Hazard Profile: Water and Wastewater Infrastructure Interdependencies

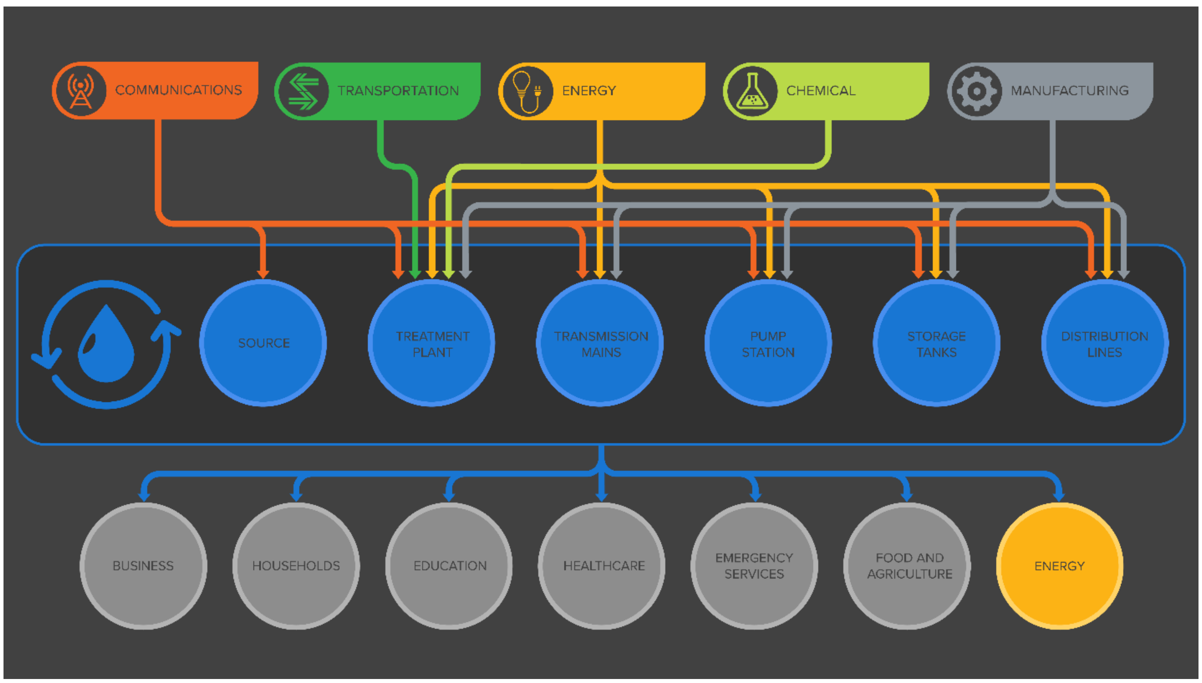
The availability of reliable water and wastewater service is vital for the functioning of a normal society. Fifty-six utilities that make up our regional water and wastewater infrastructure sector provide water and wastewater services to residents in the GRADD region. These utilities treat and distribute drinking water and collect, transmit, and treat sewage to provide for the wellbeing of the public and facilitate commerce and day to day life. Using the Infrastructure Resiliency Planning Framework (IRPF), a resource created by the Cybersecurity and Infrastructure Security Agency (CISA) in collaboration with GRADD and Kentucky Emergency Management (KYEM), GRADD planners conducted a risk assessment of the water and wastewater infrastructure sector in the seven county GRADD region. Using methodologies and resources from the IRPF, GRADD planners interviewed all 56 utilities responsible for the water infrastructure across the region to identify threats and develop local hazard mitigation strategies to address gaps and vulnerabilities for the water and wastewater infrastructure.

Planning Process

Sixteen critical infrastructure sectors exist whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof. Among the 16 critical infrastructure sectors, the communications, energy, transportation, and water and wastewater sectors stand out due to the dependencies that exist between each of these four core sectors and between them and the remaining 12 critical sectors. Throughout its history, GRADD has been an integral partner with the water and wastewater utilities throughout the region, therefore a targeted assessment and planning effort specific to the water and wastewater sector was selected as the focus of this planning effort which relies on the application of the IRPF methodologies and resources.

Source: CISA Infrastructure Dependency Primer

For the water and wastewater infrastructure sector to function, it must receive services from other sectors of critical infrastructure. Examples consist of electrical power to run treatment plants and pumps, fuel for backup generators in the case of power failure, chemicals required to treat source water and wastewater, communications systems necessary to efficiently operate, monitor and maintain system components, critical manufacturing to supply system components, and transportation systems for access, maintenance, and repair of treatment, distribution, and collection networks. Sectors that are dependent on drinking water and wastewater services to function consist of firefighting capabilities for emergency services, food processing plants and restaurants in the food and agriculture sector, healthcare, water for steam generators at power plants in support of the energy sector and more. The severity of a water emergency that deprives the public of reliable water and/or wastewater service can bring daily life to a standstill in a matter of hours, rendering schools, businesses, and critical facilities inoperable.



