What to Do with Natural Source Zone Depletion: Fitting New NSZD Developments into Regulatory Frameworks and Site Management Practices

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Background/Objectives. The groundwater community's understanding of petroleum-impacted sites has evolved in recent years because of recognition that natural source zone depletion (NSZD) is a key part of the LNAPL conceptual site model and it is responsible for the loss of hundreds to thousands of gallons of hydrocarbon per acre year. Yet, the community is still trying to resolve on where NSZD fits into the existing regulatory frameworks that typically have specific requirements regarding COC concentrations and to remove free-product to the maximum extent practicable. A holistic approach is needed where NSZD data are integrated with MNA and other information for better long-term management of these sites.

Approach/Activities. To better integrate NSZD into long-term site management for a large site we clearly identified specific regulatory requirements or site objectives, and correlated them with the type of attenuation data needed to evaluate them:

- Groundwater quality - longevity of COC impacts: Requires time-series of groundwater monitoring data under a conventional monitoring and MNA framework. The concentration trend data can then be supplemented with LNAPL composition data.
- Current risk assessment: Requires recent COC concentrations in various media, assessed through a standard risk-assessment framework (e.g., ASTM RBCA).
- Future risk profile: Requires knowledge about future attenuation of specific COCs inferred from literature and site-specific MNA-type measurements.
- Longevity of bulk petroleum impacts: Requires NSZD measurements. At this site relevant data were collected using CO_2 traps and thermal NSZD measurements.
- Assess efficacy of active remediation systems: Requires NSZD measurements to compare rates of bulk hydrocarbon removal, supplemented with composition of extracted COCs (e.g., by SVE) to understand the change in risk profile.
- Remedy selection: Because current and future risks are already managed at the site, NSZD is being evaluated at an equal footing with other active remediation technologies, and is being assessed for economic, technical and regulatory feasibility.

Results/Lessons Learned. Key lessons learned include:

- As defined in MNA guidance documents, groundwater concentration trend data for COCs is still a key element for understanding risk and for managing petroleum-impacted sites.
- Risk is the primary factor for managing any impacted site but is not tied directly to NSZD.
- Currently NSZD data can only be used to confirm that bulk hydrocarbons are biodegrading and to estimate their longevity at a site. More research is needed to understand how different LNAPL "buckets" (e.g., aromatic, linear alkanes, etc.) or specific COCs are degraded by NSZD processes and how mass and risk is reduced over time.
- Remediation timeframe projections for NSZD vs. active remediation will be a key metric in choosing between active and passive (NSZD and MNA) remedies at low risk sites.
- A key factor emerged regarding assessing the true benefits of implementing active remediation solely to reduce remediation timeframes, particularly when the benefits only accrued in the distant future (e.g., reducing timeframe from 300 to 200 years, for example).

- Regulatory acceptance of NSZD can be achieved by engaging stakeholders early and explaining how risk, timeframe, and NSZD tie together in existing regulatory frameworks.