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Geochemical Characterization of Ground-water Flow in the Santa Fe Group Aquifer System, Middle Rio Grande Basin, New Mexico

Water-Resources Investigations Report 03-4131

U.S. Department of the Interior
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34834

Cover photo:

View looking west from the Sandia Mountains across the Albuquerque metropolitan area. Mount Taylor, approximately 30 miles west of the western boundary of the basin, appears on the horizon. The Rio Grande and the distinctive bosque of the inner valley are visible across the middle part of the image.

Geochemical characterization of ground-water flow in the Santa Fe Group aquifer system, Middle Rio Grande Basin, New Mexico

By L. Niel Plummer, Laura M. Bexfield, Scott K. Anderholm, Ward E. Sanford, and Eurybiades Busenberg

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U.S. DEPARTMENT OF THE INTERIOR
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CONTENTS

Abstract 1
Introduction 3
Purpose and Scope 5
Previous Investigations 5
Acknowledgments 6
Description of the Study Area 7
Climate 7
Surface Water 8
Rio Grande 8
Tributaries 11
Geologic Setting 13
Tectonic Framework 13
Santa Fe Group Aquifer System 15
Hydrostratigraphic Units 15
Petrologic Data 17
Ground-Water-Flow System 20
Methods 25
Data Used in the Investigation 25
New Middle Rio Grande Basin Study Data 25
Site Characteristics 25
Sample Collection, Analysis, and Reporting Units for Water Samples 30
Field Procedures 30
Ground Water 31
Surface Water 32
Inorganic Chemistry 32
Isotopes 33
Sulfur-34 33
Oxygen-18 and Hydrogen-2 33
Tritium 34
Carbon-14 and Carbon-13 36
Dissolved Gases 40
Major Dissolved Gases (Nitrogen, Argon, Oxygen, Carbon Dioxide and Methane) 40
Helium and Neon by Gas Chromatography 40
Helium, Neon, and Helium-3/Helium-4 Isotope Ratio by Mass Spectroscopy 40
Chlorofluorocarbons 41
Sulfur Hexafluoride 41
Quality-Assurance and Quality-Control Procedures 41
Inorganic Chemistry 41
Field Blank 42
Sample Filtration 42
Replicate Analyses (Field Duplicates and Re-Sampled Wells) 43
Electrical Balance 43
Hydrogen-2 and Oxygen-18 Isotopes of Water 43
Carbon-13 and Carbon-14 Isotopic Composition of Dissolved Inorganic Carbon 45
Historical Data 46
U.S.Geological Survey National Water Information System Database 47

City of Albuquerque Database 47
Sources of Recharge and Underflow to the Santa Fe Group Aquifer System 52
Precipitation 52
Inorganic Chemical Composition 52
Oxygen-18 and Hydrogen-2 53
Tritium 56
Sulfur-34 56
Surface Water 57
Inorganic Chemical Composition 57
Oxygen-18 and Hydrogen-2 58
Tritium 61
Sulfur-34 63
Mountain-Front Ground Water 64
Inorganic Chemical Composition 64
Oxygen-18 and Hydrogen-2 65
Tritium 65
Sulfur-34 66
Ground-Water Inflow 66
Inorganic Chemical Composition 66
Oxygen-18 and Hydrogen-2 67
Tritium 67
Sulfur-34 67
Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin 68
Field Parameters 68
Water Type 73
Major-Element Chemistry 73
Anions 73
Chloride 73
Sulfate and Sulfur-34 of Dissolved Sulfate 74
Bicarbonate and Carbon-13 of Dissolved Inorganic Carbon 83
Nitrate and Dissolved Nitrogen Gas 86
Fluoride 88
Cations 88
Calcium 88
Sodium 88
Magnesium 93
Potassium 93
Silica 93
Minor-Element Chemistry 93
Variations in Chemical Composition of Ground Water with Depth 104
Hydrogen-2 and Oxygen-18 Isotopes in Ground Water 109
Previous Studies 109
Comparability of Results 112
Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water in the Albuquerque Area 115
Temporal Variations 118
Purge Test 121
Variations with Depth 121
Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water Basin-Wide 129
Carbon-14 Activity of Dissolved Inorganic Carbon in Ground Water from the Middle Rio Grande Basin 131
Variations with Depth 131

Areal Variations 133
Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water Sources 136
Northern Mountain Front Zone 139
Northwestern Zone 144
West-Central Zone 146
Western Boundary Zone 147
Rio Puerco Zone 149
Southwestern Mountain Front Zone 150
Eastern Mountain Front Zone 150
Abo Arroyo Zone 152
Tijeras Fault Zone Zone 156
Tijeras Arroyo Zone 157
Northeastern Zone 158
Central Zone 160
Discharge Zone 163
Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water 166
Initial Carbon-14 Activity in Recharge Water, A_o 166
Geochemical Adjustments to the Radiocarbon Data 167
Implications for Geochemical Reactions from Carbon-13 Data 171
Geochemical Mass Transfer Models 173
NETPATH 173
Formulation of Geochemical Models 173
Source Waters 173
Phases 180
Carbon Isotopic Composition of Sources 180
Model Results 180
Evapotranspiration 181
Mixing Fractions of Source Waters 181
Mineral Mass Transfer 182
Adjusted and Unadjusted Radiocarbon Ages 183
Sensitivity of the Radiocarbon Age to Reaction Uncertainty 184
Regional Variations in Unadjusted Radiocarbon Age 184
Mixing of Waters in the Well Bore 186
Radiocarbon Calibration 198
Interpretation of Environmental and Climatic Information from Radiocarbon Ages, Stable Isotopes, and Dissolved Gases 201
Age Gradients 201
Historical Variations in Stable Isotopic Composition of Rio Grande and Eastern Mountain Front Recharge 205
Paleorecharge Temperatures 208
Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon 219
Summary of Implications from Geochemical and Isotopic Data for the Conceptual Model of the Aquifer System 223
Tracing Sources of Water Through the Basin 223
Direction of Ground-Water Flow 224
Origin of the Ground-Water Trough 225
Ground-Water Flow in Relation to Faults and Other Structural Features 226
Stratigraphic Controls on Ground-Water Flow 229
Source, Mechanism, and Timing of Recharge to the Middle Rio Grande Basin 229

Summary 231
References 233
Appendixes [also on CD-ROM in pocket]
Appendix A. Chemical and isotopic data of ground water collected from the Middle Rio Grande Basin, June 1996 - August 1998 244
A1. Location and well-construction information for ground-water sites 245
A2. Summary of field parameters and major-element chemistry 251
A3. Summary of minor-element chemistry 260
A4. Summary of trace-element chemistry 267
A5. Summary of dissolved gases (nitrogen, argon, oxygen, carbon dioxide, and methane) 275
A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases 280
A7. Summary of chlorofluorocarbon concentrations in water from wells and springs 288
A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs 292
A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs 298
A10. Summary of all stable hydrogen and oxygen isotope data for water from City of Albuquerque production wells 305
A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs 311
A12. Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^{3}H/^{3}He$ Age 317
Appendix B. Chemical and isotopic composition of surface water from the Middle Rio Grande Basin, June 1996 - March 1999, and stable isotopic composition of surface water and precipitation in archived samples from the 1980s 320
B1. Identification of surface-water sites from the Middle Rio Grande Basin and vicinity 321
B2. Surface-water field parameters and major-element chemistry 322
B3. Summary of minor-element chemistry in surface water 329
B4. Summary of trace-element chemistry in surface water 334
B5. Summary of chlorofluorocarbon concentrations in surface water 340
B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water 343
B7. Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived precipitation samples, Albuquerque 349
B8. Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived surface-water samples from the early 1980s 350
B9. Tritium concentrations in surface water 351
Appendix C. Chemical and isotopic compositions of air, rocks, and plants, and saturation indices for selected minerals in ground water from the Middle Rio Grande Basin 354
C1. Selected data on the chemical and isotopic composition of air and shallow unsaturated zone air 355
C2. Solid carbonates, limestone, and caliche samples analyzed for $\delta^{13}C$ and ^{14}C activity 356
C3. Stable carbon isotopic composition of plants, $\delta^{13}C$ 358
C4. Summary statistics of saturation indices for selected minerals by hydrochemical zone 359
Appendix D. Summary of quality-assurance and quality-control data 360
D1. Concentrations of major elements and selected trace elements in standard reference water samples 361
D2. Standard reference materials, recommended concentrations, measured concentrations by direct-current plasma spectroscopy, and measured standard deviations 362
D3. Standard reference materials, recommended concentrations, measured concentrations by ion chromatography, and measured standard deviations 363
D4a. Concentrations of trace elements in standard reference water samples and high

purity working standards 364
D4b. Concentrations of trace elements in standard reference water samples and high purity working standards-- Continued 365
D5. Standard reference materials, recommended concentrations, measured concentrations by inductively-coupled plasma-mass spectroscopy, and measured standard deviations for the 1997 samples 366
D6. Concentrations of major and trace metals by ICP-MS in blank water acidified with reagent grade and Baker Chemical Co. Ultrex nitric acid 368
D7a. Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters 369
D7b. Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters -- Continued 370
D8. Concentrations of selected trace metals in 5 ground-water samples filtered through 0.45-micron cartridge filters in the field and then through 0.2- or 0.1-micron membrane filters in the laboratory 371
D9. Comparison of water temperature and excess air calculated from dissolved gas analyses of laboratory water samples equilibrated with air and analyzed with the MRGB samples, 1996 through 1998 372
D10. Summary of QA/QC data for radiocarbon activity measurements 373
Appendix E. Supplementary water-quality data from the USGS NWIS database 374
E1. Location and well construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone 375
E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone 379
E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone 384
Appendix F. Supplementary water-quality data from the City of Albuquerque database 390
F1. Location and well-construction information for City of Albuquerque production wells, by hydrochemical zone 391
F2. Summary of field parameters and major- and minor-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone 393
F3. Summary of trace-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone 394

BACK POCKET

CD-ROM Containing:

1. Readme file
2. Electronic copy of this report in PDF format
3. Microsoft Excel spreadsheet containing data of appendix tables

FIGURES

1-2. Maps showing:
1. Selected physiographic features of the Middle Rio Grande Basin and vicinity 4
2. Normalized mean annual precipitation in the Middle Rio Grande Basin and vicinity, 1931-60 9

3-4. Plots showing:
3. Average monthly precipitation at the (a) Albuquerque Airport and (b) Sandia Peak stations, 1971-2000 10
4. Mean monthly discharge for the Rio Grande at Albuquerque, water years 1974-98 11

5-6. Maps showing:
5. Simplified structure of the Middle Rio Grande Basin 14
6. Major faults and volcanic fields of the Middle Rio Grande Basin 16

7. Geologic section along Paseo del Norte in northern Albuquerque 18

8-11. Maps showing:
8. Inferred lateral extent of major lithostratigraphic units during the Pliocene in central New Mexico 19
9. Predevelopment water levels in the Middle Rio Grande Basin 22
10. Water levels that represent 1999-2002 conditions in the production zone of the Santa Fe Group aquifer system in the Albuquerque area 23
11a. Locations of ground-water and surface-water samples collected outside the Albuquerque area, and locations of precipitation samples collected on Sevilleta National Wildlife Refuge 26
11b. Locations of ground-water and surface-water samples collected inside the Albuquerque area 27

12-16. Plots showing:
12. Comparison of tritium measurements 35
13. Tritium concentration in ground water as a function of CFC-12 concentration 36
14. Calibration of Conventional Radiocarbon Age to calendar years, B.P. 39
15. Percent difference between duplicate samples as a function of the cumulative percent of the samples analyzed 44
16. The difference in concentration between pairs of ground-water samples as a function of the concentration of cations in ground water 44

17-18. Maps showing:
17a. Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set outside the Albuquerque area 48
17b. Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set inside the Albuquerque area 49
18. Locations of City of Albuquerque production wells 51

19-26. Plots showing:
19. Comparison of $\delta^{18}O$ values in Albuquerque precipitation: (a) Samples collected by C. Yapp, 1981-84, (b) Samples collected by R. Hejl, 1987-89 54
20. Relation between $\delta^{2}H$ and $\delta^{18}O$ isotopic composition of precipitation and ground water from monitoring wells in the vicinity of Albuquerque 55
21. Tritium concentration in precipitation at Albuquerque, 1960-97 57
22. Comparison of $\delta^{2}H$ isotopic composition of Rio Grande water from 1980-83 and 1996-99 59
23. Comparison of monthly values of $\delta^{2}H$ in surface waters from the Middle Rio Grande Basin, 1997-99 60
24. Relation between $\delta^{2}H$ and $\delta^{18}O$ isotopic composition of surface waters in the vicinity of Albuquerque 62

25. Tritium concentration in surface waters from the Middle Rio Grande Basin, in relation to tritium concentration in precipitation, 1996-98, and discharge of the Rio Grande 63
26. Stable S isotopic composition, $\delta^{34}S$, of sulfate in surface waters of the Middle Rio Grande Basin, 1997-99, in relation to discharge of the Rio Grande at Albuquerque 65

27-30. Maps showing:
27. Specific conductance for ground water of the Middle Rio Grande Basin 69
28. pH for ground water of the Middle Rio Grande Basin 70
29. Dissolved-oxygen concentration for ground water of the Middle Rio Grande Basin 71
30. Water temperature for ground water of the Middle Rio Grande Basin 72

31. Piper diagram showing water types for all ground-water samples from the Middle Rio Grande Basin 74

32-35. Maps showing:
32a. Water types of ground-water samples throughout the Middle Rio Grande Basin 75
32b. Water types of ground-water samples inside the Albuquerque area 76
33. Chloride concentration for ground water of the Middle Rio Grande Basin 77
34. Sulfate concentration for ground water of the Middle Rio Grande Basin 78
35. Ratio of sulfate to chloride concentration for ground water of the Middle Rio Grande Basin 79

36-37. Plots showing:
36. Comparison of dissolved sulfate concentrations and $\delta^{34}S$ for waters of mountain-front recharge and Rio Grande origin 81
37. Comparison of $\delta^{34}S$ with dissolved-oxygen concentration for water of Rio Grande and mountain-front origin 82

38-39. Maps showing:
38. Alkalinity for ground water of the Middle Rio Grande Basin 84
39. Stable carbon isotopic composition, $\delta^{13}C$, of dissolved inorganic carbon for ground water of the Middle Rio Grande Basin 85

40. Plot showing comparison of $\delta^{13}C$ isotopic composition of plant matter and shallow unsaturated zone CO_2 gas from the eastern mountain front in the vicinity of Albuquerque 86

41-58. Maps showing:
41. Nitrate concentration for ground water of the Middle Rio Grande Basin 87
42. Fluoride concentration for ground water of the Middle Rio Grande Basin 89
43. Calcium concentration for ground water of the Middle Rio Grande Basin 90
44. Sodium concentration for ground water of the Middle Rio Grande Basin 91
45. The ratio of calcium to sodium concentration for ground water of the Middle Rio Grande Basin 92
46. Magnesium concentration for ground water of the Middle Rio Grande Basin 94
47. Potassium concentration for ground water of the Middle Rio Grande Basin 95
48. Silica concentration for ground water of the Middle Rio Grande Basin 96
49. Arsenic concentration for ground water of the Middle Rio Grande Basin 98
50. Barium concentration for ground water of the Middle Rio Grande Basin 99
51. Boron concentration for ground water of the Middle Rio Grande Basin 100
52. Bromide concentration for ground water of the Middle Rio Grande Basin 101
53. Lithium concentration for ground water of the Middle Rio Grande Basin 102
54. Molybdenum concentration for ground water of the Middle Rio Grande Basin 103
55. Strontium concentration for ground water of the Middle Rio Grande Basin 105
56. Uranium concentration for ground water of the Middle Rio Grande Basin 106
57. Vanadium concentration for ground water of the Middle Rio Grande Basin 107
58. Locations of deep monitoring wells included in the data set for the Middle Rio Grande Basin 108

59-63. Plots showing:
59. (a) Specific conductance values, and (b) chloride concentrations with depth for selected deep monitoring well nests in the Middle Rio Grande Basin 110
60. Comparison of δ^2H isotopic composition of water samples 113
61. Comparison of δ^2H and $\delta^{18}O$ isotopic compositions of water from City of Albuquerque production wells 114
62. Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque production wells, 1987-90 and 1996-97 116
63. Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque production wells collected in 1980-82 and 1996-97 116

64. Map showing δ^2H isotopic composition of ground water in the vicinity of Albuquerque 117

65-68. Plots showing:
65. $\delta^{18}O$ isotopic composition of water from City of Albuquerque production wells collected in the early 1980s and 1996-97 119
66. Comparison of $\delta^{18}O$ isotopic composition of water from City of Albuquerque production wells 120
67. Short-term variations in (a) $\delta^{18}O$ and (b) δ^2H isotopic composition of water pumped from the City of Albuquerque production wells, Charles 4 and Duranes 1 121
68. Variations in δ^2H isotopic composition of water from selected monitoring wells in the vicinity of Albuquerque 122

69-70. Maps showing:
69. Location of monitoring wells in the vicinity of Albuquerque 123
70. Location of the Paseo del Norte, Menaul, and Los Padillas cross-section lines and locations of wells shown on the cross sections, Albuquerque 125

71-73. Diagrams showing:
71. Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Paseo del Norte Boulevard, Albuquerque, showing ranges of δ^2H for ground water 126
72. Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Menaul Boulevard, Albuquerque, showing ranges of δ^2H for ground water 127
73. Schematic hydrogeologic cross section of the Los Padillas vicinity showing ranges of δ^2H for ground water 128

74. Map showing stable H isotopic composition, δ^2H, for ground water in the Middle Rio Grande Basin ... 130

75-76. Plots showing:
75. Values of δ^2H and $\delta^{18}O$ isotopic composition for all ground water from the Middle Rio Grande Basin in relation to the global meteoric water line 132
76. ^{14}C activity as a function of depth below the water table in narrow-screened piezometers, Albuquerque vicinity 132

77-78. Maps showing:
77. ^{14}C activity of dissolved inorganic carbon from ground water of the Middle Rio Grande Basin 134
78. Hydrochemical zones defined for ground water in the Middle Rio Grande Basin 137

79. Piper diagram showing representative major-element compositions for ground water from the various hydrochemical zones in the Middle Rio Grande Basin 140

80-86. Plots showing:
80a-c. Relation of (a) sulfate to chloride, (b) calcium to chloride, and (c) calcium to sulfate concentrations in ground water of the Northern Mountain Front zone, Middle Rio Grande Basin, and area precipitation and surface water 142

81. Relation of (a) sulfate to chloride and (b) nitrate to chloride concentrations in ground water of the Northwestern zone, Middle Rio Grande Basin, and area precipitation and surface water 145
82. Relation of sulfate to chloride concentrations in ground water of the West-Central zone, Middle Rio Grande Basin, and area precipitation and surface water 146
83. Relation of sulfate to chloride concentrations in ground water of the Western Boundary zone, Middle Rio Grande Basin, and area precipitation and surface water 148
84. Relation of sulfate to chloride concentrations in ground water of the Rio Puerco zone, Middle Rio Grande Basin, and area precipitation and surface water. 149
85. Relation of sulfate to chloride concentrations in ground water of the Southwestern zone, Middle Rio Grande Basin, and area precipitation 151
86. Relation of sulfate to chloride concentrations in ground water of the Eastern Mountain Front zone, Middle Rio Grande Basin, and area precipitation 151

87a-87b. Maps showing:
87a. Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, outside the Albuquerque area 153
87b. Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, inside the Albuquerque area 154

88-90. Plots showing:
88. Relation of sulfate to chloride concentrations in ground water of the Abo Arroyo zone, Middle Rio Grande Basin, and area precipitation and surface water 155
89. Relation of sulfate to chloride concentrations in ground water of the Tijeras Fault Zone zone, Middle Rio Grande Basin, and area precipitation 156
90. Relation of sulfate to chloride concentrations in ground water of the Tijeras Arroyo zone, Middle Rio Grande Basin, and area precipitation and surface water 157

91. Map showing ground-water samples of the Tijeras Arroyo zone, Middle Rio Grande Basin 159

92. Plots showing relation of sulfate to chloride concentrations in ground water of the Northeastern zone, Middle Rio Grande Basin, and area precipitation and surface water 160

93. Map showing ground-water samples of the Northeastern zone, Middle Rio Grande Basin 161

94. Plot showing relation of sulfate to chloride concentrations in ground water of the Central zone, Middle Rio Grande Basin, and area precipitation and surface water 162

95. Map showing ground-water samples of the Central zone, Middle Rio Grande Basin 164

96. Plot showing relation of sulfate to chloride concentrations in ground water of the Discharge zone, Middle Rio Grande Basin, and area precipitation 165

97-99. Plots showing:
97. ^{14}C activity in ground water as a function of (a) CFC-12 concentration and (b) tritium concentration, Middle Rio Grande Basin 168
98. ^{14}C activities and CFC-12 concentrations measured in ground water from the Middle Rio Grande Basin, in relation to concentrations expected for water in equilibrium with atmospheric values, 1957-97 169
99. Variations in $\delta^{13}C$ of dissolved inorganic carbon as a function of ^{14}C activity of the Middle Rio Grande Basin 172

100. Map showing unadjusted radiocarbon age of dissolved inorganic carbon in ground water for the Middle Rio Grande Basin 185

101-103. Diagrams showing:
101. Schematic hydrochemical cross section of the Middle Rio Grande Basin, aligned with Paseo del Norte Boulevard, Albuquerque, showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries 187
102. Schematic hydrochemical cross section of the Middle Rio Grande Basin, aligned with Menaul Boulevard showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries 188
103. Schematic hydrochemical cross section of the Los Padillas vicinity showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries 189

104-112. Plots showing:
104. Concentration of CFC-12 in ground water from narrow-screened piezometers in the vicinity of Albuquerque, as a function of depth below the water table 199
105. Relation between radiocarbon years and calendar years 200
106. Correction to be added to the Conventional Radiocarbon Age to correct to calendar years 200
107. Profiles of radiocarbon age as a function of depth from piezometer nests from the Middle Rio Grande Basin 202
108. Age gradients in years per foot of aquifer 203
109. Radiocarbon age as a function at the depth below the water table, Eastern Mountain Front zone 204
110. δ^2H isotopic composition of ground water of Rio Grande origin (Central zone) as a function of radiocarbon age, Middle Rio Grande Basin 205
111. Comparison of the δ^2H isotopic composition of ground water from the Central zone with water recharged along the eastern mountain front as a function of radiocarbon age, Middle Rio Grande Basin 206
112. Comparison of N_2-Ar recharge temperature with the measured ground-water temperature for waters from the West-Central and Eastern Mountain Front zones, Middle Rio Grande Basin 211

113a-113b. Maps showing:
113a. N_2-Ar recharge temperatures for the West-Central zone waters, Middle Rio Grande Basin 212
113b. N_2-Ar recharge temperatures for the upper-most hydrochemical zones in the Middle Rio Grande Basin 213

114-117. Plots showing:
114. N_2-Ar recharge temperatures of ground water from the Central Zone and Eastern Mountain Front zone, Middle Rio Grande Basinas a function of radiocarbon age 216
115. Comparison of N_2-Ar recharge temperatures for waters from the Eastern Mountain Front and West-Central zones as a function of radiocarbon age 218
116. $\delta^{13}C$ isotopic composition of dissolved inorganic carbon as a function of radiocarbon age, Middle Rio Grande Basin 220
117. Values of $\delta^{13}C$ isotopic composition of dissolved inorganic carbon in relatively young (post-bomb) waters of the Northern Mountain Front, Northwestern, Eastern Mountain Front and Central hydrochemical zones, Middle Rio Grande Basin, as a function of (a) radiocarbon age, (b) tritium concentration, and (c) CFC-12 concentration 221
118. Schematic diagrams of (a) representative change in water chemistry across a fault in the Middle Rio Grande Basin, with greater recharge rates and hydraulic conductivity on one side of the fault relative to the other, and (b) representative discontinuity in the water levels across the fault 227

TABLES

1. Climatic data from selected stations in the Middle Rio Grande Basin and vicinity, period of record 8
2. Statistical summary of well-construction information by well type, Middle Rio Grande Basin 28
3. Terminology of ^{14}C reporting units 38
4. Summary of chemical and isotopic properties of representative end-member waters for the Middle Rio Grande Basin 50
5. Average stable isotopic composition of surface waters from the Middle Rio Grande Basin 61
6. Average tritium activity in surface water, Middle Rio Grande Basin, January 1997- February 1998 ... 64
7. Estimated ^{14}C gradients with depth for ground water from the Middle Rio Grande Basin 133
8. Median values of selected water-quality parameters by hydrochemical zone for the Middle Rio Grande Basin 138
9. Parameters for which the Mann-Whitney test indicated statistically different medians between adjacent hydrochemical zones at the 95-percent confidence level for ground-water samples from the Middle Rio Grande Basin 141
10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study 174
11. Summary of predominant ground-water sources by hydrochemical zone for the Middle Rio Grande Basin 182
12. Summary of average mineral mass transfers and evaporation factor by hydrochemical zone for ground water from the Middle Rio Grande Basin 183
13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin 191

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED UNITS

Conversion Factors

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic centimeters (cm^3)	0.06102	cubic inch
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
[1] foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
gram (g)	0.03527	ounce
inch (in.)	25.4	millimeter
kilogram (kg)	2.205	pound
kilometer (km)	0.6215	mile
square kilometer (km^2)	0.3861	square mile
meter (m)	3.281	foot
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
becquerel per liter (Bq/L)	0.027	picocuries per liter
terra becquerels (TBq)	27	curies
tritium units (TU)	3.19	picocuries per liter
kilopascal (kPa)	5.28	atmosphere, standard
picogram (pg)	$1x10^{-12}$	gram
femtogram (fg)	$1x10^{-15}$	gram

[1] The standard unit for transmissivity is cubic foot per day per square foot times feet of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Temperature in degrees Celsius (^oC) may be converted to degrees Fahrenheit (^oF) by using the formula: $^oF=(1.8)(^oC) + 32$.

Stable isotope ratios are reported as δ values computed from the formula

$$\delta_x = \left(\frac{R_x}{R_{STD}} - 1\right)1000$$

where R_x is the ratio of the isotopes measured in the sample and R_{STD} is the isotope ratio in the reference standard. The value of R_x is in parts per thousand (per mil).

Vertical Datum

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929-a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Base Credits

The base for the maps of the Middle Rio Grande Basin was compiled from several sources. The hydrography is from 1977-78 U.S. Geological Survey digital data, scale 1:100,000. Cultural features are from 1992 City of Albuquerque digital data, scale 1:2,400, and digitized from 1977-78 U.S. Geological Survey maps, scale 1:100,000. Other sources are noted on the maps themselves.

Abbreviations

kg	kilogram
L	liter
mL	milliliter
pg	picogram
mol	mole
µmol	micromole
fmol	femtomol
fg	femtogram
pptv	parts per trillion by volume
mg/L	milligrams per liter
µg/L	micrograms per liter
STP	standard temperature and pressure, 0 degrees Celsius and 1 atmosphere pressure
pCi/L	picocuries per liter
TU	tritium units
pmC	percent modern carbon

Geochemical Characterization of Ground-water Flow in the Santa Fe Group Aquifer System, Middle Rio Grande Basin, New Mexico

By L. Niel Plummer, Laura M. Bexfield, Scott K. Anderholm, Ward E. Sanford, and Eurybiades Busenberg

ABSTRACT

Chemical and isotopic data were obtained from ground water and surface water throughout the Middle Rio Grande Basin (MRGB), New Mexico, and supplemented with selected data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) and City of Albuquerque water-quality database in an effort to refine the conceptual model of ground-water flow in the basin. The ground-water data collected as part of this study include major- and minor-element chemistry (30 elements), oxygen-18 and deuterium content of water, carbon-13 content and carbon-14 activity of dissolved inorganic carbon, sulfur-34 content of dissolved sulfate, tritium, and dissolved atmospheric gases including nitrogen, argon, helium, chlorofluorocarbons, and sulfur hexafluoride from 288 wells and springs in parts of the Santa Fe Group aquifer system. The surface-water data collected as part of this study include monthly measurements of major- and minor-element chemistry (30 elements), oxygen-18 and deuterium content of water, chlorofluorocarbons, and tritium content at 14 locations throughout the basin. Additional data include stable isotope analyses of precipitation and of ground water from City of Albuquerque production wells collected and archived from the early 1980's, and other data on the chemical and isotopic composition of air, unsaturated zone air, plants, and carbonate minerals from throughout the basin.

The data were used to identify 12 sources of water to the basin, map spatial and vertical extents of ground-water flow, map water chemistry in relation to hydrogeologic, stratigraphic, and structural properties of the basin, determine radiocarbon ages of ground water, and reconstruct paleo-environmental conditions in the basin over the past 30,000 years.

The data indicate that concentrations of most elements and isotopes generally parallel the predominant north to south direction of ground-water flow. The radiocarbon ages of dissolved inorganic carbon in ground water range from modern (post-1950) to more than 30,000 years before present, and appear to be particularly well defined in the predominantly siliciclastic aquifer system. Major sources of water to the basin include (1) recharge from mountains along the north, east and southwest margins (median age 5,000-9,000 years); (2) seepage from the Rio Grande and Rio Puerco (median age 4,000-8,000 years), and from Abo and Tijeras Arroyos (median age 3,000-9,000 years); (3) inflow of saline water along the southwestern basin margin (median age 20,000 years); and (4) inflow along the northern basin margin that probably represents recharge from the Jemez Mountains during the last glacial period (median age 20,000 years). Water recharged from the Jemez Mountains during the last glacial period occurs at the water table in the central part of the basin and beneath younger recharge along the Rio Grande and the northern mountain front.

In some parts of the basin, boundaries between hydrochemical zones appear to be near major faults that may affect ground-water flow. However, in other parts of the basin, such as along the east side of Albuquerque near the Sandia Fault zone, ground-water flow appears to be unaffected by major faults. Upward leakage of saline water occurs along some faults and can be a source of salinity and elevated arsenic concentrations in some ground water.

A trough in the modern and predevelopment water table west of Albuquerque is centered along a zone of predominantly late Pleistocene age water through the center of the basin and is flanked and overlain along the trough boundary by water that infiltrated from the Rio Puerco on the west and the Rio Grande to the east. It is suggested that the ground-water trough is a relatively recent transient feature of the Santa Fe Group aquifer system.

At Albuquerque, a distinct north-south boundary in deuterium content of ground water marks the division between recharge from the eastern mountain front and that from the Rio Grande. Water beneath approximately two-thirds of the City of Albuquerque is predominantly of Rio Grande origin infiltrated from areas north of the city.

The stable isotope data for ground water in the vicinity of Albuquerque indicate little movement of ground water in response to withdrawals from public supply wells during the past 20 years, even though in places the modern water table has fallen as much as 140 feet below the predevelopment potentiometric surface. Small shifts over the past 20 years in stable isotope composition of water discharged from public supply wells along the boundaries between the West-Central zone (paleowater) and Central zone (Rio Grande water) west of the Rio Grande, and along the boundary between the Central zone and Eastern Mountain Front zone east of the Rio Grande indicate local areas where paleowater of Rio Grande origin is beginning to move west and east in response to ground-water pumping.

Age gradients from piezometer nests range from 0.1 to 2 yr cm^{-1} and indicate a recharge rate of about 3 cm yr^{-1} for recharge along the eastern mountain front and infiltration from the Rio Grande near Albuquerque. There has been appreciably less recharge along the eastern mountain front in areas both north and south of Albuquerque.

The δ^2H isotopic composition of water, and recharge temperatures based on dissolved N_2 and Ar data, were interpreted in conjunction with the radiocarbon age to improve understanding of water source, and mechanism and timing of recharge. The N_2-Ar recharge temperatures vary widely throughout the MRGB. The minimum recharge temperature for a particular hydrochemical zone appears to be near the mean annual temperature, and the maximum recharge temperature approaches that of ground water beneath the deep (greater than 300 feet) unsaturated zones. The dissolved gas recharge temperatures demonstrate cases of both focused (cold recharge temperatures) and diffuse flow (warm recharge temperatures) recharge mechanisms in the predominantly semi-arid MRGB.

During the last glacial period, water recharged to the West-Central zone varied widely in stable isotope composition and recharge temperature, indicating the occurrence of both diffuse and focused recharge of low- and high-altitude precipitation. The range in δ^2H of West-Central zone waters from the last glacial maximum (LGM, approximately 18,000 radiocarbon years before present, B.P.), indicates recharge that occurred over a 4,000-foot range in altitude.

Ground water in the Central zone was recharged by direct infiltration from the Rio Grande and apparently records surface-water temperature and stable isotopic composition at the time of recharge. The dissolved N_2-Ar data indicate that the average temperature of water infiltrated from the Rio Grande varied by only about ± 1 degree Celsius (°C) from the modern mean annual temperature (13.6°C) at Albuquerque over the past 27,000 years. Rio Grande water was coldest (12.7 ± 1.4°C) during the period 15,000-27,000 years B.P., and warmest (14.5 ± 1.4°C) during the period 5,000-9,000 years B.P., and averaged 13.0 ± 2.2°C during the past 5,000 years. Together, the stable isotope data and dissolved gas recharge temperatures indicate that in the past, the timing of the spring runoff of northern New Mexico and southern Colorado snowmelt varied, coming late into early- to mid-summer during cold periods and overlapping, in part, with the summer monsoon season (currently July-October). During warm periods, such as modern times, the peak discharge of the Rio Grande occurred in mid- to late spring in advance of the summer monsoon season.

Recharge temperatures from approximately 20,000 radiocarbon years ago were as low as 3.2°C, as recorded in the dissolved gas composition of water recharged north of the basin, and 8.1°C along the eastern mountain front. During the last 5,000 years, the δ^2H isotopic composition of eastern mountain front recharge has decreased about 7 per mil. This decrease indicates an average cooling of about 1.4°C following the mid-Holocene warm period. Over the same time span, the δ^2H isotopic composition of Rio Grande water increased approximately 6 per mil, consistent with a shift in season of peak snowmelt into the beginning of the summer monsoon season.

The $\delta^{13}C$ isotopic composition of dissolved inorganic carbon in ground water is remarkably constant throughout most of the basin indicating a nearly constant historical predominance of C_4 over C_3 plants. However, recent recharge along the basin margins indicates a rather abrupt increase in C_3 plant abundance during the past 1,000 years, and perhaps even more recently than 1,000 years, as recorded in depleted $\delta^{13}C$ isotopic compositions of dissolved inorganic carbon (DIC).

This study demonstrates the benefits of obtaining a diverse and extensive chemical and isotopic dataset when characterizing hydrochemical processes in ground-water systems, retrieving historical environmental records from ground water, and/or refining conceptual models of ground-water system.

INTRODUCTION

The Middle Rio Grande Basin (MRGB) of central New Mexico (fig. 1) recently was the subject of a multi-year (1995-2001) inter-disciplinary investigation by the U.S. Geological Survey (USGS) and other agencies to improve understanding of the water resources in the basin (Bartolino and Cole, 2002). The population of the basin, which includes the City of Albuquerque, increased approximately 119 percent between 1970 and 2000, from about 314,900 to 690,000 people (Bartolino and Cole, 2002). Since the mid-1940's, groundwater withdrawals in the vicinity of Albuquerque have resulted in declines in water levels in excess of 120 feet (Bexfield and Anderholm, 2002b). Hawley and Haase (1992) showed that the highly productive sediments of the Santa Fe Group aquifer system, from which the City of Albuquerque obtains its water supply, are much less extensive and thinner than previously thought (Bjorklund and Maxwell, 1961; Reeder and others, 1967). A series of investigations, including the 6-year USGS study, were conducted beginning in the early 1990's to improve understanding of the geohydrologic framework and hydrologic conditions in the aquifer system (Hawley and Haase, 1992; Thorn and others, 1993; Thomas, 1995; Hawley and others, 1995; Kernodle and others, 1995; Constantz and Thomas, 1996; Haneberg and Hawley, 1996; Hawley, 1996; McAda, 1996; Anderholm, 1997; Bexfield and Anderholm, 1997, 2000, 2002; Stone and others, 1998; Tiedeman and others, 1998; Connell and others, 1998; Grauch and others, 1999, 2001; Bexfield and others, 1999; Bartolino and Niswonger 1999; Anderholm 2001; Plummer and others, 2001; Sanford and others, 2001; Connell 2001; McAda and Barroll 2002; Bartolino and Cole 2002; Sanford and others, 2004), and to incorporate the new information into improved versions of the USGS groundwater-flow model for the basin (Kernodle and Scott, 1986; Kernodle and others, 1987; Kernodle and others, 1995; Kernodle 1998; McAda and Barroll 2002). This report presents results from a part of the 6-year USGS investigation, in which chemical and isotopic data from groundwater in the MRGB were used to identify and map groundwater flow of various sources of water to the basin, evaluate radiocarbon ages, and refine the conceptual model of the Santa Fe Group aquifer system.

Previous investigations in other ground-water basins (see for example, Plummer and others, 1990; Busby and others, 1991; Robertson, 1991; Parkhurst and others, 1995; Thomas and others, 1996; Plummer and Sprinkle, 2001) have demonstrated that the chemical and isotopic compositions of water can be extremely useful in identifying geochemical and hydrologic processes in ground-water systems. For example, major- and minor-element chemistry can help to delineate the spatial extent of waters of similar chemical composition and to determine the amounts of evaporation and the types of rocks and minerals in the ground-water-flow system. Stable isotopes of water can be used to identify different sources of water and the particular altitude and/or climatic conditions at which recharge occurred. Selected radioactive isotopes can be used to determine ground-water ages, which are useful in calculating flow rates and recharge rates. Dissolved gases in water help to determine mechanisms of ground-water recharge. The use of isotopes and dissolved gases, in combination with other essential hydrologic and geologic information, can provide a detailed and accurate picture of the movement of water through a ground-water-flow system.

The data set collected for this chemical and isotopic study of ground water in the MRGB is uniquely large and comprehensive. A total of 288 wells and springs were sampled for a wide variety of constituents. Data discussed in this report include major and minor elements, stable isotopes of water (^{2}H and ^{18}O), stable carbon isotopic composition (^{13}C) of dissolved inorganic carbon (DIC), stable sulfur isotopic composition (^{34}S) of dissolved sulfate (SO_4), and radioactive carbon isotopic composition (^{14}C) of DIC.

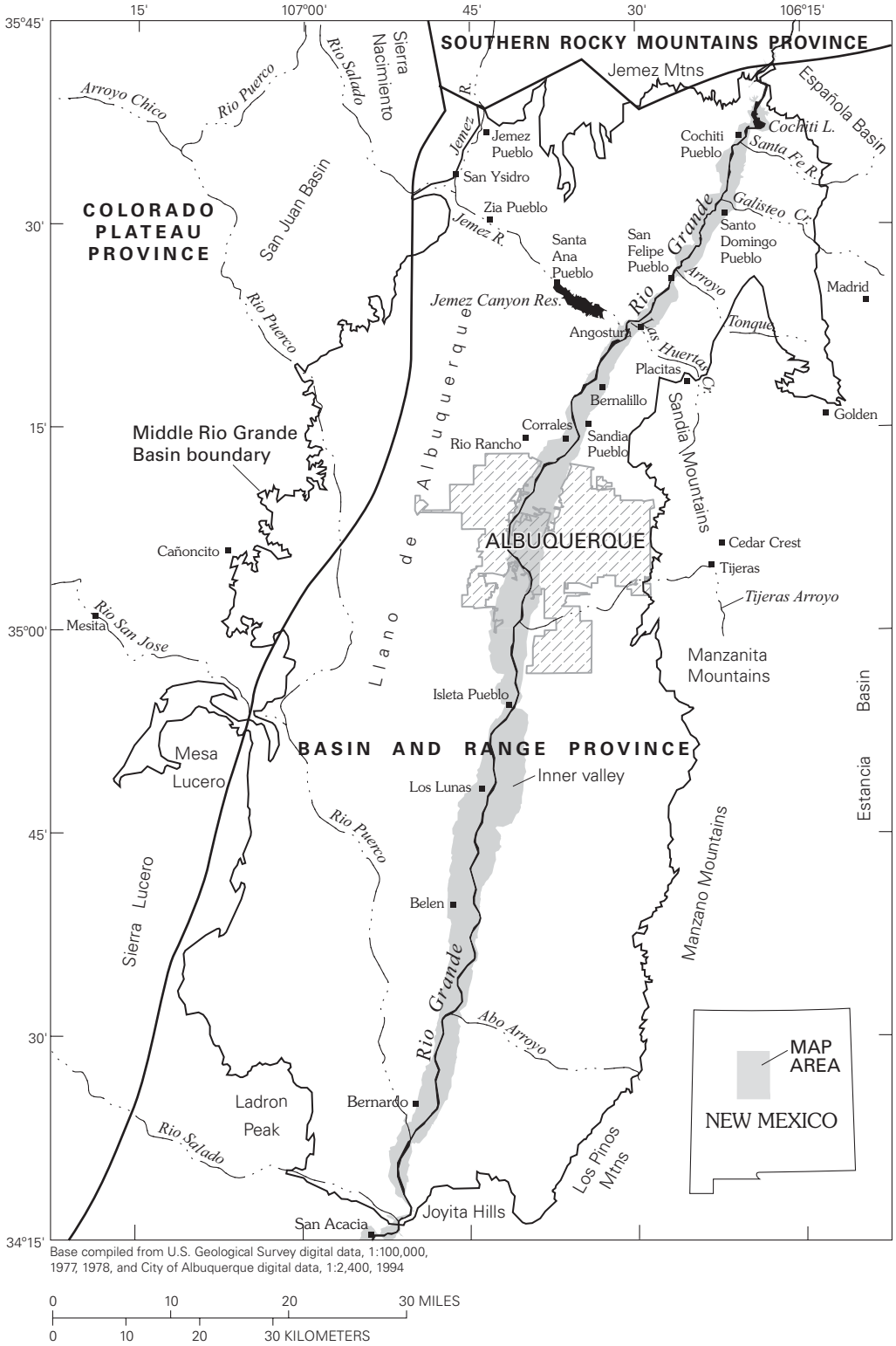

Figure 1. Selected physiographic features of the Middle Rio Grande Basin and vicinity, New Mexico.

Data for concentrations of dissolved nitrogen (N_2), argon (Ar), helium (He), neon (Ne), sulfur hexafluoride (SF_6), chlorofluorocarbons (CFCs), tritium (^3H), and tritiogenic helium-3 ($^3He_{tri}$) also are presented. These chemical and isotopic data are synthesized to permit identification of particular ground-water-recharge sources and processes and of ground-water-flow paths and travel times. Sanford and others (2004) discuss use of the results of this chemical and isotopic investigation to refine the USGS ground-water-flow model for the basin, as given in McAda and Barroll (2002).

Purpose and Scope

For this study, selected chemical and isotopic data from ground water of the Santa Fe Group aquifer system in the MRGB have been examined to improve understanding of the hydrologic system. Particular purposes of this investigation were to: (1) characterize the chemical composition of water in the aquifer system and delineate areas of similar properties; (2) identify individual sources and mechanisms of ground-water recharge; (3) delineate ground-water-flow paths and areas of mixing; (4) determine the major physical and chemical processes affecting chemical and isotopic compositions; (5) determine ground-water ages and calculate associated travel times; and (6) estimate historical and recent recharge rates for the basin.

This report describes the distributions of chemical and isotopic parameters in ground water of the MRGB and relates these parameters to the current knowledge of the hydrogeology of the basin and potential sources of recharge to the aquifer system. Supplementary chemical and isotopic data for surface water, air, solids, and unsaturated-zone gas also are discussed. In addition to chemical data collected specifically in connection with this MRGB study, the report includes selected historical data from the USGS National Water Information System (NWIS) database and the City of Albuquerque. Geochemical processes in the aquifer system are modeled and used to test sensitivity of radiocarbon age of ground water to uncertainties in geochemical reactions. The radiocarbon ages are combined with other chemical, geologic, and hydrologic data to retrieve from the aquifer system information about variations in ground-water age with depth and timing of other hydrologic and environmental processes occurring in the basin over the past 30,000 years.

Previous Investigations

Thorn and others (1993) and Bartolino and Cole (2002) provide comprehensive overviews of the geohydrology of the MRGB (otherwise known as the Albuquerque Basin) and refer to most of the key publications that have contributed to the current knowledge. Therefore, only the investigations most relevant to the current study are mentioned here. Kelley (1977) and Lozinsky (1988) provided detailed studies of the basin geology, including structure and stratigraphy, and Hawley and Haase (1992) focused particular attention on the hydrogeology of the Santa Fe Group aquifer system in the Albuquerque area. Anderholm (1985) provided mineralogic data for some aquifer materials. Russell and Snelson (1990) investigated the deep structure of the basin, and Heywood (1992) presented data on isostatic residual gravity anomalies that could be used to estimate basin thickness and geometry. Investigations of ground-water resources within individual counties of the basin were conducted by Spiegel (1955) for Socorro County, Titus (1963) for Valencia County, and Bjorklund and Maxwell (1961) for Bernalillo and Sandoval Counties.

Subsequent to publication of the report by Thorn and others (1993), numerous additional studies of the geology and hydrology of the MRGB have been conducted, many of which are part of the multidisciplinary 6-year effort by the USGS and other agencies to improve understanding of the water resources of the basin. Bartolino and Cole (2002) describe these studies in some detail. Studies included in this effort include investigations of fault locations (Minor and Shock, 1998) and lithologic variations using high-resolution aeromagnetic data (Grauch and others, 1999; 2001), estimation of mountain-front recharge using environmental tracers (Anderholm, 2001; Niswonger and Constantz, 2001), and investigation of interaction between the Rio Grande and the aquifer system (Bartolino and Niswonger, 1999). In addition, Bexfield and Anderholm (2000) published a predevelopment water-level map for the MRGB.

Various investigations have focused on the geochemistry of ground water in the MRGB. Anderholm (1988) presented a detailed study of the geochemical data available for the basin at that time and the implications of geochemistry for recharge sources and for chemical processes occurring in the aquifer system. Logan (1990) conducted a similar type of study for the Albuquerque area using geochemical

data then available primarily for municipal-supply wells. Bexfield and others (1999) summarized data that had been collected over a 10-year period by the City of Albuquerque from its municipal-supply wells; Bexfield and Anderholm (2002a) discussed the implications of those data for the aquifer system of the Albuquerque area.

Acknowledgments

The successful completion of this study required the contributions of a large number of people. Some people provided assistance in the form of advice about the information needed to improve knowledge of the aquifer system, whereas others graciously provided access to their lands and information about their wells, and still others assisted in searching for wells in the field, collecting samples, and analyzing water samples. The authors thank the numerous individual landowners who provided access to their wells. In addition, the authors wish to particularly acknowledge the contributions of those people and agencies listed below, and apologize to those we have inadvertently overlooked.

Many of the Indian Pueblos with lands located in the MRGB participated in this study by providing permission to sample wells, in addition to assistance in locating both wells and records of well construction. Therefore, the authors thank the Governors, Governors' staffs, and environmental departments' staffs of the Pueblos of Cochiti, Isleta, Jemez, Sandia, San Felipe, Santa Ana, Santo Domingo, and Zia. The authors also thank Bill White with the Bureau of Indian Affairs for his assistance in contacting the Pueblos and his advice about the most appropriate wells for sampling. Also, water samples from many of the windmills on Pueblo lands could not have been obtained without the generous assistance of John Sanchez and the windmill crew of the Southern Pueblos Agency.

Individuals from many Federal, State, and local agencies provided access to wells and assisted in locating the most appropriate wells for sampling. Those agencies include the U.S. Forest Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, Kirtland Air Force Base, Sandia National Laboratories, the New Mexico Office of the State Engineer, the New Mexico Environment Department, the University of New Mexico, the City of Albuquerque, the City of Belen, and the Town of Los Lunas. Doug Earp and others with the City of Albuquerque Environment Department were particularly helpful both in locating monitoring wells to sample and in contributing their time and equipment to obtaining water samples from deep piezometer nests drilled by the City of Albuquerque in cooperation with the USGS. Individuals from the City of Albuquerque Water Utility Division also spent a great deal of time and effort providing access to many city production wells and collecting water samples from each well for analysis of stable isotopes of H and O. The advice and assistance of Linda Logan of the New Mexico Office of the State Engineer is gratefully acknowledged.

Many utilities and other businesses also generously provided access to wells. These include Rio Rancho Utilities, Rio Grande Utilities, Sandia Peak Utility Company, National Utilities, New Mexico Utilities, DRESCO, Intel, AT&T, King Brothers Ranch, and the Huning Ltd. Partnership.

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DESCRIPTION OF THE STUDY AREA

The MRGB is located in the Basin and Range physiographic province of central New Mexico (fig. 1). The basin, which covers about 3,060 square miles and contains basin-fill deposits up to about 14,000 feet thick (Thorn and others, 1993), is among a series of alluvial basins that are located in the Rio Grande rift and contain deposits that constitute important aquifers for the region. The basin boundaries have been defined by the extent of Cenozoic deposits. The basin is surrounded partly by mountain ranges, which include the Jemez Mountains to the north, the Sandia, Manzanita, Manzano, and Los Pinos Mountains to the east, and the Joyita Hills and Ladron Peak to the south (fig. 1). Lower topographic relief occurs along the west side of the basin, which is bounded by the Lucero and Nacimiento uplifts and the Rio Puerco fault zone. Within the basin, piedmont slopes extend from the eastern mountain fronts toward the main drainage, the Rio Grande, which is inset in a terraced valley with a flood plain up to about 4.5 miles wide. The Rio Puerco also is inset in a terraced valley; the high mesa between these two drainages has been designated the Llano de Albuquerque (Hawley and Haase, 1992). Land-surface altitude above sea level ranges from about 4,700 feet at the southern end of the basin to about 8,000 feet on the flanks of the Sandia and Monzano mountains.

Most land in the MRGB is classified as rangeland, whereas other land-use types and land cover (in order of decreasing area) are forest, urban, agriculture, barren land, and water (Thorn and others, 1993). Most rangeland is classified as “mixed” and most forests consist primarily of piñon and juniper, except in riparian areas where they consist largely of phreatophytes. Urban areas include the City of Albuquerque, which is the largest city in New Mexico. In 2000, the population of the Albuquerque metropolitan area was about 712,700 people (U.S. Census Bureau, 2001). All of the communities in the basin rely primarily on ground water for domestic and industrial uses. Agricultural land is confined primarily to the Rio Grande flood plain, where depth to water generally is less than about 25 feet (Anderholm, 1997). Most agriculture is irrigated with surface water that is diverted from the Rio Grande into a system of canals. Riverside and interior ground-water drains in the flood plain maintain ground-water levels several feet below land surface.

Climate

The climate of the MRGB generally is categorized as semiarid, although the climate in parts of the surrounding mountainous areas ranges to humid continental (Thorn and others, 1993). As a result of altitude differences, precipitation in the region varies widely with location. For the period of record (variously between 1914 and 2003), weather stations at lower altitudes within the basin (Bernardo and the Albuquerque Airport, respectively) showed mean annual precipitation from 7.9 to 8.6 inches (table 1 and fig. 2). Mean annual precipitation at weather stations in surrounding areas of higher altitude (Sandia Park and Mountainair, respectively) was 19.0 and 14.3 inches. Mean annual snowfall ranged from 4.0 inches at Bernardo to 58.7 inches at Sandia Park.

At lower altitudes, most precipitation occurs between the months of July and October (fig. 3a). Precipitation during this time comes primarily from high-intensity thunderstorms of relatively short duration. Most winter precipitation is from lower-intensity storms of longer duration. Winter storms make a greater contribution to annual precipitation at higher altitudes, although the months of July through September in these areas tend to be wettest (fig. 3b). Total annual precipitation at any particular location can be quite variable from year to year. At the Albuquerque Weather Service Forcast Office (WSFO) Airport location, total annual precipitation between 1914 and 2003 ranged from 3.29 to 15.88 inches; at Sandia Park (1935-2001), the range was from 9.96 to 32.76 inches (fig. 2). Annual potential evaporation in the region is substantially greater than annual precipitation, ranging from less than 50 inches in the eastern part of the basin to more than 60 inches in the southern and central parts of the basin (Thorn and others, 1993).

Characteristics of the climate in the MRGB include large daily temperature changes and low humidity. For the period of record (table 1), the average difference between daily maximum and minimum temperatures was 14.9°C at the Albuquerque WSFO Airport and 16.0°C at Sandia Park. Mean annual temperatures for weather stations in the region range between 9.6 and 13.6°C (table 1). For the period 1914-2003, mean monthly temperatures at the Albuquerque Airport ranged from 1.8°C in January to 25.6°C in July.

Table 1. Climatic data from selected stations in the Middle Rio Grande Basin, New Mexico, and vicinity, period of record

[From Western Region Climate Center, Desert Research Institute, http://www.wrcc.dri.edu/summary/climsmnm.html]

Station name	Station altitude (feet)	Period of record	Mean January temperature (ºC)	Mean July temperature (ºC)	Mean annual temperature (ºC)	Mean annual precipitation (inches)	Mean annual snowfall (inches)
Albuquerque WSFO AP[1]	5,309	1914-2003	1.8	25.6	13.6	8.6	9.9
Sandia Park	7,019	1935-2001	-0.8	20.6	9.6	19.0	58.7
Bernardo	4,735	1933-2003	1.8	25.1	13.3	7.9	4.0
Mountainair	6,520	1914-2003	0.3	21.8	10.8	14.3	24.6

[1]WSFO AP is Weather Service Forecast Office at Albuquerque Airport

Surface Water

Rio Grande

The main surface drainage for the MRGB is the Rio Grande, which extends the entire length of the basin (fig. 1). The headwaters of the Rio Grande are located in the San Juan Mountains of southwestern Colorado, which exceed 13,500 feet in altitude (Ellis and others, 1993). Prior to entering the basin, the present-day Rio Grande is affected by irrigation diversions and return flows, reservoirs on its tributaries—completed as early as 1913 (Crawford and others, 1993)—and inflow that includes surface water diverted from the San Juan River Basin. Where it enters the MRGB, the Rio Grande has a drainage area of about 14,900 square miles.

Within the basin, the configuration of the river and its seasonal discharge patterns have been altered by man-made structures. Prior to regulation, the Rio Grande probably was a perennial, braided river that migrated back and forth across the flood plain, with its discharge reflecting seasonal snowmelt and storm events (Crawford and others, 1993). The frequency of periodic flooding increased as a result of greater sediment deposition associated with land-use activities, so that a system of levees and jetty jack works was emplaced during the 1920's-50's to confine the river to a single channel. Also during this time period, the system of irrigation canals in the valley was improved and levees and interior and riverside drains were constructed. The drains lowered the water table so that lands that had been waterlogged by previous canal leakage and irrigation could be reclaimed.

Substantial irrigation diversions both upstream and downstream of Albuquerque affect the discharge of the Rio Grande. Norman (1968) reports that as a result of irrigation diversions, the river channel has been completely dry at times below the town of Bernalillo. Since 1973, the discharge of the Rio Grande has been regulated by Cochiti Dam at the north end of the basin for flood and sediment control. Regulation has resulted in greater discharge throughout the irrigation season and an otherwise more even seasonal distribution of discharge than would be expected under "natural" conditions (fig. 4). For water years (the water year is from October 1 through September 30, and named for the 2nd of the two years spanned) 1974-98, the mean annual discharge of the Rio Grande at Albuquerque was about 1,450 cubic feet per second (Ortiz and others, 1999).

The Rio Grande alternately gains and loses flow through the MRGB. At the north end of the basin, ground-water inflow apparently adds to discharge in the river between Cochiti Dam and San Felipe; Trainer and others (2000) measured increases in discharge between these two sites on individual days in February of 1974. In the vicinity of Albuquerque, seepage of water to the aquifer system is known to occur from both the Rio Grande and its associated irrigation system. Although the exact quantity of seepage is uncertain, ground-water temperature profiles obtained beneath the river near Albuquerque by Bartolino and Niswonger (1999) were used to estimate downward fluxes of about 0.058 to 0.12 feet per day. Spiegel (1955) indicates that in Socorro County, at the south end of the basin, the inner valley of the Rio Grande gains ground water from the adjacent mesas, but the river channel actually might lose water naturally to the inner valley because evapotranspiration in the inner valley is greater than inflow from the mesas. The chemistry of water in the Rio Grande and implications

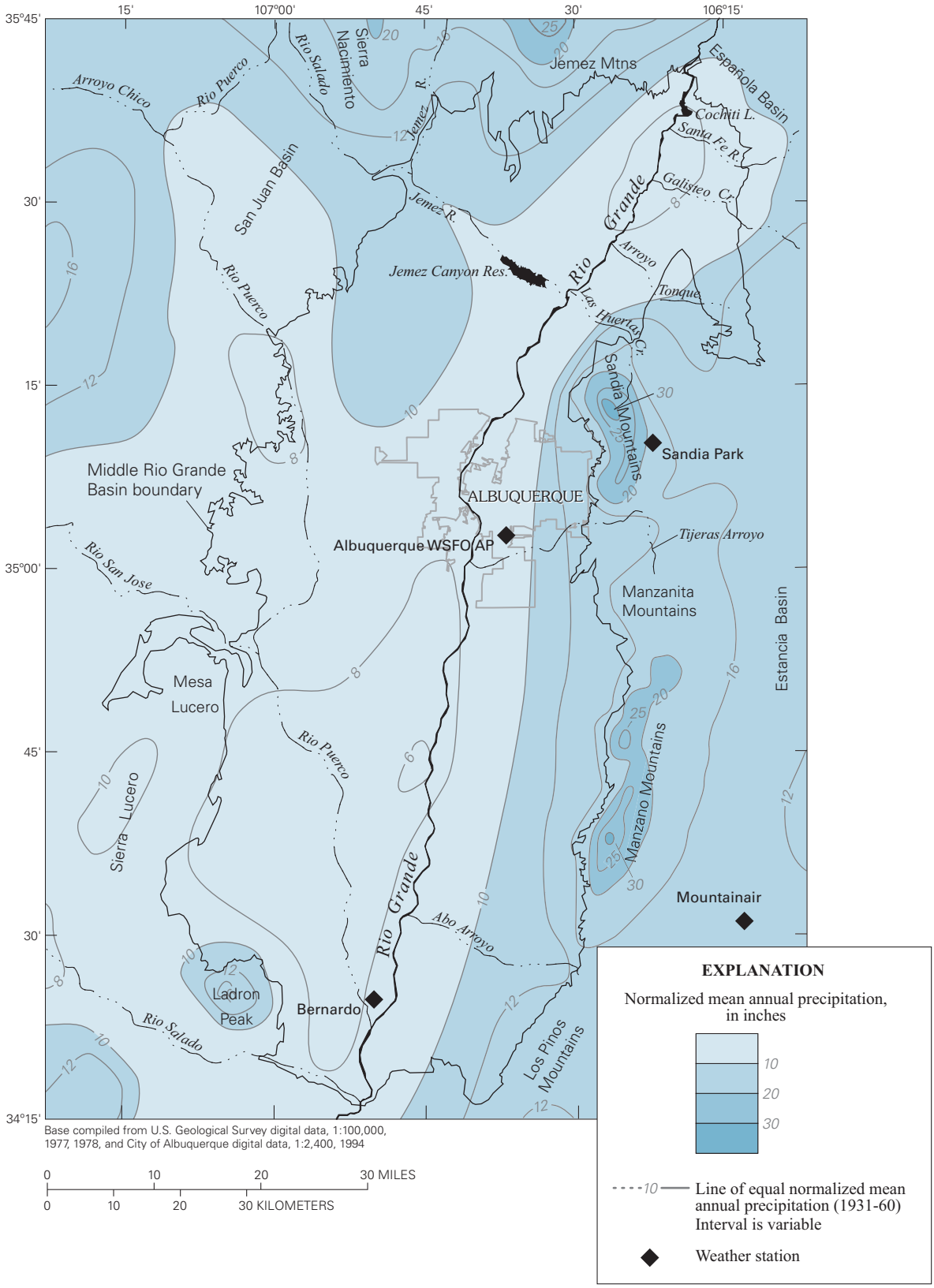


Figure 2. Normalized mean annual precipitation in the Middle Rio Grande Basin and vicinity, central New Mexico, 1931-60. (from U.S. Department of Commerce, no date).

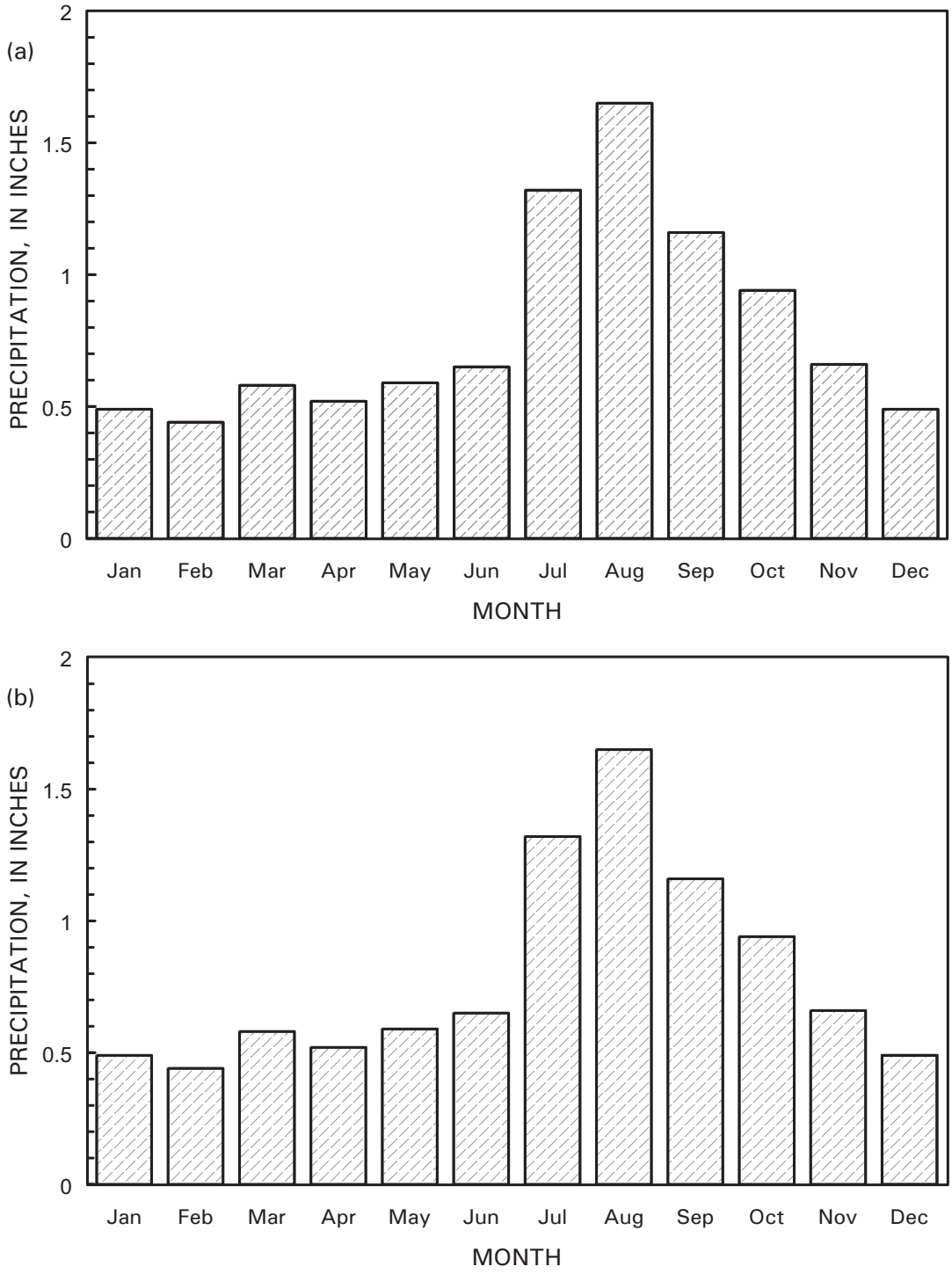


Figure 3. Average monthly precipitation at the (a) Albuquerque Airport and (b) Sandia Peak stations, New Mexico, 1971-2000.

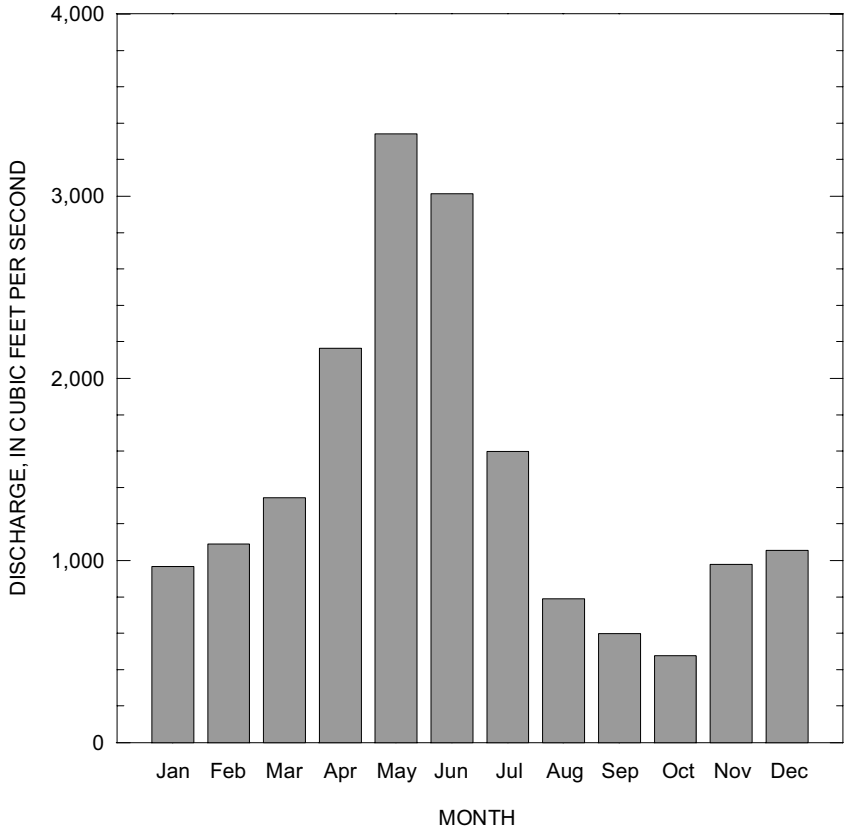


Figure 4. Mean monthly discharge for the Rio Grande at Albuquerque, New Mexico, water years 1974-98.

of the infiltration of river water for ground-water chemistry are discussed in the sections "Sources of Recharge and Underflow to the Santa Fe Group Aquifer System" and "Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water Sources".

Tributaries

Although the Rio Grande and Santa Fe River are the only perennial streams in the MRGB, several tributaries can contribute substantial flow to the Rio Grande, and potentially can contribute substantial quantities of recharge to the underlying aquifer system. Of the tributaries for which detailed streamflow records are available, the Jemez River and the Rio Puerco are among the largest (fig. 1). However, numerous ephemeral channels also can carry substantial quantities of water to the Rio Grande during large storm events. In addition, man-made channels, such as ground-water drains and flood-diversion channels, also are tributary to the Rio Grande. The chemistry of water in tributaries to the Rio Grande and implications for the chemistry of the Rio Grande and for the aquifer system because of infiltration are discussed in the section "Sources of Recharge and Underflow to the Santa Fe Group Aquifer System".

The Jemez River originates in the Jemez Mountains at the north end of the basin (fig. 1), which exceed 11,000 feet in altitude. In its upper reaches, the river receives substantial contributions from both ground-water discharge, including discharge from some geothermal springs, and snowmelt, which typically contributes most of the discharge from March through June. Runoff from summer thunderstorms also contributes flow. At the Jemez River near Jemez, the mean annual discharge for 1954-98 was 79.6 cubic feet per second; on average, about 70 percent of the total annual discharge was recorded from March through June (Ortiz and others, 1999). Upstream of the town of Jemez, the river drains an area consisting primarily of Precambrian crystalline rocks, Paleozoic sandstone, shale, and limestone, and Tertiary and Quaternary volcanic rocks (Craigg, 1992). Shortly after entering

the MRGB, the Jemez River is joined by the Rio Salado, which drains Cretaceous, Jurassic, and Triassic rocks in a semiarid area west of the Sierra Nacimiento (Craigg, 1992). From there, the Jemez River flows primarily southeast across basin-fill sediments toward the Rio Grande. Seepage investigations conducted by Craigg (1992) showed seasonal variations in the tendency for the Jemez River to lose or gain flow between the Jemez River near the Jemez streamflow gage and Santa Ana Pueblo (fig. 1). During March, the river generally gained throughout this reach, while during August (when evapotranspiration is high) the river was a losing stream between Zia and Santa Ana Pueblos.

Discharge of the Jemez River to the Rio Grande has been regulated since 1953 by Jemez Canyon Dam (intended solely for desilting and flood control); the mean average discharge below the dam was 62.6 cubic feet per second for 1943-98 (Ortiz and others, 1999). Where the Jemez River meets the Rio Grande north of Bernalillo, its drainage area is about 1,050 square miles (Craigg, 1992).

The Rio Puerco enters the MRGB from the San Juan Basin to the northwest (fig. 1). Near its headwaters, the Rio Puerco drains Precambrian and Paleozoic rocks on the west side of San Pedro Mountain, in the vicinity of Cuba, New Mexico. However, upstream of the MRGB, most of the drainage area of the Rio Puerco is underlain by Cretaceous sedimentary rocks (Spiegel, 1955). Once within the basin, the river flows over primarily Quaternary and Tertiary deposits. Risser and Lyford (1983) state that for the 1935-76 water years, a discontinued streamflow gage (Rio Puerco at Rio Puerco) located about 6 miles downstream from the confluence of the Rio Puerco and the Rio San Jose showed that the Rio Puerco was dry about 50 percent of the time; the mean annual discharge was about 58 cubic feet per second. About 77 percent of the total annual discharge at the site occurred during the summer storm season of July through October. During the remainder of the year, most of the flow was contributed by the Rio San Jose, which drains areas underlain by Triassic, Jurassic, and Cretaceous rocks (Spiegel, 1955).

The Rio Puerco meets the Rio Grande just south of Bernardo (fig. 1), where its drainage area is about 7,350 square miles and its mean annual discharge (at the Rio Puerco near Bernardo) was 42.5 cubic feet per second for water years 1940-98 (Ortiz and others, 1999). Records of discharge for 1940-47 for the Rio Puerco at Rio Puerco and the Rio Puerco near Bernardo indicated that this reach of the river lost an average of at least 5,800 acre-feet per year (Spiegel, 1955). The Rio Puerco channel historically has undergone large-scale, rapid changes; over about the past 3,000 years, the channel has experienced three episodes of aggradation and incision (Elliot and others, 1999). The most recent episode of incision began in the late 1880's. As a result of incision, the Rio Puerco carries a high suspended-sediment load that averages about 2,580,000 tons per year (Ellis and others, 1993).

Tijeras Arroyo enters the MRGB just south of the Sandia Mountains (fig. 1). The arroyo drains mainly Paleozoic and Precambrian rocks at altitudes up to about 9,800 feet and has a drainage area of about 99.3 square miles where it enters the basin (Anderholm, 2001). Although flow in Tijeras Arroyo is perennial in some sections east of the basin because of spring and ground-water discharge, water in the arroyo typically infiltrates a short distance inside the MRGB boundary because of the permeability and thickness of basin-fill sediments. In response to storm runoff (particularly during the summer), the arroyo intermittently flows to the Rio Grande. Streamflow gages located about 1,500 feet apart were operated near the mountain front for the periods April 1943-June 1949 and May 1989-September 1991. Data from these sites indicate that the arroyo shows little or no response to snowmelt (Anderholm, 2001). Also, the data indicate that the mean annual discharge in Tijeras Arroyo has decreased substantially from greater than 13 cubic feet per second during 1944-48 (U.S. Geological Survey, 1960) to less than 0.15 cubic feet per second during 1990-91 (data from the U.S. Geological Survey National Water Information System database). Anderholm (2001) suggests that this observed decrease in discharge probably is related to recent development in the watershed. If discharge was consistently higher in the past, ground-water recharge by infiltration through Tijeras Arroyo likely also was higher.

Abo Arroyo enters the MRGB just south of the Manzano Mountains (fig. 1) and has the largest watershed along the eastern edge of the basin (about 248 square miles). The arroyo drains mostly Paleozoic sedimentary rocks, along with some crystalline Precambrian rocks (Anderholm, 2001). Data collected from a streamflow gage near the mountain front for October 1996-September 1997 show a small amount of perennial flow, which infiltrates a short distance inside

the basin boundary. Anderholm (2001) assumes a discharge of about 0.35 cubic feet per second in calculating the yearly base flow at the gage site. The effect of snowmelt on discharge apparently is small, but summer storms result in high flows that can account for over half of the annual discharge at the gage (Anderholm, 2001), and that periodically reach the Rio Grande.

Several additional ephemeral channels have the potential to contribute substantial amounts of recharge to the aquifer system and to periodically contribute substantial flow to the Rio Grande. However, little generally is known about the amount and seasonality of discharge of these channels within the margins of the MRGB. These channels include Galisteo Creek, Las Huertas Creek, Arroyo Tonque, and the Rio Salado (fig. 1). Flow in the Santa Fe River, in the northeastern part of the basin, is sustained largely by outflow from the City of Santa Fe sewage-treatment plant. The mean annual discharge at the Santa Fe River above Cochiti Lake was about 11.6 cubic feet per second for water years 1970-98 (Ortiz and others, 1999).

Geologic Setting

Tectonic Framework

The crustal extension that resulted in the formation of the Rio Grande rift began in the late Oligocene, about 32 million years ago, and continues into the present (Russell and Snelson, 1990). Successive episodes of extension caused large blocks of crust to drop down relative to adjacent areas, forming a series of generally north- to south-trending structural and physiographic basins that are hydrologically connected. These basins occur over a distance of more than 600 miles from Colorado to Texas. The basins are typified by thin crust, high heat flow, young faulting, recent volcanism, and thick basin fill (Lozinsky, 1988).

For this study, the MRGB (or Albuquerque Basin) is defined by Thorn and others (1993) to include the Santo Domingo Basin and the Hagan Embayment (fig. 5). As defined, the basin is about 100 miles long and 35 miles wide and is the third largest basin in the Rio Grande rift. South of the Santo Domingo Basin, the MRGB consists of two subbasins formed by a northern, eastward-dipping half-graben and a southern, westward-dipping half-graben (Russell and Snelson, 1990). Recent studies (Heywood, 1992; Grauch and others, 1999) show the presence of a high in isostatic residual gravity between the Santo Domingo Basin and the Calabacillas subbasin (fig. 5) that corresponds to the Ziana anticline as delineated by Kelley (1977) and to a structural high in basement rocks. A gravity high also is indicated between the Calabacillas and Belen subbasins near their eastern extents. These gravity highs are representative of transitional areas between subbasins where the denser, relatively low permeability rocks that underlie the Santa Fe Group rise closer to the land surface (Grauch and others, 2001). These transitional areas are covered by Santa Fe Group, but its thickness here can be less than 3,000 feet, compared with more than 10,000 feet within the Santo Domingo Basin and the two subbasins (Grauch and others, 1999 and 2001). The deep, inner portions of the subbasins generally also are bordered on the sides by shallow benches that step up to the margin areas (Hawley and Haase, 1992). These benches include the Hubbell and Laguna benches (fig. 5).

The west side of the MRGB is bounded mainly by the Ladron Mountains, the Lucero uplift, and the Rio Puerco fault zone (fig. 1). The Ladron Mountains in the southwest consist primarily of Precambrian granitic and metamorphic rocks and some Paleozoic rocks. The Lucero uplift tilts westward and is composed of Paleozoic limestone, sandstone, and shale capped by late Cenozoic basalt flows (Hawley and Haase, 1992). Faults separating the Lucero uplift from the basin juxtapose Pennsylvanian rocks with Precambrian or Permian rocks in some areas and juxtapose Permian with Triassic rocks in other areas (Anderholm, 1988). The Rio Puerco fault zone is a northeast-trending fault belt that separates the basin from the Colorado Plateau. These faults generally juxtapose Mesozoic rocks with Santa Fe Group deposits (Anderholm, 1988). West of the fault zone, exposed rocks include Cretaceous sandstone and shale and local Jurassic gypsum and clastic units (Hawley and Haase, 1992).

The northern part of the basin is bounded primarily by the Nacimiento uplift and the Jemez Mountains (fig. 1). The Nacimiento uplift in the northwest includes Precambrian plutonic and metamorphic rocks overlain by Paleozoic and Mesozoic sedimentary rocks (Hawley and Haase, 1992). Just east of the uplift are the Jemez Mountains, a major Cenozoic volcanic center of mafic to silicic rocks. East of the Jemez Mountains, the MRGB is

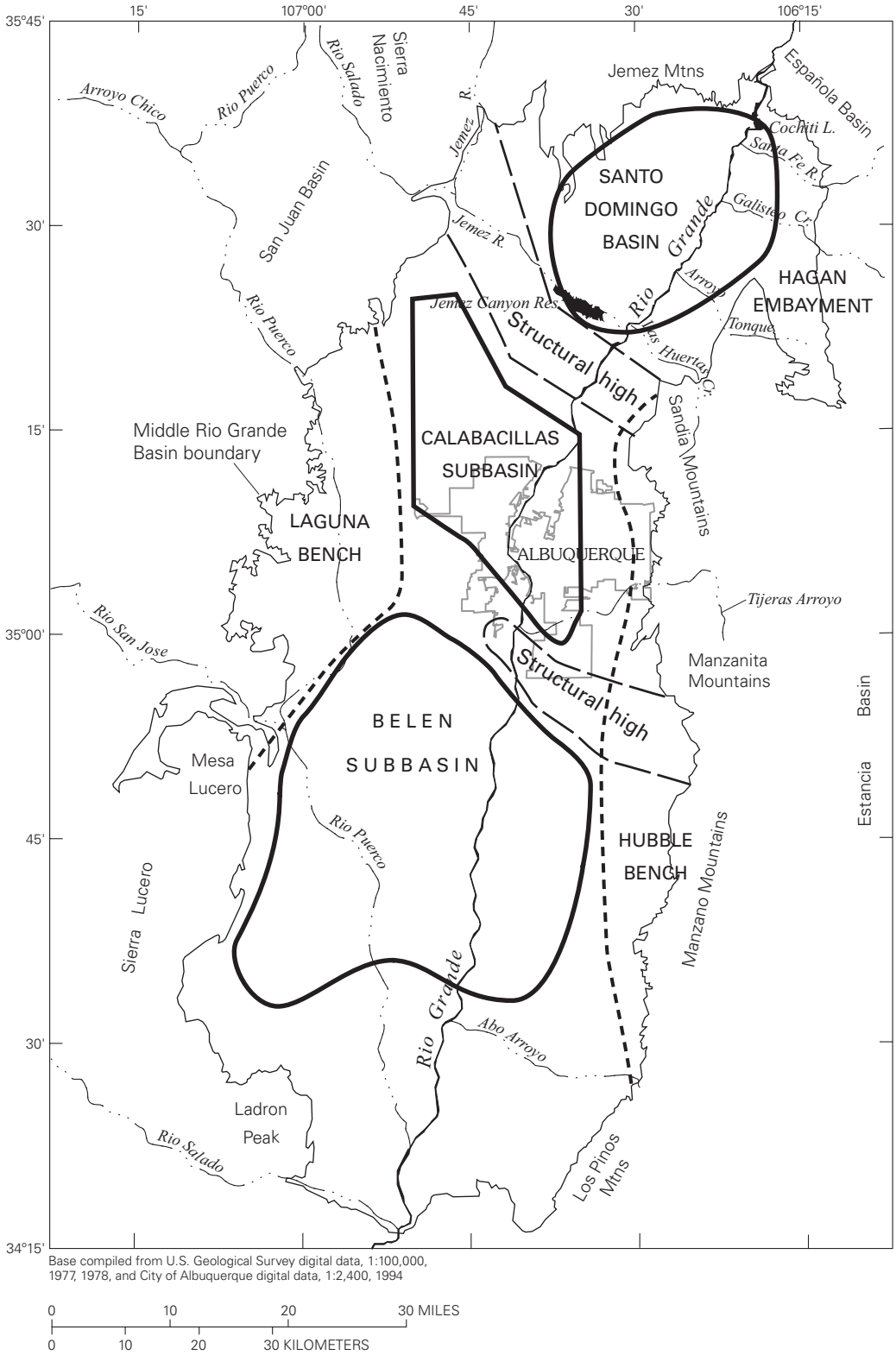


Figure 5. Simplified structure of the Middle Rio Grande Basin, New Mexico (Grauch and others, 1999).

connected to the Española Basin, a rift basin, by a narrow area referred to by Kelley (1977) as the White Rock channel. The Hagan Embayment, which constitutes the eastern part of the Hagan Basin (the part that is underlain by Santa Fe Group deposits) (Kelley, 1977), is included within the northeastern portion of the MRGB. The Hagan Embayment is bounded on the east by La Bajada fault, which juxtaposes Santa Fe Group sediments on the west side of the fault with Mesozoic beds on the east side (Kelley, 1977).

The fault-line scarp of the uplifted blocks of the Sandia, Manzano, and Los Pinos Mountains marks the distinct eastern boundary of the basin (fig. 1). These blocks consist primarily of a core of west-facing Precambrian metamorphic and plutonic rocks that are overlain unconformably by east-facing dip slopes of Paleozoic limestone and sandstone (Anderholm, 1988; Hawley and Haase, 1992). In the southeast, the Precambrian, Paleozoic, and Mesozoic rocks of the Joyita Hills bound the basin. South of the MRGB, the Joyita uplift on the east and the Socorro uplift on the west converge, forming a constriction between the MRGB and the Socorro Basin.

Besides the basin-bounding faults, numerous additional faults extend through parts of the MRGB (fig. 6) (Minor and Shock, 1998). Most of these faults offset Santa Fe Group deposits of similar lithology, although some faults result in the juxtaposition of geologic units that differ substantially in age and hydrologic properties (Kelley, 1977). Although the effects of faults on the hydrologic system of the basin have not been well characterized, the predevelopment water-level map of Bexfield and Anderholm (2000) indicates faults that appear to have the greatest effect on water levels. These faults appear to include portions of the Rincon, Sandia, Tijeras, Hubbell Springs, Jemez, Sand Hill, and Cat Mesa Faults as defined by Kelley (1977) (fig. 6). Faults that do not show large offsets causing the juxtaposition of different geologic units do not appear to affect predevelopment water levels. Therefore, any effects that might be caused by cementation along faults of small displacement are not readily apparent from the water-level map. Another property of faults that has not been well characterized is their potential to facilitate upward flow of deep water into shallower parts of the aquifer system.

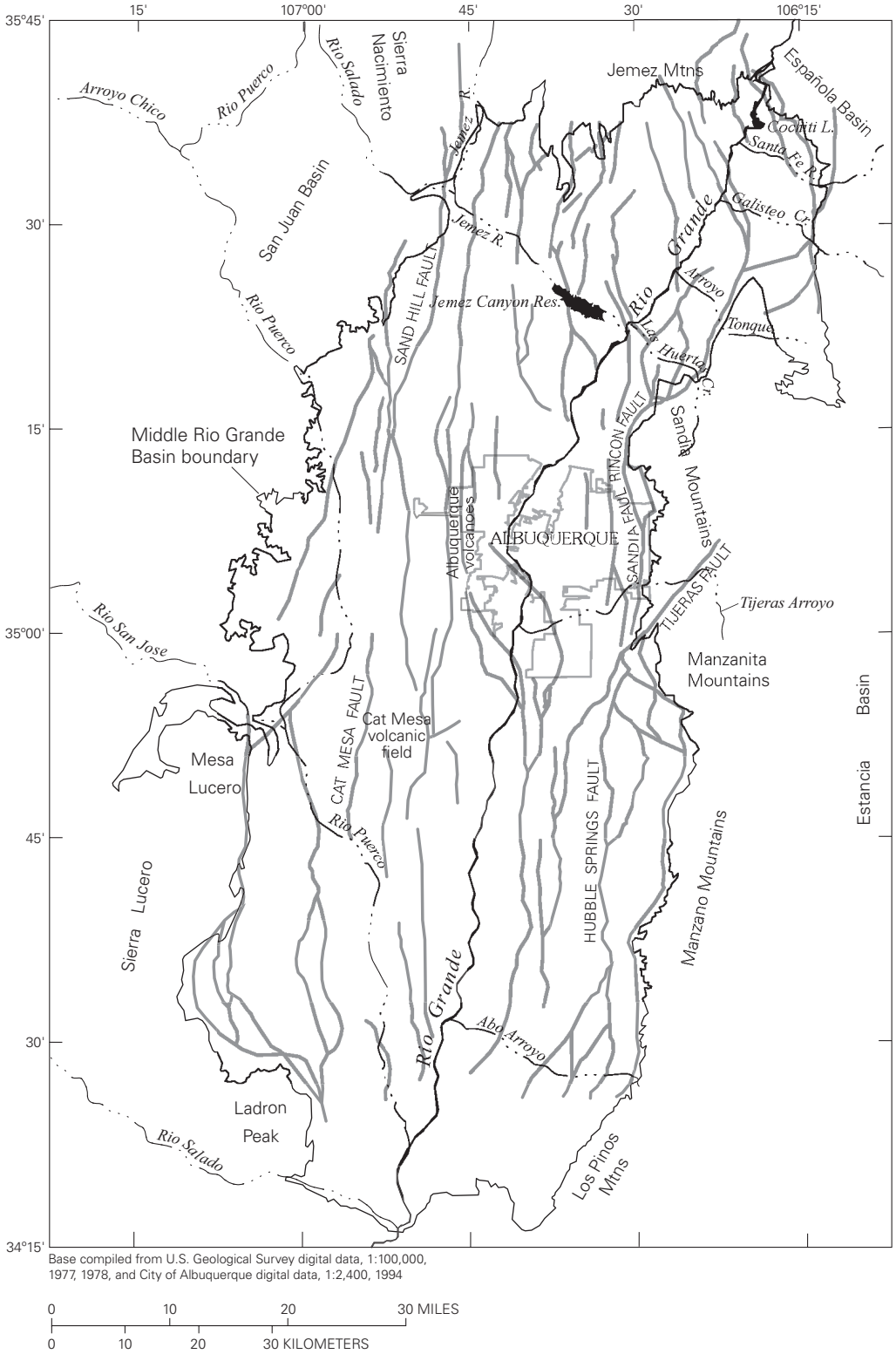
Santa Fe Group Aquifer System

The primary aquifer system of the MRGB consists of the generally unconsolidated to moderately consolidated basin-fill sediments of the Santa Fe Group. The Santa Fe Group aquifer system is defined by Thorn and others (1993) as including both the Santa Fe Group deposits, which are of Oligocene to middle Pleistocene age, and the more recent (post-Santa Fe Group) flood-plain, channel, and basin-fill deposits of Pleistocene to Holocene age that are in hydraulic connection with the Santa Fe Group. For this report, the Thorn and others (1993) definition is assumed whenever the term “Santa Fe Group aquifer system,” or simply, “aquifer system” is used. Hawley and Haase (1992) provide a detailed discussion of the hydrostratigraphic and lithofacies units of the aquifer system in the general vicinity of Albuquerque, where the largest body of information is available. The following discussion is from their publication, except where otherwise specified.

Hydrostratigraphic Units

Santa Fe Group deposits, which range in thickness from about 3,000 to over 14,000 feet, have been divided broadly into upper, middle, and lower units based on depositional environment and age. As a whole, the group consists primarily of alluvium from both nearby mountains and distant sources outside the basin, but includes locally thick playa-lake and eolian deposits, as well as some volcanic rocks. The lower Santa Fe Group, which was deposited about 30 to 15 million years ago and ranges in thickness from approximately 1,000 to 3,500 feet, represents deposition in a shallow, internally drained basin prior to the substantial uplift of surrounding mountains. The unit consists largely of piedmont-slope, eolian, and fine-grained basin-floor deposits. The basin-floor sediments were deposited primarily in playa lakes and generally have small hydraulic conductivity.

The middle Santa Fe Group, which was deposited about 15 to 5 million years ago and ranges from about 250 to 9,000 feet thick, represents the time of the most active tectonism and highest sedimentation rates in the basin. Deposition of piedmont-slope sediments continued and fluvial deposition occurred on the basin floor as a result of the transport of sediments into the basin by major fluvial systems from the north, northeast, and southwest. These systems probably



Base compiled from U.S. Geological Survey digital data, 1:100,000, 1977, 1978, and City of Albuquerque digital data, 1:2,400, 1994

Figure 6. Major faults and volcanic fields of the Middle Rio Grande Basin, New Mexico. (faults from Mark Hudson and Scott Minor, U.S. Geological Survey, written commun., 1999).

flowed into playa lakes located in the southern part of the basin. During this time, the Calabacillas and Belen subbasins filled to form a single topographic basin. In the central part of the basin (near the City of Albuquerque), the top of the middle Santa Fe Group has been delineated using a distinctive red-brown clay layer that can be up to a few hundred feet thick. Connell and others (1998) named this layer the Atrisco member. The exact geographical extent of the layer is not known.

The upper Santa Fe Group, which was deposited about 5 to 1 million years ago and generally is less than about 1,000 feet thick (except in some areas near Albuquerque), consists largely of intertonguing piedmont-slope and fluvial basin-floor deposits. During this time, the ancestral Rio Grande system developed and was joined by two ancestral tributaries, the Rio San Jose and Rio Puerco. Because the fluvial system was of fairly high energy during this time, the ancestral river sediments that were deposited include thick zones of clean sand and pebble gravel and compose some of the most productive aquifer materials in the basin. When the Rio Grande and Rio Puerco began to cut their present valleys, Santa Fe Group deposition ceased.

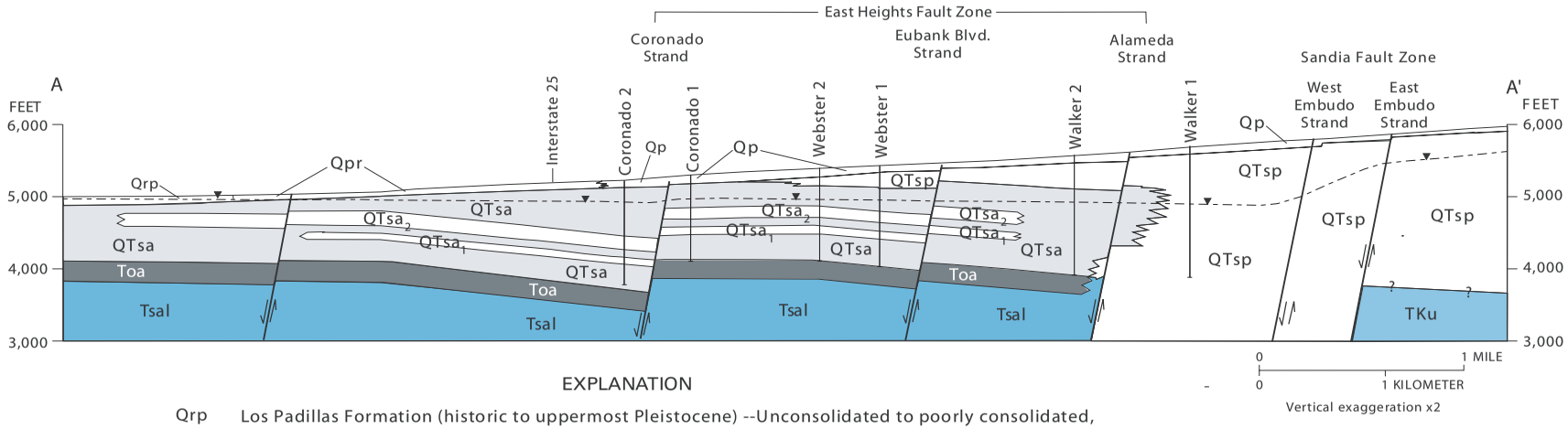
Deposition of post-Santa Fe Group sediments occurred during a series of river incision and partial backfilling episodes. River valley aggradation has been occurring over about the past 10,000 to 15,000 years because of large tributary input of sediment. Younger basin and valley fills include fan, pediment, inset-terrace, eolian, and floodplain deposits and volcanics. Younger valley fill is up to about 130 feet thick and provides a connection between the surface-water system and the underlying Santa Fe Group. Two volcanic fields, the Albuquerque field and the Cat Hills field (fig. 6), were emplaced during middle to late Pleistocene time.

More detail on the lithofacies units of the Santa Fe Group aquifer system can be found in Hawley and Haase (1992), Thorn and others (1993), and Connell and others (1999). A geologic section of hydrostratigraphic and lithofacies units typical of the Santa Fe Group aquifer system in the vicinity of Albuquerque is shown in figure 7. A conceptual diagram of the extent of major lithostratigraphic units throughout the basin during the Pliocene is shown in figure 8. The Sierra Ladrones Formation is subdivided into: piedmont facies along the east and southwest margins of the basin, ancestral Rio Grande facies through the center of the basin, and ancestral Rio Puerco/Rio San Jose facies in the southwest (fig. 8) (Connell and others, 1999; Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2001). Fluvial deposits of the ancestral Jemez River, which contain abundant silicic-intermediate-basaltic volcanic sediments derived from the Jemez Mountains, compose the Cochiti Formation and the northern part of the Arroyo Ojito Formation. Farther south, the Arroyo Ojito Formation includes primarily fluvial deposits of the ancestral Rio Puerco (Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2001).

Horizontal hydraulic conductivity values assigned to aquifer materials for the ground-water model of the MRGB constructed by Kernodle and others (1995) were based on the descriptions of Hawley and Haase (1992). These values generally ranged from less than 5 feet per day for most of the lower and middle Santa Fe Group to more than 40 feet per day for parts of the upper Santa Fe Group and post-Santa Fe Group alluvium.

Petrologic Data

Hawley and Haase (1992) discuss the composition and origin of sediments within the Santa Fe Group deposits. Much of their information is from cores and cuttings obtained from City of Albuquerque production wells. They found that sandstone composition ranged from arkose to feldspathic litharenite. Framework grains consisted of monocrystalline quartz, feldspar, and rock fragments, with lesser amounts of biotite, muscovite, chlorite, and heavy minerals. Rock fragments were volcanic, granitic/gneissic, sedimentary, and metamorphic, with volcanic fragments being most abundant. Volcanic fragments consisted primarily of plagioclase-dominated porphyries with lesser amounts of rhyolite. Below the northeastern part of Albuquerque, sediments at depths of about 200 to 3,200 feet were described as volcanic-rich, with glassy pumice being present from about 200 to 400 feet. Hawley and Haase (1992) concluded that the glassy pumice was probably derived from the Jemez volcanic field, whereas volcanic detritus likely originated from southern Colorado and northern New Mexico, such as from the San Juan volcanic field. Non-framework components of sandstones from all wells were principally detrital clay, zeolites, and calcite. Fine-grained sediments that were



EXPLANATION

Qrp	Los Padillas Formation (historic to uppermost Pleistocene) --Unconsolidated to poorly consolidated, fine- to coarse-grained sand and rounded gravel with interbeds of fine-grained sand, silt, and clay derived from the Rio Grande
Qp	Piedmont and stream alluvium, undivided (historic to middle Pleistocene)
Qpr	Fluvial deposits, piedmont alluvium, and stream alluvium, undivided (historic to middle Pleistocene)
QTsa	Axial-fluvial deposits of the ancestral Rio Grande, undivided (lower Pleistocene to Pliocene)
	$QTsa_2$ Upper sandy mudstone marker bed (Pliocene)
	$QTsa_1$ Lower sandy mudstone marker bed (Pliocene)
QTsp	Piedmont deposits (lower Pleistocene to Miocene)
Toa	Arroyo Ojito Formation, Atrisco Member (Pliocene) --Moderately to well consolidated, locally cemented succession of fine-grained silty sandstone and mudstone
Tsal	Lower fluvial deposits (Pliocene to upper Miocene)
TKu	Lower Tertiary and Cretaceous sedimentary rocks, undivided (Paleogene-Cretaceous)

Figure 7. Geologic section along Paseo del Norte in northern Albuquerque. (modified from Connell, 1997). See line A-A' on figure 18 for location.

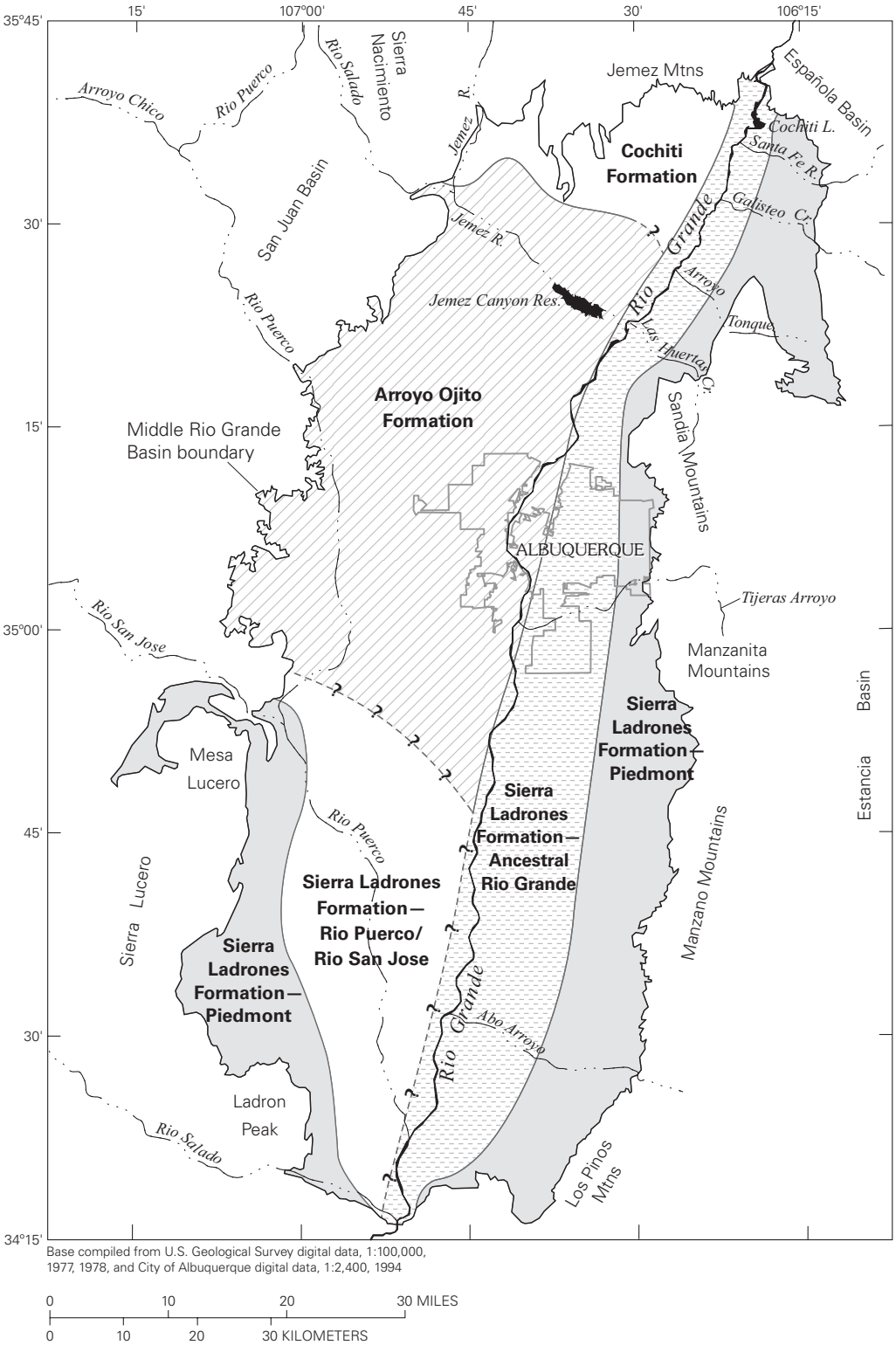


Figure 8. Inferred lateral extent of major lithostratigraphic units during the Pliocene in central New Mexico. (modified from Connell and others, 1999).

sampled consisted primarily of clay, with lesser amounts of sand and silt, and occasionally calcite cement. The principal clay minerals present were smectite, illite, kaolinite, and interlayered illite/smectite. The bulk composition of well cuttings was estimated to be approximately 60-percent granitic-metamorphic detritus of Precambrian derivation, 30-percent volcanic detritus of middle Tertiary derivation, and less than 10-percent sedimentary detritus of Paleozoic or Mesozoic derivation.

Additional investigators, including Lozinsky (1988), Stone and others (1998), and Anderholm (1985) have documented petrographic data similar to those of Hawley and Haase (1992). Lozinsky (1988) observed generally similar sandstone composition around the MRGB, including in the northern, central, southeastern, and southwestern parts of the basin. He found that monocrystalline quartz and plagioclase feldspar were the dominant detrital grains, but that their percentages could vary spatially and vertically. Rock fragments were primarily volcanic in all areas, although volcanic fragments were generally less numerous in the northwest part of the basin. In samples collected throughout the basin, Anderholm (1985) found that calcium smectite and mixed layer illite-smectite were the most common clay groups and quartz, calcite, plagioclase, and orthoclase were the most common nonclay minerals; gypsum also was observed in several whole-rock samples. Similarly, as a part of the present investigation, whole rock x-ray diffraction analysis of 14 samples of well cuttings from various locations and depths collected during drilling of monitoring wells in the vicinity of Albuquerque commonly identified quartz, plagioclase feldspar, potassium feldspar, smectite, calcite, and mica. Dolomite was detected in two samples, as were possible identifications of pyroxene and kaolinite.

Cementation, primarily by calcite, affects the hydraulic conductivity of aquifer materials across parts of the basin. Calcite in the form of caliche has been observed in Quaternary deposits, such as those capping the mesa that separates the valleys of the Rio Grande and Rio Puerco (Kelley, 1977). Below the northeastern part of Albuquerque, Hawley and Haase (1992) observed that Santa Fe Group sediments were mostly unconsolidated or poorly cemented to a depth of about 1,300 feet. However, they did find caliche-cemented sandstones in about the upper 200 feet of strata. Cementation and induration were observed to be appreciable at depths of about 1,700 to 2,000 feet. In a core hole located near the western edge of Albuquerque, Stone and others (1998) observed sandstones that were indurated and cemented by calcite that virtually filled the entire original pore space. Scattered carbonate in nodular concretions, discontinuous patches, and thin lenses was observed throughout the core. Lozinsky (1988) also noted calcite as the primary cement in various parts of the basin.

Mozley and others (1995) also have observed that calcite is the most abundant cement in the Santa Fe Group, occurring both as concretions and as laterally extensive cemented beds that can form thick aquicludes/aquitards over substantial areas. Calcite was observed to be most abundant in sediments associated with tributaries to the Rio Grande, in closed-basin fluvial facies, and in piedmont facies; calcite was least abundant in ancestral Rio Grande facies. Although coarser-grained and better-sorted sediments appeared to be preferentially cemented (reducing the hydraulic conductivity of aquifer materials that were originally among the most permeable), the lack of cementation in the permeable Rio Grande facies indicated that pore-water chemistry could be a substantial factor in determining the extent of cementation. Mozley and Goodwin (1995) observed selective calcite cementation along the Sand Hill fault in the western part of the basin. They concluded that the calcite had precipitated from flowing ground water and that the concretions were elongate parallel to flow at the time of precipitation.

Ground-Water-Flow System

The ground-water-flow system of the MRGB between Cochiti and San Acacia is complex and in some areas has not been well characterized because of a lack of data. Multiple sources of recharge to the aquifer system are present across the basin. Land use, particularly the presence of irrigation and septic systems, has added to the potential sources of recharge. Characterization of the flow system also has been complicated by drawdown because of sustained ground-water pumping, particularly in the vicinity of Albuquerque, which has altered directions of ground-water flow and probably changed the rates of recharge resulting from various sources. Faults that juxtapose relatively permeable deposits with impermeable units also appear to affect directions and rates of ground-water flow. These faults also have been proposed as

possible conduits for the upward flow of relatively deep (from depths of thousands of feet) ground water (Bexfield and Anderholm, 2002a).

A map of predevelopment water levels compiled by Bexfield and Anderholm (2000) indicates that ground-water movement through the central part of the basin has historically been oriented primarily north to south (fig. 9). Near the basin margins, ground-water flow has historically been oriented primarily toward the central part of the basin. Maps published by Bjorklund and Maxwell (1961) and Titus (1961) of pre-1960 water levels show similar patterns, although they indicate a greater east-to-west component of ground-water flow east of the Rio Grande in the vicinity of Albuquerque.

On various predevelopment water-level maps of the region (Bexfield and Anderholm, 2000; Bjorklund and Maxwell, 1961; Meeks, 1949; Titus, 1961; Titus, 1963), a depression in the water-level surface, commonly referred to as the "ground-water trough", is apparent west of the Rio Grande, from just south of the Jemez River south to the area of Los Lunas (fig. 9). This trough is located on the east side of the Sand Hill and Cat Mesa faults. Previous investigators have theorized that the presence of the trough indicates that there is a thicker sequence of more permeable material in the area of the trough than in areas on either side (Kernodle and others, 1995). However, lithologic logs of wells drilled in the trough area generally do not appear to support this hypothesis (Hawley, 1996; Stone and others, 1998). Further discussion of the origin of the ground-water trough is given in the section "Summary of Implications from Geochemical and Isotopic Data for the Conceptual Model of the Aquifer System".

There has been a steady increase in ground-water pumping in the MRGB since about the mid-1940's (Thorn and others, 1993; Bartolino and Cole, 2002). Estimates of urban, rural, commercial, and industrial ground-water withdrawals in the MRGB were 97,000, 131,000, and 152,700 acre-feet for the years of 1970, 1980, and 1990 (Thorn and others, 1993, and references within). Estimates of total ground-water withdrawals for the 7 counties that extend over at least part of the MRGB totaled nearly 310,000 acre-feet in 1995 (Wilson and Lucero, 1997; Bartolino and Cole, 2002). Over the period 1974-92, 72 percent of the total basin ground-water withdrawals were made by the City of Albuquerque (Thorn and others, 1993). Pumping in the vicinity of Albuquerque has resulted in substantial declines in water levels, as indicated by water-level data for 1999-2002 (Bexfield and Anderholm, 2002b) (fig. 10). The largest and most widespread declines compared to predevelopment levels are east of the Rio Grande, where water levels have fallen in excess of 120 feet; declines of as much as 100 feet have been observed west of the Rio Grande (Bexfield and Anderholm, 2002b). Water-level declines have resulted in ground-water movement being directed into the major pumping centers on the east and west sides of the Rio Grande (fig. 10). These large-scale shifts in the directions of ground-water flow during the past 40 to 50 years locally may affect interpretation of some geochemical data, although ground-water flow velocities are low enough that regionally significant changes in water-quality patterns are not likely to have occurred during this time period. Smaller-scale changes in ground-water flow directions also likely have occurred as a result of ground-water pumping in the vicinity of other communities, such as Bernalillo, Los Lunas, and Belen.

Bexfield and Anderholm (2002a) investigated water levels in deep nested piezometers in the Albuquerque area and found that the direction and magnitude of vertical hydraulic gradients differed substantially around the city. Vertical gradients in piezometer nests located in the Rio Grande flood plain and west of the river were directed primarily downward. In piezometer nests located outside of the flood plain to the east of the Rio Grande, vertical gradients were directed primarily upward, except in the two shallowest completions of a piezometer nest located near the mountain front. The largest downward gradients appeared to exist near the mountain front and west of the Rio Grande. However, seasonal differences in ground-water pumping affected both the direction and magnitude of gradients in some piezometer nests. Because data are not available from deep nested piezometers prior to sustained ground-water pumping, it is not known how well these vertical gradients represent predevelopment conditions.

Many investigators have attempted to identify and quantify the major sources of recharge to the aquifer system of the basin. Estimates of the quantity of recharge contributed by various sources have been compiled in reports describing ground-water models of the basin, such as Kernodle and others (1995). Mountain-front recharge probably is one of the most important sources of recharge to the basin (Thorn and others, 1993; Anderholm, 2001). Mountain-front

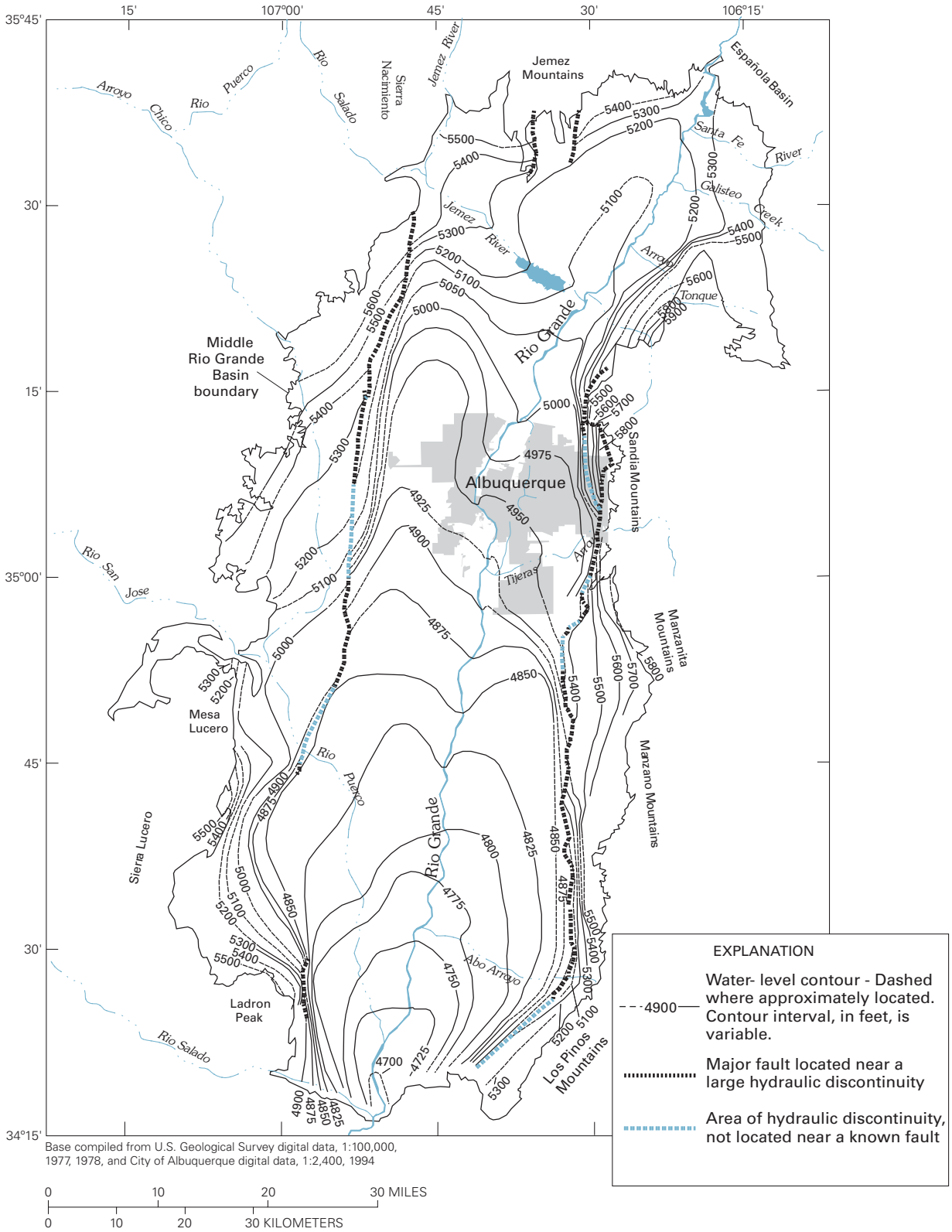


Figure 9. Predevelopment water levels in the Middle Rio Grande Basin, New Mexico. (modified from Bexfield and Anderholm, 2000; faults modified from Mark Hudson and Scott Minor, U.S. Geological Survey written commun., 1999).

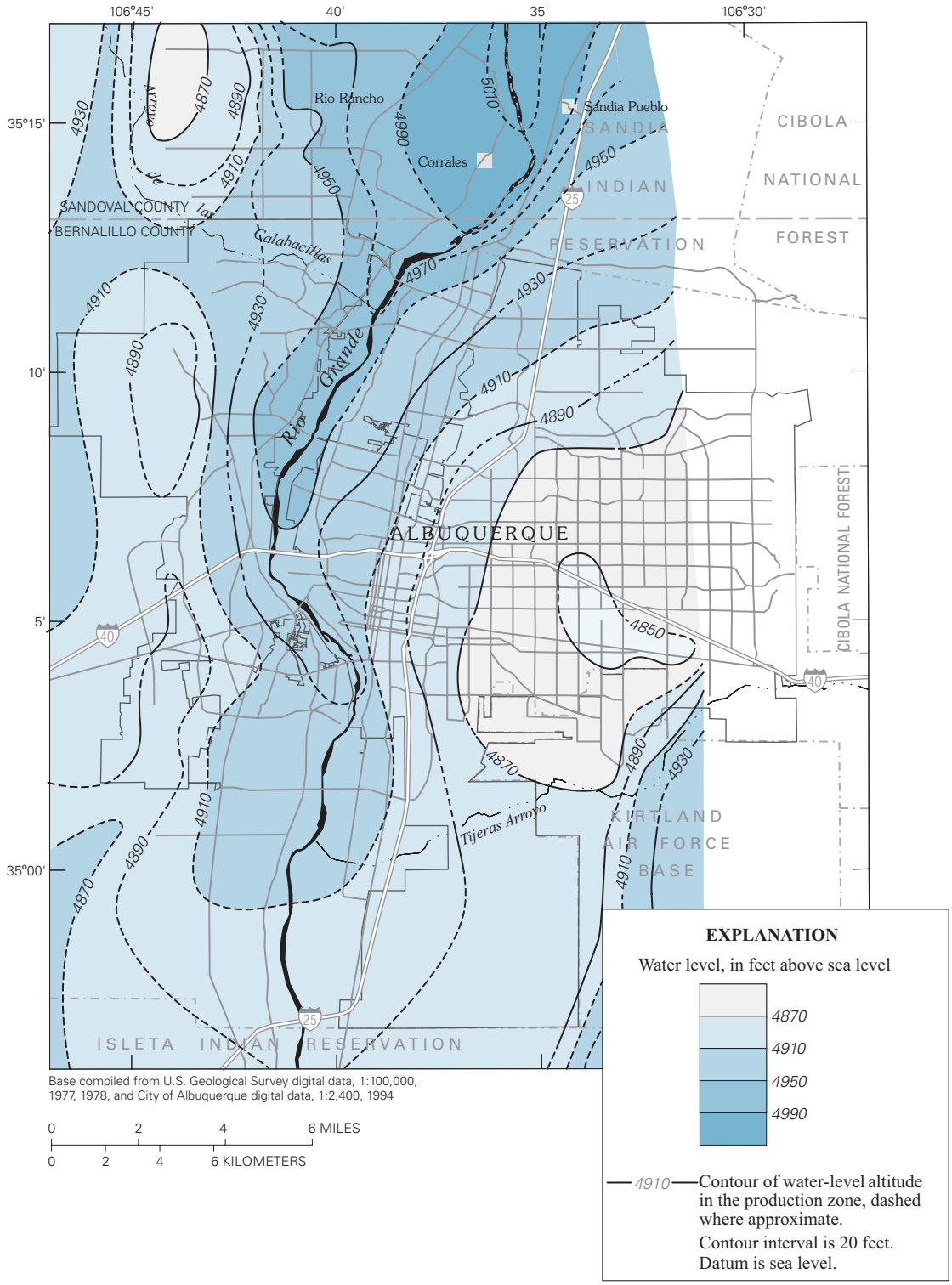


Figure 10. Water levels that represent 1999-2002 conditions in the production zone of the Santa Fe Group aquifer system in the Albuquerque area, New Mexico (modified from Bexfield and Anderholm, 2002a).

recharge is the general term used to describe recharge that occurs parallel to mountainous areas along the margins of a regional aquifer system, and usually refers more specifically to infiltration through mountain stream channels and to shallow subsurface inflow (Anderholm, 2001). Estimates of the quantity of mountain-front recharge occurring along the east side of the basin range from about 11,000 to 38,000 acre-feet per year (Anderholm, 2001). Mountain-front recharge could also be substantial along the Jemez Mountains in the northern part of the basin, and perhaps along the Ladron Mountains in the southwest, although studies have not been performed to establish the quantities of recharge occurring to the MRGB from these areas.

Subsurface ground-water inflow from adjacent basins also occurs along the margins of the MRGB, typically at fairly substantial depths. Along the northern margin of the basin, inflow occurs from the basin-fill deposits of the upgradient Española Basin and possibly from the Jemez volcanic deposits. Ground-water inflow along the entire northern margin has been estimated at about 14,300 acre-feet per year (Kernodle and others, 1995). Along the western margin, inflow probably occurs from Mesozoic rocks of the San Juan Basin toward the north and from Precambrian and Palezoic rocks toward the south. Ground-water inflow along the entire western margin has been estimated at about 8,800 acre-feet per year (Kernodle and others, 1995). Deep ground-water inflow may also occur from Precambrian and Paleozoic rocks along the eastern margin of the basin, and from Paleozoic and Mesozoic rocks in the area of the Hagan Embayment (fig. 5), but the quantity of inflow occurring in these areas is not well known.

As discussed above, infiltration is known to occur from the Rio Grande and its tributary streams and arroyos, as well as from the irrigation systems in the Rio Grande flood plain. The quantity of water from these sources that contributes to ground-water recharge is affected by evapotranspiration. Also, in the Rio Grande flood plain, the quantity of recharge is dependent upon the complex interactions between the river and the canals and drains of the associated irrigation system. Kernodle and others (1995) estimated through use of their ground-water model that about 79,000 acre-feet of water was contributed to the aquifer system from the Rio Grande and associated canals during the year ending in March 1994. Substantial quantities of recharge from the Jemez River, the Santa Fe River, Galisteo Creek, the Rio Puerco, Tijeras Arroyo, Abo Arroyo, and the Rio Salado (fig. 1) were also assumed in model simulation. Other sources that probably contribute to recharge, particularly in the Rio Grande flood plain (where depths to water typically are less than about 25 feet), include infiltrating irrigation water and septic systems. Residents of most areas that fall outside of the incorporated boundaries of the City of Albuquerque or selected other cities, such as Los Lunas and Belen, have individual septic systems. Although the direct infiltration of precipitation within the basin is a potential source of recharge to the aquifer system, any such infiltration is probably fairly localized and the quantity of recharge it contributes generally is believed to be minor (Anderholm, 1988).

Ground water discharges from the MRGB to the Socorro Basin near San Acacia (fig. 1). Ground-water discharge also occurs within the MRGB through evapotranspiration (particularly in the Rio Grande flood plain), ground-water pumpage, and discharge of ground water into drains and some reaches of the Rio Grande. The Kernodle and others (1995) ground-water model indicated that under predevelopment conditions, ground-water discharge occurred primarily through evapotranspiration. However, ground-water pumpage, estimated to be about 152,700 acre-feet in 1990 for all uses (Thorn and others, 1993), has substantially reduced the amount of ground-water discharge that occurs through evapotranspiration.

METHODS

Data Used in the Investigation

The data used in this investigation include both new data collected specifically for this USGS MRGB study and historical ground- and surface-water data from the USGS NWIS database and the City of Albuquerque. Details about site characteristics, sample collection, and sample analysis for each data source are discussed below.

New Middle Rio Grande Basin Study Data

Site Characteristics

For the MRGB study, more than 300 sets of samples were collected at 288 ground-water sites (wells and springs) across the basin (fig. 11, and appendix A) between June 1996 and August 1998. Sampling sites were selected primarily on the basis of location in an attempt to attain the best possible areal coverage of the basin. Efforts also were made to locate wells with discrete sampling intervals (in other words, short screened intervals) and groups of wells that allowed samples to be obtained from a variety of depths within the aquifer system at a given location. However, in most areas of the basin except in the vicinity of Albuquerque, so few wells were available for sampling that well construction was not a primary consideration. About 100 of the wells are located in or near Albuquerque.

Ground-water sampling sites consisted of 280 wells and 8 springs (table A1). Of the wells that were sampled, 116 were classified as monitoring wells (wells from which water is not obtained for any purpose other than monitoring of water level and ground-water quality), 82 were classified as production wells (wells used to supply water to more than 3 households or to industrial operations), 34 were classified as domestic wells (wells used to supply water to fewer than 3 households), 45 were classified as windmills (wells having a piston mechanism to lift water, which is used primarily to water livestock), and 3 were classified as stock wells (wells with submersible pumps, where water is used primarily for livestock). Well depths ranged from about 23 to 2,020 feet, with a median of about 500 feet. Screen lengths ranged from 5 to 1,270 feet, with a median of 20 feet. Casing material was steel in at least 167 wells and polyvinylchloride (PVC) in at least 108 wells; the material was not noted for 5 wells. Construction information for each category of well type is summarized in table 2, which shows that production wells typically were deepest but also had the longest screened intervals, whereas monitoring wells typically provided the most discrete sampling intervals.

All data from each ground-water source (wells and springs) are listed in appendix A. A unique 3-digit site number preceeded by “S” (designated “Syyy”) was assigned to each ground-water site. Each water sample was assigned a unique 3-digit sample number preceeded by “NM” (designated “NMxxx”). In some cases, multiple samples were collected at a particular site.

Based on the chemical and isotopic data of this investigation, source areas of recharge were identified and each water sample in appendix A was assigned to a primary hydrochemical zone, indicating the primary source area for recharge; in some cases, samples were identified as containing water from a secondary hydrochemical zone. Thirteen hydrochemical zones were recognized and numbered 1-13. The basis and definition of the various hydrochemical zones is discussed in the section “Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water Sources”. Data from some of the ground-water sites sampled for the MRGB study have not been included in the main body of data used for most analysis. These data are marked in the tables of appendix A with an “E” (for “exotic”) as the primary hydrochemical zone. Data for 14 sites (S009, S023, S038, S057, S063, S067, S070, S202, S249-251, S256, S258, and S273) were removed from the main data set because the sites fell outside the boundaries of the MRGB and may have produced water from an aquifer system other than that of the Santa Fe Group. Data for a few other selected sites were removed from the main data set because they were determined not to be representative of regional water quality. Examples are data from wells that were believed to produce water from a perched system not in hydraulic connection with the Santa Fe Group aquifer system (S094), wells that were believed to have been substantially affected by local contamination and/or evapotranspiration (S099, S129, S182, S225, and S282), wells that were believed to produce water associated primarily with geothermal systems (S028, S054, S112, and S211), and wells that

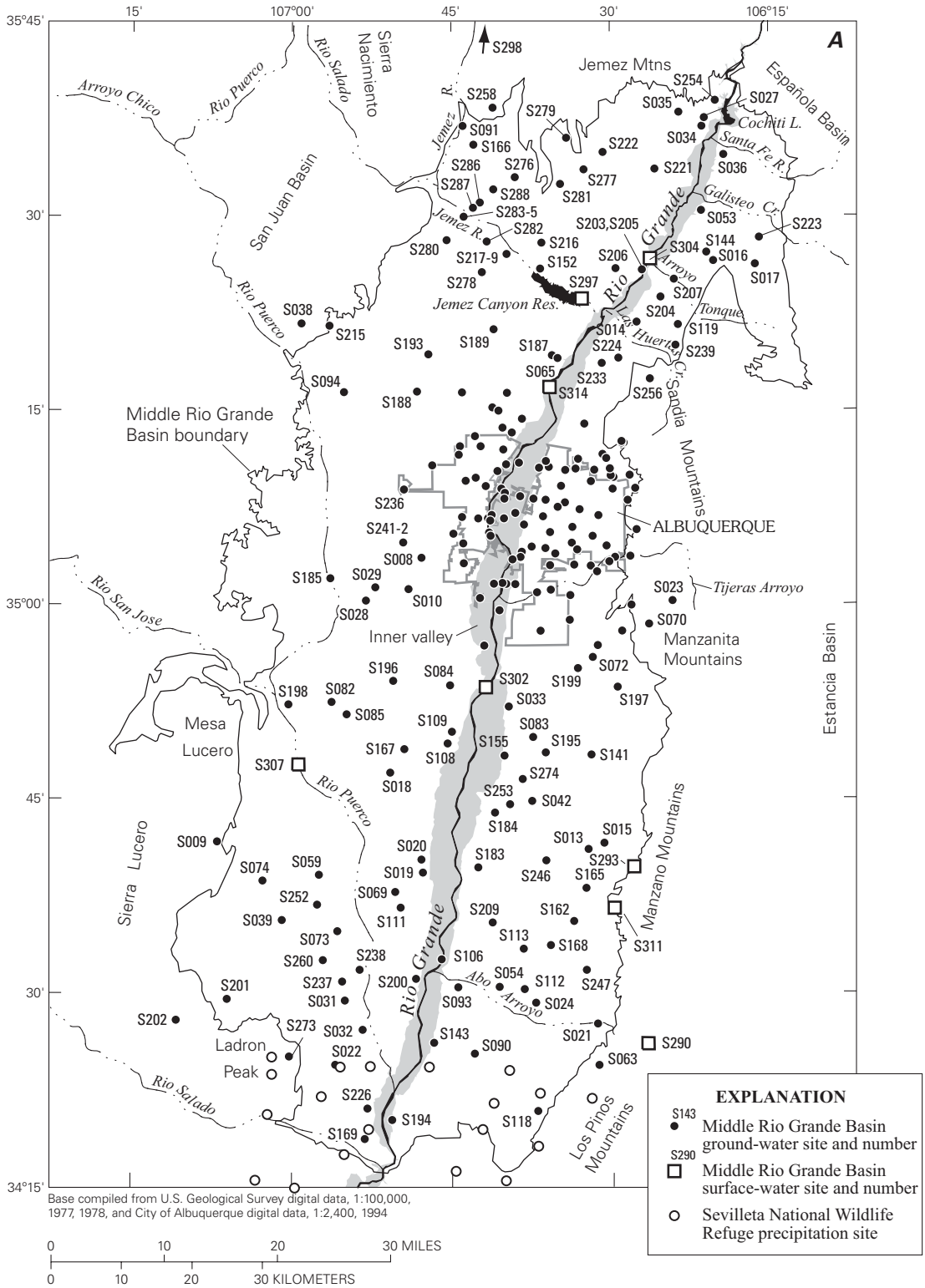


Figure 11a. Locations of ground-water and surface-water samples collected for the Middle Rio Grande Basin study outside the Albuquerque area, and locations of precipitation sites on Sevilleta National Wildlife Refuge (Moore, 1999).

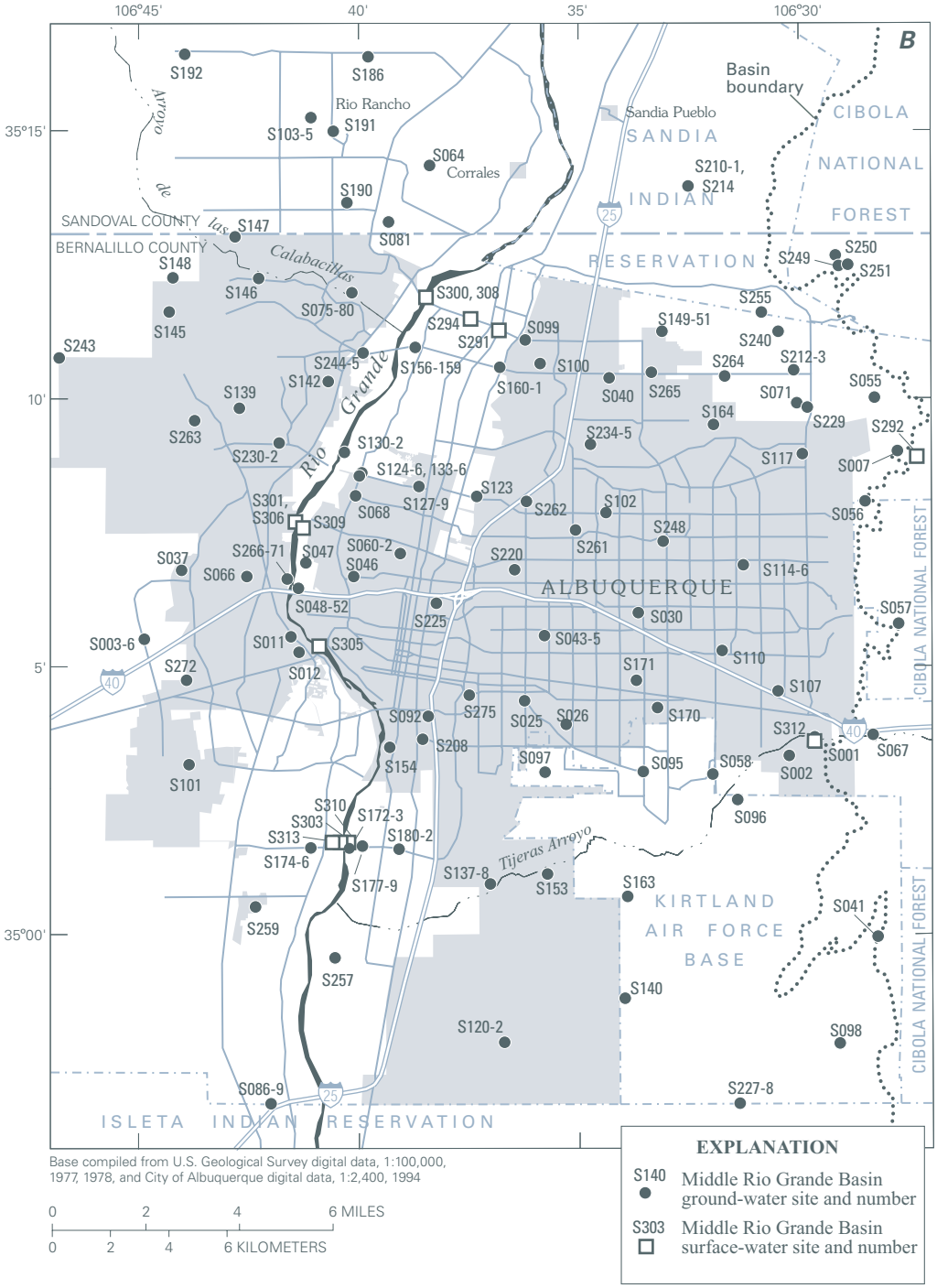


Figure 11b. Locations of ground-water and surface-water samples collected for the Middle Rio Grande Basin study inside the Albuquerque area.

Table 2. Statistical summary of well-construction information by well type, Middle Rio Grande Basin, New Mexico

[Length of sample interval is in feet; all other data are in feet below land surface; nd, not determined]

Parameter	Number of wells	Minimum value	Median value	Maximum value
Domestic wells				
Depth of well	34	55	379	985
Depth to top of sample interval	27	120	390	965
Depth to bottom of sample interval	27	130	400	980
Length of sample interval	27		20	40
Depth to water	32	8	252	530
Monitoring wells				
Depth of well	116	23	394	1,805
Depth to top of sample interval	115	10	349	1,634
Depth to bottom of sample interval	115	20	415	1,795
Length of sample interval	115	5	10	270
Depth to water	115	6	98	887
Production wells				
Depth of well	81	81	1,000	2,020
Depth to top of sample interval	79	19	425	1,355
Depth to bottom of sample interval	79	81	950	2,000
Length of sample interval	79	18	400	1,270
Depth to water	81	4	269	1,101
Stock wells				
Depth of well	3	120	192	460
Depth to top of sample interval		nd	nd	nd
Depth to bottom of sample interval		nd	nd	nd
Length of sample interval		nd	nd	nd
Depth to water	2	107	139	171
Windmills				
Depth of well	44	42	291	1,109
Depth to top of sample interval	7	125	269	715
Depth to bottom of sample interval	7	135	279	725
Length of sample interval	7	5	10	40
Depth to water	33	13	207	991

were believed to have been affected only locally and at relatively shallow depths by surface-water bodies (S091 and S152). Some of these data are nevertheless discussed in certain sections of this report; the *exotic* waters discussed in such sections are explicitly identified.

Each ground-water site, the site number, site name, location, altitude, depth, water level, and other well construction information is listed in table A1. Also listed are the primary and secondary hydrochemical zone numbers, assigned as a part of this investigation.

All the chemical and isotopic data for ground-water samples collected as a part of this study are listed in tables A2-A12. The site number, sample number, site name, date of collection, and primary and secondary hydrochemical zone is listed for each sample (except for those in table A10 that contain isotopic data specific for City of Albuquerque production wells that were sampled only for ^{2}H and ^{18}O isotopic composition). The water-quality parameters measured in the field (temperature, dissolved oxygen, pH, and specific conductance), and the major-element chemical composition (Ca, Mg, Na, K, Cl, Br, SO_4, and HCO_3) are

listed in table A2. The concentrations of selected minor constituents (Sr, SiO_2, Fe, Mn, NO_3 (as N), and F) are listed in table A3. The concentrations of selected trace elements (Al, B, Ba, Li, Zn, Pb, Cu, Rb, V, Cr, Co, Mo, As, Se, and U) for each ground-water sample are listed in table A4. Not all constituents were measured for each water sample.

The concentrations of selected dissolved gases (N_2, Ar, O_2, CO_2, and CH_4) are listed in table A5 for each ground-water sample. Additional values given in table A5 are discussed in a later section of this report and include the assigned altitude of recharge, a calculated concentration of excess N_2 from denitrification, and the recharge temperature and excess air calculated at the recharge altitude. The results of a sensitivity calculation of the recharge temperature and excess air as a function of recharge altitude, calculated with and without consideration of denitrification, are summarized in table A6.

The concentrations of the chlorofluorocarbons (CFCs), CFC-11, CFC-12, and CFC-113, in picograms of CFC compound per kilogram of water (pg/kg) are given in table A7 for each ground-water sample. The CFC concentrations are also given as the calculated atmospheric partial pressure and percentage of modern concentrations. For uniformity of results, and because the presence of most CFCs indicate anthropogenic sources rather than recharge conditions, the calculated atmospheric partial pressures and percentage of modern concentrations of CFCs in ground-water samples assume an altitude of 5,000 feet above sea level and temperature of 13.5°C. For some water samples containing recent recharge (water recharged within the past 50 years), the atmospheric partial pressure and percent modern concentration should be re-calculated at the actual recharge altitude and temperature, if recharge date is desired (Plummer and Busenberg, 1999). Because of uncertainties in recharge conditions resulting from infiltration of water through relatively deep unsaturated zones and/or contamination from anthropogenic sources, ground-water age based on CFCs was not evaluated as a part of this report. Instead, the CFC data were used to recognize water samples that contained at least a fraction of post-1940's water.

The concentrations of dissolved sulfur hexafluoride and dissolved helium gas determined by gas chromatography at the U.S. Geological Survey Dissolved Gas Laboratory, Reston, Virginia, and by mass spectrometric methods at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York, respectively, are summarized in table A8.

The values of the stable H and O isotopic compositions of water, δ^2H and $\delta^{18}O$, and stable S isotopic composition of dissolved SO_4, $\delta^{34}S$, are given for each ground-water sample in table A9. The stable isotopic composition of water from City of Albuquerque production wells analyzed by the U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia are given in table A10. Water samples from City of Albuquerque wells collected as a part of this study (1996-97), archived samples collected by C. Yapp from the early 1980's and re-analyzed by the USGS as a part of this study, and additional water samples collected by City of Albuquerque personnel from all City of Albuquerque production wells that were in operation during July-August 1997 are included in the table. Values of δ^2H reported by Yapp (1985) and values of δ^2H and $\delta^{18}O$ reported by Lambert and Balsley (1997) are included for comparison.

The tritium concentration and uncertainty in the tritium measurement, the CFC-12 concentration, the stable carbon isotopic composition of DIC, $\delta^{13}C$, the measured ^{14}C activity and standard deviation of the measurement, and the unadjusted radiocarbon age in years are given for each ground-water sample in table A11. The inclusion of CFC-12 and tritium concentration is redundant with other tables but useful in recognizing water samples that may contain fractions of post-nuclear detonation (post-bomb) ^{14}C activities.

Data collected for the determination of the $^3H/^3He$ age of water are summarized in table A12. The data were measured at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Palisades, New York. Values of tritium concentration, δ^3He, $^3He/^4He$ isotope ratio, the dissolved He and Ne concentration, the calculated values of Δ^4He and ΔNe in percent of solubility equilibrium, the uncorrected $^3H/^3He$ age (uncorrected for terrigenic helium sources) and the corrected $^3H/^3He$ age (corrected for presence of terrigenic helium assuming an $^3He/^4He$ ratio of $2x10^{-8}$ for terrigenic helium), and associated uncertainties are summarized in table A12. Although the tritium and helium data are referred to in this report, the $^3H/^3He$ ages are not, because the emphasis of the present study concerns

ground-water recharge and flow on the 10 ka timescale; however, the $^3H/^3He$ ages are included for completion of the data collected as a part of this study.

Surface-water samples also were collected for the MRGB study at multiple sites. Between January 1997 and April 1999, samples were collected as frequently as monthly at up to 14 surface-water sites on the Rio Grande and associated drains and irrigation canals, the Jemez River, the Rio Puerco, Tijeras Arroyo, and Bear Canyon Arroyo (fig. 11, and appendix B). The site number, site name, latitude, longitude, and altitude of each surface-water site sampled are given in table B1. The site number, sample number, site name, and date of collection are given for each sample in tables B2-B6, and B9. The barometric pressure, water temperature, pH, dissolved oxygen concentration, specific conductance, and the major-element concentrations of Ca, Mg, Na, K, Cl, Br, SO_4, and HCO_3 are given for each water sample in table B2. The minor-element chemistry including Sr, SiO_2, Fe, Mn, NO_3 (as N), and F for each surface-water sample are listed in table B3. The trace element concentrations of Al, B, Ba, Li, Zn, Pb, Cu, Rb, V, Cu, Co, Mo, As, Se, U, Ag, and Cd in surface-water samples are given in table B4. The water temperature and altitude of the sample site, and concentrations of CFC-11, CFC-12, and CFC-113 in picomoles per kilogram (pM/kg) and in pg/kg are given in table B5. The CFC concentrations are also given in table B5 as the partial pressure in parts per trillion by volume, pptv, calculated at the water temperature and site altitude, and as percent saturation with respect to solubility equilibrium with air, assuming average air mixing ratios of 270, 543, and 84 pptv for CFC-11, CFC-12, and CFC-113, respectively, during the period of sampling.

Values of stable O and H isotopic composition of water, δ^2H and $\delta^{18}O$, stable S isotopic composition of dissolved SO_4, $\delta^{34}S$, stable C isotopic composition of DIC, $\delta^{13}C$, and radioactive carbon isotopic composition of DIC, ^{14}C activity, in surface water samples are given in table B6. Values of the stable H and O isotopic composition of precipitation that was collected and archived in the 1980's and analyzed by the U.S. Geological Survey Stable Isotope Laboratory as a part of this investigation are summarized in table B7. Values of the stable H and O isotopic composition of Rio Grande water and other surface-water sources in samples that were collected and archived in the 1980's and analyzed by the U.S. Geological Survey Stable Isotope Laboratory as a part of this investigation are given in table B8. Measurements of tritium concentration and associated error measured in surface-water samples collected as a part of this investigation, June 1996 through February 1998, are summarized in table B9. Not all constituents were measured at all sites and all sampling times.

Additional data collected as a part of this study are tabulated in appendix C. Chlorofluorocarbon and sulfur hexafluoride concentrations measured in air samples and shallow unsaturated-zone air collected in the vicinity of the MRGB are given in table C1. Values of $\delta^{13}C$ and ^{14}C activity measured on limestone and caliche fragments from the MRGB are given in table C2. Values of $\delta^{13}C$ measured on plants sampled along the Sandia and Manzano Mountain front are given in table C3. Values of saturation indices calculated for selected minerals for each hydrochemical zone are given in table C4. Quality-control and quality-assurance data that are discussed in the next section of this report are given in appendix D, and additional water-quality data selected from the USGS NWIS and City of Albuquerque data sets are listed in appendices E and F.

Sample Collection, Analysis, and Reporting Units for Water Samples

Field Procedures

Ground-water samples were collected between June 1996 and August 1998 from a variety of sources, including municipal production wells, domestic wells with permanently installed submersible pumps, monitoring wells, and springs. Surface-water samples were collected between June 1996 and April 1999. At most ground-water sites, a closed path was established between the source and sampling equipment to prevent contact of the sample with air. However, in a few cases, such as for some windmills, it was not possible to construct a closed path from the source to the sample container. For these samples, parameters that could be altered by gas-exchange with the atmosphere (including CFCs, N_2-Ar, $^3H/^3He$) were not collected. Parameters measured at all ground-water and surface-water sites included water temperature (^oC), specific conductance (µS/cm at 25^oC), dissolved oxygen (mg/L), and pH (units). A commercial pH probe was calibrated using standard buffers of pH 4.0, 7.0, and 10.0 in the field prior to taking the first sample of the day. A commercial dissolved oxygen probe was

calibrated at each site with water-saturated air, with correction for the local barometric pressure. A specific conductance probe was calibrated approximately weekly using standard KCl solutions of specific conductivity in the ranges of 100 and 1000 µS/cm at 25°C, obtained from the U.S. Geological Survey Laboratory, Ocala, Florida, after calibration against National Institute of Standards and Technology (NIST) standards. The field parameters were measured within a flow-through cell connected to the discharge line from the well. Accuracy of the field measurements were typically ±0.1 units for pH, ± 0.1 mg/L for dissolved oxygen, ± 0.2°C for water temperature, and ± 2 percent of the reported value for specific conductance. There are a few exceptions to these general values for accuracy of field parameters. Water temperature is generally not reliable for samples from monitoring wells that are more than 120 feet below land surface because pumping rates were too low (approximately 0.8 gallons per minute) to prevent temperature changes within the sample tubing during purging. Some of the samples from windmills were also affected, because of low discharge rates on calm days. However, most windmills located on pueblos were sampled using a mechanical device connected to the lift pipe to drive the pump and produce steady discharge from the well. In other cases, windmills were operating for unknown periods, depending on the prevailing wind conditions, but were likely adequately purged prior to sampling.

Wells were normally purged of at least three casing volumes before sampling, except for some of the deepest completions of monitoring wells that were purged of at least one casing volume. Stability in field parameters including water temperature, specific conductance, pH, and dissolved oxygen provided additional guidelines in determining when to sample wells. Samples were collected in appropriate containers and preserved in accordance with the procedures specified in U.S. Geological Survey (1998). Samples for cations were filtered through 0.45-micron filters and collected in acid-rinsed 250-mL polyethylene bottles (denoted the FA, filtered and acidified, sample). A cartridge filter attached to the tubing was purged of air. The containers were rinsed three times with the filtered water before filling. The FA bottles were then acidified with ultra pure nitric acid (lot number NA 5318-1GS1, http://wwwnwql.cr.usgs.gov/USGS/certificates/na5318.0196.html). Exactly the same procedure was used for the field blanks, except inorganic blank water was used in this case (Ocala lot number 95171-22 bottle 222, http://owqrl.er.usgs.gov/certificates/ibw/ibw_22.shtml). The samples for anions were filtered through 0.45-micron filters and collected in 500-mL polyethylene bottles, after rinsing the bottle 2-3 times with the sample (denoted the FU, filtered, unacidified sample). Titration alkalinity usually was determined within 2-3 days of collection at a local field laboratory from an approximately 35-mL aliquot taken from the FU sample. The bottles, filters, and acid were obtained from the U.S. Geological Survey's National Water-Quality Laboratory. Collection procedures for other chemical and isotopic substances are listed separately below.

Ground Water

Details of the various ground-water sources, including total depth, depth to water, length of the open interval, well type, casing material, and type of pump used to sample are given in table A1. For all in-service wells, the permanently installed pumps were used and samples were taken before any form of treatment, such as chlorination, and before water entered a pressure tank, such as in use with domestic wells. Most municipal production wells in the vicinity of Albuquerque were sampled in the early morning, near the end of each nightly production run. Typically, the municipal production wells had been in continuous operation for periods of 8 hours or more prior to sampling. Domestic wells were pumped continuously during sampling by opening sufficient outlets to keep the pump in continuous operation.

Various pump types were used to sample monitoring wells, depending mainly on depth to water. For relatively shallow wells, where depth to water was less than approximately 200 feet, a portable electric pump with steel impellor, capable of discharging up to about 8 gallons per minute (gpm) (denoted Grundfos (model Rediflow 2) in table A1), was used to purge the well of at least three casing volumes. The Grundfos pump was fitted with 250 feet of discharge line. Sampling was then performed using a stainless-steel piston-type pump driven by compressed nitrogen (denoted Bennett in table A1) that discharged water at about 1 gpm. The Bennett pump (Bennett pump model 1400) was placed just above the open interval of the well, if the depth to the open interval was less than 200 feet below land surface. The pump discharge was split

at the pump between a ¼-inch Nylon line and ¼-inch copper line. In other cases, discharge from the Grundfos pump was split at the pump and sampled through a Nylon line (denoted Grundfos in table A1).

For monitoring wells outside the inner valley of the Rio Grande, depth to water was as much as 800 feet or more. For all monitoring wells with depth to water greater than approximately 200 feet, a higher capacity stainless-steel piston-type pump was used (also denoted as Bennett on table A1), and was driven by compressed air. The high capacity Bennett pump (Bennett Sample Pumps model 1800) was attached to a power reel mounted on a trailer. A stainless steel "Y" connector was fabricated to split the discharge from the pump to two separate lines that carried water to the surface. One discharge line was ½-inch polypropolene used for purging and supply to a flow-through cell where pH, dissolved oxygen, specific conductance and water temperature were measured. The other line was ¼-inch Nylon, which was split at the land surface to a second ¼-inch Nylon line, both of which were used to collect all the water samples, including the chlorofluorocarbon, tritium/helium-3, and sulfur hexafluoride samples. A clamp was used to restrict flow on the ½-inch line during sampling from the ¼-inch lines. The two discharge lines were bundled with two air lines; one from the compressor to drive the piston pump and the other to exhaust the air to the land surface. All four lines were wound on the power reel. An oil-lubricated electric compressor that produced compressed air (165 psi) and a generator were also mounted on the trailer and used to drive the pump and power reel. The compressed air was cleaned using an in-line filter and dried in a cold trap prior to entering the pump. Where depth to water was less than 800 feet, the high capacity piston pump was placed typically 50-75 feet below the water table and the well was purged of at least three casing volumes. The pump was then lowered to a point just above the open interval or to the maximum length of discharge line on the reel (800 feet) for sampling. Discharge rate was typically about 1.2 gpm and, in some cases, well purging required more than 10 hours to complete. Because of the long discharge line and depth of the unsaturated zone, water temperatures measured at the land surface from deep monitoring wells were usually not representative of *in-situ* temperatures. For some of the monitoring wells, depth to the open interval exceeded 1,500 feet below the land surface, and for these, the open interval of the well could not be reached by the high-capacity piston pump. In these cases, the pump was left at approximately 800 feet below land surface, but because of the considerable depth to the water table, the pump was, in cases of thick unsaturated zones, typically set at relatively shallow depths below the water table for sampling.

At the monitoring wells SWAB 1 and SWAB 2, the water table was more than 800 feet below the land surface and could not be reached by the Bennett pump. For these, water samples were obtained using a swabbing technique. A power winch was used to lower a swab device down the well casing. The device allowed water to pass through as it was lowered below the water table, but allowed water to be lifted on the upstroke. The device was capable of lifting 15-20 gallons of water to the land surface with each cycle. The wells were purged sufficiently to discharge fresh water from the aquifer system, but the total volume of water removed did not exceed two casing volumes.

Springs were sampled either with a Bennett pump or peristaltic pump. The Bennett pump was placed in the opening of the spring where maximum discharge occurred. In springs with low flow, such as some seeps, a drive point with a screened opening was placed in the spring (seep) and pumped with a peristaltic pump.

Surface Water

Surface-water samples were simple grab samples taken from the main flow within the stream channel. An open container was rinsed at least two times with surface water, and returned to shore where about 500 mL of native water was pumped with a peristaltic pump to rinse the tubing. The peristaltic pump was used to filter the sample water through 0.45-micron cartridge filters for FA and FU samples. Surface-water samples typically were collected for major and minor-element chemistry, stable isotopes of water, tritium, and chlorofluorocarbons. In addition, the field parameters of pH, dissolved oxygen, specific conductance, and temperature were measured.

Inorganic Chemistry

Filtered unacidified water samples collected in 500-mL polypropolene bottles were returned to the local USGS field laboratory where titration alkalinity was determined, usually within 2-3 days after collection. The procedure consisted of titrating water

samples of about 30 grams, weighed to the nearest 0.0001 g, with standardized HCl. The HCl was standardized with NIST Standard Reference Material 192a sodium carbonate. The Na_2CO_3 was heated at 285°C for one hour and then cooled to room temperature in a desiccator. Portions of between 4 and 10 mg of the reference Na_2CO_3 were weighed to the nearest microgram and titrated with HCl. Duplicate analyses agreed to better than 1 percent. The titrations were performed with a Radiometer Research Meter Model PHM84 and a Radiometer Autoburette Model ABU80 in derivative mode. Four liters of acid were prepared with concentrations of 0.03976 ± 0.00006N in 1996, 0.02996 ± 0.00007N in 1997, and 0.02948 ± 0.00006N in 1998.

Major cations and silica were analyzed from the acidified samples at the U.S. Geological Survey's Common-Use Laboratory in Reston, Virginia using the ARL SpectraSpan V, a multi-element direct-current plasma spectrometer (DCP). The instrument is equipped with the Interface Design Adam analytical manager and background corrector.

Trace elements were measured in the acidified samples with a Perkin Elmer Elan 6000 inductively coupled plasma instrument with a mass spectrometer detector (ICP-MS), using procedures described in U.S. Environmental Protection Agency (USEPA) method 200.8 (U.S. Environmental Protection Agency, 1994). The quadropole mass separator has a high degree of specificity, there are few molecular interferences, and isotopic overlaps are predictable and correctable by evaluating other isotopes of the same element or of the interfering element. The background mass-spectral features of the argon plasma are characterized by Tan and Horlick (1986). All isotopic corrections were performed by the software package of the ICP-MS. Oxide interference corrections were made separately. The analytical procedures are described by Faires (1992).

A Dionex series 4000i ion chromatograph equipped with a Dionex AS14 column was used for the analysis of F, Cl, NO_3, and SO_4. Bromide was measured with a Dionex DX-120 ion chromatograph. The eluant solution concentration was 3.5 mmol/L sodium carbonate with 1 mmol/L sodium bicarbonate. Standards were prepared using VHG Laboratory multi-ion standard solution #1 (ICM1-100) and solution #4 (ICM4-100), and Dionex standard multi-element solutions.

Isotopes

Sulfur-34

The stable S isotopic composition of dissolved SO_4, $\delta^{34}S$, was determined for SO_4 in approximately 170 water samples (28 surface-water samples and 142 ground-water samples). The isotopic abundance of sulfur-34 is expressed in per mil deviation from the sulfur isotopic composition of the Vienna Canyon Diablo Troilite (VCDT; Krouse and Coplen, 1997; Coplen and Krouse, 1998), where $\delta^{34}S$ relative to VCDT is

$$\delta^{34}S = \left(\frac{\left(\frac{^{34}S}{^{32}S}\right)_{Sample}}{\left(\frac{^{34}S}{^{32}S}\right)_{VCDT}} - 1 \right) 1000 . \qquad (1)$$

Barium sulfate was precipitated in the laboratory from the FU water sample, using methodology described in Carmody and others (1998). The $BaSO_4$ was filtered, dried, and homogenized, converted to SO_2 in a Carlo Erba Elemental Analyzer 2500, and analyzed in a Finnigen Delta Plus Continuous Flow Isotope Ratio Mass Spectrometer system at the U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia. The analytical method was based on that of Giesemann and others (1994). The $\delta^{34}S$ values were normalized on scales such that the $\delta^{34}S$ values of the standards IAEA-SO-6 $BaSO_4$ and NBS 127 $BaSO_4$ were -32.85 and 20.91 per mil, respectively. The average 1-σ precision of $\delta^{34}S$ values is ± 0.2 per mil.

Oxygen-18 and Hydrogen-2

The U.S. Geological Survey Stable Isotope Laboratory in Reston, Virginia analyzed a total of 907 water samples from the MRGB for the stable isotope ratios of oxygen ($^{18}O/^{16}O$) and hydrogen ($^{2}H/^{1}H$). The samples are as follows:

- 341 ground-water samples from the 288 ground-water sites sampled throughout the MRGB between June 1996 and August 1998 (as discussed above), including approximately 150 samples from wells in the vicinity of Albuquerque.

- 267 water samples from the Rio Grande and associated drains and laterals, Bear Canyon Arroyo, and Tijeras Arroyo collected approximately monthly from January 1997 through April 1999, and variously from the Rio Grande, Abo Arroyo, the Rio Puerco, the Jemez River, and Embudo and Embudito Springs during the period June 1996 through April 1999 (as discussed above).
- 91 water samples from all active City of Albuquerque production wells from July through August 1997.
- 17 archived samples of precipitation from Albuquerque, collected by Robert Hejl (formerly with the USGS, Albuquerque) between May 1987 and July 1988.
- 191 archived water samples collected in the early 1980's by Crayton Yapp, (formerly with the University of New Mexico, Albuquerque) from various sources in the vicinity of Albuquerque, including multiple samples from City of Albuquerque production wells, local precipitation, the Rio Grande, and Embudo Spring in Embudo Canyon along the west side of the Sandia Mountain front near Albuquerque.

All water samples collected during and subsequent to June 1996 for determination of stable isotopic composition were collected in 60-mL glass bottles with polycone-seal liner caps and untreated. Many of the original water samples collected by Crayton Yapp in the early 1980's had been retained in their original glass bottles and were re-analyzed for stable isotope composition as a part of this study. The water samples of Crayton Yapp, in their original 250-mL glass bottles, were archived at Sandia National Laboratories (SNL) and made available to the USGS. Labels on the bottles identified the water source, sample date, and a "raw water sample, RSW" sample number. The RSW numbers on the bottles were largely consecutive to 301, but only 193 samples remained in archive at SNL. From these bottles, aliquots were poured off into 60-mL glass bottles with polycone-seal caps, labeled, and returned to SNL. After providing the sample to be returned to SNL, two samples of precipitation were of insufficient volume to be analyzed by the USGS. The remaining 191 water samples were analyzed by the U.S. Geological Survey Stable Isotope Laboratory in Reston, Virginia. Forty of the 45 samples with δ^2H values tabulated in Yapp (1985) remain and were re-analyzed at the USGS laboratory (table A10).

The stable isotopes of oxygen and hydrogen (expressed as $\delta^{18}O$ and δ^2H) determined on water samples at the USGS Stable Isotope Laboratory, Reston, Virginia are expressed as the per mil (parts per thousand) deviation from the Vienna SMOW (VSMOW, Vienna Standard Mean Ocean Water; Coplen, 1996) standard as

$$\delta^{18}O = \left(\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{VSMOW}} - 1 \right) 1000 , \qquad (2)$$

and

$$\delta^{2}H = \left(\frac{\left(\frac{^{2}H}{^{1}H}\right)_{sample}}{\left(\frac{^{2}H}{^{1}H}\right)_{VSMOW}} - 1 \right) 1000 . \qquad (3)$$

The $\delta^{18}O$ and δ^2H values were normalized (Coplen, 1988) on scales such that the $\delta^{18}O$ and δ^2H values of SLAP (Standard Light Antarctic Precipitation) are -55.5 and -428 per mil, respectively. The one standard deviation (1-σ) accuracy of O- and H-isotope results were 0.1 and 0.8 per mil, respectively.

Tritium

Tritium values for ground-water samples are given in tables A11 and A12, and for surface-water samples in table B9. Tritium was determined in water from 180 ground-water sites (200 samples) and 20 surface-water sites (117 samples). Each tritium sample was collected in a 500-mL glass bottle with a polycone seal cap. A head space of approximately 2-3 mL was left in the bottles during filling to accommodate expansion on warming. Tritium activity is reported in tritium units (TU) where 1 TU is defined as 1 atom of ^3H in 10^{18} atoms of ^1H. Two laboratory procedures were used to determine tritium activity. Water samples sent to the U.S. Geological Survey Low-Level Tritium Laboratory in Menlo Park, California (all surface-water samples and a subset of the ground-water samples)

were enriched electrolytically and analyzed by liquid scintillation counting, following procedures described in Thatcher and others (1977). The 1-σ analytical precision of these values was typically ± 0.3-0.6 TU.

For all of the ground-water samples in which tritium/helium-3 dating was attempted, tritium was determined by the helium in-growth method (Clarke and others, 1976; Bayer and others, 1989) at the Noble Gas Laboratory at Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York. The 1-σ analytical precision of these values is typically ± 0.1-0.3 TU. In 18 ground-water samples, tritium was determined by both laboratories. The average difference was -0.32 TU (LDEO-USGS), which is within the reported precision of the measurements. However, the standard deviation of the differences was 3.7 TU, indicating some errors higher than the reported precision of the measurements. Although the helium in-growth method usually is more precise than the electrolytic enrichment/liquid scintillation counting method, analytical problems at the LDEO laboratory may have affected some of the reported tritium values, especially in the samples from 1996. The 18 co-measured samples are compared in figure 12. Two of the LDEO samples have a significant low bias relative to the USGS values and one of these is significantly negative, indicating analytical error. Three other LDEO values have a significant positive bias relative to the USGS values. The remaining 13 co-measured samples are in agreement within the reported analytical precision (fig. 12). In the 18 co-measured samples, the USGS tritium measurement was selected over the LDEO value, even if the two differed by less than 0.3 TU. Overall, the LDEO tritium data set was accepted, however, because of its consistency with the CFC-12 data. In comparing tritium and CFC-12 concentrations, two populations of samples are present in the complete MRGB ground-water data set. One group of samples has low tritium (<1.0 TU) and variable CFC-12 (group B on fig. 13). These are apparently old (pre-bomb)

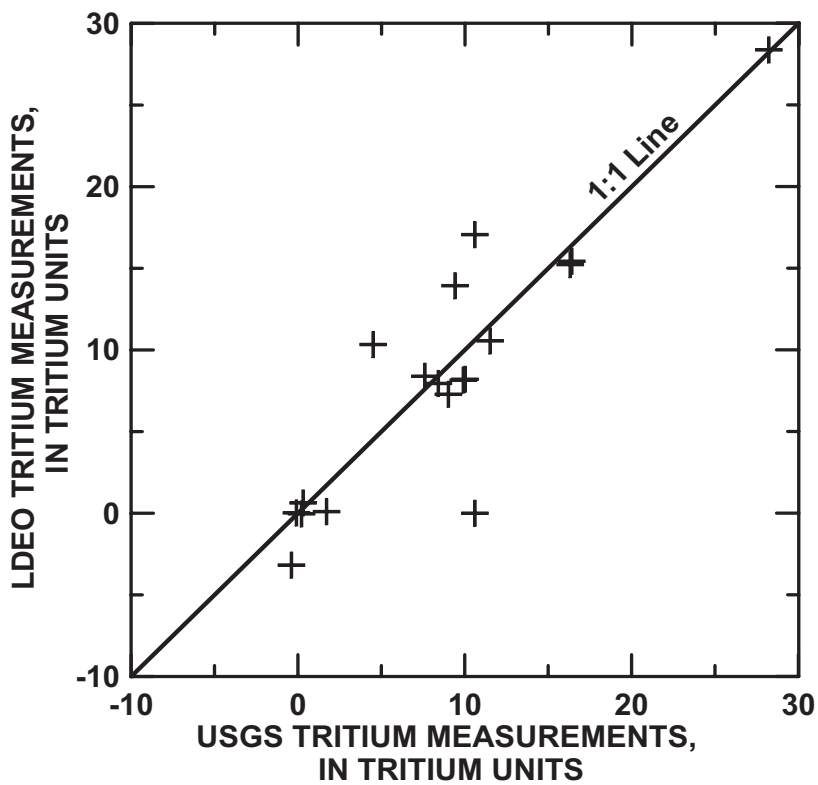


Figure 12. Comparison of tritium measurements from the Noble Gas Laboratory of Lamont-Doherty Earth Observatory (LDEO) and from the U.S. Geological Survey (USGS) Low-Level Tritium Laboratory.

waters that are mixed with a very low fraction of young and/or CFC-12 contaminated water. The second group of samples represents water that has infiltrated since the late 1950's (group A on fig. 13), and has tritium concentrations greater than about 4 TU and variable CFC-12 concentrations. Both the USGS and the LDEO sample sets demonstrate these patterns when compared to CFC-12 concentrations (fig. 13). Therefore, there is no basis for rejection of one data set over the other.

Carbon-14 and Carbon-13

Water samples for the determination of $\delta^{13}C$ and ^{14}C activity of dissolved inorganic carbon (DIC) were filtered in the field (0.45-micron filter) and collected in two ways: (1) the DIC was precipitated in the field as $BaCO_3$ (in duplicate) in 500-mL safety-coated glass bottles with polycone-seal cap, without headspace, using an excess of CO_2-free $Ba(OH)_2$ solution (pH>11) and returned to the laboratory for further processing, and (2) a 250-ml water sample was collected without headspace in safety-coated glass bottles with septum caps (in duplicate).

In the laboratory, following procedure (1), the $BaCO_3$-$BaSO_4$ precipitate from the first collection procedure was washed and filtered under nitrogen with CO_2-free deionized water. The precipitate was dried in air and homogenized by passage through a 60-mesh sieve, and stored in a capped glass bottle. Each sample was considered to be a mixture of $BaCO_3$ and $BaSO_4$. The DIC content was estimated from the titration alkalinity assuming 90-percent recovery of the precipitate. The dry homogenized powders and estimates of the weight of each sample needed to produce 5 mg of carbon were submitted to a contract

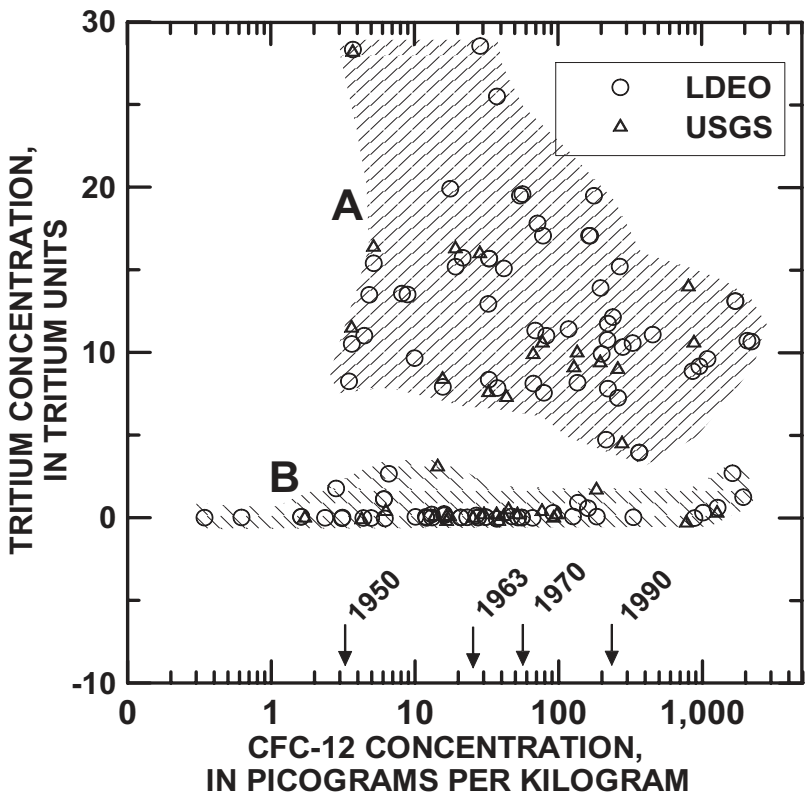


Figure 13. Tritium concentration in ground water as a function of CFC-12 concentration. Both tracers occur in post-1950's water. Apparent ages based on CFC-12 concentration are shown for recharge at 13.6 °C and altitude of 5,000 feet. The highest tritium concentrations are associated with the mid-1960's atmospheric testing of nuclear bombs. Data are from the Noble Gas Laboratory of Lamont-Doherty Earth Observatory (LDEO), Palisades, New York, and the U.S. Geological Survey (USGS) Low-Level Tritium Laboratory, Menlo Park, California. Two groups of waters are recognized: (A) those that contain both CFC-12 and tritium are probably post-1950's infiltration waters, and (B) those with low tritium content but significant CFC-12 concentrations are probably mixtures of old water and small fractions of CFC-12 contaminated water.

laboratory (Environmental Isotope Laboratory, University of Waterloo, Waterloo, Ontario, Canada) for preparation of CO_2 gas and determination of $\delta^{13}C$. The CO_2 was produced by acidification in an extraction line. Water was removed in a cold trap and the dry, homogeneous CO_2 gas was flame-sealed into three separate Pyrex glass tubes (breakseals). The breakseals were labeled and one sample was used by the contract laboratory to determine $\delta^{13}C$, one was sent under sub-contract to an Accelerator Mass Spectrometry (AMS) facility (Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand) for graphite target preparation and ^{14}C determination, and one was retained at the contract laboratory as a backup. The $\delta^{13}C$ of DIC in the sample was determined by mass spectrometry on the Vienna Pee Dee Belemnite (VPDB) scale with a precision of typically ± 0.3 per mil or better. The AMS facility prepared the graphite sample targets and determined the ^{14}C activity of DIC in the sample. For samples collected in the summer of 1996 (NM001 - NM186), values of $\delta^{13}C$ and ^{14}C activity of DIC were determined on the $BaCO_3$ samples.

For samples collected in 1997 and 1998 (procedure (2)), values of $\delta^{13}C$ and ^{14}C activity of DIC were determined on samples in which the CO_2 was extracted from water samples collected in the glass septum bottles. Following generation of CO_2 by acidification in the extraction line, the same procedures were followed as in procedure (1).

All ^{14}C activity measurements are reported as the ^{14}C activity ratio, ^{14}a, expressed in "percent of modern carbon" (pmC) at the time of sampling, not normalized for ^{13}C fractionation and defined as

$$pmC = {}^{14}a \cdot 100 = \left(\frac{{}^{14}A_{sample}}{{}^{14}A_{reference}} \right) 100, \qquad (4)$$

where

$^{14}A_{sample}$ is the absolute (specific) ^{14}C activity of the sample (in disintegrations per minute per gram of carbon), and

$^{14}A_{reference}$ is the standard activity defined as 95 percent of the activity of National Bureau of Standards (NBS) oxalic acid (Ox 1) in the year A.D. 1950 (see, for example, Mook and van der Plicht, 1999).

Various other ^{14}C reporting units are used in the radiocarbon literature. Stuiver and Polach (1977) recommend reporting ^{14}C measurements that have been normalized for isotope fractionation effects to a common $\delta^{13}C$ value of –25 per mil. These recommendations for normalization have been adopted by most radiocarbon laboratories world-wide, providing conformity in reporting units between the various radiocarbon laboratories and continuity of results with previously reported data. However, for geochemical and hydrologic use, it is the number of atoms of ^{14}C that need to be considered, and not the normalized values (Kalin, 1999), and in some cases it is necessary to "de-normalize" the commonly reported normalized ^{14}C activity (Mook and van der Plicht, 1999). Normalized ^{14}C activities can be converted to non-normalized values by the equation (Mook and van der Plicht, 1999) as

$$\begin{aligned} {}^{14}a^{S} &= {}^{14}a_{N} \left[\left(1 + {}^{13}\delta / 1000\right) / 0.975 \right]^{2} \\ &\exp\left[-\left(t - 1950\right) / 8267 \right], \end{aligned} \qquad (5)$$

where

$^{14}a^{S}$ is the ^{14}C activity ratio of the sample at the time of sample collection,

$^{14}a_{N}$ is the commonly reported normalized ^{14}C activity ratio,

$^{13}\delta$ is the $\delta^{13}C$ of the DIC in per mil,

t is the year of sample collection or year of analysis,

8267 is $1/\lambda$, where λ is the ^{14}C decay constant;

λ is (ln 2) / (5730), where 5730 is the modern ^{14}C half-life.

The practice of normalization of ^{14}C measurements is well established in the radiocarbon community, but, unfortunately, geochemists and hydrologists sometimes fail to recognize that radiocarbon dating of dissolved inorganic carbon (DIC) in ground water is based on the actual measured ^{14}C activity rather than the commonly reported normalized ^{14}C activity that has been modified (normalized) for assumed ^{13}C isotope fractionation from an assumed initial value of -25 per mil to the measured $\delta^{13}C$ of the sample. In some cases, such as in studies of ^{14}C activity in plants, bones, and tree rings, it is convenient and scientifically justifiable to normalize ^{14}C activities to a common $\delta^{13}C$ value of -25 per mil, to correct for in-vitro fractionation processes that affect both ^{13}C and ^{14}C. However, in ground water, most of the isotopic variation in $\delta^{13}C$ of DIC is caused by water-rock interaction, in other words, by geochemical reactions in

the aquifer. For example, $\delta^{13}C$ of DIC can be more positive than -25 per mil because of isotope dilution from dissolution of carbonate rocks that are enriched in ^{13}C, and not because of in-vitro fractionation processes. When dating DIC in ground water, the actual number of ^{14}C atoms in the dissolved inorganic carbon is needed to determine the time elapsed since the DIC of the modern reservoir (that is, the soil CO_2 derived from plants and air) and its ^{14}C atoms were recharged and isolated from air. Corrections (adjustments) to the ^{14}C of DIC are normally made through geochemical calculations (see for example, Fontes and Garnier, 1979; Wigley and others, 1978; Wigley and Muller, 1981; Kalin, 1999; Mook and van der Plicht, 1999), such as can be made with the computer program NETPATH (Plummer and others, 1994).

The commonly recognized reporting units of ^{14}C data are summarized in table 3. All ^{14}C activity values used in this report are based on $\delta^{14}C$ or pmC, which have been corrected for decay since 1950 to the date of measurement (but not normalized with ^{13}C differences from –25 per mil). The value of pmC is related to $\delta^{14}C$ by

$$pmC = \left(\frac{\delta^{14}C}{1000} + 1\right)100 . \qquad (6)$$

$\delta^{14}C$ is related to $\Delta^{14}C$ by the equation (Stuiver and Robinson, 1974)

$$\delta^{14}C = \left(\frac{1 + \Delta^{14}C/1000}{0.975^2 / \left(1 + \delta^{13}C/1000\right)^2} - 1\right)1000 . \qquad (7)$$

The absolute percent Modern (pM) relative to the NBS I oxalic acid standard, normalized for ^{13}C isotope fractionation, and corrected for decay since 1950 to the date of measurement is

$$pM = \left(\frac{\Delta^{14}C}{1000} + 1\right)100 . \qquad (8)$$

The Conventional Radiocarbon Age (Stuiver and Polach, 1977), t, is expressed in years before 1950, the year on which the absolute international radiocarbon standard was based. Because pM is referenced to the year of measurement, the Conventional Radiocarbon Age is

$$t = \frac{5568}{\ln 2} \ln\left(\frac{100}{pM}\right) - \frac{y - 1950}{1.029} , \qquad (9)$$

where

5568	is the "Libby half-life" of ^{14}C,
y	is the year of measurement, and
1.029	is the ratio of $\lambda_{5730}/\lambda_{5568}$.
λ	is the decay constant equal to ln 2 divided by the ^{14}C half-life, and
5730	is the modern ^{14}C half-life.

Table 3. Terminology of ^{14}C reporting units

[‰, per mil; %, percent; 1σ, 1 standard deviation; NBS, National Bureau of Standards (now NIST, National Institute of Standards and Technology, U.S. Department of Commerce)]

Value	Unit	Uncer-tainty	Unit	Description
$\Delta^{14}C$	‰	± 1σ	‰	Per mil depletion or enrichment relative to the NBS I oxalic acid standard, normalized for ^{13}C isotopic fractionation, and corrected for decay since 1950.
$\delta^{14}C$	‰	± 1σ	‰	Per mil depletion or enrichment relative to the NBS I oxalic acid standard, corrected for decay since 1950. Not normalized for ^{13}C isotopic fractionation.
pM	%	± 1σ	%	Absolute percent Modern (pM) relative to the NBS I oxalic acid standard, normalized for ^{13}C isotopic fractionation, and corrected for decay since 1950.
pmC	%	± 1σ	%	Percent modern carbon (pmC) relative to the NBS I oxalic acid standard, corrected for decay since 1950. Not normalized for ^{13}C isotopic fractionation.
t	years	± 1σ	years	Conventional Radiocarbon Age, years before 1950.

In this study, all radiocarbon ages are reported as "unadjusted radiocarbon ages", t_{unadj}, and are analogous to the Conventional Radiocarbon Age, but based on the non-normalized ^{14}C activity, pmC, rather than the normalized, pM. Thus, the unadjusted radiocarbon age is defined

$$t_{unadj.} = \frac{5568}{\ln 2} \ln\left(\frac{A_o}{pmC}\right) - \frac{y-1950}{1.029}, \qquad (10)$$

where

A_o is the initial ^{14}C activity in pmC at time of recharge.

By convention, a value of 100 percent is normally assigned to A_o, but in application, appropriate values of A_o should be evaluated taking into account geochemical processes occurring in the recharge areas of aquifers. Geochemical corrections can lower estimates of A_o to values less than 100 percent, and in cases of extensive water-rock reaction, values of A_o as low as 10 percent have sometimes been used. As demonstrated in the section "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water", values of A_o in the MRGB appear to be near 100 percent.

Regardless of the extent of geochemical corrections to A_o, use of the Libby half-life rather than the modern ^{14}C half-life in calculation of unadjusted radiocarbon age (or Conventional Radiocarbon Age) permits use of radiocarbon calibration scales (Stuiver and others, 1998). Radiocarbon calibration scales are needed because the strength of the Earth's geomagnetic field has varied over time, and, consequently, the ^{14}C activity of atmospheric CO_2 has varied in the past, and for the most part has been greater than 100 pM (Bard and others, 1990; Bard and others, 1993; Stuiver and others, 1986; Stuiver and Reimer, 1993; Bartlein and others, 1995). By using the Libby half-life for ^{14}C and making the appropriate corrections for geochemical reactions, calendar years before present (BP), where present refers to 1950, can be interpreted using radiocarbon calibration scales (Stuiver and others, 1998). The correction of the unadjusted radiocarbon age (unadjusted for geochemical reactions) to calendar years (Stuiver and others, 1998) is small for samples with radiocarbon ages of less than 10,000 years (fig. 14). The correction increases for samples with radiocarbon ages of 10,000 to 20,000 years. For example, if the radiocarbon age (Libby half-life, adjusted for all

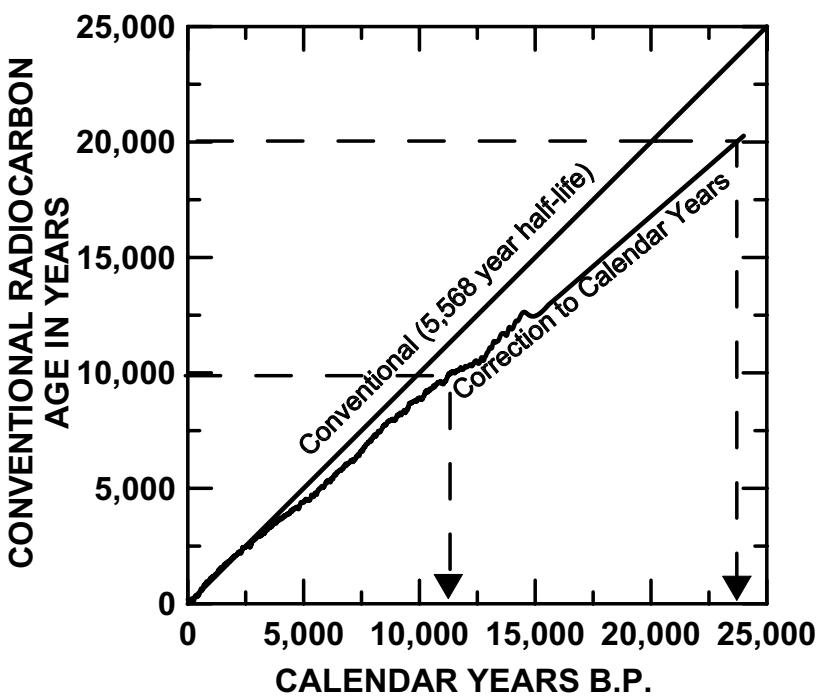


Figure 14. Calibration of Conventional Radiocarbon Age to calendar years, before present (B.P., where present is defined as the year the year 1950; Stuiver and others, 1998). The dashed lines sh two examples in which radiocarbon ages of 10,000 and 20,000 years were converted to calendar years.

geochemical reactions) is 20,000 years, the corresponding age in calendar years is nearly 24,000 years (fig. 14). Radiocarbon ages based on the Libby half-life of 5,568 years are related to radiocarbon ages based on the modern ^{14}C half-life of 5,730 years by the equation

$$t_{Libby} = 0.972\, t_{5730} \quad . \qquad (11)$$

In subsequent sections of this report, reference to radiocarbon age refers to the unadjusted radiocarbon age (Libby half-life) based on the un-normalized (measured) ^{14}C activity, without calibration to calendar years.

Dissolved Gases

Major Dissolved Gases (Nitrogen, Argon, Oxygen, Carbon Dioxide and Methane)

The water samples for determination of dissolved N_2, Ar, O_2, CO_2 and CH_4 gases were collected in 150-mL septum bottles that were filled without headspace in the field. The samples were stored on ice in the field, and in a refrigerator at 4°C in the laboratory prior to analysis. Concentrations of N_2, Ar, O_2, CO_2 and CH_4 were measured in the U.S. Geological Survey Dissolved Gas Laboratory, Reston, Virginia using gas chromatography procedures (See http://water.usgs.gov/lab/cfc/). Replicate analyses of N_2 and Ar in laboratory standards prepared by equilibrating water samples with air at 9, 16 and 24°C were typically within 1 percent and yielded calculated equilibration temperatures within ± 0.5°C (See Busenberg and others, 1998 for further details). The dissolved O_2 and CO_2 analyses have uncertainties similar to dissolved N_2 and Ar in laboratory standards, but can deviate as much as 20 percent of the reported value among replicate ground-water samples because of varying extents of microbiological processes occurring in the sample bottles.

Helium and Neon by Gas Chromatography

The water samples for determination of dissolved He and Ne by gas chromatography were collected in 150-mL septum bottles that were filled without headspace in the field. The samples were stored on ice in the field, and in a refrigerator at 4°C in the laboratory prior to analysis. After allowing the samples to come to room temperature overnight, a 10-mL headspace was created by removing some of the water through the septum with a needle connected to a vacuum pump. The water was allowed to equilibrate with this headspace overnight at room temperature before analysis. The entire headspace was injected into a gas chromatograph.

The concentrations of He and Ne were measured with a thermal conductivity detector (TCD). The procedure is given in Busenberg and others (2000) and is similar to the procedure described by Sugisaki and others (1982). The instrument was calibrated with five standards by injections of 1, 2, and 3 cubic centimeters (cm^3) of a gravimetric standard gas containing 35.0 parts per million by volume (ppmv) per volume of He. The concentration of He in this standard is known to within ± 1 percent. The two other standards used were 2.0 and 3.0 cm^3 of dry air. The concentrations of He and Ne in air are 5.24 and 18.18 ppmv per volume of gas (Committee on Extension to the Standard Atmosphere, 1976).

The precisions of the gas-chromatographic results are ± 10 and 20 percent for He and Ne, respectively. He and Ne results obtained by gas chromatography compare well with the results obtained by mass spectroscopy (Busenberg and others, 2000).

Helium, Neon, and Helium-3/Helium-4 Isotope Ratio by Mass Spectroscopy

Including replicates, and some incomplete analyses, a total of 138 samples were analyzed for the noble gases, He and Ne, and He isotopic composition, δ^3He, (table A12) in an attempt to date waters by the tritium/helium-3 method (Schlosser and others, 1988; Schlosser and others, 1989; Solomon and Sudicky, 1991; Solomon and others, 1993; Schlosser and others, 1998; Solomon and Cook, 1999). The samples were collected in 80-cm long copper tubes with pinch-off clamps. Back pressure was applied to limit the potential for gas bubble formation during collection. The samples were analyzed at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, using mass-spectrometric procedures (Ekwurzel and others, 1994; Ludin and others, 1998). Gases were extracted quantitatively (>99.9 percent) from water samples in the copper sample tubes using a vacuum extraction line and transferred into flame-sealed glass ampoules. After separation of water vapor and dissolved gases in cryogenic traps, He isotopes were measured on a VG

5400 mass spectrometer. Analyses of duplicate samples agreed within the analytical error of about ± 2 percent for the ^{4}He concentration and ± 1 percent for the ^{3}He/^{4}He ratio. Neon was measured in parallel to the He isotopes in a quadrupole mass spectrometer with a precision of ≤± 4 percent. The analytical errors assigned to the He and Ne concentrations, as well as the ^{3}He/^{4}He ratios, were based on factors affecting both the extraction procedures and the mass spectrometric measurements. The term δ^3He expresses the deviation of the ^{3}He/^{4}He ratio of the sample from that of air in percent as

$$\delta^3\mathrm{He} = \left(\frac{\left(\frac{^3He}{^4He}\right)_{sample}}{\left(\frac{^3He}{^4He}\right)_{air}} - 1 \right) 100, \qquad (12)$$

where the ^{3}He/^{4}He ratio of air is equal to 1.384×10^{-6} (Clarke and others, 1976).

Chlorofluorocarbons

Water samples for determination of chlorofluorocarbons (CFCs) were fused into borosilicate 60-mL ampoules in the field using collection procedures that exclude contact with air (Busenberg and Plummer, 1992). Concentrations of CFC-11 (trichlorofluoromethane, $CFCl_3$), CFC-12 (dichlorodifluoromethane, CF_2Cl_2), and CFC-113, (trichlorotrifluoroethane, $C_2F_3Cl_3$), were determined at the U.S. Geological Survey Chlorofluorocarbon Laboratory, Reston, Virginia using purge and trap gas chromatography with an electron-capture detector (ECD) (Busenberg and Plummer, 1992; http://water.usgs.gov/lab/cfc/). The CFC concentrations are referenced to average air compositions measured at Niwot Ridge, Colorado (Climate Monitoring and Diagnostics Laboratory (CMDL) of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (see http://www.cmdl.noaa.gov/)). The standard deviation of repeated measurements is typically less than 2 percent of the reported value for CFC-11 and CFC-12, and about 3 percent for CFC-113, but increases as concentrations approach the detection limits of about 1 pg/kg for CFC-113 and about 0.5 pg/kg for CFC-11 and CFC-12. The analytical precision is about 50 percent at the detection limit and about 3 percent above 25 pg/kg. Eight standards and a blank were used for calibration because the ECD response does not vary linearly with concentration. The calibration ranges of the gas chromatograph were 0-1,200 pg/kg for CFC-11, 0-2,500 pg/kg for CFC-12, and 0-900 pg/kg for CFC-113. Reported concentrations beyond the above calibration limits should be considered as estimates of concentrations of the three CFCs.

Sulfur Hexafluoride

Water samples for analysis of sulfur hexafluoride, SF_6, were collected in 4- or 2.5- L plastic-coated glass bottles. The bottles were filled by placing the water inflow tube in the bottom of the bottle, displacing the air with water. After at least 3 L of overflow, the tube was slowly removed. The bottles were sealed with screw caps with conical liners without headspace. The conical liners in the caps allowed for some expansion of the water on warming. However, caps periodically were loosened slightly to prevent the glass bottles from breaking when the ground-water temperature was significantly lower than the ambient air temperature. Most SF_6 analyses were performed in a field laboratory near the sampling site, using instrumentation and procedures of Busenberg and Plummer (2000). However, some bottles were shipped to the U.S. Geological Survey laboratory in Reston, Virginia. All SF_6 analyses were performed by purge and trap gas-chromatographic procedures (Busenberg and Plummer, 2000). Standard deviations of about 3 percent were routinely obtained for repeated measurements of standards. The calibration was linear through the entire measuring range. For water samples, precision was about 50 percent at the detection limit of 0.02 femtomoles per kilogram (fMol/kg) and about 5 percent for concentrations greater than 0.1 fMol/kg.

Quality-Assurance and Quality-Control Procedures

Inorganic Chemistry

Quality-assurance and quality-control (QA/QC) data are summarized in appendix D. The recommended concentrations of five major and four trace elements in three standard reference water samples that were analyzed along with the water samples from the MRGB are given in table D1. The recommended and measured concentrations and the standard deviations of the reference materials analyzed

by the DCP are given in table D2. The detection limits for Ca, Mg, Sr, SiO_2, Na, K, Fe, Mn, and Al by DCP are less than 0.1, 0.01, 0.005, 0.1, 0.05, 0.1, 0.01, 0.005, and 0.005 ppm, respectively. Accuracies for measurement of Ca, Mg, Sr, SiO_2, Na, K, Fe, Mn, and Al by DCP are 3 to 5, 3 to 5, 3 to 5, 5, 3 to 5, 5 to 10, 5 to 10, 5, and 10 to 15 percent, respectively.

The accuracy of the ion chromatographic (IC) system was checked with Simulated rainwater 2 (table D3, High Purity Standards). Bromide standard solutions were prepared from Dionex standard solutions and measured separately. Detection limits for Cl, SO_4, NO_3, and F are less than 1, 2, 0.1, and 0.05 ppm, respectively. The Br detection limit was determined by the volume of the sampling loop injected into the ion chromatograph and ranged from less than 0.005 to less than 0.02 ppm. The precisions for measurement of Cl, SO_4, NO_3, F, and Br are 3, 3 to 5, 3 to 5, 3, and 10 percent, respectively.

Trace elements were measured with an ICP-MS using the standard reference solutions given in table D4. The water used to prepare the standards and blanks was prepared by passing deionized water through a Millipore Milli-Q system to obtain ultra-pure, 18-megaohm reagent-grade water. Blanks were prepared in the acid-washed, 250-mL polypropylene bottles that were used to collect the ground-water samples. The samples were acidified in the field with the same lot of nitric acid. Working standard solutions were prepared from Claritas PPT grade 10 ppm multi-element solutions purchased from Spex CertiPrep. The acidified blanks were compared to reagent water and results are given in table D5. Separate blanks containing 100 ppm Ca and Cl also were used to determine for the possible presence of interfering molecular ions that can form in the argon plasma (Tan and Horlick, 1986). The recommended and measured concentrations and the standard deviations of the reference materials analyzed are given in table D5.

Field Blank

A field blank was collected in such a way as to identify potential contamination problems in field-collection and laboratory-handling procedures of the FA samples. An FA sample bottle was rinsed two times with inorganic blank water (Ocala lot number 95171-22 bottle 222, http://owqrl.er.usgs.gov/certificates/ibw/ibw_22.shtml), and about 500 mL of the blank water was pumped with a peristaltic pump to rinse the tubing. A cartridge filter was attached to the tubing and purged of air, and the FA bottle was then rinsed three times with the filtered organic-free blank water, and then filled with this water to produce the field blank. The FA bottle was then acidified in the field with ultra-pure nitric acid (lot number NA 5318-1GS1, http://wwwnwql.cr.usgs.gov/USGS/certificates/na5318.0196.html), and a second FA bottle with reagent-grade nitric acid (table D6). The concentrations of metals in samples acidified with reagent grade and Ultrex (ulta-pure) nitric acids, analyzed by ICP-MS and DCP, were nearly identical indicating that the sampling and laboratory handling procedures did not normally introduce metals contamination.

Sample Filtration

Concentrations of most major and trace cations, obtained for nine samples that were filtered in the field through standard 0.45-micron cartridge filters, were indistinguishable from the results obtained from samples collected from the same sites at the same time and filtered in the field by tangential filtration through 0.1-micron and 30,000-dalton pore-size filters; however, the 30,000-dalton tangential filter may contaminate some samples with Cu and Pb, whereas the 0.1-micron tangential filter may introduce a slight amount of Pb (table D7). There were appreciable differences in concentrations with test samples filtered through standard 0.2-micron membrane filters. All samples filtered through the 0.2-micron membrane filters were contaminated with Cu, Zn, Fe, and Al, relative to those filtered through a 0.45-micron membrane filter; some of the samples filtered through the 0.2-micron membrane filter also appear to be contaminated with Sr, Mg, and possibly Co and Pb, with respect to the 0.45-micron filter (table D7). Apparently, the 0.2-micron membrane filters were the source of contamination of the ground-water samples used in the filtration test. All of the results of this study are based on filtration using the 0.45-micron cartridge filters. The results indicate that, overall, the 0.45-micron cartridge filter used in this study performed as well as tangential filtration procedures at 0.1-micron and 30,000-dalton pore sizes on ground-water samples from the study area. The results also indicate that the reported concentrations represent dissolved concentrations and, apparently, colloids are not important sources of metals transport in the MRGB ground water sampled.

The concentrations of 12 trace elements in 5 samples that were filtered through 0.45-micron cartridge filters in the field are shown in table D8. The filtered water was refiltered in the laboratory through 0.2- and 0.1-micron membrane filters. The only appreciable decreases in concentration with reduced filter size were observed for Cr, Cu, and/or Zn concentrations in two samples (NM481 and NM258). No appreciable decreases in concentrations of these three trace metals were observed in any of the other samples. This suggests that filtration through the 0.2- and 0.1-micron pore-size filters removed particles in the sample; these particulates may have passed through the 0.45-micron filters or were introduced after the samples were filtered. One sample (NM323) showed an increase in concentrations of Ba, Cu, and Zn with reduced filter size, indicating possible contamination from the filter or contamination introduced during laboratory processing of the sample.

Replicate Analyses (Field Duplicates and Re-Sampled Wells)

Replicate analyses for five major elements and Sr in 79 ground-water samples from the study area were performed by DCP. The percent difference in replicate analyses as a function of the cumulative percent of analyses is shown in figure 15. The results of duplicate analyses agreed to better than 5 percent for Ca, SiO_2, Mg, Na, Sr, and K in 95, 89, 82, 75, 68, and 60 percent of the analyses, respectively. Replicate analyses agreed to better than 10 percent in 92 percent of the samples for all elements with the exception of K, which agreed in 84 percent of the samples (K is difficult to analyze because the emission spectrum is in the ultraviolet part of the spectrum). The percent difference between duplicate analyses generally increases as the sample concentration decreases (fig. 16), which provides guidelines on analytical uncertainties that can be expected as a function of concentration range.

Duplicate analyses for trace elements were performed on approximately 57 pairs of ground-water samples from New Mexico. For Al, As, B, Ba, Cr, Cu, Li, Mn, Mo, Pb, Rb, Se, U, V, and Zn, the pairs of analyses agreed to within ± 10 percent in 46, 75, 91, 96, 34, 59, 92, 64, 96, 56, 96, 88, 79, 77 and 43 percent of the cumulative total of analyses, respectively. The agreement was within ± 20 percent for 68, 97, 100, 100, 49, 78, 100, 86, 100, 71, 100, 88, 100, 96 and 67 percent of the cumulative total of the analyses of the above trace elements, respectively. The higher deviations between pairs of analyses were observed at or near the detection limits of the trace metals.

Electrical Balance

The charge balance between the anions and cations in 352 analyses was calculated using the equation

$$\frac{100\times(e_{cations}-e_{anions})}{(e_{cations}+e_{anions})/2}=CB \qquad (13)$$

where

CB is the percent difference between the sum of the equivalents of cations and anions, and

e is the sum of the equivalents of cations or anions.

In only 4 percent of the samples the difference was greater than ± 5 percent. The charge balance was better than ± 1, ± 2, ± 3, ± 4, and ± 5 percent in 26, 48, 66, 84, and 96 percent, respectively, of the samples analyzed.

Hydrogen-2 and Oxygen-18 Isotopes of Water

The standard deviations of $\delta^{18}O$ values determined by the USGS on water collected from an individual well over relatively short periods of time were examined as an indication of analytical variability. Because some natural variability could be expected, this examination provides a measurement of the maximum likely analytical variability. From the archived Yapp samples (1980-82), there were typically 0-3 samples re-analyzed by the USGS per well. However, for 6 wells, as many as 11-14 waters (Ponderosa 2, Thomas 3, Volcano Cliffs 2, West Mesa 3, Duranes 4, and Atrisco 2) were re-analyzed by the USGS. In the USGS samples (1996-97), there were typically only 2 waters to be compared. The average of the standard deviations from the re-analyzed Yapp samples (1980-82) and the USGS samples (1996-97) were 0.12 and 0.06 per mil in $\delta^{18}O$, respectively. The maximum deviation in $\delta^{18}O$ from a single well was only 0.10 per mil in the USGS samples and 0.28 per mil in the re-analyzed Yapp samples (removing samples from West Mesa 3 that apparently show considerable natural variation).

The USGS Stable Isotope Laboratory was one of 44 laboratories that participated in the International Atomic Energy Agency (IAEA) intercomparison of

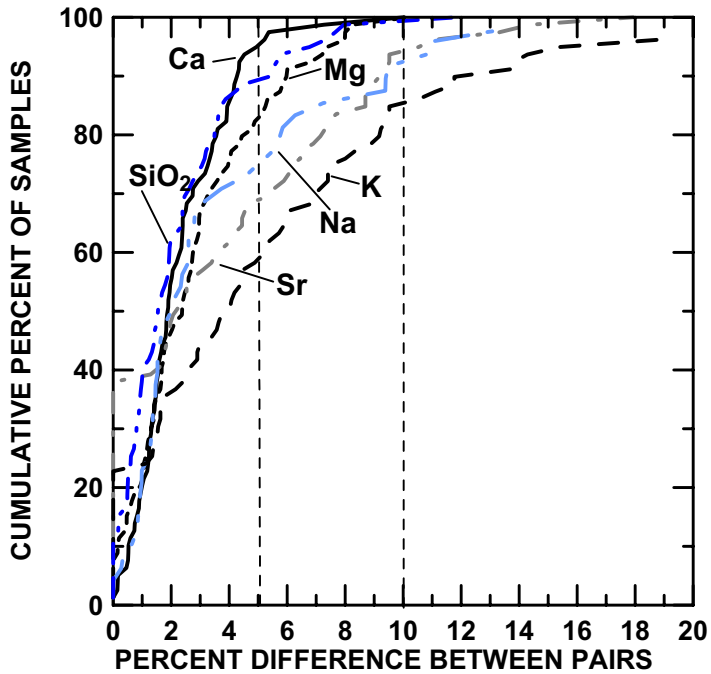


Figure 15. . Percent difference between duplicate samples as a function of the cumulative percent of the samples analyzed from the Middle Rio Grande Basin. The dashed lines represent 5 and 10 percent difference between duplicate analyses.

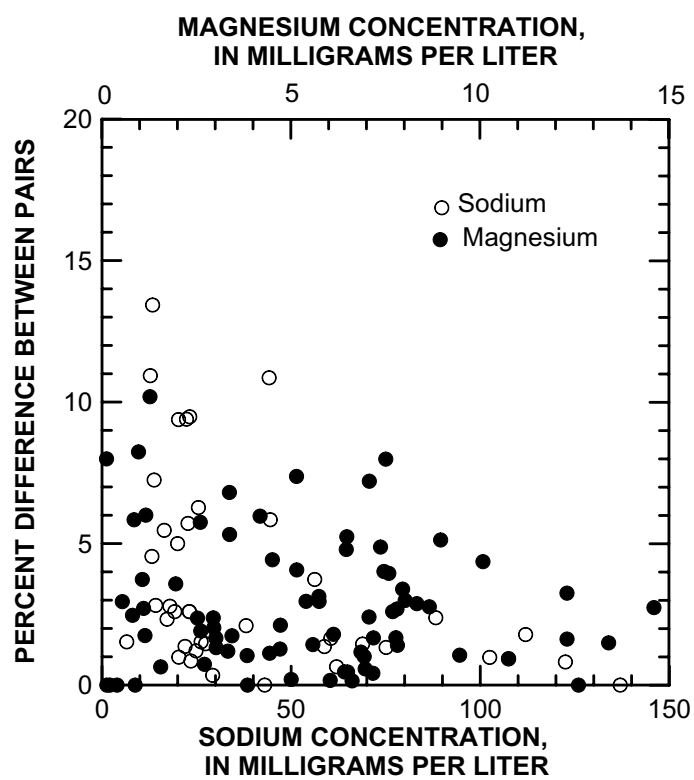


Figure 16. The difference in concentration between pairs of ground-water samples from the Middle Rio Grande Basin as a function of the concentration of cations in ground water.

measurements of the stable isotope composition of the GISP (Greenland Ice Sheet Precipitation) water sample distributed by the IAEA (Gonfiantini and others, 1995). The USGS Stable Isotope Laboratory completed an audit of the United States supply of VSMOW distributed by NIST. In 32 analyses of 3 samples of SMOW and VSMOW (Coplen and Hopple, 1995), δ^2H averaged 0.0 per mil with standard deviations of 0.6 to 1.3 per mil; in 16 determinations of the same SMOW and VSMOW samples $\delta^{18}O$ averaged 0.0 ± 0.05 per mil. Seven replicate analyses of SLAP reported by Coplen and Hopple (1995) averaged isotopic compositions identical to the internationally accepted compositions of this standard (δ^2H = -428.0 per mil, $\delta^{18}O$ = -55.50 per mil, Gonfiantini and others, 1995), with 1-σ precisions of ± 0.8 and ± 0.03 per mil for δ^2H and $\delta^{18}O$, respectively. The USGS Stable Isotope Laboratory reported O- and H-isotope results with 1-σ precisions of 0.1 and 0.8 per mil, respectively, for all the MRGB samples analyzed as a part of this study.

Carbon-13 and Carbon-14 Isotopic Composition of Dissolved Inorganic Carbon

Tests showed that samples preserved as $BaCO_3$ were not as stable as samples collected in glass septum bottles without preservatives. Apparently, air reacted with the $BaCO_3$, resulting in isotopic exchange of atmospheric CO_2 with $BaCO_3$, which can affect the values of both $\delta^{13}C$ and ^{14}C activity. In an effort to assess the magnitude of possible isotopic variations and to validate the $\delta^{13}C$ and ^{14}C measurements, six QA/QC procedures were undertaken during the course of the investigation.

1. Laboratory precision. The AMS facility provided information on their laboratory analytical precision. Eighty-three replicate determinations of the $^{14}C/^{13}C$ isotope ratio of an oxalic acid standard determined as a normal part of the operation of the AMS facility during the period December 18, 1996 through March 16, 1997, when many of the samples from this study were analyzed, varied by only ± 1.5 percent (R. Sparks, Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand, written commun., 1997). In another test, 8 samples each of two sources of silk thread (16 samples in all) were processed separately and analyzed with mean ^{14}C activities of 86.3 and 86.2 pmC for the two sources, and analytical ranges of 85.5 ± 0.7 to 86.7 ± 0.7 pmC for one source and 85.2 ± 0.7 to 86.9 ± 0.7 pmC, respectively, for the other source (R. Sparks, Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand, written commun., 1997). The average standard deviation of the replicate analyses of the two sets of samples was ± 0.5 pmC, or only about ± 0.6 percent of the reported ^{14}C activity. Analyses of samples with low ^{14}C activity are less precise than those with high ^{14}C activity, and probably in the range of ± 5 percent of the reported activity in samples in the range of 3 to 8 pmC. For example, the ^{14}C activity of CO_2 in three of the backup breakseals was determined at the AMS facility and compared to the first determination from the original breakseal sent to the AMS facility. The three samples had average ^{14}C activities of 7.7, 5.4, and 3.0 pmC and differences in the replicate analyses were 4.8, 3.3, and 6.4 percent of the reported average value, respectively.

2. Comparison of results from $BaCO_3$ samples and septum bottle samples. Seven samples that were originally analyzed from $BaCO_3$ powders from the 1996 sampling were re-analyzed using the water sample from the septum bottle that was collected at the same time, but had been stored for approximately 1 year prior to analysis (group 1 of table D10). The ^{14}C activities determined on the samples from the septum bottles were either nearly identical to the results from the $BaCO_3$ samples or were lower in ^{14}C activity than the values determined on the original $BaCO_3$ samples (table D10). On average, the ^{14}C activities determined on $BaCO_3$ samples were only about 5 percent greater than values determined on the archived septum bottles, although the largest deviation was about 14 percent in one sample. Therefore, all differences were small, and in the case of ^{14}C samples with low ^{14}C activity, within the laboratory precision. Values of $\delta^{13}C$ of DIC from the $BaCO_3$ samples also were either mostly the same as those from the septum bottles (within the analytical uncertainty) or were shifted toward the $\delta^{13}C$ of CO_2 in air (approximately -8 per mil) from the value found for DIC in the septum bottle. That is, samples from septum bottles that were more depleted in ^{13}C than air were enriched in ^{13}C in the $BaCO_3$ sample relative to the septum bottles, and those in septum bottles that were more enriched in ^{13}C than air were depleted in ^{13}C in the $BaCO_3$ samples relative to those from the septum bottles (table D10).

3. Comparison of ^{14}C results from $BaCO_3$ samples with storage. Twelve samples of $BaCO_3$ from the 1996 sample set were re-submitted approximately 1 year following the initial analysis and re-analyzed (group 2 of table D10). In the interim between the initial analysis and re-analysis, the samples had been stored in capped glass bottles with, otherwise, no special precautions to exclude air. Most of the powders gained ^{14}C with time. The maximum increase in ^{14}C activity in one sample was a change of about 32 percent from the initial analysis, whereas the average increase in ^{14}C activity from the original analysis of all 12 samples was 14 percent on storage of about 1 year. Two factors probably contribute to the uptake of CO_2 from air. Recrystallization of the $BaCO_3$ precipitate probably occurs, and this process probably involves an isotope exchange process. Also, some samples of the precipitate may not have been sufficiently washed to remove all the $Ba(OH)_2$. Samples with high dissolved SO_4 would be most affected because $BaSO_4$ forms a fine precipitate that tends to clog filters and slow the washing process. Precipitates that still contained $Ba(OH)_2$ would react with air and take up additional CO_2 over time. Because the CO_2 from the original sample set of $BaCO_3$ powders from the 1996 sampling was extracted into breakseal tubes within approximately 3 months of preparation, the time during which changes in ^{14}C activity prior to extraction could occur was limited, particularly in comparison to the 12 months between preparation and extraction for the re-analyzed samples. The exchange of ^{14}C with air prior to CO_2 extraction of the original set of $BaCO_3$ samples apparently resulted in a change of only about 5 percent, on average, as the comparison with analyses from septum bottles (group 1, table D10) indicates. This difference is small and has been ignored in interpretation of radiocarbon age of DIC in the ground-water samples.

4. Re-sampling of wells and comparison of ^{14}C results from septum bottles. In this test, eight wells that had been sampled in 1997 were re-sampled in 1998. During both years, ^{14}C samples were collected in septum bottles using identical collection procedures (group 3, table D10). Most of the wells re-sampled were deep monitoring wells that had been completed and developed within the year prior to the initial sampling. Differences in results in this sample set reflect uncertainties in analytical methods, field collection, and the extent to which identical water samples can be withdrawn from the monitoring wells. Traces of CFC-12 were detected in many of the samples from the monitoring wells, probably indicating that traces of drilling fluid were still present in the ground-water environment in the vicinity of the well screen. The re-sampling and collection of water samples from these wells by other agencies in the interim following the initial sample collection helped to further develop the wells prior to the second sampling in 1998. No systematic change in ^{14}C activity was found between the initial and second sampling (table D10). In terms of percent change, the largest change was for the deep completion of the 98th Street well (site S003), where the ^{14}C activity increased from 0.6 to 1.1 pmC between the initial and second sampling. As these values are near the limits of the radiocarbon dating method, the differences in ^{14}C activity at the 98th Street well are probably within expected limits. The rest of the samples either increased or decreased in ^{14}C activity with changes of approximately ± 0 to ± 8 percent of the average value, with an average change of only ± 0.2 percent from the original value for all the samples.

5. Storage effects of ^{14}C samples in septum bottles. Duplicates of two samples collected in septum bottles were analyzed approximately 1 year apart (group 4, table D10). The results were nearly identical.

6. Duplicate extraction and analysis of $BaCO_3$. Quality-assurance procedures identified one sample of $BaCO_3$ that was likely extracted twice, one time after the other, but analyzed as if it were two separate samples. The results for this sample were included (group 5, table D10) because they give some information on the differences that can result in the original homogenization of the $BaCO_3$ samples, extraction of CO_2, and subsequent analysis. In this case, the ^{14}C activities of the two extractions were 11.7 and 12.2 pmC (table D10).

Historical Data

To obtain the most accurate representation of water chemistry in the MRGB that could reasonably be achieved, data collected specifically for the current study were supplemented with historical data. Supplementary data were obtained from two main sources that were readily accessible, that contained data for a substantial number of sample sites, and that included specific location information for those sites. These sources, which are described below, are the

USGS NWIS database and a database maintained by the City of Albuquerque on water chemistry from its production wells. No effort was made to obtain data from sources that did not include location information for sites in latitude and longitude or State-plane coordinates, that included only a small number of localized sites, or that did not have data in a digital format.

U.S.Geological Survey National Water Information System Database

The NWIS database maintained by the New Mexico District Office of the USGS includes water-chemistry data for ground-water sites (including both wells and springs) and surface-water sites across New Mexico. In addition to chemical analyses for samples collected primarily by the USGS as early as 1941, the database contains latitude and longitude for each ground-water sample site and, typically, includes well construction information. For this report, all available ground-water samples obtained from sites located within the MRGB were retrieved from the database. Samples that did not include either trace-element analyses or a full analysis of all major ions were not retained. Samples with major-element analyses that did not give an ion balance of 10 percent or better also were discarded. Finally, duplicate samples for the same site were eliminated (in general, the most recent sample was retained, unless a prior sample was analyzed for more parameters). For an individual ground-water site, a sample collected specifically for the MRGB study was always retained over any samples available from the NWIS database. Ground-water sites for which data were retained are shown in figure 17a,b; the data are given in appendix E, table E1. In addition to ground-water data, surface-water data also were retrieved from the NWIS database for selected sites (fig. 17a,b). Discharge-weighted compositions for surface-water sites in NWIS are summarized in table 4, along with other representative end-member water compositions for the MRGB. Chemical analysis of most ground- and surface-water samples from NWIS was performed at a USGS laboratory; methods of analysis vary because the dates of sample collection encompass many years. Although it cannot be determined with certainty, all samples are believed to have been passed through 0.45-micron filters, with minor-element samples being acidified in the field.

City of Albuquerque Database

Since 1988, the City of Albuquerque has periodically collected and analyzed water-quality samples from its production wells (fig. 18) through a voluntary effort to improve understanding of the regional ground-water resource. The database that has been compiled as a result of this effort is described by Bexfield and others (1999). The median constituent concentrations presented by Bexfield and others (1999) for major elements, minor elements, and field parameters from each of 93 production wells (generally deep wells with long screened intervals, see table 2 for example) were included in the data set used for this investigation, along with data for one additional well. Median values of the major ions for 93 of these 94 wells gave ion balances within 11 percent; one well (Vol Andia 1) had an ion balance of 15 percent. For production wells that also were sampled between June 1996 and August 1998 specifically for the MRGB study, the City of Albuquerque data for major elements, minor elements, and field parameters were eliminated; however, City of Albuquerque data were retained in favor of historical NWIS data when data for the same site were present in both databases. City of Albuquerque data are for unfiltered samples; minor-element samples were acidified on the day of collection. Readers are referred to Bexfield and others (1999) for further details on sample collection and methods of analysis, which have varied over time for some individual parameters.

One other data set was examined, but rejected. This data set included stable isotope measurements, some of which are tabulated in Logan (1990) and other values are unpublished, for approximately 500 ground-water samples collected from City of Albuquerque production wells during the period February 1987 – June 1990 (B. Gastian, City of Albuquerque, oral commun., 1997). Stable isotope samples were analyzed on the VSMOW scale by a contract laboratory; however, the analytical precision was not reported. The standard deviation of $\delta^{18}O$ values determined on water collected from an individual well over relatively short periods was examined for data from the contract laboratory for each City of Albuquerque production well. There are typically 3-5 replicate analyses from the contract laboratory on samples collected between 1987 and 1990, and as many as 44 samples at one well (at Love 1, site S110). The average standard deviation of $\delta^{18}O$ values from all replicate

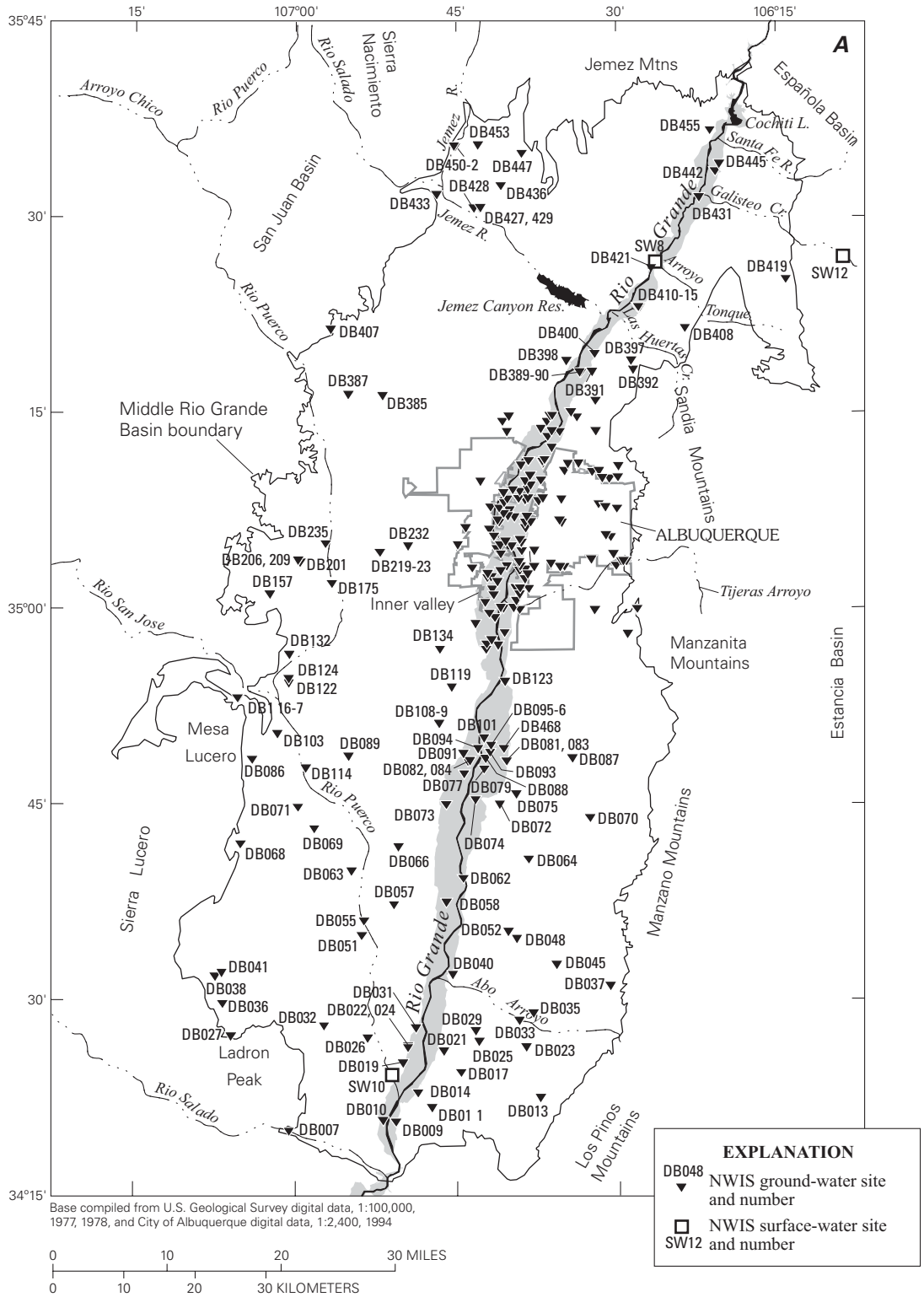


Figure 17a. Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set outside the Albuquerque area. Surface water sites SW8, SW10, and SW12 are the USGS gauge stations Rio Grande at San Felipe (site 08319000), Rio Puerco near Bernardo (site 08353000), and Galisteo Creek above Galisteo Reservoir (site 08317850), respectively.

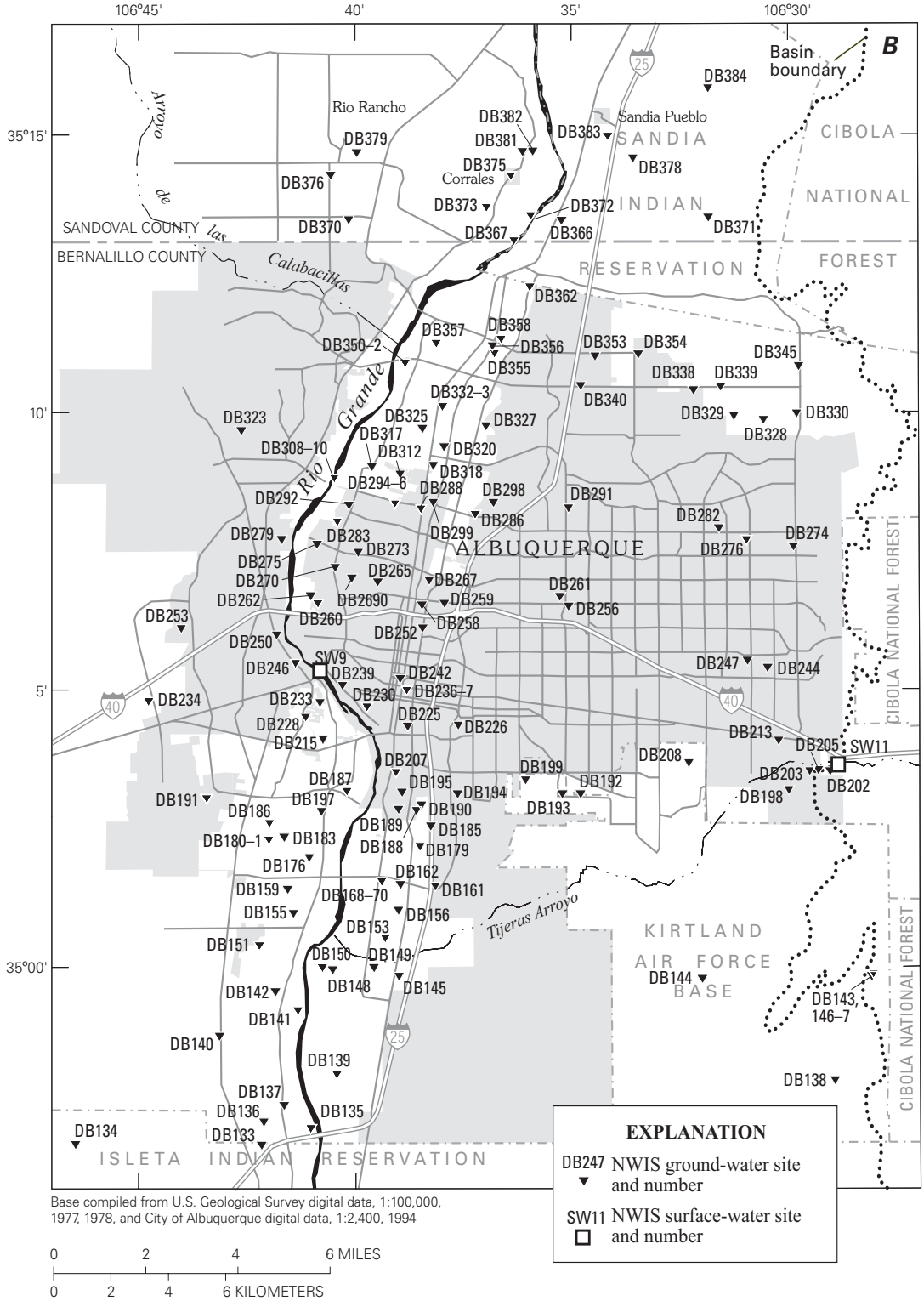


Figure 17b. Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set inside the Albuquerque area.

Table 4. Summary of chemical and isotopic properties of representative end-member waters for the Middle Rio Grande Basin, New Mexico

[Sevilleta, [Moore, 1999, Precipitation chemistry data on the Sevilleta National Wildlife Refuge, 1989-1995 (http://sevilleta.unm.edu/research/local/nutrient/precipitation/#data)]; PRECIPx8, Sevilleta with evapotranspiration (ET) factor of 8-fold; NMF, Northern Mountain; NMF, Northern Mountain Front, median, this study; EMF, Eastern Mountain Front, median, this study; SWMF, Southwestern Mountain Front, NWIS, representative sample; NEGW, Northeast Ground-Water Inflow, NWIS, representative sample; SWGW, Southwest Ground-Water Inflow, NWIS, median; ASSP, Arroyo Salado Spring; MWGW, Mid-West Ground-Water Inflow, NWIS, median; Saline 1, Mineralized upward leakage from Domestic Well #04, NM041; Saline 2, Mineralized upward leakage from Coyote Spring, NM031; RP, Discharge-weighted average NWIS Rio Puerco at Bernardo; RGA, Discharge-weighted average NWIS Rio Grande at Albuquerque; RGSF, Discharge-weighted average NWIS Rio Grande at San Felipe; JRW, Discharge-weighted average NWIS Jemez River below Jemez Canyon Dam; ABO, Median Abo Arroyo; TIJ, Discharge-weighted average NWIS Tijeras Arroyo above Four Hills Road; GAL, Galisteo Creek above Galisteo Reservoir, June 1974; LUC, Lucero-24, mg/L, milligrams per liter; per mil, parts per thousand; pmC, percent modern carbon; Est., estimated; nd, no data]

Source	pH (standard units)	Est. dissolved oxygen (mg/L)	Alkalinity as HCO_3^- (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Silica as SiO_2 (mg/L)	Est. $\delta^{13}C$ ($^o/_{oo}$)	Est. ^{14}C activity (pmC)
Precipitation												
Sevilleta (1989-95) bulk	5.4	nd	1.7	0.94	0.09	0.12	0.15	0.21	1.40	nd	- 8.	100
Precipitation with ET of 8-fold												
PRECIPx8	5.4	8.0	0.525 [1]	7.5	0.7	1.0	1.2	1.7	11.2	nd	- 8.	100
Mountain-front recharge												
NMF	7.4	8.	124.	29.	3.9	16.	4.3	4.4	14.	53.	-12.	100.
EMF	7.4	8.	212.	61.	7.5	16.	1.6	6.4	31.	23.	-12.	100.
SWMF	7.3	8.	207.	54.	12.	19.	1.3	12.	33.	29.	-12.	100.
Ground-water inflow												
NEGW	7.5	0.	328.	67.	15.	67.	5.	27.	63.	13.	- 4.	2.
SWGW	7.7	0.	2,073.	474.	230.	6,069.	143.	7,202.	5,020.	21.	- 4.	2.
ASSP	6.7	7.4	1,180.	606.7	512.8	5,910.	148.8	8,070.	3,750.	17.2	2.8	7.6
MWGW	7.7	0.	1,366.	300.	145.	3,532.	117.	2,700.	3,250.	21.	- 4.	2.
Upward leakage of saline waters												
Saline 1	7.	0.1	181.6	185.	25.7	1,530.	107.	2,520.	296.2	43.4	- 7.5	23.
Saline 2	6.5	2.8	1,305.	322.	70.3	382.	43.7	581.3	139.5	16.9	- 0.6	4.8
Surface waters												
RP	8.	1.	183.	138.	29.	200.	7.	46.	707.	10.	- 0.1	64.
RGA	8.1	8.	118.	37.	6.4	22.	3.	9.2	58.	18.5	- 7.5	100.
RGSF	8.1	8.	112.	34.5	6.3	17.	2.6	4.8	50.	18.	- 7.5	100.
JRW	8.1	8.	129.	39.	4.6	62.	5.5	50.	79.	22.	- 2.9	83.
ABO	8.3	8.	254.	297.	105.	123.	1.5	61.	1,049.	19.	- 7.1	87.
TIJ	8.2	8.	243.	102.	21.	39.	5.5	82.	105.	16.	- 7.1	87.
GAL	8.1	8.8	220.	150.	45.	140.	3.7	23.	630.	17.	- 6.	100.
LUC	6.8	nd	536.	171.	56.8	131.	5.4	46.	183.	18.	- 5.	100.

[1] mg/L as CO_2.

analyses provided by the contract laboratory was 0.22 per mil, and the maximum deviation from a single well ranged over more than 1 per mil. The stable isotope analyses used in this study were all obtained from the USGS Stable Isotope Laboratory, Reston, Virginia, and have a reported 1-σ precision of 0.1 per mil in $\delta^{18}O$.

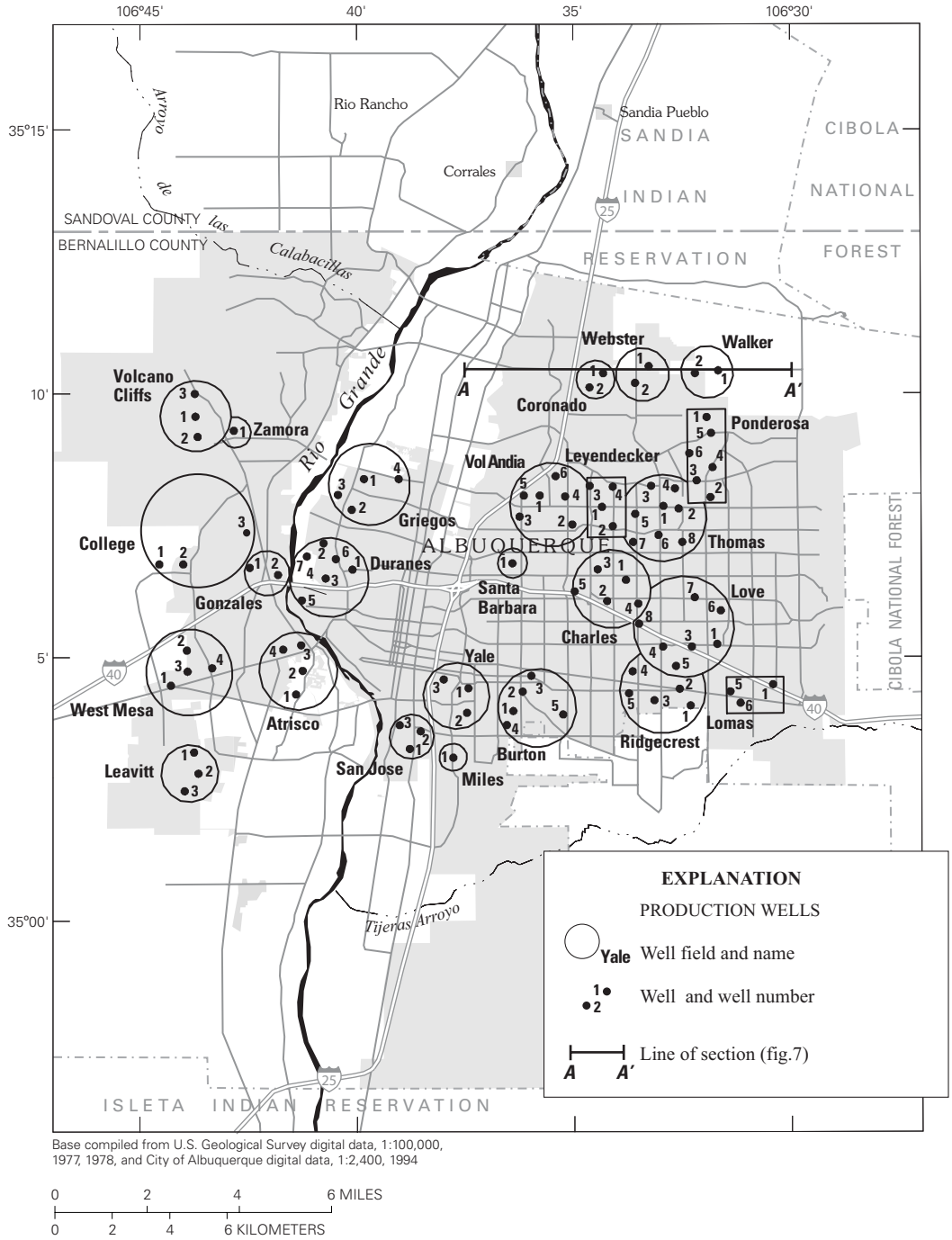


Figure 18. Locations of City of Albuquerque production wells. Wells for which City of Albuquerque, New Mexico, data were included in the final data set are listed in appendix F.

SOURCES OF RECHARGE AND UNDERFLOW TO THE SANTA FE GROUP AQUIFER SYSTEM

As discussed in the "Description of the Study Area" section, multiple sources of recharge are known to contribute water to the Santa Fe Group aquifer system. These sources include mountain-front recharge processes, infiltration from the Rio Grande, tributaries to the Rio Grande, and arroyos, and ground-water inflow from adjacent basins. Although physical and chemical processes can affect these waters as they recharge and move along ground-water-flow paths, the chemical and isotopic characteristics of ground-water samples are likely to broadly reflect the characteristics of the source. The Santa Fe Group aquifer system of the MRGB is composed primarily of unreactive material—sands and gravels from the chemical and mechanical breakdown of silicate rocks and minerals—so that solute concentrations are likely to change only slightly with distance down a flow path. Therefore, knowledge of the chemical and isotopic characteristics of potential recharge waters should be extremely useful in identifying the primary recharge sources to various areas of the basin.

Because of the importance of characterizing possible sources of recharge to the basin, efforts were made to compile chemical and isotopic data for these sources. In addition to information on general water chemistry (major and trace elements), data were obtained on the $\delta^{18}O$ and $\delta^{2}H$ compositions of water because, although processes causing local variations in isotope composition can be recognized in a qualitative sense, it is not possible to *a priori* predict the isotopic composition of recharge waters with sufficient accuracy to be of use in tracing source waters in the MRGB. Having measured the chemical and isotopic composition of source waters to the basin, it was, in many cases, possible to use this information to trace ground-water flow.

The major factors that can affect the $\delta^{18}O$ and $\delta^{2}H$ isotopic composition of precipitation are season, latitude, temperature, altitude, storm track, and amount of precipitation. Most of the isotopic variations associated with these factors can be related to isotope-fractionation effects that occur during evaporation at the moisture source(s) and during moisture condensation (see Dansgaard, 1964; Rozanski and others, 1993; Clark and Fritz, 1997; Coplen and others, 1999; and references therein). In addition, most surface waters and shallow soil waters in the MRGB are evaporated partially. Depending on the relative humidity, evaporated surface waters can be enriched in ^{2}H and ^{18}O relative to the original source (Gat, 1981; Gilath and Gonfiantini, 1983; van der Straaten and Mook, 1983; Gonfiantini, 1986).

Precipitation

Inorganic Chemical Composition

Data for the inorganic chemical composition of precipitation in the general area of the MRGB are available from several sources: Popp and others (1984) for both wet and bulk precipitation at Albuquerque and Socorro; the University of New Mexico's Long-Term Ecological Research Program (LTER) on Sevilleta National Wildlife Refuge for bulk precipitation at the southern end of the MRGB; and the National Atmospheric Deposition Program for wet precipitation at Cuba and Bandelier, north of the basin. For this investigation, bulk precipitation data from the LTER were selected to represent historical precipitation chemistry. Bulk rather than wet precipitation chemistry was chosen for comparison to ground-water compositions because bulk concentrations are more representative of water that infiltrates after contact with dry particulate matter. LTER data were chosen over data from Popp and others (1984) because LTER data were available for a longer period of time at multiple sites. The LTER network (Sevilleta National Wildlife Refuge; fig. 11a) included 20 precipitation collectors from 1989 to 1995, and 6 collectors for 1996 to 2000. Samples were analyzed monthly for Na, K, Ca, Mg, NO_3, NH_4, SO_4, and Cl concentrations, along with conductivity and total Kjeldahl-N and PO_4 (http://sevilleta.unm.edu).

Average bulk precipitation compositions were calculated for the LTER data (table 4) by weighting the concentrations according to the quantity of precipitation represented by each sample. The data indicate that during the period of record (1989-2000), SO_4 concentrations exceeded Cl concentrations by several times; the ratio of SO_4 to Cl concentrations in milliequivalents per liter (meq/L) averaged about 5.2 (the yearly average varied from 3.4 in 1991 to 8.1 in 1998). Calcium was the dominant cation. The ratio of Ca to Na concentrations in meq/L averaged 9.6 (the

yearly average varied from 5.4 in 1990 to 13.1 in 1989).

Precipitation chemistry has probably fluctuated between the time that much of the sampled ground water recharged (as long as tens of thousands of years ago) and today. Sulfate concentrations in precipitation today are probably higher than in the past, as a result of sulfur emissions associated with human activity that would have caused SO_4 (and the associated ratio to Cl) to increase. Variations in wind direction, amounts of atmospheric dust, and distance from the ocean are other factors that likely have changed over time and could have affected the composition of precipitation. Although the modern precipitation composition used for comparison to ground water may not represent the exact composition at the time of recharge, it provides a common reference point for comparison.

Oxygen-18 and Hydrogen-2

Historical data on the stable isotope composition of precipitation in the vicinity of the MRGB is limited primarily to that of Yapp (1985), who found a wide range of -6 to -158 per mil in the δ^2H composition of amount-weighted precipitation samples collected monthly over 2 years from the roof of the Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque. Yapp (1985) did not tabulate the amounts of precipitation, but indicated that the yearly weighted average precipitation was -60 per mil in δ^2H.

Precipitation samples were not collected systematically as a part of the current MRGB investigation. However, two sets of archived samples of precipitation from the vicinity of Albuquerque were analyzed for stable isotope composition: (1) the above-mentioned archived samples of precipitation collected by Crayton Yapp from October 1981 to March 1984 from the roof of Northrop Hall, University of New Mexico (latitude 35°04’58”, longitude 106°37’20”, altitude 5,160 feet above sea level), and (2) precipitation samples collected by Robert Hejl, May 1987 – July, 1988 from a location in Albuquerque (latitude 35°07’09”, longitude 106°29’43”, altitude 5,840 feet above sea level). The precipitation samples were collected on an event basis and composited monthly. There is a strong seasonal signal in stable isotopic composition, with the most depleted precipitation during the winter months of January and February, and the most enriched during part of the summer monsoon period of June-August (Yapp, 1985). Two seasonal records in $\delta^{18}O$ from the Yapp and Hejl samples are shown in figure 19. A least squares fit to all the precipitation samples defines a local meteoric water line for the vicinity of Albuquerque of

$$\delta^2H = 7.76\ \delta^{18}O + 4.73\ , \qquad (14)$$

as shown in figure 20. The average deuterium excess ($d_{excess}=\delta^2H-8.0\delta^{18}O$) is 7.1 per mil. The amount-weighted precipitation from 1987-1988 in the Hejl samples analyzed by the USGS has the isotopic composition, δ^2H = -56, $\delta^{18}O$ = -7.9 per mil. For consistency with the USGS measurements on the Hejl precipitation samples and other USGS stable isotope measurements (see section “Comparability of Results” in “Hydrogen-2 and Oxygen-18 Isotopes in Ground Water” for further details), Yapp’s reported yearly weighted δ^2H composition of precipitation at Albuquerque from the early 1980’s, -60 per mil, was adjusted to -62 per mil, and using the correlation of figure 20, the adjusted, amount-weighted $\delta^{18}O$ value of -8.6 per mil was estimated. Apparently, precipitation during 1987-1988 at Albuquerque was slightly more enriched in ^2H and ^{18}O than that from the early 1980’s.

The local meteoric water line at Albuquerque has a slightly lower slope ($\delta^2H/\delta^{18}O$=7.76) and lower d_{excess} (7.1 per mil) than that of cold ground water of meteoric origin from the Jemez Mountain region ($\delta^2H = 8\delta^{18}O + 12$, Vuataz and Goff, 1986; see also Adam and others, 1995) near Los Alamos, northwest of the study area, or that of precipitation from the Sangre de Cristo Mountains near Santa Fe, northeast of the study area ($\delta^2H = 8\delta^{18}O + 11.1$, Anderholm, 1994). Precipitation samples from the Sangre de Cristo Mountains were collected between August 1987 and March 1989 at an altitude of approximately 7,400 feet above sea level with an average amount-weighted δ^2H of -65.2 per mil (Anderholm, 1994). Additional stable isotope data are available for precipitation in the Los Alamos vicinity (Adams and others, 1995), and for water from wells, springs and streams in the Jemez Mountains region (Trainer and others, 2000).

From the recharge altitudes of cold meteoric waters from the Jemez Mountains, Vuataz and Goff (1986) found that the slopes of δ^2H and $\delta^{18}O$ with altitude (in meters), $\Delta\delta^2H/\Delta E$ and $\Delta\delta^{18}O/\Delta E$, where ΔE is the change in altitude in meters, were -2.2 and -0.32 per mil per 100 m, respectively. That is, δ^2H and $\delta^{18}O$ decrease by about 2.2 and 0.32 per mil, respectively,

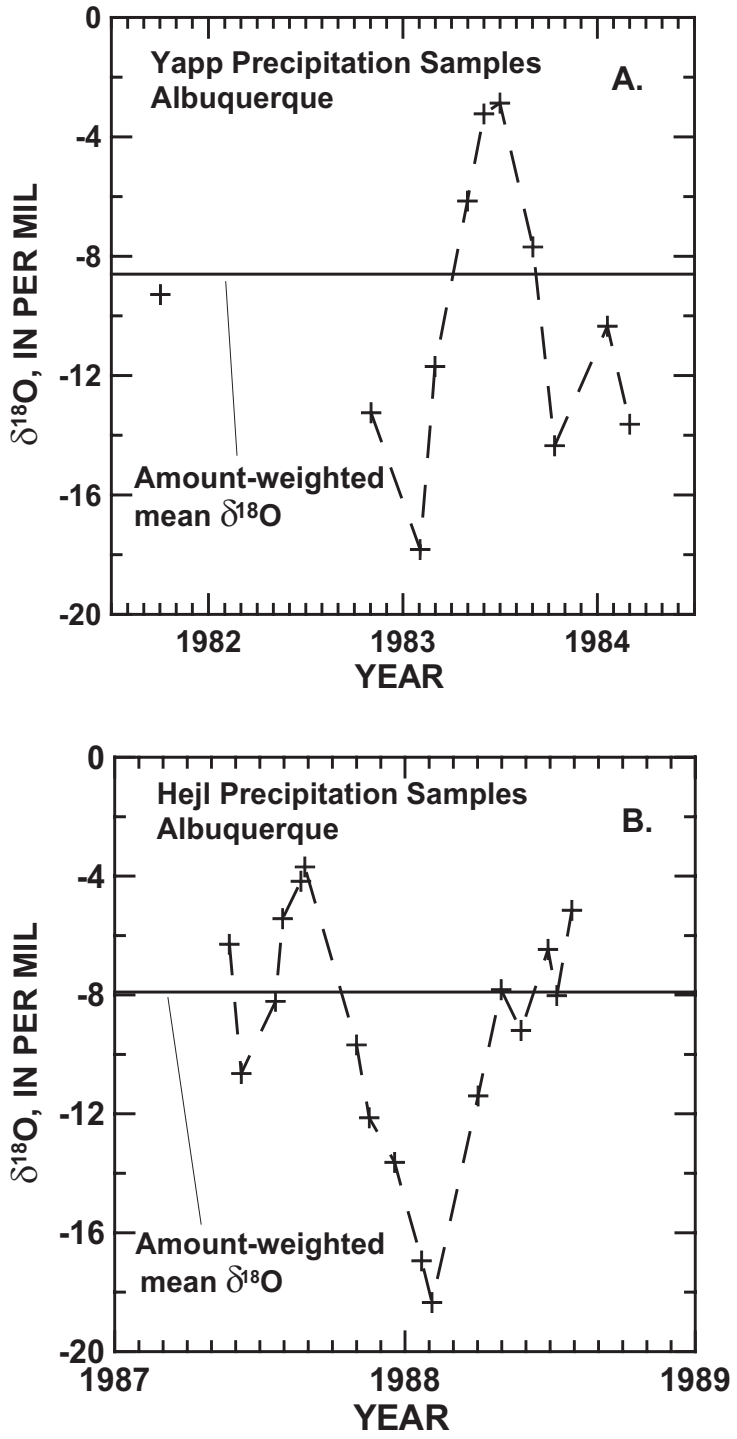


Figure 19. Comparison of $\delta^{18}O$ values in Albuquerque, New Mexico, precipitation: (a) Samples collected by C. Yapp, 1981-1984, (b) Samples collected by R. Hejl, 1987-1989.

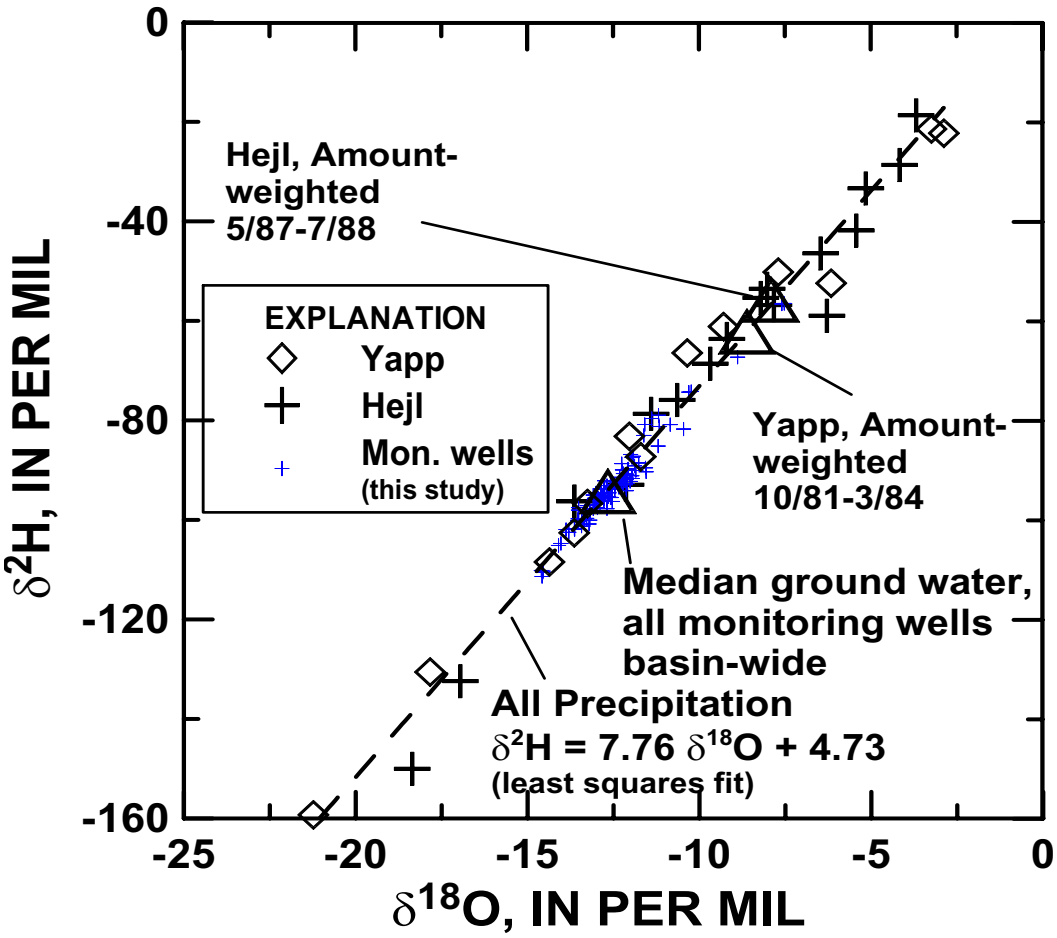


Figure 20. Relation between δ^2H and $\delta^{18}O$ isotopic composition of precipitation and ground water from monitoring wells in the vicinity of Albuquerque, New Mexico.

per 100 m increase in altitude, which is similar to shifts in stable isotopic composition of precipitation as a function of altitude (often referred to as the "altitude effect") reported from many other mountainous areas world-wide under a range of climatic and latitude differences (Vuataz and Goff, 1986).

The "altitude effect" can be derived by combining expressions for the latitudinal, yearly average temperature dependence of isotopic fractionation (van der Straaten and Mook, 1983) with values of the lapse rate (Meyer, 1992), which expresses the rate of average cooling at the earth's surface as a function of increasing altitude. The latitudinal, yearly average temperature dependence of δ^2H and $\delta^{18}O$ were derived from theoretical expressions of Rayleigh isotope fractionation in the condensation of water vapor across a latitudinal temperature gradient using known values of the temperature dependence of the isotope fractionation factors (van der Straaten and Mook, 1983)

$$d\delta^2H_c/dt = 6.0 - 0.09t\ , \qquad (15)$$

$$d\delta^{18}O_c/dt = 0.72 - 0.01t\ , \qquad (16)$$

where t is temperature in °C and the subscript "c" refers to condensation from vapor.

If the lapse rate is -5.5°C per km (Meyer, 1992) (-1.7°C per 1000 feet), at an average temperature of 10°C, the change in δ^2H with change in altitude, ΔE, $\Delta\delta^2H/\Delta E$, is -2.8 ± 0.5 per mil/100 m, and the change in $\delta^{18}O$ with change in altitude, $\Delta\delta^{18}O/\Delta E$, is -0.34 ± 0.05 per mil/100 m. The expressions above show that values of the "altitude effect" should theoretically decrease (become more negative) as average temperature is lowered, or as altitude increases. Consequently, for condensation at 5°C, $\Delta\delta^2H/\Delta E$ and

$\Delta\delta^{18}O/\Delta E$ become –3.0 ± 0.5 and –0.37 ± 0.05 per mil/100 m.

These calculations show that the "altitude effect" is primarily a temperature effect in isotope fractionation. Consequently, isotope shifts observed for moisture falling at different altitudes on the side of a mountain, are, to a good approximation, caused by the same isotope fractionation processes that cause shifts in stable isotopic composition of ground water recharged to aquifers as a function of temperature changes in the recharge area. There are several approximations that were introduced by van der Straaten and Mook (1983) in deriving the above equations, such as lack of water vapor exchange with local sources. van der Straaten and Mook (1983) found greater discrepancies between theoretical and observed isotopic values at lower temperatures. Although the theoretical values of the "altitude effect" are nearly identical to the values of the "altitude effect" observed by Vuataz and Goff (1986) in cold meteoric water from the Jemez Mountains, those of Vuataz and Goff (1986) were used because they were determined in the vicinity of the MRGB and probably include local isotopic effects that could not be included in the theoretical calculations of van der Straaten and Mook (1983). However, the theoretical model shows that the value of the "altitude effect" should vary slightly with temperature (altitude), being more negative for precipitation at higher altitude or lower temperature than the conditions under which they were observed on the slopes of the Jemez Mountains (recharge altitude range of 7,400 to 9,400 feet; Vuataz and Goff, 1986).

Tritium

The USGS low-level tritium laboratory has measured the activity of tritium in precipitation collected at Albuquerque over sampling intervals of weekly to quarterly since August 1958. The total record contained more than 200 measurements at the end of the year 2001. Tritium in precipitation data for Albuquerque for the period 1958-98 are available from International Atomic Energy Agency (IAEA), IAEA (2001), and data from 1999 through 2001 were obtained from R.L. Michel (U.S. Geological Survey, written commun., 2002). The precipitation samples, from a location at latitude 35°03'00"N, longitude 106°37'12"W and altitude 5,312 feet above sea level, were collected on an event basis and composited for the reported interval.

The highest tritium concentration in precipitation at Albuquerque was 4,400 TU in April, 1964, following the 1963-1964 period of atmospheric testing of nuclear bombs. The amount-weighted mean tritium concentrations were 1,898.7 and 1,688.3 TU, respectively, for the years 1963 and 1964 (IAEA, 2001), and fell rapidly from the late 1960's. The amount-weighted mean tritium concentration was about 200 TU in 1970 and 23 TU in 1980. Tritium concentrations measured in precipitation for Albuquerque from 1958 to 1998 are shown in figure 21. In more recent years, between 1985 and June 1997, the average tritium concentration in precipitation at Albuquerque was 13.4 TU, with a standard deviation of ± 6.4 TU. After correction for radioactive decay to June 1997, precipitation from the period 1985 through June 1997 would have an average tritium concentration of 9.1 ± 3.7 TU in the Albuquerque vicinity in June 1997. Ground water resulting from infiltration of precipitation from the mid-1960's would contain tritium in the range of about 100-700 TU in June 1997, if not diluted with older or younger water.

