

## Use of Big Data to Understand Remedy Effectiveness at California Petroleum Sites

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**Background/Objectives.** Over the last four decades, substantial resources have been invested to remediate petroleum release sites. Although substantial progress has been achieved in attainment of regulatory site closure, there is still debate regarding the relative importance of different attenuation mechanisms (e.g., volatilization, dissolution, and biodegradation) for the reduction of contaminant concentrations over time.

Since 2001, California has required site investigation and monitoring results be uploaded into the publicly-available GeoTracker database. Today, this database includes groundwater monitoring results from over 10,000 corrective action sites and includes over 2,500,000 individual measurements of benzene concentrations in groundwater. This very large database is a valuable resource for understanding overall progress in petroleum site remediation and the key remediation processes contributing to this progress.

**Approach/Activities.** We have utilized the GeoTracker database to evaluate progress in remediation of petroleum sites in California. Starting with a population of approximately petroleum 9000 sites included in GeoTracker before 2012, we tracked progress in groundwater remediation and site closure. In addition, we compared in the attenuation of individual petroleum constituents to evaluate the importance of different attenuation mechanisms: dissolution, volatilization, and biodegradation.

**Results/Lessons Learned.** The GeoTracker database reflects significant progress in site remediation in California. The number of petroleum release sites with on-going groundwater monitoring has decreased from nearly 6000 sites in the early 2000s to approximately 1600 sites at the end of 2016. For sites with at least seven years of monitoring, more than half the sites exhibited a greater than 90% decrease in maximum benzene concentration and more than 25% of the exhibited a greater than 99% decrease. Although toluene, ethylbenzene, and xylenes also show large decreases in concentration, there are clear differences in site attenuation rates between these constituents with ethylbenzene showing the smallest median concentration decrease (82%) and toluene, which is less soluble and less volatile than benzene, showing the largest median decrease (98%). These data are consistent with monitoring results from the Bemidji, MN natural attenuation research where readily biodegradable constituents such as toluene attenuated most rapidly. These data suggest that biodegradation has been a significant contributor to the overall reduction in dissolved petroleum concentrations at petroleum release sites. The GeoTracker database can also be used to evaluate the effect of different active remediation technologies on individual constituents based on their solubility and volatility. For example, do sites with soil vapor extraction show larger decreases in benzene (more volatile) compared to ethylbenzene (less volatile)?