Source: CISA Infrastructure Dependency Primer

The Infrastructure Resiliency Planning Framework (IRPF) is a toolkit that provides hazard mitigation planners an overview of critical infrastructure, infrastructure interdependencies and resources to support the planning process focused on increasing infrastructure resiliency. GRADD, along with KYEM, was an integral partner in the development of the IRPF and worked continuously with CISA during its development by providing feedback from an end-user perspective. GRADD planners reviewed the IRPF methodology and resources and selected a planning process tailored to evaluating the regional water and wastewater infrastructure sector as part of this planning effort. The planning process consisted of the following:

1. Assessment of existing data pertinent to water and wastewater infrastructure.
2. Identification of data gaps and items of critical concern.
3. Development of an infrastructure resiliency survey to standardize data collection.
4. Advertisement of the planning process to water and wastewater utilities.
5. In person interviews with utilities to complete the infrastructure resiliency survey.

6. Analysis of data collected from water and wastewater utilities.
7. Community meetings to discuss threats and identify local hazard mitigation strategies.
8. Presentations to GRADD councils detailing the results of the planning effort.
9. Documenting vulnerabilities for water and wastewater infrastructure in the region.

The planning process to arrive at this risk assessment consisted of six months of data collection, stakeholder interviews, data analysis, and community engagement and required over 400 hours of work by GRADD planners. Below is a breakdown of each of the steps used during the planning process.

Assessment of Existing Data

Area Development Districts in the state of Kentucky have a close working relationship with utilities who provide water and wastewater service in the region thanks to the area Water Management Councils that maintain regional Water Management Plans mandated by Kentucky Revised Statue (KRS) 151 and 244A. The GRADD Water Management Council consists of representatives from water and wastewater utilities, elected officials, and representatives of local health departments who work in close partnership with GRADD infrastructure planners to develop and implement the Water Management Plan, to develop future water and wastewater projects, and to administer water and wastewater projects funded by state or federal funding programs.

The existing relationships between GRADD and the stakeholders responsible for managing the water and wastewater infrastructure sector were instrumental in the success of this planning effort. The IRPF contains resources to assist in the selection and education of stakeholders prior to launching an infrastructure resiliency planning effort; however, GRADD planners did not directly engage with those resources due to the existing working relationships with core stakeholders. In addition to the existing interpersonal relationships, technical data relating to water and wastewater assets and systems was readily available to GRADD planners via the Water Resource Info System (WRIS). The WRIS includes a geographic information system (GIS), information on water resources, drinking water systems, wastewater treatment systems, project development, emergency response, regulations, and planning. GRADD planners were able to reference information housed in WRIS to obtain a base level of understanding about the regional water & wastewater infrastructure systems. The existence of the GRADD Water Management Council and the WRIS system were crucial resources that aided in the successful implementation of this planning effort. Future infrastructure planning efforts should look to similar resources prior to launching a planning effort similar to the one completed for this risk assessment. If these resources were not preset, it is estimated the planning timeline would need to be expanded by four to six weeks if not longer in order to adequately recruit stakeholders and build a basic understanding of the infrastructure systems being evaluated as part of the infrastructure resilience planning effort.

Identification of Data Gaps and Items of Critical Concern

Challenges faced during the initial stages of this planning effort were the cross utilization of existing data for new purposes and presenting resiliency as a critical aspect in the day-to-day decision-making process for water and wastewater utilities. The intention of the WRIS system is to serve as a hub for water resource planning, which focuses on access, reliability, and efficiency. Utilizing this data for hazard mitigation planning was challenging at times; however, as the planning process progressed, opportunities to exploit and expand upon the existing data presented themselves.

Throughout this planning effort, GRADD planners repeatedly encountered stakeholders who confused the concept of resilience with reliability, and this confusion became one of the items of critical concern throughout the project. Reliability refers to the dependability and consistent service provided, whereas resiliency is the capacity to recover quickly from a setback. GRADD planners observed many of the infrastructure system operators confused the two terms due to the day to day demands of operating their respective systems. GRADD planners developed talking points utilizing methods and resources from the IRPF to educate stakeholders on the concept of resiliency throughout the planning process.

A second area of concern selected for intentional focus was the infrastructure dependency that exists between the water and wastewater and energy sectors. The 2009 Western Kentucky Ice Storm, as discussed elsewhere in the GRADD Hazard Mitigation Plan and later in this risk assessment, was a seminal movement for the region and exposed this interdependence with devastating results. Information about energy dependencies and existing assets to mitigate these dependencies was a large focus of the planning effort. As the planning process progressed, GRADD planners strived to get stakeholders to move away from a hyper focus on this area of concern and give equal attention to other gaps or vulnerabilities where resiliency could be increased for the regional water and wastewater systems supporting the region.

