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Project Summary

Processes Affecting Subsurface Transport of Leaking Underground Tank Fluids

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This document presents the fundamental theories and an understanding of the processes controlling migration and fate in the subsurface of material released from an underground storage tank.

Processes affecting the migration of fluids from a leaking underground storage tank and their effects on monitoring methods are reviewed by experts. An understanding of these processes is critical to an understanding of the methods that monitor underground storage tanks for material released from the tank in the environment surrounding the tank.

Soil heterogeneities and the potential for multiphase flow will lead to high monitoring uncertainties if leak detection systems rely on liquid sampling alone. Vapor transport is also affected by these properties, although to a lesser degree. More research is needed, however, to better understand the physics of vapor transport. The processes of adsorption, partitioning, and microbial alteration of fluids in the subsurface may have strong effects on the uncertainty of monitoring systems. Fate processes have received less attention than liquid and vapor transport processes and will require significantly more research before the effects are fully understood.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Estimates of the number of underground storage tanks in the United States range from 3 to 5 million. Estimates of the number of leaking tanks vary, but increasingly more incidents of leaking tanks are being reported. These tanks may contaminate soil and ground water to the extent that the environment and human health is adversely impacted.

The Solid Waste Disposal Act was amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA; Public Law 98-616) to provide for the development and implementation of a comprehensive regulatory program for underground storage tanks (USTs). Tanks containing hazardous waste are subject to regulation under Subtitle C of the Resource Conservation Recovery Act of 1976. Tanks containing petroleum and hazardous substances are subject to regulation under Subtitle I of the Hazardous and Solid Waste Amendments; regulations for these will be proposed in 1987 and will become final in 1988. Regulations for tanks containing hazardous waste were promulgated by the EPA (40 CFR Part 264) on July 14, 1986.

Many approaches exist in the prevention, detection, and cleanup of leaked product from USTs. One approach is to monitor the environment outside the tank to determine if product is entering the environment from the tank, piping, or surface spills. The Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-Las Vegas) is conducting research to evaluate the feasibility of monitoring outside the tank for leaks from the tank.

The environment outside a tank is subject to a number of factors that may

affect and complicate detecting a leak from a tank system (Figure 1). These factors affect the transport and fate of product from the tank to the external leak detection system. Studies of these factors, particularly factors affecting organic and petroleum products, have been initiated in recent years in response to an increasing number of reported cases where the environment or humans have been exposed to material released from USTs. In addition, recent state and Federal laws and regulations on ground-water contamination have served to increase the need of researchers to understand the processes affecting the subsurface transport and fate of leaking underground tank fluids.

Approach

The demand for technical guidance that has been created by new regulations has created a need to develop and disseminate information quickly. Initial steps taken by EMSL-Las Vegas to evaluate external leak detection systems have included surveys of the literature, Federal, state and local agencies, industry, and academia. The results from these surveys will be made available in a variety of reports and technical notes. The first effort to develop information on the processes affecting the subsurface transport of product from leaking USTs consisted of several experts being asked to summarize the existing knowledge on: liquid flow, vapor flow, soil surface and interfacial effects of product in the environment around a tank, and the implications of subsurface biological activity in the monitoring of USTs. Four experts in these areas covered their respective fields, and a team of hydrogeologists from the Desert Research Institute coordinated the experts in their examination of the problems posed by external leak detection monitoring of USTs.

Each expert was asked to refer to the available literature and to describe in layman's terms the present state of knowledge in the subject area. Each expert was also asked to address those areas where the understanding of the processing affecting subsurface transport of leaking undergound tank fluids was weak and where further research was required. The conclusions reached by each expert were consolidated and summarized in the trial section of the full report where the advantages and complications of a number of monitoring approaches were listed against four fate and transport processes. The monitoring approaches were: active and passive liquid monitoring,

