MEETING SUMMARY:

SEVERE WEATHER & CRITICAL INFRASTRUCTURE RESILIENCE: PREPARING WASHINGTON D.C.

CENTER FOR CLEAN AIR POLICY
DISTRICT DEPARTMENT OF THE ENVIRONMENT (DDOE)
DISTRICT OFFICE OF PLANNING (OP)

APRIL 2013

CCAP
CENTER FOR CLEAN AIR POLICY

Acknowledgments

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Center for Clean Air Policy (CCAP)
District Department of Environment (DDOE)
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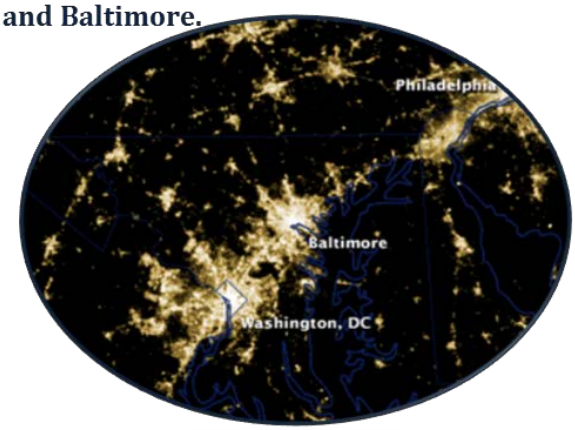
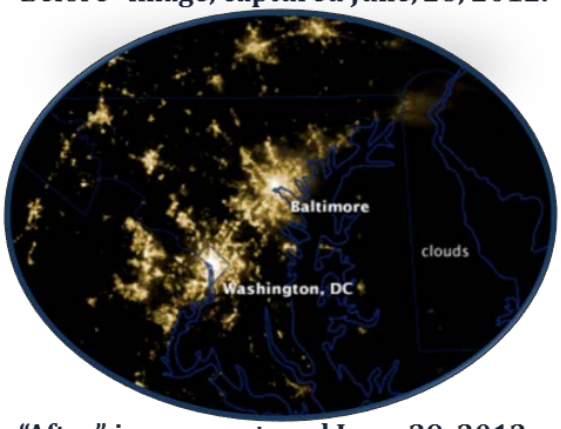
April 23, 2013

Images courtesy of NASA's Earth Observatory showing the impacts of the "derecho" that had intense lightening, rain, and hurricane force winds causing power outages across Washington, DC and Baltimore.



"Before" image, captured June, 28, 2012.



"After" image, captured June, 29, 2012.

Introduction

What happens when the power goes out, the Metro shuts down, or key streets flood? In the short-term government agencies and companies execute emergency management plans. Yet in the wake of Hurricane Sandy, the June 2012 derecho, recent record heat and blizzards, we are seeing longer-lasting disruptions to the power grid, transportation networks and business operations that have led to tragic loss of life and significant economic losses. What passes for "normal" weather appears to be changing for the worse – and we need to be ready for the weather both in the current climate as well as the future. With this in mind, the District is initiating a climate change adaptation assessment to examine current and projected risks from severe weather and to develop a resilience plan to sustain and enhance the District's economy and quality of life.

On March 14, the District Department of Environment (DDOE), the District Office of Planning (OP), and the Center for Clean Air Policy (CCAP) held a workshop to gather input to help shape future preparation efforts to ensure they reflect stakeholder knowledge, experience and priorities. The workshop united an unprecedented grouping of government and corporate experts. Many participants met each other in person for the first time, despite working on complementary efforts, and appreciated the chance to meet and learn from each other. There was

strong rapport; the workshop succeeded in creating a good sense of group cohesion, purpose and promise for future collaboration. Workshop goals included:

1. Disseminate and share expert information concerning:
    a) Problems: Current trends, projected weather-related risks;
    b) Solutions: Leading public and private preparedness efforts.
2. Understand stakeholder priorities and concerns
3. (Start to) Identify collaboration opportunities to foster long-term resilience, such as:
    a) Actions across government agencies and public-private;
    b) Identify efforts that can be launched in the short-term and advance multiple policy goals.

Workshop participants recommended the following next steps (see page 17 for more details):

- Vulnerability studies on sea level rise, severe weather and urban heat
- Economic scenario analyses
- "What If" flooding analysis
- Increase green infrastructure
- "Undergrounding" power lines
- Install Metro ventilation grate extensions
- Improve transportation choices (resilience benefits of biking, walking, and public transit)
- Identify further collaboration opportunities.

Speaker summaries

Welcome and Opening Remarks

Steve Winkelman (CCAP), Keith Anderson (Acting Director, DDOE), and Harriet Tregoning (Director, OP) welcomed attendees. Keith Anderson noted recent severe weather events in the District and explained that the Sustainable DC plan addresses both greenhouse gas (GHG) emission reduction as well as climate change adaptation. Harriet Tregoning emphasized that resilience measures can go beyond preparing for and recovering from disasters, but can bolster the economy and enhance quality of life the District. She noted how building efficiency measures and transportation choices can both reduce GHGs and enhance economic and community resilience.

Next Steve Winkelman discussed resilience. According to the National Academy of Sciences, **resilience** is the ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events. Our vision of resilience is that when the next superstorm or heat wave comes, we will still be able to turn on the lights, get to work and do our jobs, and enjoy life. Resilience includes reducing vulnerability and exposure to hazards. Different communities talk about this in different ways… for instance, some might call it security, or hazard mitigation, or sustainability. In fact there's a rich and growing literature on different aspects of and approaches to resilience (see Appendix B).

Climate adaptation, one approach to resilience, consists of five key steps:

1. **Assess climate impacts.** For example, use climate models to asses different future scenarios.
2. **Identify risks and vulnerabilities.** Based on the local context, recent impacts, critical infrastructure location and condition (e.g., elevation, state of repair).
3. **Assess potential solutions.** Review best practices, analyze effectiveness, and assess costs and benefits.
4. **Develop and Implement Action Plan.** Define thresholds, prioritize short- and long-term actions, measure progress and revise plans accordingly.
5. **Garner support for implementation.** Address top concerns of public and decision makers, visualize solutions, and quantify risks and benefits.

Weather- and Climate-related Risks in DC: Current and Projected

Deke Arndt, Chief, Climate Monitoring Branch, National Climatic Data Center (NCDC) began this session. According to NCDC, average annual temperatures in the United States have risen 1-2°F in the last 100 years. Deke focused in on the DC region (Maryland and Virginia) using NCDC's Climate at a Glance, a tool that shows temperature and precipitation trends over the last hundred years in each state. From 1900 to today in both Maryland and Virginia, seasonally averaged temperatures have increased, spring and autumn precipitation levels have increased, and summer precipitation levels have decreased. Recently, the average temperature for 2012 was the hottest or second hottest on record (over 118 years) in almost every US state. Much of the Midwest suffered the lowest precipitation on record.

