National Transportation Safety Board

Washington, DC 20594

Pipeline Accident Brief

Accident No.:	DCA-10-FP-009
Type of System:	Crude oil transmission pipeline
Accident Type:	Pipeline damage with release
Location:	Romeoville, Illinois
Date:	September 9, 2010
Time:	11:30 a.m., central daylight time[1]
Owner/Operator:	Enbridge Energy, Limited Partnership
Fatalities/Injuries:	None
Damage/Clean-up Cost:	$46.6 million
Material Released:	Heavy crude oil
Quantity Released:	6,430 barrels (270,000 gallons)
Pipeline Pressure:	101 pounds per square inch, gauge
Maximum Operating Pressure:	619 pounds per square inch, gauge
Component Affected:	34-inch diameter steel crude oil transmission pipeline

The Accident

On September 9, 2010, at 11:30 a.m., a 34-inch-diameter pipeline (Line 6A)[2] owned and operated by Enbridge Energy, Limited Partnership (Enbridge) leaked beneath the street pavement adjacent to 717 Parkwood Avenue in the Village of Romeoville (Romeoville), Will County, Illinois, releasing about 6,430 barrels of Saskatchewan heavy crude oil.[3] Damages, including the cost of the environmental remediation, totaled about $46.6 million.

The crude oil leak occurred at an industrial park about 0.6 mile west of the Des Plaines River, and 0.9 mile west of the Chicago Sanitary and Ship Canal. The closest residential areas were about 200 yards from the spill site, which was also within populated and ecologically sensitive areas designated as high consequence areas in Title 49 *Code of Federal Regulations* (CFR) 195.450.

[1] All times are central daylight time.

[2] Line 6A is part of the Enbridge liquid pipeline system that originates in Edmonton, Alberta, Canada. The 1,900-mile US portion, known as the Lakehead System, consists of pipelines of various diameters and ages operated from a control center in Edmonton. The pipeline delivers 670,000 barrels per day of synthetic, light, medium, and heavy crude oils.

[3] The Enbridge Line 6A leak volume calculation indicated a total release of 7,752 barrels, including a supervised drain down of 1,325 barrels that did not leak from the pipeline.

Enbridge reported that the monitoring system showed no indication of a leak during the several hours before discovering the crude oil release. At 9:36 a.m. on September 9, 2010, a passerby reported a water leak near 717 Parkwood Avenue to the Romeoville Public Works Department (PWD). The PWD immediately dispatched an equipment operator to investigate the water leak. At 9:46 a.m., the equipment operator notified the PWD water superintendent that water was discharging from expansion joints and cracks in the pavement from what he believed was a leaking service line. The equipment operator closed a valve on the water service line to Northfield Block Company, a privately owned business near the leak site, stopping the water discharge. Concluding that the leak was not creating a safety hazard, he turned the valve back on to restore water service to the facility—the water flow resumed from cracks in the pavement. He recommended a water leak detection company to a Northfield Block Company representative.

About 11:30 a.m., a technician from Water Services, Inc., the water leak detection company hired by Northfield Block Company, arrived at the scene to locate the source of the leak. In addition to the leaking water, the technician observed oil discharging from beneath the pavement in the vicinity of the reported water leak.

At 12:04 p.m., the Romeoville Fire Department received a report about a gas-like odor at 719 Parkwood Avenue, the location where oil was flowing out of the ground. Firefighters were dispatched to conduct an outdoor gas odor investigation. Upon their arrival at 12:11 p.m., they observed black oil discharging from expansion joints and cracks in a 30 square foot area of an asphalt-and-concrete driveway at the entrance to the Northfield Block Company. They described a heavy flow of oil running south along the street gutter in a 4-foot wide stream that was about 6 inches deep (see figure 1). The fire department immediately notified Enbridge, and a control center operator initiated the oil pipeline shutdown at 12:29 p.m.

