The 2010 Marshall, Michigan Tar Sands Oil Spill

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1 Introduction

On 25 July 2010, an oil pipeline transporting diluted bitumen from the tar sands region of Alberta, Canada ruptured near Marshall, Michigan. Over the course of 17 hours, oil gushed from a six-foot seam in the pipeline. By the time personnel from the pipeline company Enbridge, Inc., finally realized the line was compromised, over a million gallons of oil had spilled into Talmadge Creek, a tributary of the Kalamazoo River. The oil traveled almost two miles down the creek and entered the river, which flows some 130 miles in a northwesterly direction until it reaches Lake Michigan. Because a spill of this type and magnitude had never before occurred in a body of fresh water, it would ultimately take nearly seven years and cost more than a billion dollars to clean it up, making it the costliest inland oil spill in the US history. Although largely overshadowed by the deadly Deepwater Horizon disaster in the Gulf of Mexico just two months before, the Marshall spill is significant for what it taught scientists, industry, and the public about the behavior of diluted bitumen in fresh water, for bringing into visibility the threats posed by the nation's vast and still-growing pipeline infrastructure to sensitive freshwater resources, and for its bellwether role in North American grassroots and indigenous movements focused on water protection. This essay will proceed in three sections, starting with the background and causes of the spill, turning next to the environmental effects of the spill, including the important findings of the National Academies of Sciences, Engineering, and Medicine, and turning finally to some of the broader political implications of the Marshall disaster for environmental activism in the Anthropocene.

2 Background and Causes

The Enbridge pipeline that ruptured near Marshall, at the time called "Line 6B," is part of the company's "Lakehead system" of pipelines in the Great Lakes Region that transports Canadian crude oil and other liquid petroleum products to refineries in the Midwest and Canada. Originally constructed in 1969, Line 6B runs for roughly 210 miles, originating at a terminal in Griffith, Indiana, traversing the state of Michigan, and terminating in Sarnia, Ontario. The original pipeline was 30 in. in diameter and capable of shipping roughly 350 000 barrels per day. Enbridge first began to ship diluted bitumen through Line 6B in 1999. Diluted bitumen – "dilbit" for short, but often commonly referred to as "tar sands" oil (a term disliked by the oil industry) – differs from conventional crude oil [1]. A semi-solid form of petroleum, bitumen is a type of "tough oil" typically extracted by surface mining or in situ recovery – a process whereby steam is injected deep underground to liquefy the bitumen so that it can be pumped to the surface [2]. Prior to transport by pipeline, the bitumen must be diluted with a mixture of other hydrocarbons until it has reached an appropriate level of viscosity. Although dilbit has been shipped via pipeline for more than 40 years, in the twenty-first century the practice has become the source of significant controversy, in no small part owing to the Line 6B rupture in Marshall.

The details of the spill have been well-documented in news reports, including a Pulitzer Prize-winning series or articles published in the online newspaper *Inside Climate News*, and in the findings of an investigation conducted by the National Transportation Safety Board (NTSB) [3]. At about 6 p.m. on 25 July 2010, Enbridge

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control room personnel in Edmonton, Alberta – some 1500 miles away from Marshall – were notified by alarm of a pressure drop in Line 6B soon after beginning a pre-planned 10-hour shutdown of the pipeline. Over the next several minutes, additional alarms would sound, indicating serious problems with the pipeline. Control room operators assumed that the problem was "column separation": the formation of an air bubble in the line, a not uncommon circumstance that typically subsides on its own. As a result, operators took no action, not realizing that a six-foot seam had opened up in the pipeline, spilling oil into Talmadge Creek. In fact, at 4 a.m., the end of the scheduled shutdown period, Enbridge restarted the pipeline, once again setting off control room alarm systems. Following a brief shutdown to address the problem, operators decided that an increase in pressure would help resolve the column separation. At around 7 a.m., still unaware of the rupture, they restarted the line for a second time. Alarms continued to sound. Just before 8 a.m., operators shut the line down again. Over the next two hours, control room personnel discussed what they still assumed was a column separation. A supervisor contacted a regional manager in Chicago about dispatching someone to do a visual inspection of the line near Marshall, but the regional manager informed him the step was unnecessary and advised instead restarting the line. An hour later, at 11:17 a.m., control center personnel were finally informed by a local energy company employee that Line 6B was leaking oil into the creek. Only then – a full 17 hours after the rupture occurred – did Enbridge close remote shutoff valves, finally sealing the stretch of leaking pipe. Thirty minutes after that the first Enbridge employee finally appeared on site.

