Hydrologic, Lithologic, and Chemical Data For Sediment in the Shallow Alluvial Aquifer at Two Sites near Fallon, Churchill County, Nevada, 1984–85

By Michael S. Lico, Alan H. Welch, and Jennifer L. Hughes

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23. Well DR-AH-17A, depth 4.0 feet
24. Well DR-AH-17A, depth 8.0 feet
25. Well DR-AH-17A, depth 14.5 feet

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CONVERSION FACTORS AND ABBREVIATIONS

"Inch-pound" units of measure used in this report may be converted to International System (metric) units by using the following factors:

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<th>Multiply</th>
<th>By</th>
<th>To obtain</th>
</tr>
</thead>
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<td>Meters (m)</td>
</tr>
<tr>
<td>Feet per day (ft/d)</td>
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<td>Meters per day (m/d)</td>
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</tr>
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<tr>
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To convert from the phi (ϕ) size scale to the millimeter scale:
size, in millimeters = 10⁻ϕ/3.322
HYDROLOGIC, LITHOLOGIC, AND CHEMICAL DATA FOR SEDIMENT IN THE SHALLOW ALLUVIAL AQUIFER AT TWO SITES NEAR FALLON, CHURCHILL COUNTY, NEVADA, 1984-85

By Michael S. Lico, Alan H. Welch, and Jennifer L. Hughes

ABSTRACT

The U.S. Geological Survey collected an extensive amount of hydrogeologic data from the shallow alluvial aquifer at two study sites near Fallon, Nevada, from 1984 through 1985. These data were collected as part of a study to determine the geochemical controls on the mobility of arsenic and other trace elements in shallow ground-water systems. The main study area is approximately 7 miles south of Fallon. A subsidiary study area is about 8 miles east of Fallon. The data collected include lithologic logs and water-level altitudes for the augered sampling wells and piezometers, and determinations of arsenic and selenium content, grain size, porosity, hydraulic conductivity, and mineralogy for sediment samples from cores.

INTRODUCTION

The U.S. Geological Survey collected hydrologic, lithologic, and chemical data from the shallow alluvial aquifer near Fallon, Nev. (fig. 1) in 1984 and 1985. These data were collected as part of the national Toxic Waste Program of the U.S. Geological Survey. The purpose of this specific study is to ascertain the geochemical controls affecting the mobility of arsenic and other trace elements in a variety of geochemical environments. The data presented in this report are from a study of a shallow alluvial ground-water system. The bulk of the data were collected from an area approximately 7 miles south of the city of Fallon, Nev., designated as the Dodge Ranch study area (fig. 2). Other data were collected approximately 8 miles east of Fallon in the Harmon Lake study area (fig. 3). The Dodge Ranch study area consists of an array of 10 sampling wells, 22 piezometers (water-level monitoring wells), and 4 staff gages within an area of approximately 0.06 square mile. The staff gages are located in irrigation ditches and drains. The Harmon Lake study area consists of nine sampling wells within an area of approximately 0.5 square mile. The locations of wells, piezometers, and staff gages are shown in figures 2 and 3, and basic information regarding the sites is listed in tables 1 and 2.
FIGURE 1.--Location of study areas (crosshatched).
FIGURE 2.--Locations of sampling wells, piezometers, and staff gages at Dodge Ranch study area (SW 1/4NW 1/4 of section 6). Numbers and letters next to well, piezometer, and staff-gage symbols are abbreviated forms of those listed in tables 1 and 2.
FIGURE 3.—Location of sampling wells at Harmon Lake study area. Numbers and letters next to well symbols are abbreviated forms of those listed in table 1.
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TABLE 1.—Well locations, numbers, altitudes, and depths—Continued

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HARMON LAKE STUDY AREA

Sampling Wells

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\(^1\) Completed well depth is bottom of screened interval, relative to land surface.
TABLE 2.—Staff-gage locations and water-level altitudes at Dodge Ranch study area

[Altitudes are expressed in feet above 3,900 feet; "--" indicates no data available]

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<table>
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<td>Nov. 20, 1984</td>
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</tr>
<tr>
<td>May 1, 1985</td>
<td>32.73</td>
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The local well numbering system used in this report is based on the rectangular subdivision of the public lands referenced to the Mount Diablo base line and meridian. Each number consists of three units separated by spaces: The first unit is the township, preceded by an N or S to indicate location north or south of the base line. The second unit is the range, preceded by an E to indicate location east of the meridian. The third unit consists of the section number and letters designating the quarter section, quarter-quarter section, and so on (A, B, C, and D indicate the northeast, northwest, southwest, and southeast quarters, respectively), followed by a number indicating the sequence in which the well was recorded. For example, well N17 E29 06BCB06 is the sixth well recorded in NW\(\frac{1}{4}\) of the SW\(\frac{1}{4}\) of the NW\(\frac{1}{4}\) of section 6, Township 17 North, Range 29 East, Mount Diablo base line and meridian.

