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Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring[1]

This standard is issued under the fixed designation D5980; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

~~ε1 NOTE—The units statement in 1.5 was revised editorially in August 2010.~~

1. ~~Scope~~ Scope*

1.1 This guide covers the use of existing wells for environmental site characterization and monitoring. It covers the following major topics: criteria for determining the suitability of existing wells for hydrogeologic characterization and groundwater quality monitoring, types of data ~~required~~needed to document the suitability of an existing well, and the relative advantages and disadvantages of existing large- and small-capacity wells.

1.2 This guide should be used in conjunction with Guide D5730, that provides a general approach for environmental site investigations.

1.3 This guide does not specifically address design and construction of new monitoring or supply wells. Refer to Practices D5092 and D5787.

1.4 This guide does not specifically address groundwater sampling procedures. Refer to Guide D5903.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 Pertinent guides addressing specific information necessary to utilize existing wells for hydrologic and water-quality data for environmental site characterization. A comprehensive list of guides, standards, methods, practices, and terminology is contained in Guide D5730. Other guidance documents covering procedures for environmental site investigations with specific objectives or in particular geographic settings may be available from federal, state, and other agencies or organizations. The appropriate agency or organization should be contacted to determine the availability and most current edition of such documents.

2.2 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

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

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

***A Summary of Changes section appears at the end of this standard**

~~D4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) (Withdrawn 2010)[3]~~
D5092 Practice for Design and Installation of Groundwater Monitoring Wells
D5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site
D5408 Guide for Set of Data Elements to Describe a Groundwater Site; Part One—Additional Identification Descriptors
D5409 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two—Physical Descriptors
D5410 Guide for Set of Data Elements to Describe a Groundwater Site;Part Three—Usage Descriptors (Withdrawn 2016)[3]
~~D5474 Guide for Selection of Data Elements for Groundwater Investigations~~
D5521 Guide for Development of Groundwater Monitoring Wells in Granular Aquifers
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]
D5753 Guide for Planning and Conducting Borehole Geophysical Logging
D5787 Practice for Monitoring Well Protection
D5903 Guide for Planning and Preparing for a Groundwater Sampling Event
~~D5978 Guide for Maintenance and Rehabilitation of Groundwater Monitoring Wells~~
D5979 Guide for Conceptualization and Characterization of Groundwater Systems

3. Terminology

3.1 *Definitions*—For common definitions of technical terms used in this standard, refer to Terminology D653.

3.2 ~~*Definitions:*~~*Definitions of Terms Specific to This Standard:*

~~3.1.1 Except as noted below, all definitions are in accordance with Terminology D653:~~

~~3.1.2 *aquifer, n*—a geologic formation, group of formations, or part of a formation that is saturated and is capable of providing a significant quantity of water (see Practice D5092).~~

~~3.1.3 *monitoring well (observation well), n*—a special well drilled in a selected location for observing parameters such as liquid level or pressure changes or for collecting liquid samples. The well may be cased or uncased, but if cased, the casing should have openings to allow flow of borehole liquid into or out of the casing.~~

~~3.1.4 *observation well, n*—for the purposes of this guide, an existing well constructed for other purposes that is also used to measure water levels and to collect groundwater quality samples. Observation well may be referred to as "well" in this guide.~~

3.2.1 *supply (production) well, n*—well primarily installed for public supply, irrigation, and industrial use. Supply wells may be used as an observation well.

4. Significance and Use

4.1 This guide describes a general approach for the use of existing wells in environmental investigations with a primary focus on the subsurface and major factors affecting the surface and subsurface environment.

4.2 Existing wells represent a valuable source of information for subsurface environmental investigations. Specific uses of existing wells include:

4.2.1 Well driller logs provide information on subsurface lithology and major water-bearing units in an area. Existing wells can also offer access for downhole geophysical logging for stratigraphic and aquifer interpretations. Examples include natural gamma logs in cased wells and an entire suite of methods in uncased bedrock wells (see Guide D5753). This information can assist in developing the preliminary conceptual model of the site.

4.2.2 Well tests using existing wells may provide information on the hydrologic characteristics of an aquifer.

4.2.3 Monitoring of water levels in existing wells, provided that they are cased in the aquifer of interest, allow development of potentiometric maps and interpretations of groundwater flow ~~directions.~~directions and gradients.

4.2.4 Existing wells are the primary means by which regional drinking water quality is evaluated and monitored.

4.2.5 Existing wells may assist in the mapping of contaminant plumes, and in ongoing monitoring of groundwater quality changes at the site-specific level.

