INTRODUCTION

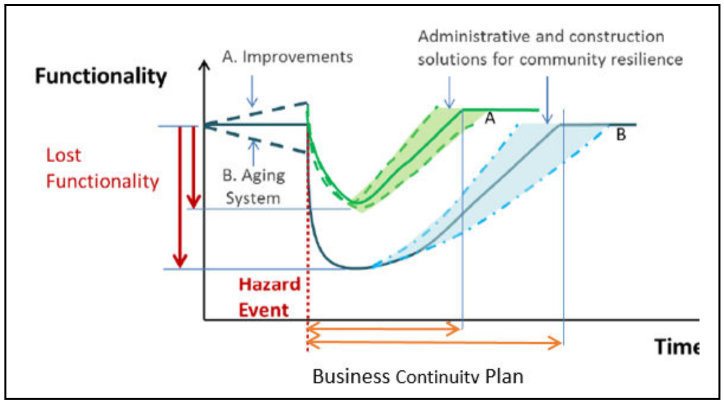

Figure 1: Resiliency Curve in Continuity of Operations [Modified from NIST (2015)]

Every community across the United States faces hazardous events, including natural, technological, and human-caused. To minimize the disruptions they cause to essential services provided by the built environment, many communities have started to develop plans to improve the resilience of their buildings and infrastructure systems. This is an important first step forward in disaster preparedness. For each infrastructure system to effectively respond to and rapidly recover from disruptions, measures must be taken to protect business operations from financial, managerial, and functional perspectives, and to develop organizational resiliency. Some organizations, utilities and businesses are exploring business continuity as a basis for responding to and recovering from catastrophic events (see Figure 1).

There are, however many regional and national water utilities, as well as other types of infrastructures, that have either not developed, or have only partially formed, business continuity plans. Key learnings from other disasters demonstrate that restoring services such as water promptly is critical to the survival of the economy, and to allowing residents to live their lives normally. Some locations hit by disaster (like New Orleans after Hurricane Katrina) became "ghost towns" without restoration of basic services, because residents were forced to leave with no jobs, housing or infrastructure. The post Katrina population of New Orleans fell by more than 50%. Ten years later, the population had recovered to 80% of pre Katrina levels. Economic survival of the Portland Metro area and the State economy will depend upon pre disaster planning and timely post disaster restoration.

Portland Water Bureau (PWB or the bureau) management has been expanding resiliency planning to mitigate, prepare for, respond to and recover from catastrophic events. As part of that forward thinking approach, the authors, including members of the American Society of Civil Engineer's (ASCE's) Infrastructure Resilience Division (IRD), decided to compare the bureau's existing Continuity of Operations Plan (COOP) with the ASCE/IRD Business Continuity Plan (BCP) template. PWB is conducting a case study to examine the bureau's existing COOP in comparison to the features of the BCP template, in order to identify all critical resiliency considerations to enhance COOP planning efforts. PWB's goal with this effort is to demonstrate the business need and criticality of this level of continuity planning, in order to build resilient organizations.

A comparison of the BCP template to PWB's COOP plan was done to determine whether BCPs are different in scope or how they vary from COOPs, what their mission and guiding rules are, and whether our existing COOP is adequate for continuity planning. A draft BCP specifically for this case study was developed, however, because COOPs are required by the Federal Emergency Management Agency (FEMA) for government agencies, all study findings will be merged into the existing PWB COOP.

Before proceeding with the comparison, background information on the bureau's water system is provided. Following that is a discussion of the risks and hazards the bureau plans for. Next is the PWB COOP, the BCP, the initial findings of the case study, the benefits of and barriers to conducting the case study, and subsequent lessons learned. Lastly are the next steps planned, and a conclusion.

PWB BACKGROUND

The Portland Water Bureau[1] is the largest water supplier in the State of Oregon, serving approximately 960,000 customers and providing water service to 19 wholesale customers in the Portland Metropolitan area. In addition to serving nearly 25% of the state, a significant percentage of the entire state's economy is produced within the Portland Metropolitan area so providing consistent, reliable, high quality drinking water is paramount for the livability of the city, the region and the state.

PWB provides high quality water, excellent customer service and stewardship of the critical infrastructure, fiscal, and natural resources entrusted to our care. PWB is a recognized leader among water service agencies across the country.

