

THE ELK RIVER MCHM SPILL: A CASE STUDY ON MANAGING ENVIRONMENTAL RISKS

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Abstract

On January 9, 2014, a large chemical spill occurred on the bank of the Elk River near Charleston, WV. Within hours, the potable water supply for more than 300,000 people was contaminated, and the incident captured national headlines for weeks. Although the primary chemical, crude 4-methylcyclohexanemethanol, or MCHM, is considered nonhazardous, the impacts of the spill are significant – with all stakeholders, including the public, members of industry, and relevant government agencies experiencing losses. More than a year later, this case continues to garner significant attention, with many still questioning just how it could have happened given the complex regulatory system in the US. In retrospect, the Elk River spill highlights the need for a more proactive approach to environmental protection, shifting from prescriptive regulation to comprehensive risk management. The lessons learned are particularly important for “gray” areas within regulatory framework, such as the vast area of nonhazardous chemicals.

1.0 Introduction

Early on January 9, 2014, approximately 10,000 gallons of crude 4-methylcyclohexanemethanol (MCHM) leaked from a storage tank sitting on the bank of the Elk River near Charleston, West Virginia (WVDEP, 2014; CSB, 2014). MCHM is a chemical commonly used in preparation of fine coal, and is considered nonhazardous in terms of transportation and storage regulations, and also toxicity (CDC, 2014a). Freedom Industries, Inc., a producer and vendor of specialty chemical products, had acquired the storage facility where the spill occurred from Etowah River Terminal, LLC just a few weeks prior in December 2013 (WVDEP, 2014; Freedom, 2005). The direct cause of the spill was ultimately determined to be two small holes in the base of the 76-year-old tank, which were created due to corrosion damage (Bauerlein and McWhirter, 2014).

The spill site was located just over a mile upstream from the intake of a municipal water treatment facility operated by West Virginia American Water (WVAW), which serves a population of 300,000 across nine counties in central West Virginia (CDC, 2014a). In a matter of hours, the leaked MCHM made its way through the treatment facility and into the water of nearby homes and businesses, where its strong smell was noticed almost immediately. On the evening of the spill, WVAW concluded that its conventional treatment processes, which include carbon filters to remove a variety of contaminants from water, were not capable of fully removing the MCHM and a “Do Not Use” order was issued for all customers (WVAW, 2014a).

With little information readily available regarding the potential human health effects of MCHM, the US Centers for Disease Control and Prevention (CDC) quickly issued an advisory ruling that set a maximum screening level of 1 ppm for safe drinking water (CDC, 2014a). Based on this recommendation, the “Do Not Use” order remained in effect for a total of eight days, until January 17, when the WVAW distribution water was confirmed to have MCHM concentrations below the approved level (WVAW, 2014a). However, due to the pungent odor of the chemical, its presence was still recognizable in the WVAW facility and in consumers’ tap water after the order was lifted (Manuel, 2014). Recent studies have shown that the chemical can be detected in water at *sub-ppb concentrations*, a fact which undoubtedly added to growing public concern (Rosen et al., 2014, Gallagher et al., 2014). In response to numerous complaints and demands, WVAW continued flushing the treatment facility and pipes until February 25 when MCHM levels were measured below 2 ppb (WVAW, 2014b), and eventually replaced the affected filter media (WVAW, 2014c).

Over the two weeks following the Elk River spill, 584 cases of nausea, diarrhea, and epidermal irritation were reported at hospitals in the greater Charleston area, 369 of which were directly attributed to exposure to water contaminated with MCHM by experts from the West Virginia Bureau of Public Health (WVBPH) and US Agency for Toxic Substances and Disease Registry (ATSDR) (WVBPH and ATSDR, 2014). In addition to these cases, concerns were raised about the possibility of long-term exposures in the event that the chemical sorbed to water treatment or plumbing materials and could be later released (Tullo et al., 2014). Research on this topic, as well as

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others related to the fundamental properties of MCHM, was initiated shortly after the spill and is ongoing (Cooper, 2014). Moreover, while no fish kills or significant environmental damage was reported after the spill, the West Virginia Division of Natural Resources has continued to perform surveys to identify possible impacts on fish and other organisms (WVDNR, 2014).

