EMBARGOED UNTIL 11 am EDT ON 5.11.2017

U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT

CHEMICAL SPILL CONTAMINATES PUBLIC WATER SUPPLY IN CHARLESTON, WEST VIRGINIA

OVER 300 MEMBERS OF THE PUBLIC SOUGHT MEDICAL TREATMENT FOR POTENTIAL EXPOSURE

THE SPILL RESTRICTED WATER USE FOR NEARLY 300,000 RESIDENTS

FREEDOM INDUSTRIES, INC.
CHARLESTON, WV
JANUARY 9, 2014

KEY ISSUES:

- TANK INSPECTIONS AND MAINTENANCE
- RISK COMMUNICATION
- PUBLIC WATER SYSTEMS SAFETY AND RISK ASSESSMENT
- TOXICOLOGICAL INFORMATION

REPORT NO. 2014-01-I-WV
FEBRUARY 2017

[This page intentionally left blank.]

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ºC	degrees Celsius
ºF	degrees Fahrenheit
AAR	After Action Report
ANSI	American National Standards Institute
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
AST	aboveground storage tank
ATSDR	Agency for Toxic Substances Disease Registry
AW	American Water
AWWA	American Water Works Association
BWN	Boil Water Notice
CASPER	Community Assessment for Public Health Emergency Response
CDC	Centers for Disease Control and Prevention
CERC	Crisis and Emergency Risk Communication
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMP	Consequence Management Plan
CHDM	Cyclohexane Dimethanol
CSB	Chemical Safety Board
CWA	Clean Water Act
DHHS	Department of Health and Human Services
DNU	Do Not Use
EHS	extremely hazardous substance
EJHA	Environmental Justice Health Alliance for Chemical Policy Reform
EMP	Event Management Practice
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPM	Emergency Preparedness Manual
ERT	Etowah River Terminal
FD	Fire Department
FEMA	Federal Emergency Management Agency
GAC	granular activated carbon
GAO	Government Accountability Office
GC	gas chromatography
GC-MS	gas chromatography mass spectrometry

GHS	Globally Harmonized System of Classification and Labeling of Chemicals
Gpm	gallons per minute
GPP	Groundwater Protection Plan
GPR	Groundwater Protection Rule
HCS	Hazard Communication Standard
ICR	Information Collection Request
ICS	Incident Command System
KCHD	Kanawha Charleston Health Department
$KMnO_4$	potassium permanganate
KPEPC	Kanawha Putnam Emergency Planning Committee
KVTP	Kanawha Valley Treatment Plant
LD	lethal dose
LDS	leak detection system
LEPC	Local Emergency Planning Committee
LRMRC	Legislative Rule-Making Review Committee
MCHM	methylcyclohexanemethanol
MGD	million gallons per day
MIC	methyl isocyanate
mpy	mils per year
MSDS	material safety data sheet
NTP	National Toxicology Program
NIMS	National Incident Management System
NOEL	No Observed Effect Level
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRDC	Natural Resources Defense Council
OEHS	Office of Environmental Health Services
OSHA	Occupational Safety and Health Administration
PAC	powder activated carbon
PCACS	People Concerned About Chemical Safety
PMN	premanufacture notice
Ppb	parts per billion
PPH, stripped	polyglycol ethers
Ppm	parts per million
Ppt	parts per trillion

PQS	Pennzoil-Quaker State
PSC	Public Service Commission
PWSSSC	Public Water System Supply Study Commission
PVA	polyvinyl acetate
SARA	Superfund Amendments and Reauthorization Act
SB	Senate Bill
SDS	safety data sheet
SDWA	Safe Drinking Water Act
SERC	State Emergency Response Commission
SLTC	Salt Lake Technical Center
SNUN	significant new use notice
SPCC	Spill Prevention, Control, and Countermeasure
SPRP	Spill Prevention Response Plan
STI	Steel Tank Institute
SWAP	Source Water Assessment Program
SWAR	Source Water Assessment Report
SWPPP	Stormwater Pollution Prevention Plan
TPQ	threshold planning quantity
TSCA	Toxic Substances Control Act
UCMR3	Third Unregulated Contaminant Monitoring Rule
WHEAT	Water Health Economic Assessment Tool
wt%	weight percent
WVAG	West Virginia Office of the Attorney General
WVAW	West Virginia American Water
WVBPH	West Virginia Bureau of Public Health
WVDEP	West Virginia Department of Environmental Protection
WVDHHR	West Virginia Department of Health and Human Resources
ZCC	zone of critical concern
ZPC	zone of peripheral concern

PREFACE

With the acceptance of public comments and the release of the Freedom Industries investigation report at a public meeting on September 28, 2016, in Charleston, West Virginia, Chemical Safety Board (CSB) Board Members committed to considering an addendum to the report after addressing any additional written comments received in the 48-hour period following the public meeting. The investigative team has reviewed all comments received and at the request of the Board, made the changes found herein. This preface explains some of the activities initiated in response to the incident, prior to CSB's arrival. These activities, directed towards mitigating the effects of the spill, presented the investigative team with challenges in determining the composition of the spilled tank contents. The preface also outlines additional information that supplements previous material contained in the Freedom Industries investigation report. Finally, minor editorial corrections were made throughout the revision of the report that includes the timeline of events and portions of Section 3 which were re-ordered for continuity and clarity.

Early Mitigation Efforts and Tank Sample Characterization

The Freedom Industries investigation report is modified to add context to characterization of the tank sample. Although CSB's notification of the incident and subsequent information gathering through calls to responding agencies began on Thursday, January 9, 2014, a decision to launch an investigative team to the Freedom site was not made until January 12, 2014, and the team arrived at the site on Monday, January 13, 2014. By this time, all material from tanks 395, 396, and 397 had already been transferred to Baker storage containers at Freedom's Poca facility as part of Freedom's emergency response and clean-up efforts. Therefore, CSB was not able to gather independent samples of material directly from the tanks at Freedom.

Accordingly, the CSB partnered with Occupational Safety and Health Administration (OSHA) inspectors on site to obtain a sample of material from one of the Baker storage containers purported to contain material from tank 396. As is standard under OSHA authority, the objective of the OSHA sampling was limited to compliance purposes and, as a result, did not address the identification of the unknown chemicals in the sample tested. CSB did not pursue any additional testing and cannot report any findings beyond what OSHA provided. A summary of the OSHA analysis is in Section 3.1.

When the leak was discovered, Freedom began efforts to remove all materials from tanks 395, 396, and 397 with vacuum trucks provided by a contractor to mitigate the source of chemicals flowing into the Elk River. It was communicated to CSB that, due to exigent circumstances, the vacuum trucks were not cleaned prior to transport. At the Freedom Poca facility, recovered tank contents were transferred from the vacuum trucks into Baker storage containers, as previously mentioned.

Although documentation from OSHA states that the contents of tank 396 were transferred to an individual Baker storage container, CSB was not present to observe and verify the transfer. Likewise, there is no record that the Baker storage containers at the Poca facility were cleaned prior to receiving the transferred material. Thus, assurances cannot be made that the contents of any of the three tanks were free from contamination of any material present in the vacuum trucks or containers that were emptied or used on the day of the incident.

Leak Quantity

Early estimates of the quantity of chemicals spilled provided by Freedom Industries ranged from about 1,000 gallons to 10,000 gallons over a 12-day period immediately after the incident occurred. A closer examination of T-396 inventory on January 8, 2014, and the amount of transferred mixture recovered in the Baker tank at the Poca site yielded a net loss of about 11,000 gallons. The breakdown of chemicals and volume of each can now be found in Table 4, and the newer quantity spilled is reflected throughout the report.

Estimated Time to leak 11,000 Gallons

Based on estimated leak rates through the two holes noted on the floor of T-396 (0.4 and 0.75-inches diameter) the amount of time for 11,000 gallons to be released was revised to between 6 and 8 hours from the previous estimate of 24 hours. The details of these estimates are presented in Section 3.2.5.

Release of Contractors' Reports

Contractor reports that documented metallurgical evaluation for portions of the tank involved in the release and inspection reports for all three tanks in Crude MCHM service at the time of the incident are released on January 25, 2017, with the revised Freedom Industries report and can be found on the CSB website at this location.[Attach hyperlink]

Nomenclature

The report is modified throughout to clarify the characterization of the material that leaked into the Elk River. The team footnoted early in the original report that, "Although Shurflot 944 is the product name for the material that leaked from tank 396, this report refers to the leaked material as Crude Methylcyclohexanemethanol (MCHM). MCHM is commonly used when referring to this incident and MCHM makes up the greatest percentage of Shurflot 944." Though the report used this convention, the team recognizes that the released material was a mixture of chemicals containing Crude MCHM and polyglycol ethers (PPH, stripped). In order to ensure greater clarity and minimize the likelihood of mischaracterizing the material that leaked into the Elk River, the team has reviewed each reference of the leaked material and made changes where necessary.

Breaches of Underground Pipe and Odor Complaints

On January 31, 2014, during mitigation of the site, there was a breach of an underground pipe by a backhoe that is thought to have released material that mirrored that which was released from T-396 on January 9, 2014. The quantity that was released was estimated to be in the "tens of gallons" range by the Director of Emergency Response and Homeland Security. Workers contained the release in a cutoff trench, and it did not reach the Elk River. There were multiple complaints throughout the first month from citizens of smelling a strong licorice-like aroma in the Charleston area. While some of these events came to the attention of CSB investigators, none were directly attributable to the release of January 9th, or indicated a resumption of spillage from the tanks involved.

1.0 EXECUTIVE SUMMARY

Incident Description

On January 9, 2014, West Virginia Department of Environmental Protection (WVDEP) inspectors arrived at the Freedom Industries (Freedom) chemical storage and distribution facility in Charleston, West Virginia, in response to complaints from the public about a chemical odor. Upon arrival, WVDEP inspectors discovered a chemical leaking from tank 396, an aboveground storage tank (AST). The leaking tank contents were originally reported as crude methylcyclohexanemethanol (MCHM),[1] but 13 days later Freedom reported it was a mixture of Crude MCHM[2] and polyglycol ethers (PPH, stripped),[3,4] called Shurflot 944.[5] The chemical mixture escaped tank 396 through two small holes on the tank floor and traveled down a descending bank into the adjacent Elk River. The holes were caused by pitting corrosion[6] that initiated on the internal surface of the tank floor. The tank contents drained into the gravel and soil surrounding tank 396 and found multiple pathways into the river. The secondary containment or dike wall, originally designed to control leaks, had cracks and holes from disrepair that allowed the mixture, containing Crude MCHM and PPH, stripped, to escape the containment. The leak also found a pathway to the river through a subsurface culvert,[7] located under adjacent ASTs.

After prompting by WVDEP, Freedom took action to stop the leak and prevent further contamination by deploying services to recover the spill and vacuum the remaining tank contents. However, nearly 11,000 gallons of a mixture containing Crude MCHM and PPH, stripped had already entered into the surrounding soil and Elk River. Once in the river, it flowed downstream to the intake of the West Virginia American Water (WVAW) water treatment facility, about 1.5 miles downriver from Freedom. WVAW's water treatment and filtration methods were unable to treat and remove all of the chemical mixture in its water treatment process and as a result, it contaminated the drinking water within WVAW's distribution system. That evening, WVAW issued a Do Not Use (DNU) order for 93,000 customer accounts (approximately 300,000 residents) across portions of nine counties.

---

[1] According to the Eastman Safety Data Sheet, Crude MCHM has a licorice and alcohol-like smell that is detectable at concentrations as low as 0.15 part per billion. Eastman Chemical. Safety Data Sheet for Crude MCHM. Revised 9/15/2016. http://ws.eastman.com/ProductCatalogApps/PageControllers/MSDS_PC.aspx?Product=71014291 (February 2, 2017)

[2] Crude MCHM is a mixture of chemicals. See Table 3 for the range of expected concentrations of the various components that make up Crude MCHM.

[3] Crude MCHM and PPH, stripped are used in froth flotation to assist in the removal of impurities in coal for the mining industry.

[4] West Virginia Department of Environmental Protection. News Bulletin. http://www.dep.wv.gov/news/Pages/Freedom-verifies-two-chemicals-(Crude-MCHM,-PPH)-in-tank.aspx (September 7, 2016).

[5] Although Shurflot 944 is the product name for the material that leaked from tank 396, this report refers to the leaked material as a mixture of Crude MCHM and PPH, stripped.

[6] Pitting corrosion is a form of localized corrosion that leaves deep pits or holes in the surface of a metal.

[7] A culvert is a tunnel or pipe that is located under a structure and used to direct water, usually to prevent flooding of a highway, street or road.

Consequences

After the issuance of the DNU order, hospital emergency departments reported an increase in patient visits.[8] Public health officials reviewed 369 records of emergency room visits in 10 local hospitals between January 9 and January 23, 2014. The records included patients who reported one or a combination of symptoms including nausea, rashes, vomiting, abdominal pain and diarrhea following exposure to the water through inhalation, ingestion and/or skin contact.[9] Although hospitals could not confirm if the chemicals in tank 396 caused the documented symptoms, public health agencies concluded that the symptoms appeared to correspond with the first few days of the incident. The Safety Data Sheet (SDS) for Crude MCHM lists eye, skin and respiratory irritation as hazards from exposure to undiluted MCHM.[10]

In addition to the symptoms reported immediately following the leak into the public water supply, residents affected by the DNU order were advised to restrict usage of tap water for drinking, cooking and bathing for four to nine days, depending on their location. The DNU order resulted in closures of many businesses, schools and public offices. The Federal Emergency Management Agency (FEMA), the West Virginia National Guard, other state agencies and WVAW worked to ensure affected residents had water available. Some residents reported that the unpleasant and highly detectable licorice odor of spilled chemical components remained in the water for several weeks following the leak, even after residents flushed their piping as requested by WVAW and the West Virginia Department of Health and Human Resources (WVDHHR). In a survey conducted by the West Virginia Bureau of Public Health (WVBPH) and the Centers for Disease Control and Prevention (CDC), many residents reported belief that the water was not safe to drink after WVAW lifted the water restrictions.[11]

Freedom's communication to the public, state and federal agencies, WVAW and first responders regarding the chemicals and quantity of chemicals involved in the leak was deficient. Freedom failed to

---

[8] West Virginia Department of Public Health and Agency for Toxic Substances and Disease Registry. Elk River Chemical Spill Effects. http://www.dhhr.wv.gov/News/chemical-spill/Documents/ElkRiverMedicalRecordSummary.pdf (July 8, 2016).

[9] West Virginia Department of Health and Human Resources. Findings of Emergency Department Record Review from Elk River Chemical Spill. http://www.wvdhhr.org/communications/news_releases/DHHR%20Press%20Release%20-%20Findings%20of%20Emergency%20Department%20Record%20Review%20from%20Elk%20River%20Chemical%20Spill.pdf (July 9, 2016).

[10] Eastman Chemical Company. Safety Data Sheet for Crude MCHM. Version 2.0. August 18, 2011. Safety Data Sheets, formerly known as Material Safety Data Sheets (MSDS), contain important information about the hazards of chemicals in a uniform format. SDSs must contain information such as chemical identification, first aid and firefighting measures, physical and chemical properties and toxicological information among other categories. In addition, SDSs must be readily accessible to employees and emergency responders. The Hazard Communication Standard was recently updated to conform to the Globally Harmonized System Classification and Labeling of Chemicals (GHS). The GHS uses the term "Safety Data Sheet" and therefore the regulation no longer uses the term "Material Safety Data Sheet." For purposes of this report, any safety sheet will be referred to as an SDS despite the fact it may not comply with the updated format and was referred to as an MSDS at the time of the spill.

[11] Center for Disease Control and Prevention. Disaster Response and Recovery Needs of Communities Affected by the Elk River Chemical Spill. http://www.dhhr.wv.gov/News/2014/Documents/WVCASPERReport.pdf (July 9, 2016).

immediately communicate information about all the chemicals present inside tank 396 and did not inform the public that the second chemical, a mixture of polyglycol ethers, (PPH, stripped), was also present in tank 396 until 12 days after leak discovery. Freedom instead provided the SDS for Crude MCHM to WVAW and emergency responders after the spill. The SDS for Crude MCHM was the only available information about the spilled chemicals at the time of the incident, and offered little information to immediately establish the threat to humans.

At the request of WVBPH, CDC used the available toxicological information on the Crude MCHM SDS to recommend a screening level of 4-MCHM at 1 part-per-million (ppm). Eastman Chemical Company, the Crude MCHM manufacturer, voluntarily conducted toxicological testing on Crude and 4-MCHM prior to the incident and made those studies available to public health officials on the evening of January 10. Though not required to do so, Eastman's tests did not include studies at low doses that would have assisted public health professionals in promptly communicating the risk of exposure when residents began reporting symptoms. Freedom continued to revise its estimate of the quantity released, which increased from about 1,000 to 10,000 gallons over the course of 12 days. The CSB ultimately estimated the leaked volume to be almost 11,000 gallons.

Key Findings

Chemical Safety Board (CSB) investigators gathered information to understand both the technical cause of the incident as well as the role of WVAW and federal, state and local agencies when responding to the contaminated water supply. In examining these issues, CSB identified the following key findings:

1. At Freedom Industries, a mixture containing Crude MCHM and PPH, stripped leaked from an aboveground storage tank (tank 396) through two holes. These holes, measuring approximately 0.75 and 0.4 inches in diameter, formed due to pitting corrosion that degraded the thickness of the tank floor from the interior. Although the soil side of the tank bottom was corroded as most tank bottoms are, the amount of soil side corrosion was insignificant compared to the pitting corrosion that directly led to the incident.

2. Once the mixture escaped tank 396, it moved through the soil beneath the tank and migrated to the Elk River through two pathways: (1) the failing secondary containment wall located between tank 396 and the Elk River, and (2) a deteriorated underground culvert located around tank 396.

3. CSB found no documentation of prior inspections or maintenance conducted by Freedom or the prior facility owner, Etowah River Terminal (ERT), which would have identified and addressed internal corrosion in tank 396. Such inspections and maintenance could have identified and addressed the interior corrosion and holes in tank 396.

4. Freedom was required to maintain adequate secondary containment under the West Virginia/National Pollutant Discharge Elimination System (NPDES) General Water Pollution Control Permit's Stormwater Pollution Prevention Plan and the Groundwater Protection Rule. Freedom was aware of the deteriorated secondary containment wall but did not repair it prior to the incident. CSB found no evidence that Freedom or ERT implemented a Stormwater Pollution Prevention Plan or Groundwater Protection Plan. WVDEP did not inspect the site for compliance

with these programs due to resource constraints.

5. Freedom did not have any leak prevention or leak detection system in place to immediately provide notification of tank leaks.

6. Once the mixture containing Crude MCHM and PPH, stripped entered the Elk River, it flowed into WVAW's water intake, located about 1.5 miles away from the Freedom facility site. The water treatment process was not capable of fully treating and removing the chemicals. This allowed the mixture to contaminate the drinking water.

7. WVAW and WVBPH decided WVAW could not shut down its drinking water treatment system because there was no alternative raw water supply and doing so could have compromised fire protection and sanitation. In addition, depressurizing the water distribution system would have caused extensive damage and further delays in water restoration. Accordingly, a "Do Not Use" order was issued less than two hours after WVAW detected odors in the treated water intended for distribution.

8. The DNU order was not issued immediately because WVAW was mistakenly informed that Crude MCHM was a flocculant, rather than a frothing agent, and that only 1,000 gallons was released. WVAW assumed its water treatment and filtration system was capable of fully treating and removing the chemicals from the water.

9. Source water protection efforts vary by state, and as a result, surface water treatment plants across the United States are subject to different requirements to protect drinking water sources. In response to new state requirements after the Freedom incident, WVAW submitted a source water protection plan to WVBPH that goes beyond existing federal requirements. Because American Water (AW) provides guidance and some oversight through required policies to its subsidiary water utilities across the United States, AW is well positioned to establish requirements for its subsidiary surface water treatment plants to develop and implement plans similar to WVAW's plan to ensure they are adequately prepared for potential contamination events.

10. Local, state and federal public health officials only had information from Eastman's Crude MCHM Safety Data Sheet and later, toxicological studies, to communicate to the public and credibly determine the risk of exposure. As the crisis evolved, residents in the Charleston area were given unclear and conflicting announcements because of the changing information from Freedom and government agencies, which increased public uncertainty about the safety of the drinking water.

11. The American Water Works Association, a nonprofit scientific and educational association for managing and treating water, is well positioned to assist water utilities by disseminating important lessons that are learned from chemical contamination incidents that could potentially affect a drinking water distribution system.

Lessons Learned

CSB's investigation of Freedom led the agency to find several issues related to identifying and assessing hazardous chemicals stored near water treatment intakes, as well as responding to and communicating public health risks during drinking water contamination incidents. Since the incident, the State of West Virginia, WVAW, and other agencies and organizations have established requirements and implemented practices that have addressed many of the gaps that CSB identified early in its investigation. Because requirements regarding ASTs and source water protection vary by state, CSB has developed the following key lessons for AST owners and operators, state governments, drinking water utilities and public health officials across the United States to use so that they are adequately prepared for, can respond to and are able to effectively communicate the public health risks of an incident involving the release of a hazardous chemical near a drinking water source.

1. AST owners and operators of facilities storing chemicals near drinking water sources should establish regular inspection programs and routinely monitor tanks and secondary containment to verify tank integrity and containment of leaks. They should coordinate with nearby water utilities and emergency response organizations to ensure that the information about their stored chemicals (e.g., chemical characteristics, quantity, and toxicological information) is communicated and can be made immediately available in the event of a leak.

2. AST owners and operators covered under existing regulatory programs (e.g., Spill Prevention, Control, and Countermeasure; National Pollutant Discharge Elimination System) should ensure that the associated spill prevention and protection plans under those programs are updated and implemented to reduce the potential for leaks from ASTs and secondary containment.

3. Due to the large number of existing chemicals in commerce, the Environmental Protection Agency's review of all chemicals under the federal Toxic Substances Control Act could take years. Many of these chemicals lack toxicological information; therefore, states should take immediate action to protect source waters and the public from these unknown and potentially hazardous chemicals. This can be achieved through increased inspections and enforcement at chemical storage facilities near water sources and coordination between emergency response organizations and public health agencies.

4. States should establish Source Water Assessment Programs that mandate source water protection planning by water utilities. States should ensure that water utilities have full and simple access to the data necessary to support this mandate. Water utilities should complete Source Water Protection Plans that include the following components:

    a. System operational information;
    b. Source water delineation and characterization;
    c. Potential significant sources of contamination;
    d. Management strategies;
    e. Source water monitoring;
    f. Communications and contingency; and
    g. Alternate sources of supply.

Source Water Protection Plans should be updated at least every three years or when there is a substantial change in the potential sources of significant contamination within the identified zone of critical concern.

5. Water utilities should engage with their Local Emergency Planning Committee and/or State Emergency Response Commission to obtain Tier II information and use that information to identify water intakes that could potentially be at risk of contamination from those chemicals in the event of a spill.

6. Water utilities should assess the capabilities of their water treatment systems to treat and remove potential leaks from all potential sources of significant contamination within their zone of critical concern. Where feasible, water utilities should use established laboratory analytical methods to detect the presence or measure the concentration of potential hazardous chemicals or classes of hazardous chemicals.

7. Public health agencies should coordinate with water utilities, emergency response organizations and facilities that store chemicals near drinking water sources to ensure that information concerning chemicals and potential risks to the public are immediately available in the event of a spill. They should establish a communication framework to ensure information, as it becomes available, is communicated through one entity or organization.

Recommendations

As a result of the causes and findings of this investigations, CSB makes recommendations to the following recipients (see Section 8 for the full language of the recommendations):

1. The American Water Works Association
2. American Water Works Company, Inc.
3. Eastman Chemical Company

2.0 FACTUAL INFORMATION

2.1 Incident Description

2.1.1 Leak Discovery

On January 9, 2014, WVDEP received an air quality complaint of an odor suspected of coming from the Freedom facility in Charleston, West Virginia (Figure 1).[12] At about 10:00 AM that same morning, the Kanawha County Metro 911 call center received reports of a chemical odor at the intersection of Interstates I-77 and I-79 in Charleston, about 1.5 miles from the Freedom site. WVDEP inspectors arrived at the Freedom site around 11:05 AM and met with the President of Freedom to discuss the odor complaints. At about the same time, a Freedom employee informed the Freedom President of the leaking tank, initially reported to contain Crude MCHM. The Freedom President escorted WVDEP to the suspected leak location near tank 396, where inspectors observed an ongoing leak that was described as an upwelling, "fountain-like" flow into a 400-square-foot pool of liquid estimated to be three or four inches deep. WVDEP noted that the northwest corner of the leak pool was continuously flowing into a 12-inch-diameter underground culvert and seeping under and through a secondary containment[13] wall surrounding the ASTs into the adjacent Elk River. The Elk River is a tributary of the Kanawha River, which in turn is a tributary of the Ohio River.

Freedom personnel used a cinder block and a single bag of absorbent in an attempt to contain the flowing chemicals seeping from the containment wall. This method proved immediately ineffective as the absorbent bag floated away. Freedom had no additional leak containment supplies onsite. WVDEP inspectors determined that the spill threatened the local public water supply intake at the WVAW water treatment facility, located about 1.5 miles downstream[14] and ordered Freedom to remediate the site. At 11:56 AM, WVDEP notified the Water Quality and Environmental Compliance Supervisor for WVAW (WVAW Supervisor) of a Crude MCHM leak of an unknown quantity into the Elk River. When the WVAW Supervisor asked what Crude MCHM was, the WVDEP inspector indicated it was a flocculant[15] or a coagulant. At about 1:05 PM, a vacuum truck arrived at Freedom to collect the pooled liquid and remaining tank contents.

2.1.2 Leak Response

Upon notification of the leak, the WVAW Supervisor drove to the Freedom site to obtain more information. He later reported to CSB investigators that there was a noticeable sheen on top of the water

---

[12] West Virginia Department of Environmental Protection. Air Quality Complaint Investigation Form. Complaint Number CH-2014-0193. 2014. http://www.courtswv.gov/supreme-court/clerk/pdf/cases-of-interest/covenant-v-huffman/14-0112Appendix.pdf (May 24, 2016).

[13] Secondary spill containment is the containment of hazardous liquids in order to prevent soil and water pollution. Common techniques include the use of spill berms to contain oil-filled equipment, fuel tanks, truck washing decks or any other places or items that may leak hazardous liquids.

[14] Downstream Strategies. The Freedom Industries Spill. http://www.downstreamstrategies.com/documents/reports_publication/freedom-spill-report_1-20-14.pdf (May 24, 2016).

[15] Both used in water treatment, flocculants and coagulants assist in clumping together suspended solids or particulates to facilitate sedimentation.

in the Elk River adjacent to the leak location. While onsite, he was again informed that the tank material was a flocculant. The WVAW Supervisor was familiar with the term because WVAW uses flocculants on a routine basis.

The WVAW Supervisor called WVAW treatment plant operators to update them about the leak and request that they turn on the powder activated carbon (PAC) and increase the potassium permanganate feed as a precaution. There were printer issues at Freedom, and the WVAW Supervisor did not view a hard copy of the Eastman Crude MCHM SDS until 1:00 PM that afternoon, about an hour after he arrived onsite.[16] Freedom provided the WVAW Supervisor with an SDS for Crude MCHM, but at the time, did not disclose that fact that tank 396 contained a chemical mixture of Crude MCHM and PPH, stripped. Upon reviewing the SDS, the WVAW Supervisor concluded that the Crude MCHM characteristics were not consistent with what he would expect to see in a flocculant and informed the WVDEP of the presence of alcohols in the material. At some point later while at the Freedom site, someone working onsite, possibly a representative from Freedom or a trucking company, informed the WVAW Supervisor that tank 396 contained a frothing agent, not a flocculant. Frothing agents are used in the mining industry to separate coal from rock—they create foam or bubbles to which coal particulates attach and can be separated.[17] Shortly after, WVDEP estimated that the quantity released was between 1,000 and 5,000 gallons.

Around 2:00 PM, WVAW operators reported a faint odor in the raw river water coming into the water treatment plant. Based on the estimated quantity spilled, available information about Crude MCHM and the status of water storage within the distribution system, WVAW decided to continue to monitor the water throughout the filtration process and relied on the PAC and water purification system to remove the odor and taste issues that may be associated with the chemical. Shortly after 4:00 PM, WVAW determined that the filters did not fully remove the chemicals. At around 5:00 PM, WVAW advised WVBPH and later the Governor's Office that WVAW detected chemical odors in the water beyond the filters, and that the water distribution system might be contaminated.[18] According to WVAW, shutting down the Elk River intake was not a viable option because of the impact it would have on fire protection and sanitation; furthermore, this impact would have lasted longer had the system been depressurized due to closing the intake.

Shortly before 6:00 PM, WVAW, after consultation with the Governor's Office, WVDEP and WVBPH, issued the DNU order. The DNU order applied to customers in nine counties that receive water from WVAW's Kanawha Valley Treatment Plant (KVTP) and lasted up to nine days. On January 10, WVDEP issued violations to Freedom under the State of West Virginia Water Pollution Control Act, Groundwater

[16] That day, staff from the City of Charleston and Kanawha County Office of Emergency Management obtained the current MCHM SDS and offered a copy to WVAW personnel, who stated they already had it.

[17] Nalco Chemical Company. Process for Coal Flotation Using 4-methylcyclohexanemethanol Frothers. https://www.google.com/patents/US4915825?dq=methylcyclohexanemethanol+froth&hl=en&sa=X&ved=0ahUKEwid3O-Kor7NAhXGNiYKHXQ3D6EQ6AEIIDAA (July 8, 2016).

[18] Office of the Governor. After Action Review. http://www.dhsem.wv.gov/West%20Virginia%20Public%20Water%20Supply%20Study%20Commission/Documents/After%20Action%20Review.PDF (February 3, 2017).

Protection Act and Air Pollution Control Act. WVDEP found that the spill of a "chemical described as 4-MCHM" caused "conditions not allowable in the Elk River by creating odors in the vicinity of state waters, by requiring an unreasonable degree of treatment for the production of potable water."[19] WVDEP also issued a notice of violation to Freedom for discharging an air pollutant that caused an objectionable odor at any location occupied by the public.[20] WVDEP ordered Freedom to immediately remove the material from the ASTs and submit a site remediation plan within 24 hours.

WVBPH requested that CDC recommend a safe drinking water level for 4-MCHM based on the Crude MCHM SDS, the only information available shortly after leak discovery. 4-MCHM is the main component of Crude MCHM, making up 68 to 89% concentration.[21]The state obtained and adopted from CDC a 1 ppm short-term screening level concentration for 4-MCHM in drinking water during the afternoon of January 10. WVAW, the National Guard and private labs developed a method to test for 4-MCHM in drinking water, which began analyzing samples later that day. WVAW developed a systematic distribution system flushing program using hydraulic models that allowed WVAW to predict where the chemical was located and remove it from the distribution system. Once zones within the distribution system had multiple test results below the CDC limit, customers were allowed to flush their home plumbing. On January 13, WVAW and WVDHHR advised residents to flush their pipes before using the water. On January 15, WVBPH and CDC issued a drinking water advisory cautioning pregnant women to drink bottled water until "there are no longer detectable levels of MCHM in the distribution system."[22] On January 21, 2014—three days after the DNU order was lifted—the President of Freedom announced that another chemical mixture, PPH, stripped, was also released into the Elk River during the initial spill.[23] The detailed leak discovery and response timeline of events is depicted in Appendix A.

[19] Department of Environmental Protection. Order Issued under the Water Pollution Control Act and the Groundwater Protection Act. http://www.dep.wv.gov/pio/Documents/Freedom%20Industries%20Order%208028.pdf (July 8, 2016).
[20] Department of Environmental Protection. Notice of Violations to Freedom Industries. January 10, 2014.
[21] Eastman Chemical. Safety Data Sheet for Crude MCHM. Revised 9/15/2016. http://ws.eastman.com/ProductCatalogApps/PageControllers/MSDS_PC.aspx?Product=71014291 (February 2, 2017)
[22] State of West Virginia Department of Health and Human Resources Bureau for Public Health Commissioner Office. Water Advisory for Pregnant Women. http://www.dhsem.wv.gov/Documents/Advisory%20-%201-15-2014.pdf (July 8, 2016).
[23] West Virginia Bureau of Public Health. CDC Statement on PPH. http://www.dhhr.wv.gov/News/chemical-spill/Documents/CDCstmtonPPH.pdf (July 8, 2016).

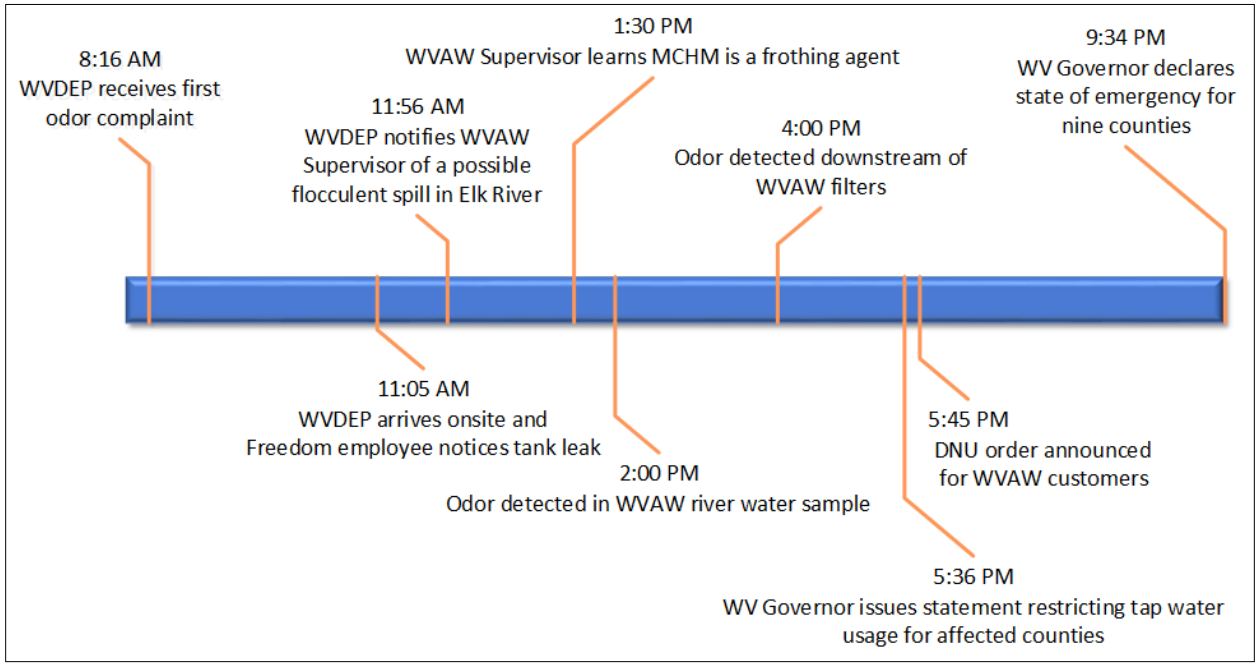


Figure 1. Timeline of leak response for January 9, 2014. Some event times are approximate. (Source: CSB)

2.1.3 Consequences

As a result of the spill, residents and visitors in the Charleston area served by WVAW were advised to restrict their tap water usage, and many people who ingested or bathed in the water before or during the water use restrictions reported various symptoms.[24] Animal toxicological studies dermal and eye irritation at high concentrations of both Crude and pure (distilled) MCHM.[25] During the spill, residents contacted the West Virginia Poison Center reporting rashes, nausea, vomiting, diarrhea and other symptoms.[26]

[24] According to the Agency for Toxic Substances and Disease Registry and WVBPH, "it was possible that the symptoms reported to be caused by exposure to MCHM could have been caused by other mild clinical illnesses such as a cold, flu or viral infections." Agency for Toxic Substances and Disease Registry, West Virginia Bureau of Public Health, Elk River Chemical Spill Health Effects, Findings of Emergency Department Record Review. April 2014. http://www.dhhr.wv.gov/News/chemical-spill/Documents/ElkRiverMedicalRecordSummary.pdf (January 31, 2017).

[25] Dennis J. Paustenbach, Bethany Winans, Rachel M. Novick & Steven M. Green (2015). The toxicity of crude 4-methylcyclohexanemethanol (MCHM): review of experimental data and results of predictive models for its constituents and a putative metabolite, Critical Reviews in Toxicology, 45:sup2, 1-55, DOI: 10.3109/10408444.2015.1076376. http://dx.doi.org/10.3109/10408444.2015.1076376 (February 7, 2017).

[26] WV Poison Control Center and Midatlantic Center for Children's Health and the Environment. Fact Sheet. February 2014. http://www.legis.state.wv.us/legisdocs/2014/committee/interim/water/Documents/Bureau%20for%20Public%20Health%20Packet.pdf (November 14, 2016).

Immediately following the DNU order, area hospitals reported an increase in emergency room visits. Patients reported symptoms of nausea (most common), rash, vomiting, abdominal pain and diarrhea.[27] Between January 9 and January 23, 2014, WVBPH and the Agency for Toxic Substances and Disease Registry (ATSDR) reviewed 584 emergency department records. Of those 584 records, 369 records were further analyzed for patients who had symptoms and reported exposure to the water. Of the 369 records analyzed, 13 patients were hospitalized for chronic conditions such as kidney, liver or lung disease, and the remaining 356 were treated and released after receiving intravenous fluids and/or medications for nausea or itching.[28] WVBPH and ATSDR found that 52.6% of the patients reported exposure to the contaminated water while bathing, showering or other skin contact; 43.9% from eating, drinking or swallowing; and 14.6% through inhalation (see Section 4 for a description of the public health impact).[29]

The spill affected 93,000 customers (approximately 300,000 residents) in nine West Virginia counties,[30] including roughly 51,400[31] residents in Charleston, West Virginia, the state capital. In the days following the spill, local residents were given a number of drinking water announcements that were unclear and confusing.

Samples collected from the water distribution system in public buildings and schools on January 25 revealed that 4-MCHM levels were 50 parts per billion (ppb), consistently lower than the safe concentration established by CDC at 1 ppm. Despite these concentrations of 4-MCHM in the laboratory tests, many citizens continued to detect chemical odors in their tap water and reported remaining skeptical of the overall safety of the drinking water for several weeks following the incident.[32]

Immediately following the DNU order, the State of West Virginia was challenged with providing potable water to residents and healthcare facilities. Emergency responders made it a priority to provide water first to healthcare providers and schools so they could maintain continuous operations. FEMA, West Virginia National Guard, first responders, city governmental agencies, civic groups and multiple state agencies worked together to distribute water in 2,500,000 one-gallon jugs, 9,500,000 liter bottles and 19,000,000 bottles (16 ounces and smaller) to the public during the water use restrictions.[33] Various stores were also

---

[27] Agency for Toxic Substances and Disease Registry, West Virginia Bureau of Public Health, Elk River Chemical Spill Health Effects, Findings of Emergency Department Record Review. April 2014. http://www.dhhr.wv.gov/News/chemical-spill/Documents/ElkRiverMedicalRecordSummary.pdf (January 31, 2017).

[28] *Ibid*.

[29] *Ibid*.

[30] Affected counties included Boone, Cabell, Clay, Jackson, Kanawha, Lincoln, Logan, Putnam and Roane.

[31] 2010 Census. http://www.census.gov/ (August 8, 2016).

[32] Schade C.P., Wright N., Gupta R., Latif D.A., Jha A., et al. Self-Reported Household Impacts of Large-Scale Chemical Contamination of the Public Water Supply, Charleston, West Virginia, USA. May 2015. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0126744 (February 3, 2017); Office of the Governor. After Action Review. http://www.dhsem.wv.gov/West%20Virginia%20Public%20Water%20Supply%20Study%20Commission/Documents/After%20Action%20Review.PDF (February 3, 2017).

[33] Office of the Governor. After Action Review. http://www.dhsem.wv.gov/West%20Virginia%20Public%20Water%20Supply%20Study%20Commission/Documents/After%20Action%20Review.PDF (February 3, 2017).

able to stock large quantities of bottled water after the incident. Five other water treatment plants, including another WVAW facility and four publicly owned plants, provided additional water via 14 bulk water tankers to those affected by the DNU order. WVAW supplied bulk water for seven weeks following the spill.

In Charleston, the spill plume in the Elk River entered the Kanawha River and flowed down into the Ohio River. The United States Geological Survey and Ohio River Valley Water Sanitation Commission detected 4-MCHM in river water samples as far downriver as Louisville, Kentucky (about 400 miles downstream of the spill).[34,35]

2.2 Freedom Industries

Freedom Industries, organized as a corporation in 1992, identified itself as a full-service producer of specialty chemicals for the mining, steel and cement industries. The company produced freeze conditioning agents, dust control suppressants, flotation reagents and water treatment polymers in addition to other specialty chemicals.[36] Freedom had ownership of the facility for only nine days prior to the incident. On December 31, 2013, Freedom merged with the prior site owner, the Etowah River Terminal, LLC.[37] At the site in Charleston, Freedom stored and sold Shurflot 944, a mixture containing Crude MCHM and PPH stripped, in addition to calcium chloride and glycerin.

Freedom temporarily stored chemicals in ASTs and carried out financial transactions between chemical manufacturers and end-users. Freedom was accessible by barge and truck, but all movement into and out of the site in recent history was conducted strictly by truck in bulk shipments. Material that arrived at the Freedom facility was discharged from the tank trucks into the storage tanks. The facility had two computer-controlled loading and unloading zones with elevated platforms that were sloped and graded to contain the contents of tank trucks. The inventory was measured as material was shipped to customers. When customer specifications required blending, pre-weighed tankers received the desired quantity of material and then took it to a blending facility. On the day of the incident, 19 employees were listed on the company roster; 18 of those were located onsite.

---

[34] Forman William T., et al. Determination of (4-methylcyclohexyl) Methanol Isomers by Heated Purge-and-Trap GC/MS in Water Samples from the 2014 Elk River, West Virginia, Chemical Spill. July 2015. http://www.sciencedirect.com/science/article/pii/S0045653514012648 (September 8, 2016).

[35] Schulte, Jerry G. ORSANCO's Role in Source Water Protection, Emergency Response and the Protection of Drinking Water Utilities. http://www.rrt5.org/Portals/0/docs/ElkRiverSpill-ORSANCO.pdf (February 3, 2017).

[36] Bloomberg. Company Overview of Freedom Industries. http://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=4614734 (July 8, 2016).

[37] Prior to the merger, Freedom and ERT were separate entities; however, both companies were owned by three of the same principals. On December 6, 2013, the equity in Freedom was acquired by Chemstream Holdings, which also acquired all of the membership interests in ERT. At the time of acquisition, Poca Blending, LLC (Poca), and Crete, LLC (Crete), were wholly owned subsidiaries of Freedom. On December 31, 2013, a corporate restructuring occurred pursuant to which Etowah, Poca and Crete were merged with and into Freedom, with Freedom as the sole surviving entity following the merger. The property, including tanks and related equipment, had been sold to Chemstream Holdings, which had acquired its ownership of the equity in Freedom and membership units of ERT just 34 days prior to the incident. The facility and the storage and distribution processes were not changed by Freedom after the purchase until the January 2014 incident.

2.2.1 Site History

Dating back to the late 1930s, the site stored a variety of chemicals in ASTs under multiple owners and operators. The property is bordered to the north by a wooded area. To the east of the site is a railroad corridor and Barlow Drive. A steep wooded slope is located beyond Barlow Drive (Figure 2).

Figure 2. Etowah River Terminal located between Barlow Drive and the Elk River. (Source: CSB)

Residences are located immediately south of the site, while the Elk River is located along the western border.[38] Elk Refining Company was the original owner of the facility and purchased various acreages of land between 1938 and 1947. Over time, varying sizes of ASTs were added as the facility grew. Prior to ERT's ownership of the site, it was owned by Pennzoil-Quaker State (PQS) (formerly known as Pennzoil United, Inc.). PQS sold the land and equipment to ERT in 2001.[39]

The site consisted of a two-story warehouse/office building, a garage/storage building, asphalt parking lots, a graveyard, a fire (pump) house, a flare, a fuel loading rack, an oil loading rack, an oil/water separator, a dock, two former fire houses, a former pump house, a former loading rack, 19 ASTs and associated aboveground product piping. The ASTs at ERT were installed in 1938, 1940, 1945, 1950 and 1951, with the exception of an 8,000-gallon additive tank that was installed in 1991 (see Table 1). Table 1 identifies the 14 main ASTs located inside the diked areas and describes the AST contents in 2003 (before Freedom owned the facility) and in 2014 (after Freedom took ownership of the facility).

[38] Shaw Environmental, Inc. Additional Site Characterization Former Pennzoil-Quaker State Etowah Terminal. November 2003.
[39] The real estate purchase agreement was signed on October 5, 2001, by PQS.