The bureau has delivered drinking water from the forest to customers' faucets since 1895. The water comes primarily from the Bull Run Watershed[2], an unfiltered surface water supply from rainfall that generates a highly reliable source for the region with two dams and reservoirs and a capacity of more than 200 million gallons per day. This supply is fed 26 miles by gravity to Portland by three large diameter conduit pipes from the Bull Run Headworks to in-town storage tanks and reservoirs. The water distribution system consists of 100 miles of large diameter pipes, and 2,200 miles of smaller diameter pipes. The bureau is also fortunate to have a high quality secondary water source with the Columbia South Shore Well Field[3] along the south side of the Columbia River. This second source augments supply during summer months, allows the bureau to manage turbidity issues in the Bull Run Watershed, and can meet the current winter average daily demand of the City on its own when necessary.

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[1] Portland Water Bureau Webpage https://www.portlandoregon.gov/water/26426
[2] Bull Run Watershed Webpage https://www.portlandoregon.gov/water/29784
[3] Columbia South Shore Well Field Webpage https://www.portlandoregon.gov/water/29785

The bureau has over $8 billion in system assets, a proposed annual budget of $212 million and a projected five-year Capital Improvement Program budget of approximately $392 million. Figure 2 below summarizes the main assets in the water system in addition to the two sources.

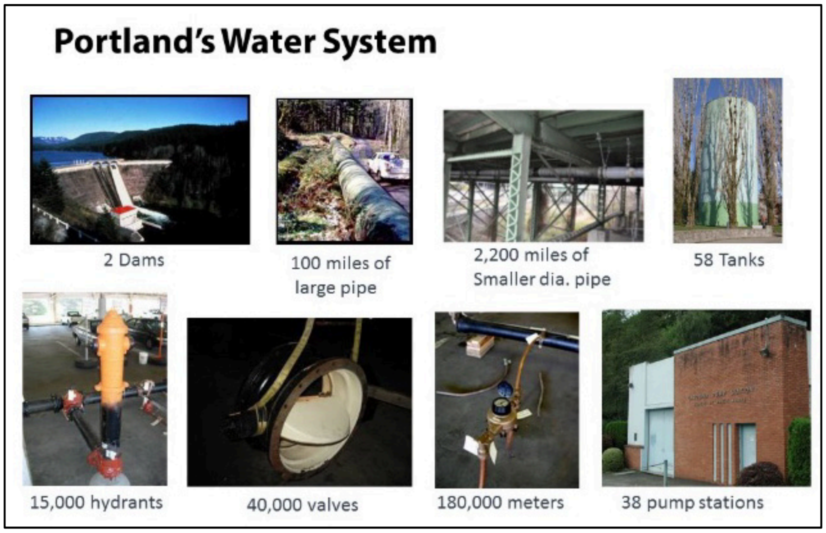

Figure 2. PWB's Water System

The bureau is recognized as a national leader in pioneering its model of asset management in the water utility industry. This method of prioritizing key maintenance, replacement, and construction needs helps maximize the impact of limited resources against the significant maintenance needs of a large water system that is over 100 years old. The bureau has a comprehensive proactive program focused on protecting the natural environment that provides the region's water, as well as mitigating the downstream impacts on fish habitat. In addition, the PWB Emergency Management Program, with 85 trained responders, 6 Damage Assessment Teams, an Emergency Operations Center and a host of emergency equipment at the ready, ensures effective response to emergencies of all types.

HAZARDS AND RISKS TO PWB WATER SYSTEM

The City of Portland recognizes there are a number of natural and man-made hazards, such as volcanoes and earthquakes, storm events and forest fires that could affect the water system and resiliency of the bureau and the city. In general, hazards and risks to the City of Portland include:

Bridges, Rivers and Non-Engineered Fills – The City of Portland is bounded on the north by the Columbia River, and divided east and west by the Willamette River. In addition, there are numerous gullies, lakes, ravines, and streams that were filled in over the last two hundred years with a variety of non-engineered materials to create more buildable land mass. Known as "Bridge City," Portland's waterways are spanned by a number of bridges, both old and new with varying levels of seismic performance. All of these factors create vulnerability from flooding, ice or storm events, or earthquakes, which could cut off sections of the city from others due to bridge failure or soil liquefaction, essentially creating isolated "islands," and causing difficulty for emergency response in these areas.