Prior to the Elk River spill, MCHM was not commonly known to the public, nor was the risk of a large spill of the chemical to a potable water supply. MCHM has been used extensively in coal processing as a frother in the flotation process, allowing very fine coal particles to be separated from ash-forming minerals (i.e., impurities) that detract from the coal product quality and lead to undesirable emissions and/or waste products during coal combustion (Tullo et al., 2014). Perhaps ironically, the advent of fine coal flotation has provided significant environmental improvements to coal production practices; and MCHM was originally patented as more environmentally-friendly frother than others in regards to common use (Christie, Fortin, and Gross, 1990).

The Elk River spill has been characterized as one of the largest human-made environmental disasters in recent history (NSF, 2014), and it serves as a poignant case study for environmental management in the context of chemicals – even those generally considered nonhazardous. A recent article by Manuel (2014) on this case highlighted the importance of crisis management and risk communication in regards to environmental emergencies. Timely provision of clear and accurate information is certainly critical to minimizing impacts on public health, as well as maintaining public trust in the entities that are providing information, be they industry members, regulatory authorities, government officials, or members of the scientific community. Another fundamental lesson to be learned from the Elk River spill, however, centers on crisis prevention and, more broadly, risk management.

2.0 Risk Management

2.1 Risk Management Principles

Risk management systems are used to identify, assess, and mitigate risks, including environmental, social, and economic risks, or some combination thereof. The concept of risk management is not at all new, and in fact use of some general principles in various sectors of society dates back to antiquity (Grier, 1981). In the past century, risk management has seen systematic and widespread incorporation in much of the business world (Dionne, 2013). The increasing focus on risk management in enterprise is attributed to a number of factors, including increased severity of the consequences associated with contemporary and/or manmade risks, growing evidence that effective strategies provide measurable results, a larger population of qualified individuals to analyze and mitigate risks, and a greater interest by a variety of stakeholders in activities that aim to prevent, rather than remediate, negative events (Covello and Mumpower, 1985). In short, risk management activities can provide some stability in an unstable market. Beyond business, however, risk management systems have a host of other applications – from coordination of large-scale natural disaster preparedness and response efforts (e.g., see Espon, 2005) to environmental management of specific industrial sites.

Like all management systems, risk management systems include human (i.e., knowledge, motivation and accountability), systematic (i.e. structure and processes), and physical elements (i.e., tools and resources). Human elements are highly dependent on the scope of the system, which may be relatively small (e.g., focused on a particular site) or massive (e.g., when the system forms the basis of a national regulatory system). No matter the scope of the system, however, core processes center on risk identification, assessment, and mitigation. In the case of environmental management, risk identification seeks to determine what potential hazards or failures exist. Common hazards include those that may release chemicals, damage ecosystems, or interfere with activities of nearby communities. As noted by Joy (2004), the exercise of risk identification can be challenging as it requires thinking abstractly to develop a comprehensive list of hazards; but for the industrial sector, identifying possibilities that would allow unwanted and/or uncontrolled exchanges of energy (e.g., chemical energy released via an explosion) can facilitate the process.

Risk assessment seeks to evaluate the likelihood and impacts of specific risks. This process may be relatively simple and qualitative or highly detailed, and, depending on site characteristics and management objectives, multiple risk assessment methods are often used in concert. Fault Tree Analysis (FTA) and Failure Modes and Effects Analysis (FMEA) are two common methods that see great use in industrial applications, including for assessment of occupational and environmental safety risks (Pennock and Haimes, 2001). While FTA focuses in-depth on root causes for specific failures (Mikulak, McDermott, and Beauregard, 2009), FMEA also examines the order in which risks should be mitigated (Bertsche, 2008). Risk mitigation (i.e., elimination or reduction of risks to an acceptable level) is indeed the ultimate aim of any risk management system. Effective

systems often incorporate iterative processes to analyze alternative mitigation strategies, including the costs, benefits, and subsequent risks associated with each said strategy (Haimes, 1991 and 1998).

