Germantown Water Crisis
July 2023

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Executive Summary

This report contains a summary of a series of events which led to the contamination of the Germantown water supply in July 2023. The investigation looked into factors which caused the contamination, the city's efforts to restore water service, and the city's communications with businesses and residents throughout the crisis.

On July 18, 2023, heavy storms downed trees and caused damage across Germantown and Shelby County. Damage resulting from the storm knocked out electrical power across most of Germantown, including the City's two water treatment plants which supply drinking water to the entire city. The loss of electrical power set in motion a series of events whose timing and circumstances resulted in a water contamination emergency lasting for over eight days.

On July 18th at 6:40 PM, the Southern Avenue Water Plant switched to emergency generator power to operate the plant and continue to supply water to the community. On the following day, electrical power was restored to most of the city. However, there was a problem with the 3-phase service at the Southern Avenue Plant causing the plant to continue to rely on generator supplied power.

On Wednesday, July 19th, a fuel trailer brought diesel fuel to resupply the diesel engine powering the generator. During the refilling of the diesel engine, the city employee filling the engine failed to monitor the refueling process and allowed the tank to overflow onto the ground surrounding the generator. The spilled diesel fuel flowed downhill from the engine and made its way to a collection area adjacent to the main supply line running from the treatment plant to an underground reservoir. A hole caused by a deteriorated iron plug, whose existence was unknown to city employees and consulting engineers, allowed the diesel fuel to enter into the reservoir and then be pumped out to homes across the city.

The city quickly responded with a notice to immediately stop using water for contact uses and consumption. They drained the reservoir and flushed water lines over the next three days, only to find that water samples continued to contain levels of diesel fuel (referred to in tests as diesel range organics). Consultants with detection equipment located the deteriorated plug in the supply line on Monday, July 24th. The line was repaired, and a second effort to flush the system began. On Thursday, July 27th, eight days after the contamination reached the water supply, the water plant and distribution lines tested free of contamination. Homeowners and businesses began the process of flushing all water supply outlets to remove contamination from the home or business. The process of flushing homes and businesses continued for several days depending on individual circumstances.

This report looks at Germantown's emergency preparedness before the water crisis, the actions taken after the contamination occurred, including the process of identifying how the spilled diesel fuel found its way into the water system, and suggests opportunities to rethink crisis communications and ways to capitalize on lessons learned.

Introduction

I was asked to conduct a review of the July 2023 water contamination emergency to assist the City of Germantown in determining if improvements are needed in the City's operating procedures and emergency operations planning and processes.

Specifically, I was asked to:

- fully review the emergency operational component of managing the crisis from inception to conclusion,
- review the City's communications efforts throughout the crisis, and
- make recommendations for any improvements needed in any department or in any element of the emergency response effort.

The entire event from the accidental fuel spill to full recovery efforts has been investigated. The report begins with an explanation of the City's water system operations and a full explanation of the accidental contamination. Interviews were conducted with employees involved in the emergency response that followed the contamination accident. All employees who had leadership responsibility during the event and the employees who work at the Southern Avenue Water Plant were interviewed for this report.

Representatives of Tennessee Department of Environment and Conservation (TDEC), Ensafe, and A2H Engineering were also interviewed. Members of both the business and residential communities were interviewed to understand the impact of the contamination on businesses and homeowners. In the business community, interviews were conducted with representatives from the medical community including Methodist Hospital, Campbell Clinic, and others. Discussions were also held with restaurant owners and operators, retailers, and other small businesses who were impacted.

The facts in this case are well documented in records by the City. This report contains summaries of the incident and actions taken by the City. Every effort has been made to accurately reflect the history of the events. If there are errors in this report, they should not be construed to replace the records kept by the City. The report also avoids any analysis or commentary on the chemistry of the contamination, the level of tests conducted, analysis of test results, or impacts on public health. Those topics have been addressed by competent professionals with relevant expertise and experience. The primary focus of this report is an analysis of the actions taken by the City to find opportunities for improvement and to reduce the chances of a similar event in the future.

This report is not intended to apportion blame, nor to assess individual or collective responsibility. The sole objective of this report is to draw lessons from the occurrence which may help prevent future accidents or incidents.

Municipal Water Systems

Municipal water systems consist of four major components:

1. wells and pumps which pump water from the underground aquifer (sometimes from rivers and lakes),
2. treatment plants which purify the water for consumption,
3. storage reservoirs and elevated tanks for meeting peak demands, and
4. a system of underground pipes which deliver water to homes and businesses.

Most municipal water systems across the United States rely on surface water for the majority if not all of their water supply. Surface water, just as it sounds, means water comes from rivers and lakes. The Memphis area is blessed with an abundant supply of underground water stored in the Memphis Sand Aquifer. It is one of the purest bodies of water in North America and in the world.

The Memphis Sand aquifer is a freshwater aquifer that sits hundreds of feet underground. According to the University of Memphis Center for Applied Earth Science and Engineering Research (CAESER), most of the drinking water in the Memphis area is around 2,000 years old. The USGS reports that the aquifer covers some 7,400 square miles.

The City of Germantown has two water plants, the Johnson Road Plant and the Southern Avenue Water plant, that supply water to a total of 14,505 customers throughout the city. Water wells in Germantown pump from a depth of 300 to 600 feet. Water making its way down into the aquifer from that depth has been on a journey taking up to 500 years. Memphis is the largest city in the United States to rely 100% on aquifer water. Likewise, Germantown's water supply is 100% from the Memphis Sand Aquifer.

City of Germantown's Water System

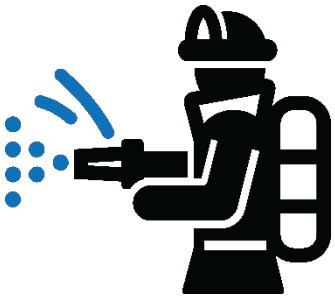
The Germantown Municipal water system consists of two water treatment plants: The Southern Avenue Plant and the Johnson Road Plant. "Water Plant" is the term commonly used to refer to the entirety of the infrastructure which makes up the wells, treatment, and storage of treated water. Actually, each of those components could be located separate from each other. It is a benefit to have all of the three components in close proximity to each other.

The Southern Avenue Plant consists of the treatment facility, two underground storage tanks or reservoirs (referred to throughout the report as the east reservoir and west reservoir), an elevated storage tank, and ten wells located in the general vicinity of the plant. This plant is

capable of treating and delivering 12 million gallons of water per day if needed. On an average day, the plant treats and delivers approximately 6 million gallons per day.

The Johnson Road Plant consists of well pumps, a treatment facility, an underground storage tank, or reservoir, and a recently completed elevated storage tank near Forest Hill Irene Road and Poplar Pike.

In general, the Johnson Road Plant supplies water to the easternmost side of Germantown and the Southern Avenue plant supplies water to the western side of the city. That is an oversimplification because the network of water mains are interconnected. The only segregation that occurs is due to the pressures supplied by the plants which work outward from the plant and the customer demands across the system.



