservation, there may be little ability for customers to cut back further during drought. While this phenomenon, known as "demand hardening," may be problematic in western states with more extensive conservation programs, it is probably not a significant issue in the Chicago area.

13 There is much more to pricing policy. CMAP has provided more detail on this topic in the Full-Cost Water Pricing Guidebook. See **http://www.cmap.illinois.gov/water-2050/full-cost-water-pricing**.

Wastewater

Background

As with drinking water utilities, it is likely that municipal wastewater operators will face more variability in weather conditions in the future. Designs for new wastewater treatment plants or modifications to old plants may need to take these changes into account. Plants are typically designed to function within a range of operating temperatures and flows into the plant. Climate change may make conditions to fall outside that range, causing difficulties meeting permitted discharge limits, odor problems, and other issues.[15] For instance, it is likely that there will be longer periods of low inflow with periodic high flows corresponding to storms. Pollutant concentrations ("wastewater strength") may be higher during these low-flow periods, potentially requiring design changes as well.

Furthermore, wastewater treatment plants are particularly vulnerable to flooding. With gravity sewer systems, treatment plants are typically located at low points in the landscape near the receiving waters for the discharge. Thus, municipalities should examine flood protection for treatment plants if they are indeed at risk. Siting for new treatment plants, with their long design lives, may need to account for the possibility of increased future flood risk.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in climate variability	**Increases challenge of system planning**
More frequent occurrence of heavy rainfall	**More frequent and severe flooding, disrupting wastewater treatment plant operations**

Wastewater treatment plants, like this plant in New Lenox, are major municipal assets. Photo courtesy of Bing Maps.

Potential Adaptation Measures

Request climate-resilient designs for new wastewater facilities.
Municipalities should consider that climatic conditions may change during the design life of a wastewater plant, e.g., an increase in average summer temperature of a few degrees or lower summer low flows. Furthermore, flood protection for new facilities should be examined with an eye toward an increased magnitude or frequency of flooding. Consultants should be specifically asked about their experience in these areas as part of a request for qualifications or proposals.

Consider additional flood protection for existing wastewater treatment plants.
A local vulnerability assessment should include an analysis of flood risk for treatment plants, pump stations, etc. On that basis municipalities should consider additional flood protection, such as higher berms around plants.

14 The use of Lake Michigan is governed by a complex set of laws, rules, and court decrees. The state issues permits to individual communities to use lake water subject to an overall limit of about 2.1 billion gallons per day for Illinois. This overall limit accounts not only for drinking water but for the use of lake water for other purposes, including the improvement of navigation and water quality in the Chicago River. Stormwater that runs off into the Chicago and Calumet Rivers rather than into Lake Michigan is also counted against the limit, so that larger amounts of runoff from higher precipitation would reduce the amount of drinking water legally available from Lake Michigan.

15 Water Environment Research Foundation. 2010. Implications of Climate Change for Adaptation by Wastewater and Stormwater Agencies. See **http://www.werf.org/a/k/Search/ResearchProfile.aspx?ReportID=CC2R08**.

Local Roads

Background

Municipalities own and manage almost 15,000 centerline miles of roadway in the region,[16] and climate change is expected to have a mixed impact on them. Hotter summers may lead to rutting on asphalt pavements and buckling on concrete pavements. Pothole formation may become more severe if freeze-thaw cycles become more frequent due to warmer weather in winter.[17] In general, a warmer climate reduces pavement life.[18] On the upside, climate change may lengthen the construction season and lessen the need for snow removal,[19] although it is not clear that annual snowfall totals are growing smaller in the Chicago area (see Appendix A).

Besides being affected by climate change, roads also affect the local climate. Pavement materials increase the felt effects of climate change by contributing to the urban heat island effect. In summer, the sun can heat unshaded dry pavement to temperatures in excess of 120°F.[20] During the evening the heat retained by pavement and other dark urban surfaces rewarms the air so that the ambient temperature in developed portions of the Chicago region may be 2°F hotter than surrounding rural areas (see Appendix A). These higher nighttime temperatures directly and indirectly exacerbate certain health problems and can make the effects of heat waves worse (see "Managing Temperature" section).

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increased average temperature	**Pavement buckling and rutting; lengthened construction season and lower snow-fighting costs**
Increased frequency of heavy rainstorms	**Increased damage to bridges due to stream scour; inadequate hydraulic opening in some culverts**

Pavement on Columbus Drive in downtown Chicago buckled during 103 °F heat in July 2012.
Photo courtesy of Nancy Harty/WBBM Newsradio/CBS.

Rapid temperature fluctuations may accelerate pothole formation.
Photo courtesy of Flickr user DDohler.

16 See **http://www.dot.state.il.us/adhighwaystats.html**.

17 Meyer, M. D., Amekudzi A. A., and O'Har, J. P. 2010. Transportation Asset Management Systems and Climate Change: An Adaptive Systems Management Approach. Transportation Research Record 2160: 12-20.

18 Illinois Department of Transportation, 2005, Pavement Technology Advisory - Performance Graded Binder Materials For Hot Mix Asphalt - PTA-D4. See **http://www.dot.il.gov/materials/research/pdf/ptad4.pdf**.

19 National Climate Assessment and Development Advisory Committee 2013. Draft National Climate Assessment. See Chapter 5 on transportation. See **http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap5-transportation.pdf**. Accessed February 19, 2013.

20 U.S. EPA, Reducing Urban Heat Islands: Compendium of Strategies, October, 2008. Chapter 5, Cool Pavements, p.1. See **http://www.epa.gov/hiri/resources/pdf/CoolPavesCompendium.pdf**.

Potential Adaptation Measures

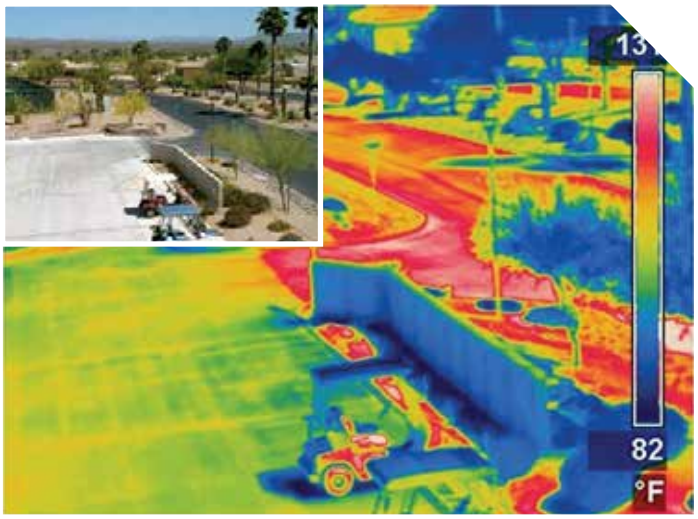
Utilize a formal pavement management system.
A pavement management system models pavement deterioration due to traffic and weather using a set of defined procedures for collecting and analyzing the data. A form of asset management, its purpose is to assist public works departments in finding the optimum way to maintain pavements in serviceable condition over a given period of time for the least cost. A pavement management system addresses timing of repairs, stressing preventive maintenance as well as appropriate rehabilitation treatments and economic analyses of alternatives.

Without a pavement management system, a municipality may focus maintenance budgets on repairing streets in the worst condition first.[21] Instead, these systems focus on targeting maintenance to roads in acceptable quality before they deteriorate beyond maintenance and into much more costly reconstruction. Investing in a formal pavement management system would help save municipalities money and have other benefits regardless of climate change.