The site-naming system used in the tables and figures of this report indicates the study area, type of measuring point, and site number. The first segment of the designation indicates study area: DR for Dodge Ranch and HL for Harmon Lake. The second segment indicates the type of measuring site: AH for auger hole (sampling wells and piezometers) and SG for staff gage. The third segment indicates the site number within each study area.

The authors thank William Slentz and Ray Lannen of Island Ranch and Circle D Feeds for access to their property, as well as the U.S. Bureau of Reclamation and the Truckee-Carson Irrigation District for information on irrigation of the Fallon area. We also acknowledge Darrell K. Nordstrom and Ivan Barnes of the U.S. Geological Survey, Menlo Park, Calif., for use of their analytical facilities. Special thanks are extended to Patrick A. Glancy of the U.S. Geological Survey, Carson City, Nev., for his insight into the geochemistry and stratigraphy of the Fallon area.

METHODS OF STUDY

Emplacement of Sampling Wells and Piezometers

Sampling wells and piezometers in the Dodge Ranch and Harmon Lake study areas were drilled with either a 3-inch solid-stem auger or a 7-inch hollow-stem auger. No drilling fluids were used during drilling. The sampling wells and piezometers were logged by noting each change in lithology. Selected logs are listed in table 5. Wells and piezometers were cased with 2-inch inside-diameter polyvinyl chloride (PVC) pipe. Perforated intervals consisted of premanufactured machine-slit PVC well screens (0.006-inch slots). Washed Monterey sand was added to the annulus to cover the screened interval; then bentonite pellets were added to create a seal at least 1 foot thick. The remainder of the annular space was backfilled with drill cuttings. A surface seal was emplaced with bentonite pellets. The wells and piezometers were capped and cement water-meter boxes were placed over the wells.
Water Levels

Water levels were periodically measured in the sampling wells and piezometers at the Dodge Ranch and Harmon Lake study areas. These data are tabulated in tables 3 and 4. Hydrographs showing the water-level variations with time in 10 representative wells at the Dodge Ranch area are presented in figure 4. Water levels for a representative date, September 11, 1985, are shown for the Dodge Ranch area in figure 5. Water-level data for the staff gages are listed in table 2.

Collection of Sediment Samples

Sediment samples were collected during the drilling. Cores were taken through the hollow-stem auger with a stainless-steel, split-spoon drive sampler fitted with a polycarbonate liner. The cores were removed from the sampler, capped, and the ends sealed with paraffin. All cores were kept refrigerated until analysis. In addition, bulk sediment samples were obtained as the auger brought the cuttings to land surface. These samples were placed into plastic containers and sealed.

Laboratory Analysis of Sediment Samples

Lithologic and chemical analyses made on the sediment samples from the Dodge Ranch study area included determinations of grain-size, porosity, hydraulic conductivity, total arsenic content, total selenium content, arsenic content of specific grain-size fractions, and arsenic content of specific grain types. Tables 6 through 10 list the results of these analyses.

Grain-size analysis was made on the unconsolidated sediment by standard dry and wet sieving methods (Folk, 1955, p. 33-40). The silt- and clay-sized fractions were analyzed by the pipette method of Folk (1955, p. 37-40).

Statistical data for the sieve analysis of sediments from the Dodge Ranch study area were calculated using methods outlined by Folk (1955, p. 42-53) and Pettijohn (1975, p. 39), and are presented in table 9. The grain-size distribution in sediment samples is shown in figures 6-29. To convert the grain sizes from the phi-size scale used in figures 6-29 to the millimeter scale, use the following table:

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FIGURE 4.--Changes in water-level altitudes with time in selected wells at Dodge Ranch study area.
FIGURE 4.—continued.
FIGURE 5.--Water-level altitudes for September 11, 1985, in wells at Dodge Ranch study area. Values listed are in feet above 3,900 feet.
Samples for arsenic and selenium analysis were prepared by grinding the sediment to a fine powder and dissolving it in a mixture of hydrofluoric, hydrochloric, and perchloric acids to which nitric acid was added to maintain oxidizing conditions. Arsenic and selenium were then determined by hydride-generation atomic-absorption analysis (Skougstad and others, 1979, p. 61-63).

Porosity was determined using the resaturation method described by Amyx and others (1960, p. 39-57).

Hydraulic conductivity was determined using standard steady-state techniques incorporating the Darcy Law of homogeneous flow (Amyx and others, 1960, p. 71-83). Deionized water was used as the permeating fluid at ambient temperature. These data are listed in table 10.