Deke then summarized the biggest risks facing the District – Big Heat, Big Rain, and Sea Level Rise. For the first two, he provided a brief overview of different types of extreme weather and their causes. Violent weather comes

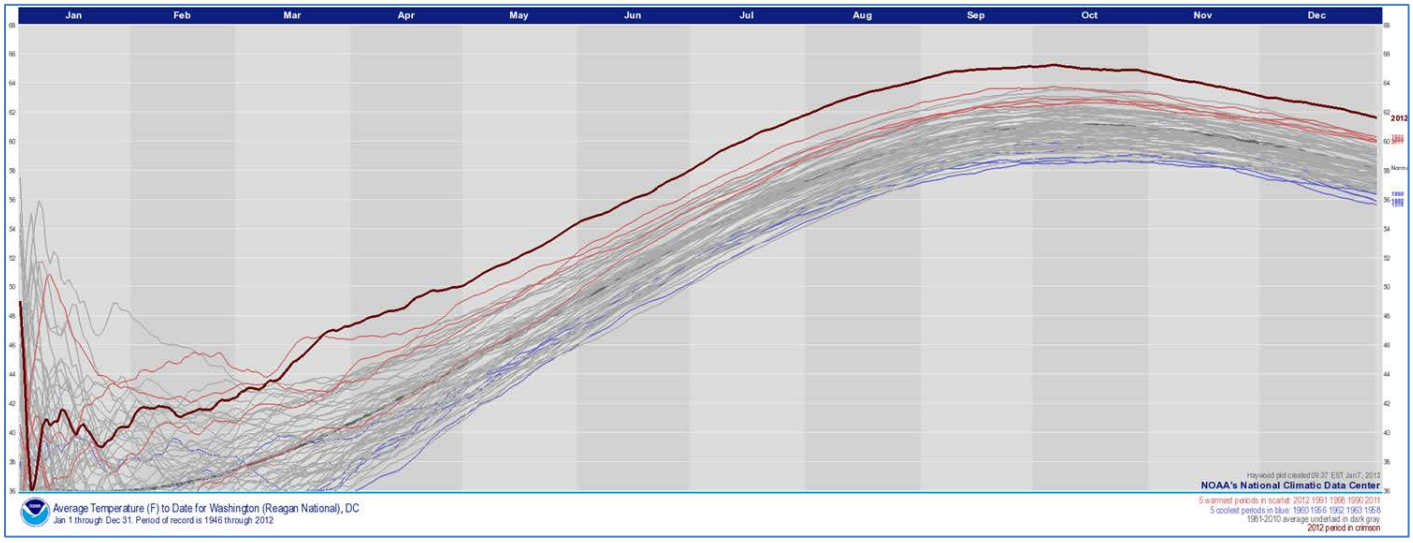


Figure 1: This figure illustrates average temperature at the Regan National Airport over 66 years (1946-2012). The red lines show the 5 warmest periods (2012, 1991, 1998, 1990, and 2011) and 2012 in crimson and the blue lines the 5 coolest periods (1960, 1956, 1962, 1963, and 1958) below it. The highest average temperature in September 2012 was 65°F and the lowest during the same month was 57°F. Source: NOAA.

from instability combined with wind shear. Hurricanes come from warm water and a supportive shear profile. Heat waves include entrenched warm air and "blocking patterns". Extreme precipitation leading to flooding requires sufficiently moist air and sufficient "lift" or rising motion.

Deke concluded by discussing how in the U.S., we are seeing changes in certain types of extreme weather, specifically, increases in very heavy precipitation events and the extent and severity of droughts. He mentioned a useful "rule of thumb" with the caveat that it works often, but not always: for general precipitation in a changing climate wet places/seasons/phenomena get wetter and dry places/seasons/phenomena get drier.

Laurens Van der Tak, Vice President, CH2M Hill, discussed a case study on storm sewer infrastructure planning with climate change risk in nearby Alexandria, Virginia. Alexandria plans for 1 in 10 year events and yet has experienced repeated and increasingly frequent flooding events. CH2M Hill performed a review of the City's stormwater design criteria and potential impacts of climate change (urban drainage, riverine flooding, sea level rise, storm surge). Using a range of IPCC Fourth Assessment Report values, CH2M Hill predicted a 4-25% increase in annual precipitation and a projected mean high Higher Water Level of 2.9-5 ft. above current sea level by 2100 (Figure 2). As Old Town Alexandria's ground surface is at elevation 3.2 ft., these predictions mean that by 2100, Alexandria will be underwater at least twice a month (and in some scenarios twice a day). This may be an underestimate, since the projections do not include ice melt projections. Laurens noted that green infrastructure can help alleviate this problem for strong storms, but not for major storm surges as the benefit is likely attributed to no more than the first four inches of flooding.

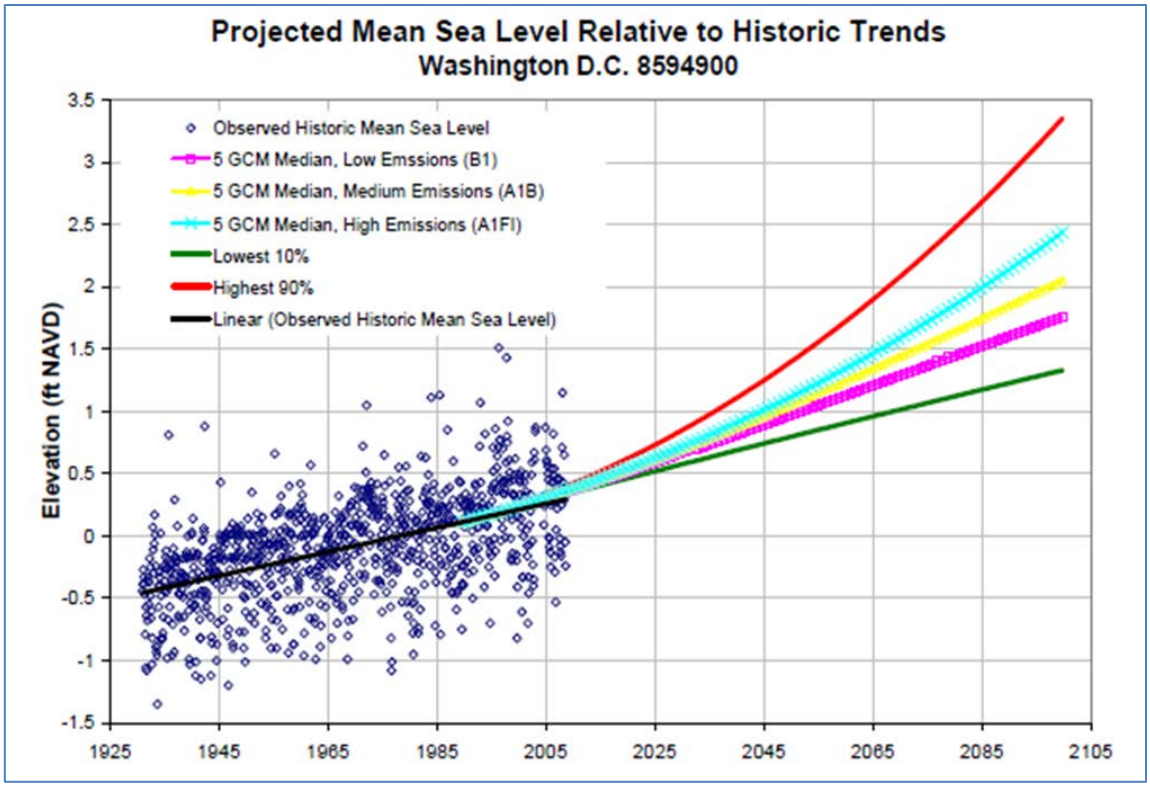


Figure 2: Projected mean higher high water relative to historic trends for the District. Old Town Alexandria's ground surface, denoted by the thick maroon line, is at elevation 3.2 ft. Source: CH2M Hill.

