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## **EAST AFRICAN STANDARD**

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**Standard guide for set of data elements to describe a ground-water site — Part 2: Physical descriptors**

**EAST AFRICAN COMMUNITY**

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## Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

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East African Community

P O Box 1096

**Arusha**

Tanzania

Tel: 255 27 2504253/8

Fax: 255-27-2504481/2504255

E-Mail: [eac@eachq.org](mailto:eac@eachq.org)

Web: [www.each.int](http://www.each.int)

## Introduction

In the preparation of this East African Standard, the following source was consulted extensively:

ASTM D5409-93(2004)], *Standard guide for set of data elements to describe a ground-water site — Part 2: Physical descriptors*

Assistance derived from this source and others inadvertently not mentioned is hereby acknowledged.

Draft for comments only — Not to be cited as East African Standard



# Standard Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two—Physical Descriptors<sup>1</sup>

This standard is issued under the fixed designation D 5409; 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 Part Two of three guides to be used in conjunction with Practice D 5254 that delineates the data desirable to describe a ground-water data collection or sampling site. This guide identifies physical descriptors, such as construction and geologic elements, for a site. Part One (Guide D 5408) describes additional information beyond the minimum set of data elements that may be specified to identify any individual ground-water site, while Part Three identifies usage descriptors, such as monitoring, for an individual ground-water site.

NOTE 1—A ground-water site is defined as any source, location, or sampling station capable of producing water or hydrologic data from a natural stratum from below the surface of the earth. A source or facility can include a well, spring or seep, and drain or tunnel (nearly horizontal in orientation). Other sources, such as excavations, driven devices, bore holes, ponds, lakes, and sinkholes, that can be shown to be hydraulically connected to the ground water are appropriate for the use intended.

NOTE 2—Part One (Guide D 5408) includes data confidence classification descriptor (one element), geographic location descriptors (four elements), political regime descriptor (one element), source identifier descriptors (four elements), legal descriptors (nine elements), owner descriptors (two elements), site visit descriptors (three elements), other identification descriptors (two elements), other data descriptors (three elements), and remarks descriptors (three elements). Part Three (Guide D 5410) includes monitoring descriptors (77 data elements), irrigation descriptors (four data elements), waste site descriptors (nine data elements), and decommissioning descriptors (eight data elements). For a list of descriptors in this guide, see Section 3.

1.2 These data elements are described in terms used by ground-water hydrologists. Standard references, such as the Glossary of Geology (1)<sup>2</sup> and various hydrogeologic professional publications, are used to determine these definitions. Many of the suggested elements and their representative codes

are those established by the Water Resources Division of the U.S. Geological Survey, and used in the National Water Information Systems computerized data base (1-19).

NOTE 3—The purpose of this guide is to suggest data elements that can be collected for ground-water sites. This does not uniquely imply a computer data base, but rather data elements for entry into any type of permanent file.

NOTE 4—Component and code lists given with some of the data elements, for example “Type of Spring,” are only suggestions. These lists can be modified, expanded, or reduced for the purpose intended by the company or agency maintaining the ground-water data file.

NOTE 5—Use of trade names in this guide is for identification purposes only and does not constitute endorsement by ASTM.

1.3 This guide includes the data elements desirable to document a ground-water site beyond those given in the “Minimum Set of Data Elements.” Some examples of the data elements are well depth, contributing aquifer, and permanence of spring. No single site will need every data element, for example, springs do not need well depth and well casing data. Each record (group of related data elements) for a site has mandatory data elements, such as the type of lift for the lift record. However, these elements are considered necessary only when that specific record is gathered for the site.

1.4 The values given in either inch-pound units or SI units are to be regarded separately as the standard. The values given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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*

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

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<sup>2</sup> The boldface numbers in parentheses refer to a list of references at the end of the text.

document means only that the document has been approved through the ASTM consensus process.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site
- D 5408 Guide for Set of Data Elements to Describe a Ground-Water Site; Part One—Additional Identification Descriptors
- D 5410 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Three—Usage Descriptors

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of terms applicable to this guide, see Terminology D 653.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *code*—a suggested abbreviation for a component, for example, “G” is the code suggested for the galvanized iron component of data element casing material.

3.2.2 *component*—a subdivision of a data element, for example, galvanized iron is one of 30 components suggested for data element casing material.

3.2.3 *data element*—an individual segment of information about a ground-water site, for example, casing material. The data element is in the Casing Record record.

3.2.4 *record*—a set of related data elements that may need to be repeated to fully describe a ground-water site. For example, a well that consists of several diameters of casing from the top end to the bottom will need more than one Casing Record record (the record includes data elements depth to top, depth to bottom, diameter, casing material, and casing thickness) to fully describe the construction of the well. However, if only a single size of casing is used in the well, the record is utilized once.

3.2.5 *record group*—a set of related records. For example, the lift record group includes the lift record, power record, and standby record. Some record groups consist of only one record, for example, the spring record group includes only the spring record.

## 4. Summary of Guide

4.1 This guide includes the following physical descriptor data elements to describe a ground-water site. Single elements usually need one entry for a site, while repeated elements commonly require several records to fully describe the conditions and history of the site.

Single Elements:

<sup>3</sup> 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.

- Individual Site Characteristics:
  - Land Use (in vicinity of site)
  - Drainage Basin/Watershed
  - Relationship to Surface Stream/Lake, etc.
  - Hole Depth
  - Well Depth
  - Source of Depth Data
  - Primary Aquifer
- Repeated Elements:
  - Construction Record Group:
    - Construction Record:
      - Date Construction Began
      - Date Construction Ended
      - Name of Contractor
      - Source of Construction Data
      - Method of Construction
      - Type of Drilling Fluid
      - Volume of Drilling Fluid
      - Type of Finish
      - Type of Seal
      - Depth to Bottom of Seal
      - Method of Development
      - Length of Time of Development
      - Volume of Liquid Removed During Development
      - Special Treatment
    - Hole Record:
      - Depth to Top of the Hole Interval
      - Depth to Bottom of the Hole Interval
      - Diameter of the Hole Interval
    - Casing Record:
      - Depth to Top of the Cased Interval
      - Depth to Bottom of the Cased Interval
      - Diameter of the Cased Interval
      - Casing Material
      - Casing Thickness
    - Opening or Screen Record:
      - Depth to Top of the Open Interval
      - Depth to Bottom of the Open Interval
      - Diameter of the Open Interval
      - Type of Material in the Open/Screened Interval
      - Type of Openings in the Open Interval
      - Length of Openings
      - Width of Openings
      - Mesh of Screen
      - Packing Material
      - Size of Packing Material
      - Thickness of Packing Material
      - Depth to Top and Bottom of Packing Material
    - Repairs Record:
      - Date of Repairs
      - Nature of Repairs
      - Name of Contractor Who Made Repairs
      - Percent Change in Performance After Repairs
    - Special Cases Record:
      - Well Clusters:
        - Number of Wells in Cluster
        - Depth of Deepest Well in Cluster
        - Depth of Shallowest Well in Cluster
        - Diameter of Well Cluster
      - Collector Well/Laterals:
        - Number of Laterals in Collector Well
        - Depth of Laterals in Collector Well
        - Length of Laterals in Collector Well
        - Diameter of Laterals in Collector Well
        - Mesh of Screen in Laterals
    - Ponds:
      - Length of Pond
      - Width of Pond
      - Depth of Pond
      - Volume of Pond
    - Tunnel or Drain:
      - Length of Tunnel or Drain
      - Width of Tunnel or Drain
      - Depth of Tunnel or Drain
      - Bearing (Azimuth) Tunnel or Drain
      - Dip of Tunnel or Drain
  - Lift Record Group:

