COLUMBUS
Climate Adaptation Plan

Completed December 2018

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Cervenec, J., A. B. Wilson, G. R. Dipre, A. Shockey, D. Celebrezze. *Columbus Climate Adaptation Plan*. 2018.

Available online at ***byrd.osu.edu/columbus***.

How to Read

October 2018
Dear Reader,

The Columbus Climate Adaptation Plan (CCAP) is the result of four years of effort that involved looking critically at climate change impacts, risks, and vulnerabilities in Columbus. The result is a set of prioritized actions that should be taken by city government, regional organizations, and residents to make the city more climate resilient. This document utilizes our understanding of Earth processes and climate change to help inform our local public policies. The CCAP Task Force sought involvement of stakeholders, technical experts, and the general public in developing this plan.

The CCAP includes a significant amount of information, and the Task Force acknowledges that readers have limited time. Therefore, the document is a series of thematic chapters designed to be read independently of each other. On page 4, readers will find a list of terms and abbreviations that are used throughout the document. Chapter 1 provides an overview of the science of climate change and local impacts felt in Columbus, as well as a table that includes all of the action statements. Chapters 2 through 9 discuss the action statements specific to each theme. Chapter 10 discusses accountability and considerations for future work to improve climate resiliency.

While 43 actions are recommended to be taken by the City, the list is prioritized into necessary (denoted with an N) and aspirational actions (denoted with an A), based on the methodology outlined in Appendix A. The necessary actions are those deemed most impactful and easiest to implement based on expertise, cost, and will, and are therefore given higher priority. Approximately 16 actions were deemed to be of lowest priority and have been included in Appendix B for reference only.

Active participation by City departments will be necessary to make these actions a reality—including allocation of staffing, assets, and funding. Furthermore, this document provides valuable information for everyone living, working, and playing in Columbus, regardless of their involvement with city government. Many of the actions are educational initiatives and collaborative ventures that require involvement from other levels of government, non-profit organizations, businesses, and private citizens. It is the hope of this Task Force that the CCAP provides value in educating all members of our community in addition to providing a roadmap for how the City can accelerate our preparation for a changing climate.

The CCAP is based on the best information available to the Task Force and our contributors at the time the document was written. As additional information is gathered, our climate changes, and the community responds to these changes, the CCAP will need to be updated. Lastly, the CCAP outlines actions that can be taken to adapt to climate change, but does not outline the city's approach to mitigating our emissions of greenhouse gases that contribute to climate change. This is a separate but related conversation that is of critical importance to avoid the worst impacts of climate change.

Regards,
Jason Cervenec
Chair, Columbus Climate Adaptation Plan Task Force
Education & Outreach Director, Byrd Polar and Climate Research Center

Terms and Abbreviations

A

AEP American Electric Power
AMI Advanced Metering Infrastructure
AMP American Municipal Power

B

BMPs Best Management Practices
BPCRC Byrd Polar and Climate Research Center

C

CCAP Columbus Climate Action Plan
CDC Center for Disease Control and Prevention
CDOP Columbus Division of Power
COBE Central Ohio BioEnergy
COTA Central Ohio Transit Authority
CPH Columbus Public Health
CRPD Columbus Recreation and Parks Department
CSO Combined Sewer Overflow

D

DPU Department of Public Utilities
DPS Department of Public Safety
DOSD Division of Sewerage and Drainage

E

ESF1 Emergency Support Function 1 (developed by FCEM & HS)
EV Electric Vehicles

F

FC CERT Franklin County Community Emergency Response Team
FCC Federal Communications Commission
FCEM & HS Franklin County Emergency Management and Homeland Security
FCEO Franklin County Engineer's Office
FCPH Franklin County Public Health
FSWCD Franklin Soil and Water Conservation District
FEMA Federal Emergency Management Agency

G

GHG Greenhouse Gas
GI Green Infrastructure
GIS Geographic Information System (a tool for visualizing/mapping data to help interpret patterns and trends)
GLISA Great Lakes Integrated Sciences and Assessments
GPD Gallons Per Day
GPS Global Positioning System

H

HAB Harmful Algal Bloom
HEAP Home Energy Assistance Program
HVAC Heating, Ventilation, and Air Conditioning
HWAP Home Weatherization Assistance Program

I

InFACT OSU's Initiative for Food and Agricultural Transformation
IPCC Intergovernmental Panel on Climate Change

L

LED Light-emitting Diode
LEED Leadership in Energy and Environmental Design

M

MGD Million Gallons per Day
MORPC Mid-Ohio Regional Planning Commission

N

NAAQS National Ambient Air Quality Standards
NFIP National Flood Insurance Program
NOx Nitrogen Oxides
NWF National Wildlife Federation
NWS National Weather Service
NYPA New York Power Authority

O

ODA Ohio Department of Agriculture
ODH Ohio Department of Health
ODOT Ohio Department of Transportation
OEMA Ohio Emergency Management Agency
OEPA Ohio Environmental Protection Agency
Ohio WARN Ohio Water/Wastewater Emergency Response Network
OOT Office of the Ohio Treasurer
OP3 Ohio Public-Private Partnership
OPHA Ohio Public Health Association
OSU Ohio State University

P

PACE Property Assessed Clean Energy
PM Particulate Matter
PUCO Public Utilities Commission of Ohio

S

SCOO State Climate Office of Ohio
SCPZ Stream Corridor Protection Zone
SSO Sanitary Sewer Overflow
SWDM Stormwater Drainage Manual

U

UHI Urban heat island
USGS United States Geological Survey

V

VOCs Volatile Organic Compounds

W

WAM Work Asset Management system
WHO World Health Organization
WQAL Water Quality Assurance Lab
WWMP Wet Weather Management Plan

climate change mitigation
A human intervention to reduce the sources or enhance the sinks of greenhouse gases.[1]

climate change adaptation
The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.[2]

co-benefit
Benefits that are not the direct goal of a recommended action in this document but rather a beneficial side effect.

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1 Intergovernmental Panel on Climate Change. 2014. Fourth Assessment Report. ***https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml***. Accessed Jun. 2018.

2 Intergovernmental Panel on Climate Change. 2014. Fourth Assessment Report. ***https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml***. Accessed Jun. 2018.

Introduction

Science of Climate Change

Climate change is one of the most serious threats confronting society. Characterized by changes in temperature and precipitation, climate change is a threat multiplier to challenges already facing the world including crop production, food security, and water quality. As stated in the ***U.S. Fourth National Climate Assessment: Climate Science Special Report***, "it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence."[1, 2] The human influence is the direct increase in greenhouse gases (GHGs), so called for their innate ability to absorb and maintain heat in Earth's atmosphere. While an optimal range of GHGs (e.g., water vapor, carbon dioxide, methane) are vital for keeping the planet's temperatures stable and habitable, human activities, such as the burning of fossil fuels, increasing deforestation, and development have resulted in accumulation of GHGs in the atmosphere at rates unprecedented since human settlements began (Fig. 1). These higher levels of GHGs have increased temperatures and led to major climate impacts that are altering our world's natural and human-constructed systems.

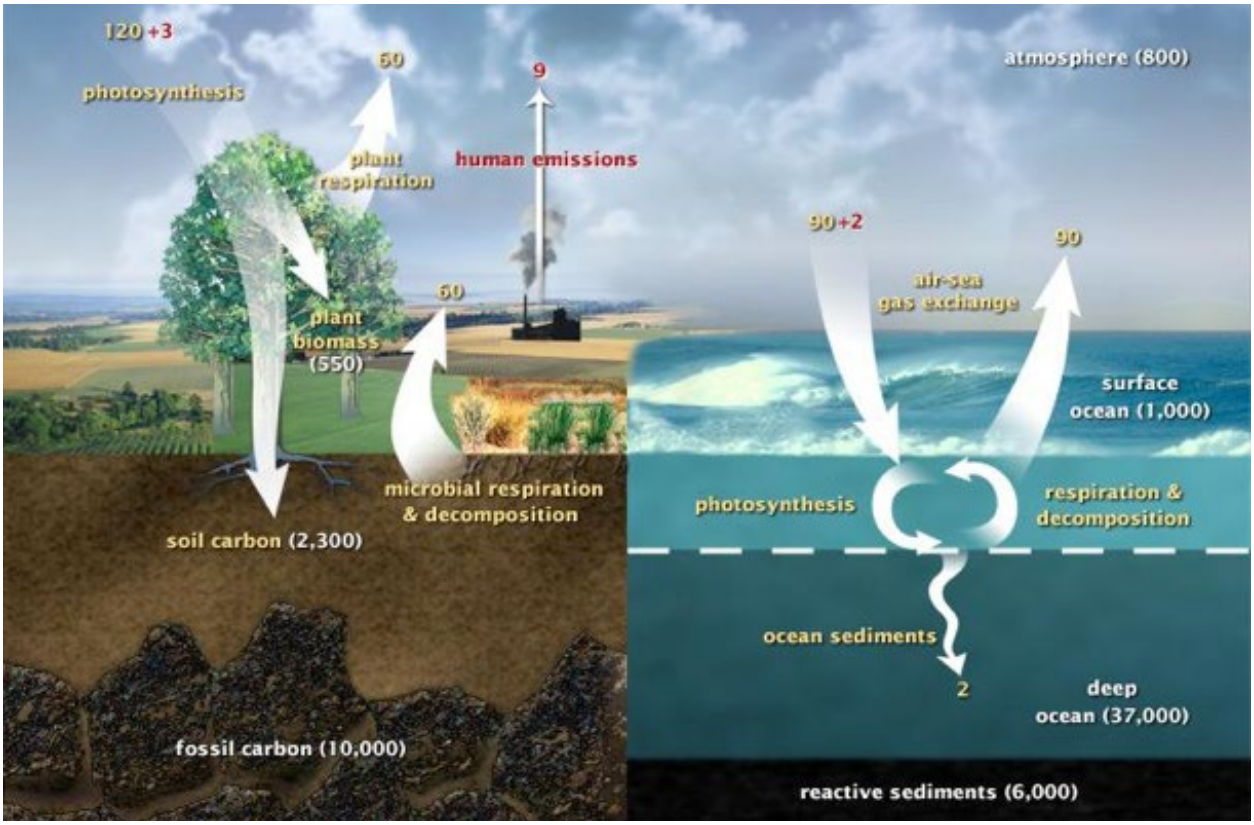

Figure 1. *Diagram of the fast carbon cycle shows the movement of carbon between land, atmosphere, and oceans. Yellow numbers are natural fluxes, and red numbers are human contributions in gigatons of carbon per year. White numbers indicate stored carbon. (Diagram adapted from U.S. DOE, Biological and Environmental Research Information System).*[6]

Importance of Climate Adaptation

There is no "one-size fits all" solution to climate change adaptation, but sharing best-practices, learning by doing, iterative processes, and stakeholder involvement can support progress. Adaptation actions can fulfill other societal goals and therefore be incorporated into existing decision-making processes for sustainable development and disaster risk reduction. Climate change vulnerability intersects with other stresses such as pollution and poverty, therefore demanding examination of overall threats while weighing tradeoffs between costs, benefits, and risk. Unfortunately, climate change adaptation is still in its infancy with many actions having only recently been initiated, in both the public and private sectors, and comprehensive evaluation metrics do not exist.[9] A list of additional resources discussing the science of climate change, impacts of climate change, and climate adaptation are provided in Table 1. Readers are encouraged to examine at least the executive summary of each resource to learn more.

Since the Industrial Revolution, when humans started emitting significant amounts of GHGs, global temperatures have been on the rise. The 2017 average global temperature across land and ocean surface areas was 1.51°F (0.84°C) above the 20th century average. Sixteen of the 17 warmest years on record have occurred since 2001, and the 6 warmest years have occurred since 2010.[3, 4] These trends are expected to continue through the end of the twenty-first century, with projections ranging from an additional warming of 2.5°F (1.4°C) in best-case scenarios to 10°F (5.5°C) in worst-case scenarios.[5] This warming has resulted in a number of climatic and environmental changes that are challenging communities around the world. Sea-level rise, due to melting land ice and warming ocean temperatures, has led to increasing high tides, greater erosion, and extensive flooding for some coastal communities and low-lying island nations.[7] More severe and frequent precipitation events have caused infrastructure damage and loss of life. Extended droughts and heat waves have created food and water shortages. These types of threats are expected to become more common and more severe as the climate continues to change.[8]

All individuals, businesses, and governments have and will continue to be affected by climate change. However, changes vary from region to region. To adequately prepare our community for climate impacts, it is important to understand the current and projected local effects of climate change, while recognizing how some populations will be disproportionately impacted. For example, children, the elderly, and low-income and socially-isolated populations are expected to be more vulnerable to climate impacts in Central Ohio that include flooding, droughts, extended heat waves, and deteriorated air quality.

Nations, states, and cities throughout the world have started to implement strategies that reduce GHG emissions (mitigation) and limit the damage that is likely to occur to natural and human-

constructed systems (adaptation). While it is vital that the global community takes aggressive action to reduce GHG emissions to avoid the worst climate-change impacts, Earth's climate is already locked-in to a certain amount of warming. Some GHGs (e.g., carbon dioxide) remain in the atmosphere for long periods of time. By acknowledging the changes that Columbus has already experienced and those that are likely to occur, this document aims to prepare our city and its residents for a more climate-resilient future.

Impacts of Climate Change on Columbus

The ***Climate Change in Columbus, Ohio*** report outlines many of the projected climate impacts for our city and region, and it also identifies the primary vulnerabilities that are likely to result from them.[12] Based on local climatological data and input from sector-specific stakeholders, it identifies eight climate impacts and fourteen priority vulnerabilities for Columbus that are expected to arise due to one of the two major climate changes projected for the region: rising temperatures and increasing precipitation.

Temperatures in Columbus have risen at rates faster than both the national and global averages (2.3°F from 1951-2012), with the greatest warming occurring during the spring and at night.[13] Precipitation has also increased, rising 19.8% from 1951 to 2012, and the largest increase has occurred during the fall.[9] Additionally, extreme-precipitation events have become more frequent. Based on model projections, our temperatures are expected to rise another 3 to 5°F by mid-century, and up to 10°F by the end of the century.[14] While precipitation is most likely to continue to increase during the cooler seasons, it

Resources	Organization	Web Link
Fourth National Climate Assessment (2018)	U.S. Global Change Research Program	***https://www.globalchange.gov/nca4*** [1]
Warming of 1.5°C (2018)	Intergovernmental Panel on Climate Change	***http://www.ipcc.ch/report/sr15*** [8]
Fifth Assessment Report (2014)	Intergovernmental Panel on Climate Change	***http://www.ipcc.ch/report/ar5*** [10]
Climate Change: Evidence and Causes (2014)	U.S. National Academy of Sciences and Royal Society	***http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes*** [11]

Table 1. *Resources for science of climate change, impacts of climate change, and climate adaptation information.*

will likely be most variable during the summer. By the end of the century, our summers are likely to resemble those of Arkansas and Louisiana, while our winters will be more like Virginia and North Carolina (Fig. 2).[15]

As a result of these changes, Columbus is expected to face a number of risks and challenges. For example, warmer temperatures raise the likelihood of extreme-heat events, which lead to more heat-related illnesses, increased water and energy demand, and induce more stress on local vegetation. Warmer temperatures also lead to air-quality issues, especially in the city, due to stagnant air and increased energy demand. This ultimately produces more emissions from our current forms of cooling. Columbus also experiences a severe urban heat island effect - a phenomenon whereby built structures within the city retain heat more than the surrounding rural areas - which will likely intensify. Increased precipitation also poses a major risk. Extreme-precipitation events have the potential to cause flooding, damage infrastructure, and cause transportation issues. Other consequences such as mold buildup, waterborne pathogens, and decreased water quality all negatively affect public health.[12]

The actions proposed in this document are specifically designed to address the risks and vulnerabilities identified in Climate Change in Columbus, Ohio. With Central Ohio expected to experience significant population growth and associated development between now and 2050, individual and collective actions need to immediately consider the information contained in this report.[16] Cities around the world are taking similar steps and beginning to share their initiatives.[17]

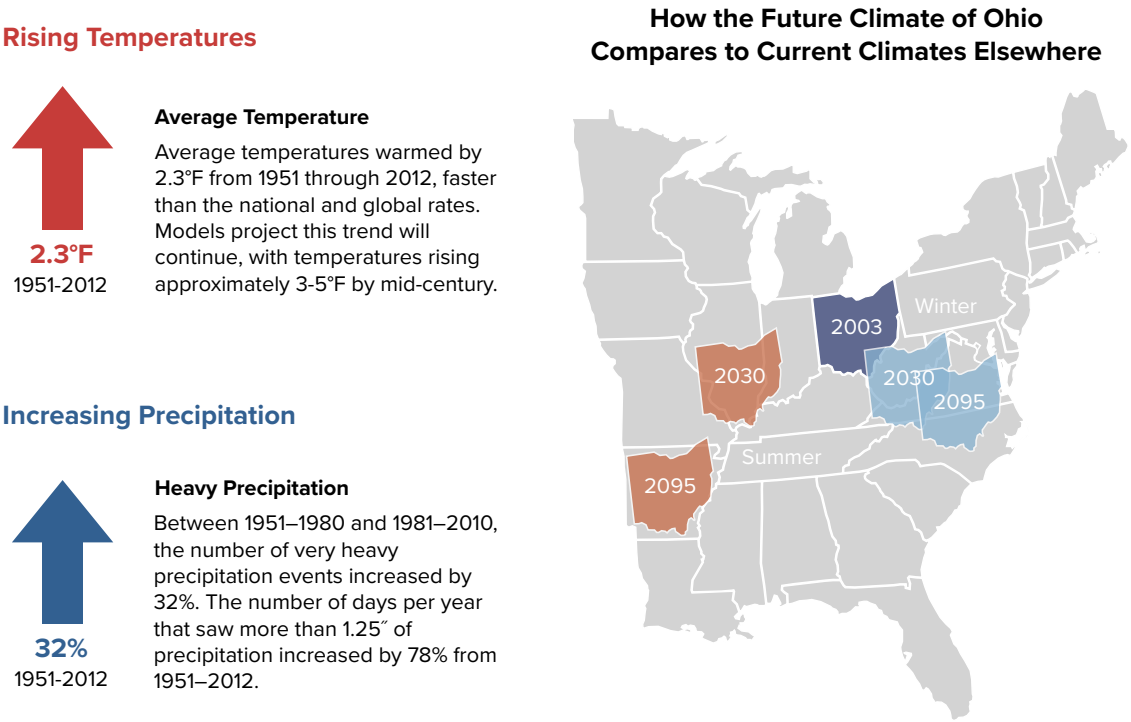

Figure 2. *Observed historical temperature and precipitation changes in Columbus, Ohio and changes likely to occur.*[15]

Efforts to Reduce Emissions in Columbus

While this plan does not directly address climate change mitigation strategies, since 2005 the City of Columbus has implemented programs and taken steps to reduce carbon emissions.[19] Mayor Ginther signed onto the ***Compact of Mayors*** in 2016, which represents a commitment to take inventory of GHG emissions, create reduction targets, establish a system of monitoring and measurement, and develop an action plan.[20] Improvements to the city's transportation system, being developed through the ***Smart Columbus*** initiative, should reduce emissions from the transportation sector.[21] While all of these programs represent positive steps forward, they are insufficient to transition Columbus to a carbon neutral community, and additional actions will need to be taken to mitigate GHG emissions associated with Columbus.

Purpose of the CCAP

In summer 2016, a Task Force, led by the Byrd Polar and Climate Research Center at The Ohio State University and including individuals from the City of Columbus and MORPC, began a two-year effort to develop this Columbus Climate Adaptation Plan (CCAP). The purpose of the CCAP is to provide specific, prioritized actions that the City of Columbus, along with its residents, non-profit organizations, and local businesses, can take to make Columbus a more climate-resilient community.

According to the IPCC's Fifth Assessment Report, climate adaptation is "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." Likewise, the IPCC defines climate mitigation as "A human intervention to reduce the sources or enhance the sinks of greenhouse gases."[18] The primary goal of this document is to prepare the city and its residents for the projected changes that will result from climate change (adaptation). The primary goal of this plan is not to reduce Columbus' carbon emissions (mitigation), which is being addressed separately by the City. However, there are mitigation co-benefits (benefits that are not the direct goal of a recommended action but rather a beneficial side effect) resulting from some actions within the plan, all of which are tied to transportation and heating and cooling of buildings.

The prioritized actions of this report are found in eight technical chapters (numbered 2 through 9). Each of these technical chapter represents either a major climate impact (e.g., Extreme Heat, Flooding) or a sector that will be heavily affected by climate change (e.g., Emergency Preparedness, Vulnerable Populations). While each action is only listed once in the document, the Task Force recognizes that some actions could easily be placed in multiple chapters as they result in benefits that fall outside the confines of one climate impact or sector. While actions are meant to be implemented by specific

city departments, with accountability following these departmental assignments, it was outside the scope of work for the Task Force to designate these assignments. Likewise, many of the actions involve educational campaigns that will benefit from shared best practices and central coordination between city departments via Sustainable Columbus. Engaging education-focused organizations that work in both formal and informal learning (e.g., Columbus City Schools, Columbus Parks & Recreation, Columbus and Franklin County Metro Parks, Franklin Park Conservatory, COSI, Franklin County Extension, Franklin County Soil & Water) ensures that key constituencies, including youth, are involved in climate resilience efforts. The Task Force strove to make this document accessible to a broad audience, realizing that all members of the community have something to gain by reading it and actively engaging in the process of building resilience.

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Recommended Climate Adaptations for Columbus

Extreme Heat

- N1 — Establish a larger, better coordinated, more responsive network of cooling centers and draft clear guidelines for network members.
- N2 — Implement educational campaign, health advisories, and best practices for time spent outdoors in extreme heat.

Air Quality & Energy

- A1 — Internalize climate resilience practices in city planning to reduce the urban heat island.
- A2 — Provide programs to distribute fans, air conditioners, and water to vulnerable populations.
- N3 — Modernize electric grid for greater resilience and more efficient energy distribution.
- N4 — Implement educational campaign on idling reduction.
- A3 — Implement educational campaign on energy audits and renewable energy to reduce emissions for residential and business users.
- A4 — Increase number of air quality monitoring stations to provide baseline data and public educational opportunities.
- A5 — Use data and best practices to adapt transportation modes and inform economics of transportation.

Flooding

- N5 — Design and implement an educational campaign that leads to reduced impacts of stormwater and basement sewage backups, promotes use of green infrastructure, and accurately conveys risks to and responsibilities of property owners.
- N6 — Review city regulations, technical documents, departmental processes and plans, property owner programs, enforcement mechanisms, and monitoring efforts to ensure that current practices reduce localized flooding and basement/sewage backups.
- N7 — Develop an emergency plan that can be implemented during a flood to ensure adequate transportation and logistics for critical resources.
- N8 — Identify and assess risk associated with older flood control and stormwater infrastructure, and use data gathered to reduce risk by developing property owner education, informing the city's capital projects, and establishing property owner requirements.
- A6 — Advocate for state and federal government to implement policies that reduce erosion and runoff and promote infiltration.

Water Quality

- N9 — Implement the City of Columbus Watershed Management Plan and work with regional partners to implement the Sustaining Scioto Adaptive Management Plan.
- N10 — Understand the types, likelihood, and severity of events that could adversely impact the quality of drinking water sources.
- N11 — Continue upgrades to sewer system and sewage treatment infrastructure to reduce sewage contamination of waterways.
- N12 — Design an educational campaign for individuals and businesses on proper use of tap water during an emergency.
- A7 — Improve data collection to anticipate and respond to harmful algal blooms (HABs).
- A8 — Continue upgrades to water and sewage treatment infrastructure to reduce harmful alagal bloom (HAB) toxins in drinking water.

Water Use

- N13 Implement educational campaign on reducing water use.
- A9 Develop event-based water use criteria.
- A10 Update building code to require more efficient water use.
- A11 Improve irrigation through changes in infrastructure and practices that more efficiently use water.
- A12 Improve efficiency of water use in city fountains, pools, splash pads, and ponds.

Ecosystems

- N14 Promote sustainable landscaping practices for residential, commercial, and industrial properties.
- A13 Develop guidelines for city property on application of fertilizers, herbicides, pesticides, and animal waste.
- A14 Collaborate with landscaping and fertilizer companies to improve services and use of products.
- A15 Implement educational campaign for landowners to promote responsible use of fertilizers, herbicides, and pesticides.
- A16 Collaborate with organizations, agencies, and private landowners to identify and create additional green space, urban tree canopy, and urban farms.

Emergency Preparedness

- N15 Use geographic information systems (GIS) to map fixed critical assets and vulnerable populations susceptible to environmental hazards.
- N16 Evaluate city preparedness and response during and after environmental hazard emergencies.
- A17 Track and communicate costs associated with preparing for and responding to environmental hazards.
- A18 Establish contingency contracts so that sufficient resources are available in case of environmental hazard emergencies.
- A19 Develop new app or integrate with existing app for environmental hazard alerts.
- A20 Implement educational campaign to inform the public about insurance and other shared risk programs available for environmental hazards.

Vulnerable Populations

- N17 Identify representative advocacy organizations for diverse and vulnerable populations.
- N18 Facilitate cross-cultural dialogue, offer training for service providers, and share best practices.
- N19 Ensure diverse modes of communication during environmental hazard emergencies to reach diverse and vulnerable populations.
- N20 Implement educational campaign on environmental hazard preparedness to reach diverse and vulnerable populations.
- N21 Coordinate closely with the Ohio public-private partnership to manage food and water access for vulnerable populations during environmental hazard emergencies.
- N21 Require disclosure of known property problems for sale or rental of property.
- A22 Require or incentivize that monthly utility costs for rental properties be reported to potential tenants.

