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MEMORANDUM

To: **CMAP Committees**

From: CMAP staff

Date: March 21, 2017

Re: Alternative Futures: What if climate change impacts intensified?

As part of ON TO 2050 development, CMAP is undertaking an "alternative futures" planning process focusing on exogenous factors that are largely beyond the control of any one entity, including CMAP and our regional partners. These factors include the environment, consumer preferences, technological advancements, and macroeconomic trends.

Based on research and feedback from stakeholders, CMAP envisions five different futures for the region, imagining life in 2050 where…

- Climate change impacts have intensified.
- More people have chosen walkable communities.
- The economy has transformed.
- Innovations have enhanced transportation.
- Public resources are further constrained.

The Alternative Futures planning exercise, which draws upon ongoing CMAP work and ON TO 2050 products, will inform the agency's phase of broad public engagement in spring and summer 2017. CMAP will identify the key macro-level drivers shaping each future and their potential impacts. With written and interactive materials, staff will depict the imagined futures' effects on residents and businesses. With the assistance of committees, CMAP will also propose strategies to help mitigate potential negative outcomes and capitalize on opportunities that might arise. At the end of the futures phase, staff will emphasize crosscutting strategic actions and policies that will help the region thrive across a wide range of possible outcomes.

Each of the futures will be addressed in a series of five memos, beginning with this one that describes a future in which climate change impacts have intensified greatly. CMAP developed this future based on the assumption that energy consumption levels, land use and development

decisions, and other human activity that contributes to greenhouse gas emissions will continue at the same rate or higher between 2017 and 2050, and climate mitigation efforts worldwide will be limited. This future also assumes that technological advances will not have greatly reduced greenhouse gas emissions. The temperature, precipitation, and drought projections used throughout this memo, as well as the outcomes, are therefore based on a high-emissions scenario, which helps ensure that CMAP and its partners are considering the most prudent strategies to prepare for possible impacts. The CMAP climate resilience strategy paper provides greater specifics about relevant partners and recommended actions.[1] While we obviously hope that reduced emissions can avert the most extreme outcomes, many impacts described here will in fact occur, although perhaps at lesser intensity.

In a future with intensified climate change impacts, high greenhouse gas emissions have led to more extreme temperatures, warmer winters, more intense and frequent storms, and droughts. By 2050, these impacts have strained the region's infrastructure and natural systems, disproportionately affecting the most vulnerable residents. Shifting habitats and agricultural zones, drought, and water supply and quality issues also present economic and environmental challenges. Potential economic opportunities may arise from population growth and increased reinvestment, as residents and industries from areas more severely impacted by climate change impacts move to the region.

Primary driver: high greenhouse gas emissions

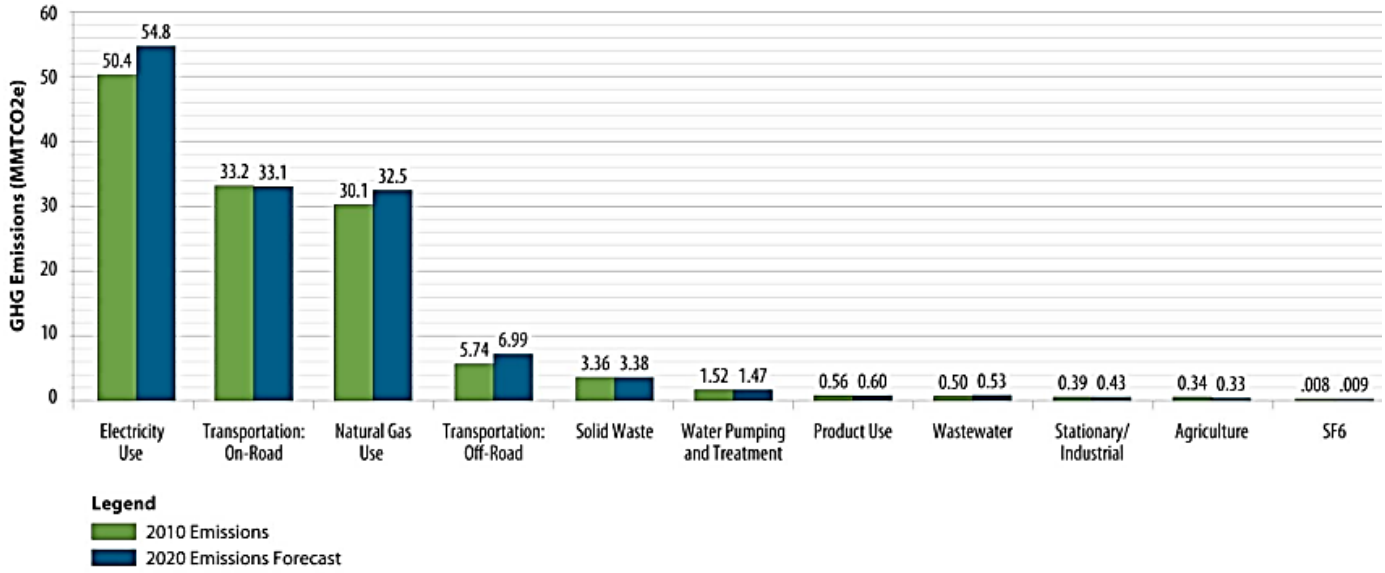
In 2050, decades of continued fossil fuel use have increased greenhouse gas emissions.