Table 1. AST Conditions: Former PQS Etowah Terminal and Freedom in 2014

Historical AST Conditions				
Storage Tank Number	Year Installed	Capacity (gallons)	2003 Contents	2014 Contents
392	1991	8,000	Additive	N/A
393	1951	420,000	Kerosene	Off Spec Glycerin Blends
394	1938	420,000	Kerosene	Glycerin
395	1938	46,200	Bulk Oil	Crude MCHM, PPH, stripped[40]
396	1938	46,200	Bulk Oil	Crude MCHM, PPH, stripped
397	1938	46,200	Bulk Oil	Crude MCHM, PPH, stripped
398	1945	420,000	Bulk Oil	Glycerin
399	1940	420,000	Gasoline	Glycerin
400	1940	420,000	Gasoline	Glycerin
401	1940	420,000	Gasoline	Glycerin
402	1940	420,000	Gasoline	Weak Salt
403	1950	420,000	Diesel	28% Calcium Chloride
404	1950	420,000	Diesel	35% Calcium Chloride
405	1951	420,000	Diesel	38% Calcium Chloride

Stormwater drains located in the diked area and on the asphalt parking lot on the northern end of the site flowed into an oil/water separator located on the eastern side of the site, which then drained into the Elk River. Stormwater that fell on the asphalt parking lot located on the southern end of the site flowed into catch basins along the western edge of the facility and was discharged into the Elk River.[41]

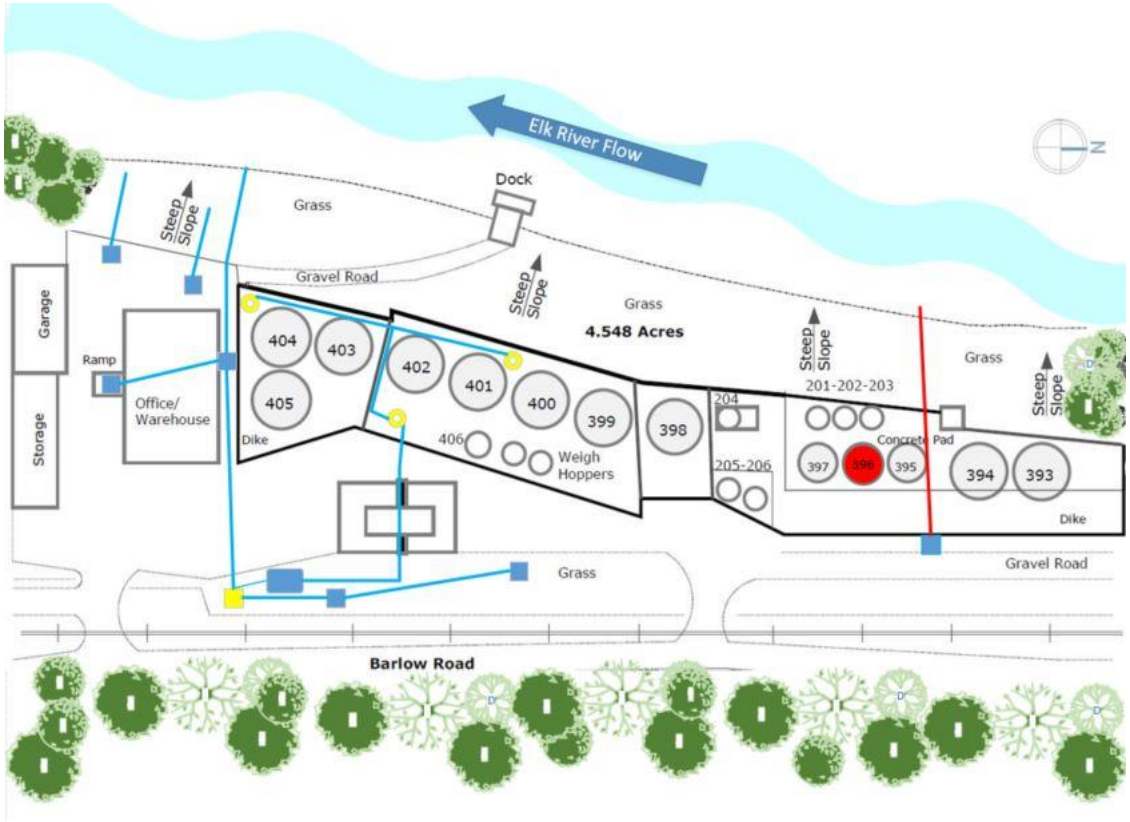
ERT operated the site as a bulk storage terminal for freeze conditioning agents including ethylene glycol and calcium chloride solutions and was zoned for industrial use. The sale from PQS to ERT included all tanks on the site, including tanks 395, 396 and 397, which were subsequently used to store a mixture containing Crude MCHM and PPH, stripped for sale and distribution to various customers in the Charleston area. At the time of the sale, tanks used to store lubricant oil residue and diesel fuel (tanks 393, 394, 395, 396, 397, 403, 404 and 405) were not cleaned by PQS. If ERT were to introduce different chemicals to these tanks, it would have had to clean the tanks prior to their use to eliminate any product contamination. Only tanks that contained gasoline (tanks 398, 399, 400, 401 and 402) were cleaned by PQS so that, if needed, ERT would have been able to demolish and dispose of the tanks, lines and piping without additional cleaning.[42] At the time the sale to ERT was completed, permits, approvals and authorizations from federal, state and local governments relating to the property and equipment were required as shown in Table 2. An ERT site plot plan from 2010 (Figure 3) displays the facility layout that remained largely unchanged after Freedom took ownership.

[40] Tank 395 was mislabeled as Glycerin at the time of the incident.
[41] The site drainage will be discussed in detail in Section 3.3 of this report.
[42] Pennzoil-Quaker State Company. Real Estate Purchase Agreement. PQS: Texas. October 2001.

Table 2. PQS and ERT Environmental Permits and Reports[43]

West Virginia Department of Environment Division of Environmental Protection Office of Air Quality	Certificate to Operate ID #039 00035 Yearly Inspection Internal Floating Roof Seals (5-Year Inspection for PQS Only)
West Virginia Department of Environment Division of Environmental Protection Office of Water Resources	Generator of Hazardous Waste ID #WVD055573745 (PQS Only) #WVR000502559 (ERT/Freedom Only) Groundwater Protection Fee WVNPDES Permit ID #WV0111457 (Yearly Inspection for PQS and ERT)
West Virginia Emergency Response Commission	Annual Tier II Filing Fee
United States Coast Guard	Operations Manual (Subject to Yearly Review)
Oil Pollution Act	Facility Response Plan (Yearly Review by United States Coast Guard)
Spill Prevention, Control, and Countermeasure	Spill Prevention, Control, and Countermeasure Plan (Subject to 5-Year Review)
Superfund Amendments and Reauthorization Act (SARA) Title 312 Local Emergency Response Commission	Annual Filing
SARA Title 313	Annual Filing

[43] This is a complete list from the 2001 purchase agreement that identifies permits that were required for PQS's prior use of the property.



Legend: Etowah River Terminal Site Plot Plan	
396	Aboveground Storage Tank 396 Containing Crude MCHM and PPH, Stripped Mixture
	Drain
	Industrial Sewer System Drain
	Sump
	Stormwater Culvert
	Stormwater Sewer System

Figure 3. 2010 Etowah River Terminal site plot plan. (Source: Etowah River Terminal [adapted])

2.2.2 Chemical Storage

2.2.2.1 Tanks Containing Crude MCHM and PPH, Stripped

Thirteen ASTs were located on the Freedom site at the time of the incident. These tanks included three 46,200-gallon ASTs (395, 396 and 397) containing a mixture of Crude MCHM and PPH, stripped (Figure

4).[44] Before 2009, the tanks were used to store either glycerin or calcium chloride. According to Freedom, tank 396 held 88.5% Crude MCHM, 7.3% PPH, stripped and 4.2% water by weight on the day of the incident.[45]

Figure 4. MCHM- and PPH, stripped-containing tanks at Freedom post-incident. (Source: CSB)

Tanks 395, 396 and 397 were 20 feet in diameter by 20 feet tall. The tanks had a lap-riveted[46] shell, cone roof and a 0.25-inch lap-welded[47] bottom. Tank 397 was a blend tank that was used to mix Crude MCHM and PPH, stripped to produce ShurFlot 944.[48] The final product was stored in tanks 396 and 397 as well as in totes for sale (Figure 5).

[44] Crude MCHM is used in the froth flotation process of coal washing and preparation.
[45] Freedom Industries, Inc. Letter to West Virginia DEP describing the composition of the materials in Tank 396. January 22, 2014. Charleston, West Virginia. http://www.dep.wv.gov/pio/Documents/Freedom%20Response%20to%20WVDEP%20Order.pdf (January 31, 2017).
[46] Lap riveting is riveting in which the ends or edges of plates overlap and are riveted together.
[47] A lap joint is formed by overlapping two plates and welding them together.
[48] ShurFlot 944 is a Freedom Industries product used for flotation in the mining industry.

Figure 5. A ShurFlot 944 tote located at the Freedom facility. (Source: WVDEP)

2.2.2.1.1 ShurFlot 944

ShurFlot 944 was Freedom's propriety blend of mostly Crude MCHM and PPH, stripped, and was the product that leaked into the Elk River.[49] According to Freedom's SDS, ShurFlot 944 is composed of a blend of alcohols, glycol ethers and carboxylates. The product, used for flotation, is a clear dark yellow or brown liquid with a strong odor. Freedom's SDS for ShurFlot 944 is similar to the Crude MCHM SDS and states that it can cause skin, eye and respiratory irritation and is harmful if swallowed, possibly resulting in nausea and vomiting.

2.2.2.1.2 Crude MCHM

Crude MCHM is manufactured by the Eastman Chemical Company (Eastman).[50] Eastman's SDS for Crude MCHM states that it contains a mixture of six different chemical compounds, including 4-MCHM

[49] Although Shurflot 944 is the product name for the material that leaked from tank 396, this report refers to the leaked material as a mixture containing Crude MCHM and PPH, stripped.

[50] Eastman, headquartered in Kingsport, Tennessee, manufactures specialty chemicals and products including additives, adhesives, fibers and specialty fluids for industry, transportation, construction, agriculture and other markets. Eastman commercialized MCHM for coal purification in 1996. In 1997, Eastman voluntarily conducted toxicology studies of Crude MCHM. As of the publication date of this report, Eastman is the only United States producer of Crude MCHM.

and water (see Table 3).[51] 4-MCHM ($CH_3C_6H_{10}CH_2OH$), made up the highest percentage of the Crude MCHM and was the main chemical that entered the drinking water supply.[52]

Table 3. Crude MCHM Compounds and Percent Concentration from Eastman SDS (Revised August 18, 2011).

Chemical Name	Range of Concentrations
4-methylcyclohexanemethanol	68-89%
4-(methoxymethyl)cyclohexanemethanol	4-22%
Water	4-10%
methyl 4-methylcyclohexanecarboxylate	4-10%
dimethyl 1,4-cyclohexanedicarboxylate	5%
Methanol	1%
1,4-cyclohexanedimethanol	1-2%

Crude MCHM is used in the froth flotation process to remove impurities from coal (such as shale and clay).[53] It acts as a foaming agent to bind to organic matter. The patent for Crude MCHM claimed prior agents used for this purpose, such as 2-ethyl hexanol, were believed to cause birth defects, and Crude MCHM is a less hazardous alternative to conventional frothing products.[54] The substance has a characteristic licorice smell later determined to be detectable at concentrations as low as one part per trillion (ppt) post-incident.[55]

According to the Eastman Crude MCHM SDS, people should avoid contact with undiluted Crude MCHM during handling, as it can cause eye and skin irritation. At elevated temperatures, Crude MCHM vapors can also cause eye and respiratory tract irritation. Crude MCHM is also listed as harmful if swallowed (Figure 6). No occupational exposure detection methods or limits exist for Crude MCHM. The Eastman SDS lists exposure limit information only for methanol, which the SDS reported to be 1% of the mixture.

[51] Crude MCHM is a colorless liquid at room temperature. According to the Eastman SDS, Crude MCHM freezes at 32°F (0°C) and boils at 356°F (180°C). It has a flash point of 235°F (112.8°C) and is water soluble with a density less than water. Crude MCHM has a Hazardous Material Identification System health rating of 2 of 4, flammability rating of 1 of 4 and a chemical reactivity rating of 0.

[52] Crude MCHM is comprised of several chemically similar substances in which 4-MCHM is present at the highest concentration.

[53] Nalco Chemical Company. Process for coal flotation using 4-methylcyclohexanemethanol frothers. https://www.google.com/patents/US4915825?dq=methylcyclohexanemethanol+froth&hl=en&sa=X&ved=0ahUKEwid3O-Kor7NAhXGNiYKHXQ3D6EQ6AEIIDAA (February 1, 2017).

[54] Nalco Chemical Company. Process for coal flotation using 4-methylcyclohexanemethanol frothers. https://www.google.com/patents/US4915825?dq=methylcyclohexanemethanol+froth&hl=en&sa=X&ved=0ahUKEwid3O-Kor7NAhXGNiYKHXQ3D6EQ6AEIIDAA (July 8, 2016); C&EN Washington, Obscure Chemical Taints Water Supply. http://cen.acs.org/content/dam/cen/92/7/09207-cover.pdf (July 8, 2016).

[55] One part per trillion is analogous to one drop of detergent in enough water to fill a string of railroad cars 10 miles long.


SECTION 2: Hazards identification

WARNING!
HARMFUL IF SWALLOWED
CAUSES SKIN AND EYE IRRITATION
AT ELEVATED TEMPERATURES, VAPOR MAY CAUSE IRRITATION OF EYES AND RESPIRATORY TRACT

Figure 6. Crude MCHM Safety Data Sheet excerpt. (Source: Eastman Chemical 2011)

2.2.2.1.3 Polyglycol Ethers (PPH, stripped)

Twelve days after the tank released its contents and the spill became known, Freedom disclosed that an additional product, PPH, stripped, was also present in tank 396 at the time of the leak. PPH, stripped,[56] also used as an extender, made up 7.3% of tank 396's contents. PPH, stripped is a mixture of propylene glycol phenyl ether and di-propylene glycol phenyl ether. "Stripped" likely refers to the distillation process that removes sodium hydroxide and other impurities from di-propylene glycol phenyl ether manufactured by The Dow Chemical Company (Dow)..

The Freedom SDS for PPH, stripped states that the chemical composition is made up of 100% polyglycol ethers and the exact chemical identities are proprietary due to trade secret protections.[57] Also according to the SDS, PPH, stripped causes skin and serious eye irritation and handlers are instructed to avoid inhaling PPH, stripped vapors. It is also a combustible liquid.

The chemical constituents of PPH, stripped, Dow's propylene glycol phenol ether and di-propylene glycol phenyl ether, pose similar potential health effects. According to the Dow SDSs, both chemicals can cause eye and skin irritation and have low toxicity from skin absorption or ingestion.[58] These chemicals have been found to cause birth defects in lab animals only at levels toxic to the mother.[59]

2.2.3 Post-Incident Freedom Developments

On January 10, 2014, WVDEP issued a Consent Order to Freedom to begin removing all material from all ASTs and store the material in an offsite area that provided adequate secondary containment. In addition, the order required Freedom to immediately take all necessary measures to contain, recover and remediate the material that escaped the breached AST and secondary containment dikes, including installation of interceptor trenches adjacent to the Elk River and installation and maintenance of booms[60] and absorbents in affected waterways. The order also required Freedom to immediately conduct an

[56] Unless stated otherwise, the term "PPH" in this report will refer to the Freedom PPH, stripped product that was also present in tank 396.
[57] Freedom Industries. PPH, Stripped SDS. http://www.dhsem.wv.gov/Documents/PPH%20Stripped%20MSDS.pdf (July 8, 2016).
[58] Dow. Propylene Glycol Phenol Ether SDS. http://www.dow.com/webapps/msds/ShowPDF.aspx?id=090003e8806933b4 (July 8, 2016).
[59] Dow. Di-propylene Glycol Phenyl Ether SDS. http://www.dow.com/webapps/msds/ShowPDF.aspx?id=090003e8806933b4 (July 8, 2016).
[60] A boom is a temporary floating barrier used to contain leaks on a body of water.

integrity test of all ASTs and secondary containment structures for the entire facility.[61] In addition, Freedom was required to submit to WVDEP a corrective action plan that would include the following:

1. An outline of all actions to be taken to immediately remove and appropriately store materials from the site.
2. A detailed plan to appropriately implement a remediation of all contaminated soil and/or groundwater.
3. An outline of how all contaminated material and/or unusable product will be properly disposed.
4. A plan and schedule for the ultimate disposition of the products stored in these tanks, including T-396 tank contents that were being stored at the Poca Blending facility.[62]

By January 11, 2014, Freedom had removed all of the tank contents from the ASTs and transported it offsite to Poca Blending, LLC in four large banker tanks.[63] On January 17, 2014, Freedom filed for bankruptcy with the U.S. Bankruptcy Court Southern District of West Virginia. On January 24, 2014, WVDEP issued a consent order to Freedom to dismantle and manage removal of all ASTs, associated piping, machinery and equipment associated with the bulk storage operations at ERT. A tank decommissioning plan dated March 7, 2014, and a companion remediation plan dated March 17, 2014, were prepared, which WVDEP approved. Tanks 393 through 402 were demolished, while tanks 403 through 405 were used for water runoff monitoring and storage compliance with the WVDEP Consent Order. The onsite buildings, including the office, garage and storage facility, were not demolished. The retaining walls and retention areas remained intact so that no contamination of areas from tank 396 occurred during the demolition.[64] Today, the Freedom site no longer has any tanks on the facility and only the office/warehouse, garage and storage buildings remain (Figure 7). Freedom entered into the Voluntary Remediation Program in late February 2015, and the land has undergone extensive remediation since then (Figure 8). See Appendix B for a summary of fines and charges to Freedom officials.

[61] West Virginia Department of Environmental Protection. Consent Order Issued under the Water Pollution Control Act West Virginia Code, Chapter 22, Article 11 and the Groundwater Protection Act West Virginia Code, Chapter 22, Article 12: Order No. 8207; WVDEP, Charleston, WV. November 12, 2014.

[62] West Virginia Department of Environmental Protection. Order Issued under the Water Pollution Control Act West Virginia Code, Chapter 22, Article 11 and the Groundwater Protection Act West Virginia Code, Chapter 22, Article 12; WVDEP Charleston, WV. January 10, 2014.

[63] West Virginia Department of Environmental Protection. Order Issued under the Water Pollution Control Act West Virginia Code, Chapter 22, Article 11 and the Groundwater Protection Act West Virginia Code, Chapter 22, Article 12; WVDEP Charleston, WV. January 10, 2014.

[64] United States Bankruptcy Court Southern District of West Virginia. Case No. 2:14-bk-20017 [2014 Bankr. S.D.W.Va. (No. 2:14-bk-20017)].

Figure 7. Demolition of the tanks at Freedom. (Source: Charleston Gazette)

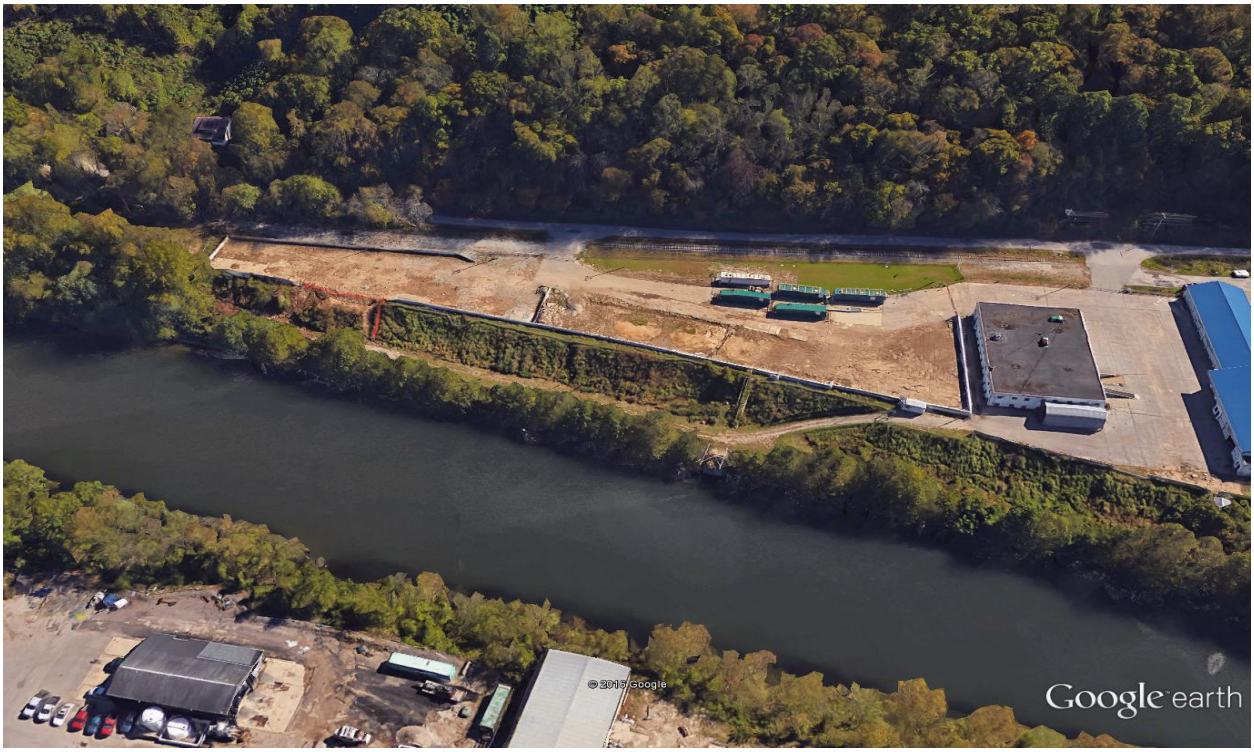


Figure 8. Freedom site post-demolition. (Source: Google)

2.2.4 Proximity to Water Treatment Intake and Transmission Main

The Freedom facility is located approximately 1.5 miles upstream from the raw water intake of the WVAW[65] Kanawha Valley Treatment Plant (Figure 9).

Figure 9. Location of the WVAW water intake along the Elk River. (Source: WVAG)

When WVAW KVTP was being designed, company officials initially proposed, to the Public Service Commission (PSC), to consolidate three existing water systems and to use two intakes—an existing one on the Elk River upstream from Freedom and a new one on the Kanawha River. The intake on the Kanawha River at Chelyan was denied by the West Virginia Department of Health[66] in a permit issued on March 27, 1969, because Kanawha River water was not suitable for drinking. On August 15, 1969, after submitting revised plans, WVAW was approved by the Department of Health for a new single river intake on the Elk River at the new treatment plant site.

WVAW's service area comprises 12 counties, nine of which were directly affected by this incident. CSB estimated the distance from the release at Freedom to the WVAW KVTP water intake was about 1.5 miles downstream in the Elk River (Figure 10).

[65] WVAW is discussed in further detail in Section 4.6 of this report.
[66] West Virginia Department of Health is currently known as West Virginia Department Bureau of Public Health.

Figure 10. Approximate distance from the release at Freedom to the WVAW KVTP intake. (Source: Google Earth)

The single water intake on the Elk River provided the medium through which the tank contents were distributed throughout the Kanawha Valley water system, affecting thousands of consumers who relied on access to quality water. The contamination of the water distribution system affected public health and led many to distrust the water quality immediately following the incident. WVAW and KVTP played a key role in how the chemicals spread through the water distribution system and how the contamination was remediated immediately after the incident and in the weeks that followed. It is important to understand the background and operations of the water utility company and the water treatment plant in order to recognize their level of involvement in this incident. The rest of Section 2 of this report provides a brief background on these entities, while a more detailed assessment of the plans, policies and procedures they followed is discussed in Section 4.6.

2.3 West Virginia American Water

WVAW is a subsidiary of American Water[67] that provides water service to approximately 550,000 people in 288 communities in West Virginia. WVAW also serves many industrial clients locally including Toyota, Dow Chemical and Bayer CropScience.[68] Currently, WVAW has four operating regions that include 17 facilities, nine of which are water treatment plants. WVAW's service area (Figure 11) comprises portions of 12 counties, nine of which were directly affected by this incident.

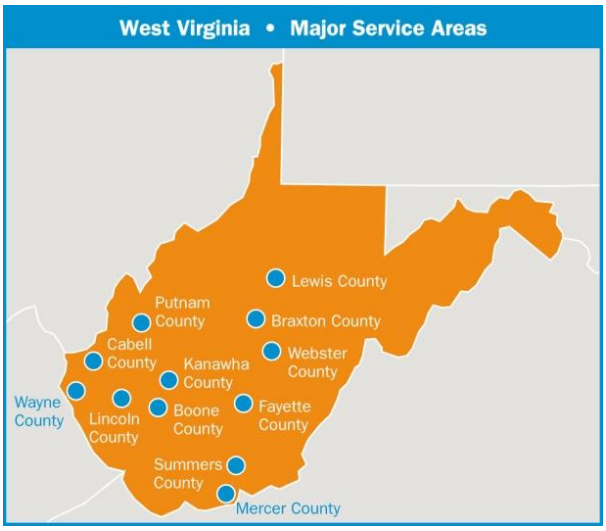


Figure 11. Major service areas in West Virginia. (Source: WVAW)

The West Virginia PSC sets rules that WVAW is required to follow. These regulations are intended to ensure the public is receiving high-quality water at a fair price. All service rate increases are directly related to the cost of providing high-quality service and are subject to a public review process and approval by the West Virginia PSC.[69] WVAW follows regulations created by the Environmental Protection Agency (EPA) and enforced by WVBPH that are intended to help provide high-quality drinking water. WVAW conducts more than 45,000 tests per year for about 100 potential contaminants, checking drinking water quality at every stage of the water treatment and delivery process.[70]

2.3.1 Kanawha Valley Treatment Plant

WVAW KVTP is a conventional coagulation and filtration water treatment facility that serves the Kanawha Valley System—a surface water system. At the time of the incident, KVTP was supplying water to approximately 93,660 service connections. The maximum treatment for the Kanawha Valley District is 50 million gallons per day (MGD). In 2010, the plant treated on average 32 MGD of water at a rate of approximately 22,000 gallons per minute while operating 24 hours per day. Later in 2014, the

[67] American Water is discussed in Section 4.6.
[68] American Water. http://www.amwater.com/wvaw/About-Us/ (July 13, 2015).
[69] *Ibid*.
[70] West Virginia American Water. The Care of Water. West Virginia American Water: West Virginia. 2016. http://www.amwater.com/files/AMER0525_WV_WEBbrochure.pdf (July 22, 2016).

plant treated on average 29 MGD. The plant supplies water through a distribution system of approximately 2,400 miles of pipeline to a total population of 195,000.[71] Finished water storage capacity in the system is calculated to be approximately 38 million gallons in 104 tanks.

Public surface drinking water sources are treated through various steps that include coagulation and flocculation,[72] sedimentation,[73] filtration[74] and chemical disinfection.[75] The KVTP facility receives water from the Elk River and treats it through chemical and filtration processes. Raw water enters the water treatment plant from a conventional side-channel intake. A floating boom and three bar racks, approximately 15 feet high, prevent floating material and large debris from entering the system, while parallel traveling screens catch smaller, suspended debris. Upon intake, potassium permanganate ($KMnO_4$) and polyaluminum chloride, a flocculant, are added to the river water to oxidize chemical contaminants such as iron, manganese, arsenic or other organic chemicals and remove suspended solids.[76] Then sodium hydroxide, a caustic soda, can be added to remove organic contaminants when needed.

The PAC[77] (PAC; Watercarb 800) may be used to augment the treatment process and is physically removed in the upflow clarifiers at the plant. In these clarifiers the PAC becomes part of the sludge blanket through which the water flows in the clarifiers and thus increases the contact time with the PAC. In addition, the 16 granular activated carbon (GAC; Calgon 8x30) filters remove organic contaminants and control for taste and odor.[78] A coagulant,[79] polyaluminum chloride, and a polymer called Superfloc are used to remove turbidity via mixing during the coagulation and flocculation process in four sludge blanket clarifiers where solids are removed.

---

[71] The 195,000 population served is based on multiplying customer accounts by census data regarding household size.

[72] Coagulation and flocculation are the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc. Center for Disease Control. Community Water Treatment. http://www.cdc.gov/healthywater/drinking/public/water_treatment.html (March 28, 2016).

[73] During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation. http://www.cdc.gov/healthywater/drinking/public/water_treatment.html (March 28, 2016).

[74] Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses and chemicals. http://www.cdc.gov/healthywater/drinking/public/water_treatment.html (March 28, 2016).

[75] After the water has been filtered, a disinfectant (for example, chlorine or chloramine) may be added to kill any remaining parasites, bacteria and viruses, and to protect the water from germs when it is piped to homes and businesses. http://www.cdc.gov/healthywater/drinking/public/water_treatment.html (March 28, 2016).

[76] Lesson 2 Appendix of Common Chemicals Used in Public Water System Treatment. http://www.wvdhhr.org/wateroperators/wv_advanced_course/resources/l2u1/l2appendix.pdf (March 28, 2016).

[77] Powdered activated carbon is an organic material often made of wood, lignite, and/or coal which absorbs natural organic compounds, synthetic chemicals and controls taste and odors.

[78] McGuire, M. J. Oxidation Studies with Crude 4-methylcyclohexanemethanol in Water. Technical Memorandum. Michael J. McGuire Inc. West Virginia Testing Assessment Project: West Virginia. May 2014.

[79] Coagulants cause the suspended matter in water to clump together, due to either a physical texture of the chemical or the electrical charges of the coagulant and the colloidal particles. http://www.wvdhhr.org/wateroperators/wv_advanced_course/resources/l2u1/l2appendix.pdf (March 28, 2016).

Prior to moving to the GAC filters, chlorine can be added when conditions dictate for pre-filtration disinfection.[80] More sodium hydroxide is added to adjust the pH; zinc ortho-phosphate is added as corrosion control to create a protective layer inside pipes in the water distribution system, and to prevent leaching of lead from service pipes; and fluoride is added at 0.7 ppm to prevent dental cavities.[81] Finally, this water moves to the clearwell,[82] where the chlorine is given retention time to disinfect the water and then it is distributed into the system. See Figure 12.

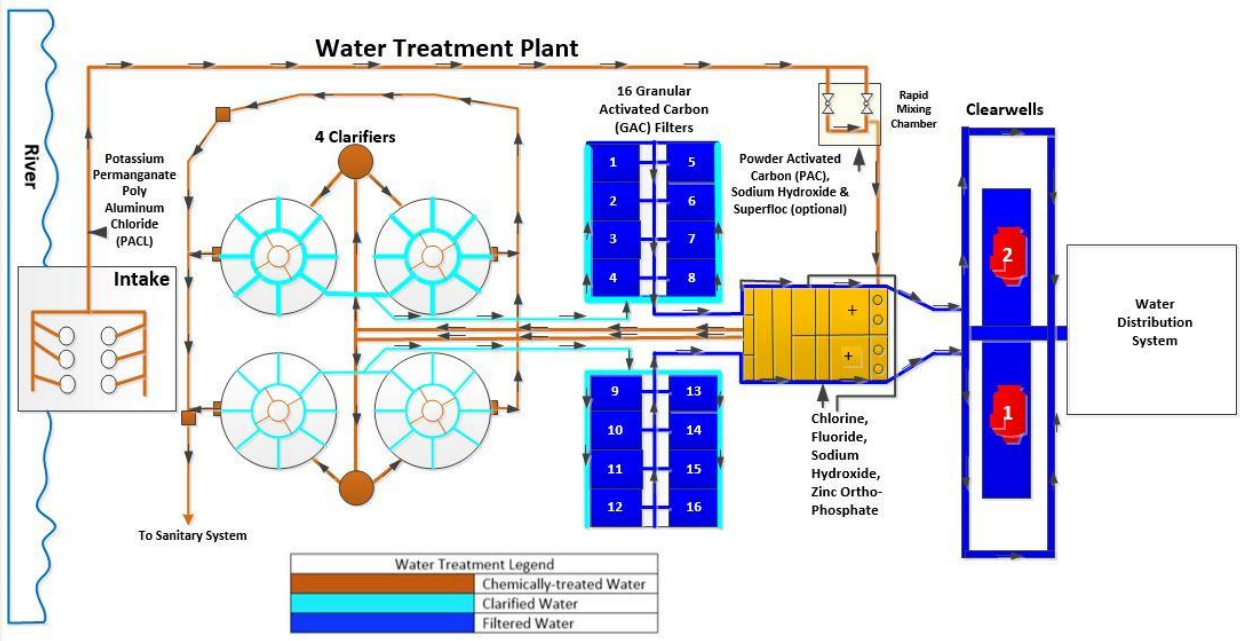


Figure 12. A simplified process diagram of a water treatment plant. (Source: CSB)

Every two hours, KVTP operators sample and test water at various points of the treatment process (i.e., raw, before clarification, after clarification/before filtering, after filtering, finished water) for turbidity, pH and chlorine. Once during each 12-hour shift, operators test plant water for iron, manganese, chloride, fluoride, phosphate, hardness, alkalinity, taste and odor and take samples from the finished water to test for bacteria. Daily, during the morning shift, operators check zinc and aluminum levels in the finished water. Weekly, WVAW records a fluoride measurement taken from the raw water. Operators calibrate pH and fluoride meters in the plant at least once a day. During each shift, employees conduct a full plant walk-through, observing the basement, chemical feed rooms, chlorine room, high and low service pumps, traveling screens and other equipment. Every night, employees monitor flow meter readings from the sludge building, gas meter, intake, power building and substation. Every four hours, employees monitor and record tank levels in the Kanawha Valley and Bluestone distribution systems, checking trends and

[80] Chlorine is added twice to the treatment process, once before the GAC filters and the second time at the filters. McGuire, M. J. Oxidation Studies with Crude 4-methylcyclohexanemethanol in Water. Technical Memorandum. Michael J. McGuire Inc. West Virginia Testing Assessment Project: West Virginia. May 2014.

[81] CDC. Fluoridation of Drinking Water and Corrosion of Pipes in Distribution Systems Fact Sheet. https://www.cdc.gov/fluoridation/factsheets/engineering/corrosion.htm (February 3, 2017).

[82] A clearwell is a contact tank that provides chlorine disinfection to treated water prior to being pumped to the water distribution system.

monitoring and recording chlorine levels at booster stations. KVTP does not test for specific chemicals unless the results of the previously discussed water tests are abnormal or there are changes in water quality parameters. A more detailed assessment of the plans, policies and procedures regarding monitoring and testing is discussed in Section 4.6.3.

3.0 TECHNICAL ANALYSIS

Following the incident, CSB examined the tanks, containment wall and surrounding terrain to determine the cause of the spill and to understand the failure that allowed the contents of the tank to leak and travel into the Elk River. CSB also requested and reviewed available documentation of specifications and prior inspections of the tanks at the site. The technical analysis found that:

1. Approximately 11,000 gallons of a chemical mixture containing Crude MCHM and PPH, stripped, leaked from tank 396 through two holes (approximately 0.75 and 0.4 inches in diameter) on the tank floor. The holes were caused by pitting corrosion that degraded the thickness of the floor from the tank interior. Although the soil side of the tank bottom was corroded as most tank bottoms are, the amount of soil side corrosion was insignificant compared to the pitting corrosion that directly led to the incident.
2. Once the chemical mixture escaped tank 396 through the holes on the bottom, it traveled along the ground surface, moved through the soil and gravel pad beneath the tank, and extended toward two pathways to the Elk River: (1) through the failing secondary containment wall, and (2) through the deteriorated underground culvert.
3. CSB found no documentation of prior maintenance or inspections by Freedom or ERT that would have identified and addressed the internal corrosion in tank 396.
4. Freedom and ERT did not validate the integrity of the secondary containment system, nor did they maintain the secondary containment wall that surrounded the tanks despite knowing the wall was in poor condition; as a result, cracks and holes in the wall allowed the leak to escape the containment and travel into the Elk River.
5. Freedom did not have any leak prevention or leak detection system in place to immediately provide notification of tank leaks.
6. Extremely cold weather conditions in early January 2014 may have caused a frost heaving effect in the ground surrounding the Freedom tanks. Movement of the tank bottom or soil beneath the tank may have contributed to the onset of the spill.

3.1 Leak Quantity and Chemical Composition

When CSB investigators arrived onsite on January 13, the contents of tanks 395 and 397, and the remaining contents of tank 396, had already been removed via vacuum truck and relocated to Baker storage containers at Freedom's Poca Blending facility. To estimate the quantity of spilled material, CSB investigators reviewed Freedom's tank inventory documentation and subtracted the volume of the recovered chemicals from tank 396 at Poca Blending from the last known volume of tank 396 prior to the incident. Tank 396 had an inventory of about 30,906 gallons on January 8, 2014. CSB investigators measured the Baker storage container's level on January 16, 2014, and estimated a volume of about 20,000 gallons of recovered material from tank 396, resulting in an estimated net loss of about 11,000 gallons (Table 4).

Table 4. Total Estimated Volume of Material Released.

Chemical	Estimated Volume Released (gallons)[83]
4-Methylcyclohexanemethanol	8,900
Methanol	160
Cyclohexanemethanol	17
Propylene glycol phenyl	91
Unknowns	1,800
Total Estimated Volume	10,967

In interviews with CSB investigators, Freedom personnel stated that Crude MCHM and PPH, Stripped were the only materials contained within tank 396 at the time of the incident. Beyond interviews, CSB partnered with the OSHA Charleston area office to collect a sample of material from the storage tank that leaked for further chemical analysis.

The tank 396 sample obtained by OSHA for chemical analysis was taken from the storage container at the Poca Blending facility on January 17, 2014. CSB found through interviews that the vacuum trucks used to remove the contents of tank 396 were not cleaned prior to their use during the leak response and remediation efforts. Further, CSB could not verify that the storage tanks at Poca Blending were clean prior to receiving the material from tank 396. Ultimately, it is possible that the sample of tank 396 contents may have been contaminated by remnant chemicals in either the vacuum trucks and/or the Poca Blending facility storage tanks.

The sample of tank 396 material was sent to OSHA's Salt Lake City Test Center where the chemical composition was analyzed on January 27, 2014, using GC-MS, followed by a quantitative gas chromatography (GC) analysis on February 24, 2014.[84] A summary of the reported analytes and their percent concentrations is given in Table 5.

[83] Calculated by multiplying 11,000 (estimated gallons released) by the percent compositions listed in Table 5.
[84] In both instances, OSHA used standard internal protocols to conduct the tests, which included extracting bulk liquid samples with isopropyl alcohol.

Table 5. Summary of Reported Qualitative and Quantitative Chemical Analyses of Tank 396 Contents.

	Qualitative GC-MS	Quantitative GC
Reported analytes and their percentages	Major analytes detected: • 4-methylcyclohexanemethanol • 2-methylcyclohexanemethanol (2-MCHM)[85] Minor analytes detected: • Methanol • Cyclohexanemethanol • Propylene glycol phenyl ether (PPH and/or isomer) • Unknowns	• 4-methylcyclohexanemethanol (81.1%) • Methanol (1.42%) • Cyclohexanemethanol (0.15%) • Propylene glycol phenyl ether (PPH and/or isomer) (0.83%) • Unknowns (16.5%)

The objective of OSHA's analyses was limited to compliance purposes and, as a result, did not address the identification of the unknown chemicals in the sample tested. CSB did not pursue any additional testing and cannot report any findings beyond what OSHA provided.

3.2 Tank Failure Analysis

3.2.1 Tank Entry and Visual Inspection

After the incident, tank inspectors certified by the American Petroleum Institute (API)[86] conducted internal and external inspections of tanks 395, 396 and 397 to document the most recent condition of the tanks prior to dismantling, and to determine the exact route through which the contents leaked from the tank or tanks.[87] The 20-foot-diameter tanks were most likely constructed in the late 1930s and the material properties were consistent with tanks of that vintage typically used to store petroleum products.[88,89] The

[85] The indication of 2-MCHM was most likely the result of a misidentification of the peak by a mass spectral library that OSHA uses to aid in the identification of unknowns. For the qualitative tests, OSHA relied upon a mass spectral library to tentatively identify the components of the tank 396 sample. After the initial data collection, OSHA purchased an analytical standard of 4-MCHM that contained both *cis*- and *trans*-4-MCHM isomers to calibrate its GC data. Results from the analytical standard indicate that the mass spectral library had misidentified the 2-MCHM and in fact OSHA was observing *cis*- and *trans*-4-MCHM isomers in its own GC data. The percentage of 4-MCHM reported in Table 5 is a summation of both the *cis*- and *trans*-4-MCHM isomers observed by OSHA in the tank 396 sample.

[86] The American Petroleum Institute is a trade association that develops standards and practices for the oil and gas industry and certifies qualified personnel to inspect ASTs in accordance with accepted industry practices.

[87] A hydrocutting firm cut a large door sheet in the shell of each tank for safe entry by inspectors.

[88] Powers, Gary, API 653 Inspection Report Tank 395. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_395_rev_0.pdf (March 1, 2017); Powers, Gary, API 653 Inspection Report Tank 396. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_396.pdf (March 1, 2017); Powers, Gary, API 653 Inspection Report Tank 397. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_397_rev_0.pdf (March 1, 2017).

[89] Chemical analysis indicated the tank floor was a low-carbon steel containing 0.25 weight percent (wt%) carbon and 0.41 wt% manganese, with other trace elements commonly found in carbon steels. The microstructure was consistent with hot-finished steel.

cylindrical shell and cone roof were of an obsolete,[90] single lap-riveted[91] construction.[92] The tanks contained a 0.25-inch lap-welded bottom that API certified inspectors estimated to be a replacement for the original lap-riveted bottom.[93,94]

During a visual inspection of the bottom interior of tank 396, inspectors identified deep, isolated pits or crevices near the shell (side) of the tank in addition to two holes on the tank floor (Figure 13).[95] CSB determined that the two holes, approximately 0.75 inches and 0.4 inches in diameter, were the source of the leak (Figure 14).

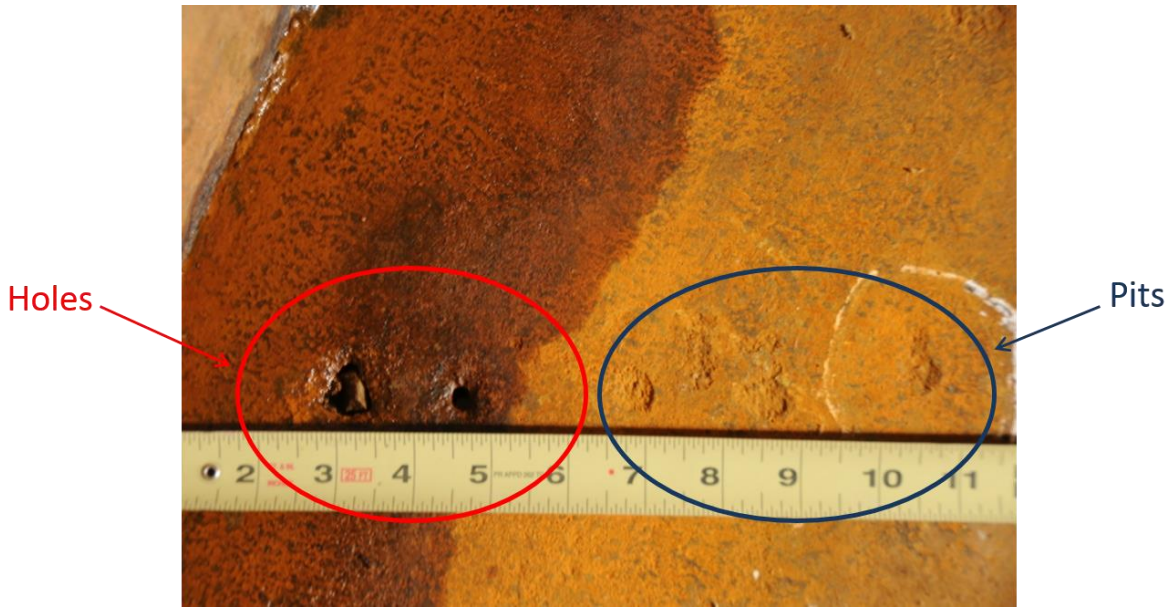


Figure 13. The bottom of tank 396 with holes and pits identified. (Source: CSB)

[90] Welding began to replace the use of rivets as the preferred method of storage tank construction in the late 1930s. Lieb, John M. Recent Developments in API Storage Tank Standards to Improve Spill Prevention and Leak Detection/Prevention (EPA). https://archive.epa.gov/emergencies/content/fss/web/pdf/liebpaper.pdf (July 25, 2016).

[91] Single lap-riveting refers to rolled steel plates attached together with rivets.

[92] Powers, Gary, API 653 Inspection Report Tank 395. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_395_rev_0.pdf (March 1, 2017); Powers, Gary, API 653 Inspection Report Tank 396. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_396.pdf (March 1, 2017); Powers, Gary, API 653 Inspection Report Tank 397. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_397_rev_0.pdf (March 1, 2017).

[93] *Ibid.*

[94] A lap weld is a type of weld in which one metallic surface overlaps another.

[95] Powers, Gary, API 653 Inspection Report Tank 396. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_396.pdf (March 1, 2017).