The final area of critical concern for the GRADD region specific to drinking water infrastructure was the existence and functionality of interconnects between neighboring water utilities. Interconnects are typically used on a day-to-day basis when a water utility does not operate its own water treatment plant and purchases water from a neighboring utility. These types of interconnects are commonly referred to as purchase points or permanent interconnects, and water utilities know the capabilities of these nodes within their system since they are factored into the reliability and efficiency of their system. In some cases, neighboring utilities have installed emergency interconnects at points where their system terminates near a neighboring system. The existence of these interconnects and their location are known; however, the functionality of these nodes is, for the most part, unknown. Emergency interconnects can remain closed for years or may never been utilized and are also unlikely to have been evaluated as part of a system's hydraulic modeling.

Development of Infrastructure Resiliency Survey

To best utilize the data collected during this planning process, a standard set of questions were used throughout the planning effort. This decision would provide GRADD planners with a structure to follow during the data collection process and ensure the data collected was of a similar type and could be easily analyzed. The IRPF provides a System Owner/Operator Dependency Interview Guide that served as a starting point for the development of a final question set that was utilized for this planning process. IRPF methodologies and resources were built upon to arrive at the final set of 35 interview questions that made up the GRADD Water and Wastewater Infrastructure Resiliency Survey. The survey questions used were:

1. What is the name of your system?
2. Do you have your own water treatment plant, or do you purchase your drinking water?
3. From whom do you purchase your water?
4. Do you have your own wastewater treatment plant?
5. Insert total drinking water customers.
6. Insert total wastewater customers.
7. Is there on-site generator capacity to supply backup power in case of a power outage?

8. What type of fuel does the generator require?
9. Is there a plan in place for fuel delivery?
10. What portion of operations can be sustained on generator power?
11. If operating on generator power will lead to degraded operations or unknown, please explain.
12. How long can your facility or system operate on generator power?
13. Does the facility or system depend on natural gas or other fuel for normal operations?
14. Does the facility or system rely on communications systems to function?
15. Are the operating systems for the critical facility or system connected to the internet?
16. Does the facility or system have a cybersecurity plan in place?
17. Does the facility or system depend on external suppliers for daily operations?
18. What transportation routes does the facility or system rely on for access and/or delivery of materials?
19. Does your system have resiliency within its supply chain?
20. Please explain the nature of the specialized personnel required to operate your system/facility and list backups using the P.A.C.E methodology.
21. Within your system, are there particular nodes or facilities that are especially critical to system operations?
22. Please list the nodes and/or facilities that are critical to your system.
23. How long could the system or facility operate if it lost a critical node, facility, or service on which it is dependent?
24. Does the system have an alternate means of operating if a critical facility or node is disabled?
25. Is it possible to bypass a critical node/facility and restore service?
26. What is the estimated time to restore operations if a critical node/facility is disabled?
27. Is the system able to operate at partial capacity?
28. If the system is able to operate at partial capacity, is there a priority arrangement for downstream customers?
29. Does your system have any interconnects with neighboring systems?
30. Please provide details on the type and intended use of the interconnect(s).
31. Do you have plans/partnerships in place to get alternate critical services following a disaster?
32. How might your continuity, emergency, restoration, and/or recovery plans depend on agencies or entities outside of your organization?
33. Do you have an emergency response plan in place for your system?
34. GRADD has identified the likely need for hydraulic modeling of local/regional water systems. Have you previously performed any modeling of your system?
35. Please give a brief description of the hydraulic modeling for your system.

Questions one through six of the survey collect data about the infrastructure system being evaluated. Questions seven through 13 collect data concerning energy sector dependencies and mitigation assets. Questions 14 through 16 collect data for communications sector dependencies and mitigation actions. Questions 17 through 19 collect data for transportation sector dependencies. Questions 20 through 26 collect data about critical personnel and critical system components (aka, nodes). Questions 27, 28 and 31 through 33 collect data about emergency response planning for the water or wastewater system. And Questions 29, 30, 34, and 35 collect data for water infrastructure systems pertinent to interconnects and hydraulic modeling. This question set created an online survey to ensure the standardization of answers and allowed for analysis of the data collected by the survey. Once the survey questions were developed, a pilot test was conducted with a water and wastewater utility to demonstrate the effectiveness and expose any gaps in the data being collected. The pilot test confirmed the questions were adequate for the planning process and no changes were necessary. GRADD planners used the experience from the pilot test to create an effective interview strategy to be used during the in-person system interview phase of the planning process.

