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Standard Guide for Developing Representative Background Concentrations at Sediment Sites—Framework Overview, Including Conceptual Site Model Considerations¹

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1. Scope

1.1 This guide provides an overarching framework for the development of representative background concentrations for sediment at contaminated sediment sites. It is intended to inform, complement, and support (but not supersede) the requirements or guidelines established by local, state, tribal, federal, or international agencies.

1.2 Technically defensible representative background concentrations for sediment are critical for several purposes (Guide E3242) (1)². These include sediment site delineation, establishing remedial goals, remedy selection, assessment of risks posed by representative background concentrations, and establishing appropriate post-remedial monitoring plans.

1.3 As part of the overall framework presented in this guide, Guide E3240 provides a general discussion of how Conceptual Site Model (CSM) development fits into the risk-based corrective action framework for contaminated sediment sites. However, not all elements of a CSM need to be considered when developing representative background concentrations for sediment at a sediment site; those that do are discussed in detail in Section 7 of this guide.

1.3.1 As additional data are collected and analyzed, the sediment site CSM should be updated as needed.

1.3.2 This guide is related to several other guides. Guide E3344 describes how to select appropriate background reference areas. Guide E3164 covers the sampling methodologies used in the field to obtain sediment samples (whether from the sediment site or background reference areas), and Guide E3163 discusses appropriate laboratory methodologies to use for the

chemical analysis of potential contaminants of concern (PCOCs) in sediment samples. Guide E3242 describes how to evaluate candidate background data sets (including the use of statistical, geochemical, and chemical forensic methodologies) to obtain representative background data sets and then how to use these data sets to develop representative background concentrations for sediment. Relevant content contained in Guides E3163, E3164, E3242, and E3344 is summarized herein, but the individual guides should be consulted for more detailed coverage of these topics.

1.4 Representative background concentrations for sediment are typically used in contaminated sediment corrective actions performed under various regulatory programs, including the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Although many of the references cited in this guide are CERCLA oriented, the guide is applicable to corrective actions performed under local, state, tribal, federal, and international corrective action programs. However, this guide does not provide a detailed description of the existing background requirements or guidance for each jurisdiction. The requirements for the regulatory entity under which the corrective action is being performed should be reviewed to confirm compliance.

1.5 This guide would optimally be applied at the start of any sediment corrective action program but can be used at other points in the program as well.

1.6 *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.*

1.7 *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.*

¹ This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.04 on Corrective Action.

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

2. Referenced Documents

2.1 ASTM Standards:³

- D7659** Guide for Strategies for Surface Sampling of Metals and Metalloids for Worker Protection
- D7720** Guide for Statistically Evaluating Measurand Alarm Limits when Using Oil Analysis to Monitor Equipment and Oil for Fitness and Contamination
- E178** Practice for Dealing With Outlying Observations
- E1689** Guide for Developing Conceptual Site Models for Contaminated Sites
- E2993** Guide for Evaluating Potential Hazard in Buildings as a Result of Methane in the Vadose Zone
- E3163** Guide for Contaminated Sediment Risk-Based Corrective Action—Selection and Application of Analytical Methods and Test Procedures
- E3164** Guide for Contaminated Sediment Site Risk-Based Corrective Action – Baseline, Remedy Implementation and Post-Remedy Monitoring Programs
- E3240** Guide for Risk-Based Corrective Action for Contaminated Sediment Sites
- E3242** Guide for Developing Representative Background Concentrations at Sediment Sites—Data Evaluation and Development Methodologies
- E3248** Guide for NAPL Mobility and Migration in Sediment – Conceptual Models for Emplacement and Advection
- E3282** Guide for NAPL Mobility and Migration in Sediments – Evaluation Metrics
- E3300** Guide for NAPL Mobility and Migration in Sediment—Evaluating Ebullition and Associated NAPL/Contaminant Transport
- E3344** Guide for Developing Representative Sediment Background Concentrations at Sediment Sites—Selection of Background Reference Areas

3. Terminology

3.1 Definitions:

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

3.1.2 *corrective action*, *n*—the sequence of actions that may include site assessment and investigation, risk assessment, evaluations of potential remedial action alternatives, interim remedial action, remedial action, operation and maintenance of the remedy, monitoring of progress, making “No Further Action” determinations, and completion of the remedial action. **(Guide E3240)**

3.1.3 *distribution*, *n*—as used in statistics, a set of all the various values that individual observations may have and the frequency of their occurrence in the sample or population. **(Guide D7720)**

3.1.4 *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. **(Guide E3300)**

3.1.4.1 *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.

