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Standard Guide for Conceptualization and Characterization of Groundwater Systems[1]

This standard is issued under the fixed designation D5979; 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.

ε1 NOTE—Reapproved with editorial changes in May 2019.

1. Scope

1.1 This guide covers an integrated, stepwise method for the qualitative conceptualization and quantitative characterization of groundwater flow systems, including the unsaturated zone, for natural or human-induced behavior or changes.

1.2 This guide may be used at any scale of investigation, including site-specific, subregional, and regional applications.

1.3 This guide describes an iterative process for developing multiple working hypotheses for characterizing groundwater flow systems. This process aims at reducing uncertainty with respect to conceptual models, observation, interpretation, and analysis in terms of hypothesis and refinement of the most likely conceptual model of the groundwater flow system. The process is also aimed at reducing the range of realistic values for parameters identified during the characterization process. This guide does not address the quantitative uncertainty associated with specific methods of hydrogeologic and groundwater system characterization and quantification, for example, the effects of well construction on water-level measurement.

1.4 This guide addresses the general procedure, types of data needed, and references that enable the investigator to complete the process of analysis and interpretation of each data type with respect to geohydrologic processes and hydrogeologic framework. This guide recommends the groups of data and analysis to be used during each step of the conceptualization process.

1.5 This guide does not address the specific methods for characterizing hydrogeologic and groundwater system properties.

1.6 This guide does not address model selection, design, or attribution for use in the process of groundwater flow system characterization and quantification. This guide does not address the process of model schematization, including the simplification of hydrologic systems and the representation of hydrogeologic parameters in models.

1.7 This guide does not address special considerations required for characterization of karst and fractured rock terrain. In such hydrogeologic settings, refer to Quinlan (**1**)[2] and Guide D5717 for additional guidance.

1.8 This guide does not address special considerations regarding the source, fate, and movement of chemicals in the subsurface.

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 guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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

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:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D5254/D5254M Practice for Minimum Set of Data Elements to Identify a Groundwater Site (Withdrawn 2019)[4]

D5408 Guide for Set of Data Elements to Describe a Groundwater Site; Part One—Additional Identification Descriptors (Withdrawn 2019)[4]

D5409/D5409M Guide for Set of Data Elements to Describe a Groundwater Site;Part Two—Physical Descriptors (Withdrawn 2019)[4]

D5410 Guide for Set of Data Elements to Describe a Groundwater Site;Part Three—Usage Descriptors (Withdrawn 2016)[4]

D5447 Guide for Application of a Numerical Groundwater Flow Model to a Site-Specific Problem

D5474 Guide for Selection of Data Elements for Groundwater Investigations

D5609 Guide for Defining Boundary Conditions in Groundwater Flow Modeling

D5610 Guide for Defining Initial Conditions in Groundwater Flow Modeling

D5717 Guide for Design of Ground-Water Monitoring Systems in Karst and Fractured-Rock Aquifers (Withdrawn 2005)[4]

D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *conceptual model, n*—an interpretation or working description of the characteristics and dynamics of the physical system.

3.1.2 *groundwater flow model, n*—application of a mathematical model to represent a regional or site-specific groundwater flow system.

3.1.3 *hydrologic system, n*—the general concepts of the hydrologic elements, active hydrologic processes, and the interlinkages and hierarchy of elements and processes.

3.1.4 For definitions of other terms used in this guide, see Terminology D653 and Guide D5447.

4. Summary of Guide

4.1 This guide presents an integrated approach for conceptualizing and characterizing groundwater systems. The conceptualization and characterization process includes: Problem Definition and Database Development (Section 6); Preliminary Conceptualization (Section 7); Surface Characterization (Section 8); Subsurface Characterization (Section 9); Hydrogeologic Characterization (Section 10); Groundwater System Characterization (Section 11); and Groundwater System Quantification (Section 12) (see Fig. 1). Conceptualization and characterization is an iterative process beginning with a theoretical understanding of the groundwater system followed by data collection and refinement of the understanding. Additional data collection and analysis, and the refinement of the groundwater system conceptual model occurs during the entire process of conceptualization and characterization, and during groundwater model development and use (see Fig. 1).