Besides the obvious function of supplying clean water for daily lives, water plants also provide water for fire suppression. There must be an abundant supply of water along with significant pressure in order to deliver mass quantities of water to extinguish fires. Elevated storage tanks provide storage benefits, but they are more important for supplying static pressure throughout the city. Without elevated tanks, high pressure pumps would be required to pump from underground storage tanks and supply the needed pressure for customer needs and fire suppression. Water pressures remain very consistent due to the elevated water in the overhead storage tanks. Water pressure averages 60 pounds per square inch (psi). Water systems are required to maintain a minimum pressure of 20 psi at all times.

Water systems are designed to deliver water when it's needed. Water consumption follows the daily routines of homeowners and businesses. Water plants and distribution systems are designed to deliver high volumes of water in the early morning hours when homeowners are starting their day, and then again in the early evening hours when families are preparing meals, showering, and ending their day. In summer months, irrigation increases the peak demands. The vast majority of water is used in the morning and early evening hours. Water plants are designed to be able to meet these peak demand periods and still be able to supply the volume and pressure needed to fight fires.

Oversight and Regulatory Environment

The Tennessee Department of Environment and Conservation (TDEC) is responsible for managing and protecting the state's natural resources. The Division of Water Resources within TDEC focuses on surface water, ground water, and drinking water. The Division has general supervision over construction and operation of public works systems and is authorized to adopt and enforce regulations governing operation and maintenance of these facilities.

Water system operators must meet the requirements of the Federal Safe Drinking Water Act with respect to water quality and information reporting. The Environmental Protection Agency

(EPA) has delegated responsibility for enforcement oversight of the Safe Drinking Water Act to TDEC.

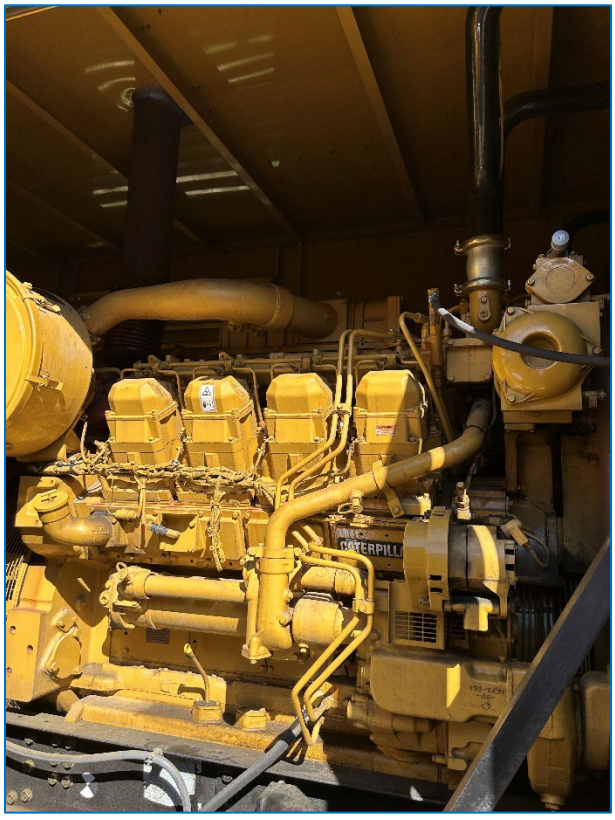
Water systems the size of Germantown's are tested at least 50 times per month for quality standards. All samples are reported to TDEC, Division of Water Resources. The City's water supply is required to maintain the quality standards as set forth by the EPA and TDEC.

TDEC headquarters are located in Nashville with field offices throughout the state. The TDEC local field office is located in Bartlett.

Event Summary

On Tuesday, July 18th, heavy storms knocked out electrical power to areas across Shelby County. Approximately 130,000 MLGW customers were without power. Most City of Germantown facilities lost power due to the storm damage and switched to backup emergency generators to provide power. Both water plants lost electricity and switched to emergency generator power.

The Southern Avenue Water Plant emergency generator began powering the plant at 6:40 PM on July 18th when electric power was interrupted.

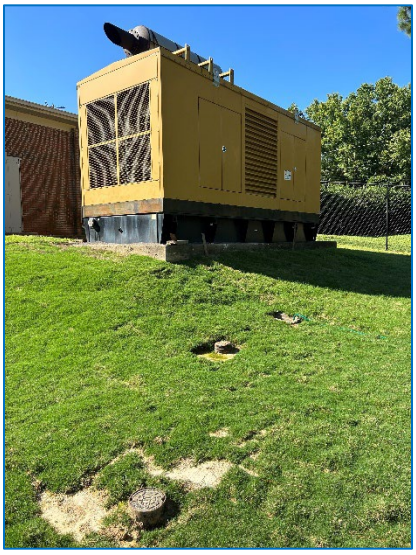


Diesel Engine powering Southern Avenue Plant

The Southern Avenue Plant generator is capable of producing 480 volts at 60 Hz. It is powered by a Caterpillar brand diesel engine producing up to 2,000 horsepower. The engine consumes 54.6 gallons of diesel fuel per hour running at 75% capacity. It holds 58 gallons of oil. Emergency power is essential to maintaining water service to homes and businesses and in maintaining adequate supply and pressure for fire suppression.

By Wednesday, July 19th, electric power had been restored to most of the City. However, there was a problem with three phase electrical power to the Southern Avenue water plant. The emergency generator continued to power the plant until Friday, July 21st at 10:15 AM. The Southern Avenue Plant operated solely on generator power from Tuesday, July 18th at 6:40 PM through Friday, July 21st, at 10:15 AM.

On Wednesday, July 19th, a Fleet Services employee refilled the generator fuel tank at the Southern Avenue Plant. The fuel tank is located underneath the diesel engine that powers the generator. The fuel tank has a capacity of 1,750 gallons, enough fuel to run the generator uninterrupted for up to four days. During the refilling of the tank, the employee failed to maintain line-of-sight vision to the generator. When the tank reached capacity, the fuel fill valve did not automatically trip off as it was designed to do. Consequently, (according to a later investigation conducted by the City) 250 to 300 gallons of diesel fuel overflowed from the fuel tank onto the ground surrounding the generator. The employee shut off the fuel but did not report that fuel had spilled onto the ground. The spill would not be known to other City personnel until Thursday afternoon, July 20th.



Generator at Southern Avenue Plant

On Thursday morning, July 20th, at approximately 9:10 AM, the City received the first call reporting an odor similar to the smell of kerosene or diesel fuel in their water. Throughout the afternoon more calls were reported. Thirty-four calls were received on Thursday, July 20th.

The City sent employees to the areas where the complaints originated to look for any signs of system problems and indications of contamination in the water supply. Employees also began checking areas around both water plants for signs of a problem. At approximately 2:45 PM, employees discovered an area on the ground around the Southern Avenue Plant generator smelling of diesel fuel.

Employees immediately began to dig a trench around the area that appeared contaminated to contain the spill and prevent migration. Employees also began checking the diesel engine for potential fuel leaks. At the time, the most obvious or logical cause was suspected to be either a fuel line leak on the engine, or a leak in the fuel tank.