4.3 Data from existing wells should only be used when characteristics of the well have been sufficiently documented to determine that they satisfy criteria for the purpose for which the data are to be used.

5. General Considerations in Selection and Use of Existing Wells

5.1 Selection and use of existing wells should take place in the context of a conceptual framework consisting of a description of the system, including, as necessary, physical and cultural characteristics, such as climate, hydrology, ecology, physiography, population, water use and land use, and hypotheses about processes of interest that occur within that system. A step-wise approach for conceptualization and characterization is a direct approach to develop the framework for Hydrologic Systems as described in

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

Kolm (**1**)[4], (see Guide D5979). Conceptualization of hydrologic and regional groundwater quality systems can be formulated using the methods outlined in Alley (**2**). The framework is reviewed and refined by an iterative process of data collection and analysis, testing hypotheses with data collected, and identifying data needs to further revise the framework. Refinement must be made within the limits established by the accuracy, precision, and completeness of the data. Methods for data collection are selected that will provide data appropriate for testing hypotheses which evaluate the conceptual framework.

5.2 Well design and installation can criticallygreatly affect the quality of water level measurements and groundwater samples.groundwater monitoring. Such effects apply both to existing wells and to wells specifically installed for a purpose. The effects of well design and installation, therefore, need to be considered regardless of whether existing wells are selected or if wells are specifically installed for a specific purpose. The most common feature of an existing well that may render it unsuitable for water level measurement or water-quality monitoring is that the well is completed in multiple hydrogeologic units are connected causing water levels and water-quality parameters to reflect a mixing of multiple hydrogeologic units. Such data cannot be reliably compared with data from wells completed in the individual hydrogeologic units.

5.3 Major steps in the selection of existing wells for environmental investigations include: developing specific criteria for evaluating the suitability of existing wells in relation to the objectives of the investigations (see Section 6), conducting an inventory of existing wells in the area of interest (see 8.1), documenting the characteristics of the wells identified in the inventory that are relevant to the selection criteria (see 8.2), and identification of wells that satisfy the selection criteria (see Section 9).

6. Well-Selection Criteria

6.1 Assessing the suitability of existing wells for hydrological and groundwater quality studies requires development of specific well-selection criteria. The criteria are based on considerations of project objectives by defining the problem to be solved, the conceptual framework, and data-collection requirements.

6.2 *Specific Well-Selection Criteria*—Specific criteria will depend on the objectives of the investigation. The following general criteria will apply to most situations:

6.2.1 The well is suitably located for use in relation to the conceptual framework.

6.2.2 The well must be completed in the targeted hydrogeologic unit or units.

6.2.3 Well design and construction must not bias water level measurements or water-quality sampling results (see Note 1). Section 7 provides information on the general characteristics of major types of existing wells.

NOTE 1—Gillham et al. (**3**), provides information on the suitability of materials coming in contact with water samples and that table provides information on the compatibility of well casing materials with different organic contaminants.

6.2.4 The well is accessible for measurements and sampling.

6.2.5 The well's maintenance condition may not compromise it as a sampling point; however, there are examples that may compromise it as a sampling point, that is, a cracked casing allowing non-screened water into the well.

6.3 *Examples of Well Selection Criteria*—The following are illustrative examples of criteria for specific investigation objectives (see Note 2).

NOTE 2—These are illustrative examples and should not be construed as recommended criteria.

6.3.1 A project to determine the quality of potable groundwater might require the following selection criteria: wells selected must be used for public water supply, must be geographically distributed over the entire aquifer of interest, and must be able to be sampled prior to any water treatment.

6.3.2 All wells or a subset of wells down-gradient from a hazardous-waste site would be unsuitable to include in a network designed for a study to determine non-point source groundwater quality.

6.3.3 Choosing a well located down-gradient of a complex mix of land uses would be inappropriate in a study designed to assess the effects of specific land uses on groundwater quality.

6.3.4 A supply well screened over a long interval would not be appropriate for investigating small-scale vertical variations in water quality down-gradient of a landfill, or for potentiometric mapping.

6.3.5 A well constructed of PVC (polyvinylchloride) with glued joints would not be suitable for sampling if the volatile-organic compounds of interest in the groundwater also are found in the glue used to join the sections of well casing. Similarly, a well constructed of steel may not be suitable for the sampling of metals.

6.3.6 Selecting an observation well in an area undergoing rapid development would be avoided in constructing a network of wells for evaluating long-term trends in groundwater quality because of the possibility of the well being destroyed by later development.

