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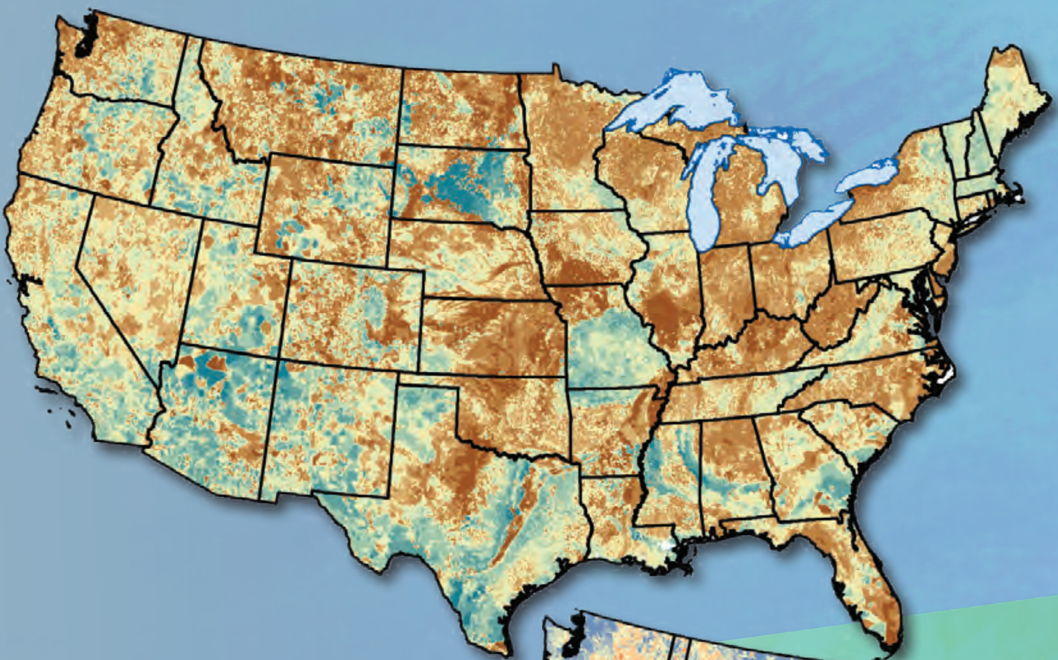
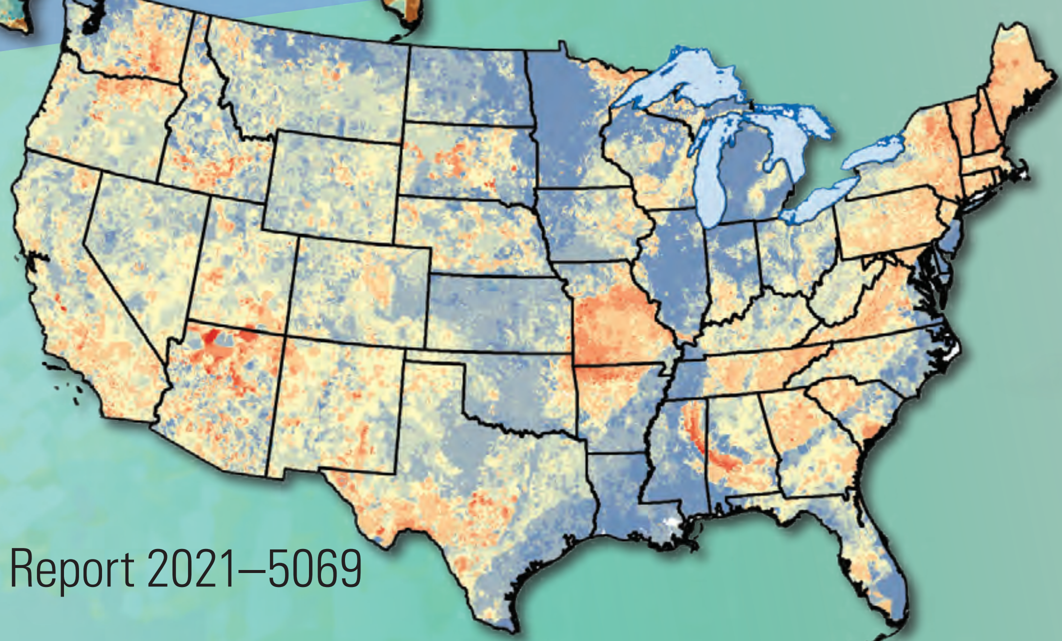
Depth of Groundwater Used for Drinking-Water Supplies in the United States





Scientific Investigations Report 2021–5069

U.S. Department of the Interior
U.S. Geological Survey

Cover. Moving median of the depth to the bottom of the open interval (top) and the open interval length (bottom) from domestic-supply wells in the conterminous United States; from figures 14 and 15 of this report.

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By James R. Degnan, Leon J. Kauffman, Melinda L. Erickson, Kenneth Belitz, and Paul E. Stackelberg

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Abstract

Groundwater supplies 35 percent of drinking water in the United States. Mapping the quantity and quality of groundwater at the depths used for potable supplies requires an understanding of locational variation in the characteristics of drinking-water wells (depth and open interval). Typical depths of domestic- and public-drinking-water supply wells vary by and within aquifer across the United States. The depths to the top and bottom of the zones from which drinking water is withdrawn are important predictor variables in regional- and national-scale statistical water models, but spatially extensive maps of the depths to drinking-water-supply sources are not consistently available in modeled regions. Therefore, it was necessary to generate a set of grids representing surfaces of the approximate common depth and length of open intervals in the wells from which water is withdrawn for domestic- and public-drinking-water supply (withdrawal zones) within the conterminous United States.

Well data (about 7.6 million records) were compiled from several sources, including the U.S. Geological Survey's National Water Information System (600,922 records), the U.S. Environmental Protection Agency's Safe Drinking Water Information System dataset (66,540 records, primarily public-supply wells), a groundwater ambient monitoring dataset (31,448 records, primarily domestic-supply wells), individual State data (6,096,503 records), a national brackish aquifer study (96,885 records), and a glacial aquifer study (729,564 records).

Fifty-seven principal aquifers and 65 secondary hydrogeologic regions have been designated in the conterminous United States. The principal aquifers and secondary hydrogeologic regions vary in depth, thickness, lithology, and transmissivity characteristics. Some principal aquifers underlie secondary hydrogeologic regions, and may in turn be overlain by glacial sediment or basin and valley fill aquifers, which may also be used as drinking-water sources. The principal aquifer and secondary hydrogeologic region polygons were merged with overlying sediment polygons, where present, including glacial sediment, coarse glacial sediment, and stream valley alluvium (alluvium) polygons, to generate unique hydrogeologic settings across the conterminous United States. A total of 288 distinct hydrogeologic settings resulted from the merging of principal aquifer, secondary hydrogeologic region, glacial sediment, coarse glacial sediment, and alluvium polygons.

Each well was assigned to a hydrogeologic setting on the basis of location. Hydrogeologic setting well groupings were used to guide calculations of the median value for well depth and depth to and length of open intervals across the hydrogeologic setting. Where well data were sparse or missing, wells from hydrogeologic settings with similar well construction properties, geology, physiography, and topography were grouped and used to calculate the moving median depth (if less than five wells in a 100-kilometer [62.1-mile] radius) and to estimate open interval length (if not available within hydrogeologic setting). Grids were generated to represent what might be considered as the "typical" or "median" domestic- and public-supply well in an area. The well properties are defined with moving median grids of top depth, bottom depth, and length of open interval at a 1-square-kilometer (0.38-square-mile) grid cell scale.

Median depths and open intervals of domestic- and public-supply wells varied by lithology of the hydrogeologic setting and overlying sediment. Overall, the median depths were 142 feet (43.3 meters) for all domestic-supply wells and 202 feet (61.6 meters) for all public-supply wells. The median open intervals were 21 feet (6.4 meters) for domestic-supply wells and 49 feet (14.9 meters) for public-supply wells. The shallowest median bottom open interval depths for domestic-supply wells were in the secondary hydrogeologic regions with coarse glacial sediment, which suggests that the wells are most commonly completed in the permeable coarse glacial sediment and not in the underlying secondary hydrogeologic region. Public-supply wells were completed at relatively shallow median depths when drilled in permeable sediment that overlie secondary hydrogeologic regions. When public-supply wells were completed in principal aquifers, the median depths were typically greater than wells completed in secondary hydrogeologic regions.

Well data used in this study were limited to those available from national or State digital databases. Several quality-assurance checks were performed during data compilation, but a comprehensive quality assurance inspection for each of the data sources was outside the scope of this study. Grids defining typical open intervals in domestic- and public-supply wells are presented. Although there are many places where multiple aquifers are stacked, these results correspond primarily to the aquifer with the highest documented number of wells for each use.

Introduction

Worldwide, groundwater supplies 50 percent of drinking water (Zekster and Everett, 2004), and in the United States, it supplies 35 percent of drinking water (Dieter and others, 2018). The use of groundwater as a potable supply is limited, however, where its quality is adversely affected by anthropogenic and geogenic contaminants (Nordstrom, 2002; Foster and Chilton, 2003). Mapping the quantity and quality of groundwater at the depths from which it is pumped from domestic- and public-supply wells requires an understanding of the characteristics of these well types, such as the depths and lengths of their open intervals (whether through a well screen or an open borehole) in aquifers and the water-bearing rocks or unconsolidated materials in which the wells are completed. The presence of geogenic contaminants varies, in part, by aquifer depth and type across the United States (Ayotte and others, 2011), and thus the variability in the depth of domestic- and public-supply wells used for drinking water is of concern for resource and consumer protection and for the assessment of data gaps (Yager and others, 2018).

Depths to the top and bottom of open intervals in wells from which water is withdrawn for drinking water are important variables in statistical models used to predict groundwater quality regionally (Ayotte and others, 2016; Ransom and others, 2017; Rosecrans and others, 2017a, b, 2018; Erickson and others, 2018), and across the United States (Nolan and Hitt, 2006; Ayotte and others, 2017; Stanton and others, 2017). Several regional- and national-scale machine-learning models are being developed for the purpose of making water-quality predictions and maps of the depths relevant to drinking water supply (for example, Ransom, 2019; Erickson and others, 2021). Spatially extensive maps of depths to groundwater used for drinking-water supplies are not consistently available in modeled regions. Therefore, it was necessary to generate a set of grids that represent the surfaces of the approximate depth and length of the open interval of a typical well used for drinking-water supply (withdrawal zone) across the conterminous United States. Depending on the lithology of the material in which a well is completed, the open interval may represent a well screen (generally in unconsolidated rock) or an open borehole (generally in consolidated rocks). Both well depth and open interval vary by the type of water use, the hydrogeology, and the type of well (screened or open borehole), so it was important to separately define the domestic-supply withdrawal zone and the public-supply withdrawal zone.

The objectives of the study described here were to (1) inventory well-construction data, (2) inventory top depth, bottom depth, and length of open intervals of wells on a regional scale, (3) estimate missing open intervals, and (4) generate moving median grids of top depth, bottom depth, and lengths of open intervals of typical domestic and public-supply wells across the conterminous United States. This study is presented in the context of hydrogeologic settings (fig. 1), which are an aggregate of a principal aquifer (U.S. Geological Survey, 2003) or a secondary hydrogeologic region (Belitz and others, 2019b) with overlying sediment (if present). Hydrogeologic settings were used as a way of grouping wells that might be expected to be similar.

Purpose and Scope

This report describes the data sources and the methods used to gather and summarize the data on the typical depth to groundwater used for drinking-water supplies in the conterminous United States. Depths to the top and bottom of the open intervals of wells used for drinking water are important variables in statistical models used to predict groundwater quality (Rosecrans and others, 2017a). Such statistical modeling studies use continuous grid maps of variables to generate maps of water quality and contaminant conditions. A coast-to-coast set of continuous grids representing depths of open intervals in typical wells were generated to help facilitate the modeling efforts. The grids are presented as static map figures and interactive maps in this report; data are available in Kauffman and others (2021).

Previous Studies

Well depth and aquifer depth were identified as significant statistical variables in models of groundwater quality in previous regional and national modeling efforts, but spatially extensive maps of depths to drinking-water supplies are not consistently available in modeled regions. Degradation of drinking-water quality from high arsenic concentrations was found to increase with depth in North Carolina, but maps of spatially varying depth were cited as a limitation and future research area in a statewide modeling effort (Kim and others, 2011). Depth to the drinking water supply was an influential variable in a multicounty arsenic modeling effort in the glacial aquifer in north-central United States (Minnesota), but only regional-scale median depths were available for probability mapping (Erickson and others, 2018). Detailed aquifer depth information subsequently became available (Yager and others, 2018), however, and was an important variable for more recent preliminary mapping of high concentrations of arsenic and manganese in glacial aquifers across the northern United States (Erickson and others, 2021). A national study using a logistic regression to develop probability maps of high concentrations of arsenic identified the depths of domestic wells and aquifers as data gaps (Ayotte and others, 2017). Depths of domestic- and public-supply wells commonly were similar, but public-supply wells were generally deeper, such as in the High Plains principal aquifer (Bruce and Oelsner, 2001) and in a four-State study of well characteristics and arsenic concentrations (Erickson and Barnes, 2005). A study covering the entire glaciated region of the United States also found that depths of domestic- and public-supply wells were similar, but in hydrogeologic terrains where sediments are thickest, public-supply wells were deeper (Erickson and others, 2019).

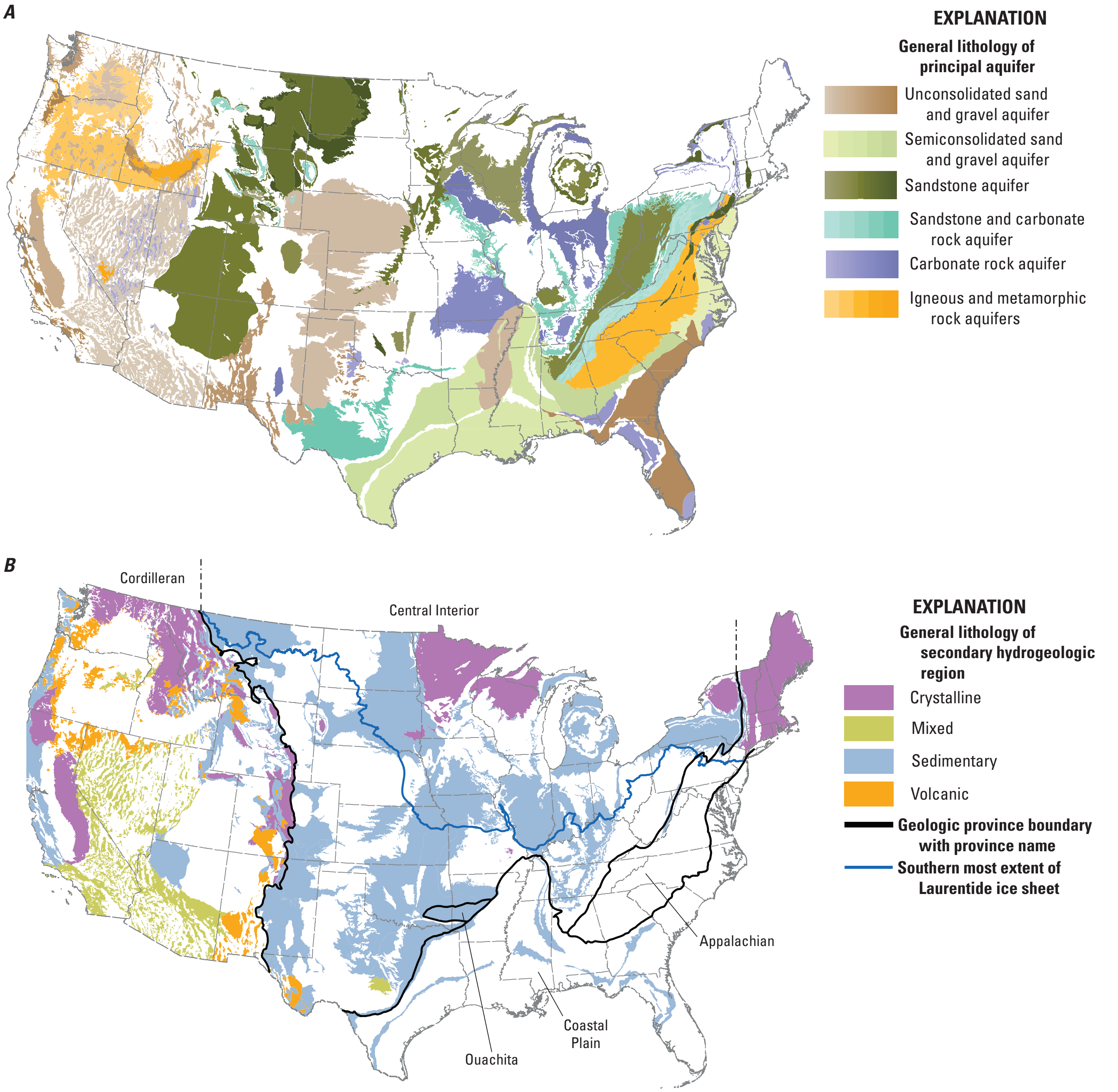


Figure 1. Maps of the conterminous United States showing *A*, principal aquifers, categorized by general lithology (shading differentiates individual principal aquifers) and *B*, secondary hydrogeologic regions classified by primary lithology (modified with permission from Belitz and others, 2019b).

Nationwide, depths to productive aquifers that supply potable water are inherently variable, as has been described in several publications, for example, U.S. Geological Survey (2003). The 57 principal aquifers and 65 secondary hydrogeologic regions identified in the conterminous United States differ in depth, thickness, lithology, and transmissivity characteristics. Some secondary hydrogeologic regions overlie principal aquifers, and both are sometimes overlain by glacial sediment or basin and valley fill, which also may be used as drinking-water supply sources. The likelihood of encountering brackish groundwater is also depth-dependent across most of the country, with deeper wells more likely to yield water containing high concentrations of dissolved solids (Stanton and others, 2017). All these factors can influence the depth and length of the open intervals of wells.

Semiconsolidated sand aquifers are common along the southern and eastern coastal regions of the United States, including the coastal lowlands aquifer system along the gulf coast and the North Atlantic Coastal Plain aquifer system along the central Atlantic coast. These aquifer systems are composed of semihorizontal layers that comprise multiple semiconsolidated sand aquifers interbedded with aquitards, and the layers can have spatially varying thicknesses and depths. For example, the North Atlantic Coastal Plain aquifer system has thin and shallow layers to the west that become thicker and deeper to the east (Masterson and others, 2016). Additionally, hydrologic and water-quality characteristics can vary within each aquifer layer, resulting in variability in the typical depths of the layer developed for different types of water use, whether domestic or public supply (Brown and others, 2019; Degnan and others, 2020).

Sandstone, sandstone and carbonate, and carbonate principal aquifers and secondary hydrogeologic regions are present throughout the country, with principal aquifers generally having hydrogeologic properties more conducive to larger well yields and water-supply volumes (Miller, 1999). Examples in the western part of the country include the Colorado Plateaus aquifers (Robson and Banta, 1995), the upper Tertiary aquifers, and the coast ranges secondary hydrogeologic regions (Belitz and others, 2019b). In the central part of the country examples include the Cambrian-Ordovician aquifer system, the Ozark Plateaus aquifer system, and interior Permian secondary hydrogeologic region. The Pennsylvanian aquifers, the Floridan aquifer system, and the gulf coastal secondary hydrogeologic region are examples in the eastern and southeastern parts of the country (Miller, 1990). These aquifers and aquifer systems commonly are layered sedimentary units that include low permeability confining or semiconfining units between aquifers. Water quality and hydraulic conductivity can vary spatially and with depth, and parts of the aquifer systems contain highly mineralized water or have relatively low permeability. Carbonate rocks can have intergranular porosity as well as significant secondary porosity from large solution openings such as channels that resulted from dissolution weathering.

Crystalline or volcanic principal aquifers and secondary hydrogeologic regions are present primarily in the northwestern, western, north-central, and northeastern parts of the country. Examples include the basaltic-rock aquifers of the Pacific Northwest and the Columbia Plateau, the Sierra Nevada, the Canadian Shield, and the Northern Appalachian Mountains secondary hydrogeologic regions. The thickness and hydrologic characteristics of these aquifers vary greatly based on the nature of the environment of placement (for example, volcanic ash fall as opposed to volcanic flows) and the age, degree of weathering, and fracturing of the rocks.

Unconsolidated basin and valley fill overlying some principal aquifers are composed of sand and gravel deposits, sometimes interbedded with fine-grained materials. These overlying sediment aquifers can be spatially extensive and vary in thickness and hydrologic properties. Examples include California's Central Valley, the Basin and Range in the southwestern United States, and the High Plains Aquifer in the central United States. The typical depths of the aquifers used for water supply vary with water table depth, type of water use, and water capacity requirements (Miller, 1999).

In the northern part of the United States, within the glaciated areas that cover parts of 24 States, glacial sediments can be an important source of drinking water. The thickness and hydraulic conductivity of glacial sediments vary from very thin coverage (meters) in the Northeast and in areas with significant topographic relief to very thick (tens to hundreds of meters) in the Midwest and in far western Washington (Yager and others, 2018; Erickson and others, 2019). Large areas of the northeastern United States rely on thin, discontinuous till and fractured bedrock for drinking water supplies. Thick deposits of permeable stratified sediments in the southern part of the glaciated area, along the coasts, and in narrow valleys throughout are also developed for drinking-water supplies.

Machine-learning water-quality models of constituents of concern are in development for several important drinking-water aquifers in the glacial aquifer systems in the northern United States, with the goal of mapping water quality at depths relevant to drinking-water supply (Stackelberg and others, 2021). Several preliminary or published national- and regional-scale groundwater quality models found that depth was an influential model predictor. One study (Ransom, 2019) found that predicted nitrate concentrations across the United States are dependent upon depth. Another study (DeSimone and others, 2020) found that predicted pH and redox conditions were depth dependent in the North Atlantic Coastal Plain aquifer system, and a study in California (Rosecrans and others, 2017b) found that depth was an important predictor variable for redox conditions in the Central Valley. In the glacial aquifers system in the Midwest, anoxic redox conditions and high concentrations of arsenic and manganese were more likely at deep depths (Erickson and others, 2021). Another study (Stackelberg and others, 2021) generated depth to drinking-water supply grids to help predict pH in the glacial aquifer system and mapped pH predictions at typical domestic- and public-drinking-water supply depths.

Thus, the depth to the withdrawal zone in wells that supply drinking water differs across the country because of the inherent variability in the characteristics and conditions of hydrogeologic settings. A national-scale grid of typical depths for domestic- and public-drinking-water supply will allow better local, regional, and national-scale predictions and mapping of areas of concern or hazards to sources of drinking water.

Study Methods

The depths to open intervals in drinking-water supply wells vary by aquifer and region, and the availability and reliability of the information can be expected to vary by dataset and source. The open interval is defined as the length and top and bottom depth of zone within a well from which water is withdrawn through a well screen or open borehole. The well depth is the bottom of the completed well, which is not always as deep as the original hole depth. Hole depth is always the same or deeper than well depth. Hydrogeologic settings were aggregated from existing aquifer information and used to organize and interpret results. Missing values for depth to the top and lengths of open intervals were estimated on the basis of information gleaned from analysis of combinations of well depth and screen depth and length for each defined hydrogeologic setting. Grids describing the open intervals of typical domestic- and public-supply wells were developed from the processed data for the wells.

Compilation, Processing, and Quality Assurance of Well Data

Well construction and location data were compiled from records for about 7.2 million domestic wells and 428 thousand public-supply wells across the conterminous United States. The data were obtained from several sources, including the National Water Information System (NWIS; U.S. Geological Survey, 2019), a national brackish aquifer study (Stanton and others, 2017), a glacial aquifer study (Bayless and others, 2017), and many individual State datasets (table 1). The individual State data commonly included information from well-construction databases developed from drillers' logs. In addition to individual State datasets, State data were also a part of the USGS National Water-Quality Assessment (NAWQA) Project's National Groundwater Aggregation database (NGA), which included data from the Safe Drinking Water Information System (U.S. Environmental Protection Agency, 2013) from each State and ambient groundwater monitoring programs. The diverse nature of data sources required standardization of data fields used to store information about well construction. To that end, the interrelated NWIS data fields such as casing

Table 1. Numbers of wells for which well depth and open interval data were compiled, by data source and type of well.

[National Water Information System (NWIS) data are from U.S. Geological Survey (2019); glaciated data are from Bayless and others (2017); National Groundwater Aggregation (NGA) and individual State data are from Kauffman and others (2021); brackish data are from Stanton and others (2017). %, percent]

Data source	All wells, number of wells		After duplicates removed		
			Number of wells		Percentage of wells, with open interval
	With depth	With open interval	With depth	With open interval	
Domestic-supply wells					
NWIS	523,719	293,143	417,228	227,552	54.50%
Glaciated	683,552	274,972	298,079	142,734	47.90%
NGA	31,448	2,164	11,474	1,259	11.00%
Brackish	73,003	26,488	30,747	11,884	38.70%
Individual State data	5,881,441	3,640,523	4,979,594	3,105,800	62.40%
Total	7,193,163	4,237,290	5,737,122	3,489,229	60.80%
Public-supply wells					
NWIS	77,203	48,502	63,106	40,675	64.50%
Glaciated	46,012	31,275	28,892	19,898	68.90%
NGA	66,540	14,871	33,875	9,204	27.20%
Brackish	23,882	13,343	10,237	5,191	50.70%
Individual State data	215,062	114,748	184,380	99,415	53.90%
Total	428,699	222,739	320,490	174,383	54.40%
All wells					
Total	7,621,862	4,460,029	6,057,612	3,663,612	60.50%

length, open interval length, depth to the bottom and top of open interval, depth of well bottom, and depth of hole bottom were used to hold appropriate data from other databases. This resulted in different data-collection and preservation protocols, which in turn led to data standardization procedures necessary for this study. Data and statistics from different sources were reviewed, processed, and combined into domestic- and public-supply datasets. Data sources, the fields used to define the standardized descriptions of the open intervals (top and bottom depths and total length), and summary statistics are published in Kauffman and others (2021). Automated data-quality checks included scripts to compare well construction and location information and to identify duplicates for removal. Duplicates were defined as wells within the same 328 by 328 ft (100 by 100 m) grid cell with the same reported bottom depth of the open interval. In cases where duplicates were identified, one of the wells was kept (with preference given to a record containing the depth to the top of the open interval), and the remainder were removed.

Among the various data sources, different types of data fields, field names, and levels of data consistency existed. For each data source, fields were evaluated and prioritized for defining, insofar as possible, the depth to the top and bottom of the open interval. An algorithm was developed to create, prioritize, and populate commonly named fields for the characteristics of open intervals. The depth to the bottom of the open interval was populated first because, in some instances, that value was used to compute the depth to the top of the open interval. When populating the depth to the bottom of the open interval, fields directly related to the bottom depth of the screen or open hole were used whenever provided. If those data were not available, then the information on total well depth was used, followed by information on hole depth. In NWIS, hole depth is equal to or greater than the finished well depth (U.S. Geological Survey, 2019). Fields directly related to the top of the screen or open hole were used first to populate the depth to the top of the open interval. If those data were not available, the depth to the top of the open interval was calculated by subtracting a reported screen or open hole length from the bottom depth. If those data fields were not available, the reported bottom casing depth or length was used. A field defining the open interval length was populated by calculating the difference between the bottom depth and top depth of the open interval. If fields for the top depth or the open interval were not available, the open interval was estimated as described in the “Estimating Length of Open Intervals” section of this report. If a bottom depth was not available, that well was not included in the dataset.

A series of quality-assurance and decision steps were implemented to identify and correct processing errors resulting from differences in the way the various data sources describe the top and bottom depths of the open interval. The process of digitizing well records can lead to transcription errors or misinterpretations of what is recorded on the paper records; these data checks were an attempt to minimize this type of error, but some errors will still remain in the final dataset. In cases in which a scanned version of the well records was available, it appears that the open interval length was at times recorded as the depth to the bottom of the open interval (usually a screen). The quality-assurance steps, in order of how they were implemented to compile the final data, were as follows.

1. If the preferred method of identifying and populating the bottom of the open interval field resulted in a depth value that was four times less than that obtained by using an alternative method (for example well depth or hole depth), then the deeper measurement was used.

2. If the bottom depth was less than the top depth and the alternative value of bottom depth was greater than the top depth, then the alternative value of bottom depth was used to populate the field.

3. If the top depth was greater than the bottom depth and the top depth was equal to the alternative bottom depth, then it was assumed that the bottom and top depths were switched so they were reversed.

