Tracking of Release and Remediation Progress from Large Pipeline Break East of Dallas, Texas: Protection of Lake Tawakoni Water Supply

Joseph E. Odencrantz

A gasoline pipeline owned by Explorer Pipeline Company ruptured leaking methyl tertiary butyl ether (MTBE), a gasoline additive, into a creek and lake that the city of Dallas used as a water source. Because of the contamination, the city had to build a pipeline (nine feet in diameter, over two and three-quarters of a mile in length, and built in three months) to another lake, at a cost of about $9 million. The volume of the release was estimated at 1.7 million gallons of gasoline containing MTBE at 9 percent per volume. Thousands of soil, water, and groundwater samples were taken to track the MTBE plume as it migrated from the spill site, through almost 30 miles of creek and throughout a lake containing 700,000 acre-feet (228 billion gallons) of water. Four years after the spill, MTBE remains throughout the groundwater system, primarily in the drainage basin along the almost 30 miles of creek. This article focuses on the detailed tracking of all sampling data and the impact that the ongoing threat of MTBE contamination had on the water supplier.

INTRODUCTION

The City of Dallas learned about the Explorer Pipeline gasoline release late in the evening on March 9, 2000. They immediately shut down their intake on Lake Tawakoni as a precautionary measure when informed that the leaked gasoline contained methyl tertiary butyl ether (MTBE). Dallas Water Utilities (DWU) relies on the water from Lake Tawakoni to provide its 1.8 million users with approximately 30 percent of their water. The DWU intake remained shut down for over five months and resumed pumping on August 17, 2000. The migration of MTBE became of interest to the greater metropolitan area of Dallas and was featured on television broadcasts and in newspapers throughout Texas as DWU managed the aftermath of the pipeline rupture as best it could. There are two lawsuits that arose as a result of this spill. The first case was the City of Dallas versus the Explorer Pipeline over its response and pipeline costs, and the second case was the landowners on East Caddo Creek versus Explorer Pipeline for damage to their properties.

The spill migrated into East Caddo Creek and traveled 28 miles into Lake Tawakoni, a surface-water source DWU relies on to serve 30 percent of its customers. The magnitude of the release was initially estimated to be 500,000 gallons at the time of the release, and crews did their best to contain the free product with vacuum trucks, underflow dams, cofferdams, and booms (Exhibit 1). Needless to say, once the gasoline makes

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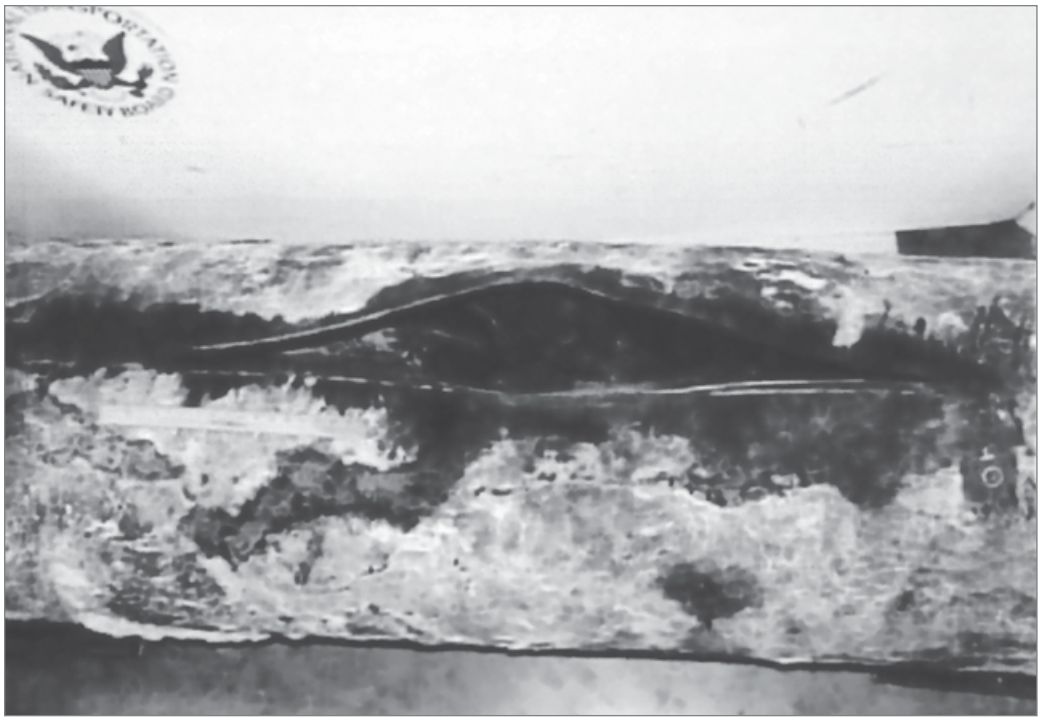

Exhibit 1. Rupture: Fish-mouth crack, 50.5 inches long, maximum width of 6 3/4 inches in 28-inch steel pipe (National Transportation Safety Board, 2001)

its way to a creek and then a major rainstorm hits, there is not much anyone can do to contain the forces of nature. Further, the high solubility of MTBE in water (over 4,000,000 µg/L) makes for extremely difficult containment when there is water present.

