The Road to Resiliency for South Carolina Water Utilities Paved by Planning, Persistence, and Careful Navigation of Realities and Hypotheticals

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Abstract. Planning for a resilient future from known and emerging threats is a topic of interest among many organizations, especially in the utility sector. South Carolina communities depend on reliable and safe sources of drinking water and generally do not anticipate interruptions or issues with their water providers. With the rate at which the state is growing, the dependency will only increase. SynTerra worked with five utilities in South Carolina to assess their risk and resilience and develop or update emergency response plans. This paper reports on key takeaways from this experience in an effort to provide guidance on lessons learned to work toward a resilient future. The overall purpose of this paper is an effort to provide a firsthand account of how assessments and plans can be used as a guide for continuous improvement toward resiliency, with an ultimate goal of protecting human health.

INTRODUCTION

Most of us associate resilience with positive attributes and successful outcomes. We want to be resilient people with resilient systems. Being resilient, as defined by Merriam-Webster (2021), means “tending to recover from or adjust easily to misfortune or change.” To achieve resiliency, we must first identify the potential “misfortune” or “change” that could occur.

When we talk about resiliency of water utilities, we often focus on updating infrastructure. Undoubtedly, infrastructure is a key element of protecting the utility and human health from potential threats, but there is much more to establishing a truly resilient utility. The focus should not be exclusively on infrastructure; rather, the focus should be on addressing multiple elements of a water utility, including technical, organizational, social, and economic considerations (Pagano et al. 2017). Failing or aging infrastructure, outdated or nonexistent plans, ill-managed or limited budgets, poor public communication, and lack of education and training can all lead to vulnerabilities at a public water utility (Alva-Lizarraga et al. 2013). Understanding your utility’s strengths and weaknesses and incorporating new strategies into a plan can better position the utility to handle natural or humanmade disasters.

With the emergence of new threats to South Carolina utilities, whether from a new source, an unforeseen pandemic like COVID-19, or ever-changing climatic disturbances, it is essential for utilities to set a plan in action to withstand or recover from threats. Planning for future and enduring water utility resilience can be a tedious task filled with hypothetical scenarios, budget analysis, and tabletop exercises, all of which result in a substantial and complex document that might sit on a shelf or data server for years. Nevertheless, the exercise of performing a risk and resilience assessment (RRA) and updating or developing an emergency response plan (ERP) can provide tools that help the utility protect customers in the future.

BACKGROUND

With the US Environmental Protection Agency’s (US EPAs) issuance of the 2018 America’s Water Infrastructure Act (AWIA), most water utilities should already be working on or have a completed RRA and ERP in place for the next 5 years. The legislation was enacted to improve drinking water quality, deepen infrastructure investments, and enhance public health and quality of life.

The objective of an RRA is to evaluate the vulnerabilities, threats, and consequences to a utility from potential hazards (US EPA 2019a). Or, in terms of resilience, the objective is
to identify the potential “misfortune” or “change” that could negatively affect the utility.

The 2018 AWIA legislation presented utilities with the opportunity to use a regulatory requirement for ongoing risk management, which proactively supports utility operations. The American Water Works Association (AWWA) published the J-100-10(1) (J-100) standard to help utilities meet the requirements of this legislation, but in reality, it established a framework for the aforementioned ongoing utility risk and resilience management. The key advantage to this process is that the evaluation takes the abstract concepts of vulnerability and risk and turns them into a quantifiable metric, allowing the utility to identify areas of improvement and make targeted modifications. To date, SynTerra, a science and engineering consulting firm headquartered in South Carolina, assisted 5 water utilities in South Carolina of varying sizes, from 15,000 to 400,000 people in their service population, to accomplish risk assessments and develop or update ERPs. While these documents often feel like a shelf placeholder, they contain valuable information, much of which should be put into practice to establish enduring resiliency and protect human health in the future.