4. If the bottom depth was less than 20 feet (ft) and the top depth was greater than 20 ft, then the top depth was used for the bottom depth and the top depth was set to null.

5. If the top depth was greater than the bottom depth and none of the above conditions were met, then the top and bottom depths were reversed.

Aggregation of Hydrogeologic Settings

Polygonal areas coincident with boundaries of previously defined principal aquifers (U.S. Geological Survey, 2003) and secondary hydrogeologic regions (Belitz and others, 2019b) were merged with polygons representing areas of permeable overlying sediment, where present, including those representing glacial sediment, coarse glacial sediment, and stream valley alluvium (alluvium), to generate unique hydrogeologic settings across the conterminous United States. The intent of these unique hydrogeologic settings was to differentiate areas on the basis of expected depth of drinking water supplies. Maps of glacial deposits, on which stratified-coarse material was differentiated, were originally developed to support regional productivity and water-quality mapping efforts (Bayless and others, 2017; Haj and others, 2018; Yager and others, 2018). The alluvium polygons were defined in areas south of the maximum extent of glaciation that were mapped either as alluvial sediments or coarse-grained proglacial sediments (Soller and others, 2009). Geographic information system (GIS) polygon files of all hydrogeologic settings are from Kauffman and others (2021).

Each well was assigned to a hydrogeologic setting on the basis of its location, and hydrogeologic setting well groupings were used to assess well depth and open interval data. Open intervals were estimated on the basis of data from within the hydrogeologic setting where a well was located, as described below. When well data were sparse or missing, wells from hydrogeologic settings with similar well construction properties, geology, physiography, and topography were grouped for depth or open interval analysis.

In many instances, well records did not include enough information to directly determine the open interval length. In all cases, however, the records selected contained data on depths to the bottom of the open interval, well, or hole. Cumulative distribution functions (CDFs) of the lengths of open intervals in nearby or adjacent wells with known or calculated open interval lengths were used to estimate open intervals for wells without those data. This procedure was followed only if data on the depth to the bottom of the open interval and on the geologic setting at adjacent wells were sufficiently similar. For example, the Mann-Whitney-U test (Mann and Whitney, 1947; Helsel and Hirsch, 2002) was used to determine if the CDFs of bottom depths of the open intervals for one hydrogeologic setting were similar to those for a hydrogeologic setting with missing open interval length data. Three tests were computed for each pair of CDFs using the function mannwhitneyu (SciPy, 2020): the first test compared the two CDFs directly with a two-sided test; a one-sided test was done to see if the CDF being compared was less than 90 percent of the base CDF; and the third test was done to determine if the CDF being compared was greater than 110 percent of the base CDF. A p-value of 0.05 was used to indicate statistical significance.

Estimating Length of Open Intervals

Data for either the bottom of the open interval or the total well depth were available in the records for all wells that were included in the analyses for this report. In 41 percent of the records, data for the length of the open interval were missing. The length of the open interval was estimated when the value was missing and also when there was no information on the depth to the top of the open interval from which a length could be calculated. A relation between the bottom depth and length of the open interval was defined for each hydrogeologic setting by a two-slope linear function (described in detail in this section) developed on the basis of data for wells for which both bottom depth and length data were available. When well records did not include the length of the open interval, the value was estimated using the two-slope linear function for the hydrogeologic setting and the bottom depth of the open interval for each well.

Four parameters described the two-slope linear function used to represent the relation between the depth of the bottom of the open interval (b) to the length of the open interval (l). The first parameter was the y-intercept (l_0), which had to be a value of 1 or greater. The second and third parameters were the slope values for each of the two linear segments (m_1, m_2). Both slopes had to be greater than 0, and the slope of the second segment had to be greater than the first. The final parameter is the breakpoint (s) where the second line begins. For $b < s$,

$$l = l_0 + m_1 b, \text{ and} \tag{1}$$

for $b > s$,

$$l = l_0 + m_1 s + m_2 (b - s). \tag{2}$$

The data points were split into bins to minimize the effect of outliers in fitting a line to the data. Median values of each bin were used in the fitting process. The number of bins varied based on the number of data points. If there were more than 10,000 data points, the number of bins was calculated as the square root of the total number. For data points numbering between 500 and 10,000, 100 bins were used. For data points numbering between 31 and 500, the number of bins was calculated by dividing by 3 and converting to an integer. More than 30 data points were required to fit a line.

An equation to describe the relation between the bottom depth and the length of the open interval was defined separately for domestic- and public-supply wells for each hydrogeologic setting. When fewer than 30 data points were available in a hydrogeologic setting, additional data points were added from neighboring hydrogeologic settings that were similar (CDFs were within 10 percent). If there were still fewer than 30 points after adding points from similar neighbors, the relation was based on all the wells in hydrogeologic settings with the same lithology and overlying sediment type.

Generation of Open Interval Grids

An empirical approach was used to create grids that represent the surfaces of open intervals of a “typical” well. In this report, maps of grids (also known as rasters) are used to represent surfaces of the depths to the top and bottom and the lengths of the open intervals in domestic- and public-supply wells from which drinking water is withdrawn. Data from well records were used to map open intervals of wells by hydrogeologic setting across the conterminous United States. Each grid cell was assigned a hydrogeologic setting value from the center of the cell. A moving-median algorithm was used to create the grids because it functions as a smoothing algorithm on the individual data points, minimizing the effect of outliers.

Three moving-median open interval grids were generated for a 1-kilometer (km; 0.62-mile [mi]) grid across the conterminous United States for both public- and domestic-supply wells. A minimum target of five wells was used to compute the median value assigned to each cell and for each grid. Initially, all the wells in a cell that belonged to the same hydrogeologic setting as the cell center were selected. Additional wells were needed when the number of wells was less than five. The search radius for additional wells was increased systematically to a maximum distance of 101 cells (a 100-km [62.1-mi] radius; figs. 2 and 3) from the original cell or to the radius at which the target number of wells in the same hydrogeologic setting was obtained. The expanding-radius, moving-median grid-interpolation technique was similar to methods used in the glacial-aquifer hydrogeologic framework mapping project (Yager and others, 2018). If five wells were not available within a 100-km (62.1-mi) radius within the hydrogeologic setting, then the cell was assigned the median value of the entire hydrogeologic setting.

Grids were first calculated on the basis of available data for the actual top depth, bottom depth, and length of the open interval. A second version of the grids was created by merging actual data with estimated values for top depth and length of the open interval. Then, hybrid grids were created by merging data from the two versions, according to the following rules: Values based entirely on actual open interval data were given priority and were exclusively used when the well density was higher than five wells in a 10-km (6.21-mi) radius. Estimated values were combined with actual values to create hybrid grids when the search radius to find five wells with actual data on the top depth of the open interval was 10 km (6.21 mi) more than the search radius to find five wells with either an actual or estimated top depth of the open interval.

For some hydrogeologic settings, no public-supply well data were available. If a hydrogeologic setting contained data for fewer than 10 wells, then the data for the wells in that hydrogeologic setting were combined with those in another hydrogeologic setting to create typical-well open interval grids. In these cases, the CDF comparison steps were used to determine which neighboring hydrogeologic setting well construction data were suitable to include.

A variable smoothing algorithm was applied to the open interval grids to account for uncertainty in well locations, hydrogeologic setting boundaries, and areas with low data density. Smoothing minimized steep gradients in the open interval depth and thickness grids that occur across hydrogeologic setting boundaries. The smoothing was adjusted by a smoothing factor based on well spatial density. The smoothing factor is calculated dividing the distance to reach the five nearest wells by 10 and then adding plus 1. For example, if the distance to reach five wells is 40 km (24.9 mi), then each cell was assigned the value obtained by averaging across two cells in each direction, or a 5-square-kilometer (km^2; 1.92-square-mile [mi^2] grid of 1-km^2 (0.38-mi^2) cells. This procedure helps to minimize local anomalies while maintaining the overall structure of the data.

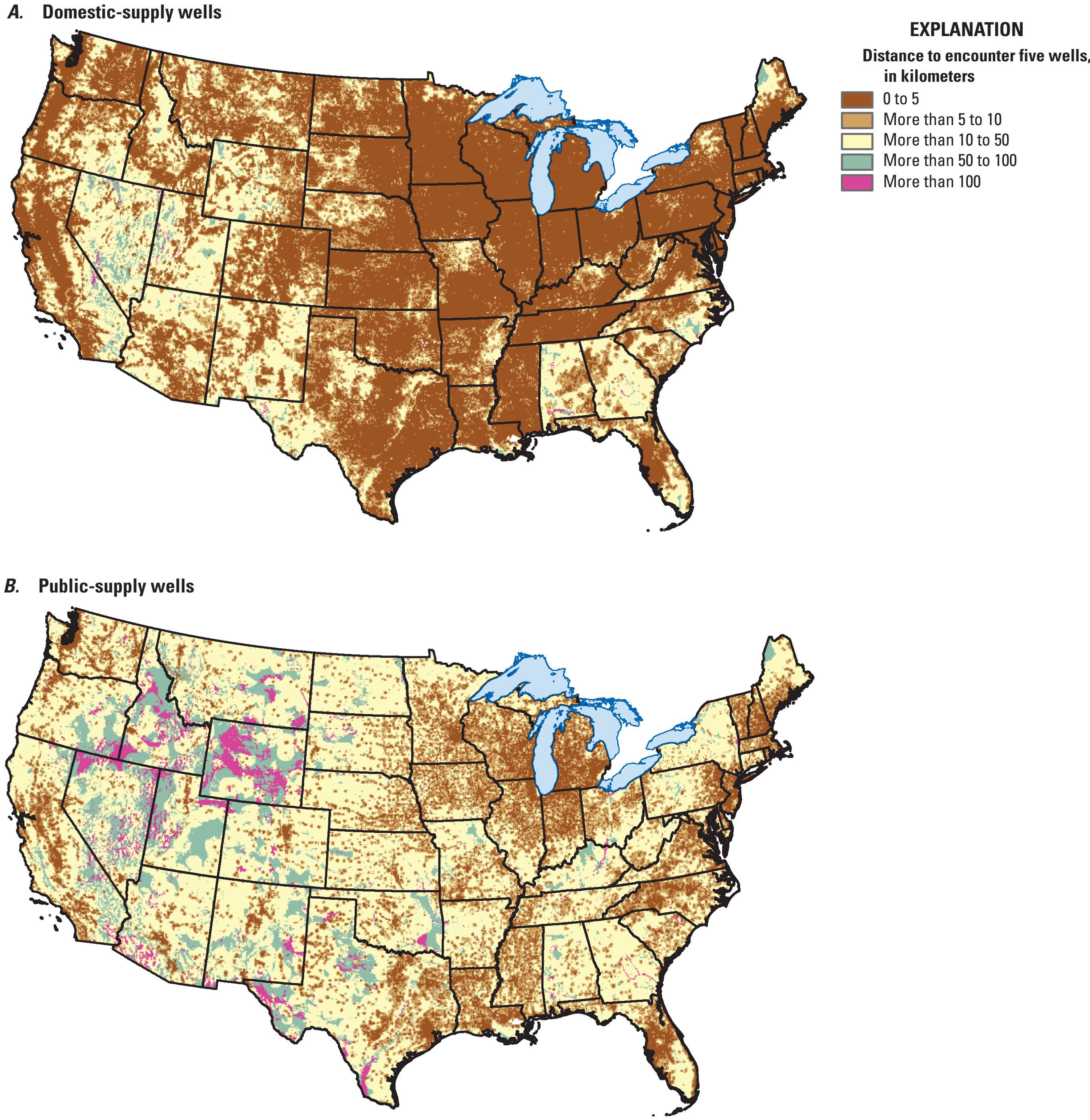


Figure 2. Maps showing the distance from a cell within a grid required to reach five wells with sufficient information to compute a median value for the bottom of the open interval for *A*, domestic-supply wells and *B*, public-supply wells in the conterminous United States. Grids presented here are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

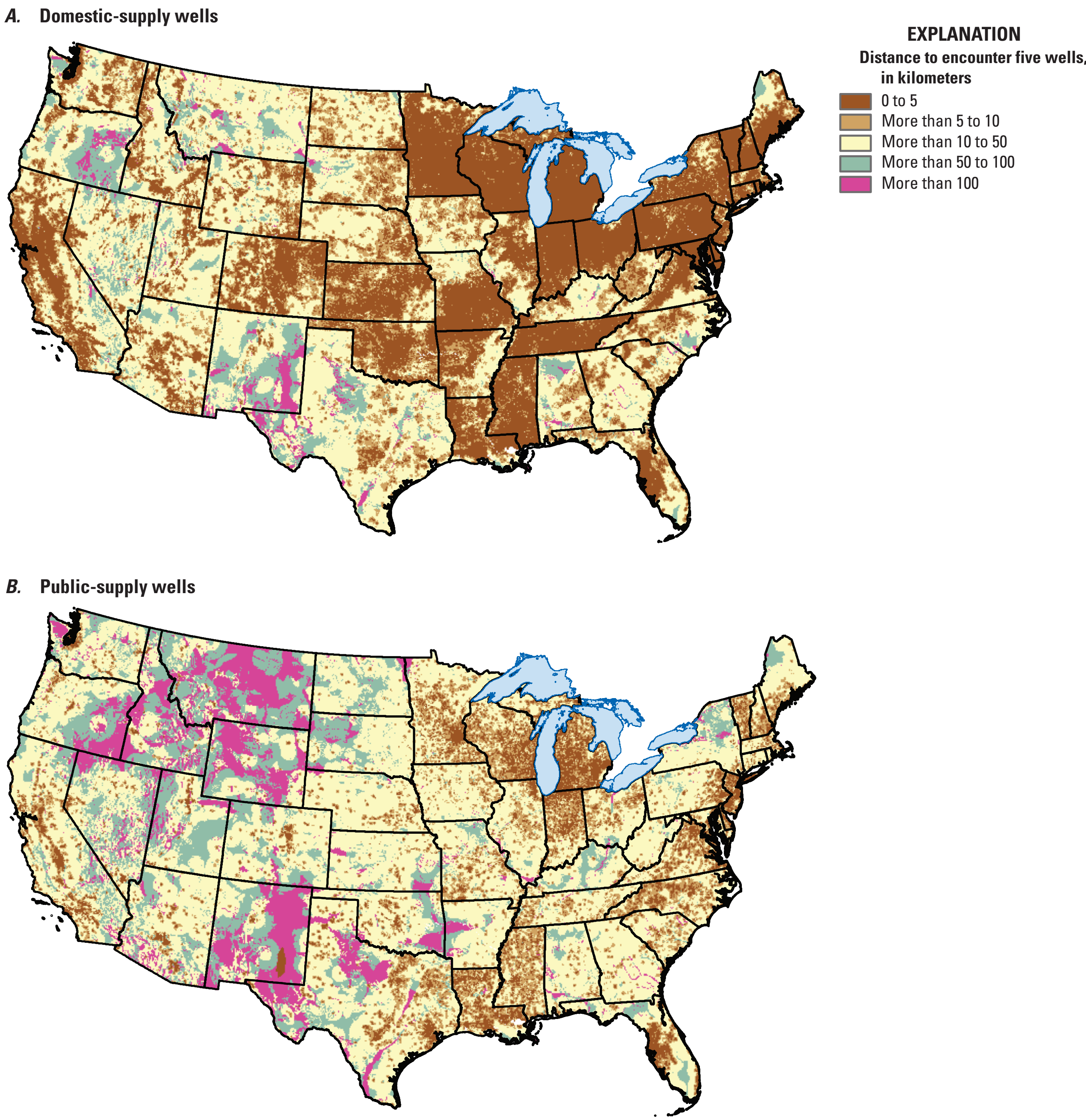


Figure 3. Maps showing the distance from a cell within a grid required to reach five wells with sufficient information to compute a median value for the open interval length for *A*, domestic-supply wells and *B*, public-supply wells in the conterminous United States. Grids presented here are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

Results of Analyses

Hydrogeologic settings were used to provide a framework for processing the well data and to organize summaries of the data. Grids were generated to represent data density and surfaces of approximate common depth and length of open intervals in the wells from which water is withdrawn for domestic- and public-drinking-water supply (withdrawal zones) within the conterminous United States.

Hydrogeologic Settings

Geospatial datasets of principal aquifers, secondary hydrogeologic regions, and overlying sediments including glacial sediment, coarse glacial sediment, and stream valley alluvium (alluvium) were merged to create a hydrogeologic setting dataset for the entire United States (fig. 1.1*A–I*). Principal aquifer designations and boundaries in the current [2021] geospatial dataset include changes that have occurred since extents of the principal aquifers were published in the Groundwater Atlas of the United States (Miller, 1999). For example, in the eastern United States, the Piedmont and Blue Ridge crystalline-rock aquifers were added (fig. 1.1*B*). The Pacific Northwest basaltic-rock aquifers were generalized by combining the northern California volcanic-rock aquifers, Pliocene and younger basaltic-rock aquifers, Miocene basaltic-rock aquifers, and volcanic and sedimentary-rock aquifers into one. The Pacific Northwest basin-fill aquifers were divided into separate Columbia Plateau basin-fill, Snake River basin-fill, and Pacific Northwest basin-fill aquifers. The Puget-Willamette Lowland aquifer system was also divided into the Puget Sound aquifer system (fig. 4*A*) and the Willamette lowland basin-fill aquifer.

The secondary hydrogeologic regions originally included three small areas with an “x” prefix (Belitz and others, 2019b) that were interpreted to be areas that likely should have been grouped with the corresponding principal aquifer. For this work, these areas were combined with the principal aquifers. The secondary hydrogeologic regions combined with principal aquifers were “xPuget Sound,” “xColorado Plateau,” and “xValley and Ridge” (fig. 4). Fifty-seven principal aquifers and 65 secondary hydrogeologic regions were intersected with glacial sediment, coarse glacial sediment, and alluvium overlying sediment data (fig. 5) to generate 288 distinct hydrogeologic setting areas (fig. 1.1*A–I*; table 2). Secondary hydrogeologic regions had more area with overlying sediment, including glacial sediment and coarse glacial sediment, but principal aquifers had more overlying alluvium (fig. 6*A* and *B*).

Principal aquifers cover about 20 percent more area of the United States than secondary hydrogeologic regions (table 2), but the same number of hydrogeologic settings (144) have been designated in each type of setting. Sandstone and unconsolidated deposits of sand and gravel make up the largest principal aquifer areas (15.1 and 18.7 percent, respectively), and sedimentary lithologies make up the largest area of secondary hydrogeologic regions (25.5 percent). Hydrogeologic settings with overlying sediment accounted for a large portion but less than half the total hydrogeologic setting areas.

Sources and Density of Well Data

Across the Nation, the sources and density of wells for which construction records show either depth or open interval data or both vary widely. National, regional, and State datasets, including NWIS, were useful for filling in gaps in States with little or no publicly available well data (table 1). Few data were available in several hydrogeologic settings, and in some hydrogeologic settings, no data were available for public-supply wells. Maps showing the density of well depth and open interval data (in terms of distance to nearest five wells with available data) illustrate the spatial variability of those data (figs. 2 and 3). Records for depth and open interval in domestic-supply wells outnumber those for public-supply wells by more than 17 to 1. About half the compiled well records for each well use have open interval information (table 1). Individual State datasets provided more data than all other sources combined.

The total number of well records (duplicates removed) from the five data sources with depth information was 5,737,122 for domestic-supply wells and 320,490 for public-supply wells (table 1). The average density of wells overall was 1.9 wells per square mile for domestic-supply wells and 0.11 well per square mile for public-supply wells (table 3), though the spatial distribution of the wells was variable.

Records for about 3.5 million domestic-supply wells and 174,000 public-supply wells included data sufficient to determine the length of open intervals (table 3). Because fewer well records were available with open interval length data compared with data for depth, the average density in the number of wells with open interval length data decreased to 1.2 wells per square mile for domestic-supply wells and 0.06 well per square mile per square mile for public-supply wells (table 3).

Large areas for which very few well data were available were identified throughout the country. Most of these areas coincide with regions of low population, but in some areas, any existing data were not publicly available or accessible. In the eastern United States, large swaths of mostly uninhabited forest in northwestern Maine, for example, had a very low well density (figs. 2*A* and *B*). Well density, or at least available data for wells, was also very low in southern Florida, western Alabama, and southeastern North Carolina (more than 50- to 100 km [31.1 to 62.1 mi] to encounter five domestic-supply wells). In the West, western Texas, southern and northeastern New Mexico, northwestern and southwestern Arizona, southeastern California, eastern Oregon, and most of Nevada and Utah had low well densities compared with other regions (figs. 2*A* and *B*). Overall, spatial patterns in actual domestic-supply well density closely matched those indicated with estimates of domestic-supply well density available from a previous study by Johnson and others (2019).

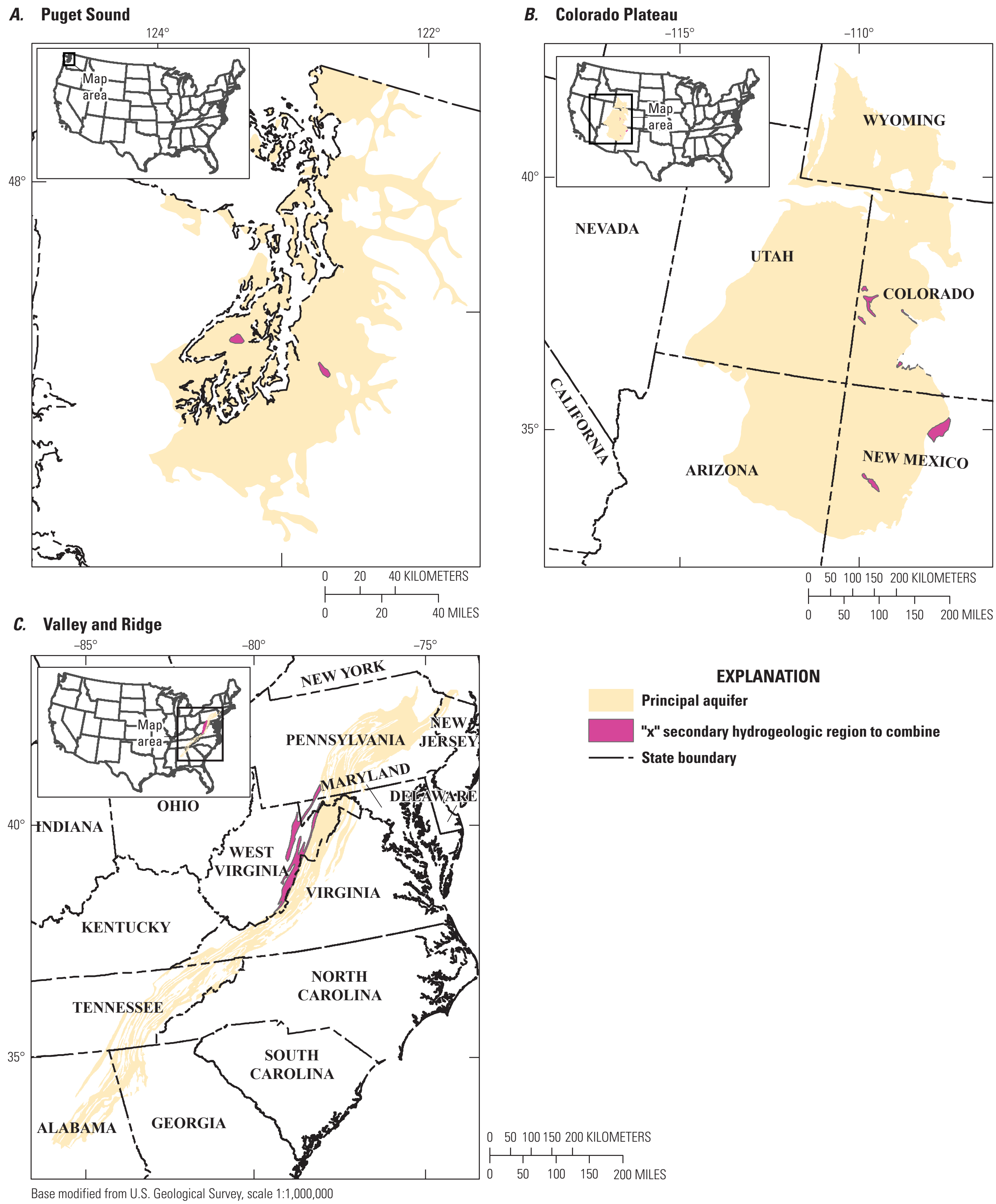


Figure 4. Maps showing examples of secondary hydrogeologic regions that were combined with principal aquifers in the *A*, Puget Sound, *B*, Colorado Plateau, and *C*, Valley and Ridge principal aquifers.

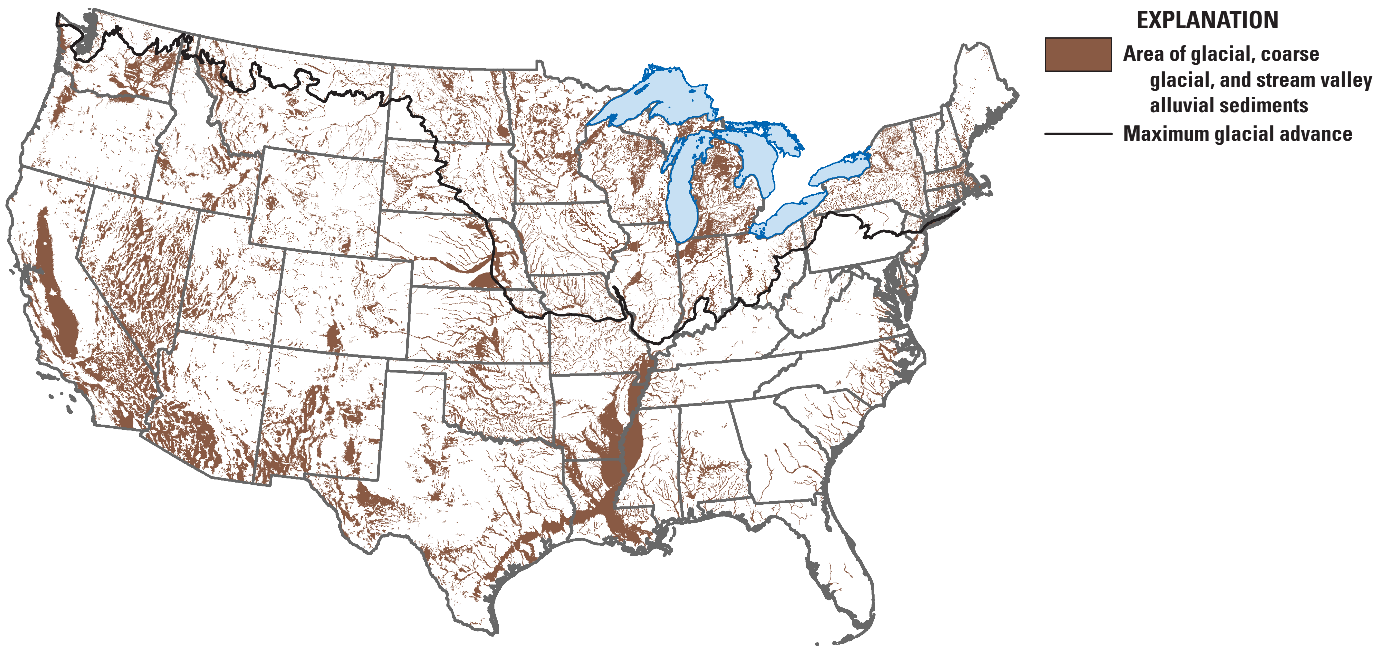


Figure 5. Map showing the locations of glacial, coarse glacial, and stream valley alluvial sediments in the conterminous United States.

Open interval data in general were not as widely available as depth data, and in some instances, records contained almost no data on open intervals. Records for domestic-supply in Oregon, Montana, New Mexico, and Texas included far less data on open intervals than records for domestic-supply wells in other parts of the conterminous United States (fig. 3*A*). Records for public-supply wells also had less open interval data in southeastern Oregon, Montana, Wyoming, New Mexico, western Arkansas, eastern Kansas, and northern New York than did records for domestic-supply wells in other parts of the conterminous United States (fig. 3*B*).