- Lift Record:
  - Type of Lift
  - Date Permanent Lift was Installed
  - Depth of Intake
  - Manufacturer of Lift Device
  - Serial Number
  - Pump Rating
- Power Record:
  - Type of Power
  - Horsepower Rating
  - Name of Power Company
  - Power-Company Account Number
  - Power-Meter Number
- Standby Lift Record:
  - Additional Lift
  - Name of Company that Maintains Lift
  - Rated Pump Capacity
  - Type of Standby Power
  - Horsepower of Standby Power Source
- Geologic Record Group:
  - Geophysical Log Record:
    - Date of Log
    - Type of Log
    - Depth to Top of Logged Interval
    - Depth to Bottom of Logged Interval
    - Source of Log Data
  - Geohydrologic Unit Record:
    - Aquifer Unit(s)
    - Contributing Unit
    - Depth to Top of Interval
    - Depth to Bottom of Interval
    - Lithology
    - Description of Material
  - Sample/Unconsolidated Material Record:
    - Sample Weight
    - Sample Interval
    - Particle Size
    - Percent of Total Sample
    - Particle Shape
    - Mineralogy
  - Sample/Consolidated Material Record:
    - Drill Cuttings or Core
    - Sample Size (Weight)
    - Sample Interval
    - Mineralogy
    - Core Length
    - Core Diameter
    - Core Recovery-Percent
    - Bedding
    - Structure
    - Porosity
- Hydraulic Record Group:
  - Hydraulics Record:
    - Hydraulic/Aquifer Unit
    - Hydraulic/Aquifer Unit Type
    - Depth to Top of Unit
    - Depth to Bottom of Unit
    - Static Water Level
    - Measurement Date and Time
    - Unit Contribution
  - Aquifer Parameters Record:
    - Transmissivity
    - Horizontal Hydraulic Conductivity
    - Vertical Hydraulic Conductivity
    - Coefficient of Storage
    - Leakance
    - Diffusivity
    - Specific Storage
    - Specific Yield
    - Barometric or Tidal Efficiency
    - Porosity
    - Specific Capacity
    - Method Used to Determine Aquifer Characteristics
    - Availability of File of Detailed Results
- Spring Record Group:
  - Spring Record:
    - Name of Spring

- Type of Spring
- Permanence of Spring
- Sphere of Discharge
- Discharge
- Date of Discharge
- Improvements
- Number of Spring Openings
- Flow Variability
- Accuracy of Flow Variability
- Magnitude of Spring

## 5. Significance and Use

5.1 Data at ground-water sites are gathered for many purposes. Each of these purposes generally requires a specific set of data elements. For example, when the ground-water quality is of concern not only are the 'minimum set of data elements' required for the site, but information concerning the sample collection depth interval, method of collection, and date and time of collection are needed to fully qualify the data. Another group of elements are recommended for each use of the data, such as aquifer characteristics or water-level records. Normally the more information that is gathered about a site by field personnel, the easier it is to understand the ground-water conditions and to reach valid conclusions and interpretations regarding the site.

5.2 The data elements listed in this guide and Guides D 5408 and D 5410 should assist in planning what information can be gathered for a ground-water site and how to document these data.

NOTE 6—Some important data elements may change during the existence of a site. For example, the elevation of the measuring point used for the measurement of water levels may be modified because of repair or replacement of equipment. This frequently occurs when the measuring point is an opening in the pump and the pump is modified or replaced. Because changes cannot always be anticipated, it is preferable to reference the height of the measuring point to a permanent nearby altitude datum. The measuring point is referenced by being the same altitude (zero correction) or above (negative correction) or below (plus correction) the altitude datum. All appropriate measurements should be corrected in reference to the altitude datum before entry into the permanent record. Care must be exercised to keep the relationship of these data elements consistent throughout the duration of the site.

5.3 Some data elements have an extensive list of components or possible entries. For example, the aquifer identification list described in 6.1.8 has over 5000 entries. Lengthy lists of possible entries are not included in this guide, however, information on where to obtain these components is included with the specific data element.

NOTE 7—This guide identifies other sources, lists, etc., of information required to completely document information about any ground-water site.

## 6. Documentation of Individual Site Characteristics

### 6.1 Introduction:

6.1.1 A vast number of data elements can be documented about a ground-water site to thoroughly describe its location, physical features, relationship to other features on the earth's surface, and to designate what information is gathered at the site. These data elements typically are transcribed once for a site, in contrast to data elements that may be repetitive, such as water levels. Many of these data are extremely valuable in the

characterization of sites that fall into certain categories, for example wells, for which the primary aquifer is an essential element to assist in the identification of the source of water at the site (2-5, 7, 8, 10-17, 19).

6.1.2 *Land Use (in Vicinity of Site)*—Document the use of the land in the area surrounding the ground-water site. This data element is important if there is a possibility of the use affecting the availability or quality of the water. If more than one significant land use is nearby, such as industrial and farming, document each purpose (5, 16).

6.1.3 *Drainage Basin/Watershed*—Document the name or other identification of the watershed and drainage basin where the site is located. Maps with watersheds delineated are available from the State Conservationists, U.S. Department of Agriculture, Soil Conservation Service located in each of the states, possessions, and associated areas. Information about river basins is available on maps in “Atlas of River Basins of the United States” published by the U.S. Department of Agriculture, Soil Conservation Service (20).<sup>4</sup>

6.1.4 *Relationship to Surface Stream/Lake, etc.*—Document information concerning the influence of any nearby surface-water source upon the ground-water site. For example, the ground-water source for the site could be directly connected to a surface-water body (recharging the aquifer or discharging to the surface-water body) or have no connection and be influenced by a seasonal variation in loading of the surface water body upon the aquifer (4, 7, 8, 16).

NOTE 8—This information is more useful if a quantitative estimate of the amount of connection is given rather than a yes, there is a connection, or no, there is no connection notation. For example, a ground-water body that is only influenced by seasonal loading of a surface-water body would have 0 % connection. While a stream or lake that is partially or completely linked to the ground-water body could have from 1 to 100 % connection, however, a quantitative value seldom can be determined. Usually, the range of thickness of the aquifer penetrated by the surface water body or thickness and lithology of the material between the aquifer and surface water body is all that is known about the connection.

6.1.5 *Hole Depth*—If applicable, document the total depth that the hole was drilled, in feet or metres below a datum at or near land surface. Many times the hole is drilled deeper in order to explore stratum below the completed depth of the final well. This number is always equal to or greater than the well depth. The hole depth is important because the information concerning the stratum below the final well can be critical in understanding ground-water conditions at the site. Document the accuracy or confidence classification for this data element (4, 5, 7, 8, 13, 14, 16). If applicable, note orientation and angle of hole if not vertical.

<sup>4</sup> Regional contacts for obtaining information are as follows: Northeastern United States contact Director, Northeastern National Technical Center, USDA, SCS, 160 East 7th Street, Chester, PA 19013. Southern United States contact Director, Southern National Technical Center, USDA, SCS, Fort Worth Federal Center, Bldg. 23, Room 60, Felix and Hemphill Streets, PO Box 6567, Fort Worth, TX 76115. Midwestern United States contact Director, Midwest National Technical Center, USDA, SCS, Federal Bldg., Room 345, 100 Centennial Mall North, Lincoln, NE 68508-3866. Western United States contact Director, Western National Technical Center, USDA, SCS, Federal Bldg., Room 248, 511 N.W. Broadway, Portland, OR 97209-3489.

GROUND-WATER SITE INDIVIDUAL SITE CHARACTERISTICS	
Site Identification _____	Date Prepared _____
Prepared by _____	(Name)
-----	
<i>Individual Site Characteristics:</i>	
Land Use (In Vicinity of Site) _____	(Describe)
Drainage Basin/Watershed _____	(Name)
Relationship to Surface Stream/Lake _____	(Describe)
Hole Depth _____ (Feet/Meters)	Accuracy _____
Well Depth _____ (Feet/Meters)	Accuracy _____
Source of Depth Data _____	(Name)
Primary Aquifer _____	(Name)

FIG. 1 Example Form

6.1.6 *Well Depth*—If applicable, document the depth of the finished well, in feet or metres below a datum at or near land surface. This depth is important as a means to delineate the maximum depth at which water is entering the well bore. Document the accuracy or confidence classification for this data element (4, 5, 7, 8, 13, 14, 16).

6.1.7 *Source of Depth Data*—If applicable, document the source of the hole and well depth information. Suggested source of depth data components and representative codes are as follows (13):

- A—Reported by a government agency
- D—From driller’s log or report
- G—Private geologist-consultant or university associate
- L—Depth interpreted from geophysical logs by personnel of source agency
- M—Memory (owner, operator, driller)
- O—Reported from records by owner of well
- R—Reported by person other than owner, driller, or another government agency
- S—Measured by personnel of reporting agency
- Z—Other source (describe)

6.1.8 *Primary Aquifer*—Document the identification of the primary aquifer unit from which the water is withdrawn or monitoring data are collected. A convenient and systematic method of coding geologic units was described by Cohee (6) in the American Association of Petroleum Geologists Bulletin. This method is used by the U.S. Geological Survey to code aquifer and geologic unit names in a national file (Catalog of Aquifer Names and Geologic Unit Codes used by the Water Resources Division) (for example, Edwards Limestone of Texas is coded 218EDRD). Information needed to obtain an ordered list of aquifers and related codes is available from the following (6, 13):<sup>5</sup>

NOTE 9—An example of a form (see Fig. 1) for documenting the data elements as described under “Individual Site Characteristics” is illustrated here to show a method of design for this tool. The forms are commonly known as field forms or as coding forms (for computer entry). This type of form is routinely used for transcribing field data while at the ground-water site and entering non-field information at the agency’s or company’s office. It should be noted that each form has the site identification (primary identification as used by the agency or company), date of field visit, and person that recorded the data as the first entries. These three data items are mandatory to ensure correct filing of the information, either in cabinets or in a computer data base, and for quality control.

