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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GROUND-WATER QUALITY IN NEVADA--
A PROPOSED MONITORING PROGRAM

By Jon O. Nowlin

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CONVERSION FACTORS AND ABBREVIATIONS

For those readers who may prefer to use metric units rather than U.S. Customary units, the conversion factors for terms in this report are listed below:

Multiply	by	To obtain
Acres	4,047	Square meters (m^2)
Acre-feet (acre-ft)	1,233	Cubic meters (m^3)
Cubic feet per second (ft^3/s)	28.32	Liters per second (L/s)
Cubic feet per second (ft^3/s)	0.02832	Cubic meters per second (m^3/s)
Feet (ft)	0.3048	Meters (m)
Gallons (gal)	3.785	Liters (L)
Gallons per minute (gal/min)	0.06309	Liters per second (L/s)
Inches (in)	25.40	Millimeters (mm)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.590	Square kilometers (km^2)

GROUND-WATER QUALITY IN NEVADA--A PROPOSED MONITORING PROGRAM

By Jon O. Nowlin

ABSTRACT

A program was designed for the systematic monitoring of ground-water quality in Nevada. Basic hydrologic and water-quality principles are discussed in the formulation of a rational approach to developing a statewide monitoring program. A review of ground-water monitoring efforts in Nevada through 1977 indicates that few requirements for an effective statewide program are being met. A suggested program has been developed that consists of five major elements: (1) A Background-Quality Network to assess the existing water quality in Nevada aquifers, (2) a Contamination Source Inventory of known or potential threats to ground-water quality, (3) Surveillance Networks to monitor ground-water quality in selected hydrographic areas, (4) Intensive Surveys of individual instances of known or potential ground-water contamination, and (5) Ground-Water Data File to manage data generated by the other monitoring elements. Two indices have been developed to help assign rational priorities for monitoring ground water in the 255 hydrographic areas of Nevada: (1) A Hydrographic-Area Priority Index for surveillance monitoring, and (2) A Development-Potential Index for background monitoring of areas with little or no current development.

Requirements for efficient management of data from ground-water monitoring are discussed and the three major systems containing Nevada ground-water data are reviewed. More than 11,000 chemical analyses of ground water have been acquired from existing systems and incorporated into a prototype data base.

INTRODUCTION

Purpose and Scope of the Study

Water in Nevada is regarded as a more valuable resource than the precious metals for which the State is noted (Scott and others, 1971). Ground water is an important part of the State's water resources. Water-use estimates for Nevada in 1969 (Smales and Harrill, 1971) showed that 84 percent of rural domestic withdrawals, 63 percent of public-supply withdrawals, and 59 percent of industrial and institutional withdrawals were supplied by ground water. Of some 60 major public-supply systems inventoried for the 1969 study, 78 percent were supplied solely by ground water, 15 percent by both ground water and streams, and 7 percent by surface-water sources. Sources of supply for major water uses in 1969 are illustrated in figure 1.

Federal and State water-quality-monitoring efforts historically have been concentrated on protecting surface-water resources. The cultural need for easy, quick, and economic means of disposing of wastes was often served by relatively accessible surface water which was expected to either dilute the waste to acceptable concentrations or, at the least, flush it downstream. The rising environmental awareness of the American public has focused on the visible surface water, resulting in a plethora of laws and regulations inhibiting or prohibiting the traditional methods of waste disposal and promoting on-land or underground disposal of wastes. The attendant increased risk of ground-water contamination has been legislatively recognized in Public Law 92-500 (the Water Pollution Control Act Amendments of 1972) which include mandates for the States to develop monitoring programs for ground-water quality and by the Safe Drinking Water Act of 1974 (Public Law 93-523), which specifies monitoring requirements for public water supplies and underground injection systems.

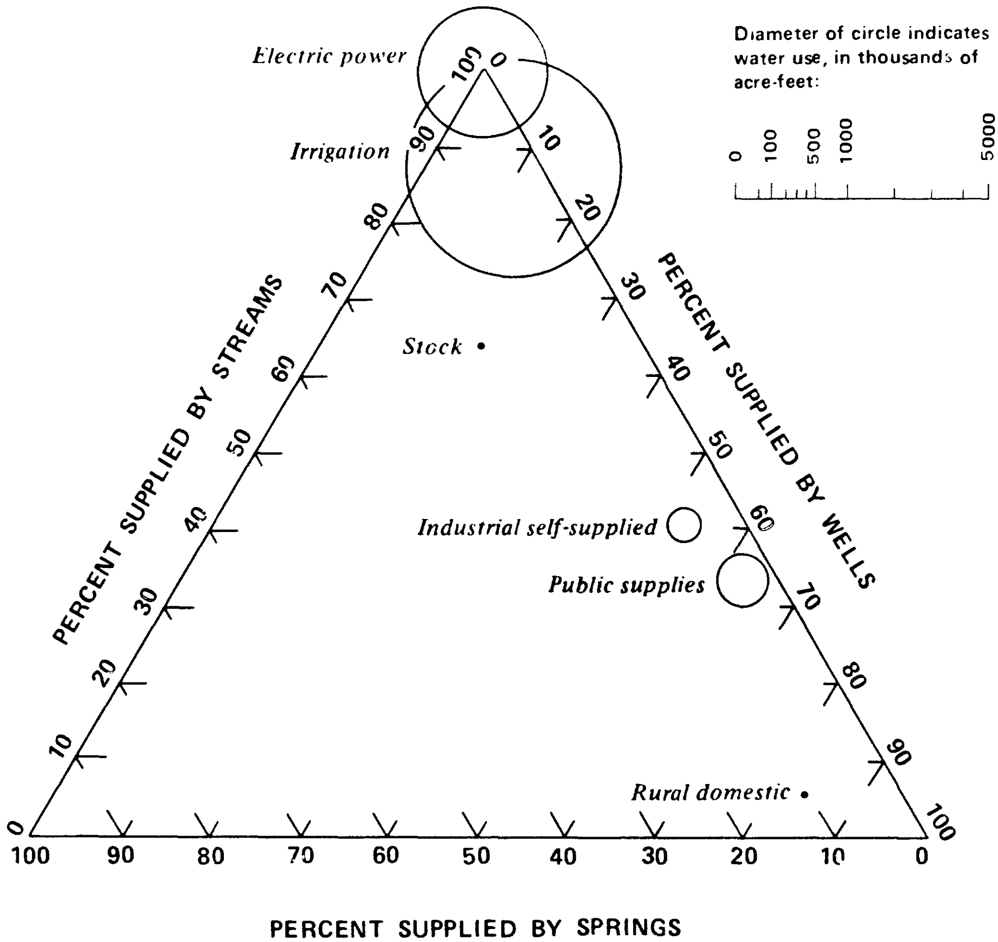


FIGURE 1.--Sources of supply for major water uses as of 1969 (based on data from Smales and Harrill, 1971).

In response to requirements of Public Law 92-500, the Division of Environmental Protection (DEP) of the Nevada Department of Conservation and Natural Resources was designated as the agency to establish and maintain a program to monitor ground-water quality in Nevada. The U.S. Geological Survey (USGS) was asked to assist in the design of such a program to meet the objectives of Public Law 92-500, which include (1) determination of existing ground-water quality, (2) providing early detection of ground-water contamination, and (3) inventorying sources of ground-water contamination.

This report contains suggestions for establishing such a program for Nevada. Specific program elements are described along with suggested methods for selection of: Monitoring sites, constituents and properties to be determined, sampling frequencies, sample-collection techniques, and data-processing and analysis procedures. Recognizing that the ultimate constraints on any monitoring system are economic, the report presents rational schemes for setting implementation priorities for program elements. Selection of specific sampling sites has not been attempted on a statewide basis; such details must follow more thorough hydrologic evaluation of selected target areas.

This report was completed in 1978, but other commitments precluded its publication at that time. The material herein has not been updated since the 1978 draft. Thus, the discussion of specific legal mandates existing monitoring programs in Nevada and available systems for managing ground-water data along with the bibliography on ground-water quality in Nevada deal with the period prior to about 1977. In contrast, the general discussions regarding suggested methods for establishing a monitoring program in Nevada remain pertinent in the 1980's.

Hydrographic and Climatic Setting

Nevada lies almost entirely within the Great Basin, that part of the Basin and Range Province which drains into topographically closed basins rather than to the sea. Of the State's total area of 110,540 square miles only 16 percent drains to the sea--5,230 square miles within the Snake River Basin in the northeastern part of the State and 12,376 square miles within the Colorado River Basin in the southeastern part (Scott and others, 1971). The topography of the State is characterized by isolated north-trending mountain ranges with intervening sediment-filled valleys or basins. The valleys are commonly flat floored and elongated parallel to the mountain trends; in many valleys an ephemeral lake or playa forms the terminus of the drainage system. Sedimentary deposits in the valleys are generally thick, with local thicknesses in some valleys estimated to exceed 8,000 ft (Glancy and Katzer, 1975). The typical hydrologic system for a valley consists of recharge by precipitation near the bordering mountain ranges, seasonal and ephemeral surface-water runoff to the terminal playa lake, ground-water storage in the alluvial valley, and discharge by evaporation and transpiration.

Nevada's unique topographic setting has resulted in the valley commonly being the basic unit of social, economic, and water development. Rush (1968) divided the State into 14 hydrographic regions and approximately 250 individual hydrographic areas (individual valleys or valley segments) based on topographic or hydrologic boundaries (table 1, fig. 2). These areas are commonly used by State and Federal agencies in Nevada for indexing or compiling hydrologic data, and they will be thus used in this report.

Table 1.--*Hydrographic regions and areas in Nevada*

1-NORTHWEST REGION

1. Pueblo V.
2. Continental Lake V.
3. Gridley Lake V.
4. Virgin V.
5. Sage Hen V.
6. Guano V.
7. Swan Lake V.
8. Massacre Lake V.
9. Long V.
10. Macy Flat
11. Coleman V.
12. Mosquito V.
13. Warner V.
14. Surprise V.
15. Boulder V.
16. Duck Lake V.

2-BLACK ROCK DESERT REGION

17. Pilgrim Flat
18. Painters Flat
19. Dry V.
20. Sano V.
21. Smoke Creek Desert
22. San Emidio Desert
23. Granite Basin
24. Hualapai Flat
25. High Rock Lake V.
26. Mud Meadow
27. Summit Lake V.
28. Black Rock Desert
29. Pine Forest V.
30. Kings River V.
    (A) Rio King Subarea
    (B) Sod House Subarea
31. Desert V.
32. Silver State V.
33. Quinn River V.
    (A) Orovada Subarea
    (B) McDermitt Subarea

3-SNAKE RIVER BASIN

34. Little Owyhee River Area
35. South Fork Owyhee River Area
36. Independence V.
37. Owyhee River Area
38. Bruneau River Area
39. Jarbidge River Area
40. Salmon Falls Creek Area
41. Goose Creek Area

4-HUMBOLDT RIVER BASIN

42. Marys River Basin
43. Starr V. Area
44. North Fork Area
45. Lamoille V.
46. South Fork Area
47. Huntington V.
48. Dixie Creek--Tenmile
    Creek Area
49. Elko Segment
50. Susie Creek Area
51. Maggie Creek Area
52. Marys Creek Area
53. Pine V.
54. Crescent V.
55. Carico Lake V.
56. Upper Reese River V.
57. Antelope V.
58. Middle Reese River V.
59. Lower Reese River V.
60. Whirlwind V.
61. Boulder Flat
62. Rock Creek V.
63. Willow Creek V.
64. Clovers Area
65. Pumpernickel V.
66. Kelly Creek Area
67. Little Humboldt V.
68. Hardscrabble Area
69. Paradise V.
70. Winnemucca Segment
71. Grass V.
72. Imlay Area
73. Lovelock V.
    (A) Oreana Subarea
74. White Plains

5-WEST CENTRAL REGION

75. Bradys Hot Springs Area
76. Fernley Area
77. Fireball V.
78. Granite Springs V.
79. Kumiva V.

6-TRUCKEE RIVER BASIN

80. Winnemucca Lake V.
81. Pyramid Lake V.
82. Dodge Flat
83. Tracy Segment
84. Warm Springs V.
85. Spanish Springs V.
86. Sun V.
87. Truckee Meadows
88. Pleasant V.
89. Washoe V.
90. Lake Tahoe Basin
91. Truckee Canyon Segment

7-WESTERN REGION

92. Lemmon V.
    (A) Silver Lake Subarea
    (B) Lemmon Subarea
93. Antelope V.
94. Bedell Flat
95. Dry V.
96. Newcomb Lake V.
97. Honey Lake V.
98. Skedaddle Creek V.
99. Red Rock V.
100. Cold Spring V.