Records for several hydrogeologic settings had few domestic-supply-well data, and several other settings had no public-supply well data available. Hydrogeologic settings without public-supply well data include the Arbuckle-Simpson (with alluvium), Texas-Triassic, Front Range, Texas Cretaceous, Northern Rocky Mountains-S, and Blue Mountains areas (fig. 1.1*C*, *G*, and *I*). Parts of these aquifers without overlying sediments had public-supply well data, however, which were used to estimate public-supply open interval grids in areas with overlying sediments where data were not available, as described in the "Open Interval Depths and Lengths" section of this report. Data for fewer than 10 public-supply wells were available for several hydrogeologic settings. These include Cape Cod and islands–glacial, Roswell Basin aquifer system, Blue Mountains, and Ozarks Paleozoic and –X (with and without alluvium), Washington-Oregon coast ranges S and V, Ada-Vamoosa aquifer, Middle Rocky Mountains-X, Florida-T, north-central interior–PZ glacial, upper Tertiary aquifers, Texas-Pennsylvanian, Ordovician aquifers, Ouachita Mountains, north-central interior–PZ, and Northern Cascade Mountains hydrogeologic settings with alluvium (fig. 1.1*A*–I; Kauffman and others, 2021). In some hydrogeologic settings with small numbers of wells, wells were combined with those of similar hydrogeologic settings to calculate hydrogeologic setting median open interval depths and lengths. In other cases, where similar hydrogeologic settings were not available, as few as two wells were used to generate a median for a hydrogeologic setting.

Well data density was related with the presence of overlying sediment. More wells are in areas with overlying sediment even though most of the country does not have overlying sediment (fig. 6). In secondary hydrogeologic regions, the proportion of domestic-supply wells by overlying sediment type were similar to proportions of public-supply wells by sediment type, indicating both types of wells were installed in similar settings. Distributions of all wells by sediment type in principal aquifers were different from their distributions in secondary hydrogeologic regions (fig. 6*A* and *B*), but the distribution of domestic- and public-supply wells by sediment type within secondary hydrogeologic regions (fig. 6*D* and *F*) or within principal aquifers (fig. 6*C* and *E*) were similar. Principal aquifers have more domestic- and public-supply wells than secondary hydrogeologic regions, indicating that principal aquifers are more often used for a water supply than secondary hydrogeologic regions (table 3). Hydrogeologic settings with no overlying sediment have many more wells in principal aquifers than secondary hydrogeologic regions because the overlying sediment is often used as a water supply in secondary hydrogeologic regions (fig. 6*C*–*F*; tables 3 and 4).

Table 2. Numbers of hydrogeologic settings, and area, by lithology, for principal aquifers and secondary hydrogeologic regions.

Lithology of hydrogeologic setting	All hydrogeologic settings				No overlying sediments		Stream valley alluvium		Glacial sediment		Coarse glacial sediment	
	Number of regions	Number of settings	Area, in square miles	Percentage of total	Number	Area, in square miles	Number	Area, in square miles	Number	Area, in square miles	Number	Area, in square miles
Principal aquifers[1]												
Carbonate-rock aquifers	14	34	180,172	6	12	98,657	10	12,576	6	56,243	6	12,695
Igneous and metamorphic-rock aquifers	5	12	196,297	6.5	5	186,545	5	8,930	1	747	1	75
Sandstone and carbonate-rock aquifers	4	12	135,126	4.5	4	102,572	4	6,449	2	22,566	2	3,539
Sandstone aquifers	15	40	451,450	15.1	11	295,406	11	22,556	9	105,360	9	28,128
Semiconsolidated sand aquifers	5	10	251,124	8.4	5	191,313	5	59,811		—	—	—
Unconsolidated sand and gravel aquifers	14	36	561,438	18.7	14	332,437	14	211,732	4	11,398	4	5,871
Total	57	144	1,775,606	59.2	51	1,206,930	49	322,055	22	196,314	22	50,308
Secondary hydrogeologic regions[2]												
Crystalline	14	31	279,977	9.3	8	104,432	7	4,784	8	139,861	8	30,900
Mixed	4	7	106,142	3.5	4	93,114	3	13,028		—	—	—
Sedimentary	38	86	764,928	25.5	29	394,544	29	66,412	14	248,995	14	54,976
Volcanic	9	20	72,638	2.4	9	66,683	9	5,522	1	425	1	8
Total	65	144	1,223,685	40.8	50	658,773	48	89,746	23	389,281	23	85,884
All principal aquifers and secondary hydrogeologic regions												
Total	122	288	2,999,291	100	101	1,865,703	97	411,801	45	585,595	45	136,191

[1]Data are from Miller (1999).

[2]Data are from Belitz and others (2019b).

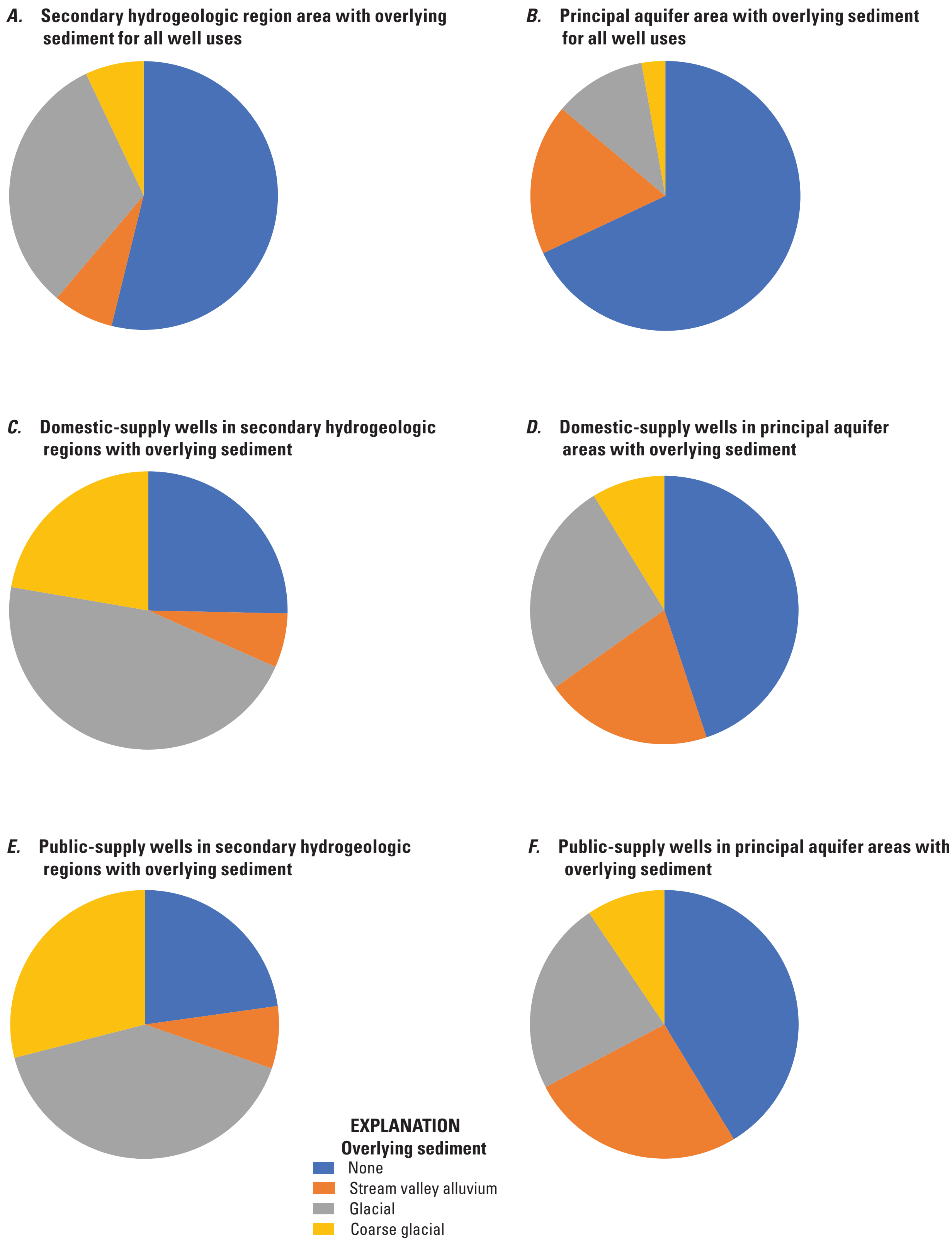


Figure 6. Pie charts showing the proportion of area with and without sediment overlying *A*, secondary hydrogeologic regions; *B*, principal aquifers; and proportion of wells in areas with and without overlying sediment for *C*, domestic-supply wells in hydrogeologic settings, *D*, domestic-supply wells in principal aquifers *E*, public-supply wells in secondary hydrogeologic regions, and *F*, public-supply wells in principal aquifers in the conterminous United States.

Table 3. Number and density of wells, and median values for depths to top and bottom, and lengths of open interval, by type of region and lithology for all wells and wells in hydrogeologic settings without overlying sediment for domestic- and public-supply wells.

Lithology of hydrogeologic setting	All wells							Wells with no overlying sediments				
	Number of wells		Density, in wells per square mile		Open interval median, in feet			Number of wells		Open interval median, in feet		
	With open interval	With depth	Open interval	Depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length
Domestic-supply wells												
Principal aquifers												
Carbonate-rock aquifers	504,339	686,995	2.8	3.81	82	160	60	254,154	275,616	84	230	130
Igneous and metamorphic-rock aquifers	164,178	285,700	0.84	1.46	52	200	144	160,764	238,293	52	205	145
Sandstone and carbonate-rock aquifers	139,516	239,415	1.03	1.77	60	175	85	70,241	132,760	52	205	116
Sandstone aquifers	677,822	884,617	1.5	1.96	84	138	25	154,136	240,919	80	180	83
Semiconsolidated sand aquifers	334,588	523,756	1.33	2.09	140	160	10	269,102	413,791	137	156	10
Unconsolidated sand and gravel aquifers	312,434	1,005,095	0.56	1.79	110	142	34	139,368	324,134	100	160	40
Total	2,132,877	3,625,578	1.2	2.04	84	150	31	1,047,765	1,625,513	83	184	58
Secondary hydrogeologic regions												
Crystalline	525,947	750,183	1.88	2.68	57	150	48	47,327	146,782	90	204	60
Mixed	27,854	58,607	0.26	0.55	135	250	60	20,253	47,343	130	255	66
Sedimentary	795,318	1,242,307	1.04	1.62	78	105	10	158,791	288,839	80	145	45
Volcanic	7,233	72,355	0.1	1	100	164	40	5,045	53,198	110	180	40
Total	1,356,352	2,123,452	1.11	1.74	69	122	10	231,416	536,162	83	172	50
All wells												
Total	3,489,229	5,749,030	1.16	1.92	80	142	21	1,279,181	2,161,675	83	180	56

Table 3. Number and density of wells, and median values for depths to top and bottom, and lengths of open interval, by type of region and lithology for all wells and wells in hydrogeologic settings without overlying sediment for domestic- and public-supply wells.—Continued

Lithology of hydrogeologic setting	All wells							Wells with no overlying sediments				
	Number of wells		Density, in wells per square mile		Open interval median, in feet			Number of wells		Open interval median, in feet		
	With open interval	With depth	Open interval	Depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length
Public-supply wells												
Principal aquifers												
Carbonate-rock aquifers	19,044	33,254	0.11	0.18	102	205	80	7,533	12,625	107	256	121
Igneous and metamorphic-rock aquifers	8,270	14,391	0.04	0.07	65	260	221	7,276	11,840	65	275	228
Sandstone and carbonate-rock aquifers	4,759	9,468	0.04	0.07	93	242.5	110	2,818	4,947	104.5	305	133
Sandstone aquifers	26,310	38,820	0.06	0.09	100	175	46	4,264	7,712	93	300	182
Semiconsolidated sand aquifers	27,888	39,960	0.11	0.16	311	384	40	20,271	28,935	320	390	40
Unconsolidated sand and gravel aquifers	31,981	79,416	0.06	0.14	200	245	96	10,189	22,827	164	260	100
Total	118,252	215,309	0.07	0.12	148	245	63	52,351	88,886	166	300	80
Secondary hydrogeologic regions												
Crystalline	14,005	29,914	0.05	0.11	60	148	20	1,220	3,694	90	248	70
Mixed	2,077	3,079	0.02	0.03	120	300	130	1,437	2,264	115	300	137
Sedimentary	39,482	69,616	0.05	0.09	90	125	15	7,987	15,926	153	300	80
Volcanic	568	3,277	0.01	0.05	83	156	64.5	417	2,160	85	168	69
Total	56,132	105,886	0.05	0.09	81	135	20	11,061	24,044	132	270	81
All wells												
Total	174,384	321,195	0.06	0.11	118	202	49	63,412	112,930	160	300	80

Table 4. Numbers of wells with median values for depth to top and bottom, and length of open interval by type of region and lithology, for wells with overlying sediment for domestic- and public-supply wells.

[—, no data]

Lithology of hydrogeologic setting	Alluvial valley overlying sediment					Glacial overlying sediment					Coarse glacial overlying sediment				
	Number of wells		Open interval median, in feet			Number of wells		Open interval median, in feet			Number of wells		Open interval median, in feet		
	With open interval	With depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length
Domestic-supply wells															
Principal aquifers															
Carbonate-rock aquifers	14,562	20,779	84	255	185	181,648	306,109	79	140	24	52,674	83,713	67	105	8
Igneous and metamorphic-rock aquifers	2,946	31,302	71.25	180	60	375	14,482	61	150	106	89	1,458	82	150	25
Sandstone and carbonate-rock aquifers	995	3,307	83	172	40	61,571	90,845	61	145	62	6,687	12,160	70	117	36
Sandstone aquifers	25,348	44,083	87	110	30	327,331	402,500	88	140	22	170,688	195,005	82	104	8
Semiconsolidated sand aquifers	65,477	109,639	168	180	10	—	—	—	—	—	—	—	—	—	—
Unconsolidated sand and gravel aquifers	160,532	524,948	120	145	30	9,692	127,135	107	117	5	2,783	27,049	68.3	91	15
Total	269,860	734,058	122	150	20	580,617	941,071	83	138	27	232,921	319,385	79	104	8
Secondary hydrogeologic regions															
Crystalline	3,486	23,589	88	135	40	340,684	411,108	51	161	100	134,318	165,638	60	90	5
Mixed	7,589	11,170	140	225	44	—	—	—	—	—	—	—	—	—	—
Sedimentary	37,196	82,197	42	70	20	344,087	561,969	82	110	8	253,704	306,318	75	85	5
Volcanic	2,001	16,752	88	140	25	167	2,127	78	120	9	4	65	77.25	105	24
Total	50,272	133,708	55	100	20	684,938	975,204	65	127	10	388,026	472,021	70	87	5
All domestic-supply wells															
Total	320,132	867,766	110	144	20	1,265,555	1,916,275	74	132	20	620,947	791,406	72	94	5

Table 4. Numbers of wells with median values for depth to top and bottom, and length of open interval by type of region and lithology, for wells with overlying sediment for domestic- and public-supply wells.—Continued

[—, no data]

Lithology of hydrogeologic setting	Alluvial valley overlying sediment					Glacial overlying sediment					Coarse glacial overlying sediment				
	Number of wells		Open interval median, in feet			Number of wells		Open interval median, in feet			Number of wells		Open interval median, in feet		
	With open interval	With depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length	With open interval	With depth	Depth to top	Depth to bottom	Length
Public-supply wells															
Principal aquifers															
Carbonate-rock aquifers	601	1,096	200	301	115	7,572	13,674	104	208	74	3,310	5,843	82	135	25
Igneous and metamorphic-rock aquifers	375	1,760	100	202	148	533	675	57	248	191	86	107	81.2	138	29
Sandstone and carbonate-rock aquifers	176	394	125	215	55	1,373	3,149	77	210	101	391	965	65	101	30
Sandstone aquifers	1,099	2,145	71	110	35	12,478	17,514	105	180	50	8,465	11,286	92.8	130	20
Semiconsolidated sand aquifers	7,617	11,017	294	370	40	—	—	—	—	—	—	—	—	—	—
Unconsolidated sand and gravel aquifers	19,342	39,323	235	312	108	2,028	15,118	170	150	12	421	2,057	85	102	20
Total	29,210	55,735	240	313	71	23,984	50,130	105	180	53	12,673	20,258	89	127	20
Secondary hydrogeologic regions															
Crystalline	268	1,011	96.85	120	46	7,356	15,551	59	187	50	5,160	9,466	58	85	10
Mixed	640	814	130	300	120	—	—	—	—	—	—	—	—	—	—
Sedimentary	2,249	5,182	58	88	20	14,886	27,193	97	133	11	14,308	21,113	75	87	10
Volcanic	138	889	80	140	60	12	209	73	120	10	1	9	29	43	10
Total	3,295	7,896	78	120	40	22,254	42,953	83	148	15	19,469	30,588	70	87	10
All domestic-supply wells															
Total	32,505	63,631	220	295	67	46,238	93,083	95	165	30	32,142	50,846	76	100	11

Open Interval Depths and Lengths

All 6.1 million wells for which data were included in this study had depth information, but 40 percent were missing open interval data (table 1). The median depths to the bottom of the open interval were 142 ft (43.3 m) for domestic-supply wells and 202 ft (61.6 m) for public-supply wells (table 3). The median open interval length was 21 ft (6.4 m) for domestic-supply wells and 49 ft (14.9 m) for public-supply wells (table 3). Most of the median depths (fig. 7) and open interval lengths (fig. 8) of supply wells in secondary hydrogeologic region areas were shallower and of shorter length than those in the principal aquifers; this pattern is more evident in the wells with overlying sediment. Overall and when grouped by rock type and overlying sediment type, the median length of the open interval in domestic-supply wells was generally shorter than that in public-supply wells for the same grouping, with a few exceptions such as for wells in crystalline rock aquifers with overlying glacial sediment (fig. 8; table 4). Open interval values had inconsistent or scattered relations with depth, but the patterns varied by hydrogeologic setting and were more consistent when examined by hydrogeologic settings. This made it possible to estimate open intervals in hydrogeologic settings where data were sparse (table 3). Open interval data were critical to the development of the top depth and length of the open interval grids.

Median well depths and lengths of open intervals in records for domestic- and public-supply wells varied with similar patterns by lithology of the hydrogeologic setting (fig. 1.1) and type of overlying sediment, but were different in a few discrete areas (figs. 9, 10, and 11; table 4). Overall, the median bottom depths of open intervals for public-supply wells in each major rock type in principal aquifers are deeper than those in domestic-supply wells (fig. 7*A* and *B*; table 3). The median depths of domestic- and public-supply wells in crystalline and volcanic rock types in secondary hydrogeologic regions are similar; however, the public-supply well depth is slightly less (table 3). Also, the median open interval bottom depth for wells completed in areas with overlying glacial sediment were greater than those with overlying coarse glacial sediment (fig. 7; table 4). Looking at principal aquifer lithology, the median open interval bottom depth for wells completed in carbonate rock aquifers was greater if they had overlying stream valley alluvium, because well installers likely drilled through the alluvium and targeted these deeper, generally more highly productive formations (table 4).

Domestic-supply wells in hydrogeologic settings with overlying glacial sediment were deepest when completed in crystalline rocks. Domestic-supply wells completed in semiconsolidated sand had the shortest median open interval in hydrogeologic settings without overlying sediments. Domestic-supply wells completed in carbonate rocks had the longest median open intervals in hydrogeologic settings with overlying alluvium. Where coarse glacial sediment was present above sedimentary and crystalline rocks, median open interval lengths for domestic-supply wells were the shortest.

The median public-supply well open interval was shortest when wells were drilled in hydrogeologic settings with sedimentary lithology with overlying glacial sediment and coarse glacial sediment (table 4). Public-supply wells drilled in areas without overlying sediments had the shortest open intervals in hydrogeologic settings with semiconsolidated sand aquifers. The longest median lengths of open intervals in public-supply wells were for wells in igneous and metamorphic rocks, perhaps owing to their low porosity and few interconnected water-bearing fractures.

The data required to generate grids of the depth to the top and length of open intervals were not widely available. Records for more than half of the wells in some datasets used in this study, such as the domestic-supply well NGA dataset (table 1), were missing open interval data. When examining open interval bottom depth versus length, some hydrogeologic settings had narrow data distributions whereas others had large departures from the median. Some CDFs showed significant increases in open interval top depths where hydrogeologic settings had overlying sediment (tables 1.1 and 1.2; Kauffman and others, 2021). Some open interval fitting equations produced exaggerated estimates of open interval lengths. Most bedrock wells completed with open boreholes had a 1:1 slope of open interval bottom depth to open interval length with an offset that varied with the presence of overlying sediment (Kauffman and others, 2021). In general, the slope of that relation was lower in hydrogeologic settings with overlying stream valley alluvium. Wells completed in unconsolidated or semiconsolidated material commonly had bimodal (or multimodal) relations of depth to the bottom to length of open interval, and estimates of open interval length included multiple modes representing multiple withdrawal zones. For example, the Basin and Range basin-fill aquifer and the Basin and Range basin-fill aquifer with overlying alluvium have two slightly different bimodal relations of open interval length to open interval bottom depth for domestic-supply wells (fig. 12*A* and *B*).

Drinking Water Supply Open Interval Grids

Grids representing the positions of open intervals of typical domestic- and public-supply wells were developed to support large regional or national scale water-resource and water-quality investigations. Three grids were created for both domestic- and public-supply wells: depth to top of open interval (fig. 13), depth to bottom of the open interval (fig. 14), and median length of open interval (fig. 15). In less populated States, such as Arizona and South Dakota, some large areas with minor variation in open interval depths and lengths are related to differences in data density, which are apparent in both well-use type maps.

The typical-well open interval grids vary by hydrogeologic setting. For example, domestic- and public-supply wells are deep in South Dakota because they must be drilled through low-permeability shales to reach the underlying productive

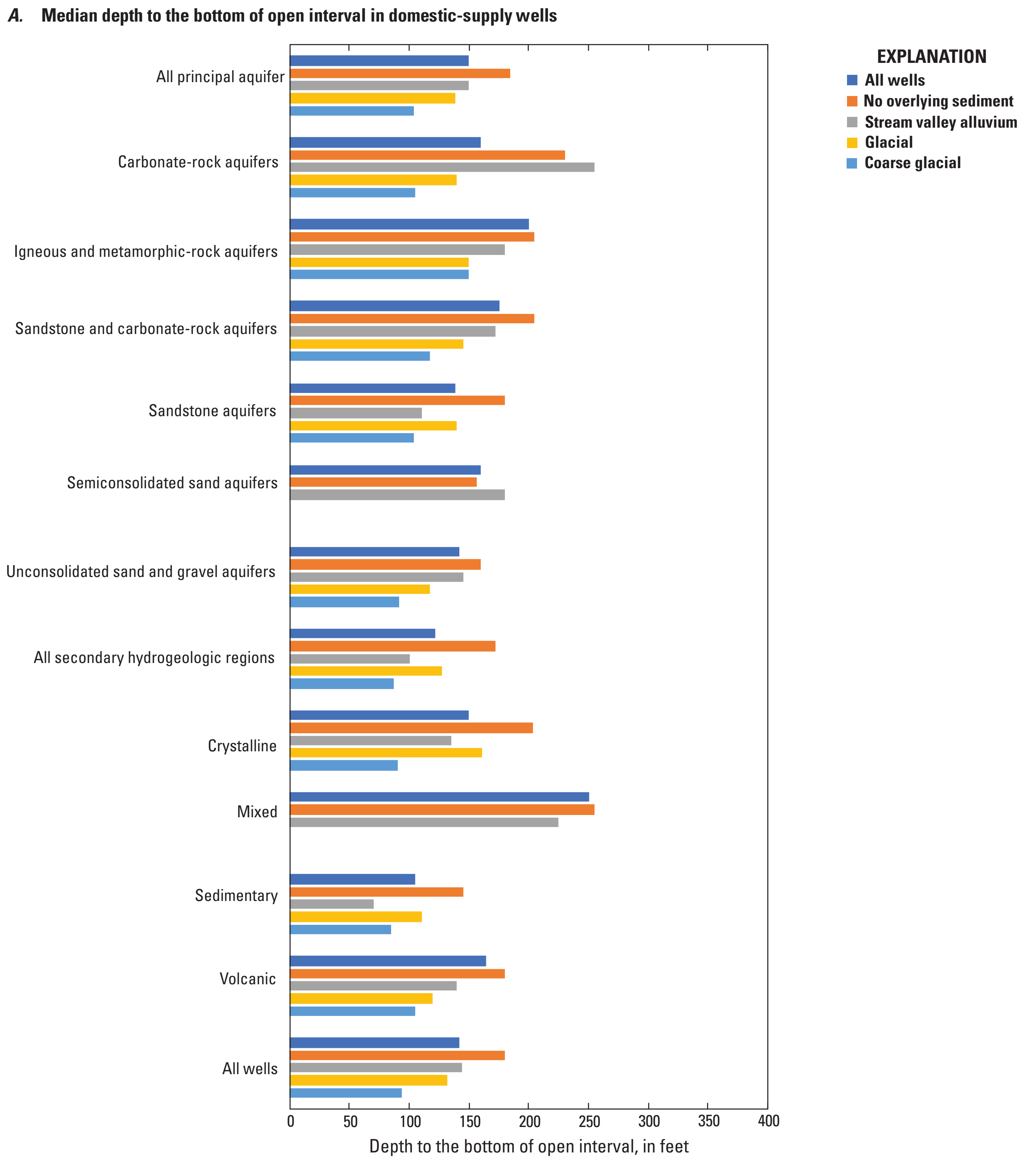


Figure 7. Bar graphs showing the median depth to the bottom of open interval in wells used for drinking water, by lithology and with and overlying sediment, for *A*, domestic- and *B*, public-supply wells in the conterminous United States.