The released oil flowed into a storm water drainage ditch and then to a storm water management pond. Both required subsequent excavation and restoration activities to remove the oil.

Three days later, Enbridge crews excavated the area around the damaged water and crude oil pipelines. Investigators observed a 1.5-inch diameter hole on the underside of the oil pipeline directly above the leaking 6-inch diameter water pipe that crossed 5 inches beneath the Enbridge pipeline. The earthen material around the pipes contained large rocks and coarse gravel. The water pipe was severely corroded and had three large holes on top of the pipe facing the oil pipeline.

Figure 1. Aerial view of Parkwood Avenue looking southeast, September 9, 2010

Emergency Response

About 12:11 p.m., the Romeoville Fire Department reported the oil leak to the PWD. The assistant fire chief obtained the Enbridge emergency contact information from a nearby pipeline marker and notified the company of the release at 12:28 p.m.

At 12:29 p.m., the Enbridge control center initiated a shutdown of Line 6A and isolated the leak. The control center staff notified the assistant fire chief that they had initiated a shutdown and that they were contacting oil spill cleanup contractors to respond. Firefighters observed the oil flow diminish within 35 to 40 minutes.

Enbridge notified the National Response Center at 1:06 p.m., then notified the Illinois Environmental Protection Agency, the US Coast Guard, and the Illinois Emergency Management Agency.

Responding fire department units, including a hazardous materials response team, established a command post and evacuated nearby businesses. The fire and public works departments established a control point for the oil spill at the storm water management pond. Firefighters attempted to contain the oil in the gutter along Parkwood Avenue, but the release volume was too great to control with the equipment they had. Crude oil entered two storm drain inlets then flowed into a 1.5-acre storm water management pond that drains into the Des Plaines River.

Subsurface oil at the spill site accumulated under the Parkwood Avenue pavement and migrated along underground utility pipes. Some of the oil entered the sanitary sewer system via compromised piping and manhole covers, where the oil flowed into the Romeoville Waste Water Treatment Plant–South Plant. Operators diverted the contaminated influent to holding tanks and a retention basin. No oil was released from the waste water treatment plant. Responders also placed oil booms at the storm water retention pond spillway to prevent the release from entering the Des Plaines River. Enbridge spill response contractors contained the oil in the pond using boom and skimming equipment.

Enbridge, the US Environmental Protection Agency, and the Romeoville emergency responders established a unified command. Cooperating agencies included the Pipeline and Hazardous Materials Safety Administration, the Romeoville mayor, the village manager, and the police and the fire departments. Enbridge financed the clean-up operations and remedial actions.

Pipeline Information

The pipeline was constructed in 1968 of flash-welded[4] American Petroleum Institute (API) X52 steel pipe manufactured by A.O. Smith. The 34-inch-diameter pipe had a nominal wall thickness of 0.281 inches. The pipe was coated with a single wrap of 18-inch wide Polyken polyethylene tape. The tape was field applied by machine after the bare metal pipe was coated with a primer to ensure adhesion and bonding. The tape coating was damaged and disbonded (that is, the adhesive bond between the pipe and its protective polyethylene tape coating had deteriorated) in the area where the leak occurred.

The maximum operating pressure (MOP) of the pipeline segment was 619 psig. Enbridge estimated that the pipeline pressure at the time and location of the accident was 101 psig.

Several other underground pipes ran parallel to the oil pipeline, including a storm sewer, a sanitary sewer, a natural gas pipeline, and water pipes. A 6-inch-diameter ductile iron cement lined water service pipe ran perpendicular to and below the Enbridge pipeline with a separation of only 5 inches. The oil pipeline leak occurred directly above the water pipe.

[4] The longitudinal weld seam is formed by electric flash welding, a resistance welding process in which the ends are joined by heating and forging without the addition of filler metal.

Corrosion Protection

In addition to the polyethylene tape wrap on the pipeline, Enbridge operated a cathodic protection system using impressed dc electrical current rectifiers[5] to protect the line from corrosion. The nearest anode bed for the cathodic protection was located about 1.4 miles upstream of the accident location.