4.2 This guide presents an approach that can be used at any scale. The nature of the problem to be solved will determine the type and scale of data collected.

5. Significance and Use

5.1 Conceptualization and characterization of a groundwater system is fundamental to any qualitative or quantitative analysis. This conceptualization begins with simple abstractions in the investigator's mind, emphasizing the major components of the studied system, that can be rendered in qualitative terms or simple illustrations. The extent of further development of the representation of the system depends on the character of the groundwater problem and the project objective. The abstract concept may suffice, or it may be further defined and quantified through use of analytical models of increasing complexity, and, in some cases, numerical models may be employed. If numerical models are used, the level of detail and sophistication of features represented in the model is likely to increase as the project develops. Evolution of conceptualization of a groundwater flow system should be terminated when the results of the related analyses are sufficient for the problem being addressed.

5.2 This guide may be used in the following:

5.2.1 Evaluating natural variations in groundwater flow systems.

5.2.2 Evaluating anthropogenic stresses on groundwater flow systems, such as pumping for water supply, irrigation, induced infiltration, or well injection.

5.2.3 Evaluating presence and velocity of groundwater contaminants.

5.2.4 Designing and selecting mathematical models to simulate groundwater systems; and completing model schematization and attribution based on the problem defined, characterized groundwater flow system, and model(s) selected.

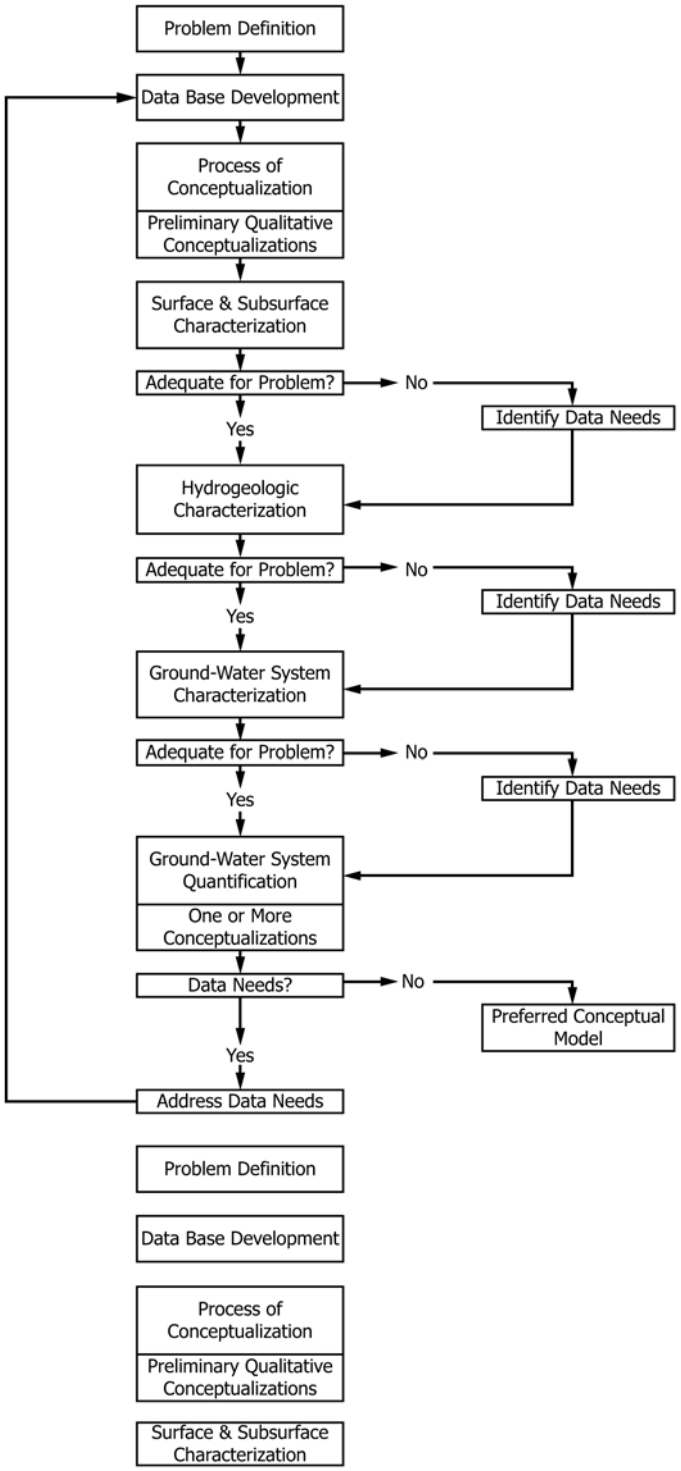
5.2.5 Designing groundwater remediation systems.