ASSESSMENT METHOD

To facilitate the assessment, SynTerra conducted 5 to 6 workshops for the RRA and 2 to 3 workshops for the ERP, depending on the amount of information needed for each drinking water utility client. SynTerra followed the basic steps outlined in the AWWA J-100 standard for the RRA, the AWWA M19 Emergency Planning for Water and Wastewater Utilities document (Gay et al. 2018), and the USEPA Community Water System ERP Template and Instructions (US EPA 2019b) for the ERP. SynTerra chose a facilitated workshop approach that aligned with the complex nature of information-gathering required for RRA and ERP completion. The utilities had 3 to 10 employees present at each workshop. Upper-level management was present during each workshop, along with personnel from different departments (treatment plant, distribution line, public relations, etc.) to allow for viewpoints from various perspectives within the organization. SynTerra’s assessment team consisted of 2 to 3 personnel with experience in water, wastewater, or planning.

Because assessment information is dense and many abstract concepts are discussed, it is beneficial to take “small bites” and give everyone plenty of time to digest topics and details. Prior to a workshop, SynTerra’s assessment team sent meeting materials to the clients as needed to help facilitate the discussion in the workshop. During the workshop, SynTerra provided workshop-specific handouts to help the client follow along with the presentation and exercise. SynTerra also facilitated exercises to help engage the utility in the discussion. Once a workshop concluded, SynTerra’s assessment team sent workshop deliverables to the client, which included meeting minutes, completed tables based on information from the workshop, follow-up questions, or requests for missing information. A stepwise approach using facilitated workshops over a year provides the opportunity to modify information as necessary during the process. Figure 1 demonstrates the general approach SynTerra took to conduct workshops and complete RRA and ERP reports.

To assess risk in terms of a dollar amount for the RRA and to determine a utility resilience baseline, SynTerra used both the US EPA’s Vulnerability Self-Assessment Tool (VSAT 2.0) and the AEM Corporation’s Program to Assist Risk and Resilience Examination (PARRE). These platforms helped facilitate discussions regarding consequences, countermeasures, likelihood, and vulnerability. Ultimately, using these tools provided additional aid for assessing overall risk and resiliency.

FINDINGS

The following section details SynTerra’s knowledge gained during the process. Using the J-100 standard as a reference, we compiled a few key takeaways for implementing risk, resilience, and emergency response in utility planning and management based on our experience.

RISK AND RESILIENCE ASSESSMENT

Key Takeaway 1: Involve a Diverse Team

The first and most critical takeaway of conducting an RRA and an ERP is the identification and involvement of utility personnel. Successful assessments are the result of collaboration between the key information centers of the utility. The utilities SynTerra worked with involved diverse teams by including personnel from all levels in each workshop. Typically, a workshop would include a few executive-level personnel, middle management, and a few employees from the line crew, treatment plant, maintenance, or other operations. Including personnel from all levels allowed for a more meaningful conversation about the system as a whole and provided broader perspectives on how to reduce the utility’s risk to malevolent or natural hazards.

Key Takeaway 2: Utility Resiliency Index (URI) Continuous Improvement

The second takeaway is the establishment of a utility resilience baseline using the URI. The URI is a risk-management tool that can assess a utility’s capability to respond to and recover from an incident affecting critical operations (AWWA 2010). The URI uses 12 indicators to calculate the index (Figure 2). The indicators are divided into two subsets: operational, which is the ability of the utility to react to and/or resolve various hazards that interrupt service; and financial, which
Figure 1. RRA and ERP processes.
is the ability of the utility and its service area to react to and/or resolve various hazards that may interrupt revenue to the utility.

