THE FLOOD CREWS OF 2010

A HISTORY OF RHODE ISLAND'S 2010 FLOODS AS TOLD BY THE STATE'S WASTEWATER COLLECTION AND TREATMENT OPERATORS

Nicolas Q. Holbrook

FOREWORD

At about 7:00 a.m. on Tuesday, March 30th 2010, Peter Eldridge, then the superintendent of the West Warwick Regional Wastewater Treatment Facility, called me on my personal cell. It had been raining heavily for hours and Pete, just back from morning rounds, wanted me to see things for myself. I'm part of the team at the Rhode Island Department of Environmental Management's Office of Water Resources that regulates the state's wastewater systems, as well as licenses and provides training to the men and women in that profession—a role I had been in at the time of the floods for twenty-one years.

When you work with people for two decades, you can tell when they're worried. The official NOAA forecast that morning was for flooding of the Pawtuxet River at just about a foot-and-a-half higher than the levels we'd seen two weeks earlier. That's when an historic crest of the river threatened, but did not overwhelm, two wastewater treatment facilities—the Warwick plant and Pete's in West Warwick. Based on what we experienced then, even with an additional foot or two, the plants would have been protected by their existing flood-control structures. There would again be issues in the collection systems, but we had all learned lessons from a few weeks back, which had wastewater crews ready for the projected flooding.

And yet there was something about the rain that morning that prompted this unusual request for an early morning tour.

Pete picked me up at my house—just a few blocks from the wastewater facility. We checked the plant and then drove down Providence Street, which already had standing water at its lowest point between Sacred Heart Church and the old Providence Street School. Across town, the North Branch of the Pawtuxet River was rising near the Clyde Street Pumping Station, where wastewater crews were preparing for more flooding. On we went, past a culvert under Wakefield Street that I've driven over hundreds of times. I'd never seen it roaring with water as it was that morning.

When Peter and I drove back to the plant, Providence Street was now closed off between River Street and the steep rise by the Fish Bowl Aquarium. Police officers moved determinedly in the downpour, sloshing through the water at their feet. They must have known it would be a busy day for them, and for all public-safety professionals.

But none of us expected what was to come. In the next five or six hours—and the days, weeks, and months ahead—another group of civil servants would also be called upon. Their job would be to protect and rebuild one of the basic services of civilization.

This report hopes to preserve some of the memories of the men and women who work in the wastewater collection and treatment profession—fellow Rhode Islanders who came away from the Great Flood of 2010 with tales of comradery and long hours working to protect and then repair millions of dollars of wastewater infrastructure.

This report is not a regulatory review or a quantitative analysis. While it will make a helpful training tool for the future, its simple goal is to record the history of people who lived through a sudden and terrible event, and who came through it with a new appreciation of their profession and the world in which they live.

Last summer, my office offered to listen to and record the words of anyone in the wastewater profession who wanted to tell their stories. Interviews were held and videoed, and transcripts written—all of which will be available for future use. What follows herein is the synthesis of what we heard. Many thanks to the women and men who shared their memories. As the report notes, this group tends to be a humble and quiet lot—a profession not familiar with spotlights. You can be sure that for every story that follows, there are dozens more that, I hope, we might learn someday and add to this history.

Thanks also to others who helped explain the bigger picture—especially Dave Vallee of the National Weather Service and Michelle Burnett of the Emergency Management Agency. And thanks to those who helped with editing, formatting, and dissemination.

I'd especially like to thank the author, Nick Holbrook, who worked for a time as an intern in my office, and agreed to continue with an unpaid internship to use his writing skills and his love of history to record the stories that I always worried would be lost.

Thanks to Nick, and all those who made this small effort a reality, we've preserved a piece of our history—stories about a time when the chips were down, and in true Rhode Island fashion, neighbors rose up, came together, and did whatever they could to make things right.

Bill Patenaude
Principal Engineer
RI DEM Office of Water Resources
March 1st, 2017

TABLE OF CONTENTS

Figure 1: Operators at the flooded West Warwick Regional Wastewater Treatment Facility greet colleagues as they use a boat to assess plant damage after the historic March 30-31, 2010 flooding of the Pawtuxet River.

Cover photos:

Background: The flooded Warwick Sewer Authority's wastewater treatment facility (State of Rhode Island). Foreground: Crews at the West Warwick Regional Wastewater Treatment Facility attempting to sandbag plant components. (Marc Levesque, West Warwick.).

Introduction

In 2009-10, the Northeastern United States was hit by a series of slow-moving storms which, in Rhode Island, culminated in late March 2010 with what some call the "Great Flood," or just "the 2010 Flood." The floods were unlike anything many people in the state had ever experienced. "Small depressions in the woods became small ponds . . . streams became rivers and rivers became raging torrents," remembers Kevin Cleary, the Town Engineer for the town of Smithfield, RI. The floods left an indelible impression on the way many consider the water around them. The flooding resulted in the loss of homes, belongings, businesses, and in the case of Rhode Island's wastewater treatment industry, precipitated a dramatic struggle to keep one of modern civilization's most basic utilities operational and available for the public. The story of these great efforts are best told by those who were on the front lines—the operators and staff of wastewater collection and treatment facilities, who work year-round to perform a job that is largely unseen and, therefore, underappreciated.

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The flooding that occurred in Rhode Island in March 2010 was not coastal, as might happen during the storm surge of a hurricane, but rather it was riverine: the spill-over from rivers rising above their banks and flowing across their floodplains. This happened along several of the state's major rivers, which are fed by the numerous streams, tributaries, and other water bodies in their sizable watersheds. Many areas of Rhode Island experienced severe flooding twice that March; first on the 15th, which broke all previous flood records, and again on the 30-31st, an unprecedented event that exceeded the record set just two weeks earlier. The floods were much covered in the news at the time, and scrutinized afterwards by both government and media. Absent from much of the narrative were the accounts of the crews at Rhode Island's wastewater treatment facilities.

To capture that element of the story, this report provides first-hand accounts from men and women working that March at five of the most impacted plants: West Warwick, Warwick, and Cranston, which are located on the Pawtuxet River; Westerly, on the Pawcatuck River; and Bristol, which struggled with extensive local flooding from multiple smaller water bodies.

Understanding the geography and hydrology of these rivers and communities is key to understanding why these rivers flooded, and why the effects were felt so markedly at those facilities and elsewhere.

The headwaters of the North Branch of the Pawtuxet River flow out from the foot of the Gainer Memorial Dam, in Scituate. The South Branch begins as a marshy stream at the Big River Reservoir, in Coventry. The two branches meander through neighborhoods and wetlands, over aging mill dams and under bridges. The Pawtuxet River Main Stem begins in West Warwick, at the confluence of its two branches. From there it winds through the communities of West Warwick, Warwick, and Cranston, before emptying into Narragansett Bay at Pawtuxet Village.

The 3,200-foot-long Gainer Dam is located at the southern end of the Scituate Reservoir. The massive earthen dam was built for water storage, and today provides sixty percent of Rhode Island's population with drinking water. It is designed to collect and hold as much water as possible, only releasing excess water into the North Branch of the Pawtuxet River when the reservoir level exceeds the height of its spillway.

Figure 2: The Gainer Dam spillway on a normal day, with only a trickle being added to normal flows that come from the dam's central outlet, which feeds the North Branch of the Pawtuxet River. See Figure 3 for an image of the spillway's raging torrent on March 31st, 2010 (NWS/NERFC)

Flood control dams are designed differently: they essentially slow and sequester river water so that it can be released over time in a controlled manner. The Gainer Dam lacks this ability; excess water will exit the reservoir until the level behind the dam drops again.

The Pawcatuck River begins at Worden's Pond in South Kingstown, Rhode Island. It flows southwest before being joined by the Wood River and turning south, where it forms part of the state border between the towns of Pawcatuck, Connecticut and Westerly, Rhode Island. The river widens as it passes by Westerly, flowing past the town center and the village of Watch Hill. It empties into Little Narragansett Bay where the fresh and saline waters mix as they drift around the dilapidated ruins of Fort Mansfield on Napatree Point and out to Block Island Sound.

Bristol, Rhode Island was a unique case in that its flooding was not caused by a major river overflowing. Indeed, Bristol has no major rivers running through it. The town is located on a peninsula that juts south from Warren, Rhode Island into Narragansett Bay. Although famous for its two-hundred-foot Mount Hope, where Metacomet (King Phillip) fought and died during King Phillip's War, much of Bristol lies closer to sea level, especially on its western side. The area is also marshy, and contains a number of small streams and water courses which can be quickly filled during periods of prolonged rainfall.

It is a common practice to locate treatment plants in the low-lying areas

near rivers or coasts to maximize the assistance of gravity in getting wastewater through sewer pipes. Remote pump stations are utilized to propel wastewater through sewer pipes that must travel uphill. These stations require electricity to operate and demand routine monitoring and maintenance. The more work gravity does, the better.