Weather – Wind/Rain/Ice/Snow – Being located next to the Columbia River Gorge, which serves to accelerate wind speeds, situated 60 miles east of the Oregon Coast, and surrounded by mountains and elevated foothills, Portland gets a variety of weather conditions ranging from heavy rain storms, strong sustained winds, to snow and ice accumulation. These weather conditions also cause frequent power outages and turbidity events in PWB's unfiltered primary supply.

Flood – Portland does not see many flooding events that impact the water system, but when they occur they are significant and widespread. These include the floods of 1964, 1996, 2007, and 2017. Failure of dams, such as could occur in a major earthquake, would cause catastrophic flooding in low lying areas. Flood events on the Columbia River and subsequent levee damage or breach could impact PWB's secondary supply.

Landslides – Weather conditions, terrain, and ground conditions can cause landslides that impact the water system. Heavy winter and spring rains saturate the ground and contribute to landslides that can damage roads, bridges and other infrastructure. Landslides can also cause turbidity and debris in reservoirs, affecting water quality. A series of winter storms in 1995-96 caused a landslide in the watershed that broke two of the three conduits to the city.

Forest Fire / Turbidity – Water Source Risk – The Bull Run Watershed is a restricted use area approximately 26 miles east of Portland surrounded by the Mt. Hood National Forest and some privately owned forested properties. Forest fires, regardless of the cause, can result in denuding the ground, triggering prolonged turbidity events in PWB's primary supply inside the watershed. This could make the primary water source unusable for months or even years without filtration until the turbidity can be flushed out.

Pandemic – Portland is a business hub with an international airport, conference facilities and hotels, along with shipping port, mass transit and heavy rail lines that move passengers and freight from all over the world. In the past few decades there have been medical scares carried by passengers across the globe – SARS, Ebola, Avian Flu, etc., that have raised concern and awareness of how Portland would respond to and recover from a pandemic event.

Terrorism – Portland is a large city with frequent visitors, making it as susceptible to acts of terrorism as other large metropolitan cities.

Biohazard / Hazardous Materials – With extensive rail lines and major trucking routes, there is the potential for spills of chemicals and other hazardous materials due to auto accidents or train derailments, along with fuel pipeline ruptures.

Earthquakes – Earthquakes are a significant risk to the City of Portland. Earthquake risk information provided by the Oregon Department of Geology and Mineral

Industries (DOGAMI)[4] for the Pacific Northwest region indicates an elevated risk of a catastrophic earthquake. Recent studies indicate there is a 15 to 20% chance of a catastrophic earthquake occurring in the next 50 years; southern Oregon's odds are 40%. This earthquake would result from a full breach of the Cascadia Subduction Zone[5] (CSZ) fault that runs along the North American coast line from northern California near Mendocino to Vancouver, British Columbia, Canada. The projected estimate is a M_W 9.0 magnitude earthquake lasting up to five minutes, followed by hundreds of aftershocks, each of sufficient strength to be classified as significant earthquakes, and a widespread coastal tsunami. Also, the existence of three local crustal faults in the Portland area pose the risk of generating M_W 6.5 earthquakes.

Existing Foundational Plans

Oregon Resilience Plan – The Oregon Resilience Plan[6] (ORP) provides earthquake risk guidance for government entities at the state, county, city, and bureau levels, and for utilities and businesses to reduce risks and improve recovery from major seismic events. ORP includes information on the likely impacts of a magnitude M_W 9.0 earthquake, the acceptable time to restore services following the earthquake, and the necessary changes to practice and policies, that, if implemented during the next 50 years, will allow Oregon to reach the ORP's specific desired resilience targets.

ORP also recommends that all "water and wastewater agencies complete a seismic risk assessment and mitigation plan as part of periodic updates to facility plans." One of the goals for the water service providers in the Willamette Valley/I-5 Corridor is to restore their backbone systems to be functioning within 48 hours after the earthquake and 80% to 90% of the system operational within one month. These changes are to be implemented by the end of 50 years and will require considerable capital investment to accomplish. Currently, statewide the water recovery time is estimated to be at the one to three years range, or longer, depending on location and severity.

The largest risk in the Pacific Northwest Region is a Cascadia Subduction Zone Earthquake. While many locally debate which hazard constitutes the highest risk, the authors contend that if PWB is prepared for a CSZ type event, it will be prepared for almost anything.

City of Portland Natural Hazard Mitigation Plan – A 2010 and 2016 updated Natural Hazard Mitigation Plan (NHMP)[7] for the City of Portland identified 67 unique PWB action items requiring short to long-term solutions to improve resiliency. Feedback from the community was solicited and the list was prioritized for short or long-term incorporation in to PWB project plans. These efforts will enhance continuity and resilience. Some recommendations from the NHMP are listed in Table 1.