Protect and re-establish overland flow paths.
Storm drains and ditches serving local roads in older areas generally are designed to handle the five-year storm. With future rainfall patterns, street flooding may become a more common occurrence given this standard, which is important to address as street flooding is inconvenient, can damage cars, and impede passage of emergency vehicles.

The most economical fix for this problem is to protect or re-establish overland flow paths to convey runoff from streets when storm sewers are overwhelmed. In a residential area, for instance, this "backup" capacity could run through swales along property lines in a subdivision. Flow paths may be identified as part of the stormwater master plan recommendation in the "Drainage and Flood Protection" section.

Implement site-scale green infrastructure during reconstruction.
When a road is being reconstructed, drainage improvements may be made at fairly low additional cost. Roadside rain gardens, swales, or tree boxes could be installed, as could permeable pavement in low traffic areas or where street parking is allowed. These techniques mimic natural drainage, allowing water to infiltrate into the ground or be taken up by plants. Small-scale green infrastructure improvements are often looked on favorably by residents.



Lighter-colored pavements have higher albedo values, meaning that they reflect more of the sun's rays and consequently stay cooler.
Source: **http://www.ecocem.ie/home.htm**.

Reduce contribution of local roads to the urban heat island effect.
A number of materials and techniques are available to reduce pavement temperature. These "cool pavements" generally have a more reflective road surface (i.e., a higher albedo). Examples include using lighter colored aggregate or concrete pigments, micro-surfacing with high-albedo material (a thin sealing layer used for road maintenance), and white-topping, which is the practice of adding a layer of concrete pavement over existing asphalt.[22] A local example of new material testing is the City of Chicago pilot project on Blue Island Avenue and Cermak Road in the Pilsen neighborhood that includes use of a microthin concrete overlay to extend pavement life and increase solar reflectance.[23] Another example is the Village of Lombard's use of ultra-thin white topping.[24]

In addition to changes in pavement materials, municipalities may consider a more vigorous program of planting and maintaining street trees (see "Open Space and Urban Forestry" section). Street trees shade pavement and increase evaporative cooling. They also have numerous benefits besides moderating temperatures, including enhanced aesthetics, property value increases to neighboring properties, and stormwater runoff reduction.[25]

21 CMAP, Arterials and Streets, Infrastructure and Operations, January 2009. See **http://tinyurl.com/a7nhwkg**.

22 U.S. EPA, Reducing Urban Heat Islands: Compendium of Strategies, October, 2008. See **http://www.epa.gov/hiri/resources/compendium.htm**.

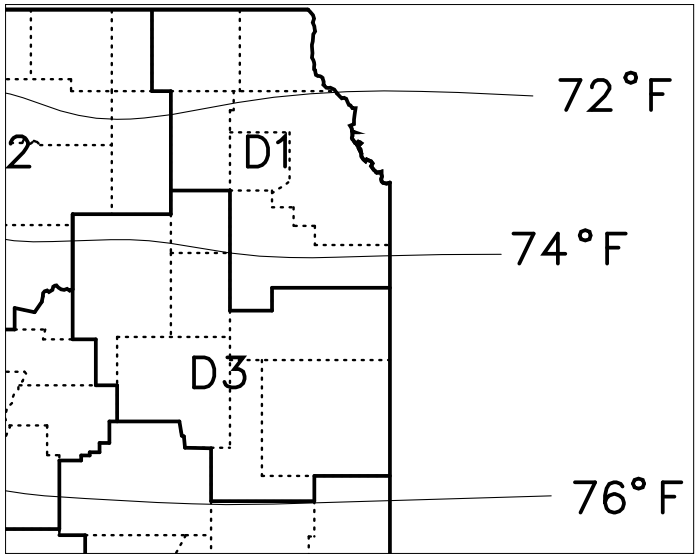
23 City of Chicago website accessed November 7, 2012. See **http://www.cityofchicago.org/city/en/depts/cdot/provdrs/conservation_outreachgreenprograms/news/2012/oct/cdot_opens_the_pilsensustainablestreet.html**.

24 See **http://www.pwmag.com/concrete/avoid-full-reconstruction-with-ultra-thin-whitetopping.aspx**.

25 The Morton Arboretum. 2010. The Role of Our Urban Forest in the Chicago Metropolitan Region's Future. See **http://www.cmap.illinois.gov/strategy-papers/urban-forestry**.

Consider pavement designs suited to an altered climate. On new roads and repaving or reconstruction projects, municipalities may consider pavement designs better suited to hotter conditions. For hot mix asphalt surfaces, which are typical for low-traffic local roads, the chief considerations for resisting rutting are asphalt binder grade and pavement thickness. One approach would be to increase slightly the thickness of the asphalt mixture beyond what is required for the current temperature.[26] A stiffer binder grade[27] could also be selected. However, the typical design life of a local road surface is only about 20 years, and changes in summer temperature during that time period are not likely to require significant changes in pavement design. Based on the Illinois Department of Transportation (IDOT) Bureau of Local Roads and Streets Manual standards, a design temperature change of 1-2°F would call for a pavement surface only about 0.25 inches thicker.

Other effects of climate change could be considered. One impact reported from extreme drought combined with high temperatures is clay shrinkage, leading in some cases to severe pavement buckling.[28] It is not clear that this would occur in northeastern Illinois, however, given that soils are predominantly silty clay and that local roads are designed to have at least a foot of aggregate or stabilized subgrade soil beneath them.



Design pavement mixture temperatures for hot mix asphalt (conventional flexible) from the IDOT Bureau of Local Roads and Streets Manual, Figure 44-3E.

Source: Illinois Department of Transportation.

Other Considerations

For road projects funded with state motor fuel tax allocations, road design and materials are largely determined by IDOT's Bureau of Local Roads and Streets Manual. While these are periodically updated, they do not reflect expected changes in climate. Future updates that consider future climate conditions may help municipalities enhance the resilience of their roadway infrastructure. Additionally, consideration could be given to facilitating and encouraging the use of promising new pavement materials and green infrastructure treatments. The Manual allows for special or experimental provisions (see Chapter 11); the need for using high-albedo materials or pavements designed for higher future temperatures could potentially be addressed through this mechanism. Finally, bridge and culvert design specifications for local roads may also need to be reviewed for their adequacy in the face of climate change, particularly in the scour they are expected to experience and the design flow that culverts are expected to pass.

26 The binder grade is a rating for the asphalt cement used in hot mix asphalt pavements specified according to the U.S. Department of Transportation "Superpave" system. The Superpave binder specifications are based on expected performance — maximum 7-day pavement temperature, minimum pavement temperature, loading duration based on truck speed, and traffic volume — in contrast to the older system of viscosity-graded ("AC") binders.

27 Design guidance for this is provided in the IDOT Bureau of Local Roads and Streets Manual, Chapter 44. See **http://www.dot.il.gov/blr/manuals/Chapter%2044.pdf**. See section 44-3.03 for conventional flexible pavements.

28 Reported in Texas and North Carolina during the 2012 drought. See Matthew L. Wald And John Schwartz, "Weather Extremes Leave Parts of U.S. Grid Buckling," New York Times, July 25, 2012, accessed February 19, 2013. See **http://www.nytimes.com/2012/07/26/us/rise-in-weather-extremes-threatens-infrastructure.html?_r=0**.