Greenhouse gasses contribute to climate change by trapping heat in the Earth's atmosphere. In large concentrations, these gasses -- including carbon dioxide, methane, and nitrous oxide, among others -- create a barrier that prevents heat from reflecting back into space, similar to the glass ceiling of a greenhouse. Human activity, such as the burning of fossil fuels, has increased the concentration of these gasses in the atmosphere, causing the climate to warm. If human activity, as well as existing policies and mitigation efforts, remain the same, regional emissions

[1] Chicago Metropolitan Agency for Planning, *Climate Resilience,* December 2016, http://cmap.is/2n6Zrr5

are expected to increase 28 percent by 2050.[2,3] As the primary driver of climate change, greenhouse gas emissions contribute to more extreme heat and more intense and frequent storms and droughts in our region.

Figure 1. Chicago region greenhouse gas emissions by sector for 2010 and 2020 forecast



Source: ICF International, "Chicago 2010 regional greenhouse gas emissions inventory," Prepared for Global Philanthropy Partnership with the City of Chicago and the Chicago Metropolitan Agency for Planning, May 2012.

Impacts of intensified climate change

In 2050, high levels of greenhouse gas emissions have led to significant changes in the climate. Summer days are insufferably hot. Winters are on average warmer, although the extremely cold days are colder than ever. Storms are more severe, and rainy periods last longer. Prolonged drought has increased hardship for communities without access to Lake Michigan water.

[2] Chicago Metropolitan Agency for Planning, *Chicago 2010 Regional Greenhouse Gas Emissions Inventory*, May 2012, https://www.cityofchicago.org/content/dam/city/progs/env/CCAP/Chicago_2010_Regional_GHG_Inventory.pdf.

[3] In 2010, the Chicago region produced an estimated 15 MTCO2e metric tons of carbon dioxide equivalent (MMTCO2e) per person, a per capita rate that is below the national average of 22.2 MMTCO2e and comparable to peer regions. Emissions in the Chicago region have remained fairly constant in recent years.

In the year 2050, average temperatures are expected to increase by 3 to 5°F.[4] Such increases would boost the number of days per year in which the temperature hits 100°F -- currently zero to two days -- to fifteen days by 2050.[5] Nighttime temperatures would be warmer, frequently reaching the high 70s and low 80s. The results would include more frequent and more powerful heat waves: By mid-century, nearly every other year the region could see an extreme heat event on par with the 1995 heat wave that killed more than 700 Chicago residents.[6]

Winters in northeast Illinois by 2050 would be characterized by mild temperatures, heavy rains, periodic deep freezes, and 22 fewer days below freezing than current annual rates.[7] The warmer temperatures would cause more frequent freeze-thaw events to occur[8] and more precipitation to fall as sleet and freezing rain.[9] At the same time, extremely cold days would be 4colder and last longer due to fluctuations in the polar jet stream.[10]

A warming climate would trigger changes in the region's water cycle, specifically through stronger, more frequent storms and longer, more persistent droughts. The once-rare 100-year storm event, defined for northeastern Illinois as a 24-hour storm producing at least 7.58 inches of rain, would occur much more regularly.[11, 12] Total annual precipitation in the Chicago region could be expected to increase 20 to 30 percent by the end of the century.[13] Wetter winters would be offset by drier summers, with long periods of drought periodically interrupted by heavy,

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[4] National Oceanic and Atmospheric Administration, "Record of Climatological Observations -- Chicago O'Hare International Airport, Jan. 01, 2016 -- Dec. 31, 2016," 2016.

[5] Hayhoe, K., S. Sheridan, L. Kalkstein, and J. S. Greene. "Climate Change, Heat Waves, and Mortality Projections for Chicago. *Journal of Great Lakes Research*," 2010, http://www.bioone.org/doi/abs/10.1016/j.jglr.2009.12.009

[6] Ibid.

[7] Kunkel, K.E., Steven, L.E., and Stevens, S.E., "Climate of the Midwest. U.S. Guidance document prepared for the US National Climate Assessment," 2012.

[8]U.S. Department of Transportation Federal Highway Administration, "Planning for systems management and operations as part of climate change adaptation," 2017.

[9] Angel, Jim. Presentation on Climate Change in Northeastern Illinois to Chicago Metropolitan Agency for Planning, Oct. 27, 2016.

[10] University of Sheffield, "Extreme cold winters fueled by jet stream and climate change," ScienceDaily, 26 October 2016, www.sciencedaily.com/releases/2016/10/161026081551.htm.

[11] Since the 1980s, the Chicago region has experienced the 100-year storm at least three times.

[12] Chicago Metropolitan Agency for Planning, "Climate Adaptation Guidebook, Appendix A: Primary Impacts of Climate Change in the Chicago Region," 2013.

[13] Hayhoe, K., S. Sheridan, L. Kalkstein, and J. S. Greene, "Climate Change, Heat Waves, and Mortality Projections for Chicago," *Journal of Great Lakes Research*, 2010, http://www.bioone.org/doi/abs/10.1016/j.jglr.2009.12.009

potentially damaging storms.[14] These dry periods may cause soils to become less porous, which increases the risk of flash flooding and erosion.[15]

Life in 2050 with intensified climate impacts

In 2050, Chicago residents could face a future with more extreme temperatures, severe storms, and persistent droughts. The outcomes described below assume that current trends and policies (e.g., land use trends, infrastructure investments, public assistance programs, etc.) will remain the same.

