AFTER-ACTION REVIEW PRELIMINARY FINDINGS

FEBRUARY 2025

PREPARED FOR

City of Richmond
900 E Broad Street
Richmond, VA 23219

Contact: Scott Morris, DBA, P.E.
Phone: (804) 646 - 7970

PREPARED BY

HNTB Corporation
2900 S Quincy Street
Suite 600
Arlington, VA 22206

Contact: Darren Burkhart, P.E.
Phone: (317) 636 – 4682

EXECUTIVE SUMMARY

HNTB was contracted by the City of Richmond to perform an after-action review of the events at the Richmond Department of Public Utilities (DPU) Water Treatment Plant (WTP) that led to a loss of water service for residents across the region. HNTB made a site visit, conducted staff interviews, reviewed available records and data, and reviewed additional, publicly available information for the initial phase of the after-action review. Additional details and recommendations will be developed in later phases.

Event Description: The following is a high-level description of the event that led to the loss of water service. Additional details surrounding the event are included in the preliminary findings report.

- Main Feeder 1 from Dominion Energy went out. Main Feeder 2 still had power.
- Power did not automatically transfer from Main Feeder 1 to Main Feeder 2 due to an equipment failure and the WTP completely lost power.
- Without power, operators were not able to close filter effluent valves or turn on filter effluent pumps. The backup battery powered system did not close the filter effluent valves.
- With flow of water continuing through the filters, the water level increased in both clearwells until it reached the plant basements and submerged equipment and critical electrical equipment.
- Diesel-fueled pumps were used to pump water out of the basements, but they were not able to pump at the rate required to overcome or even keep up with flow rate of water coming through the filters.
- The water in the basements damaged equipment which resulted in a complete WTP outage for nearly 36 hours.

Preliminary Recommendations: The following actions are recommended for immediate implementation.

- Operate the WTP in Summer Mode all the time or at least during storm events that have risks of power outages.
- Develop a Bus Tie/ATS failure plan, train all electrical staff on the plan, and post the plan on each Bus Tie cabinet (SG 6 and SG 7).
- Implement all other recommendations and develop severe storm event response protocol with requirement that maintenance staff on call during storm events can respond in 30 minutes or less.
- Provide a filter effluent valve UPS with a parallel duplicate back-up UPS, both with minimum runtime of one (1) hour, and ensure that both function as intended to close all filter effluent valves on loss of power.
- Install a SCADA UPS with a longer runtime, a minimum of one (1) hour.
- Develop written SOPs for plant operation with the input of plant staff. Then, establish a system for training staff on standard procedures and regularly updating SOPs.
- Expand DPU Emergency Operations Manual to include scenario and process-specific actions plant staff across the entire WTP should take during emergency events.

The following actions are recommended for implementation over several years given the time or financial implications of the recommendations.

- Review staffing plans and consider the addition of a float operator to each shift, so that typical staffing is four (4) operators per shift. If there is an issue getting coverage for an operator that needs a day off, there are always a minimum of three (3) operators.
- Raise as many critical electrical systems above the plant basements as practical.
- Provide an automatic transfer system for the existing back-up generator system (understood to be included as part of a current capital project).

AFTER-ACTION REVIEW PRELIMINARY FINDINGS

1. Introduction

HNTB was contracted by the City of Richmond to perform an after-action review of the events at the Richmond Department of Public Utilities (DPU) Water Treatment Plant (WTP) on January 5 and January 6, 2025, that led to a loss of water service for residents across the region. The purpose of this report is to summarize the initial phase of the after-action review.

2. Investigation Process to Date

For this phase of the after-action review HNTB made a site visit, conducted staff interviews, reviewed available records and data, and reviewed additional, publicly available information.

HNTB was on site at the DPU's WTP Monday, January 27, 2025, through Wednesday, January 29, 2025. HNTB was joined on site by three (3) representatives from the Virginia Department of Health (VDH) Office of Drinking Water (ODW): Bailey Davis, Chief of Field Operations, Jane Nunn, Compliance and Enforcement, and James Reynolds, Richmond Field Office.

After arriving on site Monday, HNTB was given a tour of the facility by Doug Towne, Plant Operations Superintendent, and Leroy Rice, Plant Operations Supervisor, Senior. While on site HNTB interviewed the following DPU staff and VDH staff were also present for all interviews:

1. Kenny Weeks, Program and Operations Manager
2. Arnie Eberly, Program and Operations Supervisor
3. Matt (Evans) Brizendine, Utility Plant Specialist Supervisor – Electrical
4. Victor Fischer, Plant Operator
5. Leroy Rice, Plant Operations Supervisor, Senior
6. Doug Towne, Plant Operations Superintendent
7. Eric Whitehurst, Deputy Department Director, Senior
8. Demario Roache, Utility Plant Specialist – I&C
9. Oral Gardner, Utility Plant Specialist – Mechanical
10. Logan Roach, Plant Operator
11. Charles Watts, Plant Operations Supervisor
12. Wyatt Cotner, Plant Operator
13. Tom Marsh, Plant Operator
14. Donald Murray, Plant Operator

HNTB also requested and received numerous documents from DPU. DPU has indicated they are working to provide the remaining documents requested and additional documents may be requested in the future to complete the after-action review.