<sup>5</sup> Geologic Names Unit, U.S. Geological Survey, 439 National Center, Reston, VA 22092.

## 7. Documenting of Miscellaneous Repetitive Data Elements

### 7.1 Introduction:

7.1.1 Many of the ground-water data elements require multiple records or entries to completely describe a site. Time-related elements, such as water levels, discharge measurements, and water chemistry, may present hundreds or thousands of records over a period of many years that answer a specific question about a single site. These time-related data help to determine historical trends and serve to establish bench-mark conditions for the site (4, 5, 13, 14).

7.1.2 Other data elements that are not time related, such as casing lengths, spring openings, and some geophysical logs, require a sequence of records to thoroughly describe the site. These data are extremely valuable in site characterization, for example, wells for which the construction components are required to understand the source of the water (4, 5, 13, 14).

7.2 *Construction Record Group*—The construction record group includes records for documenting data elements relating to any type of structure built for withdrawal of water or monitoring at a ground-water site, including construction, hole, casing, openings or screen, repairs, and special cases, such as well clusters, collector wells, ponds, tunnels, and drains (2, 3, 5, 7, 8, 13-17). If applicable, any construction that may have modified the ambient ground water conditions should be documented. Examples include grouting, blasting, hydrofracturing, and local disruption such as tunnels, underground chambers, or excavations.

7.2.1 *Construction Record*—The construction record includes data elements relating to the date of construction, contractor, construction method, drilling fluids, finish, and development. Data elements that are included in the construction record are the following:

7.2.1.1 *Date Construction Began*—If applicable, document the date (year, month, day in YYYYMMDD format) on which the construction work was initiated at the ground-water site.

NOTE 10—Although this guide is written to be used with any type of data file, date information should be arranged in year, month, day, and time (24-h clock) format (for example, 19910822094158 for 1991, August 22nd, 9 h, 41 min, and 58 s AM), especially for ease of interchanging information among data systems (computerized files). This is the format recommended by the American National Standard for Information Systems (ANSI) and adopted as a Federal Information Processing Standards (FIPS) system (21, 22).

7.2.1.2 *Date Constructed Ended*—If applicable, document the date (year, month, day in YYYYMMDD format) on which the construction work was completed at the ground-water site.

7.2.1.3 *Name of Contractor*—If applicable, document the name and address of the principal individual or company that did the construction work at the ground-water site (for example, drilled the well).

7.2.1.4 *Source of Construction Data*—If applicable, document the source of the information concerning the construction at the ground-water site (for example, driller's log or geologist's log). Suggested source of construction data components and representative code are as follows:

- A—Reported by a government agency
- D—From driller's log or report

- G—Private geologist-consultant or university associate
- L—Depth interpreted from geophysical logs by personnel of source agency
- M—Memory (owner, operator, driller)
- O—Reported from records by owner of well
- R—Reported by person other than owner, driller, or another government agency
- S—Measured by personnel of reporting agency
- Z—Other source (describe)

7.2.1.5 *Method of Construction*—If applicable, document the method by which the ground-water site was constructed. Suggested method of construction components and representative codes are as follows:

- B —Bored or augered, generalized
- L —Wash boring
- M —Hollow-stem auger
- N —Solid-stem auger
- E —Bucket auger
- A —Direct air-rotary method, with bit
- K —Direct air-rotary method, with downhole hammer
- H —Direct mud rotary
- R —Reverse circulation rotary (no casing)
- F —Dual-wall reverse circulation, generalized
- G —Dual-wall reverse rotary
- I —Dual-wall reverse percussion
- C —Cable-tool
- P —Air-percussion drill
- Q —Hydraulic percussion
- S —Jet percussion
- J —Jetted by water
- D —Dug or excavated
- T —Trenching, dammed pond, or drain
- V —Driven pipe
- U —Cone penetration
- W —Combined driven and jetting
- Z —Other (describe)

NOTE 11—Several of the method of construction components are the same or similar methods (jetted by water and wash boring), but with different name identifications. In addition, several of the components that have generalized names, for example, bored or augered also have the specific methods (hollow-stem auger, solid-stem auger, etc.) included in the list.

7.2.1.6 *Type of Drilling Fluid*—If applicable, document the type and amount of additives (in pounds or kilograms) used in the drilling fluid (water) for the construction of the ground-water site. Suggested additive components and representative codes are as follows:

- A —Acrylic polymers
- D —Attapulgite
- E —Baking soda
- B —Barites
- F —Biodegradable material
- G —Caustic soda
- C —Cellulosic polymers
- H —Chromelignosulfonates
- I —Chrysotile asbestos
- J —Complex phosphates
- K —Lignitic materials
- L —Lime
- Q —Lubricants
- M —Modified guar gum products
- R —Modified polysaccharide
- N —Native clay
- O —Organic polymers
- P —Peptized bentonite
- U —Pregelatinized starch
- V —Soda ash
- W —Sodium carboxymethylcellulose
- S —Standard bentonite
- X —Surfactants
- T —Tannins
- Z —Other (describe)

7.2.1.7 *Volume of Drilling Fluid*—If applicable, document the volume (in gallons or litres) of drilling fluid lost in the drilled hole. Specify the unit of measurement. Document the accuracy or confidence classification for this data element. It may be difficult to quantify losses in air drilling. Estimates may be made by comparing output versus compressor capacity.

7.2.1.8 *Type of Finish*—If applicable, document the method of finish or the nature of the openings that allow water to enter the well. Suggested type of finish components and representative codes are as follows:

- C —Porous concrete
- G —Gravel-packed screen
- H —Horizontal gallery or collector
- O —Open-ended casing
- P —Perforated or slotted casing
- S —Screen, commercial
- T —Sand point, driven screen
- W —Walled or shored
- X —Open-hole in aquifer
- Z —Other (describe)

7.2.1.9 *Type of Seal*—If applicable, document the type and amount (in pounds or kilograms) of material used to seal the well against the entry of surface water and the leakage of water between aquifers having different hydraulic pressures. Suggested type of seal components and representative codes are as follows:

- B —Bentonite
- C —Clay or cuttings
- G —Cement grout
- N —None
- Z —Other (describe)

7.2.1.10 *Depth to Bottom of Seal*—If applicable, document the depth to the bottom of the seal in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

7.2.1.11 *Method of Development*—If applicable, document the primary method used to develop the well. Suggested method of development components and representative codes are as follows:

- A —Pumped with air lift
- B —Bailed
- D —Chemical, for example, dry ice
- C —Surged, compressed air
- J —Jetted, air or water
- N —None
- P —Overpumped
- S —Surge block
- Z —Other (describe)

7.2.1.12 *Length of Time of Development*—If applicable, document the number of hours and minutes that the well was bailed, pumped, or surged for development. Document the accuracy or confidence classification for this data element.

7.2.1.13 *Volume of Liquid Removed During Development*—If applicable, document the volume of liquid (in gallons or litres) removed from well during development. Specify the unit of measurement. Document the accuracy or confidence classification for this data element.

7.2.1.14 *Special Treatment*—If applicable, document any special treatment that was applied during development of the well. Suggested special treatment components and representative codes are as follows:

- C —Chemical (acid, and so forth)

- D —Dry ice
- E —Explosives
- F —Deflocculent
- H —Hydrofracturing
- M —Mechanical abrasion
- Z —Other (describe)

7.2.2 *Hole Record*—The hole record includes data elements that relate to the description of the opening constructed for emplacement of hardware into the ground for the development of a monitoring or production well at a ground-water site. For many sites, several distinct hole length and size intervals are required for the completion of the well. Data elements that are included in the hole record are the following:

7.2.2.1 *Depth to Top of the Hole Interval*—If applicable, document the depth to the top of the hole interval, in feet or metres below a datum at or near land surface. The first or uppermost section of the hole starts at or near the datum. Document the accuracy or confidence classification for this data element.

7.2.2.2 *Depth to Bottom of the Hole Interval*—If applicable, document the depth to the bottom of the hole interval, in feet or metres below the datum. Document the accuracy or confidence classification for this data element.

7.2.2.3 *Diameter of the Hole Interval*—If applicable, document the nominal diameter of that interval of the hole, in inches or millimetres. Document the accuracy or confidence classification for this data element. Caliper logs may be very useful as documentation.

