



Designation: E2616 – 09 (Reapproved 2020)

# Standard Guide for Remedy Selection Integrating Risk-Based Corrective Action and Non-Risk Considerations<sup>1</sup>

This standard is issued under the fixed designation E2616; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers the selection of appropriate remedial actions at sites where a release of chemicals (for example, vapor-phase, dissolved-phase, or non-aqueous phase liquids (NAPL)) into the environment has occurred. This overall remedy selection process is illustrated in Fig. 1. The guide is intended to be applied within a risk-based corrective action (RBCA) framework.

1.2 The purpose of this guide is to facilitate the selection of acceptable remedial actions and to minimize bad decisions leading to the selection of remedial actions that do not satisfy both the risk-based remedial action objectives and the non-risk remedial action objectives.

1.3 This guide is intended to be applied at sites that require a remedial action to address unacceptable human health or ecological risks, other regulatory requirements, and/or other unacceptable site conditions. Prior to use of this guide, a site assessment should be completed resulting in: (1) the establishment of remedial action objectives, (2) a determination that a remedial action is required to achieve the remedial action objectives, (3) an identification of site areas requiring a remedial action, and (4) a conceptual site model that reflects the results of the site assessment. The risk-based remedial action objectives are assumed to have been established using RBCA or another risk-based assessment method that results in the identification of appropriate remedial action objectives based on an evaluation of sources, exposure pathways, and potential receptors. Remedial action objectives may be established using Guide E1739, Guide E2081, and/or Guide E2205. In addition, applicable federal, state, and local regulations, statutes, and policies should be followed and should form the basis for determining risk-based and non-risk remedial action objectives. The remedial action objectives may include resource protection standards and the prevention of aesthetic or nuisance impacts in addition to protection of human health and the environment.

<sup>1</sup> 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.

Current edition approved Nov. 1, 2020. Published November 2020. Originally approved in 2009. Last previous edition approved in 2014 as E2616–09(2014). DOI: 10.1520/E2616-09R20.

1.4 Each risk-based remedial action objective for an exposure pathway will typically include numeric remedial action levels for each chemical of concern (COC). Remedial action levels may also be developed for non-risk remedial action objectives such as resource protection standards. The non-risk remedial action levels may include thickness or mobility criteria for NAPL. The selected remedy must be effective and timely for each remedial action objective based on the consideration of the associated exposure pathway or resource protection standard.

1.5 To facilitate the selection of acceptable remedial actions, this guide establishes a process for remedy selection (Fig. 2) that involves:

1.5.1 *Development of risk-based remedial action objectives* that includes identification of complete exposure pathways and numeric remedial action levels (Section 5).

1.5.2 *Development of non-risk remedial action objectives* based on resource protection and other non-risk considerations. Resource protection objectives typically include numeric remedial action levels while other non-risk criteria are typically non-numeric and may include: remediation timeframe, implementability, cost effectiveness, regulatory compliance, property use requirements, liability control, and community concern (Section 5).

1.5.3 *Evaluation of protectiveness* to identify protective remedial actions that will be effective and timely for each risk-based remedial action objective for the site (Section 6).

1.5.4 *Evaluation of the retained remedies using the non-risk remedial action objectives* to identify acceptable remedial actions that satisfy the minimum level for each non-risk criterion (Section 7).

1.5.5 *Remedial action selection* to select the acceptable remedial action to be implemented at the site (Section 8).

1.5.6 *Remedy design and implementation* to ensure that the selected remedy is effectively implemented at the site and satisfies the remedial action objectives (Section 9).

1.6 This guide is intended for use in the selection of final remedial actions. This guide may also be used in the selection of interim measures provided that risk-based remedial action objectives and non-risk remedial action objectives are available for the evaluation of these interim measures.

