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Standard Guide for NAPL Mobility and Migration in Sediment— Evaluating Ebullition and Associated NAPL/Contaminant Transport[1]

This standard is issued under the fixed designation E3300; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide addresses the processes that lead to (or influence) ebullition-facilitated nonaqueous phase liquid (NAPL)/contaminant transport, methods for quantifying that transport, considerations for sample timing, sampling procedures, and use of results in extrapolating an annual ebullition-facilitated NAPL/contaminant load to a site, or a portion of a site. This guide is not intended to address remediation of sites where ebullition-facilitated transport of NAPL/contaminants is occurring, fate and transport of contaminants subsequent to the ebullition transport mechanism, the measurement of contaminant concentrations within the gas bubbles, ebullition-associated human health and ecological risk, NAPL advection, or determining the depth of ebullition below the mudline. Additionally, gas transport without NAPL/contaminants is possible in areas with gas generation and limited NAPL contamination of the sediment, which is covered in this guide. Ebullition should be evaluated at sites where sediment capping is anticipated.

1.2 The users of this guide should be aware of the appropriate regulatory requirements that apply to sediment sites where NAPL is present or suspected to occur. The user should consult applicable regulatory agency requirements to identify appropriate technical decision criteria and seek regulatory approvals, as necessary.

1.3 ASTM standard guides are not regulations; they are consensus standard guides that may be followed voluntarily to support applicable regulatory requirements. This guide may be used in conjunction with other ASTM guides developed for sediment programs. The guide supplements characterization and remedial efforts performed under international, federal, state, and local environmental programs, but it does not replace regulatory agency requirements.

1.4 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1689 Guide for Developing Conceptual Site Models for Contaminated Sites

E1739 Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites

E2081 Guide for Risk-Based Corrective Action

E2531 Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface

E2993 Guide for Evaluating Potential Hazard as a Result of Methane in the Vadose Zone

E3163 Guide for Selection and Application of Analytical Methods and Procedures Used during Sediment Corrective Action

E3248 Guide for NAPL Mobility and Migration in Sediment – Conceptual Models for Emplacement and Advection

3. Terminology

3.1 *Definitions:*

3.1.1 *biogenic, adj*—resulting from the activity of living organisms (Guide E2993).

3.1.2 *contaminant, n*—substance not normally found in an environment at the observed concentration (Guide E2993).

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.3 *flux, n*—mass crossing a unit area per unit time in any phase (for example, LNAPL, dissolved-phase, vapor-phase) (Guide E2531).

3.1.3.1 *Discussion*—For ebullition, the unit area of interest is the sediment-water interface.

3.1.4 *migrating NAPL, n*—NAPL that can move at the NAPL body scale, such that the NAPL body may advectively expand in at least one direction under observed or reasonably anticipated field conditions (Guide E3248).

3.1.5 *mobile NAPL, n*—NAPL that may move by advection within the connected void spaces of the sediment under specific physical and chemical conditions, as may be demonstrated by laboratory testing, or as may be interpreted based on mathematical calculations or modeling (Guide E3248).

3.1.6 *non-aqueous phase liquid, n*—chemicals that are insoluble or only slightly soluble in water that exist as a separate liquid phase in environmental media (Guide E3248).

3.1.6.1 *Discussion*—NAPL may be less dense than water (light non-aqueous phase liquid [LNAPL]) or more dense than water (dense non-aqueous phase liquid [DNAPL]).

3.1.7 *sediment*—a matrix of porewater and particles including gravel, sand, silt, clay, and other natural and anthropogenic substances that have settled at the bottom of a tidal or nontidal body of water (Guide E3163).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acetoclastic organisms, n*—microbial organisms that convert acetic acid to methane.

3.2.2 *acetogenesis, n*—the biological formation of acetic acid from carbon dioxide or organic acids.

3.2.3 *cone sampler, n*—a sampler that uses an inverted cone or funnel of sufficient size to trap and measure gas released from the sediment.

3.2.3.1 *Discussion*—The cone is typically connected to a frame for supporting the sampler during field deployment and provides additional volume for gas collection. The sampler can be positioned near the sediment surface or within the water column.

3.2.4 *corral sampler, n*—a sampler that consists of an inflatable boom to isolate the gas measurement area, with a thin film placed over the sampling area to trap gas bubbles released from the sediment.

3.2.5 *ebullition, n*—a process of gas (primarily methane) generation in sediments where the quantity of gas generated is sufficient for gas bubbles to nucleate, grow, fracture the sediment, and then escape into the overlying water body.

3.2.5.1 *Discussion*—Depending on the composition of a particular sediment, the gas bubbles generated and released by ebullition may strip constituents out of the sediment and transport these into the overlying water.

3.2.6 *ebullition active area, n*—a subarea within a larger ebullition study area where gas ebullition occurs consistently during an ebullition survey.

3.2.7 *ebullition rate, n*—the rate of volumetric gas production from the sediment, measured in micromoles of gas per unit surface area of sediment per unit of time.

3.2.8 *flux chamber, n*—a device with an isolation chamber that can trap gas bubbles rising through the water column.

3.2.8.1 *Discussion*—The isolation chamber is equipped with vent valve for sampling the headspace and measuring the volume of accumulated gases.

3.2.9 *hydrogenotrophic organisms, n*—microbial organisms that use molecular hydrogen as a metabolic energy source.

3.2.10 *labile organic matter, n*—carbon-based materials that can be consumed and broken down by microorganisms, with the typical eventual metabolic end products being methane or carbon dioxide, or both.

3.2.11 *mesophilic organisms, n*—microbial organisms that can grow at a moderate temperature range of 20 °C – 45 °C with an optimum growth temperature in the range of 30 °C – 39 °C.

3.2.12 *methanogenesis, n*—the generation of methane by microorganisms, typically through the consumption of labile organic matter (OM).

3.2.13 *methanotrophic organisms, n*—a group of microbial organisms that utilize methane as a carbon source.

3.2.14 *nucleation, n*—the initial formation of a separate gas phase bubble in a surrounding liquid that is supersaturated with that gas.

3.2.15 *oil-particle aggregate—OPA, n*—a particle formed in a surface water body resulting from the adherence to (or penetration into) an oil droplet by minerals or organic material.

3.2.16 *seep, n*—a location that slowly releases small quantities of NAPL from sediments or other water interfaces

3.2.16.1 *Discussion*—Seeps differ from ebullition because the release of the NAPL from the sediments and the flux of the NAPL across the sediment-water interface occur without facilitation from gas bubbles. Seeps and ebullition can be coincident but they are fundamentally separate phenomena.

3.2.17 *sheen, n*—a silvery, rainbow, or dark rainbow film on the water surface.

3.2.18 *sheen blossom, n*—the emergence of NAPL transported by a gas bubble at the water surface followed by spreading of NAPL into a sheen at the air-water interface.

3.2.19 *tent sampler, n*—a square or rectangular frame covered by a thin film to trap gas bubbles.

3.2.19.1 *Discussion*—The film is equipped with a sampling port for sample collection and measuring the total volume of gas trapped by the sampler. The rectangular frame floats on the water surface and can move vertically with changes in water depth.

4. Significance and Use

4.1 Ebullition is ubiquitous in sediment and is primarily a significant concern when there is associated NAPL/contaminant transport, resulting in exposure risk to humans, ecological receptors, or both. Ebullition may also be a concern when capping has been chosen as part of a site remedy.

4.2 Understanding the potential for ebullition-facilitated NAPL/contaminant transport in sediment is an important element of an overall conceptual site model (CSM) that forms