While Enbridge personnel failed to respond appropriately to severe leak alarms up in Edmonton, local residents in Michigan were sounding their own alarms. The first calls to 911 operators expressing concerns about foul odors of gas or oil began at 9:25 p.m. on July 25; before that, other residents had notified the local gas utility company. Those calls would continue for hours and overnight, as local firefighters and utility workers searched for signs of a gas leak. Overwhelmed by the smell, some residents nearest to the spill site had begun to evacuate their homes even before the spill was discovered. By the time Enbridge initiated its official spill response, thick black muck had already traveled a mile and a half downstream of the rupture and spilled over the banks of Talmadge Creek, coating both flora and fauna. In a vain attempt to prevent the oil from reaching the Kalamazoo River a couple of miles away, emergency responders installed absorbent booms and dug culverts to divert the oil's flow. But by the afternoon of July 26, oil was already spilling into the river, helped considerably by unusually heavy rains that had fallen for three straight days prior to the spill.

In 2012, the NTSB released the results of its investigation into the causes of the spill. The report criticized Enbridge for "pervasive organizational failures," including inadequate training of its control room personnel, which allowed the leak to go undetected for so long [4, p. 121]. According to the report, for example, control room operators failed to adhere to the company's own safety protocols, such as the "10-minute rule," which stipulated that if a suspected column separation could not be resolved within 10 minutes, the line would be shut down until the situation is confirmed or corrected [4, p. 52]. Enbridge had developed the rule almost 20 years before following another spill incident. On 3 March 1991, a rupture in an Enbridge pipe (at that time, the company was called Lakehead Pipe Line) spilled 1.7 million gallons of crude oil in Grand Rapids, Minnesota, making it the largest oil spill in Minnesota state history. In a scenario that would be repeated almost 20 years later with the Line 6B pipe, control center staff in 1991 misinterpreted or disregarded alarms and other indications of abnormalities in the line and as a result, pumped oil into the ruptured line for another hour. Because of this and other control room procedural failures, the NTSB concluded that "Enbridge control center staff had developed a culture that accepted not adhering to the procedures" [4, p. 101].

In addition to highlighting the control room failures that prevented swift detection of the spill, the NTSB report also detailed the physical causes of the pipeline failure. NTSB concluded that Enbridge practiced "deficient integrity management procedures," which allowed known defects in the pipeline to worsen until it finally failed [4, p. 121]. Specifically, Enbridge's own pipeline inspection data from tests conducted as far back as 2005 revealed anomalies on Line 6B in the form of corrosion fatigue cracks along the section of pipe that ruptured. Portions of the polyethylene tape used to protect the external surface of the pipe when it was originally installed in 1969 had disbanded from the steel. Because the section of pipeline was installed through a wetland, moisture had penetrated areas that were no longer protected, leaving the steel pipe vulnerable to corrosive conditions. When inspection data from in-line tests revealed corrosion fatigue and crack features on the pipe, Enbridge misinterpreted the data and as a result, failed to take remediating action to prevent the the cracks from worsening over time.

A third major factor contributing to the severity of the spill according to the NTSB was "insufficient public awareness and education," which prevented quick detection and swift action by local emergency responders and therefore allowed the spill to continue for almost