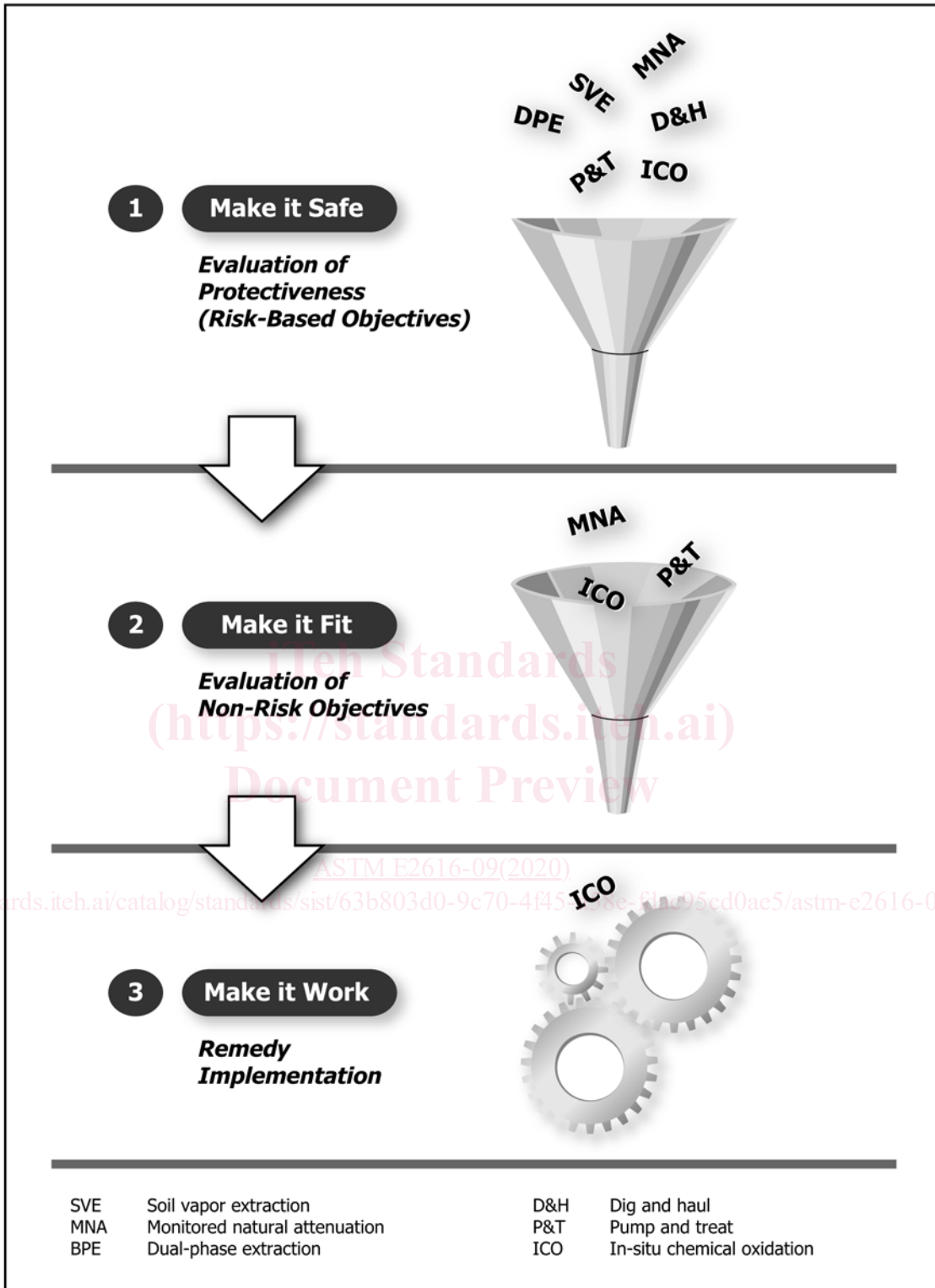