Property damage from flooding has increased.

More intense and frequent storms would compromise quality of life, damage property, hinder economic activity, and endanger safety. In areas along rivers and streams, floodplains would flood more frequently. Drainage systems in built-out parts of the region would often be overwhelmed, causing more basement backups and ponding in yards and parks, while impairing access on roads. Between 2007-14, urban flooding resulted in approximately $1.98 billion[16] in damages in the CMAP region.[17,18] By mid-century, federal and state governments, residents, businesses, and municipalities will likely be paying significantly more to address property damage and accidents caused by flooding and rain. Private insurers may also choose to exclude flood prone areas, particularly where stormwater infrastructure has not been upgraded, from coverage, leading to greater dependence on federal programs.

Lakes and rivers are more polluted.

Between 2001 and 2015, approximately 140,000 acres of agricultural and natural lands were developed. If such trends continue, the associated development may lead to an overall increase in the pollutants discharged into the region's water bodies as stormwater picks up sediment, metals, oils, and many other pollutants. Heavy rains more frequently overwhelm the sewer

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[14] Federal Highway Administration, "Regional Climate Change Effects," December 18, 2015, https://www.fhwa.dot.gov/environment/climate_change/adaptation/publications/climate_effects/effects03.cfm

[15] Huff, F. A., and J. R. Angel, "Rainfall Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois (Bulletin 70)," Illinois State Water Survey, 1989, http://www.isws.illinois.edu/atmos/statecli/PDF/b70-all.pdf.

[16] Data includes private insurance claims, National Flood Insurance Program (NFIP) claims, and Federal disaster relief claims from individual Assistance (IA) and Public Assistance (PA) programs.

[17] This figure includes Cook, Lake, DuPage, Kane, Will, and McHenry counties. The UFAA report did not include Kendall County in the CMAP region.

[18] State of Illinois Department of Natural Resources, "Report for the Urban Flooding Awareness Act. Prevalence and Cost," 2015, p.8.

systems and lead to more combined sewer overflows, where untreated sewage is released into waterways.[19]

Parts of the region are running out of groundwater. Residents and businesses must pay more for water.

The aquifer that provides water for many parts of northwest Will County and the eastern portion of Kane County could be completely depleted in 2050 -- and aquifers that supply water to areas in Kane County, southeast Kendall County, and northern Kendall County could be at least partially desaturated.[20] With limited access to Lake Michigan for drinking water, [21] communities who are dependent upon already stressed groundwater supplies could face growing water supply issues during periods of drought. Municipalities may need to switch water sources and build new wells and treatment plants, which could increase the costs of water. Furthermore, because groundwater feeds into multiple water bodies, withdrawals from shallow aquifers would also negatively impact the ecosystems of streams, lakes, wetlands, and Lake Michigan.[22]

Habitats have shifted, bringing new species and requiring changes to agricultural practices.

Some native plant and animal species, including street trees, do not thrive in a warmer climate with more variable rainfall. These species gradually would move to new habitats or become locally extinct. At the same time, some species not currently found in northeast Illinois, including invasive species such as the highly destructive kudzu vine, could begin to establish themselves in the Chicago area.[23]

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[19] City of Chicago, "Combined Sewers," undated, https://www.cityofchicago.org/city/en/depts/bldgs/supp_info/combined_sewers.html

[20] Mannix, Devin H., et al., "Groundwater Availability in Northeastern Illinois from Deep Sandstone Aquifers," Illinois State Water Survey, Fact Sheet 2 from Contract Report 2015-02.

[21]The Illinois diversion of Lake Michigan water is governed by a U.S. Supreme Court Consent Decree (Wisconsin v. Illinois, 388 U.S. 426 (1967); 449 U.S. 48 (1980)). The Illinois diversion is limited to 3,200 cubic feet/second. This amount is roughly equivalent to 2.1 billion gallons of water per day. The Level of Lake Michigan Act, 615 Illinois Compiled Statutes (ILCS) 50/1 et seq., is the Illinois law that governs Lake Michigan water use for those communities with an allocation for lake water through a permit system.

[22] Grannemann, N.G. et. al., "The importance of ground water in the Great Lakes Region," U.S. Geological Survey, Water Resources Investigations Report 00-4008, 2000.

[23] Hellmann, Jessica, J, Knute, J. Nadelhoffer, Louis R. Iverson, Lewis H. Ziska, Sephen N. Matthews, Philip Myers, Anantha M. Prasad, and Matthew P. Peters, "Climate Change Impacts of Terrestrial Ecosystems in Metropolitan Chicago and its Surrounding, Multi-State Region," *Journal of Great Lakes Research*, 2010, https://naldc.nal.usda.gov/download/49775/PDF

Shifting habitat ranges would also impact agriculture. In the short term, the region's farms may benefit from warmer temperatures. However, these benefits would gradually be outweighed by more frequent crop failures due to heat stress, drought, severe flooding, accelerated insect and pest growth[24], and persistent drought.[25] Demand for irrigation for farming would grow more quickly than any other water use, creating competition for increasingly scarce groundwater.[26] Large-scale droughts in other parts of the United States could also disrupt agricultural markets and lead to changes in global and national food supply. This would increase the value of agricultural land and crops in the region.