Other employees followed what they thought would be the natural flow away from the generator to an access entry hatch located at the southeast corner of the east reservoir. They then opened the entry hatch and discovered an oily film floating on the surface of the water in the east reservoir.

After having investigated complaints at locations around the city, it was clear that diesel fuel had reached the network of water mains. Even though some parts of the city appeared unaffected because the water system is interconnected, City leaders felt it should be assumed contamination could be present across the entire water supply. At 3:30 PM a city-wide notice was issued to alert the entire community to stop using water for any form of contact immediately. Water should only be used for toilet flushing.

With the discovery of the contamination, Germantown went into Emergency Operations Center management protocol establishing an Emergency Operations Command Center and calling

employees to work around the clock. A State of Emergency was put in place by Mayor Mike Palazzolo at approximately 3:30 PM on Thursday, July 20th.

Equipment was brought to the site to remove contaminated soil around the generator. The removed dirt was taken to a storage bay at the Public Works complex. Crews removed what they thought was all of the contaminated soils.

It would later be discovered, with the assistance of detection equipment, that the diesel fuel had migrated to the area between the treatment plant and the reservoir. The additional contaminated area would not be discovered until Monday July 24th.

Even with the discovery of the diesel contamination on the ground and in the reservoir, it was still unclear how the diesel found its way into the east reservoir. The water system is a closed system. All of the water infrastructure in the immediate vicinity is located underground and is fully enclosed.

It was initially assumed diesel fuel had entered the east reservoir through an entry hatch. An investigation couldn't reveal how the diesel fuel could have made its way into the entry hatch, but with no other visible signs, it was assumed the access hatch was the entry point. The actual point of entry into the reservoir was later found to be a small hole, about an inch and a half in diameter, in the supply line between the treatment plant and the underground reservoir. This water line is made of ductile iron and is 24 inches in diameter, located several feet underground. However, this hole would not be found until Monday afternoon, July 24th.

Entry Hatch – East Reservoir

With any environmental contamination, municipalities are required to report incidents to the proper regulatory authorities. The City immediately notified TDEC, EPA, and the Shelby County Health Department.

With the source of contamination presumed contained, the City began efforts to remove the residual diesel fuel from all parts of the system. Accepted methods of removing contaminated water from the water system infrastructure depends on the chemical structure of the contaminant. In the case of diesel fuel, the only method of remediation is to remove all of the contaminated water from the system. The process started with removing water from the reservoir. It was the reservoir water that was contaminated, not ground water entering the plant, so the process was simply to drain the reservoir, clean the inside of the reservoir, then refill the reservoir with clean contaminant-free water.

With clean water in the reservoir and water tower, distribution lines could be flushed to remove the contaminated water from the City's water mains. City workers would open fire hydrants and flush water out of the mains. Then water samples from the flushed mains would be tested to ensure that no contaminants remained. Test results would have to be sent to TDEC to get their approval of the test results and authorization to allow flushing of private lines. Once all the mains and distribution lines were certified clear of contaminants, with TDEC's approval, the City could notify homeowners and businesses to flush water through all of their water systems. To flush water from the home or business, it meant opening every water outlet. Homeowners had to identify every water fixture and every source of water flowing through the home, including water heaters, refrigerators, icemakers, showers, washing machines, etc. Any water filters located within lines had to be replaced to remove contaminants that could be trapped in the filters.

That was the intended plan of action. City officials consulted with TDEC to obtain approval of the remediation plan. The City began Thursday night, with TDEC approval, draining water from the Southern Avenue reservoirs. The City had one pump on site. Two pumps were rented to speed up the process, but it was still a time-consuming effort. It wasn't until approximately 1:30 AM, Friday morning, that the water level in the east reservoir was down to about two feet deep, but low enough for contractors to enter the reservoir and begin remediation and clean-up efforts.

The City turned to Hepaco Environmental Company for advice and assistance with clean-up and remediation. Hepaco employees entered the eastern reservoir to clean and treat the reservoir of any remaining diesel fuel residuals. Hepaco applied a neutralizing agent to the inside of the east reservoir. The pumps were not able to lower the water level of the west reservoir to a point low enough to enter. Pumping took place throughout the night and as morning approached the water levels had to be adequate for early morning demands. Without enough time to lower the water level in the west reservoir, the neutralizing agent was poured into the west reservoir and mixed by agitating it through pumping action.

Hopeful that the reservoir had been cleaned and free from contamination, the City began refilling the reservoir and flushing water lines. Flushing of lines took place around the clock Friday, Saturday, and Sunday. As flushing occurred, water samples were taken and tested. Samples were also taken from both reservoirs at the Southern Avenue Plant. Test results from Friday, Saturday, and Sunday samples continued to show detected levels of contamination both at points in the system and at the reservoir. The City continued to keep water use restrictions in place.

Friday and Saturday test results showed a decrease in contamination levels. In an effort to plan for the best result but prepare for the worst, the city contacted Ensafe Saturday evening. When test results on Sunday showed an increase in contamination levels, again the city contacted Ensafe. By Monday, July 24th, the City had completed an investigation of the fuel spill and now fully understood the scope of the diesel fuel spill. Ensafe arrived on site with equipment to test the soils around the spill area to ensure that all contaminated soils were accounted for and properly treated. It was through Ensafe's detection equipment that additional soil

contamination was found and traced to an area collecting around a small hole in the water line entering into the east reservoir.

Even though the reservoir had been drained and treated, diesel contamination had continued to seep into the small hole in the water line supplying treated water to the reservoir and continued to contaminate the water supply. The line was repaired, and contamination of the reservoir was finally abated. Testing around the area showed no other signs of contaminated soils.

Late Monday evening and throughout the night, the process of clearing the reservoir and flushing water lines began all over again. It was Wednesday, July 26th when the City and its regulatory partners agreed that water sampling results were clear and flushing of lines could begin again with confidence that there was no further contamination at the water plant. On Wednesday, the City's water mains were flushed in a systematic fashion to flow clean water out away from the plant and into the extremities of the city network. On Thursday, July 27th, residents and businesses were asked to begin flushing lines throughout their homes and businesses.

In the days that followed, City staff continued to take and test water samples across the city, and directly from homes and businesses. Complaints of odor and water quality continued for several days, showing a gradual decline over the following weeks.

Review of the Emergency Response

Following an emergency or crisis event, we always look back and question ourselves and the actions of our team. How well prepared were we? How well did we execute?

Preparedness

I interviewed the employees involved in the emergency response, and the Incident Commander and Emergency Management Director. I conducted a review of the timeline of events and actions at each interval, and the City's emergency response preparations and the Utility Department's emergency response plan.

How well prepared was Germantown? Prior to the event, I believe most other jurisdictions familiar with Germantown, including other cities, emergency management agencies, and State agencies would have believed Germantown was better prepared and better poised to handle an emergency of this type than most other cities in the state.

Germantown conducts extensive emergency management plans and exercises. Across all departments, there are employees with experience in disaster response and recovery. Germantown has a certified Hazardous Materials Response Team (HAZMAT) and has extensive training and experience in hazardous materials containment and clean-up.