Overview of Sustainable DC, Climate Change and Hazard Mitigation Efforts

Brendan Shane, Chief, Office of Policy & Sustainability, District Department of the Environment, discussed Sustainable DC quoting Mayor Vincent C. Gray as saying "In just one generation—20 years—the District of Columbia will be the healthiest, greenest, and most livable city in the United States."

Figure 3: Mayor Vincent C. Gray at the Sustainable DC kickoff. Source: DDOE.

The District has already made significant progress. From 2006 to present, greenhouse gas emissions in DC have decreased by 12%, while the population has increased by 8% and the number of jobs has increased by 40,000. This is due to both improvements in the energy mix as well as energy efficiency. In addition, the District currently:

- buys 100% green power;
- has more than 230 LEED-certified energy-efficient buildings, with over 1000 registered projects;
- leads the nation last year in green roof installations (1.2 million sq. ft.) and the numbers keep growing;
- runs the largest bike share in U.S. (19,000+ members);
- has encouraged fewer car trips so that half of District trips are by transit, walking, or bike; and

Sustainable DC identified four challenges (Jobs and the Economy, Health and Wellness, Equity and Diversity, Climate and Environment) and seven solutions (Built environment, Energy, Food, Nature, Transportation, Waste, Water). Key climate-related goals for 2032 include:

Figure 4: Green infrastructure outside of the District Department of the Environment. By 2032, the District plans to use 75% of its landscape to filter or capture rainwater for reuse. Source: DDOE

- **Energy efficiency and greenhouse gas reduction**
  - Reduce citywide energy use and GHG emissions by 50%.
  - Increase renewable energy use to 50%
  - Make 75% of all trips by walking, biking, or transit
- **Climate change adaptation**
  - Critical Infrastructure: All new building and major infrastructure projects will undergo climate change impact analysis as part of the regulatory process**.**
  - Emergency Services: Prepare the District emergency services to respond to severe climate-related events such as extreme heat, storms and flooding.
  - Transit: Design transit systems for resilience to extreme weather events.
  - Electricity: Reduce power outages to between 0 and 2 events of less than 100 minutes per year.
  - Water and Green Infrastructure: Use 75% of landscape to filter/ capture rainwater for reuse (Figure 4). Install 2 million square feet of green roofs. Establish pervious surface minimums for targeted zoning districts.

Brendan also announced a Spring 2013 kick-off of District-specific risk analysis study on sea level rise and storm surges, extreme weather, and urban heat impacts.

Frederick Goldsmith, Critical Infrastructure Specialist, Homeland Security and Emergency Management Agency (HSEMA) discussed how the District's severe weather leads to power outages and flooding, and remarked that

climate change will only make those worse. HSEMA conducted a Hazard Vulnerability Assessment for the city covering all wards; results will be distributed to the public soon. Frederick then discussed that all-hazards planning will also enhance severe weather resilience by identifying at-risk functions as well as **encouraging everyone to have and practice a resilience plan**.

HSEMA's publications include:

- Washington DC - District Response Plan
- Washington DC - 2012 Heat Emergency Plan
- Washington DC - Shelter-In-Place Guide
- Be Ready DC - Family Emergency Preparedness Guide
- It's A Disaster Guide
- Washington DC - Security Guidance for Commercial Buildings Guide

Best Resilience Practices, Part 1: Electricity

Brent Dorsey, Director, Corporate Environmental Programs, Entergy discussed how Gulf Coast-based Entergy is responding to the business case for climate preparedness out of economic self-interest and as a community leader. Even under the current climate, significant risks exist for the Gulf Coast (flooding, sea level rise, wind, and land subsidence). Among economic sectors, oil and gas assets are particularly vulnerable. Furthermore, even in the near term, loss from extreme event "tail risks" may increase and occur more often. In total, the Gulf Coast is vulnerable to growing environmental risks today with over $350 billion of cumulative expected losses by 2030; losses could be twice as high if other "consequentials" and second hand effects are factored in. Key uncertainties to address this vulnerability include (1) the impact of climate change, (2) the cost and effectiveness of measures to mitigate and adapt, and (3) the ability to gain alignment and overcome obstacles moving forward.

Driving a "practical" solution that takes Gulf Coast "resilience" to the next level represents an optimal solution to balance the cost requirements with the risks that impact the Gulf Coast. Potentially attractive measures can decrease the annual loss between today and 2030 and keep the risk profile of the region constant. Cost beneficial utility measures (**Figure 5**) can address more than $830 million of loss by 2030 (including broader co-benefits such as indirect economic losses and ecosystem services provided by wetland preservation). Entergy is following through on adaptation and sponsoring studies in three ways. First, Entergy sponsored a resilience study with America's Wetland Foundation released at World Deltas 2010 Dialogue and the subsequent Blue Ribbon Resilient Communities Program. Second, Entergy is improving asset resiliency through internal evaluations of critical infrastructure, focusing on transmission and distribution through generation and vegetation management, and expanding resiliency to include other affected utilities. Third, Entergy is an active player in the legislative and regulatory world.

