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Standard Guide for Conceptualization and Characterization of Ground-Water Systems[1]

This standard is issued under the fixed designation D 5979; 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.

ε[1] NOTE—Paragraph 1.10 was added editorially October 1998.

1. Scope

1.1 This guide covers an integrated, stepwise method for the qualitative conceptualization and quantitative characterization of ground-water 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 ground-water 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 ground-water 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 ground-water 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 ground-water system properties.

1.6 This guide does not address model selection, design, or attribution for use in the process of ground-water 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 D 5717 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 and health 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

2.1.1 This procedure is used in conjunction with the following ASTM Standards:

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3,4]

D 5254 Practice for the Minimum Set of Data Elements to Identify a Ground Water Site[5]

D 5408 Guide for the Set of Data Elements to Describe a Ground Water Site; Part 1—Additional Identification Descriptors[5]

D 5409 Guide for the Set of Data Elements to Describe a Ground Water Site; Part 2—Physical Descriptors[5]

D 5410 Guide for the Set of Data Elements to Describe a

[1] This guide is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

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

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 04.09.

Ground Water Site; Part 3—Usage Descriptors[5]

D 5447 Guide for Application of a Ground-Water Flow Model to a Site-Specific Problem[5]

D 5474 Guide for Selection of Data Elements for Ground-Water Investigations[5]

D 5609 Guide for Defining Boundary Conditions in Ground Water Flow Modeling[5]

D 5717 Guide to Design of Ground-Water Monitoring Systems in Karst and Fractured Rock Aquifers[5]

D 5730 Guide to Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone, and Ground Water[5]

3. Terminology

3.1 *Definitions:*

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

3.1.2 *ground-water flow model*—application of a mathematical model to represent a regional or site-specific ground-water flow system.

3.1.3 *hydrologic system*—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 D 653 and Guide D 5447.

