HISTORICAL OIL CONTAMINATION TRAVEL DISTANCES IN GROUND WATER AT SENSITIVE GEOLOGICAL SITES IN MAINE

BUREAU OF REMEDIATION & WASTE MANAGEMENT
MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION

APRIL 30, 2002

Introduction:

Private drinking water supply wells are an extremely important source of drinking water for many Mainers. Forty-one (41) percent of Maine's housing units[1] and approximately 50% of Maine residents[2] get their drinking water from private wells. Ensuring that these wells are adequately protected from contamination sources and continue to provide healthful drinking water is a fundamental public health and environmental protection policy of the State of Maine, as evidenced in the numerous Maine statutes and regulations with this common goal.

Based on findings that new UST facilities in Maine do have oil discharges despite the use of state-of-the-art technology (including secondary containment) and may subsequently pose a risk to groundwater and nearby receptors[3], the Maine Legislature in 2001 enacted a law governing the siting of new underground oil storage tank (UST) facilities (PL 2001, Chapter 302; An Act To Protect Sensitive Geologic Areas From Oil Contamination). One of the provisions of this law is to protect private drinking water supply wells from contamination. New UST facilities and their components were required as of October 1, 2001 to be located 300 or more feet from an existing private drinking water well. A variance from this standard is available for those cases where it can be demonstrated there is no hydrogeological connection between the proposed facility site and the wells within the 300 foot protective setback.

In response to a proposal during the 2002 legislative session to reduce the protection zone from 300 feet to 75 feet between existing private wells and proposed new UST facilities, the Department of Environmental Protection evaluated the technical merit of a 75 foot setback as a means of protecting drinking water wells from oil discharges that have been documented to occur at state-of-the-art facilities due to human error and equipment failure. The Department also took a broader look at oil

---

[1] U.S. Census Bureau; Maine Housing Characteristics: 1990.
[2] State of Maine, Depts. Of Human Service, Environmental Protection and Conservation; The Presence of MTBE and Other Gasoline Compounds in Maine's Drinking Water; Oct. 13, 1998; p. 12.
[3] Maine DEP records indicate that 9% of new UST facilities installed between 1995 and 2000 suffered one or more discharges within their first five years of operation. Discharges ranged from one to 6,000 gallons.

contamination travel distances and their relationship to the numbers of private wells contaminated and associated remediation costs.

Methodology:

To evaluate the protectiveness of a 75 foot buffer, the Department studied travel distances of various oil compounds from documented discharge sources by way of groundwater to either drinking water supply wells or monitoring wells. A survey of sites in sensitive geological settings similar to those at the heart of this legislative policy debate was conducted. The survey was based on a 20 percent random sample of the 394 oil remediation sites on the Department's August 18, 2001 priority list of such sites. Bureau of Remediation & Waste Management project management staff, geologists and environmental engineers working on each of the 85 sites selected randomly, were surveyed as to the petroleum contaminants documented by laboratory analyses in the groundwater, the linear distance from the contaminant source to the farthest affected drinking or monitoring well, the number of private and/or public drinking water supply wells contaminated, and the investigation/remediation/third party damage claim costs incurred by the Department as of January 15, 2002. Groundwater contamination data was collected for Gasoline Range Organics (GRO)[4], Diesel Range Organics (DRO)[5], and MTBE or other gasoline oxygenates (e.g. TBA – tertiary butyl alcohol, TAME – tert-amyl methyl ether). For the purposes of this survey contamination was defined as any concentration above reporting limits for any one of the above analytes. For the State Health & Environmental Testing Laboratory (HETL) in the Maine Bureau of Health and most State certified private laboratories, the reporting limits for these parameters are 10 parts per billion (ppb) for GRO, 50 ppb for DRO, and 1 ppb for MTBE. This definition is consistent with that in the Department' s regulations, Chapter 691, Rules for Underground Oil Storage Facilities.