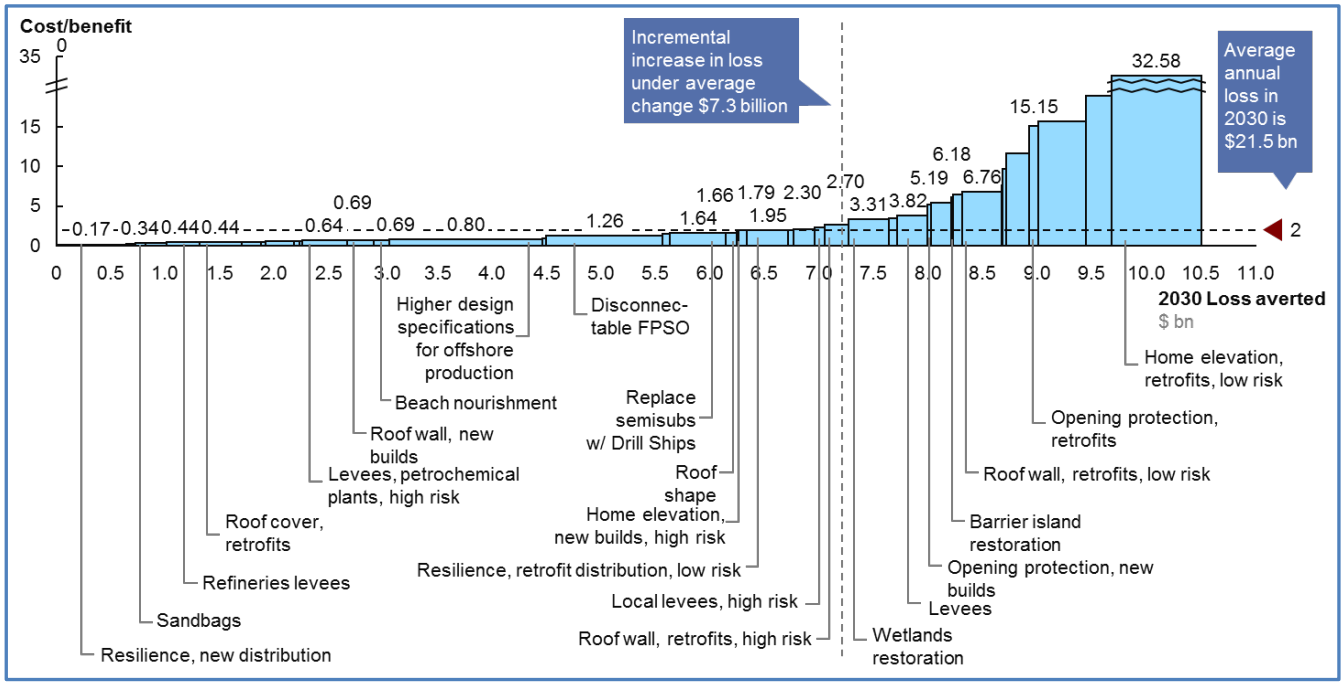


Figure 5: Cost-benefit ratios and effectiveness of Gulf Coast resilience measures showing that potentially attractive measures can address the increase in annual loss between today and 2030 and keep the risk profile of the region constant. Source: Entergy.

Best Resilience Practices, Part 2: Insurance

Stephen Weinstein, Senior VP, RenaissanceRe discussed how reinsurance companies make billion dollar decisions informed by climate science and tap best practices in hazard mitigation to prepare. Reinsurers are incented to help mitigate climate risks that are reinsured. RenRe provides "atmospheric perils intelligence," funds large scale testing facilities such as the RenaissanceRe Wall of Wind at Florida International University and the Institute for Business and Home Safety Research Center, supports multiple conferences, including the award-winning Risk Mitigation Leadership Forum Series (www.mitigationleadership.com) and communicates resilience to the public through StormStruck at Walt Disney World's EPCOT Center. Steve's scientists ran simulations on the estimated impacts to the District and its region of a Category 4 hurricane making landfall at North Carolina, which the insurance industry expects could happen with "some frequency". Given current ocean levels, this scenario would cause a significant storm surge towards and inundation of the District. While Steve cautioned that these simulations were merely estimates, they reflected private sector risk management techniques and capital allocation decisions, and could also be compared with inundation impacts in New York City of Sandy. Steve urged policymakers involved in land use, building code and related decisions to be cognizant of the best available science, both in terms of expected trends and known prior events.

"The number one focus of public policy should be reducing risk to human life." Steve noted that the Congressional General Accounting Office and other independent expert research have concluded that the National Flood Insurance Program (NFIP), state-level insurance and reinsurance entities, and federal reinsurance can mask risks, shift liability to others, and fail to discourage risky development. Steve suggested consideration of federal programs that would encourage rather than disincentivize private and public hazard mitigation and adaption investments, including means-tested tax credits, sales tax holidays and matching grants. Steve also urged consideration of a hazard mitigation-focused program similar to PACE (property assessed clean energy) in which communities would provide financing to private individuals to make resilience improvements, with costs factored into taxes over 20 years (or so). Steve noted that the insurance industry experts estimated that building to code would cut annual expected losses from natural disasters significantly; and that building to higher standards such as the IBHS "FORTIFIED" programs could reduce expected costs even more. Regarding opportunities moving forward, Steve supported updating flood maps, a systematic review of green infrastructure benefits, and partnering with the disaster safety community.

Best Resilience Practices, Part 3: Visualizing Solutions & Measuring Benefits

Steve Winkelman reviewed extreme weather facing Washington, DC, including flooding, storms, and heat. What does resilience in the District look like? It's more than reacting to a storm**.** Our vision of resilience is that when the next superstorm or heat wave comes, we will still be able to turn on the lights, get to work and do our jobs, and enjoy life. Resilience includes reducing vulnerability and exposure to hazards. All-hazards resilience is ideal; the best resilience measures achieve multiple goals (e.g., building resilience and energy efficiency; green infrastructure). It will be necessary to balance timing, costs, efficiency and interactions with other policies.

Although communities have different approaches and words for resilience, notable public/private collaborations for resilience exist worldwide. Steve highlighted Toronto's Weatherwise Partnership, which improves extreme weather resilience in the electrical sector, and the New York City Building Resiliency Task Force is developing recommendations on buildings codes. He presented some images visualizing solutions, including improving flood maps (NYC), green roofs (Chicago, Figure 6), and heat mapping (Toronto, Figure 7).

Figure 6: Chicago City Hall Green Goof and Cook County building with black asphalt roof. Infrared image of the roofs indicates a temperature of 74 °F (29 °C) on the Green Roof and 151°F (66 °C) on the asphalt roof.
Source: Chicago Climate Action Report.

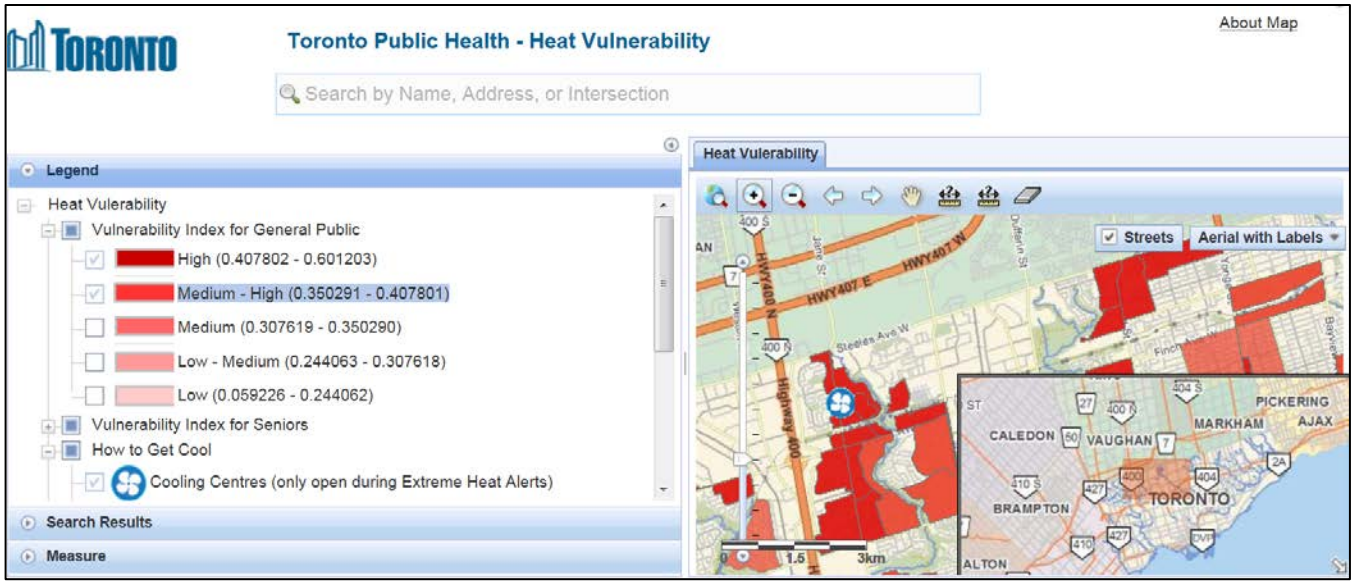


Figure 7: Toronto Public Health has a publically available, interactive Heat Vulnerability Map. Source: Toronto Public Health.