8-CARSON RIVER BASIN

101. Carson Desert
    (A) Packard Desert
102. Churchill V.
103. Dayton V.
104. Eagle V.
105. Carson Valley

9-WALKER RIVER BASIN

106. Antelope V.
107. Smith V.
108. Mason V.
109. East Walker Area
110. Walker Lake V.
    (A) Schurz Subarea
    (B) Lake Subarea
    (C) Whisky Flat--Hawthorne
        Subarea

10-CENTRAL REGION

111. Alkali V. (Mineral)
    (A) Northern Part
    (B) Southern Part
112. Mono V.
113. Huntoon V.
114. Teels Marsh V.
115. Adobe V.
116. Queen V.
117. Fish Lake V.
118. Columbus Salt Marsh V.
119. Rhodes Salt Marsh V.
120. Garfield Flat
121. Soda Spring V.
    (A) Eastern Part
    (B) Western Part
122. Gabbs V.
123. Rawhide Flats
124. Fairview V.
125. Stingaree V.
126. Cowkick V.
127. Eastgate V. Area
128. Dixie V.
129. Buena Vista V.
130. Pleasant V.
131. Buffalo V.
132. Jersey V.
133. Edwards Creek V.
134. Smith Creek V.
135. Ione V.
136. Monte Cristo V.
137. Big Smoky V.
    (A) Tonopah Flat
    (B) Northern Part
138. Grass V.
139. Kobeh V.
140. Monitor V.
    (A) Northern Part
    (B) Southern Part
141. Ralston V.
142. Alkali Spring V. (Esmeralda)
143. Clayton V.
144. Lida V.
145. Stonewall Flat
146. Sarcobatus Flat
147. Gold Flat
148. Cactus Flat
149. Stone Cabin V.
150. Little Fish Lake V.
151. Antelope V. (Eureka & Nye)
152. Stevens Basin
153. Diamond V.
154. Newark V.
155. Little Smoky V.
    (A) Northern Part
    (B) Central Park
    (C) Southern Part
156. Hot Creek V.
157. Kawich V.
158. Emigrant V.
    (A) Groom Lake V.
    (B) Papoose Lake V.
159. Yucca Flat
160. Frenchman Flat
161. Indian Springs V.
162. Pahrump V.
163. Mesquite V. (Sandy V.)
164. Ivanpah V.
    (A) Northern Part
    (B) Southern Part
165. Jean Lake V.
166. Hidden V. (South)
167. Eldorado V.
168. Three Lakes V. (Northern Part)
169. Tikapoo V. (Tickaboo V.)
    (A) Northern Part
    (B) Southern Part
170. Penoyer V. (Sand Spring V.)
171. Coal V.
172. Garden V.
173. Railroad V.
    (A) Southern Part
    (B) Northern Part
174. Jakes V.
175. Long V.
176. Ruby V.
177. Clover V.
178. Butte V.
    (A) Northern Part (Round V.)
    (B) Southern Part
179. Steptoe V.
180. Cave V.
181. Dry Lake V.
182. Delamar V.
183. Lake V.
184. Spring V.
185. Tippett V.
186. Antelope V. (White Pine & Elko)
    (A) Southern Part
    (B) Northern Part
187. Goshute V.
188. Independence V. (Pequop V.)

11-GREAT SALT LAKE BASIN

189. Thousand Springs V.
    (A) Herrell Siding--Brush Creek Area
    (B) Toano--Rock Spring Area
    (C) Rocky Butte Area
    (D) Montello--Crittenden Creek
        Area (Montello V.)
190. Grouse Creek V.
191. Pilot Creek V.
192. Great Salt Lake Desert
193. Deep Creek V.
194. Pleasant V.
195. Snake V.
196. Hamlin V.

12-ESCALANTE DESERT

197. Escalante Desert

13-COLORADO RIVER BASIN

198. Dry V.
199. Rose V.
200. Eagle V.
201. Spring V.
202. Patterson V.
203. Panaca V.
204. Clover V.
205. Lower Meadow Valley Wash
206. Kane Springs V.
207. White River V.
208. Pahroc V.
209. Pahranagat V.
210. Coyote Spring V.
211. Three Lakes V. (Southern Part)*
212. Las Vegas V.
213. Colorado River V.
214. Piute V.
215. Black Mountains Area
216. Garnet V. (Dry Lake V.)
217. Hidden V. (North)*
218. California Wash
219. Muddy River Springs Area (Upper Moapa V.)
220. Lower Moapa V.
221. Tule Desert
222. Virgin River V.
223. Gold Butte Area
224. Greasewood Basin

14-DEATH VALLEY BASIN

225. Mercury V.
226. Rock V.
227. Fortymile Canyon
    (A) Jackass Flats
    (B) Buckboard Mesa
228. Oasis V.
229. Crater Flat
230. Amargosa Desert
231. Grapevine Canyon
232. Oriental Wash

* Noncontributing part of the
Colorado River Basin

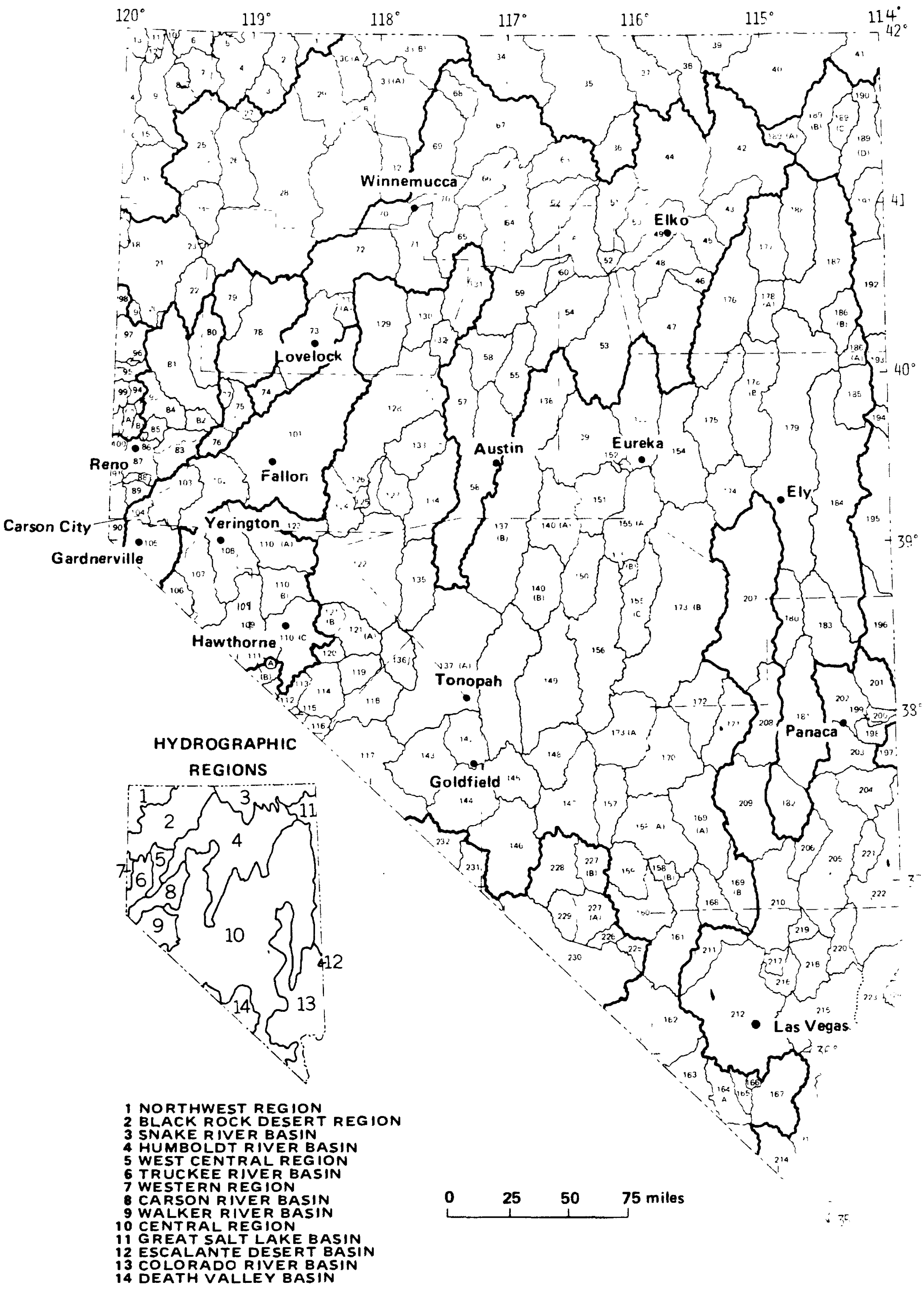
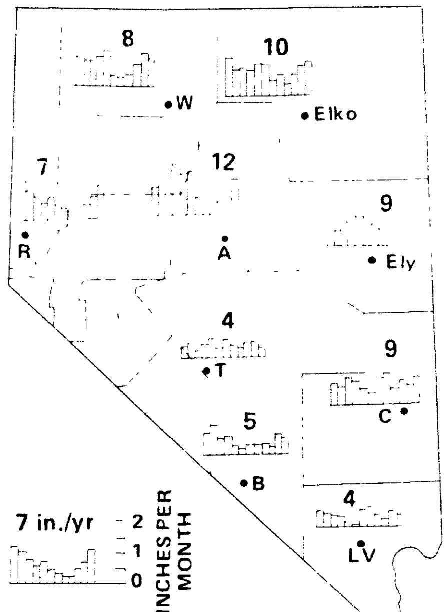
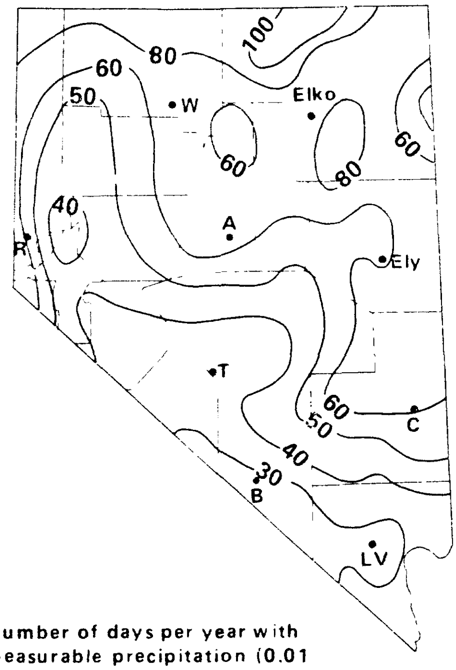


FIGURE 2.--Hydrographic regions and areas.

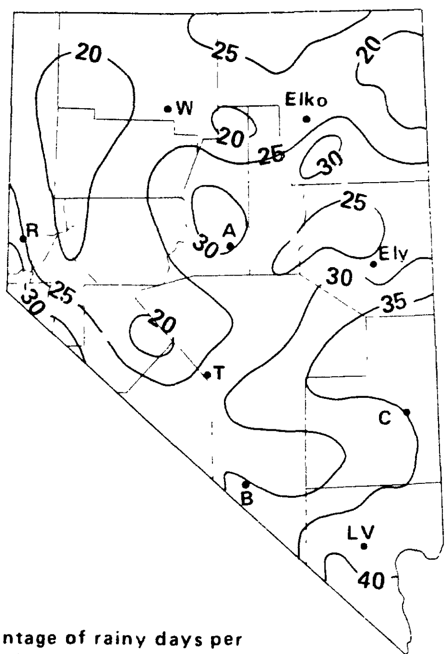
Nevada's climate is the driest of the 50 States, with precipitation ranging from less than 4 inches per year in the drier southern valleys to more than 30 inches per year in the higher mountain ranges (Houghton and others, 1975). Precipitation events are infrequent and short-lived, but their distribution is relatively uniform over the year and they may be intense during short periods (fig. 3A-C). The low humidity and abundant sunshine result in evaporation rates in the State ranging from more than 80 inches in the southeastern part to about 40 inches in the northeastern corner (fig. 3D). Low precipitation coupled with high evapotranspiration results in high soil-moisture deficits on the floors of many of the lower valleys (fig. 4), a factor placing severe limitations on the amount of local ground-water recharge.



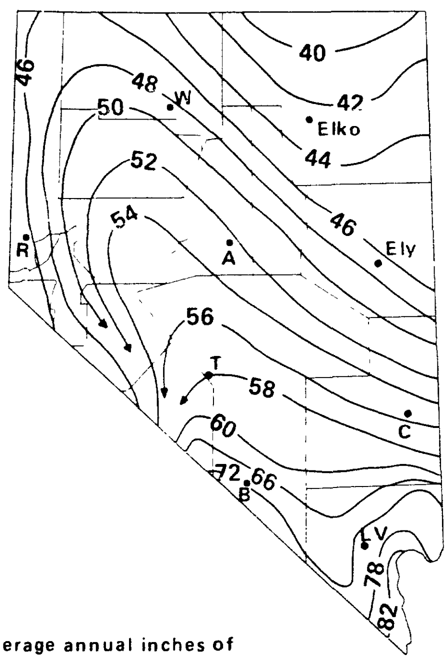
A. Precipitation summaries at selected Nevada stations



B. Number of days per year with measurable precipitation (0.01 inch or more)



C. Percentage of rainy days per year with moderate to heavy precipitation (0.25 inch or more)



D. Average annual inches of evaporation from lake surfaces in Nevada

FIGURE 3.--Climatic data (from Houghton and others, 1975). Towns are indicated as follows: A, Austin; B, Beatty; C, Caliente; LV, Las Vegas; R, Reno; T, Tonopah; and W, Winnemucca.