Electric Infrastructure

Background

Municipalities have a major interest in electrical service even though they are not, for the most part, directly responsible for providing it. Climate change impacts may make electric service less reliable for their residents and increase peak demand for electricity in the summer because of air conditioner use, straining the electric grid. These impacts could lead to potentially dangerous situations that municipalities would be partly responsible for managing.

For most customers, the main reliability concern is outages. Weather events account for over half of all power outages, often aggravated by fallen limbs from trees.[29] Since storm intensity is expected to increase, outages are likely to become more frequent as well. Municipalities may address this issue by minimizing utility line conflicts with street trees and by supporting efforts to place electric lines underground. The ability to operate critical facilities continuously may also be compromised, so municipalities should consider undertaking a review of backup power supplies.

More broadly, municipalities may hedge against unreliability by encouraging the generation of some power locally.[30] The vast majority of power used in the Chicago area is generated by central station power plants and delivered to customers through the electric grid. With distributed generation, by contrast, some power is generated onsite or closer to its use, reducing exposure to outages in the electric grid. A number of institutions and apartment complexes in New York were able to function normally for several days after Hurricane Sandy because they were able to generate power and heat locally.[31] Locally generated power could also include alternative energy sources like solar or small-scale wind power. Shifting some demand to these sources would also have benefits for climate change mitigation by reducing carbon dioxide emissions.

Downed power lines may become more common with more severe storms occurring more frequently.

Source: Photo courtesy of Chicago Metropolitan Agency for Planning.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in average summer temperature and frequency of heat waves	**Greater peak demand for electricity because of increased cooling needs**
Increase in frequency and intensity of storms	**Increased damage to trees and power poles, knocking down electrical lines, and disrupting electrical supply**

29 Hall, 2012. "Out of Sight, Out of Mind: An Updated Study on the Undergrounding Of Overhead Power Lines". Edison Electric Institute. See **http://eei.org/ourissues/electricitydistribution/Documents/UndergroundReport.pdf**.

30 U.S. EPA. 2008. Clean Energy Strategies for Local Governments. See **http://www.epa.gov/statelocalclimate/documents/pdf/on-site_generation.pdf#page=4**.

31 American Council for an Energy Efficient Economy, December 6, 2012, "How CHP Stepped Up When the Power Went Out During Hurricane Sandy." See **http://www.aceee.org/blog/2012/12/how-chp-stepped-when-power-went-out-d**.

Potential Adaptation Measures

Convert electric lines to run underground.
In new developments, utilities are mostly placed underground. However, existing overhead utilities in already-developed areas may also be converted to run underground. The benefits may include higher reliability during high winds and storms, protection from falling trees during storms and a reduced need for tree trimming programs, reduced exposure to wildlife, and improved aesthetics.[32] The main downside is the cost, which can be quite high and which would be borne by ratepayers in the municipality.[33]

One way to balance residents' expectations of costs and benefits could be to selectively place utilities underground only where there are major conflicts with street trees or where the reliability benefits would be maximized. Costs could also be reduced by placing utilities underground as part of road reconstruction projects. There are other tradeoffs as well. While outages occur less frequently, faults take longer to find and fix with distribution system components underground. The municipality would need to work directly with Commonwealth Edison (ComEd) to place utilities underground.

Minimize conflicts with trees on public and private property.
In communities with overhead electric wires, street trees and trees on private property can present conflicts with utility infrastructure. As the "Open Space and Urban Forestry" section discusses, an expansion of tree planting is an important way for municipalities to manage heat. While the surest solution over the long term is placing utilities underground, shorter term approaches can also suffice. First, the tree pruning programs operated by ComEd are of value, and municipalities should work cooperatively with the utility and supplement its efforts where trained crews are available. Selectively removing and replacing lower quality trees with trees whose growth forms accommodate overhead wires is effective. Municipal urban forestry programs may proactively do this.

Review of backup power supplies for critical facilities.
Local governments operate numerous critical facilities, particularly water and wastewater utilities and facilities associated with emergency management services. These generally have generators for backup power, but storms of greater intensity may lead to longer outage durations. Current generators may be designed as backup for transient interruptions, not to operate for several days during an outage. They may not supply full power, so that water or wastewater treatment plants do not provide complete treatment. Undertaking a review of emergency backup power supplies, and budgeting for improvements as necessary, would provide assurance to residents that critical facilities can operate continuously following more intense storms.

Permit and encourage distributed energy generation.
Municipal zoning and building code regulations may make small-scale electric generation more difficult. These regulations can be updated to permit and incentivize technologies like photovoltaic panels and small wind turbines while minimizing aesthetic or noise impacts.[34] Going further than merely permitting alternative energy, new homes can be required to be "solar-ready" regardless of whether owners intend to install solar panels. Building codes would be revised to make sure that new homes would not require rewiring or other building modification to use solar power.

Support energy efficiency efforts.
The most cost-effective means of reducing stress on the electric during heat waves is to reduce overall energy consumption. Some actions have relatively low costs because of utility incentives. Air sealing and insulating a building to reduce energy leakage is the most immediate opportunity to reduce the amount of energy needed to cool the space. Additionally, installing energy efficient air conditioning units will also decrease stress on the electrical infrastructure. Utility incentives are available to help offset the costs of purchase and installation of a number of energy efficiency products.

32 Hall, 2012. "Out of Sight, Out of Mind: An Updated Study on the Undergrounding Of Overhead Power Lines". Edison Electric Institute. See **http://eei.org/ourissues/electricitydistribution/Documents/UndergroundReport.pdf**.

33 By Illinois Commerce Commission rules, ratepayers in a municipality choosing to place its utilities underground would need to cover the cost of the conversion through a rider on their electric bills.

34 See PAS Essential Info Packet 32: Planning and Zoning for Wind Energy, **http://www.planning.org/pas/infopackets/subscribers/eip32.htm**. Also see PAS Essential Info Packet 30: Planning and Zoning for Solar Energy, **https://www.planning.org/research/solar/faq.htm**.

Standards for Building and Site Planning

Background

Since most buildings will be in service for decades — 60-80 years, on average — it is worth considering whether buildings constructed to today's standards will be suited to a different climate. One concern is the possible need to make structures sturdier. Stronger or more frequent storms could cause more significant building damage, such as broken windows or water intrusion through the roof. Indeed, wind/hail losses and water damage are already the two most frequently reported claims for homeowner insurance.[35] Besides storm impacts, building durability problems associated with warmer, more humid climates may become more prevalent in northeastern Illinois. For example, subterranean termites may begin to do more damage to wood-framed buildings. Increased moisture infiltration may lead to problems with mold and mildew.

The heavy electric load caused by air conditioners during hot periods can strain the electric grid, threatening blackouts. Building efficiency improvements reduce this strain. They have crossover value for climate mitigation, as well. After all, heating, cooling, and powering buildings accounts for almost two thirds of the greenhouse gases emitted from the Chicago region.[36] More efficient buildings would tend to reduce these emissions, as would renewed attention to techniques for meeting cooling demand "passively," e.g., through proper orientation of buildings on their lots. Additionally, implementing building codes that ensure new buildings or renovation to existing building stock includes energy efficiency measures such as increasing the amount of insulation and air sealing required.

Finally, buildings affect the climate as the climate affects buildings. In particular, sun shining directly onto a dark-colored roof warms the roof and then reheats the surrounding air, contributing to the urban heat island effect just as dark pavement does (see "Local Roads" section).