Two particularly useful tools common to risk management systems are risk matrices and risk registries. Risk matrices provide a visual comparative analysis between risks based on their probability of occurrence and severity of impacts. In the context of environmental management efforts, access to such information is critical for prioritizing and allocating resources, review of improvement efforts, and analysis of historical trends or future scenarios. Risk registries, on the other hand, are created to develop and organize a “living” list of risks as a way to categorize them by their sources, their impacts, or otherwise. Figure 1 illustrates a hypothetical risk matrix for an aboveground storage tank, such as the one that spilled MCHM into the Elk River; as shown, factors related to the tank’s wear, contained substance, capacity and proximity to water resources might all be considered if risk identification and assessment exercises are carried out by a site owner or operator, or a regulatory authority. Table 1 provides two example entries in a hypothetical risk registry associated with the matrix shown in Figure 1. Here, possible mitigation plans are paired with specific risks.

Regarding the systematic elements of risk management systems, continuous improvement is key. In the case of application to environmental management, the process of iterative review allows the system and all of its components to be updated with changes in any domain, including the physical environment itself, policy, social expectations, or technological advancements. In addition to being dynamic, risk management systems are tacitly comprehensive. As such, they can provide consideration for environmental risks that have not been specifically addressed otherwise. For example, in the case of a risk management system at an industrial site, risks might be identified and mitigated that are not covered by any regulatory requirements.

2.2 Environmental Regulation

In addition to usage within the industrial sector, risk management systems may also form the basis of environmental regulatory frameworks. Regulation in Australia and New Zealand provides a good example of this approach, as discussed below. In the US, regulation has loosely been based on what is now known as the precautionary principle, which states that while there may not be scientific evidence supporting the potential for harm, by a specific chemical for example, precaution should be taken to prevent harm from occurring (Arrow and Fischer, 1974; Lofstedt, 2003). In fact, the original drafts of the Clean Air Act (CAA), the Clean Water Act (CWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), among other statutes, all have precautionary elements. Per the above description, such statutes also have inherent elements of risk management in regards to their development and implementation (e.g., prioritization of regulatory focus on threats with the broadest or most severe potential impacts).

Much discussion has been made of the differences between environmental regulation from a precautionary perspective versus a risk assessment perspective (e.g., see De Bruijn, Hansen, and Munn, 2003), with the primary distinction being the definition of (or means of determining what constitutes) an acceptable level of harm. However, acknowledging that both perspectives have merit and can even be interpreted as parallel in terms of their broad goals or processes, an altogether different discussion can be had regarding the operationalization of protective principles into environmental regulation. Of particular interest are the human elements of the resulting environmental management systems (i.e., regulatory systems) and their stakes in successes or failures – meaning, which stakeholders are involved and how can they impact or be impacted by environmental management efforts? Moreover, the relative specificity between management policies and managed sites is of interest – meaning, is a regulatory approach “one-size fits all or top down” versus “site-specific or bottom up”?

In the US, environmental policy has arguably evolved toward very prescriptive regulation, with legislative action frequently in response to one or a series of events highlighting a particular hazard or shortcoming of previous policy. Indeed, some of the most significant federal legislation in the environmental arena can be traced to high profile incidents. For example, the discovery of toxic contamination in the Love Canal community (New York, 1978) helped prompt CERCLA (USEPA, 2013), and the Exxon Valdez oil spill in the Prince William Sound (Alaska, 1989) resulted in the Oil Pollution Act (OPA) (USEPA, 2014d). In fact, the Federal Emergency Management Agency (FEMA) was born out of the environmental crisis response following the Three Mile Island (Pennsylvania) nuclear disaster (USEPA, 2014b). While these and other response-driven federal actions have clear merits, their history illustrates the US’ tendency to approach environmental regulation by continually “closing loopholes” from the top down.

This approach has inadvertently placed much of the burden for environmental risk management on government, rather than on industry or particular site operators. In practice, this means that specific regulation is often broadly applied, even in instances where no benefit may be realized. The ability of state agencies with primacy (versus federal agencies) to interpret and enforce certain statutes does promote better focus on relevant issues. For example, states with primacy under the CWA can set their own water quality standards for pollutant discharges so long as their standards are at least as stringent as the federal standards set by the Environmental Protection Agency (USEPA, 2012a). However, even when it is more focused, prescriptive environmental regulation suffers from another critical issue: any risks not foreseen by those creating and enforcing the regulations may not be adequately addressed. Though some industry members certainly do implement comprehensive environmental management programs in-house, going “beyond compliance” is just that – beyond what is compulsory.