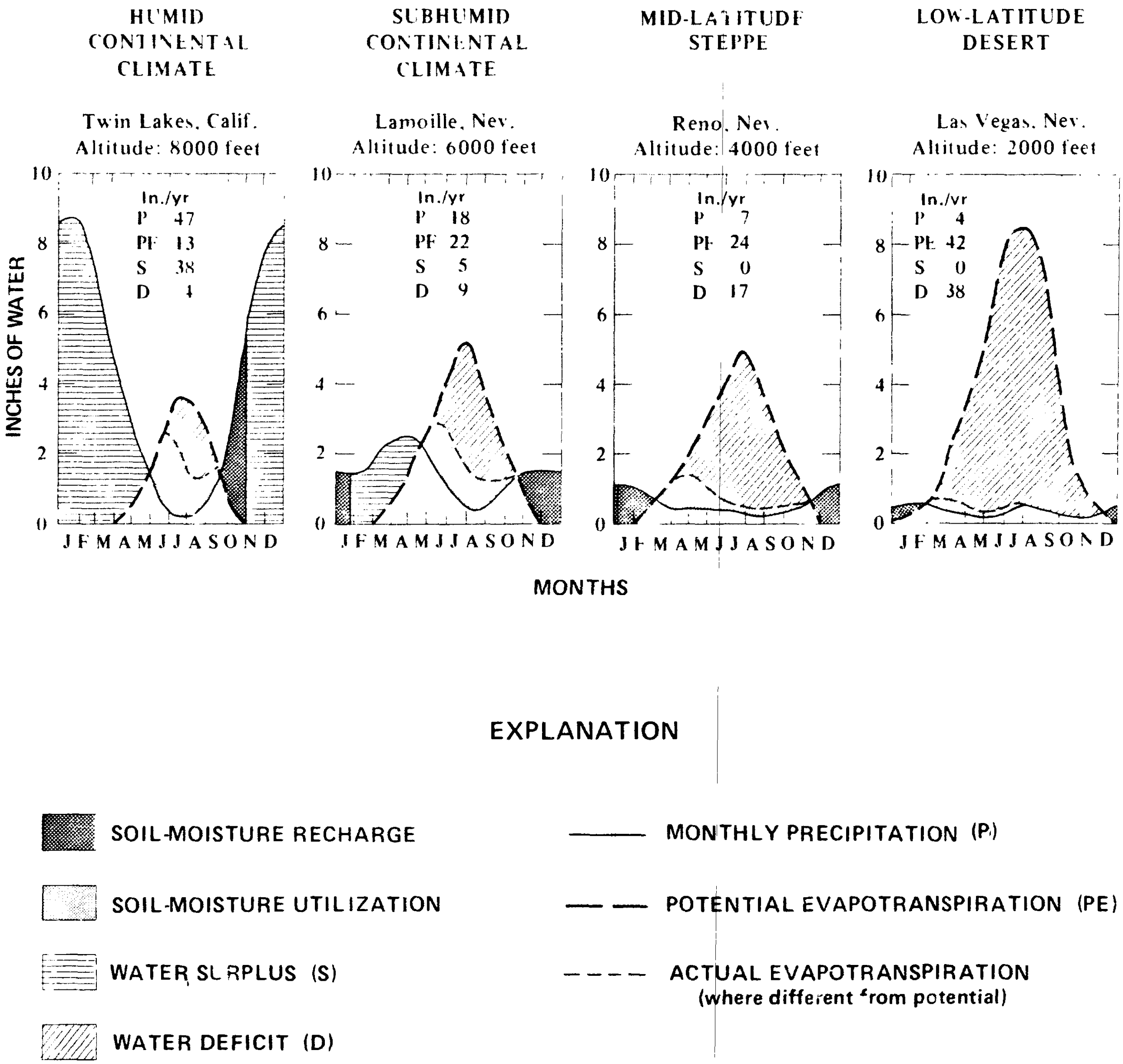


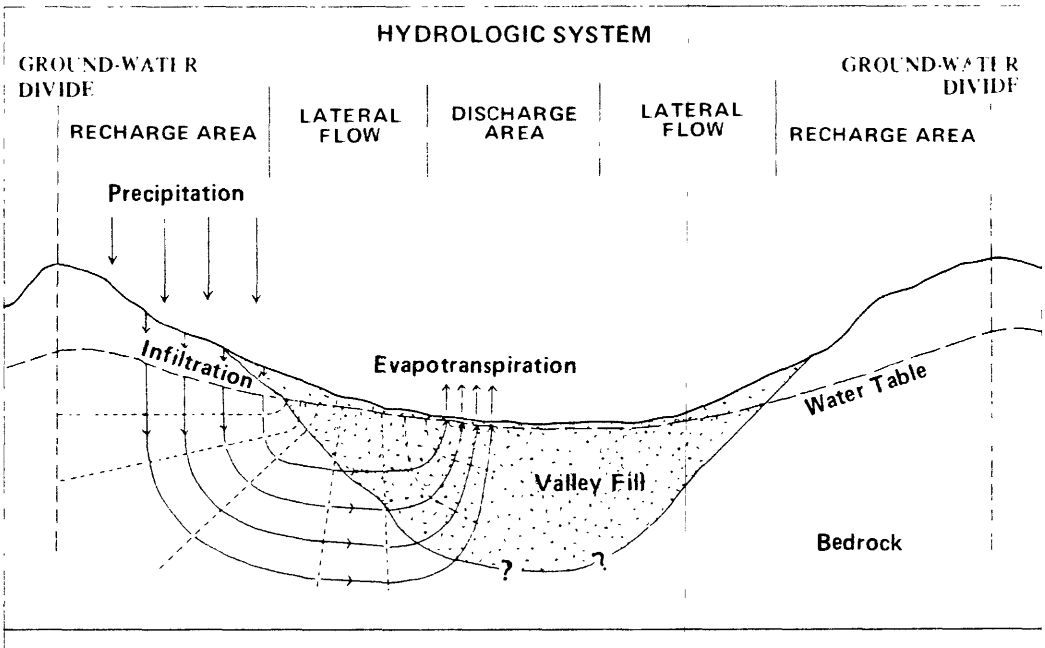
FIGURE 4.--Seasonal water and soil-moisture balance for four climatic zones in and adjacent to Nevada (from Houghton and others, 1975).

Concepts of Ground-Water Quality

The occurrence and movement of ground water is governed primarily by the nature of geologic units through which it moves. The quality of ground water at any given point in a ground-water flow system is a function of (1) the quality of the original recharge water (surface and subsurface, either natural or cultural), (2) the mineralogy of the materials through which it moves, and (3) the duration of contact with those materials.

Hydrologic Framework

A conceptual model of ground-water movement in a hypothetical desert basin is reproduced in figure 5. Under natural conditions the greatest source of recharge is from precipitation in the bordering mountain ranges. In Nevada, such precipitation may be several times greater than on the valley floors. Some water is stored and transmitted through fractures and faults in the mountain mass to discharge as base flow to mountain streams or as underflow to the adjacent valley fill. Direct precipitation and surficial runoff from the mountain front recharge the higher alluvial fans. The higher altitudes of the mountain and alluvial-fan recharge areas provide the hydraulic potential to move the ground water downgradient to the discharge areas. Natural recharge in the lower parts of the basins is minor to nonexistent, as precipitation commonly is insufficient to satisfy the soil-moisture deficiency in the unsaturated zone. Natural discharge occurs from the valley floor, primarily through soil moisture evaporation and transpiration losses from vegetation. In open-basin valleys with sufficient recharge, ground water may be discharged as base flow in perennial streams leaving the valley. In closed-basin valleys, surface-water flow may be ephemeral, ending at a playa, or perennial, into a terminal lake.



GEOCHEMICAL SYSTEM

RECHARGE AREA	LATERAL FLOW	DISCHARGE AREA
SHALLOW AQUIFERS: Generally good quality	SHALLOW AQUIFERS: Quality generally degrades going downgradient	SHALLOW AQUIFERS: Quality poor to saline; may improve with depth
DEEP AQUIFERS: Generally good quality; locally may be mineralized	DEEP AQUIFERS: Generally good quality; locally may be mineralized	DEEP AQUIFERS: Generally fair to good quality; locally may be mineralized

FIGURE 5.--Idealized ground-water flow system for an intermontane arid basin (modified from Domenico and others, 1964).

Deeper patterns of ground-water circulation may exist in areas underlain by geologic materials of sufficient permeability; there may be net inflow or outflow of ground water between individual basins in such a regional ground-water system. Such systems have been described for carbonate-rock terranes in southern and southeastern Nevada (Eakin, 1966; Mifflin, 1968; Blankennagel and Weir, 1973; Winograd and Thordarson, 1975).

Natural Determinants of Ground-Water Quality

The processes controlling the quality of natural waters have been discussed in detail by Hem (1970). Precipitation in the mountain recharge areas is dilute. From the time precipitation enters the pore spaces of the soil profile, the water is exposed to a variety of chemical reactions that affect its quality. Infiltrating recharge water dissolves various substances from the surrounding rock materials as it percolates towards the water table. Rates of ground-water movement in the saturated zone are typically in the range of 5 feet/yr to 5 feet/day (Todd, 1959). Residence times in aquifers are, in many places, sufficient for the water to be in chemical equilibrium with the surrounding rock materials. The quality of a natural water moving downgradient from recharge in the mountains to discharge at the valley floor thus reflects the cumulative effects of its present and prior geologic environments, with concentrations of dissolved solids increasing with distance and time from the recharge area. Near-surface materials in many of the valley floors of closed basins are alternating layers of fine-grained lakebed deposits—clay, silt, and evaporite minerals with high salt contents. Salts are concentrated in the near-surface zones of discharge areas by the evapotranspiration "still." Much shallow ground water in the discharge zones of desert valleys is highly mineralized, with concentrations of salts (notably sodium chloride and sodium sulfate) exceeding recommended limits for most beneficial uses.

Cultural Determinants

Man's influence on ground-water quality may be significant at virtually any point in the flow system from recharge to discharge. The quality of precipitation may be degraded downwind from urban or industrial areas with atmospheric pollution. The resulting precipitation may have lower pH and greater concentrations of sulfate, metals, and organic compounds than noncontaminated precipitation. The quality of infiltrating water in recharge zones may be degraded by disposal of both liquid and solid wastes, excessive application of agricultural chemicals, and mineral-extraction activities. Water in transit at depth in the flow system may be degraded by (1) waste injection, (2) surficial contamination moving down improperly sealed or abandoned well casings, or (3) migration of more mineralized water, either through natural flow barriers breached by wells or mine shafts, or induced by local overpumping. Mineralization of near-surface ground water in discharge areas by the concentration effects of natural evapotranspiration may be increased in magnitude or areal extent by intensive agriculture.

Man's activities also affect ground-water quality by changing the dynamics of the natural flow system. Hydraulic potentials in natural discharge areas increase with depth, favoring the extraction of deeper ground water that commonly has better quality than water near the surface. Intensive development may result in the lowering of heads of deep aquifers to the point where gradients are reversed and the poor quality water in upper water-table aquifers is induced to recharge and degrade the deeper ground water. The degradation may be exacerbated by pollution of the shallow water by domestic, municipal, agricultural, or industrial wastes.

Criteria and Standards for Ground Water

The terms criteria and standards are often confused. Water-quality criteria are recommendations, based on available scientific data, for maximum concentrations of constituents in water applied to specific beneficial uses. Water-quality standards are those criteria selected by regulatory authorities to be the maximum concentrations allowable by law.

Existing water-quality standards in Nevada stress the protection of surface water for various beneficial uses, with little specific provision for ground water. Nevada Water Pollution Control Regulations peripherally include ground water under the general class of "All waters of the State," to which narrative rather than numerical standards are applied (Nevada Bureau of Environmental Health, 1975). Nevada Water Supply Regulations apply numerical standards to ground water used as sources of supply to public water-distribution systems (Nevada Division of Health, 1977) and are summarized in table 2. These standards are based on National Primary and Secondary standards promulgated by the U.S. Environmental Protection Agency (EPA, 1976c; 1977) and apply to finished water taken from the purveyor's distribution system rather than to raw water as withdrawn from the source aquifer.

Water-quality criteria are functions of the intended water use. Comprehensive criteria for water quality have been published in a number of references, the more recent of which are the reports by the National Academy of Science and Engineering (1974) and the U.S. Environmental Protection Agency (1976b). Criteria that apply to uses likely to be supplied by ground water are summarized in table 3; included are recommended concentrations for

TABLE 2.—*Nevada drinking-water standards as applied to ground-water sources (Nevada Division of Health, 1977)*

Public water supplies: Those supplies in service for 60 or more days per year that (a) have 15 or more connections or (b) serve an average of 25 or more persons per day.
Community supplies: Those public supplies operating on a year-round basis.
Point sampled: Tap that delivers water representative of the supply system.