3. Water Treatment Plant Overview

A brief overview of the WTP is included for reference in other sections of the preliminary findings. The WTP has a rated capacity of 132 million gallons per day (MGD) and consists of two interconnected treatment trains, Plant 1 built in 1924, and Plant 2 built in 1950, which are shown in **Figure 1.** The WTP typically treats 50 to 75 MGD.

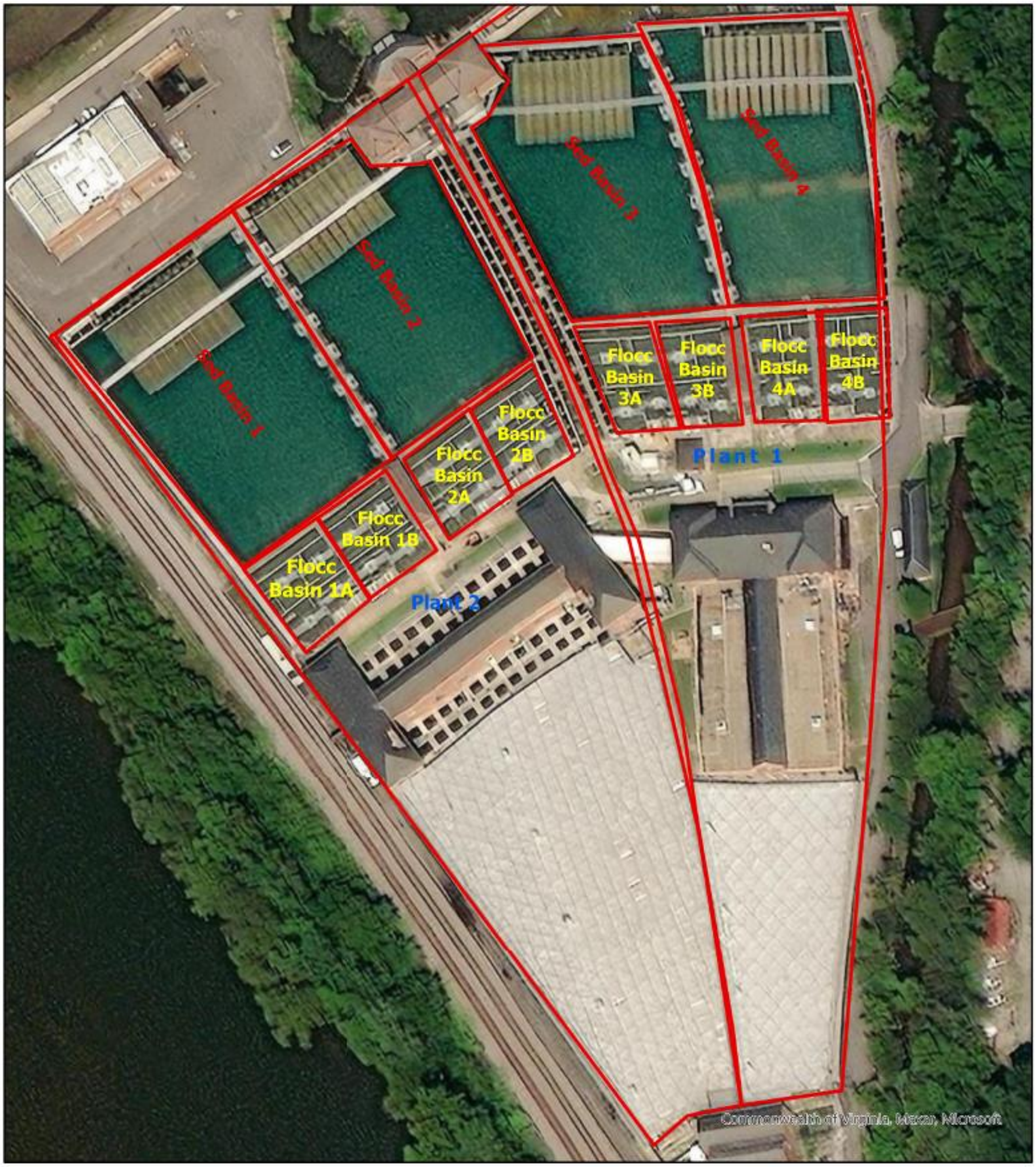

Figure 1. WTP Overview[1]

3.1. Water Treatment Plant Process

The following terms are used throughout the description of the WTP and upset events and are defined here for reference. Note: There are many other systems, subsystems, equipment and controls not specifically mentioned here because they are not in the direct path of flow from raw to

[1] U.S. Environmental Protection Agency. (2022). *Safe Drinking Water Act Compliance Inspection Report*

finished water or related to the events being reviewed.