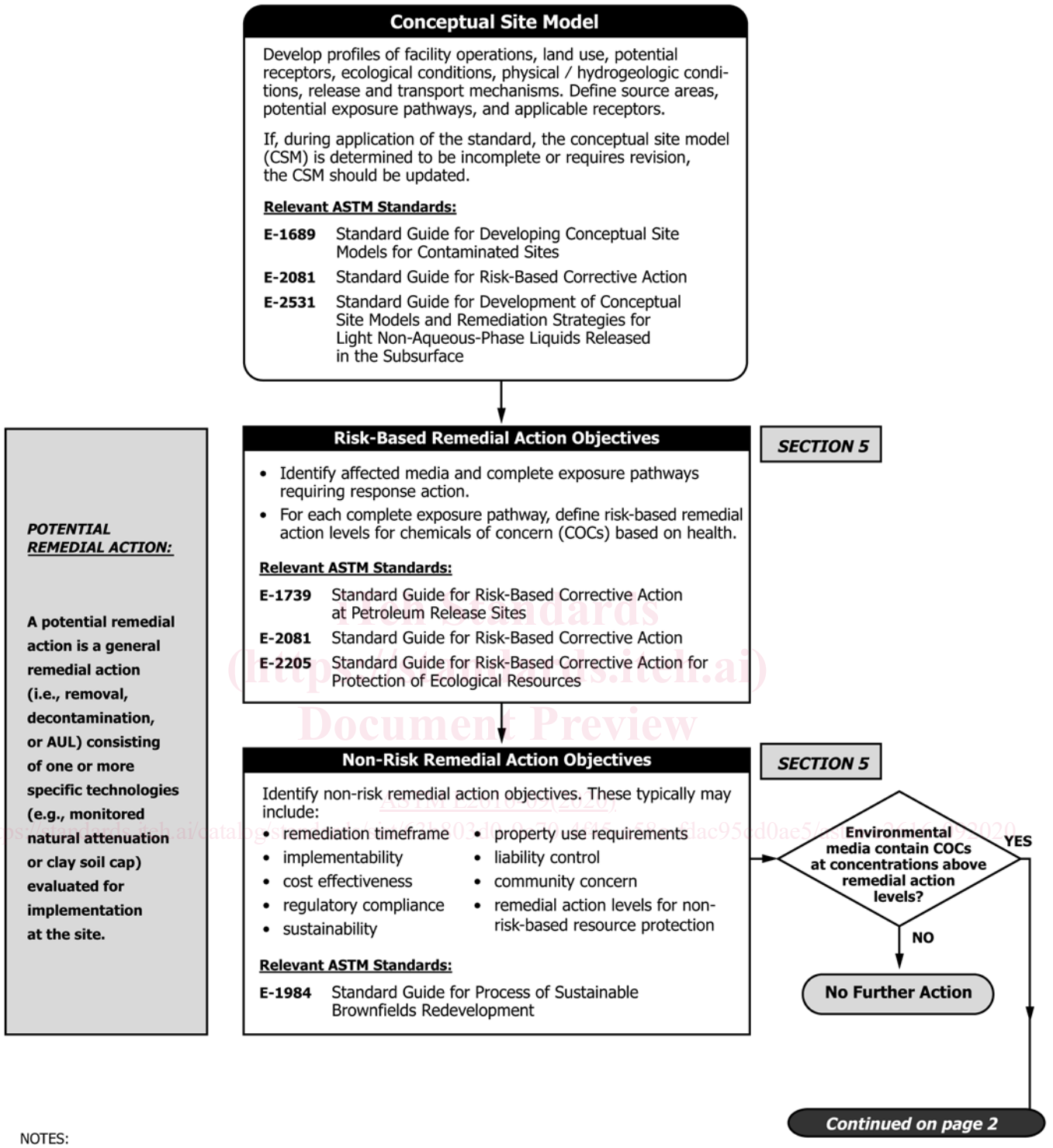