Advertisement of the Planning Process

Educating stakeholders about infrastructure dependencies was conducted throughout the planning process. This process began with a presentation to water and wastewater utilities during the GRADD Water Management Council where GRADD planners, as well as representatives from CISA and KYEM, presented council members with the Infrastructure Dependency Primer and discussed the fundamentals of infrastructure dependencies and interdependencies. As GRADD planners approached the kickoff of in-person system interviews, outreach to representatives who manage the day-to-day delivery of water and wastewater service within the GRADD region continued to re-introduce them to the planning process and give them an introduction as to what their involvement in the process would entail. A resource from the IRPF was used as a starting point for the advertisement of this stage of the planning process. GRADD planners utilized the Stakeholder Invitation Letter provided by CISA as a starting point to develop the following template used to contact all water and wastewater utilities:

> Hello,
>
> I am contacting you to set up a time when I can meet with the system operator(s) to discuss the infrastructure dependencies for [system]. Below is a little background for the project I am working on.
>
> The Green River Area Development District (GRADD) and the Cybersecurity & Infrastructure Security Agency (CISA) have established a partnership to identify high-risk dependencies that exist between different infrastructure sectors. One of the main goals of this intergovernmental partnership is to foster an increased adoption of water infrastructure resiliency within GRADD Communities region wide.
>
> To increase our regional resiliency, we must first systematically highlight specific dependencies across our current water and wastewater system infrastructure. We have developed a questionnaire to document infrastructure dependencies, critical system components, disaster response plans, and system modeling information for the water and wastewater systems supporting GRADD Communities.
>
> I would like to set up a meeting on [date/time] to discuss the infrastructure dependencies for [system]. Please let me know if this timeframe works for you or if there's a better date/time to meet and discuss this project.
>
> Thank you for your participation in this initiative and I look forward to collaborating with you to increase infrastructure resiliency throughout our region.

Sent via email to all water and wastewater utilities, this template is dissimilar to the Stakeholder Invitation Letter provided in the IRPF in many ways. This departure was driven by several factors including the existing relationships between the infrastructure sector and the planning organization (GRADD), the early identification of confusion among system operators between reliability and resilience, and the desire to introduce key infrastructure dependency concepts in person as the starting point for the interview conversation. This final consideration, the presentation of infrastructure dependency concepts in person, ensured system operators were able to ask questions and come to a level of understanding that supported the planning activities end objective identifying local hazard mitigation strategies to increase resiliency of our water and wastewater utilities.

In Person Interviews

Individual in person system interviews were the most time-consuming portion of the planning process, but also the most valuable in terms of data collected and stakeholder education. GRADD planners conducted interviews across the seven-county region and traveled a total of 1,784 miles across three months to complete the interview process. Each system interview centered on a guided conversation about infrastructure dependencies between the water and wastewater sector and the energy, communication, and transportation sectors, critical nodes and personnel, emergency procedures, interconnects, and hydraulic modeling to collect data that would later be entered into the online survey tool. Before presenting the infrastructure resiliency survey questions, GRADD planners provided system operators with an overview of infrastructure interdependencies to serve as context for the planning process and highlight the end goal of increasing resilience for the water and wastewater sector within the region. As previously discussed, the amalgamation of reliability with resilience was frequently encountered among system operators. Reliability refers to the dependability and consistent service provided, whereas resiliency is the capacity to recover quickly from a setback. GRADD planners observed that many of the system operators confused the two terms due to the day to day demands of operating their respective systems; however, when presented with a distinction between the two concepts, system operators were able to quickly adapt and delineate between them. A key concept used to demonstrate this distinction was the fallacy of creating a fail-safe system. Attempting to create a fail-safe system is expensive and impractical, while creating a resilient, fail-safe system is both realistic and achievable. The need for resiliency within the water and wastewater sector is evident due to pressures from aging infrastructure and increasingly common extreme weather events. System operators possessed a keen insight and awareness of the threats to their systems. GRADD planners found that using the idea of a fail-safe system that is resilient and mitigates the impacts of system failures when they inevitably occur was fruitful and fostered quality conversations during the interview process.

Data Analysis

Survey data was entered into the online survey tool throughout the interview process, and a detailed analysis was conducted when all in-person system interviews were completed. The selection of an online survey tool to house data for this planning effort enabled effective data analysis by providing a standardized answer format that could be exported into a spreadsheet and manipulated to reveal data trends and patterns. Specific attention was paid to the core data collection topics of infrastructure dependencies, critical personnel and nodes, emergency procedures, interconnects, and hydraulic modeling. The ability to parse data in spreadsheet format allowed GRADD planners to break out key points of data for further investigation, and allowed planners to identify cascading dependencies between water utilities as treated drinking water is sold and purchased between utilities. Specific factors that appeared during this stage of the planning process are discussed later in this risk assessment. Data analysis was completed at the regional and county level, and gaps and vulnerabilities were identified for further discussion with stakeholders during the next stage of the planning process. A key aspect of this project was data security, as some of the information collected by the infrastructure resiliency survey is sensitive or proprietary. Data gathered by this project was carefully vetted by GRADD planners to ensure that proprietary, sensitive, or non-public information was protected while also informing the final output of the planning process. Future infrastructure planning efforts should be proactive in creating a data security plan and be prepared for industry concerns about the sharing of proprietary, sensitive, or non-public information. Data security was often discussed throughout the in-person interviews conducted during this planning process, and GRADD planners were able to obtain information critical to the success of the process due to the existing working relationship and trust between GRADD and the water and wastewater system operators.