In the case of Superstorm Sandy, adaptation measures such as green infrastructure at Brooklyn Bridge Park and Governor's Island worked, buildings built to newer codes fared better, and execution of good planning ensured that sectors were better prepared (for example, Goldman Sachs sand bagged two days in advance and used back-up generators).

Steve then discussed District solutions that are already being implemented. For instance, Bloomingdale Park reduces stormwater runoff (**Figure 8**), a WMATA grate extension reduces subway flooding (**Figure 9**), and capital bike share and bike lanes improve transit network efficiency and redundancy that can also reduce emissions and enhance resilience.

Figure 8: Bloomingdale Park reduces stormwater runoff. Source: Bloomingdale Park's landscape artist Tom Noll.

Figure 9: Left: Georgia Avenue air intake vent is low to the ground. Right: WMATA is beginning to install grate extensions that reduce subway flooding. Source: WMATA.

Steve then mentioned some frameworks to think about when measuring resilience, sample physical metrics, and some introductory thoughts on how planning now saves money later. For instance, Philadelphia benefits more by managing stormwater runoff using green infrastructure, and Toronto saves money by implementing improved culvert designs. Best practices can yield resilience and energy savings benefits for multiple stakeholders (Figure 10).

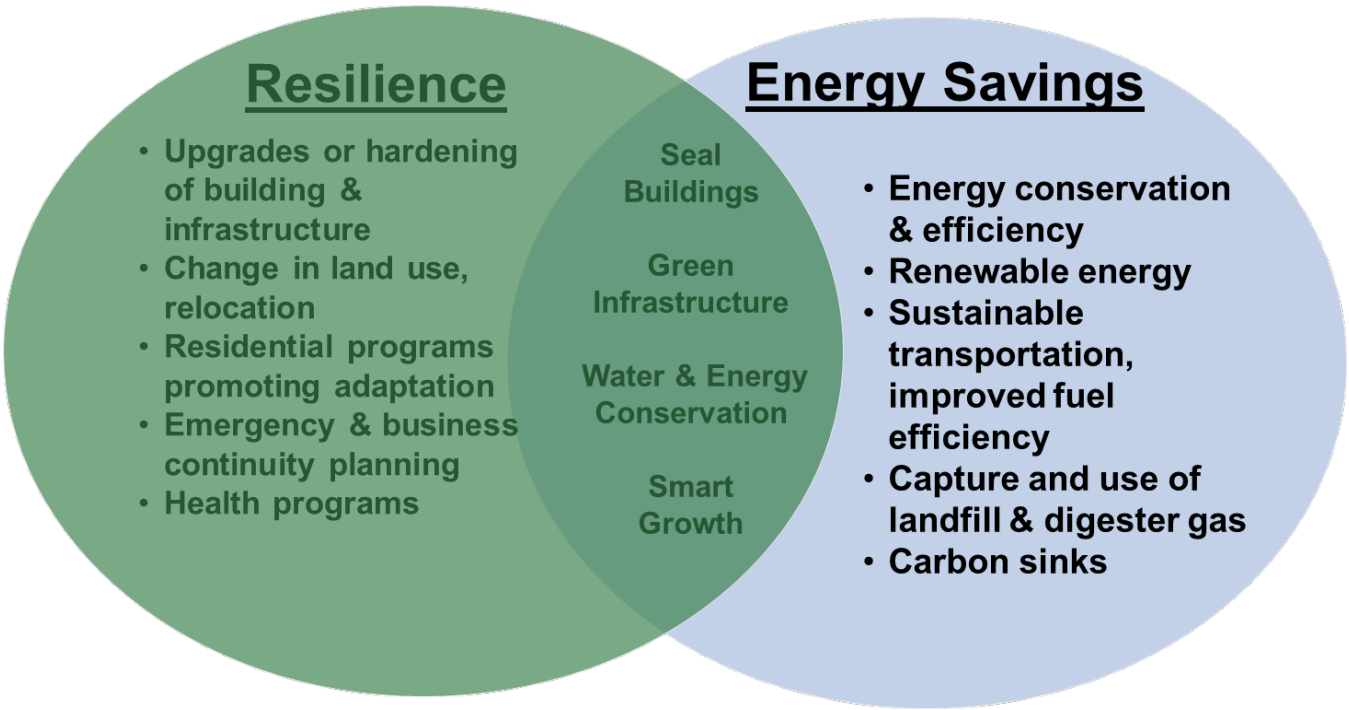


Figure 10: Best resilience practices achieve multiple goals. Source: CCAP, Adapted from Penney 2008, "Emerging Climate Change Adaptation Strategies".

Group Discussion

At the end of the meeting participants shared some of the issues that they were optimistic about or concerned about; some highlights are listed below. Workshop participants identified the main climate-related challenges facing the District as:

- **Heat;**
- **Flooding;**
- **Energy and Water Security;** and
- **Communicating Preparedness**.

These problems will have increasing implications for District residents and government agencies, the functioning of the federal government, national security and cultural and historic resources. We all want to leave the world a better place for our children, but we are concerned as to how we'll do it given funding, policy and institutional barriers and the increasing rate of greenhouse gas emissions. We need to both reduce greenhouse gas emissions and become more resilient to climate change impacts, and increasingly look for options that can advance both goals.

Reasons for Concern

- Insufficient GHG reductions;
- Insufficient funding;
- Institutional inertia;
- Timing of resilience measures ;
- Low public engagement;
- Ability to prioritize next steps given uncertainty in impacts, costs and benefits; and
- Can we effectively prepare for something as big as Sandy (or worse)?

Reasons for Optimism

- Many resilience efforts already underway – in government and private sectors;
- Diversity and expertise of stakeholders at workshop encouraging;
- A lot of progress being made, such as heat island, green roofs;
- A compelling economic case for planning and acting now to avoid future losses;
- Many win-win opportunities (reduce GHGs, enhance resilience, improve quality of life and economy);
- Critical Infrastructure Resilience is a framing that many can understand and support; and
- A lot of experience and successes to build upon.

Challenges abound with diverse roles and responsibilities for government agencies, private companies and District residents. Making tangible short-term progress, such as implementation actions from Sustainable DC, will help engage stakeholders in solutions going forward. Participants were encouraged by the multiple efforts on critical infrastructure resilience in the District that are already underway on the part of local, regional and federal agencies, as well as by private companies (see Appendix C for highlights of some of these efforts). Participants were also impressed by the diversity, expertise and energy of the workshop participants – some of whom they were meeting for the first time, others with which they were able to deepen their engagement.