In contrast to the prescriptive and top down approach to environmental regulation in the US, in Australia and New Zealand the responsibility for identifying and managing risks lies with both government and industry (Gough, 1997). Oftentimes, regulatory authorities in these countries are charged to identify and assess risks (i.e., potential hazards for which there is any likelihood of environmental impact) for any site requiring a license under the Environmental Protection Act; and then, working with the authorities, the site operator must develop and implement mitigation plans. While such a bottom up approach may not prevent all possible environmental incidents, the point is that the responsibility for managing risks lies explicitly both with authorities having topical expertise and operators having site-specific experience – who together are arguably better equipped to identify, assess and mitigate risks than either may be on their own.

Australia and New Zealand have been recognized for implementing an environmental risk management approach for regulation of industry activities since 1995, when Standards Australia published AS/NZS 4360 *Risk Management* (IEEE, 2013). The associated guideline document has since been used as the framework for an international standard, ISO 31000:2009, which has a goal of evolving the decision-making process in businesses by integrating risk management as a factor (IEEE, 2013). It should be noted, of course, that the principles of environmental risk management, including involvement of stakeholders and site-specificity, are not exactly foreign to the US. Indeed, USEPA has extensive experience with the subject and even has a National Risk Management Research Laboratory; though, with the exception of some specific policies (e.g., the Risk Management Plan Rule promulgated under the 1990 amendments CAA addresses chemicals deemed hazardous, see USEPA, 2009), comprehensive risk management per se has yet to see wide application on the ground via regulation

2.3 Nonhazardous Chemicals

Chemicals not specifically deemed hazardous present a significant “gray” area in environmental management, particularly when regulation is highly prescriptive. Chemicals that are categorized as nonhazardous are generally those that do not present acute physical (e.g., combustibility) or acute or chronic health hazards (e.g., causticity, toxicity). In the case of the crude MCHM that spilled into the Elk River, the question of hazardousness is even fuzzy. Crude MCHM, which is produced by Eastman Chemical Company as a saleable byproduct, is actually a mixture of several chemicals, the main ingredient being its namesake (Tullo et al., 2014). Although it is considered nonhazardous in regards to physical and toxicity hazards, crude MCHM is a skin, eye, and respiratory irritant according to its material safety datasheet (MSDS) (Eastman, 2011).

In the US, the Toxic Substances Control Act (TSCA) gives USEPA authority to regulate chemicals in the case of a new chemical substance, new use of a substance, or evidence of exposure risks from a substance (TSCA); this means that, in general, substances already in use upon TSCA passage in the late 1970s may go largely unregulated unless specifically deemed hazardous. The Federal Occupational Safety and Health Administration (OSHA) requires entities that manufacture or import chemicals (i.e., those responsible for the origin of a chemical within the US) to determine whether those chemicals do indeed present hazards (OSHA, 2012). Additionally, these entities have the responsibility of communicating up-to-date information about hazards to those who may handle chemicals (e.g., during transport, storage, or usage) (OSHA, 2012). Once a chemical has been deemed hazardous, it can be targeted by regulations aimed at controlling releases to the environment, such as the TSCA; the CWA; the Spill Prevention, Control and Countermeasure (SPCC) Rule under the OPA; or the Resource Conservation and Recovery Act (RCRA). However, chemicals lumped into the nonhazardous category are much more difficult to control in practice. Even onsite, a material safety data sheet (MSDS) is not generally required by law nor recommended by OSHA to communicate information about a chemical to workers (OSHA, 1996).