INITIAL CHARACTERIZATION: NATURE AND EXTENT

The Sabine River Authority (SRA) owns Lake Tawakoni, and DWU/Dallas has the rights for approximately 80 percent of the water contained in the lake. The SRA is a governmental agency responsible for the control, storage, preservation, and distribution of water from Lake Tawakoni as well as its tributaries (Freeze & Nichols, Inc., 2000). The SRA was the first organization to collect water samples in Lake Tawakoni. The first water sample (sampling location 4A—30 miles from the spill site) in Lake Tawakoni that contained MTBE was collected at 3:30 P.M. on March 12, 2000, or 2 days, 17 hours, and 10 minutes after the rupture occurred. MTBE was detected at 1,200 µg/L and benzene at 46.6 µg/L in the East Caddo Inlet mid-channel of Lake Tawakoni. This sample is approximately 4,200 feet from where East Caddo Creek becomes Lake Tawakoni. As confirmation, the Texas Natural Resource Conservation Commission (TNRCC) detected 9,000 µg/L of MTBE and 629 µg/L of benzene at the 34 Bridge, or 6,200 feet upstream from the dividing line between East Caddo Creek and Lake Tawakoni, or 10,400 feet upstream/up-lake from sampling location 4A. The TNRCC sample was collected at 7:20 P.M. on March 12, the same day.

The next day, March 13, 2000, at 1:35 P.M., at a sampling location approximately 8,500 feet down lake from sample location 4S, or 2.8 miles into Lake Tawakoni, 5,980

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µg/L of MTBE and 74.5 µg/L of benzene were detected at sample location 5S. A major rain event on March 10 and 11, 2000, served to effectively wash the first of many slugs of contamination into Lake Tawakoni (1.47 inches measured at the Lake Tawakoni Dam and a large increase flow in the Cowleech Fork Sabine River at Greenville on March 10, 2000, at 6:00 P.M. until 2:00 P.M. on March 11, 2000). The next task was to track the slug of MTBE through Lake Tawakoni, and DWU would assist Explorer Pipeline and the Sabine River Authority with the data collection from the source to their intake in Lake Tawakoni in the days that followed. Before the City of Dallas took its first sample, the City of West Tawakoni would have to deal with gasoline constituents at its intake, discovered first at 9:41 A.M. on March 15, 2000, at SRA sampling location 6A. The first detections were MTBE at 101 µg/L at the surface and 74.9 µg/L at the lake bottom. The West Tawakoni intake is located approximately 4.6 miles into Lake Tawakoni, or 33.8 miles from the spill site. The City of West Tawakoni had water delivered by tanker trucks for nine days and eventually switched to a specialized treatment system capable of treating MTBE-affected water.

The City of Dallas hired an MTBE consultant (the author) who began work on March 15, 2000, at Dallas City Hall. The objective of the engagement was to determine the impact of MTBE on the city water supply. After a briefing on most of the available information on this date, the City of Dallas collected hundreds of samples at the release site, from East Caddo Creek, and from Lake Tawakoni the following day. The City of Dallas was interested in collecting its own independent data set for city water professionals and for the City Council to use for decision making.

Release Site Evaluation

The Dallas consultants collected soil, groundwater, and pooled water samples on March 16, 2000, in the vicinity of the ruptured pipeline, an area approximately 600 feet by 1,200 feet. The pipeline rupture occurred approximately 1,000 feet north of East Caddo Creek, and the gasoline migrated over terraces and then into the head of a ravine on a drainage pathway toward East Caddo Creek. Sixteen soil borings were installed to depths ranging from 8 to 16 feet, and three borings were completed as groundwater monitoring wells. The soil borings yielded MTBE concentrations as high as 754,000 µg/kg, and the lateral extent was identified with some certainty on the upstream/eastern side of the rupture point. The lateral extent of MTBE in soil on the downstream side of the most downstream soil borings was refined by considering water samples collected from pooled water in this vicinity. The five pools contained MTBE concentrations in water that ranged from 22,400 µg/L to 65,800 µg/L. The estimate of the total volume of MTBE-impacted soils was 80,500 cubic yards that contained an estimated mass of 11,000 pounds of MTBE over an area of approximately 7.9 acres in the uppermost two feet of soil and 3.5 acres in soil 8–10 feet below grade (EA Engineering, Science, and Technology, 2000c).

The estimate of the total volume of MTBE-impacted soils was 80,500 cubic yards that contained an estimated mass of 11,000 pounds of MTBE. . .

The three groundwater wells were installed to a depth of 20 feet. Only two of the wells produced water, and the MTBE concentrations ranged from 25,000 µg/L to 551,000 µg/L over a one-month period in those wells. The well closest to the rupture (approximately 200 feet west) yielded 0.19 feet of free product gasoline after one month. The wells recharged at a slow rate, and the shallow groundwater appears to be the result of discontinuous perched layers. The soil consists of clay from 5 to 8 feet underlain by 3–5 feet of silty clay, which overlies a 3–5-foot-thick weathered limestone layer. The 17–20-feet-below-grade region appears to be gray calcareous clay.