In the course of conducting this general analysis, the geology of the individual sites and wells were not differentiated (bedrock, sand and gravel aquifer vs. other geological settings). Based on the Department's overall experience investigating and remediating various oil discharge sites effecting private drinking water supplies, it would be reasonable to assume most of the contaminated private wells were bedrock wells. The survey also did not make any distinction between the various types of oil discharge sources (UST facilities, aboveground oil storage facilities – including home heating oil tanks and piping, or surface spills). Based on its over 15 years of field experience, the Department is comfortable with the assumption that once a discharge of oil has occurred at a sensitive site, the source is not a significant factor in determining how far contamination travels once reaching the soil and then groundwater. However, the Department did distinguish between different types of oil products and petroleum

[4] Maine Health & Environmental Testing Laboratory (HETL) Method 4.1.17, Modified Method for Determining Gasoline Range Organics; Sept. 6, 1995

[5] Maine HETL Method 4.1.25, Modified Method for Determining Diesel Range Organics; Sept. 6, 1995.

analytes to test whether their different chemical and physical properties made a difference in the distances they traveled and, in particular, the frequency with which they traveled more than 75 feet.

Findings:

Of the 85 oil discharge sites selected for the survey, 38 sites lacked one or more of the needed data. The most common reasons for the unavailability of data for a particular site or survey parameter included the source of the oil contamination being unknown, multiple sources of contamination, and sites where a hydrogeological investigation has not yet been undertaken.

The findings show that the majority of petroleum discharges result in contamination traveling in groundwater further than 75 feet. The frequency with which the dissolved phase of petroleum contamination (for all product types and analytes) traveled more than 75 feet is summarized in Figure 1. Of the 47 sites for which adequate data was available, at seventy (70) percent of sites, the oil contamination traveled in excess of 75 feet. Breaking the findings down by the product type and analyte, travel distances greater than 75 feet were evident in 56% of heating oil/diesel fuel (DRO only) contamination cases, 80% of gasoline cases (GRO only), and 82% of MTBE cases. Travel distance findings for #2 heating oil/diesel fuel are consistent with those of an earlier study in Maine, where 50% of wells were contaminated above the Maine drinking water standard of 50 ppb beyond 75 feet from the contamination source.[6]

Taking a broader view of the survey findings when comparing the number of sites and travel distances, it was found that at three-quarters (76%) of sites, groundwater contamination traveled as far as 300 feet. As illustrated in Figure 2, at the remaining 24% of sites, one or more oil analytes were found to have traveled more than 300 feet. When analyzing the frequency with which individual analytes traveled distances greater than 300 feet from the contamination source, MTBE did so most frequently (32% of sites), followed by GRO (25%) and DRO (17%).

The average documented distance traveled for GRO and DRO were 295 and 140 feet, respectively. The average MTBE travel distance was 300 feet. The maximum distance documented between a discharge source and a contaminated well was 1670 feet. The analyte was GRO, more specifically benzene, found at concentrations above the Federal and State drinking water standard of 5 ppb in a residential bedrock well.

Oil discharge sites within the sample population contaminated a total of 123 private wells and 18 public drinking water supply wells. Most of the public wells were transient (e.g. stores, restaurants, motels) or non-transient non-community supplies

[6] Rand, John B.; Mother Nature's Cure, Proceedings of Lessons Learned in the Remediation of Petroleum-Contaminated Sites in Maine; Consulting Engineers of Maine & the Maine Dept. of Environmental Protection; Augusta, Maine; April 28, 1994.

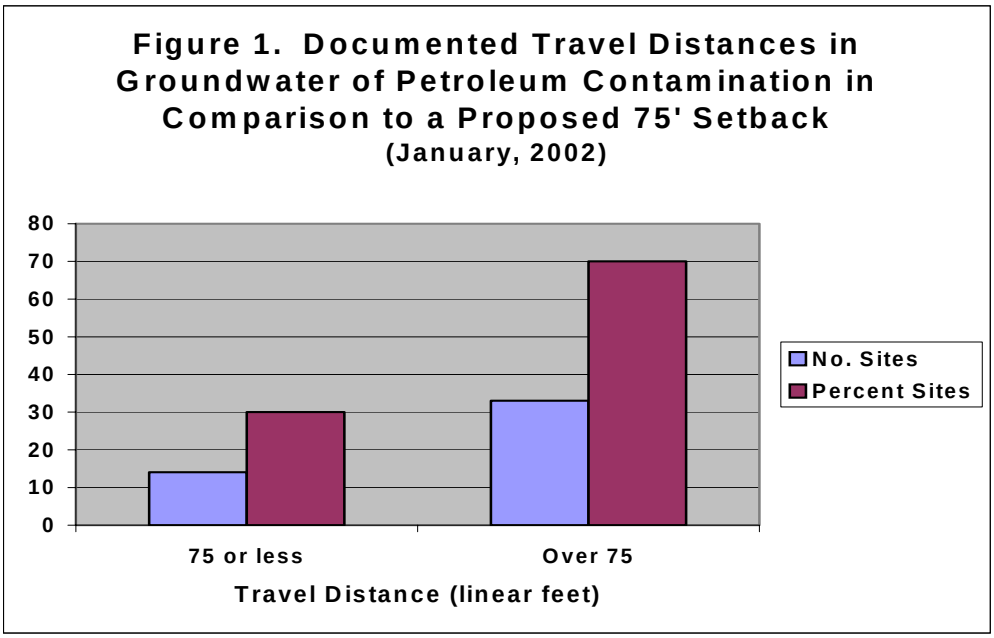
Figure 1. Documented Travel Distances in Groundwater of Petroleum Contamination in Comparison to a Proposed 75' Setback
(January, 2002)
80
70
60
50
40
30
20
10
0
No. Sites
Percent Sites
75 or less
Over 75
Travel Distance (linear feet)