[4] DOGAMI webpage: http://www.oregongeology.org/sub/earthquakes/earthquakehome.htm
[5] Cascadia Subduction Zone, Oregon Emergency Management, Hazards and Preparedness: http://www.oregon.gov/oem/hazardsprep/Pages/Cascadia-Subduction-Zone.aspx
[6] Oregon Resilience Plan http://www.oregon.gov/OEM/emresources/Plans_Assessments/Pages/Other-Plans.aspx
[7] Portland Natural Hazard Mitigation Plan (Map) https://www.portlandoregon.gov/pbem/67578

Table 1. Natural Hazards – NHMP Sample Action Items:

	NHMP 2016 – Action Items	Lead
1	Continue to assess the vulnerability of the water system to seismic events and work toward hardening the backbone system	PWB
2	Install remote operating valves to isolate existing river crossings	PWB
3	Install isolation valves where distribution system is tied in to backbone	PWB
4	Provide seismic upgrades to water pump stations	PWB
5	Continue to monitor dam safety at Mt. Tabor and Washington Park reservoirs.	PWB
6	Provide seismic upgrades to water storage tanks	PWB

Portland Water Bureau Seismic Study – A key recommendation from the ORP is for each entity to evaluate its own seismic risks and resiliency needs in order to meet the targeted goals of recovery set forth in the ORP. From 2014 to 2017, PWB conducted a seismic study to evaluate the water system, the seismic hazards from a CSZ event, and research what was required to reach resiliency goals within the next 50 years. The resulting PWB Water System Seismic Study (WSSS), to be published later in 2017, provides additional resilience planning guidance and direction for the bureau. The WSSS contains a series of earthquake hazard maps – for liquefaction, strong ground movement, lateral spread and earthquake induced landslides. The maps are overlaid with the water system in a Geographic Information System (GIS). The study describes the current state of the water system and identifies the critical infrastructure (or backbone) needed to be operational within 48-hours. It details the types of projects needed to prepare the bureau for a CSZ earthquake.

PWB CONTINUITY OF OPERATIONS

In 2013, all federal government agencies were directed by FEMA to develop COOPs, in order to ensure that primary mission essential program functions would continue to be performed during a wide range of emergencies. FEMA created a basic COOP template for use by all federal agencies. The planning mandate was implemented by state and local jurisdictions shortly thereafter, and states, counties and cities tailored the template for their use. The Oregon State Office of Emergency Management (OEM) required the local jurisdictions to develop COOPs, and the U.S. Environmental Protection Agency (EPA) encouraged water and wastewater agencies to develop COOPs based on both EPA and FEMA guidelines.

In 2013, City of Portland bureaus began developing their initial COOPs. The Bureau of Emergency Management (PBEM) coordinates COOP Planning with each City bureau. All bureaus have developed COOP plans, and these bureau COOPs were used to prepare a comprehensive City-wide COOP.

The initial PWB COOP was developed over the course of several months with input from PWB staff, using the basic FEMA template and considering three scenario events – single building/single bureau event; pandemic influenza potentially affecting multiple bureaus; and a catastrophic event affecting the entire city and surrounding region. Because PWB has numerous risks that could disrupt the operations of the bureau and impact the region, the bureau prepared the COOP using a multi-hazard approach for a catastrophic event. The plan is scalable depending on the magnitude of the event. The COOP includes core capabilities such as essential functions, alerts and notifications, delegations of authority, succession planning, and other standard COOP elements. The instructions and supporting information in the COOP are comprehensive and sufficient to respond to many types of disasters.

BUSINESS CONTINUITY PLAN

The ASCE/IRD Disaster Response and Recovery Committee recommends using a Business Continuity Plan template for infrastructures to plan their recovery from catastrophic events. The BCP template was jointly developed by the Water Research Foundation (WRF), American Water Works Association (AWWA), and the EPA. This joint WRF Project #4319 was funded by WRF, EPA and AWWA. The template contains many of the elements that COOPs do, including essential functions, critical resources, vital records, and teams. The BCP template was originally developed for use by water utilities and is customizable to fit the individual organization's needs. The PWB case study considers and evaluates this ASCE/IRD recommendation.