Section 4.3.10 of the National Association of Corrosion Engineers (NACE)[6] standard states that underground piping systems should be installed so that they are physically separated from foreign metallic structures at crossings and parallel installations and in such a way that electrical isolation can be maintained. Furthermore, since April 1970, 49 CFR 195.250 has prescribed that a minimum clearance of 12 inches must be maintained between a pipeline and any other underground structure. A reduction in this clearance is allowed only if adequate provision is made for corrosion control, which was not done at this location.

Survey Data and Leakage History

Enbridge reported that between 2000 and 2008, it did not identify any defects of concern from eight in-line inspections for corrosion, metal loss, dents, or cracks in the area where the pipeline damage was located. However, an August 2008 inspection using a magnetic flux leakage (MFL) tool[7] identified a metal object near the area of the damaged pipeline. Records indicated no history of excavation to repair or work on the pipeline at the location of the leak.

Enbridge reported that its supervisory control and data acquisition (SCADA) system, its commodity movement and tracking (CMT) system,[8] and its material balance system (MBS)[9] did not indicate any anomalies during the several hours preceding the discovery of the crude oil leak by the Water Services, Inc. technician.

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[5] Impressed current cathodic protection is considered more effective than galvanic cathodic protection in long pipelines. An external dc electrical power source imparts current into the soil through sacrificial metal (the anode), which corrodes instead of the protected metal.

[6] NACE is an industry organization dedicated to the study of corrosion by promoting research of new technology and trade standards and publications.

[7] Sensors on MFL inspection tools detect the leakage fields as they move through the pipeline. Pipe wall changes such as metal loss will cause some of the magnetism to leak outside of the pipe wall. MFL tool specifications describe that a tool has a 90 percent probability of identifying general metal loss that is greater than 10 percent of the wall thickness.

[8] At Enbridge, CMT is a system that performs real-time monitoring of the oil in the pipeline. Control center operators manually perform an accounting of the volumes in the pipeline every 2 hours to check for delivery volumes and potential leaks.

[9] The Enbridge MBS uses a real-time pressure transient pipeline model, which operates in parallel with the SCADA and CMT systems to compare actual and expected flows and pressures between pipeline sections.

Water Supply Pipe Crossing

The Illinois Underground Utility Facilities Damage Prevention Act mandates the use of the Joint Utility Locating Information for Excavators, Inc. (JULIE) one-call system for all excavations on pipeline right-of-ways. Will County, Illinois, began using the JULIE system in August 1974.[10]

The JULIE system requires that prior to any nonemergency excavation an excavator must do the following:

(1) Take reasonable action to become aware of the location of underground utility facilities.

(2) Plan the excavation or demolition to avoid or minimize interference with the underground utility facilities.

(3) Provide notice through the statewide one-call system not more than 14 days nor less than 48 hours in advance of the start of the operation.

(4) Provide support for existing underground utility facilities during and following the operation.

(5) Properly backfill all excavations. Utility owners or operators are required by the legislation to maintain written records of the notice.

Romeoville records indicate that the 6-inch water pipe that passed beneath Line 6A was installed in 1977. At that time, service connections were subject to the requirements of the Village of Romeoville, Illinois, Code of Ordinances.[11] The ordinance required that the application to begin proposed plumbing work shall be made to the building inspector by the plumber as agent of the property owner. Romeoville records did not identify the plumber who installed the water pipe, nor did they indicate whether JULIE or Enbridge had been notified of the project. Enbridge had no record documenting the existence of the water pipe and no record from JULIE for any excavation work at that location.

[10] In 1976, JULIE was accepted by the Illinois Commerce Commission as being compliant with the one-call notification section of Illinois General Order 185.

[11] Village of Romeoville, Illinois, Code of Ordinances, Title V, Chapter 50: Waterworks System.