	Milligrams per liter, except as indicated		Monitoring requirements for public supplies served by ground-water sources	
Constituent or property	Maximum concentration or value	Recommended concentration or range [1]	Non-community supplies	Community supplies
Inorganic and physical			Initial analyses by June 1979; subsequent sampling at 3-year intervals, or more frequently where warranted	
Arsenic	0.05	—	—	X
Barium	1	—	—	X
Cadmium	.01	—	—	X
Chloride	400	250	X	X
Chromium	.05	—	—	X
Color (units)	—	15	X	X
Copper	—	1	X	X
Dissolved solids	1,000	500	X	X
Fluoride	[2]1.4-2.4	—	—	X
Foaming agents (MBAS)	—	.5	X	X
Iron	.6	.3	X	X
Lead	.05	—	—	X
Magnesium	150	125	X	X
Manganese	.1	.05	X	X
Mercury	.002	—	—	X
Nitrate (as N)	10	—	X	X
Odor (threshold number)	—	3	X	X
pH (units)	—	6.5-8.5	X	X
Selenium	.01	—	—	X
Silver	.05	—	—	X
Sulfate	500	250	X	X
Zinc	—	5	X	X
Organic pesticides			Analyses only for systems selected by State (based on likelihood of contamination)	
Endrin	0.0002			
Lindane	.004			
Methoxychlor	.1			
Silvex	.01			
Toxaphene	.005			
2,4-D	.1			
Microbiology			Initial sampling by June 1978. Sampled once during each calendar quarter during which system is operating, or at frequency determined by State	Required number of samples per month based on population served
Coliform group, membrane-filtration method [3]				
Mean of all samples/month	1 colony/100 mL			
Single sample	<20/month or 4 colonies/100 mL			
5 percent of all samples	<20/month			
Chlorine residual			May be substituted for not more than 75 percent of required microbiological samples. Minimum sampling frequency is daily, at rate at least 4 times that required for microbiological samples	
Free chlorine	0.2			
Radioactivity				Initial analyses by June 1980
Alpha, gross	15 pCi/L			Average or annual composite of 4 quarterly samples [4]
Radium, combined 226 and 228	5 pCi/L			(5)

[1] Recommended values should not be exceeded where suitable alternate supplies are, or can be made, available.
[2] Fluoride limits are based on annual average of maximum daily air temperatures: <12.0°C (53.7°F), 2.4 mg/L; 12.1 to 14.6°C (53.8 to 58.3°F), 2.2 mg/L; 14.7 to 17.6°C (58.4 to 63.8°F), 2.0 mg/L; 17.7 to 21.4°C (63.9 to 70.6°F), 1.8 mg/L; 21.5 to 26.2°C (70.7 to 79.2°F), 1.6 mg/L; 26.3 to 32.5°C (79.3 to 90.5°F), 1.4 mg/L.
[3] Standards for determination by Multiple Fermentation Tube Method exist but are not included in this table.
[4] More frequent monitoring at State discretion in the vicinity of suspected sources. Systems having multiple sources with differing radioactivity concentrations shall monitor the individual point sources.
[5] In localities where Ra-228 may be present, monitoring is recommended when gross-alpha activity exceeds 2 pCi/L; otherwise, when gross alpha exceeds 5 pCi/L.

water to be used for domestic supplies, stock watering, irrigation, and fish and wildlife propagation. The latter category is included for the potential use of ground water as a supplementary source of water for hatchery operations or for commercial fish farms. Criteria are not included for industrial uses, as specific requirements vary greatly from industry to industry. Where the references cited in table 3 presented different values for the same criterion, the value tabulated is that recommended by the most recent of the references.

TABLE 3.—*Water-quality criteria for beneficial uses of ground water*

Principal references: 1, Nevada Division of Health, 1977; 2, U.S. Public Health Service, 1962; 3, U.S. Environmental Protection Agency, 1976c,d; 4, National Academies of Sciences and Engineering, 1974; 5, McKee and Wolf, 1963. Multiple criteria for the same parameter are listed in the same order as their references.

Parameters	Units	Drinking water	Industrial	Agricultural			Fresh-water aquatic life	Principal references	Remarks ["(a)" indicates remark for specific item in main body of table]
				Livestock	Irrigation				
					Continuous use, all soils	20-yr use, fine soils, pH 6.0-8.5			
Principal inorganic chemical constituents	mg/L								
Silica (SiO_2)		—	1-100	—	10	50	—	5	
Calcium (Ca)		—	10-500	—	—	—	—	5	
Magnesium (Mg)		125; 150	5-30	500-5,000	—	—	—	1, 5	
Sodium (Na)		10-200	50	2,000	crop-specific	—	—	5	
Potassium (K)		1,000-2,000	—	—	—	—	200-2,000	5	
Iron (Fe)		0.3; 0.6	0.1	—	5.0	20	1.0	1, 3, 4, 5	
Manganese (Mn)		0.05; 0.1	0.05	10	0.2	10	1.0	1, 4, 5	
Bicarbonate (HCO_3)		—	—	—	—	—	30-130	4	
Sulfate (SO_4)		250; 500	20-250	500	200	—	—	1, 5	
Chloride (Cl)		250; 400	50	1,500	100	—	1,500	1, 5	
Fluoride (F)		1.4-2.4	1.0	2.0	1.0	15	1.5	1, 4, 5	
Nitrate (NO_3), as N		10	—	100	—	—	90 (a)	1, 3	(a) Warm-water species
Nitrite (NO_2), as N		1.0	—	10	—	—	51/0.06 (a)	3	(a) Warm-water species/salmonids
Ammonia (NH_3), as N		0.5	—	—	—	—	0.02 (a)	2, 3	(a) Or 0.05 X 96 hr. LC50
Phosphorus (P), as P		—	—	—	—	—	—	3	Concentrations in excess of 0.25 mg/L, as P, may stimulate eutrophication in receiving waters
Phosphate (PO_4), as P		—	—	—	—	—	—	3	
Orthophosphate ($O-PO_4$), as P		—	—	—	—	—	—	3	
Other common chemical or physical parameters									
Alkalinity, as $CaCO_3$	mg/L	—	—	—	—	—	>20	3	
Chlorine residual	ug/L	200	—	—	—	—	2.0-10	3	
Color	Pt-Co units	15	—	—	—	—	—	1	
Gases, total pressure ($CO_2+N_2+O_2$)	percent of atmospheric	—	—	—	—	—	110	3	
Hydrogen sulfide (H_2S)	ug/L	50	—	—	—	—	2	3	
Odor	threshold number	3	—	—	—	—	—	1	
Oxygen, dissolved	mg/L	—	—	—	—	—	5.0	3	
pH	units	6.5-8.5	—	4.5-9.0	—	—	6.5-90	1, 3	
Residual sodium carbonate (RSC)	mg/L	—	—	—	1.25-25	—	—	5	
Solids, dissolved	mg/L	500; 1,000	2,500	3,000	700	—	2,000	1, 5	
Solids, suspended	mg/L	—	—	—	—	—	25-400	3	
Turbidity	JTU	5	—	—	—	—	—	1	

TABLE 3.--*Water-quality criteria for beneficial uses of ground water*—Continued

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Trace metals and other minor inorganics	ug/L								
Aluminum (Al)		—	—	5,000	5,000	20,000	—	4	
Arsenic (As)		50	—	200	100	2,000	1,000	1, 3, 5	
Barium (Ba)		1,000	—	—	—	—	5,000	1, 5	
Beryllium (Be)		—	—	—	100	500	11/1,100 (a)	3	(a) Soft/hard water
Boron (B)		—	—	5,000	750	2,000 (a)	—	3	(a) 500 for sensitive crops
Cadmium (Cd)		10	—	50	10	50	0.4-12	1, 3, 4	
Chromium (Cr)		50	—	1,000	100	1,000	100	1, 3, 4	
Cobalt (Co)		—	—	1,000	50	5,000	—	4	
Copper (Cu)		1,000	—	—	200	5,000	0.1 (a)	1, 3, 4	(a) Or 0.1 X 96 hr. LCD50
Lead (Pb)		50	—	100	5,000	10,000	30 (a)	1, 3, 4	(a) Or 0.01 X 96 hr. LCD50
lithium (Li)		—	—	—	2,500 (a)	2,500 (a)	—	4, 5	(a) 75 for citrus crops
Mercury (Hg)		2	—	10	—	—	0.05	1, 3	
Molybdenum (Mo)		—	—	1	10 (a)	50 (a)	—	4	(a) 0.50 for acid soils
Nickel (Ni)		—	—	—	200	2,000	(a)	4	(a) 0.01 X 96 hr. LCD50
Selenium (Se)		10	—	10	20	20	(a)	1, 3, 4	(a) 0.01 96 hr. LCD50
Silver (Ag)		50	—	—	—	—	(a)	1	(a) 0.01 X 96 hr. LCD50
Uranyl (UO_2)		5,000	—	—	—	—	—	2	
Vanadium (V)		—	—	100	100	10,000	—	2, 4	
Zinc (Zn)		5,000	25,000	25,000	2,000	10,000	(a)	3	(a) 0.01 X 96 hr. LCD50
Organic chemicals Miscellaneous									
Cyanide (Cn)	ug/L	0.1; 0.2	—	—	—	—	5.0 (a)	3, 4	(a) Or 0.05 X 96 hr. LCD50
Detergents (LAS, MBAS)	mg/L	.5	—	—	—	—	.2 (a)	1, 4	(a) Or 0.05 X 96 hr. LCD50
Oil and grease	mg/L	—	—	—	—	—	(a)	4	(a) Or 0.05 X 96 hr. LCD50
Phenolics	ug/L	1.0	—	1×10^6	50,000	—	1.0	3, 5	
Plasticizers, phthalate, esters	ug/L	—	—	—	—	—	3	3	
Polychlorinated biphenols (PCB's)	ug/L	(a)	—	—	—	—	.001	3	(a) Minimum exposure

TABLE 3.--*Water-quality criteria for beneficial uses of ground water*--Continued

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Pesticides									
Organochlorine pesticides	ug/L								
Aldrin		1	—	—	—	—	0.003	3, 4	
Chlordane		3	—	—	—	—	.01	3, 4	
DDT		50	—	—	—	—	.001	3, 4	
DDE		—	—	—	—	—	.006	4	
Dieldrin		1	—	—	—	—	.003	3, 4	
Endosulfan		—	—	—	—	—	.003	3	
Endrin		.2	—	—	—	—	.004	1, 3	
Heptachlor		.1	—	—	—	—	.001	3, 4	
Heptachlor Epoxide		.1	—	—	—	—	—	4	
Lindane		4.0	—	—	—	—	.01	1, 3	
Methoxychlor		100	—	—	—	—	.03	1, 3	
Mirex		—	—	—	—	—	.001	3	
Toxaphene		5	—	—	—	—	.005	1, 3	
Organophosphate insecticides	ug/L								
Azinphosmethyl		—	—	—	—	—	0.001	4	
Ciodrin		—	—	—	—	—	.1	4	
Coumaphos		—	—	—	—	—	.001	4	
Demeton		—	—	—	—	—	.1	3	
Diazinon		—	—	—	—	—	.009	4	
Dichlorvos		—	—	—	—	—	.001	4	
Dioxathion		—	—	—	—	—	.09	4	
Disulfonton		—	—	—	—	—	.05	4	
Dursban		—	—	—	—	—	.001	4	
Ethion		—	—	—	—	—	.02	4	
EPN		—	—	—	—	—	.06	4	
Fenthion		—	—	—	—	—	.006	4	
Guthion		—	—	—	—	—	.01	3	
Malathion		—	—	—	—	—	.1	3	
Mevinphos		—	—	—	—	—	.002	4	
Naled		—	—	—	—	—	.004	4	
Oxydemeton methyl		—	—	—	—	—	.4	4	
Parathion		—	—	—	—	—	.04	3	
Phosphamidon		—	—	—	—	—	.03	4	
TEPP		—	—	—	—	—	.4	4	
Trichlorophon		—	—	—	—	—	.002	4	
Carbamate insecticides	ug/L								
Carbaryl		—	—	—	—	—	.02	4	
Zectran		—	—	—	—	—	.1	4	

TABLE 3.--*Water-quality criteria for beneficial uses of ground water*—Continued

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Herbicides, fungacides, defoliants	ug/L								
Aminotriazole		—	—	—	—	—	300	4	
Dalapon		—	—	—	—	—	110	4	
Dicamba		—	—	—	—	—	200	4	
Dichlobenil		—	—	—	—	—	37	4	
Dichlone		—	—	—	—	—	.2	4	
Dignat		—	—	—	—	—	.5	4	
Diuron		—	—	—	—	—	1.6	4	
2, 4-D (BEE)		100	—	—	—	—	4.0	1, 4	
2, 4-5T		2	—	—	—	—	—	4	
Fenae (sodium salt)		—	—	—	—	—	45	4	
Silvex (2,4-5TP; BEE)		10	—	—	—	—	2.5	4	
Silvex (7,4-5TP; PGBE)		10	—	—	—	—	2.0	4	
Simazine		—	—	—	—	—	10.0	4	
Botanicals	ug/L								
Allethrin		—	—	—	—	—	.02	4	
Pyrethrum		—	—	—	—	—	.01	4	
Rotenone		—	—	—	—	—	10.0	4	
Bacteriological	Colonies/100 mL								
Coliform Group:									
Mean in month		1	—	—	—	—	—	1	
Single sample (<20 samples)		4	—	—	—	—	—	1	
5 percent of samples (>20 samples)		4	—	—	—	—	—	1	
Fecal coliforms		—	—	—	1,000	—	—	4	
Radiological	pCi/L								
Gross alpha		15	—	15	15	—	—	1, 4	See table 2
Gross beta		(a)	—	(a)	—	—	—	1, 4	(a) Annual total or
Radium-226		(a)	—	(a)	—	—	—	1, 4	single-organ dose <4
Strontium-90		(a)	—	(a)	—	—	—	1, 4	millirem/yr

RATIONALES FOR MONITORING GROUND-WATER QUALITY

Purposes For Monitoring

The process of monitoring has been defined as "a scientifically designed surveillance system of continuing measurements and observations, including evaluation procedures" (Todd and others, 1976). Water-quality monitoring has three basic purposes: (1) Water-use protection--monitoring to provide warning of undesirable or hazardous changes in quality to protect one or more specific water uses; (2) pollution control--monitoring to provide data that support pollution-control functions; and (3) research--monitoring to acquire data that define environmental systems and processes affecting water quality. A comprehensive water-quality monitoring program addresses, in varying degrees, all three information needs, providing data on the existing quality of the water resource, the effects of pollution on that resource, and a scientific basis for understanding the processes, both natural and cultural, that affect the quality of that resource. Specific areas of emphasis differ among different monitoring programs, depending upon administrative and legal mandates for monitoring, the uses and values of the target resource, and economic constraints on the monitoring agency.