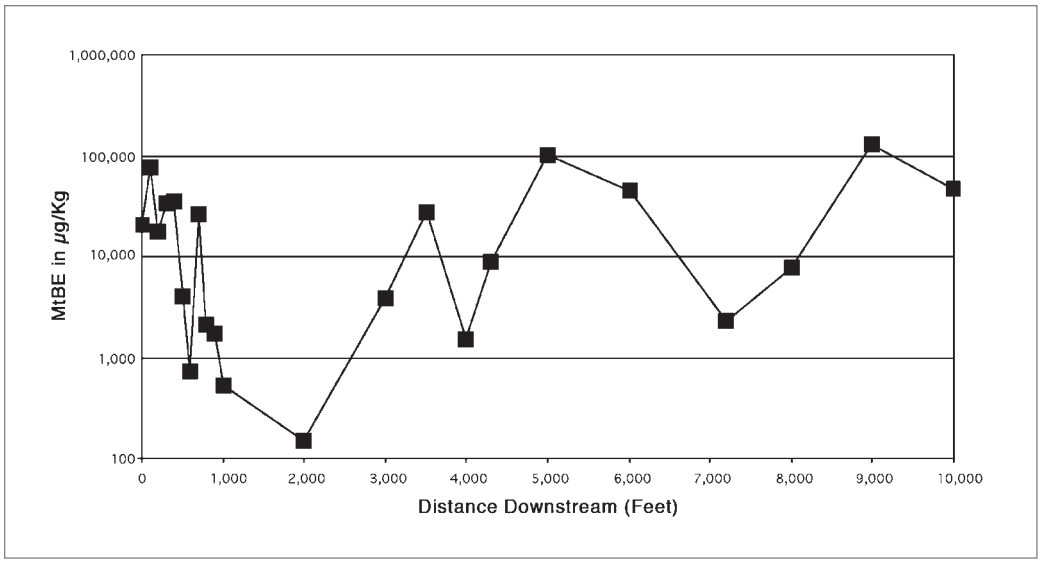

Exhibit 2. MTBE in stream-bank soils on March 16, 2000

East Caddo Creek Assessment

Dallas consultants collected stream bank and water samples on March 16, 2000, from the spill site to 17 miles down East Caddo Creek. The majority of samples were collected in the first 10,000 feet of East Caddo Creek downstream of the spill site. Up to five stream-bank and water samples were taken from ten sections spaced 100 feet apart and then ten sections spaced approximately 1,000 feet apart (EA Engineering, Science, and Technology, 2000a). The results from the stream-bank soil samples are averaged for each section and plotted in Exhibit 2.

The data trends indicate widespread MTBE loading over a little less than two miles. There appears to be a cyclic increasing trend with distance over the sample area, and the peaks are most likely coincident with free product pools. Exhibit 3 shows MTBE in water samples collected from the spill site to 17 miles downstream.

Leachability Testing

On March 22, 2000, stream-bank soil samples were collected at four locations in the first 9,000 feet downstream from the spill site in order to estimate the saturation and dissolution of MTBE via simulated leaching in the laboratory. ASTM D4874M-Volatiles (C1-C10) entitled "Leaching Solid Material in a Column Apparatus" was strictly adhered to by PTS Laboratories Inc. in Santa Fe Springs, California. A summary of the test results is shown in Exhibit 4.

The results from the leachability tests documented a very large mass loading of MTBE in all four samples; with an average concentration of MTBE after one pore volume of 101,750 µg/L (Exhibit 5). As a side note, the average concentration of benzene was 1,350 µg/L after one pore volume of water pass-through. The data were used to substantiate the concern of MTBE loading from the stream banks starting at the spill site and going to Lake Tawakoni.

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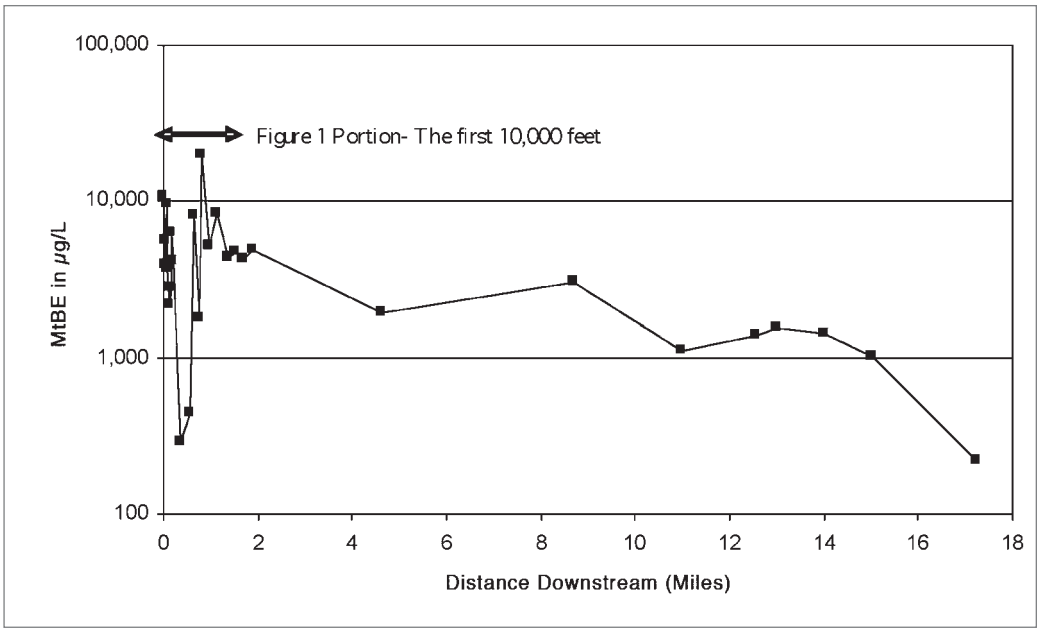

Exhibit 3. MTBE in Caddo Creek water samples taken on March 16, 2000

Lake Tawakoni Plume Movement and Mass Calculations

The initial slug of MTBE that entered Lake Tawakoni that was described previously began entering the massive water body on or about March 12, 2000. Both DWU and the SRA dispatched several crews in boats to intensely sample for MTBE for several weeks. Exhibit 6 depicts one of the most widely disseminated versions of the Lake Tawakoni MTBE plume based on samples collected on March 26, 2000. As depicted by the map, the plume had migrated throughout a large portion of the water body.