Wastewater coming into a treatment facility from the sewer system is typically reported in millions of gallons per day (MGD). The MGD amount can vary depending on a number of factors, including sewer system use and wet weather. Wastewater enters a treatment facility at the headworks, where screens and large, comb-like devices called "bar racks" are used to remove large debris. Other systems remove sand and grit, which can damage pipes and machinery further down the line. Wastewater then enters primary settling tanks, or clarifiers. Clarifiers work by slowing the rate of flow and allowing lighter materials to float and heavy material to drop out of the wastewater stream. Long boom arms rotate at the tops and bottoms of circular primary clarifier tanks, or across the tops and along the bottoms of rectangular ones. In both cases these arms collect the solids and push them into troughs for removal. These processes are known collectively as primary treatment.

Secondary treatment is designed to remove suspended, dissolved pollutants in wastewater—which can be substantial. These pollutants do not settle and will not float. Treating these wastes includes a process called "aeration," where systems of powerful blowers and diffusers inject air into the wastewater, much like in a home aquarium. This results in "activated sludge," which is made up of water and rich, biologically active solids. Another term for this is "mixed liquor." With the oxygen provided by the blowers, naturally occurring microscopic organisms in the mixed liquor consume the incoming biological matter, converting it into larger biological masses that are heavy enough to settle farther along the process—thus removing the pollutants from the wastewater. Secondary treatment requires another round of clarification to allow the still-active biologic matter to settle. Some of this matter is recycled to the front of the aeration tanks to seed the incoming wastewater with biologically active microorganisms. More complex aeration processes are also used to remove pollutants like ammonia, nitrogen, and phosphorous.

"Rotating Biological Contactors" (RBCs), another form of secondary treatment used especially in Bristol, employ simpler means to bring oxygen and microorganisms to the wastewater. RBCs are made up of many wide disks that rotate partially submerged through the water. The disks splash oxygen into the waste stream as they allow helpful microorganisms to grow on the disks, which in turn feed on the pollutants.

No matter which biological treatment is used, the final treatment for wastewater before being discharged back into nature is disinfection. This is typically achieved with liquid

chlorination, but sometimes with ultraviolet radiation.

Facilities are designed with floods in mind—most typically by elevating buildings and doors, and raising walls around tanks. Some, like the Warwick Sewer Authority (WSA) plant in Warwick, are protected by an earthen berm, or levee. In 2010, Warwick's levee was eighteen feet high and built to protect against a one-hundred-year flood, meaning a flood of a magnitude that has a one-percent chance of happening in any given year.

Plants also have standard operating procedures (SOPs) to be followed in the event of emergencies like flooding. However, despite the plans and best efforts of wastewater professionals, the magnitude of the 2010 storms proved to be overwhelming.

At a wastewater treatment plant, significant wet weather brings a unique set of problems. With sewers relying on gravity to move water, heavy rains and flooding can dramatically increase the amount of water coming into a treatment plant through infiltration and inflow, or "I/I." *Infiltration* is the name for the process by which groundwater trickles into old or damaged pipes. *Inflow* occurs when rainwater flows into sanitary sewer systems, such as from open or leaking manhole covers, or from illegal connections from basement sump pumps. During floods, all of that combined water has to make its way to the wastewater treatment plants—and through them—before being discharged back into nature. Treatment facilities are typically built with extra capacity to accommodate the runoff of heavy precipitation, as well as the future growth of the municipalities they serve. When the volume of water exceeds a collection system's capacity, the extra untreated water is discharged in one of two ways: either in uncontrolled *sanitary sewer overflows*, where wastewater escapes from low points in a collection system, such as from manholes or sewer connections, or, in a handful of communities, in *combined sewer overflows*, which are engineered outlets designed and built mostly in the early twentieth century, which provide outlets when excess wastewater and rain water pressurizes underground pipes beyond what can be safely conveyed.

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The Set-Up

Conditions leading to Rhode Island's perfect storm

The set-up for the March 2010 floods can be traced to the fall of 2009, which saw above-average precipitation. Snowfall that had covered the ground in winter melted in the heavy rains of that February, saturating the earth across the region. In the Pawtuxet River watershed, this extra water began raising the elevation of the Scituate Reservoir. Normally, the reservoir does not approach overflow capacity until the wet months of spring, but in March 2010 the Scituate Reservoir had been spilling

continuously for over a month. Downstream, the ground was also saturated with water from rain and melting snow. The water-absorbing action of tree roots would not kick in until after the cold of winter had passed. This meant that any water landing on the ground remained on the ground, running off into the streams and tributaries that feed the Pawtuxet Main Branch.

David Vallee, the lead hydrologist with the National Oceanic and Atmospheric Administration's Northeast River Forecast Center, had been tracking the storms with his team at the Weather Forecast Center in Taunton, MA. On March 13-15, heavy rains had elevated the Pawtuxet River to a record-breaking fifteen feet above its flood stage.

Michelle Burnett was the State National Flood Insurance Program Coordinator with the Rhode Island Emergency Management Agency (RIEMA) at the time. "The 15th [of March] came as a surprise to the entire state," says Burnett. "We had seen the modeling coming in from the National Weather Service, but never did we expect it to be as high as it was." RIEMA activated its Emergency Operations Center ("the Jack Bauer room," as Burnett calls it) and was on hand offering logistical and informational support to the affected communities in both the lead-up and immediate aftermath.

Overall, the mid-March event was manageable, but it did leave some in the state shaken. Vallee and his team, meanwhile, were forecasting more wet weather—maybe another five inches. The heaviest rain was projected to hit further north, impacting the Blackstone River, as well as the Taunton River and lower Merrimack Valley in Massachusetts. But Mother Nature had other plans.

Figure 3: The Gainer Dam spillway at the Scituate Reservoir at 10:30 a.m., March 31st, 2010. Flow was an unprecedented 2.5 feet over the flashboards at a pool elevation of 287.80 feet. See Figure 3 for the spillway on a normal day, with only a trickle flowing over the flashboards. (David Vallee, NWS/NERFC)

On the morning of Monday, March 29, Vallee was met by his forecast team as he walked into the Taunton office. "When you walk into your office and your forecast team tells you to sit down, you know you're in for a bad day." They proceeded to brief Vallee on the startling scenario for the Pawtuxet River that their models were predicting. It was bad, and could potentially break the record set just two weeks prior. The Weather Forecast Center had been issuing flood advisories all weekend. By Monday afternoon into early Tuesday morning the 30th, NOAA was projecting a sixteen-foot flood crest within twenty-four to thirty-six hours. Later the forecast went to just over seventeen feet—more than two-feet above what the Pawtuxet had seen two