In any emergency involving water systems, an important key to successful management and recovery is expertise and knowledge of the operating system. The employees involved in this incident have years of experience in operating the water plant and distribution system. They have extensive knowledge and understanding of the water system, how it operates, the location of critical pieces such as wells, pumps, and control valves. Germantown had critical data about the system, along with Geographic Information Systems (GIS) based maps and coordinates to be able to locate any components that could have been key to the response.

I believe Germantown had the leadership experience and the resources to manage the crisis. Leading up to the crisis, Germantown's emergency planning was "state of the art," meaning emergency preparation followed best practices and lessons learned from jurisdictions all across the country. In the days prior to the emergency, it is doubtful that an independent review of Germantown's emergency planning and preparations would have found opportunities for meaningful improvement.

Execution

Almost universally, every post emergency evaluation reveals that no emergency follows a plan. Emergency Management is about planning for the unexpected. Emergency response is about having the capability to pivot into whatever the emergency requires.

Execution focuses on the response and recovery actions taken to stop the contamination and restore water service. The analysis of the response and recovery effort actually needs to be broken down into two parts: the problem-solving effort and the work required to clear the system of contamination.

Response and Recovery Efforts

Once contamination of this type is in the water system, there is only one method of removing it. Water has to be removed from the system. Water lines have to be flushed with fresh clean water to remove contaminants. Unfortunately, that is a time-consuming process. The amount of flushing required can't be prescribed. It is a process of flushing, testing water quality, and flushing again if necessary. The only way to know if flushing has been successful is water testing. This is also a time-consuming process. Recovery efforts were prisoner to the time it took to flush and test water samples. Germantown personnel worked through the night to clear the reservoir and flush the water mains. Even with the extraordinary effort from the testing lab, given the lag times it took to run lab tests on water samples, it would have been difficult to shorten the flushing and testing function.

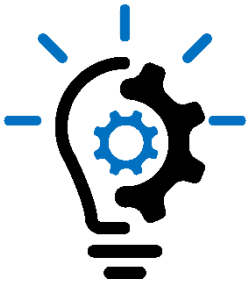
Essentially, the City had to conduct two emergency recovery operations. Germantown crews worked Thursday night through Sunday to clear the reservoirs, flush water mains, and test water samples only to find out that diesel fuel had continued to seep into the reservoir. The actual source of the contamination wasn't found and repaired until Monday, July 24th. Then, the recovery process had to start all over again.

There were two efforts to purge the system of contaminated water. Each process took most of three days to clear the reservoir, flush water mains, and then test for water quality. In either of those processes, it might have been possible to reduce the time it took, but at best the reduction would be measured in a few hours, not days. The reason the remediation lasted 8 days is due to the delay in finding the point of entry into the water system. It took from Thursday afternoon July 20th, when the spill was discovered, until Monday afternoon, July 24th, to locate the actual problem and begin the ultimate recovery process.

The ultimate recovery work started Monday afternoon, and by Wednesday afternoon most of the work was completed. Water quality test results were received on Thursday, and the City's water supply was cleared for use. Homeowners and businesses were able to start flushing their lines Thursday afternoon.

The pivotal point in this emergency response was the length of time it took to locate the hole in the supply line which was the diesel fuel point of entry into the water reservoir.

Problem Solving



The total length of time residents were without potable water was due to problem solving more than execution.

Critics may argue that experienced and well-trained plant operators should have known or had an educated insight that would have revealed the problem sooner. In this case, it may be that knowledge of the system actually hampered discovery of the root cause of the contamination.

City employees were told that the water smelled like kerosene, or diesel fuel. The immediate response was to check the plants for any signs of problems and to flush the system near the homes to get contaminants out of the line. Most complaints about water quality are resolved by flushing the lines. Flushing lines around the location of the complaints was a logical first response and in accordance with industry practices.

When employees discovered a fuel spill on the ground. The first assumption was a fuel line on the diesel engine was leaking. That would have been by far a more logical occurrence than a spill occurring during refueling. Refueling regularly happens without incident. Presented with fuel on the ground and no report of a spill, it seemed logical to look for a leak at the engine first. Employees began by ruling out a leak at the generator but continued to investigate other possible causes.

Knowing that fuel had spilled onto the ground above the reservoir, employees then had to determine how the diesel could have found its way into the water supply. Water supply systems are sealed. The infrastructure downgrade from the generator consisted of an underground reservoir and underground supply lines. It seemed a reasonable assumption that the diesel had to have entered the reservoir through an access hatch. The main entry hatch was assumed to be the point of contamination entering into the reservoir because it was the first logical explanation. It was in line with the suspected ground flow and even though it was sealed, it was assumed that somehow the contamination entered through it.

Perhaps because of their familiarity with the system infrastructure, employees knew that the probability of any other cause of contamination was highly unlikely.

A veteran plant operator or water maintenance worker would normally assume a leaking supply line would present itself in short order. Water lines are normally under pressure. When a line develops even a small fracture, the pressure pushes water out with such force that it usually pushes through the surface in a matter of minutes.

There was no sign of a water leak. The ground around the supply line was not damp. There was no sign of a sinkhole. In the absence of the signs you'd expect to see around a compromised water line, the main entry hatch was assumed to be the point of entry.

Logical problem solving would also point to the fact that test results from Thursday through Saturday with lower concentrations of contamination meant that what the City had done was working, and the problem was close to being solved.

This is not to say that the problem-solving process was defective, it just took time. Even with what seemed a logical cause of the contamination, employees were not fully convinced and continued to look for other causes. As the event went into its third day, employees went back to look for signs of a spill trail in the grass. There was no evidence of damage to the grass leading up to the entry hatch. By Sunday, employees were convinced the contamination had to have entered the system another way. They called Ensafe to bring detection equipment to help track down what they were not able to see on the surface. It was the detection equipment which identified a trail of diesel fuel under the surface leading to a collection area around the water supply line from the treatment plant. The diesel had collected in a void around an old pipe plug which had eroded away leaving a hole about an inch and a half in diameter.

In this problem-solving effort, experienced professionals were guided by their knowledge of the highly unlikely and improbable. Their problem-solving process followed the model of first looking to the logical and probable and then progressing to the unlikely and improbable. The root cause of the problem, a deteriorated plug in a 24-inch supply line, is a highly improbable and unlikely condition no one expected to exist.

After we discover the root cause of a problem, there is a tendency to think someone should have known. But the truth is, we know these things only in retrospect. The phenomenon of making judgements about the past based on knowledge that became available only after the event occurred is referred to as retrospective fallacy. When we look back with the full knowledge of the cause of a failure, event, or disaster, we selectively focus on those events or information that is known to be particularly important in retrospect, that is, after the failure has occurred. Before an event, the information available to the decision makers may not have stood out from dozens or even hundreds of other bits of information presented at the time. To the extent that we retrospectively identify information as particularly important, even though it may not have been thought to have been particularly important by competent people working at the time, we are committing what is called retrospective fallacy. Because we can't "unknow" what we now know, it is difficult if not unfair to look back in judgment of what others should or shouldn't have known.