Under the direction of DWU's MTBE consultant, employees from DWU were able to estimate the volume of impacted water and the mass of MTBE on two different occasions, March 16 and 26, 2000. These plume parameters are contained in Exhibit 7. These data indicated that a large amount of MTBE migrated to the lake.

Exhibit 4. Leachability test results

Location	Distance in ft.*	Soil-ug/kg (ppb)	One PV Water-ug/L (ppb)	Two PV Water-ug/L (ppb)	One PV Time Days	Two PV Time Days
Station 0+00	0	83,000	150,000	24,000	15	32
Station 03+00	300	34,000	45,000	15,000	10	20
Station 35+00	3,500	47,000	32,000	5,900	16	35
Station 90+00	9,000	110,000	180,000	24,000	1	1

* Measured from the intersection of Caddo Creek and the Explorer Pipeline (station 0+00). PV = Pore Volume

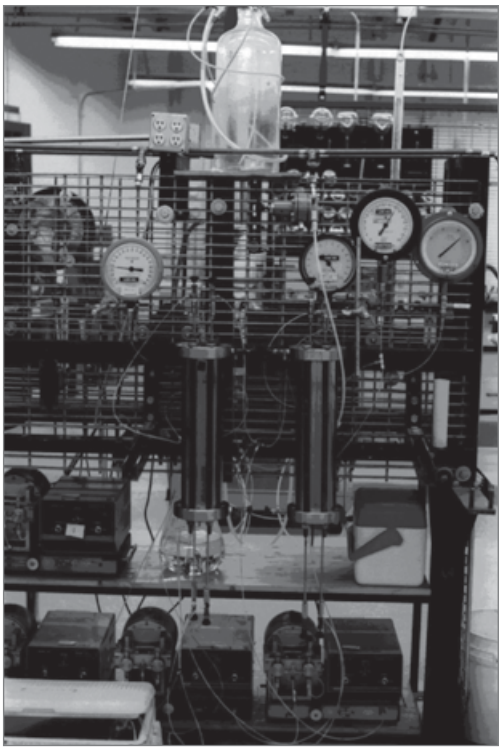

Exhibit 5. Leaching test apparatus—MTBE dissolution in water from stream-bank soils

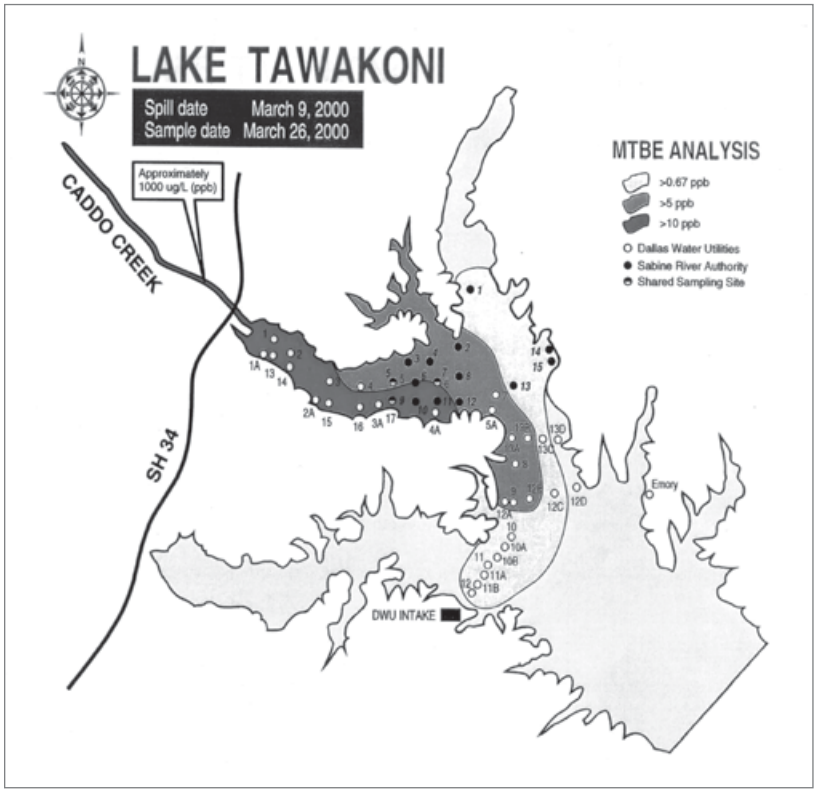

Exhibit 6. MTBE plume in Lake Tawakoni, March 26, 2000

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Exhibit 7. Comparison of MTBE mass and volume of lake water impacted

	MTBE Mass (Pounds)	Volume Impacted (Acre-feet)	Percent of Lake Impacted	Average MTBE (ug/L)
March 17, 2004	36,200	24,250	3.5	574.4
March 27, 2004	8,086	335,000	48.5	8.85

WATER SUPPLY SOLUTION

As a result of DWU shutting down its intake due to concern over the MTBE release, Dallas lost 190 million gallons per day (MGD) of its water supply. Exhibit 8 shows the historical DWU usage for the years 1998 and 1999m with a depiction of total system capacity and the reduction of that capacity due to the loss of flow from Lake Tawakoni. It was clear that the city would not be able to supply its water customers with water in the summer of 2000 without an additional approximately 90 MGD. The City of Dallas had to decide if it was going to pump water from Lake Tawakoni and, if not, what it was going to do without being able to withdraw water from Lake Tawakoni. The city contemplated the implementation of Stage 3 water restrictions that would prevent lawn watering, hosing off of certain areas, and reduction measures by high-volume users through water audits. It did not help matters that Dallas was also in its fifth year of a drought cycle.