- Low service pumps: pump water from the raw water basin to raw water channels that flow to the flocculation basins.
- Raw water channels: channels in which polymer and alum are mixed with the raw water to start the coagulation and flocculation processes needed to settle out as many solids as possible.
- Flocculation basins: tanks that provide gentle mixing of the raw water to continue the flocculation process and settle out as many solids as possible.
- Sedimentation basins: large tanks that provide large cross-sectional volume, which allows the water to slow down and become less turbulent. As the water becomes less turbulent, solids start to settle out, leaving only smaller, lighter non-settleable solids suspended in the water.
- Filter influent gates: open and close to allow or stop the flow of water into the filters (these gates are manually operated).
- Filters: tanks with filter media that removes the non-settled, non-soluble solids from the water.
- Filter effluent valves: open and close to control the flow of water from the filters to the clearwells (these valves are typically automatically operated).
- Clearwells: water storage structures below the filters that hold water to be used in the backwash cycle to clean the filters or pumped to the finished water basins.
- Filter effluent pumps: pump water from the clearwells to the finished water basins.
- Finished water basins: water is stored until pumped into the distribution system for customer use.

Under normal operation WTP flow is lifted by four (4) low service pumps to then flow by gravity through two (2) raw water channels, eight (8) flocculation basins, four (4) sedimentation basins, and 22 filters, ten (10) in Plant 1 and twelve (12) in Plant 2. Lower flow rates can pass through those treatment steps entirely by gravity if the James River level is high enough. Filtered water enters clearwells under the filters in each plant. The filtered water is pumped from the clearwells to finished water basins and is then pumped to distribution. A flow diagram for the WTP is shown in **Figure 2**.

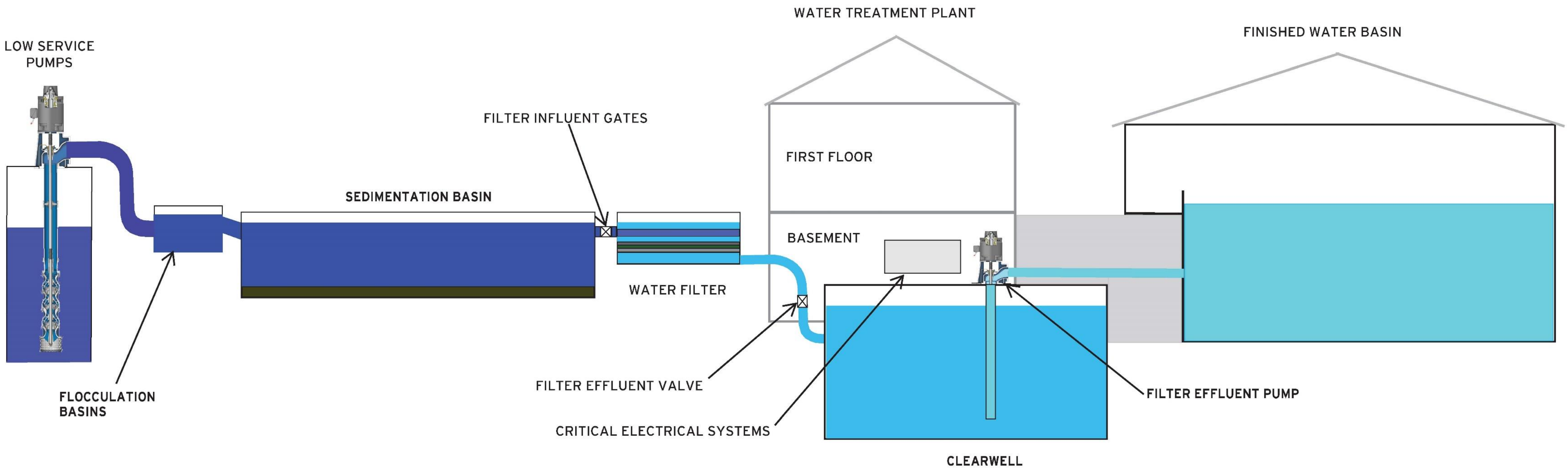

Figure 2. WTP Flow Diagram

3.2. Water Treatment Plant Power

The following electrical and control terms are used throughout the description of the upset event and are defined here for reference. Note: HNTB requested electrical drawings, switchgear drawings, and switchgear operation & maintenance, but not all of these documents have been received. The descriptions herein are based upon staff interviews and HNTB's experience and understanding of similar equipment and may be revised in future after-action review documents.