The intersection of several conditions created what could be called a "Black Swan" event, something that had never happened until it happened. This water contamination crisis happened because several things happened at just the right time and in the right sequence.

1. Power was lost at the Southern Avenue Water Plant. The water plant could not be shut down because water supply was needed for fire suppression. The diesel engine powering the generator needed fuel to keep the plant operational.

2. A fuel spill occurred due to human error and a failure of the fuel shut off mechanism. Had the shut off mechanism functioned properly, the human error would not have mattered. In turn, had the fueling process been responsibly monitored, the shut-off

valve failure wouldn't have mattered. *(Even with the human error, had it been reported immediately with an accurate account of the amount of fuel spilled, the city would have had a chance to contain the spill before it reached the water system.)*

3. The diesel generator was located above grade from the water reservoir and the compromised water supply line. Had the generator been equipped with exterior containment structure, or had the generator been located downhill from the reservoir, the spill would have flowed away from the reservoir. No contamination would have occurred.

4. The water supply line transporting water from the treatment plant to the reservoir had developed a hole caused by a deteriorated plug placed in the line years ago and undocumented on any of the City's plans. If not for the hole in the supply line, the spilled diesel fuel would not have made its way into the water supply. The entry hatch later proved to be water tight.

Timing becomes an important part of the perfect alignment enabling the contamination to occur. If not for the power failure, the generator would not have been in use. Had power been restored to the Southern Avenue Plant at the same time power was restored to the rest of the area, the generator engine would not have been refueled and therefore the fuel spill would not have occurred. Within a few more days or at least within a few weeks, signs of the water leak would have been revealed. The leaking pipe had already begun to blow out a void around the leak. It was only a matter of time until a sinkhole appeared. Sinkholes around water infrastructure is a clear sign of a leak. Maintenance workers would have discovered the leak and repaired it.

As all these elements have become known in retrospect, critics have asked why the generator was located so close to the reservoir, and why wasn't there an automatic shut off on the fueling mechanism? Why wasn't there a catch basin around the generator to contain spills? Why wasn't there someone supervising the employee to make sure the refueling was done properly?

To evaluate whether someone should have known, or whether a person should have acted in a particular manner, the question we have to ask is "whether there was a failure to behave with the standard of care that a person of ordinary prudence would have exercised under the same circumstances."

To determine "standard of care," there has to be a determination of whether technology or generally accepted practices were mature or immature. Maturity of a practice or technology means that the practice has been in existence for such a period of time that design failures have been identified, and techniques for avoiding failures are well known.

The original generator was installed at this location adjacent to the water plant building in 1978. The current generator replaced the original in 2007. It was placed next to the plant to overcome the difficulties of locating the generator some distance from the building it is intended to power. Diesel powered generators are the accepted practice for emergency power and widely used across the nation. Diesel generators can withstand earthquakes and are not

prone to interrupted fuel supply such as natural gas. It is a mature accepted practice with years of experience without incident. The generator stayed at this location for 56 years without incident. At this plant and at this location, it is now known that the location of the generator is a problem. To conclude that it should have been known before the incident is committing a retrospective fallacy.

Before the events of this contamination occurred, there were no signs or warnings that any of the contributing factors were suspect and should be reconsidered. Thus, to say employees should have known is to say that employees who worked the facility daily, and even the regulatory agencies who are responsible for oversight, should have been looking for a black swan; something that was not known to exist at the time.

It may not be important to the analysis of the contamination problem, but I think it is worth pointing out that City employees were in emergency management mode on Tuesday July 18th. The Southern Avenue Water Plant lost power during the storm. The Southern Avenue Plant is especially important to the City's water supply because it supplies water to the elevated water storage tank. Employees worked around the clock on Tuesday and into the day Wednesday to keep the plant operating and to maintain critical water supply levels. The Water Plant employees were working through a water supply crisis for almost 40 hours when the first complaints of odor in the water were received.

Communications Review

Throughout the event, Germantown held press conferences, issued city wide messages, created information videos, held a public meeting with subject matter experts to answer questions, and posted information on the City's website. For complete transparency, the City posted the results of all the water tests conducted at each step along the way. Staff set up webpages to invite the public to ask questions and posted answers for everyone to see. Even with all of those efforts, during interviews with City employees and later with members of the community, one of the first remarks was something to the effect of "we could have done a better job communicating."

The public communications component of the emergency response is one of the most widely commented on and the aspect of the crisis that so many have an opinion of.

Accurate exchange of information in a crisis is critical. It is fundamental to successful crisis management. It is how we make the right decisions. It is how the community prepares and how they protect their families. This subject deserves further review and much more planning focus than is provided in this report. The next emergency will likely be completely different. The emergency response required will be different. It will require different actions and different resources. But the process of exchanging accurate information among emergency responders

and City crews and the process of informing the community will always be much the same. It may vary in scope, but the process will follow the same fundamental patterns.

The report doesn't attempt to analyze whether some of the perceptions with communication were valid or not. Community perceptions were both good and bad and that basically defines the problem with communication. If our message isn't received and understood as we intended, by definition we have a communication problem.

When respondents were asked to explain their opinion about the communication effort, most of the sentences began with, "it seemed like," or "it felt like." That again, is the problem with communication. We would love for it to be transactional. But it is a transaction influenced by emotions, feelings, and attitudes. What we hear is influenced by what we believe, how we feel, and our emotional state at the time.

I don't believe the problems with communication, or the public's perception of communication, had anything to do with a lack of effort on the part of the employees working on the communication effort. The employees involved worked long hours every day throughout the crisis. For a small team, they produced an impressive body of work.

In this case, the demand for information and the need for a rapid response was overwhelming. Consider that Germantown has a population of around 42,000. The entire population was affected. It also affected every business and every employee that works in a Germantown business. Every hospital patient, every clinic patient, and their families were interested stakeholders. It was also a widely publicized news story. Because it involved a municipal water system contamination, and because it was a rare event, there were parties reaching far beyond Germantown's borders monitoring and seeking information.

Analysis

Information is critical in a crisis. Communication is how we gather information. Information is how we make the right decisions. Actually, that sentence should read "accurate information is how we make the right decisions," and therein lies the problem. Communication, both internal and external, is one of the most difficult elements of an emergency response to manage. It is complicated because communication is complicated.

One-on-one interviews revealed several instances where the City's message was misunderstood. With literally thousands of information exchanges throughout the crisis, it is not unexpected, but it is a reminder of the importance of the content and structure of our messages.

As managers, we are forever creating systems. We can engineer a system for public communications, but if we forget the fundamentals of basic communication exchange and understanding, our system will never work. It is vital to have a sound communications strategy for emergency operations. But even more important is the quality of the messaging transmitted

through that communications strategy. Don't forget the importance of clear, coherent, complete messages. Be intentional in your language choices and phrasing. Pay attention to what you are not saying. Your communication strategy must have an editing component to ensure your messages cannot be misunderstood.

A simple framework for a communication strategy is: Be Prepared, Be Responsive, Be Honest.