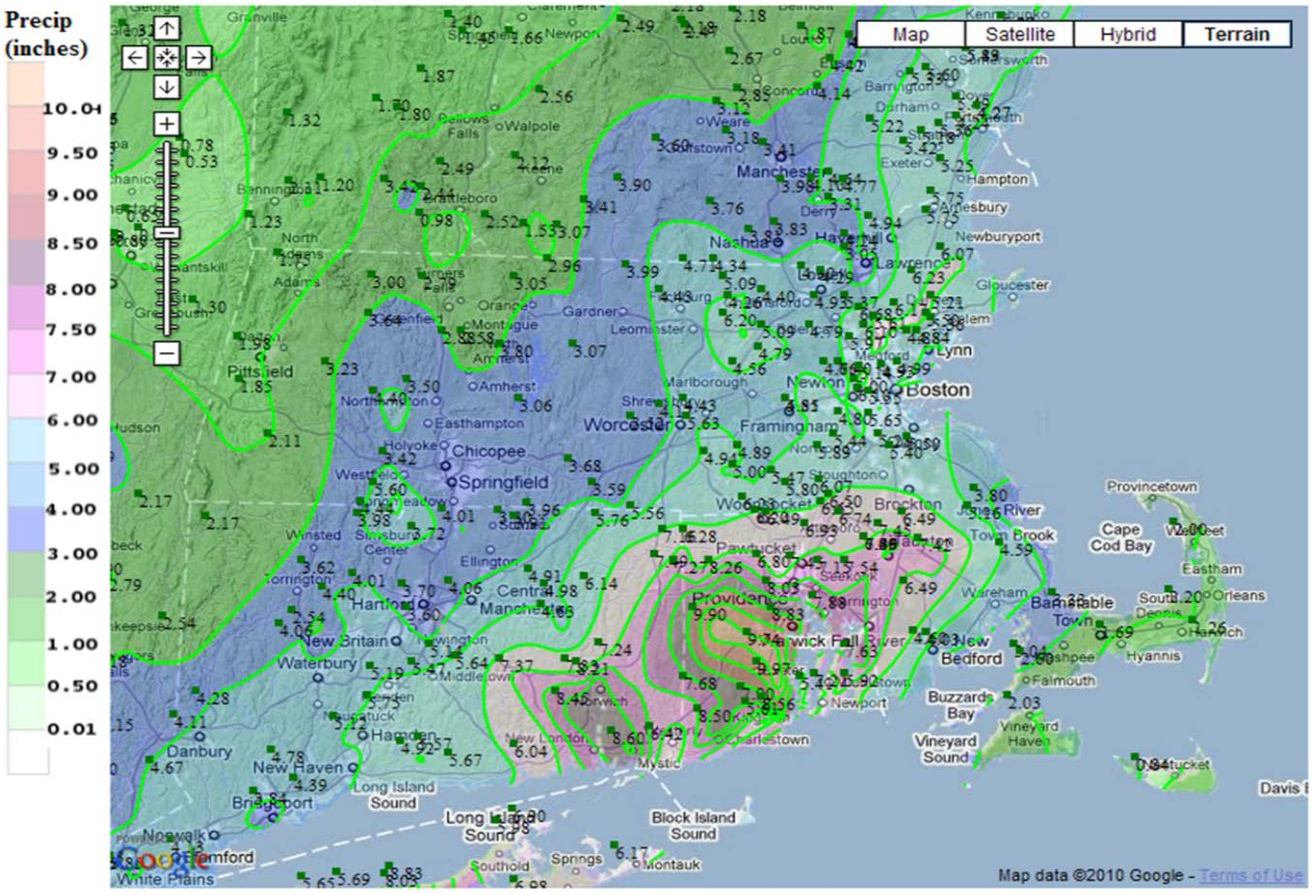

Figure 4. Final total rainfall amounts of the March 29th - 31st storm. (NWS)

weeks prior. Based on which wastewater infrastructure had and had not flooded during the mid-March flood, sixteen or seventeen feet would have been precarious but manageable at the treatment facilities. But over the next few hours—as wastewater crews were dealing with flood waters and as NOAA modelers struggled to connect spotty and quickly changing data with river models that had never seen such flooding—the forecast was upped again to nineteen feet.

The river crested on Wednesday, March 31st, at 20.79 feet.

Parts of Rhode Island ended up receiving almost ten inches of rain from the March 29-31 storm. Flooding would shut down portions of Interstate 95, the Warwick Mall, and damage hundreds of homes and businesses, along with several wastewater treatment plants.

The Great Flood of 2010 was not a surprise because no one saw it coming; it was a surprise because it exceeded all expectations.

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West Warwick

Trying to hold back the river

The West Warwick Regional Wastewater Treatment Facility is located on the Pawtuxet River at 1 Pontiac Avenue in West Warwick. It was built in 1942, with its last major upgrade completed in 2016. It treats a daily average of about 5.2 MGD.

Of the three communities with wastewater facilities on the Pawtuxet River—Warwick, West Warwick, and Cranston—West Warwick is the furthest up river; the first in line. Pontiac Avenue bends around and cradles the wetlands that bound the wastewater plant to the north and east. To the south is the Pawtuxet River, which flows under a trestle bridge before curving sharply away from the plant. The facility grounds slope downward from the front gate, past the administration building and aeration tanks to the secondary clarifiers and finally to the river itself.

During the storm of March 13-15, historic levels of river water encroached into the facility grounds, but existing flood protection measures kept the waters at bay with no interruption of operations. Brian Lavallee was an operator there at the time. "I remember coming off the steps out of the aeration building and [the water] was almost up to my knees, and it was starting to encroach into the plant, but that's about as far as it got." The Pawtuxet River came up about fifteen feet above its normal level. The back of the plant lies closest to the river, and is a full ten feet lower than the front of the plant, just under one-thousand feet away. This means that when West Warwick floods, it does so gradually, much like an incoming tide on an ocean beach. Structures at the back of the plant may be submerged while others are high and dry. Peter Eldridge, who was West Warwick's superintendent at the time, remembers that the plant handled that first flood well. "There were some issues we had with infiltration into [a] pump room," says Eldridge, "but we were able to contain all that and get those pumped out." Overall, damages were light and the staff relaxed believing that the record flood they had just weathered would be the last for the foreseeable future.

As the stormy night of March 29-30 gave way to morning, the river had once more risen perceptibly. Dave Vallee's office was projecting a flood crest at just over sixteen feet on the following day, a foot or so higher than the historic flood seen just two weeks earlier. But the rains fell heavier and in different regions than forecasted, and places like West Warwick began to flood faster than they had during the "small flood" of March 15th. At 7:00 am on Tuesday the 30th, Eldridge phoned Bill Patenaude, a Principal Engineer at the Rhode Island Department of Environmental Management (DEM). Patenaude oversees DEM's Operation and Maintenance program, which regulates daily operations of the state's wastewater infrastructure. He also happens to live near the West Warwick facility. "I brought Bill back down to the plant, where I was

just seeing at the time the Pawtuxet River come into the area of the contact tank at the back of the plant." They also checked on the Clyde Street pump station, which was already being flooded by water from the river.

Figure 5: Crews at West Warwick make a final attempt to sandbag equipment before evacuating. (Marc Levesque)

By mid-morning, facility staff were already in full swing stacking sandbags around buildings and trying to move equipment out of harm's way. "And as we were doing that," recalls Lavallee, "it seemed like no time at all— maybe like an hour, hour and a half—we had to stop because no matter how high we kept putting the sandbags, it just kept overflowing the wall." He and several other operators had been building a sandbag wall around the electrical box where power comes into the plant, but the river was rising faster than the sandbags could be stacked. Generators kicked in after main power was lost, but soon those too were submerged. "Just before we left the plant, we were in the [administration] building and the payloader operator was moving us in and out of the building because the water was so high," says Chief Operator James DiCaprio. By this point, the water was at least waist-deep.

Marc Levesque was behind the wheel of the payloader. A technician for the facility's compost program, Levesque found himself shuttling equipment, sandbags, and personnel around the flooded plant in the bucket of his payloader. Heavy rain was still pouring down. The staff had been working in this fashion for only about an hour when "[w]e got a surge from somewhere," Levesque remembers, "the water . . . just *rose*." The last thing the bucket-borne crew was able to do was refill the oil tanks for the screw pumps located in the back of the plant. The payloader console lit up with alarm lights as the water, now at head-height, began to flood the engine compartment. Levesque called out that they had to leave now or start swimming. It was around 11:00 am. The payloader plied its way back towards the front of the plant, and high ground.

Figure 6: The Pawtuxet River rises towards the five-foot flood protection walls of West Warwick's secondary clarifiers on Tuesday, March 30th as plant staff evacuate. (West Warwick)

"[W]ater started going over the secondary clarifiers, it was filling up the pump rooms . . . [then] all the aeration basins were under water, and one of the

primary tanks was under water," says Eldridge, remembering how the Pawtuxet River surged ever higher into the plant. Watching the one-hundred-foot diameter clarifiers go under was especially dramatic; akin to watching an above-ground pool fill from the outside-in. "The guys were trying to protect the power situation coming into the plant with sandbags, but at that time the secondaries were overtaken and we had to back away . . . and evacuate to the front of the plant." Staff rode Levesque's payloader to dry land near the facility's front gate. Eldridge phoned RI DEM's Patenaude and the West Warwick town manager at around 12:30 p.m. to report the unthinkable—the facility was being evacuated. The river continued to creep into the plant until it crested at 20.79 feet on Wednesday.

Figure 7: West Warwick's five-foot high secondary clarifiers are overtopped by the rising Pawtuxet on Tuesday afternoon, March 30th. (West Warwick)

"Heartbreaking" is how operator Mike Bedard describes the decision to evacuate the plant. "Definitely devastating, definitely psychologically so." Heartbreaking, and stressful, adds DiCaprio. "I don't think many of us could handle another one of those. It was bad. When you [came] in and to see it, your heart just dropped."

While the flood waters caused no structural damages to the facility's tanks or buildings, anything electrical and everything that was not metal or concrete was ruined. It was at least two days before the river had subsided to the point where staff could begin to access the facility. West Warwick's treatment process relies on ultraviolet light for final disinfection, but the facility was without power. Operators quickly set up temporary chlorination as a substitute.

About 20 MGD was flowing in to the plant at the time—four times the facility's normal rate—and a lot of unwanted material with it. Debris is normally collected and removed from the incoming flow by automated bar racks at the headworks. This system went offline as well, and the incoming flow backed up on clogged debris as it tried to enter the plant. "We were afraid to open the doors to the headworks [building]," says Lavallee. "[Water] was just pouring out underneath the doors."

Figure 8: At higher ground, water from the flooded town makes its way into West Warwick's mostly submerged treatment facility, and out the doors of its headworks building. (West Warwick)

Primary treatment was still technically operating, as gravity allowed wastewater to continue free-flowing into

the clarifiers and the solids to settle out. Still needed was electricity to power the large boom arms that sweep the solids into troughs for collection and removal. These were back online in two weeks. In the meantime, portable pumping systems were brought in to remove the solids as they continued to enter the facility. Getting the sludge to the center of the tanks, however, had to be done the old-fashioned way—with manual labor.