Extreme Heat

Actions

N1 Establish a larger, better coordinated, and more responsive network of cooling centers and draft clear guidelines for network members.

N2 Implement educational campaign, health advisories, and best practices for time spent outdoors in extreme heat.

A1 Internalize climate resilience practices in city planning to reduce the urban heat island.

A2 Enhance programs to distribute fans, air conditioners, and water to vulnerable populations.

Background

The ***Climate Change in Columbus Ohio*** report identifies increasing temperatures as one of the two climate changes that have and will likely continue to affect our city.[1] From 1951 to 2012, the annual average temperature for Columbus warmed by 2.3°F, which was faster than both the national and global rates. This trend is expected to continue, with annual average temperatures projected to rise by an additional 3 to 5°F by mid-century. Increasing temperatures result in several impacts – deteriorated air quality, stress on vegetation, increased demand for water and energy – that can negatively affect our community. One of the most concerning effects is the projected increase in extreme heat events by mid- twenty-first century, including an increase in the warmest day of the year (> 6°F), with an additional 20 to 40 days per year of high temperatures greater than 90°F (comparison made to the 1976-2005 period).[2]

Extreme heat refers to air temperatures that are much hotter than average. Extreme heat events are generally characterized by consecutive days of excessively hot weather, often including elevated humidity and warm nighttime temperatures. The lack of cooling at night leads to sustained heat indices and health concerns. These events are already occurring throughout the country and are expected to increase in severity and frequency as the climate continues to change. The projected increase in extreme heat events increases the likelihood of more heat-related illnesses and deaths in Columbus.

According to the National Weather Service, heat remains one of the greatest weather-related causes of death in the United States.[3] In 2016, 94 people died as a result of extreme heat. Although the most vulnerable are those living in permanent homes with little to no air conditioning, loss of life can include others as well. Individuals engaging in strenuous outdoor work during periods of high temperatures are at increased risk as well as those that are socially isolated and unable to cool themselves during widespread heat waves. Of particular note is the loss of life that occurred during the ***summer of 1995 in Chicago***, where more than 700 individuals were estimated to have died in an extended heat wave.[4] Similar events have been documented within the United States and around the globe.[5]

To combat the risks associated with extreme heat, two necessary (N) actions and two aspirational (A) actions are proposed. These actions provide ways for the public to avoid the negative effects of extreme heat and ensure that best practices will be utilized for anyone that has to spend time outdoors on dangerously hot days. Additionally, these actions focus on providing resources for vulnerable populations who are disproportionately affected by heat-related illnesses, often due to limited mobility, lack of access to residential air conditioning, and/or failure to be a part of a community that can provide support during an emergency (e.g., faith community, neighborhood group, senior citizen center). Many groups of people are especially vulnerable to heat-related illness, including infants and young children, the elderly, people with chronic medical conditions, low-income households, and outdoor workers. If the proposed actions are taken, Columbus can minimize the serious risks posed by continuously rising temperatures.

N1 **Establish a larger, better coordinated, and more responsive network of cooling centers and draft clear guidelines for network members.**

Cooling centers provide air-conditioned facilities that are open to the public during extreme heat events. By simply providing an air-conditioned environment, these facilities can significantly reduce the risk of heat-related illness, especially for the members of the community that do not have access to household cooling.[6] Additionally, many of these facilities provide water to protect against dehydration. The City of Columbus should establish a larger, better coordinated network of cooling centers to accommodate residents during extreme heat events. This network could include a combination of public and private facilities operating under the same guidelines.

Currently, 29 of the 34 cooling centers in Franklin County are located in the City of Columbus.[7] The majority of these facilities are community centers run by the City of Columbus Recreation and Parks Department (CRPD). They operate as cooling centers during their respective hours of operation, which is generally Tuesdays through Saturdays from 11 am to 9 pm.[8] If extreme heat conditions warrant extended hours to support vulnerable populations, Community Center hours can be adjusted to accommodate residents during these events as the City recently did during extreme heat events in July 2018. The American Red Cross (Ohio Buckeye Region) also utilizes the CRPD centers for emergency needs, related to conditions that include extreme heat but also other emergency situations. While these buildings are geographically well-distributed and often in close proximity to transit routes, there are no centers that are open 24 hours a day.

Establishing a larger, better coordinated network of cooling centers would ensure that sufficient cooling centers are available and that all facilities operate as part of an organized network using the same guidelines that are designed to be responsive to the needs of the community. These guidelines should establish the requirements necessary for each of the facilities to operate as a cooling center, recommended hours of operation, the appropriate temperatures the centers should maintain to ensure cooling, and additional services that may be offered. Additional services may include providing food and water, allowing pets, offering information, or providing resources and activities that de-escalate tension and ease transition (e.g., activities for families and children, counseling, etc.). Key community organizations, such as the American Red Cross, could play instrumental roles in this process. Facilities with backup power generation should be provided in the network to maintain operations in the event of a power failure. If backup generators are installed or updated at these facilities, natural gas generators should be prioritized over diesel generators in order to ensure greater efficiency and cleaner emissions.

Another reason to establish a network of cooling centers is that while a list of "formal" cooling centers can be provided to citizens, many residents might seek cooling in other "informal" locations such as retail centers, churches, libraries, and buses. There are ample opportunities for local businesses, faith communities, and community assets to participate in the cooling center network. Residents will turn to trusted locations, regardless of their identified status as "formal" cooling centers. Therefore, it is important to involve these facilities in planning and communication to efficiently extend coverage of this important resource throughout Franklin County. Under the Extreme Heat Plan, ***Franklin County Emergency Management and Homeland Security (FCEM & HS)*** will coordinate information flow between various agencies, community partners, and the general public during an extreme heat

emergency, but the responsibility of opening and managing cooling centers will fall to local governments and non-profit organizations.[9]

Updated plans for a network of cooling centers during extreme heat events will also draw from and inform plans for heating centers during extreme cold events.

N2 **Implement educational campaign, health advisories, and best practices for time spent outdoors in extreme heat.**

A proactive educational campaign should be offered to the general public to emphasize the dangers of extreme heat. It should especially target individuals who work outdoors (e.g., construction workers, yard/tree care professionals, roofers), supervise children (e.g., summer camp supervisors and coaches), and care for senior citizens (e.g., social workers, nursing homes, faith communities). This campaign should clearly articulate ways to reduce risk by stressing sufficient hydration, reducing strenuous activities outdoors during the hottest hours of the day, and encouraging frequent cooling breaks when working outdoors.

Likewise, this campaign should include materials that will be distributed when a heat wave is imminent. These materials should include the recommended actions for the general population to take to mitigate the impacts of heat waves, which are largely the same as those of the proactive campaign. Specific reminders should be included for caretakers who look after high-risk populations. These reminders empower individuals to take action, thus reducing the likelihood of a high-risk populations being overlooked and emergency services being overtaxed. Additionally, information regarding specific heat wave events, such as the intensity and expected duration, should be available through the ***MyColumbus*** and ***ALERT Franklin County*** apps (A19).[10, 11] Educational campaigns need to take into account the methods of reaching particular audiences (e.g., television, radio, print media), languages spoken within all communities, literacy status, and trusted information sources within neighborhoods/ populations (e.g., faith communities and neighborhood centers). Detailed guidance for working with vulnerable populations is provided in a ***2007 public health report by Wingate***, the ***BRACE Framework from the CDC***, and a ***2018 publication of the OPHA***.[12, 13, 14]

To have maximum impact and avoid duplication of services, the City of Columbus should coordinate with FCEM & HS and the Extreme Heat Plan, updated in 2017. For instance, FCEM & HS has already identified conditions that activate their plan, developed a list of community partners to be engaged, and specified communication methods to be employed.[9]

A1 **Internalize climate resilience practices in city planning to reduce the urban heat island.**

The urban heat island (UHI) is defined as a city/metropolitan area that is warmer than its surrounding rural region as a result of human activities and has long been established as an accepted phenomenon.[15] Reduced vegetation and pervasive use of asphalt and concrete lead to heat absorption and reduced evapotranspiration, while tall buildings and narrow streets restrict air flow. Together, these features often cause a significant increase in air temperature within the city. The difference between urban and rural areas is generally greatest after sunset, and in a ***study of 60 major US cities including Columbus***, the difference was as much as 24°F.[16] Columbus had the 8th most intense UHI, with summers averaging 4.4°F higher in the city compared to rural areas, and the fastest-growing UHI with a 0.84°F per

decade increase since 1970. UHIs have many negative impacts, including increased energy consumption and reduced air and water quality, and they exacerbate the risks associated with extreme heat for those who live in or spend most of their time in the city.[17] Especially at risk are the high-risk populations discussed above and those who do not have or cannot afford to run air conditioning.

Additional actions can be taken to reduce the intensity of the UHI in Columbus. One of the most important strategies is to increase the amount of vegetation and tree coverage throughout the city.[18] In 2015, ***Branch Out Columbus*** began an initiative to grow the urban tree canopy by planting 300,000 trees by 2020.[19] CRPD is working with The Nature Conservancy and has identified the need for a strategic plan to guide implementation, as fewer than 40,000 new trees have been planted to date. "Green roofs" also lower temperatures by providing shade and cooling through evapotranspiration.[20]

Another strategy to reduce the UHI involves utilizing reflective and permeable materials on new or rehabilitated roofs and paved surfaces.[21] These materials lead to cooling by reflecting heat and sunlight away from buildings and pavement, and they have the added benefit of reducing stormwater runoff. Some roofing materials are even independently certified through the ***Energy Star Program***.[22] Not all surfaces are suitable for utilizing these materials, but they should be considered in new construction projects. This would apply to any projects requiring approval by the city. Additionally, incentive programs could be implemented to encourage the use of green infrastructure (GI), such as the ***stormwater credit program*** that rewards properties that incorporate green infrastructure with credits that reduce their stormwater service fees.[23] Through the ***Greenspot*** program, Columbus already promotes many of these practices for both businesses and households, and there should be an increased effort to grow the number of Greenspot participants.[24]

As mentioned above, the effects of UHI also extend to air quality issues. The most direct connection is through increased energy consumption due to cooling, which leads to greater emissions of air pollutants and greenhouse gases. Additionally, sunlight and high temperatures play a role in the formation of ground-level ozone, so this pollutant can become more prevalent as temperatures rise due to the UHI effect. Therefore, reducing the UHI can lead to several co-benefits that can increase the health and well-being of Columbus residents.

A2 Enhance programs to distribute fans, air conditioners, and water to vulnerable populations.

A number of social service organizations have campaigns during the summer to provide fans, and in more limited cases, air conditioning to their constituent audiences. For example, ***IMPACT Community Action*** offers a ***Home Energy Assistance Program (HEAP)*** which can aid with seasonal heating and cooling costs and provide support for replacing old appliances with new, energy-efficient ones.[25] The organization also provides a ***Home Weatherization Assistance Program (HWAP)*** to increase energy efficiency and lower energy bills for low-income households through services such as housing unit inspections, air-leakage detection, and home insulation.[26] The city should work with these organizations and others to increase the reach of services and fill identified gaps. With warmer conditions expected, particularly warmer nighttime lows coincident with higher humidity, fans may not provide sufficient cooling for the elderly or those with certain medical conditions. The same is true for individuals who need air filtration during hot days with air quality alerts. However, there are considerations that

must be made with air-conditioner distribution, including additional load on the household grid, ability to enclose a room for cooling, and affordability of a higher electric bill for the resident. Efficient distribution of fans and air conditioners could reduce demand on cooling centers. A program to distribute fans and air conditioners could replicate the network model described for cooling centers. Information on agencies providing distribution of fans and those entities that could be engaged to expand efforts in an emergency is available in the FCEM & HS Extreme Heat Plan, which was updated in 2017.[9]

In addition to fans and air conditioners, drinking water distribution programs could be established to ensure sufficient hydration during extreme heat events. ***Columbus Public Health (CPH) distributed water*** to citizens affected by nitrate exceedances in the drinking water in some parts of the city in 2016.[27] Likewise, the ***Toledo region water crisis*** due to harmful algal blooms (HABs) impacted over 500,000 people in the summer of 2014 and resulted in a response from local and state government and the Ohio Public Private Partnership (OP3).[28] These two events were on opposite ends of a delivery spectrum. While hot days require consumption of additional water by residents, there is no anticipated shortage of water as long as water supplies are not contaminated. Fortunately, Columbus has an inherent resilience due to its three separate water supplies, one of which is groundwater, but algal blooms are becoming an increasingly common occurrence in many waterways in Ohio.[29] Therefore, the hazard exists for source water polluti that could impact a larger population and result in the need for widespread distribution of water. As with many hazards, this would impact vulnerable populations the most. A plan to distribute water should be integrated with any plans already developed by FCEM & HS.

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Air Quality & Energy

Actions

N3 Modernize electric grid for greater resilience and more efficient energy distribution.

N4 Implement educational campaign on idling reduction.

A3 Implement educational campaign on energy audits and renewable energy to reduce emissions for residential and business users.

A4 Increase number of air quality monitoring stations to provide baseline data and public educational opportunities.

A5 Use data and best practices to adapt transportation modes and inform economics of transportation.

Background

Increasing temperatures will likely lead to deteriorated air quality in Columbus.[1] More people will be exposed to ground-level ozone (smog) and small liquid droplets or solids (particulate matter: PM) that are harmful to their health. While the federal ***Clean Air Act*** combined with local efforts have significantly improved air quality in Central Ohio, climate change threatens to set back some of this progress.[2] While all actions in this plan are primarily designed to adapt to climate change rather than mitigate it, action statements within this chapter may yield reduced greenhouse gas (GHG) emissions as a co-benefit. For instance, actions to reduce emissions of other airborne pollutants from transportation and heating sources in the city, such as ground-level ozone and PM, will also reduce GHGs.

An anticipated population increase in the Central Ohio region of between 500,000 and 1 million new residents will likely increase demand for electricity in Franklin County and Columbus, making resiliency planning in the event of extreme heat events even more important.[3] Extreme heat events will likely lead to increased demand for electricity to provide cooling, which may tax electrical systems when they are least efficient. Actions in this chapter that reduce energy use will provide climate adaptation through the creation of a more resilient grid while also yielding the co-benefit of climate change mitigation through reduced GHGs.

Increasing frequency and intensity of extreme precipitation events also threaten vulnerable utility infrastructure through both localized flooding and flooding of rivers. Relocation and replacement of infrastructure deemed to be at risk will provide an additional level of climate adaptation.

Air Quality

Pollution and its associated air quality impacts are not new problems for cities. Humans have long burned biomass for energy, transportation, and heat. Two pollutants of concern are PM and ground-level ozone. PM can enter the bloodstream and cause major health issues, while ground-level ozone can cause irritation of the nose and throat, chest tightness, coughing, and shortness of breath. Episodes of elevated PM are more frequent during the wintertime when the atmosphere is more likely to be stable. During summer, increased sunlight duration, combined with emissions from power plants and vehicles, can lead to the development of ground-level ozone. Increasing duration of consecutive hot days also leads to air stagnation and the buildup of ground-level ozone over time. Under particular circumstances, Central Ohio receives air pollution from upwind areas outside the region, including Cincinnati and Dayton. Together, these processes can lead to elevated air pollution levels and impacts to public health.

People most sensitive to the health effects of ground-level ozone and PM are those with heart or lung disease, children and the elderly, and those that are often active outdoors. In Columbus, the ***Mid-Ohio Regional Planning Commission (MORPC)*** monitors both of these pollutants, issuing daily air quality forecasts and providing alerts when levels are considered unhealthy for sensitive groups of people.[4] The ***End of Season Report from 2017*** showed that pollutant levels considered unhealthy for sensitive groups were reached on 2 days.[5] On 80 days in 2017, ozone pollution levels were “moderate or higher” according to the Air Quality Index system, and on 25 days PM pollution levels were “moderate or higher”. Air quality has

continued to improve in Central Ohio in recent decades despite population growth in the region (Fig. 3).

Decreases in ground-level ozone and PM are driven by changes in emissions from vehicles and power plants.[7] Ground transportation is still the largest source of volatile organic compounds (VOCs) and nitrogen oxides (NOx), which react with sunlight to form ground-level ozone. However, national emission control programs have served to decrease emissions from this sector significantly. The decrease in emissions from power plants has been driven by a mix of both national emission control programs and the decrease in numbers of coal-fired power plants due to the falling price of natural gas and subsequent coal plant retirements.

Along with these two main drivers, local efforts to improve air quality have been increasing.[7] Local governments and public transit providers have been converting their fleets to cleaner fuels and electric vehicles (EV); more businesses and governments are adopting no-idling policies and employing anti-idling technologies in their fleets; the ***Central Ohio Greenways*** trail system has expanded; and MORPC and partners are working to increase the number of commuters biking, busing and carpooling to work instead of driving alone through initiatives like the annual ***Central Ohio Commuter Challenge***.[8, 9] Taken together,

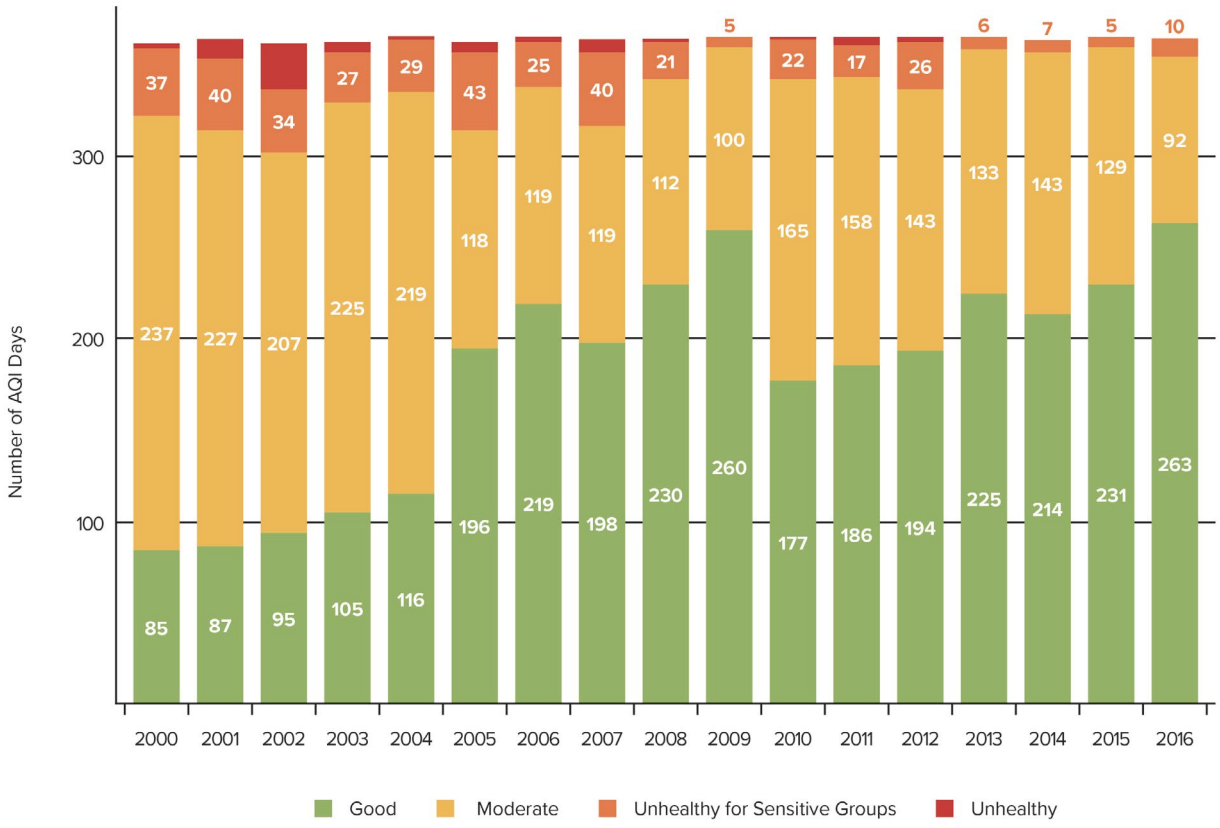

Figure 3. *Number of days meeting various air quality standards for Central Ohio from 2000 to 2016. Mid-Ohio Regional Planning Commission, 2017.*[6]

these efforts lead to cleaner air and are important for shifting the norms and behaviors that affect air quality, especially with a future of continued population growth and climate change impacts in the region.

Energy

Temperatures in Columbus have been rising at rates greater than the national average and are expected to continue to rise in the future.[1] Evidence shows that nights are warming faster than days, creating additional demand for cooling. Ultimately, these increasing temperatures could lead to greater energy consumption and emissions from power plants.

The recently released ***Franklin County Energy Study*** provides a detailed look at energy use within Franklin County between 2010 and 2015.[10] Franklin County is a net importer of energy in both fuels for transportation and heating and electricity for use in residential, commercial, and industrial settings. Overall, 69% of energy in Franklin County dissipates as heat rather than being used for its intended function. This number suggests that there are significant savings and environmental benefits to be derived from improving energy efficiency. Much of the energy generation and distribution system for Franklin County is regulated by state and federal agencies, which limits direct actions that the City can take to improve resilience and efficiency. There are a number of initiatives currently offered by Franklin County, the City of Columbus, local electricity and natural gas providers to improve energy efficiency for customers, which reduces overall energy consumption and stress on the grid.

This plan focuses on maintaining or improving air quality by reducing emissions of airborne pollutants and by providing a more resilient electrical grid through reduced peak demand and modernized infrastructure. Acknowledging that Columbus faces impacts of climate change, including extreme heat and intense rainfall events, regardless of future emissions, this chapter outlines two necessary (N) actions and three aspirational (A) actions that can be taken to adapt to these imminent changes. While climate mitigation steps that seek to reduce emissions of GHGs for their own sake should also be taken by Columbus, such efforts are outside the scope of this plan.

N3 **Modernize electric grid for greater resilience and more efficient energy distribution.**

While modernizing the electric grid and making distribution more efficient have the co-benefit of reducing GHG emissions and may be seen as climate change mitigation efforts, their inclusion in this document focuses on climate adaptation. Increasing temperatures will result in the need for greater cooling capacity. Individuals who already use air conditioning might need to run it more, and those who currently do not use air conditioning might elect to do so. This greater need for cooling will subsequently create periods of increased load on the electric grid. At the same time, rising temperatures make cooling processes and electrical distribution less efficient and lead to increasing infrastructure (i.e., transformers) failures. By making the grid more efficient and reducing consumer demand, electrical systems will not be overtaxed when they operate least efficiently and are of critical need for public health. By making the electric grid more resilient, its components will be able to operate in extreme temperatures while facing high demand. Likewise, components of the grid should be moved out of hazard zones (e.g., floodplains) that are more vulnerable to climate change impacts.

American Electric Power (AEP) Ohio and Columbus Division of Power (CDOP) provide electricity to the majority of Columbus customers. AEP Ohio has been implementing a number of grid modernization initiatives, each needing approval by the Public Utilities Commission of Ohio (PUCO). AEP Ohio has moved forward with advanced metering, appliance incentives, energy audits, and demand response. While the City of Columbus does not have any direct control over these initiatives involving AEP, the city could advocate for those that enhance efficient energy distribution and reduce energy usage during peak demand. Likewise, efforts to make the electrical grid more resilient, such as the movement of an AEP Ohio substation out of the floodplain near The Ohio State University campus, should continue, and careful consideration should be given to the conditions (i.e.,temperatures and durations at those temperatures) under which components of the grid will need to operate over their expected life spans.

CDOP serves approximately 14,000 customers and the street light system (53,000+ lights) throughout the City. The division purchases its power through long-term contracts with energy suppliers and uses the revenue from its energy sales to support and maintain the street light system at no cost to taxpayers.[11] Like AEP Ohio, CDOP is proceeding with advanced metering infrastructure and offers a demand response program to customers. Demand response gives customers an opportunity to play a major role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. Columbus has greater control over the actions of the CDOP because it is a division of city government. It is important to note that any actions taken by the City should ensure that citizens still receive affordable and reliable electricity. In addition to its current initiatives, it is recommended that CDOP examine the resilience of its components to threats of extreme heat and flooding.

Part of grid modernization includes variable rate billing, like time-of-use pricing, that will incentivize consumers to use electricity when it is not at peak demand. For such programs to succeed, consumers will need to be educated and have access to tools to make decisions to reduce their consumption during certain times of the day. Without education and tools, consumers who are unaware of when they consume electricity or do not have a choice when they consume electricity could face higher costs, and the benefits of variable rate billing could be more difficult to accomplish.

Smart Columbus

The ***Smart Columbus*** initiative has a priority to promote decarbonization through utility-scale renewable projects like AEP Solar and Wind Generation and grid modernization projects like Advanced Metering Infrastructure (AMI).[12] Likewise, this program is working to increase the adoption of electric vehicles (EV) and multi-modal mobility options. An example of a Smart Columbus initiative was a $3,000 rebate on the purchase of EVs by public fleets in Summer 2017. Without transitioning toward greater use of renewables, the use of EVs could merely shift the problems of ground-level ozone and PM emitted for transportation in Columbus from Central Ohio to other regions.

N4 **Implement educational campaign on idling reduction.**

An idling reduction education campaign will allow for climate adaptation by reducing emissions that contribute to deteriorated air quality, especially during extreme heat conditions. Idling reduction policies have been implemented by many school districts to protect youth and reduce the inhalation of PM from diesel exhaust. Still, while it is more common to see anti-idling signage in close proximity to building air intakes, there are a significant number of fleets and individual vehicles that continue to idle when not in motion. A focused educational campaign within Columbus could help alter these harmful practices. Unfortunately, many individuals are still idling their vehicles based on outdated practices that are not necessary with modern vehicles.[13] For instance, driving off gently after running the vehicle for 30 seconds will warm up the engine and interior more quickly than idling. Starters and batteries are more durable than in the past and will not be damaged by being turned on and off when stopped at a drive through or to pick someone up.