7.2.3 *Casing Record*—The casing record includes all information that relates to the description of the casing material placed into the ground for the construction of a monitoring or production well at a ground-water site. For many sites, several distinct length and size intervals are required for the completion of the well. Data elements that are included in the casing record are the following:

7.2.3.1 *Depth to Top of the Cased Interval*—If applicable, document the depth to the top of the cased interval, in feet or metres below a datum at or near land surface. The first or uppermost section of the casing starts at or near the datum. Document the accuracy or confidence classification for this data element.

7.2.3.2 *Depth to Bottom of the Cased Interval*—If applicable, document the depth to the bottom of the cased interval, in feet or metres below the datum. Document the accuracy or confidence classification for this data element.

7.2.3.3 *Diameter of the Cased Interval*—If applicable, document the inside diameter of that interval of the casing, in inches or centimetres. Document the accuracy or confidence classification for this data element.

7.2.3.4 *Casing Material*—If applicable, document the type of casing material used for the construction of the well. Note if casing joint or other components are different than casing material. Suggested casing material components and representative codes are as follows:

- E —Acrylonitrile butadiene styrene (ABS)
- A —Aluminum
- H —Asbestos cement
- B —Brick
- J —Carbon structural steel
- L —Chlorotrifluoroethylene (CTFE)

- N —Coal tar epoxy coated steel
- U —Coated steel
- C —Concrete
- D —Copper
- O —Cupro-nickel
- F —Fiberglass-reinforced epoxy
- Q —Fluorinated ethylene propylene (FEP)
- G —Galvanized iron
- K —Kai-well
- V —Perfluoroalkoxy (PFA)
- X —Polytetrafluoroethylene (PTFE)
- Y —Polyvinyl chloride (PVC)
- 1 —Polyvinylidene fluoride (PVDF)
- P —PVC, fiberglass, other plastic (general term)
- R —Rock or stone
- 2 —Rubber-modified polystyrene
- 3 —Silicon bronze
- 4 —Stainless steel
- S —Steel
- T —Tile
- 5 —Transite
- W —Wood
- I —Wrought iron
- M —Other metal (describe)
- X —Other material, not metal (describe)

- F —Fiberglass-reinforced epoxy
- Q —Fluorinated ethylene propylene (FEP)
- G —Galvanized iron
- K —Kai-well
- V —Perfluoroalkoxy (PFA)
- X —Polytetrafluoroethylene (PTFE)
- Y —Polyvinyl chloride (PVC)
- 1 —Polyvinylidene fluoride (PVDF)
- P —PVC, fiberglass, other plastic (general term)
- R —Rock or stone
- 2 —Rubber-modified polystyrene
- 3 —Silicon bronze
- 4 —Stainless steel
- S —Steel
- T —Tile
- 5 —Transite
- W —Wood
- I —Wrought iron
- M —Other metal (describe)
- X —Other material, not metal (describe)

7.2.3.5 *Casing Thickness*—If applicable, document the thickness of the casing wall, in inches or centimetres. Document the accuracy or confidence classification for this data element.

7.2.4 *Opening or Screen Record*—The opening or screen record includes all information that relates to the description of the open or screened area that allows for the passage of water into a well at a ground-water site. For some sites, several distinct length and size intervals of open or screened areas are required for the completion of the well. Data elements that are included in the opening or screen record are the following:

7.2.4.1 *Depth to Top of the Open Interval*—If applicable, document the depth to the top of the open interval, in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

7.2.4.2 *Depth to Bottom of the Open Interval*—If applicable, document the depth to the bottom of the open interval, in feet or metres below the datum. Document the accuracy or confidence classification for this data element.

7.2.4.3 *Diameter of the Open Interval*—If applicable, document the diameter of the open interval, in inches or centimetres. The diameter documented normally would be the inside diameter for a screen and the hole diameter for an open hole. Document the accuracy or confidence classification for this data element.

7.2.4.4 *Type of Material in the Open/Screened Interval*—If applicable, document the type of material used for the construction of the open/screened interval. Suggested type of material in the open interval components and representative codes are as follows:

- E —Acrylonitrile butadiene styrene (ABS)
- A —Aluminum
- H —Asbestos cement
- B —Brick
- J —Carbon structural steel
- L —Chlorotrifluoroethylene (CTFE)
- N —Coal tar epoxy coated steel
- U —Coated steel
- C —Concrete
- D —Copper
- O —Cupro-nickel

7.2.4.5 *Type of Openings in the Open Interval*—If applicable, document the type of openings in this interval. Suggested type of openings in the open interval components and representative codes are as follows:

- B —Bridge slot
- C —Continuous slot wire-wound
- F —Open hole in fractured rock
- L —Lowered or shutter-type screen
- M —Mesh screen
- P —Perforated, porous, or slotted casing
- R —Wire-wound screen
- S —Screen, type not known
- T —Sand point
- W —Walled or shored
- X —Open hole, undefined rock condition
- Z —Other (describe)

7.2.4.6 *Length of Openings*—If applicable, document the length or long dimension of the perforations, slots, or mesh of the screen, in inches or centimetres. Document the accuracy or confidence classification for this data element.

7.2.4.7 *Width of Openings*—If applicable, document the short dimension of the perforations, slots, or mesh of the screen, in inches or centimetres. Document the accuracy or confidence classification for this data element.

7.2.4.8 *Mesh of Screen*—If applicable, document the slot or mesh size of the screen, in inches or centimetres. Using the mesh of screen data element may be preferable to using the length and width of openings elements. Document the accuracy or confidence classification for this data element.

7.2.4.9 *Packing Material*—If applicable, document the type of material and supplier (or analysis) used to pack the space or void on the outside of the screened interval. Suggested packing material components and representative codes are as follows:

- B —Beads, glass
- C —Crushed stone—describe type
- G —Gravel, sorted
- H —Gravel, unsorted
- I —Gravel, graded pack
- M —Mixture of sand and gravel
- N —Natural formation material
- S —Sand, sorted
- R —Sand, unsorted
- T —Sand, graded pack
- Z —Other (describe)

7.2.4.10 *Size of Packing Material*—If applicable, document the grain size of the sorted material or the range of grain size of the unsorted or graded packing material, in inches or

millimetres. Document the accuracy or confidence classification for this data element.

7.2.4.11 *Thickness of Packing Material*—If applicable, document the thickness of the material packed between the screen and the natural formation, in inches or centimetres (thickness = (hole size-screen size)/2). Document the accuracy or confidence classification for this data element.

7.2.4.12 *Depth to Top and Bottom of Packing Material*—If applicable, document the depth to the top and to the bottom of the packing material, in feet or metres below the datum. Document the accuracy or confidence classification for this data element.

7.2.5 *Repairs Record*—The repairs record includes all information that relates to repair work done on previously constructed facilities at the ground-water site. For many sites, several occurrences of repairs are normal. Data elements that are included in the repairs record are the following:

7.2.5.1 *Date of Repairs*—If applicable, document the date (year, month, day in YYYYMMDD format) that the repairs were completed.

7.2.5.2 *Nature of Repairs*—If applicable, document the type of repairs that occurred at the ground-water site. Suggested nature of repair components and representative codes are as follows:

- B —Blocked off
- C —Cleaned
- D —Deepened
- I —Pump intake lowered
- L —Liner installed
- O —Slotted or perforated
- P —Plugged back
- S —Screen replaced
- Z —Other (describe)

7.2.5.3 *Name of Contractor Who Made Repairs*—If applicable, document the name and address of the contractor that performed the repairs.

7.2.5.4 *Percent Change in Performance After Repairs*—If applicable, document the percent change in the performance (plus or minus) of the ground-water site. For example, percent change = ((new yield – old yield)/old yield) (100 %). Document the accuracy or confidence classification for this data element.

7.2.6 *Well Cluster*—A well cluster is multiple wells or a gallery of wells that are connected to one pumping source. This type of withdrawal system is used in areas of thin and shallow aquifers where each well in the cluster produces a small amount of water. However, in combination, the wells in the cluster yield the amount of water needed for the use intended. Data elements that are not given below and are needed to document the construction details for the well cluster are found under the construction record, hole record, casing record, and opening or screen record.

NOTE 12—Cluster wells are intended for the production of water (for example, a small public water supply or commercial facility) where potable water sources are limited. This type of withdrawal system is not initially intended for hydrologic investigations or for use in the determination of the water-quality characteristics of an aquifer.

NOTE 13—Well cluster, collector well/laterals, ponds, and tunnel or drain fall in the special cases record for documenting information that is unique to the other sources of ground water (other than wells and springs).

7.2.6.1 *Number of Wells in Cluster*—If applicable, document the number of wells in the cluster that are connected into one pumping system.

7.2.6.2 *Depth of Deepest Well in Cluster*—If applicable, document the depth of the deepest well in the cluster. Document the accuracy or confidence classification for this data element.