FIG. 1 Remedial Selection Process

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

1.8 This guide is not intended to specifically address contractor health and safety issues. It is the responsibility of the user of this guide to ensure that Occupational Safety and

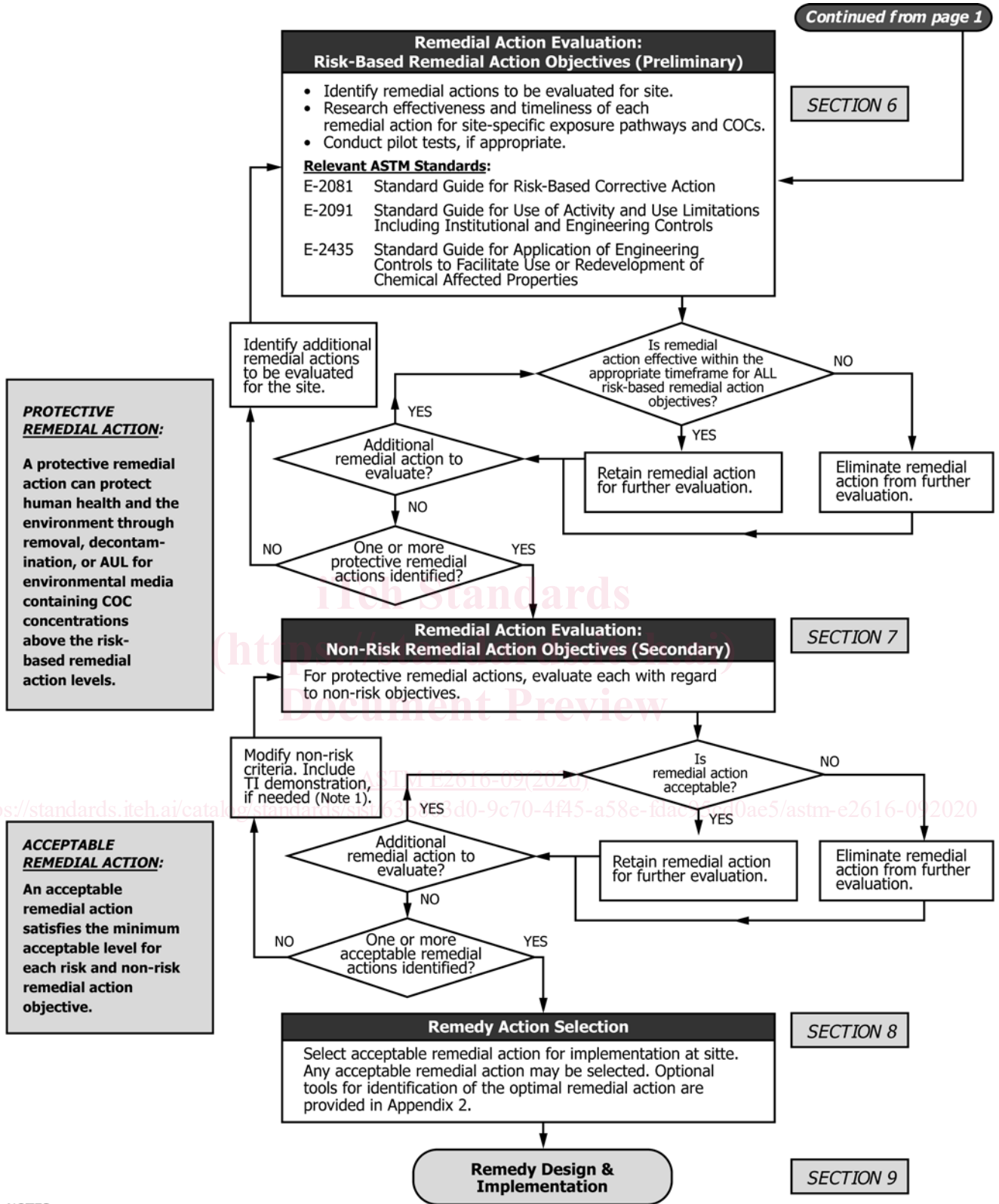


NOTES:

TI = Technical Impracticability  
 AUL = Activity and Use Limitation

FIG. 2 Remedy Selection Flowchart

Continued from page 1



**PROTECTIVE REMEDIAL ACTION:**  
A protective remedial action can protect human health and the environment through removal, decontamination, or AUL for environmental media containing COC concentrations above the risk-based remedial action levels.

**ACCEPTABLE REMEDIAL ACTION:**  
An acceptable remedial action satisfies the minimum acceptable level for each risk and non-risk remedial action objective.

NOTES:

1) TI = Technical Impracticability  
AUL = Activity and Use Limitation

2) The remedy selection process must identify at least one remedy that addresses all risk-based objectives. If all protective remedies are eliminated based on the evaluation of non-risk objectives, then the user must: i) identify additional potential remedies for evaluation, or ii) modify the non-risk objectives so that one or more protective remedy is considered acceptable.

FIG. 2 Remedy Selection Flowchart (continued)

Health Administration (OSHA) regulatory requirements are met, and appropriate industry practices are consulted for guidance.