The sediment from a few wells at the Dodge Ranch study area was analyzed for mineral content by x-ray diffraction analysis using a Picker\textsuperscript{1} diffractometer. Sediment samples were split into two size fractions (greater than 2 micrometers and less than 2 micrometers) by centrifugation. The two fractions were analyzed by the authors using standard x-ray diffraction techniques (Carroll, 1970, p. 51-61; Nuffield, 1966, p. 130-137). Results of the x-ray diffraction analyses are listed in tables 11 and 12.

\textsuperscript{1} The use of a trade name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.
HYDROGEOLOGIC DATA
## TABLE 3.—Water-level altitudes in wells at Dodge Ranch study area
([Values are expressed in feet above 3,900 feet; "—" indicates no data available])

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TABLE 3.—Water-level altitudes in wells at Dodge Ranch study area—Continued
**TABLE 4.**—Water-level altitudes in wells at Harmon Lake study area

[Values are expressed in feet above 3,900 feet; "--" indicates no data available]

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<td>7.61</td>
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<td>7.26</td>
<td>9.53</td>
<td>6.92</td>
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<td>Depth (feet)</td>
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<td></td>
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<td></td>
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<tr>
<td>Sand, very-fine-grained, silty, dark yellowish brown (10YR4/2), well-sorted, sub-rounded, quartz-rich, 5 percent muscovite</td>
<td>4.0</td>
<td>4.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sand, very-fine-grained, silty, dark yellowish brown (10YR4/2), well-sorted, rounded, quartz-rich</td>
<td>2.5</td>
<td>6.5</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Sand, very-fine-grained, silty, dark yellowish brown (10YR4/2), well-sorted, rounded, quartz-rich, 1 percent muscovite</td>
<td>6.5</td>
<td>13.0</td>
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<tr>
<td>WELL DR-AH-14A:</td>
<td>Thickness (feet)</td>
<td>Depth (feet)</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Sand, very-fine- to medium-grained, dark yellowish brown (10YR4/2), quartz-rich, clay pods up to 0.5 inch</td>
<td>5.0</td>
<td>5.0</td>
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</tr>
<tr>
<td>Sand, very-fine- to fine-grained, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>5.0</td>
<td>10.0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine-grained, dark yellowish brown (10YR4/2), moderately well-sorted, well-rounded, quartz-rich</td>
<td>3.0</td>
<td>13.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine-grained, dark yellowish brown (10YR4/2), moderately well-sorted, well-rounded, quartz-rich, 1 percent muscovite</td>
<td>4.0</td>
<td>17.0</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Clay, dark yellowish brown (10YR4/2)</td>
<td>2.6</td>
<td>19.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WELL DR-AH-15C:</td>
<td>Thickness (feet)</td>
<td>Depth (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>------------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine-grained, dark yellowish brown (10YR4/2), poorly sorted, quartz-rich</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, very-fine- to fine-grained, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>5.0</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine-grained, dark yellowish brown (10YR4/2), well sorted, quartz-rich</td>
<td>5.0</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine- to medium-grained, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>5.0</td>
<td>20.0</td>
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TABLE 5.—Lithologic logs of selected wells at the Dodge Ranch study area—Continued

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<thead>
<tr>
<th>Material</th>
<th>Thickness (feet)</th>
<th>Depth (feet)</th>
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<tbody>
<tr>
<td>WELL DR-AH-15C (continued):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay, sandy, dark yellowish brown (10YR4/2)</td>
<td>13.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Clay, black (N1), stiff, minor sand lenses, sulfurous odor</td>
<td>28.5</td>
<td>61.5</td>
</tr>
<tr>
<td>WELL DR-AH-16A:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine- to very-coarse-grained, dark yellowish brown (10YR4/2), poorly sorted, sub-rounded, quartz-rich, minor clay pods</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Sand, very-coarse-grained, dark yellowish brown (10YR4/2), poorly sorted, sub-angular, quartz-rich</td>
<td>6.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Sand, fine- to coarse-grained, silty, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>8.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Clay, dark yellowish brown (10YR4/2), silty</td>
<td>2.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Sand, fine- to coarse-grained, silty, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>6.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Clay, silty, dark yellowish brown (10YR4/2)</td>
<td>1.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Sand, fine- to coarse-grained, silty, dark yellowish brown (10YR4/2), quartz-rich</td>
<td>1.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Clay, light olive-gray (5Y5/2)</td>
<td>2.0</td>
<td>29.0</td>
</tr>
<tr>
<td>WELL DR-AH-17A:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, fine- to medium-grained, dark yellowish brown (10YR4/2), quartz-rich, minor clay pods</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Clay, silty, dark yellowish brown (10YR4/2)</td>
<td>3.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Sand, fine- to very-coarse-grained, dark yellowish brown (10YR4/2), sub-rounded, quartz-rich, some clay pods</td>
<td>7.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Sand, fine-grained, dark yellowish brown (10YR4/2), well sorted, sub-rounded, quartz-rich, silty in places</td>
<td>10.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Material</td>
<td>Thickness</td>
<td>Depth</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
<td>--------</td>
</tr>
<tr>
<td>Sand, very-fine- to fine-grained, dark yellowish brown (10YR4/2), sub-rounded to rounded, quartz-rich</td>
<td>2.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Clay, light olive-gray (5Y5/2)</td>
<td>18.0</td>
<td>45.0</td>
</tr>
</tbody>
</table>