- **Be Prepared.** Preparation means understanding the breadth and depth of what is required to effectively communicate with a wide range of people, businesses, state and federal agencies, and other entities with a wide range of needs. In an emergency, your customer base explodes. The process of gathering information, disseminating messages, and gathering feedback can be complicated and can require significant resources in each area, depending on the emergency. Being prepared means planning for every possibility, understanding what may be required and translating that into an execution strategy.

- **Be Responsive.** Police, Fire, and recovery workers need rapid access to specific types of information. We understand what they need, and we understand the urgency and importance of timing. We plan for it. We have systems in place to communicate with emergency workers. In the community context, being responsive means understanding what your community needs to know and when they need to know. In an emergency, we have to understand that there are different entities with differing information needs. Being responsive means understanding the community makeup and the types of information each segment needs as well as when they need to know. Schools, churches, hospitals, nursing homes, restaurants, retailers, and homeowners each have differing interests and information needs. To be responsive, emergency plans need to understand those needs.

  On everyone's list of effective communications you'll find some mention of the need to be personable, empathetic, and respectful. If the information we send the community doesn't address their needs, we fail to show understanding, which means we have no empathy, which means we are showing no respect.

  It may be in the digital age that we have forgotten that communication involves a feedback loop. For communication to occur, information has to be received and we have to confirm that it was understood as it was intended. The framework doesn't change in a crisis, it just moves faster, and it takes a lot of resources to get it right.

  The need to be responsive means we have to constantly monitor the community's needs, which is why a feedback loop is vital. A communications strategy must place an emphasis on the feedback loop.

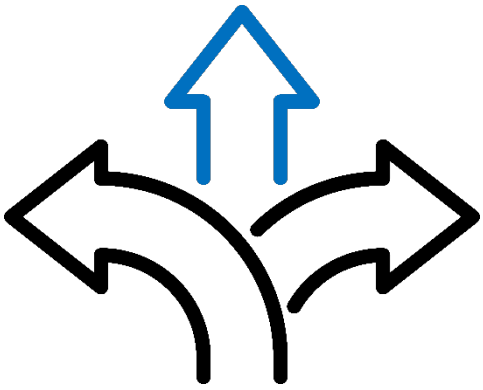
  The ability to be responsive also overlaps with being prepared. It takes resources to be responsive. There is no value in a communications strategy, without the people, technology, and resources to execute.

- **Be Honest.** If the message is to be believed, we have to trust the messenger. If the community doesn't believe the message, we haven't communicated.

  In a crisis, rumors and misinformation run rampant. The community needs to be able to depend on the City for accurate information. The City should be the one place everyone turns to for the truth. In the drive to be the source for accurate information, leadership has a natural predisposition to report only the known and verified facts. We criticize officials when we learn that information they released turned out to be wrong. It takes courage to tell the world about the chaotic and messy process of shifting through and trying to validate the accuracy of hundreds or thousands of bits of information. But that's what happens in an emergency. Most of the information we have in the early hours of an emergency is imperfect. Over and over again we've learned that what we believed in the first few hours, sometimes days, of an emergency was later proven to be inaccurate. In a world where cell phone videos on social media sites are reporting events live, today's community expects to be brought along throughout the process of working through problems.

  To be transparent, we have to explain what we know, what we don't know and what we are doing to find out.

Crisis Communication Strategies



The Communications team needs a member directly connected to the EOC. The Public Information Officer should be embedded with the decision makers and current with every aspect of the emergency response. Direct involvement is critical to be able to effectively provide the types of information the community needs.

A communications structure should be formed around crafting messages, editing, and ensuring accuracy, and ease of understanding, an architecture of message dissemination, and an architecture of information gathering which includes all those things needed to be responsive.

Germantown operates with a staff of four within the communications division. When a crisis lasts for several days or even weeks, a small staff can be stretched to their limits. To fully commit to effective communication in an emergency, the City will need more resources and personnel than you could ever hope to have on staff. The City should develop a plan to cross train other City personnel where possible, who could assist with tasks such as answering phones, creating a call log, returning phone calls, and helping research answers to questions from the community. It may be possible to recruit and train volunteers to help. Tasks like monitoring news reports and social media sites to report on the stories being told, questions being asked and issues that need to be responded to could possibly be carried out by

volunteers working from home. Germantown has an amazing wealth of knowledge and experience in the community. A call for volunteers could produce an outstanding team.

Every other aspect of emergency preparedness involves establishing partnerships with outside vendors and mutual aid agreements with other jurisdictions. There is a community of Public and Private Information Officers in the area. It would be worth exploring the idea of recruiting fellow information professionals to help out in critical situations.

Most public information officers would concede that a large part of the job today is correcting mis-information. Community information is produced at staggering rates. When an emergency takes place, social media sites explode with stories, rumors and third hand information. In an emergency, mis-information has the capacity to actually endanger lives. We cannot ignore false narratives and mis-information. A communication plan has to account for the need to correct mis-information.

Develop a team to serve as a feedback loop ensuring the messages are received and are understood. Monitor social networks and the City's own websites for conversations taking place. The chatter that takes place on social media is an indication of how well your messages are understood. Questions posted on the City's or any website, identify areas in need of better understanding. A team focused on information gathering can pass along points that need to be better explained.

The City also needs a team dedicated to answering questions. Most emergencies generate some level of anxiety. The lack of a response from the City leads to even greater anxiety and frustration.

Maintain contact information for expert advice. Preplan for emergencies by establishing sources of assistance in specialty areas. Make sure you have someone you can call for advice on about any topic.

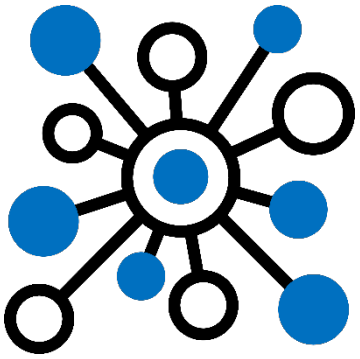
Establish segment groups to share information with and from which to gather feedback. Look for groups that may need the same types of information, such as local restaurants, medical facilities, nursing homes, schools, churches, and Homeowner Associations. If it is possible to establish a network of contacts in those segments, they in turn become a valuable resource for information dissemination.

Cultivate relationships with HOA's. Have contact information for at least someone in every neighborhood. Recruit HOA Presidents to help with information dissemination and feedback. Homeowner Associations are great at getting the message out and in gathering information about their neighborhood. Residents have much more confidence in the quality of the information when they know someone from their neighborhood is in "direct contact" with the City.

Cultivate relationships with news outlets. Maintain up to date contact information with someone from every major news source and make sure they have direct contact information with someone able to speak for the City. Reach out to have conversations about emergency

planning. Ensure they understand how emergency communications will operate. In return, understand their operations and their needs. Understand their schedules, their deadlines, and the best time to provide updates. Plan regular updates, even if you have nothing to report. When we aren't hearing anything, we develop an anxiety that maybe something is happening, and we are being left out. Even if an update is simply confirmation that nothing has changed since the last update and there is no new information, media personnel gain a level of comfort which promotes a level of trust. Set a time for the next update and commit that if there is breaking news, you will report it when it happens.