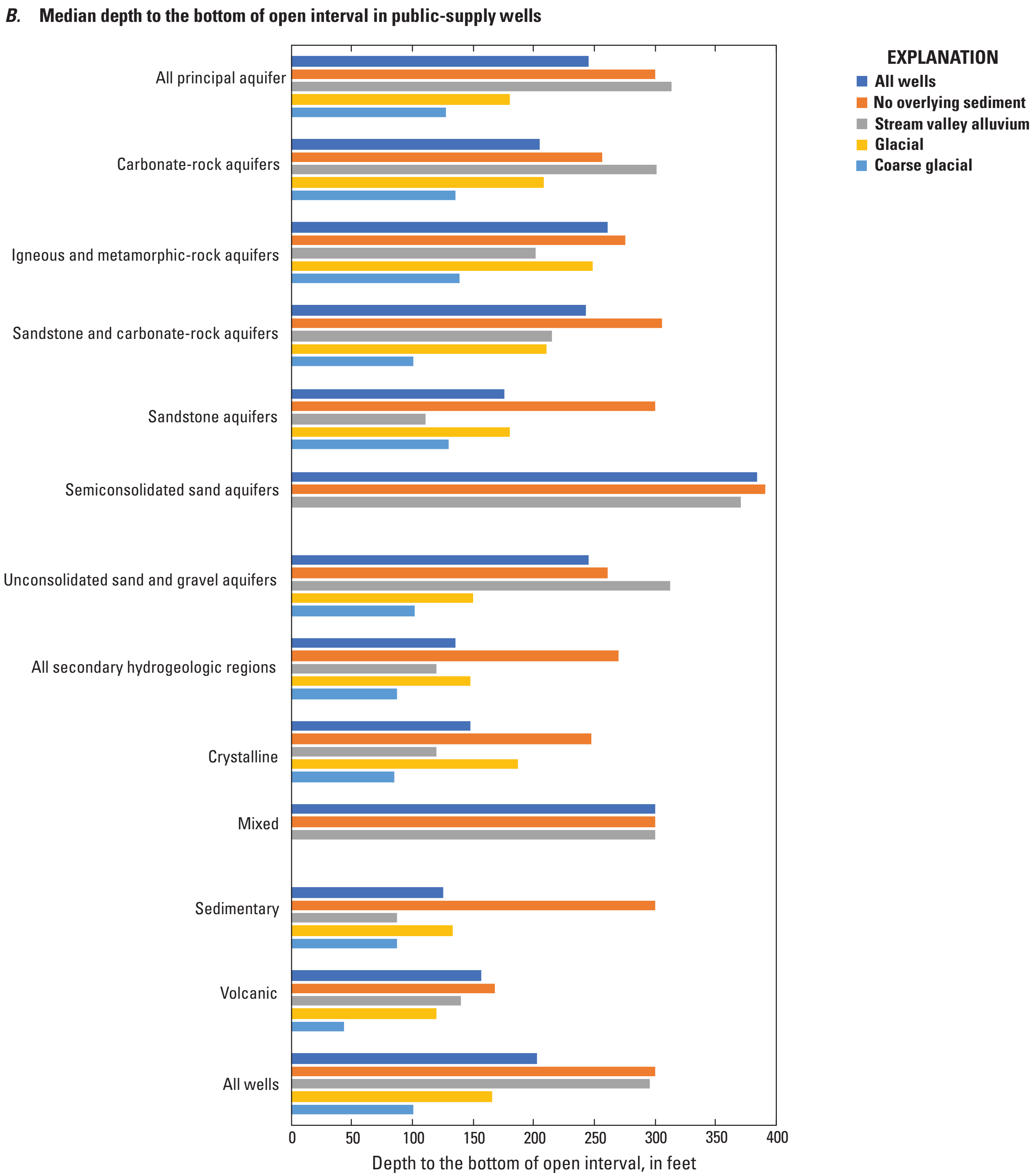


Figure 7.—Continued

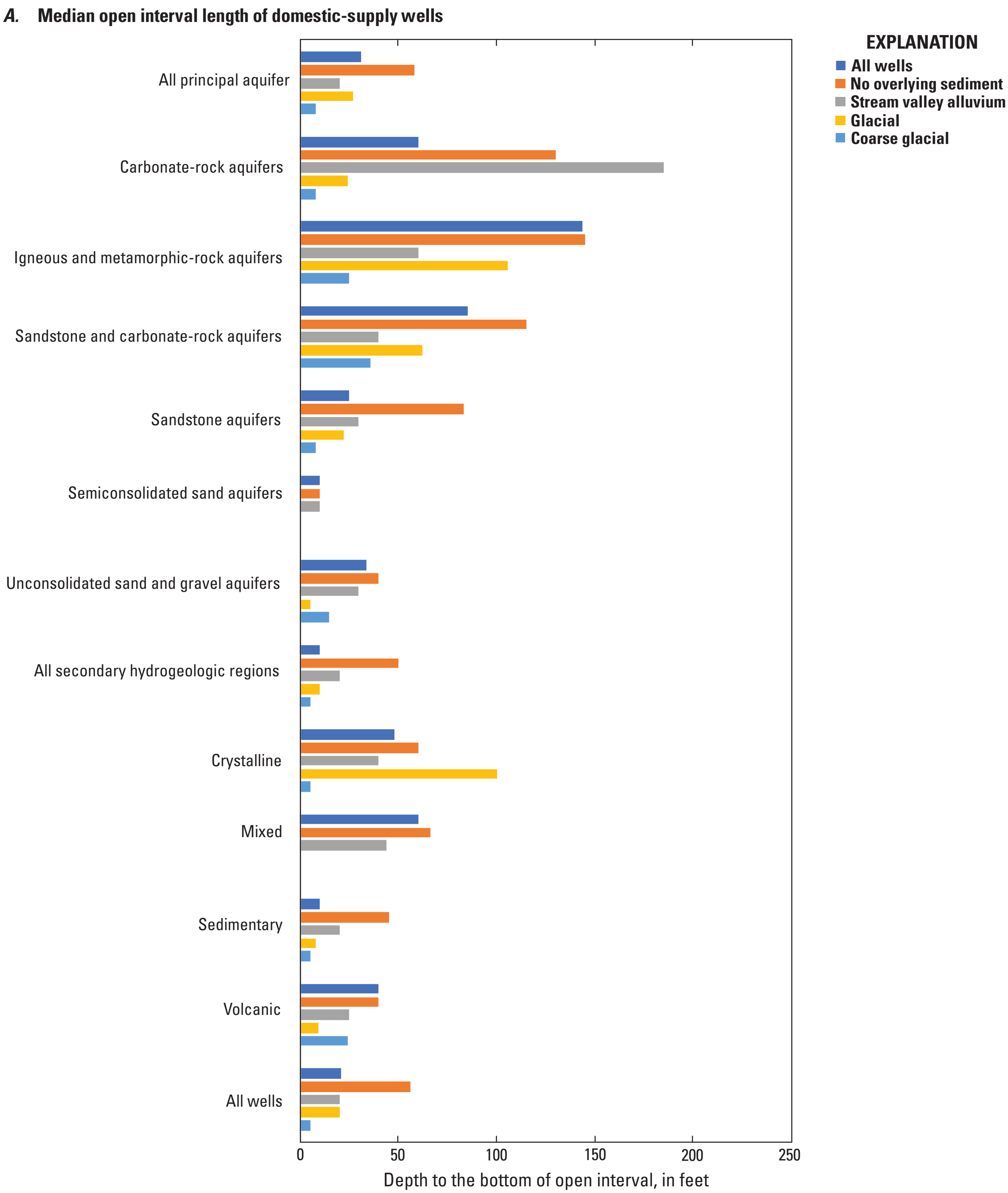


Figure 8. Bar graphs showing the median length of the open interval in wells used for drinking water, by lithology and overlying sediment, for *A*, domestic- and *B*, public-supply wells in the conterminous United States.

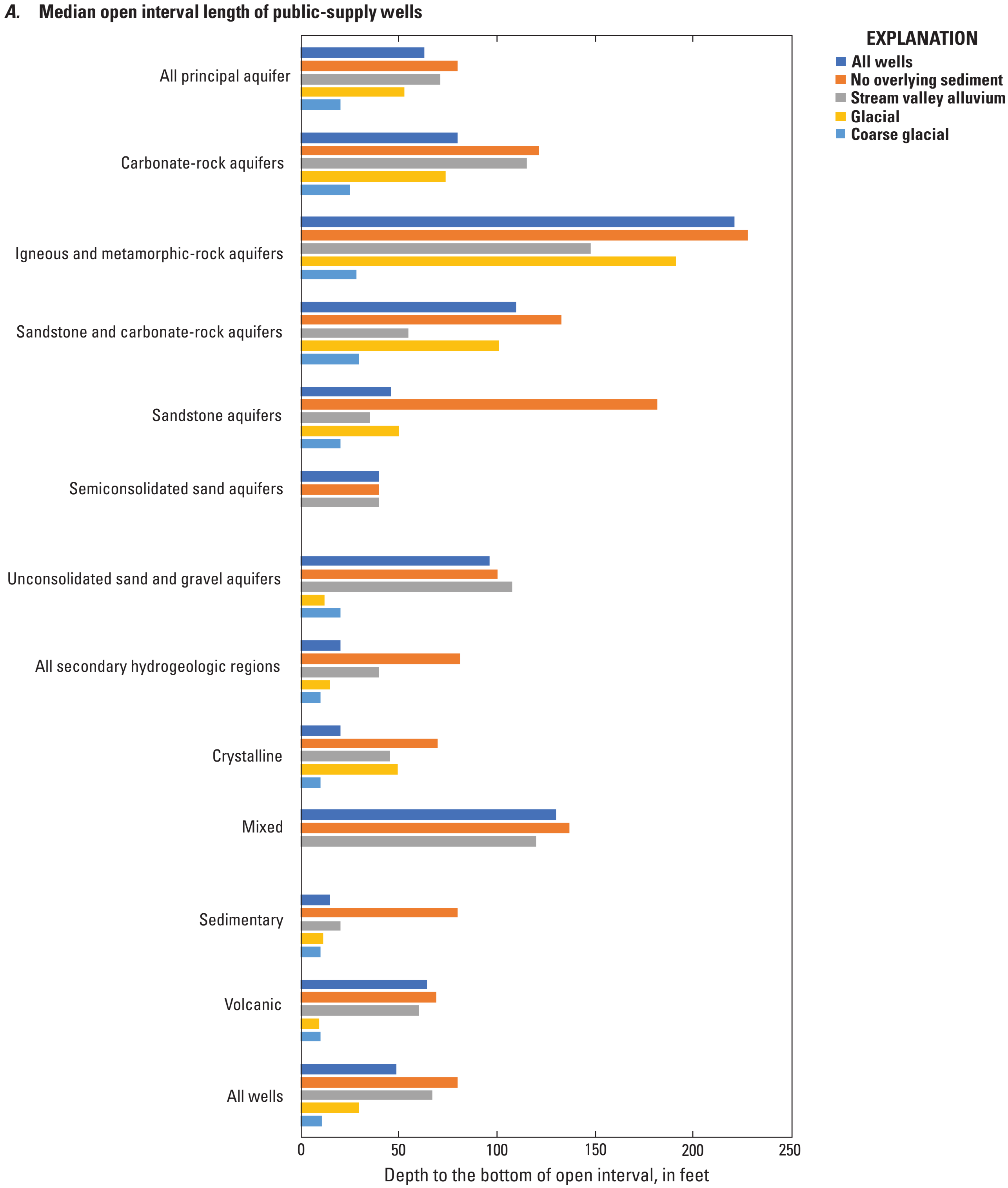


Figure 8.—Continued

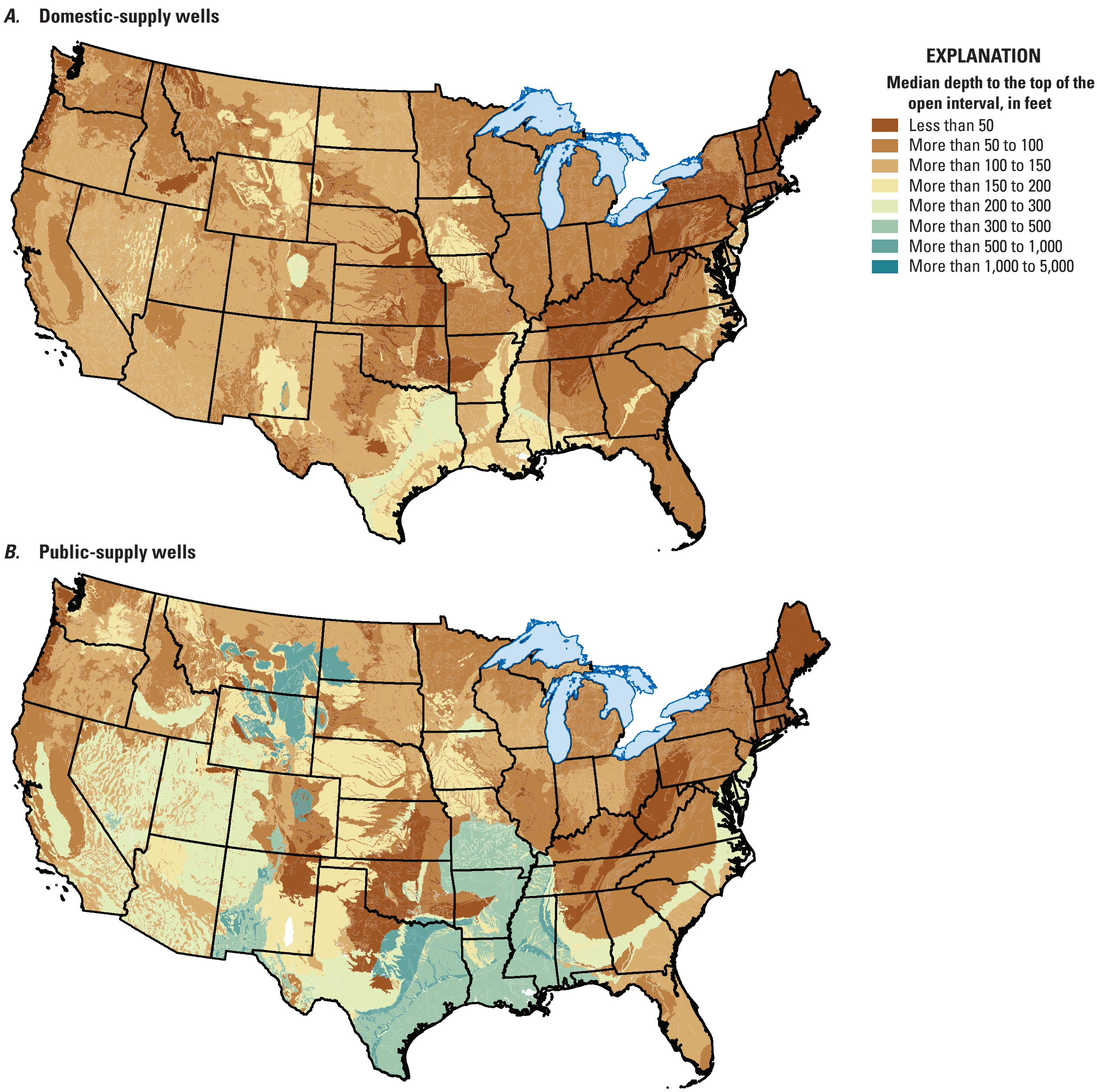
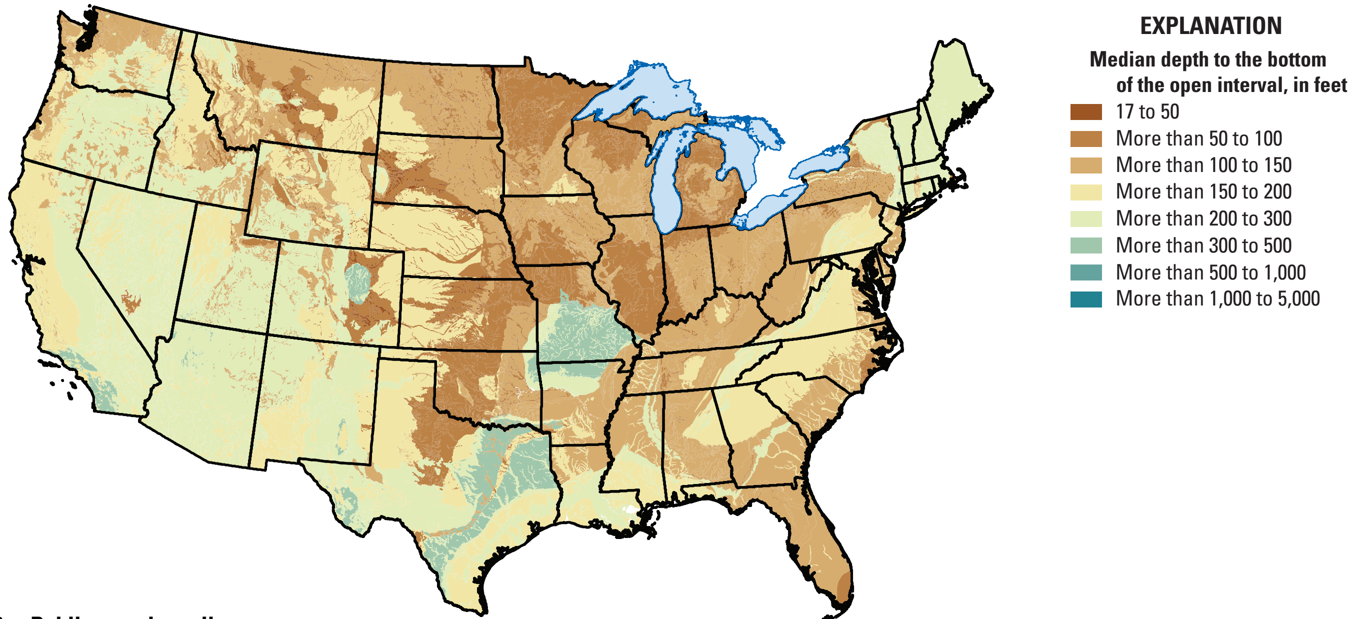


Figure 9. Maps showing the median depth to the top of the open interval of wells used for drinking water for each hydrogeologic setting by *A*, domestic- and *B*, public-supply wells in the conterminous United States. Hydrogeologic setting names and locations are identified in figure 1.1 of this report.

A. **Domestic-supply wells**



B. **Public-supply wells**

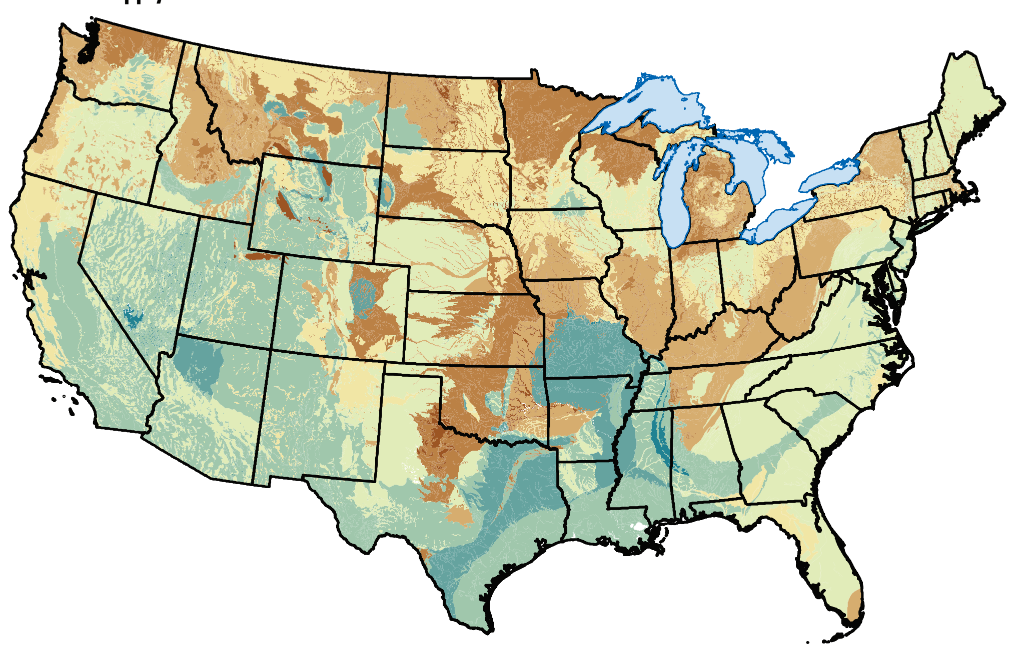


Figure 10. Maps showing the median depth to the bottom of the open interval of wells used for drinking water for each hydrogeologic setting by *A*, domestic- and *B*, public-supply wells in the conterminous United States. Hydrogeologic setting names and locations are identified in figure 1.1 of this report.

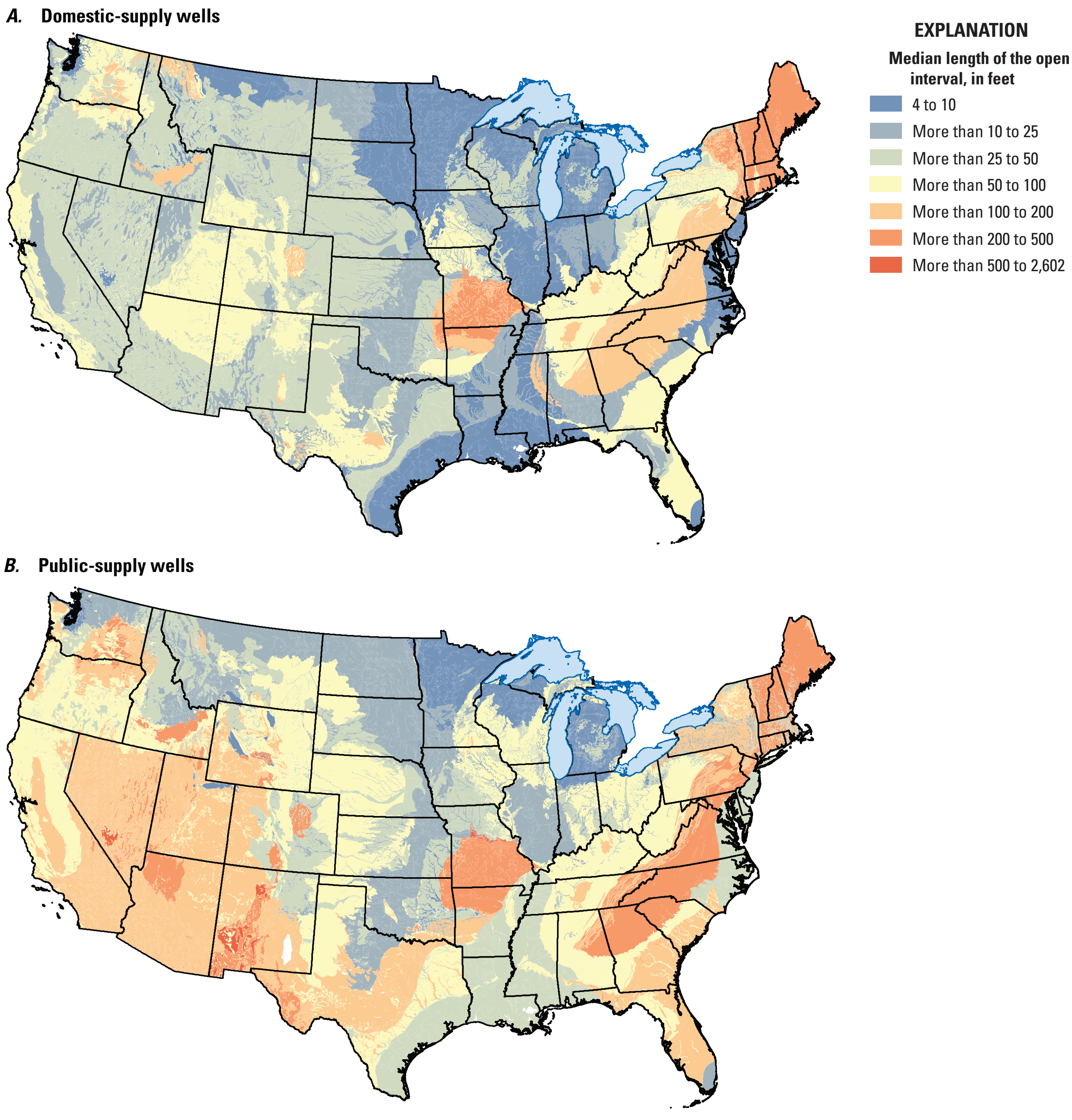


Figure 11. Maps showing the median length of the open interval in wells used for drinking water for each hydrogeologic setting by *A*, domestic- and *B*, public-supply wells in the conterminous United States. Hydrogeologic setting names and locations are identified in figure 1.1 of this report.

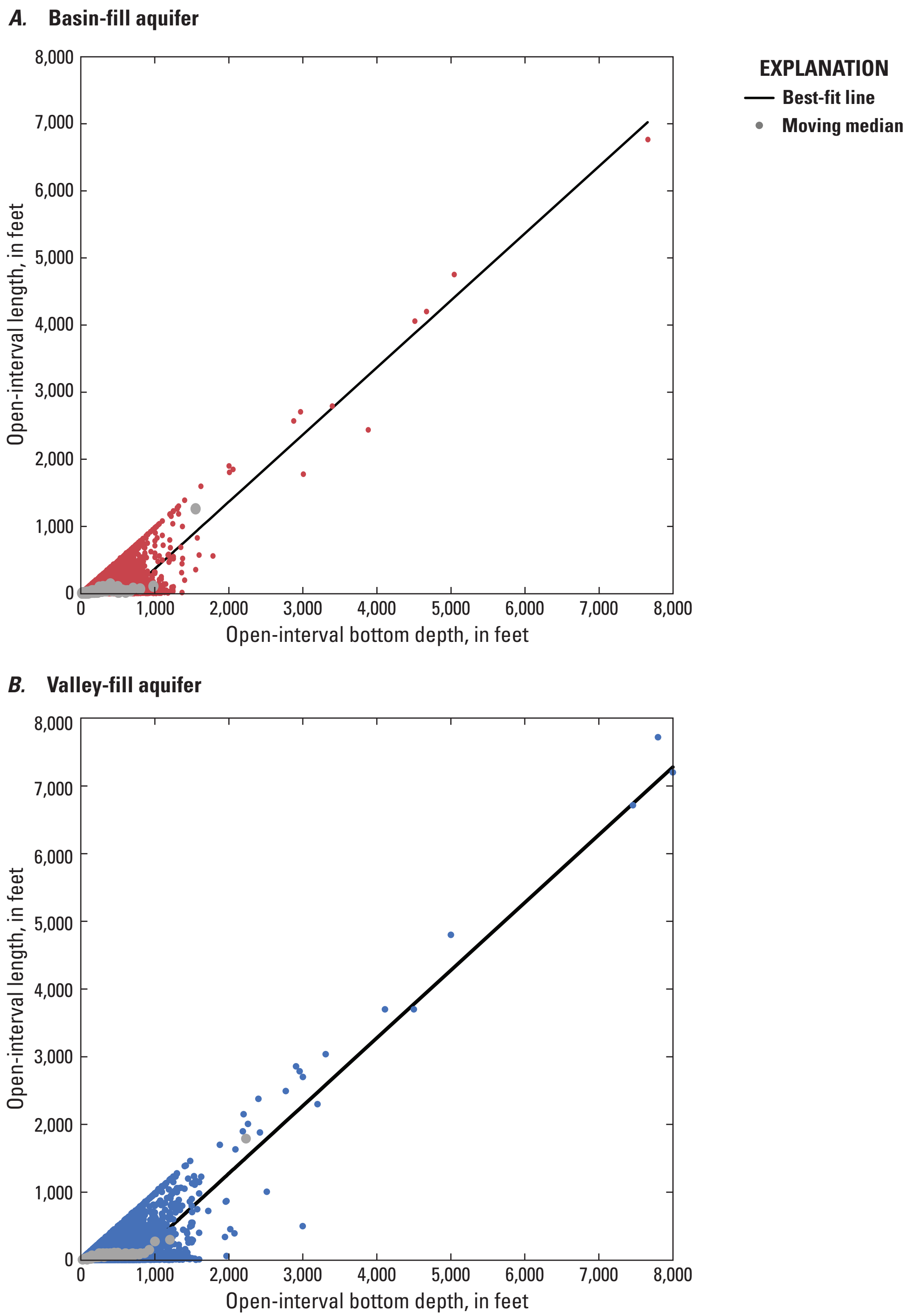


Figure 12. Graphs showing an example of a bimodal relation between open interval length and well depth (best fit shown with black line) for domestic-supply wells in the *A*, Basin and Range basin-fill aquifer and *B*, Basin and Range basin-fill aquifer with overlying stream valley alluvium, in the conterminous United States. Hydrogeologic setting names and locations are identified in fig. 1.1*H* of this report.