The fundamental purpose of monitoring the quality of ground water is to provide data necessary for the protection of both present and future beneficial uses of the water. The need of such protection for a given aquifer is dependent upon the nature and magnitude of existing and potential threats to the quality of the ground water, the magnitude and value of current and potential uses of the water, the sensitivity of those uses to changes in water quality, and the availability of alternative sources of water. To actually protect ground water, however, a monitoring program must be part of an overall management and control effort. Monitoring without appropriate action provides only documentation, not protection.

Legal Mandates

Provisions for ground-water monitoring are made under two major pieces of Federal legislation: Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, and Public Law 93-523, the Safe Drinking Water Act of 1974.

Public Law 92-500

Under provisions of the Federal Water Pollution Control Act Amendments of 1972, each State is mandated to establish and operate systems to monitor the quality of water in the State. Section 106 of the act ties eligibility for grants supporting pollution-control programs to the requirement that the State include in its programs:

> "*** the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on... the quality of navigable waters and to the extent practicable, ground waters including biological monitoring; and provision for annually updating such data***"

Regulations implementing the provisions of Public Law 92-500 are contained in Combined Federal Regulations (CFR), 1974, and include the following as primary objectives for a State water-quality monitoring program:

1. Determine compliance with permit terms or conditions,
2. Develop and maintain an understanding of the quality (and causes and effects of such quality) of the waters in the State for the purpose of supporting State water pollution control activities,
3. Report on such quality and its causes and effects, and
4. Assess the effectiveness of the State's pollution abatement program.

Ground-water monitoring is included as one of six monitoring activities specified for inclusion in a State water-monitoring program:

"The water monitoring program of the state shall include the following monitoring activities:

1. Intensive monitoring surveys;
2. Fixed station monitoring of representative points;
3. Compliance monitoring***;
4. Ground-water monitoring;
5. Quality assurance activities relating to sampling, sample transport, and laboratory analysis and support; and
6. Data processing, reporting, and interpretation***"

Public Law 92-500 consistently delegates authority for pollution-abatement programs, including that for monitoring, to the States. Appendix A, Section 40 CFR (Combined Federal Regulations), provides broad outlines for a water-quality monitoring "strategy" rather than issuing regulations defining technical details of monitoring.

Cooperation between Federal, State, local, and private agencies involved in water resources, geology, and public health is assumed and encouraged insofar as such activities "***meet, to the satisfaction of the Regional [EPA] Administrator, the laboratory support and quality assurance requirements set forth in this Appendix [A, 40 CFR], and where sampling frequency, parameter coverage, station locations, and data availability meet pollution abatement program requirements***."

Public Law 93-523

The Safe Drinking Water Act of 1974 has several provisions dealing with protecting ground-water resources for drinking-water supply. The most direct provisions were those promulgated in the National Interim Primary Drinking Water Standards, which specify monitoring requirements for public water supplies served by ground-water sources (U.S. Environmental Protection Agency, 1976c). Those requirements are listed below (also see table 2):

Parameters	Sampling frequency
Coliform bacteria	Quarterly for systems serving 1,000 people or less, frequencies for greater populations a function of the population.
Inorganic chemicals	Every 3 years
Organic chemicals	As specified by the State
Radiochemical	Every 4 years

Other provisions of the Act spell out authority for regulation that will require ground-water monitoring for support. Section 1424 (e) provides for the designation for protection of "an aquifer which is the sole or principal drinking water source for the area, and which, if contaminated, would create a significant hazard to public health." If such determination is made, no Federal funds are allowable for any development that could contaminate the aquifer through a recharge zone.

Further authority has been extended by the Act for control of underground-waste implacement, protecting aquifers containing water with less than 10,000 mg/L of dissolved solids that are used, or have the potential for use, as sources of drinking water.

Objectives of a State Program

General water-monitoring requirements at the State level are outlined in a recommended-practice document published by the U.S. Environmental Protection Agency (1975):

1. The ultimate goal of monitoring is to fulfill the data and information needs of the State pollution control program.
2. Monitoring is part of the overall State program, not an end in itself--only justifiable work is to be done.
3. Monitoring is used to collect, evaluate, and present data and other information in a rational and methodical manner.
4. The annual monitoring work load is commensurate with the money and manpower resources available.

The document outlines four overall objectives for monitoring ground water:

1. To obtain data for the purpose of determining existing baseline conditions in ground-water quality and quantity.
2. To provide data for the early detection of ground-water pollution or contamination, particularly in areas of ground-water use.
3. To identify existing and potential ground-water pollution sources and to maintain surveillance of those sources in terms of their impact on ground-water quality.
4. To provide a data base upon which management and policy decisions can be made concerning the surface and subsurface disposal of wastes and the management of ground-water resources.

Data Requirements

Meeting the objectives of ground-water monitoring on a statewide basis will require the collection and evaluation of a large amount of diverse data. Specific needs will differ with the particular hydrologic system being analyzed, but the general categories may include data on:

1. Water use--to evaluate the relative importance of the resource to be protected.
2. Waste-disposal practices--to evaluate potential sources of degraded recharge water.
3. Geologic characteristics--to define natural controls on water occurrence, movement, and quality.
4. Hydrologic characteristics--to quantify the amount of water and the dynamics of its movement.
5. Climatic factors--to determine the amount and distribution of natural recharge.
6. Water quality—to describe the natural, or background, quality of recharge water, the quality of the ground water itself, and the changes in quality with movement in the hydrologic system.

Definition of the Resource to be Protected

The ultimate goal of any monitoring system is to provide information to support decisions or actions required to protect a resource from degradation that would affect current or future uses. The first step in a systematic approach to ground-water monitoring is to characterize the target aquifers by defining their areal and vertical extent, sources of recharge, points of discharge, and the nature of their boundaries. The amount of available data will differ with the intensity of development of the area being studied. Similarly, the need for data will differ with the size and complexity of the hydrologic system, the magnitude of real or potential contamination sources, and the distribution and intensity of water withdrawals. Fortunately, those areas with the most pressing needs for monitoring are usually areas of intensive ground-water use. Thus, existing water-supply wells generally will be of sufficient density to allow at least a preliminary characterization of the hydrologic system. Exceptions will involve background and point-source monitoring in lightly developed basins. In such cases preliminary estimates of the hydrologic characteristics will have to be made from a sparse number of data points, supplemented by any available geologic and physiographic information.

Determining Background Water Quality

Once an aquifer system has been preliminarily defined, the existing, or "background," quality of its native, uncontaminated water must be determined. In highly stressed areas, historical data may be of sufficient density and reliability to determine variations in water quality at various points in the system. In undeveloped areas, natural spring flow and seepage may be sampled, if available; if not, preliminary estimates of water quality may have to be inferred from available knowledge of the geology and physiography of the area.

Inventory of Monitoring Targets

With the exception of samplings to determine background quality, monitoring implies the existence of known, suspected, or potential sources of contamination. For point-source monitoring, the source whose presence instigated the monitoring effort is known. In contrast, areal monitoring requires an inventory of potential sources of contamination. The search for potential sources should be guided by the preliminary definition of the hydrologic system. An evaluation of the possible effect of a potential contamination source on ground-water quality may be based on its physical position in the hydrologic system, the nature of the contaminants, and the estimated quality of the native ground water.

Classification of contamination sources.--Sources of ground-water contamination have been categorized by mode of occurrence as (1) point, (2) line, and (3) diffuse (Schmidt, 1975). Point sources are those covering a limited, definable area which is approximately one-dimensional at the scale of interest. Examples include solid- or liquid-waste disposal in pits, ponds, lagoons, and wells; chemical stockpiles; and leaking well casings. Line sources are those predominantly linear at the scale of interest. Examples include waste disposal in ditches or streambeds, leaking pipelines, and road-salt runoff from highways. Diffuse (non-point) sources are those with a significant areal extent at the scale of interest, including agricultural return flow, general urbanization, and induced recharge from poor-quality aquifers. Obviously, the classification of any particular source depends on the scale of the investigation. Septic-tank effluent could, for example, be considered as a line source if one were attempting to model the movement of leachate from a leach line in the unsaturated zone, as a point source in terms of defining the development of a contaminated plume at the water table, or as part of a diffuse source in terms of the impact of suburban sprawl on the quality of a large hydrologic system.

Contamination sources have also been classified by cultural origin: Municipal, agricultural, industrial, oil field wastes, mining wastes, and miscellaneous (Todd and others, 1976). Candidates for these classes are listed along with their modes of occurrence in table 4. Ground water may also be contaminated by natural sources such as deep brines, buried organic deposits, saline geothermal waters, and deposits of soluble salts.

An inventory of monitoring targets must include the determination of the expected types of contaminants from each source. Major classes of potential contaminants are listed in table 5. Todd and others (1976) have reviewed the contaminants that can be expected for the sources listed in the table. Case histories of various types of contamination are becoming numerous in ground-water literature and have been annotated by Meyer (1973), Summers and Spiegel (1974), and Tinlin (1976) among others.

Establishing the Hydrologic Framework

Once the potential sources of contamination have been identified, their impact on the ground-water resource must be assessed. The preliminary conceptual model of the hydrologic system must be refined to predict the fate of the contaminants in the subsurface environment. Gathering data to define fully the hydrologic controls on contaminant movement may be prohibitively expensive; economic constraints may require that assessments of many contamination problems be based on less-than-optimum hydrologic data.

Table 4.--*Major sources and causes of ground-water contamination by waste disposal (from Todd and others, 1976)*

SOURCE	CATEGORY			COMMON METHOD OF DISPOSAL						
	Point	Line	Diffuse	Percolation Pond	Surface Spreading and Irrigation	Seepage Pits and Trenches	Dry Stream Beds	Landfills	Disposal Wells	Injection Wells
Municipal										
Sewer Leakage	X	X		NOT APPLICABLE						
Sewage Effluent	X	X	X	X	X		X		X	
Sewage Sludge	X		X		X	X		X		
Urban Runoff	X	X	X	X	X		X		X	
Solid Wastes	X				X			X		
Lawn Fertilizers			X		X					
Agricultural										
Evapotranspiration and Leaching (Return Flow)			X		X					
Fertilizers			X		X					
Soil Amendments			X		X					
Pesticides and Herbicides			X		X					
Animal Wastes (Feedlots and Dairies)	X		X	X	X	X		X		
Stockpiles	X			NOT APPLICABLE						
Industrial										
Cooling Water	X		X	X					X	
Process Waters	X			X					X	X
Storm Runoff	X		X	X	X		X		X	
Boiler Blowdown	X			X					X	
Stockpiles	X			NOT APPLICABLE						
Water Treatment Plant Effluent	X			X				X	X	
Hydrocarbons	X			X					X	X
Tanks and Pipeline Leaks	X	X		NOT APPLICABLE						
Oilfield Wastes										
Brines	X	X	X	X	X	X	X			X
Hydrocarbons	X			X					X	X
Mining Wastes	X	X	X	X			X	X	X	X
Miscellaneous										
Polluted Precipitation and Surface Water		X	X	NOT APPLICABLE						
Septic Tanks and Cesspools			X		X	X		X		
Highway Deicing		X		NOT APPLICABLE						
Seawater Intrusion			X	NOT APPLICABLE						

TABLE 5.--*Classification of potential ground-water contaminants (adapted from Todd and others, 1976)*

A.--By type of constituent

Physical	Organic Chemical
Temperature	Carbon
Density	Chlorophylls
Odor	Extractable organic matter
Turbidity	Methylene blue active substances
Inorganic Chemical	Nitrogen
Major constituents	Chemical oxygen demand
Other constituents	Phenolic material
Trace elements	Pesticides (insecticides and herbicides)
Gases	Hydrocarbons
Bacteriological	**Radiological**
Coliform group	Gross alpha activity
Fecal streptococci	Gross beta activity
Pathogenic micro-organisms	Strontium
Enteric viruses	Radium
	Tritium