The natural, pre-nuclear detonation tritium concentration in precipitation was estimated at approximately 8 TU (Thatcher, 1962) in the southwestern United States. Therefore, water recharged from infiltration of precipitation, such as along the mountain-front margins of the basin, prior to the year 1950 would contain less than 0.5 TU in the late 1990's, the time during which the sampling for this study was conducted. Water samples containing more than 0.5 TU are post-1950's in age or are mixtures containing a fraction of post-1950's water. Additional data on tritium in precipitation at Albuquerque, Socorro, Los Alamos, and vicinity are given in von Buttlar and Wendt (1958), Rabinowitz and Gross (1972), and Adam and others (1995).

Sulfur-34

No samples were collected for determination of the sulfur isotopic composition of sulfur in precipitation as a part of this study. However, Mast and others (2001) measured $\delta^{34}S$ of SO_4 in Rocky Mountain snowpacks at 52 high-altitude sites along the Continental Divide from northern New Mexico through parts of Montana. The average annual $\delta^{34}S$ values of snow were a function of latitude and ranged between values near +4 per mil in northern New Mexico to +8 per mil in central Wyoming, and then decreased through northern Wyoming into Montana. In parts of northern

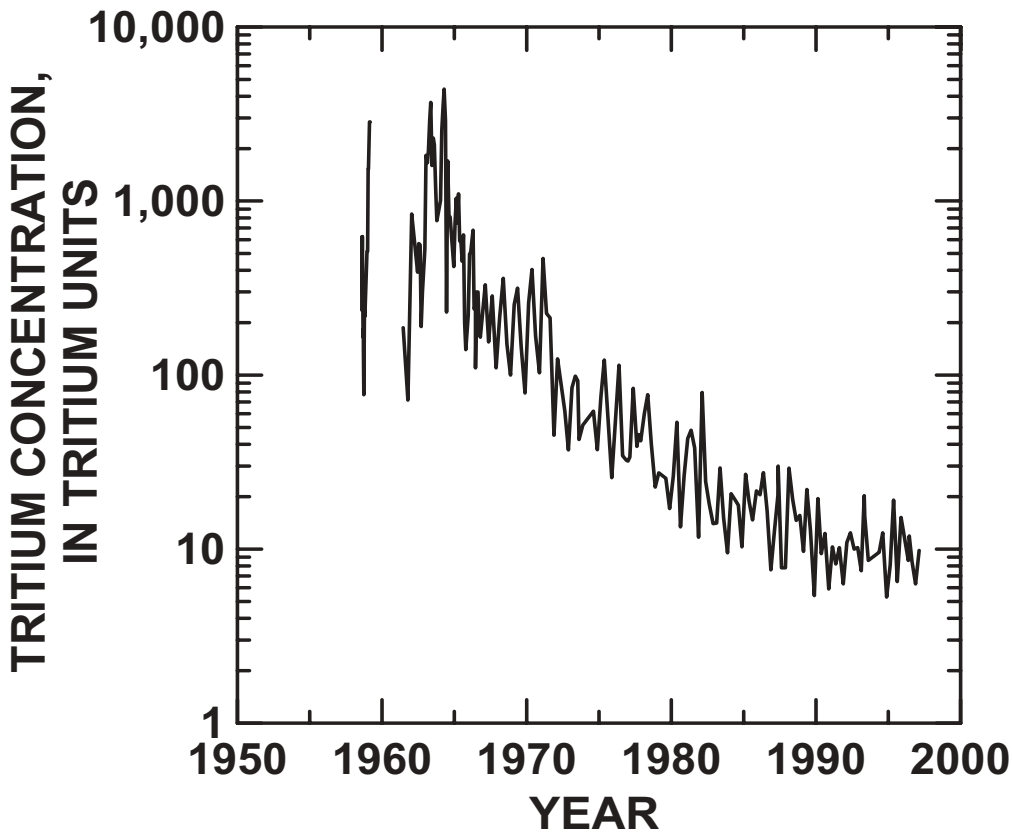


Figure 21. Tritium concentration in precipitation at Albuquerque, New Mexico, 1960-97 (International Atomic Energy Agency, 2001).

New Mexico and southern Colorado, $\delta^{34}S$ of S in snowpack averaged +4.4 ± 0.7 per mil between 1993 and 1999 (Mast and others, 2001). The averaged values of $\delta^{34}S$ reported by Mast and others (2001) are in agreement with earlier measurements of $\delta^{34}S$ of SO_4 in snow and wetfall from other high altitude parts of the Rocky Mountains (Turk and others, 1993; Finley and others, 1995), and from other parts of North America (see Jamieson and Wadleigh, 2000, and references therein).

Surface Water

Inorganic Chemical Composition

Chemical data are available from both the NWIS database and recent sampling through the MRGB study for surface water in several streams that could potentially contribute recharge to the Santa Fe Group aquifer system. Chemical analyses and their associated discharge data were used to calculate discharge-weighted mean compositions from the NWIS data for selected sites (table 4). Discharge data were not collected in association with the MRGB samples, and in many cases such data were not available from other sources. Therefore, median values were tabulated from the MRGB data, without considering discharge.

The dissolved solute content of surface water in the Rio Grande is relatively dilute compared to water in many other streams of the basin (table B2, table 4) (Bexfield and Anderholm, 1997). NWIS data for the Rio Grande at San Felipe (site SW8 in fig. 17a;) and Rio Grande at Albuquerque (site SW9 in fig. 17b) yielded discharge-weighted average specific conductance values of 297 and 323 µS/cm, respectively. MRGB data yielded a median specific conductance value of 360 µS/cm for a site located on the Rio Grande near the north end of Albuquerque at Alameda Blvd. (site S300 in fig. 11b). Discharge-weighted average ratios of SO_4 to Cl concentrations (in meq/L) from NWIS are 7.7 at San Felipe and 4.7 at Albuquerque; the median ratio value for the MRGB site is 3.7. The typical ratio for precipitation (5.2), therefore, falls within the range obtained for sites on the Rio Grande.

Discharge-weighted average ratios of Ca to Na concentrations (in meq/L) from NWIS are 2.3 at San Felipe and 1.9 at Albuquerque; the median ratio value for the MRGB site is 2.1. These ratios differ substantially from the typical ratio for precipitation (9.6). As part of the MRGB study, riverside drains and an irrigation canal also were sampled regularly. Median values of nearly all chemical constituents for water at these sites differed only minimally from the median values for water in the Rio Grande.

The chemical composition of water in the Jemez River can differ substantially between a site several miles north of the MRGB, in the Jemez Mountains, and a site just below Jemez Canyon Dam, near the conflunce of the Jemez River with the Rio Grande. NWIS data for the Jemez River at Jemez (site S298 in fig. 11a) and below Jemez Canyon Dam (site S297 in fig. 11a) yielded discharge-weighted average specific conductance values of 233 and 528 µS/cm, respecively. MRGB data yielded median specific conductance values of 455 µS/cm for the site near Jemez and 937 µS/cm for the site below Jemez Canyon Dam. Between these two sites, the Jemez River receives mineralized flow from the Rio Salado; also, evapotranspiration, including in the Jemez Canyon Reservoir, and diversions for irrigation probably affect the chemical composition of water in the river. Discharge-weighted average ratios of SO_4 to Cl concentrations from NWIS are 0.4 at Jemez and 1.2 below the dam; the median ratio value for the MRGB site at Jemez is 0.2 and below the dam is 0.9. These ratios differ substantially from the typical ratios for precipitation and for the Rio Grande. Discharge-weighted average ratios of Ca to Na concentrations (in meq/L) from NWIS are 1.8 at Jemez and 0.7 below the dam; the median ratio value for the MRGB site at Jemez is 1.1 and below the dam is 0.6. These ratios also differ substantially from the typical ratio for precipitation.

Surface water in the Rio Puerco tends to be relatively mineralized compared to water in other streams of the MRGB. NWIS data for the Rio Puerco at Bernardo (site SW10 in fig. 17a) yielded a discharge-weighted average specific conductance value of 1,640 µS/cm. MRGB data for a site about 28 miles upstream (site S307 in fig. 11a) yielded a median specific conductance value of 3,210 µS/cm. The discharge-weighted average ratio of SO_4 to Cl concentrations from NWIS for the site at Bernardo is 11.3; the median ratio from the MRGB site is 2.6. The ratios from these two different sources might differ substantially because the Rio Puerco flows at Bernardo less often than at the site upstream, and is most likely to flow when precipitation events have greatly increased runoff/discharge. The ratios for SO_4 to Cl in the Rio Puerco fall outside the annual ratio range for precipitation. The discharge-weighted average ratio of Ca to Na concentrations from NWIS data at Bernardo is 0.8; the median ratio value for the MRGB site is 0.5. These ratios differ substantially from the typical ratio for precipitation.

Data for Abo Arroyo in the southeastern part of the MRGB are limited to two samples collected for the MRGB study at a site located a few miles outside the basin margin (site S290 in fig. 11a). The median specific conductance value for these samples is 2,230 µS/cm. The median ratio of SO_4 to Cl concentrations is 17.3; the median ratio of Ca to Na concentrations is 2.4. Both of these ratios differ substantially from the typical ratios for precipitation.

Data are available for similar basin-margin locations on Tijeras Arroyo from both the MRGB study (site S312 in fig. 11b) and the NWIS database (site SW11 in fig. 17b). NWIS data for the arroyo yielded a discharge-weighted average specific conductance value of 847 µS/cm; MRGB data yielded a median specific conductance value of 997 µS/cm. The discharge-weighted average ratio of SO_4 to Cl concentrations from NWIS is 1.0, as is the median ratio from the MRGB study. The discharge-weighted average ratio of Ca to Na concentrations from NWIS is 3.0; the median ratio value for the MRGB study is 2.9. The ratios for SO_4 to Cl and Ca to Na in Tijeras Arroyo are substantially lower than the typical ratios for precipitation.

Data are available in NWIS for two samples from Galisteo Creek above the reservoir, located a few miles outside the northeast basin margin (site SW12 in fig. 17a). The discharge-weighted average specific conductance value for the two samples is 1,680 µS/cm. The discharge-weighted average ratio of SO_4 to Cl concentrations is 22, and of Ca to Na concentrations is 1.3. Both of these ratios differ substantially from the typical ratios of precipitation.

Oxygen-18 and Hydrogen-2

Measurements of the stable isotope composition of surface waters were made for the current investigation to determine if ground water with surface-water sources could be distinguished from other ground waters occurring in the MRGB on the basis of stable isotope composition.

Yapp (1985) presented a 3-year record (February 1980 - June 1983) of approximately monthly values of δ^2H for water samples from the Rio Grande collected at the Corrales Road Bridge on State Highway 46 (now Alameda Blvd.), near the subsequent MRGB site S300 (fig. 11b), averaging -92 per mil in δ^2H. The δ^2H composition of the Rio Grande varied seasonally, with the most depleted waters occurring in the months of May and June, coinciding with peak discharge from snowmelt from the higher altitude source waters for the Rio Grande in southern Colorado and northern New Mexico, and the most enriched waters occurring in the summer months, when the river contained discharge from summer thunderstorms. Even the lack of a depleted, spring snowmelt signal in waters in the Rio Grande in May-June 1981 coincided with climatic conditions in the previous winter when the snowpack in the headwaters region for the Rio Grande averaged about 50 percent below normal. It was concluded that seasonal differences in the δ^2H composition of the Rio Grande were a function of snowpack thickness from the previous winter combined with variations in melting rate and amount of local summer precipitation. During the period October 1980 through October 1982, the δ^2H composition of water from the Rio Grande ranged from -103 to -79 per mil. Yapp (1985) showed that water from the Rio Grande at Albuquerque was, on average, more depleted in δ^2H than either yearly averaged precipitation at Albuquerque or mountain-front recharge from the Sandia and Monzano Mountains at Albuquerque.

Values of δ^2H in water from the Rio Grande from 1980 through 1983 (C. Yapp samples re-analyzed by the USGS Stable Isotope Laboratory) are compared with δ^2H values in Rio Grande water collected as a part of this study (1996-1999) and also analyzed by the USGS Stable Isotope Laboratory in figure 22. The validity of the stable isotope data obtained from the

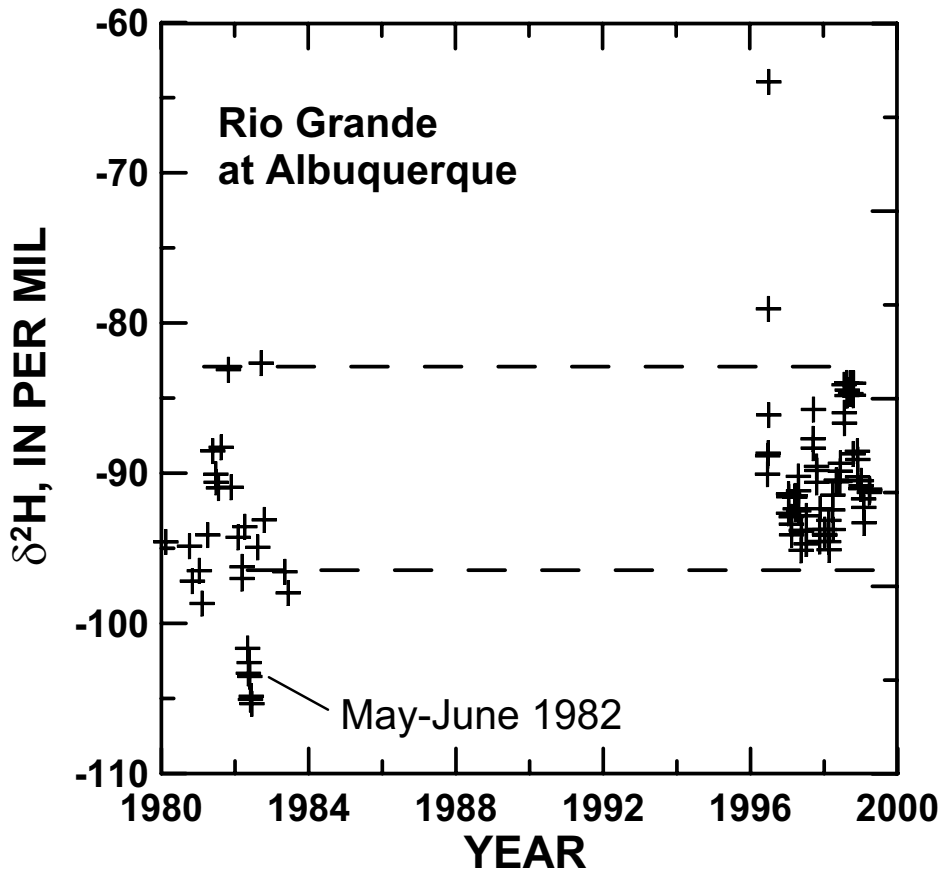


Figure 22. Comparison of δ^2H isotopic composition of Rio Grande water from 1980 through 1983 (C. Yapp samples re-analyzed by the USGS Stable Isotope Laboratory) with Rio Grande water collected as a part of this study (1996-99). The horizontal dashed lines bracket the range of most values of δ^2H of Rio Grande collected between 1996 and 1999, which were more enriched in ^2H than some Rio Grande water samples from 1980 to 1983.

re-analyzed, archived samples is given in the section "Hydrogen-2 and Oxygen Isotopes in Ground Water". Rio Grande water was apparently more depleted in ^2H in the early 1980's than the period 1997 through 1999. The average δ^2H value for Rio Grande water from the early 1980's was -95.5 per mil, and from 1997 through 1999 was -89.9 per mil. The stable isotopic composition of Rio Grande water is in part a function of the amount of snowfall from the previous winter in source-water areas for the Rio Grande in southern Colorado and northern New Mexico. The most depleted water in the Rio Grande averaged -103.7 per mil during the annual peak runoff of May-June 1982. The stable isotopic composition of Rio Grande water is also affected by evaporation (Phillips and others, 2003), which causes some enrichment in ^2H and ^{18}O, and by inflow from tributaries and ground water along gaining reaches of the river. Although water in the Rio Grande was more enriched in stable isotope composition during the mid- to late-1990's relative to the early 1980's, the isotopic composition of the Rio Grande also varied seasonally during the mid- to late-1990's, with most enriched water occurring during low-flow conditions in late summer and early fall, and most depleted water occurring in winter and early spring (fig. 23). The isotopic composition of water in the drains and canals along the Rio Grande closely follows the isotopic composition of the Rio Grande (fig. 23). Samples from other surface-water sites show small but consistent seasonal patterns in stable isotopic composition that mimic the seasonal pattern of the Rio Grande. These include streams that contain runoff from mountain-front areas, such as Tijeras Arroyo and Jemez River at Jemez (fig. 23).

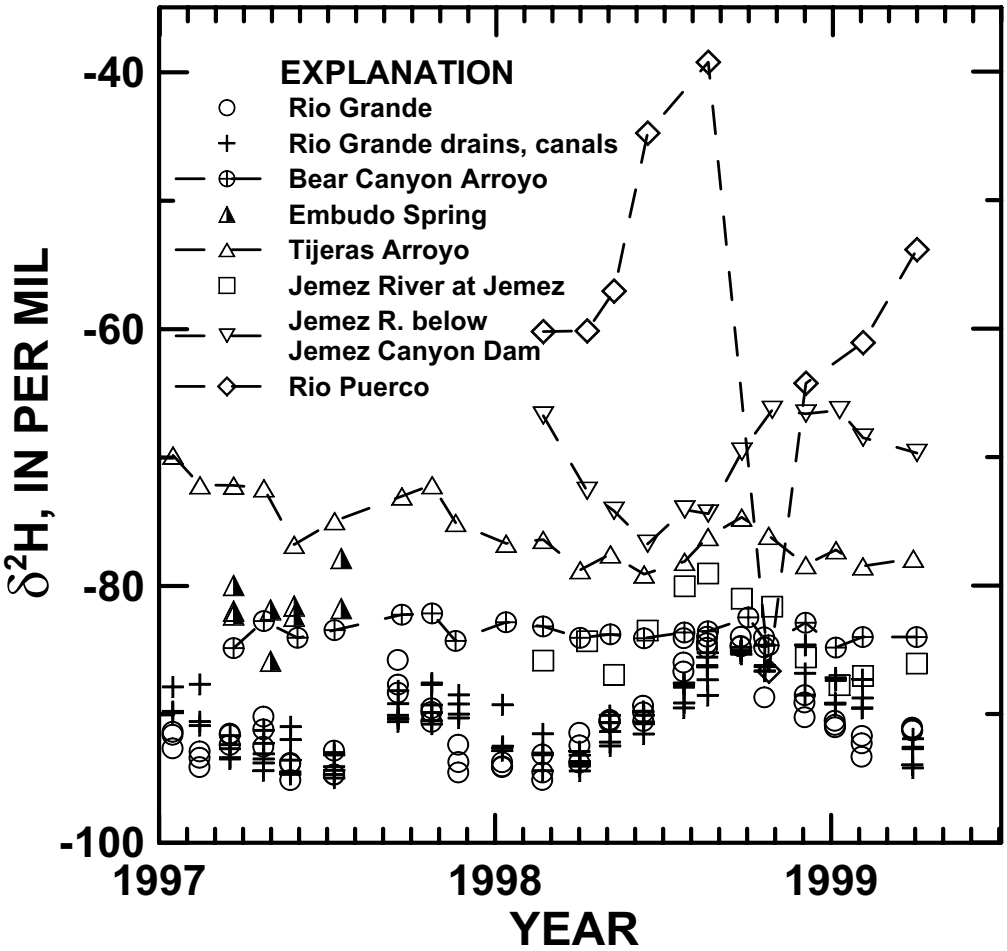


Figure 23. Comparison of monthly values of δ^2H in surface waters from the Middle Rio Grande Basin, New Mexico, 1997-99.

Table 5. Average stable isotopic composition of surface waters from the Middle Rio Grande Basin, New Mexico

[‰, per mil]

Source	Period of record	Number of samples	Average δ^2H ‰	Standard deviation	Average $\delta^{18}O$ ‰	Standard deviation	Average ^2H excess ‰	Standard deviation
Rio Grande	1980-83	29	-95.5	6.1	-12.7	0.9	5.8	2.2
Rio Grande	1996-99	72	-89.9	4.6	-12.0	0.6	6.2	1.4
Rio Grande Drains and Laterals	1996-99	110	-90.2	2.9	-12.1	0.4	6.4	1.2
Bear Canyon Arroyo	1996-99	20	-83.5	0.9	-11.8	0.1	11.0	1.0
Embudo and Embudito Sprs.	[1] 1997	11	-81.8	1.9	-11.4	0.3	9.7	1.0
Tijeras Arroyo	1996-99	22	-75.7	2.6	-10.5	0.4	8.3	1.0
Jemez River at Jemez	1998-99	12	-84.1	3.0	-11.7	0.5	9.3	2.0
Rio Puerco at Hwy. 6	1998-99	9	-58.6	13.3	-6.9	2.7	-3.4	10.5
Abo Arroyo	1997	2	-59.2	5.6	-8.3	1.0	7.1	2.2

[1]Includes 2 samples for 1983 (C. Yapp).

Average and standard deviations of δ^2H, $\delta^{18}O$, and $^2H_{excess}$ are summarized in table 5 for surface waters in the MRGB. Although isotopic composition varies with season, water from the Rio Grande is typically more depleted in ^2H and ^{18}O than water from Tijeras Arroyo. Yapp (1985) also found that Tijeras Arroyo had a δ^2H composition near -70 per mil. The most enriched surface waters sampled in the MRGB are those from Abo Arroyo in the southeast part of the basin and water from the Rio Puerco (table 5).

Over the sampling period, the deuterium excess, $^2H_{excess}$, averaged about 6 per mil for water in the Rio Grande. Apparently, there is some temporal variability in the $^2H_{excess}$ of water from the Rio Grande. Between January 1997 and March 1999, the $^2H_{excess}$ of Rio Grande water peaked near 8 per mil in winter 1998 and was as low as 4 per mil in winter 1997.

Values of δ^2H and $\delta^{18}O$ for all surface water samples from the MRGB, including samples from some mountain-front streams discussed in the next section are compared in figure 24. Excluding samples from the Jemez River below Jemez Canyon Dam and samples from the Rio Puerco that appear evaporated, the rest of the surface-water samples are correlated along the line

$$\delta^2H = 8.15\ \delta^{18}O + 9.0 \quad . \qquad (17)$$

Apparently, most surface waters in the MRGB plot close to the global meteoric water line (fig. 24), and have isotopic compositions similar to that of local precipitation at Albuquerque (eq. 14). The samples from the Rio Grande, Jemez River, Tijeras Arroyo, and Bear Canyon Arroyo do not indicate isotopic compositions that have been appreciably affected by evaporation.

Tritium

Tritium concentrations were determined approximately monthly in selected surface-water sources in the MRGB between January 1997 and February 1998. Most of the samples are from the Rio Grande and associated drains and canals in the vicinity of Albuquerque (See appendix B, table B9) (figs. 11b and 17b). Two other sites sampled approximately monthly for tritium are Tijeras Arroyo at Four Hills Rd. and Bear Canyon Arroyo (sites S312 and S292, respectively, fig.11b). A few other tritium samples were analyzed from the Rio Puerco at Highway 6 (site S307, fig. 11a), the Jemez River at Jemez (site S298, fig. 11a), and Abo Arroyo (site S290, fig. 11a). Tritium values in the selected surface-water sites are compared with tritium in precipitation at Albuquerque in figure 25. Several patterns are evident. First, the strong seasonal cycle in tritium in precipitation, associated with the “spring high” is apparent. Elevated tritium concentrations in precipitation from spring into early summer are usually attributed to the spring rise of the tropopause (Rozanski and others, 1991; Doney and others, 1992), which results in some exchange of stratospheric tritium with moisture in the troposphere.

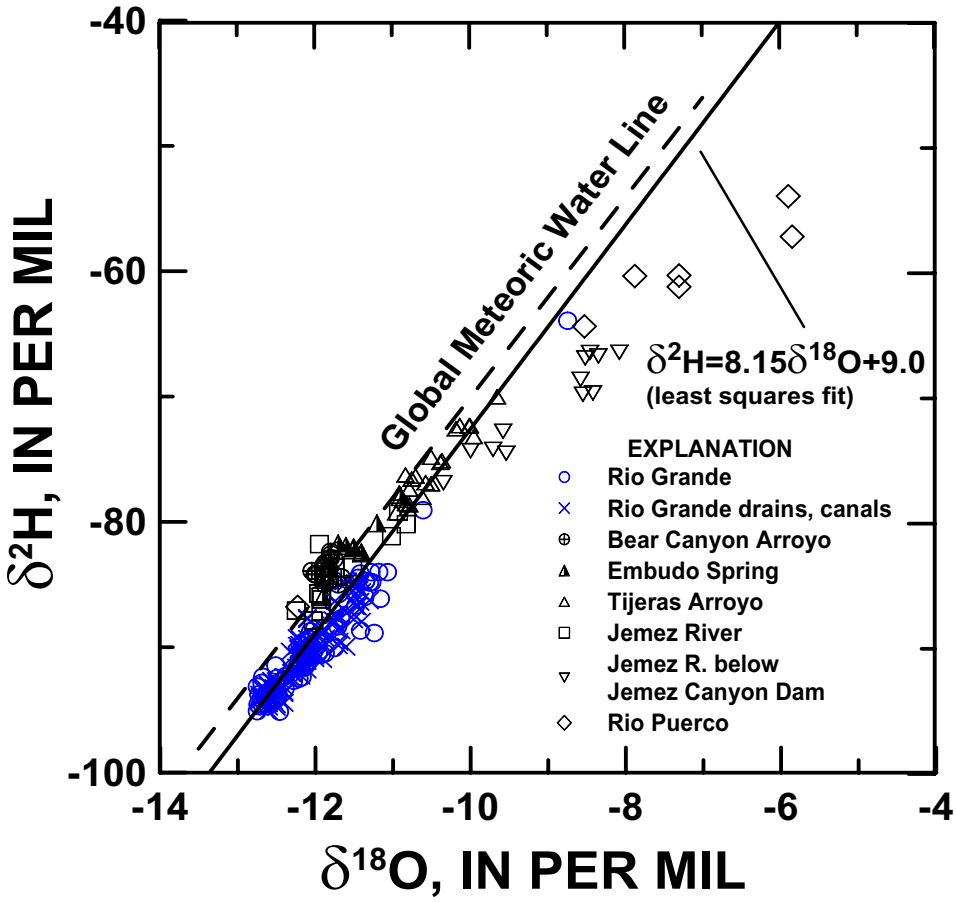


Figure 24. Relation between δ^2H and $\delta^{18}O$ isotopic composition of surface waters in the vicinity of Albuquerque, New Mexico.

Elevated tritium concentrations are apparent in spring runoff from Bear Canyon and from the Rio Grande (fig. 25), but are not clear in data from Tijeras Arroyo.

The seasonal signal of tritium in the Rio Grande may also reflect increased tritium associated with melting of winter snow pack in the southern Rocky Mountains. Because of a latitudinal effect, moisture falling in the southern Rockies should be elevated in tritium concentration relative to that of moisture falling at Albuquerque. Latitudinal gradients of tritium concentration in precipitation have been evaluated by Rozanski and others (1991) and can be used to estimate the average tritium in precipitation in recharge areas for the MRGB north of Albuquerque. The average latitudinal variation of log TU per degree of latitude in the northern hemisphere is approximately 0.023 log TU/degree latitude (Rozanski and others, 1991). Considering the latitudinal gradient, precipitation in the northern-most extent of the drainage basin for the MRGB, an area in the southern Rocky Mountains of southern Colorado located about 4 degrees latitude north of Albuquerque, should average about 11.2 TU relative to the average tritium content of precipitation at Albuquerque, 9.1 TU in 1997. If other factors such as variations in moisture sources are not significant, precipitation falling within the MRGB drainage between Albuquerque and its northern-most extent should range between 9.1 and 11.2 TU on average. The spring seasonal high in tritium concentration in Rio Grande water at Albuquerque probably reflects the combined effects of melting of snow pack from more northern sources and contributions from spring precipitation that is seasonally elevated in tritium concentration from stratosphere sources. In the period January 1997 through February 1998, tritium concentration in Rio Grande water at Albuquerque varied from 8 to about 11 TU, averaging about 9.2 TU. The average, standard deviation, and number of samples

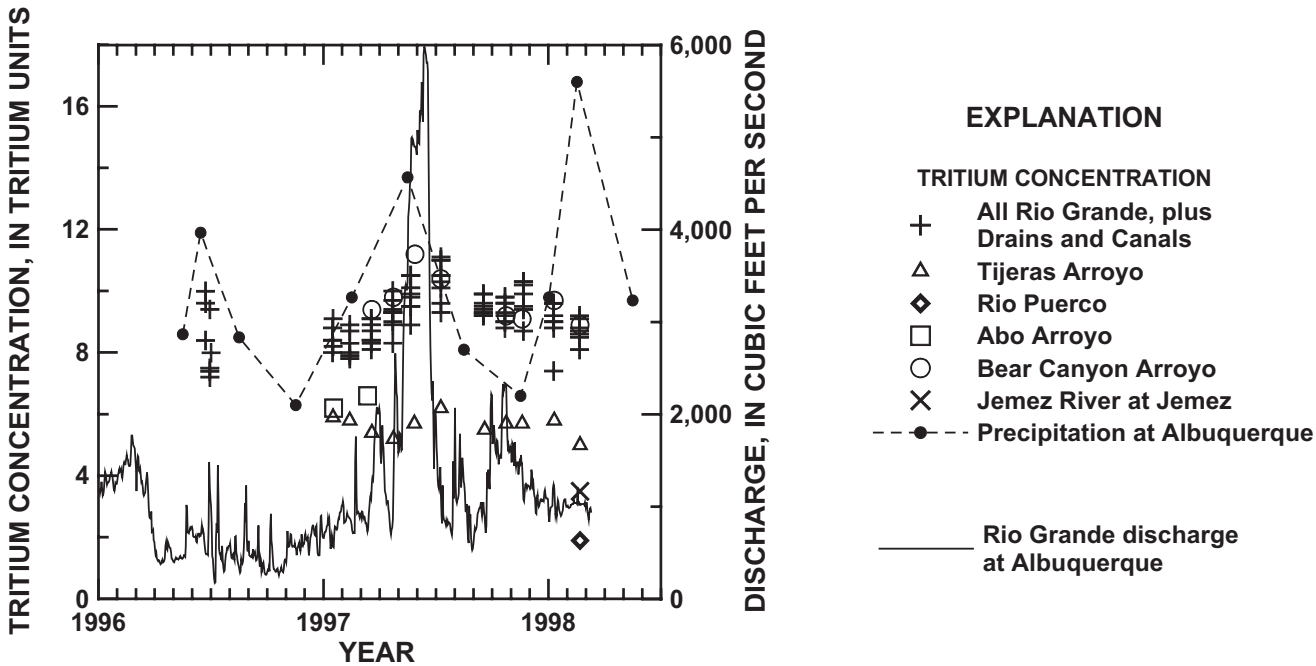


Figure 25. Tritium concentration in surface waters from the Middle Rio Grande Basin, New Mexico, in relation to tritium concentration in precipitation, 1996-98, and discharge of the Rio Grande.

analyzed for tritium from surface-water sites are summarized in table 6. In contrast to water from Bear Canyon and the Rio Grande and associated drains and laterals, the average tritium concentration in water from Tijeras Arroyo was only 5.6 ± 0.3 TU between January 1997 and February 1998 (table 6). Sparse data for other streams indicate appreciably lower tritium activity elsewhere in surface water of the MRGB (table 6). One sample from the Rio Puerco contained only 1.9 TU. Apparently, waters from the Jemez River, Tijeras Arroyo, Abo Arroyo, and the Rio Puerco contain significant fractions of pre-nuclear detonation (pre-1950's) water. In contrast, the Rio Grande apparently contains high fractions of recent runoff from the watershed, including a spring peak discharge dominated by melting of the snow pack in southern Colorado and northern New Mexico. Recent runoff from the Sandia Mountains at Albuquerque is apparently the dominant source for water in Bear Canyon Arroyo.

Sulfur-34

The isotopic composition of sulfur in SO_4, $\delta^{34}S$, was determined in 27 samples of surface waters from the MRGB. For the Rio Grande at Alameda Blvd. (S300 in fig. 11b), $\delta^{34}S$ of dissolved SO_4 averaged -1.8 ± 2.2 per mil in 14 approximately monthly samples collected between January 1997 and June 1998, with an average SO_4 concentration of 49 ± 9 mg/L. For the Rio Puerco at Highway 6, $\delta^{34}S$ of dissolved SO_4 averaged 1.8 ± 5.1 per mil in nine approximately monthly samples collected between February 1998 and April 1999, with an average SO_4 concentration of 1,100 ± 300 mg/L. For three samples from the Jemez River below Jemez Canyon Dam, $\delta^{34}S$ of dissolved SO_4 averaged 7.8 ± 0.8 per mil between February and June, 1998 in water that contained an average of 116 ± 34 mg/L SO_4. One sample from the Chamizal Lateral near Alameda Blvd. (SO_4 = 48.6 mg/L) had a $\delta^{34}S$ value of dissolved SO_4 of 8.25 per mil. As indicated by the high standard deviation, $\delta^{34}S$ of dissolved SO_4 can be variable in water from the Rio Grande and especially the Rio Puerco.

Seasonal variations in $\delta^{34}S$ of dissolved SO_4 for the Rio Grande, the Rio Puerco, and the Jemez River in relation to discharge of the Rio Grande at Albuquerque are shown in figure 26. Both the Rio Grande and the Rio Puerco contain SO_4 that is more depleted in ^{34}S in the spring-early summer than at other times of the year.

Table 6 Average tritium activity in surface water, Middle Rio Grande Basin, New Mexico, January 1997 through February 1998

[TU, Tritium Unit]

River Source [1]	Site number	Average Tritium concentration (TU)	Standard deviation (TU)	Number of samples
Bear Canyon Arroyo	S292	9.7	0.8	8
Chamizal Lateral at Alameda Blvd	S294	9.6	0.7	6
West Riverside Drain at Rio Bravo Blvd	S313	9.5	0.5	9
Riverside Drain at Campbell Rd.	S309	9.3	0.8	11
Rio Grande at Campbell Rd.	S301	9.2	0.8	11
Rio Grande at Alameda	S300	9.2	1.1	13
Alameda Drain at Alameda Blvd	S291	9.2	0.6	4
Riverside Drain at Rio Bravo Blvd	S310	9.1	0.5	11
Rio Grande at Rio Bravo Blvd	S303	9.1	1.1	12
Riverside Drain at Alameda Blvd	S308	9.0	0.5	11
Jemez River below Jemez Canyon Dam	S297	6.5	0.4	1
Abo Arroyo	S290	6.4	0.3	2
Tijeras Arroyo at Four Hills	S312	5.6	0.3	11
Jemez River at Jemez	S298	3.5	0.3	1
Rio Puerco at Hwy 6	S307	1.9	0.3	1

[1]See appendix B

For example, the sulfur isotopic composition of SO_4 varied from + 6.3 per mil (February 1999) to - 8.3 per mil (May 1998) in the Rio Puerco, and from + 1.3 per mil (March 1997) to - 5.3 per mil (May 1997) in the Rio Grande at Alameda Blvd.

Seasonal data on δ^2H, $\delta^{18}O$, and ^3H in water from the Rio Grande (see above) indicate that the peak seasonal discharge of the Rio Grande in the period (April) May - June is dominated by water from melting of the winter snowpack in parts of southern Colorado and northern New Mexico. Although peak spring discharge of the Rio Grande and Rio Puerco can be dominated by high-altitude runoff, the sulfur isotopic data indicate that the runoff must contain contributions of sulfur from other sulfur source(s) that are, on average, depleted in ^{34}S relative to that of precipitation within the Rio Grande and Rio Puerco watersheds. Turk and others (1993) found that some lakes in the Rocky Mountains also contained SO_4 depleted in ^{34}S relative to that of precipitation and attributed the depletion to weathering (oxidation) of sulfide minerals. It is likely that the depletion in ^{34}S of SO_4 in peak spring discharge on the Rio Grande and Rio Puerco reflects weathering of sulfide minerals within their drainage basins.

If mountain-front ground water in the vicinity of the MRGB is dominated by atmospheric sulfur sources (average $\delta^{34}S$ of atmospheric S near 4.4 per mil, Mast and others, 2001), and there are no additional sulfur sources or sinks, such as through sulfide-mineral oxidation or SO_4 reduction, it may be possible in some cases to distinguish mountain-front recharge from ground water derived from the Rio Grande (average $\delta^{34}S$ near -2 per mil) on the basis of the sulfur isotopic composition of the dissolved SO_4.

Mountain-Front Ground Water

Inorganic Chemical Composition

Along mountainous basin margins, ratios of major cations and anions in both surface water in streams and ground water tend to reflect the inorganic chemical ratios found in precipitation. MRGB data from a mountain-front stream, Bear Canyon Arroyo

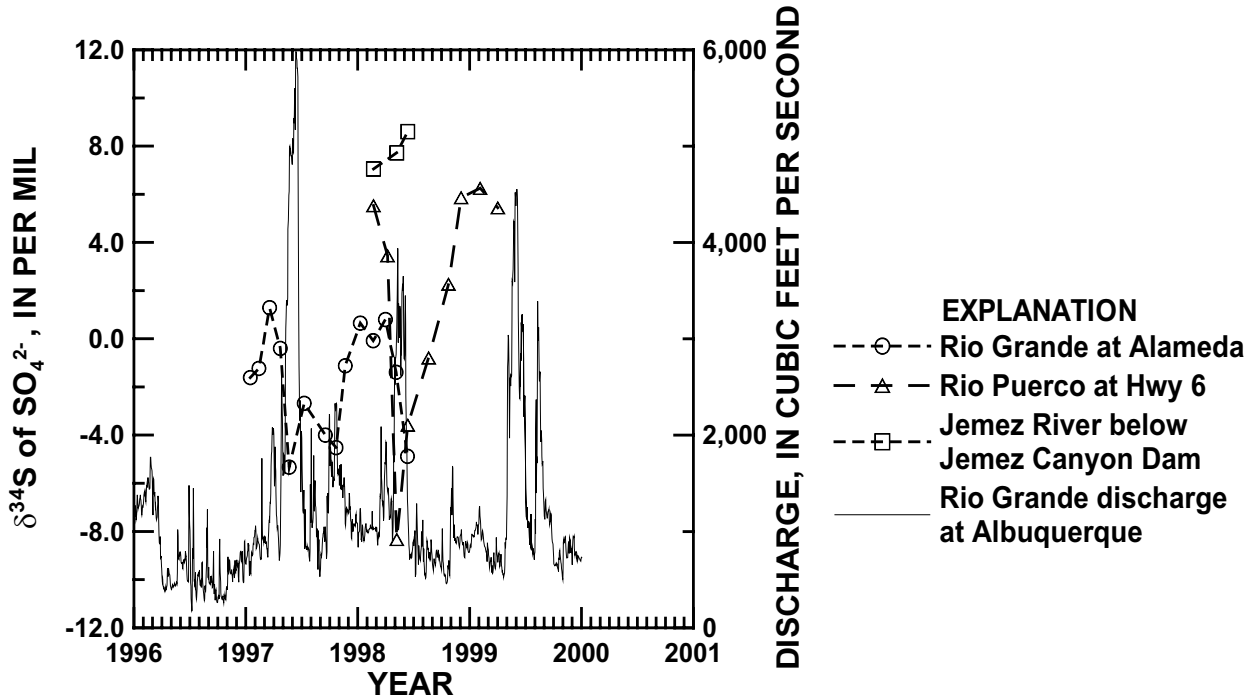


Figure 26. Stable S isotopic composition, $\delta^{34}S$, of sulfate in surface waters of the Middle Rio Grande Basin, New Mexico, 1997-99, in relation to discharge of the Rio Grande at Albuquerque.

(site S292 in fig. 11b), yield a median ratio (in meq/L) of 5.8 for SO_4 to Cl concentrations and of 6.2 for Ca to Na concentrations, both of which fall within the range of annual ratios obtained from chemical data for precipitation (table 4). The median specific conductance value of 477 µS/cm, however, indicates that substantial evapotranspiration has occurred relative to precipitation. Based on an event-weighted average Cl concentration of 0.21 mg/L in precipitation and a median Cl concentration of 5.1 mg/L in Bear Canyon Arroyo, surface water in the arroyo represents precipitation that has been evaporated to the extent that Cl has been concentrated by a factor of about 24. Two MRGB ground-water samples (NM002 and NM042; table A2) collected from wells near the eastern mountain front yield ratios of 4.8 and 4.7 for SO_4 to Cl concentrations and of 5.9 and 5.5 for Ca to Na concentrations, respectively. Again, these ratios are similar to those of modern precipitation, but may reflect a slight shift in precipitation chemistry through time or geochemical reactions occurring in the soil zone or aquifer. The Cl concentrations of 6.5 and 7.0 in water from these wells reflect an evaporation factor of about 30 relative to precipitation.

Oxygen-18 and Hydrogen-2

Yapp (1985) found that recharge from the Sandia Mountains east of Albuquerque, obtained from an arroyo in Bear Canyon and Embudo Spring in Embudo Canyon, ranged from -80 to -83 per mil in δ^2H. Samples obtained for this study from similar sites (tables A9, B6) support Yapp's conclusion that water derived from the Rio Grande should, on average, be depleted in ^2H by at least 10 per mil relative to average recharge from the Sandia Mountain front at Albuquerque. Other data indicate that mountain-front waters from northern margins of the basin have similar isotopic composition to that from the Sandia and Manzano Mountains near Albuquerque (Vuataz and Goff, 1986; Anderholm, 1994).

Tritium

Tritium concentrations are near values for modern precipitation in ground water along the eastern mountain front. Nine water samples from Embudo (S057) and Embudito (S056) springs, located just outside of the MRGB in the Sandia Mountains east of

Albuquerque, had tritium concentrations between 10.0 and 11.0 TU in April through July 1997. A water sample from Tunnel spring (site S256, NM169) in June 1996 contained 12.2 TU and water samples from private production wells in the Sandia Mountains east of the basin boundary (sites S249-S251, NM163, NM165, NM166, respectively, table A11) contained 10.6, 0.9, and 9.6, TU in June 1996. Water from a domestic well in Bear Canyon (S007, NM002) contained 10.6 TU in June 1996 and water at the base of the Sandia Mountains on the east edge of Albuquerque (S229, NM515) had a tritium concentration of 8.3 TU in July 1998. During the period 1996 through 1997, precipitation at Albuquerque averaged 9.9 ± 3.1 TU, with the highest tritium concentrations occurring in spring-early summer precipitation.

Ground-water samples containing more than 0.2 TU always contained detectible concentrations of chlorofluorocarbons, especially CFC-12. The mountain-front ground-water samples containing appreciable concentrations of tritium also contained 137 to 1,100 pg/kg of CFC-12. As a means of detecting recently recharged water or water samples containing fractions of young water, samples for chlorofluorocarbon analysis were routinely collected wherever a closed path could be established between the source and the sampling equipment. Samples where CFCs were not collected included some seeps, wells, and windmills that, for various reasons, introduced air into the sample prior to discharge. For these samples, tritium was routinely measured. Because of the low detection limit for CFCs and the stability of CFC-12, CFC-12 provided a useful tracer of young water (post-1940's water) or of samples containing a fraction of young water. The absence of CFC-12 and/or tritium provided a useful criterion for identifying water samples in which the ^{14}C activity had not been contaminated with ^{14}C from atmospheric testing of nuclear bombs.

Sulfur-34

Five ground-water samples in which $\delta^{34}S$ of SO_4 was measured are probably representative of modern mountain-front recharge. All samples are from the Sandia Mountains on the eastern margin of the Basin. These samples are from Embudo (S057) and Embudito (S056) springs (NM044, NM043, respectively), and private wells (sites S055, S249, S007, and samples NM042, NM163, NM002). The five samples have tritium concentrations from 7.8 to 10.8 TU, and CFC-12 concentrations from 207 to 886 pg/kg. The SO_4/Cl ratio (meq/meq) in the five mountain-front ground-water samples averaged 5.4 ± 2.3, with an average SO_4 concentration of 62 ± 32 mg/L. The sulfur isotopic composition, $\delta^{34}S$, of the dissolved SO_4 averaged 4.4 ± 1.1 per mil. Annual SO_4/Cl ratios (meq/meq) in precipitation from the NADP Cuba and Bandelier stations, and from the Sevilleta National Wildlife Refuge, were similar to that of the mountain-front ground-water samples, averaging 5.9 ± 0.9 with average SO_4 concentrations of 0.8, 0.7, and 1.4 mg/L, respectively, in the years 1989 through 1995, indicating an evapotranspiration factor in the ground water of more than 20-fold. The observed range in the average $\delta^{34}S$ of SO_4 in ground water from mountain-front areas, after concentration by evapotranspiration, is within the range of average $\delta^{34}S$ values of sulfur in SO_4 of snowpack from the Rocky Mountains of northern New Mexico and southern Colorado that averaged 4.4 ± 0.7 per mil between 1993 and 1999 (Mast and others, 2001), and is consistent with an atmospheric source.

Ground-Water Inflow

Inorganic Chemical Composition

Ground-water inflow appears to be an important source of recharge to the MRGB along the western margin and in the area of the Hagan Embayment (fig. 5). Historical NWIS data are available for several wells and springs located along the western margin of the basin. These data indicate that the chemical composition of ground-water inflow varies from north to south. From about the Rio Salado (the northern one that flows into the Jemez River) north (fig. 1), the available data for specific conductance range from about 530 to more than 11,000 µS/cm. The median ratio (in meq/L) of SO_4 to Cl concentrations is 0.56 and of Ca to Na concentrations is 0.28. Most of these samples are from the Triassic Chinle Formation or from Quaternary alluvium. From about the Rio San Jose north to the Rio Salado, the available data for specific conductance range from about 1,650 to 41,500 µS/cm. The median ratio of SO_4 to Cl concentrations is 1.2 (although it ranges as high as about 110) and of Ca to Na concentrations is 0.09. These samples are from Cretaceous, Jurassic, and Triassic rocks. From about the Rio San Jose south, the available data for specific conductance

range from about 3,000 to 45,000 µS/cm. The median ratio of SO_4 to Cl concentrations is 0.58 and of Ca to Na concentrations is 0.13. These samples are primarily from Permian and Pennsylvanian rocks.

NWIS ground-water samples for the area of the Hagan Embayment come from Quaternary and Cretaceous deposits. The median specific conductance value is 1,220 µS/cm. The median ratio of SO_4 to Cl concentrations is 3.5 and of Ca to Na concentrations is 1.1.

Oxygen-18 and Hydrogen-2

Stable-isotope data are limited for wells and springs located along the western margins of the basin. Data available from Goff and others (1983) for about five sites near the margins of the MRGB in the area of the Lucero Uplift indicate that δ^2H varies from about –83.6 to –63.8 per mil. Samples collected for the current MRGB investigation (NM265, NM330, NM335, and NM485 in table A9) indicate that δ^2H of water along the western margins typically ranges from about –65 to –60 per mil, although one sample had a value of –99.7 per mil. No stable isotope data are known to be available for waters located along the northeastern margin of the basin in the area of the Hagan Embayment.

Tritium

All indications are that inflow along the basin margins is old (10,000-year (10 ka) time scale) water and free of tritium, chlorofluorocarbons, and any other environmental tracer of anthropogenic origin. Although tritium was detected in water from a few wells in the southwest part of the basin, and in the northeast near the Hagan Embayment, the source can be attributed to surface water.

Sulfur-34

Dissolved SO_4 in water from seven wells completed in the Permian San Andres Limestone and/or Permian Glorieta Sandstone, located in an area within approximately 50 miles of the southwestern margin of the MRGB had an average $\delta^{34}S$ of 11.8 ± 0.6 per mil (Plummer, L.N. and Anderholm, S.K., U.S. Geological Survey, unpublished data, 1987). Ten samples of Permian anhydrite and gypsum from core and outcrop in the Glorieta Sandstone and San Andres Limestone from the vicinity of Mesa Lucero along the southwestern margin of the MRGB had an average $\delta^{34}S$ composition of 12.6 ± 1.3 per mil (Plummer, L.N. and Anderholm, S.K., U.S. Geological Survey, unpublished data, 1987). The observed sulfur isotopic composition of dissolved SO_4, anhydrite, and gypsum is typical of values reported for Permian evaporates of marine origin (Holser and Kaplan, 1966; Claypool and others, 1980).

The sulfur isotopic composition of sedimentary sulfides can vary widely, but when formed accompanying microbially mediated sulfate reduction, is almost always depleted in ^{34}S relative to the SO_4 source (see for example, Hoefs, 1987; Clark and Fritz, 1997). The kinetic fractionation between dissolved sulfate and hydrogen sulfide is typically from 20 to 30 per mil (Pearson and Rightmire, 1980; Rye and others, 1981; Habicht and Canfield, 1997; Plummer and others, 1990). Gautier (1987) gives extensive data on the sulfur isotopic composition of pyrite from North American Cretaceous shales.

CHEMICAL AND ISOTOPIC COMPOSITION OF GROUND WATER IN THE MIDDLE RIO GRANDE BASIN

Chemical and isotopic data for ground water of the MRGB were examined for relations and spatial patterns that could be useful in determining recharge sources, directions of ground-water flow, and geochemical processes. Areal distributions of water types and selected chemical and isotopic data are discussed in this section, as are the apparent relations among constituents. The hydrologic and geochemical implications of the observed data characteristics are presented. Saturation indices for selected minerals discussed below were calculated using the geochemical software package PHREEQC (Parkhurst, 1995), (table C4).

Because the majority of ground-water samples used in this investigation were obtained from wells that were drilled and operated to supply water to people or stock, or to monitor the quality of a municipal water resource, the available data are biased toward regions of the MRGB where water appropriate for these uses could typically be found. Nevertheless, overall spatial coverage of the basin is sufficient. Also, the data typically represent conditions in about the upper 1,750 feet of the saturated zone, and in many places in about the upper 600 feet of the saturated zone, so that the data probably are not representative of conditions in deeper parts of the aquifer system. Nevertheless, the data should provide an accurate picture of the part of aquifer system currently used as the primary ground-water resource.

Field Parameters

Ground water in the MRGB ranges from dilute to highly mineralized. Values of specific conductance vary within the basin from about 128 to 41,400 microsiemens per centimeter at 25°C (µS/cm). This parameter is conservative in that it is not expected to decrease as water moves down a ground-water flow path (unless mixing occurs with a large quantity of water of another source having a lower specific conductance), so that it can be useful in delineating areas of broadly similar ground-water chemistry. Contours of specific conductance in ground water of the MRGB (fig. 27) indicate that the highest values (greater than 2,000 µS/cm) typically occur near the western margin of the basin, where mineralized ground waters are believed to enter the basin from Paleozoic and Mesozoic rocks to the west. Values greater than about 1,000 µS/cm also are observed near the Hagan Embayment in the northeast part of the basin, near the Tijeras Fault Zone along the eastern margin, and at the southern end of the basin. The lowest values of specific conductance (less than 400 µS/cm) occur along parts of the northern and eastern mountain fronts, and in an area extending across Rio Rancho and Albuquerque in the north-central part of the basin. A small area of relatively low-conductance water (relative to other parts of the basin) is present near Ladron Peak in the southwestern part of the basin, where it is surrounded by much higher-conductance water.

Most ground water within the MRGB is slightly alkaline. Contours of pH (fig. 28) indicate that the highest values (greater than 8.0 standard units) are present across much of the western half of the basin. Values of 8.0 or more also are present across a large area in the southeast. Values of 7.5 or less occur along parts of the northern and eastern mountain fronts, near the Hagan Embayment, and in areas along Abo Arroyo and the Rio Puerco.

Dissolved-oxygen concentrations indicate that most ground water in the MRGB is oxidized. Concentrations greater than 2.0 mg/L are common in all parts of the basin except along the Rio Grande and part of the western margin, where concentrations typically are less than 0.5 mg/L (fig. 29). Concentrations also can be low in deeper wells, particularly west of the Rio Grande. Concentrations of greater than 5.0 mg/L are present along much of the northern and eastern mountain fronts, and across much of the western half of the basin.

Water temperatures at the depths sampled in the MRGB generally range between about 15 and 30°C. Most ground-water temperatures are warmer than the modern mean annual temperature at Albuquerque (13.6°C) (fig. 30), and indicate heating under the effect of the local geothermal gradient (Reiter, 2001). Water temperatures exceed 30°C in an area in the west-central part of the basin.

Water temperatures typically are less than 20°C along basin margins, along the Rio Grande, the Rio Puerco, and Abo Arroyo, and across the northernmost section of the basin (fig. 30). The lowest water

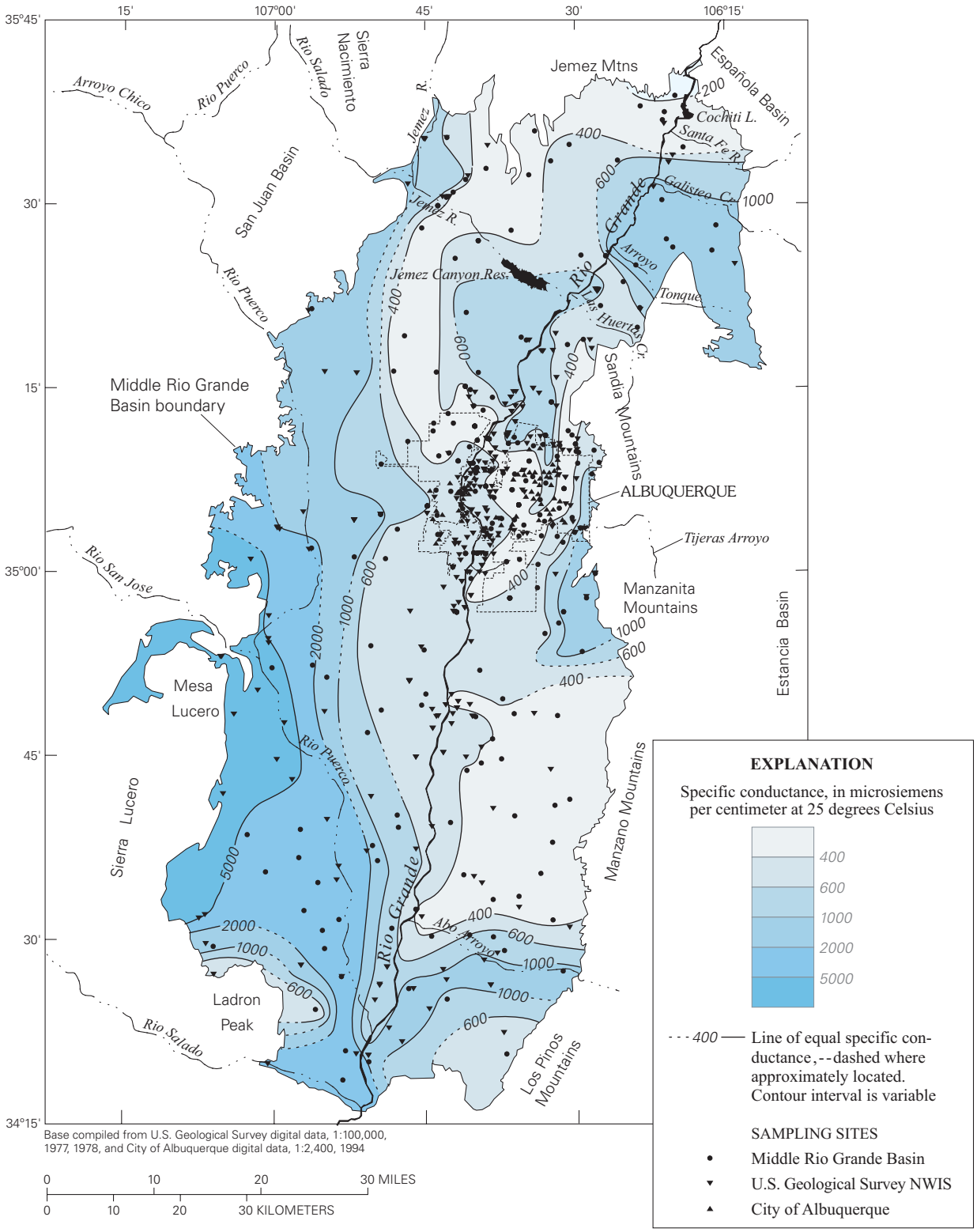


Figure 27. Specific conductance for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

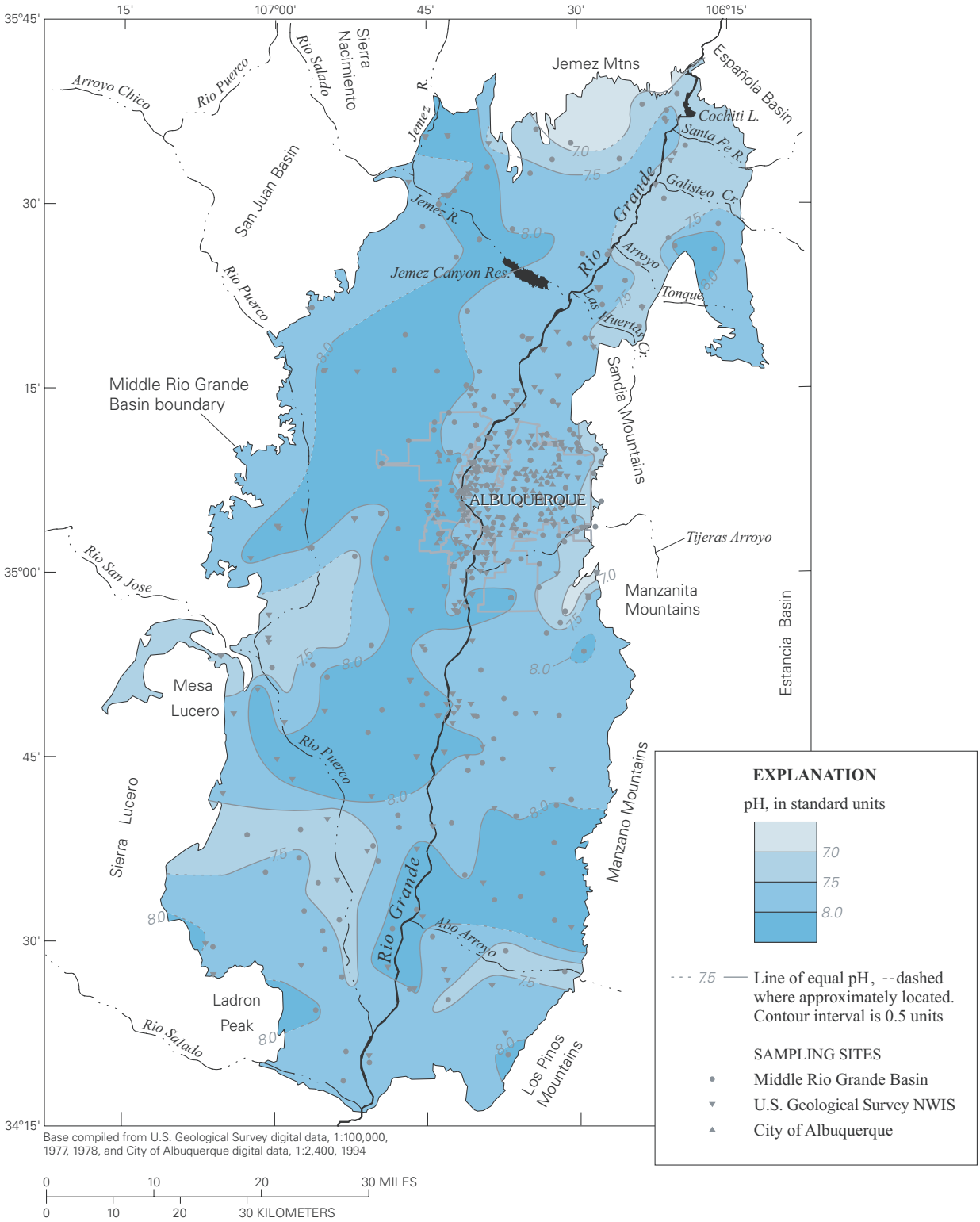


Figure 28. pH for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

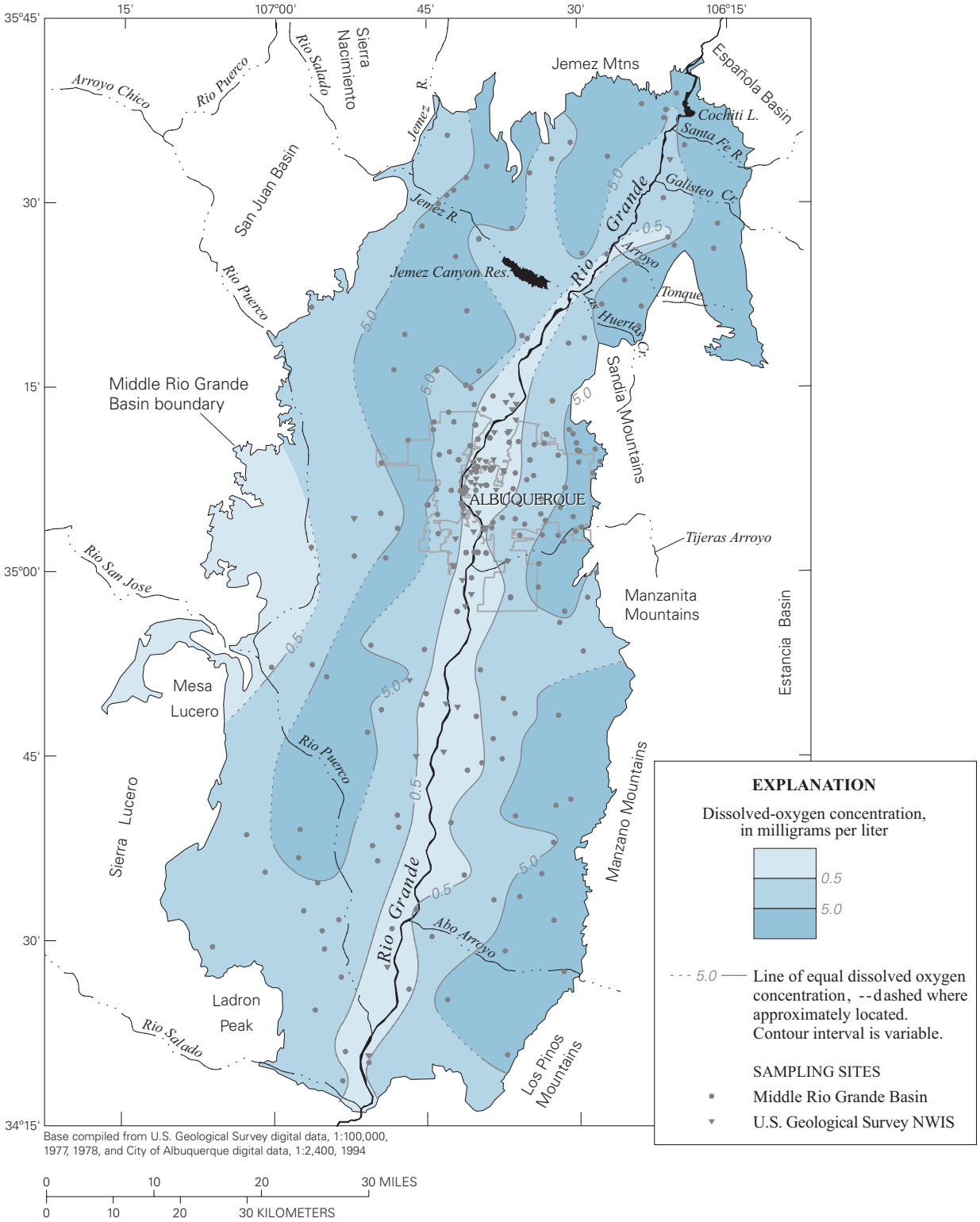


Figure 29. Dissolved-oxygen concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS--Data from the U.S. Geological Survey National Water Information System.

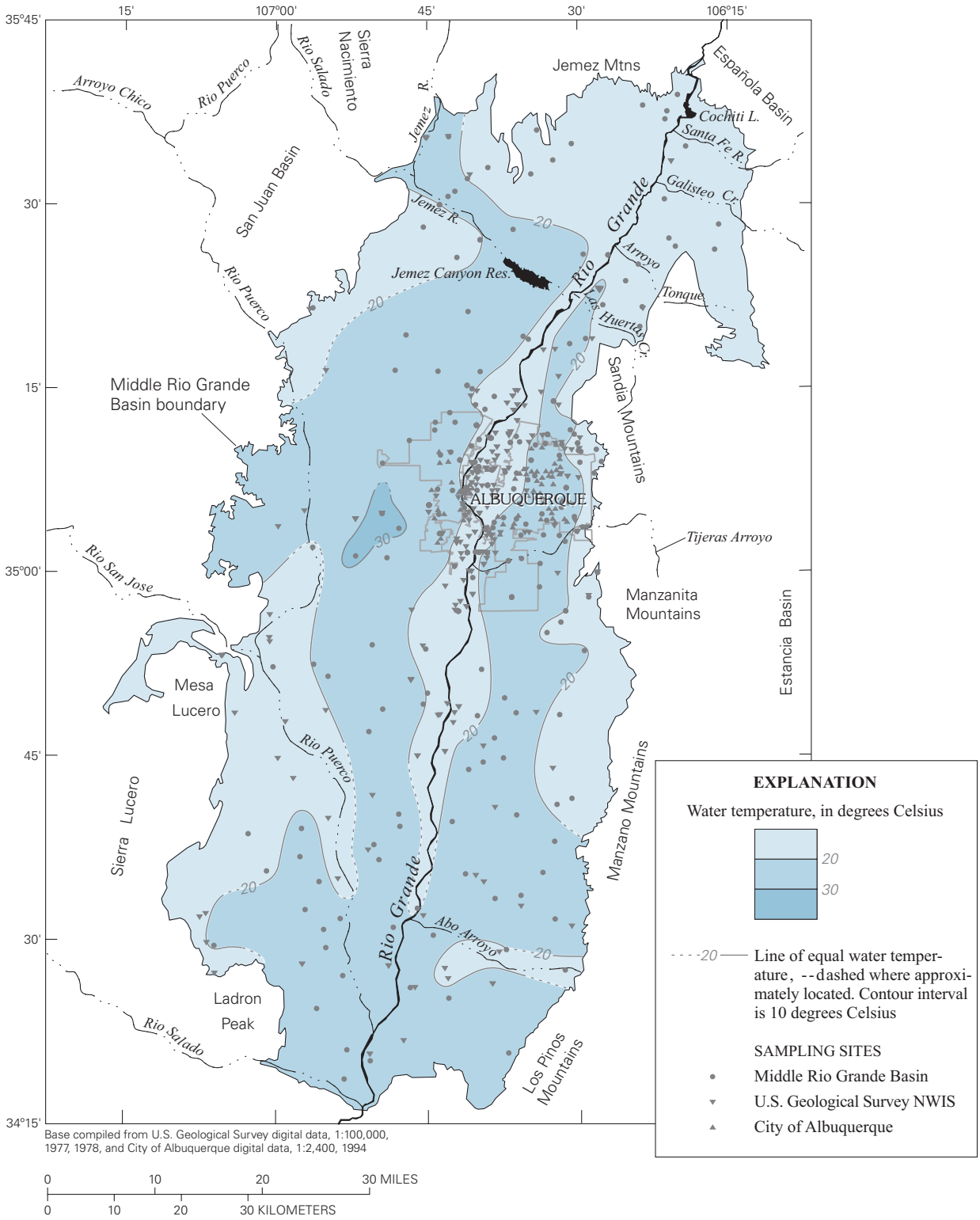


Figure 30. Water temperature for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System

temperatures are found in shallow water samples at relatively high altitudes, for example, discharge from Embudo and Embudito springs along the eastern mountain front above Albuquerque (altitudes of 6,600 and 6,440 feet above sea level, respectively) has water temperatures of 8-9°C.

Water Type

Broad differences in water quality among a group of samples can be observed by plotting their chemical compositions on a Piper diagram (fig. 31), which shows the relative proportion of the major ions present in the samples. Of the 12 possible water types (excluding the Mg-containing water types which do not occur in the basin), 11 are represented by waters from the MRGB— all but Ca/Cl waters. The most common water type among the samples analyzed is Ca / CO_3 + HCO_3, followed by Na + K / CO_3 + HCO_3 and Mixed-cation / CO_3 + HCO_3 (fig. 31). Because sample sites are not distributed evenly across the basin, the most common water type among the samples analyzed does not necessarily represent the most common water type by volume for ground water in the basin.

Different water types tend to group in distinct areas of the basin. With respect to cations, the Na + K type generally dominates west of the Rio Grande (except near the northern end of the basin), whereas the Ca type generally dominates east of the Rio Grande (fig. 32). Mixed-cation samples are relatively common near the Rio Puerco, in the southeastern part of the basin, and in some parts of Albuquerque. With respect to anions, the CO_3 + HCO_3 type dominates across much of the eastern and northern parts of the basin (fig. 32). The SO_4 type dominates in areas near Abo Arroyo and the Hagan Embayment, as well as across much of the western part of the basin; the mixed-anion type also is relatively common west of the Rio Grande. The Cl type occurs primarily in the southwestern part of the basin.

Major-Element Chemistry

Anions

The following sections present data on concentrations of chloride, sulfate, the ^{34}S isotopic composition of dissolved sultate, bicarbonate, the ^{13}C isotopic composition of bicarbonate, nitrate, dissolved nitrogen gas, and dissolved fluoride in ground water from the MRGB.

Chloride

Chloride typically is a conservative constituent in ground water. Contours of Cl concentration in the MRGB (fig. 33) indicate that concentrations of greater than 1,000 milligrams per liter (mg/L) occur along the western margin of the basin, south of the Rio San Jose. Concentrations of 50 mg/L or greater are present across much of the southwestern part of the basin and near the Tijeras Fault Zone. These concentrations also occur in isolated areas northwest of Bernalillo and in the northeastern part of Albuquerque. Chloride concentrations of less than 10 mg/L are present along much of the northern and eastern mountain fronts. These low concentrations also extend across large areas southward from the Jemez mountain front and westward from the Manzano mountain front.

In general, Cl concentrations in the basin likely reflect the amount of evapotranspiration that water has undergone during recharge through mountain-front areas or rivers/arroyos. However, in some parts of the basin, these concentrations appear to indicate mixing between local recharge and old, mineralized waters sourced from adjacent basins or from depth within the MRGB, such as from hydrothermal fluids (Rao and others, 1996). In the southwestern part of the basin, high Cl concentrations probably indicate Na-Cl brine entering the basin from Paleozoic rocks to the west. Near the Tijeras Fault Zone, high Cl concentrations could be associated with the leakage of mineralized waters upward and/or basinward along the major faults of the area. The anomalously high Cl concentrations near Bernalillo and in northeastern Albuquerque appear consistent with the upward movement of deep, mineralized waters along faults, or possibly over structural highs, as has been suggested by previous investigators (Anderholm, 1988; Trainer and others, 2000; Bexfield and Anderholm, 2002a; Bexfield and Plummer, 2002). Water-quality data collected from piezometer nests (discussed below) support the presence of more mineralized waters at depth in these areas.

Anderholm (2001) used Cl concentrations from ground water near the mountain front and from bulk precipitation to estimate the amount of mountain-front recharge along the eastern side of the basin. Results from this chloride mass-balance method (Dettinger,

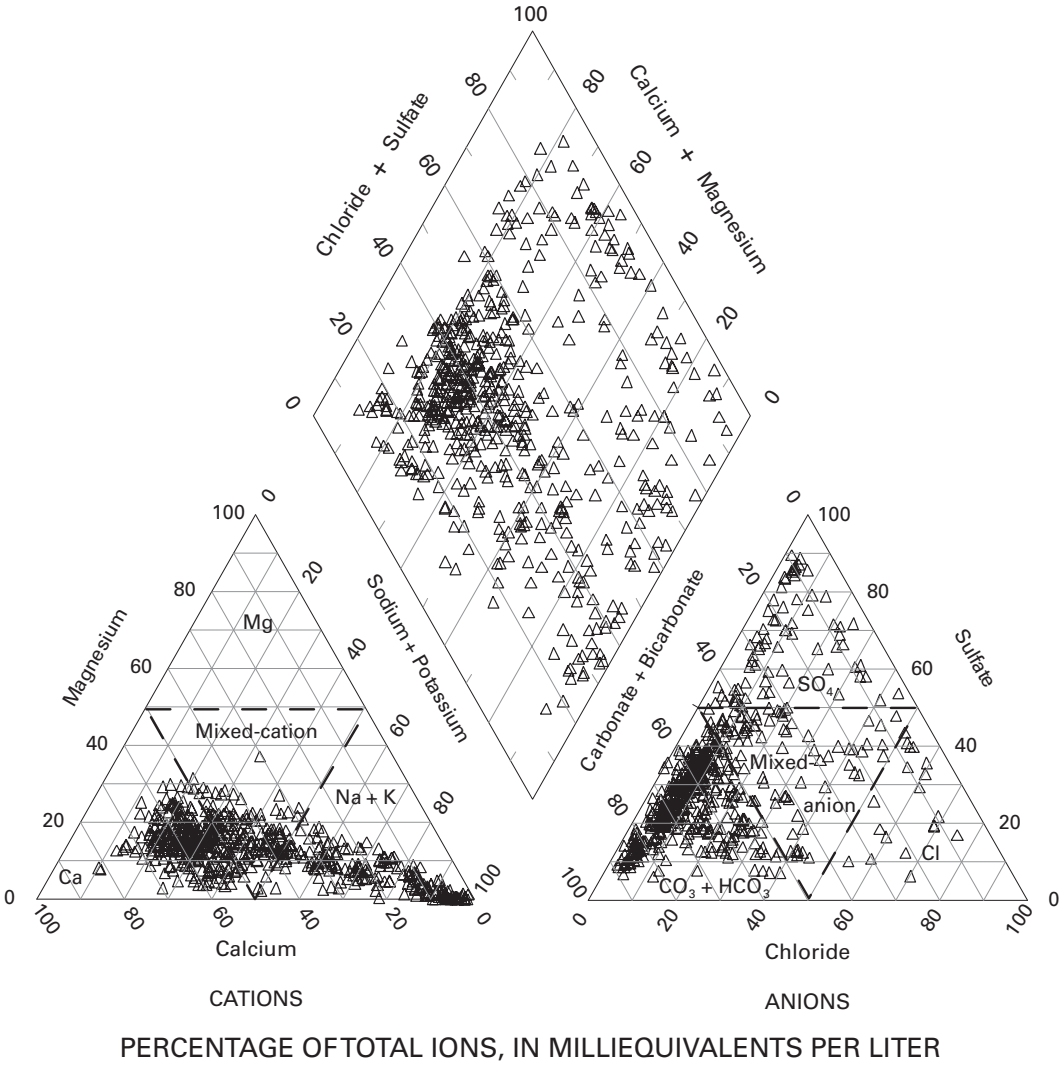


Figure 31. Piper diagram showing water types for all ground-water samples from the Middle Rio Grande Basin, New Mexico.

1989) yielded estimates of total mountain-front recharge along the eastern side of about 11,000 acre-feet per year, as opposed to estimates of about 36,000-38,000 acre-feet per year based on water-yield regression equations (Anderholm, 2001).

Sulfate and Sulfur-34 of Dissolved Sulfate

Although SO_4 concentrations are not necessarily conservative because of common rock-water interactions and biological processes, these concentrations indicate useful patterns in ground water of the MRGB. Contours of SO_4 concentration (fig. 34) show that the highest values (greater than 1,000 mg/L) tend to occur along the western margin of the basin and along much of the Rio Puerco. Concentrations of greater than 200 mg/L are present across much of the western and southern parts of the basin, as well as near the Hagan Embayment and the Tijeras Fault Zone. Concentrations of less than 50 mg/L are common along much of the northern and eastern mountain fronts and extend outward from these margins across substantial areas of the basin.

A map of the ratios of SO_4 to Cl concentrations (meq/L) shows that these ratios (unitless) exceed 10 in areas along part of the western margin, near the Hagan Embayment in the vicinity of Galisteo Creek, and near Abo Arroyo (fig. 35). As discussed above in the section on sources of water to the basin, ratios of this magnitude are consistent with infiltration through Abo

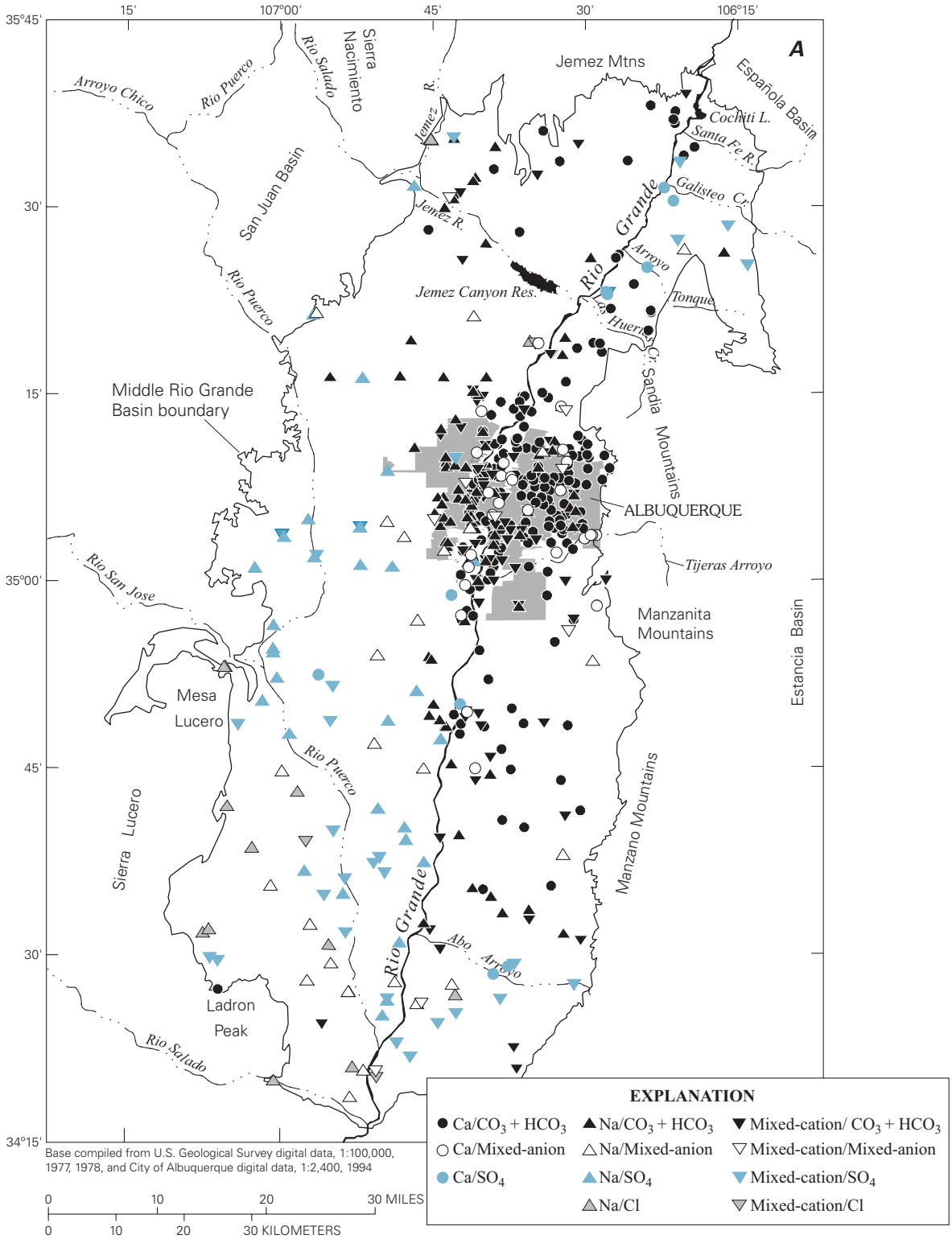


Figure 32a. Water types of ground-water samples throughout the Middle Rio Grande Basin. (Water types based on the Piper diagram of figure 31.)

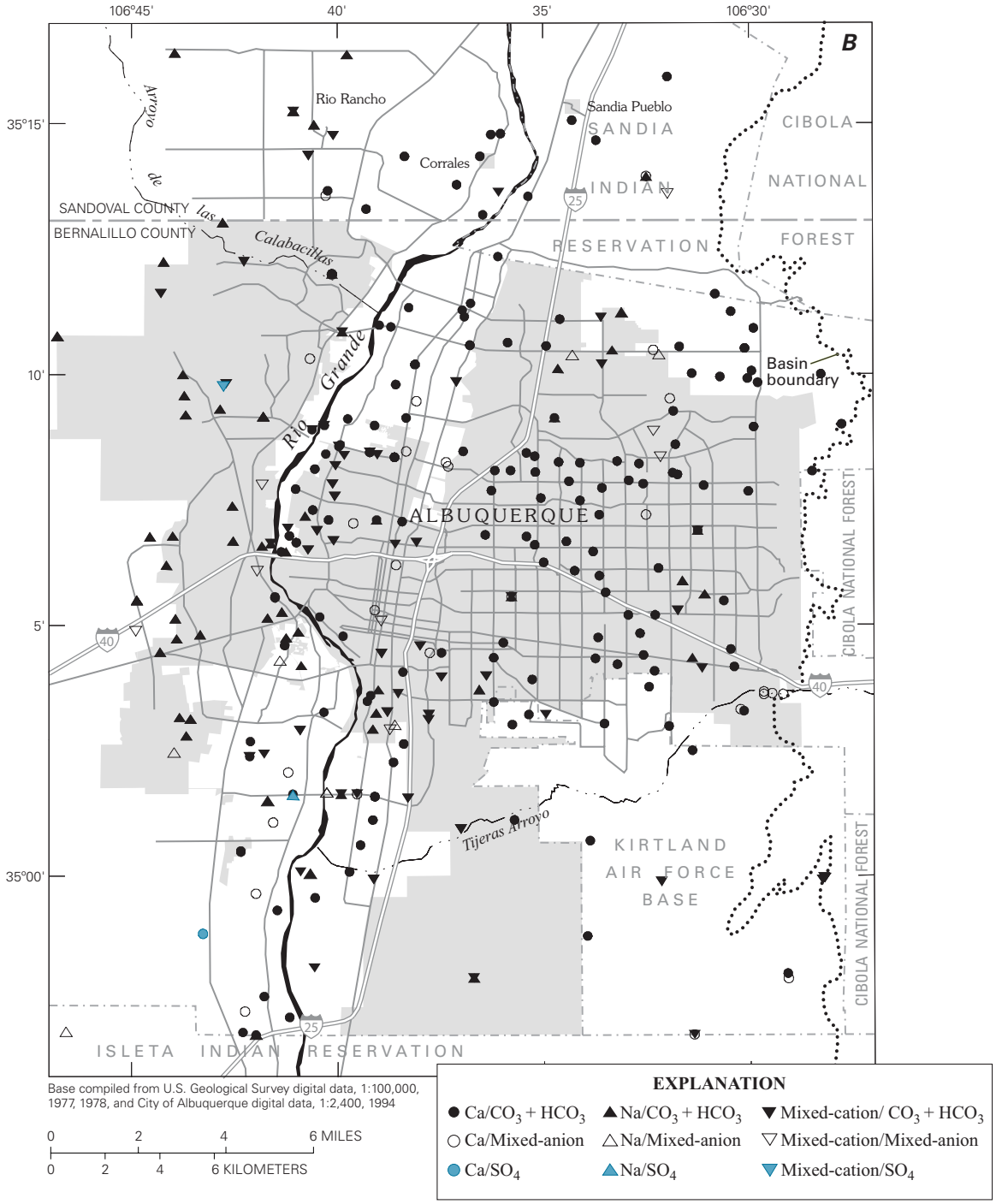


Figure 32b. Water types of ground-water samples inside the Albuquerque area, New Mexico. (Water types based on the Piper diagram of figure 31.)

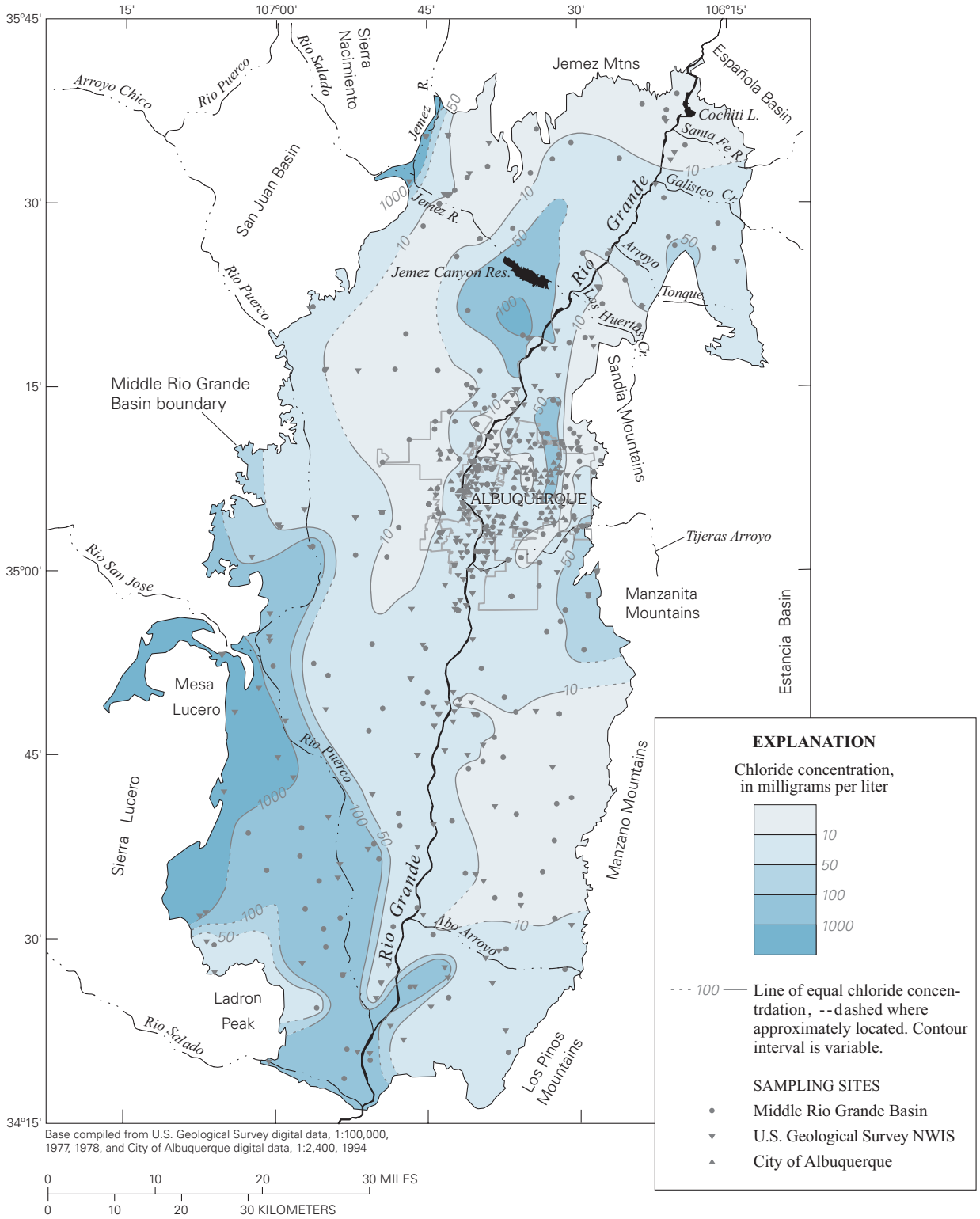


Figure 33. Chloride concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

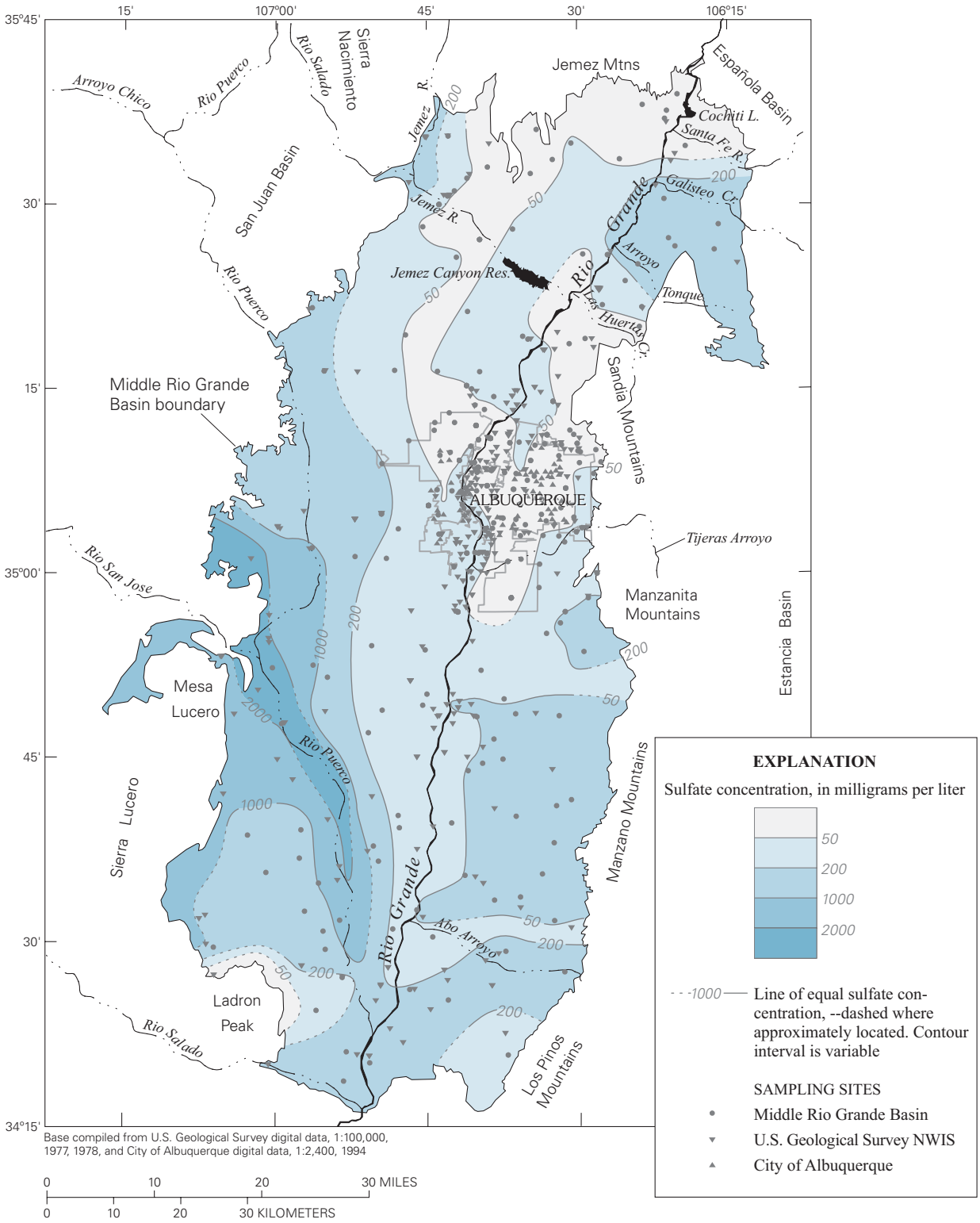


Figure 34. Sulfate concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

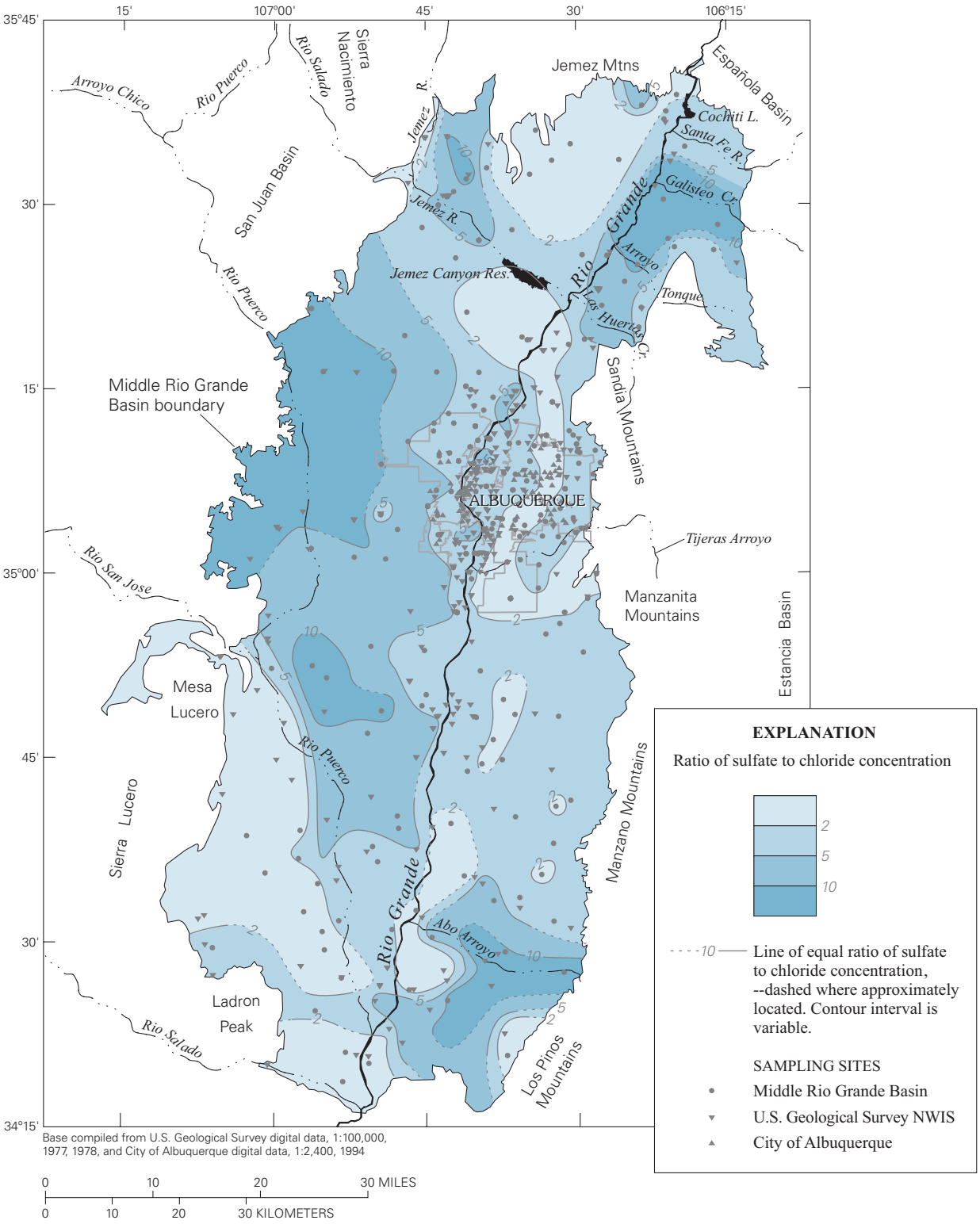


Figure 35. Ratio of sulfate to chloride concentration (concentrations in milliequivalents per liter) for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

Arroyo or possibly the Rio Puerco and are found in some ground-water samples obtained along the western margin. These relatively high SO_4 concentrations in ground water of the basin generally appear to be associated with waters from areas where gypsum is present. In particular, Mesozoic and/or Paleozoic rocks along the western margin of the basin and in the drainage areas for the Rio Puerco and Abo Arroyo contain gypsum deposits. Gypsum also is present in Mesozoic rocks in the area of the Hagan Embayment, probably resulting in the high SO_4 to Cl ratios found in ground water of this area. Even in these areas of high SO_4 to Cl ratio, nearly all ground-water samples are undersaturated with respect to gypsum.

Sulfate to Cl ratios between 2 and 10 are common in ground water throughout a large part of the basin (fig. 35). Among potential recharge waters, ratios of this magnitude are most consistent with precipitation and seepage from the Rio Grande. Therefore, it appears that mountain-front and/or river recharge may be important across large areas of the basin. Along with Cl concentrations, SO_4 concentrations in these areas probably can be used to estimate the amount of evapotranspiration resulting as precipitation recharged along basin margins or as surface water infiltrated and recharged the aquifer system.

Sulfate to Cl ratios less than 2 occur along parts of the western margin, in an area extending from the central Jemez Mountains into northeastern Albuquerque, and in isolated areas throughout the rest of the basin (fig. 35). These areas are generally coincident with those of elevated Cl discussed above, where brine entering the basin from Paleozoic rocks to the west or mineralized water moving upward from depth are believed to affect water chemistry in the upper several hundred feet of the aquifer system.

The isotopic composition of sulfur in dissolved SO_4 of the MRGB is a function of the isotopic composition of the sulfur source(s) and the extent of sulfate reduction and/or sulfide oxidation within the aquifer system. Some waters along the southwestern basin margin have elevated SO_4 concentrations, and may have sulfur isotopic compositions dominated by dissolution of Permian evaporite-mineral sources. For example, water from a windmill at site S201 on the southwestern basin margin (NM329) has a dissolved SO_4 concentration of 936 mg/L with a $\delta^{34}S$ value of 9.4 per mil, a value only slightly lower than average values of Permian gypsum sources (Holser and Kaplan, 1966; Claypool and others, 1980). As discussed earlier, 10 samples of anhydrite and gypsum from Permian rocks along the southwestern margin of the basin had an average $\delta^{34}S$ composition of 12.6 ± 1.3 per mil.

The average value of $\delta^{34}S$ from the 152 measurements of ground-water SO_4 from throughout the MRGB is 0.5 ± 6.0 per mil, spanning a range of nearly 43 per mil, from -23.0 to 19.7 per mil. Many of the water samples from the MRGB seem to have sulfur isotopic compositions that reflect mixed sources of sulfur. Aerobic samples probably have not been affected by sulfate reduction, but may contain sulfur from oxidation of sulfide minerals, which are typically depleted in ^{34}S. Oxidation of sulfide minerals (alone) would lead to waters with $\delta^{34}S$ isotopic compositions less than that of sulfur in precipitation (less than approximately 4 per mil in $\delta^{34}S$). Water samples with $\delta^{34}S$ values greater than approximately 4 per mil represent samples that have dissolved an excess of Permian evaporates relative to sulfide-oxidation sources of S, and/or have been affected by incomplete sulfate reduction. Water samples with $\delta^{34}S$ values greater than approximately 12.6 per mil (the average isotopic composition of Permian sulfates) represent samples where the dissolved SO_4 has undergone incomplete sulfate reduction. For example, samples from the SWAB-3 well (NM158-NM159) have $\delta^{34}S$ values of dissolved SO_4 that range from 16.2 to 19.7 per mil.

Although there is considerable data on the sulfur isotopic composition of sulfur in modern precipitation, sulfur of recent atmospheric origin is at least, in part, derived from anthropogenic sources (Mast and others, 2001), and may not be entirely representative of atmospheric sulfur in the past.

Most of the sulfur isotopic data were obtained in the vicinity of Albuquerque in an attempt to determine if, on the basis of $\delta^{34}S$ values of dissolved SO_4, waters derived from mountain-front sources could be separated from waters derived from Rio Grande sources. Analysis of the sulfur isotope data proved only marginally successful in this effort. In the section "Tracing Sources of Water in the Middle Rio Grande Basin—Definition of Hydrochemical Zones and Water Sources", a variety of isotopic and chemical parameters are used to recognize and classify water of mountain-front and Rio Grande source. Using the resulting classification (see discussion of hydrochemical zones in the the section "Tracing Sources of Water in the Middle Rio Grande Basin"), the mountain-front waters (spanning an age range of modern to approximately 20 ka)

have an average $\delta^{34}S$ composition of 3.6 ± 3.3 per mil, whereas the Rio Grande source waters (spanning an age range of modern to 27 ka) average -0.9 ± 6.4 per mil. The mountain-front waters contain sulfur predominantly of atmospheric source. Two processes primarily account for variations in $\delta^{34}S$ in the Rio Grande sources: (1) the seasonal variations in the isotopic composition of Rio Grande water (fig. 26), and (2) following infiltration, release of sulfur depleted in ^{34}S during oxidation of sulfide minerals in sediment of the inner valley of the Rio Grande. Dissolved SO_4 concentrations and $\delta^{34}S$ for all waters analyzed of apparent mountain-front and Rio Grande origin are compared in figure 36. Although there is considerable overlap in the more enriched samples, the highest $\delta^{34}S$ values (except for those from S244 and S245 which have undergone sulfate reduction) are in mountain-front waters and the lowest in waters apparently of Rio Grande origin. The waters most depleted in ^{34}S also contain the highest concentrations of dissolved SO_4 (fig. 36), and are from wells located in the inner valley of the Rio Grande. These samples depleted in ^{34}S are apparently of Rio Grande origin, and have been appreciably affected by oxidation of sulfide minerals. The two dashed lines that bracket the SO_4 and $\delta^{34}S$ values on figure 36 were determined assuming a hypothetical initial dissolved SO_4 concentration of 30 mg/L with $\delta^{34}S$ of 2.0 per mil accompanying oxidation of sulfides of -30 per mil with evapotranspiration factors from 1.0 to 5.0.

Apparently, the separation in average $\delta^{34}S$ of SO_4 of Rio Grande origin from that of mountain-front origin results from sulfide oxidation in parts of the inner valley of the Rio Grande where Rio Grande

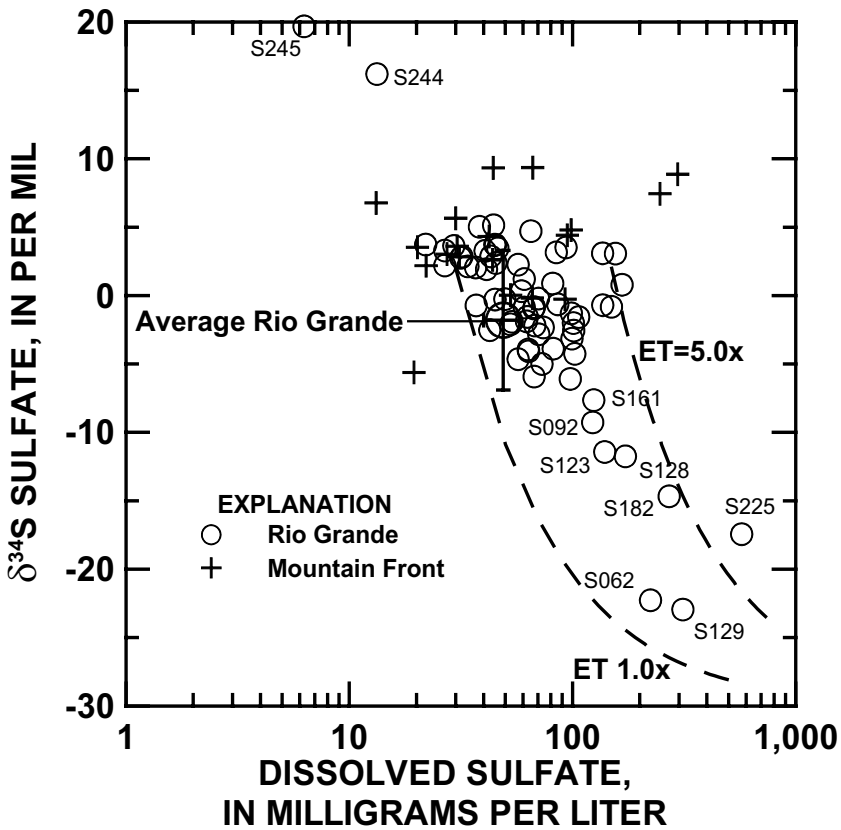


Figure 36. Comparison of dissolved sulfate concentrations and stable S isotopic composition of dissolved sulfate, $\delta^{34}S$, for waters of mountain-front recharge and Rio Grande origin. The highest $\delta^{34}S$ values occur in mountain-front waters and the lowest in waters of Rio Grande origin. The waters most depleted in $\delta^{34}S$ also contain the highest concentrations of dissolved sulfate, and are from wells located in the inner valley of the Rio Grande. The two dashed lines bracket the range of sulfate and $\delta^{34}S$ values that would result from a hypothetical initial dissolved sulfate concentration of 30 mg/L with $\delta^{34}S$ of 2.0 per mil accompanying oxidation of sulfides of -30 per mil with evapotranspiration factors (ET) from 1.0 to 5.0.

source waters predominate. This sulfide oxidation results in dissolved-SO_4 concentrations that are depleted in ^{34}S relative to that in waters of mountain-front origin. For example, ground-water samples of either a mountain-front or Rio Grande source that contain more than 0.1 mg/L of dissolved oxygen tend to be located outside the inner valley of the Rio Grande and have similar $\delta^{34}S$ values (fig. 37). In contrast, samples from the inner valley, where dissolved oxygen concentrations are less than 0.1 mg/L, tend to have SO_4 concentrations that are depleted in ^{34}S relative to SO_4 of mountain-front origin. Because the depleted sulfur occurs predominantly in the relatively young, inner-valley ground water, sulfide oxidation in the inner valley of the Rio Grande may be a relatively recent phenomenon. With the installation of drains and canals along the Rio Grande, and in response to lowered water levels accompanying ground-water withdrawals near Albuquerque, dissolved oxygen has apparently been introduced to greater depths in the inner valley of the Rio Grande in the 20th century, which has permitted oxidation of sedimentary sulfide minerals that have formed previously in otherwise anoxic sediments.

The ^{34}S isotopic composition of dissolved sulfur can be used in recognizing Permian sources of SO_4 ($\delta^{34}S$ of SO_4 in the range of 9 to 12 per mil). Permian sources of sulfur probably affect waters in Abo Arroyo, the Rio Puerco, ground-water inflow to the western side of the MRGB, and inflow from the northeast in the vicinity of the Hagan Embayment. The contrast in sulfur isotopic compositions is useful in recognizing water samples probably affected by oxidation of sulfide minerals ($\delta^{34}S$ of SO_4 generally less than 0 per mil). However, it is probably not possible to separate waters of Rio Grande origin from those of mountain-front origin in the MRGB on the basis of sulfur isotopic composition.

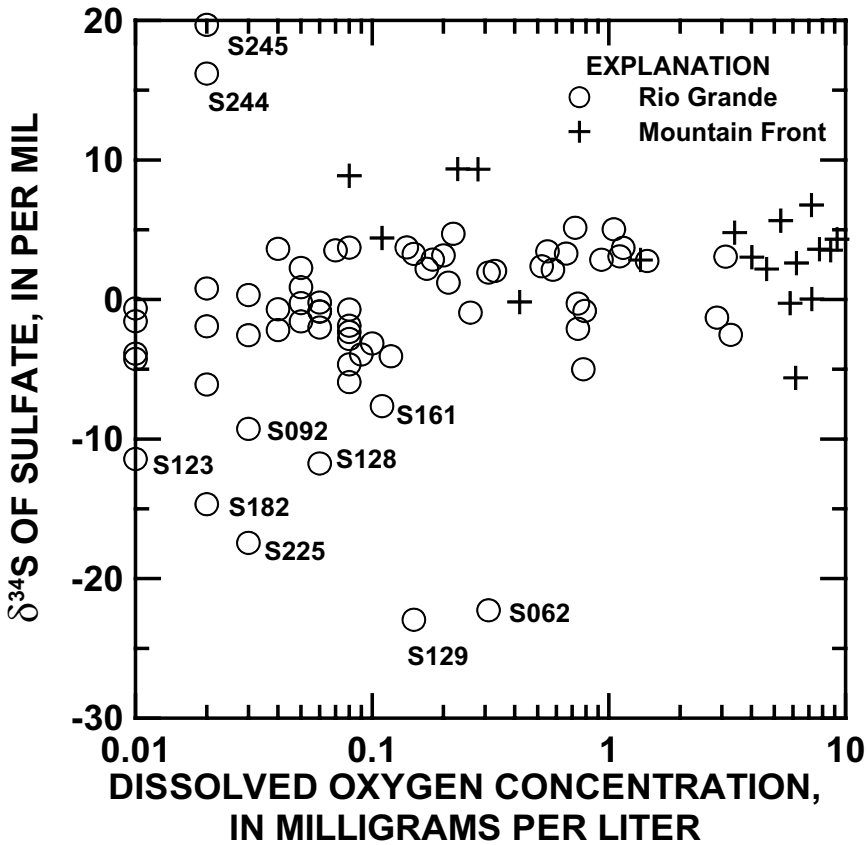


Figure 37. Comparison of stable S isotopic composition of dissolved sulfate, $\delta^{34}S$, with dissolved-oxygen concentration for water of Rio Grande and mountain-front origin, New Mexico. The range of $\delta^{34}S$ values is similar in mountain-front and Rio Grande waters in aerobic samples, but $\delta^{34}S$ generally becomes more depleted in ^{34}S in low-oxygen waters.

Bicarbonate and Carbon-13 of Dissolved Inorganic Carbon

Total alkalinity as HCO_3 through most of the center of the basin is less than 200 mg/L, and commonly less than 150 mg/L (fig. 38). High values of alkalinity are present along much of the eastern mountain front and near the western margin of the basin. Particularly high values can be indicative of areas of extensive carbonate-mineral reactions, and if occurring in the aquifer following recharge, can have an appreciable effect on interpretation of radiocarbon age. Even in areas of lower alkalinity, calculations indicate that most ground-water samples are near or at saturation with respect to calcite.

Approximately 250 measurements of $\delta^{13}C$ of the dissolved inorganic carbon, DIC, in ground water from the MRGB average -7.9 ± 2.0 per mil. The $\delta^{13}C$ values show only small variations spatially throughout the basin (fig. 39). Waters relatively enriched in ^{13}C in the southwestern part of the basin probably reflect values of ^{13}C from the source water, rather than the effects of reactions within the basin. $\delta^{13}C$ values of approximately -10 to -12 per mil can be traced along parts of the northern and eastern mountain fronts where, over short distances (several miles), they increase to approximately -8 per mil (fig. 39). Over large sections of the basin, from approximately the Jemez River to the southern extent of the basin, $\delta^{13}C$ values are nearly constant along the general north to south direction of regional ground-water flow. This result suggests that geochemical reactions that could affect the dissolved inorganic carbon are not extensive.

There are, however, small differences in $\delta^{13}C$ values among some waters. For example, $\delta^{13}C$ values of DIC are slightly more negative in waters near the Rio Grande than in other parts of the basin, probably reflecting the oxidation of organic carbon as redox reactions occur in the fluvial sediments of the inner valley of the Rio Grande.

In order to use ^{13}C data to recognize geochemical reactions that affect the DIC in the MRGB, the various $\delta^{13}C$ compositions of the carbon sources must be appreciably different. Carbon sources within the basin include limited occurrences of carbonate minerals (mainly calcite cement, lithic fragments of limestone, and caliche), organic carbon (plants and soil organic matter), and soil-gas CO_2.

A limited number of measurements of $\delta^{13}C$ of calcites were made for this study (Appendix C, table C2). Ten samples of Pennsylvanian limestones that cap the Sandia and Manzano Mountains on the eastern side of the basin had $\delta^{13}C$ values of -0.9 ± 1.9 per mil. Eleven specimens of caliche from soils and drill cuttings from throughout the basin had $\delta^{13}C$ values of -4.3 ± 0.9 per mil. Three of the eleven caliche samples were radiocarbon dated and had $\delta^{13}C$ values of -2.9, -3.8, and -5.3 per mil, with Conventional Radiocarbon Ages of 27.4, 7.2, and 2.3 ka B.P., respectively. Although the data are limited, the isotopic values for the three caliche samples are consistent with a possible decrease in the proportion of C_4 plants in late Holocene ecosystems, as discussed in more detail below (Grover and Musick, 1990; Liu and others, 1996).

Twenty-six plant specimens were collected in late April-early May 1997 at Embudo and Embudito Arroyos, and from the base of the Manzano Mountains on Kirtland Air Force Base. Plants included grasses, chamisa, willow, juniper, and apache plume. Various parts of the plants were analyzed for $\delta^{13}C$, including foliage, stems, roots, and wood (table C3). Two distinct groups of $\delta^{13}C$ values were evident, with median $\delta^{13}C$ values of -26.4 and -14.5 per mil (fig. 40). Plants utilizing the C_3 photosynthetic cycle include most trees, shrubs, and herbs, and grasses that prefer cool, wet-growing seasons, whereas C_4 plants are almost entirely grasses that can tolerate hot, dry growing seasons (Morgan and others, 1994). Plants undergoing the C_3 and C_4 photosynthetic pathways are recognized today by average $\delta^{13}C$ values typically -26.5 ± 2.5 and -12.5 ± 1.2 per mil, respectively (Morgan and others, 1994; Deines, 1980); thus, the two groups of plants analyzed from the eastern mountain front at Albuquerque are characteristic of plants utilizing the C_3 and C_4 photosynthetic pathways. The $\delta^{13}C$ of pre-industrial atmospheric CO_2 was about 1.5 per mil more positive than modern air (Peng, 1985; Francey and others, 1999); therefore, pre-industrial $\delta^{13}C$ values of C_3 and C_4 plants would have been about -25 and -11 per mil, respectively.

Twenty-two samples of unsaturated-zone air were collected from June 1996 through October 1997 from shallow depths (approximately 3 feet) and analyzed for gas composition and $\delta^{13}C$ isotopic composition of the CO_2. The soil-gas samples were from Bear Canyon, Kirtland Air Force Base, and Tijeras Arroyo vicinities along the eastern mountain front near Albuquerque (table C1). The median isotopic composition of the soil-gas samples was -14.8 per mil in $\delta^{13}C$ (fig. 40). The soil gas had a range in $\delta^{13}C$ values that was greater than that of either of the

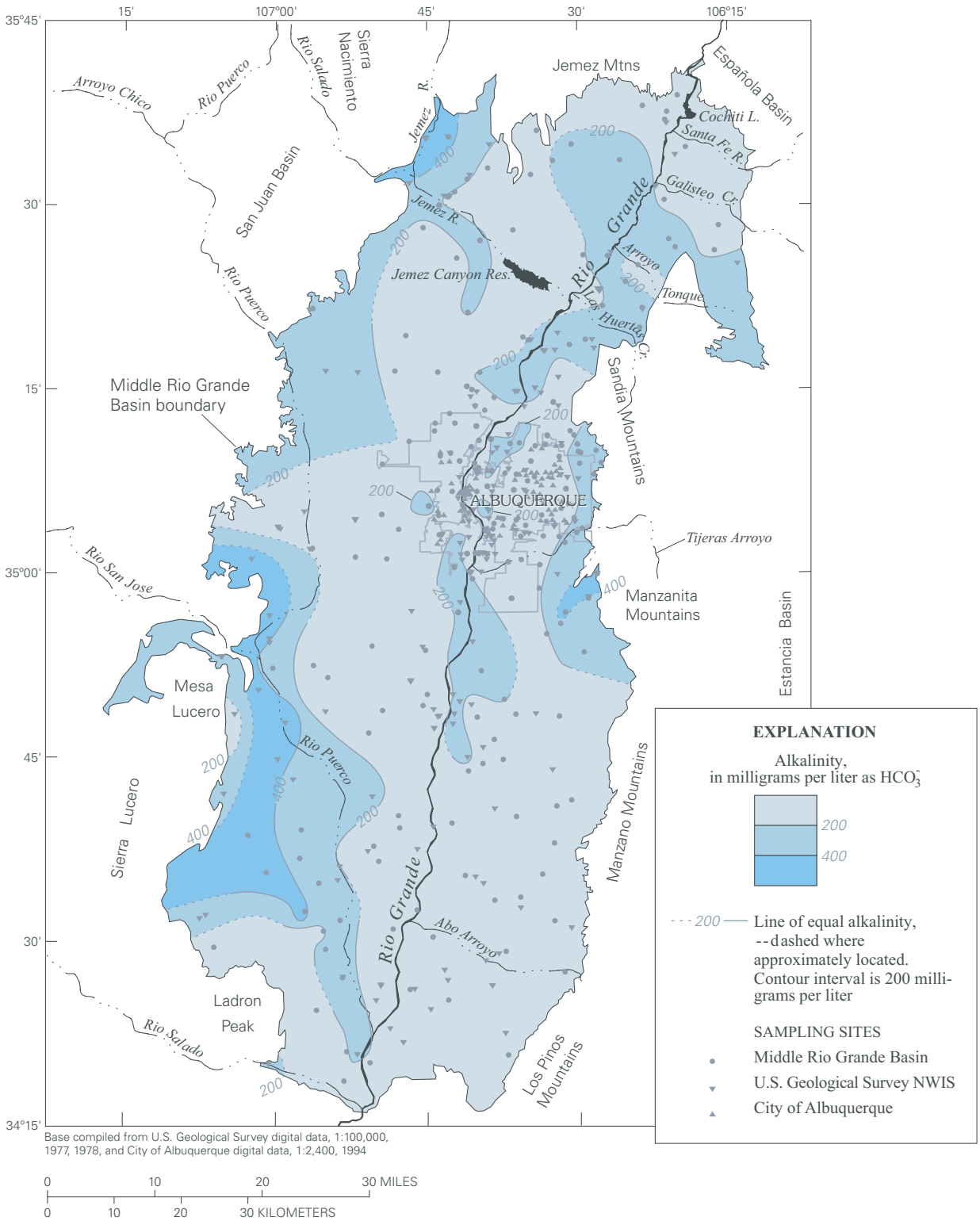


Figure 38. Alkalinity for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

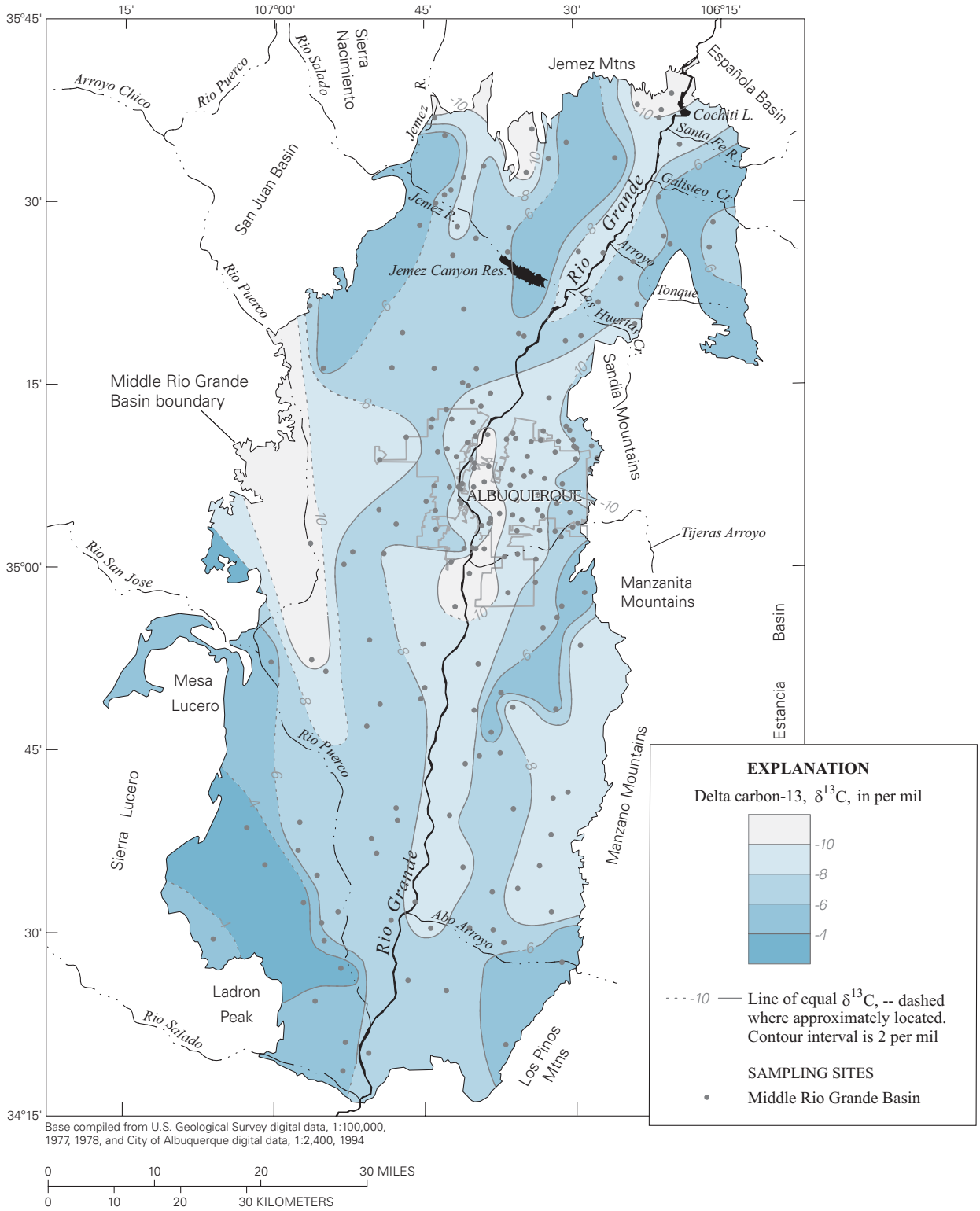


Figure 39. Stable carbon isotopic composition, $\delta^{13}C$, of dissolved inorganic carbon for ground water of the Middle Rio Grande Basin, New Mexico.

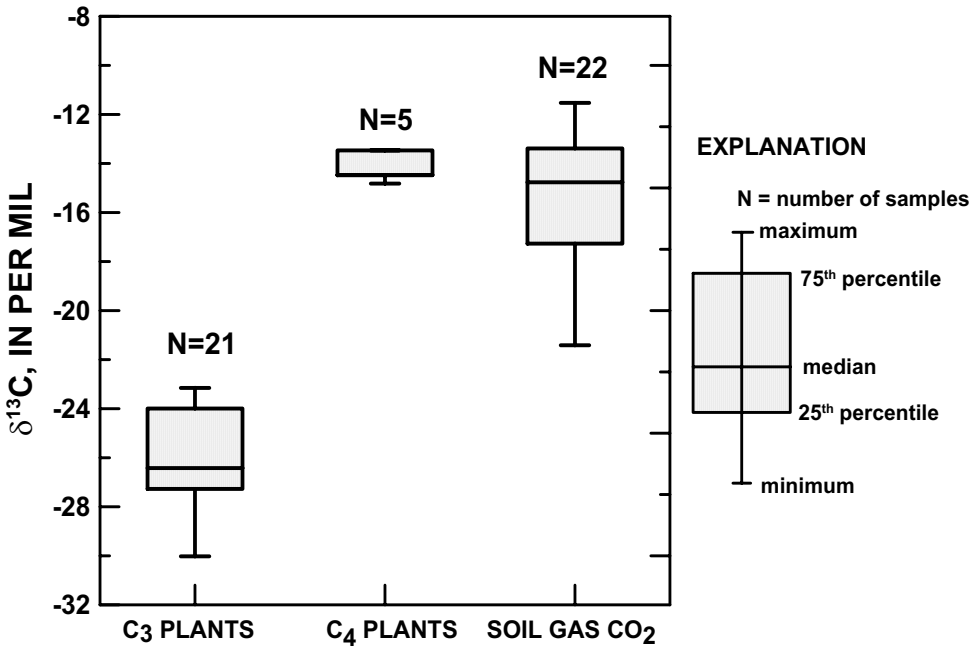


Figure 40. Comparison of $\delta^{13}C$ isotopic composition of plant matter and shallow unsaturated zone CO_2 gas from the eastern mountain front in the vicinity of Albuquerque, New Mexico.

two individual plant groups, varying from -11.5 to -21.4 per mil.

The sampling of plants and unsaturated-zone gas was not sufficient to permit generalization regarding the distribution of plant types throughout the basin, or even the distribution in the eastern mountain front environment, but does indicate that: (1) both C_3 and C_4 plants are present in the MRGB, (2) the soil-gas CO_2 sampled is likely a mixture of CO_2 from both C_3 and C_4 plants, and (3) most of the soil-gas samples collected had CO_2 predominantly from C_4 plants, even though most of the actual plant specimens collected and analyzed were from C_3 plants. Possible historical variations in C_3-C_4 plant distributions in the MRGB are discussed in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

Nitrate and Dissolved Nitrogen Gas

Nitrate concentration (as N) is less than 0.5 mg/L along much of the Rio Puerco and Rio Grande, and along parts of the Jemez River and the western margin of the basin (fig. 41). The median NO_3 concentration throughout the MRGB is 0.3 mg/L, with a mean value of 1.0 ± 2.0 mg/L. In most areas where ground water contains more than 1.0 mg/L of dissolved oxygen, NO_3 concentration is between 0.5 and 2 mg/L. Concentrations exceeding 2 mg/L are common in the northwestern part of the basin, and reach a maximum of 11.5 mg/L (as N) in water from one well (sample NM180) along the northwestern margin of the basin. Elevated concentrations of NO_3 can be traced from the northwestern margin of the basin in a generally south-southeast direction to the Lincoln piezometer nest (NM497-NM499), where NO_3 concentrations in ground water are from 4.7 to 5.8 mg/L (see region marked ">2.0" extending from the northwestern part of the basin to the western side of Albuquerque, fig. 41).

Natural accumulations of NO_3 at the land surface have been observed in arid regions (Böhlke and others, 1997) and may be a source of NO_3 to ground water in parts of the MRGB. During wet climatic periods, the accumulated NO_3 is apparently dissolved and recharged to ground water. Other elevated NO_3 concentrations in the MRGB are found in ground water near some test facilities on Kirtland Air Force Base (samples NM010, NM059), or in other areas where ground water may be affected by discharge from septic tanks and other domestic sources.

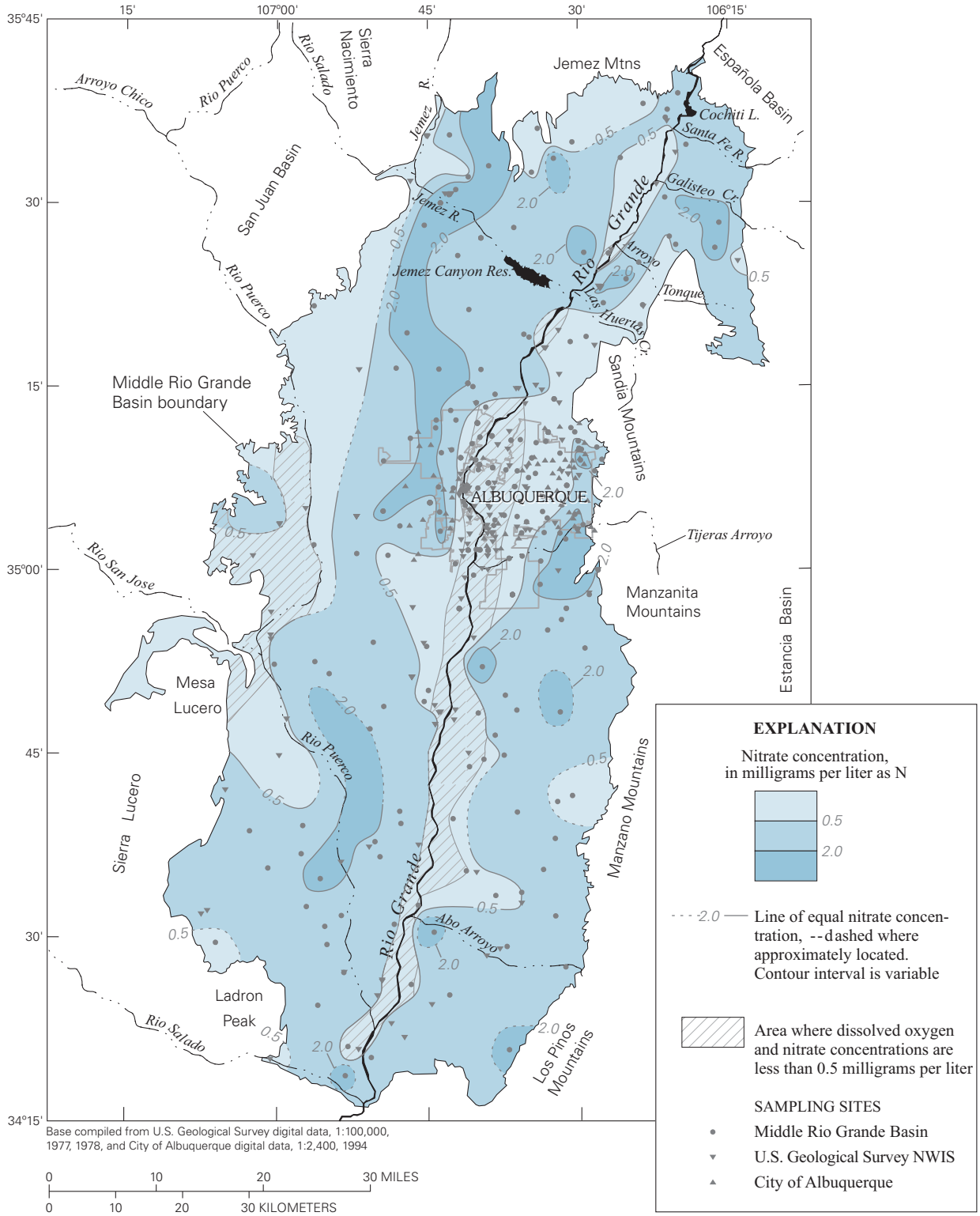


Figure 41. Nitrate concentration for ground water of the Middle Rio Grande Basin, New Mexico.

Denitrification, whereby NO_3 is converted to molecular nitrogen through a series of biological processes, is possible in those areas of the basin where dissolved-oxygen concentrations are low (typically less than 0.5 mg/L). Areas where low dissolved-oxygen and low NO_3 concentrations coincide are shown in figure 41. Evidence of denitrification can be found in some measured concentrations of dissolved nitrogen gas that exceed N_2 concentrations derived from equilibrium with air and dissolution of excess air (Heaton, 1981; Heaton and Vogel, 1981; Busenberg and others, 1993) during recharge. Of the 284 analyses of dissolved gases, 30 percent contained estimated excesses of N_2 gas that were attributed to denitrification (tables A5 and A6). In the samples affected by denitrification, the average calculated amount of denitrification was 1.5 ± 1.0 mg/L, with a maximum value of 4.0 mg/L as N.

Fluoride

Fluoride concentrations are less than 1.0 mg/L throughout large areas of the MRGB (fig. 42). However, concentrations typically exceed 1.0 mg/L along the western and southern margins of the basin, where concentrations greater than 2.0 mg/L also are common. Concentrations greater than 1.0 mg/L also are present across broad areas in the west-central part of the basin, near the Tijeras Fault Zone, along the Sandia mountain front, and near the Hagan Embayment. Nearly all ground-water samples in the basin are undersaturated with respect to fluorite (CaF_2), indicating that equilibrium reactions with this mineral probably are not the dominant control on F concentrations. Weathering of volcanic rocks and pH-dependent exchange and sorption reactions also can release F into solution (Robertson, 1991), and are potential controls on F concentrations in the MRGB. However, no relationship between pH and F concentrations is evident in the basin for the data set as a whole.

Cations

The following sections present data on concentrations of calcium, sodium, magnesium, potassium, and silica in ground water from the MRGB.

Calcium

Although Ca concentrations generally are not conservative as a result of rock-water interactions, including calcite dissolution/precipitation, gypsum dissolution/precipitation, and cation exchange, they do demonstrate useful patterns in the MRGB. The highest Ca concentrations (greater than 100 mg/L) are throughout most of the southwestern area of the basin and along parts of the Rio Puerco, Abo Arroyo, and the Sandia mountain front; high concentrtations also are present in the area of the Hagan Embayment (fig. 43). Calcium concentrations of less than 20 mg/L are present across areas extending southward from the western Jemez Mountains past Los Lunas and westward from the southern Manzano Mountains.

Sodium

Similar to Ca, Na concentrations generally are not conservative (because of processes such as feldspar weathering and cation exchange) but do show useful patterns in the basin. The highest Na concentrations (greater than 100 mg/L) are present across much of the western part of the basin, as well as near the Tijeras Fault Zone (fig. 44). Concentrations less than 20 mg/L occur mainly along parts of the northern and eastern mountain fronts.

A map of the ratios of Ca to Na concentrations (in meq/L) shows that these (unitless) ratios are less than 5 throughout the entire basin, with the exception of a small area near the eastern mountain front at Albuquerque (fig. 45). Therefore, whereas the ratios of SO_4 to Cl concentrations are consistent with precipitation even at large distances from the mountain fronts, the ratios of Ca to Na concentrations are not. Near mountain fronts, these cation ratios indicate the occurrence of reactions within the soil zone or aquifer that increase concentrations of Na relative to Ca, even at relatively short distances from the recharge source. In the MRGB, such reactions are likely to include weathering of silicate minerals—particularly plagioclase feldspar—and/or cation exchange. Locally, the Ca to Na ratios between 2 and 5 that are common from the eastern mountain front to just west of the Rio Grande also could indicate areas of infiltration from the Rio Grande or from Abo or Tijeras Arroyos, which have ratios in this range. Ratios between 0.5 and 2 in ground water near the Rio Puerco are consistent with infiltration from this stream. Ratios between 0.5 and 2 in the area of northeastern Albuquerque where elevated Cl concentrations have been observed could indicate that the deep, mineralized water believed to mix with shallow ground water in this area has high Na concentrations relative to Ca.

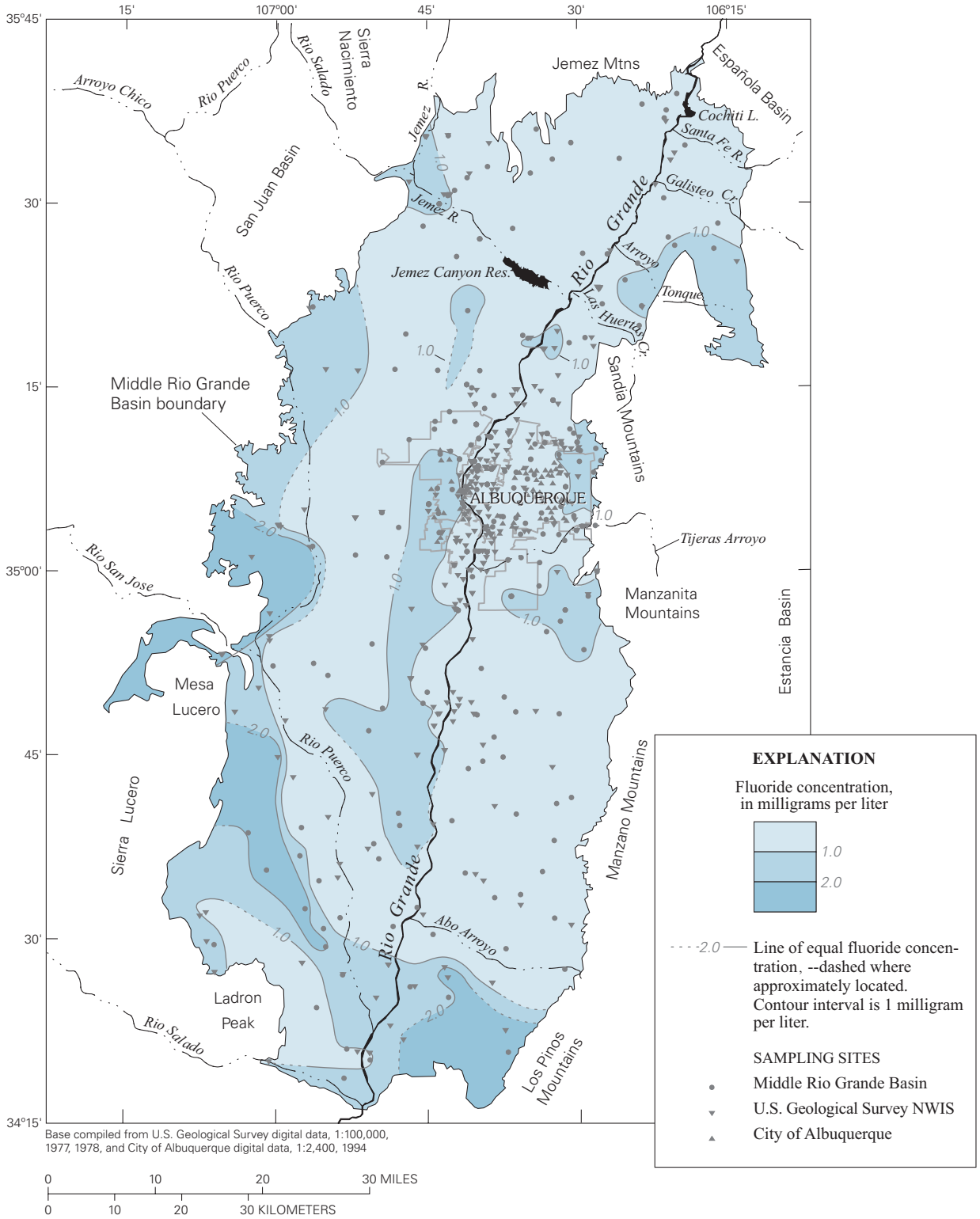


Figure 42. Fluoride concentration for ground water of the Middle Rio Grande Basin, New Mexico

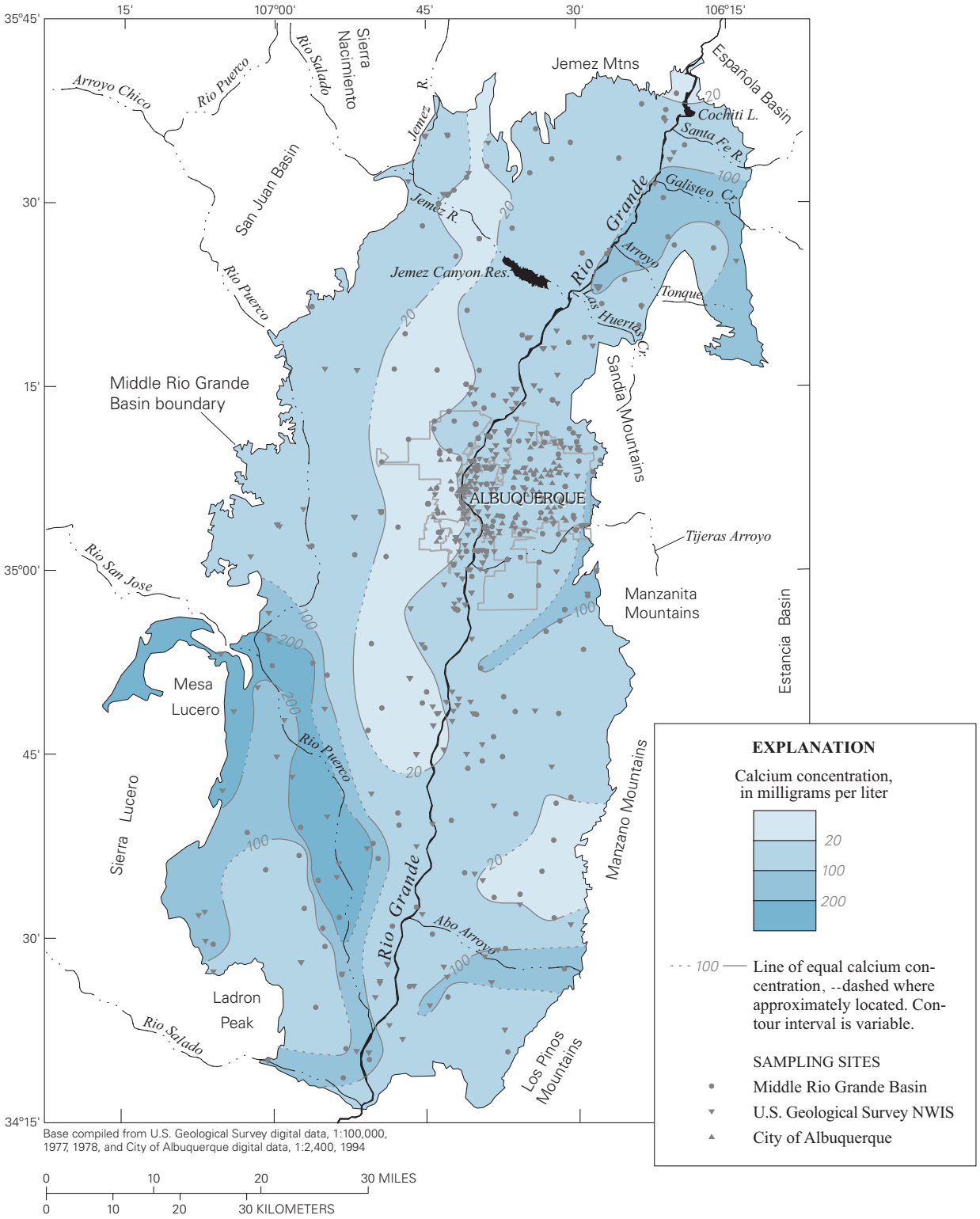


Figure 43. Calcium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

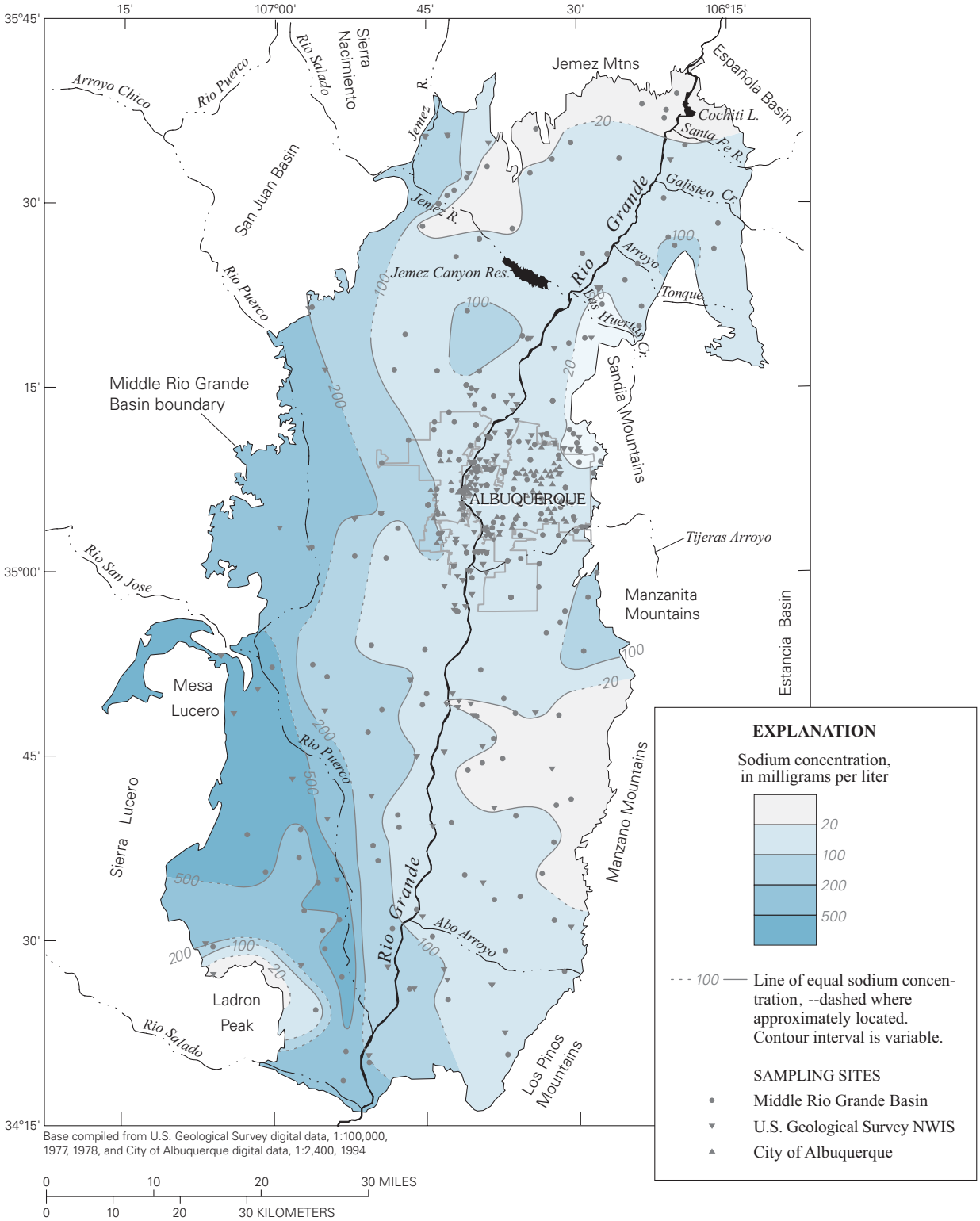


Figure 44. Sodium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

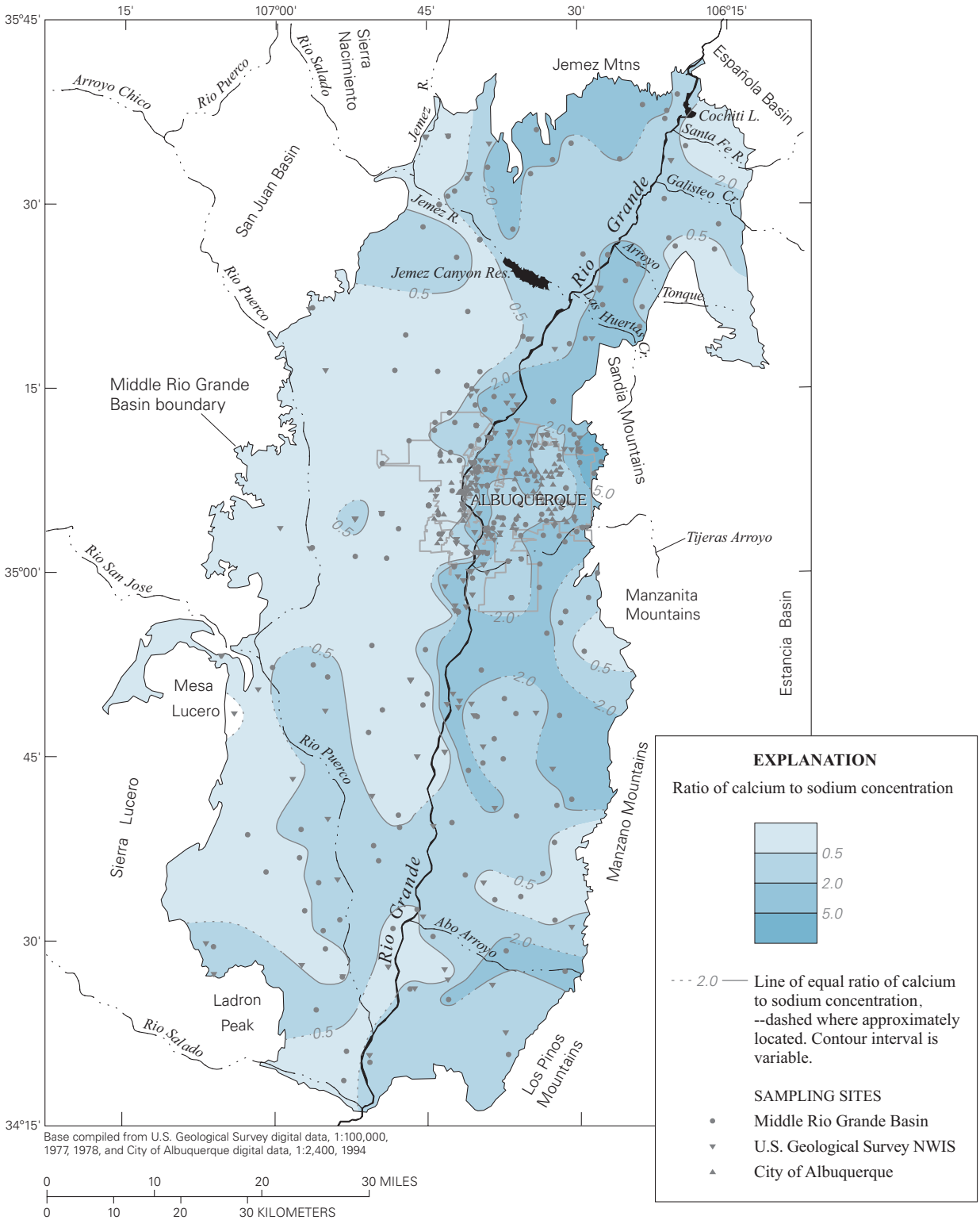


Figure 45. The ratio of calcium to sodium concentration (concentrations in milliequivalents per liter) for ground water of the Middle Rio Grande Basin, New Mexico.

Ca to Na ratios of 0.5 or less are widespread in the western part of the MRGB (fig. 45). In the southwestern part of the basin, these ratios are consistent with the presence of Na-Cl brine leaking into the aquifer system from Paleozoic rocks to the west. Farther north, where SO_4 to Cl ratios generally indicate recharge sources associated with precipitation or seepage from the Rio Grande, high concentrations of Na relative to Ca may be the result of cation exchange. Anderholm (1988) used a generalized material-balance model to show that silicate weathering could not account for the high Na concentrations observed in this area, and that Ca concentrations were lower than would be expected from the amounts of carbonate dissolution, gypsum dissolution, and silicate weathering indicated by other constituents. The occurrence of cation exchange in the western part of the basin is consistent with the presence of fine-grained sediments in the area, including calcium smectite and mixed layer illite-smectite clays with high ion-exchange capacities (Anderholm, 1985; Hawley and Haase, 1992; Stone and others, 1998).

Magnesium

Magnesium concentrations in ground water of the MRGB usually are less than 10 mg/L across broad areas, but exceed 10 mg/L in some parts of the basin (fig. 46). Concentrations greater than 10 mg/L occur across the entire southwestern part of the basin, much of the southeastern part (south of about Abo Arroyo), and along the far western margin of the basin north of the Rio San Jose (but data here are sparse). Within these areas, concentrations along the Rio Puerco and just north of Ladron Peak typically exceed 50 mg/L; the concentration for one well sample near the mouth of Abo Arroyo also exceeds 50 mg/L. Additional areas with Mg concentrations exceeding 10 mg/L include the northeastern part of the basin (near the Hagan Embayment) and an area extending along the eastern mountain front from Albuquerque to the Tijeras Fault Zone. In most of these areas of relatively high Mg concentration (as opposed to most other areas of the basin), ground-water samples generally are saturated with respect to dolomite. Most of these areas could receive water from Paleozoic and Mesozoic rocks located along basin margins, which may contain more dolomite than rocks in other source areas. Relatively high Mg concentrations also occur in part of the Rio Grande inner valley, but probably are not associated with waters sourced in Paleozoic or Mesozoic rocks; evapotranspiration could be the cause of higher concentrations in this area.

Potassium

Contours of K concentration throughout the MRGB (fig. 47) indicate that concentrations generally are less than 10 mg/L. The primary area where concentrations exceed 10 mg/L is the southwestern part of the basin, where brine from Paleozoic rocks to the west is present. Concentrations less than 3 mg/L are present along much of the eastern mountain front, except for a small area extending from Albuquerque to the Tijeras Fault Zone. Concentrations less than 3 mg/L also are present over limited areas of the western half of the basin. Weathering of silicate minerals, including potassium feldspar, mica, and volcanic glass, probably is the most likely source of K in ground water of the basin.

Silica

Dissolved SiO_2 concentrations are not conservative because of rock-water interactions, and indicate a general pattern of increasing concentration with distance away from the eastern and western margins of the MRGB (fig. 48). The highest SiO_2 concentrations (greater than 50 mg/L) are present primarily down the center of the basin. The lowest concentrations (< 20 mg/L) are mainly along the eastern mountain front, along the western margin of the basin, and near Ladron Peak. Anderholm (1988) suggested that SiO_2 concentrations greater than about 30 mg/L in the basin could result from dissolution of volcanic glass in sediments derived from the Jemez volcanic field. This conclusion is consistent with the observation by Hawley and Haase (1992) that glassy pumice from the Jemez area is present in fluvial deposits beneath Albuquerque. Silica concentrations of approximately 50 mg/L (SiO_2) are common in waters associated with weathering of silicate minerals such as plagioclase feldspars (Davis, 1964; Langmuir, 1997).

Minor-Element Chemistry

The processes that affect minor-element chemistry in ground water often are complex and poorly understood. Nevertheless, concentrations of

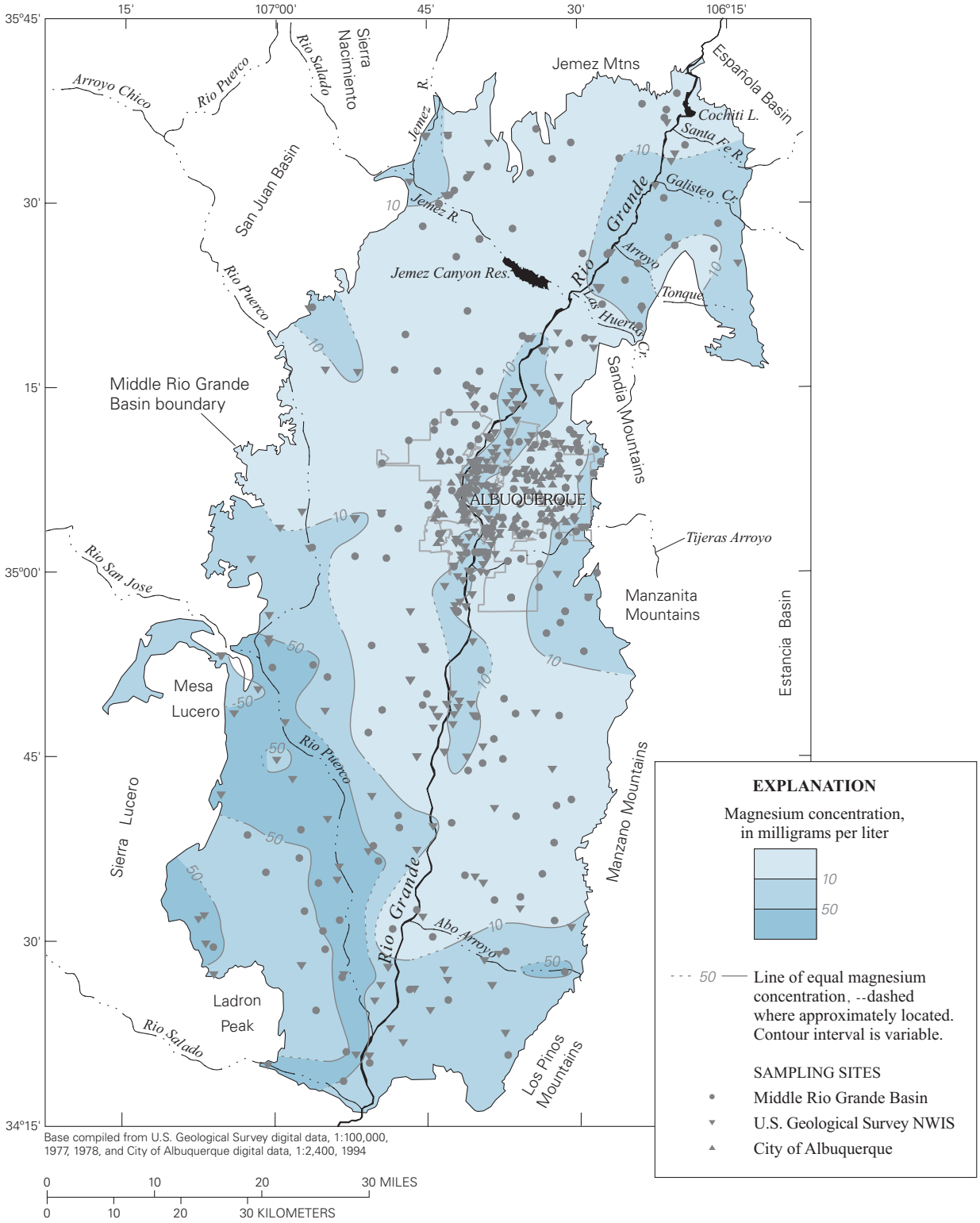


Figure 46. Magnesium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

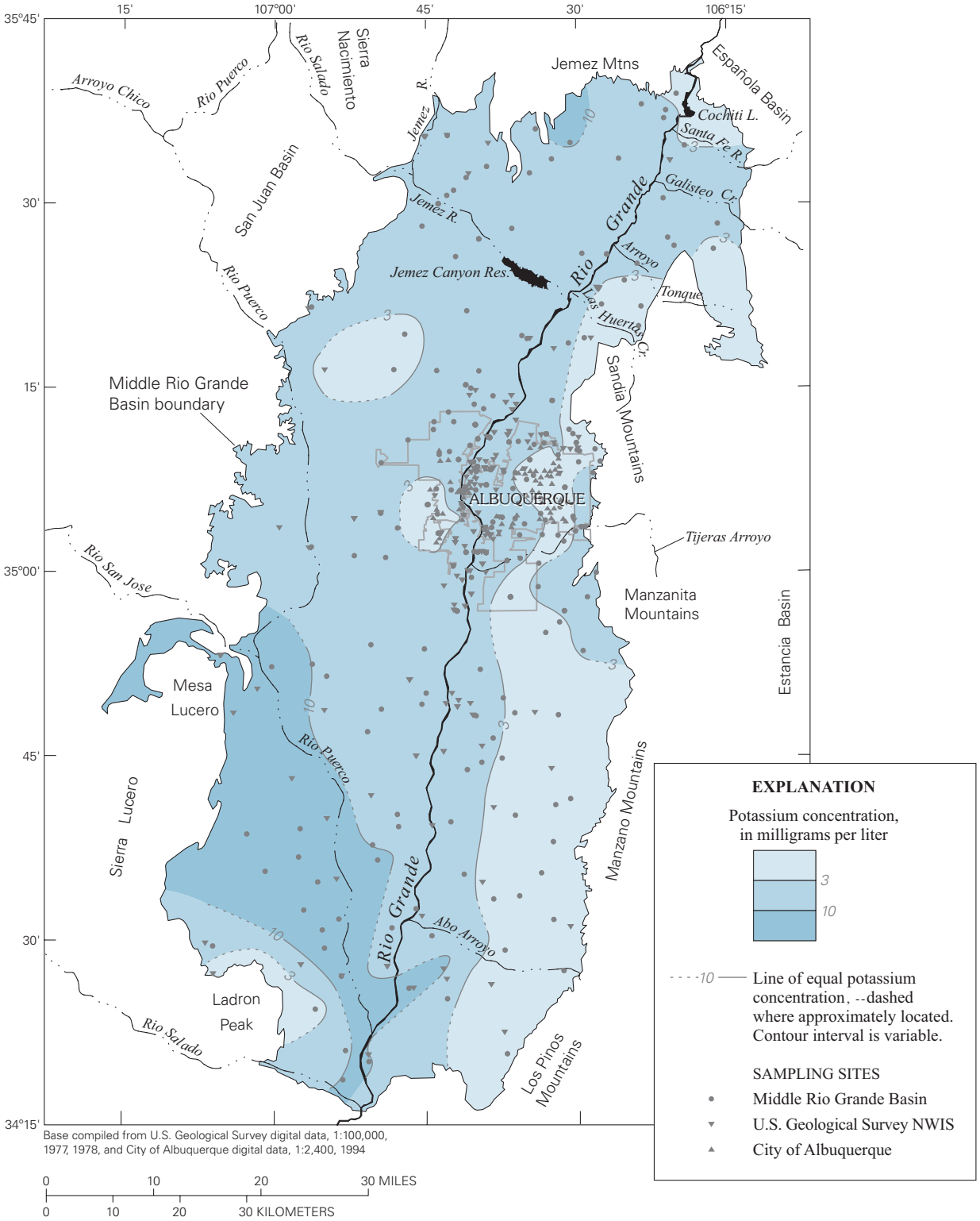


Figure 47. Potassium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

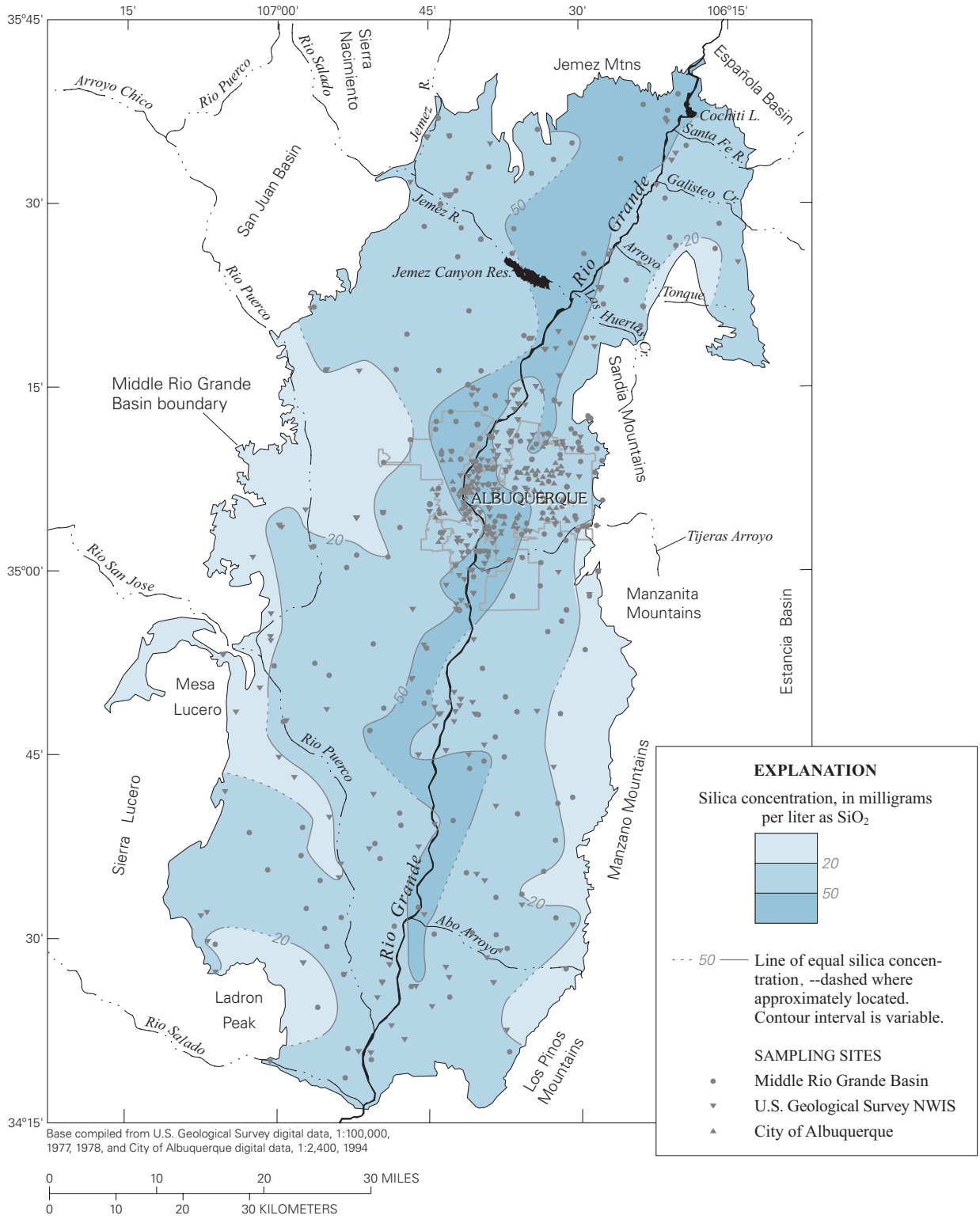


Figure 48. Silica concentration for ground water of the Middle Rio Grande Basin, New Mexico.

minor elements can still provide useful information about areas where water sources are likely to differ or where particular chemical processes are likely to be occurring. This section discusses aspects of the concentrations of arsenic, barium, boron, lithium, molybdenum, strontium, uranium, and vanadium in ground water of the MRGB. Concentration data for other minor or trace elements in ground water of the MRGB are given in tables A3 and A4.

Arsenic concentrations in ground water of the MRGB generally are lowest (< 3 µg/L) along the eastern and western margins of the basin (fig. 49). Concentrations greater than 20 µg/L are present across much of the northwestern part of the basin and the western part of Albuquerque. Smaller areas of elevated As concentration occur in the northeastern part of Albuquerque and the southern half of the basin. Bexfield and Plummer (2002) showed that elevated As is associated with two primary sources. One source is mineralized water of deep origin (thousands of feet), the distribution of which was discussed above with respect to anomalous Cl concentrations. Geologic structure likely controls the geographic distribution of this mineralized water by allowing upwelling along major faults or as the result of structural highs (Bexfield and Plummer, 2002). Mixing with this water elevates the As concentrations of ground water at shallower depths of the aquifer system in parts of the central and eastern areas of the basin. The other high-As source affects ground water in the northwestern part of the basin and is associated with silicic volcanism in the Jemez Mountains to the north. Recharge of water through rocks that have been altered by contact with geothermal fluids could account for the high As in ground water of the area. Adsorption/desorption processes involving metal oxides and clays also appear to affect As concentrations along flow paths in the northwestern part of the basin, where the highest As concentrations typically occur for samples with pH values of 8.5 or higher.

Barium concentrations are relatively high throughout much of the central and eastern parts of the basin, commonly exceeding 100 µg/L (fig. 50). Concentrations in other areas usually are less than 20 µg/L. Potassium feldspar, in which Ba commonly substitutes for K, may be the major source of Ba to ground water of the basin. Most ground-water samples in the basin are near or at saturation with respect to barite, $BaSO_4$; therefore, mineral equilibrium is likely an important control on Ba concentrations. Sorption to clay minerals also could be an important control.

Boron concentrations show fairly consistent patterns in ground water of the basin. The highest concentrations (greater than 0.5 mg/L) typically are along the western margin of the basin (fig. 51), primarily in the southwest. Concentrations of less than 0.1 mg/L occur across broad areas east of the Rio Grande and along much of the northern margin of the basin, indicating that mountain-front recharge water probably is relatively low in B. Boron commonly is enriched in evaporite minerals, such as those present along the western margin of the basin. Boron also tends to be enriched in hydrothermal systems, such as that found in the Jemez Mountains, which may help to explain relatively high B concentrations that extend south from the Jemez Mountains, on the west side of the Rio Grande.

Bromide concentrations are less than 0.2 mg/L throughout much of the MRGB (fig. 52). However, concentrations exceeding 0.2 mg/L, and in some cases 0.5 mg/L, are along the western basin margin, at the southern end of the basin, near the Hagan Embayment in the northeast, and near the Tijeras Fault Zone. These higher concentrations may be associated with high-Cl source waters to these parts of the basin, which receive recharge from Paleozoic and Mesozoic sedimentary rocks. A few additional concentrations exceeding 0.2 mg/L appear likely to result from mixing with high-Cl water of deep origin, as discussed above.

Lithium concentrations exceed 200 µg/L primarily in the southwestern part of the MRGB and near the Tijeras Fault Zone (fig. 53). Brenner-Tourtelot and Machette (1979) showed that Li-rich brine has moved through sediments in the southwestern part of the MRGB and that clays of the Popotosa Formation (respresenting basin-fill deposits of early to late Miocene age) exposed in the area are consequently associated with large quantities of Li. Lithium-rich brine also may be present in the area of the Tijeras Fault Zone; Li also is elevated in some high-Cl waters that appear to upwell in particular locations around the basin. Lithium concentrations generally appear to be lowest (< 20 µg/L) along much of the eastern mountain front.

Molybdenum concentrations are less than 5 µg/L across broad areas of the basin (fig. 54). Concentrations exceeding 10 µg/L are present along the western margin of the basin, extending eastward for up to 14

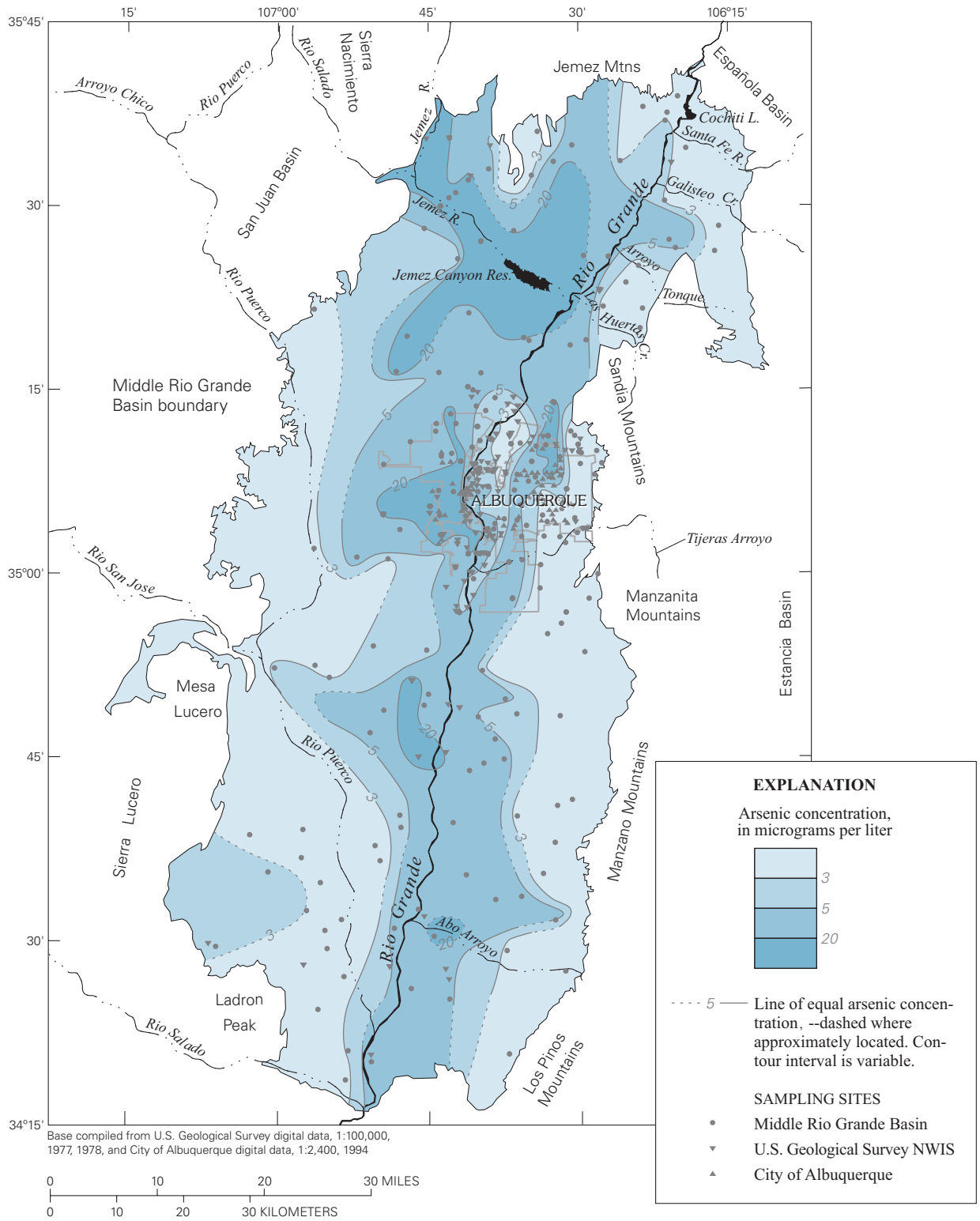


Figure 49. Arsenic concentration for ground water of the Middle Rio Grande Basin, New Mexico.

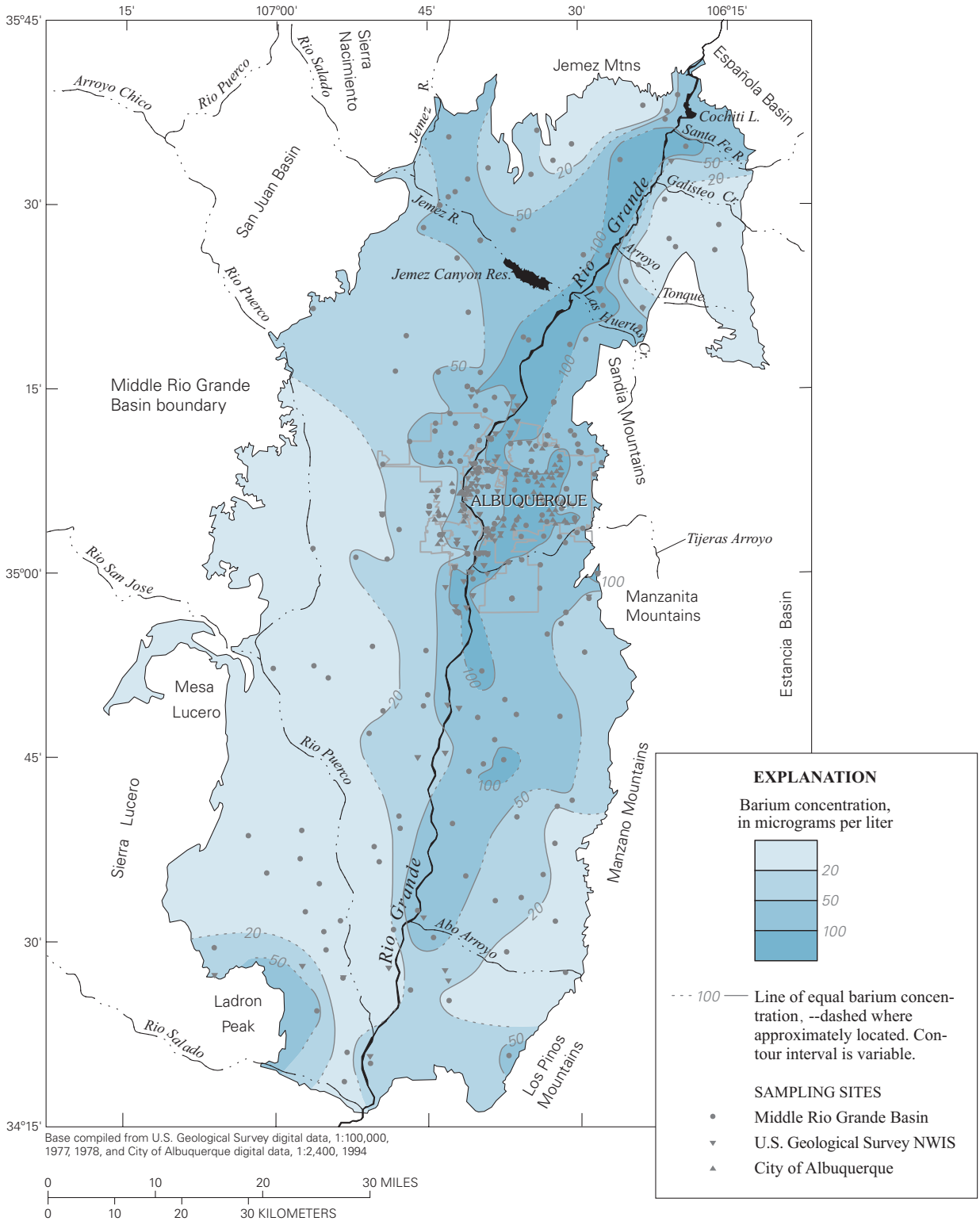


Figure 50. Barium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

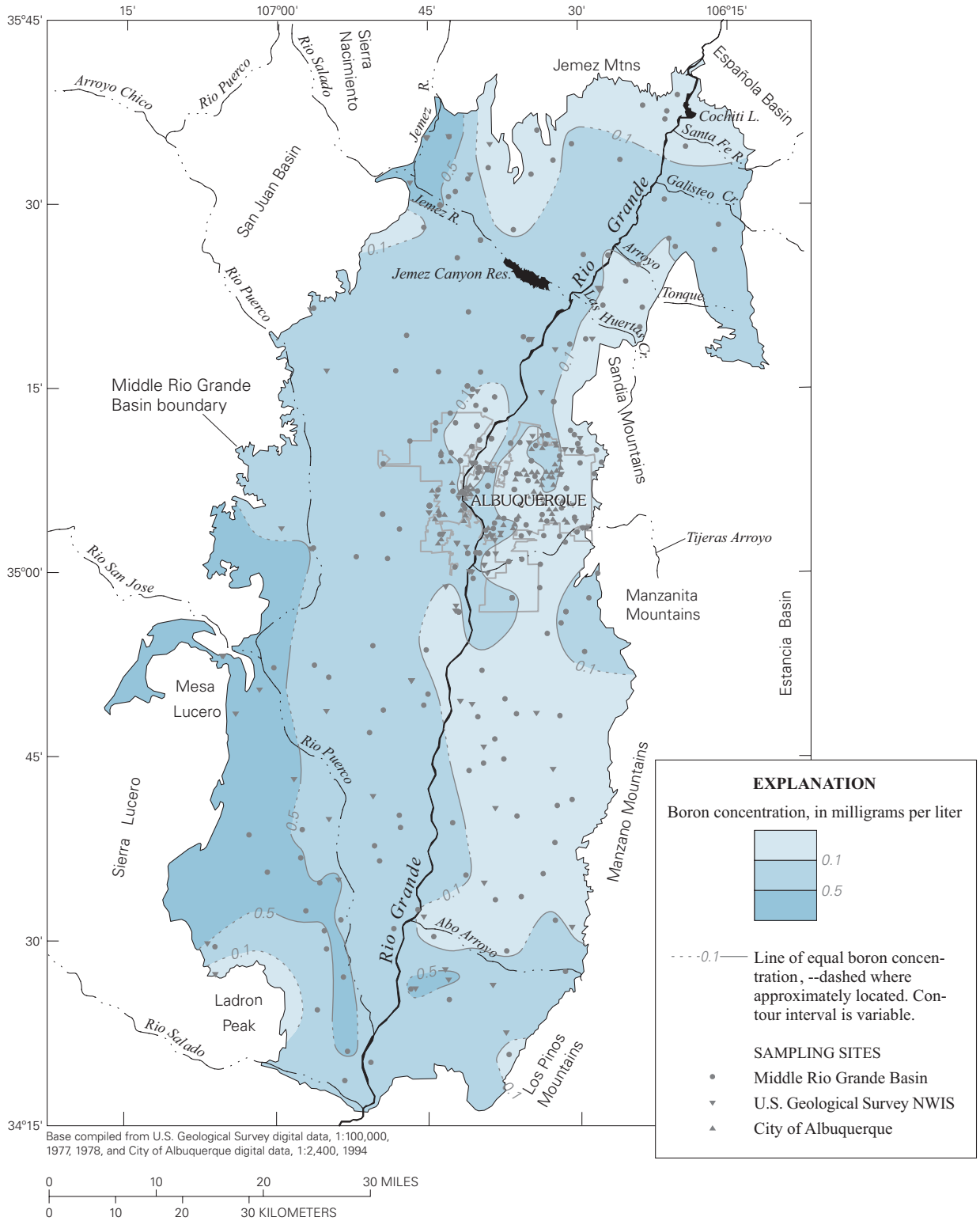


Figure 51. Boron concentration for ground water of the Middle Rio Grande Basin, New Mexico.

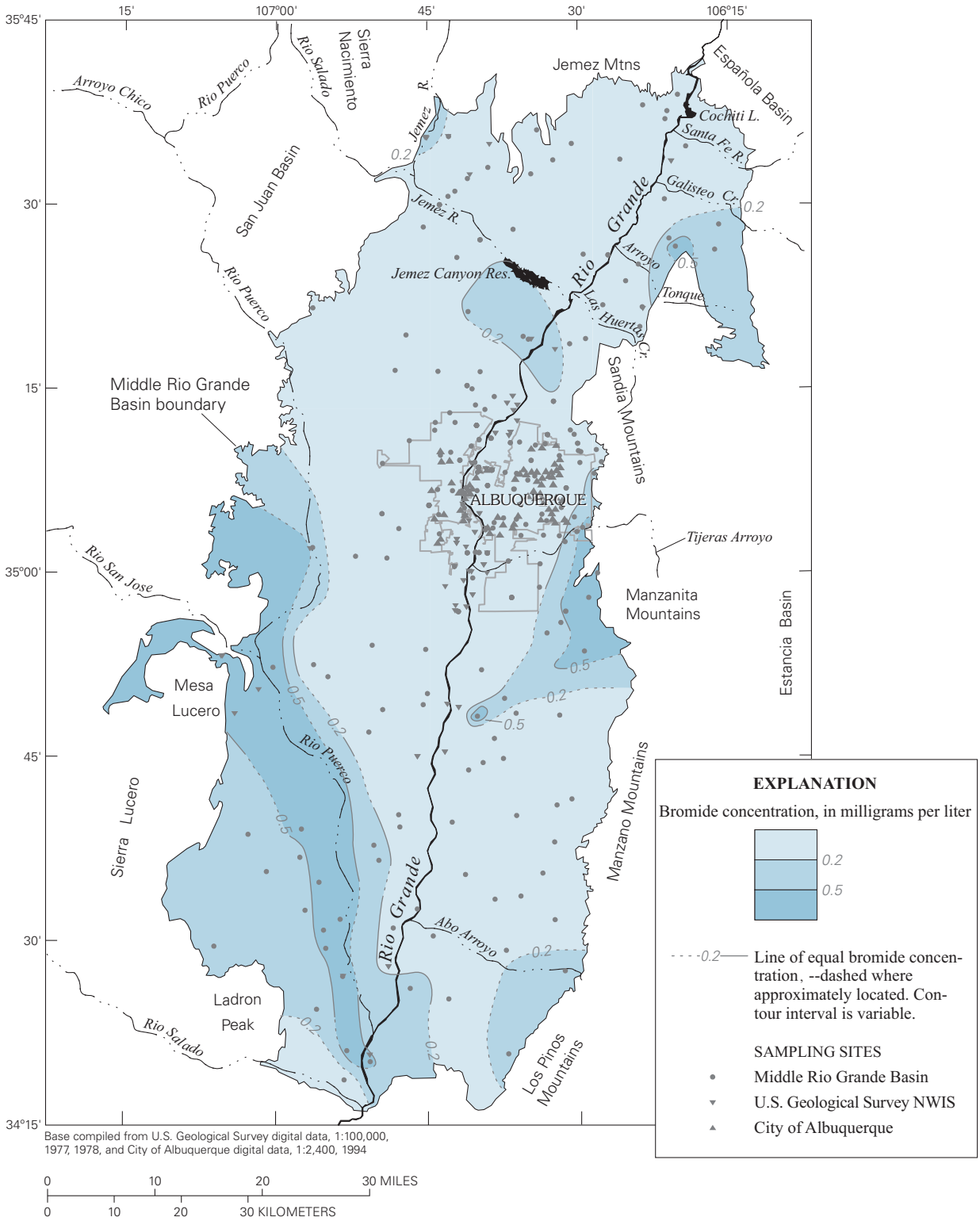


Figure 52. Bromide concentration for ground water of the Middle Rio Grande Basin, New Mexico.

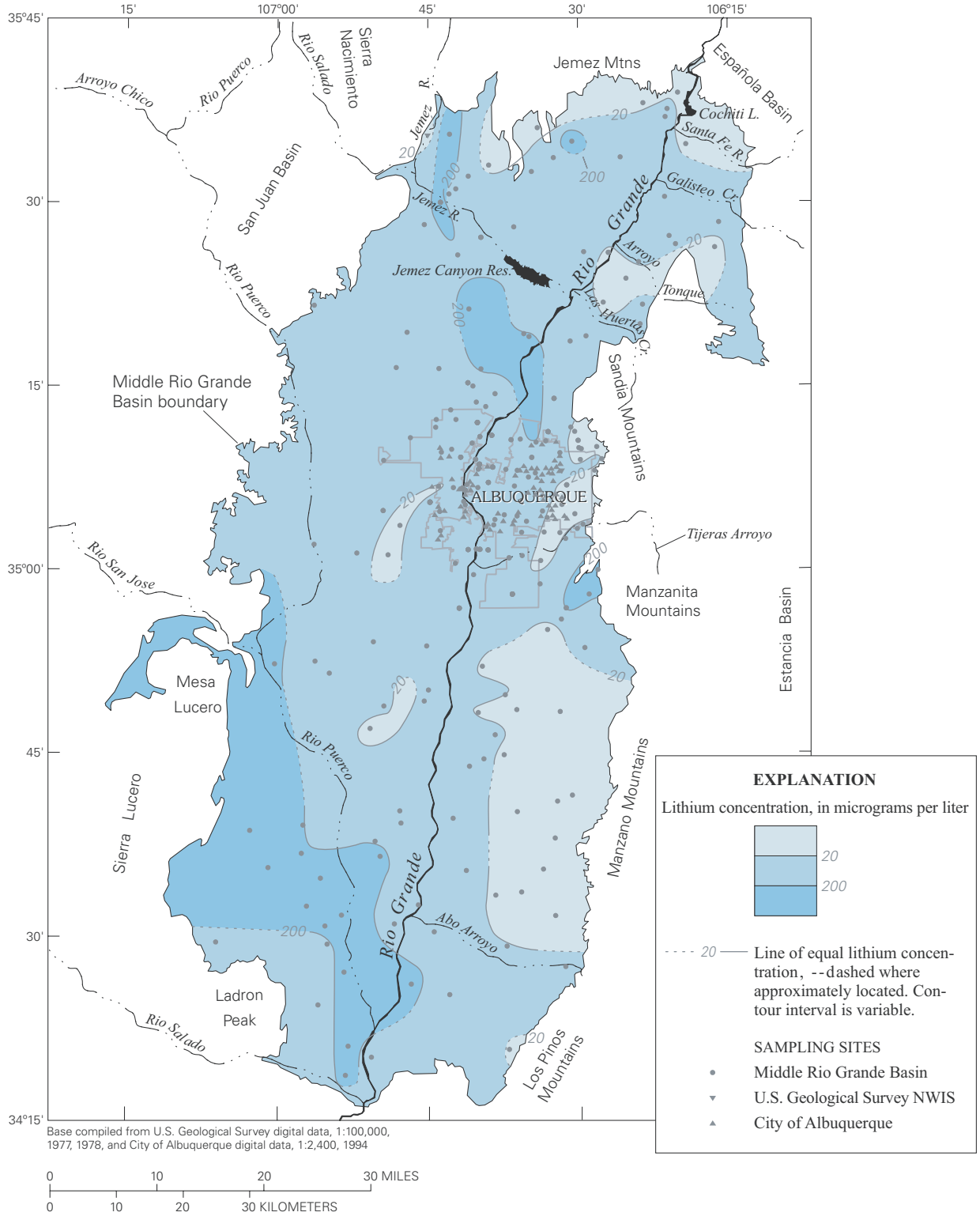


Figure 53. Lithium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

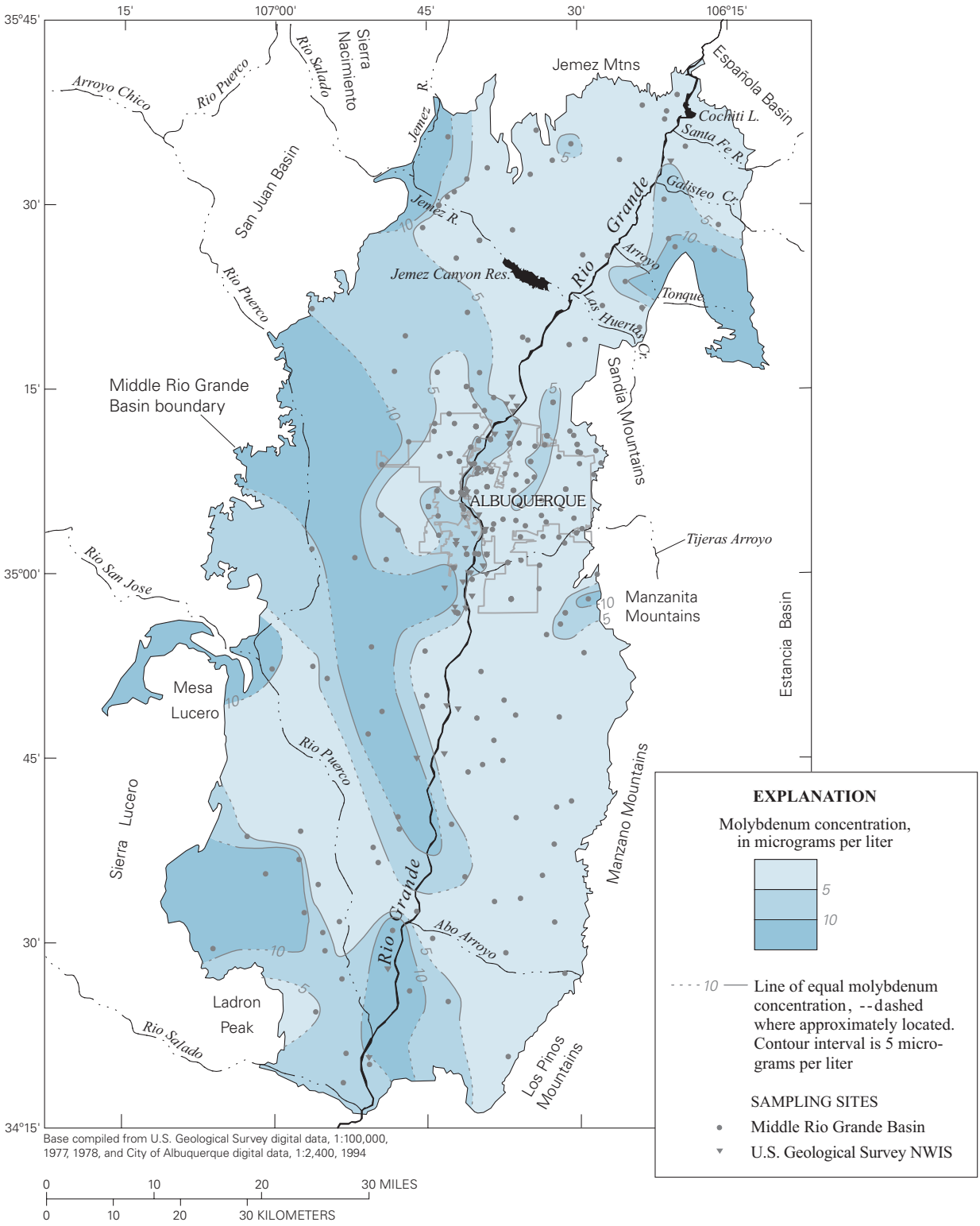


Figure 54. Molybdenum concentration for ground water of the Middle Rio Grande Basin, New Mexico.

miles in places. Concentrations of this magnitude also are at the south end of the basin and in the northeastern area, near the Hagan Embayment. The source of Mo in ground water of the basin is not known.

Strontium concentrations vary substantially throughout the MRGB. The highest concentrations (> 1,000 µg/L) generally are along the western margin of the basin and throughout the southwestern and southeastern parts of the basin (fig. 55). Concentrations of this magnitude also are present in the northeastern part of the basin (near the Hagan Embayment) and near the Tijeras Fault Zone. Concentrations substantially less than 500 µg/L are found along most of the eastern mountain front and throughout large sections of the central part of the basin. Strontium commonly replaces Ca in mineral structures, so that the higher concentrations may indicate greater contact with carbonate rocks, such as those along the western margin of the basin, in the Hagan Embayment, and in the vicinity of the Tijeras Fault Zone. Other sources of strontium include plagioclase feldspars and gypsum that can contain strontium in substitution for calcium.

Uranium concentrations are low (< 5 µg/L) in ground water throughout much of the basin (fig. 56). However, concentrations of about 10 µg/L or greater are in some ground water along the Rio Puerco, near the Tijeras Fault Zone, near Abo Arroyo, in the northeastern part of the basin, and near the Rio Grande. Some of the higher concentrations of U may be associated with the infiltration of surface water; U has been detected in water of the Rio Puerco, Abo Arroyo, and Tijeras Arroyo at concentrations exceeding 10 µg/L (table B4).

Similar to As, vanadium concentrations generally tend to be lower along the eastern and western margins than through the center of the basin (fig. 57). Concentrations along the margins typically are less than 5 µg/L, whereas concentrations exceed 10 µg/L across broad areas in the southeastern part of the basin and extending south from the Jemez Mountains. Adsorption/desorption processes may affect concentrations of V, which (like As) is present primarily as a negative oxyanion under the redox conditions of ground water in the MRGB.

Other minor elements for which ground-water samples were analyzed include Fe, Mn, Cr, Cu, Pb, Al, Rb, Co, Se, and Zn (tables A3 and A4). Because of contact with steel well casings, concentrations of Fe, Mn, Cr, Cu, Pb, and Zn in some samples may not be representative of concentrations present in ground water of the aquifer system. Samples from steel windmills may have been appreciably affected because of the small quantities of water pumped from these wells and the large amount of time during which pumping may not occur. These factors can allow for long contact times between ground water and the well casing (especially relative to steel-cased municipal-supply wells). Therefore, the use of these data in this investigation was limited. Examination of the data indicates that Zn and Fe concentrations in ground-water samples from windmills may have been most severely affected by corrosion of galvanized pipe.

Variations in Chemical Composition of Ground Water with Depth

Monitoring-well nests screened at substantially different depths are located at several sites across the MRGB, primarily in the vicinity of Albuquerque. Twenty such monitoring-well nests are shown in figure 58 and identified in table A1. In all of these nests, the deepest completion is at least 450 feet below the water table and the difference between the shallowest and deepest completions is at least 250 feet, and generally is more than 400 feet. Most of the nests are among those installed as part of a program started in 1996 by the City of Albuquerque, the New Mexico Office of the State Engineer, Bernalillo County, and the USGS to obtain water-level and water-quality information from multiple parts of the aquifer system, including from depths rarely reached by other wells. These nests typically contain three piezometers that are screened at the water table, near the middle of the pumped zone of the closest municipal supply wells, and near the bottom of or below the pumped zone (up to about 1,500 feet below the water table).

The data shown in tables A1-A4 for selected chemical parameters indicate that, although chemical variations are observed within the upper 2,000 feet of the aquifer system, areal variations on a basin-wide scale are generally higher than vertical variations in a particular location. The data also show that chemical parameters do not tend to vary in the same manner with depth in all areas of the basin. For example, specific conductance values for the Garfield piezometer nest (nest N, fig. 58) are lower in water from the deep completion than the shallow completion, but values for the 98th Street nest (nest F, fig. 58) are higher in water from the deep completion than the shallow completion.

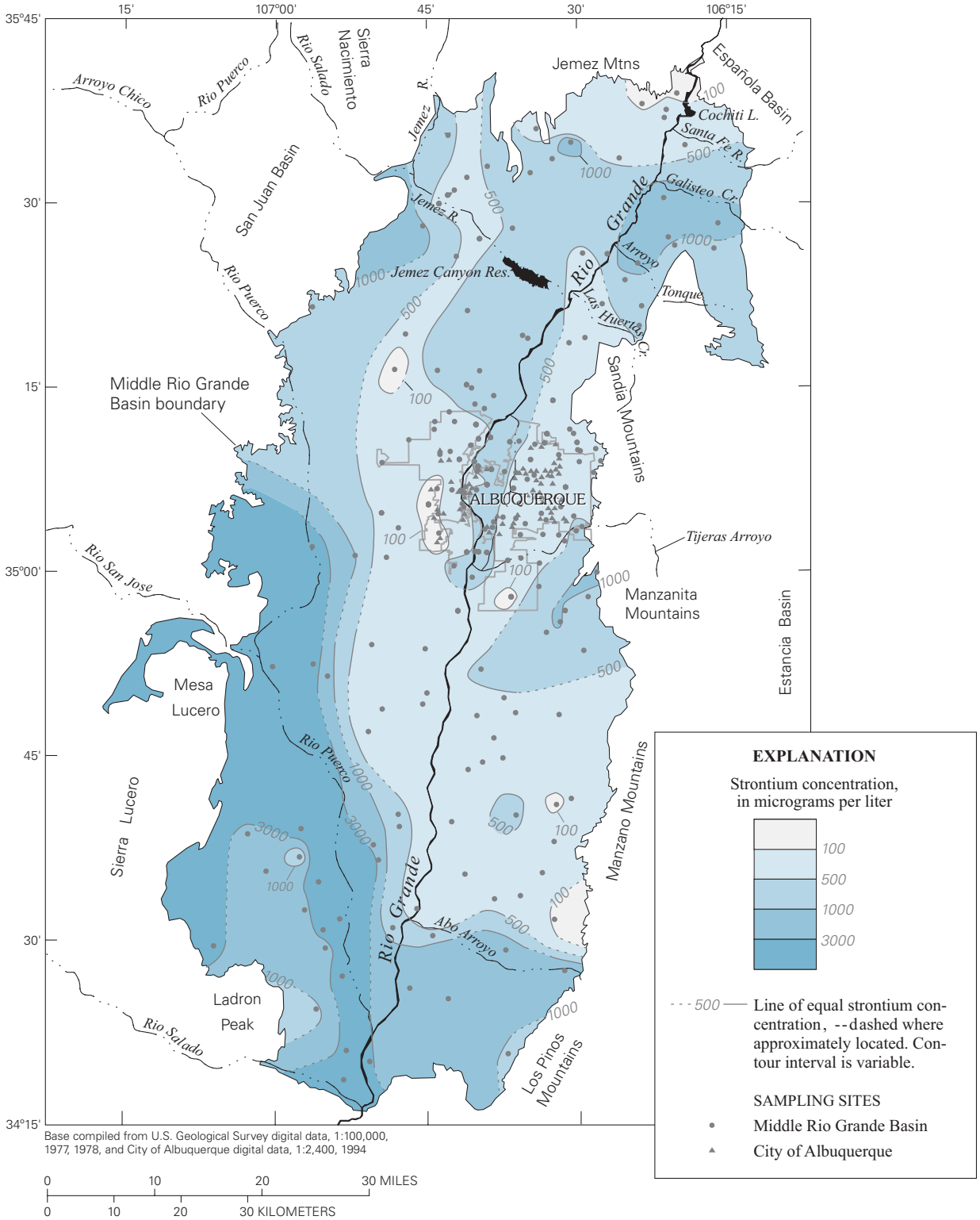


Figure 55. Strontium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

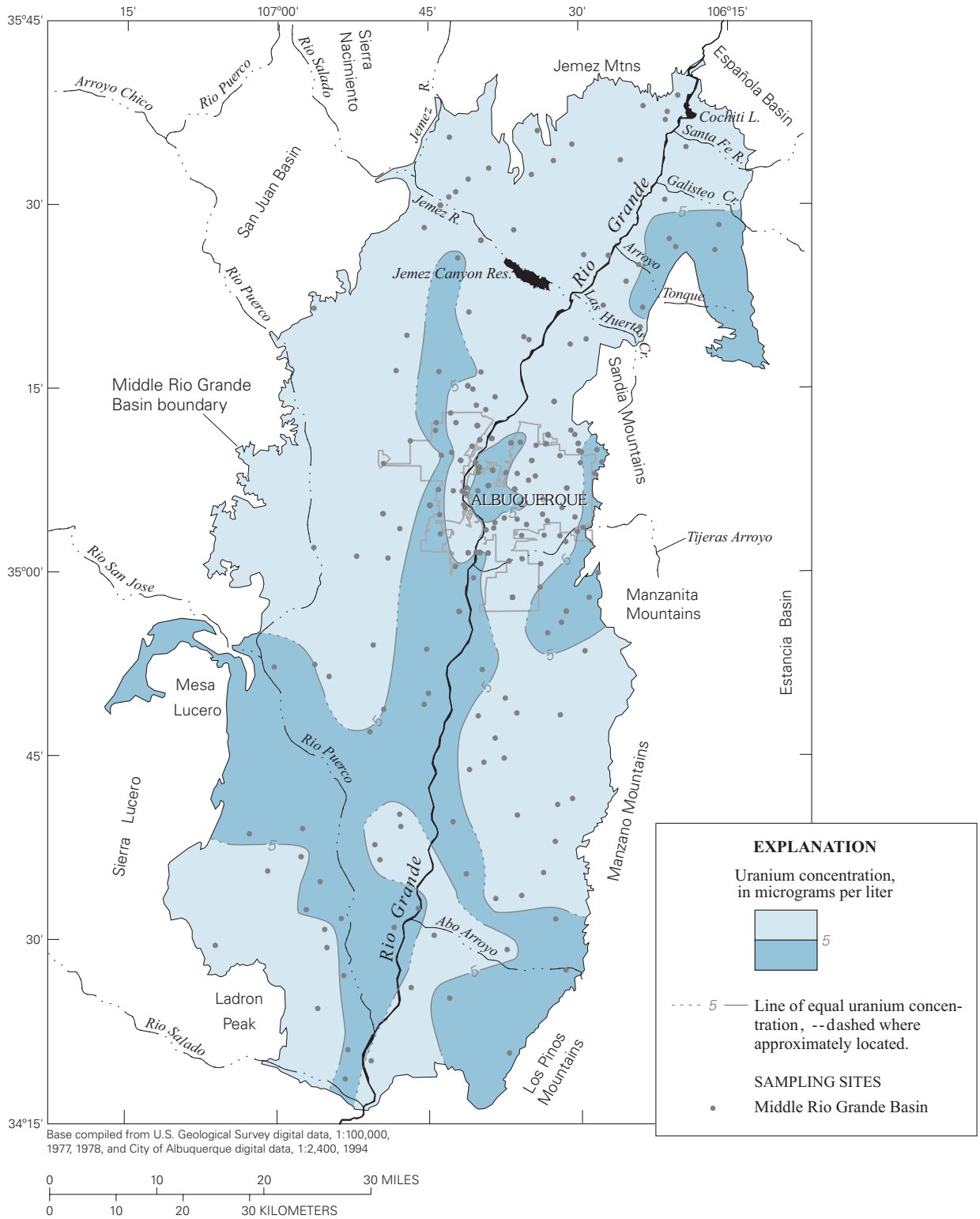


Figure 56. Uranium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

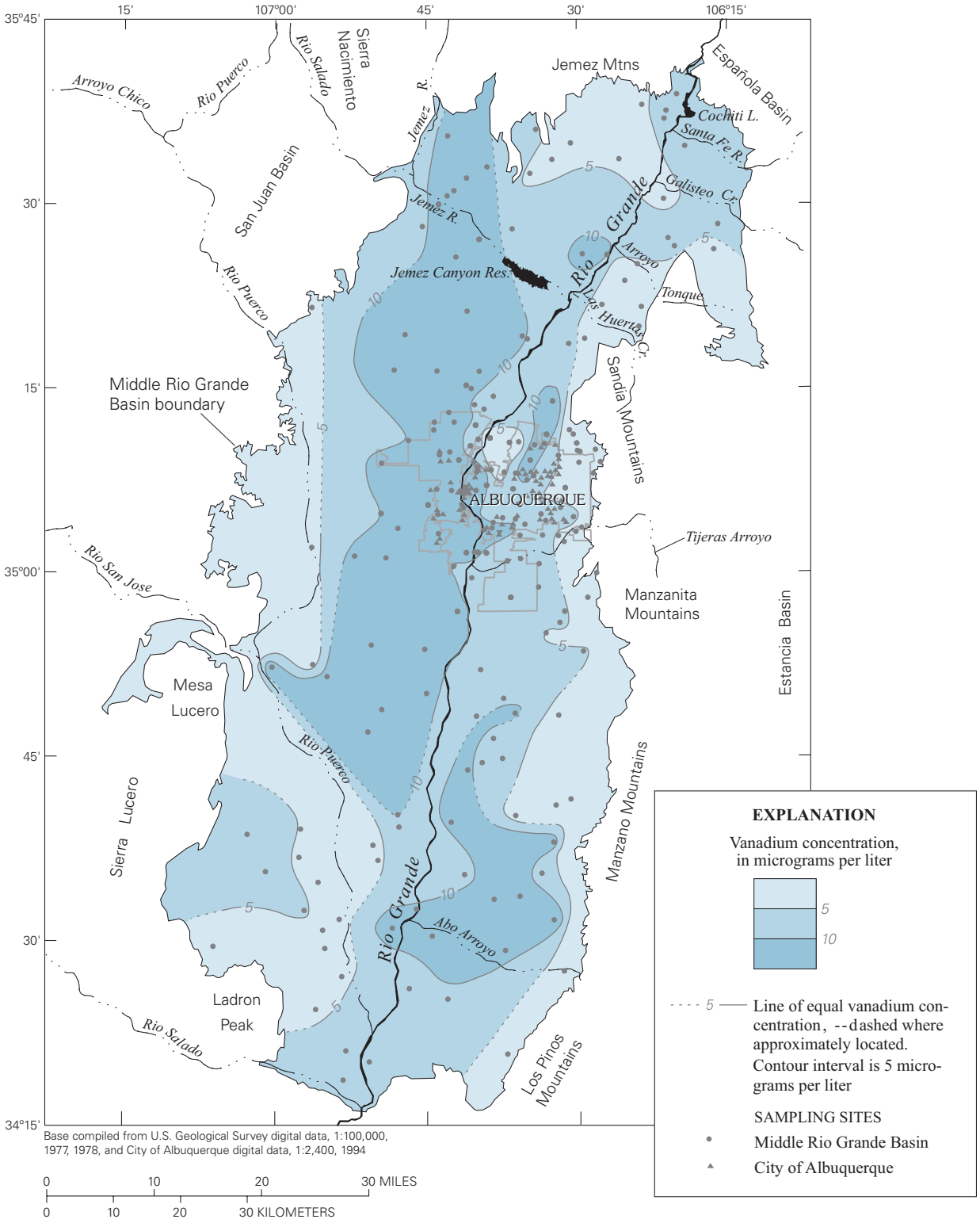


Figure 57. Vanadium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

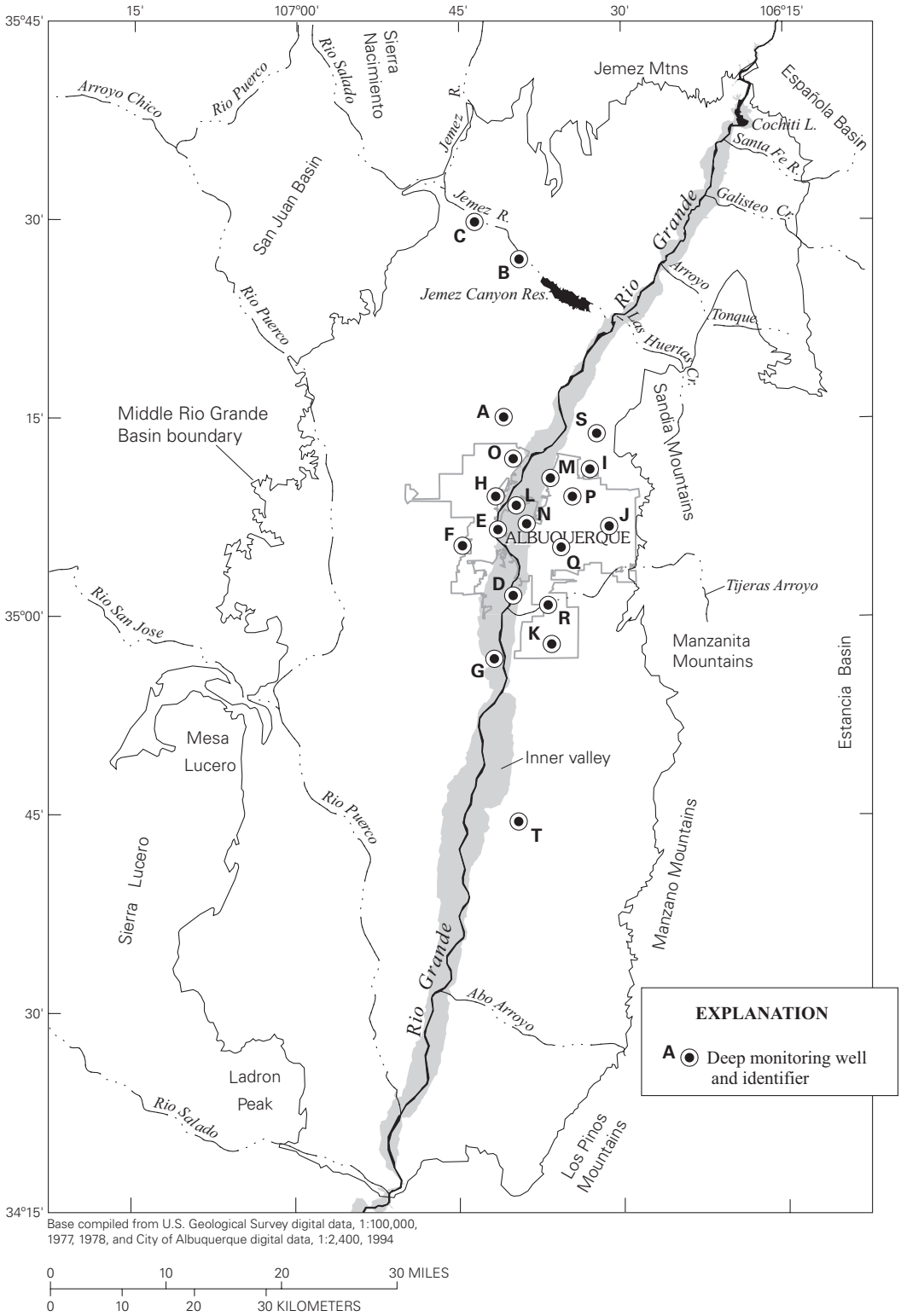


Figure 58. Locations of deep monitoring wells included in the data set for the Middle Rio Grande Basin, New Mexico (see table A1 for well identification).

Therefore, vertical variations in water chemistry probably do not result from the same processes at all locations. Bexfield and Anderholm (2002a) discuss the variation observed in data collected by the City of Albuquerque Environment Department from several of the well nests listed in table A1. They conclude that evapotranspiration, land-use practices, different water sources, and longer flow paths/times at depth likely contribute to variations observed with depth in different well nests.

Some well nests are located in the flood plain of the Rio Grande or the Jemez River, where the water table is within about 50 feet of land surface. In these areas, evapotranspiration and land use can reasonably be expected to affect water quality at shallow depths. Factors such as these probably contribute to higher specific conductance values and Cl concentrations in shallow relative to deep completions of the Garfield (nest N in figure 58), Isleta (nest G), Paseo 3 (nest M), and Zia Ball Park (nest C) well nests (fig. 59). The effects of evapotranspiration and land use are likely to be important only in the shallow completions of wells located in areas where the water table is near the land surface.

Other well nests are located in areas that previously have been identified as potential sites of upwelling of deep, mineralized water having high Cl and As concentrations (Bexfield and Plummer, 2002). Upwelling of mineralized water probably contributes to higher specific conductance values and Cl concentrations in deep relative to shallow completions of the Nor Este (nest I) and Sister Cities (nest P) well nests (fig. 59). The same process also may affect other well nests located near major structural features (faults and/or structural highs). Mixing of deep, mineralized water with water in shallower parts of the aquifer system may be important over broad areas of the basin.

Other regional factors that could cause substantial vertical variation in water chemistry in the MRGB include differences in recharge area, ground-water travel times, or geologic materials along flow paths at different depths. Because the sediments of the Santa Fe Group aquifer system at the depths studied for this investigation consist primarily of alluvium of granitic and metamorphic derivation, the geologic materials that water contacts do not differ substantially with depth and are not likely to be a major factor in chemical variation. The importance of differences in recharge area and travel times for water at various depths within the basin will be discussed in greater detail below. Overall, the most common and consistent (but not ubiquitous) changes in water chemistry with increasing depth in the aquifer system appear to be increases in temperature, Na, As, and B concentrations, and decreases in Ca concentration. Additional information on variations in stable isotopic composition of water and ^{14}C activity of DIC with depth is given below.

Hydrogen-2 and Oxygen-18 Isotopes in Ground Water

In most cases, it is likely that the stable isotopic composition of ground water in the MRGB records the isotopic composition of the source water, as has been observed in other semiarid regions (Vogel and Van Urk, 1975). As identified previously, the likely sources of water to the basin include recharge from precipitation along mountain fronts, seepage from rivers and arroyos (including the Rio Grande, the Rio Puerco, the Jemez River, and Tijeras and Abo Arroyos), and subsurface ground-water inflow from adjacent basins. Following recharge, few processes can affect the isotopic composition of ground water within the MRGB. Except for thermal waters discharging along fault zones or in geothermal areas such as the Jemez Mountains, most ground-water temperatures do not exceed 30°C in the MRGB and the stable isotope composition can be regarded as unaffected by water-rock interaction or geothermal isotope exchange processes (Panichi and Gonfiantini, 1981). In the recharge process, soil water taken up by plants is not fractionated (White and others, 1985; Ehleringer and Dawson, 1992; Dawson, 1993), and, thus, the stable isotopic composition of ground water is insensitive to plant uptake, even though the dissolved solutes can be concentrated by a factor of two or more during the growing season in shallow ground-water environments such as the inner valley of the Rio Grande (Anderholm, 1988).

Previous Studies

Stable isotope data for waters from the MRGB and vicinity can be found in Goff and others (1983), Yapp (1985), Vuataz and Goff (1986), Logan (1990), Anderholm (1994), and Lambert and Balsley (1997). Yapp (1985) first recognized most of the prominent features of the isotopic composition of precipitation, surface water, and ground water in the vicinity of

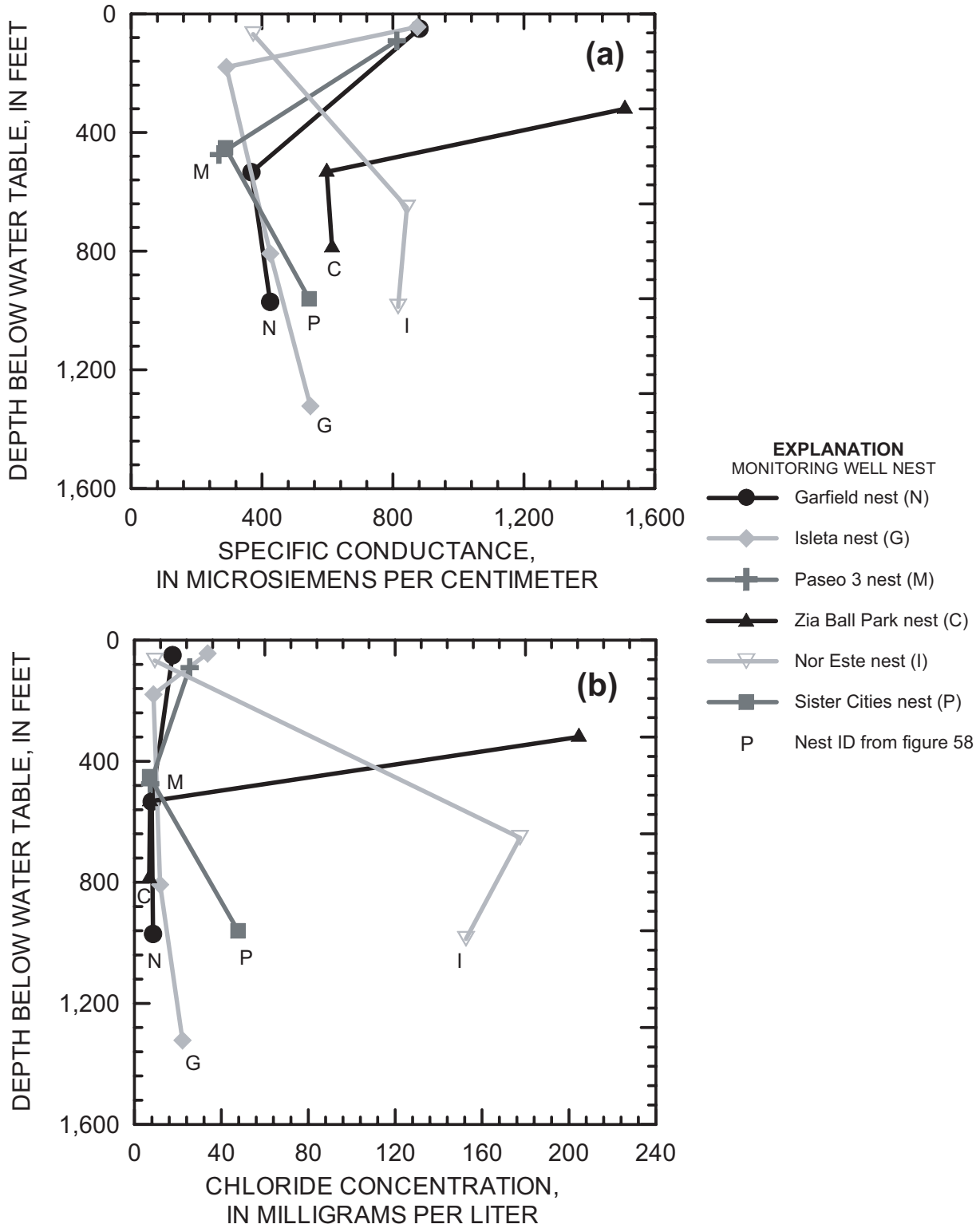


Figure 59. (a) Specific conductance values, and (b) chloride concentrations with depth for selected deep monitoring well nests in the Middle Rio Grande Basin, New Mexico. The monitoring well nests are located on figure 58 and identified in table A1.

Albuquerque. Yapp (1985) tabulates and/or plots approximately 147 measurements of δ^2H (VSMOW scale) of waters from the vicinity of Albuquerque collected between October 1980 and October 1982. The $\delta^{18}O$ composition of the water samples was not determined by Yapp.

Yapp (1985) found that ground water from City of Albuquerque production wells varied widely between -77 and -104 per mil in δ^2H over a lateral distance of only 12 miles at Albuquerque. Because none of the local ground-water samples were as enriched in ^2H as the average local precipitation sampled (-60 per mil), Yapp (1985) suggested that little of the ground water at Albuquerque can be recharged locally by direct infiltration of precipitation; however, the possibility of seasonally-weighted direct infiltration could not be excluded. The possibility of seasonal weighting of direct infiltration favoring the winter months was also considered unlikely by Yapp (1985) because the amount of winter precipitation is generally the lowest of any season of the year in an already arid climate. Yapp (1985) concluded that runoff from the Sandia and Manzano Mountains and recharge from the Rio Grande were the most likely modern contributions to ground water in the Albuquerque area.

Three distinct groups of waters were recognized in the Albuquerque vicinity based on their δ^2H isotopic composition (Yapp, 1985). Ground water along the eastern side of Albuquerque nearest the Sandia Mountains (referred to by Yapp as "Eastern domain" waters) was consistently enriched in ^2H (δ^2H of -75 to -86 per mil), and was attributed to recharge from precipitation that fell in the Sandia Mountains. Over a narrow transition striking north-northeast, and of horizontal width of only about 1 to 2 miles, the δ^2H isopleths of ground water at Albuquerque became distinctly depleted in ^2H, to a composition similar to that of Rio Grande water (approximately -92 to -94 per mil). Yapp (1985) referred to the depleted waters as "Western domain" waters, which ranged in δ^2H from -90 to -104 per mil, and suggested that they represented waters recharged by infiltration of Rio Grande water. Within the "Western domain" waters, Yapp (1985) recognized a third group of waters on the west side of the Rio Grande, southwest of Albuquerque, that were even more depleted than modern Rio Grande water; these waters were referred to by Yapp as "Deuterium-depleted Deep water", with δ^2H values of -102 to -104 per mil. Yapp (1985) suggested that the "Deuterium-depleted Deep water" could be waters recharged from the Rio Grande at a time when the river was, on average, about 10 per mil more depleted in ^2H than at present. Further evidence was presented showing that δ^2H values of ground water actually decreased further east of the Rio Grande to -98 per mil, suggesting that the production wells discharged ground-water mixtures containing appreciable fractions of the "Deuterium-depleted Deep water", which presumably occurred at some depth beneath the zone of modern Rio Grande water east of the river. As is shown below, all but one of the conclusions of Yapp (1985) are strongly supported by the findings of this study. The exception is the actual origin of the "Deuterium-depleted Deep water", which was tentatively suggested by Yapp (1985) to represent infiltration from the Rio Grande, possibly during the "Little Ice Age" (extending from approximately A.D. 1450 to 1620). The present study also recognizes the "Deuterium-depleted Deep water" of Yapp (1985), and documents its eastern extent at depth beneath Albuquerque, but its age is on the order of 20,000 radiocarbon years, and it represents a predominant water type in the MRGB extending north to south through most of the west-central part of the basin. The source of the "Deuterium-depleted Deep water" can still be debated, but as shown below from many lines of evidence, the "Deuterium-depleted Deep water" is not derived from the Rio Grande.

In spring of 1995 Sandia National Laboratories (SNL) collected water samples from 25 municipal-supply wells in Albuquerque and analyzed these waters for δ^2H and $\delta^{18}O$. The results are reported in Lambert and Balsley (1997) on the VSMOW scale and compared with values of δ^2H reported by Yapp (1985) for the same wells sampled in the early 1980's. The δ^2H values of most of the samples were similar to those reported by Yapp (1985), but were shifted to more depleted values, by as much as 5 per mil in the 1995 samples relative to the δ^2H values reported by Yapp (1985). The prominent patterns in isotopic variation in the vicinity of Albuquerque observed by Yapp (1985) were confirmed in the 1995 samples. "Eastern domain" water was defined by Lambert and Balsley (1997) as $\delta^2H > -86$ per mil and $\delta^{18}O > -12.1$ per mil, and a "central domain" water, presumably derived predominantly from the Rio Grande, had $\delta^2H < -95$ per mil and $\delta^{18}O < -13.2$ per mil. Lambert and Balsley (1997) noted that samples from only a few wells had δ^2H values near the "baseline" value for Rio Grande water defined by Yapp (1985) of -92 per mil. They suggested that the apparent shift to slightly more

depleted δ^2H in 1995 relative to the early 1980's may reflect the response of the aquifer system to pumping in the eastern domain and southwest areas, resulting in an expansion of the central-basin region. In comparing stable isotope results for samples from the same wells collected over a span of approximately 15 years, the assumption was made that both laboratories, reporting on the VSMOW scale, would find identical results if the same sample of water were analyzed in either laboratory. This assumption was not, however, investigated by Lambert and Balsley (1997), and left open the question of whether there are temporal shifts in the δ^2H composition of water pumped from some municipal wells in Albuquerque, or whether the differences reflect some artifact of the analytical procedures between the two laboratories. This question is addressed below.

Comparability of Results

Analyses from the USGS Stable Isotope Laboratory, Yapp (1985), Lambert and Balsley (1997), and the contract laboratory for the City of Albuquerque production wells (Logan, 1990, and City of Albuquerque, unpublished data) were examined for comparability. As discussed in the "Methods" section, analyses were performed at the USGS Stable Isotope Laboratory for newly collected ground- and surface-water samples, archived precipitation samples, and archived water samples that had been collected and previously analyzed by Yapp (1985). Values of δ^2H reported by Yapp (1985) and the re-analyzed values from the USGS Stable Isotope Laboratory are compared in figure 60. Apparently, there is a small but systematic bias between the two sets of δ^2H values, with the values reported by Yapp (1985) being more enriched in ^2H than those determined by the USGS laboratory. In only two samples, δ^2H measured in the USGS laboratory was more enriched in ^2H than the value reported by Yapp (1985). Excluding these two samples (Love 3 and Volcano Cliffs 2, both sampled on August 18, 1981) as being possibly evaporated on storage, the remaining 38 samples average 2.0 ± 1.1 per mil more depleted in ^2H in the analyses from the USGS laboratory than reported by Yapp (1985). Although 15-17 years elapsed between measurements, the differences shown in figure 60 for the remaining 38 samples are small and in the opposite direction to that expected for evaporation (evaporation would cause an enrichment in ^2H). The difference between δ^2H values reported by Yapp (1985), and those of the re-analyzed waters indicates that for the most depleted waters, the bias between Yapp (1985) and the USGS laboratory is greater than for the more enriched waters (fig. 60). The least squares slope of the correlation between the USGS re-analyzed values and the Yapp (1985) reported values is 0.965, representing a difference of 3.5 per mil over a range of 100 per mil, or 3.5 percent of the reported value.

No significant offset was found in δ^2H values reported by SNL and the USGS (fig. 61a). Although the identical water samples collected in 1995 and analyzed by Lambert and Balsley (1997) were not available, 19 of the 25 wells sampled by SNL in 1995 were re-sampled in either 1996 or 1997, with stable isotopes analyzed by the USGS. The average deviation in δ^2H between the SNL and USGS (δ^2H_{SNL} - δ^2H_{USGS}) analyses of the 19 samples was 0.3 ± 1.5 per mil. This result suggests that δ^2H values from SNL can be compared directly to the USGS values without further correction, but that 2.0 per mil, on average, should be subtracted from δ^2H values reported by Yapp (1985) in order to compare Yapp's δ^2H values with those measured as a part of this study. Although Yapp (1985) did not measure $\delta^{18}O$, values of $\delta^{18}O$ were measured by Lambert and Balsley (1997) and also can be compared without correction to the USGS values determined on waters sampled from the same 19 wells. In this case, there is a slight deviation in $\delta^{18}O$ between the two sets of samples, with the SNL values averaging 0.12 per mil ± 0.08 per mil more depleted in $\delta^{18}O$ than those values determined by the USGS (fig. 61b). The difference is small and, on average, within the analytical uncertainties, yet apparently systematically biased to slightly more negative $\delta^{18}O$ values in the SNL analyses reported by Lambert and Balsley (1997).

It is possible that in the case of Lambert and Balsley (1997), the differences in $\delta^{18}O$ reflect real temporal differences in the isotopic composition of water pumped from Albuquerque municipal wells, but if so, depletion in ^2H on the order of 1.0 per mil in the SNL samples relative to the USGS samples would be expected. Instead, a small enrichment of 0.3 per mil was found in the ^2H values of the SNL samples relative to the USGS samples. Therefore, it is likely that the SNL values are slightly depleted in ^{18}O relative to the USGS values, with an average bias of 0.12 per mil in $\delta^{18}O$.

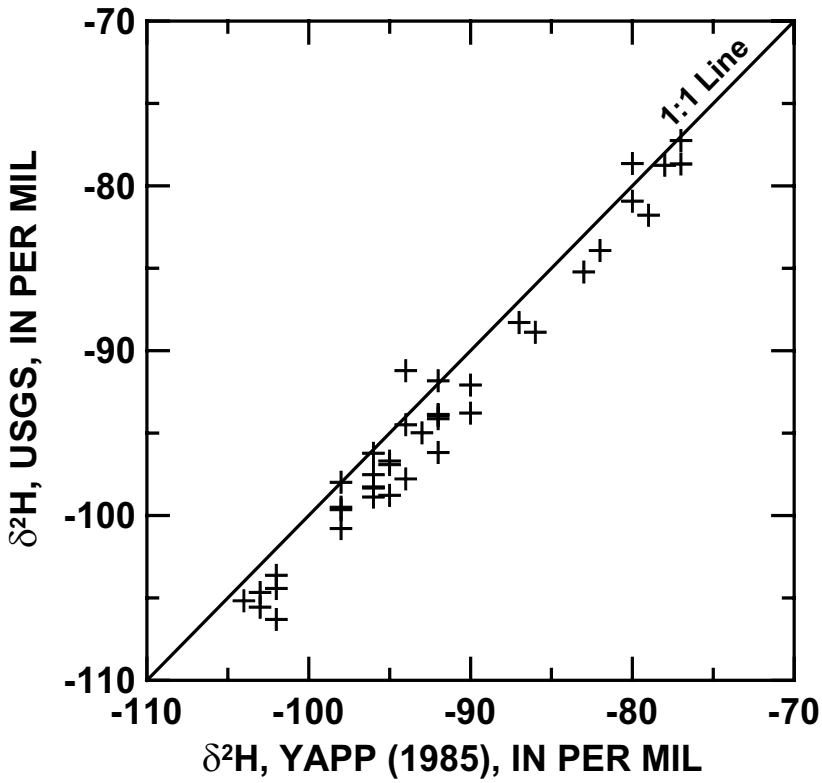


Figure 60. Comparison of δ^2H isotopic composition of water samples reported by Yapp (1985) with U.S. Geological Survey (USGS) re-analyzed values from the archived water samples, determined as a part of this study in the Middle Rio Grande Basin, New Mexico. The values reported by Yapp (1985) are slightly enriched in ^{2}H relative to those values determined by the USGS laboratory.

The results from the contract laboratory for samples from the City of Albuquerque production wells were compared to the USGS results for the re-analyzed Yapp samples from 1980 to 1982, and the USGS samples from 1996 to 1997. The stable isotope analyses from the contract laboratory are in reasonably good agreement with the other data sets, as shown by Logan (1990), but do not appear to have been determined with sufficient precision or accuracy to permit recognition of possible temporal variations in the isotopic composition of water discharged from City of Albuquerque production wells. As mentioned in the "Methods" section, the average standard deviation of δ^{18}O values from all replicate analyses provided by the contract laboratory was 0.22 per mil, as compared to 0.12 and 0.06 per mil in δ^{18}O for the average of the standard deviations from the re-analyzed Yapp samples (1980-82) and the USGS samples (1996-97). The maximum difference in δ^{18}O from a set of representative samples (samples all from the same well) analyzed by the contract laboratory ranged over more than 1 per mil, but was only 0.10 per mil in the USGS samples and 0.28 per mil in the re-analyzed Yapp samples (removing samples from West Mesa 3 (site S272) that apparently show considerable natural variation). Although part of the remaining variation in standard deviation in replicate samples is attributed to real variations in the isotopic composition of water pumped from the municipal wells, the relative differences between the sources of stable isotope data indicate that the most precise data were obtained from the USGS laboratory, either of samples collected by Yapp in the early 1980's and re-analyzed by the USGS, or of samples collected as a part of this study (1996-97) and analyzed by the USGS laboratory.

In addition to the problems with precision of measurements between the contract laboratory and the USGS laboratory, there are more fundamental problems in the accuracy of the analyses from the contract laboratory. To demonstrate these problems, the average δ^{18}O value was computed for water from each well, as reported for each sample set: (1) the

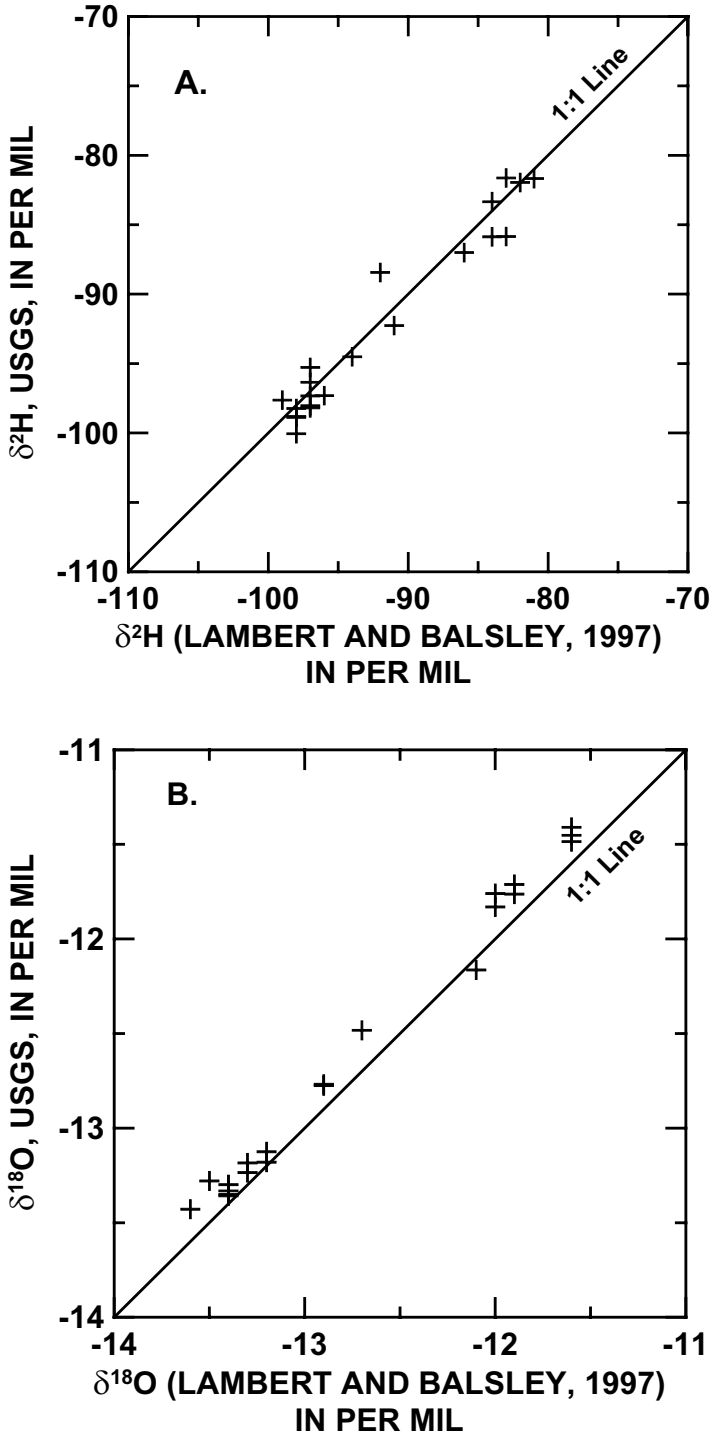


Figure 61. Comparison of δ^2H and δ^{18}O isotopic compositions of water from City of Albuquerque, New Mexico, production wells reported by Lambert and Balsley (1997) and the U.S. Geological Survey (USGS). (A) Comparison of δ^2H isotopic composition of water samples reported by Lambert and Balsley (1997) for water samples collected in 1995 with USGS analyses of water samples collected from the same wells in 1996 and 1997. (B) Comparison of δ^{18}O isotopic composition of water samples reported by Lambert and Balsley (1997) for water samples collected in 1995 with USGS analyses of water samples collected from the same wells in 1996 and 1997.

contract laboratory (1987-90), (2) the Yapp samples from 1980 to 1982 re-analyzed by the USGS, and (3) the USGS samples from 1996 to 1997. The difference in the average $\delta^{18}O$ values between the contract lab and the USGS analyses (contract lab 1987-90 analytical values minus USGS 1996-97 analytical values), and between the Yapp samples and the USGS analyses (re-analyzed Yapp samples 1980-82 minus USGS 1996-97) was -0.23 and -0.01 per mil in $\delta^{18}O$. That is, for the population of municipal wells as a whole, the contract lab $\delta^{18}O$ results are more depleted in ^{18}O relative to the USGS results of either the re-analyzed Yapp samples from the early 1980's or the samples from 1996-1997 (fig. 62). As seen in a following section of this report ("Temporal Variations"), the stable isotopic composition of water from some wells in the Albuquerque vicinity has shifted since the early 1980's (West Mesa 3, Ponderosa 2, Ponderosa 3, Leavitt 1, College 1, College 2, and Charles 4). Removing these samples from the averaging, the average standard deviation of the differences between the contract laboratory (1987-90) and the USGS Laboratory (1996-97) was -0.25 ± 0.18 per mil at 74 wells, and the differences between the re-analyzed Yapp samples (early 1980's) and the USGS samples (1996-97), at 19 City of Albuquerque municipal wells, spanning nearly 17 years, was -0.05 ± 0.10 per mil in $\delta^{18}O$ (fig. 63).

Unfortunately, no water samples analyzed by the contract laboratory (1987-90) were retained and, therefore, they cannot be re-analyzed. However, given the stated differences between the results from the contract laboratory and results from the USGS laboratory, all stable isotope results from the contract laboratory were disregarded in comparison of historical data in this report, because the results from the re-analyzed Yapp samples from the early 1980's and the analyses from 1996 to 1997 span the range of historical data.

Finally, if the adjustment of 2.0 per mil in $\delta^{2}H$ is applied to the original analyses of Yapp (1985), the baseline for the $\delta^{2}H$ composition of ground water derived from the Rio Grande at Albuquerque, proposed by Yapp (1985), is shifted from -92 per mil to -94 per mil. Water from Bear Canyon in the Sandia Mountains, indicative of "Eastern Domain" water, is then shifted from -83 to -85 per mil. These adjusted values for "baseline" Rio Grande water and "Eastern Domain" water are nearly identical to the $\delta^{2}H$ values reported by Lambert and Balsley (1997), of -95 and -86 per mil, respectively. These values leave little possibility for historical shifts in stable isotopic composition of most ground water pumped from wells in the vicinity of Albuquerque.

Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water in the Albuquerque Area

Approximately 380 stable isotope measurements of ground water in the vicinity of Albuquerque have been made as a part of this study. The data include re-analysis of 132 ground-water samples collected by C. Yapp in the early 1980's, analysis of 91 water samples from City of Albuquerque production wells from summer 1997, and analysis of approximately 150 water samples collected as a part of this investigation in the period 1996-98 from the vicinity of Albuquerque (tables A9-A10). The samples collected as a part of this study include samples from City of Albuquerque production wells, domestic wells, and a network of monitoring wells. Samples from the monitoring-well network provide details of the vertical variation in chemical and isotopic composition of ground water to depths of more than 1,000 feet below the water table. These monitoring wells give the most representative stable isotope analyses of ground water in the MRGB because they sample relatively narrow intervals of aquifer, minimizing mixing of waters in the well bore. Comparison of the results from the re-analyzed water samples from the early 1980's with the isotopic analyses of water from the mid- to late- 1990's provides new information on possible ground-water flow during approximately the past 20 years in the Albuquerque area in response to withdrawal from municipal-supply wells.

Although there are variations in stable isotopic composition of ground water with depth in the Albuquerque vicinity, horizontal variations across the basin are greater than most vertical variations, permitting stable isotope variations to be contoured (fig. 64). Most ground water beneath the eastern-most third of Albuquerque and north of Tijeras Arroyo has $\delta^{2}H$ values of -80 to -85 per mil (fig. 64). This water is similar in isotopic composition to mountain-front recharge along the western side of the Sandia Mountains at Albuquerque, as seen at Bear Canyon and Embudo and Embudito Springs (table 5). South of Tijeras Arroyo in the region beneath most of Kirtland Air Force Base, the stable isotopic composition of ground water is enriched in ^{2}H by typically 10 per mil or more relative to mountain-front recharge at

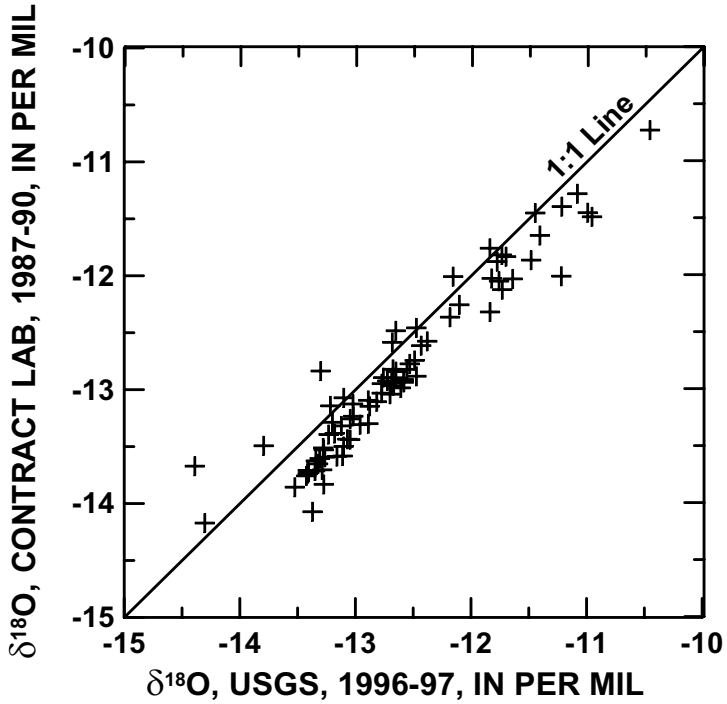


Figure 62. Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque, New Mexico, production wells collected in 1987-90 and analyzed by a private contract laboratory with analyses of water samples collected in 1996-97 and analyzed by the U.S. Geological Survey.

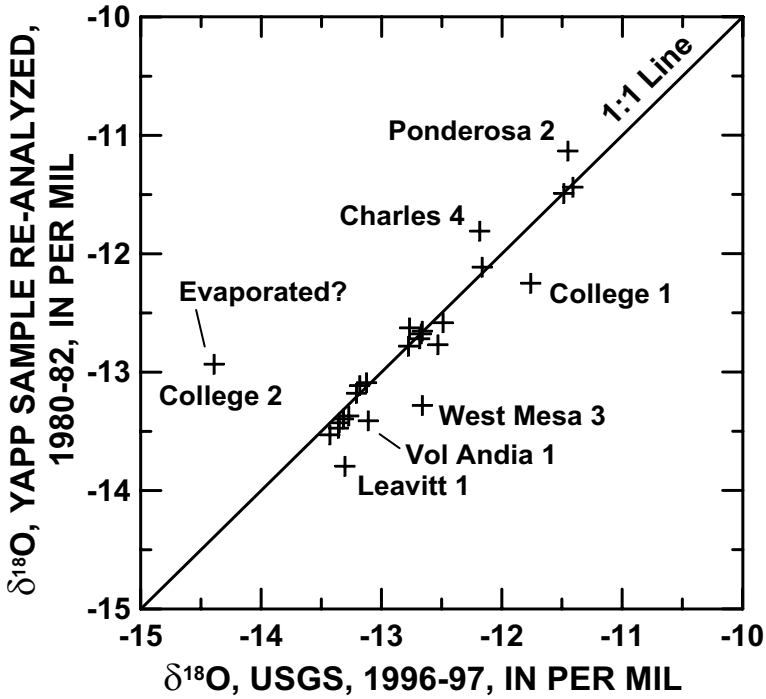


Figure 63. Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque, New Mexico, production wells collected in 1980-82 and re-analyzed by the U.S. Geological Survey (USGS) with water samples collected from the same wells in 1996-97 and analyzed by the USGS.

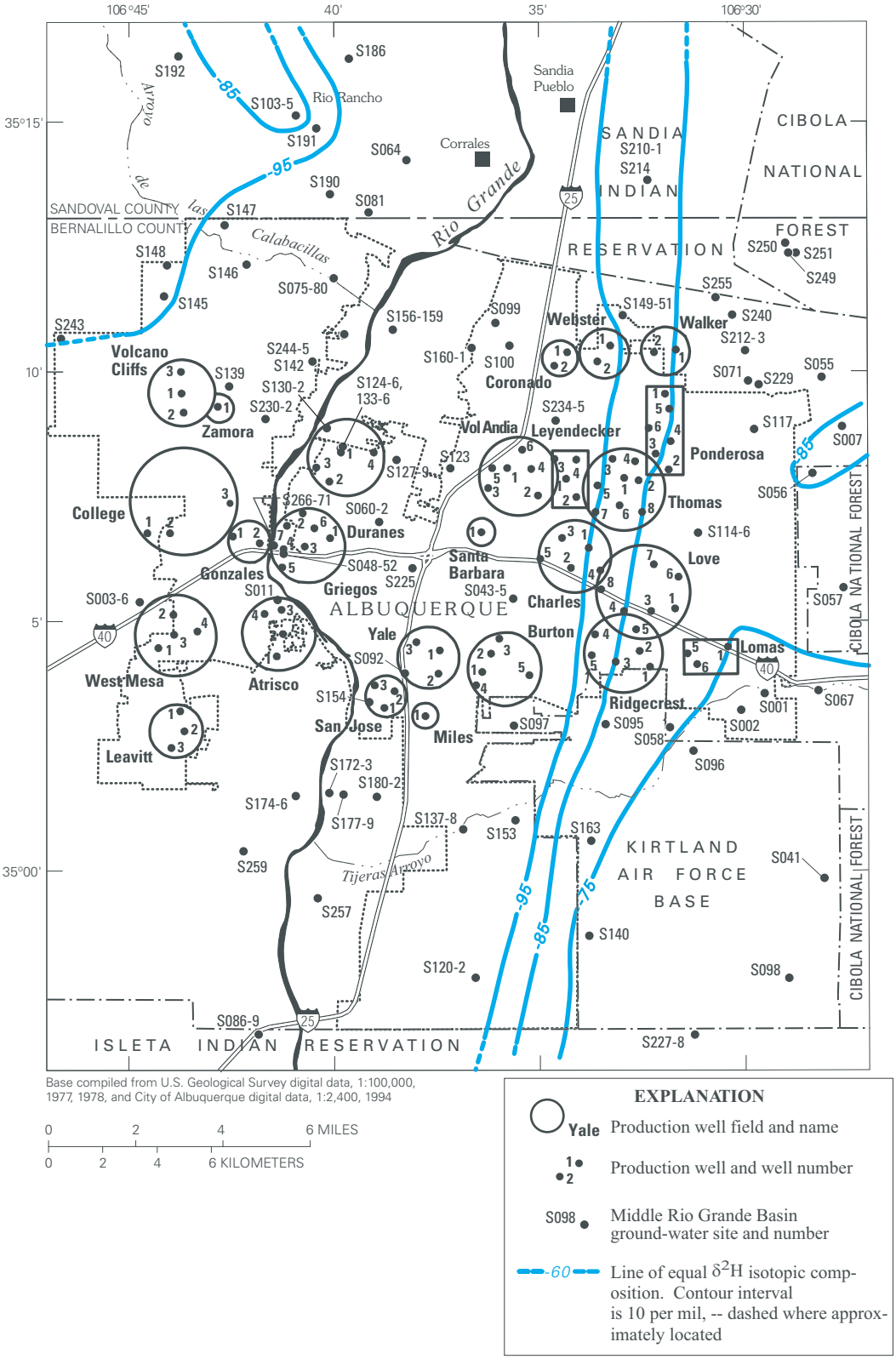


Figure 64. δ^2H isotopic composition of ground water in the vicinity of Albuquerque, New Mexico.