Postaccident Investigation

The oil pipeline sustained a 1.5-inch-diameter hole (see figure 2) about the 6:00 o'clock (bottom) position directly above the water pipe that crossed beneath it. The pipeline wall was thinned and deformed inward around the edges of the hole.

Figure 2. External view of the hole in the bottom of the 34-inch-diameter oil pipeline

The outer surface deformed inward within a diameter of about 3 inches and was visible on the interior surface of the pipe. Piles of small rocks about 0.125 inch in diameter were covered in oil and stuck to the interior surface of the pipeline.

The oil pipeline tape coating was heavily damaged in the area above the water pipe, likely from the water jetting against it. Strips of ripped and disbonded coating and tape hung down from the sides of the pipeline in the vicinity of the leak location (see figure 3).

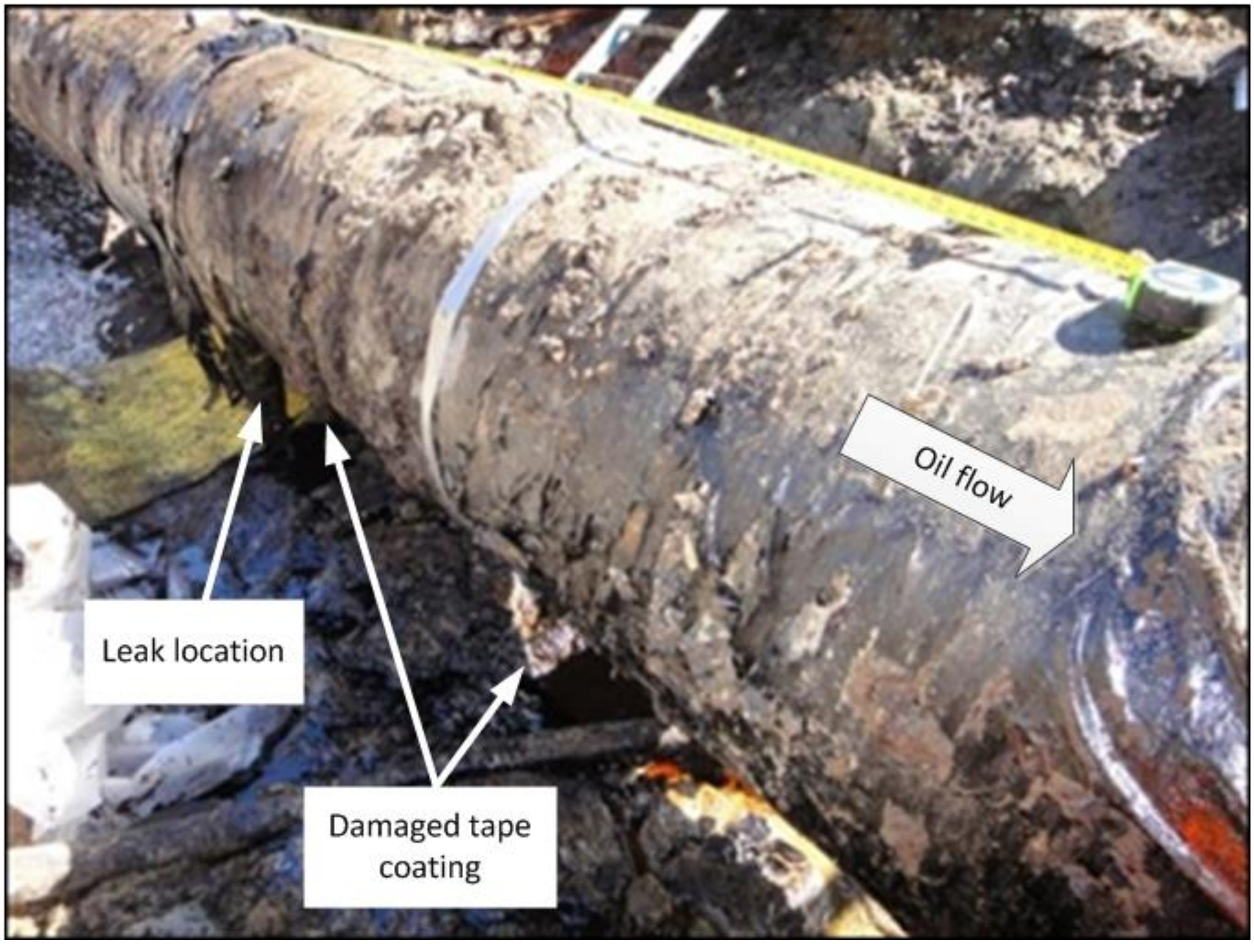

Figure 3. View of the damaged tape coating on the oil pipeline in the excavated trench

Sliding contact damage (gouging) on the outer surface of the oil pipeline was observed within 24 inches downstream from where the water pipe passed under the pipeline (see figure 4). Deformed pipe wall material protruded from the surface of many of the marks, most likely caused by digging tool strikes that occurred during the excavation work when the water pipe was installed.