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

7. General Characteristics of Major Types of Existing Wells

7.1 There are two general categories of existing wells available for hydrologic and groundwater quality studies: large- and small-capacity supply or production wells installed for drinking, irrigation, and industrial use (see 7.2 and 7.3); and wells specially designed and installed to monitor hydrologic or water-quality studies, or both (see 7.4). Each type of well has its own general advantages and disadvantages.

7.2 *Large-Capacity Supply Wells*—Large-capacity supply wells are usually developed for drinking water systems that supply multiple households, and for irrigation and industrial purposes.

7.2.1 *Advantages:*

7.2.1.1 Documentation of well construction commonly is good.

7.2.1.2 Large-capacity wells generally are well developed and fully purged.

7.2.1.3 Long-term access may be possible, particularly for municipal wells.

7.2.1.4 Large-capacity wells generally provide a larger vertical mix of water in an aquifer or aquifer system than small-capacity wells, and thus can provide a more integrated measure of regional groundwater quality than small-capacity wells.

7.2.1.5 Much of the water produced for irrigation and municipal water is from large-capacity wells equipped with taps which allow a direct sample of the pumped water.

7.2.1.6 Long-term water-quality and quantity data may be available.

7.2.2 *Disadvantages:*

7.2.2.1 Large-capacity wells may not have flow-rate controls and a sampling point near the well head.

7.2.2.2 High pumping rates may entrain artifacts, such as colloids or suspended material, into the sample stream.

7.2.2.3 Pumping schedules could be irregular: for example, irrigation wells generally are pumped seasonally, and could lead to seasonal variations in water quality that actually are an artifact of the pumping regime.

7.2.2.4 Large capacity wells may have a long vertical gravel pack, screened or open intervals might span more than one aquifer or aquifer system, making them unsuitable for potentiometric mapping or water quality monitoring. For example, dilution of contaminant concentrations wells with long screen intervals may result in large errors if concentrations are used for detailed delineation of the geometry and concentrations of contaminant plumes or for detection of contaminants in low concentrations (Pohlmann and Alduino (**4**)).

7.2.2.5 Wells with high pumping rates may draw water from water-bearing units other than those screened even if the well is screened solely within one unit; thus, the vertical integration of water from water-bearing units might be unknown.

7.2.2.6 Local hydraulics may be atypical of regional groundwater movement as a result of compaction or enhanced downward flow.

7.2.2.7 Municipal wells that produce water not meeting water-quality standards are usually abandoned, implying that the remaining population of municipal wells is biased toward acceptable water quality.

7.2.2.8 Down-hole chlorination or other chemical treatment might affect water chemistry, so that samples do not reflect ambient groundwater composition.

7.2.2.9 Depth-dependent differences in water quality could be lost, as water sampled could reflect a mixture of water obtained at different depths.

7.3 *Small-Capacity Supply Wells*—Small-capacity supply wells are usually developed for domestic water use involving a single household.

7.3.1 *Advantages:*

7.3.1.1 Domestic wells are a major source of drinking-water supply for rural population, so wells reflect this resource use.

7.3.1.2 Good to excellent areal and depth coverage in some areas, particularly for water-table aquifers.

7.3.1.3 Small-capacity pumping rates limit withdrawal of water from water-bearing formations other than those screened.

7.3.1.4 The low pumping rates of small-capacity wells are less likely to entrain artifacts, such as colloids or suspended material, into the sample stream than the high pumping rates of large-capacity wells.

7.3.2 *Disadvantages:*

7.3.2.1 Domestic wells may not be available in urban and suburban areas.

7.3.2.2 Documentation of well-construction characteristics may not be available.

7.3.2.3 Well construction, pressure tanks and treatment, and/or pumps may preclude being able to collect a sample at the well head.

7.3.2.4 The relation between well locations, septic systems, and other potential processes that could affect groundwater chemistry must be established in order to correctly assess what conditions water-quality data truly reflect.

7.3.2.5 The ~~open~~screened interval may provide connections for more than one water-bearing unit, making a well unsuitable for potentiometric mapping or water quality monitoring.

7.4 *Existing Monitoring Wells*—Existing monitoring wells may be available that have been installed for purposes other than the current investigations.

7.4.1 *Advantages:*

7.4.1.1 Well construction details are usually well documented.

7.4.1.2 Well construction usually avoids interconnection of different water-bearing units.

7.4.1.3 Well construction is usually designed to optimize quality of groundwater samples.

7.4.2 *Disadvantages*—Well location, screen interval, or well construction details may not be suitable for the purpose of the current environmental investigation.

8. Well Inventory and Documentation

8.1 *Well Inventory*—Selection of wells begins with an inventory of existing production wells or previously installed monitoring wells in the locale of interest (see Guide D5521~~). In~~), in order to collect information related to well selection criteria (see Section 6 and 8.2).