Alternative energy generation and energy efficiency can have benefits in both climate change mitigation and adaptation.
Source: Photo courtesy of iStockphoto.com.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in intensity and frequency of storms	**Increased damage to roofs, windows, and other building components**
Increase in average summer temperature	**Increased cooling demand and use of energy for cooling**
Increased in humidity in spring and fall	**Increased moisture intrusion and negative effects on building durability**

35 Insurance Information Institute, Homeowners losses ranked by claims frequency, 2006-2010. See **http://www.iii.org/facts_statistics/homeowners-and-renters-insurance.html**.

36 Chicago Metropolitan Agency for Planning, "Regional Inventory Shows Patterns of Greenhouse Gas Emissions," May 22, 2012, see **http://www.cmap.illinois.gov/policy-updates/-/blogs/regional-inventory-shows-patterns-of-greenhouse-gas-emissions**.

37 Examples of wind-resistance building requirements in hurricane-prone areas can be found at **http://www.hurricanescience.org/society/risk/currentandemergingtech/**.

38 Taken partly from Chapter 5 of Building America Best Practices Series Volume 16: 40% Whole-House Savings in the Mixed-Humid Climate at **http://www1.eere.energy.gov/buildings/residential/ba_guides_studies_mixed_humid.html**.

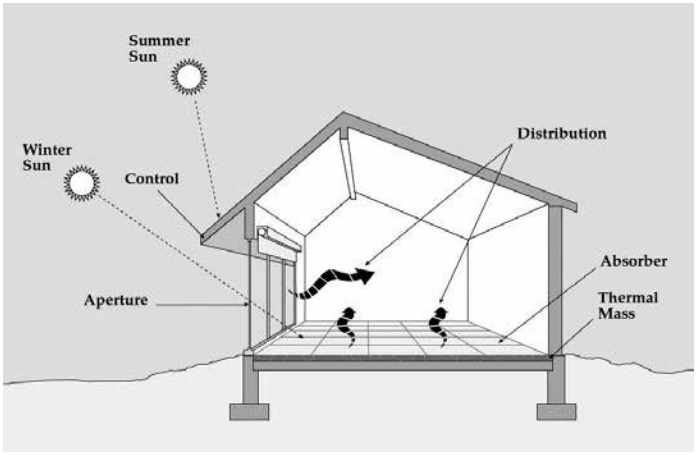
Potential Adaptation Measures

Encourage participation in voluntary "above-code" programs for wind/hail resistance.
Building codes for areas with high wind hazards often specify impact-resistant glass or window protection, material and fastening requirements for roofs, cabling or straps to attach the roof through the walls to the foundation, and so forth.[37] It is not clear the extent to which measures like this will be needed and cost-effective in the Chicago area. However, the Insurance Institute for Business and Home Safety offers its FORTIFIED Home program, a third-party certification system that encourages homeowners to make a variety of improvements to reduce exposure to various natural hazards. Some insurance carriers may offer premium discounts for certification in the program. Municipalities may help market these programs to residents. Certification would be beneficial for residents regardless of climate change.

Require measures to improve building material durability.
Review building codes to ensure adequate resistance to moisture, pests, and decay, which are threats now but may become more severe in the upcoming years. Possibilities include:[38]

- **Resistance to moisture intrusion.** Instead of oriented strand board (OSB) for exterior sheathing, require rigid foam. Require sill wrap, corner shields, and adhesive flashing tape to protect against water intrusion when installing windows. Specify door jambs that are designed for water and rot resistance.
- **Pest and decay resistance.** In framed homes, use borate pressure-treated lumber for termite and fungal resistance. Soil pretreatment can also be specified for termite resistance. Consider using paints that contain mildewcides.

Require the use of "cool roofs."
To address the contribution of roofs to the urban heat island effect, building codes can require the use of cool roof materials and lighter colors, specifying performance standards for solar reflectance.[39] The barriers to this change are relatively minor and the strategy has been shown to be effective.[40] Outreach to homeowners should help overcome the notion that cool roofs must be white — roofing materials can come in a variety of lighter shades — or are too costly. For those municipalities that encourage vegetated or "green" roofs, some of the same benefits of cool roofs will be achieved as well.



Passive solar design can minimize the need for additional heating and cooling. In this diagram, the "control" is a longer eave to block summer sun and the aperture is a south-facing window that takes in sunshine in the winter.
Source: U.S. Department of Energy.

Encourage or require passive solar design.
A growing movement in building construction is to utilize passive solar design. This approach maximizes benefits from a building's site, local climate, and construction materials to minimize energy use year-round. Municipalities can encourage this type of construction through land use regulations[41] and building codes, and the resulting buildings can look little different from a conventional home in a typical neighborhood. A few elements of passive solar design are as follows:

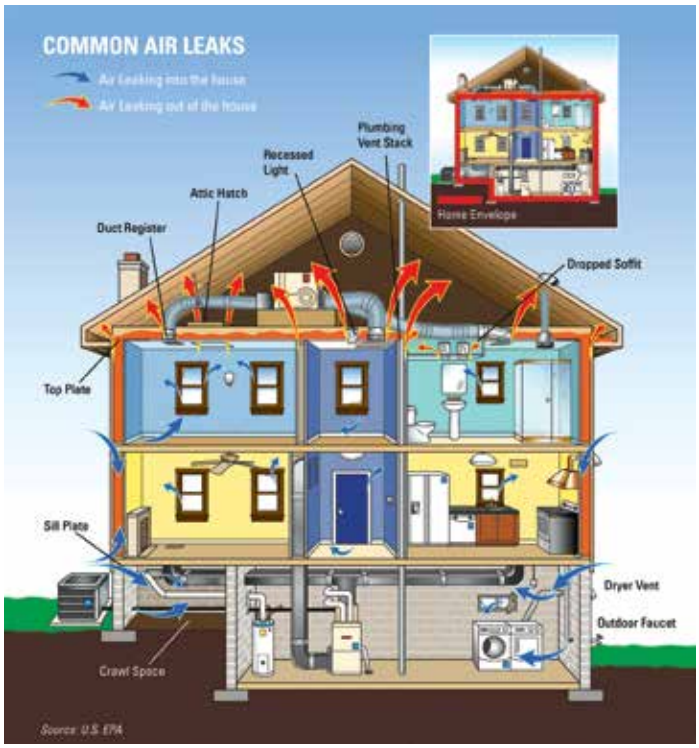
- **Building orientation.** To take maximum advantage of solar energy in the winter, a residence needs to be oriented with its longest wall facing southward. Subdivision regulations can specify a minimum percentage of lots that will allow the longest wall to face south, leaving it to site designers to determine how best to meet the goal (lot shape, street orientation, building placement, etc.).
- **Windows and overhangs.** South-facing windows allow low winter sun to shine in and warm the house. In the summer, when the sun is much higher in the sky, long roof overhangs, awnings, or porches block the sun. Municipalities can specify window placement and overhang lengths in building codes.
- **Trees.** Planting shade trees along the west side of the house can reduce energy use further.[42] Tree locations, types, and distances to structures can be specified in landscape codes.

39 For instance, the City of Chicago requires that new residential and commercial low-slope roofs have a minimum initial solar reflectance value of 0.72 or a three-year aged value of 0.50. See also Cool Roof Codes and Programs at **http://www.coolroofs.org/documents/Cool_Roof_Ratings_Codes_and_Programs021710.pdf**.