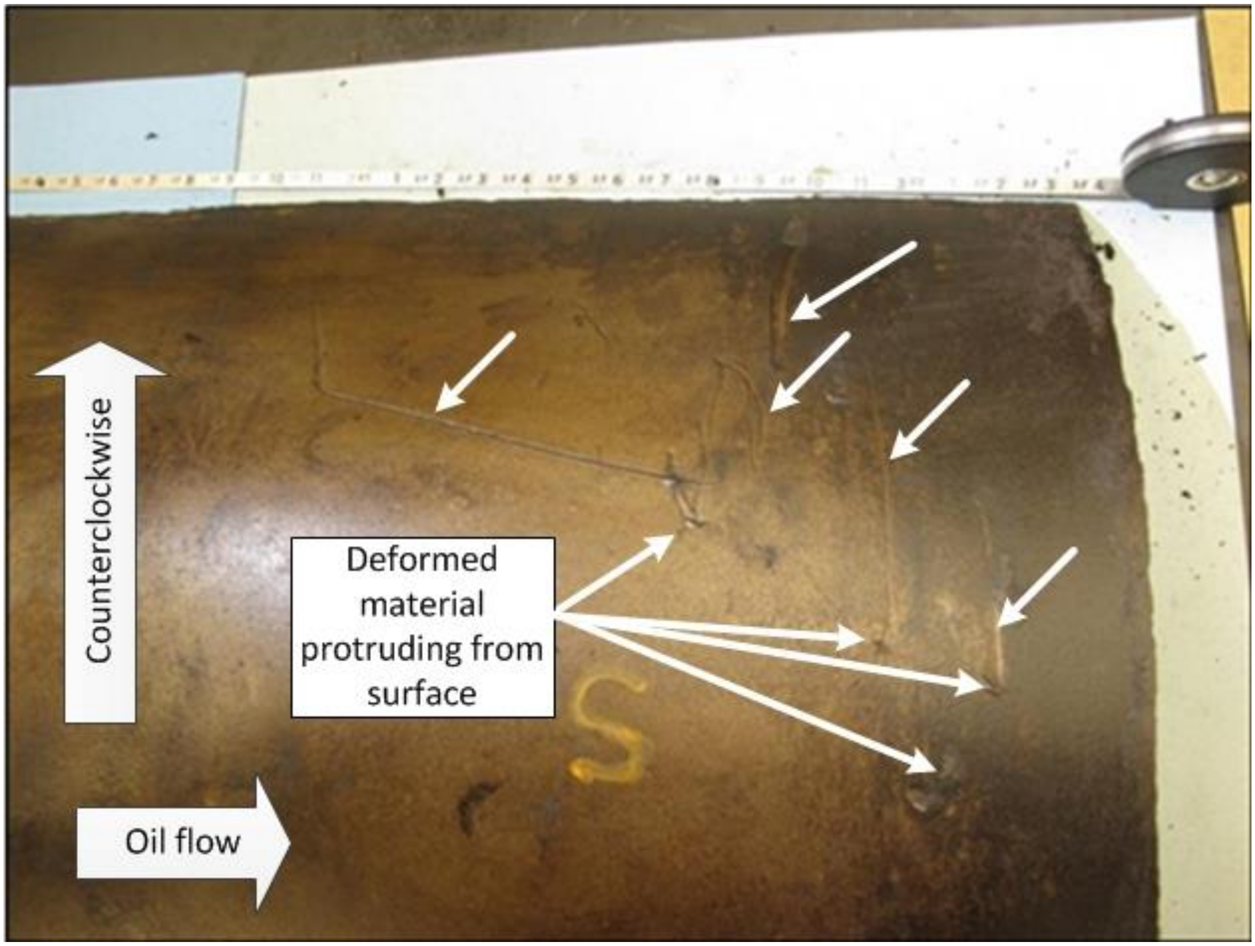

Figure 4. Sliding contact gouges (individual arrows) and deformed material on the outer surface of the oil pipeline near the water pipe intersection

The water pipe was corroded and had three large holes through the pipe wall and concrete liner on the upper half of the pipe in the immediate area directly below the oil pipeline (see figure 5). The largest hole measured 5.1 inches around the circumference and had an irregular shape. The metal edges of the holes were rounded and oxidized. A corrosion pitted area extended about 16 inches upstream and downstream along the top and sides of the pipe from the center of the largest hole. The bottom of the pipe as well as the entire circumference upstream and downstream beyond the corroded area did not exhibit significant corrosion.

Figure 5. Large holes and corrosion damage on the top of the 6-inch-diameter water pipe

Trench Conditions

Upon excavating the damaged pipes, investigators observed large rocks and coarse gravel between the bottom of and in contact with the oil pipeline and the top of the water pipe. The NTSB Materials Laboratory examined six large rocks that had been firmly wedged between the oil pipeline and the water pipe. Some were stained black, consistent with deposited oil. The rock shapes were compared to the shape of the hole and inward deformation in the oil pipe; however, no conclusive match was found.

The trench backfill along the oil pipeline north and south of the leak location was sand, in contrast to the large rocks that were used as the backfill in the vicinity of the water pipe crossing.

Sequence and Mechanism of the Pipeline Hole Formation

