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**Resilient  
Infrastructure  
Planning Exercise  
Summary of Findings  
Portland, Oregon  
June 2018**



**Institute for  
Sustainable Solutions**

PORTLAND STATE UNIVERSITY

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# ACKNOWLEDGEMENTS

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*The quotes featured throughout this report were made by RIPE participants.*

# Introduction

According to NOAA (2018), the U.S. spent a record \$306 billion on weather and climate disasters in 2017, up nearly \$100 billion from the previous record in 2005 following Hurricane Katrina. From unprecedented rainfall and flooding from Hurricane Harvey in Houston, Texas, to ravaging wildfires and devastating mudslides near Santa Barbara, California, cities across the U.S. are grappling with how to better prepare for and recover from catastrophic natural disasters. These events bring into focus the need to prepare for similarly unprecedented events in Portland.

The Resilient Infrastructure Planning Exercise (RIPE) began in early 2017 as an effort to better understand the risks posed by major natural disasters to the City of Portland's (City) infrastructure, and to identify near- and long-term steps to build the resilience of those systems.

RIPE was specifically focused on the intermediate and long-term recovery phase of a disaster, rather than emergency response (see Figure 1). The Federal Emergency Management Agency (FEMA) describes the recovery process as a sequence of interdependent and often concurrent activities that progressively advance a community toward a successful recovery. Steps taken by Portland to build resilience (e.g., mitigation and preparation), and to have clearly established recovery priorities in place prior to a disaster, will have positive cascading effects resulting in a faster and more successful recovery.

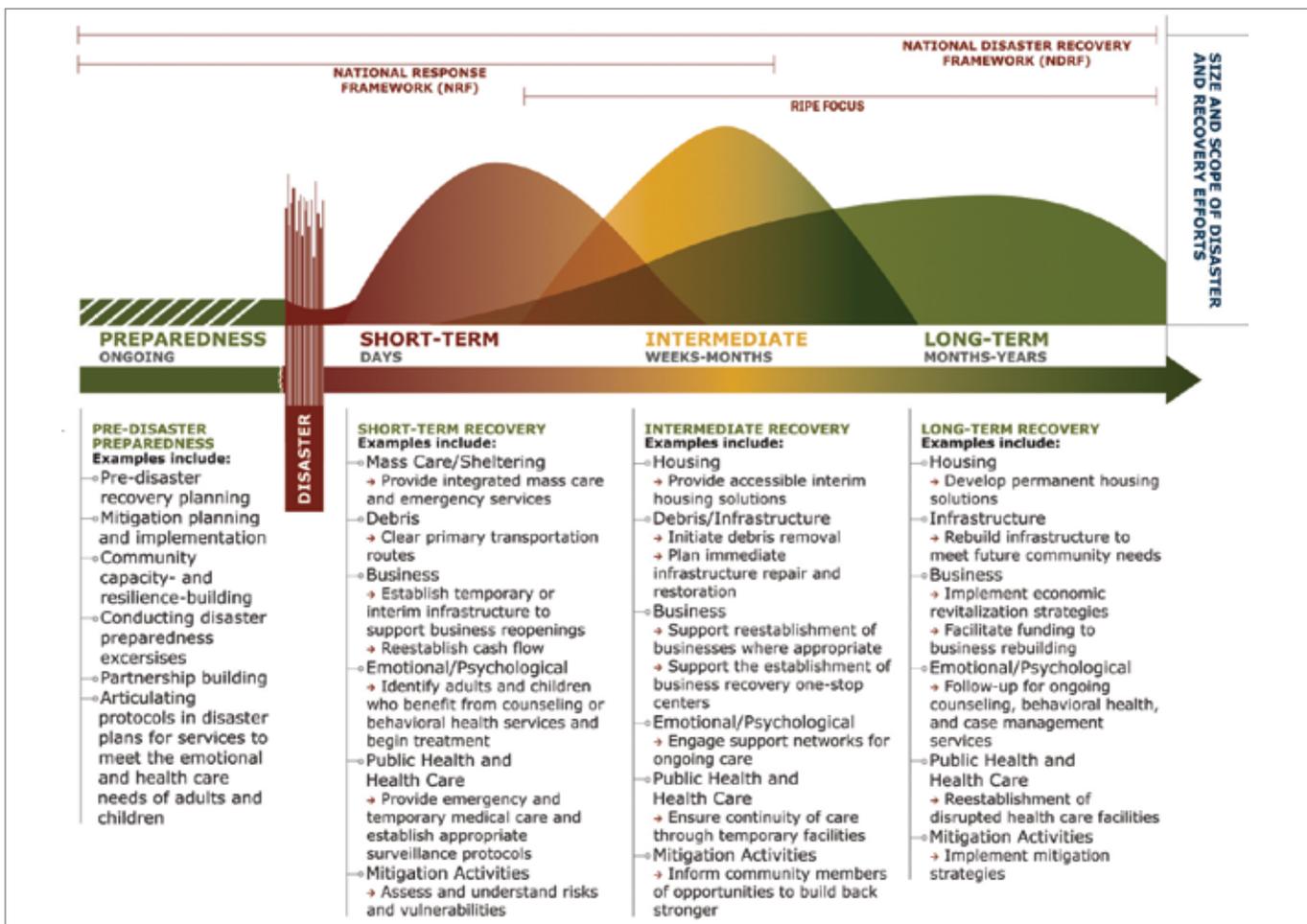


Figure 1. FEMA recovery continuum (FEMA 2011). RIPE focused on the intermediate and long-term phases of recovery

RIPE focused on two types of disasters that pose a very real threat to Portland including a Cascadia Subduction Zone earthquake, and major flooding and landslides precipitated by a historically unprecedented rain-on-snow event made more severe from climate change.

City staff from six bureaus, along with partners at Portland State University's Institute for Sustainable Solutions, used the disaster scenarios to help identify critical infrastructure, assess interdependencies, and estimate the expected time required to recover and/or rebuild those systems. The RIPE process confirmed, refined, and elevated the importance of resilience and recovery planning work in the City of Portland.

Each infrastructure bureau manages assets that can be impacted by failures of the systems managed by other infrastructure bureaus. For example, the Bureau of Environmental Services requires water from the

Portland Water Bureau to flush their sewer and storm water systems to facilitate repairs. The Water Bureau is dependent on the Bureau of Transportation to access critical pump and pipe networks to make repairs. In turn, critical emergency routes and roads could be compromised by sinkholes created by broken water and sewer pipes. Portland Parks & Recreation has essential equipment that can be deployed to help all bureaus in the face of an emergency, however that equipment may be stranded due to roads damaged from floodwaters or liquefied soils following a major natural disaster.

If one bureau's assets fail, there could be cascading impacts for the other bureaus. Investing in resilience and recovery planning can prevent these cascading failures, protect critical infrastructure and the community, and help Portland rebuild efficiently and equitably after a disaster.

RIPE participants felt that citywide resilience and recovery planning would pay big dividends, not only following a disaster but more immediately by creating opportunities for more informed decision-making and for cross-bureau collaboration. Key takeaways from the RIPE workshops (discussed in greater detail in the Key Findings section of this report, page 8) included:

- A. Resilience and recovery planning is a smart investment,** but Parks and Transportation need additional resources and staff capacity, as well as direction from leadership, to be able to fully engage in this work.
- B. Success requires cross-bureau preparation,** as well as engagement of external partners, stakeholders, and the community.
- C. Bold leadership and a cross-bureau support structure to facilitate the work will help maintain the momentum engendered by the RIPE workshops.** Time is of the essence. Resilience and recovery planning and investments take time, and a coordinated approach needs to start now.
- D. Uncovering interdependencies will enable more effective and equitable recovery after a disaster,** and an integrated citywide recovery strategy will bring it all together. This will require governance in planning now, and for decision-making and direction during recovery.
- E. Rebuilding smarter and more equitably requires a shared community vision that should be shaped prior to a disaster.** The City also needs a process for making post-disaster recovery decisions that enables relatively streamlined decision-making, but with greater public transparency and engagement.

What follows is a report on the first year of efforts by a team of City staff and partners at Portland State University's Institution for Sustainable Solutions to identify opportunities to build Portland's disaster resilience and set the stage for quicker and more equitable recovery from a damaging event. The following sections provide background for this work, detail the RIPE process, present the key findings and outline next steps.

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# Background

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Climate change is the greatest social and environmental challenge of the 21st century. It poses a serious threat not just to Oregon's natural treasures — forests, mountain snows and rivers — but also to our jobs and our health. Oregon is already starting to feel the consequences of this warming. Snowpack is declining, summer stream-flows are decreasing, wildfire activity is increasing, sea level is rising and coastal waters are acidifying from carbon pollution (Dalton, et al. 2017). In particular, a warmer atmosphere will increase the risk of large atmospheric river events and other storms that have historically caused rain-on-snow flooding and landslides in the Portland area, damaging infrastructure and putting communities at risk.

Also, in 2017, Portland witnessed firsthand the destruction of the Eagle Creek Fire. Fortunately, that fire remained in the Columbia River Gorge, but its proximity to Oregon's most populated urban area was a glimpse of how much damage could be done if such a fire were to ravage Forest Park. Floods and fires are increasingly likely risks in Portland's climate future.

Beyond climate and weather-related disasters, there is a 17 to 21 percent chance of a magnitude 8.5 or greater Cascadia Subduction Zone earthquake occurring in our region within the next 50 years (Goldfinger, personal communication, August 29, 2016). Modern Portland has never experienced the kind of destruction that an event of this magnitude will have on a major urban area, and because subduction earthquakes were not understood until recently, Portland's building codes have been largely inadequate. No one knows when the next subduction zone quake will occur, but all evidence points to the possibility that one will hit the region during our lifetimes (OSSPAC 2013).

These concerns have been the focus of recent efforts at the state, regional and local levels. The Oregon Resilience Plan was developed specifically to address the deficiencies in our state's infrastructure and systems in the event of a major earthquake (OSSPAC 2013). A regional recovery framework for the Portland metro region is currently under development through the Regional Disaster Preparedness Organization. The City recently adopted the Mitigation Action Plan (PBEM 2016), and City bureaus have developed continuity of operations (COOP) plans. The City has also worked with neighborhood associations to educate residents about how to survive a major disaster and assembled neighborhood emergency teams to manage response efforts in advance of official emergency assistance.

The Oregon Resilience Plan has identified time-to-recovery goals designed to improve the ability for continued prosperity and a stable economy in the weeks, months and years following a major a disaster. Portland residents' expectations about the City's current capacity to respond and recover are far from reality, however. For example, 83 percent of Portlanders expect local government to provide emergency aid within three days of a disaster, and 42 percent say they would leave Portland if electricity and water are not restored within two weeks (PBEM 2017).

As things stand now, Portland would be unable to recover in a timely manner without significant investments to enhance infrastructure resilience in the coming decades. While some bureaus are working to improve resilience, current City investments are not expected to result in infrastructure systems that can meet the State's goals within the 50-year timeframe.

# RIPE Process

The focus of RIPE was to consider natural disaster resilience and recovery from a city-wide and cross-bureau approach. In 2015, the Portland City Council asked the Citywide Asset Managers Group (CAMG) how resilience fit in with their work to manage the repair, replacement and maintenance of the City's critical infrastructure. In exploring that question, the asset managers found it challenging to separately quantify the resilience measures and confirmed that successful resilience planning necessitated further coordination among bureaus and outside organizations.

The RIPE project team came together around an opportunity provided by the Global Consortium for Sustainable Outcomes (GCSO) CapaCities Project, an international program exploring the ability of city governments to increase capacity for sustainability planning through partnerships with local universities. It builds on an existing partnership between the City of Portland and Portland State University's Institute for Sustainable Solutions (ISS) which facilitated and project-managed the RIPE process.