DEVELOPMENT OF A DRAFT BCP

As part of this case study, PWB developed a draft BCP. Guidelines PWB followed in developing the BCP, which were also used in developing the existing PWB COOP, were: water system restoration – backbone and prioritized pressure mapping, critical restoration and water delivery. Catastrophic consequences from a CSZ M_W 9.0 earthquake are assumed. From comparing the BCP template to the PWB COOP, several important conclusions were drawn, which are shared in the initial findings.

INITIAL CASE STUDY FINDINGS

Comparison of both plans revealed many similarities: In order to compare the BCP template to the COOP plan, data was directly transferred from the COOP to the BCP template, making notes about each category. As information transfer progressed multiple similarities between the plans were observed. A comparison spreadsheet was developed to document those similarities and to identify and resolve the differences between them. Table 2 represents this initial evaluation.

Table 2. Comparison of PWB COOP and BCP

Major Sections	PWB COOP '14	BCP Template	Gap - Opportunity to include in future updates
Introduction - Plan Approval, Record of Changes, Distribution & Instructions	Y	Y	Both BCP and COOP templates have standard introduction sections, information/description.
Purpose, Scope, Situations & Assumptions, Threats & Risks	3 scenarios - minor to catastrophic (CSZ)	4 scenarios - minor to catastrophic	COOP template goes into more detail about purpose, scope of the plan, situation overview, planning assumptions, objectives, security and privacy. Both scalable, flexible depending on event.

Legend: Y - included; N - not included

Table 2. Comparison of PWB COOP and BCP – *Continued*

Major Sections	PWB COOP '14	BCP Template	Gap - Opportunity to include in future updates
Concept of Operations - Triggers, Activations, Actions, Continuity, Devolution, Reconstitution, Readiness, Preparedness	Y	Y	Both contain ConOps, standard activation, continuity, readiness. Preparedness needs to be developed. Additional authority for managers to activate COOP.
Mission Essential Functions	Y	Y	Included in both; expand on interdependencies; look outside region.
Facilities	Y	Y	BCP should tie to essential functions; identify functions that can be performed in alt locations; security needs, access.
Critical Resources	Y	Y	Info is in essential functions, but type and quantity of what we need/use as critical could use more detail; BCP template goes into more detail.
Personnel	Y	N	COOP essential only listed; add staff contacts to appendix.
Vital Records and Data (Including Electronic Records and Databases)	Y	Y	Both need more detail - Identify where files/records are located, which web portals or programs are used, who has access, technology vulnerabilities.
Team, Responsibilities, Organization	Y	Y	Use titles not names; More detail on what each team will do - These are separate from essential functions, the "COOP Team" roles; COOP has more than BCP.
Lines of Succession; Delegation of Authority	Y	Y	OK in both. Lists title and bureau role; needs more detail in lower functions; Provide more information on what each role would be responsible for in disaster.
Communications	Y	Y	BCP needs Alerts & Notifications section. Need to provide clear reporting instructions, essential personnel rules - for disasters, and for COOP events; call down list; reporting alternatives.
Test, Training & Exercises	N	Y	Existing COOP does not expand on training program; need to provide examples and timelines. BCP does.
Plan Maintenance	Y	Y	Not specific in update timing; could provide steps, distribution, who published to - section could be expanded. Both need calendar.
Appendices	Y	Y	Both should list of types of reference categories; Appendices present in both.

Legend: Y - included; N - not included

Benefits – The benefits of conducting the case study were: (1) identifying missing elements by comparing BCP to COOP provided planning opportunities that might have otherwise been overlooked; (2) there are gaps in both plans, identifying and resolving them contribute to enhanced resiliency in existing COOP; (3) researching the elements of a BCP allowed PWB to understand the challenges other agencies face when creating their own plans; and (4) continual COOP updates, while making comparison difficult, assure COOP readiness.

Barriers – Barriers to completing the case study were: (1) BCP and COOP were similar enough that there is no need have both; (2) government agencies are required to maintain COOPs, therefore a BCP does not meet FEMA guidelines for PWB; (3) limited personnel and resources; (3) lack of succinct information comparing a BCP to a COOP made research difficult; (4) a long term case study would have required significant time investment for research and analysis; and (5) existing COOP work must take priority over the case study to continue to meet City and FEMA requirements.