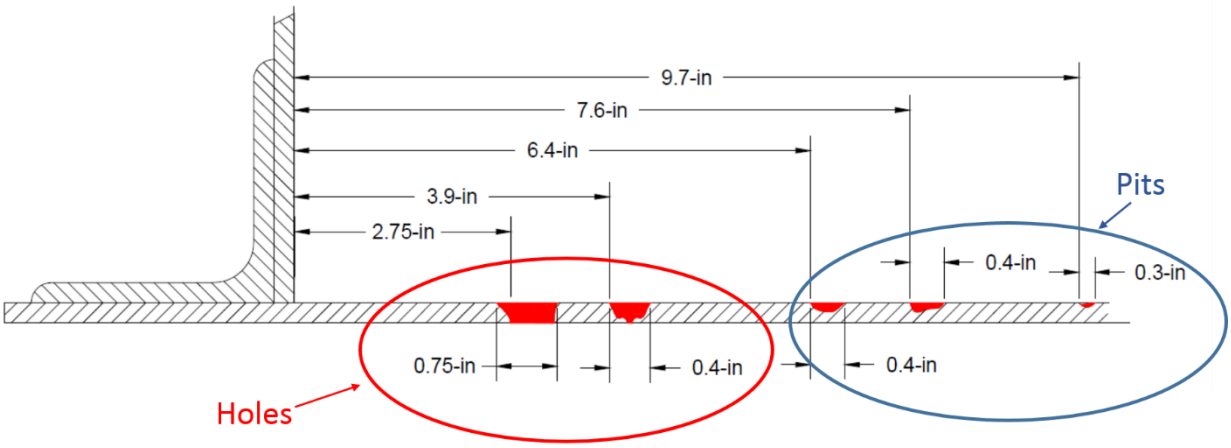


Figure 14. The bottom and shell wall of tank 396 with holes and pits identified through floor thickness. (Source: Powers[96])

API certified inspectors also entered and examined the two adjacent tanks reported to contain a mixture of Crude MCHM and PPH, stripped—395 and 397—and found similar pitting conditions. Tank 397 contained a 0.2-cm-diameter hole in the bottom in addition to deep isolated pits originating from the interior surface of the tank floor.[97] There is no evidence that tank 397 leaked in January 2014, and the hole identified during the inspection may have been plugged with debris. Pitting as deep as 0.2 inches was identified in tank 397, penetrating through about 80% of the bottom thickness.[98] When examining tank 395, inspectors did not identify any through-thickness holes in the bottom, but pitting as deep as 0.125 inches degraded nearly half the thickness of the bottom interior surface.[99]

In addition to the pitting and holes in the bottom, tank 396 had other visual abnormalities observed during the interior visual inspection, such as structural integrity issues and additional corrosion sites. Tank 396 had several damaged roof deck support rafters on the inside.[100] The roof support column in the center of the tank was made of materials susceptible to corrosion damage and the column was not affixed to the bottom to avoid lateral movement.[101] The tank had isolated areas of active corrosion on the roof with some internal seeps during rain.[102] API certified inspectors noted that the external coating on the shell and

[96] Powers, Gary, API 653 Inspection Report Tank 396. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_396.pdf (March 1, 2017).
[97] Powers, Gary, API 653 Inspection Report Tank 397. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_397_rev_0.pdf (March 1, 2017).
[98] *Ibid*.
[99] Powers, Gary, API 653 Inspection Report Tank 395. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_395_rev_0.pdf (March 1, 2017)
[100] Powers, Gary, API 653 Inspection Report Tank 396. Powers Engineering, Inc., http://www.csb.gov/assets/1/19/API653_Internal_Inspection_Freedom_Industries_Tank_396.pdf (March 1, 2017).
[101] *Ibid.*
[102] *Ibid.*

roof of the tank was nearing the end of its useful life as indicated by peeling and evidence of corrosion.[103] Although no obvious corrosion holes were found on the roof, loose rivets or lap joints likely allowed rain to enter the tank.

3.2.2 Pitting Corrosion

CSB commissioned metallurgical testing of cut carbon steel coupons[104] from tank 396 to determine if the holes in the bottom resulted from a failure mechanism that occurred over time, possibly due to corrosion, or if the failure was sudden, such as a puncture to the tank floor from the exterior.

An examination of the morphology, or structure, of the holes and pits on the tank 396 sample revealed that the holes were caused by pitting corrosion that originated from the internal bottom surface of the tank and propagated toward the soil side. [105]

Corrosion is an electrochemical reaction between a metal alloy and its environment, and can lead to degradation of structures. It can attack materials uniformly, degrading metals at an even rate across the surface, known as general corrosion. However, pitting corrosion is confined to a point or small area that takes the form of cavities, some of which can perforate through the thickness of the metal. Pitting corrosion can be difficult to detect because it is highly localized and the rate at which the depth of the pit increases is often greater than the width.[106] Corrosion products, such as rust, can cover the pits, making them harder to find during an inspection.

One feature of pitting corrosion is that pits usually initiate on the upper surface of a horizontally placed metal and grow in the direction of gravity.[107] The internal surface of the tank 396 floor had isolated pitting that degraded into its thickness (Figure 15). In comparison, the corrosion on the soil side of tank 396 was characteristic of uniform or general corrosion that would be expected on carbon steel of that age, with shallow pits and patches of iron oxides. The rate of pitting corrosion in a localized area is many times greater than the uniform rate of corrosion over an entire surface of a metal.[108]

---

[103] *Ibid.*

[104] A coupon is a material specimen or sample used for test or analysis.

[105] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).

[106] Schweitzer, P. A. Corrosion Engineering Handbook, 2nd ed. Taylor & Francis: Boca Raton, FL. 2007. http://app.knovel.com/hotlink/pdf/id:kt00C9XHJ1/corrosion-engineering/fundamentals-metallic (July 8, 2016).

[107] *Ibid*.

[108] Byars, H. G. Corrosion Control in Petroleum Production, 2nd ed. TPC Publication 5 NACE International. 1999. http://app.knovel.com/hotlink/pdf/id:kt0080E7H4/corrosion-control-in/concentration-cells (July 8, 2016).

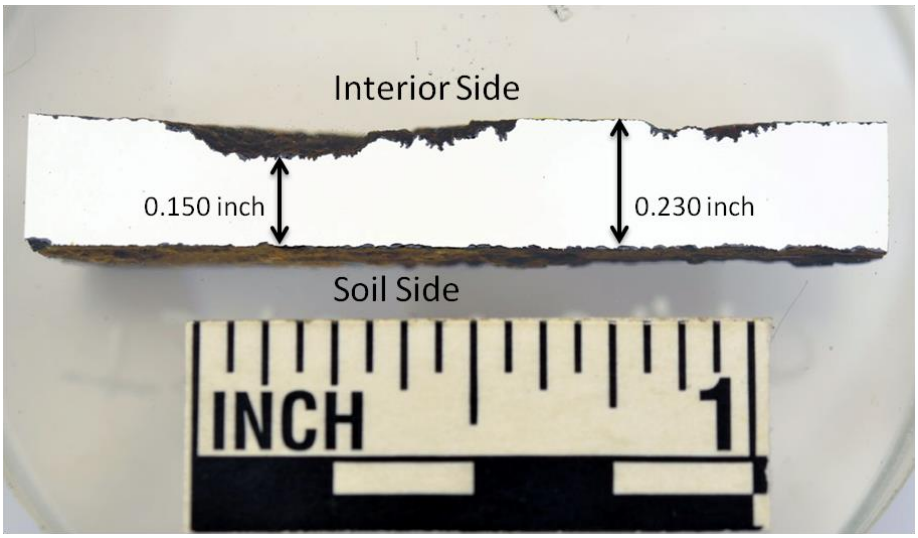


Figure 15. Cross-section of tank floor showing thickness variations from corrosion. (Source: Anamet[109])

Metal resists corrosion by forming a passive film or oxidation layer on the surface of the material. The film is formed naturally over time as the metal is exposed to air. Examples include patina formed on copper or rust formed on iron.[110] Mill scale is an oxide of iron formed during the hot-rolling of steel during manufacturing. Mill scale develops to a uniform thickness and can protect metal surfaces from additional corrosion in some areas. However, microscopic cracks or discontinuities in the mill scale can increase corrosion rates because the unprotected area of the metal is exposed. Pitting corrosion is often initiated by the breakdown of the passive film or oxide, such as mill scale on the metal surface. Damage mechanisms can include localized mechanical damage, or chemical damage such as acidity, oxygen concentrations and high concentrations of chlorides (as in seawater).[111]

Laboratory analysis by energy dispersive x-ray spectroscopy detected silicon, chlorides, iron and oxygen, consistent with aqueous corrosion.[112,113] Aqueous corrosion is an electrochemical reaction of materials caused by a wet environment. The presence of water provides a conductive medium for the electrochemical reaction and consequent formation of corrosion products on a metal surface. Corrosion

[109] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).

[110] Schweitzer, P. A. Corrosion Engineering Handbook, 2nd ed. Taylor & Francis: Boca Raton, FL. 2007. http://app.knovel.com/hotlink/pdf/id:kt00C9XHJ1/corrosion-engineering/fundamentals-metallic (July 8, 2016).

[111] Nace. Pitting Corrosion. https://www.nace.org/Pitting-Corrosion/ (July 8, 2016).

[112] Additional detected elements included aluminum, calcium, titanium, sulfur and potassium. Chloride ions and oxidizing agents such as Cu^{+2} and Fe^{+3} salts, as well as hydroxides, chromates and silicates are often associated with pitting corrosion.

[113] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).

products can include ions in the water or precipitated salts, such as chlorides, and hydrogen gas.[114] Tank 396 was a closed tank, however holes identified in the roof likely allowed rainwater to enter the tank.

Although the CSB found evidence that the prior owner, ERT, added hydrochloric acid to the contents of tank 397 in 2012,[115] CSB did not find evidence from documentation or interviews of any such addition to tank 396. OSHA's Salt Lake Technical Center lab determined a pH range of 4.5-5 (mildly acidic) for the tank 396 sample that was obtained from the Baker storage containers post incident.[116] If ERT officials added hydrochloric acid to the tank 396 or lowered the pH of the tank with some other chemical, this may have initiated the corrosion or accelerated the corrosion rate of the tank interior. CSB could not come to a definitive conclusion regarding when the holes in the bottom of the tank formed or if the presence of an acid contributed to the corrosion.

3.2.3 Corrosion Rate Analysis

In order to establish a timeline for corrosion formation over the years, an analysis was conducted to obtain the corrosion pitting rate for tank 396. The results from the corrosion rate analysis were used to determine the rate at which the corrosion penetrated the bottom thickness from the tank interior. Analysis of the pit morphology indicated that the corrosion of the holes that penetrated the bottom of tank 396 was initiated from the top surface of the bottom plates (internal product-side corrosion) rather than the underside.

CSB retained a tank expert to conduct a corrosion rate analysis based on the observed pitting and the data available during the incident investigation. Although it was recognized that the corrosion rates were variable and unknown, the best reasonable assumption at the time of the study was that the corrosion rate was constant over the life of tank 396 at 12.3 mils per year (mpy)[117] with the corrosion rate bounded between 10 and 15 mpy.

An evaluation of the tank bottom in comparison to the tank shell indicated that tank 396 had two tank bottoms during its service life: the original riveted tank bottom and then a 250-mil (0.25-inch-thick) (6.35-mm) welded steel bottom that was retrofitted into the tank sometime after the original riveted bottom was replaced. The original riveted bottom was likely used until it failed and then the tank was retrofitted with a new welded steel bottom in order to continue its liquid storage function. The

[114] Chilingar, G. V.; Mourhatch, R. A.; Ghazi D. Fundamentals of Corrosion and Scaling—For Petroleum and Environmental Engineers. Gulf Publishing Company. 2008. http://app.knovel.com/hotlink/pdf/id:kt006AXOZ1/fundamentals-corrosion/introduction-corrosion-2 (July 8, 2016).

[115] Etowah River Terminal Plant Manager, email message to Laboratory Manager, "8.08.12 Neutralization of Tank 397." August 8, 2012.

[116] To obtain this result, OSHA used a pH testing strip intended for aqueous solutions. As this sample is a non-aqueous mixture, the reported pH should be considered a relative value for comparison to other samples, rather than a direct correlation with an aqueous pH value. The pH value is not an indication that acid was added to the tank, and should not be interpreted as such.

[117] The unit mpy (mils per year or thousandths of an inch per year) is a common designation for corrosion rate.

replacement bottom of tank 396 was a welded construction using lap-welded bottom plates, which suggests the bottom was retrofitted sometime after 1945 (Figure 16).[118]

Figure 16. Retrofitted welded bottom of tank 396 (inside of tank). (Source: CSB)

Without original tank drawings or documentation, it was assumed that the original tank 396 bottom lasted 25 years from its construction in 1938, and estimated that its replacement took place sometime after 1963, while the site was under the ownership of the Elk Refining Company or PQS. Tank inspectors estimated, based on the post-incident condition of the tank floor, that the second bottom was at least 25 years old. At some point after the installation of the second bottom, polyvinyl acetate (PVA),[119] discussed in Section 3.2.4, was also likely added to the bottom of the tank to patch existing holes or prevent future corrosion (see Figure 17).

[118] Tank welding did not commonly occur until about 1945, when the technology developed during World War II was deployed for industrial purposes. After World War II, the practice of riveting gave way to welded steel construction.

[119] Best practices dictate that a permanent lap-welded patch could have been used when the tank bottom failed.

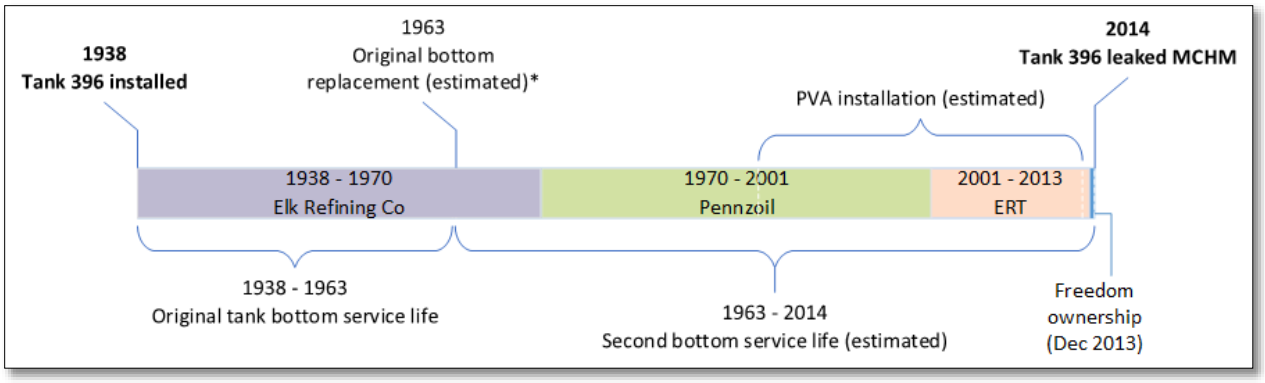


Figure 17. Tank 396 timeline. Original bottom replacement date based on 25-year service life. (Source: CSB).

3.2.4 Polyvinyl Acetate Material

During the initial examinations prior to dismantling tank 396, inspectors noticed remnants of what could have been a flexible organic liner or patch, adhered to the interior surface of the tank floor, likely applied sometime before the leak occurred (Figure 18).[120] Analytical testing determined that the chemical composition of the material was PVA.[121]

Figure 18. Remnants of coating on interior tank floor. (Source: Anamet[122])

[120] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).
[121] *Ibid.*
[122] *Ibid.*

CSB investigators were unable to find documentation of the PVA material applied to the bottom of tank 396, but it is possible that the material, intended to be a liner or patch, was applied during prior facility ownership when tank 396 stored hydrocarbons. While there was no evidence of welded repairs around the bottom of tank 396, investigators believe the PVA could have been applied for general corrosion prevention, or to patch a leak and return to service. Recommendations from prior inspections of the larger tank 398 called for the application of "an epoxy sealer to the bottom 6 inches of the shell and also apply sealer onto the chime" in 1997. Another possible source of the PVA remnants was reported to be a backflow of contents from the vacuum truck post-incident that occurred in the course of emptying the tanks. However, metallographic and microscopic examinations revealed corrosion product underneath the PVA, indicating that the PVA was applied to the bottom of the tank sometime before the incident (Figure 19).[123]

The PVA could have been applied to act as a soft patch or liner to prevent corrosion or leaks. Soft patches have been used for temporary roof repairs in the tank industry for years. Often, the patches are thick elastomeric polymers made from a variety of materials, including rubber, neoprene, glass cloth, asphalt, and mastic or epoxy sealing materials; the choice depends on the contents of the tank and the service conditions.[124] According to API Recommended Practice 575, leaks in roofs can be repaired by soft patches that do not involve cutting, welding, riveting or bolting of the steel. Best practices discourage the use of patches in lieu of permanent repairs for tank roofs, but recommend them only for temporary operations since it is known that they could be delaminated from the surfaces with a fairly high probability in an unpredictable manner. Many factors affect how well patches adhere to the steel surfaces including surface preparation, the patch material, mixing and preparation, the compatibility of the material with the product and other factors.

Also used to control corrosion, liners can be applied as coatings and have been proven to effectively prevent internal corrosion in the bottom of steel tanks.[125] For carbon steel tanks containing hydrocarbons, water and other ions can settle out of mixtures and cause various types of corrosion, including localized metal loss or pitting corrosion. PVA is a type of polyvinyl ester that is typically used to line tanks containing water, crude oil, aromatics and solvents.[126]

[123] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).

[124] American Petroleum Institute. Recommended Practice 575, Inspection Practices for Atmospheric and Low-Pressure Storage Tanks, 3rd ed. API Publishing: Washington, DC. April 2014.

[125] American Petroleum Institute. Recommended Practice 652, Lining of Aboveground Petroleum Storage Tank Bottoms, 4th ed. API Publishing Services: Washington, DC. 2014.

[126] *Ibid*.

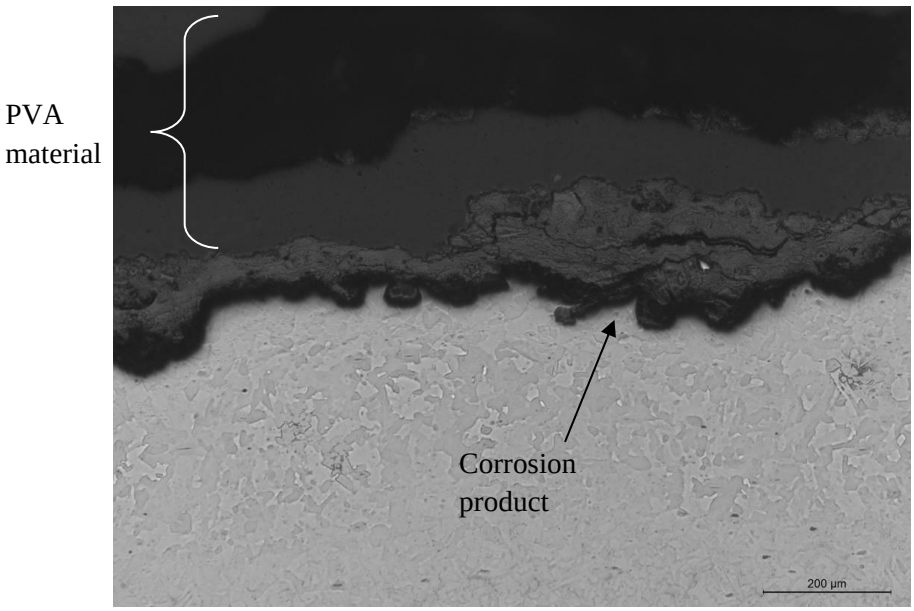


Figure 19. Corrosion product beneath PVA. (Source: Anamet[127])

3.2.5 Frost Heave Effect, Flow and Leak Scenario

A frost heaving effect, caused by extremely low temperatures, may have contributed to the sudden release of the mixture containing Crude MCHM and PPH, stripped from the bottom of tank 396. The severe cold weather in early January 2014, referred to as a "polar vortex,"[128] brought bitterly cold temperatures to the Midwest, South and much of the eastern and northeastern United States.[129] The Charleston area set a new minimum temperature record of -3°F just two days before leak discovery.[130]

Frost heaving occurs when the freezing of water-saturated soil causes the deformation and upward thrust of the ground surface.[131] When water freezes, it expands. This expansion is often referred to as frost

[127] McFadden, Sam, Metallurgical Evaluation of Tank Coupon 396-F/S9/10 from Freedom Industries, Charleston, WV. Anamet, Inc. http://www.csb.gov/assets/1/19/CSB_Freedom_Industries_5005.0486A_Final_Redacted.pdf (March 1, 2017).

[128] A polar vortex is a large pocket of very cold air, typically the coldest air in the Northern Hemisphere, which sits over the polar region during the winter season. http://www.accuweather.com/en/weather-news/what-is-a-polar-vortex/21793077 (September 21, 2016).

[129] https://www.wunderground.com/news/polar-vortex-plunge-science-behind-arctic-cold-outbreaks-20140106 (September 21, 2016).

[130] The average minimum temperature for the same date is 26°F. https://www.wunderground.com/history/airport/KCRW/2014/1/7/DailyHistory.html?req_city=Charleston&req_state=WV&req_statename=West+Virginia&reqdb.zip=25301&reqdb.magic=1&reqdb.wmo=99999 (September 21, 2016).

[131] Rempel, A. W.; Wettlaufer, J. S.; Grae Worster, M. Premelting Dynamics in a Continuum Model of Frost Heave. *J Fluid Mechanics*. 2004, *498*, 227-244.

jacking or frost heaving.[132] Freezing weather prevalent at that time of year caused the frost heaving[133] of the soil underneath the tank, which possibly led to the flexure or movement of the tank bottom in the vicinity of the holes. The movement provided enough bending on the bottom plates to possibly dislodge the PVA material or other debris blocking flow through the bottom holes. Once the material became dislodged, the pressure from the filled tank 396 may have enabled the sudden gushing flow of liquid from the tank bottom. Approximately 11,000 gallons of the tank contents had leaked from tank 396 prior to leak discovery. Based on CSB calculations, the time for 11,000 gallons to drain from the tank, assuming leakage through the 0.4-inch hole, the 0.75-inch hole, or both holes, is approximated below:[134]

Leak size	Time to drain 11,000 gallons
0.4-inch diameter	~28 hours
0.75-inch diameter	~8 hours
Both 0.4 and 0.75-inch holes open	~6 hours

On the day of the incident, air quality complaints from the public began around 10:00 AM and the material was removed from tank 396 at around 1:00 PM. Considering that the smell of the 4-MCHM contaminated water was detectable by humans at concentrations in water as low as one part per trillion, it seems unlikely that the leak occurred through the 0.4-inch hole for a 28-hour period without public notice the prior day. Instead, a leak through either the 0.75-inch hole or both the 0.75- and 0.4-inch holes seems plausible because the leak could have started in the early morning hours, but was not noticed or reported by local residents until the morning of January 9.

Finally, the soil beneath the gravel base for the tank was clay, and as a result the lowest resistance flow path for a leak should have been through the gravel and then along the ground surface (Section 3.3). Interviews with Freedom officials and employees indicated that they never noticed such a leak prior to the incident.

3.2.6 Tank Integrity and Inspections

Freedom and ERT did not have a program in place to ensure that the ASTs and associated equipment were properly maintained with regular inspection and testing programs. It is generally accepted as good practice to use recognized industry practices, such as API Standards for tanks storing petroleum, petrochemicals, organic liquids and liquid chemicals, to ensure the integrity of a tank. CSB requested and reviewed documentation from Freedom and ERT and found no evidence of a program in place to ensure that the ASTs and associated equipment were properly maintained with regular inspection and testing programs. This is partly because only a limited number of regulatory requirements governing ASTs would have compelled Freedom to have such programs, and the company did not voluntarily choose to do

[132] Black, P. B.; Hardenberg, M. J. Historical Perspectives in Frost Heave Research. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory**,** 1991. Special Rep. 91-23, pp. 3-7.

[133] Frost heave requires freezing temperatures (temperature gradient) for a prolonged period of time. This was evident in the prolonged wintry weather of 2013 to 2014.

[134] The following formula was used: $t = 2A_t(\sqrt{(z_1)} - \sqrt{(z_2)})/[C_dA_o\sqrt{(2g)}]$, where A_t is the cross-sectional area of the tank, z_1 is the height of the fluid in the tank at the start of the leak, z_2 is the height of the fluid when flow from the tank is stopped, C_d is the coefficient of discharge (in this case assumed to be 0.62), A_o is the area of the leak orifice, and g is gravitational acceleration.

so. Documentation provided to CSB after the incident bears little evidence of rigorous, formal tank inspections that would have identified potential leaks.

CSB was able to obtain some inspection documentation under the ownership of PQS and ERT, but there is no documentation of internal inspections of tanks 395, 396 and 397. Freedom indicated that the three tanks were not inspected at least ten years before the January 2014 incident. The larger tanks on the facility more recently received internal inspections under the ownership of ERT. Certified internal inspections of the larger tanks, conducted in 2008 to 2010, stated that the original tank bottoms were replaced between 1994 and 1999. Almost all of the 2008 internal inspection reports identified that the tanks were overdue for inspections and noted the damaged secondary containment. However, none of the prior inspection documentation focused on tanks 395, 396 and 397.

CSB investigators obtained a record of a two-page report of a previous informal review of the tanks at the Freedom site that was performed by a third-party consultant in October 2013, prior to the change of site ownership. The brief report included a visual inspection summary and stated that tanks 395, 396 and 397 were riveted but provided no information about their internal condition. The report also noted that "the tanks have been maintained to some structural adequacy, but not necessarily in full compliance with API-653 or EPA standards" and also stated that the tanks were not suitable for petroleum or regulated products without costly upgrades. The 2013 report, dated just over two months before the incident, noted that the "condition of the other tank floors is questionable," when referring to the tanks that had not undergone previous internal inspections. In the report, the inspector recommended developing a schedule to have each tank completely inspected by a certified tank inspector over the next 5 years.

3.2.6.1 Monitoring and Inspection Requirements for ASTs

CSB found that Freedom did not have a detailed record of its tank history, maintenance and inspection records for tank 396. While the API Standard 653[135] does have requirements for AST inspections, the tanks at Freedom were not required to comply with the standard under any state or federal law (see Section 5). Regular monitoring and maintenance of the tanks are necessary to ensure they operate effectively. Tank monitoring requirements may include visual examination of all tanks in operation, piping, valve, pump and other equipment surfaces for cracks, corrosion or releases on a weekly and monthly basis.[136]

Also, the secondary containment area around the tanks should be visually monitored daily, weekly and monthly.[137] Daily, weekly or monthly monitoring includes walking around the facility to identify cracks in the containment areas and to determine if any maintenance deficiencies or equipment malfunctioning is occurring around the tanks, which could cause a release or leak. Records of all periodic inspection and

[135] API 653, Tank Inspection, Repair, Alteration and Construction, is a recognized standard developed by API that covers the inspection, repair and modification of ASTs that store petroleum and chemicals.

[136] Minnesota Pollution Control Agency. Monitoring Requirements for Aboveground Storage Tanks. April 2004. https://www.pca.state.mn.us/sites/default/files/t-a1-03.pdf.

[137] Benton, Phillip, Storage Tank Inspection and Compliance. 2011. http://www.hdrinc.com/sites/all/files/content/white-papers/white-paper-images/4596-storage-tank-inspection-and-compliance_0.pdf.

monitoring activities also must be kept by tank owners. The records for tank monitoring activity would include the name of the person doing the monitoring, monitoring method or methods used, date of the monitoring activity, results of the monitoring and type of leak detection method used.[138]

3.2.6.2 Leak Prevention and Detection

CSB found that Freedom did not have any leak prevention[139] or leak detection system[140] (LDS) in place as recommended by best practices and industry guidelines, nor did it have an effective leak containment[141] process. A leak monitoring system is a method that can be used by a tank inspector from outside the tank to detect leaks in the bottom of the tank, such as secondary catchment under the tank bottom with a leak detection sump, or a sensitive gauging system. Leak prevention systems may include cathodic protection to reduce the likelihood of corrosion[142] (in accordance with API Recommended Practice 651[143]) and a thick film liner[144] (in accordance with API Recommended Practice 652[145]). Although the PVA material could have originally been applied to prevent corrosion or leaks in the tank, it was evident upon visual inspections of the tank bottom post-incident that the PVA liner or patch was not inspected or maintained, nor was it scheduled and documented for future inspections.

Freedom did not have any level indication device, gauge system or measurement to capture the actual amount of the leak, which contributed to the changing estimates of the spill amount. There was no West Virginia state or federal requirement that would have made the installation of an LDS mandatory for ASTs. Although LDSs have been widely used in underground storage tanks, CSB found that LDSs are rarely used in non-hydrocarbon oil-based facilities with ASTs. The commonly adopted LDSs that have been developed in the oil industry range from simple visual inspection of floor sumps under the ASTs to automated, electronic data-gathering instruments to sophisticated consoles and computer systems. Most continuous monitoring systems incorporate automatic leak alarm capabilities while other methods of leak detection are conducted as part of a regularly scheduled maintenance program and rely on daily visual inspections for evidence of initial leak detection.

Other LDS technologies include the use of liquid sensing cables, which are placed either in the interstitial space of a double-walled tank or buried in the soil beneath the tank; soil vapor monitoring; or acoustic emissions tests. These systems can be programmed to monitor a tank continuously or they can be part of

---

[138] Minnesota Pollution Control Agency. Monitoring Requirements for Aboveground Storage Tanks. April 2004. https://www.pca.state.mn.us/sites/default/files/t-a1-03.pdf.

[139] Leak prevention is any process that is designed to deter a leak from occurring in the first place.

[140] Leak detection is any process or system that is designed to find a leak after one has occurred.

[141] Leak containment is any process or system that is designed to contain a leak and to isolate the contained liquid from contaminating groundwater or surface water.

[142] Cathodic protection is a technique used to reduce corrosion of a metal surface by making the entire surface the cathode of an electrochemical cell.

[143] American Petroleum Institute. Recommended Practice 651, Cathodic Protection of Aboveground Petroleum Storage Tanks, 4th ed. API Publishing: Washington, DC. September 2014.

[144] A thick film liner is a system or device, such as a membrane, installed beneath a storage tank, in or on the tank dike, to contain any accidentally escaped product.

[145] American Petroleum Institute. Recommended Practice 652, Lining of Aboveground Petroleum Storage Tank Bottoms, 4th ed. API Publishing Services: Washington, DC. 2014.

the regularly scheduled tank testing and maintenance program.[146] Despite the existence of these LDS technologies, CSB investigators found that most existing ASTs (10,000 gallons or greater) do not have LDSs; rather, the owners of the AST overly rely on visual inspections, which are not always effective in accurately detecting leaks at the initial stage. In addition, only a few new aboveground storage facilities across the nation have installed LDSs, especially in states (such as Alaska) with existing regulation for ASTs.[147]

3.2.7 American Petroleum Institute Standards on AST Leaks

A review of the petroleum industry's approach to the protection of the environment indicated that multifaceted and numerous standards have been developed to address environmental protection from potential escapes of both liquid and gaseous substances. However, these methods may not be adopted by owners of non-petroleum-based ASTs if not incorporated into existing regulatory programs. API has developed and published numerous standards that have guided the construction of ASTs since the mid-1930s; however, API did not develop standards to address specific maintenance and inspection issues for existing ASTs until the late 1980s and 1990s.

One of the most notable standards that API developed for ASTs is API 653, "Tank Inspection, Repair, Alteration, and Reconstruction."[148] API Standards 650[149] and 653 are considered two of the primary industry standards by which most aboveground welded storage tanks are designed, constructed and maintained.[150] Table 6 highlights various API Standards and other documents that address leak and spill prevention, detection or containment for aboveground tanks.

Table 6. API Standards, Recommended Practices and Publications Addressing Spill and Leak Prevention, Detection or Containment for ASTs or AST Facilities.

API Number	Title	Leak Prevention	Leak Detection	Leak Containment
Standard 650	Welded Steel Tanks for Oil Storage	Yes	Yes	Yes

[146] *Ibid.*

[147] Alaska Department of Environmental Conservation. Technical Review of Leak Detection Technologies Volume II Aboveground Bulk Fuel Storage Tanks. https://dec.alaska.gov/spar/ppr/docs/ldetect2.pdf. (March 1, 2017).

[148] First published in 1991, the tank inspection, repair, alteration and reconstruction methods described in API 653 have been noted to have significantly improved the safety and reliability of existing tanks (when properly applied). Lieb, John M. Recent Developments in API Storage Tank Standards to Improve Spill Prevention and Leak Detection/Prevention (EPA). 2001. https://archive.epa.gov/emergencies/content/fss/web/pdf/liebpaper.pdf (July 25, 2016).

[149] The first edition of API 650 was published in 1961, but its predecessor, API 12C, had been in use since 1936, when welding began to replace riveting as the preferred construction method. Both API 12C and API 650 address only newly constructed tanks. API 650 covers material, design, fabrication, erection and testing requirements for aboveground, vertical, cylindrical, closed and open-top, welded steel storage tanks in various sizes and capacities. This standard applies to tanks with internal pressures approximating atmospheric pressure, but ranging as high as 2.5 pounds per square inch. This standard applies to newly constructed tanks before they have been placed in service.

[150] These standards address both newly constructed and existing ASTs used in the petroleum, petrochemical and chemical industries.

Standard 653	Tank Inspection, Repair, Alteration, and Reconstruction	Yes	Yes	Yes
RP 651	Cathodic Protection of Aboveground Storage Tanks	Yes	No	No
RP 652	Lining of Aboveground Storage Tank Bottoms	Yes	No	No
RP 2350	Overfill Protection for Storage Tanks in Petroleum Facilities,1996	Yes	No	No
Standard 2610	Design, Construction, Operation, Maintenance, and Inspection of Terminal & Tank Facilities	Yes	Yes	Yes
RP 575	Inspection of Atmospheric and Low-Pressure Storage Tanks	Yes	Yes	No
Publication 306	An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks, 1991	No	Yes	No
Publication 307	An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks, 1991	No	Yes	No
Publication 315	Assessment of Tank Field Dike Lining Materials and Methods, 1993	No	No	Yes
Publication 322	An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks, 1994	No	Yes	No
Publication 323	An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks, 1994	No	Yes	No
Publication 325	An Evaluation of a Methodology for the Detection of Leaks in Aboveground Storage Tanks, 1994	No	Yes	No
Publication 334	A Guide to Leak Detection for Aboveground Storage Tanks, 1995	No	Yes	No
Publication 340	Liquid Release Prevention and Detection Measures for Aboveground Storage Facilities, 1997	Yes	Yes	Yes

Publication 341	A Survey of Diked-Area Liner Uses at Aboveground Storage Tank Facilities	No	Yes	Yes

3.3 Tank Leak to the Elk River

Once the mixture containing Crude MCHM and PPH, stripped escaped tank 396 through the holes on the bottom, it traveled along the ground surface, moved through the soil and gravel pad beneath the tank, and extended toward two pathways to the Elk River: (1) through the failing secondary containment wall, and (2) through the deteriorated underground culvert.

3.3.1 Site Geotechnical Analysis

After tanks 395, 396 and 397 were dismantled and removed from the site, CSB commissioned a geotechnical analysis to examine the permeability[151] and soil characteristics immediately below the tanks. The purpose of the analysis was to characterize the flow of the mixture containing Crude MCHM and PPH through the tank holes into the soil to understand how long the leak could have been present in the soil before detection. The analysis concluded that the 4- to 6-inch gravel pad directly beneath the tank was highly permeable, through which the tank contents quickly traveled at the onset of the release. PQS remediated the soil and gravel beneath some of the tanks in 2002, prior to the sale of the site to ERT. However, the remediation did not include the soil beneath tank 396. As a result, it is likely the soil beneath the tanks had remained unchanged since the late 1930s when the tanks were constructed. It is also possible that some gravel and soil was added during the replacement of the tank 396 bottom, estimated by CSB to have taken place sometime in the 1960s (see Section 3.2.3). The tank floor was placed directly on the gravel, with no release prevention barrier. Release prevention barriers can include external liners or concrete pads placed under a tank to prevent the escape of released material and channeling release material for leak detection.[152]

Soil samples near tank 396 were collected and tested in accordance with ASTM International.[153] Analysis of the soil boring revealed the presence of a gravel base immediately under the tank. The examination of the soil characteristics revealed the prevalence of alluvial deposits of sand, gravel, silt and clay at the site (Figure 20).

[151] Soil permeability is the property of the soil to transmit water and air. The size of the soil pores is of great importance with regard to the rate of infiltration (movement of water into the soil) and to the rate of percolation (movement of water through the soil). Pore size and the number of pores closely relate to soil texture and structure, and also influence soil permeability. ftp://ftp.fao.org/fi/CDrom/FAO_training/FAO_training/General/x6706e/x6706e09.htm (September 21, 2016).

[152] American Petroleum Institute. Standard 653, Tank Inspection, Repair, Alteration and Reconstruction, 4th ed. API Publishing: Washington, DC. November 2014.

[153] ASTM International (formerly the American Society for Testing and Materials) is a standards organization that develops, publishes and delivers voluntary international consensus technical standards. http://www.astm.org/ABOUT/overview.html (September 21, 2016).

Figure 20. Gravel base under tank 396 and other tanks containing mixtures with Crude MCHM and PPH, Stripped. (Source: Terracon)

The porous gravel base, which separated the native surficial clay, was measured as approximately 4 inches thick under each tank. The soil beneath the gravel base was found to be clay-like. The minimum coefficient of permeability[154] of the surficial clay was less than 10^{-7} cm/sec, which indicated moderate to slow permeability (see Figure 21).

Because gravel is highly permeable, it offers little resistance to flow (Figure 22). Therefore, any leak in tank 396 would have been observed at the perimeter or soaking the ground around the tank. However, none of the Freedom employees interviewed by CSB reported noticing the leak prior to the day of the incident.

[154] Permeability is commonly measured in terms of the rate of water flow through the soil in a given period of time. It is usually expressed either as a permeability rate in centimeters per hour (cm/h), millimeters per hour (mm/h) or centimeters per day (cm/d), or as a coefficient of permeability (k) in meters per second (m/s) or in centimeters per second (cm/s). ftp://ftp.fao.org/fi/CDrom/FAO_training/FAO_training/General/x6706e/x6706e09.htm (September 21, 2016).

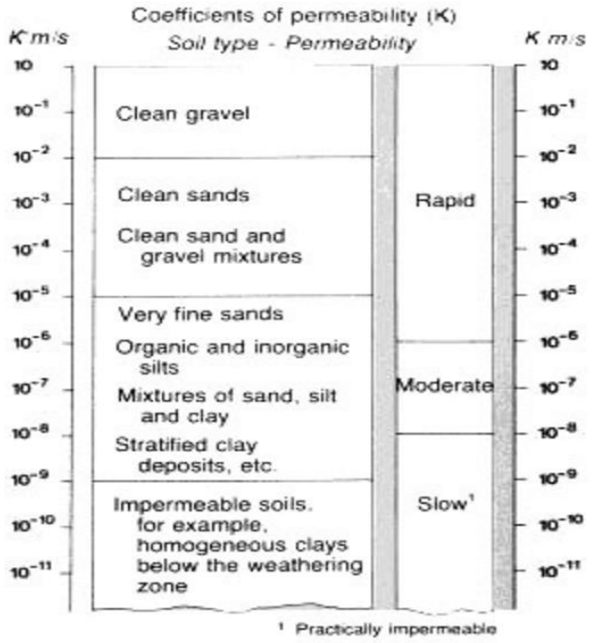


Figure 21. Permeability coefficients for different types of soils. (Source: Food and Agriculture Association)

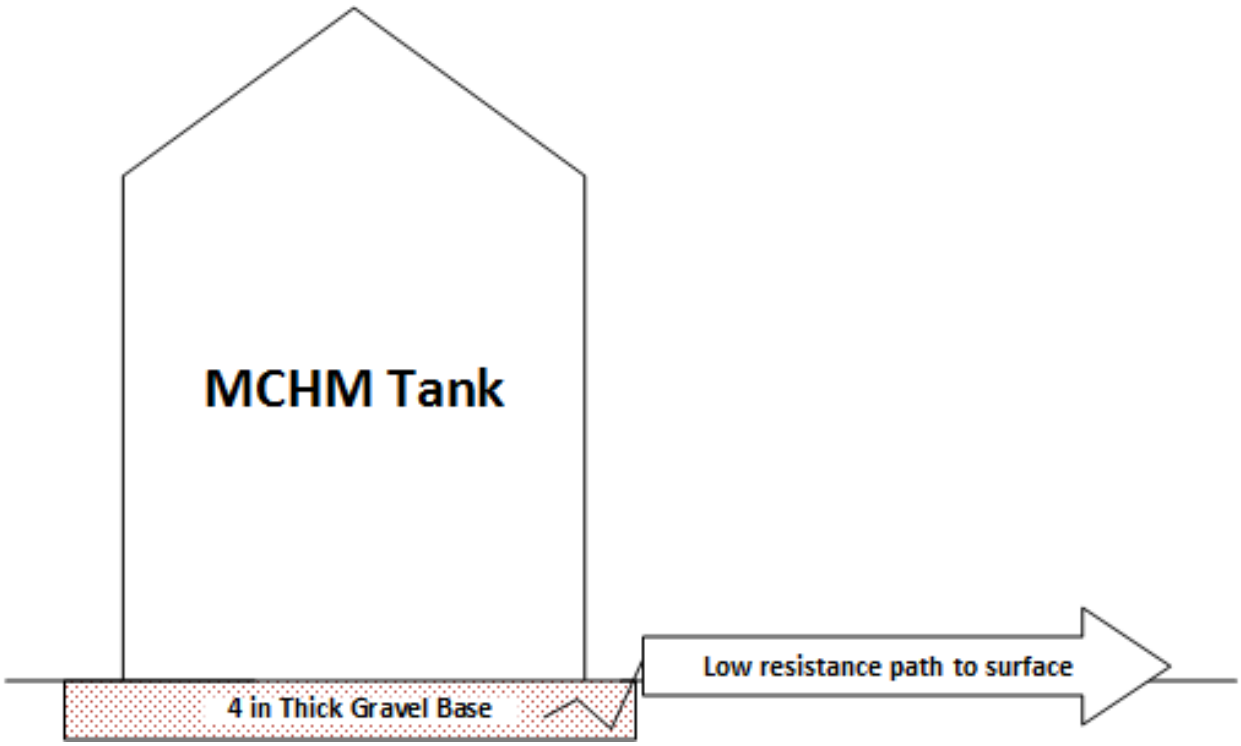


Figure 22. Low resistance flow path provided by gravel base. (Source: CSB)

3.3.1.1 History of the Soil: Voluntary Remediation of Lead- and Hydrocarbon-Contaminated Soil

Years ago, under the ownership of PQS, soil samples taken near several storage tanks were analyzed. This analysis revealed concentrations of lead beyond the federal limit. This discovery led PQS to pursue a path toward remediating the site, which explains the presence of clay material and gravel on the site. After the sale of the PQS facility to ERT, the site was voluntarily remediated in 2002 to ensure there was no soil or groundwater contamination resulting from PQS's ownership. In October 2004, approximately 33.5 tons of lead-impacted surface soil between tanks 400 and 399 and on the northeastern side of tank 399 were excavated and transported to a permitted facility. The excavation was restored by backfilling the area with low-permeability clay material that was smoothed and compacted. The compacted, low-permeability clay material was covered with gravel. The condition of the land remained as such with clay material covered with gravel when Freedom took ownership of the site. In February 2007, WVDEP issued a letter based on the review of the groundwater monitoring reporting for the ERT that stated "results demonstrate that the contaminants pose no threat to the nearest receptor, the Elk River."[155] WVDEP supported discontinuing groundwater sampling at this site based on the stable and low levels of lead and declining levels of hydrocarbons.

3.3.2 Secondary Spill Containment

In the absence of a release prevention barrier under the tank, the next barrier to prevent the tank contents from escaping into the environment was the secondary containment walls or dike[156] walls that surrounded the tanks. All of the tanks onsite were surrounded on all sides by masonry brick walls, or dikes that were fabricated to function as secondary spill containment[157] for any spills that might have occurred.[158] Two separate dikes surrounded the tanks. The first dike contained tanks 398 through 405. It was also separated from the second dike by a concrete wall between tank 398 and the pump house. The second dike surrounded tanks 393 through 397. Figure 23 provides a visual delineation of both dikes.

The tanks holding mixtures of Crude MCHM and PPH, stripped were contained within the second dike, which was constructed of brick, concrete block and poured concrete and was designed to act as secondary containment in the event of a complete breach of the tanks. The tank contents continued to flow from the bottom of tank 396 to the low point of the northwest corner of the dike wall. The elevation of the tanks was above the Elk River, which allowed for the chemicals to ultimately flow under the failed and deteriorated unreinforced dike walls toward the river. It is possible the extreme freezing condition provided some resistance to the flow; however, when temperature increased on January 9, the material released in the ground thawed and the leak became unrestricted, with increased odor intensity.[159] Once outside the containment area, the leak flowed for many hours, trickling down the short, steep escarpment into the Elk River and ultimately into the public water supply.

---

[155] WVDEP. Letter to Shaw Environmental Service. Response to 2006 Groundwater Monitoring Report, February 15, 2007.

[156] A dike is a barrier constructed to control or confine hazardous substances and prevent them from entering sewers, ditches, streams or other flowing waters.

[157] Secondary spill containment is the containment of hazardous liquids in order to prevent soil and water pollution.

[158] Secondary containment walls constructed of earthen berms, concrete or other materials are common structures in petroleum and chemical storage industry facilities for the purpose of containing a major release.

[159] The average temperature (39°F) was above freezing (33°F) on January 9, 2014, the day the leak was detected.

Figure 23. View from inside the dike wall facing the Elk River of the concrete block walls with no reinforcement (Left); dike wall along the tank farm parallel to the Elk River (Right). (Source: CSB)

The dike walls were in poor condition, and in December 1991 Pennzoil decided to upgrade a portion of the dike wall that ran parallel to the Elk River around tanks 399 through 402 in an effort to minimize the potential for spills from the tank farm to reach the river. The construction plan called for a 260-linear-foot concrete wall to be installed just inside and abutting the existing brick wall, and the remaining brick containment wall was to be repointed.[160] After the upgrade was completed, the Spill Prevention, Control, and Countermeasure (SPCC)[161] plan for the facility should have been updated by facility personnel and recertified by a Registered Professional Engineer. The repairs identified in the construction plan were never performed.