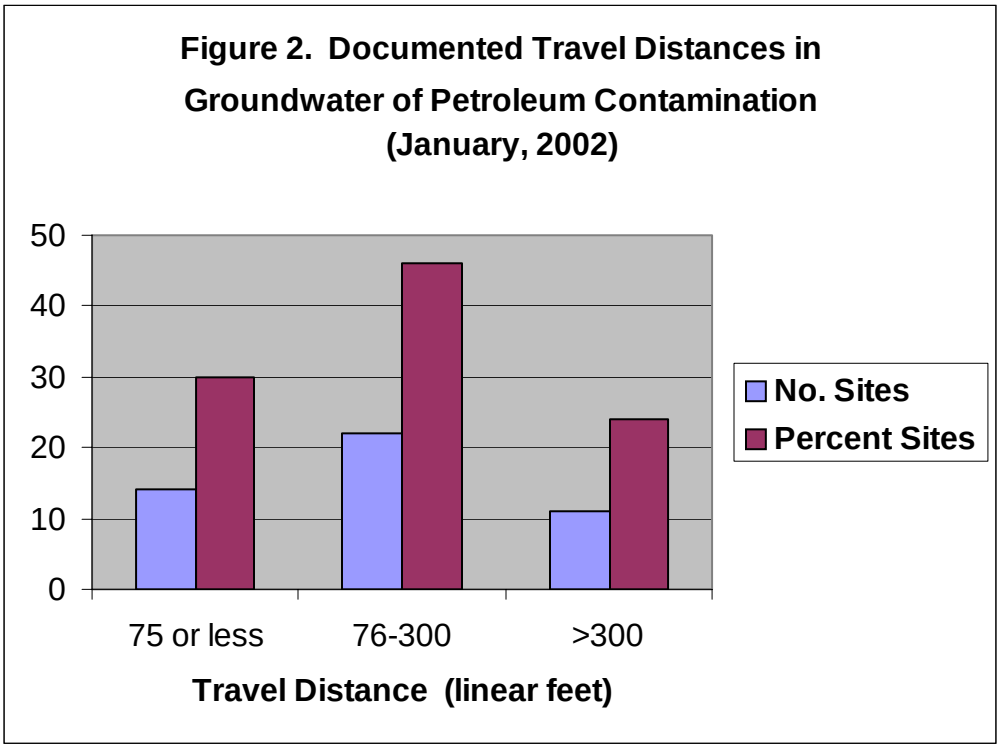
Figure 2. Documented Travel Distances in Groundwater of Petroleum Contamination
(January, 2002)
50
40
30
20
10
0
No. Sites
Percent Sites
75 or less
76-300
>300
Travel Distance (linear feet)

(e.g. schools and larger places of employment). Two community water supplies were impacted – one a trailer park and the second a multi-unit residential housing development.

The survey data presented in Table 1 below shows a clear relationship between oil (GRO, DRO and MTBE) contamination travel distance and remediation site costs. The smaller number of sites where petroleum contamination traveled over 300 feet, contaminated the most drinking water supply wells and resulted in a disproportionate percentage of the total remediation costs due to much higher average per site remediation costs. Of the total number of private wells contaminated, 58 percent were associated with sites where one or more petroleum analytes traveled in excess of 300 feet from its source. In comparison, sites where contamination traveled 75 feet or less, nine (9) percent of the total number of private wells contaminated were located.