- Main Feeder: the plant may be powered from two (2) main power suppliers labelled as Main Feeder 1 and Main Feeder 2. Power flows from Dominion Energy through either Main Feeder 1 or Main Feeder 2 to Switchgear SG 6.

- Backup Generator: diesel-fueled engines that generate back-up power for the WTP. A tertiary backup generator system that was installed to provide back-up power to Switchgear SG 6 if a hurricane or other natural disaster causes widespread power line failures that would result in the plant not having access to either of the two electric utility power feeds for a long duration of time. The system was installed in response to a hurricane that left the plant without power for several days. The generator system is currently manually operated, but there is a capital project in process that will automate start-up of and transfer to the generator system.

- Switchgear SG 6: a series of control cabinets designed to act like large light switches to turn on and off power to electrically protect the plant and to switch over to auxiliary/backup power during a loss of power from the electric utility. SG 6 contains Bus Tie (or Automatic Transfer Switch (ATS)) designed to switch power from Main Feeder 1 to Main Feeder 2 or from Main Feeder 2 to Main Feeder 1, if either power source loses power. There is also manual transfer switch to transfer power from the generator system to the WTP. Power flows from SG 6 to SG 7.

- Switchgear SG 7: a duplicate circuit of SG 6, which connects power from SG 6 to the WTP via switchboards, electrical panels, Motor Control Centers (MCC), and other power distribution panels and devices.

- SCADA: Supervisory Control and Data Acquisition (SCADA), which is a type of automation and control system that the plant operators use to collect data on how the WTP is operating and to control how the WTP processes are adjusted and operated.

- Electric Valve Actuator: electrical motor used to remotely operate a valve.

- UPS: Uninterruptable Power Supply (UPS) which utilizes batteries to store energy and provide back-up power for connected systems.

- Agastat Relay: electromechanical time delay relay inside the Bus Tie Cabinet (part of the switchgear). The Agastat Relay closes the bus tie switch between sides 1 and 2 of the switchgear, after the power has been off for the set amount of time.

- Relay: a type of electromechanical switch used to turn power off and on.

- ATS: Automatic Transfer Switch (ATS) and is another way of describing the Bus Tie Cabinet function. When there is a power supply failure, the ATS automatically switches over to backup power supply.

- Switch: for the purposes of this document, switch refers to a type of electrical device that is used to open or close an electrical circuit, which turns on and off the power to attached electrical components.

- Summer Mode: refers to the WTP being fed from both incoming power feeders. Allows power from both feeders to flow through each side of the switchgear to different portions of the plant.
- Winter Mode: refers to the WTP being fed from incoming power Main Feeder 1. This allows the entire WTP to be supplied power by Feeder 1 which is less expensive power than Feeder 2. Winter Mode operation was established by DPU over 20 years ago as a cost savings measure during times of the year that power outages from thunderstorms are significantly less frequent. The change to Winter Mode happens after September 30 and the change back to Summer Mode happens by May 30.

3.3. Switchgear SG 6 and SG 7 Operation

Switchgear SG 6 and SG 7 are operated in one of two modes of operation: Summer Mode or Winter Mode. An illustration of Summer Mode in Switchgear SG 6 and SG 7 is shown in **Figure 3** and an illustration of Winter Mode in Switchgear SG 6 and SG 7 is shown in **Figure 4.** Summer Mode mitigates the risk of a complete WTP power outage when one (1) of the Main Feeders loses power. It also allows the Bus Tie/ATS in SG 7 to act as a spare for the Bust Tie/ATS in SG 6. Winter Mode is utilized to take advantage of less expensive power from Main Feeder 1 but requires the Bus Tie/ATS in SG 6 to operate to restore power to the WTP when Main Feeder 1 loses power. When operating in Winter Mode, the Bus Tie/ATS in SG 6 becomes a singular critical component with no redundancy.

3.4. UPS Operation

The are two (2) primary UPS units that provide backup power to the SCADA system and filter effluent valves. UPS units are typically only provided for critical systems due to cost and sizes are kept to a minimum to mitigate any adverse effects of power outages or fluctuations. Based on staff interviews, it is unclear if the filter effluent valve UPS does what it is intended to do and closes filter effluent valves on loss of power.