1.9 *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.*

1.10 *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:<sup>2</sup>

**D6235** Practice for Expedited Site Characterization of Vadose Zone and Groundwater Contamination at Hazardous Waste Contaminated Sites

**D7294** Guide for Collecting Treatment Process Design Data at a Contaminated Site—A Site Contaminated With Chemicals of Interest

**E1689** Guide for Developing Conceptual Site Models for Contaminated Sites

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

**E1912** Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases (Withdrawn 2013)<sup>3</sup>

**E1943** Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites

**E2081** Guide for Risk-Based Corrective Action

**E2091** Guide for Use of Activity and Use Limitations, Including Institutional and Engineering Controls

**E2205** Guide for Risk-Based Corrective Action for Protection of Ecological Resources

**E2435** Guide for Application of Engineering Controls to Facilitate Use or Redevelopment of Chemical-Affected Properties

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

## 3. Terminology

### 3.1 Conceptual Model Terms:

3.1.1 *site*—The area(s) defined by the likely physical distribution of the COCs from a source area. A site could be an entire property or facility, a defined area or portion of a facility or property, or multiple facilities or properties. One facility may contain multiple sites. Multiple sites at one facility may be addressed individually or as a group.

3.1.2 *site assessment*—The characterization of a site to determine whether a release has occurred, the concentrations of the COCs in environmental media, and the distribution of the COCs. The site assessment collects data on soil, groundwater, air, and surface water quality; site characteristics (for example, subsurface geology, geochemistry, soil properties and structures, hydrology and surface characteristics), land and resource use, and potential receptors, and generates information to develop a conceptual site model to support risk-based decision making. The results of the site assessment are used to (1) establish remedial action objectives, (2) determine whether a remedial action is required to achieve the remedial action objectives, (3) identify site areas requiring a remedial action, and (4) develop a conceptual site model that reflects the results of the site assessment. The site assessment may be conducted using Practice **D6235** or Guide **E1912**.

3.1.3 *complete exposure pathway*—The route a COC takes from the source area(s) to a human or ecological receptor. A complete exposure pathway describes a mechanism by which an individual or population is or could be exposed to COCs originating from the site. Each exposure pathway is associated with a source, a point of exposure, and an exposure route. If the exposure point is not at the source, a transport/exposure mechanism is included.

3.1.4 *conceptual site model*—The integrated representation of the physical and environmental context, the complete and potentially complete exposure pathways and the potential fate and transport of chemicals(s) of concern at a site. The site conceptual model should include both the current understanding of the site and the 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.

3.1.5 *risk-based remedial action objectives*—A set of objectives based on protection of human health and the environment developed for the site that identifies the COCs, affected environmental media, complete exposure pathways, and risk-based remedial action levels.

3.1.6 *non-risk remedial action objectives*—A set of objectives based on non-risk considerations for current and future site management. These objectives may include action levels based on aesthetic criteria or other resource protection standards with non-risk remedial action levels. In addition, these objectives not directly based on COC concentrations such as: remediation timeframe, implementability, cost effectiveness, regulatory compliance, property use requirements, liability control, and community concern.

3.1.7 *remedial action levels*—Concentrations of COCs in the source media and/or receptor media below which remedial actions are not required in order to satisfy the remedial action objectives. Non-risk remedial action levels may include resource protection standards not linked to a complete exposure pathway (that is, the application of drinking water standards to

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

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

water resources not currently used for drinking water). Non-risk remedial action levels may also include thickness or mobility criteria for NAPL.

### 3.2 *Types of Remedial Action Technologies:*

3.2.1 *removal*—A remedial action technology to take environmental media away from the site to another location for storage, processing, or disposal in accordance with all applicable requirements.

3.2.2 *decontamination*—A remedial action technology based on permanent and irreversible treatment processes to an environmental medium so that the threat of release of COCs at concentrations above the remedial action levels is eliminated.

3.2.3 *activity and use limitation (AUL)*—A remedial action technology that relies on institutional controls (ICs) or engineering controls (ECs) (collectively, ICs and ECs are known as “activity and use limitations”) to prevent exposure to COCs present in environmental media at concentrations above the remedial action levels. An AUL technology can be used to eliminate a complete or potentially complete exposure pathway by eliminating the receptor or by preventing transport of the COCs to the receptor. AUL measures must be combined with appropriate maintenance, monitoring, and any necessary further remedial action to satisfy the remedial action objectives and be protective of human health and the environment.

### 3.3 *Remedy Selection:*

3.3.1 *remedial action*—One or more technologies implemented at a site to address environmental media containing COCs at concentrations exceeding the remedial action levels defined for the site. A remedial action for a site may involve removal, decontamination, and/or AUL technologies including monitoring.

