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# Standard Guide for Establishing Nomenclature of Groundwater Aquifers[1]

This standard is issued under the fixed designation D6106; 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.

## 1. Scope

1.1 This guide covers a series of options but does not specify a course of action. It should not be used as the sole criterion or basis of comparison and does not replace or relieve professional judgement.

1.2 This guide contains instructions and suggestions for authors of groundwater (hydrogeologic) reports in assigning appropriately derived and formatted aquifer nomenclature. Discussed are the water-bearing units that may require name identification, which are, ranked from largest to smallest, aquifer system, aquifer, and zone. Guidance is given on choosing the source of aquifer names, those are from lithologic terms, rock-stratigraphic units, and geographic names.

1.3 Included are examples of comparison charts and tables that can be used to define the hydrogeologic framework. Illustrations of eleven different hypothetical aquifer settings are presented to demonstrate the naming process.

1.4 Categories of items not suggested as a source of aquifer names are reviewed because, although they should be avoided, they occur in published documents. These categories are the following: time-stratigraphic names, relative position, alpha-numeric designations, depositional environment, depth of occurrence, acronyms, and hydrologic conditions.

1.5 Confining units are discussed with the suggestion that these units should not be named unless doing so clearly promotes an understanding of a particular aquifer system. Suggested sources of names for confining units correspond to those for aquifer names, which are lithologic terms, rock-stratigraphic units, and geographic names.

1.6 It is suggested that in reports that involve hydrogeology, the author should consider first not naming aquifers (see 6.2).

1.7 Format and expression styles are assessed along with the general cautions related to name selection of aquifers and confining units.

1.8 This guide is a modification of a previously published report (**1**).[2]

1.9 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This guide 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 guide 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 guide 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:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1129 Terminology Relating to Water

D5409 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two—Physical Descriptors

D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D5474 Guide for Selection of Data Elements for Groundwater Investigations

## 3. Terminology

3.1 *Definitions*—Except as discussed as follows, all definitions are in accordance with Terminologies D653 and D1129. The following terms are examined in detail in order to clarify the method of assigning nomenclature to the aquifers and associated units:

3.2 *Introduction*—Aquifers do not lend themselves to brief, neat, and simple definitions; therefore, a flexible hierarchy of terms is used in these guidelines. The terms that are used for water-yielding rocks from largest to smallest are: aquifer

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

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

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system (2), aquifer (3), and zone (4). Confining units (3) are discussed because of the stratigraphic relationship with the water-bearing units.

3.2.1 Parallelism between the hierarchy of terms for water-yielding rocks and rock-stratigraphic terms, namely, aquifer system (group), aquifer (formation), and zone (member), should be avoided because water-yielding rocks can cross the boundaries of geologic units or constitute only part of a geologic unit. The scale of the study also may determine the best usage. For example, at the local scale, an aquifer system could be defined totally within a single formation, and at the regional scale, a formation or group could be totally within and only a part of a single aquifer or an aquifer system. Again, the guidelines for aquifer nomenclature must remain flexible to meet a variety of hydrogeologic scales and settings.

3.2.2 A discussion of the terms aquifer, aquifer system, zone, and confining unit is provided here to give authors a common reference base. Although complete agreement on these definitions has not been achieved, the terms are adequate to transfer knowledge from authors to readers of reports. It is not the purpose of these guidelines to formally redefine the terms or to define new terms to take their place.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *aquifer, n*—This term probably has more shades of meaning than any other term in hydrology (5), see Terminology D653. It can mean different things to different people and different things to the same person at different times.

3.3.1.1 *Discussion*—Meinzer (5) defined an aquifer as "a rock formation or stratum that will yield water in sufficient quantity to be of consequence as a source of supply is called an *aquifer*, or simply a *water-bearing formation*, *water-bearing stratum*, or *water-bearer*. It is water-bearing, not in the sense of holding water, but in the sense of carrying or conveying water."

3.3.1.2 Lohman and others (3) refined Meinzer's definition of an aquifer as "a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs."