Share what you know and don't know - and what you can. Media understands what we can and cannot release. When we can't provide information, explain why and when it is likely to be available. Be honest and open. The public has a right to know, and in an emergency, there is a stronger sense of the need to know. Provide as much information as possible.



Continue to keep the community informed of actions taken after the recovery. Report on progress made to relocate the generator. Report on all lessons learned and improvements made and any actions that improve resilience.

Work to establish trust every day. There is an adage in sports which says, "you play like you practice." Emergency communication isn't too dissimilar to routine public information throughout the year. It just comes faster and more intense. Follow a version of your emergency communications strategy throughout the year in your normal routines. It makes for good practice.

Trust is built over time and through ongoing relationships. If we are open and honest in every interaction, there is a likelihood that we will be trusted in our communications when the need is critical.

Manage Communications in the same way you manage emergency rescue, whatever it takes for as long as it takes.

Operational Conclusions and Recommendations

By the time this report is submitted, numerous operational improvements will have already been made or are working their way towards implementation. Steps have already been taken to move the generator to a location further away and down drainage from the reservoirs. The diesel engine has already been fitted with a spill proof system and more effective automatic shut-off. Once relocated, the generator will be surrounded with a containment structure to make sure any leak or spill in the future will be contained within the leak proof catch basin.

The City is also taking steps to evaluate all other emergency generators to make sure leaks or spillage is reduced to an unlikely if not impossible probability.

It is worth mentioning that the City has completed construction of the second Water Tower near the Johnson Road plant at Forest Hill and Poplar Pike. This second tower will provide enough pressure and additional water supply to be able to take the Southern Avenue Plant out of service, should a future need arise. The benefit will be significant, even for regular maintenance and repairs. During this contamination event, had the second tower been operational, the City could have shut down the entire Southern Avenue water plant and isolated the contamination before it made it into all parts of the City. Even though it was already under construction and was not part of a response to the accidental contamination, it is one of the most effective operational improvements to the City's water distribution system.

- After any emergency, there should be a post-mortem examination to identify lessons learned. From conversations with staff, I'm aware those meetings have taken place and planned long-term look backs will take place. Keep the community informed of those actions and improvements resulting from lessons learned.

- Look at emergency response roles and responsibilities and identify any gaps that need to be filled. Employees city wide should be cross trained in at least two different support roles to give the City greater flexibility. Identify employees who may have other skills that can be used in support roles in an emergency. All emergency planning should start with an assumption that your first plan won't work as it should. You should always assume that key people won't be able to respond. You need others to take their place. In a multiple day recovery event, frontline workers have to rest. Cities need backup support to step in for continuity. Identify talent that may be hiding in plain sight.

- Train employees city-wide on lessons learned and expectations for future events. Ensure that all employees understand the City's response plans and the roles their fellow employees will play in an emergency.

- Train employees to think and observe like a risk assessor. Risk assessors and emergency planners are constantly looking at situations and assessing likelihoods. We run the risk of becoming blind to potential threats right in front of us. Familiarity can cause us to walk past a thing or situation every day without recognizing it as a potential problem.

- Disasters rarely have a single cause. They are usually the unexpected interaction of multiple errors, structural or technological failures, or bad decisions. Many catastrophes are caused by several small things happening at just the right time in just the right sequence. Small failures happen regularly but cause no immediate harm. We commonly ignore the warnings embedded in small failures, and so they often go unexamined or even worse, are seen as signs that systems are resilient, and things are going well. In disaster and crisis analysis, it is common to find multiple near misses preceded and foreshadowed the disaster event.

- Studies have also shown that we are likely to accept or dismiss errors in processes if the outcome is successful. We tend to assume that if the outcome was successful, the process that led to it was fundamentally sound, even when the outcome was due to blind luck. We shouldn't accept the phrase, "you can't argue with success." We should constantly question success.

- Train employees to constantly watch for signs of a potential bigger problem. Fix small accidents or failures so that they can't happen again. Question processes and standard operating procedures when outcomes aren't as good as they could be. Look for warning signs that a potential flaw might be hidden from view.

- Train all employees in fundamental problem solving. Effective problem solving is deliberate. In the chaos of an unfolding emergency, and in the rush to act fast, it is harder to validate what is correct and makes us more likely to depend on what seems intuitive or self-evident as fact. Functioning under a deliberate problem-solving discipline means all information has to be tested to ensure that what we think we know is accurate. It is especially important when our actions could have serious and lasting consequences. Making the right decisions depends on accurate information. Root cause analysis means deliberate questioning. Problem solving disciplines need to be a fundamental part of how emergency responses are carried out. Ensure that all employees, not just those in leadership roles, understand critical analysis of a problem and the need to question what we think we know. Make sure your Emergency Operations Center is staffed with personnel whose responsibility includes ensuring decisions flow from a disciplined problem-solving methodology.

- Make sure your external contracts are updated regularly. The ability to respond quickly may depend on your ability to reach expert advice, medical providers, and equipment contractors. Ensure you have pre-existing contracts, or memos of understanding with contractors, experts, and suppliers when the need arises. To act quickly, contractors and vendors need to know beforehand what is expected of them. In an emergency, pre-planned responses from suppliers and contractors saves hours or even days.

- Meet with and plan emergency response needs with local hospitals and nursing homes. Germantown is blessed to have a full-service hospital with advanced capabilities at Methodist Germantown. In a mass casualty situation, hospital personnel have to react fast. Having pre-planned protocols in place is critical. Bring Methodist Hospital

leadership and other medical providers together to discuss emergency plans. Establish plans for direct lines of communications. Involve medical providers in the emergency operations response.

- Hospital and medical care operations should never be interrupted. In any emergency situation, inform your medical partners. They may be affected in ways you couldn't fore-see. Out of an abundance of caution, maintain direct lines of communications.
- Reach out to the Tennessee Department of Environment and Conservation and the Federal Environmental Protection Agency and encourage them to become partners with local governments to be a resource during environmental emergencies. TDEC and EPA have access to resources and a depth of knowledge critical in crises involving contaminations or other environmental hazards. When public safety is at risk, we need to erase the lines between jurisdictions and authority structures and focus on making the right decisions to protect the public and the environment.
- Always assume the problem is bigger than it is presented. Don't wait to contact partners and outside resources. There isn't a downside to contacting them early in the process.

Appendix

Role of Waypoint Analytical

In the report, there was a discussion of the remediation process. To remove contamination from the water system, the reservoirs had to be drained and cleared of any residual diesel fuel, then with the clean water in the reservoirs, the water mains were flushed to discharge any contamination. The reservoir and the water mains had to be certified as free of contamination before residents could start pulling water from the mains into the home. Water samples were taken at points throughout the process for testing. Testing methodologies and standards for water quality were established by TDEC and in compliance with the standards for safe drinking water.

In order to conduct the tests and certify that the samples tested met TDEC standards, laboratories have to be certified to test drinking water. In Memphis, there is only one laboratory certified to conduct tests at the level of detection required, and with the certified employees necessary to satisfy water quality certification standards. That company is Waypoint Analytical located at 2790 Whitten Road, Memphis.