TABLE 5.--*Classification of potential ground-water contaminants*--*Continued*

B.--By source

Source	Type of contaminant and potential importance					
	Physical	Inorganic chemical	Trace elements	Organic chemical	Bacterio-logical	Radio-logical
Municipal						
Sewer leakage	Minor	Primary	Secondary	Primary	Primary	Minor
Sewage effluent	Minor	Primary	Secondary	Primary	Primary	Minor
Sewage sludge	Minor	Primary	Primary	Primary	Primary	Minor
Urban runoff	Minor	Secondary	Variable	Primary	Minor	Minor
Solid wastes	Minor	Primary	Primary	Primary	Secondary	Minor
Lawn fertilizers	Minor	Primary	Minor	Minor	Minor	Minor
Agricultural						
Evapotranspiration and leaching	Minor	Primary	Minor	Minor	Minor	Minor
Fertilizers	Minor	Primary	Secondary	Secondary	Minor	Minor
Soil amendments	Minor	Primary	Minor	Minor	Minor	Minor
Pesticides	Minor	Minor	Minor	Primary	Minor	Minor
Animal wastes (feed-lots and dairies)	Minor	Primary	Minor	Secondary	Primary	Minor
Stockpiles	Minor	Primary	Minor	Variable	Variable	Minor
Industrial						
Cooling water	Primary	Minor	Primary	Minor	Minor	Minor
Process waters	Variable	Primary	Primary	Variable	Minor	Variable
Storm runoff	Minor	Secondary	Variable	Primary	Minor	Minor
Boiler blowdown	Primary	Secondary	Primary	Minor	Minor	Minor
Stockpiles	Minor	Primary	Variable	Variable	Minor	Variable
Water-treatment plant effluent	Minor	Primary	Secondary	Minor	Minor	Minor
Hydrocarbons	Secondary	Secondary	Secondary	Primary	Minor	Minor
Tank and pipeline leakage	Variable	Variable	Variable	Variable	Minor	Variable
Oilfield Wastes						
Brines	Primary	Primary	Primary	Minor	Minor	Minor
Hydrocarbons	Secondary	Secondary	Secondary	Primary	Minor	Minor
Mining Wastes	Minor	Primary	Primary	Variable	Minor	Variable
Miscellaneous						
Polluted precipitation and surface water	Variable	Variable	Variable	Variable	Variable	Variable
Septic tanks and cesspools	Minor	Primary	Minor	Secondary	Primary	Minor
Highway deicing	Minor	Primary	Minor	Secondary	Minor	Minor
Seawater intrusion	Primary	Primary	Primary	Minor	Minor	Minor
Natural Sources						
Evapotranspiration	Minor	Primary	Secondary	Minor	None	Minor
Evaporite deposits	Minor	Primary	Primary	None	None	Minor
Hydrothermal activity	Primary	Primary	Variable	None	None	Variable

Many factors affect the infiltration of contaminants into the subsurface and their transport into an aquifer (fig. 6). Documentation of contaminant movement may require collection of hydrologic data for the soil horizons, the unsaturated zone, and the saturated zone.

Soil permeabilities determine the infiltration rate of wastes through the soil horizons. Effective permeabilities are influenced by the types of soil, the soil moisture and temperature, and the viscosity and chemical properties of the contaminants. Reactions tending to reduce, or attennate, the strength of a contaminant in the soil zone include filtration, sorption, ion exchange, buffering, precipitation, volatilization, spontaneous decay, dilution dispersion, and biologic uptake. Factors that may increase the strength of contaminants include solution of soil minerals, evapotranspiration, desorption of previously adsorbed materials, and ion exchange between the waste and the soil minerals. The degree to which any of these factors is effective is a function of the type and amount of contaminant, the rate of movement through the soil zone, the mineral and organic composition of the soil, and the soil depth. Theoretical quantification of these factors is difficult; laboratory determinations of infiltration rates and contaminant transport may be made using properly collected soil samples and aliquots of the particular contaminant in question. Field determinations of infiltration rates may be made using infiltrometers; porous-cup samplers may be employed to obtain soil-water samples for analysis.

Rates of flow in the unsaturated zone may vary greatly. The specific retention capacity of the materials in the unsaturated zone must be satisfied before a significant downward flux occurs; in areas where evapotranspiration losses exceed available recharge, this may never happen. In areas of large evapotranspiration losses and shallow water tables, the net vertical flux may

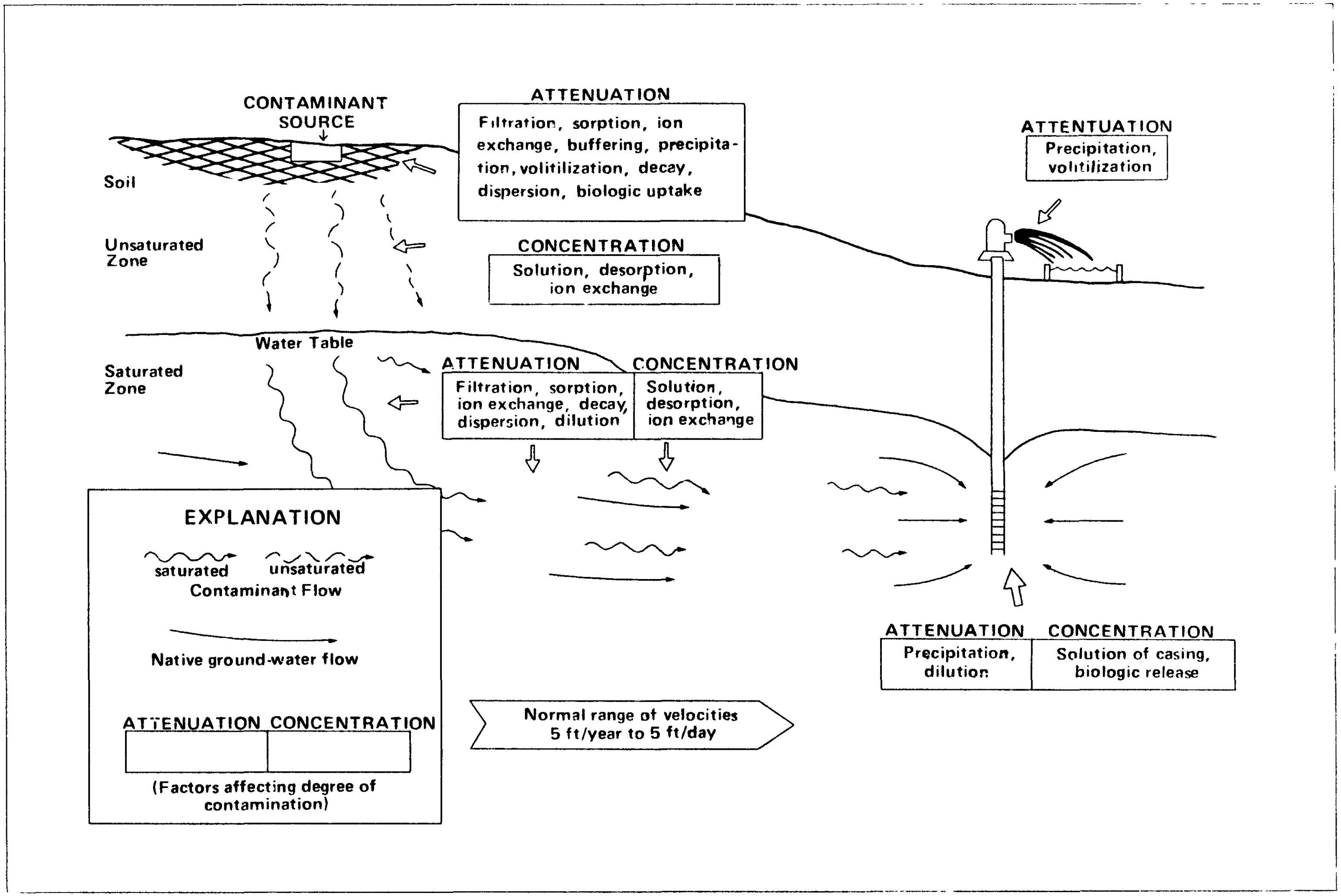


FIGURE 6.--Hydrologic factors affecting transport and concentration of contaminants in an idealized ground-water flow system.

be upward, precluding contamination of the aquifer except in the immediate vicinity of the waste application. Reactions that attenuate contaminants in the unsaturated zone are similar in type to those in the overlying soil profile, except that biologic activity usually decreases greatly with depth.

Definition of the ground-water flow system in the saturated zone is usually achieved by determining hydrologic gradients on the basis of water-level measurements, and determining aquifer permeabilities from drilling cuttings and core samples, by aquifer tests, or by making estimates from drillers' logs. Attenuation of contaminants in the saturated zone is a function of the physical and chemical characteristics of the aquifer (or aquifers), the rate and direction of water movement, and the chemistry of both the contaminant and the native water.

Uniform mixing of the contaminant and native water generally does not occur, instead, the contaminated water tends to form a plume, with concentrations decreasing away from the source. A variety of reactions may occur within the plume, including solution of aquifer minerals, ion exchange, and sorption or desorption. Physical or chemical fractionation of complex contaminants may develop, resulting in multiple fronts or waves of differing water quality within the plume. Episodes of contaminated recharge are often intermittent rather than continuous, resulting in a series of contamination plumes within the aquifer. The position of the plumes and the concentrations of contaminants within them may vary markedly with time.

Chemical and physical reactions affecting ground-water flow and contaminant transport may also occur in the vicinity of discharging wells. Converging ground water at well perforations results in higher velocities, which may increase solution of the aquifer materials and of metallic components of the well. The higher velocities near the well result in decreased pressure, which may change the chemical equilibrium of the water, causing precipitation of dissolved constituents. Biologic processes also are known to occur in the vicinity of the well.

The final set of reactions affecting the quality of the withdrawn ground water occurs during the pumping process. Aeration in the well bore and at the point of discharge may induce precipitation of dissolved materials. Contaminant losses also may result from escape of dissolved gasses or by volatilization.

The simplistic illustration in figure 6 is based on assumption of a homogeneous, isotropic aquifer contiguous with the unsaturated zone. Real-world hydrology seldom presents such a convenient simplicity. A composite of some of the potential hydrologic complications is shown in figure 7. Homogeneity and isotropy seldom exist in valley-fill sedimentary deposits such as those forming many of the aquifers in Nevada. The depositional history of most alluvial aquifers results in greater horizontal than vertical permeability in both the saturated and unsaturated zones. The structural fabric of bedrock aquifers may be highly linear; flow of fluids in bedrock aquifers commonly is controlled by fracture zones, faults, joints, solution cavities in carbonate rocks, and interbeds between volcanic flows. The net effect of hydrologic complexities may be either to attenuate contaminants or to offer a more direct flow path from their source to a point of water use.

The amount of geologic and hydrologic detail needed for effective monitoring is partly a function of the scale of the investigation. For areal studies involving diffuse sources, a generalized large-scale definition of the ground-water flow system may suffice. Detailed investigation of point or line sources requires more exact definition of the hydrology.

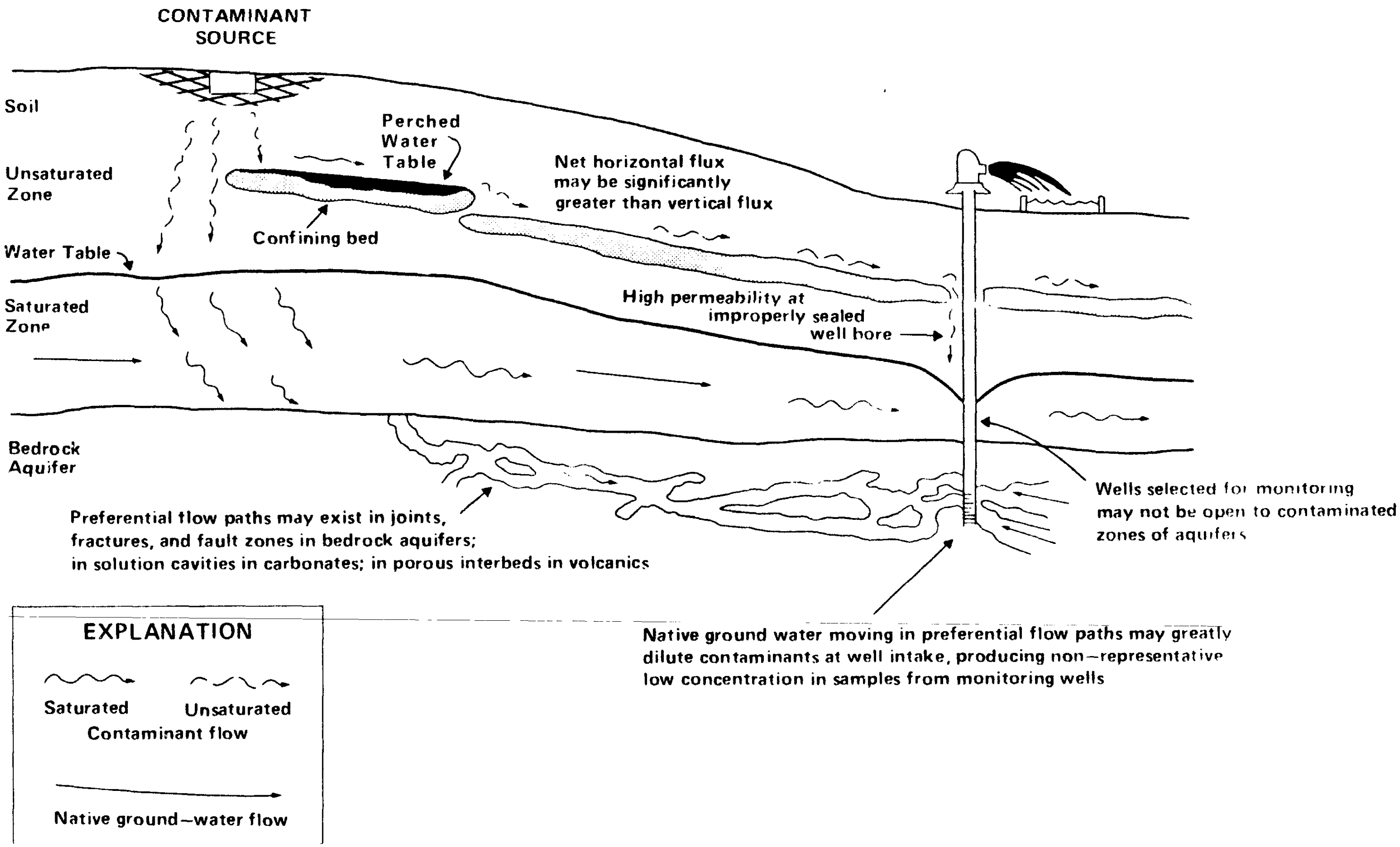


FIGURE 7.--Examples of some hydrologic complexities in "real-world" flow systems.