Health challenges change and increase.

Climate change impacts would create or exacerbate multiple health issues.[27] Extreme heat causes higher rates of heat-related stress, strokes, and other health issues that can potentially lead to illnesses or death. The risk of diseases transmitted by pathogens and parasites, such as Lyme disease, could increase in warmer weather. Air pollution,[28] especially ozone, would get worse because of higher temperatures, aggravating asthma, chronic bronchitis, and emphysema.[29] Impaired water quality could lead to higher rates of water related illnesses. More frequent and intense storms would also increase the risk of accidents, particularly on roads.

Transportation is obstructed more frequently by weather related events.

Flooding and severe weather will likely impair surface transportation -- including cars, busses, trucks, and trains -- more frequently by causing congestion, road closures, and accidents, leading to time lost and increased costs due to repeated rerouting. During the summer months, extreme heat could cause more pavement and railways to buckle, disrupting traffic and endangering commuters. More freeze-thaw cycles -- a characteristic of warmer winters -- would crack pavement and lead to pothole formation. Municipalities and transportation agencies would face higher maintenance and operation costs. Disruptions in rail and highway networks would also pose challenges to the freight and logistics industries in the region. These

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[24] U.S. Global Change Research Program, "2014 National Climate Assessment: Human health," 2014.

[25] Pryor, S. C., et. al., "Chapter 18: Midwest," *Climate Change Impacts in the United States: The Third National Climate Assessment*, 2014, http://nca2014.globalchange.gov/report/regions/midwest.

[26] Chicago Metropolitan Agency for Planning, "Water 2050: Northeastern Illinois Regional Water Supply/Demand Plan," 2010, http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757.

[27] Center for Disease Control and Prevention, "Climate effects on health," July 26, 2016.

[28] In 2016, Illinois EPA and U.S. EPA issued 7 air pollution action day alerts. These alerts occur when air quality levels reach a category deemed unsafe because of elevated ozone or fine particulate matter levels.

[29] U.S. Environmental Protection Agency, "Ozone Pollution: Health effects of ozone pollution," 2016.

disruptions are built into the cost of doing business, which would increase costs and travel times for residents and businesses alike.

Energy and water infrastructure systems are more strained.

In addition to transportation, other infrastructure systems, including water and energy, would become strained. More frequent freeze-thaw cycles would increase the risk of water pipes bursting. More extreme heat would also increase demand for energy, leading to more blackouts and brownouts as demand surpasses capacity. Severe thunderstorms, ice storms, and strong winds could damage overhead power lines, and cause power outages that disrupt business productivity and threaten public safety.

Population growth and new industries create new economic opportunities. Existing industries face challenges from climate change impacts.

Many communities outside of the region could face even greater impacts. In part due to warming waters, global sea level could rise by 1 to 4 feet by 2100, worsening problems such as flooding and erosion in many coastal cities.[30] Warmer waters would create more powerful hurricanes and typhoons, threatening homes and businesses along coasts.[31] More arid regions that had extremely hot summers in 2016, such as the American Southwest, could become even hotter and drier. Manufacturing industries such as steel, petroleum, chemicals, and food processing have a high rate of water consumption as well as water-related energy requirements (i.e., process water, cooling, and boiler feed). [32] By 2050, these water-intensive industries would have moved from drought-impacted areas in the United States to areas with dependable and bountiful water access, including the Chicago region. Similarly, population in the region could increase due to migration from regions facing even more severe distress by climate change impacts.

Disproportionately affected communities

Lower income residents, the elderly, and populations of color are at greater risk from the negative outcomes of climate impacts.

[30] U.S. Global Change Research Program, "Climate change impacts in the United States: The third national climate assessment," 2014.

[31] U.S. Environmental Protection Agency, "Future of climate change," Undated.

[32] Ellis, Mark, et al. "Industrial water use and its energy implications," American Council for an Energy Efficient Economy, 2001.

Some population groups would experience the impacts of climate change more acutely than others due to location (higher rate and/or intensity of exposure due to location), increased sensitivity, and lesser adaptive capacity (the ability to adapt to and cope with climate change).[33]

The effects of extreme heat would be most severe in urban centers where impervious surfaces, such as roadways, parking lots, and rooftops, will heat up during the day and remain hot well into the night. The phenomenon, known as the urban heat island effect, currently causes temperatures in the City of Chicago to be 2°F warmer than surrounding communities. The temperature difference between urban and non-urban areas could grow, as summers get hotter. Most residents of urban heat islands would be lower income people and people of color.[34,35] Furthermore, with fewer financial resources, lower income residents would be less able to afford housing in areas with abundant green spaces or pay for amenities like air conditioning during the summer or heat during the winter.[36] Older adults, who are less physically able to respond to changes in temperature, would face a greater risk of heat or cold related deaths and illnesses.[37] Older adults and persons of color will increase in population by 2050, underscoring the need to reduce and ameliorate the negative impacts of climate change.