## RIPE Workshop Participating Bureaus and Departments

### City of Portland

- Bureau of Development Services (BDS)
- Bureau of Environmental Services (BES)\*
- Bureau of Internal Business Services (BIBS)
- Bureau of Planning and Sustainability (BPS)\*
- Bureau of Revenue and Financial Services
- Bureau of Technology Services
- City Budget Office (CBO)
- Office of Management and Finance (OMF)
- Office of Mayor Ted Wheeler
- Portland Bureau of Emergency Management (PBEM)\*
- Portland Bureau of Transportation (PBOT)
- Portland Fire & Rescue (PF&R)
- Portland Parks & Recreation (PP&R)
- Portland Water Bureau (PWB)

### Multnomah County

- Multnomah County Bridges
- Multnomah County Emergency Management

\* RIPE project team coordinating bureau



The RIPE project team established the following objectives for the project. In identifying these objectives, the group was informed by the Oregon Resilience Plan (OSSPAC 2013), Portland’s Mitigation Action Plan (PBEM 2016), and similar resilience and recovery efforts in other communities — most notably Boulder, Colorado (BCC 2016a, 2016b, 2016c) following a cascading series of natural disasters involving fire, flooding, and landslides.

**RIPE Objectives:**

- Identify the City’s critical or “backbone” infrastructure.
- Assess the City’s ability to get critical infrastructure back online following a disaster, particularly for populations disproportionately impacted including communities of color and low-income populations.
- Better understand the interdependencies between different infrastructure systems.
- Develop citywide priorities to improve the City’s overall resilience to extreme events.

Staff from across the City participated in a series of two day-long workshops (see Figures 2 and 3). Each workshop focused on disaster recovery (i.e., the months and years following a major natural disaster), as opposed to emergency response (i.e., the hours and days following). At the workshops, two scenarios were explored (see Appendix A for the scenario details):

- **Scenario one:** Historically unprecedented rain-on-snow event, made more severe by climate change, that causes flooding greater than a 500-year flooding event which could plausibly breach the levees, accompanied by landslides (see Figure 4).
- **Scenario two:** Magnitude 8.5 Cascadia Subduction Zone earthquake (see Figure 5).

Instead of aiming for a prescriptive outcome, the intent of the workshops was to begin cross-bureau discussions to identify vulnerabilities and interdependencies, and to lay the foundation for a multi-bureau disaster resilience and recovery framework.



Figure 2. Portland Bureau of Transportation staff share information with workshop participants on their core services and critical infrastructure such as emergency transportation routes..



Figure 3. Workshop participants use interactive maps to explore vulnerabilities and interdependencies.

Each scenario offered bureaus the opportunity to assess the impacts of the extreme event on their infrastructure, as well as the critical assets of the other infrastructure bureaus. Each bureau considered the following questions:

1. What critical infrastructure assets would be damaged?
2. Where would bureaus prioritize repairs?
3. How would considering the disproportionate impacts on communities of color and low-income populations shift repair priorities?
4. What are the interdependencies between the different bureaus' assets?
5. How can bureaus help each other?
6. How might bureaus hinder each other?
7. How could bureaus rebuild their systems better, smarter or more equitably?
8. What are the next steps for the City to plan for the effective and efficient recovery following a major natural disaster?
9. What can we do now, and what should we do in the coming years?

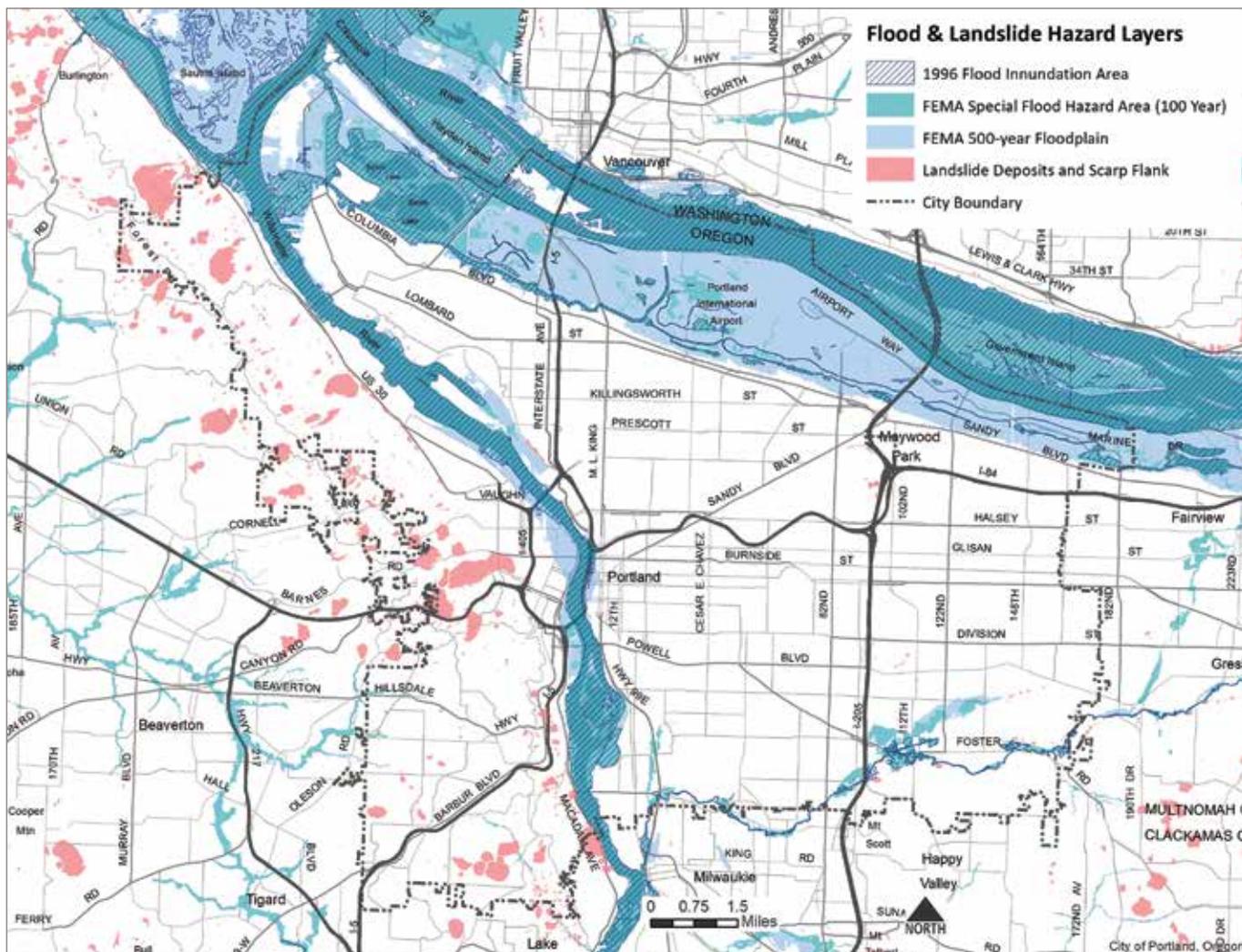


Figure 4. 500-year flood scenario showing extreme flooding along the Columbia and Willamette Rivers, and Johnson Creek.

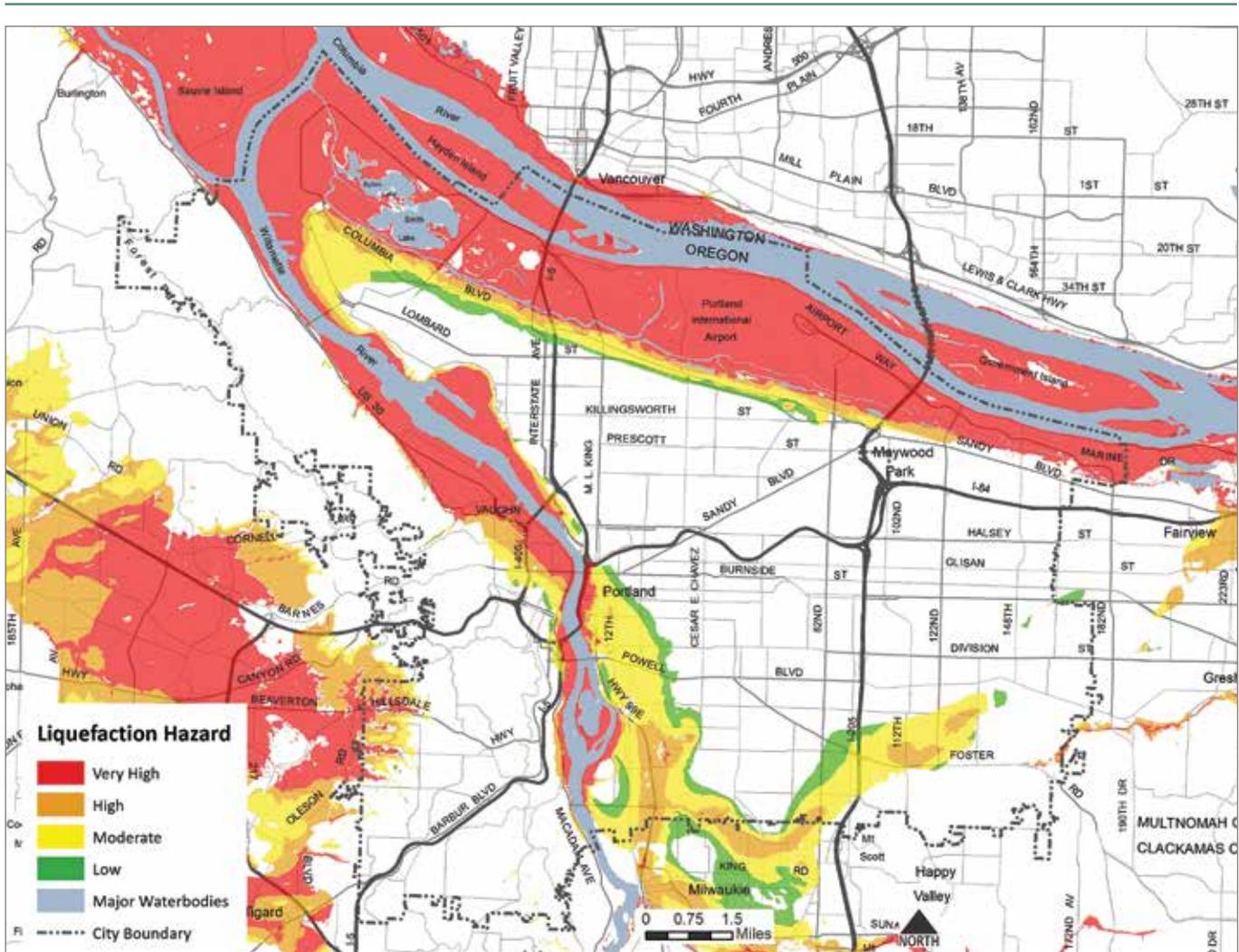


Figure 5. Areas of liquefaction ranging from low (green) to very high (red), likely to be activated in a Cascadia Subduction Zone earthquake.

Opening and closing surveys were distributed to RIPE workshop participants to understand the key findings and impacts (see Appendices B and C for more details). Participant surveys revealed overall enthusiasm for the RIPE effort, 100 percent of respondents ranked the workshops as an important use of their time, and cross-bureau collaboration ranked as one of the greatest impacts.

The workshops provided an opportunity for bureaus to learn about and discuss critical interdependencies that would have otherwise remained unconsidered and unaddressed. Staff also articulated that making this work a priority for the City would require: 1) leadership at all levels of the organization, including City Council and bureau directors, 2) clear expectations of staff to advance and integrate resilience and recovery planning into their everyday work, and 3) the resources needed to develop robust bureau-specific plans (especially for Parks and Transportation), as well as an integrated citywide resilience and recovery framework.

# Key Findings

## A. Resilience and recovery planning is a smart investment

*“Planning is money well spent, and investment in mitigation is more cost-effective than ‘repair and replace’ after a disaster.”*

From New York to Boulder, San Francisco to Seattle, Atlanta to Boston, and Chicago to Dallas, U.S. cities are actively strengthening their ability to better manage ongoing stresses and prepare for, withstand and recover from major natural disasters. Portland should join these world-class cities by building on the solid foundation of existing efforts and facilitating a robust citywide recovery and resilience planning initiative.

Resilience and recovery planning requires cross-departmental work and creates the opportunity to come up with solutions that might not otherwise be identified. Such planning efforts will help City bureaus develop the tools and knowledge needed to reform policies, and identify where and how to invest to increase Portland’s

resilience in the face of extreme events. RIPE participants felt that focusing on such efforts in the near-term would pay big dividends, not only following a major natural disaster, but by minimizing the impacts of more common, less-disruptive natural hazard events.