Table 1
Oil Contamination Travel Distances and Remediation Costs[7]

Linear Distance (ft.)	Percent Sites	Percent of Total Remediation Costs	Average Per Site Remediation Cost
≤75	30	9	$45,000
76 – 300	46	43	$148,000
>300	24	48	$331,000

Survey Limitations:

The contaminant travel distance survey data have a number of limitations which are fairly obvious, but which should be highlighted in order to keep the survey's findings and conclusions in proper context. Foremost, no site geology information was collected which may effect travel distances. Instead the Department assumed that dissolved phase petroleum contamination traveled via bedrock fractures at most sites included in the survey sample. Although probably a very safe assumption in the vast majority of cases, it certainly prevents us the opportunity to document to what extent site specific geology was an important variable in determining linear travel distances.

Measuring travel distance from the contamination source in linear distance, although appropriate for the regulatory purposes of this survey, it does not reflect actual travel paths and distances in the field, especially in bedrock. Laws and regulations use linear protective setbacks, therefore it was necessary to look at linear travel distances in the survey. However, the actual travel distance of dissolved phase petroleum

[7] Includes primarily emergency response, site investigation costs, and long-term soil and ground water remediation costs, including the treatment and replacement of contaminated drinking water supply wells.

contamination can be quite different. A remediation site in the municipality of South Thomaston in the mid-coast region of Maine and included in the survey, provides an excellent example of this difference. Loose piping joints resulted in a gasoline discharge from a small convenience store. Despite the removal of nearly 660 tons of contaminated soil, MTBE contaminated the bedrock groundwater. Forty-four (44) wells in the neighborhood provided monitoring locations, 18 of which were found contaminated. The linear distance to the farthest contaminated private drinking water well is approximately 935 feet. Based on well monitoring results and studying the local bedrock geology, it appears the MTBE traveled about 750 feet northwest from the source, then 560 feet back toward the southeast, and finally 740 feet to the southwest. In actuality, the MTBE contamination probably traveled in excess of 2000 feet in an indirect path dictated by bedrock fractures and other site-specific conditions.

It should also be noted that the travel distances presented are not the absolute maximum linear distances the analytes traveled from the source. They represent the distance between the source and the farthest, available groundwater monitoring point in which the analyte was documented above laboratory reporting levels. How much further contamination traveled beyond these monitoring locations is not known. The travel distances presented here are therefore somewhat conservative.

Conclusions:

1. There is no hydrogeological basis in Maine to support a 75 foot setback as adequate to protect private drinking water supplies from contamination resulting from petroleum discharges at new UST facilities. At most sites studied (70%), petroleum contamination in groundwater was found to travel more than 75 feet from its source.
2. Even in the case of the least mobile contaminant in groundwater studied, DRO (associated with heating oil and diesel fuel discharges), DRO traveled farther than 75 feet from the source of the petroleum at more than 50% of contamination sites. In so doing it contaminated wells at or above the State of Maine drinking water standard of 50 ppb.
3. For use in a statewide regulatory program, over a broad range of hydrogeological conditions and different product types, a 300 linear foot setback between UST facilities and private wells provides adequate protection at most sites (76 percent). The inclusion of a variance procedure as provided in Maine law based on site-specific hydrogeology provides the flexibility for that minority of sites where there is no hydrogeological connection between the UST facility and nearby wells.
4. A relatively small proportion of sites (24%) were found where petroleum contamination traveled in excess of 300 feet. However this minority of sites can have a disproportionately high fiscal impact (48% of total costs) due to significantly higher than average per site remediation costs. Average site remediation costs at such sites ranged from two to six times greater than the statewide average.

5. Despite Maine's UST siting standards, costly remediation cases effecting private drinking water supplies resulting from oil discharges at new UST facilities are likely to continue to occur, albeit hopefully in smaller numbers if Maine's siting standards prove effective.
6. The findings above are applicable to all potential petroleum discharge sources to the environment, including underground and aboveground oil storage tank facilities.

Questions may be directed to George Seel, Division of Technical Services, Bureau of Remediation & Waste Mgmt., MDEP at (207) 287-2651.