3.3.1.3 Both of these definitions imply that the aquifer is bounded by or is included within the formation(s) (or stratum), but the concept of the aquifer extending across formational boundaries is not indicated explicitly. In many local studies covering a few tens to a few hundred square miles, the aquifer and the formation may be the same. In these studies, few problems may exist in defining the aquifer. However, since the late 1970s, studies of regional aquifers that may cover hundreds of thousands of square miles have been made under the Regional Aquifer-System Analysis (RASA)[4] Program. Results from several of the RASA studies have shown that regional aquifers may include numerous formations and rock types and that the aquifers cut across formational and lithologic boundaries so that no one formation is completely representative of the aquifer.

3.3.1.4 In studies of regional scope, the shape and the boundaries of the permeable rocks that form the aquifer have greater importance to understanding the flow system than do the individual formational boundaries. A definition that places less emphasis on the formal term *formation* (6) and more on *permeable rocks* has merit. For example, aquifer is defined in the Glossary of Geology (7) as "a body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs."

3.3.1.5 Regardless of the fine points in any definition, delineating permeable rocks should be the major goal of hydrogeologists in mapping and describing an aquifer. By the same token, detailed knowledge of the stratigraphic units and post-depositional processes, such as solution, cementation, folding, and faulting, are essential in determining where the boundaries of the aquifer are located and in understanding the flow system. In addition, hydraulic properties (hydraulic conductivity and storage coefficient) throughout the aquifer usually are not determined directly but are estimated by indirect means, such as aquifer tests, analyses of drill cuttings and cores, borehole geophysical logging, and surface geophysical surveys.

3.3.1.6 In many situations, hydrologic estimates and extrapolations can be made on the basis of rock type alone without any determination of hydrologic properties. For example, a wide-spread, thick clay separating two sand units tentatively could be designated as a confining unit on the basis of geologists' logs and borehole geophysical logs alone without any hydrologic data.

3.3.2 *aquifer system, n*—Poland and others (2) define an aquifer system as "a heterogeneous body of intercalated permeable and poorly permeable material that functions regionally as a water-yielding hydraulic unit; it comprises two or more permeable beds (aquifers) separated at least locally by aquitards (confining units) that impede groundwater movement but do not greatly affect the regional hydraulic continuity of the system."

3.3.2.1 *Discussion*—The definition could be more general if the term *aquifers* were used in place of *permeable beds*. *Bed* implies a single stratigraphic unit, whereas, the individual aquifer could include or cross many *beds*.

3.3.2.2 *Confining unit* should be used instead of *aquitard* because the definition of confining unit is broad enough to include varying degrees of *leakiness*.

3.3.2.3 The hierarchy of aquifer and aquifer-system names may not always be consistent in practice. Because of differences in scales of investigations, individual aquifers may be combined into a single aquifer system, which may be only a part of another aquifer system over a larger area. Authors have the responsibility to explain these relationships clearly with comparison charts and descriptions in the text.

3.3.3 *confining unit, n*—confining bed was defined by Lohman and others (3) as " . . . a term which will now supplant the terms *aquiclude, aquitard*, and *aquifuge* in reports of the U.S. Geological Survey and is defined as a body of *impermeable* material stratigraphically adjacent to one or more aquifers. In nature, however, its hydraulic conductivity may range from nearly zero to some value distinctly lower than that of the aquifer. Its conductivity relative to that of the aquifer, it

[4] RASA, Regional Aquifer-System Analysis Program, a systematic study of a number of regional groundwater systems that represent a significant part of the water supply of the United States. These studies are managed by the Water Resources Division of the U.S. Geological Survey.

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confines should be specified or indicated by a suitable modifier, such as slightly permeable or moderately permeable."

3.3.3.1 *Discussion*—Although the Lohman and others (**3**) definition of *confining bed* is descriptive and should be used, the term *confining unit* is more general and appropriate than *confining bed*, especially where more than a single bed makes up the confining unit.

3.3.3.2 The term *bed* is not correct usage for a thick sequence of stratigraphic units that could be of member or formation rank. *Bed* is particularly inappropriate when used for intrusive igneous rocks beneath an aquifer. The term *bed* has a formal definition in the 1983 North American Stratigraphic Code (**6**) and should not be used in definitions of aquifer nomenclature.

3.3.3.3 Many confining units are leaky and in some areas, under natural conditions, may contribute significant amounts of water to the aquifers they confine, and even larger quantities of water as heads are lowered in the aquifer by pumping. In areas where withdrawals from aquifers have caused large declines in head, considerable amounts of water may be derived from water stored in the confining unit.