40 U.S. Environmental Protection Agency. n.d. Reducing Urban Heat Islands: Compendium of Strategies – Cool Roofs. See **http://www.epa.gov/heatisland/resources/pdf/CoolRoofsCompendium.pdf**.

41 Resources like Passive House Institute provide extensive information about passive solar. The American Planning Association PAS Essential Info Packet 30: Planning and Zoning for Solar Energy **https://www.planning.org/research/solar/faq.htm) provides numerous code examples, including many from the Midwest**.

42 E. Kusnierz and G. Dwyer. 2010. The Role of Our Urban Forest in the Chicago Metropolitan Region's Future. See **http://tinyurl.com/c7z5ugl**.



The Energy Star program rates the efficiency of the entire home and is an example of an "above-code" program. This image from Energy Star shows how the whole building envelope affects energy efficiency.

Source: U.S. Environmental Protection Agency.

Encourage participation in "above-code" programs for energy efficiency for new construction. For additional efficiency gains beyond the 2009 International Energy Conservation Code (IECC),[43] municipalities may consider taking a voluntary or market-based approach and encouraging participation in the Energy Star program. Similar to the program associated with appliances with the same name, the Energy Star program for homes rates the efficiency of the entire home, enabling homebuyers to compare utility costs between homes. Municipalities can encourage builders to have their programs qualified by Energy Star and help market the benefits of energy efficiency to residents and potential residents.[44]

Other Considerations

Because of the extensive technical requirements of building codes, most municipalities adopt model codes, which have now been systematized by the International Code Council as the "I-codes." Requirements in these codes will change as the climate does. Much research remains to be done by universities, the federal government, and industry about what new requirements are appropriate. At least some building changes may ultimately be encouraged by the insurance industry through insurance premium discounts.

43 The Illinois Energy Efficient Building Act requires the use of the 2009 IECC by most municipalities — except the City of Chicago and municipalities that previously enforced the 2006 IECC code — and prevents them from requiring more stringent standards for residential construction. They are free to require more stringent standards for commercial buildings.

44 Ways to encourage participation can be found at **http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Non_code_options.pdf?0dd4-f9d0**.

Managing Heat

Background

One of the most significant public health concerns from climate change is heat waves. They are expected to occur more frequently and last longer. Many studies document the relationship between extreme heat waves and increased sickness and death,[45] finding that they cause heat stroke, dehydration, and exacerbate other health conditions. For example, more than 700 deaths were attributed to the July 1995 heat wave in Chicago.[46] The Centers for Disease Control and Prevention (CDC) estimates that from 1979-2003, more people died in the U.S. from extreme heat than from hurricanes, lightning, tornados, floods, and earthquakes combined.[47] This threat will grow as temperatures rise.

Heat-related deaths and illnesses are considered preventable, according to the CDC,[48] and municipalities can aid in prevention. The major recommendation for municipalities is to increase preparedness for heat waves, including notifying residents about upcoming extreme heat, educating them about ways to mitigate the effects, and directing them to cooling shelters. After the 1995 heat wave, the City of Chicago formed a Commission on Extreme Weather Conditions and developed a comprehensive Extreme Weather Operations Plan. A study of the City's response to a heat wave that occurred four years later reported that planning may have helped reduce mortality during that event.[49]

The health effects of extreme or extended periods of heat are unevenly distributed throughout the population. The greatest impacts fall on those with lower incomes, the very old, the very young, the disabled, the uninsured, and the isolated,[50] and consequently measures to identify and reach out to these groups will be required. Those in more densely developed areas are impacted to a greater degree because of the urban heat island effect.[51] The urban heat island effect results in higher nighttime temperatures, which limits the ability of people to recover before the heat of the next day. The lack of nighttime relief during heat waves is strongly correlated with increased mortality.[52] Thus, it is important to take steps to reduce urban heat island effects.

An elderly woman is assisted by emergency personnel during the 1995 heat wave in Chicago.
Source: Chicago Tribune archive photo, Aug. 13, 1995.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in frequency, duration, and severity of extreme heat periods	**Increased mortality from heat-related causes**

45 See **http://www.as.miami.edu/geography/research/climatology/JGR_manuscript.pdf**.

46 Palecki, M.A., S.A. Changnon, and K.E. Kunkel. 2001. The nature and impacts of the July 1999 heat wave in the midwestern United States: Learning from the lessons of 1995. Bulletin of the American Meteorological Society 82(7):1353-1368.

47 See **http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp**.

48 *Morbidity and Mortality Weekly Report*, June 7, 2013. See **http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6222a1.htm?s_cid=mm6222a1_w**.

49 Naughton MP, Henderson A, Mirabelli MC, et al. Heat-related mortality during a 1999 heat wave in Chicago. Am J Prev Med. 2002;22:221–227. See **http://www.nchh.org/Portals/0/Contents/Article0777.pdf**.

50 See **http://library.globalchange.gov/products/assessments/2004-2009-synthesis-and-assessment-products/sap-4-6-analyses-of-the-effects-of-global-change-on-human-health-and-welfare-and-human-systems**.

51 See **http://www.epa.gov/climatechange/impacts-adaptation/health.html**.

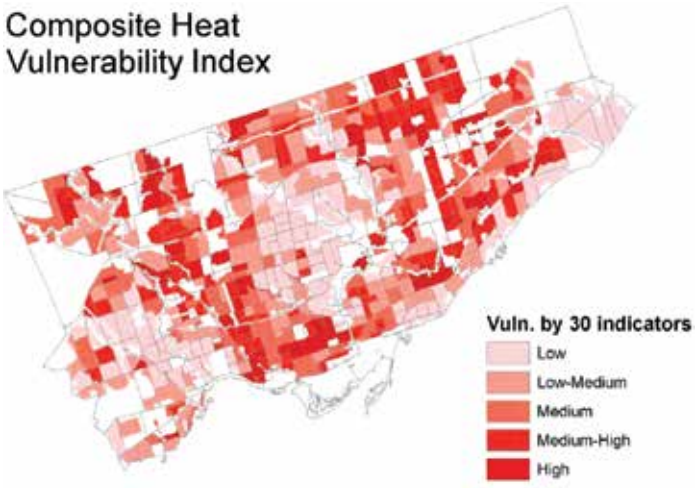
52 See **http://www.climatechange.ca.gov/climate_action_team/reports/2012-08-31_Extreme_Heat_Adaptation_Interim_Guidance_Document.pdf**.

Potential adaptation measures

Develop an extreme heat plan and assign a staff lead. The contents of an extreme heat plan typically would include shelter and aid agreements with park and school districts, townships, and others. A plan would specify a chain of communications and outline clear responsibilities to each department involved. If the County has already developed a plan, the municipality should consider joining that effort. Collaboration with senior services, groups representing disabled citizens, and other social services can help insure that vulnerable groups receive targeted support. Additional partners in a plan or parties to an aid agreement may include representatives from hospitals, faith communities, educational institutions, and others.

Identify concentrations of vulnerable populations. Municipalities can document locations of vulnerable population groups to help target services during extreme heat conditions. Using partners' local knowledge is one way to help identify concentrations of at-risk citizens including the elderly, lower-income households, and others. Mapping vulnerable populations can also provide a useful tool to help identify potential response strategies.