Figure 9: West Warwick staff manually pushing sludge to the center of idled primary clarifiers. From there, the sludge would be pumped away in tanker trucks. (RIDEM)

Working with engineering contractor Jim Geremia and Associates, West Warwick was able to restore the more complicated aeration systems of secondary treatment within two months, much sooner than many had thought would be possible.

All the while, staff were busy cleaning and trying to track down and account for equipment that had been scattered by the flood. "[T]he fence going around [the facility] was six feet [high], and every bit of fence was under water," said Lavallee. Equipment, office supplies, even large oil drums had been lifted by the water and deposited outside the fence. "Everything was floating in the swamp. We had to send a party out afterwards to grab all the stuff because you couldn't leave it there." An untold amount of debris had floated into the plant as well. Garbage, tree limbs, anything the swollen river had picked up before reaching West Warwick wound up stuck in treatment tanks or strewn across the ground, even inside buildings. "Probably the good first week was cleaning," remembers Eldridge. "Every pump room that West Warwick has was twenty feet full of wastewater. That all had to be pumped out and fully cleaned." Brian Lavallee recalls that process: "I can remember when the water went down, walking up to the top and opening up the hatch to look into the [approximately twenty-foot deep] pump room, and the water was flush to the top of the hatch. We just looked and said 'Oh, this is going to be fun!'"

Figure 10: West Warwick two days after the crest of the Pawtuxet. (State of Rhode Island)

Besides the offices and pump rooms, West Warwick staff had also lost the contents of their personal lockers, and had nowhere to eat or wash up. Most of the buildings at the plant had to be gutted

and sprayed for mold, so access was limited to a single small building near the plant entrance. "That one building that was left had a concrete pad . . . and we pretty much sat up there for easily the first month or two, just dining al fresco," says Lavallee. Eventually some trailers were brought in for additional room and storage, but with twenty-four staff members plus contractors, space was limited. "[I]n the rain, everybody kind of huddled in this one building." West Warwick's entire administrative staff had to set up shop in one of the trailers. Their offices, located in the facility's single-floored administration building, were a total loss. Before evacuating, the office staff tried to elevate what equipment and documents they could on top of cabinets and bookshelves, but the river came up too high. Papers, computers, furniture, almost everything was either destroyed outright or contaminated with sewage and had to be thrown away. A drying trailer was brought in for the copious amount of documents that had been damaged. Operator Patty Sheridan spent months in the cramped trailer stacked high with paper files, photocopying each page and discarding the soiled originals.

Christine Suvajian, the current Administration Director for West Warwick's sewer authority, was serving in an administrative role at the time. She remembers balancing the hectic day-to-day work with the process of re-equipping the administrative staff. The offices had to be rebuilt essentially from scratch, everything "from a chair to a filing cabinet," Suvajian explains, "plus, try to do your job on top of it."

Disaster relief and recovery contractor Clean Care was hired to handle most of the physical cleaning, especially in the buildings. A crew of no less than twenty-five worked to remove the literal tons of mud and waste that had blanketed the plant. "Miracle workers, what those people did," says DiCaprio, without a hint of hyperbole. "We'd still be working on it if it was just us that had to do that. It would have taken years." Once the plant was clean, the rest of the operators, maintenance staff, and contractors could come in and begin restoring the treatment processes.

Figure 11: With flood waters long gone came remnants of frenzied attempts to sandbag critical components at the West Warwick Regional Wastewater Treatment Facility. (RIDEM)

One of superintendent Eldridge's main concerns was for the morale of his staff. Meetings were held first thing every day to touch base and hand out work assignments. Eldridge had to make it clear that there was a recovery plan in motion and that there was a future for the plant and all of its employees. "Some of the guys [thought] we were going to get laid off," Eldridge recalls. Operators had no plant to operate and contractors were being

brought in to start the major recovery work. Still, there was plenty to be done and every pair of hands would be needed to get the plant back. Eldridge had food brought in and even arranged for a priest to visit the plant and be available to talk with the staff. Tough as it was, that trying period is remembered almost fondly by Eldridge now. "We were a family there. We all came in, and we all met there, and we all got our work orders for what section we were going to work on; just so they know what's going on and they see a light at the end of this wet tunnel."

Things didn't really return to normal at the plant for about a year. Bringing the plant back to its pre-flood condition—and in some instance, in better condition—was expensive and time-consuming. Engineer Jim Geremia, president of James J. Geremia & Associates, oversaw the entire reconstruction. His company was no stranger to the West Warwick facility, having been the principle design engineer of the plant for three decades. "We built that plant (in its current configuration) over the course of ten or fifteen years," Geremia remembers, speaking in his Providence office. The flood necessitated an almost complete overhaul. "[W]e replaced all of the mechanical equipment, ninety percent of it, in thirteen months."

Part of the rebuild included improvements to the backup power system. The generators are now elevated for higher floods than their predecessors, and can power the entire plant in the event of a power loss. Some officials have proposed constructing a berm around the facility, like the one that surrounds the Warwick plant, but space is an issue. The wetlands come right up to the fence line bordering the plant, and when wetlands are filled in, the loss must be offset somewhere else. A berm may also compound flooding issues by diverting the extra water elsewhere. It is a complex issue without a simple solution, but one that continues to be examined.

On March 29, 2010, President Barack Obama had declared a state of disaster in Rhode Island, which made available federal monies for response and recovery. Town insurance covered the lion's share of the recovery cost, which, together with the Federal Emergency Management Agency (FEMA), required scrupulous record-keeping so that expenses could be justified. "You had to monitor everything, because you didn't want things to get out of hand," Geremia recalls. "So you had to spend your time arguing, discussing, presenting your case why that was an eligible expense." A single misplaced receipt or undocumented part could mean the difference between insurance or local taxpayers footing the bill. "FEMA got to be everybody's favorite word," says Lavallee.

In the end, insurance and FEMA funds covered about three-quarters of the thirteen-million-dollar project. Thanks to the diligent work of those involved, local taxpayers were spared the full cost of recovery, which was substantial. "Stuff was just ruined," says Lavallee. "You don't realize it—water is just so powerful."

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Warwick

Stuck in the bowl

The Warwick Sewer Authority's Wastewater Treatment Facility is located on the Pawtuxet River at 125 Arthur W. Devine Boulevard. It was built in 1965, with its last major upgrade completed in 2016. It treats a daily average of about 4.5 MGD.

We basically dodged a bullet," says Pat Doyle, who was the Assistant Superintendent at the Warwick Sewer Authority (WSA) facility in 2010. That sentiment was shared by many in Rhode Island's wastewater industry following the rain and flooding of March 13-15. The Pawtuxet River had crested at 14.7 feet, uncomfortably close to the top of Warwick's eighteen-foot high levee that bounds its treatment facility on three sides. At the peak of that first flood, Doyle and then superintendent Joel Burke climbed the levee and drove a stake into the ground at the high-water mark. At the time it was a new record. A few pump stations around the city were damaged by flooding, but the plant itself had handled the resulting heavy incoming flows well and was able to continue operating through the duration of the storm.

To some, that flooding was seen as a test of their sewer system—and an opportunity to assess vulnerabilities and develop plans to address them. Janine Burke-Wells, Executive Director at the WSA (and no relation to Joel Burke), remembers some of the meetings that were held in the wake of the mid-March storm: "[A]s we were starting to analyze our vulnerabilities, we were focused on our collection system and things along the river, and our Oakland Beach pump station that's on [Greenwich Bay]. Really hadn't even started looking at the plant."

Figure 12: At 14.7 feet, the Pawtuxet threatens but does not overwhelm the 18-foot levee at the Warwick wastewater facility on March 15th. (WSA)

As the March 29-31 storm hit, staff at the WSA were concerned, but not panicked. The memory of the record flooding earlier in the month was still fresh, and it seemed improbable that this storm would be any worse. After all, on Monday, March 29th, NOAA was predicting flooding levels similar to the mid-March event. On Tuesday morning, even as West Warwick staff were struggling to sandbag buildings and equipment in their plant upstream, Warwick's protective berm on the north, west, and south sides of the facility continued to hold back the rising river. By now almost eight inches of rain had fallen in a mere twenty-four hours.

Superintendent Joel Burke was a 25-year veteran at the Warwick facility. Throughout that morning, he and his staff

kept a close eye on a downstream USGS river-depth gauge, noting the gradual rise in the river. Operators at the WSA kept an eye on their berm as well.

"We were scrambling up the inside of the levee to measure the remaining freeboard on the backside of the berm," says Burke. "In what became a very surreal, slow moving morning, the river kept inching higher toward the top of the levee."

Heavy flows were also coming into the plant from the collection system, to a point where operators were having difficulty keeping up. The WSA and the City of Warwick made the decision to shut down some pump stations and put out calls urging customers to conserve water in an effort to lower the flow coming into their plant. Some areas of Warwick were already being evacuated, which lessened the incoming wastewater flow somewhat.

Just before 1:00 p.m., not long after West Warwick's crew evacuated their plant, Pat Doyle was working with an electrician in the motor control room towards the back of the plant adjacent to the western portion of the berm. They were trying to restore power to the disinfection building.