Albuquerque, and is similar in isotopic composition to many of the surface-water samples from Tijeras Arroyo (table 5) and water associated with the Tijeras Fault Zone southeast of Albuquerque (fig. 64). To the west of these two regions, and beneath approximately the western two-thirds of the City of Albuquerque, the stable isotopic composition of ground water becomes appreciably depleted in ^2H. The transition to isotopically-depleted water occurs over a narrow zone, of width less than approximately 1 mile, and strikes approximately north-south (fig. 64). West of the transition zone, the δ^2H values of water are typically more negative than -90 per mil, in the range of -90 to -100 per mil. Some waters, in an area south and southwest of Albuquerque, have δ^2H values more negative than -100, reaching -110 per mil at the mid-depths of the 98th Street well nest (sites S004 and S005) (fig. 64). Waters in the range of -90 to -100 per mil are similar in isotopic composition to that of the Rio Grande, as pointed out by Yapp (1985). Also, the "Deuterium-depleted Deep water" recognized by Yapp (1985) discharges from wells in the College, Leavitt and West Mesa well fields in the southwestern part of Albuquerque (table A10) and from the mid-depths of the monitoring wells at 98th Street west of Albuquerque and Mesa Del Sol (site S121) east of the Rio Grande, in the southern part of Albuquerque (table A9) (fig. 64).

In sharp contrast to the relatively depleted waters throughout most of the vicinity of Albuquerque, some of the most enriched ground-water samples of the entire MRGB occur in the Lincoln nest (sites S103-S105), west of Corrales, and northwest of Albuquerque, where δ^2H values of -56.6, -56.5, and -67.3 per mil were found at the shallow, medium, and deep completions, respectively (fig. 64). The samples from the Lincoln nest do not appear evaporated and were probably recharged at relatively low altitudes in the northern part of the basin.

Temporal Variations

Temporal variations in the stable isotope composition of ground water in the vicinity of Albuquerque were examined as a means to estimate the extent to which the patterns mapped in figure 64 are representative of predevelopment conditions, and to investigate areas where ground-water flow in response to withdrawals can be identified in the vicinity of Albuquerque. Here, the stable isotopic composition of water pumped from specific wells at Albuquerque is compared for samples collected in 1996 to 1997 with those re-analyzed from the C. Yapp set of samples that were collected in the early 1980's. Values of $\delta^{18}O$ in water from many of the production wells in Albuquerque that were in operation in the early 1980's and the late 1990's are compared in figure 65. Values of $\delta^{18}O$ are plotted instead of δ^2H because the $\delta^{18}O$ measurements have higher precision than δ^2H measurements. It is apparent that the $\delta^{18}O$ range of isotopic composition for water from all City of Albuquerque production wells spans approximately 3 per mil. Water from most individual wells sampled over several years' time varies in $\delta^{18}O$ by $\pm$ 0.2 per mil or less. Apparently, then, most water pumped from City wells has been nearly constant in isotopic composition from the early 1980's through the late 1990's (fig. 65). Wells (with sufficient records from the early 1980's) that have produced water nearly constant in isotopic composition since the early 1980's can be found in the Atrisco, Burton, Duranes, Griegos, Leyendecker, Love, Ridgecrest, Santa Barbara, Thomas, Volandia, Volcano Cliffs, West Mesa (fig. 66), and Yale well fields (fig. 65).

Waters from only a few wells clearly show a shift in stable isotopic composition between the early 1980's and the late 1990's, and these tend to be located along the boundaries between differing water sources. These wells include Ponderosa 2 and Charles 4, which were producing water more depleted in stable isotopes in the late 1990's than in the early 1980's, and wells 1-3 in the Leavitt field, which were producing water somewhat more enriched in stable isotopic composition in the late 1990's than in the early 1980's (figs. 64-65). The shifts in stable isotopic composition over time are detected because the wells indicating changes in isotopic composition over time are located near boundaries between source waters of appreciably different isotopic composition. Apparently, old ground water of Rio Grande origin has moved slightly in response to hydraulic gradients created by pumping along the boundaries between the various water sources at Albuquerque. Ponderosa 2 and Charles 4 are located in the eastern part of Albuquerque, along the boundary between the depleted water, presumably derived from the Rio Grande, and the enriched water from mountain-front recharge. Apparently, resident ground water of (paleo) Rio Grande origin is moving eastward over time to mix with mountain-front recharge withdrawn from the Ponderosa and Charles fields. The Leavitt Field is located west of the Rio Grande and southwest

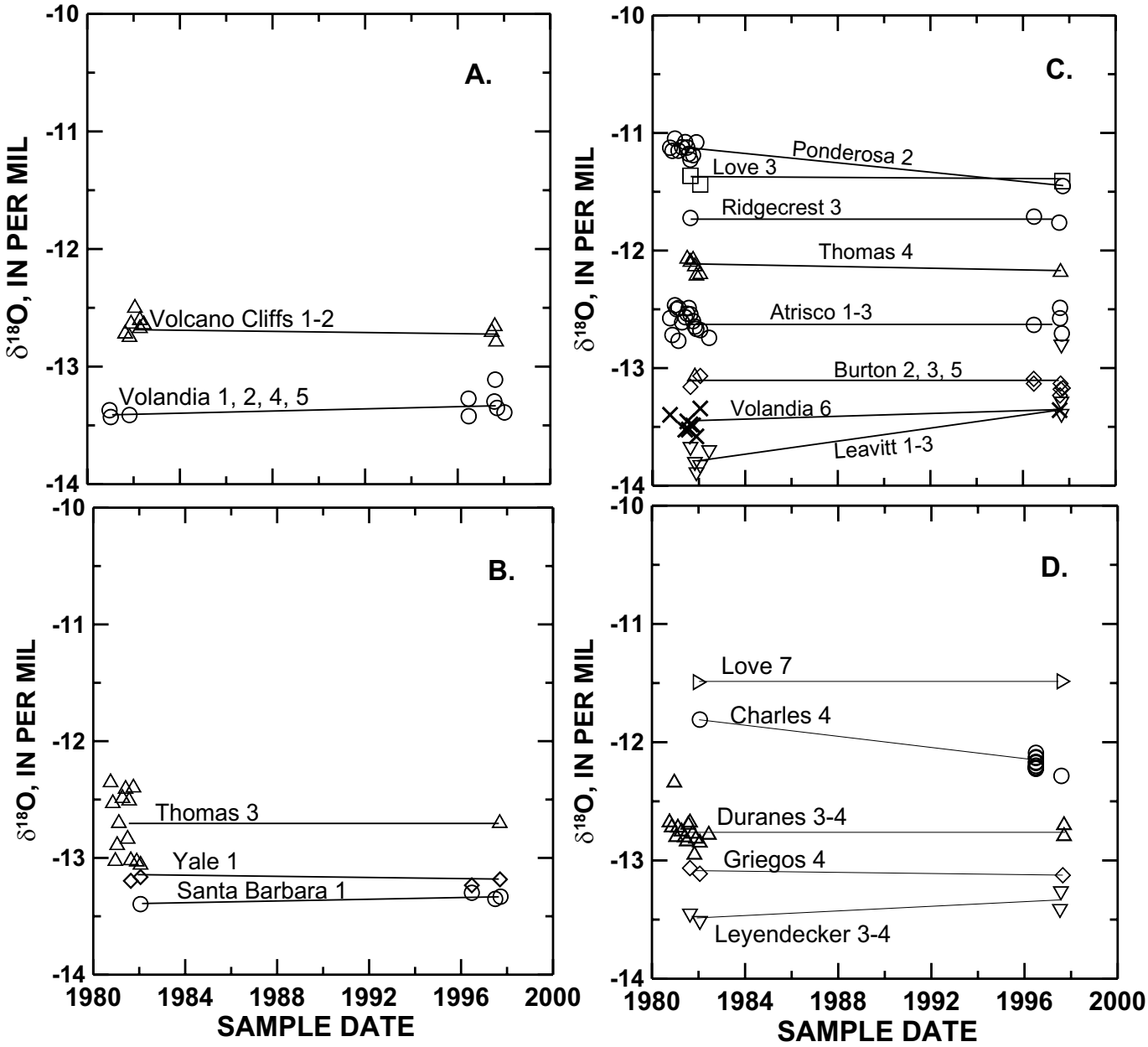


Figure 65. $\delta^{18}O$ isotopic composition of water from City of Albuquerque, New Mexico production wells collected in the early 1980s and 1996-97. Water samples from the early 1980s were collected by C. Yapp and re-analyzed by the U.S. Geological Survey. (A) Volcano Cliffs 1 and 2, Volandia 1, 2, 4, and 5. (B) Thomas 3, Yale 1, and Santa Barbara 1. (C) Ponderosa 2, Love 3, Ridgecrest 3, Thomas 4, Atrisco 1, 2, and 3, Burton 2, 3, and 5, Volandia 6, and Leavitt 1, 2, and 3. (D) Love 7, Charles 4, Duranes 3 and 4, Griegos 4, and Leyendecker 3 and 4.

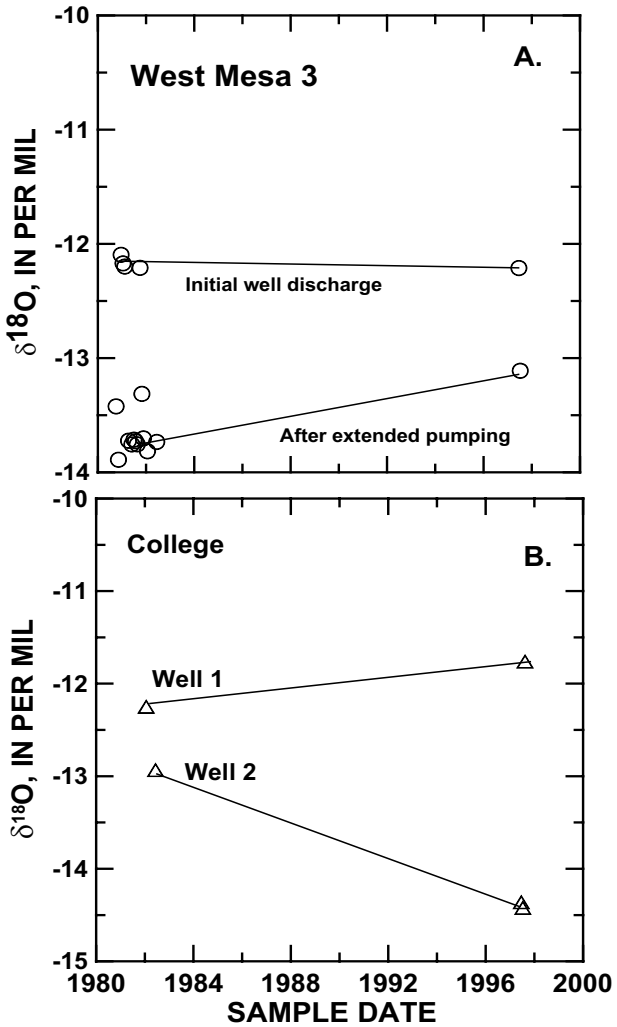


Figure 66. Comparison of $\delta^{18}O$ isotopic composition of water from City of Albuquerque, New Mexico production wells (A) West Mesa 3 and (B) College 1 and 2. Water samples from the early 1980's were collected by C. Yapp and re-analyzed by the U.S. Geological Survey.

of Albuquerque in an area of the "Deuterium-depleted Deep water" water of Yapp (1985). This water typically is more depleted in stable isotopic composition than the "Western Domain" water from the Rio Grande. Extended movement of the (paleo) Rio Grande source water westward is apparent in the Leavitt field, as seen in a shift to slightly more enriched waters, relative to the "Deuterium-depleted Deep water", toward the composition of Rio Grande water during the period from the early 1980's to the late 1990's (fig. 64).

Changes in the isotopic compositions of discharge from several wells also may be related to changes in the relative amounts of waters differing vertically in isotopic composition that intercept well screens. Yapp (1985) pointed out that water from West Mesa 3 was depleted in stable isotopic composition when the well had produced continuously for periods of days, and was more enriched when initially run following extended dormant periods. These two water types were found in the 1997 sampling at West Mesa 3 and suggest shallow inflow of the Rio Grande source water as the well recovers following periods of pumping (fig. 66) and discharge of the deeper, more depleted "Deuterium-depleted Deep water" after extended periods of pumping. Water pumped from College 2 is apparently withdrawing greater proportions of "Deuterium-depleted Deep water" today than in the early 1980's (fig. 66). College 2 is slightly deeper than West Mesa 3.

Purge Test

The stable isotope composition of discharge from two wells (Charles 4 and Duranes 1) was measured approximately hourly over a period of 6 hours, and compared with results from the same wells from single samples taken 1 week earlier in 1996 and one sample taken a year later in 1997 (fig. 67). Prior to the 6-hour purge test, each well had not been pumped for approximately 12 hours. The variations in $\delta^{18}O$ over 6 hours of pumping (fig. 67a) at these two wells were small, but probably reflect real changes in sources of water being pumped from the aquifer system, as the withdrawal of ground water from different parts of the aquifer system approaches steady state. The variations in $\delta^{2}H$ in part reflect real variations over time, but also are subject to higher analytical uncertainty than those in $\delta^{18}O$, as indicated by decreasing $\delta^{2}H$ and increasing $\delta^{18}O$ in Duranes 1 (fig. 67b).

Variations with Depth

Water from many of the monitoring wells in the Albuquerque vicinity is nearly constant in stable isotope composition to depths of at least 1,200 feet below the water table (fig. 68). Well nests with total depths greater than 500 feet below the water table and contain water most likely affected by infiltration from the Rio Grande include Del Sol, Garfield, Hunter Ridge, Isleta, Montaño 6, Montesa, Sierra Vista, Sister

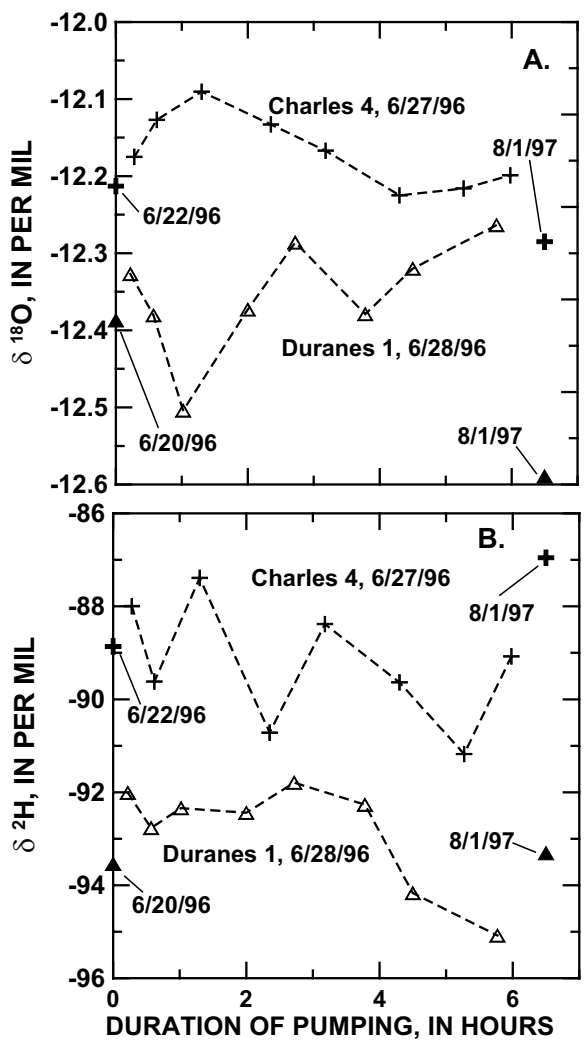


Figure 67. Short-term variations in (A) $\delta^{18}O$ and (B) $\delta^{2}H$ isotopic composition of water pumped from the City of Albuquerque, New Mexico, production wells, Charles 4 and Duranes 1.

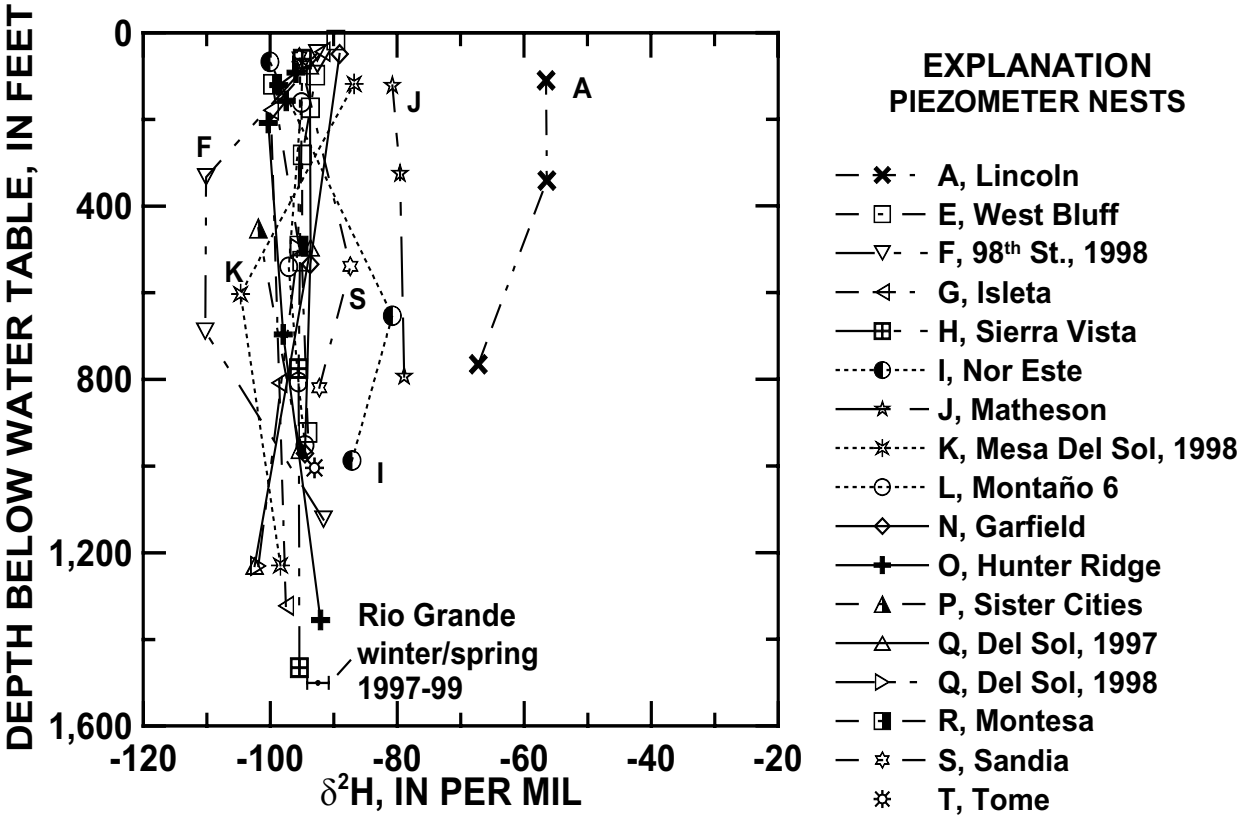


Figure 68. Variations in δ^2H isotopic composition of water from selected monitoring wells in the vicinity of Albuquerque, New Mexico (see figures 58 and 69 for location, and appendix A1 for well-construction information).

Cities, and West Bluff (fig. 69). The average δ^2H and δ^{18}O stable isotopic composition of water from these selected monitoring wells is -95.6 ± 3 and -12.88 ± 0.5 per mil, respectively. As shown in a later section of this report, the average radiocarbon ages of these waters exceed 10 ka (range of nearly modern to more than 20 ka). The δ^2H value of -95.6 ± 3 per mil that could be assumed for historical Rio Grande water from ground water in these wells is nearly identical to the adjusted "baseline" value for Rio Grande water from Yapp (1985) (see previous discussion), the "baseline" value for Rio Grande water suggested by Lambert and Balsely (1997), and the average δ^2H value (-95.5 per mil) for the re-analyzed Yapp samples of Rio Grande water from the early 1980's. The average δ^2H of Rio Grande water from the period 1997 to 1999, (-89.9 per mil) is higher than the historical "baseline" values from ground water, and higher than stable isotope values of Rio Grande water from the early 1980's, and may reflect changes in meteorological and/or environmental factors since the early 1980's.

Several well nests indicate significant deviations in stable isotopic composition from that of "baseline" Rio Grande water (fig. 68). Water from the Lincoln nest in Rio Rancho northwest of Albuquerque (point "A" on fig. 69) has δ^2H values of -56.5 per mil at the shallow and intermediate depths, and -67.3 per mil at nearly 800 feet below the water table. Enriched water of this type has not been recognized before in the Albuquerque area, and may represent water that was recharged at lower altitudes in the northern part of the basin (see the section "Tracing Sources of Water in the Middle Rio Grande Basin— Definition of Hydrochemical Zones and Water Sources"). The Matheson nest (point "J" on fig. 68) is characteristic of eastern mountain-front recharge. Two nests in the northern part of the area (Sandia (S) and Nor Este(I)) seem to be affected by eastern mountain-front recharge at their intermediate depths and by more isotopically depleted water at the shallow and deep sampling intervals. [Note: The stable isotope data raise some question as to whether the water from the mid-depth of the Sandia

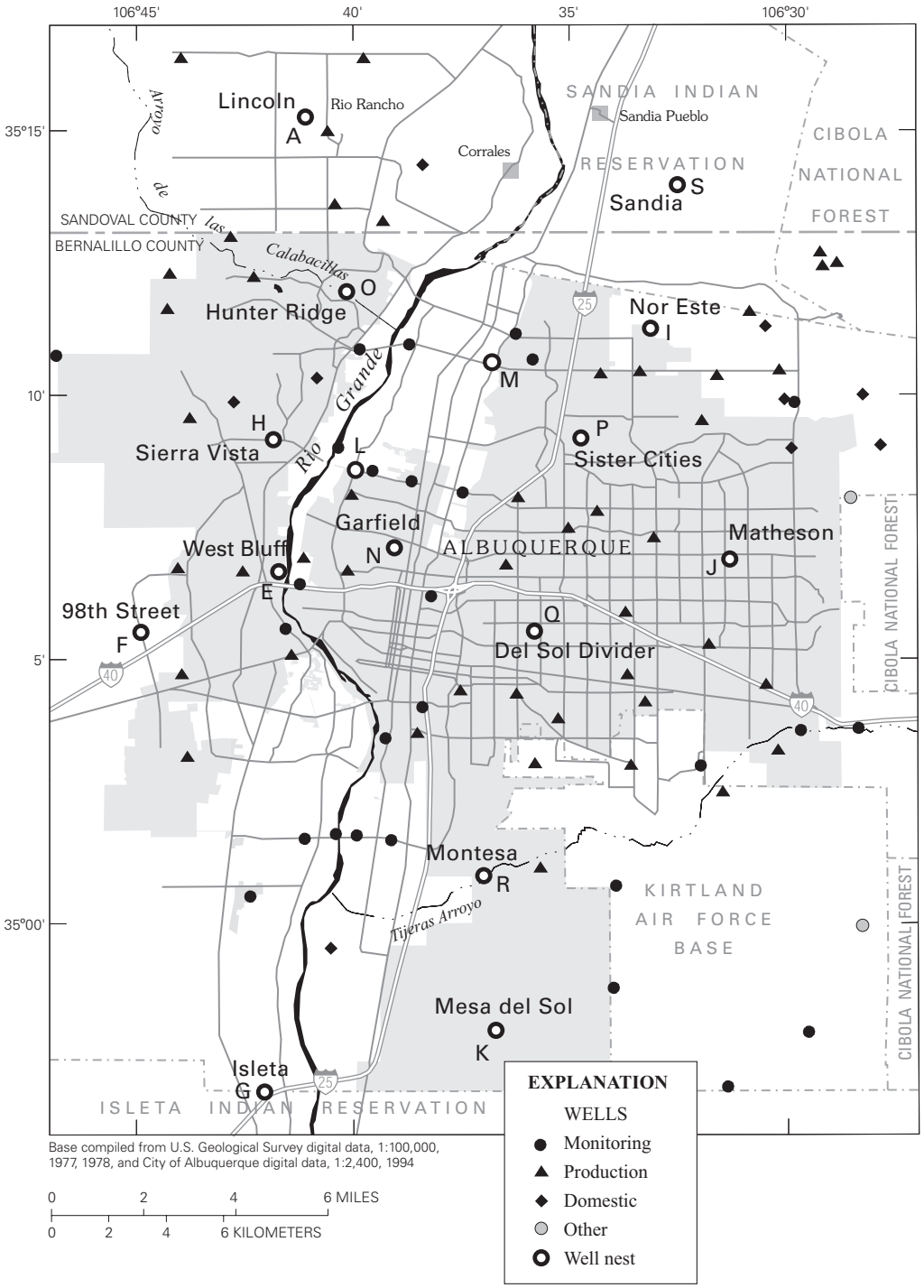


Figure 69. Location of monitoring wells in the vicinity of Albuquerque, New Mexico.

nest (S211) belongs in the sub-set of *exotic* samples (table A1). Following completion of this investigation, field tests confirmed the depth and identification of the Sandia piezometers.] The presence of "Deuterium-depleted Deep water" is evident in the intermediate depths of the 98th Street nest (F) west of Albuquerque and the Mesa Del Sol nest (K) in the southern part of Albuquerque (fig. 68). Some of the depleted water may also be present in the deepest piezometer of the Del Sol Divider (also referred to as Del Sol in this report, point Q) well nest (fig. 68). The shallow piezometer of Mesa Del Sol well nest probably contains portions of water from the eastern mountain front and/or Tijeras Arroyo. The shallow piezometer of the 98th Street well nest probably intercepts water from the Rio Grande.

Three cross sections were constructed along east-west lines through the Albuquerque area based on Hawley (1996) and information provided by Sean Connell (New Mexico Bureau of Geology and Mineral Resources, written commun., 2002). Well-construction information was extrapolated to each section along lines normal to the section lines. The northern-most section is aligned approximately along Paseo del Norte Boulevard, across northern Albuquerque, whereas the central and southern-most sections are, respectively, aligned approximately along Menaul Boulevard and the Los Padillas area, south of Albuquerque (fig. 70). Each cross section shows the approximate location of major faults, stratigraphic boundaries, land-surface altitude, the water table, and depths of the open intervals of the selected wells. Symbols show ranges of δ^2H values of water with labels in δ^2H values shown for each well, plotted at the depth of the open interval, or, in the case of production wells, plotted in the middle of the open interval. The most definitive information is provided by the monitoring wells, which are open to narrow intervals of the aquifer system (typically 5 to 10 feet). On the Paseo del Norte section (fig. 71), the wells providing the most definitive depth information include Nor Este (S149-51), Sister Cities (S234-5), Paseo 3 (S160-1), SWAB 3 (S244-5), Hunter Ridge (S075-80), Sierra Vista (S231-2), SWAB 2 (S243), and SAF (S236). Along the Menaul section (fig. 72) the most important wells are Matheson (S114-6), Del Sol (S043-5), Garfield (S060-2), West Bluff (S266-71), and 98th Street (S003-6). Only two wells provide definitive depth information on the Los Padillas section (fig. 73), Mesa Del Sol (S120-22) and Isleta (S086-89). Even though samples from most of the production wells produce mixtures of water over intervals of typically 500 to 1,000 feet of aquifer system, the monitoring wells show that, in many areas, vertical variations in isotopic composition are small (fig. 68) and, therefore, production wells usually produce waters consistent in isotopic composition with areal patterns determined by samples from the monitoring wells.

The predominant features recognized in the stable isotope data in map view in the Albuquerque area (fig. 64) are evident in greater detail in the cross sections (figs. 71-73). Enriched eastern mountain front recharge is evident in all three cross sections. Along the northernmost section (fig. 71), the mountain-front recharge crosses the Sandia Fault Zone and extends beneath more depleted Rio Grande water at Nor Este (S149-51). Further north of the Paseo del Norte section, eastern mountain front water occurs at the middle depth in the Sandia piezometer nest on Sandia Pueblo (figs. 68-69). In the Menaul section (fig. 72), eastern mountain front water reaches depths of more than 1,000 feet below the water table at the Matheson nest (S114-6), with nearly constant δ^2H values of -80.8, -79.6, and -78.9 per mil at the shallow, intermediate and deep piezometers, respectively. The boundary between eastern mountain-front recharge and water derived from the Rio Grande occurs between the Thomas well field and the Matheson nest (figs. 64 and 72). Along the southern-most section (fig. 73), water enriched in ^2H from the eastern mountain front, Tijeras Arroyo, and the Tijeras Fault Zone occurs at Hubbell Spring (S072), the monitoring wells SFR-3 (S227-8) and MRN-1 (S140) on Kirtland Air Force Base, and possibly the shallow well in the Mesa Del Sol nest (S120-2).

Water with δ^2H values in the range from -90 to -100 per mil is beneath most of the Albuquerque area and probably represents water derived from the Rio Grande. Some water at intermediate depths beneath Albuquerque is more depleted in ^2H than at either the shallow or deep depths. This depletion is seen at the intermediate depth at Sister Cities (S235; δ^2H of -102 per mil) and Hunter Ridge (S078; δ^2H of -100 per mil), and in discharge from production wells Leyendecker 1 (S107; δ^2H of -99.1 per mil), and Santa Barbara 1 (S220; δ^2H of -98.8 per mil). The "Deuterium-depleted Deep water" of Yapp (1985) appears in the two intermediate depths at 98th Street (S004-5; δ^2H of -110 and -110 per mil), in discharge from production wells College 2 (S037; δ^2H of -109 per mil), West Mesa 4 (δ^2H of -104.2 per mil), and the intermediate depth at

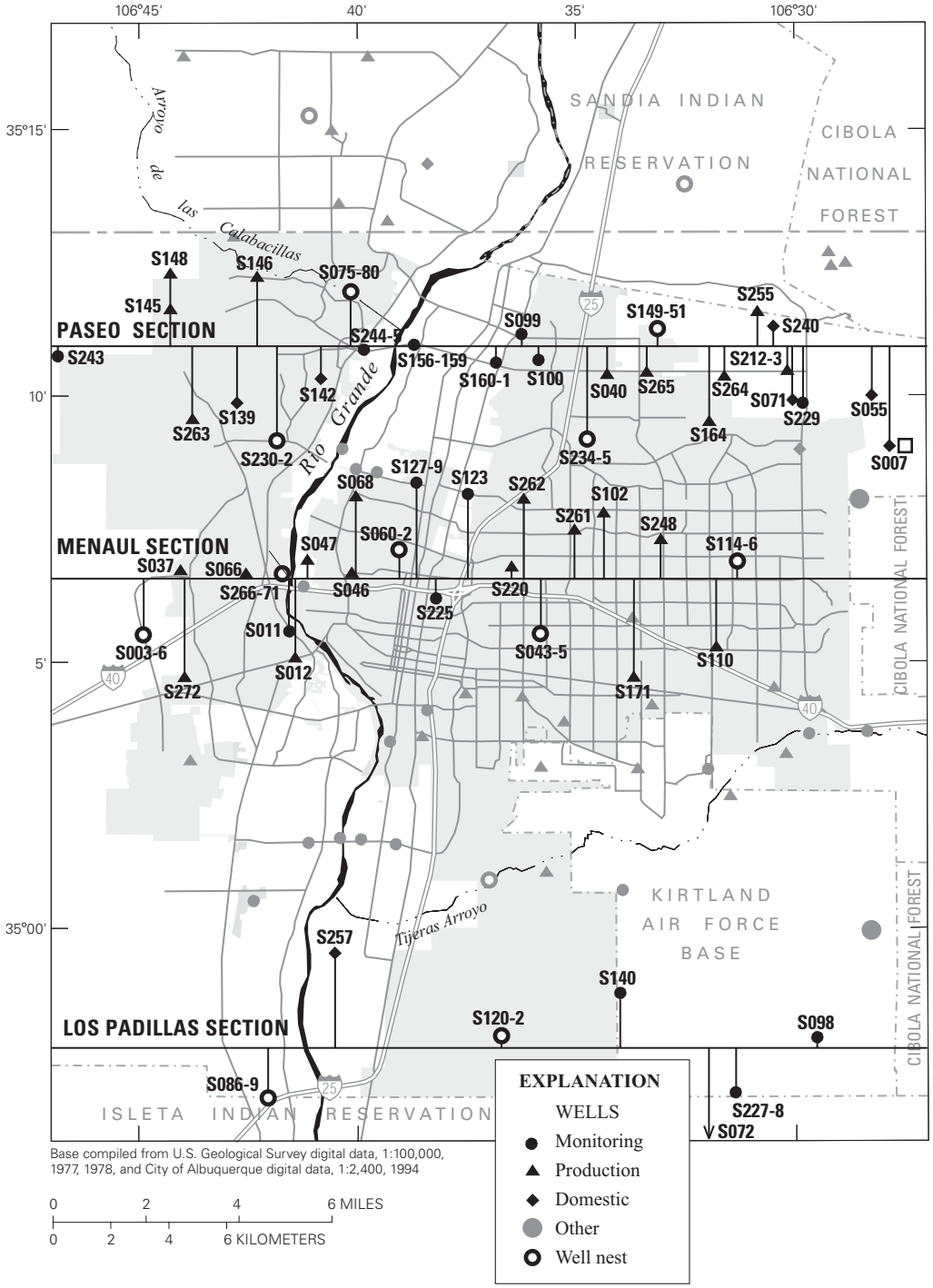


Figure 70. Location of the Paseo del Norte, Menaul, and Los Padillas cross-section lines and locations of wells shown on the cross sections, Albuquerque, New Mexico. See figure 11b and table A1 for identification of wells.

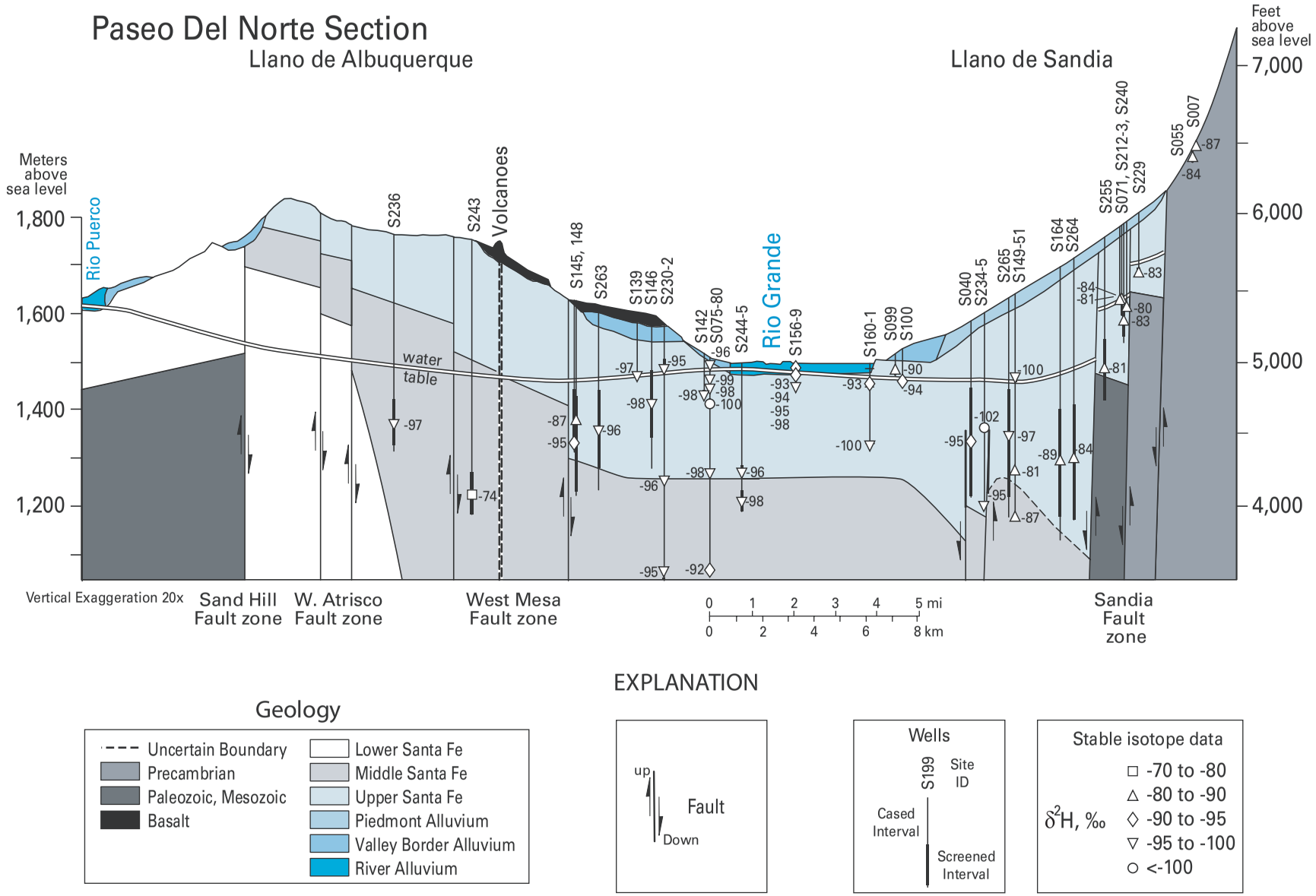


Figure 71. Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Paseo del Norte Boulevard, Albuquerque, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of δ^2H for ground water. The cross-section line is shown on figure 70.

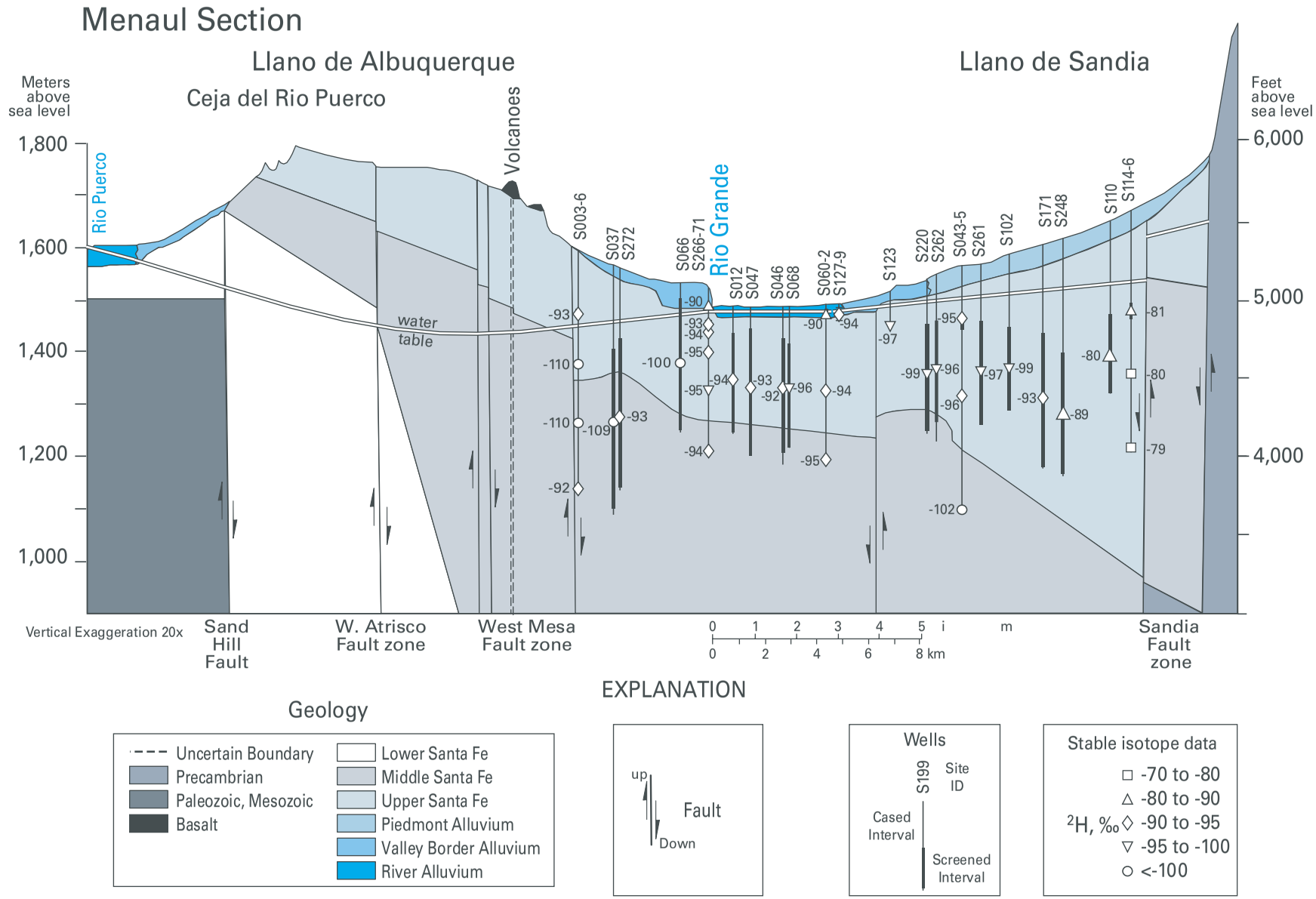


Figure 72. Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Menaul Boulevard, Albuquerque, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of δ^2H for ground water. The cross-section line is shown on figure 70.

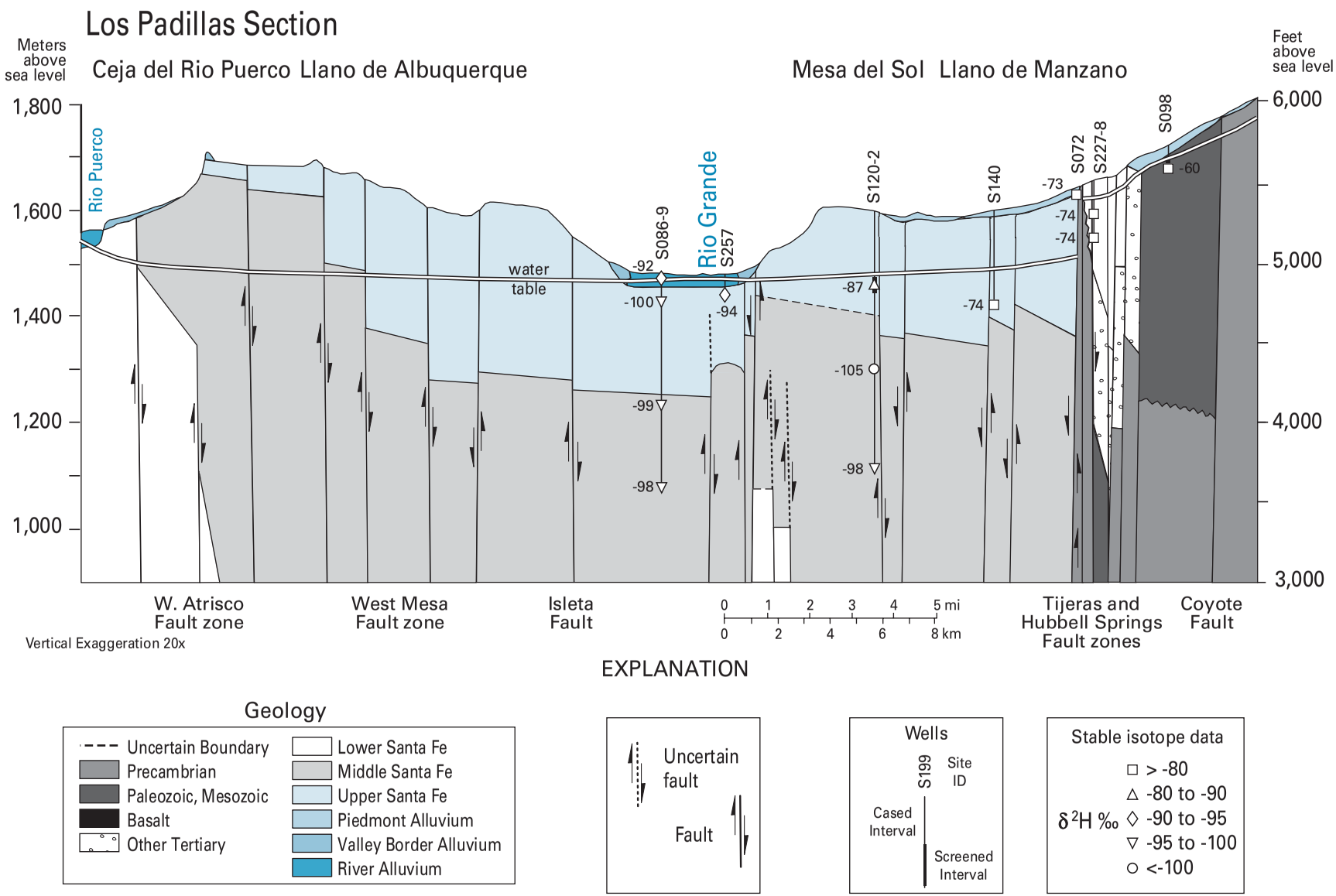


Figure 73 Schematic hydrogeologic cross section of the Los Padillas vicinity, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of δ^2H for ground water.

Mesa Del Sol (S121; δ^2H of -105 per mil). Some of this depleted water may also occur at the deepest interval of Del Sol Divider (S043; δ^2H of -102 per mil) and may be mixed with water from the Rio Grande at the intermediate depths at Isleta (S087-8; δ^2H of -99.9 and -98.6 per mil). Finally, water somewhat enriched in ^{2}H at SWAB 2 (S243; δ^2H of -73.6 per mil) and New Mexico Utilities 1 (S145; δ^2H of -87.3 per mil) may contain fractions of the enriched water found at the Lincoln nest (S103-5) approximately 7 miles further north.

Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water Basin-Wide

Only a few monitoring wells with narrow sampling intervals and depths of more than 200 feet below the water table were available for sampling outside of the Albuquerque area. Ground-water sampling points outside of the Albuquerque area were, for the most part, either windmills, stock wells, or domestic wells that provided samples from shallow parts of the aquifer system. Still, nearly 250 wells were sampled basin-wide outside of the Albuquerque area that provide an overall consistent pattern in stable isotopic composition of ground water, predominantly in the upper 200 feet of the aquifer system. Results from the monitoring wells outside of the Albuquerque area, such as the wells at Santa Ana Boundary (S217), Zia BMT (S288), Zia Ball Park (S283), and Tome (S253), indicate that in parts of the basin, the patterns established in the upper 200 feet of the aquifer system are representative of water to depths of at least 1,000 feet below the water table, as was found in many of the monitoring wells in the Albuquerque area. The lack of variation in stable isotopic composition with respect to depth indicates that the flow directions determined from water-quality data in the shallow wells (most wells sampled) may extend some 1,500 feet or more below the water table throughout much of the MRGB.

The average δ^2H composition of water from the wells sampled outside the vicinity of Albuquerque is -82.1 per mil, compared to waters sampled from the Albuquerque vicinity, which average -92.4 per mil in δ^2H. Water in the vicinity of Albuquerque is more depleted in comparison to waters basin-wide because most ground water in the vicinity of Albuquerque is derived from the relatively depleted Rio Grande, whereas many of the waters outside the Albuquerque area were derived form sources more enriched in ^{2}H than that of the Rio Grande. The range of δ^2H values of all the water sampled outside the Albuquerque area is 65 per mil (-118.3 to -52.9 per mil), compared to 38 per mil (-111.3 to -73.7 per mil) in the Albuquerque area.

Similar to many of the major water-quality parameters, the stable isotopic composition of ground water can be contoured throughout most of the MRGB (fig. 74). Important features of the stable isotope contour map include: (1) contours in stable isotope composition tend to align north to south in the central part of the basin, parallel to the direction of the general north to south flow of ground water, (2) a zone of isotopically depleted water extends over the central part of the northern two-thirds of the basin, and is found beneath relatively-enriched water in the northern part of the basin, (3) an area of isotopically enriched water extends along the western and southwestern parts of the basin, along Abo Arroyo, and in a narrow band that extends southward from the northern margin of the basin, (4) a zone of water with δ^2H values in the -90s per mil range extends north-south along both sides of the Rio Grande throughout most of the basin, and (5) water with δ^2H values in the -70s and -80s per mil range extends along the eastern and northern margins of the basin (fig. 74).

Based on stable isotope data, it appears that the "Deuterium-depleted Deep water" recognized by Yapp (1985) in southwestern parts of Albuquerque is part of a regional pattern in depleted stable isotope composition of water that extends through the west-central part of the basin from the northernmost boundary (at depth) south to an area in the vicinity of Belen. The "Deuterium-depleted Deep water" water occurs in Rio Rancho wells 9 (site S193) and 13 (site S188) approximately 20 miles northwest of Albuquerque, and is found in deep monitoring wells in the northern part of the basin (Zia BMT (S288), Zia Ball Park (S283-S284), and Santa Ana Boundary (S217-S219) monitoring wells; samples NM186, NM181-NM182, and NM144-NM146, respectively) to depths of more than 1,000 feet below the water table. The "Deuterium-depleted Deep water" water is present beneath a relatively thin zone of somewhat enriched water (δ^2H values in the -80s per mil range), along the northern margin of the basin at sites S288, S283-S284, and S217-S219. Along the Rio Grande in the central part of the basin, the "Deuterium-depleted Deep water" is present beneath water of Rio Grande composition (δ^2H values in the -90s per mil range) such as at the 98th St. (sites S004-S005) and Mesa Del Sol (sites S120-S121) nests. The

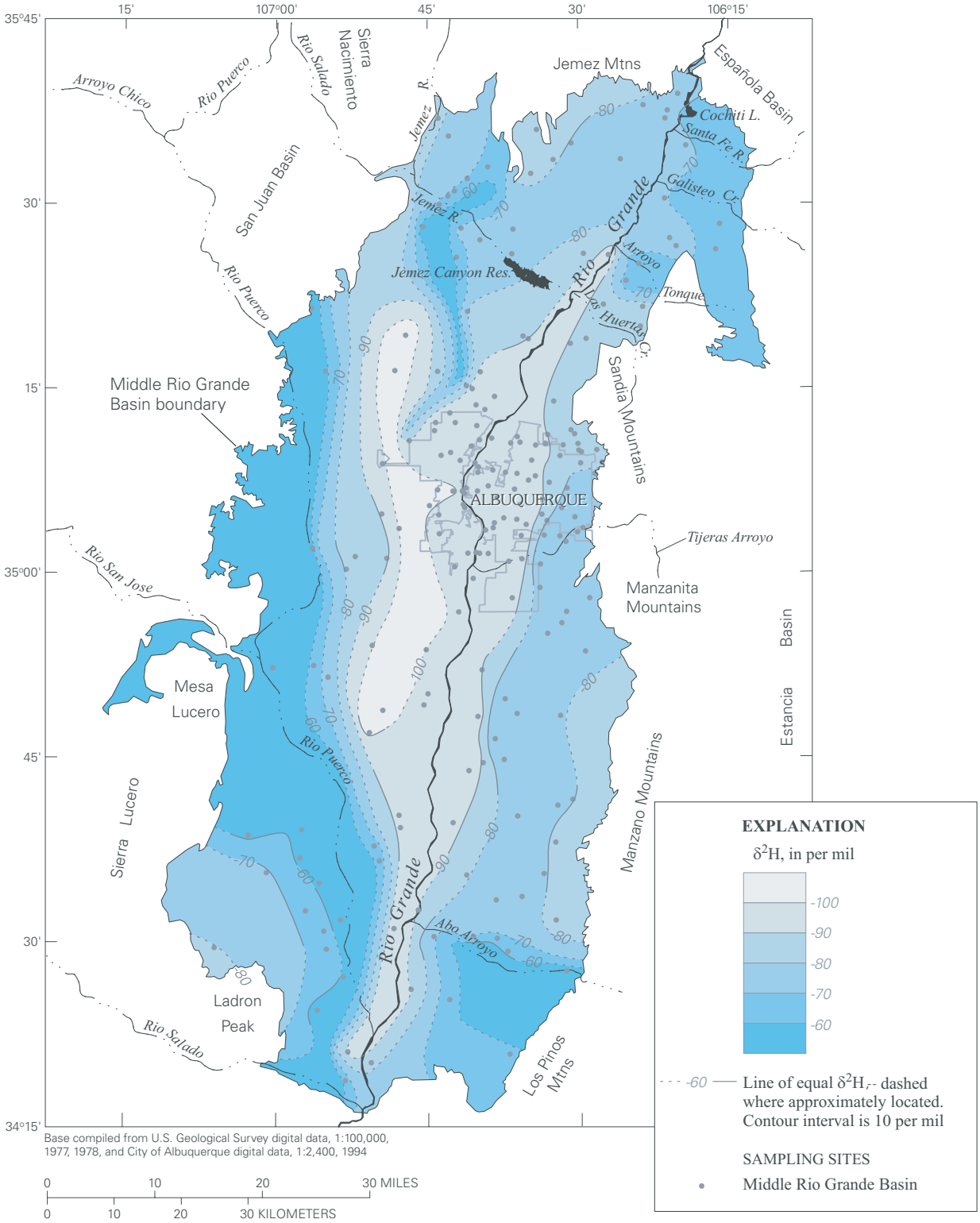


Figure 74. Stable H isotopic composition, δ^2H, for ground water in the Middle Rio Grande Basin, New Mexico.

"Deuterium-depleted Deep water" appears to merge with multiple sources of ground water in the southern part of the basin.

West of the central area of "Deuterium-depleted Deep water", the stable isotopic composition of ground water is greatly enriched by comparison. The presence of the enriched western waters parallels the Rio Puerco in the western and southwestern parts of the basin. The isotopic composition of this ground water is similar to values measured for water from the Rio Puerco (table 5), and it is likely that infiltration from the Rio Puerco contributes part of the water found in the western and southwestern parts of the basin.

Water along the northern, eastern, and southwestern margins of the basin tends to have values of δ^2H in the range of -80s per mil that are indicative of mountain-front recharge.

The sharp boundary between mountain-front recharge (δ^2H values in the -80s per mil) and Rio Grande water (δ^2H values in the -90s per mil) found at Albuquerque (fig. 64) appears to extend north through Sandia Pueblo to San Felipe Pueblo, where depleted Rio Grande water pinches out at the Rio Grande. The stable isotope pattern is consistent with the suggestion of Yapp (1985) that, north of San Felipe, there may be net discharge of ground water to the Rio Grande, but further south from San Felipe, there is net loss of Rio Grande water to the aquifer system. Based on stable isotope data, the zone of influence of infiltration from the Rio Grande is approximately 10 miles in width just north of Albuquerque, remains about 10-miles wide through most of Albuquerque, and then narrows south of Albuquerque parallel to the Rio Grande (fig. 74). Waters with stable isotopic composition similar to the Rio Grande appear to mix with other western, northern, and eastern sources of water in the southernmost part of the basin.

In comparison to surrounding waters, some of the most anomalous waters in the MRGB are the enriched waters at the Lincoln Middle School monitoring nest (S103-105) northwest of Albuquerque, where the shallow, medium, and deep completions have δ^2H values of -56.6, -56.5, and -67.3 per mil, respectively. This enriched water may originate as low-altitude recharge from arroyos in the northern parts of the basin, but insufficient spatial coverage of samples hampered tracing of the source further north and northeast of the Lincoln well nest. The samples from the Lincoln nest have relatively low deuterium excess of 3.7 to 4.2 per mil, compared to the average deuterium excess of 6.8 per mil for waters basin-wide outside of the Albuquerque area and 7.2 per mil for waters within the vicinity of Albuquerque.

Values of δ^2H and $\delta^{18}O$ for all ground-water samples from the MRGB are shown in figure 75. The samples generally plot parallel to the global meteoric water line, with a slope slightly less than 8.0. The ground waters (n=335) are correlated according to the least squares fit,

$$\delta^2H = 7.62\ \delta^{18}O + 2.48 \qquad (18)$$

The deuterium excess of all ground-water samples, computed assuming a slope of 8.0, averages 6.9 per mil.

Although stable isotopes can be extremely useful in recognizing sources or water to the MRGB, it could be misleading to base such interpretation solely upon stable isotope data, without considering all the available chemical and isotopic data. The section "Tracing Sources of Water in the Middle Rio Grande Basin—Definition of Hydrochemical Zones and Water Sources" discusses interpretations of hydrologic information based on all chemical and isotopic data collected as a part of this study.

Carbon-14 Activity of Dissolved Inorganic Carbon in Ground Water from the Middle Rio Grande Basin

Variations with Depth

The various piezometer nests throughout the MRGB (predominantly in the Albuquerque vicinity) provide useful information on the ^{14}C activity gradients with depth in the basin (fig. 76). Activities at the water table vary from 6 percent modern carbon (pmC) at 98th Street (S006) to nearly 120 pmC in the inner valley of the Rio Grande, such as at the shallow depth of the Isleta well nest (S089; 118 pmC). In general, ^{14}C activities measured in the piezometer nests decrease with increasing depth below the water table (fig. 76). Selected piezometer nests and/or other wells with depth information were used to estimate the ^{14}C activity gradients with depth in the aquifer system of the MRGB (table 7). The lowest ^{14}C activity gradients were found in wells completed in the west-central parts of the basin, just west of Albuquerque; these gradients vary from about 0.003 to 0.02 pmC per foot. Higher ^{14}C activity gradients can occur in northern parts of the

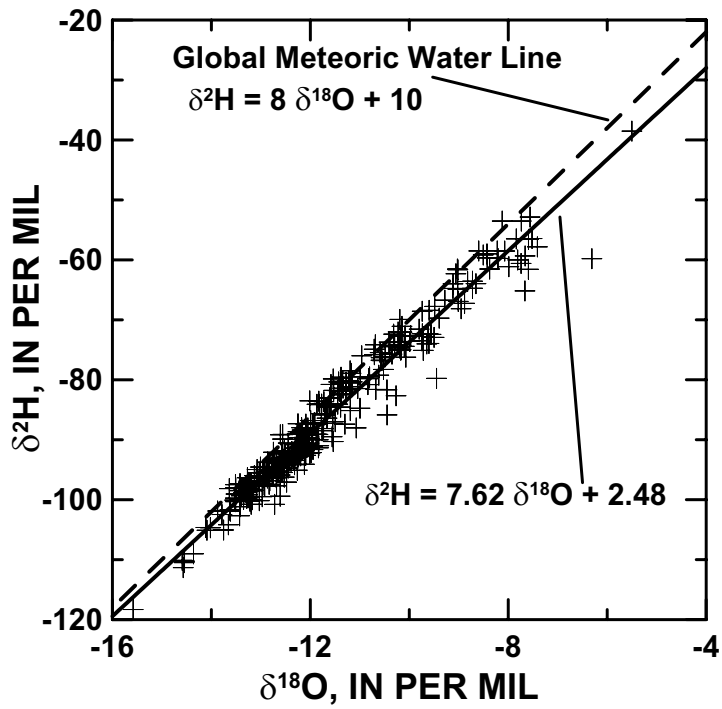


Figure 75. Values of δ^2H and $\delta^{18}O$ isotopic composition for all ground water from the Middle Rio Grande Basin, New Mexico, sampled as a part of this study in relation to the global meteoric water line. The solid line shows a least squares fit to the ground-water data.

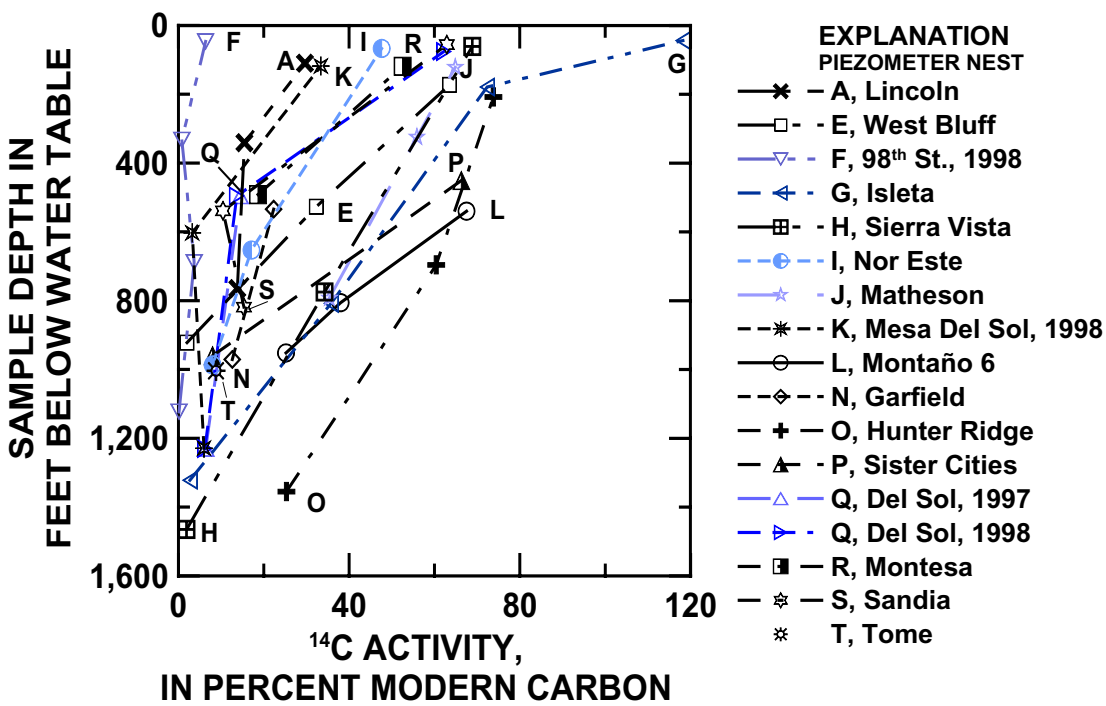


Figure 76. ^{14}C activity as a function of depth below the water table in narrow-screened piezometers in the vicinity of Albuquerque, New Mexico (see figures. 58 and 69 for location, and table A1 for well-construction information).

basin, such as at the Zia Ball Park (sites S283-S285) and Windmill #12 (S276) wells (table 7). Vertical ^{14}C activity gradients vary from about 0.03 to 0.08 pmC per foot in areas where recharge is from the eastern mountain front and/or from the Rio Grande.

Areal Variations

Maps showing spatial variations in chemical and isotopic properties of water on a basin-wide scale are considered representative of average values for the saturated upper-most 500 feet of the aquifer system. In the vicinity of Albuquerque, the upper 500 feet of the aquifer system is consistent with the primary depth interval intercepted by many of the City of Albuquerque production wells. In constructing a map showing spatial variations of ^{14}C activity throughout the MRGB (fig. 77), approximately 200 measurements of ^{14}C activity of DIC were plotted on a map; in the cases of multi-depth monitoring wells, values were plotted that were from the mid-depths of the piezometers, typically from about 300 to 500 feet below the water table. This choice in sample depth from piezometers was preferable to plotting ^{14}C data from the shallow depth of piezometers that, in some cases, intercepts the water table and can contain fractions of anthropogenic ^{14}C, and preferable to the deep sample depths of piezometer nests, that typically are below the maximum depth of most of the other wells sampled throughout the basin.

The measured ^{14}C activities of DIC of ground water from 211 sites (excluding redundant samples) in the MRGB range from 0.62 to 123.1 pmC. The average ^{14}C activity for all the sites sampled was 44.0 ± 31.6 pmC with a median value of 39.7 pmC. The average ^{14}C activity varies in different parts of the basin. For example, along the eastern mountain front, ^{14}C activity averages 50.9 ± 33.0 pmC, and in areas receiving recharge from the Rio Grande (as defined in the section "Tracing Sources of Water in the Middle Rio Grande Basin— Definition of Hydrochemical Zones and Water Sources"), ^{14}C activity of DIC averages 61.6 ± 28.0 pmC. In contrast, DIC in water in the region extending nearly the length of the west-central part of the basin has an average ^{14}C activity of 13.9 ± 12.1 pmC.

A smooth continuum of ^{14}C activity is apparent throughout the basin (fig. 77). Most of the contours in ^{14}C activity align in a north-south direction. ^{14}C activities are highest along the eastern mountain front, along the northern margin of the basin, and along the inner valley of the Rio Grande, corresponding to areas where recharge has most likely occurred in the past 5-10 ka. Relatively high ^{14}C activities also are present near areas where Abo Arroyo, the Rio Puerco, and the Jemez River enter the basin (fig. 77). Waters with low values of ^{14}C activity of DIC are present along the western and southwestern basin margins. A zone of low ^{14}C activity extends through nearly the entire

Table 7. Estimated ^{14}C gradients with depth for ground water from the Middle Rio Grande Basin, New Mexico

[Monitoring Well ID, Monitoring well identification number, see fig. 58; pmC, percent modern carbon; Hydrochemical zones: 2, Northwestern; 3, West-Central; 8, Eastern Mountain Front; 12, Central]

Site no.	Monitoring well ID	Well nest	Hydro-chemical zone	^{14}C gradient (pmC/ foot)
S103-S104	A	Lincoln	2	0.017
S285, S276	C	Zia Ball Park (S) to Windmill #12	3	0.06
S003-S006	F	98th Street	3	0.003
S241-S242	na	SWAB 1	3	0.023
S114-S115	J	Matheson	8	0.05
S149-S150	I	Nor Este	8	0.04
S212-S213	na	Sandia Peak	8	0.03
S043-S044	Q	Del Sol	12	0.03
S060-S061	N	Garfield	12	0.04
S075-S077	O	Hunter Ridge	12	0.05
S234-S235	P	Sister Cities	12	0.07
S266-S268	E	West Bluff	12, 3	0.08
S230-S232	H	Sierra Vista	12, 3	0.05

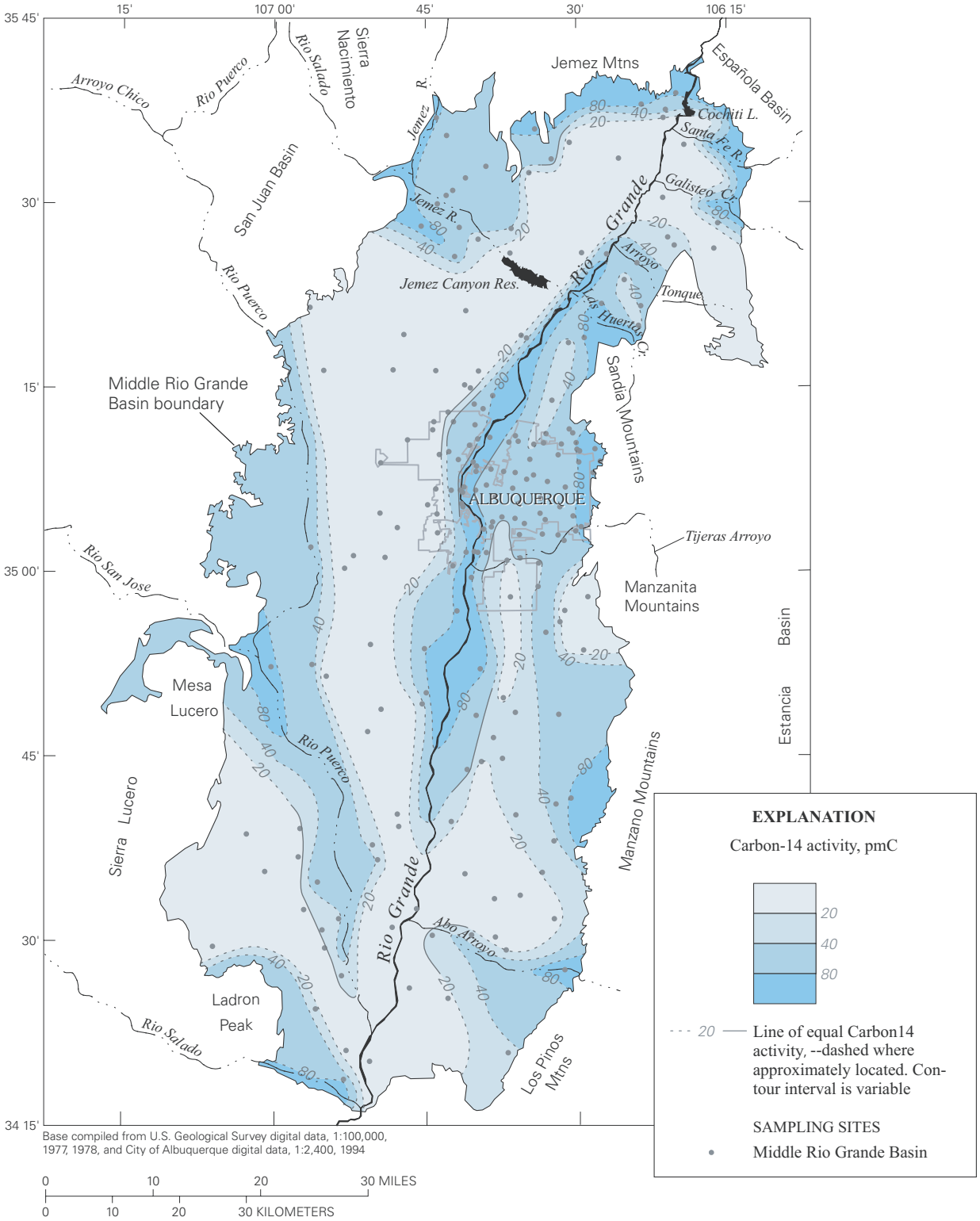


Figure 77. ^{14}C activity in percent modern carbon, pmC, for dissolved inorganic carbon from ground water throughout the Middle Rio Grande Basin, New Mexico.

length of the west-central part of the basin. The ^{14}C activities generally indicate that waters in the MRGB have ages on a time scale of 10s of thousands of years. Interpretation of radiocarbon age requires consideration of recharge conditions and geochemical processes affecting ^{14}C activity within the basin. Radiocarbon ages are interpreted in the section "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water".

As a means of estimating the uncertainty of contours in ^{14}C activity drawn on figure 77, which is based on data from a variety of wells completed in the upper 500 feet of the aquifer system, the ^{14}C gradients of table 7 were applied to estimated depth variations of ± 200 feet. Consequently, for contours drawn in ^{14}C activity along mountain-front recharge areas and near parts of the Rio Grande where infiltration from the river recharges the aquifer system (with ^{14}C activity gradients of 0.03 to 0.07 pmC per foot), variations of ± 200 feet indicate maximum uncertainties of ± 6 to ± 14 pmC in values plotted on figure 77. In the west-central parts of the basin, where ^{14}C activity gradients are low (0.003 to 0.02 pmC per foot), variations of ± 200 feet could result in maximum uncertainties of ± 0.6 to ± 4 pmC in values of ^{14}C activity plotted on the map. These uncertainties are relatively small compared to the large spatial variations in ^{14}C activity shown in figure 77 throughout the MRGB.

TRACING SOURCES OF WATER IN THE MIDDLE RIO GRANDE BASIN-- DEFINITION OF HYDROCHEMICAL ZONES AND WATER SOURCES

The chemical and isotopic parameters discussed in the section "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin", and mapped in figures 27-30, 33-35, 38-39, 41-57, 64, 74, and 77 reveal areas of ground water of distinctly different chemical and isotopic character in the MRGB, with boundaries that can be defined clearly in most cases. These areal patterns are evident even though water chemistry and isotopic composition has been observed to differ with depth, and ground-water pumpage has recently altered the hydraulic-head distribution of the aquifer system, primarily in the vicinity of Albuquerque. The chemical and isotopic patterns along with information on sample location within the basin have been used to define 13 hydrochemical zones (fig. 78) that represent 12 sources of recharge and an area of discharge for the basin (Plummer and others, 2000). For reference purposes, the zones were assigned names that either reflect a geographical location within the basin (Northeastern (11), Northwestern (2), Western Boundary (4), West-Central (3), Central (12), Northern Mountain Front (1), Eastern Mountain Front (8), Southwestern Mountain Front (6), and Discharge (13) zones) or a major hydrologic or geologic feature of the area (Rio Puerco (5), Abo Arroyo (7), Tijeras Arroyo (10), and Tijeras Fault Zone (9) zones). A unique number was assigned to each hydrochemical zone, shown in parentheses after each zone name above and on figure 78. The hydrochemical zone names are used throughout the text, but to save space, zone numbers are used in some of the tables of this report. Although water chemistry within each zone is broadly similar, localized effects from evapotranspiration, contamination, possible mixing with geothermal waters, or other factors have been observed in parts of the basin. Areas with indications of these localized effects have not been separated from the broader zones.

The hydrochemical zones defined in this study provide insight into likely recharge sources, flow paths, and aquifer properties. Although the zones are broadly similar to those defined by previous investigators in the basin (Anderholm, 1988; Logan, 1990), they are not identical. The hydrochemical zones of Anderholm (1988) are more generalized than those defined in this study, probably largely because fewer data points were available, and with fewer analytes. The regions of Logan (1990) also were defined using fewer data points and are based on proximity to suspected recharge sources and on aquifer permeability in addition to geochemistry. A recent study of water chemistry in the Albuquerque area by Bexfield and Anderholm (2002a) used detailed hydrochemical regions that are generally consistent with those defined in this study. The previous studies have not had the benefit of the extensive stable isotope and radiocarbon data obtained as a part of this study.

Each ground-water sample in the data set for the basin was assigned to a particular hydrochemical zone based on location and chemistry (appendix A). The boundaries between hydrochemical zones are known most precisely in areas where sample sites of differing chemistry were located in close proximity. In areas where fewer sampling sites were available, the boundaries between zones are less well defined. In addition, whereas figure 78 provides a reasonable two-dimensional representation of zone boundaries, these boundaries are not strictly vertical within the aquifer system. For example, the chemical and isotopic data indicate that the West-Central zone actually extends at depth beneath essentially the entire Northwestern zone and may extend beneath parts of the Northern Mountain Front and Central zones. In some instances, samples from different depths within the same well nest were assigned to different zones. Therefore, a sample assigned to a particular zone can appear to be located in an adjacent zone because of depth considerations (fig. 78). Finally, the boundaries shown between zones are not meant to indicate extremely sharp shifts in water chemistry, but rather areas of greatest transition between two water types. Various individual samples were recognized as apparent mixtures of water from different zones. With this recognition, the sample was categorized as belonging to the zone with the chemical characteristics that appeared most dominant within the sample, and the sample was characterized as having properties of both a primary and secondary hydrochemical zone (appendix A).

The general chemical characteristics of each hydrochemical zone are discussed below, particularly as they relate to the primary source of water to the zone. Although some variability results within each hydrochemical zone, the median values of selected parameters given in table 8 show that the "typical" chemistry for each zone is distinct, as do the

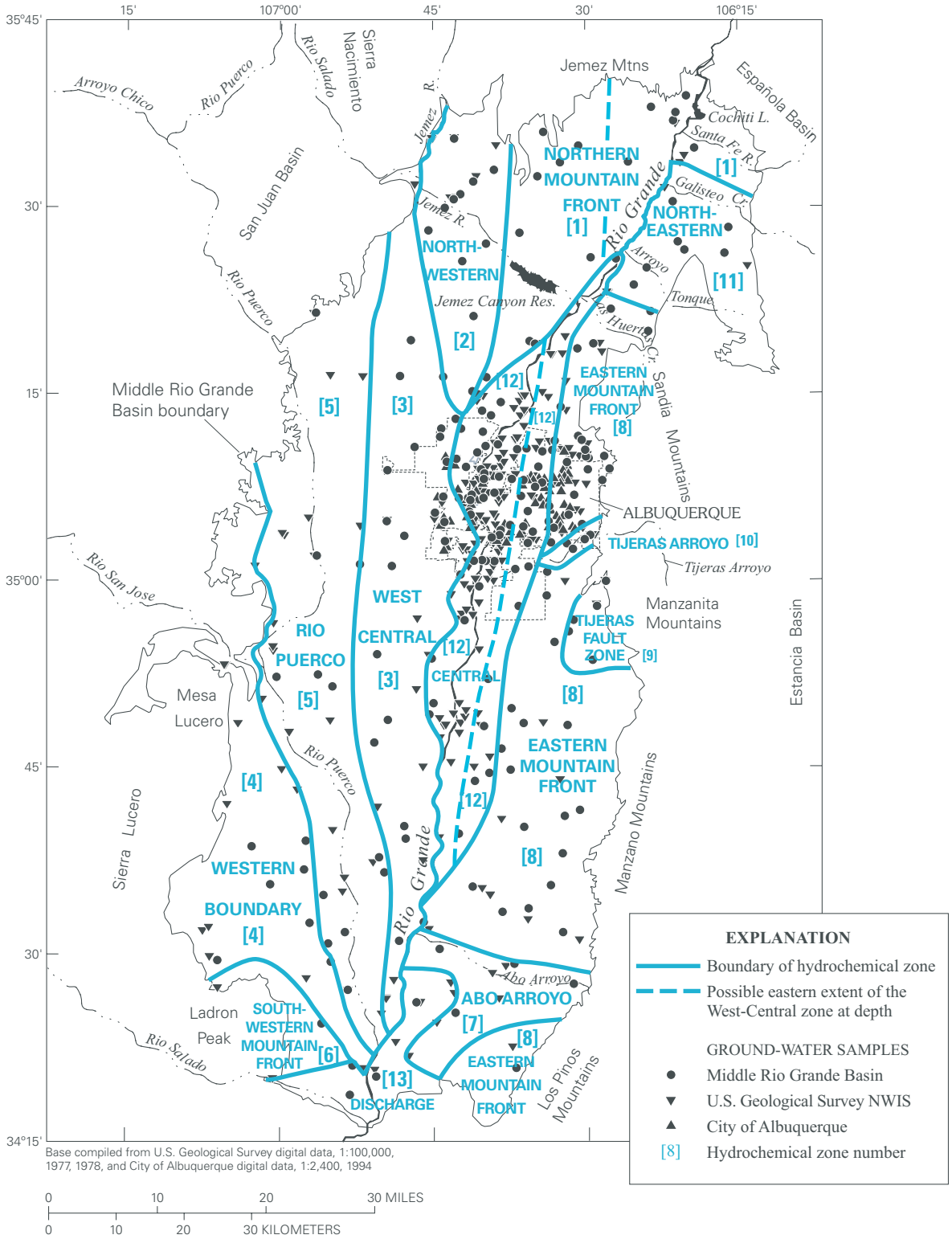


Figure 78. Hydrochemical zones defined for ground water in the Middle Rio Grande Basin, New Mexico. The dashed line represents the possible extent of the West-Central zone at depth beneath other zones.

Table 8. Median values of selected water-quality parameters by hydrochemical zone for the Middle Rio Grande Basin, New Mexico

[nd, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; mg/L, milligrams per liter; mg/L, micrograms per liter; pmC, percent modern carbon]

Hydrochemical zone	Hydrochemical zone no.	Specific conductance (µS/cm)	Field pH	Water temperature (ºC)	Dissolved oxygen (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Alkalinity (mg/L as HCO_3)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	Nitrate (mg/L as N)	Al (µg/L)	As (µg/L)
Northern Mountain Front	1	340	7.49	18.9	5.1	38.5	6.1	20.0	4.9	137.	19.5	5.6	0.35	0.08	53.3	0.56	nd	3.2
Northwestern	2	400	7.84	20.6	6.7	33.9	4.2	49.9	5.7	160.	44.8	8.5	0.61	0.07	30.1	2.44	nd	9.8
West Central	3	535	8.22	23.8	3.0	12.0	2.5	103.	4.2	174.	92.0	13.4	0.99	0.11	34.5	1.24	6.76	23.2
Western Boundary	4	4,572	7.70	22.0	4.1	135.	56.4	589.	15.2	300.	793.	820.	1.64	0.38	22.5	0.86	5.00	1.8
Rio Puerco	5	2,731	7.50	20.0	3.7	135.	42.7	290.	10.4	190.	1,080.	185.	0.63	0.64	21.8	0.88	5.00	1.0
Southwestern Mountain Front	6	462	8.11	19.1	4.4	52.6	13.5	27.8	2.5	202.	53.0	15.	1.02	0.21	17.6	1.12	3.31	0.2
Abo Arroyo	7	1,055	7.45	20.7	6.2	92.5	34.4	49.2	3.1	148.	346.	25.9	0.90	0.17	24.0	1.40	4.14	5.2
Eastern Mountain Front	8	382	7.67	22.0	5.2	45.0	5.1	29.2	2.2	157.	31.0	10.5	0.60	0.17	28.4	0.31	5.56	2.0
Tijeras Fault Zone	9	1,406	7.42	18.5	4.7	171.	36.0	95.0	6.1	599.	100.	139.	1.27	0.69	18.9	1.09	5.22	2.2
Tijeras Arroyo	10	677	7.39	16.1	7.0	89.4	24.5	29.3	3.8	240.	115.	56.6	0.60	0.35	19.5	3.79	4.09	1.0
Northeastern	11	1,221	7.50	19.4	6.4	141.	29.5	81.8	4.8	208.	390.	22.7	0.51	0.19	38.5	0.64	4.34	2.7
Central	12	436	7.74	18.1	.1	42.9	8.0	31.0	6.4	158.	66.0	16.6	0.44	0.09	47.0	0.08	6.00	5.4
Discharge	13	1,771	7.70	20.6	.1	93.0	31.0	190.	10.5	157.	290.	280.	1.40	0.47	39.0	0.42	4.50	9.9

Hydrochemical Zone	Hydrochemical zone no.	Ba (mg/L)	B (mg/L)	Cr (µg/L)	Cu (µg/L)	Fe (mg/L)	Pb (µg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)	Sr (mg/L)	U (µg/L)	V (µg/L)	Zn (µg/L)	δD (per mil)	$\delta^{18}O$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
Northern Mountain Front	1	0.062	0.043	1.2	0.8	0.060	0.20	0.058	0.005	1.7	0.31	1.0	6.4	258.	-77.7	-10.9	- 8.5	33.4
Northwestern	2	0.056	0.118	2.0	0.4	0.030	0.10	0.068	0.002	3.4	0.57	2.7	15.6	9.0	-64.7	- 8.7	- 6.9	29.6
West Central	3	0.032	0.239	5.7	0.5	0.028	0.11	0.045	0.002	8.2	0.20	3.7	27.9	5.0	-96.7	-12.7	- 7.2	8.8
Western Boundary	4	0.014	0.900	10.6	3.0	0.213	0.12	0.251	0.041	9.9	2.09	4.4	5.7	118.	-64.4	- 9.1	- 4.7	6.2
Rio Puerco	5	0.014	0.291	3.0	3.4	0.130	0.10	0.253	0.015	7.0	3.92	6.0	3.4	117.	-61.6	- 8.5	- 7.7	36.4
Southwestern Mountain Front	6	0.045	0.094	1.9	9.3	0.030	0.41	0.041	0.007	3.0	0.86	0.9	1.0	252.	-53.5	- 7.7	- 5.8	40.0
Abo Arroyo	7	0.017	0.130	4.4	2.0	0.105	0.10	0.031	0.004	3.4	1.48	5.4	9.5	8.1	-65.2	- 9.1	- 6.7	24.1
Eastern Mountain Front	8	0.084	0.050	1.0	1.7	0.031	0.27	0.020	0.003	2.0	0.32	3.6	7.5	6.7	-81.0	-11.4	- 8.7	47.2
Tijeras Fault Zone	9	0.046	0.347	1.7	4.3	0.111	0.34	0.227	0.023	3.7	1.11	7.3	6.3	61.5	-74.2	-10.3	- 1.0	9.7
Tijeras Arroyo	10	0.057	0.060	1.1	1.0	0.050	0.10	0.017	0.005	1.9	0.47	3.7	3.0	4.5	-75.7	-10.3	- 6.8	72.8
Northeastern	11	0.018	0.215	3.2	3.7	0.170	0.11	0.040	0.004	6.7	1.72	8.5	3.8	99.5	-68.6	- 9.7	- 6.4	28.5
Central	12	0.083	0.085	1.0	0.8	0.041	0.10	0.040	0.015	5.0	0.40	3.6	9.3	5.0	-95.4	-12.8	- 8.9	61.0
Discharge	13	0.030	0.630	10.2	1.7	0.080	0.15	0.326	0.010	10.3	3.02	3.9	7.1	16.2	-90.8	-12.1	- 7.0	10.8

major-element compositions plotted for each zone on the Piper diagram of figure 79. Spatial patterns (hydrochemical zones) were defined on basin-scale maps by comparing all the chemical and isotopic data from one well with that from adjacent wells. The process of assigning wates to particular hydrochemical zones took into account also a conceptualization of likely sources of recharge to the basin, their chemical and isotopic composition, knowledge of the predevelopment water levels, and well location. This process resulted in recognition of areas that seem to have similar chemical and isotopic properties, and could be related to a particular source of recharge. After all samples were assigned to hydrochemical zones, the Mann-Whitney statistical test (also known as the Wilcoxon rank-sum test) was used between adjacent zones for several water-quality parameters to determine whether the samples actually could have come from separate populations. The test calculates whether the median values from the two groups being compared are statistically different, or whether they could represent the medians of two groups drawn from the same population. The test is nonparametric and so does not require the statistical distributions of the groups being compared to have the same shape or variability (Helsel and Hirsch, 1995). The test was used to compare only those hydro-chemical zones that contained at least 10 samples for most constituents, which included every zone except the Southwestern Mountain Front and Discharge zones. Selected parameters for which the test showed statistically different medians between zones at the 95-percent confidence level are listed in table 9 and discussed briefly below.

Northern Mountain Front Zone

The Northern Mountain Front zone includes areas located on both sides of the Rio Grande (fig. 78). West of the river, the zone extends from the base of the Jemez Mountains in the north to the vicinity of the Rio Grande on the south and east. East of the river, the zone extends from the basin boundary on the north and east to a few miles south of the Santa Fe River. No major surface-water drainages are located in the upgradient parts of the zone. Therefore, potential sources appear to be limited primarily to mountain-front recharge, particularly the infiltration of precipitation, and intermittent streamflow in upland areas. Other sources of recharge could contribute water to the aquifer system locally, such as by infiltration through the Rio Grande, Jemez River, or Santa Fe River, or by underflow from the Española Basin to the north. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in some areas and mixes with ground water of downgradient zones in other areas at its southern extent.

Ground water of the Northern Mountain Front zone is characterized by low values of specific conductance relative to all other zones (table 8). Ground water in this zone tends to have particularly low concentrations of Na, SO_4, Cl, F, Br, B, Mo, Sr, and U, but particularly high SiO_2 concentrations. The dominant water type is Ca / CO_3 + HCO_3 (fig. 79). The median deuterium content and carbon-14 activity are -77.7 per mil and 33.4 pmC, respectively.

To look for samples with similar composition, the concentrations of selected major ions in ground water of the zone were plotted against Cl concentrations (expected to be conservative) on graphs that included the theoretical evaporation trends of average bulk precipitation collected on Sevilleta National Wildlife Refuge and average Jemez River water collected from the sample site below Jemez Canyon Dam (figs. 80a and b). On these graphs and similar graphs for subsequent hydrochemical zones, the theoretical surface-water evaporation trend is shown for both more concentrated and more dilute compositions than the average composition calculated from available data. Surface-water compositions can be expected to be more dilute than “typical” during periods of high runoff from precipitation events or snowmelt, which are periods when infiltration may be greatest. During these times, the chemical composition of water in some streams might be expected to approach the average chemical composition of precipitation. However, for the graphs presented in this report, the surface-water compositions were allowed to approach the graph origin at their dilute ends, which is negligibly different from the average composition of precipitation for the purposes of data analysis performed here.

Graphs of SO_4 and Ca against Cl (figs. 80a and b) indicate that the general composition of most ground-water samples from the Northern Mountain Front zone are fairly similar to those of bulk precipitation, which is consistent with recharge through the infiltration of precipitation or intermittent streamflow. Based on the Cl concentration of precipitation, most

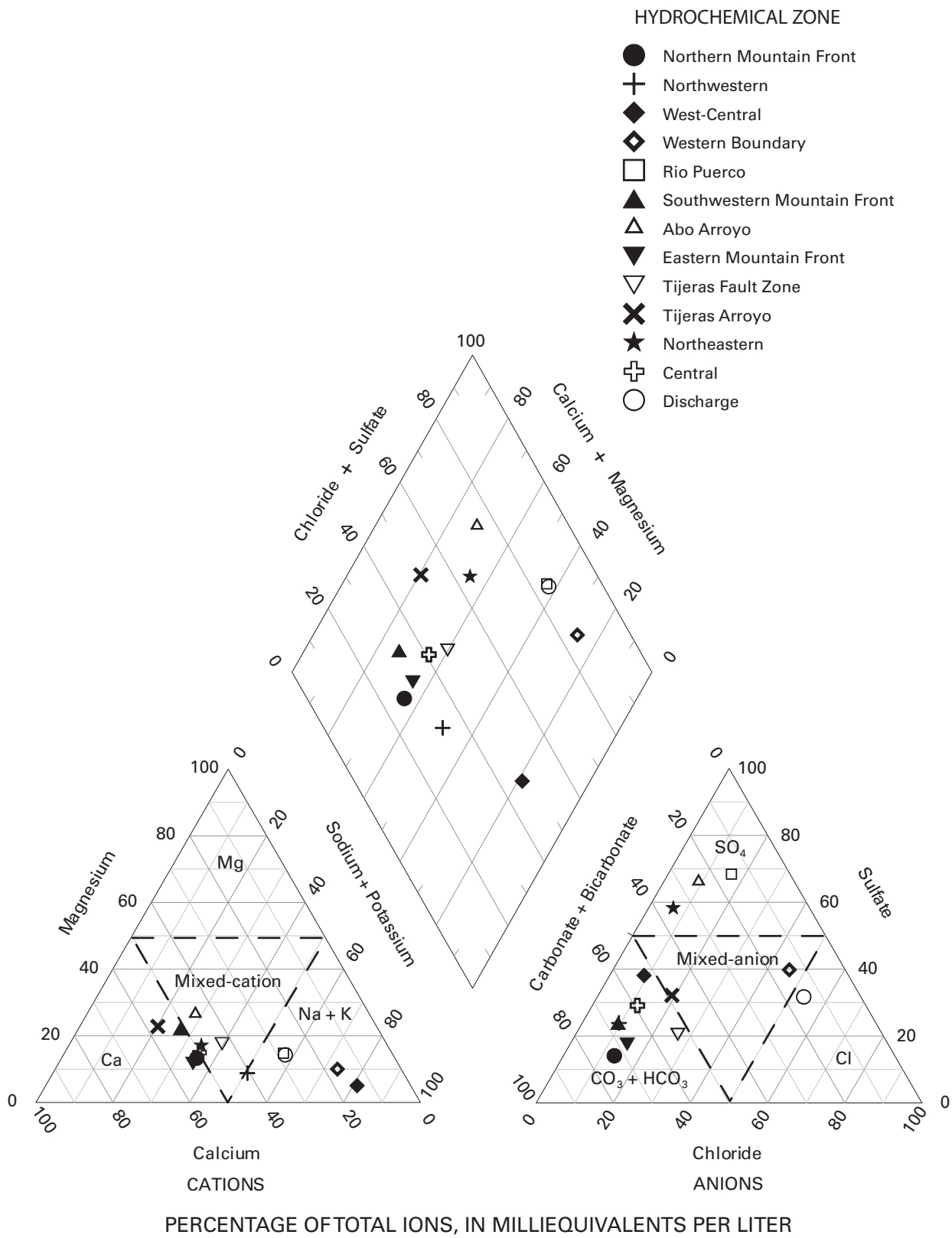


Figure 79. Representative major-element compositions for ground water from the various hydrochemical zones in the Middle Rio Grande Basin, New Mexico.

Table 9. Parameters for which the Mann-Whitney test indicated statistically different medians between adjacent hydrochemical zones at the 95-percent confidence level for ground-water samples from the Middle Rio Grande Basin, New Mexico

["X" indicates that medians for that parameter were statistically different for the zones listed]

Hydrochemical zones compared	Hydro-chemical zone numbers	Specific conduc-tance	pH, field	Water temper-ature	Dis-solved oxygen	Cal-cium	Magne-sium	Sodium	Potas-sium	Alka-linity	Sulfate	Chlo-ride	Fluo-ride	Bro-mide	Silica	Nitrate	Alumi-num
Northern Mountain Front and Northwestern	1 - 2		X		X						X		X		X	X	
Northwestern and West Central	2 - 3	X	X	X	X	X	X	X			X		X	X		X	X
West Central and Rio Puerco	3 - 5	X	X	X		X	X	X	X		X	X		X	X		
Western Boundary and Rio Puerco	4 - 5	X						X	X	X		X	X				
Abo Arroyo and Eastern Mountain Front	7 - 8	X				X	X	X			X	X				X	
Eastern Mountain Front and Tijeras Fault Zone	8 - 9	X	X	X		X	X	X	X	X	X	X	X	X	X	X	
Eastern Mountain Front and Tijeras Arroyo	8 - 10	X	X	X		X	X		X	X	X	X			X	X	
Tijeras Fault Zone and Tijeras Arroyo	9 - 10	X			X		X	X		X		X	X			X	
Northeastern and Eastern Mountain Front	8 - 11	X		X		X	X	X	X	X	X	X			X		X
Northeastern and Northern Mountain Front	1 - 11	X				X	X	X		X	X	X	X	X			
Central and Eastern Mountain Front	8 - 12	X		X	X		X		X		X	X	X	X	X	X	
Central and Northern Mountain Front	1 - 12	X	X		X	X	X				X	X				X	X
Central and West Central	3 - 12	X	X	X	X	X	X	X	X		X	X	X		X	X	

Hydrochemical zones compared	Hydro-chemical zone numbers	Arsenic	Barium	Boron	Chrom-ium	Copper	Iron	Lead	Lith-ium	Manga-nese	Molyb-denum	Stron-tium	Ura-nium	Vana-dium	Zinc	Deute-rium	Carbon-14	Carbon-13
Northern Mountain Front and Northwestern	1 - 2			X			X					X		X		X		
Northwestern and West Central	2 - 3	X	X	X	X						X	X		X		X	X	
West Central and Rio Puerco	3 - 5	X	X			X	X		X	X	X	X		X	X	X	X	
Western Boundary and Rio Puerco	4 - 5			X													X	X
Abo Arroyo and Eastern Mountain Front	7 - 8		X	X	X			X				X				X		X
Eastern Mountain Front and Tijeras Fault Zone	8 - 9			X			X		X	X		X	X				X	X
Eastern Mountain Front and Tijeras Arroyo	8 - 10	X						X				X				X		X
Tijeras Fault Zone and Tijeras Arroyo	9 - 10	X		X					X	X	X	X					X	
Northeastern and Eastern Mountain Front	8 - 11		X	X	X		X				X	X			X	X		X
Northeastern and Northern Mountain Front	1 - 11			X		X					X	X	X			X		X
Central and Eastern Mountain Front	8 - 12	X		X		X	X	X	X	X	X	X			X	X		
Central and Northern Mountain Front	1 - 12			X						X	X		X		X	X		
Central and West Central	3 - 12	X	X	X	X					X	X	X		X			X	X

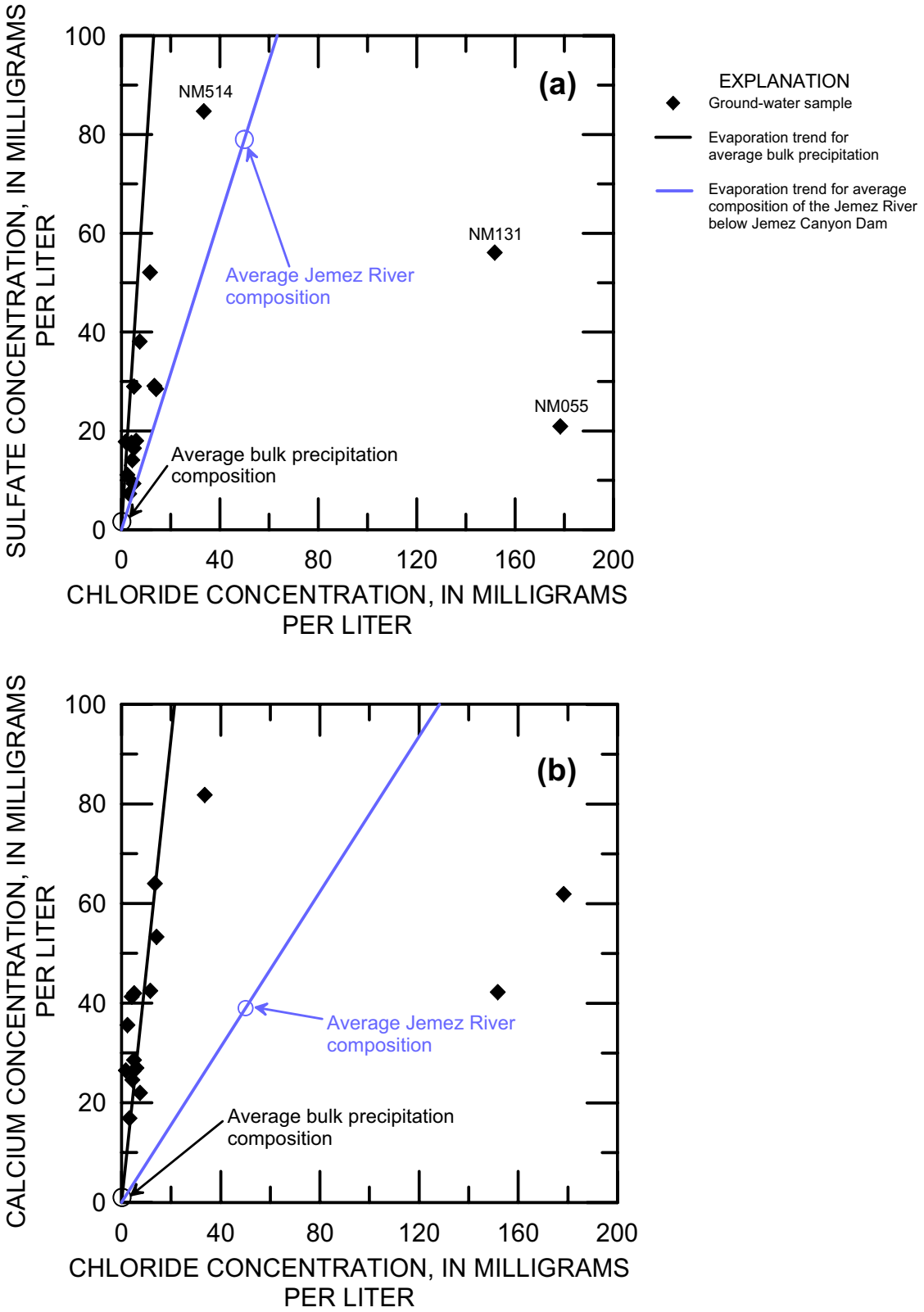


Figure 80a-b. Relation of (a) sulfate to chloride and (b) calcium to chloride concentrations in ground water of the Northern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

samples appear to have been concentrated up to about 66-fold during recharge. However, there are a few samples that show Cl concentrations substantially higher than expected based on the ion ratios of precipitation. Two of these samples (NM055 and NM131) are from sites located at the southern end of the zone (south of the Jemez River) and one sample (NM514) is from a site located near the base of the Jemez Mountains. The two samples from sites located downgradient of the Jemez River have substantial excess Cl relative even to the discharge-weighted average Jemez River chemistry determined from NWIS. Therefore, it appears most likely that all three high-Cl samples could be affected by mixing with deep, mineralized water having a high concentration of Cl relative to SO_4.

Interestingly, although most of the ground-water samples from the Northern Mountain Front zone plot fairly close to the precipitation evaporation line on the graph of SO_4 and Cl (fig. 80a), nearly all plot slightly to the Cl side of the line. These same samples plot closely along or almost evenly on either side of the precipitation evaporation line for Ca and Cl (fig. 80b), but nearly all plot far to the Ca side of the precipitation evaporation line for Ca and SO_4 (fig. 80c). If the samples were affected by appreciable amounts of calcite dissolution, Ca would plot above the precipitation line relative to Cl (fig 80b). Therefore, these plots indicate that the SO_4 concentrations of modern precipitation samples are slightly higher relative to Cl than the concentrations present during recharge of the ground-water samples. This conclusion is consistent with the modern release of sulfur into the atmosphere as a result of industrial activities.

In summary, the generally dilute nature of ground water in the Northern Mountain Front zone,

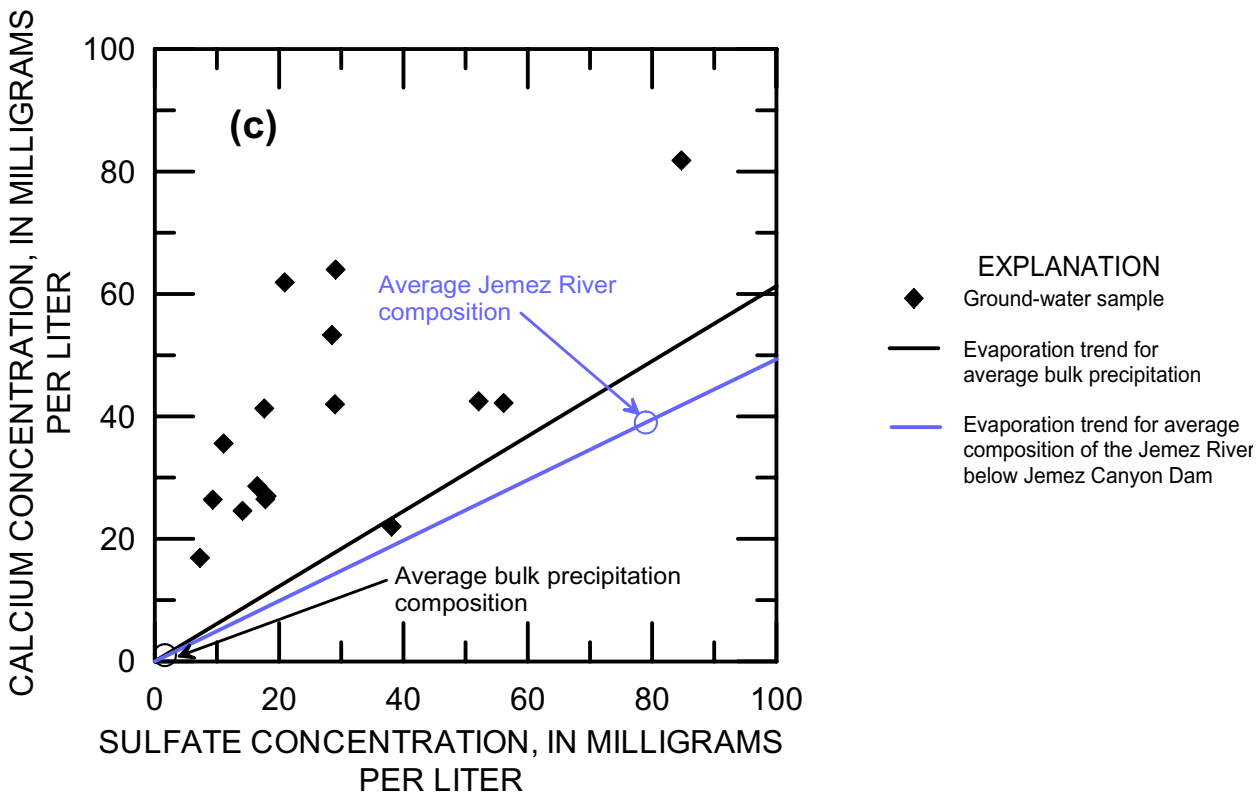


Figure 80c. Relation of calcium to sulfate concentrations in ground water of the Northern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

along with constituent ratios, the low concentrations of most minor elements, and the moderately light deuterium contents, are consistent with mountain-front recharge processes. However, some samples indicate mixing with a high-Cl source, such as a deep, mineralized water. The high SiO_2 concentrations characteristic of the zone may reflect weathering of silicic volcanic rocks associated with Jemez Mountain volcanism in the area.

Northwestern Zone

The Northwestern zone extends in a relatively narrow band from the base of the Jemez and Nacimiento Mountains on the north and west to boundaries with other zones near Albuquerque to the south (fig. 78). Potential recharge sources in upgradient areas include mountain-front recharge processes, infiltration through the Jemez River, and possibly ground-water inflow from north of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably mixes at its southern end with greater quantities of water from other, downgradient zones.

Similar to the Northern Mountain Front zone, ground water of the Northwestern zone generally has relatively low specific conductance compared to other zones (table 8). Compared to most other zones, ground water in this zone also has relatively low concentrations of Ca, Mg, SO_4, Cl, Br, and U, but relatively high concentrations of dissolved oxygen, NO_3, As, and V, and relatively high pH. The dominant water types are Na + K / and mixed-cation / CO_3 + HCO_3 (fig. 79). The median deuterium content and carbon-14 activity are –64.7 per mil and 29.6 pmC, respectively. The Mann-Whitney test indicates that ground water of the Northern Mountain Front and the adjacent Northwestern zone differs in the median values of 11 water-quality parameters, including 4 major constituents (as defined above, the major constituents are Ca, Mg, Na, K, HCO_3, SO_4, Cl, F, SiO_2, and NO_3), pH, and deuterium content (table 9).

For selected parameters, ground-water samples from the zone were plotted against the evaporation trends for bulk precipitation and the Jemez River (fig. 81). Similar to the Northern Mountain Front zone, most samples fall close to (but slightly to the Cl side of) the precipitation evaporation trend for SO_4 and Cl (fig. 81a), which is consistent with recharge through the infiltration of precipitation or intermittent streamflow. Based on the Cl concentration of precipitation, most of these samples appear to have been concentrated up to about 60-fold during recharge. However, three samples (DB427, DB429, and NM133) fall close to the Jemez River evaporation trend and one sample (DB428) is clearly distinct from either trend. Samples DB427-9 are from wells located within about 1 mile of the Jemez River and could reasonably be expected to include some fraction of infiltration from the river. In contrast, sample NM133 is from a well screened deep (at depths of greater than 820 feet) and located several miles south of the river. Therefore, it seems unlikely that infiltration from the Jemez River would provide the highest fraction of water in this sample. Deep, mineralized water could be a more reasonable source of high-Cl water to the well. Several widely scattered samples from the zone, including samples from wells more than 800 feet deep, show NO_3 concentrations of greater than 5 mg/L. These samples fall along the precipitation evaporation trend for NO_3 and Cl concentration (fig. 81b) and contain fairly high dissolved-oxygen concentrations, which is consistent with a natural source of NO_3 and the relative lack of NO_3 reduction.

Samples from a few wells located near the Jemez River were removed from the data set, and, therefore, removed from consideration as part of this hydrochemical zone, because of high specific conductance values and compositions that indicated the samples represented primarily the local infiltration of Jemez River water that had been greatly evapotranspired. Because such samples appeared to represent local processes and occurred infrequently, they also were not combined into a separate hydrochemical zone.

In summary, the chemical composition of water in the Northwestern zone generally is consistent with mountain-front recharge processes, although some samples show evidence of local mixing with infiltration from the Jemez River. Compared with adjacent hydrochemical zones, the enriched ^2H content of most ground water in the zone indicates that recharge occurred at relatively low altitudes along the Jemez Mountains. In addition, the presence of relatively high concentrations of some minor elements indicates that ground water of this zone may have contacted geothermally altered rocks in the area of the Jemez Mountains during or subsequent to recharge (Bexfield and Plummer, 2002).

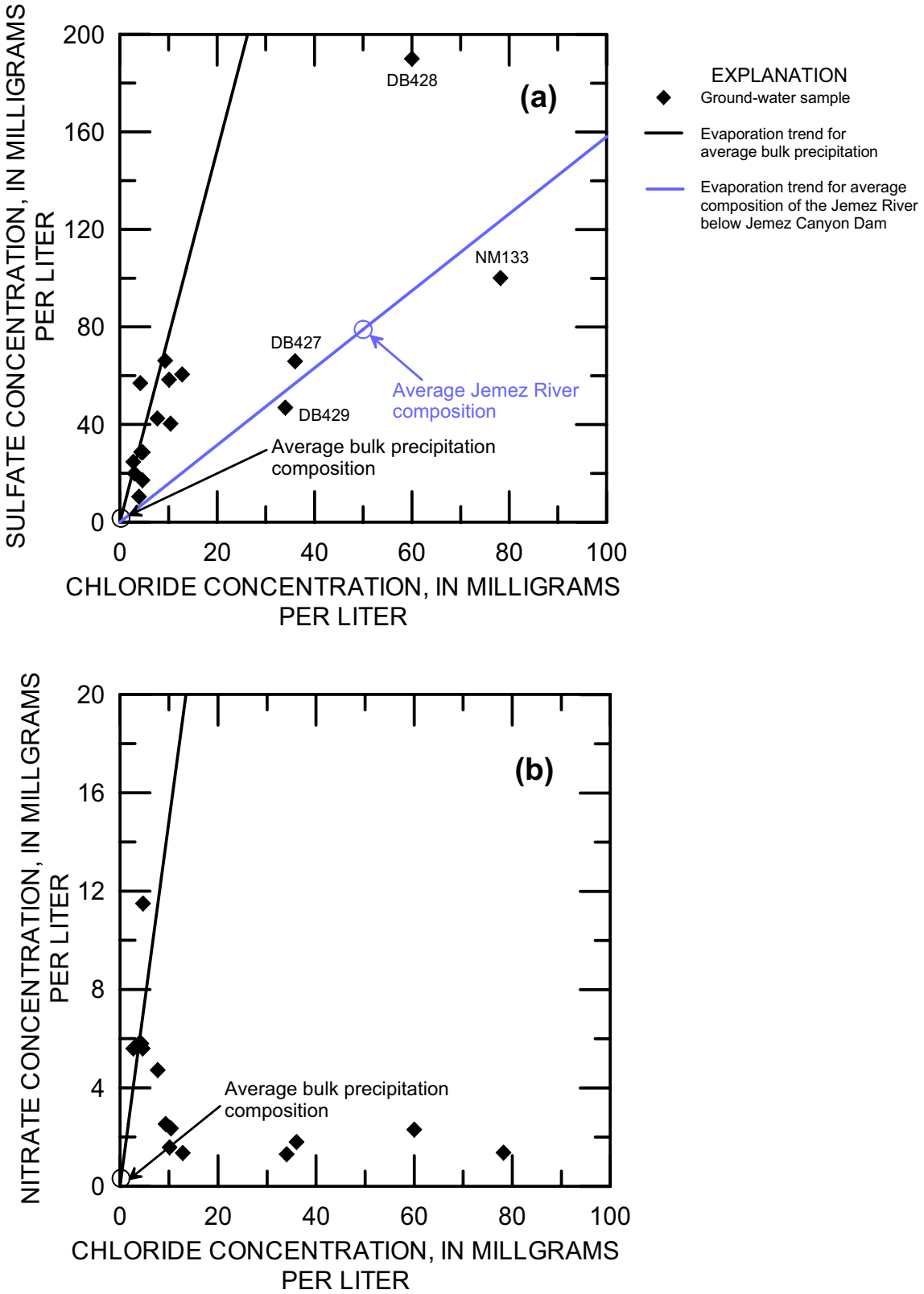


Figure 81. Relation of (a) sulfate to chloride and (b) nitrate to chloride concentrations in ground water of the Northwestern zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

West-Central Zone

The West-Central zone begins at the base of the Jemez and Nacimiento Mountains (at depth beneath the Northwestern zone) in the northwestern part of the MRGB (fig. 78). The West-Central zone extends south through much of the western portion of the basin between the Rio Puerco and the Rio Grande until it ends at the Rio Grande south of Belen. In some areas, the zone may also extend eastward under the Rio Grande to the east side of the basin at depth, but its full extent is unclear (fig. 78). Potential sources of ground-water recharge to the zone include mountain-front recharge processes and possibly ground-water inflow from north of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and may mix with water of the Central zone along its eastern boundary and with water of the Rio Puerco zone along its western boundary.

Ground water of the West-Central zone typically has moderate specific conductance relative to other zones (table 8). Ca, Mg, and Sr concentrations are low, whereas pH values and As and V concentrations are high. Compared to other zones, concentrations of Na and Mo also are relatively high. The dominant water type is Na + K / CO_3 + HCO_3 (fig. 79), although Na + K / mixed-anion and Na + K / SO_4 water types also are common. The median deuterium content and carbon-14 activity are –96.7 per mil and 8.8 pmC, respectively. The limited data as a function of depth along the northern margin of the basin indicate that ground water of the West-Central zone extends under ground water of the Northwestern zone at depth, and may extend under parts of the Northern Mountain Front and Central zones. The Mann-Whitney test indicates that ground water of the West-Central and the adjacent Northwestern zone differs in the median values of 21 water-quality parameters, including 6 major constituents, specific conductance, pH, deuterium content, and carbon-14 activity (table 9).

Ground-water samples from the zone generally plot along the precipitation evaporation trend for SO_4 and Cl concentrations (fig. 82), which is consistent

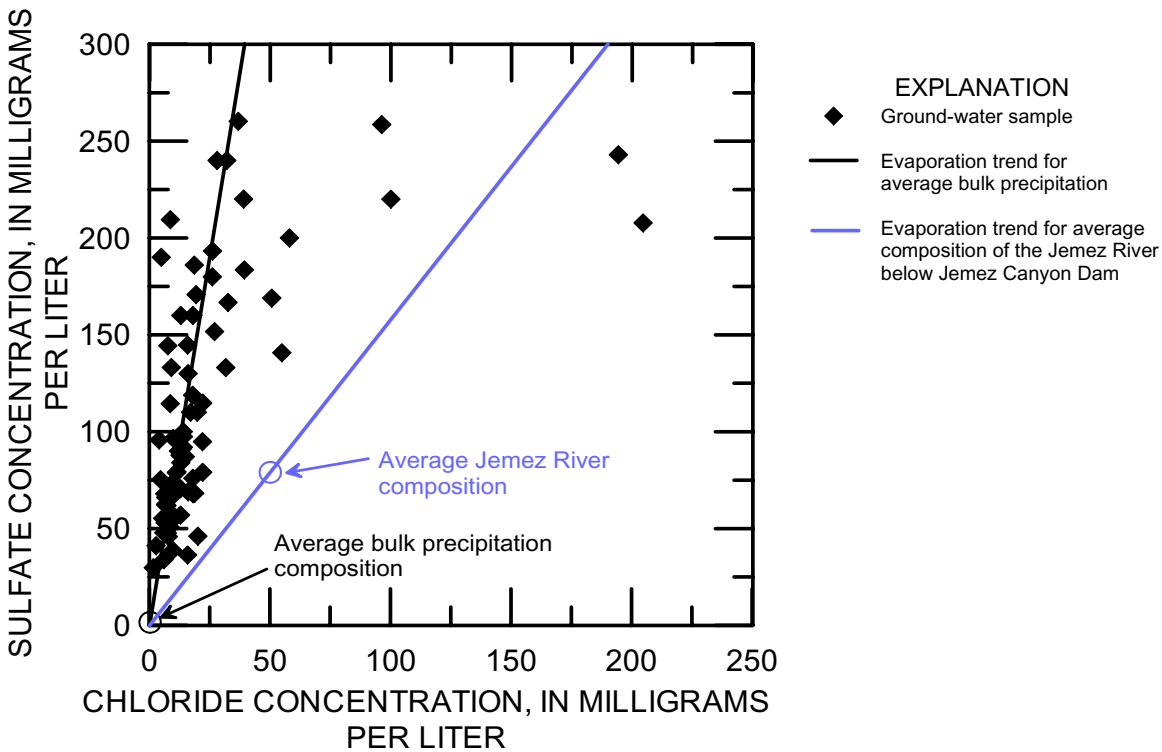


Figure 82. Relation of sulfate to chloride concentrations in ground water of the West-Central zone, Middle Rio Grande Basin, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

with recharge through infiltration of precipitation or intermittent streamflow in upland areas. Only a low percentage of samples show substantial "excess" SO_4 or Cl. These sampling sites are scattered across the zone and may indicate localized mixing with deep, mineralized water. Based on the Cl concentration of precipitation, most ground-water samples in the zone appear to have been concentrated between about 8- and 270-fold during recharge.

The major-element composition of most ground-water samples from the West-Central zone indicate that the primary source of water is the infiltration of precipitation in or near the Jemez Mountains, either directly or as intermittent streamflow. The depleted ^2H content of most samples indicates that recharge occurred at high altitude and/or during a time when the local climate was colder than today. Also, the generally low carbon-14 activity, along with the observation that West-Central zone water is present at depth beneath the adjacent Northwestern zone water, indicates that recharge to this zone may occur farther north than recharge to the Northwestern zone and generally travel longer, deeper flow paths into the basin. High-altitude parts of the Jemez Mountains appear to be the most likely recharge area that could explain depleted ^2H content and long travel times, although the possibility of a recharge area even farther north cannot be completely ruled out. Bexfield and Plummer (2002) concluded that the high concentrations of some trace elements, including As, in the zone were probably the result of contact of local recharge water with geothermally altered rocks and subsequent control by pH-dependent adsorption/desorption processes.

Western Boundary Zone

The Western Boundary zone extends along much of the western margin of the MRGB. The zone generally extends eastward into the basin to within a few miles of the Rio Puerco and may extend to the Rio Grande at its far southeastern tip (fig. 78). The likely sources of recharge to the zone include ground-water inflow from Mesozoic to Paleozoic rocks west of the basin and local arroyo recharge. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and mixes with water of the Rio Puerco zone along its eastern boundary.

Ground water of the Western Boundary zone typically has the highest specific conductance of any zone (table 8). Concentrations of Mg, Na, K, Cl, F, and B are high. Concentrations of Ca, SO_4, and Li and alkalinity values are also high relative to most other regions. Concentrations of SiO_2, As, and Ba are relatively low. The typical water types are Na + K / Cl and Na + K / mixed-anion (fig. 79). The median deuterium content and carbon-14 activity are –64.4 per mil and 6.2 pmC, respectively.

Ground-water samples from the zone generally plot far to the Cl side of the precipitation evaporation trend for SO_4 and Cl concentrations (fig. 83). Only three samples plot close to the evaporation trends for either precipitation or the Rio Puerco (using the discharge-weighted average from historical NWIS data, table 4). The two samples (NM329 and DB036) that plot near the Rio Puerco evaporation trend are from sites located near the basin margin just northwest of the Ladron Mountains and could represent ground-water inflow from different rock types than are present along most of the rest of the western basin boundary. The sample (NM167) that plots closest to the precipitation-evaporation trend is from a site located near the boundary between the Western Boundary and Rio Puerco hydrochemical zones and may represent a mixture of both waters, rather than a water derived from local infiltration of precipitation.

The observation that most samples from the zone plot far to the Cl side of the precipitation and surface-water evaporation trends for SO_4 and Cl indicates that some fraction of the ground water is saline water that has been affected by processes other than infiltration and evapotranspiration of local sources. Spring sample NM485 (S009), which shows particularly elevated concentrations of Cl and Na that probably are associated with halite dissolution, along with a low carbon-14 activity and an enriched ^2H content, likely is representative of the composition of brine leaking into the basin in the area of the Lucero Uplift. (This sample was excluded from the final data set for the MRGB because the spring falls outside of the basin boundary.) Goff and others (1983) also sampled high-Cl ground water in the zone and concluded that the water probably originates at depth in the vicinity of the Comanche fault zone and has dissolved halite, gypsum, limestone, and dolostone. These origins could explain the elevated levels of Li, which replaces Na in small quantities in evaporite minerals such as halite

(Rankama and Sahama, 1950). The study by Goff and others did not find evidence of high-temperature origins for the high concentrations of Cl, Na, and Li.

Because ground-water samples from within the basin generally show substantially lower specific conductance and higher carbon-14 values than water from spring sample NM485, the brine must be mixing with younger, more dilute water from another source as it enters the basin. Goff and others (1983) found evidence of mixing between high-Cl water and dilute surface meteoric water in the zone based on relations between selected constituents. The most likely source for dilute meteoric water probably is infiltration of arroyo flow from runoff because of storm events, although direct infiltration of precipitation also may be possible in areas, or in the past during climatic periods wetter than today. These processes would occur at relatively low altitudes along the western basin margin that would be consistent with the observed deuterium contents of the ground water. Calculations using the Cl concentrations from NM485 and Sevilleta bulk precipitation indicate that the Cl concentration at site S074 (fig. 11a; sample NM285, table A2) would result from a mixture of about 11-percent brine with about 89-percent precipitation, assuming no other sources or sinks for Cl. These calculations indicate that the quantity of brine leaking into the basin along the western boundary is likely to be substantially lower than the quantity of precipitation entering the aquifer system within the basin. Nevertheless, ground-water samples do not plot along the precipitation evaporation trend because the concentrations of major constituents in the brine are so high that the chemical signature of the brine dominates that of the precipitation.

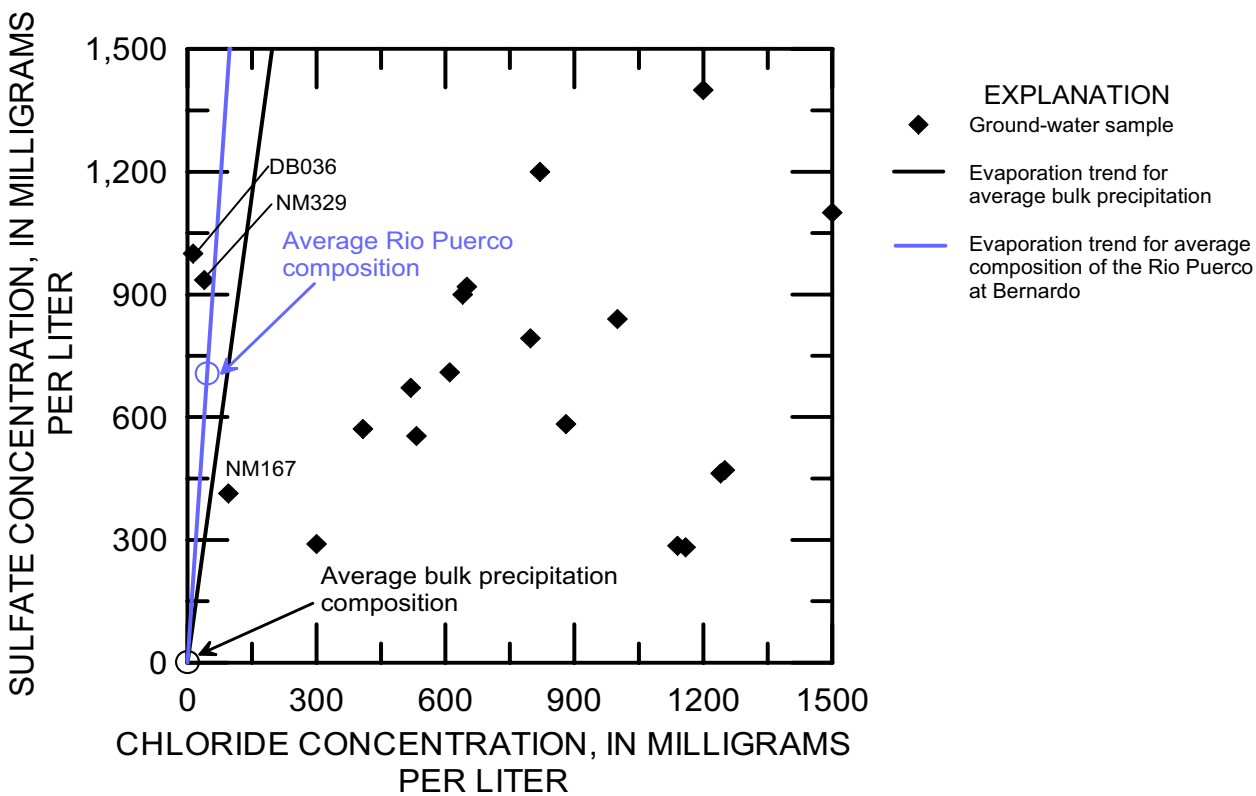


Figure 83. Relation of sulfate to chloride concentrations in ground water of the Western Boundary zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

Rio Puerco Zone

The Rio Puerco zone stretches along the Rio Puerco throughout its length within the MRGB (from the western boundary of the basin to the Rio Grande) and generally extends for a few miles east and west of the river (fig. 78). Possible sources of recharge to the zone include infiltration from the Rio Puerco and ground-water inflow from Mesozoic and/or Paleozoic rocks along the western margin of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in the southern part of the basin, and possibly mixes with some water of the West-Central zone along its eastern boundary.

Ground water of the Rio Puerco zone typically has the second-highest specific conductance of any zone (table 8). Concentrations of SO_4 and Sr are high. Concentrations of Ca, Mg, Na, K, Cl, Br, Li, and U also are relatively high compared to most other zones. Concentrations of SiO_2, As, Ba, and V are relatively low. The dominant water types are mixed-cation / and Na + K / SO_4 (fig. 79). The median deuterium content and carbon-14 activity are –61.6 per mil and 36.4 pmC, respectively. The Mann-Whitney test indicates that ground water of the Rio Puerco and the adjacent West-Central zone differs in the median values of 23 water-quality parameters, including 7 major constituents, specific conductance, pH, deuterium content, and carbon-14 activity (table 9). The test indicates that ground water of the Western Boundary and the Rio Puerco zone differs in the median values of 9 water-quality parameters, including 5 major constituents, specific conductance, carbon-13 content, and carbon-14 activity (table 9).

Ground water in the zone shows a wide range of ratios between SO_4 and Cl concentrations (fig. 84). Some samples fall along the evaporation trend for the Rio Puerco (using the discharge-weighted average from historical NWIS data) (table 4), whereas others fall near the precipitation evaporation trend, or even to the right of both evaporation trends (toward the Cl axis). Samples from the Rio Puerco zone that are farthest right of the evaporation trends approach the composition of samples from the Western Boundary zone. This range of ratios between SO_4 and Cl concen-

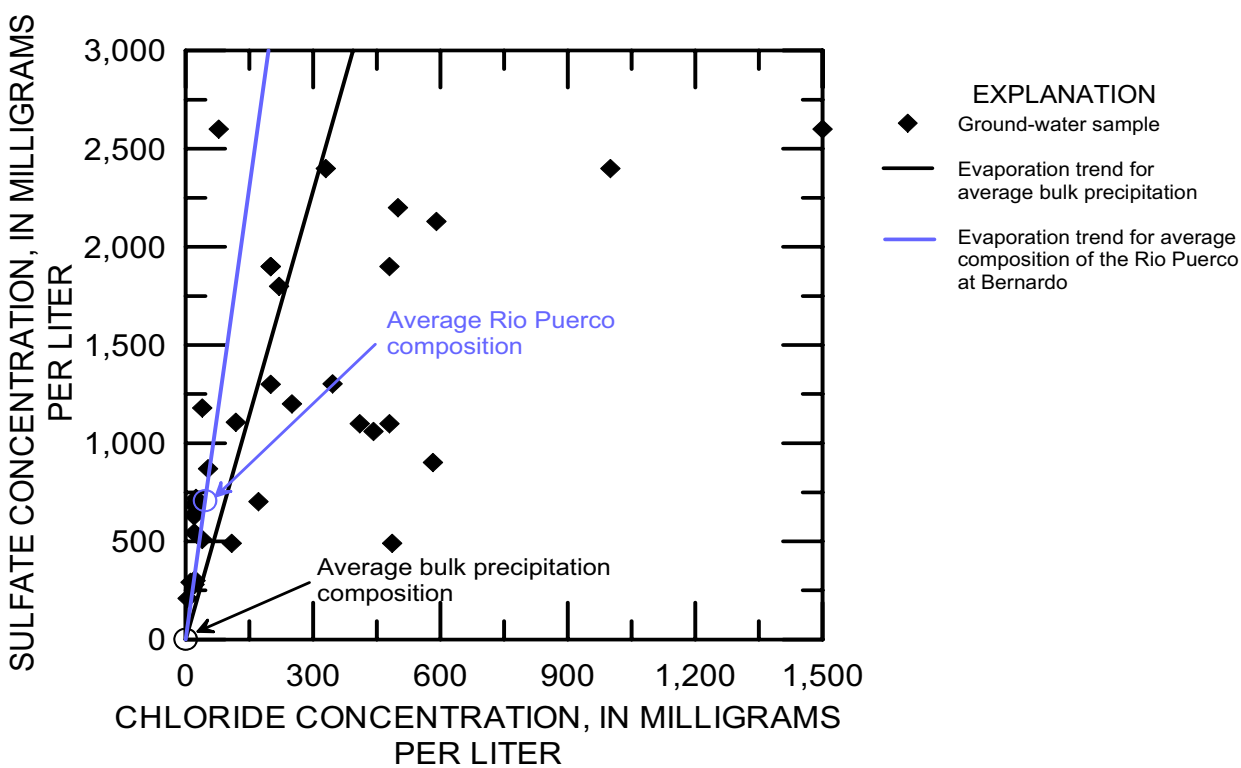


Figure 84. Relation of sulfate to chloride concentrations in ground water of the Rio Puerco zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

trations for water in the Rio Puerco zone may represent a mixing continuum between surface water infiltrating from the Rio Puerco (or ground water leaking from the same rock types drained by the Rio Puerco) and water from the Western Boundary zone. Water samples that fall near the precipitation evaporation trend, then, probably would represent intermediate mixtures of Rio Puerco zone and Western Boundary zone waters rather than ground water closely associated with the infiltration of precipitation.

Several samples that fall near the Rio Puerco evaporation trend for SO_4 and Cl concentrations have lower concentrations of both constituents than the discharge-weighted average concentrations calculated for the Rio Puerco. This observation could indicate that more infiltration occurs during higher flows of the Rio Puerco when the water is more dilute, or that the composition of the Rio Puerco has changed somewhat through time. Alternatively, these samples could represent the inflow of ground water from Mesozoic rocks along the northwestern border of the basin. This inflow would come from rock types similar to those drained by the Rio Puerco, but could be more dilute than the surface water in the river because of less evapotranspiration. Goff and others (1983) sampled similar ground waters of high SO_4 relative to Cl in the area of the Lucero uplift, particularly west and northwest of the Lucero monocline. They proposed that these waters are of low-temperature origin and are dissolving gypsum, limestone, dolostone, and evaporite minerals (not including substantial amounts of halite). However, the generally higher carbon-14 activities in ground water from the Rio Puerco zone as compared to the Western Boundary zone are consistent with a greater component of younger water, such as infiltration through the arroyo, rather than just a greater contribution of old ground water of different composition.

Southwestern Mountain Front Zone

The Southwestern Mountain Front zone, which is defined by only two samples (S022 and DB027, figs. 11a and 17a), extends from the base of the Ladron Mountains on the south and west to boundaries with other zones a few miles within the basin (fig. 78). Potential sources of recharge to the zone include mountain-front recharge processes along the Ladron Mountains and possibly ground-water inflow along the basin margins. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably mixes with greater quantities of water from the downgradient Western Boundary zone, although some water may discharge to the Rio Grande.

The Southwestern Mountain Front zone is delineated on the basis of only two samples, so that a comparison with the ground-water chemistry of other zones is difficult. The average values of the two samples in the zone (table 8) indicate that specific conductance is moderately low, as are concentrations of Na and K. Concentrations of SiO_2, As, U, and V are particularly low, while pH values are quite high. Water types of the two samples are mixed-cation / CO_3 + HCO_3 and Ca / CO_3 + HCO_3 (fig. 79). The one sample analyzed for deuterium content and carbon-14 activity had values of –53.5 per mil and 40.0 pmC, respectively. Although the Mann-Whitney test could not be performed between the Southwestern Mountain Front and Western Boundary zones, the difference in chemistry is evident from the values of most chemical parameters.

The two ground-water samples from the Southwestern Mountain Front zone plot quite close to the precipitation evaporation trend for SO_4 and Cl concentrations (fig. 85). Therefore, their major-element compositions appear consistent with the infiltration of precipitation or intermittent streamflow along the mountain front. The generally low concentrations of minor elements also support this recharge source, although the single known deuterium content indicates recharge at a relatively low altitude. Based on the Cl concentration of precipitation, the samples appear to have been concentrated about 33- to 110-fold during recharge.

Eastern Mountain Front Zone

The Eastern Mountain Front zone extends along most of the Sandia, Manzanita, Manzano, and Los Pinos mountain fronts at the eastern boundary of the MRGB (fig. 78). The zone is broken up, however, by the occurrence of other, smaller hydrochemical zones in the areas of Tijeras Arroyo, the Tijeras Fault Zone, and Abo Arroyo. The Eastern Mountain Front zone typically does not stretch all the way from the mountain front to the Rio Grande, except just north of Abo Arroyo. The most likely source of recharge to the zone is mountain-front recharge processes, although ground-water inflow along the eastern basin margin

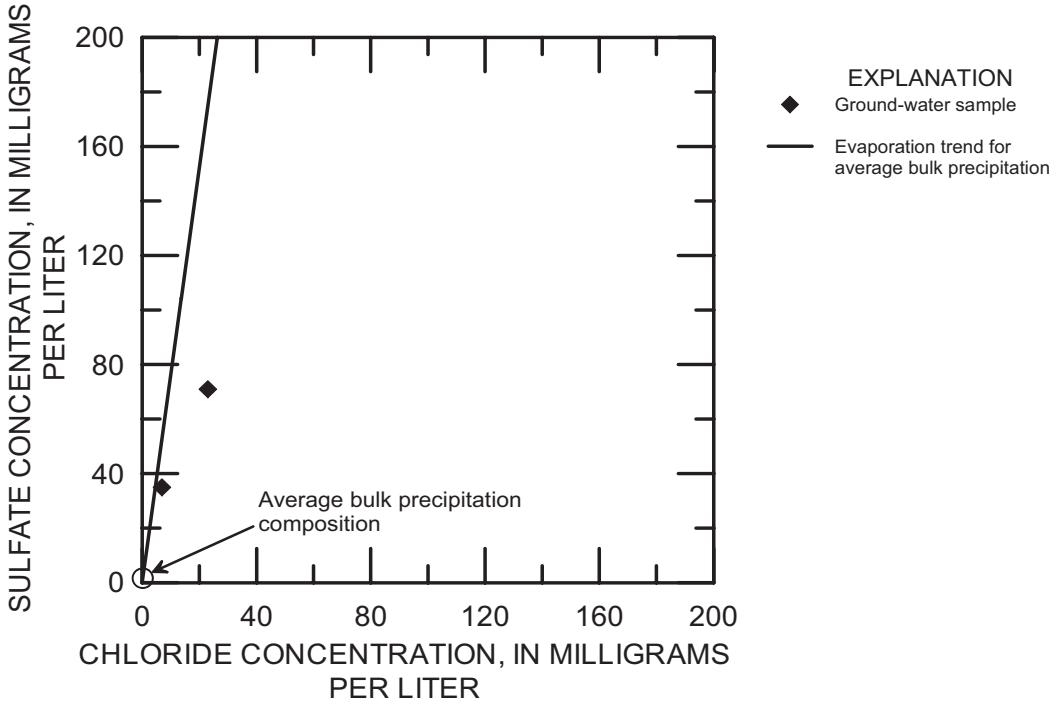


Figure 85 Relation of sulfate to chloride concentrations in ground water of the Southwestern zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

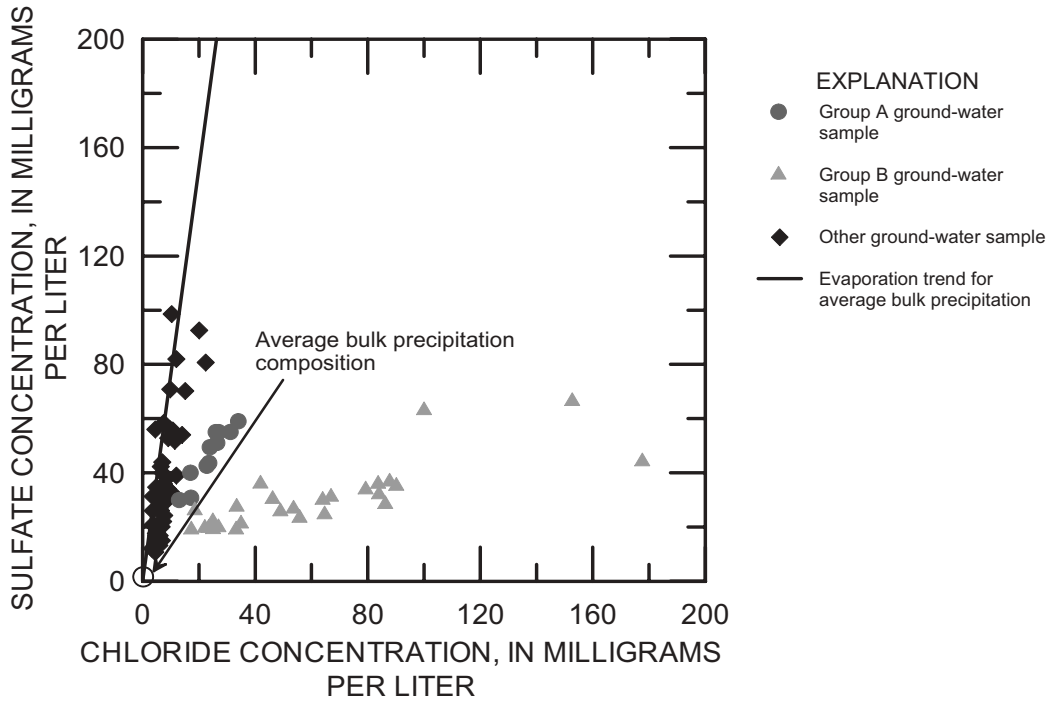


Figure 86. Relation of sulfate to chloride concentrations in ground water of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

also may contribute substantial amounts of water. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and possibly mixes with water of the Central zone along its western boundary.

Typical ground water of the Eastern Mountain Front zone has the second-lowest conductance of any zone (table 8). Compared to other zones, concentrations of Mg, Na, SO_4, Cl, F, NO_3, As, B, Li, Mo, and Sr are relatively low; K concentrations are particularly low. Concentrations of Ba are particularly high. The dominant water type is Ca / CO_3 + HCO_3 (fig. 79). The median deuterium content and carbon-14 activity are -81.0 per mil and 47.2 pmC, respectively.

Many ground-water samples from the zone plot close to the precipitation evaporation trend for SO_4 and Cl concentrations (fig. 86). Based on the Cl concentration of precipitation, most of these samples appear to have been concentrated about 16- to 75-fold during recharge. However, several other samples plot in one of two apparent groups that show relatively high amounts of Cl. Samples in Group A of figure 86 are scattered across the entire hydrochemical zone, but samples in Group B are nearly all located in a similar area of Albuquerque (fig. 87a and b). Most Group B samples have previously been discussed by Bexfield and Anderholm (2002a) and Bexfield and Plummer (2002), who conclude that water with elevated Cl flows upward from deeper parts of the aquifer system in this area, either along faults or as the result of a structural high located at the north end of Albuquerque. Mixing with such water also appears to contribute to elevated concentrations of some minor constituents. Logan (1990) suggested that this area of high Cl concentrations could be associated with strong effects of wetting/drying cycles upon infiltration of recharge water through alluvial fans and arroyos. However, the north-south orientation of the area (extending north of the Sandia Mountains), its presence only some distance away from the mountain front, and the persistence of—and increase in—high Cl concentrations with depth in piezometer nests of the area (fig. 59 and table A2) appear to contradict this idea that shallow, mountain-front processes are responsible for the elevated Cl in the area of Group B. Because most of the Group B samples are from sites located along or near major faults in the basin (fig. 87a), upwelling of deep, mineralized water also appears more likely than shallow mountain-front processes to result in elevated Cl concentrations in these samples.

Overall, the major-element composition of most ground water in this zone is consistent with infiltration of precipitation and intermittent streamflow in upland areas. This conclusion is supported by the generally low concentrations of most minor elements, the moderately depleted deuterium contents of most samples, and the high carbon-14 activities near the mountain front.

Abo Arroyo Zone

The Abo Arroyo zone stretches between the mountain front and the Rio Grande and extends from just north of Abo Arroyo to boundaries with other hydrochemical zones on the south (fig. 78). Possible sources of recharge to the area include the infiltration of surface water through Abo Arroyo, ground-water inflow from the Abo Arroyo watershed upstream of the MRGB boundary, and mountain-front recharge processes. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in some areas and mixes with, or possibly evolves to, water of the Discharge zone in other areas.

Ground water of the Abo Arroyo zone typically has a moderately high specific conductance (table 8). Compared to other zones, concentrations of K, Ba, and Li are relatively low, whereas concentrations of Mg, SO_4, and NO_3 are relatively high. The typical water type is mixed-cation / SO_4 (fig. 79). The median deuterium content and carbon-14 activity are -65.2 per mil and 24.1 pmC, respectively. The Mann-Whitney test indicates that ground water of the Abo Arroyo and the adjacent Eastern Mountain Front zone differs in the median values of 14 water-quality parameters, including 6 major constituents, specific conductance, and deuterium and carbon-13 contents (table 9).

Sulfate and Cl concentrations for ground-water samples from the Abo Arroyo zone were plotted against evaporation trends for precipitation and for surface water from Abo Arroyo (fig. 88). The surface-water composition used for figure 88 was that of one of the two surface-water samples collected from Abo Arroyo specifically for the MRGB study (table B2). Although this composition does not represent a long-term average, it probably is a reasonable estimate of a typical composition for comparison purposes. The

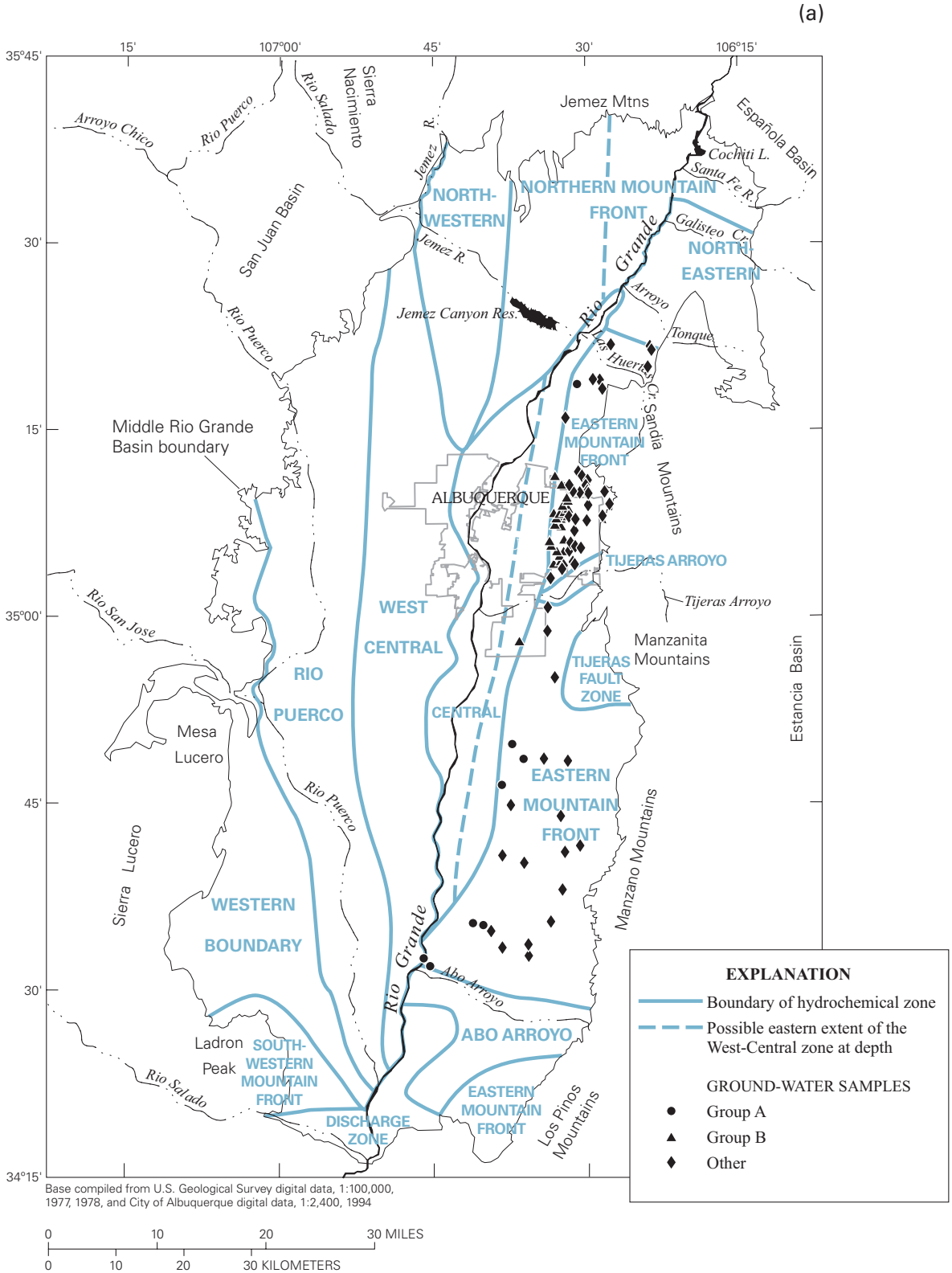


Figure 87a. Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, outside the Albuquerque area. See figure 86 for definitions of Groups A, B and Other.

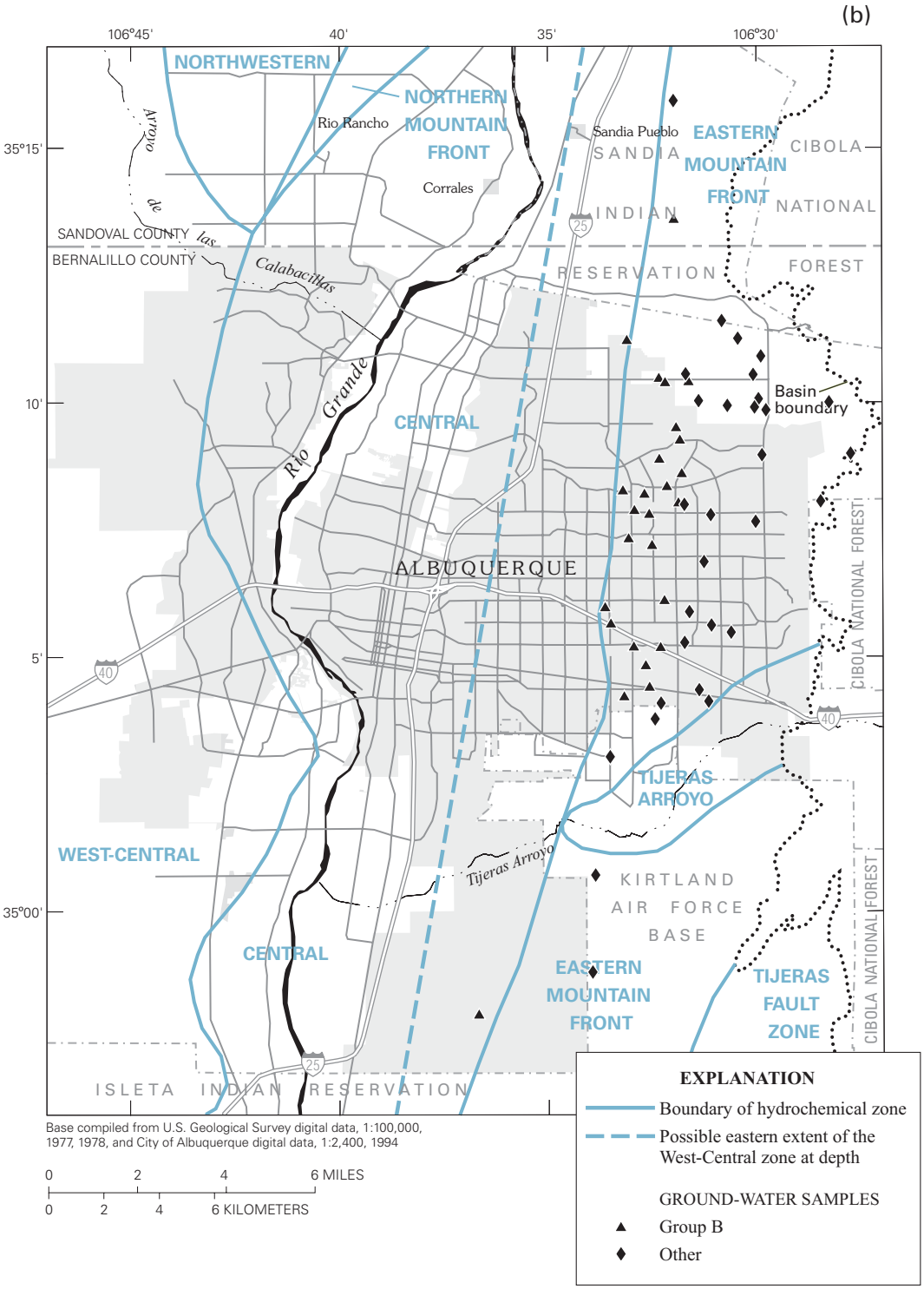


Figure 87b Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico,inside the Albuquerque area. See figure 86 for definitions of Groups B and Other.

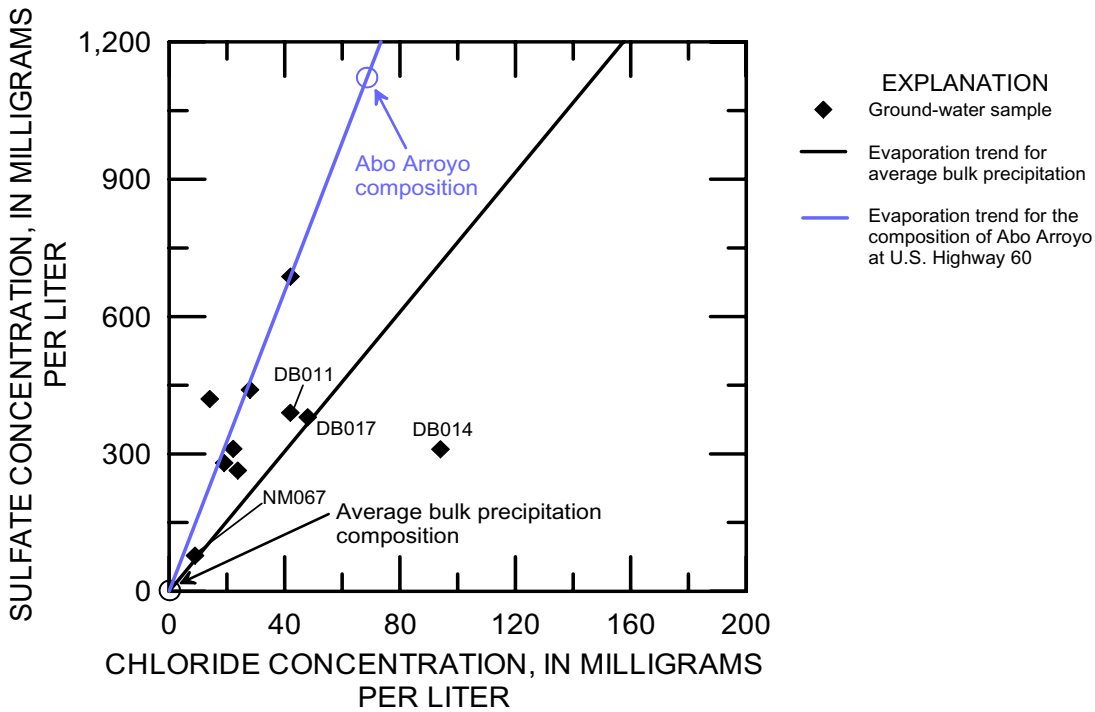


Figure 88. Relation of sulfate to chloride concentrations in ground water of the Abo Arroyo zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

sample shows the dominance of SO_4 over Cl in water from the arroyo, which drains gypsum-containing Paleozoic rocks above the basin. Most of the ground-water samples of the zone fall fairly close to the evaporation trend for Abo Arroyo and have deuterium contents that are consistent with infiltration through the arroyo as an important recharge source. All of these samples are more dilute than the compositions observed in Abo Arroyo, which indicates that recharge along the arroyo is most likely to occur during runoff events associated with summer storms. This conclusion is the same reached by Anderholm (2001), who studied Cl concentrations in the area. One sample (NM067) from a well located close to the Rio Grande (where Abo Arroyo contains water only after very heavy storm events) is especially dilute and plots close to the precipitation evaporation trend. This sample probably represents a mixture of dilute water of a mountain-front recharge source with a very low amount of recharge from Abo Arroyo. Three other samples (DB011, DB014, and DB017) also show a higher concentration of Cl relative to SO_4 than would be expected from recharge through Abo Arroyo. All three samples are from wells located in the southern part of the Abo Arroyo zone, in an area of transition to the Discharge zone (which has elevated Cl relative to SO_4), and probably represent mixtures between water from these two zones.

Several ground-water samples that fall near the Abo Arroyo evaporation trend for SO_4 and Cl concentrations have lower concentrations of both constituents than either surface-water sample collected for the MRGB study. This observation could indicate that more infiltration commonly occurs when water in the arroyo is more dilute, such as would be expected during high flows. Alternatively, these samples could represent the inflow of ground water from Paleozoic rocks (particularly gypsum) in the Abo Arroyo watershed upstream of the basin. Such inflow could be more dilute than the surface water in the arroyo because of less evapotranspiration. However, the observation that samples from wells more than 10 miles from (and apparently upgradient of) the potential source and path of ground-water inflow appear to contain a fraction of high-SO_4 water indicates that the arroyo (in either its present or a past configuration) may be the more likely source.

Tijeras Fault Zone Zone

The Tijeras Fault Zone zone encompasses a small area extending a few miles into the basin from the eastern mountain front (fig. 78). The northern and western edges of the zone are located near the Tijeras Fault Zone, which is part of a system of northeast-striking, nearly vertical faults that probably have accommodated rift extension (GRAM, Inc. and William Lettis & Associates, Inc., 1995). In the area, faults of this system apparently juxtapose Precambrian granitic rocks and Precambrian greenstone in some places and Precambrian granitic rocks and Pennsylvanian limestone in other places. Investigations have suggested that these faults have the potential to be substantial barriers to the westward flow of ground water, but also may be conduits for flow in some areas (GRAM, Inc. and William Lettis & Associates, Inc., 1995). Potential sources of recharge to this zone include mountain-front recharge processes along the Manzanita Mountains and inflow of deep ground water across the eastern basin margin. Additional ground-water samples from this area, along with more detailed discussion of individual wells and their chemical compositions, can be found in Rust Geotech (1995).

Ground water of the Tijeras Fault Zone zone typically has a relatively high specific conductance (table 8). Compared to other zones, pH values and SiO_2 concentrations are relatively low, whereas alkalinity values and concentrations of Ca, Mg, Cl, F, Br, B, Li and U are relatively high. Mixed-cation / CO_3 + HCO_3 is the most common water type (fig. 79). The median deuterium content and carbon-14 activity are –74.2 per mil and 9.7 pmC, respectively. The Mann-Whitney test indicates that ground water of the Tijeras Fault Zone zone and the adjacent Eastern Mountain Front zone differs in the median values of 22 water-quality parameters, including all 10 major constituents, specific conductance, pH, carbon-13 content, and carbon-14 activity (table 9).

Most of the 6 ground-water samples from the zone do not plot close to the precipitation evaporation trend for Cl and SO_4 concentrations (fig. 89). Instead, most samples show a greater proportion of Cl than would be expected from precipitation. Elevated Cl could indicate that these samples include at least a fraction of high-Cl water from deep fracture systems along the Tijeras Fault Zone, which would be consistent with a generally lower carbon-14 activity than ground water in the Eastern Mountain Front zone. The

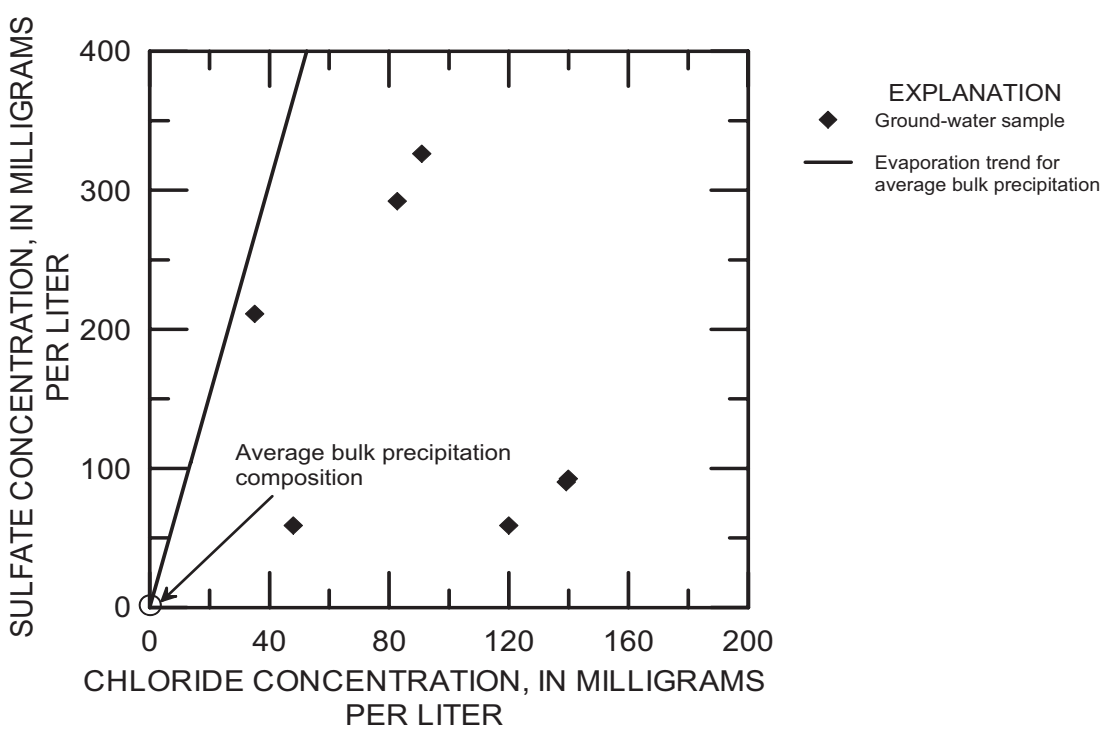


Figure 89. Relation of sulfate to chloride concentrations in ground water of the Tijeras Fault Zone zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

fraction of shallow mountain-front recharge water present in the samples in relation to high-Cl is unknown. However, the fraction of dilute mountain-front recharge probably increases downgradient so that the signature of the Tijeras Fault Zone zone water eventually becomes indistinguishable from that of the Eastern Mountain Front zone.

Tijeras Arroyo Zone

The Tijeras Arroyo zone encompasses a small area stretching along Tijeras Arroyo from where it leaves the mountain front to about 6 miles within the MRGB (fig. 78). Potential sources of recharge to the zone are the infiltration of surface water through the arroyo and ground-water inflow from the Tijeras Arroyo watershed upstream of the basin. Mountain-front recharge processes also are likely to contribute a portion of the water recharging this zone.

Ground water of the Tijeras Arroyo zone typically has a moderate specific conductance (table 8). Compared to other zones, pH values and concentrations of Na, K, SiO_2, As, B, Li, Mo, and V are relatively low, whereas alkalinity values and concentrations of dissolved oxygen and NO_3 are relatively high. Water types are Ca / CO_3 + HCO_3 and Ca / mixed-anion (fig. 79). The median deuterium content and carbon-14 activity are –75.7 per mil and 72.8 pmC, respectively. The Mann-Whitney test indicates that ground water of the Tijeras Arroyo and the adjacent Eastern Mountain Front zone differs in the median values of 16 water-quality parameters, including 8 major constituents (table 9). The test also indicates that ground water of the Tijeras Arroyo and nearby Tijeras Fault Zone zone differs in the median values of 15 parameters, including 6 major constituents and carbon-14 activity.

Compositions of ground-water samples from the zone were plotted against evaporation trends for precipitation and Tijeras Arroyo (fig. 90). The composition used for Tijeras Arroyo is the discharge-weighted average calculated from NWIS data (table 4). The plot of SO_4 and Cl concentrations indicates that most ground-water samples fall into one of two main groups. Group A is located close to the evaporation trend for precipitation and contains low concentrations of Cl relative to average Tijeras Arroyo water, which

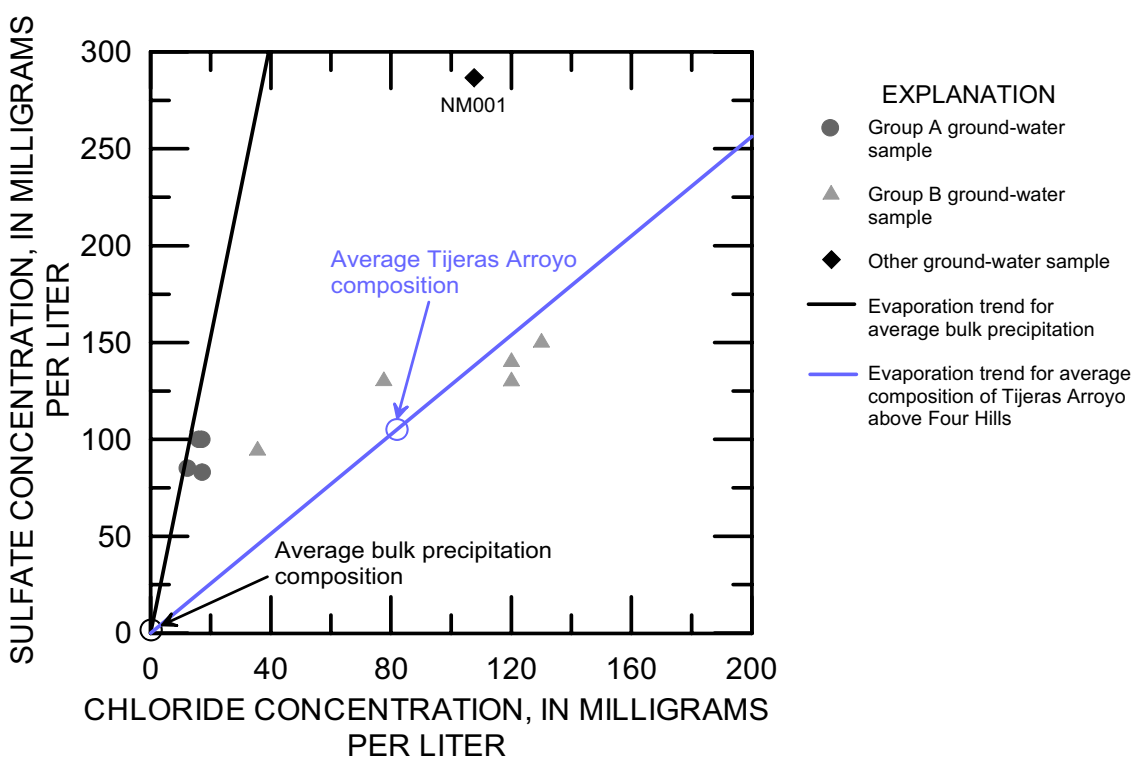


Figure 90. Relation of sulfate to chloride concentrations in ground water of the Tijeras Arroyo zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

would be consistent with a dominant fraction of mountain-front recharge water (fig. 90). Group B is located near the evaporation trend for Tijeras Arroyo and contains Cl concentrations similar to or slightly higher than that of average arroyo water, which would be consistent with a dominant fraction of arroyo recharge (fig. 90). Group B samples also tend to have higher carbon-14 activities. The sampling sites of Group B generally are located closer to the mouth of Tijeras Arroyo (fig. 91), where flow is perennial, and would be likely to receive a higher fraction of young water from arroyo infiltration than Group A waters would receive. One sample (NM001) does not appear to belong to either group. Because the well (S001) is located near the mouth of Tijeras Arroyo, the sample composition would be expected to fall among those of Group B, but the SO_4 concentration relative to Cl is unusually high. The source of the excess SO_4 in this sample is not known. However, it is possible that ground water from the Tijeras Arroyo watershed flows into the MRGB in this area and contains slightly elevated SO_4 relative to the arroyo. Alternatively, this sample may represent substantial evapotranspiration of a mixture of arroyo water and runoff from a precipitation event. As the locations of Group A and Group B sample sites indicates, ground water of the Tijeras Arroyo zone probably mixes with a greater quantity of water from the Eastern Mountain Front and/or Central zone downgradient, until the signature of Tijeras Arroyo zone water is no longer distinguishable.

Northeastern Zone

The Northeastern zone stretches from just north and east of Galisteo Creek to just south and west of Arroyo Tonque, and from the basin boundary to the Rio Grande (fig. 78). Potential sources of recharge to the zone include ground-water inflow from adjacent areas, including the Hagan Embayment, the infiltration of surface water through arroyo channels, and possibly mountain-front recharge processes, particularly in the southern part of the zone. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande.

Ground water of the Northeastern zone typically has a relatively high specific conductance (table 8). Compared to other zones, concentrations of F, Ba, and Li are relatively low, whereas alkalinity values and concentrations of Ca, SO_4, SiO_2, Sr, and U are relatively high. The dominant water types are Ca / SO_4 and mixed-cation / SO_4 (fig. 79). The median deuterium content and carbon-14 activity are –68.6 per mil and 28.5 pmC, respectively. The Mann-Whitney test indicates that ground water of the Northeastern and the adjacent Eastern Mountain Front zone differs in the median values of 20 water-quality parameters, including 8 major constituents, specific conductance, and deuterium and carbon-13 contents (table 9). The test also indicates that ground water of the Northeast and the adjacent Northern Mountain Front zone differs in the median values of 16 parameters, including 7 major constituents, specific conductance, and deuterium and carbon-13 contents.

Compositions of ground-water samples from the zone were plotted against evaporation trends for precipitation and Galisteo Creek above Galisteo Reservoir (fig. 92). On the graph of SO_4 and Cl concentrations, several ground-water samples plot fairly close to the precipitation evaporation trend (labeled Group A in figure 92), but several others have a higher proportion of SO_4 than would be expected from precipitation (labeled Group B). Group B samples tend to plot between the evaporation trends for precipitation and Galisteo Creek, indicating possible mixing between mountain-front recharge water and surface-water infiltration from local arroyos. One sample (S016; NM258) has a higher proportion of Cl than would be expected from precipitation. This sample is located near an intersection of major faults (figs. 93 and 6) and may be receiving a contribution of high-Cl water upwelling along these faults.

Most samples that plot closest to the precipitation evaporation trend for SO_4 and Cl are located in the southern or southeastern parts of the zone, closest to the Sandia mountain front and the Hagan Embayment (fig. 93). These samples may represent ground water that was recharged primarily by mountain-front processes, with SO_4 and Cl concentrations that have not been highly altered by rock-water interactions. Sample DB421 may also include some water recharged through the Rio Grande. Compared to the Cl in precipitation, these samples appear to have been concentrated about 50- to 260-fold during recharge. The deuterium contents that are available for these samples are only moderately depleted, indicating that the precipitation that resulted in recharge did not occur at particularly high altitude.

The Group B samples that contain excess SO_4 relative to Cl are spread across the rest of the

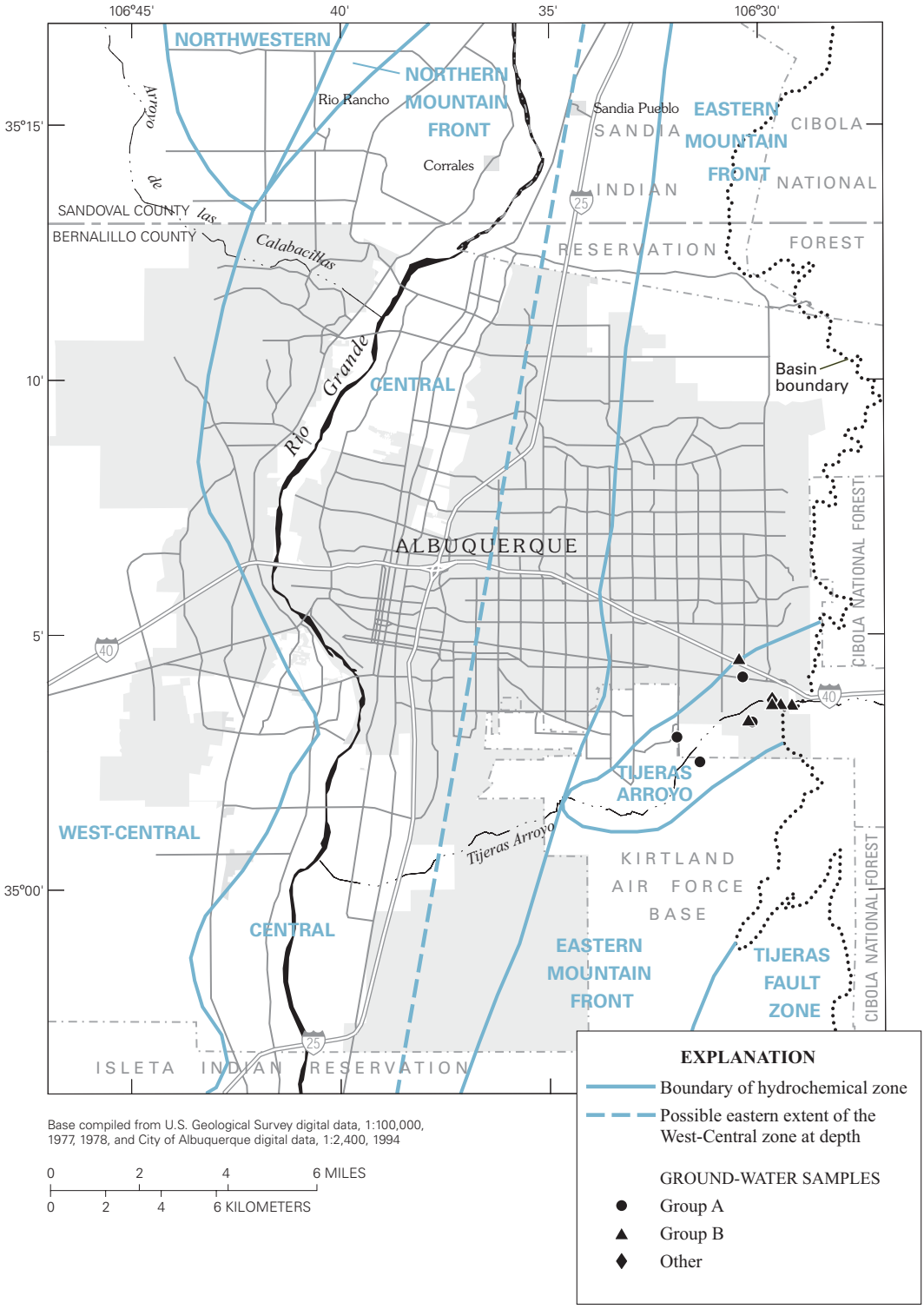


Figure 91. Ground-water samples of the Tijeras Arroyo zone, Middle Rio Grande Basin, New Mexico. See figure 90 for definition of Groups A, B, and Other.

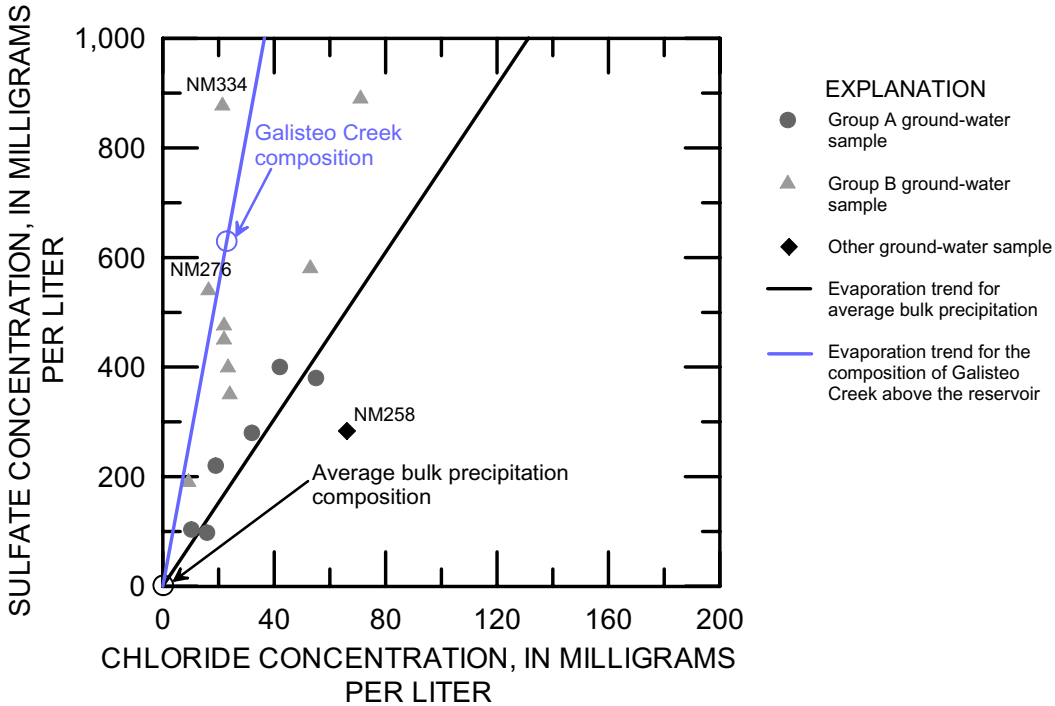


Figure 92. Relation of sulfate to chloride concentrations in ground water of the Northeastern zone, Middle Rio Grande Basin, New Mexico and area precipitation and surface water.

ground-water zone (fig. 93). The highest ratio of SO_4 to Cl occurs in NM334, which was obtained from a well (S207) located next to Arroyo Tonque. Sample NM276 from a well (S053) located just south of Galisteo Creek also has a relatively high ratio of SO_4 to Cl that is consistent with surface water in the creek. Both of these arroyos drain areas that include Mesozoic rocks containing gypsum. Also, both NM334 and NM276 have relatively high carbon-14 activities, indicating that surface water infiltrating through the arroyos of the area probably is the source contributing high concentrations of SO_4 to the ground water. Subsurface inflow of ground water that has had contact with gypsum outside the basin also could be occurring along parts of the eastern basin boundary and contributing some high-SO_4 recharge to the area. The presence of springs along the eastern basin margin indicates that ground-water inflow probably occurs there.

Central Zone

The Central zone stretches along the Rio Grande from San Felipe Pueblo (fig. 1) in the north to just north of Abo Arroyo in the south (fig. 78). The zone varies in width from about one to nearly ten miles and generally extends farther away from the river on the east side of the Rio Grande than on the west side. Location alone implies that the Rio Grande is the most likely source of recharge to the zone. The Rio Grande source is strongly supported by the stable isotope data, and geochemical modeling with NETPATH (see the section “Geochemical Mass Transfer Models”). Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges back to the Rio Grande.

Ground water of the Central zone typically has a relatively low specific conductance (table 8). Compared to other zones, concentrations of dissolved oxygen, Na, SO_4, F, Br, NO_3, B, Li, and Sr are relatively low, whereas concentrations of K, SiO_2, As, Ba, and V are relatively high. The dominant water types are Ca / CO_3 + HCO_3 and mixed-cation / CO_3 + HCO_3 (fig. 79). The median deuterium content and carbon-14 activity are –95.4 per mil and 61.0 pmC, respectively. The Mann-Whitney test indicates that ground water of the Central and the adjacent Eastern Mountain Front zone differs in the median values of 22 water-quality parameters, including 7 major constituents, specific conductance, and deuterium content (table 9). The test indicates that ground water of the

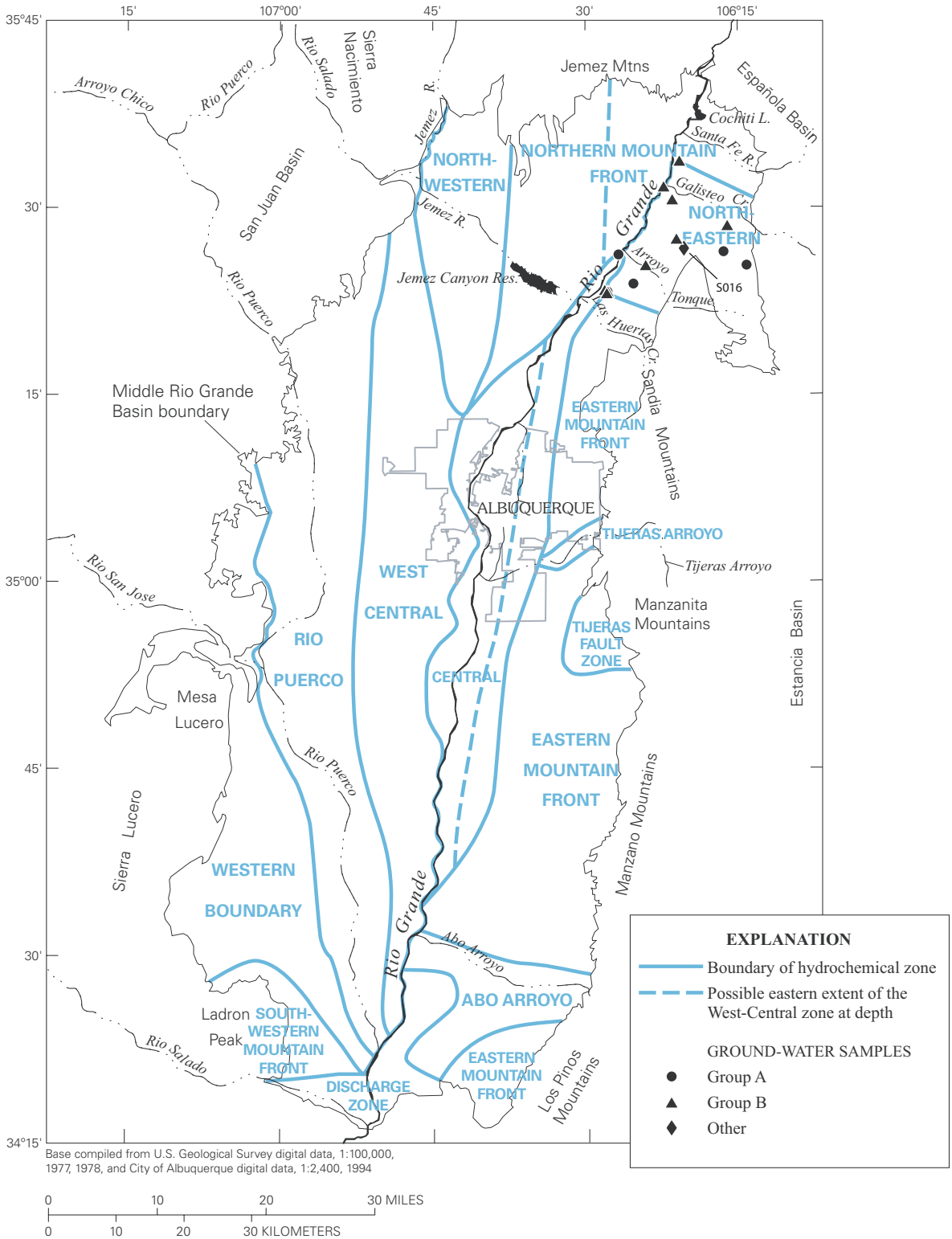


Figure 93. Ground-water samples of the Northeastern zone, Middle Rio Grande Basin, New Mexico. See figure 92 for definition of Groups A, B, and Other.

Central zone also differs in the median values of 15 water-quality parameters (including 5 major constituents, specific conductance, and deuterium content) with respect to the Northern Mountain Front zone, and 23 parameters (including 9 major constituents, specific conductance, carbon-13 content, and carbon-14 activity) with respect to the West-Central zone, which are the two other major zones adjacent to the Central zone.

Chemical compositions of ground water from the Central zone were plotted against evaporation trends for precipitation and for the Rio Grande (fig. 94). Discharge-weighted average concentrations from NWIS data were used for the Rio Grande at San Felipe and the Rio Grande at Albuquerque (fig. 17, table 4). Data from the two river sites generally are similar and should provide a reasonable range of potential recharge chemistry for recent river infiltration. The composition of river water may have changed somewhat over the period of time during which the sampled ground water recharged (see the section "Interpretation of Environmental and Climatic Information from Radiocarbon Ages, Stable Isotopes and Dissolved Gases"). Because it is not known how the composition might have changed, the composition of current river water is the most reasonable approximation of the chemistry of past recharge. Furthermore, there are no obvious trends in major-element chemistry of Central-zone waters with radiocarbon age.

The plot of SO_4 and Cl concentrations shows that most ground-water samples for the zone fall fairly close to the evaporation trends for both precipitation and the two Rio Grande sites (fig. 94, group B). The evaporation trend for precipitation is actually bracketed by the trends for the two river sites, indicating that the major-element composition of the river is closely related to that of area precipitation and making it difficult to distinguish the primary recharge source from major elements alone. However, the depleted ^2H content of ground water in the region, relative to that of Eastern Mountain Front water, indicates that infiltration through the Rio Grande, and not local precipitation, is the primary source of recharge. The conclusion that ground water of the area is derived from infiltration through the river, and not from the recharge of precipitation along the eastern mountain front, is also supported by the relatively high carbon-14 activity of much of the ground water, particularly at shallow depths and near the river. Although several ground-water samples have lower concentrations of Cl

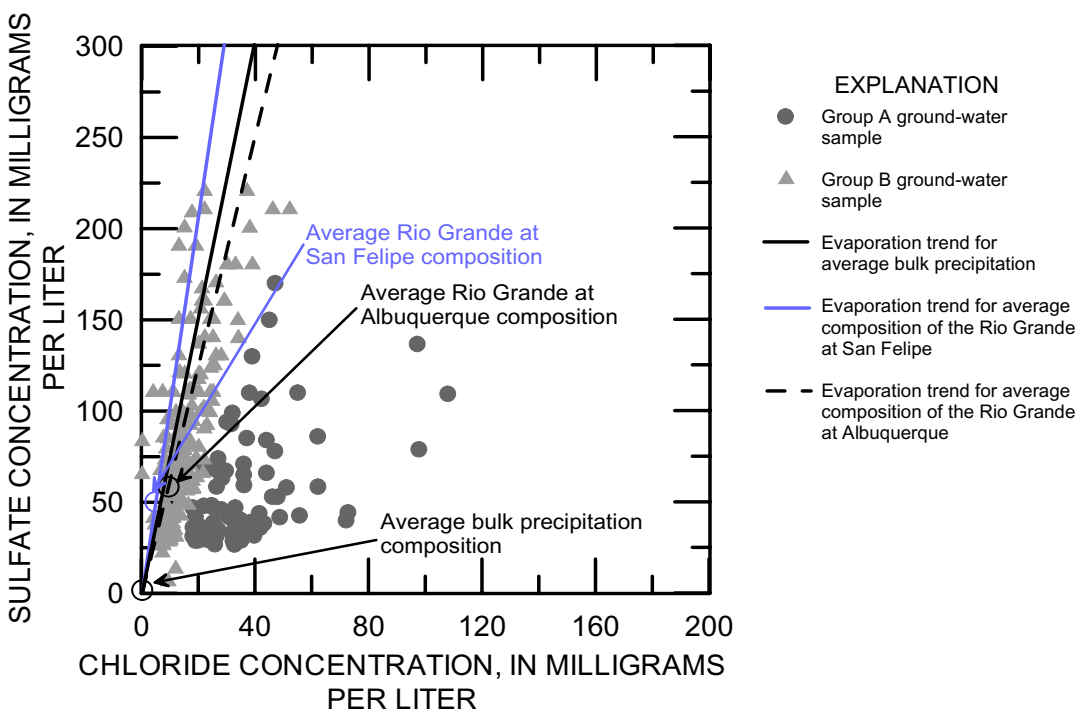


Figure 94. Relation of sulfate to chloride concentrations in ground water of the Central zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

and SO_4 than average Rio Grande water at either site, their concentrations almost all fall within the overall range of concentrations observed in individual samples of river water contained in the NWIS database and, therefore, do not eliminate the river as the likely recharge source. The Cl concentrations in most ground water of the zone indicate that typical Rio Grande water is concentrated less than 8-fold during recharge.

Although most ground-water samples in the zone fall near the river evaporations trends for SO_4 and Cl, many others show excess Cl (Group A). These wells are located primarily in areas previously identified by Bexfield and Anderholm (2002a) and Bexfield and Plummer (2002) as having unusual chemical compositions, probably because of mixing with upwelling mineralized water from deeper parts of the aquifer system. These areas include the eastern margin of the zone through Albuquerque and an area just north and west of Kirtland Air Force Base (fig. 95). Only a low fraction of high-Cl water would be required to account for most of the Cl concentrations observed. As discussed for high-Cl wells in the Eastern Mountain Front zone, no other likely sources of additional Cl to the area are known. High-Cl water could be moving upward along faults or as the result of structural highs located both at the north end of Albuquerque and near the southern edge of Kirtland Air Force Base (fig. 5). Bexfield and Plummer (2002) indicate that mixing with high-Cl water or with ground water from the West-Central zone are the primary sources of locally elevated concentrations of As, and possibly other minor elements, in ground water of the Central zone.

Discharge Zone

The Discharge zone is located at the southern tip of the MRGB and extends for several miles both east and west of the Rio Grande (fig. 78). Ground-water flow from the MRGB to the Socorro Basin to the south is restricted to a relatively small cross-sectional area at the "San Acacia constriction", where the eastern and western structural boundaries of the basin converge (Thorn and others, 1993). Possible sources of water to the Discharge zone include several of the upgradient hydrochemical zones, including the Southwestern, Western Boundary, Rio Puerco, Central, Eastern Mountain Front, and Abo Arroyo zones. Ground water of the Discharge zone probably discharges to the Rio Grande or to the Socorro Basin to the south.

Ground water of the Discharge zone typically has a relatively high specific conductance (table 8). Compared to other zones, concentrations of dissolved oxygen and NO_3 are relatively low, whereas concentrations of Na, K, Cl, F, Br, SiO_2, As, B, Li, Mo, and Sr are relatively high. Water types vary, but anions tend to be mixed or dominated by Cl (fig. 79). The median deuterium content and carbon-14 activity are -90.8 per mil and 10.8 pmC, respectively. The Mann-Whitney test was not used to compare median values of water-quality parameters with those in other zones because the Discharge zone contains only 7 samples. However, median values for several parameters, including some major constituents, appear to differ substantially from those of surrounding zones (table 8).

A plot of SO_4 and Cl concentrations for ground-water samples from the Discharge zone shows that all samples have substantially more Cl relative to SO_4 than would be expected from precipitation (fig. 96). Some samples have even higher Cl to SO_4 ratios than most samples from the adjacent Western Boundary zone. Therefore, ground water of the zone appears highly altered by rock-water interactions occurring over a long time period (tens of thousands of years), as supported by generally low carbon-14 activities. Although ground-water compositions suggest that the Western Boundary zone may be the primary contributor of water to the Discharge zone, other factors indicate otherwise. The observations that many samples from the Discharge zone have lower specific conductance than those of the Western Boundary zone and that many are located substantially far north and east of the terminus of the Western Boundary zone suggest that the high-Cl chemical signatures usually are the result of another source. However, none of the other adjacent hydrochemical zones show high-Cl signatures, except in certain cases where mixing with deep, mineralized water is suspected. Therefore, ground water of the Discharge zone could be a mixture of fractions of water from the adjacent hydrochemical zones with fractions of high-Cl water moving upward from deeper parts of the aquifer system. Close to the south end of the MRGB, upward movement of deeper water to allow discharge through the constriction to the Socorro Basin would be expected. Phillips and others (2003) showed that the chloride concentration of water in the Rio Grande increased at the southern end of the MRGB corresponding to inflow of saline ground-water discharge from the basin.

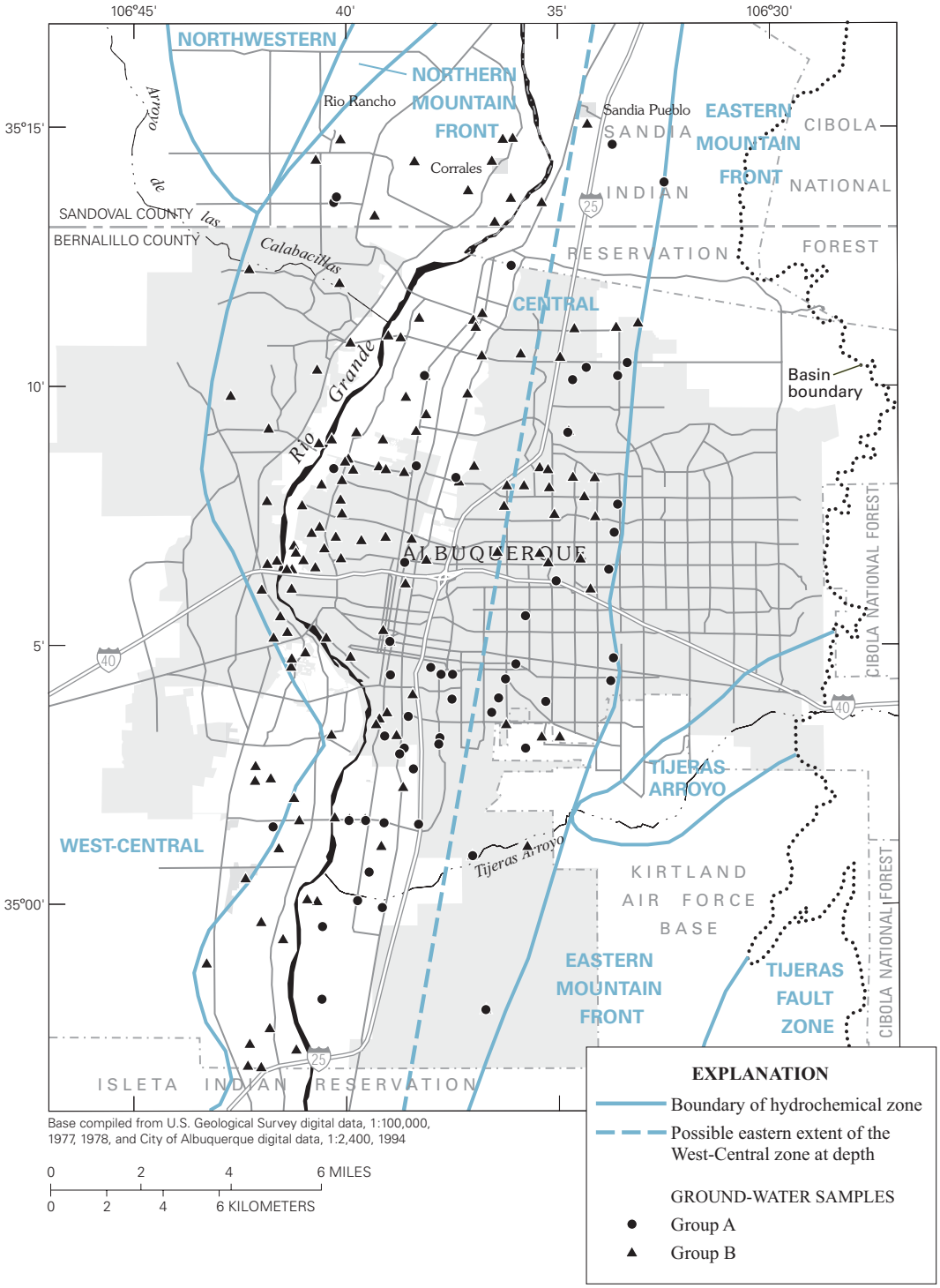


Figure 95. Ground-water samples of the Central zone, Middle Rio Grande Basin, New Mexico. See figure 94 for definition of Groups A and B.

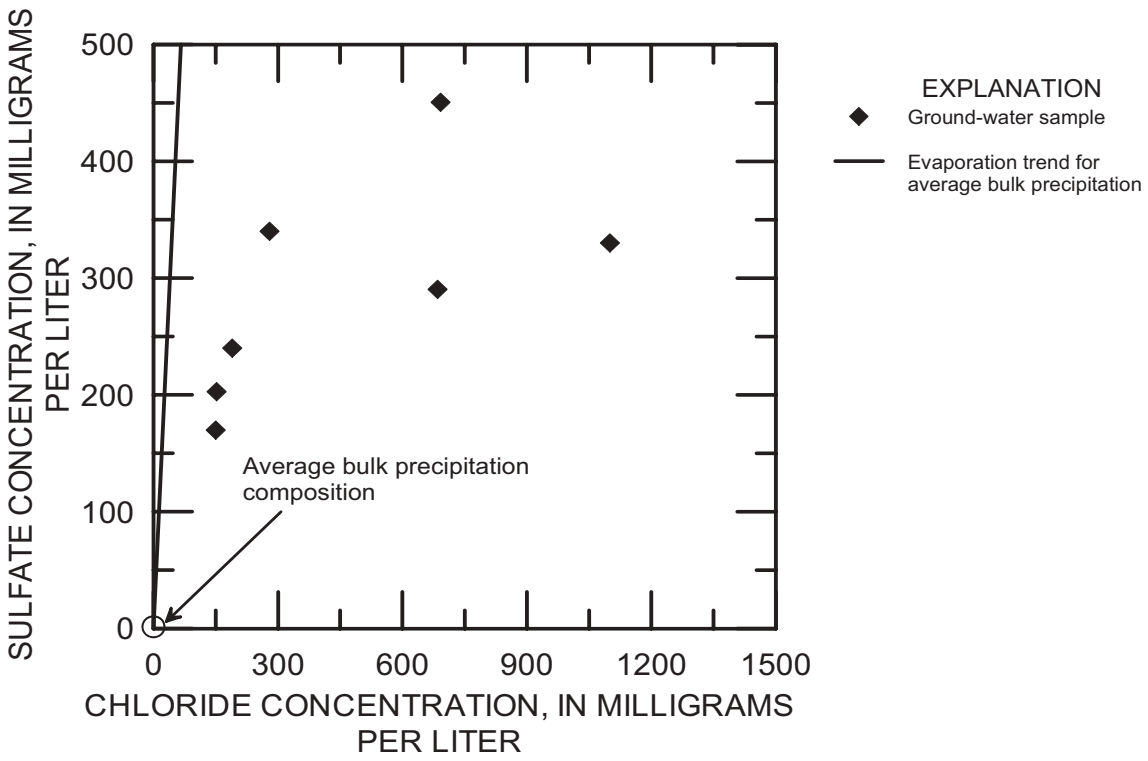


Figure 96. Relation of sulfate to chloride concentrations in ground water of the Discharge zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

INTERPRETATION OF RADIOCARBON AGE OF DISSOLVED INORGANIC CARBON IN GROUND WATER

Radiocarbon dating of DIC in ground water is based on the radioactive decay of ^{14}C (half-life 5,730 years). ^{14}C is of cosmogenic origin, being produced in the upper atmosphere by the interaction of cosmic rays with atmospheric ^{14}N. The cosmogenic ^{14}C is rapidly oxidized to $^{14}CO_2$ and mixes into the lower atmophere, where it is absorbed by plants during photosynthesis and becomes incorporated into the biologic and hydrologic cycles. Past variations in the solar wind and the geomagnetic fields of the Sun and Earth have caused variations in the flux of cosmic rays reaching the Earth, resulting in variations in the atmospheric concentration of $^{14}CO_2$ (Kalin, 1999). The modern, pre-nuclear detonation atmospheric activity of ^{14}C is, by convention, 100 pmC, corresponding to 13.56 disintegrations per minute per gram of carbon in the year A.D. 1950 (Stuiver and Pollach, 1977).

^{14}C is added to ground water during recharge by interaction of infiltrating water with soil CO_2 from plant root respiration and microbial degradation of soil organic matter (see for example, Kalin, 1999). Following recharge, the DIC becomes isolated from the modern ^{14}C plant-soil gas-air reservoir and decays with time. There are many physical and chemical processes that can affect the ^{14}C activity of DIC in ground water beyond that of radioactive decay in the aquifer system that must be considered in order to interpret radioarbon ages and their uncertainties. The most important considerations in radiocarbon dating of the MRGB samples can be grouped under four general topics:

(1) determination of the initial ^{14}C activity, A_o, of DIC in ground-water recharge, at the point where the infiltrating water is isolated from the modern unsaturated zone ^{14}C reservoir,

(2) determination of the extent of geochemical reactions within the aquifer system following recharge and their effect on the initial ^{14}C activity,

(3) evaluation of the extent to which old water is mixed with young water in samples pumped from wells, and

(4) correction for historical variations in the atmospheric ^{14}C activity, through application of the radiocarbon calibration scale.

These four topics are discussed below.

Initial Carbon-14 Activity in Recharge Water, A_o

In the unsaturated zone, the CO_2 partial pressure typically is substantially higher than atmospheric (about $10^{-3.5}$) as a result of biological activity. As infiltrating water moves through the unsaturated zone, it tends to equilibrate with the gas in the unsaturated zone. During infiltration, CO_2 in the infiltrating water is augmented by soil-zone CO_2. The dissolved CO_2 reacts with carbonate and silicate minerals in the recharge area, resulting in increased concentrations of dissolved inorganic carbon (DIC) in the infiltrating water.

The term A_o refers to the initial ^{14}C activity of DIC in ground water that occurs following recharge and isolation of the water from the modern ^{14}C reservoir of unsaturated-zone CO_2. A_o must be known or estimated in order to date the ^{14}C of DIC in ground water in hydrologic systems. Many of the waters in recharge areas of the MRGB contain tritium and/or CFCs, which is an indication of the presence of post-1950's water. Water from the post-1950's bomb era has ^{14}C activities that are greater than the values that were present historically in the recharge areas, and, if these observed values from recharge areas are used in dating, radiocarbon ages will be biased old.

Several models have been proposed that can be used to estimate A_o values in recharge waters (see for example, Mook, 1972; Wigley and others, 1978; Fontes and Garnier, 1979; Mook, 1980; Fontes, 1990; Plummer and others, 1994; Kalin, 1999). Use of these models requires information about the ^{13}C and ^{14}C isotopic composition of unsaturated-zone CO_2 and carbonate minerals in the recharge area, and the extent to which carbonate minerals react with the infiltrating water. If the pre-1950's recharge water formed in isotopic equilibrium with unsaturated-zone CO_2, while reacting with carbonate minerals (for example, calcite, such as occurs in caliche) in the unsaturated zone to chemical and isotopic equilibrium, A_o would be expected to be near 102 pmC, assuming that the ^{14}C activity of the unsaturated-zone CO_2 was 100 pmC, and the equilibrium fractionation factor for ^{14}C between CO_2 gas and HCO_3^- is twice the ^{13}C equilibrium fractionation factor. In the other extreme, if infiltrating water equilibrates with unsaturated-zone CO_2 in the absence of carbonate minerals, and reacts with old, ^{14}C-free calcite in the saturated zone in isolation from the unsaturated zone ^{14}C reservoir, A_o will be

near 50 pmC. The first scenario, leading to A_o of 102 pmC, is referred to as "open-system" evolution, and the second scenario, leading to A_o of 50 pmC, represents "closed-system" evolution. There are an unlimited number of intermediate possibilities between the open- and closed-system evolution models, depending on the ^{14}C activity of the unsaturated zone carbonate material and the extent to which chemical and isotopic equilibrium are approached during infiltration in the unsaturated zone and in the saturated zone. Unfortunately, there is insufficient chemical and isotopic data to permit accurate modeling of A_o in the MRGB.

In this study, ^{14}C, ^{3}H, and CFC data from ground water were used to estimate values of A_o for the waters from the MRGB. ^{14}C activities of DIC as a function of CFC-12 and ^{3}H activity for all waters from the Northern Mountain Front, Northwestern, West-Central, Eastern Mountain Front, and Central hydrochemical zones, respectively, are compared in figure 97. Water in the Northern Mountain Front, Northwestern, and Eastern Mountain Front zones was probably recharged along mountain fronts that border the basin to the north and east, and water from the West-Central zone may have recharged in high-altitude areas north of the basin. Water from the Central zone originated as seepage from the Rio Grande. Many of the ground-water samples have low ^{14}C activities and are likely 10's of thousands of years old, especially those of the West-Central zone (fig. 97). A_o can be inferred, however, as the maximum ^{14}C activity in samples with the lowest CFC-12 and/or lowest ^{3}H content, as these samples were likely the youngest samples that recharged prior to the bomb era (pre-1952). The maximum ^{14}C activity in ground water low in CFC-12 (<20 pg/kg) and low in ^{3}H (<0.5 TU) is near 100 pmC, and probably within the range of 95 to 102 pmC (fig. 97), consistent with predominantly open-system evolution. During the past approximately 20 years, the ^{14}C activity of atmospheric CO_2 has averaged 120 ± 10 pmC in the northern hemisphere (fig. 98). Most of the observed ^{14}C activities in samples that contain ^{3}H or CFCs are in the range of 95 to 120 pmC, and again consistent with the assumption of open-system evolution (fig. 97). As no samples with ^{14}C activities higher than 123 pmC were observed, it is assumed that waters recharged during the mid-1960's and early 1970's (fig. 98) were not sampled in recharge areas, or were mixed and diluted with older water because of well construction when sampled. The ^{14}C activity of DIC in two samples of water from the Rio Grande at San Felipe (S304) and Alameda (S300), north of Albuquerque, from June 29, 1996, were 96.1 and 97.1 pmC, respectively. Three other samples from the Rio Grande collected on March 30, 1998 at Albuquerque (sites S300, S301, and S303, table B6) had ^{14}C activities of 88.2, 88.9, and 82.9 pmC, respectively. The slightly lower ^{14}C activity at S303 (Rio Grande at Rio Bravo) is from an area of discharge from the Albuquerque sewage treatment plant and coincides with an increase in chloride in Rio Grande water that has been attributed to discharge of water from the sewage treatment plant (Phillips and others, 2003). The ^{14}C activity of DIC in the source water from the City of Albuquerque production system is typically in the 50-70 pmC range which could account for the somewhat lower ^{14}C activity at Rio Bravo. The relatively high ^{14}C activity of DIC in the Rio Grande from June 29, 1996 corresponds to a high flow of the river.

In summary, the distribution of ^{14}C activities (fig. 97) in both mountain front areas and in recent seepage from the Rio Grande suggests that A_o is likely in the range of 95 to 102 pmC. Throughout this report, a value of A_o equal to 100 pmC is assumed for all waters from the MRGB. The unadjusted radiocarbon ages of this report would be decreased by 400 years if calculated using a value of A_o of 95 pmC instead of 100 pmC, and increased by 150 years if calculated using an A_o value of 102 pmC instead of 100 pmC.

Geochemical Adjustments to the Radiocarbon Data

Mountain-front recharge (infiltration of precipitation, intermittent stream flow, and subsurface movement of ground water from mountainous areas) is believed to be the primary source of ground water to the Northern Mountain Front, Northwestern, West-Central, Eastern Mountain Front, Southwestern Mountain Front, Abo Arroyo, Tijeras Fault Zone, and Tijeras Arroyo zones. Similar recharge processes likely contribute some water to the aquifer system in the Western Boundary and Northeastern zones, as well. Source rocks in the Jemez Mountain region consist primarily of Cenozoic mafic to silicic volcanic rocks, whereas those in the mountains along the eastern basin margin consist primarily of Precambrian plutonic and metamorphic rocks with some Paleozoic limestone and sandstone (Hawley and Haase, 1992). In the area of Ladron Peak in the southwest, the source rocks consist

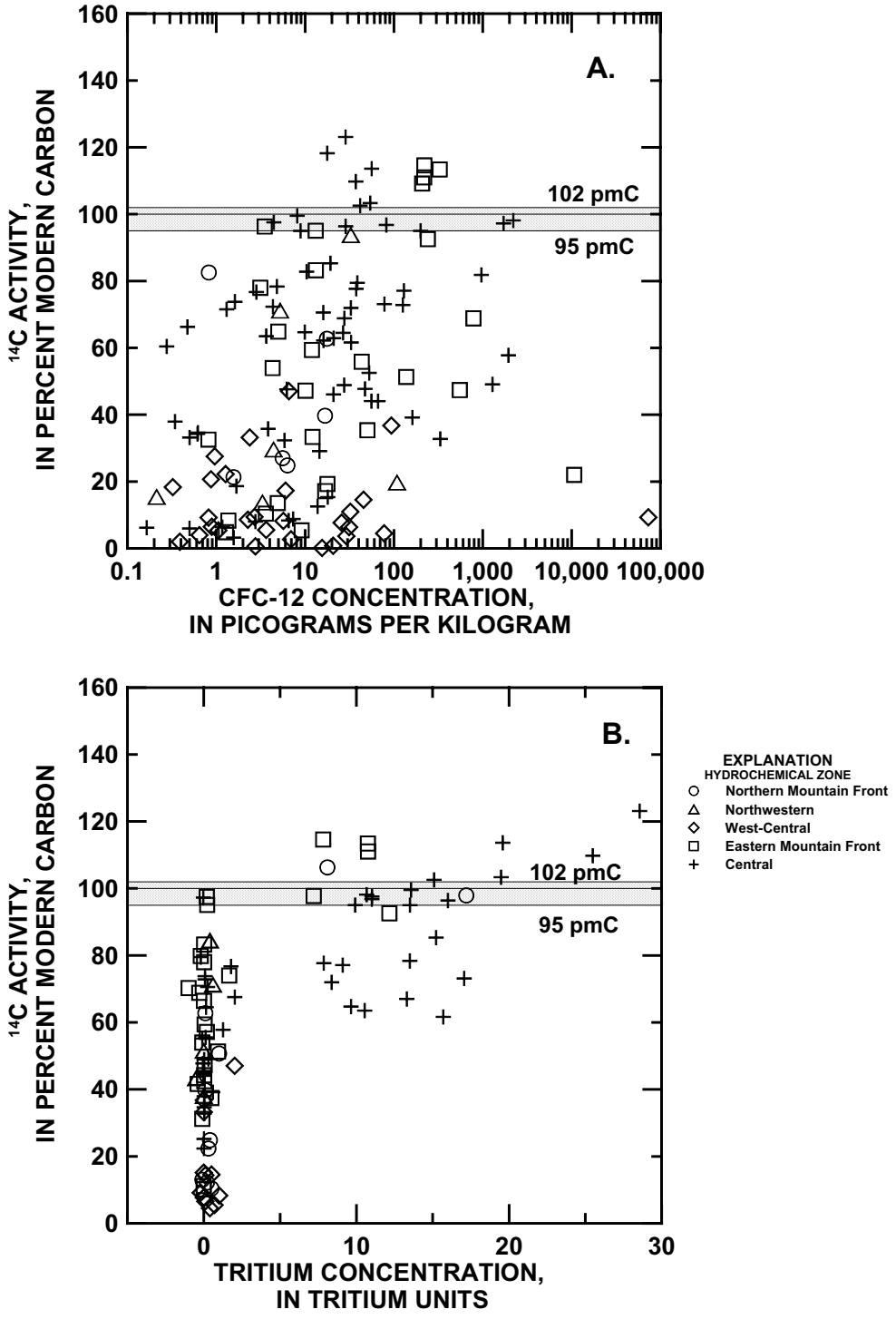


Figure 97. ^{14}C activity in ground water as a function of (A) CFC-12 concentration and (B) tritium concentration, Middle Rio Grande Basin, New Mexico.

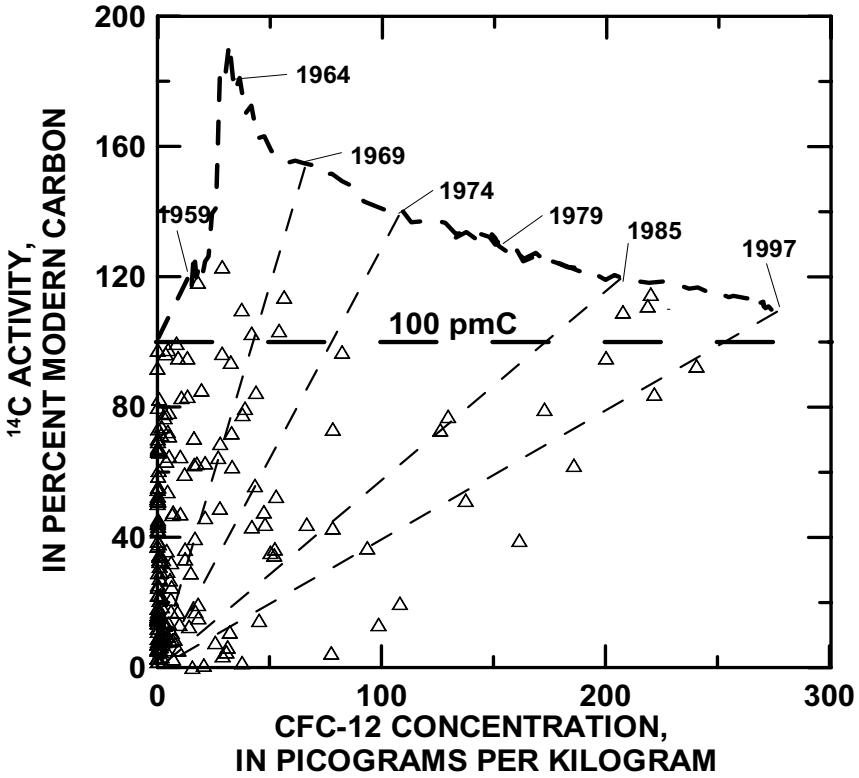


Figure 98. ^{14}C activities and CFC-12 concentrations measured in ground water from the Middle Rio Grande Basin, New Mexico, in relation to concentrations expected for water in equilibrium with atmospheric values, 1957-97. The dashed lines represent hypothetical mixing of old water with water from 1969, 1974, 1985, and 1997.

primarily of Precambrian granitic and metamorphic rocks and some Paleozoic rocks. In these recharge areas, the expected major processes are evapotranspiration, dissolution of carbonate minerals, and weathering of silicates.

The amount of evapotranspiration resulting as water infiltrates through the soil zone can be estimated by comparing the Cl concentration of ground water in mountain front areas to the Cl concentration assumed for regional bulk precipitation. This method of estimation assumes no other important sources (or sinks) of Cl, which should be a reasonable assumption for most of the mountain front areas of the MRGB, where the source rocks are primarily silicates with essentially no evaporites. Most MRGB and NWIS ground-water samples along the Jemez mountain front tend to have Cl concentrations between about 2.5 and 7.5 mg/L (table 4), as compared to the average concentration of 0.21 mg/L calculated for local bulk precipitation from LTER data collected at Sevilleta National Wildlife Refuge. These values indicate that precipitation was concentrated about 12- to 36-fold during recharge. Along the eastern mountain front, ground-water samples generally have Cl concentrations between about 3.5 and 12.5 mg/L, indicating that precipitation was concentrated about 17- to 60-fold during recharge. The higher Cl concentrations tend to occur from about Abo Arroyo south. Along Ladron Peak, ground-water samples have Cl concentrations of 6.9 and 23 mg/L, indicating concentration by evapotranspiration of about 33- to 110-fold. It is not known whether higher Cl concentrations in the southern part of the basin are the result solely of greater rates of evapotranspiration or are also associated with greater amounts of Paleozoic sedimentary rocks in the recharge areas, which might yield more Cl to recharge water.

Because sediments of the Santa Fe Group aquifer system are derived largely from the surrounding uplands, the mineralogy and chemical processes encountered by water recharging through the streambeds of rivers and arroyos on the basin floor are expected to be similar to those encountered by water recharging near the mountain front. However, the

solute concentrations in this water are substantially higher than that of precipitation, and may not encounter unsaturated conditions upon infiltration. Therefore, evaporation during recharge through streambeds may be negligible relative to that occurring in mountain-front areas, and mass transfers associated with water-sediment reactions may be low.

Redox reactions associated with the oxidation of buried organic matter may be important in ground water near rivers, such as in parts of the Central and Rio Puerco zones. Hydrochemical zones that appear to receive substantial recharge through the infiltration of river or arroyo water are the Rio Puerco, Abo Arroyo, Tijeras Arroyo, Northeastern, and Central zones. Surface water in these areas appears to usually be near or at saturation with respect to several silicate and carbonate minerals prior to infiltration. Therefore, the dissolution of large amounts of these minerals upon infiltration is unlikely.

Ground water that flows from adjacent basins into the aquifer system of the MRGB generally has been in extended contact with minerals similar to those present within the MRGB. Thus, little water-rock reaction is likely to take place during inflow into the basin, and mass transfers are likely to be low. The most substantial chemical changes are expected if and when ground-water inflow mixes with local recharge.

If geochemical reactions occur that affect the dissolved inorganic carbon, these reactions usually result in a lowering of the ^{14}C activity of DIC, independent of the radioactive decay of ^{14}C. Applied to the initial ^{14}C activity, the carbonate reactions will lower the adjusted value of A_o (termed A_{nd}, where "nd" refers to no decay), resulting in adjusted radiocarbon ages that are younger than the unadjusted radiocarbon age. It is, therefore, important to recognize and quantify the effects of any geochemical reactions occurring in the MRGB that can affect the ^{14}C activity of DIC.

Possible reactions that can affect the DIC in the MRGB include dissolution of carbonate minerals (primary and secondary calcite, and calcite in caliche), calcite precipitation, carbon isotopic exchange with calcite, and oxidation of organic matter. Cation exchange reactions, in which Ca^{2+} is taken up on clay surfaces in exchange for Na^{+}, will lower the calcite saturation state and permit additional dissolution of calcite, if calcite is present locally in the aquifer mineralogy. Anderholm (1985) showed that calcium smectite and mixed-layer, illite-smectite clays, both of which have high ion exchange capacities, are present in the Santa Fe Group aquifer system. Cation exchange may be an important process affecting waters in the West-Central zone, where there are high Na and HCO_3 concentrations, low Ca concentrations (in some cases, less than 3 mg/L), and high pH values (exceeding 8.5). Because saturation indices for calcite remain near 0 and the Na/Ca mole ratio generally exceeds 2:1 for ground water throughout the West-Central zone, the continual dissolution of calcite appears to be the most likely source of additional Ca to replace that lost during cation exchange. This process of cation exchange accompanied by additional calcite dissolution probably also occurs to some extent in ground water of other zones, including the Northern Mountain Front, Northwestern, Eastern Mountain Front, and Central zones. The dissolution of calcite accompanying ion exchange dilutes the ^{14}C activity of DIC in the ground water, and if not accounted for in age interpretation, the radiocarbon age is biased old. Weathering of primary silicates, such as plagioclase feldspars, releases Ca^{2+} to ground water and raises the pH, both of which can cause calcite to precipitate. Because of isotope fractionation, ^{14}C is slightly enriched in calcite precipitates relative to its isotopic abundance in the dissolved phase. Not correcting for this enrichment causes calculated radiocarbon ages to be biased old; however, the effect of silicate weathering and $CaCO_3$ precipitation on radiocarbon ages is generally low compared to dissolution of calcite.

In most cases, changes in the chemical composition of ground water along flow paths in the MRGB appear to be minor. This observation is consistent with the composition of sediments of the Santa Fe Group aquifer system, which consist largely of sands and gravels derived from the weathering of silicate rocks and minerals. These sediments are likely to be unreactive and result in fairly low mass transfers. The primary minerals in the sediments of the Santa Fe Group aquifer system include quartz, plagioclase feldspars, potassium feldspars and clay minerals (Anderholm, 1988; Hawley and Haase, 1992). As discussed above, calcite is, for the most part, very low in abundance in the sediments of the MRGB, and where it occurs, it is usually as calcite cement rather than primary lithic fragments. Most waters are saturated to slightly oversaturated with respect to calcite throughout the basin (appendix C, table C4). It is possible that waters near saturation with calcite could represent a partial equilibrium state in which

calcite dissolves or precipitates from ground water that is only slightly undersaturated or slightly oversaturated with respect to calcite, while being driven by co-occurrence of one or more irreversible reactions. Possible irreversible reactions include (1) weathering of plagioclase feldspars that would cause net calcite precipitation, (2) weathering of plagioclase feldspars with cation exchange of Ca^{2+} for Na^{+} on clay minerals that could cause net dissolution of calcite, (3) oxidation of organic matter that would release CO_2 and cause dissolution of calcite (if present in the aquifer sediment), and (4) isotope exchange with calcite that would alter the carbon isotopic composition. If it has occurred, oxidation of organic matter is probably indicated only in water in some anaerobic parts of the inner valley of the Rio Grande. With exception of the inner valley Rio Grande waters, most ground water of the MRGB is aerobic indicating low organic carbon content.

Data on the $\delta^{13}C$ of DIC and geochemical mass balance reaction modeling indicate that, although geochemical reactions may be occurring in the MRGB that affect the carbon isotopic composition of the DIC, they are, for the most part, minor and have a small effect on the unadjusted radiocarbon age.

Implications for Geochemical Reactions from Carbon-13 Data

Within an individual hydrochemical zone, $\delta^{13}C$ values generally vary by only a few per mil (fig. 39), except in zones affected by mountain-front recharge and where mixing is important. In particular, within the Northwestern, West-Central, Abo Arroyo, Tijeras Arroyo, Northeastern, and Discharge zones, the 10th and 90th percentiles of $\delta^{13}C$ values differ by only 2.5 per mil or less. In the Central zone, this difference is 2.7 per mil. In the Southwestern Mountain Front zone, only one $\delta^{13}C$ value is available, and variability cannot be evaluated. In the Tijeras Fault Zone, Western Boundary, and Rio Puerco zones, where local recharge is believed to be mixing with older, more mineralized waters, $\delta^{13}C$ values can vary up to almost 9 per mil.

For hydrochemical zones that receive recharge primarily from mountain-front processes (the Northern Mountain Front, Northwestern, West-Central, and Eastern Mountain Front zones), $\delta^{13}C$ values immediately along the mountain front usually are substantially lower (more negative, typically -12 per mil) than those $\delta^{13}C$ values further downgradient (typically -7 to -8 per mil). Within a relatively short distance of the mountain front (perhaps 2 to 3 miles), $\delta^{13}C$ values increase and remain fairly constant throughout the rest of the zone. The shift in $\delta^{13}C$ values along the basin margin is discussed further in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

Although variability in $\delta^{13}C$ values downgradient of the mountain front typically is small in the hydrochemical zones that receive recharge from mountain-front processes, mixing with upwelling mineralized water may result in heavy $\delta^{13}C$ values in some localized areas. No data are available specifically for deep, mineralized water, but the $\delta^{13}C$ values of this water are likely to be elevated because of longer contact times with carbonate minerals in the aquifer system. Mixing with this water in parts of the Northern Mountain Front zone may explain the elevated $\delta^{13}C$ values (greater than -7 per mil) that tend to occur in water from wells with higher Cl concentrations.

In the Central zone, the most depleted $\delta^{13}C$ values (values more negative than about -10 per mil) are in the shallowest wells (total depth less than about 200 feet below land surface), and particularly in the inner valley of the Rio Grande. Therefore, these lighter values appear to be present primarily where oxidation of organic matter is likely to occur. In most other parts of the Central zone, $\delta^{13}C$ values tend to vary over a narrow range of about -8 to -10 per mil, indicating that carbonate reactions probably are not extensive.

In the Western Boundary, Rio Puerco, and Tijeras Fault Zone zones, variations in $\delta^{13}C$ probably reflect mixing between old, mineralized waters and local recharge rather than the occurrence of extensive carbonate reactions. A water sample from Arroyo Salado Spring, just outside the western boundary of the MRGB (Site S009, fig. 11a), indicates that the $\delta^{13}C$ value of DIC in brine leaking into the basin from Paleozoic rocks to the west is about 2 per mil. This enriched value probably is the result of long contact time and isotope exchange with limestone present in rocks outside the basin margins. As discussed earlier, ground water in the Western Boundary zone appears to have progressively higher fractions of local recharge with distance from the western boundary. The pattern of increasingly light $\delta^{13}C$ values with distance from the western boundary is consistent with this pattern of mixing between waters of differing source. Local recharge water, similar to that near the mountain fronts, is likely to have a $\delta^{13}C$ content of about -10 per mil. Mixing of this water and water with a $\delta^{13}C$ value

similar to that of Arroyo Salado Spring (site S009) can account for the lighter values (as light as -6.9 per mil) found in ground water of the Western Boundary zone. Similarly, some ground water in the Rio Puerco zone is believed to contain fractions of Western Boundary-zone ground water. The $\delta^{13}C$ content of water in the Rio Puerco also is enriched in $\delta^{13}C$ relative to mountain-front recharge (only one measurement of $\delta^{13}C$ of DIC in Rio Puerco water was obtained, giving a value of -0.11 per mil), but is more depleted in $\delta^{13}C$ than ground-water inflow along the western margin of the basin. Apparently, the $\delta^{13}C$ content of ground water in the Rio Puerco zone can vary substantially, depending on the fractions of water from the differing parts of the watershed present in the area. Finally, ground water of the Tijeras Fault Zone zone is believed to be a mixture of local mountain-front recharge with mineralized water leaking upward along the major faults of the area. A sample from Coyote Spring, a mineralized spring near the basin margin (Site S041, fig. 11b), indicates that mineralized water in the area can have $\delta^{13}C$ values as heavy as -0.6 per mil, probably as a result of extended contact with Pennsylvanian limestone. $\delta^{13}C$ values in ground water of the zone are progressively lighter with distance downgradient, probably as the result of greater fractions of mountain-front recharge water with $\delta^{13}C$ contents near -12 per mil.

Variations in $\delta^{13}C$ of DIC in the Northern Mountain Front, Northwestern, West Central, Western Boundary, Rio Puerco, Eastern Mountain Front and Central zones as a function of the ^{14}C activity are shown in figure 99. Samples with ^{14}C activity greater than 95 pmC, designated Modern on figure 99, tend to have somewhat lower values of $\delta^{13}C$ than older waters in the basin. In the samples with ^{14}C activities less than 95 pmC, there appears to be a trend to somewhat enriched ^{13}C values with lower ^{14}C activity in the overall data set, but the apparent trend results mostly from differences in $\delta^{13}C$ of different hydrochemical zones and the fact that a large number of samples from the West-Central zone have low ^{14}C activity and are

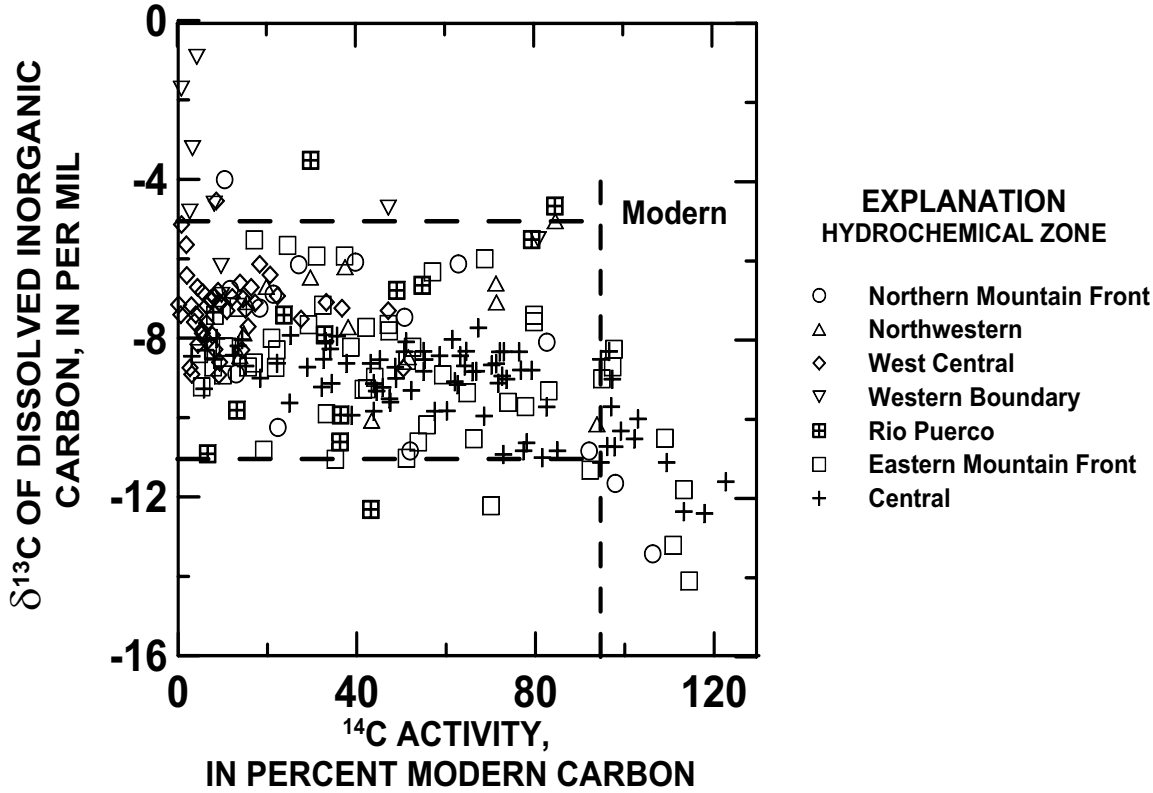


Figure 99. Variations in $\delta^{13}C$ of dissolved inorganic carbon (DIC) as a function of ^{14}C activity of the DIC in the Middle Rio Grande Basin, New Mexico. The horizontal lines bracket $\delta^{13}C$ values of DIC resulting from equilibrium with soil gases with $\delta^{13}C$ values of -14 to -20 per mil. The vertical line separates modern (post-1950's) samples from older waters.

slightly more enriched in ^{13}C than waters from the Central zone. Although there do not appear to be appreciable trends in $\delta^{13}C$ of DIC within individual hydrochemical zones, there are small differences in $\delta^{13}C$ between some hydrochemical zones (fig. 99) that may represent differences in $\delta^{13}C$ of source waters recharged to the zone. The differences in $\delta^{13}C$ of source waters result, in part, from differences in the isotopic composition of carbonate minerals in recharge areas and the relative abundances of C_3 and C_4 plants in recharge areas. Aspects of the apparent historical abundances of C_3 and C_4 plants in recharge areas of the MRGB are discussed in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

The upper and lower horizontal lines on figure 99 correspond to the upper and lower limits of $\delta^{13}C$ of HCO_3^- that would be present in recharge waters, if they evolved under open-system conditions in isotopic equilibrium with soil gas CO_2 with $\delta^{13}C$ values of -14 to -20 per mil, similar to the range of $\delta^{13}C$ of soil gases measured along the eastern mountain front (fig. 40). The relatively few samples outside of these lines are samples with $\delta^{13}C$ values more positive than -5.0 per mil from the Western Boundary, Rio Puerco and Tijeras Fault Zone zones that have likely had appreciable contact with Permian limestones and may have mixed with saline waters enriched in $\delta^{13}C$, and two samples (Rio Puerco and Eastern Mountain Front zones) with $\delta^{13}C$ values more negative than -11 per mil. Although the $\delta^{13}C$ data do not eliminate the possibility of geochemical reactions occurring among carbonate phases in the MRGB, they are consistent with the conclusion that little reaction occurs among carbonates in large parts of the basin.

Geochemical Mass Transfer Models

Another means of testing the geochemical data for chemical reactions is to construct geochemical mass-balance models between hypothetical recharge waters and ground-water compositions occurring within the basin. Although it is not possible to identify all the reactions in the basin, some reactions can be eliminated based on thermodynamic and isotopic constraints (Plummer and others, 1983; Parkhurst and Plummer, 1993). By also including ^{13}C and ^{14}C data in the reaction modeling, sensitivity of the radiocarbon ages to possible reactions can be evaluated. Waters from the Discharge zone were excluded in geochemical modeling because they represent mixtures of waters and mass transfers from multiple zones that have evolved chemically from virtually all source waters in the basin.

NETPATH

The geochemical mass balance code, NETPATH (Plummer and others 1994), was used to construct mass-balance models for the origin of waters in the basin and to investigate the sensitivity of the unadjusted radiocarbon ages to effects of possible geochemical reactions. NETPATH uses equations of chemical mass balance, electron balance, and isotope mass balance to define all possible net geochemical reactions between the analyzed initial and final water compositions along a flow path. Because pairs of samples generally cannot be identified along a specific flow path in the MRGB, representative initial water compositions were defined for each hydrochemical zone. The geochemical reactions were constrained among reasonable reactant and product minerals and gases for the system, and to be consistent with the observed mineralogy, chemical, and isotopic data of the aquifer system. Each geochemical reaction model was also solved as an isotope-evolution problem (Wigley and others 1978; Wigley and others, 1979), accounting for various isotopic sources and isotope fractionation along the reaction path to predict the isotopic composition at the end point in the reaction, including adjustment of the initial ^{14}C activity for geochemical reactions.

Formulation of Geochemical Models

Each ground-water sample in the MRGB was assumed to have evolved from a primary initial water composition that was subsequently altered to varying degrees by

(1) evapotranspiration/dilution processes,
(2) mixing with surface water(s),
(3) mixing with saline upward leakage water(s),
(4) mixing with ground-water inflow from adjacent basins, and
(5) water/rock reaction

Source Waters

The choice of initial waters (primary water; table 10) and other source waters varied with each hydrochemical zone. The compositions of the initial waters

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study.