Next Steps

The conversation has started and action is underway. Several years ago, we would never have had this many people even able to define resilience. Today we have a great mix of stakeholders across multiple disciplines uniting to address critical infrastructure resilience. While there is much that government agencies and companies can do on their own, the greatest successes will result from collaborative action. It will be essential to continue assessing and communicating the economic, safety and security benefits of critical infrastructure resilience. Washington, DC, can and will set an example for the nation. Workshop participants recommended the following next steps:

- **Vulnerability studies on sea level rise, severe storms, and urban heat**. Develop a comprehensive climate change vulnerability assessment, including GIS vulnerability mapping to identify flooding zones and hot spots, communities at risk and strategic areas to target response measures (e.g., green infrastructure, cooling centers, social outreach and health services). Address opportunities for buildings and energy systems (efficiency, resilience to avoid outages). Apply Georgetown's Urban Heat Tool Kit. Hold a workshop to pursue collaborative action on this front.

- **Economic scenario analyses** of the opportunity costs of not adapting and the benefits of comprehensive resilience strategies. This is critical for engaging the public and decision leaders (as in CCAP's *Growing Wealthier* matrix).

- **"What If" flooding analysis**. It was noted that the original prediction for Sandy was a 21-foot surge for parts of the District. Conduct analyses and facilitate stakeholder discussions to understand what a 21' surge would mean for critical infrastructure, District and Federal agency functions, business continuity, people's daily lives, and the regional economy.

- **Increase green infrastructure**. Analysis, stakeholder discussions and collaboration to assess benefits, costs, opportunities and challenges for storm water, urban heat and energy consumption and to plot a course of action to build upon current efforts. Also consider appropriate tree canopy management to protect power lines (e.g., Pepco's "Right Tree, Right Place" effort).

- **"Undergrounding" power lines**. Pursue findings of undergrounding study; consider strategic opportunities to phase implementation and identify financing.

- **Install metro ventilation grate extensions**. Identify which stations are at risk of flooding through air intake vents. Work with stakeholders and land owners to implement. Engage artists to beautify grate extensions (perhaps in a functional way as New York City did with bike racks and benches).

- **Improve transportation choices.** Identify possibilities to enhance biking, walking, and public transit in the city.

- **Identify further collaboration opportunities.** A great deal is already happening in the District on critical infrastructure resilience and climate adaptation at the local level, federal level and in private companies. CCAP offers to start to document existing efforts so we can compare assets, cross-fertilize and use our limited resources efficiently. It will also be useful to identify institutional barriers and discuss how to surmount them to bolster collaboration.

Survey Results

16 participants completed our post-workshop "next steps" survey. The majority of the respondents said that the workshop was "extremely useful" or "somewhat useful" for "developing valuable new contacts and/or strengthening strategic relationships" (82%) and the same percentage and number of respondents said the workshop was "extremely useful" or "somewhat useful" for "learning about weather and climate risks and best resilience practices," and the majority of respondents said the workshop was extremely useful or useful for "advancing my organization's resilience efforts" (75%).

Next steps: How useful would further analysis, discussion and collaborative action be on…	"Extremely useful" %	# of responses	Rating average
b. Economic analyses of climate impacts and resilience scenarios?	63	10	3.56
c. "What if" flooding analysis of a Sandy-like storm?	56	9	3.56
i. Inventory of existing resilience efforts in DC?	44	7	3.25
a. Urban heat vulnerability mapping?	38	6	3.19
d. Green infrastructure (effectiveness, costs, opportunities)?	38	6	3.25
f. Metro grate extensions to prevent flooding?	31	5	3.00
g. Transportation choices (resilience benefits of bike, walk, transit)?	25	4	2.94
h. Protecting cultural resources?	19	3	2.81
e. Undergrounding power lines?	7	1	2.50

Figure 11. Summary table of the next steps ranked by the most "extremely useful" ratings and by the average rating score.

Based on the **rating average**, both the ***economic analysis of climate impacts and resilience scenarios*** (b) and the ***"what if" flooding analysis of a Sandy-like storm*** (c) tied for first place for next steps moving forward. However, the economic analysis received the most "extremely useful" responses (63%). The additional comments from the survey also reinforced these results emphasizing the interest in both analyzing the cost of inaction ***and*** focusing in on reasonable future sea level rise and storm surge flood scenarios.

Appendix A: Meeting Agenda

Severe Weather & Critical Infrastructure Resilience

Preparing Washington DC
March 14, 2013
District Department of Environment
1200 First Street NE (by NoMa Metro), 10th floor conference room

What happens when the power goes out, the Metro is shut down, or key bridges flood? Leading companies and government agencies execute well-rehearsed emergency management plans. Yet in the wake of Sandy, the derecho, record heat and blizzards, we have seen longer-lasting disruptions to the power grid, transportation networks and business operations that have led to tragic loss of life and major economic losses. What passes for "normal" weather appears to be changing for the worse -- are ready for it?

The District is initiating a climate change adaptation assessment to examine current and projected risks from severe weather and to **develop an infrastructure resilience plan** to sustain and enhance the DC economy and quality of life. Our vision of resilience is that when the next superstorm or heat wave comes, we will still be able get to work, turn on the lights, heat or cool our buildings, do our jobs, use our cell phones and plumbing.

We want your input to help shape this effort and ensure that it reflects priority stakeholder concerns. Group discussion will identify issues of greatest concern, highlight opportunities for collaboration, and gather input for an advisory group to guide future planning, research, capacity building, outreach, policy and action.

8:15 AM **Continental breakfast**

8:45 AM **Welcome & Introductions**

Keith A. Anderson, Acting Director, District Department of the Environment
Harriet Tregoning, Director, District of Columbia Office of Planning
Steve Winkelman, Director of Adaptation, Center for Clean Air Policy
Participant introductions

9:00 AM **Weather- and Climate-related Risks in DC: Current and Projected**

Deke Arndt, Chief, Climate Monitoring Branch, National Climatic Data Center
- Historic temperature, precipitation, sea level, and extreme weather in the District
- Conceptualizing extreme events: Why do these occur, and how is climate connected?
- Forecasted climate impacts in the District

Laurens Van der Tak, Vice President, CH2M Hill
- Nearby risks: Recent work in Alexandria, Virginia

Q & A, discussion

10:00 AM **Overview of Sustainable DC, Climate Change and Hazard Mitigation Efforts**

Brendan Shane, Chief, Office of Policy & Sustainability, DDOE
Fred Goldsmith, Critical Infrastructure Specialist, HSEMA
Q & A, discussion

10:45 AM **Break**

11:00 AM **Best Resilience Practices, Part 1: Electricity**

Brent Dorsey, Director, Corporate Environmental Programs, Entergy

Entergy is responding to the business case for climate preparedness out of economic self-interest and as a community leader.

- Entergy experience and response to extreme weather events
- Lessons learned and implications for the District
- Community engagement: How should public and private groups coordinate?

Q & A, discussion

12:00 PM **Lunch**

Coffee talk: round-the-table updates on participant resilience efforts

1:00 PM **Best Resilience Practices, Part 2: Insurance**

Stephen Weinstein, Senior VP, RenaissanceRe

RenRe makes billion dollar decisions informed by climate science and taps best practices in hazard mitigation to prepare.

- Recent trends in Global and US losses from extreme weather events, role of climate
- Best practices in hazard mitigation and climate adaptation
- Lessons learned and implications for the District
- Community engagement: How should public and private groups coordinate?