A 2013 estimate to repair the degraded dike walls included digging a new footer 3 feet deep alongside the existing block walls, replacing or shoring approximately 1,000 feet of existing dike wall, and relocating the conduits and piping that were attached to the wall. The estimated cost was $225,000,[162] and the need to upgrade the dike walls was clearly recognized by management; however, the walls were not repaired prior to the incident. The dike walls surrounding the tanks were not maintained; consequently, on the day of the incident, the content of the tank was able to flow through the deteriorated portions of those walls. As demonstrated in Figure 24 (left), many sections of the dike walls featured large holes and cracks that would not contain spills in the event of a complete breach of the tanks. This particular portion of the dike wall surrounded tank 398 and was located east of the tank, closer to Barlow Drive than the Elk River. Figure 24 (right) shows a hole between two dike walls that was located fairly close to the Elk River. The cement mortar between concrete blocks had deteriorated over time in several areas around the dikes. In

[160] Repointing is the grinding or raking out of existing mortar between joints of a masonry unit and replacing with new mortar.

[161] SPCC is discussed in further detail in Appendix E. SPCC plans incorporate specific steps for preventing, controlling and mitigating oil spills that are required for facilities that store oil and oil-containing products exceeding certain capacity thresholds where there is a possibility that an oil spill would reach a navigable water.

[162] Witherup Fabrication and Erection, Inc. Budgetary Costs for Etowah Tank Farm Upgrades and Repairs. Witherup Fabrication and Erection, Inc.: Pennsylvania. December 2, 2013.

addition, although concrete caps were used around the top of the dike walls, many of these caps were missing or had deteriorated, which allowed for rainwater or other elements to infiltrate the walls.

Figure 24. The dike walls that surrounded the tank farms were in poor condition. (Source: CSB)

3.3.3 Culvert

Freedom drained stormwater that collected in the tank farm by directing it to an oil/water separator before discharging it into the river. The diked areas had valves to permit the release of accumulated rainwater. These valves were closed at all times except during draining operations. The facility was also protected with surface drains that led to an oil/water separator. Treated stormwater from the oil/water separator was discharged directly into the Elk River (Figure 25) in accordance with the National Pollutant Discharge Elimination System[163] permit number WV0045225. Section 5.3.1 discusses further details of Freedom's NPDES permit.

[163] NPDES is a permit program that makes it unlawful for a person to discharge any pollutant from a point source into waters of the United States, unless an NPDES permit is first obtained.

Figure 25. Ice-filled oil/water separator discharge pipe into the Elk River. (Source: WVDEP)

The site consisted of a storm drainage system including a 12-inch-diameter corrugated steel culvert that began on the northeast edge of the site and ran across and beneath the secondary containment area to the northwest edge of the site toward the Elk River. The culvert ran between tanks 394 and 395 and was approximately 30 feet north of tank 396. Figure 26 provides an approximate subsurface configuration of the culvert in a cross-sectional view. The exact location of where the culvert inlet began was unknown. A portion of the released material flowed to and along the culvert pipe bedding until it reached the culvert discharge location or outlet, which was located outside the secondary containment structure and drained into the Elk River (Figure 27).[164]

[164] Civil & Environmental Consultants, Inc. Water Quality Sampling & Interim Remedial Measures Plan Tank 396 Release. Civil & Environmental Consultants, Inc.: Pennsylvania. January 26, 2014.

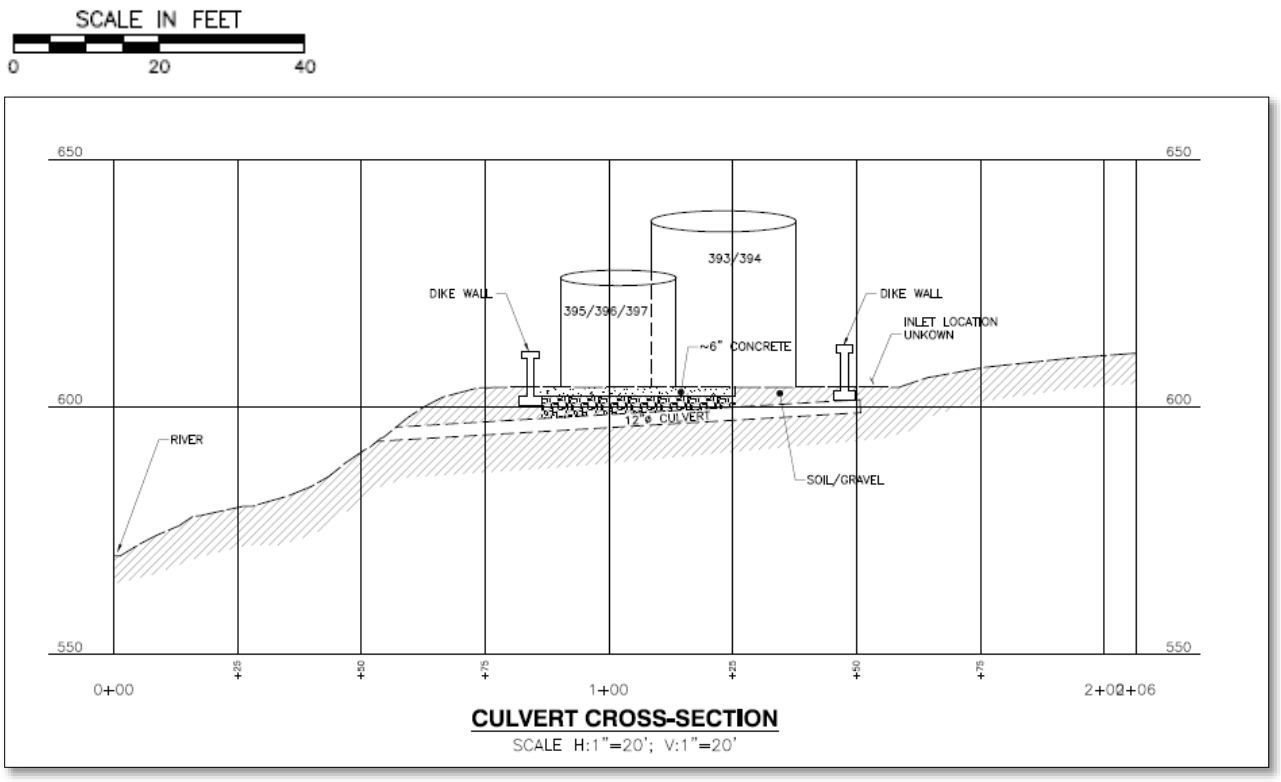


Figure 26. Cross-section of culvert beneath the Freedom site between tanks 394 and 395. (Source: Civil & Environmental Consultants, Inc. January 20, 2014)

Figure 27. Water flowing through a corrugated steel culvert extending from the hillside (Left); stormwater pipe above interceptor trench (Right). (Source: WVDEP)

After the January 9 release, stormwater from around the site continued to flow through the culvert pipe; however, pumping near the culvert inlet and inside the secondary containment area limited the quantity of water flowing outside the culvert pipe through the pipe bedding. In accordance with WVDEP, Freedom developed plans to investigate and remediate impacted soil and groundwater along the culvert. On January 18, 2014, site remediation contractors excavated a hole approximately 9 feet inside the east

containment wall in an effort to locate the culvert. The bottom of the culvert had deteriorated and crumbled once the dirt was removed by the contractors. On January 29, 2014, three water samples were collected by WVDEP for comparison around the culvert: (1) near the culvert inlet, upstream of the secondary containment wall, (2) at the culvert discharge point along the slope facing the Elk River, and (3) from the exposed culvert inside the containment area. The samples were analyzed for 4-MCHM and the results are captured in Table 7. The results indicate that the water in and around the culvert was impacted by 4-MCHM and that there was a larger concentration in Sample 3 within the containment area as was expected during the remediation process. CSB investigators were able to photo-document the remnants of the excavated culvert left on the Freedom site more than a year after the incident (Figure 28).[165]

Table 7. Results for MCHM Samples around Culvert[166]

Parameter	Sample 1 (Culvert Inlet)	Sample 2 (Culvert Outlet)	Sample 3 (Culvert Containment Area)
4-MCHM, mg/l[167]	0.036	0.074	0.180

Figure 28. Photo taken on June 15, 2015, of remnants of the culvert that ran between tanks 394 and 395 beneath the site. (Source: CSB)

[165] West Virginia Department of Environmental Protection. Environmental Enforcement Inspector's Report. West Virginia Department of Environmental Protection: West Virginia. January 18, 2014.
[166] *Ibid*.
[167] A milligram per liter (mg/l) is equivalent to one part per million (ppm).

4.0 PUBLIC HEALTH CONSEQUENCE ANALYSIS

The magnitude of the January 2014 spill resulted in a significant public health response from local and state officials. Immediately following the incident, there was no publicly available information on the contents of tank 396 with the exception of the Eastman SDS for Crude MCHM, the main chemical constituent of the tank. With only the Eastman SDS available, public health agencies had little information to communicate to the public about the toxicity of the spilled chemical. In addition, Freedom revised its initial release estimate and communicated that another chemical was present in the tank after the DNU order was lifted in all areas. As the crisis evolved, new and conflicting information increased the public's uncertainty about the safety of their drinking water.

4.1 Water Supply Contamination and Testing

Prior to the January 2014 incident, WVAW was aware that the site of the Freedom incident was a potential source of water contamination from a 2002 Source Water Assessment Report (see Section 5.4.1), but was unaware that Freedom stored Shurflot 944, a mixture of mostly Crude MCHM, and PPH, stripped, upstream of the intake. WVAW did not voluntarily request and review publicly available information, such as the Freedom site's Tier II Emergency and Hazardous Chemical Inventory forms, to understand what chemicals were stored onsite. In addition, prior to the incident, WVAW was not required by applicable regulations to obtain such information for many of the compounds present in tank 396. Furthermore, no health standard or screening level had been established for those chemicals by any government agency. As a result, WVAW was not familiar with the chemical characteristics, sampling methods, or the ability of its filtration system to treat potential leaks of those chemical compounds.

WVAW asserts that, upon notification of the leak, it had two options to respond to the spill of the chemical into the public water supply: (1) close the Elk River intake, or (2) keep the intake open and rely on the WVAW treatment and filtration process. With only a few hours of tap water in reserve, WVAW chose to keep the intakes open and issue a water use restriction to avoid sacrificing fire protection and sanitation capabilities in the Charleston area and to maintain a water supply for industrial users. WVAW reported that the record-setting cold temperatures followed by warm weather in early January caused an increased number of water distribution line and pipe breaks throughout the system due to frost heave. In addition, customers kept faucets slightly running to prevent frozen pipes. These factors contributed to the low inventory of finished water, requiring WVAW to run at full capacity (43-45 million gallons per day). According to WVAW, shutting down the water treatment plant would have resulted in a prolonged outage, keeping customers without access to water for any purpose, including fire protection and sanitation capabilities, potentially longer than the DNU order was in place.[168]

When the WVAW Supervisor arrived at the Freedom property and observed the spill, he called back to the WVAW KVTP and instructed staff to begin adding PAC and additional potassium permanganate to enhance the treatment process. He was told by WVDEP that the leaked chemical was possibly a flocculant. WVAW did not attempt to verify this information until it received from Freedom an SDS for

[168] House Transportation and Infrastructure Committee. Testimony of Jeffrey L. McIntyre. http://www.amwater.com/files/McIntyre%20Testimony%202%206%202014%20Final.pdf (July 11, 2016).

Crude MCHM sometime before 2:00 PM that day, upon which the WVAW Supervisor discovered that the chemical was instead used as a frothing agent.[169] Freedom provided WVAW with Eastman's SDS for Crude MCHM, not the Freedom SDS for Shurflot 944, the product inside tank 396. Up until that point, WVAW states that it was confident that the treatment process could filter out the flocculant, since flocculants are often used in water treatment.

Shortly after 2:00 PM, an odor was detected in the WVAW raw water intake. The plant continued to monitor the water and began to notice an odor as it moved through the water treatment process, even after coagulant formula was added in the mixing changer area to the clarifier units. That afternoon, WVAW reviewed the toxicological information available on the Crude MCHM SDS and concluded that the listed acute toxicity was significantly lower than other chemicals that typically concern the facility.

Around 3:00 PM, WVAW assumed that the majority of the plume had traveled past the water treatment plant, based on observed foaming in the river. At 4:05 PM, the WVAW Manager for Water Quality and Environmental Compliance reported receiving a cup of the filtered water that had an odor, chemical taste and slight beige tint. Upon realizing the filters could not fully treat and remove the spilled chemical mixture, WVAW, WVBPH and other state officials discussed the leak with the West Virginia Governor's Office. They discussed options for shutting down the plant and waiting for the plume to pass as well as issuing a DNU order. Because of the risk to sanitation and fire protection, a consensus decision was made to issue the DNU order in response to the leak.

Because WVAW claims it was not aware of the chemicals that Freedom stored upstream of the intake, and because there were no established sampling methods to determine the concentrations of the chemicals in the water, WVAW and WVBPH were unable to immediately communicate the risk of drinking water contamination to the public. Since WVAW lacked the capability to test for spilled chemicals, WVDHHR retrieved a sample of the water and WVAW sent it to its nearby Huntington Water Treatment Plant, which had a gas chromatograph-mass spectrometer,[170] to test for organic chemicals. WVAW also coordinated with a research group within the DuPont Corporation and National Guard to develop a method to isolate the 4-MCHM in water.

4.2 Reported Symptoms after Drinking Water Exposure

After WVAW issued the DNU order, the West Virginia Poison Control Center began receiving calls with reports of rashes, nausea, vomiting and other symptoms.[171] On January 9, WVBPH requested that CDC

[169] WVAW obtained a copy of the SDS via email prior to 2:00 PM that day; however, the WVAW Supervisor was unable to view the document on his mobile phone while onsite.

[170] Gas Chromatography Mass Spectrometry is a technique for the analysis and quantitation of organic volatile and semi-volatile compounds. Gas chromatography is used to separate mixtures into individual components using a temperature-controlled capillary column.

[171] West Virginia Department of Health and Human Resources. Findings of Emergency Department Record Review from Elk River Chemical Spill. http://www.wvdhhr.org/communications/news_releases/DHHR%20Press%20Release%20-%20Findings%20of%20Emergency%20Department%20Record%20Review%20from%20Elk%20River%20Chemical%20Spill.pdf (July 9, 2016).

determine the safe drinking water level for 4-MCHM, the main constituent of the leaking mixture. At that time, CDC could only rely on the information on the SDS and later, the proprietary toxicological data on Crude and 4-MCHM that Eastman made available on the evening of January 10. Furthermore, and unknown at the time of the spill, the leaked chemical was composed of various concentrations of different chemicals that made up Crude MCHM and PPH, stripped.

To better understand the impact of the chemical spill on the public, WVBPH began tracking emergency department visits and requested that ATSDR commence syndromic surveillance[172] to analyze a total of 584 hospital charts of individuals who sought medical care at the emergency rooms in local hospitals from January 9 until January 23, 2014 (Figure 29). WVBPH and ATSDR further analyzed 369 of the 584 records of individuals who reported symptoms and exposure to the contaminated water. Of the reported symptoms, skin, eye and respiratory tract irritation are consistent with Crude MCHM exposure.[173,174] Of the 369 people who visited local emergency departments, 13 (3.5%) were admitted for other chronic illnesses.[175] The remaining 356 (96.5%) were treated and released. Some treatments included medications for nausea and itching, and intravenous fluids were also administered.[176] Though the reports of symptoms corresponded with the first few days of the incident, WVBPH and ATSDR could not confirm if the contaminated water caused the symptoms. The syndromic surveillance report noted that the reported symptoms are similar to cold, flu and other common viruses.[177]

[172] Syndromic surveillance programs are designed to detect unusual disease patterns, through the collection and combination of multiple electronic data sources during a release. Gelting, R. J.; Miller, M. D. Linking Public Health and Water Utilities to Improve Emergency Response. Universities Council on Water Resources. *Journal of Contemporary Water Research and Education*. 2004, *129*, 22-26.

[173] West Virginia Department of Health and Human Resources. Findings of Emergency Department Record Review from Elk River Chemical Spill. http://www.wvdhhr.org/communications/news_releases/DHHR%20Press%20Release%20-%20Findings%20of%20Emergency%20Department%20Record%20Review%20from%20Elk%20River%20Chemical%20Spill.pdf (July 9, 2016).

[174] Eastman Chemical Company. Safety Data Sheet for Crude MCHM. Version 2.0. August 18, 2011.

[175] *Ibid.*

[176] *Ibid.*

[177] *Ibid.*

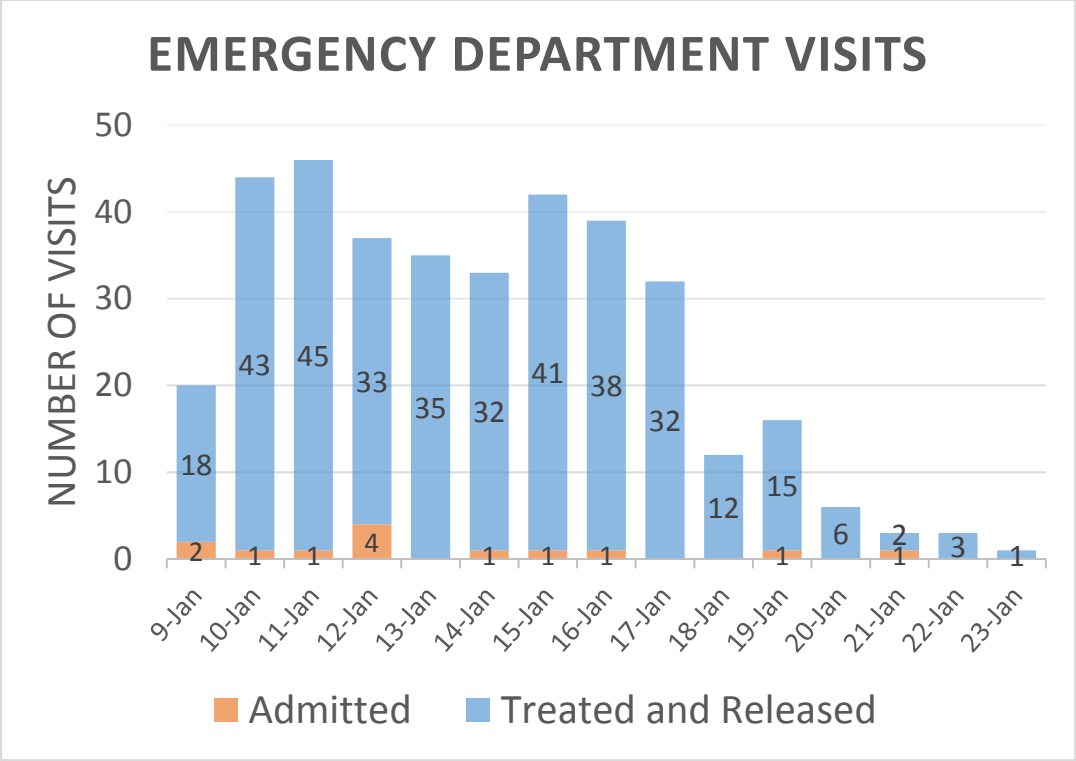


Figure 29. Summary of emergency department visits, January 9-23, 2014. (Source: WVBPH/CDC)

The 369 treated individuals reported that the most common route of contaminated water exposure was skin contact through bathing and showering (52.6%). Second was ingestion (43.9%) and third, breathing a water mist of vapor (14.6%). Some treated individuals reported more than one possible route of exposure. The most common symptoms reported and documented at local hospitals were nausea, rash, vomiting and abdominal pain, with some individuals reporting more than one symptom (see Table 8). Hospitals reported that laboratory test results did not indicate acute kidney or liver damage as a result of exposure. WVBPH and CDC also found that individuals possessed symptoms associated with how they reported exposure to the water, such as nausea or vomiting from ingestion and skin irritation from bathing.

Table 8. Symptoms Reported to Emergency Department, January 9-23, 2014 (Source: WVBPH/CDC)

Symptom	Number	Percentage
Nausea	141	38
Rash	105	29
Vomiting	104	28
Abdominal pain	90	24
Diarrhea	90	24
Headache	81	22
Itching	73	20
Sore throat	55	15
Eye pain	54	15
Cough	47	13

In early April 2014, a community assessment survey by WVDHHR through WVBPH in collaboration with CDC, revealed that many residents reported they had sought medical treatment at other medical facilities and some reported symptoms but did not seek medical treatment.[178] In a Kanawha-Charleston Health Department (KCHD) telephone survey of 499 respondents (59.8% response rate), 31% of residents reported symptoms. Of those symptomatic residents, 45% sought medical care at a primary care physician, 27% at an emergency room and 25% at an urgent care facility.[179] In addition, 25% of those residents reported symptoms prior to the issuance of the DNU order.[180]

4.3 Using Available Toxicological Information to Determine Acceptable Levels for Acute Exposure

At the onset of the spill, WVBPH asked CDC to establish a recommended screening level for 4-MCHM (see Appendix D for an explanation of toxicological studies). CSB learned that CDC only had the Eastman SDS for Crude MCHM immediately after the spill, which had little information that could be used to determine an exposure threshold.[181] Once the significance of the spill was realized, Eastman released seven proprietary toxicological studies on the evening of January 10. Using available information from the Crude MCHM SDS and Eastman's toxicological studies, CDC recommended a short-term screening level of 1 ppm (or 1,000 ppb) for 4-MCHM via ingestion only, that was not likely to be associated with any adverse effects.[182]

When determining the 1 ppm threshold for the short-term drinking water advisory, CDC used quantitative and qualitative information on exposures, the susceptibility of the population, the potential routes of exposure, and a number of uncertainty factors. CDC extrapolated downward from the available toxicological studies on Crude MCHM and 4- MCHM to recommend an exposure level not associated with any adverse health outcomes when ingested. The No Observed Effect Level (NOEL) was determined to be 100 mg/kg/day for lab rat oral ingestion of 4-MCHM.[183] CDC used the body weight of a child, with an estimated ingestion of 1 liter of water per day, as the most sensitive population in the drinking water advisory calculation.[184] In addition, CDC applied the highest uncertainty factors to account for the difference between animals and humans, sensitive humans and weaknesses in the toxicological evidence.

---

[178] Center for Disease Control and Prevention. Disaster Response and Recovery Needs of Communities Affected by the Elk River Chemical Spill. http://www.dhhr.wv.gov/News/2014/Documents/WVCASPERReport.pdf (July 9, 2016).

[179] Gupta, R. Public Health and the Largest Chemical Drinking Water Contamination Incident in US History. http://www.kchdwv.org/KCHD/media/KCHD-Media/PDF%20Files/WV-Chemical-Spill-Mountain-State-Symposium-5-9-14F.pdf (July 11, 2016).

[180] *Ibid.*

[181] The only information contained in the SDS for 4-MCHM was a Lethal Dose 50 for ingestion (LD50: (Rat): 825 mg/kg) and an LD50 for dermal exposure (>2000 mg/kg (Rat)).

[182] Center for Disease Control and Prevention. Information about MCHM. 2014 West Virginia Chemical Release. http://emergency.cdc.gov/chemical/MCHM/westvirginia2014/mchm.asp (July 11, 2016).

[183] Center for Disease Control and Prevention. Information about MCHM. 2014 West Virginia Chemical Release http://emergency.cdc.gov/chemical/MCHM/westvirginia2014/mchm.asp (July 11, 2016).

[184] Centers for Disease Control and Prevention. Emergency Preparedness and Response. Information about MCHM 2014 West Virginia Chemical Release. Summary Report of Short-Term Screening Level Calculation and Analysis of Available Animal Studies for Crude and 4-MCHM. http://emergency.cdc.gov/chemical/MCHM/westvirginia2014/mchm.asp (July 11, 2016).

After recommending the 1 ppm screening level, CDC ran additional computational toxicological models and verified that the 1 ppm determination, based on the Crude MCHM SDS and Eastman's toxicological studies, was adequate for ingestion. An independent review by an expert panel composed of members from the National Toxicology Program (NTP), National Institute for Environmental Health Sciences, National Library of Medicine and the Departmental Office of Assistant Secretary for Emergency Response supported the drinking water advisory of 1 ppm established by CDC. The panel found that the method CDC employed was "a traditional approach[185] that used reasonable and common assumptions to develop health protective drinking water health advisory levels"[186] during the spill. In June 2016, the NTP completed a yearlong study to evaluate the toxicity of the chemicals similar in structure to those spilled in the Elk River and evaluate the adequacy of the screening level established by CDC. These studies also supported CDC's recommended screening level of 1 ppm.[187]

Following the spill, initial testing of the water entering WVAW KVTP showed levels of 4-MCHM above the WVBPH/CDC health threshold of 1 ppm, which declined in the days following the spill. According to WVAW raw and finished water testing data provided to the CSB, at 5:00 PM on January 9, water entering WVAW contained levels of 4-MCHM measuring 13.7 ppm in the raw influent (river water) and 4.6 ppm after treatment at the plant tap (final product). On January 10, at 12:30 AM, water testing showed 4-MCHM in the raw water at WVAW measuring 1.04 ppm and 3.35 ppm, but in the outgoing water at 1.02 and 1.56 ppm, respectively (Figure 30).

[185] CDC used the Environmental Protection Agency Health Advisory method described by Donohue and Lipcomb 2002.

[186] West Virginia Testing Assessment Project. Report of Expert Panel Review of Screening Levels for Exposure to Chemicals from the January 2014 Elk River Spill. Toxicology Excellence for Risk Assessment. May 12, 2014. http://www.tera.org/Peer/WV/WV%20Expert%20Report%2012%20May%202014.pdf (September 24, 2016).

[187] NTP Research Program on Chemicals Spilled into the Elk River in West Virginia. National Toxicology Program http://ntp.niehs.nih.gov/ntp/research/areas/wvspill/wv_finalupdate_july2016_508.pdf (September 25, 2016).

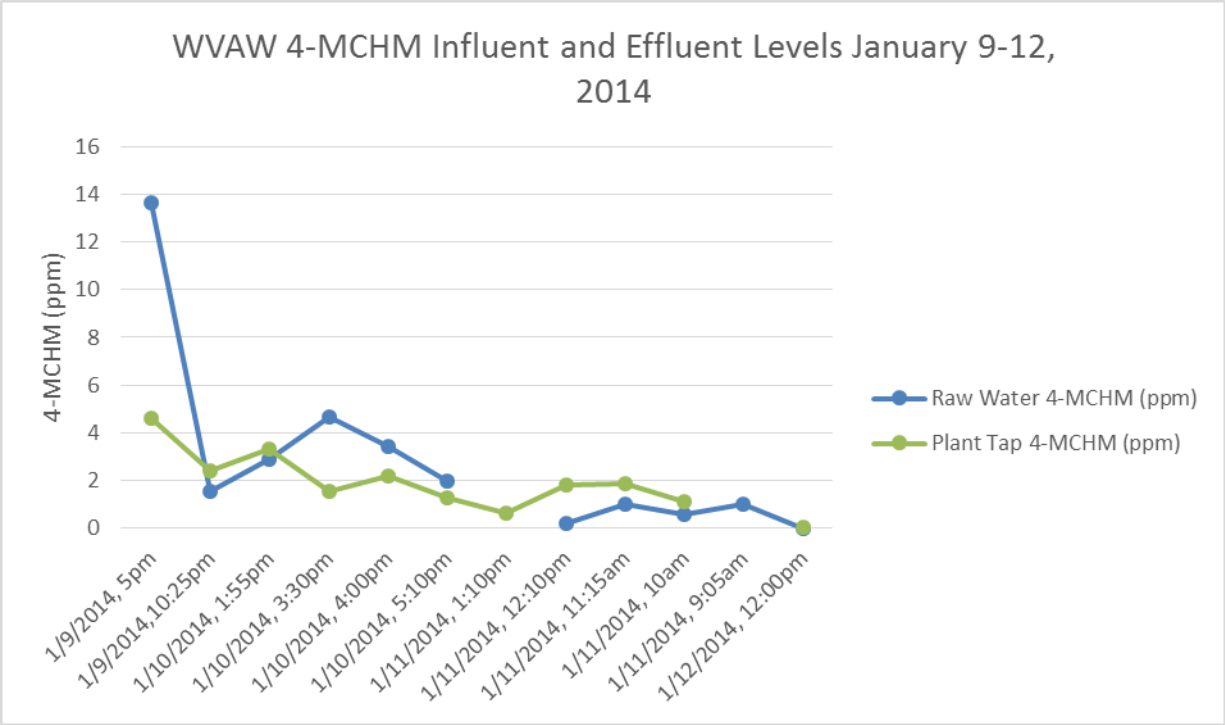


Figure 30. 4-MCHM levels in influent (river water) and finished water (final product) at WVAW KVTP on January 9-12, 2014. (Source: WVAW)

As 4-MCHM concentrations decreased below the screening level, WVAW began to lift water restrictions and by January 18, the DNU was lifted in all affected areas. Water samples collected from WVAW's raw water intake, distribution system and the community still had detectable concentrations of 4-MCHM in some areas at this time. [188] After the DNU was lifted, 4-MCHM concentrations within the distribution system were as high as 282 ppb in one area while other areas were below the detection limit of 2 ppb.[189] Charleston-area residents remained skeptical of the safety of their drinking water even after WVAW lifted the DNU order.[190] This is partly because residents could still smell the objectionable licorice-like odor in their water even after concentration levels were reduced well below the 1 ppm drinking water advisory. (Figure 31).

[188] MCHM Operational Sampling Results. http://www.dhsem.wv.gov/Documents/1%20Copy%20of%20PUB%20MCHM%201APR14%201500.pdf; http://www.dhsem.wv.gov/Documents/Sampling%20Results/MCHM%20Test%20Results%20at%202ppb.pdf (February 6, 2017).

[189] *Ibid.*

[190] Office of the Governor. After Action Review. http://www.dhsem.wv.gov/West%20Virginia%20Public%20Water%20Supply%20Study%20Commission/Documents/After%20Action%20Review.PDFhttp://www.governor.wv.gov/Documents/After%20Action%20Review.PDF (Feburary 3, 2017).

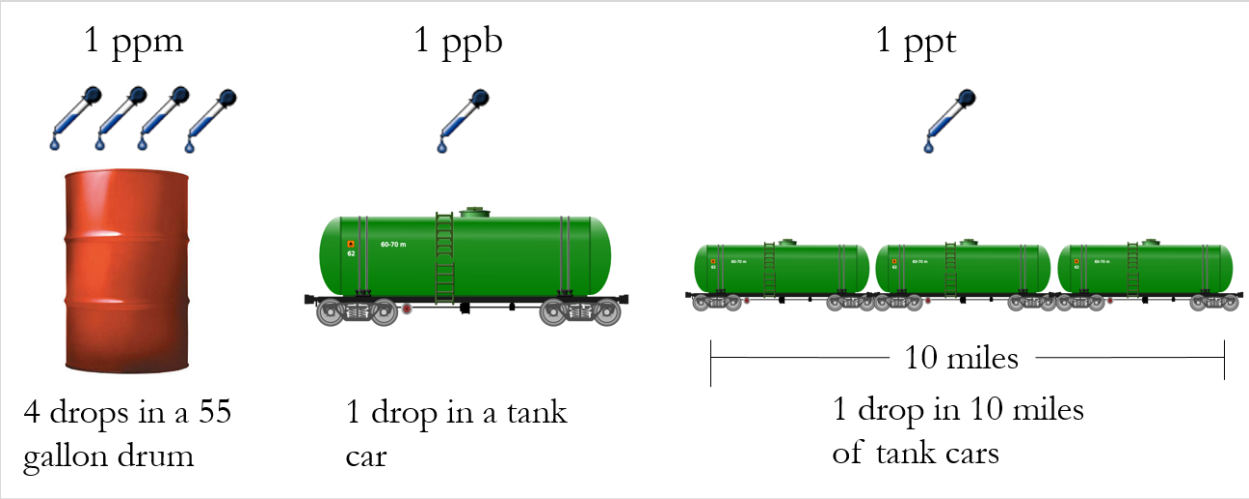


Figure 31. Equivalent concentrations of ppm, ppb and ppt notations. The CDC short-term screening level of 4-MCHM was 1 ppm. Studies regarding the odor threshold for 4-MCHM components suggest that some residents may have been able to smell odors in their water at levels as low as 0.060 ppb (60 ppt).[191] (Source: CSB)

4.4 Deficient Crisis and Risk Communication

CSB concluded that the initial lack of information about the spilled chemical, combined with new and conflicting information becoming available as the crisis evolved, greatly affected the ability of public health agencies to credibly communicate the risk of the leaked chemicals following the incident. CSB evaluated aspects of the spill response against principles contained within the Department of Health and Human Services (DHHS) and CDC's *Crisis Emergency Risk Communication* (CERC) (2014 Edition) manual. Public health professionals and public information officers apply elements of the CERC to effectively communicate during an emergency.[192] The CERC manual defines risk communication as "information about the expected type (good or bad) and magnitude (weak or strong) of an outcome from a behavior or exposure."[193] Risk communication assists the public in making decisions on how to avoid adverse outcomes or how to respond to them, such as undergoing medical treatment.[194] The CERC manual states that a public health crisis evolves through phases and it is essential that the communication evolves through these phases. The crisis and emergency risk communication life cycle includes the following phases: pre-crisis, initial, maintenance, resolution and evaluation. Figure 32 describes the phases in depth. Each phase requires its own type of information.

[191] Gallagher et al., Tale of Two Isomers: Complexities of Human Odor Perception for *cis*- and *trans*-4 Methylcyclohexanemethanol from the Chemical Spill in West Virginia. Environmental Science and Technology. 2015 49 (3), 1319-1327 DOI: 10.1021/es5049418. http://pubs.acs.org/doi/abs/10.1021/es5049418 (February 3, 2017).

[192] Department of Health and Human Services, Centers for Disease Control and Prevention. Crisis and Emergency Risk Communication. 2014. http://emergency.cdc.gov/cerc/resources/pdf/cerc_2012edition.pdf (March 30, 2016).

[193] *Ibid.*

[194] *Ibid.*

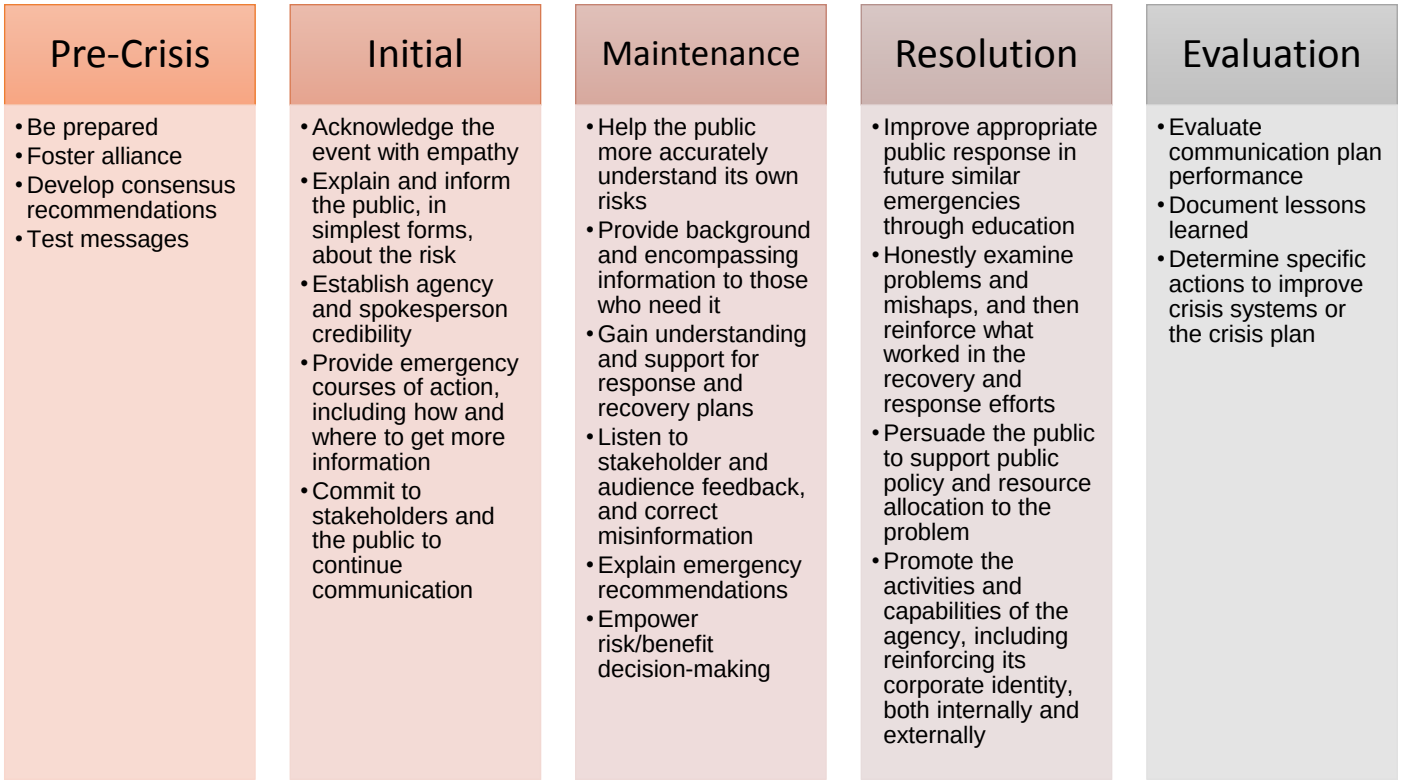


Figure 32. DHHS/CDC crisis and emergency risk communication life cycle. (Source: CDC)

During the pre-crisis stage, organizations responsible for responding to and providing public information about the crisis are expected to anticipate the types of disasters their jurisdiction might experience. CSB learned the Public Water Emergency Annex (B12) of the Kanawha Putnam Emergency Management Plan for the Charleston area addressed only isolated water system losses, not the complete loss of the water system.[195] In the Kanawha Putnam Emergency Planning Committee (KPEPC) After Action Report (AAR) of the January 9, 2014 incident, four items were listed to be addressed as lessons learned from the spill:

1. Expand assumptions to include other types of threats (e.g., complete loss of system).
2. List all available resources (e.g., water tanks).
3. Develop a public preparedness component.
4. Role of public health in testing the water (e.g., bulk tanks).

The KPEPC AAR also identified the lack of a response plan at the state or county level for Crude MCHM because no information was available on the known hazards of the chemical.[196]

[195] Kanawha Putnam Emergency Planning Committee. West Virginia American Water Incident. After Action Report. 2014.
[196] *Ibid.*

Another aspect of the pre-crisis phase is to develop and test communication systems and networks. However, during the spill, the West Virginia Governor's Office, WVBPH and WVAW were all reporting information to the public. The KPEPC AAR identified the lack of a unified command for Kanawha and Putnam counties, as well as the exclusion of the county health department from the command and control structure during the incident response.[197]

During the initial response phase, public health agencies must convey useful information to the public with instructions on what to do. According to the CERC manual, information must be as accurate as possible with the recognition that it is constantly changing and agencies must be willing to publicly acknowledge a gap in essential information. "Accuracy in what is released and the speed in which response officials acknowledge the event are critical at this stage."[198] During the maintenance phase, it is essential that public health agencies and emergency responders manage the information flow to the public by remaining in close coordination with all partners to avoid hyperbole and speculation.

In the days following the spill, local residents were given many instructions: a DNU order issued on January 9, which was lifted for some areas on January 13 with an advisory to flush their pipes; and then, on January 15, a drinking water advisory issued by WVBPH, in consultation with CDC, cautioning pregnant women to drink bottled water until "there are no longer detectable levels of MCHM in the distribution system."[199] These warnings and drinking water advisories were unclear and seemingly contradicted each other, with some occurring after the DNU was lifted for some areas (see Appendix A). On January 18, the DNU order was lifted for all areas;[200] but on January 21, the President of Freedom announced that another chemical, a mixture of polyglycol ethers (PPH, stripped), was also released from tank 396 (Figure 33).[201]

[197] *Ibid.*

[198] Department of Health and Human Services, Centers for Disease Control and Prevention. *Crisis and Emergency Risk Communication;* 2014. http://emergency.cdc.gov/cerc/resources/pdf/cerc_2012edition.pdf (March 30, 2016).

[199] State of West Virginia Department of Health and Human Resources Bureau for Public Health Commissioner Office. Water Advisory for Pregnant Women. http://www.dhsem.wv.gov/Documents/Advisory%20-%201-15-2014.pdf (July 8, 2016).

[200] Center for Disease Control and Prevention. Disaster Response and Recovery Needs of Communities Affected by the Elk River Chemical Spill. http://www.dhhr.wv.gov/News/2014/Documents/WVCASPERReport.pdf (July 9, 2016).

[201] West Virginia Bureau of Public Health. CDC Statement on PPH. http://www.dhhr.wv.gov/News/chemical-spill/Documents/CDCstmtonPPH.pdf (July 8, 2016).

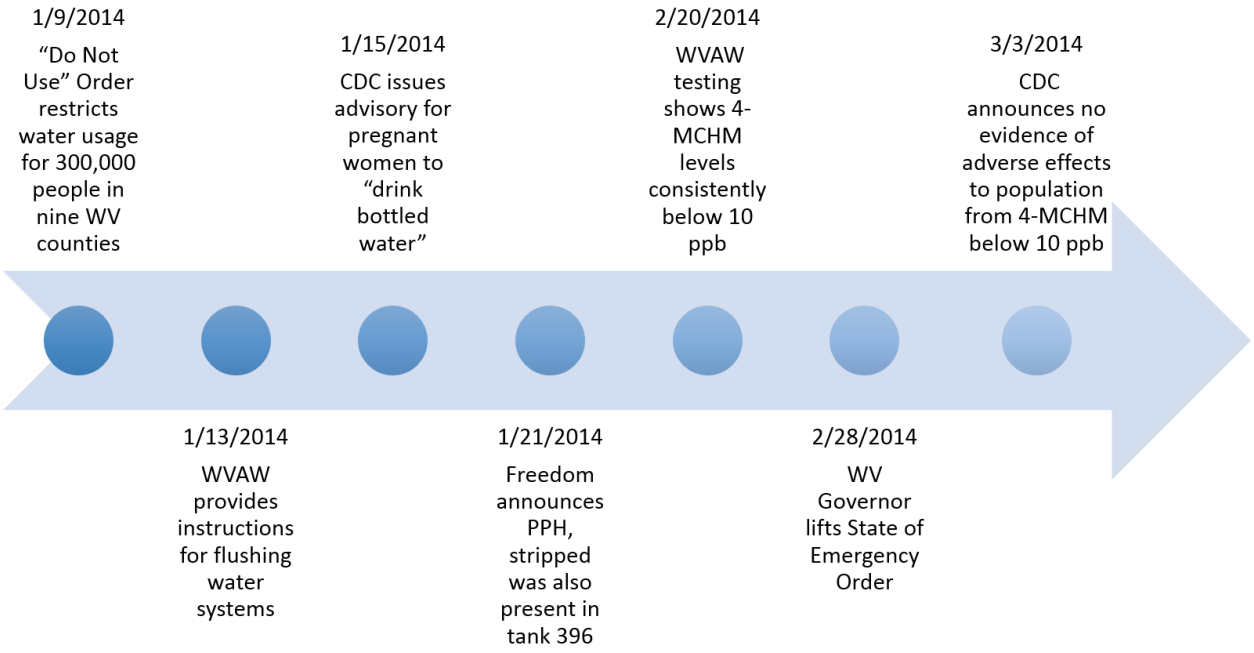


Figure 33. Timeline of drinking water advisories and announcements issued to residents affected by the spill. (Source: CSB)

Finally, the KPEPC AAR found that one of the most challenging aspects of the spill from a response and public notification perspective was that Freedom did not provide reliable information during the first week of the incident in reporting the correct amount of chemical released from the tank.[202] In addition to the fact that Freedom did not immediately disclose all chemicals contained in tank 396, Freedom would not or could not provide an accurate estimate of the quantity of chemicals that leaked. The amount changed from an estimated 1,000 gallons to 7,500 during the first week, to a revised total of 10,000 gallons on January 27, 2014.[203]

The resolution phase of the CERC life cycle provides an opportunity to reinforce public health messages, promote personal preparedness and obtain public buy-in to policies addressing the problem. However, surveys conducted by CDC and WVBPH found residents did not trust the public drinking water supply months after the spill (see Section 4.4.1).

[202] Kanawha Putnam Emergency Planning Committee. West Virginia American Water Incident. After Action Report. 2014.

[203] WVDEP. Freedom Revises Spill Estimate [press release]. Charleston, WV: West Virginia Department of Environmental Protection. January 27, 2014. http://www.dep.wv.gov/news/pages/Freedom-revises-spill-estimate.aspx (July 25, 2014).

In the final evaluation phase of the CERC life cycle, responders and public health officials share learnings from the experience, document specific actions and recommendations to improve crisis communication, evaluate the communication plan and improve their pre-crisis activities.[204] The success of future responses is contingent on adequately preplanning an effective communication strategy to the public. Lessons learned from the KPEPC AAR, in addition to the creation of new spill reporting requirements and the passage of Senate Bill (SB) 373 and 423 (see Section 5.2.2), attempt to ensure public health and emergency response agencies are prepared for future events in West Virginia. This report also shares lessons learned to encourage emergency planning and coordination between water utilities and public health agencies across the United States.