This campaign should include vehicles with gasoline engines, whereas previous campaigns only targeted those with diesel engines. The message should clearly articulate the economic and environmental benefits of reduced idling and a description of why these practices are not needed with modern vehicles. High-impact target audiences could include fleet managers and delivery services. The city should create ways of conveying this information to the general public by utilizing freeway traffic information boards and social media outlets. With the shift towards electric fleets and personal vehicles, the need for this program will be reduced over time as internal combustion engines become a smaller part of the transportation sector. Projected changes in the vehicle market show considerable growth for EVs.[14]

A3 **Implement educational campaign on energy audits and renewable energy to reduce emissions for residential and business users.**

While this action has the co-benefit of reducing GHG emissions and may be seen as a climate change mitigation effort, its inclusion in this document focuses on climate adaptation. As was described earlier in this chapter, increasing temperatures may result in the greater need for cooling. By reducing demands by individuals and businesses, the electric grid will not be overtaxed at a time when it is least efficient and of critical need for public health.

Energy efficiency programs are provided by utilities under programs funded by ratepayers and approved by PUCO. In Columbus, both ***AEP*** Ohio and ***Columbia Gas*** provide energy efficiency programs, including online information, rebates, and energy audits.[15, 16] Energy audits are one of the most cost-effective ways to reduce energy consumption. As part of these programs, an expert conducts an independent analysis, property owners are given a detailed report that includes payback periods for energy efficiency actions, and contractors can be hired to make remediations on a schedule determined by the property owner. For the convenience of customers, audits for both electricity and natural gas can often be completed at the same time. To incentivize high-impact actions, the utilities often subsidize actions with short repayment periods. There are additional programs for both energy audits and energy efficiency remediations targeted at low-income populations. While these programs have the potential to save customers money and have a significant environmental benefit, the programs have already saturated the market of early adopters and face increasing difficulty engaging the next tier of customers. For many, it may seem counterintuitive that the utility would offer programs to save them money and reduce their consumption of energy, but Ohio law and regulations established a ***ratepayer-funded program for energy efficiency*** delivered through the utilities.[17, 18] The CDOP does not currently offer but is considering the implementation of a program similar to AEP Ohio.[19]
The City of Columbus should build on its partnership with utilities like AEP and Columbia Gas to serve as trusted ambassadors in an educational campaign to reach new audiences. Conversations with utility providers revealed interest in reaching a larger audience with these programs, presenting an opportunity for partnership with the City of Columbus. Audiences to be targeted should include those who offer the overall greatest energy savings for the investment of financial resources and those that lack the financial resources to make remediation on their own and for which utilities are a disproportionately high cost.

In recent years, AEP Ohio and Columbia Gas have partnered with the City of Columbus to develop an ***Energy Efficiency Roadmap for Columbus Businesses and Organizations*** and pilot a ***Community Energy Savers*** initiative.[20, 21] AEP Ohio and the City worked with the Discovery District as the first Columbus Community Energy Savers neighborhood. Since then, AEP Ohio and the City teamed up with Columbia Gas of Ohio to work with other neighborhoods within Columbus. Community Energy Savers is a program that offers a framework for public utilities to work collaboratively with the City and neighborhood partners to deliver an educational campaign that works to accomplish mutually beneficial goals of reducing energy consumption and saving customers money.

Educational campaigns should inform AEP Ohio and Columbia Gas customers about the portfolio of energy audits available and share ***Community Assistance Programs*** available to low-income populations.[22, 23] The City of Columbus had success with its ***GreenSpot*** program, which encourages and provides resources to residents,

Financing Energy Efficiency

The Columbus-Franklin County Finance Authority's EnergyWorks program provides financing to businesses and non-profit organizations located in Franklin County for cost-effective energy efficiency programs in both new and existing facilities.[25] This initiative can be combined with Property Assessed Clean Energy (PACE), allowing property owners to finance their improvements through future property tax payments, thus enabling the use of upfront funds for improvements that can be paid back incrementally over time.[26] The recent energy efficiency renovation of the PNC Plaza in downtown Columbus is an example of a project that took advantage of EnergyWorks and PACE. Energy efficiency can be increased and peak demand can be reduced through careful design of new facilities and retrofitting of existing facilities.

businesses, and community groups to implement green practices.[24] This project might provide insight for an educational campaign on energy audits and renewable energy.

In any built system, human behavior is often a determinant in performance. This is especially true in residential and business properties with spaces that are shared by multiple users who are not directly responsible for energy costs. In addition to infrastructure improvements, successful incentives will need to be based on understanding behaviors and target those that align with reduced consumption by individuals living and working within a building.

Therefore, social scientists, in addition to engineers, should contribute to efforts to improve energy efficiency and reduce peak demand. Likewise, any educational campaign, especially one targeted at businesses and nonprofits, should highlight the Columbus-Franklin County Finance Authority's ***EnergyWorks*** and ***Property Assessed Clean Energy (PACE)*** programs.[25, 26] These programs offer critical financial arrangements that make large up-front investments viable by distributing their costs to businesses and nonprofits over a period of time and impacting how these costs appear on an organization's balance sheet. Greater details about such an initiative are anticipated in the forthcoming ***Local Government Energy Partnership*** from MORPC.[27]

Columbus customers who receive their electricity through the CDOP or AEP Ohio have the opportunity to purchase a portion or all of their electricity from renewable sources. Over the past two years, CDOP has developed the ***EcoSmart Choice Green Pricing Program*** and taken steps to educate customers including: updating the CDOP website with new content about advanced metering infrastructure (AMI), EcoSmart and green purchase power commitments and providing a link for customers to enroll in EcoSmart; designing and sending EcoSmart postcards to customers; issuing a press release regarding CDOP Green Energy Options; forwarding talking points for EcoSmart to CDOP staff and Department of Public Utilities

(DPU) customer service representatives; posting social media content to DPU social media accounts; and including information within a newsletter mailed to CDOP customers as a monthly bill insert in September/October 2017.[28] A campaign promoting renewable energy options to AEP Ohio customers would need to focus on explaining the process for selecting an electricity supplier and navigating the PUCO ***Apples to Apples Comparison*** tool (specifically the renewable energy field).[29]

Installing energy efficient appliances and performing remediations recommended by energy audits provide greater grid resilience through reduced peak demand. Likewise, on-site electricity production, provided by systems such as residential solar, can reduce peak demand if electricity production is coupled with demand. For instance, solar panels are likely to deliver maximum production during sunny days in the summer when demand for electricity for air conditioning is also likely to be greatest.

Regardless of whether Columbia Gas, AEP Ohio, or CDOP are involved, an educational campaign focused on energy efficiency or renewable energy should look closely at current awareness and participation among customers and subsequently work to reduce identified barriers to participation. Establishing key milestones will allow success to be monitored and campaign efforts to be adapted.

A4 Increase number of air quality monitoring stations to provide baseline data and public educational opportunities.

An increased number of air quality monitoring stations will provide more data to inform planning by MORPC and the City of Columbus and encourage individuals to change behaviors in ways that will reduce both emissions and exposure. There is a growing body of research on the localized nature of air pollution that suggests traditional estimates of citywide air pollution based on a few select measurements are inaccurate, and personal exposure can vary tremendously between locations, even those short distances apart.[30] Infrastructure, including plantings, also plays a role in the transport and removal of air pollutants.[31] There are currently three ground-level ozone sensors and two PM sensors, maintained by ***Ohio EPA***, collecting data from three sites in Columbus; a fourth site is currently offline.[32] These stations provide near real-time data for air quality alerts and long-term data sets for planning. Likewise, data collected from these stations determine Columbus' compliance with federal air quality standards. The stations provide a coarse look at air pollution within the city but do not capture the differences in air quality that occur across Columbus neighborhoods.

Therefore, to enhance observations specific to areas throughout the city and improve both planning and education, Columbus should increase the number of stations within the network. The extra monitors added by the City would not be part of the Ohio EPA monitoring network as there are specific criteria for inclusion in that network. Hence, these additional sensors would not be for compliance with federal ***National Ambient Air Quality Standards (NAAQS)***, but rather to collect additional data for the Columbus region to inform planning and educate the public.[33] This initiative would provide a structure for air quality monitoring similar to one that already exists for water quality monitoring within the state. In Ohio, there are three levels of classification for water quality data, with Level 1 used solely for education to Level 3 used for regulation. Watershed groups, largely volunteers, play a critical role in collecting Level 2 data that promotes public awareness while also serving as an initial water quality screening and identifying problematic pollution

Yay Bikes!

Bicycle advocacy organization ***Yay Bikes!*** influences the conditions that help people safely and comfortably ride bicycles for transportation.[38] Surveys show that most people would like to ride more for that purpose, but obstacles such as fear of riding in traffic can prevent them from doing so. Upon engaging thousands of these "bike curious" folks on fun, educational How We Roll and Year of Yay! rides, it's clear that, for many, mode shift is just a short ride away. Once they're riding, Yay Bikes! provides parking solutions through Dero bike rack consulting and Yay Valet! event-day bike valets. Meanwhile, Yay Bikes! Professional Development Rides are transforming the way hundreds of professionals throughout Ohio are designing for bicycle friendly communities.

sources that are beyond the financial resources of Ohio EPA to monitor.[34] The model that has been employed for water quality could be mirrored for air quality.

Due to infrastructure costs, the technical skills required of staff, the need to validate data, and possible logistical considerations of siting, station placement is critical. Data collected in early years will provide an air pollution baseline for comparison as the city continues to grow in population and development, and transportation patterns change. Educational opportunities should include the health impacts of ground-level ozone and PM to contextualize the importance of data collection. Likewise, finer resolution data collection is more likely to motivate individuals to consider air quality impacts in the places where they live, work, and play. Such awareness could inform decision-making (e.g., where and when to exercise, the undesirability of a residence downwind of a heavily used interstate) and advocacy for public policies (e.g., better emissions controls, improved public transportation). Likewise, individuals can elect to change their behaviors to reduce their emissions of air pollutants (e.g. for instance, by electing to drive less) or reduce their exposure to air pollutants (e.g., by avoiding the outdoors during times of elevated air pollution).

Air quality monitoring stations, while traditionally expensive, have been declining in cost over the past few years. In fact, some consumer-grade systems have been developed and integrated into networks that allow citizen scientists to collect data. One of the concerns about these systems is maintaining quality control of data; but, with sufficient education about their limitations, there may be a role that consumer-grade systems can play in both supplementing data collection and educating the public. Over time, a larger network of stations should provide a more refined temporal and spatial view of pollution, allowing the City of Columbus and individuals to make decisions that improve public health and quality of life. An example of a citizen science network with a digital platform that aggregates and displays data collected using low-cost, easily-installed sensors for PM is ***PurpleAir***.[35]

Central Ohio Transit Authority — COTA

As central Ohio's population continues to grow, access to diverse mode choices becomes increasingly important. COTA has taken a proactive approach to expand mode choice by launching the CBUS, a free Downtown circulator, and CMAX Cleveland Avenue Bus Rapid Transit, which connects low-income communities to jobs, education, training and medical appointments. On May 1, 2017, COTA restructured its bus network to better serve our growing region; by using demographic and travel data and an emerging method of splitting competing service purposes into two design criteria, COTA created a more effective bus network.

A5 Use data and best practices to adapt transportation modes and inform economics of transportation.

Reducing emissions from vehicles with internal combustion engines will reduce emissions of GHGs and other airborne pollutants. Ground-level ozone pollution levels are observed to increase with higher temperatures resulting in worse air quality. As such, this action is specifically designed to address deteriorated air quality that could result from transportation emissions interacting with extreme heat in Columbus.

There is a growing and changing landscape of transportation options in large cities such as Columbus, and an expanding suite of data collection tools available to better understand people's needs and preferences. This data collection, in coordination with planning among the various players in transportation, allows Columbus' transportation options to serve people in a more effective and efficient way with lower transportation emissions. Small nudges, whether incentives or disincentives, could be introduced to promote behaviors that move the system in this direction. These incentives and disincentives could focus on a suite of efforts to reduce overall transportation pollution through a reduced number of single-occupancy trips, lowered use of polluting fuels, increased use of low-emissions vehicles, expanded access to EV charging stations, and expanded transportation options and times.

Change is easiest when financial decisions of individuals align with desired behaviors. For example, variable demand-based fares could be introduced to incentivize transportation, including commutes outside of peak hours. With commuters, this structure is only likely to work if educational campaigns or other incentives engage employers who have the ability to adjust work hours. Sometimes, these barriers to behavioral change are not readily obvious, but once overcome, can tip a system toward greater adoption. For instance, research has shown that while many employees express interest in vanpools, many are unwilling to actually participate once such programs begin. With the addition of a limited number of rides home in a cab each year in cases of emergencies

(a relatively small cost), a greater number of individuals were willing to join the vanshares.[36] Finding the root of barriers to participation may require careful data collection and consultation with social scientists.

We also know that the "last mile" of transport (a phrase initially coined for delivery of goods but more recently applied to the stretch between a primary mode of transport and an individual's final destination) is often the missing link in a system and a focus of the Smart Columbus initiative.[37] Careful consideration should be given to ways that existing components of the transportation system can bridge the "last mile", and where new components need to be created to fill voids. When various options are explored, all other things being equal, those that result in lower emissions should be given preference. These decisions should be underpinned by the data collected in Columbus, experts in the transportation sector, and research conducted globally. Efforts to incentivize purchase of a greater number of EVs and provide charging stations, in addition to offering multi-modal transportation options, are all being led by the Smart Columbus initiative.[12] Other options to be explored include encouraged use of bicycling and walking for short-distance trips, increased circulation of free buses through high traffic areas, exploration of special circulators on certain days or weeks of the year, and special programs that expose and allow individuals to explore alternate transportation modes.

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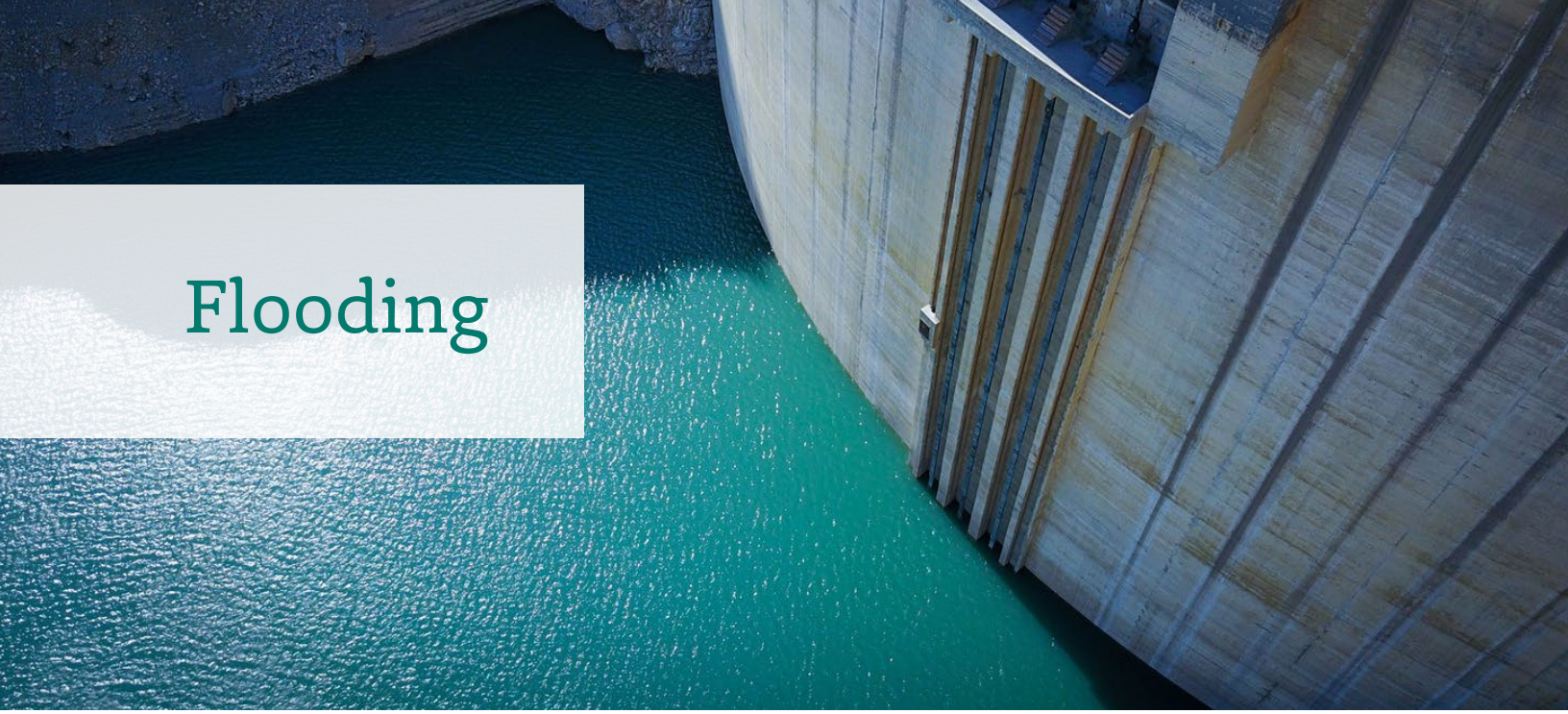

Flooding

Actions

N5 Design and implement an educational campaign that leads to reduced impacts of stormwater and basement sewage backups, promotes use of green infrastructure, and accurately conveys risks to and responsibilities of property owners.

N6 Review city regulations, technical documents, departmental processes and plans, property owner programs, enforcement mechanisms, and monitoring efforts to ensure that current practices reduce localized flooding and basement/sewage backups.

N7 Develop an emergency plan that can be implemented during a flood to ensure adequate transportation and logistics for critical resources.

N8 Identify and assess risk associated with older flood control and stormwater infrastructure, and use data gathered to reduce risk by developing property owner education, informing the city's capital projects, and establishing property owner requirements.

A6 Advocate for state and federal government to implement policies that reduce erosion and runoff and promote infiltration.

Background

Increased precipitation, one of two broad climate changes identified in the Great Lakes Integrated Sciences and Assessment (GLISA) ***Climate Change in Columbus, Ohio*** report, will create a greater flood risk for Columbus.[1] This increased flood risk creates major vulnerabilities to energy and water infrastructure, health, and transportation. The National Centers for Environmental Information climate change ***summary for Ohio*** highlights changes that have already taken place since the mid-twentieth century, including an increase in average annual precipitation and extreme events (greater than two inches per day).[2] Future projections include increases in precipitation during autumn, winter, and spring that may affect timing and locations of flooding.

Flooding and basement backups are not only dependent on precipitation but also decisions made by the City, developers, and residents. While most consider it ill-advised to construct buildings and critical infrastructure in floodplains, flooding occurs outside of these areas as well. GLISA notes that throughout the Midwest, minor infrastructure and property inundation often occurs at 1.25" of daily rainfall. For Columbus, there were 2.8 more days per year in 2012 where precipitation exceeded 1.25" compared to 1951, meaning the potential for basement backups and standing water on streets has increased.[1]

The August 2017 Houston floods, resulting from Hurricane Harvey, serve as a recent, cautionary case study. Development patterns resulted in a significant increase in impervious surfaces and location of structures within reservoirs.[3] The sustained rainfall during Harvey inundated the region and caused significant damage to both public and private infrastructure. The region saw smaller flooding events during the springs of 2015 and 2016 and summer of 2018, indicating that the flooding during Harvey was not an isolated event. Furthermore, an investigation over an eight-county region around Houston in 2015, using a random sampling of permits issued by the Army Corps of Engineers to developers, discovered an oversight failure in enforcing wetlands mitigation. The failure resulted in only 236 acres being installed when 1,306 acres should have been installed.[4] In this case, the lack of ground-truthing that mitigation wetlands were installed was the issue, not permitting. In a city without sufficient regulation and oversight, proper installation of risk-reducing measures may not be taken voluntarily, and the failure of individual property owners to comply can result in damage to properties other than their own.

Current floodplain maps underestimate flood risk, and engineering technical bulletins designed to inform infrastructure projects understate the frequency and intensity of extreme rainfall events. These maps and technical bulletins, which until recently have used historical data to anticipate future events, need to rely more heavily on computer modeling of complex Earth-system processes to inform planning for a future that is different than the past. Employing such computer modeling, while having a cost, ensures that infrastructure is designed to handle the conditions it will likely be subjected to over its lifetime.

Understanding the different causes of localized flooding and basement backups, as well as the City's current and future infrastructure plans, is key to adapting to the risk of increasing precipitation in Columbus. In order to address these vulnerabilities, we propose four necessary (N) actions and one aspirational (A) action to adapt to the increased flood risks.

N5 **Design and implement an educational campaign that leads to reduced impacts of stormwater and basement sewage backups, promotes use of green infrastructure, and accurately conveys risks to and responsibilities of property owners.**

To maintain proper drainage and mitigate property damage during flooding events, the City has installed a network of infrastructure along major drainages. Following the massive floods of 1913 and 1959, measures were taken to mitigate damage from future events. However, these were still not sufficient, and a 7-mile long Franklinton Floodwall was built between 1993 and 2004. Maintenance schedules and flood control plans guide the upkeep and use of the physical infrastructure. However, stormwater systems in many areas have not been upgraded to include floodgates or backflow preventers; where they have been implemented, unintended or additional property development may lead to increased susceptibility of basement backups. Private flood control infrastructure was also installed during this time, but not all of it was documented and maintenance is not consistent.

Water flows through storm sewers under the force of gravity to lower elevations including the city's major rivers. During elevated river levels, flow in storm sewers may reverse direction and flow from the river into protected areas. Floodgates and backflow preventers are designed to restrict water flow from inundating these protected areas. Stormwater infrastructure, without floodgates or backflow preventers, may therefore exacerbate localized flooding.

Basement flooding occurs primarily through a failure in the sanitary sewage/combined stormwater collection system (most of the city has separate systems) or other stormwater drainage issues, and the two are rarely related. The property owner is responsible for the portion of the sewage collection system extending from the building to the point of connection to the city sewer, while the City is responsible for the rest. A failure in the sewer collection system caused by blockage (e.g., roots, debris, grease, pipe failure) can lead to basement flooding. The system-designed carrying capacity can also be overwhelmed by excessive infiltration and inflow during a rain event (e.g., residential downspouts directing stormwater to the sewer system), causing water to back up into the property owner's basement. Poor stormwater drainage (e.g., poor grading around the building, altered stormwater drainage paths on/over/across the property) can also cause basement flooding, as water enters through basement windows or defects in the floors and/or walls.

In the case of backflow preventers, their cost is negligible if installed during construction or retrofitted when pipes are exposed, but their impact can be tremendous if they prevent even one basement backup. Likewise, solutions to direct water at least eight feet from a building's foundation and services to routinely clear roots and debris from sanitary sewer lines are low-cost options available to all homeowners. Consideration should be given to redundancy in systems. For instance, sump pumps are commonly used in new construction, but without a battery backup, they will not function during an intense rainfall event with a power outage. Both backflow preventers and sump pumps require periodic inspection, proper maintenance, and an understanding of their limits.

Increasing precipitation is a threat multiplier to the capacity for the city's sewer and stormwater infrastructure. Therefore, the City of Columbus has been a leader in green infrastructure (GI) deployment—encouraging the use of GI in private development and constructing GI as part of its own operations. GI, as guided by ***Blueprint Columbus***, reduces impacts of stormwater runoff by temporarily storing water, promoting

infiltration and uptake of water by vegetation, and capturing sediment and pollutants contained within runoff.[5] GI also has the potential to provide co-benefits, including ecosystem restoration, mitigation of the urban heat island, the addition of local jobs, and aesthetic beauty. The City currently provides funding to the Franklin Soil and Water Conservation District (FSWCD) for the ***Community Backyards program*** to do on-property consultations with homeowners wishing to install GI on their private property.[6]

The City should work to identify knowledge gaps in the shared responsibility of reducing flooding and basement backups (e.g., grading, backflow preventers and their maintenance, cleaning out of sanitary sewer lines, relining, downspout disconnects, and clearing drainage swales) and installing GI. This includes encouraging landlords to communicate the needs to tenants as well as notifying property owners who are known to be at risk but may not be aware. Since new risks might be uncovered as technical documents are updated, model runs more accurately capture performance of the system, and policies are reviewed, the Department of Public Utilities (DPU) should swiftly communicate information to property owners through website material, bill inserts, and yearly hot cards mailed to property owners. In essence, the city needs to clearly communicate its best understanding of the system in a timely fashion so that property owners and tenants have opportunities to reduce their risk.

N6 **Review city regulations, technical documents, departmental processes and plans, property owner programs, enforcement mechanisms, and monitoring efforts to ensure that current practices reduce localized flooding and basement/sewage backups.**

Regulations and Technical Documents

The City of Columbus has two existing documents that will continue to address localized flooding and basement/sewage backups in the city. These include the ***Columbus City Code Chapter 1150 (Floodplain Management)*** and the ***Stormwater Drainage Manual (SWDM)***.[7, 8] Updates to these documents should include enhanced specifications for wetlands, catchments, and stormwater pipes to take into account greater loads due to more intense rainfall events. New construction and retrofits should be required to include infrastructure that has the ability to store stormwater or promote its infiltration into the subsurface.