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

3.1.5.1 *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]).

3.1.6 *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. **(Guide E3282)**

3.1.7 *outlying observation*, *n*—an extreme observation in either direction that appears to deviate markedly in value from other members of the sample in which it appears. **(Practice E178)**

3.1.8 *sediment*, *n*—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)**

3.1.9 *sheen*, *n*—a silvery, rainbow, or dark rainbow film on the water surface. **(Guide E3300)**

3.1.10 *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. **(Guide E3300)**

3.1.11 *upper tolerance limit (UTL)*, *n*—the upper confidence limit (with specified confidence level) for a percentile of a distribution. **(Guide D7659)**

3.1.11.1 *Discussion*—The UTL is the value below which a specified fraction of the population will be found, with a specified level of confidence. For example, the 95/95 UTL is a value for which one would have 95% confidence that 95% of the population is below the UTL.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *anthropogenic background*, *n*—human-made substances present in the environment due to human activities, not specifically related to site-related releases or activities (current or historical).

3.2.1.1 *Discussion*—The definition of “anthropogenic background” varies with jurisdiction. In some jurisdictions, the regulator defines anthropogenic background as having both human-made and naturally occurring components. In this guide, the definition of anthropogenic background includes only the human-made component.

3.2.2 *background (aka “reference”)*, *n*—substances, conditions, or locations that are not influenced by the sediment site; these are usually a combination of naturally occurring (consistently present in the environment but not influenced by human activity) and anthropogenic (influenced by human activity but not related to specific releases or activities [current or historical] at the sediment site) components.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

3.2.3 *background reference areas*, *n*—sediment areas that have similar physical, chemical, geological, biological, and land use characteristics as the sediment site being investigated but are not affected by site-related releases or activities (current or historical).

3.2.4 *background threshold value (BTV)*, *n*—a measure of the upper limit of the representative background concentration that is developed from a representative background data set.

3.2.5 *candidate background data set*, *n*—a raw (that is, unprocessed) data set obtained either by the collection of data from background reference areas or by the extraction of background data from the sediment site data set, or a combination of both.

3.2.5.1 *Discussion*—The candidate background data set must first be evaluated using the framework described in Guide E3242 and Section 6 to obtain a representative background data set, which can then be used to develop a representative background concentration for sediment at the sediment site.

3.2.6 *cleanup level*, *n*—the prescribed average or point sediment concentration of a chemical (that is, a molecular or elemental contaminant) that shall not be exceeded at the remediated site.

3.2.7 *conceptual site model (CSM)*, *n*—the integrated representation of the physical and environmental context, the complete and potentially complete exposure pathways, and the potential fate and transport of PCOCs at a site.

3.2.7.1 *Discussion*—The CSM should include both the current understanding of the site and an understanding of the potential future conditions and uses for the site. It provides a method to conduct the exposure pathway evaluation; inventory the exposure pathways evaluated; and determine the status of the exposure pathways as incomplete, potentially complete, or complete.

3.2.8 *contaminant of concern (COC)*, *n*—a substance identified as posing a risk based on a tiered risk assessment and that may warrant corrective action.

3.2.8.1 *Discussion*—Typically, all PCOCs identified for a sediment site are evaluated in the risk assessment process. PCOCs that have sediment concentrations greater than risk-based thresholds identified in the risk assessment process are defined as COCs. Thus, the COCs identified for a sediment site are a subset of the PCOCs identified for that site.

3.2.9 *false outlier*, *n*—measurement that is very large or small relative to the rest of the data but represent true extreme values of a distribution and indicate more inherent variability in the population than was expected.