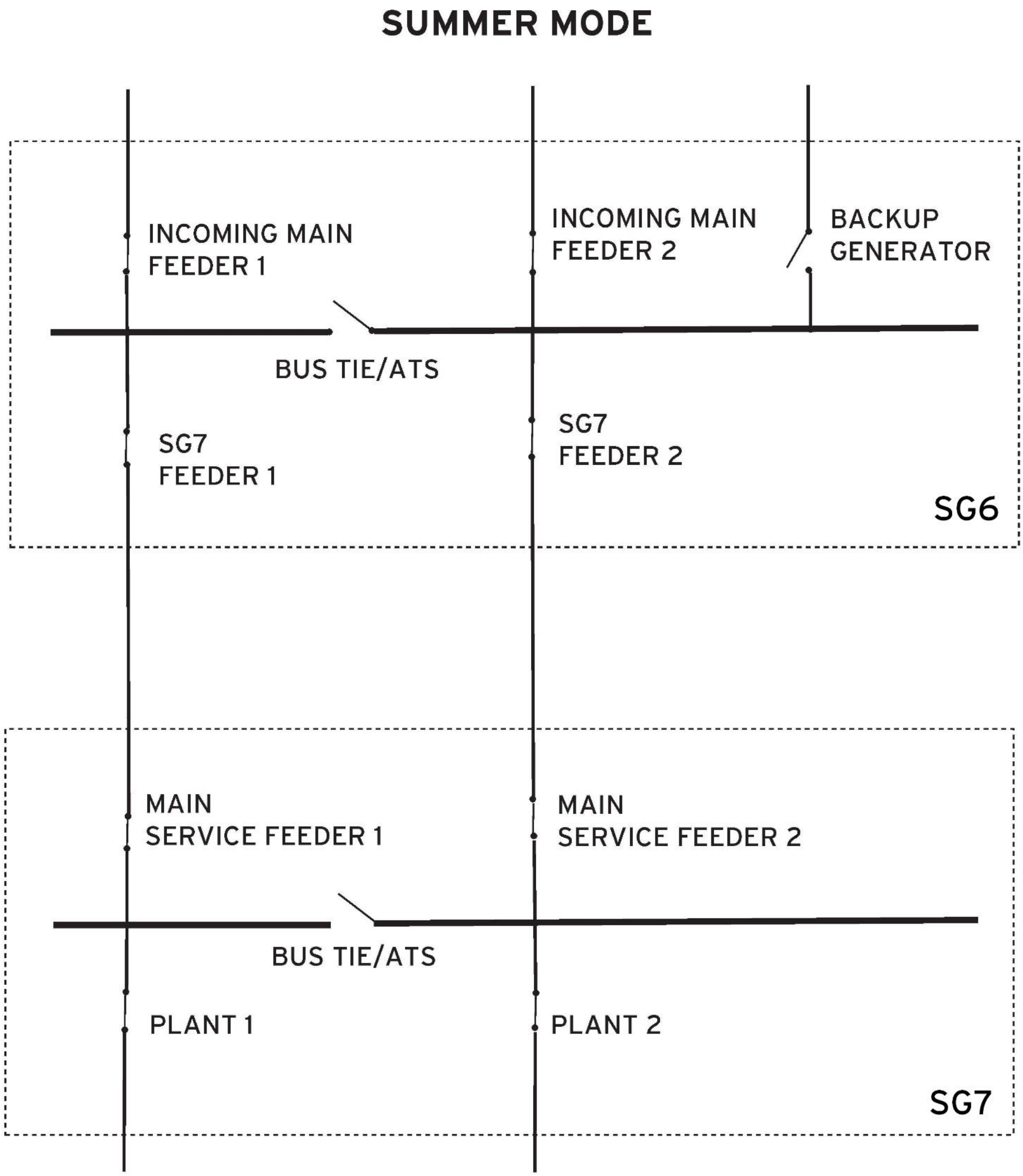

Figure 3. Switchgear SG 6 and SG 7 Summer Mode

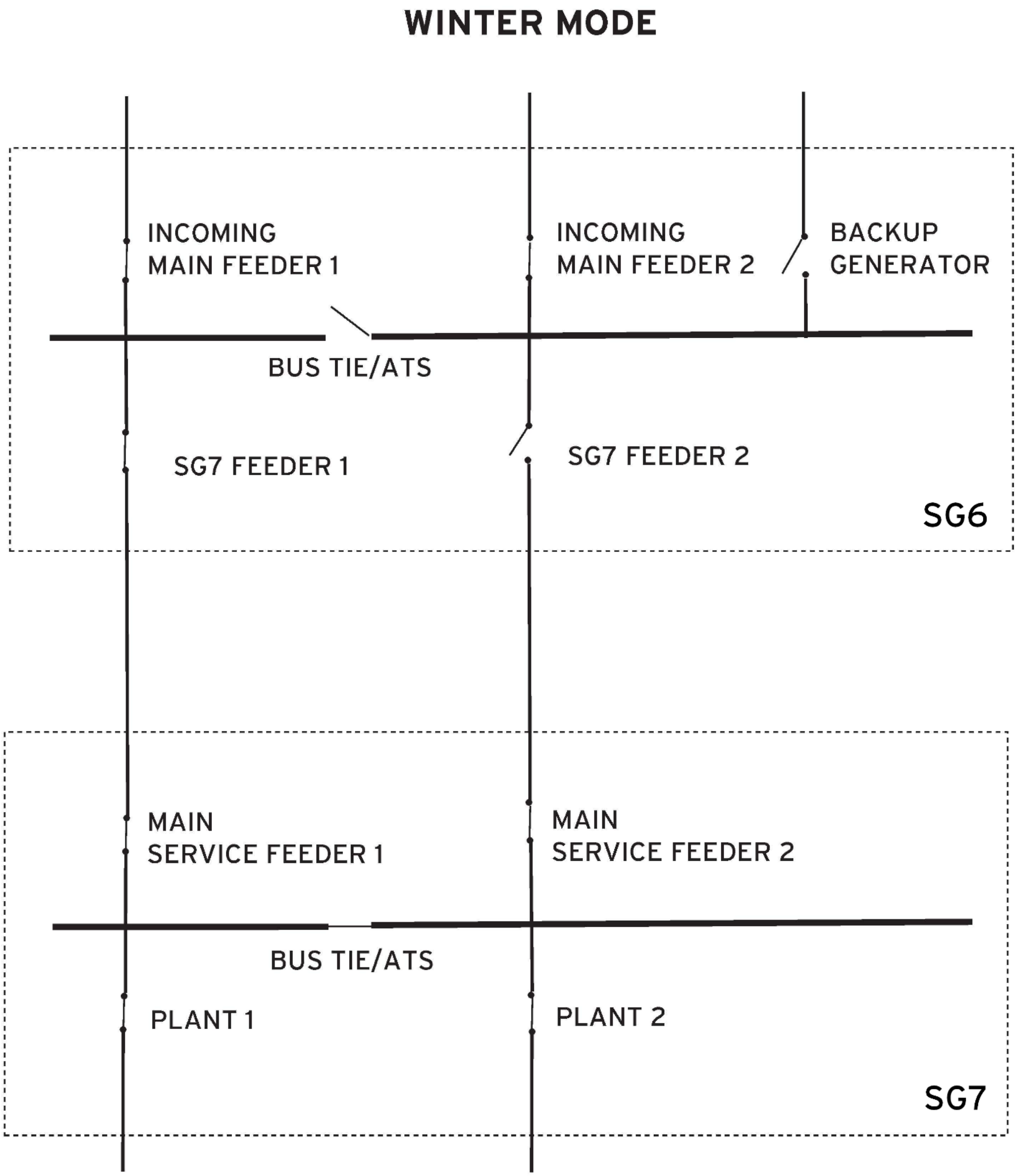

Figure 4. Switchgear SG 6 and SG 7 Winter Mode

4. Event Description

The WTP experienced a complete loss of power in the early morning hours of January 6, 2025. The WTP was operating in Winter Mode. Main Feeder 1 from Dominion Energy went out, likely due to icing from the winter storm occurring at the time. Main Feeder 2 still had power. The Bus Tie/ATS in SG 6 failed to automatically transfer from Main Feeder 1 to Main Feeder 2 and the WTP completely lost power. Without power, operators were not able to close filter effluent valves or turn on filter effluent pumps. The filter effluent valve UPS failed to close the filter effluent valves. With forward flow of water continuing through the filters by gravity, the water level increased in both clearwells until it reached the plant basements with pumps, valve actuators, electrical panels, and other equipment; ultimately reaching over six (6) feet high in both basements. Diesel-fueled pumps were used to pump water out of the basements, but they were not able to pump at the rate required to overcome or even keep up with flow rate of water coming through the filters. The water in the basements damaged equipment which resulted in a complete WTP outage for nearly 36 hours. Power was restored approximately one hour and 20 minutes after it was lost but by that time the water level was several feet high in both basements and equipment was damaged.

5. Timeline

Through information provided by DPU prior to the site visit, staff interviews, and review of SCADA, HNTB compiled the following timeline of events. Additional events may have occurred that are not listed. This timeline is intended to capture the critical items related to the event.

FRIDAY, JANUARY 3, 2025	