Other population groups at risk during days of extreme heat or cold would be people with existing medical conditions, those without health insurance coverage, infants and children who are more sensitive to extreme temperatures, people who live alone, and outdoor workers with higher rates of exposure to high heat. Climate change impacts would also broadly affect populations that live in areas of the region more prone to droughts and flooding or are far away from public services. Residents and businesses located in areas at risk of depleted groundwater would have to pay more for water. Again, higher water rates would have a greater impact on lower income households. People and businesses along rivers would experience damaged property and impaired quality of life due to floods. Residents in less dense suburban neighborhoods must often travel further, typically by car, to obtain goods and services. These households -- which tend to have limited transportation options or are socially isolated – could have greater difficulty reaching people and critical services that could help them during storms, floods, or other emergencies.

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[33] Füssel, Hans-Martin and Richard J.T. Klein, "Climate change vulnerability assessments: An evolution of conceptual thinking," *Climatic Change*, 2005.

[34] Wen, Ming, et. al., "Spatial disparities in the distribution of parks and green spaces in the USA," *Annals Behavioral Medicine*, 2013 (45) 18-27.

[35] Wolch, Jennifer R., Jason Byrne, Joshua P. Newell, "Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'", *Landscape and Urban Planning*, 2014 (125) 234-244.

[36] Centers for Disease Control and Prevention, "Extreme Heat and Your Health: Heat and the Low Income," 2011.

[37] Centers for Disease Control and Prevention, "Extreme Heat and Your Health: Heat and the Elderly," 2011.

Strategies to prepare for intensified climate change impacts

CMAP and partners can begin taking a number of actions now to reduce greenhouse gas emissions and prepare for a future with more climate impacts. Many of the GO TO 2040 recommendations -- reinvesting in infill areas, promoting more transit options, conserving open spaces -- serve to improve livability and reduce greenhouse gas emissions. Below are additional strategy areas for CMAP and partners to mitigate climate change and its negative impacts. These approaches are described in more detail in ON TO 2050 research of Climate Resilience[38] and other topics (see Attachment: Related CMAP Strategy Papers). Examples of specific actions or policies are listed under each strategy. Note that these examples are not a comprehensive or prioritized list for possible actions.

1. **Explicitly integrate climate change mitigation and resilience goals into planning and development.**

Planning efforts can help to reduce greenhouse gas emissions and mitigate the negative impacts of climate change. In undertaking community planning processes, such as comprehensive plans and capital improvement plans, municipalities should assess climate risks and impacts and incorporate those considerations into near- and long-term priorities. This planning may include identifying critical assets (see above) as well as resilient land use planning.

Examples of strategies to integrate climate goals into planning and development include:

- Update floodplain and other place-based mapping based on new rainfall and climate impact information.
- Direct development away from floodplains and wetlands through conservation easements, zoning restrictions, and transfer of development rights (TDR) programs.
- Encourage and incentivize infill and TOD development.
- Update ordinances and zoning codes to improve stormwater mitigation, permit low- and zero-emissions generation, and reduce impervious surface creation.

2. **Enhance multi-sector, cross-jurisdictional planning to strengthen climate resilience of communities and residents.**

Climate change impacts have wide-reaching effects that often do not conform to manmade jurisdictional boundaries. For example, flooding can affect multiple communities along a

[38] Chicago Metropolitan Agency for Planning, "Climate Resilience Strategy Paper," 2016.

river, damaging public and private property and impeding transportation as well as local economies. Similarly, solutions for effective climate change mitigation and adaptation require multi-sector, multi-jurisdictional approaches to share resources, identify gaps, develop plans, and implement strategies. The Chicago region already possesses a number of cross-jurisdictional agencies responsible for promoting the efficient use of infrastructure and natural resources, including CMAP, Illinois Department of Natural Resources, Metropolitan Water Reclamation District, Northwest Water Planning Alliance, and the Regional Transportation Agency. Coordinated planning by key agencies can also help municipalities preserve critical natural resources, connect critical assets such as transit to underserved areas, incorporate stormwater management to prevent or mitigate flooding areas, and enhance local and regional economies. Improved coordination can also help to achieve co-benefits that leverage scarce resources. Cooperation is also necessary to leverage information resources, as discussed in the following strategy regarding data driven policy and programming. CMAP and partners should actively encourage cross-jurisdictional cooperation to promote climate change mitigation and adaptation in planning processes.

Examples of strategies for cross-jurisdictional coordination include:

- Freight and passenger railroads, as well as federal, state, and local transportation agencies, work together to strengthen freight and passenger rail network against climate impacts.
- Implement a groundwater monitoring and permitting system, requiring coordination with Illinois State Water Survey, private industries, agricultural, and municipalities.
- Transportation, stormwater, and development agencies incorporate green infrastructure at the site scale.
- Conservation groups, municipalities, state and local land managers, and philanthropies work to strengthen natural land protection and stewardship.
- Land use, economic development, and transportation agencies and private sector partners work to enable higher density, mixed-use developments.
- Shared funding sources for cross-jurisdictional and cross-programmatic projects.
- Regional partnership between multiple sectors for long-term resilience planning.