3.3.3.4 Poland and others (**2**) retained the terms *aquiclude* and *aquitard* in their definitions related to studies of the mechanics of aquifer systems and land subsidence due to fluid withdrawal. An aquiclude was defined as a body of saturated but relatively impermeable material that is characterized by very low values of *leakance* (the ratio of vertical hydraulic conductivity to thickness) and transmits negligible interaquifer flow.

3.3.3.5 An aquitard is a saturated poorly permeable bed that has values of leakance that range from relatively low to relatively high. Where an aquitard is sufficiently thick, it may form an important groundwater storage unit.

3.3.3.6 The general term *confining unit* is preferable to aquitard, aquiclude, and aquifuge, as recommended by Lohman and others (**3**).

3.3.3.7 Estimation of the *leakiness* of the confining unit should be discussed if this hydrologic information is available.

3.3.4 *erathem, n*—a geologic time term, used in this guide, is defined as the largest formal chronostratigraphic unit generally recognized, next in rank above system; the rocks formed during the era of geologic time, such as the Mesozoic Erathem composed of the Triassic System, the Jurassic System, and the Cretaceous System (**7**).

3.3.5 *zone, n*—the term zone may be used to subdivide an aquifer for the purpose of delineating a particular hydrologic characteristic that is not typical of the entire aquifer. For example, the *Fernandina permeable zone* is a high-permeability subunit of the Lower Floridan aquifer (**4**). The zone consists of vuggy, locally cavernous limestone and is traceable for as much as 100 miles in coastal Georgia and Florida. The permeability of the zone greatly exceeds that of most of the Lower Floridan aquifer.

3.4 *Terms to Be Avoided*—The use of terms that are intended to be synonymous with *aquifer* or aquifer system should be avoided. Terms, such as *hydrofer* or *aquiformation* should not be used in lieu of aquifer; *aquigroup* should not be used in place of aquifer system.

3.4.1 The term *aquifer* may be less precise than we would like, but it has been used and accepted widely in the hydrologic literature since it was defined originally.

3.4.2 Coining new terms for aquifer and aquifer system that either are synonyms or defined with slightly different meaning is not an advancement. It only creates confusion especially among people who are not hydrogeologists. Use of the term *aquiformation* also infers an equivalence between aquifer and formation that is not always correct.

## 4. Significance and Use

4.1 An essential requirement of hydrogeologists in evaluating the hydraulic properties of a segment of earth materials is to define and map hydrogeologic units, aquifers, and confining units, which are determined on the basis of relative permeability. Discussion of the hydrogeologic units is facilitated by individual designations (see Practices D5409, D5434, and D5474).

4.2 Determinations of hydrogeologic units are based on indirect methods, knowledge of the geologic materials (geologic mapping, surface geophysical surveys, borehole geophysical logs, drill-cuttings and core descriptions, and so forth), and hydraulic testing (aquifer tests, laboratory permeability tests on core samples, and so forth).

4.3 The physical properties of all rock units will change if traced laterally and vertically. The rock units are broken by unconformities and faults, which may or may not affect the flow of groundwater. The process of designating and naming aquifers and confining units, therefore, is a somewhat subjective undertaking, and, if not thoroughly documented, can lead to confusion.

4.4 Guidelines for naming aquifers can help avoid some of the confusion and problems associated with hydrogeologic studies if the guidelines are straight forward to apply, flexible, and applicable to studies of a variety of scales from site-specific to regional.

4.5 The guidelines that follow include discussions of the terminology of aquifer nomenclature, the definition of the hydrogeologic framework, the suggested procedures for naming aquifers, and examples of naming aquifers.

4.6 These guidelines have resulted from numerous discussions on the subject of aquifer nomenclature among hydrogeologists. Although unanimous agreement on these proposals has not been achieved, the exercises provided an extremely useful purpose in creating additional thought and discussion.

## 5. Documentation for Defining the Hydrogeologic Framework

5.1 *Introduction*—In hydrogeologic studies, as in purely geologic investigations, the orderly, consistent designation of pertinent parts of the geologic framework is essential to a clear reporting and understanding of the study results.

5.1.1 In groundwater studies, this involves definition and correlation of water-yielding rock materials and relating those rock materials to established rock-stratigraphic units.