In addition, resilience and recovery planning and investments can significantly reduce disaster-related costs. A recent study funded by FEMA found that building resilience to flooding, wind, earthquakes and fire can save \$6.00 in future disaster recovery costs for every \$1.00 spent on hazard mitigation; this is in addition to avoided deaths, injuries and post-traumatic stress disorder cases (MMC 2017).

### Parks and Transportation bureaus need planning resources

*“Political will and ongoing financial resources are imperative, but both are tenuous.”*

Individual asset-owning bureaus need resources to participate in this work. Parks and Transportation are at a different place compared to Water and Environmental Services in terms of available resources. Even though both are essential service providers critical to recovery, Parks and Transportation do not currently have the resources or staff capacity to fully engage in resilience and recovery planning, much less implementation.

For example, Parks’ critical facilities need to be identified, assessed and prioritized, and money needs to be allocated for upgrades. Transportation funding is limited and often has spending restrictions which present challenges

for coordination and collaboration with other bureaus. Environmental Services and Water have done robust work in this arena and are positioned to assist the other bureaus in accelerating their work. At the same time, they still have work to do to fully integrate resilience and recovery considerations into their investment decisions (e.g., capital improvement program project selection and budgets).

Addressing the resource gap for Parks and Transportation was one of the top priorities identified by all of the bureaus that participated in the RIPE workshops. Other priorities included: leveraging existing funding and projects to build resilience, advocating for funding for needed planning and staffing efforts, and securing new and ongoing resources to make needed resilience investments.

*“If we identify key projects as a group we are more likely to get funding. Decision-makers are waiting for someone to advocate for these improvements.”*

## B. Success requires cross-bureau preparation

*“We have a bureau-centric approach to resiliency, but bureaus need each other to recover. The City needs bureaus to work together to recover post disaster, but our critical assets aren’t well aligned.”*

There are significant opportunities to improve the likelihood of Portland’s successful recovery following a major natural disaster. All bureaus — including Water and Environmental Services, who already have robust resiliency planning efforts underway — will benefit from enhanced efforts to identify all the City’s critical assets and understand their interdependencies.

### Uncovering interdependencies enables effective recovery

The City’s infrastructure systems can interact in ways that could amplify damage and create unexpected vulnerabilities and cascading failures (e.g., broken pipes washing out roads). There are also opportunities to leverage investments in some assets to enhance the resilience of other infrastructure systems (e.g., hardening Parks’ irrigation wells so they can provide non-potable water sources during recovery).

To understand interdependencies, bureaus must first identify their own critical assets and evaluate their condition and performance. This evaluation should build on existing asset inventories and conditions assessments developed by bureau asset managers. However, bureaus are at different stages in this process. Parks, for instance, learned during the flooding scenario that critical maintenance and equipment storage facilities are likely to be stranded and inaccessible in a major flood event.

Similarly, Transportation has yet to determine the risks of a 500-year flood and major landslides to City-owned bridges. For Environmental Services and Water, the bureaus with the greatest capacity and experience with resilience planning and investment, concerns arose regarding unexpected interdependencies and vulnerabilities. In a seismic scenario, for instance, bureaus identified the potential for Environmental Service’s pump stations to overflow sewage into the groundwater protection area of the Columbia South Shore Well Field, meriting further assessment.

*“There will be widespread water quality issues across the city and a shortage of drinking water in both scenarios.”*



*“The first roads Transportation would clear after a disaster aren’t necessarily the same roads Water or Parks would need cleared. This is something we can begin to think through now.”*

The transportation network is critical for recovery, both because other agencies depend on the transportation network, and because the failure of other bureaus’ assets can compromise important roads and bridges. In both the flooding and seismic scenarios, many assets identified as critical by Environmental Services, Parks and Water are likely to be inaccessible. Transportation’s top priority would be clearing and repairing emergency transportation routes to meet the transportation needs of emergency responders and hospitals. However, many of those emergency routes are not near the critical assets that the other infrastructure bureaus will need immediate access to for repairing and restoring critical services like drinking water and sewage treatment.

In addition, many of the emergency routes also intersect with important water, sewer and storm-water pipes. In a major seismic event, these water pipes may break, resulting in washed out emergency routes and sinkholes.



## City bureaus can't do it alone

The RIPE workshops intentionally focused exclusively on City-owned and managed infrastructure as a starting point for the discussion. However, identifying the interdependencies and potential cascading failures with infrastructure systems managed by other entities and agencies is also critical to the City's resilience and recovery planning.

In particular, many of the City's infrastructure systems are reliant on services provided by the utility companies. Power outages are to be expected and some estimate that it could take two to six months to recover electricity following a major earthquake. Without power, Environmental Services and Water will be unable to test

and repair critical water and wastewater pump stations, which will delay their own recovery efforts. Similarly, important recovery services such as medical facilities and schools are dependent on the water, sewer and transportation services provided by the City.

Several entities such as Multnomah County, the Port of Portland, and utility companies have expressed interest in the RIPE effort. They, along with other City bureaus and key stakeholders, will add value to the work as it continues and expands.

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## C. Bold leadership and a support structure will maintain momentum

Successful cross-bureau collaboration, effective investments in resilience and timely recovery after a disaster will require significant levels of coordination across all the City's infrastructure bureaus. While opportunities for immediate, low-cost collaborative projects exist, citywide resilience cannot continue to be approached by only a few bureaus and in a piecemeal fashion.

Champions at both the bureau director and City Council levels are needed to prioritize this work, facilitate sustained progress and ensure investments that both enhance the City's resilience and enable future recovery in a timely fashion. Such leadership will prioritize integrated citywide resilience and recovery planning efforts that help improve livability by addressing today's community priorities, while also ensuring a smarter, more efficient and more equitable city tomorrow — with or without a disaster.

### Time is of the essence

*"Someone needs to 'own' recovery."*

Recovery planning takes time. Investing in building the resilience of infrastructure systems takes even longer. The Oregon Resilience Plan, for example, sets a 50-year horizon to implement various policy and investment priorities. No one can predict if the Cascadia fault will rupture today or fifty years from now, and climate change is only increasing the likelihood of damaging precipitation events in the future. There is no time to lose.

Each year the City invests about half-a-billion dollars (City of Portland 2017) to maintain, repair, replace, and rehabilitate existing infrastructure or build new infrastructure assets that will be in place for generations. This means that bureaus are often missing opportunities to build greater resilience into existing projects, thereby locking in infrastructure that may be maladapted for extreme events for the foreseeable future. City leaders must begin prioritizing citywide resilience and recovery planning and investments now, to prevent a major natural disaster from being catastrophic for Portland in the future.

### Citywide preparation needs a support structure

Portland's infrastructure bureaus have existing asset management programs and functions that enable informed decision-making. For example, the cross-bureau Citywide Asset Managers Group (CAMG) works to enhance coordination and dissemination of best practices. Future resilience and recovery planning efforts should leverage those existing efforts, while addressing challenges related to political will and funding needs to support robust resilience recovery planning.

Perhaps the greatest concern voiced by RIPE participants was that, without an organizing or supporting structure to foster collaboration, champion efforts and seek additional resources, the conversations that began in the workshops would lose momentum as participants returned to their day-to-day responsibilities.

Ideas for creating such a support structure included 1) identifying lead staff in each infrastructure bureau to drive bureau-specific resilience progress and enhance citywide collaboration, 2) create a cross-bureau resilience and recovery team, building on the Citywide Asset Managers Group model, for sharing best practices, standardizing methodologies and enabling bureau-to-bureau mentorship, and/or 3) creating a resilience coordinator position to convene staff, facilitate the work at a citywide scale and further the detailed work, tasks and opportunities identified through the RIPE workshops.

## D. An integrated citywide recovery strategy will bring it together

Citywide resilience and recovery planning would allow Portland's infrastructure bureaus — along with key partners, stakeholders and the community — to identify the obstacles that will be encountered during recovery when there will be great pressure to act quickly. Such an effort would also help to identify near-term, as well as post-disaster opportunities to approach rebuilding in ways that enhance equity, health, prosperity and natural resources.

Establishing strategic recovery priorities, prior to a disaster, will not only enable infrastructure bureaus to more effectively deploy limited resources and equipment, but will also help ensure that communities most vulnerable to the impacts of a disaster are not left behind in the recovery efforts. For example, East Portland is home to many communities of color and low-income populations. These communities are often hit hardest by a disaster because of underlying socio-economic disparities; in other words, they have access to fewer resources to respond to and recover from a disaster.

Although much of East Portland would likely fair better than other parts of the city during a major flood, landslide or earthquake event, key employment areas for people living in East Portland would be significantly impacted (see Figure 6). This means that while the homes of people living in East Portland might survive, many marginalized community members would not be able to return to work for prolonged periods of time. The disproportionate direct and indirect impacts of a disaster, as well as from any delays in recovery efforts needed in vulnerable communities, must be accounted for in establishing the City's recovery priorities.

Ideally, bureau-specific resilience and recovery plans would be integrated into a citywide recovery strategy that: defines how bureaus measure resilience (e.g., critical asset condition and performance), establishes recovery guiding principles and priorities, tracks status toward achieving Oregon's time-to-recovery goals, and outlines actions and investments to close the gap.

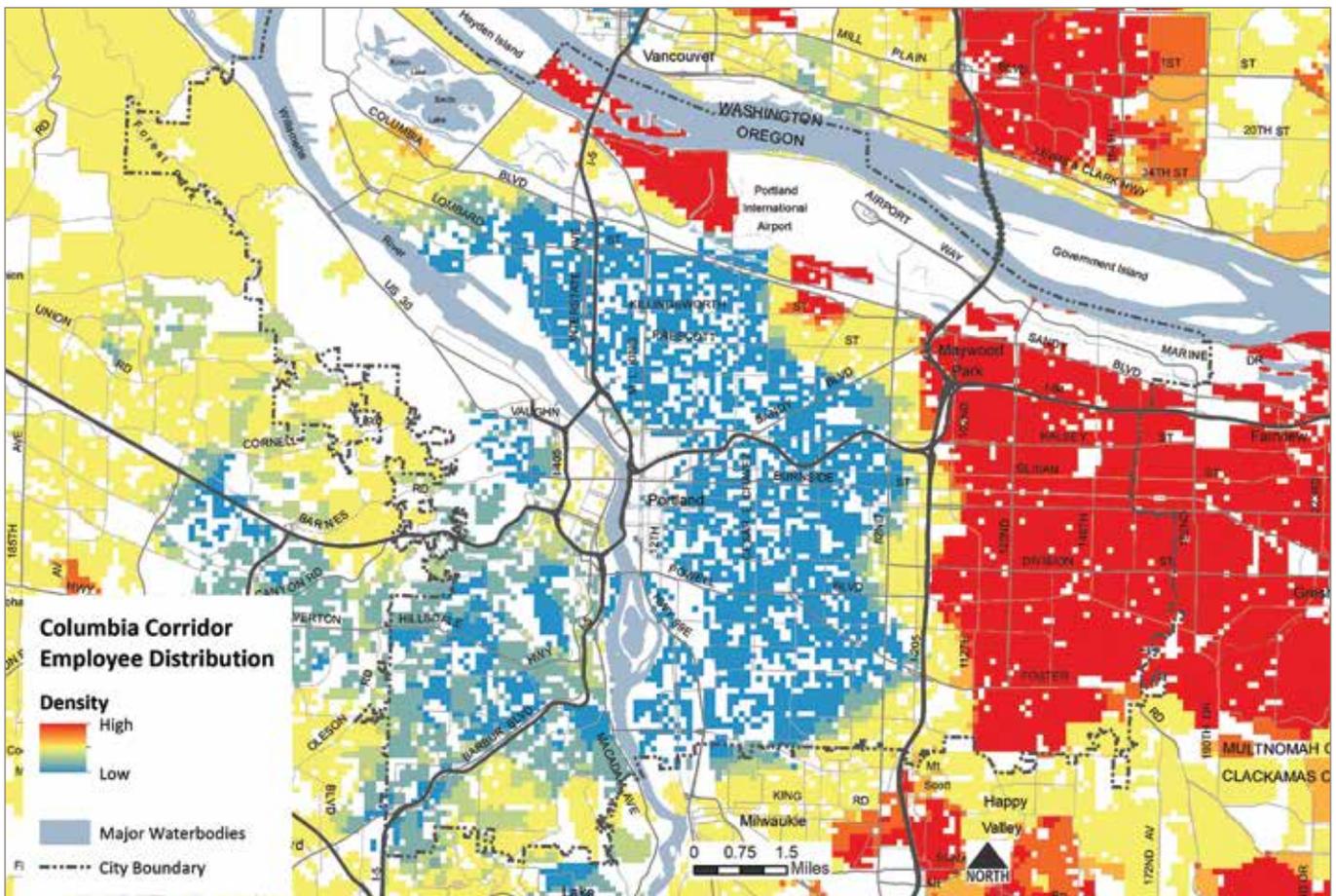


Figure 6. The Columbia Corridor is a key employment area along the Columbia River that would be significantly impacted in either of the scenarios explored in the RIPE workshops. High numbers of people living in East Portland (where many communities of color and low-income populations reside) work in the Columbia Corridor.