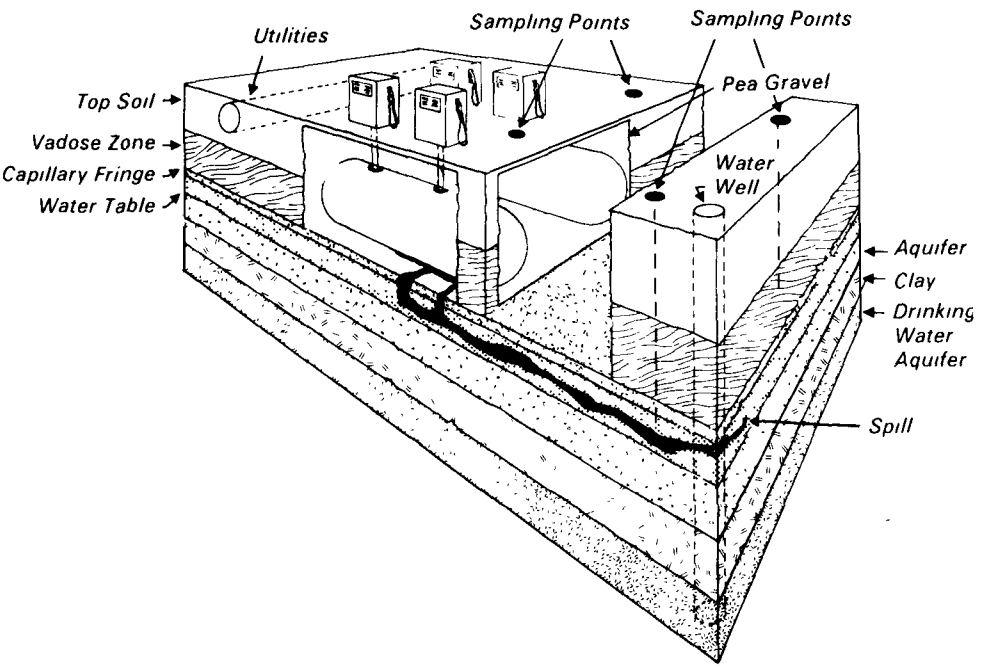

Figure 1. *The hydrogeologic environment around underground storage tanks can be complicated even under idealized circumstances.*

Table 1. *Parameters Affecting the Transport and Fate of Organics in the Soil and Ground Water*

Soil	Contaminant	Environmental
	Fluid Transport Parameters	
Multiphase permeability	*Density*	*Temperature*
Residual saturation	*Viscosity*	*Precipitation*
Pore size distribution	*Solubility*	*Depth to water table*
Fracture density	*Surface tension*	
Wettability		
Soil texture		
Porosity		
Variability of soil properties		
	Vapor Transport Parameters	
Porosity	*Volatility*	*Biological activity*
Water content	*Vapor diffusivity*	*Recharge*
Soil structure & variability	*Distribution coefficients*	*Temperature*
Permeability to air		*Barometric changes*
		Water table fluctuations
	Surface Chemistry Parameters	
Moisture content	*Solubility*	*Temperature*
Organic content	*Concentration*	*Pressure*
Clay content		
Soil surface area		
Pore water chemistry		
	Microbiological Parameters	
Soil gas diffusion	*Nutrient loading*	*Temperature*
Colonization potential	*Toxicity*	*Recharge & groundwater*
Oxygen concentration	*Solubility*	*transport*
Methane concentration	*pH*	
Contaminant velocity		

active and passive vapor monitoring, and surface and borehole geophysics.

Conclusions

The monitoring of leaks from outside the tank is complicated by a number of factors (Table 1), and no one monitoring approach will be applicable for all applications. The assessment of those factors in evaluating the performance of external leak detection monitoring systems is not easy. Uncertainty in flow directions because of variations in conductivity, water content, texture, etc. is a major problem in obtaining predictable performance from an external leak detection sensing system. Since an increase in the distance from the leak to the sensor also increases the number of heterogeneities encountered and, hence, increases the uncertainty in flow direction, it is important to locate the sensor close to the leak source. Tank installations may be engineered to reduce further the heterogeneity near the tank, and this would make the sensor location less sensitive.

Active samplers, i.e., samplers that pump the environment, appear to be less affected by transient spills; however, further research is needed to develop sensor criteria.

The present state of knowledge is limited in the transport and fate processes affecting leaked organic products from USTs. Further research is needed to understand those processes.

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The complete report entitled "Processes Affecting Subsurface Transport of Leaking Underground Tank Fluids," (Order No. PB 87-201 521/AS; Cost: $13.95, subject to change) will be available only from:

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