14 hours after the initial calls reporting unusual smells in the area [4, p. 121]. Soon after those first calls on July 25, local firefighters were dispatched to investigate the cause of the odors, which they assumed was a natural gas leak. Unfamiliar with the odors associated with crude oil and apparently unaware of the presence of the Enbridge pipeline in the general vicinity, the firefighters failed to locate the source of the smell; as the NTSB put it, emergency officials "lacked actionable knowledge" [4, p. 103]. Even after the leak was finally discovered, initial environmental response efforts proved similarly ineffective. First responders focused their initial efforts on containing the spread of the oil miles down the Kalamazoo River – partly out of concern that the oil might eventually reach Lake Michigan – rather than preventing the oil from entering the river closer to the spill site. Unaware of how much oil had been released, responders installed sorbent booms at the furthest most point downriver where sheen was observed, even as oil continued to pool and rush through a culvert pipe just a quarter mile from the source. Focusing containment efforts upriver closer to the rupture, the NTSB found, could have significantly reduced the amount of oil that made its way into the Kalamazoo River. Even the containment measures Enbridge did take on Talmadge Creek, such as the use of sorbent booms, were ineffective, since such booms are most appropriate only for small spills on stagnant waters, not for large releases in fast-flowing tributaries like Talmadge Creek.

In addition to its findings regarding Enbridge integrity management procedures and control center operations, the NTSB report criticized the federal agency charged with overseeing pipeline safety, the Pipeline Hazardous Materials Administration (PHMSA), for lax or insufficient regulatory requirements. Specifically, the NTSB found that the Code of Federal Regulations does not provide clear requirements detailing when a pipeline operator should take action to repair pipeline defects. Nor did PHMSA require Enbridge to excavate and inspect crack defects once they were found – a discovery that, because of unclear regulatory requirements, Enbridge did not even report to PHMSA for more than 460 days. Lastly, the NTSB cited a lack of specific federally mandated spill response standards developed and enforced by PHMSA as a contributing factor to the severity of the spill. As a result of these findings, the NTSB issued a number of specific recommendations to PHMSA, Enbridge, and pipeline industry trade groups designed to improve regulatory oversight and industry safety practices and spill response planning. As of 2019, PHMSA had completed action on only some of those recommendations.

Meanwhile, in response to the Marshall spill, as well as deadly pipeline incidents in San Bruno, California and Allentown Pennsylvania in 2010 and 2011, respectively, Congress in 2011 passed the Pipeline Safety, Regulatory Certainty, and Job Creation Act [5]. Signed into law by President Obama in 2012, the bill increased civil penalties for regulatory violations, and charged PHMSA with developing new standards pertaining to public awareness, spill response plans, and leak detection. The law also required PHMSA to conduct two studies related to the transportation of diluted bitumen by pipeline: the first on the potentially corrosive effects of dilbit on pipelines and the second a study of the effects of dilbit on the environment in the event of a spill. Both studies were eventually conducted by the National Academies of Sciences, Engineering, and Medicine and released in 2013 and 2016, respectively. I discuss the latter study in more detail below.

3 Environmental Effects

The historical significance of the Marshall involves not just corporate and regulatory failures but new knowledge about the particular properties of the material released. During the initial phase of containment and recovery, emergency responders and cleanup crews operated on the assumption that they were dealing with conventional crude oil. Nor did Enbridge disabuse them of that notion. In fact, for more than a week after the spill, then Enbridge CEO Patrick Daniel specifically denied, when asked by reporters, that the material spilled from Line 6B was diluted bitumen [6]. Those denials proved significant, since the chemical properties of diluted bitumen cause it to behave differently when released into the environment than conventional crude. Neither Enbridge and its contractors nor officials from the Environmental Protection Agency, which oversaw the cleanup effort, were adequately prepared to contend with that behavior and the challenges dilbit posed to ordinary methods of recovery. As a result, not only did Enbridge fail to meet the EPA's initial cleanup deadline of 27 September 2010, just two months after the spill. And while the EPA signed off on cleanup efforts in 2014, work would continue for another two years under the supervision of the Michigan Department of Environmental Quality (MDEQ).