1 Colors are for undried samples and are based on Rock-Color Chart (Munsell System) distributed by Geological Society of America.
TABLE 6.—Total arsenic in sediment from wells at Dodge Ranch study area

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Size fraction (millimeters)</th>
<th>Total arsenic (milligrams per kilogram as As)</th>
<th>Sediment description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-1</td>
<td>7.0</td>
<td>Whole rock</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-2</td>
<td>4.0</td>
<td>Whole rock</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-2</td>
<td>7.0</td>
<td>Whole rock</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-3</td>
<td>9.0</td>
<td>Whole rock</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-4</td>
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<tr>
<td>DR-AH-4</td>
<td>10.0</td>
<td>Whole rock</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-5</td>
<td>4.0</td>
<td>Whole rock</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-7</td>
<td>3.0</td>
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<td>17</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-8</td>
<td>4.0</td>
<td>Whole rock</td>
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</tr>
<tr>
<td>DR-AH-9</td>
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<td>8</td>
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<td>DR-AH-10</td>
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<td>DR-AH-12</td>
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<tr>
<td>DR-AH-14A</td>
<td>3.5-4.0</td>
<td>&lt; 0.0625</td>
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<tr>
<td>DR-AH-14A</td>
<td>9.0-9.5</td>
<td>&lt; 0.0625</td>
<td>11</td>
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<tr>
<td>DR-AH-15A</td>
<td>8.5-10</td>
<td>0.25-0.125</td>
<td>6.0</td>
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</tr>
<tr>
<td>DR-AH-15A</td>
<td>8.5-10</td>
<td>0.125-0.0625</td>
<td>7.0</td>
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<tr>
<td>DR-AH-15A</td>
<td>8.5-10</td>
<td>&lt; 0.0625</td>
<td>11</td>
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<tr>
<td>DR-AH-15A</td>
<td>19.5-20</td>
<td>2.00-1.00</td>
<td>14</td>
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<tr>
<td>DR-AH-15A</td>
<td>19.5-20</td>
<td>1.00-0.50</td>
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</tr>
<tr>
<td>DR-AH-15A</td>
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<td>0.50-0.25</td>
<td>5.0</td>
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<tr>
<td>DR-AH-15A</td>
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<td>0.25-0.125</td>
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<td>0.125-0.0625</td>
<td>10</td>
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</tr>
<tr>
<td>DR-AH-15A</td>
<td>19.5-20</td>
<td>&lt; 0.0625</td>
<td>14</td>
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<tr>
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<td>4-5</td>
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<td>5.0</td>
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</tr>
<tr>
<td>DR-AH-15C</td>
<td>4-5</td>
<td>0.25-0.125</td>
<td>6.0</td>
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<tr>
<td>DR-AH-15C</td>
<td>4-5</td>
<td>0.125-0.0625</td>
<td>6.4</td>
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<tr>
<td>DR-AH-15C</td>
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<td>&lt; 0.0625</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>DR-AH-15C</td>
<td>4-5</td>
<td>Whole rock</td>
<td>4.4</td>
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<td>Brown clay</td>
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<td>Sandy brown clay</td>
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<tr>
<td>DR-AH-15C</td>
<td>50-50.5</td>
<td>0.125-0.0625</td>
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</tr>
<tr>
<td>DR-AH-15C</td>
<td>50-50.5</td>
<td>&lt; 0.0625</td>
<td>7.0</td>
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TABLE 6.—Total arsenic in sediment from wells at Dodge Ranch study area—Continued