[no., number; na, not applicable; NMF, Northern Mountain Front; Saline 1, NM041; RP, Discharge-weighted average National Water Information System (NWIS) Rio Puerco; RGA, discharge-weighted average NWIS Rio Grande at Albuquerque; JRW, Discharge-weighted average NWIS Jemez River; MWGW, Mid-West Ground-Water Inflow; SWGW, Southwest Ground-Water Inflow; SWMF, Southwestern Mountain Front, NWIS; EMF, Eastern Mountain Front, median; ABO, median Abo Arroyo; Saline 2, Coyote Spring, NM029; TIJ, Discharge-weighted average NWIS Tijeras Arroyo; NEGW, Northeast Ground-Water Inflow; LUC, Lucero-24, Los Alamos National Laboratory, Representative of southwest arroyo water; GAL, Galisteo Creek above Galisteo Reservoir, used as arroyo source in hydrochemical zone 11; ASSP, Arroyo Salado Spring; 1 σ, one standard deviation; pmC, percent modern carbon; ka, thousands of years; Compositions of end-member waters are given in table 4]

							Source waters and percent in mixture						Mass transfer, millimoles per kilogram water																		
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
		Zone 1: Northern Mountain Front																													
S027	NM486	CEPO 02	21.3	0.22	12.4	4	NMF	100.00	na	na	na	na	-0.37	0.33	0.00	-0.22	-0.33	-0.14	0.00	0.00	1.15	-12.21	- 6.89	99.96	12.4	12.4	12.4	0.0	14.6	14.6	0.0
S034	NM027	Private Production Well #04	51.9	0.59	5.3	4	NMF	100.00	na	na	na	na	-0.32	0.31	0.00	-0.21	-0.17	-0.10	0.00	0.00	0.99	-12.15	-10.84	99.97	5.3	5.2	5.2	0.0	5.8	5.8	0.0
S035	NM487	Windmill #37	97.9	0.69	0.2	5	NMF	100.00	na	na	na	na	-0.10	1.12	2.93	-0.77	0.00	-0.33	0.33	0.00	0.39	-12.04	-11.66	99.99	0.2	0.2	- 1.0	0.0	0.0	0.0	0.0
S036	NM026	Private Production Well #03	82.6	0.90	1.5	4	NMF	100.00	na	na	na	na	0.50	0.00	0.72	0.00	-0.35	0.11	0.00	0.00	0.93	-10.27	- 8.10	85.60	0.3	1.6	0.3	1.2	1.6	0.2	1.4
S065	NM055	Domestic Well #05	27.0	0.25	10.5	1	NMF	92.33	Saline 1	7.67	na	na	-0.41	0.00	0.00	0.00	-0.09	-1.24	-0.13	0.00	0.90	-11.69	- 6.18	88.69	9.6	9.5	9.5	1.0	12.2	11.0	1.2
S187	NM131	Rio Rancho 12	24.8	0.23	11.2	5	NMF	92.86	Saline 1	7.14	na	na	-0.22	0.39	0.00	-0.27	-0.72	0.00	0.35	0.00	0.82	-11.65	- 9.60	89.45	10.3	10.5	10.2	0.9	13.1	11.9	1.1
S189	NM133	Rio Rancho 15	18.3	0.19	13.7	4	NMF	97.08	Saline 1	2.92	na	na	0.51	0.00	0.70	0.00	-0.37	1.23	0.81	0.00	1.00	-10.10	- 6.93	82.34	12.1	13.5	12.1	1.6	16.1	14.2	1.9
S206	NM510	Windmill #38	13.0	0.15	16.4	3	NMF	99.88	Saline 1	0.12	na	na	0.43	0.00	0.58	0.00	0.14	0.86	0.25	0.00	1.00	-10.39	- 8.90	86.57	15.2	16.4	15.3	1.2	19.4	18.1	1.4
S216	NM143	Windmill #09	39.7	0.49	7.4	4	NMF	99.75	Saline 1	0.25	na	na	-0.23	0.04	0.00	-0.02	0.00	-0.12	0.35	0.00	1.07	-12.09	- 6.08	99.59	7.4	7.4	7.4	0.0	8.4	8.4	0.0
S221	NM530	Windmill #45	12.2	0.19	16.9	2	NMF	99.64	Saline 1	0.36	na	na	1.09	0.00	2.49	0.00	0.39	0.38	0.15	0.00	1.00	- 9.74	- 5.83	80.99	15.2	15.3	15.3	1.7	20.0	18.1	2.0
S222	NM514	Windmill #39	10.4	0.16	18.2	2	NMF	98.85	Saline 1	1.15	na	na	1.36	0.00	4.85	0.00	-0.28	0.79	0.70	0.00	1.00	-10.05	- 4.31	83.50	16.7	16.7	16.7	1.4	21.5	19.8	1.6
S254	NM168	Private Production Well #12	92.0	0.81	0.7	4	NMF	100.00	na	na	na	na	-0.12	0.05	0.33	-0.03	0.30	0.00	-0.04	0.00	0.72	-12.09	-10.82	99.98	0.7	0.7	0.7	0.0	0.6	0.6	0.0
S277	NM525	Windmill #40	50.7	0.38	5.5	3	NMF	100.00	na	na	na	na	-1.10	0.92	0.00	-0.63	-1.82	-0.49	-0.05	0.00	3.21	-13.00	- 7.47	99.80	5.4	5.5	5.4	0.0	6.1	6.1	0.0
S279	NM527	Windmill #42	106.3	0.75	- 0.5	5	NMF	100.00	na	na	na	na	0.85	0.00	2.40	0.00	0.78	0.00	0.06	0.00	0.54	-10.14	-13.43	84.52	- 1.8	- 0.5	- 1.8	1.4	- 0.8	- 2.4	1.7
S281	NM528	Windmill #43	22.3	0.22	12.0	4	NMF	100.00	na	na	na	na	-0.39	0.82	0.58	-0.57	-1.50	0.00	-0.06	0.00	1.12	-12.13	-10.25	99.97	12.0	12.1	11.5	0.0	14.1	14.1	0.0
		Zone 2: Northwestern																													
S103	NM497	Lincoln D	13.8	0.20	15.9	5	NMF	99.89	Saline 1	0.11	na	na	0.34	0.01	0.00	-0.01	0.00	0.84	0.27	0.00	1.06	-10.39	- 8.44	86.51	14.7	15.9	14.7	1.2	18.9	17.5	1.4
S104	NM498	Lincoln M	15.5	0.19	15.0	3	NMF	99.98	Saline 1	0.02	na	na	0.08	0.38	0.00	-0.26	0.00	0.60	0.20	0.00	0.87	-11.58	- 7.08	96.44	14.7	15.0	14.7	0.3	17.8	17.4	0.3
S105	NM499	Lincoln S	29.6	0.35	9.8	6	NMF	99.98	Saline 1	0.02	na	na	-0.01	0.24	0.00	-0.17	0.00	0.08	0.05	0.00	0.93	-12.00	- 6.46	99.96	9.8	9.8	8.7	0.0	11.3	11.3	0.0
S191	NM326	Rio Rancho 4	19.8	0.17	13.0	3	NMF	99.77	Saline 1	0.23	na	na	0.14	0.00	0.22	0.00	0.04	0.85	0.46	0.00	1.00	-11.35	- 6.70	94.38	12.6	13.1	12.6	0.5	15.3	14.8	0.6
S192	NM128	Rio Rancho 8	14.7	0.16	15.4	5	NMF	99.81	Saline 1	0.19	na	na	0.00	0.00	-0.14	0.00	-0.54	0.83	0.54	0.00	1.00	-11.48	- 7.62	99.59	15.4	15.4	15.4	0.0	18.2	18.2	0.0
S276	NM179	Windmill #12	38.1	0.38	7.8	4	NMF	99.96	Saline 1	0.04	na	na	0.16	0.50	0.00	-0.35	-0.96	-0.06	0.00	0.00	0.74	-11.20	- 7.25	93.32	7.2	7.8	6.6	0.6	8.8	8.1	0.7
S278	NM526	Windmill #41	71.3	0.50	2.7	4	NMF	99.80	Saline 1	0.20	na	na	0.08	0.00	0.00	0.00	-0.60	0.39	0.31	0.00	1.36	-11.57	- 7.09	96.20	2.4	2.7	2.4	0.3	2.9	2.6	0.4
S280	NM180	Windmill #13	84.5	0.92	1.4	4	NMF	99.97	Saline 1	0.03	na	na	0.33	0.20	0.00	-0.14	-0.69	0.00	0.18	0.00	0.91	-10.47	- 5.04	87.25	0.3	1.4	- 0.6	1.1	1.4	0.1	1.3
S286	NM184	Private Production Well #13	71.2	0.62	2.7	4	NMF	100.00	na	na	na	na	-0.58	2.52	2.68	-1.74	-3.28	0.00	0.27	0.00	0.62	-12.13	- 6.61	99.97	2.7	2.7	0.2	0.0	2.9	2.9	0.0
S287	NM185	Private Production Well #14	37.4	0.37	7.9	4	NMF	99.97	Saline 1	0.03	na	na	-0.72	0.73	0.00	-0.50	-1.55	0.00	0.06	0.00	2.03	-12.41	- 6.20	99.87	7.9	7.9	7.3	0.0	9.0	9.0	0.0
		Zone 3: West Central																													
S003	NM481	98th St. D	0.1	0.10	53.4	4	NMF	92.48	Saline 1	7.52	na	na	1.96	0.00	1.73	0.00	-0.41	5.00	2.16	0.00	1.00	- 7.90	- 7.15	63.15	49.7	53.3	49.8	3.7	40.9	48.1	- 7.2
S004	NM482	98th St. MD	3.7	0.12	26.5	3	NMF	99.84	Saline 1	0.16	na	na	0.44	0.00	0.00	0.00	-0.66	1.60	0.45	0.00	1.52	-10.00	- 7.51	83.19	25.0	26.5	23.9	1.5	29.5	28.2	1.3
S005	NM483	98th St. MS	0.8	0.11	38.9	4	NMF	100.00	na	na	na	na	1.99	0.00	1.92	0.00	-0.58	3.52	0.95	0.00	0.91	- 8.11	- 4.95	67.61	35.8	38.9	35.8	3.1	41.0	37.7	3.3
S006	NM484	98th St. S	6.4	0.15	22.1	3	NMF	99.78	Saline 1	0.22	na	na	1.01	0.00	0.00	0.00	-0.23	2.15	0.66	0.00	0.85	- 8.27	- 7.62	68.75	19.1	22.2	19.1	3.0	25.5	22.5	3.1
S008	NM003	Private Production Well #01	5.5	0.10	23.3	4	NMF	99.77	Saline 1	0.23	na	na	0.00	0.22	0.00	-0.15	-0.61	1.36	0.88	0.00	0.97	-11.98	- 7.76	99.65	23.3	23.3	22.8	0.0	26.7	26.7	0.0
S010	NM255	Private Production Well #16	9.3	0.28	19.1	4	NMF	99.83	Saline 1	0.17	na	na	-0.05	0.00	-0.28	0.00	-0.67	1.54	1.04	0.00	1.00	-10.64	- 8.60	99.96	19.1	19.1	19.1	0.0	22.4	22.4	0.0
S018	NM260	Domestic Well #21	11.0	0.13	17.8	3	NMF	99.55	Saline 1	0.45	na	na	0.20	0.00	0.49	0.00	0.07	1.81	1.35	0.00	1.00	-11.07	- 7.30	92.52	17.1	17.7	17.2	0.6	21.0	20.3	0.7
S019	NM007	Belen 4	14.6	0.17	15.5	3	NMF	99.14	Saline 1	0.86	na	na	-0.19	0.00	0.93	0.00	-0.29	1.46	1.84	0.00	1.00	-12.03	- 7.18	99.07	15.4	15.5	15.5	0.1	18.3	18.3	0.1
S020	NM008	Belen 5	16.4	0.17	14.5	3	NMF	99.41	Saline 1	0.59	na	na	-0.10	0.00	0.74	0.00	-0.18	1.52	1.61	0.00	1.00	-12.00	- 6.65	99.32	14.5	14.5	14.5	0.1	17.2	17.1	0.1
S029	NM015	Cerro Colorado Landfill PW	7.4	0.12	21.0	3	NMF	99.01	Saline 2	0.99	na	na	-0.11	0.00	0.00	0.00	-0.51	1.91	1.91	0.00	1.18	-11.17	- 7.22	88.69	20.0	20.7	20.0	1.0	24.4	23.4	1.0
S037	NM264	College 2	5.4	0.09	23.5	3	NMF	99.90	Saline 1	0.10	na	na	0.77	0.00	0.00	0.00	-0.34	1.94	0.55	0.00	0.94	8.67	- 7.80	74.25	21.1	23.5	21.1	2.4	26.8	24.5	2.3
S066	NM056	Gonzales 1	47.0	0.40	6.1	3	NMF	99.73	Saline 1	0.27	na	na	0.08	0.00	0.20	0.00	0.01	1.13	0.67	0.00	1.00	-11.59	- 7.30	96.37	5.8	6.0	5.7	0.3	6.8	6.4	0.3
S086	NM492	Isleta D	2.7	0.19	29.0	5	NMF	99.17	Saline 1	0.83	na	na	0.00	0.50	0.00	-0.34	-1.06	2.04	1.20	0.00	0.87	-11.94	- 8.74	98.74	28.9	29.0	28.2	0.1	31.6	31.5	0.1
S101	NM294	Leavitt 1	17.3	0.14	14.1	4	NMF	99.66	Saline 1	0.34	na	na	0.60	0.00	0.00	0.00	-0.32	1.73	0.58	0.00	0.99	- 9.21	- 7.10	78.54	12.2	14.1	12.1	1.9	16.7	14.3	2.4
S108	NM076	Los Lunas 3	27.6	0.24	10.4	3	NMF	99.73	Saline 1	0.27	na	na	0.37	0.00	0.40	0.00	0.07	1.44	0.59	0.00	1.00	-10.53	- 7.52	87.52	9.3	10.3	9.3	1.1	12.0	10.7	1.3

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

							Source waters and percent in mixture						Mass transfer, millimoles per kilogram water																			
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
S109	NM077	Los Lunas 4	50.5	0.42	5.5	4	NMF	99.66	Saline 1	0.34	na	na	0.29	0.00	0.42	0.00	0.11	1.19	0.44	0.00	1.00	-10.81	- 8.65	89.86	4.6	5.4	4.7	0.9	6.1	5.1	1.0
S145	NM308	NM Utilities 1	13.9	0.16	15.8	4	NMF	99.83	Saline 1	0.17	na	na	-0.18	0.08	0.00	-0.05	0.00	0.24	0.21	0.00	1.11	-11.99	- 6.60	99.72	15.8	15.8	15.8	0.0	18.8	18.8	0.0
S147	NM310	NM Utilities 3	15.7	0.17	14.9	5	NMF	99.82	Saline 1	0.18	na	na	0.10	0.09	0.00	-0.06	0.00	1.00	0.46	0.00	1.15	-11.40	- 7.70	95.64	14.5	14.8	14.1	0.4	17.6	17.2	0.4
S148	NM311	NM Utilities 4	7.4	0.09	21.0	3	NMF	99.92	Saline 1	0.08	na	na	0.14	0.00	0.10	0.00	0.06	0.75	0.40	0.00	1.00	-10.98	- 7.00	94.21	20.5	21.0	20.5	0.5	24.4	23.9	0.5
S166	NM509	Rabbit Hill	8.6	0.13	19.7	4	NMF	100.00	na	na	na	na	0.20	0.00	0.17	0.00	-0.74	0.79	0.17	0.00	3.05	-11.07	- 4.53	92.21	19.1	19.7	19.1	0.6	23.1	22.4	0.7
S167	NM107	Domestic Well #12	5.9	0.11	22.8	3	NMF	99.89	Saline 1	0.11	na	na	0.03	0.00	0.00	0.00	-0.37	1.80	1.28	0.00	1.05	-11.84	- 7.89	98.58	22.7	22.8	22.6	0.1	26.2	26.1	0.1
S172	NM322	Rio Bravo 5 D	3.1	0.08	27.9	3	NMF	95.99	Saline 1	4.01	na	na	-0.15	0.00	0.00	0.00	-0.33	2.80	2.53	0.00	0.55	-11.44	- 8.90	93.97	27.4	27.8	27.4	0.5	30.6	30.2	0.4
S174	NM109	Rio Bravo 1 D	15.1	0.19	15.2	5	NMF	98.88	Saline 1	1.12	na	na	0.09	0.00	-0.38	0.00	-0.36	2.09	1.56	0.00	1.00	- 9.97	- 7.27	94.43	14.7	15.2	14.7	0.5	18.0	17.4	0.5
S175	NM110	Rio Bravo 1 M	33.2	0.28	8.9	5	NMF	98.90	Saline 1	1.10	na	na	0.00	0.29	0.00	-0.20	-0.52	2.17	1.70	0.00	0.84	-11.92	- 7.09	98.33	8.7	8.8	8.7	0.1	10.2	10.0	0.2
S186	NM130	Rio Rancho 10	12.2	0.23	16.9	4	NMF	99.61	Saline 1	0.39	na	na	0.16	0.00	0.00	0.00	-0.57	0.97	0.49	0.00	1.54	-11.19	- 7.03	92.90	16.3	16.9	16.3	0.6	20.0	19.3	0.7
S188	NM132	Rio Rancho 13	3.0	0.09	28.2	4	NMF	99.99	Saline 1	0.01	na	na	0.00	0.41	0.00	-0.28	-1.03	1.45	0.64	0.00	0.99	-12.00	- 7.10	99.98	28.2	28.2	27.2	0.0	30.9	30.9	0.0
S193	NM129	Rio Rancho 9	7.7	0.12	20.6	4	NMF	99.94	Saline 1	0.06	na	na	0.24	0.00	-0.29	0.00	-0.53	1.21	0.35	0.00	1.00	- 9.81	- 7.81	89.65	19.7	20.6	19.7	0.9	24.0	23.1	0.9
S196	NM135	Windmill #05	36.8	0.34	8.0	4	NMF	99.67	Saline 1	0.33	na	na	0.04	0.00	0.00	0.00	-0.26	1.33	0.77	0.00	1.10	-11.78	- 7.38	97.82	7.9	8.0	7.6	0.2	9.2	8.9	0.2
S200	NM139	Private Production Well #08	9.2	0.18	19.1	3	NMF	99.44	Saline 1	0.56	na	na	-0.15	0.00	0.38	0.00	-0.30	1.88	1.77	0.00	1.00	-12.02	- 7.08	99.26	19.1	19.1	19.1	0.1	22.5	22.4	0.1
S217	NM144	Santa Ana Boundary D	6.5	0.14	22.0	4	NMF	100.00	na	na	na	na	1.79	0.00	1.59	0.00	-0.46	2.87	0.54	0.00	0.63	- 8.18	- 7.18	68.18	18.9	22.0	19.0	3.1	25.4	22.3	3.1
S218	NM145	Santa Ana Boundary M	8.2	0.12	20.1	5	NMF	100.00	na	na	na	na	3.73	0.00	4.01	0.00	0.14	4.72	0.70	0.00	0.37	- 7.51	- 6.81	62.60	16.3	20.0	16.3	3.8	23.5	19.3	4.2
S219	NM146	Santa Ana Boundary S	5.5	0.15	23.2	4	NMF	75.00	JRW	25.00	na	na	0.86	0.00	0.00	0.00	-0.37	1.41	0.06	0.00	1.00	- 7.95	- 6.64	77.04	21.2	23.2	21.2	2.1	26.6	24.6	2.0
S230	NM516	Sierra Vista D	1.9	0.11	31.9	4	NMF	98.61	Saline 1	1.39	na	na	0.59	0.00	0.00	0.00	-0.57	2.94	1.73	0.00	1.00	- 9.44	- 5.53	77.66	29.9	31.9	29.8	2.0	34.0	32.3	1.7
S236	NM155	SAF (Soil Amendment Facility)	4.5	0.13	24.9	4	NMF	99.83	Saline 1	0.17	na	na	-0.02	0.00	-0.28	0.00	-0.59	2.40	2.03	0.00	1.00	-11.00	- 8.01	99.94	24.9	24.9	24.9	0.0	28.1	28.1	0.0
S241	NM519	SWAB Test Hole 1 D	6.6	0.16	21.9	4	NMF	98.01	Saline 1	1.99	na	na	0.07	0.00	0.00	0.00	-0.44	1.78	1.33	0.00	1.76	-11.52	- 6.87	94.19	21.4	21.8	21.4	0.5	25.3	24.8	0.5
S242	NM520	SWAB Test Hole 1 S	9.1	0.14	19.2	4	NMF	99.54	Saline 1	0.46	na	na	0.00	0.36	0.00	-0.24	-1.04	1.68	0.95	0.00	1.11	-11.97	- 8.92	99.29	19.2	19.2	17.6	0.1	22.6	22.5	0.1
S243	NM521	SWAB Test Hole 2 D	14.4	0.16	15.6	3	NMF	99.89	Saline 1	0.11	na	na	0.43	0.00	0.00	0.00	-0.53	0.98	0.27	0.00	0.84	-10.04	- 8.28	83.60	14.2	15.6	14.2	1.4	18.5	16.7	1.7
S263	NM346	Volcano Cliff 1	9.5	0.13	19.0	4	NMF	99.88	Saline 1	0.12	na	na	-0.05	0.03	0.00	-0.02	0.00	0.55	0.32	0.00	1.12	-11.78	- 7.10	99.81	18.9	18.9	18.7	0.0	22.3	22.3	0.0
S266	NM347	West Bluff Nest 1 Well 1	2.0	0.07	31.4	5	NMF	97.96	Saline 1	2.04	na	na	0.00	0.23	0.00	-0.16	-0.81	2.43	1.73	0.00	0.91	-11.86	- 6.40	96.91	31.2	31.4	30.9	0.2	33.6	33.4	0.2
S272	NM353	West Mesa 3	9.0	0.11	19.3	2	NMF	99.86	Saline 1	0.14	na	na	0.47	0.00	0.00	0.00	-0.41	1.44	0.35	0.00	1.10	- 9.74	- 6.80	82.45	17.8	19.3	17.5	1.5	22.7	21.0	1.7
S283	NM181	Zia Ball Park D	18.3	0.23	13.6	1	NMF	99.91	Saline 1	0.09	na	na	1.28	0.00	0.92	0.00	-0.48	2.34	0.54	0.00	1.00	- 8.54	- 6.12	71.09	10.9	10.9	10.9	2.7	16.1	12.7	3.4
S284	NM182	Zia Ball Park M	20.7	0.24	12.7	2	NMF	99.89	Saline 1	0.11	na	na	1.28	0.00	0.79	0.00	-0.49	2.31	0.49	0.00	1.00	- 8.42	- 6.39	70.12	9.8	11.1	9.8	2.8	14.9	11.3	3.6
S285	NM183	Zia Ball Park S	22.2	0.29	12.1	4	NMF	98.17	Saline 1	1.83	na	na	-1.13	1.05	0.00	-0.72	-2.07	0.00	0.33	0.00	4.06	-12.36	- 6.93	97.14	11.8	11.8	9.4	0.2	14.2	13.9	0.3
S288	NM186	Zia BMT D	8.3	0.17	20.0	2	NMF	100.00	Saline 1	na	na	na	0.26	0.00	0.00	0.00	-0.72	1.40	0.54	0.00	2.02	-10.76	- 8.27	89.64	19.1	19.2	19.2	0.9	23.4	22.5	0.9
		Zone 4: Western Boundary																														
S031	NM263	Windmill #18	8.1	0.10	20.1	3	LUC	84.25	ASSP	15.75	na	na	-2.74	0.44	0.00	-0.30	0.00	5.50	6.59	0.00	0.40	- 3.02	- 4.60	73.36	17.7	18.9	17.6	2.5	23.6	20.9	2.7
S039	NM266	Windmill #20	0.8	0.06	38.9	5	LUC	93.73	ASSP	6.27	na	na	1.27	0.50	0.00	-0.35	0.00	9.10	3.95	0.00	1.17	- 3.54	- 1.70	80.16	37.1	38.6	36.7	1.8	41.0	39.1	1.9
S059	NM278	Windmill #21	9.8	0.10	18.7	2	LUC	83.96	ASSP	16.04	na	na	-9.20	0.00	0.00	0.00	0.53	-9.94	6.08	0.00	0.59	- 4.31	- 6.90	72.59	16.1	16.2	16.1	2.6	22.0	19.1	2.9
S074	NM285	Windmill #23	4.2	0.10	25.4	4	LUC	91.43	ASSP	8.57	na	na	-1.48	0.02	-1.58	-0.02	0.00	1.09	0.00	0.00	1.18	- 2.77	- 0.90	84.59	24.1	24.1	23.6	1.3	28.5	27.3	1.2
S169	NM320	Rest Area	80.7	0.74	1.7	2	LUC	89.06	ASSP	10.95	na	na	-6.90	0.00	0.00	0.00	0.59	-0.77	7.94	0.00	0.51	- 4.04	- 5.50	80.42	0.0	0.0	0.0	1.8	1.8	- 0.2	2.0
S201	NM329	Windmill #26	2.7	0.10	29.1	1	LUC	99.99	ASSP	0.01	na	na	-6.28	0.00	0.00	0.00	0.36	4.83	18.98	0.00	0.47	- 5.77	- 4.80	99.76	29.1	29.0	29.0	0.0	31.6	31.6	0.0
S252	NM167	Windmill #10	9.7	0.24	18.7	3	LUC	97.56	ASSP	2.44	na	na	-1.52	0.00	0.00	0.00	0.49	9.23	8.34	0.00	0.39	- 4.74	- 6.17	95.23	18.4	18.7	18.4	0.4	22.1	21.7	0.4
S260	NM345	Windmill #33	3.3	0.10	27.4	3	LUC	89.61	ASSP	10.39	na	na	-0.45	0.00	0.00	0.00	0.33	8.27	6.23	0.00	0.58	- 3.36	- 3.20	81.49	25.8	25.8	25.8	1.6	30.2	28.9	1.4
		Zone 5: Rio Puerco																														
S032	NM262	Windmill #17	29.8	0.21	9.7	6	RP	90.80	SWGW	9.20	na	na	0.49	0.00	0.03	0.00	0.36	0.02	0.00	0.00	0.81	- 1.99	- 3.50	28.50	- 0.3	1.5	- 0.3	10.1	11.3	- 0.6	11.8
S069	NM058	Domestic Well #06	36.5	0.35	8.1	4	RP	94.79	MWGW	5.21	na	na	-1.11	0.00	1.31	0.00	0.53	-3.54	0.00	0.00	0.58	- 4.51	- 9.31	60.15	4.0	4.4	4.0	4.1	9.2	4.4	4.8
S073	NM062	Windmill #03	49.1	0.42	5.7	4	RP	84.50	MWGW	15.51	na	na	-4.35	0.00	1.93	0.00	0.18	-8.27	0.00	0.00	0.96	- 6.64	- 6.99	51.40	0.4	0.5	0.4	5.3	6.4	0.3	6.1
S082	NM409	Windmill #36	43.3	0.40	6.7	3	RP	100.00	na	na	na	na	-2.27	0.00	1.58	0.00	0.38	-0.98	7.17	0.00	0.85	- 6.07	-12.30	80.07	4.9	5.1	5.0	1.8	7.6	5.5	2.1
S085	NM408	Windmill #35	13.2	0.12	16.3	4	RP	100.00	na	na	na	na	-2.64	0.75	3.55	-0.51	0.00	1.98	5.46	0.00	0.44	- 9.82	- 9.80	96.79	16.0	15.9	15.0	0.3	19.3	19.0	0.3
S111	NM079	Domestic Well #10	54.7	0.46	4.8	4	RP	93.80	MWGW	6.21	na	na	-2.52	0.00	0.42	0.00	0.38	-4.77	0.00	0.00	0.81	- 3.88	- 6.76	50.21	- 0.7	- 0.2	- 0.7	5.5	5.4	- 1.0	6.3
S185	NM324	Domestic Well #31	36.3	0.37	8.1	5	RP	98.78	MWGW	1.22	na	na	0.39	0.07	2.24	-0.05	0.00	-1.06	0.00	0.00	1.50	- 4.36	-10.60	70.51	5.3	6.0	5.3	2.8	9.3	5.9	3.4
S198	NM137	Windmill #07	84.5	0.71	1.4	3	RP	92.37	MWGW	7.63	na	na	-2.09	0.00	0.34	0.00	-0.03	-2.27	0.00	0.00	2.37	- 3.60	- 4.65	45.15	- 5.0	- 1.7	- 5.1	6.4	1.4	- 7.3	8.7

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

							Source waters and percent in mixture					Mass transfer, millimoles per kilogram water																			
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
S237	NM341	Windmill #30	23.8	0.29	11.5	3	RP	77.56	SWGW	22.44	na	na	-5.62	0.90	1.55	-0.62	0.00	-12.87	0.00	0.00	0.29	- 5.06	- 7.40	30.96	2.1	2.1	0.6	9.4	13.5	2.3	11.2
S238	NM342	Windmill #31	32.9	0.35	8.9	4	RP	92.90	MWGW	7.10	na	na	-2.54	0.13	1.36	-0.09	0.00	-4.53	0.00	0.00	1.47	- 5.36	- 7.90	58.49	4.6	4.7	4.5	4.3	10.3	5.1	5.2
		Zone 6: Southwestern Mountain Front																													
S022	NM009	Windmill #02	40.0	0.41	7.4	4	SWMF	100.00	na	na	na	na	-0.91	0.00	-1.81	0.00	-0.41	0.00	0.04	0.00	1.92	- 6.63	- 5.76	101.09	7.4	7.5	7.3	- 0.1	8.3	8.4	- 0.1
		Zone 7: Abo Arroyo																													
S021	NM261	Stock Well #01	83.9	0.70	1.4	2	EMF	47.70	ABO	52.30	na	na	-0.97	0.00	0.00	0.00	-0.12	-0.04	0.08	0.00	1.20	- 9.58	- 5.40	92.87	0.8	0.9	0.9	0.6	1.4	0.8	0.7
S024	NM011	Domestic Well #02	17.1	0.18	14.2	5	EMF	59.36	ABO	40.64	na	na	-0.05	0.06	0.00	-0.04	0.00	-0.17	-1.33	0.00	0.83	- 9.94	- 6.94	94.47	13.7	13.7	13.7	0.5	16.8	16.2	0.6
S090	NM064	Domestic Well #08	13.0	0.17	16.4	5	EMF	58.26	ABO	41.74	na	na	-0.54	0.13	0.00	-0.09	0.00	0.05	-0.49	0.00	0.76	-10.07	- 6.49	94.29	15.9	15.9	15.9	0.5	19.4	18.9	0.5
S093	NM067	Domestic Well #09	31.1	0.28	9.4	7	EMF	95.41	ABO	4.59	na	na	-0.77	0.27	-1.11	-0.18	0.00	0.33	0.00	0.00	1.00	- 8.85	- 8.54	99.94	9.4	8.8	9.4	0.0	10.8	10.8	0.0
		Zone 8: Eastern Mountain Front																													
S007	NM002	Domestic Well #01	113.4	0.96	- 1.0	3	EMF	100.00	na	na	na	na	0.07	0.00	0.84	0.00	0.00	-0.05	0.11	0.00	1.01	-11.81	-11.84	98.46	- 1.1	- 1.0	- 1.2	0.1	- 1.4	- 1.5	0.2
S013	NM256	Windmill #14	74.0	0.55	2.4	3	EMF	99.49	Saline 1	0.51	na	na	-0.61	0.00	0.00	0.00	-0.36	0.27	0.14	0.00	0.23	-10.38	- 9.60	99.54	2.4	2.3	2.3	0.0	2.6	2.5	0.0
S014	NM257	Private Production Well #17	79.8	0.66	1.8	4	EMF	99.94	Saline 1	0.06	na	na	0.00	0.00	0.00	0.00	0.10	-0.13	0.32	0.00	0.94	-11.91	- 7.40	99.96	1.8	1.8	1.8	0.0	1.9	1.9	0.0
S015	NM006	Windmill #01	97.7	0.87	0.2	6	EMF	99.89	Saline 1	0.11	na	na	-0.38	0.34	0.00	-0.23	-0.34	0.00	0.11	0.00	0.65	-12.10	- 8.26	99.90	0.2	0.2	0.2	0.0	0.0	0.0	0.0
S030	NM016	Charles 4	51.4	0.43	5.3	7	EMF	98.33	Saline 1	1.67	na	na	-0.10	0.19	0.00	-0.13	0.08	0.00	0.05	0.00	0.69	-11.96	- 8.54	98.83	5.3	5.3	5.0	0.1	5.9	5.8	0.1
S042	NM031	Domestic Well #03	21.0	0.20	12.5	4	EMF	100.00	na	na	na	na	-3.48	0.00	1.63	0.00	0.27	0.01	2.61	0.00	1.05	-13.01	- 7.95	99.80	12.5	12.5	12.5	0.0	14.7	14.7	0.0
S055	NM042	Elena Gallegos	109.2	0.91	- 0.7	4	EMF	100.00	na	na	na	na	0.32	0.01	0.92	-0.01	-0.04	0.00	0.10	0.00	1.09	-11.23	-10.50	93.57	- 1.2	- 0.7	- 1.3	0.5	- 1.0	- 1.7	0.7
S056	NM043	Embudito Spring	114.6	1.06	- 1.1	3	EMF	100.00	na	na	na	na	0.08	0.00	1.43	0.00	-0.05	-0.05	0.32	0.00	1.61	-11.82	-14.10	98.48	- 1.2	- 1.1	- 1.3	0.1	- 1.5	- 1.6	0.2
S071	NM060	Domestic Well #07	97.5	0.80	0.2	3	EMF	100.00	na	na	na	na	0.00	0.42	0.45	-0.29	-0.52	-0.19	-0.10	0.00	0.94	-12.00	- 8.75	100.00	0.2	0.2	- 0.4	0.0	0.1	0.1	0.0
S083	NM407	Windmill #34	17.2	0.32	14.2	5	EMF	99.23	Saline 1	0.77	na	na	-0.40	0.15	0.00	-0.11	0.00	0.07	0.20	0.00	1.04	-12.10	- 5.50	99.44	14.1	14.1	14.1	0.0	16.7	16.7	0.1
S095	NM068	Kirtland 1	59.4	0.51	4.2	5	EMF	99.83	Saline 1	0.17	na	na	-0.33	0.12	0.00	-0.08	0.00	0.13	0.32	0.00	0.85	-12.10	- 8.89	99.86	4.2	4.2	4.2	0.0	4.6	4.6	0.0
S106	NM295	Domestic Well #23	11.2	0.11	17.6	7	EMF	99.13	Saline 1	0.87	na	na	-0.73	0.71	0.00	-0.49	0.00	0.58	0.27	0.00	0.84	-12.08	- 8.20	99.35	17.6	17.6	17.3	0.0	20.8	20.8	0.1
S110	NM078	Love 1	47.2	0.39	6.0	7	EMF	99.86	Saline 1	0.14	na	na	-0.28	0.21	-0.49	-0.15	0.00	0.36	0.00	0.00	0.77	-11.06	- 7.63	100.09	6.0	6.0	6.0	0.0	6.7	6.8	0.0
S113	NM080	Domestic Well #11	8.3	0.14	20.0	4	EMF	99.91	Saline 1	0.09	na	na	-0.07	0.00	0.00	0.00	0.40	1.06	0.33	0.00	0.55	-12.02	- 7.43	99.93	20.0	19.9	19.9	0.0	23.4	23.4	0.0
S114	NM500	Matheson D	35.4	0.29	8.4	6	EMF	99.97	Saline 1	0.03	na	na	-0.09	0.28	0.00	-0.19	0.00	0.53	-0.01	0.00	0.66	-12.04	-11.03	99.97	8.4	8.4	8.4	0.0	9.5	9.5	0.0
S115	NM501	Matheson M	55.9	0.41	4.7	3	EMF	99.97	Saline 1	0.03	na	na	0.16	0.14	0.00	-0.10	0.00	1.00	-0.06	0.00	0.77	-11.51	-10.16	95.88	4.3	4.7	4.4	0.3	5.2	4.8	0.4
S116	NM502	Matheson S	64.9	0.52	3.5	1	EMF	99.92	Saline 1	0.08	na	na	0.00	0.98	1.51	-0.68	-0.90	0.12	0.00	0.00	0.56	-12.00	- 9.35	99.96	3.5	3.5	3.5	0.0	3.8	3.8	0.0
S117	NM298	Domestic Well #25	95.1	0.67	0.4	5	EMF	100.00	Saline 1	0.00	na	na	0.00	0.00	-0.03	0.00	-0.02	-0.02	-0.03	0.00	0.98	-11.82	- 9.00	100.01	0.4	0.4	0.2	0.0	0.3	0.3	0.0
S118	NM299	Windmill #24	37.4	0.38	7.9	5	EMF	98.70	Saline 1	1.30	na	na	-0.53	0.09	0.00	-0.06	0.00	0.14	0.36	0.00	0.80	-11.80	- 5.90	99.05	7.8	7.8	7.8	0.1	9.0	8.9	0.1
S119	NM300	Domestic Well #26	47.4	0.34	6.0	3	EMF	99.87	Saline 1	0.13	na	na	-0.87	0.56	0.00	-0.39	-0.91	0.00	0.13	0.00	2.09	-12.33	- 7.80	99.83	6.0	6.0	6.0	0.0	6.7	6.7	0.0
S122	NM505	Mesa Del Sol S	33.4	0.27	8.8	6	EMF	99.48	Saline 1	0.52	na	na	-0.87	0.56	0.00	-0.39	0.00	0.01	-0.05	0.00	0.94	-12.40	- 9.88	99.55	8.8	8.7	8.7	0.0	10.1	10.1	0.0
S140	NM306	MRN 1	42.2	0.30	6.9	5	EMF	99.70	Saline 1	0.30	na	na	-0.54	0.05	0.00	-0.04	0.00	0.00	0.35	0.00	1.08	-12.18	- 7.70	99.74	6.9	6.9	6.9	0.0	7.8	7.8	0.0
S141	NM095	National Utility 7	68.8	0.60	3.0	5	EMF	100.00	na	na	na	na	-0.12	1.17	1.02	-0.81	-1.30	0.00	-0.08	0.00	0.51	-12.02	- 5.97	100.00	3.0	3.0	1.7	0.0	3.2	3.2	0.0
S149	NM312	Nor Este D	8.0	0.11	20.3	5	EMF	90.99	Saline 1	9.01	na	na	-0.87	0.37	0.00	-0.25	0.00	0.49	0.49	0.00	0.65	-11.51	- 8.70	93.58	19.8	20.0	19.7	0.5	23.7	23.2	0.5
S150	NM313	Nor Este M	17.1	0.19	14.2	5	EMF	89.47	Saline 1	10.53	na	na	-1.17	0.57	0.00	-0.39	0.00	-0.61	0.09	0.00	0.65	-11.79	- 8.60	92.49	13.6	13.7	13.4	0.6	16.8	16.0	0.8
S162	NM317	Stock Well #03	52.7	0.48	5.2	7	EMF	99.83	Saline 1	0.17	na	na	-0.77	0.87	0.00	-0.60	-0.78	0.00	-0.08	0.00	0.56	-12.03	- 8.20	99.82	5.1	5.2	5.2	0.0	5.7	5.7	0.0
S163	NM318	PL 2	38.8	0.36	7.6	5	EMF	99.77	Saline 1	0.23	na	na	-0.39	0.10	0.00	-0.07	0.00	0.13	0.33	0.00	0.87	-11.98	- 8.20	99.81	7.6	7.6	7.6	0.0	8.6	8.6	0.0
S164	NM106	Ponderosa 1	42.5	0.36	6.9	6	EMF	96.51	Saline 1	3.49	na	na	-0.27	0.24	-0.42	-0.17	0.00	-0.35	0.00	0.00	0.84	-11.09	- 9.25	97.71	6.7	6.7	6.6	0.2	7.8	7.5	0.2
S165	NM328	Windmill #25	10.2	0.16	18.4	6	EMF	99.55	Saline 1	0.45	na	na	-0.16	0.24	0.00	-0.17	0.00	1.63	0.51	0.00	0.65	-11.09	- 8.90	99.67	18.4	18.4	18.1	0.0	21.7	21.6	0.0
S168	NM319	Domestic Well #30	5.4	0.11	23.4	5	EMF	99.79	Saline 1	0.21	na	na	-1.80	1.59	0.00	-1.10	-1.99	0.00	0.10	0.00	0.71	-12.47	- 9.20	99.70	23.4	2.1	2.1	0.0	26.8	26.7	0.0
S170	NM108	Ridgecrest 3	70.3	0.72	2.8	7	EMF	98.72	Saline 1	1.28	na	na	-0.32	0.33	0.02	-0.23	0.00	-0.13	0.00	0.00	0.64	-12.05	-12.20	99.09	2.8	2.7	2.6	0.1	3.1	3.0	0.1
S195	NM134	Domestic Well #13	22.2	0.21	12.1	6	EMF	99.54	Saline 1	0.46	na	na	-1.01	0.38	-0.59	-0.26	0.00	-0.15	0.00	0.00	0.96	-10.81	- 8.24	99.92	12.1	12.1	12.1	0.0	14.2	14.2	0.0
S199	NM138	Windmill #08	57.2	0.49	4.5	4	EMF	99.33	Saline 1	0.67	na	na	-0.25	0.02	0.00	-0.01	0.00	-0.10	0.54	0.00	0.96	-12.05	- 6.30	99.52	4.5	4.5	4.5	0.0	5.0	4.9	0.0
S209	NM336	Domestic Well #33	15.8	0.16	14.8	6	EMF	98.63	Saline 1	1.37	na	na	-0.42	0.00	0.00	0.00	0.67	0.55	0.46	0.00	0.64	-11.61	- 8.70	99.01	14.7	14.8	14.7	0.1	17.5	17.5	0.1
S212	NM141	Sandia Peak 1	78.0	0.65	2.0	1	EMF	99.83	Saline 1	0.17	na	na	0.00	2.23	3.43	-1.54	-2.10	-0.33	0.00	0.00	0.45	-12.00	- 9.73	99.94	2.0	2.0	2.0	0.0	2.1	2.1	0.0
S213	NM142	Sandia Peak 3	83.2	0.69	1.5	7	EMF	99.96	Saline 1	0.04	na	na	-0.01	0.05	0.09	-0.03	0.00	0.04	0.00	0.00	0.98	-11.83	- 9.30	100.00	1.5	1.5	1.4	0.0	1.5	1.5	0.0
S224	NM148	Domestic Well #14	79.9	0.68	1.8	5	EMF	100.00	na	na	na	na	1.23	0.00	1.81	0.00	0.69	0.24	0.27	0.00	0.55	- 9.84	- 7.56	81.96	0.2	1.8	0.2	1.6	1.9	0.1	1.8

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

							Source waters and percent in mixture					Mass transfer, millimoles per kilogram water																			
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
S229	NM515	SH03 UNM	96.3	0.75	0.3	5	EMF	100.00	na	na	na	na	0.49	0.04	1.50	-0.03	-0.02	0.00	0.09	0.00	0.79	-10.98	- 9.42	91.52	- 0.4	0.3	- 0.5	0.7	0.2	- 0.7	0.8
S233	NM153	Domestic Well #16	32.6	0.30	9.0	7	EMF	99.63	Saline 1	0.37	na	na	-0.62	0.62	0.00	-0.43	-0.50	0.00	-0.03	0.00	1.45	-12.29	- 7.14	99.68	9.0	8.7	8.9	0.0	10.4	10.3	0.0
S239	NM156	Domestic Well #17	22.0	0.26	12.2	4	EMF	100.00	na	na	na	na	0.01	0.00	0.66	0.00	-0.01	0.24	-0.01	0.00	1.18	-11.98	- 8.92	99.85	12.2	12.2	12.2	0.0	14.3	14.3	0.0
S240	NM157	Domestic Well #18	66.4	0.58	3.3	4	EMF	99.99	Saline 1	0.01	na	na	-0.21	0.44	0.00	-0.31	-0.33	0.00	-0.13	0.00	0.78	-12.07	-10.51	99.98	3.3	3.3	3.1	0.0	3.6	3.6	0.0
S246	NM343	Windmill #32	31.2	0.32	9.4	6	EMF	99.60	Saline 1	0.40	na	na	-0.25	0.28	0.00	-0.19	0.00	0.52	0.91	0.00	0.59	-11.82	- 5.90	99.70	9.3	9.4	9.2	0.0	10.8	10.8	0.0
S247	NM161	Domestic Well #19	4.9	0.14	24.3	6	EMF	99.81	Saline 1	0.19	na	na	0.40	0.19	0.00	-0.13	0.00	2.05	0.22	0.00	0.68	-10.86	- 8.50	90.40	23.5	2.4	2.3	0.8	27.5	26.8	0.7
S248	NM162	Thomas 6	44.2	0.37	6.6	6	EMF	96.91	Saline 1	3.09	na	na	-0.33	0.27	-0.11	-0.19	0.00	-0.44	0.00	0.00	0.79	-11.75	- 8.95	97.86	6.4	6.4	6.2	0.2	7.4	7.2	0.2
S255	NM523	Tramway East	54.0	0.39	5.0	5	EMF	99.94	Saline 1	0.06	na	na	-0.27	1.06	0.00	-0.73	-1.13	0.00	-0.10	0.00	0.77	-12.09	-10.41	99.94	5.0	5.0	2.5	0.0	5.5	5.5	0.0
S264	NM174	Walker 1	41.6	0.34	7.0	6	EMF	95.88	Saline 1	4.12	na	na	-0.20	0.40	-0.01	-0.27	0.00	-0.55	0.00	0.00	0.58	-11.88	- 9.26	97.11	6.8	6.8	6.8	0.2	7.9	7.7	0.3
S274	NM177	Domestic Well #20	24.7	0.24	11.2	6	EMF	99.56	Saline 1	0.44	na	na	-0.83	0.14	-0.61	-0.09	0.00	-0.09	0.00	0.00	1.36	-10.76	- 5.80	99.94	11.2	11.3	11.2	0.0	13.1	13.1	0.0
		Zone 9: Tijeras Fault Zone																													
S072	NM061	Hubbell Spring	42.8	0.37	6.8	3	EMF	100.00	na	na	na	na	-1.37	0.00	-1.68	0.00	-0.30	-0.12	0.08	0.00	5.49	- 5.53	- 6.40	101.31	6.9	6.9	6.8	- 0.1	7.7	7.8	- 0.1
S197	NM136	Windmill #06	4.8	0.13	24.5	2	EMF	96.26	Saline 2	3.74	na	na	-3.62	3.53	0.00	-2.43	-4.69	0.00	0.68	0.00	3.25	- 9.96	- 8.22	74.14	22.1	22.1	12.8	2.4	27.7	25.5	2.2
S227	NM151	SFR 3D	9.7	0.14	18.8	1	EMF	84.22	Saline 2	15.77	na	na	0.00	0.00	1.14	0.00	-0.03	-0.24	0.17	0.00	1.44	- 4.96	- 0.98	45.99	12.5	12.5	12.5	6.2	22.1	14.7	7.4
S228	NM152	SFR 3S	13.2	0.15	16.2	3	EMF	61.19	Saline 2	38.81	na	na	0.00	0.00	-2.00	0.00	0.42	-0.40	0.79	0.00	0.60	- 1.35	- 0.95	18.39	2.6	2.6	2.6	13.6	19.2	2.8	16.4
		Zone 10: Tijeras Arroyo																													
S001	NM001	4Hills-1	94.0	0.67	0.5	4	EMF	2.85	TIJ	91.60	Saline	5.55	-1.36	0.03	0.00	-0.02	0.00	-0.28	1.89	0.00	1.00	- 5.34	- 8.40	58.53	- 3.8	- 3.8	- 3.8	4.3	0.4	- 5.2	5.6
S002	NM250	Private Production Well #15	82.7	0.69	1.5	2	EMF	31.43	TIJ	64.70	Saline	3.87	-0.87	0.00	0.00	0.00	0.00	-0.41	0.49	0.00	1.00	- 6.72	- 6.80	67.71	- 1.6	- 1.6	- 1.6	3.1	1.6	- 2.1	3.7
S058	NM277	Eubank 1	62.0	0.52	3.8	4	EMF	92.33	TIJ	7.67	na	na	-1.11	0.79	0.00	-0.54	-0.98	-0.11	0.50	0.00	1.00	-11.90	- 6.20	98.87	3.7	3.8	3.7	0.1	4.2	4.1	0.1
S096	NM069	Kirtland 11	46.0	0.42	6.2	5	EMF	86.12	TIJ	13.88	na	na	-0.21	0.00	0.00	0.00	0.08	0.21	0.43	0.00	1.01	-11.38	- 7.90	98.11	6.1	6.1	6.1	0.2	7.0	6.8	0.2
S107	NM075	Lomas 1	72.8	0.62	2.6	6	EMF	62.85	TIJ	37.15	na	na	-0.65	0.00	0.00	0.00	0.03	0.06	0.34	0.00	1.03	-10.42	- 6.20	94.98	2.1	2.5	2.1	0.4	2.7	2.3	0.5
		Zone 11: Northeastern																													
S016	NM258	Windmill #15	28.5	0.24	10.1	4	EMF	50.29	NEGW	47.73	Saline	1.98	0.00	0.22	0.00	-0.15	0.08	3.54	2.42	0.00	1.00	- 7.13	- 5.30	41.70	3.1	4.6	2.4	7.0	11.7	3.3	8.4
S017	NM259	Windmill #16	18.1	0.15	13.7	4	EMF	66.05	NEGW	33.95	na	na	-2.22	2.17	0.00	-1.50	-2.79	0.00	0.42	0.00	1.19	- 8.96	- 7.40	56.79	9.2	9.2	9.2	4.5	16.2	10.6	5.6
S053	NM276	Private Production Well #18	76.5	0.65	2.1	4	EMF	98.88	NEGW	1.11	na	na	-2.54	1.43	0.00	-0.99	-1.89	0.00	1.95	0.00	2.48	-13.98	- 5.60	97.89	2.0	1.9	- 2.7	0.2	2.3	2.1	0.2
S144	NM097	Private Production Well #06	29.2	0.37	9.9	5	EMF	59.33	NEGW	40.67	na	na	-1.73	0.17	0.00	-0.11	0.00	0.52	2.87	0.00	1.49	- 8.59	- 6.80	49.77	4.3	8.2	3.5	5.6	11.4	4.7	6.7
S204	NM332	Windmill #28	19.6	0.27	13.1	5	EMF	94.68	NEGW	5.21	Saline	0.11	-0.34	0.00	0.00	0.00	0.06	0.15	0.73	0.00	1.00	-11.29	- 6.40	92.30	12.5	12.5	11.1	0.6	15.5	14.7	0.8
S207	NM334	Private Production Well #22	69.3	0.49	2.9	3	EMF	14.18	GAL	85.82	na	na	-0.54	0.19	0.08	-0.13	0.00	-1.01	2.57	0.00	1.00	- 6.96	- 6.10	99.94	2.9	3.0	3.0	0.0	3.2	3.2	0.0
S223	NM338	Windmill #29	19.5	0.26	13.1	3	EMF	80.41	GAL	19.59	na	na	-1.21	0.00	-1.45	0.00	-0.17	-0.24	0.00	0.00	2.38	- 6.13	- 6.70	100.90	13.2	13.2	13.2	- 0.1	15.5	15.6	- 0.1
		Zone 12: Central																													
S011	NM004	Atris-1	96.8	0.80	0.3	6	RGA	99.92	Saline 1	0.08	na	na	-0.02	0.12	0.18	0.18	0.00	-0.02	0.00	0.32	1.09	- 9.16	- 8.34	99.91	0.3	0.3	0.2	0.0	0.1	0.1	0.0
S012	NM005	Atrisco 3	64.7	0.53	3.5	5	RGA	100.00	na	na	na	na	-0.08	0.00	-0.48	0.00	0.31	0.30	-0.07	0.25	1.58	- 7.04	- 8.31	100.42	3.5	3.5	3.5	0.0	3.8	3.8	0.0
S025	NM012	Burton 2	47.7	0.40	5.9	6	RGA	99.33	Saline 1	0.67	na	na	-0.37	0.34	0.00	-0.24	0.00	-0.39	-0.30	0.18	1.25	- 8.84	- 9.08	99.14	5.9	5.8	5.8	0.1	6.6	6.6	0.1
S026	NM013	Burton 5	44.7	0.37	6.5	7	RGA	99.26	Saline 1	0.74	na	na	-0.32	0.39	0.00	-0.27	0.00	-0.40	-0.36	0.24	1.16	- 9.13	- 9.35	99.09	6.4	6.4	5.6	0.1	7.3	7.2	0.1
S033	NM025	Private Production Well #02	96.4	1.15	0.3	3	RGA	100.00	na	na	na	na	-0.76	0.95	0.00	-0.65	-1.29	-0.51	-0.18	0.24	3.65	- 9.79	-10.56	99.88	0.3	0.4	0.3	0.0	0.2	0.2	0.0
S040	NM028	Coronado 1	32.8	0.27	9.0	8	RGA	97.70	Saline 1	2.30	na	na	0.04	0.04	0.00	-0.03	0.57	0.00	-0.24	0.22	1.08	- 8.61	- 8.50	95.44	8.6	8.7	8.1	0.4	10.3	9.8	0.5
S043	NM488	Del Sol D	6.2	0.14	22.3	8	RGA	98.89	Saline 1	1.11	na	na	-0.19	0.51	0.00	-0.35	0.00	0.25	-0.30	0.24	1.31	- 9.00	- 8.27	98.66	22.2	22.3	21.7	0.1	25.7	25.6	0.1
S043	NM267	Del Sol D	6.4	0.09	22.1	7	RGA	98.92	Saline 1	1.08	na	na	-0.36	0.45	0.00	-0.31	0.00	0.11	-0.29	0.25	1.40	- 9.13	- 8.00	98.68	22.0	22.0	21.6	0.1	25.5	25.4	0.1
S044	NM489	Del Sol M	13.7	0.16	16.0	7	RGA	98.50	Saline 1	1.50	na	na	0.21	0.00	0.00	0.00	0.46	-0.11	-0.27	0.23	1.18	- 8.07	- 8.33	89.71	15.1	15.8	14.3	0.9	19.0	17.9	1.0
S044	NM268	Del Sol M	14.5	0.16	15.5	6	RGA	98.61	Saline 1	1.39	na	na	0.00	0.08	0.00	-0.06	0.34	-0.24	-0.25	0.27	1.25	- 8.74	- 8.00	98.35	15.4	15.4	15.1	0.1	18.4	18.2	0.2
S045	NM490	Del Sol S	62.2	0.48	3.8	6	RGA	96.54	Saline 1	3.46	na	na	-0.62	0.20	0.00	-0.14	0.00	-1.19	0.33	0.15	1.12	- 9.01	- 9.06	95.71	3.5	3.7	3.4	0.4	4.2	3.8	0.4
S046	NM032	Duranes 1	73.1	0.60	2.5	6	RGA	99.92	Saline 1	0.08	na	na	-0.35	0.30	0.00	-0.20	0.00	0.13	0.09	0.25	1.74	- 9.24	-10.86	99.86	2.5	2.5	0.9	0.0	2.7	2.7	0.0
S047	NM270	Duranes 7	72.0	0.64	2.6	5	RGA	100.00	na	na	na	na	0.13	0.00	0.03	0.00	0.64	0.35	0.02	0.34	1.11	- 8.22	- 9.10	94.47	2.2	2.7	2.2	0.5	2.8	2.3	0.5
S060	NM279	Garfield D	12.6	0.16	16.7	5	RGA	100.00	na	na	na	na	0.16	0.49	0.63	-0.34	0.00	0.95	0.08	0.28	0.93	- 9.02	- 8.40	94.81	16.2	16.7	15.2	0.4	19.7	19.2	0.5
S061	NM280	Garfield M	22.3	0.19	12.0	5	RGA	100.00	na	na	na	na	0.43	0.00	0.50	0.00	1.15	0.66	-0.09	0.28	0.87	- 8.11	- 8.60	86.30	10.9	12.1	10.9	1.2	14.1	12.7	1.5
S062	NM491	Garfield S	81.8	0.68	1.6	5	RGA	100.00	na	na	na	na	0.13	0.05	1.26	-0.03	-0.04	0.00	0.54	0.25	1.90	- 9.67	-10.70	96.26	1.3	1.7	1.3	0.3	1.7	1.3	0.3
S064	NM283	Domestic Well #22	82.8	0.69	1.5	4	RGA	99.98	Saline 1	0.02	na	na	-0.35	0.20	0.00	-0.14	0.00	-0.24	-0.02	0.30	1.57	- 9.13	- 9.70	99.92	1.5	1.5	1.5	0.0	1.6	1.6	0.0

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

							Source waters and percent in mixture					Mass transfer, millimoles per kilogram water																				
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
S068	NM057	Griegos 3	67.0	0.55	3.2	4	RGA	99.96	Saline 1	0.04	na	na	-0.36	0.52	0.75	-0.36	0.00	0.04	0.00	0.25	1.20	-10.21	- 8.81	99.89	3.2	3.2	2.8	0.0	3.5	3.5	0.0
S075	NM286	Hunter Ridge Nest 1 Well 1	25.3	0.22	11.0	3	RGA	99.98	Saline 1	0.02	na	na	0.33	0.00	0.00	0.00	0.57	0.81	-0.02	0.31	1.17	- 7.61	- 7.90	87.29	9.9	11.0	9.9	1.1	12.9	11.5	1.4
S076	NM287	Hunter Ridge Nest 1 Well 2	60.4	0.54	4.0	5	RGA	100.00	na	na	na	na	0.52	0.00	0.80	0.00	1.02	0.02	-0.07	0.26	0.79	- 8.26	- 9.80	85.26	2.8	4.0	2.8	1.3	4.4	3.0	1.5
S078	NM289	Hunter Ridge Nest 2 Well 1	73.8	0.62	2.4	5	RGA	100.00	na	na	na	na	-0.15	0.48	0.67	-0.33	-0.08	0.00	0.30	0.31	0.98	- 9.63	- 9.00	99.99	2.4	2.4	2.0	0.0	2.6	2.6	0.0
S081	NM292	Private Production Well #19	55.2	0.46	4.8	5	RGA	99.98	Saline 1	0.02	na	na	0.00	0.21	0.00	-0.14	0.33	-0.03	-0.23	0.26	1.24	- 8.85	- 8.80	99.98	4.8	4.8	4.8	0.0	5.3	5.3	0.0
S084	NM063	Windmill #04	79.5	0.66	1.8	8	RGA	99.94	Saline 1	0.06	na	na	-0.21	0.27	0.00	-0.19	0.00	0.09	-0.26	0.19	1.69	- 8.81	- 8.77	99.90	1.8	1.8	1.1	0.0	1.9	1.9	0.0
S087	NM493	Isleta MD	35.8	0.33	8.3	4	RGA	99.95	Saline 1	0.05	na	na	0.64	0.00	0.00	0.00	0.57	1.14	-0.18	0.25	1.13	- 6.91	- 7.92	77.43	6.2	6.8	6.2	2.1	9.4	7.0	2.5
S088	NM494	Isleta MS	72.3	0.51	2.6	4	RGA	99.93	Saline 1	0.01	na	na	0.18	0.00	0.00	0.00	0.37	0.03	-0.27	0.25	0.94	- 8.24	- 8.37	92.29	2.0	2.6	0.8	0.6	2.8	2.1	0.7
S089	NM495	Isleta S	118.2	0.83	- 1.3	3	RGA	100.00	na	na	na	na	-0.03	0.00	-0.34	0.00	-0.13	-0.13	-0.21	0.25	3.67	- 7.80	-12.49	100.25	- 1.3	- 1.4	- 1.4	0.0	- 1.8	- 1.8	0.0
S097	NM070	Kirtland 14	48.9	0.41	5.8	7	RGA	99.43	Saline 1	0.57	na	na	-0.23	0.36	0.00	-0.25	0.00	-0.37	-0.36	0.23	1.10	- 9.01	- 8.74	99.30	5.7	5.7	4.6	0.1	6.4	6.4	0.1
S102	NM074	Leyendecker 1	72.8	0.68	2.5	7	RGA	99.90	Saline 1	0.10	na	na	0.24	0.24	0.00	-0.17	0.00	-0.16	-0.25	0.22	0.93	- 7.89	- 8.92	89.89	1.7	2.5	- 0.2	0.9	2.7	1.8	1.0
S120	NM503	Mesa Del Sol D	6.0	0.19	22.6	8	RGA	99.44	Saline 1	0.56	na	na	0.29	0.49	0.00	-0.34	0.00	1.46	0.13	0.25	0.91	- 7.87	- 9.24	87.74	21.6	22.6	19.4	1.0	26.0	25.0	1.0
S121	NM504	Mesa Del Sol M	3.2	0.20	27.5	8	RGA	98.93	Saline 1	1.07	na	na	0.38	0.27	0.00	-0.19	0.00	1.05	-0.28	0.25	0.96	- 7.60	- 8.58	84.31	26.2	27.5	24.1	1.4	30.4	29.2	1.2
S121	NM302	Mesa Del Sol M	8.3	0.09	20.0	7	RGA	98.91	Saline 1	1.09	na	na	0.41	0.27	0.00	-0.19	0.00	1.10	-0.23	0.61	0.95	- 6.79	- 8.50	85.36	18.7	19.9	17.8	1.3	23.4	22.0	1.3
S124	NM082	Montaño 2 D	103.3	0.85	- 0.3	4	RGA	100.00	na	na	na	na	-0.30	0.00	-0.27	0.00	0.18	-0.29	-0.23	0.25	2.07	- 8.12	-10.03	100.21	- 0.2	0.5	- 0.3	0.0	- 0.5	- 0.5	0.0
S125	NM083	Montaño 2 M	109.8	0.94	- 0.7	4	RGA	100.00	na	na	na	na	-0.31	0.08	0.03	-0.06	0.00	-0.31	-0.15	0.25	2.35	- 9.23	-11.12	99.97	- 0.8	- 0.8	- 0.8	0.0	- 1.1	- 1.1	0.0
S127	NM085	Montaño 4 D	95.0	0.82	0.4	4	RGA	100.00	na	na	na	na	-0.32	0.00	-0.51	0.00	0.14	-0.29	-0.29	0.25	2.09	- 7.00	-11.07	100.46	0.4	0.5	0.4	0.0	0.3	0.3	0.0
S128	NM086	Montaño 4 M	113.6	0.97	- 1.0	5	RGA	100.00	na	na	na	na	0.50	0.16	1.25	-0.11	0.00	0.09	0.51	0.25	1.61	- 8.76	-12.34	87.24	- 2.1	- 1.1	- 2.1	1.1	- 1.4	- 2.8	1.4
S130	NM088	Montaño 5 D	97.6	0.95	0.2	5	RGA	100.00	na	na	na	na	0.01	0.00	0.32	0.00	0.57	0.04	0.02	0.25	1.13	- 9.26	- 9.00	99.42	0.2	0.2	0.2	0.0	0.1	0.0	0.1
S131	NM089	Montaño 5 M	95.0	0.81	0.4	5	RGA	100.00	na	na	na	na	0.27	0.00	0.50	0.00	0.03	0.01	0.05	0.25	0.90	- 8.61	- 8.51	90.72	- 0.4	0.4	- 0.4	0.8	0.3	- 0.6	0.9
S133	NM091	Montaño 6 D	25.2	0.23	11.1	6	RGA	100.00	na	na	na	na	-0.22	0.52	0.33	-0.36	0.00	0.08	-0.05	0.25	1.09	- 9.48	- 9.57	99.98	11.1	11.1	10.6	0.0	12.9	12.9	0.0
S134	NM092	Montaño 6 MD	38.0	0.31	7.8	6	RGA	100.00	na	na	na	na	-0.07	0.25	-0.21	-0.17	0.91	0.00	-0.11	0.25	0.95	- 8.17	- 8.62	100.17	7.8	7.8	7.4	0.0	8.8	8.9	0.0
S135	NM093	Montaño 6 MS	67.5	0.56	3.2	4	RGA	100.00	na	na	na	na	-0.51	0.39	-0.44	-0.27	0.00	-0.34	-0.23	0.25	1.40	- 7.31	- 7.69	100.41	3.2	3.2	3.1	0.0	3.4	3.5	0.0
S137	NM506	Montesa M	18.6	0.21	13.5	3	RGA	99.36	Saline 1	0.64	na	na	-0.03	0.00	0.00	0.00	0.84	-0.13	-0.31	0.25	1.04	- 8.94	- 8.97	99.23	13.4	13.4	13.4	0.1	15.9	15.9	0.1
S138	NM507	Montesa S	52.5	0.37	5.2	8	RGA	99.90	Saline 1	0.10	na	na	0.18	0.00	0.00	0.00	0.49	0.04	-0.29	0.20	1.02	- 8.00	- 9.28	92.11	4.5	5.2	4.0	0.7	5.7	5.0	0.8
S139	NM305	Domestic Well #27	43.4	0.31	6.7	5	RGA	100.00	na	na	na	na	0.27	0.00	0.47	0.00	1.02	0.11	-0.11	0.29	0.96	- 8.30	- 8.60	90.88	5.9	6.7	5.9	0.8	7.6	6.6	0.9
S142	NM307	Domestic Well #28	73.3	0.55	2.5	4	RGA	99.83	Saline 1	0.18	na	na	-0.53	0.23	-0.43	-0.16	0.00	-0.37	0.00	0.26	1.80	- 7.45	- 8.30	100.12	2.5	2.6	2.5	0.0	2.7	2.7	0.0
S146	NM309	NM Utilities 2	50.9	0.47	5.4	6	RGA	100.00	na	na	na	na	0.00	0.00	-0.31	0.00	0.51	0.09	-0.30	0.24	1.47	- 7.78	- 8.30	100.05	5.4	5.5	5.4	0.0	6.0	6.0	0.0
S151	NM508	Nor Este 3	47.6	0.35	6.0	6	RGA	100.00	na	na	na	na	0.01	0.23	-0.13	-0.16	0.00	0.41	-0.26	0.69	1.38	- 8.36	- 9.49	99.43	5.9	5.9	5.3	0.0	6.7	6.6	0.1
S153	NM315	Open Space	55.2	0.51	4.8	5	RGA	100.00	na	na	na	na	0.38	0.15	0.27	-0.11	0.31	0.00	-0.16	0.25	0.74	- 8.01	- 8.30	86.45	3.6	4.8	3.3	1.2	5.3	3.9	1.3
S155	NM316	Domestic Well #29	55.5	0.51	4.7	4	RGA	100.00	na	na	na	na	-0.33	0.03	-0.57	-0.02	0.00	-0.28	-0.32	0.26	1.75	- 6.82	- 8.50	100.48	4.8	4.8	4.7	0.0	5.2	5.3	0.0
S156	NM100	Paseo 2D	76.7	0.68	2.1	4	RGA	100.00	na	na	na	na	-0.36	0.01	-0.71	-0.01	0.00	-0.30	-0.25	0.25	1.75	- 5.72	- 8.27	100.75	2.2	2.2	2.1	- 0.1	2.3	2.3	- 0.1
S157	NM101	Paseo 2MD	102.6	0.84	- 0.2	4	RGA	100.00	na	na	na	na	-0.09	0.00	-0.21	0.00	0.00	-0.20	0.01	0.25	1.46	- 8.20	-10.46	100.17	- 0.2	- 0.2	- 0.2	0.0	- 0.4	- 0.4	0.0
S160	NM104	Paseo 3D	64.5	0.53	3.5	4	RGA	100.00	na	na	na	na	0.26	-0.08	0.99	0.00	0.52	-0.08	-0.25	0.24	0.79	- 9.13	- 8.66	92.48	2.9	3.5	2.9	0.6	3.8	3.1	0.7
S161	NM105	Paseo 3M	98.1	0.70	0.2	3	RGA	100.00	na	na	na	na	0.13	0.00	0.49	0.00	-0.04	-0.17	-0.13	0.25	2.76	- 9.03	-10.70	95.20	- 0.2	0.2	- 0.3	0.4	0.0	- 0.5	0.5
S171	NM321	Ridgecrest 4	46.1	0.43	6.2	7	RGA	98.85	Saline 1	1.15	na	na	0.00	0.14	0.00	-0.10	0.06	-0.38	-0.31	0.23	1.03	- 8.61	- 9.20	98.61	6.1	6.1	4.3	0.1	7.0	6.8	0.1
S173	NM323	Rio Bravo 5 M	97.3	1.11	0.2	4	RGA	99.92	Saline 1	0.08	na	na	0.36	0.00	0.00	0.00	0.80	0.93	0.08	0.33	1.05	- 7.52	- 9.70	86.20	- 1.0	0.2	- 1.0	1.2	0.1	- 1.3	1.4
S177	NM112	Rio Bravo 2 D	61.6	0.51	3.9	6	RGA	99.93	Saline 1	0.07	na	na	0.01	0.00	0.00	0.00	0.78	0.39	0.00	0.25	1.21	- 8.87	- 7.96	99.30	3.8	3.9	0.9	0.1	4.3	4.2	0.1
S178	NM113	Rio Bravo 2 M	78.4	0.64	2.0	4	RGA	99.28	Saline 1	0.72	na	na	-0.17	0.00	0.00	0.00	0.58	-0.04	0.10	0.25	1.54	- 9.04	-10.56	99.12	1.9	1.9	1.8	0.1	2.1	2.0	0.1
S179	NM114	Rio Bravo 2 S	99.5	0.85	0.0	7	RGA	99.91	Saline 1	0.09	na	na	-0.18	0.17	0.00	-0.12	0.00	-0.02	-0.06	0.25	1.94	- 9.08	-10.31	99.88	0.0	0.0	- 1.4	0.0	- 0.1	- 0.1	0.0
S180	NM115	Rio Bravo 4 D	34.6	0.29	8.5	7	RGA	99.47	Saline 1	0.53	na	na	0.01	0.00	0.00	0.00	0.69	-0.34	-0.31	0.25	1.01	- 8.88	- 9.05	98.95	8.4	8.5	8.0	0.1	9.7	9.6	0.1
S181	NM116	Rio Bravo 4 M	77.7	0.75	2.0	5	RGA	97.42	Saline 1	2.58	na	na	-0.55	0.00	0.00	0.00	0.46	-0.96	0.42	0.24	1.31	- 9.48	-10.84	96.91	1.8	1.9	1.7	0.3	2.1	1.9	0.3
S183	NM126	Rio Grande Utility 5	33.2	0.30	8.9	8	RGA	99.47	Saline 1	0.53	na	na	0.00	0.00	0.00	0.00	0.00	0.66	-0.09	0.23	1.25	- 8.81	- 8.12	99.08	8.8	8.8	6.0	0.1	10.2	10.1	0.1
S184	NM127	Rio Grande Utility 6	51.3	0.46	5.4	4	RGA	100.00	na	na	na	na	0.15	0.00	0.45	0.00	0.81	-0.04	-0.22	0.25	0.87	- 8.95	- 8.30	94.77	4.9	5.3	5.0	0.4	6.0	5.4	0.5
S190	NM325	Rio Rancho 2	71.6	0.66	2.7	6	RGA	99.05	Saline 1	0.95	na	na	-0.11	0.34	0.04	-0.23	0.00	-0.51	0.00	0.34	1.12	- 8.53	- 8.60	98.91	2.6	2.6	1.7	0.1	2.9	2.8	0.1
S203	NM331	Private Production Well #20	77.1	0.54	2.1	4	RGA	99.98	Saline 1	0.02	na	na	0.72	0.00	0.00	0.00	0.03	-0.05	0.16	0.31	1.35	- 6.46	- 8.76	75.67	- 0.1	0.0	- 0.1	2.2	2.2	- 0.3	2.6
S205	NM333	Private Production Well #21	58.8	0.41	4.3	5	RGA	100.00	na	na	na	na	0.91	0.00	2.03	0.00	2.02	0.07	0.20	0.31	0.48	- 8.49	- 8.40	82.53	2.7	4.3	2.7	1.5	4.7	2.9	1.8

Table 10. Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

							Source waters and percent in mixture					Mass transfer, millimoles per kilogram water																			
Site no.	Sample no.	Site name	^{14}C activity (pmC)	^{14}C ± 1 σ (pmC)	Conventional, unadjusted ^{14}C age, Libby half-life (ka)	No. of mass balance models found	Primary water	Percent primary water	Secondary water	Percent secondary water	Additional secondary water	Percent additional secondary water	Calcite	Plagioclase feldspar	CO_2	Kaolinite	SiO_2	Ca-Na cation exchange	Gypsum	CH_2O	Evaporation factor	[1] Calculated $\delta^{13}C$ (per mil)	Observed $\delta^{13}C$ (per mil)	Initial ^{14}C activity adjusted for geochemical reactions (pmC)	Adjusted ^{14}C Age Libby half-life (ka)	Maximum adjusted ^{14}C Age Libby half-life (ka)	Minimum adjusted ^{14}C Age Libby half-life (ka)	Difference unadjusted ^{14}C age minus adjusted age, Libby half-life (ka)	Unadjusted ^{14}C calendar years (ka)	Adjusted ^{14}C calendar years (ka)	Difference unadjusted calendar years minus adjusted calendar years (ka)
S208	NM140	San Jose 2	29.1	0.25	9.9	8	RGA	99.33	Saline 1	0.67	na	na	0.00	0.03	0.00	-0.02	0.90	0.18	-0.02	0.23	1.01	- 8.82	- 8.65	99.19	9.9	9.9	7.0	0.1	11.5	11.4	0.1
S210	NM511	Sandia D	15.3	0.16	15.1	8	RGA	98.69	Saline 1	1.31	na	na	0.00	0.19	0.00	-0.13	0.08	0.41	-0.22	0.22	1.47	- 8.78	- 8.66	98.42	14.9	15.0	13.2	0.1	17.8	17.7	0.1
S214	NM513	Sandia S	62.9	0.48	3.7	7	RGA	97.34	Saline 1	2.66	na	na	0.09	0.00	0.00	0.00	0.20	-0.47	-0.02	0.24	1.28	- 8.52	- 9.31	93.16	3.2	3.5	1.6	0.6	4.1	3.4	0.6
S220	NM147	Santa Barbara 1	49.1	0.46	5.7	6	RGA	99.90	Saline 1	0.10	na	na	0.00	0.10	0.00	-0.07	0.32	-0.08	-0.17	0.24	0.99	- 8.88	- 8.97	99.88	5.7	5.7	5.3	0.0	6.4	6.4	0.0
S231	NM517	Sierra Vista M	34.2	0.28	8.6	5	RGA	100.00	na	na	na	na	0.92	0.00	0.16	0.00	1.08	1.60	-0.02	0.25	0.88	- 6.55	- 8.24	71.80	5.9	8.7	5.9	2.7	9.9	6.6	3.2
S232	NM518	Sierra Vista S	68.9	0.49	3.0	7	RGA	99.69	Saline 1	0.31	na	na	0.21	0.44	1.05	-0.31	0.00	0.58	0.00	0.22	1.04	- 8.88	- 9.92	93.51	2.5	3.0	1.8	0.5	3.2	2.6	0.6
S234	NM339	Sister Cities D	8.0	0.11	20.3	5	RGA	98.47	Saline 1	1.53	na	na	0.22	0.00	0.59	0.00	0.92	0.37	-0.09	0.25	1.00	- 8.73	- 7.30	91.32	19.5	20.2	19.6	0.7	23.7	22.9	0.8
S235	NM340	Sister Cities M	66.3	0.46	3.3	5	RGA	100.00	na	na	na	na	0.26	0.27	0.57	-0.19	0.00	-0.08	-0.30	0.32	0.77	- 8.62	- 8.80	91.65	2.6	3.3	2.0	0.7	3.6	2.8	0.8
S244	NM158	SWAB 3 - 760	44.1	0.51	6.6	5	RGA	100.00	na	na	na	na	-0.08	0.07	-0.63	-0.05	0.00	0.06	-0.50	0.25	1.27	- 6.20	- 9.81	100.61	6.6	6.6	6.6	- 0.1	7.4	7.5	- 0.1
S245	NM159	SWAB 3 - 980	44.1	0.37	6.6	4	RGA	100.00	na	na	na	na	-0.47	0.66	0.00	-0.45	-0.46	-0.26	-0.54	0.25	0.99	- 9.23	- 9.06	99.97	6.6	6.6	6.6	0.0	7.4	7.4	0.0
S253	NM522	Tome D	8.8	0.14	19.5	8	RGA	98.89	Saline 1	1.11	na	na	0.22	0.00	0.00	0.00	0.56	0.51	-0.22	0.25	1.11	- 8.08	- 8.00	89.54	18.6	19.4	17.9	0.9	22.9	22.0	0.9
S257	NM344	Domestic Well #34	85.3	0.63	1.3	6	RGA	99.76	Saline 1	0.24	na	na	0.04	0.09	0.00	-0.07	0.00	-0.07	-0.14	0.30	2.05	- 8.64	-10.80	97.96	1.1	1.3	0.7	0.2	1.3	1.1	0.2
S259	NM171	VGP-1	123.1	1.02	- 1.7	3	RGA	100.00	na	na	na	na	0.29	0.00	0.24	0.00	-0.02	0.00	0.16	0.25	2.28	- 8.26	-11.58	89.47	- 2.6	- 1.7	- 2.5	0.9	- 2.2	- 3.4	1.2
S261	NM172	Volandia 2	70.6	0.60	2.8	5	RGA	100.00	na	na	na	na	-0.39	0.74	0.00	-0.51	-0.73	-0.40	-0.29	0.23	1.13	- 9.16	- 8.63	99.96	2.8	2.8	2.3	0.0	3.0	3.0	0.0
S262	NM173	Volandia 5	57.8	0.49	4.4	7	RGA	99.73	Saline 1	0.27	na	na	-0.13	0.20	0.00	-0.14	0.00	-0.25	0.09	0.24	1.00	- 8.97	- 9.80	99.66	4.4	4.4	2.8	0.0	4.8	4.8	0.0
S265	NM175	Webster 1	45.5	0.39	6.3	8	RGA	98.86	Saline 1	1.14	na	na	0.11	0.00	0.00	0.00	0.52	0.07	-0.28	0.22	1.14	- 8.35	- 8.50	94.04	5.8	6.2	5.2	0.5	7.1	6.5	0.6
S267	NM348	West Bluff Nest 1 Well 2	32.3	0.25	9.1	2	RGA	99.91	Saline 1	0.09	na	na	-0.12	0.68	0.70	-0.47	0.00	0.41	0.00	0.46	0.98	- 9.39	- 9.20	99.91	9.1	9.0	8.4	0.0	10.4	10.4	0.0
S269	NM350	West Bluff Nest 2 Well 1	63.5	0.45	3.6	6	RGA	99.96	Saline 1	0.04	na	na	-0.49	0.49	0.00	-0.34	-0.17	0.00	0.09	0.30	1.38	- 9.25	- 8.40	99.88	3.6	3.6	3.6	0.0	4.0	4.0	0.0
S275	NM178	Yale 1	39.2	0.35	7.5	4	RGA	100.00	na	na	na	na	-1.38	1.42	0.00	-0.98	-1.69	-0.72	-0.42	0.23	2.71	-10.63	- 9.90	99.79	7.5	7.6	7.5	0.0	8.5	8.5	0.0
		No Zone: Exotic Water																													
S023	NM010	Burn Site Well	49.6	0.41	5.6	3	EMF	97.76	Saline 1	2.24	na	na	0.00	0.00	1.46	0.00	-0.14	-0.41	1.25	0.00	1.05	-11.93	- 7.70	98.88	5.6	5.6	5.5	0.1	6.3	6.2	0.1
S057	NM044	Embudo Spring	111.0	1.13	- 0.8	3	EMF	100.00	na	na	na	na	0.18	0.00	2.20	0.00	-0.08	-0.03	0.47	0.00	1.25	-11.65	-13.20	97.12	- 1.1	- 0.9	- 1.1	0.2	- 1.2	- 1.5	0.3
S063	NM282	Windmill #22	46.4	0.50	6.2	2	EMF	100.00	na	na	na	na	-1.41	0.00	-1.99	0.00	-0.37	-0.25	-0.05	0.00	13.27	- 3.22	- 5.60	101.70	6.3	6.3	6.1	- 0.1	6.9	7.1	- 0.2
S067	NM284	Granite Hill	34.5	0.29	8.5	3	EMF	90.88	TIJ	9.12	na	na	-0.96	0.37	0.00	-0.26	-0.59	0.00	0.53	0.00	1.73	-11.92	- 7.90	98.68	8.4	8.3	8.4	0.1	9.8	9.7	0.1
S070	NM059	HERTF	40.6	0.38	7.2	2	EMF	97.75	Saline 1	2.25	na	na	0.00	0.00	0.41	0.00	0.06	-0.50	0.55	0.00	0.94	-11.92	- 7.50	98.58	7.1	7.1	7.1	0.1	8.2	8.1	0.1
S091	NM496	Private Production Well #23	93.8	0.66	0.5	4	JRW	98.99	Saline 1	1.01	na	na	1.29	0.00	2.80	0.00	0.52	0.33	-0.42	0.00	1.00	- 6.40	-10.16	78.75	- 1.4	- 1.0	- 2.2	1.9	0.4	- 1.9	2.3
S094	NM293	Stock Well #02	79.3	0.61	1.9	4	Precip.	100.00	na	na	na	na	0.70	0.11	1.37	-0.07	0.00	1.16	0.42	0.00	3.28	- 7.50	- 5.50	66.28	- 1.4	1.8	- 2.0	3.3	2.0	- 1.9	3.9
S112	NM297	Domestic Well #24	13.6	0.12	16.0	2	EMF	97.78	Saline 1	2.22	na	na	-1.52	0.06	0.00	-0.04	0.00	-0.21	1.30	0.00	1.53	-13.34	- 7.20	98.07	15.9	15.9	15.9	0.2	19.0	18.8	0.2
S152	NM098	Private Production Well #07	62.7	0.55	3.7	4	JRW	94.56	Saline 1	5.44	na	na	-0.07	0.13	2.34	-0.09	0.00	-2.12	0.17	0.00	1.00	- 7.82	- 6.11	99.99	3.7	3.8	3.7	0.0	4.1	4.1	0.0
S202	NM330	Windmill #27	47.2	0.35	6.0	3	LUC	99.86	ASSP	0.14	na	na	-8.48	0.00	0.00	0.00	0.10	-0.99	7.80	0.00	0.72	- 6.21	- 4.70	99.42	6.0	6.0	6.0	0.0	6.8	6.7	0.1
S211	NM512	Sandia M	10.4	0.14	18.2	7	EMF	93.95	Saline 1	6.05	na	na	-0.59	0.69	0.00	-0.48	0.00	0.73	0.10	0.00	0.81	-11.96	- 8.20	95.72	17.8	18.0	17.2	0.3	21.4	21.0	0.4
S250	NM165	Private Production Well #10	51.3	0.43	5.4	4	EMF	99.86	Saline 1	0.14	na	na	-0.51	0.19	0.00	-0.13	-0.25	0.00	0.21	0.00	1.21	-12.21	-11.00	99.86	5.4	5.3	5.3	0.0	6.0	5.9	0.0
S256	NM169	Tunnel Spring	92.6	0.77	0.6	4	EMF	100.00	na	na	na	na	5.64	0.10	7.18	-0.16	0.00	-0.16	0.26	0.00	0.35	- 7.92	-11.30	65.99	- 2.7	0.6	- 2.7	3.3	0.5	- 3.6	4.2
S258	NM524	Vallecito Springs	43.4	0.33	6.7	2	NMF	99.94	Saline 1	0.06	na	na	0.68	0.00	2.24	0.00	-0.70	0.48	0.22	0.00	1.00	-10.41	-10.07	86.71	5.6	5.5	5.5	1.1	7.6	6.2	1.4
S273	NM176	Windmill #11	36.5	0.34	8.1	4	SWMF	100.00	na	na	na	na	-1.02	0.14	-0.61	-0.10	-0.54	0.00	0.04	0.00	2.45	-10.77	- 3.99	100.25	8.1	8.2	8.1	0.0	9.2	9.3	0.0
S282	NM529	Windmill #44	51.6	0.38	5.3	1	JRW	62.41	Saline 1	37.59	na	na	-2.14	0.00	2.99	0.00	0.22	-9.08	6.98	0.00	1.00	-10.19	- 8.47	81.67	3.7	3.7	3.7	1.6	5.9	4.0	1.9

[1] NETPATH models were constructed assuming an initial $\delta^{13}C$ of -12 per mil, similar to that found in modern recharge waters.

and other end-member source-water compositions used in the geochemical models are given in table 4. In many cases, the chemical compositions of the source waters represent averages of sample compositions from the NWIS surface-water database, or in the cases of ASSP, Saline Water 1 and Saline Water 2, the compositions are those of individual samples collected as a part of this investigation (see table 4).

Phases

Phases considered in the geochemical models as possible reactants and products included calcite, plagioclase feldspar (AN_{38}), carbon dioxide gas, kaolinite, silica, gypsum, Ca/Na exchange, and, in areas undergoing redox reactions, organic carbon (designated CH_2O for carbon of oxidation state zero). The choices of phases considered are only representative of groups of phases that can occur in the MRGB.

The models also included the possibility of evapotranspiration or dilution. Evapotranspiration or dilution factors are computed in NETPATH as a special case of mixing, in which an initial water, which can mix with various natural sources (such as surface waters) mixes with an additional initial water (pure water; addition or removal). Both evaporation and dilution factors are computed in NETPATH as positive numbers (≥ 1). If dilution occurs, NETPATH divides the initial concentrations by the evaporation factor, resulting in a decrease in concentration. In evaporation, all initial concentrations are increased (multiplied) by the evaporation factor in NETPATH. See Plummer and others (1994) for further details on how evaporation is calculated in NETPATH. The dilution factor is the inverse of the evaporation factor in table 10, i.e., values of the evaporation factor <1.

Carbon Isotopic Composition of Sources

The initial ^{14}C activity of source waters was assumed to be 100 pmC for DIC in precipitation and mountain-front recharge (as discussed above), and was assumed to be the measured value for surface waters and samples ASSP, Saline Water 1 and Saline Water 2 (see table 4). The ^{14}C activity of DIC in ground-water inflow was assumed to be low (2 pmC). Only one measurement of ^{14}C activity of DIC in water from the Rio Puerco was available (64 pmC). Additional calculations were made in which the ^{14}C activity of DIC in Rio Puerco water was assumed to be 100 pmC. This value was used to represent possible conditions during times of high flow/runoff.

Values of $\delta^{13}C$ of DIC in source waters were assigned using logic similar to that used to assign ^{14}C activities. Consequently, $\delta^{13}C$ of DIC in mountain-front waters was set to a value of -12 per mil, which is that observed in ground water in areas where mountain-front recharge occurs. From several lines of evidence (see discussion in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon"), there may have been a higher abundance of C_4 plants in recharge areas of the MRGB in the past than today, resulting in $\delta^{13}C$ values of recharge waters more positive than that observed today ($\delta^{13}C$ of recharge near -8 per mil, historically). However, in all the geochemical models constructed, a $\delta^{13}C$ value of -12 per mil was used (see table 4) that is consistent with modern observations. Because the stable carbon isotopes were not used to constrain the geochemical reactions, the calculated mass transfers do not depend on the assumed initial value of $\delta^{13}C$ of DIC in recharge waters. However, the difference between the calculated $\delta^{13}C$ of DIC and the assumed initial value of -12 per mil gives an indication of the relative extent of carbonate reactions in the aquifer system. If the geochemical reactions can be shown to have little effect on the $\delta^{13}C$ of DIC in the aquifer, this indicates that the initial $\delta^{13}C$ of DIC recharged to the aquifer system was near the value observed in ground water. Consequently, it may be possible to use the observed $\delta^{13}C$ values to infer paleoclimatic conditions and possible historical variations in C_3 and C_4 plant abundance in recharge areas of the MRGB.

Model Results

Results of the geochemical modeling exercise for each ground-water sample are summarized in table 10. The results are grouped by hydrochemical zones and include, for each water analysis, the measured ^{14}C activity of DIC and unadjusted radiocarbon age (Libby half-life), the number of models found by NETPATH, and results from one "representative" model for each water. The representative model includes the primary initial water and the percent of the primary initial water (100 percent if mixing is not included), names and percentages of other source waters in mixtures, mass transfers of calcite, plagioclase feldspar, carbon dioxide, kaolinite, silica, cation exchange, gypsum, and organic matter, the value of the evaporation factor (>1.0

for evaporation, <1.0 for dilution), the calculated and observed $\delta^{13}C$, the initial ^{14}C activity after adjustment for the calculated geochemical reaction (A_{nd}), the adjusted radiocarbon age (Libby half-life), and the maximum and minimum adjusted radiocarbon ages found for all the models by NETPATH. For samples in the Rio Puerco zone (zone 5), table 10 includes calculations in which the ^{14}C activity of DIC in Rio Puerco water was assumed to be 64 pmC. Additional calculations (not shown in table 10) were made for the zone 5 waters in which the ^{14}C activity of DIC in Rio Puerco water was assumed to be 100 pmC, yielding adjusted ages about 2 ka older than those calculated at 64 pmC.

Evapotranspiration

The initial waters used in the NETPATH models (table 4) were averaged and/or representative recharge waters observed along the basin margins and/or representative surface waters. Consequently, all evapotranspiration/dilution factors were calculated relative to these starting waters, rather than with respect to the composition of precipitation. The geochemical mass transfer calculations indicate net evaporation (evapotranspiration) throughout most of the MRGB, except in the Western Boundary and Eastern Mountain Front zones, where overall dilution (modeled with pure water) is indicated. Several hydrochemical processes would lead to a calculation of "dilution" in the NETPATH models. During periods of wetter climate, mountain-front recharge waters may have contained less dissolved Cl, as well as other ions, than in the initial waters of table 4. Thus, NETPATH would calculate a dilution factor to produce more dilute observed samples. Occassionally, dilution was also noted in other waters with mountain-front recharge sources, though, in general, the effect throughout the hydrochemical zone was of evaporation. Dilution was also commonly found in the Western Boundary zone. Waters in the Western Boundary zone were modeled primarily as mixtures of arroyo recharge (using source water LUC, table 4) along the basin margin with inflow of saline ground water, which was assumed to have composition of the water sampled at Arroyo Salado Spring (sample ASSP, table 4). The calculated dilution factor for the Western Boundary zone may reflect uncertainty in source-water composition, although the possibilities of dilution from local infiltration of meteoric water or of historical variations in the salinity of Rio Puerco water also cannot be excluded. Water in the Rio Puerco, Abo Arroyo, and Central zones is dominated by infiltration of surface water. There may be historical variations in surface-water composition beyond the discharge-weighted average compositions given in table 4. For example, it is possible that the composition of the Rio Grande was more dilute at times in the past than today. Net evaporation for most ground waters with surface-water sources was calculated in NETPATH, probably because the concentrating effect of evapotranspiration in river valleys exceeds historical variations in surface-water composition. In the Rio Puerco zone, the calculated evaporation factor varies widely among individual water samples (0.3 (dilution) to 3.3 (evaporation)), which may indicate, in part, historical variations in the salinity of Rio Puerco water.

Mixing Fractions of Source Waters

The possibility that many of the waters of the MRGB are mixtures of 2 or more source waters was considered. Potential for upward leakage of saline water was considered throughout the basin. There are only limited data available on the composition of saline water in the MRGB. However, some wells and springs located near faults contain high fractions of saline water. Two analyses of saline water collected as a part of this investigation were included in the modeling. One sample, designated "Saline Water 1" is predominantly a NaCl-type water from a domestic well (S054, NM041) (table 4). "Saline Water 1" was considered to be representative of upward leakage of NaCl-type saline waters throughout most of the basin. A second saline water, designated "Saline Water 2", is a Na-Ca-HCO_3-Cl-type water that discharges from Coyote Spring (S041, NM029) associated with the Tijeras Fault Zone in the Monzano Mountains. This water type is thought to be representative of saline sources locally in Tijeras Arroyo and in the Tijeras Fault Zone area. Although the composition of saline waters probably varies in different parts of the basin, the consistent use of "Saline Water 1" through most parts of the basin provides a relative scale for comparison on a regional basis. The mathematical solution to the evaporation factor, mixing fraction(s), and mass transfer was based in NETPATH on the solution to the entire set of mass-balance equations and constraints, and, because there were no constraints that were independent of the solution compositions, could not be based on a single constraint such as Cl.

Ranges and averages of the percent contribution from the primary and secondary water in each sample are summarized by hydrochemical zone in table 11. The geochemical models indicate that most samples in the Northern Mountain Front, Northwestern, West Central, Southwestern Mountain Front, and Eastern Mountain Front zones contain typically more than 90-percent mountain-front source water that has mixed with generally low fractions of saline upward leakage water. The fractions of "Saline Water 1" were lowest in the Northwestern and Southwestern Mountain Front zones, and averaged 1.5, 0.7, and 1.0 percent in the Northern Mountain Front, West Central, and Eastern Mountain Front zones, respectively.

The geochemical models indicate that water samples from the Western Boundary and Rio Puerco zones contain, on average, 7.8 and 7.4 percent, respectively, of ground-water inflow from sources along the western margin of the basin. Water samples in the Rio Puerco zone contain an average of approximately 93 percent Rio Puerco water. Water samples from the Abo Arroyo zone were predominantly of Eastern Mountain Front origin mixed with an average of 28 percent Abo Arroyo water. Water from the Central zone was almost entirely of Rio Grande origin, averaging 99.6 percent water of Rio Grande origin (range 96.5-100 percent), which was mixed with "Saline Water 1". Waters from the Tijeras Fault Zone and Tijeras Arroyo were found to be complex mixtures of Eastern Mountain Front water with varying fractions of Tijeras Arroyo water and "Saline Waters 1 and 2". Water in the Northeastern zone is apparently complex mixtures of Eastern Mountain Front water, Northeast Ground-Water Inflow, surface water from Galisteo Creek, and "Saline Water 1" (table 11).

Mineral Mass Transfer

The average values of mineral mass transfer, in millimoles per kilogram of water (mmol/kg water), for each hydrochemical zone and the average calculated evaporation factor are summarized in table 12. The calculated average mass transfers are generally quite low, yet there is probably some significance to the differences in values between hydrochemical zones. The NETPATH models indicate that, on average, there is net precipitation of low amounts of calcite through most of the MRGB. The exception is the West-Central zone, where low calculated amounts of calcite dissolve in association with low increases in Ca/Na cation exchange. The calculated net calcite mass transfer is near zero in other parts of the basin (Northern Mountain Front, Northwestern, and Central zones). The calculations indicate that low amounts of plagioclase feldspar weathering occur throughout the MRGB. Small masses of kaolinite, and probably other clay minerals, were calculated to form throughout the basin as primary aluminosilicate minerals such as plagioclase feldspars dissolve.

Table 11. Summary of predominant ground-water sources by hydrochemical zone for the Middle Rio Grande Basin, New Mexico

[no, number; na, not applicable; NMF, Northern Mountain Front; Saline 1, NM041; RP, discharge-weighted average National Water Information System (NWIS) Rio Puerco; RGA, discharge-weighted average NWIS Rio Grande at Albuquerque; MWGW, Mid-West Ground-Water Inflow; SWGW, Southwest Ground-Water Inflow; SWMF, Southwestern Mountain Front, NWIS; EMF, Eastern Mountain Front, median; ABO, median Abo Arroyo; Saline 2, Coyote Spring, NM029; TIJ, discharge-weighted average NWIS Tijeras Arroyo; NEGW, Northeast Ground-Water Inflow; GAL, Galesteo Creek above Galisteo Reservoir, used as arroyo source in hydrochemical zone 11; ASSP, Arroyo Salado Spring; LUC, Lucero-24, Los Alamos National Laboratory, Representative of southwest arroyo water]

Zone no.	Hydrochemical zone	Primary water	Percent range of primary water	Average percent of primary water	Secondary water	Percent range of secondary water	Average percent of secondary water	Additional secondary water	Percent range of additional secondary water	Average percent of additional secondary water
1	Northern Mountain Front	NMF	92.3 - 100	98.5	Saline 1	0 - 7.3	1.5	na	na	na
2	Northwestern	NMF	97.1 - 100	99.9	Saline 1	0 - 2.9	0.1	na	na	na
3	West Central	NMF	92.5 - 100	99.3	Saline 1	0 - 7.5	0.7	na	na	na
4	Western Boundary	LUC	84.0 - 100	92.2	ASSP	0 - 16.0	7.8	na	na	na
5	Rio Puerco	RP	77.6 - 100	92.6	MWGS or SWGW	0 - 22.4	7.4	na	na	na
6	Southwestern Mountain Front	SWMF	100	100.0	Saline 1	0	0.0	na	na	na
7	Abo Arroyo	EMF	47.7 - 100	72.1	ABO	0 - 52.3	27.9	na	na	na
8	Eastern Mountain Front	EMF	89.5 - 100	99.0	Saline 1	0 - 10.5	1.0	na	na	na
9	Tijeras Fault Zone	EMF	61.2 - 100	89.5	Saline 1,2	0 - 38.8	10.5	na	na	na
10	Tijeras Arroyo	EMF	2.9 - 92.3	61.6	TIJ	9.1 - 91.6	37.4	Saline 2	0 - 6.6	1.6
11	Northeastern	EMF	14.2 - 98.9	66.3	NEGW, GAL	1.1 - 85.8	33.4	Saline 1	0 - 2.0	0.3
12	Central	RGA	96.5 - 100	99.6	Saline 1	0 - 3.5	0.4	na	na	na

Table 12. Summary of average mineral mass transfers and evaporation factor by hydrochemical zone for ground water from the Middle Rio Grande Basin, New Mexico

[no., number; mmols per kg water, millimoles per kilogram of water; CH_2O, organic carbon; evaporation factor greater than 1 for evaporation, less than 1 for dilution; mineral mass transfer negative for precipitation (outgassing), positive for dissolution; nd, not detected.]

Zone no.	Hydrochemical zone	Average mass transfer (mmols per kg water)								Evap-oration Factor
		Calcite	Plag-ioclase	CO_2	Kaol-inite	SiO_2	Ca-Na Ex-change	Gypsum	CH_2O	
1	Northern Mountain Front	0.1	0.3	1.1	- 0.2	- 0.2	- 0.2	0.1	nd	1.1
2	Northwestern	0.1	0.0	0.0	0.0	0.0	0.8	0.3	nd	1.1
3	West Central	0.4	0.1	0.3	- 0.1	- 0.4	1.8	0.9	nd	1.1
4	Western Boundary	- 4.0	0.1	- 0.2	- 0.1	0.3	2.9	7.3	nd	0.7
5	Rio Puerco	- 2.0	0.2	1.4	- 0.1	0.2	- 3.2	1.2	nd	1.2
6	Southwestern Mountain Front	- 1.0	0.1	- 1.2	- 0.1	- 0.5	0.0	0.0	nd	2.2
7	Abo Arroyo	- 0.7	0.1	- 0.6	- 0.1	- 0.1	0.0	- 0.4	nd	3.4
8	Eastern Mountain Front	- 0.3	0.3	0.4	- 0.2	- 0.2	0.1	0.2	nd	0.9
9	Tijeras Fault Zone	- 0.8	0.6	- 0.1	- 0.4	- 0.8	- 0.3	0.6	nd	2.1
10	Tijeras Arroyo	- 0.9	0.2	0.0	- 0.1	- 0.2	- 0.1	0.7	nd	1.1
11	Northeastern	- 1.2	0.6	- 0.2	- 0.4	- 0.7	0.4	1.6	nd	1.5
12	Central	0.0	0.2	0.1	- 0.1	0.2	0.1	- 0.1	0.3	1.3

Additional sources of carbon included CO_2 gas and organic matter (CH_2O). The CO_2 mass transfer is expected to be low, as most ground-water systems are closed to gas exchange after recharge. Although the calculated CO_2 mass transfers are not zero, they are low and reflect, in part, uncertainties in the DIC content of paleorecharge waters, as well as small analytical errors that are ultimately compensated for in NETPATH in the calculated masses of neutral phases like CO_2 and CH_2O. Cation exchange (release of Na and uptake of Ca) appears to occur in the Northwestern, West Central, Western Boundary, and Northeastern zones, and as uptake of Na and release of Ca in the Rio Puerco zone. Gypsum occurrence is low or zero throughout most of the MRGB sediment, except in parts of the Western Boundary, Rio Puerco, and Northeastern zones, where the calculated mass of gypsum dissolution is higher than in other hydrochemical zones. The small differences in gypsum mass transfer outside of the Western Boundary and Rio Puerco zones probably reflect, at least in part, uncertainty in the calcium sulfate content of source waters to the MRGB. Redox reactions were considered only in the Central zone, where anoxic conditions are present in the inner valley of the Rio Grande. On average, a net oxidation of organic matter of 0.28 mmols/kg was calculated for waters in the inner valley of the Rio Grande. Inclusion of iron sulfide and ferric hydroxide phases in the models with redox and iron constraints indicated, in most models, oxidation of pyrite, as indicated in the sulfur-34 data of figure 36.

Adjusted and Unadjusted Radiocarbon Ages

In most cases, the adjusted radiocarbon age is nearly identical to the unadjusted radiocarbon age, indicating that geochemical reactions do not appreciably affect the calculated ages (table 10). The magnitude of the geochemical adjustments can be judged by the magnitude of the differences in unadjusted and adjusted ages. For zones 1-12, respectively, the average differences in unadjusted and adjusted radiocarbon ages (both ages calculated using the Libby half-life) are 0.5, 1.2, 1.0, 1.2, 4.9, -0.1, 0.2, 0.1, 3.7, 1.3, 2.5, and 0.3 ka, respectively. The largest differences between unadjusted and adjusted radiocarbon ages are for some waters from the Rio Puerco, Tijeras Fault Zone, and Northeastern zones, and result from mixing with high fractions of old ground water with low ^{14}C activity. The geochemical modeling found mixtures containing as much as 22 percent of Southwest Ground-Water Inflow (^{14}C activity assumed to be 2 pmC) in the Rio Puerco zone. In the Tijeras Fault Zone zone, the sample from SFR-3S (S228) contained nearly 39 percent of Saline 2 water (^{14}C activity assumed to be 5 pmC), and in the Northeastern zone, 3 of the 7 waters contained 34 – 48 percent of Northeastern Ground-Water Inflow (^{14}C activity

assumed to be 2 pmC). Most of the samples from the Northern Mountain Front, Northwestern, West-Central, Western Boundary, Southwestern Mountain Front, Abo Arroyo, Eastern Mountain Front, Tijeras Arroyo, and Central zones have adjusted ages nearly identical to the unadjusted age because the geochemical mass transfers are small and the samples contain low fractions of old ground-water inflow or old saline sources.

Sensitivity of the Radiocarbon Age to Reaction Uncertainty

Sensitivity calculations, in which compositions of clays, feldspars, and ion exchangers were varied within reasonable limits, did not appreciably alter adjusted ^{14}C ages. Other calculations were made to test the possibility of isotopic exchange of calcite with the ground water DIC. If calcite/limestone fragments in the sediment of the MRGB recrystallize, they can exchange their ^{13}C and ^{14}C isotopic composition with that of the DIC in ground water. Because most carbonate minerals in the sediment are enriched in ^{13}C and depleted in ^{14}C relative to the isotopic composition of HCO_3 in recharge waters, isotopic exchange would, in effect, increase the $\delta^{13}C$ of HCO_3^- and lower the adjusted ^{14}C activity, resulting in adjusted radiocarbon ages that are younger than those calculated in samples unaffected by carbon isotope exchange. In many cases, particularly with waters near mountain-front recharge areas, whereas inclusion of isotopic exchange could improve the agreement in calculated and observed $\delta^{13}C$, the resulting adjusted radiocarbon age was impossibly young (negative age) in samples that from other hydrologic considerations are likely to be several to perhaps ten thousand years in age. Because most samples appear to have a net flux of calcite precipitation, further isotopic exchange with surfaces of secondary calcites would probably not appreciably alter the ^{13}C and ^{14}C isotopic composition of the DIC in ground water.

Other calculations in which the compositions of cation exchangers and clay minerals were varied had little effect on the adjusted radiocarbon age. There are three reasons why the adjusted radiocarbon ages are insensitive to uncertainty in composition of reactant and product minerals-- (1) silicate weathering reactions, which have little or no effect on the ^{14}C activity of the DIC, predominate, (2) mineral mass transfers that do occur and do affect the DIC reservoir are low, and (3) calcite tends to form (precipitate) during weathering of plagioclase feldspar over large parts of the basin, which does not appreciably affect the ^{14}C activity of DIC. Calcite precipitation has little effect on the ^{14}C activity because the fractionation factor between HCO_3 and calcite is small and the mass of calcite precipitated is small relative to the mass of HCO_3 in ground water. Similarly, calcite cementation has little effect on the $\delta^{13}C$ of DIC in ground water.

As a means of evaluating the sensitivity of adjusted radiocarbon ages to model uncertainty, the range of the adjusted ages calculated among the total number of models in NETPATH for an individual water sample is given in table 10. Also given is the difference between the unadjusted radiocarbon age (Libby half-life) and the representative adjusted radiocarbon age from NETPATH (converted to the Libby half-life).

The evaluation using NETPATH is not exhaustive, but shows again that the extent of geochemical reactions affecting the chemical and isotopic composition of waters in the MRGB is probably small and has generally negligible effect on the initial ^{14}C activity, A_o. Although the reaction modeling is non-unique, any other reactions that might affect the waters of the MRGB are also thought not to appreciably affect the initial ^{14}C activity. Therefore, the unadjusted radiocarbon age was adopted in the present investigation.

Regional Variations in Unadjusted Radiocarbon Age

The unadjusted radiocarbon age of water in the upper approximately 500 feet of the Santa Fe Group aquifer system throughout the MRGB is shown in figure 100. The youngest water (0-2 ka) occurs along the mountain-front basin margins (eastern edge of the Eastern Mountain Front zone, the northeast, northwest, and southwest margins of the basin), and along parts of the Rio Grande, Rio Puerco, and Jemez River. Water with DIC unadjusted radiocarbon age of 0-10 ka extends along nearly the entire reach of the Rio Grande, the Rio Puerco, Galisteo Creek, Tijeras Arroyo, and Abo Arroyo, associated with recent surface-water infiltration. The oldest water generally is in the West-Central zone, the Western Boundary zone, and parts of the Eastern Mountain Front zone, as well as throughout the Discharge zone (fig. 100).

The median unadjusted radiocarbon age of DIC in ground water from 275 analyses throughout the MRGB, excluding samples contaminated with post-bomb ^{14}C, is 8.1 ka, with a range of approximately 0 to more than 50 ka. In the mountain-front hydrochemical zones, the median unadjusted radiocarbon ages, for the

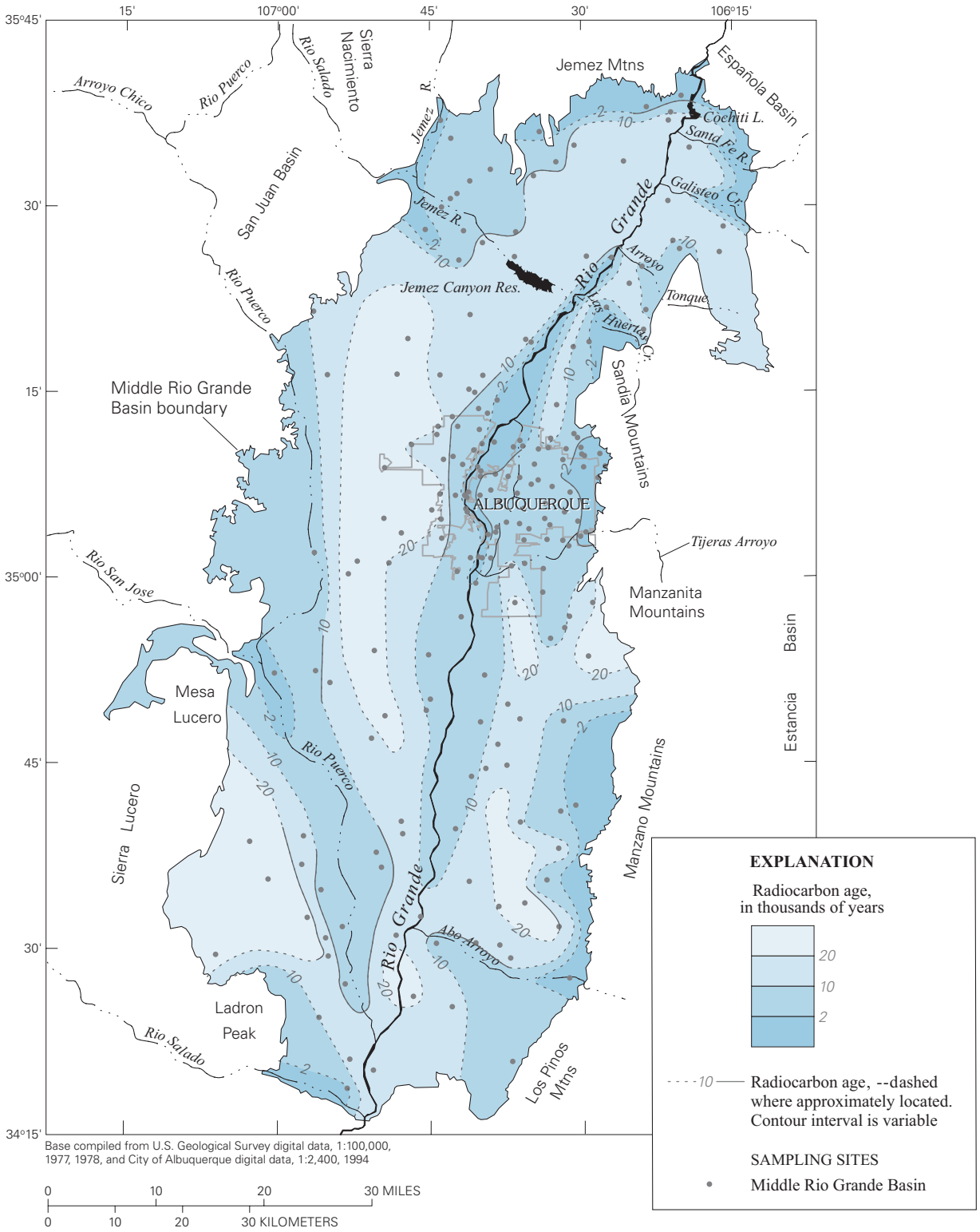


Figure 100. Unadjusted radiocarbon age of DIC in ground water for the Middle Rio Grande Basin, New Mexico.

Northern Mountain Front, Northwestern, Southwestern, and Eastern Mountain Front zones, are 8.8, 8.8, 7.7, and 5.2 ka, respectively. Water in the West-Central, Western Boundary, and Discharge zones has median unadjusted radiocarbon ages of 19.5, 20.4, and 17.9 ka, respectively. The median age of water in the Discharge zone is younger than water in the West-Central and Western Boundary zones because of mixing with relatively younger water from other adjacent zones. Ground water dominated by river/arroyo sources has median unadjusted radiocarbon ages of 8.1, 4.6, and 3.2 ka for the Rio Puerco, Central, and Tijeras Arroyo zones, respectively. The median unadjusted radiocarbon ages of DIC in water from the Abo Arroyo, Tijeras Fault Zone, and Northeastern zones are 9.4, 16.2, and 10.0 ka, respectively.

Variations in radiocarbon age and stable isotopic composition of water are shown as a function of depth along three east-west cross sections in the vicinity of Albuquerque in relation to hydrochemical zone boundaries in figures 101-103. The locations of the cross sections are shown on figure 70. Details of the hydrogeology and stable isotopic composition of water are given in figures 71-73. Three ranges of radiocarbon age are shown on figures 101-103: <5 ka, 5-20 ka, and >20 ka. Relatively younger water of Eastern Mountain Front and Rio Grande origin overlies the relatively older water of the West-Central zone in the vicinity of Albuquerque (figs. 101-103).

Evidently, the width of the Central zone (Rio Grande origin) is greatest at the water table and decreases with depth. Several monitoring well nests are of sufficient depth to extend through the Central zone into the West-Central zone, west of the Rio Grande (figs. 101-103), and into the Eastern Mountain Front zone, east of the Rio Grande (fig.101). The maximum depth of the Central zone exceeds 1,500 feet. Radiocarbon ages of the Central zone waters range from modern to greater than 20 ka beneath Albuquerque. There is a steep lateral gradient in radiocarbon age in the upper 500 feet of the aquifer system separating waters of the Central and West-Central zones, particularly along the Menaul and Los Padillas sections (figs. 102-103). The boundary between the Eastern Mountain Front and Central zones slopes to the west along the Paseo Del Norte section (fig. 101), but may be nearly vertical further to the south of Paseo Del Norte (figs. 102-103). Along the Los Padillas section (fig. 103), water of Eastern Mountain Front origin lies above Central zone water near the water table (S122).

Mixing of Waters in the Well Bore

All ground water pumped from wells is a mixture, because the well has a finite open interval over which the water is withdrawn. However, for wells with narrow open intervals (for example, less than 50 feet in the MRGB), changes in chemical and isotopic composition can be small over the depth of the open interval. Consequently, mixing may not normally be noticed in ground-water discharge from wells with narrow open intervals, unless the open interval is near or at the water table, where ^{14}C activity gradients or gradients in anthropogenic consitituents like CFCs or ^{3}H with depth can be large. Mixing of water in wells results in a mixed ^{14}C activity of DIC in the well discharge; the most extreme case being mixing of relatively old (at least pre-1950's) ground water with young, post-1950's water that has elevated ^{14}C activity, resulting in ^{14}C activities that can be appreciably higher than those of the old (unmixed) fraction.

Evidence for well-bore mixing in the MRGB is seen in the comparison of ^{14}C activities with the CFC-12 and/or ^{3}H data. Some samples have low ^{14}C activities that indicate unadjusted radiocarbon ages of more than 1,000 years, yet contain detectible concentrations of CFC-12 (>0.5 pg/kg) and/or ^{3}H (>0.3 TU) that indicate samples containing at least a fraction of post-1950's water (fig. 98). The upper line of figure 98 shows ^{14}C activities of CO_2 from measurements made at Schauinsland, Germany (1977-97) (Levin and Kromer, 1997), and Vermunt, Austria (1959-83) (Levin and others, 1994), which are considered representative of northern-hemisphere ^{14}C atmospheric activities. During the mid-1960's, the ^{14}C activity in the atmosphere nearly doubled (from 100 pmC, pre-bomb, to nearly 200 pmC in 1964) as a result of atmospheric testing of thermo-nuclear devices. The atmospheric ^{14}C activity is plotted in figure 98 as a function of the CFC-12 concentration, in pg/kg, that would be in ground water recharged in equilibrium with air at 6,500 feet altitude and 10°C. The numbers on the curve give the corresponding date of recharge. The dashed lines show hypothetical mixing lines of young and old water. Samples that plot below the heavy dashed atmospheric curve and contain more than approximately 5 pg/kg of CFC-12 (fig. 98), a concentration that is 10 times above

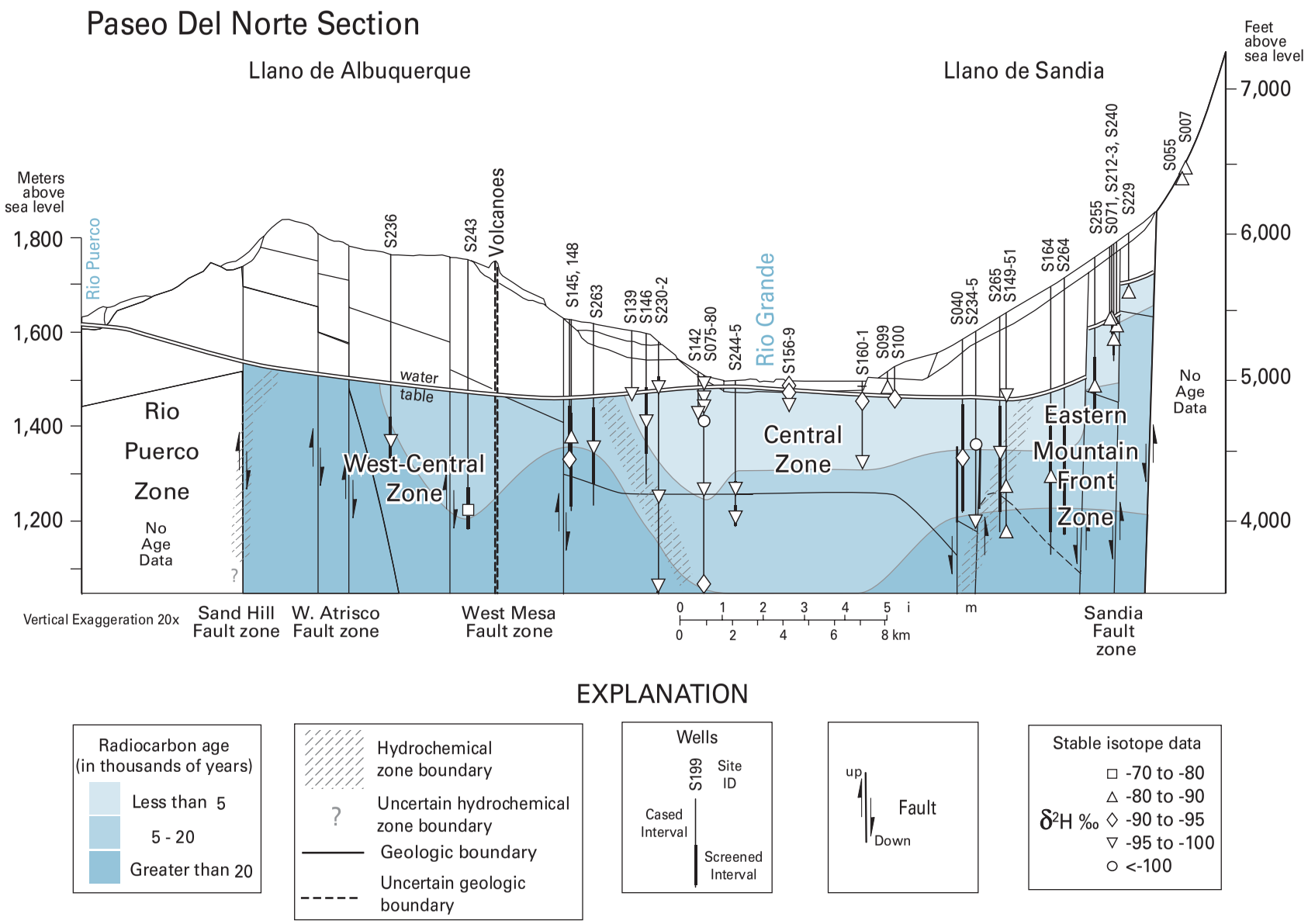


Figure 101. Schematic hydrochemical cross section of the Middle Rio Grande Basin, New Mexico, aligned with Paseo del Norte Boulevard, Albuquerque, showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross section is located on figure 70. See figure 71 for details of the hydrogeology.

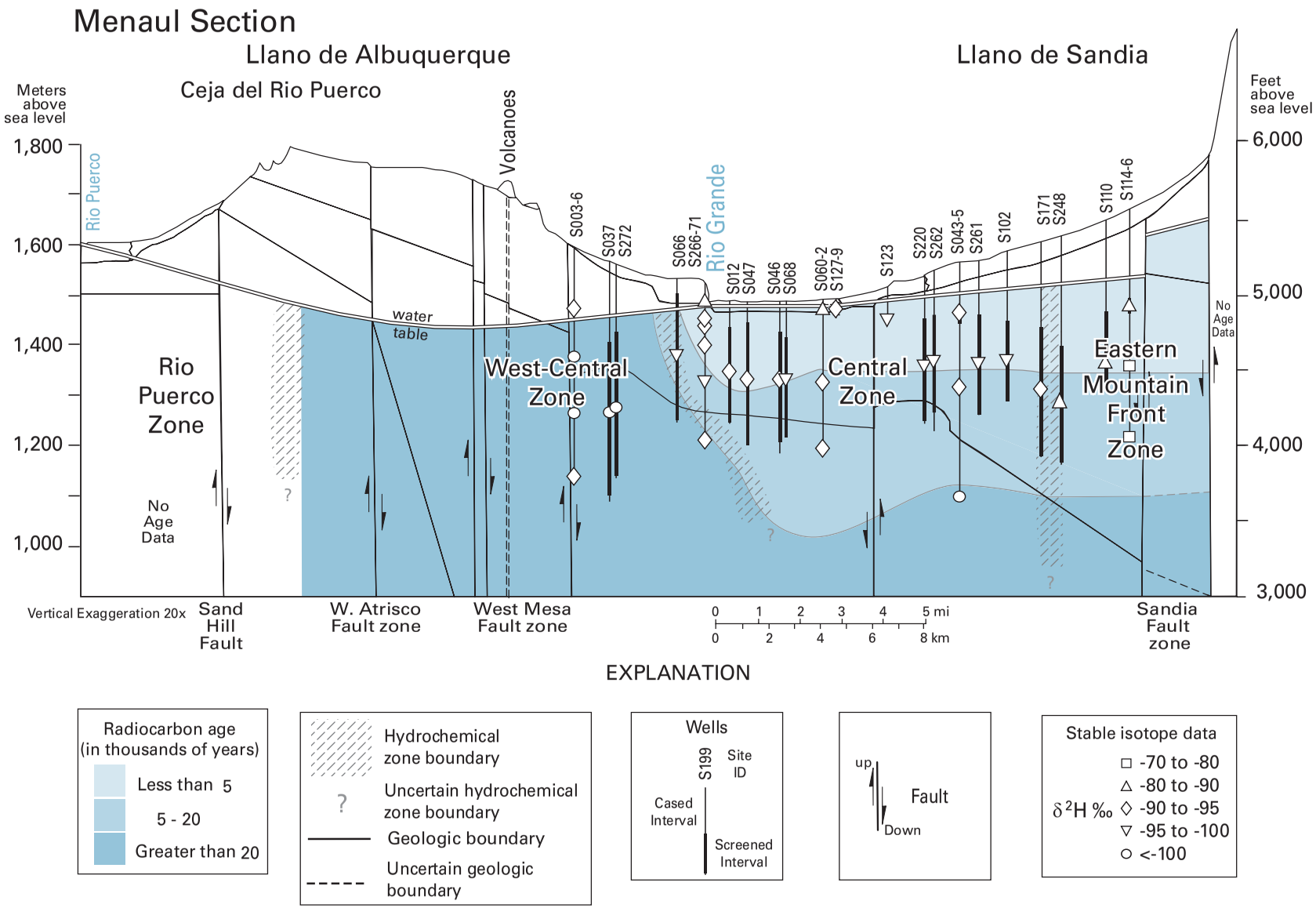


Figure 102. Schematic hydrochemical cross section of the Middle Rio Grande Basin, New Mexico, aligned with Menaul Boulevard showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross section is located on figure 70. See figure 72 for details of the hydrogeology.

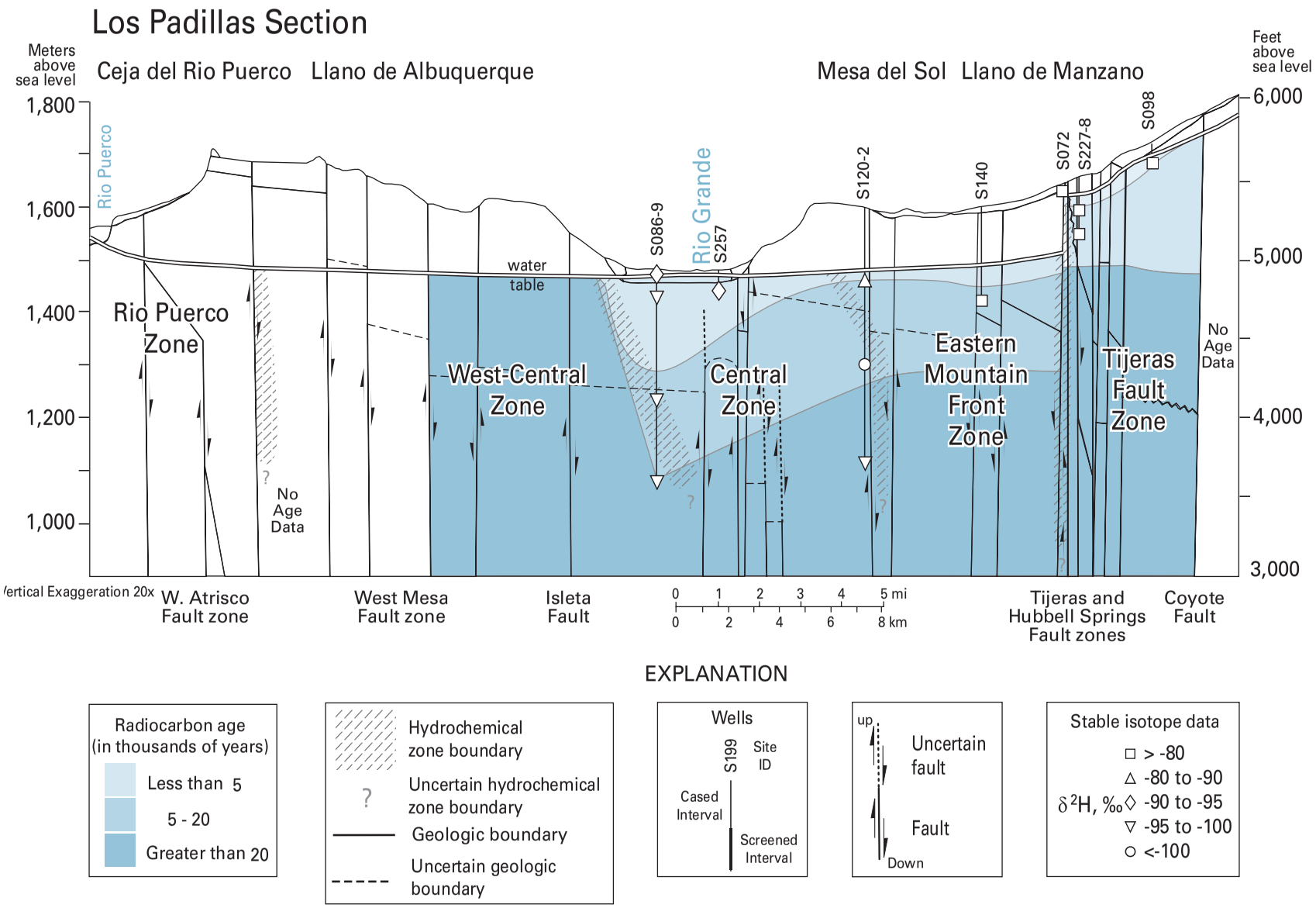


Figure 103. Schematic hydrochemical cross section of the Los Padillas vicinity showing ranges of δ^2H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross-section line is shown on figure 70. See figure 73 for details of the hydrogeology.

the analytical detection limit of 0.5 pg/kg, are likely mixtures that contain a fraction of post-1950 water.

Eleven of the ground-water samples have ^{14}C activities of more than 100 pmC and, based on the ^{14}C activity alone, are post-1950 in age or contain fractions of post-1950 recharge. All of the 11 samples with ^{14}C activities that are more than 100 pmC also contain elevated tritium concentrations (7.8-28.6 TU) and/or elevated concentrations of CFC-12 (18-327 picograms per kg (pg/kg) of CFC-12) (table 13).

Water recharged prior to 1950 in the MRGB would contain less than approximately 3 pg/kg of CFC-12 and less than about 0.2 TU. Of the 263 ^{14}C measurements of DIC in ground-water samples from the MRGB (table 13), CFC-12 was analyzed in 216 of the samples, and ^{3}H was determined in 148 samples. Tritium was determined in 46 of the 47 samples that could not be analyzed for CFC-12 (mostly windmills where there was the possibility of air contamination prior to sampling). Both ^{3}H and CFC-12 were measured in 102 of the samples with ^{14}C measurements (table 13). Of the 216 samples with CFC-12 analyses, 101 contained ≤3 pg/kg of CFC-12, and 81 of the 148 samples with ^{3}H determined contained ≤0.2 TU. A total of 162 samples contained ≤3 pg/kg of CFC-12 and/or ≤0.2 TU of tritium. Although still mixtures, these 162 samples (62 percent of the samples with ^{14}C measurements) do not contain an appreciable fraction of post-1950's water. However, 115 of the 216 samples with CFC-12 analyses contain a fraction of post-1950 water. Of the 47 samples in which CFCs could not be measured reliably, 19 samples had ^{3}H concentrations greater than 0.2 TU and also likely contained a fraction of post-1950's water. Thus, based on CFC-12 and/or ^{3}H data, 51 percent of the ground-water samples with ^{14}C measurements likely contain at least a small fraction of post-1950's water.

In the MRGB, ground-water mixtures pumped from wells that are open to large intervals of the aquifer system (> 200 feet) can be mixtures of water from large ranges in age. In some cases, pumping can lower the water table around the well screen, permitting water withdrawals from near the water table. Ground-water mixtures are common in discharge from municipal production wells that can be open to more than 800 feet of aquifer system and can discharge hundreds of gallons per minute. The mixing is not always evident in major-element chemical composition or even stable isotope composition, if the aquifer system is fairly uniform in chemical and/or isotopic composition with depth. ^{14}C and other environmental tracers with concentrations that vary with ground-water age can be affected by mixing processes, particularly if there are steep age gradients with respect to depth.

The uncertainty in ^{14}C activity of DIC in water discharging from wells was estimated using the ^{14}C data from the piezometer nests (table 7) that permitted estimation of the local depth gradient in ^{14}C activity, and using well-construction information defining the length of the open interval of the well. To a first approximation, it was assumed that the flow of ground water into the open interval of the well was constant with depth. Although this approximation may be valid for some Albuquerque production wells, Thorn (2000) presents detailed flowmeter logs from six Albuquerque production wells that show considerable variation in the amount of flow contributed by different lithologies across large screened intervals. In some cases, for example, well Love 6, it would be more reasonable to assume that the well discharge is derived from only the upper half of the screened interval. In other wells, for example at Gonzales 2, Gonzales 3, and Ponderosa 3, the assumption that flow is derived evenly across the open interval is well justified (Thorn, 2000). All radiocarbon ages determined for this study were based on the measured (unadjusted) ^{14}C activity, but, in estimating the age uncertainty, the uncertainty in the measurement was allowed to vary, in many cases, to an extent considerably higher than the reported analytical uncertainty (table 10).

Samples containing < 5 pg/kg of CFC-12 and/or <0.5 TU of ^{3}H from piezometer nests or wells with narrow sampling intervals (generally < 50 feet of open interval) that did not intercept the water table were considered the most reliable of all the ^{14}C samples, and were assigned error bounds equal to the reported analytical uncertainty (table 13). Samples containing < 5 pg/kg of CFC-12 and/or ^{3}H of <0.5 TU that were from wells with large open intervals (> 50 feet), including municipal production wells, usually had uncertainties in ^{14}C activity greater than those samples from narrow sampling intervals. For these samples, estimates of the ^{14}C activity gradient nearest the well (table 7) were used in conjunction with the length of the open interval to estimate the uncertainty in ^{14}C activity.

Ground-water samples containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of ^{3}H from piezometers with screens that do not intercept the water table likely contain drilling fluid. For these samples,

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico

[bls, below land surface; no., number; nd, not determined; na, not applicable; MW, monitoring well; DW, domestic well; PW, production well; SP, spring; WM, windmill; SW, stock well; TU, tritium unit; pg/kg, picogram per kilogram; P, sample as powder of precipitated barium carbonate; S, water sample collected in septum bottle; pmC, percent modern carbon; O, old, datable on the ^{14}C timescale; M, modern, ^{14}C age probably less than 200 years or post-bomb; yrs, years]

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C ±1σ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
Zone 1: Northern Mountain Front																					
S027	NM486	CEPO 02	MW	5,335	320	149	121	270	315	45	Grundfos	nd	2	-6.9	S	21.3	0.2	12,415	O	0.2	0.2
S034	NM027	Private Production Well #04	PW	5,298	250	nd	190	nd	nd	nd	Unknown	nd	0	-10.8	P	51.9	0.6	5,264	O	5.	5.
S035	NM487	Windmill #37	WM	5,533	290	nd	150	nd	nd	nd	Windmill	17.2	nd	-11.7	S	97.9	0.7	170	M	nd	nd
S036	NM026	Private Production Well #03	PW	5,362	300	90	160	250	300	50	Unknown	nd	1	-8.1	P	82.6	0.9	1,540	O	0.9	10.
S065	NM055	Domestic Well #05	DW	5,172	330	160	160	320	330	10	Submersible	nd	6	-6.2	P	27.0	0.3	10,518	O	0.3	1.
S187	NM131	Rio Rancho 12	PW	5,240	1,487	574	226	800	1,435	635	Turbine	0.4	6	-9.6	S	24.8	0.2	11,188	O	15.	15.
S206	NM510	Windmill #38	WM	5,542	535	nd	461	nd	nd	nd	Windmill	- 0.1	nd	-8.9	S	13.0	0.2	16,395	O	0.2	2.
S216	NM143	Windmill #09	WM	5,725	637	nd	585	nd	nd	nd	Windmill	0.1	17	-6.1	P	39.7	0.5	7,421	O	0.5	10.
S221	NM530	Windmill #45	WM	5,632	555	nd	nd	nd	nd	nd	Windmill	0.2	nd	-5.8	S	12.2	0.2	16,926	O	0.5	3.
S222	NM514	Windmill #39	WM	6,107	260	nd	nd	nd	nd	nd	Windmill	0.5	nd	-4.3	S	10.4	0.2	18,181	O	0.2	2.
S254	NM168	Private Production Well #12	PW	5,525	690	91	265	356	690	334	Turbine	nd	0	-10.8	P	92.0	0.8	667	O	8.	8.
S277	NM525	Windmill #40	WM	5,946	100	nd	37	nd	nd	nd	Windmill	1.0	nd	-7.5	S	50.7	0.4	5,456	O	1.	5.
S279	NM527	Windmill #42	WM	6,275	56	nd	13	nd	nd	nd	Windmill	8.1	nd	-13.4	S	106.	0.8	-489	M	nd	nd
S281	NM528	Windmill #43	WM	6,281	1,109	nd	991	nd	nd	nd	Windmill	0.3	nd	-10.3	S	22.3	0.2	12,043	O	1.	5.
Zone 2: Northwestern																					
S103	NM497	Lincoln D	MW	5,450	1,260	705	496	1,200	1,240	40	Bennett	nd	3	-8.4	S	13.8	0.2	15,909	O	0.2	2.
S104	NM498	Lincoln M	MW	5,450	835	316	494	810	830	20	Bennett	nd	0	-7.1	S	15.5	0.2	14,997	O	0.2	2.
S105	NM499	Lincoln S	MW	5,450	595	5	486	490	590	100	Bennett	0.0	4	-6.5	S	29.6	0.4	9,768	O	3.	3.
S191	NM326	Rio Rancho 4	PW	5,415	990	274	396	670	990	320	Turbine	nd	108	-6.7	S	19.8	0.2	13,021	O	3.	6.
S192	NM128	Rio Rancho 8	PW	5,827	1,618	102	880	982	1,599	617	Turbine	nd	0	-7.6	P	14.7	0.2	15,385	O	10.	10.
S189	NM133	Rio Rancho 15	PW	5,794	1,310	45	775	820	1,290	470	Turbine	nd	0	-6.9	P	18.3	0.2	13,655	O	5.	5.
S276	NM179	Windmill #12	WM	5,970	727	48	667	715	725	10	Windmill	0.0	nd	-7.3	P	38.1	0.4	7,756	O	0.4	5.
S278	NM526	Windmill #41	WM	5,618	448	nd	373	nd	nd	nd	Windmill	0.6	nd	-7.1	S	71.3	0.5	2,718	O	1.	10.
S280	NM180	Windmill #13	WM	5,554	240	9	116	125	135	10	Windmill	0.4	nd	-5.0	P	84.5	0.9	1,356	O	0.9	5.
S286	NM184	Private Production Well #13	PW	5,615	572	150	242	392	552	160	Submersible	nd	5	-6.6	P	71.2	0.6	2,729	O	0.6	6.
S287	NM185	Private Production Well #14	PW	5,525	320	110	150	260	320	60	Submersible	nd	0	-6.2	P	37.4	0.4	7,903	O	0.4	4.
Zone 3: West Central																					
S003	NM251	98th St. D	MW	5,320	1,544	1,113	421	1,534	1,539	5	Bennett	nd	3	-7.4	S	0.62	0.1	40,833	O	0.1	0.5
S003	NM481	98th St. D	MW	5,320	1,544	1,113	421	1,534	1,539	5	Bennett	nd	16	-7.2	S	0.13	0.1	53,382	O	0.1	0.1
S004	NM252	98th St. MD	MW	5,320	1,112	679	423	1,102	1,107	5	Bennett	nd	1	-7.4	S	3.98	0.1	25,897	O	0.1	1.
S004	NM482	98th St. MD	MW	5,320	1,112	679	423	1,102	1,107	5	Bennett	nd	29	-7.5	S	3.69	0.1	26,505	O	0.1	1.
S005	NM483	98th St. MS	MW	5,320	749	323	416	739	744	5	Bennett	nd	21	-5.0	S	0.79	0.1	38,887	O	0.1	0.2
S006	NM484	98th St. S	MW	5,320	438	-3	391	388	433	45	Bennett	0.1	31	-7.6	S	6.37	0.2	22,119	O	0.2	2.
S008	NM003	Private Production Well #01	PW	5,725	1,292	244	834	1,078	1,272	194	Unknown	0.7	0	-7.8	P	5.47	0.1	23,343	O	1.	1.
S010	NM255	Private Production Well #16	PW	5,688	1,300	461	781	1,242	1,294	52	Submersible	nd	72,872	-8.6	S	9.31	0.3	19,071	O	0.3	5.
S018	NM260	Domestic Well #21	DW	5,320	660	165	475	640	660	20	Submersible	nd	32	-7.3	S	11.0	0.1	17,753	O	0.1	10.
S019	NM007	Belen 4	PW	4,920	504	0	150	150	504	354	Submersible	0.5	45	-7.2	P	14.6	0.2	15,484	O	2.	5.
S020	NM008	Belen 5	PW	4,930	600	291	144	435	600	165	Submersible	nd	0	-6.7	P	16.4	0.2	14,537	O	2.	2.

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S029	NM015	Cerro Colorado Landfill PW	PW	5,830	1,661	457	898	1,355	1,655	300	Unknown	nd	0	-7.2	P	7.35	0.1	20,970	O	2.	2.
S037	NM264	College 2	PW	5,226	1,605	221	329	550	1,564	1,014	Turbine	nd	1	-7.8	S	5.39	0.1	23,461	O	2.	2.
S066	NM056	Gonzales 1	PW	5,111	970	183	167	350	950	600	Turbine	2.7	7	-7.3	P	47.0	0.4	6,058	O	24.	24.
S086	NM492	Isleta D	MW	4,900	1,340	1,312	18	1,330	1,335	5	Bennett	nd	7	-8.7	S	2.71	0.2	28,985	O	0.2	2.
S101	NM294	Leavitt 1	PW	5,076	1,140	95	193	288	1,128	840	Turbine	nd	6	-7.1	S	17.3	0.1	14,103	O	2.	4.
S108	NM076	Los Lunas 3	PW	4,965	605	150	182	332	562	230	Submersible	nd	1	-7.5	P	27.6	0.2	10,356	O	5.	5.
S109	NM077	Los Lunas 4	PW	4,981	610	149	129	278	582	304	Submersible	nd	0	-8.7	P	50.5	0.4	5,496	O	10.	10.
S145	NM308	NM Utilities 1	PW	5,390	1,050	115	533	648	1,050	402	Turbine	nd	0	-6.6	S	13.9	0.2	15,845	O	4.	4.
S147	NM310	NM Utilities 3	PW	5,460	1,364	161	489	650	1,351	701	Turbine	nd	0	-7.7	S	15.7	0.2	14,878	O	7.	7.
S148	NM311	NM Utilities 4	PW	5,455	1,357	153	539	692	1,339	647	Turbine	nd	0	-7.0	S	7.36	0.1	20,959	O	6.	6.
S166	NM509	Rabbit Hill	MW	5,655	608	251	102	353	603	250	Grundfos	nd	2	-4.5	S	8.59	0.1	19,717	O	0.1	4.
S167	NM107	Domestic Well #12	DW	5,358	985	435	530	965	980	15	Submersible	nd	0	-7.9	P	5.85	0.1	22,803	O	0.1	0.1
S172	NM322	Rio Bravo 5 D	MW	4,931	149	128	11	139	144	5	Grundfos	nd	0	-8.9	S	3.11	0.1	27,879	O	0.1	1.
S174	NM109	Rio Bravo 1 D	MW	4,931	149	nd	11	139	144	5	Bennett	0.0	0	-7.3	P	15.1	0.2	15,181	O	0.2	0.2
S175	NM110	Rio Bravo 1 M	MW	4,931	104	nd	11	94	99	5	Bennett	0.0	2	-7.1	P	33.2	0.3	8,855	O	0.3	0.3
S186	NM130	Rio Rancho 10	PW	5,504	1,470	269	556	825	1,450	625	Turbine	nd	0	-7.0	P	12.2	0.2	16,912	O	9.	9.
S188	NM132	Rio Rancho 13	PW	6,055	1,920	242	1,101	1,343	1,721	378	Turbine	nd	0	-7.1	P	3.00	0.1	28,168	O	2.	2.
S193	NM129	Rio Rancho 9	PW	6,054	1,540	38	1,082	1,120	1,520	400	Turbine	0.0	26	-7.8	P	7.72	0.1	20,575	O	5.	5.
S196	NM135	Windmill #05	WM	5,470	620	nd	599	nd	nd	nd	Windmill	0.0	94	-7.4	P	36.8	0.3	8,037	O	0.3	30.
S200	NM139	Private Production Well #08	PW	4,840	249	132	92	224	249	25	Submersible	nd	1	-7.1	P	9.23	0.2	19,140	O	0.2	0.2
S217	NM144	Santa Ana Boundary D	MW	5,322	750	724	6	730	750	20	Bennett	nd	1	-7.2	P	6.47	0.1	21,994	O	0.1	1.
S218	NM145	Santa Ana Boundary M	MW	5,322	492	456	16	472	492	20	Bennett	nd	6	-6.8	P	8.24	0.1	20,052	O	0.1	3.
S219	NM146	Santa Ana Boundary S	MW	5,322	210	159	31	190	210	20	Bennett	nd	4	-6.6	P	5.54	0.2	23,241	O	0.2	1.
S230	NM516	Sierra Vista D	MW	5,110	1,644	1,455	179	1,634	1,639	5	Bennett	nd	0	-5.5	S	1.89	0.1	31,879	O	0.1	0.5
S236	NM155	SAF (Soil Amendment Facility)	PW	5,866	1,463	194	922	1,116	1,429	313	Turbine	0.4	77	-8.0	P	4.50	0.1	24,911	O	2.	2.
S241	NM519	SWAB Test Hole 1 D	MW	5,796	1,179	254	885	1,139	1,179	40	Swab	0.1	nd	-6.9	S	6.57	0.2	21,871	O	0.5	0.5
S242	NM520	SWAB Test Hole 1 S	MW	5,796	1,121	93	887	980	1,121	141	Swab	- 0.2	nd	-8.9	S	9.12	0.1	19,236	O	2.	2.
S243	NM521	SWAB Test Hole 2 D [1]	MW	5,730	1,805	728	797	1,525	1,795	270	Swab	0.1	nd	-8.3	S	14.4	0.2	15,595	O	0.2	2.
S263	NM346	Volcano Cliff 1	PW	5,335	1,200	70	458	528	1,056	528	Turbine	nd	3	-7.1	S	9.45	0.1	18,951	O	0.1	3.
S266	NM347	West Bluff Nest 1 Well 1	MW	5,100	1,095	912	173	1,085	1,090	5	Grundfos	nd	0	-6.4	S	2.00	0.1	31,425	O	0.1	0.1
S272	NM353	West Mesa 3	PW	5,145	1,365	166	239	405	1,353	948	Turbine	nd	0	-6.8	S	9.00	0.1	19,343	O	2.	2.
S283	NM181	Zia Ball Park D	MW	5,397	770	736	14	750	770	20	Bennett	nd	0	-6.1	P	18.3	0.2	13,625	O	0.2	1.
S284	NM182	Zia Ball Park M	MW	5,397	506	471	15	486	506	20	Bennett	nd	1	-6.4	P	20.7	0.2	12,660	O	0.3	1.
S285	NM183	Zia Ball Park S	MW	5,397	300	261	19	280	300	20	Bennett	nd	1	-6.9	P	22.2	0.3	12,079	O	0.3	1.
S288	NM186	Zia BMT D	MW	5,740	800	nd	nd	750	800	50	Bennett	1.0	nd	-8.3	P	8.29	0.2	20,003	O	0.2	1.
		Zone 4: Western Boundary																			
S031	NM263	Windmill #18	WM	4,850	143	nd	112	nd	nd	nd	Windmill	- 0.7	nd	-4.6	S	8.14	0.1	20,150	O	0.1	3.
S039	NM266	Windmill #20	WM	5,249	439	nd	nd	nd	nd	nd	Pump Jack	- 0.1	nd	-1.7	S	0.79	0.1	38,887	O	0.1	0.5
S059	NM278	Windmill #21	WM	5,190	395	41	349	390	395	5	Pump Jack	0.1	14	-6.9	S	9.80	0.1	18,659	O	0.1	1.
S074	NM285	Windmill #23	WM	5,434	620	nd	545	nd	nd	nd	Pump Jack	0.1	nd	-0.9	S	4.24	0.1	25,389	O	0.1	1.
S169	NM320	Rest Area	PW	4,905	212	9	164	173	212	39	Submersible	15.6	nd	-5.5	S	80.7	0.7	1,720	O	0.7	10.
S201	NM329	Windmill #26	WM	5,654	630	nd	nd	nd	nd	nd	Windmill	0.0	nd	-4.8	S	2.68	0.1	29,074	O	0.1	1.

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S252	NM167	Windmill #10	WM	5,188	428	18	371	388	428	40	Pump Jack	0.5	nd	-6.2	P	9.69	0.2	18,749	O	0.2	3.
S260	NM345	Windmill #33	WM	5,004	281	62	207	269	279	10	Windmill	0.5	nd	-3.2	S	3.29	0.1	27,427	O	0.1	1.
Zone 5: Rio Puerco																					
S032	NM262	Windmill #17	WM	4,771	61	nd	34	nd	nd	nd	Windmill	0.3	nd	-3.5	S	29.8	0.2	9,736	O	0.2	10.
S069	NM058	Domestic Well #06	DW	5,191	590	205	385	590	590	nd	Submersible	0.2	52	-9.3	P	36.5	0.4	8,107	O	0.4	5.
S073	NM062	Windmill #03	WM	5,035	268	nd	225	nd	nd	nd	Windmill	- 0.2	nd	-7.0	P	49.1	0.4	5,720	O	0.4	5.
S082	NM409	Windmill #36	WM	5,570	720	nd	599	nd	nd	nd	Windmill	0.1	42	-12.3	S	43.3	0.4	6,733	O	2.	10.
S085	NM408	Windmill #35	WM	5,423	700	nd	580	nd	nd	nd	Windmill	0.2	99	-9.8	S	13.2	0.1	16,254	O	1.	4.
S111	NM079	Domestic Well #10	DW	5,169	657	237	400	637	657	20	Submersible	nd	0	-6.8	P	54.7	0.5	4,842	O	0.5	1.
S185	NM324	Domestic Well #31	DW	5,280	150	nd	75	nd	nd	nd	Submersible	nd	12	-10.6	S	36.3	0.4	8,134	O	0.4	10.
S198	NM137	Windmill #07	WM	5,125	212	nd	134	nd	nd	nd	Windmill	7.3	44	-4.7	P	84.5	0.7	1,354	O	0.7	30.
S237	NM341	Windmill #30	WM	5,010	440	nd	nd	nd	nd	nd	Windmill	0.0	nd	-7.4	S	23.8	0.3	11,538	O	0.3	5.
S238	NM342	Windmill #31	WM	4,849	90	nd	52	nd	nd	nd	Windmill	- 0.3	nd	-7.9	S	32.9	0.4	8,935	O	0.4	5.
Zone 6: Southwestern Mountain Front																					
S022	NM009	Windmill #02	WM	5080	316	nd	nd	nd	nd	nd	Windmill	0.0	nd	-5.8	P	40.0	0.4	7,356	O	0.4	5.
Zone 7: Abo Arroyo																					
S021	NM261	Stock Well #01	SW	5,373	192	nd	171	nd	nd	nd	Submersible	11.8	221	-5.4	S	83.9	0.7	1,407	M	nd	nd
S024	NM011	Domestic Well #02	DW	5,181	400	nd	nd	nd	nd	nd	Submersible	0.0	2	-6.9	P	17.1	0.2	14,201	O	0.4	3.
S090	NM064	Domestic Well #08	DW	5,032	360	40	280	320	360	40	Submersible	nd	3	-6.5	P	13.0	0.2	16,395	O	0.2	2.
S093	NM067	Domestic Well #09	DW	4,910	350	190	150	340	350	10	Submersible	nd	1	-8.5	P	31.1	0.3	9,382	O	0.3	2.
Zone 8: Eastern Mountain Front																					
S007	NM002	Domestic Well #01	DW	6,490	55	nd	30	nd	nd	nd	Submersible	10.6	327	-11.8	P	113.	1.0	-1,010	M	nd	nd
S013	NM256	Windmill #14	WM	5,450	270	40	220	260	270	10	Windmill	1.7	nd	-9.6	S	74.0	0.6	2,421	O	0.6	15.
S014	NM257	Private Production Well #17	PW	5,320	360	70	240	310	360	50	Submersible	- 0.2	nd	-7.4	S	79.8	0.7	1,810	O	4.	20.
S015	NM006	Windmill #01	WM	5,634	42	nd	13	nd	nd	nd	Windmill	7.2	nd	-8.3	P	97.7	0.9	184	M	nd	nd
S030	NM016	Charles 4	PW	5,324	1,055	70	386	456	1,032	576	Turbine	0.0	0	-8.5	P	51.4	0.4	5,348	O	14.	14.
S042	NM031	Domestic Well #03	DW	5,067	480	110	350	460	480	20	Submersible	nd	0	-8.0	P	21.0	0.2	12,537	O	0.2	0.2
S055	NM042	Elena Gallegos	PW	6,455	95	-8	28	20	95	75	Submersible	nd	207	-10.5	S	109.	0.9	-705	M	nd	nd
S056	NM043	Embudito Spring	SP	6,440	na	na	na	na	na	na	Peristaltic	7.8	220	-14.1	S	115.	1.1	-1,095	M	nd	nd
S071	NM060	Domestic Well #07	DW	5,988	600	178	392	570	590	20	Submersible	0.2	0	-8.8	P	97.5	0.8	205	M	nd	nd
S083	NM407	Windmill #34	WM	5,142	440	nd	313	nd	nd	nd	Windmill	- 0.2	17	-5.5	S	17.2	0.3	14,159	O	1.	5.
S095	NM068	Kirtland 1	PW	5,383	1,199	123	427	550	800	250	Submersible	0.1	12	-8.9	P	59.4	0.5	4,187	O	6.	6.
S106	NM295	Domestic Well #23	DW	4,781	160	142	8	150	160	10	Submersible	0.0	0	-8.2	S	11.2	0.1	17,615	O	1.	1.
S110	NM078	Love 1	PW	5,462	1,170	7	589	596	1,096	500	Turbine	0.1	10	-7.6	P	47.2	0.4	6,029	O	13.	13.
S113	NM080	Domestic Well #11	DW	5,055	352	97	240	337	352	15	Submersible	nd	1	-7.4	P	8.33	0.1	19,964	O	0.1	1.
S114	NM500	Matheson D	MW	5,575	1,520	733	727	1,460	1,500	40	Bennett	nd	50	-11.0	S	35.4	0.3	8,353	O	0.3	4.
S115	NM501	Matheson M	MW	5,575	1,045	300	720	1,020	1,040	20	Bennett	nd	43	-10.2	S	55.9	0.4	4,676	O	2.	2.
S116	NM502	Matheson S	MW	5,575	705	17	583	600	700	100	Bennett	0.0	5	-9.4	S	64.9	0.5	3,475	O	3.	3.
S117	NM298	Domestic Well #25	DW	5,985	447	66	373	439	445	6	Submersible	0.2	13	-9.0	S	95.1	0.7	406	M	nd	nd
S118	NM299	Windmill #24	WM	5,512	196	nd	115	nd	nd	nd	Windmill	0.5	nd	-5.9	S	37.4	0.4	7,898	O	5.	5.
S119	NM300	Domestic Well #26	DW	5,760	150	nd	70	nd	nd	nd	Submersible	nd	551	-7.8	S	47.4	0.3	6,000	O	2.	10.

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S122	NM304	Mesa Del Sol S	MW	5,326	525	13	407	420	520	100	Bennett	nd	18	-10.8	S	19.3	0.2	13,227	O	15.	0.2
S122	NM505	Mesa Del Sol S	MW	5,326	525	13	407	420	520	100	Bennett	0.0	12	-9.9	S	33.4	0.3	8,819	O	0.3	3.
S140	NM306	MRN 1	MW	5,304	607	130	417	547	587	40	Bennett	nd	0	-7.7	S	42.2	0.3	6,925	O	0.3	5.
S141	NM095	National Utility 7	PW	5,510	150	nd	80	nd	nd	nd	Submersible	- 0.3	785	-6.0	P	68.8	0.6	3,001	O	5.	10.
S149	NM312	Nor Este D	MW	5,460	1,525	977	538	1,515	1,520	5	Bennett	nd	0	-8.7	S	7.96	0.1	20,329	O	0.1	1.
S150	NM313	Nor Este M	MW	5,460	1,193	643	540	1,183	1,188	5	Bennett	nd	0	-8.6	S	17.1	0.2	14,177	O	0.2	2.
S162	NM317	Stock Well #03	SW	5,320	460	nd	nd	nd	nd	nd	Submersible	nd	0	-8.2	S	52.7	0.5	5,152	O	0.5	5.
S163	NM318	PL 2	MW	5,330	617	126	451	577	597	20	Bennett	nd	0	-8.2	S	38.8	0.4	7,599	O	0.4	2.
S164	NM106	Ponderosa 1	PW	5,647	1,800	210	754	964	1,693	729	Turbine	0.0	0	-9.3	P	42.5	0.4	6,883	O	20.	20.
S165	NM328	Windmill #25	WM	5,440	420	nd	335	nd	nd	nd	Windmill	0.0	nd	-8.9	S	10.2	0.2	18,377	O	0.2	2.
S168	NM319	Domestic Well #30	DW	5,137	400	100	290	390	400	10	Submersible	nd	9	-9.2	S	5.41	0.1	23,431	O	0.1	1.
S170	NM108	Ridgecrest 3	PW	5,385	1,475	148	472	620	1,436	816	Turbine	0.0	0	-12.2	P	70.3	0.7	2,837	O	20.	20.
S195	NM134	Domestic Well #13	DW	5,176	600	260	320	580	600	20	Submersible	nd	0	-8.2	P	22.2	0.2	12,076	O	0.2	0.2
S199	NM138	Windmill #08	WM	5,350	44	nd	23	nd	nd	nd	Windmill	0.2	nd	-6.3	P	57.2	0.5	4,494	O	0.5	20.
S209	NM336	Domestic Well #33	DW	4,970	480	140	320	460	480	20	Submersible	nd	0	-8.7	S	15.8	0.2	14,817	O	0.2	0.2
S212	NM141	Sandia Peak 1	PW	5,978	800	199	361	560	760	200	Turbine	0.0	3	-9.7	P	78.0	0.7	1,998	O	4.	4.
S213	NM142	Sandia Peak 3	PW	5,978	603	23	360	383	583	200	Turbine	0.0	13	-9.3	P	83.2	0.7	1,475	O	5.	5.
S224	NM148	Domestic Well #14	DW	5,462	580	236	324	560	580	20	Submersible	nd	0	-7.6	P	79.9	0.7	1,802	O	0.7	0.7
S229	NM515	SH03 UNM	MW	6,060	495	-25	445	420	490	70	Bennett	8.3	4	-9.4	S	96.3	0.8	302	M	nd	nd
S233	NM153	Domestic Well #16	DW	5,338	400	150	225	375	395	20	Submersible	nd	1	-7.1	P	32.6	0.3	9,011	O	0.3	0.3
S239	NM156	Domestic Well #17	DW	6,080	300	35	225	260	300	40	Submersible	nd	10,691	-8.9	P	22.0	0.3	12,163	O	0.3	10.
S240	NM157	Domestic Well #18	DW	5,943	550	110	400	510	530	20	Submersible	0.0	0	-10.5	P	66.4	0.6	3,287	O	0.6	0.6
S246	NM343	Windmill #32	WM	5,160	380	nd	nd	nd	nd	nd	Windmill	- 0.1	nd	-5.9	S	31.2	0.3	9,364	O	0.3	5.
S247	NM161	Domestic Well #19	DW	5,380	640	208	390	598	638	40	Submersible	nd	1	-8.5	P	4.86	0.1	24,293	O	0.2	0.2
S248	NM162	Thomas 6	PW	5,408	1,536	224	536	760	1,520	760	Turbine	0.0	0	-9.0	P	44.2	0.4	6,557	O	12.	12.
S255	NM523	Tramway East	PW	5,880	1,100	224	474	698	1,098	400	Turbine	- 0.1	4	-10.4	S	54.0	0.4	4,954	O	10.	10.
S264	NM174	Walker 1	PW	5,699	1,723	189	802	991	1,711	720	Turbine	- 0.4	0	-9.3	P	41.6	0.3	7,038	O	14.	14.
S274	NM177	Domestic Well #20	DW	5,050	368	128	220	348	368	20	Submersible	nd	0	-5.8	P	24.7	0.2	11,246	O	0.2	0.2
Zone 9: Tijeras Fault Zone																					
S041	NM030	Coyote Spring (NM029)	SP	5,840	na	na	na	na	na	na	Bennett	0.3	92	-0.6	S	4.83	0.1	24,342	O	0.1	2.
S072	NM061	Hubbell Spring	SP	5,437	na	na	na	na	na	na	Peristaltic	nd	78	-6.4	P	42.8	0.4	6,817	O	0.4	26.
S197	NM136	Windmill #06	WM	5,725	295	nd	204	nd	nd	nd	Windmill	0.2	31	-8.2	P	4.76	0.1	24,460	O	0.1	2.
S227	NM151	SFR 3D	MW	5,494	362	149	163	312	352	40	Bennett	nd	4	-1.0	P	9.67	0.1	18,766	O	30.	3.
S228	NM152	SFR 3S	MW	5,494	222	19	164	182	212	30	Bennett	nd	10	-1.0	P	13.2	0.2	16,242	O	30.	3.
Zone 10: Tijeras Arroyo																					
S001	NM001	4Hills-1	MW	5,669	70	-32	57	25	65	40	Bennett	4.0	364	-8.4	P	94.0	0.7	501	M	nd	nd
S002	NM250	Private Production Well #15	PW	5,647	1,200	34	616	650	1,180	530	Turbine	nd	785	-6.8	S	82.7	0.7	1,526	O	20.	20.
S058	NM277	Eubank 1	MW	5,457	615	-16	566	550	610	60	Bennett	1.7	185	-6.2	S	62.0	0.5	3,835	O	0.5	20.
S096	NM069	Kirtland 11	PW	5,466	1,327	125	545	670	1,327	657	Unknown	0.0	0	-7.9	P	46.0	0.4	6,241	O	15.	15.
S107	NM075	Lomas 1	PW	5,595	1,300	-31	731	700	1,300	600	Turbine	nd	0	-6.2	S	72.8	0.6	2,552	O	15.	15.
Zone 11: Northeastern																					

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S016	NM258	Windmill #15	WM	5520	55	nd	25	nd	nd	nd	Windmill	0.0	nd	-5.3	S	28.5	0.2	10,078	O	0.2	5.
S017	NM259	Windmill #16	WM	5780	300	nd	240	nd	nd	nd	Windmill	- 0.2	nd	-7.4	S	18.1	0.2	13,726	O	0.2	5.
S053	NM276	Private Production Well #18	PW	5382	nd	nd	nd	nd	nd	nd	Submersible	13.7	nd	-5.6	S	76.5	0.7	2,150	O	2.	30.
S144	NM097	Private Production Well #06	PW	5496	800	173	347	520	760	240	Submersible	nd	1	-6.8	P	29.2	0.4	9,886	O	5.	5.
S204	NM332	Windmill #28	WM	5320	175	nd	115	nd	nd	nd	Windmill	- 0.3	nd	-6.4	S	19.6	0.3	13,107	O	0.3	5.
S207	NM334	Private Production Well #22	PW	5260	286	138	130	268	286	18	Submersible	nd	0	-6.1	S	69.3	0.5	2,941	O	0.5	5.
S223	NM338	Windmill #29	WM	5594	292	nd	nd	nd	nd	nd	Windmill	0.1	nd	-6.7	S	19.5	0.3	13,115	O	0.3	5.
		Zone 12: Central																			
S011	NM004	Atris-1	MW	4,960	31	13	13	26	31	5	Bennett	11.0	82	-8.3	P	96.8	0.8	264	M	nd	nd
S012	NM005	Atrisco 3	PW	4,950	813	167	13	180	804	624	Turbine	9.7	10	-8.3	P	64.7	0.5	3,496	O	27.	27.
S025	NM012	Burton 2	PW	5,284	857	7	418	425	845	420	Turbine	0.1	47	-9.1	P	47.7	0.4	5,941	O	10.	10.
S026	NM013	Burton 5	PW	5,275	1,170	135	415	550	1,150	600	Turbine	0.0	0	-9.4	P	44.7	0.4	6,475	O	14.	14.
S033	NM025	Private Production Well #02	PW	4,974	182	21	121	142	172	30	Submersible	16.0	29	-10.6	P	96.4	1.2	297	M	nd	nd
S040	NM028	Coronado 1	PW	5,288	1,186	95	384	479	1,184	705	Turbine	0.0	332	-8.5	S	32.8	0.3	8,962	O	14.	14.
S043	NM267	Del Sol D	MW	5,210	1,567	1,220	337	1,557	1,562	5	Bennett	nd	1	-8.0	S	6.37	0.1	22,119	O	0.1	1.
S043	NM488	Del Sol D	MW	5,210	1,567	1,220	337	1,557	1,562	5	Bennett	nd	0	-8.3	S	6.20	0.1	22,337	O	0.1	0.5
S044	NM268	Del Sol M	MW	5,210	842	486	346	832	837	5	Bennett	nd	0	-8.0	S	14.5	0.2	15,523	O	0.2	0.5
S044	NM489	Del Sol M	MW	5,210	842	486	346	832	837	5	Bennett	nd	0	-8.3	S	13.7	0.2	15,997	O	0.2	2.
S045	NM490	Del Sol S	MW	5,210	425	-34	349	315	415	100	Bennett	0.2	16	-9.1	S	62.2	0.5	3,813	O	3.	5.
S046	NM032	Duranes 1	PW	4,960	1,000	170	34	204	924	720	Turbine	10.6	78	-10.9	P	73.1	0.6	2,516	O	25.	25.
S047	NM270	Duranes 7	PW	4,954	950	140	4	144	950	806	Turbine	7.6	33	-9.1	S	72.0	0.6	2,644	O	30.	30.
S060	NM279	Garfield D	MW	4,964	1,020	946	49	995	1,010	15	Grundfos	nd	0	-8.4	S	12.6	0.2	16,672	O	0.2	0.2
S061	NM280	Garfield M	MW	4,964	582	504	48	552	572	20	Grundfos	0.0	0	-8.6	S	22.3	0.2	12,047	O	0.2	0.2
S062	NM491	Garfield S	MW	4,964	93	-1	44	43	83	40	Grundfos	9.2	964	-10.7	S	81.8	0.7	1,610	M	nd	nd
S064	NM283	Domestic Well #22	DW	5,230	315	79	222	300	315	15	Submersible	nd	10	-9.7	S	82.8	0.7	1,516	O	0.7	3.
S068	NM057	Griegos 3	PW	4,968	916	240	20	260	916	656	Turbine	13.3	0	-8.8	P	67.0	0.6	3,217	O	30.	30.
S075	NM286	Hunter Ridge Nest 1 Well 1	MW	5,110	1,518	1,345	163	1,508	1,513	5	Grundfos	nd	0	-7.9	S	25.3	0.2	11,034	O	0.2	2.
S076	NM287	Hunter Ridge Nest 1 Well 2	MW	5,110	855	686	159	845	850	5	Grundfos	nd	0	-9.8	S	60.4	0.5	4,046	O	0.5	2.
S078	NM289	Hunter Ridge Nest 2 Well 1	MW	5,110	359	198	151	349	354	5	Grundfos	0.1	2	-9.0	S	73.8	0.6	2,440	O	0.6	2.
S081	NM292	Private Production Well #19	PW	5,227	2,020	461	269	730	2,000	1,270	Turbine	nd	0	-8.8	S	55.2	0.5	4,769	O	32.	32.
S084	NM063	Windmill #04	WM	5,016	167	-3	150	147	167	20	Windmill	- 0.2	39	-8.8	P	79.5	0.7	1,847	O	0.7	50.
S087	NM493	Isleta MD	MW	4,900	815	798	7	805	810	5	Bennett	nd	4	-7.9	S	35.8	0.3	8,261	O	0.3	3.
S088	NM494	Isleta MS	MW	4,900	185	169	6	175	180	5	Bennett	nd	4	-8.4	S	72.3	0.5	2,603	O	0.5	5.
S089	NM495	Isleta S	MW	4,900	50	4	6	10	40	30	Bennett	19.9	18	-12.5	S	118.	0.8	-1,345	M	nd	nd
S097	NM070	Kirtland 14	PW	5,322	1,000	20	360	380	1,000	620	Submersible	0.0	28	-8.7	P	48.9	0.4	5,753	O	14.	14.
S102	NM074	Leyendecker 1	PW	5,285	1,000	55	413	468	996	528	Turbine	0.1	126	-8.9	P	72.8	0.7	2,546	O	20.	20.
S120	NM503	Mesa Del Sol D	MW	5,326	1,630	1,179	401	1,580	1,620	40	Bennett	nd	1	-9.2	S	5.99	0.2	22,613	O	0.2	5.
S121	NM302	Mesa Del Sol M	MW	5,326	1,015	578	412	990	1,010	20	Bennett	nd	7	-8.5	S	8.32	0.1	19,974	O	0.1	5.
S121	NM504	Mesa Del Sol M	MW	5,326	1,015	578	412	990	1,010	20	Bennett	nd	2	-8.6	S	3.24	0.2	27,550	O	0.2	2.
S124	NM082	Montano 2 D	MW	4,970	147	117	21	138	143	5	Bennett	19.5	54	-10.0	P	103.	0.9	-263	M	nd	nd
S125	NM083	Montano 2 M	MW	4,970	99	73	17	90	95	5	Bennett	25.5	37	-11.1	P	110.	0.9	-748	M	nd	nd
S127	NM085	Montano 4 D	MW	4,975	132	78	45	123	128	5	Bennett	13.5	9	-11.1	P	95.0	0.8	412	M	nd	nd

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S128	NM086	Montano 4 M	MW	4,974	94	42	43	85	90	5	Bennett	19.6	56	-12.3	P	114.	1.0	-1,026	M	nd	nd
S130	NM088	Montano 5 D	MW	4,977	150	125	10	135	145	10	Bennett	11.0	4	-9.0	P	97.6	1.0	197	M	nd	nd
S131	NM089	Montano 5 M	MW	4,977	75	53	7	60	70	10	Bennett	9.9	200	-8.5	P	95.0	0.8	411	M	nd	nd
S133	NM091	Montano 6 D	MW	4,970	983	941	31	972	978	6	Bennett	0.0	0	-9.6	P	25.2	0.2	11,075	O	0.2	0.2
S134	NM092	Montano 6 MD	MW	4,970	836	796	30	826	831	5	Bennett	0.0	0	-8.6	P	38.0	0.3	7,783	O	0.3	5.
S135	NM093	Montano 6 MS	MW	4,970	568	530	28	558	563	5	Bennett	2.0	0	-7.7	P	67.5	0.6	3,153	O	0.6	10.
S137	NM506	Montesa M	MW	5,100	708	482	216	698	703	5	Bennett	nd	2	-9.0	S	18.6	0.2	13,499	O	0.2	5.
S138	NM507	Montesa S	MW	5,100	330	49	211	260	320	60	Bennett	0.0	53	-9.3	S	52.5	0.4	5,175	O	2.	5.
S139	NM305	Domestic Well #27	DW	5,197	326	nd	264	nd	nd	nd	Submersible	nd	0	-8.6	S	43.4	0.3	6,711	O	0.3	5.
S142	NM307	Domestic Well #28	DW	5,064	275	156	103	259	274	15	Submersible	nd	0	-8.3	S	73.3	0.6	2,498	O	0.6	0.6
S146	NM309	NM Utilities 2	PW	5,280	1,000	48	302	350	800	450	Turbine	nd	0	-8.3	S	50.9	0.5	5,418	O	12.	12.
S151	NM508	Nor Este S	MW	5,460	608	-3	541	538	598	60	Bennett	0.0	6	-9.5	S	47.6	0.4	5,960	O	0.4	2.
S153	NM315	Open Space	PW	5,145	462	43	262	305	410	105	Turbine	- 0.1	nd	-8.3	S	55.2	0.5	4,781	O	0.5	15.
S155	NM316	Domestic Well #29	DW	4,895	210	145	55	200	210	10	Submersible	0.1	0	-8.5	S	55.5	0.5	4,731	O	0.5	5.
S156	NM100	Paseo 2D	MW	4,989	150	119	16	135	145	10	Bennett	1.8	3	-8.3	P	76.7	0.7	2,132	O	0.7	10.
S157	NM101	Paseo 2MD	MW	4,989	95	68	12	80	90	10	Bennett	15.1	42	-10.5	P	103.	0.8	-204	M	nd	nd
S160	NM104	Paseo 3D	MW	5,006	544	469	70	539	544	5	Bennett	0.2	27	-8.7	P	64.5	0.5	3,521	O	0.5	4.
S161	NM105	Paseo 3M	MW	5,006	144	86	53	139	144	5	Bennett	10.7	2,205	-10.7	S	98.1	0.7	152	M	nd	nd
S171	NM321	Ridgecrest 4	PW	5,344	1,424	141	431	572	1,412	840	Turbine	nd	21	-9.2	S	46.1	0.4	6,224	O	17.	17.
S173	NM323	Rio Bravo 5 M	MW	4,931	104	83	11	94	99	5	Grundfos	13.1	1,713	-9.7	S	97.3	1.1	224	M	nd	nd
S177	NM112	Rio Bravo 2 D	MW	4,929	154	nd	12	144	149	5	Bennett	15.7	33	-8.0	P	61.6	0.5	3,888	O	0.5	20.
S178	NM113	Rio Bravo 2 M	MW	4,929	91	nd	11	81	86	5	Bennett	13.5	5	-10.6	P	78.4	0.6	1,959	O	0.6	20.
S179	NM114	Rio Bravo 2 S	MW	4,929	49	nd	11	39	44	5	Bennett	13.6	8	-10.3	P	99.5	0.9	39	M	nd	nd
S180	NM115	Rio Bravo 4 D	MW	4,933	149	nd	23	139	144	5	Bennett	0.0	1	-9.1	P	34.6	0.3	8,516	O	0.3	0.3
S181	NM116	Rio Bravo 4 M	MW	4,933	124	nd	24	114	119	5	Bennett	7.9	38	-10.8	P	77.7	0.8	2,028	O	0.8	10.
S183	NM126	Rio Grande Utility 5	PW	4,958	670	132	158	290	660	370	Unknown	nd	1	-8.1	P	33.2	0.3	8,862	O	10.	10.
S184	NM127	Rio Grande Utility 6	PW	5,010	602	140	191	330	590	260	Unknown	nd	0	-8.3	P	51.3	0.5	5,356	O	10.	10.
S190	NM325	Rio Rancho 2	PW	5,266	751	213	295	508	751	243	Turbine	nd	1	-8.6	S	71.6	0.7	2,689	O	6.	6.
S203	NM331	Private Production Well #20	PW	5,050	110	42	23	65	100	35	Submersible	9.1	129	-8.8	S	77.1	0.5	2,090	O	0.5	20.
S205	NM333	Private Production Well #21	PW	5,050	557	502	15	517	547	30	Submersible	nd	0	-8.4	S	58.8	0.4	4,260	O	0.4	2.
S208	NM140	San Jose 2	PW	4,992	1,000	168	96	264	996	732	Turbine	3.1	15	-8.7	P	29.1	0.3	9,916	O	20.	20.
S210	NM511	Sandia D	MW	5,440	1,305	809	486	1,295	1,300	5	Bennett	nd	18	-8.7	S	15.3	0.2	15,065	O	0.2	5.
S214	NM513	Sandia S	MW	5,440	535	6	479	485	525	40	Bennett	0.1	21	-9.3	S	62.9	0.5	3,726	O	2.	2.
S220	NM147	Santa Barbara 1	PW	5,139	1,000	55	257	312	984	672	Turbine	0.3	1,285	-9.0	P	49.1	0.5	5,719	O	15.	15.
S231	NM517	Sierra Vista M	MW	5,110	928	765	153	918	923	5	Bennett	nd	1	-8.2	S	34.2	0.3	8,609	O	0.3	3.
S232	NM518	Sierra Vista S	MW	5,110	210	-9	149	140	200	60	Bennett	0.0	28	-9.9	S	68.9	0.5	2,998	O	0.5	5.
S234	NM339	Sister Cities D	MW	5,340	1,308	950	348	1,298	1,303	5	Bennett	nd	3	-7.3	S	8.03	0.1	20,259	O	0.1	1.
S235	NM340	Sister Cities M	MW	5,340	799	441	348	789	794	5	Bennett	nd	0	-8.8	S	66.3	0.5	3,306	O	0.5	1.
S244	NM158	SWAB 3 - 760	MW	4,995	840	668	42	710	790	80	Bennett	0.0	66	-9.8	P	44.1	0.5	6,584	O	0.5	20.
S245	NM159	SWAB 3 - 980	MW	4,995	1,055	826	44	870	1,050	180	Bennett	0.0	56	-9.1	P	44.1	0.4	6,580	O	0.4	15.
S253	NM522	Tome D	MW	5,020	1,200	989	196	1,185	1,195	10	Grundfos	nd	7	-8.0	S	8.80	0.1	19,523	O	0.1	3.
S257	NM344	Domestic Well #34	DW	4,920	109	nd	12	nd	nd	nd	Submersible	16.3	19	-10.8	S	85.3	0.6	1,277	O	0.6	30.
S259	NM171	VGP-1	MW	4,923	64	51	8	59	64	5	Bennett	28.6	29	-11.6	P	123.	1.0	-1,669	M	nd	nd

Table 13. Estimation of uncertainties in ^{14}C activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

Site no.	Sample no.	Site name	Well type	Altitude (feet)	Depth (feet bls)	Feet of water above top of screen	Water level, (feet bls)	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Type of pump	Tritium (TU)	CFC-12 concen-tration (pg/kg)	$\delta^{13}C$ (per mil)	Sample as $BaCO_3$ powder, P, or dis-solved, S	Meas-ured ^{14}C activity (pmC)	^{14}C $\pm 1\sigma$ (pmC)	Conv., un-adjusted ^{14}C age Libby halflife (yrs)	Old, O or Modern, M	Esti-mated "+" uncer-tainty (pmC)	Esti-mated "-" uncer-tainty (pmC)
S261	NM172	Volandia 2	PW	5,208	1,016	28	332	360	852	492	Turbine	0.3	16	-8.6	P	70.6	0.6	2,800	O	12.	12.
S262	NM173	Volandia 5	PW	5,112	1,020	38	222	260	900	640	Turbine	1.3	1,942	-9.8	S	57.8	0.5	4,406	O	16.	16.
S265	NM175	Webster 1	PW	5,436	1,484	90	530	620	1,345	725	Turbine	- 0.1	0	-8.5	P	45.5	0.4	6,333	O	15.	15.
S267	NM348	West Bluff Nest 1 Well 2	MW	5,100	689	517	162	679	684	5	Grundfos	nd	6	-9.2	S	32.3	0.3	9,071	O	0.3	0.3
S269	NM350	West Bluff Nest 2 Well 1	MW	5,100	328	163	155	318	323	5	Grundfos	11.5	4	-8.4	S	63.5	0.5	3,647	O	0.5	30.
S275	NM178	Yale 1	PW	5,159	1,000	69	267	336	960	624	Turbine	0.6	161	-9.9	S	39.2	0.4	7,531	O	18.	18.
		Zone 13: Discharge																			
S143	NM096	Private Production Well #05	PW	4,755	258	218	20	238	258	20	Unknown	nd	1	-7.3	P	7.46	0.1	20,850	O	1.	1.
S194	NM327	Domestic Well #32	DW	4,730	130	100	20	120	130	10	Submersible	1.2	6	-7.0	S	10.8	0.1	17,863	O	0.1	5.
S226	NM150	Domestic Well #15	DW	4,860	223	73	137	210	220	10	Submersible	nd	2	-5.3	P	11.6	0.2	17,290	O	0.2	1.
		No Zone: Exotic Water																			
S009	NM485	Arroyo Salado Spring	SP	5,744	na	na	na	na	na	na	None	2.6	nd	1.8	S	7.64	0.2	20,659	O	0.2	7.
S023	NM010	Burn Site Well	PW	6,369	341	163	68	231	341	110	Unknown	0.7	68,206	-7.7	S	49.6	0.4	5,639	O	5.	20.
S028	NM014	Cerro Colorado Landfill MW	MW	5,488	746	-15	570	555	616	61	Submersible	nd	37	2.0	S	1.59	0.1	33,268	O	nd	nd
S038	NM265	Windmill #19	WM	5,720	100	nd	nd	nd	nd	nd	Windmill	- 0.1	nd	-10.9	S	6.68	0.1	21,738	O	0.1	2.
S054	NM041	Domestic Well #04	DW	5,065	390	nd	nd	nd	nd	nd	Submersible	nd	0	-7.6	P	29.3	0.3	9,867	O	nd	nd
S057	NM044	Embudo Spring	SP	6,600	na	na	na	na	na	na	Peristaltic	10.8	219	-13.2	S	111.	1.1	-840	M	nd	nd
S063	NM282	Windmill #22	WM	5,980	180	nd	nd	nd	nd	nd	Windmill	0.2	nd	-5.6	S	46.4	0.5	6,177	O	0.5	2.
S067	NM284	Granite Hill	MW	5,749	89	nd	32	nd	nd	nd	Grundfos	nd	52	-7.9	S	34.5	0.3	8,549	O	0.3	5.
S070	NM059	HERTF	PW	6,227	500	44	405	449	500	51	Unknown	0.3	1,014	-7.5	S	40.6	0.4	7,239	O	20.	20.
S091	NM496	Private Production Well #23	PW	5,525	81	14	5	19	81	62	Submersible	13.0	33	-10.2	S	93.8	0.7	515	M	nd	nd
S094	NM293	Stock Well #02	SW	5,700	120	nd	107	nd	nd	nd	Submersible	nd	173	-5.5	S	79.3	0.6	1,866	O	20.	20.
S112	NM297	Domestic Well #24	DW	5,131	560	80	460	540	560	20	Submersible	nd	5	-7.2	S	13.6	0.1	16,038	O	2.	2.
S152	NM098	Private Production Well #07	PW	5,350	440	59	141	200	380	180	Submersible	0.1	18	-6.1	P	62.7	0.6	3,745	O	5.	5.
S202	NM330	Windmill #27	WM	5,911	nd	nd	nd	nd	nd	nd	Windmill	6.4	nd	-4.7	S	47.2	0.4	6,036	O	0.4	25.
S211	NM512	Sandia M	MW	5,440	1,025	529	486	1,015	1,020	5	Bennett	nd	4	-8.2	S	10.4	0.1	18,158	O	0.2	3.
S249	NM164	Private Production Well #09	PW	6,610	240	-146	206	60	240	180	Submersible	10.6	886	-11.0	P	51.3	0.4	5,360	M	nd	nd
S256	NM169	Tunnel Spring	SP	6,410	na	na	na	na	na	na	Peristaltic	12.2	240	-11.3	S	92.6	0.8	622	M	nd	nd
S258	NM524	Vallecito Springs	SP	5,840	na	na	na	na	na	na	None	- 0.5	nd	-10.1	S	43.4	0.3	6,713	O	5.	10.
S273	NM176	Windmill #11	WM	5,680	280	nd	nd	nd	nd	nd	Windmill	0.8	nd	-4.0	P	36.5	0.3	8,100	O	0.3	10.
S282	NM529	Windmill #44	WM	5,400	147	nd	85	nd	nd	nd	Windmill	0.0	nd	-8.5	S	51.6	0.4	5,323	O	1.	5.

[1] SWAB Test Hole 2 D probably has a broken casing at 1,130 feet below land surface. Measured water level was 803.25 feet. Sample may be from about 327 feet below the water table.

the error bars in ^{14}C activity were increased based on estimates of the ^{14}C activity of the ground water and of the drilling fluid. The drilling fluid was assumed to have been made with water from the City of Albuquerque distribution system (50 to 70 pmC), and with CFC concentrations approaching that of water in equilibrium with air at the time of drilling. Reference air-water equilibrium CFC concentrations at 5,000 feet altitude for CFC-11, CFC-12, and CFC-113 are, at 10°C, 655, 300 and 85 pg/kg, respectively; at 13°C, 530, 250, 68 pg/kg, and at 20°C, 400, 190, and 50 pg/kg, respectively. Apparently, some of the monitoring-well nests were not developed sufficiently after completion at the intermediate and deep intervals to remove all the water introduced in drilling (see, for example, 98th Street, Tome, Matheson, Sandia, and Isleta, figure 104). CFC-12 was detected in many of the shallow intervals of piezometer nests, but most of these wells have screens of more than 40-100 feet and either intercept the water table or are within 10 feet of the water table.

Ground-water samples containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of ^{3}H can occur in wells that contain a mixture of water from both old and young sources. Examples of such wells include those that intercept the water table, are completed at shallow depths in the inner valley of the Rio Grande, or are affected by areal infiltration or seepage from rivers and arroyos. Although these samples can contain a fraction of young (post-1950's) water, there is usually not enough information to estimate either the amount of young water in the mixture or the age of the young fraction. In the MRGB, all samples that contained ^{14}C activities that were greater than 100 pmC also contained CFC-12 concentrations that were greater than 5 pg/kg and/or ^{3}H activities greater than 0.5 TU, and were judged to be predominantly post-bomb water. For these samples, no fraction of old water could be dated; the samples were designated modern (M), and the error bars were left as the reported values of the analytical errors. When the ^{14}C activity was less than 100 pmC and the sample contained CFC-12 concentrations that were higher than 5 pg/kg and/or ^{3}H activities higher than 0.5 TU, the sample was assumed to be a mixture of post- and pre-bomb water. In estimating error bars that encompassed the age of the old fraction, the upper error bound was assigned the analytical value, but the lower bound was increased based on estimates of local ^{14}C activity gradients.

Ground-water samples from domestic wells containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of ^{3}H may have been contaminated by local anthropogenic sources, such as seepage from septic tanks. In this case, it was assumed that the source of added carbon had a ^{14}C activity of 100 pmC. For samples containing less than 50 pg/kg CFC-12, it is likely that the fraction of septic-tank or other young water is small. For this group of samples, the upper error bound for ^{14}C activity was the analytical value, but the lower value was increased several pmC.

The ^{14}C data along with information on the type of well, well construction, tritium and CFC-12 concentrations, the measured ^{14}C activity with reported analytical uncertainty, and the estimated uncertainty in the ^{14}C activity taking into account the potential mixing processes discussed above are summarized in table 13. The most reliable ^{14}C ages are those from monitoring wells and domestic wells, because of the relatively narrow open intervals (10-20 feet) of these well types, compared to production wells with median open intervals of 400 feet (table 2). Many of the radiocarbon ages from the production wells are of little use because the uncertainty in the ^{14}C age can span more than 10,000 years as a result of the large open interval of the well. For example, Private Production well #19 (S081, NM292), with an open interval of 1,270 feet, has an unadjusted radiocarbon age of about 4,800 years that may vary within the age interval of 2,100 to 11,800 years based on the estimated uncertainty (table 13). In contrast, the median ^{14}C age for all of the monitoring wells with ^{14}C data is 11,600, and the median ^{14}C age uncertainty associated with the relatively narrow open intervals is -100 to +1,000 years (table 13).

Radiocarbon Calibration

As shown above, it was concluded that the unadjusted radiocarbon age accurately represents the radiocarbon age of ground water throughout most of the MRGB. Excluding waters from the Tijeras Fault Zone and Northeastern zones, which have higher average geochemical corrections (3.7 and 2.5 ka, respectively), the average difference between the unadjusted radiocarbon age and the NETPATH-adjusted age is only 0.5 ka (unadjusted radiocarbon age minus NETPATH-adjusted age, Libby half-life) in 231 samples. The close agreement in unadjusted radiocarbon age and NETPATH-adjusted age results from

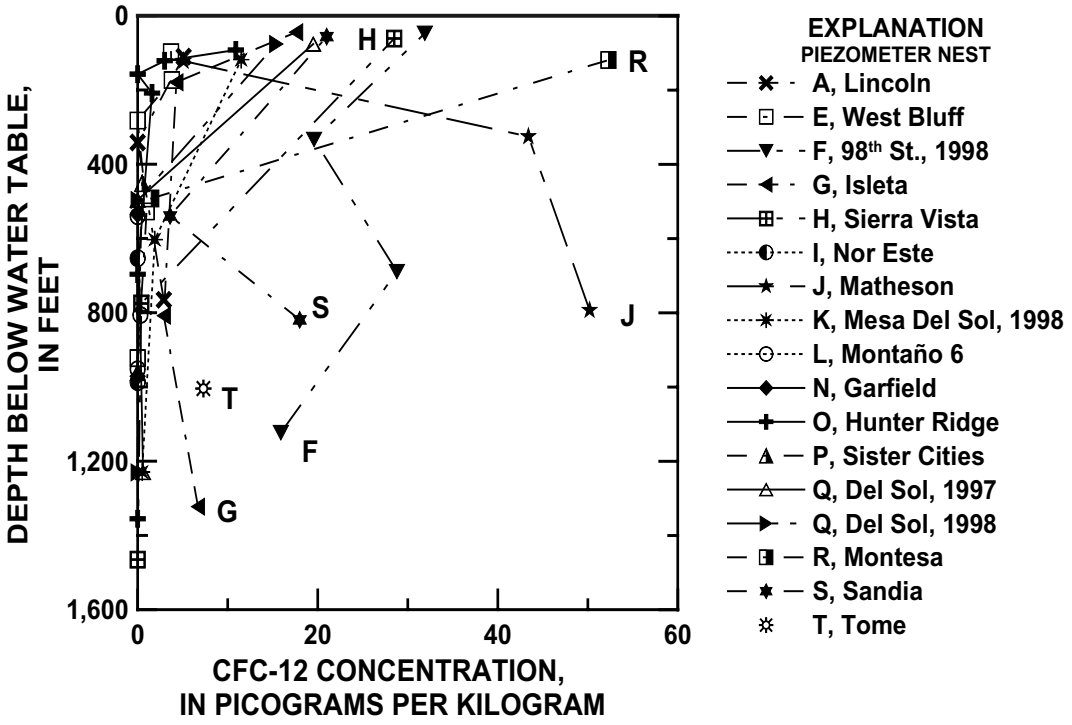


Figure 104. Concentration of CFC-12 in ground water from narrow-screened piezometers in the vicinity of Albuquerque, New Mexico as a function of depth below the water table (see figures 58 and 69 for location, and appendix A1 for well construction information).

A_o being near 100 pmC and corrections for geochemical reactions being small throughout most of the aquifer system. Carbon-14 is not often so "well behaved" in all ground-water systems, but in the MRGB, mountain-front infiltration waters apparently evolve under open-system conditions that result in pre-bomb A_o values near 100 pmC. The DIC of Rio Grande water, which recharges most of the central part of the basin, also appears to be near 100 pmC under pre-bomb conditions. Other surface-water sources also have high ^{14}C activities. In addition, the ^{14}C activity of DIC in most waters appears to be little affected by water/rock reactions in the basin. This result is mostly a consequence of the fact that the Santa Fe Group aquifer system of the MRGB is low in carbonate mineral and organic carbon content; where calcite occurs, it is usually precipitating as secondary cementation rather than dissolving, which has little effect on the ^{14}C activity. It has been assumed that these conditions prevailed over the historical span of the waters sampled in the MRGB, as there is little reason to expect that these conditions differed appreciably in the past. The average difference between the unadjusted radiocarbon age and NETPATH-adjusted age is 0.1 ka in the Eastern Mountain Front zone and 0.3 ka in the Central zone, where the most precise age-depth data are available from piezometer nests typically in the vicinity of Albuquerque.

Because the radiocarbon ages in the MRGB seem mostly insensitive to the recharge and reaction processes that usually obscure radiocarbon dating in many carbonate aquifers, it was concluded that the radiocarbon ages in the MRGB may be accurate enough to warrant further conversion to calendar years, taking advantage of recent compilations and extensions of radiocarbon calibration data. The conversion to calendar years is still a small refinement for ground-water systems, but probably provides more accurate estimates of calendar ages and travel times for use in calibration of a ground-water flow model (Sanford and others, 2001; 2004).

Calendar years as a function of radiocarbon years are shown in figure 105 and are based on ^{14}C measurements from tree ring, coral and lake varve chronologies (Stuiver and others, 1998; Bard and others, 1998; Kitagawa and van der Plicht, 1998a,

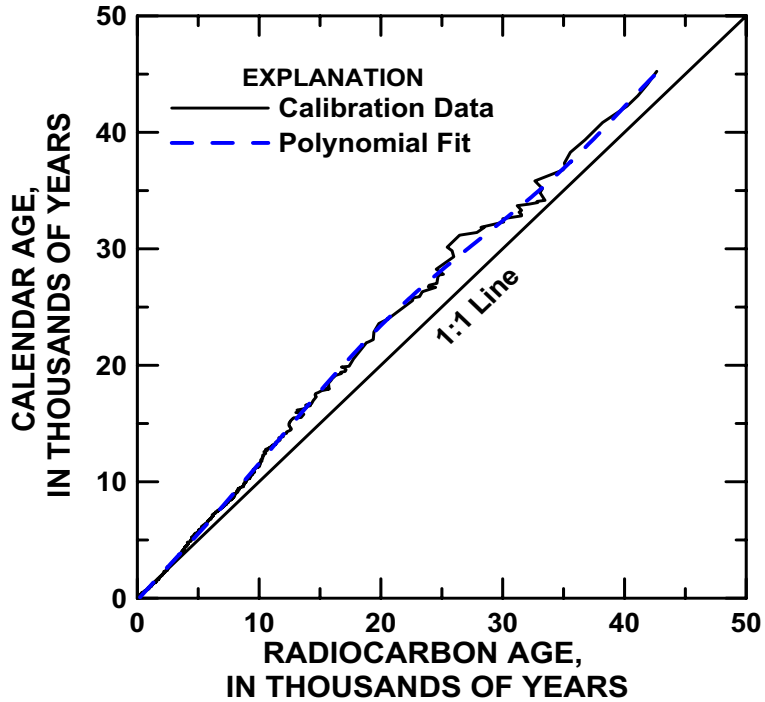


Figure 105. Relation between radiocarbon years and calendar years. The blue line is a 6-degree polynomial fit (eqn. 19)

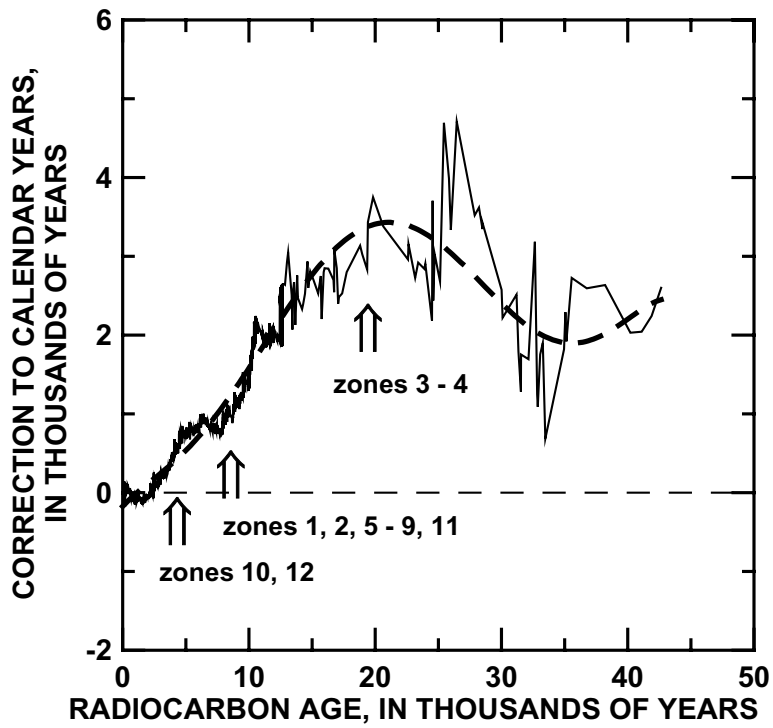


Figure 106. Correction to be added to the Conventional Radiocarbon Age to correct to calendar years. For most waters of the Middle Rio Grande Basin, the correction is less than 1,000 years. For waters from the West-Central and Western Boundary hydrochemical zones (zones 3 and 4, respectively), the calendar year ages are, on average, about 3 thousand years greater than the radiocarbon age. See table 8 for names of hydrochemical zones corresponding to specific zone numbers.

1998b, 2000). A polynomial (eqn. 19) was fitted to the data of figure 105 and used to estimate calendar years from the apparent unadjusted radiocarbon age (Libby half-life),

$$\text{Cal. Yrs. B.P.} = -173.94 + 1.1713A - 2.0521\times10^{-5}A^2 + 4.0150\times10^{-9}A^3 - 2.4519\times10^{-13}A^4 + 5.7738\times10^{-18}A^5 - 4.6915\times10^{-23}A^6, \quad (19)$$

where A is the unadjusted radiocarbon age (Libby half-life) in years. Over the range of most of the unadjusted radiocarbon ages of the waters in the MRGB, the calendar year age differs from the unadjusted radiocarbon age by between 0 and about 3 ka. The correction that is added to the apparent unadjusted radiocarbon age to correct to calendar years is given in figure 106. Waters from the Tijeras Arroyo and Central zones (zones 10 and 12) have median unadjusted radiocarbon ages of approximately 5 ka and, for these, the average calendar age is less than 1 ka greater than the unadjusted radiocarbon ages. Water from the Northern Mountain Front, Northwestern, Rio Puerco, Southwestern Monutain Front, Abo Arroyo, Eastern Mountain Front, and Tijeras Fault Zone zones (zones 1, 2, 5-9, and 11) have, on average, calendar year ages that are about 1 ka greater than the apparent unadjusted radiocarbon age. The oldest waters sampled in the MRGB, from the West-Central and Western Boundary zones (zones 3 and 4), have unadjusted calendar year ages that are typically 3 ka older than the unadjusted radiocarbon ages. The unadjusted radiocarbon ages and calendar year ages of DIC for all the MRGB waters are given in table 10. Although the radiocarbon calibration data obtained from tree rings (Stuiver and others, 1998) and $^{230}Th/^{234}U$ dating or corals (Bard and others, 1998) are relatively precise, greater uncertainties in radiocarbon calibration are associated with data obtained from varves (Kitagawa and van der Plicht, 1998a, 1998b). Recently, additional calibration data have been obtained from a stalagmite in the calendar year age range of 11 to 45 ka that indicate large variations in atmospheric ^{14}C activity between 33 and 45 ka (Beck and others, 2001; Bard, 2001). Although radiocarbon calibration to about 20 ka now seems well established, extension of the calibration to the dating limits of the radiocarbon method (about 45 ka) is currently under investigation by the radiocarbon scientific community. Most of the radiocarbon ages from the MRGB are in the range of 0 - 20 ka, where calibration data are most reliable. Nevertheless, in keeping with previous work in the hydrochemical sciences, all radiocarbon age information used in this report is based on the (unadjusted) radiocarbon age, rather than calendar years. However, a companion report (Sanford and others, 2004) uses the calendar year ages in calibrating a ground-water flow model.

INTERPRETATION OF ENVIRONMENTAL AND CLIMATIC INFORMATION FROM RADIOCARBON AGES, STABLE ISOTOPES, AND DISSOLVED GASES

This section describes the use of ground-water ages and stable isotope and dissolved gas compositions in conjunction with depth information to examine (1) variations in radiocarbon age with depth in various parts of the basin, (2) historical variations in the stable isotopic composition of paleowater of Rio Grande and eastern mountain front origin, (3) paleo-recharge temperatures of ground water in the West-Central, Eastern Mountain Front, and Central zones, and (4) historical variations in the abundance ratio of C_4/C_3 plants throughout the MRGB. As is the case for many areas where environmental records can be retrieved from ground-water archives, trends in chemical and isotopic data with radiocarbon age can be demonstrated in the MRGB, but their causes cannot be established with certainty.

Age Gradients

Numerous data are available describing radiocarbon age as a function of depth in various parts of the MRGB. Although water composition and stable isotopic composition are relatively constant to depths of more than 600 feet in parts of the MRGB, there can be appreciable variation in ground-water age with depth. The most reliable age information as a function of depth was obtained from the piezometer nests that are open to relatively narrow intervals (typically 5 to 10 feet) of the aquifer system (fig. 107). The average age gradient, expressed as years per foot of aquifer (yr ft^{-1}), was calculated between the upper- and bottom-most interval from the piezometer nests that extend vertically across 200 to more than 1,300 feet of the aquifer system. The average age gradient from this set of piezometer nests is 18 ± 12 yr ft^{-1}. The average age between the upper and lowest interval is 12.2 ± 6.1 ka.

The magnitudes of age gradients were observed to differ among piezometer nests based on location and mean age of water. Some of the smallest age gradients (indicative of relatively large thicknesses of water of similar age) were calculated between the upper- and bottom-most intervals of piezometer nests along the eastern mountain front (Eastern Mountain Front zone), such as at nest S114-S116 (7.0 yr ft^{-1} with a mean age of 6.9 ka); along the west side of the Rio Grande north of Albuquerque (Central zone), at nest S075-S078 (7.6 yr ft^{-1}, mean age of 6.7 ka); and between nests S004 and S006 (mostly West-Central zone), (6.7 yr ft^{-1}, mean age of 24.3 ka). Age gradients in the upper 500 to 800 feet of the Central zone along the west side of the Rio Grande are lower than on the east side of the Rio Grande. However, below 800 feet, age gradients in the Central zone tend to be higher west of the Rio Grande than observed east of the Rio Grande (fig. 107a).

Most age gradients do not extrapolate to zero age at the water table (fig. 107), indicating that ground water in the piezometer nest likely has moved horizontally from the point of recharge, and that following recharge and flow to the present location, little or no additional water has been added to the water table for periods as long as 20 ka (S004, fig. 107b). The piezometer nests from the Eastern Mountain Front zone (fig. 107b) that extrapolate nearest to zero age at the water table (S212 and S114) are located adjacent to the eastern mountain front at Albuquerque.

More detailed age-depth information is found by calculating age gradients between each depth interval for each piezometer nest. Typically, two values are found for each nest, between the deep and medium completions and the medium and shallow completions. Several piezometer nests have four completions, yielding three values of the age gradient at those locations. The resulting age gradients, calculated between each pair of open intervals, vary between about 3 and 60 yr ft^{-1} (fig. 108). Higher age gradients generally are found between the deep and medium completions than between the medium and shallow completions. During the past 16 ka, the piezometer nests indicate a possible maximum age gradient at about 10 ka and minimum between about 12-16 ka. Based on the limited data, the age gradients (in yr ft^{-1}) tend to decrease from a maximum at 10 ka to relatively low values during the past few thousand years (fig. 108). Although there is an appearance of temporal variation in age gradients, it can be ambiguious to examine age gradients out of context for the ground-water flow system. Furthermore, flow in recharge areas is not vertical at any of the piezometer nests, and some nests are located near discharge areas. For example, in the period 15 to 25 ka, age gradients vary by a factor of nearly 20 (fig. 108). The age gradients from two piezometers in the youngest (and most

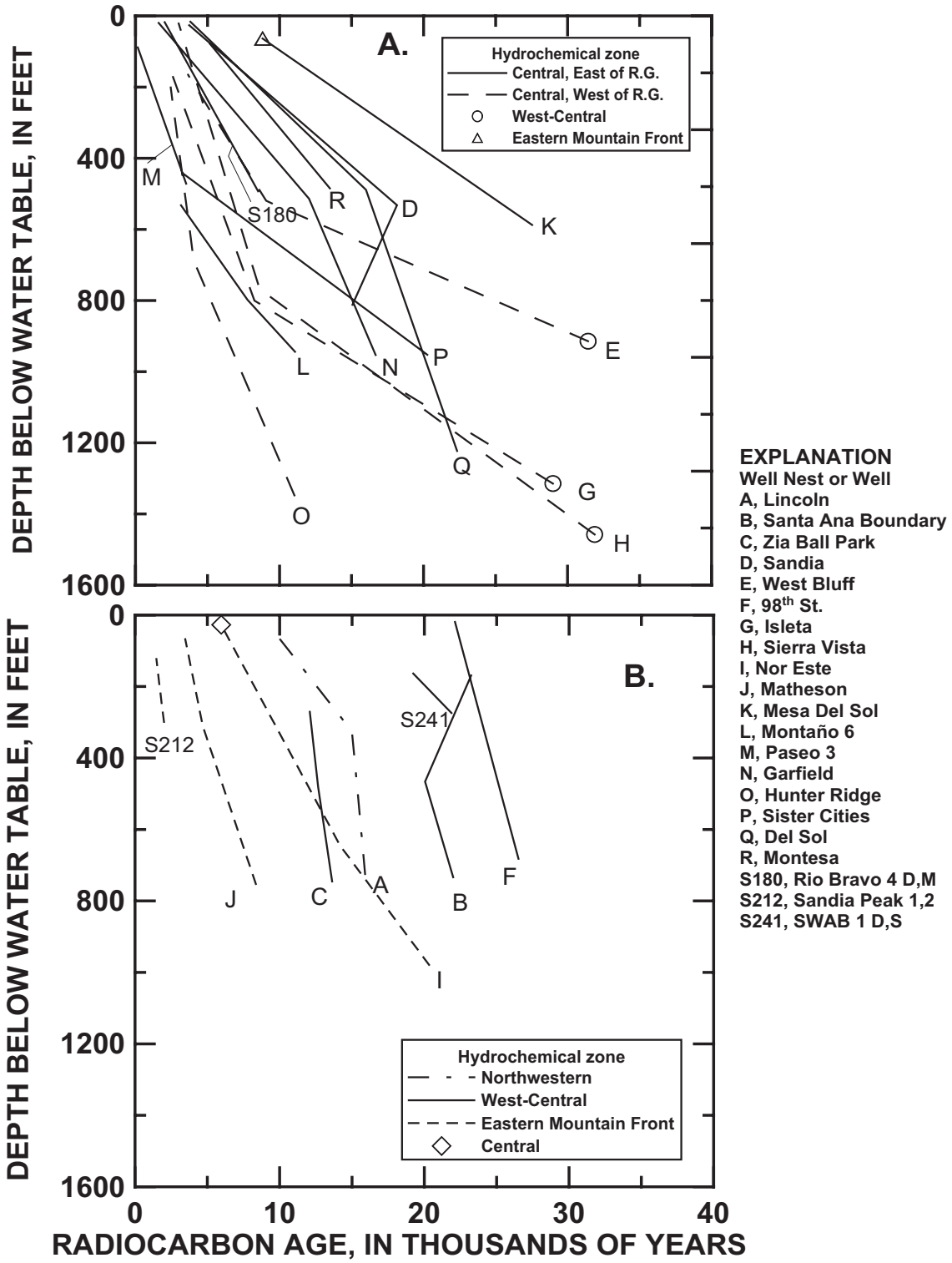


Figure 107. Profiles of radiocarbon age as a function of depth from piezometer nests from the Middle Rio Grande Basin. (A) Piezometer nests or wells penetrating waters of the Central hydrochemical zone, either east or west of the Rio Grande. Symbols denote piezometer nests where the deep completion is in the West-Central zone or the shallow completion is in the Eastern Mountain Front zone. (B) Piezometer nests or wells in the Northwestern, West-Central and Eastern Mountain Front zones. Water at the shallow completion of the piezometer nest in the Eastern Mountain Front zone at site S149 is of Rio Grande origin (Central zone). See figures 11a, 11b, 59, and 69 for well locations, and table A1 for well construction information.

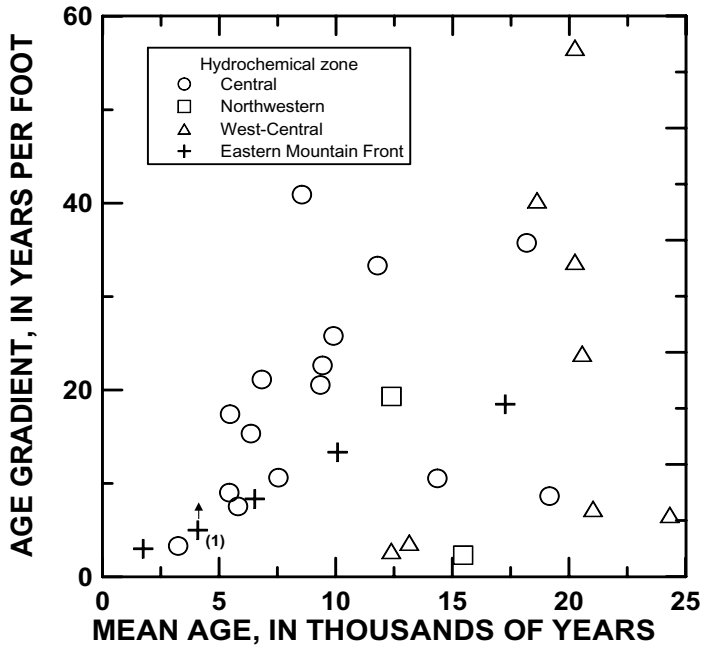


Figure 108. Age gradients in years per foot (yr ft^{-1}) of aquifer calculated between each pair of open intervals for each piezometer nest and plotted at the mean radiocarbon age of the two intervals. Age gradients vary from about 3 to 60 yr ft^{-1} of aquifer in the upper 1,300 feet of aquifer and are quite variable for waters older than about 10 ka. Relatively low age gradients are found for waters recharged in the past 5 ka. (1) S115-S116 mid-shallow interval. Water-level measurements indicate that water at the shallow depth of piezometer S116 is perched, resulting in likely under-estimation of the age gradient between the mid and shallow depths at this piezometer.

shallow) waters along the eastern mountain front and the Central zone are about 3 yr ft^{-1} (fig. 108). The implied modern recharge rate near the eastern mountain front and Rio Grande from these two piezometers is on the order of 0.1 ft yr^{-1}, assuming an average porosity of 0.3, and is within the range of recharge rates reported for other semiarid environments (see for example, Scanlon and others, 2002; Flint and others, 2002; Zhu and others, 2003).

Along the eastern mountain front, there appear to be two different age-depth relations. In the calculations of figure 109, radiocarbon ages for all samples from wells in the Eastern Mountain Front zone (production, domestic, and monitoring wells) were used and age was plotted at the mid-depth of the open interval in feet below the water table. Water from the Eastern Mountain Front zone found north of Albuquerque or south of Tijeras Arroyo has a relatively high age gradient (approximately 150 yr ft^{-1}) in relation to waters from the Eastern Mountain Front zone at Albuquerque (approximately 12 yr ft^{-1}) (fig. 109). Apparently, over at least the past 10 ka, there has been appreciably more recharge along the eastern mountain front at Albuquerque than either to the north or south of the Albuquerque vicinity. Factors that may contribute to this difference are a greater thickness of ancestrial Rio Grande sands at Albuquerque than elsewhere along the eastern mountain front (Hawley and Haase 1992), the presence of the Hubbell Bench and Tijeras and Hubbell Springs fault zones to the south that place low permeability rocks at shallow depths, and higher precipitation rates along the Sandia Mountains at Albuquerque than along lower altitude portions of the eastern mountain front.

Although an evaluation of the climate history of the southwestern U.S. is beyond the scope of this investigation, two studies (Allen and Anderson, 2000, and Polyak and others, 2001) are of particular significance because they provide direct information on the timing of moisture delivery to the near vicinity of the MRGB.

Allen and Anderson (2000) radiocarbon dated high stands of paleo-Lake Estancia, and interpreted sedimentologic, biologic, and geochemical proxies to identify nine periods of wet climate in the Estancia Basin, central New Mexico, east of the MRGB (fig. 1), between 12 and 24 ka, B.P. The high stands of Lake Estancia record the pluvial of the last glacial period

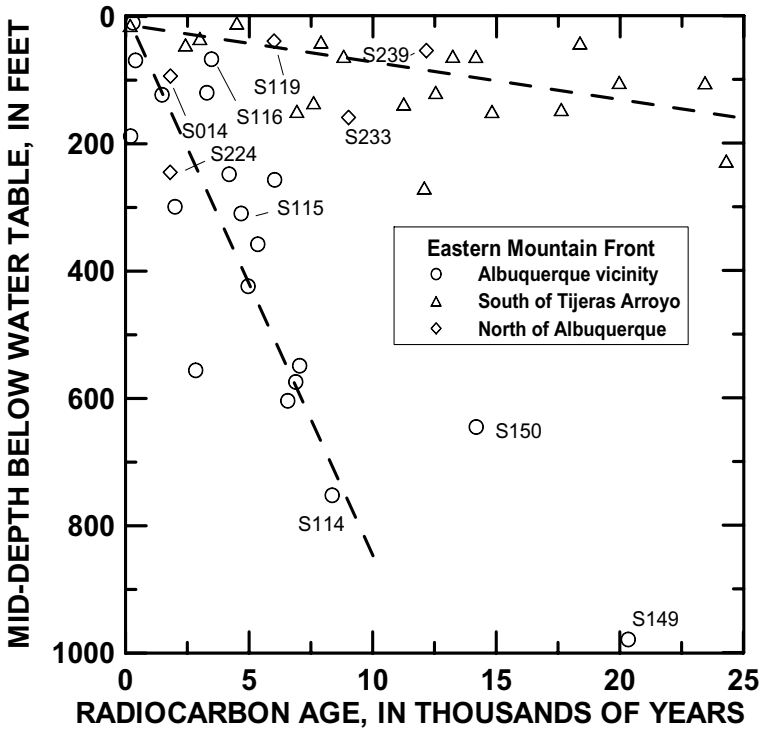


Figure 109. Radiocarbon age as a function at the depth below the water table of the mid-point of the open interval for all wells from the Eastern Mountain Front zone. Two age-depth relations are apparent. A relatively thick zone of recharge from the eastern mountain front is seen at Albuquerque, but in areas north of Albuquerque and south of Tijeras Arroyo, there has been relatively less recharge of comparable age to the Eastern Mountain Front zone.

throughout the southwestern U.S. (Benson and others, 1990, 1998, 2004; Oviatt and others, 1992, Phillips and others, 1992; Wilkins and Currey, 1997; Allen and Anderson, 2000, and references therein). Lake Estancia expanded and contracted repeatedly during the last glacial period, with high stands beginning at about 23.3 and 22 ka B.P., and was maintained near its maximum altitude between 20 and 15 ka B.P., referred to as the "Glacial Maximum Highstand" (GMH) by Allen and Anderson (2000). The 15 ka GMH was terminated by an abrupt dry episode that lasted about 1 ka. Two more wet periods (highstands) followed, beginning at about 13.9 and 13.1 ka B.P. The climate during the 13.9 ka highstand was apparently as wet as during the GMH. Lake Estancia desiccated after 12 ka B.P., followed by a brief expansion at about 10 ka B.P. Mid-Holocene deflation of the basin floor began about 7 ka B.P., near the onset of the generally dry and warmer conditions elsewhere in North America during the middle Holocene (8-4 ka B.P.) (for example, Dean and others, 1996). Important dry periods indicated by the Lake Estancia record are 14-15 ka B.P., 12 to 10 ka B.P., and after 10 ka B.P. into the mid-Holocene (Allen and Anderson, 2000). The maximum in age gradients from the piezometers (fig. 108) at about 10 ka B.P. generally is consistent with the expected low amounts of recharge at the beginning of the Holocene.

In another important record of wet periods in New Mexico, Polyak and others (2001) show that two stalagmites from Hidden Cave, Guadalupe Mountains, in extreme southeastern New Mexico, grew between 3,200 and 800 years ago, based on uranium series dating. The stalagmites contained 12 species of mites that are known to live in climates that are wetter and cooler than the present in southeastern New Mexico. The stalagmites contain no record of growth either prior to 3,200 years ago, or after 800 years ago. There is considerable evidence that the mid-Holocene warm period (8-4 ka) was followed by a change to near present-day conditions that began about 4 ka B.P. in the north-central parts of the United States and shifted with time to the southwestern United States (MacKay and Elias, 1992, Thompson and others, 1993; Nordt and others, 1994; Dean, 1997). Evidence from packrat middens suggests that the late Holocene became

increasingly arid (Betancourt and others, 2001); however, other studies indicate wetter intervals within the late Holocene (Toomey and others, 1993; Buck and Monger, 1999; Wilkins and Currey, 1999; Polyak and others, 2001). The data of figure 108 suggest generally that recharge rates in the past 2-4 ka B.P. may have been higher than in the period 5-10 ka B.P.

Historical Variations in Stable Isotopic Composition of Rio Grande and Eastern Mountain Front Recharge

Recharge of water from the Rio Grande to ground water in the Central zone has apparently occurred throughout the past 25 ka. Radiocarbon-dated ground water in the Central zone provides a record of historical variations of the stable isotopic composition of Rio Grande water that recharged the aquifer system. The δ^2H stable isotopic composition of ground water from the Central zone was apparently at a minimum during the last glacial period, with two values of δ^2H measured near -105 per mil with radiocarbon ages of 20 and 28 ka B.P. (fig. 110). Values of δ^2H of water from the Central zone rose to a local maximum of about -94 per mil at about 15 ka B.P., and then fell to a local minimum of -98 to -100 per mil at about 5 ka B.P. During the past 5 ka, water from the Central zone has become more enriched in ^2H, reaching values of δ^2H near -90 per mil in modern waters (fig. 110). All measurements from Central zone ground water are included in figure 110. Some samples were from production wells with open intervals of as much as 1,200 feet, which can affect the radiocarbon age because of mixing in the well bore. Samples with negative radiocarbon ages contain fractions of post-bomb water and are the youngest of the data set. These samples normally would plot with samples of zero radiocarbon age on figure 110, but were left with apparent negative ages to separate those samples from water samples that are young but pre-bomb in age. Regardless of their radiocarbon age, their stable isotopic composition is representative of recent (post-bomb) water.

Values of δ^2H of ground water from the Central zone and Eastern Mountain Front zone having

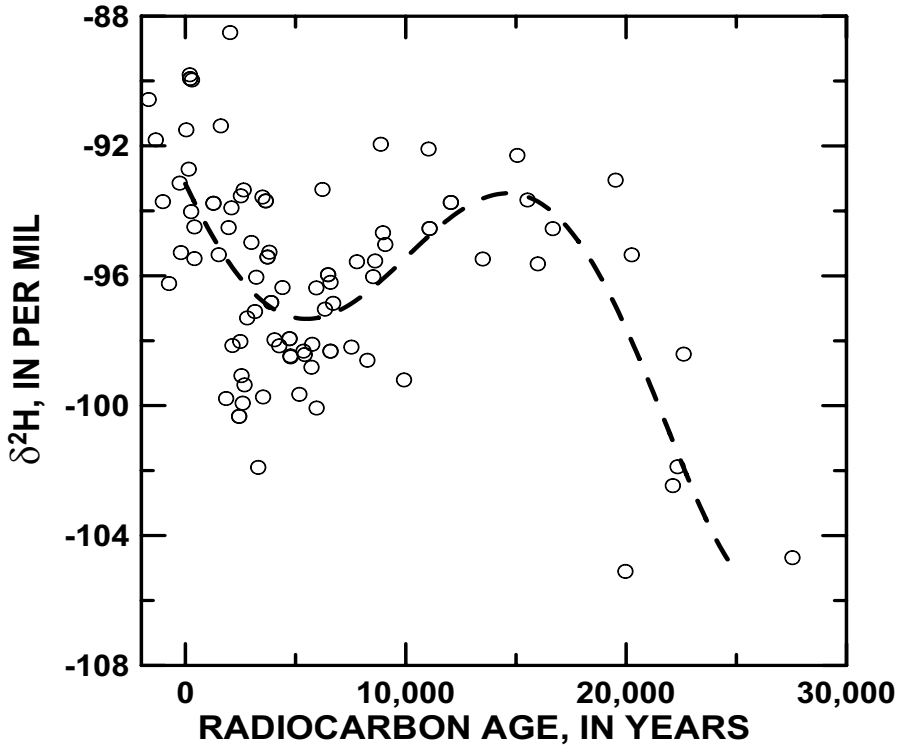


Figure 110. δ^2H isotopic composition of ground water of Rio Grande origin (Central zone) as a function of radiocarbon age, Middle Rio Grande Basin, New Mexico. The dashed line is a 5-degreee polynomial fit to the data points.

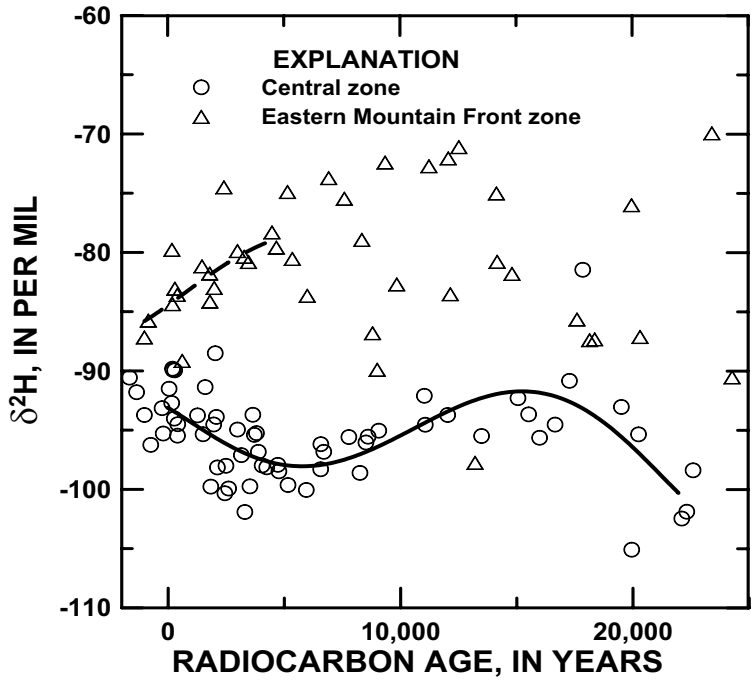


Figure 111. Comparison of the δ^2H isotopic composition of ground water from the Central zone with water recharged along the eastern mountain front as a function of radiocarbon age, Middle Rio Grande Basin, New Mexico. The lines represent 5-degree polynomial fits to the data.

radiocarbon ages from modern to more than 22 ka B.P. are shown in figure 111. Samples from wells with more than 200 feet of open interval were excluded. Apparently, the pattern in historical variations in the stable isotopic composition of water from the Central zone was not sensitive to well-screen length in the present data set, probably because only 20 percent of the samples were from wells with screens greater than 200 feet.

During the past 5,000 years, while δ^2H of water from the Central zone increased by nearly 6 per mil from a local minimum near –98 per mil, δ^2H of moisture recharged along the eastern mountain front became more depleted in ^2H, by about 7 per mil (fig. 111). The changes in δ^2H of Central-zone water and Eastern Mountain Front-zone water during the past 5 ka, as evidenced in the ground-water samples, are small, but vary in opposite direction as a function of radiocarbon age (fig. 111). Most ground water from the Eastern Mountain Front zone with radiocarbon ages greater than 5 ka B.P., range in δ^2H isotopic composition from about -90 to -70 per mil with little evidence of temporal variability (fig. 111). Water recharged from the Rio Grande to the Central zone apparently had a local minimum in δ^2H isotopic composition at approximately 5 ka B.P., had a maximum at about 15 ka B.P., and had an overall minimum at about 22 ka B.P. (fig. 111).

It was shown in the section "Sources of Recharge and Underflow to the Santa Fe Group Aquifer System" that over the past 20 years, the δ^2H of Rio Grande water has varied with the extent of winter snow pack in southern Colorado and northern New Mexico. Winters with high snowfall in southern Colorado and northern New Mexico are followed by spring runoff in the Rio Grande that is more depleted in ^2H than in years of low snowfall. Sulfur isotope and tritium data (discussed earlier) also indicate that Rio Grande water is a mixture of ground-water sources and snowmelt. During the summer and fall, Rio Grande water is enriched in ^2H (fig. 23), reaching values of δ^2H, for example, of approximately -85 per mil in August through October of 1998 (table B6). The enriched values are probably representative of base flow from the Rio Grande drainage basin mixed with runoff of lower-altitude precipitation from the summer monsoon season. The summer monsoon season occurs today in the months of July through October in the MRGB.

The depleted stable isotope values for Rio Grande water at about 20-28 ka B.P. probably indicate

cooling during the last glacial period and high proportions of snowmelt in the Rio Grande. Recharge temperatures determined from measurements of noble gases in ground water from the Carrizo aquifer (central Texas) and the San Juan Basin (northwestern New Mexico) were 5.2 ± 0.7 and 5.5 ± 0.7°C lower, respectively, during the last glacial maximum (approximately 20,000 radiocarbon years B.P.) than during the Holocene (Stute and others, 1992; Stute and others, 1995). Phillips and others (1986) found depletion of some 25 per mil in δ^2H of Pleistocene-age water relative to modern waters from the central San Juan Basin, northwestern New Mexico, and an average cooling of 5 to 7°C during the last glacial period. Thompson and others (1999) reconstructed the pattern of annual temperature and annual precipitation in the vicinity of Yucca Mountain, southern Nevada, from studies of packrat middens for four intervals of the late Pleistocene. For the periods of 35-30 ka, 27-23 ka, 20.5-18 ka, and 14-11.5 ka, mean annual temperature was lower than today by about 4, 5, 8, and 5.5°C, respectively, and mean annual precipitation was estimated to be 1.5, 2.2, 2.4, and 2.6 times modern levels of precipitation, respectively. Lake Estancia, to the east of the MRGB, had nine high stands from about 22 ka to 12 ka (Allen and Anderson, 2000); thus, it is reasonable to assume an increased snow pack through much of this period. Yet, the Rio Grande actually became more enriched in ^2H during the period from about 22 to 15 ka (fig. 110).

To a first approximation, water in the Rio Grande contains fractions of high altitude (relatively depleted in ^2H) snowmelt from southern Colorado and northern New Mexico and runoff of precipitation that falls at lower altitude (relatively enriched in ^2H) within the Rio Grande drainage basin, including runoff from thunderstorms during the summer monsoon season (July-October). During the pluvial from about 22 ka to 12 ka, as recorded at Lake Estancia (Allen and Anderson, 2000), the somewhat enriched stable isotope composition of paleo-Rio Grande water (ground water from the Central zone which reached a maximum in δ^2H at about 15 ka B.P.) indicates an increased fraction of low-altitude runoff mixed with snowmelt in discharge of the Rio Grande (fig. 111), despite mean annual temperatures that were likely lower than today. During the mid-Holocene warm period (4-8 ka B.P.), the δ^2H of the Rio Grande was actually more depleted than today, reflecting less low-altitude runoff from the drainage basin, and a higher fraction of snowmelt from the mountains of southern Colorado and northern New Mexico than today.

Two scenarios were considered to explain the historical variability in the δ^2H isotopic composition of Central zone ground water: 1) variability in amounts of low-altitude precipitation delivered to the basin, and 2) changes in the timing of peak runoff of snowmelt from northern New Mexico and southern Colorado. Both scenarios would vary the proportions of depleted high-altitude snowmelt and low-altitude runoff in Rio Grande discharge.

In the first scenario, dry climatic periods would lead to less runoff of low-altitude precipitation and higher fractions of snowmelt in Rio Grande discharge, resulting in Rio Grande water that is relatively depleted in ^2H. Periods of relatively enriched ^2H isotopic composition of Rio Grande water would result from periods of increased low-altitude precipitation in the basin. Consequently, the stable isotope record from the Central zone would indicate increased low-altitude precipitation in the basin during the last pluvial, from about 22 to12 ka B.P. and during the past approximately 5 ka. (fig. 111). The relatively depleted stable isotopic composition of Central zone water from the mid-Holocene warm period, approximately 4-8 ka B.P., would indicate a period of decreased low-altitude precipitation in the basin.

Even though the discharge of the Rio Grande may have been higher during the pluvial of the last glacial period (12-22 ka B.P.), the fraction of water from low-altitude recharge in the river also apparently increased, causing an increase in the δ^2H isotopic composition of the river relative to the mid-Holocene, when supposedly less low-altitude runoff occurred. During the past 5 ka, the rise in δ^2H of Rio Grande water of about 7 per mil may again reflect an increased fraction of low-altitude water relative to the dry period of the mid-Holocene, even though river discharge is probably less today than in the late Pleistocene pluvial.

In the second scenario, it is recognized that the timing of the spring snowmelt in the mountains of southern Colorado and northern New Mexico shifts with changes in seasonal temperature. During the last glacial period, colder temperatures would delay the spring snowmelt and delay the season of peak spring runoff of isotopically depleted snowmelt. A cooling of 5°C during the LGM may have caused periods of peak runoff of snowmelt to overlap, at least in part, with the summer monsoon season, resulting in an increase in the fraction of low-altitude summer precipitation mixed

with mountain snowmelt. The resulting isotopic composition of the Rio Grande during peak runoff would be enriched in ^2H relative to that of snowmelt. During warm climatic periods, mountain snowmelt would occur in early spring and likely peak prior to the summer monsoon season, as presently, resulting in peak runoff of the Rio Grande that is more depleted in ^2H than in cold times when snowmelt is delayed. This scenario implies that recharge to ground water of the Central zone occurs primarily during periods of high Rio Grande discharge.

On the basis of the available data, neither of the two scenarios for explaining the historical variations in the isotopic composition of Central-zone ground water can be eliminated, and it is likely that, to some extent, both processes described in the two scenarios contribute to the isotopic composition of Rio Grande water.

The stable isotopic composition of Eastern Mountain Front-zone water (triangles on fig. 111) is primarily a function of altitude and temperature effects (Dansgaard, 1964). Because of isotope fractionation, precipitation from higher altitude and lower temperature is more depleted than precipitation falling at lower altitude and higher temperature. More depleted precipitation falls in colder than warmer climates. There is a wide variation in δ^2H of water recharged along the Eastern Mountain Front, particularly for waters older than 5 ka B.P. (fig. 111). However, some of the most depleted waters from the Eastern Mountain Front have radiocarbon ages from the LGM, approximately 20 ka B.P., and these are near -90 per mil in δ^2H. The maximum range in δ^2H of Eastern Mountain Front zone water varies from about -70 per mil in some samples recharged during the mid-Holocene to about -90 per mil in some samples from the LGM. If the change in δ^2H of water between the LGM and the mid-Holocene results from temperature effects only, a temperature variation of about 3.9 ± 0.2°C is indicated based on the temperature dependence of isotope fractionation (van der Straaten and Mook, 1983). In the past 5 ka, the decrease of about 7 per mil in δ^2H of water recharged along the Eastern Mountain Front, if the result of temperature changes only, indicates average cooling along the eastern basin margin of about 1.4°C (van der Straaten and Mook, 1983). However, further study is needed to determine if other processes, such as change in moisture source or shift in predominant season of recharge, could account for the decrease in δ^2H along the basin margin during the past 5 ka.

Even though the trends in stable isotope composition of the Rio Grande and eastern mountain front recharge are in opposite directions during the past 5 ka, they both may indicate a consistent climatic scenario—for example, increased low-altitude precipitation accompanied by cooling of about 1.4°C during the past 5 ka along the eastern mountain front. Similar conclusions can be drawn from the $\delta^{18}O$ data. There is no evidence that this climatic trend has changed in the most recent past, but the data are probably not precise enough to resolve climatic changes during the past 1 ka. More reliable indicators of recent climatic change can be found in the stalagmite record of Polyak and others (2001), and the tree-ring record of Grissino-Mayer (1995, 1996). The stalagmite record indicates a cooler, wetter climate during the period 3,200 to 800 years, B.P., which changed to the present warmer and dryer climate about 800 years ago. Grissino-Mayer (1995, 1996) used tree-ring data to reconstruct a record of precipitation at El Malpais National Monument, located about 70 miles west of the MRGB in northwestern New Mexico, spanning the the period 136 B.C. to A.D. 1992. The tree-ring data record alternating periods of above-normal and below-normal rainfall. Periods of above-normal rainfall occurred during A.D. 81-257, 521-660, 1024-1398, and 1791-1992. Below-normal rainfall occurred during the periods A.D. 258-520, 661-1023 and 1399-1790. During the past 200 years, rainfall at El Malpais National Monument exceeded any since A.D. 660, and the period 1978-1992 was the wettest 15-year period of the entire 2,129-year tree ring record. The minimum and maximum averaged annual rainfalls interpreted from short-term (10-year smoothing) tree-ring records were 12.86 and 16.65 inches per year, respectively.

Paleorecharge Temperatures

Measured concentrations of dissolved N_2 and Ar were used to estimate recharge temperatures and quantities of excess air (Herzberg and Mazor, 1979; Heaton, 1981; Heaton and Vogel, 1981; Heaton and others, 1983; Busenberg and others, 1993; Stute and Schlosser, 1999) in MRGB ground-water samples, as summarized in table A5. Recharge temperature is the temperature at the water table during recharge, and excess air refers to quantities of air trapped during

recharge that subsequently dissolved under increased hydrostatic pressure during periods when the water table rose above the capillary fringe. Recharge temperature is determined from the measured dissolved gas concentrations using the temperature dependence of the Henry's Law solubilities of atmospheric gases and an assumed altitude (barometric pressure) of recharge. Although the accuracy of the reported recharge temperature is typically ± 0.5°C on laboratory standards (table D9), the altitude of recharge in the MRGB is uncertain for some hydrochemical zones. The highest uncertainties in recharge altitude apply to water from the West-Central zone that could potentially have infiltrated above 11,000 feet above sea level along the highest flanks of the Jemez Mountains, or at approximately 5,000 feet at the water table within parts of the MRGB.

In calculation of recharge temperatures from the dissolved gas data, a most likely recharge altitude was assumed for each hydrochemical zone and was varied by ± 1,500 feet (table A6). Water recharged at 6,500 ± 1,500 feet has an uncertainty in recharge temperature of ± 2°C (table A6). Recharge temperatures were calculated for assumed recharge altitudes of 5,000, 6,500, or 8,000 feet (table A6). As the altitude of the Rio Grande is near 5,000 feet, no water in the basin is recharged at altitudes lower than about 5,000 feet. The average rechare altitudes of waters recharged in the Northwestern, Western Boundary, Rio Puerco, Northeastern, and Central hydrochemical zones were assumed to be 5,000 feet. A recharge altitude of 6,500 feet was assumed for water recharged in the Northern Mountain Front, Eastern Mountain Front, Tijeras Fault Zone, and Tijeras Arroyo hydrochemical zones. Water in the West-Central hydrochemical zone was assumed to have recharged at an average altitude of 8,000 feet. The recharge temperature is underestimated if the recharge altitude is overestimated. Thus, if water within parts of the West-Central zone recharged the MRGB by direct infiltration to the water table near 5,000 feet, the recharge temperatures calculated assuming recharge at 8,000 feet would be underestimated by 4-5°C (table A6). Conversely, if water in the West-Central zone were recharged at altitudes of, for example, 11,000 feet along the Jemez Mountains, the recharge temperature calculated assuming recharge at 8,000 feet would be biased high by about 4-5°C. Although the recharge altitude can be particularly uncertain for recharge in the West-Central zone, recharge altitudes of more than 14,000 feet (the highest altitude along the Jemez Mountains) would be required to lower some of the N_2-Ar recharge temperatures to the present mean annual temperature at Albuquerque (13.6°C). The impossibility of explaining some of the very warm recharge temperatures (such as 30°C) observed in parts of the MRGB by assuming high recharge altitudes is further demonstrated considering that, because of altitude, recharge temperatures would be considerably lower than 13.6°C at high altitude, requiring recharge altitudes considerably higher than 14,000 feet. Although the assumption of higher-altitude recharge can help to lower the calculated recharge temperatures for waters from the West-Central zone, additional processes must be affecting the waters in the West-Central zone in order to account for the calculated warm recharge temperatures. In contrast, the recharge altitude is known within approximately 200 feet for water recharged as infiltration from the Rio Grande, and the resulting uncertainty in recharge temperature is probably less than ± 0.3°C.

In reducing waters, denitrification processes can reduce dissolved NO_3 to N_2 gas. If not recognized and corrected for, denitrification leads to a warm bias in recharge temperature, an overestimate of excess air in ground-water samples, and a low estimate of total NO_3 initially recharged in ground water. Several procedures were utilized to refine recharge temperatures, excess air, and amounts of denitrification. For aerobic samples (dissolved oxygen concentrations greater than approximately 0.5 mg/L), it was assumed that denitrification had not occurred, and that the samples were not mixtures of anaerobic and aerobic waters. In this case, the recharge temperature and excess air were calculated directly from the dissolved N_2 and Ar data, using the assumed recharge altitude for the particular hydrochemical zone in which the sample was located; the quantity of N_2 derived from denitrification was assumed to be zero. For waters with low dissolved oxygen concentrations (dissolved oxygen concentrations less than approximately 0.5 mg/L), such as in some samples from the inner valley of the Rio Grande, there is potential for denitrification. In calculating recharge temperatures of anaerobic waters, average quantities of excess air or average recharge temperatures were assumed, based on results from aerobic samples in the same hydrochemical zone, and then used with the dissolved N_2 and Ar data to estimate quantities of denitrification. The results are summarized in tables A5-A6.

Throughout the MRGB, most ground-water temperatures are appreciably warmer than the modern mean annual temperature at Albuquerque (13.6°C) (fig. 30). Median ground-water temperatures vary by hydrochemical zone from 16.1°C (water in the Tijeras Arroyo zone) to 23.8°C (water in the West-Central zone) (table 8). Maximum water temperatures are about 30°C for some water on the West Mesa, west of Albuquerque. Warm ground-water temperatures in the MRGB result from heating under the effect of the local geothermal gradient (Reiter, 2001). The lowest water temperatures are found in shallow water samples at relatively high altitude— for example, discharge from Embudo and Embudito Springs along the eastern mountain front above Albuquerque (altitudes of 6,600 and 6,440 feet, respectively) has water temperatures of 8-9°C.

In arid and semiarid environments, recharge can occur (if at all) as continuous, diffuse infiltration of water, maintaining close contact with the unsaturated zone air, or as transient, focused recharge in response to, for example, floods in arroyos or stream valleys that bypass most water contact with the unsaturated-zone air (Gee and Hillel, 1988). Therefore, water may partially or fully equilibrate with the unsaturated zone air during diffuse-flow recharge (resulting in warm recharge temperatures calculated from the dissolved N_2-Ar data), or retain N_2 and Ar concentrations acquired at the land surface during focused recharge (resulting in cold recharge temperatures calculated from the dissolved N_2-Ar data). Except for direct infiltration from rivers, recharge temperatures calculated from dissolved gas data may be biased warm (depending on the extent of gas exchange during infiltration) because of warming during infiltration in recharge areas to the MRGB. If a paleoclimate signal remains in the calculated recharge temperatures, it will be found primarily in the samples with the lowest recharge temperatures for each hydrochemical zone as a function of time.

The recharge temperatures calculated from the dissolved N_2-Ar concentrations for water samples from the West-Central zone and the Eastern Mountain Front zone are plotted against the measured water temperatures in figure 112. The recharge temperatures for waters from the West-Central zone were calculated assuming a recharge altitude of 8,000 feet, and those from the Eastern Mountain Front zone were calculated for recharge at 6,500 feet. A relatively large range in recharge temperature is indicated, from about 3 to 22°C for waters from the West-Central zone and about 8 to 18°C for waters from the Eastern Mountain Front zone. Points plotting nearest the 1:1 line indicate ground water that has calculated recharge temperatures similar to the measured water temperature, such as could be found in recharge that is still near the water table in the area where infiltration occurred. Most samples have water temperatures that are appreciably warmer than the calculated recharge temperature, indicating warming in the aquifer system under effect of the local geothermal gradient, presumably as a result of ground-water circulation to depths below the water table following recharge (see for example, Reiter, 2001).

Assuming an average lapse rate of about -5.5 °C/km (Meyer, 1992), and the mean annual temperature of 13.6°C at Albuquerque (altitude approximately 5,000 feet above sea level), recharge temperatures of about 11.1 and 8.6°C would be anticipated for water recharged at 6,500 and 8,000 feet, respectively, today. A cooling of 5°C in the mean annual temperature at the last glacial maximum (Stute and others, 1992, 1995) could lead to recharge temperatures of 3-4°C for higher altitude recharge along the flanks of the Jemez Mountains (8,000 feet) and recharge temperatures of about 6 and 9°C at altitudes of 6,500 and 5,000 feet during that time. Some waters from the West-Central zone were apparently recharged near 4°C, if the recharge altitude was near 8,000 feet (fig. 112). Examples include waters from sites S193, S288, S166, and S219 that have recharge temperatures of 3.2, 4.5, 5.4, and 5.8°C, and radiocarbon ages of 20.6, 20.0, 19.7, and 23.2 ka B.P., respectively. One other sample from the West-Central zone, S175, (Fig. 112) has a recharge temperature of 4.1°C and radiocarbon age of 8.9 ka. Two horizontal lines (fig. 112) show the modern mean annual temperature estimated for recharge at altitudes of 6,500 and 8,000 feet (11.1 and 8.6°C, respectively). Most of the waters from the West-Central zone have recharge temperatures lower than the mean annual temperature at Albuquerque (13.6°C), and many have recharge temperatures lower than 8.6°C (fig. 112). Recharge temperatures in the West-Central zone waters that are lower than the modern mean annual temperature (8.6°C) indicate recharge that occurred at altitudes higher than 8,000 feet (barometric pressure lower than that at 8,000 feet, and mean annual temperature lower than 8.6°C), or recharge that occurred during the last glacial period, when mean annual temperature would be lower than that observed today. Similarly, waters from the Eastern Mountain Front

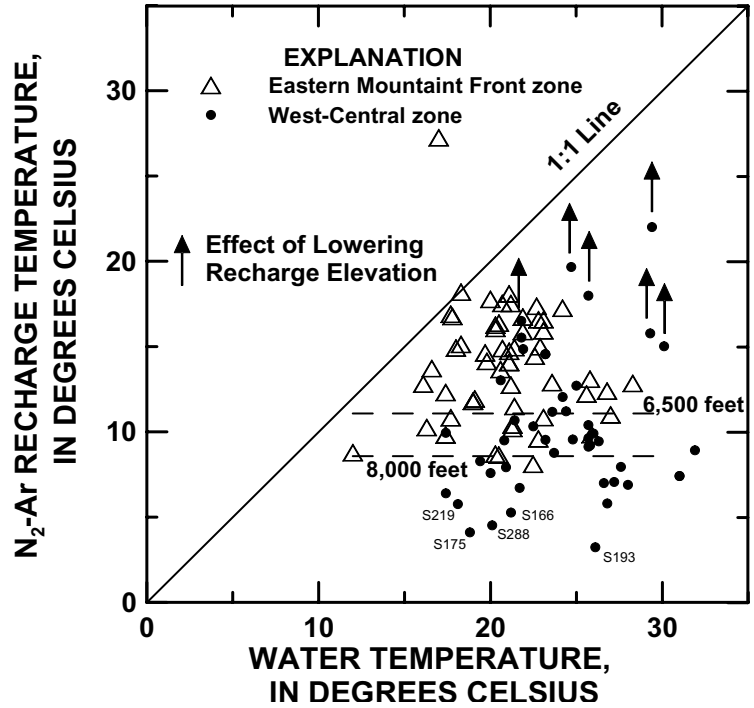


Figure 112 Comparison of N_2-Ar recharge temperature with the measured ground-water temperature for waters from the West-Central and Eastern Mountain Front zones, Middle Rio Grande Basin, New Mexico. The arrows show the effect on the calculated recharge temperature if a lower elevation of recharge is assumed in the calculation. The recharge temperatures were calculated assuming altitudes of 6,500 feet for the Eastern Mountain Front and 8,000 feet above sea level for the West-Central zone waters, respectively. The dashed lines show the estimated modern mean annual temperature for altitudes of 6,500 and 8,000 feet.

zone with recharge temperatures lower than 11.1°C indicate recharge that occurred at altitudes higher than 6,500 feet, where mean annual temperature would be lower than 11.1°C and barometric pressure would be lower than that at 6,500 feet, or recharge during the last glacial period, when mean annual temperature would be lower than that observed today.

Other waters from the West-Central and Eastern Mountain Front zones were recharged at temperatures appreciably warmer than the paleo and modern mean annual temperature (fig. 112). These samples may indicate recharge that has occurred by diffuse infiltration through a relatively thick unsaturated zone (probably greater than 300 feet) where the infiltration water is warmed along a geothermal gradient prior to reaching the water table. Where recharge has occurred through a warm unsaturated zone, such as may be the case for some samples from the West-Central and Eastern Mountain Front zones with recharge temperatures warmer than the mean annual temperature, the recharge altitudes were probably lower than 8,000 feet and 6,500 feet, respectively, because the water table altitude may be below 8,000 feet in recharge areas for the West-Central zone, and below 6,500 feet for the Eastern Mountain Front zone (fig. 9). The arrows on figure 112 indicate that the calculated recharge temperatures for some samples from the West-Central zone would be closer to the 1:1 line if the samples were recharged at an altitude lower than 8,000 feet.

Calculated recharge temperatures in relation to hydrochemical zones for all samples in those hydrochemical zones in which the N_2 and Ar dissolved-gas measurements were made are shown in figures 113a,b. Several distinct patterns in recharge temperature are recognized in parts of the MRGB (figs. 113a,b).

N_2-Ar recharge temperatures for all West-Central zone waters, calculated assuming a recharge altitude of 8,000 feet, are shown in figure 113a. In the northern part of the basin, waters from the West-Central zone are included in figure 113a that were identified beneath the Northwestern zone. Also shown are waters from the West-Central zone that were

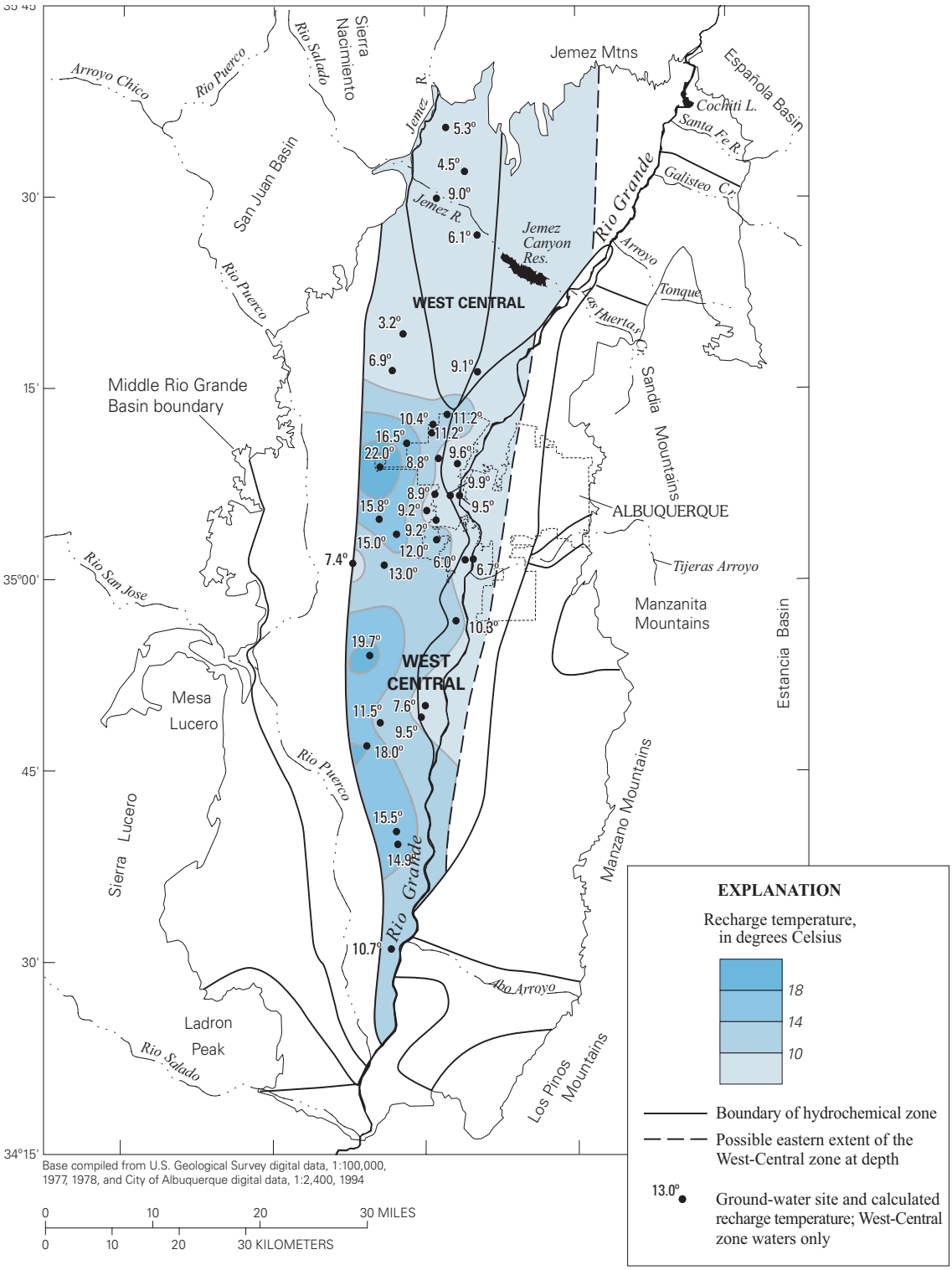


Figure 113a. N_2-Ar recharge temperatures for all dissolved gas samples from the West-Central zone of the Middle Rio Grande Basin, New Mexico, calculated at an assumed recharge altitude of 8,000 feet. Included are samples in the West-Central zone from beneath the Northwestern zone in the northern part of the basin and beneath the Central zone along the Rio Grande. Site labels indicate the calculated recharge temperatures. Two groups of recharge temperatures are evident. Relatively low recharge temperatures are found for samples from the West-Central zone in the northern third of the basin and along the eastern half of the zone. Relatively warm recharge temperatures occur in the western half of the southern two-thirds of the West-Central zone.

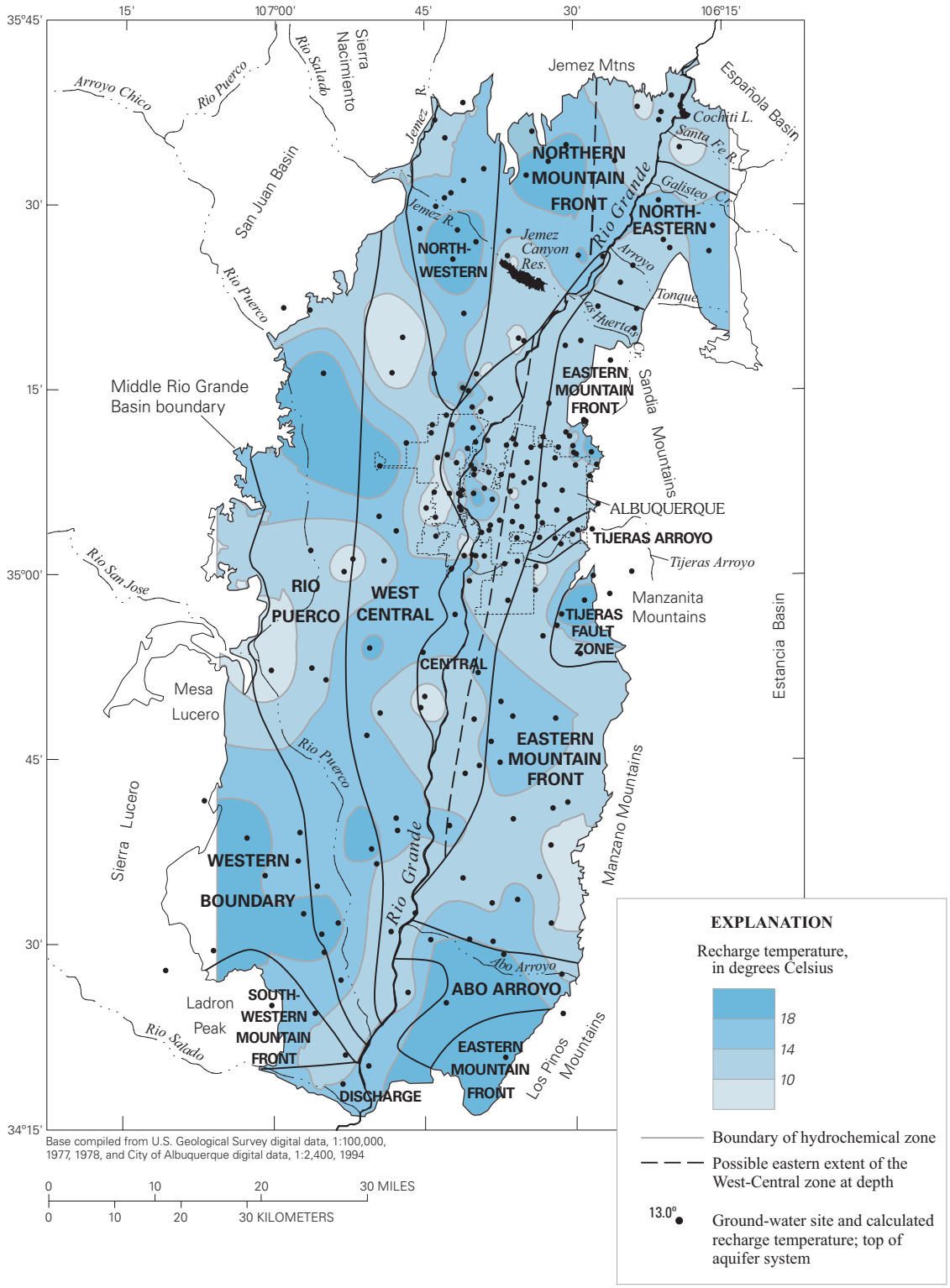


Figure 113b. N_2-Ar recharge temperatures for all dissolved gas samples from the upper-most hydrochemical zones in the Middle Rio Grande Basin, New Mexico, including the West-Central zone where it is at the water table. Excluded are samples from the West-Central zone beneath the Northwestern and Central zones (fig. 113a). The waters from the Northern Mountain Front and Northwestern zones have warm recharge temperatures in comparison to waters from the West-Central zone at lower depths in the northern third of the basin (fig. 113a). Most samples throughout the MRGB have recharge temperatures warmer than 14ºC. See text for recharge altitudes used in the calculations and tables A5 and A6 for summaries of the calculations.

identified beneath Central zone waters (fig. 113a). The labels for the West-Central zone samples give the calculated recharge temperature for each sample. Two general groupings of recharge temperatures are evident for the West-Central zone waters. Along the northern third and eastern half of the basin, West-Central zone waters have recharge temperatures less than 10°C. Across the northern third of the basin, West-Central zone waters have an average recharge temperature of 6.7 ± 2.0°C. Along the western half of the southern two-thirds of the basin, West-Central zone waters have appreciably warmer recharge temperatures than those in the northern third and eastern half of the basin, typically warmer than 10°C and as warm as 22°C (fig. 113a). Whereas the waters from the northern third and eastern half of the West-Central zone have recharge temperatures consistent with the suggested recharge source along the flanks of the Jemez Mountains, most of the waters along the western half of the southern two-thirds of the West-Central zone were warmed appreciably in contact with air and have exchanged gases. These waters of the West-Central zone with warm recharge temperatures apparently have a different mechanism of recharge than those recognized along the northern margin of the basin, yet they retain the otherwise same chemical and isotopic signature of West-Central zone waters (tables 8-9).

The N_2-Ar recharge temperatures for all measured samples from zones at the top of the water table across the MRGB are mapped in figure 113b. Waters from the Northern Mountain Front and Northwestern zones have average recharge temperatures of 13.5 ± 4.1 and 18.1 ± 3.0°C, respectively— more than 7°C warmer than waters from the West-Central zone beneath the Northern Mountain Front and Northwestern zones. The waters in the Northern Mountain Front and Northwestern zones are younger than those in the West-Central zone (table 8), and, based on relatively enriched stable isotopic composition, were recharged at lower altitudes than those of the West-Central zone. The dissolved gas recharge temperatures indicate that the waters from the Northern Mountain Front and Northwestern zones were warmed during recharge, such as may have occurred during infiltration through relatively deep unsaturated zones along the northern margin of the basin. Other evidence of warming during recharge is seen in waters in the southeast part of the basin, in recharge in the vicinity of the Tijeras Fault Zone, in eastern mountain front recharge near Albuquerque, and in areas along the western margin of the basin (fig. 113b).

There are also differences in recharge temperatures across the northern mountain front, with relatively low recharge temperatures (7.9 - 12.5°C) in the northeastern part of the Northern Mountain Front zone, and relatively high recharge temperatures (15.7 - 20.3°C) in the northwestern part of the zone (fig. 113b). Presumably, these differences reflect differences in recharge mechanism, with higher proportions of focused recharge through arroyos in the northeast, and greater proportions of diffuse infiltration in the northwestern part of the Northern Mountain Front zone. Depths to the water table are typically larger in the northwestern part of the Northern Mountain Front zone than in the northeast, being as much as 991 feet to the water table in the northwestern part of the Northern Mountain Front zone, and typically 141-226 feet in the northeastern part of the zone. The median groundwater temperature in the Northern Mountain Front zone is 18.9°C (table 8), with a median radiocarbon age of about 7 ka B.P., and median δ^2H of -77.7 per mil.

All of the samples from the Northwestern hydrochemical zone have relatively warm recharge temperatures (14.1-24.5°C), indicative of predominantly diffuse recharge. Water levels are typically 300-500 feet below land surface in the Northwestern hydrochemical zone. Water from the Northwestern zone can be traced south to the Lincoln Middle School piezometer nest (sites S103-105), where the deep, medium and shallow completions have recharge temperatures of 19.4, 18.3, and 19.4°C, respectively, and span the upper-most 600 feet of the aquifer system, and to the nearby Rio Rancho wells 4 and 8 (sites S191 and S192), where recharge temperatures are 18.6 and 17.7°C, respectively. Further to the south of the Lincoln nest, the waters sampled were of Rio Grande origin and waters of the Northwestern hydrochemical zone were no longer recognized. Most waters from the Northwestern hydrochemical zone have radiocarbon ages of less than about 15 ka (median radiocarbon age of 7.7 ka B.P.), and most have relatively enriched δ^2H (median δ^2H of -64.7 per mil). The δ^2H values of water from both the Northern Mountain Front and Northwestern hydrochemical zones are enriched in ^2H relative to Eastern Mountain Front zone water (-81.0 per mil), and indicative of low-altitude recharge to the MRGB. Some of the waters from the Northern

Mountain Front and Northwestern hydrochemical zones have approximately modern radiocarbon ages.

Water from the West-Central zone has recharge temperatures that range from 3.2 to 22.0°C, which is the highest range in recharge temperatures calculated for any hydrochemical zone in the MRGB. In the northern part of the basin, low recharge temperatures (4.5 to 9.9°C) are found in water from the six wells that intercept water from the West-Central hydrochemical zone beneath waters of the Northwestern zone (water from sites S288, S166, S218, S219, S283, S285). Low recharge temperatures (3.2 and 6.9°C) are found at Rio Rancho wells 9 and 13 (S193 and S188, respectively) in the northwestern part of the West-Central zone. Low recharge temperatures (7.6 to 11.2°C) are also found along the eastern-most half of the West-Central zone from an area just northwest of Albuquerque south to vicinity of Belen (fig. 113a). Warm recharge temperatures (14.9 to 22.0°C) can be found in water from the westernmost half of the West-Central zone from the vicinity of site S243 south to Belen. The axis of the ground-water trough (fig. 9) approximately divides waters with warm recharge temperatures on the west side of the West-Central zone from those with cold recharge temperatures on the east side of the West-Central zone. The waters in the West-Central zone with low recharge temperatures can be traced throughout the eastern-most half of the West-Central zone to the northern margin of the basin beneath water of the Northwestern hydrochemical zone (fig. 113a). The waters with warm recharge temperatures occurring in the western-most half of the West-Central zone have exchanged gases with warm unsaturated-zone air during recharge, indicating a different mechanism of recharge than that for waters with cold recharge temperatures in the eastern-most half of the West-Central zone. All of the waters from the West-Central zone typically have old radiocarbon ages (median radiocarbon age of 19.7 ka B.P.) and are depleted in ^{2}H (median ^{2}H of -96.7 per mil) relative to waters of the Northern Mountain Front, Northwestern, and Eastern Mountain Front zones.

Most recharge temperatures of waters from the Eastern Mountain Front zone range from 8.1 to 18.2°C. The lowest temperatures (8-9°C) are about 2°C warmer than that expected for recharge during the last glacial period at altitudes of approximately 6,500 feet, and occur in waters with radiocarbon ages of modern to about 18 ka B.P. Relatively low recharge temperatures (8.1-13.7°C) are calculated for waters along the northeastern part of Albuquerque (fig. 113b), while along the southeastern side of Albuquerque, Eastern Mountain Front zone waters have relatively warm recharge temperatures (15.0 to 17.4°C). The lowest recharge temperatures from the Eastern Mountain Front zone, being near the expected mean annual temperature, probably indicate waters originating primarily as focused recharge through a series of arroyos and canyons that capture runoff from the Sandia Mountains to the east. Relatively warm recharge temperatures in southeastern Albuquerque are apparently recharged by more diffuse infiltration through the warm unsaturated zone; the median water temperature of the Eastern Mountain Front zone is 22.0°C, and the median calculated recharge temperature is 14.3°C.