3. Integrate green infrastructure at all scales: site, community, and region

Green infrastructure exists at many scales: At the site level, green infrastructure includes small natural areas or naturalized features that provide ecological services and best management practices for stormwater management. Small parks and open spaces at the community level provide aesthetic, recreational, and ecological benefits. Regional green infrastructure is broadly characterized by interconnected natural areas that serve a variety of ecosystem functions and provide habitat. At all scales, green infrastructure is highly regarded for its ability to provide "co-benefits," that is, accomplish multiple goals

simultaneously: retain stormwater, reduce air and noise pollution, sequester carbon, increase biodiversity, provide wildlife habitat, reduce the heat island effect, and create recreational opportunities.[39] When used for stormwater management, green infrastructure can also be less costly than when traditional stormwater management systems are used alone.[40] As such, CMAP and partners should support efforts to integrate green infrastructure at all scales.

Examples of green infrastructure implementation strategies include:

- Identify critical natural assets (e.g., wildlife corridors, conservation zones, etc.) at regional and local scales through technical analysis and participatory processes.
- Protect priority species and improve and expand native habitats.
- Promote landscape ordinances and conservation design practices to provide site scale green infrastructure, preserve land, and prepare for changing habitats.
- Create opportunities and reduce barriers to integrating green infrastructure with gray infrastructure such as roads and achieve co-benefits.
- Assess incentives for private property owners to incorporate green infrastructure

4. Protect agricultural assets from climate change impacts

As an integral component of the region's open space system, fertile agricultural lands mitigate climate change impacts by helping to retain and recharge water, control floods, and manage soil. Activities related to the production, movement, and processing of agricultural products are also significant to the regional economy, particularly in rural communities.[41,42] CMAP and partners should continue to promote farmland protection programs. Partners, with the assistance of CMAP, should also help to adapt agricultural practices to a future with more heat waves, drought, and more frequent and intense storms. In addition, the region should support greater crop diversification, including production of more local foods for consumption here in the region.[43,44] Partners should take the lead in implementing more resilient farmland management practices.

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[39] Allen, Will, et. al., "Green infrastructure vision: Version 2.3 ecosystem service valuation," The Conservation Fund final report for Chicago Metropolitan Agency for Planning," 2015.

[40] U.S. Environmental Protection Agency, "Reducing stormwater costs through low impact development (LID) strategies and practices," December 2007.

[41] In 2012, Illinois food and agricultural export value ranked fifth in the nation.

[42] FARM Illinois, "A food and agricultural roadmap for Illinois," May 2015.

[43] Currently, nearly 80 percent of the state's agricultural production are beans and grains for export, ethanol, feed, and processed foods and additives.

[44] FARM Illinois, "A food and agricultural roadmap for Illinois," May 2015.

Examples of strategies to increase resilience of agricultural assets include:

- Identify key agricultural assets in the region.
- Adopt land use planning strategies that recognize agricultural value and focus development in infill areas with existing infrastructure.
- Encourage crop diversification and more resilient farmland management practices (e.g., cover cropping and no-till planting).
- Establish state and/or county agricultural conservation easement programs to preserve farmland.
- Investigate barriers to local food production, including access to land, infrastructure and financing.
- Explore conservation and restoration options for farmland prone to chronic flooding or drought.

5. Prioritize and protect critical physical assets from extreme weather events

CMAP and partners should identify and strengthen regional assets that mitigate the negative effects of extreme heat and storms. Vital regional assets are necessary for residents and communities to function safely, particularly in periods of stress. Some examples may include the regional freight rail and highway network that is integral to the movement of goods nationwide; the public transit system that enables people without cars to get around; communications infrastructure that provides vital information in the case of emergencies; public institutions that can serve as community gathering centers or warming/cooling facilities in times of crisis; energy generation and distribution systems that power homes, businesses, and other resources; community assets, such as hospitals that are essential for dealing with health effects of climate impacts; and water treatment plants that are essential to maintaining an adequate supply of clean drinking water. Critical assets should be protected throughout all stages of their lifecycle, from planning and design to operation and maintenance.

Examples of strategies to protect critical assets include:

- Identify critical assets at regional and local scales through a mix of technical analysis and participatory processes.
- Explore the potential impacts of climate change on the regional freight network, and strategies to mitigate these impacts.
- Update design standards and maintenance and operating procedures for physical infrastructure (communications, energy, transportation, water, green infrastructure) to account for intensified climate change impacts.
- Encourage research, adoption, and coordination of more resilient decentralized energy systems and communication systems.

- Account for interdependency of critical systems in planning and design processes.

6. **Implement policies that effectively price use of energy, natural resources, and public infrastructure**

Equitably structured pricing policies can encourage conservation, reduce emissions, and provide a stable source of revenue for needed infrastructure maintenance. The full value of energy, water, and other natural resources include positive externalities like ecosystem services that mitigate the impacts of severe storms and heat. The region's natural resources already provide an estimated $4.2 billion in flood control benefits every year.[45] Consumption and degradation of these resources can have negative impacts, including increasing carbon emissions and reducing the capability of natural systems to function. By offering incentives and creating markets, pricing policies can encourage individual and institutional actions that conserve resources and reduce greenhouse gas emissions. As stated above, critical assets must be protected from extreme weather events. Public infrastructure like the transportation system and water treatment facilities have maintenance, operations, and delivery costs that are often not included in the price users pay, costs that are likely to increase as climate impacts become more severe. Prices that capture the full costs of infrastructure will help to ensure that infrastructure is safe, reliable, and updated. Pricing policies should take into consideration equity implications.