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Size fraction (millimeters)</th>
<th>Total arsenic (milligrams per kilogram as As)</th>
<th>Sediment description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-15C</td>
<td>50-50.5</td>
<td>Whole rock</td>
<td>6.4</td>
<td>Black clay</td>
</tr>
<tr>
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<td>60-60.5</td>
<td>Whole rock</td>
<td>25</td>
<td>Black clay</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>4.5-5.0</td>
<td>&lt; 0.0625</td>
<td>9.1</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>9.5-10</td>
<td>2.00-1.00</td>
<td>14</td>
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</tr>
<tr>
<td>DR-AH-16A</td>
<td>9.5-10</td>
<td>1.00-0.50</td>
<td>4.4</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>9.5-10</td>
<td>0.50-0.25</td>
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</tr>
<tr>
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<td>0.25-0.125</td>
<td>8.0</td>
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</tr>
<tr>
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<td>0.125-0.0625</td>
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</tr>
<tr>
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<td>&lt; 0.0625</td>
<td>17</td>
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</tr>
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<td>DR-AH-16A</td>
<td>19.5-20</td>
<td>1.00-0.71</td>
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<td>1.00-0.71</td>
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<td>Feldspar</td>
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<td>1.00-0.71</td>
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<td>Stained feldspar</td>
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<td>1.00-0.71</td>
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<td>Light lithic fragments</td>
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<td>Feldspar</td>
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<td>2.00-1.00</td>
<td>0.4</td>
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</tr>
<tr>
<td>DR-AH-16A</td>
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<td>--</td>
</tr>
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</tr>
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</tr>
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</tr>
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<td>&lt; 0.0625</td>
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</tr>
<tr>
<td>DR-AH-16A</td>
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<td>0.25-0.125</td>
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<td>29.5-30</td>
<td>0.125-0.0625</td>
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</tr>
<tr>
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<td>&lt; 0.0625</td>
<td>14</td>
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</tr>
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<td>DR-AH-17A</td>
<td>9-10</td>
<td>0.25-0.125</td>
<td>18</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>9-10</td>
<td>0.125-0.0625</td>
<td>19</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>9-10</td>
<td>&lt; 0.0625</td>
<td>15</td>
<td>--</td>
</tr>
<tr>
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<td>9-10</td>
<td>Whole rock</td>
<td>18</td>
<td>Fine clayey sand</td>
</tr>
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</table>

-23-
<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Size fraction (millimeters)</th>
<th>Total arsenic (milligrams per kilogram as As)(^1)</th>
<th>Sediment description</th>
</tr>
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<td>1.00-0.50</td>
<td>16</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20</td>
<td>0.50-0.25</td>
<td>18</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20</td>
<td>0.25-0.125</td>
<td>9.0</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20</td>
<td>0.125-0.0625</td>
<td>11</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20</td>
<td>&lt; 0.0625</td>
<td>20</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>28-29</td>
<td>0.25-0.125</td>
<td>14</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>28-29</td>
<td>0.125-0.0625</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>28-29</td>
<td>&lt; 0.0625</td>
<td>13</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>28-29</td>
<td>Whole rock</td>
<td>16</td>
<td>Silty sand</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>45.5-46.5</td>
<td>Whole rock</td>
<td>7.5</td>
<td>Light olive-gray clay</td>
</tr>
</tbody>
</table>

\(^1\) Analysts: wells DR-AH-1 through 12, U.S. Geological Survey Central Laboratory, Arvada, Colo.; all other wells, Terra-Tek Core Services, Salt Lake City, Utah.
TABLE 7.—Total selenium in sediment from wells at Dodge Ranch study area

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Size fraction (millimeters)</th>
<th>Selenium (milligrams per kilogram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-14A</td>
<td>3.5-4.0</td>
<td>&lt; 0.0625</td>
<td>0.03</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>9.0-9.5</td>
<td>&lt; 0.0625</td>
<td>0.06</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>9.5-10.0</td>
<td>&lt; 0.0625</td>
<td>0.04</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>19.5-20.0</td>
<td>&lt; 0.0625</td>
<td>0.03</td>
</tr>
<tr>
<td>DR-AH-15C</td>
<td>25.5-26.5</td>
<td>Whole rock</td>
<td>0.07</td>
</tr>
<tr>
<td>DR-AH-15C</td>
<td>60.0-60.5</td>
<td>Whole rock</td>
<td>0.02</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>4.5-5.0</td>
<td>&lt; 0.0625</td>
<td>0.30</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>9.5-10.0</td>
<td>&lt; 0.0625</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>19.5-20.0</td>
<td>&lt; 0.0625</td>
<td>&lt; 0.03</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>29.5-30.0</td>
<td>&lt; 0.0625</td>
<td>0.13</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20.0</td>
<td>&lt; 0.0625</td>
<td>0.10</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>28.0-29.0</td>
<td>Whole rock</td>
<td>0.06</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>45.5-46.5</td>
<td>Whole rock</td>
<td>0.08</td>
</tr>
</tbody>
</table>

1 Analyst: Terra-Tek Core Services, Salt Lake City, Utah.
TABLE 8.—Grain-size distribution of sediment from wells at Dodge Ranch study area