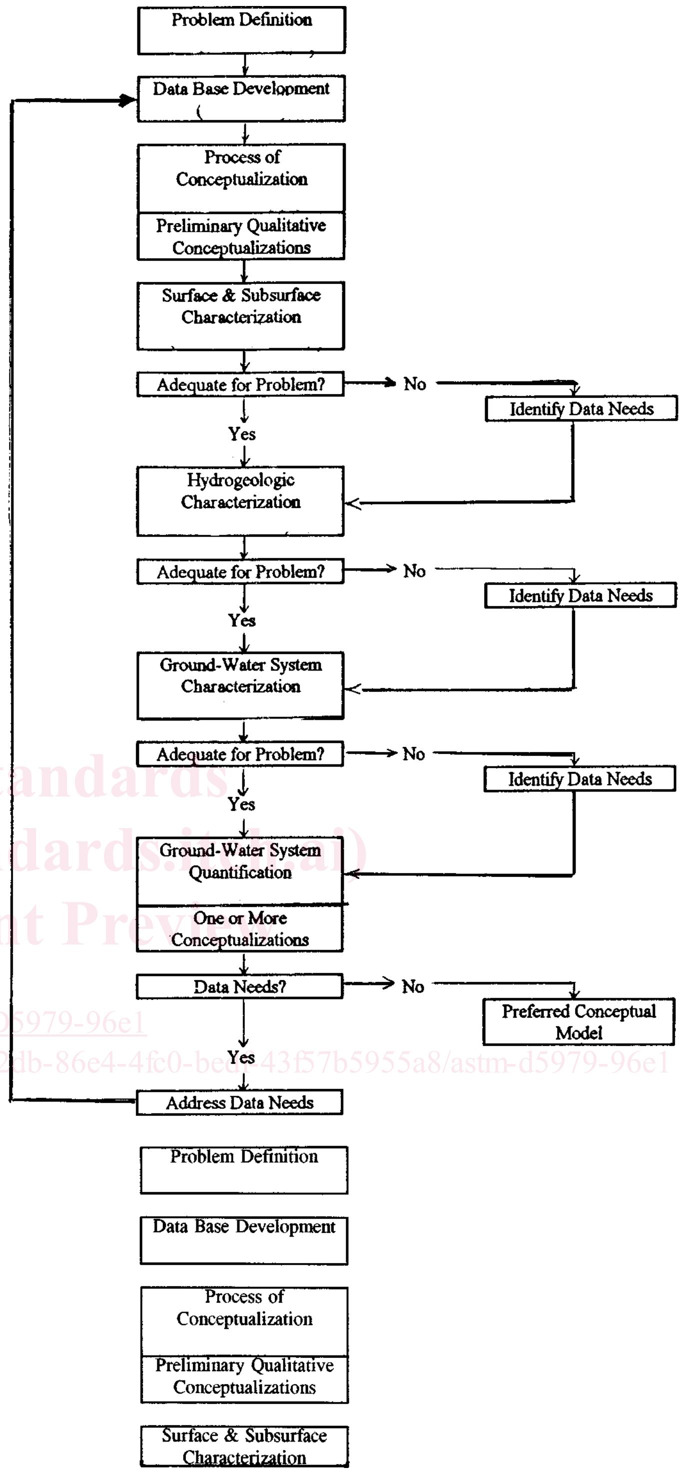
4. Summary of Guide

4.1 This guide presents an integrated approach for conceptualizing and characterizing ground-water systems. The conceptualization and characterization process includes: Problem Definition and Data Base Development (Section 6); Preliminary Conceptualization (Section 7); Surface Characterization (Section 8); Subsurface Characterization (Section 9); Hydrogeologic Characterization (Section 10); Ground-Water System Characterization (Section 11); and Ground-Water System Quantification (Section 12) (see Fig. 1). Conceptualization and characterization is an iterative process beginning with a theoretical understanding of the ground-water system followed by data collection and refinement of the understanding. Additional data collection and analysis, and the refinement of the ground-water system conceptual model occurs during the entire process of conceptualization and characterization, and during ground-water 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 ground-water 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 ground-water problem and the project objective. The abstract concept may suffice, or it may be further defined and quantified through use of analytical models of



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

FIG. 1 Procedure for Conceptualization and Characterization of Ground-Water Flow Systems (32)

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 ground-water 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 ground-water flow systems.

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

5.2.3 Evaluating presence and velocity of ground-water contaminants.

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

5.2.5 Designing ground-water 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 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 D 5717.

5.4 The methods and amount of effort required for conceptualization, characterization, and quantification of ground-water 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 ground-water 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 D 5730, Practice D 5254, and Refs **(2, 3, 4,** and **5)** 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 **(6)** for further guidance.

6. Problem Definition and Data Base Development

6.1 *Define the Objectives of the Project*—Once the objectives are defined, identify the appropriate facets and scale of the ground-water 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 ground-water 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 data base. See Guides D 5254, D 5408, D 5409, D 5410, D 5474, and D 5730 for data elements to identify a ground-water site.

6.3.1 Collect data, such as maps, tables, and reports, from available published and unpublished sources, and field and

TABLE 1 Data Topics and Types

Topography and Remote Sensing:	
(a)	Topography
(b)	Aerial photography
(c)	Satellite imagery
(d)	Multispectral data
(e)	Thermal imagery
(f)	Radar, side-looking airborne radar, microwave imagery
Geomorphology:	
(a)	Surficial geology or geomorphology maps
(b)	Engineering geology maps
(c)	Surface water inventory maps
(d)	Hydrography digital line graphs
Geology:	
(a)	Geologic maps and cross sections
(b)	Lithologic or drillers logs, or both
Geophysics:	
(a)	Gravity, electromagnetic magnetics, resistivity, and seismic survey data or interpretations, or both
(b)	Natural seismic activity data
(c)	Borehole geophysical data
Climate:	
(a)	Precipitation data
(b)	Temperature, humidity, and wind data
(c)	Evaporation data
(d)	Effects of climate change on hydrologic system information
Vegetation:	
(a)	Communities or species maps, or both
(b)	Density map
(c)	Agricultural species, crop calendars, consumptive use data
(d)	Land use—Land cover maps
Soils:	
(a)	Soil surveys
(b)	Soil properties determined from laboratory analysis
Hydrology:	
(a)	Potentiometric head data
(b)	Subsurface test information
(c)	Subsurface properties determined from laboratory analyses
(d)	Previous work regarding modeling studies, hydrogeologic and ground-water system maps
(e)	Spring and seep data
(f)	Surface water data
(g)	Well design, construction, and development information
Hydrochemistry/Geochemistry (Related to Ground-Water Flow System):	
(a)	Subsurface chemistry derived from well samples
(b)	Surface water chemistry
(c)	Rock and soil chemistry
(d)	Water quality surveys
Anthropogenic Aspects:	
(a)	Planimetric maps
(b)	Land use—Land cover maps
(c)	Roads, transportation, political boundary DLGs
(d)	Land ownership maps include historical information, if available
(e)	Resource management maps