3.2.10 *high nondetect*, *n*—a nondetect concentration with a highly elevated detection limit; for example, a concentration that resides in the upper decile of the analyte's data distribution (that is, a detection limit above the 90th percentile of the data set).

3.2.11 *natural background*, *n*—naturally occurring substances present in the environment in forms (and at concentrations) that have not been influenced by human activity.

3.2.12 *population*, *n*—in statistics, a comprehensive set of values consisting of all possible observations or measurements of a certain phenomenon from which a sample is to be drawn.

3.2.13 *potential contaminant of concern (PCOC)*, *n*—a contaminant whose sediment concentrations at the site may exceed applicable screening levels.

3.2.13.1 *Discussion*—In risk assessments, PCOCs are often referred to as “chemicals of potential environmental concern” (COPECs) and “chemicals of potential concern” (COPCs).

3.2.14 *reference element*, *n*—a major element that represents the mineral to which a trace element may be adsorbed.

3.2.15 *representative background concentrations*, *n*—chemical concentrations that are inclusive of naturally occurring sources and anthropogenic sources similar to those present at a sediment site but are not from site-related releases or activities (current or historical).

3.2.16 *representative background data set*, *n*—a background data set obtained by evaluating a candidate background data set using a defined framework to remove data points that are not representative of background conditions for the sediment.

3.2.16.1 *Discussion*—The evaluation determines if there are any data points in the candidate background data set that are not representative of sediment site background conditions. These data points are then removed from the candidate background data set (using technically justifiable rationale) to obtain a representative background data set. Typically, the representative background data set can be used to develop a BTV, which is a measure of the upper limit of this data set; it is the BTV that is often used as the representative background concentration for sediment at the sediment site. In this guide, the defined framework involves using the data evaluation and development methodologies described in detail in Guide E3242.

3.2.17 *sediment site*, *n*—the area defined by the likely physical distribution of COCs from a source area and the adjacent areas required to implement the corrective action; a site could be an entire water body or a defined portion of a water body.

3.2.18 *tolerable error rate*, *n*—the specified maximum acceptable error rate set by the decision maker.

3.2.19 *trace element*, *n*—an element defined as generally being present at less than 0.1 weight percent in the sediment sample.

3.2.19.1 *Discussion*—Natural trace element concentrations are typically one or more orders of magnitude less than those of the reference elements that are indicative of the mineral to which trace elements adsorb. Trace elements that are typically evaluated geochemically include metals (such as copper) and metalloids (such as arsenic).

3.2.20 *true outlier*, *n*—measurements that are very large or small relative to the rest of the data and are a result of transcription errors, data coding errors, or measurement system problems, or not representative of the investigated data population as confirmed by other lines of evidence.

3.2.21 *urban runoff*, *n*—a non-point source of contaminants to the water body.

3.2.21.1 *Discussion*—Typically, this is stormwater from city streets and adjacent properties that carries contaminants into receiving waters directly by overland flow or indirectly via sewer systems.

4. Significance and Use

4.1 *Intended Use:*

4.1.1 This guide may be used by various parties involved in sediment corrective action programs, including regulatory agencies, project sponsors, environmental consultants, toxicologists, risk assessors, site remediation professionals, environmental contractors, and other stakeholders.

4.2 *Importance of the CSM:*

4.2.1 The CSM should be updated as needed and refined to describe the physical properties, chemical composition and occurrence, biological features, and environmental conditions of the sediment corrective action program (Guide E1689).

4.3 *Reference Material:*

4.3.1 This guide should be used in conjunction with other ASTM guides listed in 2.1 (especially Guides E3240, E3242, and E3344); this guide should also be used in conjunction with the material in the References at the end of this guide (including (1)). Using these reference materials will direct the user in developing representative background concentrations for sediment at a sediment site.

4.4 *Flexible Site-Specific Implementation:*

4.4.1 This guide provides a systematic but flexible framework to accommodate variations in approaches by regulatory agencies and by the user based on project objectives, site complexity, unique site features, regulatory requirements, newly developed guidance, newly published scientific research, changes in regulatory criteria, advances in scientific knowledge and technical capability, and unforeseen circumstances.