Where the aquifer system and surface-water sources are in contact, seepage from surface-water sources passes directly into the aquifer system; for those samples, the calculated recharge temperature probably represents the surface-water temperature at the time of recharge. For example, waters from the Tijeras Arroyo zone have a narrow range of recharge temperatures (11.8-12.7°C) that probably represent average water temperatures of discharge from Tijeras Arroyo. Twenty-two, approximately monthly, measurements of the temperature of Tijeras Arroyo water between January 1997 and March 1999 averaged 13.8°C (table B2). Streambed temperatures recorded at 30-minute intervals in 1990 at a depth of approximately 1 foot beneath Tijeras Arroyo ranged from about 3 to 23 °C (Constantz and Thomas, 1996), with an average temperature of 12-13°C. Water from the Central zone (of Rio Grande origin) has N_2-Ar recharge temperatures that range from 7.3 to 23.4°C. These recharge temperatures, more than any others in the MRGB, are probably most representative of water temperatures at the time of recharge. The recharge temperatures from the Central zone are examined in more detail below.

Relatively warm recharge temperatures (14.2 to 21.9°C) are calculated for waters in the southwestern part of the basin (Western Boundary and Rio Puerco zones) (fig. 113b) and may indicate diffuse recharge of infiltration from the Rio Puerco and other arroyos in areas where, in the past, they were not in direct contact with the water table. Water levels in the vicinity of the warm recharge temperatures form the Western Boundary and Rio Puerco zones range from 269 to 390 feet below land surface.

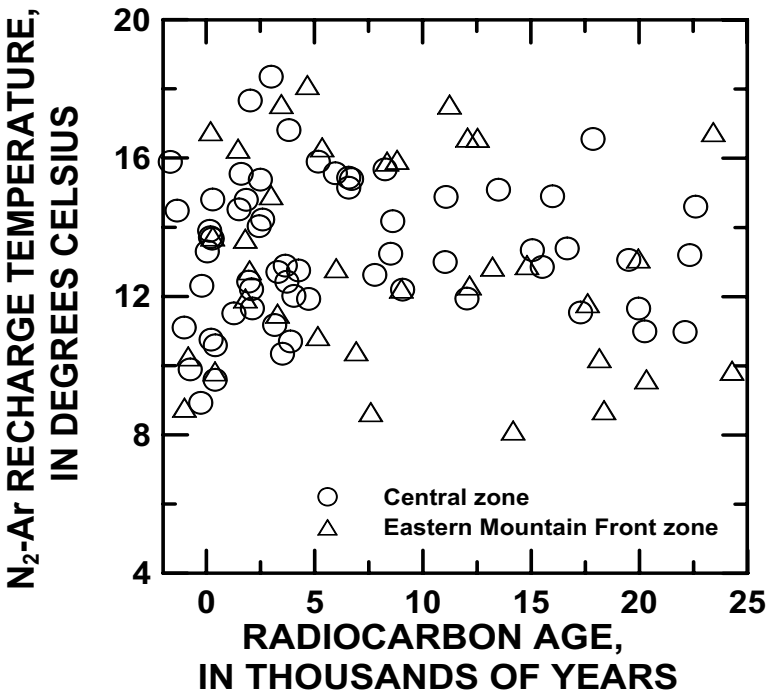


Figure 114. N_2-Ar recharge temperatures of ground water from the Central Zone and Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, as a function of radiocarbon age.

Recharge temperatures for waters from the Eastern Mountain Front zone are compared to recharge temperatures of waters from the Central zone as a function of radiocarbon age in figure 114. As discussed above, an uncertainty of ± 1,500 feet in recharge altitude for waters from the Eastern Mountain Front zone results in uncertainties of ± 2°C in calculated recharge temperature, whereas recharge temperatures for waters of Rio Grande origin are probably reliable within the analytical precision of ± 0.5°C. Yet, the recharge temperatures for waters from the Eastern Mountain Front and the Central zone vary considerably (fig. 114). Recharge temperatures from the eastern mountain front vary from 8.1 to 18.1°C, with the minimum corresponding to the expected modern recharge temperature for recharge at about 8,000 feet. Of the measurements obtained for recharge temperature of waters from the eastern mountain front, the values average 11.4 ± 2.8, 13.9 ± 3.3, 12.9 ± 2.9, and 13.6 ± 3.0°C over the radiocarbon age intervals of 15-27 ka, 11-13 ka, 5-9 ka, and 0-5 ka B.P. Over the same radiocarbon age spans, the average of values of recharge temperature for waters from the Central zone are 12.7 ± 1.4, 13.3 ± 1.5, 14.5 ± 1.4, and 13.0 ± 2.2°C, respectively. The number of samples in each age range differ and the uncertainties represent one standard deviation of the values averaged.

Whereas recharge temperatures of waters recharged through the Eastern Mountain Front can be biased warm because of infiltration through relatively deep unsaturated zones, the waters from the Central zone probably indicate actual Rio Grande water temperatures as the surface water infiltrated the aquifer system. During the period June 1996 through March 1999, 74 monthly measurements of the temperature of Rio Grande water near Albuquerque (table B2) averaged 13.9 ± 7.6°C, which is near the modern mean annual temperature at Albuquerque of 13.6°C and within the range of the N_2-Ar recharge temperatures calculated for all of the paleowaters of Rio Grande origin, 12.7 ± 1.4 to 14.5 ± 1.4°C. Presently (2003), Rio Grande water temperatures are maximum in late July (modern values near 25°C) and minimum in early January (modern values near 0°C) (table B2). All values of recharge temperature for Central zone waters range from 8.9 to 18.4°C. Using the modern seasonal temperature variation of the Rio Grande and assuming that the N_2-Ar concentrations in Rio Grande water are in equilibrium with the atmosphere at the temperature of the air-water interface, the temperature range of 8.9

to 18.4°C corresponds to recharge occurring in the modern seasonal periods mid-March to early June, and mid-September to late November. Because the fall season usually is a period of low flow in the Rio Grande, it is more likely that the predominant season of ground-water recharge to the Central zone occurred during the spring when river discharge was probably high.

The coolest average recharge temperatures retrieved from paleo Rio Grande water samples were from the period 15-27 ka B.P., and warmest from the period 5-9 ka B.P.; however, because the standard deviations of the two groups overlap, it is only possible to conclude that the average temperature of Rio Grande water recharged to the MRGB has been nearly constant for the past 27 ka, and the average temperature over the four time periods has been within about 1°C of the modern mean annual temperature. A significant implication is that, if the average recharge temperatures of Central zone waters record long-term temporal variations in mean annual temperature near Albuquerque, the cooling of some 5°C, which occurred at higher altitudes along the basin margins during the LGM (Stute and others, 1992, 1995) is not observed in the waters recharged along the lower altitudes of the Rio Grande within the basin.

If Rio Grande water recharges predominantly during peak spring flow, the averaged recharge temperatures represent spring temperatures in the Rio Grande rather than the mean annual temperature, and, thus, cannot be compared to the present mean annual temperature at Albuquerque. Yet, the relative minimum in Rio Grande recharge temperature during the last glacial period is still only about 1°C cooler than modern Rio Grande temperatures. One possibility to explain the apparent lack of paleoclimatic variation in average Rio Grande water temperatures over the past 27 ka is that the timing of peak discharge of the Rio Grande is probably linked to seasonal temperature, coming later during cold periods and earlier when the climate is warmer. As a result, the average water temperatures of the Rio Grande during peak discharge may not have varied appreciably over the past 27 ka, as observed.

If, during the LGM, the mean annual temperature in the southwestern U.S. lowered approximately 5°C relative to the modern mean annual temperature, the observed range of recharge temperatures of paleo Rio Grande waters (8.9-18.4°C), representing the time of peak discharge in the Rio Grande, indicates that the season of peak discharge and peak infiltration of Rio Grande water to the aquifer system shifted approximately 30-60 days later into the summer, resulting in peak Rio Grande runoff from mountain snowmelt in June and July, rather than April and May as is observed today. As a result, the paleo water temperatures of the Rio Grande during peak discharge, as recorded in the dissolved N_2 and Ar concentrations in ground-water infiltration from the river, would appear to be nearly constant through time.

Of the two scenarios discussed earlier to explain the historical variations in stable isotopic composition of Central-zone ground water, the N_2-Ar recharge temperature data are consistent with the hypothesis of a seasonal shift in the timing of peak river discharge. Thus, during cool climatic periods, peak discharge and runoff of snowmelt would occur later into the summer, when river-water temperatures had warmed to the range currently observed in mid- to late-spring, and possibly overlapping with part of the summer monsoon season. The resulting dischage of the Rio Grande could contain fractions of both snowmelt and precipitation from summer thunderstorms, and, within the range of stable isotopic composition of water observed for the Rio Grande, would be relatively enriched in ^2H. During warm climates, peak discharge and runoff of snowmelt would occur earlier in the year, such as is observed today, in advance of the summer monsoon season, and Rio Grande discharge would contain a higher fraction of mountain snowmelt, resulting in stable isotopic compositions that are relatively depleted in ^2H. Although seasonal shift in peak discharge in response to seasonal temperature is consistent with the observed stable isotope and paleo recharge temperature variations, the possibility of historical variations in the amount of precipitation cannot be excluded. Increased delivery of low-altitude precipitation, such as from summer thunderstorms, during the pluvial that followed the LGM could also contribute to elevated ^2H content of paleo Rio Grande water that peaked around 15 ka B.P. (fig. 111), and decreased low-altitude precipitaition during the mid-Holocene warm period (4-8 ka B.P.) could have resulted in relatively depleted ^2H content of Rio Grande water. Both processes in combination probably affected the ^2H content of Rio Grande water, and further study of the strength and timing of the summer monsoon would improve understanding of the relative importance of changes in temperature and contribution of summer precipitation

in affecting the stable isotopic composition of Rio Grande water.

Although the average temperature of paleo Rio Grande water has been nearly constant over time, there are small differences in average temperatures that may be important, particularly during the past 5 ka. Since the mid-Holocene warm period (4-8 ka B.P.), there has been a small shift in the average temperature of Rio Grande water recharged to the MRGB, being about 1.5°C cooler today than during the mid-Holocene warm period. A similar extent of cooling was suggested by the stable isotope data from the eastern mountain front waters over the past 5 ka B.P. (fig. 111).

Recharge temperatures of waters from the Eastern Mountain Front zone and the West-Central zone are shown in figure 115. As with the Eastern Mountain Front-zone waters, waters from the West-Central zone show large variations in recharge temperature. Apparently, during the last pluvial period recorded in Lake Estancia, 24 to about 12 ka B.P. (Allen and Anderson, 2000), recharge to the West-Central zone occurred both as focused recharge (and/or possibly through relatively shallow unsaturated zones), resulting in low N_2-Ar recharge temperatures, and as diffuse infiltration (through relatively deep unsaturated zones), resulting in warm recharge temperatures. Most samples older than about 24 ka B.P. plot in a narrow and relatively low range of recharge temperatures relative to those of radiocarbon age of about 10 to 24 ka B.P. (fig. 115). This indicates that during the last glacial maximum and during the pluvial period that followed, recharge to the West-Central zone occurred both as diffuse infiltration and as focused recharge, while during periods prior to about 24 ka B.P., recharge to the West-Central zone contained a higher fraction of focused-recharge water. Waters with radiocarbon age younger than about 8 ka were not observed in the West-Central zone.

The labels on the data points of figure 115 give the corresponding value of δ^2H, in per mil, of water in the sample. Most of the samples with the lowest recharge temperatures from the West-Central zone are

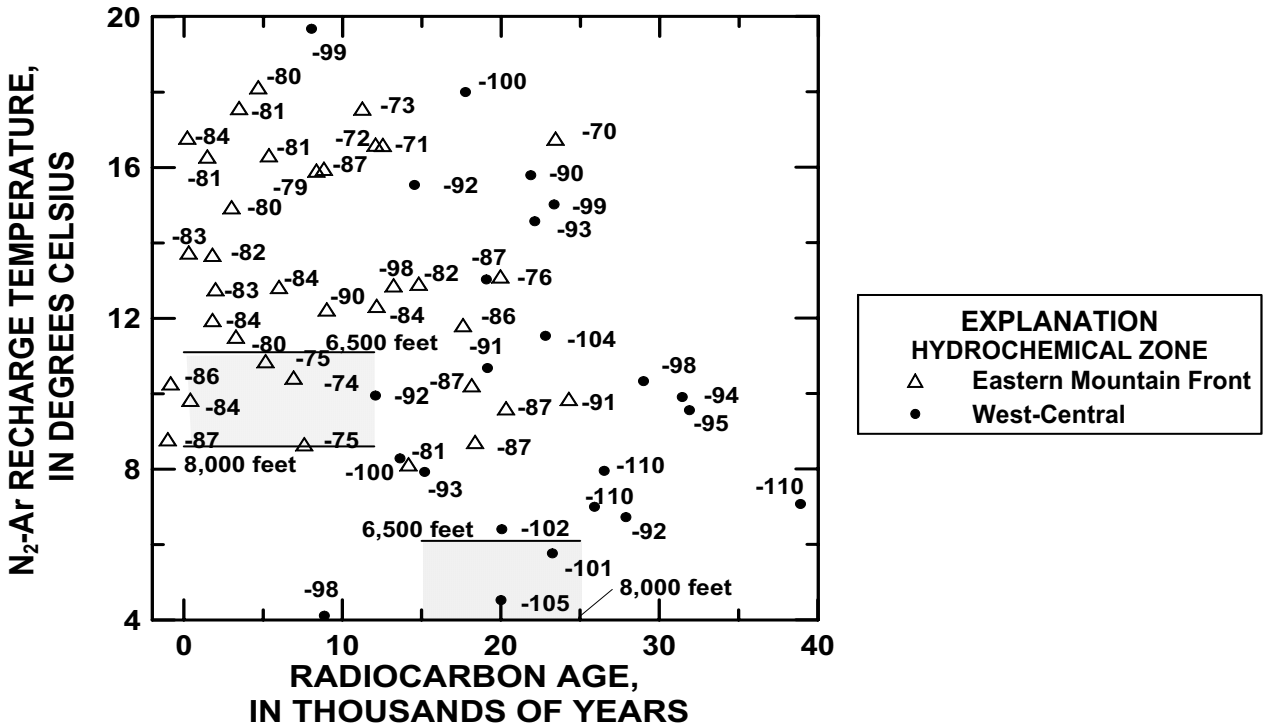


Figure 115. Comparison of N_2-Ar recharge temperatures for waters from the Eastern Mountain Front and West-Central zones as a function of radiocarbon age. The labels are values of δ^2H in per mil for the water sample. An uncertainty of ± 1,500 feet in recharge altitude results in an uncertainty of ± 2 °C in recharge temperature. The shaded patterns show the modern and Last Glacial Maximum estimated mean annual temperatures for recharge at 6,500 and 8,000 feet. Most samples have recharge temperatures that are warmer than the estimated mean annual temperature.

also depleted in ^2H, consistent with focused recharge at higher altitude. Most of the samples from the West-Central zone with warm recharge temperatures that were recharged during the last glacial period are enriched in ^2H relative to those with low recharge temperatures (fig. 115), consistent with diffuse recharge of precipitation falling at relatively low altitude. Using the relation describing variations in δ^2H with altitude, $\Delta\delta^2H/\Delta E$ = -2.2 per mil per 100 m altitude (Vuataz and Goff, 1986), the range in δ^2H values found for waters from the West-Central zone recharged during the last glacial period (δ^2H = -81 to -110 per mil) represents precipitation that fell over a range in altitude of approximately 1,200 m (3,900 feet). Similarly, the range in δ^2H values of waters from the West-Central zone that are older than about 24 ka B.P. (-94 to -110 per mil) could represent precipitation that fell over a range in altitude of about 730 m (2,400 feet).

Waters from the Eastern Mountain Front zone vary less in their stable isotope composition than waters from the West-Central zone, presumably because recharge altitude varies less for waters from the Eastern Mountain Front zone than for waters from the West-Central zone. Most of the waters from the Eastern Mountain Front zone have δ^2H values of about -71 to -87 per mil (fig. 115), which could represent precipitation that fell over a range of approximately 730 m (2,400 feet) in altitude. Both the West-Central and Eastern Mountain Front zones can be recharged as either focused or diffuse infiltration, resulting in a wide range of recharge temperatures recorded in dissolved N_2 and Ar concentrations.

Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon

It was shown in the sections "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin" and "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water" that $\delta^{13}C$ of DIC in ground water from the MRGB varies little as a function of ^{14}C activity of the DIC (fig. 99), except in some of the most recent waters located in mountain-front recharge areas, and in some waters from the inner valley of the Rio Grande that have been affected by oxidation of organic carbon. Having interpreted the radiocarbon age of the DIC, temporal variations in $\delta^{13}C$ of the DIC are now examined for waters specifically located along (1) the northern and eastern margins of the basin (Northern Mountain Front, Northwestern, and Eastern Mountain Front zones), (2) the West-Central zone that contains water apparently recharged along the flanks of the Jemez Mountains, and (3) the Central zone of Rio Grande origin. These zones were selected because they are least affected by possible geochemical reactions with carbonate minerals. The mineralogy is predominantly silicate, and where carbonate reactions were detected in geochemical mass-balance models using NETPATH, the reaction was usually precipitation of small amounts calcite cement accompanying dissolution of plagioclase feldspar. Because the fractionation factor between HCO_3 and calcite is small and the mass of calcite precipitated is small relative to the mass of HCO_3 in ground water, little change in $\delta^{13}C$ of DIC occurs in areas undergoing calcite cementation. The modeled geochemical reactions had almost no effect on the $\delta^{13}C$ of the initial water (table 10). Therefore, it seems reasonable to assume that the values of $\delta^{13}C$ of DIC in ground water in these parts of the MRGB are representative of $\delta^{13}C$ of the source water. The results of this study then indicate that $\delta^{13}C$ of the recharge waters to the MRGB has been remarkably constant for nearly the past 25 ka (fig. 116).

Of the 195 values of $\delta^{13}C$ with radiocarbon ages greater than 200 years shown in figure 116, $\delta^{13}C$ of DIC averages -8.2 ± 1.4 per mil. In the 16 samples from the MRGB with radiocarbon ages less than 200 years (of which 11 samples have ^{14}C activities greater than 100 pmC and likely contain a fraction of post-bomb water), $\delta^{13}C$ of DIC averages -11.3 ± 1.5 per mil. Nine of the 16 samples are from the Central zone and could possibly be affected by microbial degradation of organic carbon in the inner valley of the Rio Grande; however, geochemical modeling showed only small amounts of oxidation of organic carbon (table 10). The remaining seven samples include the post-bomb waters from the Northern and Eastern Mountain Front zones, and average -11.9 ± 2.0 per mil. These samples occur in remote areas where it is unlikely that they are affected by anthropogenic organic carbon sources such as seepage from septic tanks. Examples include water from Embudito and Embudo Springs in the Sandia Mountains east of Albuquerque (sites S056 and S057) with $\delta^{13}C$ values of -14.1 and -13.2 per mil, respectively; water from Domestic Well #01 in Bear Canyon northeast of Albuquerque (S007, $\delta^{13}C$ of -11.8 per mil); water from Tunnel Spring along the eastern mountain front north of Albuquerque (S256, $\delta^{13}C$ =

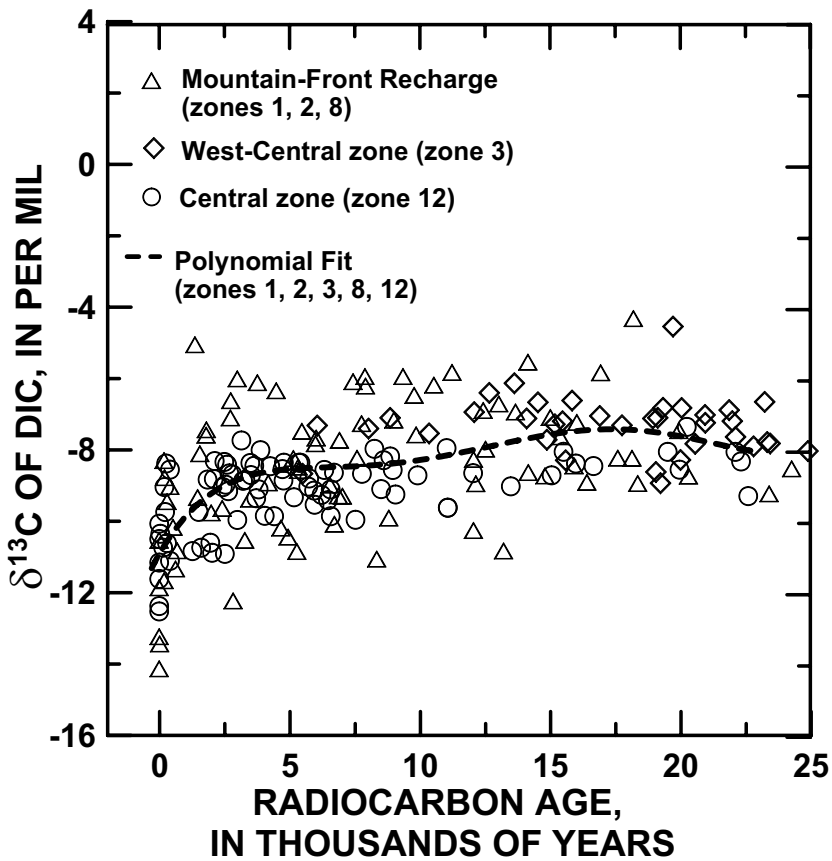


Figure 116. $\delta^{13}C$ isotopic composition of dissolved inorganic carbon (DIC) as a function of radiocarbon age for waters from basin margins (hydrochemical zones 1, 2, and 8), the West-Central zone (zone 3), and the Central zone (zone 12), Middle Rio Grande Basin, New Mexico. The dashed line is a 5-degree polynomial fit to the data

-11.3 per mil), and water from Windmill #42 along the northern margin of the basin (S279, $\delta^{13}C$ = -13.4 per mil). Today, and in the recent past (perhaps as recently as only the past 200 years), $\delta^{13}C$ of DIC in recharge waters along the basin margins may have become depleted in ^{13}C by about 3 per mil relative to a value of about -8.2 per mil that prevailed for the previous 25,000 years. No geochemical reactions were found using NETPATH that would account for an increase of 3 per mil in ^{13}C between post-bomb and pre-bomb waters along the basin margins.

The recent apparent decrease in the $\delta^{13}C$ isotopic composition of DIC in recharge waters along the basin margin and in water of Rio Grande origin may indicate a fairly recent increase in the abundance of C_3 plants relative to C_4 plants in MRGB recharge areas. The timing of the onset of the decrease in $\delta^{13}C$ of DIC in recharge waters cannot be resolved precisely from the radiocarbon ages. The polynomial fit to the data of figure 116 suggests that $\delta^{13}C$ of DIC was nearly constant from about 25 ka to about 5 ka, with a decrease by about 1 per mil at 5 ka, followed by an abrupt decrease in ^{13}C that occurred apparently within the past 1 ka or less. The CFC-12, tritium, and ^{14}C data indicate that most of the shift in $\delta^{13}C$ occurred prior to the mid-1960's along the basin margins (fig.117c), in low-tritium (pre-bomb) waters (fig.117b), and may have begun within the past 200 to 1,000 years (fig.117a).

Measurements of $\delta^{13}C$ of pedogenic carbonates in southern Arizona indicate C_4 dominance during the last glacial period, followed by a decrease that has been attributed to a replacement of C_4 grasslands during the Holocene by C_3/CAM desert shrubs and succulents (Liu and others, 1996). Liu and others (1996) attributed the replacement to climatic factors including an increase in temperature and reduction in summer precipitation at the end of the last glacial period. The

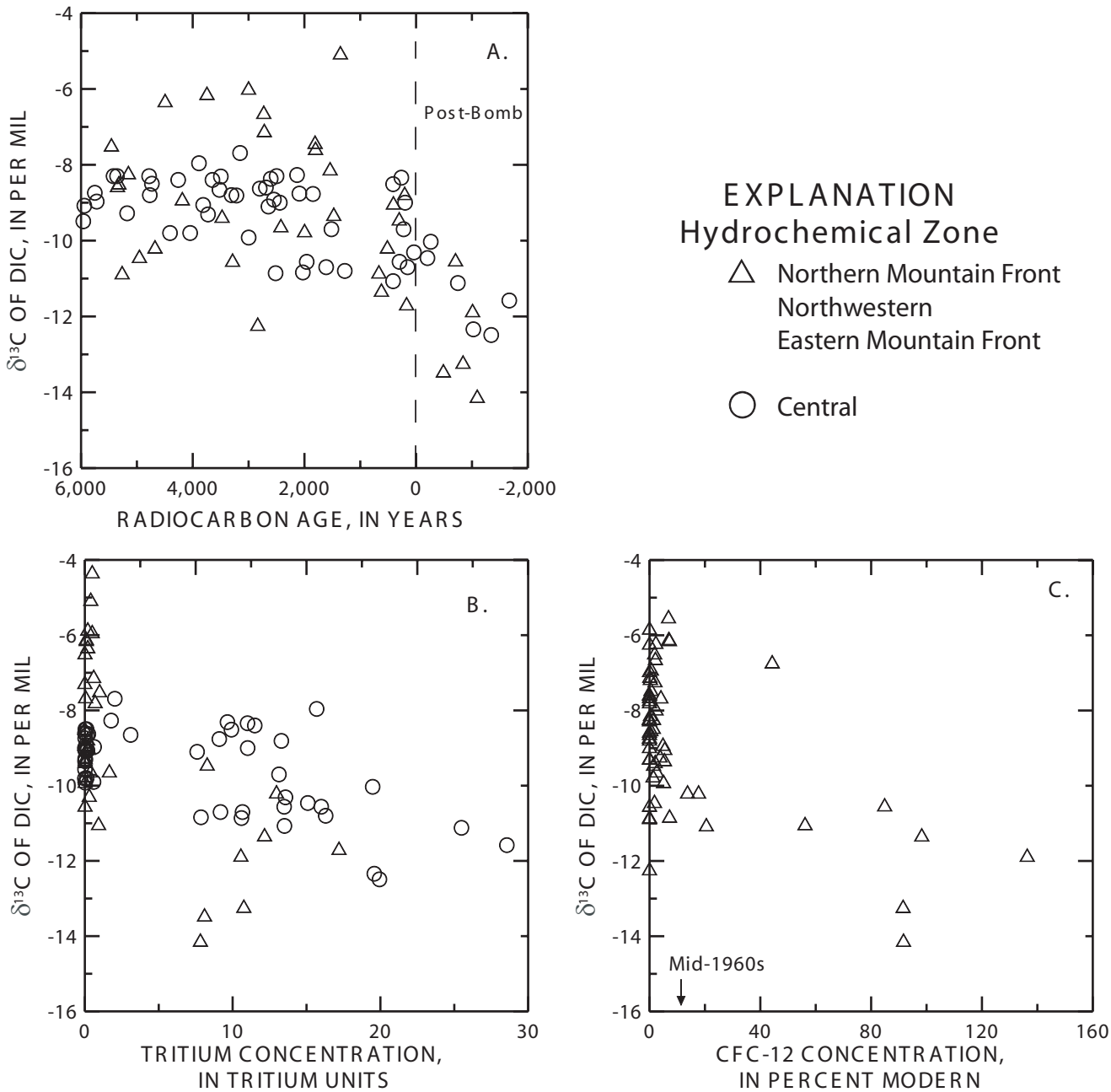


Figure 117. Values of $\delta^{13}C$ isotopic composition of dissolved inorganic carbon, DIC, in relatively young (post-bomb) waters of the Northern Mountain Front, Northwestern, Eastern Mountain Front and Central hydrochemical zones, Middle Rio Grande Basin, New Mexico, as a function of (A) radiocarbon age, (B) tritium concentration, and (C) CFC-12 concentration (as percent of modern).

landscape in southern Arizona was apparently dominated by C_4 grasslands for most of the past 700 ka (Liu and others, 1996).

The $\delta^{13}C$ values from the MRGB (-8.2 ± 1.4 per mil) are considerably more enriched in ^{13}C than those reported by Phillips and others (1989) for waters in the San Juan basin, in northwestern New Mexico (average $\delta^{13}C$ of -14.1 ± 3.4 per mil). From studies of $\delta^{13}C$ of herbivore tooth enamal, Connin and others (1998) found that during the last glacial period there was an increase in C_4 plant abundance eastward across the southwestern United States, which may, in part, account for the differences between the $\delta^{13}C$ values of the San Juan basin and MRGB. Using modern correlations between climate and C_4 grass abundance, Connin and others (1998) concluded that there was significant summer precipitation in parts of southern Arizona and New Mexico during the last glaciation.

The data presented here indicate that C_4 plant dominance prevailed in the MRGB through the last glacial period and through most of the Holocene. The increase in C_3 dominance in the MRGB is a relatively recent phenomena, as has been observed in southern New Mexico (Grover and Musick, 1990; Monger and others, 1998), parts of southeastern Arizona (McPherson and others, 1993), and along the Rio Grande Plains of southern Texas, where measurements of $\delta^{13}C$ and ^{14}C activity of soil organic carbon indicate that a shift from C_4 grassland to C_3 woodland occurred as recently as the past 50 to 100 years (Boutton and others, 1998). Apparently, a number of factors including amount and seasonality of precipitation, temperature, soil texture, and atmospheric P_{CO2} can influence the relative abundances of C_3 and C_4 plants (Epstein and others, 1997; Huang and others, 2001). The processes responsible for the apparent decrease in $\delta^{13}C$ of DIC over time in the MRGB are not understood. Regardless of the processes responsible for determining the $\delta^{13}C$ of DIC recharged to the MRGB, the ground-water chemistry clearly documents recharge of DIC to the MRGB that has been relatively enriched in ^{13}C throughout most of the past 25 ka.

SUMMARY OF IMPLICATIONS FROM GEOCHEMICAL AND ISOTOPIC DATA FOR THE CONCEPTUAL MODEL OF THE AQUIFER SYSTEM

The chemical and isotopic data collected for ground water in the MRGB as a result of this study have enabled evaluation and refinement of the conceptual model of the aquifer system of the basin. Specifically, the data have been used to examine the following aspects of the system: (1) the major locations of recharge to the basin, (2) the long-term historic direction of ground-water flow, and relation of that flow to the predevelopment water levels, (3) possible origins of the ground-water trough, (4) the effects of major structural and stratigraphic features of the basin on ground-water flow, and (5) implications for the mechanism of recharge and timing of paleo-environmental conditions in the basin. The radiocarbon ages and locations of the hydrochemical zone boundaries from this study also have been used to help calibrate a ground-water-flow model for the basin (Sanford and others, 2004). Modifications to the conceptual model based on geochemical data now available for the basin also have been incorporated into a recent revision of the USGS flow model (McAda and Barroll, 2002). This section summarizes some of the major implications of the geochemical and isotopic data for the conceptual model of the flow system and, where appropriate, describes how the previous conceptual model has changed as a result of this study. As was stated earlier in this report, the geochemical data used in this study were collected from wells completed in the upper few thousand feet of the Santa Fe Group aquifer system, so that the findings presented here may not all apply throughout the entire depth of the basin.

Tracing Sources of Water Through the Basin

This study has shown that ground water of the MRGB can be grouped into zones of distinctly different chemical "signatures" that typically have well-defined boundaries. These zones enable the delineation of waters having separate recharge sources, and their extents facilitate determination of the relative importance of each recharge source. In most cases, ground water having separate recharge sources differs in both major-/minor-element chemistry and isotopic composition. In other cases, the use of isotopic data, particularly ^{2}H, ^{18}O, and ^{14}C, is essential to differentiating waters of separate origin. The individual chemical and isotopic "signatures" within the basin can be associated with the observed composition of recharge water from particular sources, or with the expected composition based on the geology and physiography of a potential recharge area. This study has demonstrated that, because the sediments of the Santa Fe Group aquifer system are relatively unreactive, the chemical composition of ground water in the basin generally changes little along a flow path. This consistency in composition allows source-water associations to be traced over long distances through the aquifer system.

The distribution and extent of the 13 hydrochemical zones defined for the MRGB (the chemical and isotopic "signatures" of which have been discussed in the section "Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water sources") indicate the presence of multiple sources of recharge to the aquifer system of the basin. Mountain-front recharge sources appear to dominate over large areas of the basin, particularly along the northern and eastern margins of the basin, as well as in the southwestern corner. Mountain-front recharge was previously known to be important along the Sandia, Manzanita, and Manzano Mountains of the eastern basin margin (Kernodle and others, 1995). Mountain-front recharge was also suspected to contribute water to the aquifer system along the Ladron Mountains in the southwest (Kernodle and Scott, 1986), but no previous studies presented direct evidence of the importance of this source. The importance of mountain-front recharge water as opposed to ground-water inflow along the Jemez Mountains in the north also does not appear to have been well characterized previously. Although mountain-front recharge appears to occur along the entire northern boundary of the basin that is bordered by the Jemez Mountains, the chemical composition of recharge water along the boundary is not uniform, which indicates that the recharge mechanisms and/or characteristics of the flow paths may vary. In particular, water of the West-Central zone, which originates in the western part of the Jemez Mountains and extends southward through most of the length of the basin (fig. 78), differs considerably in chemical and isotopic composition from water recharging in the eastern part of the mountains. Most water of the West-Central zone may actually enter the

basin as underflow even though the water apparently originated at high altitude, as indicated by ^{2}H and ^{18}O. This water may have infiltrated in the area of the Valles Caldera and migrated to a substantial depth before reaching the basin.

Another important source of recharge to the aquifer system of the MRGB, particularly in the area of Albuquerque, is infiltration from the Rio Grande. This study has helped to define both the extent and age of water sourced at the river. The ^{2}H and ^{18}O compositions of ground water have been particularly useful in delineating the river's area of influence, as indicated by the boundaries of the Central zone, which has been shown to extend from about San Felipe on the north to near Abo Arroyo on the south (fig. 78). Ground water of the Central zone extends 2 to 3 miles beyond the flood plain of the Rio Grande—particularly to the east—and has been identified at substantial depth (on the order of 2,000 feet). This study indicates that water has been entering the aquifer system from the Rio Grande for tens of thousands of years and has historically flowed primarily north to south under the Albuquerque area (figs. 64, 74, and 78). Therefore, movement of infiltration from the Rio Grande beyond the flood plain has not occurred primarily as the result of water-level declines associated with intense pumping of ground water for municipal supply. The long-term contribution of this source of recharge to a large part of the central area of the basin is probably of greater magnitude than previously thought.

This study has confirmed that infiltration from ephemeral streams can be an important source of recharge in some areas of the MRGB. In particular, recharge from the Rio Puerco appears to be one of the primary sources of water to the aquifer system in the western part of the basin. The chemical and isotopic composition of ground water associated with the Rio Puerco can be identified across a large area extending both east and west of the present stream channel. Such a large area of influence does not appear to have been previously recognized, and may result partly from a lack of other substantial recharge sources in the western part of the basin. Similarly, infiltration through Abo Arroyo has been shown to have a large area of influence in the southeastern part of the basin. Ground water that has infiltrated from Tijeras Arroyo also can be identified by its chemical and isotopic composition, but has extended over only a fairly limited area compared to infiltration from the Rio Puerco and Abo Arroyo, possibly because of a high quantity of mountain-front recharge in the area. Infiltration from the Jemez River appears to be limited primarily to a relatively narrow and shallow area located directly along the river, which differs from the previous assumption that the Jemez River is an important source of recharge to the aquifer system in the northern part of the basin (Kernodle and others, 1995).

The underflow of ground water from adjacent basins has been confirmed to contribute water to the aquifer system of the MRGB along its western margin, as well as in limited areas of the eastern margin. Ground water from Paleozoic and Mesozoic rocks to the west appears to leak into the basin and mix with a greater quantity of water that infiltrates locally, possibly from ephemeral streams. Ground water also leaks into the northeastern part of the MRGB from the Mesozoic rocks of the Hagan Basin. The area that shows evidence of this underflow is not extensive, which indicates that the quantity of ground water entering the MRGB from the Hagan Basin probably is relatively small. In the area of the Tijeras Fault Zone, mineralized water associated with the fault system appears to leak into the basin. This water then mixes with local mountain-front recharge over a fairly broad area, and perhaps migrates to depth below the more plentiful and more dilute mountain-front water. Overall, the results of this study have shown that the quantity of underflow entering the MRGB along the western and eastern margins is probably less than previously determined (Kernodle and others, 1995). However, as mentioned above, underflow from the area of the Jemez Mountains may contribute a substantial quantity of recharge to the basin.

Direction of Ground-Water Flow

Both conservative geochemical tracers and boundaries between hydrochemical zones indicate that ground-water flow in the MRGB has historically been directed primarily north-south through the center of the basin, with a greater east-west component near the basin margins. As discussed in the section "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin", values of specific conductance, Cl, and the stable isotopes of water indicate that the dominant component of ground-water flow in the basin is from north to south. Similarly, the orientations of the Central, West-Central, and Rio Puerco hydro-

chemical zones in particular demonstrate the importance of north-south flow (fig. 78).

Although predevelopment hydraulic head maps for the MRGB (Titus, 1961; Bjorklund and Maxwell, 1961; Bexfield and Anderholm, 2000) are broadly consistent with the primary direction of ground-water flow indicated by geochemical data, there are some apparent inconsistencies. In particular, predevelopment hydraulic heads indicate greater east-west components of flow through the center of the basin than is indicated by the orientation of the hydrochemical zones. The differences in flow direction indicated by hydraulic heads and geochemical tracers likely are associated with the different time horizons and depths represented by the two types of information.

Carbon-14 data from this study of the MRGB indicate that most ground water resides in the aquifer system for thousands to tens of thousands of years. Therefore, the hydrochemical zones defined on the basis of current ground-water chemistry in the basin probably reflect aquifer-system conditions (including ground-water-flow directions) present on the order of thousands of years into the past, and may not yet reflect the current hydraulic-head distribution. In addition, predevelopment hydraulic-head maps for the basin were based on conditions primarily in the shallow part of the aquifer system (to a depth of at most a few hundred feet), whereas geochemical data were collected from wells reaching greater depths, where ground-water flow directions may differ.

As a result of this study, the conceptual model of how ground water moves through the aquifer system of the MRGB has been refined. The geochemical data indicate that ground water in the Albuquerque area has not flowed almost directly west from the eastern mountain front to the inner valley of the Rio Grande, as previously reported (Kernodle and Scott, 1986). Instead, the water chemistry beneath Albuquerque indicates that ground water flows mostly north to south through the city area, and this flow has occurred over at least the past 20,000 years. The rather distinct boundary between water sourced from the Rio Grande and mountain-front recharge water to the east (as most clearly indicated by a substantial difference in ^{2}H and ^{18}O across a short distance, 1 to 2 miles) indicates that similar flow conditions prevailed in the area for many thousands of years, relatively unaffected by dispersion or mixing. However, recharge from the Rio Grande does not appear to have moved a substantial distance toward the ground-water trough that is shown by hydraulic-head maps present in the western part of the basin. Previous conceptual models assumed that much of the ground water in the area of the trough was sourced at the river (Yapp, 1985; Logan, 1990), or possibly even the mountain front (Logan, 1990).

Origin of the Ground-Water Trough

The predevelopment hydraulic-head maps of Meeks (1949), Titus (1961), Bjorklund and Maxwell (1961), and Bexfield and Anderholm (2000) have all indicated the presence of a ground-water trough in the western part of the MRGB, extending from near the Jemez River on the north to Belen on the south, and from a series of major faults on the west to near the Rio Grande on the east (fig. 9). Water levels in the trough can be as much as 50 feet lower than the level of the Rio Grande directly to the east. Geochemical data from this study show that ground water flowing along the axis of the trough occurs within the West-Central hydrochemical zone and likely originated in the area of the Jemez Mountains during the last glacial period. Although hydraulic heads indicate that water sourced both at the western margin of the basin and at the Rio Grande should be flowing into the trough, the geochemical data indicate that this flow has not occurred. The lack of evidence that these waters have reached the axis of the trough appears to contradict one conceptual model that the trough is present primarily as the result of a large thickness of permeable materials near its axis as compared to along its flanks (though still quite impermeable compared with other parts of the basin) (Kernodle and others, 1995). Such a configuration would cause the area to act as a sort of “drain” for the aquifer system in the western part of the basin. Recent geohydrologic data for the area do not support this conclusion (Hawley, 1996).

One possible explanation for the presence of the trough that would be consistent with the observed geochemical data is that the trough is a transient feature of the aquifer system in the MRGB. As mentioned above, changes with time in the quantity and distribution of recharge around the basin could result in a change in the distribution of hydraulic head. If the trough developed relatively recently as a result of such changes, water sourced at the western margin of the basin and at the Rio Grande may not yet have moved into the trough area. Radiocarbon ages of waters sourced from the western margin that are located today

just west of the trough, and Rio Grande waters just east of the trough, are approximately 10 ka. Waters younger than 10 ka are observed farther to the west and east toward the Rio Puerco and Rio Grande sources, respectively. This suggests that water has been flowing toward the trough from the Rio Puerco and Rio Grande since the beginning of the Holocene. Using a ground-water-flow model for the MRGB, Sanford and others (2001) found that the trough could be simulated merely by lowering the quantities of recharge from certain known sources of water to the basin.

Another factor that could contribute to the presence of the trough could be the existence of features that limit ground-water flow into the trough from the east and west. Such features could include major faults that are relatively impermeable or low-conductivity geologic strata. Most major faults within the MRGB trend north to south; therefore, cementation of any of several major faults could be consistent with the restriction of east-west ground-water flow. Also, the presence of a dipping geologic layer of low permeability could retard east-west flow. For example, Connell and others (1998) have shown that the fine-grained Atrisco Member of the Arroyo Ojito Formation dips downward from west to east beneath the Albuquerque area. This layer could restrict flow of infiltration from the Rio Grande westward toward the trough. The same or a similar layer of low-permeability material might possibly also restrict the eastward flow of water infiltrating through the Rio Puerco. Further research would be necessary to conclude whether these types of restrictions are present in such a configuration that would contribute to the presence of the trough. Such restrictions would act only to limit flow toward the trough and not to prevent it entirely. Therefore, even if flow restrictions are important, the absence of water sourced from the Rio Grande and from the western margin near the axis of trough indicates that the trough is likely a transient rather than a long-term feature.

Ground-Water Flow in Relation to Faults and Other Structural Features

Because ground-water chemistry in the MRGB enables delineation both of waters from particular recharge sources and of ground-water-flow directions, chemistry can be used to investigate the possible effects of faults on regional ground-water flow in the basin. In particular, correspondence of a boundary between hydrochemical zones with the location of a fault could be an indication that horizontal ground-water flow is restricted across that fault. Flow across a fault can be restricted by reduced permeability and hydraulic conductivity in the fault zone resulting from cementation and/or sediment deformation, or by the juxtaposition of relatively high-conductivity aquifer materials on the upgradient side of the fault against relatively low-conductivity materials on the downgradient side. Alternatively, correspondence of a chemical boundary with a fault could indicate that recharge rates and hydraulic properties of the aquifer materials differ substantially on either side of the fault. For example, if recharge rates and hydraulic conductivity are much greater on one side of the fault than the other, the quantity of water from the low-recharge source that can mix with water from the high-recharge source will be relatively small and will probably have little effect on the water chemistry on the high-conductivity, high-recharge side of the fault (fig.118). Where either horizontal flow across a fault is restricted, or recharge rates and hydraulic conductivity differ greatly on either side of a fault, a hydraulic discontinuity may result, as would be indicated by a substantial difference in water-level altitudes across the fault (fig.118).

In the MRGB, a few boundaries between hydrochemical zones appear to correspond fairly closely in places with “major” faults identified by Mark Hudson and Scott Minor (U.S. Geological Survey, written commun., 1999). Such regional differences in ground-water chemistry in the vicinity of faults, indicating possible effects of faults on ground-water flow, do not appear to have been previously identified in the basin. Two examples are the boundary between the Rio Puerco and West-Central zones and the boundary between the Tijeras Fault Zone and Eastern Mountain Front zones. In the northern half of the basin, the boundary between the Rio Puerco and West-Central zones corresponds fairly well in places with the Tenorio and Sand Hill faults identified by Kelley (1977). The boundary between the Tijeras Fault Zone and Eastern Mountain Front zones corresponds fairly well in places with the Tijeras and Colorada faults, also identified by Kelley (1977). In the areas of both the Tenorio/Sand Hill faults and the Tijeras/Colorada faults, the predevelopment water-level map of Bexfield and Anderholm (2000) shows the occurrence of hydraulic discontinuities that indicate the likely effects of these faults on ground-water flow.

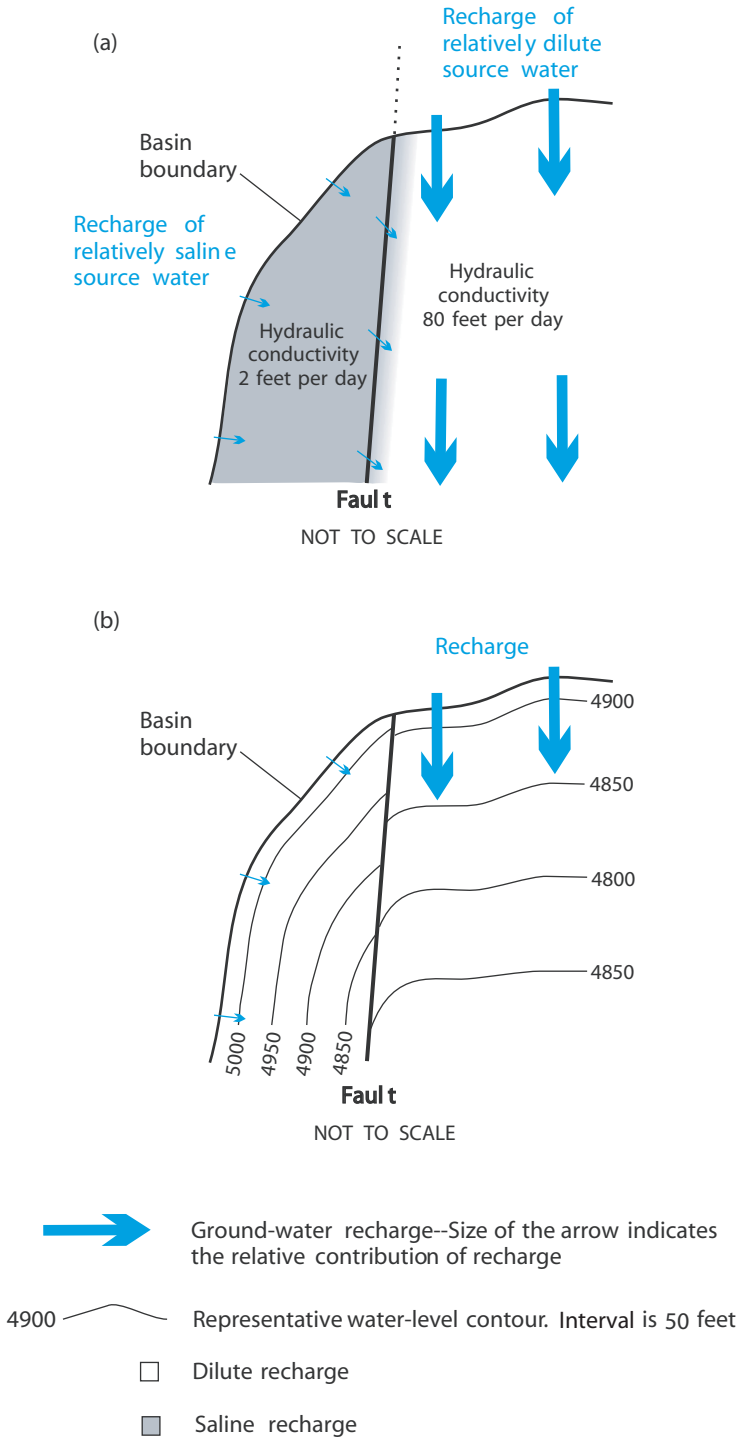


Figure 118. Schematic diagrams of (a) representative change in water chemistry across a fault in the Middle Rio Grande Basin, New Mexico, with greater recharge rates and hydraulic conductivity on one side of the fault relative to the other, and (b) representative discontinuity in the water levels across the fault.

The general correspondence of differences in ground-water chemistry with particular fault locations may indicate that horizontal ground-water flow is restricted across those faults—flow being primarily from west to east in the case of the Tenorio/Sand Hill faults, and from east to west in the case of the Tijeras/Colorada faults. The area surrounding the Sand Hill fault has been shown to include a zone of deformation that might reduce horizontal flow across the fault (Rawlings and Goodwin, 2001); also, the Sand Hill fault zone has been shown to be preferentially cemented by calcite (Mozley and Goodwin, 1995; Heynekamp and others, 1999). The Tijeras/Colorada faults offset different geologic units by hundreds to thousands of feet, and a contrast in hydraulic properties between the juxtaposed units (as opposed to cementation or deformation in the fault zone) could be the primary explanation for any restriction to horizontal ground-water flow in the area of these faults. However, in the case of both the Tenorio/Sand Hill faults and the Tijeras/Colorada faults, the aquifer materials on the downgradient side of the fault zone are much thicker and more conductive than materials on the upgradient side. Also, in both cases, recharge to the hydrochemical zone on the downgradient side (the West-Central zone or Eastern Mountain Front zone) is believed to be much greater than recharge to the zone on the upgradient side (the Rio Puerco zone or Tijeras Fault Zone zone). Therefore, the chemical differences observed across the faults at the boundaries between the hydrochemical zones could result from mixing of a relatively small quantity of water from the upgradient zone with a much higher quantity of water from the downgradient zone (as described earlier in this section).

Whereas differences in ground-water chemistry appear across sections of the "major" faults mentioned above, differences in chemistry are not evident in other areas where important—even basin-bounding—faults are present. For example, the water-level map of Bexfield and Anderholm (2000) indicates the presence of a hydraulic discontinuity along the Sandia fault adjacent to the front of the Sandia Mountains. However, the data available in the area from this study indicate that the distinct chemical boundary between water sourced from the Rio Grande and water sourced along the eastern mountain front occurs several miles west of the Sandia fault and is apparently unrelated to the location of the fault. The data do not show a difference in ground-water chemistry across the fault itself, indicating that ground-water flow is not restricted across the fault. The hydraulic discontinuity in this area is probably the result of the large saturated thickness of conductive materials on the west side of the fault relative to the small saturated thickness of materials of similar hydraulic conductivity on the east side of the fault. This configuration results in a much greater transmissivity and a correspondingly flatter hydraulic gradient on the west side of the fault. Therefore, not all "major" faults in the basin appear to have characteristics that appreciably limit ground-water flow across them. Similarly, there appears to be little indication from either chemistry or water levels indicating that "minor" faults with small offset of similar sediments substantially limit horizontal ground-water flow, at least on a regional scale.

As discussed in earlier sections, the geochemical data from this study have provided new information that the presence of major faults may actually enhance or cause vertical ground-water flow in some areas of the MRGB. Elevated water temperatures and Cl and As concentrations, in particular, usually are in close proximity to "major" faults in the basin, especially at locations in the northern part of the basin, the northeastern part of Albuquerque, and the southeastern part of the basin. These elevated concentrations appear to be indicative of ground water from a deep source that is moving upward to mix with water at shallower depths of the aquifer system. The association of these elevated concentrations with the locations of faults indicates that vertical movement of ground water could be enhanced in fault zones by increased vertical conductivity resulting from deformation. Elevated Cl and As concentrations also are common in the vicinity of the structural highs located near the northern and southern extents of Albuquerque that separate the subbasins within the MRGB, as well as near the structural high/constriction that separates the MRGB from the Socorro Basin to the south. The thinning of Santa Fe Group deposits (which are relatively conductive compared to basement rocks) across structural highs could result in upward movement of ground water, both along faults that bound these highs and within the entire aquifer system. Ground water would tend to move to shallower depths of the aquifer system across structural highs in order to maintain flow within the more conductive sediments. Upward movement of ground water along faults and near structural highs/constrictions was not previously a part of the conceptual model for the basin.

Stratigraphic Controls on Ground-Water Flow

The geochemical data collected for this study indicate that stratigraphy may be important in controlling ground-water flow in some areas of the basin. Several deep piezometer nests show substantial variability in ground-water chemistry (including ground-water age) with depth. In some cases, water from different depths in the same piezometer nest belong to different hydrochemical zones, and, therefore, have different recharge sources and flow paths. Such variability indicates a lack of vertical mixing in some areas of the aquifer system, which could be the result of anisotropy and/or differences in hydraulic properties of aquifer materials with depth. Therefore, evidence from this study suggests that stratigraphic controls may act to substantially limit vertical ground-water movement on a regional scale in the basin. However, as mentioned in the previous section on ground-water flow related to faults, it also appears that stratigraphy/structure may actually enhance vertical ground-water movement in areas where structural highs cause relatively impermeable materials to be present closer to the land surface and/or in areas where major faults are present.

As mentioned above in relation to the ground-water trough west of Albuquerque, extensive layers of particularly fine-grained material may affect not only the vertical, but also the horizontal direction of ground-water flow in the MRGB on a regional scale. For example, because the fine-grained Atrisco Member dips to the east across the center of the basin and is present at depth below more conductive materials, it could limit both downward and westward movement of water sourced at the Rio Grande. Similarly, extensive coarse-grained layers also may affect ground-water flow. For example, in the vicinity of Albuquerque, Hawley and Haase (1992) identified the presence of a thick section of north-south trending coarse-grained ancestral Rio Grande deposits extending several miles east from the Rio Grande. Ground-water chemistry data and analysis from this study indicate that water sourced at the Rio Grande has historically flowed primarily north to south through this general area, which may be largely attributed to the presence of these high-conductivity sediments.

Source, Mechanism, and Timing of Recharge to the Middle Rio Grande Basin

The stable isotope data, in conjunction with the dissolved gas recharge temperatures and radiocarbon ages, have been useful in interpretation of source, mechanism and timing of recharge to the aquifer system. Recharge temperatures calculated from measured concentrations of dissolved N_2 and Ar vary widely throughout the MRGB. The minimum in the calculated N_2-Ar recharge temperatures for a particular hydrochemical zone appears to be near the mean annual temperature for the assumed recharge area for that zone, and the maximum recharge temperature approaches that of ground water beneath the relatively deep unsaturated zones. Apparently, the dissolved gas recharge temperatures demonstrate cases of both focused (cold recharge temperatures) and diffuse flow (warm recharge temperatures) recharge mechanisms in semiarid regions such as the MRGB.

Some interesting patterns in paleo-recharge temperatures emerge when the recharge temperatures are examined spatially in the MRGB. Relatively warm recharge temperatures are found for most waters recharged along the northern margin of the basin (western parts of the Northern Mountain Front zone and throughout the Northwestern zone), indicating recharge primarily by diffuse infiltration through relatively deep and warm unsaturated zones. Waters from the northeast part of the Northern Mountain Front zone have cold recharge temperatures indicative of relatively shallow and/or focused recharge. Many of the waters from the West-Central zone have cold recharge temperatures, as cold as the expected 3-4°C for waters recharged at 8,000 feet along the flanks of the Jemez Mountains during the LGM. The waters from the West-Central zone with cold recharge temperatures were found beneath Northwestern zone waters in the northern part of the basin and traced south throughout the basin along the eastern-most half of the West-Central zone. Waters with relatively warm recharge temperatures also were measured in the West-Central zone and can be traced along the western-most half of the West-Central zone. The axis of the ground-water trough approximately divides West-Central zone waters with warm recharge temperatures (on the west side of the trough) from West-Central zone waters with cold recharge temperatures (on the east side of the trough).

During the last glacial period, water recharged to the West-Central zone varied widely in stable isotope composition and recharge temperature, indicating both diffuse and focused recharge of low- and high-altitude precipitation. The range in δ^2H of West-Central zone waters from the LGM suggests recharge that occurred over a 4,000-foot range in altitude.

Ground water in the Central zone was recharged by direct infiltration from the Rio Grande, and apparently records surface-water temperature at the time of recharge. The indication from the dissolved N_2-Ar data is that the long-term average temperature of the Rio Grande that infiltrated into the Central zone varied only ± 1°C from the modern mean annual temperature at Albuquerque over the past 27 ka, even though the regional mean annual temperature was likely some 5°C colder during the LGM than today. The stable isotope composition of paleo Rio Grande water was relatively depleted in ^2H during the mid-Holocene warm period and relatively enriched in ^2H in the pluvial following the LGM. These observations may indicate that during the past, the timing of the spring runoff of northern New Mexico and southern Colorado snowmelt varied, coming late into early- to mid-summer during cold periods and overlapping, in part, with the summer monsoon season (currently July-October). During warm periods, such as modern times, the peak discharge of the Rio Grande occurred in mid- to late-spring, in advance of the summer monsoon season. These observations indicate that the Central zone is recharged primarily during the season of peak runoff of mountain snowmelt and that the season of peak runoff has shifted by as much as 2 months between the LGM and modern times.

During the last 5 ka, the δ^2H isotopic composition of Eastern Mountain Front recharge has decreased about 7 per mil, suggesting an average cooling of about 1.4°C following the mid-Holocene warm period. Over the same time span, the δ^2H isotopic composition of Rio Grande water has increased approximately 6 per mil, consistent with a shift in the season of peak snowmelt into the beginnings of the summer monsoon season.

SUMMARY

A large number of measurements of the chemical and isotopic composition of ground water and surface water were used to refine the conceptual model of ground-water flow in about the upper 2,000 feet of the Santa Fe Group aquifer system of the MRGB, and improve understanding of the water resources of the basin, as discussed in the previous section of this report. The extensive regional coverage, supplemented with data from the USGS National Water Information System and City of Albuquerque water-quality database, permitted definition and mapping of the spatial extents of 12 regional sources of water to the MRGB, and estimation of radiocarbon ages.

The chemical and isotopic analyses indicate that the composition of most ground water in the basin changed little after recharge, and can be traced over large distances (tens of miles) through the primarily siliciclastic sediment of the aquifer system. Radiocarbon ages adjusted for geochemical reactions in the aquifer system are nearly identical to the unadjusted radiocarbon ages and range from less than 1 ka to more than 30 ka.

Predominant sources of water to the basin include (1) recharge from mountains along the northern, eastern and southwestern basin margins (median age 5-9 ka); (2) seepage from the Rio Grande and Rio Puerco (median age 4-8 ka), and from Abo and Tijeras Arroyos (median age 3-9 ka); (3) inflow of saline water along the southwestern basin margin (median age 20.4 ka); and (4) inflow along the northern basin margin (median age 19.9 ka) that probably represents recharge from the Jemez Mountains during the last glacial period.

Piezometer nests provided critical information on variations in chemical and isotopic composition with depth to nearly 1,500 feet below the water table, particularly in the vicinity of Albuquerque. In some cases, the data from piezometers and other wells permitted characterization of the three-dimensional aspects of water composition. For example, the data indicate that paleowater (approximately 20 ka), present at the water table through the west-central part of the basin, extends beneath more recent mountain-front recharge in northern parts of the basin, and beneath water of Rio Grande origin under western parts of Albuquerque.

Age gradients from all available piezometer nests ranged from 0.1 to 2 yr cm^{-1}. Age gradients from two piezometer nests indicate "modern" (past few thousand years) recharge rates of approximately 3 cm yr^{-1} for infiltration from the Rio Grande at Albuquerque and recharge along the eastern mountain front at Albuquerque. Historically, there have been higher amounts of recharge to the Eastern Mountain Front zone at Albuquerque than to vicinities either north or south of Albuquerque along the eastern mountain front.

Chlorofluorocarbon and/or tritium concentrations were measured in water samples at all wells where ^{14}C samples were taken. These measurements permitted identification of samples that might be contaminated with nuclear bomb-era ^{14}C or drilling fluid, and that might consequently have a young bias in radiocarbon age. Gradients in ^{14}C activity of dissolved inorganic carbon with depth were determined from the piezometer nests and used to estimate uncertainty in radiocarbon age in mixtures of ground water pumped from wells that are open to hundreds of feet of the aquifer system.

Detailed study of the ^{2}H and ^{18}O isotopic composition of source waters to the basin helped to delineate flow directions and boundaries between water sources. The stable isotope data for ground water in the vicinity of Albuquerque indicate little movement of ground water in response to withdrawals from production wells during the past 20 years, even though, in places, the modern water table has fallen as much as 140 feet below the predevelopment potentiometric surface. Small shifts over the past 20 years in stable isotope composition of water discharged from public supply wells along the boundaries between the West-Central zone (paleowater) and Central zone (Rio Grande water) west of the Rio Grande, and along the boundary between the Central zone and Eastern Mountain Front zone east of the Rio Grande, indicate local areas where paleowater of Rio Grande origin likely is beginning to spread west and east in response to ground-water pumping in the vicinity of Albuquerque.

The geochemical data show that ground water flowing along the axis of a ground-water trough in the western part of the MRGB, extending from near the Jemez River on the north to Belen on the south, and from a series of major faults on the west to near the Rio Grande on the east, originated in the area of the Jemez Mountains during the last glacial period. Although hydraulic heads indicate that water sourced both at the western margin of the basin and at the Rio Grande

should be flowing into the trough, the geochemical data indicate that this flow has not occurred. The absence of water sourced from the Rio Grande and from the western margin near the axis of ground-water trough indicates that the trough is probably a transient rather than a long-term feature of the aquifer system.

Over the past 5 ka, the isotopic composition of water recharged along the eastern mountain front has become depleted in ^{2}H by about 7 per mil, consistent with an average cooling of about 1.4°C. Over the same period, $\delta^{2}H$ of ground water recharged from the Rio Grande increased by nearly 6 per mil from a minimum near –98 per mil. Seasonal shifts in the timing of peak discharge and/or historical changes in the amounts of low-altitude precipitation along the basin margins may account for the long-term trends in the stable isotopic composition of Rio Grande water. The $\delta^{2}H$ of water recharged from the Rio Grande to the Central ground-water zone (ground water of Rio Grande origin) was low at approximately 5 ka B.P., a maximum at about 15 ka B.P., and a minimum at about 22 ka B.P.

The recharge temperatures calculated from dissolved N_2 and Ar concentrations in paleowater recharged from the Rio Grande indicate that the long-term average water temperature at the time of predominant infiltration was nearly constant for the past 27 ka, and within about ±1°C of the modern mean annual temperature. This observation is consistent with seasonal shifts in the timing of peak discharge on the river. Where infiltration occurs through deep (greater than 300 feet deep) unsaturated zones, the dissolved-gas recharge temperatures are biased warm by as much as 10°C relative to the mean annual temperature (13.6°C at Albuquerque).

The $\delta^{13}C$ isotopic composition of dissolved inorganic carbon in ground water is remarkably constant throughout most of the basin, indicating a nearly constant historical predominance of C_4 over C_3 plants in recharge areas for the aquifer system, and little effect of geochemical reactions on radiocarbon age. However, during the past 1 ka, or perhaps even more recently, the $\delta^{13}C$ isotopic composition of dissolved inorganic carbon of water recharged along the basin margins and at the Rio Grande has become depleted in ^{13}C. This ^{13}C depletion could indicate a recent increase in C_3 plant abundance relative to C_4 plants, as has been observed in other parts of the southwest U.S.

Extensive chemical and isotopic datasets, such as obtained for the MRGB during this and previous studies, are uncommon in the hydrologic sciences. This study demonstrates the benefits of obtaining a diverse and extensive chemical and isotopic dataset when characterizing hydrochemical processes in ground-water systems, retrieving historical environmental information from ground water, and/or refining conceptual models of ground-water systems.

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Appendix A. Chemical and isotopic data of ground water collected from the Middle Rio Grande Basin, June 1996 through August 1998

Table A1. Location and well-construction information for ground-water sites

[Monitoring Well ID, See figs. 58 and 69; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; dms, degrees/minutes/seconds; bls, below land surface; na, not applicable; nd, not determined; PVC, polyvinylchloride; PW, production well; WW, windmill; DW, domestic well; MW, monitoring well; SW, stock well; SP, spring; SXXX, No site number assigned; A sampling pump was used when a fixed pump was not available.]

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
		Zone 1: Northern Mountain Front																			
S027		CEPO 02	1	na	353736	1062104	5,335	16N.06E.07.332	353736106210401	320	121.13	8/3/1998	270	315	45	MW	na	Grundfos	PVC	4	nd
S034		Private Production Well #04	1	na	353657	1062116	5,298	16N.06E.18.311	353657106211601	250	190.	nd	nd	nd	nd	PW	submersible	na	steel	nd	nd
S035		Windmill #37	1	na	353805	1062329	5,533	16N.05E.10.242	353805106232901	290	150.	nd	nd	nd	nd	WW	windmill	na	steel	6	nd
S036		Private Production Well #03	1	na	353443	1061913	5,362	16N.06E.32.224	353443106191301	300	160.	5/25/1967	250	300	50	PW	submersible	na	steel	6	5/25/1967
S065		Domestic Well #05	1	na	351901	1063458	5,172	13N.03E.36.113	351901106345801	330	160.	9/2/1994	320	330	10	DW	submersible	na	PVC	4	9/2/1994
S187		Rio Rancho 12	1	na	351915	1063529	5,240	13N.03E.26.433	351915106352801	1,487	226.	1994	800	1,435	635	PW	turbine	na	steel	nd	3/3/1987
S206		Windmill #38	1	3	352556	1062929	5,542	14N.04E.23.143	352448106294601	535	460.58	2/9/1995	nd	nd	nd	WW	windmill	na	steel	nd	nd
S216		Windmill #09	1	na	352759	1063627	5,725	14N.03E.03.434	352757106362301	637	585.	6/10/1958	nd	nd	nd	WW	windmill	na	steel	nd	6/1/1958
S221		Windmill #45	1	na	353340	1062547	5,632	15N.05E.05.243	353340106254701	555	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S222		Windmill #39	1	3	353458	1063037	6,107	16N.04E.27.333	353455106304201	260	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S254		Private Production Well #12	1	na	353856	1062000	5,525	16N.06E.05.132	353856106200001	690	265.	nd	356	690	334	PW	turbine	na	steel	nd	nd
S277		Windmill #40	1	na	353338	1063228	5,946	15N.04E.05.143	353337106323301	100	36.6	4/21/1998	nd	nd	nd	WW	windmill	na	steel	6	1937
S279		Windmill #42	1	na	353605	1063404	6,275	16N.03E.24.421	353608106340401	56	13.18	1/11/1984	nd	nd	nd	WW	windmill	na	steel	8	2/13/1959
S281		Windmill #43	1	3	353230	1063440	6,281	15N.03E.12.322	353238106342901	1,109	990.99	11/7/1994	nd	nd	nd	WW	windmill	na	steel	8	2/1/1960
		Zone 2: Northwestern																			
S103	A	Lincoln D	2	na	351515	1064104	5,450	12N.02E.24.144	351515106410401	1,260	495.5	9/2/1997	1,200	1,240	40	MW	na	Bennett	steel	2	8/30/1997
S104	A	Lincoln M	2	na	351515	1064104	5,450	12N.02E.24.144A	351515106410402	835	494.3	9/2/1997	810	830	20	MW	na	Bennett	steel	2	8/30/1997
S105	A	Lincoln S	2	na	351515	1064104	5,450	12N.02E.24.144B	351515106410403	595	485.5	9/10/1997	490	590	100	MW	na	Bennett	steel	2	8/30/1997
S191		Rio Rancho 4	2	3	351459	1064034	5,415	12N.03E.24.442	351459106403401	990	396.	9/1/1969	670	990	320	PW	turbine	na	steel	16	9/1/1969
S192		Rio Rancho 8	2	3	351625	1064357	5,827	12N.02E.16.214	351627106435301	1,618	880.	8/21/1978	982	1,599	617	PW	turbine	na	steel	18	8/3/1978
S189		Rio Rancho 15	2	na	352117	1064057	5,794	13N.02E.13.322	352117106405701	1,310	775.	8/8/1993	820	1,290	470	PW	turbine	na	steel	nd	nd
S276		Windmill #12	2	na	353302	1063856	5,970	15N.03E.08.123	353255106385601	727	667.	6/4/1981	715	725	10	WW	windmill	na	steel	6	4/22/1970
S278		Windmill #41	2	na	352542	1064203	5,618	14N.02E.23.321	352542106420401	448	373.3	1/23/1984	nd	nd	nd	WW	windmill	na	steel	5	10/10/1939
S280		Windmill #13	2	na	352811	1064523	5,554	14N.02E.05.323	352810106452201	240	116.	4/18/1957	125	135	10	WW	windmill	na	steel	6	10/3/1955
S286		Private Production Well #13	2	na	353106	1064214	5,615	15N.02E.23.141	353106106421401	572	242.	10/16/1995	392	552	160	PW	submersible	na	steel	nd	10/16/1995
S287		Private Production Well #14	2	na	353041	1064255	5,525	15N.02E.22.414	353044106425101	320	150.	4/11/1983	260	320	60	PW	submersible	na	steel	5	3/9/1971
		Zone 3: West Central																			
S003	F	98th St. D	3	na	350530	1064452	5,320	10N.02E.17.44	350530106445201	1,544	421.46	4/21/1997	1,534	1,539	5	MW	na	Bennett	PVC	3	2/15/1997
S004	F	98th St. MD	3	na	350530	1064452	5,320	10N.02E.17.44A	350530106445202	1,112	422.69	4/21/1997	1,102	1,107	5	MW	na	Bennett	PVC	3	2/15/1997
S005	F	98th St. MS	3	na	350530	1064452	5,320	10N.02E.17.44B	350530106445203	749	416.	4/21/1997	739	744	5	MW	na	Bennett	PVC	3	2/15/1997
S006	F	98th St. S	3	na	350530	1064452	5,320	10N.02E.17.44C	350530106445204	438	391.3	4/21/1997	388	433	45	MW	na	Bennett	PVC	3	2/15/1997
S008		Private Production Well #01	3	na	350336	1064751	5,725	10N.01E.25.333	350336106475101	1,292	834.	10/31/1987	1,078	1,272	194	PW	submersible	na	steel	6	10/31/1987
S010		Private Production Well #16	3	na	350112	1064902	5,688	09N.01E.10.422	350112106490201	1,300	781.	6/4/1965	1,242	1,294	52	PW	submersible	na	steel	6	6/4/1965
S018		Domestic Well #21	3	na	344701	1065050	5,320	07N.01E.33.334	344701106505001	660	475.	10/14/1983	640	660	20	DW	submersible	na	PVC	5	10/14/1983
S019		Belen 4	3	5	343917	1064747	4,920	05N.01E.13.33	343917106474701	504	150.	12/1/1967	150	504	354	PW	submersible	na	steel	14	12/1/1967
S020		Belen 5	3	5	344017	1064754	4,930	05N.01E.12.313	344017106475401	600	144.	nd	435	600	165	PW	submersible	na	steel	nd	nd
S029		Cerro Colorado Landfill PW	3	5	350121	1065208	5,830	09N.01E.07.244	350121106520801	1,661	898.	5/3/1990	1,355	1,655	300	PW	turbine	na	steel	10	5/3/1990
S037		College 2	3	na	350647	1064400	5,226	10N.02E.09.232	350647106440001	1,605	329.	1993	550	1,564	1,014	PW	turbine	na	steel	nd	9/10/1978
S066		Gonzales 1	3	12	350641	1064232	5,111	10N.02E.11.131	350642106422801	970	167.2	11/1/1992	350	950	600	PW	turbine	na	steel	20	11/1/1992
S086	G	Isleta D	3	na	345650	1064159	4,900	08N.02E.02.413	345650106415901	1,340	17.89	12/18/1997	1,330	1,335	5	MW	na	Bennett	PVC	2	12/16/1997
S101		Leavitt 1	3	na	350310	1064350	5,076	10N.02E.33.232	350309106434501	1,140	193.	1993	288	1,128	840	PW	turbine	na	steel	nd	1973
S108		Los Lunas 3	3	12	344915	1064528	4,965	07N.02E.20.133	344915106452801	605	182.	nd	332	562	230	PW	na	na	steel	nd	nd
S109		Los Lunas 4	3	12	345009	1064503	4,981	07N.02E.17.232	345009106450301	610	129.	6/28/1979	278	582	304	PW	na	na	steel	14	6/28/1979
S145		NM Utilities 1	3	na	351137	1064417	5,390	11N.02E.09.324	351137106441701	1,050	533.	1992	648	1,050	402	PW	turbine	na	steel	16	5/24/1960
S147		NM Utilities 3	3	na	351302	1064247	5,460	11N.02E.03.221	351302106424701	1,364	489.	4/1/1980	650	1,351	701	PW	turbine	na	steel	16	4/1/1980
S148		NM Utilities 4	3	na	351215	1064413	5,455	11N.02E.04.344	351215106441301	1,357	539.	9/30/1994	692	1,339	647	PW	turbine	na	steel	16	9/30/1994
S166		Rabbit Hill	3	na	353534	1064251	5,655	16N.02E.27.213A	353534106425101	608	102.27	8/4/1998	353	603	250	MW	na	Grundfos	PVC	2	nd
S167		Domestic Well #12	3	na	344851	1064928	5,358	07N.01E.22.431	344851106492801	985	530.	3/14/1991	965	980	15	DW	submersible	na	steel	5	3/14/1991
S174		Rio Bravo 1 D	3	na	350137	1064105	4,931	09N.02E.12.214A	350137106410501	149	11.31	1/24/1996	139	144	5	MW	na	Bennett	steel	5	nd
S175		Rio Bravo 1 M	3	12	350137	1064105	4,931	09N.02E.12.214B	350137106410502	104	11.21	1/24/1996	94	99	5	MW	na	Bennett	steel	5	nd
S172	D	Rio Bravo 5 D	3	12	350140	1064016	4,958	09N.03E.07.114B	350138106401103	515	12.1	12/2/1992	500	510	10	MW	na	Grundfos	PVC	4	9/24/1992
S186		Rio Rancho 10	3	na	351623	1063946	5,504	12N.03E.18.231	351623106394601	1,470	556.	1994	825	1,450	625	PW	turbine	na	steel	nd	12/21/1985
S188		Rio Rancho 13	3	na	351630	1064812	6,055	12N.01E.14.212	351630106481201	1,920	1,101.15	12/20/1989	1,343	1,721	378	PW	turbine	na	steel	nd	12/20/1989
S193		Rio Rancho 9	3	na	351923	1064707	6,054	13N.01E.25.432	351922106470601	1,540	1,082.	10/31/1984	1,120	1,520	400	PW	turbine	na	steel	18	7/10/1984
S196		Windmill #05	3	na	345406	1065030	5,470	08N.01E.21.431	345406106503001	620	598.9	5/11/1993	nd	nd	nd	WW	windmill	na	steel	6	5/1/1964
S200		Private Production Well #08	3	na	343103	1064827	4,840	03N.01E.02.23	343103106482701	249	92.	7/3/1984	224	249	25	PW	submersible	na	steel	6	7/3/1984
S217	B	Santa Ana Boundary D	3	na	352710	1063945	5,322	14N.03E.07.431A	352708106394301	750	6.35	8/16/1985	730	750	20	MW	na	Bennett	steel	2	nd

Table A1. Location and well-construction information for ground-water sites-- Continued

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
S218	B	Santa Ana Boundary M	3	na	352710	1063945	5,322	14N.03E.07.431B	352708106394302	492	15.96	8/16/1985	472	492	20	MW	na	Bennett	steel	2	nd
S219	B	Santa Ana Boundary S	3	na	352710	1063945	5,322	14N.03E.07.431C	352708106394303	210	31.22	8/16/1985	190	210	20	MW	na	Bennett	steel	2	nd
S230	H	Sierra Vista D	3	na	350910	1064148	5,110	11N.03E.26.243	350910106414801	1,644	178.75	8/8/1997	1,634	1,639	5	MW	na	Bennett	PVC	2	7/20/1997
S236		SAF (Soil Amendment Facility)	3	na	350855	1064928	5,866	11N.01E.27.421	350846106492601	1,463	922.11	4/25/1988	1,116	1,429	313	PW	turbine	na	steel	10	3/12/1988
S241		SWAB Test Hole #1 D	3	1	350449	1064931	5796	10N.01E.22.322C	350449106493103	1179	884.95	4/12/1994	1,139	1,179	40	MW	na	swab	PVC	2	6/25/1981
S242		SWAB Test Hole #1 S	3	1	350449	1064931	5796	10N.01E.22.322B	350449106493102	1121	886.8	4/12/1994	980	1,121	141	MW	na	swab	PVC	2	6/25/1981
S243		SWAB Test Hole #2 D	3	na	351046	1064648	5730	11N.02E.18.313D	351046106464704	1805	796.97	4/12/1994	1,525	1,795	270	MW	na	swab	PVC	2	11/1/1981
S263		Volcano Cliff 1	3	na	350935	1064343	5,335	11N.02E.28.222	350950106434001	1,200	458.	1993	528	1,056	528	PW	turbine	na	steel	nd	9/24/1968
S266	E	West Bluff Nest 1 Well 1	3	na	350638	1064137	5,100	10N.02E.11.244	350638106413701	1,095	173.11	10/24/1996	1,085	1,090	5	MW	na	Grundfos	PVC	3	7/18/1996
S272		West Mesa 3	3	na	350444	1064354	5,145	10N.02E.21.412	350443106395801	1,365	239.	4/1/1974	405	1,353	948	PW	turbine	na	steel	16	1974
S283	C	Zia Ball Park D	3	na	353000	1064350	5,397	15N.02E.28.421A	353000106435001	770	14.36	8/16/1985	750	770	20	MW	na	Bennett	steel	2	nd
S284	C	Zia Ball Park M	3	na	353000	1064350	5,397	15N.02E.28.421B	353000106435002	506	15.11	9/9/1985	486	506	20	MW	na	Bennett	steel	2	nd
S285	C	Zia Ball Park S	3	2	353000	1064350	5,397	15N.02E.28.421C	353000106435003	300	19.21	8/16/1985	280	300	20	MW	na	Bennett	steel	2	nd
S288		Zia BMT D	3	na	353208	1064059	5,740	15N.02E.13.122	353208106405901	800	nd	nd	750	800	50	MW	na	Bennett	steel	2	nd
		Zone 4: Western Boundary																			
S031		Windmill #18	4	na	342924	1065505	4,850	03N.01W.14.114	342922106550301	143	112.47	2/9/1995	nd	nd	nd	WW	windmill	na	steel	6	nd
S039		Windmill #20	4	na	343539	1070055	5,249	04N.02W.02.433	343539107005501	439	nd	nd	nd	nd	nd	WW	pump jack	na	steel	nd	1947
S059		Windmill #21	4	na	343907	1065729	5,190	05N.01W.20.222	343907106572901	395	349.	3/24/1963	390	395	5	WW	pump jack	na	steel	5	nd
S074		Windmill #23	4	na	343841	1070244	5,434	05N.02W.21.422	343839107024401	620	545.49	5/24/1956	nd	nd	nd	WW	pump jack	na	steel	8	1953
S169		Rest Area	4	na	341841	1065317	4,905	01N.01W.13.244	341839106531601	212	164.08	10/31/1995	173	212	39	PW	submersible	na	steel	nd	8/23/1976
S201		Windmill #26	4	na	342934	1070604	5,654	03N.03W.12.443	342934107060401	630	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S252		Windmill #10	4	na	343649	1065738	5,188	05N.01W.32.423	343650106573501	428	370.5	10/18/1993	388	428	40	WW	pump jack	na	PVC	6	10/18/1993
S260		Windmill #33	4	na	343230	1065707	5,004	04N.01W.28.323	343230106570301	281	207.33	5/8/1956	269	279	10	WW	windmill	na	steel	6	1956
		Zone 5: Rio Puerco																			
S032		Windmill #17	5	na	342707	1065325	4,771	03N.01W.25.441	342707106532202	61	34.44	2/2/1993	nd	nd	nd	WW	windmill	na	steel	6	nd
S069		Domestic Well #06	5	na	343748	1065021	5,191	05N.01E.28.41	343748106502101	590	385.	10/31/1995	590	590	nd	DW	submersible	na	steel	5	10/31/1995
S073		Windmill #03	5	na	343447	1065545	5,035	04N.01W.15.211	343447106554201	268	224.79	5/9/1956	nd	nd	nd	WW	windmill	na	steel	nd	1933
S082		Windmill #36	5	na	345231	1065617	5,570	08N.01W.34.311	345231106561701	720	599.2	5/11/1993	nd	nd	nd	WW	windmill	na	steel	8	10/1/1960
S085		Windmill #35	5	na	345132	1065452	5,423	07N.01W.02.342	345132106545201	700	580.2	1/25/1993	nd	nd	nd	WW	windmill	na	steel	8	11/1/1934
S111		Domestic Well #10	5	na	343634	1064951	5,169	05N.01E.34.33	343634106495101	657	400.	7/27/1994	637	657	20	DW	submersible	na	PVC	4	7/27/1994
S185		Domestic Well #31	5	na	350204	1065623	5,280	09N.01W.04.424	350204106562301	150	75.25	10/30/1995	nd	nd	nd	DW	submersible	na	PVC	5	1957
S198		Windmill #07	5	na	345218	1070018	5,125	08N.02W.36.341	345218107001801	212	133.6	5/7/1993	nd	nd	nd	WW	windmill	na	steel	6	5/1/1968
S215		Sandoval Spring	5	4	352136	1065622	5,860	13N.01W.16.224	352136106562201	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S237		Windmill #30	5	4	343053	1065518	5,010	03N.01W.02.311	343053106551801	440	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S238		Windmill #31	5	na	343146	1065340	4,849	04N.01W.36.233	343145106533601	90	52.1	11/21/1949	nd	nd	nd	WW	windmill	na	steel	6	1949
		Zone 6: Southwestern Mountain Front																			
S022		Windmill #02	6	na	342426	1065559	5,080	02N.01W.10.341	342426106555901	316	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
		Zone 7: Abo Arroyo																			
S021		Stock Well #01	7	na	342732	1063133	5,373	03N.04E.28.244	342723106312001	192	170.95	6/23/1997	nd	nd	nd	SW	submersible	na	steel	8	1955
S024		Domestic Well #02	7	8	342914	1063719	5,181	03N.03E.15.131	342914106371901	400	nd	nd	nd	nd	nd	DW	submersible	na	steel	nd	7/1/1919
S090		Domestic Well #08	7	na	342516	1064260	5,032	12N.02E.03.43	342516106430001	360	280.	3/12/1996	320	360	40	DW	submersible	na	PVC	5	3/12/1996
S093		Domestic Well #09	7	8	343024	1064431	4,910	03N.02E.09.11	343024106443101	350	150.	7/26/1992	340	350	10	DW	submersible	na	PVC	4	7/26/1992
		Zone 8: Eastern Mountain Front																			
S007		Domestic Well #01	8	na	350860	1062746	6,490	11N.04E.25.424	350900106274401	55	30.49	6/21/1996	nd	nd	nd	DW	submersible	na	PVC	nd	nd
S013		Windmill #14	8	na	344103	1063218	5,450	05N.04E.05.432	344103106321801	270	220.	5/17/1995	260	270	10	WW	windmill	na	PVC	5	5/17/1995
S014		Private Production Well #17	8	na	352148	1062733	5,320	13N.05E.18.111	352148106273301	360	240.	6/21/1983	310	360	50	PW	submersible	na	nd	6	6/21/1983
S015		Windmill #01	8	na	344132	1063050	5,634	05N.04E.03.114	344133106304801	42	13.02	1957	nd	nd	nd	WW	windmill	na	steel	nd	1945
S030		Charles 4	8	na	350559	1063339	5,324	10N.04E.18.211	350602106333201	1,055	386.	1968	456	1,032	576	PW	turbine	na	steel	nd	7/31/1968
S042		Domestic Well #03	8	na	344451	1063734	5,067	06N.03E.16.243	344451106373401	480	350.	nd	460	480	20	DW	submersible	na	PVC	5	3/8/1995
S055		Elena Gallegos	8	na	351000	1062816	6,455	11N.04E.24.124	351020106282001	95	28.	6/3/1983	20	95	75	PW	submersible	na	nd	5	6/3/1983
S056		Embudito Spring	8	na	350804	1062829	6,440	11N.04E.36.323	350804106282901	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S071		Domestic Well #07	8	na	350955	1063003	5,988	11N.04E.22.423	350955106300301	600	392.	7/24/1993	570	590	20	DW	submersible	na	PVC	4	7/24/1993
S083		Windmill #34	8	na	344945	1063726	5,142	07N.03E.16.442	344945106372601	440	313.1	5/18/1993	nd	nd	nd	WW	windmill	na	steel	8	3/1/1958
S095		Kirtland 1	8	na	350302	1063332	5,383	10N.04E.31.411	350258106332801	1,199	427.	8/1/1949	550	800	250	PW	submersible	na	steel	12	8/1/1949
S106		Domestic Well #23	8	na	343236	1064605	4,781	04N.02E.30.243	343238106460501	160	8.	6/24/1991	150	160	10	DW	submersible	na	PVC	4	6/24/1991
S110		Love 1	8	na	350517	1063145	5,462	10N.04E.16.334	350517106314401	1,170	589.	1993	596	1,096	500	PW	turbine	na	steel	14	11/8/1954
S113		Domestic Well #11	8	na	343323	1063826	5,055	04N.03E.21.31	343323106382601	352	240.	1/30/1991	337	352	15	DW	submersible	na	PVC	4	1/30/1991
S114	J	Matheson D	8	na	350653	1063116	5,575	10N.04E.09.214	350653106311601	1,520	727.44	7/18/1997	1,460	1,500	40	MW	na	Bennett	steel	2	7/16/1997
S115	J	Matheson M	8	na	350653	1063116	5,575	10N.04E.09.214A	350653106311602	1,045	720.38	7/18/1997	1,020	1,040	20	MW	na	Bennett	steel	2	7/16/1997

Table A1. Location and well-construction information for ground-water sites-- Continued

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
S116	J	Matheson S	8	na	350653	1063116	5,575	10N.04E.09.214B	350653106311603	705	582.64	7/18/1997	600	700	100	MW	na	Bennett	steel	2	7/16/1997
S117		Domestic Well #25	8	na	350857	1062954	5,985	11N.04E.27.424	350857106295401	447	373.	2/22/1972	439	445	6	DW	submersible	na	steel	6	2/22/1972
S118		Windmill #24	8	na	342047	1063708	5,512	01N.03E.03.12	342045106370701	196	114.65	7/26/1949	nd	nd	nd	WW	windmill	na	steel	8	10/1/1948
S119		Domestic Well #26	8	11	352137	1062338	5,760	13N.05E.15.223	352137106233801	150	70.	nd	nd	nd	nd	DW	submersible	na	steel	6	1964
S122	K	Mesa Del Sol S	8	na	345758	1063642	5,326	09N.03E.10.342B	345758106364003	525	406.76	6/20/1997	420	520	100	MW	na	Bennett	steel	3	6/6/1997
S140		MRN 1	8	na	345848	1063357	5,304	09N.04E.30.132	345848106335701	607	417.46	7/5/1997	547	587	40	MW	na	Bennett	steel	5	1/22/1995
S141		National Utility 7	8	na	344822	1063160	5,510	07N.04E.28.133	344822106320001	150	80.	2/5/1964	nd	nd	nd	PW	submersible	na	steel	8	2/5/1964
S149	I	Nor Este D	8	na	351114	1063306	5,460	11N.04E.18.222	351114106330601	1,525	538.48	6/6/1997	1,515	1,520	5	MW	na	Bennett	PVC	3	6/3/1997
S150	I	Nor Este M	8	na	351114	1063306	5,460	11N.04E.18.222A	351114106330602	1,193	540.22	6/6/1997	1,183	1,188	5	MW	na	Bennett	PVC	3	6/3/1997
S162		Stock Well #03	8	na	343530	1063343	5,320	04N.04E.07.233	343530106334301	460	nd	nd	nd	nd	nd	SW	submersible	na	steel	nd	nd
S163		PL 2	8	na	350042	1063353	5,330	09N.04E.18.114	350042106335301	617	451.16	7/7/1997	577	597	20	MW	na	Bennett	steel	5	11/18/1994
S164		Ponderosa 1	8	na	350931	1063156	5,647	11N.04E.28.111	350931106315501	1,800	754.	1993	964	1,693	729	PW	turbine	na	steel	18	4/28/1979
S165		Windmill #25	8	na	343802	1063233	5,440	05N.04E.29.142	343756106324301	420	335.	1962	nd	nd	nd	WW	windmill	na	steel	nd	1962
S168		Domestic Well #30	8	na	343338	1063553	5,137	04N.03E.23.411	343338106355301	400	290.	7/16/1988	390	400	10	DW	submersible	na	PVC	4	7/16/1988
S170		Ridgecrest 3	8	na	350413	1063313	5,385	10N.04E.30.243	350401106331401	1,475	472.	11/15/1974	620	1,436	816	PW	turbine	na	steel	16	11/15/1974
S195		Domestic Well #13	8	na	344832	1063618	5,176	07N.03E.26.113	344832106361801	600	320.	2/15/1996	580	600	20	DW	submersible	na	PVC	4	2/15/1996
S199		Windmill #08	8	na	345504	1063313	5,350	08N.04E.18.424	345504106331301	44	22.7	5/18/1993	nd	nd	nd	WW	windmill	na	steel	6	8/1/1969
S209		Domestic Well #33	8	na	343524	1064120	4,970	04N.02E.11.244	343524106412001	480	320.	6/8/1996	460	480	20	DW	submersible	na	PVC	4	6/8/1996
S212		Sandia Peak 1	8	na	351031	1063007	5,978	11N.04E.15.434	351031106300701	800	361.	7/17/1988	560	760	200	PW	turbine	na	steel	14	7/17/1988
S213		Sandia Peak 3	8	na	351031	1063007	5,978	11N.04E.15.434A	351031106300702	603	360.	7/8/1988	383	583	200	PW	turbine	na	steel	14	7/8/1988
S224		Domestic Well #14	8	na	351903	1062917	5,462	13N.04E.35.122	351903106291701	580	324.	12/14/1994	560	580	20	DW	submersible	na	PVC	4	12/14/1994
S229		SH03 UNM	8	na	350950	1062948	6,060	11N.04E.23.331	350950106294801	495	445.16	7/28/1998	420	490	70	MW	na	Bennett	PVC	4	nd
S233		Domestic Well #16	8	na	351838	1063052	5,338	13N.04E.33.422	351838106305201	400	225.	11/24/1993	375	395	20	DW	submersible	na	PVC	4	11/24/1993
S239		Domestic Well #17	8	na	352001	1062353	6,080	13N.05E.27.211	352001106235301	300	225.	6/16/1982	260	300	40	DW	submersible	na	PVC	5	6/16/1982
S240		Domestic Well #18	8	na	351115	1063027	5,943	11N.04E.15.122	351115106302701	550	400.	8/6/1992	510	530	20	DW	submersible	na	PVC	4	8/6/1992
S246		Windmill #32	8	na	344012	1063617	5,160	05N.03E.11.331	344015106362201	380	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S247		Domestic Well #19	8	na	343142	1063232	5,380	04N.04E.32.24	343142106323201	640	390.	8/29/1994	598	638	40	DW	submersible	na	PVC	4	8/29/1994
S248		Thomas 6	8	na	350720	1063305	5,408	10N.04E.06.422	350720106330401	1,536	536.	1993	760	1,520	760	PW	turbine	na	steel	nd	11/14/1988
S255		Tramway East	8	na	351136	1063050	5,880	11N.04E.10.313	351136106305001	1,100	474.	1/19/1966	698	1,098	400	PW	turbine	na	steel	12	1/19/1966
S264		Walker 1	8	na	351025	1063140	5,699	11N.04E.21.121	351025106323801	1,723	802.	1993	991	1,711	720	PW	turbine	na	steel	18	1980
S274		Domestic Well #20	8	na	344629	1063827	5,050	06N.03E.05.422	344629106382701	368	220.	11/5/1993	348	368	20	DW	submersible	na	PVC	4	11/5/1993
		Zone 9: Tijeras Fault Zone																			
S041		Coyote Spring	9	na	345957	1062812	5,840	09N.04E.24.211	345957106281201	na	na	na	na	na	na	SP	na	Bennett	na	na	nd
S072		Hubbell Spring	9	8	345555	1063151	5,437	08N.04E.09.314	345555106314701	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S098		KAFB-1902	9	na	345757	1062905	5,790	09N.04E.35.241	345757106290501	114	85.8	12/6/1993	79	104	25	MW	na	Bennett	steel	4	7/2/1992
S197		Windmill #06	9	na	345335	1062932	5,725	08N.04E.26.144	345335106293201	295	203.6	5/18/1993	nd	nd	nd	WW	windmill	na	steel	5	6/1/1967
S227		SFR 3D	9	na	345650	1063122	5,494	08N.04E.04.413	345650106312201	362	162.61	11/3/1995	312	352	40	MW	na	Bennett	PVC	2	11/5/1992
S228		SFR 3S	9	na	345650	1063122	5,494	08N.04E.04.413A	345650106312202	222	163.5	11/3/1995	182	212	30	MW	na	Bennett	PVC	2	11/10/1992
		Zone 10: Tijeras Arroyo																			
S001		4Hills-1	10	8	350340	1062940	5,669	10N.04E.26.331	350339106294001	70	57.25	1994	25	65	40	MW	na	Bennett	PVC	4	nd
S002		Private Production Well #15	10	8	350319	1063014	5,647	10N.04E.34.214	350317106300901	1,200	616.17	9/30/1957	650	1,180	530	PW	turbine		steel	18	10/1/1957
S058		Eubank 1	10	8	350259	1063158	5,457	10N.04E.32.422	350259106315801	615	566.33	5/10/1964	550	610	60	MW	na	Bennett	steel	4	nd
S096		Kirtland 11	10	8	350230	1063124	5,466	09N.04E.04.213	350228106312401	1,327	545.	2/27/1972	670	1,327	657	PW	na	na	steel	16	1/18/1972
S107		Lomas 1	10	na	350431	1063028	5,595	10N.04E.22.342	350430106302401	1,300	731.	1993	700	1,300	600	PW	turbine	na	steel	16	1962
		Zone 11: Northeastern																			
S016		Windmill #15	11	na	352633	1062018	5,520	14N.06E.18.422	352633106201801	55	25.08	1979	nd	nd	nd	WW	windmill	na	steel	6	nd
S017		Windmill #16	11	na	352617	1061624	5,780	14N.06E.14.431	352617106162401	300	240.	nd	nd	nd	nd	WW	windmill	na	steel	8	1965
S053		Private Production Well #18	11	na	353025	1062122	5,382	15N.05E.25.222	353025106212201	nd	nd	nd	nd	nd	nd	PW	submersible	na	nd	nd	nd
S144		Private Production Well #06	11	na	352713	1062056	5,496	14N.06E.07.341	352713106205601	800	347.2	4/8/1993	520	760	240	PW	submersible	na	steel	8	4/8/1993
S204		Windmill #28	11	na	352345	1062516	5,320	14N.05E.33.341	352344106251201	175	115.	1956	nd	nd	nd	WW	windmill	na	steel	nd	1956
S207		Private Production Well #22	11	na	352506	1062400	5,260	14N.05E.27.124	352506106240001	286	130.	10/31/1979	268	286	18	PW	submersible	na	steel	6	10/31/1979
S223		Windmill #29	11	na	352820	1061559	5,594	14N.06E.01.311	352820106155901	292	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
		Zone 12: Central																			
S011		Atris-1	12	na	350533	1064131	4,960	10N.02E.14.424A	350533106413101	31	12.55	1994	26	31	5	MW	na	Bennett	steel	2	3/1/1990
S012		Atrisco 3	12	3	350516	1064121	4,950	10N.02E.24.112	350508106411901	813	13.	1993	180	804	624	PW	turbine	na	steel	16	8/18/1958
S025		Burton 2	12	na	350421	1063613	5,284	10N.03E.26.111	350421106361001	857	418.	1993	425	845	420	PW	turbine	na	steel	18	1962
S026		Burton 5	12	na	350355	1063517	5,275	10N.03E.26.422	350355106351501	1,170	415.1	12/5/1996	550	1,150	600	PW	turbine	na	steel	nd	1991
S033		Private Production Well #02	12	na	345205	1063942	4,974	07N.03E.06.212	345205106384201	182	121.	nd	142	172	30	PW	submersible	na	steel	8	nd
S040		Coronado 1	12	na	351023	1063418	5,288	11N.03E.24.221	351025106341601	1,186	384.	1993	479	1,184	705	PW	turbine	na	steel	18	1/8/1974
S043	Q	Del Sol D	12	na	350534	1063547	5,210	11N.03E.14.324	350534106354701	1,567	336.69	10/24/1996	1,557	1,562	5	MW	na	Bennett	PVC	3	5/7/1996

Table A1. Location and well-construction information for ground-water sites-- Continued

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
S044	Q	Del Sol M	12	na	350534	1063547	5,210	11N.03E.14.324A	350534106354702	842	345.61	10/24/1996	832	837	5	MW	na	Bennett	PVC	3	5/7/1996
S045	Q	Del Sol S	12	na	350534	1063547	5,210	11N.03E.14.324B	350534106354703	425	348.66	10/24/1996	315	415	100	MW	na	Bennett	PVC	3	5/7/1996
S046		Duranes 1	12	na	350641	1064006	4,960	10N.03E.07.141	350642106401101	1,000	34.	1993	204	924	720	PW	turbine	na	steel	16	12/8/1959
S047		Duranes 7	12	na	350656	1064112	4,954	10N.02E.12.121	350655106395001	950	4.	2/1/1953	144	950	806	PW	turbine	na	steel	nd	4/21/1953
S048		Duranes Yard 1	12	na	350628	1064122	5,100	10N.02E.12.312	350628106412201	105	6.62	2/27/1997	95	100	5	MW	na	Grundfos	PVC	3	1/12/1997
S049		Duranes Yard 2	12	na	350628	1064122	5,100	10N.02E.12.312A	350628106412202	75	7.07	2/27/1997	65	70	5	MW	na	Grundfos	PVC	3	1/13/1997
S050		Duranes Yard 3	12	na	350628	1064122	5,100	10N.02E.12.312B	350628106412203	50	6.78	2/27/1997	40	45	5	MW	na	peristaltic	PVC	3	1/14/1997
S051		Duranes Yard 4	12	na	350628	1064122	5,100	10N.02E.12.312C	350628106412204	30	7.09	2/27/1997	20	25	5	MW	na	peristaltic	PVC	3	1/16/1997
S052		Duranes Yard 5	12	na	350628	1064122	5,100	10N.02E.12.312D	350628106412205	25	7.21	2/27/1997	15	20	5	MW	na	peristaltic	PVC	3	1/16/1997
S060	N	Garfield D	12	3	350706	1063903	4,964	10N.03E.05.341	350706106390301	1,020	49.44	10/24/1996	995	1,010	15	MW	na	Grundfos	PVC	3	9/11/1996
S061	N	Garfield M	12	na	350706	1063903	4,964	10N.03E.05.341A	350706106390302	582	48.28	10/24/1996	552	572	20	MW	na	Grundfos	PVC	3	9/11/1996
S062	N	Garfield S	12	na	350706	1063903	4,964	10N.03E.05.341B	350706106390303	93	43.51	10/24/1996	43	83	40	MW	na	Grundfos	PVC	3	9/11/1996
S064		Domestic Well #22	12	na	351421	1063822	5,230	12N.03E.29.422	351421106382201	315	221.5	6/20/1997	300	315	15	DW	submersible	na	PVC	4	6/1/1992
S068		Griegos 3	12	na	350811	1064003	4,968	11N.02E.36.442	350802106402901	916	20.	1993	260	916	656	PW	turbine	na	steel	nd	11/19/1954
S075	O	Hunter Ridge Nest 1 Well 1	12	3	351200	1064008	5,110	11N.03E.07.141	351201106400501	1,518	162.73	10/24/1996	1,508	1,513	5	MW	na	Grundfos	PVC	3	6/14/1996
S076	O	Hunter Ridge Nest 1 Well 2	12	na	351200	1064008	5,110	11N.03E.07.141A	351201106400502	855	158.61	10/24/1996	845	850	5	MW	na	Grundfos	PVC	3	6/14/1996
S077	O	Hunter Ridge Nest 1 Well 3	12	na	351200	1064008	5,110	11N.03E.07.141B	351201106400503	238	146.11	10/24/1996	148	228	80	MW	na	Grundfos	PVC	3	6/14/1996
S078	O	Hunter Ridge Nest 2 Well 1	12	na	351200	1064008	5,110	11N.03E.07.141C	351201106400504	359	150.65	10/24/1996	349	354	5	MW	na	Grundfos	PVC	3	6/23/1996
S079	O	Hunter Ridge Nest 2 Well 2	12	na	351200	1064008	5,110	11N.03E.07.141D	351201106400505	305	147.95	10/24/1996	295	300	5	MW	na	Grundfos	PVC	3	6/23/1996
S080	O	Hunter Ridge Nest 2 Well 3	12	na	351200	1064008	5,110	11N.03E.07.141E	351201106400506	268	147.39	10/24/1996	238	258	20	MW	na	Grundfos	PVC	3	6/23/1996
S081		Private Production Well #19	12	na	351318	1063918	5,227	12N.03E.32.3312	351306106394001	2,020	269.	4/26/1994	730	2,000	1,270	PW	turbine	na	steel	36	7/11/1994
S084		Windmill #04	12	na	345345	1064513	5,016	08N.02E.29.213	345346106451201	167	150.1	1/26/1996	147	167	20	WW	windmill	na	steel	nd	2/1/1916
S087	G	Isleta MD	12	3	345650	1064159	4,900	08N.02E.02.413A	345650106415902	815	7.26	12/18/1997	805	810	5	MW	na	Bennett	PVC	2	12/16/1997
S088	G	Isleta MS	12	na	345650	1064159	4,900	08N.02E.02.413B	345650106415903	185	6.08	12/18/1997	175	180	5	MW	na	Bennett	PVC	2	12/16/1997
S089	G	Isleta S	12	na	345650	1064159	4,900	08N.02E.02.413C	345650106415904	50	6.42	12/18/1997	10	40	30	MW	na	Bennett	PVC	2	12/16/1997
S092		JMC-1	12	na	350404	1063825	4,997	10N.03E.29.242A	350404106382502	163	114.67	1994	148	158	10	MW	na	Bennett	PVC	4	1988
S097		Kirtland 14	12	na	350301	1063546	5,322	10N.03E.35.322	350302106354301	1,000	360.	1969	380	1,000	620	PW	submersible	na	steel	16	1969
S100		LALF-9	12	na	351038	1063552	5,093	11N.03E.14.341	351038106355201	233	145.64	1994	218	228	10	MW	na	Bennett	PVC	4	nd
S102		Leyendecker 1	12	na	350752	1063423	5,285	11N.03E.36.443	350752106342101	1,000	413.	1993	468	996	528	PW	turbine	na	steel	18	11/13/1959
S120	K	Mesa Del Sol D	12	na	345758	1063642	5,326	09N.03E.10.342	345758106364001	1,630	400.56	6/20/1997	1,580	1,620	40	MW	na	Bennett	steel	3	6/6/1997
S121	K	Mesa Del Sol M	12	na	345758	1063642	5,326	09N.03E.10.342A	345758106364002	1,015	412.48	6/20/1997	990	1,010	20	MW	na	Bennett	steel	3	6/6/1997
S123		MONT - 5A	12	na	350810	1063719	5,018	11N.03E.33.424A	350810106371901	200	116.21	1994	185	195	10	MW	na	Bennett	PVC	4	1989
S124		Montaño 2 D	12	na	350836	1063956	4,970	na	350836106395601	147	20.7	1/24/1996	138	143	5	MW	na	Bennett	steel	5	nd
S125		Montaño 2 M	12	na	350836	1063956	4,970	na	350836106395602	99	17.1	1/24/1996	90	95	5	MW	na	Bennett	steel	5	nd
S126		Montaño 2 S	12	na	350836	1063956	4,970	na	350836106395603	40	14.28	1/24/1996	30	35	5	MW	na	Bennett	steel	5	nd
S127		Montaño 4 D	12	na	350821	1063837	4,975	11N.03E.32.234A	350821106383701	132	45.33	1/24/1996	123	128	5	MW	na	Bennett	steel	5	nd
S128		Montaño 4 M	12	na	350821	1063837	4,974	11N.03E.32.234B	350821106383702	94	42.8	1/24/1996	85	90	5	MW	na	Bennett	steel	5	nd
S130		Montaño 5 D	12	na	350859	1064019	4,977	11N.03E.30.313B	350859106401603	150	9.79	12/17/1992	135	145	10	MW	na	Bennett	PVC	4	nd
S131		Montaño 5 M	12	na	350859	1064019	4,977	11N.03E.30.313A	350859106401602	75	7.39	12/17/1992	60	70	10	MW	na	Bennett	PVC	4	nd
S132		Montaño 5 S	12	na	350859	1064019	4,977	11N.03E.30.313	350859106401601	25	7.46	12/17/1992	10	20	10	MW	na	Bennett	PVC	4	nd
S133	L	Montaño 6 D	12	na	350834	1063958	4,970	11N.03E.31.213A	350836106395401	983	31.	11/10/1994	972	978	6	MW	na	Bennett	PVC	2	nd
S134	L	Montaño 6 MD	12	na	350834	1063958	4,970	11N.03E.31.213B	350836106395402	836	30.01	11/10/1994	826	831	5	MW	na	Bennett	PVC	2	nd
S135	L	Montaño 6 MS	12	na	350834	1063958	4,970	11N.03E.31.213C	350836106395403	568	28.25	11/10/1994	558	563	5	MW	na	Bennett	PVC	2	nd
S136	L	Montaño 6 S	12	na	350834	1063958	4,970	11N.03E.31.213D	350836106395404	182	20.62	11/10/1994	172	177	5	MW	na	Bennett	PVC	2	nd
S137	R	Montesa M	12	na	350056	1063701	5,100	09N.03E.10.342A	350056106370102	708	216.06	10/2/1997	698	703	5	MW	na	Bennett	PVC	2	9/10/1997
S138	R	Montesa S	12	na	350056	1063701	5,100	09N.03E.10.342B	350056106370103	330	211.22	10/2/1997	260	320	60	MW	na	Bennett	PVC	2	9/10/1997
S139		Domestic Well #27	12	na	350949	1064242	5,197	11N.02E.22.441	350946106424601	326	264.49	6/17/1997	nd	nd	nd	DW	submersible	na	steel	6	nd
S142		Domestic Well #28	12	na	351019	1064040	5,064	11N.02E.24.223	351019106404001	275	103.05	10/30/1995	259	274	15	DW	submersible	na	PVC	4	1/18/1983
S146		NM Utilities 2	12	na	351215	1064216	5,280	11N.02E.02.343	351215106421601	1,000	302.	10/5/1963	350	800	450	PW	turbine	na	steel	16	6/26/1963
S151	I	Nor Este S	12	na	351114	1063306	5,460	11N.04E.18.222B	351114106330603	608	540.73	6/6/1997	538	598	60	MW	na	Bennett	PVC	3	6/3/1997
S153		Open Space	12	10	350107	1063543	5,145	09N.03E.11.324	350107106354301	462	262.	1/6/1982	305	410	105	PW	turbine	na	steel	16	1/6/1982
S154		ORLF-2	12	na	350329	1063917	4,940	10N.03E.32.111	350329106391701	51	17.65	1994	46	51	5	MW	na	Bennett	steel	2	1989
S155		Domestic Well #29	12	na	344818	1064007	4,895	07N.03E.30.321	344817106401001	210	55.4	4/3/1995	200	210	10	DW	submersible	na	PVC	5	6/4/1993
S156		Paseo 2D	12	na	351057	1063842	4,989	11N.03E.17.233	351057106384201	150	16.42	12/17/1992	135	145	10	MW	na	Bennett	PVC	4	nd
S157		Paseo 2MD	12	na	351057	1063842	4,989	11N.03E.17.233A	351057106384202	95	11.63	12/17/1992	80	90	10	MW	na	Bennett	PVC	4	nd
S158		Paseo 2MS	12	na	351057	1063842	4,989	11N.03E.17.233B	351057106384203	45	11.81	12/17/1992	30	40	10	MW	na	Bennett	PVC	4	nd
S159		Paseo 2S	12	na	351057	1063842	4,990	11N.03E.17.233D	351057106384204	23	10.6	8/2/1993	13	23	10	MW	na	Bennett	PVC	2	nd
S160	M	Paseo 3D	12	na	351035	1063647	5,006	11N.03E.15.344C	351035106364703	544	69.95	8/24/1993	539	544	5	MW	na	Bennett	PVC	2	nd
S161	M	Paseo 3M	12	na	351035	1063647	5,006	11N.03E.15.344C	351035106364702	144	53.2	8/24/1993	139	144	5	MW	na	Bennett	PVC	4	nd
S171		Ridgecrest 4	12	na	350445	1063341	5,344	10N.04E.19.322	350445106334001	1,424	431.	12/11/1974	572	1,412	840	PW	turbine	na	steel	16	11/11/1974
S173	D	Rio Bravo 5 M	12	3	350140	1064016	4,958	09N.03E.07.114	350138106401101	150	7.3	1/9/1992	135	145	10	MW	na	Grundfos	PVC	4	1/8/1992
S176		Rio Bravo 1 S	12	na	350137	1064105	4,931	09N.02E.12.214C	350137106410503	38	10.5	4/4/1995	28	33	5	MW	na	Bennett	steel	5	nd

Table A1. Location and well-construction information for ground-water sites-- Continued

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
S177		Rio Bravo 2 D	12	na	350138	1063955	4,929	09N.03E.07.131A	350138106395501	154	12.23	1/24/1996	144	149	5	MW	na	Bennett	steel	5	nd
S178		Rio Bravo 2 M	12	na	350138	1063955	4,929	09N.03E.07.131B	350138106395502	91	11.47	1/24/1996	81	86	5	MW	na	Bennett	steel	5	nd
S179		Rio Bravo 2 S	12	na	350138	1063955	4,929	09N.03E.07.131C	350138106395503	49	11.31	1/24/1996	39	44	5	MW	na	Bennett	steel	5	nd
S181		Rio Bravo 4 M	12	na	350135	1063906	4,933	09N.03E.08.144B	350135106390602	124	23.79	1/24/1996	114	119	5	MW	na	Bennett	steel	5	nd
S180		Rio Bravo 4 D	12	na	350135	1063906	4,933	09N.03E.08.144A	350135106390601	149	22.55	1/24/1996	139	144	5	MW	na	Bennett	steel	5	nd
S183		Rio Grande Utility 5	12	3	343940	1064238	4,958	05N.02E.15.244	343940106423801	670	158.	5/14/1984	290	660	370	PW	na	na	steel	8	5/14/1984
S184		Rio Grande Utility 6	12	na	344355	1064100	5,010	06N.02E.24.144	344355106410001	602	190.5	8/31/1985	330	590	260	PW	na	na	steel	14	8/31/1985
S190		Rio Rancho 2	12	na	351340	1064014	5,266	12N.03E.31.132	351340106401401	751	295.	7/1/1963	508	751	243	PW	turbine	na	steel	12	7/1/1963
S203		Private Production Well #20	12	na	352552	1062701	5,050	14N.05E.19.231	352552106270101	110	23.	7/15/1977	65	100	35	PW	submersible	na	steel	8	7/15/1977
S205		Private Production Well #21	12	na	352552	1062701	5,050	14N.09E.19.231A	352552106270102	557	14.8	12/5/1986	517	547	30	PW	submersible	na	steel	8	12/5/1986
S208		San Jose 2	12	3	350338	1063832	4,992	10N.03E.29.443	350336106383201	1,000	96.	1993	264	996	732	PW	turbine	na	steel	16	1960
S210	S	Sandia D	12	na	351357	1063230	5,440	12N.04E.29.433	351357106323001	1,305	485.77	6/26/1998	1,295	1,300	5	MW	na	Bennett	PVC	2	nd
S214	S	Sandia S	12	na	351357	1063230	5,440	12N.04E.29.433B	351357106323003	535	479.12	6/26/1998	485	525	40	MW	na	Bennett	PVC	2	nd
S220		Santa Barbara 1	12	na	350648	1063625	5,139	10N.03E.10.223	350648106362501	1,000	257.	1993	312	984	672	PW	turbine	na	steel	16	11/18/1963
S231	H	Sierra Vista M	12	3	350910	1064148	5,110	11N.03E.26.243A	350910106414802	928	153.04	8/8/1997	918	923	5	MW	na	Bennett	PVC	2	7/20/1997
S232	H	Sierra Vista S	12	na	350910	1064148	5,110	11N.03E.26.243B	350910106414803	210	148.79	8/8/1997	140	200	60	MW	na	Bennett	PVC	2	7/20/1997
S234	P	Sister Cities D	12	na	350908	1063444	5,340	11N.03E.25.322	350908106344401	1,308	348.09	10/24/1996	1,298	1,303	5	MW	na	Bennett	PVC	3	3/31/1996
S235	P	Sister Cities M	12	na	350908	1063444	5,340	11N.03E.25.322A	350908106344402	799	348.34	10/24/1996	789	794	5	MW	na	Bennett	PVC	3	3/31/1996
S244		SWAB #3 - 760	12	na	351051	1063953	4995	11N.03E.18.411C	351051106395303	840	41.9	6/28/1996	710	790	80	MW	na	Bennett	PVC	2	11/6/1981
S245		SWAB #3 - 980	12	na	351051	1063953	4995	11N.03E.18.411D	351051106395304	1,055	43.71	6/28/1996	870	1,050	180	MW	na	Bennett	PVC	2	11/6/1981
S253	T	Tome D	12	na	344431	1063934	5,020	06N.03E.18.442	344431106393401	1,200	195.98	8/6/1998	1,185	1,195	10	MW	na	Grundfos	PVC	2	8/11/1998
S257		Domestic Well #34	12	na	345934	1064033	4,920	09N.02E.24.244	345934106403301	109	12.25	12/18/1980	nd	nd	nd	DW	submersible	na	PVC	4	12/18/1980
S259		VGP-1	12	na	350030	1064221	4,923	09N.02E.14.134A	350030106422101	64	8.24	1994	59	64	5	MW	na	Bennett	steel	2	1990
S261		Vol Andia 2	12	na	350732	1063504	5,208	10N.03E.01.133	350732106350101	1,016	332.	1993	360	852	492	PW	turbine	na	steel	16	11/5/1960
S262		Vol Andia 5	12	na	350805	1063611	5,112	11N.03E.35.313	350809106360901	1,020	222.	1993	260	900	640	PW	turbine	na	steel	16	9/4/1960
S265		Webster 1	12	na	351029	1063320	5,436	11N.04E.18.434	351029106332001	1,484	530.	1993	620	1,345	725	PW	turbine	na	steel	nd	10/18/1977
S267	E	West Bluff Nest 1 Well 2	12	3	350638	1064137	5,100	10N.02E.11.244A	350638106413702	689	161.91	10/24/1996	679	684	5	MW	na	Grundfos	PVC	3	7/18/1996
S268	E	West Bluff Nest 1 Well 3	12	na	350638	1064137	5,100	10N.02E.11.244B	350638106413703	437	155.32	10/24/1996	422	427	5	MW	na	Grundfos	PVC	3	7/18/1996
S269	E	West Bluff Nest 2 Well 1	12	na	350638	1064137	5,100	10N.02E.11.244C	350638106413704	328	155.25	10/24/1996	318	323	5	MW	na	Grundfos	PVC	3	8/18/1996
S270	E	West Bluff Nest 2 Well 2	12	na	350638	1064137	5,100	10N.02E.11.244D	350638106413705	254	155.57	10/24/1996	244	249	5	MW	na	Grundfos	PVC	3	8/18/1996
S271	E	West Bluff Nest 2 Well 3	12	na	350638	1064137	5,100	10N.02E.11.244E	350638106413706	173	155.51	10/24/1996	143	163	20	MW	na	Grundfos	PVC	3	8/18/1996
S275		Yale 1	12	na	350427	1063729	5,159	10N.03E.21.443	350426106372601	1,000	267.	1993	336	960	624	PW	turbine	na	steel	16	1963
SXXX		Geoprobe 1	12	na	351658	1063552	4,982	nd	nd	45.5-20.2	nd	nd	nd	nd	1	MW	na	peristaltic	steel	1	7/1/1996
SXXX		Geoprobe 2	12	na	351658	1063554	5,054	nd	nd	40.5-23.4	nd	nd	nd	nd	1	MW	na	peristaltic	steel	1	7/1/1996
		Zone 13: Discharge																			
S143		Private Production Well #05	13	na	342608	1064647	4,755	03N.02E.31.333	342608106464701	258	20.	12/7/1995	238	258	20	PW	submersible	na	PVC	6	12/7/1995
S194		Domestic Well #32	13	na	342010	1065043	4,730	01N.01E.04.342	342013106503901	130	20.	7/26/1983	120	130	10	DW	submersible	na	PVC	5	7/25/1983
S226		Domestic Well #15	13	na	342104	1065301	4,860	02N.01E.31.313	342107106530401	223	136.64	10/31/1995	210	220	10	DW	submersible	na	PVC	4	7/2/1975
		No Zone: Exotic Water																			
S009		Arroyo Salado Spring	E	E	344148	1070704	5,744	06N.03W.35.443	344148107070401	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S023		Burn Site Well	E	E	350017	1062423	6,369	09N.05E.16.233	350017106242301	341	68.	2/20/1986	231	341	110	PW	na	na	PVC	4	2/20/1986
S028		Cerro Colorado Landfill MW	E	E	350020	1065308	5,488	09N.01E.18.333	350021106531101	746	570.	11/10/1988	555	616	61	MW	submersible	na	steel	4	1981
S038		Windmill #19	E	E	352147	1065911	5,720	13N.01W.18.121	352147106591101	100	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S054		Domestic Well #04	E	E	343030	1064046	5,065	03N.02E.01.44	343030106404601	390	nd	nd	nd	nd	nd	DW	submersible	na	PVC	4	1989
S057		Embudo Spring	E	E	350547	1062744	6,600	10N.04E.13.242	350548106274901	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S063		Windmill #22	E	E	342424	1063129	5,980	02N.04E.16.222	342413106311701	180	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S067		Granite Hill	E	E	350343	1062821	5,749	10N.04E.25.324	350343106280901	89	32.23	10/26/1995	nd	nd	nd	MW	na	Grundfos	steel	6	11/1/1975
S070		HERTF	E	E	345830	1062636	6,227	09N.05E.30.322	345830106263601	500	405.	7/13/1990	449	500	51	PW	submersible	na	steel	5	7/13/1990
S091		Private Production Well #23	E	E	353701	1064358	5,525	16N.02E.16.411	353700106435701	81	5.	3/19/1982	19	81	62	PW	submersible	na	steel	10	1959
S094		Stock Well #02	E	E	351627	1065512	5,700	12N.01W.14.111	351627106550401	120	107.17	6/20/1980	nd	nd	nd	SW	submersible	na	steel	nd	nd
S099		LALF-1	E	E	351105	1063612	5,064	11N.03E.15.242	351105106361201	146	98.34	1992	101	141	40	MW	na	Bennett	steel	2	nd
S112		Domestic Well #24	E	E	343020	1063825	5,131	03N.03E.09.111	343020106382501	560	460.	5/19/1997	540	560	20	DW	submersible	na	PVC	4	5/19/1997
S129		Montaño 4 S	E	E	350821	1063837	4,975	11N.03E.32.234C	350821106383703	50	43.2	1/24/1996	40	45	5	MW	na	Bennett	steel	5	nd
S152		Private Production Well #07	E	E	352558	1063638	5,350	14N.03E.22.124A	352558106363801	440	141.	nd	200	380	180	PW	submersible	peristaltic	steel	6	nd
S182		Rio Bravo 4 S	E	E	350135	1063906	4,933	09N.03E.08.144C	350135106390603	49	24.09	1/24/1996	39	44	5	MW	na	Bennett	steel	5	nd
S202		Windmill #27	E	E	342801	1071054	5,911	03N.03W.20.314	342801107105401	nd	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S211	S	Sandia M	E	E	351357	1063230	5,440	12N.04E.29.433A	351357106323002	1,025	485.58	6/26/1998	1,015	1,020	5	MW	na	Bennett	PVC	2	nd
S225		SBM-1	E	E	350610	1063814	4,985	10N.03E.09.333A	350610106381401	150	93.44	1994	135	145	10	MW	na	Bennett	PVC	4	1988
S249		Private Production Well #09	E	E	351229	1062905	6,610	11N.04E.02.414	351229106290501	240	206.1	7/2/1996	60	240	180	PW	submersible	na	PVC	5	10/31/1989
S250		Private Production Well #10	E	E	351240	1062909	6,630	11N.04E.02.234	351240106290901	287	194.12	7/2/1996	225	280	55	PW	submersible	na	nd	5	8/27/1976
S251		Private Production Well #11	E	E	351229	1062853	6,760	11N.04E.02.424	351229106285301	320	225.	7/2/1996	60	320	260	PW	submersible	na	nd	5	10/23/1985

Table A1. Location and well-construction information for ground-water sites-- Continued

Site no.	Monitoring Well ID	Site name	Primary hydrochemical zone	Secondary hydrochemical zone	Latitude (dms)	Longitude (dms)	Land surface altitude (feet)	Local well no.	USGS site ID	Depth (feet bls)	Water level (feet bls)	Water level date	Depth to top of screen (feet bls)	Depth to bottom of screen (feet bls)	Screen length (feet)	Well type	Fixed pump type	Sample pump type	Casing material	Casing diameter (inches)	Date constructed
S256		Tunnel Spring	E	E	351728	1062624	6,410	12N.05E.05.334	351728106262001	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S258		Vallecito Springs	E	E	353822	1064104	5,840	16N.02E.01.334	353822106410401	na	na	na	na	na	na	SP	na	peristaltic	na	na	nd
S273		Windmill #11	E	E	342509	1070022	5,680	02N.02W.12.112	342509107002201	280	nd	nd	nd	nd	nd	WW	windmill	na	steel	nd	nd
S282		Windmill #44	E	E	352804	1064142	5,400	14N.02E.02.422	352813106412701	147	85.04	1/23/1984	nd	nd	nd	WW	windmill	na	steel	6	11/1/1968
SXXX		Soda Dam Spring	E	E	354733	1064112	6383	nd	nd	nd	nd	nd	na	na	na	SP	na	peristaltic	steel	0.5	8/20/1996
SXXX		Jemez Spring	E	E	354620	1064128	6215	nd	nd	nd	nd	nd	na	na	na	SP	na	peristaltic	steel	0.5	8/20/1996

Table A2. Summary of field parameters and major-element chemistry

[SXXX, no site no. assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Temp., field water temperature; ºC, degrees Celsius; O_2, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25º C; Ca^{2+}, calcium; Mg^{2+}, magnesium, Na^{+}, sodium; K^{+}, potassium; Cl^{-}, chloride; Br^{-}, bromide; SO_4^{2-}, sulfate; HCO_3^{-}, total titration alkalinity as bicarbonate; na, not applicable; nd, not determined]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
		Zone 1: Northern Mountain Front															
S027	NM486	CEPO 02	1	na	8/3/1998	19.8	3.5	7.6	250	28.6	3.67	16.4	4.3	5.0	0.07	16.5	124.1
S034	NM027	Private Production Well #04	1	na	8/28/1996	18.5	5.7	7.7	226	24.6	3.93	15.8	4.2	4.4	0.09	14.1	112.1
S035	NM487	Windmill #37	1	na	7/31/1998	17.7	7.0	7.2	211	26.5	3.85	6.49	3.8	1.7	nd	17.8	104.3
S036	NM026	Private Production Well #03	1	na	8/28/1996	15.6	6.2	7.4	323	41.3	6.62	19.8	2.8	4.1	0.08	17.6	178.4
S065	NM055	Domestic Well #05	1	na	8/17/1996	18.9	4.9	7.7	774	61.9	8.66	68.1	7.1	178.	0.46	20.9	101.6
S187	NM131	Rio Rancho 12	1	na	8/13/1996	26.7	2.5	7.9	772	42.2	2.60	107.	6.1	152.	0.36	56.1	103.6
S206	NM510	Windmill #38	1	3	8/3/1998	25.5	6.2	8.0	409	22.0	6.65	57.3	8.2	7.4	0.10	38.1	197.0
S216	NM143	Windmill #09	1	na	8/27/1996	20.1	5.4	7.8	357	42.5	7.02	16.1	6.3	11.6	0.17	52.1	128.2
S221	NM530	Windmill #45	1	na	8/20/1998	20.4	5.5	7.1	550	64.0	10.3	39.0	7.0	13.4	0.07	29.1	304.3
S222	NM514	Windmill #39	1	3	8/6/1998	17.1	1.3	6.6	784	81.8	9.69	69.6	12.9	33.5	0.10	84.7	339.0
S254	NM168	Private Production Well #12	1	na	8/28/1996	18.4	6.8	7.1	174	16.9	3.33	12.0	2.4	3.2	nd	7.27	91.4
S277	NM525	Windmill #40	1	na	7/28/1998	19.4	4.7	7.4	429	53.3	8.45	20.2	5.2	14.1	0.08	28.5	202.8
S279	NM527	Windmill #42	1	na	7/28/1998	18.5	nd	7.0	255	35.6	5.63	8.80	4.3	2.4	0.02	11.1	146.2
S281	NM528	Windmill #43	1	3	7/28/1998	20.7	2.6	7.8	286	26.4	2.15	30.9	4.5	4.9	0.08	9.34	160.4
		Zone 2: Northwestern															
S103	NM497	Lincoln D	2	na	7/23/1998	21.8	4.1	7.4	400	21.4	2.64	60.0	6.6	7.7	0.11	42.5	155.3
S104	NM498	Lincoln M	2	na	7/23/1998	21.1	6.5	8.1	318	19.0	2.98	43.0	6.7	4.4	0.07	28.7	122.9
S105	NM499	Lincoln S	2	na	7/23/1998	20.8	6.7	7.8	293	28.9	4.98	21.8	7.4	4.6	0.06	17.2	123.2
S191	NM326	Rio Rancho 4	2	3	6/20/1997	20.9	3.8	8.1	415	19.1	3.04	58.5	5.9	10.1	0.10	58.4	156.9
S192	NM128	Rio Rancho 8	2	3	8/13/1996	26.4	4.9	8.0	395	17.7	3.47	57.2	4.2	9.3	0.13	66.2	127.3
S189	NM133	Rio Rancho 15	2	na	8/13/1996	25.2	6.1	7.6	777	37.3	3.84	117.	5.7	78.2	0.22	100.	202.2
S276	NM179	Windmill #12	2	na	8/27/1996	17.2	12.	8.1	250	33.7	1.56	15.3	3.9	3.9	0.07	10.4	107.6
S278	NM526	Windmill #41	2	na	7/29/1998	19.5	6.9	7.7	456	40.2	5.25	49.9	4.7	12.8	0.07	60.6	184.0
S280	NM180	Windmill #13	2	na	8/27/1996	18.6	7.8	7.9	381	47.5	6.13	17.5	6.5	4.7	0.05	28.6	138.7
S286	NM184	Private Production Well #13	2	na	8/26/1996	20.4	7.9	7.8	331	34.0	4.71	32.3	4.6	2.7	nd	24.7	159.7
S287	NM185	Private Production Well #14	2	na	8/26/1996	20.3	7.7	7.7	400	28.1	4.32	54.3	7.0	10.4	0.08	40.4	180.6
		Zone 3: West Central															
S003	NM481	98th St. D	3	na	8/4/1998	26.3	<0.1	8.0	1695	5.6	1.09	360.	3.5	194.	0.27	243.	363.2
S003	NM251	98th St. D	3	na	6/17/1997	25.7	0.2	8.4	1,701	7.0	1.13	362.	3.6	203.	0.44	252.	362.2
S004	NM482	98th St. MD	3	na	8/4/1998	27.6	<0.1	8.4	622	1.8	0.09	140.	1.2	12.7	0.08	87.8	252.4
S004	NM252	98th St. MD	3	na	6/18/1997	26.6	0.3	9.1	631	2.3	0.12	137.	1.4	11.1	0.10	90.3	252.6
S005	NM483	98th St. MS	3	na	8/4/1998	27.2	0.1	7.8	714	5.3	0.72	162.	2.8	4.0	0.05	95.7	331.0
S005	NM253	98th St. MS	3	na	7/4/1997	26.8	0.1	8.3	734	5.7	0.62	157.	4.4	4.6	0.44	97.5	331.4
S006	NM484	98th St. S	3	na	8/5/1998	23.2	3.0	9.0	500	8.5	0.05	99.9	2.4	8.4	0.11	66.2	182.0
S006	NM254	98th St. S	3	na	6/17/1997	25.0	2.8	8.9	507	7.3	0.09	108.	3.8	8.9	0.13	83.1	199.9
S008	NM003	Private Production Well #01	3	na	8/12/1996	30.1	4.0	8.2	474	13.4	0.81	82.6	3.4	9.9	nd	96.5	134.3
S010	NM255	Private Production Well #16	3	na	6/23/1997	20.6	5.1	8.9	485	7.1	0.83	89.3	3.8	8.6	0.09	114.	120.5
S018	NM260	Domestic Well #21	3	na	6/26/1997	25.7	5.3	8.1	649	19.4	7.55	106.	6.1	15.8	0.12	145.	178.4
S019	NM007	Belen 4	3	5	8/16/1996	21.9	3.3	7.7	762	38.0	13.4	96.3	7.2	26.2	0.02	193.	176.2
S020	NM008	Belen 5	3	5	8/16/1996	21.8	3.9	7.8	693	29.7	10.8	94.9	7.1	19.4	0.14	171.	171.4

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	31.0	2.4	7.4	1,018	35.5	4.19	149.	7.5	36.9	0.11	260.	162.0
S037	NM264	College 2	3	na	6/19/1997	31.9	5.0	8.9	482	3.8	0.38	100.	1.4	6.6	0.11	62.4	184.3
S066	NM056	Gonzales 1	3	12	6/20/1996	23.2	3.0	8.3	460	14.1	2.53	72.1	5.8	11.2	0.09	78.8	156.7
S086	NM492	Isleta D	3	na	7/29/1998	22.5	0.1	8.4	548	3.6	0.32	113.	1.6	22.1	0.13	115.	122.1
S101	NM294	Leavitt 1	3	na	6/26/1997	24.2	4.9	8.6	464	7.4	1.21	100.	2.2	12.9	0.14	70.5	175.6
S108	NM076	Los Lunas 3	3	12	8/14/1996	20.8	0.3	8.2	470	10.1	3.19	86.4	6.3	11.3	0.07	71.8	183.5
S109	NM077	Los Lunas 4	3	12	8/14/1996	20.0	0.5	8.1	438	11.0	3.44	75.7	6.2	13.0	0.08	56.9	178.9
S145	NM308	NM Utilities 1	3	na	6/18/1997	23.6	5.0	8.0	351	24.7	7.15	33.8	5.3	9.6	0.10	38.7	137.6
S147	NM310	NM Utilities 3	3	na	6/18/1997	24.4	2.2	8.2	453	15.1	2.62	75.7	7.1	10.4	0.08	67.8	164.6
S148	NM311	NM Utilities 4	3	na	6/18/1997	25.7	3.8	8.1	389	21.0	5.66	51.6	4.1	6.5	0.07	53.0	148.6
S166	NM509	Rabbit Hill	3	na	8/4/1998	21.2	3.6	7.4	858	36.4	6.98	160.	8.9	13.4	0.12	90.9	445.4
S167	NM107	Domestic Well #12	3	na	8/14/1996	26.7	0.9	8.3	582	10.2	2.76	105.	4.0	7.6	0.08	144.	146.8
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	21.7	<0.1	8.8	674	10.4	0.21	114.	2.1	54.9	0.24	141.	75.9
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	20.9	0.1	8.5	694	13.1	1.44	129.	4.3	32.7	0.20	167.	123.8
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	18.8	0.1	8.5	620	13.6	1.99	115.	4.6	27.1	0.17	152.	118.8
S186	NM130	Rio Rancho 10	3	na	8/13/1996	25.7	6.3	7.7	622	25.5	1.78	102.	5.1	22.0	0.15	94.8	217.4
S188	NM132	Rio Rancho 13	3	na	8/13/1996	28.0	6.5	8.7	424	3.0	0.08	88.1	1.7	4.6	0.08	75.2	142.7
S193	NM129	Rio Rancho 9	3	na	8/13/1996	26.1	7.3	8.5	359	4.3	0.13	72.8	2.0	6.0	0.07	47.8	137.2
S196	NM135	Windmill #05	3	na	8/21/1996	24.7	3.0	7.7	503	9.3	3.18	90.3	4.3	14.1	0.09	97.4	147.7
S200	NM139	Private Production Well #08	3	na	8/29/1996	21.4	0.2	8.0	689	19.7	7.00	111.	5.6	18.6	0.15	186.	149.7
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	18.0	2.7	9.0	444	4.4	0.25	92.8	3.3	2.8	nd	41.1	227.2
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	17.4	3.9	8.5	412	6.3	0.40	85.3	3.4	1.6	nd	29.7	226.3
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	18.1	4.8	8.3	472	12.0	0.74	92.4	4.1	15.8	nd	36.3	229.5
S230	NM516	Sierra Vista D	3	na	7/22/1998	24.8	<0.1	8.7	858	6.2	0.50	172.	1.6	39.3	0.23	183.	180.8
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	29.4	4.9	8.2	700	13.5	0.88	129.	3.9	8.7	0.08	209.	119.2
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	29.3	0.9	7.8	1,239	28.9	3.94	226.	8.8	96.3	0.22	259.	243.9
S242	NM520	SWAB Test Hole 1 S	3	1	8/1/1998	28.5	2.0	8.4	589	6.8	0.41	117.	3.3	17.9	0.09	119.	154.8
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	21.8	4.0	8.1	322	15.2	2.29	52.6	4.3	6.0	0.08	33.9	136.3
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	23.7	3.9	8.1	381	20.7	4.27	49.1	7.7	8.4	0.08	50.8	147.1
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	26.0	0.1	8.7	780	7.0	0.16	147.	2.4	50.8	0.28	169.	131.0
S272	NM353	West Mesa 3	3	na	6/19/1997	25.8	4.7	8.8	460	5.2	0.55	92.9	2.3	8.8	0.09	53.4	189.8
S283	NM181	Zia Ball Park D	3	na	8/26/1996	19.4	5.3	8.3	614	8.3	1.01	125.	5.6	6.8	0.06	66.0	273.1
S284	NM182	Zia Ball Park M	3	na	8/26/1996	18.6	3.9	8.6	598	7.8	1.29	124.	5.6	7.2	0.06	61.8	270.2
S285	NM183	Zia Ball Park S	3	2	8/26/1996	17.4	4.5	8.1	1,509	65.2	9.96	238.	9.2	205.	0.46	208.	279.4
S288	NM186	Zia BMT D	3	na	8/27/1996	20.1	0.3	8.5	789	10.0	0.73	162.	4.0	9.1	0.14	133.	311.3
		Zone 4: Western Boundary															
S031	NM263	Windmill #18	4	na	6/24/1997	29.5	3.2	7.7	3,091	72.8	31.5	526.	15.4	533.	0.57	554.	259.2
S039	NM266	Windmill #20	4	na	6/21/1997	19.8	3.4	7.6	4,738	60.0	21.3	1,076.	41.5	650.	0.38	919.	923.7
S059	NM278	Windmill #21	4	na	6/23/1997	23.5	7.4	7.4	3,735	303.	99.0	364.	13.4	798.	0.69	793.	143.9
S074	NM285	Windmill #23	4	na	6/21/1997	16.5	2.3	7.3	4,405	126.	45.3	809.	30.7	881.	0.38	583.	632.2
S169	NM320	Rest Area	4	na	6/30/1997	20.3	12.	7.6	2,766	135.	50.0	375.	9.9	408.	0.44	571.	179.4
S201	NM329	Windmill #26	4	na	7/2/1997	23.1	4.8	7.8	1,783	227.	56.4	165.	5.3	38.9	0.22	936.	147.6
S252	NM167	Windmill #10	4	na	8/29/1996	22.2	5.8	7.8	1,598	32.9	13.4	270.	10.0	94.9	0.43	414.	240.1
S260	NM345	Windmill #33	4	na	6/25/1997	27.6	2.9	7.8	3,510	68.5	28.6	651.	16.4	519.	0.31	672.	433.2

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
		Zone 5: Rio Puerco															
S032	NM262	Windmill #17	5	na	6/24/1997	25.0	4.3	7.6	3,804	153.	64.2	610.	15.0	582.	0.60	903.	309.4
S069	NM058	Domestic Well #06	5	na	8/16/1996	25.8	4.2	7.4	1,379	142.	42.3	124.	8.7	108.	0.31	490.	141.8
S073	NM062	Windmill #03	5	na	8/16/1996	22.2	5.0	7.3	3,234	307.	101.	328.	13.2	442.	0.70	1,060.	203.0
S082	NM409	Windmill #36	5	na	9/10/1997	20.0	2.0	7.8	2,250	316.	70.3	131.	10.4	38.9	0.17	1,180.	118.3
S085	NM408	Windmill #35	5	na	9/10/1997	22.0	6.5	6.5	1,275	80.8	36.1	133.	7.2	20.3	0.13	543.	64.7
S111	NM079	Domestic Well #10	5	na	8/16/1996	26.0	<0.1	7.5	1,893	193.	65.4	154.	12.6	172.	0.35	702.	102.3
S185	NM324	Domestic Well #31	5	na	6/16/1997	18.0	0.2	7.3	2,378	298.	88.6	290.	8.3	118.	0.28	1,107.	485.7
S198	NM137	Windmill #07	5	na	8/21/1996	19.5	0.4	7.1	5,420	372.	149.	831.	15.2	591.	1.19	2,130.	350.6
S215	NM335	Sandoval Spring	5	4	7/1/1997	21.3	1.2	7.5	1,120	60.3	16.9	165.	3.3	11.5	0.09	291.	354.6
S237	NM341	Windmill #30	5	4	6/24/1997	19.0	4.7	7.7	2,502	150.	53.5	279.	14.4	486.	0.73	490.	102.2
S238	NM342	Windmill #31	5	na	6/24/1997	21.5	4.1	7.2	3,457	339.	105.	341.	18.0	346.	0.68	1,303.	256.9
		Zone 6: Southwestern Mountain Front															
S022	NM009	Windmill #02	6	na	8/19/1996	30.7	4.4	8.3	447	37.1	12.0	36.6	2.5	23.0	0.21	70.9	135.1
		Zone 7: Abo Arroyo															
S021	NM261	Stock Well #01	7	na	6/23/1997	18.5	5.6	7.4	1,583	181.	71.7	84.4	2.4	42.1	0.29	687.	198.1
S024	NM011	Domestic Well #02	7	8	8/17/1996	22.1	7.0	7.2	819	91.0	32.2	43.6	2.5	23.8	0.18	264.	171.0
S090	NM064	Domestic Well #08	7	na	8/19/1996	23.6	6.8	7.5	922	90.1	33.7	49.2	3.4	22.2	0.16	311.	146.5
S093	NM067	Domestic Well #09	7	8	8/15/1996	22.8	3.9	8.0	400	31.9	6.04	39.8	6.2	8.9	0.12	78.0	115.2
		Zone 8: Eastern Mountain Front															
S007	NM002	Domestic Well #01	8	na	6/21/1996	12.0	9.2	7.5	401	71.0	14.8	13.9	2.7	6.5	0.07	42.3	269.6
S013	NM256	Windmill #14	8	na	6/24/1997	17.8	0.2	9.8	128	7.40	5.53	8.4	1.1	4.5	0.09	10.7	50.5
S014	NM257	Private Production Well #17	8	na	6/19/1997	19.1	8.2	7.5	455	74.3	4.31	10.4	1.3	7.5	0.09	58.4	202.4
S015	NM006	Windmill #01	8	na	8/24/1996	18.1	7.7	7.7	273	35.7	5.60	14.6	0.6	6.0	0.08	26.8	129.9
S030	NM022	Charles 4	8	na	6/27/1996	20.7	4.0	7.6	379	42.5	3.37	28.1	2.5	30.2	0.12	25.6	147.2
S030	NM021	Charles 4	8	na	6/27/1996	20.5	4.0	7.6	376	42.7	3.36	27.8	2.5	30.0	0.12	26.7	147.4
S030	NM024	Charles 4	8	na	6/27/1996	21.1	4.1	7.7	381	43.6	3.30	28.7	2.4	31.0	0.12	26.7	147.8
S030	NM020	Charles 4	8	na	6/27/1996	20.3	4.5	7.6	364	41.0	3.36	27.8	2.4	26.4	0.11	26.7	147.5
S030	NM019	Charles 4	8	na	6/27/1996	20.0	5.2	7.6	342	40.8	3.17	25.3	2.3	16.4	0.10	26.7	149.5
S030	NM018	Charles 4	8	na	6/27/1996	19.8	5.5	7.6	334	40.9	3.20	24.6	2.4	14.9	0.09	26.7	148.9
S030	NM017	Charles 4	8	na	6/27/1996	19.7	5.6	7.6	335	39.9	3.26	23.6	2.4	15.1	0.10	26.7	149.0
S030	NM023	Charles 4	8	na	6/27/1996	21.1	4.0	7.6	382	42.9	3.29	29.0	2.5	31.7	0.12	27.0	147.3
S030	NM016	Charles 4	8	na	6/22/1996	20.5	4.0	7.7	381	44.1	3.54	30.4	2.6	33.4	0.12	27.4	149.6
S042	NM031	Domestic Well #03	8	na	8/14/1996	22.8	4.2	7.9	254	27.0	5.31	17.5	2.4	6.7	0.09	20.1	120.9
S055	NM042	Elena Gallegos	8	na	6/25/1996	17.0	6.2	7.4	543	84.8	13.2	17.6	2.3	7.0	0.09	43.9	303.8
S056	NM227	Embudito Spring	8	na	4/29/1997	9.70	7.2	8.2	494	65.8	16.5	14.8	3.6	5.9	0.06	43.7	250.8
S056	NM239	Embudito Spring	8	na	5/27/1997	11.9	6.9	8.1	504	70.8	17.0	17.2	3.7	5.9	0.07	44.8	265.5
S056	NM213	Embudito Spring	8	na	3/21/1997	6.20	7.8	8.1	539	69.4	17.9	18.2	3.3	6.8	0.00	57.4	270.6
S056	NM214	Embudito Spring	8	na	3/21/1997	7.50	9.9	8.4	535	70.0	17.9	17.9	3.4	6.8	0.00	57.4	271.3
S056	NM043	Embudito Spring	8	na	7/2/1996	17.7	3.4	7.3	884	127.	30.8	22.1	6.0	10.3	0.23	98.6	468.4
S056	NM364	Embudito Spring	8	na	7/17/1997	19.0	3.0	7.5	785	108.	29.0	45.4	3.9	112.	0.39	125.	166.5
S056	NM240	Embudito Spring	8	na	5/27/1997	15.3	7.7	8.5	507	nd	nd	nd	nd	nd	nd	nd	nd
S071	NM060	Domestic Well #07	8	na	6/19/1996	17.8	8.7	7.4	402	66.5	7.21	12.5	1.8	6.0	0.10	20.2	224.3
S083	NM407	Windmill #34	8	na	9/10/1997	21.5	4.7	7.7	517	55.8	9.34	34.4	3.1	27.0	0.20	55.0	205.8

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S095	NM068	Kirtland 1	8	na	6/25/1996	21.4	7.2	7.6	392	49.0	7.35	22.4	3.0	9.1	0.12	52.8	171.5
S106	NM295	Domestic Well #23	8	na	6/26/1997	19.0	0.6	8.0	413	26.0	5.89	55.6	6.2	23.9	0.11	49.4	153.7
S110	NM078	Love 1	8	na	6/22/1996	24.2	5.7	7.5	288	29.9	2.21	29.3	2.4	7.7	0.10	24.3	133.2
S113	NM080	Domestic Well #11	8	na	8/15/1996	25.8	3.6	8.1	284	16.2	5.74	36.4	1.7	4.8	0.06	34.7	124.6
S114	NM500	Matheson D	8	na	7/31/1998	21.9	1.3	7.2	264	26.2	1.01	29.3	2.4	4.8	0.08	19.5	131.0
S115	NM501	Matheson M	8	na	8/1/1998	21.1	2.9	7.4	322	20.9	1.40	49.3	2.5	5.5	0.05	19.6	168.9
S116	NM502	Matheson S	8	na	8/1/1998	20.7	5.5	7.3	311	40.1	3.56	20.8	2.1	4.7	0.10	17.6	163.6
S117	NM298	Domestic Well #25	8	na	6/17/1997	17.4	8.0	7.6	390	59.4	8.68	14.9	1.6	6.3	0.07	27.9	210.3
S118	NM299	Windmill #24	8	na	6/27/1997	20.8	7.0	8.1	479	40.8	16.6	34.7	1.3	31.2	0.33	55.0	152.7
S119	NM300	Domestic Well #26	8	11	6/19/1997	16.1	5.8	7.3	714	84.4	16.7	54.2	2.6	20.1	0.19	92.6	332.0
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	23.1	2.0	7.4	357	30.8	7.47	30.8	5.0	18.5	0.08	26.1	153.0
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	28.3	0.4	8.9	484	5.6	0.16	93.6	1.4	21.3	0.10	66.0	160.9
S140	NM306	MRN 1	8	na	7/5/1997	21.3	5.6	7.4	515	58.8	15.3	22.9	4.6	15.1	0.17	70.2	196.0
S141	NM095	National Utility 7	8	na	8/14/1996	18.0	7.8	7.7	264	36.3	2.53	16.7	1.4	3.3	0.06	12.1	140.4
S149	NM312	Nor Este D	8	na	7/3/1997	22.8	0.2	8.1	816	27.9	4.97	118.	5.4	153.	0.38	66.4	110.2
S150	NM313	Nor Este M	8	na	7/2/1997	22.5	0.3	7.8	843	41.5	8.02	102.	8.0	178.	0.35	44.1	98.0
S162	NM317	Stock Well #03	8	na	6/30/1997	23.1	7.2	8.1	214	22.6	2.99	17.3	1.0	5.9	0.09	13.2	100.0
S163	NM318	PL 2	8	na	7/7/1997	20.5	5.2	7.6	416	48.4	7.91	23.4	3.4	10.7	0.14	55.6	168.9
S164	NM106	Ponderosa 1	8	na	6/20/1996	27.0	1.6	7.6	562	60.5	2.70	47.4	5.0	79.3	0.24	33.8	150.5
S165	NM328	Windmill #25	8	na	6/24/1997	20.3	1.8	8.6	368	9.06	1.85	65.5	1.2	11.5	0.17	52.6	137.3
S168	NM319	Domestic Well #30	8	na	6/27/1997	21.9	5.2	8.5	224	12.6	2.70	29.9	0.9	8.3	0.13	29.5	86.3
S170	NM108	Ridgecrest 3	8	na	6/22/1996	22.7	4.6	7.8	329	38.6	4.41	22.1	3.4	24.9	0.11	22.1	132.4
S170	NM412	Ridgecrest 3	8	na	11/18/1997	21.7	4.1	7.9	341	38.1	4.40	22.6	3.1	25.9	0.13	23.7	131.9
S195	NM134	Domestic Well #13	8	na	8/14/1996	23.1	3.2	7.8	317	31.4	7.40	20.4	2.2	17.2	0.17	30.8	123.7
S199	NM138	Windmill #08	8	na	8/23/1996	18.0	nd	7.6	532	74.2	12.6	21.2	1.4	22.4	0.25	80.7	195.8
S209	NM336	Domestic Well #33	8	na	6/27/1997	23.6	0.2	7.9	383	27.4	5.37	40.0	3.6	26.4	0.12	51.0	124.8
S212	NM141	Sandia Peak 1	8	na	6/26/1996	21.2	7.6	7.5	314	49.3	5.32	16.0	1.4	4.8	0.07	14.3	188.5
S213	NM142	Sandia Peak 3	8	na	6/26/1996	20.3	7.8	7.4	379	58.2	6.74	18.7	1.7	7.4	0.12	30.4	202.0
S224	NM148	Domestic Well #14	8	na	8/23/1996	20.6	4.3	7.5	385	61.1	6.50	14.7	1.8	3.5	nd	31.3	213.2
S229	NM515	SH03 UNM	8	na	7/28/1998	16.6	8.8	7.1	437	67.0	8.04	13.1	1.6	5.1	0.09	31.2	231.1
S233	NM153	Domestic Well #16	8	na	8/23/1996	25.6	1.9	7.3	543	65.2	4.79	44.1	4.5	22.8	0.10	42.6	253.8
S239	NM156	Domestic Well #17	8	na	8/17/1996	17.4	6.8	7.1	490	60.7	13.4	31.6	2.0	7.5	0.08	35.9	267.0
S240	NM157	Domestic Well #18	8	na	6/19/1996	21.4	8.0	7.6	288	42.2	2.63	17.6	1.5	5.2	0.07	14.3	163.0
S246	NM343	Windmill #32	8	na	6/24/1997	25.0	5.8	7.9	388	42.4	4.06	29.5	2.2	9.8	0.16	70.8	122.6
S247	NM161	Domestic Well #19	8	na	8/15/1996	25.9	5.8	8.5	371	4.5	0.21	78.8	1.4	7.6	0.09	35.7	176.8
S248	NM162	Thomas 6	8	na	6/21/1996	22.9	1.4	7.6	521	58.2	4.68	37.0	3.3	67.0	0.20	31.1	154.9
S255	NM523	Tramway East	8	na	7/30/1998	22.6	5.6	7.6	295	48.2	4.61	24.7	1.8	6.0	0.07	16.8	156.9
S264	NM174	Walker 1	8	na	6/18/1996	26.8	2.5	7.7	448	50.4	2.50	34.7	3.1	64.7	0.20	24.6	123.4
S274	NM177	Domestic Well #20	8	na	8/15/1996	21.2	4.9	7.5	445	46.1	11.6	27.7	4.5	23.6	0.21	43.6	182.2
		Zone 9: Tijeras Fault Zone															
S041	NM029	Coyote Spring	9	na	6/28/1996	17.5	2.8	6.5	3,500	322.	70.3	382.	43.7	581.	2.45	140.	1,305.
S041	NM030	Coyote Spring	9	na	7/1/1996	17.3	1.7	6.1	3,243	nd	nd	nd	nd	nd	nd	nd	nd
S072	NM061	Hubbell Spring	9	8	8/23/1996	18.2	4.8	7.5	849	77.3	31.2	58.3	1.9	35.1	0.36	211.	229.7
S098	NM071	KAFB-1902	9	na	6/28/1996	19.4	4.5	7.3	1,360	156.	27.7	100.	9.1	82.7	0.71	292.	277.9
S197	NM136	Windmill #06	9	na	8/23/1996	20.3	0.3	8.2	1,405	22.1	14.0	260.	3.2	90.9	1.19	326.	270.4
S227	NM151	SFR 3D	9	na	8/24/1996	19.8	5.7	6.6	1,407	171.	39.6	90.1	6.7	140.	0.66	92.6	599.3

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S228	NM152	SFR 3S	9	na	8/24/1996	20.7	5.5	6.9	1,189	127.	30.6	84.7	5.4	139.	0.65	90.2	426.4
		Zone 10: Tijeras Arroyo															
S001	NM001	4Hills-1	10	8	6/29/1996	16.4	5.0	7.3	1,214	146.	49.1	45.1	4.9	108.	0.73	287.	240.2
S002	NM250	Private Production Well #15	10	8	7/3/1997	15.8	15.	7.5	717	98.9	31.3	26.5	2.7	77.6	0.35	130.	240.4
S058	NM277	Eubank 1	10	8	7/4/1997	19.7	6.4	7.7	474	56.4	10.0	23.8	1.8	12.2	0.16	85.1	155.7
S096	NM069	Kirtland 11	10	8	6/25/1996	23.4	7.0	7.4	517	67.8	12.2	29.3	3.2	17.1	0.21	83.1	205.1
S107	NM075	Lomas 1	10	8	6/22/1996	22.2	7.4	7.3	507	63.1	13.1	28.4	3.8	35.6	0.35	94.3	183.8
S107	NM410	Lomas 1	10	na	11/18/1997	21.8	7.2	7.5	596	75.2	12.5	26.5	4.0	33.6	0.43	95.0	181.5
		Zone 11: Northeastern															
S016	NM258	Windmill #15	11	na	6/18/1997	18.7	11.	8.4	1,252	24.9	4.67	236.	3.8	66.1	0.67	284.	289.8
S017	NM259	Windmill #16	11	na	6/18/1997	19.4	6.6	8.2	528	28.4	2.81	76.3	1.8	15.9	0.25	97.9	159.7
S053	NM276	Private Production Well #18	11	na	6/25/1997	16.8	2.8	7.2	1,282	146.	31.8	91.4	5.8	16.4	0.12	540.	162.9
S144	NM097	Private Production Well #06	11	na	8/28/1996	20.9	0.2	7.4	1,284	135.	35.2	94.0	9.4	22.0	0.22	476.	240.1
S204	NM332	Windmill #28	11	na	7/3/1997	19.5	14.	7.6	538	71.1	14.5	27.3	3.0	10.3	0.09	104.	201.8
S207	NM334	Private Production Well #22	11	na	7/3/1997	19.3	6.7	7.3	1,579	279.	57.1	87.3	4.4	21.5	0.15	877.	173.7
S223	NM338	Windmill #29	11	na	6/25/1997	18.6	6.3	7.6	1,079	104.	30.0	73.7	5.1	23.4	0.27	399.	147.4
		Zone 12: Central															
S011	NM004	Atris-1	12	na	6/22/1996	19.3	0.1	7.6	390	42.8	6.98	26.3	4.7	12.2	0.06	63.6	149.7
S012	NM005	Atrisco 3	12	3	6/20/1996	18.6	0.2	8.0	450	29.6	5.43	56.7	7.3	14.5	0.07	80.7	155.3
S025	NM012	Burton 2	12	na	6/19/1996	21.2	2.9	7.8	378	40.0	7.52	24.0	5.5	32.7	0.13	38.7	130.6
S026	NM013	Burton 5	12	na	6/19/1996	21.9	0.4	7.8	361	37.7	7.30	23.6	4.8	32.2	0.10	28.7	129.0
S033	NM025	Private Production Well #02	12	na	8/21/1996	17.4	0.8	7.4	859	125.	14.4	44.9	5.3	33.6	0.19	149.	289.8
S040	NM028	Coronado 1	12	na	6/18/1996	22.8	0.7	7.9	558	36.0	7.79	62.1	7.9	72.7	0.22	44.3	146.1
S043	NM488	Del Sol D	12	na	7/21/1998	21.1	0.5	7.7	489	22.0	5.34	75.6	7.3	48.6	0.11	41.7	155.2
S043	NM267	Del Sol D	12	na	7/1/1997	22.3	0.5	7.9	500	20.5	4.93	70.2	7.1	51.2	0.16	45.4	154.3
S044	NM489	Del Sol M	12	na	7/21/1998	21.2	0.5	7.4	516	48.9	7.55	46.6	5.6	55.5	0.13	42.6	160.4
S044	NM268	Del Sol M	12	na	6/26/1997	20.3	0.6	7.7	515	50.0	7.41	41.3	5.7	55.4	0.16	46.3	160.5
S045	NM269	Del Sol S	12	na	6/26/1997	18.4	2.9	7.6	715	80.0	15.0	26.4	5.7	103.	1.07	98.8	95.5
S045	NM490	Del Sol S	12	na	7/21/1998	18.6	3.3	7.4	753	90.2	16.4	25.3	5.6	108.	1.25	109.	94.9
S046	NM032	Duranes 1	12	na	6/20/1996	20.2	<0.1	7.6	593	45.0	9.55	59.1	10.6	19.7	0.09	117.	187.3
S046	NM035	Duranes 1	12	na	6/29/1996	18.2	0.1	7.2	727	64.2	15.1	65.3	11.8	24.9	0.11	156.	222.9
S046	NM036	Duranes 1	12	na	6/29/1996	18.4	0.1	7.3	708	66.6	15.3	64.8	12.2	24.6	0.11	156.	224.0
S046	NM033	Duranes 1	12	na	6/29/1996	18.1	0.1	7.4	728	63.6	14.7	64.3	12.0	24.9	0.11	156.	223.2
S046	NM037	Duranes 1	12	na	6/29/1996	18.4	0.1	7.3	704	64.7	15.3	63.6	13.4	24.9	0.11	157.	225.0
S046	NM039	Duranes 1	12	na	6/29/1996	18.9	<0.1	7.2	717	65.3	14.2	57.9	12.9	24.6	0.11	159.	225.0
S046	NM038	Duranes 1	12	na	6/29/1996	18.4	0.1	7.3	711	65.9	14.6	61.8	12.6	24.9	0.11	159.	225.7
S046	NM040	Duranes 1	12	na	6/29/1996	18.9	0.1	7.3	731	63.2	13.6	60.9	13.0	24.9	0.11	159.	224.1
S046	NM034	Duranes 1	12	na	6/29/1996	18.3	0.2	7.4	735	64.0	14.7	62.3	11.6	24.6	0.11	159.	224.6
S047	NM270	Duranes 7	12	na	6/26/1997	17.7	0.2	7.9	415	32.5	6.28	42.1	7.8	10.2	0.07	66.5	155.7
S048	NM271	Duranes Yard 1	12	na	7/5/1997	15.8	0.1	7.8	385	40.2	7.73	23.3	6.8	10.4	0.05	62.2	142.3
S049	NM272	Duranes Yard 2	12	na	7/5/1997	17.2	0.1	7.8	388	41.6	6.68	24.8	5.6	11.1	0.06	60.8	148.2
S050	NM273	Duranes Yard 3	12	na	7/5/1997	16.4	0.1	7.8	408	45.9	7.70	22.4	5.2	9.6	0.06	70.7	155.2
S051	NM274	Duranes Yard 4	12	na	7/5/1997	14.9	<0.1	7.7	424	50.0	7.99	23.5	3.7	14.0	0.07	67.9	163.3
S052	NM275	Duranes Yard 5	12	na	7/5/1997	15.9	<0.1	7.7	414	47.6	7.76	22.2	3.5	16.5	0.07	62.7	152.6
S060	NM279	Garfield D	12	3	6/19/1997	26.7	0.2	8.1	425	14.6	2.29	67.5	6.4	8.6	0.06	60.8	169.5

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S061	NM280	Garfield M	12	na	6/19/1997	22.9	0.2	8.0	368	21.0	5.01	45.4	8.2	8.0	0.03	43.1	162.8
S062	NM491	Garfield S	12	na	7/28/1998	17.8	0.1	6.8	881	123.	21.3	43.2	6.7	17.5	0.08	208.	306.0
S062	NM281	Garfield S	12	na	6/19/1997	18.8	0.3	7.2	947	128.	25.1	41.4	7.9	19.7	0.06	224.	326.9
S064	NM283	Domestic Well #22	12	na	6/20/1997	17.8	0.1	7.7	498	54.1	9.12	23.1	7.2	15.7	0.09	81.6	168.7
S068	NM057	Griegos 3	12	na	6/21/1996	19.4	0.2	6.8	399	34.9	6.29	37.9	7.7	12.2	0.06	69.7	142.9
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	23.1	0.2	8.0	423	19.3	2.98	69.7	6.4	11.3	0.06	65.1	177.7
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	20.6	0.2	7.7	354	42.7	7.32	18.3	8.0	7.3	0.05	40.6	163.2
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	19.8	3.1	7.7	652	67.3	15.6	40.5	6.7	20.5	0.17	156.	168.8
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	19.5	0.2	7.8	446	48.9	8.31	28.1	6.5	9.0	0.06	84.6	156.5
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	18.6	0.1	7.7	483	57.1	11.4	26.3	5.7	12.5	0.11	93.5	165.4
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	18.7	1.1	7.6	589	72.2	15.3	29.2	6.1	19.8	0.19	137.	165.5
S081	NM292	Private Production Well #19	12	na	7/2/1997	20.3	0.3	7.8	378	39.7	5.94	29.7	7.3	11.9	0.08	44.4	160.4
S084	NM063	Windmill #04	12	na	8/21/1996	18.0	3.2	7.5	451	32.2	6.83	52.0	7.5	18.0	0.10	57.4	184.4
S087	NM493	Isleta MD	12	3	7/29/1998	20.2	<0.1	7.8	425	10.8	1.55	85.3	5.1	11.8	0.06	46.2	189.8
S088	NM494	Isleta MS	12	na	7/29/1998	18.4	<0.1	7.6	291	30.2	4.68	22.0	5.1	8.8	nd	30.0	127.8
S089	NM495	Isleta S	12	na	7/29/1998	17.4	<0.1	7.2	875	119.	16.1	59.2	7.5	33.7	0.14	140.	357.3
S092	NM066	JMC-1	12	na	6/28/1996	19.8	<0.1	7.6	653	76.1	15.3	35.5	7.9	24.1	0.11	123.	227.5
S097	NM070	Kirtland 14	12	na	6/25/1996	21.7	0.7	7.8	336	37.9	6.81	20.5	4.0	25.8	0.08	26.8	127.6
S100	NM073	LALF-9	12	na	6/29/1996	16.1	0.1	7.7	715	115.	13.4	26.7	6.6	20.5	0.09	120.	297.0
S102	NM074	Leyendecker 1	12	na	6/21/1996	19.1	0.9	7.9	311	43.4	3.63	18.3	2.6	10.9	0.07	32.0	132.9
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	25.9	3.3	7.8	400	27.4	6.02	49.9	4.9	20.2	0.09	42.6	162.7
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	27.9	<0.1	8.4	458	3.5	0.09	95.3	1.1	21.3	0.11	65.6	143.0
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	25.7	0.8	7.8	490	13.9	2.11	103.	4.3	26.3	0.09	73.0	204.9
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	23.6	<0.1	8.1	428	4.5	0.22	86.2	1.0	34.6	0.11	32.5	149.8
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	28.4	0.1	8.6	440	5.5	0.26	88.7	1.2	35.0	0.12	37.0	158.6
S123	NM081	MONT - 5A	12	na	6/27/1996	17.6	<0.1	7.8	500	69.4	14.4	20.0	5.5	33.9	0.17	140.	119.9
S124	NM082	Montaňo 2 D	12	na	6/19/1996	16.7	0.1	7.6	477	56.6	14.9	18.2	9.1	19.0	0.08	74.0	194.7
S125	NM083	Montaňo 2 M	12	na	6/19/1996	15.4	<0.1	7.5	629	75.2	19.8	21.2	12.0	21.6	0.09	101.	257.5
S126	NM084	Montaňo 2 S	12	na	6/19/1996	15.7	<0.1	7.5	673	92.3	12.9	37.9	7.9	16.9	0.08	97.7	300.6
S127	NM085	Montaňo 4 D	12	na	6/20/1996	17.3	0.1	7.7	429	50.8	11.4	18.3	8.2	19.2	0.10	63.3	166.9
S128	NM086	Montaňo 4 M	12	na	6/19/1996	17.4	0.1	7.2	914	123.	26.6	45.6	9.8	14.8	0.10	173.	345.5
S130	NM088	Montaňo 5 D	12	na	6/24/1996	18.1	0.1	7.6	417	41.7	9.76	26.7	7.8	10.4	0.06	67.5	166.2
S131	NM089	Montaňo 5 M	12	na	6/24/1996	14.3	0.1	7.7	378	44.8	7.41	20.5	3.5	8.3	0.05	57.1	156.5
S132	NM090	Montaňo 5 S	12	na	6/24/1996	22.4	0.1	7.4	370	41.2	7.59	21.8	4.2	6.4	0.04	67.3	138.7
S133	NM091	Montaňo 6 D	12	na	6/18/1996	18.4	0.1	7.9	374	33.5	6.37	35.8	8.7	10.0	0.04	57.1	149.5
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	20.5	0.1	8.8	311	32.0	5.68	24.4	9.2	8.8	0.04	44.9	124.5
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	18.2	0.1	8.8	311	37.2	7.62	17.0	7.9	12.9	0.05	49.8	117.0
S136	NM094	Montaňo 6 S	12	na	6/18/1996	16.8	0.1	8.3	393	44.2	12.3	17.5	8.1	15.1	0.07	73.9	144.4
S137	NM506	Montesa M	12	na	7/27/1998	23.8	<0.1	7.5	359	30.8	7.23	26.7	8.0	26.2	0.08	31.2	129.5
S138	NM507	Montesa S	12	na	7/27/1998	20.9	1.6	7.5	315	31.6	4.31	26.0	4.2	11.9	nd	30.7	136.4
S139	NM305	Domestic Well #27	12	na	6/17/1997	23.8	1.2	7.7	377	37.4	7.66	26.1	9.2	8.9	0.05	45.2	164.8
S142	NM307	Domestic Well #28	12	na	6/17/1997	18.6	1.0	7.8	500	61.7	9.34	20.0	9.3	24.5	0.14	105.	130.4
S146	NM309	NM Utilities 2	12	na	6/18/1997	21.7	1.0	7.9	391	31.2	5.54	38.5	7.8	13.5	0.10	42.2	164.0
S151	NM508	Nor Este S	12	na	7/20/1998	21.0	0.4	7.7	373	26.1	4.23	48.7	4.5	9.5	0.06	37.6	165.8
S151	NM314	Nor Este S	12	na	7/2/1997	20.8	0.7	7.9	385	19.3	3.00	61.0	3.8	12.7	0.06	45.0	169.9
S153	NM411	Open Space	12	na	11/18/1997	18.0	2.4	8.0	282	35.3	3.85	16.9	2.2	7.0	nd	28.9	130.8

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S153	NM315	Open Space	12	10	6/17/1997	20.4	nd	8.0	289	35.8	3.84	17.9	2.2	6.8	0.00	31.6	127.3
S154	NM099	ORLF-2	12	na	6/27/1996	18.1	<0.1	8.0	331	41.2	7.44	22.8	6.6	8.7	0.05	53.7	154.3
S155	NM316	Domestic Well #29	12	na	6/27/1997	19.2	0.1	7.8	357	40.2	9.51	16.6	2.7	16.1	0.55	48.3	133.8
S156	NM100	Paseo 2D	12	na	6/26/1996	16.0	<0.1	8.2	354	42.9	7.20	14.8	4.1	16.1	0.06	59.1	119.5
S157	NM101	Paseo 2MD	12	na	6/26/1996	16.5	<0.1	7.9	461	60.9	8.55	18.7	3.2	13.4	0.06	85.9	166.2
S158	NM102	Paseo 2MS	12	na	6/26/1996	18.0	<0.1	8.0	487	59.1	7.87	30.6	4.1	13.1	0.06	81.9	196.1
S159	NM103	Paseo 2S	12	na	6/26/1996	17.8	<0.1	7.7	673	89.8	12.1	33.3	6.7	17.4	0.07	103.	283.6
S160	NM104	Paseo 3D	12	na	6/21/1996	18.1	0.2	6.8	268	32.1	6.82	14.4	3.8	7.3	0.03	26.8	123.8
S161	NM105	Paseo 3M	12	na	6/21/1996	17.7	0.1	6.8	812	121.	16.0	39.4	7.2	25.4	0.10	125.	360.4
S171	NM321	Ridgecrest 4	12	na	6/26/1997	21.4	1.5	7.8	393	44.9	5.64	24.8	3.5	39.5	0.12	31.6	132.8
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	15.5	<0.1	8.2	439	18.2	4.18	69.5	6.9	11.9	0.06	69.1	163.5
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	20.2	0.1	7.3	596	85.8	10.9	27.9	5.8	20.6	0.08	99.4	238.7
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	19.0	0.1	8.1	429	26.9	6.52	49.1	10.7	13.1	0.06	70.4	162.8
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	19.9	0.1	7.8	619	56.5	13.6	48.0	12.0	42.2	0.14	107.	186.5
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	20.7	0.1	7.7	610	59.7	12.4	47.8	9.9	22.1	0.09	101.	229.7
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	21.7	<0.1	8.0	339	39.7	7.90	14.5	6.8	22.9	0.07	29.4	135.3
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	20.4	<0.1	7.4	819	96.3	19.8	22.5	10.5	97.1	0.28	137.	122.7
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	26.1	0.6	7.7	467	32.1	7.96	50.1	8.0	28.3	0.11	63.1	160.9
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	22.8	0.1	7.7	316	30.8	8.64	17.7	5.6	8.0	nd	31.8	143.6
S190	NM325	Rio Rancho 2	12	na	6/20/1997	17.8	1.6	7.7	472	58.6	9.19	20.2	6.5	36.0	0.31	59.2	138.5
S203	NM331	Private Production Well #20	12	na	7/3/1997	16.0	1.1	7.6	527	81.8	12.8	27.2	4.7	13.2	0.09	121.	226.6
S205	NM333	Private Production Well #21	12	na	7/3/1997	17.1	0.1	7.4	298	38.1	7.12	12.1	3.9	4.4	0.03	37.4	139.7
S208	NM140	San Jose 2	12	3	6/20/1996	27.0	0.6	7.9	418	30.7	6.57	41.4	9.5	26.4	0.09	58.4	133.6
S210	NM511	Sandia D	12	na	7/30/1998	21.1	1.1	7.4	622	24.1	6.78	92.9	7.4	62.0	0.16	58.3	181.3
S214	NM513	Sandia S	12	na	7/30/1998	18.6	0.1	8.5	735	79.5	12.6	51.9	8.6	97.5	0.24	78.8	187.8
S220	NM147	Santa Barbara 1	12	na	6/19/1996	20.4	0.3	7.9	313	34.4	4.74	22.4	4.2	10.7	0.06	36.8	128.6
S220	NM337	Santa Barbara 1	12	na	6/26/1997	19.8	0.3	7.9	324	34.4	4.67	20.9	4.2	11.5	0.09	41.2	128.5
S231	NM517	Sierra Vista M	12	3	7/22/1998	22.4	0.1	8.4	416	8.0	1.13	83.8	5.9	8.1	0.05	49.4	178.8
S232	NM518	Sierra Vista S	12	na	7/22/1998	19.2	4.6	7.6	462	30.4	5.62	62.2	6.5	17.7	0.15	61.2	199.1
S234	NM339	Sister Cities D	12	na	6/30/1997	20.5	0.7	7.7	544	29.5	8.24	62.3	9.2	47.7	0.14	52.8	176.7
S235	NM340	Sister Cities M	12	na	6/27/1997	18.6	0.1	7.8	289	32.5	5.01	17.0	2.8	7.0	0.03	22.0	136.6
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	16.5	<0.1	9.0	250	16.0	1.74	32.7	3.2	11.7	0.07	13.3	124.8
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	16.5	<0.1	8.7	208	17.0	3.51	19.3	6.2	9.1	0.05	6.3	109.5
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	16.6	<0.1	8.9	195	15.8	3.13	20.9	5.9	8.8	0.04	8.2	110.3
S253	NM522	Tome D	12	na	8/6/1998	27.6	<0.1	7.5	478	20.2	5.26	69.4	5.8	41.3	0.11	43.7	155.9
S257	NM344	Domestic Well #34	12	na	6/17/1997	16.0	0.1	7.4	688	77.5	12.6	48.6	9.1	31.5	0.16	92.7	258.7
S259	NM171	VGP-1	12	na	6/27/1996	18.1	<0.1	7.5	951	125.	17.8	50.2	9.1	21.0	0.11	167.	355.4
S261	NM172	Vol Andia 2	12	na	6/21/1996	19.6	0.6	7.9	300	42.0	4.15	15.9	2.4	10.4	0.07	34.0	121.3
S262	NM173	Vol Andia 5	12	na	6/18/1996	18.0	0.3	7.9	371	48.6	5.83	17.7	3.0	16.1	0.08	67.0	123.6
S265	NM175	Webster 1	12	na	6/18/1996	22.1	1.1	7.8	441	32.8	5.72	48.2	5.9	43.1	0.11	38.3	154.8
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	24.4	0.2	7.8	412	25.4	4.09	50.5	8.8	11.1	0.06	56.8	160.6
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	20.0	0.2	7.9	400	30.5	4.86	42.5	9.0	10.8	0.05	55.5	157.1
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	18.7	0.1	7.8	461	39.4	7.07	40.8	9.1	14.1	0.07	91.9	139.7
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	17.0	0.2	7.8	430	43.9	8.16	31.9	8.4	11.9	0.07	79.9	150.5
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	16.4	1.4	7.4	447	53.7	8.64	24.6	4.5	14.3	0.09	60.4	175.2
S275	NM178	Yale 1	12	na	6/19/1996	22.0	1.6	7.8	376	41.7	7.31	24.3	6.0	24.9	0.12	47.2	127.6

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (ºC)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	15.2	0.1	8.0	384	43.8	6.43	22.8	4.6	8.2	0.10	58.8	155.3
SXXX	NM046	Geoprobe #1 (40.8')	12	na	7/1/1996	15.1	0.0	8.1	364	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM047	Geoprobe #1 (35.8')	12	na	7/1/1996	15.5	0.0	8.1	375	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM048	Geoprobe #1 (30.5')	12	na	7/1/1996	16.1	0.0	8.1	359	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	16.7	0.1	8.0	363	39.1	6.46	21.3	3.4	7.4	0.07	51.3	150.9
SXXX	NM050	Geoprobe #1 (20.2')	12	na	7/1/1996	17.0	0.1	8.0	365	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	16.0	0.1	7.9	399	48.0	6.28	26.2	4.4	10.8	0.06	58.8	160.3
SXXX	NM052	Geoprobe #2 (35.3')	12	na	7/1/1996	16.3	0.0	7.8	355	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM053	Geoprobe #2 (30.2')	12	na	7/1/1996	16.5	0.1	8.0	369	nd	nd	nd	nd	nd	nd	nd	nd
SXXX	NM054	Geoprobe #2 (23.4')	12	na	7/1/1996	15.7	0.1	7.9	397	nd	nd	nd	nd	nd	nd	nd	nd
		Zone 13: Discharge															
S143	NM096	Private Production Well #05	13	na	8/19/1996	23.0	0.1	7.7	1,157	64.5	21.1	124.	19.3	152.	0.37	203.	135.5
S194	NM327	Domestic Well #32	13	na	6/30/1997	20.9	1.8	7.6	2,452	238.	53.2	212.	10.5	685.	0.59	290.	60.5
S226	NM150	Domestic Well #15	13	na	8/19/1996	20.6	0.1	7.7	3,076	93.0	49.0	495.	8.5	692.	0.53	450.	188.0
		No Zone: Exotic Water															
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	21.4	7.4	6.7	27,860	607.	513.	5,910.	149.	8,070.	2.07	3,750.	1,180.
S023	NM010	Burn Site Well	E	E	6/25/1996	17.9	3.6	7.2	1,060	137.	43.8	32.9	3.8	66.1	0.90	165.	297.3
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	25.4	0.8	6.2	11,680	561.	108.	2,190.	135.	2,680.	3.09	2,190.	861.5
S038	NM265	Windmill #19	E	E	7/1/1997	17.1	0.6	8.4	5,180	32.5	4.77	1,177.	7.5	195.	0.28	2,134.	302.2
S054	NM041	Domestic Well #04	E	E	8/17/1996	27.0	0.1	7.0	8,200	185.	25.7	1,530.	107.	2,520.	1.78	296.	181.6
S057	NM242	Embudo Spring	E	E	5/27/1997	12.1	8.2	8.2	494	71.0	15.6	14.0	2.8	4.7	0.08	46.2	254.7
S057	NM241	Embudo Spring	E	E	5/27/1997	12.4	2.4	7.4	542	76.5	17.2	16.0	3.2	5.1	0.07	48.6	284.0
S057	NM228	Embudo Spring	E	E	4/29/1997	11.0	4.4	7.5	646	88.0	21.6	18.4	3.8	6.8	0.09	63.8	325.7
S057	NM365	Embudo Spring	E	E	7/17/1997	15.4	4.2	7.4	648	105.	26.4	24.4	4.8	9.7	0.13	70.8	406.3
S057	NM044	Embudo Spring	E	E	7/2/1996	16.3	0.1	7.1	775	110.	25.4	18.3	4.0	8.5	0.18	94.8	399.4
S057	NM215	Embudo Spring	E	E	3/21/1997	8.50	4.3	7.3	756	102.	25.7	22.0	3.5	9.4	0.15	103.	353.4
S063	NM282	Windmill #22	E	E	6/28/1997	19.2	3.6	7.4	1,255	163.	41.8	60.1	4.0	84.9	1.06	344.	277.5
S067	NM284	Granite Hill	E	E	7/4/1997	18.6	0.1	7.4	777	91.4	23.6	40.5	8.9	23.0	0.35	153.	272.8
S070	NM059	HERTF	E	E	6/28/1996	24.0	3.0	7.0	795	100.	24.5	25.8	2.6	59.6	0.55	85.0	204.5
S091	NM496	Private Production Well #23	E	E	8/4/1998	14.5	nd	7.4	819	62.1	14.6	92.0	14.5	75.1	0.24	40.7	348.3
S094	NM293	Stock Well #02	E	E	6/20/1997	20.6	5.2	7.5	960	26.4	7.72	183.	2.5	5.6	0.05	170.	382.1
S099	NM072	LALF-1	E	E	6/29/1996	18.6	<0.1	7.3	1,296	175.	27.0	56.7	9.5	44.9	0.19	280.	380.1
S112	NM296	Domestic Well #24	E	E	6/21/1997	53.8	nd	nd	nd	94.8	32.2	63.0	9.5	95.6	0.20	247.	175.8
S112	NM297	Domestic Well #24	E	E	6/21/1997	53.8	nd	7.0	1,075	97.9	33.4	63.1	8.6	95.6	0.20	247.	174.8
S129	NM087	Montaňo 4 S	E	E	6/19/1996	18.8	0.2	7.1	1,340	202.	40.4	74.1	10.7	25.7	0.11	312.	449.6
S152	NM098	Private Production Well #07	E	E	8/22/1996	18.6	1.8	7.2	1,127	138.	22.7	46.4	7.7	185.	0.49	107.	240.4
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	20.7	<0.1	6.9	1,251	164.	32.4	73.9	10.7	66.4	0.35	271.	305.8
S202	NM330	Windmill #27	E	E	7/2/1997	18.5	4.9	7.8	1,305	132.	98.1	67.5	4.6	41.5	0.44	672.	133.5
S211	NM512	Sandia M	E	E	7/30/1998	21.3	0.8	7.6	748	24.3	4.83	122.	8.5	128.	0.27	45.5	147.5
S225	NM149	SBM-1	E	E	6/29/1996	20.4	<0.1	6.7	2,010	328.	51.1	90.8	12.7	75.6	0.38	573.	417.4
S249	NM164	Private Production Well #09	E	E	6/26/1996	nd	nd	nd	nd	49.4	7.84	13.3	1.3	9.4	0.07	29.3	172.4
S249	NM163	Private Production Well #09	E	E	6/26/1996	18.3	5.3	7.4	365	51.0	7.85	13.3	1.3	9.6	0.07	30.0	173.6
S250	NM165	Private Production Well #10	E	E	6/26/1996	18.3	0.1	7.3	483	62.9	10.6	25.1	1.4	11.9	0.17	62.1	218.3
S251	NM166	Private Production Well #11	E	E	6/26/1996	17.7	6.0	7.2	382	51.0	9.74	15.3	1.8	5.8	0.09	38.4	186.8
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	12.9	5.2	7.4	407	108.	5.68	3.54	0.9	2.2	0.04	19.5	325.4

Table A2. Summary of field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date sampled	Temp (°C)	O_2 (mg/L)	pH	Sp. Cond. (µS/cm)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^{-} (mg/L)
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	12.9	6.2	7.5	381	106.	5.66	3.49	0.9	2.2	0.04	19.5	325.7
S258	NM524	Vallecito Springs	E	E	8/4/1998	17.4	nd	6.9	463	45.9	9.09	39.2	10.7	6.0	0.08	35.4	249.4
S273	NM176	Windmill #11	E	E	8/19/1996	22.6	3.0	7.8	727	41.0	43.7	51.5	3.9	29.4	0.41	89.3	324.3
S282	NM529	Windmill #44	E	E	7/29/1998	18.8	3.8	7.2	4,399	650.	87.4	199.	21.2	980.	1.90	829.	189.6
SXXX	NM065	Jemez Spring	E	E	8/20/1996	55.5	nd	6.3	3,931	158.	7.32	560.	75.0	873.	2.41	41.6	755.7
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	40.6	2.0	6.6	6,540	353.	32.5	834.	181.	1,500.	4.29	42.1	1,538.

Table A3. Summary of minor-element chemistry

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Sr, strontium, SiO_2, silica; Fe, iron; NO_3 as N, dissolved nitrate as nitrogen; Mn, manganese; F, fluoride; mg/L, milligrams per liter; nd, not determined; na, not applicable]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
		Zone 1: Northern Mountain Front									
S027	NM486	CEPO 02	1	na	8/3/1998	0.17	65.7	0.03	<0.001	0.59	0.76
S034	NM027	Private Production Well #04	1	na	8/28/1996	0.16	65.2	0.03	<0.004	0.83	0.46
S035	NM487	Windmill #37	1	na	7/31/1998	0.09	52.8	0.06	0.008	0.26	0.18
S036	NM026	Private Production Well #03	1	na	8/28/1996	0.26	29.7	0.02	<0.004	0.88	0.33
S065	NM055	Domestic Well #05	1	na	8/17/1996	0.55	41.9	0.06	<0.004	0.96	0.96
S187	NM131	Rio Rancho 12	1	na	8/13/1996	0.80	31.0	0.05	<0.004	0.52	0.36
S206	NM510	Windmill #38	1	3	8/3/1998	0.36	61.2	0.13	0.005	2.16	0.55
S216	NM143	Windmill #09	1	na	8/27/1996	0.51	60.1	0.06	0.015	0.91	0.65
S221	NM530	Windmill #45	1	na	8/20/1998	0.25	76.4	0.11	0.028	0.53	0.15
S222	NM514	Windmill #39	1	3	8/6/1998	1.1	35.9	3.18	0.193	0.04	0.34
S254	NM168	Private Production Well #12	1	na	8/28/1996	0.08	53.7	0.03	<0.004	0.62	0.28
S277	NM525	Windmill #40	1	na	7/28/1998	0.63	38.3	0.09	0.005	3.03	0.29
S279	NM527	Windmill #42	1	na	7/28/1998	0.15	54.3	0.15	0.009	0.02	0.18
S281	NM528	Windmill #43	1	3	7/28/1998	0.74	26.5	0.17	0.004	0.38	0.28
		Zone 2: Northwestern									
S103	NM497	Lincoln D	2	na	7/23/1998	0.57	57.1	0.02	0.003	4.72	0.99
S104	NM498	Lincoln M	2	na	7/23/1998	0.53	70.6	0.02	<0.001	5.81	0.76
S105	NM499	Lincoln S	2	na	7/23/1998	0.85	65.9	0.02	<0.001	5.60	0.61
S191	NM326	Rio Rancho 4	2	3	6/20/1997	0.70	55.4	0.09	0.006	1.58	0.82
S192	NM128	Rio Rancho 8	2	3	8/13/1996	0.66	20.3	0.05	<0.004	2.53	0.67
S189	NM133	Rio Rancho 15	2	na	8/13/1996	0.55	30.2	0.06	<0.004	1.36	1.08
S276	NM179	Windmill #12	2	na	8/27/1996	0.68	24.4	0.03	<0.004	5.80	0.14
S278	NM526	Windmill #41	2	na	7/29/1998	0.57	22.5	0.04	0.004	1.35	0.77
S280	NM180	Windmill #13	2	na	8/27/1996	1.2	24.0	0.03	0.005	11.5	0.35
S286	NM184	Private Production Well #13	2	na	8/26/1996	0.48	27.2	0.01	<0.004	5.60	0.37
S287	NM185	Private Production Well #14	2	na	8/26/1996	0.42	28.2	0.01	<0.004	2.35	0.77
		Zone 3: West Central									
S003	NM481	98th St. D	3	na	8/4/1998	0.53	27.4	0.02	0.005	0.04	2.10
S003	NM251	98th St. D	3	na	6/17/1997	0.56	28.0	0.03	0.009	0.01	2.10
S004	NM482	98th St. MD	3	na	8/4/1998	0.07	20.2	0.01	0.009	0.04	1.11
S004	NM252	98th St. MD	3	na	6/18/1997	0.08	20.5	0.02	0.003	0.03	1.18
S005	NM253	98th St. MS	3	na	7/4/1997	0.23	17.8	0.02	0.009	0.01	2.28
S005	NM483	98th St. MS	3	na	8/4/1998	0.20	16.5	0.02	0.039	0.01	2.08
S006	NM484	98th St. S	3	na	8/5/1998	0.18	33.4	0.01	<0.001	3.14	1.14
S006	NM254	98th St. S	3	na	6/17/1997	0.21	29.5	0.02	<0.001	2.78	1.15
S008	NM003	Private Production Well #01	3	na	8/12/1996	0.34	32.1	0.05	<0.004	1.61	0.81
S010	NM255	Private Production Well #16	3	na	6/23/1997	0.32	12.7	0.12	0.007	0.02	0.71
S018	NM260	Domestic Well #21	3	na	6/26/1997	0.46	57.1	0.05	<0.001	2.04	1.02
S019	NM007	Belen 4	3	5	8/16/1996	0.83	35.7	0.01	<0.004	1.65	0.98
S020	NM008	Belen 5	3	5	8/16/1996	0.65	42.1	0.05	<0.004	1.76	1.11
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	1.1	26.3	0.01	<0.004	1.57	0.52
S037	NM264	College 2	3	na	6/19/1997	0.07	30.6	0.02	0.000	2.30	0.99
S066	NM056	Gonzales 1	3	12	6/20/1996	0.22	53.5	0.02	<0.004	1.27	1.15
S086	NM492	Isleta D	3	na	7/29/1998	0.04	22.9	0.02	0.004	1.17	1.96
S101	NM294	Leavitt 1	3	na	6/26/1997	0.09	33.4	0.02	0.001	2.78	1.19
S108	NM076	Los Lunas 3	3	12	8/14/1996	0.20	57.3	0.02	<0.004	0.02	0.94
S109	NM077	Los Lunas 4	3	12	8/14/1996	0.18	59.7	0.03	<0.004	0.03	0.79
S145	NM308	NM Utilities 1	3	na	6/18/1997	0.42	65.0	0.05	0.005	2.88	0.73
S147	NM310	NM Utilities 3	3	na	6/18/1997	0.27	68.7	0.05	0.005	1.10	0.94
S148	NM311	NM Utilities 4	3	na	6/18/1997	0.33	56.7	0.06	0.005	2.90	0.81
S166	NM509	Rabbit Hill	3	na	8/4/1998	0.82	25.5	0.04	<0.001	1.83	0.58
S167	NM107	Domestic Well #12	3	na	8/14/1996	0.21	32.5	0.03	<0.004	0.98	0.78
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	0.14	18.0	0.05	0.006	0.01	1.78

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	0.14	31.2	0.05	0.004	1.10	1.45
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	0.16	36.4	0.03	<0.004	1.00	1.57
S186	NM130	Rio Rancho 10	3	na	8/13/1996	0.71	29.1	0.03	<0.004	1.71	0.93
S188	NM132	Rio Rancho 13	3	na	8/13/1996	0.08	21.8	0.05	<0.004	1.50	0.90
S193	NM129	Rio Rancho 9	3	na	8/13/1996	0.11	21.0	0.01	<0.004	2.11	0.54
S196	NM135	Windmill #05	3	na	8/21/1996	0.21	41.1	0.18	0.025	1.49	0.82
S200	NM139	Private Production Well #08	3	na	8/29/1996	0.57	35.1	0.03	<0.004	1.24	0.77
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	0.15	15.8	0.04	<0.004	1.24	0.67
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	0.21	22.5	0.04	<0.004	1.56	0.71
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	0.33	23.3	0.05	<0.004	0.69	0.80
S230	NM516	Sierra Vista D	3	na	7/22/1998	0.14	18.5	0.02	0.008	0.02	0.89
S236	NM155	SAF (Soil Amement Facility)	3	na	8/12/1996	0.39	17.5	0.11	<0.004	0.86	0.53
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	0.66	46.9	0.04	0.120	0.19	0.89
S242	NM520	SWAB Test Hole 1 S	3	1	8/1/1998	0.11	18.6	0.02	0.012	0.93	0.60
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	0.49	17.8	0.27	0.024	3.61	0.83
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	0.37	62.3	0.07	0.009	1.27	0.95
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	0.14	19.1	0.04	0.007	0.76	1.29
S272	NM353	West Mesa 3	3	na	6/19/1997	0.07	31.0	0.02	0.006	2.38	1.33
S283	NM181	Zia Ball Park D	3	na	8/26/1996	0.09	24.4	0.02	0.005	2.32	6.14
S284	NM182	Zia Ball Park M	3	na	8/26/1996	0.12	23.7	0.02	<0.004	2.28	5.70
S285	NM183	Zia Ball Park S	3	2	8/26/1996	0.99	25.9	0.09	<0.004	2.35	3.09
S288	NM186	Zia BMT D	3	na	8/27/1996	0.26	19.4	0.04	<0.004	0.33	0.64
		Zone 4: Western Boundary									
S031	NM263	Windmill #18	4	na	6/24/1997	2.1	20.1	0.16	0.066	1.41	2.15
S039	NM266	Windmill #20	4	na	6/21/1997	1.6	64.2	0.56	0.047	0.59	3.92
S059	NM278	Windmill #21	4	na	6/23/1997	4.9	29.3	0.46	0.027	0.67	nd
S074	NM285	Windmill #23	4	na	6/21/1997	2.1	23.1	0.90	0.141	1.55	2.05
S169	NM320	Rest Area	4	na	6/30/1997	3.5	27.0	0.30	0.015	6.87	1.20
S201	NM329	Windmill #26	4	na	7/2/1997	12.	18.5	1.1	0.074	0.01	1.07
S252	NM167	Windmill #10	4	na	8/29/1996	0.84	18.4	0.01	0.008	1.09	1.64
S260	NM345	Windmill #33	4	na	6/25/1997	1.4	22.0	0.21	0.036	1.04	2.12
		Zone 5: Rio Puerco									
S032	NM262	Windmill #17	5	na	6/24/1997	4.2	26.3	0.26	0.028	1.64	1.68
S069	NM058	Domestic Well #06	5	na	8/16/1996	2.5	24.6	0.23	0.033	1.96	0.44
S073	NM062	Windmill #03	5	na	8/16/1996	4.7	21.8	0.51	0.033	2.62	0.38
S082	NM409	Windmill #36	5	na	9/10/1997	5.1	28.0	0.40	0.033	0.42	0.22
S085	NM408	Windmill #35	5	na	9/10/1997	2.0	28.9	0.13	0.007	0.34	0.54
S111	NM079	Domestic Well #10	5	na	8/16/1996	3.6	27.0	0.27	0.050	1.55	0.41
S185	NM324	Domestic Well #31	5	na	6/16/1997	3.9	22.7	0.69	1.56	0.11	1.03
S198	NM137	Windmill #07	5	na	8/21/1996	6.2	21.8	1.6	0.121	1.10	0.63
S215	NM335	Sandoval Spring	5	4	7/1/1997	0.82	30.6	0.17	0.047	0.09	1.44
S237	NM341	Windmill #30	5	4	6/24/1997	3.9	22.9	0.31	0.031	1.72	1.22
S238	NM342	Windmill #31	5	na	6/24/1997	6.2	29.7	0.50	0.036	1.48	0.41
		Zone 6: Southwestern Mountain Front									
S022	NM009	Windmill #02	6	na	8/19/1996	0.86	9.2	0.05	0.004	1.12	0.73
		Zone 7: Abo Arroyo									
S021	NM261	Stock Well #01	7	na	6/23/1997	2.1	16.2	0.37	0.036	0.99	0.89
S024	NM011	Domestic Well #02	7	8	8/17/1996	1.2	21.8	0.11	0.010	1.38	0.48
S090	NM064	Domestic Well #08	7	na	8/19/1996	1.8	23.5	0.13	<0.004	1.48	1.27
S093	NM067	Domestic Well #09	7	8	8/15/1996	0.51	42.8	0.02	<0.004	3.32	0.51
		Zone 8: Eastern Mountain Front									
S007	NM002	Domestic Well #01	8	na	6/21/1996	0.18	23.3	0.08	0.006	1.00	1.30
S013	NM256	Windmill #14	8	na	6/24/1997	0.02	0.3	0.02	<0.004	0.01	0.13
S014	NM257	Private Production Well #17	8	na	6/19/1997	0.30	27.0	0.04	0.004	0.75	0.25
S015	NM006	Windmill #01	8	na	8/24/1996	0.20	18.5	0.12	0.005	0.01	0.19
S030	NM019	Charles 4	8	na	6/27/1996	0.22	24.0	0.03	<0.004	0.30	0.33

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S030	NM024	Charles 4	8	na	6/27/1996	0.26	24.4	0.03	<0.004	0.27	0.32
S030	NM017	Charles 4	8	na	6/27/1996	0.22	24.0	0.04	<0.004	0.32	0.33
S030	NM018	Charles 4	8	na	6/27/1996	0.22	24.2	0.04	<0.004	0.33	0.33
S030	NM021	Charles 4	8	na	6/27/1996	0.26	24.6	0.04	<0.004	0.30	0.32
S030	NM020	Charles 4	8	na	6/27/1996	0.25	24.6	0.04	<0.004	0.28	0.32
S030	NM023	Charles 4	8	na	6/27/1996	0.26	24.2	0.04	<0.004	0.28	0.32
S030	NM016	Charles 4	8	na	6/22/1996	0.29	29.5	0.04	<0.004	0.27	0.33
S030	NM022	Charles 4	8	na	6/27/1996	0.27	24.4	0.05	<0.004	0.28	0.32
S042	NM031	Domestic Well #03	8	na	8/14/1996	0.32	40.9	0.03	<0.004	0.46	0.45
S055	NM042	Elena Gallegos	8	na	6/25/1996	0.23	23.5	0.05	0.005	0.16	1.97
S056	NM227	Embudito Spring	8	na	4/29/1997	0.19	24.4	0.04	0.004	0.05	1.36
S056	NM239	Embudito Spring	8	na	5/27/1997	0.22	28.9	0.06	0.003	0.01	1.39
S056	NM213	Embudito Spring	8	na	3/21/1997	0.22	25.0	0.07	0.004	0.02	1.61
S056	NM214	Embudito Spring	8	na	3/21/1997	0.22	25.2	0.08	0.005	0.01	1.58
S056	NM364	Embudito Spring	8	na	7/17/1997	0.37	35.9	0.08	0.007	0.01	1.38
S056	NM043	Embudito Spring	8	na	7/2/1996	0.34	32.7	0.14	0.021	0.44	0.98
S071	NM060	Domestic Well #07	8	na	6/19/1996	0.15	21.6	0.04	<0.004	2.80	1.62
S083	NM407	Windmill #34	8	na	9/10/1997	0.51	36.2	0.05	0.006	0.22	0.41
S095	NM068	Kirtland 1	8	na	6/25/1996	0.36	27.2	0.04	<0.004	0.77	0.51
S106	NM295	Domestic Well #23	8	na	6/26/1997	0.38	64.0	0.05	0.003	0.24	0.41
S110	NM078	Love 1	8	na	6/22/1996	0.26	30.2	0.03	<0.004	0.66	0.70
S113	NM080	Domestic Well #11	8	na	8/15/1996	0.39	26.1	0.05	<0.004	0.31	0.78
S114	NM500	Matheson D	8	na	7/31/1998	0.29	28.7	0.03	0.181	0.02	0.83
S115	NM501	Matheson M	8	na	8/1/1998	0.15	25.5	0.02	0.017	0.02	0.71
S116	NM502	Matheson S	8	na	8/1/1998	0.20	23.7	0.02	0.004	0.67	0.52
S117	NM298	Domestic Well #25	8	na	6/17/1997	0.19	21.4	0.03	<0.004	2.69	1.15
S118	NM299	Windmill #24	8	na	6/27/1997	0.52	23.7	0.07	<0.004	3.87	2.34
S119	NM300	Domestic Well #26	8	11	6/19/1997	0.70	21.2	0.24	0.008	0.33	1.21
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	0.31	61.4	0.03	0.058	0.24	0.67
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	0.01	51.3	0.04	0.009	0.01	2.19
S140	NM306	MRN 1	8	na	7/5/1997	0.85	29.1	0.08	0.006	3.78	0.42
S141	NM095	National Utility 7	8	na	8/14/1996	0.14	16.5	0.03	<0.004	2.07	0.17
S149	NM312	Nor Este D	8	na	7/3/1997	0.24	34.0	0.04	0.116	0.14	1.46
S150	NM313	Nor Este M	8	na	7/2/1997	0.34	44.1	0.05	0.063	0.10	0.55
S162	NM317	Stock Well #03	8	na	6/30/1997	0.12	23.1	0.04	0.004	0.55	0.24
S163	NM318	PL 2	8	na	7/7/1997	0.46	26.3	0.05	0.004	0.80	0.48
S164	NM106	Ponderosa 1	8	na	6/20/1996	0.69	35.1	0.05	0.006	0.12	0.53
S165	NM328	Windmill #25	8	na	6/24/1997	0.19	26.7	1.45	0.018	0.74	0.61
S168	NM319	Domestic Well #30	8	na	6/27/1997	0.32	15.9	0.02	0.000	0.52	0.55
S170	NM108	Ridgecrest 3	8	na	6/22/1996	0.39	31.0	0.03	<0.004	0.40	0.50
S170	NM412	Ridgecrest 3	8	na	11/18/1997	0.40	31.2	0.03	0.003	0.08	0.56
S195	NM134	Domestic Well #13	8	na	8/14/1996	0.40	48.8	0.05	<0.004	1.37	0.35
S199	NM138	Windmill #08	8	na	8/23/1996	0.55	23.7	0.06	<0.004	1.48	0.31
S209	NM336	Domestic Well #33	8	na	6/27/1997	0.19	41.1	0.04	0.006	0.05	0.48
S212	NM141	Sandia Peak 1	8	na	6/26/1996	0.16	28.7	0.03	<0.004	0.28	0.52
S213	NM142	Sandia Peak 3	8	na	6/26/1996	0.20	25.9	0.03	<0.004	0.79	1.18
S224	NM148	Domestic Well #14	8	na	8/23/1996	0.44	35.1	0.06	<0.004	0.27	0.39
S229	NM515	SH03 UNM	8	na	7/28/1998	0.17	19.8	0.03	<0.001	1.39	1.68
S233	NM153	Domestic Well #16	8	na	8/23/1996	0.48	56.5	0.07	<0.004	0.35	0.30
S239	NM156	Domestic Well #17	8	na	8/17/1996	0.68	26.1	0.05	<0.004	0.26	0.78
S240	NM157	Domestic Well #18	8	na	6/19/1996	0.14	28.7	0.04	<0.004	0.23	0.49
S246	NM343	Windmill #32	8	na	6/24/1997	0.52	25.9	0.11	0.008	1.51	0.17
S247	NM161	Domestic Well #19	8	na	8/15/1996	0.08	25.5	0.01	<0.004	0.67	0.49
S248	NM162	Thomas 6	8	na	6/21/1996	0.41	34.8	0.04	0.011	0.12	0.49
S255	NM523	Tramway East	8	na	7/30/1998	0.27	26.3	0.03	0.004	0.27	0.91
S264	NM174	Walker 1	8	na	6/18/1996	0.37	31.4	0.04	0.004	0.16	0.71
S274	NM177	Domestic Well #20	8	na	8/15/1996	0.55	45.1	0.03	<0.004	1.24	0.34

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
		Zone 9: Tijeras Fault Zone									
S041	NM029	Coyote Spring	9	na	6/28/1996	1.6	16.9	0.35	1.39	0.28	1.90
S072	NM061	Hubbell Spring	9	8	8/23/1996	1.1	27.0	0.10	0.006	0.87	0.79
S098	NM071	KAFB-1902	9	na	6/28/1996	0.87	19.7	0.12	0.031	1.13	3.01
S197	NM136	Windmill #06	9	na	8/23/1996	0.72	12.4	0.22	0.034	0.14	1.23
S227	NM151	SFR 3D	9	na	8/24/1996	1.3	29.1	0.16	<0.008	1.09	1.41
S228	NM152	SFR 3S	9	na	8/24/1996	1.1	27.6	0.12	0.015	0.90	1.31
		Zone 10: Tijeras Arroyo									
S001	NM001	4Hills-1	10	8	6/29/1996	0.95	18.5	0.14	0.011	4.16	0.98
S002	NM250	Private Production Well #15	10	8	7/3/1997	0.60	18.5	0.10	0.006	2.86	0.52
S058	NM277	Eubank 1	10	8	7/4/1997	0.30	22.2	0.06	0.003	2.21	0.39
S096	NM069	Kirtland 11	10	8	6/25/1996	0.47	27.4	0.07	0.004	4.16	0.55
S107	NM075	Lomas 1	10	8	6/22/1996	0.39	22.9	0.05	0.005	3.80	0.43
S107	NM410	Lomas 1	10	na	11/18/1997	0.38	23.7	0.06	0.005	0.84	0.49
		Zone 11: Northeastern									
S016	NM258	Windmill #15	11	na	6/18/1997	0.50	40.2	0.18	0.006	0.64	1.25
S017	NM259	Windmill #16	11	na	6/18/1997	0.90	16.6	0.06	0.011	2.36	1.16
S053	NM276	Private Production Well #18	11	na	6/25/1997	1.7	38.1	0.18	0.010	1.80	0.75
S144	NM097	Private Production Well #06	11	na	8/28/1996	1.9	46.6	0.46	0.030	0.11	0.51
S204	NM332	Windmill #28	11	na	7/3/1997	0.85	26.3	0.07	0.006	2.30	1.12
S207	NM334	Private Production Well #22	11	na	7/3/1997	2.0	30.6	0.24	0.020	1.89	0.35
S223	NM338	Windmill #29	11	na	6/25/1997	2.9	26.7	0.25	0.013	2.73	0.60
		Zone 12: Central									
S011	NM004	Atris-1	12	na	6/22/1996	0.42	30.4	0.06	0.538	0.03	0.38
S012	NM005	Atrisco 3	12	3	6/20/1996	0.46	58.8	0.04	0.022	0.16	0.81
S025	NM012	Burton 2	12	na	6/19/1996	0.40	55.6	0.03	0.006	0.44	0.44
S026	NM013	Burton 5	12	na	6/19/1996	0.39	55.4	0.03	0.005	0.09	0.43
S033	NM025	Private Production Well #02	12	na	8/21/1996	0.70	44.1	0.09	0.085	5.44	0.32
S040	NM028	Coronado 1	12	na	6/18/1996	0.37	60.8	0.05	<0.004	0.36	0.80
S043	NM488	Del Sol D	12	na	7/21/1998	0.29	74.4	0.03	<0.001	0.53	1.00
S043	NM267	Del Sol D	12	na	7/1/1997	0.26	73.4	0.03	0.010	0.54	1.06
S044	NM489	Del Sol M	12	na	7/21/1998	0.48	55.0	0.06	0.081	0.48	0.56
S044	NM268	Del Sol M	12	na	6/26/1997	0.49	56.5	0.09	0.111	0.53	0.53
S045	NM490	Del Sol S	12	na	7/21/1998	0.75	38.3	0.06	0.001	4.11	0.31
S045	NM269	Del Sol S	12	na	6/26/1997	0.69	39.6	0.08	0.010	3.70	0.34
S046	NM032	Duranes 1	12	na	6/20/1996	0.68	70.9	0.07	0.015	0.09	0.55
S046	NM034	Duranes 1	12	na	6/29/1996	1.1	64.6	0.07	0.025	0.01	0.36
S046	NM033	Duranes 1	12	na	6/29/1996	1.0	64.4	0.07	0.026	0.00	0.37
S046	NM035	Duranes 1	12	na	6/29/1996	1.1	66.5	0.07	0.029	0.01	0.37
S046	NM037	Duranes 1	12	na	6/29/1996	1.1	65.0	0.07	0.029	0.01	0.36
S046	NM039	Duranes 1	12	na	6/29/1996	1.0	61.2	0.07	0.029	0.01	0.35
S046	NM038	Duranes 1	12	na	6/29/1996	1.1	62.0	0.08	0.026	0.01	0.36
S046	NM036	Duranes 1	12	na	6/29/1996	1.2	69.3	0.08	0.030	0.01	0.38
S046	NM040	Duranes 1	12	na	6/29/1996	0.92	56.7	0.08	0.026	0.01	0.35
S047	NM270	Duranes 7	12	na	6/26/1997	0.52	63.3	0.05	0.012	0.04	0.63
S048	NM271	Duranes Yard 1	12	na	7/5/1997	0.52	56.7	0.05	0.247	0.01	0.47
S049	NM272	Duranes Yard 2	12	na	7/5/1997	0.46	43.4	0.05	0.704	0.01	0.35
S050	NM273	Duranes Yard 3	12	na	7/5/1997	0.46	24.8	0.05	0.724	0.01	0.32
S051	NM274	Duranes Yard 4	12	na	7/5/1997	0.39	19.1	0.05	0.577	0.01	0.29
S052	NM275	Duranes Yard 5	12	na	7/5/1997	0.35	19.8	0.05	0.053	0.01	0.31
S060	NM279	Garfield D	12	3	6/19/1997	0.21	50.9	0.04	0.025	0.16	0.97
S061	NM280	Garfield M	12	na	6/19/1997	0.33	75.9	0.06	0.117	0.07	0.97
S062	NM491	Garfield S	12	na	7/28/1998	0.88	37.2	2.23	2.84	0.02	0.54
S062	NM281	Garfield S	12	na	6/19/1997	0.97	37.2	2.62	3.69	0.01	0.53
S064	NM283	Domestic Well #22	12	na	6/20/1997	0.57	52.2	0.07	0.007	1.08	0.35
S068	NM057	Griegos 3	12	na	6/21/1996	0.47	68.5	0.04	<0.004	0.03	0.41
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	0.56	61.4	0.05	0.016	0.08	0.59

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	0.37	63.1	0.12	0.045	0.01	0.32
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	0.60	43.2	0.09	0.016	0.78	0.42
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	0.37	47.9	0.07	0.085	0.01	0.37
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	0.50	44.1	0.08	0.017	0.07	0.39
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	0.57	42.8	0.09	0.012	0.29	0.39
S081	NM292	Private Production Well #19	12	na	7/2/1997	0.50	66.5	0.06	0.002	0.27	0.30
S084	NM063	Windmill #04	12	na	8/21/1996	0.46	65.5	0.17	0.006	0.24	0.46
S087	NM493	Isleta MD	12	3	7/29/1998	0.14	59.9	0.03	0.049	0.28	1.18
S088	NM494	Isleta MS	12	na	7/29/1998	0.29	37.9	0.03	0.074	0.02	0.45
S089	NM495	Isleta S	12	na	7/29/1998	0.91	38.7	0.43	1.26	0.02	0.40
S092	NM066	JMC-1	12	na	6/28/1996	0.65	59.0	0.06	0.011	0.20	0.24
S097	NM070	Kirtland 14	12	na	6/25/1996	0.34	49.8	0.03	0.006	0.33	0.40
S100	NM073	LALF-9	12	na	6/29/1996	0.62	31.7	0.10	0.216	0.01	nd
S102	NM074	Leyendecker 1	12	na	6/21/1996	0.26	34.0	0.02	<0.004	0.79	0.45
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	0.01	50.7	0.02	0.004	0.02	2.12
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	0.11	60.3	0.05	0.085	0.01	0.78
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	0.27	63.8	0.05	0.101	0.14	0.77
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	0.02	37.2	0.03	0.008	0.02	1.34
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	0.02	37.2	0.04	0.015	0.01	1.48
S123	NM081	MONT - 5A	12	na	6/27/1996	0.73	40.9	0.05	0.012	0.06	0.27
S124	NM082	Montaňo 2 D	12	na	6/19/1996	0.69	60.5	0.08	0.014	0.05	0.24
S125	NM083	Montaňo 2 M	12	na	6/19/1996	0.87	58.2	0.07	0.140	0.03	0.18
S126	NM084	Montaňo 2 S	12	na	6/19/1996	0.64	34.2	0.81	1.52	0.02	0.45
S127	NM085	Montaňo 4 D	12	na	6/20/1996	0.52	55.8	0.03	0.008	0.04	0.26
S128	NM086	Montaňo 4 M	12	na	6/19/1996	0.94	48.6	0.12	0.072	0.02	0.38
S130	NM088	Montaňo 5 D	12	na	6/24/1996	0.48	59.5	0.04	0.020	0.02	0.38
S131	NM089	Montaňo 5 M	12	na	6/24/1996	0.34	18.5	0.06	0.195	0.05	0.31
S132	NM090	Montaňo 5 S	12	na	6/24/1996	0.33	22.9	0.03	<0.004	0.50	0.39
S133	NM091	Montaňo 6 D	12	na	6/18/1996	0.46	62.5	0.11	0.486	0.19	0.45
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	0.53	87.7	0.03	<0.004	0.01	0.40
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	0.53	67.2	0.06	0.016	0.01	0.36
S136	NM094	Montaňo 6 S	12	na	6/18/1996	0.65	60.1	0.05	0.009	0.04	0.23
S137	NM506	Montesa M	12	na	7/27/1998	0.36	72.1	0.03	0.062	0.09	0.60
S138	NM507	Montesa S	12	na	7/27/1998	0.30	49.2	0.03	0.002	0.07	0.46
S139	NM305	Domestic Well #27	12	na	6/17/1997	0.49	76.8	0.06	0.006	0.10	0.95
S142	NM307	Domestic Well #28	12	na	6/17/1997	0.59	64.2	0.07	0.007	0.01	0.24
S146	NM309	NM Utilities 2	12	na	6/18/1997	0.30	72.1	0.06	0.006	0.63	0.65
S151	NM314	Nor Este S	12	na	7/2/1997	0.22	49.2	0.03	0.098	0.02	0.72
S151	NM508	Nor Este S	12	na	7/20/1998	0.30	46.4	0.10	0.177	0.02	0.67
S153	NM411	Open Space	12	na	11/18/1997	0.16	34.4	0.05	0.007	0.08	0.47
S153	NM315	Open Space	12	10	6/17/1997	0.16	35.9	0.09	0.008	0.35	0.41
S154	NM099	ORLF-2	12	na	6/27/1996	0.37	38.3	0.04	0.099	0.05	0.39
S155	NM316	Domestic Well #29	12	na	6/27/1997	0.45	36.4	0.06	0.007	0.01	0.32
S156	NM100	Paseo 2D	12	na	6/26/1996	0.39	34.4	0.04	0.051	0.01	0.27
S157	NM101	Paseo 2MD	12	na	6/26/1996	0.44	27.2	0.04	0.449	0.01	0.23
S158	NM102	Paseo 2MS	12	na	6/26/1996	0.35	31.4	0.40	1.15	0.05	0.54
S159	NM103	Paseo 2S	12	na	6/26/1996	0.49	24.2	0.06	0.940	0.82	0.60
S160	NM104	Paseo 3D	12	na	6/21/1996	0.32	39.4	0.04	0.058	0.00	0.32
S161	NM105	Paseo 3M	12	na	6/21/1996	0.94	45.1	0.08	1.89	0.47	0.29
S171	NM321	Ridgecrest 4	12	na	6/26/1997	0.40	33.8	0.06	0.005	0.12	0.34
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	0.28	70.0	0.04	0.007	0.01	0.69
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	0.58	31.4	0.22	0.646	0.01	0.40
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	0.34	78.7	0.05	0.015	0.10	0.99
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	0.75	83.0	0.06	0.018	0.06	0.38
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	0.52	60.5	0.06	0.160	0.01	0.76
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	0.38	60.8	0.11	0.488	0.05	0.45
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	0.89	61.0	0.09	0.048	3.09	0.36
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	0.39	73.2	0.03	<0.004	0.16	0.50

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	0.41	58.6	0.04	<0.004	0.01	0.38
S190	NM325	Rio Rancho 2	12	na	6/20/1997	0.55	49.4	0.08	0.011	0.82	0.42
S203	NM331	Private Production Well #20	12	na	7/3/1997	0.58	27.4	0.06	0.133	2.08	0.28
S205	NM333	Private Production Well #21	12	na	7/3/1997	0.14	67.6	0.17	0.012	0.01	0.48
S208	NM140	San Jose 2	12	3	6/20/1996	0.39	76.0	0.03	<0.004	0.68	0.68
S210	NM511	Sandia D	12	na	7/30/1998	0.31	55.0	0.03	0.104	0.23	1.03
S214	NM513	Sandia S	12	na	7/30/1998	0.93	39.6	0.06	0.038	0.04	0.31
S220	NM147	Santa Barbara 1	12	na	6/19/1996	0.29	46.4	0.03	<0.004	0.17	0.49
S220	NM337	Santa Barbara 1	12	na	6/26/1997	0.31	44.1	0.04	0.004	0.19	0.52
S231	NM517	Sierra Vista M	12	3	7/22/1998	0.14	73.2	0.02	0.034	0.06	1.10
S232	NM518	Sierra Vista S	12	na	7/22/1998	0.41	53.7	0.03	0.077	0.45	0.63
S234	NM339	Sister Cities D	12	na	6/30/1997	0.39	74.0	0.03	0.011	0.77	0.95
S235	NM340	Sister Cities M	12	na	6/27/1997	0.37	29.7	0.05	0.081	0.01	0.47
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	0.15	30.0	0.06	0.031	0.27	0.15
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	0.22	39.6	0.06	0.049	0.01	0.52
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	0.20	36.4	0.10	0.042	0.01	0.51
S253	NM522	Tome D	12	na	8/6/1998	0.28	58.2	0.02	0.036	0.02	0.88
S257	NM344	Domestic Well #34	12	na	6/17/1997	0.60	52.6	0.11	0.062	2.27	0.43
S259	NM171	VGP-1	12	na	6/27/1996	0.90	39.6	0.52	1.21	0.16	0.39
S261	NM172	Vol Andia 2	12	na	6/21/1996	0.27	33.6	0.03	<0.004	1.12	0.41
S262	NM173	Vol Andia 5	12	na	6/18/1996	0.40	33.4	0.04	0.005	0.31	0.40
S265	NM175	Webster 1	12	na	6/18/1996	0.33	57.1	0.04	0.006	0.14	0.77
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	0.34	67.2	0.03	0.009	0.06	1.04
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	0.47	68.0	0.04	0.010	0.05	1.08
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	0.52	62.3	0.08	0.109	0.01	0.74
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	0.46	59.7	0.05	0.015	0.01	0.81
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	0.44	23.1	0.05	0.225	0.28	0.31
S275	NM178	Yale 1	12	na	6/19/1996	0.37	61.0	0.04	0.005	0.63	0.45
SXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	0.36	27.2	0.55	0.500	0.01	0.39
SXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	0.29	22.0	0.46	1.15	0.01	0.38
X	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	0.36	28.7	0.32	0.557	0.01	0.37
		Zone 13: Discharge									
S143	NM096	Private Production Well #05	13	na	8/19/1996	1.5	39.6	0.07	0.009	0.01	1.59
S194	NM327	Domestic Well #32	13	na	6/30/1997	3.0	29.1	0.30	0.017	0.82	0.54
S226	NM150	Domestic Well #15	13	na	8/19/1996	3.0	24.2	0.20	<0.012	0.42	1.12
		No Zone: Exotic Water									
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	17.	17.2	1.5	0.019	0.02	0.50
S023	NM010	Burn Site Well	E	E	6/25/1996	1.1	16.0	0.12	0.014	23.3	0.49
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	13.	22.2	2.7	1.01	0.01	0.73
S038	NM265	Windmill #19	E	E	7/1/1997	2.2	10.7	0.38	0.061	0.01	2.75
S054	NM041	Domestic Well #04	E	E	8/17/1996	5.8	43.4	0.24	0.390	0.01	6.40
S057	NM228	Embudo Spring	E	E	4/29/1997	0.24	20.9	0.06	0.005	0.09	1.69
S057	NM241	Embudo Spring	E	E	5/27/1997	0.21	22.9	0.06	<0.001	0.01	1.51
S057	NM365	Embudo Spring	E	E	7/17/1997	0.26	23.7	0.07	0.015	0.01	1.72
S057	NM242	Embudo Spring	E	E	5/27/1997	0.19	21.0	0.07	0.026	0.01	1.71
S057	NM215	Embudo Spring	E	E	3/21/1997	0.30	21.8	0.10	0.007	0.04	1.73
S057	NM044	Embudo Spring	E	E	7/2/1996	0.26	23.3	0.38	0.036	0.01	1.28
S063	NM282	Windmill #22	E	E	6/28/1997	1.3	12.4	0.71	0.145	0.12	0.77
S067	NM284	Granite Hill	E	E	7/4/1997	0.44	25.9	0.11	0.113	0.03	2.57
S070	NM059	HERTF	E	E	6/28/1996	0.68	25.9	0.08	0.020	17.3	2.52
S091	NM496	Private Production Well #23	E	E	8/4/1998	0.85	53.3	0.60	0.682	0.02	1.19
S094	NM293	Stock Well #02	E	E	6/20/1997	0.60	29.7	0.09	<0.004	7.64	1.32
S099	NM072	LALF-1	E	E	6/29/1996	1.2	43.4	0.71	3.10	0.01	nd
S112	NM297	Domestic Well #24	E	E	6/21/1997	1.3	43.0	0.31	0.056	0.04	0.43
S112	NM296	Domestic Well #24	E	E	6/21/1997	1.5	47.1	0.36	0.077	0.04	0.43
S129	NM087	Montaňo 4 S	E	E	6/19/1996	1.3	47.5	0.71	4.03	0.05	0.69
S152	NM098	Private Production Well #07	E	E	8/22/1996	1.8	32.5	0.13	0.007	0.23	0.11
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	0.91	63.6	0.14	0.036	0.02	nd

Table A3. Summary of minor-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S202	NM330	Windmill #27	E	E	7/2/1997	2.5	17.1	0.25	0.057	2.63	0.65
S211	NM512	Sandia M	E	E	7/30/1998	0.26	61.0	0.02	0.023	0.21	1.57
S225	NM149	SBM-1	E	E	6/29/1996	1.84	59.9	0.26	0.031	0.01	1.10
S249	NM164	Private Production Well #09	E	E	6/26/1996	0.13	19.5	0.04	0.005	1.42	2.08
S249	NM163	Private Production Well #09	E	E	6/26/1996	0.12	18.1	0.06	0.009	1.47	2.03
S250	NM165	Private Production Well #10	E	E	6/26/1996	0.25	27.0	0.05	0.041	0.04	2.42
S251	NM166	Private Production Well #11	E	E	6/26/1996	0.16	21.8	0.06	0.006	0.38	2.46
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	0.23	10.6	0.05	0.006	0.33	0.41
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	0.23	10.7	0.06	0.007	0.33	0.41
S258	NM524	Vallecito Springs	E	E	8/4/1998	0.35	11.2	0.07	0.143	0.05	1.29
S273	NM176	Windmill #11	E	E	8/19/1996	1.2	18.1	0.16	0.101	0.03	0.79
S282	NM529	Windmill #44	E	E	7/29/1998	5.5	43.0	0.74	0.141	9.44	0.40
SXX	NM154	Soda Dam Spring	E	E	8/20/1996	1.9	40.0	0.35	0.600	0.01	3.14
SXX	NM065	Jemez Spring	E	E	8/20/1996	0.64	97.1	0.41	0.234	0.01	4.72

Table A4. Summary of trace-element chemistry

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Al, aluminum; B, boron; Ba, barium; Li, lithium; Zn, zinc; Pb, lead; Cu, copper; Rb, rubidium; V, vanadium; Cr, chromium; Co, cobalt; Mo, molybdenum; As, arsenic; Se, selenium; U, uranium; mg/L, milligrams per liter; µg/L, micrograms per liter; nd, not determined]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
		Zone 1: Northern Mountain Front																		
S027	NM486	CEPO 02	1	na	8/3/1998	8.	0.024	0.025	0.030	2.	<0.05	0.2	1.7	9.0	7.	<0.05	1.6	4.5	2.	0.8
S034	NM027	Private Production Well #04	1	na	8/28/1996	5.	0.023	0.094	0.026	2.	0.12	0.5	nd	5.8	3.	nd	1.8	1.7	nd	0.8
S035	NM487	Windmill #37	1	na	7/31/1998	5.	0.011	0.007	0.004	4,340.	0.35	3.1	1.8	3.6	<1.	<0.05	1.1	1.1	<1.	0.1
S036	NM026	Private Production Well #03	1	na	8/28/1996	6.	0.032	0.182	0.008	5.	0.72	0.7	nd	7.	1.	nd	1.8	1.7	nd	3.3
S065	NM055	Domestic Well #05	1	na	8/17/1996	4.	0.197	0.163	0.289	3.	<0.1	1.7	nd	10.	1.	nd	6.6	7.6	nd	0.7
S187	NM131	Rio Rancho 12	1	na	8/13/1996	3.	0.159	0.120	0.180	3.	<0.1	<0.1	nd	17.	2.	nd	1.0	45.	nd	1.0
S206	NM510	Windmill #38	1	3	8/3/1998	5.	0.113	0.071	0.062	4,230.	1.6	1.3	13.	30.	4.	<0.05	3.1	29.	2.	1.0
S216	NM143	Windmill #09	1	na	8/27/1996	5.	0.076	0.052	0.059	700.	0.2	0.9	nd	9.3	6.	nd	2.3	5.6	nd	3.1
S221	NM530	Windmill #45	1	na	8/20/1998	3.	0.118	0.141	0.058	388.	<0.05	0.4	3.8	2.8	<1.	0.52	1.0	1.7	1.	3.5
S222	NM514	Windmill #39	1	3	8/6/1998	4.	0.173	0.009	0.208	1,140.	0.07	0.7	67.	<0.1	<1.	1.4	6.9	15.	<1.	4.1
S254	NM168	Private Production Well #12	1	na	8/28/1996	3.	0.019	0.129	0.016	18.	0.19	1.3	nd	6.3	<1.	nd	0.7	2.	nd	0.3
S277	NM525	Windmill #40	1	na	7/28/1998	4.	0.050	0.002	0.060	349.	0.52	4.2	32.	1.4	<1.	0.06	1.0	24.	<1.	2.0
S279	NM527	Windmill #42	1	na	7/28/1998	3.	0.021	0.034	0.006	330.	0.20	8.2	3.1	6.4	<1.	0.07	0.5	1.7	1.	0.2
S281	NM528	Windmill #43	1	3	7/28/1998	3.	0.035	0.040	0.102	186.	0.38	0.4	42.	3.1	<1.	0.05	1.8	1.7	<1.	2.6
		Zone 2: Northwestern																		
S103	NM497	Lincoln D	2	na	7/23/1998	7.	0.166	0.082	0.089	5.	0.05	0.4	6.9	18.	4.	0.07	8.4	10.	1.	2.7
S104	NM498	Lincoln M	2	na	7/23/1998	4.	0.118	0.056	0.068	5.	<0.05	0.2	8.2	23.	5.	<0.05	3.2	9.8	<1.	1.7
S105	NM499	Lincoln S	2	na	7/23/1998	4.	0.080	0.067	0.057	8.	<0.05	0.2	13.	13.	2.	<0.05	1.8	5.4	1.	2.8
S189	NM133	Rio Rancho 15	2	na	8/13/1996	2.	0.365	0.039	0.266	3.	<0.1	0.1	nd	13.	4.	nd	9.1	11.	nd	3.0
S191	NM326	Rio Rancho 4	2	3	6/20/1997	5.	0.230	0.051	0.111	11.	<0.1	0.7	10.	21.	4.	<0.05	11.	14.	<1.	3.7
S192	NM128	Rio Rancho 8	2	3	8/13/1996	5.	0.174	0.052	0.054	4.	0.11	0.4	nd	15.	9.	nd	4.8	5.0	nd	6.9
S276	NM179	Windmill #12	2	na	8/27/1996	5.	0.025	0.048	0.009	816.	0.64	1.7	nd	16.	<1.	nd	0.3	9.3	nd	0.9
S278	NM526	Windmill #41	2	na	7/29/1998	4.	0.177	0.046	0.168	2,080.	0.18	1.2	3.6	7.4	<1.	<0.05	3.4	3.2	<1.	4.6
S280	NM180	Windmill #13	2	na	8/27/1996	3.	0.088	0.068	0.022	255.	0.49	0.9	nd	7.4	<1.	nd	1.5	4.8	nd	2.5
S286	NM184	Private Production Well #13	2	na	8/26/1996	2.	0.059	0.096	0.029	89.	0.5	<0.1	nd	21.	<1.	nd	1.6	15.	nd	2.3
S287	NM185	Private Production Well #14	2	na	8/26/1996	3.	0.161	0.056	0.088	9.	<0.1	0.2	nd	32.	2.	nd	4.9	19.	nd	1.4
		Zone 3: West Central																		
S003	NM251	98th St. D	3	na	6/17/1997	<5.	1.02	0.041	0.282	5.	0.22	0.3	2.3	55.	14.	<0.1	15.	40.	3.	16.
S003	NM481	98th St. D	3	na	8/4/1998	8.	0.843	0.035	0.264	<1.	<0.05	0.4	2.2	53.	10.	<0.05	15.	39.	1.	15.
S004	NM252	98th St. MD	3	na	6/18/1997	59.	0.313	0.018	0.063	7.	<0.1	0.3	0.9	11.	2.	<0.05	7.5	52.	<1.	99.
S004	NM482	98th St. MD	3	na	8/4/1998	32.	0.296	0.012	0.078	<1.	<0.05	<0.1	0.6	12.	4.	<0.05	5.8	52.	<1.	86.
S005	NM253	98th St. MS	3	na	7/4/1997	14.	0.373	0.034	0.040	3.	<0.1	0.3	14.	0.2	<1.	<0.05	10.	12.	<1.	7.3
S005	NM483	98th St. MS	3	na	8/4/1998	10.	0.368	0.037	0.048	<1.	<0.05	0.1	5.3	<1.	<1.	<0.05	10.	12.	<1.	6.0
S006	NM254	98th St. S	3	na	6/17/1997	43.	0.243	0.029	0.030	16.	<0.1	0.8	4.4	48.	17.	<0.05	14.	21.	3.	5.2
S006	NM484	98th St. S	3	na	8/5/1998	37.	0.218	0.034	0.033	<1.	<0.05	0.2	3.8	50.	16.	<0.05	8.0	22.	3.	3.7
S008	NM003	Private Production Well #01	3	na	8/12/1996	5.	0.142	0.034	0.015	12.	0.8	2.2	nd	27.	10.	nd	8.7	10.	nd	2.6
S010	NM255	Private Production Well #16	3	na	6/23/1997	4.	0.128	0.015	0.010	20.	1.2	18.	2.9	4.5	<1.	0.17	7.3	2.9	<1.	1.0
S018	NM260	Domestic Well #21	3	na	6/26/1997	9.	0.268	0.025	<0.001	50.	0.5	4.9	14.	28.	18.	<0.05	15.	8.3	2.	4.9
S019	NM007	Belen 4	3	5	8/16/1996	2.	0.227	0.019	0.105	2.	<0.1	0.2	nd	8.7	8.	nd	8.6	2.7	nd	3.8
S020	NM008	Belen 5	3	5	8/16/1996	2.	0.222	0.020	0.096	2.	<0.1	0.2	nd	10.	10.	nd	11.	3.4	nd	3.6
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	3.	0.117	0.032	0.042	2.	<0.1	0.8	nd	13.	5.	nd	13.	7.5	nd	4.1
S037	NM264	College 2	3	na	6/19/1997	16.	0.292	0.018	<0.001	10.	<0.1	0.4	0.9	85.	11.	<0.05	6.2	33.	2.	5.5
S066	NM056	Gonzales 1	3	12	6/20/1996	5.	0.214	0.035	0.053	nd	<0.1	0.4	nd	46.	4.	nd	4.3	25.	nd	4.2

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S086	NM492	Isleta D	3	na	7/29/1998	9.	0.505	0.010	0.018	2.	<0.05	0.6	2.5	173.	<1.	<0.05	11.	96.	3.	1.4
S101	NM294	Leavitt 1	3	na	6/26/1997	4.	0.212	0.024	0.033	2.	<0.1	0.6	1.8	66.	5.	<0.05	4.5	37.	3.	6.6
S108	NM076	Los Lunas 3	3	12	8/14/1996	5.	0.181	0.031	0.022	3.	<0.1	0.4	nd	52.	1.	nd	5.	18.	nd	8.0
S109	NM077	Los Lunas 4	3	12	8/14/1996	5.	0.13	0.038	0.034	<1.	0.1	0.2	nd	41.	<1.	nd	4.2	13.	nd	9.3
S145	NM308	NM Utilities 1	3	na	6/18/1997	5.	0.111	0.071	0.032	5.	<0.1	0.5	6.7	20.	3.	<0.05	2.8	7.9	2.	8.2
S147	NM310	NM Utilities 3	3	na	6/18/1997	9.	0.190	0.038	0.052	7.	0.3	0.9	5.5	50.	6.	<0.05	4.0	28.	1.	3.7
S148	NM311	NM Utilities 4	3	na	6/18/1997	3.	0.178	0.059	0.037	8.	0.2	0.5	4.6	23.	7.	0.20	5.9	10.	2.	8.6
S166	NM509	Rabbit Hill	3	na	8/4/1998	8.	0.857	0.060	0.464	6.	<0.05	0.6	6.0	57.	29.	<0.05	31.	23.	2.	3.2
S167	NM107	Domestic Well #12	3	na	8/14/1996	3.	0.224	0.014	0.026	18.	<0.1	<0.1	nd	43.	11.	nd	16.	9.8	nd	5.0
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	5.	0.411	0.024	0.051	2.	<0.1	0.6	1.0	17.	3.	<0.1	13.	24.	1.	1.2
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	49.	0.442	0.033	0.049	nd	0.2	4.1	nd	40.	11.	nd	11.	31.	nd	4.3
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	10.	0.330	0.017	0.052	nd	0.1	0.6	nd	48.	10.	nd	9.5	40.	nd	4.0
S186	NM130	Rio Rancho 10	3	na	8/13/1996	4.	0.355	0.032	0.207	6.	<0.1	0.1	nd	13.	5.	nd	8.	18.	nd	4.7
S188	NM132	Rio Rancho 13	3	na	8/13/1996	9.	0.217	0.023	0.030	1.	0.1	0.4	nd	72.	11.	nd	7.4	45.	nd	1.7
S193	NM129	Rio Rancho 9	3	na	8/13/1996	7.	0.183	0.039	0.031	<1.	<0.1	0.3	nd	42.	6.	nd	6.2	39.	nd	1.9
S196	NM135	Windmill #05	3	na	8/21/1996	2.	0.175	0.001	0.024	76.	0.6	<0.1	nd	9.6	1.	nd	17.	4.3	nd	2.3
S200	NM139	Private Production Well #08	3	na	8/29/1996	2.	0.237	0.020	0.063	16.	0.2	0.5	nd	23.	2.	nd	11.	9.8	nd	6.3
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	5.	0.209	0.051	0.090	179.	3.1	0.3	nd	26.	5.	nd	1.7	111.	nd	1.6
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	3.	0.241	0.068	0.115	218.	2.3	0.4	nd	119.	8.	nd	1.0	264.	nd	1.3
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	4.	0.249	0.066	0.147	147.	2.8	0.3	nd	39.	8.	nd	1.2	230.	nd	2.6
S230	NM516	Sierra Vista D	3	na	7/22/1998	22.	0.464	0.024	0.099	2.	<0.05	0.9	0.9	<0.1	<1.	<0.05	8.2	24.	<1.	2.3
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	5.	0.122	0.021	0.026	2.	<0.1	0.6	nd	26.	13.	nd	12.	11.	nd	2.3
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	8.	0.343	0.182	0.118	6.	<0.05	0.4	6.0	3.3	<1.	0.12	33.	25.	2.	1.2
S242	NM520	SWAB Test Hole 1 S	3	1	8/1/1998	9.	0.134	0.048	0.027	19.	0.09	0.2	1.6	9.1	<1.	0.06	8.2	7.2	2.	1.3
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	6.	0.108	0.214	0.035	10.	0.32	2.1	2.0	4.0	5.	<0.05	4.7	2.1	2.	4.7
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	4.	0.151	0.061	0.042	16.	<0.1	0.7	9.0	26.	8.	<0.05	3.3	14.	2.	4.4
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	2.	0.457	0.025	0.023	3.	<0.1	0.2	0.8	59.	<1.	<0.05	15.	36.	3.	2.7
S272	NM353	West Mesa 3	3	na	6/19/1997	<1.	0.234	0.019	0.027	12.	<0.1	0.3	1.2	73.	<1.	<0.05	5.3	39.	2.	7.5
S283	NM181	Zia Ball Park D	3	na	8/26/1996	3.	0.697	0.057	0.410	515.	1.2	0.4	nd	22.	3.	nd	23.	13.	nd	0.4
S284	NM182	Zia Ball Park M	3	na	8/26/1996	5.	0.619	0.034	0.397	132.	1.6	0.2	nd	24.	3.	nd	18.	21.	nd	0.6
S285	NM183	Zia Ball Park S	3	2	8/26/1996	4.	0.621	0.235	0.649	434.	0.9	1.2	nd	17.	3.	nd	8.4	17.	nd	0.4
S288	NM186	Zia BMT D	3	na	8/27/1996	1.	0.211	0.051	0.105	nd	<0.1	0.3	nd	16.	16.	nd	5.8	100.	nd	1.2
		Zone 4: Western Boundary																		
S031	NM263	Windmill #18	4	na	6/24/1997	<5.	0.382	0.006	0.174	25.	<0.1	1.1	4.4	2.2	11.	0.28	6.2	<1.	4.	2.3
S039	NM266	Windmill #20	4	na	6/21/1997	<5.	1.59	0.013	0.629	644.	1.9	11.	48.	16.	38.	<0.5	17.	<10.	<10.	3.2
S059	NM278	Windmill #21	4	na	6/23/1997	<5.	0.366	0.016	0.312	211.	0.2	2.9	6.6	5.4	12.	0.14	2.2	<1.	6.	4.8
S074	NM285	Windmill #23	4	na	6/21/1997	<5.	1.28	0.014	0.550	1,176.	0.1	9.6	86.	6.6	<2.	0.65	4.8	<1.	4.	5.5
S169	NM320	Rest Area	4	na	6/30/1997	<5.	0.351	0.013	0.251	6.	<0.1	2.7	5.7	7.7	9.	<0.1	8.1	1.8	6.	6.0
S201	NM329	Windmill #26	4	na	7/2/1997	<5.	0.439	0.023	0.102	19.	<0.1	3.2	5.5	1.2	7.	0.13	18.	6.6	2.	0.5
S252	NM167	Windmill #10	4	na	8/29/1996	<1.	0.555	0.014	0.190	12.	<0.1	1.2	nd	4.3	10.	nd	25.	2.	nd	4.1
S260	NM345	Windmill #33	4	na	6/25/1997	<5.	1.11	0.010	0.433	275.	<1.	3.6	6.2	6.	11.	<0.5	12.	<10.	10.	10.
		Zone 5: Rio Puerco																		
S032	NM262	Windmill #17	5	na	6/24/1997	<5.	0.881	0.011	0.327	51.	<0.1	6.3	5.0	4.1	11.	0.15	7.2	1.3	19.	12.
S069	NM058	Domestic Well #06	5	na	8/16/1996	3.	0.222	0.013	0.191	49.	0.1	1.4	nd	3.3	1.	nd	2.1	0.9	nd	3.1
S073	NM062	Windmill #03	5	na	8/16/1996	7.	0.394	0.017	0.295	1,480.	0.1	7.0	nd	3.1	9.	nd	1.9	0.8	nd	9.0
S082	NM409	Windmill #36	5	na	9/10/1997	11.	0.095	0.018	0.041	3,560.	1.4	4.6	5.5	3.3	2.	0.22	0.7	1.2	9.	6.0
S085	NM408	Windmill #35	5	na	9/10/1997	5.	0.139	0.014	0.069	886.	1.4	2.9	5.1	11.	14.	0.14	8.1	1.5	4.	1.0
S111	NM079	Domestic Well #10	5	na	8/16/1996	4.	0.213	0.013	0.253	8.	<0.1	2.3	nd	4.	1.	nd	3.2	1.	nd	2.6

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S185	NM324	Domestic Well #31	5	na	6/16/1997	<5.	0.267	0.015	0.074	9.	<0.1	4.4	1.4	1.5	9.	0.23	7.0	<1.	3.	1.5
S198	NM137	Windmill #07	5	na	8/21/1996	7.	1.11	0.007	0.767	180.	0.2	0.7	nd	18.	<1.	nd	18.	6.2	nd	37.
S215	NM335	Sandoval Spring	5	4	7/1/1997	7.	0.210	0.038	0.067	18.	<0.1	0.7	0.5	3.7	<1.	0.13	7.5	1.6	2.	11.
S237	NM341	Windmill #30	5	4	6/24/1997	<5.	0.344	0.014	0.253	650.	<0.1	3.4	14.	3.4	3.	0.21	9.3	<1.	8.	2.1
S238	NM342	Windmill #31	5	na	6/24/1997	<5.	0.315	0.008	0.289	117.	<0.1	13.	5.3	3.2	4.	0.62	0.8	<1.	8.	13.
		Zone 6: Southwestern Mountain Front																		
S022	NM009	Windmill #02	6	na	8/19/1996	3.	0.177	0.059	0.041	252.	0.4	9.3	nd	1.	2.	nd	3.0	0.4	nd	0.9
		Zone 7: Abo Arroyo																		
S021	NM261	Stock Well #01	7	na	6/23/1997	<5.	0.148	0.009	0.028	13.	<0.1	2.5	0.6	3.9	5.	0.14	3.0	1.3	3.	9.1
S024	NM011	Domestic Well #02	7	8	8/17/1996	4.	0.073	0.017	0.019	49.	<0.1	1.2	nd	10.	1.	nd	3.7	2.6	nd	3.2
S090	NM064	Domestic Well #08	7	na	8/19/1996	2.	0.160	0.016	0.049	4.	<0.1	1.5	nd	8.9	4.	nd	6.5	7.7	nd	7.9
S093	NM067	Domestic Well #09	7	8	8/15/1996	4.	0.063	0.081	0.034	2.	0.1	2.8	nd	18.	7.	nd	3.	23.	nd	1.2
		Zone 8: Eastern Mountain Front																		
S007	NM002	Domestic Well #01	8	na	6/21/1996	44.	0.014	0.043	0.015	nd	0.4	3.6	nd	2.	<1.	nd	1.6	<1.	nd	6.1
S013	NM256	Windmill #14	8	na	6/24/1997	5.	0.055	0.021	0.008	89.	0.3	0.4	2.5	0.4	2.	<0.05	0.4	<1.	<1.	<0.1
S014	NM257	Private Production Well #17	8	na	6/19/1997	4.	0.025	0.206	<0.001	55.	0.3	0.6	0.9	1.4	1.	0.14	1.0	1.	2.	3.3
S015	NM006	Windmill #01	8	na	8/24/1996	127.	0.022	0.052	0.008	28.	0.3	10	nd	2.4	<1.	nd	1.2	0.8	nd	1.0
S030	NM016	Charles 4	8	na	6/22/1996	26.	0.085	0.174	0.016	nd	0.2	0.6	nd	4.	<1.	nd	1.0	1.	nd	2.1
S030	NM017	Charles 4	8	na	6/27/1996	5.	0.063	0.158	0.014	nd	0.2	0.4	nd	4.	<1.	nd	0.7	1.	nd	1.8
S030	NM018	Charles 4	8	na	6/27/1996	4.	0.068	0.158	0.014	nd	0.1	0.4	nd	4.	<1.	nd	0.7	<1.	nd	1.9
S030	NM019	Charles 4	8	na	6/27/1996	4.	0.077	0.156	0.015	nd	0.1	0.4	nd	4.	<1.	nd	0.8	<1.	nd	1.9
S030	NM020	Charles 4	8	na	6/27/1996	7.	0.077	0.166	0.016	nd	0.1	0.3	nd	4.	<1.	nd	0.9	1.	nd	1.9
S030	NM021	Charles 4	8	na	6/27/1996	4.	0.079	0.167	0.017	nd	0.1	0.4	nd	4.	<1.	nd	0.9	1.	nd	2.0
S030	NM022	Charles 4	8	na	6/27/1996	9.	0.083	0.167	0.017	nd	0.2	0.5	nd	4.	<1.	nd	0.9	1.	nd	2.0
S030	NM023	Charles 4	8	na	6/27/1996	8.	0.088	0.168	0.017	nd	0.2	0.4	nd	4.	<1.	nd	1.0	1.	nd	2.0
S030	NM024	Charles 4	8	na	6/27/1996	4.	0.085	0.169	0.017	nd	0.1	0.3	nd	4.	<1.	nd	1.0	1.	nd	2.0
S042	NM031	Domestic Well #03	8	na	8/14/1996	5.	0.031	0.102	0.009	5.	<0.1	0.2	nd	9.3	7.	nd	3.6	16.	nd	2.2
S055	NM042	Elena Gallegos	8	na	6/25/1996	10.	0.030	0.049	0.023	nd	1.0	14	nd	2.	<2.	nd	1.0	<2.	nd	21.
S056	NM043	Embudito Spring	8	na	7/2/1996	5.	0.047	0.126	0.036	nd	<0.2	2.0	nd	3.	<2.	nd	<1.	<2.	nd	11.
S056	NM213	Embudito Spring	8	na	3/21/1997	1.	0.017	0.065	0.021	40.	0.1	1.0	0.6	1.9	<1.	0.40	1.5	0.4	<1.	8.2
S056	NM214	Embudito Spring	8	na	3/21/1997	1.	0.017	0.067	0.022	4.	0.1	1.0	0.4	1.8	<1.	<0.1	1.5	0.4	<1.	7.9
S056	NM227	Embudito Spring	8	na	4/29/1997	1.	0.021	0.062	0.022	50.	0.1	1.0	0.6	2.2	<1.	0.10	1.2	0.4	<1.	5.2
S056	NM239	Embudito Spring	8	na	5/27/1997	1.	0.021	0.064	0.026	35.	0.1	1.2	0.7	2.1	<1.	0.10	1.1	0.4	<1.	4.6
S056	NM364	Embudito Spring	8	na	7/17/1997	1.	0.005	0.044	0.013	104.	0.1	3.5	0.4	nd	<1.	<0.1	0.3	0.3	1.	3.2
S071	NM060	Domestic Well #07	8	na	6/19/1996	4.	0.022	0.071	0.011	nd	0.5	1.7	nd	1.	<1.	nd	0.7	<1.	nd	5.6
S083	NM407	Windmill #34	8	na	9/10/1997	3.	0.097	0.078	0.027	557.	1.1	1.7	3.9	8.	3.	<0.1	5.9	7.7	3.	4.1
S095	NM068	Kirtland 1	8	na	6/25/1996	4.	0.036	0.105	0.017	nd	0.1	0.6	nd	6.	<1.	nd	1.8	1.	nd	1.9
S106	NM295	Domestic Well #23	8	na	6/26/1997	9.	0.113	0.071	0.042	7.	0.1	3.7	7.6	9.6	1	<0.05	4.2	16.	2.	12.
S110	NM078	Love 1	8	na	6/22/1996	5.	0.029	0.101	0.016	nd	<0.1	0.6	nd	7.	<1.	nd	1.7	1.	nd	1.4
S113	NM080	Domestic Well #11	8	na	8/15/1996	6.	0.080	0.034	0.018	2.	<0.1	0.5	nd	36.	13.	nd	2.6	15.	nd	3.6
S114	NM500	Matheson D	8	na	7/31/1998	5.	0.024	0.090	0.019	7.	<0.05	0.1	0.7	1.	<1.	0.09	5.8	1.9	<1.	0.8
S115	NM501	Matheson M	8	na	8/1/1998	4.	0.026	0.061	0.017	6.	0.13	0.3	0.7	4.6	2.	0.05	6.5	1.9	<1.	4.0
S116	NM502	Matheson S	8	na	8/1/1998	4.	0.021	0.077	0.013	5.	<0.05	0.2	0.3	3.1	2.	0.05	1.7	0.8	<1.	2.3
S117	NM298	Domestic Well #25	8	na	6/17/1997	3.	0.022	0.057	0.007	12.	<0.1	0.9	0.1	1.4	4.	0.10	2.0	<1.	<1.	7.5
S118	NM299	Windmill #24	8	na	6/27/1997	5.	0.103	0.072	0.020	754.	0.9	5.9	4.1	3.9	3.	0.08	1.4	1.1	5.	4.5
S119	NM300	Domestic Well #26	8	11	6/19/1997	4.	0.064	0.045	0.052	21.	0.3	2.0	4.1	1.8	<1.	<0.05	4.6	<1.	2.	6.1
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	128.	0.332	0.003	0.035	4.	0.1	0.6	1.7	0.3	<1.	0.12	22.	30.	<1.	1.9
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	6.	0.040	0.053	0.042	4.	0.07	0.2	6.3	14.	2.	0.10	6.9	8.8	2.	7.2