Community Meetings

Community engagement is critical to any planning process and particular care was taken to ensure community leaders participated in this planning effort. For this planning activity, achievement of community engagement occurred through meetings held at the county level with the following stakeholders:

- Water and wastewater system operators
- Emergency management personnel
- Elected officials (or their designated representatives)

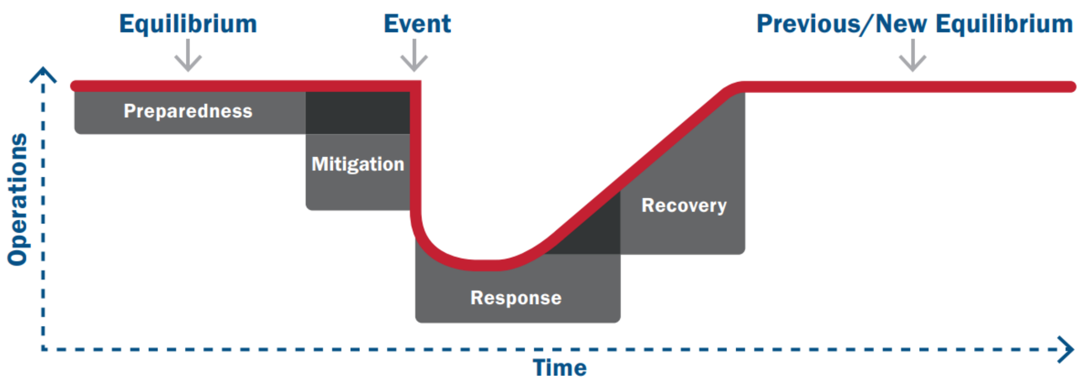
Selection of this group of community stakeholders ensured that candid conversations could take place about the existing gaps and vulnerabilities that existed within the water and wastewater infrastructure systems supporting the GRADD region, while protecting proprietary, sensitive, or non-public data collected during the planning process.

GRADD planners conducted non-public meetings with stakeholders in each of the seven counties that make up the GRADD region. During these meetings stakeholders were provided a recap of the planning process, including an overview of infrastructure interdependencies and a distinction between reliability and resilience before conversations turned towards gaps and vulnerabilities specific to the community. Community stakeholders were presented with an overview of the gaps and vulnerabilities for the water and wastewater sector due to infrastructure dependencies from the energy, communications, and transportation sectors. Also discussed was information concerning gaps and vulnerabilities from critical personnel and critical nodes within each utility providing water or wastewater service to the community. These meetings were informal and benefited from existing professional relationships between water and wastewater utilities and elected officials, and conversations were honest and productive due to the non-public nature of the meeting. In some communities this meeting served as a point of contact between emergency managers and water and wastewater utilities who had not previously collaborated with each other; however, this relationship was previously in place in several of the GRADD counties.

After discussing the data concerning gaps and vulnerabilities, stakeholders suggested projects ideas that could be developed into local hazard mitigation strategies to increase the resilience of the water and wastewater sector supporting their community. GRADD planners utilized resources provided by CISA to help stakeholders generate project ideas across four types of activities:

- Preparedness
    - Activities undertaken to anticipate relevant threats/hazards and the possible consequences from their occurrences, including prevention and protection activities; speaks to the adaptability of infrastructure systems and the process of integrating and acting on lessons learned.

- Mitigation
    - Activities undertaken to resist and/or absorb the negative impacts of an event, reducing the severity or consequences of a hazard; speaks to the robustness of infrastructure.
- Response
    - Activities and programs undertaken or developed to respond and adapt to the adverse effects of an event; speaks to the resourcefulness of infrastructure owners and operators in managing a crisis.
- Recovery
    - Activities and programs designed to help entities return operating conditions to an acceptable level and recover from an event; speaks to the ability to get services back online quickly.



Discussions about future actions to improve resiliency of water and wastewater service in the region was the most valuable component of the planning activity for community stakeholders. Each stakeholder brought a distinct perspective on what was possible or practical and these perspectives, when discussed among peers from diverse groups who collectively serve the community, spurned creativity and produced a wide-ranging list of options for local hazard mitigation strategies for communities in the GRADD region.