4.4.1 Public Distrust of Drinking Water Safety

On February 20, 2014, WVAW announced that levels of 4-MCHM in the water distribution system were below 10 ppb.[205] The West Virginia Governor lifted the state of emergency on February 26, 2014, and CDC announced on March 3, 2014, that it found no evidence of adverse health effects to any segment of the population at 4-MCHM levels below 10 ppb for consumption.[206] WVBPH found that by March 1, 5% of the population was drinking tap water, and in a survey conducted in April 2014 the number increased to 35-40%. A telephone survey administered in April 2014 by KCHD found that among 499 participants, about 54% believed the water was not safe to drink.[207]

As part of the public health response to the spill, CDC, at the request of WVBPH, also conducted a community survey called the Community Assessment for Public Health Emergency Response (CASPER) on April 8-10, 2014, to assist WVBPH in evaluating the response and improving future responses. CASPER had three objectives: (1) assess the perceived impact of the chemical spill on households, (2) provide WVBPH with information on household water use and practices before, during and after the DNU order, and (3) assess communications to identify effective approaches for current and future events.[208]

Results from 171 household interviews showed that most households were able to obtain water within one day of the spill and many stores quickly sold out of water; 21.7% of households reported one or more

---

[204] Department of Health and Human Services, Centers for Disease Control and Prevention. *Crisis and Emergency Risk Communication;* 2014. http://emergency.cdc.gov/cerc/resources/pdf/cerc_2012edition.pdf (March 30, 2016).

[205] WVAW. West Virginia American Water Update: All Samples Throughout Distribution System Below 10 Parts Per Billion: Flushing and Testing Continues to Help Address Odor; February 20, 2016. http://www.amwater.com/wvaw/customer-service/customer-communications/page25633.html (September 15, 2016).

[206] Public Service Commission of West Virginia. PSC Initiates General Investigation into WVAWC's Response to MCHM Spill. Public Service Commission of West Virginia: West Virginia. May 29, 2014. http://www.psc.state.wv.us/scripts/WebDocket/ViewDocument.cfm?CaseActivityID=397808&NotType=%27WebDocket%27.

[207] Latif, D. et al. Community Assessment Population Survey (CAPS). Communications during the West Virginia Water Crisis: A Survey of the Population. 2014.

[208] Center for Disease Control and Prevention. Disaster Response and Recovery Needs of Communities Affected by the Elk River Chemical Spill. http://www.dhhr.wv.gov/News/2014/Documents/WVCASPERReport.pdf (July 9, 2016).

health issues from the spill; and 3.5% reported mental health issues resulting from the spill. The survey also found that 37.4% of households actually used the drinking water during the DNU order, while 68.8% stated they used the water after the order was lifted. When asked whether they thought the water was safe to drink after the DNU order was lifted, 36.1% stated they agreed it was safe after the order was lifted.[209] Recommendations from the CASPER survey report include, among others, asking households to prepare a 3-day water supply, improving communication during an emergency, increasing community education around water safety and promoting health and mental health services available to the community.[210] In addition, to address the lack of chemical information available during the initial phase of the crisis, the KPEPC AAR recommends that all facilities submit detailed SDS and Tier II reports electronically to the local fire departments, KPEPC and State Emergency Response Commission. The recommendations also address reviewing the information collected on tanks that store chemicals near public water supplies under WV SB 373 to ensure adequate planning is occurring (see Section 5.2).[211]

4.5 Prior Chemical Release Incidents Investigated by CSB

CSB investigated two other incidents in the Charleston area that resulted in acute chemical releases affecting both workers and the local community. In 2008, a 4,500-gallon pressure vessel exploded, releasing methomyl at the Bayer CropScience facility in Institute, West Virginia.[212] Methyl isocyanate (MIC)[213] is a highly toxic chemical used to produce methomyl. Bayer CropScience made MIC at the Institute site and stored it in a tank located approximately 70 feet from the exploding pressure vessel. The explosion killed two workers and injured six firefighters who were exposed to toxic chemicals.[214] In addition, 40,000 residents including students at West Virginia State University were asked to shelter-in-place for three hours and local highways and roadways were closed for hours due to the smoke from the explosion.[215]

The second event was a series of toxic chemical releases that occurred on January 22-23, 2010, at the DuPont plant in Belle, West Virginia, when three gases—methyl chloride, oleum and phosgene—triggered an emergency response. In the five days leading up to the first incident on January 22, 2010, 2,000 pounds of methyl chloride were released from the distributed control system. Then on January 23, a leak in a sample pipe released a fuming cloud of oleum into the atmosphere, requiring the help of the

[209] Center for Disease Control and Prevention. Disaster Response and Recovery Needs of Communities Affected by the Elk River Chemical Spill. http://www.dhhr.wv.gov/News/2014/Documents/WVCASPERReport.pdf (July 9, 2016).
[210] *Ibid.*
[211] Kanawha Putnam Emergency Planning Committee. West Virginia American Water Incident. After Action Report. 2014.
[212] U.S. Chemical Safety and Hazard Investigation Board. Pesticide Chemical Runaway Reaction Pressure Vessel Explosion. http://www.csb.gov/assets/1/19/Bayer_Report_Final.pdf (July 11, 2016).
[213] MIC is the toxic chemical that was released into the Bhopal community after an explosion at the Union Carbide facility in Bhopal, India.
[214] *Ibid.*
[215] *Ibid.*

local fire department to mitigate.[216] On the same day, a phosgene transfer hose failed, spraying a worker in the face as he was checking the weight of a 1-ton phosgene cylinder, fatally injuring him.[217]

In the Bayer CropScience report, CSB concluded that the incidents at both Bayer and DuPont revealed regulatory deficiencies that were not identified or corrected through voluntary compliance or existing enforcement mechanisms prior to the incidents. In addition, the Kanawha Valley contains many facilities that handle large quantities of acutely toxic and hazardous materials covered under similar regulatory programs. In January 2011, following the release of the Bayer CropScience investigation, CSB issued a recommendation to KCHD to create a Hazardous Chemical Release Program working in conjunction with WVDHHR and WVDEP. The Hazardous Chemical Release Program would authorize direct participation from state or local government programs in facility safety planning and oversight. In April 2011, Dr. Rahul Gupta, then head of KCHD, wrote to WVDHHR asking for support to commence such a program. In May 2011, WVDHHR denied KCHD support, stating, "We have always operated under the premise that the in-house health and safety oversight of chemical facilities lies within the purview of OSHA and the EPA. In addition, WVDEP issues permits for air and water emissions from these facilities which require their understanding of the processes which produce those emissions. At the current time, WVDHHR does not have the regulatory or technical expertise to implement the recommendations contained in the Board's report."

The chemical storage of Crude MCHM at the Freedom facility was not covered under performance-based standards such as OSHA's Process Safety Management or EPA's Risk Management Programs. In addition, the condition of Freedom's tank 396 and secondary containment skirted enforcement due to WVDEP's lack of inspections. On May 19, 2014, four months after the spill, KCHD wrote to the Speaker of the West Virginia House of Delegates to express its interest in establishing the Hazardous Chemical Release Prevention Program, stating, "It is our assertion that an existing Hazardous Chemical Release Prevention Program, as envisioned by CSB, would have provided our communities the best prospect of preventing disasters such as the January 9th Elk River chemical spill."[218]

On March 8, 2014, the West Virginia Legislature passed SB 373, which established the Public Water System Supply Study Commission (PWSSSC) in order to study and report back to the legislature on several topics, including CSB's recommendations from the Bayer CropScience incident of 2008.[219] PWSSSC created four working groups, of which Working Group 4 was tasked with reviewing CSB's recommendations, in particular the recommendation to establish a Chemical Release Prevention Plan within KCHD. People Concerned About Chemical Safety (PCACS)[220] held numerous multisector stakeholder meetings through 2015 to review existing chemical release prevention programs at the federal and state levels and to create the outline of a Chemical Release Prevention Plan for Kanawha County,

---

[216] U.S. Chemical Safety and Hazard Investigation Board. DuPont Corporation Toxic Chemical Releases. http://www.csb.gov/assets/1/19/CSB%20Final%20Report.pdf (July 11, 2016).
[217] *Ibid.*
[218] Kanawha-Charleston Health Department. May 19, 2014, Letter to the Honorable Tim Miley, Speaker West Virginia House of Delegates. CSB Doc Name: Attachment 2 WV Senate Concurrent Resolution 98.
[219] http://www.legis.state.wv.us/wvcode/ChapterEntire.cfm?chap=22&art=31 (August 2, 2016).
[220] People Concerned About Chemical Safety is a community organization in the Kanawha Valley that promotes environmental justice and chemical safety through education and advocacy.

with eventual application to the State of West Virginia. Members of Working Group 4 participated in this process and ultimately concluded that PWSSSC agreed with CSB's recommendations, and reported to the legislature that it should urge the Governor and West Virginia state agencies to implement CSB's recommendation as outlined by the West Virginia Chemical Release Prevention Program Plan.

SB 373 also enacted Section 16-1-9e of the West Virginia Code, which calls for WVBPH to work with CDC and other federal agencies to "creat[e], organiz[e], and implement a medical study to assess any long-term health effects resulting from the chemical spill that occurred on January 9, 2014, and which exposed the public to chemicals, including 4-MCHM."[221] The responsibility for the long-term health effects study resides with the Commissioner of Health. To meet this requirement, WVBPH commissioned the National Toxicology Program to conduct a low birthweight study of babies born to women who were pregnant during the spill. The yearlong study, completed in June 2016, evaluated the toxicity of Crude and 4-MCHM and concluded that exposure at or below the screening level of 1 ppm is considered not likely to be associated with any adverse effects.[222] Studies on exposures to pregnant lab animals via ingestion at levels well above the screening level were shown to produce low birthweights.[223] NTP's study of the prevalence of low birthweight children born to mothers expecting during the time of the spill found no evidence of low birthweights.[224]

4.6 AW and WVAW Response to Water Contamination

4.6.1 American Water Works Company, Inc.

American Water Works Company, Inc.[225] is the largest investor-owned and publicly traded water and wastewater utility company in the United States.[226] AW is a Delaware-incorporated holding company and as such conducts its business operations through its subsidiaries.[227] AW subsidiaries operate as regulated utilities in 16 states and serve an estimated 14 million people in more than 45 states and parts of

[221] S.B. 373, 2014 W. VA 2015. http://www.legis.state.wv.us/Bill_Text_HTML/2014_SESSIONS/RS/bills/SB373%20SUB2.pdf (July 11, 2016).
[222] National Toxicology Program. NTP Research Program on Chemical Spilled into the Elk River in West Virginia Final Update. http://ntp.niehs.nih.gov/ntp/research/areas/wvspill/wv_finalupdate_july2016_508.pdf (August 3, 2016).
[223] *Ibid.*
[224] *Ibid.*
[225] American Water Works Company, Inc., together with its subsidiaries, including West Virginia American Water, is referred to as American Water in this report, however legally American Water is American Water Works Company, Inc.
[226] AW subsidiaries operate approximately 80 surface water treatment plants, 500 groundwater treatment plants, 1,000 groundwater wells, 100 wastewater treatment facilities, 1,100 treated water storage facilities, 1,200 pumping stations, 90 dams and 46,000 miles of mains and collection pipes. In addition, AW and its subsidiaries have more than 6,400 employees.
[227] United States Securities and Exchange Commission. Form 10-K Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934 for the Fiscal Year Ended December 31, 2014. American Water Works Company, Inc.: Voorhees, NJ. 2014. http://ir.amwater.com/Cache/29123208.PDF?Y=&O=PDF&D=&FID=27943982&T=&OSID=9&IID=4004387 (July 20, 2016).

Canada.[228] AW's regulated subsidiaries are subject to economic regulation by state Public Utility Commissions (or in the case of West Virginia, the Public Service Commission) and water quality standards by EPA and/or state authorities.

AW's complex business model includes two types of operations—those in which it owns the assets (regulated operations) and those in which it manages assets and provides water and wastewater services for a municipality or other entity (nonregulated operations). It serves residential homes and businesses but also performs nonregulated contract operations for municipalities that own their utility systems (Figure 34).[229] AW's corporate-level management efforts are generally decentralized, allowing its subsidiaries or utilities to address operational and jurisdictional issues in accordance with applicable federal, state and local laws and regulations, while encouraging coordination and information sharing among subsidiaries and support functions within American Water Works Service Company. AW's business model and management approach allows the subsidiary or utility to be responsible for establishing its own internal processes regarding daily operations for the treatment and delivery of water to the community as long as these processes follow applicable federal, state and local laws and regulations.

AW has implemented general plans, policies and procedures that its subsidiaries are expected to follow. In addition, AW implemented practices that subsidiaries use as guidance and implement consistent with the facility- specific circumstances and local regulatory requirements; however, the practices are not requirements established by AW. In addition, AW does not formally monitor or track which plans, policies or procedures are followed by its utilities; however, AW indicated that it monitors implementation of the environmental policies and practices through internal audit functions and through formalized monthly reporting between state subsidiary environmental functions and American Water Service environmental department personnel and periodic meetings and conference calls. CSB reviewed many of the AW and WVAW plans, policies and procedures to determine how similar they were and whether they were followed on the day of the incident. Even though WVAW's plans, policies and procedures mostly aligned with AW's, the differences between them would not have changed the way in which WVAW responded to the incident, nor would they have prevented the mixture containing Crude MCHM and PPH, stripped from entering the water distribution system.

[228] American Water. "West Virginia American Water Our States." http://www.amwater.com/wvaw/About-Us/our-states.html (July 13, 2015).
[229] American Water. "West Virginia American Water Corporate Information." http://www.amwater.com/wvaw/About-Us/Corporate-Information/ (July 13, 2015).

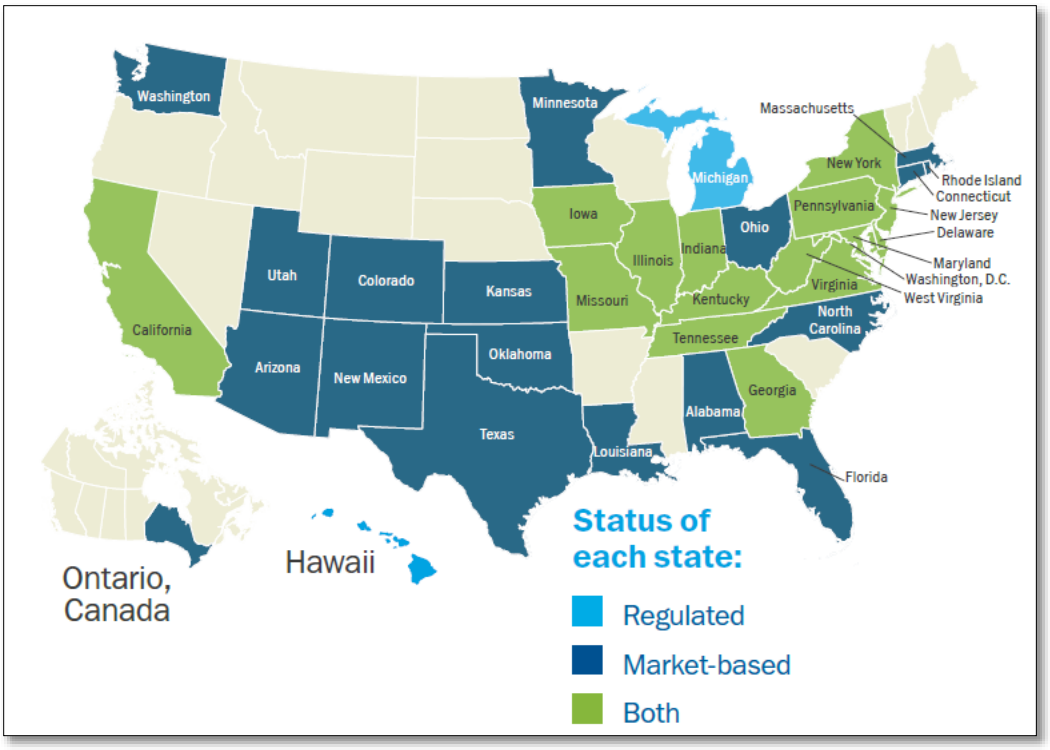


Figure 34. States in which AW operates.[230] (Source: AW)

As regulated public utilities, investor-owned water companies have been granted authority by each state's PSC[231] to operate in a particular service area. WVAW is regulated by the West Virginia PSC, which initiated an investigation into the MCHM leak on May 21, 2014, due to the numerous complaints received from WVAW customers. The focus of the PSC investigation is to determine whether WVAW's actions in reaction to the spill and the presence of MCHM in its raw water or finished water supply constitute unreasonable or inadequate practices, acts or services as provided for in state law.[232] The development of water quality standards is outside the scope of its investigation. The PSC investigation of the Freedom incident is ongoing.

4.6.2 Use of Boil Water and Do Not Use Notices

Water utilities issue Boil Water Notices (BWNs) or Do Not Use Notices when conditions exist that have the potential to cause adverse public health effects.[233] For example, consistent with WVDHHR rules and

[230] American Water. Corporate Responsibility Report 2013-2014. 2015. http://amwater.com/files/American-Water-CR-2013-14.pdf (June 29, 2016).

[231] In West Virginia, the Public Service Commission supervises and regulates the rates, services, operations and most other activities of all public utilities. PSC processes and acts on petitions filed by these regulated entities. It also acts on complaints against utilities and common carriers.

[232] Public Service Commission of West Virginia. PSC Initiates General Investigation into WVAWC's Response to MCHM Spill. Public Service Commission of West Virginia: West Virginia. May 21, 2014. http://www.psc.state.wv.us/press/2014/Press_20140521.pdf (May 23, 2016).

[233] Appendix C discusses other instances where BWNs may occur.

guidance, WVAW would potentially issue a BWN any time a customer service disruption occurs in the form of total loss of water or pressure below 20 pounds per square inch.[234] WVDHHR requires that BWNs and DNUs be issued by the public water system as soon as practical, but no later than 12 hours after the public water system becomes aware of the conditions warranting a BWN or DNU. [235] In addition, a DNU is issued when boiling the water will not ensure that it is safe to drink and may have the opposite effect of concentrating contaminants, or when any chemical or hydrocarbon contamination of unknown quantity that may pose an immediate public health risk is present within a public water system. It is significant to note that in 2008 the "Boil Water Notices for Public Systems" procedure[236] allowed for a 24-hour window to issue a BWN or a DNU; however, in 2009 this window was changed to 12 hours. At 11:56 AM, WVAW became aware of the spill, but it did not detect the MCHM in its filtered water until 4:18 PM and the DNU notice was issued at 5:45 PM.

WVAW did not receive any complaints of licorice-smelling water from customers prior to becoming aware of the release from Freedom. Even though the public notice was issued within the 12-hour time frame, the chemicals were still able to reach the drinking water supply for thousands of consumers, many of whom may have been using the water prior to the release of a public notice. Since the Freedom incident, West Virginia code now requires public water systems to develop a "communications plan that documents the manner in which the public water utility, working in concert with state and local emergency response agencies, shall notify the local health agencies and the public of the initial spill or contamination event and provide updated information related to any contamination or impairment of the source water supply or the system's drinking water supply, with an initial notification to occur in any event no later than 30 minutes after the public water system becomes aware of the spill, release or potential contamination of the public water system." WVBPH clarified this requirement through rulemaking stating that "initial notification to the public to occur in any event no later than 30 minutes after the public water system becomes aware that the spill, release or potential contamination of the public water system poses a potential threat to public health and safety."[237]

In addition, on January 13, 2014, WVAW launched an interactive webpage, "Kanawha Valley Lift Zone Map," that allowed the public to enter their residential or business address to determine if their home or business was within or near an affected area and provided the status of the water service. The interactive map was meant to be a general guide, and individuals who found themselves to be near an "alert boundary"[238] were asked to contact WVAW directly for more specific information. The webpage also provided information on the DNU orders being lifted by zones. This information was also communicated

[234] West Virginia American Water. Response to Main Breaks and Boil Water Advisories Maintaining Water Quality in the Distribution System. February 2009.

[235] West Virginia Department of Health and Human Resources. Manual of Environmental Health Procedures Boil Water Notices for Public Water Systems Procedure DW-23. December 8, 2008, and June 6, 2009.

[236] A DNU order is issued pursuant to Procedure DW-23 ("Boil Water Notices for Public Systems") from WVDHHR's *Manual of Environmental Health Procedures*.

[237] West Virginia American Water Kanawha Valley Water System. Source Water Protection Plan. West Virginia American Water: West Virginia. June 2016.

[238] Water systems are separated by pressure zones based on elevations. Public alerts typically affect pressure zones (not necessarily municipal boundaries). The alert boundaries on the interactive map were organized by pressure zones.

through various media outlets and autodialer calls to affected homes and businesses. A temporary 24/7 hotline was established to provide additional clarification.

4.6.3 WVAW's Monitoring and Testing Process

According to a 2011 WVAW comprehensive planning study[239] along with information provided by AW, plant operators at WVAW—in addition to their daily monitoring and testing practices[240]—conduct quarterly, annual and multiyear water quality sampling that is analyzed at the plant or in the AW Belleville, Illinois, laboratory. Selected contaminants of concern include inorganics, metals, minerals, pesticides, herbicides, priority pollutants, volatile organic chemicals and bacteriological parameters.[241] Quarterly, WVAW tests for disinfection byproducts, including trihalomethane, and haloacetics are measured from eight locations in the distribution system. Total organic carbons and alkalinity are measured in samples taken from raw water and finished water. Annually, finished water is tested for inorganic chemicals, metals and minerals, arsenic, nitrate and Volatile Organic Carbons. Once every three years, in two consecutive quarters, finished water is sampled and measured for synthetic organic carbons. Lead and copper are also monitored every three years, with 50 samples taken at customer taps. Radiological materials are tested once every six years.

In April 2014, WVAW monitored for 30 contaminants (28 chemicals and two viruses) in accordance with EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3).[242] The purpose of UCMR3 is to collect occurrence data for contaminants suspected to be present in drinking water but that do not have health-based standards set under the Safe Drinking Water Act (SDWA).[243] 4-MCHM is not one of the 30 contaminants listed under UCMR3 because it is not considered to be a common chemical found in source water, nor has the severity of the long-term health effects due to its presence in drinking water been fully examined, limiting its potential for inclusion in UCMR3. If WVAW voluntarily chooses to monitor unregulated contaminants other than those required by EPA, it makes those decisions based on the geographic location of the treatment plants and the potential contaminants that may affect the water. For example, WVAW monitors for bromides in West Virginia due to water treatment plants and their source waters being located near fracking activities and the potential for bromides to create trihalomethanes, which are regulated substances.

There is no regulatory requirement to implement a specific policy regarding monitoring or sampling and analytical methods for non-EPA regulated contaminants that are located near water intakes and that could potentially enter the water distribution system. Neither AW nor WVAW has a specific policy addressing monitoring or sampling and analytical methods for unregulated chemicals. After the Freedom incident, in

[239] Comprehensive planning studies are used to assess the availability and reliability of the water supply. It allows WVAW to study, evaluate and adjust risk relative to water quality, quantity and service continuity. It also helps to plan for source water protection, drought management and emergency response.

[240] WVAW's daily monitoring and testing practices are discussed in further detail in Section 2.3.1.

[241] American Water Asset Planning. West Virginia American Water Kanawha Valley System Comprehensive Planning Study. West Virginia American Water: West Virginia. May 2011.

[242] West Virginia American Water. Document Request WVAWD01. West Virginia American Water: West Virginia. February 28, 2014.

[243] SDWA requires EPA to evaluate contaminants that present the greatest health concern and to regulate those contaminants that occur at concentration levels and frequencies of public health concern.

2015 AW implemented a "Source Water Quality Awareness Practice," in an effort to maximize awareness of source water contamination issues. The practice provides general guidance to all AW utilities; however, the Source Water Assessment Program[244] requirements in West Virginia established after the spill are much more rigorous and detailed than AW's practice.

4.6.3.1 WVAW's Hazardous Materials Removal Methods

In 1989, WVAW and KVTP developed a report titled "Emergency Contingency Plan," which examines deficiencies with respect to potential emergency events at the plant. The report identifies existing hazards, the resulting consequences of those hazards and some possible solutions. The report states that the maximum permissible length of plant shutdown should not exceed 12 hours because the total storage capacity at that time was less than one day's supply. An average consumption per hour was 1.33 million gallons, and it would require eight hours to regain the loss.[245] As part of the Emergency Contingency Plan, the recommended removal methods for the treatment of hazardous material spills within the water system were addressed. These removal methods include:

- Accelerated biodegradation
- Activated carbon
- Aeration
- Booms and skimmers
- Burning
- Ionic clays
- Ion exchange
- Neutralization—precipitation
- Oleophilic materials
- Peat moss
- Vacuum pumping

The plan includes a list of hazardous substances and the two phases of removal methods appropriate for each substance. The hazardous substances were identified with assistance by EPA and based on the degree of hazard to the water supply, the amount and concentration of a material, its properties and its effect on the waters to which it was introduced. When two phases of removal methods are available for a substance, phase I techniques must be applied prior to initiating phase II. Phase I removal methods are used if spilled material is not diluted (or still concentrated) or if the water supply contains both dissolved and undissolved spilled material. Phase II removal methods are used if spilled material has been diluted and is dissolved in the water supply. Of the six different chemical compounds listed on the Crude MCHM SDS (Table 3), methanol is the only hazardous substance listed in the plan. At the time the plan was developed, the site stored petroleum-based products, not Crude MCHM or PPH, stripped, which are not listed in the plan and are not regulated chemicals, nor are they identified as materials that would generally

[244] The Source Water Assessment Program is discussed in further detail in Section 5.4.1.
[245] West Virginia-American Water Company Kanawha Valley District. Emergency Contingency Plan. July 7, 1989, p. 16.

be hazardous to a water supply.[246] WVAW's removal method for methanol involved phase I removal by aeration.[247]

In response to the Freedom release, WVAW decided not to close the water intake, which would have allowed the mixture containing Crude MCHM and PPH, stripped to bypass the intake. WVAW did not have accurate information regarding the extent of the spill or the length of the plume and was concerned that shutting the intake for more than a short time would lead to system depressurization that would prevent WVAW from delivering any water to customers for an extended period of time. It believed that its water treatment process could effectively handle the chemical, so it ultimately relied on its treatment process, including PAC and GAC to remove the chemicals. However, this removal method was not sufficient in eliminating the Crude MCHM or PPH, stripped, partly due to the volume of chemicals spills. Treatment methods can be critical tools in removing contaminants from the water; however, prevention is a superior approach where feasible, especially when addressing contaminants that cannot easily be removed from the water once they have been introduced.

4.6.4 AW and WVAW Emergency Preparedness and Response

According to guidance from the American Water Works Association (AWWA), a water utility's objectives in the initial response to a confirmed contamination event should be the "protection of its customers from exposure to the contaminated water, protection of the water utility infrastructure and health and environmental protection during disposal of contaminated water."[248] The actions WVAW took in response to the Freedom incident are discussed in detail in Section 2.1.2 of this report. However, it is also important to understand the corporate- and facility-level plans, policies and procedures WVAW should have followed when responding to and managing not only the Freedom incident, but all contamination incidents or events. This section will not only discuss the emergency preparedness and response plans AW and WVAW had in place at the time of the incident, but also identify the organizational and operational improvements WVAW made in response to the incident.

4.6.4.1 WVAW Incident and Event Management Practice

On the day of the Freedom incident, WVAW implemented its Incident and Event Management Practice. This section outlines the AW policy from which WVAW's practice was developed, describes WVAW's practice in further detail and identifies an element of AW's policy that WVAW did not implement. AW's policy on incident and event management covers events of all sizes and types of risk. All AW business units and functions should prepare specific and adequate incident and event management procedures that are consistent with their policies and include the following:

1. Safety management (e.g., people, environment, product, property).

[246] West Virginia-American Water Company Kanawha Valley District. Emergency Contingency Plan. July 7. 1989, pp. 22, 22a-22l.

[247] By artificially maintaining the required dissolved-oxygen level through mechanical aeration or other oxygen-replacement techniques, the lethal effects from the discharge of such substances can be eliminated. An alternative method to aeration for methanol removal is to burn the material; however, this method is to be used only after consultation with local authority, the federally appointed on-scene coordinator or approval by EPA.

[248] Water Research Foundations (formerly AWWA Research Foundation). Guidance for Decontamination of Water System Infrastructure. Water Research Foundations: Colorado. 2007.

2. Business continuity (e.g., repair of damaged assets, restoration of services).
3. Interactions with clients, regulators and other key stakeholders.
4. Incident assessment and reporting arrangements that comply with established reporting thresholds and processes.
5. Incorporation of the National Incident Management System (NIMS) and the Incident Command System (ICS).

WVAW adopted an Event Management Practice (EMP) that is consistent with AW's plans and adheres to the four levels of AW's incident scale,[249] principal event support team names and responsibilities/roles and criteria for events that must be reported to internal and external organizations. AW's event scale is based on operational issues, such as safety, service or technical situations, environmental issues, and reputation and relationships. The level at which the event is managed is retained at the local operation or lowest level possible unless (1) a determination is made that indicates that level of management cannot adequately manage the event, or (2) the event has escalated. The practice involves seven major actions, which have been organized into "action cards" for ease of use during the decision-making process of an event:

1. Event recognition.
2. Event risk assessment.
3. Event analysis process.
4. Development and implementation of an incident action plan.
5. Communications.
6. Event reporting to corporate.
7. Event closedown.
8. AW event scale for assessing event risk at the corporate, state or functional level.

AW provides standard ICS and AW Incident Management forms[250] to assist in documenting and managing resources and operations of the incident or event; however, WVAW did not use these forms to document after-incident and event closedown actions; rather, it relied on e-mail to capture the decision-making processes post-incident. AW policy indicates that information within these forms should be augmented at the earliest opportunity to address the risks that, because of their nature, require more detailed measures and emergency plans.[251] The EMP is reevaluated at least annually by the utility's local operational risk management department and an annual drill is conducted unless the utility experienced a certain-level event within the year. This department also ensures that employees who may be involved in an incident are trained on the EMP, NIMS and ICS. On the day of the incident, not only did WVAW

[249] AW's incident scale provides a standard tool for the measurement of event risk and is used to indicate the severity, speed and scale of emergency response appropriate to the situation and the management effort required to resolve the situation. Level 1 is an alert and an opportunity to prepare for any deterioration, whereas Level 4 is a particularly severe event with significant implications for the business.

[250] In addition, AW developed a "Business Continuity Planning Template," which includes event preparation checklists and templates for a contingency plan for regional business units; however, these checklists and templates were not specifically designed to address water contamination due to hazardous materials spill events, although elements of the checklists and templates can apply to this type of event.

[251] American Water. Incident and Event Management Practice. American Water: New Jersey. 2011.

implement its Incident and Event Management Practice, but it also employed provisions of its *Emergency Preparedness Manual* and Consequence Management Plan.[252]

4.6.4.2 WVAW *Emergency Preparedness Manual*

WVAW's *Emergency Preparedness Manual* (EPM) is a guide for establishing appropriate actions to maintain service while involved in an emergency situation.[253] The American Water Works System's 1979 *Emergency Procedures Handbook*, which was the impetus for WVAW's future emergency planning and preparedness manuals and plans, states, "A comprehensive emergency response plan, updated annually, is a requirement for any well managed company." The handbook also indicated that the appropriate responsive action for a distribution contamination event should be: "Once it has been determined that actual contamination exists, immediately notify customers, in the affected area, disconnect services and remove meters there, isolate the area, and flush that part of the system."

Prior to the January 2014 spill, the EPM was last updated in August 2012 and includes six policies. The final policy in the EPM is WVAW's Security Plan (Terrorism) Policy, which contains procedures on how to accomplish tasks in accordance with established policies. The Security Plan was developed as newly recognized threats to the water system emerged. Within the Security Plan, WVAW maintains a crisis management program that emphasizes prevention and effective emergency preparedness, response and recovery. The program consists of planning, training and exercising, as well as coordination with the local jurisdictions with whom it contracts to provide water supplies and federal, state and local regulators.[254] The policy states: "Within WVAW, responsibility for emergency response, management support, and crisis management is assigned to organizational units, based on either their vulnerability to hazards or their identified role to support response, or both. Accountability for the delivery of safe water to our customers begins with the senior executives of the company and extends downward through staff and managers of districts, individual facility supervisors, and individual associates." WVAW developed procedures within this policy that identify general steps to take if contamination of a source or distribution system occurs. Even though these procedures were designed to be specific to intentional acts or events, they could also be applicable to an unintentional or accidental hazardous materials contamination event. The general process for addressing any event involves determining whether the source or system threatened is indeed part of WVAW. If it is, then appropriate sampling protocols are initiated in conjunction with appropriate local, state and federal environmental and law enforcement agencies. Also, if contaminants are present, public notifications are made.

---

[252] AW developed a Consequence Management Plan (CMP) as a response component to its overarching Emergency Response Plan. The CMP aids in minimizing the impacts of not just intentional, but also accidental, water quality degradation as a streamlined plan that is intuitive to all critical water utility personnel. Consequence management actions are initiated upon identification of a possible contamination incident to (1) establish the credibility of the possible contamination incident, (2) minimize public health and economic consequences, and (3) guide the remediation and recovery effort. The plan itself guides a utility through actions that should be taken following detection of a possible water contamination incident.

[253] West Virginia American Water Company. Policies 1:3 Authority of Emergency Procedures. West Virginia American Water Company: West Virginia. August 2012.

[254] West Virginia American Water Company. Policies 1:6 Security Plan (Terrorism). West Virginia American Water Company: West Virginia. August 2012.

In addition, separate from the Security Plan Policy, but contained within the EPM, WVAW developed a procedure to address situations where contamination of the distribution system occurs.[255] This procedure identifies possible indicators of potential system contamination. One of the identified indicators is irregular taste, odor or color as reported by a customer (as was the case during the Freedom release) or as detected during routine sample collection. After Freedom's release of chemicals into the Elk River, odors were detected during sample collection and at the tap by customers. The procedure provides steps that should be taken if contamination is suspected; however, the procedures do not provide detailed actions that should be taken by WVAW employees. Instead, they provide a general approach. The EPM contains another procedure on how to address situations where contamination of the raw water supply occurs.[256] This procedure identifies steps that should be taken once a contaminant is detected.[257] Distribution system contamination[258] is a more serious public health problem than source water contamination[259] because the contaminant may quickly reach the customer's tap, as was the case after the Freedom release. Finally, the manual provides a comprehensive list of resources and entities, including local, state and federal agencies that are available to the company during an emergency event.[260]

4.6.4.3 AW's Environmental Policy and Practices

AW's Environmental Policy outlines the company's commitments to compliance with all relevant environmental laws, regulations and standards. Through this policy, AW has established related practices that provide more specific guidance to utilities. AW developed a practice titled, "Environmental Audit Process Practice" that ensures a utility's compliance with applicable regulations and that tracks its environmental stewardship efforts, by linking its Environmental Management Plan system with an internal audit program. According to AW's 2013-2014 *Corporate Responsibility Report*, the audit program reviews plans, procedures and physical facilities in an effort to identify potential vulnerabilities. The report indicates nearly all of AW's facilities have been internally audited at least once during the past five years, and AW has developed a custom-designed audit tool that includes a risk-based list of questions. Based on the audit's findings recommendations are developed, which address issues related to environmental regulation compliance, AW requirements or industry standards. Regulated utilities also submit monthly reports to department-level managers at the utility, which are expected to identify any significant incidents or noncompliance events. Information from these monthly reports is also discussed in regularly scheduled conference calls and meetings. These mechanisms allow for information exchange regarding a utility's performance relative to regulatory requirements and AW policies and practices.

---

[255] West Virginia American Water. Emergency Preparedness Manual Procedure 2:10. West Virginia American Water Company: West Virginia. August 2012.

[256] West Virginia American Water. Emergency Preparedness Manual Procedure 2:11. West Virginia American Water Company: West Virginia. August 2012.

[257] West Virginia American Water. Company Procedure List. West Virginia American Water Company: West Virginia. August 2012.

[258] Distribution system contamination is where the contaminant has already reached the water treatment plant's system of pipes that distribute water to the public.

[259] Source water contamination is where the contaminant enters a surface water or groundwater prior to entering the water distribution system.

[260] West Virginia American Water Company. Emergency Preparedness Manual. West Virginia American Water Company: West Virginia. September 2004.

AW's "Environmental Non-Compliance Reporting Practice" provides direction to utilities on the process for recording environmental instances of noncompliance. The practice applies to all environmental instances of noncompliance under the SDWA and the Clean Water Act (CWA). The practice also states that all employees are responsible for reporting environmental incidents of non-compliance including, but not limited to "failure to perform required sampling, notification of non-compliance from a regulatory agency, not meeting standards established by American Water, or an event that could have a substantial impact on public health or the environment." AW tracks all enforcement authority notices of violations (NOVs) a utility may receive.[261] On the day of the incident, WVAW reported the contamination event to AW because it was a catastrophic event, and no NOV was issued to WVAW by WVBPH. In addition, AW uses these NOVs to track and monitor instances of non-compliance across all environmental regulations and considers this process important in determining areas that need corporate attention and calculating drinking water compliance rates.[262]

4.7.4.4 AW and WVAW Post-Incident Improvements

After the Freedom incident AW determined that improvements needed to be made in the areas of source water protection planning, exploration of alternative water sources and enhancement of the emergency customer notification system. Following the January 2014 spill and the associated legislative changes, WVAW installed analytical equipment and built a new $400,000 laboratory at KVTP equipped with two GC-MSs capable of testing the drinking water for volatile organic compounds and semivolatile organic compounds. It also conducted a study of early detection technology and has installed some source water monitoring equipment as a baseline level system.[263] WVAW also installed source water monitoring technologies[264] at treatment facilities at a cost of approximately $30,000 per facility. These devices are not intended to identify specific contaminants; rather, they alert water systems of a potential change in water quality, indicating a potential for further testing. This addition exceeds the monitoring requirements established by new state legislation.

In 2014, AW conducted a critical asset study that involved the use of EPA's Water Health Economic Assessment Tool (WHEAT) to analyze the likelihood and consequences of the failure of water systems. WHEAT was designed to assist utility owners and operators in quantifying an adverse event's public health consequences (i.e., injuries and fatalities), utility-level financial consequences, direct and indirect regional economic consequences and downstream impacts.[265] Through this study, AW identified more than 50 critical water and wastewater system assets and, where applicable, recommendations for additional inspections, emergency response planning measures or capital improvements were made. In 2015, AW introduced a new customer emergency communication system, called CodeRED, which uses outbound calls to alert customers about incidents that could impact their water quality and water usage.

---

[261] American Water. Environmental Non-Compliance Reporting Practice. American Water: New Jersey. 2010.
[262] *Ibid*.
[263] West Virginia American Water. 2014 Annual Water Quality Report. Elk River Regional System. PWS ID WV3302116 2015. http://www.amwater.com/ccr/kanawhavalley.pdf (November 2015).
[264] WVAW's source water monitoring technologies include continuous raw water quality monitoring with online, multiparameter devices.
[265] EPA. Water Health and Economic Analysis Tool Version 3.0. EPA: Washington, DC. May 2014. https://www.epa.gov/sites/production/files/2015-04/documents/epa817f14003.pdf (May 25, 2016).

AW also plans to develop outage maps that provide new direct notification to employees in the case of an emergency.[266] In January 2016, WVAW updated the emergency contact information in KVTP's *Emergency Preparedness Manual* and developed contingency and communications plans for the Kanawha Valley system as part of its source water protection planning process,[267] which includes notification to the public within 30 minutes of becoming aware that a contamination event poses a potential risk to public health and safety.

This section provided an overview of the applicable AW and WVAW plans, policies, procedures and practices that existed or were implemented on the day of the incident. CSB's review of WVAW's emergency response highlights many important lessons that other water utilities may be able to learn from.

4.7 American Water Works Association

Established in 1881, AWWA is the largest nonprofit, scientific and educational association dedicated to managing and treating water. AWWA has approximately 50,000 members, including American Water and West Virginia American Water, and one of its main goals is to support water utilities in evaluating and improving their water quality, operations, maintenance and infrastructure. AWWA offers education to water professionals by providing access to standards, water supply best practice manuals, training, networking, conferences and regulatory advisories.[268] CSB found that AWWA is well positioned to assist water utilities by disseminating important lessons that are learned from chemical contamination incidents that could potentially affect a drinking water distribution system.

In addition, several different programs and types of publications are used to support AWWA's mission. One key program is the AWWA standards process, which has existed for more than 100 years to produce peer-reviewed[269] voluntary consensus standards for processes used by the water utility industry and intended to improve a utility's overall operations and service. AWWA standards, which are American National Standards Institute (ANSI) approved, are recognized worldwide and have been adopted by many utilities and organizations. Through this program, AWWA publishes over 170 ANSI/AWWA standards that provide information on a variety of issues such as design, installation, disinfection, treatment and manufacturing of products including pipes, chemicals, storage tanks, valves, meters and other appurtenances; industry-recognized consensus prerequisites; and practices for water utility management and operations.[270]

---

[266] American Water. Corporate Responsibility Report 2013-2014. American Water: New Jersey. 2015.
[267] The source water protection planning process is discussed in further detail in Section 5.4.1.
[268] http://www.awwa.org/about-us.aspx.
[269] These standards are developed by following procedures defined by committees under the AWWA Standards Council and accredited by the American National Standards Institute.
[270] http://www.awwa.org/resources-tools/resource-development-groups/standards-program/standards-development-process.aspx (August 2, 2016).

Two AWWA standards could be helpful to water utilities in the areas of source water protection and emergency preparedness. First, AWWA's Source Water Protection Standard[271] provides support and guidance for a drinking water utility to protect its drinking water supply sources through planning, developing and implementing a successful source water protection program. Second, AWWA's Emergency Preparedness Practices[272] is a voluntary management standard that is used to define the minimum emergency preparedness requirements for water utilities to respond to emergencies and restore normal operations, minimizing the disruption of critical services while sustaining public health, protecting property and maintaining consumer confidence.

[271] American National Standards Institute/American Water Works Association. G300-14: Source Water Protection. 2010.

[272] American National Standards Institute/American Water Works Association. G440-11: Emergency Preparedness Practices. 2011.

5.0 REGULATORY ANALYSIS

5.1 Regulatory Summary of Crude MCHM and PPH, stripped

Both Crude MCHM and PPH, stripped are hazardous chemicals according to OSHA's Hazard Communication Standard (HCS). These mixtures are hazardous chemicals because of the physical and health hazards they pose. As a result, any distributor storing these chemicals must have available an SDS and provide it to downstream users.

Any distributor or manufacturer of hazardous chemicals is also regulated under the Emergency Planning and Community Right-to-Know Act (EPCRA). Any distributor storing more than 10,000 pounds of either MCHM or PPH, stripped must submit a Tier II form alerting its Local Emergency Planning Committee (LEPC) of the amount stored. Table 9 outlines the applicability of relevant statutes and regulations covering chemicals. The terms "hazardous chemical" and "hazardous substance" have very different meanings under various laws, and although MCHM is a hazardous chemical,[273] it is not listed as a hazardous substance.[274]

Table 9. Applicability of Various Federal Regulations to MCHM Stored at Freedom

Agency	Regulation or Statute	Yes	No
OSHA	HCS – 1910.1200 – "Hazardous chemical"	✓	
EPA	EPCRA § 311 and § 312 – "Hazardous chemical"	✓	
EPA	Clean Water Act § 311 – "Hazardous Substance"		✓
EPA	EPCRA § 302 – "Extremely hazardous substance"		✓
EPA	EPCRA § 313 – "Toxic chemical"		✓
EPA	Comprehensive Environmental Response, Compensation, and Liability Act – "Hazardous substance"		✓
EPA	Resource Conservation and Recovery Act – "Hazardous waste"		✓
EPA	Clean Air Act 112(r) – Regulated Chemicals for Accidental Release Prevention		✓

[273] The term "hazardous chemical" in this report shall mean any chemical that poses physical or health hazards as defined by OSHA under the HCS. See Section 5.7.1.

[274] Section 311 of the Clean Water Act required EPA to establish regulations designating hazardous substances and determining those quantities of any oil and hazardous substances, the discharge of which may be harmful to the public health or welfare or the environment of the United States, including but not limited to fish, shellfish, wildlife, and public and private property, shorelines and beaches. 33 U.S.C. § 1321(b). Table 117.3 in 40 C.F.R. 117.3, which is titled "Reportable Quantities of Hazardous Substances," lists substances that were designated hazardous under Section 311(b)(4) of the CWA. Currently, approximately 300 chemicals are listed. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) defines a hazardous substance as any substance designated a hazardous substance under the CWA as well as certain substances having certain characteristics under other environmental statutes or included on other EPA lists. Approximately 2,000 elements, compounds, mixtures, solutions and substances are considered CERCLA hazardous substances, which, when released into the environment, may present substantial danger to the public health or welfare or the environment. 42 U.S.C. § 9601-9602.

5.2 Regulation of Aboveground Storage Tanks

ASTs are subject to both federal and state/local regulations. One of those federal regulations is the Spill Prevention, Control and Countermeasure rule, which was promulgated under the authority of the CWA. Although the SPCC rule regulates some aspects of ASTs,[275] its applicability is limited to oil.[276] Because Freedom stored fatty acid, an oil, in an AST onsite, it was required to adhere to SPCC requirements. While not a direct cause, CSB found that compliance with certain SPCC requirements, such as secondary containment, may have helped prevent the incident because of the proximity of Freedom's fatty acid AST to the AST that leaked.[277]

Other federal regulations are similar in that they apply only to particular storage tanks or containers that contain certain chemicals or classes of chemicals. Another example is OSHA's flammable liquids standard. Like SPCC, this regulation applies only to tanks or vessels containing certain liquids, in this case flammable liquids. For a full discussion of OSHA's flammable liquids standard, see Section 5.7.2. Because no uniform federal program regulates all ASTs, owners must navigate a web of miscellaneous statutes and regulations that directly or indirectly govern tanks, and states are left to fill those gaps with regulations.