Flood stage conditions on Talmadge Creek and the Kalamazoo River at the time of the spill meant that oil had been carried over the banks of both waterways, covering flora and fauna and saturating the banks, surrounding wetlands, as well as residential and commercial properties. All told, the spill affected more than 1500 acres of in-stream habitat, nearly 3000 acres of floodplain habitat, and 185 acres of upland habitat [7]. The oil traveled nearly 40 miles down the Kalamazoo River, collecting in pools and soiling the river's infrastructure of

rocks, logs, and small islands. Birds, mammals, fish, and reptiles were also coated in oil. These included dozens of birds (chiefly Canadian geese), numerous mammals (such as muskrats), and thousands of turtles. Many animals died, while others were captured, rehabilitated, and released – although release was complicated by the risk of re-oiling or disturbance by ongoing cleanup activities. For that reason, some birds were taken to alternative locations while turtles were released in locations upstream of oiled areas or in areas believed to be free of oil. The number of fish and benthic invertebrates, such as mussels, killed or affected by the spill and cleanup efforts (vacuums, boat actions) remains unknown.

Humans were also affected. For centuries, the Kalamazoo River has played a crucial role in the lifeways of the Nottawaseppi Huron Band of the Potawatomi Tribe and the Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians. The spill and its cleanup affected these tribes' harvesting of animals for subsistence, the gathering of plants for medicinal use, and traditional ceremonial practices. The Kalamazoo River also hosts many different recreation activities for local residents and visitors, including fishing, hunting, boating, and paddling. These activities were interrupted as the river was closed for the remainder of 2010 and all of 2011. Portions of the river were also closed to recreation during parts of 2013 and 2014 and the Michigan Department of Community Health issued Fish Consumption and Swimming Advisories which remained in effect until June 2012. Perhaps more importantly, many residents were uprooted or suffered health effects. Three days after the spill, local officials issued a voluntary evacuation order, owing mainly to increased levels of benzene in the air – a result of the evaporation of the oil's diluents – displacing more than 100 families. Others chose to remain in their homes. Nearby residents began to report adverse health conditions such as headaches, nausea, vomiting, and trouble breathing. Reports of such symptoms continued for at least a month after the spill, the effects of which remain unknown, as no comprehensive study of the human health effects of the spill have ever been conducted [8].

Cleanup crews installed more than 30 miles of containment and sorbent booms on the river, while excavators dredged the creek and river banks. The two-mile area along Talmadge Creek was so overwhelmed with oil that it had to be completely destroyed, its banks, the surrounding area, and the creek bed all excavated, hauled away, and cleaned, after which the creek could be completely re-constituted – an artificially created version of itself based upon aerial imagery. Similar dredging was much less tenable on the Kalamazoo River, as it risked destroying the sensitive ecosystems and riverine features upon which fish, turtles, and mammals like beavers rely for security, though in some parts of the river, entire islands whose muskrat burrows proved collected significant amounts of oil, were excavated and reconstituted with backfill. Yet despite the recovery of the vast bulk of the oil that found its way to the river, remediation workers continued to discover more, much of it, surprisingly enough, at the river's bottom. Contractors found that agitating the water or disturbing the riverbed would cause black flakes or sometimes tar-like balls to rise to the surface of the water. Upon further investigation, they discovered that such flecks and gobs of submerged oil were being carried downriver and settling at collection points, sometimes several inches below the sediment on the river's bottom.

The settling of the oil on the bottom of the river turned out to be the greatest unforeseen challenge for cleaning up the river. A study published by the National Academy of Sciences in 2016 on the "Effects of Diluted Bitumen on the Environment" found that the "chemical and physical properties" of diluted bitumen "differ substantially" from more conventional crude oils [9, p. 3]. Those differences primarily involve the behavior of the bitumen when subjected to weathering processes which in turn creates special challenges when released into bodies of water. Contrary to the findings of a 2013 study commissioned by Enbridge which claimed that diluted bitumen floats, the NAS study explained that bitumen has a "strong tendency to adhere" [9, p. 3]. As a result, it combines with sediment and other particles suspended in water; in this state, its density can exceed that of freshwater, causing it to sink – which is precisely what happened in the Kalamazoo River. In order to recover the sunken oil, cleanup crews had to resort to novel techniques such as agitation of the riverbed – which caused sheen to rise to the surface of the water where it could be collected. When that technique proved inadequate, dredging was employed. Tens of thousands of cubic yards of oil-contaminated sediment were removed from the river, transported to remediation sites for cleaning, and then returned – a costly, disruptive, and laborious process. As a result of these methods, approximately 80% of the oil in the river was eventually recovered. However, an environmental benefit analysis late in the process revealed that the disruptions caused by continued dredging outweighed the benefits of recovering the remaining oil. For that reason, an estimated 80 000 gallons of oil was left in the sediment, spread throughout the river system, where it will remain.