Supervision of GRADD Councils

Throughout the planning process, the GRADD Water Management Council and GRADD Hazard Mitigation Council remained informed of the purpose and progress of this planning activity. The planning activity first presented to the water and wastewater utilities during the GRADD Water Management Council meeting at the beginning of the planning process, where GRADD planners as well as representatives from CISA and Kentucky Emergency Management presented council members with the Infrastructure Dependency Primer and discussed the fundamentals of infrastructure dependencies and interdependencies. During the planning process, the Water Management Council and GRADD Hazard Mitigation Council were provided with an update on the status of the planning effort, a recap of lessons learned, and a forecast for the future of the project.

After the collection of project ideas during the community meeting portion of the planning activity, GRADD planners reviewed projects from a regional perspective and conducted a second round of data analysis to look for additional information that could be gleaned from the data due to topics or themes that arose during the community stakeholder meetings. Several key concepts were prevalent in multiple communities, and some communities faced similar challenges but approached mitigating the problem in diverse ways. Project ideas were organized by region and county in preparation for a final report to both the Water Management and Hazard Mitigation Councils. At this point of the planning process the GRADD GIS analyst created maps to illustrate data collected from water and wastewater system operators. Maps showing the total area served by water treatment plants, as well as source water contamination threat areas for the region efficiently illustrated areas of concern for many community stakeholders and GRADD council members. Maps were also created for community stakeholders and GRADD council members to illustrate how water and wastewater system components might be affected by natural hazards that affect the region. The system component maps were created using publicly available data; however, the nature of the maps produced were deemed sensitive in nature and not fit for public dissemination and are therefore omitted from this risk assessment.

Final reports provided to the GRADD Water Management Council and GRADD Hazard Mitigation Council marked the completion of the outreach portion of this planning activity. The final report presented to the councils provided regional level statistics for water and wastewater infrastructure sector in the areas of infrastructure dependencies from the energy, communications, and transportation sectors, vulnerabilities pertaining to critical personnel and critical nodes, and interconnect and hydraulic modeling data for systems in the GRADD region. Maps produced by GRADD during the planning process were presented to members of each council to highlight key data points that were discovered because of the data collected during the planning effort. A recap of community project lists was provided, and discussion was held among council members about how communities could pursue projects in the future. One aspect specific to the Water Management Council final report was to provide an overview of federal programs that offer funding for mitigation activities and how these programs compare to funding sources that have been traditionally used to fund capital projects in the region.

The final reports to the GRADD Water Management Council and GRADD Hazard Mitigation Council began the process to formally document the findings of this planning activity with a goal of increasing the resiliency of the water and wastewater infrastructure section in the GRADD region. The following section discusses the findings of this planning effort appropriate for public dissemination. Some information gathered during the planning process has been withheld from the following section due to it containing proprietary, sensitive, or non-public information.

Vulnerabilities for Water and Wastewater Infrastructure

Alongside natural hazards, the water and wastewater infrastructure sector has several key vulnerabilities due to its dependence on other critical infrastructure sectors. Infrastructure dependency as defined by the IRPF is a relationship of reliance within and among infrastructure assets and systems that must be maintained for those systems to operate and provide services. Dependencies can be one direction or bi-directional (interdependencies) and can be upstream or downstream. As discussed earlier, the water and wastewater sector rely on services from the energy, communications, transportation, chemical, and critical manufacturing sectors to function. Two other areas investigated by GRADD staff during this planning process were critical personnel and critical nodes necessary for operation of the water and wastewater infrastructure sector. GRADD staff conducted interviews with each of the 56 utilities that provide water and wastewater service across the region to identify vulnerabilities for our regional water infrastructure and found the following:

Natural Hazards

Natural hazards affecting the GRADD region, although not the primary focus of this planning effort, often pose a significant threat to reliable water and wastewater service throughout the region. Source water treated and distributed as clean drinking water can be vulnerable to dam and levee failures and drought. Flooding can impact source water if raw water intakes are silted over or damaged by flood debris. Underground pipes represent the majority of components used by of water and wastewater infrastructure to deliver services and are vulnerable to any natural hazard that causes ground movement such as earthquakes, extreme temperatures, landslides, and land subsidence. Earthquakes pose a threat to above ground infrastructure components including water towers, treatment plants, and communication components necessary for the efficient management of water and wastewater utilities. Above ground components are also vulnerable to damage from tornados and severe thunderstorms; these hazards can also uproot trees and often cause damage to buried pipe. Pandemics introduce a vulnerability where critical personnel are incapacitated or quarantined causing operational disruptions to utilities. Mandatory stay-at-home orders issued in response to a pandemic also add stress to water systems due to higher consumption as noted during the COVID-19 pandemic when water utilities saw a 20% increase in demand. The water and wastewater infrastructure sector is also vulnerable to the effects of climate change as extreme temperatures drive more frequent and violet natural hazard events.