Indeed, federal regulation of nonhazardous chemicals in the US is scarce. Under the Emergency Planning and Community Right to Know Act (EPCRA), all facilities that manufacture, process or store hazardous chemicals must also report to state and local authorities and emergency responders an inventory of *all* chemicals onsite (USEPA, 2012b). But, as illustrated by the Elk River spill, this requirement does not necessarily translate to preparedness for potential releases. Even in Australia, where there are site-specific risk management requirements, nonhazardous chemicals present challenges, as they must be identified as potential risks in order to be addressed. For chemicals that presently have little or no toxicology information available, the Australian Environmental Health Standing Committee (enHealth) has published guidelines for evaluating exposure thresholds for toxicological concern (EnHealth, 2012). While such guidance is similar to OSHA's standards for evaluation of new chemicals manufactured in or imported to the US, enHealth guidelines are importantly not limited to occupational exposures, and the end goal of chemical evaluation is to ensure potential health risks to *any* humans, including those who may be affected by a chemical release, are appropriately considered in the aforementioned environmental risk management activities at sites handling or storing chemicals.

3.0 The Elk River Spill in Retrospect

News of the Elk River MCHM spill captured national headlines for weeks – with many questions surrounding how this incident could have occurred considering the current regulatory framework in the US, and how so little could be known about a chemical sitting just upstream of a municipal water source. Looking back, the answer is simply that, at the time of the spill, neither regulatory requirements nor corporate policies forced mitigation of the specific risk that ultimately resulted in the storage tank failure, and a range of impacts to various stakeholder groups (Table 2). In fact, the parties that ultimately shared responsibility for the spill and the subsequent drinking water contamination were largely in compliance with relevant regulation. Rather, it appears that MCHM's classification as a nonhazardous chemical combined with failures to apply risk management principles on the ground, at both the storage tank facility and the affected water treatment facility, amounted to serious gaps in environmental management.

3.1 Gaps in the System

Eastman had conducted testing to determine the chemical's hazards (Eastman, 1990); and an inventory of chemicals stored at the site had been provided to WVDEP about a year before the spill, as required by the EPCRA (Etowah River Terminal, 2013). Moreover, Freedom possessed the required industrial storm water permit for the site under the CWA, which was issued by WVDEP to the previous owner (WVDEP, 2009a). Although plans for storm water pollution prevention (SWPPP) and groundwater protection (GPP) were required to be kept on site, and quarterly inspections were supposed to be conducted by the site operator (WVDEP, 2009b), WVDEP apparently did not require the operator to provide documentation (Ross, 2014). The SWPPP specifically addresses spill prevention and response, including in the instance of tank rupture, and visual site inspections by employees (CTL, 2002). While a post-spill inspection by the Chemical Safety Board (CSB) noted cracks in a containment wall that was intended to prevent release of spilled chemicals (Mufson, 2014, without documentation of prior inspections it is impossible to know when the cracks occurred, or when the MCHM storage tank first showed signs of severe wear. Indeed, it is even difficult to ascertain if the operator inspections were completed on schedule, and for which tanks. A host of possibilities certainly exists, including scenarios in which only tanks containing chemicals considered hazardous were routinely inspected.

It does seem clear that the site had not been fully inspected by a regulatory authority since 1991, with only preliminary inspections in 2002 due to a change in ownership (Berzon and Maher, 2014) – but regulation does not appear to exist that required otherwise. Considering the timing of the spill in relation to Freedom's acquisition of the storage tank facility, it seems particularly unfortunate that neither regulatory authorities nor Freedom performed a site assessment that may have raised any red flags about potential spill risks and impacts.

Regarding the affected water treatment facility, over a decade before the spill, WVAV had written a source water assessment report under Safe Drinking Water Act (SDWA) requirements (SWAR) (WVDHHR, 2002). The SWAR did identify the upstream chemical storage facility as a potential source of contamination, though at the time the report was written MCHM was not stored there. While a follow-up source water protection plan was never formally created before the spill, law did not require this. In retrospect, despite a host of regulations and even identification of potential risks posed by the storage facility, the Elk River spill occurred – and much to the apparent surprise of all involved. Could a comprehensive risk management approach at either the regulatory or site level have prevented this incident, or at least mitigated its impacts?