Chapter 1150 should continue to be used to protect the city's inhabitants from flooding, stream bank erosion, and the hazards associated with developing in the floodway. This Columbus City Code gives the City the authority to regulate development in the floodplain. If development is proposed in the 100-year floodplain, it must be properly elevated, and any flood volume lost due to filling the floodplain fringe must be offset so that the flood carrying capacity of the watercourse is maintained. Only very limited development is allowed in the floodway, such as reforestation, wetland reforestation, and construction of recreation trails. These regulations help to protect the population from flooding that could otherwise occur as a result of new development and redevelopment; these regulations should continue to be enforced.

The City should continue its protection of existing water resources via enforcement of the SWDM. The SWDM requires the permanent protection of the Stream Corridor Protection Zone (SCPZ) —the stream and riparian area along the stream—for streams in Columbus and prohibits development in this zone without being granted an exception from current city zoning requirements. The SWDM sets forth the City's wetland policy,

requiring preservation of existing wetlands in the SCPZ and encouraging mitigation of wetland impacts outside the SCPZ, within the limits of the development site. The SWDM also requires the installation of stormwater controls during and post development to reduce soil erosion and protect water quality. The SWDM is currently reviewed and updated periodically to capture recent trends in extreme rainfall, but the document does not take into account projections for the frequency, intensity, and duration of rainfall events expected by the middle to end of this century. It is imperative that each iteration of the SWDM consider the current and projected precipitation changes, as many subsequent decisions made in Columbus are guided by this document.

The SWDM informs Blueprint Columbus and provides design criteria for the use of GI such as green roofs, permeable pavement, rainwater harvesting, and bioretention facilities. The City offers up to a ***100 percent reduction in stormwater fees*** to property owners who install GI to manage stormwater runoff from their properties.[9] This policy is designed to encourage installation of GI as a means of stormwater quantity and quality control. The City should continue to incentivize the installation of GI via the GI credit, should continue to use GI in its own construction programs, and may wish to consider adopting additional policies or practices that require or incentivize the installation of GI on private property as a means of reducing the impacts of stormwater runoff from public and private property.

Departmental Processes and Plans

The City should analyze whether current storm sewer sizing requirements will be sufficient to convey the stormwater loads from more intense and higher frequency rainfall events as projected. The DPU already has a review plan in place to identify projects where there may be sanitary sewer capacity issues that require modeling of these scenarios. If capacity issues are found, DPU requires the developer to reduce density, requires upsizing the stormwater infrastructure, or disapproves the development. Through Blueprint Columbus, DPU will disconnect improper perimeter drains from basement floor drains for over 18,000 acres of property located in the city. Studying the impact of improvements installed through Blueprint Columbus will inform the next generation of infrastructure and provide guidance in future code updates.[5] Although systematically identifying unlawful connections outside of Blueprint Columbus areas will be challenging, the City should consider legislation requiring an inspection of basement perimeter drains and remediation of improperly connected drains on all properties at the sale of the property.

Property Owner Programs

The City should consider policies or best practices that require or incentivize any new or redevelopment projects to use GI to reduce runoff. For homeowners, the Community Backyards program offers rebates for the purchase of native plants. This program is an example of how an agency can deploy a number of innovative strategies to reduce runoff using incentives.[10] Market mechanisms, including assessing a cost per volume of anticipated or actual runoff, should also be considered. Regardless, the costs associated with runoff, which have often been an externality, need to be explicitly accounted for in both development and redevelopment.

In some cases, technology, such as backflow preventers on sewage and stormwater systems, can be installed to reduce damage to property during localized flooding. ***Project Dry Basement*** is a program currently run by the DPU and is

designed to prevent sanitary sewer backups in single- and two-family homes.[11] If a home is eligible, the City will provide installation of an approved backflow prevention device on the home sewer line using the City's certified plumbing contractor. This program should continue.

Enforcement Mechanisms and Monitoring Efforts

Sufficient enforcement is required to ensure that property owners and developers abide by approved plans in compliance with regulations. The City, as a regulated municipal separate storm/sewer system, is required pursuant to its ***National Pollutant Discharge Elimination System*** permit to maintain the legal authority necessary to inspect, monitor, and enforce construction and post-construction stormwater controls.[12] Additionally, the City's code, erosion and sediment pollution regulations, and its SWDM (which has been promulgated as a Director's rule) give the City enforcement authority to require properties to return to compliance and pay a penalty if they violate requirements of the City code, regulation, or rule.[13, 14]

Over 500 construction sites are inspected annually to ensure erosion and sediment control practices are properly implemented. City inspectors also perform frequent inspections of stormwater quality controls on public and private property to make sure controls are maintained and operable. And under the ***Pretreatment Program***, over 275 industries are inspected annually to confirm that Ohio Environmental Protection Agency (OEPA) permit requirements for such users are met.[15] The City annually inspects residential septic treatment systems for compliance with public health requirements. The City annually inspects home-septic treatment systems for compliance with public health requirements. Underpinning all of these efforts is the City's commitment to monitor its stormwater outfalls during dry weather to detect illicit discharges that might be introduced into the storm sewer system. When the City finds violations of stormwater code, regulations, or rules, it takes action to return a property to compliance first through administrative enforcement and later through judicial enforcement if a property fails to return to compliance. This combination of monitoring and enforcement is essential to ensure that the quantity controls in the SWDM, which are designed to prevent flooding from occurring, are properly constructed and maintained. As precipitation increases, this will become increasingly critical to ensure that the Columbus population is properly protected.

To inform policies and modeling over the long-term, a monitoring program should be created that collects data (e.g., water storage and flow, sediment movement, and nutrient loads) annually from a certain portion of completed projects. Such a program would gauge the efficacy of various installed solutions and ensure that they result in the desired storage or infiltration goals. This program would create a continual feedback loop to guide future decisions. The City, in consultation with experts, should determine the data to be collected, the number of sites to be examined annually, and current policies that may connect to this program.

N7 **Develop an emergency plan that can be implemented during a flood to ensure adequate transportation and logistics for critical resources.**

Extreme precipitation can inundate low-lying roadways, fill reservoirs beyond capacity, render bridges unusable, and necessitate closing of floodgates. For this reason, Columbus should have an emergency transportation plan in place

to use when necessary. During floods, it can become increasingly difficult to move people out of harm's way in a timely fashion or to transport assets to neighborhoods in need. As was witnessed in South Carolina in 2015, California in 2016 and 2017, and Houston in summer 2017, a geographically widespread and temporally sustained event can prevent resources from getting to those individuals who need them.[16, 17, 18] While the Great Flood of 1913 was the last time that Ohio experienced such widespread conditions, increased precipitation make such events more likely.

Franklin County Emergency Management and Homeland Security (FCEM & HS) has developed the Emergency Support Function 1 (ESF1): Transportation that may be implemented during floods.[19] ESF1 is responsible for management of transportation systems and management of transportation infrastructure during threats or in response to actual incidents. Activities under this ESF1 are directed by Franklin County Engineer's Office (FCEO) and Central Ohio Transit Authority (COTA) with support from many other transportation industry entities. Transportation encompasses all transit surface modes, including ground transportation, air travel, and rail routes; transportation infrastructures (roads, routes, and bridges); and assets that move people and supplies in and out of Franklin County. During disaster events, it may become necessary to relocate citizens to protected areas. Conducting these types of movement is the primary responsibility of COTA supported by agencies charged through ESF1. This emergency support function also includes the ***City of Columbus Downtown Evacuation Plan*** and the Mid-Ohio Regional Planning Commission (MORPC) ***Evacuation Framework***.[20, 21] The City needs to determine whether ESF1 is sufficient for emergency transportation in Columbus during floods or if a supplement is needed for the city. All planning documents should be periodically updated as our scientific understanding of flood threats improves and lessons are learned from floods affecting other communities.

As is noted in the Emergency Preparedness chapter of this plan, Columbus should develop geographic information system (GIS) resources that tag critical assets and transportation infrastructure that may be affected by a flood. By sharing this information with various stakeholders, new transportation routes could be developed based on a variety of circumstances. Particularly vulnerable populations, such as those in close proximity to a floodplain or unable to relocate due to inaccessibility of transportation, should also be identified on the GIS resource. The ***Ohio Department of Transportation (ODOT)*** recently identified transportation links that are most at risk due to climate change; these include one that is susceptible to flooding in Central Ohio and should be included in all planning documents.[22] GIS staff members knowledgeable in the data will be necessary throughout the entirety of an emergency to provide information to decision makers and emergency services and to create updated maps that may be shared with the public. Such a staff position exists within FCEM & HS.

In addition to transporting people away from affected areas, plans need to be developed to provide transportation and logistics for critical resources, such as medical supplies and bottled water. GIS resources should be used to identify both critical assets (e.g., hospitals, fire stations, shelters, and distribution centers) and transportation routes between them (e.g., primary and secondary routes). These GIS tools should include identification of neighborhoods and routes that are likely to be inundated under various scenarios. In the case of l regional events, plans should specify procurement of supplies from outside the region via reliable transportation routes.

Following a series of recent floodwall exercises, DPU began exploring the creation of a live map to display safe-travel options in the event floodgates are closed. If this tool was pushed into development, it would involve collaboration between DPU, the Department of Public Safety, Columbus Police, and Columbus Fire on the creation of roadway routing for emergency and residential vehicles. While this tool would only be used during major river flooding, it would be a first step to identifying and communicating transportation routes.

N8 **Identify and assess risk associated with older flood control and stormwater infrastructure, and use data gathered to reduce risk by developing property owner education, informing the city's capital projects, and establishing property owner requirements.**

The City of Columbus reviews and implements stormwater infrastructure improvements based on needs informed by engineering modeling as well as flooding and water-in-basement complaints raised by its residents. Engineering modeling can be enhanced by updating the SWDM, which informs modeling based on anticipated frequency, intensity, and duration of rainfall events. Updating the SWDM is discussed above. Likewise, the City can continue to utilize reported flooding and water-in-basement complaints contained within its management database (WAM), including use of GIS cluster/heat mapping, to inform capital projects.

DPU has established an Internal Floodwall Committee within the Division of Sewerage and Drainage (DOSD) tasked with gathering all physical information related to the floodwall, including deficiencies and guidance for developers who intend to build in close proximity to the floodwall. This ensures that developers understand the regulatory requirements of the Army Corp of Engineers. The City is also taking inventory of, evaluating, and improving floodwall protections to flood-prone properties. The Internal Floodwall Committee should include flood-control infrastructure on private property and sewage/stormwater infrastructure that passes through floodwalls.

Based on needs, the City should install floodgates and backflow preventers, construct new storm sewers with greater flow capacity, install GI, work to educate property owners, or develop multicomponent solutions to address localized flooding. The City should continue to prioritize improvement projects that address localized flooding based on information that is learned through updated modeling, analyses of flooding and reported water-in-basement events, and efforts of the Internal Floodwall Committee. Through examination of overall impact and risk to impacted property owners, DOSD will determine where to add these components.

The City should provide property owners and tenants the necessary information on elevated flood risks in a timely fashion and in understandable formats. Without this information, individuals are unable to properly prepare and take actions to reduce their liability. The work of the Infrastructure Committee within DOSD should continue and may result in recommended requirements for property owners with privately-held flood control measures.

A6 **Advocate for state and federal government to implement policies that reduce erosion and runoff and promote infiltration.**

As the well-known educational refrain states, "we all live downstream." This is true of Columbus, which largely receives its drinking water from surface and groundwaters that originate north of the city. These lands are largely used for

agriculture, with the rest primarily being residential property. During storm events, runoff can deliver pollutants and sediment to the waterways that travel downstream to Columbus. These pollutants include fertilizer, herbicides, and pesticides from non-point sources, while the sediment is largely composed of topsoil from non-vegetated surfaces. These materials can damage aquatic ecosystems and make water treatment more difficult and therefore costly. As we have seen with inland lakes, such as Buckeye Lake and Grand Lake St. Marys, there are both economic and quality-of-life consequences that result from impaired waterways.

Water concerns in the Midwest have historically been of lower consequence than those in more water-stressed regions of the country because water supplies here are plentiful relative to population size. However, water quality issues have become more frequent and severe in Ohio, as has been the case with the increasing occurrence of harmful algal blooms (HABs) throughout the state. While local municipalities and water districts are responsible for providing drinking water, with the ***OEPA playing a role in certifying drinking water quality***, the state and federal governments are responsible for the regulation of practices within watersheds.[23] This creates tension as local municipalities have no direct control of what arrives in their waterways—even drinking water supplies—from landowners upstream. Despite this, it is the downstream residents that assume the cost of treating the water. In Columbus, this was manifested in a contingency contract for $1 million for reagents and $3 million for upgrades to a water treatment facility to address poor drinking water taste associated with algal blooms.[24] Downstream locations also lose out on recreation opportunities and the aesthetic enjoyment of nature as water quality deteriorates.

As with all code and zoning requirements, state law limits actions that can be taken by the City. The City should work collaboratively with state and federal agencies and elected officials to improve the management of our aquatic ecosystems and water resources on a larger scale. ***Sustaining Scioto***, an effort to ensure sufficient drinking water for Columbus in light of our anticipated population growth, provides a blueprint through mid-century.[25] State actions, such as an addition to the state budget bill in 2017 that weakens protections to lands surrounding reservoirs, impair the ability of Columbus to provide safe water for its citizens.[26, 27] When necessary, the City should reiterate to state agencies and elected officials concerns about limits on its ability to deliver safe and affordable service. Ongoing conversations on the protection of our waters need to be informed by published research, best practices, and respect for the rights of all individuals within a watershed. Creative solutions, such as payment to landowners for ecosystem services, could emerge from such conversations.

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Water Quality

Actions

N9 Implement the City of Columbus Watershed Management Plan and work with regional partners to implement the Sustaining Scioto Adaptive Management Plan.

N10 Understand the types, likelihood, and severity of events that could adversely impact the quality of drinking water sources.

N11 Continue upgrades to sewer system and sewage treatment infrastructure to reduce sewage contamination of waterways.

N12 Design an educational campaign for individuals and businesses on proper use of tap water during an emergency.

A7 Improve data collection to anticipate and respond to harmful algal blooms.

A8 Continue upgrades to water and sewage treatment infrastructure to reduce harmful algal bloom toxins in drinking water.

Background

Increasing precipitation and rising temperatures heighten the risk of water supply contamination and the need for water treatment in Columbus.[1] Since the Hoover brothers pioneered new methods of water treatment in the early 1900's, Columbus has been a leader in providing its residents with high-quality drinking water. The Columbus water system has significant natural resilience because it gets its water from a variety of sources: the Scioto River, Big Walnut Creek, and groundwater that is pumped from the Scioto River Valley aquifer. In 2016, the Division of Water supplied over 49.5 billion gallons of drinking water to over 1.2 million residents throughout the Greater Columbus Area.[2]

However, all three of the water sources are susceptible to pollutants and need to be treated to meet water quality standards. Regional plans, such as ***Sustaining Scioto***, are in place to protect the quality of water in Columbus and should be implemented and continually evaluated to ensure they are adequate.[3] Some pollutants pose a risk to public health, such as nitrates and toxins from harmful algal blooms (HABs), while others affect the odor, taste, or clarity of our water. Pollutants enter the Scioto River and Big Walnut Creek in a variety of ways, from point source discharges (discharges from wastewater treatment plants and industry) that are regulated by the State and from non-point source discharges (runoff from farm fields, suburban lawns, and parks) that are largely unregulated. Due to a lack of overlying clay sediments, our groundwater is at a higher risk of contamination than many other groundwater sources.[4] As Columbus continues to grow and develop, the contamination pathways will likely increase, and water quality issues may become more frequent. More frequent and intense precipitation events will likely induce more runoff, while rising temperatures are expected to contribute to increasing pathogen concentrations in surface waters.[1] This chapter has four necessary (N) and two aspirational (A) actions to address water quality in Columbus.

N9 **Implement the City of Columbus Watershed Management Plan and work with regional partners to implement the Sustaining Scioto Adaptive Management Plan.**

The City of Columbus owns and operates three water treatment plants that serve the city and most of Central Ohio: The Dublin Road Water Plant, Hap Cremean Water Plant, and Parsons Avenue Water Plant. Each plant has a different water supply. The Dublin Road Water Plant utilizes water from the Griggs, O'Shaughnessy, and John R. Doutt Reservoirs and distributes it to northwestern and southwestern Franklin County and downtown Columbus. The Hap Cremean Water Plant treats water from the Hoover Reservoir and serves The Ohio State University (OSU) campus and northern Franklin County. The Parsons Avenue Water Plant withdraws groundwater and serves southeastern Franklin County. Several plans are already in place to protect these water sources. These plans should be implemented and continually evaluated to ensure that Columbus water customers continue to have access to safe drinking water.

The ***Watershed Management Section*** of the Columbus Department of Public Utilities (DPU) protects the city's surface-water supplies at its four reservoirs by jointly managing the reservoirs and adjacent land with the Columbus Recreation & Parks Department to protect drinking water quality.[5] In 2015, DPU began an analysis of its watershed to evaluate watershed characteristics, identify immediate and persistent risks to the watershed, identify strategies to address these risks, and develop a City Watershed Master Plan for implementation of these strategies.[5] The Watershed Management Section is currently implementing this plan with a focus on 1) reducing nutrients, sediments, and other agriculture-related contaminants of concern, 2) reducing the risk to source water associated with industrial, residential, and developed land uses, and 3) implementing best management of city-owned reservoir property to protect the integrity of shorelines and water quality. The City continues to implement this plan to reduce the risk of contaminated source water.

In 2015, a partnership led by the Mid-Ohio Regional Planning Commission (MORPC) released Sustaining Scioto, a document to guide actions among a number of agencies to ensure that there is sufficient, clean drinking water for residents and businesses of Central Ohio.[3] This document, which took four years to complete, is a comprehensive look at drinking water sourced by the Upper Scioto Basin. Sustaining Scioto provides near-, mid-, and long-term action items related to planning, collaboration, public education, emergency preparedness, operating procedures, and resource protection. Analyses included simulations by the U.S. Geological Survey (USGS) that take into account changes in climate, reservoir operations, land cover, and water use within the basin.[6] While the simulations include population growth for Central Ohio based on projections by MORPC, they did not factor in population relocation from elsewhere in the country due to climate impacts.

There is no need to develop an additional long-term management plan, but the City Watershed Master Plan and Sustaining Scioto should be updated periodically and the continued work of the partners to enact actions in these long-term documents should continue to be supported. The updates should include re-examinations of land use and development patterns, climate conditions, and population growth that includes climate-related migration. These updates will ensure that sufficient, high-quality drinking water will be provided for Columbus and Central Ohio residents, even as the community and the climate continue to change.

N10 **Understand the types, likelihood, and severity of events that could adversely impact the quality of drinking water sources.**

Understand and Plan for Adverse Impacts to Source Water Quality

The City Watershed Master Plan identifies and categorizes pollutants of consequence to the city's reservoirs and source water. It identifies future water-quality concerns using predictive modeling based on changes in the watershed such as conversion of agricultural land to impervious cover. The City Watershed Master Plan identifies immediate risks to the watershed, persistent risks, risks to continue to monitor/inspect, and risks for periodic assessment. This assessment has informed the Watershed Management Section's work regarding traditional reservoir security and property management responsibilities. It has resulted in program updates including new agricultural and watershed conservation initiatives and a new focus on spill preparedness and intake protection. The Watershed Management Section should continue to implement these initiatives and periodically review its plans based on the most recent projections.

Sustaining Scioto also provides an improved understanding of the potential climate change-related risks including a greater frequency of extended dry periods interspersed with extreme rainfall events. The runoff that results from extreme precipitation events can lead to excess delivery of pollutants into waterways. As understanding of increased precipitation and extreme heat events improves, the City should continue to refine its near-, mid-, and long-term projections of the likelihood that these events will lead to nitrate or other water-quality limit exceedances that could affect the ability to provide safe drinking water. Excess nutrients, along with increasing temperatures, may result in HABs or greater concentrations of toxins in the water. As the nutrients and pollutants transported by runoff often originate from different non-point sources outside of the city, including agriculture, it is difficult to control how much is being delivered to our streams, rivers, and groundwater. In order to protect against this type of pollution, it is first necessary to improve our understanding of the types of events and conditions that can negatively affect our water quality. To better understand the likelihood of occurrence and ranges of severity of these events, additional data will need to be collected from watersheds and interpreted by the research community.

Understand and Plan for Adverse Impacts to the Treatment of Source Water

Critical infrastructure should be continually assessed to ensure that it is not susceptible to flooding and has a resilient electric supply. Many of these resilience requirements are already part of federal and state laws. For example, the Ohio Environmental Protection Agency (OEPA) requires treatment facilities to be located outside the floodplain and have two completely independent power supplies.[7] OEPA also requires all essential water-treatment chemicals to have at least a 30-day supply. To further improve its resilience, DPU is also in the process of adding standby power at both the Dublin Road and Hap Cremean water plants to provide backup power in the event of a regional power outage. The city's wastewater treatment plants are also built with 100% redundancy of designed treatment capacity. Both wastewater treatment plants have been recently upgraded, and utilizing all redundancy, can treat up to three times their design capacity for a sustained treatment capacity of 480 million gallons per day.

Franklin County Emergency Management and Homeland Security (FCEM & HS) can provide

insight to continuing operations during regional flooding and electrical service disruptions. In the case of major water emergencies, the OEPA requires that each community water system maintain a written contingency plan for providing safe drinking water.[8] These plans should be continually updated as our knowledge improves.

N11 **Continue upgrades to sewer system and sewage treatment infrastructure to reduce sewage contamination of waterways.**

In 2005, the City of Columbus developed a Wet Weather Management Plan (WWMP) to satisfy two consent orders from the OEPA to reduce combined sewer overflows (CSO) and sanitary sewer overflows (SSO). Due to aging infrastructure, combined stormwater and sanitary sewer lines, and insufficient sewage treatment capacity, Columbus released millions of gallons of sewage each year during multiple rain events. In addition, some property owners experienced sewage backups in basements. The WWMP proposed mid- and long-term projects to be completed over a 40-year schedule; most of the improvements were set to take place before 2025, reducing pollution by 85% during the first 20 years.[9] Projects outlined in the WWMP included constructing new tunnels to direct flows to treatment plants, building storage tanks, and treatment plant improvements. Priority was given to CSO improvement, and by 2015, over one billion dollars had been spent to complete numerous WWMP projects and substantially reduce CSO volume.

Following the first ten years of implementation, the City revised the WWMP in 2015 and adopted ***Blueprint Columbus***, an integrated plan to capitalize on new technologies and flexibility provided by US EPA.[10] Blueprint Columbus addresses SSOs through three private-property improvement "pillars": lateral lining, which addresses inflow and infiltration of rainwater into our sewer system by sealing sanitary laterals; roof water redirection; and sump pumps, which direct water away from the home's foundation so that it cannot infiltrate through the lateral connection. The fourth pillar of Blueprint Columbus is green infrastructure (GI; e.g., rain gardens, pervious pavement), which is installed in residential areas to provide additional retention for the stormwater that was previously infiltrating pipes (Fig. 4). GI also has the added benefit of filtering stormwater runoff, which is said to be the source of 64% of pollution in our rivers and streams.

The Blueprint Columbus solutions are deemed less expensive, more rapidly deployable, and of greater benefit to the local economy while providing co-benefits to ecosystems and

Figure 4. *Four pillars utilized by the City to address sanitary sewer overflows within Blueprint Columbus.*[10]

Replacing Impermeable Surfaces

One potential target to reduce impermeable surfaces is Columbus City Schools. ***Blueprint Columbus*** has already started working with some schools in neighborhoods such as Clintonville and Linden and is developing a Blueprint schools curriculum. Paved lots could be converted to playgrounds with permeable surfaces, and rain gardens and natural landscapes should be planted. Co-benefits of these actions include a reduction in heat absorbed by blacktopped surfaces. ***Chicago*** has already seen success with this type of action.[11]

neighborhoods. Blueprint Columbus is currently in the second year of implementation, with data being collected as portions of the project are completed. Based on the results of these projects, plans may need to be adapted. Currently, Blueprint Columbus provides the best plan to reduce sewage contamination of waterways with accountability provided by OEPA. Deploying GI through Blueprint Columbus is an innovative way to detain additional stormwater and reduce the amount of total suspended solids (phosphorus, nitrogen, metals, etc.) entering the city's streams, further improving the city's water quality.

N12 **Design an educational campaign for individuals and businesses on proper use of tap water during an emergency.**

One of the challenges during a drinking-water emergency is ensuring individuals and businesses are aware of the emergency and know how to respond. How to handle the water during an emergency often depends on the pollutant that is present. Most water outages are due to a water main break, and individuals are accustomed to advisories to boil their water. Not all pollutants can be addressed through boiling, such as toxins produced by HABs. A second challenge is ensuring that people know the ways in which the water may safely be used (e.g., use in bathing and flushing toilets only), even if it cannot be consumed. Recent drinking-water crises in the cities of Toledo, Ohio and Flint, Michigan provide contrasting case studies in public health response and messaging.

Since most individuals do not have access to detailed knowledge on water pollutants, accurate information needs to be clearly communicated in a timely fashion. A team of experts within Columbus Public Health and DPU, with backgrounds in science, communication, and the local community, needs to vet information before it is broadcast. To the extent possible, this messaging should be developed in advance of emergencies to facilitate rapid dissemination when needed.