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## E. Rebuilding smarter and more equitably requires vision

A major earthquake or flood would mean redeveloping whole neighborhoods, or the whole city. Although devastating, with thoughtful pre-disaster planning there is an opportunity to build back a smarter, more efficient and more equitable city. An integrated citywide plan to increase resilience and to recover in the weeks, months and years following a major natural disaster would enable the City to set expectations around redevelopment goals and processes, and make investments now that set Portland on a path to rebuild smarter.

*“Improvements should not be constrained by historical codes and policies. We should try to think about long-term sustainability and build better and smarter now ... a recovery plan has value and benefits even in the absence of disaster.”*

Land use and infrastructure planners, together with the community, could envision today what rebuilding Portland could be like in the future. What new plans and zoning codes might make sense? Where would development in the future be prohibited? What areas could be repurposed as parks or natural areas? Could the transportation system be rebuilt to radically shift transportation modes toward transit, biking and walking? Could disaster contingencies be built into long-term infrastructure and land use plans by including provisions to automatically suspend, withdraw or amend rules that impede recovery?

The process of envisioning a rebuilt, more sustainable and equitable Portland would be a useful investment of time and resources, even in the absence of a disaster, because it can provide a reference for a future Portland that could be achieved through policies, plans and investments already under way.

### We need a process for making post-disaster recovery decisions

There is currently no structure for effective and efficient decision-making for the time between emergency response (i.e., hours to days) and normal operations following a major natural disaster (i.e., months to years).

The City’s Disaster Policy Council will fill this function during emergency response, and the City Council will resume such responsibilities once the City is largely recovered. There is a need to fill the gap between these two governance structures that would enable relatively streamlined decision-making, but with greater public transparency and engagement.

For example, the government in Christchurch, New Zealand, had to create a recovery agency and build its governance arrangements from scratch following the 2010/2011 Canterbury earthquakes because no agreed upon ‘off-the-shelf’ solution existed. These delays significantly hampered the community’s ability to recover, the impacts of which are still being felt today. A Portland recovery governance council, guided by an adopted citywide resilience and recovery strategy (as outlined earlier in this section), would enable more deliberate decisions and would likely be the determining factor in whether Portland has a successful and timely recovery.

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# Next Steps

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Following the workshops, the RIPE project team worked with participants to review, synthesize and prioritize the findings outlined in this report. A handful of concrete next steps emerged, along with a list of potential priority actions that warranted further consideration.

## Potential near-term resilience and recovery actions

RIPE participants identified several potential near- and mid-term actions to move the City's resilience and recovery work forward. The following list outlines several of the action ideas that warranted additional consideration and prioritization (this list does not, however, constitute commitments made by City bureaus for implementation).

1. Strategizing and leveraging the support of other bureaus to secure additional resources for Parks and Transportation to engage in resilience and recovery planning; this includes identifying mutually beneficial investments across bureaus, prioritizing resilience and recovery in the allocation of general fund resources, support in the development of resilience and recovery plans, and identifying other opportunities to address gaps in under-resourced bureaus.
2. Identifying opportunities for collaboration across bureaus, including "last mile" connections for critical transportation routes. For example, bureaus should align their capital replacement programs to improve efficiency, reduce overall cost, and ensure access to critical assets. Similarly, City bureaus should agree on a process to prioritize service recovery for critical facilities.
3. Focusing multi-bureau investments to build up the resilience of key locations and corridors in the city (rather than spreading those investments out in a scattered approach). Creating "resilient islands" around hospitals, schools, community centers and other important community recovery areas, and "resilient corridors" to more quickly restore North-South and East-West (including over the river) transportation connections.
4. Establishing various coordination and collaboration structures to support bureau-specific and citywide resilience and recovery planning and investments, potentially including:
  - A cross-bureau citywide resilience team.
  - A resilience leadership council (e.g., bureau directors).
  - A citywide resilience coordinator position.
  - Formal mentoring relationships to leverage existing expertise in Water and Environmental Services to bolster the efforts of Parks, Transportation, and Facilities.
  - Integrating resilience planning and investments into decision-making structures (e.g., capital improvement program project lists and budgets).
  - Opportunistically incorporating resilience into existing projects already being planned and constructed.
  - Cultivating leadership and champions that prioritize this work at all levels of the organization (e.g., staff, directors, City Council, external partners).
5. Exploring many of the interdependencies and potential cascading failures identified during the workshops (e.g., pipe breaks causing failures of emergency transportation routes, potential contamination of the wellfield protection area from damaged sewer pipes and pumps, utilizing Parks' expertise related to volunteer training and deployment, etc.).
6. Leveraging the City's partnership with Portland State University, and other academic institutions, to accelerate, facilitate and augment the City's efforts and assist with engaging additional stakeholders.

7. Evaluating the various options and best practices for facilitating cross-bureau collaboration and developing a citywide resilience and recovery strategy, including internal organizing structures and/or the creation of a citywide resilience coordinator position.
8. Developing an integrated resilience and recovery strategy that articulates recovery guiding principles, establishes recovery priorities and guides strategic investments. Such a strategy would consider and address disproportionate impacts of a disaster, and the associated recovery, on communities of color and low-income populations. The strategy should also address key recovery coordination issues such as: debris removal and storage, managing human waste, mitigating business and economic losses, and establishing key contractual relationships pre-disaster (e.g. construction contractors, sampling laboratories).
9. Establishing effective structures to store and share relevant resilience and recovery planning information across bureaus (e.g., information and maps of the City's critical assets, risks and vulnerabilities assessments, planning documents, lists of bureau experts and their credentials/certifications).
10. Identifying resilient and strategic post-disaster locations where multiple bureaus (and other key agencies) could co-locate recovery functions and equipment to optimize coordination and collaboration.
11. Developing a plan for how to most effectively utilize the adaptable space and functions of parks and schools to facilitate recovery, including the role they play as community gathering places.
12. Aligning the expectations, both internally and externally, about City bureaus' recovery priorities, expected timelines and core responsibilities (e.g., Water is responsible for restoring the City's drinking water system, not providing emergency bottled water; Environmental Services is not responsible for removing human waste from people's homes until the sewer system is operational; Transportation will be prioritizing repairs along emergency routes and major arterials, but not to County-owned bridges over the Willamette).
13. Creating a shared vision for how, following a major disaster, a smarter, more efficient and more equitable Portland could be rebuilt to help guide recovery decision-making, when there will be significant pressure to quickly make decisions.
14. Establishing a recovery governance council, structure, and guidelines for making decisions and investments during an extended recovery period — In other words, a decision-making structure between emergency response (Disaster Policy Council) and normal operations (City Council).

### RIPE project team next steps

The RIPE project team is committed to pursuing the following near-term actions, including:

1. Pursuing resources for more resilience and recovery work, including additional grant funding from the Global Consortium for Sustainable Outcomes and other potential partners, as well as supporting efforts to secure additional internal City resources.
2. Sharing and expanding on the results of the RIPE workshops and this report with other City staff, bureau directors, external partners and City Council.
3. Establishing an interim collaboration structure facilitated by PSU's Institute for Sustainable Solutions and with representatives from the infrastructure bureaus, emergency management, planning and sustainability, and the budget office to further refine next steps and foster opportunities for collaboration.
4. Leveraging academic resources — including grant funding, applied research, internships, and class engagements — to augment and inform City staff efforts.

The findings outlined in this report, together with the potential actions and next steps outlined above, create the foundation from which City bureaus, Portland State University and other partners will advance and operationalize a robust resilience and recovery planning and investment program for the City's infrastructure systems. These efforts promise to pay big dividends not only following a disaster, but more immediately by creating opportunities for more informed decision-making and cross-bureau collaboration.

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# Appendices

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# APPENDIX A – WORKSHOP DISASTER SCENARIOS

## 500 Year Flood and Landslides Scenario

A wet winter and heavy snow in late January was followed by a warm atmospheric river in mid-February 2018. These conditions created a historic, 500-year flood on both the Willamette and Columbia Rivers. The Columbia River ultimately reached 35' at the Vancouver Gage, and the Willamette 36' at the Morrison Gage. During the first week of rain and flooding:

- In the West Hills, a series of landslides and blown-out ditches and culverts closed Burnside, Cornell, Skyline, Canyon Road, St. Helens Road, and numerous residential streets. Damaged water and sewer pipes drained directly to the hillside, exacerbating problems. A landslide also damaged several West Hills water pump stations and tanks, leaving customers without water.
- Landslides also damaged two Bull Run supply conduits between Bull Run and Lusted Hill. The Bull Run reservoirs subsequently experienced turbidity levels requiring a shutdown of supply.
- The Columbia River overtopped levees in the Multnomah County Drainage District (MCDD). The Bridgeport Neighborhood, Columbia Corridor Industrial area, and the Portland International Airport were evacuated. Water spilled into the Columbia South Shore Well Field.
- A 100-year flood on the Sandy River led to cross-breaching of the MCDD levee system. Groundwater pumps, well infrastructure and electrical connections were damaged and could not provide backup supply. Terminal reservoirs in town were left with just a few days' worth of water to serve customers. Water restrictions were put in place and emergency potable supplies were established.
- The Willamette River flooded downtown to Third Street, the South Waterfront, and the waterfront Pearl. The Ankeny Pump Station was submerged and stopped functioning. Downtown buildings not flooded by the river were filled with backed-up sewage.
- A dock broke loose in the Willamette, floated down and hit the Hawthorne Bridge. Debris piled up around it, undermining a footing and closing the bridge.
- Johnson Creek flooded, closing Foster Road and the businesses along it. The Holgate Lake also re-appeared at 122<sup>nd</sup> and Holgate. Many residences throughout Portland experienced basement flooding; the problem was particularly bad near Johnson Creek and Holgate Lake.

Floodwaters on the Columbia and Willamette took ten days to recede. One month later:

- In the West Hills, most roads have been re-opened, but major work is needed to permanently stabilize hillsides. Power and water service is back on, but with temporary repairs.
- Two Bull Run supply conduits are being repaired. A third conduit is being used to access Bull Run supply because turbidity is no longer an issue. Customers are no longer reliant on emergency water.
- Repairs are ongoing at the Columbia South Shore Well Field pump station to ensure service is restored in time to augment supply for the coming summer.
- The airport has resumed service and big downtown businesses have mostly re-opened for business, many with "pardon our mess," signs and repair work still ongoing.
- Many smaller businesses have not re-opened, especially near the airport and on Foster Road. Many industrial sites are still assessing risk from hazardous materials releases related to flooding.
- The Hawthorne Bridge has not re-opened; engineers are still assessing the extent of damage.
- People living and working in structures with moldy basements and crawl spaces are now reporting respiratory problems. Area hospitals have seen a surge in emergency room visits.
- PBOT reports that debris in ROW continues to be a problem as people dump wet carpets, furniture, etc.