Doyle recalls "the chief operator came and said, 'What are you guys doing?' And I said, 'We're trying to get power restored to the chlorine building so we can continue disinfection,' and he said, 'Why?' And I'm like, 'What do you mean *why?*' And he said, 'We gotta abandon ship, we gotta leave. Water's coming over the top of the levee!'"

Figure 13: Warwick's 18-foot levee overtopped, bringing water into the plant and flooding process tanks and buildings soon after. (WSA)

The west side of the berm was overtopped at about 1:15 p.m. As the water poured over, it became trapped and began to fill the facility like a giant swimming pool. There was nothing that could be done to stop it. Just one half-hour later and with no alternative, the National Guard ordered the facility to be evacuated. Some vehicles and heavy equipment had already been moved to a nearby overpass, above the reach of the river. Additional office equipment was quickly stashed on the second floor of the WSA's operations building. Staff also managed to grab some of the remaining computers and documents before they left for safety. Joel Burke recalls that those final hours just before and after the levee was overtopped were the most exhausting of the day, both mentally and physically: "I was at a complete loss for words as the city's Director of Emergency Management watched me shut the front gates to a flooded facility." The Pawtuxet River would continue to rise and crest the next day, March 31st, at 20.79 feet; more than double its flood stage elevation.

BettyAnne Rogers is the Pretreatment Coordinator and Lab Director at the WSA. She remembers how quickly the events of that day developed. "Kind of like a whirlwind; you walk into work in the morning, and the next thing you know you're watching on the news that your office is underwater. That was disturbing."

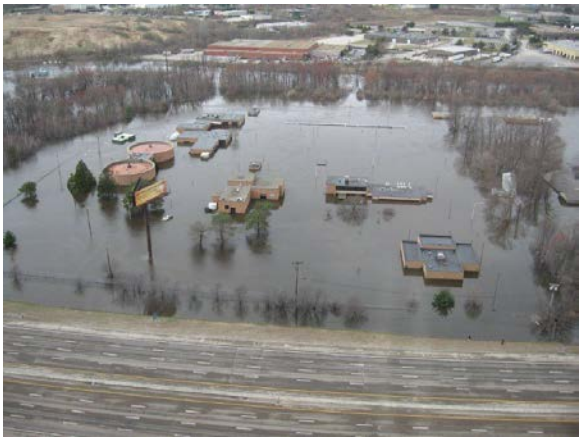

Figure 14: The flooded Warwick wastewater facility sits between the surging Pawtuxet and the closed Interstate 95 on Wednesday, March 31st. (State of Rhode Island)

Recovery started almost as soon as the rain stopped. Unlike at the West Warwick facility, where staff were able to advance into the plant as the flooded Pawtuxet receded, the WSA's protective levees that were built to keep the river out were now holding six feet of water inside the facility. The grounds would not drain dry, and staff couldn't get in except by boat or in waders. By the afternoon of Thursday April 1, contractors assisting WSA staff had set up temporary electrical power and began pumping out the facility. Initially, administrative and clerical staff had been sent home. "I didn't know what else to do with them," says Burke-Wells. "I told them not to come in the next day." But no one at the WSA wanted to stay home. Staff began calling in asking what they could do to help.

Recovery operations were directed first from the Emergency Operations Center (EOC) at the Warwick Fire Department, and then from temporary office space set up in a vacant building just a quarter mile from the WSA facility. It would be July before they were able to return to their rebuilt offices at the facility.

In the meantime, small crews were busy maintaining around the clock checks of the city's forty-eight pumping stations. Normally, the stations are monitored electronically from the facility's operations center, but with power and communication systems down, and the operations room flooded, the only way to ensure that the stations were working was through regular physical inspections.

Contracting services were obtained from Hart Engineering and AECOM Technology Corporation, both of whom had worked on recent upgrades. "So AECOM along with Hart developed this critical path of recovery," recalls Pat Doyle. Restoring temporary power and getting wastewater flowing through the facility again was a priority, but first the estimated twenty-five-million gallons of water trapped inside the levee had to be pumped out. Enormous twelve-inch pumps were set up on the levee to carry the water up and out of the flooded facility. In one example of ingenuity, a worker located a submerged storm drain in the facility by wading through the waist-deep water with a broomstick,

while another consulted an image of the plant on Google Earth and shouted directions. Once located, they were able to lower a hose into the manhole and pump directly from the facility's storm drain system. This allowed water to be pumped out of the plant from the lowest possible point, and eliminated the need to move hoses around chasing puddles.

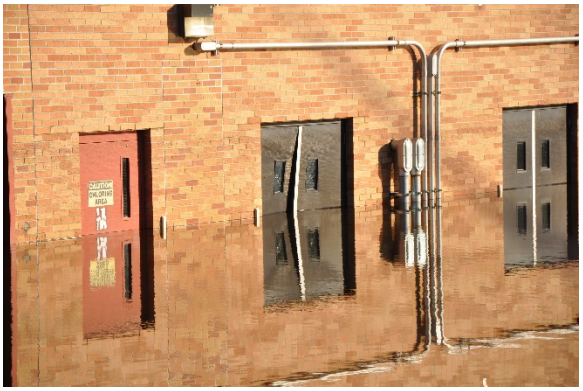

Figure 15: Warwick's disinfection building, where operators had been working to restore power when the nearby levee was overtopped. (WSA)

Debris was cleared from the headworks and clarifiers, and within three days WSA staff could now manage gravity flow through the facility. Secondary treatment requires waste-digesting microorganisms and electricity, and the flood had taken out both. A temporary chlorine drip for disinfection was set up at the end of the plant—a system that, without power and instrumentation, needed to be manned round the clock with plant staff and even help from the US Environmental Protection Agency.

Temporary power was established a week and a half later, and the secondary treatment tanks were reseeded with microorganisms from other wastewater facilities. It took another two to three months before secondary treatment was fully restored and operating within normal parameters. As Janine Burke-Wells wryly notes, "some of the solids and BOD results were even better than before…probably because everything was nice and clean now."

At the same time, work was underway to restore the buildings and physical facilities at the plant. Water has an astounding capacity for destruction, and the WSA had been sitting in six feet of it. Pat Doyle was on-site throughout the recovery. Like West Warwick, floodwaters had not damaged the structural integrity of Warwick's tanks or buildings, but the buildings had to be gutted; everything was ripped out and rebuilt. "[E]very wire in the place was pulled and replaced," said Doyle.

Figure 16: Warwick's wastewater facility on Saturday, April 3rd as flood water continued to be pumped back over the berm. (RIDEM)

The gutted buildings had to be inspected and cleared by an industrial hygienist to ensure that no mold or bacteria were lurking inside. Rogers remembers the first time she was able to re-enter her office after the water had been pumped out. "Everything was all over the place. My plants were really

happy; they had been fed very well. And it was really hot and humid, it was like *Little Shop of Horrors* when you walked in."

Figure 17: A once ordered office at the WSA in disarray after flood waters receded. (RIDEM)

Doyle recalls the personal toll that the rebuild took on the staff and operators at the WSA. Uniforms and belongings had been lost, along with any semblance of a normal routine; simply punching in at the start of a shift was an issue. Emergency showers and portable toilets had to be brought in, with running water tapped from a nearby fire hydrant. Doyle and the rest of the staff rolled with the punches. "It was months and months before you could sit down and eat your lunch in a normal environment, or have a clean locker to store your clothes."

Recovery work at the plant was not only focused on restoring the bare minimum of necessities; it was an opportunity to create a more effective, more efficient, and more resilient wastewater treatment facility. "Everyone wanted to help," says Burke-Wells, "and everyone wanted to make things better."

An illustrative example of the improvements that were made is the new analysis lab located in the operations building. After the flood, the lab looked like it had been lifted off its foundation and violently shaken. Anything that could float had been picked up by the water and deposited randomly around the room. Heavier, expensive instruments were simply submerged and ruined. The only piece of equipment that survived was an old pH meter that had fallen off a cabinet and landed on a floating bit of debris. The lab chemicals, many of which had leaked and were potentially dangerous, had to be inventoried and removed by a hazardous waste team. As the lab was being stripped and cleaned, then Process Control Operator Chuck Labbé set about the task of restocking it. "I basically sat at a desk, I literally just closed my eyes, and I walked through the lab in my mind. What did I need to buy, what do I need to improve on? I went through every single item . . . and I put a large list together." The lab today is as clean and organized as an upscale restaurant kitchen and has been modernized with new equipment, allowing laboratory staff to do their job that much better.

A critical component of a treatment facility's operation is its SCADA (Supervisory Control and Data Acquisition) system, which allows operators in the plant to monitor the various systems within the treatment plant in real time. It also allows electronic communication with remote pump stations. Just prior to the facility being overwhelmed, operations staff disconnected the SCADA servers from the first floor of the Operations Building and moved them upstairs. This saved the servers, but left operators with no way of

knowing how the city's forty-eight pump stations were operating, if at all. Until SCADA communications were reestablished, teams continued their round-the-clock checks of the remote stations. As part of the reconstruction, the SCADA system is now permanently housed on the second floor.