On March 17, 2000, DWU learned the TNRCC did not have a drinking water standard for MTBE, and TNRCC issued the following clarification language in a facsimile to a Dallas consultant:

> Since there is no Maximum Contaminant Level for MTBE, the TNRCC does not have the authority to mandate a MTBE level in drinking water. The TNRCC does, however, have a cleanup level for MTBE in groundwater. The residential cleanup standard for MTBE in groundwater is 240 ppb, which is based on the prevention of long-term health effects. We are confident the MTBE in drinking water at this level would not pose an unacceptable health risk. We also recognize that 240 ppb MTBE in groundwater would present taste and odor problems. Therefore, for Type I and Type II groundwater (which is groundwater that is potable or used as a drinking water supply), we apply a cleanup standard of 15 ppb, which is based on taste and odor.

DWU was not satisfied with this and learned about very low thresholds of odor and taste previously published as 2.5 and 2 μg/L, respectively (US EPA, 2000). As a result of not wanting to be criticized for delivering MTBE-tainted water on potentially a large-scale basis, DWU decided to impose a concentration cutoff of 0.67 μg/L before it would accept water from Lake Tawakoni. Further, the city wanted some reassurance about the possibility of dealing with future slugs of MTBE entering its water supply from Lake Tawakoni. The DWU now had to implement a plan to obtain enough capacity to meet the water supply needs of Dallas in the summer of 2000. DWU, with approval from Dallas City Council, proceeded to pursue the path of building a new pipeline to Lake Ray Hubbard in the event Lake Tawakoni was unusable during the peak demand period. The subterranean pipeline was built in approximately three months, was 14,650 feet in length and 96 inches in diameter, and provided DWU with the additional capacity just in time without the benefit of Lake Tawakoni.

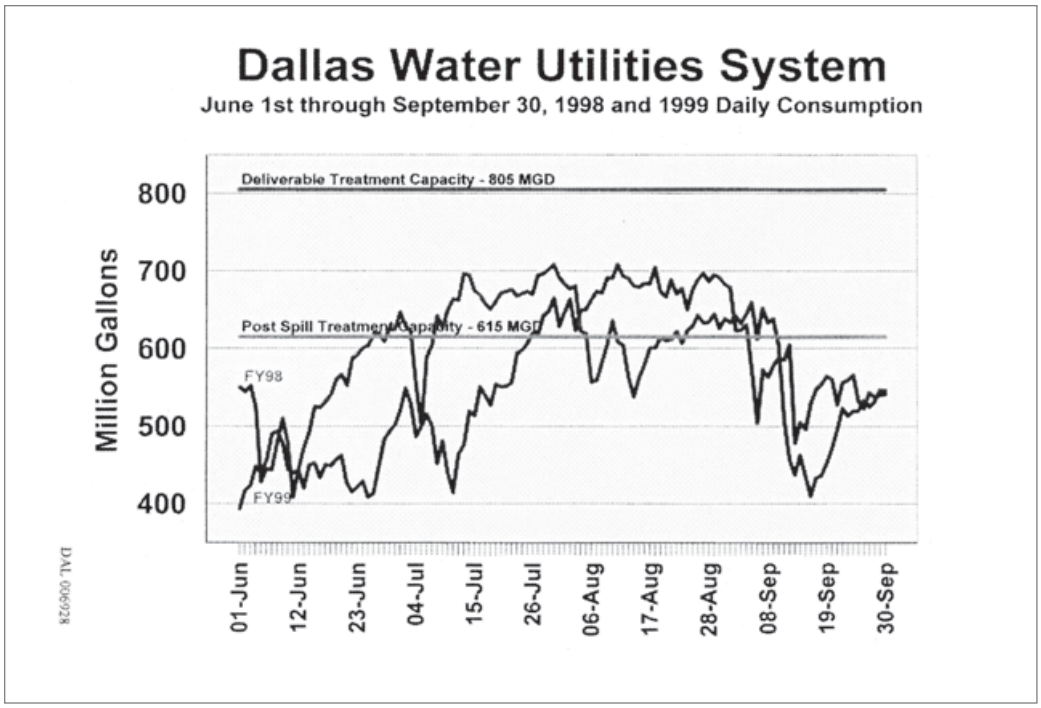

Exhibit 8. DWU historical usage and post spill capacity reduction

EARLY WARNING SYSTEM: SUMMER OF 2000

Concern about additional slugs of MTBE from East Caddo Creek in Lake Tawakoni continued throughout the summer of 2000. DWU insisted on a detailed remediation plan for East Caddo Creek, yet Explorer Pipeline never produced a comprehensive plan. DWU was also concerned about the spill site cleanup activities releasing MTBE from aeration lagoons, the excavation pit itself, the large volume of untreated excavated soils, and the mass of MTBE stored in the stream bank as clearly documented by the March 16, 2000 data. Explorer Pipeline reported on-site MTBE concentrations in water as high as 4,404,800 µg/L on May 1, 2000, which might be the highest MTBE measurement in water from a release anywhere. Clearly, there was a tremendous amount of uncontained MTBE, and DWU insisted that mass removal occur along East Caddo Creek. Exhibit 9 shows the site remediation activities, the pipeline, and East Caddo Creek.

Exhibit 10 shows a time history of MTBE concentrations in samples from the 903 Bridge in to East Caddo Creek during the summer of 2000.