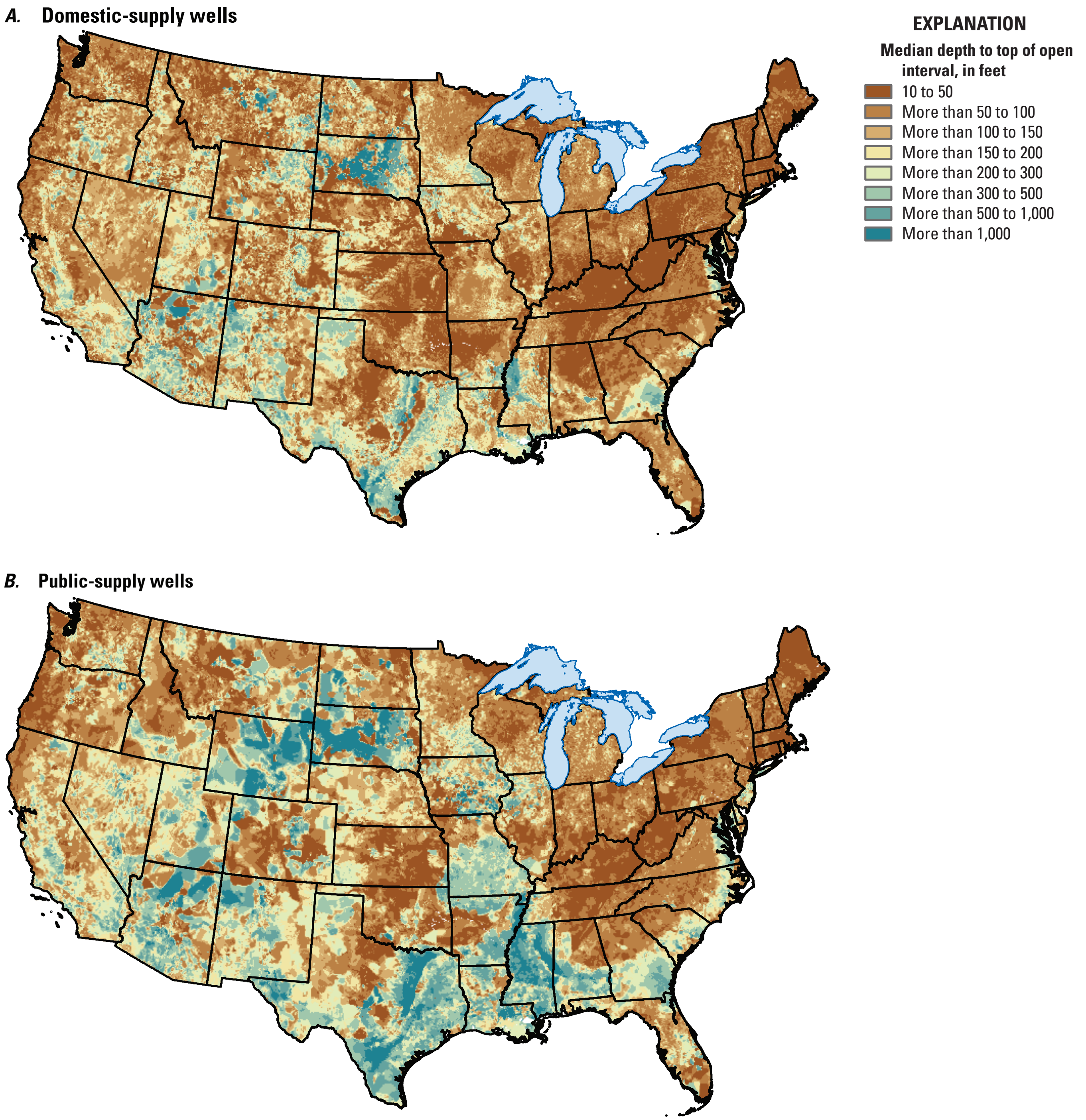


Figure 13. Maps showing the moving median of the depth to the top of the open interval of *A*, domestic- and *B*, public-supply wells in the conterminous United States. The grids in these maps are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

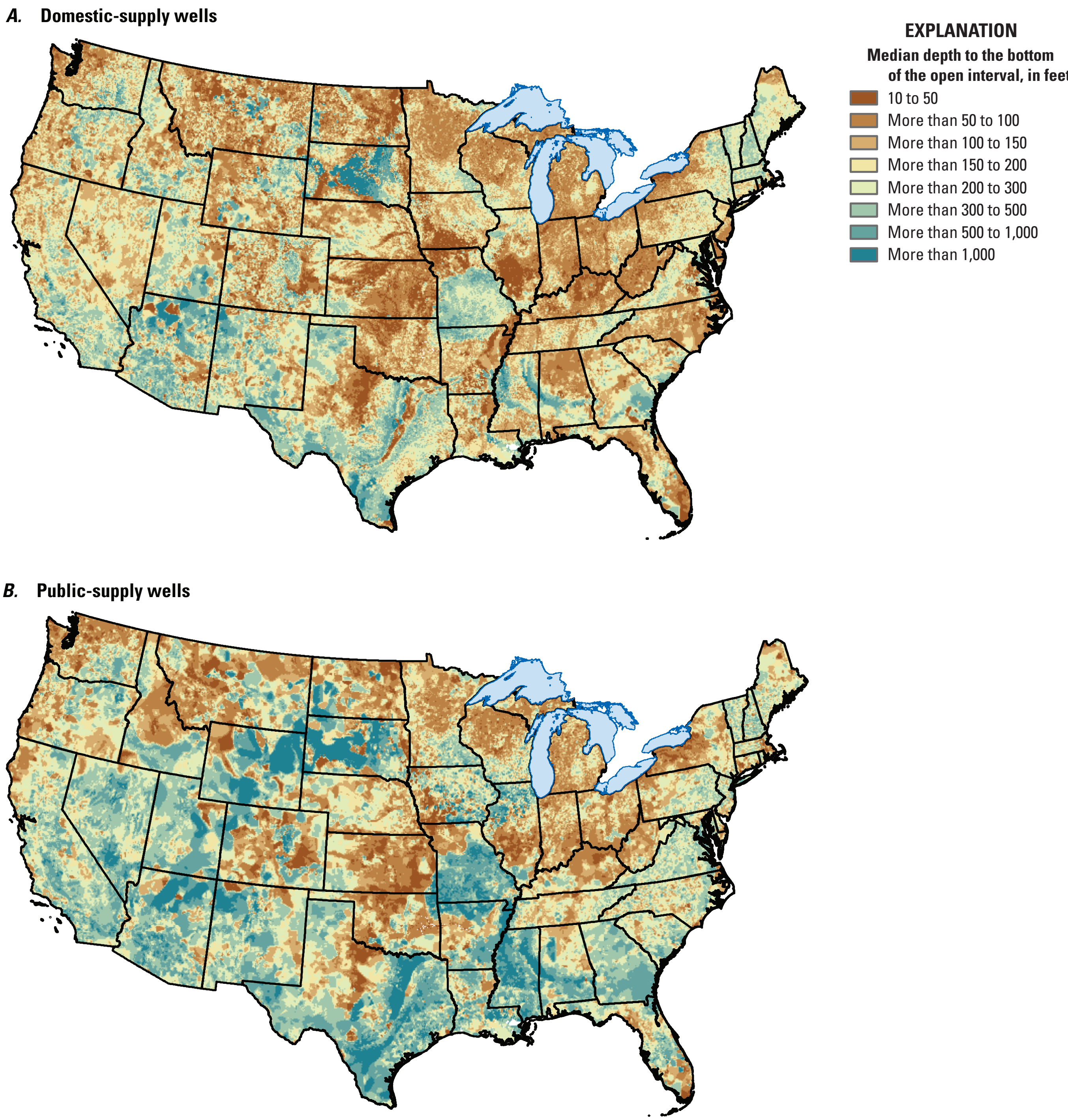


Figure 14. Maps showing the moving median of the depth to the bottom of the open interval of *A*, domestic- and *B*, public-supply wells in the conterminous United States. The grids in these maps are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

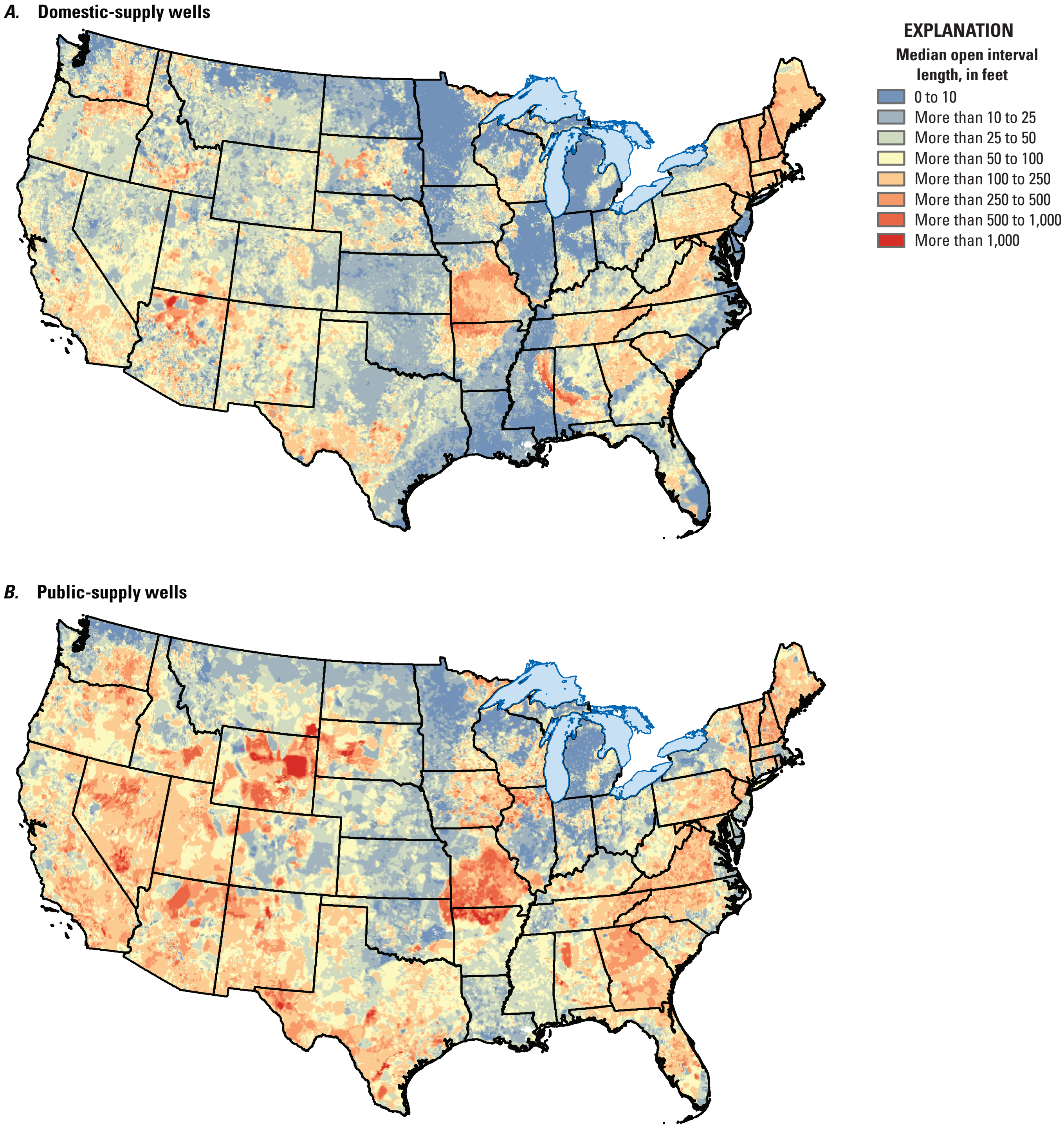


Figure 15. Maps showing the moving median of the open interval length of *A*, domestic- and *B*, public-supply wells in the conterminous United States. The grids in these maps are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

water-bearing rocks. Therefore, the smoothed interpolated grids reflect the underlying data. Similarly, open interval depths and lengths in the Ozarks karst system centered in Missouri were among the deepest and longest in the United States, which is reflected in the interpolated grids (figs. 13–15 and 1.1). In contrast, the top and bottom of the open intervals of typical wells are shallow in areas of Nebraska and Kansas in the alluvial valley hydrogeologic setting (figs. 13 and 14). Shorter open intervals are evident in the open interval grids in the North Atlantic and Southeast Coastal Plain, Coastal Lowlands, Mississippi Embayment, and the High Plains principal aquifers and in much of the glaciated area where wells produce water from thin permeable layers (figs. 15 and 1.1).

Patterns in the difference in the typical-well open interval grids help identify areas where domestic- and public-supply wells might produce water from a different aquifer or from different parts of the same aquifer within a hydrogeologic setting (fig. 16). Information regarding where different resources may be in use could help improve our understanding of differences in water quality or availability. In addition, these spatial patterns in the grids take the shape of recognizable geologic formations where higher densities of wells exist. In general, public-supply wells are deeper and have longer open intervals than domestic-supply wells; however, this might not be the case in areas where the shallow overlying alluvium, glacial sediment, or coarse glacial sediment are the most productive aquifers. Some of these features are of limited areal extent and therefore can be more easily targeted by municipalities with greater flexibility in the selection of well location than individual homeowners on small properties. Such areas are most prevalent in the northern glaciated and western mountainous regions of the United States.

Domestic Supply

At the national scale, some principal aquifer extents are identifiable in the domestic-supply well grid patterns, such as the deeper top and bottom grids in the Denver Basin in east-central Colorado (figs. 13 and 14). In the east, banding associated with the Piedmont and Blue Ridge principal aquifer in the domestic-supply well bottom-depth grid can be seen when zoomed in to New Jersey, Pennsylvania, and Virginia (fig. 13*A* and 14*A*). Deep domestic-supply wells are indicated by a visibly deep depth grid in the Imperial Valley, California, on the eastern half of the southern border with Mexico (fig. 13*A*).

Public Supply

At the national scale, the extents of some large principal aquifers are identifiable in depth patterns (figs. 13*B* and 14*B*) in the public-supply well grid patterns, such as those for the Basin and Range principal aquifers in Nevada (alternating shallow and deep bands) and Colorado Plateaus (relatively shallow area). The well-density-dependent smoothing factor pattern is observable as artifacts (such as straight lines or large polygons in the grid with the same value) in the public-supply well grids at the national scale in a triangular area between western North Dakota, northwestern Texas, and Idaho where the data are not as dense (figs. 13*B*, 14*B*, and 15*B*). Many principal aquifers are distinguished by a characteristic depth that is reflected in the grids. For example, the High Plains aquifer is observable as an area of shallower wells in the public-supply well grid in north central Texas, Oklahoma, and Kansas (figs. 13*B*, 14*B*, and fig. 1.1). Similarly, the outline of the Coastal Lowlands, Mississippi Embayment, Southeastern Coastal Plain and Northern Atlantic Coastal Plain principal aquifers is apparent in the public-supply well top of open interval grid as a deep zone of drinking-water supplies (figs. 14*B* and 1.1). A deep anomaly in the grid extends from South Dakota through Wyoming, Utah, and Arizona (figs. 13*B* and 14*B*). The Edwards-Trinity principal aquifer in Texas appears as a relatively deep area in the public-supply well open interval grids (figs. 13*B*, 14*B*, and 1.1).

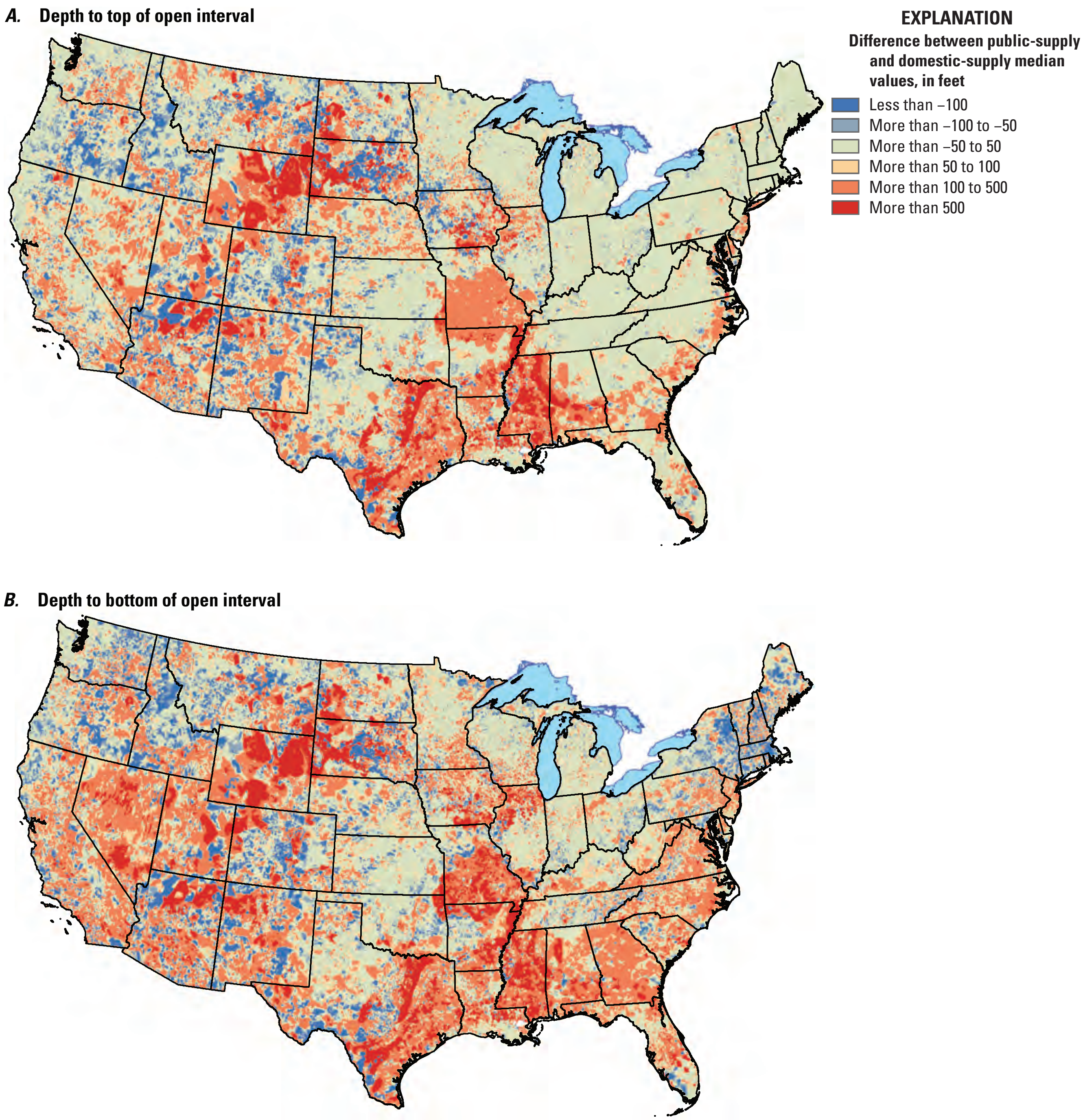


Figure 16. Maps showing the differences (subtraction) between the moving median grids for *A*, depth to the top, *B*, depth to the bottom, and *C*, length of the open interval in domestic- and public-supply wells in the conterminous United States. The grids in these maps are also accessible in an interactive searchable map at https://doi.org/10.3133/sir20215069.

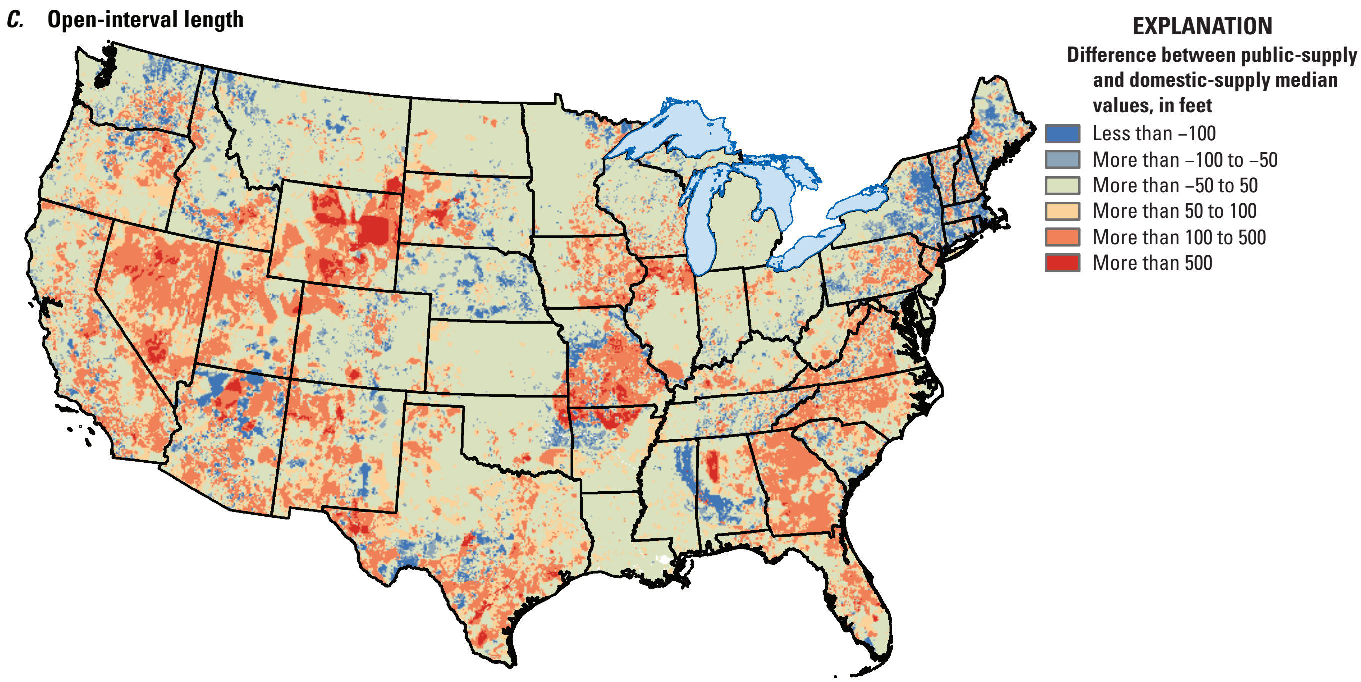


Figure 16.—Continued

Discussion

Effect of Overlying Sediment on Depths of Open Intervals in Wells

The presence of coarse sand and gravel deposits can influence the depth to which wells are drilled in some secondary hydrogeologic regions. The shallowest median depths of domestic-supply wells are in the secondary hydrogeologic regions with overlying coarse glacial sediment, which suggested that the wells are completed in the permeable coarse glacial sediment and not in the secondary hydrogeologic region below. Where coarse glacial sediment overlies secondary hydrogeologic regions with sedimentary, crystalline, and volcanic lithology, median open interval lengths for domestic-supply wells were the shortest, which also indicated that many of the wells were completed in the overlying coarse glacial sediment or with open intervals in both the coarse glacial sediment and the secondary hydrogeologic region. The secondary hydrogeologic regions typically are not permeable enough for wells with short open intervals to produce an adequate water supply unless overlying water-bearing sediment is also present.

Public-supply wells were completed at relatively shallow median depths when they were in secondary hydrogeologic regions with permeable sediment overlying crystalline, sedimentary, and volcanic rock aquifers. When public-supply wells were completed in principal aquifers where permeable aquifers are overlain by fine sediment or clay, the median depths were greater (table 3). The median lengths of open intervals in public-supply wells for each hydrogeologic setting lithology are longer than those in domestic-supply wells except for wells in crystalline rock aquifers. Shorter open intervals in public-supply wells completed in crystalline lithology hydrogeologic settings are likely a consequence of the wells actually being completed in the overlying sediments above the crystalline rock aquifers rather than in the crystalline rock aquifers themselves.

Characteristics of Wells in Glacial Aquifer Systems

Withdrawal zones in drinking-water supply wells in the glacial aquifer systems overlie bedrock aquifers across the northern United States (Stackelberg and others, 2021); in many areas, including the central interior geologic province (fig. 1), such zones are the primary drinking-water sources (Erickson and others, 2019). Statistical models have been developed to characterize the properties of groundwater in the glacial aquifer systems, including models for pH, redox conditions, and concentrations of selected constituents, such as arsenic and manganese. Results of those model simulations are presented in maps of predictions of the water-quality characteristics at depths relevant to drinking-water supply (Erickson and others, 2019; Stackelberg and others, 2021); therefore, it was necessary to generate a glacial aquifer system-specific set of domestic- and public-supply well depth grids in order to help use and interpret the simulation results. The glacial aquifer system drinking-water well depth grids are an example of distinguishing aquifer-specific drinking-water supply zones in a stacked aquifer system.

The glacial aquifer system open interval grids (Stackelberg and others, 2021) were generated using methods similar to those used in this study and were based on depth data for about 1.2 million domestic-supply wells and about 69,000 public-supply wells. Records for approximately 820,000 domestic-supply wells and 41,000 public-supply wells included data on the length of the open interval. The wells withdrawing water from the glacial aquifer systems are a subset of the total dataset used in this study. Withdrawal zones identified in this study are the same in some areas where the glacial aquifer system is the primary source and vary in other areas where there are stacked aquifers or where the glacial aquifer system is not used as a drinking-water supply. Briefly, several attributes were used to distinguish a well producing water from a glacial aquifer rather than from a principal aquifer or secondary hydrogeologic region: national and local aquifer names, aquifer type (sand and gravel, till, or bedrock, for example), and open interval depth less than depth to bedrock (Yager and others, 2018). In addition, well depths were compared to the depth to the top of bedrock or to the bottom of overlying Quaternary sediments to distinguish aquifer type.

The glacial aquifer system consists of sediments of varying composition and complexity—factors that can influence well characteristics such as depths and open intervals—so grouping areas were created considering wells that produce water from the glacial aquifer. The grouping areas are unique to the glacial aquifer system and represent a stacked aquifer that is above the hydrogeologic setting used to process data in this study. The grouping area was determined on the basis of the hydrogeologic terrane and whether the Quaternary sediment is classified as coarse grained stratified or not (Haj and others, 2018). The glacial aquifer system researchers used methods similar to those used in this study to choose a target number of wells (five) for each cell to use for depth and length median calculation, by first considering the wells within the cell. Stackelberg and others (2021) also used a smoothing algorithm, similar to that used in this study, to create the glacial aquifer system grids by averaging each cell using two cells in each direction, or a 5×5 grid of cells. While not changing the overall structure of the data, this smoothing procedure helped remove local anomalies.

Comparing the glacial aquifer system-specific drinking-water depth grids with the depth grids on a national scale illustrated where bedrock aquifers are more commonly used than glacial aquifers. For example, the moving median depth of domestic-supply drinking-water wells as determined by Stackelberg and others (2021) is much shallower on a national basis than for wells in the glacial aquifer systems in areas where glacial sediment is thin as determined in the present study. Areas with thin glacial sediment include the northern New England States, northeastern and southeastern Minnesota, southwestern Wisconsin, and northern Missouri, which primarily use bedrock wells for drinking-water supply. Another notable difference between the glacial aquifer system and the national drinking water grids is that domestic- and public-supply well depths are more similar in the glacial aquifer system than nationally. In the national study, the depths of public-supply wells are significantly greater than those of domestic-supply wells, especially in western and southeastern States.

Data Gaps and Limitations

Well data used in the analyses in this study were limited to those data available from national or State digital databases. The 1-km^2 (0.38-mi^2) resolution of grids that define the depth to open intervals in drinking-water wells was chosen because it is a common model scale and sizes are functional at the national scale. This resolution does not represent the accuracy of the grid, which varies and is limited by well data density. In general, areas with sparse populations have sparse well density. Results from this study show the density of data for and estimates of locations of domestic-supply wells to be similar to those in studies of small-scale or regional studies, for example, studies in northern Maine, inland in southern Florida, and in broad expanses west of the continental divide (Johnson and Belitz, 2017; Johnson and others, 2019). Data for wells used for other than a drinking-water source, such as for irrigation, were available in areas of sparse data and could be used for filling in data gaps by using a correction factor. Machine-learning models may also have the potential for filling in gaps in well data with predictions of the open interval length and depth using geologic, physiographic, topographic, and hydrologic position variables (Belitz and others, 2019a).

Several quality-assurance and data-decision steps were performed during data compilation to select data to include. However, exhaustive quality assurance to help fill in missing records for each of the data sources was outside the scope of this study. Other well records, in paper or scanned form, were not used. Many of the State digital datasets were not developed until the 1980s, and they commonly do not include records for older wells. For example, in the northeastern United States, dug wells completed in till account for only about 0.4 percent of the documented water supply for the region. In many rural areas, dug wells are still in use but may not have been reported, and they were the only available groundwater supply before the technology to drill bedrock wells became widespread (Olcott, 1995; U.S. Geological Survey, 2003).

Well drilling and construction methods have changed over time and with advances in technology. For example, older bedrock wells were commonly drilled to shallow depths with a cable-tool (or percussion) rig, whereas newer bedrock wells are commonly drilled deeper with air rotary rigs to intercept more water-bearing zones and thus meet an increasing demand for additional yield (Moore and others, 2002). Older hand-dug wells in glacial material had stone casings and often were not recorded; this type of well is now constructed with excavators and lined with concrete tiles. The newest technology for completing dug wells in glacial till incorporates a sanitary design that creates additional storage by placing a large volume of crushed stone around a small-diameter well casing during construction (Winston and Ayotte, 2018; Carlisle and others, 2019). Unlike bedrock wells, depths of wells in shallow till have not changed over time with advances in technology. Drill date and method information were sometimes included in the source datasets and could be used to help understand variations in open interval length and depth relations, but are not used in this study.

The principal results of the analyses described and illustrated in this report are the open interval grids for domestic- and public-supply wells. Although multiple (or stacked) aquifers are present in many areas in the United States, the results presented here are intended to represent the most commonly used aquifer or aquifers in an area and therefore indicate the open intervals with the highest documented number of wells for each use. Only one withdrawal zone is represented with one set of open interval grids, but the grids may represent different aquifers within a single hydrogeologic setting as one undulating or aquifer cross cutting set of grids. Separate stacked aquifers, for example, are not accounted for in the multiple stacked principal aquifers or multiple aquifers within principal aquifers, such as the Central Valley in California, the North Atlantic Coastal Plain, and the Coastal Lowlands of Texas and Louisiana (fig. 1.1*H*, *B*, and *C*, respectively). In the Coastal Lowlands principal aquifer along the coasts of Texas and Louisiana, the aquifer bottom grid appears as a rough but horizontal plane (fig. 13), but the plane cuts across several dipping aquifer layers.

Well depths in this study were not compared with the Quaternary thicknesses (Yager and others, 2018) as they were for the glacial aquifer system open interval grid generation (Stackelberg and others, 2021). Mapped aquifer top and bottom grids and other hydrogeologic information that could be used to constrain the depth of drinking-water-supply wells also were not used. State and regional maps of depth to bedrock (DiGiacomo-Cohen and others, 2020), which could be used to constrain the bottom of well screens in unconsolidated material or the top of productive zones in bedrock aquifers, were not used in this effort. Grids of the depths of open intervals in drinking-water-supply wells presented in this report represent the typical open interval of wells in use and not the total potential developable resource. The difference between the moving median grids and actual aquifer withdrawal zones within the aquifer could be identified by a more comprehensive examination of the hydrogeologic data analyzed in this study.