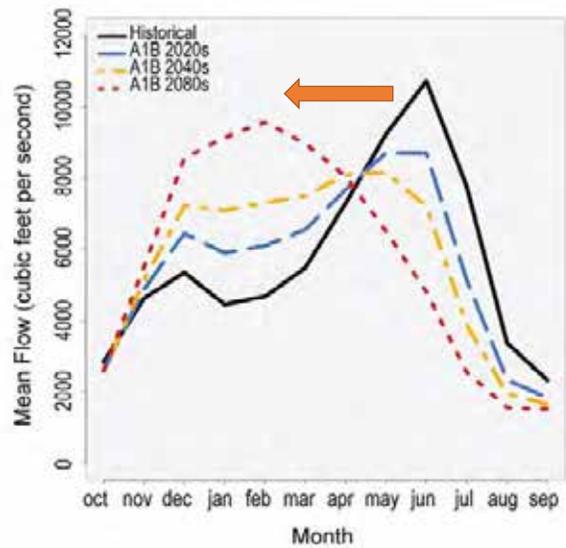


## Plausibility of scenario



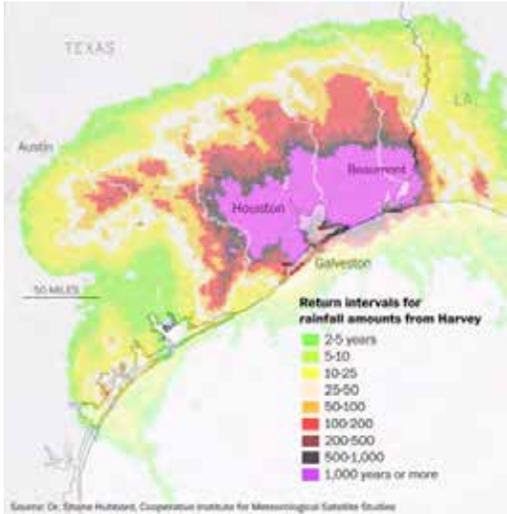
The Oregonian (Willamette Falls, 1996)

## Future Shift in Timing of Stream Flows



National Climate Assessment 2014

## Plausibility of scenario



Paul Fesko, City of Calgary

## Heavy snowpack



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## Atmospheric River

### CW3E Atmospheric River Update – Outlook

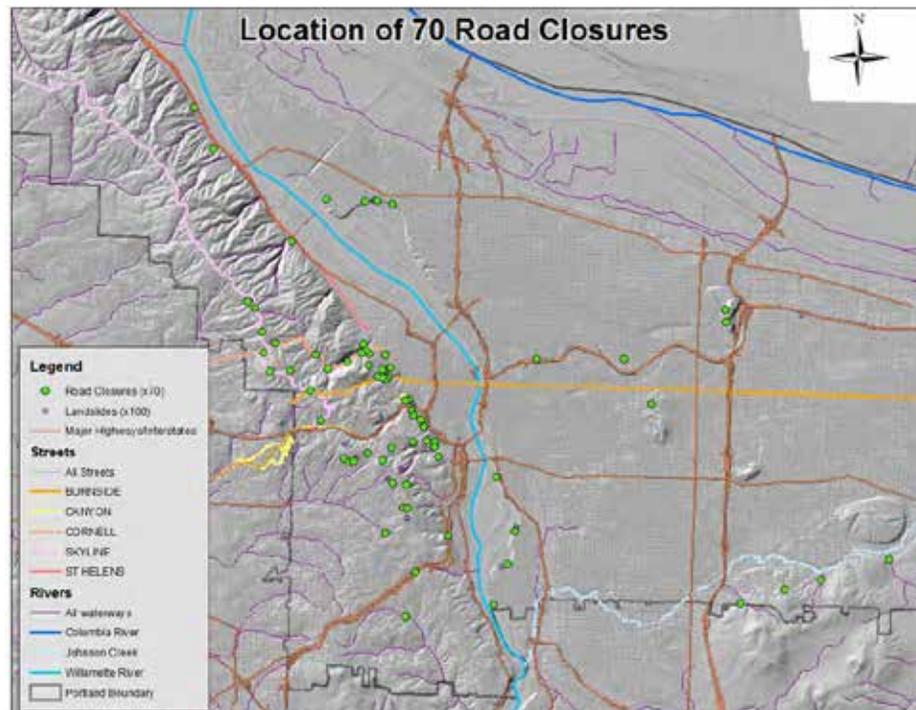
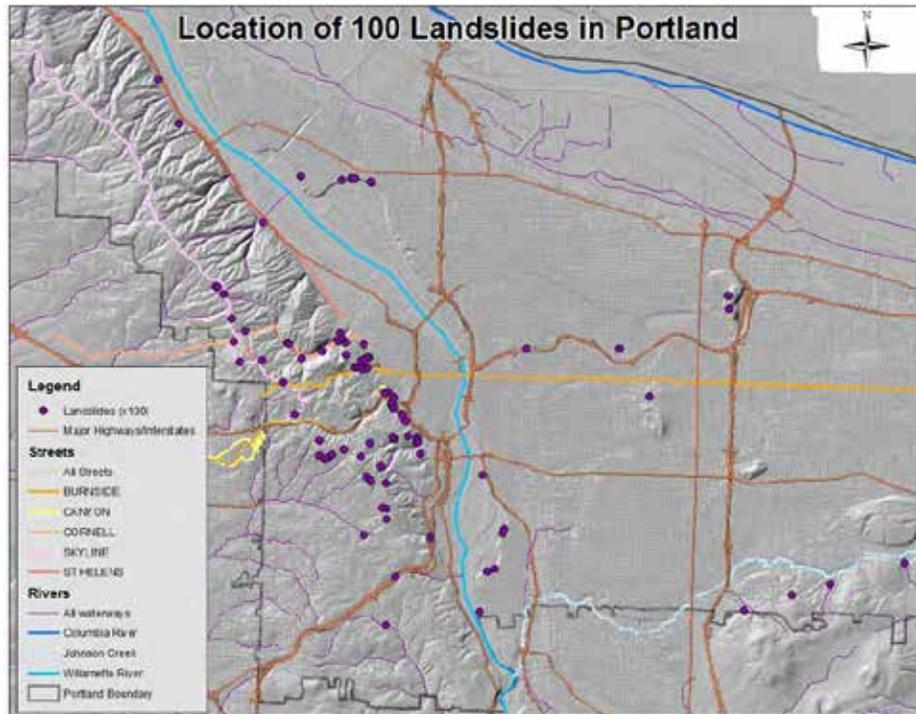


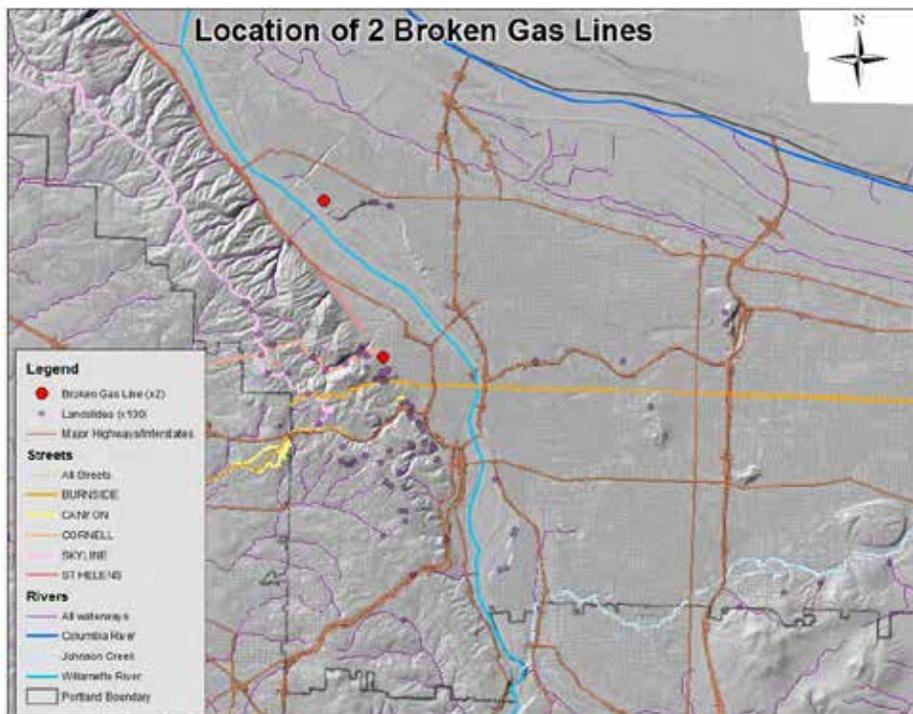
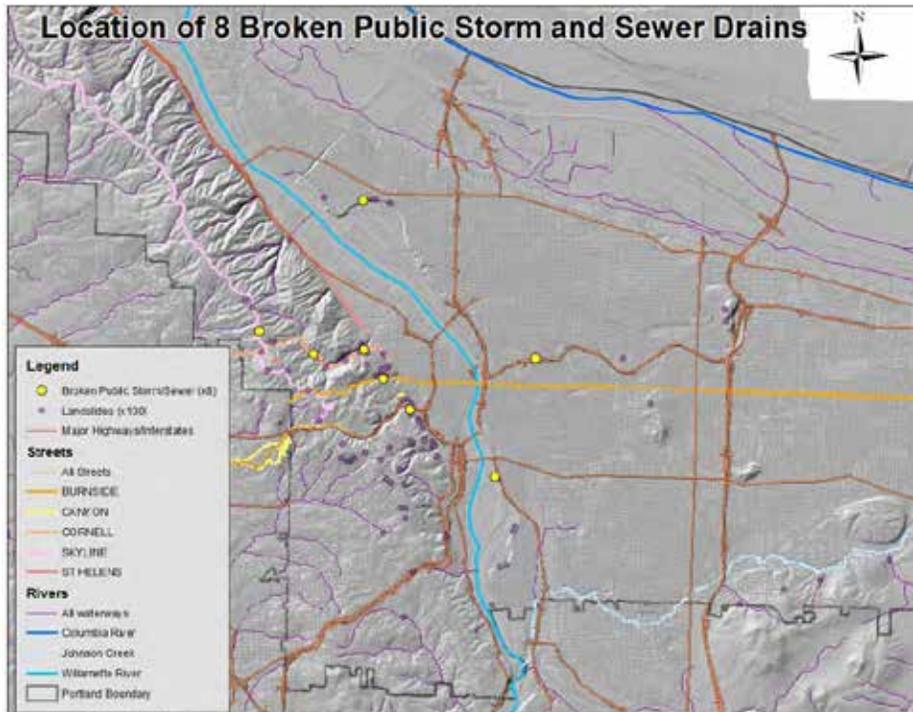
The synoptic scale configuration that is leading to these consecutive ARs over the Pacific Ocean is providing impressive satellite imagery that exhibits a cloud band that spans the entire northern Pacific Ocean (~5,000-miles). Photo credit NWS Seattle.

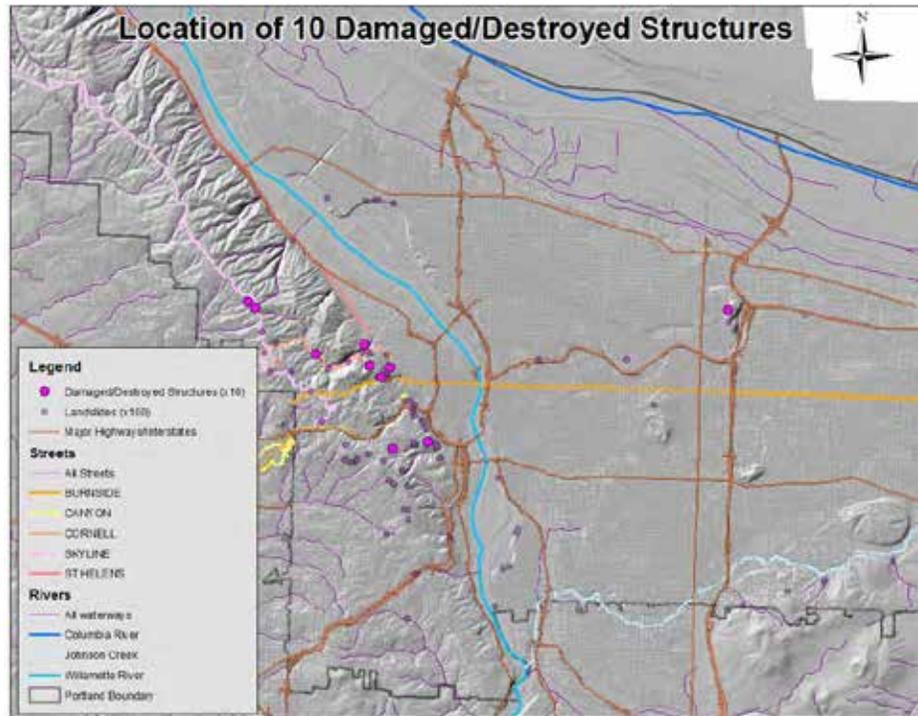
## Day one: West Hills

- Landslides and blown-out culverts close Burnside, Cornell, Skyline, Canyon Road, St. Helens, and numerous residential streets.
- Power and water service is cut by the slides.
- A landslide damages several West Hills water pump stations and tanks, leaving customers out of service.