Water quality testing has to identify particles at extremely low levels. Normal laboratories are capable of detecting diesel range organics at 5 parts per million. Waypoint's equipment is capable of detecting diesel range organics at 90 parts per billion. Obviously, these very low detection levels are important in certifying water safe for consumption.

The time it took to test water samples was a critical factor in Germantown's ability to restore water service. The process of draining and cleaning the reservoir takes time. Water samples have to be taken and sent to the lab for testing. The city couldn't move on to the next step until the tests certified that the water was free of contaminants. Likewise, when a water main is flushed, samples have to be collected and sent to the lab for tests. Residents weren't allowed to use water from the mains until lab tests showed the water was clear of contaminants.

In the normal course of business, when a water sample is sent to Waypoint for testing, the average turnaround time can take seven to ten days. Every step in the testing process follows strict protocols. There are no short-cuts in the testing protocols. It is a time-consuming process. Due to the cost of laboratory equipment, certified employees, and lab setup required to be certified for water quality testing, there aren't that many other labs available for additional assistance. Waypoint reached out to other labs to help relieve the pressure and keep up the turnaround time. The next closest lab is in Nashville. They could not commit to less than 5 days and given the delivery time to get the samples to the lab, additional assistance was not an option.

Understanding the urgency in Germantown, Waypoint went to extraordinary lengths to reduce the turnaround time. Employees worked nights and through the weekend to get test results back to Germantown and TDEC. The turnaround time was reduced to 6 to 8 hours, depending on when the samples were received. Waypoint still had other clients with urgent needs but were still able to commit to making Germantown their top priority.

Purpose of Flushing Water Lines

Water main flushing is the process of opening a water hydrant to release water.

Water main flushing moves water strategically through sections of a drinking water distribution system, creating a scouring action to clean the line. The increased flow rate scours the water pipe's inner walls and helps remove debris that may have entered through a break in a line, or from naturally occurring buildup of sedimentation.

There are several reasons to flush water lines. The disinfectant chloramine becomes less effective over time. When water stays in pipes for longer periods the disinfectant becomes less effective. Its effectiveness is also lessened in summer months during high temperatures. Water quality tests are conducted regularly to measure chlorine residuals and water quality. Flushing lines gets rid of "older" water and replaces it with fresh water.

Flushing is also used to clean water mains. When there is a break in a water main, soil and contaminants can get into the lines. Flushing removes debris and contaminants from inside water lines.

Finally, flushing is conducted regularly to test flow pressures to ensure hydrants are working properly and there is an adequate water pressure for fire protection.

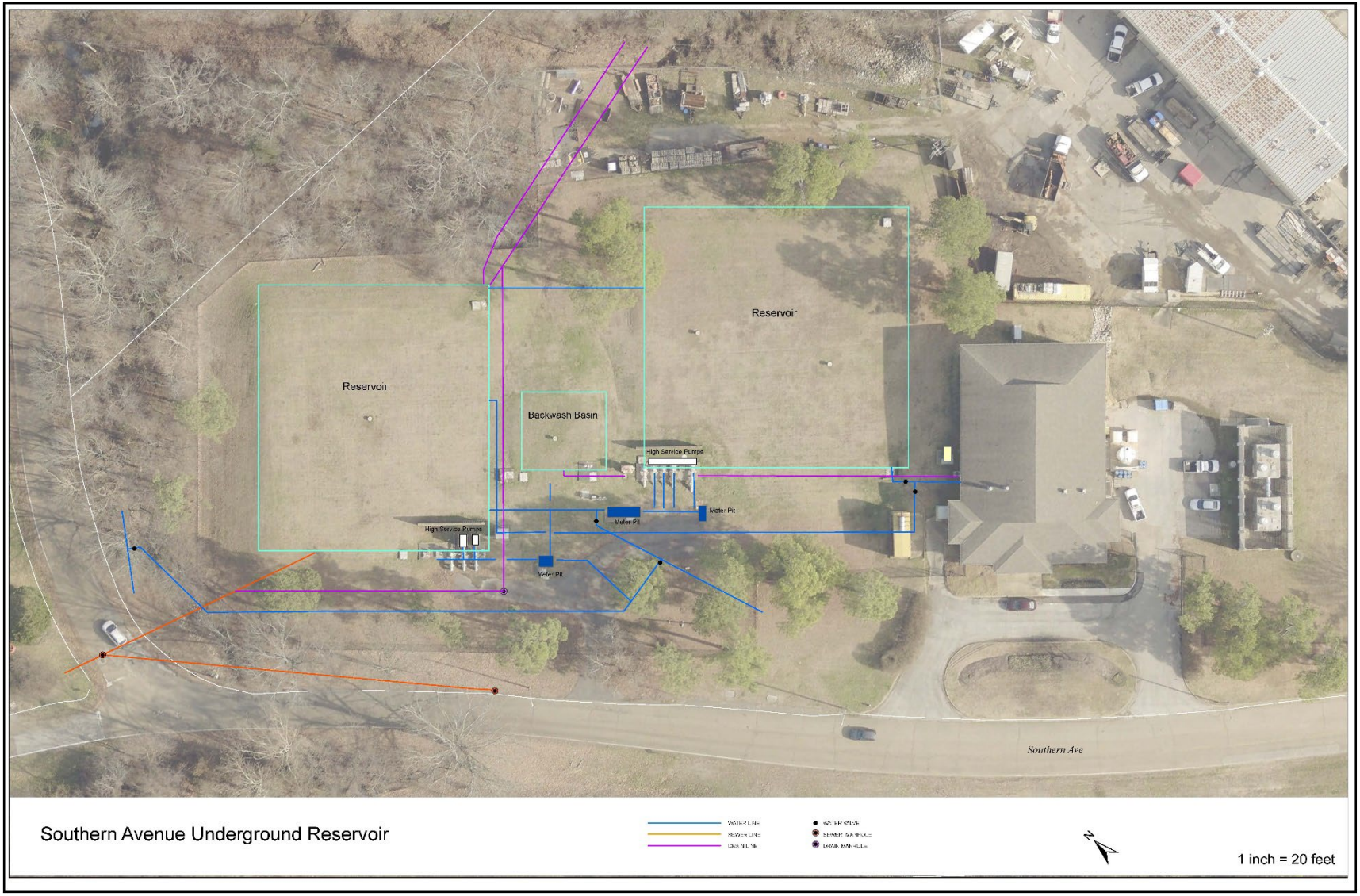
Parts Per Billion

Throughout the water crisis, water quality tests reports referenced "parts per billion." Waypoint Analytical is also capable of detecting certain diesel fuel compounds down to 20 parts per trillion. Both levels of detection are hard to put into perspective.

One part per billion is one second in 32 years, one drop of water in a 10,000-gallon swimming pool, and eight people out of the entire human population.

Even harder to comprehend is parts per trillion. One part per trillion is one second in 320 centuries, one inch in 16 million miles and one penny in 10 billion dollars.

Southern Avenue Underground Reservoir



Site Location Map