At the time of the 2014 spill, ASTs in West Virginia were inadequately regulated. The West Virginia legislature had established a comprehensive statutory framework in 1984 regulating underground storage tanks, but it did not address ASTs. Additionally, some tanks, like those found at Freedom that were regulated under some other applicable federal or state permits, also escaped strict oversight from the West Virginia government due to a lack of inspections as a result of constrained resources.[278] A Groundwater Protection Plan (GPP) and Stormwater Pollution Prevention Plan (SWPPP) were both required to be completed by Freedom and held onsite for Freedom's NPDES renewal; however, West Virginia did not require that these plans be submitted or verified by WVDEP prior to the renewal of an NPDES permit.

---

[275] SPCC applies to ASTs holding oil in aggregate amounts greater than 1,320 gallons.

[276] Oil means oil of any kind or in any form, including, but not limited to: fats, oils, or greases of animal, fish, or marine mammal origin; vegetable oils, including oils from seeds, nuts, fruits, or kernels; and, other oils and greases, including petroleum, fuel oil, sludge, synthetic oils, mineral oils, oil refuse, or oil mixed with wastes other than dredged spoil. 40 C.F.R. § 112.2 (2016).

[277] The Freedom facility was found to have fatty acid in bulk storage above the SPCC threshold, based on sampling by EPA after the incident. Thus, Freedom Industries should have prepared an SPCC plan, had it certified by a Professional Engineer and implemented appropriate secondary containment for oil containing tanks. Given the proximity of the fatty acid tank to the Crude MCHM and PPH tanks it is a possibility that tank 396 would have been located within the bounds of this secondary containment. SPCC plans are not required to be submitted to EPA. Further discussion of SPCC follows in Appendix E.

[278] West Virginia contains more permitted Industrial Stormwater facilities than WVDEP's inspection resources can meet. Therefore, WVDEP has committed to inspecting 10% of these facilities annually in exchange for an EPA grant. Although the list of facilities to be inspected is refreshed every year, there is some overlap of facilities year to year. Freedom Industries was never included on the list of facilities to be inspected when WVDEP began receiving this grant in 2007. Due to the limited resources available, WVDEP's compliance strategy focuses on major facilities that discharge more than 1 million gallons per day. There is an ongoing effort at WVDEP to incorporate the Zone of Critical Concern into the NPDES monitoring strategy, which may allow seemingly innocuous facilities to be included in the list of facilities to be inspected, given their proximate location to water intakes.

Further, the Groundwater Protection Rule (GPR) required secondary containment for all Freedom tanks; however, Freedom was never inspected for compliance with this rule, largely because prior to the AST Act, which now regulates ASTs in West Virginia, Freedom was not regulated under a WVDEP program that would have resulted in regular inspections or site visits.[279]

Some of the notable deficiencies identified in West Virginia's regulatory regime at the time of the incident include the lack of regulation when constructing ASTs, as well as the lack of required inspections for existing tanks and secondary containment. The following provides an overview of the applicable statutes and regulations relevant to the Freedom investigation and an overview of West Virginia's new AST regulatory regime, which addresses many of the deficiencies identified by CSB.

5.2.1 Groundwater Protection Rule

As mentioned in the previous section, West Virginia has state groundwater protection regulations imposing certain requirements on industrial sites to protect the groundwater. Freedom was subject to the West Virginia GPR;[280] however, this rule generally applies to industrial sites and was not designed to specifically regulate ASTs. Without consistent inspections for compliance and proper enforcement, the Freedom incident was able to occur despite the requirement for adequate secondary containment. As a result of the AST Act, WVDEP is now required to conduct regular inspections of regulated tanks. In the process of ensuring all requirements of the AST Act are being met, WVDEP will also be afforded more opportunities to check for compliance with the GPR. Before the AST Act was enacted, GPR requirements were mainly enforced during required inspections under other more specific statutes. Because ASTs in West Virginia were not directly regulated, facilities such as Freedom that did not fall under a more specific regulatory regime were required to comply with the requirements of the GPR, but WVDEP did not routinely inspect those facilities for compliance.

The GPR required Freedom to have a GPP[281] and secondary containment "that is appropriate" considering the potential to contaminate groundwater.[282] Like the federal SPCC program, the GPR attacks the problem from a containment standpoint and imposes stricter standards on those facilities more susceptible to groundwater pollution. Like the federal SPCC rule for oil tanks, the major provisions of the GPP require containment areas in order to control and hold any leaked chemicals from ASTs at industrial sites. Freedom was required to have adequate pollution prevention controls including secondary containment, which could have potentially prevented the spill into the Elk River. The GPP was not enforced, however,

[279] W. VA. CODE R. § 47-58 (1994). As a result of the AST Act, WVDEP is now aware of the universe of tanks located in West Virginia and is required to conduct tank inspections every three years for Regulated Level 1 tanks. During these inspections, WVDEP can ensure compliance with the AST Act as well as with groundwater protection regulations.

[280] W. VA. CODE R. § 47-58 (1994).

[281] W. VA. CODE R. § 47-58-4.11 (1994).

[282] W. VA. CODE R. § 47-58-4.8a (1994). "Above-ground storage tanks shall have secondary containment that is appropriate considering the potential to contaminate groundwater. Such secondary containment shall be adequately designed and constructed to contain the materials for a time sufficient to allow removal and disposal without additional contamination of groundwater, but in no case will that time be less than seventy-two (72) hours."

and the lack of WVDEP inspections allowed Freedom to continue to operate with deteriorated and inadequate secondary containment.

5.2.2 West Virginia's Aboveground Storage Tank Act

In the aftermath of the Freedom incident, the West Virginia legislature recognized that the contents of ASTs, some potentially hazardous, may not be stored in a safe manner to protect people and the environment.[283] As a result, the legislature unanimously passed a comprehensive AST bill, SB 373, which imposed strict requirements on all tanks and vessels in West Virginia that met a broad definition. However, soon after, the legislature passed SB 423, which removed some of the unintended consequences of 373.[284]

SB 423 was passed on March 14, 2015, became effective June 14, 2015, and is known as The 2015 Aboveground Storage Tank Act (AST Act). It created three categories of ASTs partially based on their location and placement near public water supplies. Although the requirements of the bill that passed are less strict than originally drafted, the AST Act addresses many of the issues that led to the failure of the tanks at Freedom.

The AST Act divides tanks[285] into three main categories. Once a tank meets the definition of AST, the tank is subject to a certain level of regulation based on its size, what it is storing and/or its location. Various requirements are imposed based on whether the tank falls in one of those categories. These categories include requirements that apply to all ASTs, specific requirements that apply to regulated Level 1 tanks and specific requirements that apply to regulated Level 2 tanks.

Although the statute imposes some requirements on tanks in the state, it also directs WVDEP to develop a comprehensive regulatory program. On July 31, 2015, after completing a public comment period and a public hearing, WVDEP filed an agency-approved rule, as required under the AST Act, with the Legislative Rule-Making Review Committee (LRMRC). LRMRC made changes to the rule, then WVDEP modified the rule based on those changes and filed the modified rule on November 23, 2015, with the West Virginia Secretary of State. However, before a rule becomes effective in West Virginia, it is packaged into a bill and must be passed by both houses of the legislature and then signed by the Governor. The West Virginia legislature failed to act on the bill that included the AST rule before the 2016 session ended, so the rule was not approved. The Aboveground Storage Tanks Rule (Rule) was reintroduced during a special legislative session in June and was passed by the legislature and signed by the Governor. The Rule is effective as of August 1, 2016. What follows is a discussion of the relevant sections of the AST Act and Rule and the role they could have played in preventing the Freedom incident.

---

[283] W. VA. CODE § 22-30-2 (2015).

[284] For example, farmers' water troughs being regulated.

[285] As amended by SB 423, W. VA. CODE § 22-30-3 provides that an AST is partially defined as a device that contains 1,320 gallons of fluid, of which 90% is above the surface of the ground. This term includes both stationary and mobile devices that remain in one location for at least 365 days. The definition excludes 12 categories of vessels that are not subject to the provisions of the article despite potentially fitting the above description, including swimming pools, process vessels and devices containing drinking water.

5.2.2.1 All ASTs

All ASTs[286] in West Virginia are now subject to certain requirements including registration and signage requirements. Owners must submit a registration form that, at a minimum, shall identify the following:

- Ownership of the tank
- Tank location
- Date of installation, if known
- Type of construction
- Capacity and age of tank
- Type of fluid stored therein[287]

Owners must also identify any other permits or licenses the tank is subject to and provide the numbers of those permits or licenses.[288] As of August 30, 2016, 39,605 tanks (Figure 35) in West Virginia are registered with WVDEP. WVDEP has created a registration form that requires not only the information listed above but also information on corrosion protection and secondary containment.[289] The information gathered through registration will be available to the public subject to the limitations contained in Section 14 of the AST Act and West Virginia's Freedom of Information Act.[290] This information will be especially useful in the event of a release to the waters of the state, which could affect a public water supply. Upon such a release, information shall be promptly made available to any emergency responders attending to the site of a spill or release and the general public shall be promptly notified.[291] Additionally, when new owners acquire a tank, they must register it within 30 days after acquisition.[292]

[286] This includes ASTs as defined in the AST Act and not specifically exempted under the AST Act or AST Rule.
[287] W. VA. CODE § 22-30-4 (2015).
[288] W. VA. CODE § 20-30-4 (2015).
[289] Aboveground Storage Tank Registration Form. WVDEP. https://apps.dep.wv.gov/ast/Sampleastform.pdf (August 2, 2016).
[290] W. VA. CODE § 22-30-14 (2015).
[291] *Ibid.*
[292] W. VA. CODE R.§ 47-63-3.1.c.2 (2016).

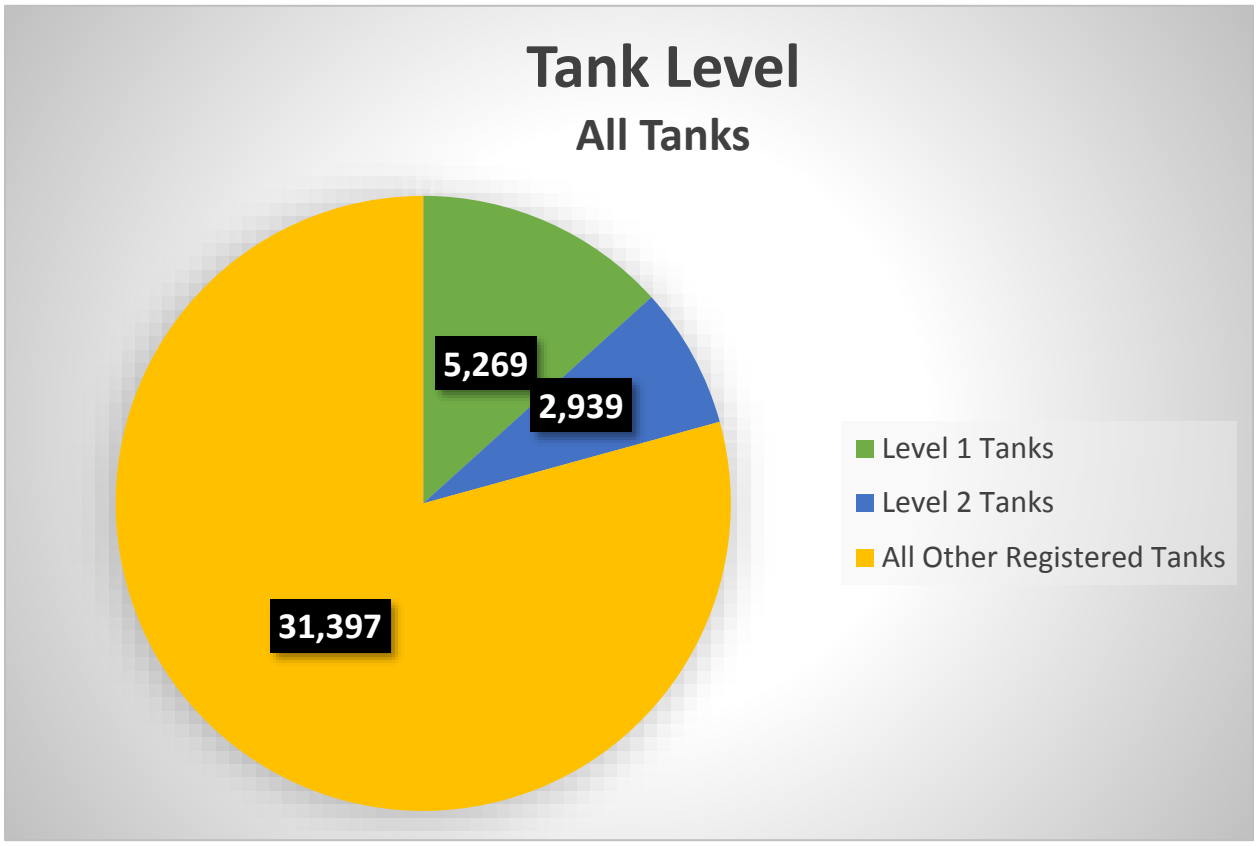


Figure 35. Breakdown of all registered ASTs in West Virginia by tank level as of August 2016. (Source: WVDEP)

All tanks in West Virginia are also required to display, either near the tank or on the tank itself, its registration number, the emergency contact number for the owner and the number for WVDEP's Spill Reporting Hotline.[293]

WVDEP is also empowered to require the owner of any AST to undertake prompt corrective action in certain instances. These actions must be necessary to protect human health, water resources and the environment from contamination.[294] WVDEP may also conduct inspections, require tank owners to furnish information and enter the tank owner's property for the purposes of developing or assisting in the development of any rule.[295]

Additionally, the location, characteristics and approximate quantities of any potential sources of significant contamination within the zone of critical concern (ZCC) or the zone of peripheral concern (ZPC) shall be made known to one or more designees of the public water utility.[296] This information will

[293] W. VA. CODE § 22-30-11 (2015).
[294] W. VA. CODE § 22-30-8 (2015). Once rules are promulgated, the Secretary must follow those rules unless certain extenuating circumstances exist.
[295] W. VA. CODE § 22-30-15 (2015).
[296] W. VA. CODE § 22-30-14 (2015).

allow water utilities to plan and make more informed decisions regarding when to close an intake in the event of a spill.

5.2.2.2 Level 1 and 2 Regulated Tanks[297]

The AST Act defined regulated ASTs and required WVDEP to develop a regulatory program for new and existing aboveground storage tanks.[298] Unless approved by WVDEP owners or operators of regulated tanks are subject to all of the requirements of the regulation.[299] Regulated tanks are broken down into two different levels and are subject to requirements in addition to the registration and labeling requirements described above. Level 1 tanks are regulated to a higher standard than Level 2 tanks given their location, capacity and the chemicals stored. Given the location of Freedom's tanks within a newly defined ZCC, the tanks would have been subject to the more stringent requirements for Level 1 tanks.

Of the 39,605 registered tanks in West Virginia, 5,269 of those are considered Level 1 tanks (Figure 35). Level 1 tanks consist of ASTs located within a ZCC, a source water protection area[300] or public surface water influenced groundwater supply source area,[301] or any other AST designated by WVDEP.[302] Level 1 tanks also include any tanks containing a CERCLA hazardous substance or a substance on the List of Lists in a concentration of 1% or greater,[303] excluding tanks containing petroleum.[304] Finally, any tank

[297] Many of the requirements apply to both Level 1 and Level 2 tanks. When a requirement is specific only to a certain level of regulated tanks, it will be explicitly stated as such.

[298] These regulations are outlined in the AST Rule which can be found at W. VA. CODE R. § 47-63 (2016).

[299] Entities regulated under certain site-specific permits or plans that require appropriate containment and diversionary structures to prevent discharged released material from reaching waters of the state may submit a request to have those permits amended to include conditions sufficient to protect the waters of the state. This would include NPDES permits, SPCC plans and GPPs. These amended plans would have to be approved by WVDEP and must include a statement indicating which industry standards (including but not limited to API 653, "Tank Inspection, Repair, Alteration, and Reconstruction") will be followed. If WVDEP approves the amended plan owners will be required to comply with all industry standards identified as applicable. Further, so long as the entity is compliant with the registration requirements of Section 4 of the AST Act, they will be deemed to be compliant with the rest of the AST Act and entitled to a certificate to operate. These entities will also be required to complete inspections and formal tank certifications. Until the permits or plans are amended and finalized, all requirements of the AST Act and its Rules are applicable. W. VA. CODE § 22-30-5(c) (2015); W. VA. CODE R. § 47-63-4.2 (2016).

[300] W. VA. CODE § 22-30-3(19) (2015). "Area within an aquifer that supplies water to a public water supply well within a five-year time-of-travel, and is determined by the mathematical calculation of the locations from which a drop of water placed at the edge of the protection area would theoretically take five years to reach the well."

[301] W. VA. CODE § 22-30-3(11) (2015). "A source of water supply for a public water system which is directly drawn from an underground well, underground river or stream, underground reservoir or underground mine, and the quantity and quality of the water in that underground supply source is heavily influenced, directly or indirectly, by the quantity and quality of surface water in the immediate area."

[302] W. VA. CODE § 22-30-3(13) (2015).

[303] The List of Lists is a list of chemicals created by EPA that includes hazardous chemicals regulated under applicable statutes. The list includes Extremely Hazardous Substances regulated under Section 302 of EPCRA, CERCLA Hazardous Substances, EPCRA Section 313 Toxic Chemicals and Clean Air Act 112(r) Regulated Chemicals for Accidental Release Prevention.

[304] W. VA. CODE § 22-30-3(13) (2015).

with a capacity of 50,000 gallons or more, regardless of its contents and location, is considered a regulated Level 1 tank.[305] Figure 36 provides a breakdown of Level 1 tanks in West Virginia.

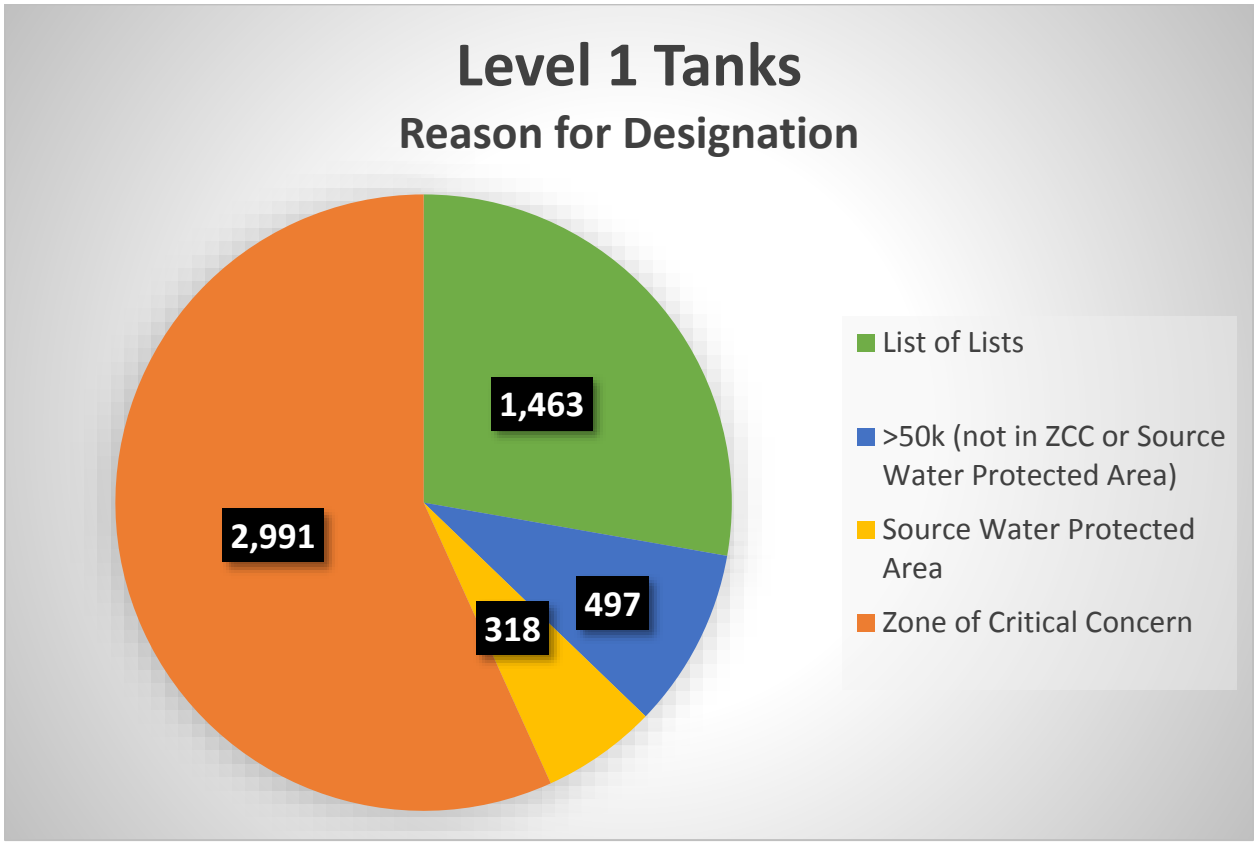


Figure 36. Level 1 tanks in West Virginia and Reason for Designation as of August 2016. (Source: WVDEP)

Included in this definition is the term "zone of critical concern," which is one of the most pertinent definitions as it relates to facilities like Freedom. The ZCC is a corridor along streams within a watershed that warrants detailed scrutiny due to its proximity to the surface water intake and the intake's susceptibility to potential contaminants within that corridor.[306] The ZCC is based on a 5-hour time-of-travel of water in the streams to the intake.[307] The width of the ZCC is 1,000 feet measured horizontally from each bank of the principal stream and 500 feet measured horizontally from each bank of the tributaries draining into the principal stream.[308] Because of the proximity of Freedom Industries to the Elk River and the WVAW intake, the facility is located within the ZCC and therefore would have been subject to the most stringent requirements under the AST Act as a regulated Level 1 tank.

Regulated Level 2 tanks consist of ASTs located within a ZPC that are not regulated Level 1 tanks. A ZPC is a corridor that extends upstream of a public water system intake and is defined by a formula

[305] *Ibid.*
[306] W. VA. CODE § 22-30-3(20) (2015).
[307] *Ibid.*
[308] *Ibid.*

devised to calculate the distance water will travel in 10 hours.[309] The width of the ZPC is 1,000 feet measured horizontally from each bank of the principal stream and 500 feet measured horizontally from each bank of the tributaries draining into the principal stream.[310] Of the 39,605 registered tanks in West Virginia, 2,939 are regulated Level 2 tanks.

Each owner or operator of a regulated AST was required to submit a Spill Prevention Response Plan (SPRP) to WVDEP by December 9, 2015.[311] The AST Act required that these plans be submitted by the deadline and be updated and resubmitted no less than every five years. These plans must, among other things, fulfill the following:

1. Describe the activity and inventory of types and amounts of fluid stored as well as reference the location of the SDSs.
2. Describe preventive maintenance programs, monitoring and inspection procedures, and employee training programs.
3. Describe general release response procedures.
4. Provide contact information for state, county and municipal emergency management agencies and the nearest downstream public water supply intake, and designate persons to be notified.

Owners and operators must also submit a revised plan or addendum under certain circumstances, such as if tank equipment has undergone substantial modifications or if tanks are removed or added. As explained earlier, Freedom did not have a comprehensive preventive maintenance program and would have been required to establish one had this regulation existed prior to the incident. These plans are subject to approval by WVDEP and, if rejected, owners and operators have 30 days to submit a revised plan. Further, failure to comply with an approved plan is considered a violation of the code.[312]

However, in lieu of developing an SPRP, the owner of a regulated AST may certify to the Secretary that the AST system is subject to a GPP or SPCC plan.[313] Although not required to be resubmitted to the AST program, these plans must be available upon request[314] and are requested prior to a WVDEP inspection to ensure that they include all associated ASTs and meet the requirements of the AST Act. If WVDEP determines that the plans do not meet the requirements, tank owners will be required to either update or develop an SPRP. WVDEP will review these plans at least once every three years for Level 1 tanks as part of the inspection process.

---

[309] W. VA. CODE § 22-30-3(21) (2015).
[310] *Ibid.*
[311] W. VA. CODE § 22-30-9 (2015); WVDEP. Spill Prevention Response Plan Guidelines for ASTs. http://www.dep.wv.gov/WWE/abovegroundstoragetanks/Pages/SpillPreventionResponsePlanRequirements.aspx (August 2, 2016).
[312] If a person is in violation of the code WVDEP may issue an order and require compliance or commence a civil action. A person who fails to comply with an order may be liable for up to $25,000 per day of noncompliance. Further, any person who intentionally violates any provision of the article, or any rule or order issued, is guilty of a misdemeanor and may be confined in a regional jail for up to one year and be fined up to $25,000. W. VA. CODE § 22-30-16 to -17 (2015).
[313] W. VA. CODE § 22-30-9(d) (2015).
[314] *Ibid.*

WVDEP has been conducting routine inspections of ASTs since the AST Act effective date and has completed 1,514 AST inspections as of August 30, 2016. Most of WVDEP's AST Inspection staff has been trained and certified as Steel Tank Institute (STI) inspectors and have also received SPCC training.[315] WVDEP plans to hire additional inspectors over the next few years to meet the goals of the AST program. WVDEP inspections include a review of all facility AST records, a review of the spill plan and an onsite inspection, as well as any action that may be deemed necessary to protect the state's waters and public health. WVDEP may also conduct non-routine inspections if something prompts it to conduct an inspection early.

In addition to WVDEP inspections, tank owners or operators must ensure each regulated tank and its associated secondary containment structure is evaluated and certified by a qualified person.[316] Qualified persons consist of professional engineers or a qualified person working under the direct supervision of a professional engineer, or an individual certified by API or STI to perform tank inspections.[317] Once this evaluation is complete, every owner and operator must submit a certification, signed by a qualifying person, documenting whether the tank and structure meet standards established in accordance with the rest of the AST Act. When this regulation became effective, WVDEP issued interpretative rule 47-62[318] outlining the requirements regulated tank owners must comply with and also providing an Interim Inspection Checklist for Initial AST Inspection.[319]

In part, this Interim Inspection Checklist required qualified persons to determine whether the AST was on a proper foundation and whether it was compatible with the materials stored, and to examine the tank system's exterior surfaces for flaws, deterioration or corrosion. In addition to the holes corroded through the floor of tank 396, signs of deterioration and corrosion were visible on the exterior of the tank that would have been noted as a deficiency in tank integrity. The poor condition of the wall would have also been easily identifiable through a visual inspection. Formal tank certifications are now required to be conducted once every three years for Level 1 tanks and every five years for Level 2 tanks. However, in the intervening years the tank owner or operator must inspect the AST and certify no changes have occurred to the system. Additionally, for Level 1 tanks, the AST Rule requires a monthly evaluation of the tank and an evaluation of the secondary containment structure every 14 days.[320] The deficient secondary containment at Freedom would have been an obvious problem during these evaluations requiring notification to WVDEP.

---

[315] The AST program is currently growing and as a result training is continuous.
[316] W. VA. CODE § 22-30-6 (2015).
[317] *Ibid.*
[318] W. VA. CODE R. § 47-62 (2014).
[319] WVDEP. Interim Inspection Checklist. http://www.dep.wv.gov/WWE/abovegroundstoragetanks/Documents/InterimInspectionChecklistforOwnerOperatorAnnualASTInspection.pdf (August 2, 2016). W. VA. CODE R. § 47-62 (2014) has been superseded by final rule W. VA. CODE R. § 47-63 (2016) effective August 1, 2016; however, owners or operators who completed an inspection under 47-62 will be in compliance with 47-63 until the next owner certified inspection is required to be completed before January 1, 2018.
[320] W. VA. CODE R. § 47-63-10.2.G.1 (2016).

As described in Section 3 of this report, Freedom did not employ, nor was it required to employ, any leak detection system for the tanks located at the site. Section 10.3 of the Rule explicitly requires the owner to ensure that regulated AST systems are monitored for leak detection at least once per calendar month, using a method or combination of methods that are capable of detecting a release from any portion of the AST. The leak detection method must be installed and operated in accordance with applicable manufacturer's specifications including routine maintenance.[321] The owner must ensure that the area beneath the tank bottom is monitored for leakage by visual, mechanical or electronic leak detection methods.[322] Visual testing is an acceptable form of leak detection for regulated ASTs so long as the entire area of concern and its secondary containment is readily accessible for view and properly illuminated by natural or artificial light.[323]

CSB found that the poor condition of the secondary containment surrounding the tanks allowed tank contents to flow directly into the Elk River. Freedom was aware of the defective nature of the secondary containment prior to the incident and had even received an estimate to repair the structure. However, it did not perform any repairs prior to the incident. The secondary containment requirements in the Rule address these issues. All regulated ASTs must have a secondary containment system that collects and contains an unintentional release from an AST and its ancillary equipment up to the first point of isolation.[324] Further, all secondary containment must be compatible with all substance(s) stored within the containment structure.[325] Owners would be required to maintain secondary containment in accordance with nationally recognized standards. Additionally, the Rule places the burden on the owner to notify WVDEP and take immediate action to remove substances from the AST systems if secondary containment for a Level 1 AST is found to be defective and the structure is not repairable within 72 hours.[326] This provision could be a valuable tool in achieving compliance.

Freedom did not have any records of previously performed internal tank inspections of tank 396 and other tanks containing mixtures of Crude MCHM and other chemicals; had inspections been conducted, evidence of corrosion would have been obvious. If Freedom had conducted internal inspections, the extent of corrosion would have been clear in tanks 395, 396 and 397. The Rule sets forth requirements for formal internal inspections on existing tanks to be performed in accordance with the requirements of STI SP001[327] and API 653.[328] These inspections would need to include, among other things, evaluation of tank-bottom integrity and shell thickness. The Rule also calls for internal inspections of new tanks with a capacity of 30,000 gallons or greater to be conducted at least once every 20 years for tanks without a Release Prevention Barrier and 30 years for tanks with a Release Prevention Barrier.[329] Additionally, all regulated tanks that have not had prior internal inspections must have one performed within 1 to 3 years,

[321] W. VA. CODE R. § 47-63-10.3.a (2016).
[322] W. VA. CODE R. § 47-63-10.3.b (2016).
[323] W. VA. CODE R. § 47- 63-10.3.c (2016).
[324] W. VA. CODE R. § 47-63-10.2.a (2016).
[325] W. VA. CODE R. § 47-63-10.2.b (2016).
[326] W. VA. CODE R. § 47-63-10.2.g.1 (2016).
[327] STI SP001, like API 653, is a nationally recognized standard for Inspection of Aboveground Storage Tanks.
[328] W. VA. CODE R. § 47-63-5.3.a (2016).
[329] W. VA. CODE R. § 47-63-5.3.b (2016).

depending on the age of the tank. If these inspections determine tanks to be not fit for service, then they must immediately be emptied and removed from service. Once a tank has been removed from service due to an internal inspection, the Rule goes on to require upgrade or permanent closure of that tank.[330]

The Freedom incident could have been prevented had proper maintenance and corrosion prevention been implemented at the facility. The Rule would require that tank owners ensure that all regulated ASTs are maintained with corrosion prevention measures that are necessary to prevent releases.[331] Acceptable methods of corrosion prevention include cathodic protection systems, external and internal coatings, internal tank liners, or certain storage practices or construction with a noncorrodible material coating. These methods are consistent with best practices, guidelines and industrial standards that, if followed, would help prevent corrosion and tank failure.[332]

CSB also found that WVAW asserted it was unaware that Freedom stored Crude MCHM and other chemicals upstream of the Elk River intake prior to the incident. The AST Act attempts to address the lack of communication between tank operators and water companies by requiring owners of regulated tanks to provide notice directly to the public water system of the type and quantity of fluid stored in the regulated tanks and the location of SDSs.[333] Owners are also required to provide notice to state, county and municipal emergency response organizations. In lieu of providing this information, owners of regulated tanks may opt to provide Tier II[334] sheets directly to the public water system.[335]

Finally, the Rule also lays out reporting and recordkeeping requirements[336] and also provides WVDEP with the authority to take corrective action.[337] The Rule provides for strict AST Design, Construction and Installation requirements for newly constructed ASTs. Notably, any new Level 1 ASTs installed after the effective date of the Rule would be required to be double walled, double bottomed or placed on a Release Prevention Barrier.[338] Additionally, newly constructed ASTs must be designed and constructed according to the most recent industry standards and owners must keep baseline data that includes, but is not limited to, shell thickness and material certifications.

The AST Act and Rule have addressed many of the gaps and deficiencies identified by CSB in the course of the Freedom investigation. With the passage of the Rule, WVDEP is now equipped with the

---

[330] W. VA. CODE R. § 47-63-5.3.g (2016).
[331] W. VA. CODE R. § 47-63-9.1 (2016).
[332] See Section 3 of this report.
[333] W. VA. CODE § 22-30-10 (2015).
[334] A Tier II form is submitted the Local Emergency Planning Committee as required by Section 312 of EPCRA. It must include (1) the chemical name or the common name indicated on the SDS, (2) an estimate (in ranges) of the maximum amount of the chemical present at any time during the preceding calendar year and the average daily amount, (3) a brief description of the chemical's manner of storage, (4) the location of the chemical at the facility, and (5) an indication of whether the owner elects to withhold location information from public disclosure. For a full analysis of EPCRA, see Section 5.5.1
[335] W. VA. CODE § 22-30-10 (2015).
[336] W. VA. CODE R. § 47-63-6 (2016).
[337] W. VA. CODE R. § 47-63-7 (2016).
[338] W. VA. CODE R. § 47-63-8.2.i (2016).

appropriate authority and tools to carry out the requirements of the statute to ensure the prevention of similar incidents in West Virginia.

5.3 Clean Water Act

Although the incident at Freedom resulted in an air release, as evidenced by multiple odor complaints, the incident necessitates a review of the CWA because tank contents were released into the Elk River. The CWA establishes the basic structure for regulating discharges of pollutants into waters of the United States and regulating quality standards for surface waters.[339] The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the nation's waters.[340] It is administered by EPA in coordination with state and tribal governments.[341] Under the CWA, EPA has implemented a number of pollution control programs, including the NPDES program. Because it is pertinent to this investigation, the NPDES program will be discussed in further detail below.

5.3.1 National Pollutant Discharge Elimination System Program

The NPDES program is the primary program associated with water pollution control in the United States. Under this program, it is unlawful for a person to discharge any pollutant from a point source into waters of the United States unless an NPDES permit is first obtained.[342] Violations may result in fines and/or imprisonment. Freedom violated the CWA by discharging a pollutant, MCHM, from point sources into the Elk River, a water of the United States, without a permit authorizing such discharge.[343] Freedom also violated certain pollution prevention requirements set forth in a general NPDES permit it obtained related to stormwater. Because the violation of these requirements likely played a role in the incident, this topic is addressed in greater detail below and in Appendix B.

An NPDES permit is typically a license for a facility to discharge a specified amount of a pollutant into a receiving water under certain conditions.[344] There are two basic types of NPDES permits: individual and general.[345] An NPDES individual permit is written to reflect site-specific conditions of a single discharger based on information submitted by that discharger in a permit application and is unique to that discharger, whereas an NPDES general permit is written to cover multiple dischargers with similar operations and types of discharges based on the limits and conditions established by national Effluent Limitations Guidelines, or in the absence of the national guidelines, the best professional judgement of the permit writer.[346] A general permit is not issued to one particular entity; instead, multiple dischargers obtain

---

[339] http://www2.epa.gov/laws-regulations/summary-clean-water-act. The CWA is located at 33 U.S.C. §§ 1251-1387 (1972). Its implementing regulations are codified at 40 C.F.R. §§ 100-149, 400-471, 500-503 (2016).
[340] 33 U.S.C. § 1251(a) (1972).
[341] http://www2.epa.gov/laws-regulations/summary-clean-water-act. The CWA does not focus directly on groundwater contamination. Groundwater is addressed in Section 5.4 of this report, 42 U.S.C. § 300f (1974), 42 U.S.C. §§ 6901-6992k (1976), and 42 U.S.C. §§ 9601-9675 (1980).
[342] 33 U.S.C. § 1342 (1972). http://www2.epa.gov/laws-regulations/summary-clean-water-act.
[343] https://www.justice.gov/usao-sdwv/pr/freedom-industries-and-former-freedom-industries-plant-manager-sentenced-roles-chemical.
[344] http://www.epa.gov/npdes/about-npdes#types.
[345] http://www.epa.gov/npdes/about-npdes#types.
[346] http://www.epa.gov/npdes/npdes-frequent-questions.

coverage under that general permit after it is issued.[347] As such, dischargers covered under general permits know their applicable requirements before obtaining coverage under that permit.[348] In addition, permits include limits as necessary to ensure that state Water Quality Standards are protected.

Freedom possessed a General WV/NPDES Water Pollution Control Permit for stormwater discharges from the WVDEP on the day of the incident.[349] This permit was issued on April 1, 2009, and expired on March 31, 2014.[350] An important requirement of the General WV/NPDES Water Pollution Control Permit for stormwater discharges is that certain pollution prevention plans must be developed. As set forth in the permit, each covered facility must have an SWPPP and a GPP.[351] SWPPPs must be prepared in accordance with good engineering practices.[352] They must identify potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity from the facility.[353] In addition, they must describe and ensure the implementation of practices that are to be used to reduce the pollutants in industrial-related stormwater discharges at the facility.[354] GPPs include similar types of requirements for groundwater.[355]

All facilities must submit a copy of the SWPPP and GPP with their application for review.[356] Although CSB did not find evidence of a GPP, it did find a SWPPP. This SWPPP was drafted by a third-party engineering firm for ERT on February 14, 2002. It assessed the potential pollutant sources and identified best management practices at the facility as well as procedures for implementing the plan and for evaluating and monitoring the effectiveness of the plan. Details regarding good housekeeping, preventive maintenance, visual inspections, spill prevention and response, sediment erosion and control, and management of runoff were all included. The plan was to be kept at the facility and reviewed and updated regularly. CSB did not find this to be the case, however, as no SWPPP subsequent to February 14, 2002, could be located. At the time of the incident, renewal of the permit did not require submission of the plans to WVDEP; rather, the SWPPP and GPP were required only to be maintained onsite. SWPPPs and GPPs are now required to be submitted during permit renewals.

---

[347] http://www.epa.gov/npdes/npdes-frequent-questions.
[348] http://www.epa.gov/npdes/npdes-frequent-questions.
[349] Under the CWA, EPA authorizes the NPDES permit program to state, tribal and territorial governments, enabling them to perform many of the permitting, administrative and enforcement aspects of the NPDES program. In states authorized to implement CWA programs, EPA retains oversight responsibilities. The State of West Virginia is authorized to implement the NPDES program, and does so through the WVDEP Division of Water and Waste Management.
[350] WV/NPDES. Multi-Sector General Water Pollution Control Permit. Permit No. WV0111457. Section B, 17. 2009.
[351] *Ibid*.
[352] *Ibid.*
[353] *Ibid.* In WVDEP's Generic SWPPP, a description of potential pollutant sources includes the loading and unloading of dry bulk materials and liquids, outdoor material storage, outdoor process activities, dust generating activities, illicit connections, and management practices and waste disposal practices.
[354] WV/NPDES. Multi-Sector General Water Pollution Control Permit. Permit No. WV0111457. Section B, 17. 2009.
[355] *Ibid.*
[356] *Ibid.*

SWPPPs also require annual site inspections, to be conducted by appropriate personnel named in the plan.[357] This inspection requires verification that (1) the description of potential pollutant sources is accurate, (2) the drainage map has been updated or otherwise modified to reflect current conditions, and (3) the controls used to reduce pollutants in stormwater discharges associated with industrial activity identified in the plan are being implemented and are adequate.[358] GPPs must include provisions for quarterly inspections of the facility to ensure that all elements and equipment of the groundwater protection programs are in place, functioning properly and managed appropriately.[359] Considering the degraded nature of the site that clearly took years to unfold, CSB determined that neither Freedom nor ERT implemented a SWPPP or GPP in the more recent years leading up to the incident.

Furthermore, the General WV/NPDES Water Pollution Control Permit requires visual inspections that are separate and distinct from the site inspections mentioned above.[360] Under this requirement, the permittee must identify qualified company personnel to inspect designated equipment and plant or other appropriate areas.[361] To the extent that the 2002 SWPPP was over a decade old, it is unlikely that the personnel identified to conduct such inspections were up-to-date at the time of the incident. The visual inspection requirement also states, "Material handling areas must be inspected for evidence of, or the potential for, pollutants entering the drainage system. A tracking or follow-up procedure should be used to ensure that adequate response and corrective actions have been taken in response to the inspection. Records of inspections shall be maintained."[362] ASTs and tank farms are clearly "material handling areas." CSB found no evidence of repairs (demonstrated at least in part by the poor condition of the site) and no documentation of a regular inspection program at Freedom.

Freedom's failure to develop, maintain and implement a SWPPP and GPP as required by its General WV/NPDES Water Pollution Control Permit for stormwater discharges resulted in Freedom's failure to analyze the spill potential of all substances stored at its facility, maintain the containment area that was supposed to prevent a chemical spill from reaching the Elk River, inspect and maintain its storage tanks, and train all personnel to ensure that they were aware of, and in compliance with, environmental laws, including the requirements of SWPPPs and GPPs.[363]

As set forth above, the implementation of a SWPPP and GPP could have helped prevent the leak and spill of the mixture containing Crude MCHM and PPH, stripped into the Elk River that occurred on the day of the incident. In analyzing possible regulatory gaps, CSB determined that WVDEP could have put Freedom on notice of its noncompliance with the pollution protection requirements of its permit had

---

[357] *Ibid.*
[358] *Ibid.*
[359] *Ibid.*
[360] WV/NPDES. Multi-Sector General Water Pollution Control Permit. Permit No. WV0111457. Section B, 17. 2009. Although the visual inspections requirement does not set forth the frequency with which visual inspections must be conducted, the use of the plural language in the title of this section suggests more than once.
[361] WV/NPDES. Multi-Sector General Water Pollution Control Permit. Permit No. WV0111457. Section B, 17. 2009.
[362] *Ibid.*
[363] https://www.justice.gov/usao-sdwv/pr/freedom-industries-and-former-freedom-industries-plant-manager-sentenced-roles-chemical.

WVDEP inspected the facility. Although there was no requirement for WVDEP to do so at the time of the incident, WVDEP will conduct increased inspections for pollution prevention practices at facilities like Freedom in accordance with the new AST Act.

5.4 Safe Drinking Water Act

Congress passed the Safe Drinking Water Act in 1974 to help protect public health by regulating the nation's public drinking water supply.[364] Originally, the SDWA focused primarily on *treatment* as the means of providing safe drinking water at the tap.[365] However, with amendments in 1986 and 1996, the SDWA began to concentrate more on *protection*, thereby helping ensure the quality of public drinking water preceding the tap, from the source.[366] In particular, the 1996 amendments enhanced the existing law by, for example, recognizing source water protection as an important component of safe drinking water.[367] EPA implemented this part of the SDWA through its Source Water Assessment Program (SWAP). Because it pertains to this investigation, SWAP will be discussed in further detail below.

5.4.1 Source Water Assessment Program

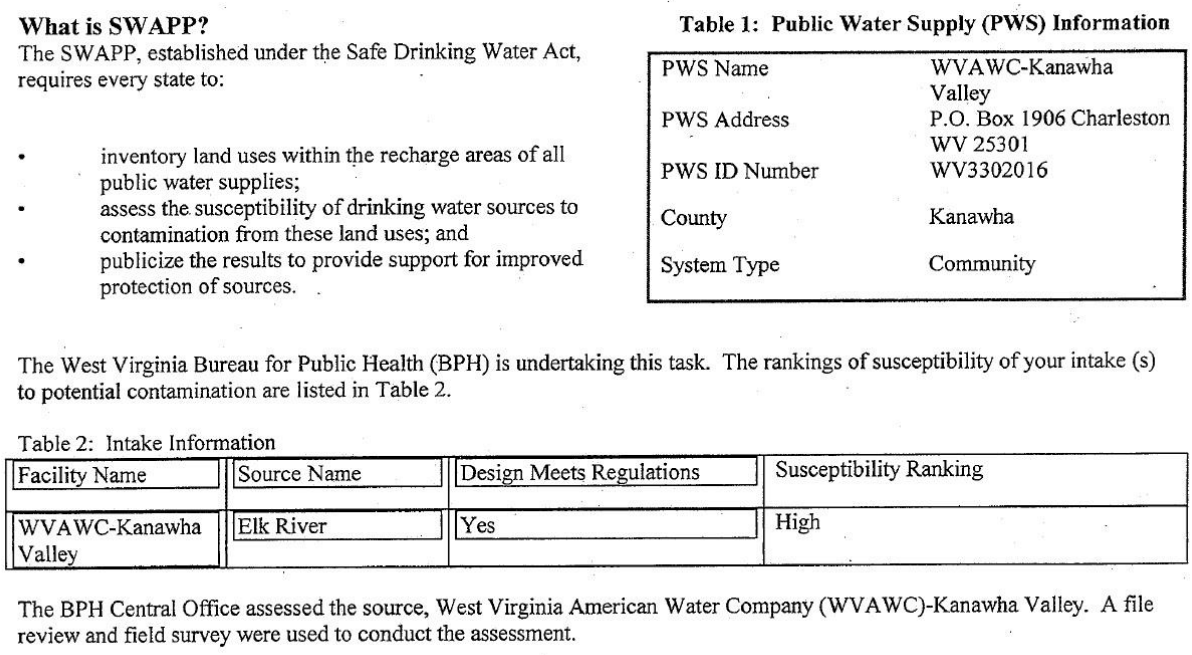
The 1996 amendments to the SDWA provided a planning process that required every state to conduct an assessment of its drinking water sources to identify significant potential sources of contamination and determine how susceptible the sources were to these threats.[368] This was achieved under SWAP, which required states to conduct assessments of public water systems to see where they might be vulnerable to contamination.[369] Each SWAP was required to include the following four elements: (1) delineating (or mapping) the source water protection areas, (2) conducting an inventory of potential sources of contamination in those areas, (3) determining the susceptibility of public water systems to those contamination sources, and (4) releasing the results of the determinations to the public.[370]

After a state's SWAP was approved by EPA, the state had two years, with a possible 18-month extension, to conduct an assessment for each public water system and make these assessments available to the public.[371] States were required to complete all assessments in the state no later than three years after EPA approved the programs.[372] The assessments, commonly called Source Water Assessment Reports (SWARs), covered public water systems in major metropolitan areas, small towns, schools, restaurants and other public facilities that had a well or surface water supply.[373] It is important to note that although SWAP is an active EPA program, the SDWA did not require it to be ongoing. Because the assessments were not required to be updated, many states' one-time SWARs were conducted in the early 2000s. This

[364] EPA. Understanding the Safe Drinking Water Act. https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf (February 7, 2017).
[365] *Ibid.*
[366] *Ibid.*
[367] *Ibid.*
[368] *Ibid.*
[369] *Ibid.*
[370] EPA Office of Water. Safe Drinking Water Act: Protecting Drinking Water Sources. EPA: Washington, DC. June 2004.
[371] *Ibid.*
[372] *Ibid.*
[373] *Ibid.*

has recently changed in West Virginia, though, where SWAP has been reinvigorated and enhanced. A discussion of this recent change is included at the end of this section.