7.2.6.3 *Depth of Shallowest Well in Cluster*—If applicable, document the depth of the shallowest well in the cluster. Document the accuracy or confidence classification for this data element.

7.2.6.4 *Diameter of Well Cluster*—If applicable, document the largest diameter or dimension, in feet or metres, of the well cluster field. Document the accuracy or confidence classification for this data element.

7.2.7 *Collector Well/Laterals*—A collector well or radial collector well consists of a large central caisson (for example, 13-ft (3.96-m) inside diameter) with laterals and horizontal screens projecting away (for example, 240 ft (13.15 m)) from the bottom of the central caisson. These radials can be in a radial or linear pattern, depending upon the configuration of the aquifer. This type of water-withdrawal system allows for the optimum development of some low-yielding aquifers and more economical development of large supplies from thin, high-production aquifers (such as under rivers). Data elements that are not given below and are needed to document the construction details for the collector well are found under the construction record, hole record, casing record, and opening or screen record. See Note 12 for an explanation of the purpose of a similar type of withdrawal system.

7.2.7.1 *Number of Laterals in Collector Well*—If applicable, document the number of laterals that are connected to the central caisson.

7.2.7.2 *Depth of Laterals in Collector Well*—If applicable, document the depth or average depth of the laterals connected to the collector well. Document the accuracy or confidence classification for this data element.

7.2.7.3 *Length of Laterals in Collector Well*—If applicable, document the length of the laterals that extend away from the collector well. If there is a large difference in the lengths, document the range in lengths or the length of each individual lateral. Document the accuracy or confidence classification for this data element.

7.2.7.4 *Diameter of Laterals in Collector Well*—If applicable, document the diameter of the laterals, in inches or centimetres. Document the accuracy or confidence classification for this data element.

7.2.7.5 *Mesh of Screen in Laterals*—If applicable, document the slot or mesh size of screens, in inches or centimetres. If there is a large difference in the mesh size of the various screens, document the range in size or the size of each individual screen. Document the accuracy or confidence classification for this data element.

7.2.8 *Ponds*—This category of the ground-water withdrawal system includes natural or constructed ponds that intercept the water table. In areas of shallow water tables, natural ponds occur or ponds can be dug into the water-bearing aquifer and the water pumped from the pond to the area of use.

7.2.8.1 *Length of Pond*—If applicable, document the longest dimension of the pond, in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.8.2 *Width of Pond*—If applicable, document the width of the pond (usually the dimension at right angle to the length), in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.8.3 *Depth of Pond*—If applicable, document the maximum or average depth of the pond (include whether the depth given is the maximum or average), in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.8.4 *Volume of Pond*—If applicable, document the average volume of water contained in the pond, in gallons, litres, or other volume unit. Document the volume unit used. Document the accuracy or confidence classification for this data element.

7.2.9 *Tunnel or Drain*—This category of the ground-water withdrawal system includes tunnels constructed principally to intercept the water table and drains constructed primarily to lower the water table in the vicinity of mines or man-made structures (23).

NOTE 14—Tunnels (called falaj, qanat, karez, and foggara in the Middle East) are used as a water collection and distribution system in many parts of the world, especially in arid regions. This nearly horizontal tunnel system is a very conservative method of skimming the upper surface of the water table. Water from drains, that are used to lower the water table at man-made structures (for example, mines), is commonly used for other purposes (for example, processing of ore). Water from drains that are used for the purpose of lowering the near-surface water table of poorly drained agricultural lands normally are discharged to nearby surface water bodies.

7.2.9.1 *Length of Tunnel or Drain*—If applicable, document the length of the tunnel or drain, in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.9.2 *Width of Tunnel or Drain*—If applicable, document the width of the channel where the water flows, in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.9.3 *Depth of Tunnel or Drain*—If applicable, document the average depth of the tunnel or drain, in feet or metres. Document the accuracy or confidence classification for this data element.

7.2.9.4 *Bearing (Azimuth) Tunnel or Drain*—If applicable, document the orientation in degrees bearing from due north of the tunnel or drain, beginning at the origin and going in direction of the terminus. Document the accuracy or confidence classification for this data element.

7.2.9.5 *Dip of Tunnel or Drain*—If applicable, document the dip in degrees from the horizontal of the tunnel or drain, beginning at the origin and ending at the terminus. Document the accuracy or confidence classification for this data element.

7.3 *Lift Record Group*—The lift record group includes records for documenting data elements relating to any type of equipment or method used for withdrawal of water at a ground-water site, including lift technique, power method, and backup or standby lift and power system (2, 4, 5, 7, 8, 13, 14, 16, 19).

7.3.1 *Lift Record*—The lift record includes all information that relates to the method and equipment that is used to remove the ground water from the aquifer. Commonly, several arrangements and types of lift systems are used over the history of a

ground-water site because of maintenance and replacement of worn equipment. In rare cases, several lift systems are used at the site at the same time. Information concerning the pump rating or yield and power consumption may be used to estimate the water usage. Data elements that are included in the lift record are the following:

7.3.1.1 *Type of Lift*—The type of lift is the specific method used to remove the water from the aquifer, either by mechanical or natural means. Suggested type of lift components and representative codes are as follows:

- A —Air lift
- B —Bucket or bailer
- C —Centrifugal pump
- G —Natural flow or gravity
- J —Jet pump
- P —Piston pump
- R —Rotary pump
- S —Submersible pump
- T —Turbine pump
- N —None
- U —Unknown
- Z —Other (describe)

7.3.1.2 *Date Permanent Lift Was Installed*—If applicable, document the date (year, month, day in YYYYMMDD format) that the lift unit was installed. This information is used to identify the age of the lift unit and to further identify the site.

7.3.1.3 *Depth of Intake*—If applicable, document the depth below a datum, in feet or metres, to the bottom of the pump intake. Document the accuracy or confidence classification for this data element.

7.3.1.4 *Manufacturer of Lift Device*—If applicable, document the name and address of the company that manufactured the pump.

7.3.1.5 *Serial Number*—If applicable, document the serial number of the pump. This data element allows for additional identification of the pump and ground-water site.

7.3.1.6 *Pump Rating*—If applicable, document the rating of the pump as the volume of the water lifted per unit of power consumed. Tables are normally available for determining the efficiency of each type of pump according to the amount of lift involved. This pump efficiency table must be used for determining the pump rating. The value should be expressed as million of gallons or litres of water per kilowatt-hour of electricity, cubic foot or metres of natural gas, gallon or litre of liquid fuel, or engine hour, depending upon type of power. Document the accuracy or confidence classification for this data element.

7.3.2 *Power Record*—The power record includes all information that relates to the type of power used to drive a lift unit or to remove water from the aquifer. Commonly, several arrangements and types of power are used over the history of a ground-water site because of maintenance and replacement of worn equipment. In rare cases, several types of power are used at the site at the same time. Data elements that are included in the power record are the following:

7.3.2.1 *Type of Power*—Document the type of energy used to power the pump or to remove the water from the aquifer. Suggested type of power components and representative codes are as follows:

- A —Animal
- C —Compressed air

- D —Diesel engine
- E —Electric motor
- F —Natural flow or gravity
- G —Gasoline engine
- H —Hand or human
- L —LP gas (propane or butane engine)
- N —Natural-gas engine
- W —Windmill
- Z —Other (describe)

7.3.2.2 *Horsepower Rating*—If applicable, document the horsepower rating of the power component given under “Type of Power.” For example, 10 hp for the rating of an electric motor used to drive a turbine pump. Document the accuracy or confidence classification for this data element.

7.3.2.3 *Name of Power Company*—If applicable, document the name and address of the company that furnishes the electricity, natural gas, or other fuel for the power source.

7.3.2.4 *Power-Company Account Number*—If applicable, document the account number under which the power company stores information on power consumption at the site.

7.3.2.5 *Power-Meter Number*—If applicable, document the meter number of the electric or gas meter which logs the power consumption of the power source.

7.3.3 *Standby Lift Record*—The standby lift record includes information that relates to the type of lift and power used as a backup to the primary lift and power system. Data elements that are included in the standby lift record are the following:

7.3.3.1 *Additional Lift*—If applicable, document the additional head (above land-surface datum) against which the pump work, in feet or metres of water.

7.3.3.2 *Name of Company that Maintains Lift*—If applicable, document the name and address of the company that is responsible for the maintenance of the pump.

7.3.3.3 *Rated Pump Capacity*—If applicable, document the manufacturer’s pump capacity rating. Document the accuracy or confidence classification for this data element.