Notify and educate residents about extreme heat events. Municipalities and partners should work with the National Weather Service (or other forecasting group) to receive early warning of potential heat waves. Plans should be made in advance to work with the media and other avenues of communication (churches, schools, etc.) to send a clear message about heat-related conditions that can be life threatening, including time during which conditions will be dangerous, how long conditions will last, and how it will feel at different times during the day and night (heat index). Content and method of notifications should be targeted to specific groups and account for age, cultural and ethnic differences, and other factors. Messages should provide information about extreme heat effects, locations where residents can stay cool, and sources for more information.[53] Municipalities can provide references for information on actions individuals can take to help themselves and others during extreme heat.[54]



The City of Toronto was able to map vulnerability to extreme heat using a number of different variables like income, the number of rental units in older high-rise buildings, etc.
Source: City of Toronto.

Coordinate with public agencies and institutions to identify locations to serve as cooling centers. Power outages and lack of access to, or the cost of, air conditioning may impede a resident's ability to withstand extreme heat. Municipalities should coordinate and develop agreements with park and library districts, townships, social service agencies, adjacent communities, and others that may have facilities that can serve as cooling centers. These locations, as well as those listed by the state[55] and other agencies, may be communicated to the public (such as contact lists and links on the municipal website and other media) prior to and during heat waves.

53 For example, the Environmental Protection Agency offers a "What You Can Do" web page that provides tips for use at home, at the office, on the road, and at school. See **http://www.epa.gov/climatechange/wycd**.

54 One example is the CDC's Emergency Preparedness and Response page at **http://emergency.cdc.gov/disasters/extremeheat/index.asp**.

55 "Keep Cool Illinois" is a state of Illinois website that lists state run cooling centers. See **http://www2.illinois.gov/keepcool/Pages/default.aspx**.

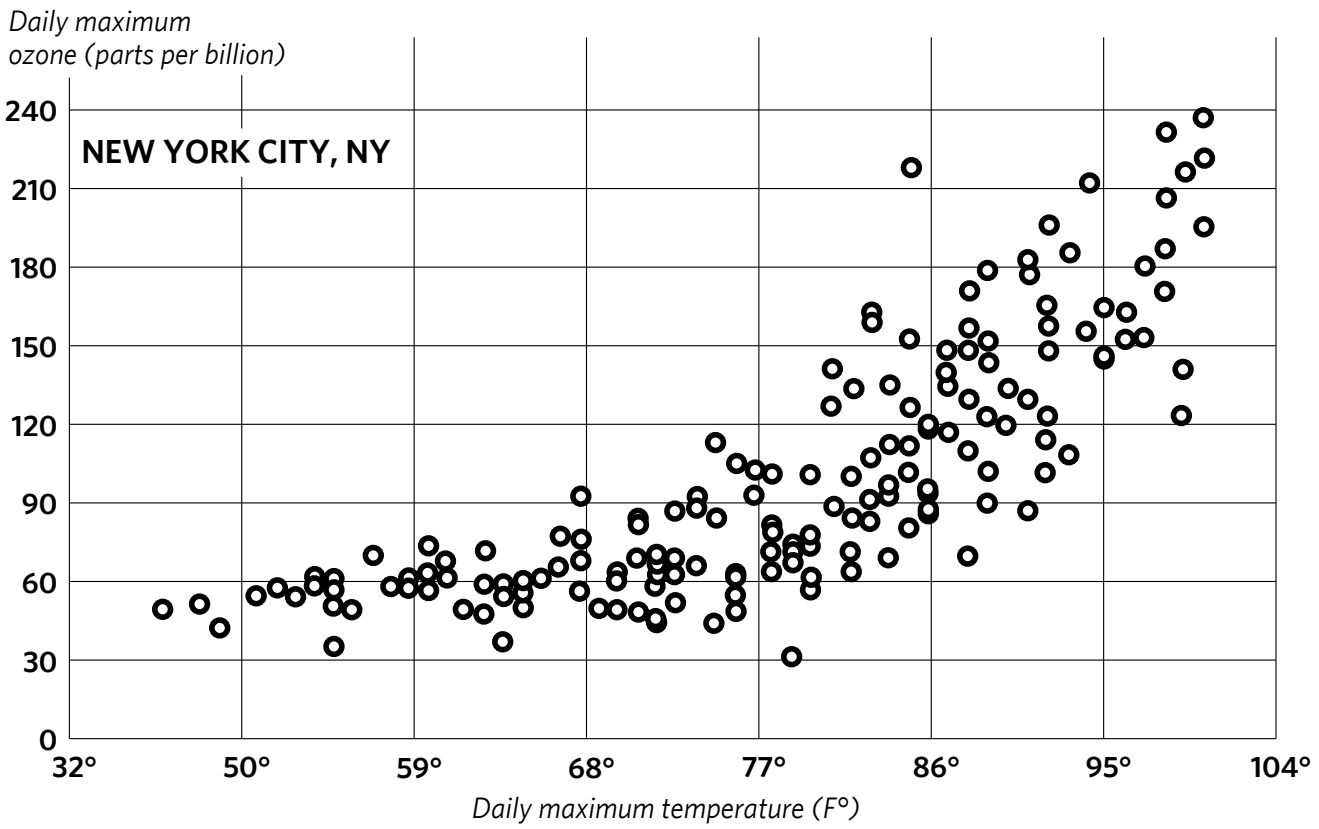
Air Quality

Background

Climate change is also expected to worsen air quality, mainly by raising concentrations of ground-level ozone.[56] This compound is formed when other air pollutants — chiefly oxides of nitrogen and volatile organic compounds — react in the presence of sunlight. The climate change connection is that higher temperatures increase the rate of ozone formation.[57] Ground level ozone exacerbates a range of respiratory conditions, including bronchitis, emphysema, and asthma, and leads to premature deaths.[58] As with heat waves, ozone tends to affect sensitive populations most, such as seniors, infants, and those with lower incomes. The Union of Concerned Scientists estimates that more than 70,000 additional occurrences of acute respiratory symptoms would occur in Illinois in 2020 as a result of increasing temperature.[59]

The main way of reducing ground level ozone is to prevent the emission of ozone precursors. Federal and state requirements for industry authorized through the Clean Air Act partly accomplish this, but at the local level many improvements can be made on a voluntary basis. Most of these improvements also have the benefit of reducing carbon emissions at the same time.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in summer temperatures	**Increased incidence of respiratory symptoms due to ground-level ozone**



Ozone formation increases with temperature, as this example from New York City shows.

Source: Union of Concerned Scientists.

56 Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). 2009. Global Climate Change Impacts in the United States. See **http://globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009**.

57 By two mechanisms: higher temperature increases the rate of reaction and increases the concentration of precursor volatile organic compounds. See Union of Concerned Scientists. July 2011. Climate Change and Your Health: Rising Temperatures, Worsening Ozone Pollution. Technical Appendix. See **http://www.ucsusa.org/global_warming/science_and_impacts/impacts/climate-change-and-ozone-pollution.html**.

58 See **http://www.epa.gov/glo/**.

59 Union of Concerned Scientists. July 2011. Climate Change and Your Health: Rising Temperatures, Worsening Ozone Pollution. See **http://www.ucsusa.org/assets/documents/global_warming/climate-change-and-ozone-pollution.pdf**.