In 1997, the Governor of West Virginia assigned the Environmental Engineering Division of the Office of Environmental Health Services (OEHS), WVDHHR as the lead agency responsible for the development and implementation of the state's SWAP. By the early 2000s, the OEHS Source Water Protection Unit completed all of the state's SWARs, including that for WVAW KVTP, a community water system, in 2002. In this SWAR, WVAW received a susceptibility ranking of "high" (Figure 37).



What is SWAPP?

The SWAPP, established under the Safe Drinking Water Act, requires every state to:

- inventory land uses within the recharge areas of all public water supplies;
- assess the susceptibility of drinking water sources to contamination from these land uses; and
- publicize the results to provide support for improved protection of sources.

Table 1: Public Water Supply (PWS) Information

PWS Name	WVAWC-Kanawha Valley
PWS Address	P.O. Box 1906 Charleston WV 25301
PWS ID Number	WV3302016
County	Kanawha
System Type	Community

The West Virginia Bureau for Public Health (BPH) is undertaking this task. The rankings of susceptibility of your intake (s) to potential contamination are listed in Table 2.

Table 2: Intake Information

Facility Name	Source Name	Design Meets Regulations	Susceptibility Ranking
WVAWC-Kanawha Valley	Elk River	Yes	High

The BPH Central Office assessed the source, West Virginia American Water Company (WVAWC)-Kanawha Valley. A file review and field survey were used to conduct the assessment.

Figure 37. WVAW–KVTP susceptibility ranking. (Source: WVAW)

The SWAR also included an inventory of Potential Significant Contaminant Sources. It identified approximately 80 Potential Significant Sources of Contamination within the ZCC for WVAW KVTP. The detailed inventory included the Etowah Terminal, where Freedom Industries would later be located and where the incident would occur.

Although the SWAR recommended that a SWAP protection plan be prepared to account for the high susceptibility ranking, the plan was not required. This plan, if developed, was recommended to incorporate the SWAR and three additional sections: (1) Contingency Planning, (2) Alternative Sources, and (3) Management Planning.[374] According to West Virginia's Source Water Assessment and Protection

[374] West Virginia Department of Health and Human Resources Bureau for Public Health Office of Environmental Health Services Source Water Protection Unit. State of West Virginia Source Water Assessment and Protection Program: Source Water Assessment Report. State of West Virginia: West Virginia, WVAWC- Kanawha Valley. July 29, 2002.

Program, "local source water protection programs *should* utilize the source water assessments from OEHS and build their programs to include a local source water protection committee or team, develop a management plan for the contaminant sources identified, and develop a contingency or emergency plan."[375] This voluntary language aligned with the federal mandate because, although the SDWA Amendments of 1996 intended to encourage states and public water supplies to go beyond source water assessments and implement efforts to manage identified sources of contamination in a manner that would protect public drinking water sources, it only required states to develop EPA-approved SWAPs.[376] CSB found that WVAW started conducting interviews with commercial entities of concern in 2006 as part of its voluntarily developed SWAP protection plan.[377] Despite also completing an associated emergency response plan, WVAW never finished conducting those interviews.[378] CSB did not find evidence indicating that WVAW surveyed the Freedom site to assess the risk of potential spills into the Elk River.[379]

Nonetheless, efforts to require state-level source water protection planning did succeed post-incident. As previously discussed in Section 5.2.2, SB 373 revised portions of Article 1 of Chapter 16 (Public Health) of the West Virginia Code to address regulation of public water systems, source water protection, grants for wellhead and source water protection, and long-term medical monitoring.[380] Key components of these revisions were approved by the 2014 Legislature and signed into law by Governor Earl Ray Tomblin on April 1, 2014.[381] The law became effective on June 6, 2014.[382] The new section required public water utilities to submit source water protection plans to WVBPH by July 1, 2016.[383] Going beyond components from the 2002 SWAR, requirements for source water protection plans must include the following: (1) a contingency plan, (2) a management plan, (3) a communication plan, (4) a list of potential sources of significant contamination (provided by WVDEP, WVBPH and Homeland Security), (5) an analysis of whether the utilities' water systems can shut intakes or otherwise have the capability for alternate water sources in the event of an emergency, and (6) an evaluation of the feasibility of implementing an early warning monitoring system.[384] CSB found these requirements exceed many of the federal SWAP

[375] West Virginia Department of Health and Human Resources Bureau for Public Health Office of Environmental Health Services Environmental Engineering Division. *State of West Virginia Source Water Assessment and Protection Program*; State of West Virginia: West Virginia, Aug 1, 1999 (emphasis added).
[376] West Virginia Department of Health and Human Resources Bureau for Public Health Office of Environmental Health Services Environmental Engineering Division. *State of West Virginia Source Water Assessment and Protection Program*; State of West Virginia: West Virginia, Aug 1, 1999.
[377] WVAW Kanawha Valley District. Source Water Assessment and Pollution Prevention Plan and Activities for the Central Division. Prepared September 7, 2006.
[378] *Ibid.*
[379] Water utilities have expressed concern with respect to accessing information this way because the utilities do not have the authority to compel third party businesses to grant them access to their sites or to provide information about stored chemicals (e.g., chemical contents may be claimed as proprietary).
[380] https://www.wvdhhr.org/oehs/eed/swap/Bill.asp.
[381] *Ibid.*
[382] *Ibid.*
[383] https://www.wvdhhr.org/oehs/eed/swap/Bill_FAQ.asp. A "public water utility" is defined as a public water system regulated by the state Public Service Commission pursuant to Chapter 24 of the state code.
[384] https://www.wvdhhr.org/oehs/eed/swap/Bill_FAQ.asp.

requirements. WVAW KVTP submitted the public version of its source water protection plan to WVBPH in June 2016.

5.5 Emergency Planning

The Freedom incident demonstrates not only the lack of information available on certain hazardous chemicals but also the need for planning relating to the release of chemicals that are not considered to be "hazardous substances" or "extremely hazardous substances." For facilities that store large amounts of hazardous chemicals within close proximity to major water sources, the need for a well-rehearsed emergency plan that includes prior communication of the chemicals to the water utility company is vital. EPCRA provides states and local emergency responders the tools to plan for situations like the Freedom spill, but the information available to these parties through the statute was not used to create a detailed response plan relating to the release of such a large amount of hazardous chemicals into the Elk River. Water utilities are also able to request chemical information submitted pursuant to EPCRA to properly plan for source water contamination from chemicals located in close proximity to intakes.

Although the information submitted under EPCRA is useful in planning activities, West Virginia has also attempted to address this planning issue under the AST Act, which requires certain information to be submitted directly to water utility companies (see Section 5.2.2). The following sections, however, discuss applicable sections of EPCRA, how they applied to the facility and the LEPC's planning activities prior to and following the incident.

5.5.1 Emergency Planning and Community Right-to-Know Act

EPCRA is a statute that was created to address emergency response and preparedness.[385] "EPCRA established a national framework for EPA to mobilize local government officials, businesses and other citizens to plan ahead for possible chemical accidents in their communities."[386] EPCRA is divided into four main categories: (1) emergency planning (§§ 301-303), (2) emergency release notification (§ 304), (3) hazardous chemical inventory reporting (§§ 311-312), and (4) toxic chemical release reporting (§ 313). The chemicals, which are covered by each section of EPCRA, are different, as are the quantities that trigger reporting (see Table 10).[387]

[385] EPCRA was passed by Congress in 1986 in response to concerns highlighted by a toxic chemical release from a Union Carbide chemical plant in Bhopal, India, that killed thousands and which was shortly followed by a similar incident in Institute, West Virginia. EPA. The Emergency Planning and Community Right-to-Know Act. https://www.epa.gov/sites/production/files/2015-05/documents/epcra_fact_sheet.pdf (August 31, 2016).

[386] CRS Report RL30798. Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency. Congressional Research Service, Washington, DC. 2010.

[387] EPA. EPCRA Fact Sheet. http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (August 31, 2016).

Table 10. EPCRA Chemicals and Reporting Thresholds (Source: EPA)

Section Number	303	304	311/312	313
Chemicals Covered	355 Extremely Hazardous Substances	>1,000 substances	Approximately 500,000 hazardous chemicals	>650 Toxic Chemicals and categories
Thresholds	Threshold Planning Quantity 1-10,000 lbs onsite at any one time	Reportable quantity, 1-5,000 lbs, released in a 24-hour period	500 lbs or Threshold Planning Quantity, whichever is less for Extremely Hazardous Substances; 75,000 gallons for gasoline; 100,000 gallons for diesel; and 10,000 lbs for all other hazardous chemicals	25,000 lbs per year manufactured or processed; 10,000 lbs per year otherwise used; persistent bioaccumulative toxics have lower thresholds

Under Section 301 of EPCRA, each state is required to create a State Emergency Response Commission (SERC) composed of individuals with expertise in the emergency response field.[388] Section 301 also requires each SERC to define emergency planning districts and to establish LEPCs for each district.[389] "The SERC supervises and coordinates the activities of the LEPC, establishes procedures for receiving and processing public requests for information collected under EPCRA, and reviews local emergency response plans."[390] The LEPCs are composed of local government, law enforcement, owners and operators of facilities subject to EPCRA, as well as individuals from other disciplines.[391]

LEPCs are required to prepare comprehensive local emergency response plans under Section 303 based on the reported chemical information from facilities.[392] These emergency plans, however, are only required to include facilities that have listed extremely hazardous substances (EHSs) present onsite in excess of the applicable threshold planning quantity (TPQ). EPA maintains a list of EHSs and the TPQ for each listed substance. Currently, 355 EHSs are listed in EPA's database.[393] Neither Crude MCHM nor PPH, stripped is an EHS; thus, they are not regulated under Section 304 and are not required to be

[388] 42 U.S.C. § 11001 (1986).
[389] *Ibid.*
[390] EPA. EPCRA Fact Sheet. http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (August 31, 2016).
[391] EPCRA § 301 requires that each LEPC be composed of representatives of the following: elected state and local officials, law enforcement officials, civil defense personnel, firefighters, first aid personnel, health personnel, local environmental personnel, members of the broadcast and print media, community groups, and owners and operators of facilities covered by EPCRA § 301(c); 42 U.S.C. § 11001 (1986).
[392] 42 U.S.C. § 11003 (1986).
[393] EPA. EPCRA Fact Sheet. http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (August 31, 2016).

included in comprehensive emergency planning. EPCRA did, however, provide Governors of each state and the SERC the power to designate additional facilities to be subject to these requirements.[394] Additionally, LEPCs have the option to include in the comprehensive plan any facility from which they receive chemical information.

Section 304 of EPCRA requires owners or operators of certain facilities to report hazardous *substance* releases immediately to SERCs and LEPCs.[395] Crude MCHM and PPH, stripped are hazardous *chemicals* under OSHA; however, neither chemical is considered a hazardous *substance* under the Comprehensive Environmental Response, Compensation, and Liability Act, nor are they EHSs.

EPCRA also requires facilities with hazardous chemicals, as defined by the Occupational Safety and Health Act, to report their inventory under Sections 311 and 312. The requirements of EPCRA Sections 311 and 312 are closely intertwined with OSHA's HCS. Sections 311 and 312 of the statute use the framework of the HCS to give the public and local emergency responders information regarding the presence of hazardous chemicals in the community.[396] As such, these sections use OSHA's definition of hazardous chemical, and cover a much greater set of chemicals than other portions of EPCRA. Approximately 500,000 products are required to have SDSs and are considered hazardous chemicals. Facilities subject to Sections 311 and 312 are those required by OSHA to keep SDSs on file, and where one or more of the chemicals is stored in quantities equal to or greater than the TPQ for that chemical. For many hazardous chemicals, including Crude MCHM and PPH, stripped, the TPQ is 10,000 pounds.[397] Freedom had more than 10,000 pounds of Crude MCHM at its facility; therefore, Freedom was required to comply with Sections 311 and 312 of EPCRA.

Under Section 311, facilities that are required to prepare or have available an SDS for a hazardous chemical must submit an SDS for each such chemical or, in the alternative, a list of such chemicals, if the amount of the chemical equals or exceeds threshold amounts.[398] This submission must be made to the SERC, LEPC and fire department with jurisdiction over the facility. Although SDS reporting is not required, if a facility chooses to submit a list, then the LEPC has the authority to request an SDS for any chemical on that list.[399] Additionally, the LEPC is also authorized to request an SDS for any hazardous chemical regardless of the quantity of the hazardous chemical at the facility.[400]

Section 312 requires facilities subject to Section 311 reporting requirements to provide additional information regarding hazardous chemicals. These facilities must annually prepare and submit, to the same local authorities, an emergency and hazardous chemical inventory form. Facilities fulfill this requirement by providing either a Tier I or Tier II inventory form. In most states, including West Virginia,

[394] 42 U.S.C. § 11002(a) (1986).
[395] 42 U.S.C. § 11004 (1986).
[396] 42 U.S.C. §§ 11021-11022 (1986).
[397] 40 C.F.R. § 370.10 (2012).
[398] 42 U.S.C. § 11021 (1986).
[399] 40 C.F.R. § 370.30(b) (2012).
[400] 40 C.F.R. § 370.21(d) (2012).

compliance with EPCRA Section 312 is fulfilled by submitting annually a Tier II form.[401] A Tier II form must include (1) the chemical name or the common name indicated on the SDS, (2) an estimate (in ranges) of the maximum amount of the chemical present at any time during the preceding calendar year and the average daily amount, (3) a brief description of the chemical's manner of storage, (4) the location of the chemical at the facility and (5) an indication of whether the owner elects to withhold location information from public disclosure.[402]

5.5.2 Emergency Planning in West Virginia

EPCRA expressly states that the statute does not preempt any state law, which means states may impose stricter requirements. West Virginia's statute, however, implements the requirements under EPCRA via the West Virginia State Emergency Act Chapter 15, Article 5, which simply mirrors the federal requirements.[403] This statute created the West Virginia State Emergency Response Commission. Under the commission's authority, West Virginia's Superfund Amendments and Reauthorization Act Program receives and manages state-level EPCRA reports. This statute also established the various LEPCs required under EPCRA.

In West Virginia, the LEPCs were established along existing county lines. The Kanawha Putnam Emergency Planning Committee covers the Charleston area, where Freedom was located, as well as the rest of Kanawha County and Putnam County.

5.5.2.1 Kanawha Putnam Emergency Planning Committee

The KPEPC consists of 15 Board Members and about 120 members, and includes ten annex committees. It is funded through member contributions and small federal and state grants. The KPEPC includes representatives from law enforcement, fire departments, emergency medical services, environmental groups, hospitals, industrial facilities and local communities. The KPEPC is responsible for emergency planning and processing of public information requests associated with the use and transport of chemicals in the area. The KPEPC's major activities include response planning, conducting emergency drills and functioning as an information source on chemicals for the community. Additionally, after a chemical spill or emergency response, the KPEPC has a subcommittee that completes an AAR to "identify actions taken and to identify strengths to be maintained and built upon, identify potential areas for further improvement, and support implementation of corrective actions."[404]

5.5.2.2 Tier II Submissions Made by Etowah River, LLC

As stated above, Freedom was subject to Section 311 and 312 reporting requirements given that Crude MCHM is considered a hazardous chemical under the HCS. Like most states, compliance with these requirements in West Virginia is fulfilled through the submission of a Tier II Emergency and Hazardous Chemical Inventory Form for the applicable chemicals within 90 days of exceeding the threshold for that

---

[401] WVDHSEM. Tier II Reporting. http://www.dhsem.wv.gov/SERCTIERII/Pages/Tier-II-Reporting-.aspx (August 2, 2016).
[402] 40 C.F.R. § 370.42(s) (2012).
[403] W. VA. CODE § 15-5A (2015).
[404] Kanawha Putnam Emergency Planning Committee. West Virginia American Water Incident. After Action Report. 2014.

chemical. In West Virginia, Tier II forms are required to include the chemical name as indicated on the SDS, an estimate in ranges of the maximum amount of the chemical present at any time during the preceding calendar year and the average daily amount, a brief description of the hazards and manner of storage, and the location of the chemical at the facility.[405]

ERT, Freedom's predecessor, had submitted these Tier II forms. These forms are backward-looking and are used to report information on chemicals at the facility in the previous year. As such, 2012 is the most recent year for which a Tier II has been submitted since, at the time of the accident, the 2013 calendar year had recently ended and Freedom was not yet required to submit its Tier II for that year. All six of the Tier II forms filed by ERT listed Crude MCHM as being an "immediate (acute) physical and health hazard." The forms also stated that the maximum daily amount onsite and the average daily amount onsite was between 100,000 and 999,999 pounds. These forms reported large quantities of hazardous chemicals located next to the area's only source of drinking water and therefore should have been used in planning for such an incident.

5.5.2.3 Kanawha Putnam Emergency Management Plan

The Kanawha Putnam Emergency Management Plan provides "general guidelines for planning, managing and coordinating the overall response and recovery activities of local government before, during and after major emergencies and disaster that affects [the] community."[406] The plan consists of a "Basic Plan" and two annexes. The "Functional" annex contains guidelines for participating agencies to use in developing agency-specific operating documents. The "Hazards" annex contains non-routine emergency scenarios. The Basic Plan and annexes provide general guidelines for planning and managing specific scenarios, but the plan deals mainly with setting up incident command and providing guidelines for communication at the time of the emergency. For this reason, EPCRA requires LEPCs to include a detailed response plan for certain facilities and provides LEPCs with the opportunity to include other facilities as they see fit. These detailed response plans are not available on the KPEPC website and the KPEPC did not have one completed for Freedom because it was neither a production facility nor a facility that stored extremely hazardous substances.

LEPCs are not required to create a detailed response plan for facilities that only store hazardous chemicals; however, LEPCs do have the authority to include these facilities in the emergency plan. Despite the availability of Tier II forms that included information about the amount and location of hazardous chemicals stored at the site, the response from officials and emergency agencies on January 9, 2014, and in the weeks following showed they were unaware of the hazards associated with storing Crude MCHM and other chemicals so close upstream from the area's only water intake.

Each emergency plan the LEPC creates must include certain minimum requirements, as described above. One of these requirements is to identify other facilities that may be subjected to additional risk because of proximity to facilities subject to emergency planning requirements.[407] If Freedom was a facility subject to

[405] WVDHSEM. Tier II Reporting. http://www.dhsem.wv.gov/SERCTIERII/Pages/Tier-II-Reporting-.aspx (August 2, 2016).
[406] KPEPC. Basic Plan. http://www.kpepc.org/shared/content/Page_objects/ahp_docs/Basic_Plan.pdf (August 5, 2016).
[407] 42 U.S.C. § 11003 (1986).

EPCRA planning requirements or one that the KPEPC included in planning, the emergency response plan developed would have likely taken into account the location of the WVAW intake downstream and planned for a leak into the river. LEPCs should use the information from Tier I and Tier II documents to plan and minimize risks when facilities like water intake and treatment plants are within such close proximity. Further, states should support LEPC planners' efforts, for instance by providing them with more resources to address similar issues and potential incidents.

As a result of the Freedom incident, West Virginia now requires owners of regulated tanks to provide notice directly to water companies of the type and quantities of fluid stored in regulated ASTs.[408] Although this information may already be available to water companies by requesting it from the appropriate LEPC, West Virginia is taking a proactive approach to ensuring all water companies are fully aware of what is stored in close proximity to their intakes. Owners of regulated tanks can fulfill this requirement by submitting the same Tier II document directly to the water company. As stated earlier, CSB found that this information was available to WVAW if they requested it from the KPEPC.

Despite the planning requirements and the opportunity for the KPEPC to notify WVAW of the contents of the Freedom tanks, WVAW was not provided any notification about the Freedom tank contents. However, Tier II information submitted to SERCs and LEPCs is publicly available.[409] Although not required by regulation, WVAW could have requested this information to determine what chemicals were being stored in close proximity to the only water intake.

5.5.2.4 After Action Report

In addition to planning, the KPEPC also completes an AAR following an incident in the Kanawha/Putnam area. This report is created to provide supportive corrective actions in relation to the KPEPC Plan. The goal of the report is to identify actions taken, strengths and weaknesses, and potential areas for further improvement.

Through the AAR, the KPEPC identified a variety of scenarios that need to be planned for, including large-scale water outages and a complete system loss. The AAR also recommends that the KPEPC review the information collected under the AST Act and determine which tanks threaten public health and safety, in particular ones that could threaten drinking water sources.

On the day of the incident, the KPEPC was familiar with Crude MCHM due to prior incidents involving the chemical but did not have an SDS for the chemical. As a result of the Freedom incident, West Virginia implemented a more efficient way of managing Tier II reports. There is now an electronic management system that has geographical information system mapping capabilities to identify nearby hospitals, ZCCs, water intakes, highways, railroads and other potential concerns.[410]

---

[408] W. VA. CODE § 22-30-10 (2015).
[409] 42 U.S.C. § 11022(e) (1986).
[410] Governor Earl Ray Tomblin. After Action Review, State of West Virginia, January 9, 2015. http://www.governor.wv.gov/Documents/After%20Action%20Review.PDF (August 2, 2016).

5.6 Chemical Regulation under the Toxic Substances Control Act

The Freedom incident highlighted the need for more information on the health effects of hazardous chemicals in the United States. The following provides an overview of the Toxic Substances Control Act (TSCA), which regulates chemicals in the United States. TSCA was recently amended to provide EPA with greater authority to regulate and test chemicals. The following first discusses relevant sections of the old statute and highlights some of the burdensome hurdles EPA had to clear to gather important information or to regulate chemicals. Section 5.6.2 then provides an overview of the major changes to TSCA as a result of the Frank R. Lautenberg Chemical Safety for the 21st Century Act.

TSCA was introduced to regulate chemicals before they became contaminants and to gather information on chemicals entering the environment. TSCA was enacted, after years of debate, to authorize EPA to collect information "about the hazards posed by chemical substances and to take action to control unreasonable risks by either preventing dangerous chemicals from making their way into use or placing restrictions on those already in commerce."[411] Although the statute seems to provide EPA with broad authority, TSCA contained serious flaws that severely limited EPA's ability to gather information and regulate chemicals.

5.6.1 TSCA Prior to 2016

Some of TSCA's deficiencies were highlighted by the Freedom incident. Eastman voluntarily conducted testing on Crude and 4-MCHM, however none of this testing was required under TSCA or any other law or regulation. These studies provided users and the public with warnings based on its acute toxicity; however because they were not required to do so, Eastman's tests did not include studies at low doses that would have assisted public professionals in responding to the spill and communicating risks to the public.

Although only recently being sold as a commercial product by Eastman, Crude MCHM has long been produced as a co-product during Cyclohexane Dimethanol (CHDM) production. When TSCA was enacted, 4-MCHM, the main constituent of Crude MCHM, was already being produced and was "grandfathered" in along with some 55,000 other chemicals. Inclusion in this inventory is what distinguishes an "existing chemical" from a "new chemical." A chemical substance cannot enter into commerce in the United States without first being placed on the inventory and in order to be considered for placement, new chemicals must comply with the new chemical requirements of Section 5. By placing the existing chemicals on the TSCA inventory, they were then, and continue to be, exempt from the EPA review required for new substances before they are sold on the market. Although EPA has instituted some programs under the old statute to review existing chemicals, 4-MCHM was not among the substances reviewed.

TSCA's coverage was intended to be broad.[412] However, as has been seen over the years since TSCA's passage, EPA has been very limited in using this authority because under the old statute it was very

[411] Government Accountability Office. Chemical Regulation: Observations on the Toxic Substances Control Act and EPA Implementation. GAO-13-696T. Washington, DC. 2013. 15 U.S.C. § 2601(b) (2002).

[412] Section 3 of TSCA provides a very broad definition of "chemical substance" that is inclusive of nearly every chemical intended for commercial purposes in the United States unless specifically excluded. Some examples of substances excluded include food, drugs and cosmetics, which are regulated under other federal statutes.

burdensome and time consuming to comply with its requirements. In general, it has historically been much easier for EPA to regulate new chemical substances than to regulate existing ones.

5.6.1.1 Chemical Testing

The first policy stated by Congress in TSCA is that "adequate data should be developed with respect to the effect of chemical substances and mixtures on health and the environment and the development of such data should be the responsibility of those who manufacture and those who process such chemical substances and mixtures."[413] Although TSCA authorizes EPA to promulgate rules that require chemical companies to conduct tests on chemicals and submit the resulting data to EPA, TSCA does not require chemical companies to develop information on the harmful effects of new or existing chemicals on human health or the environment. Given the burdensome requirements and hurdles that had to be cleared for EPA to actually require testing under a "test rule," EPA largely relied on the voluntary undertaking of testing and submission of data from chemical companies. However, when companies are left to conduct testing themselves, the scope and quality of those tests may be limited. Even though Eastman conducted numerous studies on both Crude and 4-MCHM, none of those tests were long-term studies at low doses that would have assisted public health professional in promptly communicating the risk of exposure when residents began reporting symptoms.

Section 4 of TSCA gives EPA authority to issue rules requiring manufacturers and processers to undertake and submit the results of new testing on chemicals for their effects on human health and the environment.[414] Section 4(a) provides EPA with two ways of requiring testing of chemical substances, either through a "hazard finding" or an "exposure finding."[415] Under either avenue, EPA must make certain findings before issuing a test rule. By making a hazard finding, EPA must determine that a chemical substance "may present an unreasonable risk of injury to health or the environment."[416] In order to survive judicial review, EPA has the burden of showing that the risk is "a more-than-theoretical probability."[417] Stakeholders and environmentalists often referred to this as a "Catch-22" because it required EPA to have risk information before requiring risk information to actually be developed through testing.

The United States Government Accountability Office (GAO) reported in 2005 that EPA found its authority under Section 4 to be difficult, time consuming and costly to use.[418] As a result, since EPA first began reviewing chemicals under TSCA in 1979, it has used its authority to require testing for only

[413] 15 U.S.C. § 2601(b)(1) (2002).
[414] Section 4 of TSCA is codified at 15 U.S.C. § 2603.
[415] The second way EPA may promulgate a test rule is by making an exposure finding and determining that there are substantial quantities of the chemical substance and it may enter the environment, and there is, or may be, significant or substantial human exposure. Under either avenue, EPA must also find that insufficient data exist regarding the effects of the chemical and testing of such substance or mixture with respect to such effects is necessary to develop such data. 15 U.S.C. § 2603(a)(1)(A) and (a)(1)(B) (2002).
[416] 15 U.S.C. § 2603(a)(1)(A) (2002).
[417] Chem. Mfrs. Ass'n v. EPA, 859 F.2d 977 (D.C. Cir. 1988).
[418] Government Accountability Office. Chemical Regulation: Options Exist to Improve EPA's Ability to Assess Health Risks and Manage Its Chemical Review Program. GAO-05-458. Washington, DC. June 2005.

approximately 200 of the 84,000 chemicals in commerce.[419] Further complicating the matter is that once EPA has sufficient information to satisfy these requirements, EPA had to go through the formal rulemaking process to require testing, which can be, and usually is, a long and arduous process. In fact, according to a GAO report, EPA officials stated that finalizing a test rule can take from 2 to 10 years and requires expenditure of substantial resources.[420]

5.6.1.2 New Chemical Review

Section 5 of TSCA requires manufacturers, importers and processors to notify EPA at least 90 days before producing or otherwise introducing a new chemical product or a significant new use of an existing chemical into the United States.[421] Manufacturers of new chemical substances must submit a premanufacture notice (PMN) to EPA prior to manufacturing the substance for nonexempt commercial purposes.[422] Manufacturers or processors that plan to use an existing chemical in a way EPA finds[423] to be a "significant new use" must submit a significant new use notice (SNUN). However, the only information required to be submitted with a PMN or SNUN is any information or test data that are known to, reasonably ascertainable by or in possession of the notifier, and which is related to the effect of any manufacturing, processing or distribution on health or the environment.[424]

Before Eastman began selling Crude MCHM, the company needed to ensure that all chemicals in the mixture were on the TSCA inventory or that a PMN was submitted for any chemical not listed. On October 20, 1997, Eastman submitted a PMN for the 4-(methoxymethyl)cyclohexane methanol. Eastman identified it as a component of Crude MCHM, which is a co-product as part of CHDM production. The other components of Crude MCHM that Eastman listed were already included on the TSCA inventory. Among the information submitted with the PMN was the physical and chemical properties of the chemical, the process description, an estimate of worker exposure and a safety data sheet for Crude MCHM that lacked any toxicological data. The chemical cleared EPA's PMN review in 1998 and Eastman began selling Crude MCHM commercially.

EPA does not require specific toxicological information to be submitted. Instead of the burden being on the manufacturer to prove that a chemical substance is safe, manufacturers and importers satisfy the Section 5 requirements by providing existing relevant information on the substance. In the absence of detailed information or test data, EPA is left to rely on scientific models to predict a substance's health or environmental effects, which can be difficult and unreliable, thus leaving open the possibility of a dangerous substance entering commerce without its effects being known. In the absence of chemical data,

---

[419] *Ibid.*
[420] *Ibid.*
[421] 15 U.S.C. § 2604(a)(1) and (a)(2) (2002); CRS Report RL31905. The Toxic Substances Control Act (TSCA): A Summary of the Act and Its Major Requirements. Congressional Research Service, Washington, DC. 2013.
[422] 15 U.S.C. § 2604(a)(1)(A) (2002); EPA. Filing a Pre-manufacture Notice with EPA. https://www.epa.gov/reviewing-new-chemicals-under-toxic-substances-control-act-tsca/filing-premanufacture-notice-epa (August 2, 2016).
[423] EPA must make this determination by rule. The Administrator must consider all relevant factors listed under 15 U.S.C. § 2604(a)(2) (2002).
[424] 15 U.S.C. § 2604(d)(1)(A) and (B) (2002). If the Administrator promulgates a test rule under Section 4 of TSCA however, then that information is also required to be included in the PMN or SNUN.

EPA relies mostly on scientific models to screen new chemicals. However, these models do not always accurately determine the chemicals' properties and full health effects.[425]

5.6.1.3 Control of Chemicals

In addition to information gathering and testing authority, TSCA also grants EPA the power to regulate certain substances. Section 6 authorizes EPA to adopt rules regulating the manufacturing, processing, use and disposal of existing chemicals when there is a reasonable basis to conclude that the substance presents or will present an unreasonable risk of injury to health or the environment.[426]

In order to regulate an existing chemical under Section 6(a), EPA must go through the full formal rulemaking process. Further, EPA must select the least burdensome requirements from those potential requirements that would protect adequately against the unreasonable risk.[427] For example, if EPA finds that it can manage the unreasonable risk through the use of warning labels, then it cannot ban the use of that chemical. Finally, in order to withstand judicial review, EPA must also develop substantial evidence in the rulemaking record. This includes a cost-benefit analysis and, "according to EPA officials, the economic costs of regulating a chemical are usually more easily documented than the risks of the chemical or the benefits associated with controlling those risks, and it is difficult to show by substantial evidence[428] that EPA is promulgating the least burdensome requirement."[429]

Some of the problems with Section 6 include the extreme burden placed on EPA to both regulate the substance and survive judicial review by showing it is the least burdensome control. The burden is on EPA to show that the chemical presents or will present an unreasonable risk to the public.[430] For EPA to have met this burden under the old statute, a test rule would have likely had to have been promulgated in order to obtain substantial evidence to regulate under Section 6. This led to a long burdensome process and has resulted in EPA issuing regulations under Section 6 to ban or limit the production or restrict the

[425] Government Accountability Office. Chemical Regulation: Options Exist to Improve EPA's Ability to Assess Health Risks and Manage Its Chemical Review Program. GAO-05-458. Washington, DC. June 2005.
[426] 15 U.S.C. § 2605(a) (2002).
[427] *Ibid.*
[428] The extreme burden of judicial scrutiny is demonstrated by the regulation of asbestos. EPA started considering asbestos rulemaking in 1979. EPA, under the authority of TSCA Section 6, issued a rule in 1989 phasing out most uses of asbestos. However, the U.S. Court of Appeals for the Fifth Circuit returned part of this rule because it felt that EPA failed to show that a flat-out ban was the "least burdensome" option and because EPA failed to support the decision on the record with substantial evidence. This decision was rendered despite the fact that EPA spent 10 years preparing its rule and had a huge body of scientific evidence on the adverse health effects of asbestos. As of today, there still isn't an outright ban on asbestos in the United States. This case illustrates the burdensome procedural requirements of TSCA Section 6 and the effect of the heightened standard of judicial scrutiny codified in TSCA. Corrosion Proof Fittings v. EPA, 947 F.2d 1201 (5th Cir. 1991); Government Accountability Office. Chemical Regulation: Observations on the Toxic Substances Control Act and EPA Implementation. GAO-13-696T. Washington, DC. 2013.
[429] Government Accountability Office. Chemical Regulation: Options Exist to Improve EPA's Ability to Assess Health Risks and Manage Its Chemical Review Program. GAO-05-458. Washington, DC. June 2005.
[430] 15 U.S.C. § 2605(a) (2002).

use of only five existing chemicals or chemical classes out of over 84,000 chemicals currently listed on the TSCA inventory.[431]

5.6.2 Frank R. Lautenberg Chemical Safety for the 21st Century Act

The Frank R. Lautenberg Chemical Safety for the 21st Century Act (Chemical Safety Act) was signed by the President and became law on June 22, 2016. The Chemical Safety Act amends TSCA and addresses many of the deficiencies in the statute as well as those identified in earlier reform bills. The statute gives EPA greater authority to require testing of both new and existing chemicals, requires EPA to review all existing chemicals and removes the burdensome cost-benefit analysis from the existing safety standard while implementing a new one.[432] As it relates to the Freedom incident, when EPA is prioritizing existing chemicals for review under the new framework, it must consider storage near significant sources of drinking water when determining the chemical's risk.[433] This may allow seemingly low hazard chemicals to be considered high priority based on the potential to contaminate source water. This is one of the improvements found in the Chemical Safety Act, as explained below.

EPA's authority to require testing of both new and existing chemicals is enhanced. Unlike the old statute, testing can now be required by rule, order or consent agreement.[434] This change addresses one of the major hurdles EPA faced with the long, complex rulemaking process. EPA is also provided with the authority to require the development of information for the purposes of prioritization if necessary.[435] This change addresses the Catch-22 problem discussed previously, because a lack of information for EPA to make a determination would now be sufficient to require manufacturers to produce more information.

EPA's new chemical review is also strengthened. Manufacturers and processors will still be required to submit PMNs but now EPA must review these notices and make an explicit determination that it doesn't meet the safety standard; that there is insufficient information or the chemical will be produced in substantial quantities and the chemical will be regulated pending the development of information; or that it meets the safety standard.[436] As explained above, when Eastman began producing Crude MCHM for commercial production, it had to submit a PMN for one of its constituents. Under the new statute, EPA may have requested more information and would have been required to determine whether or not the chemical would present an unreasonable risk.

Whether it is a new or existing chemical, the statute also revises the safety standard to remove the cost-benefit analysis that has hindered the agency in the past.[437] The new safety standard also requires EPA to take into account potentially exposed or susceptible subpopulations, which means "a group of individuals

---

[431] Government Accountability Office. Chemical Regulation: Observations on the Toxic Substances Control Act and EPA Implementation. GAO-13-696T. Washington, DC. 2013.

[432] EPA must determine whether a chemical use poses an unreasonable risk. This excludes consideration of costs or other nonrisk factors. EPA must also consider risks to susceptible and highly exposed populations.

[433] 15 U.S.C. § 2605(b)(1)(A) (2016).

[434] 15 U.S.C. § 2603(a)(1)(B) (2016).

[435] 15.U.S.C. § 2603(a)(2)(B) (2016).

[436] 15 U.S.C. § 2604(a)(3) (2016).

[437] 15 U.S.C. § 2604(a)(3)(C) (2016) and 15 U.S.C. § 2605(b)(4)(A) (2016) – "without consideration of costs or other nonrisk factors."

within the general population identified by the Administrator who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture such as infants, children, pregnant women, workers, or the elderly."[438] EPA can also now regulate chemicals without demonstrating that it is the least burdensome alternative.[439] As explained above, this requirement in the old statute has resulted in EPA regulating very few chemicals since its enactment.

EPA will be required to review all existing chemicals in commerce under the Chemical Safety Act, and not later than one year after enactment EPA must establish by rule a risk-based screening process to designate substances as either high- or low-priority substances for which risk evaluations are not warranted at this time.[440] When determining risk, EPA will be required to consider susceptible subpopulations as well as storage near significant sources of drinking water. By December 22, 2016, EPA must ensure that risk evaluations are being conducted on ten chemical substances from the 2014 TSCA work Plan.[441] Within 3.5 years, EPA is required to ensure that additional risk evaluations are being conducted on at least 20 high-priority substances and that at least 20 low-priority substances have been designated.[442] As of April 2016, there are currently over 84,000 chemical substances listed on the TSCA inventory for which risk evaluations will eventually have to be completed.

Once a risk evaluation is completed for a chemical, EPA must designate a new chemical for evaluation.[443] A total of 25-50% of chemicals designated at any time can be industry requested.[444] This provision coupled with the preemption clauses in previous bills has been a source of tension between industry and environmental groups. However, the new preemption provisions in this statute address some of those concerns.

Under TSCA's new preemption provisions, states may not establish or continue to enforce a statute or administrative action to prohibit the development or use of a chemical substance when EPA has determined that the substance does not present an unreasonable risk or is being restricted by EPA following a risk evaluation.[445] Further, states are barred from enacting new statutes or creating prohibitions from the date EPA defines the scope of or publishes a risk evaluation for a chemical substance.[446] Because the process of finalizing a risk evaluation can take years, the statute provide states with the opportunity to take action on a chemical substance within 18 months of EPA initiating the prioritization process for a chemical substance by enacting a statute or finalizing an administrative action.[447] Additionally, nothing in the statute shall be construed to preempt or otherwise affect any state

[438] *Ibid.*
[439] Sec. 6, 1(D), H.R. 2576, Frank R. Lautenberg Chemical Safety for the 21st Century Act. 114 Congress. 2016.
[440] 15 U.S.C. § 2605(b)(1)(A) (2016).
[441] 15 U.S.C. § 2605(b)(2)(A) (2016).
[442] 15 U.S.C. § 2605(b)(2)(B) (2016).
[443] 15 U.S.C. § 2605(b)(3)(A) (2016).
[444] 15 U.S.C. § 2605(b)(4)(E) (2016).
[445] 15 U.S.C. § 2617(a)(1)(B) (2016).
[446] 15 U.S.C. § 2617(b)(1) (2016).
[447] 15 U.S.C. § 2617(f)(2)(B) (2016).

law or regulation enacted or imposed prior to April 22, 2016.[448] Combined, these preemption provisions allow states to continue to enforce any laws or regulations passed prior to April 2016 and to act to ensure that any chemicals being prioritized are sufficiently regulated while EPA is evaluating a chemical and prior to EPA issuing any final restrictions or making any determinations. Once EPA issues any restrictions on a chemical, states are also free to issue identical requirements so long as the penalties are no more stringent than the penalties and sanctions available to EPA.[449] This will allow states to co-enforce restrictions and ensure chemicals are properly regulated within their borders.

Overall, the Chemical Safety Act amends and strengthens TSCA and addresses many of its major deficiencies. Ultimately, the Chemical Safety Act will lead to more information available for existing chemicals and more informed decisions for emergency response agencies, water utility companies and the public in general. However, EPA is still in the process of proposing regulations to determine how chemicals will be prioritized and assessed, and until these regulations are finalized it is unclear how the statute will be implemented. Additionally, given the large number of existing chemicals in commerce, even if EPA exceeds the minimum statutory requirements, it will take years for information to be available for all existing chemicals. Therefore, it is important for states to remain vigilant in protecting source waters and the public from potential unknown hazards.

5.7 Occupational Safety and Health Administration

The Occupational Safety and Health Act of 1970 created OSHA[450] to ensure safe and healthful conditions for working men and women. One means prescribed by Congress to achieve this goal is the mandate given to, and authority vested in, the Secretary of Labor to set mandatory safety and health standards. OSHA used this mandate to first issue an HCS in 1983 and has continued to use this authority to update the HCS. At the time of the incident, regulated entities were required to comply with the 1994 HCS, which was the most recent version of the standard in effect.

5.7.1 OSHA's Hazard Communication Standard

OSHA's HCS is a standard that covers all hazardous chemicals as well as all workplaces where they are used.[451] This regulation requires distributors to conduct a hazard determination and to transmit any hazard information to their employees and customers.[452] Providing information on hazards to customers allows them to ensure protection in their own workplace.[453] An SDS is the device used to transmit this information. For each hazardous chemical produced or imported, chemical manufacturers and importers shall obtain or develop an SDS.[454] The HCS also requires employers to provide their employees with

[448] 15 U.S.C. § 2617(e)(1)(A) (2016).
[449] 15 U.S.C. § 2617(d)(1)(B) (2016).
[450] 29 U.S.C. 15 §§ 651-678 (2012).
[451] OSHA. Hazard Communication in the 21st Century Workplace. https://www.osha.gov/dsg/hazcom/finalmsdsreport.html (August 2, 2016).
[452] 29 C.F.R. § 1910.1200(b)(1) (1994).
[453] OSHA. Hazard Communication in the 21st Century Workplace. https://www.osha.gov/dsg/hazcom/finalmsdsreport.html (August 2, 2016).
[454] 29 C.F.R. § 1910.1200(g)(1) (1994).

information about the hazardous chemicals to which they are exposed. Employers must further ensure that the SDSs for each hazardous chemical onsite are accessible to employees.[455]

The 1994 update to the HCS was the most recent version of the Hazard Communication Standard until it was amended in 2012 to be consistent with the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).[456] However, the effective date for compliance with all modified provisions of the 2012 standard was not until June 2015.[457] Therefore, at the time of the spill, Eastman (Crude MCHM), Dow (PPH, Basic) and Freedom (ShurFlot 944 and PPH, stripped) were regulated under the 1994 HCS.[458]

The 1994 HCS provides a very broad definition of "hazardous chemical" to include "any chemical which is classified as a physical hazard or a health hazard."[459] The HCS requires manufacturers and importers to conduct a hazard determination[460] in order to determine if a chemical poses either a physical[461] hazard or a health[462] hazard. The hazard determination requirement, however, is performance-oriented, and regulated parties that evaluate chemicals are not required to follow any specific methods for determining hazards.[463]

---

[455] *Ibid.*

[456] The GHS uses the term "safety data sheet" and therefore the regulation no longer uses the term "material safety data sheet." Although the content of the sheets has not changed, the formatting has. For purposes of this report, any safety sheet will be referred to as an SDS despite the fact it may not comply with the updated format and was referred to as an MSDS at the time of the spill.

[457] Compliance with all modified provisions of the 2012 standard must have taken place by June 1, 2015, except that the Distributor had until December 1, 2015, to comply with shipping containers with a GHS label.

[458] The GHS establishes standardized criteria for determining the health, environmental and physical hazards associated with chemicals. The GHS includes standardized requirements for labels and SDSs including consistent use of pictograms, signal words and harmonized statements. Under this approach, distributors, manufacturers and employers know exactly how to convey the hazards of the chemical once they complete the chemical evaluation and hazard classification. Although the 2012 amended regulation changes the way chemicals are classified and the way information is presented, it does not add any substantive requirements for developing toxicological or hazard information. Just like the 1994 HCS, the amended regulation still does not require any testing to be done and specifically states that testing is not required. Instead, chemical manufacturers, importers or employers classifying chemicals are only required to identify the full range of available scientific literature and other evidence concerning the potential hazards. Under the 2012 HCS, the evaluation and classification of mixtures is also roughly the same.

[459] 29 C.F.R. § 1910.1200(c) (1994).

[460] A "hazard determination" is the process of evaluating available scientific evidence in order to determine its hazards. 29 C.F.R. § 1910.1200, Appendix B (1994).