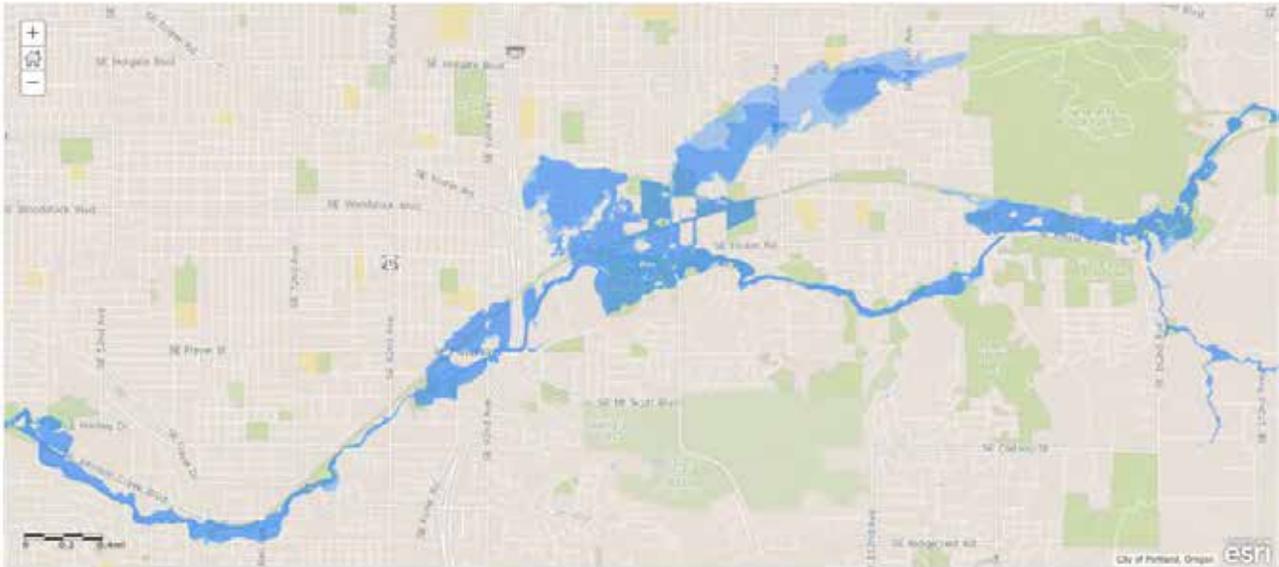


## Day two: Outer East

- Johnson Creek floods, closing Foster Road and the businesses along it.
- The Holgate Lake re-appears at 122<sup>nd</sup> and Holgate.
- Residences throughout Portland experience basement flooding; the problem is particularly bad in Lents and Powellhurst-Gilbert.



## Johnson Creek and Holgate Lake



## Day three: Bull Run & Water Supply

- Landslides damage two conduits between Bull Run and Lusted Hill, reducing supply from Bull Run



## Day three: Bull Run & Water Supply

- High turbidity in Bull Run means the supply is non-potable and has to be shut-off.
- PWB only has a few days of drinking water available in in-town terminal reservoirs and water restrictions are put in place.
- Regional emergency potable supplies are mobilized across the service area.



Regional Water Providers Consortium

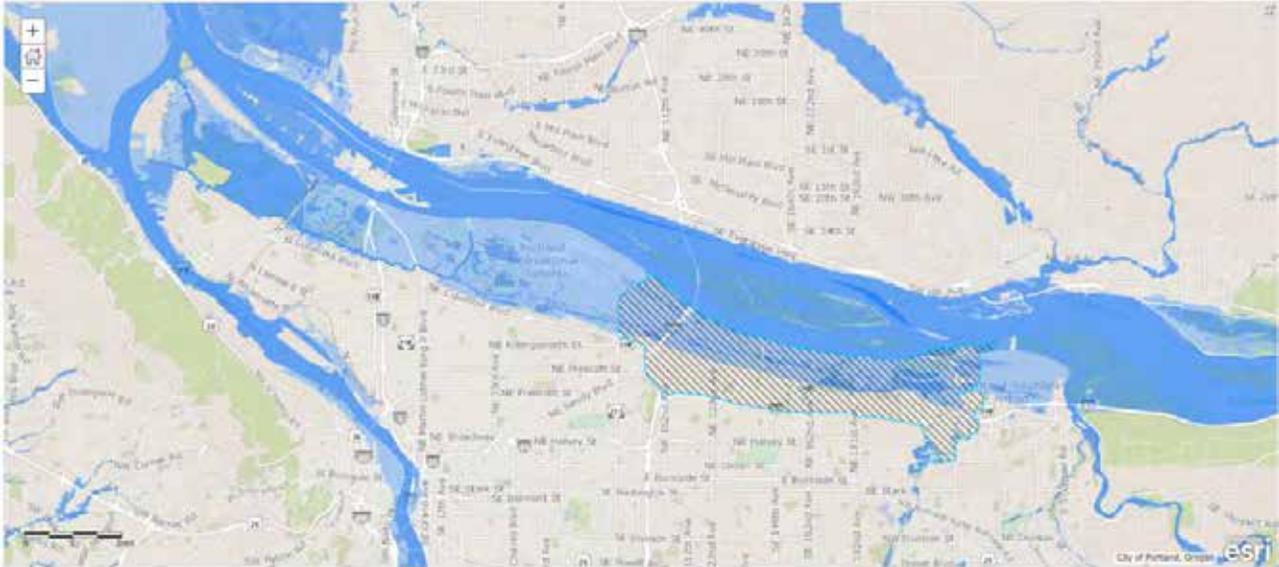
## Day four: Columbia + Sandy Rivers

- Columbia River crests at 35' at the Vancouver Gage, a 500-year flood.
- Floodwaters overtop levees throughout Multnomah County.
- Hayden Island, Bridgeport and surrounding industrial areas are evacuated.
- Portland International Airport closes.
- Floodwaters spill into the Columbia South Shore Well Field. Pumps, well infrastructure and electronics are damaged.
- Sandy River crests at the 100-year flood (41'), causing additional cross-breaching and flooding of the levee system.
- Floodwaters take ten days to recede.



The Oregonian (Sandy River 2011)

## Columbia River 500-year floodplain



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## West Hills

- Most roads have been re-opened, but major work is needed to permanently stabilize hillsides.
- Power and water service is back on, but with temporary repairs.
- Homeowners are undertaking repairs.



## East Portland

- Floodwaters have receded and homeowners and businesses are undertaking repairs as they are able.
- People living and working in structures with moldy basements and crawl spaces are now reporting respiratory problems.
- Area hospitals have seen a surge in emergency room visits for respiratory ailments.



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## Bull Run & Water Supply

- Turbidity decreased to meet regulatory requirements after two weeks
- The Water Bureau is now able to use a third undamaged conduit to provide 80% of the average winter demand.
- The two damaged Bull Run conduits are still being repaired to ensure access to 100% Bull Run supply, ideally in time for the summer supply season.



## Columbia River

- The airport has re-opened.
- Many north Portland businesses remain closed.
- Bridgeport residents are undertaking repairs as they are able.
- Repairs are ongoing at the Columbia South Shore Well Field, which has not resumed service. Groundwater supply may be needed to augment Bull Run supply in the coming summer.



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## Discussion Questions

- What damage or problems would you anticipate to the critical infrastructure of your bureau, in addition to those described?
- What communities or groups would you be most concerned about – who do you think would be in the worst situation or have the greatest needs?
- What would be your bureau's most important short-term goals?

## Discussion Questions

- What are your bureau's longer-term goals (a year or more)?
- Would you build everything back the same?
- What resources would you need from other bureaus to accomplish your short-term goals? Longer-term goals?

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## Cascadia Subduction Zone Earthquake Scenario

On June 2, 2018, the Cascadia Subduction Zone fault experienced a full rupture. A magnitude 9.1 earthquake and subsequent tsunami devastated the coasts of Oregon, Washington, and southern British Columbia. Willamette Valley cities such as Portland experienced four minutes of strong to very strong shaking. In Portland, the immediate effects of this were:

- More than 1,000 buildings collapsed or partially collapsed.
- 75% of the City's own buildings are now unusable and awaiting demolition.
- Approaches to all the Willamette River bridges were damaged; the Hawthorne Bridge collapsed into the Willamette.
- North Portland, downtown Portland up to about Third Ave, and the Linnton industrial area experienced liquefaction and permanent ground deformation.
- Linnton fuel tanks anchoring systems failed. They are not usable. The Olympic pipeline experienced numerous ruptures along its length.
- The sanitary sewer system was severely damaged.
- All three conduits from Bull Run were damaged, as was infrastructure in the Water Bureau's groundwater system, and the Willamette River pipelines.
- There were about 350 deaths, and thousands of injuries.
- Property damage is in the billions.

A month later, recovery is just beginning:

- Mobile phone service is working throughout most of the city, although data is slow.
- Power is back on in just a few areas.
- Water service has not been restored, but limited supply from Bull Run is expected in the City in a few weeks. It will take another 1 – 2 months for the water to cross the river. The water distribution system near the Willamette and Columbia Rivers, including Downtown and the Central Eastside, have received the most damage. It will be more than one year before water service is restored to all these areas. In the meantime, residents are relying on public distribution of bottled water.
- BES is directing storm flows directly to Johnson Creek and the Willamette and Columbia Rivers.
- Public distribution of essential commodities (water, food, tarps, basic first aid supplies) began about a week after the earthquake and has continued at public distribution centers. There are many national and international relief workers in the City.
- The Sellwood Bridge has re-opened
- Volunteers have cleared paths on residential streets, and there is a functional bike-ped network citywide.
- Portland Parks has expanded community garden to nearly every park; this work has become a focus for many seeking an outlet.
- About 60% of City workers have returned to work. City employees and resources that can support restoration of water and key transportation routes are focused there. Others are working in shelters and at commodity points of distribution, and assisting with damage assessment.

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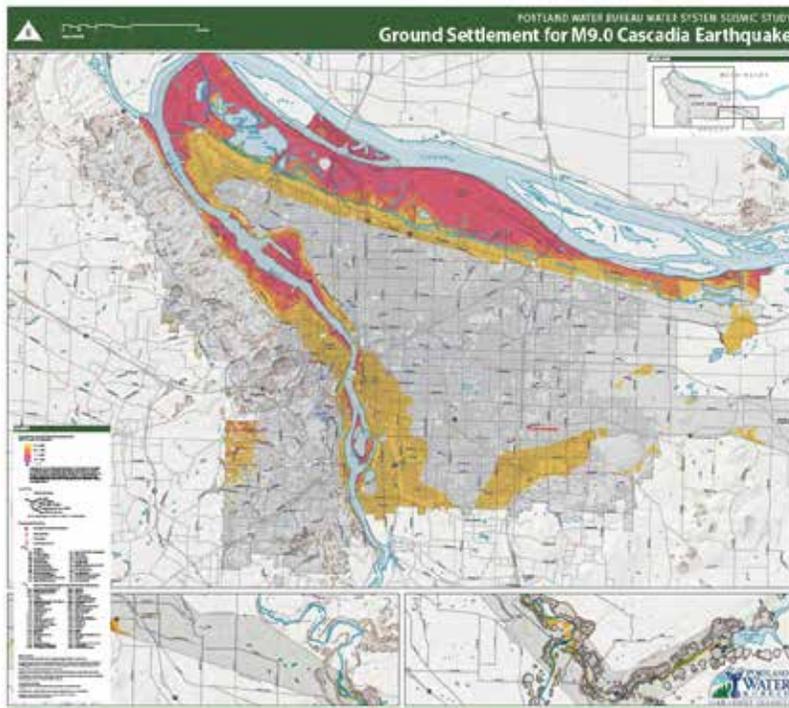
There are also significant challenges to recovery:

- The region is still experiencing aftershocks, which damage already vulnerable structures, and which many survivors find alarming.
- 10% of the population has left Portland. People who with significant medical needs have been evacuated, while other people left on their own.
- Nearly half the people who remain in the City are living outside because their houses have been damaged by the earthquake, and subsequent water and sewer damage.
- Skilled workers who can repair water and sewer systems are in short supply.
- Freeways are blocked by collapsed overpasses, other major roads are damaged, and travel through the City is slow and circuitous.
- Fuel is being delivered by truck from Eastern Oregon and is in short supply.
- Few stores have reopened.
- Schools have not re-opened.