A7 **Improve data collection to anticipate and respond to harmful algal blooms.**

The Division of Water has a ***Water Quality Assurance Lab (WQAL)*** that provides independent monitoring and analyses of watersheds and researches new treatment methods.[12] The division's extensive source-water-quality monitoring network provides an early warning to the water treatment plants for different types of water-quality events (e.g., high nitrate levels, algal blooms including HABs, spills) and other water-quality changes that may impact water treatment. The network consists of multiple real-time online monitors used in conjunction with routine grab sample analysis. Columbus started its algae monitoring program in the late 1930s and has continued routine monitoring since that time. The real-time, water-quality sensor program began in the early 1990s and has been expanded multiple times to nearly a dozen locations throughout the watershed. The grab sample program is conducted at least bi-weekly throughout the 13-county watershed for Columbus and is modified as the source-water-quality characteristics change. The sample locations include wells, creeks, rivers, reservoirs, and quarries. Columbus collaborates with OSU for water-quality testing and the United States Geological Survey for some water-quality monitors and stream gauges.

Extensive research is being conducted in the Maumee River Drainage and Western Basin of Lake Erie to ***forecast algal blooms*** that impact the water supplies of communities along the lake.[13] This research is expensive, involves extensive technical expertise, and draws from remote sensing and water sampling data. As this research continues, findings may be used to inform advances in monitoring systems in Central Ohio.

A8 **Continue upgrades to water and sewage treatment infrastructure to reduce harmful algal bloom toxins in drinking water.**

The City has constructed an ozone/biologically-active filter treatment system at both the Hap Cremean and Dublin Road water treatment plants to treat source water containing microbial pathogens, HABs, and emerging contaminants. Other cities are now emulating Columbus and designing similar systems due to the negative consequences HABs have had on their source water supplies. Within Ohio, these communities include Toledo, Oregon, and Celina.

Based on emerging research on algal-bloom occurrences and toxicity, knowledge gathered through monitoring systems, and impacts of blooms on drinking-water supplies when they occur, the City can determine how best to allocate resources for additional treatment infrastructure. Due to its high cost, investment in infrastructure should be carefully considered well in advance of its need, and options involving conservation practices that limit nutrient loading within the watershed should be considered. Such conservation practices would necessarily extend into the upper watershed outside of city boundaries. ***New York City's*** water treatment system serves as an example of a system that includes water preserves upstream in the watershed to protect water resources for the city's needs. These measures provide sufficient, clean drinking water and are less expensive than other water treatment infrastructure.[14, 15, 16]

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Water Use

Actions

N13 Implement educational campaign on reducing water use.

A9 Develop event-based, water-use criteria.

A10 Update building code to require more efficient water use.

A11 Improve irrigation through changes in infrastructure and practices that more efficiently use water.

A12 Improve efficiency of water use in city fountains, pools, splash pads, and ponds.

Background

Increasing temperatures will bring a greater demand for water and energy for industrial cooling, agriculture, and irrigation due to heat waves and an extended growing season. ***Climate projections*** indicate that summer precipitation will decline even as precipitation increases during other seasons.[1] This raises the potential for summer droughts and seasonal water shortages, particularly for industrial and agricultural uses. Because of these risks, the City should take measures to encourage efficient water use.

By increasing efficiency, local water demand and costs can be reduced. There are a variety of ways that efficiency can be improved, including utilizing compact development, which requires shorter pipes and reduces water loss through leaks; implementing conservation pricing, which allows utilities to charge increasing water rates based on higher levels of water use; and encouraging water recycling for non-potable uses, which reduces the amount of treated water used for toilets flushing and landscape irrigating.

Efficient water use is both a local and regional concern. In 2015, a team composed of the City of Columbus, DELCO Water Co., Mid-Ohio Regional Planning Commission (MORPC), United States Geological Survey (USGS), and several others collaborated to produce the ***Sustaining Scioto*** adaptive management plan.[2] The goal of this plan is to ensure that future Central-Ohio residents will be able to enjoy the same high-quality water sources that we have today by developing water utility strategies that account for population growth and climate change. Using local water usage per capita rates, as well as population projections, Sustaining Scioto projected that the water usage rates will increase by 4.3% by 2035 and by 105.2% by 2090. Although models largely agree is that supply will likely meet demand, some Sustaining Scioto models show that there are climate change scenarios where the region's water supply could become scarce.

Currently, Columbus residents use on average 115 gallons of water per day (gpd), which is comparable to other Ohio cities such as Cleveland (158 gpd) and Cincinnati (120 gpd).[3, 4, 5, 6, 7, 8] To ensure that the increasing water demand will be met, the City should continue to evaluate the local water balance, improve its understanding of how future changes may affect the water supply, and promote water use efficiency throughout the city. The City's Water Use Efficiency Plan calls for citizen engagement through ***GreenSpot*** programming, which educates residents and businesses on the environmental and economic benefits of efficient water use and encourages the implementation of efficiency by providing residents with spray nozzles and low flow showerheads.[9, 10] By building awareness of daily water use, encouraging increased efficiency, and improving estimates of future availability, Columbus will be able to meet the water demands of the future. This chapter proposes one necessary (N) and four aspirational (A) actions to ensure efficient water use.

N13 **Implement educational campaign on reducing water use.**

In 2013, for the Water Use Efficiency Plan, the City evaluated a wide range of efficiency measures and recommended additional items for implementation via GreenSpot.[9] GreenSpot is the City's signature environmental education program, with more than 17,000 members. Along with GreenSpot, the ***Community Backyards*** program educates residents on the proper use of rain barrels, which can conserve water; the program also covers compost bins and native trees and plants.[11] This program has reached 1,364 residents. GreenSpot has also incorporated water-use reduction commitments and tips in its messaging.

The Water Use Efficiency Plan suggests several additions to the Greenspot program, including the creation of a new sustainability class for businesses, engagement with the City's Top 100 users, and providing residents with efficient devices. The GreenSpot program is uniquely situated to connect consumers with information about the long-term costs and benefits associated with improvements. GreenSpot should continue to emphasize the economic and environmental co-benefits of water efficiency, including reduced energy consumption related to treating, transporting, and heating water.

To complement GreenSpot, the City should consider adding additional, more detailed consumption information in quarterly bills to ratepayers to increase awareness of personal consumption. The City is in the midst of implementing new meters and automatic metering systems that will provide increased water-usage information to customers. Once automatic metering is online, the City should consider communicating information to customers that puts their consumption in context by providing information on a property's water use relative to average comparable properties and ones that have utilized water-efficiency programs. Additionally, the City should consider increasing its promotion of efficient fixtures, such as those certified as ***WaterSense***.[15] Columbus could better publicize the availability of home water-use audits with recommendations on specific actions that property owners could take to reduce their water consumption.

Discounts or rebates for purchase of efficient fixtures, could be offered. Likewise, consumers need to understand long-term costs associated with particular efficiency improvements, including their payback periods, to increase their likelihood of taking action. There are additional economic and environmental co-benefits of water efficiency including reduced natural gas and electricity consumption for generating hot water. In fact, energy audits conducted by electric and natural gas providers often include free distribution of sink aerators and low flow showerheads due to their rapid payback periods in energy efficiency.

In Franklin County, the ***Columbus-Franklin County Finance Authority Energy Program*** offers ways for businesses, nonprofits, and government agencies to finance improvement with payback periods of up to 30 years.[16] Similarly, the Office of the Ohio Treasurer (OOT) has an energy efficiency program called ***ECO-Link*** that allows homeowners to reduce their interest rate by as much as 3% on bank loans to pay for energy-efficiency improvements over an extended period of time.[17] Both of these programs apply to water use because of the savings on electricity and natural gas associated with a reduced need to generate hot water on site. The City already collaborates with the utilities and MORPC to offer ***energy efficiency programs*** to low-income populations.[18] Specifically, they provide low flow showerheads to customers at no cost. Water efficiency and information regarding WaterSense technology should be considered an integral component of every energy audit.

The Connection Between Water Use and Energy

The interrelationship between water use and energy is well established. Reducing water use in the built environment in response to climate change has the co-benefit of reduced energy use in three primary areas: the energy needed to treat water, the energy needed to transport water from the treatment facility to the home or business and back, and the energy needed to heat water at the point of use. According to the 2009 ***Residential Energy Consumption Survey*** conducted by the United States Energy Information Administration, roughly 17% of home energy use in Ohio is for heating water. Recognizing this, most ***utilities*** across the United States have at one time offered low flow faucet attachments and showerheads.[12, 13, 14]

Finally, this campaign should include information for vulnerable populations and low-income households regarding available programs that can reduce water-utility costs. For example, current low-income and senior citizen ***discount programs*** provide a 20% discount on water- and sewer-usage charges for the households that qualify.[19] However, this also includes communicating the ways that reducing water use can lead to lower water bills. This may include information on efficient fixtures like low flow showerheads, or how to identify and fix leaking toilets and faucets. This educational campaign may be most effective by stressing the economic co-benefits that result from reduced water use rather than just the environmental benefits.

A9 **Develop event-based, water-use criteria.**

A number of factors, including extended dry periods and droughts, rising temperatures, and longer growing seasons, may lead to uncertainty in the water supply and demand. As a result, river, lake, and reservoir levels could drop, groundwater recharge may be reduced, and our water supply may be strained during certain times of the year due to changing seasonal precipitation patterns. Therefore, guidelines need to be developed for all users regarding different scenarios that might threaten the water supply. In the event of a water emergency, the Ohio Environmental Protection Agency requires each community water system to have a contingency plan to ensure that necessary water needs are met.[20] These plans provide the response and recovery actions to be taken during emergency situations, while the guidelines suggested here would be used for less critical events.

These guidelines detail the measures that will be taken in the event of heat waves, droughts, or even intense precipitation events that could affect both water availability and water quality (N10 and N12). For large users, such as agriculture and industry, water restrictions for certain activities already take effect under specific drought conditions. Currently, several utilities in the region already have limits on the amount of water they can extract from surface

water supplies, based on set minimum stream flows that need to be maintained.[21] While voluntary water conservation should be promoted and practiced at all times, certain events (e.g., droughts and extended heat waves) necessitate stricter water-use criteria.

The Department of Public Utilities (DPU), Division of Water has a drought management plan that provides a conservative timetable for initiating drought restrictions.[22] The goal is to extend the available water supply during drought conditions. The plan includes demand management in conjunction with source management. It establishes operations, actions, and procedures for responding to drought-related water shortages in advance of an actual emergency. The plan has four phases, ranging from voluntary to mandatory actions. Phase 1 calls for voluntary water conservation, including limiting outdoor water use to early morning hours. Phases 2 and 3 are both mandatory restrictions and further limit outdoor water and hydrant use. Phase 4 is employed during extreme droughts and limits water use to critical consumers (e.g., hospitals and nursing homes).

A10 Update building code to require more efficient water use.

The current Ohio Building Code reflects the 2015 edition of the International Building Code standards and is set by the state not local government. Therefore, the City should advocate that the state follow the latest international building code standards. Doing so may increase construction costs in some cases, but these revisions will improve energy and water efficiency of new buildings. Additional construction costs are often more than recovered over the life of the building, and in terms of water efficiency, the reduction in per-person water use can result in savings to the entire community through lower demand for water-treatment infrastructure. Without updated building codes, Columbus will need to continue to use incentives, such as the ***Green Columbus Fund***, to promote efficient construction and renovation.[24]

A11 Improve irrigation through changes in infrastructure and practices that more efficiently use water.

Action Statements N14 and A16 in the Ecosystems chapter of this plan describe how sustainable landscaping practices and alternate use of spaces can reduce landscaping water demands. Selecting native and low-water variety plants can provide benefits such as aesthetic beauty, additional spaces for outdoor leisure, increased food and habitats for wildlife, and reduced energy consumption through shading and wind barriers. Likewise, edible species can be planted that provide food for people. Thus, when well-designed, building landscapes may provide greater value than monoculture lawns.

Lawns should be appropriately sized and planted with varieties of grass that require the least amount of water, fertilizer, and herbicide. When it is still necessary to provide irrigation for landscapes, systems such as drip irrigation that target water to specific plants should be considered. Also, many modern irrigation systems may be integrated with weather stations and/or soil moisture sensors. Such systems allow users to deliver an appropriate volume of water at preferred intervals while taking into account natural rainfall and soil conditions. Columbus Recreation and Parks (CRPD) is leading by example in this area by installing rain sensors on all irrigation systems and well-irrigation systems on all new sports complexes when possible. As a rule, CRPD does not irrigate its parks, aside from speciality parks such as the Scioto Mile, Topiary Garden, and Park of Roses.

Drought Conditions in Central Ohio

As specified in the ***State of Ohio Emergency Operations Plan***, the Ohio Emergency Management Agency will activate the Drought Assessment Committee and Impact Task Force to appropriately match the state response to the severity of a drought.[23] Under this plan "local jurisdictions may enact ordinances to assure equitable water distribution and may establish local drought emergency public information and education programs." Emergency management activities during a regional drought emergency would be coordinated between Franklin County Emergency Management and Homeland Security and leadership of the City of Columbus, including the Department of Public Utilities, Division of Water.

A12 **Improve efficiency of water use in city fountains, pools, splash pads, and ponds.**

Columbus has renovated and constructed a number of buildings to Leadership in Energy and Environmental Design (LEED) standards over the past decade. Similar standards for efficient use of water should be applied to fountains, pools, splash pads, and ponds. To ensure a holistic analysis for new facilities or retrofits of existing facilities, any plans should consider the costs and energy consumption associated with pumps and filtration equipment.

To achieve water efficiency, some improvements have already been made to many of these public water bodies, while new construction includes water-efficient designs. To avoid using treated water, CRPD ponds are fed by streams, rivers, or wells, and they are lined using industry standard practices pursuant to the ***Ohio Pond Management Handbook***.[25] The ***Scioto Mile Fountain at Bicentennial Park*** also recirculates its water so that it does not need to be continually refilled.[26]

Additionally, signs and infographics regarding water recycling and water conservation should be displayed at fountains, splash pads, pools, or ponds that have implemented these practices; this may be achieved through the educational campaign outlined in N13. CRPD is currently developing a Sustainability Framework, which will focus on Resource Management (energy efficiency, waste reduction, air and water quality), Planning, Design and Construction Practices, Land Use, Parks, Open Space and Habitat Conservation, and Social Equity and Operations and Maintenance. CRPD should continue to research best management practices as they relate to water use in parks as part of this Sustainability Framework.

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Ecosystems

Actions

N14 Promote sustainable landscaping practices for residential, commercial, and industrial properties.

A13 Develop guidelines for city property on application of fertilizers, herbicides, pesticides, and animal waste.

A14 Collaborate with landscaping and fertilizer companies to improve services and use of products.

A15 Implement educational campaign for landowners to promote responsible use of fertilizers, herbicides, and pesticides.

A16 Collaborate with organizations, agencies, and private landowners to identify and create additional green space, urban tree canopy, and urban farms.

Background

Increasing temperatures elevate risks to freshwater ecosystems and cause shifts in natural resources. As temperatures warm, fish and wildlife habitats change, forcing plants and animals to migrate or adapt.[1] The term 'ecosystem' refers to all of the living organisms in an area and the non-living things with which they interact (e.g., soil, rivers and streams, and the atmosphere). Biological and physical environments provide numerous benefits to our communities; these benefits are referred to as ecosystem services. They influence human health and well-being, help regulate the climate, and contribute to the local economy. Some of these services are direct and tangible, such as the presence of fresh water available for consumption and food sources derived from crops and fisheries. Others, such as quantifying the exact amount of carbon dioxide sequestered by a grove of trees or calculating the aesthetic and recreational value of a forest preserve, are more abstract.

In Columbus, we have a variety of beneficial ecosystems including the major rivers and the reservoirs into which they feed, more than 12,000 acres of parks and 13 nature preserves, and the nearby farms and fields that sustain agriculture. No matter the size, it is important to understand how these ecosystems are threatened by climate change. For example, extended droughts can lead to a reduced water supply, which may result in higher mortality of non-drought tolerant plant species. Invasive plants adapted to longer growing seasons (e.g., purple loosestrife and honeysuckles) decimate native plants and jeopardize wildlife. Increased extreme precipitation events in Columbus produce more stormwater runoff, introducing more nutrients, pollutants, and sediment from urban landscapes and transporting them downstream to communities along the Scioto and Ohio Rivers.

How we choose to respond to changing conditions is important as well. In January 2018, the ***Ohio Department of Agriculture*** established new rules, guided by scientific-studies, prohibiting the sale and distribution of certain invasive plants in Ohio.[2] Recent efforts have provided a detailed look at the full costs and benefits of trees located in major Ohio cities, with the trees providing benefits that are up to five times greater than costs.[3] Columbus has a ***Tree Protection and Mitigation Executive Order***, enacted in 2015, to limit the removal of or damage to all trees on city property or along rights of way during development and construction.[4] Limiting the use of fertilizers, herbicides, and pesticides; growing native plants; and mitigating runoff through rain barrels or rain gardens are all effective, readily available practices. These measures can be adopted by residents, businesses, and the City, and several existing programs offer cost-sharing incentives. By decreasing pollutant runoff, Columbus can serve as a role model for other communities in how we care for our ecosystems.

This chapter contains one necessary (N) and four aspirational (A) actions. Three promote the responsible use of fertilizers, herbicides, and pesticides, whether it is on residential lawns or large industrial properties. The other two encourage adoption of sustainable landscaping practices and the expansion of urban greenspaces. Through these actions, we can make Columbus' varied ecosystems more resilient to climate change so that our community can continue to benefit from their invaluable services.

N14 **Promote sustainable landscaping practices for residential, commercial, and industrial properties.**

The City should build on the existing educational programming that it provides through the ***Greenspot*** and ***Get Grassy!*** programs to further promote and emphasize the importance of sustainable landscaping practices for residential, commercial, and industrial properties.[5, 6] Sustainable landscapes are those that maintain themselves (without undue labor, costs, or need for significant water, fertilizer, herbicides, and pesticides) while limiting negative impacts on surrounding natural ecosystems. Native species, adapted to the climate and pests of Central Ohio, are prime candidates to plant for sustainability. Since they require little to no treatment with fertilizers, herbicides, and pesticides, there are fewer costs associated with landscaping inputs. Likewise, these species serve as habitat and food sources for wildlife, are often drought tolerant, reduce erosion, and absorb stormwater. To maximize benefits, these plants should be appropriately grouped and planted consistently according to site conditions.

Promotion of sustainable landscaping practices should continue with the ***Community Backyards*** program that offers rebates for the purchase of native plants.[7] This program is implemented through a partnership with Franklin Soil and Water Conservation District (FSWCD), advertised through GreenSpot, and could be extended to a larger network of agencies with similar missions, many of whom are already actively involved in the Greenspot Advisory Board (e.g., Franklin Park Conservatory, Columbus Franklin County Metro Parks, National Wildlife Federation (NWF), Grange Insurance Audubon Center, and Franklin County Master Gardeners), and businesses selling related products and services (e.g., engineers, architects, landscape architects, nurseries, garden centers, and landscaping companies). Elsewhere in the country, the Chesapeake Bay Region and cities in the Western United States are examples of places working to transition their landscaping practices to embrace species adapted to local conditions.[8, 9] Successes and challenges to implementing these programs in other communities could offer valuable lessons for Columbus. For instance, attention should be given to prior research on landowners' practices and local surveys conducted to determine what motivates individuals to select landscapes that promote holistic, long-term ecosystem health. While many landowners may be willing and able to change their practices, obstacles include the accepted sense of aesthetic beauty, expectations of neighbors and customers, lack of awareness or knowledge, and costs.

Branch Out Columbus should also consider revisiting the goals of the program and embrace sustainable landscaping practices within its mission.[10] As our climate warms and winter hardiness changes, our growing zones are shifting northwestward.[11] Failure to consider this shift and the impacts on insect species could result in premature mortality of many of the trees that are currently being planted. To mitigate widespread damage to the tree canopy due to invasive species, greater awareness for tree diversity should be fostered, and efforts should be made to avoid monocultures within neighborhoods. While the list of species promoted by Branch Out Columbus already includes urban-tolerant and a number of native species, the list should expand, adding species that will be suited to the anticipated climate of the future.

Finally, city ordinances, zoning codes, and policies should be reviewed to ensure that they promote, or at least do not dissuade, property owners from installing sustainable landscaping. For instance, in 2017 the City removed the milkweed plant from the noxious weeds list. Rights of way, such as those along roads, should be considered for wildflower planting so long as

they do not block visibility or contribute to safety issues; a similar program is being conducted by the ***Ohio Department of Transportation***, which has approximately 19,000 miles of right of way in the state of Ohio.[12] The Department of Building and Zoning Services and the Department of Development are critical stakeholders that should be involved in conversations about the specifics of actions taken by the City on this issue.

A13 Develop guidelines for city property on application of fertilizers, herbicides, pesticides, and animal waste.

State law prohibits the City from regulating fertilizers, herbicides, and pesticides.[13, 14, 15, 16] This prohibition on local regulation extends to the registration, packaging, labeling, sale, storage, distribution, or use of fertilizers, herbicides, and pesticides.

However, Columbus can develop policies related to its use of fertilizers, herbicides, and pesticides within city limits and publicize these policies as examples of best management practices (BMPs). The City Recreation and Parks Department (CRPD) is developing BMPs and associated policies for the application of herbicides and pesticides on park properties, including the use of organic products and a reduction in the amount and frequency of other product applications. Serving as a model for others, CRPD has obtained the ***Environment Facilities Certification Program*** certification from the Sports Turf Manager Association for its Berliner Park facility and is working toward certification from the ***Audubon Cooperative Sanctuary Program*** for its golf facilities.[17, 18] CRPD is one of only 33 in the nation to have this certification and the only one in Ohio to have obtained such an achievement.

The City has the authority to regulate animal waste disposal.[19, 20, 21, 22] Specifically, Columbus City Code Section 2329.01 prohibits the placement of animal waste, on public or private private property and within the waters of the city.[22] Violations of these code provisions can lead to enforcement by the City's Code Enforcement Section. Additionally, through the ***PUP program***, the City works to proactively educate the public about the environmental impact of pet waste entering our waters and encourages residents to make simple behavior changes by picking up their pet waste using pet waste bags so that these impacts can be prevented.[23]

A14 Collaborate with landscaping and fertilizer companies to improve services and use of products.

There is increasing demand for landscaping companies to use practices that minimize damage to the larger, regional ecosystem. Landscaping companies, as a group, work with a significant number of properties. The scale of land under their care creates a significant opportunity for tangible ecological benefits, while also providing a way to educate individual property owners. Since property owners may not know details of actions taken by their landscaping company, or the consequences of these actions, the City should have a vested interest in promoting responsible practices. Under Ohio Law, anyone who is hired to apply fertilizer, herbicides, and pesticides is considered an "applicator" and must be certified by the state. The certification involves both training and passing of an examination. While large companies are likely to be aware of this law and abide by it, smaller operators may not. An educational campaign could be conducted targeting landscaping companies. Likewise, the City should be aware of state regulations and refer companies that, through investigation, are not certified, do not abide by product labels, and/or do not follow state regulations.

Landscaping and fertilizer companies have an incentive to be good corporate citizens as many consumers are placing more emphasis on environmental sustainability. This is creating significant economic incentives to work collaboratively with government agencies, nonprofits, and retailers to reformulate products, refine instructions, and educate the public on their use. Scotts Miracle-Gro is an example of a company that has taken steps to reduce the environmental impact of their products. Scotts Miracle-Gro ***removed phosphorus*** from its lawn fertilizers, provides educational displays with its products, and introduced technology to its spreaders to reduce application on impervious surfaces.[24] For some companies, transitioning to more ecologically sustainable practices might involve offering services rather than products (e.g., lawns might need soil testing and aeration rather than sales of seed and fertilizer).

The City, in partnership with FSWCD, currently engages landscaping companies and residents on sustainable landscaping practices through the Get Grassy! programming discussed below. The City purchases products and services that are ecologically beneficial and grows their respective markets.[25] The City's Department of Public Utilities (DPU) also produces its own landscaping/fertilizer products, which are available to the

Get Grassy! Partners

Public Agencies, Professional Organizations, and Non-Profit Groups	
City of Columbus	Office of Franklin County Commissioners
Friends of Alum Creek and Tributaries	Ohio Lawn Care Association
Friends of the Lower Olentangy Watershed	OSU Turf Extension Specialists
Grange Insurance Audubon Center	Ohio Turfgrass Foundation
Mid-Ohio Regional Planning Commission	Sierra Club

Lawn Care Companies	
Bio Green Ohio	Safe Lawns
Good Nature Organic Lawn Care	Scotts LawnService (merged with TruGreen)
Grassroots Lawn & Irrigation Service	Watershed Organic Lawn Care

Table 2. *Get Grassy! partners and participating lawn-care companies.*

public as ***Com-til Compost***.[26] The City could lead by example and use its platform as a compost producer to educate its customers about proper product application and sustainable landscaping practices.

A15 **Implement educational campaign for landowners to promote responsible use of fertilizers, herbicides, and pesticides.**

The City of Columbus and FSWCD, as part of a ***municipal separate storm sewer systems education programming***, launched Get Grassy! in 2016 to promote sustainable landscaping practices.[27] The program encourages Central Ohio residents to care for their lawns, educating them about the benefits of deeper root systems, drought and disease tolerance, and the effects of lawn-care practices on water quality. The program's primary goal is to educate and encourage residents to adopt good stormwater practices that include: proper disposal of yard waste; greater height settings on lawn mowers; appropriate watering (amount and timing); correct application of fertilizers, herbicides, and pesticides; and maintaining rainwater on properties to prevent polluted runoff. The program works through local lawn-care companies and partner groups that distribute information about the program (Table 1). Get Grassy! developed a fun ***"Seasonal How-To for Your Home Turf"*** card for distribution that includes personalized logos for partners, a website with additional resources, a commitment pledge with incentives, and an outreach plan to engage more local lawn-care companies and residents.[28]

To date, at least 4,000 residents have been reached through targeted advertising and approximately 360 Columbus residents have pledged (the primary measure of engagement) to Get Grassy! The program successfully engages surrounding municipalities as well, garnering additional pledges outside the county and state (600 pledges in total). To promote this program, FSWCD has participated in community events; provided paid advertisement and received other marketing and publicity through social media and speaking engagements; exhibited at industry trade shows; and garnered new municipal funding support.