4.5 *Regulatory Frameworks:*

4.5.1 This guide is intended to be applicable to a broad range of local, state, tribal, federal, or international jurisdictions, each with its own unique regulatory framework. As such, this guide does not provide a detailed discussion of the requirements or guidance associated with any of these regulatory frameworks, nor is it intended to supplant applicable regulations and guidance. The user of this guide will need to be aware of the regulatory requirements and guidance in the jurisdiction where the work is being performed.

4.6 *Systematic Project Planning and Scoping Process:*

4.6.1 When applying this guide, the user should undertake a systematic project planning and scoping process to collect information to assist in making site-specific, user-defined decisions for a particular project, including assembling an experienced team of project professionals. These practitioners should have the appropriate expertise to scope, plan, and execute a sediment data acquisition and analysis program. This team may include, but is not limited to, project sponsors, environmental consultants, toxicologists, site remediation professionals, analytical chemists, geochemists, and statisticians.

4.7 *Other Considerations:*

4.7.1 This guide does not provide a detailed description of all topics of a program to develop representative background concentrations for sediment. It is meant to be used in conjunc-

tion with other guides (such as Guides E3163, E3164, E3240, E3242, and E3344) to do so.

4.7.2 Sediment sampling and laboratory analyses are not covered in detail in this guide. Guides E3163 and E3164 contain extensive information concerning sediment sampling and laboratory analysis methodologies.

4.7.3 The selection of background reference areas is not covered in detail in this guide but is extensively described in Guide E3344.

4.7.4 Data quality objectives are not covered in this guide. Data quality objectives are described in (2).

4.7.5 Background study design considerations are not covered in detail in this guide, but are extensively described in other references, including Guide E3164 and (3).

4.7.6 The use of data evaluation methodologies to develop representative background data sets from candidate background data sets is not covered in detail in this guide but is discussed in more depth in Guide E3242.

4.7.6.1 Identification and removal of high nondetect values from candidate background data sets are discussed in detail in Guide E3242.

4.7.6.2 Identification and removal of outliers from candidate background data sets are discussed in detail in Practice E178, as well as Guide E3242.

4.7.6.3 Geochemical and chemical forensic methodologies used in evaluating candidate background data sets to obtain representative background data sets are discussed in detail in Guide E3242; their applications during background reference area selection are discussed in Guide E3344.

4.7.7 The use of statistical methods to develop BTVs from representative background data sets are discussed in detail in Guide E3242.

4.7.8 The use of statistical methods to compare representative background data sets to the sediment site data sets are discussed in detail in Guide E3242.

4.7.9 Geospatial analysis considerations are not thoroughly discussed in this guidance but are discussed in more depth relative to environmental evaluations in (4), which focuses on quality assurance concerns relative to geospatial analyses.

4.7.10 In this guide, “sediment” (3.1.8) is defined as a matrix being found at the bottom of a water body. Upland soils of sedimentary origin are excluded from consideration as sediment in this guide.

4.7.11 In this guide, only COC concentrations are considered. Residual background radioactivity is out of scope.

4.8 *Structure and Components of This Guide*—The user of this guide should review the overall structure and components of this guide before proceeding with use, including:

Section 1	Scope
Section 2	Referenced Documents
Section 3	Terminology
Section 4	Significance and Use
Section 5	Overview of Representative Background Concentrations for Sediment at Sediment Sites
Section 6	Framework for Developing Representative Background Concentrations for Sediment at Sediment Sites
Section 7	Conceptual Site Model Considerations When Developing Representative Background Concentrations for Sediment at Sediment Sites
Section 8	Keywords
References	



5. Overview of Representative Background Concentrations for Sediment at Sediment Sites

5.1 Importance of Representative Background Concentrations for Sediment:

5.1.1 It has been recognized for more than three decades that establishing a reliable representation of background is of key importance at contaminated sediment sites (1, 5, 6). This guide has been prepared to provide an overarching framework for the development of representative background concentrations for sediment at such sites. Technically defensible representative background concentrations for sediment are critical in establishing an appropriate remedial response and providing realistic cleanup levels.