5.1.2 Generally, authors of reports on groundwater resources are required to follow the same rules and guidelines for

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designating rock-stratigraphic units as are authors of purely geologic reports, that is, they should follow the guidelines and rules in the North American Stratigraphic Code (**6**).

5.1.3 The authors of groundwater reports, however, have an additional requirement to identify significant water-yielding parts of the geologic framework. Commonly, the water-yielding parts do not correspond exactly to named geologic units and, therefore, present additional nomenclatural problems.

5.1.4 Although exhaustive systematic guidelines for the complex task of naming geologic units have been developed over several decades (**6**), there were no comparable guidelines for naming water-yielding units until publication of *Aquifer-Nomenclature Guidelines* in 1986 (**1**). For example, see the fifth edition of *Suggestions to Authors of the Reports of the U.S. Geological Survey* (**8**); the sixth edition (**9**); the seventh edition (**10**) in 1991 includes the complete *Aquifer-Nomenclature Guidelines* (**1**); and the *Water-Resources Division Publications Guide* (**11**).

5.1.5 The proper designation of hydrogeologic units involves the consistent use of groundwater terms, as well as actual naming of the units.

5.1.6 One of the first considerations in describing an aquifer in a report is mappability. The aquifer should be mappable at the map scale used in the report of the study area. Exceptions to this rule may occur in areas where thin, highly transmissive aquifers could not be easily mapped at the principal map scale of the study but would still be important hydrologically.

5.1.7 The report should contain comparison charts; maps of the top, thickness, and geographic extent of the aquifers; and hydrogeologic cross sections. Hydraulic characteristics should be discussed to show how the aquifer differs from the underlying and overlying confining units.

5.1.8 If the author believes that additional information on the hydraulic characteristics of the aquifer in the vertical dimension is necessary, a type area, type locality, a type well, or a combination thereof, can be described.

5.1.9 Several surface exposures and wells may be required to describe the characteristics of the aquifer if the hydraulic properties of the aquifer change greatly vertically and laterally. In this case, selected surface exposures and wells can be used to illustrate important hydrologic aspects of the aquifer. For example, the surface exposures can show effects of fracturing or solution, grain size, bedding thickness, faulting, folding, and so forth, all of which may affect movement and storage of groundwater.

5.1.10 Borehole geophysical logs, cuttings and core descriptions, driller's and geologist's logs for wells can be used to illustrate hydraulic properties in the subsurface.

5.1.11 A comparison chart is one of the most essential parts of a report that involves a description of a groundwater flow system and aquifer names. The comparison charts consist of three major components:

5.1.11.1 *Component 1*—a correlation chart that shows rock- and time-stratigraphic (geologic) units for the water-bearing materials described in the report.

5.1.11.2 *Component 2*—A comparison of hydrogeologic units to layers used in digital flow model, if one is used.

5.1.11.3 *Component 3*—A comparison of hydrogeologic units of the report with those in previous reports.

5.1.12 The amount of detail in the comparison chart will be determined by the scale and complexity of the investigation. If the report contains only a few geologic and hydrogeologic units, all of the comparisons may be shown in one illustration. For complicated investigations that involve many geologic and hydrogeologic units, two or three illustrations may be required to show the comparisons.

5.1.12.1 An example of a comparison chart that shows the relation of geologic units, hydrogeologic units, and model layers is shown in Fig. 1.

5.1.12.2 Fig. 2 shows a comparison of geologic and hydrologic units with those in previous reports. A chart like that in Fig. 2 is especially important in reports where aquifers are redefined and renamed.

5.1.12.3 Fig. 3 shows an example of a correlation chart where the hydrogeologic units are made up of many rock-stratigraphic units. Unlike the chart shown in Fig. 1, the hydrogeologic units are on the left side and the rock-stratigraphic units are combined on the right side of the chart. This chart emphasizes primarily hydrogeologic units and secondarily rock-stratigraphic-units, although considerable analysis of rock-stratigraphic data from throughout the study area was required to develop the chart.

5.1.12.4 This analysis of time-stratigraphic units and rock-stratigraphic units in a correlation chart should be shown as a separate illustration because of the great number of rock-stratigraphic units to be considered. The comparison chart should make completely clear to the reader the relationships of the hydrogeologic units to the geologic units and to equivalent layers in the computer flow models, if one is included in the study.