In order for DWU to commence with pumping from Lake Tawakoni, the city insisted that an independently administered early warning system (EWS) be established such that slugs of MTBE could be tracked when they occurred. The city also required that an independent contractor operate the EWS. Exhibit 11 is a map showing the locations of the sampling sites for the EWS along East Caddo Creek and in Lake Tawakoni. East Caddo Creek was to be sampled twice per week at these locations to establish the MTBE concentrations (EA Engineering, Science, and Technology, 2000b). If any substantial increase in concentrations were detected, the 13 sampling locations in Lake Tawakoni would be immediately sampled. The contractor was hired near the end of

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Exhibit 9. Spill site and East Caddo Creek, June 10, 2000

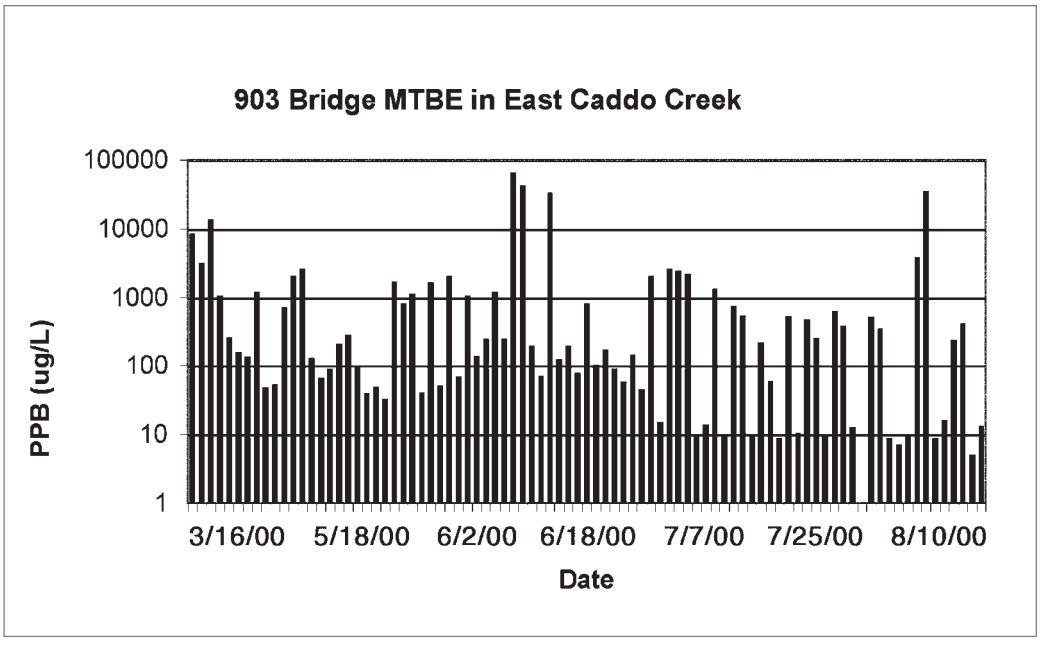

Exhibit 10. MTBE history in East Caddo Creek, Summer 2000

July 2000, and a two-week trial period took place where the DWU consultants and the independent contractor jointly operated the EWS. DWU deemed the EWS independent contractor competent and reliable, which allowed DWU to pump from Lake Tawakoni on August 17, 2000.