In 2016, after extended negotiations with the Department of Justice and the Environmental Protection Agency, Enbridge reached a settlement for violations of the federal Clean Water Act, which included $61 million in civil penalties and an additional $110 million in safety upgrades to the company's Lakehead pipeline system, of which Line 6B is a part. Two years earlier,

Enbridge had reached a settlement with the MDEQ for $75 million. In addition, Enbridge invested another $1.6 billion to replace all 210 miles of Line 6B starting in 2012. Enbridge described the project to regulators and the public as "maintenance and rehabilitation," although the project, in fact, entailed the construction of a new pipeline, at a larger diameter (and hence capable of transporting a greater volume of oil than the original Line 6B), adjacent to the old line, leaving the later in place. Mired in lawsuits, contentious negotiations with landowners and some local municipalities, and protests from activist groups, the replacement project took nearly four years to complete. That is, while the new Line 6B was placed into service in 2014, the restoration of landowners' properties continued for another two years or more. In 2017, Enbridge changed the name of Line 6B to Line 78, which includes a segment that runs from Flanagan, Illinois to Griffith, Indiana. Line 78 currently transports more than 500 00 barrels of oil per day.

As the 10-year anniversary of the spill nears, most agree that the river and surrounding ecosystems are much improved and that both flora and animal populations have proven resilient. The MDEQ continues to monitor the river for appearances of sheen and for the health of bird, turtle, fish, and insect populations. However, the long-term effects of the spill, the cleanup, and unrecovered oil on both wildlife and humans may never be known, as few ongoing scientific studies are underway.

4 Oil & Water Don't Mix

Between 2010 and 2017 the pipeline industry in the United States constructed more than 20 000 miles of new pipeline, an increase driven by the exploitation of oil and gas reserves previously considered too difficult (or too costly) to reach. This new development included not only massive investments in the extraction of diluted bitumen in the Alberta region of Canada, but also an explosion in conventional oil and natural gas production following the discovery of crude reserves in the Bakken region of North Dakota and, thanks to the loosening of regulations under the Clean Water Act in 2008, the development of hydraulic fracturing techniques that made it possible to access natural gas from the energy-rich Marcellus and Utica shale formations in the northeastern United States. Paradoxically, this boom coincided with increasingly dire warnings from scientists, like the Intergovernmental Panel on Climate Change, about the need to reduce global fossil fuel consumption in order to slow the pace of global warming and, consequently, growing national and global public concerns over the effects of anthropogenic climate change. These concerns, combined with the vivid spectacle throughout the summer of 2010 of the BP disaster in the Gulf, had already heightened public awareness of the human, environmental, and planetary dangers posed by oil and gas extraction and transportation. Within this context, the Marshall spill quickly became an important touchstone and cautionary tale for various anti-pipeline grassroots movements across North America, especially for those centered upon the protection of water.

The two most high-profile conflicts over new pipeline infrastructure projects in the twenty-first century have centered upon concerns over threats (whether perceived or actual) posed to freshwater resources. In 2008, the Canadian pipeline company TransCanada proposed its Keystone XL (KXL) pipeline, which would transport diluted bitumen from Alberta, Canada to the Gulf of Mexico. Even before the Marshall spill in 2010, strong opposition to the KXL project had emerged, primarily from citizens in Nebraska concerned about potential threats to the Ogallala Aquifer, one of the largest underground freshwater reservoirs in the world. The route originally proposed by TransCanada would have traversed the aquifer (as well as the nearby Platte River) raising concerns on the part of activists about drinking water contamination in the event of a spill. The Marshall spill heightened those concerns and eventually became a significant point of reference in debates over the potential environmental impacts of the project, debates that, perhaps for the first time in US history, would become a major national political issue. In 2015, President Barack Obama denied TransCanada a necessary presidential permit for the project. In 2017, President Donald Trump reversed that decision, although the project remains in suspension pending legal challenges and additional environmental reviews.