Responses to the indicators are assigned values and weights, which are aggregated to provide a characterization of a utility’s resilience on a scale of 0 percent to 100 percent. A low URI score for a utility indicates a lesser capability to respond to and recover from an incident, while a high URI score indicates a greater capability to recover from an incident. Among SynTerra’s clients in South Carolina, URI scores ranged from 59 percent to 84 percent based on responses to the 12 indicators. During this process, SynTerra encouraged their clients to identify any areas of improvement to increase the URI score. Examples of improvement opportunities include: 1) pursuing National Incident Management System (NIMS) certification or 2) increasing cross-training among utility personnel to increase critical staff resilience (CSR). Implementing an annual review of the URI provides a reliable metric for understanding utility resilience, setting targeted goals for improvement, and easily measuring progress.

**Key Takeaway 3: Revisit your Asset List**

The third takeaway is the importance of ongoing asset management. Asset characterization is a step in the J-100 that lays the foundation for utility asset management. The objective of the asset characterization step is to determine the assets — physical, human, or informative — that are critical to utility operations. Arguably, every asset employed by the utility is critical because each asset supports utility operation. Therefore, using the utility mission statement or some other priority evaluation is important in determining which assets should be considered critical. In the RRA process, SynTerra used a priority evaluation system in conjunction with the utility mission statement to score the assets based on three categories (Figure 3):

- **Human**: This category represents the severity of human loss or injuries if the asset is attacked.
- **Financial**: This category represents the amount of money that the utility would have to spend to repair or replace the asset if it is attacked.
- **Economic**: This category represents the effect on the surrounding community if the utility is unable to provide service due to an attack on the asset.

![Figure 3. Three categories for priority scoring.](Image)
Implementing a management system that not only inventories assets in the system, but also their status and criticality to utility operations, will allow for consistent identification of utility vulnerabilities. Additionally, SynTerra recommends that utilities should conduct an annual review of an asset list using the priority evaluation, especially if new assets are added to the system. The annual review helps utilities with capital improvement planning because the assets already will be cataloged and prioritized.

Key Takeaway 4: Understand Your Vulnerabilities
The fourth takeaway for conducting a risk and resilience assessment is vulnerability analysis, which is another step in the J-100 standard. The objective of the vulnerability analysis step is to identify the vulnerabilities that would allow a threat to be successful and cause the previously identified consequences, such as service outage or loss of life. The vulnerability, expressed as the vulnerability likelihood probability, represents a measure of both the effectiveness of an attacker/threat and of the countermeasures employed by the utility (AEM Corporation 2020). Countermeasures can be defined as the systems that are put in place to protect the utility’s critical assets. Countermeasure systems can be structural, such as a gate, or nonstructural, such as trained staff (Figure 4), and they typically lessen the consequence severity of a successful attack or event (AEM Corporation 2020).

Understanding utility countermeasures, how they are employed, and ways they can be improved is an important step in risk and resilience management. The J-100 standard presents risk as a dollar-valued amount based on the calculated vulnerability likelihood percentage. By understanding utility vulnerabilities, employed countermeasures, and available countermeasures for implementation, strategic countermeasure investments to increase utility resilience and decrease risk can be made.

After SynTerra identified countermeasures at each utility, it was recommended that they improve their countermeasures where possible. For example, if the utility did not have video cameras at their remote assets like pump stations, then installation of a 24/7 surveillance system was recommended to help reduce the success of a threat.

Key Takeaway 5: Update the RRA
Outdated or unused assessments and plans do not provide much of a benefit to a utility’s future resiliency and adaptability to changes.

Revisiting other steps in the J-100 standard, not explicitly discussed in this article, is beneficial for utility risk and resilience management. For example, threat characterization (a step in the J-100 process), which has the objective to determine the reasonable worst-case threats, natural hazards, and supply-chain scenarios, could be incorporated into the ongoing risk and resilience management. As the utility experiences new threats like changing climate patterns or increasing cyberattacks, it is recommended that asset-threat assignments be updated. Additionally, maintaining a relationship with the Local Emergency Planning Committee (LEPC) and other community stakeholders could aid in the identification of emerging threats. An annual review of events that occurred causing damage to the utility assets will also be beneficial for ongoing risk management and adaptive resiliency. Similarly, the consequences step in the J-100 process has the objective to determine what happens in the event of a successful threat and to define the consequences in terms of financial loss to the utility, fatalities, serious injuries, and economic loss to the regional economy. The J-100 standard approach monetizes anticipated consequences so that the
final risk number is presented as a dollar value. Understanding consequences as a dollar amount provides perspective for the actual magnitude of an event and sets the stage for eventual cost-benefit analyses on mitigation efforts.