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S140	NM306	MRN 1	8	na	7/5/1997	4.	0.043	0.081	0.037	29.	<0.1	2.6	3.9	6.8	4.	0.09	4.2	1.6	2.	4.7
S141	NM095	National Utility 7	8	na	8/14/1996	4.	0.044	0.067	0.003	3.	<0.1	0.6	nd	3.7	<1.	nd	0.7	0.7	nd	0.8
S149	NM312	Nor Este D	8	na	7/3/1997	10.	0.405	0.056	0.185	5.	<0.1	0.4	9.9	35.	<1.	0.09	8.6	54.	1.	2.0
S150	NM313	Nor Este M	8	na	7/2/1997	7.	0.262	0.057	0.320	20.	0.1	1.5	7.3	26.	<1.	0.15	3.7	38.	1.	1.4
S162	NM317	Stock Well #03	8	na	6/30/1997	5.	0.017	0.031	<0.001	22.	0.2	0.4	0.1	7.	3.	0.60	0.4	<1.	1.	0.6
S163	NM318	PL 2	8	na	7/7/1997	9.	0.033	0.075	<0.001	32.	<0.1	1.8	1.2	6.3	3.	0.10	3.2	1.1	1.	2.7
S164	NM106	Ponderosa 1	8	na	6/20/1996	4.	0.126	0.199	0.053	nd	0.1	0.3	nd	2.7	<1.	nd	3.2	17.	nd	7.0
S165	NM328	Windmill #25	8	na	6/24/1997	3.	0.104	0.015	0.015	102.	5.5	5.7	5.0	18.	6.	0.09	3.7	3.1	2.	8.1
S168	NM319	Domestic Well #30	8	na	6/27/1997	9.	0.039	0.044	<0.001	8.	0.3	1.0	0.7	44.	19.	<0.05	2.1	11.	2.	1.2
S170	NM108	Ridgecrest 3	8	na	6/22/1996	6.	0.030	0.159	0.015	nd	<0.1	0.7	nd	8.	1.	nd	1.2	2.	nd	1.6
S170	NM412	Ridgecrest 3	8	na	11/18/1997	6.	0.037	0.145	0.015	2.	<0.1	0.5	1.7	7.8	2.	<0.1	1.2	2.7	2.	1.7
S195	NM134	Domestic Well #13	8	na	8/14/1996	4.	0.038	0.068	0.01	3.	<0.1	0.4	nd	21.	6.	nd	2.9	3.8	nd	3.1
S199	NM138	Windmill #08	8	na	8/23/1996	4.	0.034	0.053	0.013	1,140.	1.0	7.6	nd	3.9	4.	nd	1.4	1.7	nd	16.
S209	NM336	Domestic Well #33	8	na	6/27/1997	4.	0.118	0.061	0.029	13.	0.2	1.1	3.6	4.	<1.	<0.05	5.9	13.7	3.	13.
S212	NM141	Sandia Peak 1	8	na	6/26/1996	6.	0.022	0.050	0.014	nd	0.8	0.7	nd	1.	<1.	nd	0.8	<1.	nd	2.1
S213	NM142	Sandia Peak 3	8	na	6/26/1996	5.	0.029	0.065	0.016	nd	1.0	0.8	nd	1.3	<1.	nd	0.8	<1.	nd	4.4
S224	NM148	Domestic Well #14	8	na	8/23/1996	3.	0.029	0.088	0.011	165.	1.3	0.5	nd	3.8	<1.	nd	2.3	12.	nd	2.1
S229	NM515	SH03 UNM	8	na	7/28/1998	4.	0.020	0.055	0.009	3.	0.05	0.4	0.5	1.2	<1.	0.09	2.0	0.5	1.	15.
S233	NM153	Domestic Well #16	8	na	8/23/1996	2.	0.121	0.107	0.066	8.	0.2	0.3	nd	6.7	2.	nd	2.8	18.	nd	4.3
S239	NM156	Domestic Well #17	8	na	8/17/1996	3.	0.052	0.064	0.023	6.	<0.1	0.8	nd	2.8	<1.	nd	3.1	2.4	nd	4.4
S240	NM157	Domestic Well #18	8	na	6/19/1996	5.	0.019	0.044	0.015	nd	2.0	1.0	nd	1.9	<1.	nd	0.5	<1.	nd	3.2
S246	NM343	Windmill #32	8	na	6/24/1997	4.	0.049	0.043	<0.001	239.	0.2	2.3	0.9	3.6	1	0.20	1.1	<1.	2.	1.3
S247	NM161	Domestic Well #19	8	na	8/15/1996	6.	0.134	0.005	0.010	<1.	<0.1	0.2	nd	35.	13.	nd	4.5	5.2	nd	6.7
S248	NM162	Thomas 6	8	na	6/21/1996	4.	0.103	0.176	0.024	2.	<0.1	0.3	nd	3.	<1.	nd	3.7	6.	nd	4.3
S255	NM523	Tramway East	8	na	7/30/1998	3.	0.022	0.046	0.033	63.	0.11	0.4	0.4	1.9	<1.	<0.05	1.5	0.7	1.	3.2
S264	NM174	Walker 1	8	na	6/18/1996	3.	0.040	0.093	0.041	1.	<0.1	0.3	nd	2.7	1.	nd	1.4	19.	nd	2.3
S274	NM177	Domestic Well #20	8	na	8/15/1996	3.	0.084	0.082	0.026	2.	<0.1	0.1	nd	8.2	5.	nd	2.2	4.5	nd	3.7
		Zone 9: Tijeras Fault Zone																		
S041	NM029	Coyote Spring	9	na	6/28/1996	122.	1.23	0.104	2.52	nd	<0.5	5.0	nd	2.	<2.	nd	<2.	<5.	nd	6.6
S072	NM061	Hubbell Spring	9	8	8/23/1996	3.	0.126	0.028	0.036	117.	<0.1	1.1	nd	14.	1.	nd	8.5	3.7	nd	6.4
S098	NM071	KAFB-1902	9	na	6/28/1996	7.	0.418	0.037	0.223	nd	<0.5	44.	nd	<1.	<2.	nd	16.	<2.	nd	8.0
S197	NM136	Windmill #06	9	na	8/23/1996	2.	0.426	0.014	0.079	112.	<0.1	1.5	nd	7.8	<1.	nd	1.5	2.3	nd	2.7
S227	NM151	SFR 3D	9	na	8/24/1996	5.	0.276	0.060	0.341	9.	0.2	3.6	nd	5.8	2.	nd	2.8	1.6	nd	19.
S228	NM152	SFR 3S	9	na	8/24/1996	6.	0.270	0.055	0.230	11.	0.7	50.	nd	6.8	2.	nd	4.6	1.7	nd	15.
		Zone 10: Tijeras Arroyo																		
S001	NM001	4Hills-1	10	8	6/29/1996	5.	0.082	0.046	0.027	nd	<0.2	2.0	nd	1.	<2.	nd	2.0	<2.	nd	7.8
S002	NM250	Private Production Well #15	10	8	7/3/1997	4.	0.054	0.050	<0.001	2.	0.1	0.8	0.5	1.8	1.	0.09	1.2	<1.	3.	4.5
S058	NM277	Eubank 1	10	8	7/4/1997	5.	0.041	0.043	0.013	7.	<0.1	2.8	0.3	3.9	4.	0.11	2.0	<1.	2.	3.7
S096	NM069	Kirtland 11	10	8	6/25/1996	4.	0.061	0.065	0.025	nd	<0.1	1.0	nd	5.	<1.	nd	1.9	<1.	nd	3.3
S107	NM075	Lomas 1	10	8	6/22/1996	<1.	0.030	0.106	0.017	nd	<0.1	0.3	nd	3.	<1.	nd	0.4	<1.	nd	2.7
S107	NM410	Lomas 1	10	na	11/18/1997	22.	0.031	0.089	0.017	2.	<0.1	0.8	0.3	2.8	<1.	<0.1	0.5	<1.	4.	3.7
		Zone 11: Northeastern																		
S016	NM258	Windmill #15	11	na	6/18/1997	<5.	0.439	0.013	0.070	259.	0.3	4.6	4.1	30.	16.	<0.1	31.	155.	14.	8.5
S017	NM259	Windmill #16	11	na	6/18/1997	4.	0.473	0.023	<0.001	442.	<0.1	4.2	0.4	1.5	1.	0.08	12.	1.0	3.	12.
S053	NM276	Private Production Well #18	11	na	6/25/1997	<5.	0.143	0.012	0.044	41.	<0.1	2.9	2.0	3.3	5.	0.19	5.7	1.9	5.	3.2
S144	NM097	Private Production Well #06	11	na	8/28/1996	2.	0.074	0.014	0.178	86.	0.1	1.4	nd	6.1	3.	nd	7.7	7.5	nd	14.
S204	NM332	Windmill #28	11	na	7/3/1997	4.	0.060	0.036	<0.001	263.	0.2	4.5	1.1	3.0	1.	0.08	9.4	2.0	3.	2.9
S207	NM334	Private Production Well #22	11	na	7/3/1997	<5.	0.117	0.010	0.040	22.	0.8	3.7	2.2	3.8	12.	0.22	4.7	2.3	5.	4.2

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S223	NM338	Windmill #29	11	na	6/25/1997	2.	0.215	0.013	0.033	100.	<0.1	1.2	0.9	9.2	<1.	0.09	4.7	2.2	4.	9.0
		Zone 12: Central																		
S011	NM004	Atris-1	12	na	6/22/1996	11.	0.064	0.073	0.042	nd	<0.1	0.8	nd	<1.	<1.	nd	4.4	5.	nd	1.3
S012	NM005	Atrisco 3	12	3	6/20/1996	5.	0.149	0.460	0.064	nd	<0.1	0.3	nd	19.	<1.	nd	5.1	9.	nd	4.7
S025	NM012	Burton 2	12	na	6/19/1996	5.	0.088	0.123	0.027	nd	<0.1	0.3	nd	8.	<1.	nd	3.4	4.	nd	3.8
S026	NM013	Burton 5	12	na	6/19/1996	5.	0.085	0.140	0.036	nd	<0.1	0.2	nd	8.	<1.	nd	3.7	6.	nd	2.8
S033	NM025	Private Production Well #02	12	na	8/21/1996	4.	0.098	0.147	0.017	3.	0.5	1.0	nd	5.2	1.	nd	2.7	3.5	nd	6.9
S040	NM028	Coronado 1	12	na	6/18/1996	6.	0.201	0.094	0.256	nd	0.1	1.1	nd	26.	3.	nd	4.4	27.	nd	1.4
S043	NM267	Del Sol D	12	na	7/1/1997	7.	0.286	0.108	<0.001	6.	<0.1	0.2	7.0	28.	8.	<0.05	5.8	38.	2.	4.2
S043	NM488	Del Sol D	12	na	7/21/1998	5.	0.164	0.093	0.127	2.	<0.05	0.3	6.8	29.	7.	<0.05	4.9	38.	2.	4.5
S044	NM268	Del Sol M	12	na	6/26/1997	7.	0.304	0.116	<0.001	3.	0.1	2.6	6.6	4.4	2.	0.23	7.2	9.6	1.	12.
S044	NM489	Del Sol M	12	na	7/21/1998	4.	0.191	0.097	0.070	1.	<0.05	<0.1	6.4	4.1	1.	0.07	6.6	9.5	1.	14.
S045	NM269	Del Sol S	12	na	6/26/1997	6.	0.059	0.220	<0.001	4.	<0.1	1.3	5.6	4.3	<1.	0.16	2.9	3.3	12.	1.8
S045	NM490	Del Sol S	12	na	7/21/1998	3.	0.039	0.174	0.028	3.	<0.05	0.4	5.5	3.8	<1.	0.07	2.0	3.8	13.	1.8
S046	NM032	Duranes 1	12	na	6/20/1996	4.	0.126	0.068	0.135	nd	0.1	0.5	nd	24.	<1.	nd	2.2	16.	nd	10.
S046	NM033	Duranes 1	12	na	6/29/1996	4.	0.136	0.069	0.150	nd	<0.1	0.5	nd	14.	<1.	nd	2.3	11.	nd	15.
S046	NM034	Duranes 1	12	na	6/29/1996	4.	0.132	0.074	0.152	nd	<0.1	1.4	nd	14.	<1.	nd	2.3	11.	nd	15.
S046	NM035	Duranes 1	12	na	6/29/1996	4.	0.136	0.077	0.152	nd	<0.1	0.6	nd	14.	<1.	nd	2.2	11.	nd	15.
S046	NM036	Duranes 1	12	na	6/29/1996	4.	0.140	0.081	0.158	nd	<0.1	0.5	nd	14.	<1.	nd	2.1	11.	nd	15.
S046	NM037	Duranes 1	12	na	6/29/1996	6.	0.136	0.084	0.163	nd	<0.1	0.5	nd	14.	<1.	nd	2.1	11.	nd	14.
S046	NM038	Duranes 1	12	na	6/29/1996	4.	0.142	0.087	0.162	nd	<0.1	4.8	nd	14.	<1.	nd	2.1	11.	nd	15.
S046	NM039	Duranes 1	12	na	6/29/1996	4.	0.140	0.090	0.166	nd	<0.1	0.5	nd	13.	<1.	nd	2.1	11.	nd	14.
S046	NM040	Duranes 1	12	na	6/29/1996	4.	0.145	0.091	0.167	nd	<0.1	0.4	nd	13.	1.	nd	2.0	11.	nd	14.
S047	NM270	Duranes 7	12	na	6/26/1997	6.	0.086	0.052	0.050	21.	0.4	0.7	8.0	14.	3.	0.10	4.0	7.3	<1.	6.0
S048	NM271	Duranes Yard 1	12	na	7/5/1997	5.	0.069	0.062	0.034	6.	<0.1	0.4	7.3	5.1	2.	0.46	5.6	4.6	<1.	4.3
S049	NM272	Duranes Yard 2	12	na	7/5/1997	5.	0.070	0.100	0.036	6.	<0.1	0.3	4.5	0.6	3.	0.24	4.2	3.2	<1.	2.8
S050	NM273	Duranes Yard 3	12	na	7/5/1997	5.	0.063	0.108	0.032	6.	<0.1	11	4.6	0.9	3.	0.13	4.0	4.5	<1.	3.9
S051	NM274	Duranes Yard 4	12	na	7/5/1997	7.	0.059	0.104	0.032	6.	0.1	7.9	2.4	2.9	3.	0.22	3.8	5.3	<1.	6.2
S052	NM275	Duranes Yard 5	12	na	7/5/1997	6.	0.063	0.084	0.028	10.	0.1	5.8	2.1	1.8	3.	0.14	4.2	5.5	<1.	1.6
S060	NM279	Garfield D	12	3	6/19/1997	8.	0.261	0.040	<0.001	2.	<0.1	0.1	4.4	37.	2.	<0.05	3.0	51.	<1.	3.6
S061	NM280	Garfield M	12	na	6/19/1997	5.	0.171	0.069	<0.001	18.	<0.1	<0.1	5.9	12.	<1.	0.07	5.0	22.	<1.	2.9
S062	NM281	Garfield S	12	na	6/19/1997	4.	0.107	0.041	<0.001	7.	<0.1	0.4	8.2	0.2	1.	0.45	4.9	4.7	<1.	14.
S062	NM491	Garfield S	12	na	7/28/1998	4.	0.09	0.040	0.065	3.	0.07	1.1	7.9	<0.1	<1.	0.43	4.8	4.9	<1.	12.
S064	NM283	Domestic Well #22	12	na	6/20/1997	5.	0.052	0.073	0.033	16.	0.5	0.5	11.	7.6	4.	0.12	4.0	4.5	2.	4.1
S068	NM057	Griegos 3	12	na	6/21/1996	4.	0.089	0.058	0.074	nd	<0.1	0.2	nd	14.	<1.	nd	3.4	6.	nd	4.1
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	6.	0.378	0.043	<0.001	5.	<0.1	0.0	5.1	17.	4.	<0.05	15.	5.9	<1.	8.5
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	4.	0.056	0.069	0.030	10.	<0.1	0.3	7.1	7.4	8.	0.22	4.4	4.0	<1.	4.4
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	6.	0.101	0.043	<0.001	6.	<0.1	0.3	7.3	6.2	2.	0.09	8.3	3.6	2.	3.9
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	4.	0.080	0.040	<0.001	9.	<0.1	0.2	12.	3.7	2.	0.22	9.0	2.7	<1.	2.8
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	5.	0.085	0.031	<0.001	4.	<0.1	0.1	10.	4.5	<1.	0.21	8.5	2.8	<1.	2.0
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	5.	0.087	0.034	<0.001	3.	0.1	0.3	10.	5.1	2.	0.05	4.3	3.1	2.	2.4
S081	NM292	Private Production Well #19	12	na	7/2/1997	4.	0.079	0.060	0.049	11.	0.1	2.8	7.9	10.	<1.	<0.05	5.1	4.6	<1.	4.0
S084	NM063	Windmill #04	12	na	8/21/1996	3.	0.089	0.045	0.049	377.	2.7	0.8	nd	12.	2.	nd	4.6	3.5	nd	12.
S087	NM493	Isleta MD	12	3	7/29/1998	8.	0.142	0.028	0.045	1.	<0.05	0.2	5.1	41.	<1.	<0.05	7.0	43.	<1.	8.9
S088	NM494	Isleta MS	12	na	7/29/1998	5.	0.056	0.058	0.030	2.	<0.05	0.2	6.6	4.9	<1.	0.13	4.6	5.8	<1.	1.5
S089	NM495	Isleta S	12	na	7/29/1998	4.	0.126	0.169	0.069	3.	<0.05	0.7	5.2	<0.1	<1.	0.21	7.6	3.2	<1.	1.9
S092	NM066	JMC-1	12	na	6/28/1996	11.	0.094	0.078	0.044	nd	0.1	1.2	nd	5.	<1.	nd	0.7	2.	nd	11.
S097	NM070	Kirtland 14	12	na	6/25/1996	6.	0.079	0.128	0.021	nd	<0.1	0.5	nd	10	<1.	nd	2.3	4.	nd	2.2

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S100	NM073	LALF-9	12	na	6/29/1996	3.	0.107	0.195	0.042	nd	<0.2	<1.	nd	<1.	<2.	nd	4.	2.	nd	8.0
S102	NM074	Leyendecker 1	12	na	6/21/1996	4.	0.049	0.083	0.029	nd	<0.1	0.3	nd	4.	<1.	nd	4.1	5.	nd	2.4
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	7.	0.040	0.042	0.035	15.	<0.1	1.0	5.9	15.	2.	0.08	16.	11.	3.	21.
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	8.	0.063	0.016	0.051	14.	<0.1	1.2	4.0	6.9	2.	0.13	35.	14.	2.	33.
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	51.	0.351	0.002	0.039	2.	0.06	0.3	1.3	<0.1	<1.	<0.05	9.9	45.	<1.	0.2
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	29.	0.323	0.002	0.056	5.	<0.1	0.7	1.1	0.1	<1.	<0.05	7.6	23.	<1.	1.6
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	20.	0.349	0.002	0.069	1.	<0.05	0.2	0.9	<0.1	<1.	<0.05	4.4	27.	<1.	0.6
S123	NM081	MONT - 5A	12	na	6/27/1996	6.	0.072	0.090	0.027	nd	<0.1	0.7	nd	6.	<1.	nd	1.7	4.	nd	5.1
S124	NM082	Montaňo 2 D	12	na	6/19/1996	6.	0.067	0.088	0.051	nd	<0.1	0.6	nd	7.	<1.	nd	6.6	4.	nd	6.0
S125	NM083	Montaňo 2 M	12	na	6/19/1996	5.	0.086	0.141	0.056	nd	<0.1	0.6	nd	5.	<1.	nd	8.5	3.	nd	10.
S126	NM084	Montaňo 2 S	12	na	6/19/1996	8.	0.081	0.062	0.057	nd	<0.1	1.0	nd	<1.	<1.	nd	7.2	4.	nd	0.4
S127	NM085	Montaňo 4 D	12	na	6/20/1996	5.	0.062	0.132	0.033	nd	<0.1	0.9	nd	6.	<1.	nd	3.9	5.	nd	6.4
S128	NM086	Montaňo 4 M	12	na	6/19/1996	6.	0.140	0.060	0.067	nd	<0.2	1.0	nd	3.	<2.	nd	11.	3.	nd	19.
S130	NM088	Montaňo 5 D	12	na	6/24/1996	10.	0.063	0.065	0.044	nd	<0.1	0.8	nd	6.	<1.	nd	6.8	4.	nd	2.3
S131	NM089	Montaňo 5 M	12	na	6/24/1996	7.	0.055	0.085	0.031	nd	<0.1	0.5	nd	0.5	<1.	nd	4.5	4.	nd	5.5
S132	NM090	Montaňo 5 S	12	na	6/24/1996	12.	0.048	0.074	0.023	nd	<0.1	4.8	nd	4.5	<1.	nd	3.5	2.9	nd	1.9
S133	NM091	Montaňo 6 D	12	na	6/18/1996	6.	0.120	0.093	0.110	nd	<0.1	0.6	nd	<1.	<1.	nd	5.6	4.4	nd	4.2
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	14.	0.070	0.064	0.058	nd	0.1	0.9	nd	11.	<1.	nd	1.8	6.	nd	3.3
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	15.	0.044	0.066	0.040	nd	<0.1	0.3	nd	9.6	<1.	nd	3.4	6.	nd	2.3
S136	NM094	Montaňo 6 S	12	na	6/18/1996	7.	0.068	0.071	0.040	nd	<0.1	0.8	nd	4.8	<1.	nd	11	3.8	nd	5.4
S137	NM506	Montesa M	12	na	7/27/1998	4.	0.090	0.098	0.087	3.	<0.05	0.2	7.6	10.	<1.	0.07	4.0	16.	<1.	2.1
S138	NM507	Montesa S	12	na	7/27/1998	5.	0.054	0.080	0.014	9.	<0.05	0.4	6.5	7.3	1.	<0.05	5.1	2.8	<1.	1.6
S139	NM305	Domestic Well #27	12	na	6/17/1997	5.	0.086	0.056	0.035	26.	0.3	0.5	12.	12.	5.	0.08	2.7	6.1	<1.	7.5
S142	NM307	Domestic Well #28	12	na	6/17/1997	3.	0.049	0.083	<0.001	42.	<0.1	0.2	11.	7.4	<1.	0.08	4.4	3.7	<1.	2.4
S146	NM309	NM Utilities 2	12	na	6/18/1997	3.	0.064	0.062	0.042	9.	0.4	0.7	9.1	18.	<1.	<0.05	2.6	11.	<1.	3.2
S151	NM314	Nor Este S	12	na	7/2/1997	8.	0.132	0.071	0.083	11.	<0.1	0.2	4.5	13.	<1.	0.21	16.	23.	<1.	3.4
S151	NM508	Nor Este S	12	na	7/20/1998	16.	0.118	0.084	0.100	2.	<0.05	0.2	5.3	11.	<1.	0.18	17.	22.	<1.	5.0
S153	NM315	Open Space	12	10	6/17/1997	4.	0.042	0.113	<0.001	20.	0.8	3.4	3.6	5.3	2.	2.4	3.5	2.0	<1.	0.7
S153	NM411	Open Space	12	na	11/18/1997	3.	0.043	0.108	0.010	20.	1.3	6.7	3.5	5.	2.	<0.1	3.5	2.2	<1.	0.7
S154	NM099	ORLF-2	12	na	6/27/1996	4.	0.066	0.066	0.048	nd	<0.1	0.8	nd	5.3	<1.	nd	3.6	8.	nd	3.2
S155	NM316	Domestic Well #29	12	na	6/27/1997	4.	0.047	0.062	<0.001	4.	0.1	0.9	4.0	9.	<1.	<0.05	3.0	4.5	<1.	1.9
S156	NM100	Paseo 2D	12	na	6/26/1996	23.	0.063	0.084	0.033	nd	<0.1	1.1	nd	2.7	<1.	nd	2.0	3.1	nd	2.1
S157	NM101	Paseo 2MD	12	na	6/26/1996	13.	0.068	0.057	0.041	nd	<0.1	0.5	nd	<1.	<1.	nd	4.7	3.8	nd	1.3
S158	NM102	Paseo 2MS	12	na	6/26/1996	6.	0.094	0.063	0.058	nd	<0.1	0.4	nd	<1.	<1.	nd	6.4	6.8	nd	0.2
S159	NM103	Paseo 2S	12	na	6/26/1996	6.	0.098	0.217	0.065	nd	<0.2	1.0	nd	2.	<2.	nd	2.0	2.	nd	10.
S160	NM104	Paseo 3D	12	na	6/21/1996	4.	0.050	0.071	0.030	nd	<0.1	2.1	nd	2.	<1.	nd	3.5	5.	nd	1.6
S161	NM105	Paseo 3M	12	na	6/21/1996	6.	0.101	0.067	0.061	nd	<0.2	2.0	nd	2.	<2.	nd	8.	<2.	nd	7.6
S171	NM321	Ridgecrest 4	12	na	6/26/1997	5.	0.072	0.185	<0.001	1.	<0.1	0.7	3.2	6.8	2.	0.12	1.6	2.6	1.	2.8
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	5.	0.095	0.038	0.071	5.	<0.1	0.6	5.9	15.	<1.	<0.05	9.9	21.	<1.	4.3
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	7.	0.058	0.151	0.041	nd	<0.2	1.0	nd	<1.	<2.	nd	7.	7.	nd	1.4
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	4.	0.210	0.089	0.098	nd	0.2	0.3	nd	17.	<1.	nd	4.2	23.	nd	3.3
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	5.	0.237	0.119	0.130	nd	0.2	0.6	nd	11.	<1.	nd	2.1	10.	nd	10.
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	4.	0.137	0.087	0.072	nd	0.2	8.7	nd	6.7	<1.	nd	11.	9.5	nd	7.8
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	10.	0.060	0.149	0.026	nd	0.2	0.2	nd	1.	<1.	nd	2.3	7.4	nd	2.7
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	4.	0.084	0.074	0.033	nd	0.1	0.7	nd	6.3	<1.	nd	1.0	4.7	nd	3.9
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	4.	0.131	0.081	0.039	2.	<0.1	0.2	nd	12.	1.	nd	5.8	15.	nd	5.6
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	4.	0.059	0.091	0.026	2.	<0.1	0.1	nd	12.	<1.	nd	3.2	6.8	nd	3.1
S190	NM325	Rio Rancho 2	12	na	6/20/1997	3.	0.052	0.086	<0.001	2.	<0.1	0.9	8.3	5.2	1.	0.08	3.6	5.3	<1.	2.5
S203	NM331	Private Production Well #20	12	na	7/3/1997	14.	0.064	0.150	0.018	23.	0.3	2.2	1.9	3.2	<1.	0.07	3.5	2.9	2.	6.3

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S205	NM333	Private Production Well #21	12	na	7/3/1997	4.	0.024	0.112	<0.001	2.	<0.1	0.1	1.5	16.	<1.	0.05	4.3	12.	<1.	0.8
S208	NM140	San Jose 2	12	3	6/20/1996	7.	0.175	0.086	0.107	nd	<0.1	0.4	nd	21.	3.	nd	4.6	21.	nd	2.8
S210	NM511	Sandia D	12	na	7/30/1998	16.	0.150	0.064	0.119	3.	<0.05	0.4	7.1	14.	2.	0.24	20	27.	2.	5.3
S214	NM513	Sandia S	12	na	7/30/1998	10.	0.056	0.156	0.061	6.	<0.05	0.9	17.	4.4	<1.	0.14	6.6	6.0	1.	4.7
S220	NM147	Santa Barbara 1	12	na	6/19/1996	6.	0.061	0.102	0.047	nd	<0.1	0.2	nd	8.2	<1.	nd	4.0	11.	nd	2.4
S220	NM337	Santa Barbara 1	12	na	6/26/1997	4.	0.060	0.106	<0.001	6.	<0.1	0.4	6.3	8.1	<1.	<0.05	4.0	11.	<1.	2.7
S231	NM517	Sierra Vista M	12	3	7/22/1998	7.	0.105	0.035	0.080	3.	0.07	0.2	4.6	29.	<1.	0.08	5.1	23.	<1.	3.7
S232	NM518	Sierra Vista S	12	na	7/22/1998	6.	0.076	0.072	0.042	3.	0.13	0.3	4.9	6.8	<1.	0.20	15.	5.9	3.	6.7
S234	NM339	Sister Cities D	12	na	6/30/1997	4.	0.324	0.097	0.172	9.	<0.1	0.5	8.3	25.	4.	0.25	7.9	29.	1.	2.9
S235	NM340	Sister Cities M	12	na	6/27/1997	4.	0.046	0.085	<0.001	1.	<0.1	0.1	4.1	4.5	<1.	0.21	5.1	8.5	<1.	2.6
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	9.	0.074	0.031	0.021	15.	0.1	0.9	nd	<1.	<1.	nd	10.	7.	nd	1.0
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	4.	0.068	0.061	0.020	12.	<0.1	0.7	nd	<1.	<1.	nd	10.	5.	nd	0.2
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	18.	0.072	0.061	0.017	79.	4.7	0.9	nd	<1.	<1.	nd	9.4	5.	nd	0.3
S253	NM522	Tome D	12	na	8/6/1998	6.	0.117	0.075	0.091	6.	<0.05	<0.1	4.8	6.8	<1.	<0.05	9.3	16.	1.	5.7
S257	NM344	Domestic Well #34	12	na	6/17/1997	2.	0.175	0.115	0.057	12.	<0.1	1.6	9.2	9.6	4.	0.08	2.1	8.7	3.	6.0
S259	NM171	VGP-1	12	na	6/27/1996	5.	0.142	0.071	0.071	nd	<0.2	<1.	nd	<1.	<2.	nd	7.	7.	nd	5.3
S261	NM172	Vol Andia 2	12	na	6/21/1996	5.	0.047	0.090	0.022	3.	0.6	0.4	nd	4.3	<1.	nd	3.3	6.	nd	2.1
S262	NM173	Vol Andia 5	12	na	6/18/1996	3.	0.045	0.090	0.029	2.	<0.1	0.2	nd	5.7	1.	nd	3.4	7.	nd	2.9
S265	NM175	Webster 1	12	na	6/18/1996	4.	0.157	0.077	0.150	2.	<0.1	0.2	nd	22.	2.	nd	5.5	35.	nd	2.3
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	<1.	0.111	0.050	0.042	17.	<0.1	0.3	8.9	22.	<1.	<0.05	2.2	13.	<1.	4.2
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	2.	0.080	0.055	0.028	9.	<0.1	0.1	8.6	12.	<1.	0.22	2.9	6.8	<1.	4.0
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	104.	0.067	0.067	0.027	6.	<0.1	0.3	7.9	8.2	<1.	0.23	7.5	5.4	<1.	4.3
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	8.	0.058	0.063	<0.001	4.	<0.1	0.4	8.3	7.8	1.	0.07	7.5	4.7	<1.	4.3
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	229.	0.059	0.060	<0.001	2.	<0.1	0.7	4.3	1.0	6.	0.22	2.2	3.3	<1.	2.8
S275	NM178	Yale 1	12	na	6/19/1996	3.	0.08	0.111	0.035	15.	0.1	0.2	nd	7.8	1.	nd	4.5	7.	nd	2.8
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	7.	0.078	0.063	0.051	nd	<0.1	0.3	nd	<1.	<1.	nd	9.5	8.	nd	0.1
SXXX	NM048	Geoprobe #1 (30.5')	12	na	7/1/1996	7.	0.168	0.067	0.041	nd	<0.1	0.4	nd	<1.	<1.	nd	5.4	8.	nd	0.2
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	13.	0.075	0.073	0.049	nd	<0.1	0.2	nd	<1.	<1.	nd	6.4	7.	nd	0.3
		Zone 13: Discharge																		
S143	NM096	Private Production Well #05	13	na	8/19/1996	4.	0.560	0.021	0.326	16.	0.1	0.7	nd	6.9	2.	nd	11.	12.	nd	1.3
S194	NM327	Domestic Well #32	13	na	6/30/1997	<5.	0.280	0.030	0.152	4.	<0.1	1.7	18.	7.1	20.	<0.1	4.2	7.9	5.	3.9
S226	NM150	Domestic Well #15	13	na	8/19/1996	9.	0.700	0.016	0.400	42.	<0.5	9.1	nd	11.	10.	nd	9.3	2.6	nd	5.2
		No Zone: Exotic Water																		
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	326.	3.33	0.035	2.87	170.	4.2	<10.	300.	<10.	2,200.	<5.	4.1	13.	23.	24.
S023	NM010	Burn Site Well	E	E	6/25/1996	9.	0.113	0.074	0.048	nd	1.6	2.0	nd	2.	<2.	nd	2.0	<2.	nd	5.7
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	1.	1.65	0.019	1.70	76.	<1.	7.1	nd	36.	14.	nd	20.	610.	nd	5.5
S038	NM265	Windmill #19	E	E	7/1/1997	<5.	1.09	0.005	0.458	16.	<1.	6.2	2.9	2.2	33.	0.68	6.5	<10.	<10.	<1.
S054	NM041	Domestic Well #04	E	E	8/17/1996	33.	5.00	0.046	5.70	14.	0.9	5.6	nd	17.	13.	nd	0.7	33.	nd	0.1
S057	NM044	Embudo Spring	E	E	7/2/1996	5.	0.039	0.095	0.021	nd	<0.2	<1.	nd	<1.	<2.	nd	<1.	<2.	nd	7.7
S057	NM215	Embudo Spring	E	E	3/21/1997	1.	0.023	0.090	0.019	114.	0.3	0.9	0.7	1.2	<1.	0.10	1.0	0.3	1.	15.
S057	NM228	Embudo Spring	E	E	4/29/1997	1.	0.028	0.063	0.015	85.	0.1	0.8	0.6	1.5	<1.	0.10	1.5	0.3	<1.	10.
S057	NM241	Embudo Spring	E	E	5/27/1997	1.	0.026	0.063	0.016	50.	0.1	0.7	0.6	1.0	<1.	0.10	1.1	0.3	<1.	4.7
S057	NM242	Embudo Spring	E	E	5/27/1997	1.	0.019	0.061	0.014	1.	0.1	0.6	0.3	1.3	<1.	0.20	1.4	0.3	<1.	7.0
S057	NM365	Embudo Spring	E	E	7/17/1997	1.	0.005	0.029	0.006	52.	0.1	0.4	0.2	nd	<1.	<0.1	0.4	0.2	1.	3.9
S063	NM282	Windmill #22	E	E	6/28/1997	<5.	0.088	0.017	0.076	194.	0.2	2.0	9.5	0.7	8.	0.66	8.0	1.1	3.	19.
S067	NM284	Granite Hill	E	E	7/4/1997	4.	0.093	0.030	<0.001	2.	<0.1	0.2	5.2	0.1	1.	0.10	3.8	<1.	1.	6.7
S070	NM059	HERTF	E	E	6/28/1996	7.	0.081	0.054	0.037	nd	0.8	4.0	nd	<1.	<2.	nd	13.	<2.	nd	9.1
S091	NM496	Private Production Well #23	E	E	8/4/1998	6.	0.471	0.368	0.469	7.	<0.05	0.4	12.	<0.1	<1.	0.10	9.0	20.	<1.	0.2

Table A4. Summary of trace-element chemistry-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secon-dary hydro-chemical zone	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)
S094	NM293	Stock Well #02	E	E	6/20/1997	<5.	0.213	0.003	0.103	17.	<0.1	1.9	1.6	2.0	<2.	0.14	2.6	1.4	11.	15.
S099	NM072	LALF-1	E	E	6/29/1996	3.	0.171	0.138	0.092	nd	<0.2	<1.	nd	<1.	<2.	nd	8.	8.	nd	1.2
S112	NM296	Domestic Well #24	E	E	6/21/1997	5.	0.141	0.062	0.117	564.	0.2	0.7	46.	0.4	4.	0.23	70.	56.	<1.	0.13
S112	NM297	Domestic Well #24	E	E	6/21/1997	<5.	0.144	0.054	0.147	586.	1.3	1.2	43.	0.6	2.	<0.1	61.	52.	1.	0.10
S129	NM087	Montaňo 4 S	E	E	6/19/1996	3.	0.131	0.044	0.132	nd	<0.2	2.0	nd	<1.	<2.	nd	4.0	6.	nd	77.
S152	NM098	Private Production Well #07	E	E	8/22/1996	5.	0.470	0.051	0.133	63.	0.8	4.3	nd	6.9	1.	nd	0.3	5.9	nd	12.
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	5.	0.190	0.031	0.091	nd	<0.2	1.0	nd	5.	<2.	nd	6.	2.	nd	10.
S202	NM330	Windmill #27	E	E	7/2/1997	4.	0.143	0.016	0.022	739.	<0.1	3.2	5.1	0.1	<1.	0.15	8.0	<1.	18.	3.1
S211	NM512	Sandia M	E	E	7/30/1998	9.	0.263	0.058	0.217	3.	<0.05	0.2	11.	20.	2.	0.13	8.2	47.	2.	2.8
S225	NM149	SBM-1	E	E	6/29/1996	7.	0.222	0.042	0.081	nd	<0.2	3.0	nd	3.	<2.	nd	nd	3.	nd	45.
S249	NM163	Private Production Well #09	E	E	6/26/1996	4.	0.024	0.009	0.011	183.	2.1	3.4	nd	<1.	<1.	nd	2.9	7.	nd	74.
S249	NM164	Private Production Well #09	E	E	6/26/1996	5.	0.021	0.008	0.011	201.	2.0	3.3	nd	<1.	<1.	nd	2.9	6.	nd	75.
S250	NM165	Private Production Well #10	E	E	6/26/1996	3.	0.035	0.015	0.023	4.	0.1	0.9	nd	<1.	<1.	nd	3.1	3.	nd	32.
S251	NM166	Private Production Well #11	E	E	6/26/1996	7.	0.024	0.031	0.021	10.	1.4	1.5	nd	1.	<1.	nd	2.0	<1.	nd	11.
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	4.	<0.01	0.215	0.003	nd	1.7	<1.	nd	<1.	<2.	nd	<1.	<2.	nd	1.6
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	4.	<0.01	0.219	0.003	nd	1.7	4.0	nd	<1.	<2.	nd	<1.	<2.	nd	1.6
S258	NM524	Vallecito Springs	E	E	8/4/1998	3.	0.167	0.062	0.164	165.	0.20	0.4	33.	0.2	<1.	0.12	7.6	23.	<1.	0.3
S273	NM176	Windmill #11	E	E	8/19/1996	9.	0.060	0.220	0.034	68.	0.2	5.7	nd	<1.	<1.	nd	2.3	1.9	nd	15.
S282	NM529	Windmill #44	E	E	7/29/1998	<5.	0.167	0.023	0.581	7,840.	0.74	5.7	9.0	0.7	<5.	0.51	0.4	2.6	10.	9.7
SXXX	NM065	Jemez Spring	E	E	8/20/1996	10.	7.17	0.280	8.80	12.	0.2	1.7	nd	7.5	16.	nd	<1.	550.	nd	0.1
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	23.	14.20	0.404	14.2	50.	0.4	1.4	nd	9.7	11.	nd	1.0	1,500.	nd	1.1

Table A5. Summary of dissolved gases (nitrogen, argon, oxygen, carbon dioxide, and methane)

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; N_2, nitrogen; Ar, argon; °C, degrees Celsius; mg/kg, milligrams per kilogram; cc STP/kg, cubic centimeters at standard temperature and pressure per kilogram of water; kg, kilogram; O_2, oxygen; CO_2, carbon dioxide; CH_4, methane; na, not applicable; nd, not determined; negative excess air indicates degassing]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Lab O_2 (mg/kg)	Field O_2 (mg/kg)	Lab CO_2 (mg/kg)	CH_4 (mg/kg)	Assigned recharge altitude (feet)	Excess N_2 (mg/kg)	Recom-mended recharge temp-erature (ºC)	Recom-mended excess air (cc STP/kg)
		Zone 1: Northern Mountain Front													
S027	NM486	CEPO 02	1	na	8/3/1998	14.12	0.5199	1.1	3.5	4.8	<0.0001	6,500	nd	12.5	0.6
S034	NM027	Private Production Well #04	1	na	8/28/1996	23.27	0.6858	4.3	5.7	5.4	<0.0001	6,500	nd	11.1	9.5
S035	NM487	Windmill #37	1	na	7/31/1998	16.19	0.5817	4.4	7.0	6.4	<0.0001	6,500	nd	8.8	1.6
S036	NM026	Private Production Well #03	1	na	8/28/1996	15.25	0.5730	1.8	6.2	12.2	<0.0001	6,500	nd	7.9	0.3
S065	NM055	Domestic Well #05	1	na	8/17/1996	14.57	0.5350	1.7	4.9	3.4	<0.0001	6,500	nd	11.4	0.7
S187	NM131	Rio Rancho 12	1	na	8/13/1996	15.88	0.5559	<0.1	2.5	2.7	<0.0001	6,500	1.0	9.3	0.4
S206	NM510	Windmill #38	1	3	8/3/1998	11.71	0.4406	3.4	6.2	1.5	<0.0001	6,500	nd	18.7	- 0.3
S216	NM143	Windmill #09	1	na	8/27/1996	13.94	0.5035	1.8	5.4	3.7	<0.0001	6,500	nd	14.5	0.9
S221	NM530	Windmill #45	1	na	8/20/1998	15.24	0.5371	1.5	5.5	42.5	<0.0001	6,500	nd	12.7	1.8
S222	NM514	Windmill #39	1	3	8/6/1998	12.44	0.4476	0.1	1.3	24.5	0.0110	6,500	nd	19.7	0.7
S254	NM168	Private Production Well #12	1	na	8/28/1996	17.62	0.5296	4.4	6.8	8.8	<0.0001	6,500	3.0	12.3	1.0
S279	NM527	Windmill #42	1	na	7/28/1998	13.18	0.4831	1.7	nd	15.4	<0.0001	6,500	nd	15.7	0.5
S281	NM528	Windmill #43	1	3	7/28/1998	11.61	0.4303	2.1	2.6	2.7	<0.0001	6,500	nd	20.3	0.0
		Zone 2: Northwestern													
S103	NM497	Lincoln D	2	na	7/23/1998	14.02	0.4817	1.6	4.1	3.3	<0.0001	5,000	0.5	19.4	1.0
S104	NM498	Lincoln M	2	na	7/23/1998	13.39	0.4855	3.9	6.5	2.0	<0.0001	5,000	nd	18.3	0.6
S105	NM499	Lincoln S	2	na	7/23/1998	13.62	0.4801	4.4	6.7	2.8	<0.0001	5,000	0.4	19.4	0.9
S191	NM326	Rio Rancho 4	2	3	6/20/1997	13.05	0.4784	2.2	3.8	2.3	<0.0001	5,000	nd	18.6	0.3
S192	NM128	Rio Rancho 8	2	3	8/13/1996	13.91	0.4983	1.4	4.9	3.5	<0.0001	5,000	nd	17.7	1.0
S189	NM133	Rio Rancho 15	2	na	8/13/1996	16.07	0.4906	1.9	6.1	8.3	<0.0001	6,500	2.5	15.6	0.8
S278	NM526	Windmill #41	2	na	7/29/1998	11.59	0.4225	4.1	6.9	2.5	<0.0001	5,000	nd	24.5	0.1
S286	NM184	Private Production Well #13	2	na	8/26/1996	14.79	0.5358	2.1	7.9	7.8	<0.0001	5,000	nd	14.1	0.9
S287	NM185	Private Production Well #14	2	na	8/26/1996	15.08	0.5298	2.0	7.7	8.3	<0.0001	5,000	nd	15.8	1.7
		Zone 3: West Central													
S003	NM481	98th St. D	3	na	8/4/1998	18.67	0.5406	0.1	<0.1	1.6	0.0008	8,000	3.7	9.5	1.4
S003	NM251	98th St. D	3	na	6/17/1997	17.93	0.5361	<0.1	0.2	1.6	<0.0001	8,000	3.1	9.6	1.2
S004	NM482	98th St. MD	3	na	8/4/1998	17.14	0.5580	0.1	<0.1	0.2	0.0006	8,000	1.8	8.0	1.3
S004	NM252	98th St. MD	3	na	6/18/1997	17.21	0.5707	<0.1	0.3	0.2	<0.0001	8,000	1.5	7.0	1.3
S005	NM253	98th St. MS	3	na	7/4/1997	16.63	0.5841	<0.1	0.1	1.4	0.0029	8,000	0.7	5.8	1.1
S005	NM483	98th St. MS	3	na	8/4/1998	16.71	0.5703	0.1	0.1	1.7	0.0035	8,000	1.0	7.1	1.3
S006	NM484	98th St. S	3	na	8/5/1998	13.98	0.4806	1.5	0.3	0.1	<0.0001	8,000	0.5	14.6	1.2
S006	NM254	98th St. S	3	na	6/17/1997	13.74	0.4967	0.2	2.8	0.1	0.0006	8,000	nd	12.7	1.0
S008	NM003	Private Production Well #01	3	na	8/12/1996	13.21	0.4735	4.7	4.0	0.7	<0.0001	8,000	nd	15.0	1.1
S010	NM255	Private Production Well #16	3	na	6/23/1997	12.21	0.4685	4.6	5.1	0.4	<0.0001	8,000	nd	13.0	- 0.5
S018	NM260	Domestic Well #21	3	na	6/26/1997	14.71	0.4824	4.2	5.3	2.6	<0.0001	8,000	nd	18.0	3.3
S019	NM007	Belen 4	3	5	8/16/1996	13.05	0.4717	0.1	3.3	6.0	<0.0001	8,000	nd	14.9	0.9
S020	NM008	Belen 5	3	5	8/16/1996	12.25	0.4541	<0.1	3.9	5.4	<0.0001	8,000	nd	15.5	0.2
S029	NM015	Cerro Colorado Lafill PW	3	5	8/12/1996	16.71	0.5641	<0.1	2.4	8.0	<0.0001	8,000	1.2	7.4	1.2
S037	NM264	College 2	3	na	6/19/1997	15.21	0.5476	2.8	5.0	0.3	<0.0001	8,000	nd	8.9	1.4
S066	NM056	Gonzales 1	3	12	6/20/1996	15.42	0.5382	0.2	3.0	1.8	<0.0001	8,000	0.5	9.5	1.3
S086	NM492	Isleta D	3	na	7/29/1998	15.93	0.5295	0.1	0.1	0.1	<0.0001	8,000	1.2	10.3	1.3
S101	NM294	Leavitt 1	3	na	6/26/1997	13.32	0.4938	3.2	4.9	0.6	<0.0001	8,000	nd	12.1	0.4
S108	NM076	Los Lunas 3	3	12	8/14/1996	14.74	0.5354	<0.1	0.3	1.4	<0.0001	8,000	nd	9.5	1.1
S109	NM077	Los Lunas 4	3	12	8/14/1996	14.82	0.5511	<0.1	0.5	1.5	<0.0001	8,000	nd	7.6	0.6
S145	NM308	NM Utilities 1	3	na	6/18/1997	13.84	0.5084	2.2	5.0	3.6	<0.0001	8,000	nd	11.2	0.7
S147	NM310	NM Utilities 3	3	na	6/18/1997	14.16	0.5136	0.4	2.2	2.1	<0.0001	8,000	nd	11.2	1.0
S148	NM311	NM Utilities 4	3	na	6/18/1997	14.52	0.5253	2.4	3.8	2.4	<0.0001	8,000	nd	10.4	1.1
S166	NM509	Rabbit Hill	3	na	8/4/1998	17.63	0.5955	0.9	3.6	16.5	<0.0001	8,000	1.3	5.3	1.3
S167	NM107	Domestic Well #12	3	na	8/14/1996	14.97	0.5083	<0.1	0.9	0.7	<0.0001	8,000	1.0	11.5	0.9
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	17.91	0.5713	<0.1	<0.1	0.1	<0.0001	8,000	2.3	6.7	1.1
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	17.00	0.5515	0.1	0.1	0.5	<0.0001	8,000	2.0	7.9	0.9
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	19.48	0.6080	0.8	0.1	0.6	<0.0001	8,000	3.0	4.1	1.0
S186	NM130	Rio Rancho 10	3	na	8/13/1996	15.29	0.5474	2.4	6.3	7.7	<0.0001	8,000	nd	9.1	1.5
S188	NM132	Rio Rancho 13	3	na	8/13/1996	15.71	0.5631	0.1	6.5	0.9	<0.0001	8,000	0.5	6.9	0.7
S193	NM129	Rio Rancho 9	3	na	8/13/1996	20.64	0.6188	1.0	7.3	2.5	<0.0001	8,000	4.0	3.2	0.8
S196	NM135	Windmill #05	3	na	8/21/1996	11.97	0.4269	<0.1	3.0	4.3	<0.0001	8,000	nd	19.7	0.8
S200	NM139	Private Production Well #08	3	na	8/29/1996	15.83	0.5201	<0.1	0.2	1.5	<0.0001	8,000	1.5	10.7	1.0
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	16.25	0.5762	0.8	3.9	1.2	<0.0001	8,000	0.5	6.4	1.1
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	16.49	0.5770	1.0	4.8	2.8	<0.0001	8,000	1.0	5.8	0.6
S230	NM516	Sierra Vista D	3	na	7/22/1998	17.03	0.5374	0.1	<0.1	0.4	0.0061	8,000	2.2	9.6	1.3
S236	NM155	SAF (Soil Amement Facility)	3	na	8/12/1996	11.76	0.4120	0.4	4.9	2.4	<0.0001	8,000	nd	22.0	1.1
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	14.39	0.4695	0.1	0.9	3.5	0.1114	8,000	1.2	15.8	1.3
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	21.79	0.6116	0.1	4.0	1.3	0.0007	8,000	nd	16.5	nd
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	14.77	0.5412	1.4	3.9	3.3	<0.0001	8,000	nd	8.8	0.9
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	16.78	0.5332	0.0	0.1	0.3	<0.0001	8,000	2.0	9.9	1.3
S272	NM353	West Mesa 3	3	na	6/19/1997	13.73	0.5203	2.0	4.7	0.8	<0.0001	8,000	nd	9.2	0.0
S283	NM181	Zia Ball Park D	3	na	8/26/1996	15.58	0.5502	1.1	5.3	3.6	<0.0001	8,000	0.5	8.3	1.1
S285	NM183	Zia Ball Park S	3	2	8/26/1996	14.59	0.5297	0.4	4.5	4.6	<0.0001	8,000	nd	9.9	1.1
S288	NM186	Zia BMT D	3	na	8/27/1996	18.43	0.6035	<0.1	0.3	1.5	0.0472	8,000	nd	4.5	1.1

Table A5. Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Lab O_2 (mg/kg)	Field O_2 (mg/kg)	Lab CO_2 (mg/kg)	CH_4 (mg/kg)	Assigned recharge altitude (feet)	Excess N_2 (mg/kg)	Recom-mended recharge temp-erature (ºC)	Recom-mended excess air (cc STP/kg)
		Zone 4: Western Boundary													
S039	NM266	Windmill #20	4	na	6/21/1997	14.98	0.5019	<0.1	3.4	33.1	<0.0001	5,000	1.0	17.3	1.0
S059	NM278	Windmill #21	4	na	6/23/1997	13.82	0.5191	4.7	7.4	9.4	0.0004	5,000	nd	14.2	0.0
S074	NM285	Windmill #23	4	na	6/21/1997	12.26	0.4466	0.4	2.3	45.1	<0.0001	5,000	nd	21.9	0.3
		Zone 5: Rio Puerco													
S069	NM058	Domestic Well #06	5	na	8/16/1996	35.65	0.8533	1.4	4.2	10.1	<0.0001	5,000	nd	20.5	nd
S111	NM079	Domestic Well #10	5	na	8/16/1996	17.12	0.5538	0.1	<0.1	3.6	<0.0001	5,000	1.8	12.8	1.1
S185	NM324	Domestic Well #31	5	na	6/16/1997	23.73	0.7031	0.1	0.2	33.2	0.0034	5,000	nd	12.0	nd
S198	NM137	Windmill #07	5	na	8/21/1996	20.27	0.6329	0.0	0.4	34.5	<0.0001	5,000	3.0	7.0	1.1
S237	NM341	Windmill #30	5	4	6/24/1997	12.64	0.4643	3.9	4.7	2.6	<0.0001	5,000	nd	19.8	0.2
S238	NM342	Windmill #31	5	na	6/24/1997	14.09	0.4965	1.2	4.1	20.8	<0.0001	5,000	nd	18.5	1.4
		Zone 7: Abo Arroyo													
S021	NM261	Stock Well #01	7	na	6/23/1997	17.18	0.5793	4.1	5.6	15.4	0.0018	5,000	nd	13.7	3.3
S024	NM011	Domestic Well #02	7	8	8/17/1996	13.57	0.4870	2.4	7.0	11.4	<0.0001	5,000	nd	18.6	0.9
S090	NM064	Domestic Well #08	7	na	8/19/1996	15.21	0.4628	4.8	6.8	6.1	<0.0001	5,000	nd	29.2	4.7
S093	NM067	Domestic Well #09	7	8	8/15/1996	13.40	0.4893	0.1	3.9	4.0	<0.0001	5,000	nd	17.7	0.5
		Zone 8: Eastern Mountain Front													
S007	NM002	Domestic Well #01	8	na	6/21/1996	20.90	0.6622	2.9	9.2	18.3	0.0006	6,500	nd	8.8	6.4
S014	NM257	Private Production Well #17	8	na	6/19/1997	14.21	0.5249	6.4	8.2	10.8	<0.0001	6,500	nd	12.0	0.5
S030	NM020	Charles 4	8	na	6/27/1996	13.75	0.4905	1.6	4.5	5.0	<0.0001	6,500	nd	16.1	1.2
S030	NM018	Charles 4	8	na	6/27/1996	13.61	0.5000	1.7	5.5	5.3	<0.0001	6,500	nd	14.2	0.5
S030	NM021	Charles 4	8	na	6/27/1996	13.81	0.4897	1.0	4.0	5.3	<0.0001	6,500	nd	16.4	1.3
S030	NM023	Charles 4	8	na	6/27/1996	13.89	0.5011	0.9	4.0	5.3	<0.0001	6,500	nd	14.7	1.0
S030	NM019	Charles 4	8	na	6/27/1996	13.43	0.4752	1.3	5.2	5.5	<0.0001	6,500	nd	17.8	1.3
S030	NM022	Charles 4	8	na	6/27/1996	13.96	0.5012	0.6	4.0	5.5	<0.0001	6,500	nd	14.9	1.1
S030	NM017	Charles 4	8	na	6/27/1996	13.59	0.4966	1.2	5.6	5.6	<0.0001	6,500	nd	14.7	0.6
S030	NM024	Charles 4	8	na	6/27/1996	13.93	0.5060	0.4	4.1	5.7	<0.0001	6,500	nd	14.1	0.8
S042	NM031	Domestic Well #03	8	na	8/14/1996	12.81	0.4715	0.0	4.2	4.5	<0.0001	6,500	nd	16.6	0.3
S055	NM042	Elena Gallegos	8	na	6/25/1996	10.22	0.3742	3.4	6.2	12.8	<0.0001	6,500	nd	27.3	- 0.1
S056	NM043	Embudito Spring	8	na	7/2/1996	13.45	0.5198	0.3	3.4	25.0	<0.0001	6,500	nd	10.8	- 0.6
S071	NM060	Domestic Well #07	8	na	6/19/1996	16.64	0.5356	3.6	8.7	14.9	<0.0001	6,500	nd	16.8	4.3
S095	NM068	Kirtland 1	8	na	6/25/1996	14.12	0.5037	2.3	7.2	8.0	<0.0001	6,500	nd	15.0	1.3
S106	NM295	Domestic Well #23	8	na	6/26/1997	15.25	0.5436	<0.1	0.6	2.8	<0.0001	6,500	nd	11.8	1.5
S110	NM078	Love 1	8	na	6/22/1996	19.19	0.5763	1.8	5.7	6.5	<0.0001	6,500	nd	17.3	7.0
S113	NM080	Domestic Well #11	8	na	8/15/1996	14.77	0.5267	0.2	3.6	3.1	<0.0001	6,500	nd	13.1	1.4
S114	NM500	Matheson D	8	na	7/31/1998	15.03	0.5133	0.1	1.3	4.0	<0.0001	6,500	nd	15.9	2.4
S115	NM501	Matheson M	8	na	8/1/1998	13.40	0.4728	1.2	2.9	3.4	<0.0001	6,500	nd	18.1	1.3
S116	NM502	Matheson S	8	na	8/1/1998	12.66	0.4632	3.9	5.5	6.4	<0.0001	6,500	nd	17.6	0.4
S117	NM298	Domestic Well #25	8	na	6/17/1997	18.38	0.6113	6.1	8.0	10.1	<0.0001	6,500	nd	9.8	4.1
S119	NM300	Domestic Well #26	8	11	6/19/1997	14.09	0.5170	4.9	5.8	26.4	<0.0001	6,500	nd	12.8	0.6
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	15.68	0.5232	0.1	0.4	0.1	0.0073	6,500	1.2	12.9	1.0
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	14.07	0.4917	0.1	2.0	4.5	0.0028	6,500	0.3	16.0	1.2
S140	NM306	MRN 1	8	na	7/5/1997	16.13	0.5685	3.4	5.6	10.2	<0.0001	6,500	nd	10.4	2.0
S141	NM095	National Utility 7	8	na	8/14/1996	13.89	0.4998	1.0	7.8	7.6	<0.0001	6,500	0.5	14.9	1.0
S149	NM312	Nor Este D	8	na	7/3/1997	15.90	0.5707	<0.1	0.2	0.9	<0.0001	6,500	nd	9.6	1.5
S150	NM313	Nor Este M	8	na	7/2/1997	15.98	0.5836	<0.1	0.3	1.5	<0.0001	6,500	nd	8.1	1.1
S162	NM317	Stock Well #03	8	na	6/30/1997	20.83	0.6456	7.6	7.2	1.8	<0.0001	6,500	nd	10.9	nd
S163	NM318	PL 2	8	na	7/7/1997	15.54	0.5717	3.1	5.2	7.4	<0.0001	6,500	nd	8.7	0.8
S164	NM106	Ponderosa 1	8	na	6/20/1996	15.68	0.5566	0.1	1.6	6.5	0.0002	6,500	nd	11.0	1.7
S165	NM328	Windmill #25	8	na	6/24/1997	14.68	0.5566	1.2	1.8	0.6	<0.0001	6,500	nd	8.7	0.0
S168	NM319	Domestic Well #30	8	na	6/27/1997	12.86	0.4713	3.3	5.2	1.5	<0.0001	6,500	nd	16.8	0.4
S170	NM108	Ridgecrest 3	8	na	6/22/1996	14.07	0.4781	0.4	4.6	5.3	<0.0001	6,500	0.6	17.4	1.2
S195	NM134	Domestic Well #13	8	na	8/14/1996	13.51	0.4834	<0.1	3.2	4.2	<0.0001	6,500	nd	16.6	1.0
S209	NM336	Domestic Well #33	8	na	6/27/1997	15.75	0.5447	<0.1	0.2	1.9	<0.0001	6,500	nd	12.9	2.4
S212	NM141	Sandia Peak 1	8	na	6/26/1996	15.67	0.5443	3.3	7.6	9.9	<0.0001	6,500	nd	12.8	2.2
S213	NM142	Sandia Peak 3	8	na	6/26/1996	15.97	0.5272	3.8	7.8	11.7	<0.0001	6,500	nd	16.3	3.5
S224	NM148	Domestic Well #14	8	na	8/23/1996	13.14	0.4951	0.4	4.3	13.9	<0.0001	6,500	nd	13.7	- 0.1
S229	NM515	SH03 UNM	8	na	7/28/1998	15.90	0.5417	5.1	8.8	11.0	<0.0001	6,500	nd	13.7	2.7
S233	NM153	Domestic Well #16	8	na	8/23/1996	16.35	0.5595	0.1	1.9	18.7	<0.0001	6,500	nd	12.2	2.8
S239	NM156	Domestic Well #17	8	na	8/17/1996	16.17	0.5558	<0.1	6.8	22.0	<0.0001	6,500	nd	12.3	2.6
S240	NM157	Domestic Well #18	8	na	6/19/1996	43.13	1.0214	12.	8.0	7.2	<0.0001	6,500	nd	11.5	nd
S247	NM161	Domestic Well #19	8	na	8/15/1996	14.53	0.5454	0.0	5.8	3.1	<0.0001	6,500	nd	9.9	0.2
S248	NM162	Thomas 6	8	na	6/21/1996	26.93	0.7218	5.7	1.4	4.4	<0.0001	6,500	nd	15.0	14.4
S255	NM523	Tramway East	8	na	7/30/1998	16.02	0.5391	3.1	5.6	5.3	0.0008	6,500	nd	14.5	3.1
S264	NM174	Walker 1	8	na	6/18/1996	16.27	0.5569	0.2	2.5	5.2	0.0002	6,500	nd	12.4	2.8
S274	NM177	Domestic Well #20	8	na	8/15/1996	12.94	0.4681	<0.1	4.9	9.5	<0.0001	6,500	nd	17.6	0.7
		Zone 9: Tijeras Fault Zone													
S041	NM029	Coyote Spring	9	na	6/28/1996	16.97	0.4531	4.5	2.8	1,011.0	0.0004	6,500	nd	nd	nd
S072	NM061	Hubbell Spring	9	8	8/23/1996	13.45	0.5019	2.4	4.8	11.9	<0.0001	6,500	nd	13.4	0.2
S098	NM071	KAFB-1902	9	na	6/28/1996	18.43	0.5399	3.0	4.5	22.7	<0.0001	6,500	nd	21.7	7.2
S197	NM136	Windmill #06	9	na	8/23/1996	16.49	0.5459	0.1	0.3	2.0	0.0129	6,500	1.4	11.1	1.2
S227	NM151	SFR 3D	9	na	8/24/1996	11.90	0.4286	<0.1	5.7	170.8	<0.0001	6,500	nd	21.7	0.5
S228	NM152	SFR 3S	9	na	8/24/1996	13.55	0.4866	0.9	5.5	70.6	<0.0001	6,500	nd	16.2	1.0
		Zone 10: Tijeras Arroyo													
S001	NM001	4Hills-1	10	8	6/29/1996	16.16	0.5545	1.4	5.0	18.4	<0.0001	6,500	nd	12.5	2.7

Table A5. Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Lab O_2 (mg/kg)	Field O_2 (mg/kg)	Lab CO_2 (mg/kg)	CH_4 (mg/kg)	Assigned recharge altitude (feet)	Excess N_2 (mg/kg)	Recom-mended recharge temp-erature (ºC)	Recom-mended excess air (cc STP/kg)
S002	NM250	Private Production Well #15	10	8	7/3/1997	44.51	1.0370	15.	15.	16.7	<0.0001	6,500	nd	12.7	nd
S058	NM277	Eubank 1	10	8	7/4/1997	13.39	0.5118	4.4	6.4	5.6	<0.0001	6,500	nd	11.8	- 0.4
S096	NM069	Kirtland 11	10	8	6/25/1996	26.28	0.7264	4.6	7.0	12.0	<0.0001	6,500	nd	12.6	nd
		Zone 11: Northeastern													
S053	NM276	Private Production Well #18	11	na	6/25/1997	14.79	0.5285	3.0	2.8	21.0	<0.0001	5,000	nd	15.2	1.2
S144	NM097	Private Production Well #06	11	na	8/28/1996	15.74	0.5520	<0.1	0.2	15.2	0.0018	5,000	0.5	12.9	1.0
S207	NM334	Private Production Well #22	11	na	7/3/1997	16.76	0.5749	5.0	6.7	13.9	<0.0001	5,000	nd	13.3	2.7
S223	NM338	Windmill #29	11	na	6/25/1997	15.25	0.5279	4.4	6.3	5.5	<0.0001	5,000	nd	16.6	2.1
		Zone 12: Central													
S011	NM004	Atris-1	12	na	6/22/1996	14.98	0.5423	0.5	0.1	3.0	0.0018	5,000	nd	13.7	1.0
S012	NM005	Atrisco 3	12	3	6/20/1996	14.98	0.5420	0.3	0.2	2.2	0.0020	5,000	nd	13.7	1.0
S025	NM012	Burton 2	12	na	6/19/1996	23.67	0.6820	0.1	2.9	5.3	<0.0001	5,000	nd	14.9	10.3
S026	NM013	Burton 5	12	na	6/19/1996	23.09	0.6674	1.8	0.4	3.5	<0.0001	5,000	nd	15.6	9.9
S033	NM025	Private Production Well #02	12	na	8/21/1996	16.44	0.5306	0.2	0.8	16.0	<0.0001	5,000	1.7	14.8	1.1
S040	NM028	Coronado 1	12	na	6/18/1996	15.48	0.5552	0.1	0.7	2.9	<0.0001	5,000	nd	13.0	1.3
S043	NM267	Del Sol D	12	na	7/1/1997	15.83	0.5763	0.2	0.5	2.2	<0.0001	5,000	nd	11.0	1.0
S043	NM488	Del Sol D	12	na	7/21/1998	15.36	0.5520	0.1	0.5	2.3	<0.0001	5,000	nd	13.2	1.2
S044	NM489	Del Sol M	12	na	7/21/1998	14.68	0.5289	0.1	0.5	4.9	<0.0001	5,000	nd	14.9	1.0
S044	NM268	Del Sol M	12	na	6/26/1997	14.73	0.5436	0.1	0.6	5.2	<0.0001	5,000	nd	12.8	0.5
S045	NM269	Del Sol S	12	na	6/26/1997	13.90	0.5123	1.5	2.9	3.4	<0.0001	5,000	nd	15.4	0.4
S045	NM490	Del Sol S	12	na	7/21/1998	13.89	0.5032	0.8	3.3	3.9	<0.0001	5,000	nd	16.8	0.7
S046	NM032	Duranes 1	12	na	6/20/1996	16.48	0.5149	0.9	<0.1	0.6	0.0005	5,000	nd	22.6	4.8
S046	NM039	Duranes 1	12	na	6/29/1996	17.01	0.5169	0.2	<0.1	11.0	0.0009	5,000	nd	24.0	5.6
S046	NM034	Duranes 1	12	na	6/29/1996	16.88	0.5123	0.3	0.2	11.3	0.0009	5,000	nd	24.5	5.5
S046	NM036	Duranes 1	12	na	6/29/1996	17.02	0.5302	0.1	0.1	11.3	0.0011	5,000	nd	21.5	5.1
S046	NM038	Duranes 1	12	na	6/29/1996	18.08	0.5371	0.3	0.1	11.4	0.0010	5,000	nd	23.6	6.6
S046	NM035	Duranes 1	12	na	6/29/1996	17.14	0.5318	<0.1	0.1	11.5	0.0010	5,000	nd	21.5	5.2
S046	NM033	Duranes 1	12	na	6/29/1996	17.86	0.5397	0.2	0.1	11.7	0.0009	5,000	nd	22.4	6.1
S046	NM037	Duranes 1	12	na	6/29/1996	55.13	1.1753	11.	0.1	12.1	0.0014	5,000	nd	22.4	nd
S047	NM270	Duranes 7	12	na	6/26/1997	14.39	0.5354	<0.1	0.2	2.9	0.0039	5,000	nd	13.2	0.3
S048	NM271	Duranes Yard 1	12	na	7/5/1997	15.11	0.5653	<0.1	0.1	3.1	0.0067	5,000	nd	10.8	0.2
S049	NM272	Duranes Yard 2	12	na	7/5/1997	14.52	0.5614	<0.1	0.1	2.8	0.0086	5,000	nd	10.0	- 0.6
S050	NM273	Duranes Yard 3	12	na	7/5/1997	13.73	0.5181	<0.1	0.1	0.0	<0.0001	5,000	nd	14.1	- 0.2
S051	NM274	Duranes Yard 4	12	na	7/5/1997	15.89	0.6013	<0.1	<0.1	4.8	0.0117	5,000	nd	8.0	0.1
S052	NM275	Duranes Yard 5	12	na	7/5/1997	14.45	0.5618	<0.1	<0.1	4.6	0.0116	5,000	nd	9.8	- 0.8
S060	NM279	Garfield D	12	3	6/19/1997	14.90	0.5429	<0.1	0.2	1.7	<0.0001	5,000	nd	13.4	0.8
S061	NM280	Garfield M	12	na	6/19/1997	15.24	0.5590	<0.1	0.2	2.5	0.0041	5,000	nd	11.9	0.7
S062	NM491	Garfield S	12	na	7/28/1998	14.98	0.5222	0.1	0.1	31.3	<0.0001	5,000	0.5	15.5	1.1
S062	NM281	Garfield S	12	na	6/19/1997	14.49	0.5306	<0.1	0.3	36.1	0.0002	5,000	nd	14.1	0.6
S064	NM283	Domestic Well #22	12	na	6/20/1997	15.79	0.5333	0.1	0.1	6.2	<0.0001	5,000	1.0	14.5	1.0
S068	NM057	Griegos 3	12	na	6/21/1996	15.43	0.5549	<0.1	0.2	2.4	0.0010	5,000	nd	13.0	1.3
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	14.27	0.5349	<0.1	0.2	2.2	<0.0001	5,000	nd	13.0	0.1
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	15.50	0.5628	<0.1	0.2	4.7	<0.0001	5,000	nd	12.0	1.0
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	14.07	0.5183	0.6	3.1	8.0	<0.0001	5,000	nd	14.9	0.4
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	15.13	0.5423	<0.1	0.2	4.0	0.0049	5,000	nd	14.0	1.3
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	15.07	0.5304	0.1	0.1	5.1	<0.0001	5,000	nd	15.7	1.7
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	25.14	0.6001	0.2	1.1	6.6	<0.0001	5,000	nd	nd	nd
S081	NM292	Private Production Well #19	12	na	7/2/1997	15.78	0.5739	<0.1	0.3	4.2	<0.0001	5,000	nd	11.2	1.1
S084	NM063	Windmill #04	12	na	8/21/1996	14.11	0.5198	<0.1	3.2	5.6	<0.0001	5,000	nd	14.8	0.4
S087	NM493	Isleta MD	12	3	7/29/1998	14.62	0.5229	0.1	<0.1	1.1	0.0007	5,000	nd	15.7	1.2
S088	NM494	Isleta MS	12	na	7/29/1998	14.66	0.5330	0.1	<0.1	1.7	0.0049	5,000	nd	14.2	0.8
S089	NM495	Isleta S	12	na	7/29/1998	17.12	0.5341	0.1	<0.1	13.0	0.0211	5,000	2.3	14.5	1.1
S092	NM066	JMC-1	12	na	6/28/1996	10.54	0.3745	0.1	<0.1	8.8	0.0002	5,000	nd	nd	nd
S097	NM070	Kirtland 14	12	na	6/25/1996	14.61	0.5422	<0.1	0.7	3.4	<0.0001	5,000	nd	12.8	0.4
S100	NM073	LALF-9	12	na	6/29/1996	17.49	0.5410	0.1	0.1	7.8	0.0052	5,000	2.5	13.9	1.1
S102	NM074	Leyendecker 1	12	na	6/21/1996	15.14	0.5367	0.1	0.9	3.5	0.0014	5,000	0.3	14.1	1.0
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	16.13	0.5334	0.1	<0.1	0.1	0.0125	5,000	1.3	14.6	1.1
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	19.85	0.5823	2.1	0.8	3.5	<0.0001	5,000	3.9	10.4	1.0
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	11.34	0.4304	0.4	3.3	4.3	<0.0001	5,000	nd	22.0	- 0.6
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	16.90	0.5733	0.1	<0.1	0.3	0.0047	5,000	1.1	11.3	1.1
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	15.63	0.5678	<0.1	0.1	0.4	<0.0001	5,000	nd	11.6	1.1
S123	NM081	MONT - 5A	12	na	6/27/1996	15.56	0.5373	0.2	<0.1	3.5	0.0001	5,000	1.0	13.3	0.5
S124	NM082	Montaño 2 D	12	na	6/19/1996	17.46	0.6029	<0.1	0.1	7.6	0.0281	5,000	1.0	8.9	1.0
S125	NM083	Montaño 2 M	12	na	6/19/1996	18.63	0.5810	0.1	<0.1	11.4	0.0243	5,000	3.0	9.9	0.5
S126	NM084	Montaño 2 S	12	na	6/19/1996	16.71	0.5592	<0.1	<0.1	15.6	0.0016	5,000	1.5	11.8	0.7
S127	NM085	Montaño 4 D	12	na	6/20/1996	18.64	0.5759	0.4	0.1	4.5	0.0024	5,000	3.0	10.6	0.7
S128	NM086	Montaño 4 M	12	na	6/19/1996	19.07	0.5793	0.1	0.1	32.9	0.0132	5,000	3.0	11.1	1.3
S130	NM088	Montaño 5 D	12	na	6/24/1996	14.46	0.5331	0.1	0.1	3.8	0.0181	5,000	nd	13.7	0.5
S131	NM089	Montaño 5 M	12	na	6/24/1996	15.98	0.5844	0.1	0.1	3.3	0.0018	5,000	0.3	9.6	0.4
S132	NM090	Montaño 5 S	12	na	6/24/1996	12.34	0.4286	0.1	0.1	4.3	0.0004	5,000	0.5	24.1	0.3
S133	NM091	Montaño 6 D	12	na	6/18/1996	14.88	0.5240	0.1	0.1	2.9	0.0618	5,000	0.5	14.9	0.7
S134	NM092	Montaño 6 MD	12	na	6/18/1996	14.91	0.5484	<0.1	0.1	0.6	<0.0001	5,000	nd	12.6	0.6
S135	NM093	Montaño 6 MS	12	na	6/18/1996	15.71	0.5725	<0.1	0.1	0.6	0.0002	5,000	nd	11.2	1.0
S136	NM094	Montaño 6 S	12	na	6/18/1996	16.62	0.5566	<0.1	0.1	2.7	0.0021	5,000	1.5	12.0	0.6
S137	NM506	Montesa M	12	na	7/27/1998	14.85	0.5306	0.1	5.5	2.4	<0.0001	5,000	nd	15.1	1.3
S138	NM507	Montesa S	12	na	7/27/1998	24.61	0.6918	0.1	1.6	3.7	<0.0001	5,000	nd	15.9	nd

Table A5. Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Lab O_2 (mg/kg)	Field O_2 (mg/kg)	Lab CO_2 (mg/kg)	CH_4 (mg/kg)	Assigned recharge altitude (feet)	Excess N_2 (mg/kg)	Recom-mended recharge temp-erature (ºC)	Recom-mended excess air (cc STP/kg)
S139	NM305	Domestic Well #27	12	na	6/17/1997	14.51	0.5228	0.6	1.2	4.9	<0.0001	5,000	nd	15.4	1.0
S142	NM307	Domestic Well #28	12	na	6/17/1997	14.63	0.5249	0.1	1.0	3.9	<0.0001	5,000	nd	15.4	1.1
S146	NM309	NM Utilities 2	12	na	6/18/1997	14.99	0.5387	0.2	1.0	3.9	<0.0001	5,000	nd	14.2	1.2
S151	NM508	Nor Este S	12	na	7/20/1998	13.48	0.5041	0.1	0.4	3.0	<0.0001	5,000	nd	15.6	0.0
S151	NM314	Nor Este S	12	na	7/2/1997	14.74	0.5634	<0.1	0.7	3.1	<0.0001	5,000	nd	10.2	- 0.3
S154	NM099	ORLF-2	12	na	6/27/1996	14.70	0.5558	-0.1	<0.1	3.9	<0.0001	5,000	nd	11.1	- 0.1
S155	NM316	Domestic Well #29	12	na	6/27/1997	14.51	0.5466	<0.1	0.1	3.1	<0.0001	5,000	nd	11.9	0.0
S156	NM100	Paseo 2D	12	na	6/26/1996	16.83	0.5626	<0.1	<0.1	2.1	0.1014	5,000	1.5	11.6	0.8
S157	NM101	Paseo 2MD	12	na	6/26/1996	15.22	0.5560	0.2	<0.1	3.8	0.0028	5,000	nd	12.3	0.8
S158	NM102	Paseo 2MS	12	na	6/26/1996	16.64	0.5572	0.2	<0.1	8.0	0.0024	5,000	1.5	11.9	0.6
S159	NM103	Paseo 2S	12	na	6/26/1996	19.52	0.5887	0.2	<0.1	23.8	0.0005	5,000	3.5	9.8	0.8
S160	NM104	Paseo 3D	12	na	6/21/1996	15.10	0.5685	0.2	0.2	2.3	0.0017	5,000	nd	10.3	0.1
S161	NM105	Paseo 3M	12	na	6/21/1996	20.09	0.6278	0.9	0.1	41.0	0.0002	5,000	0.0	13.9	6.3
S171	NM321	Ridgecrest 4	12	na	6/26/1997	14.42	0.5364	0.5	1.5	3.5	<0.0001	5,000	nd	13.1	0.3
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	16.17	0.5802	<0.1	<0.1	1.7	0.0470	5,000	0.2	10.7	1.1
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	15.16	0.4973	0.1	0.1	11.9	0.0260	5,000	1.0	18.6	1.5
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	16.53	0.5816	<0.1	0.1	2.4	<0.0001	5,000	0.5	10.7	1.2
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	17.76	0.5592	0.1	0.1	6.9	<0.0001	5,000	2.3	12.4	1.1
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	17.44	0.5476	<0.1	0.1	7.5	0.0046	5,000	2.3	13.3	1.1
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	19.22	0.5493	<0.1	<0.1	3.4	0.0040	5,000	4.0	13.2	1.1
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	17.12	0.5003	0.1	<0.1	5.3	0.0002	5,000	3.1	17.7	1.1
S183	NM126	Rio Grae Utility 5	12	3	8/15/1996	15.29	0.5312	<0.1	0.6	4.3	<0.0001	5,000	0.5	14.8	1.1
S184	NM127	Rio Grae Utility 6	12	na	8/15/1996	14.96	0.5512	<0.1	0.1	3.1	<0.0001	5,000	nd	12.3	0.6
S190	NM325	Rio Rancho 2	12	na	6/20/1997	15.05	0.5244	0.6	1.6	4.6	<0.0001	5,000	1.0	14.0	0.1
S203	NM331	Private Production Well #20	12	na	7/3/1997	16.39	0.5595	<0.1	1.1	9.1	<0.0001	5,000	1.0	12.2	1.0
S205	NM333	Private Production Well #21	12	na	7/3/1997	15.44	0.5565	0.1	0.1	8.2	0.0037	5,000	nd	12.7	1.2
S208	NM140	San Jose 2	12	3	6/20/1996	15.92	0.5485	0.1	0.6	2.2	<0.0001	5,000	nd	15.1	2.4
S210	NM511	Sandia D	12	na	7/30/1998	15.54	0.5473	0.1	1.1	3.9	0.0018	5,000	0.4	13.3	1.1
S214	NM513	Sandia S	12	na	7/30/1998	17.55	0.5574	0.1	0.1	0.6	<0.0001	5,000	2.2	12.4	1.0
S220	NM147	Santa Barbara 1	12	na	6/19/1996	25.49	0.7614	2.9	0.3	3.0	0.0003	5,000	0.0	8.4	10.1
S231	NM517	Sierra Vista M	12	3	7/22/1998	14.67	0.5336	0.1	0.1	0.9	<0.0001	5,000	nd	14.2	0.8
S232	NM518	Sierra Vista S	12	na	7/22/1998	13.61	0.4893	1.0	4.6	6.9	<0.0001	5,000	nd	18.4	0.9
S234	NM339	Sister Cities D	12	na	6/30/1997	14.71	0.5570	0.3	0.7	3.8	<0.0001	5,000	nd	11.0	- 0.1
S235	NM340	Sister Cities M	12	na	6/27/1997	14.61	0.5426	<0.1	0.1	2.7	0.0039	5,000	nd	12.7	0.3
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	15.24	0.5370	0.2	<0.1	0.4	4.8440	5,000	nd	15.1	1.7
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	15.37	0.5372	<0.1	<0.1	0.5	3.7693	5,000	nd	15.4	1.9
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	18.47	0.5879	0.1	<0.1	0.5	4.2553	5,000	nd	15.8	5.2
S253	NM522	Tome D	12	na	8/6/1998	16.12	0.5506	0.1	<0.1	2.1	<0.0001	5,000	0.9	13.0	1.1
S257	NM344	Domestic Well #34	12	na	6/17/1997	16.20	0.5700	<0.1	0.1	14.8	<0.0001	5,000	0.5	11.5	1.1
S259	NM171	VGP-1	12	na	6/27/1996	19.39	0.6028	0.1	<0.1	12.8	0.0008	5,000	nd	15.9	6.1
S261	NM172	Vol Andia 2	12	na	6/21/1996	15.14	0.5565	-0.2	0.6	3.0	0.0006	5,000	nd	12.0	0.7
S262	NM173	Vol Andia 5	12	na	6/18/1996	15.32	0.5521	0.1	0.3	2.5	0.0008	5,000	0.5	11.9	0.3
S265	NM175	Webster 1	12	na	6/18/1996	19.73	0.3999	7.2	1.1	0.2	<0.0001	5,000	nd	nd	nd
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	15.52	0.5619	0.1	0.2	2.6	<0.0001	5,000	nd	12.2	1.1
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	15.14	0.5717	<0.1	0.2	3.1	<0.0001	5,000	nd	10.0	0.0
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	15.73	0.5604	0.2	0.1	3.1	0.0002	5,000	nd	12.9	1.5
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	15.79	0.5773	0.1	0.2	3.7	<0.0001	5,000	nd	10.7	0.9
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	17.47	0.6344	0.1	1.4	7.6	<0.0001	5,000	nd	7.3	1.4
S275	NM178	Yale 1	12	na	6/19/1996	18.37	0.5891	0.1	1.6	3.8	<0.0001	5,000	2.5	9.4	0.6
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	14.41	0.5276	<0.1	0.1	2.5	0.0362	5,000	nd	14.4	0.6
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	17.52	0.6182	-0.1	0.1	1.9	0.1460	5,000	nd	9.3	2.2
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	14.44	0.5387	<0.1	0.1	2.5	0.0133	5,000	nd	12.8	0.2
		Zone 13: Discharge													
S143	NM096	Private Production Well #05	13	na	8/19/1996	17.59	0.5639	<0.1	0.1	3.1	0.0014	5,000	2.0	12.1	1.1
S194	NM327	Domestic Well #32	13	na	6/30/1997	14.38	0.5131	0.8	1.8	2.6	<0.0001	5,000	nd	16.6	1.2
S226	NM150	Domestic Well #15	13	na	8/19/1996	17.51	0.5682	<0.1	0.1	5.5	<0.0001	5,000	1.9	11.5	1.0
		No Zone: Exotic Water													
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	10.72	0.4016	4.0	7.4	155.8	<0.0001	5,000	nd	nd	nd
S023	NM010	Burn Site Well	E	E	6/25/1996	15.63	0.5332	0.7	3.6	25.3	<0.0001	6,500	nd	14.4	2.6
S038	NM265	Windmill #19	E	E	7/1/1997	21.41	0.6898	<0.1	0.6	2.7	0.0086	5,000	nd	8.6	nd
S054	NM041	Domestic Well #04	E	E	8/17/1996	2.985	0.1399	<0.1	0.1	9.1	0.0183	6,500	nd	nd	nd
S057	NM044	Embudo Spring	E	E	7/2/1996	15.09	0.5519	0.1	0.1	52.1	0.0170	6,500	nd	10.3	0.9
S063	NM282	Windmill #22	E	E	6/28/1997	16.35	0.5387	3.6	3.6	12.7	<0.0001	5,000	nd	17.9	3.5
S067	NM284	Granite Hill	E	E	7/4/1997	23.20	0.6255	0.1	0.1	16.5	0.0002	6,500	nd	nd	nd
S070	NM059	HERTF	E	E	6/28/1996	14.99	0.5165	1.9	3.0	13.2	<0.0001	6,500	nd	15.3	2.2
S091	NM496	Private Production Well #23	E	E	8/4/1998	16.28	0.5482	0.1	nd	15.1	0.0327	5,000	1.1	13.3	1.1
S094	NM293	Stock Well #02	E	E	6/20/1997	21.91	0.6057	4.6	5.2	20.0	<0.0001	5,000	nd	23.0	nd
S099	NM072	LALF-1	E	E	6/29/1996	17.44	0.5178	0.1	0.0	33.2	0.0015	5,000	3.0	16.0	1.1
S112	NM296	Domestic Well #24	E	E	6/21/1997	14.25	0.4924	<0.1	nd	13.9	0.0686	6,500	nd	17.2	2.0
S129	NM087	Montaňo 4 S	E	E	6/19/1996	15.83	0.5348	0.2	0.2	44.4	0.0016	5,000	1.0	14.4	1.1
S152	NM098	Private Production Well #07	E	E	8/22/1996	16.66	0.5606	0.1	1.8	26.3	<0.0001	6,500	1.5	9.3	0.7
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	18.59	0.5459	1.1	0.0	32.0	0.0105	5,000	3.5	13.4	1.0
S211	NM512	Sandia M	E	E	7/30/1998	15.80	0.5542	0.1	0.8	2.1	<0.0001	6,500	0.6	10.2	1.0
S225	NM149	SBM-1	E	E	6/29/1996	15.26	0.5149	0.1	0.0	91.4	0.0006	5,000	1.0	15.9	0.9
S249	NM164	Private Production Well #09	E	E	6/26/1996	13.65	0.4874	5.2	nd	9.8	<0.0001	6,500	nd	16.3	1.1
S249	NM163	Private Production Well #09	E	E	6/26/1996	35.29	0.8637	12.	5.3	10.7	0.0002	6,500	nd	15.2	nd

Table A5. Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Lab O_2 (mg/kg)	Field O_2 (mg/kg)	Lab CO_2 (mg/kg)	CH_4 (mg/kg)	Assigned recharge altitude (feet)	Excess N_2 (mg/kg)	Recom-mended recharge temp-erature (ºC)	Recom-mended excess air (cc STP/kg)
S250	NM165	Private Production Well #10	E	E	6/26/1996	18.06	0.5517	-0.1	0.1	9.6	0.0001	6,500	nd	18.2	6.1
S251	NM166	Private Production Well #11	E	E	6/26/1996	14.67	0.5013	5.1	6.0	14.6	<0.0001	6,500	nd	16.9	2.3
S282	NM529	Windmill #44	E	E	7/29/1998	13.74	0.4757	2.2	3.8	11.7	<0.0001	5,000	nd	21.2	1.6
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	3.888	0.1454	<0.1	2.0	429.7	0.0037	8,000	nd	nd	nd
SXXX	NM065	Jemez Spring	E	E	8/20/1996	1.164	0.0368	<0.1	nd	436.3	0.0250	8,000	nd	nd	nd

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; N_2, nitrogen; Ar, argon; Alt., altitude; °C, degrees Celsius; mg/kg, milligrams per kilogram; cc STP/kg, cubic centimeters at standard temperature and pressure per kilogram of water; na, not applicable; nd, not determined; negative excess air indicates degassing]

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (°C)	Excess air (cc STP/kg)	Recharge temp-erature (°C)	Excess air (cc STP/kg)	Recharge temp-erature (°C)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (°C)	Excess air (cc STP/kg)	Recharge temp-erature (°C)	Excess air (cc STP/kg)	Recharge temp-erature (°C)	Excess air (cc STP/kg)
		Zone 1: Northern Mountain Front																			
S027	NM486	CEPO 02	1	na	8/3/1998	14.07	0.5213	6,500	14.5	0.3	12.1	0.4	9.9	0.5	nd	14.5	0.3	12.1	0.4	9.9	0.5
S027	NM486	CEPO 02	1	na	8/3/1998	14.16	0.5185	6,500	15.1	0.6	12.8	0.7	10.5	0.8	nd	15.1	0.6	12.8	0.7	10.5	0.8
S034	NM027	Private Production Well #04	1	na	8/28/1996	23.27	0.6858	6,500	13.4	9.4	11.1	9.5	8.8	9.6	nd	13.4	9.4	11.1	9.5	8.8	9.6
S035	NM487	Windmill #37	1	na	7/31/1998	16.17	0.5819	6,500	11.0	1.4	8.8	1.5	6.6	1.6	nd	11.0	1.4	8.8	1.5	6.6	1.6
S035	NM487	Windmill #37	1	na	7/31/1998	16.21	0.5816	6,500	11.1	1.5	8.9	1.6	6.7	1.7	nd	11.1	1.5	8.9	1.6	6.7	1.7
S036	NM026	Private Production Well #03	1	na	8/28/1996	15.25	0.5730	6,500	10.1	0.2	7.9	0.3	5.8	0.4	nd	10.1	0.2	7.9	0.3	5.8	0.4
S065	NM055	Domestic Well #05	1	na	8/17/1996	14.57	0.5350	6,500	13.7	0.6	11.4	0.7	9.2	0.8	nd	13.7	0.6	11.4	0.7	9.2	0.8
S187	NM131	Rio Rancho 12	1	na	8/13/1996	15.88	0.5559	6,500	13.9	2.0	11.6	2.1	9.3	2.2	1.0	11.5	0.2	9.3	0.4	7.1	0.5
S206	NM510	Windmill #38	1	3	8/3/1998	11.69	0.4400	6,500	21.3	- 0.4	18.8	- 0.3	16.3	- 0.2	nd	21.3	- 0.4	18.8	- 0.3	16.3	- 0.2
S206	NM510	Windmill #38	1	3	8/3/1998	11.73	0.4413	6,500	21.2	- 0.4	18.7	- 0.3	16.2	- 0.2	nd	21.2	- 0.4	18.7	- 0.3	16.2	- 0.2
S216	NM143	Windmill #09	1	na	8/27/1996	13.94	0.5035	6,500	16.9	0.8	14.5	0.9	12.2	1.1	nd	16.9	0.8	14.5	0.9	12.2	1.1
S221	NM530	Windmill #45	1	na	8/20/1998	15.20	0.5363	6,500	15.1	1.6	12.8	1.8	10.5	1.9	nd	15.1	1.6	12.8	1.8	10.5	1.9
S221	NM530	Windmill #45	1	na	8/20/1998	15.27	0.5379	6,500	15.1	1.7	12.7	1.8	10.4	1.9	nd	15.1	1.7	12.7	1.8	10.4	1.9
S222	NM514	Windmill #39	1	3	8/6/1998	12.44	0.4476	6,500	22.3	0.5	19.7	0.7	17.2	0.8	nd	22.3	0.5	19.7	0.7	17.2	0.8
S254	NM168	Private Production Well #12	1	na	8/28/1996	17.62	0.5296	6,500	23.6	6.1	21.0	6.2	18.4	6.4	3.0	14.6	0.9	12.3	1.0	10.0	1.1
S279	NM527	Windmill #42	1	na	7/28/1998	13.15	0.4818	6,500	18.3	0.4	15.8	0.5	13.5	0.6	nd	18.3	0.4	15.8	0.5	13.5	0.6
S279	NM527	Windmill #42	1	na	7/28/1998	13.21	0.4843	6,500	18.0	0.4	15.6	0.5	13.2	0.6	nd	18.0	0.4	15.6	0.5	13.2	0.6
S281	NM528	Windmill #43	1	3	7/28/1998	11.55	0.4318	6,500	22.4	- 0.3	19.9	- 0.2	17.4	- 0.1	nd	22.4	- 0.3	19.9	- 0.2	17.4	- 0.1
S281	NM528	Windmill #43	1	3	7/28/1998	11.68	0.4289	6,500	23.4	0.0	20.8	0.1	18.3	0.3	nd	23.4	0.0	20.8	0.1	18.3	0.3
		Zone 2: Northwestern																			
S103	NM497	Lincoln D	2	na	7/23/1998	14.02	0.4817	5,000	21.0	1.9	18.4	2.0	16.0	2.1	0.5	19.4	1.0	16.9	1.1	14.5	1.3
S104	NM498	Lincoln M	2	na	7/23/1998	13.36	0.4846	5,000	18.4	0.6	16.0	0.7	13.6	0.9	nd	18.4	0.6	16.0	0.7	13.6	0.9
S104	NM498	Lincoln M	2	na	7/23/1998	13.41	0.4864	5,000	18.2	0.6	15.8	0.7	13.4	0.9	nd	18.2	0.6	15.8	0.7	13.4	0.9
S105	NM499	Lincoln S	2	na	7/23/1998	13.16	0.4751	5,000	19.5	0.7	17.0	0.8	14.6	0.9	nd	19.5	0.7	17.0	0.8	14.6	0.9
S105	NM499	Lincoln S	2	na	7/23/1998	14.09	0.4851	5,000	20.5	1.8	18.0	2.0	15.6	2.1	0.4	19.3	1.2	16.8	1.3	14.4	1.4
S191	NM326	Rio Rancho 4	2	3	6/20/1997	13.05	0.4784	5,000	18.6	0.3	16.1	0.4	13.7	0.6	nd	18.6	0.3	16.1	0.4	13.7	0.6
S192	NM128	Rio Rancho 8	2	3	8/13/1996	13.91	0.4983	5,000	17.7	1.0	15.3	1.1	12.9	1.2	nd	17.7	1.0	15.3	1.1	12.9	1.2
S189	NM133	Rio Rancho 15	2	na	8/13/1996	16.07	0.4906	6,500	26.2	5.0	23.5	5.2	20.9	5.3	2.5	18.0	0.7	15.6	0.8	13.2	1.0
S278	NM526	Windmill #41	2	na	7/29/1998	11.58	0.4228	5,000	24.3	0.1	21.7	0.2	19.2	0.3	nd	24.3	0.1	21.7	0.2	19.2	0.3
S278	NM526	Windmill #41	2	na	7/29/1998	11.61	0.4221	5,000	24.6	0.2	22.0	0.3	19.4	0.4	nd	24.6	0.2	22.0	0.3	19.4	0.4
S286	NM184	Private Production Well #13	2	na	8/26/1996	14.79	0.5358	5,000	14.1	0.9	11.8	1.1	9.6	1.2	nd	14.1	0.9	11.8	1.1	9.6	1.2
S287	NM185	Private Production Well #14	2	na	8/26/1996	15.08	0.5298	5,000	15.8	1.7	13.4	1.8	11.1	1.9	nd	15.8	1.7	13.4	1.8	11.1	1.9
		Zone 3: West Central																			
S003	NM251	98th St. D	3	na	6/17/1997	17.93	0.5361	8,000	23.3	6.4	20.7	6.5	18.2	6.7	3.1	14.2	1.0	11.9	1.1	9.6	1.2
S003	NM481	98th St. D	3	na	8/4/1998	18.66	0.5412	8,000	24.8	7.4	22.2	7.6	19.7	7.7	3.6	14.0	1.2	11.7	1.3	9.5	1.4
S003	NM481	98th St. D	3	na	8/4/1998	18.69	0.5400	8,000	25.2	7.5	22.5	7.7	20.0	7.8	3.7	14.0	1.1	11.7	1.2	9.4	1.3
S004	NM482	98th St. MD	3	na	8/4/1998	17.10	0.5578	8,000	16.8	4.0	14.4	4.2	12.1	4.3	1.7	12.5	1.1	10.2	1.2	8.0	1.3
S004	NM482	98th St. MD	3	na	8/4/1998	17.18	0.5581	8,000	17.0	4.2	14.6	4.3	12.3	4.4	1.8	12.4	1.0	10.1	1.1	7.9	1.3
S004	NM252	98th St. MD	3	na	6/18/1997	17.21	0.5707	8,000	15.1	3.7	12.7	3.8	10.5	3.9	1.5	11.4	1.1	9.2	1.2	7.0	1.3
S005	NM253	98th St. MS	3	na	7/4/1997	16.63	0.5841	8,000	11.7	2.1	9.5	2.2	7.3	2.3	0.7	10.1	0.9	7.9	1.0	5.8	1.1
S005	NM483	98th St. MS	3	na	8/4/1998	16.65	0.5673	8,000	14.2	2.9	11.8	3.0	9.6	3.1	1.0	11.7	1.1	9.5	1.2	7.3	1.3
S005	NM483	98th St. MS	3	na	8/4/1998	16.77	0.5732	8,000	13.6	2.8	11.3	2.9	9.1	3.0	1.0	11.2	1.1	9.0	1.2	6.8	1.3

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S006	NM254	98th St. S	3	na	6/17/1997	13.74	0.4967	8,000	17.5	0.8	15.1	0.9	12.7	1.0	nd	17.5	0.8	15.1	0.9	12.7	1.0
S006	NM484	98th St. S	3	na	8/5/1998	13.94	0.4794	8,000	21.1	1.8	18.6	2.0	16.2	2.1	0.5	19.6	1.0	17.1	1.1	14.7	1.2
S006	NM484	98th St. S	3	na	8/5/1998	14.01	0.4819	8,000	20.9	1.8	18.4	2.0	15.9	2.1	0.5	19.3	1.0	16.9	1.1	14.5	1.2
S008	NM003	Private Production Well #01	3	na	8/12/1996	13.21	0.4735	8,000	19.9	0.8	17.4	0.9	15.0	1.1	nd	19.9	0.8	17.4	0.9	15.0	1.1
S010	NM255	Private Production Well #16	3	na	6/23/1997	12.21	0.4685	8,000	17.8	- 0.7	15.4	- 0.6	13.0	- 0.5	nd	17.8	- 0.7	15.4	- 0.6	13.0	- 0.5
S018	NM260	Domestic Well #21	3	na	6/26/1997	14.71	0.4824	8,000	23.1	3.0	20.5	3.2	18.0	3.3	nd	23.1	3.0	20.5	3.2	18.0	3.3
S019	NM007	Belen 4	3	5	8/16/1996	13.05	0.4717	8,000	19.7	0.6	17.3	0.7	14.9	0.9	nd	19.7	0.6	17.3	0.7	14.9	0.9
S020	NM008	Belen 5	3	5	8/16/1996	12.25	0.4541	8,000	20.5	0.0	18.0	0.1	15.5	0.2	nd	20.5	0.0	18.0	0.1	15.5	0.2
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	16.71	0.5641	8,000	14.8	3.1	12.5	3.2	10.2	3.3	1.2	11.9	1.0	9.6	1.1	7.4	1.2
S037	NM264	College 2	3	na	6/19/1997	15.21	0.5476	8,000	13.5	1.2	11.2	1.3	8.9	1.4	nd	13.5	1.2	11.2	1.3	8.9	1.4
S066	NM056	Gonzales 1	3	12	6/20/1996	15.42	0.5382	8,000	15.4	1.9	13.0	2.1	10.7	2.2	0.5	14.1	1.1	11.8	1.2	9.5	1.3
S086	NM492	Isleta D	3	na	7/29/1998	15.82	0.5254	8,000	18.6	3.2	16.2	3.3	13.8	3.4	1.2	15.3	1.1	12.9	1.2	10.6	1.3
S086	NM492	Isleta D	3	na	7/29/1998	16.04	0.5335	8,000	17.9	3.2	15.5	3.4	13.1	3.5	1.2	14.6	1.1	12.3	1.3	10.0	1.4
S101	NM294	Leavitt 1	3	na	6/26/1997	13.32	0.4938	8,000	16.8	0.2	14.4	0.3	12.1	0.4	nd	16.8	0.2	14.4	0.3	12.1	0.4
S108	NM076	Los Lunas 3	3	12	8/14/1996	14.74	0.5354	8,000	14.1	0.9	11.7	1.0	9.5	1.1	nd	14.1	0.9	11.7	1.0	9.5	1.1
S109	NM077	Los Lunas 4	3	12	8/14/1996	14.82	0.5511	8,000	12.0	0.4	9.8	0.5	7.6	0.6	nd	12.0	0.4	9.8	0.5	7.6	0.6
S145	NM308	NM Utilities 1	3	na	6/18/1997	13.84	0.5084	8,000	15.9	0.4	13.5	0.6	11.2	0.7	nd	15.9	0.4	13.5	0.6	11.2	0.7
S147	NM310	NM Utilities 3	3	na	6/18/1997	14.16	0.5136	8,000	15.9	0.8	13.5	0.9	11.2	1.0	nd	15.9	0.8	13.5	0.9	11.2	1.0
S148	NM311	NM Utilities 4	3	na	6/18/1997	14.52	0.5253	8,000	15.0	0.9	12.7	1.0	10.4	1.1	nd	15.0	0.9	12.7	1.0	10.4	1.1
S166	NM509	Rabbit Hill	3	na	8/4/1998	17.48	0.5920	8,000	12.6	3.3	10.4	3.4	8.2	3.5	1.3	9.7	1.0	7.5	1.1	5.4	1.2
S166	NM509	Rabbit Hill	3	na	8/4/1998	17.79	0.5991	8,000	12.4	3.5	10.1	3.6	7.9	3.7	1.3	9.5	1.2	7.3	1.3	5.2	1.4
S167	NM107	Domestic Well #12	3	na	8/14/1996	14.97	0.5083	8,000	19.1	2.4	16.6	2.5	14.2	2.7	1.0	16.2	0.7	13.8	0.8	11.5	0.9
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	17.91	0.5713	8,000	16.9	4.9	14.5	5.0	12.2	5.1	2.3	11.1	0.9	8.9	1.0	6.7	1.1
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	17.00	0.5515	8,000	17.6	4.1	15.2	4.3	12.8	4.4	2.0	12.4	0.6	10.1	0.8	7.9	0.9
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	19.48	0.6080	8,000	15.3	6.1	13.0	6.2	10.7	6.3	3.0	8.4	0.8	6.2	0.9	4.1	1.0
S186	NM130	Rio Rancho 10	3	na	8/13/1996	15.29	0.5474	8,000	13.7	1.3	11.4	1.4	9.1	1.5	nd	13.7	1.3	11.4	1.4	9.1	1.5
S188	NM132	Rio Rancho 13	3	na	8/13/1996	15.71	0.5631	8,000	12.5	1.4	10.2	1.5	8.0	1.6	0.5	11.3	0.5	9.1	0.6	6.9	0.7
S193	NM129	Rio Rancho 9	3	na	8/13/1996	20.64	0.6188	8,000	16.8	7.7	14.4	7.8	12.0	7.9	4.0	7.4	0.6	5.3	0.7	3.2	0.8
S196	NM135	Windmill #05	3	na	8/21/1996	11.97	0.4269	8,000	24.9	0.6	22.2	0.7	19.7	0.8	nd	24.9	0.6	22.2	0.7	19.7	0.8
S200	NM139	Private Production Well #08	3	na	8/29/1996	15.83	0.5201	8,000	19.6	3.4	17.1	3.5	14.7	3.7	1.5	15.3	0.8	13.0	0.9	10.7	1.0
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	16.25	0.5762	8,000	11.9	1.8	9.7	1.9	7.5	2.0	0.5	10.8	0.9	8.6	1.0	6.4	1.1
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	16.49	0.5770	8,000	12.4	2.2	10.1	2.3	7.9	2.4	1.0	10.1	0.4	7.9	0.5	5.8	0.6
S230	NM516	Sierra Vista D	3	na	7/22/1998	17.03	0.5365	8,000	20.3	4.8	17.8	4.9	15.4	5.1	2.2	14.1	1.0	11.8	1.1	9.6	1.2
S230	NM516	Sierra Vista D	3	na	7/22/1998	17.04	0.5384	8,000	20.0	4.8	17.5	4.9	15.1	5.0	2.1	14.1	1.1	11.8	1.2	9.6	1.3
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	11.76	0.4120	8,000	27.3	0.8	24.6	1.0	22.0	1.1	nd	27.3	0.8	24.6	1.0	22.0	1.1
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	14.36	0.4702	8,000	24.3	2.9	21.7	3.1	19.2	3.2	1.1	20.7	1.0	18.2	1.2	15.7	1.3
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	14.42	0.4689	8,000	24.8	3.1	22.2	3.2	19.7	3.4	1.2	20.8	1.0	18.3	1.2	15.8	1.3
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	19.10	0.5535	8,000	23.9	7.7	21.3	7.8	18.7	8.0	nd	23.9	7.7	21.3	7.8	18.7	8.0
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	24.47	0.6697	8,000	19.2	12.2	16.7	12.3	14.3	12.4	nd	19.2	12.2	16.7	12.3	14.3	12.4
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	14.77	0.5412	8,000	13.3	0.7	11.0	0.8	8.8	0.9	nd	13.3	0.7	11.0	0.8	8.8	0.9
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	16.78	0.5332	8,000	20.1	4.5	17.6	4.6	15.2	4.8	2.0	14.5	1.0	12.2	1.2	9.9	1.3
S272	NM353	West Mesa 3	3	na	6/19/1997	13.73	0.5203	8,000	13.8	- 0.2	11.5	- 0.1	9.2	0.0	nd	13.8	- 0.2	11.5	- 0.1	9.2	0.0
S283	NM181	Zia Ball Park D	3	na	8/26/1996	15.58	0.5502	8,000	14.0	1.7	11.7	1.8	9.4	1.9	0.5	12.8	0.8	10.5	1.0	8.3	1.1
S285	NM183	Zia Ball Park S	3	2	8/26/1996	14.59	0.5297	8,000	14.5	0.9	12.2	1.0	9.9	1.1	nd	14.5	0.9	12.2	1.0	9.9	1.1
S288	NM186	Zia BMT D	3	na	8/27/1996	18.43	0.6035	8,000	13.3	4.4	11.0	4.5	8.8	4.6	2.0	8.8	0.9	6.6	1.0	4.5	1.1
		Zone 4: Western Boundary																			
S039	NM266	Windmill #20	4	na	6/21/1997	14.98	0.5019	5,000	20.2	2.7	17.7	2.8	15.3	2.9	1.0	17.3	1.0	14.9	1.1	12.5	1.2
S059	NM278	Windmill #21	4	na	6/23/1997	13.82	0.5191	5,000	14.2	0.0	11.8	0.1	9.6	0.2	nd	14.2	0.0	11.8	0.1	9.6	0.2

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S074	NM285	Windmill #23	4	na	6/21/1997	12.26	0.4466	5,000	21.9	0.3	19.3	0.4	16.9	0.5	nd	21.9	0.3	19.3	0.4	16.9	0.5
		Zone 5: Rio Puerco																			
S069	NM058	Domestic Well #06	5	na	8/16/1996	35.65	0.8533	5,000	20.5	23.9	18.0	24.1	15.5	24.2	nd	20.5	23.9	18.0	24.1	15.5	24.2
S111	NM079	Domestic Well #10	5	na	8/16/1996	17.12	0.5538	5,000	17.5	4.2	15.1	4.4	12.8	4.5	1.8	12.8	1.1	10.5	1.2	8.3	1.3
S185	NM324	Domestic Well #31	5	na	6/16/1997	23.73	0.7031	5,000	12.0	9.5	9.8	9.6	7.6	9.7	nd	12.0	9.5	9.8	9.6	7.6	9.7
S198	NM137	Windmill #07	5	na	8/21/1996	20.27	0.6329	5,000	13.6	6.4	11.3	6.5	9.1	6.6	3.0	7.0	1.1	4.9	1.2	2.9	1.3
S237	NM341	Windmill #30	5	4	6/24/1997	12.64	0.4643	5,000	19.8	0.2	17.3	0.3	14.9	0.4	nd	19.8	0.2	17.3	0.3	14.9	0.4
S238	NM342	Windmill #31	5	na	6/24/1997	14.09	0.4965	5,000	18.5	1.4	16.1	1.5	13.7	1.6	nd	18.5	1.4	16.1	1.5	13.7	1.6
		Zone 7: Abo Arroyo																			
S021	NM261	Stock Well #01	7	na	6/23/1997	17.18	0.5793	5,000	13.7	3.3	11.4	3.4	9.2	3.5	nd	13.7	3.3	11.4	3.4	9.2	3.5
S024	NM011	Domestic Well #02	7	8	8/17/1996	13.57	0.4870	5,000	18.6	0.9	16.2	1.0	13.8	1.1	nd	18.6	0.9	16.2	1.0	13.8	1.1
S090	NM064	Domestic Well #08	7	na	8/19/1996	15.21	0.4628	5,000	29.2	4.7	26.4	4.8	23.8	5.0	nd	29.2	4.7	26.4	4.8	23.8	5.0
S093	NM067	Domestic Well #09	7	8	8/15/1996	13.40	0.4893	5,000	17.7	0.5	15.3	0.6	12.9	0.7	nd	17.7	0.5	15.3	0.6	12.9	0.7
		Zone 8: Eastern Mountain Front																			
S007	NM002	Domestic Well #01	8	na	6/21/1996	20.90	0.6622	6,500	11.0	6.3	8.8	6.4	6.6	6.5	nd	11.0	6.3	8.8	6.4	6.6	6.5
S014	NM257	Private Production Well #17	8	na	6/19/1997	14.21	0.5249	6,500	14.3	0.4	12.0	0.5	9.7	0.6	nd	14.3	0.4	12.0	0.5	9.7	0.6
S030	NM019	Charles 4	8	na	6/27/1996	13.43	0.4752	6,500	20.3	1.1	17.8	1.3	15.4	1.4	nd	20.3	1.1	17.8	1.3	15.4	1.4
S030	NM017	Charles 4	8	na	6/27/1996	13.59	0.4966	6,500	17.1	0.5	14.7	0.6	12.3	0.7	nd	17.1	0.5	14.7	0.6	12.3	0.7
S030	NM018	Charles 4	8	na	6/27/1996	13.61	0.5000	6,500	16.6	0.4	14.2	0.5	11.8	0.6	nd	16.6	0.4	14.2	0.5	11.8	0.6
S030	NM020	Charles 4	8	na	6/27/1996	13.75	0.4905	6,500	18.5	1.0	16.1	1.2	13.7	1.3	nd	18.5	1.0	16.1	1.2	13.7	1.3
S030	NM021	Charles 4	8	na	6/27/1996	13.81	0.4897	6,500	18.9	1.2	16.4	1.3	14.0	1.4	nd	18.9	1.2	16.4	1.3	14.0	1.4
S030	NM023	Charles 4	8	na	6/27/1996	13.89	0.5011	6,500	17.2	0.8	14.7	1.0	12.4	1.1	nd	17.2	0.8	14.7	1.0	12.4	1.1
S030	NM024	Charles 4	8	na	6/27/1996	13.93	0.5060	6,500	16.5	0.7	14.1	0.8	11.8	0.9	nd	16.5	0.7	14.1	0.8	11.8	0.9
S030	NM022	Charles 4	8	na	6/27/1996	13.96	0.5012	6,500	17.3	0.9	14.9	1.1	12.6	1.2	nd	17.3	0.9	14.9	1.1	12.6	1.2
S042	NM031	Domestic Well #03	8	na	8/14/1996	12.81	0.4715	6,500	19.1	0.2	16.6	0.3	14.2	0.4	nd	19.1	0.2	16.6	0.3	14.2	0.4
S055	NM042	Elena Gallegos	8	na	6/25/1996	10.22	0.3742	6,500	30.0	- 0.3	27.3	- 0.1	24.6	0.0	nd	30.0	- 0.3	27.3	- 0.1	24.6	0.0
S056	NM043	Embudito Spring	8	na	7/2/1996	13.45	0.5198	6,500	13.1	- 0.7	10.8	- 0.6	8.6	- 0.5	nd	13.1	- 0.7	10.8	- 0.6	8.6	- 0.5
S071	NM060	Domestic Well #07	8	na	6/19/1996	16.64	0.5356	6,500	19.3	4.2	16.8	4.3	14.4	4.4	nd	19.3	4.2	16.8	4.3	14.4	4.4
S095	NM068	Kirtland 1	8	na	6/25/1996	14.12	0.5037	6,500	17.4	1.1	15.0	1.3	12.6	1.4	nd	17.4	1.1	15.0	1.3	12.6	1.4
S106	NM295	Domestic Well #23	8	na	6/26/1997	15.25	0.5436	6,500	14.1	1.4	11.8	1.5	9.6	1.6	nd	14.1	1.4	11.8	1.5	9.6	1.6
S110	NM078	Love 1	8	na	6/22/1996	19.19	0.5763	6,500	19.8	6.9	17.3	7.0	14.9	7.1	nd	19.8	6.9	17.3	7.0	14.9	7.1
S113	NM080	Domestic Well #11	8	na	8/15/1996	14.77	0.5267	6,500	15.5	1.3	13.1	1.4	10.8	1.5	nd	15.5	1.3	13.1	1.4	10.8	1.5
S114	NM500	Matheson D	8	na	7/31/1998	14.63	0.5066	6,500	18.3	1.9	15.9	2.0	13.5	2.1	nd	18.3	1.9	15.9	2.0	13.5	2.1
S114	NM500	Matheson D	8	na	7/31/1998	15.43	0.5201	6,500	18.4	2.7	15.9	2.8	13.6	3.0	nd	18.4	2.7	15.9	2.8	13.6	3.0
S115	NM501	Matheson M	8	na	8/1/1998	13.40	0.4728	6,500	20.6	1.2	18.1	1.3	15.7	1.4	nd	20.6	1.2	18.1	1.3	15.7	1.4
S116	NM502	Matheson S	8	na	8/1/1998	12.66	0.4632	6,500	20.1	0.3	17.6	0.4	15.2	0.5	nd	20.1	0.3	17.6	0.4	15.2	0.5
S117	NM298	Domestic Well #25	8	na	6/17/1997	18.38	0.6113	6,500	12.1	4.0	9.8	4.1	7.7	4.2	nd	12.1	4.0	9.8	4.1	7.7	4.2
S119	NM300	Domestic Well #26	8	11	6/19/1997	14.09	0.5170	6,500	15.2	0.5	12.8	0.6	10.6	0.8	nd	15.2	0.5	12.8	0.6	10.6	0.8
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	14.03	0.4906	6,500	19.4	1.5	16.9	1.7	14.5	1.8	0.3	18.5	1.0	16.0	1.1	13.7	1.2
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	14.11	0.4927	6,500	19.2	1.6	16.8	1.7	14.4	1.8	0.3	18.3	1.1	15.9	1.2	13.5	1.3
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	15.68	0.5232	6,500	18.6	3.0	16.1	3.1	13.7	3.3	1.2	15.2	0.9	12.9	1.0	10.6	1.2
S140	NM306	MRN 1	8	na	7/5/1997	16.13	0.5685	6,500	12.7	1.9	10.4	2.0	8.2	2.1	nd	12.7	1.9	10.4	2.0	8.2	2.1
S141	NM095	National Utility 7	8	na	8/14/1996	13.89	0.4998	6,500	17.4	0.9	14.9	1.0	12.6	1.1	nd	17.4	0.9	14.9	1.0	12.6	1.1
S149	NM312	Nor Este D	8	na	7/3/1997	15.90	0.5707	6,500	11.9	1.4	9.6	1.5	7.4	1.6	nd	11.9	1.4	9.6	1.5	7.4	1.6
S150	NM313	Nor Este M	8	na	7/2/1997	15.98	0.5836	6,500	10.3	1.0	8.1	1.1	6.0	1.2	nd	10.3	1.0	8.1	1.1	6.0	1.2
S162	NM317	Stock Well #03	8	na	6/30/1997	20.83	0.6456	6,500	13.2	6.9	10.9	7.0	8.6	7.1	nd	13.2	6.9	10.9	7.0	8.6	7.1

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S163	NM318	PL 2	8	na	7/7/1997	15.54	0.5717	6,500	10.9	0.7	8.7	0.8	6.5	0.9	nd	10.9	0.7	8.7	0.8	6.5	0.9
S164	NM106	Ponderosa 1	8	na	6/20/1996	15.68	0.5566	6,500	13.3	1.6	11.0	1.7	8.8	1.8	nd	13.3	1.6	11.0	1.7	8.8	1.8
S165	NM328	Windmill #25	8	na	6/24/1997	14.68	0.5566	6,500	11.0	- 0.1	8.7	0.0	6.6	0.1	nd	11.0	- 0.1	8.7	0.0	6.6	0.1
S168	NM319	Domestic Well #30	8	na	6/27/1997	12.86	0.4713	6,500	19.2	0.3	16.8	0.4	14.4	0.5	nd	19.2	0.3	16.8	0.4	14.4	0.5
S170	NM108	Ridgecrest 3	8	na	6/22/1996	14.07	0.4781	6,500	21.8	2.1	19.2	2.2	16.8	2.4	0.6	19.9	1.1	17.4	1.2	15.0	1.3
S195	NM134	Domestic Well #13	8	na	8/14/1996	13.51	0.4834	6,500	19.1	0.9	16.6	1.0	14.2	1.2	nd	19.1	0.9	16.6	1.0	14.2	1.2
S209	NM336	Domestic Well #33	8	na	6/27/1997	15.75	0.5447	6,500	15.3	2.2	12.9	2.4	10.6	2.5	nd	15.3	2.2	12.9	2.4	10.6	2.5
S212	NM141	Sandia Peak 1	8	na	6/26/1996	15.67	0.5443	6,500	15.1	2.1	12.8	2.2	10.5	2.4	nd	15.1	2.1	12.8	2.2	10.5	2.4
S213	NM142	Sandia Peak 3	8	na	6/26/1996	15.97	0.5272	6,500	18.7	3.4	16.3	3.5	13.9	3.6	nd	18.7	3.4	16.3	3.5	13.9	3.6
S224	NM148	Domestic Well #14	8	na	8/23/1996	13.14	0.4951	6,500	16.1	- 0.2	13.7	- 0.1	11.4	0.0	nd	16.1	- 0.2	13.7	- 0.1	11.4	0.0
S229	NM515	SH03 UNM	8	na	7/28/1998	15.78	0.5376	6,500	16.5	2.6	14.1	2.7	11.8	2.8	nd	16.5	2.6	14.1	2.7	11.8	2.8
S229	NM515	SH03 UNM	8	na	7/28/1998	16.02	0.5459	6,500	15.8	2.7	13.4	2.8	11.1	2.9	nd	15.8	2.7	13.4	2.8	11.1	2.9
S233	NM153	Domestic Well #16	8	na	8/23/1996	16.35	0.5595	6,500	14.6	2.7	12.2	2.8	10.0	2.9	nd	14.6	2.7	12.2	2.8	10.0	2.9
S239	NM156	Domestic Well #17	8	na	8/17/1996	16.17	0.5558	6,500	14.7	2.5	12.3	2.6	10.1	2.7	nd	14.7	2.5	12.3	2.6	10.1	2.7
S247	NM161	Domestic Well #19	8	na	8/15/1996	14.53	0.5454	6,500	12.1	0.1	9.9	0.2	7.7	0.3	nd	12.1	0.1	9.9	0.2	7.7	0.3
S248	NM162	Thomas 6	8	na	6/21/1996	26.93	0.7218	6,500	17.4	14.3	15.0	14.4	12.7	14.5	nd	17.4	14.3	15.0	14.4	12.7	14.5
S255	NM523	Tramway East	8	na	7/30/1998	15.92	0.5375	6,500	16.9	2.8	14.5	3.0	12.1	3.1	nd	16.9	2.8	14.5	3.0	12.1	3.1
S255	NM523	Tramway East	8	na	7/30/1998	16.11	0.5407	6,500	16.9	3.0	14.5	3.2	12.2	3.3	nd	16.9	3.0	14.5	3.2	12.2	3.3
S264	NM174	Walker 1	8	na	6/18/1996	16.27	0.5569	6,500	14.8	2.6	12.4	2.8	10.1	2.9	nd	14.8	2.6	12.4	2.8	10.1	2.9
S274	NM177	Domestic Well #20	8	na	8/15/1996	12.94	0.4681	6,500	20.1	0.6	17.6	0.7	15.1	0.8	nd	20.1	0.6	17.6	0.7	15.1	0.8
		Zone 9: Tijeras Fault Zone																			
S041	NM030	Coyote Spring	9	na	7/1/1996	5.403	0.2260	6,500	49.6	- 2.5	46.6	- 2.4	43.7	- 2.2	nd	49.6	- 2.5	46.6	- 2.4	43.7	- 2.2
S041	NM030	Coyote Spring	9	na	7/1/1996	5.905	0.2521	6,500	43.7	- 2.7	40.7	- 2.6	37.8	- 2.4	nd	43.7	- 2.7	40.7	- 2.6	37.8	- 2.4
S041	NM030	Coyote Spring	9	na	7/1/1996	6.308	0.2404	6,500	50.0	- 1.6	47.0	- 1.4	44.0	- 1.3	nd	50.0	- 1.6	47.0	- 1.4	44.0	- 1.3
S041	NM029	Coyote Spring	9	na	6/28/1996	16.97	0.4531	6,500	39.9	8.1	36.9	8.3	34.1	8.4	nd	39.9	8.1	36.9	8.3	34.1	8.4
S072	NM061	Hubbell Spring	9	8	8/23/1996	13.45	0.5019	6,500	15.8	0.0	13.4	0.2	11.1	0.3	nd	15.8	0.0	13.4	0.2	11.1	0.3
S098	NM071	KAFB-1902	9	na	6/28/1996	18.43	0.5399	6,500	24.3	7.1	21.7	7.2	19.1	7.4	nd	24.3	7.1	21.7	7.2	19.1	7.4
S197	NM136	Windmill #06	9	na	8/23/1996	16.49	0.5459	6,500	17.1	3.5	14.7	3.6	12.3	3.7	1.4	13.4	1.0	11.1	1.2	8.9	1.3
S227	NM151	SFR 3D	9	na	8/24/1996	11.90	0.4286	6,500	24.3	0.4	21.7	0.5	19.1	0.7	nd	24.3	0.4	21.7	0.5	19.1	0.7
S228	NM152	SFR 3S	9	na	8/24/1996	13.55	0.4866	6,500	18.6	0.9	16.2	1.0	13.8	1.1	nd	18.6	0.9	16.2	1.0	13.8	1.1
		Zone 10: Tijeras Arroyo																			
S001	NM001	4Hills-1	10	8	6/29/1996	16.16	0.5545	6,500	14.8	2.6	12.5	2.7	10.2	2.8	nd	14.8	2.6	12.5	2.7	10.2	2.8
S058	NM277	Eubank 1	10	8	7/4/1997	13.39	0.5118	6,500	14.1	- 0.5	11.8	- 0.4	9.6	- 0.3	nd	14.1	- 0.5	11.8	- 0.4	9.6	- 0.3
S096	NM069	Kirtland 11	10	8	6/25/1996	26.28	0.7264	6,500	14.9	12.9	12.6	13.1	10.3	13.2	nd	14.9	12.9	12.6	13.1	10.3	13.2
		Zone 11: Northeastern																			
S053	NM276	Private Production Well #18	11	na	6/25/1997	14.79	0.5285	5,000	15.2	1.2	12.9	1.4	10.6	1.5	nd	15.2	1.2	12.9	1.4	10.6	1.5
S144	NM097	Private Production Well #06	11	na	8/28/1996	15.74	0.5520	5,000	14.1	1.9	11.8	2.0	9.6	2.1	0.5	12.9	1.0	10.6	1.2	8.4	1.3
S207	NM334	Private Production Well #22	11	na	7/3/1997	16.76	0.5749	5,000	13.3	2.7	11.0	2.9	8.8	3.0	nd	13.3	2.7	11.0	2.9	8.8	3.0
S223	NM338	Windmill #29	11	na	6/25/1997	15.25	0.5279	5,000	16.6	2.1	14.2	2.2	11.9	2.3	nd	16.6	2.1	14.2	2.2	11.9	2.3
		Zone 12: Central																			
S011	NM004	Atris-1	12	na	6/22/1996	14.98	0.5423	5,000	13.7	1.0	11.4	1.1	9.1	1.2	nd	13.7	1.0	11.4	1.1	9.1	1.2
S012	NM005	Atrisco 3	12	3	6/20/1996	14.98	0.5420	5,000	13.7	1.0	11.4	1.1	9.2	1.2	nd	13.7	1.0	11.4	1.1	9.2	1.2
S025	NM012	Burton 2	12	na	6/19/1996	23.67	0.6820	5,000	14.9	10.3	12.6	10.4	10.3	10.5	nd	14.9	10.3	12.6	10.4	10.3	10.5
S026	NM013	Burton 5	12	na	6/19/1996	23.09	0.6674	5,000	15.6	9.9	13.3	10.0	11.0	10.1	nd	15.6	9.9	13.3	10.0	11.0	10.1
S033	NM025	Private Production Well #02	12	na	8/21/1996	16.44	0.5306	5,000	19.6	4.0	17.1	4.2	14.7	4.3	1.7	14.8	1.1	12.5	1.2	10.2	1.3
S040	NM028	Coronado 1	12	na	6/18/1996	15.48	0.5552	5,000	13.0	1.3	10.7	1.4	8.5	1.5	nd	13.0	1.3	10.7	1.4	8.5	1.5

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S043	NM488	Del Sol D	12	na	7/21/1998	15.33	0.5515	5,000	13.2	1.2	10.9	1.3	8.7	1.4	nd	13.2	1.2	10.9	1.3	8.7	1.4
S043	NM488	Del Sol D	12	na	7/21/1998	15.39	0.5525	5,000	13.2	1.3	10.9	1.4	8.7	1.5	nd	13.2	1.3	10.9	1.4	8.7	1.5
S043	NM267	Del Sol D	12	na	7/1/1997	15.83	0.5763	5,000	11.0	1.0	8.7	1.2	6.6	1.3	nd	11.0	1.0	8.7	1.2	6.6	1.3
S044	NM489	Del Sol M	12	na	7/21/1998	14.28	0.5213	5,000	15.0	0.7	12.7	0.8	10.4	0.9	nd	15.0	0.7	12.7	0.8	10.4	0.9
S044	NM268	Del Sol M	12	na	6/26/1997	14.73	0.5436	5,000	12.8	0.5	10.6	0.6	8.3	0.7	nd	12.8	0.5	10.6	0.6	8.3	0.7
S044	NM489	Del Sol M	12	na	7/21/1998	15.08	0.5365	5,000	14.8	1.4	12.4	1.5	10.2	1.6	nd	14.8	1.4	12.4	1.5	10.2	1.6
S045	NM490	Del Sol S	12	na	7/21/1998	13.86	0.5039	5,000	16.6	0.7	14.2	0.8	11.9	0.9	nd	16.6	0.7	14.2	0.8	11.9	0.9
S045	NM269	Del Sol S	12	na	6/26/1997	13.90	0.5123	5,000	15.4	0.4	13.0	0.5	10.7	0.6	nd	15.4	0.4	13.0	0.5	10.7	0.6
S045	NM490	Del Sol S	12	na	7/21/1998	13.91	0.5025	5,000	17.0	0.8	14.6	0.9	12.3	1.1	nd	17.0	0.8	14.6	0.9	12.3	1.1
S046	NM032	Duranes 1	12	na	6/20/1996	16.48	0.5149	5,000	22.6	4.8	20.0	4.9	17.6	5.0	nd	22.6	4.8	20.0	4.9	17.6	5.0
S046	NM034	Duranes 1	12	na	6/29/1996	16.88	0.5123	5,000	24.5	5.5	21.9	5.7	19.3	5.8	nd	24.5	5.5	21.9	5.7	19.3	5.8
S046	NM039	Duranes 1	12	na	6/29/1996	17.01	0.5169	5,000	24.0	5.6	21.4	5.7	18.9	5.9	nd	24.0	5.6	21.4	5.7	18.9	5.9
S046	NM036	Duranes 1	12	na	6/29/1996	17.02	0.5302	5,000	21.5	5.1	18.9	5.2	16.5	5.3	nd	21.5	5.1	18.9	5.2	16.5	5.3
S046	NM035	Duranes 1	12	na	6/29/1996	17.14	0.5318	5,000	21.5	5.2	19.0	5.3	16.5	5.5	nd	21.5	5.2	19.0	5.3	16.5	5.5
S046	NM033	Duranes 1	12	na	6/29/1996	17.86	0.5397	5,000	22.4	6.1	19.8	6.2	17.3	6.4	nd	22.4	6.1	19.8	6.2	17.3	6.4
S046	NM038	Duranes 1	12	na	6/29/1996	18.08	0.5371	5,000	23.6	6.6	21.0	6.7	18.5	6.9	nd	23.6	6.6	21.0	6.7	18.5	6.9
S047	NM270	Duranes 7	12	na	6/26/1997	14.39	0.5354	5,000	13.2	0.3	10.9	0.4	8.7	0.5	nd	13.2	0.3	10.9	0.4	8.7	0.5
S048	NM271	Duranes Yard 1	12	na	7/5/1997	15.11	0.5653	5,000	10.8	0.2	8.6	0.4	6.4	0.5	nd	10.8	0.2	8.6	0.4	6.4	0.5
S049	NM272	Duranes Yard 2	12	na	7/5/1997	14.52	0.5614	5,000	10.0	- 0.6	7.8	- 0.5	5.7	- 0.4	nd	10.0	- 0.6	7.8	- 0.5	5.7	- 0.4
S050	NM273	Duranes Yard 3	12	na	7/5/1997	13.73	0.5181	5,000	14.1	- 0.2	11.8	0.0	9.5	0.1	nd	14.1	- 0.2	11.8	0.0	9.5	0.1
S051	NM274	Duranes Yard 4	12	na	7/5/1997	15.89	0.6013	5,000	8.0	0.1	5.8	0.2	3.7	0.3	nd	8.0	0.1	5.8	0.2	3.7	0.3
S052	NM275	Duranes Yard 5	12	na	7/5/1997	14.45	0.5618	5,000	9.8	- 0.8	7.6	- 0.6	5.5	- 0.6	nd	9.8	- 0.8	7.6	- 0.6	5.5	- 0.6
S060	NM279	Garfield D	12	3	6/19/1997	14.90	0.5429	5,000	13.4	0.8	11.1	1.0	8.9	1.1	nd	13.4	0.8	11.1	1.0	8.9	1.1
S061	NM280	Garfield M	12	na	6/19/1997	15.24	0.5590	5,000	11.9	0.7	9.7	0.9	7.5	1.0	nd	11.9	0.7	9.7	0.9	7.5	1.0
S062	NM281	Garfield S	12	na	6/19/1997	14.49	0.5306	5,000	14.1	0.6	11.8	0.7	9.6	0.9	nd	14.1	0.6	11.8	0.7	9.6	0.9
S062	NM491	Garfield S	12	na	7/28/1998	14.96	0.5202	5,000	17.0	1.9	14.6	2.0	12.3	2.1	0.5	15.7	1.0	13.3	1.1	11.0	1.3
S062	NM491	Garfield S	12	na	7/28/1998	15.01	0.5241	5,000	16.5	1.8	14.1	1.9	11.8	2.0	0.4	15.4	1.1	13.1	1.2	10.8	1.3
S064	NM283	Domestic Well #22	12	na	6/20/1997	15.79	0.5333	5,000	17.2	2.8	14.8	2.9	12.4	3.0	1.0	14.5	1.0	12.2	1.2	9.9	1.3
S068	NM057	Griegos 3	12	na	6/21/1996	15.43	0.5549	5,000	13.0	1.3	10.7	1.4	8.5	1.5	nd	13.0	1.3	10.7	1.4	8.5	1.5
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	14.27	0.5349	5,000	13.0	0.1	10.7	0.2	8.5	0.3	nd	13.0	0.1	10.7	0.2	8.5	0.3
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	15.50	0.5628	5,000	12.0	1.0	9.8	1.2	7.6	1.3	nd	12.0	1.0	9.8	1.2	7.6	1.3
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	14.07	0.5183	5,000	14.9	0.4	12.6	0.5	10.3	0.7	nd	14.9	0.4	12.6	0.5	10.3	0.7
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	15.13	0.5423	5,000	14.0	1.3	11.7	1.4	9.5	1.5	nd	14.0	1.3	11.7	1.4	9.5	1.5
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	15.07	0.5304	5,000	15.7	1.7	13.3	1.8	11.0	1.9	nd	15.7	1.7	13.3	1.8	11.0	1.9
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	25.14	0.6001	5,000	37.6	16.2	34.7	16.3	31.9	16.5	nd	37.6	16.2	34.7	16.3	31.9	16.5
S081	NM292	Private Production Well #19	12	na	7/2/1997	15.78	0.5739	5,000	11.2	1.1	8.9	1.2	6.8	1.3	nd	11.2	1.1	8.9	1.2	6.8	1.3
S084	NM063	Windmill #04	12	na	8/21/1996	14.11	0.5198	5,000	14.8	0.4	12.4	0.5	10.2	0.7	nd	14.8	0.4	12.4	0.5	10.2	0.7
S087	NM493	Isleta MD	12	3	7/29/1998	14.59	0.5211	5,000	15.9	1.2	13.5	1.3	11.2	1.5	nd	15.9	1.2	13.5	1.3	11.2	1.5
S087	NM493	Isleta MD	12	3	7/29/1998	14.65	0.5247	5,000	15.5	1.2	13.1	1.3	10.8	1.4	nd	15.5	1.2	13.1	1.3	10.8	1.4
S088	NM494	Isleta MS	12	na	7/29/1998	14.65	0.5336	5,000	14.1	0.8	11.8	0.9	9.5	1.0	nd	14.1	0.8	11.8	0.9	9.5	1.0
S088	NM494	Isleta MS	12	na	7/29/1998	14.67	0.5325	5,000	14.3	0.9	12.0	1.0	9.7	1.1	nd	14.3	0.9	12.0	1.0	9.7	1.1
S089	NM495	Isleta S	12	na	7/29/1998	17.09	0.5338	5,000	21.0	5.0	18.5	5.2	16.0	5.3	2.3	14.4	1.0	12.1	1.1	9.8	1.2
S089	NM495	Isleta S	12	na	7/29/1998	17.16	0.5344	5,000	21.1	5.1	18.6	5.3	16.1	5.4	2.3	14.5	1.1	12.2	1.2	9.9	1.4
S092	NM066	JMC-1	12	na	6/28/1996	10.54	0.3745	5,000	31.3	0.3	28.5	0.4	25.8	0.5	nd	31.3	0.3	28.5	0.4	25.8	0.5
S097	NM070	Kirtland 14	12	na	6/25/1996	14.61	0.5422	5,000	12.8	0.4	10.5	0.5	8.3	0.6	nd	12.8	0.4	10.5	0.5	8.3	0.6
S100	NM073	LALF-9	12	na	6/29/1996	17.49	0.5410	5,000	20.9	5.4	18.4	5.6	16.0	5.7	2.5	13.9	1.1	11.6	1.2	9.3	1.3
S102	NM074	Leyendecker 1	12	na	6/21/1996	15.14	0.5367	5,000	14.9	1.5	12.6	1.6	10.3	1.7	0.3	14.1	1.0	11.8	1.1	9.6	1.2
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	11.34	0.4304	5,000	22.0	- 0.6	19.4	- 0.5	17.0	- 0.4	nd	22.0	- 0.6	19.4	- 0.5	17.0	- 0.4

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	16.10	0.5325	5,000	18.2	3.4	15.8	3.5	13.4	3.6	1.3	14.7	1.1	12.3	1.2	10.1	1.3
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	16.16	0.5344	5,000	18.1	3.4	15.6	3.5	13.3	3.6	1.3	14.5	1.1	12.2	1.2	9.9	1.4
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	19.85	0.5823	5,000	20.7	7.8	18.2	7.9	15.8	8.0	3.9	10.4	1.0	8.2	1.1	6.1	1.2
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	15.63	0.5678	5,000	11.6	1.1	9.4	1.2	7.2	1.3	nd	11.6	1.1	9.4	1.2	7.2	1.3
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	16.90	0.5721	5,000	14.1	3.1	11.8	3.2	9.5	3.3	1.1	11.4	1.2	9.2	1.3	7.0	1.4
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	16.90	0.5744	5,000	13.8	3.0	11.4	3.1	9.2	3.2	1.1	11.1	1.1	8.9	1.2	6.7	1.3
S123	NM081	MONT - 5A	12	na	6/27/1996	15.56	0.5373	5,000	15.9	2.2	13.5	2.3	11.2	2.5	1.0	13.3	0.5	11.0	0.6	8.8	0.7
S124	NM082	Montaño 2 D	12	na	6/19/1996	17.46	0.6029	5,000	11.1	2.8	8.9	2.9	6.7	3.0	1.0	8.9	1.0	6.8	1.1	4.7	1.2
S125	NM083	Montaño 2 M	12	na	6/19/1996	18.63	0.5810	5,000	17.3	5.7	14.9	5.9	12.5	6.0	3.0	9.9	0.5	7.7	0.6	5.6	0.7
S126	NM084	Montaño 2 S	12	na	6/19/1996	16.71	0.5592	5,000	15.6	3.3	13.2	3.4	10.9	3.5	1.5	11.8	0.7	9.6	0.8	7.4	0.9
S127	NM085	Montaño 4 D	12	na	6/20/1996	18.64	0.5759	5,000	18.2	6.0	15.8	6.1	13.4	6.2	3.0	10.6	0.7	8.4	0.8	6.2	0.9
S128	NM086	Montaño 4 M	12	na	6/19/1996	19.07	0.5793	5,000	18.9	6.6	16.4	6.7	14.0	6.8	3.0	11.1	1.3	8.9	1.4	6.7	1.5
S130	NM088	Montaño 5 D	12	na	6/24/1996	14.46	0.5331	5,000	13.7	0.5	11.4	0.6	9.2	0.7	nd	13.7	0.5	11.4	0.6	9.2	0.7
S131	NM089	Montaño 5 M	12	na	6/24/1996	15.98	0.5844	5,000	10.2	1.0	8.0	1.1	5.9	1.2	0.3	9.6	0.4	7.4	0.5	5.3	0.6
S132	NM090	Montaño 5 S	12	na	6/24/1996	12.34	0.4286	5,000	25.9	1.2	23.2	1.3	20.6	1.4	0.5	24.1	0.3	21.5	0.4	18.9	0.6
S133	NM091	Montaño 6 D	12	na	6/18/1996	14.88	0.5240	5,000	16.2	1.6	13.8	1.7	11.5	1.8	0.5	14.9	0.7	12.5	0.9	10.3	1.0
S134	NM092	Montaño 6 MD	12	na	6/18/1996	14.91	0.5484	5,000	12.6	0.6	10.3	0.7	8.1	0.8	nd	12.6	0.6	10.3	0.7	8.1	0.8
S135	NM093	Montaño 6 MS	12	na	6/18/1996	15.71	0.5725	5,000	11.2	1.0	8.9	1.1	6.8	1.2	nd	11.2	1.0	8.9	1.1	6.8	1.2
S136	NM094	Montaño 6 S	12	na	6/18/1996	16.62	0.5566	5,000	15.7	3.3	13.4	3.4	11.1	3.5	1.5	12.0	0.6	9.7	0.7	7.5	0.9
S137	NM506	Montesa M	12	na	7/27/1998	14.82	0.5301	5,000	15.1	1.2	12.7	1.4	10.5	1.5	nd	15.1	1.2	12.7	1.4	10.5	1.5
S137	NM506	Montesa M	12	na	7/27/1998	14.88	0.5312	5,000	15.1	1.3	12.7	1.4	10.5	1.5	nd	15.1	1.3	12.7	1.4	10.5	1.5
S138	NM507	Montesa S	12	na	7/27/1998	24.59	0.6924	5,000	15.8	11.4	13.4	11.5	11.1	11.7	nd	15.8	11.4	13.4	11.5	11.1	11.7
S138	NM507	Montesa S	12	na	7/27/1998	24.63	0.6912	5,000	16.0	11.5	13.7	11.7	11.4	11.8	nd	16.0	11.5	13.7	11.7	11.4	11.8
S139	NM305	Domestic Well #27	12	na	6/17/1997	14.51	0.5228	5,000	15.4	1.0	13.0	1.1	10.7	1.2	nd	15.4	1.0	13.0	1.1	10.7	1.2
S142	NM307	Domestic Well #28	12	na	6/17/1997	14.63	0.5249	5,000	15.4	1.1	13.0	1.2	10.7	1.3	nd	15.4	1.1	13.0	1.2	10.7	1.3
S146	NM309	NM Utilities 2	12	na	6/18/1997	14.99	0.5387	5,000	14.2	1.2	11.9	1.3	9.6	1.4	nd	14.2	1.2	11.9	1.3	9.6	1.4
S151	NM508	Nor Este S	12	na	7/20/1998	13.42	0.5033	5,000	15.5	- 0.1	13.2	0.0	10.9	0.2	nd	15.5	- 0.1	13.2	0.0	10.9	0.2
S151	NM508	Nor Este S	12	na	7/20/1998	13.54	0.5049	5,000	15.6	0.1	13.2	0.2	10.9	0.3	nd	15.6	0.1	13.2	0.2	10.9	0.3
S151	NM314	Nor Este S	12	na	7/2/1997	14.74	0.5634	5,000	10.2	- 0.3	8.0	- 0.2	5.9	- 0.1	nd	10.2	- 0.3	8.0	- 0.2	5.9	- 0.1
S154	NM099	ORLF-2	12	na	6/27/1996	14.70	0.5558	5,000	11.1	- 0.1	8.9	0.0	6.7	0.1	nd	11.1	- 0.1	8.9	0.0	6.7	0.1
S155	NM316	Domestic Well #29	12	na	6/27/1997	14.51	0.5466	5,000	11.9	0.0	9.7	0.1	7.5	0.2	nd	11.9	0.0	9.7	0.1	7.5	0.2
S156	NM100	Paseo 2D	12	na	6/26/1996	16.83	0.5626	5,000	15.4	3.4	13.0	3.5	10.7	3.6	1.5	11.6	0.8	9.4	0.9	7.2	1.0
S157	NM101	Paseo 2MD	12	na	6/26/1996	15.22	0.5560	5,000	12.3	0.8	10.0	1.0	7.8	1.1	nd	12.3	0.8	10.0	1.0	7.8	1.1
S158	NM102	Paseo 2MS	12	na	6/26/1996	16.64	0.5572	5,000	15.7	3.3	13.3	3.4	11.0	3.5	1.5	11.9	0.6	9.7	0.8	7.5	0.9
S159	NM103	Paseo 2S	12	na	6/26/1996	19.52	0.5887	5,000	18.6	7.0	16.1	7.1	13.7	7.2	3.5	9.8	0.8	7.6	0.9	5.4	1.0
S160	NM104	Paseo 3D	12	na	6/21/1996	15.10	0.5685	5,000	10.3	0.1	8.1	0.2	6.0	0.3	nd	10.3	0.1	8.1	0.2	6.0	0.3
S161	NM105	Paseo 3M	12	na	6/21/1996	20.09	0.6278	5,000	13.9	6.3	11.6	6.4	9.3	6.5	0.0	13.9	6.3	11.6	6.4	9.3	6.5
S171	NM321	Ridgecrest 4	12	na	6/26/1997	14.42	0.5364	5,000	13.1	0.3	10.8	0.4	8.6	0.5	nd	13.1	0.3	10.8	0.4	8.6	0.5
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	16.17	0.5802	5,000	11.2	1.5	9.0	1.6	6.8	1.7	0.2	10.7	1.1	8.5	1.2	6.4	1.3
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	15.16	0.4973	5,000	21.7	3.2	19.1	3.3	16.7	3.5	1.0	18.6	1.5	16.1	1.6	13.7	1.7
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	16.53	0.5816	5,000	11.8	2.0	9.6	2.1	7.4	2.2	0.5	10.7	1.2	8.5	1.3	6.3	1.4
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	17.76	0.5592	5,000	18.5	5.1	16.1	5.3	13.7	5.4	2.3	12.4	1.1	10.2	1.2	8.0	1.3
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	17.44	0.5476	5,000	19.6	5.1	17.1	5.2	14.7	5.3	2.3	13.3	1.1	11.0	1.2	8.8	1.3
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	19.22	0.5493	5,000	25.1	8.1	22.5	8.2	19.9	8.3	4.0	13.2	1.1	10.9	1.2	8.7	1.3
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	17.12	0.5003	5,000	28.0	6.5	25.3	6.6	22.7	6.7	3.1	17.7	1.1	15.2	1.2	12.9	1.3
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	15.29	0.5312	5,000	16.2	2.0	13.8	2.1	11.5	2.2	0.5	14.8	1.1	12.5	1.3	10.2	1.4
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	14.96	0.5512	5,000	12.3	0.6	10.1	0.7	7.9	0.8	nd	12.3	0.6	10.1	0.7	7.9	0.8
S190	NM325	Rio Rancho 2	12	na	6/20/1997	15.05	0.5244	5,000	16.6	1.9	14.2	2.0	11.9	2.1	1.0	14.0	0.1	11.6	0.2	9.4	0.4

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S203	NM331	Private Production Well #20	12	na	7/3/1997	16.39	0.5595	5,000	14.7	2.7	12.3	2.9	10.1	3.0	1.0	12.2	1.0	9.9	1.1	7.7	1.2
S205	NM333	Private Production Well #21	12	na	7/3/1997	15.44	0.5565	5,000	12.7	1.2	10.5	1.3	8.3	1.4	nd	12.7	1.2	10.5	1.3	8.3	1.4
S208	NM140	San Jose 2	12	3	6/20/1996	15.92	0.5485	5,000	15.1	2.4	12.8	2.5	10.5	2.6	nd	15.1	2.4	12.8	2.5	10.5	2.6
S210	NM511	Sandia D	12	na	7/30/1998	15.49	0.5470	5,000	14.3	1.7	11.9	1.8	9.7	1.9	0.4	13.3	1.0	11.0	1.1	8.7	1.2
S210	NM511	Sandia D	12	na	7/30/1998	15.59	0.5476	5,000	14.4	1.8	12.1	2.0	9.8	2.1	0.4	13.4	1.1	11.1	1.3	8.9	1.4
S214	NM513	Sandia S	12	na	7/30/1998	17.31	0.5517	5,000	18.5	4.7	16.0	4.8	13.6	4.9	2.1	12.9	1.0	10.6	1.1	8.4	1.2
S214	NM513	Sandia S	12	na	7/30/1998	17.80	0.5631	5,000	17.9	5.0	15.5	5.2	13.2	5.3	2.3	12.0	1.0	9.7	1.1	7.5	1.2
S220	NM147	Santa Barbara 1	12	na	6/19/1996	25.49	0.7614	5,000	8.4	10.1	6.2	10.2	4.1	10.3	0.0	8.4	10.1	6.2	10.2	4.1	10.3
S231	NM517	Sierra Vista M	12	3	7/22/1998	14.66	0.5348	5,000	14.0	0.8	11.6	0.9	9.4	1.0	nd	14.0	0.8	11.6	0.9	9.4	1.0
S231	NM517	Sierra Vista M	12	3	7/22/1998	14.68	0.5323	5,000	14.4	0.9	12.1	1.0	9.8	1.1	nd	14.4	0.9	12.1	1.0	9.8	1.1
S232	NM518	Sierra Vista S	12	na	7/22/1998	13.61	0.4892	5,000	18.4	0.9	15.9	1.0	13.5	1.1	nd	18.4	0.9	15.9	1.0	13.5	1.1
S232	NM518	Sierra Vista S	12	na	7/22/1998	13.61	0.4894	5,000	18.3	0.9	15.9	1.0	13.5	1.1	nd	18.3	0.9	15.9	1.0	13.5	1.1
S234	NM339	Sister Cities D	12	na	6/30/1997	14.71	0.5570	5,000	11.0	- 0.1	8.8	0.0	6.6	0.1	nd	11.0	- 0.1	8.8	0.0	6.6	0.1
S235	NM340	Sister Cities M	12	na	6/27/1997	14.61	0.5426	5,000	12.7	0.3	10.4	0.4	8.2	0.6	nd	12.7	0.3	10.4	0.4	8.2	0.6
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	15.13	0.5291	5,000	16.0	1.8	13.7	1.9	11.4	2.0	nd	16.0	1.8	13.7	1.9	11.4	2.0
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	15.36	0.5448	5,000	14.2	1.6	11.9	1.7	9.7	1.8	nd	14.2	1.6	11.9	1.7	9.7	1.8
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	15.37	0.5372	5,000	15.4	1.9	13.1	2.0	10.8	2.1	nd	15.4	1.9	13.1	2.0	10.8	2.1
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	15.48	0.5409	5,000	15.2	1.9	12.8	2.1	10.5	2.2	nd	15.2	1.9	12.8	2.1	10.5	2.2
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	21.45	0.6348	5,000	16.4	8.4	14.0	8.5	11.7	8.6	nd	16.4	8.4	14.0	8.5	11.7	8.6
S253	NM522	Tome D	12	na	8/6/1998	16.11	0.5505	5,000	15.3	2.6	13.0	2.7	10.7	2.9	0.9	13.0	1.1	10.8	1.2	8.5	1.3
S253	NM522	Tome D	12	na	8/6/1998	16.13	0.5507	5,000	15.3	2.6	13.0	2.8	10.7	2.9	0.9	13.1	1.1	10.8	1.2	8.5	1.3
S257	NM344	Domestic Well #34	12	na	6/17/1997	16.20	0.5700	5,000	12.7	2.0	10.4	2.1	8.2	2.2	0.5	11.5	1.1	9.3	1.2	7.1	1.3
S259	NM171	VGP-1	12	na	6/27/1996	19.39	0.6028	5,000	15.9	6.1	13.5	6.3	11.2	6.4	nd	15.9	6.1	13.5	6.3	11.2	6.4
S261	NM172	Vol Andia 2	12	na	6/21/1996	15.14	0.5565	5,000	12.0	0.7	9.8	0.8	7.6	0.9	nd	12.0	0.7	9.8	0.8	7.6	0.9
S262	NM173	Vol Andia 5	12	na	6/18/1996	15.32	0.5521	5,000	13.1	1.2	10.8	1.3	8.6	1.4	0.5	11.9	0.3	9.6	0.4	7.4	0.5
S265	NM175	Webster 1	12	na	6/18/1996	19.73	0.3999	5,000	75.4	15.5	73.1	15.6	70.8	15.7	nd	75.4	15.5	73.1	15.6	70.8	15.7
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	15.52	0.5619	5,000	12.2	1.1	9.9	1.2	7.7	1.3	nd	12.2	1.1	9.9	1.2	7.7	1.3
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	15.14	0.5717	5,000	10.0	0.0	7.8	0.1	5.7	0.2	nd	10.0	0.0	7.8	0.1	5.7	0.2
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	15.73	0.5604	5,000	12.9	1.5	10.6	1.7	8.4	1.8	nd	12.9	1.5	10.6	1.7	8.4	1.8
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	15.79	0.5773	5,000	10.7	0.9	8.5	1.0	6.4	1.1	nd	10.7	0.9	8.5	1.0	6.4	1.1
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	17.47	0.6344	5,000	7.3	1.4	5.1	1.5	3.1	1.6	nd	7.3	1.4	5.1	1.5	3.1	1.6
S275	NM178	Yale 1	12	na	6/19/1996	18.37	0.5891	5,000	15.3	4.9	13.0	5.1	10.7	5.2	2.5	9.4	0.6	7.2	0.7	5.1	0.8
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	14.41	0.5276	5,000	14.4	0.6	12.1	0.7	9.8	0.9	nd	14.4	0.6	12.1	0.7	9.8	0.9
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	17.52	0.6182	5,000	9.3	2.2	7.1	2.3	5.0	2.4	nd	9.3	2.2	7.1	2.3	5.0	2.4
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	14.44	0.5387	5,000	12.8	0.2	10.6	0.3	8.3	0.4	nd	12.8	0.2	10.6	0.3	8.34	0.4
		Zone 13: Discharge																			
S143	NM096	Private Production Well #05	13	na	8/19/1996	17.59	0.5639	5,000	17.2	4.6	14.8	4.8	12.5	4.9	2.0	12.1	1.1	9.8	1.3	7.6	1.4
S194	NM327	Domestic Well #32	13	na	6/30/1997	14.38	0.5131	5,000	16.6	1.2	14.2	1.3	11.8	1.4	nd	16.6	1.2	14.2	1.3	11.8	1.4
S226	NM150	Domestic Well #15	13	na	8/19/1996	17.51	0.5682	5,000	16.3	4.3	13.9	4.4	11.6	4.6	1.9	11.5	1.0	9.3	1.1	7.1	1.2
		No Zone: Exotic Water																			
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	10.72	0.4016	5,000	25.7	- 0.5	23.1	- 0.4	20.5	- 0.3	nd	25.7	- 0.5	23.1	- 0.4	20.5	- 0.3
S023	NM010	Burn Site Well	E	E	6/25/1996	15.63	0.5332	6,500	16.8	2.5	14.4	2.6	12.0	2.8	nd	16.8	2.5	14.4	2.6	12.0	2.8
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	8.100	0.3299	5,000	32.0	- 2.1	29.2	- 2.0	26.5	- 1.8	nd	32.0	- 2.1	29.2	- 2.0	26.5	- 1.8
S038	NM265	Windmill #19	E	E	7/1/1997	21.41	0.6898	5,000	8.6	6.0	6.5	6.1	4.4	6.2	nd	8.6	6.0	6.5	6.1	4.4	6.2
S054	NM041	Domestic Well #04	E	E	8/17/1996	2.985	0.1399	6,500	66.1	- 3.0	63.4	- 2.9	60.8	- 2.8	nd	66.1	- 3.0	63.4	- 2.9	60.8	- 2.8
S057	NM044	Embudo Spring	E	E	7/2/1996	15.09	0.5519	6,500	12.6	0.8	10.3	0.9	8.1	1.0	nd	12.6	0.8	10.3	0.9	8.1	1.0
S063	NM282	Windmill #22	E	E	6/28/1997	16.35	0.5387	5,000	17.9	3.5	15.4	3.7	13.1	3.8	nd	17.9	3.5	15.4	3.7	13.1	3.8

Table A6. Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

									Assuming no excess N_2							Assuming calculated excess N_2					
									Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet			Alt. 5,000 feet		Alt. 6,500 feet		Alt. 8,000 feet	
Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	N_2 (mg/kg)	Ar (mg/kg)	Assigned recharge altitude (feet)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Calcu-lated excess N_2 (mg/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)	Recharge temp-erature (ºC)	Excess air (cc STP/kg)
S067	NM284	Granite Hill	E	E	7/4/1997	23.20	0.6255	6,500	23.4	11.8	20.8	12.0	18.3	12.1	nd	23.4	11.8	20.8	12.0	18.3	12.1
S070	NM059	HERTF	E	E	6/28/1996	14.99	0.5165	6,500	17.7	2.1	15.3	2.2	12.9	2.3	nd	17.7	2.1	15.3	2.2	12.9	2.3
S091	NM496	Private Production Well #23	E	E	8/4/1998	16.28	0.5482	5,000	16.1	3.0	13.8	3.1	11.4	3.3	1.1	13.3	1.1	11.0	1.2	8.8	1.3
S094	NM293	Stock Well #02	E	E	6/20/1997	21.91	0.6057	5,000	23.0	10.4	20.4	10.5	17.9	10.7	nd	23.0	10.4	20.4	10.5	17.9	10.7
S099	NM072	LALF-1	E	E	6/29/1996	17.44	0.5178	5,000	25.4	6.3	22.7	6.4	20.2	6.6	3.0	16.0	1.1	13.6	1.2	11.3	1.3
S112	NM296	Domestic Well #24	E	E	6/21/1997	14.25	0.4924	6,500	19.7	1.8	17.2	2.0	14.8	2.1	nd	19.7	1.8	17.2	2.0	14.8	2.1
S129	NM087	Montaño 4 S	E	E	6/19/1996	15.83	0.5348	5,000	17.1	2.8	14.7	2.9	12.3	3.0	1.0	14.4	1.1	12.1	1.2	9.8	1.3
S152	NM098	Private Production Well #07	E	E	8/22/1996	16.66	0.5606	6,500	15.2	3.2	12.9	3.3	10.6	3.4	1.5	11.5	0.5	9.3	0.7	7.1	0.8
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	18.59	0.5459	5,000	23.6	7.1	21.0	7.3	18.5	7.4	3.5	13.4	1.0	11.1	1.1	8.9	1.3
S211	NM512	Sandia M	E	E	7/30/1998	15.67	0.5509	6,500	14.1	1.8	11.8	2.0	9.6	2.1	0.6	12.6	0.8	10.4	0.9	8.2	1.0
S211	NM512	Sandia M	E	E	7/30/1998	15.94	0.5575	6,500	13.8	2.0	11.5	2.1	9.3	2.2	0.6	12.4	1.0	10.1	1.1	7.9	1.2
S225	NM149	SBM-1	E	E	6/29/1996	15.26	0.5149	5,000	18.8	2.6	16.3	2.8	13.9	2.9	1.0	15.9	0.9	13.6	1.0	11.3	1.1
S249	NM164	Private Production Well #09	E	E	6/26/1996	13.65	0.4874	6,500	18.8	1.0	16.3	1.1	13.9	1.2	nd	18.8	1.0	16.3	1.1	13.9	1.2
S249	NM163	Private Production Well #09	E	E	6/26/1996	35.29	0.8637	6,500	17.6	22.9	15.2	23.0	12.8	23.1	nd	17.6	22.9	15.2	23.0	12.8	23.1
S250	NM165	Private Production Well #10	E	E	6/26/1996	18.06	0.5517	6,500	20.7	6.0	18.2	6.1	15.8	6.2	nd	20.7	6.0	18.2	6.1	15.8	6.2
S251	NM166	Private Production Well #11	E	E	6/26/1996	14.67	0.5013	6,500	19.4	2.2	16.9	2.3	14.5	2.4	nd	19.4	2.2	16.9	2.3	14.5	2.4
S282	NM529	Windmill #44	E	E	7/29/1998	13.74	0.4757	5,000	21.2	1.6	18.6	1.8	16.2	1.9	nd	21.2	1.6	18.6	1.8	16.2	1.9
SXXX	NM065	Jemez Spring	E	E	8/20/1996	1.164	0.0368	8,000	90.2	- 0.3	88.5	- 0.2	86.9	- 0.2	nd	90.2	- 0.3	88.5	- 0.2	86.9	- 0.2
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	3.888	0.1454	8,000	69.7	- 1.6	67.2	- 1.5	64.7	- 1.4	nd	69.7	- 1.6	67.2	- 1.5	64.7	- 1.4

Table A7. Summary of chlorofluorocarbon concentrations in water from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane (CF_2Cl_2); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); pg/kg, picograms per kilogram; pptv, parts per trillion by volume; na, not applicable; Modern concentrations of CFC-11, CFC-12, and CFC-113 assumed to be 271, 532, and 84.5 pptv, respectively, in calculation of Percent modern CFC.]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
		Zone 1: Northern Mountain Front												
S027	NM486	CEPO 02	1	na	8/3/1998	3.2	1.6	3.9	1.7	3.5	4.9	0.6	0.7	5.8
S034	NM027	Private Production Well #04	1	na	8/28/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S036	NM026	Private Production Well #03	1	na	8/28/1996	0.3	0.8	0.0	0.1	1.8	0.0	0.1	0.3	0.0
S065	NM055	Domestic Well #05	1	na	8/17/1996	8.5	5.6	0.0	4.3	12.2	0.0	1.6	2.3	0.0
S187	NM131	Rio Rancho 12	1	na	8/13/1996	8.4	6.3	2.4	4.3	13.8	3.0	1.6	2.6	3.5
S216	NM143	Windmill #09	1	na	8/27/1996	23.4	16.8	5.9	12.1	37.1	7.4	4.5	7.0	8.8
S254	NM168	Private Production Well #12	1	na	8/28/1996	0.3	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
		Zone 2: Northwestern												
S103	NM497	Lincoln D	2	na	7/23/1998	18.7	3.3	2.4	9.7	7.4	3.1	3.6	1.4	3.7
S104	NM498	Lincoln M	2	na	7/23/1998	119.6	0.2	0.0	62.2	0.5	0.0	22.9	0.1	0.0
S105	NM499	Lincoln S	2	na	7/23/1998	10.5	4.4	2.1	5.5	9.8	2.8	2.0	1.8	3.3
S191	NM326	Rio Rancho 4	2	3	6/20/1997	186.4	108.2	34.1	94.6	236.	41.8	34.9	44.3	49.4
S192	NM128	Rio Rancho 8	2	3	8/13/1996	0.4	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
S189	NM133	Rio Rancho 15	2	na	8/13/1996	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
S286	NM184	Private Production Well #13	2	na	8/26/1996	5.8	5.2	0.0	3.0	11.4	0.0	1.1	2.1	0.0
S287	NM185	Private Production Well #14	2	na	8/26/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Zone 3: West Central												
S003	NM481	98th St. D	3	na	8/4/1998	8.0	15.5	0.0	4.1	34.6	0.0	1.5	6.5	0.0
S003	NM251	98th St. D	3	na	6/17/1997	10.7	2.8	0.0	27.4	13.8	0.0	10.1	2.6	0.0
S004	NM482	98th St. MD	3	na	8/4/1998	31.7	29.1	0.0	16.5	64.8	0.0	6.1	12.2	0.0
S004	NM252	98th St. MD	3	na	6/18/1997	153.	0.6	0.0	80.2	1.5	0.0	29.6	0.3	0.0
S005	NM483	98th St. MS	3	na	8/4/1998	4.5	20.7	0.0	2.4	47.2	0.0	0.9	8.9	0.0
S005	NM253	98th St. MS	3	na	7/4/1997	18.6	4.2	0.0	9.4	9.1	0.0	3.5	1.7	0.0
S006	NM484	98th St. S	3	na	8/5/1998	53.8	31.3	31.3	28.0	69.7	39.4	10.3	13.1	46.6
S006	NM254	98th St. S	3	na	6/17/1997	241.	74.0	109.	122.	161.	133.	45.1	30.3	157.6
S008	NM003	Private Production Well #01	3	na	8/12/1996	0.3	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
S010	NM255	Private Production Well #16	3	na	6/23/1997	453.	72,872.	51.5	230.	158,647.	63.2	84.8	29,821.	74.8
S018	NM260	Domestic Well #21	3	na	6/26/1997	36.5	32.3	5.2	18.5	70.2	6.4	6.8	13.2	7.6
S019	NM007	Belen 4	3	5	8/16/1996	64.9	45.4	0.0	32.9	98.8	0.0	12.2	18.6	0.0
S020	NM008	Belen 5	3	5	8/16/1996	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S037	NM264	College 2	3	na	6/19/1997	0.5	1.1	0.0	0.2	2.3	0.0	0.1	0.4	0.0
S066	NM056	Gonzales 1	3	12	6/20/1996	7.3	6.6	0.0	3.7	14.3	0.0	1.4	2.7	0.0
S086	NM492	Isleta D	3	na	7/29/1998	59.1	6.9	0.0	30.8	15.5	0.0	11.4	2.9	0.0
S101	NM294	Leavitt 1	3	na	6/26/1997	5.7	6.0	0.0	2.9	13.1	0.0	1.1	2.5	0.0
S108	NM076	Los Lunas 3	3	12	8/14/1996	0.5	1.0	0.0	0.3	2.2	0.0	0.1	0.4	0.0
S109	NM077	Los Lunas 4	3	12	8/14/1996	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
S145	NM308	NM Utilities 1	3	na	6/18/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S147	NM310	NM Utilities 3	3	na	6/18/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S148	NM311	NM Utilities 4	3	na	6/18/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S166	NM509	Rabbit Hill	3	na	8/4/1998	7.8	2.3	8.1	4.1	5.1	10.1	1.5	1.0	12.0
S167	NM107	Domestic Well #12	3	na	8/14/1996	0.8	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	7.3	0.0	26.6	3.8	0.0	33.5	1.4	0.0	39.7
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	0.9	0.0	0.0	0.5	0.0	0.0	0.2	0.0	0.0
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	5.3	2.4	0.0	2.7	5.2	0.0	1.0	1.0	0.0
S186	NM130	Rio Rancho 10	3	na	8/13/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S188	NM132	Rio Rancho 13	3	na	8/13/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S193	NM129	Rio Rancho 9	3	na	8/13/1996	16.0	25.7	5.2	8.1	55.9	6.4	3.0	10.5	7.6
S196	NM135	Windmill #05	3	na	8/21/1996	127.	93.6	25.1	64.2	204.	30.8	23.7	38.3	36.4
S200	NM139	Private Production Well #08	3	na	8/29/1996	0.0	0.8	0.0	0.0	1.8	0.0	0.0	0.3	0.0
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	0.9	0.9	9.6	0.5	2.0	12.5	0.2	0.4	14.8
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	13.6	5.7	203.	6.9	12.4	249.	2.6	2.3	294.2
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	2.1	3.6	0.0	1.1	8.1	0.0	0.4	1.5	0.0
S230	NM516	Sierra Vista D	3	na	7/22/1998	37.3	0.0	0.0	19.2	0.0	0.0	7.1	0.0	0.0
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	137.	77.4	24.0	69.7	169.	29.5	25.7	31.7	34.9
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	1.2	2.7	0.0	0.6	5.9	0.0	0.2	1.1	0.0
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	7.8	0.4	19.1	4.0	0.9	24.3	1.5	0.2	28.8
S272	NM353	West Mesa 3	3	na	6/19/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S283	NM181	Zia Ball Park D	3	na	8/26/1996	0.9	0.3	331.	0.5	0.8	426.	0.2	0.1	503.8
S284	NM182	Zia Ball Park M	3	na	8/26/1996	8.3	0.9	360.	4.2	1.9	442.	1.5	0.4	523.3
S285	NM183	Zia Ball Park S	3	2	8/26/1996	5.2	1.3	39.1	2.6	2.8	48.0	1.0	0.5	56.8
		Zone 4: Western Boundary												
S059	NM278	Windmill #21	4	na	6/23/1997	18.2	13.8	0.0	9.2	30.1	0.0	3.4	5.7	0.0
		Zone 5: Rio Puerco												
S069	NM058	Domestic Well #06	5	na	8/16/1996	20.1	52.2	11.7	10.5	116.6	14.8	3.9	21.9	17.6
S082	NM409	Windmill #36	5	na	9/10/1997	95.5	42.0	6.5	48.5	91.4	8.0	17.9	17.2	9.4
S085	NM408	Windmill #35	5	na	9/10/1997	212.	98.5	18.5	107.	215.	22.7	39.6	40.3	26.9
S111	NM079	Domestic Well #10	5	na	8/16/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S185	NM324	Domestic Well #31	5	na	6/16/1997	5.4	12.2	0.0	2.8	27.2	0.0	1.0	5.1	0.0
S198	NM137	Windmill #07	5	na	8/21/1996	73.1	43.8	8.1	37.1	95.5	10.0	13.7	17.9	11.8
		Zone 7: Abo Arroyo												
S021	NM261	Stock Well #01	7	na	6/23/1997	605.	221.	27.3	307.	482.	33.5	113.3	90.6	39.7
S024	NM011	Domestic Well #02	7	8	8/17/1996	2.7	1.7	0.0	1.4	19.3	0.0	0.5	3.6	0.0
S090	NM064	Domestic Well #08	7	na	8/19/1996	6.6	3.1	0.0	3.3	6.7	0.0	1.2	1.3	0.0
S093	NM067	Domestic Well #09	7	8	8/15/1996	1.4	0.9	0.0	0.7	1.9	0.0	0.3	0.4	0.0
S007	NM002	Domestic Well #01	8	na	6/21/1996	695.5	327.0	96.1	361.	726.	121.	133.0	136.4	143.4

Table A7. Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
		Zone 8: Eastern Mountain Front												
S030	NM023	Charles 4	8	na	6/27/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S030	NM024	Charles 4	8	na	6/27/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S030	NM022	Charles 4	8	na	6/27/1996	0.5	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0
S030	NM024	Charles 4	8	na	6/27/1996	0.7	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0
S030	NM016	Charles 4	8	na	6/22/1996	0.7	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0
S030	NM021	Charles 4	8	na	6/27/1996	0.8	0.0	0.0	0.4	0.0	0.0	0.2	0.0	0.0
S030	NM018	Charles 4	8	na	6/27/1996	1.1	1.1	0.0	0.6	2.7	0.0	0.2	0.5	0.0
S030	NM020	Charles 4	8	na	6/27/1996	1.3	0.0	0.0	0.7	0.0	0.0	0.3	0.0	0.0
S030	NM019	Charles 4	8	na	6/27/1996	1.5	0.0	0.0	0.8	0.0	0.0	0.3	0.0	0.0
S030	NM017	Charles 4	8	na	6/27/1996	1.8	0.0	0.0	0.9	0.0	0.0	0.3	0.0	0.0
S042	NM031	Domestic Well #03	8	na	8/14/1996	0.4	0.0	0.0	0.2	12.6	0.0	0.1	2.4	0.0
S055	NM042	Elena Gallegos	8	na	6/25/1996	428.	207.	54.5	217.	452.	66.8	80.1	84.9	79.1
S056	NM043	Embudito Spring	8	na	7/2/1996	432.	220.	66.0	224.	488.	82.9	82.5	91.7	98.1
S056	NM227	Embudito Spring	8	na	4/29/1997	523.	287.	72.9	244.	584.	82.3	90.2	109.7	97.4
S056	NM227	Embudito Spring	8	na	4/29/1997	620.	324.	86.2	268.	614.	89.4	98.9	115.4	105.9
S056	NM214	Embudito Spring	8	na	3/21/1997	638.	401.	88.6	243.	679.	80.1	89.8	127.7	94.8
S056	NM213	Embudito Spring	8	na	3/21/1997	738.	419.	123.	261.	664.	102.	96.2	124.8	120.4
S071	NM060	Domestic Well #07	8	na	6/19/1996	0.5	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0
S083	NM407	Windmill #34	8	na	9/10/1997	58.6	16.8	3.8	29.7	36.6	4.7	11.0	6.9	5.5
S095	NM068	Kirtland 1	8	na	6/25/1996	191.	11.9	3.8	96.8	26.0	4.7	35.7	4.9	5.5
S106	NM295	Domestic Well #23	8	na	6/26/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S110	NM078	Love 1	8	na	6/22/1996	34.0	10.1	55.6	17.2	22.0	68.3	6.4	4.1	80.8
S113	NM080	Domestic Well #11	8	na	8/15/1996	1.9	1.4	0.0	0.9	3.0	0.0	0.3	0.6	0.0
S114	NM500	Matheson D	8	na	7/31/1998	247.	50.2	14.1	126.	109.	18.4	46.3	20.5	21.8
S115	NM501	Matheson M	8	na	8/1/1998	127.	43.4	27.8	64.5	94.4	34.1	23.8	17.7	40.3
S116	NM502	Matheson S	8	na	8/1/1998	15.5	5.0	1.1	8.0	11.1	1.4	3.0	2.1	1.7
S117	NM298	Domestic Well #25	8	na	6/17/1997	4.2	13.2	0.0	2.2	29.4	0.0	0.8	5.5	0.0
S119	NM300	Domestic Well #26	8	11	6/19/1997	5,591.	551.	29.8	2,837.	1,200.	36.5	1,046.9	225.5	43.2
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	0.3	17.8	0.0	0.2	38.6	0.0	0.1	7.3	0.0
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	18.9	12.1	3.1	9.8	27.1	4.0	3.6	5.1	4.7
S140	NM306	MRN 1	8	na	7/5/1997	114.	0.0	0.0	57.8	0.0	0.0	21.3	0.0	0.0
S141	NM095	National Utility 7	8	na	8/14/1996	69.1	785.	7.5	35.0	1,709.	9.2	12.9	321.3	10.9
S149	NM312	Nor Este D	8	na	7/3/1997	9.6	0.0	0.0	5.0	0.0	0.0	1.8	0.0	0.0
S150	NM313	Nor Este M	8	na	7/2/1997	4.6	0.0	0.0	2.4	0.0	0.0	0.9	0.0	0.0
S162	NM317	Stock Well #03	8	na	6/30/1997	1.9	0.0	0.0	1.0	0.0	0.0	0.4	0.0	0.0
S163	NM318	PL 2	8	na	7/7/1997	5.9	0.0	0.0	3.0	0.0	0.0	1.1	0.0	0.0
S164	NM106	Ponderosa 1	8	na	6/20/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S168	NM319	Domestic Well #30	8	na	6/27/1997	7.3	9.2	22.1	3.7	20.3	27.8	1.4	3.8	33.0
S170	NM108	Ridgecrest 3	8	na	6/22/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S195	NM134	Domestic Well #13	8	na	8/14/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S209	NM336	Domestic Well #33	8	na	6/27/1997	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
S212	NM141	Sandia Peak 1	8	na	6/26/1996	0.3	3.1	0.0	0.1	6.8	0.0	0.1	1.3	0.0
S213	NM142	Sandia Peak 3	8	na	6/26/1996	1.9	13.2	1.4	0.9	28.7	1.7	0.3	5.4	2.0
S224	NM148	Domestic Well #14	8	na	8/23/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S229	NM515	SH03 UNM	8	na	7/28/1998	67.6	3.5	0.0	35.1	7.8	0.0	12.9	1.5	0.0
S233	NM153	Domestic Well #16	8	na	8/23/1996	0.0	0.8	0.0	0.0	1.8	0.0	0.0	0.3	0.0
S239	NM156	Domestic Well #17	8	na	8/17/1996	1.9	10,691.	3.2	1.0	23,276.	3.9	0.4	4,375.	4.6
S240	NM157	Domestic Well #18	8	na	6/19/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S247	NM161	Domestic Well #19	8	na	8/15/1996	0.1	1.3	0.0	0.1	2.8	0.0	0.0	0.5	0.0
S248	NM162	Thomas 6	8	na	6/21/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S255	NM523	Tramway East	8	na	7/30/1998	18.8	4.3	0.0	6.5	9.6	1.4	2.4	1.8	1.6
S264	NM174	Walker 1	8	na	6/18/1996	1.1	0.0	0.0	0.5	0.0	0.0	0.2	0.0	0.0
S274	NM177	Domestic Well #20	8	na	8/15/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Zone 9: Tijeras Fault Zone												
S041	NM029	Coyote Spring	9	na	6/28/1996	145.	91.6	18.4	75.4	203.	22.8	27.8	38.1	27.0
S072	NM061	Hubbell Spring	9	8	8/23/1996	99.8	77.9	14.9	50.6	170.	18.3	18.7	31.9	21.7
S098	NM071	KAFB-1902	9	na	6/28/1996	444.	1,626.	90.4	225.	3,540.	111.	83.1	665.5	131.2
S197	NM136	Windmill #06	9	na	8/23/1996	18.6	30.5	5.6	9.4	66.5	6.9	3.5	12.5	8.2
S227	NM151	SFR 3D	9	na	8/24/1996	17.7	4.4	0.0	9.0	9.6	0.0	3.3	1.8	0.0
S228	NM152	SFR 3S	9	na	8/24/1996	42.3	9.6	113.	21.5	20.9	138.	7.9	3.9	163.4
		Zone 10: Tijeras Arroyo												
S001	NM001	4Hills-1	10	8	6/29/1996	887.	364.	81.0	450.	793.	99.4	166.0	149.0	117.6
S002	NM250	Private Production Well #15	10	8	7/3/1997	879.	785.	329.	459.	1,751.	420.	169.3	329.0	496.7
S058	NM277	Eubank 1	10	8	7/4/1997	288.	185.	54.9	146.	404.	67.3	53.9	75.9	79.7
S096	NM069	Kirtland 11	10	8	6/25/1996	55.2	184.	563.	28.0	400.	690.	10.3	75.2	8.2
		Zone 11: Northeastern												
S144	NM097	Private Production Well #06	11	na	8/28/1996	3.2	1.4	0.0	1.6	3.0	0.0	0.6	0.6	0.0
S207	NM334	Private Production Well #22	11	na	7/3/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Zone 12: Central												
S011	NM004	Atris-1	12	na	6/22/1996	1.2	82.1	0.0	0.6	179.	0.0	0.2	33.6	0.0
S012	NM005	Atrisco 3	12	3	6/20/1996	0.6	9.9	0.0	0.3	22.6	0.0	0.1	4.3	0.0
S025	NM012	Burton 2	12	na	6/19/1996	31.6	47.2	14.9	16.0	103.	18.2	5.9	19.3	21.6
S026	NM013	Burton 5	12	na	6/19/1996	1.3	0.0	0.0	0.7	0.0	0.0	0.2	0.0	0.0
S033	NM025	Private Production Well #02	12	na	8/21/1996	29.2	28.6	1.9	14.8	62.3	2.3	5.5	11.7	2.7
S040	NM028	Coronado 1	12	na	6/18/1996	52.6	332.	0.0	26.7	722.	0.0	9.8	135.7	0.0
S043	NM488	Del Sol D	12	na	7/21/1998	2.8	0.2	0.0	1.4	0.4	0.0	0.5	0.1	0.0
S043	NM267	Del Sol D	12	na	7/1/1997	8.0	1.2	0.0	4.2	2.7	0.0	1.5	0.5	0.0
S044	NM268	Del Sol M	12	na	6/26/1997	3.9	0.0	0.0	2.0	0.0	0.0	0.7	0.0	0.0
S044	NM489	Del Sol M	12	na	7/21/1998	3.9	0.0	0.0	2.0	0.0	0.0	0.7	0.0	0.0
S045	NM269	Del Sol S	12	na	6/26/1997	28.0	19.5	0.0	14.2	42.4	0.0	5.2	8.0	0.0
S045	NM490	Del Sol S	12	na	7/21/1998	28.7	16.2	0.0	15.0	36.1	0.0	5.5	6.8	0.0

Table A7. Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
S046	NM033	Duranes 1	12	na	6/29/1996	0.0	179.	0.0	0.0	391.	0.0	0.0	73.4	0.0
S046	NM035	Duranes 1	12	na	6/29/1996	0.0	165.	0.0	0.0	386.	0.0	0.0	72.6	0.0
S046	NM036	Duranes 1	12	na	6/29/1996	0.0	163.	0.0	0.0	381.	0.0	0.0	71.6	0.0
S046	NM037	Duranes 1	12	na	6/29/1996	0.0	173.	0.0	0.0	402.	0.0	0.0	75.7	0.0
S046	NM038	Duranes 1	12	na	6/29/1996	0.0	176.	0.0	0.0	411.	0.0	0.0	77.3	0.0
S046	NM039	Duranes 1	12	na	6/29/1996	0.0	180.	0.0	0.0	421.	0.0	0.0	79.1	0.0
S046	NM040	Duranes 1	12	na	6/29/1996	0.0	183.	0.0	0.0	399.	0.0	0.0	75.0	0.0
S046	NM034	Duranes 1	12	na	6/29/1996	0.4	160.	0.0	0.2	373.	0.0	0.1	70.2	0.0
S046	NM032	Duranes 1	12	na	6/20/1996	0.5	77.9	0.0	0.2	170.	0.0	0.1	31.9	0.0
S047	NM270	Duranes 7	12	na	6/26/1997	0.1	32.8	0.0	0.0	71.4	0.0	0.0	13.4	0.0
S048	NM271	Duranes Yard 1	12	na	7/5/1997	4.2	5.2	0.0	1.8	9.9	0.0	0.7	1.9	0.0
S049	NM272	Duranes Yard 2	12	na	7/5/1997	25.1	15.7	15.3	10.6	28.9	15.3	3.9	5.4	18.1
S050	NM273	Duranes Yard 3	12	na	7/5/1997	28.6	67.2	67.8	15.0	150.	86.1	5.5	28.3	101.9
S051	NM274	Duranes Yard 4	12	na	7/5/1997	2.5	136.	0.0	0.9	226.	0.0	0.3	42.5	0.0
S052	NM275	Duranes Yard 5	12	na	7/5/1997	5.0	197.	27.9	2.1	359.	27.5	0.8	67.4	32.5
S060	NM279	Garfield D	12	3	6/19/1997	2.4	0.0	11.3	1.2	0.0	13.9	0.5	0.0	16.5
S061	NM280	Garfield M	12	na	6/19/1997	2.1	0.0	0.0	1.1	0.0	0.0	0.4	0.0	0.0
S062	NM281	Garfield S	12	na	6/19/1997	15.5	861.	43.0	7.9	1,875.	52.7	2.9	352.4	62.4
S062	NM491	Garfield S	12	na	7/28/1998	22.9	964.	20.3	11.9	2,148.	26.1	4.4	403.8	30.9
S064	NM283	Domestic Well #22	12	na	6/20/1997	5.6	10.4	0.0	2.9	22.7	0.0	1.1	4.3	0.0
S068	NM057	Griegos 3	12	na	6/21/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	4.9	0.0	28.4	2.5	0.0	35.6	0.9	0.0	42.2
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	9.9	0.3	7.8	5.2	0.6	9.8	1.9	0.1	11.6
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	63.6	36.0	107.	33.8	82.9	136.	12.5	15.6	160.8
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	7.7	1.6	0.0	3.9	3.5	0.0	1.4	0.7	0.0
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	4.9	0.0	0.0	2.6	0.0	0.0	0.9	0.0	0.0
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	6.1	3.1	10.4	3.2	7.0	12.9	1.2	1.3	15.2
S081	NM292	Private Production Well #19	12	na	7/2/1997	1.1	0.0	0.0	0.6	0.0	0.0	0.2	0.0	0.0
S084	NM063	Windmill #04	12	na	8/21/1996	65.8	38.7	6.6	33.4	84.4	8.1	12.3	15.9	9.6
S087	NM493	Isleta MD	12	3	7/29/1998	4.6	3.8	0.0	2.4	8.7	0.0	0.9	1.6	0.0
S088	NM494	Isleta MS	12	na	7/29/1998	3.4	4.3	0.0	1.7	9.7	0.0	0.6	1.8	0.0
S089	NM495	Isleta S	12	na	7/29/1998	0.6	17.7	0.0	0.3	39.6	0.0	0.1	7.4	0.0
S092	NM066	JMC-1	12	na	6/28/1996	202.	279.	31.8	103.	608.	39.0	37.9	114.3	46.2
S097	NM070	Kirtland 14	12	na	6/25/1996	1.6	27.5	0.0	0.8	60.0	0.0	0.3	11.3	0.0
S100	NM073	LALF-9	12	na	6/29/1996	5,521.	45,228.	31,499.	2,801.	98,464.	38,638.	1,034.	18,508.	45,725.
S102	NM074	Leyendecker 1	12	na	6/21/1996	28.0	125.8	0.0	14.2	274.	0.0	5.2	51.5	0.0
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	22.3	0.5	0.0	11.3	1.1	0.0	4.2	0.2	0.0
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	85.4	108.6	90.5	43.3	236.	111.	16.0	44.4	131.4
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	112.	88.9	25.7	56.6	194.	31.5	20.9	36.4	37.3
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	0.0	6.5	0.0	0.0	14.2	0.0	0.0	2.7	0.0
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	5.9	1.6	0.0	3.0	3.5	0.0	1.1	0.7	0.0
S123	NM081	MONT - 5A	12	na	6/27/1996	3.4	79.0	0.0	1.7	172.	0.0	0.6	32.3	0.0
S124	NM082	Montaño 2 D	12	na	6/19/1996	0.7	53.9	0.0	0.3	117.	0.0	0.1	22.1	0.0
S125	NM083	Montaño 2 M	12	na	6/19/1996	0.4	37.2	0.0	0.2	83.2	0.0	0.1	15.6	0.0
S126	NM084	Montaño 2 S	12	na	6/19/1996	0.8	214.1	0.0	0.4	466.	0.0	0.2	87.6	0.0
S127	NM085	Montaño 4 D	12	na	6/20/1996	0.0	8.9	0.0	0.0	19.4	0.0	0.0	3.6	0.0
S128	NM086	Montaño 4 M	12	na	6/19/1996	0.0	56.1	0.0	0.0	122.	0.0	0.0	23.0	0.0
S130	NM088	Montaño 5 D	12	na	6/24/1996	0.3	4.4	0.0	0.2	9.7	0.0	0.1	1.8	0.0
S131	NM089	Montaño 5 M	12	na	6/24/1996	14.7	200.	11.1	7.5	435.	13.6	2.8	81.7	16.1
S132	NM090	Montaño 5 S	12	na	6/24/1996	74.0	177.	61.3	37.6	385.	75.2	13.9	72.3	89.0
S133	NM091	Montaño 6 D	12	na	6/18/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S133	NM091	Montaño 6 D	12	na	6/18/1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S134	NM092	Montaño 6 MD	12	na	6/18/1996	1.5	0.3	194.	0.7	0.7	238.	0.3	0.1	282.0
S135	NM093	Montaño 6 MS	12	na	6/18/1996	1.6	0.0	106.	0.8	0.0	130.	0.3	0.0	153.5
S136	NM094	Montaño 6 S	12	na	6/18/1996	1.0	266.8	0.0	0.5	581.	0.0	0.2	109.2	0.0
S137	NM506	Montesa M	12	na	7/27/1998	36.0	1.7	1.3	18.5	3.8	1.7	6.8	0.7	2.0
S138	NM507	Montesa S	12	na	7/27/1998	69.1	52.6	0.0	35.8	117.	0.0	13.2	22.1	0.0
S139	NM305	Domestic Well #27	12	na	6/17/1997	99.3	0.0	0.0	50.4	0.0	0.0	18.6	0.0	0.0
S142	NM307	Domestic Well #28	12	na	6/17/1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S146	NM309	NM Utilities 2	12	na	6/18/1997	2.7	0.0	0.0	1.4	0.0	0.0	0.5	0.0	0.0
S151	NM508	Nor Este S	12	na	7/20/1998	65.2	6.2	0.0	75.0	14.8	0.0	27.7	2.8	0.0
S151	NM314	Nor Este S	12	na	7/2/1997	272.	207.	48.9	108.	429.	48.6	39.9	80.6	57.6
S153	NM411	Open Space	12	na	11/18/1997	447.	37.5	25.3	227.	81.6	31.1	83.8	15.3	36.8
S154	NM099	ORLF-2	12	na	6/27/1996	53.1	117.6	5.1	26.9	256.	6.2	9.9	48.1	7.4
S155	NM316	Domestic Well #29	12	na	6/27/1997	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
S156	NM100	Paseo 2D	12	na	6/26/1996	3.0	2.8	69.8	1.5	6.2	85.6	0.6	1.2	101.3
S157	NM101	Paseo 2MD	12	na	6/26/1996	0.4	41.6	7.6	0.2	90.6	9.3	0.1	17.0	11.1
S158	NM102	Paseo 2MS	12	na	6/26/1996	0.1	453.	1.2	0.1	1,021.	1.5	0.0	192.0	1.8
S159	NM103	Paseo 2S	12	na	6/26/1996	71.0	2,068.	6.1	36.7	4,581.	7.9	13.5	861.1	9.3
S160	NM104	Paseo 3D	12	na	6/21/1996	8.2	26.8	170.	4.2	58.3	209.	1.5	11.0	247.2
S161	NM105	Paseo 3M	12	na	6/21/1996	11.2	2,205.	10.8	5.7	4,801.	13.2	2.1	902.5	15.6
S171	NM321	Ridgecrest 4	12	na	6/26/1997	0.1	20.9	0.0	0.0	46.8	0.0	0.0	8.8	0.0
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	0.6	1,713.	0.0	0.3	3,821.	0.0	0.1	718.2	0.0
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	2.0	69.1	0.0	1.0	150.	0.0	0.4	28.3	0.0
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	0.4	33.0	0.0	0.2	71.7	0.0	0.1	13.5	0.0
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	0.0	4.8	0.0	0.0	10.9	0.0	0.0	2.0	0.0
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	1.3	8.1	13.2	0.7	17.7	16.2	0.3	3.3	19.2
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	1.6	0.6	0.0	0.8	1.4	0.0	0.3	0.3	0.0
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	5.1	37.6	0.0	2.6	81.9	0.0	1.0	15.4	0.0
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	1.0	0.5	0.0	0.5	1.1	0.0	0.2	0.2	0.0
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	0.9	0.0	5.9	0.5	0.0	7.2	0.2	0.0	8.5
S190	NM325	Rio Rancho 2	12	na	6/20/1997	26.6	1.3	0.0	13.4	2.8	0.0	4.9	0.5	0.0
S203	NM331	Private Production Well #20	12	na	7/3/1997	53.0	129.	7.0	26.9	281.	8.6	9.9	52.9	10.2
S205	NM333	Private Production Well #21	12	na	7/3/1997	0.4	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
S208	NM140	San Jose 2	12	3	6/20/1996	0.0	14.5	0.0	0.0	31.6	0.0	0.0	5.9	0.0

Table A7. Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
S210	NM511	Sandia D	12	na	7/30/1998	29.0	18.0	9.0	14.7	39.1	6.7	5.4	7.4	7.9
S214	NM513	Sandia S	12	na	7/30/1998	39.4	21.0	4.4	20.0	45.7	6.0	7.4	8.6	7.1
S220	NM147	Santa Barbara 1	12	na	6/19/1996	533.	1,284.6	6.0	271.	2,797.	7.4	99.9	525.7	8.7
S231	NM517	Sierra Vista M	12	3	7/22/1998	43.7	0.6	13.3	22.6	1.4	16.9	8.4	0.3	20.1
S232	NM518	Sierra Vista S	12	na	7/22/1998	20.1	27.6	8.5	10.5	61.5	10.6	3.9	11.6	12.5
S234	NM339	Sister Cities D	12	na	6/30/1997	9.0	2.8	0.0	4.7	6.3	0.0	1.7	1.2	0.0
S235	NM340	Sister Cities M	12	na	6/27/1997	3.2	0.5	0.0	1.6	1.0	0.0	0.6	0.2	0.0
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	66.2	66.3	40.6	34.4	147.	51.7	12.7	27.6	61.1
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	0.0	55.7	0.0	3.1	104.	0.0	1.2	19.5	0.0
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	0.0	23.2	0.0	0.0	50.6	0.0	0.0	9.5	0.0
S253	NM522	Tome D	12	na	8/6/1998	33.3	7.3	31.8	14.2	16.4	40.2	5.2	3.1	47.6
S257	NM344	Domestic Well #34	12	na	6/17/1997	0.2	19.3	0.0	0.1	43.2	0.0	0.0	8.1	0.0
S259	NM171	VGP-1	12	na	6/27/1996	0.2	28.6	0.0	0.1	62.3	0.0	0.0	11.7	0.0
S261	NM172	Vol Andia 2	12	na	6/21/1996	19.1	16.0	0.0	9.7	34.9	0.0	3.6	6.6	0.0
S262	NM173	Vol Andia 5	12	na	6/18/1996	2,310.	1,942.	169.	1,172.	4,227.	208.	432.5	794.5	246.0
S265	NM175	Webster 1	12	na	6/18/1996	0.7	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	5.7	5.9	11.4	3.0	13.6	14.5	1.1	2.6	17.1
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	6.1	0.5	8.1	3.2	1.3	15.7	1.2	0.2	18.6
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	8.0	3.7	6.1	4.2	8.1	11.9	1.6	1.5	14.0
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	5.9	3.7	5.8	3.0	8.1	7.2	1.1	1.5	8.5
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	63.2	261.	21.2	32.0	568.	26.0	11.8	106.8	30.8
S275	NM178	Yale 1	12	na	6/19/1996	543.	161.	14.2	275.	351.	17.5	101.6	65.9	20.7
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	0.9	2,633.	0.0	0.5	5,733.	0.0	0.2	1,078.	0.0
SXXX	NM046	Geoprobe #1 (40.8')	12	na	7/1/1996	2.1	2,734.	0.0	1.1	5,952.	0.0	0.4	1,119.	0.0
SXXX	NM047	Geoprobe #1 (35.8')	12	na	7/1/1996	1.0	2,587.	0.0	0.5	5,633.	0.0	0.2	1,059.	0.0
SXXX	NM048	Geoprobe #1 (30.5')	12	na	7/1/1996	1.6	831.	0.0	0.8	1,810.	0.0	0.3	340.3	0.0
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	1.3	33.8	0.0	0.6	73.6	0.0	0.2	13.8	0.0
SXXX	NM050	Geoprobe #1 (20.2')	12	na	7/1/1996	2.1	25.7	0.0	1.1	56.0	0.0	0.4	10.5	0.0
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	6.7	9.1	27.9	3.4	19.9	34.2	1.3	3.7	40.4
SXXX	NM052	Geoprobe #2 (35.3')	12	na	7/1/1996	1.5	5.8	21.9	0.8	12.5	26.8	0.3	2.4	31.8
SXXX	NM053	Geoprobe #2 (30.2')	12	na	7/1/1996	2.7	17.1	29.4	1.4	37.3	36.1	0.5	7.0	42.7
SXXX	NM054	Geoprobe #2 (23.4')	12	na	7/1/1996	3.2	4.9	35.2	1.6	10.6	43.1	0.6	2.0	51.0
		Zone 13: Discharge												
S143	NM096	Private Production Well #05	13	na	8/19/1996	1.6	0.8	0.0	0.8	1.7	0.0	0.3	0.3	0.0
S194	NM327	Domestic Well #32	13	na	6/30/1997	6.4	6.1	0.0	3.3	13.7	0.0	1.2	2.6	0.0
S226	NM150	Domestic Well #15	13	na	8/19/1996	2.0	2.0	0.0	1.0	4.3	0.0	0.4	0.8	0.0
		No Zone: Exotic Water												
S023	NM010	Burn Site Well	E	E	6/25/1996	963.	68,205.	72.4	488.	148,488.	88.8	180.3	27,911.	105.1
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	32.7	37.0	623.	16.6	81.5	764.	6.1	15.3	904.4
S054	NM041	Domestic Well #04	E	E	8/17/1996	0.6	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0
S057	NM044	Embudo Spring	E	E	7/2/1996	6.7	218.5	21.0	3.4	487.	26.2	1.3	91.6	31.0
S057	NM241	Embudo Spring	E	E	5/27/1997	466.	288.	59.6	235.	625.	73.2	86.5	117.5	86.6
S057	NM241	Embudo Spring	E	E	5/27/1997	537.	269.	74.4	262.	568.	88.2	96.7	106.7	104.3
S057	NM215	Embudo Spring	E	E	3/21/1997	575.	309.	90.2	234.	555.	87.3	86.4	104.3	103.4
S067	NM284	Granite Hill	E	E	7/4/1997	4.4	51.9	14.6	2.3	115.	18.2	0.8	21.7	21.6
S070	NM059	HERTF	E	E	6/28/1996	6,747.	1,013.	486.	3,423.	2,206.	596.	1,263.2	414.8	705.5
S091	NM496	Private Production Well #23	E	E	8/4/1998	0.0	32.7	0.0	0.0	73.1	0.0	0.0	13.7	0.0
S094	NM293	Stock Well #02	E	E	6/20/1997	319.	173.	36.8	162.	376.	45.1	59.8	70.6	53.4
S099	NM072	LALF-1	E	E	6/29/1996	8,586.	77,577.	58,391.	4,356.	168,891.	71,625.	1,607.7	31,746.	84,763.
S112	NM297	Domestic Well #24	E	E	6/21/1997	0.0	4.9	0.0	0.0	10.7	0.0	0.0	2.0	0.0
S129	NM087	Montaño 4 S	E	E	6/19/1996	73.3	809.	13.7	37.9	1,795.	17.2	14.0	337.5	20.4
S152	NM098	Private Production Well #07	E	E	8/22/1996	25.5	17.6	7.0	13.0	38.3	8.6	4.8	7.2	10.2
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	1.5	21.6	0.0	0.8	47.0	0.0	0.3	8.8	0.0
S211	NM512	Sandia M	E	E	7/30/1998	26.8	3.6	2.3	13.6	7.9	5.6	5.0	1.5	6.6
S225	NM149	SBM-1	E	E	6/29/1996	12.2	71.5	12.4	6.3	158.	58.4	2.3	29.8	69.1
S249	NM163	Private Production Well #09	E	E	6/26/1996	2,378.	886.0	47.6	1,206.	1,928.	58.3	445.2	362.6	69.1
S250	NM165	Private Production Well #10	E	E	6/26/1996	105.	137.	1.0	53.4	299.	1.3	19.7	56.2	1.5
S251	NM166	Private Production Well #11	E	E	6/26/1996	365.	1,093.	47.7	185.	2,381.	58.5	68.3	447.6	69.2
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	446.	217.	54.0	226.	473.	66.2	83.5	89.0	78.3
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	460.	240.	58.6	233.	523.	71.8	86.0	98.3	85.0
SXXX	NM065	Jemez Spring	E	E	8/20/1996	22.1	4.2	9.5	11.2	9.1	11.7	4.1	1.7	13.8
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	75.2	33.0	9.5	38.2	71.9	11.7	14.1	13.5	13.9

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; SF_6, sulfur hexafluoride; He, helium; fMol/kg, femtomoles per kilogram; GC, gas chromotography; MS, mass spectrometry; ccSTP/g, cubic centimeters at standard temperature and pressure per gram; LDEO, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY; na, not available; nd, not determined]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
		Zone 1: Northern Mountain Front								
S027	NM486	CEPO 02	1	na	8/3/1998	0.408	405.			
S034	NM027	Private Production Well #04	1	na	8/28/1996	0.015	nd			
S034	NM027	Private Production Well #04	1	na	8/28/1996	0.141	nd			
S035	NM487	Windmill #37	1	na	7/31/1998	0.552	7.5			
S036	NM026	Private Production Well #03	1	na	8/28/1996	0.143	nd			
S065	NM055	Domestic Well #05	1	na	8/17/1996	1.279	nd			
S206	NM510	Windmill #38	1	3	8/3/1998	0.798	6.3			
S221	NM530	Windmill #45	1	na	8/20/1998	0.685	190.			
S279	NM527	Windmill #42	1	na	7/28/1998	nd	6.0			
S281	NM528	Windmill #43	1	3	7/28/1998	nd	5.6			
		Zone 2: Northwestern								
S103	NM497	Lincoln D	2	na	7/23/1998	5.414	18.5			
S104	NM498	Lincoln M	2	na	7/23/1998	1.683	6.8			
S105	NM499	Lincoln S	2	na	7/23/1998	1.706	5.8	4.9		
S191	NM326	Rio Rancho 4	2	3	6/20/1997	2.596	8.5			
S192	NM128	Rio Rancho 8	2	3	8/13/1996	1.251	nd			
S189	NM133	Rio Rancho 15	2	na	8/13/1996	1.265	nd			
S278	NM526	Windmill #41	2	na	7/29/1998	0.351	8.9			
S286	NM184	Private Production Well #13	2	na	8/26/1996	3.300	nd			
S287	NM185	Private Production Well #14	2	na	8/26/1996	3.170	nd			
		Zone 3: West Central								
S003	NM481	98th St. D	3	na	8/4/1998	0.299	3,418.			
S003	NM251	98th St. D	3	na	6/17/1997	1.306	2,728.			
S004	NM482	98th St. MD	3	na	8/4/1998	2.815	422.			
S004	NM252	98th St. MD	3	na	6/18/1997	7.010	297.			
S005	NM483	98th St. MS	3	na	8/4/1998	0.685	21.0			
S005	NM253	98th St. MS	3	na	7/4/1997	1.362	29.7			
S006	NM484	98th St. S	3	na	8/5/1998	2.051	23.6	9.7		
S006	NM254	98th St. S	3	na	6/17/1997	5.324	10.8			
S008	NM003	Private Production Well #01	3	na	8/12/1996	2.822	nd			
S010	NM255	Private Production Well #16	3	na	6/23/1997	nd	13.6			
S018	NM260	Domestic Well #21	3	na	6/26/1997	1.576	11.8			
S019	NM007	Belen 4	3	5	8/16/1996	1.676	nd			
S020	NM008	Belen 5	3	5	8/16/1996	2.774	nd			
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	1.455	nd			
S037	NM264	College 2	3	na	6/19/1997	2.862	11.1			
S066	NM056	Gonzales 1	3	12	6/20/1996	2.041	nd	50.4		
S086	NM492	Isleta D	3	na	7/29/1998	2.005	1,047.			
S101	NM294	Leavitt 1	3	na	6/26/1997	1.781	nd			
S108	NM076	Los Lunas 3	3	12	8/14/1996	1.339	nd			
S109	NM077	Los Lunas 4	3	12	8/14/1996	2.513	nd			
S145	NM308	NM Utilities 1	3	na	6/18/1997	0.590	8.2			
S147	NM310	NM Utilities 3	3	na	6/18/1997	2.490	13.7			
S148	NM311	NM Utilities 4	3	na	6/18/1997	3.434	11.1			
S166	NM509	Rabbit Hill	3	na	8/4/1998	5.420	253.			
S167	NM107	Domestic Well #12	3	na	8/14/1996	1.469	nd			
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	0.222	809.			
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	1.618	nd	687.5		
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	1.657	nd	488.9		
S186	NM130	Rio Rancho 10	3	na	8/13/1996	1.160	nd			
S188	NM132	Rio Rancho 13	3	na	8/13/1996	0.620	nd			
S196	NM135	Windmill #05	3	na	8/21/1996	0.282	nd			

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
S200	NM139	Private Production Well #08	3	na	8/29/1996	2.884	nd			
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	92.67	nd			
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	7.532	nd			
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	1.324	nd			
S230	NM516	Sierra Vista D	3	na	7/22/1998	0.503	892.			
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	1.519	nd			
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	nd	2,412.			
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	1.223	nd			
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	2.506	15.6			
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	2.366	835.			
S272	NM353	West Mesa 3	3	na	6/19/1997	2.424	nd			
S283	NM181	Zia Ball Park D	3	na	8/26/1996	2.525	nd			
S284	NM182	Zia Ball Park M	3	na	8/26/1996	0.222	nd			
S285	NM183	Zia Ball Park S	3	2	8/26/1996	1.578	nd			
		Zone 4: Western Boundary								
S039	NM266	Windmill #20	4	na	6/21/1997	1.433	14.3			
S059	NM278	Windmill #21	4	na	6/23/1997	1.809	13.8			
S074	NM285	Windmill #23	4	na	6/21/1997	1.450	nd			
S169	NM320	Rest Area	4	na	6/30/1997	3.351	nd			
		Zone 5: Rio Puerco								
S069	NM058	Domestic Well #06	5	na	8/16/1996	1.832	nd			
S085	NM408	Windmill #35	5	na	9/10/1997	0.485	nd			
S185	NM324	Domestic Well #31	5	na	6/16/1997	nd	2,285.			
S198	NM137	Windmill #07	5	na	8/21/1996	25.21	nd			
S237	NM341	Windmill #30	5	4	6/24/1997	0.322	73.9			
		Zone 7: Abo Arroyo								
S021	NM261	Stock Well #01	7	na	6/23/1997	0.990	5.7	6.2		
S024	NM011	Domestic Well #02	7	8	8/17/1996	1.836	nd			
S090	NM064	Domestic Well #08	7	na	8/19/1996	1.073	nd			
S093	NM067	Domestic Well #09	7	8	8/15/1996	2.620	nd			
		Zone 8: Eastern Mountain Front								
S007	NM002	Domestic Well #01	8	na	6/21/1996	2.650	nd	9.4		
S013	NM256	Windmill #14	8	na	6/24/1997	0.408	nd			
S014	NM257	Private Production Well #17	8	na	6/19/1997	0.385	5.6			
S030	NM024	Charles 4	8	na	6/27/1996	2.008	nd	66.8		
S030	NM021	Charles 4	8	na	6/27/1996	2.018	nd	176.8		
S030	NM020	Charles 4	8	na	6/27/1996	2.032	nd			
S030	NM023	Charles 4	8	na	6/27/1996	2.132	nd	139.0	176.8	66.8
S030	NM019	Charles 4	8	na	6/27/1996	2.171	nd			
S030	NM016	Charles 4	8	na	6/22/1996	3.840	nd			
S042	NM031	Domestic Well #03	8	na	8/14/1996	5.414	nd			
S055	NM042	Elena Gallegos	8	na	6/25/1996	73.02	nd	8.1		
S056	NM043	Embudito Spring	8	na	7/2/1996	1.242	nd			
S071	NM060	Domestic Well #07	8	na	6/19/1996	0.590	nd	5.6		
S095	NM068	Kirtland 1	8	na	6/25/1996	6.667	nd			
S106	NM295	Domestic Well #23	8	na	6/26/1997	7.368	404.	331.1		
S110	NM078	Love 1	8	na	6/22/1996	20.45	nd			
S113	NM080	Domestic Well #11	8	na	8/15/1996	1.875	nd			
S114	NM500	Matheson D	8	na	7/31/1998	61.49	434.			
S115	NM501	Matheson M	8	na	8/1/1998	20.53	20.2			
S116	NM502	Matheson S	8	na	8/1/1998	2.801	5.7	6.8		
S117	NM298	Domestic Well #25	8	na	6/17/1997	nd	7.3	6.4		
S118	NM299	Windmill #24	8	na	6/27/1997	0.844	nd			
S119	NM300	Domestic Well #26	8	11	6/19/1997	1.226	34.6			
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	15.09	655.			
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	17.40	147.	183.7		

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
S140	NM306	MRN 1	8	na	7/5/1997	9.550	28.7			
S141	NM095	National Utility 7	8	na	8/14/1996	1.326	nd			
S149	NM312	Nor Este D	8	na	7/3/1997	6.057	1,307.			
S150	NM313	Nor Este M	8	na	7/2/1997	4.385	609.			
S162	NM317	Stock Well #03	8	na	6/30/1997	2.195	10.0			
S163	NM318	PL 2	8	na	7/7/1997	nd	37.3			
S164	NM106	Ponderosa 1	8	na	6/20/1996	20.37	nd	1,164.		
S165	NM328	Windmill #25	8	na	6/24/1997	1.762	17.8			
S168	NM319	Domestic Well #30	8	na	6/27/1997	2.298	5.7			
S170	NM108	Ridgecrest 3	8	na	6/22/1996	9.660	267.	133.0		
S195	NM134	Domestic Well #13	8	na	8/14/1996	5.028	nd			
S209	NM336	Domestic Well #33	8	na	6/27/1997	4.890	949.			
S212	NM141	Sandia Peak 1	8	na	6/26/1996	59.39	nd	6.2		
S213	NM142	Sandia Peak 3	8	na	6/26/1996	5.228	nd	5.7		
S224	NM148	Domestic Well #14	8	na	8/23/1996	0.342	nd			
S229	NM515	SH03 UNM	8	na	7/28/1998	0.205	5.8	4.9		
S233	NM153	Domestic Well #16	8	na	8/23/1996	0.437	nd			
S239	NM156	Domestic Well #17	8	na	8/17/1996	1.145	nd			
S240	NM157	Domestic Well #18	8	na	6/19/1996	74.90	nd			
S247	NM161	Domestic Well #19	8	na	8/15/1996	1.782	nd			
S248	NM162	Thomas 6	8	na	6/21/1996	2.307	nd			
S255	NM523	Tramway East	8	na	7/30/1998	196.8	32.4			
S264	NM174	Walker 1	8	na	6/18/1996	79.25	nd	749.5		
S274	NM177	Domestic Well #20	8	na	8/15/1996	4.422	nd			
		Zone 9: Tijeras Fault Zone								
S041	NM029	Coyote Spring	9	na	6/28/1996	0.023	nd			
S072	NM061	Hubbell Spring	9	8	8/23/1996	0.223	nd			
S098	NM071	KAFB-1902	9	na	6/28/1996	0.084	nd			
S197	NM136	Windmill #06	9	na	8/23/1996	0.694	nd			
S227	NM151	SFR 3D	9	na	8/24/1996	42.07	nd			
S228	NM152	SFR 3S	9	na	8/24/1996	51.00	nd			
		Zone 10: Tijeras Arroyo								
S001	NM001	4Hills-1	10	8	6/29/1996	107.7	nd	5.7	5.6	
S058	NM277	Eubank 1	10	8	7/4/1997	6.614	5.2	4.2		
S096	NM069	Kirtland 11	10	8	6/25/1996	18.98	nd	22.1		
S107	NM075	Lomas 1	10	8	6/22/1996	5.486	nd			
		Zone 11: Northeastern								
S016	NM258	Windmill #15	11	na	6/18/1997	1.479	nd			
S017	NM259	Windmill #16	11	na	6/18/1997	0.388	nd			
S053	NM276	Private Production Well #18	11	na	6/25/1997	nd	29.4			
S144	NM097	Private Production Well #06	11	na	8/28/1996	3.931	nd			
S207	NM334	Private Production Well #22	11	na	7/3/1997	0.799	14.2			
S223	NM338	Windmill #29	11	na	6/25/1997	1.032	9.7			
		Zone 12: Central								
S011	NM004	Atris-1	12	na	6/22/1996	1.896	nd	3.9		
S012	NM005	Atrisco 3	12	3	6/20/1996	2.562	nd	74.2		
S025	NM012	Burton 2	12	na	6/19/1996	16.92	nd	27.6		
S026	NM013	Burton 5	12	na	6/19/1996	2.053	nd	82.5		
S040	NM028	Coronado 1	12	na	6/18/1996	2.601	nd			
S043	NM488	Del Sol D	12	na	7/21/1998	4.243	758.			
S043	NM267	Del Sol D	12	na	7/1/1997	7.461	nd			
S044	NM268	Del Sol M	12	na	6/26/1997	5.379	nd			
S044	NM489	Del Sol M	12	na	7/21/1998	nd	54.9			
S045	NM269	Del Sol S	12	na	6/26/1997	1.928	nd			
S045	NM490	Del Sol S	12	na	7/21/1998	2.516	5.8			
S046	NM032	Duranes 1	12	na	6/20/1996	2.667	nd	9.2		

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
S046	NM033	Duranes 1	12	na	6/29/1996	3.452	nd			
S046	NM035	Duranes 1	12	na	6/29/1996	3.452	nd	4.7	4.6	
S046	NM034	Duranes 1	12	na	6/29/1996	3.578	nd	4.6		
S046	NM036	Duranes 1	12	na	6/29/1996	3.691	nd			
S046	NM037	Duranes 1	12	na	6/29/1996	3.716	nd			
S046	NM039	Duranes 1	12	na	6/29/1996	3.766	nd			
S046	NM040	Duranes 1	12	na	6/29/1996	3.816	nd			
S046	NM038	Duranes 1	12	na	6/29/1996	3.829	nd			
S047	NM270	Duranes 7	12	na	6/26/1997	1.912	5.9	8.5		
S048	NM271	Duranes Yard 1	12	na	7/5/1997	2.088	nd	4.0		
S049	NM272	Duranes Yard 2	12	na	7/5/1997	nd	nd	4.0	4.0	
S050	NM273	Duranes Yard 3	12	na	7/5/1997	nd	5.1	3.9		
S051	NM274	Duranes Yard 4	12	na	7/5/1997	2.848	5.7	4.1		
S052	NM275	Duranes Yard 5	12	na	7/5/1997	2.404	3.6	4.0		
S060	NM279	Garfield D	12	3	6/19/1997	3.092	10.8			
S061	NM280	Garfield M	12	na	6/19/1997	2.368	6.6			
S062	NM491	Garfield S	12	na	7/28/1998	5.950	5.4	4.4		
S062	NM281	Garfield S	12	na	6/19/1997	6.178	5.9	4.2		
S064	NM283	Domestic Well #22	12	na	6/20/1997	3.714	5.6			
S068	NM057	Griegos 3	12	na	6/21/1996	0.816	nd	8.1		
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	4.245	6.0			
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	3.238	6.5			
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	2.577	6.5			
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	3.393	5.9	6.1		
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	2.381	7.1	4.3		
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	7.823	12.7	12.5		
S081	NM292	Private Production Well #19	12	na	7/2/1997	2.459	15.0			
S084	NM063	Windmill #04	12	na	8/21/1996	1.117	nd			
S087	NM493	Isleta MD	12	3	7/29/1998	7.011	20.3			
S088	NM494	Isleta MS	12	na	7/29/1998	2.387	6.5			
S089	NM495	Isleta S	12	na	7/29/1998	1.579	5.7	4.3		
S092	NM066	JMC-1	12	na	6/28/1996	203.4	nd	4.3		
S097	NM070	Kirtland 14	12	na	6/25/1996	1.980	nd	95.0		
S100	NM073	LALF-9	12	na	6/29/1996	1.992	nd	4.4		
S102	NM074	Leyendecker 1	12	na	6/21/1996	0.929	nd	5.1		
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	2.486	675.			
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	14.65	191.			
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	1.912	398.			
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	5.108	381.			
S123	NM081	MONT - 5A	12	na	6/27/1996	nd	nd	4.6		
S124	NM082	Montaňo 2 D	12	na	6/19/1996	1.286	nd	4.7		
S125	NM083	Montaňo 2 M	12	na	6/19/1996	1.212	nd	4.6		
S126	NM084	Montaňo 2 S	12	na	6/19/1996	3.657	nd	4.3		
S127	NM085	Montaňo 4 D	12	na	6/20/1996	1.391	nd	4.6		
S128	NM086	Montaňo 4 M	12	na	6/19/1996	1.632	nd	4.9		
S130	NM088	Montaňo 5 D	12	na	6/24/1996	1.406	nd	3.9		
S131	NM089	Montaňo 5 M	12	na	6/24/1996	14.54	nd	4.0		
S132	NM090	Montaňo 5 S	12	na	6/24/1996	1.028	nd	3.7		
S133	NM091	Montaňo 6 D	12	na	6/18/1996	1.731	nd	6.3		
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	1.453	nd	5.3		
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	0.481	nd	4.1		
S136	NM094	Montaňo 6 S	12	na	6/18/1996	1.449	nd	4.2		
S137	NM506	Montesa M	12	na	7/27/1998	1.222	149.			
S138	NM507	Montesa S	12	na	7/27/1998	7.024	31.9	29.4		
S139	NM305	Domestic Well #27	12	na	6/17/1997	nd	7.5			
S142	NM307	Domestic Well #28	12	na	6/17/1997	nd	5.5			
S146	NM309	NM Utilities 2	12	na	6/18/1997	2.393	4.8			
S151	NM508	Nor Este S	12	na	7/20/1998	5.679	202.	31.4		

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
S151	NM314	Nor Este S	12	na	7/2/1997	14.28	28.1			
S153	NM411	Open Space	12	na	11/18/1997	nd	nd	5.4		
S154	NM099	ORLF-2	12	na	6/27/1996	2.009	nd	4.0		
S155	NM316	Domestic Well #29	12	na	6/27/1997	1.126	5.6	4.4	4.2	
S156	NM100	Paseo 2D	12	na	6/26/1996	0.536	nd	3.9		
S157	NM101	Paseo 2MD	12	na	6/26/1996	11.17	nd	4.2		
S158	NM102	Paseo 2MS	12	na	6/26/1996	3.240	nd	4.1		
S159	NM103	Paseo 2S	12	na	6/26/1996	3.018	nd	5.1		
S160	NM104	Paseo 3D	12	na	6/21/1996	1.026	nd	4.1		
S171	NM321	Ridgecrest 4	12	na	6/26/1997	3.481	nd			
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	3.603	6.2	4.5		
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	2.299	nd	4.4		
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	2.035	nd	61.6		
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	3.089	nd	120.6		
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	2.484	nd	21.5		
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	2.776	nd	80.6		
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	3.069	nd	24.7		
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	3.189	nd			
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	1.756	nd			
S190	NM325	Rio Rancho 2	12	na	6/20/1997	2.036	5.3			
S203	NM331	Private Production Well #20	12	na	7/3/1997	2.007	52.3			
S205	NM333	Private Production Well #21	12	na	7/3/1997	2.667	39.7			
S208	NM140	San Jose 2	12	3	6/20/1996	3.177	nd	121.0		
S210	NM511	Sandia D	12	na	7/30/1998	13.15	733.			
S214	NM513	Sandia S	12	na	7/30/1998	2.981	172.	209.3		
S220	NM147	Santa Barbara 1	12	na	6/19/1996	1.142	nd	6.1		
S231	NM517	Sierra Vista M	12	3	7/22/1998	3.761	8.9			
S232	NM518	Sierra Vista S	12	na	7/22/1998	6.420	6.7	4.9		
S234	NM339	Sister Cities D	12	na	6/30/1997	4.942	44.6			
S235	NM340	Sister Cities M	12	na	6/27/1997	1.467	5.3			
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	12.49	nd			
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	19.99	nd	4.3	4.0	
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	27.83	nd			
S253	NM522	Tome D	12	na	8/6/1998	nd	1,130.			
S257	NM344	Domestic Well #34	12	na	6/17/1997	nd	136.	98.2		
S259	NM171	VGP-1	12	na	6/27/1996	4.105	nd	5.2		
S261	NM172	Volandia 2	12	na	6/21/1996	0.891	nd			
S262	NM173	Volandia 5	12	na	6/18/1996	1.319	nd	4.6		
S265	NM175	Webster 1	12	na	6/18/1996	1.440	nd			
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	3.248	8.1			
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	3.352	7.2			
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	3.912	6.9	5.0		
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	3.508	6.4	4.5		
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	3.393	5.2	4.9	4.9	
S275	NM178	Yale 1	12	na	6/19/1996	5.923	nd	22.1		
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	1.545	nd			
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	2.010	nd			
		Zone 13: Discharge								
S143	NM096	Private Production Well #05	13	na	8/19/1996	0.264	nd			
S194	NM327	Domestic Well #32	13	na	6/30/1997	8.017	6,917.			
S226	NM150	Domestic Well #15	13	na	8/19/1996	0.409	nd			
		No Zone: Exotic Water								
S023	NM010	Burn Site Well	E	E	6/25/1996	0.771	nd	8.7		
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	1.482	nd			
S038	NM265	Windmill #19	E	E	7/1/1997	0.359	12,234.			
S054	NM041	Domestic Well #04	E	E	8/17/1996	1.766	nd			
S057	NM044	Embudo Spring	E	E	7/2/1996	1.617	nd			

Table A8. Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	SF_6 (fMol/kg)	USGS He by GC (ccSTP/g x10^8)	LDEO He by MS (ccSTP/g x10^8)	Replicate 1 LDEO He by MS (ccSTP/g x10^8)	Replicate 2 LDEO He by MS (ccSTP/g x10^8)
S063	NM282	Windmill #22	E	E	6/28/1997	1.704	nd			
S067	NM284	Granite Hill	E	E	7/4/1997	210.9	301.			
S070	NM059	HERTF	E	E	6/28/1996	753.2	nd	10.9		
S091	NM496	Private Production Well #23	E	E	8/4/1998	3.349	44.3	38.6		
S094	NM293	Stock Well #02	E	E	6/20/1997	2.428	10.1			
S099	NM072	LALF-1	E	E	6/29/1996	5.283	nd	3.9	3.8	
S112	NM297	Domestic Well #24	E	E	6/21/1997	0.935	487.			
S129	NM087	Montaňo 4 S	E	E	6/19/1996	3.415	nd	4.2		
S152	NM098	Private Production Well #07	E	E	8/22/1996	0.693	nd			
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	7.463	nd			
S202	NM330	Windmill #27	E	E	7/2/1997	0.764	nd			
S211	NM512	Sandia M	E	E	7/30/1998	1.977	1,534.			
S225	NM149	SBM-1	E	E	6/29/1996	9.374	nd	4.0		
S249	NM164	Private Production Well #09	E	E	6/26/1996	168.1	nd			
S249	NM163	Private Production Well #09	E	E	6/26/1996	182.6	nd	6.3		
S250	NM165	Private Production Well #10	E	E	6/26/1996	287.9	nd	36.8		
S251	NM166	Private Production Well #11	E	E	6/26/1996	80.60	nd	5.4		
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	11.93	nd	4.0		
S282	NM529	Windmill #44	E	E	7/29/1998	1.073	139.			
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	0.000	nd			
SXXX	NM065	Jemez Spring	E	E	8/20/1996	0.342	nd			
SXXX	NM065	Jemez Spring	E	E	8/20/1996	0.689	nd			

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; δ^2H, hydrogen-2; $\delta^{18}O$, oxygen-18; SO_4^{2-}, sulfate; $\delta^{34}S$, sulfur-34; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand; mg/L, milligrams per liter; na, not applicable; nd, not determined]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
		Zone 1: Northern Mountain Front								
S027	NM486	CEPO 02	1	na	8/3/1998	-68.4	- 9.60	8.4	16.5	nd
S034	NM027	Private Production Well #04	1	na	8/28/1996	-74.4	-10.1	6.4	14.1	nd
S035	NM487	Windmill #37	1	na	7/31/1998	-80.4	-11.3	9.8	17.8	nd
S036	NM026	Private Production Well #03	1	na	8/28/1996	-72.3	- 9.62	4.7	17.6	nd
S065	NM055	Domestic Well #05	1	na	8/17/1996	-72.8	- 9.72	5.0	20.9	nd
S187	NM131	Rio Rancho 12	1	na	8/13/1996	-89.1	-11.8	5.7	56.1	nd
S206	NM510	Windmill #38	1	3	8/3/1998	-82.3	-11.3	7.9	38.1	nd
S216	NM143	Windmill #09	1	na	8/27/1996	-74.0	- 9.60	2.9	52.1	nd
S221	NM530	Windmill #45	1	na	8/20/1998	-72.1	-10.1	9.1	29.1	nd
S222	NM514	Windmill #39	1	3	8/6/1998	-78.5	-11.2	11.1	84.7	nd
S254	NM168	Private Production Well #12	1	na	8/28/1996	-76.8	-10.6	7.6	7.3	nd
S277	NM525	Windmill #40	1	na	7/28/1998	-81.7	-11.2	7.9	28.5	nd
S279	NM527	Windmill #42	1	na	7/28/1998	-84.1	-11.6	8.6	11.1	nd
S281	NM528	Windmill #43	1	3	7/28/1998	-88.0	-12.1	8.4	9.3	nd
		Zone 2: Northwestern								
S103	NM497	Lincoln D	2	na	7/23/1998	-67.3	-8.88	3.8	42.5	0.6
S104	NM498	Lincoln M	2	na	7/23/1998	-56.5	-7.52	3.7	28.7	0.9
S105	NM499	Lincoln S	2	na	7/23/1998	-56.6	-7.59	4.2	17.2	0.9
S191	NM326	Rio Rancho 4	2	3	6/20/1997	-87.0	-11.5	5.0	58.4	nd
S192	NM128	Rio Rancho 8	2	3	8/13/1996	-88.1	-11.7	5.7	66.2	nd
S189	NM133	Rio Rancho 15	2	na	8/13/1996	-81.6	-10.7	3.8	100.	8.8
S276	NM179	Windmill #12	2	na	8/27/1996	-64.9	-9.02	7.3	10.4	nd
S278	NM526	Windmill #41	2	na	7/29/1998	-61.1	-7.99	2.8	60.6	nd
S280	NM180	Windmill #13	2	na	8/27/1996	-57.8	-7.41	1.5	28.6	nd
S286	NM184	Private Production Well #13	2	na	8/26/1996	-59.0	-8.43	8.4	24.7	nd
S287	NM185	Private Production Well #14	2	na	8/26/1996	-64.7	-8.73	5.1	40.4	nd
		Zone 3: West Central								
S003	NM251	98th St. D	3	na	6/17/1997	-92.2	-12.0	3.9	252.	3.5
S003	NM481	98th St. D	3	na	8/4/1998	-91.6	-11.9	3.9	243.	2.8
S004	NM252	98th St. MD	3	na	6/18/1997	-110.	-14.6	5.9	90.3	- 1.5
S004	NM482	98th St. MD	3	na	8/4/1998	-110.	-14.5	6.1	87.8	- 1.5
S005	NM253	98th St. MS	3	na	7/4/1997	-111.	-14.6	5.2	97.5	- 2.5
S005	NM483	98th St. MS	3	na	8/4/1998	-110.	-14.6	6.6	95.7	- 2.3
S006	NM254	98th St. S	3	na	6/17/1997	-92.7	-12.2	4.9	83.1	- 2.2
S006	NM484	98th St. S	3	na	8/5/1998	-92.6	-12.1	4.2	66.2	- 1.9
S008	NM003	Private Production Well #01	3	na	8/12/1996	-99.4	-12.6	1.5	96.5	nd
S010	NM255	Private Production Well #16	3	na	6/23/1997	-87.4	-11.3	3.0	114.	nd
S018	NM260	Domestic Well #21	3	na	6/26/1997	-100.	-13.0	4.1	145.	nd
S019	NM007	Belen 4	3	5	8/16/1996	-91.0	-11.8	3.6	193.	nd
S020	NM008	Belen 5	3	5	8/16/1996	-92.1	-12.0	3.7	171.	nd
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	-88.0	-11.1	0.6	260.	nd
S037	NM264	College 2	3	na	6/19/1997	-109.	-14.4	5.9	62.4	nd
S066	NM056	Gonzales 1	3	12	6/20/1996	-100.	-13.2	5.6	78.8	nd
S086	NM492	Isleta D	3	na	7/29/1998	-97.6	-13.0	6.1	115.	0.2
S101	NM294	Leavitt 1	3	na	6/26/1997	-94.7	-12.4	4.9	70.5	nd
S108	NM076	Los Lunas 3	3	12	8/14/1996	-97.8	-12.9	5.6	71.8	nd
S109	NM077	Los Lunas 4	3	12	8/14/1996	-98.5	-13.2	6.9	56.9	nd
S145	NM308	NM Utilities 1	3	na	6/18/1997	-87.3	-11.5	5.1	38.7	nd
S147	NM310	NM Utilities 3	3	na	6/18/1997	-96.4	-12.9	6.6	67.8	nd
S148	NM311	NM Utilities 4	3	na	6/18/1997	-94.7	-12.7	6.5	53.0	nd
S166	NM509	Rabbit Hill	3	na	8/4/1998	-84.6	-11.4	6.5	90.9	nd
S167	NM107	Domestic Well #12	3	na	8/14/1996	-104.	-13.7	5.1	144.	- 4.5

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	-92.4	-12.3	6.1	141.	nd
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	-92.8	-12.4	6.2	167.	- 2.3
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	-97.7	-12.7	3.8	152.	2.1
S186	NM130	Rio Rancho 10	3	na	8/13/1996	-103.	-13.4	4.8	94.8	nd
S188	NM132	Rio Rancho 13	3	na	8/13/1996	-118.	-15.6	6.3	75.2	- 3.1
S193	NM129	Rio Rancho 9	3	na	8/13/1996	-105.	-13.8	5.0	47.8	nd
S196	NM135	Windmill #05	3	na	8/21/1996	-99.5	-13.0	4.3	97.4	nd
S200	NM139	Private Production Well #08	3	na	8/29/1996	-91.3	-11.8	3.3	186.	nd
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	-101.	-13.4	6.2	41.1	nd
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	-102.	-13.6	7.3	29.7	nd
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	-101.	-13.2	4.8	36.3	nd
S230	NM516	Sierra Vista D	3	na	7/22/1998	-95.4	-12.6	5.2	183.	0.7
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	-97.1	-12.5	2.8	209.	- 9.5
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	-89.5	-11.6	3.0	259.	- 2.5
S242	NM520	SWAB Test Hole 1 S	3	1	8/1/1998	-81.7	-10.5	1.9	119.	- 8.5
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	-73.6	-9.99	6.3	33.9	nd
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	-96.4	-12.7	5.1	50.8	nd
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	-94.1	-12.1	2.9	169.	nd
S272	NM353	West Mesa 3	3	na	6/19/1997	-92.5	-12.2	5.2	53.4	nd
S283	NM181	Zia Ball Park D	3	na	8/26/1996	-99.9	-13.4	6.9	66.0	nd
S284	NM182	Zia Ball Park M	3	na	8/26/1996	-100.	-13.2	5.4	61.8	nd
S285	NM183	Zia Ball Park S	3	2	8/26/1996	-91.9	-12.1	5.1	208.	nd
S288	NM186	Zia BMT D	3	na	8/27/1996	-105.	-14.1	8.3	133.	14.3
		Zone 4: Western Boundary								
S031	NM263	Windmill #18	4	na	6/24/1997	-64.0	-9.12	8.9	554.	nd
S039	NM266	Windmill #20	4	na	6/21/1997	-79.5	-10.8	6.9	919.	nd
S059	NM278	Windmill #21	4	na	6/23/1997	-72.9	-9.50	3.1	793.	nd
S074	NM285	Windmill #23	4	na	6/21/1997	-53.5	-8.12	11.5	583.	nd
S169	NM320	Rest Area	4	na	6/30/1997	-52.9	-7.56	7.6	571.	nd
S201	NM329	Windmill #26	4	na	7/2/1997	-81.4	-11.3	9.3	936.	9.4
S252	NM167	Windmill #10	4	na	8/29/1996	-56.5	-7.84	6.2	414.	nd
S260	NM345	Windmill #33	4	na	6/25/1997	-64.8	-9.12	8.2	672.	nd
		Zone 5: Rio Puerco								
S032	NM262	Windmill #17	5	na	6/24/1997	-64.0	-8.65	5.3	903.	nd
S069	NM058	Domestic Well #06	5	na	8/16/1996	-68.2	-8.95	3.5	490.	nd
S073	NM062	Windmill #03	5	na	8/16/1996	-60.6	-7.74	1.3	1,060.	- 2.1
S082	NM409	Windmill #36	5	na	9/10/1997	-59.8	-8.21	5.9	1,180.	nd
S085	NM408	Windmill #35	5	na	9/10/1997	-72.4	-9.56	4.1	543.	nd
S111	NM079	Domestic Well #10	5	na	8/16/1996	-60.0	-7.81	2.5	702.	- 4.4
S185	NM324	Domestic Well #31	5	na	6/16/1997	-73.5	-9.75	4.5	1,107.	nd
S198	NM137	Windmill #07	5	na	8/21/1996	-61.6	-7.59	- 0.8	2,130.	- 0.1
S215	NM335	Sandoval Spring	5	4	7/1/1997	-59.2	-8.51	8.9	291.	nd
S237	NM341	Windmill #30	5	4	6/24/1997	-63.5	-8.73	6.3	490.	nd
S238	NM342	Windmill #31	5	na	6/24/1997	-59.4	-7.66	1.9	1,303.	nd
		Zone 6: Southwestern Mountain Front								
S022	NM009	Windmill #02	6	na	8/19/1996	-53.5	-7.74	8.4	70.9	nd
		Zone 7: Abo Arroyo								
S021	NM261	Stock Well #01	7	na	6/23/1997	-58.5	-8.23	7.3	687.	nd
S024	NM011	Domestic Well #02	7	8	8/17/1996	-66.7	-9.28	7.5	264.	nd
S090	NM064	Domestic Well #08	7	na	8/19/1996	-63.6	-8.82	7.0	311.	nd
S093	NM067	Domestic Well #09	7	8	8/15/1996	-75.8	-10.7	9.8	78.0	nd
		Zone 8: Eastern Mountain Front								
S007	NM002	Domestic Well #01	8	na	6/21/1996	-87.2	-11.9	8.2	42.3	4.3
S013	NM256	Windmill #14	8	na	6/24/1997	-74.5	-10.4	8.7	10.7	nd
S014	NM257	Private Production Well #17	8	na	6/19/1997	-84.1	-11.8	10.4	58.4	nd
S015	NM006	Windmill #01	8	na	8/24/1996	-79.7	-11.4	11.3	26.8	nd
S030	NM016	Charles 4	8	na	6/22/1996	-88.9	-12.2	8.8	27.4	3.0

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S030	NM017	Charles 4	8	na	6/27/1996	-88.0	-12.2	9.4	26.7	nd
S030	NM018	Charles 4	8	na	6/27/1996	-89.6	-12.1	7.4	26.7	nd
S030	NM019	Charles 4	8	na	6/27/1996	-87.4	-12.1	9.3	26.7	nd
S030	NM020	Charles 4	8	na	6/27/1996	-90.7	-12.1	6.3	26.7	nd
S030	NM021	Charles 4	8	na	6/27/1996	-88.4	-12.2	9.0	26.7	nd
S030	NM022	Charles 4	8	na	6/27/1996	-89.6	-12.2	8.2	25.6	nd
S030	NM023	Charles 4	8	na	6/27/1996	-91.2	-12.2	6.6	27.0	nd
S030	NM024	Charles 4	8	na	6/27/1996	-89.1	-12.2	8.5	26.7	nd
S042	NM031	Domestic Well #03	8	na	8/14/1996	-71.1	-10.1	10.1	20.1	nd
S055	NM042	Elena Gallegos	8	na	6/25/1996	-84.1	-11.4	7.5	43.9	2.6
S056	NM043	Embudito Spring	8	na	7/2/1996	-38.5	-5.50	5.5	98.6	4.8
S056	NM213	Embudito Spring	8	na	3/21/1997	-82.0	-11.5	10.3	57.4	nd
S056	NM214	Embudito Spring	8	na	3/21/1997	-82.3	-11.4	9.2	57.4	nd
S056	NM227	Embudito Spring	8	na	4/29/1997	-85.9	-11.9	9.0	43.7	nd
S056	NM239	Embudito Spring	8	na	5/27/1997	-82.4	-11.4	9.0	44.8	nd
S056	NM364	Embudito Spring	8	na	7/17/1997	-77.9	-10.9	9.2	nd	nd
S071	NM060	Domestic Well #07	8	na	6/19/1996	-84.3	-11.6	8.6	20.2	3.5
S083	NM407	Windmill #34	8	na	9/10/1997	-75.0	-10.2	6.3	55.0	nd
S095	NM068	Kirtland 1	8	na	6/25/1996	-79.5	-11.0	8.4	52.8	0.0
S106	NM295	Domestic Well #23	8	na	6/26/1997	-85.7	-11.8	8.6	49.4	nd
S110	NM078	Love 1	8	na	6/22/1996	-80.2	-11.2	9.6	24.3	nd
S113	NM080	Domestic Well #11	8	na	8/15/1996	-76.0	-11.0	11.7	34.7	nd
S114	NM500	Matheson D	8	na	7/31/1998	-78.9	-11.2	10.5	19.5	3.6
S115	NM501	Matheson M	8	na	8/1/1998	-79.6	-11.4	11.5	19.6	3.0
S116	NM502	Matheson S	8	na	8/1/1998	-80.8	-11.6	11.9	17.6	3.9
S117	NM298	Domestic Well #25	8	na	6/17/1997	-83.6	-11.8	11.0	27.9	nd
S118	NM299	Windmill #24	8	na	6/27/1997	-61.7	-9.02	10.5	55.0	nd
S119	NM300	Domestic Well #26	8	11	6/19/1997	-83.7	-11.7	10.1	92.6	- 0.3
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	-97.7	-13.1	6.9	66.0	- 0.2
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	-86.8	-12.0	9.2	26.1	2.3
S140	NM306	MRN 1	8	na	7/5/1997	-73.7	-10.4	9.6	70.2	nd
S141	NM095	National Utility 7	8	na	8/14/1996	-79.9	-11.5	12.4	12.1	nd
S149	NM312	Nor Este D	8	na	7/3/1997	-87.1	-11.9	8.2	66.4	9.4
S150	NM313	Nor Este M	8	na	7/2/1997	-80.8	-10.8	5.9	44.1	9.3
S162	NM317	Stock Well #03	8	na	6/30/1997	-74.9	-10.7	10.8	13.2	6.8
S163	NM318	PL 2	8	na	7/7/1997	-75.5	-10.6	9.2	55.6	nd
S164	NM106	Ponderosa 1	8	na	6/20/1996	-89.3	-12.1	7.4	33.8	nd
S165	NM328	Windmill #25	8	na	6/24/1997	-87.3	-12.3	10.7	52.6	nd
S168	NM319	Domestic Well #30	8	na	6/27/1997	-69.9	-10.2	11.6	29.5	nd
S170	NM108	Ridgecrest 3	8	na	6/22/1996	-85.9	-11.7	7.8	22.1	2.2
S170	NM412	Ridgecrest 3	8	na	11/18/1997	nd	nd	nd	23.7	2.5
S195	NM134	Domestic Well #13	8	na	8/14/1996	-72.0	-10.2	9.8	30.8	nd
S199	NM138	Windmill #08	8	na	8/23/1996	-78.3	-10.5	5.9	80.7	nd
S209	NM336	Domestic Well #33	8	na	6/27/1997	-81.8	-11.4	9.8	51.0	nd
S212	NM141	Sandia Peak 1	8	na	6/26/1996	-83.0	-11.6	9.9	14.3	nd
S213	NM142	Sandia Peak 3	8	na	6/26/1996	-81.2	-11.2	8.1	30.4	3.6
S224	NM148	Domestic Well #14	8	na	8/23/1996	-81.8	-11.5	10.5	31.3	nd
S229	NM515	SH03 UNM	8	na	7/28/1998	-83.0	-11.6	9.7	31.2	nd
S233	NM153	Domestic Well #16	8	na	8/23/1996	-89.9	-12.6	10.6	42.6	nd
S239	NM156	Domestic Well #17	8	na	8/17/1996	-83.5	-12.0	12.6	35.9	nd
S240	NM157	Domestic Well #18	8	na	6/19/1996	-80.4	-11.4	11.1	14.3	nd
S246	NM343	Windmill #32	8	na	6/24/1997	-72.4	-10.3	10.2	70.8	nd
S247	NM161	Domestic Well #19	8	na	8/15/1996	-90.5	-12.4	9.0	35.7	nd
S248	NM162	Thomas 6	8	na	6/21/1996	-89.0	-12.3	9.2	31.1	2.8
S255	NM523	Tramway East	8	na	7/30/1998	-80.6	-11.4	10.4	16.8	nd
S264	NM174	Walker 1	8	na	6/18/1996	-84.1	-11.9	10.8	24.6	nd
S274	NM177	Domestic Well #20	8	na	8/15/1996	-72.7	-10.1	8.0	43.6	nd
		Zone 9: Tijeras Fault Zone								
S041	NM029	Coyote Spring	9	na	6/28/1996	-82.5	-11.4	8.5	140.	7.0

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S072	NM061	Hubbell Spring	9	8	8/23/1996	-72.7	-9.97	7.1	211.	nd
S098	NM071	KAFB-1902	9	na	6/28/1996	-59.8	-6.31	- 9.3	292.	2.1
S197	NM136	Windmill #06	9	na	8/23/1996	-93.0	-12.3	5.5	326.	nd
S227	NM151	SFR 3D	9	na	8/24/1996	-74.3	-10.3	8.1	92.6	nd
S228	NM152	SFR 3S	9	na	8/24/1996	-74.2	-10.2	7.6	90.2	nd
		Zone 10: Tijeras Arroyo								
S001	NM001	4Hills-1	10	8	6/29/1996	-74.0	-9.65	3.2	287.	0.9
S002	NM250	Private Production Well #15	10	8	7/3/1997	-75.7	-10.3	7.1	130.	nd
S058	NM277	Eubank 1	10	8	7/4/1997	-76.7	-10.6	7.9	85.1	nd
S096	NM069	Kirtland 11	10	8	6/25/1996	-73.7	-10.2	7.8	83.1	nd
S107	NM075	Lomas 1	10	8	6/22/1996	-76.2	-10.5	7.7	94.3	nd
S107	NM410	Lomas 1	10	na	11/18/1997	nd	nd	nd	95.0	nd
		Zone 11: Northeastern								
S016	NM258	Windmill #15	11	na	6/18/1997	-75.1	-9.72	2.6	284.	nd
S017	NM259	Windmill #16	11	na	6/18/1997	-61.5	-8.38	5.5	97.9	nd
S053	NM276	Private Production Well #18	11	na	6/25/1997	-74.7	-10.2	6.9	540.	nd
S144	NM097	Private Production Well #06	11	na	8/28/1996	-72.7	-10.2	8.8	476.	- 4.7
S204	NM332	Windmill #28	11	na	7/3/1997	-67.8	-9.49	8.1	104.	nd
S207	NM334	Private Production Well #22	11	na	7/3/1997	-68.6	-9.74	9.4	877.	nd
S223	NM338	Windmill #29	11	na	6/25/1997	-66.9	-9.01	5.2	399.	nd
		Zone 12: Central								
S011	NM004	Atris-1	12	na	6/22/1996	-94.0	-12.5	5.9	63.6	- 4.1
S012	NM005	Atrisco 3	12	3	6/20/1996	-93.6	-12.6	7.5	80.7	nd
S025	NM012	Burton 2	12	na	6/19/1996	-96.4	-13.1	8.4	38.7	nd
S026	NM013	Burton 5	12	na	6/19/1996	-96.0	-13.1	9.1	28.7	nd
S033	NM025	Private Production Well #02	12	na	8/21/1996	-90.0	-11.9	5.1	149.	- 0.8
S040	NM028	Coronado 1	12	na	6/18/1996	-94.7	-12.6	6.1	44.3	5.1
S043	NM267	Del Sol D	12	na	7/1/1997	-102.	-13.8	7.8	45.4	2.4
S043	NM488	Del Sol D	12	na	7/21/1998	-102.	-13.9	9.1	41.7	nd
S044	NM268	Del Sol M	12	na	6/26/1997	-93.7	-12.8	8.5	46.3	3.5
S044	NM489	Del Sol M	12	na	7/21/1998	-95.6	-12.8	6.5	42.6	nd
S045	NM269	Del Sol S	12	na	6/26/1997	-93.8	-12.8	8.9	98.8	- 1.3
S045	NM490	Del Sol S	12	na	7/21/1998	-95.3	-12.7	6.0	109.	nd
S046	NM032	Duranes 1	12	na	6/20/1996	-93.5	-12.4	5.6	117.	nd
S046	NM033	Duranes 1	12	na	6/29/1996	-92.0	-12.3	6.6	156.	nd
S046	NM034	Duranes 1	12	na	6/29/1996	-92.8	-12.4	6.3	159.	nd
S046	NM035	Duranes 1	12	na	6/29/1996	-92.3	-12.5	7.7	156.	nd
S046	NM036	Duranes 1	12	na	6/29/1996	-92.4	-12.4	6.5	156.	nd
S046	NM037	Duranes 1	12	na	6/29/1996	-91.8	-12.3	6.5	157.	nd
S046	NM038	Duranes 1	12	na	6/29/1996	-92.3	-12.4	6.8	159.	nd
S046	NM039	Duranes 1	12	na	6/29/1996	-94.2	-12.3	4.4	159.	nd
S046	NM040	Duranes 1	12	na	6/29/1996	-95.1	-12.3	3.0	159.	nd
S047	NM270	Duranes 7	12	na	6/26/1997	-93.4	-12.7	8.4	66.5	nd
S048	NM271	Duranes Yard 1	12	na	7/5/1997	-95.2	-12.8	7.1	62.2	- 1.9
S049	NM272	Duranes Yard 2	12	na	7/5/1997	-93.4	-12.6	7.3	60.8	- 0.9
S050	NM273	Duranes Yard 3	12	na	7/5/1997	-85.1	-11.2	4.4	70.7	- 2.8
S051	NM274	Duranes Yard 4	12	na	7/5/1997	-91.1	-12.0	4.6	67.9	- 2.2
S052	NM275	Duranes Yard 5	12	na	7/5/1997	-90.6	-12.2	6.9	62.7	- 1.6
S060	NM279	Garfield D	12	3	6/19/1997	-94.5	-13.0	9.5	60.8	1.2
S061	NM280	Garfield M	12	na	6/19/1997	-93.7	-12.9	9.1	43.1	2.9
S062	NM281	Garfield S	12	na	6/19/1997	-89.1	-11.9	5.9	224.	-22.3
S062	NM491	Garfield S	12	na	7/28/1998	-91.4	-12.3	7.1	208.	nd
S064	NM283	Domestic Well #22	12	na	6/20/1997	-95.3	-12.9	7.8	81.6	0.9
S068	NM057	Griegos 3	12	na	6/21/1996	-96.0	-12.9	7.1	69.7	nd
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	-92.1	-12.7	9.9	65.1	4.7
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	-98.0	-13.5	10.1	40.6	3.3
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	-96.0	-12.8	6.2	156.	3.1
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	-100.	-13.5	7.8	84.6	3.2