Q & A, discussion

2:00 PM **Break**

2:15 PM **Best Resilience Practices, Part 3: Visualizing Solutions & Measuring Benefits**

Steve Winkelman, Director of Adaptation, Center for Clean Air Policy

2:30 PM **Facilitated Group Discussion**

Steve Winkelman, Director of Adaptation, Center for Clean Air Policy

- Priorities, Needs and Opportunities
- Exploring Next Steps

4:00 PM **Adjourn**

CCAP's Weathering Climate Risks program is made possible through generous support from the Surdna Foundation.

Appendix B: Studies Mentioned During Steve Winkelman's Talk

- **Big picture** (physical and human systems): *Resilience* (Zolli), *Global Warming, Natural Hazards, and Emergency Management* (Bullock, Haddow, Haddow), National Climate Assessment
- **Business.** *Managing Climate Change Business Risks and Consequences* (Stoner and Wankel)
- **Economics**: *Growing Wealthier* (CCAP)
- **Flood Management**: *Design for Flooding* (Watson)
- **Energy**: "Building a Resilient Energy Gulf Coast" (Entergy)
- **Engineering**: *Designing to Avoid Disaster* (Fisher)
- **Building design**: *Green Building and Climate Resilience* (USGBC)
- **Insurance**: "Stormy Future for U.S. Property/Casualty Insurers: The Growing Costs and Risks of Extreme Weather Events" CERES
- **National Security**: *Disaster Resilience: A National Imperative* (NAS)
- **Local Sustainability**: *Sustainable DC, Climatopolis* (Kahn),"Ask the Climate Question", (CCAP), "Lessons Learned from Urban Leaders" (CCAP)
- **Risk Management:** *At War with the Weather* (Kunreuther et al)
- **Transportation:** "Transportation and Climate Adaptation" (CCAP)

Appendix C: Highlights of Participants' Current Resilience Efforts

(In alphabetical order)

District Agencies and Regional Bodies

- **District Department of the Environment, District Office of Planning (DDOE, DOP).** District agencies are partnering together to implement Sustainable DC, a citywide sustainability initiative. Sustainable DC includes several climate change adaptation goals and action items on critical Infrastructure, buildings, emergency services, electricity, water and green infrastructure. This spring the District will initiate a DC-specific risk analysis study on sea level rise and storm surges, extreme weather, and urban heat impacts.

- **District Department of the Environment (DDOE).** The District is negotiating its first deal on PACE now. Ideally the PACE program will finance retrofits, including energy and stormwater management retrofits. The District hopes to obtain hundreds of millions of dollar for this project, and stressed the need to tap private investment for these efforts.

- **Metropolitan Washington Council of Governments (MWCOG). MWCOG** received technical assistance through the EPA Smart Growth Implementation Assistance Program, which will produce a guidebook to provide an overview of climate adaptation approaches for four sectors: buildings, land use, transportation and water. More than 200 regional leaders were educated/ trained on climate adaptation throughout this project. In September 2011, MWCOG held stakeholder meetings for each of the four sectors covering impacts, vulnerabilities and best practices and gathering information from stakeholders for the guidebook. MWCOG is working with stakeholders on a wide variety of initiatives that improve community resiliency such as energy and water security. MWCOG also contributed to the National Association of Regional Councils (NARC)'s Survey of Regional Planning on Climate Adaptation to explore how regional planning organizations are responding to climate change.

- **National Capital Planning Commission (NCPC).** In 2013, NCPC is convening and facilitating an interagency working group of federal agencies and relevant organizations that own and/or manage properties and infrastructure in the monumental core of Washington, DC, to 1) understand the climate change risks to federal assets and system-wide infrastructure, 2) identify a set of shared climate adaptation priorities, and 3) facilitate sustained coordination in climate adaptation activities for 2014 and beyond. NCPC is also currently discussing a partnership with others who can help build capacity for long term climate adaptation planning in the National Capital Region.

- **Washington Metropolitan Area Transit Authority (WMATA or "Metro").** Metro is aware that it is vulnerable to severe weather impacts and is continuing to work to address these vulnerabilities. Equipment damage from flood prone vent shafts are one area of particular and immediate concern. Metro is currently conducting an analysis of its vent shafts. Vent shaft extensions will be required for certain vital locations to

protect of the entire MetroRail system from significant damage and the region from significant rail service disruption. Examples of successful vent shaft extensions can be seen at 7th Street and Constitution Avenue and on Georgia Avenue. Metro recognizes that protecting these vents will require changes to street and park-scapes and requests support from stakeholders to develop workable solutions for all parties.

Federal Government

- **Environmental Protection Agency (EPA).** EPA provides technical assistance grants, and would be happy to connect with anyone interested in these projects.

- **General Services Administration (GSA)**. As one part of its FY13 Climate Change Adaptation Action plan, GSA conducted a pilot in the National Capital Region focused on incremental climate change using NASA's 7-step climate risk assessment process translated to GSA's business model of real property and supply chain with a specific customer. The regional pilot investigated sea level rise and extreme heat impacts. The cooperative efforts resulted in a day-long session which was selected as a GreenGov Spotlight Community project.

- **National Aeronautics and Space Administration (NASA).** "In addition to super computers, we have super people who will help." At each of its facilities, NASA is identifying a local sustainability officer and creating local adaptation plans. This inspired, institutional leadership to empower local communities will continue for the long-term. They are also working with NCPC and GSA (see NCPC description).

- **National Oceanic and Atmospheric Administration (NOAA).** NOAA engages in many efforts related to critical infrastructure resilience and adaptation in a changing climate. Examples include: National Climatic Data Center climate data and services, funding opportunities focused on climate adaptation and community and ecosystem resilience through the Climate Program Office Climate COCA and SARP programs, Coastal Services Center resources and tools to inform coastal decision-making, and sectoral engagement specific to the transportation and infrastructure community with the Eastern regional climate service director. More information on the breadth of NOAA's related work includes, but is not limited to: www.climate.gov, NEclimateus.org , www.cpo.noaa.gov, and http://www.csc.noaa.gov. NOAA is collaborating with EPA and several others on a series of case studies on water utilities planning for extreme events, and emerging approaches to planning for future events.

Companies

- **Entergy.** Entergy is following through on adaptation and sponsoring studies in three ways. First, Entergy sponsored a resilience study with America's Wetland Foundation released at World Deltas 2010 Dialogue and the subsequent Blue Ribbon Resilient Communities Program. Second, Entergy is improving asset resiliency through internal evaluations of critical infrastructure, focus on transmission and distribution through generation and vegetation management, and expanding resiliency to include other affected utilities. Third, Entergy is an active player in the legislative and regulatory world.

- **Pepco Holdings, Inc.** Pepco's focus is making infrastructure stronger and smarter. First, through a "reliability enhancement plan", Pepco is working on smart technologies. They have begun installing smart meters and other smart technology to create a self-healing distribution system that can sense when something is wrong and fix things. Additionally, they are incorporating microgrid technology into their grid (working with Howard University). Second, Pepco is improving their vegetation management. They've moved from a five to three year trimming cycle ("Right Tree, Right Place"), and been undergrounding in areas where it makes sense. Full implementation of Pepco's undergrounding plan could result in an 80% reduction in outages over five years and with significant cost impacts. Pepco is discussing the funding mechanism with the Mayor's Undergrounding Task Force, and would like to see this effort advanced beginning 2014. Third, Pepco is improving their communication and outreach. They now have a "smart app" that shows outages by neighborhood, outage estimation time, minute by minute accounting of energy usage, and more.