Potential adaptation measures

Promote the use of alternative modes of transportation. An action municipalities can take that has multiple benefits, including combatting ozone pollution, is to encourage walking, biking, and transit. Buses and trains have much lower emissions of ozone precursors than cars for each mile a passenger travels, while walking and biking generate none. One critical way to encourage the use of alternative modes is to use the planning tools available to municipalities to design neighborhoods that are oriented toward transit usage and that provide a range of housing and commercial services within walking or biking distance. Another approach is to provide bicycling facilities, such as on-street bike lanes and bike parking. Municipalities can also emphasize travel demand management (TDM) by providing a TDM coordinator for businesses and other institutions to help them put in place flex schedule, telecommute, ridesharing, and other programs.

Participate in voluntary clean air associations. In the Chicago area, Partners for Clean Air,[60] Clean Air Counts,[61] and Chicago Area Clean Cities[62] provide their member organizations with tools to help them reduce air emissions. Among other things, Partners for Clean Air helps organizations take specific actions on Air Pollution Action Days — days when ozone is expected to be high — to reduce additional emissions and limit exposure. Municipalities can assist in letting their residents know when these days are expected to occur and what they can do in response. These programs can provide tools to help implement voluntary clean air programs, like trade-in programs for older gas cans (which often are not designed to prevent the escape of gas vapor) or older lawnmowers and leaf-blowers (which generally do not have clean-burning engines).

Adopt an anti-idling ordinance. Idling engines are responsible for significant air emissions locally. Limiting the idling of vehicles would result in lower fuel consumption, improved air quality, and extend the life of the engine. A number of municipalities in the Chicago area have enacted anti-idling policies that apply to vehicles operated by the municipality and its contractors. Others have adopted anti-idling ordinances that limit idling by private vehicles at certain times and locations, e.g., while waiting for school pickups or for trucks during loading and unloading. A policy or ordinance would place an upper limit on idling time, generally three to five minutes over an hour. Provision is generally made for weather and emergency vehicles.

Actions that swap cleaner burning fuels for dirtier fuels or reduce driving altogether help reduce the formation of ground-level ozone.
Photo courtesy of Flickr user Ruben de Rijcke.

Shift to clean fuel fleets for municipal vehicles. Depending on their size and the services they provide, municipalities may have a number of fleet vehicles. These fleet vehicles may be converted to use alternative fuels or simply replaced with alternative fuel vehicles if their useful life is near its end. Rebates may be available from the State of Illinois for certain kinds of conversions,[63] and implementation guidance is available from the U.S. Environmental Protection Agency (U.S. EPA),[64] among other sources.

Other Considerations

The Chicago region has not met federal ozone standards for many years.[65] Other things being equal, climate change will make it more difficult to meet them. Furthermore, standards are likely to become tighter over time, as many federal air quality standards have become more stringent over the years. Since states are required to meet air quality standards, or at least make defined increments of progress toward meeting them, pursuing local and voluntary programs like those mentioned above helps prevent the need for more drastic requirements.

60 See **http://www.cleantheair.org/for-employers/joining-pfca**.

61 See **http://www.cleanaircounts.org/**.

62 See **http://www.chicagocleancities.org/**.

63 See **http://www.illinoisgreenfleets.org/index.html**.

64 See **http://www.epa.gov/oms/stateresources/rellinks/cleanfleets.htm**.

65 CMAP. 2008. Snapshot Report on Air Quality. See **http://www.cmap.illinois.gov/cmap-regional-snapshots#Air**.

Infectious Diseases

Background

There is evidence that certain infectious diseases could become more common in northeastern Illinois because they thrive in a warmer, more humid climate. The vector-borne diseases dengue fever and West Nile Virus (mosquitoes) and Lyme disease (ticks) are among those that may become more prevalent.[66] Indeed, Illinois has already seen a significant outbreak of West Nile Virus (2002).[67] Smaller municipalities in the region generally have a limited direct role in responding to infectious diseases, which are mostly addressed by the state and by county health departments. However, prevention is an area where municipalities can be very effective, helping to control disease vectors.

Still, municipalities can help support the response efforts of other levels of government, for instance by helping provide information to their residents. As with heat mortality and worsened air quality, infectious disease is an area in which health disparities can be expected. It will be important to target information to particularly vulnerable residents, such as the elderly and those with lower incomes.

Finally, increases in heavy rainfall, as predicted in Appendix A, could also increase the risk of water-borne illnesses.[68] In 1993, for instance, Milwaukee experienced a severe Cryptosporidium outbreak because heavy rainfall washed additional pollutants into its raw water supply while the rain also made the water treatment process less effective, leading to 54 deaths. This underlines the importance of including preparedness for emergency situations as part of water utility planning (see "Water Supply" section).

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increase in average temperature and seasonal humidity	**Increased prevalence of certain vector-borne diseases**
More frequent occurrence of heavy rainfall	**Increased risk of water supply contamination**

Certain infectious diseases are likely to become more prevalent with climate change. Source: Public domain.

Potential adaptation measures

Control disease vectors.
Municipalities can help stem infectious disease by maintaining strong vector control programs. Many municipalities are part of mosquito control districts that handle spraying and monitoring, but some are not. Contract services are available for monitoring and mosquito control. Municipalities with responsibilities for maintaining stormwater facilities (ditches, ponds, storm drain inlets, etc.) may need to pay close attention to whether these facilities provide mosquito breeding grounds. Good design and maintenance can minimize mosquito breeding in stormwater facilities, but ongoing spraying of larvacide may be needed.[69] Communities will have to determine for themselves whether the risks of chemical exposure are worth the benefits in disease prevention.

Increase outreach and community education about disease prevention measures.
Municipal channels of communication can be leveraged to educate residents about disease risks, precautions, and symptoms. For instance, as part of a mosquito control program, a municipality would provide information to residents about the need to eliminate areas of standing water in private yards. County and state health departments provide a wealth of information about infectious diseases, including signs, symptoms, and treatment options, and municipalities can help channel this information to residents.

66 J. Brownstein, T. Holford, and D. Fish. 2008. Effect of climate change on Lyme Disease risk in North America. EcoHealth 2(1): 38-46. See **http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2582486/**. P. Epstein. 2001. West Nile Virus and the Climate. Journal of Urban Health 78(2): 367-371. See **http://chge.med.harvard.edu/sites/default/files/.westnileandclimatechange.pdf**. R. Erickson, K. Hayhoe, S. Presley, L. Allen, K. Long, and S. Cox. 2012. Potential impacts of climate change on the ecology of dengue and its mosquito vector the Asian tiger mosquito (Aedes albopictus). Environmental Research Letters 7:1 – 6. See **http://iopscience.iop.org/1748-9326/7/3/034003/pdf/erl12_3_034003.pdf**.

67 See **http://www.idph.state.il.us/envhealth/wnvmuni_recs.htm**.

68 J B Rose, P R Epstein, E K Lipp, B H Sherman, S M Bernard, J A Patz. 2001. Climate variability and change in the United States: potential impacts on water- and foodborne diseases caused by microbiologic agents. Environ Health Perspect. 109(Suppl 2): 211–221. See **http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240668**.

69 Minnesota Stormwater Manual, version 2. see Chapter 6, section 3.4. See **http://www.pca.state.mn.us/index.php/view-document.html?gid=8937**.