There is an ongoing effort being made at the WSA to mitigate the damage future floods might bring. Several pump stations have been elevated or hardened against flooding. The levee that surrounds the WSA is currently being raised from the 100-year-flood elevation to the 500-year. It is an expensive and time-consuming task, but short of moving the entire plant, it's the best option. Sandbags, which were used without benefit around individual units and at building entrances in West Warwick, wouldn't have worked at the WSA either, according to Pat Doyle. "The levee is 2200 feet long. It would've taken an army of guys to build that up five feet high. It wouldn't have worked." It is important to note that the levee was not breached; it was overtopped, meaning the height of the river exceeded that of the levee. Once this happens, sandbagging individual buildings or equipment within the plant is useless; the water will rise inside the levee to meet the height of the water outside. At that point, "you're not going to stop it," Doyle concludes. "If it's coming up, it's coming up."

Dealing with the floods and their aftermath required a great deal of cooperation between municipal, state, and federal governments. "We had to use every resource available to us, and that included reaching out to some of the other treatment plants and asking for help," says Rogers. "We have a really tight association here in Rhode Island." As in West Warwick, navigating the complex FEMA bureaucracy was a new experience for many. "Thankfully we had help," says Burke-Wells. "The city's EMA director, [now retired] Chief Armstrong, took us under his wing . . . and he kind of educated us on what we needed to do to show expenses to FEMA."

When not rebuilding his facility's laboratory, Chuck Labbé was also tasked with tracking expenses and itemizing losses. "They realized we have all of these expenditures going on, we have overtime, cost for new equipment, rental equipment, and they needed a way to keep track of it." Labbé programmed a database that could be easily accessed by the people who would need to use it. Even with all the tracking, Labbé recalls that the process was not without its hiccups: "I ordered a pallet of toilet paper by accident, and I only wanted a case. We got the delivery, a pallet of toilet paper, and they said 'what are we doing with this?' and I said 'Whoops!'"

Despite the occasional "whoops" moment, the rehabilitation was conducted with remarkable speed and efficiency. Burke-Wells remembers the professionalism displayed through those trying days, weeks, and months. "These guys ran into the waters, into the pump stations, jumped on boats, and got themselves where they needed to go."

♦ ♦ ♦

Cranston

Crisis at Pontiac

The Cranston Wastewater Treatment Facility is located on the Pawtuxet River at 140 Pettaconsett Avenue in Cranston. The original plant was built in 1942, with the current plant build in 1982 and having received it most recent upgrade in 2016. It treats a daily average of about 13.2 MGD. The treatment facility and collection system are operated for the City of Cranston by Veolia Water, North America.

Further downriver in Cranston, the small flood on March 15 had barely scratched the city's wastewater facility. Lead Mechanic Richard Greene recalls that the response was mostly limited to "going to pumping stations and checking them out to make sure everything was working properly." That, and setting up sump pumps to control what little flooding did occur at the stations. Earl Salisbury, currently the facility's superintendent, but the assistant superintendent in 2010, reported likewise: "We really didn't have much of a problem. We were out at pump stations checking them out, making sure everything was running right . . . so we were feeling pretty good about ourselves."

By Monday, March 29, the big storm was in full swing; it had been raining continuously in Rhode Island since Sunday, and the Pawtuxet River was slowly rising. Still, there was little worry at the plant—which sits at a higher elevation than its neighbors in Warwick and West Warwick. Referring to the earliest advisories that Monday, Salisbury remembers saying to his staff, "What's it going to go up to, fifteen [feet] again? No, we're covered."

On Monday evening, then Cranston Superintendent Dan Gorka phoned Salisbury at home and told him that the incoming flow for the plant had reached 40 MGD. That was about three times the normal flow, and at the upper limit of what the plant could handle. Almost every pump at every pump station was running and even so, barely keeping up. Salisbury came in immediately and began working with the rest of the staff to keep treatment going as best they could. David Robbins, the operations supervisor at the time, was helping coordinate the response at the plant. Additional clarifiers and pumps were brought online to take some of the extra flow and relieve pressure on the system. The plant's primary splitter box, where influent wastewater is divided and sent to any one of the plant's primary clarifiers, started spilling water out and onto the ground. "So I had an operator fill up a tote with hypo [sodium hypochlorite, which is used as a disinfectant], and we were actually putting it on the ground with the [wastewater] going into the drain to try to treat that," says Robbins.

They soon lost power to the dechlorination building, exacerbating the situation. Then the lower end of the plant, where the chlorine dosing and contact tanks are located, flooded. The swollen Pawtuxet River was now mingling

directly with the plant's treated (but not fully disinfected) discharge. But even then, staff did what they could to maintain something close to normal operations.

"We kept hypo going," Robbins said, referring to the addition of disinfectant to the flooded chlorine contact tank. "[W] e figured we'd be treating what West Warwick and Warwick wasn't treating. At least we'd be killing the fecal [bacteria] going into the river."

With the rising river threatening further chaos, the decision was made to take the plant's sludge incinerator offline. Veolia Water regularly takes sludge from other wastewater treatment plants and burns it at the Cranston facility to reduce its volume and destroy any pathogens. But now Cranston's operators were turning away sludge-hauling trucks making their normal deliveries.

Maintenance Manager Russell Demeulenaere knows the problem losing an incinerator poses, and there aren't many alternatives for disposal. "Where does it go, what do you do with it? You de-water it and bring it to the landfill, which is almost full." In 2012 for example, wastewater treatment plants statewide produced just over twenty-six thousand dry metric tons of sludge, of which seventy-three percent was incinerated.

Other staff were busy all around the plant trying to keep up with both the rising flood waters and the massive amount of water entering the plant. One big concern was the activated sludge contained in the aeration tanks. If high flows washed it out, the mixed liquor would not only contaminate the river but also disrupt the treatment process going forward. Wastewater treatment facilities are issued permits from RI DEM to discharge their treated effluent into water bodies. The quality of the effluent is monitored to ensure that the plant is operating within the limits stipulated by its permit. If the activated sludge "solids" are washed out, the plant cannot effectively perform secondary treatment. "If I lose the solids," explains Salisbury, "I'm going to have permit violations for weeks afterwards because you don't have the bacteria to treat at that point."

With the river still rising, operators who were out checking pump stations radioed that the Pontiac Avenue pump station—which handles roughly seventy percent of total flow to the treatment plant—was beginning to flood with waters from the nearby Pocasset River, a tributary of the Pawtuxet. Salisbury, along with lead mechanics Jerry Potter and Richard Greene, headed out to see for themselves. Pontiac, like many larger pump stations, is mostly underground. A shed-sized superstructure opens up on the inside to two lower levels, about thirty or forty feet to the bottom. At the time, its electrical equipment was on the second floor; the bottom floor contains the pumps. The small crew reached the station in the dark. "We got halfway down the first flight of stairs and water was pouring in from every opening," Potter remembers, "and we knew that was going to be a total loss." With rain still coming down and the

nearby Pocasset River rising outside, the crew decided to evacuate for the time being. It was close to 11:00 p.m. Upon returning to the plant, Salisbury gave his report to Superintendent Gorka: "We're losing that station. It's just a matter of time."

It was early Tuesday morning when flood waters finally shorted the electrical controls at Pontiac Avenue pump station, effectively shutting it down. In an "almost comical" turn, according to Salisbury, the loss of the station's five-hundred-and-fifty horsepower pumps, which had been sending 28 MGD to the facility at the time, brought the total flow coming into the plant back down to normal levels. The treatment process started to settle down but the loss of Pontiac and two smaller stations were matters of serious concern. Until they were back in operation, hundreds of homes in the area of the flooded pump stations would be without sewer service. But there was little to be done until the rain stopped and the river began to recede. Not only was the area around Pontiac pump station inaccessible, but the road to the facility along with many others around Cranston had flooded. Camera technician Mike Ponte remembers the difficulty just getting to and from work. "I remember after working thirty-three hours, going home eight hours, and I almost couldn't get back here . . . I couldn't go by the malls, I couldn't go Route 2, that was all shut off." Ponte normally operates the remote-controlled cameras used to inspect sewer lines, but during the flood he was busy checking pump stations, delivering what few sump pumps were available to homes with flooded basements. Chief Collections Operator Anthony DeMaio echoes the frustration of trying to operate in the flooded city: "We were getting called out to sewer clogs but we couldn't do anything. Most of the pump stations were down, and the manholes were full of water."