As with Greenspot, the Get Grassy! educational programming should collaborate further with other environmental and outdoor organizations and city departments and promote programs with similar missions (e.g., ***National Audubon Society's Audubon At Home*** and the ***NWF's Certified Wildlife Habitat)***.[29, 30] Any educational campaign should take into account past studies that acknowledge the fact that individuals already applying chemicals to their lawns are more likely to believe that lawn-care practices have a negative impact on local water quality.[31] These studies suggest that efforts to educate individuals have generally not been sufficient to cause behavioral changes and that novel approaches should be attempted.

A16 **Collaborate with organizations, agencies, and private landowners to identify and create additional green space, urban tree canopy, and urban farms.**

Green Space Initiatives

Access to green spaces in all portions of the city should be prioritized as both new construction and redevelopment occurs. Green space has been shown to improve quality of life, and research suggests that there are public health consequences to how we design and develop our urban environments. Studies over the past decade have shown that office workers with access to plants and windows show greater satisfaction in their work and that

there are mental health benefits to moving to neighborhoods with greater green space.[32, 33, 34] Attention should be paid to the distribution of these spaces within the city and their proximity to where individuals live and work. CRPD's goal is to provide green space within a 10-minute walk of all residences.

CRPD, Columbus and Franklin County Metro Parks, and school districts within the city have a significant number of properties that can serve as models for demonstrating sustainable practices. These managed green spaces should promote healthy ecosystems and protect our waterways. For instance, fertilizer, herbicide, and pesticide applications should be tailored to the particular land use, and lawns that are unused for athletic fields should be considered for ***prairie plantings (urban meadows)*** that do not require lawn care.[35] As a majority of property within the city is privately held, working to educate and incentivize the establishment and preservation of green spaces on these properties are critical to success. Legal tools, such as ***conservations easements***, are an example of such an incentive.[36] These easements are agreements between private property owners and conservation organizations, such as The Nature Conservancy or FSWCD.

Tree Canopy Initiatives

Branch Out Columbus is an initiative to plant 300,000 trees in Columbus by 2020.[10] The impetus for the program was a study that identified that the tree canopy cover is less than 15% in some portions of the city. CRPD is updating this 2014 Tree Canopy Study and intends to conduct an updated study every two years with U.S. Forest Service. The updates will capture the canopy cover of both trees being planted and those being removed. This will help identify and track areas of high-density development as well as areas where there are opportunities to plant additional trees. As was mentioned earlier in this report, Branch Out Columbus is far below its goal, having only resulted in approximately 40,000 new trees being planted to date.

The lack of trees exacerbates the urban heat island, diminishes air quality, diminishes beneficial wildlife, and reduces aesthetic appeal of neighborhoods. For vulnerable populations, shade is especially important for quality of life, as homes might not have sufficient air conditioning for summer cooling. CRPD is currently working with the ***City of Columbus Land Bank*** to identify properties that are currently owned by Land Bank, but are being leased to adjacent residents as a rent-to-own program, to implement tree planting within these lots.[37] In addition to these current initiatives, the City should consider adopting a strategic plan for Branch Out Columbus with implementation strategies that describe how to meet the program's planting goals; this could include increasing public-private partnerships.

Urban Farming Initiatives

Urban farming is a growing phenomenon in the United States that repurposes abandoned and underutilized land within cities for food production, while simultaneously creating employment and volunteer opportunities for residents. Establishing a greater percentage of the food system in close proximity to residents, when coupled with educational programs, allows individuals to better understand and appreciate the complexity of growing and distributing food.[38] Columbus has farms that are managed as businesses, those that are run as non-profit organizations, and some landowners who grow food crops in their yards for distribution to the general public.[39] These farms support the local economy, provide income to entrepreneurs, offer food to vulnerable populations, and create additional green spaces.

The City should continue to implement the ***Local Food Action Plan*** (adopted in November 2016) and the ***Green Business & Urban Agriculture Strategic Plan***.[40, 41] These plans call for supporting increases in local agriculture and promoting local purchasing by institutional buyers. Additionally, the City, through the ***Columbus Foundation***, annually provides grants up to $2,000 for community gardeners.[42] ***MidOhio Foodbank***, with funds from U.S. Department of Agriculture, provides grants up to $25,000 for urban agricultural infrastructure within Columbus.[43] The City should seek ways to partner with the statewide initiative ***Ohio Smart Agriculture***.[44] This W.K. Kellogg Foundation funded project brings together a national non-profit organization (Solutions from the Land) with The Ohio State University's ***Initiative for Food and AgriCultural Transformation (InFACT)*** to develop platforms of support for sustainable production of food, feed, fiber, energy and ecosystems in Ohio.[45]

Finally, the Department of Development Land Redevelopment Division has licensed 80 to 100 parcels for community garden and beautification projects. In support of those gardens, the Land Bank has provided 550 gallon tanks, topsoil, Com-Til from DPU, and vouchers for property improvements. All of these projects are excellent examples of the types of support the City should continue to provide to promote local food and urban farming.

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Emergency Preparedness

Actions

N15 Use GIS to map fixed critical assets, transportation routes, and vulnerable populations susceptible to environmental hazards.

N16 Evaluate city preparedness and response during and after environmental hazard emergencies.

A17 Track and communicate costs associated with preparing for and responding to environmental hazards.

A18 Establish contingency contracts so that sufficient resources are available in case of environmental hazard emergencies.

A19 Develop new app or integrate with existing app for environmental hazard alerts.

A20 Implement educational campaign to inform the public about insurance and other shared risk programs available for environmental hazards.

Background

In previous chapters, impacts from specific symptoms of climate change have been addressed. These environmental hazards – floods, heat waves, droughts, and deteriorated air and water quality – have the potential to lead to a greater number of natural disasters in our community when confronting poorly-prepared infrastructure and systems. In addition to the changing climate, increases in urbanization, population, and poverty compound disaster risk. It is necessary to ensure that the Columbus community is best prepared to handle the immediate and long-term effects of the potential disasters that may result from local climate changes.

This chapter contains two necessary (N) and four aspirational (A) actions that support preparedness as the best way to manage the effects of a natural disaster. The best-prepared communities not only limit damage from disasters, but they also ensure that the recovery process is timely and efficient. The proposed necessary actions cover three main phases that lead to a resilient community: (1) understanding who and what infrastructure will be most affected, and developing strategies that will protect them, (2) educating and training everyone that is involved in disaster response, and (3) ensuring a swift and effective recovery plan. The aspirational actions focus on providing resources both before and during environmental disasters. Whether it is through new hazard-alert tools or increasing public awareness regarding the costs associated with environmental hazards, it is critical that everyone in the community play a role. Through these actions, we can ensure that Columbus will be best situated to deal with potential hazards projected to affect our community.

N15 **Use GIS to map fixed critical assets, transportation routes, and vulnerable populations susceptible to environmental hazards.**

Columbus should develop GIS tools that tag critical assets, transportation routes, and vulnerable populations, and this information should be used for planning, queried during emergencies, and shared with appropriate stakeholders. GIS resources should be used to identify both critical assets (e.g., hospitals, fire stations, shelters, distribution centers, substations, pipelines, dams, drinking water sources), transportation routes (e.g., primary and secondary routes and alternates), and vulnerable populations. GIS staff knowledgeable in the tools that have been developed should be available during the entirety of an emergency to provide information to decision makers and emergency services and in addition to being able to generate updated maps to share with the public.

While some of the data can and should be made available to the public, others are sensitive and should only be available to vetted individuals within emergency management and public safety. Therefore, data should be tagged with a classification scheme that remains with the data to clearly articulate with whom the data may be shared. The Ohio State University (OSU) implemented a similar ***system for institutional data classification*** that includes public, internal, private, and restricted levels.[1] Likewise, contracts or partners outside City government should include access to classified information when necessary. Subsequent training should be provided to ensure that individuals, both within and outside of City government, understand and comply with the classification system.

Some facets of the GIS tool to map fixed critical assets and vulnerable populations have already been created by Franklin County Emergency Management and Homeland Security (FCEM & HS), and the Franklin County Emergency Operations Center staffs a GIS position for generation of real-time maps. Since this agency already handles emergency preparedness and response for Columbus and other jurisdictions, it makes sense to determine what partnership between the City of Columbus or FCEM & HS can best fulfill various parts of this effort, how information can flow between the City and county, and how duplication of services can be avoided.

Critical Assets

American Electric Power (AEP) currently prioritizes facilities, such as hospitals, for re-establishment of service when there is an outage. A tool identifying critical city facilities, such as fire stations and shelters, would allow utilities to also prioritize these locations. Once developed, utilities could be invited to review the GIS tool and provide feedback about facilities and routes based on their knowledge of the surrounding infrastructure.

Key natural resources that could be damaged or contaminated during environmental hazards should also be included. For instance, in July 2016, Columbus issued a warning for high nitrates in drinking water in a portion of the region.[2] The City was able to quickly post a map to its website, which was subsequently distributed to media outlets, showing the affected properties. The ability to efficiently generate such products, both for emergency responders and the public, is underpinned by robust GIS tools.

Transportation Routes

In addition to major arteries, the critical routes identified with this tool should include roads in close proximity to hospitals, or those that serve as solitary routes between shelters and

emergency services. This need was highlighted during the windstorm of 2008 resulting from the remnants of Hurricane Ike, when Columbus experienced significant electrical service outages and road closures due to downed trees.[3] Transportation routes, including some major arteries, were unusable for days after the storm.

The proposed tool should identify neighborhoods that are likely to be isolated under various scenarios, flooding being the easiest to anticipate. During major disaster events, such as floods, it may become necessary to protect citizens by moving or relocating them from areas that are threatened to areas that are more secure. These types of evacuations are directed by Columbus' Fire and Police Departments, and they are supported by the Franklin County Engineer's Office, the Central Ohio Transit Authority (COTA), FCEM & HS, and other agencies and transportation industry entities, through Emergency Support Function 1 (ESF1) Transportation of the Franklin County Emergency Operations Plan.[4] ESF1 also includes the ***City of Columbus Downtown Evacuation Plan*** and the Mid-Ohio Regional Planning Commission (MORPC) ***Evacuation Framework***.[5, 6] COTA should be engaged in planning as many of their assets are critical to moving people. For example, similar COTA arrangements have provided free transportation to the public when the city is under certain levels of ***snow emergency***.[7]

In addition to moving people, plans should be in place to provide transportation and logistics for critical resources, such as medical supplies and bottled water. In the case of a large-scale, regional event, plans should make considerations for procurement of supplies from outside the region via reliable transportation routes. Knowledge of these prioritized transportation routes could inform subsequent city investment in infrastructure such as LED street lights and traffic controls with battery backup.

The Ohio Department of Transportation (ODOT) ***Infrastructure Resiliency Plan*** recently identified transportation infrastructure that is most at risk due to climate change; information from this report relevant to transportation in Columbus should be included within the City's GIS tool.[8]

Vulnerable Populations

Particularly vulnerable populations, such as those in close proximity to a floodplain or unlikely to relocate due to inaccessibility, should be identified on the GIS tool. This would permit efficient transportation to be arranged if the impacts of the environmental hazard overlap with the vulnerable population. Data on vulnerable populations, as identified by various characteristics, was recently made available via the Populations at Risk tool by Headwaters Economics; data within the tool is derived from well-established, federal data sets and can be easily imported into any GIS tool for immediate use.[9] The next chapter of this plan focuses exclusively on vulnerable populations.

N16 **Evaluate city preparedness and response during and after environmental hazard emergencies.**

According to the FCEM & HS ***Risk Assessment for Franklin County 2016***, all of the environmental hazards noted in this adaptation plan are among the 19 threats and hazards that have been evaluated for Franklin County.[10] City preparedness and response to these threats require an assessment of risk based not only on current climate trends but also future projections. Environmental hazard emergencies currently prompt responses from various agencies.

FCEM & HS, in conjunction with OEMA, offers extensive preparedness training and response

Agencies that Respond to Environmental Hazard Emergencies

Air Quality	MORPC and Ohio Environmental Protection Agency (OEPA)
Drought	Ohio Emergency Management Agency (OEMA) and Columbus Division of Water
Flood	National Weather Service (NWS) and OEMA
Heat Waves	NWS and Ohio Department of Health (ODH)
Water Quality	Columbus Division of Water and Franklin County Public Health (FCPH)

tools for environmental hazard emergencies. All efforts of the City should integrate with and build upon resources that have already been developed by these agencies. Plans should be developed, and training should be completed well in advance of an emergency, especially considering the timeline of onset varies by hazard. For example, air quality and drought have relatively long onsets, floods and heat waves have relatively short onsets, and water quality has a relatively long onset that can manifest as an acute problem with a harmful algal bloom (HAB).

FCEM & HS currently maintains a ***Training and Exercise Plan*** for environmental hazard emergencies.[11] This training should be revised to incorporate risks magnified by climate change and disseminated to a broader audience. Drawing on training already articulated in county plans brings greater awareness to the threat of environmental hazards, reduces the likelihood of training being neglected, and allows this training to be incorporated with other programs already in place. Likewise, FCPH manages the ***Medical Reserve Corps***, and FCEM & HS manages the ***Community Emergency Response Team (FC CERT)***.[12, 13] Each of these groups have trained volunteers, many with technical knowledge, that are willing and able to serve during emergencies.

Severe floods, heat waves, and water quality issues might necessitate local emergency services and deployment of the Ohio National Guard by the Ohio Governor's Office. Coordination between City departments and external agencies is encouraged. During an event, incident management structure should be established between City leadership to facilitate communication and decision-making. FCEM & HS already serves as the emergency management agency for the City of Columbus and 41 other jurisdictions in Franklin County, streamlining communication between local municipalities and state agencies.

Mutual Aid Agreements can be prepared and signed ahead of time. The Columbus Department of Public Utilities (DPU) is currently a member of ***Ohio WARN*** (Water/Wastewater Emergency Response Network) and can request specialized assistance from other public utilities in the state.[14] They can also work with OEMA to request responses from National WARN members.

Additionally, DPU is also a member of the AMP Ohio (American Municipal Power) ***Mutual Aid Program*** that provides emergency response in the aftermath of disasters.[15]

Once the emergency has ended and basic services have been restored, much of the long-term work of clean up, restoring services, and caring for citizens falls to the city. In the case of particularly damaging events, a disaster declaration at the state or federal level can bring additional long-term support. Services such as, but not limited to, debris removal, food and water distribution, and establishment of temporary shelters are coordinated through the Franklin County Emergency Operations Center as written in the Franklin County Emergency Operations Plan.[4]

With regard to flooding, postmortem analyses of the emergency response and post event actions taken by ***Nashville in 2010*** and ***Houston in 2017*** could inform planning.[16, 17, 18] Likewise, ***Chicago in 1995*** and ***Toledo in 2014*** are cases to examine for emergency response to heat and water quality, respectively.[19, 20, 21] Chicago is a case of how planning and decision making broke down and led to tragic consequences.

A17 **Track and communicate costs associated with preparing for and responding to environmental hazards.**

While failure to mitigate and adapt to climate change may be devoid of upfront costs, individuals working in the climate resilience community know that expenses are paid over the long-term. Without an appreciation for the number and magnitude of changes, it is easy to discount the inevitable cost to communities and individuals. In order to understand the full costs of responding to environmental hazards, expenses associated with both preparing for and responding to these events should be tracked. Knowing these expenses allows policy makers and planners to better understand long-term costs associated with the decisions they are making. As additional cost information is collected over time, policies and plans, in addition to funding allocations, can be adjusted accordingly.

In a budgetary sense, costs within specific departments of City government should have options of being tagged as associated with responding to particular threats, of which climate change is one. During reporting periods, department and City leadership would be able to examine costs not just by department but by tagged themes that extend between multiple departments. Similarly, if all planning for climate change adaptation was paid by one budget allocation that needed to be divided among a number of departments, portions could then be tracked to provide accountability.

Expenses for responding to emergencies would be a bit more complex, with the necessary step of rating various emergencies and disasters as being fully or partly attributable to climate change. The City could elect to also track metrics, like costs incurred by the private sector and the percentage of those that were insured versus uninsured. If the City is unable to track costs associated with preparing for and responding to environmental hazards, weather hazards could be substituted as these are likely to be more readily tracked in both the public and private sectors. FCEM & HS has a procedure and federal forms that are required for tracking costs related with events that rise to the level of a disaster. For significant events, these procedures and documents could be used to estimate costs. For smaller events, the procedures and documents might provide the City with guidance on what could be efficiently tracked.

The DPU Work Asset Management (WAM) system provides the costs associated with all response

and recovery work assignments that result from weather-related incidents (flooding, ice/wind storms, tornado, etc.). Activities and resources tracked in WAM include personnel time, contractors, use of equipment, materials, and damaged infrastructure and large assets. Additionally, DPU can track all claims resulting from the incident. Although DPU is the only department that uses WAM, other departments use similar systems to track costs for work assignments. The City has a "Crystal" management system that is able to extract this data from the different systems within City departments.

Examples of costs that could be tracked include the City's ***contingency contract for $1 million*** for reagents, and $3 million for upgrades, to a water treatment facility to address taste associated with algal blooms.[22] These blooms are expected to become more common under a warming climate.[23] In addition, we have seen neighborhood flooding associated with increasingly common intense rainfall events, such as the ***event that struck near OSU in July 2017*** and resulted in the flooding of High Street and stranding of vehicles.[24] In this case, the costs fell on stranded motorists and businesses along High Street. Additional cost information regarding projects needing to be completed due to flooding and environmental vulnerabilities might become available upon completion of the DPU Hazard Vulnerability Assessment.

An interesting measure of costs borne by individuals would be the portion of current and future insurance costs, such as homeowners insurance, attributable to climate impacts. In order to make these hidden costs more transparent to citizens, Columbus in partnership with other cities or regional and state government could work to gather this information from the insurance industry and share it with broader community. It is likely that these estimates are already available in coastal communities. If they are available for the Midwest in general and Ohio specifically, it is uncertain whether the insurance industry would be willing to share either specific or detailed information about how climate impacts factor into their rates.

Costs associated with preparing for and responding to environmental hazard emergencies should be communicated with the public to maintain transparency and capitalize on an opportunity to educate individuals, business, and organizations about planning for resilience. Sharing this information could also help dispel the misunderstanding that inaction on climate change comes at no cost. Information could be shared online,curated for inclusion in an annual report, or embedded on signage installed as part of capital improvement projects.

A18 **Establish contingency contracts so that sufficient resources are available in case of environmental hazard emergencies.**

Based on the capacity to clean up, restore services, and care for citizens following environmental emergencies, contingency contracts should be established for services and assets that the city might need but otherwise might not be readily available. These contracts have pre-negotiated costs for procurement of particular services or assets, with included delivery schedules. In many cases, there are primary and secondary suppliers to hedge against disruptions to supply chains. Examples of contracts appropriate for environmental hazard emergencies include, but are not limited to: sandbags, bottled water, generators, environmental-cleanup contractors, and technical services for repair of HVAC (heating, ventilation, and air conditioning) and pumping systems. Each environmental hazard plan should account for services and assets that will be needed so that contracts can be established well in advance of an emergency.

With emergencies for which the City will seek reimbursement from the Federal Emergency Management Agency (FEMA), it is important to remember that ***procurement rules from FEMA*** must be followed.[25] Under these rules, pre-negotiated contracts may be utilized during an emergency (with justification of the emergency), but regular procurement procedures must be reverted to once the emergency has ended. Regular procurement procedures also require that the most restrictive procurement process be followed, regardless of whether it is at the local or federal level. FCEM & HS and OEMA have extensive knowledge of assets available from state and federal agencies and experience with planning and procurement for emergencies.

A19 Develop new app or integrate with existing app for environmental hazard alerts.

Digital tools allow individuals to receive timely and customizable information during emergencies and provide updates to emergency services, streamlining the flow of information in both directions. Over the past few years, mobile applications have gained popularity for such tasks as neighborhood communication and real-time traffic alerts. During the 2017 flooding in Houston, mobile applications emerged as novel communication vehicles between citizens and first responders when traditional communications vehicles (e.g., phone and emergency alerts) broke down. With cellular phone access at 95% and smartphone access at 77% in the United States, and the resilience of the cellular network being demonstrated in circumstances such as Hurricane Harvey, mobile apps can serve as a robust communication tool during emergencies.[26]

The City of Columbus currently has a mobile application, ***MyColumbus***, designed to provide information (non-emergency) to residents and serve as a conduit to submit 311 requests.[27] For emergency- and hazard-related information, FCEM & HS developed the ***ALERT Franklin County*** app, which is already available to all Franklin County residents.[29] Columbus has collaborated with FCEM & HS in deploying ALERT. Rather than create another mobile application for hazard alerts, the City should continue to use MyColumbus for non-emergency information but utilize ALERT for emergency communications. Columbus needs to carefully consider the role of its websites during emergencies. City websites and the MyColumbus app could all include a header to point visitors seeking out emergency information to the website of FCEM & HS and ALERT Franklin County app. The roles and limitations of the ALERT app, MyColumbus app, and websites should be clearly understood and articulated. All three platforms should work in tandem to ensure that residents receive vital information in a timely manner.

Any digital solutions will require regular maintenance and updating of features to remain secure and relevant. Likewise, similar to GIS services, staff needs to be on call during an emergency to assist with content curation and note areas for improvement. FCEM & HS is best positioned to deliver these continually evolving services. Since not everyone has access to a smartphone, especially among some vulnerable populations, more traditional methods of communication (television, radio, text alerts, etc.) will still need to be maintained for the foreseeable future. Thus, mobile applications are not a panacea for emergency communication. For those with landlines, FCEM & HS, through the Everbridge Notification System, has the ability to send out a Reverse 911 message to any area in their designated region. Although the program is managed by FCEM & HS, the City of Columbus has access to use the Everbridge database and notification capability for their employees.

The social science research community has

Improving Emergency Communications

While there have been considerable improvements to emergency communication during disasters in the United States over the past decade, additional changes that have been requested by emergency managers and have been deployed elsewhere in the world have yet to become standard in the United States. For instance, the Federal Communications Commission (FCC) does not require wireless carriers to direct wireless emergency alerts to specific, geographically targeted recipients. This is particularly important when individuals in two adjacent locations need to be given different instructions, such as individuals in one location needing to shelter in place while individuals in an adjacent location need to evacuate. Likewise, wireless emergency alerts do not allow inclusion of images, such as photographs or maps, that might be useful to recipients.[23] While mobile carriers were able to stage fuel for backup generators, portable cell sites, and additional assets during Hurricane Harvey, individuals that called 911 often received busy signals or long hold times as there was not sufficient capacity to answer calls. While this was an improvement from Hurricane Katrina, when much of the cellular network was incapacitated, overloaded 911 call centers could be alleviated by allowing excess calls to be distributed to other locations, potentially outside disaster zones, where additional infrastructure and staffing are is present to absorb the demand.[33]

demonstrated that during disaster situations, such as hurricanes and flash floods, individuals do not respond to emergency notifications in expected ways.[29, 30] Therefore, effective communication should take into account how people receive and respond to these messages. For instance, during the ***flash floods in California in January 2018***, only 10-15% of residents in Santa Barbara County evacuated when told to do so, suggesting that there was a disconnect between the messaging and the desired behavior.[31]

A20 **Implement educational campaign to inform the public about insurance and other shared risk programs available for environmental hazards.**

The public is likely not fully aware of risks associated with deteriorated air and water quality, floods, heat waves, and droughts, or ways to insure themselves for personal, business, and organizational losses. Probably the best known program for shared risk is the ***National Flood Insurance Program (NFIP)***.[34] Depending on the type of loan sought by a homeowner and the home's location relative to an established floodplain, lenders require homeowners to purchase a policy from the NFIP. But, the current program is underfunded, not all property owners understand its limitations, and the nature of the program often incentivizes property owners rebuilding on the same site following a flood without significant design changes. With climate change increasing the frequency and intensity of extreme rainfall, events are occurring more often than expected by historical probability.[35] While

there has been a recent effort to update floodplain maps to better reflect the best available science, the process is costly and contentious. Without access to updated information, property owners are therefore bound to make decisions based on understated risk. Likewise, costs associated with supplemental insurance and trends in rate structures must be considered when accounting for comprehensive long-term costs.

Each of these environmental hazards impact individuals, business, and organizations in different ways. Therefore, an educational campaign needs to target a variety of audiences, communicate information in formats tailored to those audiences, and offer solutions appropriate to audience needs. For instance, deteriorated air quality is a cost borne by individuals and hospitals. Costs associated with poor air quality that result in an increase in visits by individuals to emergency departments are paid through health insurance. Individuals without health insurance personally bear the costs or transfer the costs to hospitals through unpaid or underpaid bills.

Heat waves, droughts, and deteriorated water quality can be risks to businesses. For instance, a heatwave or drought may increase costs for plant nurseries. A regional water quality emergency may result in the temporary closure of food processors, restaurants, and businesses associated with tourism. In each of these cases, individuals and groups need to take steps to understand, reduce, and pool their particular risks. For large companies, experts can be hired to analyze risk in more sophisticated ways, reduce risk where possible, and distribute the remaining risk over the entire company. Smaller companies and individuals may require external expertise, purchase additional insurance coverage in traditional or novel marketplaces, and/or participate in public-private partnerships. An educational campaign needs to be delivered by a trusted source that has deep knowledge of both the problem and options available.