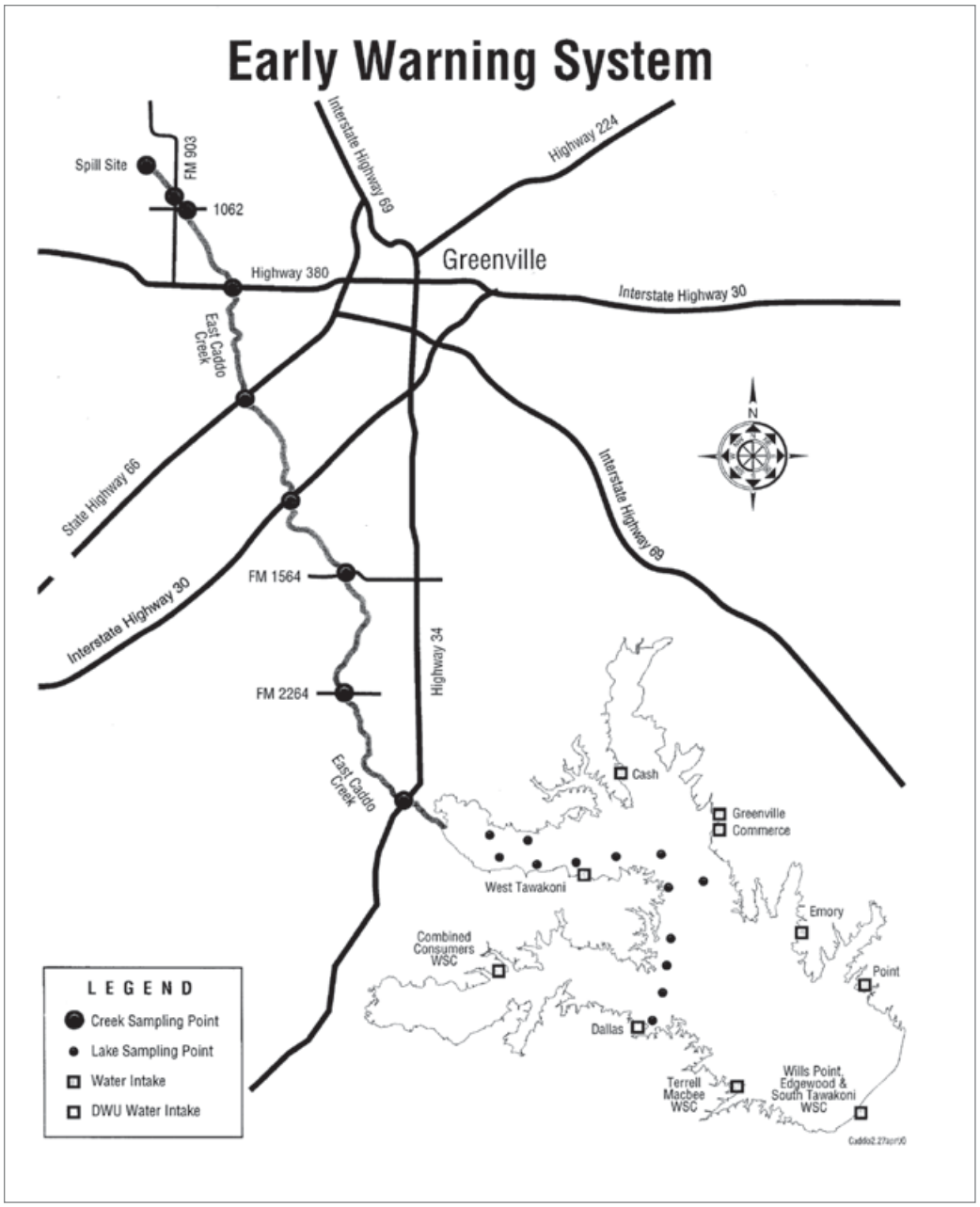

Exhibit 11. Map of early warning system sampling locations

SOURCE-AREA CLEANUP ESTIMATES

The magnitude of the spill was not fully appreciated or understood until the rupture area excavation/spill site and treatment was completed in the year 2003. One of the more problematic areas of the aftermath of the spill was estimating the extent to which the environment was impacted. As discussed earlier, DWU estimated the volume of impacted soils in the immediate vicinity of the spill was 80,500 cubic yards from data collected on March 16, 2000. Explorer Pipeline had many estimates of cleanup time and quantity over the course of time. Exhibit 12 provides a summary of the various esti-

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Exhibit 12. Estimates of soil remediation time and volume at spill site

	4/6/00	4/19/00	4/28/00	11/19/00	6/6/03	Units
Days Since Spill (3/9/00)	28	41	50	255	1,184	Days
Explorer's Cleanup Time Est.	30–60	30–60	30–60	200–250	0	Days
Explorer Remediation Quantity Est.	None	30,000	45,000	240,000	396,496	Yards
Explorer Remediation Quantity Est.	None	39,000	58,500	312,052	515,445	Tons

mates made public from April 6, 2000, through November 19, 2000, by Explorer Pipeline. It is clear the magnitude of the problem was very uncertain in the year 2000, as the last estimate of time was off by a factor of four and the quantity underestimated by 65 percent. The data presented in Exhibit 12 should be a reminder about the difficulties of making decisions on uncertain data.

PROPERTY ASSESSMENTS

In 2003 and 2004, several properties along East Caddo Creek were investigated to determine if MTBE and other gasoline constituents from the March 2000 spill were present. Soil borings were installed to depths of approximately 15 feet and between 20 and 40 feet from the bank edge of East Caddo Creek. The borings were later used to test perched groundwater. The locations were chosen based in part on the recharge of MTBE from variations in water levels/flow in the creek. During a preliminary investigation in April 2003, as much as 190 µg/kg of MTBE were detected at a depth of 12–14 feet at a property located one mile from the spill site. In the same boring, 43 µg/kg were found from 10–12 feet below grade. In the perched groundwater, as much as 4.8 µg/L were found on the same property. The soil investigation was limited to five borings on three properties.

During the months of May and June 2004, a more thorough soil and groundwater investigation was performed on ten properties, from near the spill site to approximately 15 miles downstream from the spill site. The results of the investigation showed as much as 280 µg/kg of MTBE detected at a depth of 16–18 feet at a property located approximately one mile from the spill site. In the perched groundwater, as much as 160,000 µg/L were detected on a property located approximately nine miles from the spill site (EA Engineering, Science, and Technology, 2004).

LEGAL CASES

In November 2000, the City of Dallas brought claims against the Explorer Pipeline Company for negligence, gross negligence, and trespass, and against MTBE refiners Valero, Equilon, and Phillips for product liability. The City of Dallas hired trial attorney Ted B. Lyon and his Dallas area law firm to try the case on behalf of its 2 million citizens. The city sought to recover the tax dollars it expended in responding to the release and constructing an alternative water supply pipeline. After lengthy litigation, Lyon and his legal team settled the Dallas product liability claims with the MTBE refiners for approximately $1 million. In February 2004, Lyon and his legal

team took Explorer Pipeline to trial for several weeks, and after hearing the case presented by Lyon's trial team and experts on behalf of the city of Dallas, Explorer opted to settle for approximately $9 million. In the end, the City of Dallas was able to recover all of the money that it expended in responding to the release as well as construction of the alternative water supply pipeline, which it continues to use as part of its water system.

Lyon and his trial team also represented over 35 property owners who resided along East Caddo Creek in Hunt County, Texas. That case was also brought against Explorer Pipeline and the same MTBE refiners. The property owners' product liability claims were settled with the MTBE refiners for several hundred thousand dollars. After five years of extensive litigation, in May 2005, the property owners settled their remaining claims against Explorer for several million dollars. The settlement came after it was revealed by testing in 2004 that the creek vicinity remained contaminated with MTBE concentrations as high as 160,000 ppb.

The Explorer Pipeline rupture that occurred on March 9, 2000, will undoubtedly go down in history as not only the largest MTBE release to date, but also the largest impact to surface water from MTBE from a single event.