At the site level, the response to this question must surely be affirmative. Trends in industry, including the extractive resources and their support industries, to implement environmental risk management systems regardless legal obligations are growing quite simply these systems work (e.g., see Pritchard, 2014 for in depth discussions on the topic). The realized benefits range from direct cost-savings associated with consistent regulatory compliance and avoidance of environmental accidents to long-term social acceptance of operations (often referred to as “social license”). For many global companies, or those with tight and historical ties to specific regions, the costs of risk management systems can be easily justified by such benefits; but for others, perhaps due to lack of forethought or experience, the advantages may not be clear. In the case of the Elk River spill, it is probably safe to say that those directly involved (i.e., Freedom and WVAW) have learned some important lessons regarding risk management – as have other industry members and regulatory authorities at all levels.

Although other entities in the broader lifecycle chain for MCHM (e.g., other vendors, coal producers) quickly felt negative implications of the spill (e.g., see Table 2), many actually have some level of risk management in place for nonhazardous chemicals. For example, some coal producers that use (or were using) MCHM or similar chemicals in their preparation facilities employ specific corporate policies, developed under their own broad environmental management programs, which cover storage and handling of *all* chemicals. Beyond specific GPP and SPCC guidance, such programs generally apply procedures found in the OPA (40 CFR Part 122) to storage and handling of any unregulated chemicals. It is worth noting, or reiterating, that an incident with MCHM on a better-managed site would arguably have resulted in less severe environmental and social impacts, if any at all.

3.2 The Regulatory Response

There has been dialogue at the federal level for some time about the need to amend regulation of chemicals within the US, particularly under the TSCA (e.g., see USEPA 2015). The Chemical Safety Improvement Act was introduced in 2013 (CRS, 2013) and is currently in committee. The bill seeks to reform TSCA requirements to effectively include all chemicals used in commerce, not just those that are new, are seeing new use(s), or have been specifically targeted as exposure risks. The Elk River MCHM spill has undoubtedly re-invigorated discussions between policy makers, the public, members of industry, and environmentalists along such lines of reform, and has also sparked new activities at both the federal and state level.

Just after the spill, a bill called the Chemical Safety and Drinking Water Protection Act was introduced in the US Senate (CSR, 2014), and a similar bill was introduced in the House. Details of the bill have been summarized by Ross (2014), but the main premise is protection of municipal water supplies from contamination by chemicals; and the main mechanism of protection is via key risk management principles including active participation in risk identification and assessment by water utilities, chemical storage facilities and regulators, and improved monitoring and communications standards.

At the state level, regulatory response to the Elk River spill has centered on West Virginia Senate Bill 373 (WVSB 373), which broadly seeks to tighten regulations for chemicals storage, improve protection plans for water resources, and increase transparency among stakeholders. WVSB 373 specifically created the Aboveground Storage Tank Act (ASTA). In its current form, the ASTA will apply to a wide range of industrial facilities within the state, since it covers storage of any chemical, including nonhazardous chemicals, in large quantity (i.e., 1,320 gallons or more) that are not already subject to stricter regulation at the state or federal level. An inventory system is to be implemented across the state, which will include records of various tanks characteristics, including contents and maintenance records (WVL §22-30-4). Tanks will undergo annual inspections by a certified inspector and the owner of the tanks will be responsible for reporting the condition of the tank to WVDEP (WVL §22-30-6). In addition to preventative maintenance programs, leak detection systems and SPCC plans that contain an MSDS for all chemicals stored on site will be required (WVL §22-30-4; WVL §22-30-9). Given the breadth of these new rules, it is perhaps not surprising that only months after the ASTA became effective WV is now considering revisions that would scale back the number of tanks covered (WVL, 2015) – and at the center of discussion around the proposed amendments is the classification of tanks by their risks (i.e., capacity, type of chemical contained, proximity to water or other critical environmental resources, etc.; see Maher, 2015).

Another important output from WVSB 373 is new regulation requiring water source protection plans to be implemented by distribution facilities (WVL §22-30-10). To construct an appropriate plan, water distributors must review: how source water may be diverted or what additional sources of water exist if their main supply is contaminated; what sources of potential contamination are located upstream from the distribution facility; and how any contamination may be diverted or removed from the source water. Further, an emergency environmental

management plan must be developed for use in the case of an incident that impacts water supply quality enough that responsible authorities must be contacted (WVL §22-30-10).