	Virginia Governor Glenn Youngkin declares state of emergency in advance of winter storm that will pass through Virginia January 5 and 6.
SUNDAY, JANUARY 5, 2025	
	Richmond Mayor Danny Avula declares state of emergency due to anticipated impact of severe weather.
MONDAY, JANUARY 6, 2025	
4:25 AM	WTP experiences a short power outage (power bump) that only lasts a few seconds. In response to power bump, WTP operators reduce filter effluent flow rate to 1.5 MGD. Finished water pump N3 goes out of service as a result of the power bump.
4:35 AM	WTP operators attempt to restart N3, but it fails to start effectively. Operators then prime finished water pump N1 as a replacement and start it up successfully. Operators then begin a check of critical equipment throughout the WTP. Operators increase filter effluent flow rate to 3.15 MGD once 60 MGD finish flow is reestablished.
5:45 AM	WTP loses power. SCADA system goes down and loses communication with the plant without power. Operators and WTP Mechanical staff that were on hand to help with snow clearing begin priming Godwin dewatering pumps for both Plant 1 and Plant 2. The suction side hose for the Godwin pump for Plant 1 was disconnected from the pump and had to be reconnected, causing a delay in dewatering.
5:50 AM	Operators observe water beginning to rise and flood the basements of both Plant 1 and Plant 2. Operators call WTP Electrical and I&C staff and ask them to come to the WTP to help restore power.
5:55 AM	Operators observe at least 6 feet of water in the pipe gallery (lowest level) in the basements of both Plant 1 and Plant 2.
6:05 AM	Godwin pump for Plant 2 catches prime and begins discharging water from the Plant 2 filter gallery.
6:20 AM	Water was observed spouting from finished water pump N2. The pump was in the process of being rebuilt after repairs, and a cover on N2's discharge check valve casing was not secured. Water levels had reached the bottom stair of the staircase leading down to both basements.