Figure 18: The Cranston wastewater treatment facility after the Pawtuxet had begun to subside. (State of Rhode Island)

At its height, the Pawtuxet River had risen over twenty feet and covered about a third of the Cranston plant on the side closest to the river, near the secondary clarifiers. Salisbury, who prior to working in Cranston had been the Assistant Superintendent at Warwick, phoned Warwick Superintendent Joel Burke on the afternoon of the 30th to check how they were handling the storm. Salisbury happened to call at the exact moment that Warwick staff were evacuating their plant. "Earl, it's a historic day in Warwick," Burke told him. "I am locking the gate and leaving."

The Pawtuxet River had already swallowed and forced the evacuation of

Figure 19: Veolia Water's Mike Ponte and Teddy Demarco wading through flood waters as they go about the unusual business of dealing with historic flooding at the Cranston wastewater treatment facility just outside the flooded maintenance building on March 31st, 2010. (Veolia Water)

the West Warwick and Warwick wastewater treatment facilities that Tuesday afternoon, and there were fears that Cranston—at the highest elevation of the three—could be next. Floodwaters had already approached the chlorine contact tank and began creeping into other areas of the lower plant near the river. A flood-protection wall around a small access to the plant's extensive underground tunnels performed as designed, keeping the waters from pouring into major underground systems. But water was still rising, coming close to entering process buildings, which also had access to those tunnels.

Fortunately, the efforts of the staff, as well as the higher elevation of the plant in relation to its neighboring facilities, kept Cranston mostly above water. Mostly. Besides the flooded Pontiac Avenue pumping station, which would require a momentous repair effort on the part of the staff, floodwaters had poured into the basement of the treatment facility's operations and maintenance building.

More seriously, the transformer that supplies electricity to the

maintenance building was going under water. There was an extreme danger of electrocution until main power was cut. After the flooding peaked, crews began working to pump out the maintenance basement so that the staff could gain access to its tools and equipment. Even so, a lot of material was damaged or lost. "Our basement was the storage area for all the plant's critical spare equipment," explains Russel Demeulenaere, "so there were tons of motors down there, tons of equipment that had bearings, that just had to go out and get reworked after because they would just rust if you left them alone."

Crews on the road remember the surreal feeling of driving through the flooded community. "You pull up to these pump stations, and the houses are abandoned and it's completely dark. It was very eerie," says Chief Collections Operator Ted DeMarco. "Think of it, the whole area just had cops blocking it...there was no one around." Even at the plant, unusual sights were common. The city seemed to be tipped on its head. "[I saw] boats like you would see down in the bay, coming up the river from down in Pawtuxet. Like twenty-three foot boats coming up the river," remembers Richard Salisbury, Chief Collections Operator at Cranston.

Bypassing and restoring functionality to Pontiac pump station was done in record time: about sixteen hours. In the past, the same procedure had taken a full day or more. Nevertheless, it was a non-stop slog through the water with heavy equipment, moving pumps and segments of heavy piping into place and then making the connections. Assistant Maintenance Supervisor Randy Sposato was forced to improvise several times during the process. First, he hired a tracked excavator to come and maneuver the giant pumps into position around the backside of the pump station instead of using a crane to lift the pumps up and over as they had done in the past. This ended up saving considerable time.

Figure 20: Bypass pumping being assembled at the Pontiac Avenue Pumping Station. (Veolia Water)

Another problem occurred while crews were trying to connect the station to generator power. The generators are enormous, one-thousand-gallon diesels that arrive on fifty-two-foot tractor trailers. They have to be transported with near-empty tanks and then fueled once in place because of the weight. In previous floods this hadn't been a problem, but according to Sposato, on this occasion, "they go to drop the trailer in the parking lot of the pump station here, and the landing gear of the trailer just literally started sinking into the ground . . . I had to tell them to back [the truck] under it, so it wouldn't just collapse." Sposato considered using steel road plates under

the landing gear, but didn't have access to any. He knew of an alternate product, a type of poly-resin plate. "[T]hey have the same load capacity as steel, just much lighter, so two men can carry it . . . I quickly called our vendor. He had them in stock and I got them up there, and we were able to load the trailer on them safely and securely." His quick thinking saved additional time. Ultimately the feat came down to hours of collective effort under difficult circumstances.

A smaller pump station on Youlden Avenue in Cranston was disabled as well. The neighborhood there was under five feet of water. Just across the river from Youlden is Belmont Park, a low-lying area that was bought by the government and turned into baseball fields following the flooding of 1982. Jerry Potter and Richard Greene were one of the two-person crews sent to check the station on March 30th. "We were in waders up to about our chest, and we walked half a block through the water to get to the pump station . . . with sandbags on our shoulders because the outside diesel tank was floating [and] we had to weigh it down," Potter remembers. The water had not peaked yet, and people there were still trying to evacuate. There were a few sobering moments when the Veolia operators would look up from their mad struggle and appreciate the terrible chaos around them. "There was [a] couple that had just bought the house a week before, just had a baby . . . and they had to get out because the house was going under water. It was sad the whole way around."

♦ ♦ ♦

Bristol

Every neighborhood was bad

The Bristol Wastewater Treatment Facility is located at 2 Plant Street. It was built in 1935, with its last major upgrade completed in 1996. It treats a daily average of about 2.8 MGD.

Bristol's wastewater crews were in a similar situation. The plant there is situated next to a wetland in a low part of town. During excessively heavy rain events, the wetland can fill and runoff will spill over the facility's small berm and into the treatment tanks. Floodwaters can also exceed the hydraulic capacity of the outfall pipe, causing water to back up into the plant.

"We recorded 14 million [gallons per day] coming into the facility from the collection system, but our outgoing flow meter [which at the time included both wastewater flow and inflow from water flooding the plant] recorded 22 million," remembers superintendent José DaSilva. DaSilva was Chief Operator at the time of the flood, but found himself directing the response and recovery because the superintendent was away on a personal leave of absence at the time.

Massive flooding forced water out of manholes around the town. At the Bristol plant itself, stormwater was overflowing the treatment works themselves and flooding the facility grounds. The facility treats wastewater with rotating biological contactors

(RBCs). This system is comprised of large mesh drums that sit partially in wastewater and slowly rotate to grow a layer of bacteria that consume waste. The drums and the motors that turn them were submerged as the water backed up. The motors did turn back on and kept working after the flood, but later began to fail one by one and had to be replaced.

Figure 21: Bristol's Rotating Biological Contactors going under water as local flooding throughout the town makes its way to the treatment plant on March 30th, 2010. (Bristol)

Elsewhere in town, wastewater from surcharging manholes mixed with rainwater, then poured into people's basements. Phone calls started coming in to DaSilva—mostly from homeowners requesting pump-outs for their basements. "I even had one homeowner saying, 'it's coming in my basement. I'm gonna open up the manhole [in the street to release the pressure].'" DaSilva remembered advising the caller against removing a manhole cover, explaining that such tampering would be a danger to passersby—and was thus against the law. But he also knew that residents were getting desperate. In this case, he couldn't stop the homeowner from attempting to reduce area flooding, and with more calls and emergencies coming his way, he wouldn't have time to drive to that end of town to quickly assess the situation. Much of the town was under feet of water, and the facility's six-person crew was stretched to the limit, checking pump stations around the clock, keeping the treatment plant operating as best they could, and responding to calls from frantic residents.

Brian Martin was one of the Bristol operators in the field during those first few days. The crew was split into three teams of two, who were each responsible for driving a section of the town, checking pump stations and talking with homeowners. The town fire department was involved in this effort as well and coordinated the response with Bristol's wastewater teams. It was quickly realized that, despite the desire to help the people of their town, mitigation and recovery work would have to wait until the rain stopped and the flood waters began to retreat. The two departments conferred.

"They were like, 'Listen, we're not doing [anything effective],'" Martin recalls being told—which he knew was indeed the case. "We're pumping, but we got more coming in than what we can pump out." After that point, all that the Bristol operators could do was respond to calls and explain the situation to homeowners. "[A] lot of people didn't realize it was happening everywhere in town," Martin says. "They just figured their neighborhood was bad."

♦ ♦ ♦

Westerly

Threats on the Pawcatuck

The Westerly Wastewater Treatment Facility is located on the Pawcatuck River at 87 Margin Street in Westerly. It was built in 1927, with its last major upgrade completed in 2003. It treats a daily average of about 2.5 MGD. In 2010, Westerly contracted out the operation and maintenance of its wastewater collection and treatment facilities to United Water, now Suez Environmental.

The storm on March 15th hadn't significantly impacted the Westerly treatment plant; high flows and high water stressed the primary tanks, but not much else. The town was hit much harder during the March 29-31 storm.

The treatment plant is high enough on the river bank that it was not flooded by the Pawcatuck directly, but the massive flow of wastewater coming through the town's collection system was causing other problems. By Tuesday morning, the plant's headworks and primary clarifiers were overflowing uncontrollably, and the water ran down around the operations building and began to pool in a garage on the first floor. "[T]he water was probably eight or nine feet-deep in that garage," says Westerly Chief Operator Tim Costa. "And the sump pump that's in there, that also pumps it back into the system, just couldn't keep up with it."