Percent, by weight, in each millimeter size interval

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>2.00-</th>
<th>1.00-</th>
<th>0.50-</th>
<th>0.25-</th>
<th>0.125-</th>
<th>0.0625-</th>
<th>0.031-</th>
<th>0.0156-</th>
<th>0.0078-</th>
<th>0.0039-</th>
<th>0.001-</th>
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<tbody>
<tr>
<td>DR-AH-9</td>
<td>3.5</td>
<td>0.05</td>
<td>0.11</td>
<td>0.49</td>
<td>2.95</td>
<td>24.12</td>
<td>16.02</td>
<td>55.35</td>
<td>24.44</td>
<td>13.50</td>
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<td>5.50</td>
</tr>
<tr>
<td>DR-AH-9</td>
<td>6.0</td>
<td>0.12</td>
<td>0.15</td>
<td>0.35</td>
<td>4.01</td>
<td>43.59</td>
<td>25.52</td>
<td>26.25</td>
<td>9.31</td>
<td>6.19</td>
<td>3.69</td>
<td>2.78</td>
</tr>
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<td>0.42</td>
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<td>23.28</td>
<td>29.66</td>
<td>43.57</td>
<td>17.87</td>
<td>7.15</td>
<td>7.20</td>
<td>1.83</td>
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<td>18.50</td>
<td>35.99</td>
<td>24.47</td>
<td>11.92</td>
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<td>---</td>
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</tr>
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<td>0.00</td>
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<td>19.55</td>
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</tr>
<tr>
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<td>0.18</td>
<td>0.28</td>
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<td>44.54</td>
<td>24.93</td>
<td>25.54</td>
<td>12.06</td>
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<td>2.47</td>
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<td>40.81</td>
<td>25.34</td>
<td>26.59</td>
<td>12.62</td>
<td>3.85</td>
<td>3.36</td>
<td>2.70</td>
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<td>0.41</td>
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<td>25.99</td>
<td>9.47</td>
<td>52.51</td>
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<td>1.72</td>
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<td>11.13</td>
<td>11.97</td>
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<td>0.58</td>
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<td>0.04</td>
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<td>44.33</td>
<td>44.05</td>
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<td>0.18</td>
<td>0.87</td>
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<td>6.85</td>
<td>3.22</td>
<td>4.32</td>
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</table>
TABLE 9.—Statistics of grain-size distribution of sediment from veils at Dodge Ranch study area

<table>
<thead>
<tr>
<th>Statistical parameter</th>
<th>DR-AH-14A 3.5-4 ft</th>
<th>DR-AH-14A 9-9.5 ft</th>
<th>DR-AH-15A 8.5-10 ft</th>
<th>DR-AH-15A 19.5-20 ft</th>
<th>DR-AH-16A 4.5-5 ft</th>
<th>DR-AH-16A 9.5-10 ft</th>
<th>DR-AH-16A 19.5-20 ft</th>
<th>DR-AH-16A 29.5-30 ft</th>
<th>DR-AH-17A 19.5-20 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median: phi mm</td>
<td>2.65</td>
<td>3.30</td>
<td>2.87</td>
<td>1.40</td>
<td>1.38</td>
<td>1.35</td>
<td>1.15</td>
<td>1.45</td>
<td>3.08</td>
</tr>
<tr>
<td>Mode: phi mm</td>
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<td>2.75</td>
<td>2.75</td>
<td>1.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
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<td>0.57</td>
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<td>0.60</td>
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<td>Phi quartile deviation</td>
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<td>1.12</td>
<td>1.14</td>
<td>1.17</td>
<td>1.07</td>
<td>1.12</td>
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<td>0.09</td>
<td>-0.04</td>
<td>0.00</td>
<td>0.14</td>
<td>0.31</td>
</tr>
<tr>
<td>Coefficient of skewness</td>
<td>1.05</td>
<td>0.94</td>
<td>0.97</td>
<td>1.03</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Phi quartile skewness</td>
<td>-0.05</td>
<td>0.07</td>
<td>0.03</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>Phi skewness measure</td>
<td>-2.56</td>
<td>-4.31</td>
<td>-6.20</td>
<td>-1.42</td>
<td>-0.99</td>
<td>-1.27</td>
<td>-1.02</td>
<td>-0.98</td>
<td>-6.16</td>
</tr>
<tr>
<td>Graphic Kurtosis</td>
<td>1.06</td>
<td>1.28</td>
<td>1.48</td>
<td>1.23</td>
<td>1.10</td>
<td>1.05</td>
<td>1.06</td>
<td>1.19</td>
<td>1.66</td>
</tr>
</tbody>
</table>

2 Statistical parameters are defined as follows (Folk, 1955, p. 42-53; Pettijohn, 1975, p. 39; variables used in equations below are: Pn = nth percentile; Qn = nth quartile):