Finally, if a new asset, countermeasure, or response to the URI indicators occurs, revisiting the risk assessment is recommended. That way, the utility has a better understanding of its current and future resiliency and can continuously improve on any newly identified gaps.

**EMERGENCY RESPONSE PLANNING**

One of the most effective ways to employ the results of the risk and resilience assessment is to develop, maintain, and train on the utility's emergency response plan. It is not possible to have a utility free of threats, which rings especially true after the events of 2020. Ensuring that your ERP is continuously reviewed and updated, and that staff members are properly trained on it, can help the utility respond to an unforeseen event. The ERP is a valuable source of information that helps utility employees know how to quickly and effectively respond in the event of a successful threat. Employing this plan and conducting regular training sessions with the appropriate employees will lessen the effect of humanmade or natural disasters on the utility, while also promoting employee and community safety and enhancing the ability to continuously provide safe and reliable drinking water to the community.

Similar to the RRA process, SynTerra worked with clients to develop updated ERPs through a series of workshops, in-person exercises, and follow-up reviews. SynTerra thoroughly evaluated the most recent ERP of each utility and identified any gaps or missing information that needed to be added. Additionally, SynTerra followed AWIA and US EPA guidelines (Gay et al. 2018; US EPA 2019b) to ensure that each ERP was updated to the US EPA's standards. Information gained from workshops included updated internal and external contacts, system or asset standard operating instructions, communication plans, general and incident-specific response plans outlining detection methods, mitigation steps, and post-incident actions. This process created a usable ERP that could be pulled off the shelf or quickly accessed virtually on iPads and computers in an emergency. A few key takeaways (Figure 5) gained from working with the clients are as follows.

**Key Takeaway 1: Maintain a Diverse Planning Team**

Similarly to key takeaway 1 in the risk and resilience section, including personnel from all levels of the organization in the process is vital to developing an ERP. Engaging a diverse group allowed SynTerra to gather as much information as possible about how the utility currently responds to emergencies and how to improve the process. The people working directly with the assets have a better understanding on how to handle the asset if an emergency was to occur, and people from upper management or public relations typically know how to respond and communicate with the public if an event was to occur. So, engaging a diverse planning team ensures that the plan is as thorough and useful as possible.

**Key Takeaway 2: Use the RRA as Guidance**

In general, the RRA determines the risk for a scenario that “could” happen, while the ERP addresses the actions for if something “does” happen. When updating the ERP of each utility, SynTerra used the information from the RRA to guide the ERP process. For example, if the RRA identified that the utility could not serve its clients without an asset such as membrane treatment technology, then SynTerra encouraged the development of an asset-specific response plan and procedures to quickly resume drinking water service to the customers. SynTerra encouraged the client to update the ERP with the results of the RRA in mind.

**Key Takeaway 3: Regularly Conduct Tabletop Exercises on Emergency Responses**

A key element in successful emergency response is how well the staff is trained to react. If the staff is never trained on emergency response procedures and does not understand who to contact, how to repair the asset, or what to do when an event arises, then the situation could escalate to more severe consequences such as loss of service or loss of life. The ability to respond quickly and efficiently is crucial in any emergency situation; therefore, annually conducting ERP trainings and scenario-driven tabletop exercises can aid in a utility’s resiliency.