7.3.3.4 *Type of Standby Power*—If applicable, document the type of standby power available. Suggested type of power components and representative codes are as follows:

- A —Animal
- C —Compressed air
- D —Diesel engine
- E —Electric motor
- F —Natural flow or gravity
- G —Gasoline engine
- H —Hand or human
- L —LP gas (propane or butane engine)
- N —Natural-gas engine
- W —Windmill
- Z —Other (describe)

7.3.3.5 *Horsepower of Standby Power Source*—If applicable, document the horsepower rating of the standby power source. Document the accuracy or confidence classification for this data element.

7.4 *Geologic Record Group*—The geologic record group includes records for documenting data elements relating to geophysical logs, geologic units, and geologic samples of both unconsolidated and consolidated materials (4, 5, 7, 8, 12-14, 16).

7.4.1 *Geophysical Log Record*—The log record is used to enter information about types of geophysical or other logs

available for the site. Data elements that are included in the geophysical log record are the following:

7.4.1.1 *Date of Log*—If applicable, document the date (year, month, day in YYYYMMDD format) that the geophysical log was completed at the ground-water site.

7.4.1.2 *Type of Log*—If applicable, document the type of log available for the hole. If more than one type of log was run on the well, document those with the corresponding depth intervals. Suggested type of log components and representative codes are as follows (12):

- A —Drilling time
- B —Casing collar
- C —Caliper
- D —Drillers
- E —Electric
- R —Single-point resistance
- W —Spontaneous potential
- Y —Multi-electrode
- 1 —Acoustic velocity
- 2 —Acoustic televiewer
- F —Conductivity, fluid
- G —Geologists or sample
- H —Magnetic
- I —Induction
- J —Gamma ray
- K —Dipmeter survey
- L —Lateral log
- M —Microlog
- N —Neutron
- O —Microlateral log
- P —Photographic
- Q —Radioactive-tracer
- S —Sonic
- T —Temperature
- U —Gamma-gamma
- V —Fluid velocity (flow)
- X —Core
- Z —Other (describe)

7.4.1.3 *Depth to Top of Logged Interval*— Enter the depth to the top of the logged interval, in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

7.4.1.4 *Depth to Bottom of Logged Interval*—Enter the depth to the bottom of the logged interval, in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

7.4.1.5 *Source of Log Data*—If applicable, document the source of the log information. Suggested source of depth data components and representative codes are as follows:

- A—Reported by a government agency
- D—From driller’s log or report
- G—Private geologist-consultant or university associate
- L—Depth interpreted from geophysical logs by personnel of source agency
- M—Memory (owner, operator, driller)
- O—Reported from records by owner of well
- R—Reported by person other than owner, driller, or another government agency
- S—Measured by personnel of reporting agency
- Z—Other source (describe)

7.4.2 *Geohydrologic Units Record*—The geohydrologic units record is used to document information about the rock material that yields water or is monitored at the ground-water site. Normally, information is gathered for all rock material encountered in drilling the well, both above and below the water-bearing aquifer unit. Geophysical log data (see 7.4.1) are commonly used to assist in the interpretation of rock material, especially in accurately defining depth intervals and fluid

characteristics. The more common data elements that are included in the geohydrologic units record are the following:

NOTE 15—Usually, data describing rock material are documented sequentially (top to bottom) on strip charts. These strip charts can be simple field-compiled logs generated from visual examination of the rock material by a hydrogeologist or drilling engineer. Detailed strip charts are laboratory compiled from the examination of all the properties of the field-collected rock (drilling) samples. These properties include such characteristics as color, mineralogy, luster, structure, induration, inclusions, cementation, sorting, grain size, grain shape, porosity, hardness of material, solubility, etc.

7.4.2.1 *Aquifer Unit(s)*—Document the identification of the water-bearing aquifer unit or units from which the water is withdrawn or monitoring data are collected and the non-water-bearing units above and below the aquifer. See 6.1.8 for additional information on aquifer unit identification.

7.4.2.2 *Contributing Unit*—In combination with the aquifer identification, indicate how the unit is categorized as an aquifer. Suggested contributing unit components and representative codes are as follows:

- P —Principal contributing aquifer
- S —Secondary contributing aquifer
- N —Contributes no water
- U —Unknown contribution

7.4.2.3 *Depth to Top of Interval*—If applicable, document the depth, in feet or metres below a datum at or near land surface, to the top of this aquifer or non-water-bearing unit. Document the accuracy or confidence classification for this data element.

7.4.2.4 *Depth to Bottom of Interval*—If applicable, document the depth, in feet or metres below a datum or non-water-bearing unit. Document the accuracy or confidence classification for this data element.

7.4.2.5 *Lithology*—If applicable, document the lithology of the aquifer or non-water-bearing unit. Suggested lithology components and representative codes are as follows:

Rock Term	Abbreviation
Alluvium	ALVM
Anhydrite	ANDR
Anorthosite	ANRS
Arkose	ARKS
Basalt	BSLT
Bentonite	BNTN
Boulders	BLDR
Boulders and sand	BLSD
Boulders, silt, and clay	BLSC
Breccia	BRCC
Calcite	CLCT
Caliche (hard pan)	CLCH
Chalk	CHLK
Chert	CHRT
Clay	CLAY
Clay, some sand	CLSD
Claystone	CLSN
Coal	COAL
Cobbles	COBB
Cobbles and sand	COSD
Cobbles, silt, and clay	COSC
Colluvium	CLVM
Conglomerate	CGLM
Coquina	CQUN
Diabase	DIBS
Diorite	DORT
Dolomite	DLMT
Drift	DRFT

Rock Term	Abbreviation
Evaporite	EVPR
Gabbro	GBBR
Glacial (undifferentiated)	GLCL
Gneiss	GNSS
Granite	GRNT
Granite, gneiss	GRGN
Gravel	GRVL
Gravel and clay	GRCL
Gravel, cemented	GRCM
Gravel, sand, and silt	GRDS
Gravel, silt, and clay	GRSC
Graywacke	GRCK
Greenstone	GNST
Gypsum	GPSM
Hard pan	HRDP
Igneous (undifferentiated)	IGNS
Lignite	LGNT
Limestone	LMSN
Limestone and Dolomite	LMDM
Loam	LOAM
Loess	LOSS
Marble	MRBL
Marl	MARL
Marlstone	MRLS
Metamorphic (undifferentiated)	MMPC
Muck	MUCK
Mud	MUD
Mudstone	MDSN
Other	OTHR
Outwash	OTSH
Overburden	OBDR
Peat	PEAT
Quartzite	QRTZ
Residium	RSDM
Rhyolite	RYLT
Rock	ROCK
Rubble	RBBL
Sand	SAND
Sand and clay	SDCL
Sand and gravel	SDGL
Sand and silt	SDST
Sand, gravel, and clay	SGVC
Sand, some clay	SNCL
Sandstone	SNDS
Sandstone and shale	SDSL
Saprolite	SPRL
Schist	SCST
Sedimentary (undifferentiated)	SDMN
Serpentine	SRPN
Shale	SHLE
Silt	SILT
Silt and clay	STCL
Siltstone	SLSN
Slate	SLTE
Soil	SOIL
Syenite	SYNT
Till	TILL
Travertine	TRVR
Tuff	TUFF
Volcanic (undifferentiated)	VLCC

7.4.2.6 *Description of Material*—If applicable, in combination with the lithology described in 7.4.2.5, document the adjective modifiers needed to describe the rock type of the aquifer or non-water-bearing unit. Use of meaningful abbreviations assists in condensing the description. Standard color guides are valuable in dictating consistency in describing the rock and soil material (9, 24). Various guides are available as aid to standardizing the descriptions of rock and soil materials (3). The following are examples of lithologic descriptions:

Example 1—For soft, chalky grey limestone, suggested description: LMSN, GREY, SOFT, CHALKY.

*Example 2*—For hard red sandstone, iron stained, suggested description: SNDS, HARD, RED, FE STND.

**7.4.3 Sample/Unconsolidated Material Record**—Samples of geologic materials commonly are collected when drilling holes are to be completed as monitoring or water wells. These samples are used to assist in the determination of the aquifer, vadose zone, and underlying material characteristics for evaluating the movement of water through these materials. Undisturbed unconsolidated samples are collected from driven or cored holes, while disturbed unconsolidated samples are collected from bored, rotary, and cable tool holes. This record is used to describe the geologic material in combination with data given in the sections on construction (see 7.2) and geohydrologic units (see 7.4.2).

**NOTE 16**—If samples are collected of soil materials that are located in the weathered zone (1.5 to 2.0 m or 6 ft in depth) and below the weathered zone (an additional 1.5 to 2.0 m or about 12 ft in depth) a description that is more comprehensive than the following may be required for the features that are found in these zones. Those additional features, when present, are: (1) texture (USDA and Unified estimated textures, coarse fragments), (2) sorting and roundness, (3) moisture condition (moist, wet, dry, presence of water table), (4) color and mottling, (5) consistency (rupture resistance, cementation), (6) secondary porosity features, (7) sedimentary structure, (8) presence of organic matter, and (9) effervescence in dilute HCl. The field pocket guide by Boulding (3) and Practice D 2488 presents an excellent summary of these features.