- Median: Md = P50
- Mode: Mo = midpoint of most abundant class
- Standard deviation: Sigma (1) = \( ([P84] - [P16])/4 + ([P95] - [P5])/6.6 \)
- Coefficient of sorting: So = \( \sqrt{[Q3]/[Q1]} \)
- Phi quartile deviation: Sigma (a) = 0.5\( [Q2(a) - Q1(a)] \)
- Phi deviation measure: Sigma (a) = 0.5\( [P8(a) - P16(a)] \)
- Inclusive skewness: Sk (1) = \( ([P16] + P84 - 2P50)/2[P8(a) - P16(a)] + ([P5] + P95 - 2P50)/2[P95] - [P5]) \)
- Coefficient of skewness: Sk = \( \sqrt{[Q1]/[Q3]/[Q2]} \)
- Phi quartile skewness: Sk(a) = 0.5\( [Q1(a) + Q3(a) - 2Md(a)] \)
- Phi skewness measure: a(2a) = \( 0.5(P55(a) + P95(a) - 2Md(a))/Sigma(a) \)
- Graphic Kurtosis: Kg = \( [P55(a) - P5]/2.44[P75(a) - P25(a)] \)
- Kelley's quartile kurtosis: K = \( (Q3-Q1)/(2P90-P10) \)
- Phi quartile kurtosis: K (a) = \( [Q3(a) - Q1(a)]/[P90(a) - P10(a)] \)
- Phi kurtosis measure: Beta (a) = \( 0.5(P95(a) - P5(a))/Sigma(a) \)

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TABLE 10.—Porosity and hydraulic conductivity of sediment from wells at Dodge Ranch study area

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Porosity (percent)</th>
<th>Hydraulic conductivity (feet per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-14A</td>
<td>3.5-4.0</td>
<td>44.8</td>
<td>1.02 x 10^-3</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>9.0-9.5</td>
<td>41.3</td>
<td>2.50 x 10^-5</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>19.5-20</td>
<td>53.0</td>
<td>3.62 x 10^-3</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>4.0-4.5</td>
<td>22.6</td>
<td>1.29 x 10^-4</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>9.5-10</td>
<td>22.4</td>
<td>6.16 x 10^-4</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>19.5-20</td>
<td>32.6</td>
<td>7.33 x 10^-3</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>4.5-5.0</td>
<td>30.3</td>
<td>1.80 x 10^-2</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>9.5-10</td>
<td>23.7</td>
<td>1.77 x 10^-3</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>19.5-20</td>
<td>30.6</td>
<td>1.49 x 10^-2</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>29.5-30</td>
<td>29.8</td>
<td>4.78 x 10^-3</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>19.5-20</td>
<td>26.3</td>
<td>2.74 x 10^-6</td>
</tr>
</tbody>
</table>

1 Analyst: Terra-Tek Core Services, Salt Lake City, Utah
### TABLE 11—Mineralogy of grain-size fraction greater than 2 micrometers in sediment from wells at Dodge Ranch study area

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Minerals present</th>
<th>Minerals possibly present</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-14A</td>
<td>4.0</td>
<td>Quartz, orthoclase, albite, anorthite</td>
<td>Muscovite, biotite, augite, hematite, dolomite</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>9.5</td>
<td>Quartz, orthoclase, microcline, albite, anorthite, hornblende, hypersthene</td>
<td>Biotite, tremolite, enstatite</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>20.0</td>
<td>Quartz, orthoclase, albite, microcline, hypersthene</td>
<td>Anorthite, muscovite, arsenopyrite, dolomite</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>4.5</td>
<td>Quartz, orthoclase, albite, anorthite, muscovite, hypersthene, actinolite</td>
<td>Biotite, hornblende, augite, dolomite</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>10.0</td>
<td>Quartz, orthoclase, albite, microcline, anorthite, muscovite</td>
<td>Hornblende, actinolite, enstatite, diopside, hypersthene, calcite, dolomite</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>20.0</td>
<td>Quartz, albite, anorthite, muscovite, augite, hypersthene</td>
<td>Orthoclase, microcline, biotite, actinolite, arsenopyrite, dolomite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>5.0</td>
<td>Quartz, orthoclase, anorthite, muscovite, biotite, tremolite</td>
<td>Albite, augite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>10.0</td>
<td>Quartz, orthoclase, albite, anorthite, biotite</td>
<td>Microcline, muscovite, actinolite, diopside, hematite, dimorphite II</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>20.0</td>
<td>Quartz</td>
<td>Orthoclase, microcline, albite, anorthite, hypersthene, gypsum</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>30.0</td>
<td>Quartz, microcline, albite, anorthite, hematite, gypsum</td>
<td>Orthoclase, muscovite, biotite, augite, diopside</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>20.0</td>
<td>Quartz, orthoclase, anorthite, muscovite</td>
<td>Microcline, albite, biotite, hypersthene, gypsum</td>
</tr>
</tbody>
</table>