Nor has KXL been the only pipeline infrastructure project since the Marshall spill to make national news. The massive protests in 2016–2017 against the Dakota Access Pipeline (DAPL) in North Dakota likewise became a major event and also centered upon potential dangers the pipeline posed to freshwater resources. Operated by Energy Transfer Partners, the DAPL runs for 1100 miles from the oil-rich Bakken region in northwest North Dakota to a terminal in Pakota, Illinois. En route, it crosses the Missouri River, the Mississippi River, Lake Oahe, several tributaries of Lake Sakakawea, as well as Sioux sacred sites, ancestral burial grounds, and disputed lands over which the Dakota and Lakota peoples of the Standing Rock Sioux claim sovereignty based upon the 1868 Treaty of Fort Laramie [10]. In the mid-twentieth century, the Army Corps of Engineers built a dam on the Missouri River that flooded large sections of the Standing Rock reservation and forced the relocation of tribal members inland. Yet the resulting Lake Oahe Reservoir has since become a major source

of drinking water for the Standing Rock Sioux and the nearby waterways support traditional tribal lifeways. Describing themselves as "water protectors" and adopting the slogan "Mni wiconi" – which means "Water is Life" in the Lakota language – members of the Standing Rock tribe established the Sacred Stone Camp protest site near Cannon Ball, North Dakota in 2016. Eventually, thousands of protestors and supporters, including members of Native American tribes from across the United States, gathered at the site in what became perhaps the largest demonstration in support of the environment and indigenous sovereignty in modern history. References to the Marshall spill became a common and recurring feature among protestors and in the public discourse about the Dakota Access project. In December of 2016, the Army Corps of Engineers rejected Energy Transfer's request for an easement to cross Lake Oahe pending further environmental review. In early 2017, President Trump signed an executive order granting permission to build the pipeline. In March of 2017, DAPL was officially placed into service.

Even more recently, tribal groups, residents, and environmental organizations in Michigan have initiated a grass-roots campaign calling for another pipeline owned and operated by Enbridge to be permanently shut down. Built in 1953, Line 5 is a 645-mile pipeline that originates in Superior, Wisconsin, runs across Michigan's Upper Peninsula, down the Lower Peninsula and eventually terminates in Sarnia, Ontario. At the crossing between the Upper and Lower Peninsulas, the line splits into twin pipelines of smaller diameter, which span 4.5 miles and are anchored to the lake bed. Owing to the age of the pipeline, Enbridge's track record in the state, and the sensitivity of the Straits of Mackinac, which connects Lake Michigan and Lake Huron (two of the five lakes that together comprise the largest source of freshwater in the world), a growing number of Michigan residents – including business leaders and a number of politicians – have begun to call for the decommissioning of the pipelines beneath the Straits. In 2014, in response to the Marshall spill and growing public concerns about Line 5, the state Attorney General and the Director the Department of Environmental Quality formed a task force to study the safety of Michigan's petroleum pipelines. In July 2015, the Task Force issued a report that included findings of the impact of an oil spill in the Great Lakes from Line 5, which the report said would be devastating. Following that report, Line 5 quickly became one of the central environmental issues in the state and played a pivotal role in the gubernatorial and Attorney General elections in 2018. Before leaving office, outgoing Governor Rick Snyder entered into an agreement with Enbridge to build a concrete tunnel beneath the Straits that would house a new pipeline and, its proponents argue, eliminate the danger of a release of oil into the Great Lakes. As of this writing, a new state administration has taken office, rendering the fate of the agreement unknown. Meanwhile, groups committed to the permanent removal of the pipelines beneath the Straits in order to protect the Great Lakes and to demonstrate that the dismantling of fossil fuel infrastructure in a time of global climate crisis might well be possible continue to voice their concerns via the slogan "Oil & Water Don't Mix."

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Abstract

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Keywords

diluted bitumen; oil spill; Kalamazoo River; Enbridge; tar sands

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