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	-97.5	-13.5	10.6	93.5	3.5
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	-98.7	-13.3	7.5	137.	3.1
S081	NM292	Private Production Well #19	12	na	7/2/1997	-98.5	-13.2	7.4	44.4	nd
S084	NM063	Windmill #04	12	na	8/21/1996	-99.8	-13.3	6.5	57.4	nd
S087	NM493	Isleta MD	12	3	7/29/1998	-98.6	-13.3	7.6	46.2	nd
S088	NM494	Isleta MS	12	na	7/29/1998	-99.9	-13.4	7.4	30.0	6.5
S089	NM495	Isleta S	12	na	7/29/1998	-91.8	-12.2	5.6	140.	3.3
S092	NM066	JMC-1	12	na	6/28/1996	-89.9	-12.1	7.0	123.	- 9.3
S097	NM070	Kirtland 14	12	na	6/25/1996	-98.1	-13.2	7.7	26.8	3.3
S100	NM073	LALF-9	12	na	6/29/1996	-94.2	-12.5	6.2	120.	nd
S102	NM074	Leyendecker 1	12	na	6/21/1996	-99.1	-13.4	7.7	32.0	2.9
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	-88.6	-12.3	9.4	42.6	- 2.5
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	-91.8	-12.5	8.4	73.0	- 5.0
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	-98.4	-13.2	7.0	65.6	- 0.3
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	-105.	-14.1	7.6	37.0	- 0.7
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	-105.	-14.0	7.5	32.5	- 0.9
S123	NM081	MONT - 5A	12	na	6/27/1996	-97.4	-12.8	5.2	140.	-11.4
S124	NM082	Montaňo 2 D	12	na	6/19/1996	-93.1	-12.5	7.0	74.0	- 2.3
S125	NM083	Montaňo 2 M	12	na	6/19/1996	-96.2	-12.5	4.0	101.	- 2.6
S126	NM084	Montaňo 2 S	12	na	6/19/1996	-93.4	-12.3	5.2	97.7	- 6.1
S127	NM085	Montaňo 4 D	12	na	6/20/1996	-94.5	-12.8	7.6	63.3	- 3.9
S128	NM086	Montaňo 4 M	12	na	6/19/1996	-93.7	-12.4	5.8	173.	-11.8
S130	NM088	Montaňo 5 D	12	na	6/24/1996	-89.8	-12.1	6.8	67.5	- 0.9
S131	NM089	Montaňo 5 M	12	na	6/24/1996	-95.5	-12.6	5.0	57.1	- 4.7
S132	NM090	Montaňo 5 S	12	na	6/24/1996	-90.3	-11.5	2.0	67.3	- 5.9
S133	NM091	Montaňo 6 D	12	na	6/18/1996	-94.5	-12.7	7.4	57.1	2.3
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	-95.6	-12.9	7.9	44.9	3.7
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	-97.1	-13.2	8.9	49.8	- 0.3
S136	NM094	Montaňo 6 S	12	na	6/18/1996	-95.1	-12.8	6.9	73.9	- 5.5
S137	NM506	Montesa M	12	na	7/27/1998	-95.5	-13.0	8.2	31.2	3.9
S138	NM507	Montesa S	12	na	7/27/1998	-99.7	-13.3	6.5	30.7	2.4
S139	NM305	Domestic Well #27	12	na	6/17/1997	-96.8	-12.8	5.7	45.2	3.7
S142	NM307	Domestic Well #28	12	na	6/17/1997	-98.0	-13.4	9.0	105.	nd
S146	NM309	NM Utilities 2	12	na	6/18/1997	-98.4	-13.2	6.8	42.2	nd
S151	NM314	Nor Este S	12	na	7/2/1997	-99.0	-13.5	9.0	45.0	- 0.3
S151	NM508	Nor Este S	12	na	7/20/1998	-100.	-13.5	8.2	37.6	0.5
S153	NM315	Open Space	12	10	6/17/1997	-98.5	-13.4	9.0	31.6	nd
S153	NM411	Open Space	12	na	11/18/1997	-101.	-12.7	1.0	28.9	nd
S154	NM099	ORLF-2	12	na	6/27/1996	-95.9	-12.6	5.0	53.7	- 1.9
S155	NM316	Domestic Well #29	12	na	6/27/1997	-97.9	-13.3	8.5	48.3	nd
S156	NM100	Paseo 2D	12	na	6/26/1996	-98.1	-13.3	8.4	59.1	0.3
S157	NM101	Paseo 2MD	12	na	6/26/1996	-95.3	-12.7	5.9	85.9	- 0.6
S158	NM102	Paseo 2MS	12	na	6/26/1996	-93.7	-12.6	6.8	81.9	- 3.9
S159	NM103	Paseo 2S	12	na	6/26/1996	-93.3	-12.5	7.1	103.	- 4.3
S160	NM104	Paseo 3D	12	na	6/21/1996	-99.7	-13.5	8.4	26.8	2.2
S161	NM105	Paseo 3M	12	na	6/21/1996	-92.7	-12.4	6.1	125.	- 7.6
S171	NM321	Ridgecrest 4	12	na	6/26/1997	-93.3	-12.7	8.6	31.6	2.8
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	-89.9	-12.2	7.9	69.1	nd
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	-92.9	-12.2	5.1	99.4	- 3.2
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	-96.8	-13.0	7.5	70.4	- 0.2
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	-94.5	-12.6	6.5	107.	- 1.6
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	-91.5	-12.1	5.5	101.	- 2.0
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	-96.0	-13.0	8.0	29.4	3.6
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	-88.5	-11.8	5.6	137.	- 0.7
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	-91.9	-12.4	7.1	63.1	nd
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	-98.3	-13.2	7.6	31.8	nd
S190	NM325	Rio Rancho 2	12	na	6/20/1997	-99.4	-13.4	7.8	59.2	nd
S203	NM331	Private Production Well #20	12	na	7/3/1997	-93.9	-12.6	7.0	121.	nd
S205	NM333	Private Production Well #21	12	na	7/3/1997	-98.2	-13.6	11.0	37.4	nd

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S208	NM140	San Jose 2	12	3	6/20/1996	-99.2	-13.3	7.0	58.4	nd
S210	NM511	Sandia D	12	na	7/30/1998	-92.3	-12.6	8.4	58.3	- 8.7
S214	NM513	Sandia S	12	na	7/30/1998	-95.4	-12.9	7.5	78.8	0.9
S220	NM147	Santa Barbara 1	12	na	6/19/1996	-98.8	-13.3	7.6	36.8	2.1
S220	NM337	Santa Barbara 1	12	na	6/26/1997	-98.9	-13.4	7.9	41.2	1.9
S231	NM517	Sierra Vista M	12	3	7/22/1998	-95.5	-13.0	8.7	49.4	2.2
S232	NM518	Sierra Vista S	12	na	7/22/1998	-95.0	-12.8	7.7	61.2	3.2
S234	NM339	Sister Cities D	12	na	6/30/1997	-95.4	-12.8	6.8	52.8	- 2.1
S235	NM340	Sister Cities M	12	na	6/27/1997	-102.	-13.6	7.0	22.0	3.7
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	-96.2	-13.0	8.0	13.3	16.2
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	-98.3	-13.2	7.7	6.3	19.7
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	-97.3	-13.2	8.2	8.2	nd
S253	NM522	Tome D	12	na	8/6/1998	-93.1	-12.7	8.4	43.7	- 3.9
S257	NM344	Domestic Well #34	12	na	6/17/1997	-93.8	-12.6	7.1	92.7	nd
S259	NM171	VGP-1	12	na	6/27/1996	-90.6	-12.0	5.7	167.	0.8
S261	NM172	Vol Andia 2	12	na	6/21/1996	-97.3	-13.4	10.1	34.0	2.1
S262	NM173	Vol Andia 5	12	na	6/18/1996	-96.4	-13.3	9.8	67.0	- 0.9
S265	NM175	Webster 1	12	na	6/18/1996	-97.0	-13.0	7.2	38.3	5.0
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	-95.0	-12.8	7.6	56.8	nd
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	-95.0	-13.1	9.6	55.5	nd
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	-93.7	-12.5	6.5	91.9	nd
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	-92.9	-12.5	6.8	79.9	nd
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	-89.7	-12.1	6.8	60.4	nd
S275	NM178	Yale 1	12	na	6/19/1996	-98.2	-13.2	7.7	47.2	nd
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	-95.5	-12.7	5.9	58.8	nd
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	-96.3	-12.9	7.2	51.3	nd
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	-93.3	-12.4	6.1	58.8	nd
		Zone 13: Discharge								
S143	NM096	Private Production Well #05	13	na	8/19/1996	-90.8	-12.1	6.4	203.	nd
S194	NM327	Domestic Well #32	13	na	6/30/1997	-81.5	-11.0	6.9	290.	nd
S226	NM150	Domestic Well #15	13	na	8/19/1996	-90.8	-12.3	7.4	450.	3.6
		No Zone: Exotic Water								
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	-65.2	-7.66	- 3.9	3,750.	nd
S023	NM010	Burn Site Well	E	E	6/25/1996	-76.3	-10.6	8.3	165.	- 9.8
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	-79.8	-9.45	- 4.2	2,190.	7.4
S038	NM265	Windmill #19	E	E	7/1/1997	-99.7	-13.3	6.4	2,134.	13.9
S054	NM041	Domestic Well #04	E	E	8/17/1996	-82.7	-10.3	- 0.5	296.	8.9
S057	NM044	Embudo Spring	E	E	7/2/1996	-85.8	-11.7	7.8	94.8	4.4
S057	NM215	Embudo Spring	E	E	3/21/1997	-80.0	-11.2	9.6	103.	nd
S057	NM228	Embudo Spring	E	E	4/29/1997	-81.9	-11.5	10.3	63.8	nd
S057	NM241	Embudo Spring	E	E	5/27/1997	-81.6	-11.7	11.6	48.6	nd
S057	NM242	Embudo Spring	E	E	5/27/1997	nd	nd	nd	46.2	nd
S057	NM365	Embudo Spring	E	E	7/17/1997	-81.8	-11.6	11.2	nd	nd
S063	NM282	Windmill #22	E	E	6/28/1997	-62.3	-9.06	10.2	344.	nd
S067	NM284	Granite Hill	E	E	7/4/1997	-69.7	-9.40	5.5	153.	nd
S070	NM059	HERTF	E	E	6/28/1996	-71.6	-9.80	6.9	85.0	- 1.3
S091	NM496	Private Production Well #23	E	E	8/4/1998	-79.8	-10.8	6.7	40.7	nd
S094	NM293	Stock Well #02	E	E	6/20/1997	-58.5	-8.07	6.1	170.	0.
S099	NM072	LALF-1	E	E	6/29/1996	-89.8	-12.0	6.4	280.	nd
S112	NM296	Domestic Well #24	E	E	6/21/1997	-58.5	-8.60	10.2	247.	nd
S112	NM297	Domestic Well #24	E	E	6/21/1997	-59.7	-8.43	7.7	247.	7.4
S129	NM087	Montaňo 4 S	E	E	6/19/1996	-90.7	-12.1	6.0	312.	-23.
S152	NM098	Private Production Well #07	E	E	8/22/1996	-79.2	-10.6	5.7	107.	nd
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	-90.0	-11.8	4.7	271.	-14.7
S202	NM330	Windmill #27	E	E	7/2/1997	-61.5	-9.03	10.7	672.	nd
S211	NM512	Sandia M	E	E	7/30/1998	-87.4	-11.9	8.2	45.5	2.2
S225	NM149	SBM-1	E	E	6/29/1996	-91.2	-12.0	4.6	573.	-17.4
S249	NM163	Private Production Well #09	E	E	6/26/1996	-80.4	-11.2	8.9	30.0	5.7

Table A9. Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Secondary hydro-chemical zone	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	^2H excess (per mil)	SO_4^{2-} (mg/L)	$\delta^{34}S$ (per mil)
S249	NM164	Private Production Well #09	E	E	6/26/1996	-80.5	-11.2	9.0	29.3	nd
S250	NM165	Private Production Well #10	E	E	6/26/1996	-75.1	-10.2	6.3	62.1	nd
S251	NM166	Private Production Well #11	E	E	6/26/1996	-80.2	-11.3	10.5	38.4	nd
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	-89.1	-12.6	11.4	19.5	- 5.6
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	-89.2	-12.6	11.7	19.5	nd
S258	NM524	Vallecito Springs	E	E	8/4/1998	-81.9	-11.4	9.3	35.4	nd
S273	NM176	Windmill #11	E	E	8/19/1996	-74.2	-10.7	11.3	89.3	nd
S282	NM529	Windmill #44	E	E	7/29/1998	-72.3	-9.74	5.6	829.	nd
SXXX	NM065	Jemez Spring	E	E	8/20/1996	-84.7	-11.0	3.2	41.6	nd
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	-85.9	-10.5	- 2.3	42.1	nd

Table A10. Summary of all stable hydrogen and oxygen isotope data for water from City of Albuquerque production wells

[NMXXX, sample number of this report; RWS, original "raw water sample number" of C. Yapp; COA, City of Albuquerque; Yapp (1985), see references; Lambert and Balsley (1997), see references; dms, degrees-minutes-seconds; δ^2H, deuterium; $\delta^{18}O$, oxygen-18; $\delta=((R_{sample}/R_{standard}) -1)x1000$, where R is an isotope ratio; per mil, parts per thousand; nd, not determined]

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
193	Alameda 1	1/20/1982	nd	nd	C. Yapp	-93.9	-12.7	-92		
59	Atrisco 1	2/10/1981	350418	1064122	C. Yapp	-95.6	-12.8			
nd	Atrisco 1	8/7/1997	350418	1064122	COA	-94.8	-12.6			
7	Atrisco 2	10/1/1980	350445	1064115	C. Yapp	-93.3	-12.6			
36	Atrisco 2	11/6/1980	350445	1064115	C. Yapp	-95.2	-12.7			
47	Atrisco 2	12/16/1980	350445	1064115	C. Yapp	-93.1	-12.5			
54	Atrisco 2	1/14/1981	350445	1064115	C. Yapp	-93.0	-12.5			
58	Atrisco 2	2/10/1981	350445	1064115	C. Yapp	-93.2	-12.5			
69	Atrisco 2	4/8/1981	350445	1064115	C. Yapp	-95.4	-12.6			
77	Atrisco 2	5/28/1981	350445	1064115	C. Yapp	-92.8	-12.6			
114	Atrisco 2	6/29/1981	350445	1064115	C. Yapp	-93.6	-12.5			
123	Atrisco 2	7/23/1981	350445	1064115	C. Yapp	-93.0	-12.5			
141	Atrisco 2	8/18/1981	350445	1064115	C. Yapp	-91.8	-12.5	-92		
161	Atrisco 2	9/29/1981	350445	1064115	C. Yapp	-94.6	-12.6			
170	Atrisco 2	10/27/1981	350445	1064115	C. Yapp	-96.3	-12.6			
183	Atrisco 2	11/20/1981	350445	1064115	C. Yapp	-90.8	-12.7			
270	Atrisco 2	6/9/1982	350445	1064115	C. Yapp	-94.7	-12.7			
nd	Atrisco 2	8/7/1997	350445	1064115	COA	-93.0	-12.5			
200	Atrisco 3	1/20/1982	350513	1064118	C. Yapp	-93.5	-12.7			
NM005	Atrisco 3	6/20/1996	350516	1064121	USGS	-93.6	-12.6			
nd	Atrisco 3	9/4/1997	350513	1064118	COA	-93.7	-12.7			
nd	Atrisco 4	9/4/1997	350509	1064142	COA	-94.9	-12.7			
nd	Burton 1	8/6/1997	350359	1063624	COA	-97.4	-13.0			
NM012	Burton 2	6/19/1996	350421	1063613	USGS	-96.4	-13.1			
nd	Burton 2	8/15/1997	350421	1063610	COA	-95.9	-13.1			
144	Burton 3	8/18/1981	350440	1063558	C. Yapp	-97.5	-13.2	-96		
209	Burton 3	1/20/1982	350440	1063558	C. Yapp	-96.7	-13.1	-95		
nd	Burton 3	8/15/1997	350440	1063558	COA	-97.3	-13.2		-96.0	-13.2
nd	Burton 4	8/6/1997	350343	1063633	COA	-96.0	-13.2			
NM013	Burton 5	6/19/1996	350355	1063517	USGS	-96.0	-13.1			
nd	Burton 5	9/19/1997	350355	1063515	COA	-96.9	-13.2			
134	Candelaria 1	8/18/1981	350705	1063813	C. Yapp	-97.8	-12.8	-94		
159	Candelaria 1	9/29/1981	350705	1063813	C. Yapp	-94.8	-12.6			
168	Candelaria 1	10/27/1981	350705	1063813	C. Yapp	-97.6	-12.7			
45	Candelaria 4	12/16/1980	350705	1063817	C. Yapp	-96.6	-13.1			
112	Candelaria 4	6/29/1981	350705	1063817	C. Yapp	-96.8	-12.9			
121	Candelaria 4	7/23/1981	350705	1063817	C. Yapp	-97.0	-12.9			
nd	Charles 1	8/8/1997	350628	1063348	COA	-95.9	-13.2			
nd	Charles 2	8/1/1997	350606	1063411	COA	-96.8	-13.3			
nd	Charles 3	8/1/1997	350640	1063426	COA	-99.3	-13.5			
213	Charles 4	1/20/1982	350640	1063426	C. Yapp	-85.2	-11.8	-83		
NM016	Charles 4	6/22/1996	350559	1063339	USGS	-88.9	-12.2			
NM017	Charles 4	6/27/1996	350559	1063339	USGS	-88.0	-12.2			
NM018	Charles 4	6/27/1996	350559	1063339	USGS	-89.6	-12.1			
NM019	Charles 4	6/27/1996	350559	1063339	USGS	-87.4	-12.1			
NM020	Charles 4	6/27/1996	350559	1063339	USGS	-90.7	-12.1			
NM021	Charles 4	6/27/1996	350559	1063339	USGS	-88.4	-12.2			

Table A10. Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
NM022	Charles 4	6/27/1996	350559	1063339	USGS	-89.6	-12.2			
NM023	Charles 4	6/27/1996	350559	1063339	USGS	-91.2	-12.2			
NM024	Charles 4	6/27/1996	350559	1063339	USGS	-89.1	-12.2			
nd	Charles 4	8/1/1997	350602	1063332	COA	-87.0	-12.3			
nd	Charles 5	8/8/1997	350615	1063459	COA	-97.9	-13.3			
202	College 1	1/20/1982	350643	1064442	C. Yapp	-92.1	-12.2	-90		
nd	College 1	8/13/1997	350646	1064433	COA	-88.4	-11.8		-92.0	-12.0
266	College 2	6/9/1982	350647	1064400	C. Yapp	-98.9	-12.9			
NM264	College 2	6/19/1997	350647	1064400	USGS	-109.0	-14.4			
nd	College 2	7/11/1997	350647	1064400	COA	-107.5	-14.4			
NM028	Coronado 1	6/18/1996	351023	1063418	USGS	-94.7	-12.6			
nd	Coronado 1	7/25/1997	351025	1063417	COA	-94.0	-12.6			
nd	Coronado 2	7/25/1997	351007	1063438	COA	-95.6	-13.1			
139	Don 1	8/18/1981	350416	1064518	C. Yapp	-105.2	-13.8	-104		
204	Don 1	1/20/1982	350416	1064518	C. Yapp	-105.6	-13.9	-103		
268	Don 1	6/9/1982	350416	1064518	C. Yapp	-104.6	-13.7			
NM032	Duranes 1	6/20/1996	350641	1064006	USGS	-93.5	-12.4			
NM033	Duranes 1	6/28/1996	350641	1064006	USGS	-92.0	-12.3			
NM034	Duranes 1	6/28/1996	350641	1064006	USGS	-92.8	-12.4			
NM035	Duranes 1	6/28/1996	350641	1064006	USGS	-92.3	-12.5			
NM036	Duranes 1	6/28/1996	350641	1064006	USGS	-92.4	-12.4			
NM037	Duranes 1	6/28/1996	350641	1064006	USGS	-91.8	-12.3			
NM038	Duranes 1	6/28/1996	350641	1064006	USGS	-92.3	-12.4			
NM039	Duranes 1	6/28/1996	350641	1064006	USGS	-94.2	-12.3			
NM040	Duranes 1	6/28/1996	350641	1064006	USGS	-95.1	-12.3			
nd	Duranes 1	8/1/1997	350640	1064005	COA	-93.3	-12.6			
nd	Duranes 2	8/14/1997	350708	1064058	COA	-94.4	-12.9			
6	Duranes 3	10/1/1980	350629	1064051	C. Yapp	-96.0	-12.7			
38	Duranes 3	11/6/1980	350629	1064051	C. Yapp	-95.0	-12.7			
46	Duranes 3	12/16/1980	350629	1064051	C. Yapp	-90.9	-12.3			
136	Duranes 3	8/18/1981	350629	1064051	C. Yapp	-94.1	-12.7	-92		
nd	Duranes 3	9/11/1997	350629	1064051	COA	-94.4	-12.7			
53	Duranes 4	1/14/1981	350628	1064115	C. Yapp	-96.2	-12.8			
60	Duranes 4	2/10/1981	350628	1064115	C. Yapp	-95.2	-12.7			
68	Duranes 4	4/8/1981	350628	1064115	C. Yapp	-96.4	-12.7			
76	Duranes 4	5/28/1981	350628	1064115	C. Yapp	-93.9	-12.8			
113	Duranes 4	6/29/1981	350628	1064115	C. Yapp	-95.3	-12.8			
122	Duranes 4	7/23/1981	350628	1064115	C. Yapp	-94.6	-12.7			
160	Duranes 4	9/29/1981	350628	1064115	C. Yapp	-95.5	-12.8			
169	Duranes 4	10/27/1981	350628	1064115	C. Yapp	-97.3	-12.9			
184	Duranes 4	11/20/1981	350628	1064115	C. Yapp	-96.0	-12.8			
199	Duranes 4	1/20/1982	350628	1064115	C. Yapp	-93.9	-12.8	-92		
271	Duranes 4	6/9/1982	350628	1064115	C. Yapp	-96.3	-12.8			
nd	Duranes 4	9/11/1997	350628	1064115	COA	-94.5	-12.8		-94.0	-12.9
nd	Duranes 5	9/18/1997	350605	1064118	COA	-93.5	-12.7			
nd	Duranes 6	8/1/1997	350653	1064030	COA	-92.0	-12.6			
NM270	Duranes 7	6/26/1997	350656	1064112	USGS	-93.4	-12.7			
nd	Duranes 7	8/14/1997	350656	1064110	COA	-94.8	-12.7			
NM056	Gonzales 1	6/20/1996	350641	1064232	USGS	-100.2	-13.2			
nd	Gonzales 1	8/27/1997	350642	1064228	COA	-98.1	-13.3			

Table A10. Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
nd	Gonzales 2	8/27/1997	350635	1064150	COA	-95.3	-12.9			
nd	Gonzales 3	8/7/1997	nd	nd	COA	-96.5	-13.1			
nd	Griegos 1	8/22/1997	350827	1063950	COA	-94.3	-13.0			
NM057	Griegos 3	6/21/1996	350811	1064003	USGS	-96.0	-12.9			
nd	Griegos 3	12/10/1997	350802	1064029	COA	-95.4	-12.8			
135	Griegos 4	8/18/1981	350821	1063901	C. Yapp	-96.2	-13.1	-96		
198	Griegos 4	1/20/1982	350821	1063901	C. Yapp	-96.9	-13.1	-95		
nd	Griegos 4	8/22/1997	350821	1063901	COA	-96.4	-13.1		-97.0	-13.2
140	Leavitt 1	8/18/1981	350309	1064345	C. Yapp	-104.7	-13.7	-103		
172	Leavitt 1	10/27/1981	350309	1064345	C. Yapp	-105.3	-13.8			
182	Leavitt 1	11/20/1981	350309	1064345	C. Yapp	-102.5	-13.9			
205	Leavitt 1	1/20/1982	350309	1064345	C. Yapp	-106.3	-13.8	-102		
269	Leavitt 1	6/9/1982	350309	1064345	C. Yapp	-106.3	-13.7			
nd	Leavitt 1	8/28/1997	350309	1064345	COA	-99.7	-13.3			
nd	Leavitt 2	8/28/1997	350248	1064340	COA	-96.1	-12.8			
nd	Leavitt 3	8/29/1997	350223	1064354	COA	-100.1	-13.4			
NM074	Leyendecker 1	6/21/1996	350752	1063423	USGS	-99.1	-13.4			
nd	Leyendecker 1	7/10/1997	350752	1063421	COA	-96.2	-13.4			
nd	Leyendecker 2	7/24/1997	350727	1063408	COA	-98.3	-13.4			
196	Leyendecker 3	1/20/1982	350819	1063440	C. Yapp	-99.6	-13.5	-98		
nd	Leyendecker 3	7/10/1997	350819	1063440	COA	-100.1	-13.4		-98.0	-13.6
132	Leyendecker 4	8/18/1981	350815	1063406	C. Yapp	-98.0	-13.5	-98		
nd	Leyendecker 4	7/24/1997	350815	1063406	COA	-98.0	-13.3		-97.0	-13.5
NM075	Lomas 1	6/22/1996	350431	1063028	USGS	-76.2	-10.5			
nd	Lomas 1	9/12/1997	350430	1063024	COA	-75.7	-10.4			
147	Lomas 2	8/18/1981	350459	1063046	C. Yapp	-78.7	-10.8	-78		
210	Lomas 2	1/20/1982	350459	1063046	C. Yapp	-78.7	-10.9	-77		
nd	Lomas 5	8/15/1997	350422	1063124	COA	-78.2	-11.1			
nd	Lomas 6	8/6/1997	350408	1063101	COA	-80.4	-11.0			
NM078	Love 1	6/22/1996	350517	1063145	USGS	-80.2	-11.2			
nd	Love 1	8/14/1997	350517	1063144	COA	-78.6	-11.2			
146	Love 3	8/18/1981	350511	1063214	C. Yapp	-78.6	-11.4	-80		
211	Love 3	1/20/1982	350511	1063214	C. Yapp	-80.9	-11.4	-80		
nd	Love 3	9/11/1997	350511	1063214	COA	-82.0	-11.4		-82.0	-11.6
nd	Love 4	8/14/1997	350511	1063256	COA	-84.6	-11.8			
nd	Love 5	9/11/1997	350452	1063239	COA	-86.1	-11.8			
nd	Love 6	9/5/1997	350553	1063138	COA	-80.1	-11.2			
212	Love 7	1/20/1982	350607	1063213	C. Yapp	-81.8	-11.5	-79		
nd	Love 7	9/5/1997	350607	1063213	COA	-81.6	-11.5		-83.0	-11.6
nd	Love 8	9/12/1997	nd	nd	COA	-91.4	-12.6			
nd	Miles 1	7/31/1997	350308	1063746	COA	-95.2	-13.1			
NM106	Ponderosa 1	6/20/1996	350931	1063156	USGS	-89.3	-12.1			
nd	Ponderosa 1	8/15/1997	350933	1063155	COA	-88.3	-12.1			
3	Ponderosa 2	10/1/1980	350800	1063150	C. Yapp	-78.2	-11.1			
35	Ponderosa 2	11/6/1980	350800	1063150	C. Yapp	-81.4	-11.2			
44	Ponderosa 2	12/16/1980	350800	1063150	C. Yapp	-79.8	-11.0			
62	Ponderosa 2	2/10/1981	350800	1063150	C. Yapp	-77.6	-11.2			
66	Ponderosa 2	4/8/1981	350800	1063150	C. Yapp	-80.4	-11.1			
73	Ponderosa 2	5/28/1981	350800	1063150	C. Yapp	-78.5	-11.1			
108	Ponderosa 2	6/29/1981	350800	1063150	C. Yapp	-79.7	-11.1			

Table A10. Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
118	Ponderosa 2	7/23/1981	350800	1063150	C. Yapp	-78.6	-11.2			
129	Ponderosa 2	8/18/1981	350800	1063150	C. Yapp	-77.2	-11.2	-77		
155	Ponderosa 2	9/29/1981	350800	1063150	C. Yapp	-81.0	-11.2			
188	Ponderosa 2	11/20/1981	350800	1063150	C. Yapp	-77.8	-11.1			
nd	Ponderosa 2	9/19/1997	350800	1063150	COA	-81.7	-11.5		-81.0	-11.6
nd	Ponderosa 3	9/12/1997	350820	1063217	COA	-91.8	-12.6			
nd	Ponderosa 5	8/22/1997	350918	1063154	COA	-84.0	-11.7			
nd	Ponderosa 6	8/22/1997	350851	1063220	COA	-91.4	-12.6			
nd	Ridgecrest 1	7/24/1997	350405	1063220	COA	-79.0	-11.0			
nd	Ridgecrest 2	7/24/1997	350427	1063234	COA	-84.0	-11.7			
145	Ridgecrest 3	8/18/1981	350401	1063314	C. Yapp	-83.9	-11.7	-82		
NM108	Ridgecrest 3	6/22/1996	350413	1063313	USGS	-85.9	-11.7		-84.0	-11.9
nd	Ridgecrest 3	7/25/1997	350401	1063314	COA	-83.3	-11.8		-84.0	-11.9
NM321	Ridgecrest 4	6/26/1997	350445	1063341	USGS	-93.3	-12.7			
nd	Ridgecrest 4	7/25/1997	350445	1063340	COA	-92.4	-12.8			
nd	Ridgecrest 5	7/31/1997	350420	1063344	COA	-94.9	-12.8			
nd	San Jose 1	8/29/1997	350316	1063848	COA	-92.9	-12.4			
NM140	San Jose 2	6/20/1996	350338	1063832	USGS	-99.2	-13.3			
nd	San Jose 2	8/29/1997	350336	1063832	COA	-99.2	-13.3			
nd	San Jose 3	8/29/1997	350343	1063901	COA	-97.8	-13.2			
142	San Jose 5	8/18/1981	350240	1063839	C. Yapp	-99.5	-13.2	-98		
207	San Jose 5	1/20/1982	nd	nd	C. Yapp	-98.9	-13.2	-96		
272	San Jose 5	6/9/1982	350240	1063839	C. Yapp	-99.0	-13.3			
214	Santa Barbara 1	1/20/1982	350648	1063625	C. Yapp	-98.3	-13.4	-96		
NM147	Santa Barbara 1	6/19/1996	350648	1063625	USGS	-98.8	-13.3		-98.0	-13.4
NM337	Santa Barbara 1	6/26/1997	350648	1063628	USGS	-98.9	-13.4		-98.0	-13.4
nd	Santa Barbara 1	9/18/1997	350648	1063625	COA	-98.2	-13.3		-98.0	-13.4
nd	Thomas 1	7/11/1997	350753	1063256	COA	-85.1	-11.8			
nd	Thomas 2	7/11/1997	350747	1063233	COA	-84.7	-11.6			
4	Thomas 3	10/1/1980	nd	nd	C. Yapp	-90.3	-12.3			
34	Thomas 3	11/6/1980	350813	1063321	C. Yapp	-93.5	-12.5			
43	Thomas 3	12/16/1980	350813	1063321	C. Yapp	-96.6	-13.0			
52	Thomas 3	1/14/1981	350813	1063321	C. Yapp	-96.0	-12.9			
61	Thomas 3	2/10/1981	350813	1063321	C. Yapp	-92.9	-12.7			
67	Thomas 3	4/8/1981	350813	1063321	C. Yapp	-92.1	-12.5			
74	Thomas 3	5/28/1981	350813	1063321	C. Yapp	-91.5	-12.4			
110	Thomas 3	6/29/1981	350813	1063321	C. Yapp	-93.5	-12.8			
119	Thomas 3	7/23/1981	350813	1063321	C. Yapp	-91.5	-12.5			
131	Thomas 3	8/18/1981	350813	1063321	C. Yapp	-94.5	-13.0	-94		
156	Thomas 3	9/29/1981	350813	1063321	C. Yapp	-90.7	-12.4			
186	Thomas 3	11/20/1981	350813	1063321	C. Yapp	-97.3	-13.0			
195	Thomas 3	1/20/1982	350813	1063321	C. Yapp	-95.0	-13.0	-93		
nd	Thomas 3	9/5/1997	350813	1063321	COA	-92.1	-12.7			
109	Thomas 4	6/29/1981	350813	1063240	C. Yapp	-87.4	-12.1			
130	Thomas 4	8/18/1981	350813	1063240	C. Yapp	-88.3	-12.1	-87		
157	Thomas 4	9/29/1981	350813	1063240	C. Yapp	-87.5	-12.1			
165	Thomas 4	10/27/1981	350813	1063240	C. Yapp	-89.3	-12.1			
166	Thomas 4	10/27/1981	350813	1063240	C. Yapp	-95.4	-13.1			
187	Thomas 4	11/20/1981	350813	1063240	C. Yapp	-87.9	-12.2			
194	Thomas 4	1/20/1982	350813	1063240	C. Yapp	-88.9	-12.2	-86		

Table A10. Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
nd	Thomas 4	8/15/1997	350813	1063240	COA	-87.0	-12.2		-86.0	-12.1
nd	Thomas 5	8/6/1997	350744	1063335	COA	-98.2	-13.3			
NM162	Thomas 6	6/21/1996	350720	1063305	USGS	-89.0	-12.3			
nd	Thomas 6	1/6/1998	350720	1063304	COA	-94.6	-12.8			
nd	Thomas 7	8/6/1997	350719	1063334	COA	-94.1	-13.1			
nd	Thomas 8	8/15/1997	350711	1063231	COA	-91.9	-12.5			
206	Valley Gardens	1/20/1982	350028	1064224	C. Yapp	-96.2	-12.9	-92		
167	Vol Andia 1	10/27/1981	350805	1063549	C. Yapp	-99.7	-13.4			
nd	Vol Andia 1	8/13/1997	350805	1063549	COA	-96.3	-13.1			
NM172	Vol Andia 2	6/21/1996	350732	1063504	USGS	-97.3	-13.4			
nd	Vol Andia 2	1/6/1998	350732	1063501	COA	-100.2	-13.4			
nd	Vol Andia 3	8/13/1997	350747	1063614	COA	-98.5	-13.3			
51	Vol Andia 4	1/4/1981	350803	1063511	C. Yapp	-99.9	-13.4			
nd	Vol Andia 4	9/12/1997	350803	1063511	COA	-98.9	-13.4			
42	Vol Andia 5	12/16/1980	350809	1063609	C. Yapp	-99.6	-13.4			
NM173	Vol Andia 5	6/18/1996	350805	1063611	USGS	-96.4	-13.3			
nd	Vol Andia 5	7/31/1997	350809	1063609	COA	-99.5	-13.3			
5	Vol Andia 6	10/1/1980	350828	1063521	C. Yapp	-100.9	-13.4			
75	Vol Andia 6	5/28/1981	350828	1063521	C. Yapp	-100.0	-13.5			
111	Vol Andia 6	6/29/1981	350828	1063521	C. Yapp	-102.2	-13.5			
120	Vol Andia 6	7/23/1981	350828	1063521	C. Yapp	-97.7	-13.5			
133	Vol Andia 6	8/18/1981	350828	1063521	C. Yapp	-100.8	-13.5	-98		
158	Vol Andia 6	9/29/1981	350828	1063521	C. Yapp	-100.7	-13.5			
185	Vol Andia 6	11/20/1981	350828	1063521	C. Yapp	-99.1	-13.6			
197	Vol Andia 6	1/20/1982	350828	1063521	C. Yapp	-98.3	-13.3	-96		
nd	Vol Andia 6	7/31/1997	350828	1063521	COA	-97.6	-13.4		-99.0	-13.4
252	Volcano Cliffs 1	4/9/1982	350950	1064340	C. Yapp	-94.5	-12.7			
NM346	Volcano Cliffs 1	6/19/1997	350935	1064343	USGS	-96.4	-12.7			
nd	Volcano Cliffs 1	8/7/1997	350950	1064340	COA	-95.1	-12.6			
137	Volcano Cliffs 2	8/18/1981	350914	1064340	C. Yapp	-91.2	-12.7	-94		
173	Volcano Cliffs 2	10/27/1981	350914	1064340	C. Yapp	-96.9	-12.7			
180	Volcano Cliffs 2	11/20/1981	350914	1064340	C. Yapp	-92.1	-12.6			
201	Volcano Cliffs 2	1/20/1982	350914	1064340	C. Yapp	-93.8	-12.5	-90		
253	Volcano Cliffs 2	4/9/1982	350914	1064340	C. Yapp	-94.6	-12.6			
265	Volcano Cliffs 2	6/9/1982	350914	1064340	C. Yapp	-95.8	-12.6			
nd	Volcano Cliffs 2	8/27/1997	350914	1064340	COA	-95.3	-12.8		-97.0	-12.9
nd	Volcano Cliffs 3	8/27/1997	351002	1064346	COA	-93.7	-12.7			
NM174	Walker 1	6/18/1996	351025	1063140	USGS	-84.1	-11.9			
nd	Walker 1	8/21/1997	351026	1063139	COA	-85.9	-11.8		-83.0	-12.0
nd	Walker 2	8/21/1997	351023	1063214	COA	-92.3	-12.5		-91.0	-12.7
NM175	Webster 1	6/18/1996	351029	1063320	USGS	-97.0	-13.0			
nd	Webster 1	8/28/1997	351029	1063320	COA	-97.0	-13.0			
nd	Webster 2	8/28/1997	351013	1063335	COA	-98.9	-13.3			
nd	West Mesa 1	7/10/1997	350428	1064418	COA	-108.2	-14.3			
8	West Mesa 3	10/1/1980	350444	1064354	C. Yapp	-102.9	-13.4			
37	West Mesa 3	11/6/1980	350444	1064354	C. Yapp	-107.1	-13.9			
48	West Mesa 3	12/16/1980	nd	nd	C. Yapp	-91.2	-12.1			
55	West Mesa 3	1/14/1981	350444	1064354	C. Yapp	-93.6	-12.2			
57	West Mesa 3	2/10/1981	350444	1064354	C. Yapp	-93.3	-12.2			
70	West Mesa 3	4/8/1981	350444	1064354	C. Yapp	-103.7	-13.7			

Table A10. Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

Sample no. or RWS no.	Well name	Date	Reported latitude (dms)	Reported longitude (dms)	Sample Collection	USGS δ^2H (per mil)	USGS $\delta^{18}O$ (per mil)	Reported Yapp (1985) δ^2H (per mil)	Reported Lambert and Balsley (1997) δ^2H (per mil)	Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil)
78	West Mesa 3	5/28/1981	350444	1064354	C. Yapp	-104.2	-13.8			
115	West Mesa 3	6/29/1981	350444	1064354	C. Yapp	-103.0	-13.7			
124	West Mesa 3	7/23/1981	350444	1064354	C. Yapp	-103.8	-13.7			
138	West Mesa 3	8/18/1981	350444	1064354	C. Yapp	-103.6	-13.8	-102		
162	West Mesa 3	9/29/1981	350444	1064354	C. Yapp	-93.2	-12.2			
171	West Mesa 3	10/27/1981	350444	1064354	C. Yapp	-99.2	-13.3			
181	West Mesa 3	11/20/1981	350444	1064354	C. Yapp	-105.4	-13.7			
203	West Mesa 3	1/20/1982	350444	1064354	C. Yapp	-104.4	-13.8	-102		
267	West Mesa 3	6/9/1982	350444	1064354	C. Yapp	-104.4	-13.7			
NM353	West Mesa 3	6/19/1997	350444	1064354	USGS	-92.5	-12.2			
nd	West Mesa 3	7/10/1997	350444	1064354	COA	-99.8	-13.1			
nd	West Mesa 4	8/29/1997	350442	1064318	COA	-104.2	-13.8			
143	Yale 1	8/18/1981	350426	1063726	C. Yapp	-98.3	-13.2	-96		
208	Yale 1	1/20/1982	nd	nd	C. Yapp	-98.8	-13.2	-95		
NM178	Yale 1	6/19/1996	350427	1063729	USGS	-98.2	-13.2		-97	-13.3
nd	Yale 1	9/10/1997	350426	1063726	COA	-97.3	-13.2		-97	-13.3
nd	Yale 2	9/10/1997	350358	1063729	COA	-95.2	-13.0			
nd	Yale 3	9/19/1997	350435	1063801	COA	-97.8	-13.1			
nd	Zamora 1	8/13/1997	350918	1064254	COA	-95.3	-12.9			

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; CFC-12, dichlorodifluoromethane (CF_2Cl_2); $\delta^{13}C$, carbon-13; ^{14}C, carbon-14; per mil, parts per thousand; pmC, percent modern carbon; TU, Tritium Unit, 1 TU=1 atom of ^3H in 10^{18} atoms of H; 1σ, one standard deviation; pg/kg, picograms per kilogram; $\delta=((R_{sample}/R_{standard})-1)\times1000$, where R is an isotope ratio; Source of tritium data: L, Noble Gas Laboratory of Lamont-Doherty Earth Observatory, Palisades New York, by ^3He ingrowth; M, US Geological Survey Low-Level Tritium Laboratory in Menlo Park, California, by liquid scintillation counting of enriched samples; all ground-water tritium data from source M included in this table. See table A12 for additional tritium data from source L; na, not applicable; nd, not determined]

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
		Zone 1: Northern Mountain Front											
S027	NM486	CEPO 02	1	na	8/3/1998	nd	nd	na	2	-6.89	21.3	0.2	12,415
S034	NM027	Private Production Well #04	1	na	8/28/1996	nd	nd	na	0	-10.8	51.9	0.6	5,264
S035	NM487	Windmill #37	1	na	7/31/1998	17.2	0.6	M	nd	-11.7	97.9	0.7	170
S036	NM026	Private Production Well #03	1	na	8/28/1996	nd	nd	na	1	-8.10	82.6	0.9	1,540
S065	NM055	Domestic Well #05	1	na	8/17/1996	nd	nd	na	6	-6.18	27.0	0.3	10,518
S187	NM131	Rio Rancho 12	1	na	8/13/1996	0.4	0.3	M	6	-9.60	24.8	0.2	11,188
S206	NM510	Windmill #38	1	3	8/3/1998	-0.1	0.3	M	nd	-8.90	13.0	0.2	16,395
S216	NM143	Windmill #09	1	na	8/27/1996	0.1	0.3	M	17	-6.08	39.7	0.5	7,421
S221	NM530	Windmill #45	1	na	8/20/1998	0.2	0.2	M	nd	-5.83	12.2	0.2	16,926
S222	NM514	Windmill #39	1	3	8/6/1998	0.5	0.3	M	nd	-4.31	10.4	0.2	18,181
S254	NM168	Private Production Well #12	1	na	8/28/1996	nd	nd	na	0	-10.8	92.0	0.8	667
S277	NM525	Windmill #40	1	na	7/28/1998	1.0	0.3	M	nd	-7.47	50.7	0.4	5,456
S279	NM527	Windmill #42	1	na	7/28/1998	8.1	0.4	M	nd	-13.4	106.	0.8	-489
S281	NM528	Windmill #43	1	3	7/28/1998	0.3	0.3	M	nd	-10.3	22.3	0.2	12,043
		Zone 2: Northwestern											
S103	NM497	Lincoln D	2	na	7/23/1998	nd	nd	na	3	-8.44	13.8	0.2	15,909
S104	NM498	Lincoln M	2	na	7/23/1998	nd	nd	na	0	-7.08	15.5	0.2	14,997
S105	NM499	Lincoln S	2	na	7/23/1998	0.01	0.05	L	4	-6.46	29.6	0.4	9,768
S191	NM326	Rio Rancho 4	2	3	6/20/1997	nd	nd	na	108	-6.70	19.8	0.2	13,021
S192	NM128	Rio Rancho 8	2	3	8/13/1996	nd	nd	na	0	-7.62	14.7	0.2	15,385
S189	NM133	Rio Rancho 15	2	na	8/13/1996	nd	nd	na	0	-6.93	18.3	0.2	13,655
S276	NM179	Windmill #12	2	na	8/27/1996	0.0	0.3	M	nd	-7.25	38.1	0.4	7,756
S278	NM526	Windmill #41	2	na	7/29/1998	0.6	0.3	M	nd	-7.09	71.3	0.5	2,718
S280	NM180	Windmill #13	2	na	8/27/1996	0.4	0.3	M	nd	-5.04	84.5	0.9	1,356
S286	NM184	Private Production Well #13	2	na	8/26/1996	nd	nd	na	5	-6.61	71.2	0.6	2,729
S287	NM185	Private Production Well #14	2	na	8/26/1996	nd	nd	na	0	-6.20	37.4	0.4	7,903
		Zone 3: West Central											
S003	NM251	98th St. D	3	na	6/17/1997	nd	nd	na	3	-7.40	0.62	0.1	40,833
S003	NM481	98th St. D	3	na	8/4/1998	nd	nd	na	16	-7.15	0.13	0.1	53,382
S004	NM252	98th St. MD	3	na	6/18/1997	nd	nd	na	1	-7.40	3.98	0.1	25,897
S004	NM482	98th St. MD	3	na	8/4/1998	nd	nd	na	29	-7.51	3.69	0.1	26,505
S005	NM253	98th St. MS	3	na	7/4/1997	nd	nd	na	4	nd	nd	nd	nd
S005	NM483	98th St. MS	3	na	8/4/1998	nd	nd	na	21	-4.95	0.79	0.1	38,887
S006	NM484	98th St. S	3	na	8/5/1998	0.06	0.04	L	31	-7.62	6.37	0.2	22,119
S006	NM254	98th St. S	3	na	6/17/1997	nd	nd	na	74	nd	nd	nd	nd
S008	NM003	Private Production Well #01	3	na	8/12/1996	0.7	0.3	M	0	-7.76	5.47	0.1	23,343
S010	NM255	Private Production Well #16	3	na	6/23/1997	nd	nd	na	72,872	-8.60	9.31	0.3	19,071
S018	NM260	Domestic Well #21	3	na	6/26/1997	nd	nd	na	32	-7.30	11.0	0.1	17,753
S019	NM007	Belen 4	3	5	8/16/1996	0.5	0.3	M	45	-7.18	14.6	0.2	15,484
S020	NM008	Belen 5	3	5	8/16/1996	nd	nd	na	0	-6.65	16.4	0.2	14,537
S029	NM015	Cerro Colorado Landfill PW	3	5	8/12/1996	nd	nd	na	0	-7.22	7.35	0.1	20,970
S037	NM264	College 2	3	na	6/19/1997	nd	nd	na	1	-7.80	5.39	0.1	23,461
S066	NM056	Gonzales 1	3	12	6/20/1996	2.66	0.17	L	7	-7.30	47.0	0.4	6,058
S086	NM492	Isleta D	3	na	7/29/1998	nd	nd	na	7	-8.74	2.71	0.2	28,985
S101	NM294	Leavitt 1	3	na	6/26/1997	nd	nd	na	6	-7.10	17.3	0.1	14,103
S108	NM076	Los Lunas 3	3	12	8/14/1996	nd	nd	na	1	-7.52	27.6	0.2	10,356
S109	NM077	Los Lunas 4	3	12	8/14/1996	nd	nd	na	0	-8.65	50.5	0.4	5,496
S145	NM308	NM Utilities 1	3	na	6/18/1997	nd	nd	na	0	-6.60	13.9	0.2	15,845
S147	NM310	NM Utilities 3	3	na	6/18/1997	nd	nd	na	0	-7.70	15.7	0.2	14,878
S148	NM311	NM Utilities 4	3	na	6/18/1997	nd	nd	na	0	-7.00	7.36	0.1	20,959
S166	NM509	Rabbit Hill	3	na	8/4/1998	nd	nd	na	2	-4.53	8.59	0.1	19,717
S167	NM107	Domestic Well #12	3	na	8/14/1996	nd	nd	na	0	-7.89	5.85	0.1	22,803
S172	NM322	Rio Bravo 5 D	3	na	7/4/1997	nd	nd	na	0	-8.90	3.11	0.1	27,879
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	0.00	0.01	L	0	-7.27	15.1	0.2	15,181
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	0.00	0.02	L	2	-7.09	33.2	0.3	8,855
S186	NM130	Rio Rancho 10	3	na	8/13/1996	nd	nd	na	0	-7.03	12.2	0.2	16,912
S188	NM132	Rio Rancho 13	3	na	8/13/1996	nd	nd	na	0	-7.10	3.00	0.1	28,168

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1 σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
S193	NM129	Rio Rancho 9	3	na	8/13/1996	0.0	0.3	M	26	-7.81	7.72	0.1	20,575
S196	NM135	Windmill #05	3	na	8/21/1996	0.0	0.3	M	94	-7.38	36.8	0.3	8,037
S200	NM139	Private Production Well #08	3	na	8/29/1996	nd	nd	na	1	-7.08	9.23	0.2	19,140
S217	NM144	Santa Ana Boundary D	3	na	8/22/1996	nd	nd	na	1	-7.18	6.47	0.1	21,994
S218	NM145	Santa Ana Boundary M	3	na	8/22/1996	nd	nd	na	6	-6.81	8.24	0.1	20,052
S219	NM146	Santa Ana Boundary S	3	na	8/22/1996	nd	nd	na	4	-6.64	5.54	0.2	23,241
S230	NM516	Sierra Vista D	3	na	7/22/1998	nd	nd	na	0	-5.53	1.89	0.1	31,879
S236	NM155	SAF (Soil Amendment Facility)	3	na	8/12/1996	0.4	0.3	M	77	-8.01	4.50	0.1	24,911
S241	NM519	SWAB Test Hole 1 D	3	1	8/5/1998	0.1	0.3	M	nd	-6.87	6.57	0.2	21,871
S242	NM520	SWAB Test Hole 1 S	3	1	8/1/1998	-0.1	0.3	M	nd	-8.92	9.12	0.1	19,236
S243	NM521	SWAB Test Hole 2 D	3	na	8/7/1998	0.1	0.3	M	nd	-8.28	14.4	0.2	15,595
S263	NM346	Volcano Cliff 1	3	na	6/19/1997	nd	nd	na	3	-7.10	9.45	0.1	18,951
S266	NM347	West Bluff Nest 1 Well 1	3	na	6/23/1997	nd	nd	na	0	-6.40	2.00	0.1	31,425
S272	NM353	West Mesa 3	3	na	6/19/1997	nd	nd	na	0	-6.80	9.00	0.1	19,343
S283	NM181	Zia Ball Park D	3	na	8/26/1996	nd	nd	na	0	-6.12	18.3	0.2	13,625
S284	NM182	Zia Ball Park M	3	na	8/26/1996	nd	nd	na	1	-6.39	20.7	0.2	12,660
S285	NM183	Zia Ball Park S	3	2	8/26/1996	nd	nd	na	1	-6.93	22.2	0.3	12,079
S288	NM186	Zia BMT D	3	na	8/27/1996	1.0	0.4	M	nd	-8.27	8.29	0.2	20,003
		Zone 4: Western Boundary											
S031	NM263	Windmill #18	4	na	6/24/1997	-0.7	0.2	M	nd	-4.60	8.14	0.1	20,150
S039	NM266	Windmill #20	4	na	6/21/1997	-0.1	0.3	M	nd	-1.70	0.79	0.1	38,887
S059	NM278	Windmill #21	4	na	6/23/1997	0.1	0.3	M	14	-6.90	9.80	0.1	18,659
S074	NM285	Windmill #23	4	na	6/21/1997	0.1	0.3	M	nd	-0.90	4.24	0.1	25,389
S169	NM320	Rest Area	4	na	6/30/1997	15.6	0.6	M	nd	-5.50	80.7	0.7	1,720
S201	NM329	Windmill #26	4	na	7/2/1997	0.0	0.3	M	nd	-4.80	2.68	0.1	29,074
S252	NM167	Windmill #10	4	na	8/29/1996	0.5	0.3	M	nd	-6.17	9.69	0.2	18,749
S260	NM345	Windmill #33	4	na	6/25/1997	0.5	0.3	M	nd	-3.20	3.29	0.1	27,427
		Zone 5: Rio Puerco											
S032	NM262	Windmill #17	5	na	6/24/1997	0.3	0.3	M	nd	-3.50	29.8	0.2	9,736
S069	NM058	Domestic Well #06	5	na	8/16/1996	0.2	0.3	M	52	-9.31	36.5	0.4	8,107
S073	NM062	Windmill #03	5	na	8/16/1996	-0.2	0.3	M	nd	-6.99	49.1	0.4	5,720
S082	NM409	Windmill #36	5	na	9/10/1997	0.1	0.3	M	42	-12.3	43.3	0.4	6,733
S085	NM408	Windmill #35	5	na	9/10/1997	0.2	0.3	M	99	-9.80	13.2	0.1	16,254
S111	NM079	Domestic Well #10	5	na	8/16/1996	nd	nd	na	0	-6.76	54.7	0.5	4,842
S185	NM324	Domestic Well #31	5	na	6/16/1997	nd	nd	na	12	-10.6	36.3	0.4	8,134
S198	NM137	Windmill #07	5	na	8/21/1996	7.3	0.4	M	44	-4.65	84.5	0.7	1,354
S237	NM341	Windmill #30	5	4	6/24/1997	0.0	0.3	M	nd	-7.40	23.8	0.3	11,538
S238	NM342	Windmill #31	5	na	6/24/1997	-0.3	0.3	M	nd	-7.90	32.9	0.4	8,935
		Zone 6: Southwestern Mountain Front											
S022	NM009	Windmill #02	6	na	8/19/1996	0.0	0.3	M	nd	-5.76	40.0	0.4	7,356
		Zone 7: Abo Arroyo											
S021	NM261	Stock Well #01	7	na	6/23/1997	11.77	0.23	L	221	-5.40	83.9	0.7	1,407
S024	NM011	Domestic Well #02	7	8	8/17/1996	0.0	0.3	M	2	-6.94	17.1	0.2	14,201
S090	NM064	Domestic Well #08	7	na	8/19/1996	nd	nd	na	3	-6.49	13.0	0.2	16,395
S093	NM067	Domestic Well #09	7	8	8/15/1996	nd	nd	na	1	-8.54	31.1	0.3	9,382
		Zone 8: Eastern Mountain Front											
S007	NM002	Domestic Well #01	8	na	6/21/1996	10.57	0.18	L	327	-11.8	113.	1.0	-1,010
S013	NM256	Windmill #14	8	na	6/24/1997	1.7	0.2	M	nd	-9.60	74.0	0.6	2,421
S014	NM257	Private Production Well #17	8	na	6/19/1997	-0.2	0.3	M	nd	-7.40	79.8	0.7	1,810
S015	NM006	Windmill #01	8	na	8/24/1996	7.2	0.4	M	nd	-8.26	97.7	0.9	184
S030	NM018	Charles 4	8	na	6/27/1996	nd	nd	na	1	nd	nd	nd	nd
S030	NM020	Charles 4	8	na	6/27/1996	nd	nd	na	0	nd	nd	nd	nd
S030	NM019	Charles 4	8	na	6/27/1996	0.01	0.01	L	0	nd	nd	nd	nd
S030	NM021	Charles 4	8	na	6/27/1996	0.01	0.01	L	0	nd	nd	nd	nd
S030	NM023	Charles 4	8	na	6/27/1996	0.01	0.01	L	0	nd	nd	nd	nd
S030	NM024	Charles 4	8	na	6/27/1996	0.01	0.01	L	0	nd	nd	nd	nd
S030	NM016	Charles 4	8	na	6/22/1996	0.03	0.01	L	0	-8.54	51.4	0.4	5,348
S030	NM022	Charles 4	8	na	6/27/1996	nd	nd	na	0	nd	nd	nd	nd
S042	NM031	Domestic Well #03	8	na	8/14/1996	nd	nd	na	0	-7.95	21.0	0.2	12,537
S055	NM042	Elena Gallegos	8	na	6/25/1996	nd	nd	na	207	-10.5	109.	0.9	-705
S056	NM043	Embudito Spring	8	na	7/2/1996	7.82	0.16	L	220	-14.1	115.	1.1	-1,095
S056	NM227	Embudito Spring	8	na	4/29/1997	10.0	0.5	M	287	nd	nd	nd	nd
S056	NM227	Embudito Spring	8	na	4/29/1997	10.0	0.5	M	324	nd	nd	nd	nd
S056	NM364	Embudito Spring	8	na	7/17/1997	10.1	0.5	M	nd	nd	nd	nd	nd
S056	NM239	Embudito Spring	8	na	5/27/1997	11.2	0.5	M	nd	nd	nd	nd	nd

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1 σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
S056	NM213	Embudito Spring	8	na	3/21/1997	nd	nd	na	419	nd	nd	nd	nd
S056	NM214	Embudito Spring	8	na	3/21/1997	nd	nd	na	401	nd	nd	nd	nd
S071	NM060	Domestic Well #07	8	na	6/19/1996	0.19	0.01	L	0	-8.75	97.5	0.8	205
S083	NM407	Windmill #34	8	na	9/10/1997	-0.2	0.3	M	17	-5.50	17.2	0.3	14,159
S095	NM068	Kirtland 1	8	na	6/25/1996	0.05	0.01	L	12	-8.89	59.4	0.5	4,187
S106	NM295	Domestic Well #23	8	na	6/26/1997	-0.01	0.04	L	0	-8.20	11.2	0.1	17,615
S110	NM078	Love 1	8	na	6/22/1996	0.05	0.01	L	10	-7.63	47.2	0.4	6,029
S113	NM080	Domestic Well #11	8	na	8/15/1996	nd	nd	na	1	-7.43	8.33	0.1	19,964
S114	NM500	Matheson D	8	na	7/31/1998	nd	nd	na	50	-11.0	35.4	0.3	8,353
S115	NM501	Matheson M	8	na	8/1/1998	nd	nd	na	43	-10.2	55.9	0.4	4,676
S116	NM502	Matheson S	8	na	8/1/1998	0.01	0.05	L	5	-9.35	64.9	0.5	3,475
S117	NM298	Domestic Well #25	8	na	6/17/1997	0.22	0.03	L	13	-9.00	95.1	0.7	406
S118	NM299	Windmill #24	8	na	6/27/1997	0.5	0.3	M	nd	-5.90	37.4	0.4	7,898
S119	NM300	Domestic Well #26	8	11	6/19/1997	nd	nd	na	551	-7.80	47.4	0.3	6,000
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	0.02	0.05	L	12	-9.88	33.4	0.3	8,819
S122	NM304	Mesa Del Sol S	8	na	6/29/1997	nd	nd	na	18	-10.8	19.3	0.2	13,227
S140	NM306	MRN 1	8	na	7/5/1997	nd	nd	na	0	-7.70	42.2	0.3	6,925
S141	NM095	National Utility 7	8	na	8/14/1996	-0.3	0.3	M	785	-5.97	68.8	0.6	3,001
S149	NM312	Nor Este D	8	na	7/3/1997	nd	nd	na	0	-8.70	7.96	0.1	20,329
S150	NM313	Nor Este M	8	na	7/2/1997	nd	nd	na	0	-8.60	17.1	0.2	14,177
S162	NM317	Stock Well #03	8	na	6/30/1997	nd	nd	na	0	-8.20	52.7	0.5	5,152
S163	NM318	PL 2	8	na	7/7/1997	nd	nd	na	0	-8.20	38.8	0.4	7,599
S164	NM106	Ponderosa 1	8	na	6/20/1996	0.03	0.01	L	0	-9.25	42.5	0.4	6,883
S165	NM328	Windmill #25	8	na	6/24/1997	0.0	0.3	M	nd	-8.90	10.2	0.2	18,377
S168	NM319	Domestic Well #30	8	na	6/27/1997	nd	nd	na	9	-9.20	5.41	0.1	23,431
S170	NM108	Ridgecrest 3	8	na	6/22/1996	nd	nd	na	0	-12.2	70.3	0.7	2,837
S170	NM412	Ridgecrest 3	8	na	11/18/1997	0.0	0.3	M	nd	nd	nd	nd	nd
S195	NM134	Domestic Well #13	8	na	8/14/1996	nd	nd	na	0	-8.24	22.2	0.2	12,076
S199	NM138	Windmill #08	8	na	8/23/1996	0.2	0.3	M	nd	-6.30	57.2	0.5	4,494
S209	NM336	Domestic Well #33	8	na	6/27/1997	nd	nd	na	0	-8.70	15.8	0.2	14,817
S212	NM141	Sandia Peak 1	8	na	6/26/1996	0.02	0.01	L	3	-9.73	78.0	0.7	1,998
S213	NM142	Sandia Peak 3	8	na	6/26/1996	0.02	0.01	L	13	-9.30	83.2	0.7	1,475
S224	NM148	Domestic Well #14	8	na	8/23/1996	nd	nd	na	0	-7.56	79.9	0.7	1,802
S229	NM515	SH03 UNM	8	na	7/28/1998	8.28	0.17	L	4	-9.42	96.3	0.8	302
S233	NM153	Domestic Well #16	8	na	8/23/1996	nd	nd	na	1	-7.14	32.6	0.3	9,011
S239	NM156	Domestic Well #17	8	na	8/17/1996	nd	nd	na	10,691	-8.92	22.0	0.3	12,163
S240	NM157	Domestic Well #18	8	na	6/19/1996	0.01	0.01	L	0	-10.5	66.4	0.6	3,287
S246	NM343	Windmill #32	8	na	6/24/1997	-0.1	0.3	M	nd	-5.90	31.2	0.3	9,364
S247	NM161	Domestic Well #19	8	na	8/15/1996	nd	nd	na	1	-8.50	4.86	0.1	24,293
S248	NM162	Thomas 6	8	na	6/21/1996	0.02	0.01	L	0	-8.95	44.2	0.4	6,557
S255	NM523	Tramway East	8	na	7/30/1998	-0.1	0.3	M	4	-10.4	54.0	0.4	4,954
S264	NM174	Walker 1	8	na	6/18/1996	-0.4	0.3	M	0	-9.26	41.6	0.3	7,038
S274	NM177	Domestic Well #20	8	na	8/15/1996	nd	nd	na	0	-5.80	24.7	0.2	11,246
		Zone 9: Tijeras Fault Zone											
S041	NM029	Coyote Spring	9	na	6/28/1996	0.29	0.03	L	92	nd	nd	nd	nd
S041	NM030	Coyote Spring	9	na	7/1/1996	nd	nd	na	nd	-0.60	4.83	0.1	24,342
S072	NM061	Hubbell Spring	9	8	8/23/1996	nd	nd	na	78	-6.40	42.8	0.4	6,817
S098	NM071	KAFB-1902	9	na	6/28/1996	2.69	0.05	L	1,626	nd	nd	nd	nd
S197	NM136	Windmill #06	9	na	8/23/1996	0.2	0.3	M	31	-8.22	4.76	0.1	24,460
S227	NM151	SFR 3D	9	na	8/24/1996	nd	nd	na	4	-0.98	9.67	0.1	18,766
S228	NM152	SFR 3S	9	na	8/24/1996	nd	nd	na	10	-0.95	13.2	0.2	16,242
		Zone 10: Tijeras Arroyo											
S001	NM001	4Hills-1	10	8	6/29/1996	3.95	0.08	L	364	-8.40	94.0	0.7	501
S002	NM250	Private Production Well #15	10	8	7/3/1997	nd	nd	na	785	-6.80	82.7	0.7	1,526
S058	NM277	Eubank 1	10	8	7/4/1997	1.7	0.4	M	185	-6.20	62.0	0.5	3,835
S096	NM069	Kirtland 11	10	8	6/25/1996	0.04	0.01	L	0	-7.90	46.0	0.4	6,241
S107	NM075	Lomas 1	10	8	6/22/1996	nd	nd	na	0	-6.20	72.8	0.6	2,552
		Zone 11: Northeastern											
S016	NM258	Windmill #15	11	na	6/18/1997	0.0	0.2	M	nd	-5.30	28.5	0.2	10,078
S017	NM259	Windmill #16	11	na	6/18/1997	-0.2	0.3	M	nd	-7.40	18.1	0.2	13,726
S053	NM276	Private Production Well #18	11	na	6/25/1997	13.7	0.6	M	nd	-5.60	76.5	0.7	2,150
S144	NM097	Private Production Well #06	11	na	8/28/1996	nd	nd	na	1	-6.80	29.2	0.4	9,886
S204	NM332	Windmill #28	11	na	7/3/1997	-0.3	0.3	M	nd	-6.40	19.6	0.3	13,107
S207	NM334	Private Production Well #22	11	na	7/3/1997	nd	nd	na	0	-6.10	69.3	0.5	2,941
S223	NM338	Windmill #29	11	na	6/25/1997	0.1	0.3	M	nd	-6.70	19.5	0.3	13,115

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1 σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
		Zone 12: Central											
S011	NM004	Atris-1	12	na	6/22/1996	11.01	0.22	L	82	-8.34	96.8	0.8	264
S012	NM005	Atrisco 3	12	3	6/20/1996	9.65	0.20	L	10	-8.31	64.7	0.5	3,496
S025	NM012	Burton 2	12	na	6/19/1996	0.08	0.01	L	47	-9.08	47.7	0.4	5,941
S026	NM013	Burton 5	12	na	6/19/1996	0.01	0.01	L	0	-9.35	44.7	0.4	6,475
S033	NM025	Private Production Well #02	12	na	8/21/1996	16.0	0.6	M	29	-10.6	96.4	1.2	297
S040	NM028	Coronado 1	12	na	6/18/1996	0.03	0.01	L	332	-8.50	32.8	0.3	8,962
S043	NM267	Del Sol D	12	na	7/1/1997	nd	nd	na	1	-8.00	6.37	0.1	22,119
S043	NM488	Del Sol D	12	na	7/21/1998	nd	nd	na	0	-8.27	6.20	0.1	22,337
S044	NM268	Del Sol M	12	na	6/26/1997	nd	nd	na	0	-8.00	14.5	0.2	15,523
S044	NM489	Del Sol M	12	na	7/21/1998	nd	nd	na	0	-8.33	13.7	0.2	15,997
S045	NM490	Del Sol S	12	na	7/21/1998	0.18	0.04	L	16	-9.06	62.2	0.5	3,813
S045	NM269	Del Sol S	12	na	6/26/1997	nd	nd	na	19	nd	nd	nd	nd
S046	NM032	Duranes 1	12	na	6/20/1996	10.6	0.5	M	78	-10.9	73.1	0.6	2,516
S046	NM036	Duranes 1	12	na	6/29/1996	nd	nd	na	163	nd	nd	nd	nd
S046	NM033	Duranes 1	12	na	6/29/1996	nd	nd	na	179	nd	nd	nd	nd
S046	NM034	Duranes 1	12	na	6/29/1996	11.90	0.30	L	160	nd	nd	nd	nd
S046	NM035	Duranes 1	12	na	6/29/1996	17.06	0.34	L	165	nd	nd	nd	nd
S046	NM037	Duranes 1	12	na	6/29/1996	nd	nd	na	173	nd	nd	nd	nd
S046	NM038	Duranes 1	12	na	6/29/1996	nd	nd	na	176	nd	nd	nd	nd
S046	NM039	Duranes 1	12	na	6/29/1996	nd	nd	na	180	nd	nd	nd	nd
S046	NM040	Duranes 1	12	na	6/29/1996	nd	nd	na	183	nd	nd	nd	nd
S047	NM270	Duranes 7	12	na	6/26/1997	7.6	0.4	M	33	-9.10	72.0	0.6	2,644
S048	NM271	Duranes Yard 1	12	na	7/5/1997	16.4	0.6	M	5	nd	nd	nd	nd
S049	NM272	Duranes Yard 2	12	na	7/5/1997	8.4	0.5	M	16	nd	nd	nd	nd
S050	NM273	Duranes Yard 3	12	na	7/5/1997	9.9	0.5	M	67	nd	nd	nd	nd
S051	NM274	Duranes Yard 4	12	na	7/5/1997	10.0	0.5	M	136	nd	nd	nd	nd
S052	NM275	Duranes Yard 5	12	na	7/5/1997	9.4	0.4	M	197	nd	nd	nd	nd
S060	NM279	Garfield D	12	3	6/19/1997	nd	nd	na	0	-8.40	12.6	0.2	16,672
S061	NM280	Garfield M	12	na	6/19/1997	0.03	0.14	L	0	-8.60	22.3	0.2	12,047
S062	NM281	Garfield S	12	na	6/19/1997	8.89	0.18	L	861	nd	nd	nd	nd
S062	NM491	Garfield S	12	na	7/28/1998	9.18	0.12	L	964	-10.7	81.8	0.7	1,610
S064	NM283	Domestic Well #22	12	na	6/20/1997	nd	nd	na	10	-9.70	82.8	0.7	1,516
S068	NM057	Griegos 3	12	na	6/21/1996	13.30	0.27	L	0	-8.81	67.0	0.6	3,217
S075	NM286	Hunter Ridge Nest 1 Well 1	12	3	6/20/1997	nd	nd	na	0	-7.90	25.3	0.2	11,034
S076	NM287	Hunter Ridge Nest 1 Well 2	12	na	6/21/1997	nd	nd	na	0	-9.80	60.4	0.5	4,046
S077	NM288	Hunter Ridge Nest 1 Well 3	12	na	6/20/1997	nd	nd	na	36	nd	nd	nd	nd
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	0.08	0.04	L	2	-9.00	73.8	0.6	2,440
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	-0.10	0.18	L	0	nd	nd	nd	nd
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	-0.01	0.03	L	3	nd	nd	nd	nd
S081	NM292	Private Production Well #19	12	na	7/2/1997	nd	nd	na	0	-8.80	55.2	0.5	4,769
S084	NM063	Windmill #04	12	na	8/21/1996	-0.2	0.3	M	39	-8.77	79.5	0.7	1,847
S087	NM493	Isleta MD	12	3	7/29/1998	nd	nd	na	4	-7.92	35.8	0.3	8,261
S088	NM494	Isleta MS	12	na	7/29/1998	nd	nd	na	4	-8.37	72.3	0.5	2,603
S089	NM495	Isleta S	12	na	7/29/1998	19.94	0.40	L	18	-12.5	118.	0.8	-1,345
S092	NM066	JMC-1	12	na	6/28/1996	4.5	0.5	M	279	nd	nd	nd	nd
S097	NM070	Kirtland 14	12	na	6/25/1996	0.02	0.01	L	28	-8.74	48.9	0.4	5,753
S100	NM073	LALF-9	12	na	6/29/1996	0.19	0.01	L	45,228	nd	nd	nd	nd
S102	NM074	Leyendecker 1	12	na	6/21/1996	0.08	0.08	L	126	-8.92	72.8	0.7	2,546
S120	NM301	Mesa Del Sol D	12	na	6/29/1997	nd	nd	na	89	nd	nd	nd	nd
S120	NM303	Mesa Del Sol D	12	na	6/28/1997	nd	nd	na	109	nd	nd	nd	nd
S120	NM503	Mesa Del Sol D	12	na	8/2/1998	nd	nd	na	1	-9.24	5.99	0.2	22,613
S121	NM302	Mesa Del Sol M	12	na	6/28/1997	nd	nd	na	7	-8.50	8.32	0.1	19,974
S121	NM504	Mesa Del Sol M	12	na	7/25/1998	nd	nd	na	2	-8.58	3.24	0.2	27,550
S123	NM081	MONT - 5A	12	na	6/27/1996	7.56	0.15	L	79	nd	nd	nd	nd
S124	NM082	Montaňo 2 D	12	na	6/19/1996	19.48	0.21	L	54	-10.0	103.	0.9	-263
S125	NM083	Montaňo 2 M	12	na	6/19/1996	25.50	0.51	L	37	-11.1	110.	0.9	-748
S126	NM084	Montaňo 2 S	12	na	6/19/1996	4.73	0.10	L	214	nd	nd	nd	nd
S127	NM085	Montaňo 4 D	12	na	6/20/1996	13.51	0.27	L	9	-11.1	95.0	0.8	412
S128	NM086	Montaňo 4 M	12	na	6/19/1996	19.59	0.39	L	56	-12.3	114.	1.0	-1,026
S130	NM088	Montaňo 5 D	12	na	6/24/1996	11.02	0.22	L	4	-9.00	97.6	1.0	197
S131	NM089	Montaňo 5 M	12	na	6/24/1996	9.92	0.20	L	200	-8.51	95.0	0.8	411
S132	NM090	Montaňo 5 S	12	na	6/24/1996	19.48	0.39	L	177	nd	nd	nd	nd
S133	NM091	Montaňo 6 D	12	na	6/18/1996	0.01	0.01	L	0	-9.57	25.2	0.2	11,075
S134	NM092	Montaňo 6 MD	12	na	6/18/1996	0.02	0.01	L	0	-8.62	38.0	0.3	7,783
S135	NM093	Montaňo 6 MS	12	na	6/18/1996	2.03	0.04	L	0	-7.69	67.5	0.6	3,153
S136	NM094	Montaňo 6 S	12	na	6/18/1996	15.21	0.30	L	267	nd	nd	nd	nd

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1 σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
S137	NM506	Montesa M	12	na	7/27/1998	nd	nd	na	2	-8.97	18.6	0.2	13,499
S138	NM507	Montesa S	12	na	7/27/1998	0.03	0.05	L	53	-9.28	52.5	0.4	5,175
S139	NM305	Domestic Well #27	12	na	6/17/1997	nd	nd	na	0	-8.60	43.4	0.3	6,711
S142	NM307	Domestic Well #28	12	na	6/17/1997	nd	nd	na	0	-8.30	73.3	0.6	2,498
S146	NM309	NM Utilities 2	12	na	6/18/1997	nd	nd	na	0	-8.30	50.9	0.5	5,418
S151	NM508	Nor Este S	12	na	7/20/1998	-0.02	0.05	L	6	-9.49	47.6	0.4	5,960
S151	NM314	Nor Este S	12	na	7/2/1997	nd	nd	na	207	nd	nd	nd	nd
S153	NM315	Open Space	12	10	6/17/1997	-0.1	0.3	M	nd	-8.30	55.2	0.5	4,781
S153	NM411	Open Space	12	na	11/18/1997	0.2	0.3	M	37	nd	nd	nd	nd
S154	NM099	ORLF-2	12	na	6/27/1996	11.42	0.26	L	118	nd	nd	nd	nd
S155	NM316	Domestic Well #29	12	na	6/27/1997	0.12	0.06	L	0	-8.50	55.5	0.5	4,731
S156	NM100	Paseo 2D	12	na	6/26/1996	1.78	0.04	L	3	-8.27	76.7	0.7	2,132
S157	NM101	Paseo 2MD	12	na	6/26/1996	15.09	0.30	L	42	-10.5	103.	0.8	-204
S158	NM102	Paseo 2MS	12	na	6/26/1996	11.09	0.22	L	453	nd	nd	nd	nd
S159	NM103	Paseo 2S	12	na	6/26/1996	10.72	0.21	L	2,068	nd	nd	nd	nd
S160	NM104	Paseo 3D	12	na	6/21/1996	0.15	0.01	L	27	-8.66	64.5	0.5	3,521
S161	NM105	Paseo 3M	12	na	6/21/1996	10.67	0.21	L	2,205	-10.7	98.1	0.7	152
S171	NM321	Ridgecrest 4	12	na	6/26/1997	nd	nd	na	21	-9.20	46.1	0.4	6,224
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	13.14	0.30	L	1,713	-9.70	97.3	1.1	224
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	11.34	0.23	L	69	nd	nd	nd	nd
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	15.69	0.30	L	33	-7.96	61.6	0.5	3,888
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	13.50	0.27	L	5	-10.6	78.4	0.6	1,959
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	13.58	0.27	L	8	-10.3	99.5	0.9	39
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	0.02	0.01	L	1	-9.05	34.6	0.3	8,516
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	7.86	0.16	L	38	-10.8	77.7	0.8	2,028
S183	NM126	Rio Grande Utility 5	12	3	8/15/1996	nd	nd	na	1	-8.12	33.2	0.3	8,862
S184	NM127	Rio Grande Utility 6	12	na	8/15/1996	nd	nd	na	0	-8.30	51.3	0.5	5,356
S190	NM325	Rio Rancho 2	12	na	6/20/1997	nd	nd	na	1	-8.60	71.6	0.7	2,689
S203	NM331	Private Production Well #20	12	na	7/3/1997	9.1	0.5	M	129	-8.76	77.1	0.5	2,090
S205	NM333	Private Production Well #21	12	na	7/3/1997	nd	nd	na	0	-8.40	58.8	0.4	4,260
S208	NM140	San Jose 2	12	3	6/20/1996	3.1	0.4	M	15	-8.65	29.1	0.3	9,916
S210	NM511	Sandia D	12	na	7/30/1998	nd	nd	na	18	-8.66	15.3	0.2	15,065
S214	NM513	Sandia S	12	na	7/30/1998	0.07	0.06	L	21	-9.31	62.9	0.5	3,726
S220	NM147	Santa Barbara 1	12	na	6/19/1996	0.3	0.3	M	1,285	-8.97	49.1	0.5	5,719
S231	NM517	Sierra Vista M	12	3	7/22/1998	nd	nd	na	1	-8.24	34.2	0.3	8,609
S232	NM518	Sierra Vista S	12	na	7/22/1998	0.03	0.05	L	28	-9.92	68.9	0.5	2,998
S234	NM339	Sister Cities D	12	na	6/30/1997	nd	nd	na	3	-7.30	8.03	0.1	20,259
S235	NM340	Sister Cities M	12	na	6/27/1997	nd	nd	na	0	-8.80	66.3	0.5	3,306
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	0.00	0.01	L	66	-9.81	44.1	0.5	6,584
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	0.03	0.01	L	56	-9.06	44.1	0.4	6,580
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	0.04	0.01	L	23	nd	nd	nd	nd
S253	NM522	Tome D	12	na	8/6/1998	nd	nd	na	7	-8.00	8.80	0.1	19,523
S257	NM344	Domestic Well #34	12	na	6/17/1997	16.3	0.6	M	19	-10.8	85.3	0.6	1,277
S259	NM171	VGP-1	12	na	6/27/1996	28.56	0.57	L	29	-11.6	123.	1.0	-1,669
S261	NM172	Vol Andia 2	12	na	6/21/1996	0.25	0.03	L	16	-8.63	70.6	0.6	2,800
S262	NM173	Vol Andia 5	12	na	6/18/1996	1.26	0.03	L	1,942	-9.80	57.8	0.5	4,406
S265	NM175	Webster 1	12	na	6/18/1996	-0.1	0.3	M	0	-8.50	45.5	0.4	6,333
S267	NM348	West Bluff Nest 1 Well 2	12	3	6/23/1997	nd	nd	na	6	-9.20	32.3	0.3	9,071
S268	NM349	West Bluff Nest 1 Well 3	12	na	6/24/1997	nd	nd	na	1	nd	nd	nd	nd
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	11.5	0.5	M	4	-8.40	63.5	0.5	3,647
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	28.2	0.9	M	4	nd	nd	nd	nd
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	9.0	0.4	M	261	nd	nd	nd	nd
S275	NM178	Yale 1	12	na	6/19/1996	0.59	0.01	L	161	-9.90	39.2	0.4	7,531
SXXX	NM045	Geoprobe #1 (45.3')	12	na	7/1/1996	nd	nd	na	2,633	nd	nd	nd	nd
SXXX	NM046	Geoprobe #1 (40.8')	12	na	7/1/1996	nd	nd	na	2,734	nd	nd	nd	nd
SXXX	NM047	Geoprobe #1 (35.8')	12	na	7/1/1996	nd	nd	na	2,587	nd	nd	nd	nd
SXXX	NM048	Geoprobe #1 (30.5')	12	na	7/1/1996	nd	nd	na	831	nd	nd	nd	nd
SXXX	NM049	Geoprobe #1 (25')	12	na	7/1/1996	nd	nd	na	34	nd	nd	nd	nd
SXXX	NM050	Geoprobe #1 (20.2')	12	na	7/1/1996	nd	nd	na	26	nd	nd	nd	nd
SXXX	NM051	Geoprobe #2 (40.5')	12	na	7/1/1996	nd	nd	na	9	nd	nd	nd	nd
SXXX	NM052	Geoprobe #2 (35.3')	12	na	7/1/1996	nd	nd	na	6	nd	nd	nd	nd
SXXX	NM053	Geoprobe #2 (30.2')	12	na	7/1/1996	nd	nd	na	17	nd	nd	nd	nd
SXXX	NM054	Geoprobe #2 (23.4')	12	na	7/1/1996	nd	nd	na	5	nd	nd	nd	nd
		Zone 13: Discharge											
S143	NM096	Private Production Well #05	13	na	8/19/1996	nd	nd	na	1	-7.33	7.46	0.1	20,850
S194	NM327	Domestic Well #32	13	na	6/30/1997	1.16	0.0	L	6	-7.00	10.8	0.1	17,863
S226	NM150	Domestic Well #15	13	na	8/19/1996	nd	nd	na	2	-5.33	11.6	0.2	17,290

Table A11. Summary of Tritium, CFC-12, ^{13}C, and ^{14}C data for wells and springs-- Continued

Site no.	Sample no.	Site name	Primary hydro-chemical zone	Second-ary hydro-chemical zone	Date	Tritium (TU)	Tritium error ± 1 σ (TU)	Source of tritium data L or M	CFC-12 (pg/kg)	$\delta^{13}C$ (per mil)	^{14}C (pmC)	^{14}C error (pmC)	Unadjusted ^{14}C age, Libby half-life (years)
		No Zone: Exotic Water											
S009	NM485	Arroyo Salado Spring	E	E	8/6/1998	2.6	0.3	M	nd	1.79	7.64	0.2	20,659
S023	NM010	Burn Site Well	E	E	6/25/1996	0.74	0.01	L	68,206	-7.70	49.6	0.4	5,639
S028	NM014	Cerro Colorado Landfill MW	E	E	8/12/1996	nd	nd	na	37	2.00	1.59	0.1	33,268
S038	NM265	Windmill #19	E	E	7/1/1997	-0.1	0.3	M	nd	-10.90	6.68	0.1	21,738
S054	NM041	Domestic Well #04	E	E	8/17/1996	nd	nd	na	0	-7.55	29.3	0.3	9,867
S057	NM241	Embudo Spring	E	E	5/27/1997	9.9	0.5	M	269	nd	nd	nd	nd
S057	NM365	Embudo Spring	E	E	7/17/1997	10.1	0.5	M	nd	nd	nd	nd	nd
S057	NM044	Embudo Spring	E	E	7/2/1996	10.76	0.22	L	219	-13.2	111.	1.1	-840
S057	NM228	Embudo Spring	E	E	4/29/1997	10.8	0.5	M	nd	nd	nd	nd	nd
S057	NM215	Embudo Spring	E	E	3/21/1997	nd	nd	na	309	nd	nd	nd	nd
S063	NM282	Windmill #22	E	E	6/28/1997	0.2	0.2	M	nd	-5.60	46.4	0.5	6,177
S067	NM284	Granite Hill	E	E	7/4/1997	nd	nd	na	52	-7.90	34.5	0.3	8,549
S070	NM059	HERTF	E	E	6/28/1996	0.31	0.01	L	1,014	-7.50	40.6	0.4	7,239
S091	NM496	Private Production Well #23	E	E	8/4/1998	12.97	0.26	L	33	-10.2	93.8	0.7	515
S094	NM293	Stock Well #02	E	E	6/20/1997	nd	nd	na	173	-5.50	79.3	0.6	1,866
S099	NM072	LALF-1	E	E	6/29/1996	16.1	0.7	M	77,578	nd	nd	nd	nd
S112	NM297	Domestic Well #24	E	E	6/21/1997	nd	nd	na	5	-7.20	13.6	0.1	16,038
S129	NM087	Montaňo 4 S	E	E	6/19/1996	14.0	0.6	M	809	nd	nd	nd	nd
S152	NM098	Private Production Well #07	E	E	8/22/1996	0.1	0.3	M	18	-6.11	62.7	0.6	3,745
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	15.75	0.32	L	22	nd	nd	nd	nd
S202	NM330	Windmill #27	E	E	7/2/1997	6.4	0.4	M	nd	-4.70	47.2	0.4	6,036
S211	NM512	Sandia M	E	E	7/30/1998	nd	nd	na	4	-8.20	10.4	0.1	18,158
S225	NM149	SBM-1	E	E	6/29/1996	17.83	0.40	L	71	nd	nd	nd	nd
S249	NM163	Private Production Well #09	E	E	6/26/1996	10.6	0.5	M	886	nd	nd	nd	nd
S249	NM164	Private Production Well #09	E	E	6/26/1996	nd	nd	na	nd	-11.0	51.3	0.4	5,360
S250	NM165	Private Production Well #10	E	E	6/26/1996	0.93	0.03	L	137	nd	nd	nd	nd
S251	NM166	Private Production Well #11	E	E	6/26/1996	9.62	0.19	L	1,094	nd	nd	nd	nd
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	12.16	0.24	L	240	-11.3	92.6	0.8	622
S256	NM170	Tunnel Spring 2	E	E	6/18/1996	nd	nd	na	217	nd	nd	nd	nd
S258	NM524	Vallecito Springs	E	E	8/4/1998	-0.5	0.3	M	nd	-10.1	43.4	0.3	6,713
S273	NM176	Windmill #11	E	E	8/19/1996	0.8	0.3	M	nd	-3.99	36.5	0.3	8,100
S282	NM529	Windmill #44	E	E	7/29/1998	0.0	0.3	M	nd	-8.47	51.6	0.4	5,323
SXXX	NM065	Jemez Spring	E	E	8/20/1996	nd	nd	na	4	nd	nd	nd	nd
SXXX	NM154	Soda Dam Spring	E	E	8/20/1996	nd	nd	na	33	nd	nd	nd	nd

Table A12. Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^3H/^3He$ Age

[Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; δ^3He, helium-3; $\delta^3He=(R_s/R_{air} - 1)100$; $R= {}^3He/{}^4He$; R_s, $^3He/^4He$ of sample; ^4He, helium; TU, Tritium Unit, 1 TU=1 atom of ^3H in 10^{18} atoms of H; ^4He, Helium-4; Ne, Neon; ccSTP/g, cubic centimeters at standard temperature and pressure per gram; Δ, percent difference from concentration at solubility equilibrium; Uncorrected age, age not corrected for terrigenic He; Corrected age, age corrected for terrigenic helium assuming $R(terrigenic)=2x10^{-8}$ nd, not determined; Note- Calculated age applies to the young fraction in mixtures. Tritium by helium-3 ingrowth from Lamont-Doherty Earth Observatory, except for values in parentheses which are from the USGS Low-Level Tritium Laboratory by liquid-scintillation counting on enriched samples.]

Site no.	Sample no.	Site name	Primary hydro-chem-ical zone	Second-ary hydro-chem-ical zone	Date	Tritium (TU)	Tritium error (TU)	δ^3He (percent)	δ^3He error (percent)	$^3He/^4He$ ratio $x10^{-6}$	$^3He/^4He$ ratio error (percent)	^4He (ccSTP/g)	^4He error (ccSTP/g)	Ne (ccSTP/g)	Ne error (ccSTP/g)	Δ^4He (percent)	ΔNe (percent)	Uncor-rected age (years)	Uncor-rected age error (years)	Cor-rected age (years)	Cor-rected age error (years)
		Zone 2: Northwestern																			
S105	NM499	Lincoln S	2	na	7/23/1998	0.01	0.05	-15.9	0.24	1.164	0.47	4.875E-08	2.574E-10	1.686E-07	6.169E-10	33.2	11.8	nd	nd	nd	nd
		Zone 3: West Central																			
S006	NM484	98th St. S	3	na	8/5/1998	0.06	0.04	-33.9	0.35	0.914	0.53	9.705E-08	1.883E-10	1.792E-07	6.740E-10	166.	20.4	nd	nd	nd	nd
S066	NM056	Gonzales 1 (11/20/1997)	3	12	11/20/1997	2.66	0.17	-35.2	0.15	0.898	0.43	5.035E-07	5.135E-10	1.865E-07	2.469E-10	1,220.	14.7	nd	nd	nd	nd
S174	NM109	Rio Bravo 1 D	3	12	6/17/1996	0.00	0.01	-32.2	nd	0.938	nd	6.875E-06	nd	1.980E-07	nd	17,930.	21.8	nd	nd	nd	nd
S175	NM110	Rio Bravo 1 M	3	12	6/17/1996	0.01	0.02	-17.9	1.00	1.137	1.08	4.889E-06	9.778E-08	1.883E-07	1.883E-09	12,721.	15.8	nd	nd	nd	nd
		Zone 7: Abo Arroyo																			
S021	NM261	Stock Well #01	7	na	6/23/1997	11.77	0.23	50.7	0.34	2.086	0.52	6.243E-08	8.803E-11	2.367E-07	1.413E-09	63.7	45.6	16.6	0.3	17.6	0.2
		Zone 8: Eastern Mountain Front																			
S007	NM002	Domestic Well #01	8	na	6/21/1996	10.57	0.18	-10.0	1.00	1.245	1.08	9.362E-08	1.872E-09	3.671E-07	7.341E-09	146.	126.	nd	nd	nd	nd
S030	NM016	Charles 4	8	na	6/22/1996	0.03	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S030	NM019	Charles 4	8	na	6/27/1996	0.01	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S030	NM021	Charles 4	8	na	6/27/1996	0.01	0.01	-31.7	nd	0.945	nd	1.768E-06	nd	1.826E-07	nd	4,536.	12.3	nd	nd	nd	nd
S030	NM023	Charles 4	8	na	6/27/1996	0.01	0.01	-34.0	nd	0.913	nd	1.390E-06	nd	1.831E-07	nd	3,544.	12.6	nd	nd	nd	nd
S030	NM024	Charles 4	8	na	6/27/1996	0.01	0.01	-32.4	nd	0.936	nd	6.683E-07	nd	1.776E-07	nd	1,653.	9.20	nd	nd	nd	nd
S055	NM042	Elena Gallegos	8	na	6/25/1996	nd	nd	nd	nd	nd	nd	8.111E-08	3.658E-10	1.677E-07	8.082E-10	113.	3.15	nd	nd	nd	nd
S056	NM043	Embudito Spring	8	na	7/2/1996	7.82	0.16	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S071	NM060	Domestic Well #07	8	na	6/19/1996	0.19	0.01	2.06	0.23	1.413	0.46	5.629E-08	1.013E-10	2.282E-07	1.266E-09	47.6	40.3	33.1	1.0	25.8	4.9
S095	NM068	Kirtland 1	8	na	6/25/1996	0.05	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S106	NM295	Domestic Well #23	8	na	6/26/1997	-0.01	0.04	-37.1	nd	0.871	nd	3.311E-06	nd	1.853E-07	nd	8,583.	14.0	nd	nd	nd	nd
S110	NM078	Love 1	8	na	6/22/1996	0.05	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S116	NM502	Matheson S	8	na	8/1/1998	0.01	0.05	-8.82	0.35	1.262	0.53	6.762E-08	1.467E-10	2.111E-07	8.050E-10	85.5	40.5	nd	nd	nd	nd
S117	NM298	Domestic Well #25	8	na	6/17/1997	0.22	0.03	-0.10	0.36	1.383	0.54	6.433E-08	8.877E-11	2.639E-07	1.583E-09	68.7	62.3	16.6	4.2	nd	nd
S122	NM505	Mesa Del Sol S	8	na	7/25/1998	0.02	0.05	-97.1	0.33	0.040	0.52	1.837E-06	4.041E-09	1.780E-07	6.673E-10	4,930.	19.6	nd	nd	nd	nd
S164	NM106	Ponderosa 1	8	na	6/20/1996	0.03	0.01	-31.5	2.70	0.948	2.73	1.164E-05	9.229E-07	2.039E-07	1.129E-09	30,421.	25.4	nd	nd	nd	nd
S170	NM108	Ridgecrest 3 (^3H, 11/18/97)	8	na	6/22/1996	(0.0)	(0.3)	nd	nd	nd	nd	1.330E-06	nd	1.835E-07	nd	3,388.	12.8	nd	nd	nd	nd
S212	NM141	Sandia Peak 1	8	na	6/26/1996	0.02	0.01	-22.7	nd	1.070	nd	6.205E-08	nd	2.272E-07	nd	72.3	48.0	nd	nd	nd	nd
S213	NM142	Sandia Peak 3	8	na	6/26/1996	0.02	0.01	-5.97	0.32	1.301	0.51	5.734E-08	2.351E-10	2.190E-07	6.629E-10	50.4	34.7	nd	nd	nd	nd
S229	NM515	SH03 UNM	8	na	7/28/1998	8.28	0.17	10.1	0.35	1.524	0.53	4.927E-08	9.754E-11	2.047E-07	6.718E-10	35.8	34.3	5.7	0.2	4.3	0.3
S240	NM157	Domestic Well #18	8	na	6/19/1996	0.01	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S248	NM162	Thomas 6	8	na	6/21/1996	0.02	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S264	NM174	Walker 1	8	na	6/18/1996	(-0.4)	(0.3)	nd	nd	nd	nd	7.495E-06	1.499E-07	1.997E-07	1.997E-09	19,556.	22.8	nd	nd	nd	nd
		Zone 9: Tijeras Fault Zone																			
S041	NM029	Coyote Spring	9	na	6/28/1996	0.29	0.03	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S098	NM071	KAFB-1902	9	na	6/28/1996	2.69	0.05	nd	nd	nd	nd	nd	nd	1.820E-07	7.457E-10	nd	11.9	nd	nd	nd	nd
		Zone 10: Tijeras Arroyo																			
S001	NM001	4Hills-1	10	8	6/29/1996	3.95	0.08	-4.76	0.39	1.318	0.56	5.574E-08	1.945E-10	2.120E-07	6.189E-10	46.2	30.4	-6.1	0.8	2.6	0.8
S001	NM001	4Hills-1	10	8	6/29/1996	3.95	0.08	-5.17	0.27	1.312	0.48	5.715E-08	1.137E-10	2.209E-07	1.081E-09	49.9	35.8	-7.2	0.8	-0.8	0.9
S058	NM277	Eubank 1	10	8	7/4/1997	(1.7)	(0.4)	-4.41	nd	1.323	nd	4.233E-08	nd	1.691E-07	nd	11.0	3.99	-9.4	3.3	5.2	1.3
S096	NM069	Kirtland 11	10	8	6/25/1996	0.04	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
		Zone 12: Central																			
S011	NM004	Atris-1	12	na	6/22/1996	11.01	0.22	10.8	0.48	1.534	0.62	3.929E-08	7.779E-11	1.757E-07	5.909E-10	3.04	8.07	4.0	0.2	2.0	0.2
S012	NM005	Atrisco 3	12	3	6/20/1996	9.65	0.20	-7.16	1.00	1.285	1.08	7.419E-07	1.484E-08	1.763E-07	1.763E-09	1,846.	8.44	nd	nd	nd	nd

Table A12. Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^3H/^3He$ Age-- Continued

Site no.	Sample no.	Site name	Primary hydro-chem-ical zone	Second-ary hydro-chem-ical zone	Date	Tritium (TU)	Tritium error (TU)	δ^3He (percent)	δ^3He error (percent)	$^3He/^4He$ ratio x10^{-6}	$^3He/^4He$ ratio error (percent)	^4He (ccSTP/g)	^4He error (ccSTP/g)	Ne (ccSTP/g)	Ne error (ccSTP/g)	Δ^4He (percent)	ΔNe (percent)	Uncor-rected age (years)	Uncor-rected age error (years)	Cor-rected age (years)	Cor-rected age error (years)
S025	NM012	Burton 2	12	na	6/19/1996	0.08	0.01	-28.8	3.61	0.986	3.63	2.763E-07	2.873E-08	3.305E-07	1.829E-09	625.	103.	nd	nd	nd	nd
S026	NM013	Burton 5	12	na	6/19/1996	0.01	0.01	-31.0	3.62	0.955	3.64	8.251E-07	1.139E-07	1.905E-07	1.053E-09	2,064.	17.2	nd	nd	nd	nd
S026	NM013	Burton 5	12	na	6/19/1996	0.01	0.01	nd	nd	nd	nd	nd	nd	2.045E-07	1.136E-09	nd	25.8	nd	nd	nd	nd
S040	NM028	Coronado 1	12	na	6/18/1996	0.03	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S045	NM490	Del Sol S	12	na	7/21/1998	0.18	0.04	-29.9	0.30	0.970	0.50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S046	NM032	Duranes 1	12	na	6/20/1996	11.90	0.30	nd	nd	nd	nd	9.225E-08	2.168E-10	nd	nd	142.	nd	nd	nd	nd	nd
S046	NM034	Duranes 1	12	na	6/29/1996	17.06	0.34	201.	0.22	4.163	0.46	4.640E-08	2.111E-10	1.817E-07	8.814E-10	21.7	11.8	25.1	0.3	25.5	0.3
S046	NM035	Duranes 1	12	na	6/29/1996	17.06	0.34	202.	0.22	4.176	0.46	4.662E-08	2.135E-10	1.823E-07	8.836E-10	22.3	12.1	25.3	0.3	25.6	0.3
S047	NM270	Duranes 7	12	na	6/26/1997	8.38	0.17	30.4	0.35	1.805	0.53	8.477E-08	1.882E-10	1.773E-07	7.845E-10	122.	9.05	18.2	0.3	30.7	0.3
S048	NM271	Duranes Yard 1	12	na	7/5/1997	15.42	0.18	101.	0.35	2.781	0.53	4.041E-08	5.414E-11	1.718E-07	1.037E-09	5.96	5.68	16.4	0.2	16.5	0.1
S049	NM272	Duranes Yard 2	12	na	7/5/1997	7.94	0.16	5.08	0.42	1.454	0.58	3.958E-08	4.631E-11	1.678E-07	7.692E-10	3.79	3.17	3.1	0.1	4.1	0.2
S050	NM273	Duranes Yard 3	12	na	7/5/1997	8.15	0.16	0.66	0.38	1.393	0.55	3.889E-08	5.250E-11	1.622E-07	9.709E-10	1.99	-0.26	1.1	0.2	2.1	0.4
S051	NM274	Duranes Yard 4	12	na	7/5/1997	8.19	0.16	0.15	0.37	1.386	0.54	4.109E-08	5.506E-11	1.773E-07	1.058E-09	7.75	9.04	0.9	0.2	1.3	0.4
S052	NM275	Duranes Yard 5	12	na	7/5/1997	(9.4)	(0.4)	-2.12	0.45	1.355	0.60	3.990E-08	8.578E-11	1.750E-07	7.739E-10	4.64	7.62	-0.2	0.2	-1.0	0.3
S061	NM280	Garfield M	12	na	6/19/1997	0.03	0.14	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S062	NM281	Garfield S	12	na	6/19/1997	8.89	0.18	4.49	0.37	1.446	0.54	4.177E-08	6.140E-11	1.757E-07	1.052E-09	9.53	8.04	2.7	0.2	2.5	0.4
S062	NM491	Garfield S	12	na	7/28/1998	9.18	0.12	3.34	0.37	1.430	0.54	4.373E-08	8.965E-11	1.830E-07	6.900E-10	16.3	16.5	2.1	0.2	0.8	0.3
S068	NM057	Griegos 3	12	na	6/21/1996	13.30	0.27	95.8	0.22	2.710	0.46	8.119E-08	1.405E-10	1.924E-07	1.067E-09	113.	18.3	26.1	0.0	31.2	0.2
S078	NM289	Hunter Ridge Nest 2 Well 1	12	na	6/21/1997	0.08	0.04	9.49	0.35	1.515	0.53	6.073E-08	7.105E-11	2.224E-07	1.021E-09	59.3	36.8	nd	nd	nd	nd
S079	NM290	Hunter Ridge Nest 2 Well 2	12	na	6/21/1997	-0.10	0.18	10.5	0.37	1.530	0.54	4.307E-08	9.389E-11	1.802E-07	7.951E-10	13.0	10.8	nd	nd	nd	nd
S080	NM291	Hunter Ridge Nest 2 Well 3	12	na	6/21/1997	-0.01	0.03	6.16	0.34	1.469	0.52	1.251E-07	2.752E-10	4.475E-07	1.985E-09	228.	175.	nd	nd	nd	nd
S089	NM495	Isleta S	12	na	7/29/1998	19.94	0.40	268.	0.32	5.098	0.51	4.296E-08	8.377E-11	1.795E-07	6.763E-10	13.8	13.6	25.9	0.3	25.8	0.1
S092	NM066	JMC-1	12	na	6/28/1996	10.32	0.21	11.7	0.48	1.546	0.62	4.280E-08	1.143E-10	1.788E-07	3.141E-10	12.3	9.99	4.8	0.2	4.8	0.2
S097	NM070	Kirtland 14	12	na	6/25/1996	0.02	0.01	-34.6	nd	0.905	nd	9.503E-07	nd	1.832E-07	nd	2,392.	12.7	nd	nd	nd	nd
S100	NM073	LALF-9	12	na	6/29/1996	0.19	0.01	194.	0.17	4.072	0.43	4.431E-08	1.010E-10	1.848E-07	3.931E-10	16.2	13.7	nd	nd	nd	nd
S102	NM074	Leyendecker 1	12	na	6/21/1996	0.12	0.08	-7.19	nd	1.284	nd	5.060E-08	nd	1.898E-07	nd	32.7	16.8	nd	nd	38.2	nd
S123	NM081	MONT - 5A	12	na	6/27/1996	7.56	0.15	83.0	0.21	2.533	0.45	4.624E-08	2.173E-10	1.868E-07	9.059E-10	21.3	14.9	24.2	0.1	24.6	0.2
S124	NM082	Montaño 2 D	12	na	6/19/1996	19.48	0.21	229.	0.23	4.554	0.46	4.747E-08	5.981E-11	1.979E-07	5.131E-10	24.5	21.7	25.4	0.3	25.3	0.3
S125	NM083	Montaño 2 M	12	na	6/19/1996	25.50	0.51	221.	0.23	4.447	0.46	4.613E-08	7.796E-11	1.980E-07	1.096E-09	21.0	21.8	21.1	0.3	20.8	0.3
S126	NM084	Montaño 2 S	12	na	6/19/1996	4.73	0.10	8.15	nd	1.497	nd	4.349E-08	7.394E-11	1.816E-07	1.009E-09	14.1	11.7	7.2	nd	7.1	nd
S127	NM085	Montaño 4 D	12	na	6/20/1996	13.51	0.27	187.	1.00	3.969	1.08	4.572E-08	9.144E-10	1.915E-07	1.915E-09	19.9	17.8	27.1	0.4	27.0	0.5
S128	NM086	Montaño 4 M	12	na	6/19/1996	19.59	0.39	114.	1.00	2.960	1.08	4.912E-08	9.824E-10	2.053E-07	2.053E-09	28.8	26.3	17.2	0.3	16.9	0.4
S130	NM088	Montaño 5 D	12	na	6/24/1996	11.02	0.22	12.2	0.29	1.553	0.49	3.926E-08	1.398E-10	1.698E-07	6.482E-10	2.97	4.43	4.4	0.1	3.7	0.2
S131	NM089	Montaño 5 M	12	na	6/24/1996	9.92	0.20	-0.96	0.56	1.371	0.69	4.012E-08	8.265E-11	1.763E-07	5.928E-10	5.22	8.42	0.3	0.2	-1.7	0.3
S132	NM090	Montaño 5 S	12	na	6/24/1996	19.48	0.39	-5.22	nd	1.332	nd	3.742E-08	1.400E-10	1.533E-07	5.900E-08	-1.86	-5.75	-0.7	nd	0.3	nd
S133	NM091	Montaño 6 D	12	na	6/18/1996	0.01	0.01	-23.1	nd	1.064	nd	6.268E-08	nd	1.885E-07	nd	64.4	16.0	nd	nd	nd	nd
S134	NM092	Montaño 6 MD	12	na	6/18/1996	0.02	0.01	-6.73	0.24	1.291	0.47	5.274E-08	1.139E-10	1.822E-07	1.009E-09	38.3	12.1	nd	nd	nd	nd
S135	NM093	Montaño 6 MS	12	na	6/18/1996	2.03	0.04	84.6	0.23	2.555	0.46	4.083E-08	7.757E-11	1.391E-07	7.741E-10	7.09	-14.4	42.4	0.1	46.3	0.2
S136	NM094	Montaño 6 S	12	na	6/18/1996	15.21	0.30	52.1	0.24	2.105	0.47	4.167E-08	1.921E-10	1.774E-07	7.266E-10	9.28	9.12	10.7	0.1	10.5	0.1
S138	NM507	Montesa S	12	na	7/27/1998	0.03	0.05	nd	nd	nd	nd	2.944E-07	1.563E-09	3.657E-07	1.326E-09	694.	140.	nd	nd	nd	nd
S151	NM508	Nor Este S	12	na	7/20/1998	-0.02	0.05	-22.7	0.31	1.070	0.51	3.144E-07	6.319E-10	3.745E-07	1.402E-09	760.	149.	nd	nd	nd	nd
S153	NM411	Open Space	12	na	11/18/1997	-0.04	0.14	nd	nd	nd	nd	5.382E-08	6.404E-11	1.922E-07	3.084E-10	nd	nd	nd	nd	nd	nd
S154	NM099	ORLF-2	12	na	6/27/1996	11.42	0.26	5.08	0.29	1.454	0.49	3.958E-08	1.587E-10	1.702E-07	6.494E-10	3.79	4.65	2.2	0.1	1.6	0.2
S155	NM316	Domestic Well #29	12	na	6/27/1997	0.12	0.06	9.08	0.50	1.510	0.64	4.215E-08	8.431E-10	1.756E-07	3.513E-09	10.6	8.01	nd	nd	nd	nd
S156	NM100	Paseo 2D	12	na	6/26/1996	1.78	0.04	48.0	0.21	2.048	0.45	3.894E-08	1.791E-10	1.645E-07	7.979E-10	2.12	1.17	35.0	0.1	35.2	0.3
S157	NM101	Paseo 2MD	12	na	6/26/1996	15.09	0.30	120.	0.25	3.045	0.47	4.151E-08	1.270E-10	1.775E-07	6.346E-10	8.85	9.19	19.0	0.2	18.8	0.3
S158	NM102	Paseo 2MS	12	na	6/26/1996	11.09	0.22	11.7	0.24	1.546	0.47	4.097E-08	1.893E-10	1.752E-07	7.181E-10	7.43	7.76	4.3	0.1	3.8	0.2
S159	NM103	Paseo 2S	12	na	6/26/1996	10.72	0.21	2.62	0.22	1.420	0.46	5.115E-08	2.292E-10	2.083E-07	1.001E-09	34.2	28.1	1.8	0.1	1.6	0.3
S160	NM104	Paseo 3D	12	na	6/21/1996	0.15	0.01	-5.47	nd	1.308	nd	4.088E-08	nd	1.829E-07	nd	7.22	12.5	nd	nd	nd	nd
S161	NM105	Paseo 3M	12	na	6/21/1996	10.67	0.21	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S173	NM323	Rio Bravo 5 M	12	3	7/4/1997	13.14	0.30	57.0	0.35	2.173	0.53	4.459E-08	5.573E-11	1.753E-07	8.052E-10	16.9	7.78	13.3	0.2	14.3	0.3
S176	NM111	Rio Bravo 1 S	12	na	6/17/1996	11.34	0.23	9.87	1.00	1.521	1.08	4.422E-08	8.845E-10	1.785E-07	1.785E-09	16.0	9.80	4.0	0.3	5.0	0.5
S177	NM112	Rio Bravo 2 D	12	3	6/25/1996	15.69	0.30	-14.8	1.00	1.179	1.08	6.157E-07	1.231E-08	1.910E-07	1.910E-09	1,515.	17.5	nd	nd	nd	nd

Table A12. Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^3H/^3He$ Age-- Continued

Site no.	Sample no.	Site name	Primary hydro-chem-ical zone	Second-ary hydro-chem-ical zone	Date	Tritium (TU)	Tritium error (TU)	δ^3He (percent)	δ^3He error (percent)	$^3He/^4He$ ratio $x10^{-6}$	$^3He/^4He$ ratio error (percent)	^4He (ccSTP/g)	^4He error (ccSTP/g)	Ne (ccSTP/g)	Ne error (ccSTP/g)	Δ^4He (percent)	ΔNe (percent)	Uncor-rected age (years)	Uncor-rected age error (years)	Cor-rected age (years)	Cor-rected age error (years)
S178	NM113	Rio Bravo 2 M	12	na	6/25/1996	13.50	0.27	-23.1	1.00	1.064	1.08	1.206E-06	2.412E-08	1.934E-07	1.934E-09	3,063.	19.0	nd	nd	nd	nd
S179	NM114	Rio Bravo 2 S	12	na	6/25/1996	13.58	0.27	-10.4	0.26	1.240	0.48	2.146E-07	7.791E-10	2.006E-07	7.674E-10	463.	23.4	nd	nd	34.3	0.3
S180	NM115	Rio Bravo 4 D	12	na	6/25/1996	0.02	0.01	-22.5	0.80	1.073	0.89	8.055E-07	2.376E-09	1.816E-07	6.292E-10	2,012.	11.7	nd	nd	nd	nd
S181	NM116	Rio Bravo 4 M	12	na	6/25/1996	7.86	0.16	2.07	1.00	1.413	1.08	2.472E-07	4.943E-09	1.607E-07	1.607E-09	548.	-1.16	6.2	2.2	49.7	0.5
S208	NM140	San Jose 2	12	3	6/20/1996	(3.1)	(0.4)	nd	nd	nd	nd	1.210E-06	2.419E-08	1.884E-07	1.884E-09	3,073.	15.9	nd	nd	nd	nd
S214	NM513	Sandia S	12	na	7/30/1998	0.07	0.06	-40.0	0.22	0.831	0.46	2.093E-06	2.470E-09	2.080E-07	3.411E-10	5,577.	35.5	nd	nd	nd	nd
S220	NM147	Santa Barbara 1 (6/26/97)	12	na	6/26/1997	0.63	0.13	-1.58	0.31	1.362	0.51	6.050E-08	7.078E-11	1.761E-07	2.827E-10	58.7	8.33	nd	nd	52.0	2.0
S232	NM518	Sierra Vista S	12	na	7/22/1998	0.03	0.05	-4.50	0.36	1.322	0.54	4.901E-08	9.557E-11	1.790E-07	5.792E-10	31.6	15.8	nd	nd	nd	nd
S244	NM158	SWAB 3 - 760	12	na	7/1/1996	0.00	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	0.03	0.01	-9.43	nd	1.254	nd	3.985E-08	nd	1.824E-07	nd	4.5	12.2	nd	nd	nd	nd
S245	NM159	SWAB 3 - 980	12	na	7/1/1996	0.03	0.01	2.01	0.39	1.412	0.56	4.330E-08	1.533E-10	1.772E-07	5.177E-10	13.6	8.95	nd	nd	nd	nd
S245	NM160	SWAB 3 - 980	12	na	7/1/1996	0.04	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S257	NM344	Domestic Well #34	12	na	6/17/1997	15.22	0.19	-16.9	0.50	1.150	0.64	9.816E-07	1.963E-08	1.881E-07	3.762E-09	2,474.	15.7	nd	nd	nd	nd
S259	NM171	VGP-1	12	na	6/27/1996	28.56	0.57	260.	0.30	4.978	0.50	5.194E-08	1.844E-10	2.101E-07	8.008E-10	36.2	29.2	23.2	0.1	23.2	0.1
S261	NM172	Vol Andia 2	12	na	6/21/1996	0.25	0.03	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S262	NM173	Vol Andia 5	12	na	6/18/1996	1.26	0.03	15.8	0.21	1.602	0.45	4.571E-08	2.103E-10	1.756E-07	8.515E-10	19.9	7.98	26.9	0.2	32.6	0.4
S265	NM175	Webster 1	12	na	6/18/1996	0.01	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S269	NM350	West Bluff Nest 2 Well 1	12	na	6/24/1997	10.54	0.21	289.	0.50	5.379	0.64	4.953E-08	9.907E-10	1.914E-07	3.828E-09	29.9	17.7	38.5	0.5	38.9	0.7
S270	NM351	West Bluff Nest 2 Well 2	12	na	6/24/1997	27.84	0.56	394.	0.28	6.832	0.49	4.530E-08	1.826E-10	1.923E-07	7.231E-10	18.8	18.3	27.3	0.3	27.2	0.1
S271	NM352	West Bluff Nest 2 Well 3	12	na	6/24/1997	7.28	0.15	-0.51	0.31	1.377	0.51	4.906E-08	1.521E-10	2.112E-07	7.952E-10	28.7	29.9	0.6	0.2	-1.1	0.5
S275	NM178	Yale 1	12	na	6/19/1996	0.59	0.01	-30.6	nd	0.960	nd	2.206E-07	nd	2.598E-07	nd	479.	59.8	nd	nd	nd	nd
		Zone 13: Discharge																			
S194	NM327	Domestic Well #32	13	na	6/30/1997	1.16	0.04	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
		No Zone: Exotic Water																			
S023	NM010	Burn Site Well	E	E	6/25/1996	0.74	0.01	-42.5	0.22	0.796	0.46	8.669E-08	4.040E-10	1.867E-07	9.054E-10	127.	14.8	nd	nd	27.5	0.9
S057	NM044	Embudo Spring	E	E	7/2/1996	10.76	0.22	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S070	NM059	HERTF	E	E	6/28/1996	0.31	0.01	-58.6	1.00	0.572	1.08	1.093E-07	2.185E-09	2.167E-07	4.333E-09	187.	33.2	nd	nd	nd	nd
S091	NM496	Private Production Well #23	E	E	8/4/1998	12.97	0.26	-22.8	0.31	1.069	0.51	3.862E-07	8.304E-10	1.914E-07	7.250E-10	936.	20.9	nd	nd	nd	nd
S099	NM072	LALF-1	E	E	6/29/1996	(16.1)	(0.7)	nd	nd	nd	nd	3.872E-08	7.899E-11	1.665E-07	8.144E-10	1.55	2.40	nd	nd	nd	nd
S129	NM087	Montaño 4 S	E	E	6/19/1996	(14.0)	(0.6)	nd	nd	nd	nd	4.150E-08	1.880E-10	1.769E-07	8.536E-10	8.83	8.76	nd	nd	nd	nd
S182	NM117	Rio Bravo 4 S	E	E	6/25/1996	15.75	0.32	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
S225	NM149	SBM-1	E	E	6/29/1996	17.83	0.40	83.8	0.22	2.544	0.46	4.042E-08	1.851E-10	1.683E-07	6.894E-10	6.01	3.49	13.0	0.2	13.1	0.2
S249	NM163	Private Production Well #09	E	E	6/26/1996	(10.6)	(0.5)	nd	nd	nd	nd	6.333E-08	1.444E-10	1.687E-07	3.593E-10	66.1	3.81	nd	nd	nd	nd
S250	NM165	Private Production Well #10	E	E	6/26/1996	0.93	0.03	-84.8	nd	0.210	nd	3.676E-07	nd	2.231E-07	nd	921.	45.3	nd	nd	nd	nd
S251	NM166	Private Production Well #11	E	E	6/26/1996	9.62	0.19	-8.29	0.22	1.269	0.46	5.356E-08	2.437E-10	1.821E-07	8.733E-10	40.5	12.0	nd	nd	5.3	0.2
S256	NM169	Tunnel Spring 1	E	E	6/18/1996	12.16	0.24	-1.85	0.39	1.358	0.56	4.043E-08	5.499E-11	1.676E-07	7.375E-10	6.03	3.07	-0.1	0.1	0.6	0.2

Appendix B. Chemical and isotopic composition of surface water from the Middle Rio Grande Basin, June 1996 through March 1999, and stable isotopic composition of surface water and precipitation in archived samples from the 1980s

Table B1. Identification of surface-water sites from the Middle Rio Grande Basin and vicinity

[dms, degrees-minutes-seconds; Altitude, altitude of the land surface]

Site no.	Site name	Latitude[1] (dms)	Longitude[1] (dms)	Altitude (feet)
S290	Abo Arroyo at US 60	342647	1062946	5,730
S291	Alameda Drain at Alameda	351114	1063652	4,995
S292	Bear Canyon Arroyo	350902	1062729	6,640
S293	Canyon del Trigo Stream	344013	1062751	6,250
S294	Chamizal Lateral at Alameda	351125	1063718	4,995
S297	Jemez River below Jemez Canyon Dam	352324	1063203	5,100
S298	Jemez River at Jemez	353942	1064434	5,622
S299	Bear Canyon Arroyo (lower)	350859	1062745	6,640
S300	Rio Grande at Alameda	351150	1063829	4,995
S301	Rio Grande at Campbell	350724	1064124	4,960
S302	Rio Grande at Isleta Below Diversion	345420	1064115	5,905
S303	Rio Grande at Rio Bravo	350139	1064017	4,927
S304	Rio Grande at San Felipe	352640	1062624	5,116
S305	Rio Grande at Central	350548	1064124	4,946
S306	Rio Grande at Nature Center	350725	1064124	4,960
S307	Rio Puerco at Hwy 6	344746	1065925	5,010
S308	Riverside Drain at Alameda	351146	1063825	4,995
S309	Riverside Drain at Campbell	350723	1064114	4,960
S310	Riverside Drain at Rio Bravo	350139	1064009	4,927
S311	Stream in Monte Largo Canyon	343607	1062940	6,250
S312	Tijeras Arroyo at Four Hills	350339	1062941	5,550
S313	West Riverside drain at Rio Bravo	350138	1064627	4,927
S314	Rio Grande at Arroyo de la Baranca	351658	1063552	4,982

[1]Latitude and longitude are given in degrees-minutes-seconds. For example, 384531 is 38°45'31".

Table B2. Surface-water field parameters and major-element chemistry

[mm Hg, millimeters of mercury; Temp., field water temperature; °C, degrees Celsius; O_2, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 °C; Ca^{2+}, calcium; Mg^{2+}, magnesium, Na^+, sodium; K^+, potassium; Cl^-, chloride; Br^-, Bromide; SO_4^{2-}, sulfate; HCO_3^-, total titration alkalinity as bicarbonate; nd, not determined]

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)	Cl^- (mg/L)	Br^- (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^- (mg/L)
S290	NM194	Abo Arroyo at US 60	1/16/1997	625	0.4	8.2	11.4	2,100	305.	97.6	95.0	0.9	53.0	nd	68.7	132.6
S290	NM202	Abo Arroyo at US 60	3/12/1997	624	7.9	8.3	11.4	2,370	289.	112.	150.	2.0	68.6	0.49	65.2	129.9
S290	NM622	Abo Arroyo at US 60	10/8/1998	nd	nd	nd	nd	1,633	nd	nd	nd	nd	nd	nd	83.7	109.8
S290	NM621	Abo Arroyo at US 60	6/23/1998	nd	nd	nd	nd	1,914	nd	nd	nd	nd	nd	nd	71.0	145.2
S290	NM620	Abo Arroyo at US 60	2/3/1998	nd	nd	nd	nd	2,210	nd	nd	nd	nd	nd	nd	65.6	130.4
S291	NM428	Alameda Drain at Alameda	3/31/1998	633	8.0	8.5	9.3	351	38.6	6.90	22.3	3.3	9.7	0.06	70.6	174.6
S291	NM220	Alameda Drain at Alameda	4/22/1997	633	13.4	8.2	8.6	375	41.6	7.62	19.3	3.6	9.5	<0.05	86.4	113.0
S291	NM381	Alameda Drain at Alameda	10/21/1997	639	13.8	7.8	9.4	297	34.3	5.67	15.5	3.0	6.3	<0.05	64.8	178.8
S291	NM443	Alameda Drain at Alameda	5/5/1998	634	14.1	8.2	8.5	372	41.6	7.30	21.6	3.3	10.1	0.05	60.3	177.0
S291	NM457	Alameda Drain at Alameda	6/11/1998	636	15.3	8.1	7.6	318	36.2	6.52	16.7	2.8	6.3	<0.05	69.2	172.2
S291	NM548	Alameda Drain at Alameda	9/22/1998	637	18.4	8.2	nd	359	42.4	7.35	18.1	3.2	6.6	<0.05	138.	190.7
S291	NM366	Alameda Drain at Alameda	7/9/1997	637	20.8	8.0	7.7	341	37.3	6.80	19.2	3.2	6.9	<0.05	92.3	113.0
S291	NM370	Alameda Drain at Alameda	9/16/1997	636	21.0	8.5	8.0	342	40.5	6.66	16.8	3.2	8.0	<0.05	88.6	130.4
S291	NM534	Alameda Drain at Alameda	8/18/1998	638	22.0	8.3	6.5	367	43.2	7.27	19.9	3.4	7.3	<0.05	69.0	171.1
S291	NM471	Alameda Drain at Alameda	7/22/1998	637	24.2	8.4	6.7	355	40.2	7.24	20.1	3.7	9.8	<0.05	63.4	178.2
S292	NM406	Bear Canyon Arroyo	1/9/1998	597	4.3	8.2	9.0	487	70.9	14.7	12.6	2.2	5.4	<0.05	133.	239.9
S292	NM615	Bear Canyon Arroyo	4/2/1999	591	6.1	8.3	9.1	443	62.4	12.7	11.4	2.1	3.9	<0.1	47.5	139.4
S292	NM203	Bear Canyon Arroyo	3/19/1997	609	6.6	8.1	9.0	509	72.6	15.4	13.5	2.0	6.1	0.09	976.	254.4
S292	NM591	Bear Canyon Arroyo	1/5/1999	599	6.8	8.2	9.0	481	68.5	14.8	12.6	1.9	6.8	<0.1	143.	275.7
S292	NM421	Bear Canyon Arroyo	2/20/1998	594	6.9	8.3	8.8	449	66.0	13.4	11.8	1.8	4.6	0.06	1,122.	254.2
S292	NM602	Bear Canyon Arroyo	2/3/1999	598	7.0	8.3	9.3	462	65.1	13.9	12.4	1.8	4.5	<0.1	33.4	238.0
S292	NM435	Bear Canyon Arroyo	3/31/1998	595	7.5	8.4	9.4	322	45.1	9.31	8.7	1.9	3.6	<0.05	47.9	273.2
S292	NM436	Bear Canyon Arroyo	3/31/1998	597	8.1	8.5	9.5	322	44.9	8.55	8.7	1.9	3.6	0.07	57.6	157.2
S292	NM216	Bear Canyon Arroyo	4/23/1997	595	9.0	8.1	8.4	444	62.5	13.0	11.2	2.2	4.7	0.06	60.3	169.1
S292	NM229	Bear Canyon Arroyo	5/28/1997	603	9.0	8.3	8.7	388	53.4	10.1	9.8	1.8	3.6	<0.05	72.7	177.4
S292	NM397	Bear Canyon Arroyo	11/18/1997	603	9.9	8.1	7.1	561	81.5	17.0	14.7	2.1	5.4	<0.05	69.6	172.8
S292	NM579	Bear Canyon Arroyo	12/1/1998	602	10.5	8.1	7.6	533	75.1	16.5	14.4	2.0	5.8	<0.07	60.4	165.0
S292	NM450	Bear Canyon Arroyo	5/5/1998	598	11.6	8.4	8.8	333	46.0	8.29	8.4	2.0	2.8	<0.05	65.5	169.1
S292	NM388	Bear Canyon Arroyo	10/23/1997	596	11.9	7.3	6.1	593	89.5	17.3	14.9	1.9	5.6	0.06	56.4	162.7
S292	NM567	Bear Canyon Arroyo	10/23/1998	604	13.2	7.8	6.0	575	82.3	17.7	15.5	2.0	5.9	<0.05	64.2	155.4
S292	NM464	Bear Canyon Arroyo	6/11/1998	599	13.2	8.3	8.0	368	51.2	10.0	9.7	1.9	3.2	<0.05	63.0	153.1
S292	NM555	Bear Canyon Arroyo	9/29/1998	601	14.2	7.9	nd	590	85.0	17.7	16.2	1.9	5.8	0.10	58.1	161.5
S292	NM478	Bear Canyon Arroyo	7/23/1998	603	14.5	8.1	7.3	453	64.3	13.1	12.5	1.9	4.2	0.06	58.4	161.6
S292	NM354	Bear Canyon Arroyo	7/9/1997	600	14.9	7.6	6.9	463	64.2	13.4	13.4	1.7	4.6	<0.05	55.3	162.1
S292	NM377	Bear Canyon Arroyo	9/18/1997	600	15.0	7.8	6.5	596	93.8	17.7	14.9	1.8	5.5	0.08	69.4	175.4
S292	NM541	Bear Canyon Arroyo	8/18/1998	600	17.2	7.9	6.6	499	69.6	14.7	13.8	2.0	4.4	0.08	63.5	153.0
S293	NM244	Canyon del Trigo Stream	5/29/1997	nd	12.5	7.8	7.9	140	18.0	3.70	4.1	0.5	2.5	<0.05	50.4	129.4
S294	NM427	Chamizal Lateral at Alameda	3/31/1998	633	8.3	8.5	9.4	349	38.2	6.92	21.1	3.1	9.7	0.06	57.2	160.0

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	642	10.0	8.3	9.6	397	42.3	8.08	24.1	3.6	10.5	0.08	49.7	144.1
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	633	13.4	8.3	8.5	364	40.0	7.38	18.1	3.4	9.2	<0.05	47.3	147.4
S294	NM442	Chamizal Lateral at Alameda	5/5/1998	634	13.4	8.3	8.4	369	40.7	7.21	20.9	3.3	9.6	<0.05	128.	268.8
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	640	13.7	7.8	8.2	297	34.9	5.75	15.5	3.0	6.5	<0.05	49.3	146.9
S294	NM608	Chamizal Lateral at Alameda	3/30/1999	633	14.1	8.6	8.3	361	38.0	7.02	24.7	3.5	10.1	<0.1	50.0	132.4
S294	NM560	Chamizal Lateral at Alameda	10/20/1998	639	14.9	8.1	7.8	374	43.5	7.57	20.8	3.4	7.3	<0.05	42.8	103.6
S294	NM456	Chamizal Lateral at Alameda	6/11/1998	636	15.3	8.1	7.8	316	37.3	6.49	16.6	2.8	6.1	<0.05	26.9	208.0
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	637	15.7	8.2	7.3	340	37.7	6.64	18.0	2.8	7.6	<0.05	50.8	129.7
S294	NM547	Chamizal Lateral at Alameda	9/22/1998	637	19.0	8.5	nd	356	41.9	7.29	18.7	3.0	6.5	<0.05	50.0	132.1
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	637	19.8	7.8	7.1	338	36.4	6.70	19.2	3.1	6.9	<0.05	49.6	143.7
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	637	20.5	8.2	7.4	350	42.7	6.90	17.5	3.1	7.1	<0.05	52.6	133.8
S294	NM533	Chamizal Lateral at Alameda	8/18/1998	638	21.6	8.3	6.4	364	43.7	7.30	20.2	3.4	7.4	<0.05	42.5	102.8
S294	NM470	Chamizal Lateral at Alameda	7/22/1998	637	23.0	8.4	5.8	355	39.8	6.90	20.0	3.5	6.8	<0.05	48.5	123.3
S297	NM592	Jemez River below Jemez Canyon Dam	1/6/1999	637	3.5	8.5	10.4	958	64.5	8.49	119.	10.	115.	0.22	45.9	134.1
S297	NM603	Jemez River below Jemez Canyon Dam	2/3/1999	633	4.8	8.6	10.4	972	62.8	8.67	124.	10.	121.	0.27	41.0	115.9
S297	NM422	Jemez River below Jemez Canyon Dam	2/20/1998	624	8.0	8.7	10.6	1,072	63.0	8.62	137.	11.	132.	0.29	43.4	105.5
S297	NM580	Jemez River below Jemez Canyon Dam	12/3/1998	630	8.2	8.6	10.8	939	66.0	8.27	110.	9.3	110.	0.21	41.0	114.4
S297	NM437	Jemez River below Jemez Canyon Dam	4/7/1998	629	10.1	8.5	9.5	950	59.4	7.79	125.	10.	119.	0.22	50.6	136.9
S297	NM616	Jemez River below Jemez Canyon Dam	4/1/1999	624	11.8	8.7	8.2	1,098	65.2	9.27	147.	12.	137.	0.30	45.6	133.5
S297	NM451	Jemez River below Jemez Canyon Dam	5/7/1998	632	12.3	8.5	9.8	821	55.5	6.98	98.0	8.4	95.6	0.19	55.0	150.6
S297	NM568	Jemez River below Jemez Canyon Dam	10/27/1998	635	13.0	8.2	7.5	935	61.8	8.57	116.	9.7	103.	0.12	46.4	131.6
S297	NM465	Jemez River below Jemez Canyon Dam	6/12/1998	635	15.1	8.1	6.6	703	47.1	6.33	78.6	7.3	77.4	0.14	127.	251.0
S297	NM556	Jemez River below Jemez Canyon Dam	9/24/1998	634	16.3	8.1	nd	913	60.8	8.51	102.	9.1	97.6	0.23	34.3	249.7
S297	NM479	Jemez River below Jemez Canyon Dam	7/23/1998	635	18.5	7.9	6.0	839	56.0	7.65	97.1	8.5	89.1	0.17	16.3	60.0
S297	NM542	Jemez River below Jemez Canyon Dam	8/19/1998	635	19.3	8.0	6.2	825	56.7	7.37	94.5	8.3	88.5	0.18	12.8	69.1
S298	NM593	Jemez River at Jemez	1/6/1999	626	2.2	8.4	12.0	559	48.4	5.37	60.1	9.9	74.2	0.20	44.2	121.0
S298	NM604	Jemez River at Jemez	2/3/1999	620	3.0	8.6	11.1	635	49.0	5.48	67.8	12.	89.6	0.26	50.7	143.5
S298	NM617	Jemez River at Jemez	4/2/1999	613	6.2	8.5	10.9	318	31.2	3.09	27.9	5.1	32.5	0.10	44.7	125.3
S298	NM438	Jemez River at Jemez	4/7/1998	616	6.3	8.3	10.4	212	22.8	2.72	13.9	3.2	13.5	0.05	47.0	133.1
S298	NM581	Jemez River at Jemez	12/3/1998	618	6.3	8.4	11.0	400	38.3	4.18	37.9	6.4	41.9	0.10	50.2	140.8
S298	NM452	Jemez River at Jemez	5/7/1998	619	7.5	8.2	11.4	164	21.4	2.07	8.2	1.8	10.0	<0.05	47.1	136.3
S298	NM569	Jemez River at Jemez	10/27/1998	622	11.1	8.4	8.0	223	20.3	3.40	17.3	4.7	20.3	<0.05	50.5	143.2
S298	NM423	Jemez River at Jemez	2/20/1998	610	11.3	8.7	9.4	509	44.0	4.89	45.2	8.8	63.9	0.20	41.7	116.8
S298	NM557	Jemez River at Jemez	9/24/1998	622	13.7	8.4	nd	667	53.3	6.03	65.6	13.	90.4	0.26	49.3	146.2
S298	NM466	Jemez River at Jemez	6/12/1998	623	14.0	8.3	8.5	366	37.2	3.97	26.4	5.3	34.5	0.10	125.	166.5
S298	NM543	Jemez River at Jemez	8/19/1998	625	19.7	8.5	7.6	547	47.1	5.48	49.9	9.5	66.6	0.16	44.3	124.7
S298	NM480	Jemez River at Jemez	7/23/1998	624	20.3	8.5	7.9	579	49.7	5.92	52.7	10.	72.5	0.18	46.7	136.7
S300	NM187	Rio Grande at Alameda	1/14/1997	632	0.7	8.5	12.0	431	51.1	9.14	23.8	3.9	11.4	nd	135.	246.0
S300	NM583	Rio Grande at Alameda	1/5/1999	640	3.0	8.4	11.0	422	46.4	8.48	28.0	3.8	15.9	<0.1	46.9	141.3
S300	NM398	Rio Grande at Alameda	1/8/1998	634	3.2	8.2	10.6	376	40.8	6.70	25.9	3.4	15.3	<0.05	45.6	133.4
S300	NM195	Rio Grande at Alameda	2/11/1997	635	4.1	8.5	10.6	415	47.0	8.52	26.6	3.7	14.0	nd	43.8	336.0
S300	NM413	Rio Grande at Alameda	2/19/1998	637	5.7	8.5	10.4	368	41.6	7.00	24.2	3.3	13.1	<0.05	49.2	143.8

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S300	NM389	Rio Grande at Alameda	11/20/1997	635	7.0	8.6	9.7	300	33.3	5.81	17.2	2.8	7.1	<0.05	33.3	99.3
S300	NM594	Rio Grande at Alameda	2/2/1999	639	7.0	8.7	10.7	421	43.1	7.82	28.6	3.8	16.5	<0.1	137.	282.3
S300	NM571	Rio Grande at Alameda	12/1/1998	642	7.5	8.5	9.0	424	47.7	8.47	27.6	3.8	13.2	<0.07	50.3	158.2
S300	NM425	Rio Grande at Alameda	3/31/1998	633	8.0	8.6	9.2	350	33.1	6.22	27.3	3.2	14.6	<0.05	136.	268.3
S300	NM206	Rio Grande at Alameda	3/18/1997	642	8.6	8.6	9.5	437	41.0	7.87	35.6	4.1	22.2	0.10	33.1	98.9
S300	NM218	Rio Grande at Alameda	4/22/1997	632	12.0	8.6	8.6	396	37.4	6.58	27.0	4.0	20.6	0.06	43.7	130.3
S300	NM378	Rio Grande at Alameda	10/21/1997	639	12.5	8.0	7.9	240	28.2	4.80	11.9	2.3	4.1	<0.05	43.6	84.7
S300	NM558	Rio Grande at Alameda	10/20/1998	639	13.0	8.2	8.3	376	43.4	7.62	20.7	3.3	10.0	<0.05	38.4	125.4
S300	NM440	Rio Grande at Alameda	5/5/1998	634	13.4	8.2	8.5	351	36.9	6.53	22.2	3.2	12.1	0.06	43.6	336.4
S300	NM231	Rio Grande at Alameda	5/21/1997	636	15.5	8.2	8.0	296	35.6	2.16	16.5	0.5	8.0	<0.05	42.8	122.8
S300	NM454	Rio Grande at Alameda	6/11/1998	635	15.6	8.4	7.6	273	31.3	5.73	13.6	2.5	4.7	<0.05	40.1	126.2
S300	NM606	Rio Grande at Alameda	3/30/1999	634	16.0	8.6	8.2	420	39.0	7.02	37.5	4.3	22.5	<0.1	42.4	323.9
S300	NM545	Rio Grande at Alameda	9/22/1998	637	17.4	8.6	nd	323	38.6	6.77	15.8	2.6	5.3	<0.05	44.9	142.7
S300	NM123	Rio Grande at Alameda	6/22/1996	nd	19.9	7.8	6.4	372	43.6	6.62	22.2	3.9	6.3	<0.05	50.1	146.7
S300	NM367	Rio Grande at Alameda	9/16/1997	637	19.9	8.4	7.1	307	36.4	5.95	15.8	2.7	6.5	<0.05	32.5	96.7
S300	NM356	Rio Grande at Alameda	7/9/1997	637	20.7	8.2	7.0	293	31.5	5.90	17.0	3.0	5.7	<0.05	43.3	120.7
S300	NM531	Rio Grande at Alameda	8/18/1998	638	22.5	8.6	6.0	328	39.6	6.68	17.8	3.1	5.8	<0.05	37.8	123.1
S300	NM468	Rio Grande at Alameda	7/22/1998	637	25.1	8.6	6.5	322	36.6	6.54	17.9	3.2	5.5	<0.05	48.4	147.3
S300	NM118	Rio Grande at Alameda	6/29/1996	nd	26.6	8.5	7.8	355	43.9	6.50	18.9	3.6	7.3	0.17	48.9	145.5
S301	NM189	Rio Grande at Campbell	1/14/1997	632	0.4	8.5	11.6	418	49.0	9.03	25.3	3.7	10.8	nd	52.2	150.0
S301	NM585	Rio Grande at Campbell	1/5/1999	640	2.0	8.2	11.2	412	46.1	8.09	27.7	3.7	16.2	<0.1	12.4	187.3
S301	NM400	Rio Grande at Campbell	1/8/1998	634	2.5	8.7	11.1	372	39.1	6.50	25.9	3.2	16.2	0.06	50.0	148.1
S301	NM197	Rio Grande at Campbell	2/11/1997	635	4.8	8.5	10.9	399	44.8	8.22	25.5	3.6	13.7	nd	48.3	149.1
S301	NM415	Rio Grande at Campbell	2/19/1998	636	6.2	8.4	11.0	352	38.9	6.82	24.4	3.3	13.1	0.06	53.6	155.6
S301	NM573	Rio Grande at Campbell	12/1/1998	642	6.5	8.5	9.5	408	44.8	8.05	31.3	3.5	12.9	<0.07	151.	220.7
S301	NM391	Rio Grande at Campbell	11/20/1997	635	7.2	8.6	9.8	286	31.7	5.61	17.3	2.7	6.7	<0.05	40.0	276.3
S301	NM596	Rio Grande at Campbell	2/2/1999	639	7.5	8.7	10.2	409	41.2	7.39	28.8	3.9	16.8	<0.1	1,080.	267.8
S301	NM429	Rio Grande at Campbell	3/31/1998	633	8.2	8.7	8.9	352	34.2	6.30	26.8	3.2	14.9	0.06	47.1	146.6
S301	NM208	Rio Grande at Campbell	3/18/1997	nd	11.0	8.5	9.4	440	41.4	7.89	36.4	4.2	22.8	0.10	50.6	146.4
S301	NM382	Rio Grande at Campbell	10/21/1997	639	13.8	7.6	8.1	236	27.8	4.75	12.1	2.3	3.9	<0.05	141.	264.5
S301	NM444	Rio Grande at Campbell	5/5/1998	635	15.0	8.4	8.3	356	36.9	6.74	22.2	2.8	12.4	0.07	50.8	151.9
S301	NM221	Rio Grande at Campbell	4/22/1997	635	15.3	8.5	8.6	399	36.5	6.42	26.6	4.1	21.1	0.07	46.2	144.6
S301	NM233	Rio Grande at Campbell	5/21/1997	637	15.8	8.1	7.4	298	32.3	5.68	16.8	2.4	8.2	<0.05	49.0	145.6
S301	NM561	Rio Grande at Campbell	10/20/1998	639	15.9	8.3	7.7	344	39.6	6.92	19.2	3.1	8.0	<0.05	36.7	257.2
S301	NM458	Rio Grande at Campbell	6/11/1998	636	16.2	8.3	7.6	278	31.7	5.84	13.6	2.5	5.3	<0.05	46.7	146.4
S301	NM609	Rio Grande at Campbell	3/30/1999	633	16.4	8.5	8.0	429	38.8	7.11	38.7	4.2	23.8	<0.1	46.4	135.6
S301	NM549	Rio Grande at Campbell	9/22/1998	638	17.7	8.2	nd	324	38.5	6.79	15.4	2.6	5.3	<0.05	146.	229.8
S301	NM371	Rio Grande at Campbell	9/16/1997	637	22.3	8.3	7.1	302	35.1	5.79	15.1	2.7	6.6	<0.05	50.3	143.7
S301	NM358	Rio Grande at Campbell	7/9/1997	638	23.0	8.3	6.8	294	32.3	6.10	17.6	3.0	5.8	<0.05	48.4	154.6
S301	NM535	Rio Grande at Campbell	8/18/1998	638	23.1	8.3	6.2	333	39.4	6.70	17.5	3.0	6.0	<0.05	51.9	148.7
S301	NM472	Rio Grande at Campbell	7/22/1998	637	26.6	8.4	6.2	326	37.7	6.64	18.5	3.2	5.7	<0.05	48.9	154.6
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	nd	26.3	8.2	7.7	431	44.4	6.80	21.5	3.6	6.3	0.06	49.2	146.1

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	640	0.3	8.5	11.4	428	50.4	9.03	25.4	3.6	10.9	nd	49.2	145.0
S303	NM587	Rio Grande at Rio Bravo	1/5/1999	641	4.0	8.3	11.4	401	44.6	8.07	27.5	3.4	14.5	<0.1	52.2	149.6
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	634	4.5	8.7	10.9	369	38.8	6.55	26.0	3.1	15.8	0.06	140.	198.8
S303	NM598	Rio Grande at Rio Bravo	2/2/1999	638	8.0	8.5	10.3	427	42.2	7.51	31.6	3.8	19.5	<0.1	53.4	152.1
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	633	8.1	8.5	10.7	402	44.7	8.10	25.1	3.6	13.9	nd	47.5	135.1
S303	NM575	Rio Grande at Rio Bravo	12/1/1998	642	8.2	8.5	9.9	391	44.1	7.82	24.6	3.3	10.6	<0.07	51.3	131.5
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	635	8.5	8.4	9.8	294	33.0	5.77	17.5	2.8	6.9	<0.05	30.7	167.0
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	637	8.7	8.5	11.0	356	39.0	6.76	24.4	3.3	12.9	<0.05	7.8	96.5
S303	NM431	Rio Grande at Rio Bravo	3/31/1998	634	9.0	8.5	9.5	357	34.6	6.42	27.4	3.5	14.9	0.08	1,130.	305.4
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	nd	13.2	8.4	9.1	450	42.2	8.10	36.6	4.2	23.4	0.09	48.1	145.1
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	639	15.1	7.5	8.3	244	28.5	4.79	12.0	2.4	4.2	<0.05	29.9	166.1
S303	NM446	Rio Grande at Rio Bravo	5/5/1998	634	16.2	8.4	8.3	355	36.7	6.70	22.3	3.0	12.5	0.05	51.6	129.6
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	636	16.4	8.1	7.5	304	33.0	5.81	17.3	2.6	8.4	<0.05	48.7	147.9
S303	NM563	Rio Grande at Rio Bravo	10/20/1998	639	16.9	8.2	7.2	272	31.1	5.13	15.1	3.3	5.9	<0.05	52.8	146.6
S303	NM611	Rio Grande at Rio Bravo	3/30/1999	633	16.9	8.4	8.2	400	38.9	7.13	33.0	4.0	18.1	<0.1	151.	235.0
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	633	17.0	8.4	8.4	414	38.3	6.78	26.8	4.2	22.8	0.08	48.7	136.5
S303	NM460	Rio Grande at Rio Bravo	6/11/1998	637	18.0	8.3	7.2	275	31.1	5.81	13.3	2.3	4.6	<0.05	53.4	144.5
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	nd	21.5	8.1	7.1	361	45.5	7.79	28.0	5.1	17.1	0.08	48.6	144.3
S303	NM551	Rio Grande at Rio Bravo	9/22/1998	637	23.5	8.4	nd	334	39.6	6.95	15.9	2.7	5.4	<0.05	52.0	129.8
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	636	24.1	8.3	7.0	305	36.1	5.93	17.1	2.8	6.9	<0.05	163.	256.8
S303	NM537	Rio Grande at Rio Bravo	8/18/1998	639	25.2	8.4	6.3	339	41.0	6.83	18.6	3.1	6.2	<0.05	54.0	145.9
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	638	25.2	8.4	6.9	302	32.7	6.10	17.6	3.1	5.9	<0.05	51.9	149.6
S303	NM474	Rio Grande at Rio Bravo	7/22/1998	637	27.8	8.3	6.0	339	37.9	6.83	19.1	3.3	6.1	<0.05	53.2	144.4
S304	NM122	Rio Grande at San Felipe	6/22/1996	nd	18.1	7.8	8.2	348	40.0	7.00	23.3	3.8	5.8	<0.05	24.5	176.8
S305	NM120	Rio Grande at Central	6/29/1996	nd	20.6	7.8	6.5	386	40.3	7.90	19.0	3.1	5.8	<0.05	113.	182.6
S306	NM119	Rio Grande at Nature Center	6/29/1996	nd	20.3	7.8	6.3	386	42.3	7.95	18.7	2.9	5.2	<0.05	5.8	78.3
S307	NM424	Rio Puerco at Hwy 6	2/20/1998	630	1.2	8.6	11.8	3,300	176.	97.8	410.	14.	350.	0.80	909.	186.6
S307	NM605	Rio Puerco at Hwy 6	2/3/1999	634	4.0	8.4	12.6	5,230	280.	133.	780.	28.	676.	1.11	41.0	109.2
S307	NM618	Rio Puerco at Hwy 6	4/2/1999	625	8.0	8.5	9.7	4,170	204.	114.	630.	19.	479.	1.04	47.0	132.2
S307	NM439	Rio Puerco at Hwy 6	4/7/1998	630	10.1	8.4	9.8	3,330	172.	88.9	470.	16.	326.	0.80	40.5	107.4
S307	NM582	Rio Puerco at Hwy 6	12/3/1998	631	12.0	8.5	9.7	3,210	173.	85.7	447.	15.	353.	0.67	46.5	129.4
S307	NM570	Rio Puerco at Hwy 6	10/23/1998	639	16.2	8.1	7.6	2,010	136.	43.1	235.	13.	144.	0.15	41.4	107.8
S307	NM453	Rio Puerco at Hwy 6	5/7/1998	634	16.3	8.4	8.2	2,180	165.	44.5	274.	9.6	71.8	0.18	46.8	128.5
S307	NM544	Rio Puerco at Hwy 6	8/19/1998	636	24.8	8.1	5.9	2,720	190.	45.9	351.	14.	236.	0.41	46.5	126.4
S307	NM467	Rio Puerco at Hwy 6	6/12/1998	637	28.0	8.4	7.4	2,600	180.	51.4	322.	12.	195.	0.37	46.6	125.2
S308	NM196	Riverside Drain at Alameda	2/11/1997	635	7.0	8.1	8.0	457	56.4	9.37	24.8	3.3	15.5	nd	149.	226.1
S308	NM188	Riverside Drain at Alameda	1/14/1997	632	8.3	8.2	8.4	450	55.4	9.19	23.2	3.5	11.4	nd	50.9	141.0
S308	NM426	Riverside Drain at Alameda	3/31/1998	633	8.5	8.3	8.3	354	39.0	6.99	22.9	3.0	10.5	<0.05	53.5	142.2
S308	NM414	Riverside Drain at Alameda	2/19/1998	637	8.5	8.4	10.2	376	45.4	7.20	22.2	2.9	11.7	0.05	50.8	132.4
S308	NM399	Riverside Drain at Alameda	1/8/1998	634	8.7	8.1	7.3	355	42.0	6.59	20.1	2.8	9.7	<0.05	54.2	143.8
S308	NM207	Riverside Drain at Alameda	3/18/1997	642	9.2	8.2	8.9	405	44.3	8.24	24.7	3.5	11.1	0.08	28.2	197.2
S308	NM584	Riverside Drain at Alameda	1/5/1999	640	9.5	7.9	7.1	417	48.0	8.27	23.8	3.4	12.9	<0.1	50.3	134.3

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S308	NM595	Riverside Drain at Alameda	2/2/1999	639	10.0	8.4	8.7	422	47.2	8.21	24.4	3.2	13.4	<0.1	54.2	147.8
S308	NM219	Riverside Drain at Alameda	4/22/1997	632	12.2	8.2	8.6	382	40.5	7.41	20.5	3.3	11.2	<0.05	84.2	175.4
S308	NM441	Riverside Drain at Alameda	5/5/1998	634	12.7	8.2	7.7	372	41.3	7.16	22.2	3.2	10.7	0.04	53.5	136.1
S308	NM390	Riverside Drain at Alameda	11/20/1997	635	12.9	8.6	7.6	352	40.0	6.59	19.8	3.2	8.4	<0.05	54.6	143.9
S308	NM572	Riverside Drain at Alameda	12/1/1998	642	13.0	7.8	5.8	402	47.1	8.05	22.3	3.7	11.2	<0.07	9.1	216.4
S308	NM607	Riverside Drain at Alameda	3/30/1999	634	13.0	8.4	8.6	371	39.4	7.10	25.4	3.6	11.1	<0.1	55.8	148.6
S308	NM232	Riverside Drain at Alameda	5/21/1997	636	14.7	8.1	6.9	363	40.3	6.91	18.6	2.8	9.5	<0.05	7.4	154.6
S308	NM379	Riverside Drain at Alameda	10/21/1997	639	14.8	7.5	7.0	316	36.2	5.90	16.9	3.1	7.2	<0.05	52.8	142.5
S308	NM455	Riverside Drain at Alameda	6/11/1998	636	14.8	8.1	6.6	325	38.1	6.45	17.6	2.8	6.9	<0.05	54.8	146.1
S308	NM559	Riverside Drain at Alameda	10/20/1998	639	15.6	7.9	6.6	371	42.9	7.49	20.7	3.5	7.3	<0.05	124.	190.9
S308	NM357	Riverside Drain at Alameda	7/9/1997	637	18.8	8.0	6.3	340	36.6	6.60	20.7	3.2	7.1	<0.05	995.	174.4
S308	NM546	Riverside Drain at Alameda	9/22/1998	638	19.2	8.1	nd	357	42.0	7.24	17.9	3.3	6.7	<0.05	34.5	247.4
S308	NM368	Riverside Drain at Alameda	9/16/1997	636	20.2	8.0	6.1	350	41.6	6.84	18.3	3.2	8.0	<0.05	49.6	130.7
S308	NM532	Riverside Drain at Alameda	8/18/1998	638	21.1	8.2	5.2	364	42.3	7.17	20.0	3.5	7.5	<0.05	142.	214.0
S308	NM469	Riverside Drain at Alameda	7/22/1998	638	21.8	8.2	5.6	352	41.3	7.10	19.1	3.3	6.7	<0.05	53.6	139.5
S309	NM190	Riverside Drain at Campbell	1/14/1997	632	7.9	8.2	8.8	438	53.4	8.82	23.4	3.4	10.9	nd	55.2	150.2
S309	NM198	Riverside Drain at Campbell	2/11/1997	635	8.6	8.2	9.0	447	55.2	9.22	23.6	3.3	14.3	nd	50.7	136.1
S309	NM430	Riverside Drain at Campbell	3/31/1998	634	8.7	8.3	8.6	355	39.9	7.10	22.3	2.9	10.5	0.05	52.2	128.9
S309	NM416	Riverside Drain at Campbell	2/19/1998	636	9.0	8.3	9.6	366	44.1	7.01	21.2	2.9	11.1	0.06	962.	173.5
S309	NM401	Riverside Drain at Campbell	1/8/1998	634	9.5	8.2	8.5	344	40.9	6.39	19.2	2.8	9.4	<0.05	8.3	202.8
S309	NM586a	Riverside Drain at Campbell	1/5/1999	641	9.7	7.9	7.8	411	47.3	8.19	23.0	3.4	13.4	<0.1	142.	227.4
S309	NM586	Riverside Drain at Campbell	1/5/1999	641	9.7	7.9	7.8	411	47.4	8.16	22.7	3.4	12.8	<0.1	55.5	149.2
S309	NM209	Riverside Drain at Campbell	3/18/1997	nd	10.6	8.2	9.0	408	44.7	8.32	24.8	3.5	11.3	0.06	54.8	148.0
S309	NM597	Riverside Drain at Campbell	2/2/1999	638	10.6	8.3	10.4	416	47.3	8.14	23.3	3.5	13.5	<0.1	44.5	329.5
S309	NM610	Riverside Drain at Campbell	3/30/1999	633	13.0	8.2	9.2	372	39.4	7.10	26.5	3.4	11.1	<0.1	130.	216.1
S309	NM445	Riverside Drain at Campbell	5/5/1998	634	13.0	8.3	8.3	375	41.0	7.23	21.7	2.9	11.5	0.04	55.6	142.0
S309	NM222	Riverside Drain at Campbell	4/22/1997	635	13.4	8.3	8.8	385	40.8	7.44	20.4	3.3	11.6	0.06	51.1	139.5
S309	NM574	Riverside Drain at Campbell	12/1/1998	642	13.6	8.2	6.5	393	45.4	7.85	22.1	3.6	10.7	<0.07	56.2	146.7
S309	NM392	Riverside Drain at Campbell	11/20/1997	635	14.0	8.6	7.1	334	38.3	6.31	18.8	3.2	7.6	<0.05	116.	195.6
S309	NM459	Riverside Drain at Campbell	6/11/1998	637	14.9	8.1	7.2	326	38.4	6.49	18.2	2.8	7.1	<0.05	56.8	143.2
S309	NM234	Riverside Drain at Campbell	5/21/1997	637	15.0	8.1	7.2	364	40.7	6.99	20.3	2.9	10.0	0.06	54.7	151.6
S309	NM383	Riverside Drain at Campbell	10/21/1997	639	16.2	7.9	7.3	313	36.4	5.93	17.9	3.1	7.1	<0.05	38.2	270.1
S309	NM562	Riverside Drain at Campbell	10/20/1998	639	16.8	8.1	7.5	365	42.3	7.34	19.9	3.6	7.3	<0.05	52.2	133.8
S309	NM550	Riverside Drain at Campbell	9/22/1998	638	19.4	8.2	nd	355	41.4	7.12	18.3	3.3	6.6	<0.05	55.0	143.2
S309	NM359	Riverside Drain at Campbell	7/9/1997	638	19.5	8.2	6.9	340	35.9	6.40	19.8	3.2	6.9	<0.05	54.2	147.8
S309	NM536	Riverside Drain at Campbell	8/18/1998	638	21.2	8.2	5.6	363	42.3	7.06	19.6	3.4	7.5	<0.05	51.6	130.1
S309	NM473	Riverside Drain at Campbell	7/22/1998	636	22.3	8.1	5.2	350	41.2	6.98	19.7	3.3	6.8	<0.05	56.8	145.4
S309	NM372	Riverside Drain at Campbell	9/16/1997	636	22.4	8.0	6.6	346	41.9	6.81	17.6	3.4	8.0	<0.05	146.	225.6
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	640	7.7	8.2	8.4	435	53.7	8.45	23.1	3.9	10.1	nd	9.7	235.1
S310	NM432	Riverside Drain at Rio Bravo	3/31/1998	634	9.2	8.4	9.5	356	39.3	6.95	23.3	3.2	10.1	0.08	139.	208.3
S310	NM588	Riverside Drain at Rio Bravo	1/5/1999	640	10.7	8.0	7.7	397	46.1	7.66	23.3	3.5	13.8	<0.1	55.4	160.0
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	634	11.3	8.3	8.0	362	42.5	6.44	22.2	3.3	8.9	<0.05	143.	260.7

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	633	12.4	8.2	8.6	433	53.0	8.40	23.3	3.7	11.2	nd	57.0	146.3
S310	NM576	Riverside Drain at Rio Bravo	12/1/1998	642	12.8	7.9	6.9	386	43.4	7.18	23.6	3.7	9.5	<0.07	55.6	160.4
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	nd	12.9	8.3	9.2	413	45.5	8.40	24.7	3.6	11.1	0.06	55.7	150.8
S310	NM599	Riverside Drain at Rio Bravo	2/2/1999	638	13.0	8.2	7.8	407	45.5	7.59	24.0	3.5	11.1	<0.1	61.5	155.3
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	637	13.0	8.4	8.6	364	43.2	6.72	21.7	3.4	9.7	0.05	44.4	326.9
S310	NM612	Riverside Drain at Rio Bravo	3/30/1999	633	14.1	8.3	9.0	371	40.3	7.21	26.1	3.5	10.7	<0.1	145.	247.0
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	635	14.2	8.2	7.2	376	42.4	6.70	21.7	3.9	9.3	<0.05	54.7	149.0
S310	NM447	Riverside Drain at Rio Bravo	5/5/1998	635	14.5	8.3	8.9	378	41.8	7.30	22.3	2.9	10.9	0.05	13.1	84.9
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	633	15.4	8.4	9.6	386	40.8	7.40	20.2	3.4	10.8	<0.05	56.2	152.5
S310	NM564	Riverside Drain at Rio Bravo	10/20/1998	640	15.7	8.1	7.3	338	38.9	6.62	18.9	4.0	7.0	<0.05	58.7	157.4
S310	NM461	Riverside Drain at Rio Bravo	6/11/1998	637	15.7	8.1	7.6	331	37.2	6.56	17.7	3.0	7.3	<0.05	704.	158.9
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	639	16.1	7.8	7.9	320	37.5	6.07	17.4	3.2	7.4	0.05	49.5	135.1
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	637	16.1	8.1	8.1	371	41.6	7.00	20.2	3.0	10.2	0.06	51.4	137.3
S310	NM552	Riverside Drain at Rio Bravo	9/22/1998	636	20.4	8.1	nd	367	42.6	7.24	19.2	3.4	6.9	<0.05	58.5	166.2
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	636	21.4	8.1	6.7	349	42.3	6.91	17.3	3.4	7.3	<0.05	37.7	107.1
S310	NM538	Riverside Drain at Rio Bravo	8/18/1998	638	21.5	8.1	6.6	375	43.3	7.22	20.0	3.5	7.8	<0.05	60.1	160.7
S310	NM475	Riverside Drain at Rio Bravo	7/22/1998	637	22.8	8.0	6.4	363	43.0	7.20	19.9	3.4	7.2	<0.05	62.2	170.3
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	638	25.8	8.2	7.3	355	38.8	6.80	21.5	3.2	7.6	0.05	54.8	148.9
S311	NM243	Stream in Monte Largo Canyon	5/28/1997	nd	19.4	8.0	7.1	143	16.0	3.65	5.7	0.7	2.9	<0.05	43.9	298.0
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	620	3.1	8.4	10.8	1,007	121.	27.7	45.9	3.2	110.	0.49	56.0	163.7
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	628	5.3	6.1	10.1	1,030	122.	31.4	44.8	3.8	109.	0.45	54.7	165.9
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	640	5.4	8.5	10.1	1,054	130.	30.6	43.9	4.7	115.	nd	140.	199.6
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	631	5.5	8.4	10.2	1,057	122.	30.2	46.9	3.7	112.	0.44	1,003.	276.8
S312	NM590	Tijeras Arroyo at Four Hills	1/5/1999	626	9.0	8.3	9.5	998	120.	29.0	48.4	3.2	98.9	0.34	56.1	160.6
S312	NM601	Tijeras Arroyo at Four Hills	2/2/1999	624	9.2	8.4	10.4	994	114.	28.4	48.4	3.3	98.9	0.35	56.5	164.9
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	620	9.3	8.5	9.0	1,006	123.	31.2	45.2	3.8	111.	0.34	61.5	161.1
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	619	9.4	8.5	8.9	1,068	126.	33.5	43.9	4.2	114.	0.42	60.3	170.0
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	626	11.2	8.3	8.8	1,025	125.	32.3	48.4	3.5	114.	0.39	60.1	167.5
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	619	11.5	8.2	8.6	995	117.	26.7	38.7	5.0	108.	0.39	58.6	165.6
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	618	11.8	8.4	8.6	1,036	126.	29.5	42.6	4.0	110.	nd	10.2	154.6
S312	NM578	Tijeras Arroyo at Four Hills	12/1/1998	635	12.5	8.4	9.0	1,001	115.	28.1	49.0	3.3	99.2	0.37	58.1	164.6
S312	NM434	Tijeras Arroyo at Four Hills	3/31/1998	619	14.0	8.3	8.3	1,064	125.	29.7	58.9	3.3	114.	0.33	148.	267.6
S312	NM566	Tijeras Arroyo at Four Hills	10/23/1998	630	14.7	8.2	8.3	967	112.	27.5	48.6	3.7	98.9	0.28	52.8	158.6
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	623	18.0	8.2	7.8	981	116.	28.7	41.0	4.1	107.	0.40	58.5	166.0
S312	NM614	Tijeras Arroyo at Four Hills	3/30/1999	619	18.8	8.2	7.7	991	108.	28.5	55.3	3.5	100.	0.33	60.7	162.0
S312	NM477	Tijeras Arroyo at Four Hills	7/23/1998	625	19.2	8.2	7.5	933	101.	26.3	44.0	3.4	97.0	0.36	14.8	207.2
S312	NM449	Tijeras Arroyo at Four Hills	5/5/1998	620	20.3	8.2	7.7	988	111.	27.8	44.2	3.1	104.	0.35	40.5	266.8
S312	NM463	Tijeras Arroyo at Four Hills	6/11/1998	322	20.9	8.2	7.3	991	109.	27.3	43.8	3.4	102.	0.38	141.	209.6
S312	NM554	Tijeras Arroyo at Four Hills	9/22/1998	623	22.1	8.1	nd	959	103.	27.3	47.6	3.7	98.1	0.37	58.4	166.7
S312	NM540	Tijeras Arroyo at Four Hills	8/18/1998	624	24.8	8.1	6.4	952	101.	26.5	45.9	3.8	96.3	0.37	55.7	163.9
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	623	27.4	8.1	6.4	980	108.	29.0	45.4	3.9	112.	0.39	56.2	167.4
S313	NM433	West Riverside drain at Rio Bravo	3/31/1998	634	12.4	8.5	9.3	370	40.1	6.95	25.5	3.3	11.6	0.05	47.5	153.9

Table B2. Surface-water field parameters and major-element chemistry-- Continued

Site no.	Sample no.	Site name	Date	Barometric pressure (mm Hg)	Temp. °C	pH	O_2 (mg/L)	Sp. Cond. (µS/cm at 25° C)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	Br^{-} (mg/L)	SO_4^{2-} (mg/L)	Alkalinity HCO_3^{-} (mg/L)
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	634	13.7	8.4	7.3	347	39.6	6.26	21.4	3.4	9.3	<0.05	43.6	151.4
S313	NM589	West Riverside drain at Rio Bravo	1/5/1999	640	14.1	8.1	6.8	404	48.0	7.74	24.3	4.0	12.4	<0.1	1,380.	281.0
S313	NM600	West Riverside drain at Rio Bravo	2/2/1999	638	14.8	8.3	7.2	414	45.4	7.84	25.0	3.8	12.5	<0.1	nd	nd
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	636	14.8	8.5	8.2	413	46.1	7.54	25.5	3.6	14.5	0.07	140.	217.7
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	636	15.2	8.6	9.1	363	42.4	6.81	22.1	3.5	10.7	0.06	49.8	154.2
S313	NM613	West Riverside drain at Rio Bravo	3/30/1999	633	15.9	8.2	8.0	401	43.0	7.43	28.3	3.8	12.5	<0.1	nd	nd
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	nd	16.2	8.2	7.4	434	48.0	8.55	25.9	3.9	12.7	0.08	152.	266.9
S313	NM577	West Riverside drain at Rio Bravo	12/1/1998	642	16.4	7.8	5.9	397	44.6	7.63	24.4	4.1	10.6	<0.07	7.0	126.5
S313	NM448	West Riverside drain at Rio Bravo	5/5/1998	634	16.8	8.6	8.7	390	43.9	7.34	23.8	3.1	13.8	0.07	45.9	154.3
S313	NM462	West Riverside drain at Rio Bravo	6/11/1998	637	17.3	8.5	8.0	358	39.1	6.73	21.1	3.4	10.2	<0.05	47.2	155.5
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	633	17.6	7.9	6.9	432	46.6	8.10	24.2	4.0	14.4	0.06	36.9	257.3
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	635	17.7	8.3	7.9	336	37.8	6.07	20.7	3.5	7.8	<0.05	47.6	153.8
S313	NM565	West Riverside drain at Rio Bravo	10/20/1998	640	18.6	7.8	5.0	367	41.1	7.04	21.6	4.1	7.7	<0.05	137.	232.5
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	638	20.5	7.7	6.5	347	39.7	6.33	20.2	3.9	9.1	<0.05	49.2	153.2
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	638	21.2	8.7	9.5	352	36.7	6.30	21.5	3.2	8.3	<0.05	12.4	217.2
S313	NM539	West Riverside drain at Rio Bravo	8/18/1998	638	22.7	8.5	7.0	362	41.5	6.87	20.7	3.9	8.5	<0.05	145.	255.3
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	636	23.0	8.0	7.2	353	41.9	6.62	19.3	3.5	9.1	<0.05	1,711.	330.5
S313	NM553	West Riverside drain at Rio Bravo	9/22/1998	637	23.4	8.3	nd	369	41.4	6.91	21.2	4.0	7.9	<0.05	33.1	244.4
S313	NM476	West Riverside drain at Rio Bravo	7/22/1998	636	24.0	8.7	7.2	352	38.8	6.48	22.1	3.9	8.3	<0.05	54.0	161.0
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	nd	26.9	8.0	5.9	406	47.0	8.40	19.1	4.2	6.4	0.24	nd	nd

Table B3. Summary of minor-element chemistry in surface water

[Sr, strontium, SiO_2, silica; Fe, iron; NO_3 as N, dissolved nitrate as nitrogen; Mn, manganese; F, fluoride; mg/L, milligrams per liter; nd, not determined]

Site no.	Sample no.	Site name	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S290	NM202	Abo Arroyo at US 60	3/12/1997	3.6	12.3	0.39	0.022	0.21	0.54
S290	NM194	Abo Arroyo at US 60	1/16/1997	3.8	26.1	0.30	0.149	2.75	0.72
S291	NM428	Alameda Drain at Alameda	3/31/1998	0.30	22.7	0.04	0.003	<0.02	0.36
S291	NM548	Alameda Drain at Alameda	9/22/1998	0.36	19.2	0.03	0.004	<0.02	0.29
S291	NM381	Alameda Drain at Alameda	10/21/1997	0.26	20.7	0.04	0.006	<0.02	0.26
S291	NM370	Alameda Drain at Alameda	9/16/1997	0.29	20.3	0.03	0.008	<0.01	0.30
S291	NM471	Alameda Drain at Alameda	7/22/1998	0.32	18.8	0.03	0.008	<0.02	0.34
S291	NM534	Alameda Drain at Alameda	8/18/1998	0.34	17.7	0.03	0.009	<0.02	0.36
S291	NM366	Alameda Drain at Alameda	7/9/1997	0.28	18.2	0.05	0.010	<0.01	0.29
S291	NM457	Alameda Drain at Alameda	6/11/1998	0.27	17.6	0.03	0.010	<0.02	0.36
S291	NM443	Alameda Drain at Alameda	5/5/1998	0.32	18.8	0.04	0.012	<0.02	0.43
S291	NM220	Alameda Drain at Alameda	4/22/1997	0.30	19.4	0.03	0.014	<0.01	0.31
S292	NM436	Bear Canyon Arroyo	3/31/1998	0.11	21.0	0.03	0.001	<0.02	1.17
S292	NM435	Bear Canyon Arroyo	3/31/1998	0.11	21.2	0.04	0.001	<0.02	1.18
S292	NM464	Bear Canyon Arroyo	6/11/1998	0.12	22.0	0.03	0.001	<0.02	1.74
S292	NM203	Bear Canyon Arroyo	3/19/1997	0.18	21.8	0.07	0.003	0.01	1.33
S292	NM216	Bear Canyon Arroyo	4/23/1997	0.14	21.1	0.04	0.004	0.04	1.38
S292	NM478	Bear Canyon Arroyo	7/23/1998	0.16	24.8	0.04	0.004	<0.02	1.34
S292	NM602	Bear Canyon Arroyo	2/3/1999	0.18	21.8	0.04	0.004	<0.05	1.51
S292	NM591	Bear Canyon Arroyo	1/5/1999	0.19	22.2	0.05	0.004	<0.05	1.27
S292	NM450	Bear Canyon Arroyo	5/5/1998	0.10	20.4	0.03	0.005	<0.02	1.41
S292	NM229	Bear Canyon Arroyo	5/28/1997	0.12	21.6	0.03	0.006	<0.01	1.41
S292	NM541	Bear Canyon Arroyo	8/18/1998	0.18	25.9	0.04	0.006	<0.02	1.33
S292	NM406	Bear Canyon Arroyo	1/9/1998	0.18	22.5	0.06	0.006	<0.02	1.38
S292	NM579	Bear Canyon Arroyo	12/1/1998	0.23	25.4	0.06	0.008	<0.05	1.42
S292	NM397	Bear Canyon Arroyo	11/18/1997	0.21	25.9	0.06	0.008	<0.02	1.43
S292	NM567	Bear Canyon Arroyo	10/23/1998	0.23	27.8	0.08	0.009	<0.02	1.81
S292	NM354	Bear Canyon Arroyo	7/9/1997	0.16	24.6	0.05	0.010	<0.01	1.43
S292	NM555	Bear Canyon Arroyo	9/29/1998	0.22	28.5	0.08	0.014	<0.02	1.31
S292	NM388	Bear Canyon Arroyo	10/23/1997	0.23	27.2	0.07	0.015	<0.02	1.37
S292	NM377	Bear Canyon Arroyo	9/18/1997	0.22	28.0	0.07	0.018	<0.01	1.48
S292	NM421	Bear Canyon Arroyo	2/20/1998	0.17	21.6	0.07	<0.001	<0.02	1.25
S292	NM615	Bear Canyon Arroyo	4/2/1999	0.16	20.6	0.02	<0.001	<0.05	1.57
S293	NM244	Canyon del Trigo Stream	5/29/1997	0.07	15.9	0.01	<0.001	<0.01	0.13
S294	NM547	Chamizal Lateral at Alameda	9/22/1998	0.35	18.7	0.04	0.002	<0.02	0.29
S294	NM470	Chamizal Lateral at Alameda	7/22/1998	0.31	18.8	0.03	0.003	0.04	0.33
S294	NM533	Chamizal Lateral at Alameda	8/18/1998	0.33	18.1	0.03	0.003	<0.02	0.35
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	0.29	18.9	0.05	0.004	0.08	0.26
S294	NM560	Chamizal Lateral at Alameda	10/20/1998	0.37	18.7	0.03	0.004	<0.02	0.71
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	0.28	18.7	0.04	0.005	<0.01	0.30
S294	NM427	Chamizal Lateral at Alameda	3/31/1998	0.30	22.0	0.05	0.005	<0.02	0.36
S294	NM608	Chamizal Lateral at Alameda	3/30/1999	0.29	20.2	0.01	0.005	<0.05	0.57
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	0.28	21.6	0.04	0.006	0.06	0.26
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	0.28	19.9	0.03	0.006	0.09	0.29
S294	NM456	Chamizal Lateral at Alameda	6/11/1998	0.26	17.9	0.02	0.006	<0.02	0.39
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	0.32	22.7	0.05	0.007	0.03	0.40
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	0.30	20.1	0.03	0.007	<0.01	0.32
S294	NM442	Chamizal Lateral at Alameda	5/5/1998	0.32	19.3	0.04	0.011	<0.02	0.40
S297	NM437	Jemez River below Jemez Canyon Dam	4/7/1998	0.58	26.1	0.07	0.003	<0.02	0.99
S297	NM451	Jemez River below Jemez Canyon Dam	5/7/1998	0.57	24.8	0.06	0.006	0.04	0.73
S297	NM580	Jemez River below Jemez Canyon Dam	12/3/1998	0.82	24.9	0.06	0.007	<0.05	0.78
S297	NM422	Jemez River below Jemez Canyon Dam	2/20/1998	0.65	26.5	0.08	0.010	<0.02	0.86
S297	NM603	Jemez River below Jemez Canyon Dam	2/3/1999	0.82	26.6	0.05	0.011	<0.05	1.13
S297	NM616	Jemez River below Jemez Canyon Dam	4/1/1999	0.55	26.5	0.03	0.011	<0.05	1.40
S297	NM592	Jemez River below Jemez Canyon Dam	1/6/1999	0.83	25.9	0.05	0.014	<0.05	0.91
S297	NM556	Jemez River below Jemez Canyon Dam	9/24/1998	0.69	23.3	0.06	0.042	<0.02	0.76

Table B3. Summary of minor-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S297	NM568	Jemez River below Jemez Canyon Dam	10/27/1998	0.73	23.1	0.06	0.044	0.02	1.29
S297	NM465	Jemez River below Jemez Canyon Dam	6/12/1998	0.47	21.3	0.05	0.080	<0.02	0.86
S297	NM542	Jemez River below Jemez Canyon Dam	8/19/1998	0.62	22.5	0.05	0.104	<0.02	0.67
S297	NM479	Jemez River below Jemez Canyon Dam	7/23/1998	0.63	22.7	0.05	0.154	0.06	0.67
S298	NM569	Jemez River at Jemez	10/27/1998	0.15	18.8	0.05	0.007	0.05	0.80
S298	NM438	Jemez River at Jemez	4/7/1998	0.10	22.5	0.06	0.007	<0.02	0.25
S298	NM617	Jemez River at Jemez	4/2/1999	0.12	23.7	0.04	0.008	<0.05	0.68
S298	NM581	Jemez River at Jemez	12/3/1998	0.17	33.7	0.06	0.012	<0.05	0.78
S298	NM466	Jemez River at Jemez	6/12/1998	0.14	24.4	0.05	0.012	<0.02	0.74
S298	NM543	Jemez River at Jemez	8/19/1998	0.20	35.7	0.05	0.014	<0.02	0.82
S298	NM452	Jemez River at Jemez	5/7/1998	0.07	18.5	0.32	0.016	0.02	0.17
S298	NM423	Jemez River at Jemez	2/20/1998	0.17	38.5	0.07	0.016	<0.02	0.87
S298	NM557	Jemez River at Jemez	9/24/1998	0.22	42.4	0.06	0.016	<0.02	0.98
S298	NM480	Jemez River at Jemez	7/23/1998	0.21	35.7	0.05	0.017	<0.02	0.89
S298	NM593	Jemez River at Jemez	1/6/1999	0.21	44.1	0.06	0.023	0.07	1.10
S298	NM604	Jemez River at Jemez	2/3/1999	0.22	47.6	0.07	0.029	<0.05	1.31
S300	NM468	Rio Grande at Alameda	7/22/1998	0.30	16.7	0.02	0.001	0.03	0.31
S300	NM531	Rio Grande at Alameda	8/18/1998	0.32	15.5	0.03	0.001	0.03	0.32
S300	NM545	Rio Grande at Alameda	9/22/1998	0.33	16.5	0.03	0.001	<0.02	0.26
S300	NM413	Rio Grande at Alameda	2/19/1998	0.31	23.3	0.06	0.002	0.08	0.37
S300	NM454	Rio Grande at Alameda	6/11/1998	0.23	15.4	0.03	0.002	0.14	0.33
S300	NM378	Rio Grande at Alameda	10/21/1997	0.22	19.4	0.04	0.003	0.08	0.21
S300	NM356	Rio Grande at Alameda	7/9/1997	0.24	18.0	0.04	0.003	0.08	0.26
S300	NM425	Rio Grande at Alameda	3/31/1998	0.29	21.4	0.04	0.003	<0.02	0.38
S300	NM606	Rio Grande at Alameda	3/30/1999	0.32	20.8	0.02	0.003	<0.05	0.66
S300	NM571	Rio Grande at Alameda	12/1/1998	0.45	21.8	0.03	0.003	<0.05	0.50
S300	NM123	Rio Grande at Alameda	6/22/1996	0.32	16.0	0.03	0.004	0.03	0.31
S300	NM218	Rio Grande at Alameda	4/22/1997	0.29	19.3	0.03	0.004	0.04	0.38
S300	NM558	Rio Grande at Alameda	10/20/1998	0.37	17.8	0.03	0.004	0.05	0.75
S300	NM231	Rio Grande at Alameda	5/21/1997	0.26	17.1	<0.01	0.004	0.13	0.22
S300	NM389	Rio Grande at Alameda	11/20/1997	0.24	22.0	0.04	0.005	0.03	0.34
S300	NM398	Rio Grande at Alameda	1/8/1998	0.32	23.3	0.05	0.005	0.05	0.45
S300	NM206	Rio Grande at Alameda	3/18/1997	0.34	23.3	0.05	0.005	0.08	0.45
S300	NM440	Rio Grande at Alameda	5/5/1998	0.29	17.6	0.04	0.005	<0.02	0.37
S300	NM583	Rio Grande at Alameda	1/5/1999	0.42	22.2	0.04	0.005	<0.05	0.42
S300	NM187	Rio Grande at Alameda	1/14/1997	0.36	23.5	0.05	0.006	0.20	0.44
S300	NM594	Rio Grande at Alameda	2/2/1999	0.39	22.5	0.04	0.006	<0.05	0.67
S300	NM195	Rio Grande at Alameda	2/11/1997	0.35	23.7	0.04	0.007	0.09	0.42
S300	NM367	Rio Grande at Alameda	9/16/1997	0.27	17.9	0.02	<0.003	0.05	0.29
S300	NM118	Rio Grande at Alameda	6/29/1996	0.45	12.1	0.04	<0.004	0.26	0.43
S301	NM535	Rio Grande at Campbell	8/18/1998	0.32	15.4	0.03	0.001	0.06	0.31
S301	NM561	Rio Grande at Campbell	10/20/1998	0.34	15.8	0.03	0.001	0.07	0.65
S301	NM549	Rio Grande at Campbell	9/22/1998	0.33	16.0	0.03	0.001	0.08	0.26
S301	NM472	Rio Grande at Campbell	7/22/1998	0.30	16.9	0.03	0.002	0.06	0.32
S301	NM609	Rio Grande at Campbell	3/30/1999	0.31	20.6	0.02	0.002	0.06	0.66
S301	NM233	Rio Grande at Campbell	5/21/1997	0.25	16.8	0.05	0.002	0.12	0.20
S301	NM415	Rio Grande at Campbell	2/19/1998	0.30	22.9	0.05	0.002	0.13	0.38
S301	NM458	Rio Grande at Campbell	6/11/1998	0.23	15.5	0.03	0.002	0.13	0.34
S301	NM429	Rio Grande at Campbell	3/31/1998	0.29	21.4	0.05	0.002	<0.02	0.35
S301	NM573	Rio Grande at Campbell	12/1/1998	0.42	20.3	0.03	0.003	0.07	0.43
S301	NM400	Rio Grande at Campbell	1/8/1998	0.30	22.5	0.05	0.003	0.06	0.45
S301	NM585	Rio Grande at Campbell	1/5/1999	0.41	21.4	0.03	0.003	0.07	0.42
S301	NM391	Rio Grande at Campbell	11/20/1997	0.24	22.0	0.04	0.004	0.05	0.31
S301	NM382	Rio Grande at Campbell	10/21/1997	0.22	19.4	0.03	0.004	0.08	0.21
S301	NM358	Rio Grande at Campbell	7/9/1997	0.24	17.9	0.03	0.004	0.08	0.27
S301	NM444	Rio Grande at Campbell	5/5/1998	0.28	17.4	0.04	0.004	<0.02	0.43
S301	NM221	Rio Grande at Campbell	4/22/1997	0.29	18.8	0.03	0.005	0.03	0.37
S301	NM189	Rio Grande at Campbell	1/14/1997	0.35	22.9	0.05	0.005	0.27	0.44

Table B3. Summary of minor-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S301	NM596	Rio Grande at Campbell	2/2/1999	0.39	22.1	0.04	0.005	<0.05	0.67
S301	NM208	Rio Grande at Campbell	3/18/1997	0.34	23.1	0.05	0.006	0.08	0.45
S301	NM197	Rio Grande at Campbell	2/11/1997	0.34	24.0	0.04	0.007	0.13	0.42
S301	NM371	Rio Grande at Campbell	9/16/1997	0.26	17.6	0.03	<0.003	0.06	0.29
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	0.34	21.4	0.04	0.017	1.01	0.52
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	0.25	18.0	0.04	0.000	0.08	0.29
S303	NM474	Rio Grande at Rio Bravo	7/22/1998	0.30	17.1	0.03	0.001	0.10	0.32
S303	NM611	Rio Grande at Rio Bravo	3/30/1999	0.30	20.2	0.02	0.002	0.07	0.62
S303	NM551	Rio Grande at Rio Bravo	9/22/1998	0.34	16.9	0.04	0.002	0.08	0.26
S303	NM537	Rio Grande at Rio Bravo	8/18/1998	0.33	16.0	0.03	0.002	0.08	0.34
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	0.26	17.2	0.05	0.002	0.11	0.23
S303	NM460	Rio Grande at Rio Bravo	6/11/1998	0.23	15.4	0.02	0.002	<0.02	0.34
S303	NM587	Rio Grande at Rio Bravo	1/5/1999	0.41	20.1	0.03	0.003	0.08	0.41
S303	NM575	Rio Grande at Rio Bravo	12/1/1998	0.41	19.3	0.04	0.003	0.06	0.40
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	0.30	22.2	0.05	0.003	0.14	0.38
S303	NM563	Rio Grande at Rio Bravo	10/20/1998	0.26	12.8	0.03	0.003	0.21	0.61
S303	NM446	Rio Grande at Rio Bravo	5/5/1998	0.29	17.6	0.04	0.003	<0.02	0.41
S303	NM431	Rio Grande at Rio Bravo	3/31/1998	0.29	22.0	0.06	0.003	<0.02	0.39
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	0.22	19.3	0.03	0.004	0.08	0.21
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	0.25	21.8	0.04	0.004	0.10	0.34
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	0.35	23.3	0.05	0.005	0.05	0.45
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	0.30	19.1	0.03	0.005	0.06	0.38
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	0.37	21.8	0.05	0.005	0.21	0.43
S303	NM598	Rio Grande at Rio Bravo	2/2/1999	0.39	21.4	0.04	0.005	0.09	0.68
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	0.34	22.2	0.04	0.006	0.15	0.41
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	0.31	22.2	0.04	0.033	0.11	0.41
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	0.27	17.8	0.02	<0.003	0.07	0.29
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	0.41	16.2	0.04	<0.004	0.21	0.34
S304	NM122	Rio Grande at San Felipe	6/22/1996	0.33	16.7	0.05	0.006	0.11	0.30
S305	NM120	Rio Grande at Central	6/29/1996	0.44	12.6	0.03	<0.004	<0.01	0.38
S306	NM119	Rio Grande at Nature Center	6/29/1996	0.44	12.2	0.04	<0.004	0.32	0.37
S307	NM618	Rio Puerco at Hwy 6	4/2/1999	3.4	20.8	0.15	0.001	<0.05	1.88
S307	NM467	Rio Puerco at Hwy 6	6/12/1998	2.5	9.4	0.23	0.004	<0.02	1.39
S307	NM453	Rio Puerco at Hwy 6	5/7/1998	2.1	8.9	0.23	0.011	0.18	1.34
S307	NM582	Rio Puerco at Hwy 6	12/3/1998	2.9	21.9	0.21	0.014	0.06	0.84
S307	NM605	Rio Puerco at Hwy 6	2/3/1999	4.4	26.0	0.28	0.019	0.21	0.83
S307	NM424	Rio Puerco at Hwy 6	2/20/1998	3.2	22.2	0.31	<0.001	0.06	0.85
S307	NM570	Rio Puerco at Hwy 6	10/23/1998	2.0	9.5	0.18	<0.001	0.19	2.10
S307	NM544	Rio Puerco at Hwy 6	8/19/1998	2.6	9.8	0.23	<0.001	0.69	1.28
S307	NM439	Rio Puerco at Hwy 6	4/7/1998	3.2	18.5	0.31	<0.001	<0.02	0.93
S308	NM219	Riverside Drain at Alameda	4/22/1997	0.31	20.1	0.02	0.007	<0.01	0.33
S308	NM532	Riverside Drain at Alameda	8/18/1998	0.32	18.8	0.03	0.007	<0.02	0.34
S308	NM368	Riverside Drain at Alameda	9/16/1997	0.30	21.2	0.03	0.008	0.03	0.32
S308	NM469	Riverside Drain at Alameda	7/22/1998	0.32	20.0	0.03	0.008	0.04	0.33
S308	NM546	Riverside Drain at Alameda	9/22/1998	0.35	19.7	0.03	0.008	<0.02	0.38
S308	NM559	Riverside Drain at Alameda	10/20/1998	0.37	19.2	0.03	0.009	0.02	0.77
S308	NM357	Riverside Drain at Alameda	7/9/1997	0.28	19.3	0.04	0.010	<0.01	0.30
S308	NM232	Riverside Drain at Alameda	5/21/1997	0.30	20.0	0.04	0.011	0.10	0.27
S308	NM207	Riverside Drain at Alameda	3/18/1997	0.34	22.5	0.06	0.012	0.05	0.39
S308	NM455	Riverside Drain at Alameda	6/11/1998	0.26	18.7	0.03	0.012	<0.02	0.39
S308	NM426	Riverside Drain at Alameda	3/31/1998	0.30	21.2	0.04	0.012	<0.02	0.36
S308	NM607	Riverside Drain at Alameda	3/30/1999	0.30	19.9	0.02	0.013	<0.05	0.49
S308	NM379	Riverside Drain at Alameda	10/21/1997	0.28	20.6	0.03	0.017	0.07	0.31
S308	NM441	Riverside Drain at Alameda	5/5/1998	0.32	19.4	0.04	0.017	<0.02	0.43
S308	NM390	Riverside Drain at Alameda	11/20/1997	0.30	20.6	0.03	0.034	0.03	0.38
S308	NM414	Riverside Drain at Alameda	2/19/1998	0.34	19.5	0.06	0.041	0.04	0.34
S308	NM196	Riverside Drain at Alameda	2/11/1997	0.41	18.0	0.05	0.042	0.09	0.35
S308	NM595	Riverside Drain at Alameda	2/2/1999	0.41	17.9	0.04	0.047	<0.05	0.43

Table B3. Summary of minor-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S308	NM188	Riverside Drain at Alameda	1/14/1997	0.40	17.9	0.05	0.050	0.07	0.35
S308	NM584	Riverside Drain at Alameda	1/5/1999	0.42	17.9	0.03	0.052	<0.05	0.31
S308	NM399	Riverside Drain at Alameda	1/8/1998	0.31	18.3	0.04	0.057	0.06	0.35
S308	NM572	Riverside Drain at Alameda	12/1/1998	0.42	18.9	0.03	0.061	0.05	0.34
S309	NM473	Riverside Drain at Campbell	7/22/1998	0.31	20.0	0.03	0.004	0.04	0.32
S309	NM550	Riverside Drain at Campbell	9/22/1998	0.34	20.0	0.03	0.004	<0.02	0.39
S309	NM536	Riverside Drain at Campbell	8/18/1998	0.32	18.9	0.03	0.005	<0.02	0.32
S309	NM222	Riverside Drain at Campbell	4/22/1997	0.31	19.6	0.03	0.006	0.04	0.34
S309	NM234	Riverside Drain at Campbell	5/21/1997	0.31	19.9	0.05	0.006	0.10	0.31
S309	NM359	Riverside Drain at Campbell	7/9/1997	0.29	19.2	0.04	0.006	<0.01	0.32
S309	NM372	Riverside Drain at Campbell	9/16/1997	0.30	21.2	0.03	0.006	<0.01	0.33
S309	NM562	Riverside Drain at Campbell	10/20/1998	0.35	18.9	0.03	0.006	<0.02	0.77
S309	NM459	Riverside Drain at Campbell	6/11/1998	0.27	18.9	0.03	0.007	<0.02	0.40
S309	NM430	Riverside Drain at Campbell	3/31/1998	0.31	21.2	0.04	0.007	<0.02	0.38
S309	NM610	Riverside Drain at Campbell	3/30/1999	0.30	19.2	0.02	0.009	<0.05	0.47
S309	NM383	Riverside Drain at Campbell	10/21/1997	0.28	20.9	0.03	0.010	0.05	0.29
S309	NM209	Riverside Drain at Campbell	3/18/1997	0.35	22.0	0.05	0.010	0.05	0.38
S309	NM445	Riverside Drain at Campbell	5/5/1998	0.31	18.8	0.04	0.012	<0.02	0.45
S309	NM392	Riverside Drain at Campbell	11/20/1997	0.28	20.1	0.04	0.021	0.04	0.38
S309	NM416	Riverside Drain at Campbell	2/19/1998	0.33	18.5	0.05	0.021	0.05	0.31
S309	NM597	Riverside Drain at Campbell	2/2/1999	0.41	17.2	0.03	0.023	<0.05	0.43
S309	NM574	Riverside Drain at Campbell	12/1/1998	0.41	19.0	0.03	0.024	<0.05	0.32
S309	NM586	Riverside Drain at Campbell	1/5/1999	0.42	17.9	0.04	0.025	<0.05	0.31
S309	NM586a	Riverside Drain at Campbell	1/5/1999	0.43	17.8	0.04	0.025	<0.05	0.32
S309	NM401	Riverside Drain at Campbell	1/8/1998	0.31	17.8	0.04	0.028	0.04	0.32
S309	NM198	Riverside Drain at Campbell	2/11/1997	0.40	17.2	0.05	0.037	0.07	0.33
S309	NM190	Riverside Drain at Campbell	1/14/1997	0.39	17.3	0.04	0.039	0.05	0.34
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	0.31	18.9	0.02	0.008	0.01	0.33
S310	NM538	Riverside Drain at Rio Bravo	8/18/1998	0.33	19.0	0.03	0.008	0.03	0.35
S310	NM552	Riverside Drain at Rio Bravo	9/22/1998	0.35	20.2	0.04	0.008	<0.02	0.31
S310	NM475	Riverside Drain at Rio Bravo	7/22/1998	0.33	20.1	0.03	0.009	0.05	0.34
S310	NM564	Riverside Drain at Rio Bravo	10/20/1998	0.33	17.2	0.03	0.009	0.07	0.75
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	0.31	21.1	0.03	0.011	<0.01	0.33
S310	NM461	Riverside Drain at Rio Bravo	6/11/1998	0.27	18.0	0.03	0.014	<0.02	0.42
S310	NM432	Riverside Drain at Rio Bravo	3/31/1998	0.31	21.4	0.05	0.015	<0.02	0.35
S310	NM447	Riverside Drain at Rio Bravo	5/5/1998	0.31	18.8	0.04	0.015	<0.02	0.41
S310	NM612	Riverside Drain at Rio Bravo	3/30/1999	0.30	19.7	0.02	0.015	<0.05	0.48
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	0.29	18.8	0.05	0.016	0.02	0.31
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	0.32	20.3	0.04	0.016	0.09	0.31
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	0.28	20.6	0.04	0.018	<0.02	0.30
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	0.36	22.0	0.05	0.025	0.13	0.38
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	0.34	20.6	0.05	0.120	0.05	0.35
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	0.32	22.5	0.04	0.130	0.04	0.43
S310	NM599	Riverside Drain at Rio Bravo	2/2/1999	0.40	20.8	0.04	0.134	<0.05	0.40
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	0.39	21.0	0.05	0.139	0.02	0.33
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	0.34	21.2	0.05	0.139	<0.02	0.42
S310	NM576	Riverside Drain at Rio Bravo	12/1/1998	0.40	22.1	0.05	0.162	<0.05	0.46
S310	NM588	Riverside Drain at Rio Bravo	1/5/1999	0.40	21.4	0.04	0.168	<0.05	0.31
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	0.39	21.8	0.05	0.178	0.02	0.34
S311	NM243	Stream in Monte Largo Canyon	5/28/1997	0.06	20.8	0.02	<0.001	<0.01	0.35
S312	NM554	Tijeras Arroyo at Four Hills	9/22/1998	0.66	18.4	0.10	0.002	1.16	0.49
S312	NM477	Tijeras Arroyo at Four Hills	7/23/1998	0.65	16.3	0.09	0.002	1.29	0.42
S312	NM614	Tijeras Arroyo at Four Hills	3/30/1999	0.50	13.2	0.05	0.003	1.07	0.70
S312	NM540	Tijeras Arroyo at Four Hills	8/18/1998	0.66	17.2	0.08	0.003	1.29	0.49
S312	NM566	Tijeras Arroyo at Four Hills	10/23/1998	0.69	17.3	0.09	0.004	1.12	0.95
S312	NM463	Tijeras Arroyo at Four Hills	6/11/1998	0.72	16.3	0.10	0.004	1.82	0.58
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	0.72	16.2	0.11	0.007	0.77	0.48
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	0.67	18.3	0.10	0.008	0.46	0.64

Table B3. Summary of minor-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Sr (mg/L)	SiO_2 (mg/L)	Fe (mg/L)	Mn (mg/L)	NO_3 as N (mg/L)	F (mg/L)
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	0.63	15.0	0.13	0.008	0.98	0.47
S312	NM434	Tijeras Arroyo at Four Hills	3/31/1998	0.67	16.9	0.12	0.010	2.08	0.37
S312	NM578	Tijeras Arroyo at Four Hills	12/1/1998	0.76	16.7	0.08	0.010	1.11	0.51
S312	NM601	Tijeras Arroyo at Four Hills	2/2/1999	0.76	14.7	0.07	0.011	1.31	0.61
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	0.66	17.8	0.11	0.011	0.52	0.57
S312	NM590	Tijeras Arroyo at Four Hills	1/5/1999	0.77	15.6	0.08	0.011	1.25	0.54
S312	NM449	Tijeras Arroyo at Four Hills	5/5/1998	0.72	14.7	0.12	0.014	2.17	0.35
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	0.54	15.6	0.13	0.017	0.49	0.57
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	0.66	14.7	0.09	0.018	0.70	0.55
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	0.72	15.6	0.12	0.019	0.89	0.62
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	0.70	16.2	0.11	0.020	0.77	0.55
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	0.71	16.7	0.12	0.021	0.60	0.62
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	0.69	15.9	0.13	0.023	0.81	0.50
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	0.68	17.3	0.11	0.026	0.61	0.60
S313	NM539	West Riverside drain at Rio Bravo	8/18/1998	0.31	20.2	0.04	0.044	<0.02	0.34
S313	NM476	West Riverside drain at Rio Bravo	7/22/1998	0.30	20.9	0.03	0.048	<0.02	0.36
S313	NM462	West Riverside drain at Rio Bravo	6/11/1998	0.31	20.6	0.03	0.056	<0.02	0.47
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	0.29	19.6	0.04	0.066	0.01	0.36
S313	NM433	West Riverside drain at Rio Bravo	3/31/1998	0.33	21.4	0.04	0.068	<0.02	0.34
S313	NM448	West Riverside drain at Rio Bravo	5/5/1998	0.33	19.6	0.04	0.069	<0.02	0.41
S313	NM613	West Riverside drain at Rio Bravo	3/30/1999	0.34	19.6	0.02	0.070	<0.05	0.44
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	0.37	21.1	0.05	0.084	0.02	0.36
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	0.30	22.7	0.03	0.087	<0.01	0.36
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	0.40	21.8	0.05	0.092	0.05	0.36
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	0.28	22.2	0.04	0.095	<0.02	0.43
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	0.33	20.5	0.06	0.100	0.03	0.33
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	0.39	19.9	0.03	0.105	0.03	0.35
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	0.33	21.4	0.04	0.110	0.04	0.43
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	0.31	23.1	0.04	0.110	<0.02	0.37
S313	NM565	West Riverside drain at Rio Bravo	10/20/1998	0.35	22.7	0.03	0.128	0.03	0.71
S313	NM600	West Riverside drain at Rio Bravo	2/2/1999	0.42	21.0	0.05	0.138	<0.05	0.55
S313	NM589	West Riverside drain at Rio Bravo	1/5/1999	0.42	21.8	0.04	0.147	<0.05	0.31
S313	NM577	West Riverside drain at Rio Bravo	12/1/1998	0.43	23.7	0.03	0.184	<0.05	0.43
S313	NM553	West Riverside drain at Rio Bravo	9/22/1998	0.34	23.1	0.04	0.208	0.03	0.41
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	0.47	17.5	0.05	0.009	0.20	0.36

Table B4. Summary of trace-element chemistry in surface water

[Al, aluminum; B, boron; Ba, barium; Li, lithium; Zn, zinc; Pb, lead; Cu, copper; Rb, rubidium; V, vanadium; Cr, chromium; Co, cobalt; Mo, molybdenum; As, arsenic; Se, selenium; U, uranium; Ag, silver; Cd, cadmium; mg/L, milligrams per liter; µg/L, micrograms per liter; nd, not determined]

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S290	NM194	Abo Arroyo at US 60	1/16/1997	3.	0.227	0.025	0.049	6	<0.05	2.0	0.2	6.6	<1	0.60	4.3	2.1	6	12.	nd	nd
S290	NM202	Abo Arroyo at US 60	3/12/1997	4.	0.218	0.031	0.048	4	<0.05	3.2	0.3	3.4	<1	0.40	3.9	1.4	5	16.	nd	nd
S291	NM366	Alameda Drain at Alameda	7/9/1997	1.	0.043	0.062	0.020	4	<0.05	0.9	2.0	4.3	<1	<0.1	3.3	2.0	<1	2.3	nd	nd
S291	NM220	Alameda Drain at Alameda	4/22/1997	4.	0.057	0.083	0.027	17	0.05	0.8	1.6	4.1	<1	0.20	3.8	2.6	<1	2.8	nd	nd
S291	NM428	Alameda Drain at Alameda	3/31/1998	5.	0.075	0.061	0.024	1	<0.05	0.8	1.3	4.6	<1	0.10	3.8	3.0	<1	3.4	<0.01	0.04
S291	NM381	Alameda Drain at Alameda	10/21/1997	6.	0.043	0.058	0.019	4	0.08	1.0	1.6	4.2	<1	0.09	3.0	2.9	<1	1.9	<0.01	0.05
S291	NM370	Alameda Drain at Alameda	9/16/1997	6.	0.045	0.078	0.022	4	<0.05	0.8	1.7	5.7	<1	0.10	3.9	3.3	<1	2.5	nd	nd
S291	NM443	Alameda Drain at Alameda	5/5/1998	6.	0.066	0.064	0.031	4	<0.05	0.8	1.9	4.1	<1	0.12	3.4	3.0	<1	3.1	<0.01	0.04
S291	NM471	Alameda Drain at Alameda	7/22/1998	7.	0.038	0.076	0.023	11	0.05	1.0	1.8	5.9	1.	0.13	3.8	3.4	<1	2.7	<0.01	0.03
S291	NM534	Alameda Drain at Alameda	8/18/1998	7.	0.040	0.084	0.026	2	<0.05	0.9	1.8	5.1	<1	0.13	3.6	3.2	<1	2.7	<0.01	0.02
S291	NM457	Alameda Drain at Alameda	6/11/1998	8.	0.039	0.057	0.023	4	0.05	1.0	1.7	3.3	<1	0.10	2.7	2.6	<1	2.1	<0.01	0.03
S291	NM548	Alameda Drain at Alameda	9/22/1998	9.	0.031	0.081	0.025	4	<0.05	0.8	1.8	4.5	<1	0.10	3.6	3.3	<1	2.4	0.02	<0.01
S292	NM602	Bear Canyon Arroyo	2/3/1999	1.	0.500	0.034	0.017	3	<0.05	0.4	0.4	0.9	<1	0.08	0.7	0.2	<1	5.4	0.08	0.02
S292	NM567	Bear Canyon Arroyo	10/23/1998	2.	0.371	0.053	0.024	10	<0.05	0.3	0.4	1.4	2.	0.14	0.8	0.3	<1	5.4	<0.01	0.01
S292	NM203	Bear Canyon Arroyo	3/19/1997	3.	0.012	0.047	0.018	4	<0.05	0.4	0.4	1.1	<1	0.10	0.8	0.5	<1	7.3	0.02	0.02
S292	NM354	Bear Canyon Arroyo	7/9/1997	3.	0.013	0.039	0.017	2	<0.05	0.5	0.4	1.3	<1	<0.1	0.9	0.2	<1	4.4	0.06	0.01
S292	NM216	Bear Canyon Arroyo	4/23/1997	3.	0.015	0.040	0.018	4	0.05	0.6	0.4	1.1	<1	<0.1	1.0	0.2	<1	5.1	0.01	0.02
S292	NM435	Bear Canyon Arroyo	3/31/1998	4.	0.011	0.026	0.015	4	<0.05	0.7	0.3	0.8	<1	0.07	0.7	0.2	<1	2.7	<0.01	<0.01
S292	NM229	Bear Canyon Arroyo	5/28/1997	4.	0.014	0.033	0.017	2	<0.05	0.5	0.3	0.9	<1	<0.1	0.9	0.2	<1	3.6	<0.01	0.02
S292	NM388	Bear Canyon Arroyo	10/23/1997	4.	0.015	0.053	0.022	5	0.05	0.8	0.5	0.9	2.	0.18	0.9	0.3	<1	7.1	0.01	0.02
S292	NM464	Bear Canyon Arroyo	6/11/1998	4.	0.357	0.030	0.018	6	0.05	0.5	0.3	1.1	<1	0.07	0.8	0.2	<1	2.7	<0.01	0.01
S292	NM478	Bear Canyon Arroyo	7/23/1998	4.	0.359	0.037	0.019	3	<0.05	0.4	0.6	1.6	2.	0.09	0.8	0.3	<1	3.8	<0.01	0.01
S292	NM541	Bear Canyon Arroyo	8/18/1998	4.	0.381	0.041	0.022	3	<0.05	0.5	0.4	1.0	<1	0.12	0.8	0.3	<1	4.1	<0.01	0.01
S292	NM555	Bear Canyon Arroyo	9/29/1998	4.	0.456	0.049	0.024	6	<0.05	0.6	0.7	0.9	<1	0.19	0.8	0.5	<1	5.7	<0.01	0.01
S292	NM421	Bear Canyon Arroyo	2/20/1998	4.	0.492	0.041	0.018	2	0.05	0.5	0.4	1.1	1.	0.08	0.8	0.2	<1	6.2	<0.01	0.01
S292	NM591	Bear Canyon Arroyo	1/5/1999	4.	0.532	0.037	0.019	2	<0.05	0.4	0.3	0.9	<1	0.10	0.7	0.2	<1	5.0	0.01	<0.01
S292	NM436	Bear Canyon Arroyo	3/31/1998	4.	0.570	0.027	0.015	1	<0.05	0.6	0.3	0.9	<1	0.07	0.7	0.2	<1	2.7	<0.01	0.01
S292	NM377	Bear Canyon Arroyo	9/18/1997	5.	0.020	0.054	0.023	22	0.09	0.4	0.6	1.3	<1	0.20	0.9	0.3	<1	6.7	<0.01	0.02
S292	NM450	Bear Canyon Arroyo	5/5/1998	7.	0.441	0.026	0.016	3	<0.05	0.4	0.3	0.9	<1	0.08	0.7	0.2	<1	2.4	0.01	0.01
S292	NM579	Bear Canyon Arroyo	12/1/1998	9.	0.501	0.115	0.022	5	<0.05	0.4	0.4	1.0	<1	0.11	0.7	0.2	<1	5.3	<0.01	0.01
S292	NM397	Bear Canyon Arroyo	11/18/1997	13.	0.018	0.051	0.021	4	0.10	1.3	0.5	0.9	2.	0.11	0.9	0.3	<1	7.2	<0.01	0.02
S292	NM406	Bear Canyon Arroyo	1/9/1998	30.	0.016	61.5	0.018	6	0.07	0.7	0.4	1.6	<1	0.15	0.8	0.2	<1	6.3	0.02	<0.01
S292	NM615	Bear Canyon Arroyo	4/2/1999	<1.	1.04	0.036	0.014	4	<0.05	0.5	0.4	0.9	<1	0.05	0.8	0.1	3	4.9	0.02	0.01
S293	NM244	Canyon del Trigo Stream	5/29/1997	4.	0.013	0.018	0.003	1	<0.05	1.0	0.1	0.2	<1	<0.1	0.4	0.3	<1	<0.1	0.01	0.01
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	2.	0.040	0.061	0.020	2	<0.05	0.9	2.1	4.4	<1	<0.1	3.2	2.9	<1	2.3	<0.01	0.01
S294	NM608	Chamizal Lateral at Alameda	3/30/1999	2.	0.142	0.065	0.022	2	<0.05	0.6	1.9	5.1	<1	0.10	4.5	3.2	<1	3.6	<0.01	0.01
S294	NM560	Chamizal Lateral at Alameda	10/20/1998	4.	0.042	0.094	0.026	4	<0.05	0.6	1.8	4.5	<1	0.08	3.9	3.2	<1	2.7	<0.01	<0.01
S294	NM427	Chamizal Lateral at Alameda	3/31/1998	4.	0.045	0.057	0.024	1	0.05	0.8	2.1	4.2	<1	0.10	3.8	3.0	<1	3.5	<0.01	0.02
S294	NM442	Chamizal Lateral at Alameda	5/5/1998	4.	0.053	0.062	0.030	3	0.07	0.8	2.0	3.9	<1	0.11	3.4	3.0	<1	3.0	0.05	<0.01
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	4.	0.054	0.072	0.027	4	<0.05	0.6	1.4	4.7	<1	0.10	4.7	2.8	<1	3.8	<0.01	0.01
S294	NM533	Chamizal Lateral at Alameda	8/18/1998	5.	0.044	0.078	0.026	2	<0.05	0.9	1.8	5.3	<1	0.10	3.6	3.3	<1	2.6	<0.01	0.01
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	5.	0.053	0.074	0.026	6	<0.05	0.8	1.9	4.7	<1	<0.1	3.7	2.8	<1	2.8	<0.01	0.01
S294	NM547	Chamizal Lateral at Alameda	9/22/1998	6.	0.035	0.077	0.024	2	<0.05	1.0	1.9	4.8	<1	0.09	3.6	3.5	<1	2.4	<0.01	<0.01
S294	NM456	Chamizal Lateral at Alameda	6/11/1998	6.	0.044	0.054	0.022	2	<0.05	0.9	1.7	3.5	<1	0.08	2.7	2.6	<1	2.2	<0.01	<0.01
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	6.	0.044	0.068	0.024	4	0.12	1.0	1.8	3.6	<1	0.10	2.8	2.5	<1	2.4	<0.01	0.01
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	6.	0.045	0.076	0.024	5	0.05	0.9	1.9	5.6	<1	0.10	3.9	3.4	<1	2.5	0.01	0.01
S294	NM470	Chamizal Lateral at Alameda	7/22/1998	6.	0.046	0.073	0.022	3	<0.05	0.9	1.8	5.4	1.	0.10	3.6	3.3	<1	2.6	<0.01	0.04

Table B4. Summary of trace-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	7.	0.040	0.059	0.020	6	0.07	0.9	1.7	4.1	<1	0.09	3.0	3.1	<1	1.9	<0.01	<0.01
S297	NM603	Jemez River below Jemez Canyon Dam	2/3/1999	4.	0.529	0.113	0.491	2	<0.05	1.3	12.	6.0	<1	0.16	4.0	26	1	2.5	<0.01	<0.01
S297	NM592	Jemez River below Jemez Canyon Dam	1/6/1999	4.	0.545	0.109	0.556	1	<0.05	1.1	11.	5.8	<1	0.14	3.7	24	1	2.3	<0.01	<0.01
S297	NM556	Jemez River below Jemez Canyon Dam	9/24/1998	5.	0.565	0.113	0.413	2	<0.05	1.6	12.	3.7	<1	0.17	4.1	23	1	2.0	<0.01	<0.01
S297	NM479	Jemez River below Jemez Canyon Dam	7/23/1998	7.	0.324	0.092	0.354	8	<0.05	2.0	12.	3.3	2.	0.22	3.4	24	<1	1.9	<0.01	0.01
S297	NM542	Jemez River below Jemez Canyon Dam	8/19/1998	7.	0.414	0.090	0.348	3	<0.05	0.7	12.	2.8	<1	0.22	3.3	25	<1	1.7	<0.01	<0.01
S297	NM465	Jemez River below Jemez Canyon Dam	6/12/1998	11.	0.221	0.077	0.364	2	<0.05	1.7	12.	3.8	<1	0.18	3.1	23	1	1.7	0.05	<0.01
S297	NM568	Jemez River below Jemez Canyon Dam	10/27/1998	14.	0.126	0.120	0.390	4	<0.05	0.7	12.	5.5	2.	0.14	4.2	23	1	2.1	<0.01	<0.01
S297	NM616	Jemez River below Jemez Canyon Dam	4/1/1999	14.	0.330	0.128	0.794	4	<0.05	0.5	14.	5.7	<1	0.15	4.5	28	2	2.6	<0.01	<0.01
S297	NM422	Jemez River below Jemez Canyon Dam	2/20/1998	19.	0.386	0.114	0.584	4	<0.05	1.3	13.	6.4	<1	0.13	4.3	27	1	2.8	<0.01	<0.01
S297	NM437	Jemez River below Jemez Canyon Dam	4/7/1998	30.	0.090	0.101	0.620	1	<0.05	1.4	15.	5.6	<1	0.11	3.8	25	1	2.4	<0.01	<0.01
S297	NM580	Jemez River below Jemez Canyon Dam	12/3/1998	32.	0.030	0.115	0.520	1	<0.05	1.1	11.	6.4	<1	0.17	3.7	24	1	2.3	<0.01	<0.01
S297	NM451	Jemez River below Jemez Canyon Dam	5/7/1998	388.	0.074	0.089	0.431	5	0.05	2.1	14.	4.9	<1	0.11	3.4	21	1	2.2	<0.01	0.02
S298	NM438	Jemez River at Jemez	4/7/1998	2.	0.530	0.051	0.103	2	0.05	1.1	13.	1.2	<1	0.10	1.0	9.8	<1	0.8	<0.01	<0.01
S298	NM593	Jemez River at Jemez	1/6/1999	3.	0.077	0.069	0.654	<1	<0.05	0.3	64.	1.6	<1	0.07	4.3	55	1	1.3	<0.01	0.02
S298	NM557	Jemez River at Jemez	9/24/1998	4.	0.044	0.092	0.608	2	<0.05	0.5	92.	2.3	<1	0.11	5.1	77	1	1.6	<0.01	0.03
S298	NM423	Jemez River at Jemez	2/20/1998	4.	0.520	0.068	0.517	4	<0.05	0.3	66.	2.0	<1	0.07	4.0	51	<1	1.7	<0.01	<0.01
S298	NM604	Jemez River at Jemez	2/3/1999	4.	1.57	0.071	0.598	1	<0.05	0.3	85.	2.1	<1	0.06	5.6	69	1	1.3	<0.01	0.02
S298	NM466	Jemez River at Jemez	6/12/1998	5.	0.336	0.080	0.264	5	<0.05	0.8	33.	1.6	<1	0.09	2.2	28	<1	1.3	<0.01	<0.01
S298	NM581	Jemez River at Jemez	12/3/1998	5.	0.830	0.063	0.384	1	<0.05	0.4	41.	1.3	<1	0.08	2.8	34	<1	1.2	<0.01	0.02
S298	NM617	Jemez River at Jemez	4/2/1999	5.	1.14	0.056	0.275	2	<0.05	1.1	34.	1.2	<1	0.10	2.1	26	1	0.9	<0.01	0.02
S298	NM480	Jemez River at Jemez	7/23/1998	8.	0.042	0.091	0.399	3	<0.05	0.4	70.	2.7	2.	0.11	4.2	62	<1	1.7	<0.01	<0.01
S298	NM543	Jemez River at Jemez	8/19/1998	10.	0.479	0.087	0.458	2	<0.05	0.4	66.	2.3	<1	0.12	3.8	56	<1	1.4	<0.01	0.03
S298	NM452	Jemez River at Jemez	5/7/1998	12.	0.208	0.051	0.073	5	0.23	1.0	8.4	1.2	<1	0.16	0.6	6.7	<1	0.6	<0.01	<0.01
S298	NM569	Jemez River at Jemez	10/27/1998	<5.	0.372	0.059	0.150	3	0.05	0.8	5.3	5.9	<1	0.08	1.6	14	<1	0.8	<0.01	0.02
S300	NM571	Rio Grande at Alameda	12/1/1998	1.	0.050	0.089	0.050	2	<0.05	0.8	1.9	4.4	<1	0.11	4.4	3.9	<1	3.6	<0.01	0.1
S300	NM583	Rio Grande at Alameda	1/5/1999	1.	0.052	0.079	0.056	2	<0.05	0.7	2.0	4.3	<1	0.10	4.6	4.2	<1	3.7	<0.01	0.03
S300	NM594	Rio Grande at Alameda	2/2/1999	1.	0.055	0.069	0.057	1	<0.05	0.7	2.4	4.4	<1	0.11	4.6	4.3	<1	3.7	0.05	0.04
S300	NM606	Rio Grande at Alameda	3/30/1999	1.	0.056	0.072	0.090	2	<0.05	0.7	2.4	5.3	<1	0.10	4.5	5.3	<1	3.3	<0.01	<0.01
S300	NM558	Rio Grande at Alameda	10/20/1998	3.	0.041	0.097	0.026	5	<0.05	1.1	1.4	4.4	<1	0.10	5.2	3.0	<1	2.6	<0.01	0.01
S300	NM413	Rio Grande at Alameda	2/19/1998	3.	0.043	0.064	0.046	2	0.12	1.1	2.2	4.0	<1	0.10	4.1	3.5	<1	3.8	<0.01	0.02
S300	NM545	Rio Grande at Alameda	9/22/1998	4.	0.039	0.074	0.017	2	<0.05	1.1	1.2	4.7	<1	0.09	3.4	2.6	<1	1.9	0.01	0.02
S300	NM425	Rio Grande at Alameda	3/31/1998	4.	0.047	0.055	0.053	1	0.06	0.8	2.2	4.3	<1	0.12	3.7	3.6	<1	2.9	0.03	0.04
S300	NM454	Rio Grande at Alameda	6/11/1998	4.	0.049	0.047	0.015	4	0.06	2.4	1.7	3.3	<1	0.09	2.9	1.9	<1	1.6	<0.01	0.01
S300	NM440	Rio Grande at Alameda	5/5/1998	4.	0.056	0.058	0.049	3	<0.05	1.0	2.2	3.6	<1	0.10	3.0	3.1	<1	2.3	<0.01	0.01
S300	NM187	Rio Grande at Alameda	1/14/1997	4.	0.060	0.089	0.030	31	0.12	1.3	1.9	4.1	<1	0.10	5.3	3.2	<1	4.2	<0.01	0.02
S300	NM206	Rio Grande at Alameda	3/18/1997	4.	0.114	0.079	0.084	4	<0.05	0.6	2.0	5.4	<1	0.10	4.7	4.6	<1	3.3	<0.01	0.02
S300	NM356	Rio Grande at Alameda	7/9/1997	5.	0.033	0.055	0.011	4	<0.05	1.2	1.6	4.4	<1	<0.1	2.8	2.2	<1	1.7	<0.01	0.02
S300	NM531	Rio Grande at Alameda	8/18/1998	5.	0.050	0.072	0.018	2	<0.05	1.1	1.3	6.1	<1	0.11	3.8	2.8	<1	2.3	<0.01	0.02
S300	NM195	Rio Grande at Alameda	2/11/1997	5.	0.070	0.079	0.042	6	<0.05	0.6	2.0	4.3	<1	0.10	4.9	3.1	<1	3.8	<0.01	0.01
S300	NM389	Rio Grande at Alameda	11/20/1997	6.	0.041	0.055	0.021	3	0.07	1.2	1.4	3.4	<1	0.55	3.3	2.8	<1	2.3	<0.01	0.02
S300	NM468	Rio Grande at Alameda	7/22/1998	6.	0.047	0.064	0.015	3	<0.05	1.3	1.6	5.7	<1	0.10	3.5	2.6	<1	2.3	0.02	0.01
S300	NM218	Rio Grande at Alameda	4/22/1997	6.	0.120	0.071	0.091	4	<0.05	1.0	2.6	5.1	<1	0.10	3.5	5.2	<1	2.3	<0.01	0.02
S300	NM231	Rio Grande at Alameda	5/21/1997	7.	0.053	0.064	0.034	2	<0.05	1.0	1.7	3.3	<1	0.10	2.3	2.5	<1	1.6	<0.01	0.03
S300	NM367	Rio Grande at Alameda	9/16/1997	8.	0.041	0.069	0.018	7	0.05	1.9	1.3	5.6	<1	<0.1	3.7	2.8	<1	2.1	<0.01	<0.01
S300	NM378	Rio Grande at Alameda	10/21/1997	9.	0.031	0.053	0.011	4	0.11	1.0	1.1	3.7	<1	0.07	2.4	2.0	<1	1.4	<0.01	0.02
S300	NM123	Rio Grande at Alameda	6/22/1996	10.	0.038	0.069	0.015	nd	0.20	0.2	nd	4.4	<1	nd	4.0	1.8	nd	1.8	<0.01	0.01
S300	NM118	Rio Grande at Alameda	6/29/1996	11.	0.055	0.061	0.017	nd	<0.1	<0.1	nd	4.4	<1	nd	3.4	2.3	nd	1.9	<0.01	0.01

Table B4. Summary of trace-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S300	NM398	Rio Grande at Alameda	1/8/1998	23.	0.098	0.062	0.058	5	0.11	0.9	1.9	4.4	<1	0.14	4.2	4.3	<1	3.1	<0.01	0.02
S301	NM585	Rio Grande at Campbell	1/5/1999	1.	0.049	0.079	0.058	3	<0.05	0.7	1.4	3.8	<1	0.10	4.4	3.6	<1	3.6	<0.01	<0.01
S301	NM596	Rio Grande at Campbell	2/2/1999	2.	0.053	0.070	0.059	1	<0.05	0.8	1.9	4.5	<1	0.10	4.4	4.4	<1	3.6	<0.01	0.07
S301	NM561	Rio Grande at Campbell	10/20/1998	3.	0.042	0.084	0.024	4	<0.05	0.9	1.3	4.2	<1	0.09	4.2	2.6	<1	2.4	<0.01	<0.01
S301	NM549	Rio Grande at Campbell	9/22/1998	4.	0.039	0.072	0.017	2	<0.05	0.8	1.2	4.1	<1	0.08	3.3	2.5	<1	1.8	<0.01	<0.01
S301	NM415	Rio Grande at Campbell	2/19/1998	4.	0.042	0.064	0.046	3	0.05	0.9	1.9	3.8	<1	0.10	4.0	3.3	<1	3.6	<0.01	0.02
S301	NM429	Rio Grande at Campbell	3/31/1998	4.	0.045	0.057	0.044	1	0.05	0.7	2.0	4.6	<1	0.10	3.7	3.8	<1	3.0	<0.01	0.01
S301	NM444	Rio Grande at Campbell	5/5/1998	4.	0.060	0.060	0.049	3	0.05	0.9	2.2	3.9	<1	0.11	3.0	3.3	<1	2.3	<0.01	0.01
S301	NM189	Rio Grande at Campbell	1/14/1997	4.	0.060	0.090	0.027	38	<0.05	0.8	1.5	4.0	<1	0.20	5.3	2.8	<1	4.1	<0.01	0.02
S301	NM197	Rio Grande at Campbell	2/11/1997	4.	0.071	0.079	0.041	4	<0.05	0.6	1.5	4.3	<1	0.20	4.9	3.2	<1	3.6	0.03	0.03
S301	NM208	Rio Grande at Campbell	3/18/1997	4.	0.118	0.084	0.088	4	<0.05	0.6	2.0	5.6	<1	0.10	4.9	4.7	<1	3.4	<0.01	0.03
S301	NM358	Rio Grande at Campbell	7/9/1997	5.	0.033	0.057	0.012	3	<0.05	1.1	1.7	4.4	<1	<0.1	2.8	2.2	<1	1.7	<0.01	0.02
S301	NM472	Rio Grande at Campbell	7/22/1998	5.	0.044	0.063	0.016	3	<0.05	1.2	1.8	5.5	1.	0.11	3.6	2.5	<1	2.3	<0.01	<0.01
S301	NM535	Rio Grande at Campbell	8/18/1998	5.	0.049	0.071	0.018	2	<0.05	1.1	1.4	5.2	<1	0.11	3.6	2.5	<1	2.3	<0.01	0.02
S301	NM458	Rio Grande at Campbell	6/11/1998	6.	0.060	0.049	0.016	4	0.06	1.9	1.6	3.3	<1	0.09	3.7	2.0	<1	1.6	<0.01	0.02
S301	NM221	Rio Grande at Campbell	4/22/1997	6.	0.123	0.074	0.093	4	0.07	0.9	2.4	5.3	<1	0.10	3.5	5.3	<1	2.3	<0.01	0.02
S301	NM391	Rio Grande at Campbell	11/20/1997	7.	0.036	0.058	0.018	2	0.06	0.9	1.1	3.1	<1	0.08	3.2	2.5	<1	2.3	<0.01	0.01
S301	NM233	Rio Grande at Campbell	5/21/1997	7.	0.052	0.064	0.035	1	0.05	0.9	1.7	3.4	<1	0.10	2.5	2.5	<1	1.6	<0.01	0.02
S301	NM382	Rio Grande at Campbell	10/21/1997	8.	0.029	0.051	0.010	2	0.05	0.8	1.0	3.8	<1	0.06	2.4	1.9	<1	1.3	<0.01	0.02
S301	NM371	Rio Grande at Campbell	9/16/1997	8.	0.041	0.070	0.018	4	<0.05	1.1	1.3	5.4	<1	0.20	3.6	2.8	<1	2.0	<0.01	0.02
S301	NM400	Rio Grande at Campbell	1/8/1998	29.	0.103	0.064	0.061	4	0.07	0.8	1.4	4.1	<1	0.10	4.1	4.2	<1	3.0	<0.01	0.01
S301	NM573	Rio Grande at Campbell	12/1/1998	<1.	0.048	0.088	0.047	2	<0.05	0.8	1.3	4.2	<1	0.10	4.4	3.3	<1	6.4	<0.01	<0.01
S301	NM609	Rio Grande at Campbell	3/30/1999	<1.	0.055	0.077	0.094	2	<0.05	0.6	2.4	4.7	<1	0.09	4.5	5.0	<1	3.2	<0.01	0.01
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	16.	0.069	0.065	0.026	nd	<0.1	<0.1	nd	5.1	<1	nd	6.9	3.0	nd	2.1	<0.01	0.01
S303	NM575	Rio Grande at Rio Bravo	12/1/1998	1.	0.050	0.085	0.034	2	<0.05	0.9	1.3	4.1	<1	0.09	4.2	3.0	<1	3.3	nd	0.02
S303	NM598	Rio Grande at Rio Bravo	2/2/1999	2.	0.050	0.079	0.073	2	<0.05	0.8	1.7	4.3	<1	0.11	4.4	4.7	<1	3.6	nd	0.01
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	3.	0.044	0.069	0.043	2	0.13	1.0	1.7	3.9	<1	0.10	4.0	3.3	<1	3.7	<0.01	<0.01
S303	NM446	Rio Grande at Rio Bravo	5/5/1998	3.	0.057	0.063	0.049	3	0.07	1.0	2.0	4.1	<1	0.13	3.2	3.4	<1	2.4	nd	0.01
S303	NM563	Rio Grande at Rio Bravo	10/20/1998	4.	0.041	0.064	0.019	5	0.19	1.6	2.0	4.3	<1	0.12	3.4	2.8	<1	1.7	nd	0.01
S303	NM551	Rio Grande at Rio Bravo	9/22/1998	4.	0.041	0.073	0.019	2	<0.05	0.9	1.5	4.5	<1	0.09	3.4	2.7	<1	1.9	nd	0.01
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	4.	0.061	0.093	0.028	34	0.05	0.8	1.4	4.1	<1	0.30	5.1	3.1	<1	4.2	<0.01	0.01
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	5.	0.032	0.057	0.012	2	<0.05	1.1	1.8	4.4	<1	<0.1	2.9	2.3	<1	1.7	<0.01	<0.01
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	5.	0.039	0.061	0.020	2	0.05	0.9	1.2	3.3	<1	0.07	3.4	2.7	<1	2.2	<0.01	<0.01
S303	NM474	Rio Grande at Rio Bravo	7/22/1998	5.	0.045	0.065	0.018	3	<0.05	1.2	2.0	5.2	1.	0.12	3.5	2.6	<1	2.3	nd	0.01
S303	NM460	Rio Grande at Rio Bravo	6/11/1998	5.	0.051	0.049	0.016	3	0.05	1.1	1.4	3.2	<1	0.07	2.4	1.9	<1	1.6	nd	0.01
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	5.	0.070	0.083	0.039	5	0.05	0.7	1.5	4.2	<1	0.10	4.8	3.2	<1	3.7	<0.01	0.01
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	5.	0.126	0.089	0.093	7	<0.05	0.8	1.9	5.2	<1	0.10	4.9	4.4	<1	3.4	0.02	0.01
S303	NM537	Rio Grande at Rio Bravo	8/18/1998	6.	0.050	0.071	0.020	2	<0.05	1.0	1.6	5.1	<1	0.11	3.6	2.7	<1	2.3	nd	0.01
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	6.	0.133	0.080	0.100	9	<0.05	0.9	2.2	5.1	<1	0.10	3.6	5.1	<1	2.3	<0.01	0.01
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	7.	0.054	0.065	0.036	2	<0.05	0.9	1.6	3.4	<1	0.10	2.4	2.6	<1	1.7	<0.01	<0.01
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	8.	0.030	0.053	0.012	5	0.08	0.9	1.1	4.1	<1	0.10	2.5	2.2	<1	1.4	<0.01	0.01
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	8.	0.043	0.070	0.020	4	<0.05	1.0	1.4	5.3	<1	0.10	3.7	2.8	<1	2.0	<0.01	<0.01
S303	NM431	Rio Grande at Rio Bravo	3/31/1998	13.	0.045	0.061	0.052	2	0.10	0.9	1.9	4.4	<1	0.11	3.7	3.7	<1	3.0	<0.01	<0.01
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	19.	0.053	0.082	0.020	nd	<0.1	<0.1	nd	4.9	<1	nd	3.6	2.6	nd	2.1	<0.01	0.01
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	21.	0.103	0.069	0.059	3	0.05	0.8	1.3	3.8	1.	0.09	4.1	3.9	<1	2.9	<0.01	<0.01
S303	NM587	Rio Grande at Rio Bravo	1/5/1999	<1.	0.047	0.080	0.047	2	<0.05	0.7	1.3	3.7	<1	0.10	4.3	3.1	<1	3.4	nd	0.01
S303	NM611	Rio Grande at Rio Bravo	3/30/1999	<1.	0.053	0.075	0.061	3	<0.05	0.6	2.1	4.5	<1	0.09	4.4	3.9	<1	3.3	nd	0.01
S304	NM122	Rio Grande at San Felipe	6/22/1996	28.	0.036	0.068	0.015	nd	0.20	0.2	nd	3.2	<1	nd	3.3	1.8	nd	1.7	nd	<0.01

Table B4. Summary of trace-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S305	NM120	Rio Grande at Central	6/29/1996	8.	0.059	0.083	0.015	nd	<0.1	<0.1	nd	4.9	<1	nd	3.7	1.8	nd	1.8	nd	<0.01
S306	NM119	Rio Grande at Nature Center	6/29/1996	8.	0.057	0.088	0.015	nd	<0.1	<0.1	nd	4.7	<1	nd	3.6	1.8	nd	1.8	nd	<0.01
S307	NM582	Rio Puerco at Hwy 6	12/3/1998	2.	0.070	0.044	0.577	<5	<0.05	2.7	11.	2.6	<5	0.22	4.4	8.7	7	7.5	nd	0.01
S307	NM605	Rio Puerco at Hwy 6	2/3/1999	2.	0.132	0.049	1.09	5	<0.05	4.6	19.	2.5	<5	0.24	4.7	12	9	12	nd	0.02
S307	NM570	Rio Puerco at Hwy 6	10/23/1998	4.	0.068	0.036	0.251	2	<0.05	2.8	4.4	1.9	<5	0.28	5.3	2.4	5	5.8	nd	0.01
S307	NM439	Rio Puerco at Hwy 6	4/7/1998	5.	0.065	0.056	0.520	2	<0.05	5.3	3.7	2.2	<1	0.32	4.5	5.5	5	18	nd	0.06
S307	NM424	Rio Puerco at Hwy 6	2/20/1998	5.	0.077	0.040	0.617	<1	0.06	4.8	7.9	2.3	<1	0.34	4.4	8.0	5	10	nd	0.03
S307	NM544	Rio Puerco at Hwy 6	8/19/1998	6.	0.029	0.100	0.341	<5	<0.05	6.5	2.7	1.2	<5	0.24	8.5	1.7	6	9.3	nd	0.02
S307	NM453	Rio Puerco at Hwy 6	5/7/1998	8.	0.036	0.045	0.138	3	<0.05	5.3	1.6	1.0	<1	0.27	9.3	1.2	4	13	nd	0.04
S307	NM467	Rio Puerco at Hwy 6	6/12/1998	9.	0.041	0.073	0.262	2	<0.05	5.4	2.1	1.3	1.	0.38	8.9	1.5	4	12	nd	0.01
S307	NM618	Rio Puerco at Hwy 6	4/2/1999	nd	nd	0.040	0.714	<5	<0.25	3.2	18.	2.8	<5	<0.2	5.2	11	<5	10	nd	0.02
S308	NM607	Riverside Drain at Alameda	3/30/1999	1.	0.050	0.069	0.026	2	<0.05	0.6	1.9	4.8	<1	0.10	4.3	3.3	<1	3.6	0.02	0.01
S308	NM572	Riverside Drain at Alameda	12/1/1998	2.	0.063	0.094	0.036	2	<0.05	0.9	2.0	4.4	<1	0.09	3.7	3.5	<1	3.2	<0.01	0.01
S308	NM559	Riverside Drain at Alameda	10/20/1998	3.	0.042	0.092	0.026	3	<0.05	0.7	1.9	4.7	<1	0.07	3.9	3.3	<1	2.7	0.03	0.02
S308	NM584	Riverside Drain at Alameda	1/5/1999	3.	0.073	0.092	0.037	2	<0.05	0.8	1.8	3.8	<1	0.08	3.8	3.4	<1	3.7	0.15	0.02
S308	NM595	Riverside Drain at Alameda	2/2/1999	3.	0.078	0.084	0.034	1	<0.05	0.8	1.8	3.8	<1	0.08	3.9	3.4	<1	3.9	0.09	0.02
S308	NM357	Riverside Drain at Alameda	7/9/1997	4.	0.043	0.064	0.023	11	0.09	0.9	2.0	4.4	<1	<0.1	3.3	3.2	<1	2.3	nd	0.03
S308	NM532	Riverside Drain at Alameda	8/18/1998	4.	0.043	0.077	0.027	2	0.05	0.9	1.9	5.2	<1	0.11	3.6	3.5	<1	2.4	0.17	<0.01
S308	NM426	Riverside Drain at Alameda	3/31/1998	4.	0.044	0.062	0.026	1	<0.05	0.8	2.0	4.3	<1	0.09	3.8	3.2	<1	3.3	0.06	0.02
S308	NM441	Riverside Drain at Alameda	5/5/1998	4.	0.052	0.066	0.031	3	0.05	0.9	1.9	4.0	<1	0.10	3.4	3.1	<1	3.1	0.03	0.02
S308	NM232	Riverside Drain at Alameda	5/21/1997	4.	0.057	0.072	0.032	2	<0.05	0.9	1.9	3.7	<1	0.10	3.1	2.9	<1	2.6	nd	0.03
S308	NM188	Riverside Drain at Alameda	1/14/1997	4.	0.058	0.107	0.032	31	0.09	1.4	2.0	3.7	<1	0.10	4.4	3.3	<1	4.6	nd	0.02
S308	NM196	Riverside Drain at Alameda	2/11/1997	4.	0.066	0.106	0.034	5	<0.05	0.8	1.8	3.4	<1	0.10	4.3	3.3	<1	4.4	nd	<0.01
S308	NM455	Riverside Drain at Alameda	6/11/1998	4.	0.079	0.061	0.027	3	<0.05	0.9	1.7	3.8	<1	0.07	2.9	3.1	<1	2.3	0.02	0.02
S308	NM546	Riverside Drain at Alameda	9/22/1998	5.	0.035	0.077	0.026	2	<0.05	0.9	2.0	4.7	<1	0.10	3.7	3.5	<1	2.3	<0.01	0.03
S308	NM469	Riverside Drain at Alameda	7/22/1998	5.	0.049	0.072	0.024	3	<0.05	1.0	1.8	5.3	1.	0.10	3.6	3.4	<1	2.5	<0.01	0.01
S308	NM207	Riverside Drain at Alameda	3/18/1997	5.	0.059	0.082	0.029	13	<0.05	0.6	1.8	4.7	<1	0.10	4.6	3.0	<1	3.9	nd	0.02
S308	NM414	Riverside Drain at Alameda	2/19/1998	5.	0.060	0.084	0.033	2	0.24	0.9	1.9	4.1	2.	0.14	4.1	4.0	<1	4.1	<0.01	0.02
S308	NM219	Riverside Drain at Alameda	4/22/1997	5.	0.063	0.078	0.031	14	<0.05	0.8	2.0	4.6	<1	<0.1	3.8	3.1	<1	2.9	nd	<0.01
S308	NM379	Riverside Drain at Alameda	10/21/1997	6.	0.049	0.063	0.024	4	<0.05	0.8	2.0	4.3	<1	0.07	3.5	3.4	<1	2.0	<0.01	0.02
S308	NM368	Riverside Drain at Alameda	9/16/1997	6.	0.049	0.075	0.026	8	<0.05	1.0	2.1	2.3	<1	<0.1	4.1	3.5	<1	2.3	0.02	0.02
S308	NM390	Riverside Drain at Alameda	11/20/1997	7.	0.049	0.073	0.031	2	<0.05	0.9	2.3	4.5	<1	0.08	4.0	4.4	<1	2.5	<0.01	0.02
S308	NM399	Riverside Drain at Alameda	1/8/1998	22.	0.067	0.084	0.030	5	<0.05	0.9	1.7	4.1	<1	0.09	4.2	3.9	<1	2.8	<0.01	0.05
S309	NM574	Riverside Drain at Campbell	12/1/1998	2.	0.050	0.092	0.034	2	<0.05	0.7	1.9	4.5	<1	0.08	3.6	3.6	<1	2.9	<0.01	0.01
S309	NM586a	Riverside Drain at Campbell	1/5/1999	2.	0.065	0.089	0.036	2	<0.05	0.7	1.7	3.7	<1	0.08	3.6	3.4	<1	3.5	<0.01	0.01
S309	NM359	Riverside Drain at Campbell	7/9/1997	3.	0.043	0.064	0.024	10	<0.05	1.0	2.0	4.4	<1	0.20	3.4	3.2	<1	2.2	0.03	0.01
S309	NM597	Riverside Drain at Campbell	2/2/1999	3.	0.091	0.082	0.032	2	<0.05	0.8	1.7	3.7	<1	0.07	3.7	3.4	<1	3.9	<0.01	<0.01
S309	NM610	Riverside Drain at Campbell	3/30/1999	3.	0.100	0.070	0.026	3	<0.05	0.6	1.8	4.6	<1	0.08	4.3	3.2	<1	3.6	<0.01	0.02
S309	NM190	Riverside Drain at Campbell	1/14/1997	4.	0.055	0.104	0.031	33	<0.05	0.8	2.1	3.5	<1	0.10	4.3	3.4	<1	5.1	0.02	0.02
S309	NM209	Riverside Drain at Campbell	3/18/1997	4.	0.060	0.083	0.030	4	<0.05	0.6	1.7	4.6	<1	0.10	4.6	3.0	<1	3.9	0.05	0.02
S309	NM198	Riverside Drain at Campbell	2/11/1997	4.	0.063	0.107	0.033	5	0.06	0.8	1.9	3.2	<1	0.10	4.2	3.4	<1	5.0	0.07	0.02
S309	NM383	Riverside Drain at Campbell	10/21/1997	5.	0.049	0.063	0.025	6	0.05	0.7	1.9	4.5	<1	0.08	3.6	3.5	<1	1.9	<0.01	<0.01
S309	NM234	Riverside Drain at Campbell	5/21/1997	5.	0.059	0.072	0.033	2	<0.05	0.8	1.8	3.7	<1	0.10	3.2	2.9	<1	2.6	0.03	0.02
S309	NM222	Riverside Drain at Campbell	4/22/1997	5.	0.066	0.079	0.032	11	<0.05	0.8	1.9	4.6	<1	<0.1	3.8	3.1	<1	2.9	0.05	0.02
S309	NM550	Riverside Drain at Campbell	9/22/1998	6.	0.032	0.077	0.027	3	<0.05	1.0	2.0	4.6	<1	0.08	3.7	3.6	<1	2.2	<0.01	0.02
S309	NM562	Riverside Drain at Campbell	10/20/1998	6.	0.041	0.088	0.027	3	<0.05	0.7	1.9	4.8	<1	0.07	3.9	3.4	<1	2.5	<0.01	0.02
S309	NM372	Riverside Drain at Campbell	9/16/1997	6.	0.050	0.075	0.026	6	0.05	0.8	2.0	5.3	<1	0.10	4.3	3.7	<1	2.3	0.01	0.02
S309	NM416	Riverside Drain at Campbell	2/19/1998	6.	0.058	0.083	0.031	2	0.06	0.8	1.8	3.9	<1	<0.05	3.8	3.9	<1	3.9	<0.05	<0.05

Table B4. Summary of trace-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S309	NM445	Riverside Drain at Campbell	5/5/1998	6.	0.068	0.067	0.034	4	<0.05	0.8	1.9	3.9	<1	0.10	3.4	3.2	<1	3.1	<0.01	0.02
S309	NM459	Riverside Drain at Campbell	6/11/1998	7.	0.036	0.062	0.028	4	<0.05	0.9	1.6	3.8	<1	0.08	2.9	3.0	<1	2.3	<0.01	0.02
S309	NM473	Riverside Drain at Campbell	7/22/1998	7.	0.041	0.074	0.024	3	<0.05	0.9	1.8	5.4	1.	0.13	3.6	3.6	<1	2.5	<0.01	0.02
S309	NM536	Riverside Drain at Campbell	8/18/1998	7.	0.043	0.077	0.029	3	<0.05	0.8	1.9	4.9	<1	0.23	3.6	3.5	<1	2.4	<0.01	0.02
S309	NM392	Riverside Drain at Campbell	11/20/1997	7.	0.044	0.073	0.029	5	<0.05	0.9	2.1	4.7	<1	0.08	4.1	4.4	<1	2.2	<0.01	0.02
S309	NM401	Riverside Drain at Campbell	1/8/1998	20.	0.062	0.082	0.028	4	<0.05	0.7	1.7	4.3	<1	0.08	4.0	4.1	<1	2.8	<0.01	0.01
S309	NM430	Riverside Drain at Campbell	3/31/1998	20.	0.071	0.062	0.026	2	<0.05	0.8	1.9	4.2	<1	9.0	3.7	3.3	<1	3.4	<0.01	0.01
S309	NM586	Riverside Drain at Campbell	1/5/1999	<1.	0.050	0.091	0.036	2	<0.05	0.7	1.7	3.7	<1	0.08	3.6	3.4	<1	3.6	<0.01	0.02
S310	NM612	Riverside Drain at Rio Bravo	3/30/1999	1.	0.060	0.073	0.024	2	<0.05	0.6	1.6	4.3	<1	0.09	4.3	3.1	<1	3.5	<0.05	<0.05
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	2.	0.046	0.067	0.024	2	<0.05	0.8	2.0	4.8	<1	<0.1	3.5	3.4	<1	2.4	<0.01	0.02
S310	NM599	Riverside Drain at Rio Bravo	2/2/1999	2.	0.054	0.088	0.033	1	<0.05	0.6	1.9	3.6	<1	0.10	3.5	4.3	<1	2.6	<0.05	<0.05
S310	NM564	Riverside Drain at Rio Bravo	10/20/1998	3.	0.049	0.082	0.025	4	0.10	0.8	2.0	4.5	<1	0.12	3.6	3.2	<1	2.4	<0.05	<0.05
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	3.	0.060	0.089	0.030	4	<0.05	1.0	1.6	4.6	<1	0.80	4.7	3.1	<1	3.9	<0.01	0.01
S310	NM447	Riverside Drain at Rio Bravo	5/5/1998	3.	0.066	0.069	0.033	3	<0.05	0.8	1.8	3.9	<1	0.11	3.7	3.3	<1	3.1	<0.01	0.02
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	4.	0.045	0.089	0.033	1	0.05	0.6	1.9	3.4	<1	0.09	4.0	4.5	<1	2.5	<0.01	0.02
S310	NM538	Riverside Drain at Rio Bravo	8/18/1998	4.	0.053	0.082	0.029	2	<0.05	0.8	1.8	4.9	<1	0.10	3.7	3.4	<1	2.5	<0.05	<0.05
S310	NM475	Riverside Drain at Rio Bravo	7/22/1998	4.	0.054	0.077	0.024	4	<0.05	0.8	1.8	5.2	1.	0.11	3.6	3.4	<1	2.5	<0.05	<0.05
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	4.	0.057	0.076	0.031	2	<0.05	0.7	1.8	3.6	<1	0.10	3.2	3.1	<1	2.6	<0.01	0.02
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	4.	0.059	0.107	0.034	26	<0.05	0.4	1.9	2.9	<1	0.20	3.7	4.1	<1	2.8	<0.01	0.02
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	4.	0.061	0.104	0.034	5	<0.05	0.5	1.9	2.8	<1	0.10	3.7	4.1	<1	2.9	<0.01	0.04
S310	NM461	Riverside Drain at Rio Bravo	6/11/1998	4.	0.063	0.064	0.027	5	0.07	0.9	1.6	3.8	<1	0.11	2.9	3.0	<1	2.3	<0.05	<0.05
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	4.	0.064	0.079	0.030	5	<0.05	0.8	1.8	4.4	<1	<0.1	3.8	3.0	<1	2.9	<0.01	0.12
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	5.	0.050	0.067	0.024	9	<0.05	0.6	1.8	4.3	<1	0.08	3.6	3.5	<1	1.9	<0.01	0.01
S310	NM552	Riverside Drain at Rio Bravo	9/22/1998	5.	0.051	0.077	0.024	3	<0.05	1.0	2.0	4.8	<1	0.06	3.7	3.4	<1	2.4	<0.05	<0.05
S310	NM432	Riverside Drain at Rio Bravo	3/31/1998	6.	0.050	0.065	0.026	2	0.06	0.8	1.7	4.1	<1	0.12	3.9	3.2	<1	3.3	<0.01	<0.01
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	6.	0.050	0.079	0.026	6	<0.05	0.7	1.9	5.1	<1	<0.1	4.1	3.5	<1	2.4	<0.01	0.03
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	8.	0.054	0.086	0.033	2	<0.05	0.6	2.0	3.0	<1	0.11	4.3	5.0	<1	1.8	<0.01	0.02
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	22.	0.072	0.090	0.035	4	<0.05	0.4	1.8	3.4	<1	0.10	4.2	4.8	<1	1.8	<0.01	<0.01
S310	NM588	Riverside Drain at Rio Bravo	1/5/1999	<1.	0.052	0.089	0.036	1	<0.05	0.4	1.7	3.0	<1	0.10	3.4	4.0	<1	2.2	<0.05	<0.05
S310	NM576	Riverside Drain at Rio Bravo	12/1/1998	<1.	0.053	0.082	0.037	1	<0.05	0.4	1.8	3.1	<1	0.09	3.6	4.4	<1	2.0	<0.05	<0.05
S311	NM243	Stream in Monte Largo Canyon	5/28/1997	4.	0.013	0.015	0.004	1	<0.05	1.0	0.1	0.4	<1	<0.1	0.8	0.2	<1	<0.1	<0.05	<0.05
S312	NM590	Tijeras Arroyo at Four Hills	1/5/1999	1.	0.003	0.106	0.026	3	<0.05	1.0	0.7	1.0	<1	0.19	1.3	0.7	3	6.4	<0.01	<0.05
S312	NM601	Tijeras Arroyo at Four Hills	2/2/1999	1.	0.005	0.103	0.023	3	<0.05	1.2	0.8	1.2	<1	0.19	1.4	0.8	3	6.9	<0.01	<0.05
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	2.	0.016	0.045	0.010	2	<0.05	0.2	0.5	1.1	<1	<0.1	0.6	0.5	2	2.6	<0.01	<0.05
S312	NM614	Tijeras Arroyo at Four Hills	3/30/1999	2.	<0.02	0.109	0.021	4	<0.05	0.6	1.0	1.6	<1	0.13	1.3	0.8	<1	6.8	<0.01	<0.05
S312	NM566	Tijeras Arroyo at Four Hills	10/23/1998	3.	0.016	0.126	0.028	5	<0.05	0.7	0.9	2.0	3.	0.15	1.5	0.9	3	5.8	<0.01	<0.05
S312	NM477	Tijeras Arroyo at Four Hills	7/23/1998	3.	0.021	0.102	0.023	4	<0.05	1.7	1.0	1.8	2.	0.16	1.4	0.9	3	5.6	<0.01	<0.05
S312	NM554	Tijeras Arroyo at Four Hills	9/22/1998	3.	<0.005	0.114	0.029	3	0.05	1.2	1.2	1.8	<1	0.18	1.6	1.3	3	5.8	<0.01	<0.05
S312	NM540	Tijeras Arroyo at Four Hills	8/18/1998	4.	0.005	0.114	0.026	2	0.14	1.7	1.2	1.9	<1	0.18	1.4	1.0	3	5.4	0.01	<0.05
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	4.	0.006	0.120	0.025	3	<0.05	0.8	0.9	1.2	2.	0.15	1.3	0.6	2	8.1	<0.01	<0.05
S312	NM434	Tijeras Arroyo at Four Hills	3/31/1998	4.	0.011	0.127	0.023	2	0.49	1.1	0.8	1.6	5.	0.21	1.5	0.8	3	6.2	0.02	<0.05
S312	NM449	Tijeras Arroyo at Four Hills	5/5/1998	4.	0.017	0.124	0.025	4	0.05	1.0	0.9	1.3	6.	0.20	1.5	0.9	4	6.0	<0.01	<0.05
S312	NM463	Tijeras Arroyo at Four Hills	6/11/1998	4.	0.020	0.122	0.024	16	<0.05	1.1	1.0	1.6	4.	0.20	1.2	0.9	4	5.8	<0.01	<0.05
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	4.	0.055	0.119	0.026	3	<0.05	0.7	0.9	1.6	<1	0.40	1.4	0.8	3	6.6	<0.01	<0.05
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	4.	0.057	0.125	0.027	7	<0.05	0.8	1.1	1.6	<1	0.30	1.4	1.0	2	8.6	<0.05	<0.05
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	4.	0.057	0.129	0.026	6	<0.05	0.6	0.9	1.8	<1	0.10	1.4	0.9	3	7.8	<0.05	<0.05
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	4.	0.061	0.128	0.027	13	0.06	0.8	1.0	1.9	<1	0.20	1.8	0.9	3	7.0	<0.01	<0.05
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	6.	0.056	0.126	0.026	7	<0.05	0.7	1.0	1.7	<1	0.30	1.4	0.9	2	8.0	<0.05	<0.05