* X-ray diffraction analysis.
TABLE 12.—Mineralogy of clay fraction (grain size less than 2 micrometers) in sediment from wells at Dodge Ranch study area\(^1\)

<table>
<thead>
<tr>
<th>Well</th>
<th>Depth (feet)</th>
<th>Minerals present(^2)</th>
<th>Minerals possibly present</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-AH-14A</td>
<td>4.0</td>
<td>Montmorillonite, illite, chlorite, I-M</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>9.5</td>
<td>Montmorillonite, illite, chlorite</td>
<td>Halloysite</td>
</tr>
<tr>
<td>DR-AH-14A</td>
<td>20.0</td>
<td>Montmorillonite, illite, chlorite</td>
<td>--</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>4.5</td>
<td>Chlorite</td>
<td>Montmorillonite, illite,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>dickite</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>10.0</td>
<td>Montmorillonite, illite</td>
<td>Halloysite, dickite</td>
</tr>
<tr>
<td>DR-AH-15A</td>
<td>20.0</td>
<td>Montmorillonite, illite, chlorite</td>
<td>Dickite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>5.0</td>
<td>Montmorillonite, M-CH</td>
<td>Illite, attapulgite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>10.0</td>
<td>Montmorillonite, illite, I-M</td>
<td>Chlorite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>20.0</td>
<td>Montmorillonite, illite, chlorite</td>
<td>Dickite</td>
</tr>
<tr>
<td>DR-AH-16A</td>
<td>30.0</td>
<td>Montmorillonite, chlorite</td>
<td>Illite, attapulgite</td>
</tr>
<tr>
<td>DR-AH-17A</td>
<td>20.0</td>
<td>Montmorillonite, illite, chlorite, I-M</td>
<td>--</td>
</tr>
</tbody>
</table>

\(^1\) X-ray diffraction analysis.

\(^2\) Abbreviations: I-M, mixed-layer illite-montmorillonite; M-CH, mixed-layer montmorillonite-chlorite.
FIGURE 6.--Grain-size distribution of sediment from well DR-AH-9, depth 3.5 feet.

FIGURE 7.--Grain-size distribution of sediment from well DR-AH-9, depth 6.0 feet.
FIGURE 8.--Grain-size distribution of sediment from well DR—AH—9, depth 12.5 feet.

FIGURE 9.--Grain-size distribution of sediment from well DR—AH—14A, depth 3.5 feet.
FIGURE 10.—Grain-size distribution of sediment from well DR—AH—14A, depth 9.0 feet.

FIGURE 11.—Grain-size distribution of sediment from well DR—AH—14A, depth 13.0 feet.
FIGURE 12.—Grain-size distribution of sediment from well DR—AH—14A, depth 17.0 feet.

FIGURE 13.—Grain-size distribution of sediment from well DR—AH—15A, depth 4.0 feet.
FIGURE 14.--Grain-size distribution of sediment from well DR—AH—15A, depth 7.0 feet.

FIGURE 15.--Grain-size distribution of sediment from well DR—AH—15A, depth 9.5 feet.
FIGURE 16.--Grain-size distribution of sediment from well DR–AH–15A, depth 14.0 feet.

FIGURE 17.--Grain-size distribution of sediment from well DR–AH–15A, depth 19.5 feet.
FIGURE 18.--Grain-size distribution of sediment from well DR–AH–16A, depth 4.5 feet.

FIGURE 19.--Grain-size distribution of sediment from well DR–AH–16A, depth 9.5 feet.
FIGURE 20.--Grain-size distribution of sediment from well DR-AH-16A, depth 19.5 feet.

FIGURE 21.--Grain-size distribution of sediment from well DR-AH-16A, depth 26.5 feet.
FIGURE 22.--Grain-size distribution of sediment from well DR—AH—16A, depth 29.5 feet.

FIGURE 23.--Grain-size distribution of sediment from well DR—AH—17A, depth 4.0 feet.
FIGURE 24.--Grain-size distribution of sediment from well DR–AH–17A, depth 8.0 feet.

FIGURE 25.--Grain-size distribution of sediment from well DR–AH–17A, depth 14.5 feet.
FIGURE 26.--Grain-size distribution of sediment from well DR–AH–17A, depth 15.0 feet.

FIGURE 27.--Grain-size distribution of sediment from well DR–AH–17A, depth 19.5 feet.
FIGURE 28.--Grain-size distribution of sediment from well DR—AH—17A, depth 24.0 feet.

FIGURE 29.--Grain-size distribution of sediment from well DR—AH—17A, depth 25.0 feet.
REFERENCES CITED