Though certainly response-driven, the ASTA and water source protection elements of WWSB 373, along with some proposed federal rules, highlight a growing recognition of the importance of risk management principles in environmental regulation, albeit slow. Notably, the engagement of multiple stakeholders with abilities to help identify, assess and mitigate risks is quite clear. What are not yet clear are the specific long-term outcomes of these regulatory efforts, and the trend toward more comprehensive systems in a broader sense. Indeed, despite improvements delivered by these or future regulations, gaps are inevitable, and those on the ground on where potential risks exist must remain vigilant and accountable even where no particular rules may apply.

4.0 Conclusions

In the aftermath of the Elk River spill, those deemed directly accountable were subject to financial losses. Freedom, which filed for bankruptcy eight days after the spill, was fined \$11,000 by OSHA (Associated Press, 2014a), and West Virginia assessed \$1.8M in fees for cleanup efforts and damages (Associated Press, 2014b). The US Bankruptcy Court additionally approved a \$2.9M settlement with local communities, with the funds to be spent on public cleanup projects and health studies (Associated Press, 2014c). WVAW estimates that it lost approximately \$11M in profit due to cleanup efforts and the cost of replacing its contaminated carbon filters (Associated Press, 2014d). All told, these figures amount to about \$52 per affected person in the Charleston area. To some, this may seem quite small in the context of the broad impacts of the spill. Beyond economic losses for local businesses, homeowners, and taxpayers, this incident resulted in significant consequences for stakeholder relationships (Boucher, 2014). Most critically, public trust was lost in industry and government, and to some extent the scientific community; and, even in light of new regulations or commitments to environmental management, this may very well be a long-lasting legacy of the spill (BizNGO, 2013; Orum et al., 2014).

The Elk River MCHM spill indeed provides a valuable lesson on environmental management in the US – particularly in the arena of nonhazardous chemicals. WWSB 373 and similar legislation (either passed or proposed) in other states and at the federal level aims to limit the potential for such a spill to reoccur, but regulatory reform will surely be slow and imperfect. To cover the gaps, industry simply must accelerate the cultural transition toward internalized risk management, and those with ground-level responsibilities for ensuring environmental protection, and community wellbeing, must work diligently to identify and mitigate all potential risks within their purview. The stakes get higher all the time.

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Figures and Tables

Impact					Probability	
Tank Characteristics	Minimal	Low	Medium	High		
Wear:	None	None	None	None		Unlikely
Substance Contained:	Nonhazardous	Nonhazardous	Hazardous	Hazardous		
Capacity:	Low	High	Low	High		
Proximity to Water:	Far	Far	Neighboring	Immediate		
Wear:	Slight	Slight	Slight	Slight	Potential	
Substance Contained:	Nonhazardous	Nonhazardous	Hazardous	Hazardous		
Capacity:	Low	High	Low	High		
Proximity to Water:	Far	Nearby	Neighboring	Immediate		
Wear:	Moderate	Moderate	Moderate	Moderate	Likely	
Substance Contained:	Nonhazardous	Nonhazardous	Hazardous	Hazardous		
Capacity:	Low	High	Low	High		
Proximity to Water:	Far	Nearby	Neighboring	Immediate		
Wear:	Significant	Significant	Significant	Significant	Very Likely	
Substance Contained:	Nonhazardous	Nonhazardous	Hazardous	Hazardous		
Capacity:	Low	High	Low	High		
Proximity to Water:	Far	Nearby	Neighboring	Immediate		
Wear:	Extreme	Extreme	Extreme	Extreme	Certain	
Substance Contained:	Nonhazardous	Nonhazardous	Hazardous	Hazardous		
Capacity:	Low	High	Low	High		
Proximity to Water:	Near	Neighboring	Immediate	Immediate		

Figure 1. Example of hypothetical risk matrix for an aboveground storage tank

Table 1. Example of hypothetical risk registry entries for a chemical storage facility