- **RenaissanceRe (RenRe).** RenRe provides atmospheric perils intelligence, funds large scale testing facilities such as the RenaissanceRe Wall of Wind at Florida International University and the Institute for Business and Home Safety Research Center, supports multiple conferences, and communicates resilience to the public through StormStruck at Walt Disney World's EPCOT Center.

Non-profits, Consultants, and Universities

- **Center for Clean Air Policy (CCAP).** CCAP's Weathering Climate Risks program fosters collaboration between city agencies and the private sector to develop and implement climate adaptation plans to prepare for and reduce the physical, social, and economic impacts of severe weather and a changing climate. We want to ensure that comprehensive adaptation plans don't just sit on the shelf. We aim to catalyze implementation progress on policies and processes that can be launched in the near-term because they have strong public and private sector support. Past reports include Growing Wealthier: Smart Growth, Climate Change, & Prosperity, Climate Adaptation & Transportation, The Value of Green Infrastructure for Urban Climate Adaptation, Lessons Learned on Local Climate Adaptation, Ask the Climate Question.

- **CH2M Hill**. In addition to the City of Alexandria study, CH2M Hill worked as a subcontractor to Critigen to create a website for DDOE called GreenUp DC. On this website, homeowners can examine their property from three climate resiliency perspectives. For instance, homeowners can examine their property for solar potential (photovoltaic or photo-thermal). Homeowners can also calculate the stormwater savings of certain initiatives including various green infrastructure options to reduce stormwater runoff, including tree plantings, which may eventually lead to reducing impervious pavement fees.

- **Georgetown Law.** Georgetown Law focuses on long term physical changes including urban heat work that lead to policy writing and funding, such as their Urban Heat Tool Kit. Georgetown Law have talked with DDOE to see what agencies could be doing now, and with OP about GIS mapping most vulnerable areas, stormwater data, heat islands' locations, etc.

Appendix D: Participants

The workshop united an unprecedented grouping of government and corporate experts. Most people did not already know each other despite working on complementary efforts and appreciated the chance to meet and learn from each other. There was strong rapport; the workshop succeeded in creating a good sense of group cohesion, purpose and promise for future collaboration. In total, there were 45 participants (see Table 1), 12 were from the District government, 11 were from regional or federal government, 15 were from industry (business improvement districts, energy, utilities, insurance, real estate), four were from NGOs, and three were from universities.

Table 1: Full participant List

Contacts	Sector	Name	Title
DC Homeland Security and Emergency Management Agency	**Government**	Frederick Goldsmith	Critical Infrastructure Specialist
DC Office of Planning (OP)	**Government**	Harriet Tregoning	Director
DC Office of Planning (OP)	**Government**	Tanya Stern	Chief of Staff
Department of Consumer and Regulatory Affairs (DCRA)	**Government**	Rabbiah Sabbakhan	Deputy Division Chief
Department of Consumer and Regulatory Affairs (DCRA)	**Government**	Jatinder Khokhar	Deputy Chief Building Official
District Department of the Environment (DDOE)	**Government**	Keith Anderson	Acting Director
District Department of the Environment (DDOE)	**Government**	Brendan Shane	Chief, Office of Policy & Sustainability
District Department of the Environment (DDOE)	**Government**	Daniel Barry	Senior Policy Analyst, Climate and Sustainability
District Department of the Environment (DDOE)	**Government**	John Heermans	Policy analyst
District Department of Transportation (DDOT)	**Government**	Tina Casey	Environmental Policy Analyst
District of Columbia Housing Authority	**Government**	John Jessamy	Architect/Project manager
District of Columbia Housing Authority	**Government**	R. Denise Everson	Redevelopment Planning Specialist
Federal Emergency Management Agency (FEMA)	**Government**	Leona Osborne	Program Analyst
General Services Administration	**Government**	Ann Kosmal	Architec, GSA Climate Adaptation Resiliency Team
National Aeronautic and Space Administration (NASA)	**Government**	Kim Toufectis	Master Planning Lead
National Capital Planning Commission (NCPC)	**Government**	Amy Tarce	Urban planner
National Climatic Data Center (NCDC)	**Government**	Deke Arndt	Chief, Climate Monitoring Branch
National Oceanic and Atmospheric Administration (NOAA)	**Government**	Adrienne Antoine	Program Manager
National Oceanic and Atmospheric Administration (NOAA)	**Government**	Nancy Beller-Simms	Program Manager, SARP
US Environmental Protection Agency (EPA)	**Government**	Michael Dunn	Environmental Assessment and Innovation Division
Metropolitan Washington Council of Governments (MWCOG)	**Government**	Maia Davis	Environmental Planner II
Metropolitan Washington Council of Governments (MWCOG)	**Government**	Amanda Campbell	Environmental Planner
Washington Metropolitan Area Transit Authority (WMATA)	**Government**	Rachel Healy	Sustainability Project Manager

Contacts	Sector	Name	Title
Downtown Business Improvement District (BID)	Industry	Scott Pomeroy	Sustainability Manager
Greater Washington Board of Trade	Industry	Bob Grow	Senior Director, Government Relations
NoMa Business Improvement District (NoMa BID)	Industry	Robin-Eve Jasper	President
DC Water	Industry	Maureen McGowan Holman	Sustainability Manager
DC Water	Industry	Jonathan Reeves	Emergency Response and Planning Coordinator
Entergy	Industry	Brent Dorsey	Director, Corporate Environmental Programs
Pepco Holdings, Inc.	Industry	Donna Cooper	VP Government Affairs Pepco Region
Pepco Holdings, Inc.	Industry	Wesley McNealy	Director, Corporate Environmental Services
Pepco Holdings, Inc.	Industry	Caryn Bacon	Director of Emergency Preparedness
Renaissance Reinsurance	Industry	Stephen Weinstein	General Counsel
Akridge	Industry	Leslie Morrison	Property Manager
Apartment and Office Building Association (AOBA)	Industry	Matt Smith	Chair of AOBA's Emergency Preparedness Committee
Boston Properties Inc.	Industry	Laura McNulty	SVP of Property Management
Boston Properties Inc.	Industry	Caroline Kruger	Regional Property Manager
Vornado	Industry	Deidre A. Schexnayder	Vice President of Operations
CCAP	NGO & University	Steve Winkelman	Director, Adaptation program
CCAP	NGO & University	Kelly Klima	Climate Adaptation Policy Advisor
CH2M Hill	NGO & University	Laurens van der Tak	Vice President
Udvardy Consultants	NGO & University	Shana Udvardy	Owner
Georgetown Law	NGO & University	Vicki Arroyo	Executive Director and Visiting Professor
Georgetown Law	NGO & University	Sara Hoverter	Adjunct Professor
University of Maryland	NGO & University	Haralamb Braileanu	

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