## Plausibility of the Scenario

- Likelihood of rupture along this fault is 16-22% of a magnitude greater than 8.5 in the next 50 years.
- Damage Potential (From ORP) Heavy 5/6



**Potential  
Liquefaction  
Zones**

## In 4-5 minutes:

- More than 1,000 buildings collapsed
- Approaches to all the Willamette River bridges were damaged; the Hawthorne Bridge collapsed into the Willamette.
- North Portland, downtown Portland up to about Third Ave, and the Linnton industrial area experiencing liquefaction and permanent ground deformation. Buildings are sinking or toppled.



## Within a few hours it is also clear that...

- Sanitary sewer system is severely damaged.
- All 3 Bull Run conduits are damaged, as is the Water Bureau's groundwater system, and the Willamette River pipelines.
- Freeways are blocked by collapsed overpasses; other major roads are damaged or blocked by debris.
- Linnton fuel tanks have shorn pipeline connections and some are toppled; none are usable. The Olympic pipeline has experienced numerous ruptures.



## In a few days we learn that...

- There were about 350 deaths, and thousands of injuries.
- More than 50% of Portlanders are living outside because their houses have been so damaged they unsafe to inhabit.
- 75% of City-owned buildings were constructed before 1996; most of them are now unusable.
- Property damage citywide is in the billions.



## A month later



## We're meeting some basic needs

- Mobile phone service is mostly working.
- Power service is back in a few areas.
- Sellwood Bridge has re-opened, and Tillicum is open to pedestrians only.
- Relief agencies are active in the city, distributing commodities and supporting “shelter villages.”
- Storm flows are directed to Johnson Creek, the Willamette and Columbia Rivers.
- Water is available at a few points in the City from portable wellhead disinfection and flown in bottled water supplies.



## We're striving to do more

- Major humanitarian relief efforts are being supplied from outside the region.
- 60% of City employees have returned to work, and the City is hiring day laborers to support recovery efforts.
- Limited supply from Bull Run is expected in a few weeks on the east side; in 1-2 months water will be restored to the west side.
- Volunteers have cleared paths on residential streets, and there is a functional bike-ped network citywide.
- Portland Parks has expanded access to community garden programs. When water is available this work will become the focus for many.



## Challenges as next rainy season approaches:

- Aftershocks continue to damage vulnerable structures.
- There is a need for more skilled utility workers.
- Diesel and gasoline are expensive and in short supply.
- Few stores have re-opened.
- Schools have not re-opened.
- 10% of Portlanders have left, and many others are making plans to leave.



## Breakout Discussion – Bureau-Specific Approach

- *What damage/problems with your bureau's critical infrastructure do you anticipate, in addition to those already described?*
- *What communities or groups would you be most concerned about – who do you think would be in the worst situation or have the greatest needs?*
- *What are your bureau's most important short-term goals?*
- *What are your bureau's longer-term goals (a year or more)?*
- *What is the backbone infrastructure you would prioritize?*
- *Would you build everything back the same?*
- *What resources will you need from other bureaus to accomplish your short-term goals? Longer-term goals?*



*(Note-taking form #1)*



## Inter-Bureau Rotation and Info Gathering

- *Table leaders describe what is happening for their bureaus in this scenario and what they are doing to recover*
- *Rotating bureau staff learn about what others are doing to inform their own strategies*

*(Note-taking form #2)*



## Inter-Bureau Rotation and Info Gathering

- *Table leaders describe what is happening for their bureaus in this scenario and what they are doing to recover. Discuss the following:*
  - *1-2 things you would act on – surprises / interesting takeaways from your bureau's conversation*
  - *1-2 interesting points from conversations with other bureaus*
- *Rotating bureau staff learn about what others are doing to inform their own strategies. Discuss the following:*
  - *Efforts underway by the "presenting" bureau in short term recovery, as well as long-term recovery*
  - *Challenges the "presenting" bureau is facing and the questions they have of other bureaus*
  - *Opportunities for more effective recovery through collaboration*



*(Note-taking form #2)*



# APPENDIX B – OPENING AND CLOSING SURVEYS

## RESILIENT INFRASTRUCTURE PLANNING EXERCISE OPENING SURVEY

### INSTRUCTIONS

Please rate your level of agreement to the following statements on a scale or 1 to 5. Please provide an explanation or example when possible.

1 = "Strongly disagree," or the lowest, most negative impression

3 = "Neither agree nor disagree," or an adequate impression

5 = "Strongly agree," or the highest, most positive impression

Choose N/A if the statement does seem applicable to you or this workshop

- 
1. Rate the importance of cross-bureau collaboration when it comes to asset resilience planning and implementation in the city of Portland?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

2. Rate your level of knowledge about how other city bureaus determine the recovery priorities of their critical and/or backbone infrastructure assets?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

3. Rate your understanding of the vulnerability of your bureau's critical assets when it comes to extreme precipitation events that result in a 500-year flood and massive landslides?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

4. Rate your understanding of the interdependencies of your bureau's critical assets with the assets of other bureaus when it comes to planning for and recovering from extreme precipitation events that result in a 500-year flood and massive landslides?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

5. Rate your understanding of the vulnerability of your bureau’s critical assets when it comes to a 9.0 magnitude earthquake?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

6. Rate your understanding of the interdependencies of your bureau’s critical assets with the assets of other bureaus when it comes to planning for and recovering from a 9.0 magnitude earthquake?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

7. Rate your level of consideration of potential disproportionate impacts of a disaster on communities of color and low-income populations when it comes to planning and implementing asset resilience and recovery planning and implementation?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

8. Rate your ability to identify actions that other bureaus can take to support the resilience of your bureau’s infrastructure assets.

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

9. Rate your ability to identify areas for joint-bureau collaboration to increase city asset resilience and recovery.

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

---

## RESILIENT INFRASTRUCTURE PLANNING EXERCISE CLOSING SURVEY / WORKSHOP EVALUATION

### INSTRUCTIONS

Please rate your level of agreement to the following statements on a scale or 1 to 5. Please provide an explanation or example when possible.

1 = "Strongly disagree," or the lowest, most negative impression

3 = "Neither agree nor disagree," or an adequate impression

5 = "Strongly agree," or the highest, most positive impression

Choose N/A if the statement does seem applicable to you or this workshop

Name: \_\_\_\_\_ Bureau: \_\_\_\_\_

1. Rate the importance of cross-bureau collaboration when it comes to asset resilience planning and implementation in the city of Portland?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

2. Rate your level of knowledge about how other city bureaus determine the recovery priorities of their critical and/or backbone infrastructure assets?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

3. Rate your understanding of the vulnerability of your bureau's critical assets when it comes to extreme precipitation events that result in a 500-year flood and massive landslides?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

- 
4. Rate your understanding of the interdependencies of your bureau's critical assets with the assets of other bureaus when it comes to planning for and recovering from extreme precipitation events that result in a 500-year flood and massive landslides?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

5. Rate your understanding of the vulnerability of your bureau's critical assets when it comes to a 9.0 magnitude earthquake?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

6. Rate your understanding of the interdependencies of your bureau's critical assets with the assets of other bureaus when it comes to planning for and recovering from a 9.0 magnitude earthquake?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

7. Rate your level of consideration of potential disproportionate impacts of a disaster on communities of color and low-income populations when it comes to planning and implementing asset resilience and recovery planning and implementation?

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

8. Rate your ability to identify actions that other bureaus can take to support the resilience of your bureau's infrastructure assets.

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

9. Rate your ability to identify areas for joint-bureau collaboration to increase city asset resilience and recovery.

1                      2                      3                      4                      5                      N/A

*Explanation or example?*

10. Rate your agreement with the following statement: The workshop was a good use of my time.

1                      2                      3                      4                      5                      N/A

*Explanation*

11. Please tell us what direction you would like RIPE to take in the coming months. What do you see as next steps to keep the momentum going?

12. What section (s) of the workshop did you attend and which were most valuable? (Check the box for the workshops attended and rate the value of the modules from 1 to X, with 1 being most valuable)

Attended      Value

- |                          |     |  |
|--------------------------|-----|--|
| <input type="checkbox"/> | ___ | Day 1, Module 1 – Understanding assets and interdependencies       |
| <input type="checkbox"/> | ___ | Day 1, Module 2 – Recovering from a major flood and landslides     |
| <input type="checkbox"/> | ___ | Day 2, Module 3 – Recovering from a major earthquake               |
| <input type="checkbox"/> | ___ | Day 2, Module 4 – Next steps to building a more resilient Portland |

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13. What was the most valuable take-away from this workshop?

14. Where are there opportunities for improvement in the organization and delivery of the workshop

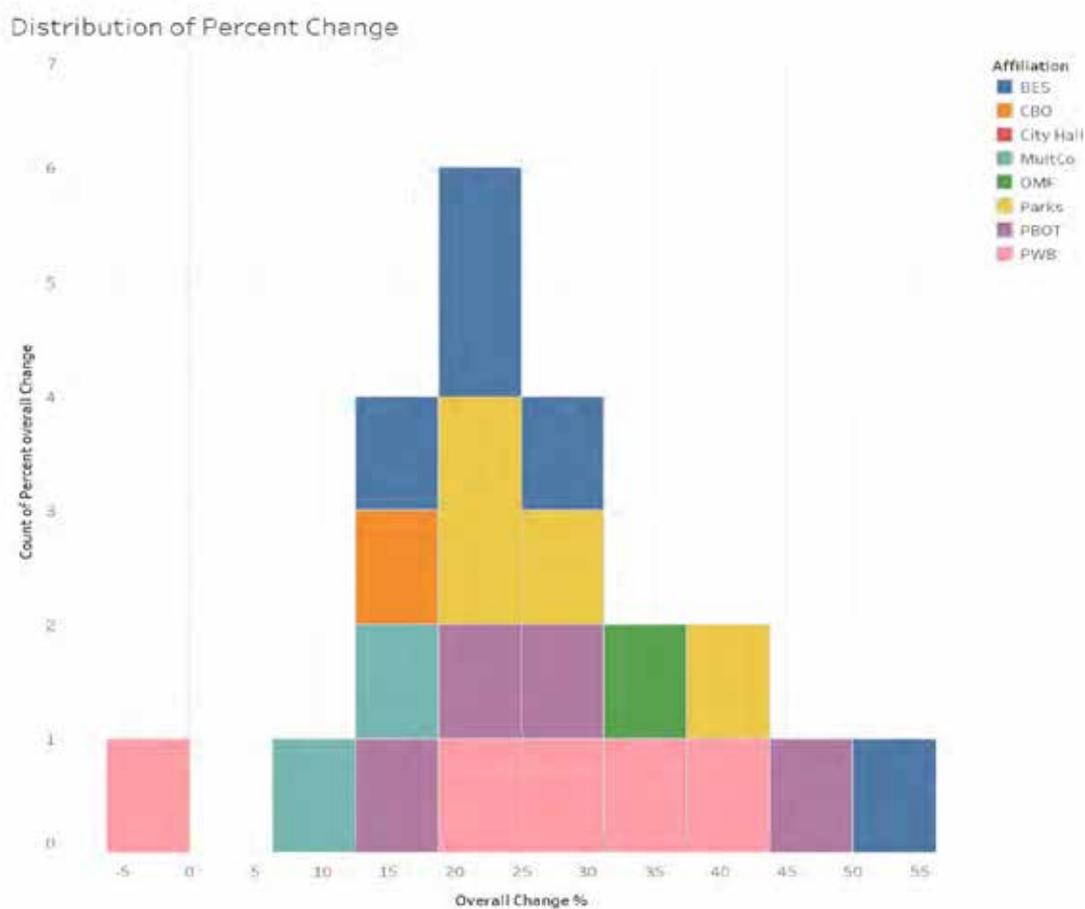
## APPENDIX C – SURVEY RESULTS

### RIPE Workshop Survey Results

Liliana Caughman & Noel Plemmons, Portland State University, Institute for Sustainable Solutions