Open Space and Urban Forestry

Background

Municipalities often are responsible for managing natural areas that have been set aside for stormwater management, passive open space, or for other purposes. These natural areas provide many additional benefits, including reducing the urban heat island effect, detoxifying and decomposing wastes, pollinating local agriculture, moderating weather extremes and their impacts, and reducing noise. Yet climate change jeopardizes the health of municipal natural areas. Like other municipal assets, the vulnerability of natural areas may also be assessed with the aim of developing asset management strategies to ensure the health of these areas. Taking modest, inexpensive steps now can help ensure resilience over the long term.

While climate affects the landscape, the landscape also affects climate. In particular, trees have a significant influence on temperature felt in urban areas, which is generally higher than surrounding undeveloped areas because of the urban heat island effect. Shading and the uptake/release of moisture from trees both moderate summer temperatures.[70] Urban trees also help lessen some of the impacts of climate change. Most importantly, they help reduce the runoff from storm events and remove air emissions that lead to ground-level ozone, which triggers asthma and has other negative health effects (see "Public Health" section).[71] Finally, trees help mitigate climate change by helping remove carbon dioxide from the atmosphere.

Urban trees help keep temperatures cooler and provide many other benefits to residents and business owners.
Photo courtesy of Chicago Metropolitan Agency for Planning.

ANTICIPATED CLIMATIC CHANGE	EXPECTED IMPACTS
Increased frequency and severity of flooding and drought	**Increased stress on street trees and municipal natural areas**
Higher summer temperature	**Increased heat stress on street trees**
Higher winter temperatures	**Increased risk of introducing new invasive species that will colonize natural areas or act as street tree pests**

70 See **http://www.epa.gov/heatisld/mitigation/trees.htm**.

71 A study of Chicago's urban forest found that trees reduce ground-level ozone over 300 tons per year; during the growing season in areas with large amounts of canopy, the study found peak pollutant removal rates of 13% over an hour. See Nowak, D. J.; Hoehn III, R. E.; Crane, D. E.; Stevens, J. C.; Fisher, C. L. 2010. Assessing Urban Forest Effects and Values: Chicago's Urban Forest. Resource Bulletin NRS-37. U.S. Department of Agriculture, Forest Service, Northern Research Station. See **http://nrs.fs.fed.us/pubs/34760**.

Potential adaptation measures

Undertake a review of natural area management for climate change.
As part of a vulnerability assessment, municipalities will want to catalog the natural areas they own and consider revamping the management of those areas. Regional partners at The Field Museum and the University of Notre Dame have developed a resource for public works, urban forestry, and landscaping staff to help them make sure natural areas are resilient to a range of climate conditions while also making the best use of limited resources.[72] Municipalities should consider using this resource to guide their efforts.

Take actions to grow and protect the urban forest.
Besides their role in helping adapt to climate change, trees bring a number of other benefits, such as higher property values and noise reduction.[73] Residents generally like and appreciate trees. Urban forestry is an approach that has benefits regardless of the need to adapt to climate change.

- **Plant more trees in public rights-of-way and provide for their long-term maintenance.** Municipalities can consider establishing a plan and budget for annual tree planting and maintenance. Studies have generally found tree planting in urban areas to have benefits that outweigh their maintenance costs. Adherence to best practices in selecting a diverse mix of species is critical so that tree populations are not wiped out by pest infestations, which are likely to become more common in the future. The Morton Arboretum publishes information on tree planting guidelines.
- **Update tree-planting requirements in ordinances.** Many municipalities have tree planting requirements as part of their subdivision, zoning, or landscaping codes (e.g., requiring a certain number of trees to be planted per foot of residential street or per parking space in a parking lot). These requirements may also need revision to reflect the most up-to-date guidance on species diversity, soil mixes and volume, planter box dimensions, and other factors. The City of Chicago has produced Tree Diversity Guidelines[74] and a tree planting list that can be used as an example.[75] Tolerance to a wider range of climatic conditions may be considered as well.

Establish open space corridors that are part of a connected regional network.
As temperatures become warmer and precipitation patterns change, plants and animals adapted to life in northeastern Illinois are expected to shift their ranges out of the region.[76] A connected set of corridors maintained in natural land cover, also known as regional-scale green infrastructure, is thought to allow plants and animals to expand their ranges in response to a changing climate.[77] This is also in line with the objective of many communities to provide greenways and recreational trails. In 2012, CMAP and the regional conservation organization Chicago Wilderness collaborated to identify a critical network of open spaces to protect in the Chicago area.[78] Municipalities could consider the following ways of helping protect this network of open spaces:

- **Update comprehensive planning and site design to protect the regional green infrastructure network.** Municipalities shape future growth through their comprehensive plans. Among many other things, these plans typically identify important natural resources and open space needs. Municipalities could include the green infrastructure areas in these plans and specify that growth should avoid them. Better yet, a site design for a development could incorporate parts of the identified green infrastructure network as open space for residents, giving it legal protection through a conservation easement.
- **Revise land/cash donation ordinances.** Ordinances requiring developers to contribute either land or funding for community open space use could be modified to encourage donation of parcels within the green infrastructure network as well. Typically these land/cash ordinances emphasize recreation, but they could also be given an natural resources dimension as well. When municipal staff reviews development proposals, they could evaluate the land donation component to determine whether it is within the green infrastructure network.
- **Purchase open space within the green infrastructure network.** Location within the green infrastructure network could be used as a factor in determining where to place new parks when purchased by a municipal park department or park district. While in many municipalities direct land purchases like this are rare, they do occur.

72 Abigail Derby Lewis, Kimberly Hall, Jessica Hellmann. 2013. Advancing Adaptation in the City of Chicago: Climate Considerations for Management of Natural Areas. See **https://adapt.nd.edu/resources/1019**.

73 E. Kusnierz and G. Dwyer. 2010. The Role of Our Urban Forest in the Chicago Metropolitan Region's Future. See **http://tinyurl.com/c7z5ugl**.

74 See **http://www.cityofchicago.org/content/dam/city/depts/streets/supp_info/TreeDiversityGuidelines.pdf**.

75 See **http://tinyurl.com/cadc6h7**.

76 For an overview, see Chicago Wilderness materials at **http://www.chicagowilderness.org/what-we-do/climate-action/**.

77 Jeff Lerner and William L. Allen, III (2012).Landscape-Scale Green Infrastructure Investments as a Climate Adaptation Strategy: A Case Example for the Midwest United States. Environmental Practice, 14, pp 45-56.

78 See **http://www.cmap.illinois.gov/green-infrastructure**.

Resources and Next Steps

Municipalities interested in adapting their assets and investment decisions to a changing climate should first conduct a vulnerability assessment, as recommended in Chapter 2, then begin a planning process to determine which impacts to address and how. Technical resources are available to help identify additional adaptation measures. Climate adaptation is a burgeoning area of planning, with many new publications and tools under development. One of the best resources is the Georgetown Climate Center, which maintains an Adaptation Clearinghouse (**www.georgetownclimate.org/adaptation/clearinghouse**).

List of Acronyms

CDC	Centers for Disease Control and Prevention
ComEd	Commonwealth Edison
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
GIS	Geographic Information Systems
IDOT	Illinois Department of Transportation
IECC	International Energy Conservation Code
OSB	Oriented Strand Board
SFHA	Special Flood Hazard Area
TDM	Travel Demand Management
U.S. EPA	U.S. Environmental Protection Agency

Chicago Metropolitan
Agency for Planning

233 South Wacker Drive, Suite 800
Chicago, IL 60606

312 454 0400
info@cmap.illinois.gov

www.cmap.illinois.gov

FY13-0119