Summary

Understanding the distribution of drinking-water supplies from a groundwater source is important to protect human health, plan resource development, and reduce treatment costs. Thirty-five percent of drinking-water supplies in the United States is withdrawn from wells that have a wide range of open interval depths and lengths. This variability in open interval depths and lengths for drinking-water supplies led to a need for a set of grids to represent the depths of the zones used for groundwater withdrawal for domestic- and public-drinking-water supply within the conterminous United States.

The well data analyzed in this study were limited to those available digitally in national or State datasets. The well data were compiled from several sources, including the National Water Information System, the Safe Drinking Water Information System dataset (primarily data for public-supply wells), a groundwater ambient monitoring dataset (primarily data for domestic-supply wells), datasets from individual States, a national brackish aquifer study, and a study of glacial aquifer systems. General spatial patterns of the density of data for domestic-supply wells determined in the study in this report closely matched the density of such data estimated in an earlier study, indicating that the dataset in this report is representative of domestic-supply wells in use in the United States.

Fifty-seven principal aquifers and 65 secondary hydrogeologic regions were merged with overlying sediment polygons to generate 288 unique hydrogeologic settings across the conterminous United States that vary in depth, thickness, lithology, and transmissivity characteristics. Some principal aquifers and secondary hydrogeologic regions overlie one another, and some are also overlain by glacial sediment, coarse glacial sediment, or stream valley alluvium, which in themselves may be used as drinking-water-supply sources. Understanding how hydrogeologic settings are based on mappable geology and align with physiography and topography in most places aided the understanding of aquifer boundaries and potential aquifer groupings. Each well was assigned to a hydrogeologic setting based on location, and hydrogeologic setting well groupings were used to assess well depth and open interval data. When well data within a hydrogeologic setting were sparse or missing, data from an adjacent or nearby hydrogeologic setting with similar well-construction properties, geology, physiography, and topography were used to estimate the median open interval parameters and to generate moving median grids. Depths to and lengths of open intervals in areas having sparse data were also estimated using a two-slope linear function developed from available data to represent the typical relation between the depth of the bottom of the open interval and the length of the open interval. Grids of moving median values for the depths to and lengths of open intervals in wells were generated at a 1-square-kilometer (0.38-square-mile) grid cell scale.

Comparisons between open interval lengths and depths in domestic-supply and public-supply wells showed several notable differences. Median depths and open intervals of domestic- and public-supply wells varied by an order of magnitude by lithology of the hydrogeologic setting and the overlying sediment across the conterminous United States. The overall median well depths were 142 feet (43.3 meters) for domestic-supply wells and 202 feet (61.6 meters) for public-supply wells. The median lengths of open intervals

were 21 feet (6.4 meters) for domestic-supply wells and 49 feet (14.9 meters) for public-supply wells. The median depths of public-supply wells in each major rock type in principal aquifers are deeper than the median depths of domestic-supply wells. The shallowest median depths of domestic-supply wells are in the secondary hydrogeologic regions overlain by coarse glacial sediment, indicating that the wells are completed in the overlying sediment and not the secondary hydrogeologic region below. Similarly, public-supply wells were completed at shallower median depths when they were in areas of permeable overlying sediment that blanketed crystalline, sedimentary, and volcanic rock secondary hydrogeologic regions. The median depths of public- and domestic-supply wells completed in crystalline and volcanic rock secondary hydrogeologic regions (without any overlying sediment) are similar, except that where the secondary hydrogeologic region is overlain by permeable deposits, the public-supply wells are slightly less deep. When public-supply wells were completed in principal aquifers, however, the median depths were typically deeper than domestic-supply wells.

Separate sets of grids defining the open intervals of drinking-water-supply wells are presented for both domestic- and public-supply wells. Although multiple overlying (or stacked) aquifers are present in many areas, results presented here are not separated by stacked aquifers and highlight the aquifer or aquifers that are most commonly used for drinking water supply in a particular area.

Acknowledgments

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Appendix 1. Hydrogeologic Settings in Principal Aquifers and Secondary Hydrogeologic Regions of the United States

***A.* Northeast**

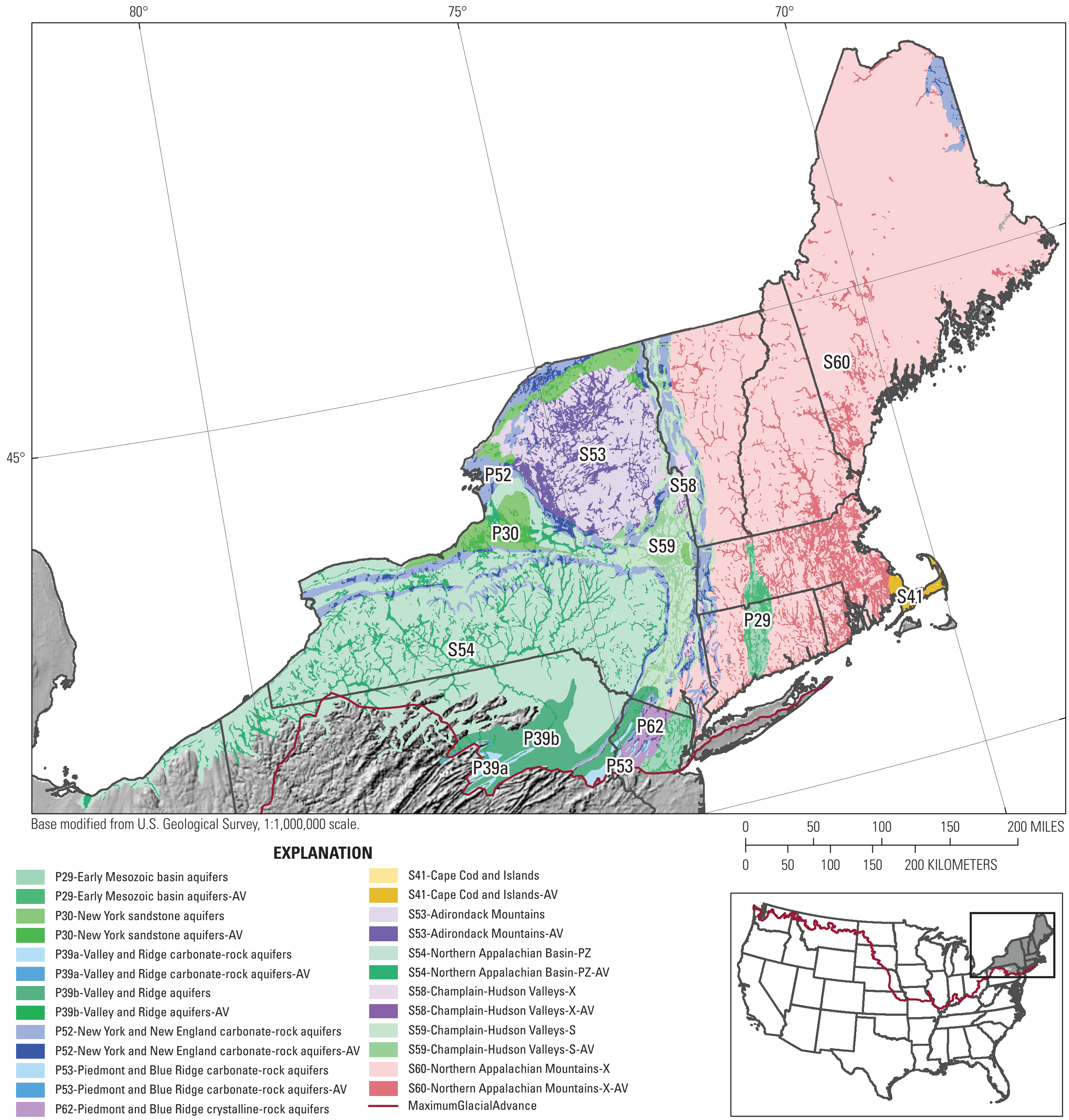


Figure 1.1. Maps showing the 288 hydrogeologic settings in the conterminous United States, by geographic area of the conterminous United States, in the *A*, Northeast; *B*, Eastern; *C*, Southeast; *D*, Central; *E*, Western Great Lakes; *F*, North Central; *G*, South Central; *H*, Southwest; and *I*, Northwest. The hydrogeologic settings are identified on the maps by a letter indicating if the hydrogeologic setting is a principal aquifer ("P") or a secondary hydrogeologic region ("S"). The numbers match those used in Belitz and others (2019) and Lovelace and others (2020). Abbreviations in the secondary hydrogeologic region names are as follows: K, Cretaceous; PZ, Paleozoic; Q, Quaternary; S, Sedimentary; T, Tertiary; V, volcanic; and X, crystalline. Hydrogeologic settings that have an "AV" suffix and lie north of the line of maximum glacial extent have coarse glacial overlying sediment; those hydrogeologic settings that lie to the south of the line of maximum glacial extent have alluvial valley overlying sediment. The hydrogeologic settings presented in the maps are also accessible as interactive searchable maps at https://doi.org/10.3133/sir20215069.