Holes were observed in the water pipe and the oil pipeline. Most likely, the large holes in the water pipe developed first due to stray current corrosion, and the hole in the oil pipeline developed due to erosion from water jet impingement on the oil pipeline.

The oil pipeline is cathodically protected with an impressed current system. A metallic object in close proximity to the oil pipeline, such as the water pipe, can disrupt the electric current flow and cause the metallic object to corrode, which is likely what caused the heavy local corrosion on the water pipe. Being only 5 inches away, the water pipe was close enough to disrupt the cathodic protection currents on the oil pipeline.

The gravel fill to the west of the oil pipeline was added after a sanitary sewer repair the previous winter and remained exposed at the surface until an asphalt patch was applied in the spring.

According to an article published by the Ductile Iron Pipe Research Association,[12] when a ductile iron pipe crosses a cathodically protected pipe, the ductile iron pipe should be encased with polyethylene for a 20-foot distance in each direction from the nearby cathodically protected pipe. Alternatively, a sacrificial anode could be attached to the water pipe to discharge the current from the anode instead of from the water pipe back to the oil pipeline. Contrary to these recommended practices, the water pipe was not provided either protection method.

Although the oil pipeline was installed with a protective coating, NTSB investigators determined the coating was most likely damaged during the water pipe installation, as evidenced by the gouges observed on the oil pipeline. The damaged oil pipeline coating provided a pathway for stray current to lead to extensive, deep corrosion on the upper side of the water pipe. Eventually, the ductile iron water pipe was so degraded that the concrete liner was unable to contain the water pressure.