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Vulnerable Populations

Actions

N17 Identify representative advocacy organizations for diverse and vulnerable populations.

N18 Facilitate cross-cultural dialogue, offer training for service providers, and share best practices.

N19 Ensure diverse modes of communication during environmental hazard emergencies to reach diverse and vulnerable populations.

N20 Implement educational campaign on environmental hazard preparedness to reach diverse and vulnerable populations.

N21 Coordinate closely with the Ohio public-private partnership to manage food and water access for vulnerable populations during environmental hazard emergencies.

A21 Require disclosure of known property problems for sale or rental of property.

A22 Require or incentivize that monthly utility costs for rental properties be reported to potential tenants.

Background

According to the ***World Health Organization (WHO)***, vulnerable populations are those subgroups who, compared to the general population, are more at risk of adverse health events and are less likely to resist or recover from threats to health.[1] A number of different groups can be considered vulnerable, including: children, pregnant women, elderly people, malnourished people, people who are ill, and people in poverty. The ***Intergovernmental Panel on Climate Change (IPCC)*** acknowledges vulnerability as the propensity or predisposition to be adversely affected.[2] The impacts from climate change are often dependent on other non-climatic factors and exposure differences. Therefore, assessing the susceptibility to harm and lack of capacity to cope and adapt is not always straightforward. Columbus should consider how climate change impacts its population and deliver climate adaptation information to its most vulnerable populations, since these groups will be disproportionately affected by climate change. An excellent overview of some of the considerations for this chapter, especially the necessary action items, is provided in a ***public health report*** by Wingate published in 2007.[3] Additional resources available from the ***Centers for Disease Control and Prevention (CDC)*** and ***Ohio Public Health Association (OPHA)*** should guide all decision making.[4, 5]

Over 30% of the population in Columbus is less than 18 years of age or more than 65 years of age, while in neighborhoods like Franklinton and the Near East, this number exceeds 35%.[6] In fact, Columbus has one of the youngest populations across a spectrum of U.S. cities and youngest of the Midwest's major cities (current median age of 35.9).[7] The estimated number of people in Columbus City Schools living below the poverty line is 27.2%, the highest of any school district in Franklin County. In areas such as Hilltop, Linden, and Weinland Park, the number rises to over 40% of the population. Columbus boasts the most diverse population in Franklin County, with people of color constituting 38.5% of the population. However, Columbus was identified as one of the most socioeconomically segregated cities in the country, as measured by the inequity between the most advantaged and most disadvantaged neighborhoods.[8] In order to adequately adapt to this changing climate, it is important for the City to understand how climate change increases risks that vulnerable populations face.

Post-analyses from previous environmental disasters reveal how specific populations can be disproportionately affected by natural hazards and how to allocate resources to achieve the greatest benefits. During the 1995 Chicago heat wave, over 700 heat-related deaths occurred throughout the city. The majority of fatalities concentrated in neighborhoods with disproportionately low-income residents who were socially disconnected and unable to sufficiently cool themselves.[9] Following the widespread, devastating floods in October of 2015, South Carolina collaborated with the University of South Carolina's Hazard and Vulnerability Research Institute to produce the ***South Carolina Action Plan for Disaster Recovery***. They utilized their Social Vulnerability Index to empirically assess social vulnerability in all counties that experienced damage. Those counties with high social vulnerability have a decreased ability to prepare for, respond to, and recover from environmental disasters (e.g., floods).[10] Although these counties did not include the most populated areas, the report demonstrates that providing resources to higher socially-vulnerable areas result in the greatest recovery benefit. In ***Louisiana during Hurricane***

Katrina, 49% of all fatalities occurred among people aged 75 or older, despite that population representing only 5.4% of the city's total population.[11]

These and other types of events illustrate how the risks associated with extreme events may be magnified for vulnerable populations and manifest in a variety of ways. For example, if a major flood requires evacuation, limited access to transportation in certain neighborhoods can result in the inability of people to leave an area. This is often the case for elderly and impoverished communities. At emergency shelters or cooling centers, problems may arise due to language differences, cultural barriers, or the inclusion/exclusion of pets. During heat waves, people with pre-existing medical conditions (e.g., asthma, high blood pressure) or on certain medications are more susceptible to heat-related illnesses and death. Likewise, individuals living in poverty are less likely to have housing with adequate cooling. Therefore, having both a pre-existing medical condition and living in poverty compounds an individual's ability to overcome a heatwave. ***Research*** indicates that there is an overall correlation between exposure to environmental pollution and the degree to which communities are segregated.[12] In Columbus, there is evidence of a ***concentration of facilities*** that deal with toxic substances on the south side of the city.[13] All of these factors should be accounted for as Columbus prepares to respond to continued warming and greater likelihood of extreme precipitation events.

Franklin County Emergency Management and Homeland Security (FCEM & HS) has identified a number of organizational liaisons that represent and engage particular communities during disasters. Collaboration and communication with vulnerable populations, often achieved by working in concert with trusted community partners who know and understand the population's needs, will lead to the most effective solutions. Since these populations are quite diverse in Columbus, careful consideration should be given to all of the populations, realizing that not all populations will need the same support. Involving leaders and representatives from diverse populations in emergency planning makes it more likely that effective steps can be taken to increase resilience to climate impacts and environmental hazards. Rather than merely responding to natural hazards in the moment, investments in planning, nurturing collaborative relationships, training, and increased coordination will likely improve outcomes when emergencies occur.

To unpack the topics highlighted above, this chapter contains five necessary (N) actions that Columbus should take to engage populations throughout the city that are more susceptible to climate impacts. By including community leaders and representatives from these populations, the City can ensure that necessary information and resources are delivered to these groups, both before and during environmental disasters. Finally, two aspirational (A) actions focus on providing pertinent information on housing properties to buyers or renters so that they may understand all potential costs associated with increased environmental risks and utilities due to climate change.

N17 **Identify representative advocacy organizations for diverse and vulnerable populations.**

Vulnerability varies based on the nature of an emergency within a community.[14] During the creation of this report, the wide diversity of vulnerable populations in Columbus and their particular needs became apparent. The Task Force recognized a lack of communication and collaboration with key leaders and representatives within these populations who could provide an overview of their concerns and needs. Establishing a network of such leaders and representatives would benefit more than the City's work on climate resilience.

The City should consider creating a directory of leaders or representatives from vulnerable populations to consult in advance of an emergency. This would ensure a stronger level of preparedness and guide the City on proper messaging and outreach. Technical experts, emergency personnel, and communications specialists are more likely to craft a successful message in consultation with these individuals. Likewise, the City should be prepared to rapidly translate written and oral communications to key languages (e.g., Spanish, Somali, etc.) and make them available to emergency personnel. For events that are highly likely to occur (e.g., extreme heat events, floods), a collection of pre-written and pre-recorded messages should be created. When particular neighborhoods are impacted by an event, door-to-door canvassing might be necessary before, during, or following that event. Over time, both the populations and their needs will change, requiring vigilance in maintaining open lines of communication with leaders/groups that are already part of the conversation while inviting participation of those who represent newly emerging populations. To support communication and ongoing engagement with emerging populations, a regular forum for exchanging ideas among these representative advocacy organizations and the City could be held.

Public health professionals are likely to have the appropriate training and experience to identify and work with diverse and vulnerable populations and should be engaged throughout the process. Existing coalitions and groups facilitated by public health can be leveraged to connect with community members and agencies providing services to vulnerable communities; however, the need for departments across the city to leverage community connections is necessary to broaden outreach efforts in Columbus neighborhoods. Detailed guidance for working with vulnerable populations is provided in a ***2007 public health report by Wingate***, the ***BRACE Framework from the CDC***, and a ***2018 publication of the OPHA***.[3, 4, 5]

N18 **Facilitate cross-cultural dialogue, offer training for service providers, and share best practices.**

The City should facilitate cross-cultural dialogue related to climate change adaptation; these conversations have strengthened relationships between neighborhoods and public health commissions, police departments, schools, and food pantries in other communities. Cross-cultural dialogue allows participants to gain a greater understanding and empathy for the circumstances of others within the community, and it can lead to positive and productive interactions in the future. When planning for climate change impacts, the dialogue should focus on those individuals who are most affected by climate change but have the least capacity to respond. These conversations need to include both the agencies and organizations that deliver services to the vulnerable populations and representatives from the communities that receive those services. There are a number of ***examples of guiding principles*** employed by

agencies and organizations facilitating cross-cultural dialogue, including those in public health.[15]

Requirements for training will be informed by the needs of vulnerable populations within Columbus and expertise from the public health community. As was mentioned earlier in this chapter, essential guidance can be found in the 2007 public health report by Wingate, the BRACE Framework from the Centers for Disease Control and Prevention, and a 2018 publication of the Ohio Public Health Association.[3, 4, 5] While accessible training materials developed for other communities can be employed, methods that are specific to Columbus should be subsequently refined and expanded. Additional training might need to be created in collaboration with the representative advocacy organizations discussed in section N17 and include integrated evaluation. Collaborative development ensures that all necessary information is included while being culturally sensitive. Likewise, it should be acknowledged that not all audiences are best reached by same delivery method. Online learning platforms offer a number of novel strategies that could supplement or replace in-person training.

Realizing that there is a wide network of collaborators with the city on any training initiative, education campaign, or emergency response, developed materials should be shared with service providers and community organizations. Needs that are identified during cross-cultural dialogues can inform city policies and subsequent training opportunities. Therefore, the dialogues discussed above can serve to improve communication and build relationships as well as enhance operations and training.

N19 Ensure diverse modes of communication during environmental hazard emergencies to reach diverse and vulnerable populations.

Not all vulnerable populations have access to either computers or smartphones, and many receive their information from a diverse array of sources. Older populations still rely on radio and television for information. Some populations might rely on a smartphone rather than a computer but have a limited data plan. For those with language barriers, friends, family members, or members of a faith community might serve as their conduit for information. Although the messaging will be different during emergencies and education campaigns, there will most likely be overlapping pathways of communication.

Both Columbus and Franklin County should utilize various language-appropriate communication to meet people where they are, using different emergency alert systems for various circumstances and different populations. Two examples include Wireless Emergency Alerts that are used for Amber Alerts, as well as systems that rely on individuals pre-registering e-mail addresses or mobile phone numbers, such as ALERT Franklin County. Following the ***October 2017 wildfires in California***, post-mortem analyses of emergency evacuations revealed that problems arose in deploying evacuation alerts.[16] While systems performed well at the county level, they often failed at the neighborhood-level. Emergency managers have to carefully determine whether to deploy alerts systems. When seconds matter to individuals that are trying to safely flee threatened neighborhoods, widespread alerts may result in individuals from otherwise safe neighborhoods evacuating unnecessarily. Large, simultaneous evacuations can clog escape routes, preventing evacuees in the most threatened neighborhoods from leaving. As mentioned in A19 under Emergency Preparedness, an emergency alert

system should integrate with whatever emergency mobile application is selected by the City of Columbus.

In addition to communications during an emergency, consideration should be given to developing ways for vulnerable populations to contact friends and family members following an event. The City and County should work with the ***Ohio Public-Private Partnership (OP3)*** to ensure that barriers are reduced for permanent repairs to and, when necessary, temporary deployment of telecommunication assets—including cellular networks, landlines, and data providers.[17] Likewise, novel technologies could be deployed, such as Facebook's Safety Check, to allow simplified communication between those experiencing the disaster and their friends and family members.[18] These supports can offer help to affected individuals, hopefully returning their lives to a greater sense of normalcy, while also reducing strain on 911 emergency operations.

N20 **Implement educational campaign on environmental hazard preparedness to reach diverse and vulnerable populations.**

Educational campaigns on environmental hazard emergencies should focus on ways to prevent harm to individuals and property during future events, particularly flooding, extreme heat, and air quality emergencies. The City should ensure that the educational campaigns suggested in other chapters of this adaptation plan include a specific focus on the impacts to vulnerable populations. There are a number of innate challenges concerning educational campaigns with vulnerable populations. These include the need to identify which vulnerable populations are most at risk during particular environmental hazards, determining the best educational methods that ensure increased awareness of how climate change impacts their lives, and convincing community organizations and individuals who might already be facing a number of other pressing needs that the educational campaign is worth their involvement. To guarantee long-term retention, the educational campaign should be provided routinely.

N21 **Coordinate closely with the Ohio public-private partnership to manage food and water access for vulnerable populations during environmental hazard emergencies.**

OP3 can nimbly respond to emergency needs for food and water access. ***During the summer of 2014***, the water supply of Toledo was contaminated due to an algal bloom near the water intake located in Lake Erie.[21] A toxin released by the bacteria rendered the water system unusable for approximately 400,000 individuals for three days. In addition to the aid from neighboring communities with separate water treatment facilities and the Ohio National Guard creating distribution points, OP3, operating under Ohio Homeland Security, was instrumental in working with large corporations to redirect bottled water to Northwest Ohio.[17] The partnership allowed better communication and coordination between government agencies and private companies that were able to provide tangible assets during the emergency. Having sufficient bottled water in stores where individuals were accustomed to shopping was more convenient for a majority of the population, and it also allowed emergency personnel and public distribution points to service those most in need. A similar arrangement could be utilized for food access during an environmental hazard emergency such as a flood.

Rather than create its own public-private partnership, Columbus should ensure that emergency planning and response personnel are part of OP3. Likewise, in working with FCEM &

Social Vulnerability Index

The CDC has created *the Social Vulnerability Index* to help local officials identify the ability of specific communities to prepare for hazards or recover from disasters.[19] While taking actions to reduce social vulnerability can decrease both human suffering and economic loss during a disaster, it might also be necessary to respond to communities that have high social vulnerability. An online tool makes this data available by census tract for emergency planning and response. The Social Vulnerability Index tool is composed of four themes: 1) socioeconomic status, 2) household composition, 3) race/ethnicity/language, and 4) housing/transportation. To inform both communication and education campaigns, GIS tools that were discussed in the Emergency Preparedness chapter of this report under action N15 should include this information on vulnerable populations within Columbus neighborhoods. Another accessible source of data on vulnerable populations, provided by census tract, is available from *Headwaters Economics Populations at Risk* tool.[20]

HS, engaging OP3 should be seen as an effective way to mount a more robust response to an emergency by bridging the strengths of the public and private sectors. Participating with OP3 does not preclude the city from working with its typical community partners and non-profits.

A21 Require disclosure of known property problems for sale or rental of property.

Many of the protections provided in federal and state law that govern real estate transactions and mortgages provide protections for buyers that are not afforded to renters. Considering that approximately one-third of the country's population does not own their own home, this gap affects a significant number of individuals and families.[22] Columbus should consider passing legislation to require landlords to provide more information to tenants about the properties they are renting so that they can better assess rental risks in light of climate change. Under Ohio landlord-tenant law, landlords have no obligation to disclose known issues, and there are no restrictions on local governments to require the disclosure of roof leaks, electrical issues, malfunctioning appliances, pests, and known hazards, such as the location of the property within a floodplain. Columbus needs to take action to increase the information made available to vulnerable populations about their residences so they are better equipped to deal with the negative consequences climate change may have on their living situation.

After the *2017 flooding in Houston associated with Hurricane Harvey*, it was revealed that several apartment buildings had flooded multiple times in the past and were located in areas known to be at high risk for flooding according to federal guidelines.[23] Many of the affected tenants were unaware of this. Of the environmental hazards listed in this plan, flooding has the

greatest potential to render buildings unusable. Flooding forces renters to evacuate, relocate, and/or replace personal property, all of which cost time and money. Properties located within floodplains and those that have flooded in the past are of greatest concern. Flooding does not just include inundation by a river or stream but also localized flooding due to insufficient storm water drainage or sewer backups that flood basements. Previous flood events may have resulted in undisclosed structural impairment in addition to health and safety issues such as damaged electrical systems and mold.

There are two recommended disclosures that would benefit tenants. These include information concerning whether the property of interest is in the 100-year and 500-year floodplains as determined by the National Oceanic and Atmospheric Administration (NOAA) and whether the property has flooded in the past. In addition to allowing tenants to determine whether they accept rental properties with known flood risks, this information would allow them to consider the level of insurance coverage that might be needed to protect their assets. Both of these disclosures should be included on a standard form developed by Columbus that would also provide links to web resources with maps of floodplains in Columbus, damage that can be caused by flooding of a property (including health risks due to mold), and considerations for insurance coverage.

Any requirements to disclose problems with a property need to be backed by sufficient penalties for landlords failing to follow through. Likewise, if renters do not have an affordable way to pursue recourse with a landlord who has not disclosed problems for which there is evidence of prior knowledge, or renters do not have other affordable options than to accept substandard properties with known problems, the intent of this requirement is rendered unfulfilled.

A22 **Require or incentivize that monthly utility costs for rental properties be reported to potential tenants.**

A ***2013 study completed by the University of North Carolina at Chapel Hill Center for Community Capital*** suggests that energy expenses can undercut the ability of homeowners to make mortgage payments, and therefore, should be factored into mortgage risk.[24] It is estimated that homeowners spend over $2,500 annually on energy bills, significant costs that sometimes exceed insurance and property taxes.[25] The situation is no different for renters, with low-income renters facing a larger financial burden from energy costs than high-income renters. While high-income renters (those earning $75,000 or more) pay approximately 1% of their income on utilities, low-income renters (those earning less than $15,000) pay approximately 15%. This higher percentage is due to both lower incomes and less-efficient properties.[26, 27] Besides purely economic considerations, difficulties in making utility payments and fear of losing service result in stress for affected households. Under the currently opaque energy market—with utility expenses for properties not publicly available and a vast majority of properties not having a completed energy audit—making such information available could result in new behavioral norms for renters with both economic and environmental benefits.

One of the challenges in promoting energy efficiency in rental properties is that landlords determine the physical infrastructure of the property, but tenants generally pay for utility costs. Economic incentives that would typically motivate improvements to a property do not function properly in this situation.[25] Additional information provided to tenants might allow them to adjust their rental choices accordingly. For instance, a renter would be more likely to prefer a more energy-efficient property with

Emerging Energy Efficiency Tools

Information on energy efficiency could be gathered by prior utility expenses, energy audits of properties, or algorithms based on publicly available property data. Two recently available online tools in this arena are ***RealEstate.com with UtilityScore*** and ***Redfin with Tendril***.[31, 32] While neither tool is perfect, they are examples of how available data can be used to provide more information to homebuyers and renters. In locations where utilities or landlords are not required or not allowed to share information on energy use, these tools are an attempt to provide renters with some useful information on properties that they are considering. Landlords may always provide potential tenants with additional information if they feel that the online tools do not adequately capture the energy use of their properties.

lower utility bills over a less energy-efficient property with higher utility bills if all other factors are equal. Such a change in behavior would create a greater demand for efficient properties. Landlords, to remain relevant in the market, would need to upgrade their properties, thus realigning economic incentives to favor efficiency. Chicago has an ordinance in effect that requires landlords to disclose electric or gas heating costs for all properties, regardless of whether a tenant or landlord is paying directly for such services.[28] This ordinance also requires the disclosure of the portion of the year a building was occupied. Additionally, Columbus could require landlords to disclose particular features of the property, such as whether the windows are double-paned and the extent of insulation. This market-based incentive only works if renters generally understand the information, it factors into their decision-making, and there are sufficient rental properties from which they may select.[29] Landlords who wish to make their properties more energy-efficient, thus making them more attractive to potential renters, may take advantage of programs described under action A3.

A growing number of rental properties have utilities provided or billed directly by third parties rather than a regulated distributor. This impacts both the rates paid by the tenant (as additional fees are often incurred) and the options available to select renewable sources (tenants would not be able to select a different supplier). Tenants, especially those from out-of-state or that are first time renters, might not know their utility providers or rates when signing a lease.

A standard disclosure form, similar to the one mentioned under A21 for flood risk, could include the utility provider (for electricity, natural gas, and water), a link to the website with current rates and average usage per square foot, and a link to the Public Utilities Commission of Ohio (PUCO) ***Energy Choice Ohio website*** with a notice of whether it applies to the property.[30] Additional information on the specific energy efficiency of a property relative to other similar properties, derived from the prior year's actual usage or an indirect evaluation based on some of the tools described in this chapter's inset, could be included on this form. The City would need to determine what information should be

included and whether regulations or incentives would motivate its inclusion. This information would allow renters to better understand the full cost of their rental decisions and seek additional information when necessary. Properties that are more efficient than average might have market incentive to advertise this information without regulations or incentives from the city, thus resulting in renters asking to see similar information of all prospective landlords.

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Looking Forward

Accountability and Next Steps

Successful implementation of this Columbus Climate Adaptation Plan (CCAP) hinges on accountability. While it is outside the scope of this plan to assign actions or estimate costs, a number of suggested practices include: (1) assigning a responsible department to address each action, (2) requiring that departmental leadership report on progress annually, (3) providing an annual public summary of progress, and (4) providing a budgetary allocation to fund climate adaptation actions outlined in this document.

CCAP was drafted with the intent to provide a reasonable number of mission-related initiatives to each city department. Proper implementation of the actions described in this report necessitates specific technical knowledge inherent to various city departments. Thus, these departments should assume leadership roles in project planning, assigning duties, and executing actions. For each action, the lead department should assemble a timeline with intermediary targets and performance indicators to guide their efforts. Development of these targets and indicators will help measure progress and articulate budgetary, resource, and staffing needs. To achieve timely action, departments should assume responsibility for developing intermediary targets and performance indicators by 2020, and these items should be collected and added to the CCAP as a supplement.

Efforts should be reported annually in departmental progress reports. These reports could then be consolidated into a larger Columbus sustainability report, published each year, that could map the completion status for each action. This process would create consistent, updated, department-wide communication of progress, while also keeping City leadership and Columbus residents informed. The existing ***Sustainable Columbus*** website could serve as the repository for these reports.[1]

For initiatives, such as the many educational campaigns outlined in the CCAP, Sustainable Columbus could also provide consistent guidelines for programs that are led by individual departments but fall under the umbrella of climate adaptation. For efforts that involve collaborations between departments, the City sustainability staff that comprise Sustainable Columbus could also serve as discussion facilitators. With access to deep knowledge of the issues and collaborators outside of city government, Sustainable Columbus is best positioned to navigate the many voices at the table through changes in policies and operations.

To assume the additional workload, the City could allocate funds related to climate adaptation for departments to utilize. Funds should be allocated for sufficient staff to assemble the annual reports and facilitate inter-departmental collaboration around climate adaptation.

The annual sustainability report should include a table documenting progress toward completion of each action item, in addition to a brief summary of accomplishments over the current year. As action items are completed, they will no longer need to be addressed in the annual updates; rather, content regarding completed actions could be collected on the Sustainable Columbus website. This website can provide the public with access to the full list of action items and progress toward each action's completion. Much of this evidence will exist on department-level websites in the form of reports and planning documents, education curricula, online training, and supporting materials. Combined, the annual sustainability report and Sustainable Columbus website could serve as a publicly-available progress report to the electorate. Cities such as ***San Francisco*** serve as an example.[2] A well-designed website provides visually appealing

information, highlights particular programs when desired, and allows users to query content in diverse ways.

The City may wish to periodically employ an independent third party to provide an assessment of climate adaptation progress. Such a third party provides an external voice to city government that may authenticate progress. The City's reporting through the ***CDOP*** might sufficiently fulfill this objective.[3]

Implementing the actions contained in this report will involve a financial investment from city government with additional support from key partners. While some actions can be achieved by building on programs already in place, others will require expansion of existing programs or the creation of novel programs. It is important to put this investment in context by remembering that failure to adapt to climate change is likely to result in significant costs borne by both the public and private sectors. Thus, investment costs for climate adaptation should not be compared with those of inaction (a cost of $0), but rather future costs to be incurred by both the public and private sectors for responding to climate impacts for which we have not adapted. These are likely to be considerably more expensive than the adaptation costs themselves.[4]

Scanning the Federal and State Landscape

Over the last decade, federal and state policies have failed to take aggressive measures to reduce greenhouse gas emissions. Some actions taken at the federal and state levels in recent years have been undermined or are facing threat of repeal.[5, 6, 7] Likewise, some climate research efforts and programs that support climate adaptation have become targets for budget cuts.[8] While economic forces are beginning to move the energy economy toward greater efficiency and renewables, our current emissions trajectory is projected to remain significantly too high to avoid serious climate impacts.[9, 10] Thus, Columbus and other communities across the country face the need to plan for climate impacts with great uncertainty of the regulatory tools, potential resources, and data and research infrastructure that will be available to both mitigate and adapt to climate change. At the same time, insurance and financial institutions are beginning to factor climate resilience into calculations that impact the availability and costs of risk-reduction tools and loans.[11, 12]

City governments are often the first line of defense for vulnerable populations and are likely to receive significant animus from citizens that identify city response to disasters as inadequate. Unfortunately, failures of planning are often not fully realized until after a disaster occurs. The City of Columbus, through its commitment to the Global Covenant of Mayors and by signing the We Are Still In Declaration, has declared that it intends to be a leader related to Climate Change initiatives. The City should continue to engage other municipal and regional governments, non-profit organizations, businesses, and residents on climate change initiatives. Lastly, the City should continue to share climate related information with citizens to improve the public awareness of climate threats, and so that they can understand why budget dollars are being allocated toward climate adaptation.

Development Within the City

Regional planning documents, such as ***insight2050***, provide projections of growth in Central Ohio by 2050. By that year, an additional 1 million people are anticipated to move into the region.[13] Insight2050 provides a continuum of scenario options for how development may proceed. It ranges from expansive, regional growth primarily utilizing undeveloped land to dense growth in existing urban areas through

infill of previously-developed land. Scenario A: Past Trends focuses on "suburban and rural, auto-oriented development" and would result in greater land consumption and resource investment. On the other end of the continuum, Scenario D: Maximum Infill would result in the least land consumption, least building energy use, least building water use, and lowest greenhouse gas emissions. This scenario is the least expensive to construct, operate, and maintain; has the lowest associated public health costs; and has the lowest household costs associated with vehicles and residential energy and water use.