5.1.13 Preparation of a comprehensive comparison chart requires a thorough search of the literature for all previous studies in the project area that contain rock-stratigraphic names and aquifer names. The comparison chart should contain the following items:

5.1.13.1 Headings entitled: Erathem, system, series, rock-stratigraphic unit, thickness, lithology, hydrogeologic unit, and hydraulic characteristics.

5.1.13.2 The geologic units that are pertinent to the hydrology under study.

5.1.13.3 The hydrogeologic units that the author is using and how they relate to geologic units and previously named hydrogeologic units.

5.1.13.4 A column that shows relations of hydrogeologic units to layers in the flow model, if one is included in the study.

5.1.14 Only the part of the geologic column that pertains to the hydrology under study should be discussed and shown in detail. The amount of discussion of the geology should be limited mainly to those aspects that affect the movement and storage of groundwater. An exception would be a situation where the details of the stratigraphy were not well known prior to the hydrologic study, and as a result of determining the hydrogeologic units a clearer understanding of the stratigraphy was achieved.

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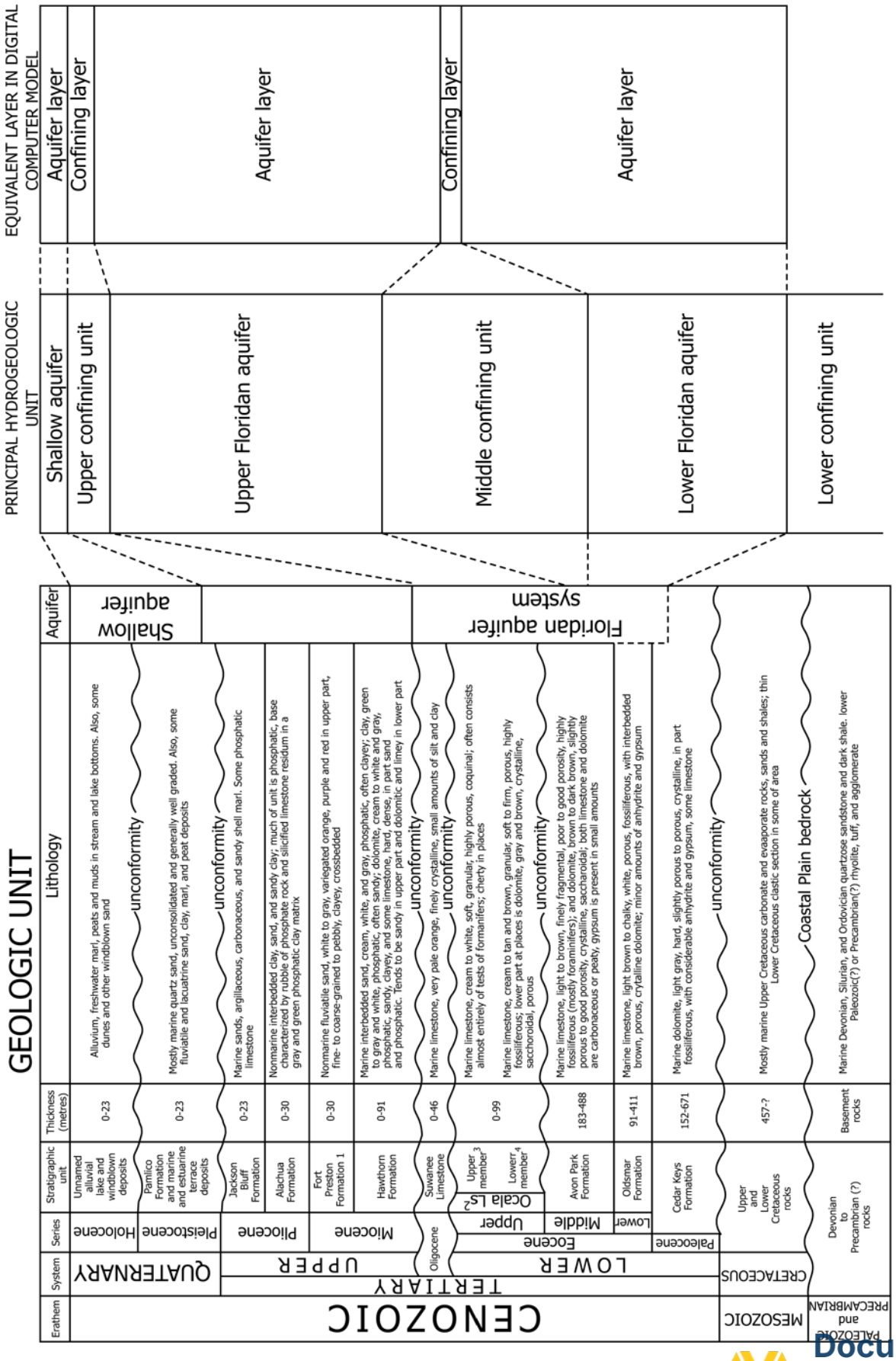