3.3.2 *potential remedial action*—A potential remedial action is any remedial action evaluated for implementation at the site as part of the risk-based remedy selection process.

3.3.3 *protective remedial action*—A protective remedial action can achieve all of the risk-based remedial action objectives through timely removal, decontamination, and/or implementation of AULs for environmental media containing COC concentrations above the risk-based remedial action levels.

3.3.4 *acceptable remedial action*—An acceptable remedial action is able to achieve all of the risk-based and non-risk remedial action objectives.

### 3.4 *Acronyms:*

3.4.1 *AUL*—activity and use limitation

3.4.2 *CMS*—corrective measures study

3.4.3 *COC*—chemical of concern

3.4.4 *EC*—engineering control

3.4.5 *ETCAP*—Environmental Technology Cost Savings Analysis Project

3.4.6 *FRTR*—Federal Remediation Technologies Roundtable

3.4.7 *FS*—feasibility study

3.4.8 *GWRTAC*—Ground Water Remediation Technologies Analysis Center

3.4.9 *IC*—institutional control

3.4.10 *ITRC*—Interstate Technology & Regulatory Council

3.4.11 *NAPL*—non-aqueous phase liquids

3.4.12 *NAVFAC*—Naval Facilities Engineering Command

3.4.13 *OSHA*—Occupational Health and Safety Administration

3.4.14 *RBCA*—risk-based corrective action

## 4. Significance and Use

4.1 This guide is intended for use within a RBCA process or other risk-based framework for protection of human health and the environment that is based on an evaluation of sources, exposure pathways, and receptors.

4.2 This guide is intended to identify the factors that should be considered in the selection and implementation of an appropriate remedial action to address COCs present in environmental media at the site at concentrations above the remedial action levels. The specific process used to select the remedial action will vary widely from site to site. However, in all cases, the selected remedial action should be both a protective remedial action (that is, achieves the risk-based remedial action objectives) and an acceptable remedial action (that is, satisfies the non-risk remedial action objectives).

## 5. Remedial Action Objectives

5.1 *Conceptual Model*—A conceptual model is an important tool that is utilized in the risk-based remedy selection process. The conceptual model provides a systematic method for use of site information based on current and potential future site-specific land use considerations. The conceptual model should identify source areas; complete, potentially complete, and incomplete exposure pathways; and human and ecological receptors. In addition, the conceptual model should identify type and concentration of COCs, affected environmental media, and specific areas within the affected environmental media to be addressed by the selected remedial action. Although a conceptual model should be developed prior to initiation of the risk-based remedy selection process, the conceptual model should be considered dynamic and should be updated as needed during the risk-based remedy selection process to reflect any changes in the understanding of the site. A conceptual model may be developed using Guide E1689, Guide E2531, and/or Guide D7294.

5.2 *Identification of Risk-Based Remedial Action Objectives*—Risk-based remedial action objectives are used to identify remedial actions that will be protective of human health and the environment. It is assumed that users of this guide will have developed appropriate risk-based remedial action objectives which are protective of human health and the environment using RBCA or a similar risk-based framework. The risk-based remedial action objectives should include: (1) identification of types and concentrations of COCs, (2) affected environmental media, (3) complete exposure pathways and resource protection requirements, and (4) remedial action levels and their basis. Remedial action objectives may be established using Guide E1739, Guide E2081, and/or Guide E2205.

**5.3 Identification of Non-Risk Remedial Action Objectives**—Non-risk remedial action objectives are used to identify remedial actions that will satisfy the current and future non-risk requirements for the site. While risk-based remedial action objectives ensure long-term protection of human health and the environment, non-risk objectives address all other site remedial action requirements and constraints, including applicable laws and regulatory requirements not already included as risk-based remedial action objectives. The non-risk remedial action objectives should cover all non-risk site constraints that will define an acceptable remedy.

**5.3.1 Example Non-Risk Remedial Action Objectives with Remedial Action Levels**—Resource protection standards are remedial action objectives that include remedial action levels but are not directly tied to human or ecological exposure. Containment or exposure control remedial actions (that is, AULs) may not be considered acceptable for some resource protection objectives. Example non-risk remedial action objectives with remedial action levels include, but are not limited to the following:

**5.3.1.1 Action levels to prevent aesthetic or nuisance impacts.**

**5.3.1.2 Application of drinking water standards to non-drinking water resources:** remedial action levels for drinking water are applied to water resources that will not be used as drinking water in the foreseeable future.