Moving forward, the City will need to holistically weigh the costs and benefits of the development practices that it elects to pursue, including the impacts on natural systems. Scenario D on the continuum proposes a less expensive route that is more aligned with the actions articulated in the CCAP. Planning will require the City to mitigate the negative water quality, air quality, and urban heat effects new development has the potential to cause. Likewise, regional conversations will be necessary, as the actions of each community impact its neighbors. Scenario D represents a departure from past practices, which more closely align with Scenario A, and will require some paradigm shifts in how development is approached by professionals at all levels if it is pursued.

Besides pursuing development more aligned with Scenario D, the City could consider creating a technical advisory board to help inform overall development principles or review specific projects. Such an advisory board might include key individuals from the departments of public utilities, public health, public safety, recreation and parks, and neighborhoods. Each would have a specific lens through which to review principles or projects, informed by the work of their professional training and department's responsibilities.

Considerations for the Future

The CCAP serves to inform decisions made in the immediate future but will need to be periodically updated to remain relevant over the longer term. For instance, the National Climate Assessment, a document written at the federal level with contributions from innumerable technical experts, is required by Congress to be updated every four years. The City should determine a regular schedule by which to re-examine the city's climatology and climate change impacts, and revisit risks, vulnerabilities, and recommended actions.

As with most communities that have developed similar documents, this plan will likely serve as the first time that many individuals in local government have considered the local impacts of climate change. By the time that this document is next updated, consideration of climate impacts will hopefully become common practice for city departments. Likewise, to be most successful in making Columbus climate resilient, this knowledge needs to be accessible to and inform actions of business owners, non-profit organizations, and residents.

There are a number of climate change impacts on the horizon that could be relevant to Columbus, but the details are poorly understood at this time. Each are complex issues intertwined with forces well outside of direct City control. Therefore, it is important that the City monitor these additional risks while taking the specific actions outlined in the CCAP.

Migration
With sea level increasing at an accelerating rate, coastal communities along the eastern U.S. are experiencing greater inundation and erosion. In other areas of the country (e.g., the western U.S.) drought is becoming an increasingly common occurrence, resulting in groundwater depletion and water resource shortages. With plentiful

water, a temperate climate, and relatively fewer natural hazards, the Midwest could be an attractive location for individuals and businesses to relocate under future climate scenarios. Important considerations will need to be made well in advance to comfortably accommodate these climate migrants. Without taking into account this potential influx of people, MORPC has estimated population growth of Central Ohio by 2050 to be 1 million. This is an increase from three years ago when MORPC estimated growth of 500,000 people.[13]

Food Production

Columbus is dependent on a food system that is intricately linked to locations outside of its borders. Climate change impairs food production and distribution through phenomena, including but not limited to, droughts, intense rainfall events, and floods. These events impact both residents of the city and businesses located throughout the region. Likewise, shocks to the food system (e.g., sudden lack of supply) could increase prices, exacerbating food insecurity that is already a challenge for some of the city's most vulnerable populations.

Pests

Climate change is adjusting the growing ranges and extending the growing season of pests that impact ecosystems, agriculture, and people. For example, climate change has already contributed to significant damage to ecosystems, as we have seen in western U.S. forests with the bark beetle and aquatic systems in the midwestern U.S. with algal blooms. Humans have been directly

Adaptation Process

Figure 5. *Climate adaptation depicted as an ongoing effort involving continued stakeholder engagement.*[14]

impacted by expanded cases of vector-borne infections including Lyme Disease, dengue, chikungunya and Zika. Experts generally agree that future climate change impacts will bring new pest threats to ecosystems, agriculture, and people.

Social and Intergenerational Justice
Any development that causes damage to a public "commons", negatively impacts existing private or public infrastructure, or necessitates future costs by the city to mitigate long-term damage it creates, can breed resentment among community members. A situation such as this has arisen in Findlay, Ohio surrounding a plan to mitigate flooding from the Blanchard River.[15] Intense rainfall events that have become more frequent and severe with climate change, combined with recent development throughout the watershed, have created multiple flooding events in downtown Findlay. Addressing the flooding issue has pitted different members of the community against one another as they decide how best to resolve the problem. Thus, development practices today can create questions of social and intergenerational justice well into the future, some which may be exacerbated by climate change.

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Appendix

The development of the CCAP began in Autumn 2016 with the seating of a Task Force composed of individuals from The Ohio State University's Byrd Polar and Climate Research Center (BPCRC), Columbus city government, and MORPC. A list of these individuals is provided in the Acknowledgments section of this document.

To guide city government, non-profit organizations, businesses, and individuals in accomplishing the recommended actions, the Task Force was charged with:

1. soliciting input and feedback from important community stakeholders and technical experts.

2. drafting a list of prioritized actions that could be taken to address climate change risks and vulnerabilities.

3. providing an accessible, written report, with sufficient background information and connections to existing initiatives.

This largely followed recommendations provided by the Climate and Energy Working Group of the Columbus Green Team in Spring 2016 and a framework from the U.S. Climate Resilience Toolkit.[1] In total, more than 90 people were directly involved in the development of the CCAP, including Task Force members, stakeholders and technical experts.

The work of the Task Force was informed by a number of assumptions.

1. Many climate change impacts are complex phenomena involving people, places, and events well outside city boundaries and the control of city government, but the city is the level of government with which individuals are mostly likely to interact. Therefore, the City has an important role to play in preparing the local community for climate impacts.

2. City government is one player in the local landscape of climate resilience. Therefore, efforts should build capacity with local businesses, non-profits, and individuals while also sharing information gathered to regional and statewide government agencies.

3. There are some prior local efforts to address risks and vulnerabilities associated with climate change. Likewise, a number of other local initiatives could be made more resilient through receipt of critical information. Therefore, efforts should build on successful past projects and take advantage of existing opportunities rather than focus on constructing brand new initiatives.

4. Resources available in both the public and private sectors are limited. Therefore, actions that have the lowest barriers to implementation and provide the maximum return on investment should be prioritized.

5. Populations within the city should not face undue harm from climate change impacts because of circumstances outside of their control. Therefore, the city has a responsibility to work proactively to protect vulnerable populations from climate change impacts.

A timeline of steps and critical milestones in the development of the CCAP is included below. In Autumn 2016, the Task Force identified the relevant departments, organizations, and technical backgrounds that would play a role in the creation, refinement, and prioritization of actions to address the vulnerabilities from the ***Climate Change in Columbus, Ohio*** report.[2] A database of community stakeholders and technical experts was created, with additions being made throughout the life of the project, that served to extend the expertise of the Task Force.

In Winter 2017, a first stakeholder meeting was held at The STEAM Factory in Franklinton. This meeting was facilitated by the Task Force members, and it involved 34 stakeholders. The stakeholders were divided into 7 groups based on their backgrounds and expertise. The 7 groups were Air and Water, Business, Community Health, Community Housing, Community Neighborhoods, Infrastructure, and Natural Systems. During the meeting, each group was asked to draft a series of action items that would address 6-7 of the priority vulnerabilities. The purpose of this process was to collect as many ideas as possible, regardless of cost or feasibility. By the end of the meeting, 412 action items had been proposed.

During Winter 2017, the list of 412 action items was reviewed and refined by the team at BPCRC. Through a process of eliminating duplicates, collapsing or combining overlapping actions, and splitting complex actions, the list was reduced to a manageable size. As the list evolved, the Task Force members reviewed the statements and refined the language, and the list was pared down to 68 action statements. The Task Force ensured that all of the statements fell within the scope of the City, and were feasible based on current science and technology, clearly written, and were sufficiently discrete in their objectives.

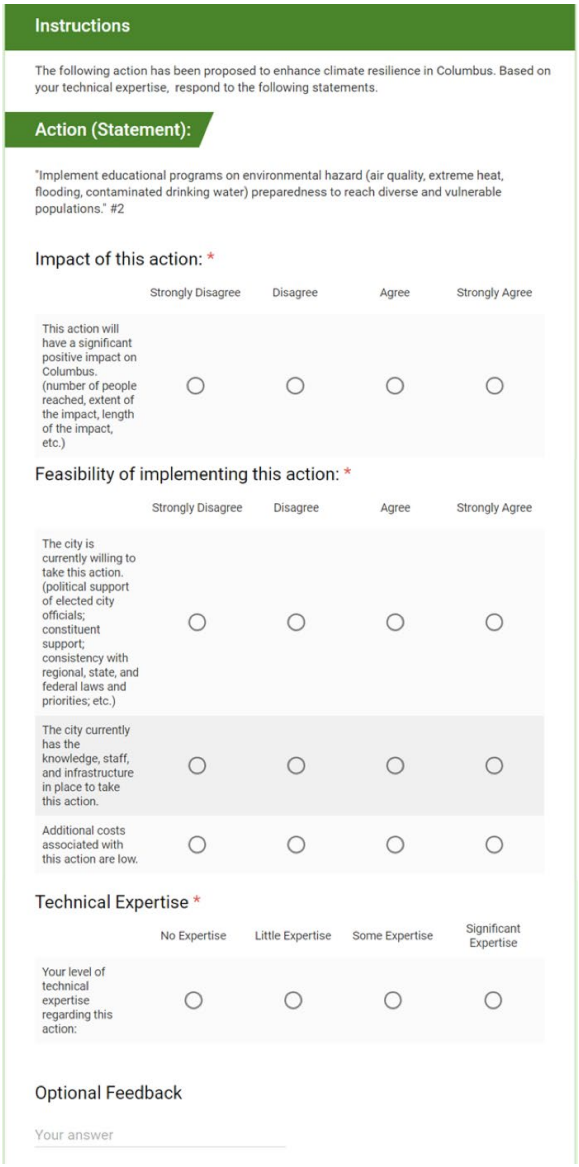
The 68 actions statements were divided into 14 categories for review by technical experts with backgrounds in fields that corresponded with each category. In Spring 2017, digital surveys for each of the 14 categories were distributed, and 45 technical experts provided feedback on the proposed action statements. Each category garnered responses from at least two technical experts, with most categories receiving at least three or more reviews. Within the survey, the experts were asked to indicate the level of (1) potential positive impact of each proposed statement, (2) feasibility of implementing each proposed statement, and (3) their technical knowledge on each proposed statement. Feasibility of implementation was parsed from three separate questions that asked experts to indicate the relative costs associated with implementation, the amount of local knowledge and resources that would facilitate implementation, and the political will and expected constituent support. Possible answers for the impact and feasibility questions ranged from “strongly disagree” to “strongly agree”, and answers for the expertise question ranged from “no expertise” to “significant expertise”. The experts were also given the opportunity to provide additional comments for each statement. An example survey question is provided at the end of this Appendix A (Figure A1).

After the surveys were returned, the responses were assigned a score of 1-4 for each question; a score of 1 corresponded with “strongly disagree” or “no expertise” answers, while a score of 4 corresponded with “strongly agree” or “significant expertise” answers. The final impact and feasibility scores from each technical reviewer were weighted by the stated expertise of the reviewer for each statement, respectively. By doing so, an index score was calculated for each action statement that gave more weight to those with greater expertise in each subject. Actions considered to have high impact and high feasibility received high index scores, while low

index scores were given to actions that experts thought would either have a low overall impact or would be difficult to implement.

The 68 action statements were ranked based on their index scores and categorized as either Necessary, Aspirational, or Not for Inclusion (see table on page 120). This prioritized list was reviewed at a second stakeholder meeting held in Summer 2017, which was attended by 30 stakeholders. Stakeholders were divided into 7 groups based on their professional backgrounds. The groups included Air Quality/Energy Use and Infrastructure, Business, Ecosystems, Extreme Heat, Flooding/Runoff, Vulnerable Populations/ Public Safety, and Water Use/Drinking Water. The review process involved confirming whether each action statement was correctly placed within the three bins (Necessary, Aspirational, or Not for Inclusion) based on the professional expertise of the stakeholders. To facilitate this review, stakeholders were provided with details of the index scores that were generated from the technical experts feedback. Most important was ensuring that the Necessary and Aspirational categories contained all actions that would be included in the final report. Final decisions regarding the movement of actions were made by the Task Force in a subsequent meeting. Twelve statements changed bins or were split (nine moved to a higher priority bin, one moved to a lower priority bin, and two were split with one portion moving to a lower priority bin). By the end of this process, 43 action statements were deemed either Necessary or Aspirational and were included in the final document for more detailed examination. During the Summer 2017 meeting, it was also determined that greater input was needed from the business community, which was subsequently sought out by the Task Force. Despite a concerted effort to coalesce a set of actions directly pertinent to community businesses, a lack of representation by Columbus business leaders resulted in the inability to effectively map specific actions to the needs of the business community.

From Autumn 2017 through Winter 2018, Task Force members at BPCRC drafted the CCAP document. The final list of 43 Necessary and Aspirational actions were divided between 8 technical chapters, each one corresponding to a major climate impact or a sector that would



Instructions

The following action has been proposed to enhance climate resilience in Columbus. Based on your technical expertise, respond to the following statements.

Action (Statement):

"Implement educational programs on environmental hazard (air quality, extreme heat, flooding, contaminated drinking water) preparedness to reach diverse and vulnerable populations." #2

Impact of this action: *

	Strongly Disagree	Disagree	Agree	Strongly Agree
This action will have a significant positive impact on Columbus. (number of people reached, extent of the impact, length of the impact, etc.)	○	○	○	○

Feasibility of implementing this action: *

	Strongly Disagree	Disagree	Agree	Strongly Agree
The city is currently willing to take this action. (political support of elected city officials; constituent support; consistency with regional, state, and federal laws and priorities; etc.)	○	○	○	○
The city currently has the knowledge, staff, and infrastructure in place to take this action.	○	○	○	○
Additional costs associated with this action are low.	○	○	○	○

Technical Expertise *

	No Expertise	Little Expertise	Some Expertise	Significant Expertise
Your level of technical expertise regarding this action:	○	○	○	○

Optional Feedback

Your answer

Figure A1. *An example survey question provided to technical experts in Spring 2017.*

be heavily affected by climate change. The chapters were reviewed by the other members of the Task Force, as well as some technical experts, for content, style, and tone. Three additional outside reviewers, who do not have technical backgrounds in any of the subjects discussed in the plan, provided a final review for style and grammar. The first draft of the document was made available for public comment from February 1, 2018 through March 9, 2018. All comments were reviewed by the Task Force, and revisions were made to the original document by BPCRC and the City of Columbus where deemed appropriate.

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[1] "Meet the Challenges of a Changing Climate." U.S. Climate Resilience Toolkit. w. (Accessed Oct. 2018).

[2] Great Lakes Integrated Sciences and Assessment (GLISA) and the University of Michigan Climate Center. *Climate Change in Columbus Ohio: An assessment of Columbus' Key Climate Changes, Impacts, and Vulnerabilities of Concern.* March 2016. ***http://research.bpcrc.osu.edu/education/greenteam/FINAL_ColumbusFinalReport_3.0.pdf.*** (Accessed Dec. 2017).

Preliminary Climate Adaptations for Columbus

Index Score	Statement
3.87958	Adopt and enforce building codes to reduce localized flooding and basement/ sewage backups.
3.46773	Continue upgrades to water and sewage treatment infrastructure to reduce sewage contamination of waterways.
2.64994	Understand the types of events, likelihood of occurrences, and ranges of severity that adversely impact drinking water availability.
2.34626	Use GIS to map fixed critical assets and vulnerable populations susceptible to environmental hazards.
2.14181	Implement education campaign for individuals and businesses on proper treatment and use of contaminated drinking water.
2.11936	Create long-term management plan for entire watershed serving Columbus that ensures sufficient drinking water.
2.11089	Evaluate capacity to clean up, restore services, and care for citizens following environmental hazard emergencies.
1.8071	Reduce impacts of stormwater runoff and promote infiltration in new development and redevelopment.
1.77721	Identify representative advocacy organizations for diverse and vulnerable populations.
1.77644	Ensure diverse modes of communication during environmental hazard emergencies to reach diverse and vulnerable populations.
1.68908	Develop a public-private partnership to manage food and water access for vulnerable populations during environmental hazard emergencies.
1.61662	Establish extreme heat education campaign and health advisories for those running summer programs. (Enveloped #32, make sure to include working conditions in new phrasing.)
1.58453	Implement education campaign to reduce water use.
1.34861	Promote sustainable landscaping practices for residential, commercial, and industrial properties.
1.06522	Review inter-agency and city-wide training and response to environmental hazard emergencies.
0.96028	Establish a network of cooling centers and draft clear guidelines for network members.

	Index Score	Statement
	0.80456	Facilitate cross cultural dialogue, offer training for service providers, and share best practices.
	0.79673	Assess and ensure adequate transportation and logistics for critical resources.
	0.76734	Develop emergency transportation plan that can be implemented during a flood.
	0.5556	Implement educational programs on environmental hazard preparedness to reach diverse and vulnerable populations.
	0.40793	Collaborate with organizations, agencies, and private landowners to support holistic, long-term ecosystem health – promoting education campaign.
	-0.1617	Modernize electric grid for greater resiliency and more efficient distribution.
	-0.3134	Implement idling reduction education campaign (specify fuel types).
	-0.5667	Implement program for individuals and businesses to reduce energy usage during peak demand.
	—	Continue upgrades to water and sewage treatment infrastructure to reduce harmful algal bloom toxins in drinking water. *(Split from other statement; no index score.)*
	1.24559	Create method of measuring and reporting water used from streams and rivers for irrigation.
	0.84745	Track and communicate costs associated with preparing for and responding to environmental hazards.
	0.55833	Develop event-based water use criteria.
	0.48952	Require or incentivize monthly utility costs for rental properties be reported to potential tenants.
	0.46305	Improve data collection to anticipate and respond to harmful algal blooms.
	0.40793	Collaborate with organizations, agencies, and private landowners to support holistic, long-term ecosystem health – identifying green space, urban canopy, urban farms.
	0.40621	Develop policies on application of fertilizers, herbicides, pesticides and animal waste.
	0.33544	Collaborate with landscaping and fertilizer companies to improve products and their application.
	0.26151	Develop new app or integrate with existing app for environmental hazard alerts.
	0.24701	Create community health action teams for environmental hazards.

	Index Score	Statement
	0.19417	Implement education campaign on energy audits and renewable energy to reduce emissions for residential and business users.
	0.13395	Provide programs to distribute fans, air conditioners, and water to vulnerable populations.
	0.0881	Internalize climate resilience practices in city planning to reduce the urban heat island.
	0.081978	Improve irrigation through changes in infrastructure and practices that more efficiently use water.
	0.05121	Require disclosure of known property problems for sale or rental of property.
	0.05121	Implement education campaign for landowner66s to promote responsible use of fertilizers, herbicides, and pesticides.
	-0.1563	Update building code to require more efficient water use.
	-0.2134	Improve efficiency of water use in city fountains, pools, splash pads, and ponds.
	-0.2721	Lobby state and federal government to implement policies that reduce erosion and runoff and promote infiltration.
	-0.3606	Retrofit flood gates or backflow preventers on stormwater infrastructure.
	-0.3996	Establish contingency contracts so that sufficient resources are available in case of environmental hazard emergencies.
	-0.562	Implement education campaign to inform the public about insurance and other shared risk programs available for environmental hazards.
	-0.5989	Increase number of air quality monitoring stations and pollutants monitored (specify collecting baseline data in statement text?).
	-0.8669	Increase investment in and/or purchase of renewable energy.
	-2.6799	Use data and best practices to adapt transportation modes and inform economics of transportation. (e.g., reduce single occupancy, lower polluting fuels, lower emissions vehicles, incentives or requirements to provide EV charging stations, expand transportation options and times to reduce overall transportation pollution).
	0.079	Implement education campaign for small business continuity planning.
	-0.8532	Develop tool that allows Columbus residents and business owners to access flood risk data in an intuitive, graphical interface.
	-1.2217	Utilize climate projections and hydrologic models to revise floodplain maps and re-evaluate locations of buildings in floodplains and use of flood control measures.

	Index Score	Statement
■	-1.2403	Aggregate real-time environmental hazard data from multiple agencies and sensors platforms for display on a dashboard.
■	-1.2858	Provide financial instruments for vulnerable populations that have insufficient cooling measures.
■	-1.2911	Incentivize relocation or retrofit of residential and commercial properties and critical transportation routes to create greater resilience.
■	-1.3387	Collaboration with coroner to identify underlying factors impacting death related to extreme heat.
■	-1.4589	Provide transportation to or create portable/mobile cooling centers.
■	-1.547	Lobby state to accept new building code, energy efficiency code, and appliance/ equipment standards.
■	-1.6377	Establish regional data hub for sharing information on natural resources.
■	-2.3699	Require energy usage and other measures of externalities (i.e. CO2, sulfates, etc.) in bidding projects and proposing policy changes.
■	-2.3984	Reassess permitting process for larger water users.
■	-2.8771	Increase use of residential and commercial water storage.
■	-3.5503	Promote on-site water treatment, water restoration, and greywater recycling within new and retrofitted buildings to increase efficient water use.
■	-4.0781	Inventory air conditioning capability of buildings and housing stock.
■	-4.6124	Require emissions testing for motor vehicles.
■	-4.6698	Create a water trading system for use during intense droughts.

THE OHIO STATE UNIVERSITY
BYRD POLAR AND CLIMATE
RESEARCH CENTER

Recommended Climate Adaptations for Columbus

Extreme Heat

N1	Establish a larger, better coordinated, more responsive network of cooling centers and draft clear guidelines for network members.
N2	Implement educational campaign, health advisories, and best practices for time spent outdoors in extreme heat.
A1	Internalize climate resilience practices in city planning to reduce the urban heat island.
A2	Provide programs to distribute fans, air conditioners, and water to vulnerable populations.

Air Quality & Energy

N3	Modernize electric grid for greater resilience and more efficient energy distribution.
N4	Implement educational campaign on idling reduction.
A3	Implement educational campaign on energy audits and renewable energy to reduce emissions for residential and business users.
A4	Increase number of air quality monitoring stations to provide baseline data and public educational opportunities.
A5	Use data and best practices to adapt transportation modes and inform economics of transportation.

Flooding

N5	Design and implement an educational campaign that leads to reduced impacts of stormwater and basement sewage backups, promotes use of green infrastructure, and accurately conveys risks to and responsibilities of property owners.
N6	Review city regulations, technical documents, departmental processes and plans, property owner programs, enforcement mechanisms, and monitoring efforts to ensure that current practices reduce localized flooding and basement/sewage backups.
N7	Develop an emergency plan that can be implemented during a flood to ensure adequate transportation and logistics for critical resources.
N8	Identify and assess risk associated with older flood control and stormwater infrastructure, and use data gathered to reduce risk by developing property owner education, informing the city's capital projects, and establishing property owner requirements.
A6	Advocate for state and federal government to implement policies that reduce erosion and runoff and promote infiltration.

Water Quality

N9	Implement the City of Columbus Watershed Management Plan and work with regional partners to implement the Sustaining Scioto Adaptive Management Plan.
N10	Understand the types, likelihood, and severity of events that could adversely impact the quality of drinking water sources.
N11	Continue upgrades to sewer system and sewage treatment infrastructure to reduce sewage contamination of waterways.
N12	Design an educational campaign for individuals and businesses on proper use of tap water during an emergency.
A7	Improve data collection to anticipate and respond to harmful algal blooms (HABs).
A8	Continue upgrades to water and sewage treatment infrastructure to reduce harmful alagal bloom (HAB) toxins in drinking water.

Water Use

N13	Implement educational campaign on reducing water use.
A9	Develop event-based water use criteria.
A10	Update building code to require more efficient water use.
A11	Improve irrigation through changes in infrastructure and practices that more efficiently use water.
A12	Improve efficiency of water use in city fountains, pools, splash pads, and ponds.

Ecosystems

N14	Promote sustainable landscaping practices for residential, commercial, and industrial properties.
A13	Develop guidelines for city property on application of fertilizers, herbicides, pesticides, and animal waste.
A14	Collaborate with landscaping and fertilizer companies to improve services and use of products.
A15	Implement educational campaign for landowners to promote responsible use of fertilizers, herbicides, and pesticides.
A16	Collaborate with organizations, agencies, and private landowners to identify and create additional green space, urban tree canopy, and urban farms.

Emergency Preparedness

N15	Use geographic information systems (GIS) to map fixed critical assets and vulnerable populations susceptible to environmental hazards.
N16	Evaluate city preparedness and response during and after environmental hazard emergencies.
A17	Track and communicate costs associated with preparing for and responding to environmental hazards.
A18	Establish contingency contracts so that sufficient resources are available in case of environmental hazard emergencies.
A19	Develop new app or integrate with existing app for environmental hazard alerts.
A20	Implement educational campaign to inform the public about insurance and other shared risk programs available for environmental hazards.

Vulnerable Populations

N17	Identify representative advocacy organizations for diverse and vulnerable populations.
N18	Facilitate cross-cultural dialogue, offer training for service providers, and share best practices.
N19	Ensure diverse modes of communication during environmental hazard emergencies to reach diverse and vulnerable populations.
N20	Implement educational campaign on environmental hazard preparedness to reach diverse and vulnerable populations.
N21	Coordinate closely with the Ohio public-private partnership to manage food and water access for vulnerable populations during environmental hazard emergencies.
N21	Require disclosure of known property problems for sale or rental of property.
A22	Require or incentivize that monthly utility costs for rental properties be reported to potential tenants.