Energy Sector Dependencies

Less than half of all utilities that supply drinking water in the GRADD region (47%) have backup power to mitigate the effects of a power outage. Of the utilities that do have backup power in place, only 57% can support all operations while 43% would have degraded service to customers. Secondary power sources to mitigate the dependency on the energy sector are slightly better for wastewater utilities, with 70% having some mitigation capabilities. Among wastewater utilities that have backup power, 44% can support all operations and 56% would experience degraded operations if they lost support from the energy infrastructure sector. Power outages can also impact the availability of fuel for vehicles necessary to maintain and repair water infrastructure. Several utilities rely on natural gas to heat treatment plants; however, this dependency poses a low vulnerability to operations as portable heaters can be brought in to mitigate the loss of natural gas service and allow operations to continue. Electrical service is the primary vulnerability to the water and wastewater infrastructure sector in the GRADD region.

Transportation Sector Dependencies

All utilities rely on the transportation sector for access to key nodes within their systems, and utilities with treatment plants (water or sewer) are reliant on the delivery of chemicals needed to treat water and wastewater. Twenty-eight utilities across the region are dependent on chemicals for treatment and have, on average, a one-month supply of necessary product kept on hand. The minimum amount of inventory kept on hand was two weeks. Access to key nodes within each system was evaluated across all 56 utilities, and 10 vulnerabilities were identified ranging from poor or limited access to treatment plants, water tanks, and wastewater lift stations as well as nodes that are regularly cut off due to flooding.

Communication Sector Dependencies

Supervisory Control and Data Acquisition (SCADA) is a computer-based system for gathering and analyzing real-time data to monitor and control equipment that deals with critical and time-sensitive materials or events. Water and wastewater infrastructure across the country relies on SCADA to monitor and control portions of the drinking water treatment and distribution systems as well as wastewater collection, transmission, and treatment. In the GRADD region, 47% of utilities rely on SCADA for day-to-day operations. The majority of water and wastewater infrastructure in the GRADD region was constructed before SCADA existed, therefore water and wastewater service to customers is still possible if the region experienced a disruption to the communications infrastructure sector, however workforce turn over and a loss of institutional knowledge can leave a system vulnerable to loss of service if manual back-up procedures are not documented and regularly exercised. A long-term disruption to the communications network, or a distribution that occurs in conjunction with a natural hazard event that impacts travel (such as a severe winter storm) could put the reliability of water and wastewater service in jeopardy due to utilities being staffed on the assumption of remote monitoring and control of their systems. Manual operation and monitoring of distribution and collection systems, especially for rural utilities that cover hundreds of square miles, can be extremely challenging without support from the communications sector. Cybersecurity vulnerabilities also fall under the communications sector. Per CISA all organizations, regardless of size, need to adopt a heightened posture regarding cybersecurity and must protect their most critical assets. Some cybersecurity concerns exist for the regional water and wastewater sector at varying degrees and should be addressed.

Critical Personnel

Title 401 of the Kentucky Administrative Regulations (KAR) mandates that certified operators have direct responsible charge of water and wastewater systems in order to safeguard the life, health, and welfare of the public and the environment. To become a certified operator, individuals must meet education and experience requirements, and then pass a written exam. Stakeholders in the GRADD water and wastewater infrastructure sector have known for some time the industry was vulnerable due to a shortage of certified operators and that suspicion was confirmed during the planning process for this risk assessment.

During system interviews, utilities were asked about critical personnel staffing levels for their primary, alternate, contingency, and emergency needs. This information was then analyzed, and local factors were taken into consideration (budgetary limitations, size of utility, etc.), and utilities were placed in one of three categories; protected, vulnerable, and at risk. For the purposes of this section, protected means utilities have at least three certified operators on staff, vulnerable means utilities have only two operators (primary and alternate), and at risk means the utility has only one certified operator and no backup. Across the region, 50% of the water and wastewater utilities are protected from the loss of critical personnel, 20% are vulnerable, and 30% are at risk.

Although the availability of critical personnel is a vulnerability for individual utilities, a robust professional network exists across the water and wastewater sector in the GRADD region. Many of the utilities who are vulnerable or at risk have relationships with neighboring utilities that can lend support and supply critical personnel if the needs arise. A quarter of the utilities who are at risk have uncertified staff that could physically (but not legally) operate the water or wastewater system which suggests that some barrier to obtaining a certification exists that should be addressed.

Critical Nodes

Water and wastewater infrastructure systems contain several components that work together to provide reliable service to the public. GRADD planners investigated the criticality of individual nodes within each water and wastewater system to look for vulnerable nodes that pose a risk to the system as a whole if they were disabled. Eighty-five percent of water and wastewater utilities reported some type of critical node in their system that, if lost, would cause significant disruption to their ability to provide service or cause a full shutdown of the system. Among the critical nodes reported, some stood out as especially critical due to the impact on the system they support if disabled. A key takeaway from this planning process is to mitigate to the extent possible the prevalence of single points of failure within critical infrastructure systems and to harden nodes critical by nature.