**5.3.1.3 NAPL removal requirements:** NAPL thickness or mobility criteria for groundwater resources where human exposure will not occur in the foreseeable future.

**5.3.2 Example Non-Risk Remedial Action Objectives without Remedial Action Levels**—Other non-risk remedial action objectives are not directly tied to site COC concentrations and therefore do not include remedial action levels.

**5.3.2.1 Timeliness**—Remedial action will be completed within a timeframe that meets the site-specific requirements.

**5.3.2.2 Implementability**—Remedial action can be implemented and will protect human health and the environment during implementation.

**5.3.2.3 Confidence**—The level of confidence that the remedial action will achieve the remedial action objectives at the site.

**5.3.2.4 Sustainability**—Remedy is sustainable based on evaluation of sustainability metrics such as energy usage, carbon dioxide emissions, natural resource usage/restoration, etc.

**5.3.2.5 Cost**—Remedy cost is acceptable.

**5.3.2.6 Regulatory Compliance**—Remedy satisfies regulatory requirements.

**5.3.2.7 Property Use Compatibility**—Remedy allows for acceptable current and future property use.

**5.3.2.8 Liability Control**—Remedy controls current and future liability associated with site.

**5.3.2.9 Community Acceptance**—Remedy is acceptable to third party stakeholders.

**5.3.3 Acceptance Standards for Non-Risk Remedial Action Objectives**—For each non-risk remedial action objective without remedial action levels, the user must identify an acceptance standard that will be used to determine whether a remedial

action satisfies the non-risk objective. For the purpose of identifying acceptable remedial actions, the acceptance standard will generally be absolute (that is, remediation time must not exceed 10 years). Relative acceptance standards (that is, one remedy is more cost effective than an alternative remedy) should not be used for the identification of acceptable remedies. Instead, relative standards should be used to select a remedial action for implementation from among the acceptable remedial actions identified in the screening process (see Section 8).

**5.4 Need for a Remedial Action**—A remedial action is required if environmental media contain COCs at concentrations above the risk-based or non-risk remedial action levels. If all COC concentrations are below the remedial action levels, then no further action is required.

## **6. Remedial Action Evaluation: Risk-Based Remedial Action Objectives**

**6.1 Identification of Potential Remedial Actions**—In risk-based remedial action screening, potential remedial actions are screened to identify protective remedial actions which can achieve all of the risk-based remedial action objectives. A potential remedial action is one or more specific technologies (for example, clay soil cap or monitored natural attenuation) representing one or more classes of remedial action (that is, removal, decontamination, or AULs) evaluated for implementation at the site. Available resources for the identification of potential remedial actions are provided in **6.3.3**.

**6.2 Remedial Action Screening Process**—Remedial action screening may be conducted in a staged manner where the simplest and easiest remedial actions are screened first. If no acceptable remedial action is identified in this initial screen, then more complex remedial actions can be identified and screened. As an alternative, a comprehensive list of potential remedial actions may be screened in a single iteration.

**6.3 Evaluation of Potential Remedial Actions**—The user must research the effectiveness and timeliness of each potential remedial action in order to determine whether the potential remedial action is capable of achieving all of the risk-based remedial action objectives.

**6.3.1 Use of the Conceptual Site Model**—The evaluation of effectiveness and timeliness for each remedial action should be made within the context of the conceptual site model (that is, the COCs, physical, geochemical, and hydrogeologic conditions, and other site-specific factors affecting technology effectiveness).

**6.3.2 Performance History**—When evaluating effectiveness and timeliness of a potential remedial action, the user should consider the performance history of the potential remedial action when applied to other sites with similar conceptual site models (that is, similar COCs, site conditions, etc.).

**6.3.3 Available Resources**—A number of resources are available to assist with the evaluation of technical effectiveness of potential remedial actions:

**6.3.3.1 Federal Remediation Technologies Roundtable (FRTR):** <http://www.frtr.gov/>

**6.3.3.2 USEPA Technology Innovation Program Contaminated Site Clean-Up Information:** <http://clu-in.org>