CONCLUSIONS

The Explorer Pipeline rupture that occurred on March 9, 2000, will undoubtedly go down in history as not only the largest MTBE release to date, but also the largest impact to surface water from MTBE from a single event. Dallas lost 30 percent of its water supply for over five months as a direct result of the spill and faced severe water shortfalls without being able to pump from Lake Tawakoni. The first massive slug of MTBE washed down East Caddo Creek almost 30 miles and into a large lake. DWU did not receive enough reassurance to be satified that its water supply would not be impacted by additional slugs of MTBE during the summer of 2000. A race to build a pipeline to a different lake then began so that the peak demand period could be satisfied. Lake Tawakoni was brought back into service on August 17, 2000, over five months after the spill, when an independently administered early warning system was put into place.

The environmental impacts from a release of over 1.7 million gallons of gasoline were documented by the collection of thousands of water, soil, and groundwater samples taken at the spill site, along East Caddo Creek and in Lake Tawakoni. The results of the data collected lead to the conclusion that MTBE had impacted almost 30 miles of East Caddo Creek, and long-term source of MTBE was now in the streambanks due to spreading caused by the large rainstorm that occurred the day after the release. There is a high probability that MTBE lingered in the East Caddo Creek watershed at the time this article was completed (Exhibit 13).

ACKNOWLEDGMENTS

I would like to thank all the attorneys at the law office of Ted B. Lyon and Associates in Mesquite, Texas, for all their assistance. I would also like to thank EA Engineering, Science, and Technology; Petroleum Testing Services; the Sabine River Authority; and the City of Dallas. Special acknowledgements go to Terrace Stewart and Michael Rickman, director and associate director, respectively, of Dallas Water Utilities in the year 2000 for their support, dedication to their water supply, and their genuine concern of protecting the citizens of Dallas.

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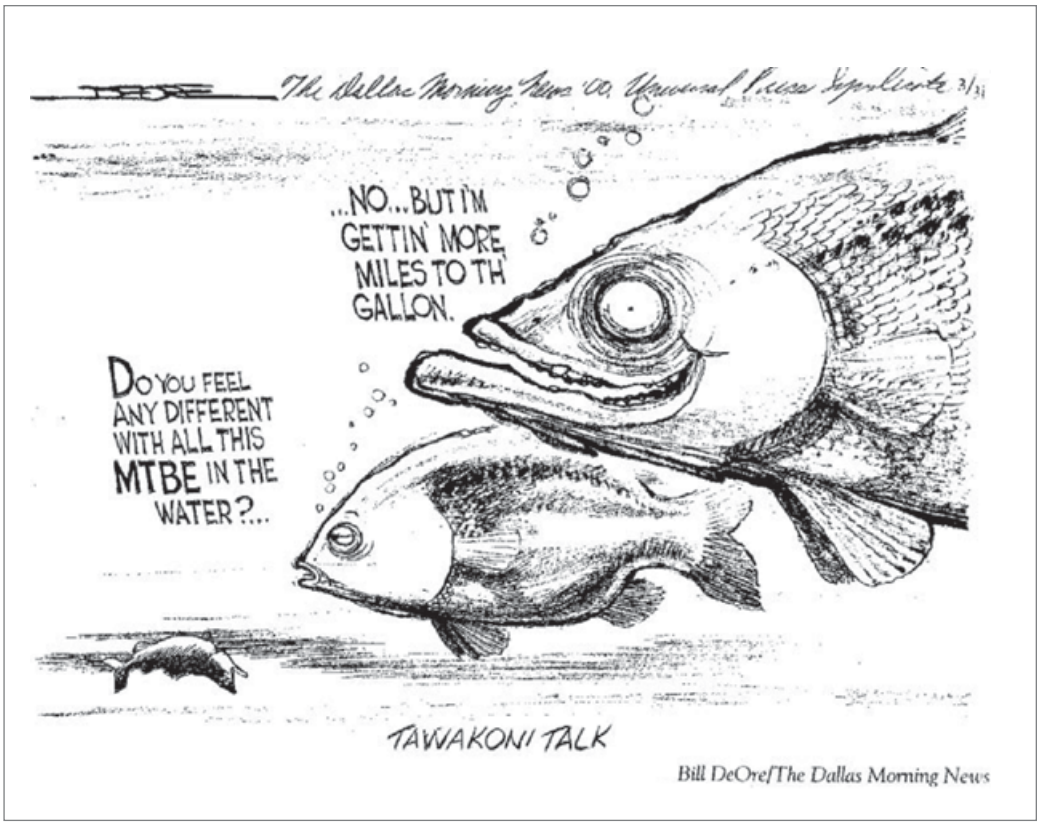

Exhibit 13. Editorial cartoon, the *Dallas Morning News*, March 31, 2000 (reprinted with permission)

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Joseph E. Odencrantz, PhD, P.E., is a civil and environmental engineer at Tri-S Environmental, Newport Beach, California, phone: (949) 644-8602, fax: (949) 644-2016, Web site: www.tri-s.com, e-mail: jodencrantz@tri-s.com. Dr. Odencrantz is internationally recognized as a water professional with expertise in watershed management, fate and transport processes, forensic evaluations, and water treatment. He obtained his MS and PhD in civil and environmental engineering from the University of Illinois at Urbana–Champaign. He received his BS in civil engineering from the University of Maine at Orono. Dr. Odencrantz is licensed to practice civil engineering in California, New York, Texas, Michigan, and Maine. He has published extensively on the fate and transport of organics in surface and groundwater systems, natural attenuation, cleanup levels, policy, and the treatment of affected water bodies. Dr. Odencrantz will be a visiting professor at the Research Center for Environmental Quality Management, Kyoto University, from January through June 2007. He can be reached in Japan at 09030562852.

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