5.2 Representative Background Concentrations for Sediment—Anthropogenic and Natural Contributions:

5.2.1 Anthropogenic background is defined in 3.2.1 and natural background is defined in 3.2.11.

5.2.2 For certain constituents (such as metals and other trace elements), the representative background concentrations for sediment contain contributions from both naturally occurring and anthropogenic background sources. For others (such as synthetic organic chemicals like PCBs), the representative background concentrations for sediment contain contributions from only anthropogenic background sources.

5.2.3 This guide recognizes ongoing background chemical inputs to a sediment site (that are not from current or historical site-related releases or activities) from point sources (such as discharges from municipal and industrial outfalls) and from non-point and diffuse watershed-wide sources (such as sediment transported from off-site, urban runoff, and atmospheric deposition).

5.3 Development of Representative Background Concentrations for Sediment:

5.3.1 For sediment sites, the goal is to develop representative background concentrations for sediment, which are equivalent to anthropogenic background for human-made chemicals and the combination of naturally occurring and anthropogenic backgrounds for naturally occurring chemicals (such as metals and other trace elements). Technically defensible representative background concentrations for sediment are typically developed using data collected from a site's background reference area (or areas), which is an area (or areas) similar to the sediment site but not affected by current or historical site-related releases or activities. Representative background concentrations for sediment can also be extracted from the sediment site data set. Development of these representative background concentrations for sediment is performed using appropriate statistical, chemical forensic, and geochemical evaluation methods (refer to Section 6).

5.3.2 At many sediment sites, multiple sources may contribute to the nature and extent of contamination. The largest contributor of contamination at sediment sites is typically current or historical site-related releases or activities. However, contamination can also result from naturally occurring sources and ongoing anthropogenic sources not connected to current or historical site-related releases or activities.

5.3.3 Off-site contamination not associated with current or historical sediment site-related releases or activities is consid-

ered a component of representative background concentrations for sediment and will continue to be a source of contamination to the sediment site unless all transport pathways for contaminated sediment onto the sediment site are eliminated. Technically defensible representative background concentrations for sediment account for any background chemical input (both naturally occurring and anthropogenic) that is expected to continue migrating onto the sediment site after the completion of corrective actions.

5.3.4 An important principle for management of contaminated sediment sites is the control of background sources of contamination, to the greatest extent practicable, prior to initiating corrective actions. However, it is rarely practicable to control all background sources before corrective action initiation at a sediment site.

5.4 Use of Representative Background Concentrations for Sediment:

5.4.1 Once established, representative background concentrations for sediment may be applied as cleanup levels at sites where these concentrations are greater than risk-based cleanup levels, thereby setting the scope and scale of the sediment site corrective actions. "The reasons for this approach include cost-effectiveness, technical practicability, and the potential for recontamination of remediated areas by surrounding areas with elevated background concentrations" (7). This approach (developed by the U.S. Environmental Protection Agency [USEPA]) highlights the importance of developing representative background concentrations for sediment that are technically defensible.

5.4.2 Additionally, representative background concentrations for sediment can assist in determining sediment site boundaries, understanding risks at a sediment site due to background concentrations, establishing and optimizing realistic post-remedy monitoring plans (Guide E3164), and assessing the performance of corrective actions (Guide E3242).

5.5 Corrective Action Sustainability:

5.5.1 In the absence of technically defensible representative background concentrations for sediment, risk-based cleanup levels may be inappropriately used at sediment sites where these representative background concentrations would actually be greater than the risk-based cleanup levels. Similarly, if the representative background concentrations for sediment have been erroneously developed, inappropriately low cleanup goals could be used in the corrective action evaluation process. Under both circumstances, surface sediments may initially meet all chemical concentration-based remedial objectives (such as cleanup levels) upon corrective action completion, but they will eventually return to representative background concentrations for sediment at some time after completion, and the cleanup levels will again be exceeded.

5.5.1.1 Due to inappropriate cleanup levels based (in part) on the selection of unrepresentative background concentrations for sediment, perceived failure of the corrective action has been observed at numerous sediment sites throughout the United States, under both federal and state jurisdiction (8). The framework outlined in this guide is intended to avoid costly perceived remedy failures due to recontamination.