**FIG. 1 Example of a Chart Showing Comparison of Geologic Units, Hydrogeologic Units, and Equivalent Units in a Digital Groundwater Flow Model (13)**

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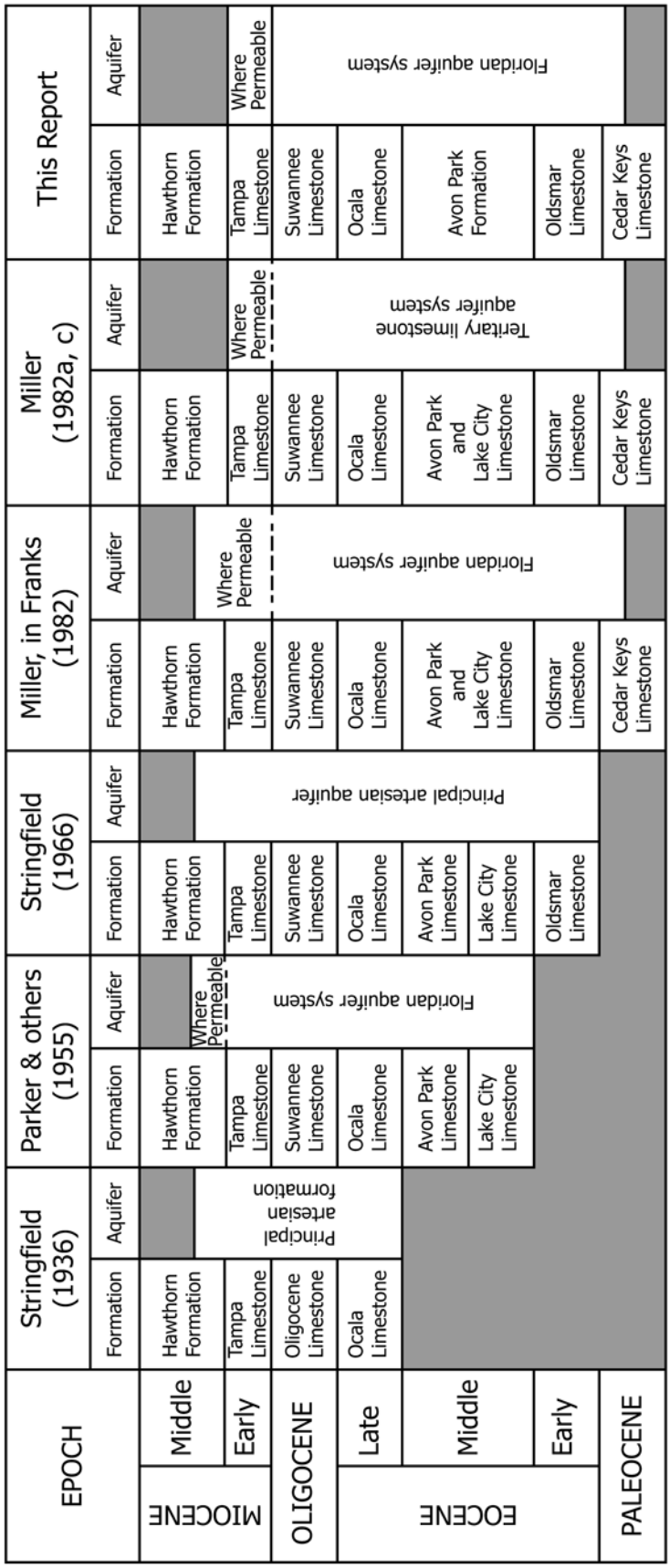


FIG. 2 Example of Chart Showing Comparisons of Geologic and Hydrogeologic Units with Those in Previous Reports (4)

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