***B.* Mid-Atlantic**

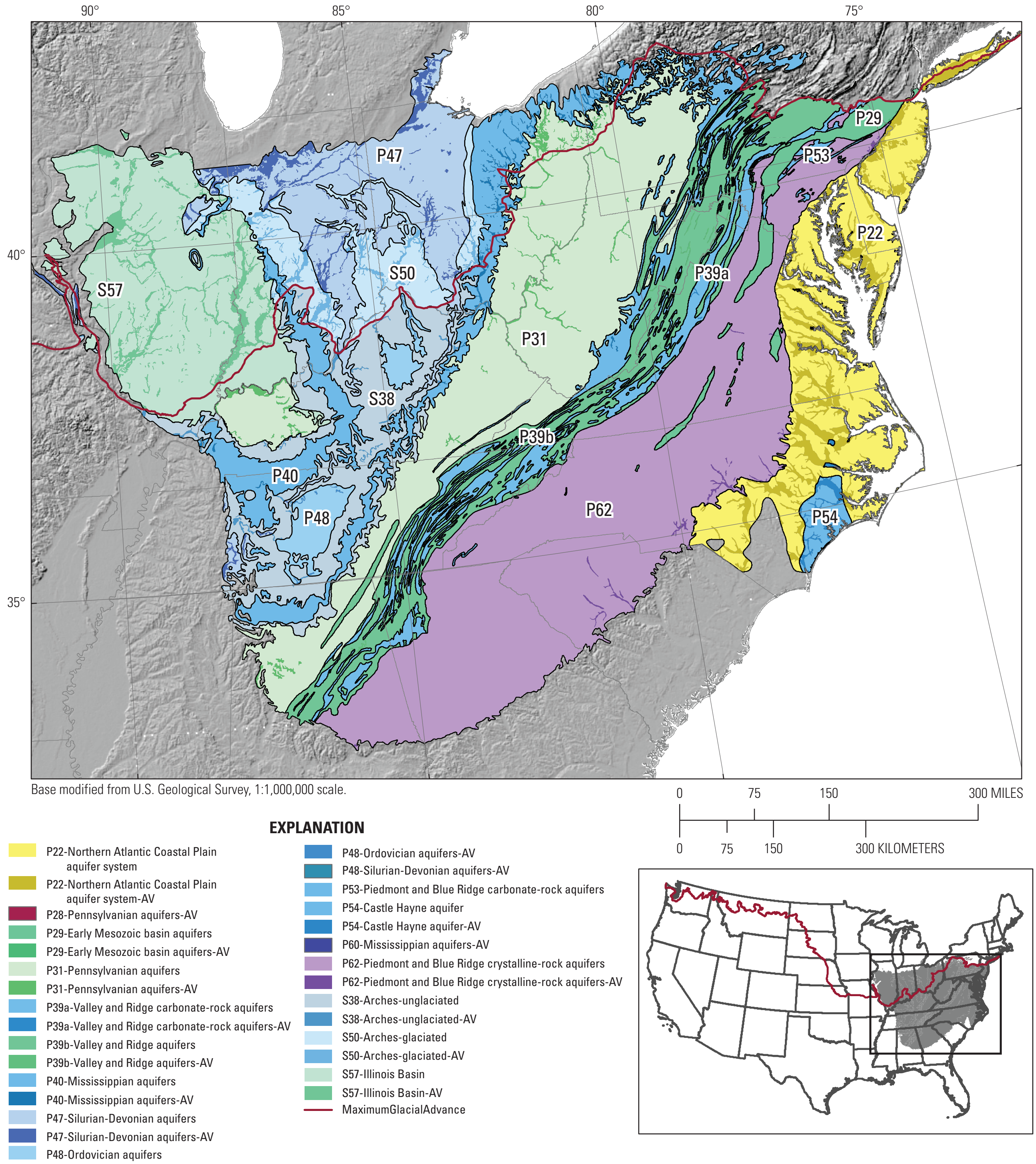


Figure 1.1.—Continued

***C.* Southeast**

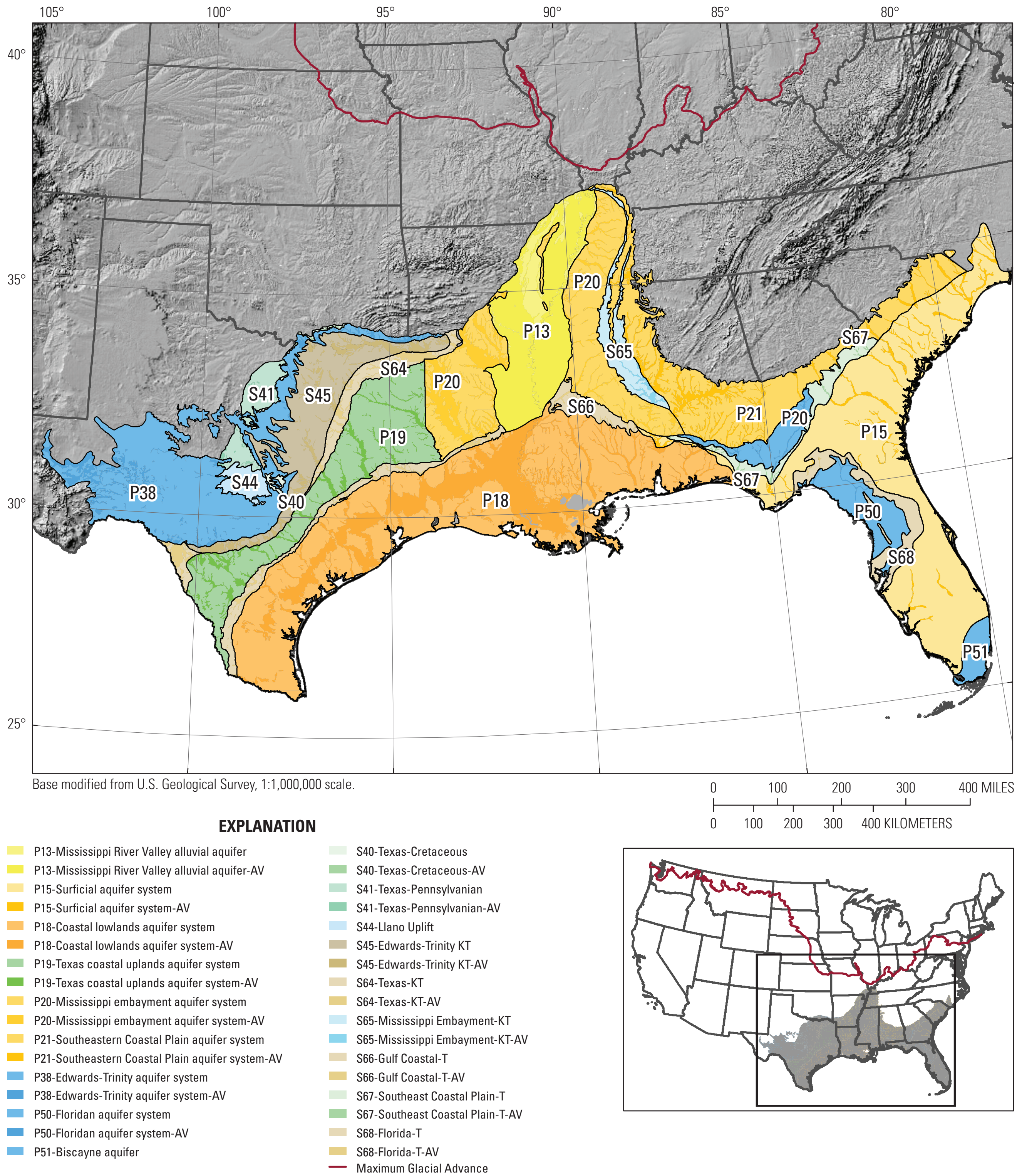


Figure 1.1.—Continued

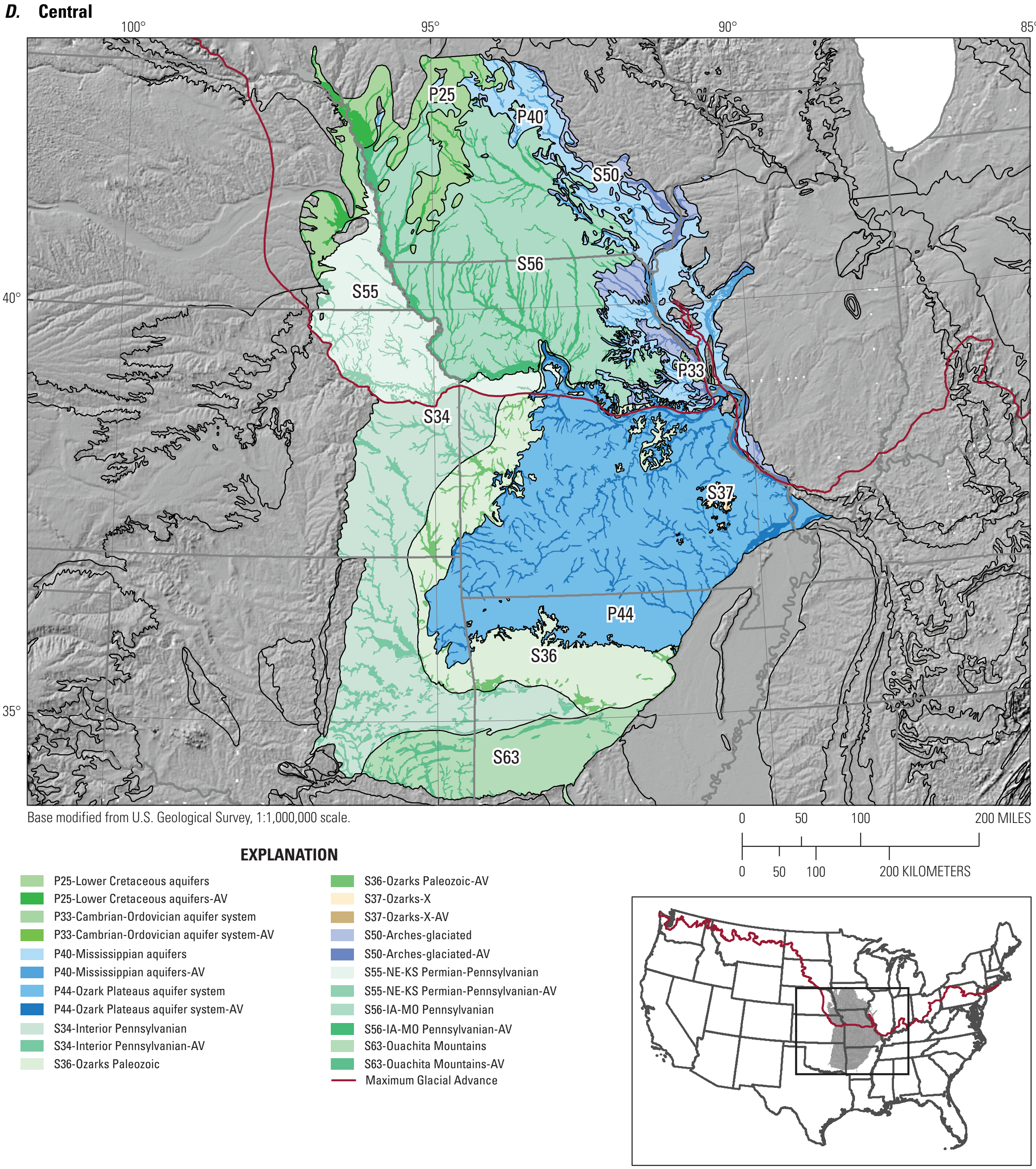


Figure 1.1.—Continued

E. **Western Great Lakes**

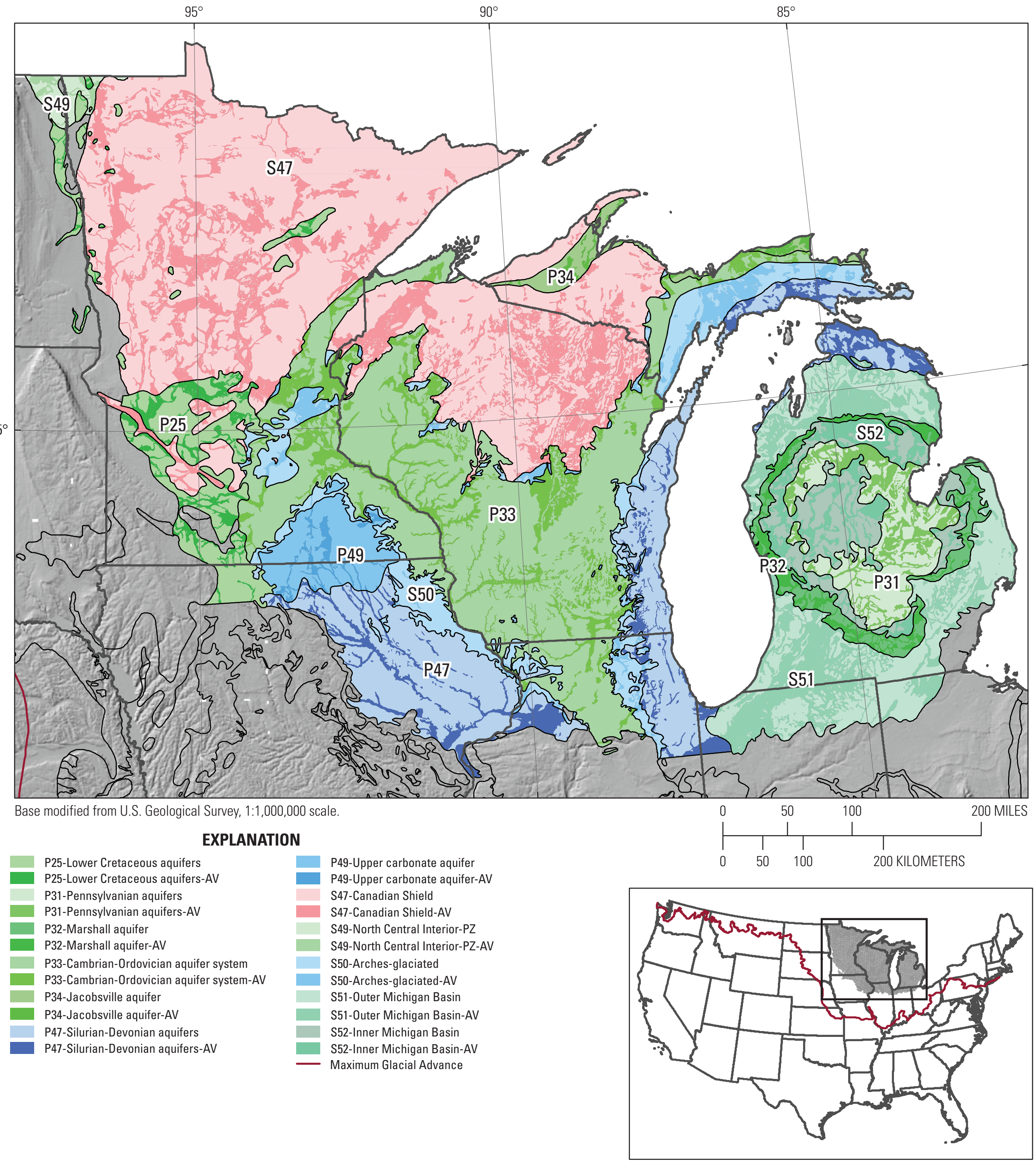


Figure 1.1.—Continued

F. **North Central**

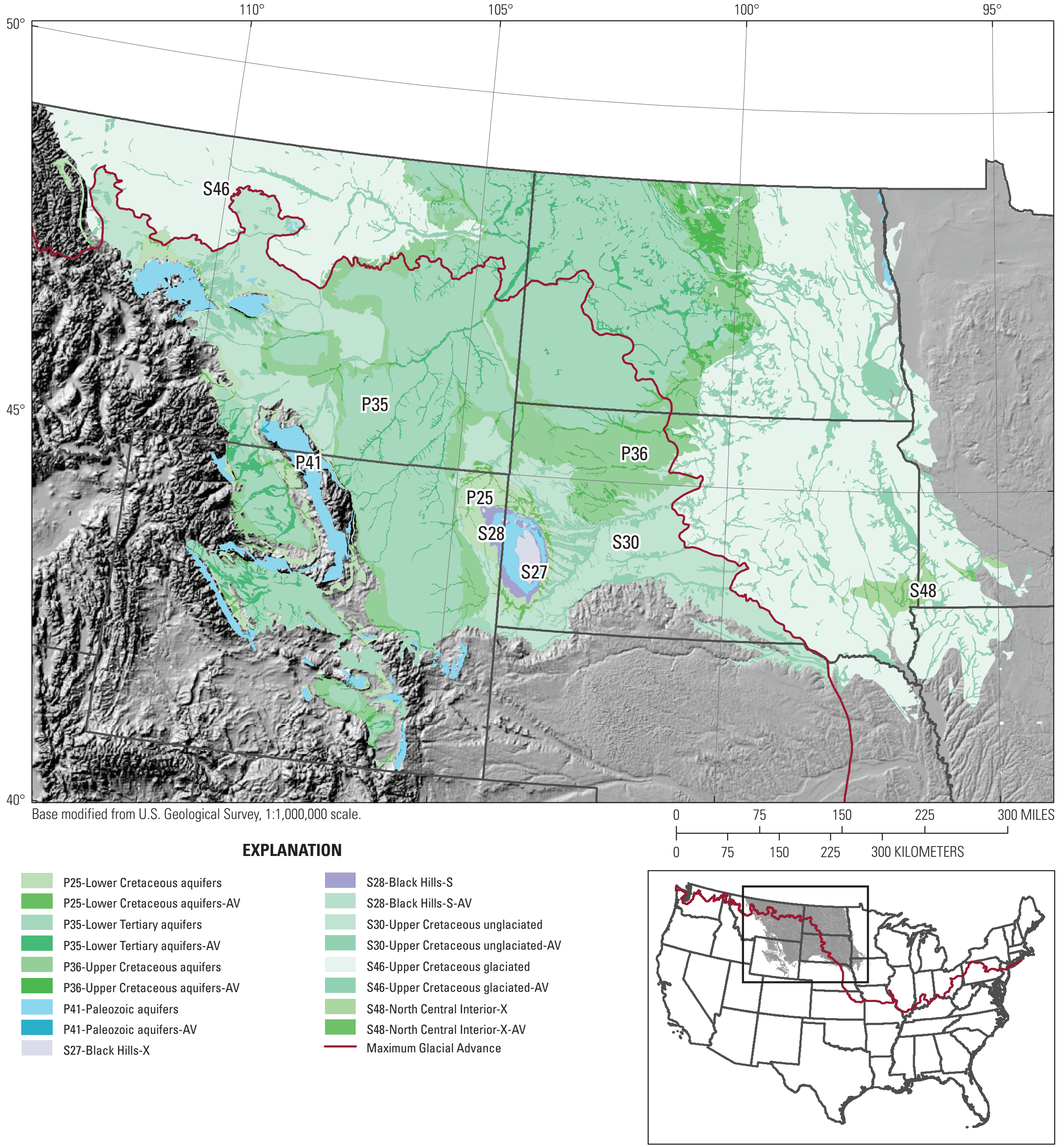


Figure 1.1.—Continued

G. **South Central**

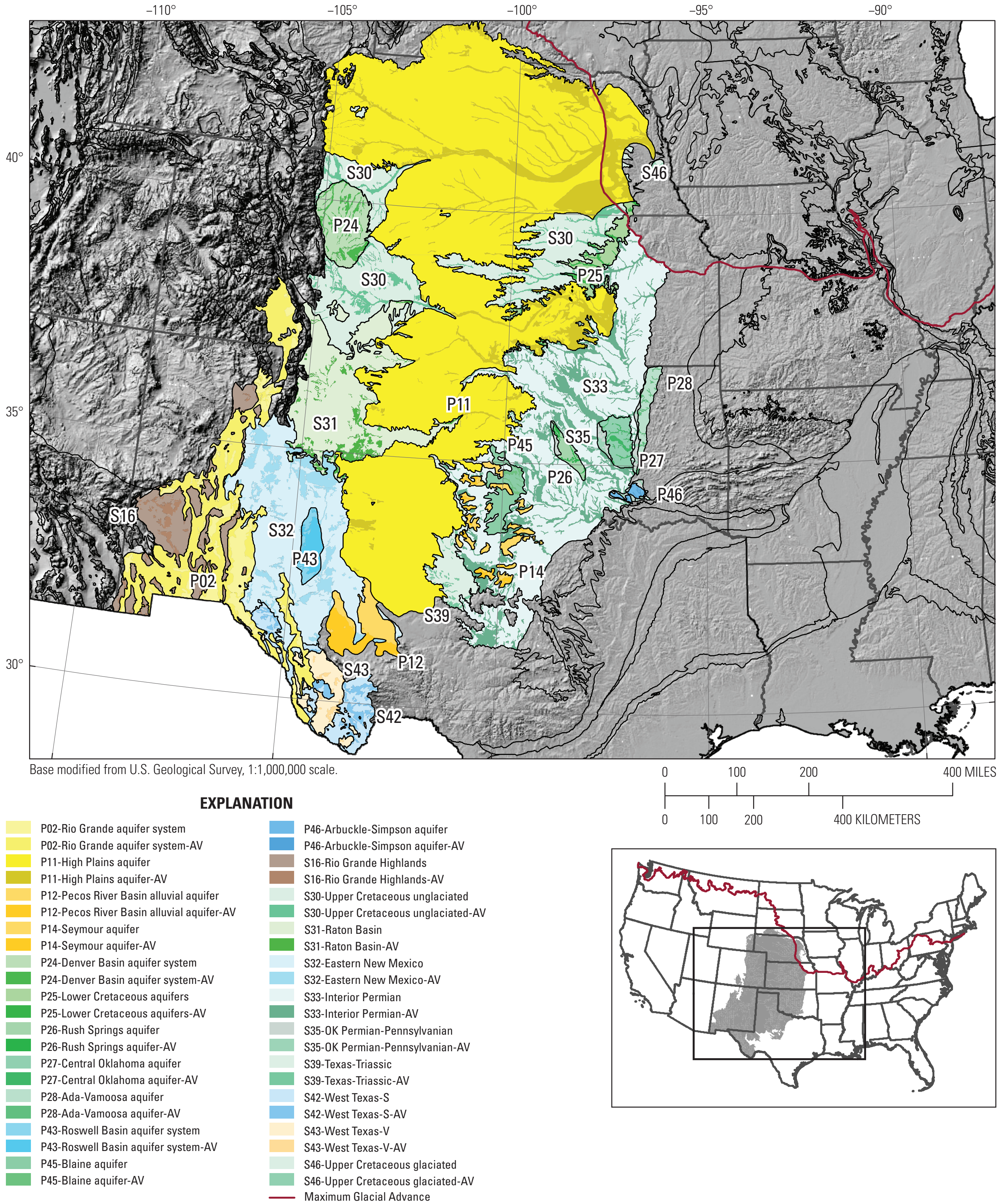
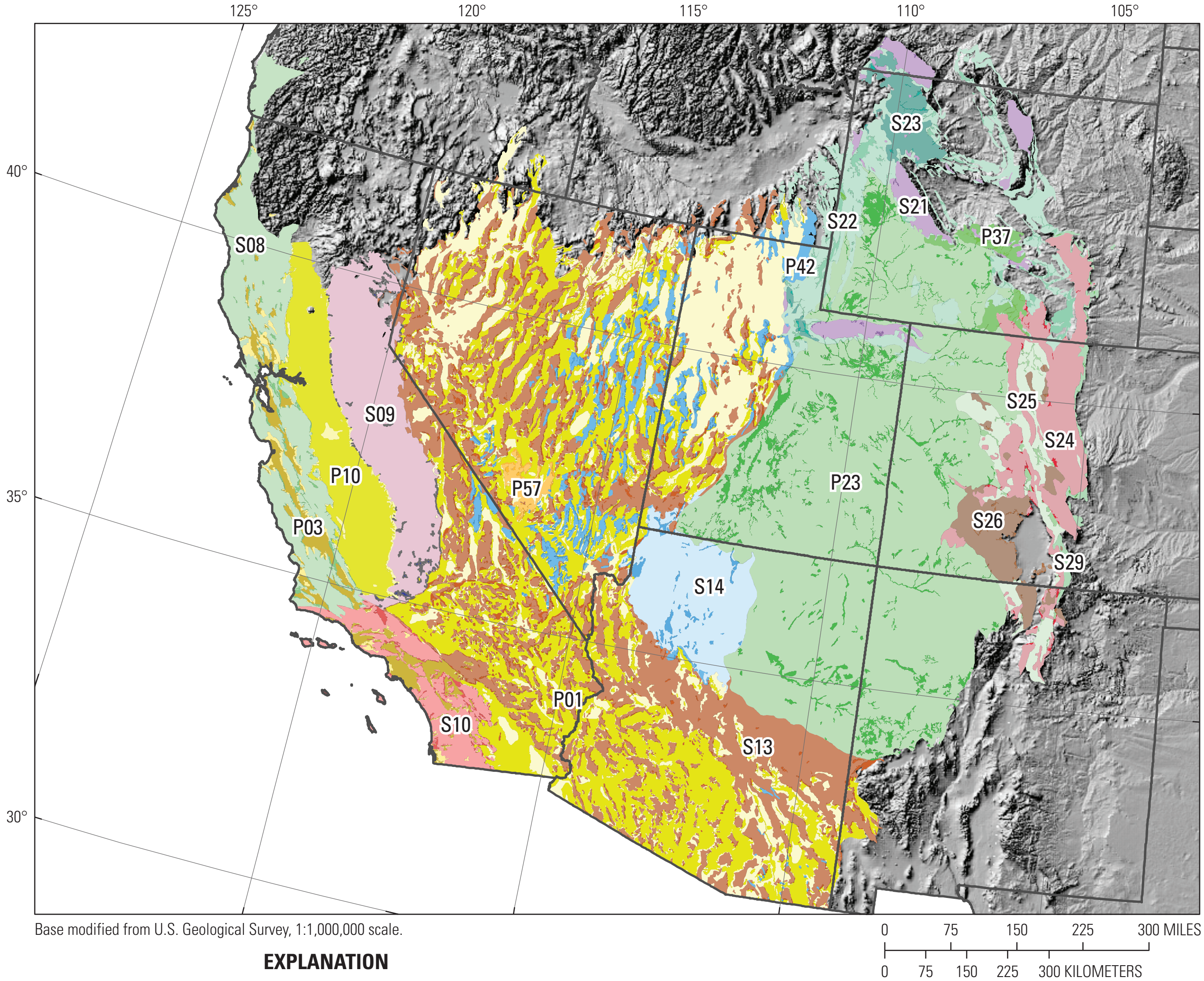


Figure 1.1.—Continued

H. **Southwest**



Base modified from U.S. Geological Survey, 1:1,000,000 scale.

EXPLANATION

- P01-Basin and Range basin-fill aquifers
- P01-Basin and Range basin-fill aquifers-AV
- P03-California Coastal Basin aquifers
- P03-California Coastal Basin aquifers-AV
- P10-Central Valley aquifer system
- P10-Central Valley aquifer system-AV
- P23-Colorado Plateaus aquifers
- P23-Colorado Plateaus aquifers-AV
- P37-Upper Tertiary aquifers
- P37-Upper Tertiary aquifers-AV
- P42-Basin and Range carbonate-rock aquifers
- P42-Basin and Range carbonate-rock aquifers-AV
- P57-Southern Nevada volcanic-rock aquifers
- P57-Southern Nevada volcanic-rock aquifers-AV
- S08-Coast Ranges
- S08-Coast Ranges-AV
- S09-Sierra Nevada
- S09-Sierra Nevada-AV
- S10-Southern California Mountains
- S10-Southern California Mountains-AV
- S13-Basin and Range Highlands
- S13-Basin and Range Highlands-AV
- S14-Grand Canyon
- S14-Grand Canyon-AV
- S21-Middle Rocky Mountains-X
- S21-Middle Rocky Mountains-X-AV
- S22-Middle Rocky Mountains-S
- S22-Middle Rocky Mountains-S-AV
- S23-Middle Rocky Mountains-V
- S23-Middle Rocky Mountains-V-AV
- S24-Southern Rocky Mountains-X
- S24-Southern Rocky Mountains-X-AV
- S25-Southern Rocky Mountains-S
- S25-Southern Rocky Mountains-S-AV
- S26-Southern Rocky Mountains-V
- S26-Southern Rocky Mountains-V-AV
- S29-Front Range
- S29-Front Range-AV
- Maximum Glacial Advance

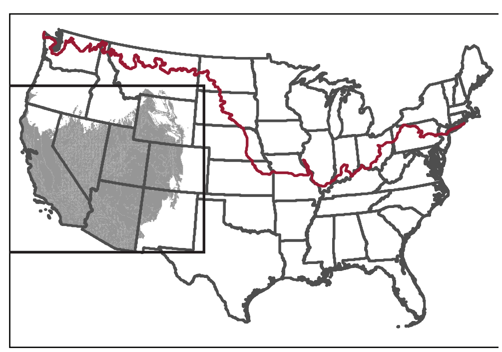


Figure 1.1.—Continued

I. **Northwest**

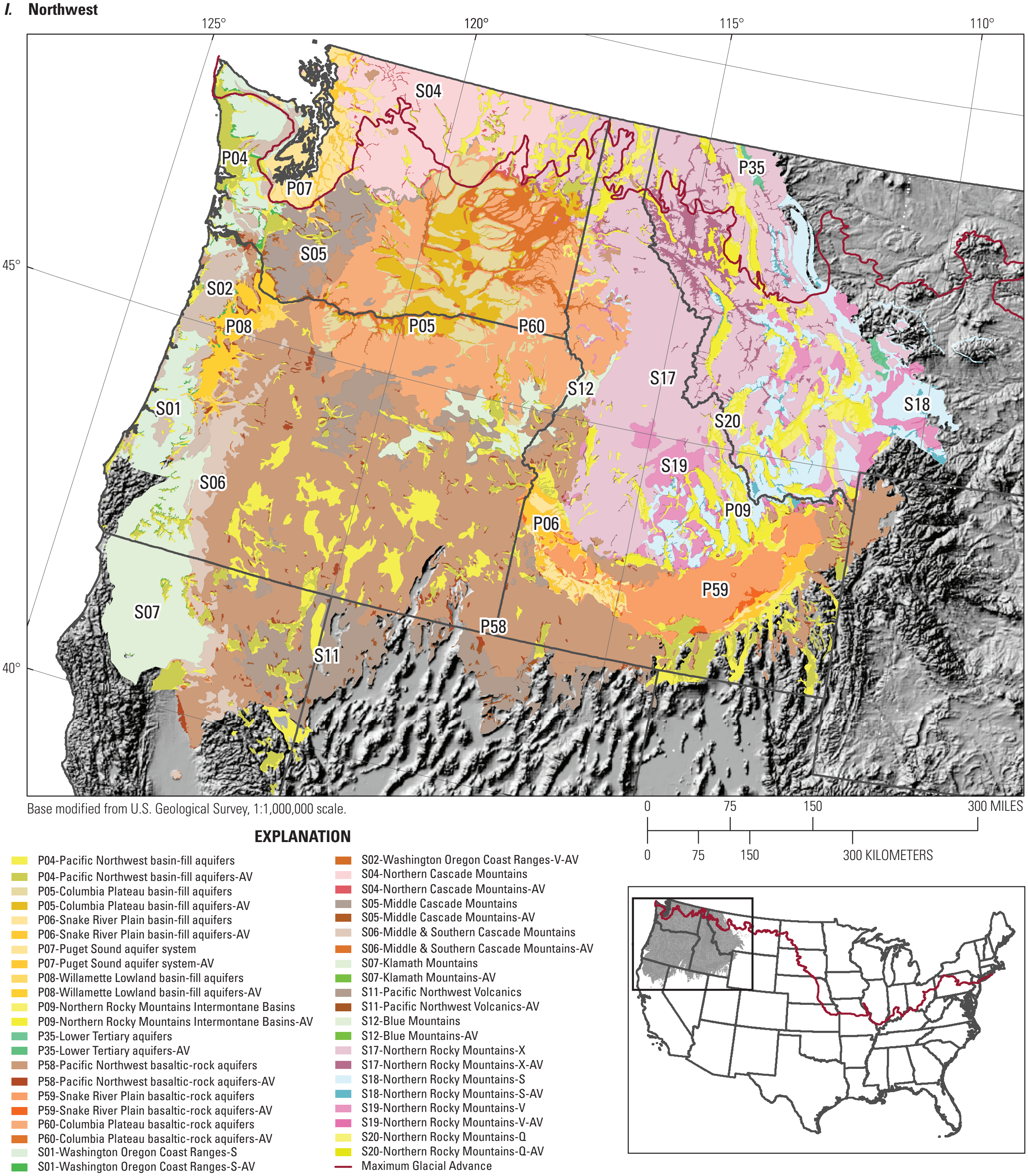


Figure 1.1.—Continued

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in domestic-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function statistical fit result			Number of wells in hydrogeologic setting without overlying sediment			Number of wells in hydrogeologic setting with overlying sediment		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P01	Basin and Range basin-fill aquifers	Stream valley alluvium	<	<	<	29,136	49,563	28,993	48,401	85,933	48,149
P02	Rio Grande aquifer system	Stream valley alluvium	>	>	W	483	4,991	483	4,114	50,824	4,109
P03	California Coastal Basin aquifers	Stream valley alluvium	X	W	>	9,541	13,474	9,537	21,827	28,490	21,822
P04	Pacific Northwest basin-fill aquifers	Coarse glacial	>	>	X	3,983	40,381	3,951	195	2,194	189
P04	Pacific Northwest basin-fill aquifers-glacial	Coarse glacial	>	>	X	702	8,853	684	195	2,194	189
P04	Pacific Northwest basin-fill aquifers	Glacial	W	W	X	3,983	40,381	3,951	702	8,853	684
P04	Pacific Northwest basin-fill aquifers	Stream valley alluvium	W	W	>	3,983	40,381	3,951	7,057	53,580	6,797
P05	Columbia Plateau basin-fill aquifers	Stream valley alluvium	W	>	>	901	11,214	898	2,947	45,695	2,885
P06	Snake River Plain basin-fill aquifers	Stream valley alluvium	>	>	X	2,155	6,069	2,069	9,874	35,720	9,370
P07	Puget Sound aquifer system-glacial	Coarse glacial	>	>	X	7,445	104,414	7,323	634	9,745	620
P08	Willamette Lowland basin-fill aquifers	Stream valley alluvium	X	>	>	171	20,187	170	801	53,082	763
P09	Northern Rocky Mountains Intermontane Basins	Coarse glacial	X	W	>	1,165	17,116	1,139	1,055	10,655	1,031
P09	Northern Rocky Mountains intermontane basins-glacial	Coarse glacial	X	W	>	880	11,117	858	1,055	10,655	1,031
P09	Northern Rocky Mountains intermontane basins	Glacial	W	<	W	1,165	17,116	1,139	880	11,117	858
P09	Northern Rocky Mountains intermontane basins	Stream valley alluvium	W	>	>	1,165	17,116	1,139	3,426	47,903	3,185
P10	Central Valley aquifer system	Stream valley alluvium	<	W	<	3,772	5,493	3,780	40,242	79,376	40,376
P11	High Plains aquifer	Coarse glacial	>	>	W	28,321	90,195	28,394	850	4,455	859
P11	High Plains aquifer-glacial	Coarse glacial	>	>	>	584	2,751	578	850	4,455	859
P11	High Plains aquifer	Glacial	>	>	<	28,321	90,195	28,394	584	2,751	578
P11	High Plains aquifer	Stream valley alluvium	>	>	>	28,321	90,195	28,394	13,964	33,640	14,077
P12	Pecos River Basin alluvial aquifer	Stream valley alluvium	X	<	X	53	436	53	16	166	16

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in domestic-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function statistical fit result			Number of wells in hydrogeologic setting without overlying sediment			Number of wells in hydrogeologic setting with overlying sediment		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P13	Mississippi River Valley alluvial aquifer	Stream valley alluvium	<	<	>	801	1,141	800	5,343	8,216	5,342
P14	Seymour aquifer	Stream valley alluvium	X	<	X	48	1,142	48	8	324	8
P15	Surficial aquifer system	Stream valley alluvium	<	<	<	58,566	62,732	58,480	1,877	1,999	1,872
P18	Coastal lowlands aquifer system	Stream valley alluvium	W	W	W	70,139	129,378	70,131	17,966	42,134	17,966
P19	Texas coastal uplands aquifer system	Stream valley alluvium	>	>	X	839	22,867	837	121	2,568	121
P20	Mississippi embayment aquifer system	Stream valley alluvium	W	X	<	32,274	40,013	32,249	8,893	10,786	8,888
P21	Southeastern Coastal Plain aquifer system	Stream valley alluvium	W	X	X	7,002	11,021	6,943	807	1,371	802
P22	Northern Atlantic Coastal Plain aquifer system	Stream valley alluvium	<	<	<	158,756	210,512	158,298	37,671	52,780	37,570
P23	Colorado Plateaus aquifers	Stream valley alluvium	>	>	>	18,662	32,901	18,624	8,408	14,407	8,387
P24	Denver Basin aquifer system	Stream valley alluvium	>	>	>	31,918	36,946	31,934	6,028	7,596	6,032
P25	Lower Cretaceous aquifers	Coarse glacial	W	>	>	2,544	8,402	2,540	9,624	14,021	9,596
P25	Lower Cretaceous aquifers-glacial	Coarse glacial	>	>	X	23,335	42,354	23,268	9,624	14,021	9,596
P25	Lower Cretaceous aquifers	Glacial	<	W	>	2,544	8,402	2,540	23,335	42,354	23,268
P25	Lower Cretaceous aquifers	Stream valley alluvium	>	>	>	2,544	8,402	2,540	1,357	3,974	1,349
P26	Rush Springs aquifer	Stream valley alluvium	W	W	W	422	999	422	118	268	117
P27	Central Oklahoma aquifer	Stream valley alluvium	>	>	X	14,629	17,214	14,634	2,749	3,380	2,751
P28	Ada-Vamoosa aquifer	Stream valley alluvium	X	X	X	1,804	2,357	1,805	248	335	248
P29	Early Mesozoic basin aquifers	Coarse glacial	<	>	>	31,500	45,895	31,512	1,046	3,608	1,041
P29	Early Mesozoic basin aquifers-glacial	Coarse glacial	<	W	>	1,095	6,740	1,094	1,046	3,608	1,041
P29	Early Mesozoic basin aquifers	Glacial	>	W	>	31,500	45,895	31,512	1,095	6,740	1,094
P29	Early Mesozoic basin aquifers	Stream valley alluvium	X	>	X	31,500	45,895	31,512	12	357	12
P30	New York sandstone aquifers-glacial	Coarse glacial	<	X	>	1,156	1,657	1,143	547	814	531
P31	Pennsylvanian aquifers	Coarse glacial	<	>	>	45,045	72,602	44,467	38,908	41,041	38,385

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in domestic-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function statistical fit result			Number of wells in hydrogeologic setting without overlying sediment			Number of wells in hydrogeologic setting with overlying sediment		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P31	Pennsylvanian aquifers-glacial	Coarse glacial	X	>	>	90,577	96,017	90,167	38,908	41,041	38,385
P31	Pennsylvanian aquifers	Glacial	<	W	>	45,045	72,602	44,467	90,577	96,017	90,167
P31	Pennsylvanian aquifers	Stream valley alluvium	<	>	>	45,045	72,602	44,467	845	2,100	762
P32	Marshall aquifer-glacial	Coarse glacial	>	>	>	30,461	31,232	30,421	33,047	33,748	33,007
P33	Cambrian-Ordovician aquifer system-glacial	Coarse glacial	X	>	>	175,528	209,625	174,937	85,148	97,212	84,867
P34	Jacobsville aquifer-glacial	Coarse glacial	X	>	>	3,439	3,648	3,425	1,761	1,826	1,752
P35	Lower Tertiary aquifers	Coarse glacial	>	>	>	5,728	17,260	5,719	352	2,135	346
P35	Lower Tertiary aquifers-glacial	Coarse glacial	>	>	W	1,127	9,189	1,104	352	2,135	346
P35	Lower Tertiary aquifers	Glacial	>	>	>	5,728	17,260	5,719	1,127	9,189	1,104
P35	Lower Tertiary aquifers	Stream valley alluvium	>	>	>	5,728	17,260	5,719	4,807	9,953	4,793
P36	Upper Cretaceous aquifers	Coarse glacial	>	>	>	1,341	5,864	1,342	157	600	154
P36	Upper Cretaceous aquifers	Glacial	>	>	>	1,341	5,864	1,342	402	2,038	399
P36	Upper Cretaceous aquifers	Stream valley alluvium	>	>	>	1,341	5,864	1,342	440	1,311	440
P37	Upper Tertiary aquifers	Stream valley alluvium	>	>	>	358	479	358	302	402	298
P38	Edwards-Trinity aquifer system	Stream valley alluvium	W	>	>	2,741	50,634	2,737	348	2,068	349
P39a	Valley and Ridge carbonate-rock aquifers	Coarse glacial	X	>	>	40,752	44,200	40,662	153	338	151
P39a	Valley and Ridge carbonate-rock aquifers-glacial	Coarse glacial	X	>	>	3,044	4,835	3,034	153	338	151
P39a	Valley and Ridge carbonate-rock aquifers	Glacial	W	>	>	40,752	44,200	40,662	3,044	4,835	3,034
P39a	Valley and Ridge carbonate-rock aquifers	Stream valley alluvium	W	>	>	40,752	44,200	40,662	88	118	86
P39b	Valley and Ridge aquifers	Coarse glacial	X	>	>	49,133	52,676	49,078	382	1,315	367
P39b	Valley and Ridge aquifers-glacial	Coarse glacial	W	>	>	16,029	22,812	15,992	382	1,315	367
P39b	Valley and Ridge aquifers	Glacial	W	W	W	49,133	52,676	49,078	16,029	22,812	15,992
P39b	Valley and Ridge aquifers	Stream valley alluvium	>	>	>	49,133	52,676	49,078	132	220	132

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in domestic-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function statistical fit result			Number of wells in hydrogeologic setting without overlying sediment			Number of wells in hydrogeologic setting with overlying sediment		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P40	Mississippian aquifers	Coarse glacial	<	>	>	17,064	25,445	16,858	6,286	10,845	5,948
P40	Mississippian aquifers	Glacial	<	W	>	17,064	25,445	16,858	45,475	68,033	44,475
P40	Mississippian aquifers	Stream valley alluvium	<	>	>	17,064	25,445	16,858	263	497	249
P41	Paleozoic aquifers	Stream valley alluvium	W	W	W	1,270	4,005	1,267	251	522	251
P42	Basin and Range carbonate-rock aquifers	Stream valley alluvium	<	W	W	503	818	501	356	464	353
P43	Roswell Basin aquifer system	Stream valley alluvium	X	>	X	1	138	1	13	4,581	13
P44	Ozark Plateaus aquifer system	Coarse glacial	W	W	W	118,696	129,329	118,694	283	332	282
P44	Ozark Plateaus aquifer system-Glacial	Coarse glacial	>	>	>	1,170	1,297	1,170	283	332	282
P44	Ozark Plateaus aquifer system	Glacial	<	<	W	118,696	129,329	118,694	1,170	1,297	1,170
P44	Ozark Plateaus aquifer system	Stream valley alluvium	W	>	>	118,696	129,329	118,694	13,726	14,966	13,724
P45	Blaine aquifer	Stream valley alluvium	X	>	X	45	242	44	35	60	35
P46	Arbuckle-Simpson aquifer	Stream valley alluvium	W	W	X	91	236	91	54	113	54
P47	Silurian-Devonian aquifers	Coarse glacial	<	X	>	1,071	1,926	1,026	47,160	74,565	46,819
P47	Silurian-Devonian aquifers-glacial	Coarse glacial	>	>	>	155,758	265,454	154,436	47,160	74,565	46,819
P47	Silurian-Devonian aquifers	Glacial	<	<	>	1,071	1,926	1,026	155,758	265,454	154,436
P47	Silurian-Devonian aquifers	Stream valley alluvium	X	X	X	1,071	1,926	1,026	159	254	154
P48	Ordovician aquifers	Stream valley alluvium	W	>	>	7,039	8,459	7,036	58	91	58
P49	Upper carbonate aquifer-glacial	Coarse glacial	>	>	>	6,249	12,117	6,240	1,098	2,591	1,097
P50	Floridan aquifer system	Stream valley alluvium	W	W	X	73,562	76,099	72,922	51	70	51
P52	New York and New England carbonate-rock aquifers-glacial	Coarse glacial	<	>	>	14,967	20,085	14,884	3,890	5,778	3,849
P53	Piedmont and Blue Ridge carbonate-rock aquifers-glacial	Coarse glacial	X	W	>	239	2,321	239	15	109	15
P53	Piedmont and Blue Ridge carbonate-rock aquifers	Glacial	<	>	>	12,085	13,758	12,069	239	2,321	239

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in domestic-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

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P54	Castle Hayne aquifer	Stream valley alluvium	X	>	X	80	141	80	20	62	20
P58	Pacific Northwest basaltic-rock aquifers	Stream valley alluvium	>	>	W	4,575	42,522	4,513	644	9,949	625
P59	Snake River Plain basaltic-rock aquifers	Stream valley alluvium	<	>	>	5,276	14,546	5,242	896	2,693	869
P60	Columbia Plateau basaltic-rock aquifers	Stream valley alluvium	>	>	X	2,065	19,464	2,043	1,307	18,485	1,296
P62	Piedmont and Blue Ridge crystalline-rock aquifers-glacial	Coarse glacial	W	W	>	375	14,482	370	89	1,458	81
P62	Piedmont and Blue Ridge crystalline-rock aquifers	Glacial	<	>	>	148,779	161,760	148,420	375	14,482	370
P62	Piedmont and Blue Ridge crystalline-rock aquifers	Stream valley alluvium	W	>	>	148,779	161,760	148,420	91	175	90
S01	Washington Oregon coast ranges-S	Coarse glacial	<	>	>	219	13,648	217	12	109	12
S01	Washington Oregon Coast Ranges-S-glacial	Coarse glacial	X	>	X	635	6,066	625	12	109	12
S01	Washington Oregon Coast Ranges-S	Glacial	<	>	>	219	13,648	217	635	6,066	625
S01	Washington Oregon Coast Ranges-S	Stream valley alluvium	X	W	X	219	13,648	217	60	4,331	57
S02	Washington Oregon coast ranges-V	Coarse glacial	<	>	X	155	14,513	154	4	65	4
S02	Washington Oregon Coast Ranges-V-glacial	Coarse glacial	X	X	X	166	2,127	165	4	65	4
S02	Washington Oregon Coast Ranges-V	Glacial	<	>	>	155	14,513	154	166	2,127	165
S02	Washington Oregon Coast Ranges-V	Stream valley alluvium	X	>	>	155	14,513	154	48	3,294	48
S04	Northern Cascade Mountains	Coarse glacial	>	>	>	99	3,367	98	168	1,633	164
S04	Northern Cascade Mountains-glacial	Coarse glacial	X	>	>	1,367	13,963	1,336	168	1,633	164
S04	Northern Cascade Mountains	Glacial	>	W	X	99	3,367	98	1,367	13,963	1,336
S04	Northern Cascade Mountains	Stream valley alluvium	<	>	X	99	3,367	98	41	1,905	41
S05	Middle Cascade Mountains	Stream valley alluvium	<	W	>	295	11,884	272	196	5,743	181
S06	Middle & Southern Cascade Mountains	Stream valley alluvium	X	>	X	738	11,440	743	86	2,071	85
S07	Klamath Mountains	Stream valley alluvium	>	>	W	2,046	23,008	2,043	263	6,983	263