Figure 22: Heavy flows arriving at the Westerly wastewater treatment plant from townwide flooding upstream overwhelmed the plant's influent structures. Crews here have installed temporary pumping to help relieve the flow and keep it in the system. (Westerly)

It took four days for wastewater flows to the plant to start going down. The garage remained flooded for over a week before it could be pumped out. As with the Cranston treatment facility, the high flows also affected some of the plant's treatment processes. "We had to shut our aeration tanks down because we were afraid of a complete washout," explains Costa. "We have a sponge-like media in our aerations tanks and we were afraid that it would actually wash it into our final clarifiers." Aeration tanks inject oxygen into wastewater, mixing it together, which supports the growth of microorganisms that consume waste. By shutting down aeration, Costa was trying to prevent those organisms and the media from escaping the tanks. This action prevented a major wash-out, which allowed the Westerly plant to resume regular treatment soon after the storm.

Meanwhile, most of the town's remote pumping stations were in high-

level alarm, indicating extremely high flow passing through them. Several were ultimately inundated and knocked out by the rising river. Scott Duerr, Project Manager at the Westerly facility, was stymied in his efforts to reach the problem stations. "Around ten at night (March 30th) we lost our pump station at New Canal. We headed out to check it out, [but we] couldn't even get down the road. The river was overflowing." The Pawcatuck River would crest at just over fifteen feet, more than double its flood stage. Most of the town was without power and significant portions of it were under water.

Figure 23: Westerly's lower garage filling with overflow from the overwhelmed plant uphill on March 30th, 2010. Eight feet of water eventually found its way to this low spot. (Westerly)

Costa watched from the steps of the treatment plant's operation building as home heating oil tanks and furniture floated by on the Pawcatuck. He remembers one particularly harrowing incident that occurred immediately after the storm had passed and the river had dropped enough to allow Duerr and himself to finally access the New Canal pumping station. They were in the process of setting up pumps to drain the station when, as Costa recalls, "Scotty [received] a call saying you guys need to get out of there because one of the dams on one of the rivers is about to break, and if it does all of that water is coming our way." They threw their equipment in the back of their truck and immediately evacuated. The dam in question, the Alton Dam, did not end up failing, but was circumvented and overtopped by the rising river and ended up contributing to flooding near the Westerly transfer station.

For the next several days the Westerly facility, now running on generator power, was home base for Duerr and his crew of four while they worked to bypass the disabled pump stations and keep water flowing through the treatment facility. "Everybody slept here in the break room," recalls Duerr. "I had a lot of tired guys."

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After the flood

Looking forward

Figure 24: On April 20th, 2010, new equipment arrives at the West Warwick Regional Wastewater Treatment Facility—as water-absorbing foliage appears around the plant—heralding the start of the long rehabilitation of plant equipment. (RIDEM)

Floods like the one that struck Rhode Island in 2010 are often reported in dry numerics: inches of rainfall over a period of time, water heights and velocity of flows. They are remembered with lines on walls, either drawn by hand or left by the water as stains of silt and mud. The personal toll natural disasters take on everyday people are worth remembering, as are the desperate, often uplifting stories of those who fight to keep the basic services of communities functioning in the face of catastrophe. Such is the case of Rhode Island's wastewater industry. As told by those who experienced it firsthand, the floods and their aftermath were about more than just long hours of overtime on little sleep; it was a coming together of like-minded people towards a shared goal, a public goal. It is a much needed comfort in the aftermath of disaster to be able to flip a switch and have the lights turn on, to turn the tap and get fresh water, or to simply be able to flush a toilet and know that the aquatic environment enjoyed by nature and humans alike will be protected and safe for use.

The Great Flood of 2010 was not without its silver linings, at least from an operational standpoint. Using data collected by fast response teams from the USGS and Army Corps of Engineers, Michelle Burnett and RIEMA were able to refine flood mapping for the state. "We wound up collecting about 500 high-water marks," says Burnett. High water elevation is often recorded by measuring the debris lines and other damage left behind by flood waters—perishable data that must be collected as quickly as possible. "All of that data has been now incorporated into revised and updated hydraulic/hydrologic flood studies [from FEMA] for all those water basins." Detailed information like this allows regulators to better inform the public about hazards in their area, and if their homes will be flood-prone in the future.

Also worth noting is that, despite the chaos and destruction of the late-March flooding, no loss of life occurred as a result. A small miracle, especially considering the unexpectedness of the event and the conditions that emergency response personnel had to work through.

The National Weather Service now has the ability to forecast flooding seventy-two hours out, rather than forty-eight, as well as to issue river forecasts out to seven days for even the potential for minor, moderate and major flooding

on the Blackstone, Pawtuxet and Pawcatuck Rivers. Dave Vallee has also become a regular speaker and trainer for the state's wastewater operator community, which keeps a strong relationship between his team, the RI DEM, and the wastewater crews.

Like other facilities, the Warwick Sewer Authority continues to address weaknesses in their flood protection infrastructure, and has implemented refined procedures for preparedness when major storms threaten the area. Cranston's crews from Veolia Water were able to streamline its bypass procedure for the Pontiac Avenue pump station on the fly, and moved its electrical equipment and generator aboveground or higher. Where possible, West Warwick has done likewise. In many ways, the lessons learned in 2010 have informed the way treatment facilities in the state plan for the future. Says Burke-Wells of the WSA, "We still, years later, we still talk about the flood a lot."

Even so, there is a reluctance among some to even talk about it, though once they begin, the stories tend to flow freely. Despite the tremendous effort and coming together of industry professionals, wastewater operators are most likely to characterize the ordeal as a simple case of doing what needed to be done. Humbleness is almost a defining characteristic of the industry. "These guys will never brag about themselves," says Burke-Wells, "but wastewater professionals across the state, hands down, showed their true colors. And it's a thankless job for the most part; we only usually get attention when it is something bad that's going on." West Warwick Operator Brian Lavallee, who now works at Rhode Island Resource Recovery, agrees. "Being in this business you have to have the ability to say nobody really cares what I do." Many in the industry feel that their efforts go largely unnoticed or unappreciated. "You don't see public involvement…[but] the employees, the superintendents, management, everybody, they should be commended" for their efforts. The culture of community is one of the strongest features of Rhode Island's wastewater treatment industry. Being part of a team is something they pride themselves on.

"There were all kinds of people helping," says Jerry Potter at Cranston. "It was a huge team effort, and without everybody pitching in it would have never got done, and it was great." Even in light of the long hours and difficult conditions, Dave Robbins, now the Assistant Superintendent at Cranston, recalls that "there was no question about getting help. Everybody automatically volunteered for help, they all jumped in." Even between staff and management, there is a bond of mutual expectation and respect. "It's awful tough to stop the river from coming in. But everyone at that plant, I couldn't ask any more from them," says Peter Eldridge. "They worked it right through. You know there was very little complaining throughout the whole process, and I don't think there was a crew that didn't give a 110%."

Eldridge has since moved to the Scarborough Wastewater Treatment

Plant in Narragansett, where he is Superintendent. Speaking from his office, he laughs as he reflects on the irony of his current situation. "When I left West Warwick I had said I was going to try to stay away from the water, get a sewer plant a little different. But now I'm right here on the ocean, and I'm putting in a berm." The berm will enclose the plant on three sides, providing a measure of protection against storm surges.

As climate warming trends continue, the Ocean State becomes more and more likely to experience increased precipitation overall and stronger, back-to-back storms like the ones that hit in 2010. Rhode Island's relationship with water is its defining characteristic. It has been a historic shaper of the industries and societies that are unique to the region. Rivers do not always flood; they are often "a thing of beauty," as David Vallee puts it. But the state of things in the present can no longer inform our expectations for the future. Smithfield Town Engineer Kevin Cleary was not alone during those days in March as he was struck by "the power of mother nature and her ability to cripple society in an instant." All the preparedness in the world is no match for the unthinkable. We are all very much at the mercy of powerful and well-nigh arbitrary natural forces.

What can be done? "The term *climate change* seems to bring no sense of urgency," worries Joel Burke. Without long-term action on a global scale, climate change has the potential to "inflict an immeasurable amount of hardship on future generations." Meeting this monumental challenge will require first and foremost a critical examination of ourselves and how we interact with the natural world.

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Partway through the recovery at the Warwick Sewer Authority, one of the contractors on site held a cookout for the staff. As a gift to everyone involved, he gave out t-shirts with the words 'Flood Crew of 2010' printed on them. Remembers Pat Doyle, "he gave everybody, not only his workers, but all the municipal employees, t-shirts. And everybody was like, 'Oh yeah, I survived the flood of 2010.'"

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Figure 25: With the waters receded and the sun returned, Veolia Water's Jack Branco (left) and Jay Keefe celebrate after long hours of powering up the flooded, bypassed Pontiac Avenue pumping station in Cranston.

About the author: *Nicolas Holbrook worked as an intern at the RIDEM from 2016-2017. He studied Environmental Technology at Cape Cod Community College and Political Science at the University of Massachusetts Dartmouth.*