Examples of pricing policies include:

- Improve pricing for the transportation system (e.g., mileage based fees, higher gas taxes, etc.).
- Explore best approach for carbon emission reductions (e.g., carbon trading or taxing).
- Real-time pricing of energy and transportation (i.e., tolling).
- Ecosystem service banking and trading.
- Explore policies to implement full cost of water and development impact fees.

7. **Assume leadership role in data driven policy and programming analysis and implementation**

Resilient infrastructure and systems can be bolstered by innovations in technology. The most recent National Oceanic Atmospheric Administration (NOAA) weather satellites can scan the Western Hemisphere every five minutes, and in areas of extreme weather

[45] Chicago Metropolitan Agency for Planning, "Green infrastructure vision: ecosystem service valuation," June 2015, http://cmap.is/2lH11wt.

formations, every 30 seconds.[46] Satellite monitoring will become even more advanced by 2050, providing more real time information about weather, the environment, and land use. Other technological advances in GPS, sensors, and other tools will provide more accurate and up-to-date information on air and water quality, groundwater levels, infrastructure, land use change, transportation conditions, real estate trends, and consumer preferences.

The usefulness of improved information is dependent on our ability to collect, synthesize, analyze, and communicate it. CMAP and partners should take a leadership role in leveraging data from advanced monitoring systems to guide policy, planning, and programming recommendations and assessments. CMAP should support partnerships for data sharing, coordinated management practices, and improved communications across jurisdictions, especially regarding data on transportation, land use, natural resources, and development. CMAP should harness improved information not only to track regional and sub-regional trends but also to assess the outcomes of associated policies and programs. Partners should take the lead in establishing standards and guidelines for data collection and analysis and investing in research and development of technology.

Examples of data driven policy and planning include*:*

- Support water management practices that adapt quickly based on monitoring, evaluation, and learning.
- Invest in flexible, resilient communication systems that are responsive to the needs of residents and businesses during immediate shocks as well as long term stresses. Develop more accurate predictive modeling (e.g., precipitation).
- Regularly update the regional greenhouse gas emissions inventory
- Conduct outcome analysis of policies and investments (e.g., impacts of green stormwater infrastructure on reducing street flooding).
- Incentivize or mandate performance based management in all sectors.
- Coordinate data sharing between organizations, agencies, and public.

8. Build climate literacy among all decision makers and the public

Policymakers, planners, developers, and residents will require a higher level of climate literacy to prepare for and implement interventions for climate change impacts. At the local level, flooding and heat can be mitigated through low-investment, site-scale interventions initiated by residents and local communities. Other issues, such as energy and transportation resilience, may require large-scale, coordinated interventions led by municipalities and agencies. To support the development and implementation of these efforts, CMAP and partners should help to educate residents and decision makers at all

[46] NOAA National Environmental Satellite, Data, and Information Service (NESDIS), "6 reasons why NOAA's GOES-R satellite matters," NESDIS News and Articles, October 11, 2016.

levels of government regarding climate change impacts and solutions to prevent or mitigate negative outcomes. In addition to analyzing trends and tracking data, CMAP should take leadership in linking climate change impacts such as flooding and heat to land use and planning decisions and outcomes and communicating about these linkages with its partners. For example, the ON TO 2050 Climate Resilience strategy paper examined land surface temperatures, which are impacted by impervious cover, and social vulnerabilities to climate change.

Examples of strategies to build climate literacy include:

- Develop and refine tools to assess climate vulnerability of community roadways, land uses, and populations.
- Continually update and improve data hub for ease of use.
- Provide more educational materials linking data to impacts to communities, elected officials, and residents.

9. Provide people with multiple mobility options

Multiple transportation options can help to ensure that people are able to access jobs and services even during severe weather events, such as flooding or snow conditions that impair transportation. By clustering employment and higher-density residential development along existing transportation corridors, especially in areas with access to Metra and CTA rail and high quality bus service, the region can help to support transit and provide access to multiple modes of transportation. At the site scale, communities should be designed to promote non-auto oriented modes of travel (e.g., walking, biking, and transit). Using low- or no-emissions modes of transportation also helps to meet greenhouse gas emissions targets that are critical to curbing climate change in the long run.

Examples of strategies to create more mobility options include:

- Strengthen transportation infrastructure to withstand climate changes.
- Invest in public transit.
- Implement and educate about complete streets and vision zero best practices when doing road construction and maintenance.
- Invest in smarter transportation infrastructure management, such as highway operations technologies (e.g., traffic control centers, dynamic message boards that can re-route travelers in case of sudden road closures).
- Prepare for and support alternative fuels and electric vehicles.
- Encourage transit-oriented-development.

10. Strengthen resilience of residents disproportionately impacted by climate change
As discussed above, some population groups would experience climate change impacts at a greater intensity and/or frequency than others due to location, adaptive capacity, and characteristics such as age, income, or household composition. Several of the strategies addressed above will be particularly important to help communities that lack sufficient capacity for responding to climate change impacts. For example, land use planning and development activities that explicitly take into consideration climate change impacts can reduce the locational vulnerabilities associated with drought and floods. Also, expanding mobility options will ensure that residents can still access their homes, jobs, and other resources when either surface transportation or transit is impaired. Increasing coordination among jurisdictions will help to achieve co-benefits and increase opportunities for shared services, both of which will assist lower capacity communities with providing critical services. And capitalizing on new economic opportunities will help to create jobs so all households, including those with lower incomes, will increase the financial security of residents.