6:30 AM	Electrical supervisor arrives at the WTP, goes to SG 7, and observes no voltage on the meter reader. He then immediately goes to check on SG 6.
6:35 AM	Godwin pump for Plant 1 catches prime after issues with priming and begins discharging water from the Plant 1 filter gallery.
6:40 AM	Electrical supervisor opens SG 6 and observes the main feed is lost and that the bus tie that ties feed 1 to feed 2 together had not closed. An attempt is made to close the breaker using the control handle, but the breaker does not close.
6:45 AM	Electrical supervisor observes the main feeds. Main Feeder 1 is open without power and Main Feeder 2 is closed and has power. Dominion Energy is called and notified that Main Feeder 1 is down.
7:00 AM	Electrical supervisor goes to Main Feeder 1 switch to observe voltage. Phase 1-2 has full voltage (4160V), but Phase 2-3 has 1800V and Phase 3-1 has 2100V. Plant Superintendent notifies DPU Director as well as Chesterfield County and Henrico County plant staff and requests a demand reduction from both systems.
7:05 AM	Electrical supervisor closes the bus tie breaker manually by closing the plunger on the breaker manually. Power is restored to the WTP via Main 2. SCADA regains power but has communication errors. There are 2 sump pumps in the basement of each Plant and an unknown number of sump pumps begin to run once power is restored. Water elevation in the Plant 2 basement has reached the bottom of the MCC panel.
7:30 AM	Dominion Energy arrives on site to evaluate and repair Main Feeder 1.
7:40 AM	Operators manually close the settling basin influent and effluent valves. Operators then work to manually close all of the filter influent valves for the next 30 to 60 minutes.
7:45 AM	Program and Operations Manager calls the WWTP maintenance staff to support and bring pumps to help dewater.
8:00 AM	Dewatering pumps and additional mechanics from WWTP arrive at WTP to support. Maintenance staff work to hook up four 2-inch submersible pumps
8:10 AM	Floodwater continues to rise. Operators and maintenance staff work to confirm that all filter influent valves are completely closed. Once this is completed, water begins to recede in the basement. Dewatering continues throughout the morning and afternoon.
8:30 AM	Dominion Energy restores power to Main 1. The bus tie at SG 1 opens automatically once power is restored.
12:30 PM	Representative from VDH arrives at the WTP and remains on site until the boil water advisory is lifted.
2:30 PM	Plant 2 is mostly dewatered, and WTP staff begin to dry motors, actuators, and other equipment.
4:26 PM	City of Richmond issues a Boil Water Advisory.
4:30 PM	Plant 1 is mostly dewatered. WTP and WWTP staff begin to dry motors, actuators, and other equipment.

6. Staff

Staffing for operations at the WTP typically consists of three (3) operators: a chief operator, Plant 1 operator, and Plant 2 operator. Prior to the event operators were on 12-hour shifts, two (2) shifts per day. After the event operators were on 8-hour shifts, three (3) shifts per day. Operations management, including Operations Supervisor, Senior and Superintendent are typically at the WTP for a typical day shift and on call at all other hours.

Maintenance staff are typically at the WTP for a typical day shift and then rotate call for after-hours maintenance needs. Staff interviewed indicated that maintenance staff may be scheduled at the WTP for additional shifts during storm events. The discipline (i.e. mechanical, electrical, or I&C) and number of maintenance staff scheduled varied based on staff interviews.

Based on staff interviews, there are occasional problems finding coverage when an operator calls in sick or otherwise cannot come in, which can result in the plant being staffed by only two (2) operators.

7. Training

Based on staff interviews, there are no established training procedures or written training manuals at WTP. While on-the-job training is irreplaceable, written training manuals and job descriptions that are updated regularly are critical to ensure every staff member has access to the same information and critical plant knowledge is not lost as staff retire or move on. Written training documents can help new staff learn procedures quickly. AWWA's (American Water Works Association) Utility Management G-Series standards recommend an education or training program to transfer appropriate knowledge, skills, and experience necessary to maintain the competencies of plant personnel to fulfill their tasks and maintain operation at the WTP. AWWA recommends continual assessment of staff skills and knowledge to support the mission of the facility.