8.1.1 Well records of municipal, irrigation, and industrial wells can be obtained from the appropriate ~~state agency, local groundwater management district, natural resource district, and local offices of the U.S. Geological Survey, Water Resources District. Ganley~~ governing agencies.~~(5) identifies the primary sources of domestic well records and identifies other locations where records may be available as of 1989.~~

8.1.2 If the locale of interest is not too large, a property-owner survey may identify additional wells that have not been recorded elsewhere. Interviews with well owners may also provide additional information that is missing from state or local agency records.

8.2 *Well Documentation*—Well documentation involves collection of all available data that are relevant to the well selection criteria. Practice D5254 identifies the minimum set of data elements to identify a groundwater site and Guides D5408, D5409, and D5410 identify additional data elements. Table 1 and Fig. 1 identifies types of information available from ~~state agency well record forms as of 1989~~ agencies in the United States well record forms. ~~(5).~~Figure 3 provides a checklist for documenting well information. Well documentation should include, but not necessarily be limited to:

8.2.1 Well identification number, type, location, elevation, and depth.

8.2.2 Lithologic log describing character and depths of different materials encountered during well drilling.

8.2.3 Hydrogeologic unit or units that supply water to the well. If accurate well logs are not available, additional investigations, such as borehole geophysical logging may be ~~required.~~needed. The major hydrogeologic units in an area must be well established in order to correlate water-bearing units in an existing well to hydrogeologic units in the area.

8.2.4 Well construction details, such as casing type, depth, screened interval, filter pack, grouts, and seals. Refer to Practice D5092 for additional information on important elements of well design and construction. Other major sources of information on this topic include: Aller et al. (**~~6~~5**), Driscoll (**~~7~~6**), Harlan et al. (**~~8~~7**), Lehr et al. (**~~9~~8**), Nielsen and Schalla (**~~10~~9**), ~~and~~ McCaulou et al. (**~~11~~10**~~).~~), and US Geologic Survey (14).

8.2.5 Well water levels. Measurements should reflect water levels without the influence of pumping if unstressed potentiometric mapping is desired.

8.2.6 Well yields, and ~~any~~ other well test results.

8.2.7 Land use in the vicinity of the well (see Figs. 2 and and (**~~12~~11**)).

8.2.8 Name, Title, and Date of Preparer.

8.3 If existing information sources are not sufficient to provide the information required to adequately document a well, it should be removed from further consideration or subject to further ~~investigations.~~evaluations. Borehole geophysical methods, as described in Guide D5753, may be useful for obtaining additional data on lithology and well construction details.

9. Well Selection

9.1 Application of the well selection criteria to wells identified in the well inventory will usually result in elimination of wells that do not meet the criteria. The set or subset of wells selected may be modified as a result of site visits to evaluate and obtain permission to use wells. If existing wells fail the selection process, then installing wells to meet the well selection criteria is necessary to solve the problem (**~~13~~12**).

9.2 Selection of a supply well or existing monitoring well for water-level measurements and/or sampling should be based on the ability to document that the following are true:

9.2.1 The hydrogeologic unit(s) have been identified with reasonable certainty for those intervals: in which the water level is being measured or from which samples are collected.

9.2.2 Possible biases caused by use and location of the well that may compromise meeting project objectives have been considered during selection.

9.2.3 The design of the well, the materials from which the well is constructed, and methods of well installation are not likely to affect the water-level measurement or the water-quality constituents of interest.

9.2.4 Well-construction integrity has been verified.

9.2.5 Possible biases caused by the pumping rate have been considered. For example, wells might be selected that have a pumping rate sufficiently low to avoid entrainment into the sample stream of sampling artifacts, such as colloids or suspended materials, or to ~~ensure~~ make sure that water will not be drawn from units other than those of interest.

9.2.6 Materials used in the construction of pumps may ~~effect~~affect the water-quality constituents of interest and should be considered when planning the collection of water samples.