In addition to these strategies, CMAP and partners should make a more concerted effort to engage with historically hard to reach communities, such as the elderly, lower income households, immigrant groups, and residents with physical challenges. Participation by residents at all levels of decision making -- from development to implementation of policies, plans, and projects -- will help ensure that the needs of the most affected populations are addressed. In addition to protecting physical assets, partners should take the lead in ensuring that people, particularly those that are socially isolated, have access to help and needed supplies, especially in emergencies. At the regional scale, formulas to allocate funds and assessment projects should reflect climate change impacts, particularly on low-income or elderly residents and persons of color.

Examples of strategies to assist disproportionately impacted communities include:

- Analyze potential climate change impacts on low-income or elderly residents or persons of color when developing plans, analyzing policies, or allocating funds.
- Strengthen ability of lower capacity communities to respond and adapt to climate change impacts through increased reinvestment.
- Develop relationships and partnerships with local community partners representing hard to reach populations.
- Implement best practices such as the use of translators or provision of child care and transportation services.

11. Prepare our economy for potential climate impacts and capitalize on new economic opportunities

Climate change will also provide new opportunities to the regional economy. New residents and businesses, such as water intensive industries, may relocate to the region from areas suffering from worse climate change impacts. Nevertheless, all new -- and existing -- businesses must become more resilient in a future with blackouts and brownouts, increased flooding and increased drought, and frequent disruptions to worker and freight transportation. CMAP should explore strategies for land use, development, transportation and freight, and workforce to build resilience for the region's existing economic clusters and to meet the needs of new industries. Supported by broad research conducted by CMAP on workforce needs, partners such as economic development agencies and community colleges should lead workforce development initiatives to ensure that residents have the skills to meet the demand for new technological advances relevant to climate change, including fields related to monitoring and analysis of data and sustainable generation and distribution of energy. CMAP and partners should also capitalize on population growth by supporting policies that create more jobs, provide housing options for all residents, and support a high quality of life.

Examples of strategies for new economic opportunities include:

- Research the effects of climate change impacts on regional economic clusters, such as freight transportation.
- Regularly update analysis of infill supportive areas and link to climate change impacts, such as flooding.
- Engage with private sector businesses in education and implementation efforts (e.g. provide data or analysis).
- Reduce supply-chain operations' vulnerability to climate change impacts.
- Support manufacturing of materials to support climate resilience (e.g., mold-resistant products).
- Identify land use and development trends related to water intensive industries and intermodal facilities.
- Provide workforce development training for new technological advances and green jobs.
- Remove barriers to development in infill areas outside of flood prone areas to attract new residents and businesses.

Next Steps

Following committee review and feedback, staff will finalize this memo and use it to inform the development of an online survey platform, MetroQuest, that will allow residents to learn about and select preferences for strategies to prepare for climate change impacts. In addition, CMAP

will deploy interactive kiosks across the region, illustrating the key features of a future with intensified climate change impacts, along with the other four alternative futures. The kiosk content will also be accessible via the CMAP website. The MetroQuest survey and kiosks will be central to an intensive public engagement period from April through August 2017.

Four other potential futures for the region have also been selected for exploration. These futures will be oriented around what the region would be like if residents showed strong preferences for mixed-use, higher density environments; if the regional economy continued to become more service-oriented and automated; if significant technological advances improved mobility; and if federal and state public resources diminished significantly. Staff will also develop a final memo where the recommendations in ON TO 2050 strategy papers will be analyzed through the lenses of the five alternative futures; the strategies that apply across many of these futures will help to inform which strategies to prioritize in ON TO 2050, which will be completed in October 2018.

Attachment: Related CMAP Strategy Papers

Strategy	Related CMAP ON TO 2050 Strategy Papers
1. Explicitly integrate climate change mitigation and resilience goals into planning and development	Climate resilience, reinvestment and infill, green infrastructure
2. Enhance multi-sector, cross-jurisdictional planning to strengthen climate resilience of communities and residents	Municipal capacity, tax policy and land use, climate resilience, transit modernization, highway operations, stormwater, water
3. Integrate green infrastructure at all scales	Green infrastructure, climate resilience, lands in transition, stormwater
4. Protect agricultural assets from climate change impacts	Lands in transition, green infrastructure, climate resilience, stormwater
5. Prioritize and protect critical physical assets for extreme weather events	Climate resilience, inclusive growth, asset management, energy, highway operations, transit modernization, transportation technology, clusters, municipal capacity
6. Implement policies that effectively price use of energy, natural resources, and public infrastructure	Transportation system funding concepts, asset management, climate resilience, green infrastructure, energy
7. Assume leadership role in data driven policy and programming analysis and implementation	Climate resilience, transit modernization, transportation technology, lands in transition, stormwater, asset management
8. Build climate literacy among all decision makers and the public	Climate resilience, stormwater, water
9. Provide people with multiple mobility options	Inclusive growth, transportation system funding concepts, transit modernization, transportation technology, highway operations
10. Strengthen resilience of residents disproportionately impacted by climate change	Inclusive growth, tax policy and land use, climate resilience, public health, human capital
11. Capitalize on new economic opportunities	Climate resilience, reinvestment and infill, human capital, innovation, and clusters