Lessons Learned

- Comparison of BCPs to COOPs revealed that the primary elements of BCPs are virtually identical to COOPs except for mission (BCP primary guidelines reference service disruptions followed by service restoration indicating a potential gap in service, whereas COOPs reference continuation of services without disruption); the difference in missions creates variance in continuity planning;
- Current methodology demonstrates that while the focus or mission of businesses may be different from government agencies, the overall goal of BCPs and COOPs are the same – restoration of primary business functions and services;
- BCP and COOP guidance comes from the same source – Investigation into the source guidance documents of the BCP and COOP found that the primary guidance originally came from FEMA. The BCP template came first from FEMA, was adopted by the EPA, and utilized by AWWA. The COOP template also came first from FEMA, was adopted by the State, Counties, and was then shared by the City of Portland's Emergency Management office, PBEM; it is possible that in the future these types of plans will be merged, and there will be only one continuity model to follow. Figure 3, created by PWB for illustration, includes the FEMA Continuity of Operations logo, and illustrates the source and path of BCP and COOP;

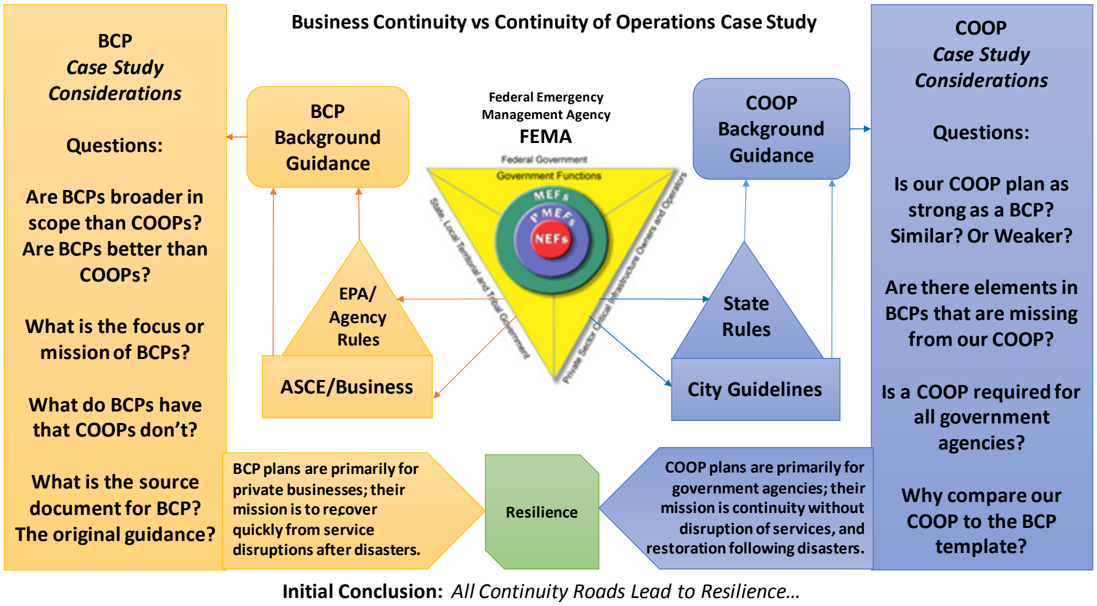

Figure 3: PWB discovered that the source of BCP and COOP guidance is FEMA

- Current FEMA Continuity Guidance recommends COOPs for both private and public elements and uses BCP and COOP interchangeably. Therefore, utilities should develop continuity plans of some kind, but they should choose the type – BCP or COOP – that is appropriate for their business requirements.
- PWB must maintain a COOP plan, however incorporating comparison findings from the case study will be advantageous.
- During the case study, numerous items were identified that are new resiliency recommendations and were neither part of the BCP or COOP; these new measures will be explored and reviewed for addition to the existing COOP.

NEXT STEPS

Report on Findings – A case study report will be presented at the September, 2017 ASCE Congress on Technical Advancement and will include the benefits of and barriers to conducting the case study, along with key findings.

Finalize the Case Study – When all elements of both the BCP and COOP plans have been explored, compared and documented, and items are identified for inclusion in the COOP, final recommendations for actions will be developed.

Integrate BCP Findings in to PWB COOP – Incorporate case study findings by merging all items to be included into the existing COOP.

CONCLUSION

In conducting the initial research and comparison for the case study, the authors recognized that COOPs are required of government agencies. Maintaining a separate BCP would not be ideal. Therefore, case study results will serve to improve PWB's existing COOP. There are benefits to both types of continuity planning – COOP or BCP – but it must be stressed that having a continuity plan is of utmost importance