Risk Identification	Risk Assessment	Risk Management
<p>Risk registry no. R1</p> <p>Description of risk Tank 75 has hazardous substances stored in a large quantity & is in immediate proximity to water source</p> <p>Risk review 11/12/12 – Review completed by John Doe</p> <p>Ownership of risk John Doe – Manager of site</p>	<p>Level of impact High</p> <p>Description of impacts</p> <ul style="list-style-type: none"> • Potential for large release of chemical • Endanger municipal water supply and wildlife • Financial losses with spill for fines and cleanup efforts <p>Level of probability Unlikely</p> <p>Mitigation responses</p> <ul style="list-style-type: none"> • Ensure secondary containment is competent • Install monitoring system for leakage • Develop weekly inspection protocol of tank for signs of wear or leakage 	<p>Mitigation status</p> <ul style="list-style-type: none"> • 01/10/13 – Installation of monitoring system on tank • 01/10/13 – Review of secondary containment competency • 02/10/13 – Review of secondary containment competency <p>Necessary actions</p> <ul style="list-style-type: none"> • Develop inspection plan
<p>Risk registry no. R2</p>	<p>Level of impact Low</p>	<p>Mitigation status</p> <ul style="list-style-type: none"> • 1/30/13 – Removal of chemical to recoat tank

<p>Description of risk</p> <p>Tank 83 shows sign of wear with corrosion developing, nonhazardous substances are stored in low quantities from nearby location to water source</p> <p>Risk review</p> <p>12/12/12 – Review completed by John Doe</p>	<p>Description of impacts</p> <ul style="list-style-type: none"> • Release of small amount of chemical • Health impact for environment • Financial losses with fines for spill and cleanup effort <p>Level of probability</p> <p>Likely</p> <p>Mitigation responses</p> <ul style="list-style-type: none"> • Recoat tank to halt corrosion • Develop schedule for tank inspection 	<p>Necessary actions</p> <ul style="list-style-type: none"> • Recoat tank • Develop inspection plan
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Table 1: Elk River spill stakeholder impacts

Stakeholders		Direct Impacts	Indirect Impacts
Public	Local Communities	<ul style="list-style-type: none"> • Loss of access to clean water • Cases of medical harm • Loss of trust with Freedom Industries, Coal Companies, & State/Federal agencies 	<ul style="list-style-type: none"> • Mistrust of local water supply • Long lasting mistrust of chemical & coal companies, state/federal agencies • Unknown effects on local wildlife • Damaged tourist industry • Area is now “infamous” • Financial losses with businesses closed
	Public at-large	<ul style="list-style-type: none"> • Loss of trust in chemical producers, storage facilities and users, and state/federal regulatory agencies 	
Industry	West Virginia American Water	<ul style="list-style-type: none"> • Financial losses • Loss of consumer trust • Public demand for increased regulation for nonhazardous chemicals 	<ul style="list-style-type: none"> • New compliance standards with WWSB 373
	Freedom Industries, Inc.	<ul style="list-style-type: none"> • Financial losses • Loss of social license/public trust • Public demand for increased regulation for nonhazardous chemicals 	<ul style="list-style-type: none"> • Potential loss of business • New compliance standards with WWSB 373
	Eastman Chemical/ other chemical producers	<ul style="list-style-type: none"> • Criticism for selling MCHM to Freedom Industries • Public demand for increased regulation for nonhazardous chemicals 	<ul style="list-style-type: none"> • Decrease in social license
	Chemical users	<ul style="list-style-type: none"> • Public demand for increased regulation for nonhazardous chemicals 	<ul style="list-style-type: none"> • New compliance standards associated with WWSB 373 • Negative press via association of MCHM with coal processing • Decrease in social license
Government	West Virginia	<ul style="list-style-type: none"> • Loss of public trust in regulatory agencies • Financial losses with clean-up effort • Negative publicity from media 	<ul style="list-style-type: none"> • Passage of WWSB 373 • Pressure for continued research on long-term effects of MCHM exposure
	Federal	<ul style="list-style-type: none"> • Loss of public trust due to varied press releases (CDC) • Financial losses with clean-up efforts 	<ul style="list-style-type: none"> • Pressure for continued research on long-term effects of MCHM exposure • Potential for increased regulatory efforts associated with nonhazardous chemicals