[12] Richard. W. Bonds, "Stray Current Effects on Ductile Iron Pipe," Ductile Iron Pipe Research Association, Birmingham, Alabama, (1997).

The holes in the water pipe became larger from the jetting water flow. The high-velocity, spraying water with suspended sand and small gravel began striking the oil pipeline until a through-wall hole developed.

Impact of the Crude Oil Release

Community

On the day of the accident, the fire department evacuated 50 persons from 11 nearby businesses. Twenty-three area businesses were closed for 1 to 9 days. The PWD temporarily plugged one sanitary sewer line, which disrupted several nearby businesses for a day.

Environment

The EPA responded to the scene on September 9, 2010, to oversee removal of oil-contaminated soil and pavement, and the cleanup and restoration of the sanitary and storm drain systems, storm water management pond, and waste water treatment plant. The EPA also supervised surface water sampling, area air monitoring, and the installation and sampling of a network of 31 groundwater monitoring wells. On October 28, 2010, the EPA transferred oversight of long-term monitoring and cleanup of contaminated ground water to the Illinois EPA.

Enbridge recovered 694,000 gallons of oil and water mixture. An additional 55,650 gallons of oil were pumped from the isolated pipeline segment. The EPA also removed about 1.5 million gallons of hazardous waste, 1 million gallons of treated water from the retention pond, 4.4 million gallons of treated sewage lagoon water, and 15,000 cubic yards of contaminated soils. A wildlife response center treated and released 141 turtles and frogs, while another 32 animals were found deceased in the field.

Costs

Enbridge’s expenses related to the release of crude oil from Line 6A, including environmental remediation, totaled $46,617,000. Federal response and oversight costs were $550,000.

Postaccident Actions Involving Hazardous Liquid Pipelines

On January 3, 2012, pipeline leak detection capability was addressed in the Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011,[13] Section 8. This Act requires the US Secretary of Transportation to submit to Congress a report on leak detection systems used by operators of hazardous liquid pipelines. The report must include an analysis of the technical limitations of current leak detection systems, including the ability of the systems to detect ruptures and small leaks that are ongoing or intermittent, and of what can be done to foster development of better technologies. The report must also address the practicability of establishing technically, operationally, and economically feasible standards for the capability of such systems to detect leaks. The Act requires the US Department of Transportation (DOT) to

[13] Public Law 112-90, January 3, 2012.

promulgate regulations mandating implementation of the technology if the DOT finds that it is practicable to establish such standards for the capability of leak detection systems to detect leaks.

On July 10, 2012, the NTSB adopted its report addressing the July 25, 2010, rupture of a 30-inch-diameter Enbridge pipeline that released more than 843,000 gallons crude oil into a wetland and the Kalamazoo River in Marshall, Michigan.[14] The NTSB issued safety recommendations to the US Secretary of Transportation, the Pipeline and Hazardous Materials Safety Administration, Enbridge Incorporated, the American Petroleum Institute, the Pipeline Research Council International, the International Association of Fire Chiefs, and the National Emergency Number Association. The NTSB expressed concern about the failure of the Enbridge control center staff to recognize abnormal conditions that might indicate a pipeline leak or rupture and issued recommendations to Enbridge to improve leak detection.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Enbridge Energy, Limited Partnership oil pipeline leak and crude oil release near the Des Plaines River in Romeoville, Illinois, on September 9, 2010, was erosion caused by water jet impingement from a leaking 6-inch diameter water pipe 5 inches below the oil pipeline.

Contributing to the accident was the interruption of the cathodic protection currents by the close proximity of the improperly installed water pipe.

Adopted: September 30, 2013

[14] National Transportation Safety Board, *Enbridge Incorporated Hazardous Liquid Pipeline Rupture and Release, Marshall, Michigan, July 25, 2010*, PAR-12/01 (Washington, DC: National Transportation Safety Board, 2012).