5.3 This guide is a flexible description of specific techniques and investigation requirements; methods defined by other ASTM Standards or non-ASTM techniques may be appropriate in some circumstances and, after due consideration, some of the techniques herein may be omitted, altered, or enhanced.

5.3.1 A comprehensive list of items to be considered conceptualization and characterization are included in the main

[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.



NOTE 1—Conceptualization and characterization is an iterative process beginning with a theoretical understanding of the groundwater system followed by data collection and refinement of the understanding. Additional data collection and analysis, and the refinement of the groundwater system conceptual model occurs during the process of conceptualization and characterization, and during groundwater model development and use.

FIG. 1 Procedure for Conceptualization and Characterization of Groundwater Flow Systems (2)

headings (Sections 6 through 13) and first subheadings (for example, 7.1 and 8.1).

5.3.2 In karst and fractured rock hydrogeologic settings, this guide should be used in conjunction with Guide D5717.

5.4 The methods and amount of effort required for conceptualization, characterization, and quantification of groundwater systems for modeling or other applications will vary with site conditions, objectives of investigation, and investigator experience. This guide does not replace proper academic training and experience in hydrogeologic principles, or in groundwater system analysis and quantification. This guide does not set mandatory guidelines and does not constitute a list of necessary steps or procedures for all investigations.

5.5 This guide may be used for project planning and data collection, but does not provide specific aspects for field characterization techniques. Refer to Table X1.1 in Guide D5730, Practice D5254/D5254M, and Refs (**3, 4, 5,** and **6**) for further guidance regarding field characterization techniques.

5.6 This guide may be used to generate the necessary information as part of the process for model selection, design, and as input to model schematization, including the simplification of hydrologic systems and the representation of hydrogeologic parameters in models. Refer to Ref (**7**) for further guidance.

6. Problem Definition and Database Development

6.1 *Define the Objectives of the Project*—Once the objectives are defined, identify the appropriate facets and scale of the groundwater system for characterization.

6.2 *Define the Site*—The boundaries of a site are defined using one or more of the following considerations: natural site characteristics (topography, soils, geology, hydrology, biota), current and past land use and ownership, or known or suspected extent of current or anticipated project-related stresses, which may include cones of depression or contaminant migration. If site boundaries are initially defined by ownership, natural site characteristics of a broader scale should be evaluated to determine whether the scope of at least parts of the investigation should include areas that are off-site. For example, investigations of groundwater contamination should include areas of potential sources upgradient and potential migration paths down-gradient from a site.

6.3 *Gather Data from Existing Sources*—This step involves locating, collecting, and organizing the data needed (see Table 1) to solve the problem into a manageable database. See Practice D5254/D5254M and Guides D5408, D5409/D5409M, D5410, D5474, and D5730 for data elements to identify a groundwater site.

6.3.1 Collect data, such as maps, tables, and reports, from available published and unpublished sources, and field and laboratory studies. Note the methods used to collect and analyze the data. Note levels of quality assurance and quality control as required by the project.

6.3.2 Collect data from interviews of local and regionally knowledgeable people. This may include, but is not limited to, worker histories, former practices, and engineering activities that either changed the site or provide historical data (location of old wells, contaminant history, and so forth).