**7.4.3.1 Sample Weight**—If applicable, document the weight, in ounces or grams, of the sample of geologic material. Indicate whether this is wet or dry weight. The volume of the sample may be included so that bulk density can be determined. Document the accuracy or confidence classification for this data element.

**7.4.3.2 Sample Interval**—If applicable, document the depth interval, in feet or metres below a datum at or near land surface, of the sample of geologic material. Document the accuracy or confidence classification for this data element.

**7.4.3.3 Particle Size**—If applicable, document the particle or grain sizes of the unconsolidated geologic material. Indicate whether this is a visual determination using a hand lens or microscope, or a mechanical analysis using calibrated sieves. The grain sizes of sand or larger-sized materials are normally recorded in millimetres, while silt and clay-sized materials are recorded in micrometres ( $\mu\text{m}$ ). Document the accuracy or confidence classification for this data element.

**7.4.3.4 Percent of Total Sample**—If applicable, document the percentage, by weight, of each particle size (see 7.4.3.3) contained in the total sample (see 7.4.3.1). Document the accuracy or confidence classification for this data element.

**7.4.3.5 Particle Shape**—If applicable, document the particle shape or roundness of the sampled particles. Common shape descriptions are rounded, sub-rounded, subangular, and angular. The shape is usually determined visually by use of a hand lens or microscope.

**7.4.3.6 Mineralogy**—If applicable, document the mineralogy of the particles in the sample. The mineralogy is usually determined visually by use of a hand lens or microscope,

however, the exact composition must be determined in the laboratory by powder X-ray diffraction. The most common visually recognizable mineral is silica ( $\text{SiO}_2$ ).

**7.4.4 Sample/Consolidated Material Record**—Samples of geologic materials commonly are collected when drilling holes to be completed as monitoring or water wells. These samples are used to assist in the determination of the aquifer or vadose zone characteristics for evaluating the movement of water through these materials. Undisturbed consolidated samples are collected from cored holes, while disturbed consolidated samples are collected from bored, rotary, and cable tool holes. This record is used to describe the geologic material in combination with data given in the sections on construction (see 7.2) and geohydrologic units (see 7.4.2).

**7.4.4.1 Drill Cuttings or Core**—If applicable, document whether the samples of consolidated geologic material is undisturbed (cored) or disturbed (for example, rotary tool).

**7.4.4.2 Sample Size (Weight)**—If applicable, document the weight, in ounces or grams, of the sample of geologic material. Indicate whether this is wet or dry weight. The volume of the sample may be included so that bulk density can be determined. Document the accuracy or confidence classification for this data element.

**7.4.4.3 Sample Interval**—If applicable, document the depth interval, in feet or metres below a datum at or near land surface, of the sample of geologic material. Document the accuracy or confidence classification for this data element.

**7.4.4.4 Mineralogy**—If applicable, document the mineralogy of the sampled interval. Indicate whether the mineralogy was field (visually with hand lens or microscope) or laboratory determined by powder X-ray diffraction. This information supplements data given in 7.4.2.

**7.4.4.5 Core Length**—If applicable, document the length of core, if feet and inches or metres and centimetres, recovered from the sample interval (see 7.4.4.3). Document the accuracy or confidence classification for this data element.

**7.4.4.6 Core Diameter**—If applicable, document the core diameter, in inches or centimetres, recovered in this interval. Document the accuracy or confidence classification for this data element.

**7.4.4.7 Core Recovery-Percent**—If applicable, document the percentage of core recovery (core length/distance of sample interval). Document the accuracy or confidence classification for this data element.

**7.4.4.8 Bedding**—If applicable, document the type of bedding or plane of stratification of the geologic materials of the recovered core. This characteristic of the rock material can be critical in the interpretation of the movement of water.

**7.4.4.9 Structure**—If applicable, document any structure or microstructure apparent in the recovered core. This characteristic of the rock material can be critical in the interpretation of the movement of water.

**7.4.4.10 Porosity**—If applicable, document the apparent porosity of the recovered geologic material. Indicate whether the porosity was field (estimated visually with a hand lens or

microscope) or laboratory determined. Document the accuracy or confidence classification for this data element.

**7.5 Hydraulic Record Group**—The hydraulic record group includes records for documenting data elements relating to hydraulic characteristics of the aquifer, including both the basic description and hydraulic parameters of the aquifer unit (**4, 5, 7, 8, 10-13, 16, 25**).

**NOTE 17**—Information given in 7.4 is commonly used to assist in the interpretation of hydraulic characteristics, especially in accuracy defining depth intervals and aquifer properties.

**7.5.1 Hydraulics Record**—The hydraulics record is used to document information about the rock unit that yields water or is monitored at the ground-water site. The more common data elements that are included in the hydraulics record are the following:

**7.5.1.1 Hydraulic/Aquifer Unit**—If applicable, document the identification of the aquifer unit or units from which the hydraulic data were determined. See 6.1.7 for additional information on aquifer unit identification.

**7.5.1.2 Hydraulic/Aquifer Unit Type**—If applicable, document the type of aquifer(s) tested for hydraulic characteristics at the ground-water site. These types normally are confined, unconfined, or a combination of confined and unconfined.

**7.5.1.3 Depth to Top of Unit**—If applicable, enter the depth to the top of the tested interval, in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

**7.5.1.4 Depth to Bottom of Unit**—If applicable, enter the depth to the bottom of the tested interval, in feet or metres below a datum at or near land surface. Document the accuracy or confidence classification for this data element.

**7.5.1.5 Static Water Level**—If applicable, document the water level, in feet or metres below a datum at or near land surface, prior to the hydraulic test. For those water levels that are above the measuring-point datum (normally artesian wells), precede the value with a minus (–) sign to distinguish those water levels from ones at or below the measuring point. Document the accuracy or confidence classification for this data element.

**7.5.1.6 Measurement Date and Time**—If applicable, document the date (year, month, day, and time of day in YYYYMM-MDDHHMM format) of the measurement of the static water level.

**7.5.1.7 Unit Contribution**—If applicable, enter the percentage of the total yield of the site that is contributed by this hydraulic/aquifer unit, if known. If part of the water that the site would otherwise produce is lost to this unit, enter the percentage of the water lost preceded by a minus sign (–). Document the accuracy or confidence classification for this data element.

**7.5.2 Aquifer Parameters Record**—The aquifers parameters record is for the documentation of hydraulic characteristics as determined by testing of the aquifer or estimation by using data facts about the aquifer.

**NOTE 18**—Data gathered during aquifer testing and generated as a result of the interpretation process are sometimes extensive. The information discussed here are the final results.

**7.5.2.1 Transmissivity**—If applicable, document the transmissivity of the aquifer. Indicate whether this data element is estimated or is determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 19**—Transmissivity is the capability of an aquifer to transmit water of the prevailing kinematic viscosity in a unit time through a unit width of the aquifer under a unit hydraulic gradient, expressed in metres squared per day.

**7.5.2.2 Horizontal Hydraulic Conductivity**—If applicable, document the hydraulic conductivity parallel to bedding of the aquifer. Indicate whether this data element is estimated or is determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 20**—Hydraulic conductivity is the capacity of the rock to transmit water, expressed as the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

**7.5.2.3 Vertical Hydraulic Conductivity**—If applicable, document the vertical hydraulic conductivity of the aquifer. Indicate whether this data element is estimated or is determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**7.5.2.4 Coefficient of Storage**—If applicable, document the coefficient of storage of the aquifer. Indicate whether this data element is estimated or is determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 21**—Coefficient of storage is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. For a confined aquifer, it is equal to the product of specific storage and aquifer thickness. For an unconfined aquifer, the storage coefficient is equal to the specific yield.

**7.5.2.5 Leakance**—If applicable, document the leakance of the confining unit in 1/day. Indicate whether this data element is from estimated hydraulic characteristics or from those determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 22**—Leakance ( $K'/b'$ ) is the vertical hydraulic conductivity of the confining unit ( $K'$ ) divided by the thickness of the confining unit ( $b'$ ).

**7.5.2.6 Diffusivity**—If applicable, document the diffusivity of the aquifer. Indicate whether this data element is from estimated hydraulic characteristics or from those determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 23**—Diffusivity is the transmissivity divided by the storage coefficient ( $T/S$  in feet (metres) squared per day).