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

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S08	Coast Ranges	Stream valley alluvium	>	>	>	14,875	22,640	14,884	3,424	4,760	3,423
S09	Sierra Nevada	Stream valley alluvium	<	W	<	27,554	77,959	27,819	1,366	2,000	1,426
S10	Southern California Mountains	Stream valley alluvium	W	>	W	7,972	15,208	7,974	1,590	2,016	1,591
S11	Pacific Northwest volcanics	Stream valley alluvium	X	>	X	471	4,885	464	102	874	102
S12	Blue Mountains	Stream valley alluvium	X	X	X	88	651	85	1	66	1
S13	Basin and Range Highlands	Stream valley alluvium	<	W	W	11,855	25,581	11,773	5,971	9,088	5,978
S14	Grand Canyon	Stream valley alluvium	W	W	>	814	2,003	805	108	191	107
S16	Rio Grande Highlands	Stream valley alluvium	X	>	X	53	1,901	53	23	907	23
S17	Northern Rocky Mountains-X	Coarse glacial	>	W	W	1,710	16,843	1,659	397	2,187	387
S17	Northern Rocky Mountains-X-glacial	Coarse glacial	<	>	>	1,054	7,995	1,060	397	2,187	387
S17	Northern Rocky Mountains-X	Glacial	>	W	<	1,710	16,843	1,659	1,054	7,995	1,060
S17	Northern Rocky Mountains-X	Stream valley alluvium	X	>	>	1,710	16,843	1,659	633	10,718	614
S18	Northern Rocky Mountains-S-glacial	Coarse glacial	X	W	X	25	191	27	3	44	3
S18	Northern Rocky Mountains-S	Glacial	>	>	X	166	6,024	164	25	191	27
S18	Northern Rocky Mountains-S	Stream valley alluvium	>	>	>	166	6,024	164	55	2,195	53
S19	Northern Rocky Mountains-V	Stream valley alluvium	X	X	W	351	4,345	342	310	1,969	300
S20	Northern Rocky Mountains-Q	Coarse glacial	>	<	<	257	2,862	252	104	663	105
S20	Northern Rocky Mountains-Q-glacial	Coarse glacial	X	W	X	49	509	51	104	663	105
S20	Northern Rocky Mountains-Q	Glacial	>	W	<	257	2,862	252	49	509	51
S20	Northern Rocky Mountains-Q	Stream valley alluvium	X	>	>	257	2,862	252	167	2,415	163
S21	Middle Rocky Mountains-X	Stream valley alluvium	X	<	X	312	846	313	23	232	23
S22	Middle Rocky Mountains-S	Stream valley alluvium	>	>	W	3,138	4,581	3,120	5,472	7,555	5,445
S23	Middle Rocky Mountains-V	Stream valley alluvium	>	>	>	831	1,050	827	671	988	670
S24	Southern Rocky Mountains-X	Stream valley alluvium	>	>	>	14,325	20,924	14,329	1,003	1,657	1,001

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

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S25	Southern Rocky Mountains-S	Stream valley alluvium	>	>	>	4,569	6,892	4,568	2,732	3,825	2,734
S26	Southern Rocky Mountains-V	Stream valley alluvium	>	>	>	2,095	2,716	2,095	549	812	549
S28	Black Hills-S	Stream valley alluvium	X	>	>	457	1,823	456	75	394	75
S29	Front Range	Stream valley alluvium	>	>	>	1,825	2,463	1,826	74	123	74
S30	Upper Cretaceous unglaciated	Stream valley alluvium	>	>	>	9,934	27,469	9,941	4,755	14,604	4,755
S31	Raton Basin	Stream valley alluvium	W	>	>	1,437	3,997	1,448	100	592	100
S32	Eastern New Mexico	Stream valley alluvium	X	>	X	248	11,689	246	43	4,111	42
S33	Interior Permian	Stream valley alluvium	>	>	>	21,063	36,150	21,079	14,774	25,259	14,760
S34	Interior Pennsylvanian	Stream valley alluvium	W	>	>	5,183	9,992	5,183	1,248	2,434	1,250
S35	OK Permian-Pennsylvanian	Stream valley alluvium	>	>	X	1,868	2,468	1,871	704	976	704
S36	Ozarks Paleozoic	Coarse glacial	<	W	W	10,176	12,165	10,195	48	54	48
S36	Ozarks Paleozoic-Glacial	Coarse glacial	>	>	W	538	575	538	48	54	48
S36	Ozarks Paleozoic	Glacial	<	<	<	10,176	12,165	10,195	538	575	538
S36	Ozarks Paleozoic	Stream valley alluvium	X	W	X	10,176	12,165	10,195	845	1,107	845
S37	Ozarks-X	Stream valley alluvium	X	X	X	527	573	527	89	94	89
S38	Arches-unglaciated	Stream valley alluvium	X	>	W	14,178	23,402	13,937	260	495	250
S39	Texas-Triassic	Stream valley alluvium	X	>	X	46	1,110	46	1	97	1
S40	Texas-Cretaceous	Stream valley alluvium	X	>	X	184	2,043	183	28	50	28
S41	Cape Cod and Islands-glacial	Coarse glacial	<	X	X	6	63	6	80	1,730	80
S41	Texas-Pennsylvanian	Stream valley alluvium	>	>	X	258	3,204	256	15	147	15
S42	West Texas-S	Stream valley alluvium	X	X	X	37	191	37	10	91	10
S43	West Texas-V	Stream valley alluvium	X	X	X	43	464	44	13	94	13
S45	Edwards-Trinity KT	Stream valley alluvium	>	>	>	1,363	15,367	1,361	783	3,422	783
S46	Upper Cretaceous aquifers-glacial	Coarse glacial	>	>	X	402	2,038	399	157	600	154

Table 1.1. Cumulative distribution function fit results for domestic-supply wells in the United States.—Continued

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S47	Canadian Shield-glacial	Coarse glacial	W	>	>	155,593	181,314	154,872	103,078	116,528	102,673
S48	North Central Interior-X-glacial	Coarse glacial	>	>	>	362	1,156	357	98	460	95
S49	North Central Interior-PZ-glacial	Coarse glacial	X	X	X	14	147	14	33	187	33
S50	Arches-glaciated-glacial	Coarse glacial	W	>	W	78,130	123,706	77,341	52,499	65,964	52,026
S51	Outer Michigan Basin-glacial	Coarse glacial	>	>	W	116,492	121,452	116,309	135,830	140,131	135,653
S52	Inner Michigan Basin-glacial	Coarse glacial	>	>	W	53,868	54,685	53,839	43,131	43,765	43,095
S53	Adirondack Mountains-glacial	Coarse glacial	<	W	W	1,882	2,313	1,860	1,073	1,390	1,058
S54	Northern Appalachian Basin-PZ	Coarse glacial	W	>	>	1,693	2,068	1,661	5,306	10,581	5,118
S54	Northern Appalachian Basin-PZ-glacial	Coarse glacial	W	>	>	38,010	55,322	37,597	5,306	10,581	5,118
S54	Northern Appalachian Basin-PZ	Glacial	X	<	<	1,693	2,068	1,661	38,010	55,322	37,597
S54	Northern Appalachian Basin-PZ	Stream valley alluvium	<	>	>	1,693	2,068	1,661	157	262	143
S55	NE-KS Permian-Pennsylvanian-glacial	Coarse glacial	>	>	>	4,232	9,812	4,204	1,345	2,742	1,341
S56	IA-MO Pennsylvanian-glacial	Coarse glacial	>	>	>	2,027	20,827	1,996	357	3,678	349
S57	Illinois Basin-glacial	Coarse glacial	>	>	>	23,486	86,886	23,352	6,115	15,624	6,096
S58	Champlain-Hudson Valleys-X-glacial	Coarse glacial	<	W	W	2,852	3,053	2,848	664	755	662
S59	Champlain-Hudson Valleys-S-glacial	Coarse glacial	<	>	>	15,421	18,063	15,265	6,236	8,476	6,143
S60	Northern Appalachian Mountains-X-Glacial	Coarse glacial	<	W	W	177,198	201,251	176,813	28,561	40,955	28,388
S63	Ouachita Mountains	Stream valley alluvium	W	W	X	4,114	6,357	4,105	451	612	451
S64	Texas-KT	Stream valley alluvium	>	>	>	280	1,332	280	244	946	243
S65	Mississippi Embayment-KT	Stream valley alluvium	W	>	>	4,153	6,107	4,150	172	291	172
S66	Gulf Coastal-T	Stream valley alluvium	>	>	X	1,905	4,816	1,905	343	881	343
S67	Southeast Coastal Plain-T	Stream valley alluvium	>	W	X	200	271	197	11	16	11
S68	Florida-T	Stream valley alluvium	X	X	X	53,933	55,705	53,683	9	15	9

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P01	Basin and Range basin-fill aquifers	Stream valley alluvium	W	<	W	2,095	2,659	2,097	6,910	9,649	6,908
P02	Rio Grande aquifer system	Stream valley alluvium	W	>	W	165	1,162	165	522	4,284	522
P03	California Coastal Basin aquifers	Stream valley alluvium	<	<	<	501	663	500	3,654	4,527	3,654
P04	Pacific Northwest basin-fill aquifers	Coarse glacial	X	>	>	285	1,255	284	7	148	6
P04	Pacific Northwest basin-fill aquifers-glacial	Coarse glacial	X	>	X	58	601	55	7	148	6
P04	Pacific Northwest basin-fill aquifers	Glacial	X	>	>	285	1,255	284	58	601	55
P04	Pacific Northwest basin-fill aquifers	Stream valley alluvium	X	X	X	285	1,255	284	461	2,094	454
P05	Columbia Plateau basin-fill aquifers	Stream valley alluvium	X	>	>	127	646	126	600	3,741	598
P06	Snake River Plain basin-fill aquifers	Stream valley alluvium	X	X	X	39	67	38	290	607	286
P07	Puget Sound aquifer system-glacial	Coarse glacial	>	>	X	1,752	13,761	1,744	110	990	110
P08	Willamette Lowland basin-fill aquifers	Stream valley alluvium	<	>	X	59	290	59	479	2,611	475
P09	Northern Rocky Mountains Intermontane Basins	Coarse glacial	<	<	X	102	437	99	62	380	60
P09	Northern Rocky Mountains Intermontane Basins-glacial	Coarse glacial	X	X	X	54	334	52	62	380	60
P09	Northern Rocky Mountains Intermontane Basins	Glacial	<	<	X	102	437	99	54	334	52

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P09	Northern Rocky Mountains Intermontane Basins	Stream valley alluvium	<	X	X	102	437	99	386	1,735	380
P10	Central Valley aquifer system	Stream valley alluvium	<	<	<	128	185	129	3,756	5,606	3,759
P11	High Plains aquifer	Coarse glacial	>	>	>	2,223	5,395	2,221	239	539	239
P11	High Plains aquifer-glacial	Coarse glacial	>	>	X	162	422	162	239	539	239
P11	High Plains aquifer	Glacial	W	>	>	2,223	5,395	2,221	162	422	162
P11	High Plains aquifer	Stream valley alluvium	>	>	>	2,223	5,395	2,221	634	2,030	634
P12	Pecos River Basin alluvial aquifer	Stream valley alluvium	X	X	X	120	277	120	3	9	3
P13	Mississippi River Valley alluvial aquifer	Stream valley alluvium	<	<	>	165	397	165	1,472	2,224	1,471
P14	Seymour aquifer	Stream valley alluvium	X	<	X	57	168	57	2	14	2
P15	Surficial aquifer system	Stream valley alluvium	W	X	>	4,104	9,226	4,103	128	192	128
P18	Coastal lowlands aquifer system	Stream valley alluvium	X	W	W	8,235	12,125	8,235	3,481	5,592	3,480
P19	Texas coastal uplands aquifer system	Stream valley alluvium	X	X	<	1,462	2,680	1,462	108	203	108
P20	Mississippi embayment aquifer system	Stream valley alluvium	>	>	>	3,127	4,361	3,127	998	1,367	996
P21	Southeastern Coastal Plain aquifer system	Stream valley alluvium	X	X	X	1,456	2,115	1,455	181	339	181
P22	Northern Atlantic Coastal Plain aquifer system	Stream valley alluvium	W	<	<	5,972	7,654	5,963	2,842	3,516	2,840
P23	Colorado Plateaus aquifers	Stream valley alluvium	>	>	>	761	1,383	758	232	393	232
P24	Denver Basin aquifer system	Stream valley alluvium	>	>	>	759	1,253	759	389	630	389
P25	Lower Cretaceous aquifers	Coarse glacial	>	>	>	120	314	120	498	1,070	497
P25	Lower Cretaceous aquifers-glacial	Coarse glacial	>	>	X	783	1,836	782	498	1,070	497

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P25	Lower Cretaceous aquifers	Glacial	>	>	>	120	314	120	783	1,836	782
P25	Lower Cretaceous aquifers	Stream valley alluvium	X	X	X	120	314	120	32	169	32
P26	Rush Springs aquifer	Stream valley alluvium	X	X	X	42	72	42	13	32	13
P27	Central Oklahoma aquifer	Stream valley alluvium	>	>	X	244	419	239	37	66	37
P28	Ada-Vamoosa aquifer	Stream valley alluvium	X	X	X	47	101	47	3	4	3
P29	Early Mesozoic basin aquifers	Coarse glacial	X	>	>	1,144	1,454	1,143	420	610	420
P29	Early Mesozoic basin aquifers-glacial	Coarse glacial	X	>	>	563	758	563	420	610	420
P29	Early Mesozoic basin aquifers	Glacial	W	>	>	1,144	1,454	1,143	563	758	563
P29	Early Mesozoic basin aquifers	Stream valley alluvium	X	X	X	1,144	1,454	1,143	13	19	13
P30	New York sandstone aquifers-glacial	Coarse glacial	X	X	X	13	42	12	9	36	9
P31	Pennsylvanian aquifers	Coarse glacial	<	>	>	948	2,050	944	1,609	1,826	1,606
P31	Pennsylvanian aquifers-glacial	Coarse glacial	W	>	>	3,289	3,808	3,285	1,609	1,826	1,606
P31	Pennsylvanian aquifers	Glacial	<	<	>	948	2,050	944	3,289	3,808	3,285
P31	Pennsylvanian aquifers	Stream valley alluvium	<	>	>	948	2,050	944	276	559	274
P32	Marshall aquifer-glacial	Coarse glacial	>	>	>	1,363	1,471	1,361	1,930	2,107	1,929
P33	Cambrian-Ordovician aquifer system-glacial	Coarse glacial	X	>	>	6,170	8,845	6,147	3,779	5,214	3,772
P34	Jacobsville aquifer-glacial	Coarse glacial	X	>	>	142	183	141	127	140	126
P35	Lower Tertiary aquifers	Coarse glacial	>	>	>	157	490	157	58	208	57
P35	Lower Tertiary aquifers-glacial	Coarse glacial	>	>	X	97	437	97	58	208	57
P35	Lower Tertiary aquifers	Glacial	>	>	>	157	490	157	97	437	97

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
P35	Lower Tertiary aquifers	Stream valley alluvium	>	>	X	157	490	157	82	218	81
P36	Upper Cretaceous aquifers	Coarse glacial	>	>	>	29	165	29	30	75	30
P36	Upper Cretaceous aquifers-glacial	Coarse glacial	>	>	>	52	134	51	30	75	30
P36	Upper Cretaceous aquifers	Glacial	>	>	>	29	165	29	52	134	51
P36	Upper Cretaceous aquifers	Stream valley alluvium	X	X	X	29	165	29	16	47	16
P37	Upper Tertiary aquifers	Stream valley alluvium	X	X	X	8	11	8	6	8	6
P38	Edwards-Trinity aquifer system	Stream valley alluvium	X	>	>	1,241	2,483	1,240	110	242	110
P39a	Valley and Ridge carbonate-rock aquifers	Coarse glacial	X	>	>	1,159	1,662	1,155	22	32	21
P39a	Valley and Ridge carbonate-rock aquifers-glacial	Coarse glacial	X	>	>	150	235	150	22	32	21
P39a	Valley and Ridge carbonate-rock aquifers	Glacial	X	>	>	1,159	1,662	1,155	150	235	150
P39a	Valley and Ridge carbonate-rock aquifers	Stream valley alluvium	<	>	>	1,159	1,662	1,155	28	34	26
P39b	Valley and Ridge aquifers	Coarse glacial	W	>	>	1,024	1,381	1,020	50	90	50
P39b	Valley and Ridge aquifers-glacial	Coarse glacial	X	>	>	390	1,029	389	50	90	50
P39b	Valley and Ridge aquifers	Glacial	W	W	W	1,024	1,381	1,020	390	1,029	389
P39b	Valley and Ridge aquifers	Stream valley alluvium	>	>	X	1,024	1,381	1,020	10	24	10
P40	Mississippian aquifers	Coarse glacial	<	>	>	484	841	473	340	875	339
P40	Mississippian aquifers	Glacial	<	W	X	484	841	473	983	2,120	981
P40	Mississippian aquifers	Stream valley alluvium	X	>	>	484	841	473	44	77	44
P41	Paleozoic aquifers	Stream valley alluvium	>	X	X	68	242	68	12	51	12
P42	Basin and Range carbonate-rock aquifers	Stream valley alluvium	X	X	X	88	108	89	85	98	86

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
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P43	Roswell Basin aquifer system	Stream valley alluvium		X			3			120	
P44	Ozark Plateaus aquifer system	Coarse glacial	>	>	>	2,129	2,472	2,129	53	65	53
P44	Ozark Plateaus aquifer system-Glacial	Coarse glacial	>	>	>	40	54	40	53	65	53
P44	Ozark Plateaus aquifer system	Glacial	X	X	X	2,129	2,472	2,129	40	54	40
P44	Ozark Plateaus aquifer system	Stream valley alluvium	>	>	>	2,129	2,472	2,129	267	337	266
P45	Blaine aquifer	Stream valley alluvium	<	X	X	3	17	3	13	24	13
P47	Silurian-Devonian aquifers	Coarse glacial	<	<	>	36	72	36	2,921	5,085	2,911
P47	Silurian-Devonian aquifers-glacial	Coarse glacial	>	>	>	6,634	12,135	6,610	2,921	5,085	2,911
P47	Silurian-Devonian aquifers	Glacial	<	<	X	36	72	36	6,634	12,135	6,610
P47	Silurian-Devonian aquifers	Stream valley alluvium	X	W	X	36	72	36	22	37	22
P48	Ordovician aquifers	Stream valley alluvium	X	X	X	232	284	232	7	7	7
P49	Upper carbonate aquifer-glacial	Coarse glacial	X	X	W	305	461	305	107	191	107
P50	Floridan aquifer system	Stream valley alluvium	<	X	<	2,923	4,657	2,917	17	59	17
P52	New York and New England carbonate-rock aquifers-glacial	Coarse glacial	X	>	>	368	700	365	171	429	171
P53	Piedmont and Blue Ridge carbonate-rock aquifers-glacial	Coarse glacial	X	>	>	60	81	60	26	27	26
P53	Piedmont and Blue Ridge carbonate-rock aquifers	Glacial	X	W	X	125	168	124	60	81	60

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

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P54	Castle Hayne aquifer	Stream valley alluvium	W	W	X	366	451	365	159	198	159
P58	Pacific Northwest basaltic-rock aquifers	Stream valley alluvium	X	>	X	509	1,401	507	70	225	70
P59	Snake River Plain basaltic-rock aquifers	Stream valley alluvium	X	X	X	66	118	65	16	22	16
P60	Columbia Plateau basaltic-rock aquifers	Stream valley alluvium	X	>	X	177	956	177	271	1,486	270
P62	Piedmont and Blue Ridge crystalline-rock aquifers-glacial	Coarse glacial	<	>	>	533	675	533	86	107	86
P62	Piedmont and Blue Ridge crystalline-rock aquifers	Glacial	W	W	>	6,454	9,359	6,353	533	675	533
P62	Piedmont and Blue Ridge crystalline-rock aquifers	Stream valley alluvium	X	X	X	6,454	9,359	6,353	17	27	17
S01	Washington Oregon Coast Ranges-S	Coarse glacial	X	>	X	56	281	56	1	18	1
S01	Washington Oregon Coast Ranges-S-glacial	Coarse glacial	X	>	X	56	411	56	1	18	1
S01	Washington Oregon Coast Ranges-S	Glacial	<	X	>	56	281	56	56	411	56
S01	Washington Oregon Coast Ranges-S	Stream valley alluvium	X	W	X	56	281	56	21	98	21
S02	Washington Oregon Coast Ranges-V	Coarse glacial	X	>	X	63	289	62	1	9	1
S02	Washington Oregon Coast Ranges-V-glacial	Coarse glacial	X	>	X	12	209	12	1	9	1
S02	Washington Oregon Coast Ranges-V	Glacial	X	W	>	63	289	62	12	209	12

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

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S02	Washington Oregon Coast Ranges-V	Stream valley alluvium	X	X	X	63	289	62	20	69	20
S04	Northern Cascade Mountains	Coarse glacial	X	>	X	25	272	25	9	125	9
S04	Northern Cascade Mountains-glacial	Coarse glacial	X	>	X	71	836	70	9	125	9
S04	Northern Cascade Mountains	Glacial	X	X	X	25	272	25	71	836	70
S04	Northern Cascade Mountains	Stream valley alluvium	X	X	X	25	272	25	34	242	32
S05	Middle Cascade Mountains	Stream valley alluvium	X	X	X	48	981	47	25	489	25
S06	Middle & Southern Cascade Mountains	Stream valley alluvium	X	>	X	93	254	93	13	66	13
S07	Klamath Mountains	Stream valley alluvium	X	>	W	124	320	125	33	96	33
S08	Coast Ranges	Stream valley alluvium	X	X	X	448	730	448	155	244	155
S09	Sierra Nevada	Stream valley alluvium	<	X	X	755	2,035	769	104	149	106
S10	Southern California Mountains	Stream valley alluvium	X	X	X	359	687	359	139	177	139
S11	Pacific Northwest volcanics	Stream valley alluvium	X	W	X	59	191	58	10	53	10
S13	Basin and Range Highlands	Stream valley alluvium	W	X	X	977	1,376	981	498	637	501
S14	Grand Canyon	Stream valley alluvium	X	X	X	146	218	146	23	33	23
S16	Rio Grande Highlands	Stream valley alluvium	X	>	X	15	148	15	1	60	1
S17	Northern Rocky Mountains-X	Coarse glacial	X	X	X	95	404	94	8	87	7
S17	Northern Rocky Mountains-X-glacial	Coarse glacial	X	>	X	56	301	55	8	87	7
S17	Northern Rocky Mountains-X	Glacial	<	W	X	95	404	94	56	301	55
S17	Northern Rocky Mountains-X	Stream valley alluvium	<	W	X	95	404	94	55	409	53
S18	Northern Rocky Mountains-S	Glacial	X	X	X	26	193	26	1	11	1

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

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S18	Northern Rocky Mountains-S	Stream valley alluvium	>	>	X	26	193	26	17	104	17
S19	Northern Rocky Mountains-V	Stream valley alluvium	X	X	X	16	104	16	20	73	19
S20	Northern Rocky Mountains-Q	Coarse glacial	X	<	X	11	59	11	6	30	6
S20	Northern Rocky Mountains-Q-glacial	Coarse glacial	X	X	X	11	32	11	6	30	6
S20	Northern Rocky Mountains-Q	Glacial	<	<	<	11	59	11	11	32	11
S20	Northern Rocky Mountains-Q	Stream valley alluvium	X	W	X	11	59	11	35	137	35
S21	Middle Rocky Mountains-X	Stream valley alluvium	X	<	X	15	51	14	1	3	1
S22	Middle Rocky Mountains-S	Stream valley alluvium	>	>	>	89	123	89	101	202	101
S23	Middle Rocky Mountains-V	Stream valley alluvium	X	X	<	66	82	66	18	39	18
S24	Southern Rocky Mountains-X	Stream valley alluvium	>	X	>	175	479	175	33	111	33
S25	Southern Rocky Mountains-S	Stream valley alluvium	X	W	>	133	272	133	67	132	67
S26	Southern Rocky Mountains-V	Stream valley alluvium	>	>	X	34	73	34	15	22	15
S28	Black Hills-S	Stream valley alluvium	X	X	X	41	142	41	8	55	8
S30	Upper Cretaceous unglaciated	Stream valley alluvium	>	>	>	266	843	266	300	951	300
S31	Raton Basin	Stream valley alluvium	X	X	>	21	182	21	9	63	9
S32	Eastern New Mexico	Stream valley alluvium	X	>	X	17	1,231	17	15	371	15
S33	Interior Permian	Stream valley alluvium	>	>	>	847	1,485	843	802	1,456	801
S34	Interior Pennsylvanian	Stream valley alluvium	>	>	>	72	230	72	38	91	37
S35	OK Permian-Pennsylvanian	Stream valley alluvium	W	>	>	157	325	156	97	215	95
S36	Ozarks Paleozoic	Coarse glacial	X	X	X	242	396	242	6	8	6

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
S36	Ozarks Paleozoic-Glacial	Coarse glacial	X	X	X	19	24	19	6	8	6
S36	Ozarks Paleozoic	Glacial	X	X	X	242	396	242	19	24	19
S36	Ozarks Paleozoic	Stream valley alluvium	X	>	>	242	396	242	15	41	15
S37	Ozarks-X	Stream valley alluvium	X	X	X	4	5	4	1	1	1
S38	Arches-unglaciated	Stream valley alluvium	W	W	>	345	524	342	51	121	51
S41	Cape Cod and islands-glacial	Coarse glacial		W			12			367	
S41	Texas-Pennsylvanian	Stream valley alluvium		X			66			4	
S42	West Texas-S	Stream valley alluvium	X	X	X	16	26	16	9	15	9
S43	West Texas-V	Stream valley alluvium	X	X	X	23	38	23	15	18	15
S45	Edwards-Trinity KT	Stream valley alluvium	>	>	<	1,516	2,785	1,516	301	559	301
S47	Canadian Shield-glacial	Coarse glacial	X	>	>	3,852	5,160	3,825	3,402	4,561	3,387
S48	North Central Interior-X-glacial	Coarse glacial	>	>	>	39	118	39	58	240	58
S49	North Central Interior-PZ-glacial	Coarse glacial	X	X	X	2	7	2	3	9	3
S50	Arches-glaciated-glacial	Coarse glacial	>	>	>	2,934	5,024	2,920	2,122	3,303	2,113
S51	Outer Michigan Basin-glacial	Coarse glacial	>	>	W	5,134	5,794	5,122	7,730	8,692	7,716
S52	Inner Michigan Basin-glacial	Coarse glacial	>	>	W	2,883	3,099	2,880	2,088	2,245	2,086
S53	Adirondack Mountains-glacial	Coarse glacial	X	X	X	12	52	11	30	97	29
S54	Northern Appalachian Basin-PZ	Coarse glacial	W	>	>	29	47	29	354	916	352
S54	Northern Appalachian Basin-PZ-glacial	Coarse glacial	X	>	>	630	2,164	626	354	916	352
S54	Northern Appalachian Basin-PZ	Glacial	X	X	<	29	47	29	630	2,164	626

Table 1.2. Cumulative distribution function fit results for public-supply wells in the United States.—Continued

[Results from cumulative distribution function fit procedure used to determine if the depths and lengths of open intervals in public-supply wells in areas with and without overlying sediment within each hydrogeologic setting are statistically different. Depths and lengths are in feet. Comparisons are based on a p-value of 0.05. X, no statistical difference; W, distribution within 10 percent; <, hydrogeologic setting with overlying sediment less than hydrogeologic setting without overlying sediment; >, hydrogeologic setting with overlying sediment greater than hydrogeologic setting without overlying sediment]

Hydrogeologic setting number	Hydrogeologic setting name	Overlying sediment	Cumulative distribution function fit statistical result			Number of wells in hydrogeologic setting without overlying sediment, in feet			Number of well in hydrogeologic setting with overlying sediment, in feet		
			Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval	Depth to top of open interval	Depth to bottom of open interval	Length of open interval
S54	Northern Appalachian Basin-PZ	Stream valley alluvium	W	>	X	29	47	29	5	19	5
S55	NE-KS Permian-Pennsylvanian-glacial	Coarse glacial	>	>	W	259	852	258	178	490	178
S56	IA-MO Pennsylvanian-glacial	Coarse glacial	>	>	>	424	1,674	421	409	1,297	406
S57	Illinois Basin-glacial	Coarse glacial	>	>	X	1,418	4,364	1,414	677	1,734	677
S58	Champlain-Hudson Valleys-X-glacial	Coarse glacial	<	X	X	39	60	38	21	35	21
S59	Champlain-Hudson Valleys-S-glacial	Coarse glacial	X	>	>	261	527	259	236	537	236
S60	Northern Appalachian Mountains-X-glacial	Coarse glacial	X	>	>	3,267	9,012	3,249	1,405	3,954	1,394
S63	Ouachita Mountains	Stream valley alluvium	X	X	X	24	126	24	6	8	6
S64	Texas-KT	Stream valley alluvium	>	>	>	63	133	63	24	53	24
S65	Mississippi Embayment-KT	Stream valley alluvium	X	>	X	455	588	455	9	23	9
S66	Gulf Coastal-T	Stream valley alluvium	>	>	>	474	640	474	122	163	122
S67	Southeast Coastal Plain-T	Stream valley alluvium	X	X	X	79	178	79	6	15	6
S68	Florida-T	Stream valley alluvium		X			3,836			5	

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