Table B4. Summary of trace-element chemistry in surface water-- Continued

Site no.	Sample no.	Site name	Date	Al (µg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Rb (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Mo (µg/L)	As (µg/L)	Se (µg/L)	U (µg/L)	Ag (µg/L)	Cd (µg/L)
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	12.	0.110	0.222	0.051	35	0.26	1.9	2.1	3.9	3.	0.35	3.4	1.2	4	13	<0.01	<0.05
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	13.	0.125	0.225	0.054	23	0.38	2.5	2.4	5.1	<1	0.30	3.7	1.8	4	12	<0.01	<0.05
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	58.	0.055	0.115	0.024	6	<0.05	0.8	0.7	1.2	<1	0.17	1.4	0.8	3	7.1	<0.01	<0.05
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	155.	0.063	0.121	0.027	4	0.09	1.0	0.9	1.3	<1	0.19	2.0	1.4	2	6.7	<0.01	<0.05
S312	NM578	Tijeras Arroyo at Four Hills	12/1/1998	<1.	0.007	0.044	0.026	2	<0.05	0.8	0.8	1.2	<1	0.22	1.4	0.9	3	6.2	<0.01	<0.05
S313	NM577	West Riverside drain at Rio Bravo	12/1/1998	1.	0.044	0.113	0.041	2	<0.05	0.5	2.4	2.7	<1	0.10	3.6	5.4	<1	2.2	<0.01	<0.05
S313	NM613	West Riverside drain at Rio Bravo	3/30/1999	1.	0.045	0.077	0.032	2	<0.05	0.5	2.1	3.0	<1	0.08	4.1	4.2	<1	3.4	nd	nd
S313	NM600	West Riverside drain at Rio Bravo	2/2/1999	2.	0.040	0.079	0.037	1	<0.05	0.6	2.4	2.4	<1	0.07	3.8	4.9	<1	3.2	nd	nd
S313	NM589	West Riverside drain at Rio Bravo	1/5/1999	2.	0.040	0.080	0.040	1	<0.05	0.4	2.2	2.3	<1	0.14	3.5	4.9	<1	2.6	<0.05	<0.25
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	3.	0.053	0.060	0.032	2	<0.05	0.6	1.9	4.1	<1	<0.1	4.0	4.7	<1	2.3	<0.01	<0.05
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	3.	0.063	0.092	0.034	5	<0.05	0.5	2.2	3.5	<1	0.20	4.6	4.0	<1	4.0	<0.01	<0.05
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	4.	0.036	0.073	0.035	2	0.05	0.6	2.2	2.9	<1	0.11	3.8	5.4	<1	3.1	<0.01	<0.05
S313	NM565	West Riverside drain at Rio Bravo	10/20/1998	4.	0.057	0.089	0.034	4	<0.05	0.4	2.4	3.4	<1	0.08	3.9	5.2	<1	2.1	<0.01	<0.05
S313	NM448	West Riverside drain at Rio Bravo	5/5/1998	4.	0.058	0.069	0.041	4	<0.05	0.6	1.9	3.1	<1	0.10	3.7	4.5	<1	3.3	<0.01	<0.05
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	4.	0.079	0.080	0.044	1	<0.05	0.6	2.0	2.8	<1	0.10	4.0	4.2	<1	3.0	<0.01	<0.05
S313	NM433	West Riverside drain at Rio Bravo	3/31/1998	5.	0.046	0.068	0.032	<1	0.06	0.6	1.9	3.3	<1	0.09	3.8	4.2	<1	3.2	<0.01	<0.05
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	5.	0.051	0.067	0.032	2	<0.05	0.5	2.2	3.2	<1	0.08	4.2	6.2	<1	1.7	<0.01	<0.05
S313	NM476	West Riverside drain at Rio Bravo	7/22/1998	5.	0.054	0.063	0.034	3	<0.05	0.6	1.8	4.4	<1	0.10	3.6	5.2	<1	2.4	<0.01	<0.05
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	5.	0.058	0.072	0.033	3	<0.05	0.5	2.1	4.1	<1	0.10	4.4	5.3	<1	2.0	<0.01	<0.05
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	5.	0.065	0.070	0.034	4	<0.05	0.4	2.3	3.7	<1	0.10	4.5	6.1	<1	1.7	<0.01	<0.05
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	5.	0.079	0.093	0.039	9	<0.05	0.5	2.2	3.8	<1	0.10	4.9	4.2	<1	3.7	<0.01	<0.05
S313	NM553	West Riverside drain at Rio Bravo	9/22/1998	6.	0.045	0.088	0.035	4	<0.05	0.5	2.4	4.9	<1	0.11	4.6	5.6	<1	2.8	<0.01	<0.05
S313	NM462	West Riverside drain at Rio Bravo	6/11/1998	8.	0.058	0.066	0.039	3	<0.05	0.6	1.8	3.4	<1	0.08	3.4	4.4	<1	2.7	<0.01	<0.05
S313	NM539	West Riverside drain at Rio Bravo	8/18/1998	14.	0.039	0.069	0.035	2	<0.05	0.6	2.0	3.6	<1	0.10	3.6	4.9	<1	2.2	<0.01	<0.05
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	18.	0.071	0.074	0.034	3	<0.05	0.5	2.0	3.2	<1	0.09	4.0	5.5	<1	2.1	<0.01	<0.05
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	12.	0.051	0.080	0.018	nd	<0.1	<0.1	nd	4.8	<1	nd	3.7	2.0	nd	1.8	nd	nd

Table B5. Summary of chlorofluorocarbon concentrations in surface water

[CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane (CF_2Cl_2); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); pg/kg, picograms per kilogram; °C, degrees Celsius; pptv, parts per trillion by volume; nd, not determined; Modern concentrations of CFC-11, CFC-12, and CFC-113 assumed to be 270, 543, and 84 pptv, respectively]

Site no.	Sample no.	Site name	Date	Recharge temp-erature (°C)	Recharge altitude (feet)	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
S290	NM194	Abo Arroyo at US 60	1/16/1997	0.4	5,730	878	504	151	210	561	82	78	103	99
S290	NM202	Abo Arroyo at US 60	3/12/1997	7.9	5,730	766	673	119	292	1135	107	108	209	129
S291	NM220	Alameda Drain at Alameda	4/22/1997	13.4	4,995	738	380	87	369	816	107	137	150	129
S291	NM381	Alameda Drain at Alameda	10/21/1997	13.8	4,995	586	331	76	296	716	93	110	132	112
S291	NM370	Alameda Drain at Alameda	9/16/1997	20.8	4,995	464	276	53	329	810	95	122	149	114
S291	NM366	Alameda Drain at Alameda	7/9/1997	20.8	4,995	487	240	50	345	702	89	128	129	108
S292	NM406	Bear Canyon Arroyo	1/9/1998	4.3	6,640	801	412	115	254	592	84	94	109	101
S292	NM203	Bear Canyon Arroyo	3/19/1997	6.6	6,640	753	556	98	275	906	85	102	167	102
S292	NM421	Bear Canyon Arroyo	2/20/1998	6.9	6,640	565	270	82	210	448	72	78	83	86
S292	NM216	Bear Canyon Arroyo	4/23/1997	9.0	6,640	660	376	105	276	694	105	102	128	126
S292	NM229	Bear Canyon Arroyo	5/28/1997	9.0	6,640	674	502	91	283	926	91	105	171	110
S292	NM397	Bear Canyon Arroyo	11/18/1997	9.9	6,640	545	291	88	237	555	91	88	102	110
S292	NM388	Bear Canyon Arroyo	10/23/1997	11.9	6,640	566	342	68	278	727	80	103	134	96
S292	NM354	Bear Canyon Arroyo	7/9/1997	14.9	6,640	477	233	65	271	564	90	101	104	108
S292	NM377	Bear Canyon Arroyo	9/18/1997	15.0	6,640	445	300	70	255	731	97	94	135	117
S293	NM244	Canyon del Trigo Stream	5/29/1997	12.5	6,250	554	287	78	277	619	95	103	114	114
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	10.0	4,995	639	406	89	266	741	89	99	137	108
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	13.4	4,995	604	383	82	302	821	100	112	151	121
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	13.7	4,995	601	321	72	302	691	88	112	127	106
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	15.7	4,995	504	247	65	283	588	91	105	108	109
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	19.8	4,995	433	221	50	293	622	84	109	115	101
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	20.5	4,995	432	298	61	302	863	106	112	159	128
S300	NM187	Rio Grande at Alameda	1/14/1997	0.7	4,995	931	518	158	221	571	85	82	105	103
S300	NM398	Rio Grande at Alameda	1/8/1998	3.2	4,995	994	556	140	277	707	89	102	130	108
S300	NM413	Rio Grande at Alameda	2/19/1998	5.7	4,995	609	295	85	197	428	64	73	79	77
S300	NM389	Rio Grande at Alameda	11/20/1997	7.0	4,995	948	455	102	332	710	84	123	131	101
S300	NM195	Rio Grande at Alameda	2/11/1997	7.0	4,995	1179	632	118	415	990	98	154	182	118
S300	NM206	Rio Grande at Alameda	3/18/1997	8.6	4,995	728	664	103	281	1129	95	104	208	114
S300	NM218	Rio Grande at Alameda	4/22/1997	12.0	4,995	626	450	78	291	906	88	108	167	106
S300	NM378	Rio Grande at Alameda	10/21/1997	12.5	4,995	604	373	71	285	760	81	106	140	98
S300	NM231	Rio Grande at Alameda	5/21/1997	15.5	4,995	699	294	80	389	695	111	144	128	134
S300	NM118	Rio Grande at Alameda	6/29/1996	19.9	4,995	62	187	nd	33	531	nd	12	98	nd
S300	NM367	Rio Grande at Alameda	9/16/1997	19.9	4,995	457	334	58	311	943	98	115	174	119
S300	NM356	Rio Grande at Alameda	7/9/1997	20.7	4,995	444	249	52	313	728	91	116	134	110
S300	NM123	Rio Grande at Alameda	6/22/1996	26.6	4,995	415	206	130	378	757	314	140	139	379
S301	NM189	Rio Grande at Campbell	1/14/1997	0.4	4,960	957	516	163	222	559	86	82	103	104
S301	NM400	Rio Grande at Campbell	1/8/1998	2.5	4,960	1071	524	147	285	640	89	106	118	107
S301	NM197	Rio Grande at Campbell	2/11/1997	4.8	4,960	965	779	149	297	1084	107	110	200	129

Table B5. Summary of chlorofluorocarbon concentrations in surface water-- Continued

Site no.	Sample no.	Site name	Date	Recharge temp-erature (°C)	Recharge altitude (feet)	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
S301	NM415	Rio Grande at Campbell	2/19/1998	6.2	4,960	627	301	95	209	450	74	77	83	89
S301	NM391	Rio Grande at Campbell	11/20/1997	7.2	4,960	858	466	119	304	735	98	113	135	118
S301	NM208	Rio Grande at Campbell	3/18/1997	11.0	4,960	655	389	104	288	744	110	107	137	133
S301	NM382	Rio Grande at Campbell	10/21/1997	13.8	4,960	555	289	74	281	626	90	104	115	109
S301	NM221	Rio Grande at Campbell	4/22/1997	15.3	4,960	551	299	75	303	699	103	112	129	124
S301	NM233	Rio Grande at Campbell	5/21/1997	15.8	4,960	506	243	65	285	582	92	106	107	110
S301	NM371	Rio Grande at Campbell	9/16/1997	22.3	4,960	396	221	55	300	685	105	111	126	126
S301	NM358	Rio Grande at Campbell	7/9/1997	23.0	4,960	388	192	47	302	610	94	112	112	113
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	26.3	4,905	328	1089	82	294	3939	194	109	725	233
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	0.3	4,927	1032	1684	164	238	1810	86	88	333	103
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	4.5	4,927	1070	484	149	323	662	104	120	122	125
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	8.1	4,927	850	433	123	317	717	109	118	132	132
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	8.5	4,927	960	449	117	367	757	105	136	139	127
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	8.7	4,927	582	276	86	224	469	78	83	86	94
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	13.2	4,927	600	296	91	296	628	110	110	116	132
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	15.1	4,927	527	273	71	285	626	94	105	115	113
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	16.4	4,927	487	233	76	282	572	111	105	105	134
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	17.0	4,927	528	267	72	315	671	109	117	124	131
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	21.5	4,927	131	193	99	96	583	186	36	107	224
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	24.1	4,927	372	199	50	304	664	105	113	122	127
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	25.8	4,927	365	189	43	319	667	96	118	123	116
S304	NM122	Rio Grande at San Felipe	6/22/1996	18.1	5,116	426	204	nd	270	541	nd	100	100	nd
S305	NM120	Rio Grande at Central	6/29/1996	20.6	4,946	49	177	nd	35	516	nd	13	95	nd
S306	NM119	Rio Grande at Nature Center	6/29/1996	20.3	4,960	45	184	100	31	532	177	12	98	213
S308	NM196	Riverside Drain at Alameda	2/11/1997	4.1	4,995	774	966	116	228	1295	79	85	238	96
S308	NM188	Riverside Drain at Alameda	1/14/1997	8.3	4,995	602	344	94	228	576	84	85	106	102
S308	NM414	Riverside Drain at Alameda	2/19/1998	8.5	4,995	533	263	77	203	443	69	75	82	83
S308	NM399	Riverside Drain at Alameda	1/8/1998	8.7	4,995	633	403	94	245	688	86	91	127	104
S308	NM207	Riverside Drain at Alameda	3/18/1997	9.2	4,995	692	608	93	276	1066	89	102	196	107
S308	NM219	Riverside Drain at Alameda	4/22/1997	12.2	4,995	1279	598	81	600	1214	93	222	224	112
S308	NM390	Riverside Drain at Alameda	11/20/1997	12.9	4,995	588	328	61	285	686	72	106	126	86
S308	NM232	Riverside Drain at Alameda	5/21/1997	14.7	4,995	537	267	63	287	608	83	106	112	100
S308	NM379	Riverside Drain at Alameda	10/21/1997	14.8	4,995	503	301	58	268	682	75	99	126	91
S308	NM357	Riverside Drain at Alameda	7/9/1997	18.8	4,995	453	247	50	293	666	80	109	123	96
S308	NM368	Riverside Drain at Alameda	9/16/1997	20.2	4,995	386	284	52	267	813	89	99	150	108
S309	NM198	Riverside Drain at Campbell	2/11/1997	4.8	4,960	674	446	95	207	621	68	77	114	82
S309	NM190	Riverside Drain at Campbell	1/14/1997	7.9	4,960	605	341	94	224	559	82	83	103	99
S309	NM416	Riverside Drain at Campbell	2/19/1998	9.0	4,960	564	275	81	221	474	75	82	87	91
S309	NM401	Riverside Drain at Campbell	1/8/1998	9.5	4,960	645	375	93	261	666	89	97	123	107
S309	NM209	Riverside Drain at Campbell	3/18/1997	10.6	4,960	663	395	105	285	741	109	106	136	132
S309	NM222	Riverside Drain at Campbell	4/22/1997	13.4	4,960	764	298	78	381	638	95	141	118	115
S309	NM392	Riverside Drain at Campbell	11/20/1997	14.0	4,960	521	297	66	268	652	82	99	120	99

Table B5. Summary of chlorofluorocarbon concentrations in surface water-- Continued

Site no.	Sample no.	Site name	Date	Recharge temp-erature (°C)	Recharge altitude (feet)	CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)	Calculated atmospheric partial pressure of CFC-11 (pptv)	Calculated atmospheric partial pressure of CFC-12 (pptv)	Calculated atmospheric partial pressure of CFC-113 (pptv)	Percent modern CFC-11	Percent modern CFC-12	Percent modern CFC-113
S309	NM234	Riverside Drain at Campbell	5/21/1997	15.0	4,960	517	255	67	280	588	89	104	108	108
S309	NM383	Riverside Drain at Campbell	10/21/1997	16.2	4,960	464	247	54	265	595	75	98	110	90
S309	NM359	Riverside Drain at Campbell	7/9/1997	19.5	4,960	393	207	48	263	575	80	97	106	97
S309	NM372	Riverside Drain at Campbell	9/16/1997	22.4	4,960	360	211	43	274	660	83	101	122	100
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	7.7	4,927	653	1770	94	238	2868	81	88	528	98
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	11.3	4,927	626	367	84	280	712	89	104	131	108
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	12.4	4,927	570	337	73	270	689	85	100	127	102
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	12.9	4,927	639	337	97	311	705	115	115	130	139
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	13.0	4,927	462	234	55	225	491	64	83	90	77
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	14.2	4,927	612	359	65	318	796	81	118	147	98
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	15.4	4,927	622	302	74	344	708	102	127	130	123
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	16.1	4,927	497	244	62	284	589	89	105	109	107
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	16.1	4,927	524	184	66	297	442	91	110	81	110
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	21.4	4,927	396	232	49	289	697	90	107	128	108
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	25.8	4,927	431	221	45	377	782	101	140	144	121
S311	NM243	Stream in Monte Largo Canyon	5/28/1997	19.4	6,250	414	206	54	291	601	97	108	111	116
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	3.1	5,550	1051	533	162	297	689	105	110	127	126
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	5.3	5,550	829	446	117	265	643	87	98	118	104
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	5.4	5,550	762	420	114	249	617	87	92	114	104
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	5.5	5,550	1003	1138	135	329	1681	103	122	310	124
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	9.3	5,550	651	251	77	266	451	75	99	83	90
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	9.4	5,550	737	434	104	303	784	102	112	144	123
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	11.2	5,550	606	542	84	275	1070	93	102	197	111
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	11.5	5,550	756	411	81	350	825	90	129	152	108
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	11.8	5,550	588	299	83	276	607	95	102	112	114
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	18.0	5,550	541	446	63	345	1191	100	128	219	120
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	27.4	5,550	299	141	35	285	540	86	106	99	103
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	13.7	4,927	512	313	69	260	680	84	96	125	102
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	14.8	4,927	467	265	59	250	605	79	93	111	95
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	15.2	4,927	397	247	60	216	572	80	80	105	96
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	16.2	4,927	504	288	76	290	700	110	107	129	132
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	17.6	4,927	495	260	56	304	670	87	113	123	104
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	17.7	4,927	493	272	51	304	705	77	113	130	93
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	20.5	4,927	351	198	34	245	572	59	91	105	71
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	21.2	4,927	400	236	41	288	702	74	107	129	89
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	23.0	4,927	308	193	35	240	616	70	89	113	84
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	26.9	5,030	123	168	38	114	624	93	42	115	112

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water

[δ^2H, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta^{34}S$, sulfur-34; $\delta=((R_{sample}/R_{standard}) -1)x1000$, where R is an isotope ratio; per mil, parts per thousand; pmC, percent modern carbon]

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S300	NM118	Rio Grande at Alameda	6/29/1996	-63.9	-8.75			
S306	NM119	Rio Grande at Nature Center	6/29/1996	-64.3	-8.90			
S305	NM120	Rio Grande at Central	6/29/1996	-65.5	-9.04			
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	-79.0	-10.6			
S304	NM122	Rio Grande at San Felipe	6/22/1996	-90.0	-11.7		- 8.3	96.05
S300	NM123	Rio Grande at Alameda	6/22/1996	-88.7	-11.4		- 10.3	97.13
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	-88.8	-11.2			
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	-86.1	-11.2			
S300	NM187	Rio Grande at Alameda	1/14/1997	-91.6	-12.2	-1.61		
S308	NM188	Riverside Drain at Alameda	1/14/1997	-89.8	-11.7			
S301	NM189	Rio Grande at Campbell	1/14/1997	-92.7	-12.3			
S309	NM190	Riverside Drain at Campbell	1/14/1997	-89.9	-11.6			
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	-91.4	-12.1			
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	-87.9	-11.4			
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	-69.9	-9.65			
S290	NM194	Abo Arroyo at US 60	1/16/1997	-63.1	-8.97			
S300	NM195	Rio Grande at Alameda	2/11/1997	-94.1	-12.5	-1.23		
S308	NM196	Riverside Drain at Alameda	2/11/1997	-90.9	-11.9			
S301	NM197	Rio Grande at Campbell	2/11/1997	-93.4	-12.5			
S309	NM198	Riverside Drain at Campbell	2/11/1997	-90.6	-12.0			
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	-92.9	-12.5			
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	-87.7	-11.5			
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	-72.2	-10.0			
S290	NM202	Abo Arroyo at US 60	3/12/1997	-55.3	-7.60			
S292	NM203	Bear Canyon Arroyo	3/19/1997	-84.9	-11.7			
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	-92.7	-12.5			
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	-91.7	-12.1			
S300	NM206	Rio Grande at Alameda	3/18/1997	-92.4	-12.2	1.29		
S308	NM207	Riverside Drain at Alameda	3/18/1997	-93.5	-12.5			
S301	NM208	Rio Grande at Campbell	3/18/1997	-91.5	-12.1			
S309	NM209	Riverside Drain at Campbell	3/18/1997	-93.4	-12.5			
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	-91.6	-12.1			
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	-92.4	-12.3			
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	-72.2	-10.0			
S292	NM216	Bear Canyon Arroyo	4/23/1997	-82.8	-11.8			
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	-93.8	-12.5			
S300	NM218	Rio Grande at Alameda	4/22/1997	-92.5	-12.2	-0.40		
S308	NM219	Riverside Drain at Alameda	4/22/1997	-93.5	-12.4			
S291	NM220	Alameda Drain at Alameda	4/22/1997	-94.4	-12.4			
S301	NM221	Rio Grande at Campbell	4/22/1997	-91.2	-12.2			
S309	NM222	Riverside Drain at Campbell	4/22/1997	-93.1	-12.4			
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	-90.2	-12.1			
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	-92.3	-12.4			
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	-91.3	-12.2			
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	-72.4	-10.2			
S292	NM229	Bear Canyon Arroyo	5/28/1997	-84.1	-12.0			
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	-94.5	-12.5			
S300	NM231	Rio Grande at Alameda	5/21/1997	-93.9	-12.5	-5.33		

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S308	NM232	Riverside Drain at Alameda	5/21/1997	-94.7	-12.5			
S301	NM233	Rio Grande at Campbell	5/21/1997	-93.8	-12.5			
S309	NM234	Riverside Drain at Campbell	5/21/1997	-93.6	-12.4			
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	-95.1	-12.5			
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	-92.0	-12.3			
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	-91.0	-12.1			
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	-76.8	-10.5			
S311	NM243	Stream in Monte Largo Canyon	5/28/1997	-74.9	-10.9			
S293	NM244	Canyon del Trigo Stream	5/29/1997	-73.7	-10.8			
S292	NM354	Bear Canyon Arroyo	7/9/1997	-83.5	-11.9			
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	-94.1	-12.7			
S300	NM356	Rio Grande at Alameda	7/9/1997	-94.7	-12.7	-2.68		
S308	NM357	Riverside Drain at Alameda	7/9/1997	-93.0	-12.6			
S301	NM358	Rio Grande at Campbell	7/9/1997	-92.8	-12.7			
S309	NM359	Riverside Drain at Campbell	7/9/1997	-93.2	-12.7			
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	-94.7	-12.6			
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	-95.0	-12.6			
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	-94.4	-12.6			
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	-75.0	-10.4			
S291	NM366	Alameda Drain at Alameda	7/9/1997	-94.7	-12.6			
S300	NM367	Rio Grande at Alameda	9/16/1997	-85.8	-11.7	-4.00		
S308	NM368	Riverside Drain at Alameda	9/16/1997	-90.3	-12.1			
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	-90.6	-12.1			
S291	NM370	Alameda Drain at Alameda	9/16/1997	-90.1	-12.1			
S301	NM371	Rio Grande at Campbell	9/16/1997	-88.3	-11.7			
S309	NM372	Riverside Drain at Campbell	9/16/1997	-89.2	-12.0			
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	-87.7	-11.7			
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	-88.2	-12.0			
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	-90.4	-12.0			
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	-73.1	-9.95			
S292	NM377	Bear Canyon Arroyo	9/18/1997	-82.3	-11.8			
S300	NM378	Rio Grande at Alameda	10/21/1997	-89.8	-12.2	-4.52		
S308	NM379	Riverside Drain at Alameda	10/21/1997	-87.7	-12.1			
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	-89.3	-12.1			
S291	NM381	Alameda Drain at Alameda	10/21/1997	-90.5	-12.1			
S301	NM382	Rio Grande at Campbell	10/21/1997	-90.6	-12.2			
S309	NM383	Riverside Drain at Campbell	10/21/1997	-87.6	-12.1			
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	-89.5	-12.1			
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	-90.8	-12.0			
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	-89.9	-11.9			
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	-72.2	-10.1			
S292	NM388	Bear Canyon Arroyo	10/23/1997	-82.2	-11.7			
S300	NM389	Rio Grande at Alameda	11/20/1997	-92.4	-12.7	-1.12		
S308	NM390	Riverside Drain at Alameda	11/20/1997	-90.3	-12.3			
S301	NM391	Rio Grande at Campbell	11/20/1997	-94.5	-12.7			
S309	NM392	Riverside Drain at Campbell	11/20/1997	-89.2	-12.2			
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	-93.7	-12.6			
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	-88.5	-11.9			
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	-90.0	-12.1			
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	-75.1	-10.4			
S292	NM397	Bear Canyon Arroyo	11/18/1997	-84.3	-11.7			

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S300	NM398	Rio Grande at Alameda	1/8/1998	-94.1	-12.7	0.65		
S308	NM399	Riverside Drain at Alameda	1/8/1998	-92.9	-12.5			
S301	NM400	Rio Grande at Campbell	1/8/1998	-93.7	-12.7			
S309	NM401	Riverside Drain at Campbell	1/8/1998	-92.6	-12.6			
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	-94.1	-12.6			
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	-89.3	-12.2			
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	-92.5	-12.3			
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	-76.7	-10.6			
S292	NM406	Bear Canyon Arroyo	1/9/1998	-82.9	-11.8			
S300	NM413	Rio Grande at Alameda	2/19/1998	-95.1	-12.7	-0.08		
S308	NM414	Riverside Drain at Alameda	2/19/1998	-94.4	-12.6			
S301	NM415	Rio Grande at Campbell	2/19/1998	-93.1	-12.8			
S309	NM416	Riverside Drain at Campbell	2/19/1998	-93.1	-12.7			
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	-94.5	-12.7			
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	-91.6	-12.3			
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	-93.2	-12.5			
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	-76.5	-10.8			
S292	NM421	Bear Canyon Arroyo	2/20/1998	-83.2	-11.9			
S297	NM422	Jemez River below Jemez Canyon Dam	2/20/1998	-66.8	-8.51	7.05		
S298	NM423	Jemez River at Jemez	2/20/1998	-85.9	-11.9			
S307	NM424	Rio Puerco at Hwy 6	2/20/1998	-60.2	-7.87	5.53		
S300	NM425	Rio Grande at Alameda	3/31/1998	-93.8	-12.7	0.80		
S308	NM426	Riverside Drain at Alameda	3/31/1998	-93.2	-12.7			
S294	NM427	Chamizal Lateral at Alameda	3/31/1998	-94.1	-12.7	8.25		
S291	NM428	Alameda Drain at Alameda	3/31/1998	-92.9	-12.6			
S301	NM429	Rio Grande at Campbell	3/31/1998	-91.4	-12.5			
S309	NM430	Riverside Drain at Campbell	3/31/1998	-94.4	-12.7			
S303	NM431	Rio Grande at Rio Bravo	3/31/1998	-92.4	-12.5			
S310	NM432	Riverside Drain at Rio Bravo	3/31/1998	-93.9	-12.7			
S313	NM433	West Riverside drain at Rio Bravo	3/31/1998	-93.7	-12.7			
S312	NM434	Tijeras Arroyo at Four Hills	3/31/1998	-78.8	-10.8			
S292	NM435	Bear Canyon Arroyo	3/31/1998	-84.1	-12.0			
S292	NM436	Bear Canyon Arroyo	3/31/1998	-83.5	-12.0			
S297	NM437	Jemez River below Jemez Canyon Dam	4/7/1998	-72.7	-9.57			
S298	NM438	Jemez River at Jemez	4/7/1998	-84.4	-11.9			
S307	NM439	Rio Puerco at Hwy 6	4/7/1998	-60.2	-7.30	3.45		
S300	NM440	Rio Grande at Alameda	5/5/1998	-90.6	-11.9	-1.39		
S308	NM441	Riverside Drain at Alameda	5/5/1998	-90.7	-12.2			
S294	NM442	Chamizal Lateral at Alameda	5/5/1998	-90.1	-12.2			
S291	NM443	Alameda Drain at Alameda	5/5/1998	-90.7	-12.2			
S301	NM444	Rio Grande at Campbell	5/5/1998	-90.5	-12.0			
S309	NM445	Riverside Drain at Campbell	5/5/1998	-92.2	-12.2			
S303	NM446	Rio Grande at Rio Bravo	5/5/1998	-90.5	-11.9			
S310	NM447	Riverside Drain at Rio Bravo	5/5/1998	-91.4	-12.2			
S313	NM448	West Riverside drain at Rio Bravo	5/5/1998	-92.5	-12.3			
S312	NM449	Tijeras Arroyo at Four Hills	5/5/1998	-77.6	-10.9			
S292	NM450	Bear Canyon Arroyo	5/5/1998	-83.8	-12.0			
S297	NM451	Jemez River below Jemez Canyon Dam	5/7/1998	-74.2	-9.99	7.72		
S298	NM452	Jemez River at Jemez	5/7/1998	-87.0	-12.2			
S307	NM453	Rio Puerco at Hwy 6	5/7/1998	-57.1	-5.84	-8.33		
S300	NM454	Rio Grande at Alameda	6/11/1998	-89.3	-12.1	-4.88		

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S308	NM455	Riverside Drain at Alameda	6/11/1998	-90.6	-12.3			
S294	NM456	Chamizal Lateral at Alameda	6/11/1998	-89.8	-12.2			
S291	NM457	Alameda Drain at Alameda	6/11/1998	-89.8	-12.2			
S301	NM458	Rio Grande at Campbell	6/11/1998	-89.9	-12.0			
S309	NM459	Riverside Drain at Campbell	6/11/1998	-91.6	-12.2			
S303	NM460	Rio Grande at Rio Bravo	6/11/1998	-90.5	-12.1			
S310	NM461	Riverside Drain at Rio Bravo	6/11/1998	-90.8	-12.1			
S313	NM462	West Riverside drain at Rio Bravo	6/11/1998	-90.1	-12.2			
S312	NM463	Tijeras Arroyo at Four Hills	6/11/1998	-79.1	-10.9			
S292	NM464	Bear Canyon Arroyo	6/11/1998	-84.1	-11.9			
S297	NM465	Jemez River below Jemez Canyon Dam	6/12/1998	-76.8	-10.3	8.60		
S298	NM466	Jemez River at Jemez	6/12/1998	-83.5	-11.5			
S307	NM467	Rio Puerco at Hwy 6	6/12/1998	-44.8	-2.36	-3.58		
S300	NM468	Rio Grande at Alameda	7/22/1998	-86.7	-11.5			
S308	NM469	Riverside Drain at Alameda	7/22/1998	-87.9	-11.7			
S294	NM470	Chamizal Lateral at Alameda	7/22/1998	-89.5	-11.7			
S291	NM471	Alameda Drain at Alameda	7/22/1998	-87.6	-11.7			
S301	NM472	Rio Grande at Campbell	7/22/1998	-86.0	-11.4			
S309	NM473	Riverside Drain at Campbell	7/22/1998	-87.8	-11.8			
S303	NM474	Rio Grande at Rio Bravo	7/22/1998	-84.1	-11.4			
S310	NM475	Riverside Drain at Rio Bravo	7/22/1998	-87.6	-11.7			
S313	NM476	West Riverside drain at Rio Bravo	7/22/1998	-89.2	-11.9			
S312	NM477	Tijeras Arroyo at Four Hills	7/23/1998	-78.2	-10.9			
S292	NM478	Bear Canyon Arroyo	7/23/1998	-83.7	-11.8			
S297	NM479	Jemez River below Jemez Canyon Dam	7/23/1998	-74.1	-9.70			
S298	NM480	Jemez River at Jemez	7/23/1998	-80.1	-10.8			
S300	NM531	Rio Grande at Alameda	8/18/1998	-84.5	-11.1			
S308	NM532	Riverside Drain at Alameda	8/18/1998	-86.3	-11.5			
S294	NM533	Chamizal Lateral at Alameda	8/18/1998	-85.6	-11.5			
S291	NM534	Alameda Drain at Alameda	8/18/1998	-86.2	-11.4			
S301	NM535	Rio Grande at Campbell	8/18/1998	-84.8	-11.3			
S309	NM536	Riverside Drain at Campbell	8/18/1998	-87.4	-11.5			
S303	NM537	Rio Grande at Rio Bravo	8/18/1998	-84.0	-11.2			
S310	NM538	Riverside Drain at Rio Bravo	8/18/1998	-85.3	-11.6			
S313	NM539	West Riverside drain at Rio Bravo	8/18/1998	-88.6	-11.7			
S312	NM540	Tijeras Arroyo at Four Hills	8/18/1998	-76.2	-10.7			
S292	NM541	Bear Canyon Arroyo	8/18/1998	-83.6	-11.9			
S297	NM542	Jemez River below Jemez Canyon Dam	8/19/1998	-74.4	-9.53			
S298	NM543	Jemez River at Jemez	8/19/1998	-79.1	-10.9			
S307	NM544	Rio Puerco at Hwy 6	8/19/1998	-39.3	-4.83	-0.79		
S300	NM545	Rio Grande at Alameda	9/22/1998	-84.7	-11.4			
S308	NM546	Riverside Drain at Alameda	9/22/1998	-85.1	-11.5			
S294	NM547	Chamizal Lateral at Alameda	9/22/1998	-85.3	-11.5			
S291	NM548	Alameda Drain at Alameda	9/22/1998	-85.1	-11.5			
S301	NM549	Rio Grande at Campbell	9/22/1998	-84.7	-11.3			
S309	NM550	Riverside Drain at Campbell	9/22/1998	-85.1	-11.4			
S303	NM551	Rio Grande at Rio Bravo	9/22/1998	-84.0	-11.3			
S310	NM552	Riverside Drain at Rio Bravo	9/22/1998	-84.8	-11.5			
S313	NM553	West Riverside drain at Rio Bravo	9/22/1998	-85.4	-11.4			
S312	NM554	Tijeras Arroyo at Four Hills	9/22/1998	-74.7	-10.5			
S292	NM555	Bear Canyon Arroyo	9/29/1998	-82.5	-11.8			

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S297	NM556	Jemez River below Jemez Canyon Dam	9/24/1998	-69.6	-8.41			
S298	NM557	Jemez River at Jemez	9/24/1998	-81.0	-11.0			
S300	NM558	Rio Grande at Alameda	10/20/1998	-84.0	-11.1			
S308	NM559	Riverside Drain at Alameda	10/20/1998	-86.3	-11.4			
S294	NM560	Chamizal Lateral at Alameda	10/20/1998	-86.7	-11.5			
S301	NM561	Rio Grande at Campbell	10/20/1998	-84.8	-11.3			
S309	NM562	Riverside Drain at Campbell	10/20/1998	-84.7	-11.4			
S303	NM563	Rio Grande at Rio Bravo	10/20/1998	-88.7	-12.1			
S310	NM564	Riverside Drain at Rio Bravo	10/20/1998	-86.2	-11.7			
S313	NM565	West Riverside drain at Rio Bravo	10/20/1998	-86.7	-11.5			
S312	NM566	Tijeras Arroyo at Four Hills	10/23/1998	-76.1	-10.8			
S292	NM567	Bear Canyon Arroyo	10/23/1998	-84.7	-11.8			
S297	NM568	Jemez River below Jemez Canyon Dam	10/27/1998	-66.4	-8.07			
S298	NM569	Jemez River at Jemez	10/27/1998	-81.7	-11.9			
S307	NM570	Rio Puerco at Hwy 6	10/23/1998	-86.7	-12.2	2.27		
S300	NM571	Rio Grande at Alameda	12/1/1998	-89.1	-12.0			
S308	NM572	Riverside Drain at Alameda	12/1/1998	-88.5	-11.7			
S301	NM573	Rio Grande at Campbell	12/1/1998	-90.2	-12.0			
S309	NM574	Riverside Drain at Campbell	12/1/1998	-86.9	-11.6			
S303	NM575	Rio Grande at Rio Bravo	12/1/1998	-88.5	-12.0			
S310	NM576	Riverside Drain at Rio Bravo	12/1/1998	-84.7	-11.6			
S313	NM577	West Riverside drain at Rio Bravo	12/1/1998	-84.7	-11.6			
S312	NM578	Tijeras Arroyo at Four Hills	12/1/1998	-78.4	-10.8			
S292	NM579	Bear Canyon Arroyo	12/1/1998	-82.9	-11.8			
S297	NM580	Jemez River below Jemez Canyon Dam	12/3/1998	-66.6	-8.34			
S298	NM581	Jemez River at Jemez	12/3/1998	-85.6	-12.0			
S307	NM582	Rio Puerco at Hwy 6	12/3/1998	-64.3	-8.52	5.86		
S300	NM583	Rio Grande at Alameda	1/5/1999	-90.5	-12.1			
S308	NM584	Riverside Drain at Alameda	1/5/1999	-89.2	-11.9			
S301	NM585	Rio Grande at Campbell	1/5/1999	-90.8	-12.2			
S309	NM586	Riverside Drain at Campbell	1/5/1999	-89.2	-11.8			
S303	NM587	Rio Grande at Rio Bravo	1/5/1999	-91.0	-12.1			
S310	NM588	Riverside Drain at Rio Bravo	1/5/1999	-87.2	-11.6			
S313	NM589	West Riverside drain at Rio Bravo	1/5/1999	-87.4	-11.7			
S312	NM590	Tijeras Arroyo at Four Hills	1/5/1999	-77.3	-10.8			
S292	NM591	Bear Canyon Arroyo	1/5/1999	-84.9	-11.9			
S297	NM592	Jemez River below Jemez Canyon Dam	1/6/1999	-66.4	-8.45			
S298	NM593	Jemez River at Jemez	1/6/1999	-87.8	-12.0			
S300	NM594	Rio Grande at Alameda	2/2/1999	-93.3	-12.4			
S308	NM595	Riverside Drain at Alameda	2/2/1999	-89.6	-12.1			
S301	NM596	Rio Grande at Campbell	2/2/1999	-92.3	-12.4			
S309	NM597	Riverside Drain at Campbell	2/2/1999	-89.5	-12.1			
S303	NM598	Rio Grande at Rio Bravo	2/2/1999	-91.7	-12.2			
S310	NM599	Riverside Drain at Rio Bravo	2/2/1999	-87.3	-11.8			
S313	NM600	West Riverside drain at Rio Bravo	2/2/1999	-88.8	-11.9			
S312	NM601	Tijeras Arroyo at Four Hills	2/2/1999	-78.5	-10.8			
S292	NM602	Bear Canyon Arroyo	2/3/1999	-84.0	-11.8			
S297	NM603	Jemez River below Jemez Canyon Dam	2/3/1999	-68.5	-8.57			
S298	NM604	Jemez River at Jemez	2/3/1999	-87.0	-11.9			
S307	NM605	Rio Puerco at Hwy 6	2/3/1999	-61.1	-7.30	6.25		
S300	NM606	Rio Grande at Alameda	3/30/1999	-91.2	-12.1		-6.4	88.23

Table B6. Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

Site no.	Sample no.	Site name	Date	δ^2H (per mil)	$\delta^{18}O$ (per mil)	$\delta^{34}S$ (per mil)	$\delta^{13}C$ (per mil)	^{14}C (pmC)
S308	NM607	Riverside Drain at Alameda	3/30/1999	-92.7	-12.5			
S294	NM608	Chamizal Lateral at Alameda	3/30/1999	-94.0	-12.5			
S301	NM609	Rio Grande at Campbell	3/30/1999	-91.0	-12.1		-6.1	88.86
S309	NM610	Riverside Drain at Campbell	3/30/1999	-92.6	-12.5			
S303	NM611	Rio Grande at Rio Bravo	3/30/1999	-91.3	-12.2		-6.4	82.92
S310	NM612	Riverside Drain at Rio Bravo	3/30/1999	-94.2	-12.5			
S313	NM613	West Riverside drain at Rio Bravo	3/30/1999	-92.0	-12.3			
S312	NM614	Tijeras Arroyo at Four Hills	3/30/1999	-77.9	-10.6		-7.1	87.18
S292	NM615	Bear Canyon Arroyo	4/2/1999	-84.0	-11.9		-10.9	112.7
S297	NM616	Jemez River below Jemez Canyon Dam	4/1/1999	-69.7	-8.54		-2.9	83.11
S298	NM617	Jemez River at Jemez	4/2/1999	-86.1	-11.9		-3.7	71.19
S307	NM618	Rio Puerco at Hwy 6	4/2/1999	-53.9	-5.89	5.44	-0.11	63.87

Table B7. Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived precipitation samples, Albuquerque

[RWS, raw water sample number of C. Yapp; dms, degrees-minutes-seconds; δ^2H, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand; nd, not determined]

RWS No.	Site Name	End date	Latitude (dms)	Longitude (dms)	Collector	δ^2H (per mil)	$\delta^{18}O$ (per mil)
179	Precip collected atop Northrop Hall UNM	10/81	350458	1063720	C. Yapp	- 61.1	- 9.3
283	Precip collected atop Northrop Hall UNM	11/82	350458	1063720	C. Yapp	- 96.6	- 13.2
286	Precip collected atop Northrop Hall UNM	2/83	350458	1063720	C. Yapp	-130.5	- 17.8
287	Precip collected atop Northrop Hall UNM	3/83	350458	1063720	C. Yapp	- 87.3	- 11.7
290	Precip collected atop Northrop Hall UNM	5/83	350458	1063720	C. Yapp	- 52.4	- 6.2
292	Precip collected atop Northrop Hall UNM	6/83	350458	1063720	C. Yapp	- 21.4	- 3.2
293	Precip collected atop Northrop Hall UNM	7/83	350458	1063720	C. Yapp	- 22.2	- 2.9
295	precip collected atop Northrop Hall UNM	9/83	350458	1063720	C. Yapp	- 50.1	- 7.7
296	Precip collected atop Northrop Hall UNM	10/11/83	350458	1063720	C. Yapp	-108.4	- 14.4
300	Precip collected atop Northrop Hall UNM	1/19/84	350458	1063720	C. Yapp	- 66.4	- 10.3
301	Precip collected atop Northrop Hall UNM	3/84	350458	1063720	C. Yapp	-102.5	- 13.6
41	Cross sectional core of snow collected at Crest of Sandia Mts near T.V. towers	11/22/80	nd	nd	C. Yapp	-159.2	- 21.2
284	Snow from 8000 ft level east side of Sandia Mts.	11/30/82	nd	nd	C. Yapp	- 83.1	- 12.0

Sample No.	Name	Begin date	End date	Latitude (dms)	Longitude (dms)	Collector	δ^2H (per mil)	$\delta^{18}O$ (per mil)
1	Precipitation	5/6/1987	5/24/1987	350709	1062943	R. Hejl	- 58.9	- 6.3
2	Precipitation	6/7/1987	6/8/1987	350709	1062943	R. Hejl	- 75.9	- 10.6
3	Precipitation	7/20/1987	7/21/1987	350709	1062943	R. Hejl	- 55.4	- 8.2
4	Precipitation	7/24/1987	7/30/1987	350709	1062943	R. Hejl	- 41.8	- 5.4
5	Precipitation	8/2/1987	8/22/1987	350709	1062943	R. Hejl	- 28.6	- 4.2
6	Precipitation	8/22/1987	8/27/1987	350709	1062943	R. Hejl	- 18.7	- 3.7
7	Precipitation	10/13/1987	10/31/1987	350709	1062943	R. Hejl	- 68.6	- 9.7
8	Precipitation	11/1/1987	11/16/1987	350709	1062943	R. Hejl	- 92.9	- 12.1
9	Precipitation	12/17/1987	12/18/1987	350709	1062943	R. Hejl	- 96.3	- 13.6
10	Precipitation	1/17/1988	1/21/1988	350709	1062943	R. Hejl	-132.4	- 16.9
11	Precipitation	2/1/1988	2/3/1988	350709	1062943	R. Hejl	-150.0	- 18.4
12	Precipitation	3/2/1988	4/1/1988	350709	1062943	R. Hejl	- 78.6	- 11.4
13	Precipitation	4/14/1988	4/30/1988	350709	1062943	R. Hejl	- 56.8	- 7.8
14	Precipitation	5/17/1988	5/25/1988	350709	1062943	R. Hejl	- 63.6	- 9.2
15	Precipitation	6/4/1988	6/28/1988	350709	1062943	R. Hejl	- 46.4	- 6.5
16	Precipitation	7/1/1988	7/9/1988	350709	1062943	R. Hejl	- 53.5	- 8.0
17	Precipitation	7/17/1988	7/28/1988	350709	1062943	R. Hejl	- 33.3	- 5.2

Table B8. Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived surface-water samples from the early 1980s

[RWS, raw water sample number of C. Yapp; dms, degrees-minutes-seconds; δ^2H, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand]

RWS No.	Name	Latitude (dms)	Longitude (dms)	Date	Collector	δ^2H (per mil)	$\delta^{18}O$ (per mil)
49	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	02/16/80	C. Yapp	- 94.6	- 12.7
9	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	10/09/80	C. Yapp	- 94.8	- 12.5
33	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	11/06/80	C. Yapp	- 97.2	- 12.5
56	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	01/14/81	C. Yapp	- 96.5	- 12.7
63	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	02/10/81	C. Yapp	- 98.6	- 12.9
71	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	04/08/81	C. Yapp	- 94.1	- 12.3
79	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/28/81	C. Yapp	- 88.5	- 11.4
106	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/27/81	C. Yapp	- 90.0	- 11.6
116	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/29/81	C. Yapp	- 90.6	- 11.6
125	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	07/23/81	C. Yapp	- 91.0	- 11.9
148	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	08/18/81	C. Yapp	- 88.2	- 11.2
174	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	10/30/81	C. Yapp	- 83.1	- 10.8
189	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	11/26/81	C. Yapp	- 90.9	- 12.0
218	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	03/14/82	C. Yapp	- 96.2	- 12.8
250	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	03/15/82	C. Yapp	- 97.0	- 12.8
254	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	04/10/82	C. Yapp	- 93.5	- 12.4
256	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/09/82	C. Yapp	-101.6	- 13.5
260	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/16/82	C. Yapp	-103.3	- 13.7
261	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/23/82	C. Yapp	-102.6	- 13.8
262	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/30/82	C. Yapp	-103.5	- 13.9
264	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/06/82	C. Yapp	-105.0	- 14.1
273	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/14/82	C. Yapp	-104.8	- 14.1
274	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/21/82	C. Yapp	-105.3	- 14.2
277	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	08/18/82	C. Yapp	- 94.9	- 12.6
279	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	09/21/82	C. Yapp	- 82.6	- 11.3
281	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	10/21/82	C. Yapp	- 93.1	- 12.5
289	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	05/15/83	C. Yapp	- 96.5	- 13.1
291	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	06/15/83	C. Yapp	- 97.9	- 13.6
216	Rio Grande at Corrales Rd Brg Hwy 46	351150	1063829	02/02/82	C. Yapp	- 94.2	- 12.7
107	Water from outlet below Cochiti dam	353705	1061924	06/27/81	C. Yapp	- 92.5	- 12.1
176	Rio Grande at NM Hwy 6 bridge, Belen, NM	343909	1064414	11/01/81	C. Yapp	- 86.8	- 11.2
2	Water Collected just above waterfall about 150 yards upstream from Simms well, Bear Canyon	350902	1062729	09/26/80	C. Yapp	- 81.8	- 11.4
285A	Embudito Spr.	350547	1062744	01/12/83	C. Yapp	- 81.3	- 11.3
285B	Embudito Spr.	350547	1062744	01/12/83	C. Yapp	- 82.8	- 11.4
297	Alamosa River at Dolores Canyon Road Br	372138	1063559	08/10/83	C. Yapp	- 98.2	- 14.3
298	Alamosa River at Alum Creek	372305	1063352	08/10/83	C. Yapp	-109.2	- 14.9
299	Alamosa River at Silver lakes Road Br over Alamosa River	372327	1062240	08/10/83	C. Yapp	- 99.9	- 14.1
259	Three Gun Spring	350557	1062618	05/12/82	C. Yapp	- 83.6	- 11.7
126	Cienega Springs,Sandia Mts	351012	1062304	07/27/81	C. Yapp	- 89.4	- 12.6
227	Lake Carlsbad at bridge on Hwy 62 & 180 in Carlsbad	322505	1041325	03/14/82	C. Yapp	- 42.3	- 5.8
221	Rio Hondo, near Hondo, at bridge on Hwy 395	332200	1051435	03/14/82	C. Yapp	- 58.8	- 8.4
154	Stream at Indian Head nest area, Santa Fe National Forest, Hwy 4, Jemez River	354942	1063839	09/26/81	C. Yapp	- 79.9	- 11.0

Table B9. Tritium concentrations in surface water

[TU, Tritium Unit, 1 TU=1 atom of ^{3}H in 10^{18} atoms of H; 1 σ, one standard deviation]

Site no.	Sample no.	Site name	Date	Tritium (TU)	± 1σ (TU)
S290	NM194	Abo Arroyo at US 60	1/16/1997	6.2	0.3
S290	NM202	Abo Arroyo at US 60	3/12/1997	6.6	0.4
S291	NM220	Alameda Drain at Alameda	4/22/1997	8.3	0.4
S291	NM366	Alameda Drain at Alameda	7/9/1997	9.3	0.4
S291	NM370	Alameda Drain at Alameda	9/16/1997	9.6	0.4
S291	NM381	Alameda Drain at Alameda	10/21/1997	9.6	0.4
S292	NM421	Bear Canyon Arroyo	2/20/1998	8.9	0.4
S292	NM397	Bear Canyon Arroyo	11/18/1997	9.1	0.4
S292	NM388	Bear Canyon Arroyo	10/23/1997	9.2	0.5
S292	NM203	Bear Canyon Arroyo	3/19/1997	9.4	0.4
S292	NM406	Bear Canyon Arroyo	1/9/1998	9.7	0.5
S292	NM216	Bear Canyon Arroyo	4/23/1997	9.8	0.5
S292	NM354	Bear Canyon Arroyo	7/9/1997	10.	0.5
S292	NM229	Bear Canyon Arroyo	5/28/1997	11.	0.5
S294	NM204	Chamizal Lateral at Alameda	3/18/1997	8.7	0.4
S294	NM369	Chamizal Lateral at Alameda	9/16/1997	9.2	0.5
S294	NM217	Chamizal Lateral at Alameda	4/22/1997	9.3	0.5
S294	NM380	Chamizal Lateral at Alameda	10/21/1997	9.6	0.5
S294	NM230	Chamizal Lateral at Alameda	5/21/1997	10.	0.5
S294	NM355	Chamizal Lateral at Alameda	7/9/1997	11.	0.5
S297	NM422	Jemez River below Jemez Canyon Dam	2/20/1998	6.5	0.4
S298	NM423	Jemez River at Jemez	2/20/1998	3.5	0.3
S300	NM118	Rio Grande at Alameda	6/29/1996	7.2	0.5
S300	NM195	Rio Grande at Alameda	2/11/1997	7.9	0.4
S300	NM206	Rio Grande at Alameda	3/18/1997	8.1	0.4
S300	NM413	Rio Grande at Alameda	2/19/1998	8.7	0.4
S300	NM187	Rio Grande at Alameda	1/14/1997	8.8	0.5
S300	NM218	Rio Grande at Alameda	4/22/1997	8.9	0.5
S300	NM398	Rio Grande at Alameda	1/8/1998	9.0	0.4
S300	NM123	Rio Grande at Alameda	6/22/1996	9.6	0.5
S300	NM378	Rio Grande at Alameda	10/21/1997	9.8	0.5
S300	NM389	Rio Grande at Alameda	11/20/1997	9.9	0.4
S300	NM367	Rio Grande at Alameda	9/16/1997	9.9	0.5
S300	NM231	Rio Grande at Alameda	5/21/1997	11.	0.5
S300	NM356	Rio Grande at Alameda	7/9/1997	11.	0.5
S301	NM189	Rio Grande at Campbell	1/14/1997	8.0	0.4
S301	NM197	Rio Grande at Campbell	2/11/1997	8.0	0.4
S301	NM400	Rio Grande at Campbell	1/8/1998	8.8	0.4
S301	NM415	Rio Grande at Campbell	2/19/1998	8.8	0.5
S301	NM208	Rio Grande at Campbell	3/18/1997	8.9	0.4
S301	NM221	Rio Grande at Campbell	4/22/1997	9.3	0.5
S301	NM371	Rio Grande at Campbell	9/16/1997	9.4	0.5
S301	NM382	Rio Grande at Campbell	10/21/1997	9.8	0.5
S301	NM233	Rio Grande at Campbell	5/21/1997	9.9	0.4
S301	NM391	Rio Grande at Campbell	11/20/1997	10.	0.4
S301	NM358	Rio Grande at Campbell	7/9/1997	11.	0.5

Table B9. Tritium concentrations in surface water-- Continued

Site no.	Sample no.	Site name	Date	Tritium (TU)	± 1σ (TU)
S302	NM124	Rio Grande at Isleta Below Diversion	6/22/1996	8.4	0.4
S303	NM402	Rio Grande at Rio Bravo	1/8/1998	7.4	0.4
S303	NM199	Rio Grande at Rio Bravo	2/11/1997	7.8	0.4
S303	NM191	Rio Grande at Rio Bravo	1/15/1997	8.2	0.4
S303	NM210	Rio Grande at Rio Bravo	3/18/1997	8.3	0.4
S303	NM417	Rio Grande at Rio Bravo	2/19/1998	8.6	0.4
S303	NM384	Rio Grande at Rio Bravo	10/21/1997	9.2	0.5
S303	NM223	Rio Grande at Rio Bravo	4/22/1997	9.3	0.5
S303	NM121	Rio Grande at Rio Bravo	6/29/1996	9.4	0.4
S303	NM373	Rio Grande at Rio Bravo	9/16/1997	9.5	0.5
S303	NM393	Rio Grande at Rio Bravo	11/20/1997	10.	0.4
S303	NM235	Rio Grande at Rio Bravo	5/21/1997	11.	0.4
S303	NM360	Rio Grande at Rio Bravo	7/9/1997	11.	0.5
S304	NM122	Rio Grande at San Felipe	6/22/1996	10.	0.4
S305	NM120	Rio Grande nr Central	6/29/1996	7.4	0.4
S306	NM119	Rio Grande nr I-40	6/29/1996	7.5	0.4
S307	NM424	Rio Puerco at Hwy 6	2/20/1998	1.9	0.3
S308	NM196	Riverside Drain at Alameda	2/11/1997	8.3	0.4
S308	NM188	Riverside Drain at Alameda	1/14/1997	8.4	0.4
S308	NM207	Riverside Drain at Alameda	3/18/1997	8.4	0.4
S308	NM414	Riverside Drain at Alameda	2/19/1998	8.5	0.4
S308	NM379	Riverside Drain at Alameda	10/21/1997	8.8	0.4
S308	NM219	Riverside Drain at Alameda	4/22/1997	9.0	0.5
S308	NM368	Riverside Drain at Alameda	9/16/1997	9.3	0.4
S308	NM232	Riverside Drain at Alameda	5/21/1997	9.5	0.4
S308	NM390	Riverside Drain at Alameda	11/20/1997	9.5	0.4
S308	NM357	Riverside Drain at Alameda	7/9/1997	9.6	0.4
S308	NM399	Riverside Drain at Alameda	1/8/1998	9.6	0.5
S309	NM416	Riverside Drain at Campbell	2/19/1998	8.1	0.4
S309	NM190	Riverside Drain at Campbell	1/14/1997	8.4	0.4
S309	NM198	Riverside Drain at Campbell	2/11/1997	8.9	0.4
S309	NM383	Riverside Drain at Campbell	10/21/1997	9.0	0.4
S309	NM209	Riverside Drain at Campbell	3/18/1997	9.1	0.4
S309	NM401	Riverside Drain at Campbell	1/8/1998	9.2	0.4
S309	NM392	Riverside Drain at Campbell	11/20/1997	9.4	0.4
S309	NM234	Riverside Drain at Campbell	5/21/1997	9.8	0.5
S309	NM372	Riverside Drain at Campbell	9/16/1997	9.9	0.5
S309	NM222	Riverside Drain at Campbell	4/22/1997	10.	0.4
S309	NM359	Riverside Drain at Campbell	7/9/1997	11.	0.5
S310	NM211	Riverside Drain at Rio Bravo	3/18/1997	8.4	0.4
S310	NM200	Riverside Drain at Rio Bravo	2/11/1997	8.7	0.4
S310	NM394	Riverside Drain at Rio Bravo	11/20/1997	8.7	0.4
S310	NM385	Riverside Drain at Rio Bravo	10/21/1997	9.0	0.4
S310	NM403	Riverside Drain at Rio Bravo	1/8/1998	9.0	0.4
S310	NM192	Riverside Drain at Rio Bravo	1/15/1997	9.1	0.4
S310	NM374	Riverside Drain at Rio Bravo	9/16/1997	9.2	0.5
S310	NM418	Riverside Drain at Rio Bravo	2/19/1998	9.2	0.5
S310	NM224	Riverside Drain at Rio Bravo	4/22/1997	9.4	0.5

Table B9. Tritium concentrations in surface water-- Continued

Site no.	Sample no.	Site name	Date	Tritium (TU)	± 1σ (TU)
S310	NM236	Riverside Drain at Rio Bravo	5/21/1997	9.5	0.4
S310	NM361	Riverside Drain at Rio Bravo	7/9/1997	10.	0.5
S312	NM420	Tijeras Arroyo at Four Hills	2/20/1998	5.0	0.4
S312	NM226	Tijeras Arroyo at Four Hills	4/23/1997	5.2	0.4
S312	NM212	Tijeras Arroyo at Four Hills	3/19/1997	5.4	0.3
S312	NM376	Tijeras Arroyo at Four Hills	9/18/1997	5.5	0.4
S312	NM396	Tijeras Arroyo at Four Hills	11/18/1997	5.7	0.3
S312	NM238	Tijeras Arroyo at Four Hills	5/27/1997	5.7	0.4
S312	NM387	Tijeras Arroyo at Four Hills	10/23/1997	5.7	0.4
S312	NM201	Tijeras Arroyo at Four Hills	2/11/1997	5.8	0.3
S312	NM405	Tijeras Arroyo at Four Hills	1/9/1998	5.8	0.4
S312	NM193	Tijeras Arroyo at Four Hills	1/15/1997	5.9	0.4
S312	NM363	Tijeras Arroyo at Four Hills	7/9/1997	6.2	0.4
S313	NM237	West Riverside drain at Rio Bravo	5/21/1997	8.9	0.4
S313	NM205	West Riverside drain at Rio Bravo	3/18/1997	9.1	0.4
S313	NM419	West Riverside drain at Rio Bravo	2/19/1998	9.1	0.5
S313	NM375	West Riverside drain at Rio Bravo	9/16/1997	9.3	0.5
S313	NM386	West Riverside drain at Rio Bravo	10/21/1997	9.3	0.5
S313	NM404	West Riverside drain at Rio Bravo	1/8/1998	9.6	0.4
S313	NM225	West Riverside drain at Rio Bravo	4/22/1997	9.7	0.5
S313	NM395	West Riverside drain at Rio Bravo	11/20/1997	10.	0.4
S313	NM362	West Riverside drain at Rio Bravo	7/9/1997	10.	0.5
S314	NM125	Rio Grande at Arroyo de la Baranca	7/1/1996	8.0	0.4

Appendix C. Chemical and isotopic compositions of air, rocks, and plants, and saturation indices for selected minerals in ground water from the Middle Rio Grande Basin

Table C1. Selected data on the chemical and isotopic composition of air and shallow unsaturated zone

[CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane (CF_2Cl_2); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); SF_6, sulfur hexafluoride; pptv, parts per trillion by volume; $\delta=((R_{sample}/R_{standard})-1)\times1000$, where R is an isotope ratio; $\delta^{13}C$, carbon-13; $\delta^{18}O$, oxygen-18; UZ, Unsaturated Zone, samples taken three feet below land surface; Fraction of gas by volume; nd, not determined; Air samples taken six feet above land surface]

Location	Date	CFC-12 (pptv)	CFC-11 (pptv)	CFC-113 (pptv)	SF_6 (pptv)	Fraction of CO_2 gas	Fraction of N_2 gas	Fraction of O_2 gas	Fraction of Ar gas	Fraction of CH_4 gas	$\delta^{13}C$ of CO_2 (per mil)	$\delta^{18}O$ of CO_2 (per mil)
					Air							
Abo Arroyo @ Hwy 47	1/16/97	559.7	268.3	80.5	nd	0.000320	nd	nd	nd	nd	-8.94	nd
Bear Canyon	6/21/96	548.6	269.9	88.7	15.05	nd	nd	nd	nd	nd	-8.39	41.22
Bear Canyon	1/15/97	538.8	259.9	82.3	nd	nd	nd	nd	nd	nd	nd	nd
Bear Canyon Ridge	5/8/97	565.7	262.3	81.7	nd	nd	nd	nd	nd	nd	nd	nd
Burn Site Kirtland AFB	6/25/96	526.6	261.4	81.0	3.73	nd	nd	nd	nd	nd	-8.28	41.10
Cochiti Windmill 170T	8/29/96	529.7	258.1	82.5	4.98	nd	nd	nd	nd	nd	nd	nd
Kirtland AFB	6/28/96	560.5	266.2	79.2	4.20	nd	nd	nd	nd	nd	nd	nd
Kirtland South	5/8/97	529.5	256.2	81.7	nd	0.000358	0.78398	0.20740	0.00923	0	-8.44	nd
Lincoln Middle School well	7/24/98	nd	nd	nd	4.30	nd	nd	nd	nd	nd	nd	nd
Mesa del Sol	7/25/98	nd	nd	nd	4.15	nd	nd	nd	nd	nd	nd	nd
Mesa del Sol	8/2/98	nd	nd	nd	4.73	nd	nd	nd	nd	nd	nd	nd
Mesa del Sol	6/28/97	nd	nd	nd	3.98	nd	nd	nd	nd	nd	nd	nd
Private Production Well #10	7/2/96	530.8	261.6	79.3	3.96	nd	nd	nd	nd	nd	nd	nd
Rio Grande @ Campbell Rd.	10/22/97	nd	nd	nd	4.58	nd	nd	nd	nd	nd	nd	nd
Rio Grande @ Rio Bravo	6/29/96	570.2	265.2	85.1	5.61	nd	nd	nd	nd	nd	nd	nd
Rio Grande @ Rio Bravo	1/15/97	544.6	264.4	82.4	nd	0.000320	nd	nd	nd	nd	-9.01	nd
Rio Rancho 13	8/13/96	550.7	267.8	88.7	6.10	nd	nd	nd	nd	nd	nd	nd
Sandia Well	7/30/98	nd	nd	nd	7.07	nd	nd	nd	nd	nd	nd	nd
Santa Ana 6T	8/27/96	529.3	260.4	83.8	3.72	nd	nd	nd	nd	nd	nd	nd
Tijeras Arroyo @ Four Hills Rd	10/22/97	nd	nd	nd	104	nd	nd	nd	nd	nd	nd	nd
Tio Pedro Windmill	8/28/96	530.2	258.9	78.4	4.60	nd	nd	nd	nd	nd	nd	nd
Tome	8/6/98	nd	nd	nd	4.91	nd	nd	nd	nd	nd	nd	nd
Tunnel Spring	6/18/96	543.0	263.7	80.8	4.27	nd	nd	nd	nd	nd	nd	nd
					Unsaturated Zone Air							
Abo Arroyo	1/16/97	554.5	256.0	76.5	nd	0.000683	0.78026	0.20639	0.00933	<0.001	-12.50	nd
Bear Canyon Arroyo	1/15/97	536.3	260.3	80.5	nd	0.000764	0.78084	0.20596	0.00928	<0.001	-16.68	nd
Bear Canyon Arroyo	2/20/97	546.3	349.3	81.9	nd	0.003053	0.77450	0.20091	0.00934	<0.001	-21.41	nd
Bear Canyon Arroyo	10/22/97	526.1	282.2	79.2	nd	0.006220	0.78201	0.20129	0.00924	<0.001	-20.05	nd
Bear Canyon Arroyo Ridge	1/15/97	nd	nd	nd	nd	0.001253	0.78043	0.20392	0.00944	<0.001	-14.62	nd
Bear Canyon Arroyo Ridge	2/20/97	544.5	265.7	83.5	nd	0.002994	0.77819	0.20363	0.00933	<0.001	-16.10	nd
Bear Canyon Arroyo Ridge	5/8/97	528.3	263.6	84.8	nd	0.006104	0.78192	0.20131	0.00936	<0.001	-14.83	nd
Bear Canyon Arroyo Ridge	10/22/97	524.4	228.1	77.6	nd	0.004310	0.78266	0.20295	0.00926	<0.001	-14.30	nd
Burn Site Kirtland AFB	6/25/96	nd	nd	nd	nd	nd	nd	nd	nd	nd	-11.53	30.02
Burn Site Kirtland AFB	6/25/96	nd	nd	nd	nd	nd	nd	nd	nd	nd	-11.77	32.14
Kirtland North	6/29/96	nd	nd	nd	nd	nd	nd	nd	nd	nd	-12.11	32.39
Kirtland North	2/20/97	555.3	262.3	79.8	nd	0.001696	0.77526	0.20409	0.00927	<0.001	-15.96	nd
Kirtland North	5/8/97	523.6	254.2	81.6	nd	0.002523	0.78294	0.20568	0.00930	<0.001	-16.23	nd
Kirtland North	10/22/97	522.6	249.8	82.8	nd	0.003040	0.78612	0.20508	0.00923	<0.001	nd	nd
Kirtland South	2/20/97	523.1	260.2	79.8	nd	0.000926	0.77493	0.20358	0.00935	<0.001	-14.42	nd
Kirtland South	5/8/97	518.2	257.3	79.9	nd	0.002266	0.78469	0.20249	0.00932	<0.001	-13.39	nd
Kirtland South	10/22/97	518.8	219.4	71.7	nd	0.002760	0.78880	0.20771	0.00934	<0.001	-13.25	nd
Private Production Well #10	7/2/96	nd	nd	nd	nd	nd	nd	nd	nd	nd	-14.71	28.84
Tijeras Arroyo @ 4-Hills	5/8/97	816.4	305.2	74.3	nd	0.077083	0.77406	0.14110	0.00932	<0.001	-17.27	nd
Tijeras Arroyo @ 4-Hills	2/20/97	1,142.	265.8	64.7	nd	0.062678	0.77977	0.13695	0.00949	<0.001	-18.39	nd
Tijeras Arroyo @ 4-Hills	1/15/97	576.7	321.7	82.2	nd	0.001555	0.78204	0.20624	0.00940	<0.001	-18.29	nd

Table C2. Solid carbonates, limestone, and caliche samples analyzed for $\delta^{13}C$ and ^{14}C activity

[RSIL, Reston Stable Isotope Laboratory, USGS; RRL, Rafter Radiocarbon Laboratory; $\delta=((R_{sample}/R_{standard})-1)\times1000$, where R is an isotope ratio; $\delta^{13}C$, carbon-13; Carbonate rock samples from Middle Rio Grande Basin.The samples are of drill cuttings and carbonate float. Drill cuttings containing carbonates were identified at the drill site by acid addition while the cuttings were still wet. In the lab, the sample was washed to remove drilling mud, and carbonate fragments were identified with acid. Each drill-cutting sample is a single fragment of carbonate from the sample bag. Each sample was ground and seived through 60-mesh sieve, separately. Other samples are caliche removed from the surface of limestone from various sites, or caliche from soils and drill cuttings. Samples collected summer 1996- winter 1997. pmC, percent modern carbon; 1s, one standard deviation, per mil; parts per thousand.]

ID No.	Sample Number	Description	RSIL $\delta^{13}C$ (per mil) [1]	RRL $\delta^{13}C$ (per mil) [1]	^{14}C Activity (pmC)	^{14}C error ± 1σ (pmC)	Conventional ^{14}C age (years)	^{14}C age error ± 1σ (years)
NP-1	1	gray limestone @ Domestic Well #01	0.1					
NP-2	2a	limestone from Sandia Crest near Tram	-0.1					
NP-3	2b	limestone from Sandia Crest near Tram	2.8					
NP-4	2c	limestone from Sandia Crest near Tram	-3.7					
NP-5	2d	limestone from Sandia Crest near Tram	-2.8					
NP-6	3	limestone @ Burn Site Well	-0.8					
NP-7	4a	Caliche from limestone surface @ Burn Site	-4.3					
NP-8	4b	limestone from Burn Site--no caliche	-1.8					
NP-9	4c	limestone from Burn Site--no caliche (chert)						
NP-10	4d	Caliche from 4c	-3.8	-3.3	40.57	0.29	7,197	60
NP-11	5a	Caliche from Domestic Well #06	-3.0					
NP-12	5b	Caliche from Domestic Well #06	-3.8					
NP-13	1	Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples	-3.3					
NP-14	2	Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples	-4.3					
NP-15	3	Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples	-6.5					
NP-16	1	Del Sol 310'-315' carbonate hand picked from drill cuttings, single samples	-4.2					
NP-17	2	Del Sol 310'-315' carbonate hand picked from drill cuttings, single samples	-4.8					
NP-18	1	Del Sol 265'-270' carbonate hand picked from drill cuttings, single samples	-4.9					
NP-19	1	West Bluff 925'-930' carbonate hand picked from drill cuttings, single samples	-5.2	-4.7	0.92	0.06	37,630	490
NP-20	1	Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples	-1.1					
NP-21	2	Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples	-1.5					
NP-22	3	Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples	-2.8					
NP-23	4	Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples	-4.9					
NP-24	1	Hunter Ridge 995'-1005' carbonate hand picked from drill cuttings, single samples	-5.4					
NP-25	1	Del Sol 260'-265' carbonate hand picked from drill cuttings, single samples	-5.3					
NP-26	1	West Bluff 285'-305' carbonate hand picked from drill cuttings, single samples	-5.8					
NP-27	1	Del Sol 965'-970' carbonate hand picked from drill cuttings, single samples	-4.9	-4.0	0.76	0.06	39,120	610
NP-28	1	Domestic Well #06 cuttings, caliche	-2.9	-3.2	3.32	0.08	27,290	190

Table C2. Solid carbonates, limestone, and caliche samples analyzed for $\delta^{13}C$ and ^{14}C activity-- Continued

ID No.	Sample Number	Description	RSIL $\delta^{13}C$ (per mil) [1]	RRL $\delta^{13}C$ (per mil) [1]	^{14}C Activity (pmC)	^{14}C error ± 1σ (pmC)	Conven-tional ^{14}C age (years)	^{14}C age error ± 1σ (years)
NP-29	1	310'-320' Garfield	-5.0					
NP-30	1	250'-260' Garfield	-5.2					
NP-31	2	250'-260' Garfield	-4.9					
NP-32	1	Bear Canyon caliche	-3.6					
NP-33	2	Bear Canyon caliche	-5.7					
NP-34	3	Bear Canyon caliche	-5.3					
NP-35	4	Bear Canyon caliche	-4.4					
NP-37	6	Bear Canyon caliche	-4.7					
NP-38	1	limestone, misc. carbonate float from Abo Arroyo	1.4					
NP-39	2	limestone, misc. carbonate float from Abo Arroyo	-1.2					
NP-40	3	limestone, misc. carbonate float from Abo Arroyo	-2.6					

[1] Differences in $\delta^{13}C$ values due mostly to inhomogenities in sample

Table C3. Stable carbon isotopic composition of plants, $\delta^{13}C$

[$\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; δ13C, carbon-13; per mil, parts per thousand; 1s, one standard deviation; nd, not determined]

Sample ID	Location	Date	Name	Selected part of plant for analysis	Comment	$\delta^{13}C$ (per mil)	± 1 σ of separate samples
p-01	Kirtland North	5/8/97	grass	flower part only	1-2 same specimen	-26.28	nd
p-02	Kirtland North	5/8/97	grass	stem of p-1		-27.27	0.50
p-03	Kirtland North	5/8/97	Chamisa	foliage	3-4 same specimen	-26.48	0.36
p-04	Kirtland North	5/8/97	Chamisa	stem		-27.70	0.08
p-05	Kirtland North	5/8/97	Apache Plume	foliage	5-6 same specimen	-25.37	0.03
p-06	Kirtland North	5/8/97	Apache Plume	stem		-26.42	0.29
p-07	Kirtland South	5/8/97	Juniper	foliage	7-8 same specimen	-23.81	0.40
p-08	Kirtland South	5/8/97	Juniper	wood stem		-23.15	0.08
p-09	Kirtland South	5/8/97	Chamisa	foliage	9-10 same specimen	-14.82	0.03
p-10	Kirtland South	5/8/97	Chamisa	woody stem		-13.47	0.08
p-11	Kirtland South	5/8/97	Apache Plume	foliage	11-12 same specimen	-23.70	0.13
p-12	Kirtland South	5/8/97	Apache Plume	woody stem		-23.90	0.04
p-13	Kirtland South	5/8/97	grass	root	13-15 same specimen	-14.47	nd
p-14	Kirtland South	5/8/97	grass	stem at base of plant		-14.48	0.11
p-15	Kirtland South	5/8/97	grass	foliage (blades of grass)		-14.45	0.18
p-16	Embudito Arroyo	4/29/97	Chamisa	woody stem		-27.65	0.12
p-17	Embudo Arroyo	4/29/97	Willow	budding foliage	17-18 same specimen	-26.72	0.34
p-18	Embudo Arroyo	4/29/97	Willow	wood branch		-27.21	0.32
p-19	Embudo Arroyo	4/29/97	Chamisa	foliage		-29.91	0.05
p-20	Embudo Arroyo	4/29/97	grass	foliage (blades)		-30.02	0.01
p-21	Embudito Arroyo	4/29/97	unknown plant	leaves	21-22 same specimen	-25.18	0.12
p-22	Embudito Arroyo	4/29/97	unknown plant	stem		-24.77	0.07
p-23	Embudito Arroyo	4/29/97	Apache Plume	foliage	23-24 same specimen	-23.99	0.16
p-24	Embudito Arroyo	4/29/97	Apache Plume	stem		-24.68	0.12
p-25	Embudito Arroyo	4/29/97	Chamisa	foliage	25-26 same specimen	-27.36	0.36
p-26	Embudito Arroyo	4/29/97	Chamisa	stem		-26.43	nd

Table C4. Summary statistics of saturation indices for selected minerals by hydrochemical zone

[All calculations based on the PHREEQC thermochemical data base (Parkhurst, 1995)]

Hydrochemical zone		Albite ($NaAlSi_3O_8$)	Ca-Mont-morillonite ($Ca_{0.165}Al_{2.33}Si_{3.67}O_{10}(OH)_2$)	Calcite ($CaCO_3$)	Chalced-ony (SiO_2)	Chlorite ($Mg_5Al_2Si_3O_{10}(OH)_8$)	Carbon dioxide ($CO_{2(g)}$) [1]	Dolomite ($CaMg(CO_3)_2$)	Fluorite (CaF_2)	Gibbsite ($Al(OH)_3$)	Gypsum ($CaSO_4$: $2H_2O$)	Illite ($K_{0.6}Mg_{0.25}Al_{2.3}Si_{3.5}O_{10}(OH)_2$)	Potassium feldspar ($KAlSi_3O_8$)	Mica ($KAl_3Si_3O_{10}(OH)_2$)	Kaolinite ($Al_2Si_2O_5(OH)_4$)	Quartz (SiO_2)	Amorphous silica ($SiO_{2(a)}$)	Talc ($Mg_3Si_4O_{10}(OH)_2$)
Northern Mountain Front	Number	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
	Minimum	- 1.68	0.17	- 1.15	0.24	-13.81	- 2.84	- 2.75	- 2.72	- 0.37	- 3.13	- 0.35	- 0.28	4.59	1.41	0.66	- 0.61	- 6.28
	Median	- 1.04	3.34	- 0.23	0.56	- 6.52	- 2.37	- 1.03	- 2.05	0.52	- 2.44	2.29	0.91	7.65	3.82	1.00	- 0.29	- 1.09
	Maximum	- 0.29	4.13	0.17	0.66	- 0.22	- 1.17	0.17	- 1.01	0.96	- 1.64	3.04	1.53	8.58	4.72	1.11	- 0.18	3.42
Northwestern	Number	11	11	13	13	11	13	13.0	13.0	11.0	13.0	11.0	11.0	11.0	11.0	13.0	13.0	13.0
	Minimum	- 1.93	- 0.28	- 0.53	0.06	- 7.07	- 3.17	- 1.65	- 2.83	- 0.28	- 2.73	- 0.67	- 0.74	4.32	1.24	0.48	- 0.78	- 1.64
	Median	- 1.43	1.27	- 0.06	0.28	- 4.51	- 2.61	- 0.62	- 1.68	0.01	- 2.28	0.66	0.17	5.95	2.45	0.72	- 0.58	- 0.21
	Maximum	- 0.11	3.52	0.36	0.66	- 1.61	- 2.18	- 0.30	- 1.24	0.65	- 1.86	2.64	1.41	8.20	4.12	1.10	- 0.19	2.59
West Central	Number	58	58	66	66	58	66	66	66	58	66	58	58	58	58	66	66	66
	Minimum	- 2.18	- 2.40	- 0.61	- 0.11	- 8.12	- 3.89	- 1.86	- 2.70	- 1.15	- 3.28	- 2.31	- 1.22	2.20	- 0.51	0.33	- 0.97	- 3.17
	Median	- 0.83	0.60	0.07	0.25	- 1.40	- 3.06	- 0.40	- 1.78	- 0.26	- 2.41	0.04	- 0.05	5.15	1.79	0.67	- 0.59	2.27
	Maximum	0.77	4.30	0.65	0.70	4.48	- 1.74	0.75	- 0.10	0.81	- 1.39	3.86	2.20	9.42	4.56	1.14	- 0.16	5.84
Western Boundary	Number	8	8	15	15	8	15	15	15	8	15	8	8	8	8	15	15	15
	Minimum	- 1.85	- 1.17	- 0.09	0.01	- 5.83	- 3.13	- 0.32	- 3.37	- 0.64	- 1.56	- 1.40	- 0.91	3.40	0.54	0.34	- 0.80	- 2.49
	Median	- 0.73	1.16	0.40	0.14	- 1.92	- 2.27	0.63	- 0.74	0.18	- 0.99	0.73	0.08	5.90	2.38	0.56	- 0.70	0.97
	Maximum	1.18	3.30	1.35	0.65	- 0.22	- 0.42	2.33	0.23	0.79	- 0.01	3.06	2.16	8.56	3.81	1.09	- 0.21	4.08
Rio Puerco	Number	11	11	21	20	11	21	21	21	11	21	11	11	11	11	20	20	20
	Minimum	- 1.57	0.66	0.05	- 0.11	- 5.03	- 3.41	- 1.24	- 1.99	- 0.23	- 1.93	0.26	- 0.40	5.37	1.75	0.31	- 0.95	- 2.87
	Median	- 0.61	2.15	0.17	0.20	- 2.65	- 2.29	0.19	- 1.21	0.57	- 0.81	1.60	0.24	7.01	3.33	0.63	- 0.65	0.89
	Maximum	- 0.21	3.00	0.89	0.30	2.10	- 1.56	1.64	- 0.47	1.02	- 0.16	2.24	0.83	8.08	4.12	0.75	- 0.55	4.25
Southwestern Mountain Front	Number	1	1	2	2	1	2	2	2	1	2	1	1	1	1	2	2	2
	Minimum	- 3.67	- 3.28	0.43	- 0.34	1.39	- 3.18	0.27	- 1.62	- 1.01	- 2.01	- 3.36	- 2.57	1.05	- 1.04	0.07	- 1.17	0.26
	Median	- 3.67	- 3.28	0.51	0.03	1.39	- 2.88	0.69	- 1.08	- 1.01	- 2.00	- 3.36	- 2.57	1.05	- 1.04	0.48	- 0.83	1.77
	Maximum	- 3.67	- 3.28	0.59	0.40	1.39	- 2.59	1.11	- 0.54	- 1.01	- 1.98	- 3.36	- 2.57	1.05	- 1.04	0.89	- 0.50	3.28
Abo Arroyo	Number	4	4	5	5	4	5	5	5	4	5	4	4	4	4	5	5	5
	Minimum	- 2.05	0.58	- 0.27	0.06	- 6.23	- 2.92	- 0.68	- 1.87	- 0.15	- 1.96	- 0.21	- 0.85	4.71	1.97	0.51	- 0.80	- 2.05
	Median	- 1.70	1.58	0.02	0.16	- 4.04	- 2.32	- 0.17	- 1.04	0.31	- 1.14	0.84	- 0.71	6.03	2.71	0.59	- 0.68	0.06
	Maximum	- 0.98	1.95	0.33	0.42	- 1.91	- 1.96	0.50	- 0.82	0.69	- 0.67	0.95	0.58	6.23	3.26	0.86	- 0.42	2.20
Eastern Mountain Front	Number	64	64	80	80	64	80	80	80	64	80	64	64	64	64	80	80	80
	Minimum	- 8.49	-10.28	- 0.68	- 1.95	-11.81	- 5.32	- 2.46	- 3.55	- 1.59	- 3.34	- 9.20	- 6.94	- 4.55	- 5.38	- 1.50	- 2.81	- 5.19
	Median	- 1.29	2.36	0.05	0.26	- 4.10	- 2.45	- 0.60	- 1.62	0.61	- 2.25	1.27	0.22	6.68	3.42	0.69	- 0.59	- 0.87
	Maximum	0.30	5.30	0.58	0.65	4.67	- 1.67	1.29	- 0.25	1.84	- 1.47	4.30	1.76	10.54	5.99	1.09	- 0.22	5.14
Tijeras Fault Zone	Number	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Minimum	- 2.02	- 1.53	- 0.02	- 0.09	-11.97	- 2.82	- 0.39	- 1.43	- 0.58	- 1.73	- 1.74	- 1.48	2.94	0.36	0.36	- 0.94	- 6.43
	Median	- 1.24	2.05	0.19	0.20	- 6.65	- 1.67	0.09	- 0.52	0.55	- 1.39	1.22	- 0.14	6.59	3.22	0.65	- 0.66	- 2.37
	Maximum	- 0.67	4.26	0.29	0.30	- 1.64	- 0.46	0.61	0.20	1.80	- 0.99	3.26	0.82	9.98	5.49	0.75	- 0.56	1.69
Tijeras Arroyo	Number	5	5	9	9	5	9	9	9	5	9	5	5	5	5	9	9	9
	Minimum	- 2.51	0.29	- 0.13	0.11	- 7.46	- 2.54	- 0.64	- 1.84	- 0.13	- 1.72	- 0.64	- 1.01	4.33	1.77	0.57	- 0.76	- 2.53
	Median	- 1.76	1.73	0.13	0.16	- 5.44	- 2.10	- 0.07	- 1.24	0.38	- 1.42	0.76	- 0.35	6.02	2.90	0.62	- 0.71	- 1.23
	Maximum	- 1.56	2.52	0.29	0.23	- 4.13	- 1.85	0.19	- 0.78	0.89	- 1.02	1.62	- 0.08	7.26	3.76	0.66	- 0.62	- 0.33
Northeastern	Number	8	8	10	10	8	10	10	10	8	10	8	8	8	8	10	10	10
	Minimum	- 1.72	- 0.18	- 0.32	0.05	- 6.64	- 3.04	- 1.00	- 1.78	- 0.27	- 1.94	- 0.73	- 0.94	4.18	1.34	0.50	- 0.81	- 4.12
	Median	- 0.76	2.04	0.10	0.44	- 4.27	- 2.12	- 0.17	- 1.42	0.28	- 0.95	1.27	0.47	6.42	3.00	0.88	- 0.42	- 0.36
	Maximum	0.03	3.80	0.50	0.71	- 0.53	- 0.76	0.53	- 0.86	0.96	- 0.44	2.84	1.38	8.37	4.54	1.15	- 0.14	3.17
Central	Number	174	174	217	216	174	217	217	213	174	217	174	174	174	174	216	216	216
	Minimum	- 1.91	0.28	- 1.08	- 2.23	-11.56	- 4.00	- 2.57	- 3.17	- 0.55	- 3.22	0.27	- 0.32	5.11	1.28	- 1.80	- 3.07	- 9.30
	Median	- 0.38	3.05	0.05	0.52	- 2.99	- 2.57	- 0.41	- 1.76	0.49	- 1.94	2.43	1.24	7.72	3.66	0.97	- 0.33	0.83
	Maximum	1.09	6.23	1.06	0.77	6.51	- 1.02	1.59	- 1.07	1.62	- 0.89	5.40	2.69	11.49	6.31	1.23	- 0.07	8.08
Discharge	Number	4	4	7	7	4	7	7	7	4	7	4	4	4	4	7	7	7
	Minimum	- 0.62	1.61	0.03	0.21	- 2.09	- 3.30	- 0.18	- 1.23	0.03	- 1.59	1.43	0.43	6.58	2.52	0.65	- 0.64	0.36
	Median	- 0.39	2.04	0.18	0.39	- 1.56	- 2.51	0.36	- 0.75	0.37	- 1.27	1.60	0.71	6.93	3.08	0.83	- 0.45	1.52
	Maximum	- 0.10	2.61	0.65	0.54	- 0.81	- 2.45	1.13	- 0.14	0.51	- 0.94	2.11	1.01	7.32	3.36	0.98	- 0.31	6.24

[1] Log CO_2 partial pressure.

Appendix D. Summary of quality-assurance and quality-control data

Table D1. Concentrations of major elements and selected trace elements in standard reference water samples

[NIST, National Institute of Standards and Technology; NRCC, National Research Council of Canada; mg/L, milligrams per liter; (2.7), provisional concentrations; nd, not determined]

Element	High Purity standard TWDW (mg/L)	NIST standard reference material 1643D (mg/L)	NRCC standard reference SLRS-3 (mg/L)
Calcium	35.0	31.04 ± 0.5	6 ± 0.4
Magnesium	9.0	7.989 ± 0.035	1.6 ± 0.2
Potassium	2.5	2.356 ± 0.035	0.70 ± 0.1
Sodium	6.0	22.07 ± 0.64	2.3 ± 0.2
Silicon	nd	(2.7)	nd
Aluminum[1]	120*	127.6* ± 3.5	31* ± 3
Iron[1]	100*	91.2* ± 3.9	100* ± 2
Manganese[1]	40*	37.66* ± 0.83	3.9* ± 0.3
Strontium[1]	250*	294.8* ± 3.4	(28.1*)

[1]Aluminum, iron, manganese, and strontium concentrations are in ug/L (micrograms per liter).

Table D2. Standard reference materials, recommended concentrations, measured concentrations by direct-current plasma spectroscopy, and measured standard deviations

[(35), provisional concentrations; mg/L, milligrams per liter; nd, not determined]

Chemical or atomic symbol	Ca (mg/L)	Mg (mg/L)	Sr (mg/L)	Si (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1643D	31.0	8.0	0.29	(2.7)	22.1	2.4	0.10	0.04	0.12
Average of 5 analyses	30.3	8.2	0.32	2.8	21.3	2.5	0.12	0.04	0.12
Standard deviation	0.8	0.3	0.03	0.1	0.5	0.1	0.00	0.00	0.01
SLRS-3	6.0	1.6	(0.028)	nd	2.3	0.7	0.10	0.00	0.03
Average of 7 analyses	6.2	1.6	0.029	1.7	2.4	0.7	0.10	0.00	0.02
Standard deviation	0.1	0.0	0.001	0.0	0.1	0.1	0.00	0.00	0.00
TMDW	35.0	9.0	0.25	nd	6.0	2.5	0.10	0.04	0.12
Average of 5 analyses	34.7	9.1	0.25	nd	6.1	2.6	0.13	0.04	0.10
Standard deviation	0.4	0.4	0.02	nd	0.3	0.1	0.01	0.00	0.02
High Ca standard	50.0	20.0	2.0	20.0	10.0	10.0	2.00	2.00	0.50
Average of 24 analyses	50.3	20.0	2.0	19.7	9.8	9.9	1.98	1.99	0.49
Standard deviation	0.9	0.2	0.1	0.5	0.3	0.3	0.05	0.04	0.02
Low Ca high standard	20.0	5.0	0.5	10.0	5.0	2.0	0.50	0.50	0.10
Average of 6 analyses	20.3	5.1	0.5	9.8	4.9	2.0	0.47	0.51	0.10
Standard deviation	0.5	0.1	0.0	0.2	0.2	0.0	0.02	0.01	0.01
Low Ca standard	10.0	nd	nd	nd	nd	nd	nd	nd	nd
Average of 6 analyses	10.1	nd	nd	nd	nd	nd	nd	nd	nd
Standard deviation	0.2	nd	nd	nd	nd	nd	nd	nd	nd

Table D3. Standard reference materials, recommended concentrations, measured concentrations by ion chromatography, and measured standard deviations

[First row is the recommended concentration and accuracy; mg/L, milligrams per liter]

Chemical or atomic symbol	Fluoride (mg/L)		Chloride (mg/L)		Nitrate (mg/L)		Sulfate (mg/L)	
High Purity Simulated rainwater	0.1	±0.01	0.98	±0.01	7.0	±0.2	10.1	±0.3
Average of 4 analyses	0.11		1.0		6.92		10.3	
Standard deviation	0.0		0.0		0.04		0.0	

Table D4a. Concentrations of trace elements in standard reference water samples and high purity working standards

[Concentrations are in ug/L (micrograms per liter); NIST, National Institute of Standards and Technology; NRCC, National Research Council of Canada; ERA, Environmental Research Associates; SRM, standard reference material; (35), provisional concentration; nd, not determined]

Symbol of element	NIST water SRM 1643D	NRCC standard SLRS-3	ERA standard WW-11	ERA standard PW-34	High Purity standard TMDW
Ag	1.27 ±0.05	nd	108.	106.	2 ±0.01
Al	127.6 ±3.5	31 ±3	762.	375.	120 ±0.6
As	56.02 ±0.73	0.72 ±0.05	32.4	81.3	80 ±0.4
B	144.8 ±5.2	nd	431.	156.	nd
Ba	506.5 ±8.9	13.4 ±0.6	649.	1130.	50 ±0.25
Be	12.53 ±0.28	0.005 ±0.00	75.7	77.5	20 ±0.1
Bi	(13)	nd	nd	nd	10 ±0.05
Cd	6.47 ±0.37	0.013 ±0.00	59.5	56.3	10 ±0.05
Co	25.00 ±0.59	0.027 ±0.00	184.	nd	25 ±0.13
Cr	18.53 ±0.2	0.30 ±0.04	119.	375.	20 ±0.1
Cu	20.5 ±3.8	1.35 ±0.07	238.	688.	20 ±0.1
Fe	91.2 ±3.9	100 ±2	276.	225.	100 ±0.5
Li	16.50 ±0.55	nd	nd	nd	20 ±0.1
Mn	37.66 ±0.83	3.9 ±0.3	432.	125.	40 ±0.2
Mo	112.9 ±1.7	0.19 ±0.01	541.	313.	100 ±0.5
Ni	58.1 ±2.7	0.83 ±0.08	324.	225.	60 ±0.3
Pb	18.15 ±0.64	0.068 ±0.00	297.	56.3	40 ±0.2
Rb	(13)	nd	nd	nd	10 ±0.05
Sb	54.1 ±1.1	0.12 ±0.01	86.5	43.8	10 ±0.05
Se	11.43 ±0.17	nd	81.1	56.3	10 ±0.05
Sr	294.8 ±3.4	(28.1)	551.	nd	250 ±1.25
Te	(1)	nd	nd	nd	3 ±0.02
Tl	7.28 ±0.25	nd	83.8	81.3	10 ±0.05
U	nd	(0.045)	nd	nd	10 ±0.05
V	35.1 ±1.4	0.30 ±0.02	314.	nd	30 ±0.15
Zn	72.48 ±0.65	1.04 ±0.09	119.	688.	70 ±0.35

Table D4b. Concentrations of trace elements in standard reference water samples and high purity working standards-- Continued

Symbol of Element	High Purity standards CWW-TM-A	High Purity standards CWW-TM-B	VHG Labs standards QCTM #1	VHG Labs standards QCTM #2
Ag	10 ±0.1	50 ±0.3	69.0	nd
Al	50 ±0.3	200 ±1.0	68.48	nd
As	10 ±0.1	50 ±0.3	180.2	nd
B	50 ±0.3	200 ±1.0	nd	99.4
Ba	50 ±0.3	200 ±1.0	126.2	nd
Be	10 ±0.1	50 ±0.3	66.7	nd
Cd	10 ±0.1	50 ±0.3	79.3	nd
Co	50 ±0.3	200 ±1.0	397.9	nd
Cr	50 ±0.3	200 ±1.0	64.9	nd
Cu	50 ±0.3	200 ±1.0	342.1	nd
Fe	50 ±0.3	200 ±1.0	425.5	nd
Mn	50 ±0.3	200 ±1.0	412.1	nd
Mo	50 ±0.3	200 ±1.0	nd	294.3
Ni	50 ±0.3	200 ±1.0	72.7	nd
Pb	50 ±0.3	200 ±1.0	112.3	nd
Sb	10 ±0.1	50 ±0.3	nd	179.1
Se	10 ±0.1	50 ±0.3	50.4	nd
Sr	50 ±0.3	200 ±1.0	nd	nd
Tl	10 ±0.1	50 ±0.3	224.5	nd
V	50 ±0.3	200 ±1.0	65.2	nd
Zn	50 ±0.3	200 ±1.0	210.2	nd

Table D5a. Standard reference materials, recommended concentrations, measured concentrations by inductively-coupled plasma-mass spectroscopy, and measured standard deviations for the 1997 samples

[Concentrations are in µg/L (micrograms per liter); (3), number of analyses; <, less than; nd, not determined]

Symbol of Element	Al	As	B	Ba	Cr	Cu	Li	Mn	Mo	Pb	Rb	U	V	Zn
Mass Number	27	75	11	135;137; 138	52	63	7	55	95;97; 98	208	85	238	51	66;68
1643D	127.6	56	144	506	18.5	20.5	16.5	37.7	112.9	18.2	(13)	nd	35.1	72.5
average (4)	120.6	51.9	139.1	507	18.9	19.6	16.6	37.5	111.6	19.5	11.7	nd	35.9	69
standard deviation	3.8	0.4	3.4	12.2	0.6	0.6	1.2	1	0.9	0.3	0.1	nd	0.9	6.2
CWW-TM-A	50	10	50	50	50	50	nd	50	50	50	nd	nd	50	50
average (5)	51.1	10.4	48.9	49.4	49.4	48.6	nd	49.7	48.9	48.7	nd	nd	49.4	53.7
standard deviation	2.2	0.4	7.6	1.2	2.3	2.2	nd	3.4	1.5	4.3	nd	nd	3.4	1.9
CWW-TM-B	200	50	200	200	200	200	nd	200	200	200	nd	nd	200	200
Average (5)	193.1	50.6	186.5	201.1	196	187.8	nd	200	189.8	214.9	nd	nd	197.9	211.3
standard deviation	9.3	0.8	8.1	10.3	10.1	4.1	nd	9.9	1.5	5.8	nd	nd	7.4	4.7
CWW-TM-E	25	5	25	25	25	25	nd	25	25	25	nd	nd	25	25
Average (6)	26.1	5.1	24.9	24.2	25.3	25.2	nd	25.1	24.4	25	nd	nd	25.4	27.2
Standard deviation	2	0.1	1.5	1.3	1.4	0.9	nd	0.9	0.3	1.9	nd	nd	1.3	0.7
PW-34	375	81.3	156	1130	375	688	nd	125	313	56.3	nd	nd	nd	688
Average (5)	372	82	171.6	1140.3	374	648	nd	123	309	58.9	nd	nd	nd	644
Standard deviation	13.8	1.4	5.2	45.2	16.1	37.9	nd	3.1	9.7	1.5	nd	nd	nd	27.5
QCTM #1	68.5	180.2	nd	126.2	64.9	342	nd	412	nd	112.3	nd	nd	65.2	210.2
Average (9)	72	179	nd	134.6	64.8	334	nd	438	nd	112.5	nd	nd	65.9	204.1
Standard deviation	2.7	4.3	nd	9.8	1.3	12.4	nd	17	nd	11	nd	nd	1.4	4
QCTM #2	nd	nd	99.4	nd	nd	nd	nd	nd	294	nd	nd	nd	nd	nd
Average (8)	nd	nd	94.9	nd	nd	nd	nd	nd	284	nd	nd	nd	nd	nd
Standard deviation	nd	nd	34.7	nd	nd	nd	nd	nd	7.8	nd	nd	nd	nd	nd
SLRS-3	31	0.7	nd	13.4	nd	1.4	nd	3.9	nd	0.1	nd	nd	0.3	1
Average (6)	30.7	0.8	nd	13.5	nd	1.5	nd	3.8	nd	0.1	nd	nd	0.5	1.7
Standard deviation	1.2	0	nd	0.4	nd	0.1	nd	0.1	nd	0	nd	nd	0.2	0.1
TMDW	120	80	nd	50	20	20	nd	40	100	40	10	10	30	70
Average (6)	110.4	66.2	nd	46.9	19.6	17.3	nd	37.8	94.5	39.3	9.7	10.7	29.7	49.7
Standard deviation	4	1.2	nd	1.3	0.8	0.5	nd	0.6	1.2	1	0.2	0.6	0.9	1.8
WW-11	762	32.4	431	649	119	238	nd	432	541	297	nd	nd	314	119
Average (6)	745	33.6	430	675	116	224	nd	423	559	311	nd	nd	318	127
Standard deviation	46.4	0.4	9.8	31.3	6.8	5.2	nd	22.3	13.7	3.9	nd	nd	17.8	6.4
Blank(H2O+HNO3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average (11)	1.7	0	<10	0	0.4	0.1	0.1	0	0.7	0	0	0	0.1	0.3
Standard deviation	2.3	0.1	nd	0	1	0.1	0.5	0.1	0.5	0	0	0	0.1	0.2
1 ppb	1	1	nd	1	1	1	1	1	1	1	1	1	1	1
Average (11)	0.9	0.9	nd	0.9	1.3	1.3	1.1	1	1	1	1	1	1	1.8
Standard deviation	0.7	0.1	nd	0.2	1.3	0.6	0.6	0.1	0.2	0.1	0	0.2	0.1	0.6
10 ppb	10	10	nd	10	10	10	10	10	nd	10	10	10	10	10
Average (11)	9.7	10.2	nd	11	10	10.4	9.1	10.2	nd	10.5	10.4	10.4	10.3	10.6
Standard deviation	0.7	0.1	nd	0.7	0.4	0.1	1.8	0.4	nd	0.3	0	1	0.3	0.2
20 ppb	20	20	nd	20	20	20	20	20	nd	20	20	20	20	20
Average (6)	19.2	20	nd	21.1	20.3	19.7	19.2	20.2	nd	21	20.4	21.3	20.2	20.3
Standard deviation	0.8	0.5	nd	0.9	0.5	0.5	1.7	0.3	nd	1.3	0.2	1.6	0.6	0.6
100 ppb	100	100	nd	100	100	100	100	100	nd	100	100	100	100	100
Average (3)	99.3	102.4	nd	104.4	101	98.3	100	98.4	nd	96.9	110.4	111	102.5	100.4
Standard deviation	1.5	2.9	nd	1.2	1.8	2.1	6.6	3	nd	5.6	8.7	6.9	1	2.8

Table D5b. Standard reference materials, recommended concentrations, measured concentrations by inductively-coupled plasma-mass spectroscopy, and measured standard deviations

Symbol of element	Se	Rb	Sr	Mo	Mo	Mo	Cd	Cs	Ba	Ba	Ba	Tl	Pb	U
Mass number	82	85	88	95	97	98	111	133	135	137	138	205	208	238
CWW-TM-A	10	nd	50	50	50	50	10	nd	50	50	50	10	50	nd
Average (3)	12.0	0.0	49.9	49.1	49.3	49.2	10.4	0.4	49.4	49.5	50.6	10.1	50.9	0.00
STD	0.00	0.00	0.33	0.7	0.62	0.71	0.36	0.02	1.61	1.7	2.31	0.16	0.93	0.00
CWW-TM-B	50	nd	200	200	200	200	50	nd	200	200	200	50	200	nd
Average (5)	56	0.0	201	197	196	197	52	0	198	199	203	51	206	0
STD	1.7	0.0	2.5	2.8	2.6	2.4	0.8	0.0	5.0	5.2	6.1	1.0	0.5	0.0
CWW-TM-E	5	nd	25	25	25	25	25	nd	25	25	25	5	25	nd
Average (3)	6	0.0	25	24	25	24	26	0.0	25	25	25	5	26	0
STD	0.0	0.0	0.2	0.4	0.4	0.4	0.6	0.0	0.8	0.8	1.1	0.1	0.3	0
1643d	11	13	295	113	113	113	6.47	nd	506	506	506	7.28	18.2	nd
Average (6)	10	11	295	114	114	113	6.00	4.5	497	520	506	7.34	18.0	0
STD	0.5	0.1	3.0	0.9	0.8	0.7	0.08	0.2	11.0	9.1	11.5	0.19	0.3	0
SLRS-3	nd	nd	28.1	0.19	0.19	0.19	0.013	nd	13.4	13.4	13.4	nd	0.068	0.05
Average (4)	0.35	1.65	32.0	0.28	0.28	0.3	0.015	0.02	13.9	13.9	14.0	0.02	0.070	0.05
STD	0.11	0.05	0.5	0.04	0.04	0	0.004	0.01	0.2	0.2	0.4	0.00	0.000	0.00
QCTM #1	50	nd	nd	nd	nd	nd	79.3	nd	126.2	126.2	126.2	224.5	112.3	nd
Average (6)	55.5	0.01	106.5	0.10	0.08	0.10	80.1	0.001	123.7	124.5	127.5	231.8	115	0.00
STD	1.3	0.00	1.0	0.06	0.07	0.06	1.5	0.004	2.6	2.9	2.2	4.8	2.1	0.00
QCTM #2	nd	nd	nd	294.3	294.3	294.3	nd	nd	nd	nd	nd	nd	nd	nd
Average (4)	0.25	0.01	0.00	290.5	289	307.7	0.81	0.01	0.00	0.20	0.00	0.06	0.29	0.00
STD	0.11	0.00	0.00	2.2	2.9	14.2	0.05	0.00	0.00	0.00	0.00	0.01	0.02	0.00
1 ppb	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average (8)	1.15	0.96	0.95	0.98	0.95	0.96	0.98	0.98	0.98	0.98	0.98	0.99	0.97	1.00
STD	0.15	0.01	0.05	0.04	0.05	0.05	0.02	0.04	0.04	0.04	0.04	0.05	0.02	0.04
5 ppb	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Average (8)	5.24	4.85	4.86	4.74	4.75	4.74	4.94	4.93	4.86	4.85	4.91	4.96	4.94	5.05
STD	0.14	0.07	0.10	0.05	0.05	0.05	0.09	0.19	0.14	0.13	0.19	0.14	0.10	0.17
10 ppb	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Average (9)	10.9	10.0	10.1	0.2	0.1	0.2	10.2	10.1	10.1	10.1	10.1	10.3	10.2	10.5
STD	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.3	0.2	0.2	0.3	0.2	0.2	0.3
50 ppb	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Average (7)	52.4	50.7	50.9	49.7	49.8	49.8	51.5	52.7	50.5	50.8	51.3	52.5	51.4	54.1
STD	0.5	0.5	0.5	0.3	0.3	0.3	0.9	0.8	1.1	1.1	1.5	1.3	0.9	1.6
20 ppb	20.0	20.0	20.0	nd	nd	nd	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Average (5)	21.2	20.0	20.2	nd	nd	nd	20.4	20.3	20.0	20.1	20.3	20.8	20.6	21.3
STD	0.4	0.2	0.3	nd	nd	nd	0.5	0.7	0.5	0.5	0.7	0.5	0.4	0.7
100 ppb (1)	104	103	103	98.7	98.5	98.8	101	102	102	102	104	104	102	104
HNO3 blank (5)	0.08	0.00	0.00	0.08	0.08	0.08	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00
STD	0.07	0.00	0.00	0.04	0.04	0.04	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.00
100 ppm Ca (3)	0.30	0.00	2.00	0.20	0.20	0.20	0.00	0.00	0.17	0.20	0.20	0.00	0.04	0.00
STD	0.08	0.00	0.08	0.28	0.28	0.28	0.00	0.00	0.05	0.00	0.00	0.01	0.00	0.00
200 ppm Cl (3)	0.30	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STD	0.00	0.00	0.00	0.05	0.05	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table D6a. Concentrations of major and trace metals by ICP-MS in blank water acidified with reagent grade and Baker Chemical Co. Ultrex nitric acid.

[µg/L, micrograms per liter; mg/L, milligrams per liter]

Symbol of element	Al (µg/L)	As (µg/L)	B (µg/L)	Be (µg/L)	Cd (µg/L)	Co (µg/L)	Cr (µg/L)	Cs (µg/L)	Cu (µg/L)	Fe (µg/L)	Li (µg/L)	Mn (µg/L)	Mo (µg/L)
Reagent grade nitric	3	<0.1	5	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<10	<0.1	<0.1	<0.1
Ultrex nitric	4	<0.1	5	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<10	<0.1	<0.1	<0.1

Symbol of element	Ni (µg/L)	Pb (µg/L)	Rb (µg/L)	Se (µg/L)	Sr (µg/L)	Tl (µg/L)	U (µg/L)	V (µg/L)	Zn (µg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)
Reagent grade nitric	1.1	<0.1	<0.1	<1	<0.1	<0.1	<1	<0.1	<1	<0.1	<0.05	<0.1	<0.05
Ultrex nitric	0.1	<0.1	<0.1	<1	<0.1	<0.1	<1	<0.1	<1	<0.1	<0.05	<0.1	<0.05

Table D6b. Concentration of major elements by DCP in a blank water-sample (lot 95171) acidified in the field. The water sample was obtained from the U.S. Geological Survey Water Quality Laboratory, Ocala, Florida.

[mg/L, milligrams per liter]

Symbol of element	Ca (mg/L)	Mg (mg/L)	Sr (mg/L)	Si (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Concentration	<0.3	<0.05	<0.01	<0.05	<0.05	<0.1	<0.01	<0.003	<0.005

Table D7a. Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters

[mg/L, milligrams per liter; µg/L, micrograms per liter; µ, microns; d, daltons, 1 dalton=1.66×10^{-24} grams; all samples were filtered during field collection]

Site no.	Sample no.	Site name	Type of filter	Filter size	Ca (mg/L)	Mg (mg/L)	Sr (mg/L)	SiO2 (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	B (mg/L)	Ba (mg/L)	Li (mg/L)
S003	NM481	98th St D	cartridge	0.45 µ	5.6	1.09	0.53	27.4	360	3.5	0.02	0.005	0.008	0.843	0.035	0.264
			tangential	0.1 µ	5.6	1.09	0.53	27.4	373	3.5	0.03	0.005	0.008	0.832	0.034	0.264
			tangential	30,000 d	5.4	1.05	0.51	26.7	360	3.5	0.02	0.005	0.012	0.832	0.034	0.273
S004	NM482	98th St MD	cartridge	0.45 µ	1.8	0.09	0.07	20.2	140	1.2	0.01	0.009	0.032	0.296	0.012	0.078
			membrane	0.2 µ	2.1	0.21	0.07	22.4	139	1.3	0.15	0.013	0.313	0.293	0.016	0.079
			tangential	0.1 µ	1.7	0.09	0.06	20.3	140	1.2	0.02	0.009	0.034	0.291	0.012	0.077
S005	NM483	98th St MS	cartridge	0.45 µ	5.3	0.72	0.20	16.5	162	2.8	0.02	0.039	0.010	0.368	0.037	0.048
			tangential	0.1 µ	5.3	0.72	0.20	16.2	165	2.8	0.02	0.038	0.014	0.365	0.037	0.048
			tangential	30,000 d	5.2	0.73	0.20	16.2	157	2.9	0.02	0.037	0.014	0.368	0.037	0.060
S088	NM494	Isleta MS	cartridge	0.45 µ	30.2	4.68	0.29	37.9	22.0	5.1	0.03	0.074	0.005	0.056	0.058	0.030
			tangential	0.1 µ	30.4	4.68	0.28	38.1	21.4	5.2	0.04	0.074	0.007	0.054	0.058	0.030
S089	NM495	Isleta S	cartridge	0.45 µ	119	16.10	0.91	38.7	59.2	7.5	0.43	1.260	0.004	0.126	0.169	0.069
			tangential	0.1 µ	118	16.10	0.90	38.5	58.4	7.4	0.43	1.260	0.004	0.122	0.167	0.067
S210	NM511	Sandia D	cartridge	0.45 µ	24.1	6.78	0.31	55.0	92.9	7.4	0.03	0.104	0.016	0.150	0.064	0.119
			membrane	0.2 µ	25.3	7.09	0.33	55.8	91.0	7.7	0.09	0.104	0.093	0.154	0.067	0.117
			tangential	0.1 µ	24.4	6.62	0.30	56.5	89.6	7.5	0.03	0.101	0.020	0.145	0.065	0.115
S211	NM512	Sandia M	cartridge	0.45 µ	24.3	4.83	0.26	61.0	122	8.5	0.02	0.023	0.009	0.263	0.058	0.217
			membrane	0.2 µ	24.3	4.90	0.27	60.8	126	8.6	0.04	0.023	0.056	0.255	0.059	0.215
			tangential	0.1 µ	24.4	4.84	0.26	62.5	123	8.6	0.03	0.020	0.008	0.256	0.059	0.213
S229	NM515	SH03 UNM	cartridge	0.45 µ	67.0	8.04	0.17	19.8	13.1	1.6	0.03	<0.001	0.004	0.020	0.055	0.009
			tangential	0.1 µ	67.9	7.87	0.16	19.5	13.5	1.8	0.04	<0.001	0.014	0.020	0.056	0.009
S230	NM516	Sierra Vista D	cartridge	0.45 µ	6.2	0.50	0.14	18.5	172	1.6	0.02	0.008	0.022	0.464	0.024	0.099
			membrane	0.2 µ	6.3	0.61	0.14	22.7	169	1.6	0.22	0.010	0.399	0.465	0.027	0.098
			tangential	0.1 µ	6.2	0.51	0.14	18.5	171	1.6	0.01	<0.01	0.021	0.452	0.024	0.097

Table D7b. Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters--Continued

Site no.	Sample no.	Site name	Type of filter	Filter size	V (µg/L)	Cr (µg/L)	Co (µg/L)	Cu (µg/L)	Rb (µg/L)	Mo (µg/L)	Zn (µg/L)	As (µg/L)	Se (µg/L)	Pb (µg/L)	U (µg/L)
S003	NM481	98th St D	cartridge	0.45 µ	53.0	10	<0.05	0.4	2.2	15	<1	39	1	<0.05	15
			tangential	0.1 µ	53.7	9	<0.05	0.5	2.2	15	<1	38	<1	<0.05	15
			tangential	30,000 d	52.7	9	<0.05	1.5	2.2	15	<1	38	<1	0.3	15
S004	NM482	98th St MD	cartridge	0.45 µ	12.0	4	<0.05	<0.1	0.6	5.8	<1	52	<1	<0.05	86
			membrane	0.2 µ	13.7	6	<0.05	1.2	0.9	5.9	8	52	<1	0.3	88
			tangential	0.1 µ	13.1	4	0.20	0.2	0.6	5.8	<1	52	<1	0.1	85
S005	NM483	98th St MS	cartridge	0.45 µ	<0.1	<1	<0.05	0.1	5.3	10	<1	12	<1	<0.05	6.0
			tangential	0.1 µ	<0.1	2	<0.05	0.2	4.9	10	<1	12	<1	0.1	6.0
			tangential	30,000 d	0.2	<1	<0.05	0.4	4.4	9.7	<1	12	<1	0.2	5.9
S088	NM494	Isleta MS	cartridge	0.45 µ	4.9	<1	0.13	0.2	6.6	4.6	2	6	<1	<0.05	1.5
			tangential	0.1 µ	4.9	<1	0.13	0.8	6.7	4.5	3	6	<1	<0.05	1.5
S089	NM495	Isleta S	cartridge	0.45 µ	<0.1	<1	0.21	0.7	5.2	7.6	3	3	<1	<0.05	1.9
			tangential	0.1 µ	<0.1	<1	0.21	0.7	5.2	7.6	3	3	<1	<0.05	1.9
S210	NM511	Sandia D	cartridge	0.45 µ	13.9	2	0.24	0.4	7.1	20	3	27	2	<0.05	5.3
			membrane	0.2 µ	13.9	2	0.24	1.5	7.1	19	9	26	2	0.2	5.2
			tangential	0.1 µ	14.2	2	0.18	0.5	7.2	18	3	27	2	0.1	5.3
S211	NM512	Sandia M	cartridge	0.45 µ	20.1	2	0.13	0.2	11	8.2	3	47	2	<0.05	2.8
			membrane	0.2 µ	19.9	2	0.05	0.5	11	8.1	6	47	2	0.1	2.8
			tangential	0.1 µ	20.0	1	<0.05	0.2	11	8.0	3	47	3	<0.05	2.7
S229	NM515	SH03 UNM	cartridge	0.45 µ	1.2	<1	0.09	0.4	0.5	2.0	3	1	1	0.1	15
			tangential	0.1 µ	1.2	<1	0.09	2.6	0.5	2.0	5	<1	1	0.2	15
S230	NM516	Sierra Vista D	cartridge	0.45 µ	<0.1	<1	<0.05	0.9	0.9	8.2	2	24	<1	<0.05	2.3
			membrane	0.2 µ	0.3	<1	0.13	1.4	1.2	7.9	31	23	<1	0.5	2.4
			tangential	0.1 µ	<0.1	<1	<0.05	1.0	0.9	8.1	3	23	1	0.1	2.3

Table D8. Concentrations of selected trace metals in 5 ground-water samples filtered through 0.45-micron cartridge filters in the field and then through 0.2- or 0.1-micron membrane filters in the laboratory

[µg/L, micrograms per liter; µ, microns]

Site no.	Sample no.	Site name	Filter size (µ)	Ba (µg/L)	V (µg/L)	Cr (µg/L)	Co (µg/L)	Cu (µg/L)	Rb (µg/L)	Mo (µg/L)	Zn (µg/L)	As (µg/L)	Se (µg/L)	Pb (µg/L)	U (µg/L)
S003	NM481	98th St. D	0.45	41	55	14	<0.1	0.3	2.3	15	5	40	3	0.2	16
			0.2	37	60	5	<0.1	0.7	2.2	15	3	39	1	0.1	15
			0.1	43	64	6	<0.1	0.9	2.2	17	5	43	2	0.2	13
S016	NM258	Windmill #15	0.45	13	60	16	<0.1	4.6	4.1	31	259	155	14	0.3	8.5
			0.2	12	31	4	<0.1	2.1	3.8	33	134	157	13	0.1	8.3
			0.1	12	34	6	<0.1	2.1	4.0	36	131	160	14	0.1	7.5
S060	NM279	Garfield D	0.45	40	37	2	<0.1	0.1	4.4	3.0	2	51	<1	<0.1	3.6
			0.2	36	40	3	<0.1	0.6	4.0	2.9	2	48	<1	<0.1	4.0
			0.1	38	43	5	<0.1	0.5	4.1	3.1	4	54	<1	0.1	3.4
S149	NM312	Nor Este D	0.45	56	35	<1	<0.1	0.4	9.9	8.6	5	54	1	<0.1	2.0
			0.2	49	38	5	<0.1	0.4	9.0	8.6	3	53	1	<0.1	2.0
			0.1	53	41	4	<0.1	0.2	9.5	9.4	3	60	2	<0.1	1.6
S173	NM323	Rio Bravo 5M	0.45	38	15	<1	<0.1	0.6	5.9	9.9	5	21	<1	<0.1	4.3
			0.2	33	17	3	<0.1	0.8	5.4	9.6	4	20	<1	<0.1	4.0
			0.1	83	18	3	<0.1	2.0	5.7	11	10	23	<1	0.2	3.5

Table D9. Comparison of water temperature and excess air calculated from dissolved gas analyses of laboratory water samples equilibrated with air and analyzed with the MRGB samples, 1996 through 1998

[ºC, degrees Celsius; cc/kg H_2O, cubic centimeters of dry excess air at 0 degrees Celsius and one atmosphere pressure per kilogram of water]

Sampling year	Number of water standards	Average bath (°C)	Calculated temperature (°C)	Observed minus calculated (°C)	Standard deviation	Calculated excess air (cc/kg of H2O)	Standard deviation
1996	3	5.7	6.0	-0.3	0.8	0.3	0.3
1996	30	24.23	24.4	-0.1	0.8	0.0	0.3
1997	6	8.98	9.0	-0.1	0.3	0.4	0.5
1997	5	16.0	16.1	-0.1	0.4	0.1	0.1
1997	9	24.54	24.4	0.1	0.5	0.0	0.2
1998	6	9.2	9.1	0.1	0.3	-0.2	0.3
1998	6	16.05	16.5	-0.5	0.3	-0.2	0.1
1998	6	25.53	25.8	-0.2	0.6	-0.1	0.1

Table D10. Summary of QA/QC data for radiocarbon activity measurements

[$\delta=((R_{sample}/R_{standard})-1)\times1000$, where R is an isotope ratio; $^{o}/_{oo}$, per mil; $\delta^{13}C$, carbon-13; pmC, percent modern carbon; S, analyzed from a water sample in a septum bottle; P, analyzed from a powder of $BaCO_3$; Group: 1, compare original powder determination to septum bottle collected at same time but stored about 1 year; 2, re-run $BaCO_3$ powder about 1 year after initial sample run; 3, re-sample the well a year later and run a new septum bottle (both samples from septum bottles); 4, re-run archived duplicate septum bottle; 5, extract second aliquot of CO_2 from original powder; Libby half-life, 5,568 years]

			First Analysis						Repeated Analysis						
Site no.	Sample no.	Site name	$\delta^{13}C$ ($^{o}/_{oo}$)	^{14}C activity (pmC)	± (pmC)	S or P	^{14}C age Libby half-life (years)	^{14}C age 5,730 half-life (years)	$\delta^{13}C$ ($^{o}/_{oo}$)	^{14}C activity (pmC)	± (pmC)	S or P	^{14}C age Libby half-life (years)	^{14}C age 5,730 half-life (years)	Group
S007	NM002	Domestic Well #01	-11.8	113.40	0.96	P	-1,010	-1,040	-12.1	113.56	0.94	S	-1,021	-1,051	1
S133	NM091	Montaňo 6D	-9.6	25.19	0.23	P	11,075	11,397	-9.9	21.96	0.21	S	12,177	12,532	1
S254	NM168	Private Production Well #12	-10.8	92.03	0.81	P	667	687	-10.0	92.11	0.79	S	660	679	1
S247	NM161	Domestic Well #19	-8.4	4.86	0.14	P	24,293	24,999	-8.8	4.71	0.12	S	24,544	25,259	1
S245	NM159	SWAB 3-980	-9.1	44.08	0.37	P	6,580	6,772	-12.5	39.47	0.33	S	7,468	7,685	1
S071	NM060	Domestic Well #07	-8.7	97.48	0.80	P	205	211	-10.2	94.58	1.10	S	448	461	1
S026	NM013	Burton 5	-9.3	44.66	0.37	P	6,475	6,664	-9.0	42.41	0.39	S	6,891	7,091	1
S111	NM079	Domestic Well #10	-6.7	54.73	0.46	P	4,842	4,983	-5.1	61.42	0.51	P	3,916	4,029	2
S239	NM156	Domestic Well #17	-8.7	22.00	0.26	P	12,163	12,517	-8.6	22.92	0.23	P	11,834	12,178	2
S283	NM181	Zia Ball Park D	-6.1	18.34	0.23	P	13,625	14,021	-6.4	23.29	0.22	P	11,705	12,046	2
S054	NM041	Domestic Well #04	-7.6	29.28	0.30	P	9,867	10,154	-7.0	32.94	0.30	P	8,920	9,180	2
S008	NM003	Private Production Well #01	-7.9	5.47	0.10	P	23,343	24,022	-8.5	6.92	0.14	P	21,454	22,078	2
S276	NM179	Windmill #12	-7.7	38.08	0.38	P	7,756	7,981	-7.1	39.68	0.33	P	7,425	7,641	2
S218	NM145	Santa Ana Boundary M	-7.0	8.24	0.12	P	20,052	20,635	-7.7	10.45	0.13	P	18,143	18,671	2
S170	NM108	Ridgecrest 3	-12.2	70.25	0.72	P	2,837	2,919	-11.9	69.43	0.66	P	2,931	3,016	2
S198	NM137	Windmill #07	-4.7	84.49	0.71	P	1,354	1,393	-3.8	87.76	0.73	P	1,049	1,079	2
S193	NM129	Rio Rancho 9	-7.9	7.72	0.12	P	20,575	21,174	-8.6	8.34	0.13	P	19,955	20,535	2
S187	NM131	Rio Rancho 12	-9.6	24.84	0.23	S	11,188	11,513	-8.9	32.54	0.26	P	9,019	9,281	2
S188	NM132	Rio Rancho 13	-7.2	3.00	0.09	P	28,168	28,987	-7.9	4.16	0.10	P	25,542	26,285	2
S120	NM304	Mesa Del Sol D	-10.8	19.27	0.15	S	13,227	13,612	-10.7	17.84	0.15	S	13,847	14,249	3
S153	NM315	Open Space	-8.3	55.15	0.51	S	4,781	4,920	-7.8	54.39	0.38	S	4,892	5,034	3
S150	NM313	Nor Este M	-8.6	17.12	0.19	S	14,177	14,590	-8.4	17.18	0.16	S	14,149	14,561	3
S149	NM312	Nor Este D	-8.7	7.96	0.11	S	20,329	20,921	-8.8	8.01	0.10	S	20,279	20,869	3
S044	NM268	Del Sol M	-8.0	14.48	0.16	S	15,523	15,974	-7.9	13.90	0.19	S	15,851	16,312	3
S121	NM302	Mesa Del Sol M	-8.5	8.32	0.09	S	19,974	20,555	-9.1	8.52	0.10	S	19,783	20,359	3
S043	NM267	Del Sol D	-8.0	6.37	0.09	S	22,119	22,763	-8.0	6.92	0.16	S	21,454	22,078	3
S003	NM251	98th St. D	-7.4	0.62	0.05	S	40,833	42,021	-7.2	1.08	0.06	S	36,375	37,433	3
S117	NM298	Domestic Well #25	-9.0	95.07	0.67	S	406	418	-9.0	96.28	0.67	S	305	313	4
S078	NM289	Hunter Ridge Nest 2 Well 1	-9.0	73.80	0.62	S	2,440	2,512	-9.0	73.50	0.51	S	2,473	2,545	4
S186	NM130	Rio Rancho 10	-6.8	11.66	0.16	P	17,263	17,765	-7.0	12.18	0.23	P	16,912	17,404	5

Appendix E. Supplementary water-quality data from the USGS NWIS database

Table E1. Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone

[nd, not determined; <, less than; na, not applicable; dms, degrees-minutes-seconds]

Sample reference number	Well number	Station number	Latitude (dms)	Longitude (dms)	Sample date	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date	Site type
	Zone 1: Northern Mountain Front											
DB445	16N.06E.31.444	353403106201601	353403	1062016	1/5/1965	nd	80	70	80	30.	1965	Well
DB455	16N.06E.18.300	353638106210701	353638	1062107	2/12/1965	nd	nd	nd	nd	nd	nd	Well
	Zone 2: Northwestern											
DB427	15N.02E.22.414	353042106424401	353042	1064244	2/27/1965	nd	323	271	297	140.	6/13/1952	Well
DB428	15N.02E.22.300	353043106431801	353043	1064318	5/19/1952	nd	nd	nd	nd	nd	nd	Well
DB429	15N.02E.22.423	353045106424101	353045	1064241	1/20/1960	nd	nd	nd	nd	nd	nd	Well
DB436	15N.02E.12.432	353226106404501	353226	1064045	4/4/1974	nd	503	nd	nd	376.27	12/18/1951	Well
DB447	16N.03E.29.3442	353454106384701	353454	1063847	6/8/1973	nd	na	na	na	na	na	Spring
	Zone 3: West Central											
DB019	02N.01E.09.220	342512106500701	342512	1065007	8/23/1949	nd	nd	nd	nd	nd	nd	Well
DB022	03N.01E.34.32	342623106493901	342623	1064939	8/24/1949	nd	nd	nd	nd	nd	nd	Well
DB031	03N.01E.23.331	342753106485501	342753	1064855	4/11/1995	4,746	210	200	210	9.74	4/11/1995	Well
DB058	05N.01E.13.332	343730106460301	343730	1064603	3/2/1965	nd	nd	nd	nd	nd	nd	Well
DB066	06N.01E.33.433	344147106502901	344147	1065029	6/6/1980	nd	556	nd	nd	417.5	5/24/1956	Well
DB073	06N.02E.18.232	344500106460301	344500	1064603	4/9/1995	4,830	355	345	355	7.22	4/9/1995	Well
DB074	06N.02E.10.341	344522106432001	344522	1064320	4/6/1995	4,829	160	150	160	8.88	4/6/1995	Well
DB077	06N.01E.05.421	344721106442201	344721	1064422	12/18/1951	nd	nd	nd	nd	nd	nd	Well
DB082	07N.02E.28.234	344819106440001	344819	1064400	11/28/1956	nd	nd	nd	nd	nd	nd	Well
DB084	07N.02E.28.234	344822106435001	344822	1064350	10/16/1957	nd	365	nd	nd	10.	11/28/1956	Well
DB091	07N.02E.21.332	344852106442901	344854	1064426	8/6/1952	nd	607	nd	nd	32.53	3/26/1956	Well
DB108	07N.02E.07.11414	345111106464101	345111	1064641	3/12/1975	nd	nd	nd	nd	nd	nd	Well
DB109	07N.02E.07.11414A	345113106464101	345113	1064641	7/16/1975	nd	nd	nd	nd	nd	nd	Well
DB119	08N.02E.29.213	345359107453001	345359	1064530	4/29/1957	nd	nd	nd	nd	nd	nd	Well
DB134	08N.01E.01.342	345654106463501	345654	1064635	5/28/1957	nd	nd	nd	nd	nd	nd	Well
DB187	10N.02E.36.413	350254106405501	350254	1064055	5/18/1965	nd	60	nd	nd	12.	11/1/1956	Well
DB189	10N.03E.32.314	350256106390801	350256	1063909	2/27/1974	nd	765	189	765	30.24	5/20/1982	Well
DB191	10N.02E.33.240	350308106433401	350308	1064334	8/25/1973	nd	nd	nd	nd	nd	nd	Well
DB215	10N.02E.25.213	350411106405501	350412	1064053	5/21/1957	nd	360	nd	nd	nd	nd	Well
DB223	10N.01E.30.222	350421106520905	350421	1065209	8/4/1960	nd	nd	nd	nd	nd	nd	Well
DB232	10N.01E.22.322	350449106493101	350449	1064931	1/17/1983	5,790	1,179	980	1,179	881.	1/25/1982	Well
DB234	10N.02E.28.212	350453106445401	350453	1064454	6/28/1972	nd	nd	nd	nd	nd	nd	Well
DB253	LAND GRANT	350612106440901	350612	1064409	12/1/1978	nd	nd	nd	nd	nd	nd	Well
DB323	11N.02E.22.441	350946106424601	350946	1064246	4/25/1957	nd	240	nd	nd	228.6	4/25/1957	Well
DB453	16N.02E.27.2134	353533106425301	353533	1064253	4/4/1974	nd	220	nd	nd	101.98	1/24/1984	Well
	Zone 4: Western Boundary											
DB007	01N.02W.01.330	341845106575801	342000	1070040	8/23/1949	nd	nd	nd	nd	9.93	11/30/1949	Well
DB010	01N.01E.05.100	342048106515801	342048	1065158	2/15/1950	nd	nd	nd	nd	nd	nd	Well
DB026	03N.01W.25.444	342707106532201	342707	1065322	nd	nd	70	nd	nd	34.97	11/21/1949	Well
DB032	03N.01W.21.332	342802106572401	342802	1065724	10/22/1982	5,125	405	nd	nd	352.	5/28/1980	Well
DB036	03N.03W.12.313	342947107064901	342947	1070649	3/18/1981	nd	nd	nd	nd	nd	nd	Well
DB038	04N.03W.35.211	343152107073001	343152	1070730	1/5/1950	nd	na	na	na	na	na	Spring
DB041	04N.03W.25.334	343209107065401	343209	1070654	1/5/1950	nd	na	na	na	na	na	Spring
DB068	06N.02W.31.400	344201107050801	344201	1070508	9/13/1950	nd	nd	nd	nd	nd	nd	Well
DB069	06N.01W.29.130	344310106581801	344310	1065818	6/6/1980	nd	567	434	564	380.	6/6/1980	Well
DB071	06N.02W.13.234	344449106594901	344449	1065949	5/29/1957	nd	133	nd	nd	74.49	4/26/1956	Well
DB116	LAND GRANT	345312107051801	345312	1070518	9/3/1941	nd	na	na	na	na	na	Spring
DB117	LAND GRANT	345312107052501	345312	1070525	4/21/1975	nd	na	na	na	na	na	Spring
DB433	15N.01E.13.422	353146106464401	353146	1064646	6/3/1959	nd	12	nd	nd	4.	6/3/1959	Well
DB450	16N.02E.29.321	353525106450201	353525	1064502	3/20/1997	nd	na	na	na	na	na	Spring
DB451	16N.02E.29.142	353528106451101	353528	1064511	8/30/1962	nd	na	na	na	na	na	Spring
	Zone 5: Rio Puerco											
DB024	03N.01E.34.430A	342629106493901	342629	1064939	8/24/1949	nd	nd	nd	nd	20.	6/1/1948	Well
DB051	04N.01W.12.341	343459106535401	343459	1065354	6/4/1980	nd	77	nd	nd	58.43	1/23/1985	Well
DB055	04N.01W.01.4111	343606106534201	343606	1065342	1/9/1950	nd	nd	nd	nd	nd	nd	Well
DB057	05N.01E.28.114	343720106505501	343720	1065055	4/24/1956	nd	nd	nd	nd	393.1	5/18/1956	Well
DB063	05N.01W.14.231	343955106545001	343955	1065450	5/27/1980	nd	100	nd	nd	90.73	4/30/1956	Well
DB086	LAND GRANT	344830107040401	344830	1070404	5/16/1975	nd	nd	nd	nd	nd	nd	Well
DB089	07N.01W.23.334	344843106550601	344843	1065506	6/6/1980	nd	576	nd	nd	508.8	4/26/1956	Well
DB103	LAND GRANT	345028107014301	345028	1070143	6/5/1975	nd	nd	nd	nd	nd	nd	Well
DB114	07N.01W.31.124	345230106591501	344748	1065905	4/26/1956	nd	97	nd	nd	74.11	2/10/1956	Well
DB122	08N.02W.24.131	345420107003801	345420	1070038	5/28/1957	nd	nd	nd	nd	nd	nd	Well
DB124	08N.02W.24.111	345440107004001	345440	1070040	4/29/1957	nd	nd	nd	nd	nd	nd	Well
DB132	08N.02W.12.111	345632107003701	345632	1070037	4/29/1957	nd	nd	nd	nd	138.05	4/29/1957	Well
DB157	09N.02W.10.300	350109107022501	350109	1070225	3/1/1965	nd	nd	nd	nd	nd	nd	Well
DB175	09N.01W.04.432	350158106563801	350158	1065638	6/5/1975	nd	nd	nd	nd	81.21	1956	Well
DB201	10N.02W.25.444	350336106593401	350336	1065934	9/26/1974	nd	nd	nd	nd	nd	nd	Well
DB206	10N.02W.25.432	350343106594801	350343	1065948	6/6/1967	nd	193	nd	nd	nd	nd	Well
DB209	10N.02W.24.4	350346106594601	350346	1065946	9/3/1953	nd	nd	nd	nd	nd	nd	Well

Table E1. Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

Sample reference number	Well number	Station number	Latitude (dms)	Longitude (dms)	Sample date	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date	Site type
DB219	10N.01E.30.222A	350421106520901	350421	1065209	2/12/1955	nd	nd	nd	nd	nd	nd	Well
DB220	10N.01E.30.222B	350421106520902	350421	1065209	2/1/1956	nd	nd	nd	nd	nd	nd	Well
DB221	10N.01E.30.222C	350421106520903	350421	1065209	10/11/1956	nd	nd	nd	nd	nd	nd	Well
DB222	10N.01E.30.222D	350421106520904	350421	1065209	11/12/1958	nd	nd	nd	nd	nd	nd	Well
DB235	10N.01W.21.132	350501106571201	350501	1065712	6/6/1967	nd	205	nd	nd	nd	nd	Well
DB385	12N.01W.17.1	351621106515301	351621	1065153	4/28/1961	nd	nd	nd	nd	nd	nd	Well
DB387	12N.01W.14.111	351627106550401	351627	1065504	6/20/1980	nd	120	nd	nd	107.17	6/20/1980	Well
DB407	13N.01W.16.230	352127106564201	352127	1065642	6/19/1980	nd	50	nd	nd	15.2	6/19/1980	Well
	Zone 6: Southwestern Mountain Front											
DB027	03N.03W.25.412	342717107060201	342717	1070602	12/22/1980	nd	na	na	na	na	na	Spring
	Zone 7: Abo Arroyo											
DB011	02N.02E.30.334	342147106472601	342147	1064726	1/25/1950	nd	nd	nd	nd	nd	nd	Well
DB014	02N.01E.23.323	342255106484401	342255	1064844	1/25/1950	nd	nd	nd	nd	nd	nd	Well
DB017	02N.02E.17.	342428106444501	342428	1064445	12/1/1949	nd	nd	nd	nd	nd	nd	Well
DB023	03N.03E.32.310	342624106384201	342624	1063842	6/12/1980	nd	nd	nd	nd	379.35	6/12/1980	Well
DB033	03N.03E.20.	342826106392001	342826	1063920	12/1/1949	nd	nd	nd	nd	nd	nd	Well
DB035	03N.03E.16.410	342900106380201	342900	1063802	12/1/1949	nd	nd	nd	nd	nd	nd	Well
	Zone 8: Eastern Mountain Front											
DB013	LAND GRANT	342231106372401	342231	1063724	5/4/1976	nd	nd	nd	nd	nd	nd	Well
DB037	03N.04E.03.110	343105106305301	343105	1063053	6/12/1980	nd	nd	nd	nd	322.05	6/12/1980	Well
DB040	04N.02E.32.100	343158106452901	343158	1064529	6/12/1980	nd	nd	nd	nd	22.75	6/12/1980	Well
DB045	04N.03E.26.144	343244106355201	343244	1063552	3/29/1950	nd	nd	nd	nd	nd	nd	Well
DB048	04N.03E.18.220	343443106393201	343443	1063932	6/12/1980	nd	370	340	360	296.9	6/12/1980	Well
DB052	04N.02E.15.443	343515106401901	343515	1064019	3/27/1950	nd	nd	nd	nd	nd	nd	Well
DB064	05N.03E.08.222	344048106382501	344048	1063825	6/18/1980	nd	nd	nd	nd	238.8	5/15/1956	Well
DB070	06N.04E.30.144	344358106324201	344358	1063242	5/28/1980	nd	na	na	na	na	na	Spring
DB087	07N.03E.25.220	344832106341901	344832	1063419	6/18/1980	nd	655	542	655	480.4	6/18/1980	Well
DB208	10N.04E.29.413	350346106322301	350346	1063227	5/5/1955	nd	1,004	504	1,004	466.	7/29/1952	Well
DB244	10N.04E.22.344	350529106303801	350529	1063038	10/4/1973	nd	nd	nd	nd	nd	nd	Well
DB247	10N.04E.16.241	350537106310601	350537	1063106	11/14/1973	5,575	nd	nd	nd	nd	nd	Well
DB274	10N.04E.03.223	350740106300201	350740	1063002	5/7/1956	nd	291	nd	nd	nd	nd	Well
DB276	10N.04E.04.221	350747106310701	350747	1063107	4/6/1965	nd	1,242	786	1,242	718.	4/13/1965	Well
DB282	11N.04E.33.331	350800106314501	350800	1063145	2/14/1974	nd	nd	nd	nd	nd	nd	Well
DB328	11N.04E.22.312	350957106304301	350957	1063043	3/16/1995	nd	655	645	655	475.	8/11/1989	Well
DB329	11N.04E.21.411	351001106312201	351001	1063124	3/15/1995	nd	930	877	882	830.	7/21/1986	Well
DB330	11N.04E.22.244	351005106295701	351004	1062957	3/24/1995	nd	515	495	505	nd	nd	Well
DB338	11N.04E.17.434	351029106322001	351029	1063220	3/15/1995	nd	670	640	670	535.	2/13/1987	Well
DB339	11N.04E.16.341	351033106314201	351033	1063142	5/1/1957	nd	736	nd	nd	683.5	5/21/1985	Well
DB345	11N.04E.15.244	351055106295401	351055	1062954	3/22/1995	nd	632	495	505	nd	nd	Well
DB371	12N.04E.32.242	351336106315901	351336	1063159	5/7/1956	nd	628	nd	nd	569.98	1/25/1957	Well
DB384	12N.04E.17.424	351556106315901	351556	1063159	5/7/1956	nd	305	nd	nd	294.	3/25/1957	Well
DB392	13N.04E.36.334	351818106282701	351818	1062827	8/9/1962	nd	nd	nd	nd	nd	nd	Well
DB397	18N.04E.36.113	351900106283801	351900	1062838	2/21/1975	nd	nd	nd	nd	nd	nd	Well
DB408	13N.05E.15.2414	352128106233501	352128	1062335	11/2/1962	nd	na	na	na	na	na	Spring
	Zone 9: Tijeras Fault Zone											
DB138	09N.04E.35.200A	345803106290601	345803	1062906	6/27/1944	nd	nd	nd	nd	nd	nd	Well
DB143	09N.04E.24.113	345955106281501	345955	1062815	7/25/1945	nd	na	na	na	na	na	Spring
DB144	09N.04E.20.221	345956106321601	345953	1063209	7/9/1957	nd	1,036	nd	nd	458.5	6/12/1959	Well
DB146	09N.04E.24.2114	345957106281201	345957	1062812	7/25/1945	nd	na	na	na	na	na	Spring
DB147	09N.04E.24.112	345958106281301	345958	1062813	7/25/1945	nd	na	na	na	na	na	Spring
	Zone 10: Tijeras Arroyo											
DB198	10N.04E.34.214	350317106300901	350317	1063009	9/27/1957	nd	1,200	nd	nd	616.17	9/30/1957	Well
DB202	10N.04E.26.431	350337106291203	350337	1062912	5/20/1992	nd	8	nd	nd	2.36	5/26/1992	Well
DB203	10N.04E.26.332	350337106294003	350337	1062940	5/20/1992	nd	12	nd	nd	9.26	5/26/1992	Well
DB205	10N.04E.26.341	350338106292801	350338	1062928	5/20/1992	nd	12	nd	nd	5.25	5/26/1992	Well
DB213	10N.04E.34.214	350410106302301	350410	1063023	9/19/1973	nd	nd	nd	nd	nd	nd	Well
	Zone 11: Northeastern											
DB410	13N.04E.01.412A	352257106275301	352257	1062753	9/25/1974	nd	nd	nd	nd	nd	nd	Well
DB411	13N.04E.01.421	352303106274601	352303	1062746	9/25/1974	nd	nd	nd	nd	nd	nd	Well
DB412	13N.04E.01.412	352304106275501	352304	1062755	11/17/1952	nd	nd	nd	nd	44.	10/15/1956	Well
DB414	13N.04E.01.243	352307106274701	352307	1062747	5/11/1953	nd	nd	nd	nd	46.	10/15/1956	Well
DB415	13N.04E.01.233	352309106280301	352309	1062803	7/26/1952	nd	nd	nd	nd	21.27	11/22/1957	Well
DB419	14N.08E.19.430	352510106140701	352510	1061407	11/1/1968	nd	nd	nd	nd	nd	nd	Well
DB421	14N.05E.19.221	352607106264301	352607	1062643	2/4/1965	nd	98	nd	nd	nd	nd	Well
DB431	15N.05E.13.330	353129106221201	353129	1062212	1/21/1965	nd	82	47	77	6.	1962	Well
DB442	15N.06E.06.411	353329106204001	353329	1062040	3/7/1995	5,225	138	131	138	24.28	3/7/1995	Well
	Zone 12: Central											
DB062	05N.02E.00	343920106442801	343920	1064428	9/25/1972	nd	nd	nd	nd	nd	nd	Well
DB072	06N.02E.03.344	344500106410501	344500	1064105	9/18/1951	nd	103	nd	nd	8.76	4/12/1956	Well
DB075	06N.03E.07.240	344548106393301	344548	1063933	6/13/1980	nd	295	nd	nd	190.	6/13/1980	Well

Table E1. Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

Sample reference number	Well number	Station number	Latitude (dms)	Longitude (dms)	Sample date	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date	Site type
DB079	07N.02E.26.333	344743106423001	344743	1064230	7/22/1963	nd	nd	nd	nd	nd	nd	Well
DB081	07N.03E.30.313A	344819106402601	344819	1064026	2/17/1982	nd	170	nd	nd	nd	nd	Well
DB083	07N.03E.30.313	344820106402601	344820	1064026	2/17/1982	nd	107	nd	nd	nd	nd	Well
DB088	07N.02E.26.112	344832106422301	344832	1064223	3/9/1956	nd	nd	nd	nd	nd	nd	Well
DB093	07N.02E.23.414	344900106415801	344900	1064158	4/9/1995	4,852	187	177	187	5.78	4/9/1995	Well
DB094	07N.02E.22.231	344916106430401	344916	1064304	4/12/1995	4,853	178	173	178	3.53	4/12/1995	Well
DB095	07N.02E.23.212	344932106415101	344932	1064151	8/3/1977	nd	nd	nd	nd	nd	nd	Well
DB096	07N.02E.23.212A	344932106415102	344932	1064151	8/3/1977	nd	nd	nd	nd	nd	nd	Well
DB101	07N.02E.28.333	345006106423001	345006	1064230	11/15/1976	nd	nd	nd	nd	nd	nd	Well
DB123	08N.02E.24.244	345425106403301	345425	1064033	4/30/1965	nd	100	nd	nd	nd	nd	Well
DB133	08N.02E.02.321	345653106421801	345653	1064218	8/6/1985	nd	65	nd	nd	nd	nd	Well
DB135	08N.02E.01.3223	345711106411001	345711	1064110	8/5/1993	nd	17	6	16	4.08	8/5/1993	Well
DB136	08N.02E.02.121	345718106421501	345718	1064215	8/9/1985	nd	119	nd	nd	nd	nd	Well
DB137	09N.02E.35.400	345736106414701	345736	1064147	8/3/1963	nd	nd	nd	nd	nd	nd	Well
DB139	09N.02E.36.222	345810106403401	345810	1064034	4/23/1995	4,907	220	210	220	8.99	4/23/1995	Well
DB140	LAND GRANT	345851106431601	345851	1064316	8/16/1985	nd	176	nd	nd	nd	nd	Well
DB141	09N.02E.24.3311	345919106412801	345919	1064128	8/13/1993	nd	19	9	19	6.25	8/13/1993	Well
DB142	09N.02E.23.233	345939106415901	345939	1064159	11/2/1987	nd	140	nd	nd	nd	nd	Well
DB145	09N.03E.20.122	345956106390801	345956	1063908	8/5/1985	nd	305	nd	nd	nd	nd	Well
DB148	09N.02E.13443	350003106404001	350003	1064040	8/8/1985	nd	58	nd	nd	nd	nd	Well
DB149	09N.03E.18.434A	350005106394302	350005	1063943	4/23/1965	nd	170	129	nd	nd	nd	Well
DB150	09N.02E.13.431	350005106405401	350005	1064054	8/8/1985	nd	50	nd	nd	nd	nd	Well
DB151	09N.02E.14.1344	350029106422101	350029	1064221	8/17/1993	nd	13	7	12	7.29	8/17/1993	Well
DB153	09N.03E.18.242	350037106392701	350037	1063927	8/5/1985	nd	103	nd	nd	nd	nd	Well
DB155	09N.02E.11.442	350104106413401	350104	1064134	4/20/1965	nd	251	nd	nd	5.6	8/1/1961	Well
DB156	09N.03E.08.300	350107106390901	350107	1063909	8/16/1946	nd	nd	nd	nd	nd	nd	Well
DB159	09N.02E.11.241	350130106414201	350130	1064142	6/23/1961	nd	86	25	80	8.04	8/1/1956	Well
DB161	09N.03E.09.113	350133106381801	350133	1063818	5/22/1956	nd	nd	nd	nd	nd	nd	Well
DB162	09N.03E.08.144A	350135106390601	350135	1063906	11/9/1993	nd	149	139	144	nd	nd	Well
DB168	09N.03E.07.241A	350138106393201	350138	1063932	11/8/1993	nd	148	138	143	nd	nd	Well
DB169	09N.03E.07.241B	350138106393202	350138	1063932	11/8/1993	nd	101	91	96	nd	nd	Well
DB170	09N.03E.07.241C	350138106393203	350138	1063932	11/8/1993	nd	49	39	44	nd	nd	Well
DB176	LAND GRANT	350204106411201	350204	1064112	9/15/1985	nd	18	nd	nd	nd	nd	Well
DB179	09N.03E.05.234	350216106383901	350216	1063839	5/2/1957	nd	92	nd	nd	60.	10/16/1956	Well
DB180	LAND GRANT	350223106420801	350223	1064208	9/19/1985	nd	70	nd	nd	nd	nd	Well
DB181	LAND GRANT	350223106420802	350223	1064208	9/19/1985	nd	24	nd	nd	nd	nd	Well
DB183	09N.02E.02.200	350226106414701	350226	1064147	8/23/1954	nd	nd	nd	nd	nd	nd	Well
DB185	10N.03E.32.444	350238106382401	350238	1063824	6/25/1980	nd	nd	nd	nd	nd	nd	Well
DB186	10N.02E.35.3443	350241106420701	350241	1064207	9/28/1993	nd	28	18	28	9.57	9/28/1993	Well
DB188	10N.03E.32.413	350255106384401	350255	1063844	6/25/1980	nd	nd	nd	nd	nd	nd	Well
DB190	10N.03E.32.412	350304106383401	350301	1063837	6/25/1980	nd	503	360	503	59.1	6/30/1982	Well
DB192	10N.03E.36.132	350313106345701	350313	1063457	5/19/1956	nd	997	nd	nd	400.	5/19/1956	Well
DB193	10N.03E.35.241	350313106352201	350313	1063522	10/25/1960	nd	nd	nd	nd	nd	nd	Well
DB194	10N.03E.33.231	350313106374701	350313	1063747	6/25/1980	nd	nd	nd	nd	nd	nd	Well
DB195	10N.03E.32.141	350315106390401	350315	1063904	5/21/1957	nd	nd	nd	nd	nd	nd	Well
DB197	10N.03E.31.1314	350316106402001	350316	1064020	8/16/1993	nd	20	10	20	10.46	8/16/1993	Well
DB199	10N.03E.35.111	350327106360901	350328	1063613	7/11/1957	nd	1,032	491	1,000	358.	10/1/1952	Well
DB207	10N.03E.29.3342	350344106391201	350336	1063912	8/11/1993	nd	29	14	29	12.1	8/11/1993	Well
DB225	10N.03E.20.344	350426106385601	350426	1063856	5/22/1957	nd	418	nd	nd	nd	nd	Well
DB226	10N.03E.21.433	350427106374601	350427	1063746	4/26/1957	nd	323	nd	nd	nd	nd	Well
DB228	10N.02E.24.33221	350436106411701	350436	1064117	8/10/1993	nd	28	18	28	9.96	8/10/1993	Well
DB230	10N.03E.19.2333	350447106395201	350447	1063952	8/4/1993	nd	18	8	18	7.69	8/4/1993	Well
DB233	10N.02E.24.233	350452106405701	350452	1064057	5/21/1957	nd	336	176	336	nd	nd	Well
DB236	10N.03E.20.124	350505106385701	350505	1063857	5/1/1957	nd	250	nd	nd	nd	nd	Well
DB237	10N.03E.20.124A	350505106385702	350505	1063857	5/1/1957	nd	60	nd	nd	nd	nd	Well
DB239	10N.03E.19.111	350510106402601	350510	1064026	4/26/1957	nd	100	nd	nd	5.67	12/7/1956	Well
DB242	10N.03E.17.343	350518106390601	350518	1063906	5/1/1957	nd	520	nd	nd	25.	10/10/1956	Well
DB246	10N.02E.14.4244	350534106413101	350534	1064131	8/17/1993	nd	16	11	16	11.24	8/17/1993	Well
DB250	10N.02E.14.211	350605106415701	350605	1064157	4/26/1957	nd	162	nd	nd	140.33	12/6/1956	Well
DB252	10N.03E.08.443	350612106383501	350612	1063835	5/21/1957	nd	351	nd	nd	nd	nd	Well
DB256	10N.03E.11.244	350636106351301	350636	1063513	5/22/1957	nd	376	327	376	nd	nd	Well
DB258	10N.03E.08.243	350637106383601	350637	1063836	5/21/1957	nd	370	200	327	nd	nd	Well
DB259	LAND GRANT	350639106380501	350639	1063805	8/29/1984	nd	nd	nd	nd	nd	nd	Well
DB260	10N.02E.12.4124	350639106410001	350639	1064100	8/4/1993	nd	27	16	26	14.7	8/4/1993	Well
DB261	10N.03E.11.200	350646106352501	350646	1063525	5/15/1952	nd	nd	nd	nd	nd	nd	Well
DB262	LAND GRANT	350647106411001	350647	1064110	8/17/1984	nd	nd	nd	nd	nd	nd	Well
DB265	LAND GRANT	350702106393701	350702	1063937	8/27/1984	nd	nd	nd	nd	nd	nd	Well
DB267	10N.03E.05.444	350704106382601	350704	1063826	5/22/1957	nd	296	163	273	nd	nd	Well
DB269	LAND GRANT	350706106401301	350706	1064013	8/22/1984	nd	nd	nd	nd	nd	nd	Well
DB270	LAND GRANT	350718106403601	350718	1064036	8/21/1984	nd	nd	nd	nd	nd	nd	Well
DB273	LAND GRANT	350734106400401	350734	1064004	8/10/1984	nd	nd	nd	nd	nd	nd	Well

Table E1. Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

Sample reference number	Well number	Station number	Latitude (dms)	Longitude (dms)	Sample date	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date	Site type
DB275	LAND GRANT	350743106410101	350743	1064101	8/14/1984	nd	nd	nd	nd	nd	nd	Well
DB279	10N.02E.02.212	350748106415001	350748	1064150	4/26/1957	nd	250	nd	nd	nd	nd	Well
DB283	LAND GRANT	350807106403301	350807	1064033	8/22/1984	nd	nd	nd	nd	nd	nd	Well
DB286	LAND GRANT	350815106372201	350815	1063722	8/9/1984	nd	nd	nd	nd	nd	nd	Well
DB288	11N.03E.32.234A	350821106383701	350821	1063837	8/13/1985	nd	132	123	128	nd	nd	Well
DB291	11N.03E.35.244	350822106351301	350822	1063513	11/5/1960	nd	nd	nd	nd	nd	nd	Well
DB292	LAND GRANT	350825106401701	350825	1064017	8/13/1984	nd	nd	nd	nd	nd	nd	Well
DB294	LAND GRANT	350827106391301	350827	1063913	9/13/1985	nd	150	140	145	nd	nd	Well
DB295	LAND GRANT	350827106391302	350827	1063913	9/13/1985	nd	99	90	95	nd	nd	Well
DB296	LAND GRANT	350827106391303	350827	1063913	9/13/1985	nd	50	40	45	nd	nd	Well
DB298	11N.03E.34.141	350828106365701	350828	1063657	5/1/1957	nd	150	nd	nd	78.95	12/11/1956	Well
DB299	LAND GRANT	350828106382001	350828	1063820	8/20/1984	nd	nd	nd	nd	nd	nd	Well
DB308	11N.02E.25.341A	350854106403701	350854	1064037	8/14/1985	nd	152	140	145	nd	nd	Well
DB309	11N.02E.25.341B	350854106403702	350854	1064037	8/14/1985	nd	93	83	88	nd	nd	Well
DB310	11N.02E.25.341C	350854106403703	350854	1064037	8/14/1985	nd	48	40	45	nd	nd	Well
DB312	LAND GRANT	350859106390601	350859	1063906	8/17/1984	nd	nd	nd	nd	nd	nd	Well
DB317	LAND GRANT	350907106394501	350907	1063945	8/14/1984	nd	nd	nd	nd	nd	nd	Well
DB318	LAND GRANT	350908106382001	350908	1063820	8/20/1984	nd	nd	nd	nd	nd	nd	Well
DB320	LAND GRANT	350928106380501	350928	1063805	8/27/1984	nd	nd	nd	nd	nd	nd	Well
DB325	11N.03E.20.400B	350948106383502	350948	1063835	5/21/1950	nd	nd	nd	nd	nd	nd	Well
DB327	11N.03E.22.3143	350951106370701	350951	1063707		nd	nd	nd	nd	nd	nd	Well
DB332	11N.03E.21.132	351012106380701	351012	1063807	11/8/1956	nd	60	nd	nd	10.	11/1/1956	Well
DB333	11N.03E.21.132A	351012106380702	351012	1063807	4/23/1965	nd	201	171	201	nd	nd	Well
DB340	11N.03E.13.332	351034106345601	351034	1063456	3/13/1995	nd				261.2	2/24/1993	Well
DB350	11N.03E.17.141	351059106385901	351059	1063859	1/5/1994	nd	150	135	145	19.56	2/14/1992	Well
DB351	11N.03E.17.141A	351059106385902	351059	1063859	1/4/1994	nd	25	10	20	6.76	12/3/1992	Well
DB352	11N.03E.17.141B	351059106385903	351059	1063859	1/5/1994	nd	600	545	555	37.71	12/3/1992	Well
DB353	11N.03E.13.231	351106106343601	351106	1063436	3/14/1995	nd	364	352	362	275.	10/9/1980	Well
DB354	11N.04E.18.124	351108106333601	351108	1063336	3/15/1995	nd	575	nd	nd	nd	nd	Well
DB355	11N.03E.15.1234	351109106365501	351109	1063655	8/1/1993	nd	27	17	27	17.36	8/1/1993	Well
DB356	11N.03E.15.121	351117106365801	351117	1063658	4/23/1965	nd	168	160	168	nd	nd	Well
DB357	11N.O3E.16.111	351120106381601	351120	1063816	5/4/1995	4,993	300	260	280	29.26	5/4/1995	Well
DB358	11N.03E.10.3442	351125106364601	351125	1063646	8/1/1993	nd	31	21	31	15.17	8/1/1993	Well
DB362	11N.03E.02.33142	351221106360601	351221	1063606	8/18/1993	nd	16	10	15	11.15	8/18/1993	Well
DB366	12N.03E.35.243	351304106352201	351333	1063522	5/8/1956	nd	15	nd	nd	nd	nd	Well
DB367	12N.03E.34.4413	351311106362801	351311	1063628	8/12/1993	nd	17	7	17	5.9	8/12/1993	Well
DB370	12N.03E.31.134	351334106401701	351334	1064017	4/27/1965	nd	338	nd	nd	270.	1/22/1964	Well
DB372	12N.03E.35.132	351338106360501	351338	1063605	3/6/1995	5,011	250	240	250	40.	5/7/1993	Well
DB373	12N.03E.34.1141	351347106370301	351347	1063706	8/12/1993	nd	29	18	28	17.94	8/12/1993	Well
DB375	12N.03E.27.4122	351421106363201	351421	1063632	9/27/1993	nd	40	25	40	20.63	9/23/1993	Well
DB376	12N.02E.25.421	351422106404201	351422	1064042	12/12/1974	5,370	nd	nd	nd	nd	nd	Well
DB378	12N.04E.30.124	351440106334301	351440	1063343	5/7/1956	nd	nd	nd	nd	154.53	3/29/1956	Well
DB379	12N.03E.30.121	351446106400601	351446	1064006	12/12/1974	5,356	nd	nd	nd	nd	nd	Well
DB381	12N.03E.27.222	351447106361601	351447	1063616	5/1/1957	nd	nd	nd	nd	nd	nd	Well
DB382	12N.03E.26.112	351448106360201	351448	1063602	5/1/1957	nd	25	nd	nd	7.	5/1/1957	Well
DB383	12N.03E.24.423	351504106341801	351504	1063418	2/26/1965	nd	96	61	96	35.	1961	Well
DB389	12N.04E.06.200	351806106332001	351806	1063320	1/21/1965	nd	nd	nd	nd	nd	nd	Well
DB390	12N.04E.06.213	351807106332801	351807	1063328	5/1/1957	nd	480	nd	nd	15.41	10/29/1956	Well
DB391	12N.04E.05.214	351809106321901	351809	1063219	9/25/1974	nd	nd	nd	nd	nd	nd	Well
DB398	13N.03E.36.123	351900106344101	351900	1063441	2/21/1975	nd	nd	nd	nd	nd	nd	Well
DB400	13N.04E.29.421	351932106320201	351932	1063202	7/26/1952	nd	nd	nd	nd	6.	7/26/1952	Well
DB413	13N.04E.01.234	352306106275801	352307	1062756	9/25/1974	nd	550	nd	nd	24.	1/15/1956	Well
DB468	07N.02E.13.441	354917106404101	344917	1064041	6/24/1968	nd	nd	nd	nd	nd	nd	Well
	Zone 13: Discharge											
DB009	01N.01E.04.123	342041106504601	342041	1065046	4/11/1995	4,725	89	84	88	21.45	4/11/1995	Well
DB021	03N.02E.31.431	342607106461901	342607	1064619	6/11/1980	nd	nd	nd	nd	100.	6/11/1980	Well
DB025	03N.02E.33.222	342650106430301	342650	1064303	5/30/1980	nd	320	nd	nd	177.95	5/30/1980	Well
DB029	03N.02E.27.123	342740106432301	342740	1064323	5/30/1980	nd	380	nd	nd	120.6	5/30/1980	Well

Table E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone

[nd, not determined; <, less than; Temp., field water temperature; ºC, degrees Celsius; O_2, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 ºC; Ca^{2+}, calcium; Mg^{2+}, magnesium, Na^+, sodium; K^+, potassium; Cl^-, chloride; SO_4^{2-}, sulfate; HCO_3^-, total titration alkalinity as bicarbonate]

Sample reference number	Sp. Cond. (µS/cm)	pH	Temp (ºC)	O_2 (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)	Na + K (mg/L as Na)	HCO_3^- (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
Zone 1: Northern Mountain Front												
DB445	365	7.7	nd	nd	42.	8.8	nd	nd	23	190	29	5
DB455	248	7.4	nd	nd	27.	4.7	nd	nd	17	120	18	6
Zone 2: Northwestern												
DB427	519	7.6	nd	nd	48.	9.	nd	nd	46	160	66	36
DB428	848	7.9	nd	nd	71.	15.	nd	nd	86	160	190	60
DB429	458	7.9	nd	nd	45.	5.2	nd	nd	45	160	47	34
DB436	490	7.9	17.0	nd	49.	1.5	56	5.5	nd	228	57	4
DB447	367	7.5	nd	nd	31.	4.	46	3.3	nd	211	20	3
Zone 3: West Central												
DB019	820	nd	nd	nd	14.	3.1	nd	nd	160	110	240	28
DB022	850	nd	nd	nd	26.	9.6	nd	nd	140	120	220	39
DB031	874	8.1	20.2	<0.10	28.	11.	140	7.3	nd	163	200	58
DB058	737	8.0	nd	nd	39.	13.	nd	nd	100	180	180	26
DB066	875	8.0	20.7	nd	57.	17.	130	5.8	nd	240	240	32
DB073	648	8.6	18.1	2.20	7.1	1.7	130	3.2	nd	168	130	16
DB074	479	8.4	17.5	0.30	11.	3.7	86	5.1	nd	174	69	16
DB077	660	nd	nd	nd	17.	8.4	nd	nd	110	160	160	18
DB082	488	8.0	18.5	nd	10.	4.3	nd	nd	94	180	68	18
DB084	470	8.1	18.0	nd	10.	3.1	nd	nd	96	190	73	9
DB091	506	nd	nd	nd	12.	3.1	nd	nd	100	190	76	18
DB108	511	7.7	18.5	nd	17.	6.4	84	5.0	nd	180	90	12
DB109	688	8.6	29.0	5.60	13.	1.	130	6.0	nd	146	160	13
DB119	470	7.9	19.0	nd	23.	6.6	nd	nd	65	180	46	20
DB134	475	8.1	20.0	nd	27.	6.9	nd	nd	66	140	96	12
DB187	545	8.2	nd	nd	39.	11.	nd	nd	65	190	100	14
DB189	514	8.0	20.5	nd	23.	5.4	77	8.3	nd	169	79	22
DB191	524	8.9	30.0	nd	6.1	0.4	110	2.0	nd	165	84	13
DB215	556	7.7	19.0	nd	33.	6.2	nd	nd	81	180	110	17
DB223	502	7.9	23.5	nd	28.	5.1	nd	nd	76	170	92	14
DB232	1,250	7.8	32.0	nd	22.	5.2	240	7.4	nd	252	220	100
DB234	657	8.6	30.0	nd	nd	nd	nd	nd	nd	nd	nd	nd
DB253	440	8.5	30.0	nd	2.5	0.2	100	1.4	nd	171	62	7
DB323	2,300	7.4	20.0	nd	220.	58.	nd	nd	270	220	1,100	31
DB453	704	8.1	15.0	nd	64.	9.2	69	9.6	nd	185	190	5
Zone 4: Western Boundary												
DB007	4,830	nd	nd	nd	150.	68.	nd	nd	860	300	840	1,000
DB010	3,910	nd	nd	nd	140.	75.	nd	nd	640	260	900	640
DB026	3,520	nd	nd	nd	110.	50.	nd	nd	620	280	710	610
DB032	1,810	7.6	22.0	nd	93.	41.	220	9.3	nd	246	290	300
DB036	1,850	8.1	18.5	nd	200.	57.	200	3.7	nd	122	1,000	13
DB038	5,110	nd	6.5	nd	128.	69.	nd	nd	885	350	463	1,240
DB041	5,200	nd	16.0	nd	138.	67.	nd	nd	887	354	471	1,250
DB068	6,520	7.7	nd	nd	280.	120.	nd	nd	1,100	280	1,100	1,500
DB069	5,400	8.0	18.8	nd	220.	71.	1,100	15.0	nd	240	1,400	1,200
DB071	5,800	8.3	18.0	nd	9.1	9.8	nd	nd	1,400	870	1,200	820
DB116	nd	nd	22.0	nd	523.	165.	6,716	194.0	nd	1,362	6,625	6,250
DB117	41,400	7.3	nd	nd	560.	350.	11,000	320.0	nd	1,530	8,900	11,000

Table E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	Sp. Cond. (µS/cm)	pH	Temp (ºC)	O_2 (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Na + K (mg/L as Na)	HCO_3^{-} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)
DB433	23,000	8.0	nd	nd	580.	150.	nd	nd	5,800	400	7,600	4,600
DB450	5,770	6.6	58.5	nd	70.7	12.2	1,129	72.5	nd	1,009	282	1,159
DB451	5,680	8.0	35.0	nd	100.	8.6	nd	nd	1,100	1,280	286	1,140
DB452	5,694	8.0	23.0	nd	110.	21.	1,300	73.0	nd	1,440	270	1,200
Zone 5: Rio Puerco												
DB024	3,460	nd	nd	nd	260.	110.	nd	nd	380	180	1,100	480
DB051	5,100	7.3	15.2	nd	360.	160.	720	11.0	nd	240	2,400	330
DB055	3,270	nd	nd	nd	280.	100.	nd	nd	340	200	1,100	410
DB057	2,960	7.2	22.0	nd	320.	120.	nd	nd	220	170	1,200	250
DB063	3,600	7.0	18.0	nd	380.	120.	430	12.0	nd	366	1,800	220
DB086	4,660	7.7	19.0	nd	410.	110.	520	34.0	nd	117	1,900	480
DB089	1,380	8.0	16.2	nd	110.	35.	160	8.8	nd	96	640	21
DB103	9,420	8.3	nd	nd	92.	30.	2,200	33.0	nd	464	2,600	1,500
DB114	8,540	7.7	18.0	nd	110.	55.	nd	nd	1,900	910	2,400	1,000
DB122	5,290	7.3	18.0	nd	330.	140.	nd	nd	830	270	2,200	500
DB124	4,910	7.4	16.5	nd	140.	43.	nd	nd	1,000	680	1,900	200
DB132	4,910	7.4	16.5	nd	140.	43.	nd	nd	1,000	680	1,900	200
DB157	5,870	8.4	nd	nd	24.	13.	nd	nd	1,480	610	2,600	78
DB175	4,360	8.1	nd	nd	45.	13.	1,000	7.1	nd	897	1,300	200
DB201	2,180	8.0	nd	nd	92.	1.2	380	6.0	nd	89	870	53
DB206	919	8.3	20.5	nd	58.	26.	nd	nd	110	180	280	21
DB209	932	nd	nd	nd	56.	29.	nd	nd	110	150	300	23
DB219	1,420	7.8	nd	nd	110.	27.	180	7.2	nd	100	630	20
DB220	1,530	7.5	25.5	3.40	130.	28.	nd	nd	180	100	680	22
DB221	1,530	7.5	25.5	nd	130.	39.	nd	nd	170	100	700	24
DB222	1,550	7.5	25.5	nd	130.	25.	nd	nd	200	97	720	24
DB235	951	8.4	21.5	nd	47.	6.	nd	nd	160	160	300	20
DB385	10,000	8.6	nd	nd	56.	14.	nd	nd	2,600	510	3,400	1,300
DB387	1,180	8.3	20.0	nd	19.	5.7	240	2.5	nd	410	210	5
DB407	1,650	7.5	16.0	nd	84.	21.	280	4.6	nd	350	510	39
Zone 6: Southwestern Mountain Front												
DB027	478	7.9	7.5	nd	68.	15.	19	2.5	nd	268	35	7
Zone 7: Abo Arroyo												
DB011	1,130	nd	20.3	nd	77.	32.	nd	nd	120	120	390	42
DB014	1,070	nd	nd	nd	88.	35.	nd	nd	84	99	310	94
DB017	1,040	nd	nd	nd	100.	38.	nd	nd	74	130	380	48
DB023	1,080	7.8	20.7	nd	110.	40.	65	3.1	nd	150	420	14
DB033	1,100	nd	nd	nd	130.	45.	nd	nd	52	160	440	28
DB035	834	nd	19.0	nd	94.	33.	nd	nd	42	170	280	19
Zone 8: Eastern Mountain Front												
DB013	466	7.9	nd	nd	30.	16.	45	2.7	nd	158	59	34
DB037	440	8.1	22.4	nd	47.	13.	34	2.6	nd	180	55	26
DB040	281	8.3	22.0	nd	29.	9.	23	4.6	nd	146	30	13
DB045	263	nd	22.0	nd	20.	6.	nd	nd	28	98	40	7
DB048	265	8.5	24.9	nd	12.	2.7	43	1.6	nd	97	56	5
DB052	357	nd	20.5	nd	40.	9.7	nd	nd	21	140	40	17
DB064	250	8.0	21.9	nd	34.	4.7	17	1.9	nd	130	22	7
DB070	340	7.8	15.5	nd	52.	4.9	19	0.6	nd	160	34	9
DB087	305	7.9	23.0	nd	33.	3.5	31	1.8	nd	150	30	5
DB208	555	7.6	21.5	nd	74.	14.	nd	nd	26	230	82	12
DB244	339	8.0	24.5	nd	37.	3.3	28	2.4	nd	151	33	7
DB247	283	8.2	25.0	nd	19.	0.9	41	1.9	nd	139	21	5
DB274	466	7.7	24.5	nd	65.	10.	nd	nd	22	200	54	14
DB276	285	7.9	24.0	nd	37.	1.8	nd	nd	23	150	18	5
DB282	275	7.9	25.5	nd	30.	1.4	26	2.0	nd	139	15	7

Table E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	Sp. Cond. (µS/cm)	pH	Temp (ºC)	O_2 (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Na + K (mg/L as Na)	HCO_3^{-} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)
DB328	376	7.7	18.0	nd	50.	3.8	17	1.3	nd	183	15	5
DB329	317	7.6	13.6	nd	43.	3.4	19	1.3	nd	163	17	5
DB330	454	7.5	17.0	nd	71.	8.2	14	1.7	nd	232	26	7
DB338	604	7.4	15.4	nd	59.	5.2	54	2.4	nd	168	32	84
DB339	331	7.5	20.5	nd	43.	7.4	nd	nd	17	170	21	6
DB345	416	7.3	18.0	nd	53.	7.1	20	1.5	nd	176	33	10
DB371	735	7.7	18.5	nd	73.	15.	nd	nd	56	180	63	100
DB384	329	7.9	20.0	nd	40.	5.9	nd	nd	24	140	39	12
DB392	439	7.5	nd	nd	79.	4.9	nd	nd	11	260	21	4
DB397	440	7.3	17.5	nd	71.	7.3	12	1.4	nd	238	26	4
DB408	590	7.4	23.5	nd	74.	9.6	nd	nd	47	329	38	9
Zone 9: Tijeras Fault Zone												
DB138	1,480	7.5	16.5	nd	180.	36.	nd	nd	98	700	59	120
DB143	2,540	nd	17.0	nd	224.	51.	nd	nd	288	956	100	355
DB144	704	7.6	23.0	nd	66.	19.	nd	nd	58	280	59	48
DB146	3,400	nd	16.0	nd	279.	65.	nd	nd	402	1,230	125	492
DB147	nd	nd	18.5	nd	188.	44.	nd	nd	190	748	78	255
Zone 10: Tijeras Arroyo												
DB198	636	7.3	14.3	nd	79.	22.	nd	nd	26	240	100	16
DB202	1,080	7.2	15.7	nd	130.	30.	55	4.1	nd	298	150	130
DB203	980	7.5	16.0	nd	110.	27.	52	5.0	nd	260	130	120
DB205	980	7.4	16.2	nd	120.	28.	53	4.2	nd	269	140	120
DB213	630	7.6	15.5	nd	80.	19.	27	3.7	nd	254	100	17
Zone 11: Northeastern												
DB410	1,050	nd	19.5	nd	150.	22.	50	3.0	nd	193	350	24
DB411	1,880	6.4	21.5	nd	210.	51.	180	11.0	nd	514	580	53
DB412	1,120	nd	nd	nd	120.	29.	nd	nd	92	350	280	32
DB414	1,520	nd	nd	nd	170.	38.	nd	nd	140	490	380	55
DB415	1,940	7.7	nd	nd	280.	55.	nd	nd	120	190	890	71
DB419	1,360	7.9	nd	nd	160.	45.	nd	nd	100	400	400	42
DB421	1,020	7.5	nd	nd	120.	22.	nd	nd	88	390	220	19
DB431	1,190	7.3	nd	nd	150.	25.	nd	nd	92	200	450	22
DB442	724	7.3	17.1	2.20	69.	18.	58	6.1	nd	213	190	9
Zone 12: Central												
DB062	470	7.6	nd	nd	44.	13.	31	6.0	nd	158	71	36
DB072	879	7.6	nd	nd	100.	18.	nd	nd	67	280	180	39
DB075	315	8.2	20.7	nd	37.	9.3	23	3.6	nd	150	37	9
DB079	861	7.5	14.0	nd	110.	15.	nd	nd	64	300	180	33
DB081	427	8.0	nd	nd	41.	11.	25	3.4	nd	134	73	22
DB083	532	8.1	nd	nd	51.	14.	34	3.8	nd	106	130	39
DB088	609	7.6	15.0	nd	71.	13.	nd	nd	33	220	110	4
DB093	317	8.0	15.8	0.10	31.	9.7	17	6.7	nd	144	32	7
DB094	309	8.1	14.8	0.10	31.	7.5	16	8.1	nd	118	42	10
DB095	295	8.2	nd	nd	29.	9.	20	5.5	nd	130	38	11
DB096	295	7.6	nd	nd	200.	30.	98	8.5	nd	310	330	200
DB101	583	7.8	nd	nd	67.	18.	22	5.3	nd	112	150	45
DB123	588	7.8	nd	nd	70.	12.	nd	nd	41	220	92	23
DB133	670	7.7	16.2	nd	88.	10.	44	5.3	nd	293	92	11
DB135	400	8.0	16.0	0.10	41.	5.5	32	3.5	nd	148	65	<0.1
DB136	520	7.7	17.5	nd	75.	10.	23	7.2	nd	162	99	24
DB137	936	7.8	15.5	nd	110.	11.	nd	nd	88	320	200	38
DB139	373	8.0	16.2	0.10	33.	6.5	28	5.9	nd	141	36	22
DB140	450	8.0	18.0	nd	50.	11.	20	7.4	nd	105	110	11
DB141	800	7.3	18.1	0.10	120.	17.	47	10.0	nd	376	130	28
DB142	482	nd	nd	nd	52.	9.5	26	7.0	nd	124	90	22

Table E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	Sp. Cond. (µS/cm)	pH	Temp (ºC)	O_2 (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Na + K (mg/L as Na)	HCO_3^{-} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)
DB145	350	7.7	23.8	nd	34.	6.5	28	8.0	nd	133	30	20
DB148	500	8.0	15.5	nd	30.	6.1	66	6.6	nd	162	80	20
DB149	341	7.8	nd	nd	42.	6.1	nd	nd	19	137	29	19
DB150	420	7.7	15.0	nd	42.	6.5	42	4.5	nd	166	56	16
DB151	982	7.3	23.4	0.91	110.	13.	76	8.8	nd	356	180	30
DB153	580	7.6	20.5	nd	82.	13.	24	7.8	nd	190	78	47
DB155	803	7.8	nd	nd	100.	15.	nd	nd	54	240	180	30
DB156	327	nd	nd	nd	40.	5.8	nd	nd	22	160	29	10
DB159	549	8.1	16.5	nd	10.	5.8	nd	nd	100	180	74	27
DB161	389	7.7	25.0	nd	32.	8.6	nd	nd	34	130	33	32
DB162	350	7.2	19.5	nd	36.	7.	17	6.9	nd	139	31	21
DB168	400	7.9	18.5	nd	35.	2.9	21	12.0	nd	77	70	17
DB169	370	8.2	18.5	nd	30.	6.4	28	8.8	nd	141	34	27
DB170	640	8.2	18.0	nd	51.	13.	60	11.0	nd	224	110	19
DB176	925	7.3	16.8	nd	130.	14.	75	6.9	nd	341	220	37
DB179	296	7.8	20.5	nd	32.	9.3	nd	nd	14	130	31	6
DB180	825	7.6	16.8	nd	85.	13.	88	6.3	nd	339	160	29
DB181	760	7.5	16.9	nd	97.	14.	70	7.5	nd	294	160	29
DB183	763	nd	nd	nd	70.	12.	nd	nd	88	300	140	25
DB185	595	7.1	23.5	nd	84.	14.	30	6.2	nd	232	110	38
DB186	479	7.7	18.1	2.65	51.	7.9	35	5.4	nd	190	79	9
DB188	465	7.4	26.0	nd	34.	7.3	48	8.1	nd	115	65	36
DB190	400	7.6	26.0	nd	28.	6.7	40	8.8	nd	115	47	33
DB192	318	7.8	20.0	nd	32.	6.6	nd	nd	25	130	36	9
DB193	263	8.0	16.5	nd	38.	1.	nd	nd	17	120	26	6
DB194	400	7.5	25.0	nd	34.	7.2	33	6.9	nd	134	34	35
DB195	389	8.0	25.5	nd	17.	7.1	nd	nd	54	150	33	19
DB197	711	7.3	16.5	0.05	89.	12.	40	5.4	nd	324	100	14
DB199	292	7.9	nd	nd	33.	6.6	nd	nd	19	130	30	9
DB207	420	7.6	17.2	0.05	48.	6.9	25	3.4	nd	166	67	10
DB225	405	7.9	nd	nd	30.	9.	nd	nd	41	140	48	22
DB226	467	8.0	nd	nd	53.	14.	nd	nd	21	110	94	30
DB228	750	7.2	18.6	0.20	85.	11.	61	7.4	nd	274	150	24
DB230	490	7.5	17.7	0.10	61.	8.8	29	4.1	nd	210	69	14
DB233	454	7.7	16.5	nd	33.	6.2	nd	nd	56	160	78	15
DB236	566	7.6	nd	nd	46.	16.	nd	nd	51	170	99	32
DB237	916	7.6	nd	nd	89.	26.	nd	nd	75	250	210	46
DB239	556	7.7	14.0	nd	63.	13.	nd	nd	38	190	110	16
DB242	889	7.5	18.0	nd	110.	29.	nd	nd	40	230	210	52
DB246	574	7.5	18.9	0.20	68.	10.	30	4.5	nd	226	99	12
DB250	583	8.0	16.0	nd	58.	14.	nd	nd	45	170	120	20
DB252	585	7.7	20.0	nd	63.	13.	nd	nd	41	180	110	24
DB256	326	7.8	17.0	nd	40.	4.8	nd	nd	20	140	29	10
DB258	380	7.8	20.0	nd	38.	8.1	nd	nd	29	140	42	19
DB259	870	7.2	17.5	4.70	97.	15.	79	7.3	nd	341	190	19
DB260	500	7.8	16.0	0.10	60.	8.	35	4.9	nd	201	83	<0.1
DB261	313	8.0	nd	nd	40.	5.2	nd	nd	20	140	34	8
DB262	350	7.9	15.0	0.20	44.	5.9	25	3.7	nd	134	65	9
DB265	790	7.3	16.0	0.20	99.	17.	43	9.5	nd	268	200	15
DB267	315	7.8	15.5	nd	34.	7.6	nd	nd	21	130	37	10
DB269	900	7.4	16.0	0.10	120.	18.	68	8.9	nd	354	210	22
DB270	530	7.8	17.5	0.30	71.	12.	30	7.6	nd	220	110	11
DB273	790	7.6	17.0	0.20	80.	13.	80	8.1	nd	354	130	13
DB275	420	7.8	15.0	0.10	50.	6.8	28	4.2	nd	146	73	8
DB279	614	7.7	nd	nd	61.	19.	nd	nd	38	170	130	26
DB283	630	7.4	14.0	0.20	71.	13.	44	5.7	nd	220	110	20
DB286	590	7.9	17.5	0.20	63.	11.	23	4.3	nd	93	110	55

Table E2. Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	Sp. Cond. (µS/cm)	pH	Temp (ºC)	O_2 (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Na + K (mg/L as Na)	HCO_3^{-} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)
DB288	270	7.9	17.5	nd	30.	6.7	17	6.2	nd	121	30	10
DB291	275	8.1	17.0	nd	34.	4.1	nd	nd	21	130	28	10
DB292	487	7.8	16.0	0.20	51.	7.2	41	3.5	nd	171	68	26
DB294	700	7.2	16.5	nd	98.	29.	30	15.0	nd	355	120	15
DB295	800	7.4	15.5	nd	88.	24.	65	14.0	nd	371	150	13
DB296	910	7.3	15.5	nd	130.	22.	55	7.3	nd	422	190	13
DB298	291	7.7	16.5	nd	34.	9.	nd	nd	13	130	31	10
DB299	610	7.7	17.0	0.20	81.	16.	27	5.5	nd	207	86	62
DB308	419	7.9	17.0	nd	51.	10.	31	6.5	nd	157	89	14
DB309	315	8.1	16.0	nd	30.	6.2	31	6.5	nd	126	53	10
DB310	430	7.9	15.0	nd	47.	8.7	31	6.9	nd	172	72	11
DB312	570	7.6	16.0	0.40	73.	19.	25	8.2	nd	220	110	25
DB317	700	7.4	15.0	0.10	100.	13.	42	5.4	nd	341	110	7
DB318	760	7.4	17.0	0.20	110.	27.	31	7.1	nd	341	150	25
DB320	380	7.8	18.0	0. 0	43.	9.6	17	4.2	nd	110	70	22
DB325	343	nd	nd	nd	40.	10.	nd	nd	12	140	41	4
DB327	958	8.4	nd	nd	100.	11.	nd	nd	110	330	220	22
DB332	939	7.6	nd	nd	120.	27.	nd	nd	49	380	170	26
DB333	365	7.6	nd	nd	40.	8.5	nd	nd	22	132	47	18
DB340	600	7.5	16.6	nd	83.	13.	23	3.6	nd	220	92	17
DB350	430	8.0	12.5	nd	55.	9.1	18	4.7	nd	155	73	12
DB351	386	8.0	8.5	nd	46.	7.3	22	2.9	nd	151	58	8
DB352	323	8.0	15.3	nd	37.	6.9	16	6.4	nd	146	33	7
DB353	527	8.1	15.3	nd	73.	13.	21	3.6	nd	198	83	17
DB354	344	7.7	17.5	nd	27.	6.7	32	6.1	nd	151	31	10
DB355	800	7.2	19.7	1.80	130.	12.	36	6.1	nd	339	160	22
DB356	281	8.0	nd	nd	35.	4.5	nd	nd	17	120	30	8
DB357	280	8.1	14.3	0.10	31.	5.8	14	4.5	nd	126	26	7
DB358	700	7.3	18.3	0.20	95.	12.	35	5.1	nd	244	160	21
DB362	765	7.1	17.5	0.20	110.	14.	33	5.1	nd	362	66	44
DB366	521	7.8	10.5	nd	63.	10.	nd	nd	38	190	94	18
DB367	420	7.8	16.0	0.05	48.	6.8	28	3.3	nd	170	59	11
DB370	501	7.8	nd	nd	57.	10.	nd	nd	29	130	58	51
DB372	317	8.0	15.0	<0.05	32.	11.	14	5.7	nd	148	30	8
DB373	900	7.2	16.0	3.80	130.	27.	34	1.5	nd	513	85	8
DB375	751	7.2	17.1	4.10	100.	12.	28	4.1	nd	324	95	9
DB376	352	7.4	13.0	nd	28.	5.	36	7.6	nd	156	35	7
DB378	631	7.8	17.0	nd	70.	19.	nd	nd	36	210	84	44
DB379	348	7.5	16.0	nd	31.	5.9	30	6.4	nd	142	37	7
DB381	906	7.5	15.0	nd	120.	22.	nd	nd	58	380	150	17
DB382	380	7.6	nd	nd	44.	12.	nd	nd	17	140	60	14
DB383	878	7.5	nd	nd	110.	17.	nd	nd	60	360	140	22
DB389	666	7.5	nd	nd	60.	11.	nd	nd	69	250	85	37
DB390	501	7.8	18.0	nd	37.	11.	nd	nd	56	170	53	46
DB391	642	nd	27.0	nd	41.	6.8	79	7.9	nd	200	40	72
DB398	860	7.7	nd	nd	98.	15.	55	5.8	nd	223	170	47
DB400	524	7.6	nd	nd	30.	6.1	nd	nd	81	230	46	28
DB413	749	6.6	25.5	nd	65.	15.	77	11.0	nd	394	29	35
DB468	327	7.9	nd	nd	34.	8.5	21	5.0	nd	130	41	11
Zone 13: Discharge												
DB009	1,771	7.7	17.2	0.10	130.	36.	190	8.9	nd	202	340	280
DB021	1,150	8.3	22.5	nd	84.	27.	120	27.0	nd	120	240	190
DB025	3,400	7.6	17.5	nd	98.	31.	770	8.6	nd	180	330	1,100
DB029	975	7.9	17.0	nd	48.	17.	140	22.0	nd	140	170	150

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone

[nd, not determined; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; F, fluoride; Br, bromide; SiO_2, silica; NO_3, nitrate; N, nitrogen; Al, aluminum; As, arsenic; Ba, barium; B, boron; Fe, iron; Li, lithium; Mn, manganese; Mo, molybdenum]

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
Zone 1: Northern Mountain Front												
DB445	0.4	nd	39.	0.32	nd	nd	nd	nd	0.020	nd	nd	nd
DB455	0.5	nd	56.	0.50	nd	nd	nd	nd	0.060	nd	nd	nd
Zone 2: Northwestern												
DB427	0.6	nd	31.	1.80	nd	nd	nd	nd	0.040	nd	nd	nd
DB428	0.6	nd	23.	2.30	nd	nd	nd	nd	nd	nd	nd	nd
DB429	0.6	nd	30.	1.30	nd	nd	nd	nd	nd	nd	nd	nd
DB436	0.4	<0.1	36.	nd	nd	4	nd	0.110	1.700	nd	<0.010	nd
DB447	0.4	0.030	33.	nd	nd	15	nd	0.050	0.020	nd	<0.010	nd
Zone 3: West Central												
DB019	1.1	nd	34.	0.72	nd	nd	nd	nd	nd	nd	nd	nd
DB022	nd	nd	nd	0.27	nd	nd	nd	nd	nd	nd	nd	nd
DB031	1.0	0.180	35.	nd	0.004	5	0.018	nd	<0.003	nd	<0.001	10
DB058	1.0	nd	29.	1.20	nd	nd	nd	nd	0.030	nd	nd	nd
DB066	0.9	nd	24.	nd	nd	nd	nd	0.250	0.330	nd	0.020	nd
DB073	1.3	0.130	45.	nd	0.015	22	0.018	nd	0.012	nd	<0.001	12
DB074	1.0	0.090	45.	nd	0.003	19	0.026	nd	<0.003	nd	<0.001	4
DB077	0.9	nd	39.	1.40	nd	nd	nd	nd	nd	nd	nd	nd
DB082	0.8	nd	51.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB084	1.8	nd	50.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB091	1.0	nd	48.	0.11	nd	nd	nd	nd	0.040	nd	nd	nd
DB108	1.1	nd	39.	0.30	nd	7	nd	0.150	0.020	nd	<0.010	nd
DB109	1.2	nd	68.	0.83	nd	24	nd	0.450	0.070	nd	<0.010	nd
DB119	1.2	nd	52.	0.09	nd	nd	nd	nd	nd	nd	nd	nd
DB134	1.2	nd	44.	0.16	nd	nd	nd	nd	nd	nd	nd	nd
DB187	0.5	nd	47.	0.02	nd	nd	nd	nd	0.380	nd	nd	nd
DB189	0.8	nd	75.	nd	nd	29	<0.100	0.200	0.030	nd	<0.010	nd
DB191	1.1	nd	40.	nd	nd	45	<0.100	0.260	0.030	nd	0.020	nd
DB215	0.6	nd	60.	0.05	nd	nd	nd	nd	nd	nd	nd	nd
DB223	0.8	nd	60.	0.16	nd	nd	nd	nd	0.020	nd	nd	nd
DB232	0.8	nd	49.	nd	nd	31	0.019	nd	0.500	nd	0.088	nd
DB234	2.2	nd	nd	nd	nd	70	0.000	0.360	0.020	nd	0.010	nd
DB253	1.0	nd	30.	nd	nd	28	0.020	nd	0.030	nd	0.005	nd
DB323	0.6	nd	15.	1.60	nd	nd	nd	nd	nd	nd	nd	nd
DB453	0.5	<0.1	30.	nd	nd	12	nd	0.240	3.700	nd	0.020	nd
Zone 4: Western Boundary												
DB007	1.0	nd	18.	0.34	nd	nd	nd	nd	nd	nd	nd	nd
DB010	0.6	nd	26.	0.45	nd	nd	nd	nd	nd	nd	nd	nd
DB026	nd	nd	nd	0.86	nd	nd	nd	nd	nd	nd	nd	nd
DB032	0.8	nd	23.	nd	nd	<1	0.040	nd	0.016	nd	0.064	nd
DB036	1.0	nd	17.	nd	nd	3	0.000	0.510	0.590	nd	0.060	nd
DB038	1.0	nd	22.	2.00	nd	nd	nd	nd	nd	nd	nd	nd
DB041	0.8	nd	24.	0.97	nd	nd	nd	nd	nd	nd	nd	nd
DB068	nd	nd	25.	0.86	nd	nd	nd	nd	nd	nd	nd	nd

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
DB069	0.6	nd	17.	nd	nd	nd	nd	0.900	0.220	nd	0.060	nd
DB071	5.0	nd	22.	0.18	nd	nd	nd	nd	nd	nd	nd	nd
DB116	4.3	nd	20.	nd	nd	nd	nd	nd	0.091	nd	nd	nd
DB117	3.8	27.000	19.	nd	nd	nd	nd	14.000	0.020	nd	0.220	nd
DB433	5.7	nd	29.	0.29	nd	nd	nd	8.100	nd	nd	nd	nd
DB450	6.86	nd	37.6	nd	nd	nd	nd	nd	<0.015	0.006	0.070	nd
DB451	7.3	nd	48.	0.07	nd	nd	nd	6.100	nd	nd	nd	nd
DB452	4.0	5.000	68.	nd	nd	69	nd	8.200	0.050	nd	1.300	nd
Zone 5: Rio Puerco												
DB024	nd	nd	nd	0.61	nd	nd	nd	nd	nd	nd	nd	nd
DB051	0.6	nd	16.	nd	nd	nd	nd	0.730	0.100	nd	0.010	nd
DB055	0.1	nd	24.	2.70	nd	nd	nd	nd	nd	nd	nd	nd
DB057	0.2	nd	24.	0.29	nd	nd	nd	nd	nd	nd	nd	nd
DB063	0.5	nd	17.	nd	nd	nd	nd	0.400	0.110	nd	0.010	nd
DB086	1.3	0.900	13.	nd	nd	nd	nd	1.500	1.200	nd	0.040	nd
DB089	1.0	nd	26.	nd	nd	nd	nd	0.200	0.050	nd	0.007	nd
DB103	1.3	4.800	15.	nd	nd	nd	nd	3.700	0.090	nd	0.040	nd
DB114	0.4	nd	27.	0.52	nd	nd	nd	nd	nd	nd	nd	nd
DB122	0.8	nd	13.	0.75	nd	nd	nd	nd	nd	nd	nd	nd
DB124	2.0	nd	16.	0.27	nd	nd	nd	nd	nd	nd	nd	nd
DB132	2.0	nd	16.	0.27	nd	nd	nd	nd	nd	nd	nd	nd
DB157	2.9	nd	7.7	0.07	nd	nd	nd	nd	nd	nd	nd	nd
DB175	3.4	0.800	13.	nd	nd	nd	nd	1.800	0.020	nd	0.070	nd
DB201	0.6	nd	nd	nd	nd	nd	nd	0.180	<0.010	nd	nd	nd
DB206	0.9	nd	23.	2.30	nd	nd	nd	nd	nd	nd	nd	nd
DB209	1.2	nd	21.	1.40	nd	nd	nd	nd	nd	nd	nd	nd
DB219	0.6	nd	15.	0.88	nd	nd	nd	nd	nd	nd	nd	nd
DB220	0.5	nd	19.	0.97	nd	nd	nd	nd	0.000	nd	nd	nd
DB221	0.6	nd	18.	0.79	nd	nd	nd	nd	0.020	nd	nd	nd
DB222	0.6	nd	19.	0.81	nd	nd	nd	nd	0.010	nd	nd	nd
DB235	0.3	nd	19.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB385	1.3	nd	9.1	0.14	nd	nd	nd	nd	nd	nd	nd	nd
DB387	1.9	nd	27.	nd	nd	nd	nd	0.230	0.050	nd	0.004	nd
DB407	1.3	nd	22.	nd	nd	nd	nd	0.230	<0.010	nd	0.002	nd
Zone 6: Southwestern Mountain Front												
DB027	1.3	nd	26.	nd	nd	0	0.030	0.010	<0.010	nd	0.009	nd
Zone 7: Abo Arroyo												
DB011	2.0	nd	24.	1.10	nd	nd	nd	nd	nd	nd	nd	nd
DB014	1.0	nd	27.	0.99	nd	nd	nd	nd	nd	nd	nd	nd
DB017	nd	nd	nd	1.80	nd	nd	nd	nd	nd	nd	nd	nd
DB023	0.9	nd	27.	nd	nd	nd	nd	0.130	0.010	nd	<0.001	nd
DB033	nd	nd	nd	1.40	nd	nd	nd	nd	nd	nd	nd	nd
DB035	nd	nd	nd	1.40	nd	nd	nd	nd	nd	nd	nd	nd
Zone 8: Eastern Mountain Front												
DB013	2.3	nd	17.	nd	nd	nd	nd	0.130	0.070	0.040	nd	nd
DB037	0.8	nd	23.	nd	nd	nd	nd	0.060	<0.010	nd	0.004	nd
DB040	0.4	nd	56.	nd	nd	8	0.090	0.010	0.030	nd	<0.001	nd
DB045	0.6	nd	17.	0.36	nd	nd	nd	nd	nd	nd	nd	nd
DB048	0.7	nd	29.	nd	nd	nd	nd	0.060	<0.010	nd	<0.001	nd

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
DB052	0.4	nd	49.	0.54	nd	nd	nd	nd	nd	nd	nd	nd
DB064	0.6	nd	40.	nd	nd	nd	nd	0.020	0.050	nd	0.002	nd
DB070	0.4	nd	11.	nd	nd	nd	nd	0.040	0.010	nd	0.020	nd
DB087	0.3	nd	26.	nd	nd	nd	nd	0.050	<0.010	nd	0.003	nd
DB208	0.3	nd	27.	0.90	nd	nd	nd	nd	0.010	nd	nd	nd
DB244	0.7	nd	24.	nd	nd	2	<0.100	0.030	0.040	nd	<0.010	nd
DB247	1.0	nd	34.	nd	nd	<1	<0.100	0.006	0.040	nd	<0.010	nd
DB274	1.4	nd	23.	1.10	nd	nd	nd	nd	0.020	nd	nd	nd
DB276	0.8	nd	26.	0.11	nd	nd	nd	nd	0.030	nd	nd	nd
DB282	0.9	nd	32.	nd	nd	4	<0.100	0.030	0.030	nd	0.050	nd
DB328	0.6	nd	26.	nd	nd	<1	nd	0.020	0.008	nd	0.001	nd
DB329	0.5	nd	26.	nd	nd	<1	nd	0.020	0.007	nd	0.003	nd
DB330	1.8	nd	23.	nd	nd	<1	nd	0.020	0.012	nd	0.001	nd
DB338	0.8	nd	32.	nd	nd	2	nd	0.220	0.006	nd	<0.001	nd
DB339	0.6	nd	26.	0.16	nd	nd	nd	nd	nd	nd	nd	nd
DB345	1.5	nd	26.	nd	nd	<1	nd	0.020	0.013	nd	<0.001	nd
DB371	0.2	nd	48.	0.09	nd	nd	nd	nd	nd	nd	nd	nd
DB384	0.6	nd	47.	0.16	nd	nd	nd	nd	0.060	nd	nd	nd
DB392	0.3	nd	19.	0.20	nd	nd	nd	nd	nd	nd	nd	nd
DB397	0.3	0.000	24.	nd	nd	nd	nd	0.030	0.040	nd	<0.010	nd
DB408	1.4	nd	16.	0.20	nd	nd	nd	nd	nd	nd	nd	nd
Zone 9: Tijeras Fault Zone												
DB138	nd	nd	nd	3.20	nd	nd	nd	nd	nd	nd	nd	nd
DB143	0.8	nd	16.	1.10	nd	nd	nd	nd	0.000	nd	nd	nd
DB144	1.3	nd	28.	2.20	nd	nd	nd	nd	0.020	nd	nd	nd
DB146	1.2	nd	15.	0.77	nd	nd	nd	nd	0.060	nd	nd	nd
DB147	0.8	nd	18.	1.80	nd	nd	nd	nd	0.000	nd	nd	nd
Zone 10: Tijeras Arroyo												
DB198	0.6	nd	20.	3.80	nd	nd	nd	nd	nd	nd	nd	nd
DB202	0.7	nd	19.	nd	nd	<1	nd	0.100	0.004	nd	nd	nd
DB203	0.6	nd	19.	0.62	nd	<1	nd	0.070	0.006	nd	nd	nd
DB205	0.6	nd	17.	nd	nd	<1	nd	0.060	0.011	nd	nd	nd
DB213	0.7	nd	20.	nd	nd	<1	<0.100	0.050	<0.010	nd	<0.010	nd
Zone 11: Northeastern												
DB410	0.4	nd	39.	nd	nd	3	<0.100	0.360	0.030	nd	<0.010	nd
DB411	0.4	nd	78.	nd	nd	4	<0.100	0.270	3.000	nd	0.070	nd
DB412	0.4	nd	72.	0.32	nd	nd	nd	nd	nd	nd	nd	nd
DB414	0.5	nd	74.	0.56	nd	nd	nd	nd	nd	nd	nd	nd
DB415	0.4	nd	42.	4.50	nd	nd	nd	nd	nd	nd	nd	nd
DB419	1.0	nd	25.	0.02	nd	nd	nd	nd	0.000	nd	nd	nd
DB421	0.6	nd	35.	0.02	nd	nd	nd	nd	0.170	nd	nd	nd
DB431	0.5	nd	34.	0.02	nd	nd	nd	nd	0.160	nd	nd	nd
DB442	0.4	0.110	63.	nd	0.003	4	0.048	nd	<0.003	nd	<0.001	5
Zone 12: Central												
DB062	0.6	nd	0.1	nd	nd	nd	nd	nd	0.060	nd	0.008	nd
DB072	nd	nd	nd	0.47	nd	nd	nd	nd	nd	nd	nd	nd
DB075	0.7	nd	41.	nd	nd	nd	nd	0.060	0.030	nd	0.006	nd
DB079	0.5	nd	31.	0.05	nd	nd	nd	nd	0.200	nd	nd	nd
DB081	0.4	nd	36.	nd	nd	nd	nd	nd	<0.010	nd	0.002	nd

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
DB083	0.3	nd	34.	nd	nd	nd	nd	nd	0.012	nd	0.064	nd
DB088	0.4	nd	35.	0.14	nd	nd	nd	nd	nd	nd	nd	nd
DB093	0.5	0.050	46.	nd	0.003	6	0.083	nd	0.037	nd	<0.001	4
DB094	0.3	0.050	48.	nd	0.004	6	0.074	nd	<0.003	nd	0.008	3
DB095	0.4	nd	45.	nd	nd	nd	nd	0.050	0.090	nd	nd	nd
DB096	0.2	nd	33.	nd	nd	nd	nd	0.160	<0.010	nd	nd	nd
DB101	0.3	nd	32.	nd	nd	nd	nd	nd	0.030	nd	<0.010	nd
DB123	0.3	nd	37.	0.05	nd	nd	nd	nd	0.180	nd	nd	nd
DB133	0.4	0.055	34.	nd	<0.010	5	0.075	0.090	0.340	nd	1.000	<10
DB135	0.4	nd	25.	nd	0.004	2	0.117	nd	0.260	nd	0.600	5
DB136	0.3	nd	51.	nd	<0.010	3	0.120	0.060	0.072	nd	0.850	<10
DB137	0.4	nd	37.	0.02	nd	nd	nd	nd	0.840	nd	nd	nd
DB139	0.5	0.080	57.	nd	0.003	10	0.027	nd	0.003	nd	0.002	3
DB140	0.4	0.083	60.	nd	<0.010	7	0.079	0.060	0.005	nd	0.007	<10
DB141	0.7	0.110	31.	1.65	0.004	3	0.110	nd	0.009	nd	2.400	6
DB142	0.3	nd	50.	nd	nd	nd	nd	nd	0.046	nd	0.800	nd
DB145	0.6	0.069	74.	0.19	<0.010	15	0.140	0.060	0.021	nd	0.003	<10
DB148	0.7	nd	55.	nd	<0.010	18	0.085	0.190	0.005	nd	0.180	<10
DB149	0.5	nd	58.	0.07	nd	nd	nd	nd	0.040	nd	nd	nd
DB150	0.5	0.028	36.	nd	<0.010	18	0.092	0.110	0.005	nd	0.520	<10
DB151	0.8	0.140	37.	nd	0.004	10	0.113	nd	0.100	nd	0.230	11
DB153	0.4	0.170	63.	nd	<0.010	3	0.200	0.080	0.042	nd	0.004	<10
DB155	0.4	nd	42.	0.05	nd	nd	nd	nd	0.040	nd	nd	nd
DB156	0.6	nd	nd	0.07	nd	nd	nd	nd	nd	nd	nd	nd
DB159	nd	nd	2.9	0.25	nd	nd	nd	nd	nd	nd	nd	nd
DB161	0.5	nd	69.	0.11	nd	nd	nd	0.070	0.050	nd	nd	nd
DB162	0.5	nd	66.	nd	nd	6	0.085	nd	nd	nd	nd	nd
DB168	0.1	nd	17.	nd	nd	8	0.053	nd	nd	nd	nd	nd
DB169	0.5	nd	82.	nd	nd	15	0.069	nd	nd	nd	nd	nd
DB170	0.7	nd	66.	nd	nd	9	0.052	nd	nd	nd	nd	nd
DB176	0.6	0.095	27.	1.09	0.010	2	0.075	0.190	0.210	nd	0.840	20
DB179	0.6	nd	57.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB180	0.6	nd	38.	nd	0.010	7	0.072	0.200	0.210	nd	0.870	10
DB181	0.7	0.093	32.	nd	0.010	5	0.097	0.150	<0.003	nd	0.680	<10
DB183	0.8	nd	38.	0.11	nd	nd	nd	nd	nd	nd	nd	nd
DB185	0.3	nd	50.	0.01	nd	3	0.200	0.120	0.050	nd	nd	nd
DB186	0.6	0.120	36.	nd	0.014	4	0.062	nd	0.110	nd	0.570	5
DB188	0.7	nd	71.	0.39	nd	21	0.100	0.170	<0.010	nd	nd	nd
DB190	0.0	nd	78.	0.41	nd	21	0.100	0.110	<0.010	nd	nd	nd
DB192	0.4	nd	38.	0.07	nd	nd	nd	0.060	0.040	nd	nd	nd
DB193	0.4	nd	32.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB194	0.5	nd	71.	0.26	nd	13	0.100	0.120	<0.010	nd	nd	nd
DB195	0.8	nd	73.	0.29	nd	nd	nd	nd	nd	nd	nd	nd
DB197	0.7	0.080	34.	nd	0.002	9	0.066	nd	2.160	nd	1.010	6
DB199	0.4	nd	38.	0.05	nd	nd	nd	nd	0.000	nd	nd	nd
DB207	0.4	0.040	26.	nd	0.003	6	0.062	nd	0.210	nd	0.230	7
DB225	0.4	nd	81.	0.18	nd	nd	nd	nd	nd	nd	nd	nd
DB226	0.4	nd	45.	0.29	nd	nd	nd	nd	nd	nd	nd	nd
DB228	0.8	0.170	31.	0.08	0.003	10	0.111	nd	0.032	nd	0.410	10
DB230	0.4	0.040	25.	nd	0.003	4	0.127	nd	0.120	nd	0.810	4
DB233	0.6	nd	62.	0.02	nd	nd	nd	nd	nd	nd	nd	nd

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
DB236	0.6	nd	75.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB237	0.6	nd	73.	0.05	nd	nd	nd	nd	nd	nd	nd	nd
DB239	0.4	nd	33.	0.07	nd	nd	nd	nd	nd	nd	nd	nd
DB242	0.4	nd	61.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB246	0.4	0.050	24.	nd	0.002	5	0.143	nd	0.009	nd	1.200	4
DB250	0.4	nd	51.	0.29	nd	nd	nd	0.030	nd	nd	nd	nd
DB252	0.4	nd	64.	0.09	nd	nd	nd	nd	nd	nd	nd	nd
DB256	0.2	nd	40.	0.16	nd	nd	nd	nd	nd	nd	nd	nd
DB258	0.4	nd	58.	0.05	nd	nd	nd	nd	nd	nd	nd	nd
DB259	0.1	nd	49.	nd	nd	3	0.030	nd	0.008	nd	0.001	nd
DB260	0.4	0.050	23.	2.78	0.003	4	0.125	nd	0.011	nd	0.710	5
DB261	0.3	nd	41.	0.07	nd	nd	nd	nd	0.010	nd	nd	nd
DB262	0.4	nd	nd	nd	nd	2	0.081	nd	0.170	nd	0.910	nd
DB265	0.5	nd	47.	nd	nd	5	0.046	nd	0.480	nd	2.300	nd
DB267	0.2	nd	50.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB269	0.4	nd	40.	nd	nd	3	0.099	nd	0.960	nd	2.800	nd
DB270	0.3	nd	57.	nd	nd	4	0.190	nd	0.047	nd	1.400	nd
DB273	0.5	nd	34.	nd	nd	4	0.086	nd	0.341	nd	1.600	nd
DB275	0.4	nd	34.	nd	nd	3	0.130	nd	0.110	nd	0.690	nd
DB279	0.6	nd	75.	0.59	nd	nd	nd	nd	nd	nd	nd	nd
DB283	0.5	nd	37.	nd	nd	3	0.091	nd	0.230	nd	0.880	nd
DB286	0.3	nd	35.	nd	nd	3	0.120	nd	0.000	nd	0.003	nd
DB288	0.4	0.054	55.	nd	0.010	7	0.084	0.050	0.003	nd	0.013	<10
DB291	0.4	nd	33.	0.00	nd	nd	nd	nd	0.230	nd	nd	nd
DB292	0.6	nd	27.	nd	nd	3	0.071	nd	0.300	nd	1.100	nd
DB294	0.2	0.067	63.	nd	0.010	3	0.120	0.150	0.004	nd	0.057	<10
DB295	0.2	0.066	64.	nd	<0.010	4	0.062	0.150	<0.003	nd	0.049	20
DB296	0.6	0.065	42.	nd	<0.010	5	0.051	0.110	0.770	nd	3.200	10
DB298	0.4	nd	35.	0.05	nd	nd	nd	nd	nd	nd	nd	nd
DB299	0.2	nd	47.	nd	nd	2	0.300	nd	0.017	nd	0.090	nd
DB308	0.3	0.078	57.	nd	<0.010	5	0.047	0.050	<0.003	nd	0.037	<10
DB309	0.5	0.051	61.	nd	<0.010	7	0.039	0.060	0.003	nd	0.009	10
DB310	0.4	0.034	46.	nd	<0.010	4	0.062	0.080	0.025	nd	0.470	10
DB312	0.3	nd	51.	nd	nd	2	0.100	nd	0.036	nd	0.074	nd
DB317	0.6	nd	35.	nd	nd	4	0.190	nd	0.740	nd	2.400	nd
DB318	0.1	nd	37.	nd	nd	<1	0.110	nd	0.120	nd	0.073	nd
DB320	0.3	nd	29.	nd	nd	2	0.180	nd	0.081	nd	0.036	nd
DB325	0.4	nd	38.	0.00	nd	nd	nd	nd	nd	nd	nd	nd
DB327	0.2	nd	28.	0.02	nd	nd	nd	nd	0.000	nd	nd	nd
DB332	0.6	nd	31.	0.02	nd	nd	nd	nd	0.040	nd	nd	nd
DB333	0.3	nd	30.	0.02	nd	nd	nd	nd	0.680	nd	nd	nd
DB340	0.3	nd	27.	nd	nd	1	0.150	0.040	0.004	nd	0.200	nd
DB350	0.2	nd	38.	nd	nd	2	0.081	nd	nd	nd	nd	nd
DB351	0.3	nd	17.	nd	nd	3	0.098	nd	nd	nd	nd	nd
DB352	0.3	nd	65.	nd	nd	4	0.051	nd	nd	nd	nd	nd
DB353	0.2	nd	29.	nd	nd	4	nd	0.050	0.023	nd	0.094	nd
DB354	0.7	nd	64.	nd	nd	18	nd	0.090	0.340	nd	0.012	nd
DB355	0.7	0.080	22.	nd	0.003	1	0.140	nd	0.005	nd	0.130	9
DB356	0.4	nd	26.	0.02	nd	nd	nd	nd	0.190	nd	nd	nd
DB357	0.3	0.040	49.	nd	0.005	4	0.063	nd	<0.003	nd	0.002	3
DB358	0.5	0.090	32.	nd	0.005	2	0.177	nd	1.400	nd	1.100	6

Table E3. Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

Sample reference number	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L as N)	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (µg/L)
DB362	0.5	0.120	33.	nd	0.002	3	0.187	nd	0.045	nd	2.300	8
DB366	0.4	nd	24.	0.07	nd	nd	nd	nd	0.010	nd	nd	nd
DB367	nd	<0.010	22.	nd	0.002	3	0.128	nd	0.470	nd	0.280	4
DB370	0.5	nd	52.	0.79	nd	nd	nd	nd	0.050	nd	nd	nd
DB372	0.5	0.030	57.	nd	0.003	6	0.052	nd	<0.003	nd	0.009	4
DB373	nd	0.220	59.	nd	0.004	6	0.072	nd	0.004	nd	0.004	11
DB375	0.5	0.070	30.	nd	0.002	3	0.162	nd	0.004	nd	<0.001	5
DB376	0.3	nd	70.	nd	nd	7	<0.100	0.080	0.080	nd	<0.010	nd
DB378	0.4	nd	35.	1.90	nd	nd	nd	0.120	0.010	nd	nd	nd
DB379	0.4	nd	60.	nd	nd	9	<0.100	0.080	0.070	nd	<0.010	nd
DB381	0.4	nd	34.	3.40	nd	nd	nd	nd	nd	nd	nd	nd
DB382	0.4	nd	26.	0.02	nd	nd	nd	nd	nd	nd	nd	nd
DB383	0.4	nd	37.	1.60	nd	nd	nd	nd	0.080	nd	nd	nd
DB389	0.6	nd	50.	0.05	nd	nd	nd	nd	0.050	nd	nd	nd
DB390	0.8	nd	nd	0.11	nd	nd	nd	nd	nd	nd	nd	nd
DB391	1.0	0.310	73.	nd	nd	nd	nd	0.560	nd	nd	nd	nd
DB398	0.4	0.300	29.	nd	nd	nd	nd	0.110	<0.010	nd	0.070	nd
DB400	1.4	nd	91.	0.11	nd	nd	nd	nd	nd	nd	nd	nd
DB413	0.3	nd	100.	nd	nd	9	<0.100	0.380	0.200	nd	<0.010	nd
DB468	0.3	nd	34.	0.00	nd	nd	nd	0.020	0.050	nd	nd	nd
Zone 13: Discharge												
DB009	1.1	0.400	39.	nd	0.004	18	0.034	nd	0.550	nd	0.260	12
DB021	1.4	nd	56.	nd	nd	nd	nd	0.960	0.080	nd	0.004	nd
DB025	2.9	nd	30.	nd	nd	4	0.030	0.860	0.040	nd	0.010	nd
DB029	1.7	nd	44.	nd	nd	17	0.030	0.220	0.010	nd	0.020	nd

Appendix F. Supplementary water-quality data from the City of Albuquerque database

Table F1. Location and well-construction information for City of Albuquerque production wells, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; dms, degrees-minutes-seconds]

Sample reference number	Station name	Latitude (dms)	Longitude (dms)	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date
	Zone 3: West Central								
WWATI01	Atrisco 1	350418	1064124	4,945	1,295	280	1,283	47.	3/19/1996
WWCOL01	College 1	350646	1064433	5,336	1,662	660	1,650	434.8	2/19/1998
WWCOL03	College 3	350723	1064233	5,180	1,490	432	1,440	nd	nd
WWLEV02	Leavitt 2	350248	1064340	5,073	1,133	281	1,121	162.6	1/7/1998
WWLEV03	Leavitt 3	350228	1064358	5,080	1,520	514	1,500	244.	1/23/1996
WWVC02	Volcano Cliffs 2	350912	1064341	5,328	900	528	876	460.	3/21/1996
WWVC03	Volcano Cliffs 3	351000	1064345	5,345	1,315	659	1,302	468.	3/21/1996
WWWM01	West Mesa 1	350428	1064418	5,175	1,176	504	1,176	299.	3/30/1996
WWWM02	West Mesa 2	350508	1064356	5,165	1,402	394	1,402	279.	4/8/1993
WWWM04	West Mesa 4	350449	1064320	5,105	1,287	387	1,275	226.	3/30/1996
WWZAM01	Zamora 1	350919	1064251	5,168	970	450	950	233.4	1/28/1998
	Zone 8: Eastern Mountain Front								
WWLOM05	Lomas 5	350421	1063124	5,494	1,670	830	1,658	644.22	12/30/1997
WWLOM06	Lomas 6	350408	1063110	5,529	1,704	880	1,692	676.77	12/30/1997
WWLOV03	Love 3	350512	1063218	5,405	1,260	600	1,260	553.	4/29/1996
WWLOV04	Love 4	350512	1063257	5,370	1,284	600	1,284	540.	4/12/1996
WWLOV05	Love 5	350450	1063240	5,390	1,248	660	1,248	552.03	4/14/1997
WWLOV06	Love 6	350553	1063138	5,505	1,521	753	1,509	651.33	1/8/1997
WWLOV07	Love 7	350608	1063213	5,440	1,485	645	1,473	581.	4/5/1994
WWLOV08	Love 8	350539	1063330	5,316	1,455	640	1,440	463.3	1/12/1998
WWPON02	Ponderosa 2	350802	1063152	5,600	1,581	801	1,569	735.64	2/9/1998
WWPON03	Ponderosa 3	350821	1063210	5,527	1,602	870	1,590	667.	2/27/1996
WWPON04	Ponderosa 4	350836	1063148	5,629	1,549	936	1,738	766.5	12/29/1997
WWPON05	Ponderosa 5	350916	1063151	5,630	1,626	939	1,613	746.33	1/9/1997
WWPON06	Ponderosa 6	350852	1063220	5,558	1,675	852	1,662	672.42	12/29/1997
WWRIG01	Ridgecrest 1	350405	1063219	5,442	1,260	636	1,260	277.	4/10/1996
WWRIG02	Ridgecrest 2	350424	1063235	5,416	1,512	730	1,500	566.42	1/12/1998
WWTOM01	Thomas 1	350753	1063256	5,445	1,092	624	1,092	595.	4/9/1996
WWTOM02	Thomas 2	350749	1063235	5,490	1,224	696	1,224	629.	4/9/1996
WWTOM03	Thomas 3	350816	1063313	5,415	1,200	672	1,200	551.	7/18/1994
WWTOM04	Thomas 4	350813	1063241	5,485	1,020	672	1,020	622.	12/18/1995
WWTOM08	Thomas 8	350712	1063231	5,462	1,655	835	1,635	605.77	2/23/1998
WWWLK02	Walker 2	351024	1063212	5,596	1,786	852	1,773	694.	4/11/1996
	Zone 12: Central								
WWATI02	Atrisco 2	350445	1064115	4,945	544	108	250	15.	11/30/1996
WWATI04	Atrisco 4	350509	1064142	4,950	500	98	475	12.32	2/9/1998
WWBUR01	Burton 1	350359	1063624	5,315	1,312	676	1,292	447.03	12/29/1997
WWBUR03	Burton 3	350439	1063559	5,215	994	358	994	360.	3/19/1996
WWBUR04	Burton 4	350343	1063634	5,275	1,276	636	1,276	440.	3/27/1996
WWCHW01	Charles 1	350628	1063348	5,315	1,056	456	1,032	477.	4/23/1996
WWCHW02	Charles 2	350605	1063415	5,262	1,020	432	996	411.18	1/26/1998
WWCHW03	Charles 3	350640	1063427	5,275	1,020	420	996	405.	5/27/1990
WWCHW05	Charles 5	350615	1063460	5,222	1,400	625	1,385	357.62	1/12/1998
WWCOR02	Coronado 2	351007	1063439	5,242	1,390	590	1,390	330.05	12/18/1998
WWDUR02	Duranes 2	350711	1064047	4,970	804	180	804	22.11	12/29/1997

Table F1. Location and well-construction information for City of Albuquerque production wells, by hydrochemical zone-- Continued

Sample reference number	Station name	Latitude (dms)	Longitude (dms)	Altitude of land surface (feet above sea level)	Depth (feet)	Depth to top of sample interval (feet)	Depth to bottom of sample interval (feet)	Water level (feet below land surface)	Water level date
WWDUR03	Duranes 3	350630	1064043	4,962	950	132	950	23.72	12/29/1997
WWDUR04	Duranes 4	350628	1064115	4,960	950	144	950	13.75	2/9/1998
WWDUR05	Duranes 5	350606	1064116	4,960	950	152	950	10.85	2/9/1998
WWDUR06	Duranes 6	350653	1064030	4,962	500	260	500	32.6	12/29/1997
WWGON02	Gonzales 2	350635	1064150	5,100	1,115	400	1,100	152.28	12/30/1997
WWGRG01	Griegos 1	350823	1063950	4,972	802	232	802	30.56	1/27/1998
WWGRG02	Griegos 2	350749	1064007	4,965	820	164	820	29.	6/8/1994
WWGRG04	Griegos 4	350824	1063902	4,975	804	218	804	48.	3/13/1996
WWLYN02	Leyendecker 2	350729	1063407	5,298	996	468	996	436.15	12/16/1997
WWLYN03	Leyendecker 3	350815	1063438	5,265	996	456	996	393.4	12/16/1997
WWLYN04	Leyendecker 4	350814	1063407	5,325	996	480	996	455.	12/5/1996
WWMIL01	Miles 1	350307	1063748	5,154	1,165	404	1,153	260.7	12/15/1997
WWRIG05	Ridgecrest 5	350420	1063345	5,355	1,470	636	1,260	418.98	2/10/1998
WWSJ01	San Jose 1	350316	1063848	4,950	600	nd	nd	41.13	12/15/1997
WWSJ03	San Jose 3	350343	1063901	4,952	1,032	192	1,032	41.3	12/15/1997
WWTOM05	Thomas 5	350744	1063335	5,356	1,450	722	1,450	489.79	2/23/1998
WWTOM07	Thomas 7	350712	1063339	5,347	1,475	659	1,460	481.96	2/23/1998
WWVAN01	Vol Andia 1	350805	1063548	5,144	972	300	972	262.99	1/12/1998
WWVAN03	Vol Andia 3	350741	1063616	5,110	900	264	900	230.01	1/8/1997
WWVAN04	Vol Andia 4	350803	1063512	5,200	876	372	876	327.37	12/29/1997
WWVAN06	Vol Andia 6	350826	1063525	5,178	984	324	984	294.95	12/29/1997
WWWEB02	Webster 2	351012	1063335	5,387	1,346	608	1,334	490.	12/14/1995
WWYAL02	Yale 2	350358	1063729	5,128	1,191	351	1,179	249.95	1/26/1998
WWYAL03	Yale 3	350435	1063800	5,080	1,004	320	992	204.	4/24/1989

Table F2. Summary of field parameters and major- and minor-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 ºC; Temp., field water temperature; ºC, degrees Celsius; mg/L, milligrams per liter; Ca^{2+}, calcium; Mg^{2+}, magnesium, Na^{+}, sodium; K^{+}, potassium; HCO_3^-, total titration alkalinity as bicarbonate; SO_4^{2-}, sulfate; Cl^-, chloride; F^-, fluoride; Br^-, bromide; SiO_2, silica; NO_3^-, nitrate; N, nitrogen]

Sample reference number	Station name	Primary hydro-chemical zone	Sp. Cond. (µS/cm)	pH	Temp. (ºC)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	HCO_3^- (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	F^- (mg/L)	Br^- (mg/L)	SiO_2 (mg/L)	NO_3^- as N (mg/L)
	Zone 3: West Central															
WWATI01	Atrisco 1	3	570	8.8	31.5	7.98	1.3	107.4	1.5	143	110.0	19.8	0.92	<0.5	46.9	1.53
WWCOL01	College 1	3	484	8.7	28.0	3.6	0.4	104.2	1.1	200	55.3	5.5	1.50	<0.5	28.7	2.91
WWCOL03	College 3	3	474	8.2	24.6	11.9	2.2	88.9	4.7	157	79.2	11.4	1.22	<0.5	49.9	1.19
WWLEV02	Leavitt 2	3	503	8.7	23.9	4.4	0.5	105.5	1.2	183	68.1	18.8	1.46	<0.5	29.8	1.31
WWLEV03	Leavitt 3	3	695	9.0	33.4	2.45	0.1	140.4	<1.0	160	133.0	31.6	1.02	<0.5	38.6	1.78
WWVC02	Volcano Cliffs 2	3	361	8.0	24.0	20.98	4.7	48.8	6.6	144	45.8	7.8	0.99	<0.5	70.3	1.68
WWVC03	Volcano Cliffs 3	3	387	8.1	24.4	16.08	3.5	61.5	5.8	152	47.7	7.4	1.00	<0.5	65.2	1.91
WWWM01	West Mesa 1	3	501	9.0	29.5	1.92	0.1	108.1	<1.0	194	67.9	6.3	1.10	<0.5	36.2	1.71
WWWM02	West Mesa 2	3	444	8.6	25.0	5.12	0.8	91.9	1.5	184	49.4	7.3	1.33	nd	32.4	nd
WWWM04	West Mesa 4	3	486	8.9	29.8	3.26	0.3	112.1	<1.0	174	87.0	14.8	1.08	<0.5	35.8	1.71
WWZAM01	Zamora 1	3	416	7.9	24.2	20.33	3.7	59.9	7.2	157	57.4	9.2	0.78	<0.5	70.8	0.86
	Zone 8: Eastern Mountain Front															
WWLOM05	Lomas 5	8	333	7.9	26.7	28.81	3.9	39.6	2.5	152	31.7	6.5	1.31	<0.5	26.6	0.54
WWLOM06	Lomas 6	8	421	7.7	25.0	45.93	6.8	39.1	2.8	175	56.2	9.6	0.87	<0.5	25.8	0.94
WWLOV03	Love 3	8	309	7.8	23.2	36.7	1.8	26.9	2.4	130	19.0	17.3	0.67	<0.5	30.2	0.31
WWLOV04	Love 4	8	364	7.7	22.7	46.45	2.6	27.6	2.7	137	21.2	35.0	0.48	<0.5	29.8	0.31
WWLOV05	Love 5	8	325	7.8	22.6	38.84	3.0	26.5	2.7	133	19.6	22.1	0.56	<0.5	28.1	0.33
WWLOV06	Love 6	8	260	7.9	25.3	24.45	1.0	33.1	1.6	133	16.8	4.8	0.87	<0.5	29.1	0.43
WWLOV07	Love 7	8	326	7.7	24.0	40.3	1.6	26.4	2.2	129	19.1	25.0	0.60	<0.5	30.6	0.25
WWLOV08	Love 8	8	440	7.7	21.7	49.77	4.6	33.7	3.0	139	25.7	49.0	0.37	<0.5	33.9	0.17
WWPON02	Ponderosa 2	8	328	7.8	25.4	42.56	1.7	27.0	1.9	133	19.6	23.5	0.79	<0.5	30.4	0.19
WWPON03	Ponderosa 3	8	630	7.6	28.1	58.08	5.9	54.6	4.9	162	35.1	90.2	0.63	<0.5	39.7	<0.05
WWPON04	Ponderosa 4	8	352	7.8	26.3	42.0	1.6	35.0	1.9	136	19.0	33.3	0.98	<0.5	30.1	0.16
WWPON05	Ponderosa 5	8	445	7.7	25.8	52.06	2.1	35.7	2.2	133	23.3	55.8	0.78	<0.5	31.1	0.18
WWPON06	Ponderosa 6	8	634	7.6	27.8	48.82	7.1	65.1	5.4	168	36.7	87.8	0.97	<0.5	42.9	<0.05
WWRIG01	Ridgecrest 1	8	400	7.5	22.7	52.4	7.6	29.0	2.5	178	51.8	11.4	0.69	<0.5	27.0	0.88
WWRIG02	Ridgecrest 2	8	328	7.8	23.8	33.61	3.3	27.7	2.7	122	19.8	27.0	0.69	<0.5	28.0	0.28
WWTOM01	Thomas 1	8	472	7.6	22.2	55.4	3.7	37.9	2.1	162	30.3	46.2	0.46	<0.5	30.7	0.55
WWTOM02	Thomas 2	8	443	7.6	24.5	52.01	3.3	40.7	2.1	160	26.7	53.6	0.48	<0.5	30.9	0.21
WWTOM03	Thomas 3	8	473	7.6	21.4	54.3	4.6	43.7	2.0	171	36.0	41.9	0.63	<0.5	36.4	0.11
WWTOM04	Thomas 4	8	500	7.6	24.0	60.09	4.2	52.0	2.3	170	30.0	64.0	0.52	<0.5	34.6	0.19
WWTOM08	Thomas 8	8	579	7.6	26.0	69.62	4.3	39.5	3.4	145	28.4	86.2	0.47	<0.5	32.0	<0.05
WWWLK02	Walker 2	8	631	7.7	28.8	39.11	5.8	79.2	5.1	171	35.9	83.7	1.23	<0.5	41.6	<0.05
	Zone 12: Central															
WWATI02	Atrisco 2	12	584	7.5	18.3	44.44	9.3	66.0	8.7	201	111.0	16.6	0.72	<0.5	65.9	<0.05
WWATI04	Atrisco 4	12	465	7.8	21.5	27.67	5.8	61.6	6.6	165	77.1	12.2	1.01	<0.5	65.8	0.37
WWBUR01	Burton 1	12	411	7.8	24.5	30.99	7.0	39.8	6.0	134	34.4	36.1	0.63	<0.5	64.5	0.18
WWBUR03	Burton 3	12	391	7.7	20.6	42.68	7.8	26.0	4.1	130	41.9	30.5	0.51	<0.5	49.7	0.42
WWBUR04	Burton 4	12	440	7.9	26.2	28.37	6.6	48.2	6.8	137	35.8	41.6	0.71	<0.5	70.2	0.24
WWCHW01	Charles 1	12	346	7.8	19.6	38.1	3.0	31.4	2.0	145	31.3	18.0	0.51	<0.5	26.8	0.25
WWCHW02	Charles 2	12	314	7.8	19.0	39.9	3.5	21.8	1.9	135	34.4	11.5	0.53	<0.5	29.0	0.36
WWCHW03	Charles 3	12	305	7.8	18.4	39.39	3.6	19.7	1.8	131	30.7	9.5	0.54	<0.5	33.1	0.49
WWCHW05	Charles 5	12	337	7.8	19.4	40.55	4.3	24.2	2.5	128	28.9	19.9	0.54	<0.5	40.4	0.10
WWCOR02	Coronado 2	12	451	7.8	20.8	31.55	7.8	49.2	5.3	169	48.2	24.6	0.79	<0.5	52.3	0.13
WWDUR02	Duranes 2	12	418	7.9	19.1	27.59	5.6	49.0	6.6	152	67.5	10.5	0.65	<0.5	63.7	<0.05
WWDUR03	Duranes 3	12	505	7.7	19.0	39.54	8.0	54.2	7.4	181	88.2	12.7	0.56	<0.5	62.4	<0.05
WWDUR04	Duranes 4	12	441	8.0	19.6	20.4	4.0	67.4	6.5	155	70.8	12.4	1.03	<0.5	63.6	<0.05
WWDUR05	Duranes 5	12	436	7.9	20.4	23.69	4.5	60.7	6.2	158	67.7	12.2	0.98	<0.5	63.0	0.13
WWDUR06	Duranes 6	12	511	7.4	19.0	52.57	12.3	42.3	9.7	204	93.4	14.4	0.41	<0.5	69.5	<0.05
WWGON02	Gonzales 2	12	432	7.9	25.3	22.21	4.2	62.1	6.9	158	63.5	10.0	0.98	<0.5	68.8	0.32
WWGRG01	Griegos 1	12	405	7.6	17.9	41.17	11.5	23.6	8.2	156	60.7	12.1	0.41	<0.5	64.4	<0.05
WWGRG02	Griegos 2	12	482	7.6	18.5	47.01	11.8	34.3	8.6	196	79.2	12.4	0.40	<0.5	68.5	<0.05
WWGRG04	Griegos 4	12	344	7.7	18.6	29.37	8.1	36.0	7.5	157	45.3	9.4	0.68	<0.5	64.7	<0.05
WWLYN02	Leyendecker 2	12	324	7.7	18.9	42.21	3.5	22.8	2.4	139	32.7	10.2	0.56	<0.5	32.0	0.37
WWLYN03	Leyendecker 3	12	301	7.8	18.0	40.05	4.2	17.3	2.1	133	29.9	8.0	0.50	<0.5	31.6	0.45
WWLYN04	Leyendecker 4	12	338	7.7	19.2	42.91	4.3	23.7	2.0	149	33.9	11.1	0.58	<0.5	32.9	0.43
WWMIL01	Miles 1	12	424	7.9	25.5	34.95	7.5	41.0	7.4	132	39.0	38.6	0.69	<0.5	71.0	0.29
WWRIG05	Ridgecrest 5	12	378	7.7	22.3	41.42	5.7	24.4	2.9	133	26.6	32.6	0.45	<0.5	37.1	0.13
WWSJ01	San Jose 1	12	570	7.3	19.0	56.53	13.4	36.2	9.2	205	108.5	16.3	0.33	<0.5	69.4	<0.05
WWSJ03	San Jose 3	12	433	8.1	24.3	17.56	4.1	65.4	6.1	141	69.3	14.7	0.95	<0.5	66.7	0.33
WWTOM05	Thomas 5	12	384	7.6	21.3	40.31	3.7	36.9	2.4	161	36.1	18.1	0.67	<0.5	36.2	<0.05
WWTOM07	Thomas 7	12	399	7.6	21.3	42.75	3.9	35.8	2.7	155	34.5	26.9	0.65	<0.5	35.0	0.12
WWVAN01	Vol Andia 1	12	375	7.9	17.2	54.7	6.6	21.2	2.3	134	51.7	13.5	0.45	<0.5	31.6	0.88
WWVAN03	Vol Andia 3	12	375	7.9	18.0	51.24	6.6	21.1	2.9	123	56.7	17.8	0.49	<0.5	37.3	0.42
WWVAN04	Vol Andia 4	12	313	7.9	17.0	43.01	4.8	16.9	1.9	132	35.6	9.5	0.45	<0.5	30.9	0.91
WWVAN06	Vol Andia 6	12	315	7.8	16.7	40.86	5.1	17.7	2.2	133	36.7	8.8	0.44	<0.5	30.9	0.62
WWWEB02	Webster 2	12	412	7.8	21.2	29.96	7.4	44.1	6.3	160	38.6	25.2	0.75	<0.5	61.8	<0.05
WWYAL02	Yale 2	12	420	7.7	23.1	37.1	8.0	33.1	6.9	131	40.1	34.8	0.60	<0.5	66.5	0.46
WWYAL03	Yale 3	12	471	7.6	24.7	44.28	9.2	38.6	7.8	150	67.1	29.5	0.54	<0.5	73.2	0.56

Table F3. Summary of trace-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; Al, aluminum; As, arsenic; Ba, barium; B, boron; Cr, chromium; Cu, copper; Fe, iron; Pb, lead; Li, lithium; Mn, manganese; Sr, strontium; V, vanadium; Zn, zinc]

Sample reference number	Station name	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Cr (µg/L)	Cu (µg/L)	Fe (mg/L)	Pb (µg/L)	Li (mg/L)	Mn (mg/L)	Sr (mg/L)	V (µg/L)	Zn (µg/L)
	Zone 3: West Central													
WWATI01	Atrisco 1	<0.040	21.7	0.010	0.352	23.0	<5.0	<0.010	<2.0	0.150	<0.002	0.097	45.5	<5.0
WWCOL01	College 1	<0.040	48.9	0.034	0.317	9.0	<5.0	0.011	<2.0	0.040	<0.002	0.064	98.6	<5.0
WWCOL03	College 3	<0.040	24.7	0.037	0.251	7.0	<5.0	<0.010	2.0	0.060	<0.002	0.203	43.4	<5.0
WWLEV02	Leavitt 2	<0.040	34.0	0.017	0.269	5.0	<5.0	<0.010	<2.0	0.040	<0.002	0.059	70.9	<5.0
WWLEV03	Leavitt 3	<0.040	34.6	0.008	0.322	23.0	<5.0	<0.010	<2.0	0.080	<0.002	0.052	74.2	<5.0
WWVC02	Volcano Cliffs 2	<0.040	11.4	0.058	0.157	5.0	<5.0	<0.010	<2.0	0.050	<0.002	0.351	21.1	<5.0
WWVC03	Volcano Cliffs 3	<0.040	15.0	0.054	0.181	6.0	<5.0	<0.010	<2.0	0.050	<0.002	0.266	27.8	<5.0
WWWM01	West Mesa 1	<0.040	27.2	0.023	0.282	11.0	<5.0	<0.010	<2.0	0.040	<0.002	0.059	48.9	<5.0
WWWM02	West Mesa 2	<0.040	39.5	0.022	0.229	nd	<5.0	<0.010	<2.0	0.040	<0.002	0.079	60.0	<5.0
WWWM04	West Mesa 4	<0.040	35.9	0.021	0.262	17.0	<5.0	<0.010	<2.0	0.040	<0.002	0.063	62.0	<5.0
WWZAM01	Zamora 1	<0.040	14.4	0.054	0.173	5.0	<5.0	<0.010	<2.0	nd	<0.002	0.317	27.3	<5.0
	Zone 8: Eastern Mountain Front													
WWLOM05	Lomas 5	<0.040	4.0	0.084	<0.050	<1.0	<5.0	<0.010	<2.0	0.020	<0.002	0.203	<10.0	<5.0
WWLOM06	Lomas 6	<0.040	<2.0	0.095	<0.050	<1.0	<5.0	0.016	<2.0	0.020	0.005	0.259	<10.0	6.0
WWLOV03	Love 3	<0.040	<2.0	0.171	<0.050	1.0	<5.0	0.012	<2.0	0.020	<0.002	0.363	<10.0	8.0
WWLOV04	Love 4	<0.040	<2.0	0.200	0.051	1.0	<5.0	<0.010	<2.0	0.020	<0.002	0.466	<10.0	<5.0
WWLOV05	Love 5	<0.040	<2.0	0.155	<0.050	2.0	<5.0	0.013	<2.0	0.020	<0.002	0.368	<10.0	<5.0
WWLOV06	Love 6	<0.040	<2.0	0.096	<0.050	1.0	<5.0	0.011	<2.0	0.020	<0.002	0.202	<10.0	<5.0
WWLOV07	Love 7	<0.040	4.0	0.184	<0.050	1.0	<5.0	0.013	<2.0	0.020	0.006	0.400	<10.0	<5.0
WWLOV08	Love 8	<0.040	<2.0	0.182	0.093	2.0	<5.0	0.016	<2.0	0.020	0.002	0.397	<10.0	13.0
WWPON02	Ponderosa 2	<0.040	6.0	0.154	<0.050	<1.0	<5.0	<0.010	<2.0	0.030	0.003	0.287	<10.0	6.0
WWPON03	Ponderosa 3	<0.040	23.2	0.194	0.226	<1.0	<5.0	0.019	<2.0	0.070	0.029	0.539	<10.0	7.0
WWPON04	Ponderosa 4	<0.040	14.0	0.121	<0.050	<1.0	<5.0	<0.010	<2.0	0.030	0.007	0.268	<10.0	7.0
WWPON05	Ponderosa 5	<0.040	25.4	0.121	0.051	<1.0	<5.0	<0.010	<2.0	0.030	0.003	0.350	<10.0	<5.0
WWPON06	Ponderosa 6	<0.040	33.9	0.128	0.232	<1.0	<5.0	0.037	<2.0	0.100	0.056	0.415	<10.0	6.0
WWRIG01	Ridgecrest 1	<0.040	<2.0	0.082	<0.050	<1.0	<5.0	0.011	<2.0	0.020	<0.002	0.279	<10.0	7.0
WWRIG02	Ridgecrest 2	<0.040	<2.0	0.150	<0.050	2.0	<5.0	<0.010	<2.0	0.020	<0.002	0.359	<10.0	6.0
WWTOM01	Thomas 1	<0.040	<2.0	0.165	0.074	1.0	<5.0	0.010	<2.0	0.020	<0.002	0.320	<10.0	<5.0
WWTOM02	Thomas 2	<0.040	<2.0	0.158	0.103	<1.0	<5.0	0.020	<2.0	0.020	0.002	0.282	<10.0	<5.0
WWTOM03	Thomas 3	<0.040	6.2	0.127	0.114	2.0	<5.0	0.033	<2.0	0.020	0.003	0.327	<10.0	<5.0
WWTOM04	Thomas 4	<0.040	<2.0	0.156	0.120	<1.0	<5.0	0.027	<2.0	0.020	0.003	0.328	<10.0	8.0
WWTOM08	Thomas 8	<0.040	12.9	0.198	0.184	<1.0	<5.0	0.059	<2.0	0.000	0.044	0.508	<10.0	9.0
WWWLK02	Walker 2	<0.040	35.5	0.084	0.224	<1.0	<5.0	0.018	<2.0	0.120	0.021	0.266	<10.0	<5.0
	Zone 12: Central													
WWATI02	Atrisco 2	<0.040	6.5	0.052	0.139	<1.0	<5.0	0.011	<2.0	0.070	0.017	0.697	12.2	6.0
WWATI04	Atrisco 4	<0.040	9.7	0.050	0.147	3.0	<5.0	<0.010	<2.0	0.070	<0.002	0.406	19.9	<5.0
WWBUR01	Burton 1	<0.040	15.0	0.118	0.134	2.0	<5.0	<0.010	<2.0	0.080	<0.002	0.332	10.5	<5.0
WWBUR03	Burton 3	<0.040	5.0	0.115	0.092	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.359	<10.0	<5.0
WWBUR04	Burton 4	<0.040	20.8	0.102	0.155	1.0	<5.0	<0.010	<2.0	0.100	<0.002	0.297	14.0	7.0
WWCHW01	Charles 1	<0.040	<2.0	0.136	0.094	2.0	<5.0	<0.010	<2.0	0.020	<0.002	0.185	<10.0	<5.0
WWCHW02	Charles 2	<0.040	<2.0	0.088	0.052	<1.0	<5.0	0.013	<2.0	0.010	<0.002	0.207	<10.0	5.0
WWCHW03	Charles 3	<0.040	2.0	0.082	0.054	<1.0	<5.0	<0.010	<2.0	0.020	<0.002	0.192	<10.0	7.0
WWCHW05	Charles 5	<0.040	4.0	0.099	0.067	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.293	<10.0	9.0
WWCOR02	Coronado 2	<0.040	15.6	0.075	0.168	1.0	<5.0	0.011	<2.0	0.000	<0.002	0.344	11.0	<5.0
WWDUR02	Duranes 2	<0.040	7.6	0.054	0.099	1.0	<5.0	<0.010	<2.0	0.070	0.003	0.379	13.6	<5.0
WWDUR03	Duranes 3	<0.040	6.2	0.051	0.126	1.0	<5.0	0.015	<2.0	0.080	0.114	0.504	12.0	6.0
WWDUR04	Duranes 4	<0.040	12.9	0.045	0.124	1.0	<5.0	<0.010	<2.0	0.070	<0.002	0.319	21.1	<5.0
WWDUR05	Duranes 5	<0.040	10.0	0.043	0.141	2.0	<5.0	<0.010	<2.0	0.060	0.004	0.353	16.7	<5.0
WWDUR06	Duranes 6	<0.040	4.3	0.058	0.110	<1.0	<5.0	0.021	<2.0	0.100	0.003	0.869	<10.0	<5.0
WWGON02	Gonzales 2	<0.040	12.8	0.048	0.160	4.0	<5.0	<0.010	<2.0	0.000	<0.002	0.329	24.5	5.0
WWGRG01	Griegos 1	<0.040	6.1	0.062	0.068	<1.0	<5.0	0.014	<2.0	0.070	<0.002	0.638	<10.0	5.0
WWGRG02	Griegos 2	<0.040	5.0	0.062	0.073	<1.0	9.0	0.014	3.0	0.080	0.016	0.710	<10.0	8.0
WWGRG04	Griegos 4	<0.040	13.0	0.054	0.074	<1.0	<5.0	0.014	<2.0	0.090	<0.002	0.422	15.7	6.0
WWLYN02	Leyendecker 2	<0.040	3.0	0.076	0.057	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.201	<10.0	<5.0
WWLYN03	Leyendecker 3	<0.040	6.0	0.083	<0.050	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.241	<10.0	<5.0
WWLYN04	Leyendecker 4	<0.040	5.0	0.075	0.064	<1.0	<5.0	<0.010	<2.0	0.040	<0.002	0.230	<10.0	<5.0

Table F3. Summary of trace-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone-- Continued

Sample reference number	Station name	Al (mg/L)	As (µg/L)	Ba (mg/L)	B (mg/L)	Cr (µg/L)	Cu (µg/L)	Fe (mg/L)	Pb (µg/L)	Li (mg/L)	Mn (mg/L)	Sr (mg/L)	V (µg/L)	Zn (µg/L)
WWMIL01	Miles 1	<0.040	16.1	0.089	0.130	1.0	<5.0	0.011	<2.0	0.060	<0.002	0.399	15.0	7.0
WWRIG05	Ridgecrest 5	<0.040	5.0	0.160	0.088	2.0	<5.0	0.018	<2.0	0.030	0.004	0.348	<10.0	<5.0
WWSJ01	San Jose 1	<0.040	6.4	0.043	0.133	<1.0	<5.0	<0.010	<2.0	0.080	<0.002	0.675	<10.0	<5.0
WWSJ03	San Jose 3	<0.040	32.7	0.062	0.230	3.0	<5.0	<0.010	<2.0	0.110	<0.002	0.259	28.7	<5.0
WWTOM05	Thomas 5	<0.040	8.6	0.086	0.113	2.0	<5.0	0.011	<2.0	0.040	0.003	0.277	<10.0	9.0
WWTOM07	Thomas 7	<0.040	6.1	0.108	0.123	2.0	<5.0	0.010	<2.0	0.030	0.004	0.303	<10.0	8.0
WWVAN01	Vol Andia 1	<0.040	7.0	0.123	0.051	<1.0	<5.0	<0.010	<2.0	0.030	0.002	0.423	<10.0	5.0
WWVAN03	Vol Andia 3	<0.040	6.8	0.100	0.058	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.403	<10.0	<5.0
WWVAN04	Vol Andia 4	<0.040	8.0	0.092	<0.050	<1.0	<5.0	<0.010	<2.0	0.030	<0.002	0.278	<10.0	<5.0
WWVAN06	Vol Andia 6	<0.040	7.9	0.126	0.052	<1.0	<5.0	0.010	<2.0	0.030	0.003	0.303	<10.0	6.0
WWWEB02	Webster 2	<0.040	27.0	0.079	0.144	1.0	<5.0	<0.010	<2.0	0.140	<0.002	0.312	16.9	6.0
WWYAL02	Yale 2	<0.040	10.8	0.102	0.115	3.0	<5.0	<0.010	<2.0	0.060	<0.002	0.382	<10.0	<5.0
WWYAL03	Yale 3	<0.040	13.0	0.089	0.170	4.0	<5.0	0.015	<2.0	0.090	<0.002	0.470	<10.0	13.0