TABLE 1 Technical Information Items and Tabulations for Agency Well Record Forms (in the United States)

	STATES																										
									Florida[b]																		
	AL	AK	AZ	AR	CA	CO	CT	DE	A	B	C	D	E	HI	ID	IL	IN	KS	KY	LA[c]	ME	MD	MA	MI	MN	MS	MO
GENERAL																											
1. Owner's Name	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2. Driller's Name	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3. Registration/License Number	•	•		•	•	•	•		•	•	•	•	•		•	•		•	•	•		•	•	•	•		
4. Permit Number		•	•		•	•	•	•	•	•	•	•	•		•	•			•			•				•	•
5. Construction Date	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
6. Well Log Confidentiality					•																						
7. Well Use	•	•		•	•		•	•	•	•	•		•		•	•	•	•	•	•	•		•	•	•	•	•
8. Nearest Septic, Sewer or Possible Contamination Source								•								•		•				•		•	•		
9. Replacement or Abandoned Wells					•			•	•	•	•		•		•			•	•	•		•			•		•
10. Comments/Remarks		•	•	•				•			•			•		•			•	•	•		•	•	•	•	
CONSTRUCTION DETAILS																											
11. Well Service				•	•				•	•	•		•		•			•	•								
12. Drilling Method	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•		•		•		•	•	•		•
13. Drilling Fluid					•			•		•									•						•		
14. Open Hole	•										•	•						•							•	•	
15. Total Well Depth	•	•	•	•	•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•		•	•	•	•
16. Borehole Diameter	•			•	•	•	•							•	•	•		•	•						•		
17. Grout	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•		•	•		•
18. Grout Material		•		•		•		•		•		•			•	•		•	•	•		•		•	•		•
19. Grout Interval	•			•	•	•		•	•	•	•	•	•	•	•	•		•	•	•		•		•	•		•
20. Grout Method					•	•									•					•		•			•		•
21. Packers	•														•												
22. Gravel Pack	•	•		•	•	•	•	•						•	•	•	•	•	•		•	•	•			•	•
23. Gravel Pack Material								•											•								
24. Gravel Pack Size					•	•	•								•												•
25. Gravel Pack Interval				•	•	•	•	•						•	•			•	•			•					•
26. Drive Shoe							•								•	•								•	•		•
27. Casing Gauge		•		•	•		•							•	•	•		•		•				•	•		•
28. Casing Diameter	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
29. Casing Material	•		•	•	•	•		•	•	•	•	•	•		•	•		•	•	•		•	•		•	•	•
30. Casing Interval or Length	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
31. Casing Stick Up		•						•								•		•						•	•		
32. Couplings	•	•	•				•								•			•	•					•	•		•
33. Perforated or Screen Material		•	•	•	•	•	•	•		•				•	•			•	•	•		•	•	•	•	•	•
34. Slot or Perforation Size	•	•	•	•	•	•	•			•				•	•	•	•		•	•		•	•	•	•	•	•
35. Perforation or Screen Interval or Length	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•		•	•	•	•	•	•
36. Well Sanitation				•												•		•	•					•	•		•
37. Pump Information	•	•	•			•		•	•	•	•			•		•	•		•			•		•	•	•	•
38. Surface Completion								•							•	•			•					•	•		
HYDROGEOLOGY																											
39. Static Water Level	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
40. Pumping Water Level	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	•	•	•
41. Aquifer Media				•		•			•	•		•	•		•	•					•	•	•		•		
42. Geologic Formation																				•	•					•	
43. Driller's Log	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
44. Well Test	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•				•		•	•	•
45. Estimated Yield	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•		•	•	•	•	•	•	•
46. Water Quality	•				•					•		•		•	•	•	•	•	•		•		•	•			
LOCATION																											
47. Owner Mailing Address	•	•	•	•	•		•		•										•		•		•	•	•	•	
48. Well Location Address		•		•	•	•	•		•	•	•		•		•	•	•	•	•	•		•	•	•	•		•
49. Well Location TRS	•	•	•	•	•	•			•	•	•	•	•		•	•	•	•						•	•	•	•
50. Well Location Lat. and Long.		•			•				•	•		•	•	•					•				•				
51. Other Location	•	•	•	•	•		•	•	•	•			•	•	•		•	•	•	•	•	•	•	•	•	•	•
52. Well Elevation			•	•										•		•	•	•	•	•				•	•	•	•

NOTE: Various factors may contribute to what are apparent inaccuracies in the data presented in this table. Misinterpretations or errors noticed by readers would be of great interest to the author.

[a] Data are not available for Georgia, Iowa, and Nebraska.

[b] Florida's water management districts are:
A St. John's River
B South Florida
C Northwest Florida
D Southwest Florida
E Suwannee

[c] Louisiana has a separate form for plugging and abandonment.

9.2.7 The type of pump may also effect the validity of collecting water samples. Air-lift pumps most likely may affect the collection of many water constituents by introducing air to the samples. Wells with oil-lubricated pumps should not be used to collect constituents affected by hydrocarbons.

9.2.8 Possible biases caused by the sampling-point location that may compromise meeting project objectives have been considered.