Multiple staff members also noted that there was no formal safety training established and that most safety measures were communicated through on-the-job training and reminders. VDH Waterworks Regulations as established in 12VAC5-590-560 require that waterworks owners institute a safety program to inform personnel of known hazards, preventive measures, and emergency procedures pertaining to the operation of the plant.

Appropriate training for both standard operation and emergency operation is critical in allowing staff to effectively respond to emergency situations, such as an extended power outage. Lack of adequate training and written training documents can lead to a lack of awareness of critical actions that need to occur in an emergency event, such as the event that occurred on January 6, 2025.

8. Operating Procedures

Based on staff interviews of WTP operators, electricians, mechanics, and instrumentation specialists, there is a lack of established written Standard Operating Procedures (SOPs) for typical plant operations and for emergency operations. Some operators noted that there are some written SOPs for basic processes, but some are over a decade old and potentially out of date and multiple operators noted that they would not know where to find these SOPs. It is standard practice at waterworks facilities that SOPs are established to ensure staff are consistent in carrying out processes to operate and maintain the WTP while meeting facility and regulatory requirements. AWWA's Utility Management G-Series standards note that developing and regularly updating SOPs for equipment and plant production processes as a best practice for WTP operation.

It is also a standard practice at waterworks facilities to establish an emergency response plan so that staff can understand how to quickly respond to an emergency situation, such as a power outage. AWWA's Utility Management G-Series standards recommend developing, documenting, and maintaining SOPs specific to emergency preparedness, noting that scenario-specific response actions should be a part of these SOPs. Richmond DPU does have an Emergency Operations Manual that was last updated in 2021, but a physical copy of this manual was not available at the WTP prior to or during the events on January 6, 2025. This plan also lacks facility and process-specific actions that operators of the WTP would need to take in the event of a power outage, which is common of waterworks of DPU's size. Staff also noted that they had never been involved in any tabletop exercises to simulate a response to emergency situations.

Virginia Department of Health Waterworks Regulations as established in 12VAC5-590-505 require that community water works shall develop and maintain an emergency management plan for extended power outages and that the plan be kept current and readily accessible in the event of a power outage. Without awareness of the location or contents of the emergency management plan, staff will not be equipped to take the necessary actions to respond in the event of an emergency.

9. Preliminary Recommendations

The step in the WTP process where water is pumped from the clearwells to the finished water basins is a limiting factor in the operation of the WTP. If either the flow is continually pumped out or the flow into the clearwells is not stopped quickly, there is a high risk of the water level rising in the basement. Maintaining power to at least the filter effluent valves is critical to ensuring that the water level does not rise from the clearwells into the basements and damage equipment.

Immediate Recommendations

The following actions are recommended for immediate implementation. Additional recommendations will be developed as HNTB continues the after-action review.

- Operate the WTP in Summer Mode all the time or at least during storm events that have risks of power outages.
- Develop a Bus Tie/ATS failure plan, train all electrical staff on the plan, and post the plan on each Bus Tie cabinet (SG 6 and SG 7).
- Review staffing plans and consider staffing the WTP with mechanical and electrical staff during storm events that have risks of power outages. If staffing at this level is not feasible, at minimum implement all other recommendations and develop severe storm event response protocol with requirement that maintenance staff on call during storm events can respond in 30 minutes or less.
- Provide a filter effluent valve UPS with a parallel duplicate back-up UPS, both with minimum runtime of one (1) hour, and ensure that both function as intended to close all filter effluent valves on loss of power.
- Install a SCADA UPS with a longer runtime, a minimum of one (1) hour.
    - Provided all other recommendations are implemented, one (1) hour of runtime for all UPS units would be sufficient under normal operating conditions. However, consideration should also be given to providing UPS units with longer runtime based on the outage that occurred during this incident, which was an hour and twenty minutes, or 1.3 hours. An additional buffer of 50-percent additional runtime should also be considered for the SCADA UPS as well, which would provide two (2) hours of runtime.
- Develop written SOPs for plant operation with the input of plant staff. Then, establish a system for training staff on standard procedures and regularly updating SOPs.
- Expand DPU Emergency Operations Manual to include scenario and process-specific actions plant staff across the entire WTP should take during emergency events.

Long-Term Recommendations

The following actions are recommended for implementation over several years given the time or financial implications of the recommendations. Additional recommendations will be developed as HNTB continues the after-action review.

- Review staffing plans and consider the addition of a float operator to each shift, so that typical staffing is four (4) operators per shift. If there is an issue getting coverage for an operator that needs a day off, there are always a minimum of three (3) operators.

- Raise as many critical electrical systems above the plant basements as practical.
- Provide an automatic transfer system for the existing back-up generator system (understood to be included as part of a current capital project).