#### *Quantitative Analysis*

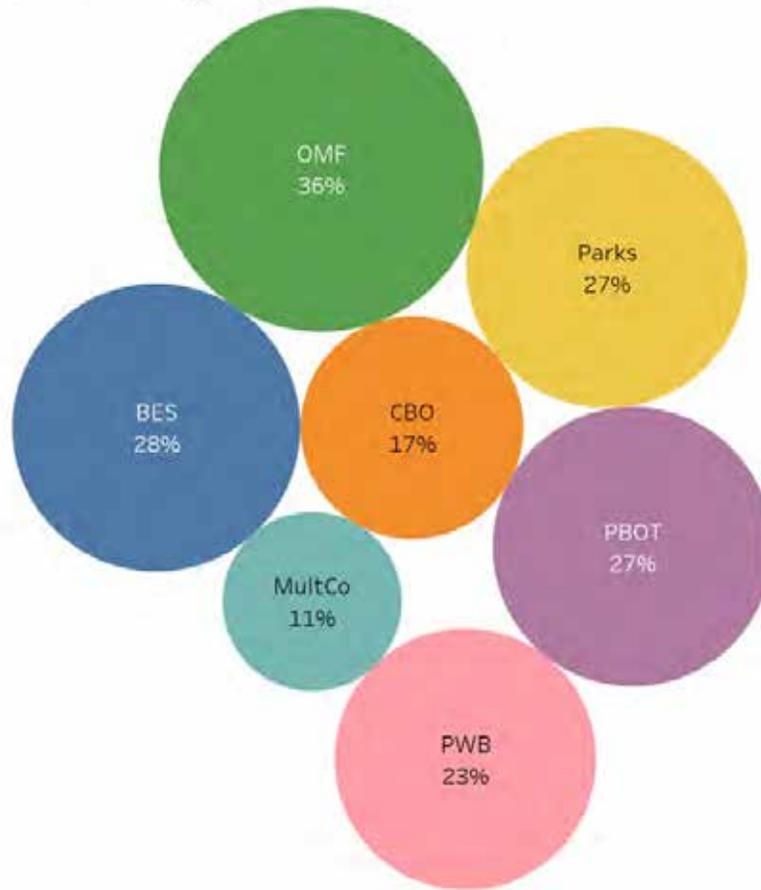
Workshop participants were asked to fill out both an opening and closing survey to help gauge value added to and to provide feedback for the workshop facilitators. The results shown in each of the following charts represents the attitude and knowledge changes participants self-reported after attending the RIPE workshops. Only participants who filled out both a before and after survey have been included in this report.



This histogram shows a distribution of the overall percent change experienced by participants, colored by affiliation. You can see that all but one participant scored higher across all survey responses after the workshops. Most participants experienced over a positive shift of over 20%.

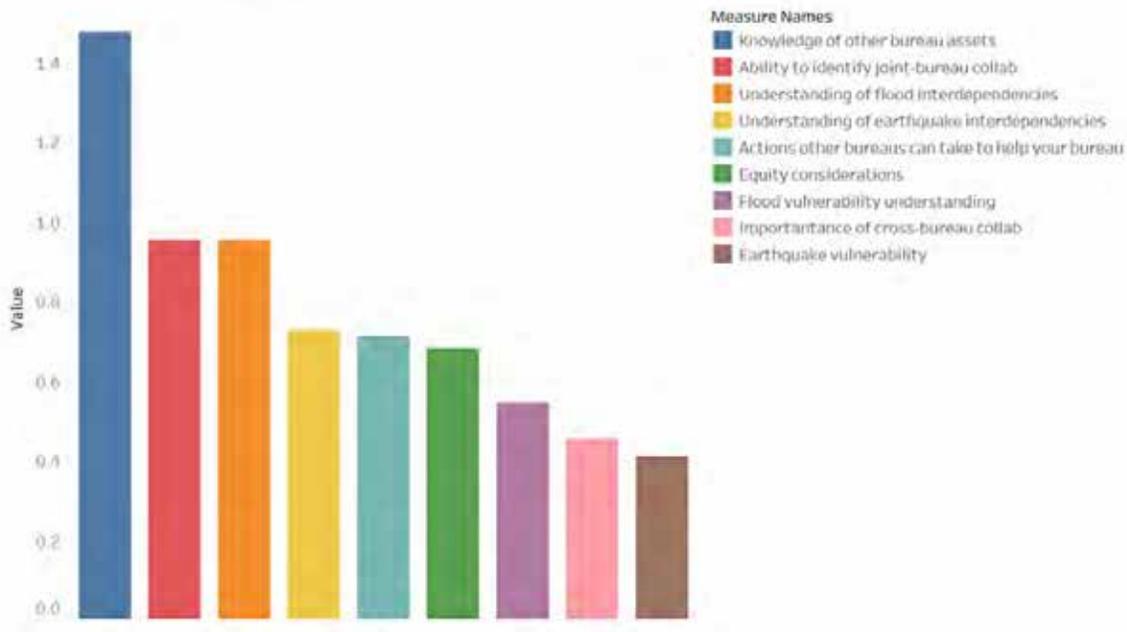
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## Percent Change by Group



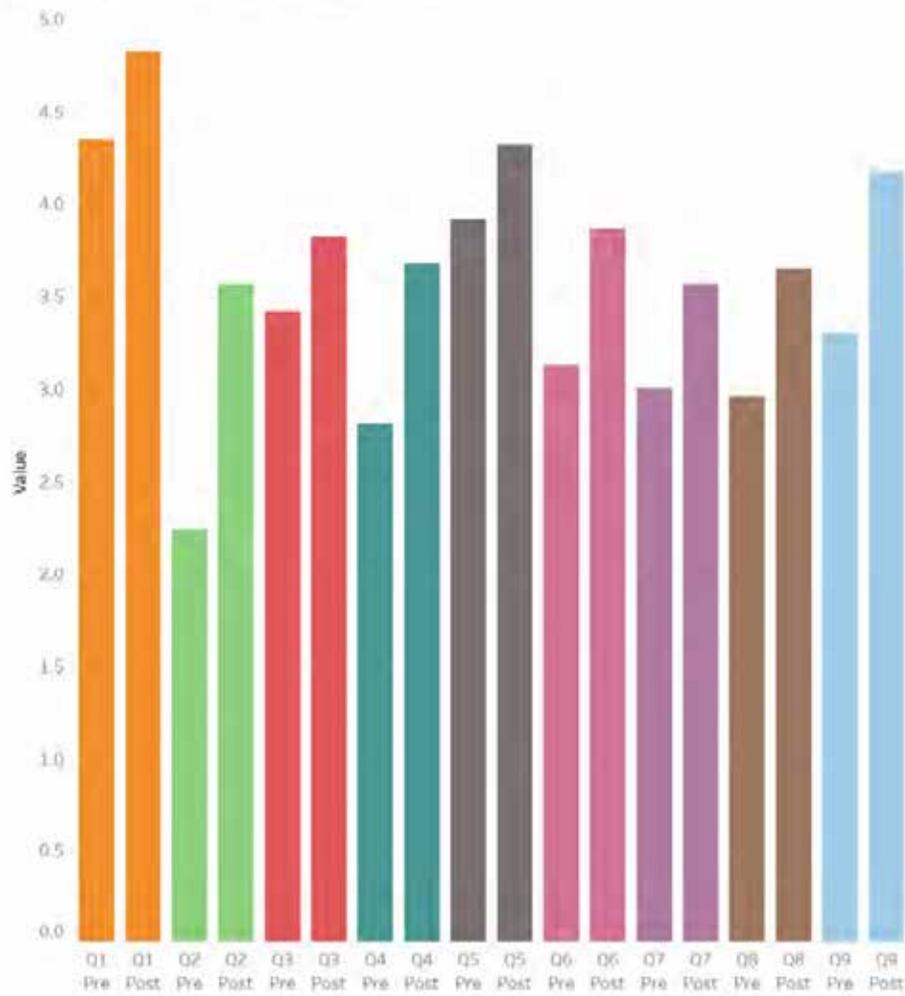
Looking at the percent change results broken down by bureau/affiliation shows that cumulatively all groups experienced a positive attitude shift overall.

Avg Change per Question



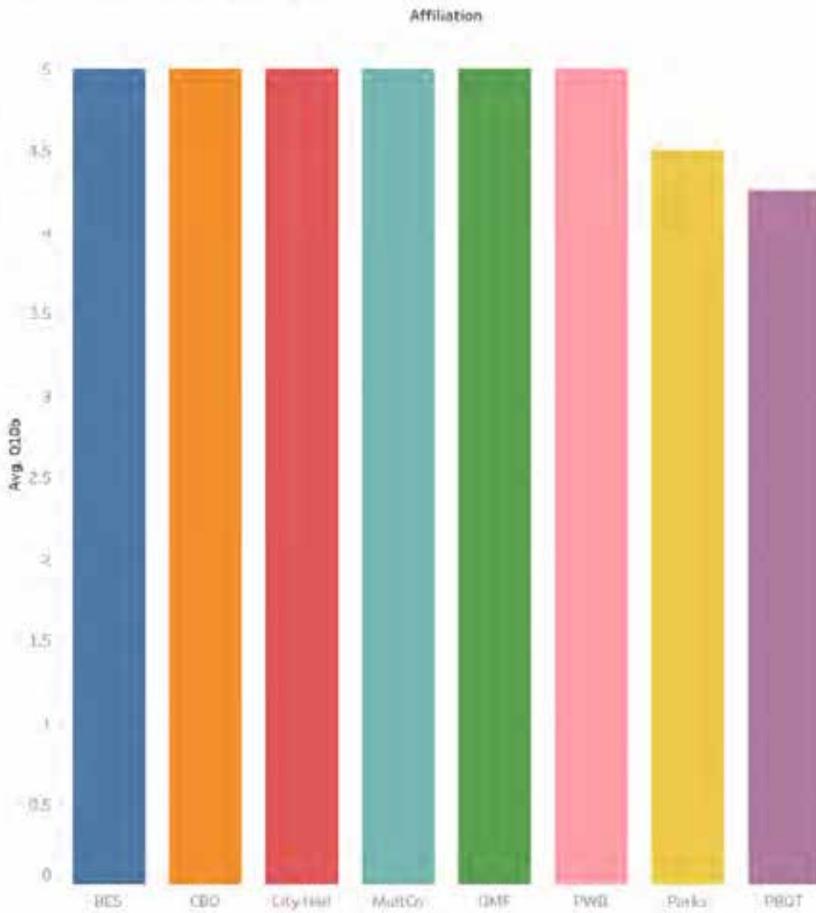
This chart shows the average change in response to each individual survey question. There were positive gains in the average score for every question on the survey. “Knowledge of other bureau assets” experienced the largest increase, with participants rating their understanding 1.4 points higher, on average. Knowledge also experienced higher increases in “identifying joint-bureau collaboration” and understanding interdependencies for both floods and earthquakes. The questions that experienced less positive change had high positive results to begin with, leaving little room for positive growth.

Pre and Post Change by Questions



This chart shows the average results for each question before the workshops (pre) and after the workshops (post). Again, we can see improvements for every question asked.

### Workshop Good Use of Time



Finally, an additional question was added to the follow-up survey which asked participants if the workshops were a good use of their time. As you can see, nearly everyone either agreed or strongly agreed with this statement.

#### *Summarization of Qualitative Data*

The importance of bureau-to-bureau collaboration was considered high in both the opening and closing surveys. Interdependencies are recognized but are not being addressed if bureaus are not communicating priorities, collaborating, pooling resources, and coordinating efforts.