Case Studies

Marion, KY Water Shortage

Marion, KY, a city of just under 3,000 located in Western Kentucky, suffered a water emergency when the dam for the city lake failed. Lake George was a 65-acre lake used as the water source for the Marion Water Department until a combination of factors lead to it running dry in the summer of 2022. Problems began at the lake in April when dam inspectors discovered water at the toe of the dam. Days later a sinkhole appeared in the face of the dam which caused fears of a total failure of the dam. Local officials elected to proactively breach the dam to reduce the water levels in the reservoir and relieve pressure on the dam. Breaching the dam drained more than 180 million gallons of water from Lake George, and, when combined with a lack of rainfall, pushed the city into a water emergency lasting months. Local and state officials were repeatedly at odds during this event, highlighting the need for proactive planning concerning how to handle a water emergency before its onset. This case study also serves as an example of a utility losing a critical node on which it was dependent to provide service to the public.

Source: Kentucky Energy And Environment Cabinet / Public Records

2021 Cyber Attacks

Computer technology is an integral part of every industry and the water and wastewater infrastructure sector is no different. In recent years, several incidents have gained national attention where cyber-attacks were carried out on drinking water utilities. One instance occurred in February 2021 when hackers attacked a water treatment plant in Oldsmar, Florida and briefly adjusted the levels of sodium hydroxide from 100 parts per million to 11,100 parts per million. If successful, the attack would have increased the levels of sodium hydroxide in the water supply to dangerous levels; however, a vigilant employee saw the intrusion attempt and stopped it before public harm occurred. A separate example comes from January 2021 when a hacker used the username and password of a former employee to log into a remote access program and delete programs used by a water treatment plant. This attack occurred on a utility that provides service in the San Francisco Bay Area and fortunately did not result in material harm but emphasizes another type of event that can occur if hackers attack water infrastructure assets.

Historical Events

Owensboro Water Main Break

In July 2018 two water mains leading out of the main Owensboro Municipal Utilities (OMU) water plant burst, causing a water emergency that impacted tens of thousands of customers across the city of Owensboro and Daviess County. The breaks occurred at 4:30AM, and by 11:00AM the county judge executive had declared a state of emergency. Crews responding to the break had to first drain water that had flooded city streets and then excavate to access the 20- and 24-inch mains that had ruptured. At the time of the break, OMU had two water treatment plants, the older Plant A where the breaks occurred, and the newer but smaller Cavin Plant. Crews managed to repair the break in less than two days; however, boil water advisories were in place for days after the repair as the distribution system was repressurized and the entire system flushed. During the emergency local schools were canceled, businesses closed due to lack of restrooms for employees and customers, and local restaurants were forced to offer limited options if they able to operate at all. This event highlights the impact of losing a critical node within a drinking water system. OMU's Plant A has since been retired and the Cavin Plant has been increased in capacity to provide service to the entire OMU water system.

Source: Courier & Press

2009 Western KY Ice Storm

An ice storm in January of 2009 was the largest disaster in modern Kentucky history and stressed the interdependence of infrastructure sectors and how those dependencies translate to impacts on the public. What began as a light freezing rain on the evening of January 26th, 2009, evolved over a period of days and resulted in three to four inches of liquid equivalent precipitation across the GRADD region, including two inches of ice. The days immediately after the precipitation were cold and windy and lead to the largest power outage on record with 609,000 homes and businesses without power across the state of Kentucky. Most city residents had power restored by February 4th, one week after the storm; however, rural residents remained without power for days or weeks longer, up to three weeks in some areas. Interdependencies between infrastructure sectors where quickly made apparent as communications and energy infrastructure failed due to power loss and over 200,000 residents lost water and wastewater service as water treatment plants, pump stations, wastewater collection systems, and sewer plants were without power. Emergency management resources were deployed to bring water systems back online as quickly as possible, but some rural utilities were without power for three weeks. Emergency and infrastructure planning was irrevocably altered after this event, and it serves as an example of how a natural hazard event can trigger cascading impacts throughout critical infrastructure sectors.

Source: Owensboro Radio

Summary

Water and wastewater service is a necessary part of daily life. Awareness of how this sector impacts daily life has risen in recent years; however, mitigation actions have focused on protecting the sector from its reliance on the energy sector by installing secondary power sources (generators) to mitigate the dependency from the energy infrastructure sector. Through a regional application of the IRPF, several gaps and vulnerabilities were highlighted that are of equal concern such as ensuring access to key system components and delivery of chemicals via the transportation sector, protecting the water and wastewater sector from communication sector dependencies, and concerns about the availability of critical personnel and the need to mitigate or harden critical nodes. A water emergency can bring local communities to a standstill within hours and could potentially lead to regional level impacts if an incident impacts a water treatment plant or water sources. Proactive planning efforts to analyze the water and wastewater infrastructure sector and develop appropriate mitigation actions are vital steps to ensuring local communities mitigate the impact of water emergencies that are expected to impact the GRADD region in the future.