[461] 29 C.F.R. § 1910.1200(c) (1994): "Physical hazard" means a chemical for which there is scientifically valid evidence that it is a combustible liquid, compressed gas, explosive, flammable, organic peroxide, oxidizer, pyrophoic, unstable (reactive) or water reactive.

[462] 29 C.F.R. § 1910.1200(c) (1994): "Health hazard" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system and agents which damage the lungs, skin, eyes or mucous membranes. Appendix A of the standard provides further definitions and explanations of the scope of health hazards covered by this section, and Appendix B of the standard describes the criteria to be used to determine whether or not a chemical is to be considered hazardous for purposes of this standard.

[463] OSHA. Guidance for Hazard Determination for Compliance with the OSHA Hazard Communication Standard. https://www.osha.gov/dsg/hazcom/ghd053107.html (August 2, 2016).

Parties must be able to demonstrate that they have adequately ascertained the hazards of the chemicals produced or imported.[464] Employers, however, are not required to evaluate chemicals if they choose to rely on the evaluation performed by the chemical manufacturer or importer.[465]

The HCS considers Shurflot 944, Crude MCHM and PPH, stripped to be hazardous chemicals because of the hazards they pose. Consequently, Freedom was required to have an SDS for these mixtures that would communicate any known risks to its employees. Freedom's SDS states that PPH, stripped causes skin and serious eye irritation. Chemicals that are irritants are included under the definition of health hazard; therefore, PPH, stripped qualifies as a hazardous chemical and triggers the requirement of an SDS.

Eastman's SDS states that Crude MCHM is harmful if swallowed (toxic) and causes skin and eye irritation (irritant). The SDS also states that, at elevated temperatures, its vapor may cause eye and respiratory tract irritation (irritant). Irritants and toxic chemicals are both categories included under the definition of health hazard, which makes Crude MCHM a hazardous chemical subject to the SDS requirement.

According to Eastman, Crude MCHM sold to Freedom does not contain PPH.[466] However, the release on January 9, 2014, was a mixture of Crude MCHM and PPH, stripped—known as Shurflot 944. CSB learned that Freedom blended Crude MCHM and PPH, stripped at the ERT site prior to distribution to its customers. As a result, Freedom was required to conduct a hazard determination. If this mixture presented different hazards than those of its individual components, Freedom would have been required to create a new SDS for the new mixture.[467]

In classifying mixtures that have not been tested as a whole, manufacturers and importers shall assume the mixture to "present the same health hazards as do the components which comprise one percent or greater of the mixture."[468] According to Freedom's Hazard Communication Program for ERT, an outside consultant prepared SDSs for Freedom. It appears the consultant relied on the information included in Eastman's SDS for Crude MCHM and included the same hazards, warnings and toxicological information in Freedom's SDS for ShurFlot 944. Absent any knowledge of new hazards from the mixtures, the consultant could rely on the information included in the SDSs for Crude MCHM and PPH, stripped.

Further, under the HCS, neither Freedom nor Eastman was required to do any chemical testing because the HCS is a communication standard and does not require testing. Rather, the HCS required the parties to consider the available scientific evidence concerning the hazards.[469] Although many tests have been

[464] 29 C.F.R. § 1910.1200, Appendix B (1994).
[465] 29 C.F.R. § 1910.1200(d)(1) (1994).
[466] Eastman. Questions and Answers Regarding Eastman's Assistance in the Emergency Response to the Spill of Crude MCHM in Charleston, West Virginia, February 27, 2014. http://www.eastman.com/literature_center/misc/q_and_a_west_virginia_spill.pdf (August 5, 2016).
[467] 29 C.F.R. § 1910.1200(D)(5) (1994).
[468] 29 C.F.R. § 1910.1200(d)(5)(ii).
[469] 29 C.F.R. § 1910.1200(d)(2) (1994).

performed voluntarily, there are many chemicals for which tests have not been done.[470] As a result, limited information may be available on all aspects of a chemical's effects. Thus, the availability of test data affects the quality of the information on the SDSs. Even the best available evidence may not provide sufficient information about the hazardous effects.

Under the 1994 standard, chemical manufacturers, importers and employers who evaluate chemicals are not required to follow any specific methods for determining hazards, but they must be able to demonstrate that they adequately ascertained the hazards of the chemicals produced or imported.[471] Since testing is not required under either the 1994 HCS or the 2012 HCS, information communicated through the SDS comes from voluntary testing done by industry and/or third parties or through other statutes and regulations that may require testing for chemicals. For example, under TSCA, EPA has the authority to require chemical testing and to regulate hazardous substances. For further analysis of TSCA, refer to Section 5.6 of this report.

5.7.1.1 Toxicological Information Required under the HCS

The 1994 HCS requires health hazards, including signs and symptoms of exposure, and any medical conditions that are generally recognized as being aggravated by exposure to the chemical, to be reported on the SDS.[472] Additionally, parties are to include on their SDS the primary routes of entry[473] and whether the hazardous chemical is listed in the National Toxicology Program Report on Carcinogens or has been found to be a potential carcinogen in the International Agency for Research on Cancer Monographs or by OSHA.[474] This information is to be obtained by examining all available data on the chemicals for which an SDS is being created. Given the lack of a testing requirement, the scientific data available are often limited. This is especially true when considering mixtures.

A majority of marketed chemical products are mixtures of chemicals that are often produced by a single manufacturer.[475] Often, limited information is available for mixtures, which makes the hazards presented by mixing the chemicals difficult to predict.[476] To address this problem, the HCS requires "the chemical manufacturer to consider the mixture to have the same effects as its hazardous ingredients in most situations."[477] The "chemical and physical properties and hazards of pure elements and chemical compounds are precise and constant,"[478] but the properties of complex mixtures can vary considerably, which may result in incomplete or misleading information communicated on an SDS.

---

[470] OSHA. Hazard Communication in the 21st Century Workplace. https://www.osha.gov/dsg/hazcom/finalmsdsreport.html (August 2, 2016).
[471] 29 C.F.R. § 1910.1200, Appendix B (1994).
[472] 29 C.F.R. § 1910.1200(g)(2)(iv) (1994).
[473] *Ibid.*
[474] 29 C.F.R. § 1910.1200(g)(2)(vi) (1994).
[475] OSHA. Hazard Communication in the 21st Century Workplace. https://www.osha.gov/dsg/hazcom/finalmsdsreport.html (August 2, 2016).
[476] *Ibid.*
[477] This is true where there are no available data for the specific mixture; *Ibid.*
[478] OSHA. Guidance for Hazard Determination for Compliance with the OSHA Hazard Communication Standard. https://www.osha.gov/dsg/hazcom/ghd053107.html (August 2, 2016).

The HCS has specific requirements for mixtures that depend on the availability of test data. Under the 1994 HCS, if a mixture has been tested as a whole, then those results should be used to determine whether the mixture is hazardous.[479] However, if a mixture has not been tested as a whole for health hazards, the mixture shall be assumed to present the same hazards as components that comprise 1% or more of the mixture.[480] Where mixtures are complex and include numerous chemicals, the SDS for that mixture is also complicated and the user is required to make some judgments on how to apply the information in a certain situation.

The HCS defines a mixture as any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.[481] Although on the day of the incident and in the days following the material that leaked from tank 396 was referred to as Crude MCHM and PPH, stripped, CSB found that Freedom sold this mixture under the commercial name Shurflot 944.[482] The SDS for Shurflot 944 states that it consists of a blend of alcohols, glycol ethers and carboxylates and does not specifically disclose that it consists of Crude MCHM and PPH, stripped. Under the toxicological information section, Freedom included the same information for skin sensitization and acute oral and dermal toxicity as was included in the Crude MCHM SDS. CSB found no evidence of Freedom conducting further testing on the Shurflot 944 mixture; therefore, it is not known whether the mixture as a whole presents greater hazards than its individual components.

5.7.2 Flammable and Combustible Liquids under 29 C.F.R. § 1910.106

Immediately after the spill, OSHA's Charleston Area Office inspected the Freedom facility and cited the company for three violations. One of the citations was for the deteriorating containment wall, which was required to be liquidtight under 29 C.F.R. § 1910.106. Because Freedom was storing flammable liquids, the company was required to comply with 29 C.F.R. § 1910.106, which regulates facilities that have flammable and/or combustible liquids stored onsite. Under the regulation, "flammable liquid" means any liquid having a flash point at or below 199.4°F (93°C). Flammable liquids are further divided into four categories based on a chemical's flash point and boiling point; however, any chemical with a flash point below 199.4°F, regardless of class, is covered under the subsection requiring dikes and/or drainage.

According to Eastman's SDS, Crude MCHM has a flash point of 235.04°F (112.8°C) and according to Freedom's SDSs for PPH, stripped and Shurflot 944, both have a flash point of over 253°F (122.78°C). None of these chemicals would appear to be flammable nor within the scope of § 1910.106; however, after the incident OSHA found the flash point of the sampled liquid to be much lower. Immediately after the spill, OSHA collected samples of the spilled material that was transported to the Poca Blending facility. On January 9, 2014, and in the days that followed, the contents of the Freedom tanks were transported to Poca Blending by Diversified Services and were stored in five Baker Frac Tanks[483] at that

[479] 29 C.F.R. § 1910.1200(d)(5)(i) (1994).
[480] 29 C.F.R. § 1910.1200(d)(5)(ii) (1994).
[481] 29 C.F.R. § 1910.1200(g)(c) (1994).
[482] OSHA obtained samples of the spilled material on the day of the incident after they were transported to the Poca blending site. The samples were analyzed by the Salt Lake Technical Center. See Section 3.1.
[483] Baker Frac Tanks were used to hold the material cleaned up at Freedom Industries following the spill. These steel tanks provide flexible liquid containment capacity for projects.

site. One of the Frac Tanks at Poca purportedly contained the contents of tank 396 and four other Frac Tanks contained a mixture of liquids transported from tanks 395, 396 and 397. OSHA collected a sample from each one of these tanks and the samples were shipped to the OSHA Salt Lake Technical Center[484] to determine the liquid's flash point. SLTC determined that the samples taken from the Frac Tank that contained material from tank 396 had a flash point of 199.8°F (93.22°C). The other four samples that contained mixtures from tanks 395, 396 and 397 had flash points of 204.8°F (96°C), 192.7°F (89.28°C), 193.1°F (89.5°C) and 191.3°F (88.5°C), respectively.

Because the tests conducted by SLTC yielded flash points below 199.4°F, the tanks containing spilled liquid were subject to the provision pertaining to drainage, dikes and walls for ASTs under § 1910.106.[485] Under this provision, the area surrounding a tank or a group of tanks containing flammable liquids shall be provided with drainage or shall be diked to prevent accidental discharge of liquid from endangering adjoining property or reaching waterways.[486] 29 C.F.R. § 1910.106 requires the "walls of the diked area shall be of earth, steel, concrete or solid masonry designed to be *liquidtight* and to withstand a full hydrostatic head."[487] The Freedom facility had a containment wall that surrounded all of the ASTs and extended the length of the property. This dike was to serve as a secondary containment system in case of a spill. However, this wall was in disrepair and was not liquidtight, as evidenced by visual examination (see Figure 24 in Section 3.3.2) and the liquid that leaked through the wall on January 9, 2014.

[484] The Salt Lake Technical Center laboratory analyzes over 400 chemicals and maintains OSHA's online Chemical Sampling Information File that provides method and sampling information. See Section 3.1 for a more detailed discussion of the chemical testing conducted at SLTC.
[485] 29 C.F.R. § 1910.106(b)(2)(vii) (2016).
[486] 29 C.F.R. § 1910.106(b)(2)(vii) (2016).
[487] 29 C.F.R. § 1910.106(b)(2)(vii)(c)(3) (2016).

6.0 KEY FINDINGS

Chemical Safety Board (CSB) investigators gathered information to understand both the technical cause of the incident as well as the role of WVAW and federal, state and local agencies when responding to the contaminated water supply. In examining these issues, CSB identified the following key findings:

1. At Freedom Industries, a mixture containing Crude MCHM and PPH, stripped leaked from an aboveground storage tank (tank 396) through two holes. These holes, measuring approximately 0.75 and 0.4 inches in diameter, formed due to pitting corrosion that degraded the thickness of the tank floor from the interior. Although the soil side of the tank bottom was corroded as most tank bottoms are, the amount of soil side corrosion was insignificant compared to the pitting corrosion that directly led to the incident.

2. Once the mixture escaped tank 396, it moved through the soil beneath the tank and migrated to the Elk River through two pathways: (1) the failing secondary containment wall located between tank 396 and the Elk River, and (2) a deteriorated underground culvert located around tank 396.

3. CSB found no documentation of prior inspections or maintenance conducted by Freedom or the prior facility owner, Etowah River Terminal (ERT), which would have identified and addressed internal corrosion in tank 396. Such inspections and maintenance could have identified and addressed the interior corrosion and holes in tank 396.

4. Freedom was required to maintain adequate secondary containment under the West Virginia/National Pollutant Discharge Elimination System (NPDES) General Water Pollution Control Permit's Stormwater Pollution Prevention Plan and the Groundwater Protection Rule. Freedom was aware of the deteriorated secondary containment wall but did not repair it prior to the incident. CSB found no evidence that Freedom or ERT implemented a Stormwater Pollution Prevention Plan or Groundwater Protection Plan. WVDEP did not inspect the site for compliance with these programs due to resource constraints.

5. Freedom did not have any leak prevention or leak detection system in place to immediately provide notification of tank leaks.

6. Once the mixture containing Crude MCHM and PPH, stripped entered the Elk River, it flowed into WVAW's water intake, located about 1.5 miles away from the Freedom facility site. The water treatment process was not capable of fully treating and removing the chemical. This allowed the mixture to contaminate the drinking water.

7. WVAW and WVBPH decided WVAW could not shut down its drinking water treatment system because there was no alternative raw water supply and doing so could have compromised fire protection and sanitation. In addition, depressurizing the water distribution system would have caused extensive damage and further delays in water restoration. Accordingly, a "Do Not Use" order was issued less than two hours after WVAW detected odors in the treated water intended

for distribution.

8. The DNU order was not issued immediately because WVAW was mistakenly informed that MCHM was a flocculant, rather than a frothing agent, and that only 1,000 gallons was released. WVAW assumed its water treatment and filtration system was capable of fully treating and removing the chemical from the water.

9. Source water protection efforts vary by state, and as a result, surface water treatment plants across the United States are subject to different requirements to protect drinking water sources. In response to new state requirements after the Freedom incident, WVAW submitted a source water protection plan to WVBPH that goes beyond existing federal requirements. Because American Water (AW) provides guidance and some oversight through required policies to its subsidiary water utilities across the United States, AW is well positioned to establish requirements for its subsidiary surface water treatment plants to develop and implement plans similar to WVAW's plan to ensure they are adequately prepared for potential contamination events.

10. Local, state and federal public health officials only had information from Eastman's Crude MCHM Safety Data Sheet and later, toxicological studies, to communicate to the public and credibly determine the risk of exposure. As the crisis evolved, residents in the Charleston area were given unclear and conflicting announcements because of the changing information from Freedom and government agencies, which increased public uncertainty about the safety of the drinking water.

11. The American Water Works Association, a nonprofit scientific and educational association for managing and treating water, is well positioned to assist water utilities by disseminating important lessons that are learned from chemical contamination incidents that could potentially affect a drinking water distribution system.

7.0 LESSONS LEARNED

CSB's investigation of Freedom led the agency to find several issues related to identifying and assessing hazardous chemicals stored near water treatment intakes, as well as responding to and communicating public health risks during drinking water contamination incidents. Since the incident, the State of West Virginia, WVAW, and other agencies and organizations have established requirements and implemented practices that have addressed many of the gaps that CSB identified early in its investigation. Because requirements regarding ASTs and source water protection vary by state, CSB has developed the following key lessons for AST owners and operators, state governments, drinking water utilities and public health officials across the United States to use so that they are adequately prepared for, can respond to and are able to effectively communicate the public health risks of an incident involving the release of a hazardous chemical near a drinking water source.

1. AST owners and operators of facilities storing chemicals near drinking water sources should establish regular inspection programs and routinely monitor tanks and secondary containment to verify tank integrity and containment of leaks. They should coordinate with nearby water utilities and emergency response organizations to ensure that the information about their stored chemicals (e.g., chemical characteristics, quantity, toxicological information) is communicated and can be made immediately available in the event of a leak.

2. AST owners and operators covered under existing regulatory programs (e.g., Spill Prevention, Control, and Countermeasure; National Pollutant Discharge Elimination System) should ensure that the associated spill prevention and protection plans under those programs are updated and implemented to reduce the potential for leaks from ASTs and secondary containment.

3. Due to the large number of existing chemicals in commerce, the Environmental Protection Agency's review of all chemicals under the federal Toxic Substances Control Act could take years. Many of these chemicals lack toxicological information; therefore, states should take immediate action to protect source waters and the public from these unknown and potentially hazardous chemicals. This can be achieved through increased inspections and enforcement at chemical storage facilities near water sources and coordination between emergency response organizations and public health agencies.

4. States should establish Source Water Assessment Programs that mandate source water protection planning by water utilities. States should ensure that water utilities have full and simple access to the data necessary to support this mandate. Water utilities should complete Source Water Protection Plans that include the following components:

    a. System operational information;
    b. Source water delineation and characterization;
    c. Potential significant sources of contamination;
    d. Management strategies;
    e. Source water monitoring;
    f. Communications and contingency; and
    g. Alternate sources of supply.

Source Water Protection Plans should be updated at least every three years or when there is a substantial change in the potential sources of significant contamination within the identified zone of critical concern.

5. Water utilities should engage with their Local Emergency Planning Committee and/or State Emergency Response Commission to obtain Tier II information and use that information to identify water intakes that could potentially be at risk of contamination from those chemicals in the event of a spill.

6. Water utilities should assess the capabilities of their water treatment systems to treat and remove potential leaks from all potential sources of significant contamination within their zone of critical concern. Where feasible, water utilities should use established laboratory analytical methods to detect the presence or measure the concentration of potential hazardous chemicals or classes of hazardous chemicals.

7. Public health agencies should coordinate with water utilities, emergency response organizations and facilities that store chemicals near drinking water sources to ensure that information concerning chemicals and potential risks to the public are immediately available in the event of a spill. They should establish a communication framework to ensure information, as it becomes available, is communicated through one entity or organization.

8.0 RECOMMENDATIONS

Several of the causal and contributing factors identified by CSB with respect to this incident have since been addressed by new legislation in West Virginia, revised policies and programs within WVDEP and WVAW, and the fact that Freedom Industries is no longer in operation. As a result, CSB's recommendations from this investigation focus on ensuring that water utilities and public health agencies are able to obtain prompt and reliable information about potential drinking water contaminants and clearly communicate public health risks.

Pursuant to its authority under 42 U.S.C. § 7412(r)(6)(C)(i) and (ii), and in the interest of promoting safer operations at AST facilities and protecting workers and communities from future accidents nationally, CSB makes the following safety recommendations:

The American Water Works Association

2014-01-I-WV-R1 Communicate the findings, lessons learned and recommendations contained within this report to all American Water Works Association members. Emphasize the importance of source water protection planning, emergency planning, and coordination with local, state and federal entities, and the public, to ensure timely notification of potential water contamination events and emergencies.

American Water Works Company, Inc.

2014-01-I-WV-R2 Establish requirements for all American Water state utilities' surface water treatment plants to undertake the following activities:

1. Conduct an inventory of all hazardous chemicals or classes of hazardous chemicals that are considered a potential source of significant contamination stored in the utility's most vulnerable source water protection area (e.g., Zone of Critical Concern). Chemicals may be identified by accessing publicly available information, which may include Tier II reporting forms submitted to local emergency planning committees and electronically available information from federal, state or local databases.
2. For each inventoried chemical or class of chemicals, conduct a prioritized assessment to determine if existing analytical methods are available to detect the presence and/or concentration of the chemical or class of chemicals in the event of a release to the water supply and if the chemical or class of chemicals is capable of being treated or removed by the utility's water treatment process.
3. For all chemicals or classes of chemicals that are not capable of being treated or removed by the treatment process, develop a contingency plan to respond to contamination events (e.g., as modeled by WVAW's Kanawha Valley Water System June 2016 Source Water Protection Plan).

Eastman Chemical Company

2014-01-I-WV-R3 Update appropriate sections of the Crude MCHM Safety Data Sheet to include toxicological and ecological information based on the June 1, 2016, National Toxicology Program's toxicity evaluation of Crude MCHM. Include information

about the effects of Crude MCHM on fetal and early life growth and development. Distribute the revised Crude MCHM SDS to all customers that previously received and are currently using or storing MCHM from Eastman, and ensure all new MCHM customers receive the revised SDS with shipment.

This signature block is placed immediately after the last recommendation.

By the
U.S. Chemical Safety and Hazard Investigation Board

Vanessa Allen Sutherland
Chair

Kristen Kulinowski
Member

Manuel Ehrlich
Member

Richard Engler
Member

Date of Board Approval

APPENDIX A: TANK LEAK TIMELINE

Table 11. Detailed MCHM Leak Timeline

Date	Time	Event
January 9, 2014	~5:00 AM	Charleston Fire Department (FD) Shift Commander reports detecting a "licorice" smell over a very large area in Charleston[488]
	8:16 AM	WVDEP receives a complaint about an unknown odor near the I-77 and I-79 split[489]
	9:29 AM	Additional complaints received through Kanawha County Metro 911[490]
	11:05 AM	WVDEP inspectors arrive at Freedom facility; Freedom employee notices MCHM pooled liquid around the bottom of the tank and flowing toward retaining wall
	~11:36 AM	WVDEP observes pool of leaked chemicals around the containment tanks at Freedom facility
	11:56 AM	WVDEP notifies WVAW Water Quality Supervisor of a possible flocculant spill of unknown quantity in Elk River
	12:22 PM	WVDHHR notifies WVAW that Crude MCHM, described as "a flocculant" is leaking into the river
	~12:30 PM	WVAW Water Quality Supervisor arrives at Freedom facility to assess leak
	12:52 PM	WVAW Water Quality Supervisor requests WVAW start feeding powder activated carbon and increase potassium permanganate ($KMnO_4$)
	1:00-1:30 PM	WVAW Water Quality Supervisor reviews a copy of SDS for Crude MCHM from Freedom, notes chemicals are not consistent with what he expected for a flocculant
	1:42 PM	WVAW Water Quality Supervisor informs WVAW management that Crude MCHM is not a flocculant, but instead a frothing agent
	2:00 PM	Odor detected in raw water sample from Elk River
	2:00 PM	WVDEP Emergency Response coordinator called Kanawha Office of Emergency Management reporting that the spill was more than originally thought[491]

[488] West Virginia Office of the Attorney General. Elk River Chemical Spill Incident Report. http://www.ago.wv.gov/Documents/010815-ElkRiverChemicalSpill.PDF (July 8, 2016).
[489] *Ibid.*
[490] *Ibid.*
[491] Kanawha Putnam Emergency Planning Committee. West Virginia American Water Incident. After Action Report. 2014.

	4:00 PM	Odor detected downstream of WVAW filters
	5:15 PM	Freedom President informs WVAW that 1,000 to 5,000 gallons of tank contents may have leaked
	5:36 PM	Governor issues statement advising residents to restrict tap water usage.[492]
	5:45 PM	WVAW issues DNU order for WVAW customers
	8:00 PM	Kanawha Charleston Health Department closes local businesses
	9:34 PM	Governor Tomblin declares state of emergency for nine counties[493]
January 10, 2014	6:00 AM	President Obama declares nine affected West Virginia counties a federal disaster area[494]
		CDC informs WVBPH that 1 part per million (ppm) is the appropriate screening level for oral ingestion of 4-MCHM-contaminated water
	7:30 AM	National Guard sampling detects concentrations of 4-MCHM at 3.35 ppm at the WVAW raw water intake and 2.4 ppm post-treatment by WVAW[495]
January 13, 2014		WVAW and WVBPH advises residents to flush pipes where 4-MCHM levels are below 1 ppm
		DNU order lifted for approximately 25,000 customers[496]
January 14, 2014		DNU order lifted for additional areas (48,000 customers total)[497]
January 15, 2014	7:00 AM	346 patients treated at local hospitals within 6 days of the release
	7:00 AM	4-MCHM detected in Ohio River at water treatment facilities in Ohio and Kentucky[498]
		CDC and WVBPH issue drinking water advisory for pregnant women

[492] Governor Tomblin. Twitter message. January 9, 2014. https://twitter.com/WVGovernor/status/421410251238170624 (February 7, 2017).
[493] Governor Tomblin. Twitter message. January 9, 2014. https://twitter.com/WVGovernor/status/421467517677105152 (February 7, 2017).
[494] FEMA. News Release: President Obama Signs West Virginia Emergency Declaration. http://www.fema.gov/news-release/2014/01/10/president-obama-signs-west-virginia-emergency-declaration (July 8, 2016).
[495] Office of the Governor. WV Governor After Action Review. http://www.governor.wv.gov/Documents/After%20Action%20Review.PDF (July 8, 2016).
[496] House Transportation and Infrastructure Committee. Testimony of Jeffrey L. McIntyre. http://www.amwater.com/files/McIntyre%20Testimony%202%206%202014%20Final.pdf (July 8, 2016).
[497] *Ibid.*
[498] On January 15, 2014, at 7:00 AM, 4-MCHM was detected in the Ohio River by Greater Cincinnati Water Works, and Louisville's Zorn Avenue intake detected a concentration at 3.5 parts per billion in river water on January 18, 2014.

		DNU order lifted for additional areas (56,800 customers total)[499]
January 16, 2014		DNU order lifted for additional areas (71,000 customers total)[500]
January 17, 2014	6:50 AM	Do Not Drink/Limited Contact order issued for certain areas; additional flushing and sampling needed due to 4-MCHM readings >1 ppm[501]
	12:50 PM	DNU ordered lifted for additional areas[502]
January 18, 2014		DNU order lifted for all areas[503]
January 21, 2014		Freedom announces PPH, stripped also present in leaking tank
January 27, 2014		Freedom revises spill estimate to 10,000 gallons[504]

[499] House Transportation and Infrastructure Committee. Testimony of Jeffrey L. McIntyre. http://www.psc.state.wv.us/scripts/WebDocket/ViewDocument.cfm?CaseActivityID=388885&NotType=%27WebDocket%27 (July 8, 2016).
[500] *Ibid.*
[501] *Ibid.*
[502] *Ibid.*
[503] *Ibid.*(July 8, 2016).
[504] WVDEP. News Release: Freedom Industries revises estimate for spill. January 27 2014. http://www.dhsem.wv.gov/Documents/Freedom%20revises%20estimate.pdf (February 7, 2017).

APPENDIX B: FREEDOM OFFICIALS

As a result of the release of the mixture containing Crude MCHM and PPH, stripped into the Elk River, six Freedom officials were charged with criminal violations. Table 12 lists the charges to which each individual pleaded guilty. On February 4, 2016, Freedom was issued a $900,000 criminal fine for three violations even though the company had filed for bankruptcy in 2014.[505]

Table 12. Summary of Freedom Fines and Charges

Freedom Official	Sentencing	Fines	Charges
President[506]	30 Days in Jail	$20,000	1. Negligent discharge of a pollutant 2. Unlawful discharge of refuse matter into navigable water 3. Negligent violation of permit condition
Former Shareholder and Former President[507]	30 Days in Jail	$20,000	1. Unlawful discharge of refuse matter into navigable water 2. Negligent violation of permit Condition
Former Shareholder and Former Vice President[508]	3 Years of Probation	$20,000	1. Unlawful discharge of refuse matter into navigable water
Former Shareholder and Former Treasurer-Secretary[509]	3 Years of Probation	$20,000	1. Unlawful discharge of refuse matter into navigable water
Operations Manager[510]	3 Years of Probation	$2,500	1. Negligent discharge of a pollutant
Environmental Manager[511]	3 Years of Probation	$10,000	1. Negligent discharge of a pollutant
Total		$92,500	

[505] Freedom Industries and Former Freedom Industries Plant Manager Sentenced for Roles in Chemical Spill. February 4, 2016. https://www.justice.gov/usao-sdwv/pr/freedom-industries-and-former-freedom-industries-plant-manager-sentenced-roles-chemical (September 15, 2016).
[506] United States v. Gary Southern, No. 2: 14-cr-00264-4, Dkt. No. 296 (S.D.W.Va.).
[507] United States v. Dennis Farrell, No. 2: 14-cr-00264-1, Dkt. No. 281 (S.D.W.Va.).
[508] United States v. Charles Herzing, No. 2:14-cr-00264-3, Dkt. No. 260 (S .D.W.Va.).
[509] United States v. William Tis, No. 2:14-cr-00264-2, Dkt. No. 277 (S.D.W.Va.).
[510] United States v. Michael Burdette, No. 2:14-cr-00276, Dkt. No. 43 (S.D.W.Va.).
[511] United States v. Robert Reynolds, No. 2:14-cr-00277, Dkt. No. 42 (S.D.W.Va.).

APPENDIX C: LEAKING PIPES AND WATER MAIN BREAKS

The American Society of Civil Engineers (ASCE) estimated that more than 1 million miles of water mains are in place in the United States and the condition of many of these pipes is unknown, largely due to pipes being located underground. Aging infrastructure poses a challenge in maintaining pipelines as many of these pipes were installed in the mid-1800s. In 2013, ASCE estimated 240,000 water main breaks per year and EPA estimates that approximately 4,000 to 5,000 miles of drinking water mains are replaced annually.[512] ASCE also reports that up to $1.3 trillion in investment could be required for water and wastewater infrastructure in the United States before 2035.[513] WVAW was the first water system in West Virginia to use electronic devices to locate and pinpoint underground leaks; however, even with the use of leak detection equipment and technology, WVAW continues to experience some level of "unaccounted-for water."[514] In WVAW's 2016 Source Water Protection Plan, WVAW estimated 3,112,781,000 gallons of total unaccounted for water in 2015. In addition, an estimated 1,136,839,000 gallons of water was lost from main leaks. Water mains often experience breaks, introducing potential contaminants to the public drinking water that is supplied through these mains. When this occurs, water utilities issue Boil Water Notices or Do Not Use notices depending on the severity of the potential contamination. As a result of the Freedom incident, WVAW issued a DNU; however, it was not as a result of a leaking pipe or water main break.

[512] American Society of Civil Engineers. 2013 Report Card for America's Infrastructure. 2013. http://www.infrastructurereportcard.org/a/#p/drinking-water/conditions-and-capacity (September 28, 2016).
[513] American Water. Corporate Social Responsibility Report 2013-2014. American Water: New Jersey. 2015.
[514] Public Service Commission. Case No. 06-0597-W-PC. November 21, 2006, p. 19. http://www.psc.state.wv.us/scripts/webdocket/ViewDocument.cfm?CaseActivityID=197353&NotType='WebDocket' (September 28, 2016).

APPENDIX D: TOXICOLOGY

Toxicology is the study of adverse effects of chemicals on living organisms.[515] Toxicity tests are conducted on laboratory animals to ascertain the toxic effects of chemicals and their applicability to humans. When determining the effects of a chemical toxicological tests examine the dose response relationship. Lethal dose 50 (LD_{50}), is a threshold used to determine the lethal effect of a toxic agent on the median or 50% of the population tested. Two main principles guide all animal studies: "(1) the effects produced by a compound in laboratory animals, when properly quantified, are applicable to humans, and (2) the exposure of experimental animals to toxic agents in high doses is a necessary and valid method of discovering possible hazards in humans because of the incidence of an effect in a population is greater as the dose or exposure increases."[516] Toxicity studies are not designed to characterize whether a chemical is safe but to determine the effects it can produce.[517]

Various types of toxicological studies exist to assess a chemical's toxicity. When the effects of a new chemical are being analyzed, the first types of studies conducted are acute toxicity studies followed by subchronic and chronic studies (see Table 13). The study types are described below.

Table 13. Typical Duration of Toxicological Studies

Study	Typical Duration
Acute	<24 hours
Subacute	<30 days
Subchronic	<90 days
Chronic	>90 days

An acute toxicity study is the first type of toxicity test performed on a new chemical. Studies may use more than one route of exposure (oral or the intended route of exposure) based on knowledge of the intended use or exposure profile. Animals are given a one-time dose and monitored for a 14-day period. Acute toxicity studies establish the LD_{50} dose, and other clinical effects of the chemical, establish whether the toxic response is reversible and provides baseline guidance on ranges of response at different doses for other studies. Acute dermal and inhalation studies are a type of acute toxicity studies that are conducted if substantial dermal and inhalation exposures are expected. In a dermal study, the site of exposure on the animal is shaved and a high dose of the chemical is applied 24 hours, removed and then followed by an observation period of 14 days, whereas in an inhalation study the exposure to the chemical occurs for 6 hours. Significant information is obtained through clinical observations and postmortem examination of animals rather than the LD_{50} value in acute toxicity studies.

Subacute toxicity studies help to understand the toxicity of a chemical after repeated administration usually over 28 days. Subchronic exposure tests the chemical for 90 days to establish a lowest observed adverse effect level, establish a no observed adverse effect level and examine the specific organ(s) affected by the chemical after repeated administration. This type of study is usually conducted in four

[515] Klaassen, C. D.; Watkins, J. B. III. *Casarett & Doull's Essentials of Toxicology*; McGraw-Hill: New York, 2003.
[516] *Ibid.*
[517] *Ibid.*

groups of ten animals each (male and female) using three doses – a high dose, an intermediate dose and a low dose (producing no toxic effect) – and an untreated control. Animals are observed daily for signs of toxicity. Further analysis is conducted after termination.

APPENDIX E: SPILL PREVENTION, CONTROL AND COUNTERMEASURE

When enacted, the CWA gave the President of the United States the authority to prevent, control and mitigate the discharge of oil and hazardous substances into certain domestic waterways. The President then delegated his authority to EPA. EPA developed its SPCC regulations pursuant to this authority; however, in doing so, it limited the scope of its regulations to pertain only to oil, even though EPA had the authority under the CWA to promulgate associated regulations for hazardous substances.[518] As a result, for over 40 years, EPA's SPCC program has applied only to oil—that is, until approval of a February 2016 settlement agreement whereby EPA agreed to begin rulemaking to include hazardous substances in its SPCC regulations. This settlement agreement will be discussed at the end of this section.

Generally, SPCC regulations strive to prevent oil from entering navigable waters through the prevention, control and mitigation of oil spills.[519] This is achieved primarily through the development of SPCC plans.[520] SPCC plans are required for facilities that store oil and oil-containing products exceeding certain capacity thresholds where there is a possibility that an oil spill would reach a navigable water.[521] Specifically, any facility that maintains a total aboveground oil storage capacity of greater than 1,320 gallons, or a total underground oil storage capacity of greater than 42,000 gallons, where there is a reasonable potential for a discharge to reach navigable waters, is subject to SPCC regulatory requirements.[522] Aboveground storage containers with a capacity of 55 gallons or more are included in the aboveground capacity threshold calculation.[523] Certain facilities, tanks, containers, materials, equipment

[518] 33 U.S.C. § 1321(b)(2)(A).

[519] EPA. Spill Prevention, Control, and Countermeasure (SPCC) Regulation, 40 CFR part 112: A Facility Owner/Operator's Guide to Oil Pollution Prevention. https://www.epa.gov/sites/production/files/documents/spccbluebroch.pdf (February 7, 2017). The SPCC rule's definition of oil derives from CWA § 311(a)(1), which defines oil as "oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil."

[520] EPA. Spill Prevention, Control, and Countermeasure (SPCC) Regulation, 40 CFR part 112: A Facility Owner/Operator's Guide to Oil Pollution Prevention. https://www.epa.gov/sites/production/files/documents/spccbluebroch.pdf (February 7, 2017). SPCC plans are not required to be submitted to EPA; rather, they must be kept onsite.

[521] *Ibid.*

[522] *Ibid*; 40 C.F.R. pt. 112.1.

[523] EPA. Spill Prevention, Control, and Countermeasure (SPCC) Regulation, 40 CFR part 112: A Facility Owner/Operator's Guide to Oil Pollution Prevention. https://www.epa.gov/sites/production/files/documents/spccbluebroch.pdf (February 7, 2017).

and lines/piping are exempted.[524] When calculating the total storage capacity of the facility, exempted oil containers and oil equipment should not be included.[525]

SPCC plans must clearly address the following: (1) operating procedures to prevent oil spills, (2) control measures to prevent a spill from reaching navigable waters, and (3) countermeasures to contain, clean up and mitigate the effects of an oil spill that reaches navigable waters.[526] The plans must be facility-specific.[527] As such, development of an SPCC plan requires detailed knowledge of the facility, including the location and capacity of oil-based storage, and the potential effects an oil spill might have on the area, environment and natural resources.[528] SPCC plans must include certain standard elements to ensure compliance with SPCC regulations.[529] Important elements of an SPCC plan include the following:

1. Facility diagram and description of the facility.
2. Oil discharge predictions.
3. Appropriate secondary containment or diversionary structures.
4. Facility drainage.
5. Site security.
6. Facility inspections.
7. Requirements for bulk storage containers including inspections, overfill and integrity testing requirements.
8. Transfer procedures and equipment (including piping).
9. Requirements for qualified oil-filled operational equipment.
10. Loading/unloading rack requirements and procedures for tank cars and tank trucks.
11. Brittle fracture evaluations for aboveground field constructed containers.

---

[524] Specifically, EPA exempts the following: (1) any facility where the completely buried oil storage capacity is 42,000 gallons or less and the aggregate aboveground oil storage capacity is 1,320 gallons or less; (2) completely buried oil tanks and associated piping and equipment that are subject to all of the technical requirements under 40 C.F.R. pt. 280 or 281; (3) underground oil storage tanks, including below-grade vaulted tanks that supply emergency diesel generators at a nuclear power generation facility licensed by the Nuclear Regulatory Commission (NRC) and subject to any NRC provision regarding design and quality criteria, including but not limited to 10 C.F.R. pt. 50; (4) permanently closed oil containers; (5) any container with an oil storage capacity less than 55 gallons; (6) any facility or part thereof used exclusively for wastewater treatment; (7) motive power oil containers; (8) hot-mix asphalt or any hot-mix asphalt container; (9) containers storing heating oil used solely at a single-family residence; (10) pesticide application equipment or related mix containers (with adjuvant oil); (11) intra-facility oil gathering lines subject to the regulatory requirements of 49 C.F.R. pt. 192 or 195; and (12) any milk and milk product container and associated piping and appurtenance. 40 C.F.R. pt. 112.1(d); EPA. Office of Emergency Management. SPCC Guidance for Regional Inspectors. Chapter 2 SPCC Rule Applicability. December 16, 2013. https://www.epa.gov/sites/production/files/2014-04/documents/2_applicability_2014.pdf (February 7, 2017).

[525] 40 C.F.R. pt. 112.1(d); EPA. Office of Emergency Management. SPCC Guidance for Regional Inspectors. Chapter 2 SPCC Rule Applicability. December 16, 2013. https://www.epa.gov/sites/production/files/2014-04/documents/2_applicability_2014.pdf (February 7, 2017).

[526] EPA. Spill Prevention, Control, and Countermeasure (SPCC) Regulation, 40 CFR part 112: A Facility Owner/Operator's Guide to Oil Pollution Prevention. https://www.epa.gov/sites/production/files/documents/spccbluebroch.pdf (February 7, 2017).

[527] *Ibid.*

[528] *Ibid.*

[529] *Ibid.*

12. Personnel training and oil discharge prevention briefings.
13. Recordkeeping requirements.
14. 5-year plan review.
15. Management approval.
16. Plan certification (by a professional engineer (PE) or, in certain cases, by the facility owner/operator).[530]

When the facility was owned and operated by Pennzoil prior to Freedom, it was a facility known to EPA Region 3, meaning it had been inspected and had an SPCC plan in place. According to EPA Region 3 records, when Freedom took over, it was no longer storing oil, and thus was no longer subject to SPCC regulations. However, when EPA analyzed a sample of a substance that Freedom called "fatty acid" post-incident, EPA determined through laboratory analysis that the fatty acid substance was classified as a type of oil that should have been covered by an SPCC plan. Freedom failed, however, to develop, implement, and obtain PE certification of such a plan after acquiring the site from ERT.

The Freedom spill highlights the fact that EPA has not yet issued regulations under SPCC that apply to hazardous substances. On July 21, 2015, the Natural Resources Defense Council (NRDC) filed a complaint on behalf of the Environmental Justice Health Alliance for Chemical Policy Reform (EJHA) and People Concerned About Chemical Safety against EPA in the U.S. District Court for the Southern District of New York, alleging that EPA had failed to prevent hazardous substance spills from industrial facilities, including ASTs.[531] The complaint set forth that, in 1978, EPA proposed hazardous substance spill regulations that would have applied to onshore facilities operating under NPDES permits, and that EPA announced anticipating the proposal of such regulations in the near future, but that EPA never finalized its proposed regulations. NRDC sought a declaration that EPA delayed initiation of the rulemaking process for hazardous substance spill regulations unreasonably, as well as an injunction ordering EPA to begin the rulemaking process without delay, setting an expeditious, enforceable schedule for EPA to follow.

EPA and NRDC ultimately decide to settle and on February 16, 2016, the United States District Court for the Southern District of New York filed a consent decree, providing the details of their settlement.[532] The settlement detailed in the consent decree requires EPA to begin a rulemaking process immediately and to finalize spill prevention rules for hazardous substances within a set time frame.[533] Within this time frame, EPA agreed to follow specific deadlines for certain rulemaking milestones.[534] For example, no later than 18 months after entry of the consent decree, EPA agreed to sign (and within 15 days thereafter transmit to the Office of the Federal Register) a notice of proposed rulemaking pertaining to the issuance of the

---

[530] *Ibid.*
[531] Environmental Justice Health Alliance for Chemical Policy Reform et al. v. U.S. Environmental Protection Agency, et al., No. 1:15-cv-05705 (S.D.N.Y. July 21, 2015); E. Lynn Grayson. Court Orders New EPA Spill Prevention Rules. Lexology. February 18, 2016. http://www.lexology.com/library/detail.aspx?g=4ce2702e-700b-4a6c-b630-3ccae05b459c.
[532] Environmental Justice Health Alliance for Chemical Policy Reform et al. v. U.S. Environmental Protection Agency, et al., No. 1:15-cv-05705-SAS (S.D.N.Y. February 16, 2016).
[533] *Ibid.*
[534] *Ibid.*

hazardous substance regulations, unless, if no later than 60 days after entry of the consent decree, EPA notified NRDC of its intent to publish a Federal Register notice regarding the collection of information.[535] If EPA notifies NRDC of this intent, the deadline for signing a notice of proposed rulemaking is extended to 28 months after entry of the consent decree.[536] The consent decree also states that, no later than 14 months after publication of the proposed hazardous substance regulations, EPA will sign (and within 15 days thereafter transmit to the Office of the Federal Register) a notice taking final action following notice and comment rulemaking pertaining to the issuance of hazardous substance regulations.[537]

EPA has notified NRDC of its intent to collect more information and is currently drafting, along with NRDC, an Information Collection Request (ICR) to learn more about facilities that store hazardous substances. In part, this effort is meant to provide EPA with more information on the pertinent issues at such facilities so that EPA can create a set of regulations that does not conflict with existing requirements or standards. EPA anticipates sending this ICR primarily to facilities, but possibly to states as well. EPA is considering sending the ICR to states because some states already have regulations for ASTs that contain hazardous substances and, again, does not want to create a conflicting set of regulations. Because of the timely nature of EPA's notification to NRDC, the proposed rule and final rule publication deadlines will be postponed to June 2018 and August 2019, respectively.

Before filing the consent decree, EPA wrote a Letter of Intent to NRDC on February 11, 2016, indicating its intention to provide biannual updates to NRDC, EJHA, PCACS and the public on its progress in the development of the proposed rule and any subsequent final rule.[538] Additionally, EPA stated that it intends to hold in 2016 a minimum of three opportunities, called community stakeholder sessions, for community stakeholders to provide their views on topics relevant to the prevention of discharges of hazardous substances, and the containment of such discharges, from onshore facilities, including methodologies and technologies for preventing such discharges.[539] These sessions may take the form of roundtable meetings, audio/visual conferences or similar methods of engagement.[540] Tentatively, one of these community stakeholder sessions will be held in West Virginia.[541] EPA stated that it intends to post a publicly available summary document reflecting information gathered from these sessions by the end of 2016.[542] According to the letter, EPA intends to inform the public of the aforementioned biannual updates and community stakeholder sessions by posting the information on EPA's website.[543]

Roughly 330 hazardous substances are listed under the CWA.[544] These substances have associated reportable quantities under CERCLA.[545] While greater coverage for hazardous substances under the

[535] *Ibid*.
[536] *Ibid.*
[537] *Ibid.*
[538] EPA Office of Solid Waste and Emergency Response. Letter of Intent to NRDC. EPA: Washington, DC. February 11, 2016.
[539] *Ibid.*
[540] *Ibid.*
[541] *Ibid.*
[542] *Ibid.*
[543] *Ibid.*
[544] 40 C.F.R. § 116 (2015).
[545] 40 C.F.R. § 117 (2015).

February 2016 settlement agreement expands the applicability of SPCC regulations, neither the mixture involved in the Freedom spill or its six components are listed as a hazardous substance under the CWA and thus will not be covered under the hazardous substances regulations. As such, even if the hazardous substances regulations had been in effect before the incident, they alone would not have triggered application of the regulations to Freedom. Nonetheless, in part because Freedom did contain oil at its Etowah facility in sufficient quantities to trigger application of SPCC, Freedom should have done more to prevent potential spills.