**Key Takeaway 4: Review the ERP after an Emergency Situation has Occurred**

In addition to annually reviewing the ERP, the utility should also review it after a confirmed emergency situation occurs. This is recommended so that the utility can identify whether process improvement is required. This is a great way to go over lessons learned and to come up with ways to respond more efficiently if future events occur.

**Key Takeaway 5: Actively Coordinate with the LEPC and Other Emergency Organizations**

Utilities should have an ongoing relationship with the Local Emergency Planning Committee (LEPC) and other emergency organizations so that the response plan is always up to date. The LEPC can help identify and plan for emerging or continued threats, therefore improving the utility’s resiliency.

Overall, a utility should have an updated ERP to increase resiliency and protect their customers. A general mission of most South Carolina water utilities is to provide safe and affordable drinking water to its customers. To fulfill that mission, a utility needs to not only understand its risk, but also
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1. Maintain a diverse planning team
2. Use the RRA as guidance
3. Regularly conduct table top exercises on Emergency Responses
4. Review the ERP after an emergency situation has occurred
5. Actively coordinate and communicate with the LEPC and other emergency entities

Figure 5. ERP key takeaways.

know how to quickly and efficiently respond to an emergency so that it can protect the health of its customers by providing a reliable supply of safe drinking water.

DISCUSSION

“The low-and-slow investment in getting staff members engaged in and trained on risk management might be more palatable relative to the potentially high financial, societal, reputational, environmental, or public health cost of an unexpected incident” (Setty et al. 2019). Communities in South Carolina are becoming more interested about the source and quality of their drinking water. With news headlines featuring drinking water contamination events to emerging threats such as Per- and polyfluoroalkyl substances (PFAS) and cyanobacteria blooms, source water pollution, and utility asset failures, it is important that utilities be resilient to current and future threats.

South Carolina utilities should use the AWWA J-100 standard as a guide for ongoing risk and resilience management. Each utility should establish a team that creates and expands a broad and diverse knowledge base and viewpoints in the utility to lead risk and resilience management. Each utility should calculate the URI as a resilience baseline and revisit the URI annually, as it provides a tangible metric for success. Establishing and maintaining an extensive asset management program provides multiple benefits for the utility in risk and resilience management. Including a priority evaluation in the program that identifies and prioritizes the critical assets provides for smart capital improvement and other utility planning. Using the program to actively track maintenance and asset status also decreases potential vulnerabilities. Then, reviewing those vulnerabilities and assessing potential countermeasures annually allows the utility to protect critical assets and increase resilience. Finally, following the J-100 standard produces risk as a dollar amount, which means that risk-reduction measures and options can be evaluated using a cost-benefit analysis.

Ultimately, identifying the utility’s vulnerabilities and adjusting emergency response accordingly increases the South Carolina community’s drinking water quality and the utility’s overall resilience. Evaluating risk and resilience and implementing an ERP is not a one-size-fits-all approach. Tailoring responses and budgeting for a rainy-day fund should focus on the utility’s challenges and on the needs of its customers. Ensuring that the plan is put into action and that information gained from the exercise is incorporated into business solutions could be an important step to upholding the utility mission.

It’s long been known that the quality of human life can be directly related to the quality and quantity of water that sustains it (Levallois et al. 2019). Therefore, it is crucial for water utilities to change their mindset from being reactive to following a proactive approach that protects human health for generations to come. South Carolina is experiencing exponential growth; the last census numbers demonstrated that areas of the state encountered population growth by more than 10% for the fifth decade in a row (Census 2020). With new population comes new demands on South Carolina water resources, and water utilities are facing rapidly evolv-
ing challenges related to that growth. While no one can predict every potential threat, scenario-driven planning bolsters preparedness for responding to unexpected occurrences and previously unknown threats. Therefore, it is beneficial for all South Carolina drinking water utilities to actively engage in the RRA and ERP processes. Planning and preparedness make for operational resiliency and a future of reliable and safe drinking water in South Carolina.

REFERENCES