**7.5.2.7 Specific Storage**—If applicable, document the specific storage of the aquifer. Indicate whether this data element is from estimated hydraulic characteristics or from those determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 24**—Specific storage is the storage coefficient divided by the

thickness of the aquifer. It is the volume of water the aquifer released from or taken into storage per unit volume of porous medium per unit change in head.

**7.5.2.8 Specific Yield**—If applicable, document the specific yield of the aquifer. Indicate whether this data element is from estimated hydraulic characteristics or from those determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 25**—Specific yield is the ratio of the volume of water that the saturated rock or soil will yield by gravity to the volume of the rock or soil. In the field, specific yield is generally determined by tests of unconfined aquifers and represents the change that occurs in the volume of water in storage per unit area of unconfined aquifer as the result of a unit change in head. Such a change in storage is produced by the draining or filling of pore space and is, therefore, mainly dependent on particle size, rate of change of the water table, and time of drainage.

**7.5.2.9 Barometric or Tidal Efficiency**—If applicable, document the barometric or tidal efficiency of the aquifer. Document the accuracy or confidence classification for this data element.

**NOTE 26**—Barometric efficiency is the ratio of the change in depth to water in a well to the inverse of water-level change in a water barometer.

**7.5.2.10 Porosity**—If applicable, document the porosity of the aquifer. Indicate whether this data element is estimated or determined by an aquifer test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 27**—Porosity of the aquifer is its property of containing interstices or voids and may be expressed quantitatively as the ratio of the volume of the interstices to the total volume.

**7.5.2.11 Specific Capacity**—If applicable, document the specific capacity of the ground-water site. Indicate whether this data element is estimated or determined by a test. Document the aquifer test method and the accuracy or confidence classification for this data element.

**NOTE 28**—Specific capacity is the rate of discharge from a well divided by the drawdown of the water level within the well at a specific time since pumping started.

**7.5.2.12 Method Used to Determine Aquifer Characteristics**—If applicable, document the method used to determine the hydraulic characteristics of the aquifer. The following are some generalized descriptions for the method used to determine aquifer characteristics components and their corresponding representative codes. If the specific aquifer test method is known, that information should be documented.

- B —Bail test
- C —Controlled single-well test methods
- D —Controlled multiple-well test methods
- N —Natural ground-water fluctuation
- P —Cyclic pumping—single well
- W —Cyclic pumping—multiple wells
- S —Slug test
- E —Estimated (describe)

**7.5.2.13 Availability of File of Detailed Results**—If applicable, document the availability and format of a file of detailed aquifer test results. Suggested availability and format of a file of aquifer test components and representative codes are as follows:

- F —Files (raw data)
- M —Machine readable
- P —Published (report or basic-data release)
- Z —Other (describe)

**7.6 Spring Record Group**—The spring record group is a single record for documenting data elements relating to properties of a spring, including both the basic description and flow characteristics of the ground-water source (4, 5, 7, 8, 13, 19, 26).

**7.6.1 Spring Record**—The spring record includes all information that relates to the description of a ground-water site that is determined to be a spring. A spring is defined as a place where ground water flows naturally from a rock or the soil onto the land surface or into a body of surface water. Data elements that are included in the spring record are the following:

**NOTE 29**—The spring record includes the data elements that relate directly to the properties of a spring, however, to completely document a spring site, additional data elements need to be selected from those described in the three “Standard Guides.” For example, the aquifer identification and lithology of the unit(s), along with the location map and photographs or sketches of the site, contribute additional information in interpreting the hydrology of the area. Most of the data elements narrated in Guide D 5408 can apply to springs, as well as applicable portions of this guide and Guide D 5410.

**7.6.1.1 Name of Spring**—If applicable, document the name by which the spring is known locally or, preferably, displayed on a published map.

**7.6.1.2 Type of Spring**—If applicable, document the type of spring at the ground-water site. Suggested type of spring components and representative codes are as follows (13):

- A —Artesian
- J —Artesian and depression
- K —Artesian and seepage or filtration
- C —Contact
- D —Depression
- F —Fracture or fault
- L —Fracture fault and depression
- G —Geyser
- B —Perched and contact
- E —Perched and depression
- H —Perched and tubular
- O —Perched and fracture
- P —Perched
- R —Perched and seepage or filtration
- S —Seepage or filtration
- T —Conduit or tubular (cave)
- Z —Other (describe)

**7.6.1.3 Permanence of Spring**—If applicable, document the permanence of the spring at the ground-water site. Suggested permanence of spring components and representative codes are as follows:

- E —Periodic—Ebb and flow, normally have periods of relatively greater discharge at regular and frequent intervals.
- G —Geyser—Discharge at more or less regular intervals. Nature of discharge is caused by expansive force of highly heated steam.
- P —Perennial—Springs that discharge continuously.
- I —Intermittent—Springs that discharge only during certain periods but at other times are dry.
- R —Response to precipitation—Exist only after periods of rainfall.
- S —Seasonal—Exist only during periods of high-water levels.
- T —Estavelle—A cave that is a spring during some periods and a sinking stream (swallet) during other periods.
- Z —Other (describe).

**7.6.1.4 Sphere of Discharge**—If applicable, document the sphere of discharge of the spring. Suggested sphere of discharge components and representative codes are as follows:

- A —Subaerial—Discharges at lands surface
- W —Subaqueous—Discharges under water

7.6.1.5 *Discharge*—If applicable, document the discharge value for the spring in gallons per minute, cubic feet (or metres) per second, litres per second, or any other standard volume/time unit. Document the volume/time unit used. Note whether the discharge is clear or sometimes turbid. Document the accuracy or confidence classification for this data element.

7.6.1.6 *Date of Discharge*—If applicable, document the date (year/month/day/time of day in YYYYMMDDHHMM format) that the discharge was measured. If the discharge value is averaged over a period of time, explain.

7.6.1.7 *Improvements*—If applicable, document the type of improvements at the spring of the ground-water site. Suggested improvement components and representative codes are as follows:

- B —Boxed or small covered basin
- C —Concrete basin
- G —Gallery
- H —Spring house
- L —Lined
- N —None
- P —Pond
- R —Pipe (not for conduction of water from spring)
- T —Trough
- Z —Other (describe)

7.6.1.8 *Number of Spring Openings*—If applicable, document the number of openings through which water discharges from the spring. Document the accuracy or confidence classification for this data element.

7.6.1.9 *Flow Variability*—If known or applicable, document the discharge variability of the spring, in percent, as expressed by the formula:

$$V = 100 \times [(a - b)/c] \quad (1)$$

where:

- V = variability, %,
- a = maximum discharge,
- b = minimum discharge, and
- c = average discharge.

Document the accuracy or confidence classification for this data element.

7.6.1.10 *Accuracy of Flow Variability*—If applicable, document the basis on which the variability of the spring was determined. Suggested accuracy of flow variability components and representative codes are as follows:

- A —Calculated from less than one year of continuous discharge record.
- B —Calculated from one to five years of continuous discharge record.
- C —Calculated from more than five years of continuous discharge record.
- D —Calculated from intermittent measurements made over a period of more than one year.
- E —Calculated from less than one year of record, or estimated.
- Z —Determined by other method (describe).

7.6.1.11 *Magnitude of Spring*—If applicable, document the magnitude of the spring. Document the accuracy or confidence classification for this data element. The following is a magnitude classification that has been used in the United States and was published by Meinzer (19, 26).

Magnitude	Inch-Pound Units	SI (Metric) Units
First	Greater than 100 ft <sup>3</sup> /s	>10 m <sup>3</sup> /s
Second	10 to 100 ft <sup>3</sup> /s	1 to 10 m <sup>3</sup> /s
Third	1 to 10 ft <sup>3</sup> /s	0.1 to 1 m <sup>3</sup> /s
Fourth	100 gal/min to 1 ft <sup>3</sup> /s	10 to 100 l/s
Fifth	10 to 100 gal/min	1 to 10 l/s
Sixth	1 to 10 gal/min	0.1 to 1 l/s
Seventh	1 pint to 1 gal/min	10 to 100 ml/s
Eighth	Less than 1 pint/min	<10 ml/s

NOTE 30—Spring magnitudes were commonly used in the older hydrogeologic literature to classify the approximate discharge from a spring. This terminology is rarely used in the current hydrology reports. The common unit for measurement in recent literature is a cubic-foot per second, that translates to 646 317 gal (2 446 310 L) per day. Meinzer used the second-foot measurement that is equal to 646 000 gal (2 445 110 L) of water per day.

## 8. Keywords

8.1 aquifer test; confidence classification; drainage basin; geohydrologic unit; geological sample; geophysical log; ground water; ground-water discharge; ground-water site; ground-water site construction; monitoring site; source agency; spring site; surface-water site; well site

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