Siting and Construction of Observation Wells

Observation wells are required to: Provide water-level data that indicate directions of ground-water movement; document the subsurface lithology; determine aquifer hydraulics; and obtain samples for analysis. The proper siting of observation wells is a crucial, difficult, expensive, and underfunded phase of most monitoring studies. The search for good observation wells begins with the initial evaluation of the aquifer. Once a preliminary conceptual model of the flow system has been made and contamination sites have been inventoried and assessed, observation wells are needed to refine the knowledge of the hydrologic system and determine the presence and movement of contaminants.

Except in background surveys or large-scale areal studies, existing production wells seldom serve as good wells for monitoring water quality. At best, production wells document only the arrival of contamination at the point of use, a condition which a well-designed monitoring program is intended to forecast in advance rather than document after the fact. Production wells are designed for high sustained yields under substantial drawdowns; thus, they are generally finished in deeper parts of aquifers, often with multiple perforated zones. Monitoring for early detection of contamination requires controlled vertical and horizontal sampling at the upper-level portions of aquifers--zones least likely to have existing production wells.

Most monitoring efforts will require the drilling of one or more observation wells. Optimum placement of these wells requires a thorough preliminary evaluation of site hydrology. Monitoring needs may dictate sampling of multiple zones in the vertical section. With proper well design, a nested set of casings may be installed with individual openings to the aquifer sections of interest. Provisions should be made to sample drill cuttings and log the penetrated materials during drilling. Core samples for laboratory determination of aquifer characteristics may be required. If the observation well is near a source of contamination, provisions should be made for obtaining samples from the unsaturated zone for analysis of pore-water extracts. For some monitoring targets, extra precautions are required to prevent aquifer contamination during drilling, particularly if the well is being drilled through materials known or suspected to be contaminated. Well design should also consider the need for obtaining water-quality samples; well-construction materials should be noncontaminating for the range of constituents or properties being monitored. Monitoring for organic contaminants will require use of metals for all components in contact with the water; conversely, non-metallic components will be required if trace metals are of interest.

Sampling Parameters and Frequencies

The parameters to be included in analyses of ground-water samples will vary with the function of the monitoring program and the nature of known or suspected sources of contamination. Source-monitoring programs will emphasize analyses for key indicator parameters that (1) most accurately trace the movement of the contaminant in the subsurface and (2) have the greatest potential for adversely affecting existing or future uses of the ground water. These two functions may be complimentary or exclusive in different monitoring situations. For example, a program to monitor septic-tank effluents on a regional scale may be able to use the nitrate ion as a parameter to satisfy both requirements; mapping variations in nitrate concentrations may help define the areal extent of the contamination, and nitrate also is one of the products of septic-tank effluents that may seriously affect domestic use of ground water. An example of conflicting functions of indicator parameters is the monitoring of contaminants from a percolation pond for the disposal of industrial wastes. In this case, a conservative parameter such as chloride may serve as an indicator of contaminant movement, despite the fact that the increases in chloride concentrations may not be great enough to impact local ground-water uses adversely. Conversely, toxic trace metals such as cadmium or mercury may be the waste constituents with the greatest potential for adverse impact on water uses, yet these constituents may be greatly attenuated within the subsurface environment and thus not serve as accurate tracers of waste migration. In such a situation, the water analyses would have to include both the best indicators and the more toxic constituents to serve the monitoring needs.

Table 5 lists general categories of contaminants that may be expected for various sources of ground-water contamination. Representative water-quality parameters are listed for each of those general categories in table 6. Most monitoring programs will not need an extensive suite of parameters for routine analyses; however, the preliminary assessment of contamination sources should include comprehensive analyses of waste samples to characterize the potential contaminants adequately. An evaluation of those results along with the results of background sampling will allow an intelligent selection of characteristics for routine monitoring.

Monitoring for background quality and monitoring to document quality changes in production wells not threatened by specific known sources of contamination require emphasis on parameters that affect particular beneficial uses of ground water. The water-quality characteristics and constituents listed in table 6 outline a broad menu for consideration in monitoring background quality. Selection of individual parameters for an initial survey of background water quality would be based on an analysis of existing

TABLE 6.--*Ground-water quality parameters to be considered for monitoring programs (adapted from Todd and others, 1976)*

Parameter	Units
Chemical - Organic	
Biochemical oxygen demand (BOD)	mg/L
Carbon chloroform extract (CCE)	ug/L
Chemical oxygen demand (COD)	mg/L
Chlorinated phenoxy acid herbicides	ug/L
Detergents (surfactants)	mg/L
Oil and grease	mg/L
Organic carbon (C)	mg/L
Organophosphorus pesticides	ug/L
Phenols	mg/L
Tannins and ligins	mg/L
Chemical - Inorganic	
Acidity	mg/L
Alkalinity	mg/L
Ammonia (NH_4)	mg/L
Bicarbonate (HCO_3)	mg/L
Calcium (Ca)	mg/L
Carbonate (CO_3)	mg/L
Chloride (Cl)	mg/L
Fluoride (F)	mg/L
Hardness	mg/L
Hydroxide (OH)	mg/L
Magnesium (Mg)	mg/L
Nitrate (NO_3 N)	mg/L
Nitrite (NO_2 N)	mg/L
Nitrogen (N N)	mg/L
Oxygen (O_2)	mg/L
pH	units
Phosphorus	mg/L
Phosphate (PO_4 P)	mg/L
Potassium (K)	mg/L
Silica (SiO_2)	mg/L
Sodium (Na)	mg/L
Solids, dissolved	mg/L
Solids, suspended	mg/L
Sulfate (SO_4)	mg/L
Sulfide (S)	mg/L
Sulfite (SO_3)	mg/L
Chemical - Trace Elements	
Aluminum (Al)	ug/L
Antimony (Sb)	ug/L
Arsenic (As)	ug/L
Barium (Ba)	ug/L
Beryllium (Be)	ug/L
Chemical - Trace Elements--continued	
Bromide (Br)	ug/L
Cadmium (Cd)	ug/L
Chromium (Cr)	ug/L
Cobalt (Co)	ug/L
Copper (Cu)	ug/L
Cyanide (CN)	ug/L
Iron (Fe)	ug/L
Lead (Pb)	ug/L
Lithium (Li)	ug/L
Manganese (Mn)	ug/L
Mercury (Hg)	ug/L
Molybdenum (Mo)	ug/L
Nickel (Ni)	ug/L
Selenium (Se)	ug/L
Silver (Ag)	ug/L
Strontium (Sr)	ug/L
Tin (Sn)	ug/L
Titanium (Ti)	ug/L
Vanadium (V)	ug/L
Zinc (Zn)	ug/L
Biological	
Coliform bacteria	colonies/100 mL
Fecal coliform bacteria	colonies/100 mL
Fecal streptococci bacteria	colonies/100 mL
Physical	
Color	units
Conductance, specific	umhos/cm at 25°C
Odor	threshold odor
Temperature	°C
Turbidity	units
Radiological	
Barium-140 (^{140}Ba)	pc/L
Cerium-141 and 144 (^{141}Cs, ^{144}Ce)	pc/L
Cesium-134 and 137 (^{134}Cs, ^{137}Cs)	pc/L
Gamma spectrometry	pc/L
Gross alpha	pc/L
Gross gamma	nc/L
Iodine-131 (^{131}I)	pc/L
Neptunium-239 (^{239}Np)	pc/L
Radium (Ra)	pc/L
Thorium (Th)	ug/L
Tritium (^{3}H)	pc/L
Uranium (U)	ug/L

historical water-quality data, knowledge of the local hydrogeologic environment, and information on the types and intensities of existing water uses and their specific water-quality requirements (see table 3). Results of the initial sampling would then be used to select a rational and economic suite of analyses for a routine sampling program.

Minimum monitoring requirements for public water supplies in Nevada are set by law and are listed in table 2. Rational monitoring of ground water used for public supplies may require the inclusion of either fewer or more parameters than those specified by law. For example, in aquifers with well-defined natural controls on ground-water quality and low probabilities of contamination from cultural sources, historical water-quality data may be adequate to define statistical relationships between inorganic parameters such as concentrations of dissolved solids, chloride, and sulfate and an index parameter such as specific electrical conductance. Once such a relationship has been defined, routine monitoring of conductance alone would provide estimates of concentrations of the major inorganic constituents at a very low cost. More comprehensive analyses would be made at legally specified intervals to check that the relationships used remain valid with time. In other situations, local hydrologic or cultural environments may require that effective monitoring include either more or different parameters than those specified in water-quality standards.

Sampling frequencies for monitoring wells will depend on: (1) The frequency of application of contaminants at the source, (2) the dynamics of the ground-water flow system, (3) the purpose of the monitoring, and (4) knowledge based on initial data. Initial sampling schedules for point-source monitoring should assume that quality will vary periodically; sampling frequencies should be close enough to document the shortest anticipated variations. Monitoring results should be examined promptly and repeatedly and the sampling schedule revised as needed.

An interesting discussion of the spacing of monitoring wells and sampling frequencies has been presented by Pettyjohn (1976). Figures 8 and 9 indicate the perils of interpreting data based on insufficient sampling points and frequencies. Figure 8 shows the differing sets of data for chloride concentrations obtained from three adjacent wells. Well A was open to the aquifer at 9 feet, well B was open at 23 feet, and well C was open to the entire vertical section. The complexity of the resultant water-quality hydrographs indicates the perils of basing conclusions on annual samples from single wells. At this particular monitoring site, single samples taken at infrequent or annual intervals would have resulted in markedly differing observations of chloride concentration depending upon the month of sampling and the sampled depth. Figure 9 shows how misleading interpretations may be when based on data from too few observation wells. Two groups of observation wells (A and B) and hypothetical target plumes of chloride contamination are illustrated in the cross section. Plan views (a) and (b) show the lines of equal chloride concentration resulting from data for observation-well groups A and B, respectively; plan view (c) shows lines derived from data for both sets of wells; and (d) shows lines that would result from full delineation of the plumes. Pettyjohn aptly summarized these problems:

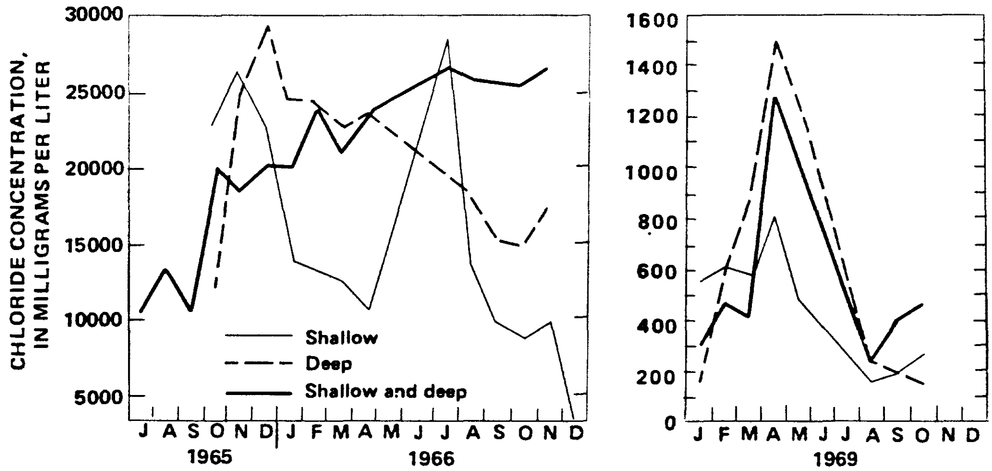
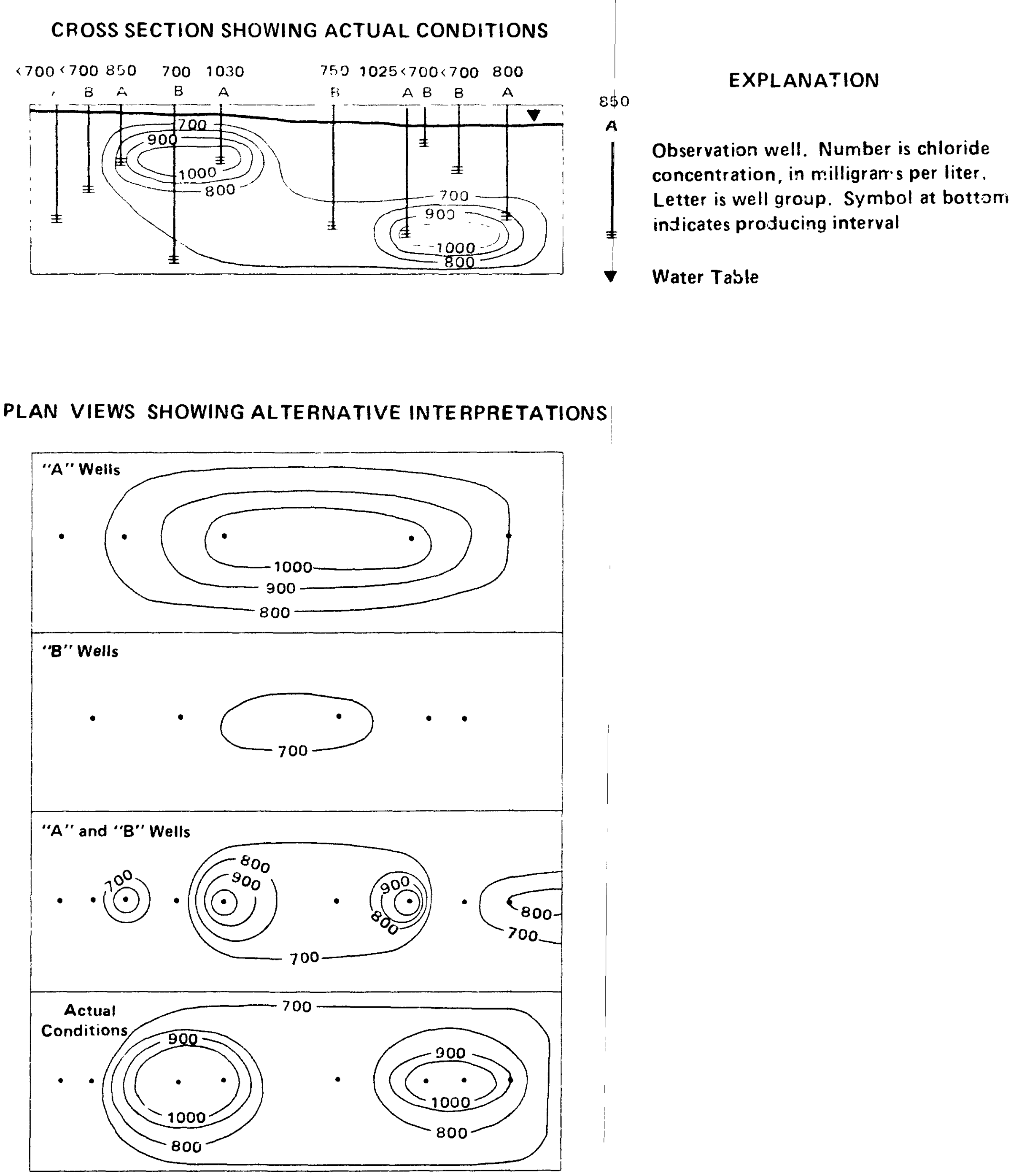


FIGURE 8.--Varying chloride concentration in water from three closely spaced observation wells with different producing intervals (modified from Pettyjohn, 1976).



Differing chloride distribution on the basis of data from different groups of observation wells.

FIGURE 9.--Differing interpretations of contamination in a hypothetical aquifer (modified from Pettyjohn, 1976, figure 9).

"Existing data indicate that in many situations, cyclic fluctuations of ground-water quality can occur and in fact may be common. These fluctuations are greatly influenced by the characteristics of the wastes, recharge events, and aquifer stratigraphy. Cyclic events can best be monitored by using a series of closely-spaced wells, each of which is screened opposite a small part of the aquifer and withdraws water from only that limited section. Moreover, samples should be collected from these wells at closely-spaced, regular intervals until the hydrologic nature of the site is recognized. Furthermore, we must not blithely pass over or ignore quality data that appear to be anomalous for they may tell us far more than the expected analysis."

Sample Collection and Analysis Techniques

The residence time of ground water in an aquifer may be long enough for the water to be in equilibrium with its chemical environment (Hem, 1970, p. 74); however, a drastic change in chemical environment is common when water is rapidly withdrawn from the aquifer by means of a pumping well. The changes in pressure and temperature between the native aquifer and atmospheric conditions at land surface may produce abrupt, significant changes in equilibria in the sample.

Eh (oxidation potential), pH, abundance of dissolved gasses (loss of CO_2, gain of O_2), and carbonate-mineral equilibria commonly change in the first few minutes as the water adjusts to atmospheric conditions. Precipitation of calcium carbonate may accompany loss of CO_2 and changing pH, resulting in lower concentrations of calcium, bicarbonate, and carbonate (and thus alkalinity and total hardness) in the sample as compared to water in the aquifer. Changes in Eh as water is brought from reducing conditions commonly found in aquifers to oxidizing environments in the atmosphere may result in precipitation of iron and manganese. Other trace metals may be lost through direct precipitation, by adsorption onto the walls of sample containers, or by sorption by the iron and manganese precipitates (phosphorus is particularly susceptible). Oxidation reactions may also affect observed concentrations of sulfur and nitrogen species. Microbiological changes during the period between sample collection and analysis may either decrease or increase measured concentrations of nutrients, and may result in the breakdown of more complex organics.

Procedures to minimize the differences between the measured quality of water samples and the true quality of the in-situ ground water fall in three categories: Collection techniques, field analyses, and sample-preparation and -preservation techniques. Sample-collection techniques should be designed to minimize the effects of environmental changes between the aquifer and the sample container. Field analyses reduce the time during which water-quality changes might occur. Sample-preparation techniques attempt to insure maximum analytical recovery in the laboratory of the constituents of interest, and sample-preservation techniques attempt to minimize changes during the period between collection and analysis. An excellent discussion of techniques for sampling and field analysis of ground water has been given by Wood (1976).

Sampling techniques.—Sampling techniques for ground water, whether from wells or springs, should be selected to obtain the most representative sample possible from the target aquifer. New wells or infrequently used wells should be thoroughly developed before sampling to: (1) Insure good hydraulic connection with the aquifer, (2) remove any sediment or loose encrustations or corrosion products from the well bore, screen, or perforations, and, for new wells, (3) remove any extraneous material introduced by drilling.

Water levels should be measured prior to development and during recovery to determine if the well is open, partially open, or plugged extensively by encrustation or sediments. If part of the screen or one of the screens in a well is not open or has reduced flow compared to another sampling period, the composite water from the well may be different in quality.

Wells should be pumped long enough prior to sampling to insure that standing water has been removed from the well bore and has been replaced by formation water. The pumping methods employed should be those that will result in the least change in sample environment for the specific target constituents. If existing production pumps are used, they should be in good working order and not pumping air due to excessive drawdown or cavitation effects. Methods for sampling wells without production pumps will depend upon depth to water, well construction, the constituents to be measured, and available equipment. Use of a portable electric submersible pump has been described by McMillion and Keeley (1968). Shallow, small-diameter wells may be sampled with a peristaltic pump (Ball and others, 1976). Deeper small-diameter wells may be pumped using gas lift (Smith, 1976) or gas pressure (Sommerfeldt and Campbell, 1975). If pumps are unavailable, a variety of devices may be employed for obtaining samples by bailing, ranging from simple homemade equipment to commercial units designed to sample discrete depths (Wood, 1976, p. 2). However, most bailers are incapable of obtaining samples uncontaminated by oxygen; exceptions are those which have positive-closure valves. For small-diameter wells, the sample volume obtained by bailers may make the process of flushing the well prior to sampling tedious and time consuming.

The sampling of springflow requires special precautions to obtain representative ground water. Well points may be driven into unconsolidated deposits in or adjacent to small springs and samples thus collected from the resulting flow. Springs discharging from consolidated rocks may be sampled by inserting a pipe into the orifice or by using a small submersible pump. Contamination by oxygen is highly probable in whatever method is used to sample springflow; if analyses are to be made for easily oxidized constituents such as iron and manganese, dissolved-oxygen concentrations may be determined in advance of sampling by inserting a probe from a dissolved-oxygen meter into the sampling stream. The sampling intake may then be located so as to minimize the concentration of dissolved oxygen.

Sampling the unsaturated zone is generally difficult. Porous-cup samplers may be placed in bore holes and samples obtained by a combination of vacuum and pressure application through a series of check valves (Wood, 1973). Useful data also may be obtained from analyses of extracts from core samples taken during test drilling in the unsaturated zone.

Field analyses.--Recent developments in instrumentation and equipment make it possible to measure some water-quality characteristics on site with precision and reproducibility equal to that traditionally obtained in the laboratory. On-site measurement is the only way to obtain truly representative values for unstable parameters such as pH, Eh, dissolved oxygen, bicarbonate and carbonate, nutrients such as ammonia, or microbiological determinations. Techniques for field analyses suitable for application to ground-water quality investigations have been discussed in detail by Wood (1976) and Ball and others (1976).

A summary of available techniques for field analyses of ground waters is presented in table 7. Analytical precisions vary with the particular instruments or techniques used and the training and diligence of the operator.

Field determinations of pH and titrations of alkalinity (bicarbonate and carbonate) are mandatory if these parameters are of particular concern to the investigation. Field filtration and incubation of bacteriological samples is highly advisable unless chilled samples can be transported to a laboratory and processed within 6 hours of collection (American Public Health Association and others, 1976, p. 907). Although commercially available water-quality field kits do not generally provide results comparable to the accuracy of laboratory analyses, such kits, if properly selected and calibrated against known standards, provide a quick method of screening water in the field for the presence of significant concentrations of constituents of interest. In this manner, a large number of samples may be screened at relatively low cost to reduce the ultimate analytical load at the laboratory. A procedure for evaluating the accuracy of test kits and its application to analyses for iron concentrations has been discussed by Duncan and others (1976).

Sample preparation and preservation.--Required sample preparation and preservation techniques will differ with the sophistication of the monitoring effort, the requirements of the receiving laboratory, and the parameters to be analyzed. Most samples collected in the course of ground-water monitoring should be filtered to remove particulate matter which may be present even though the water appears clear. Filtration must be accomplished before samples come in contact with the atmosphere, however, or easily oxidized constituents such as iron amd manganese will precipitate and be removed by the

TABLE 7.--*Available techniques for field analyses of ground water*

Parameter	Techniques	Readily obtainable precision	References
Temperature	Thermometer or meter	0.5 to 0.1°C 0.5 to 0.01°C	Wood, 1973; Stevens and others, 1975
pH	Meter	Equal to laboratory	Wood, 1976
Eh	Meter	Equal to laboratory	Wood, 1976
Specific conductance	Meter	Equal to laboratory	Wood, 1976
Dissolved oxygen	Titration or meter	Equal to laboratory	Wood, 1976
Alkalinity, carbonate, bicarbonate	Electrometric titration	Equal to laboratory	Wood, 1976
Ammonia, bromide, cadmium, calcium, chloride, copper, cyanide, fluoride, iodide, lead, nitrate, potassium, silver, sulfide, sodium, divalent cations	Meter, ion-selective electrodes	Variable with parameter, concentration, and interferences	Durst, 1969; Sekerka and Lechner, 1973; Presser and Barnes, 1974
Total coliforms, fecal coliforms, fecal streptococci	Membrane filtration	Equivalent to laboratory	Slack and others, 1973
Alkalinity, ammonia, bromine, calcium, chlorine, chromium, color, copper, cyanide, MBAS, fluoride, hardness, iodine, iron, manganese, nitrate, nitrite, phosphate, sulfate, sulfide, and others	Field kits (titration, colorimetry)	Highly variable with parameter selected and kit used; kits should be evaluated for precision and accuracy and periodically calibrated against known standards	Duncan and others, 1976

filter, resulting in laboratory concentrations for those that are lower than actual concentrations in the unoxygenated ground water. Filtration should be performed under a positive pressure maintained by the pumping device or an inert gas; vacuum filtration exposes the sample to the atmosphere and removes carbon dioxide and other gases from the filtered sample that may result in significant changes in pH, bicarbonate, and carbonate.

Samples taken for determination of constituents in the dissolved phase are by convention filtered through a membrane filter of 0.45-micrometer pore size (Skougstad and others, 1979; U.S. Environmental Protection Agency, 1976d). Filtration through such a filter also removes bacteria, thus reducing microbiological changes in the resultant samples. Colloidal material of small particle size may pass through a 0.45-micrometer filter and greatly affect measured concentrations of metals (Kennedy and others, 1974); filters of a smaller pore size (0.10 micrometer or less) may be needed for special investigations. Most commonly used filtration devices and membrane filters are constructed of plastics and are non-contaminating for routine inorganic analyses. Analyses for organic parameters such as dissolved organic carbon require use of a metalic apparatus and filters (Malcolm and Leenheer, 1973).

Sample-preservation techniques are designed to minimize chemical, physical, or biological changes in the samples during transit to the laboratory; at best, however, these techniques will only retard the inevitable changes. Preservation techniques generally attempt to stabilize samples by (1) retarding of biological action, (2) retarding hydrolysis, and (3) reducing the volatility of constituents. Specific techniques depend upon the constituents in question; analysis for a large suite of water-quality characteristics requires preparation of a number of subsamples, each with individual methods of preservation. Preservation techniques recommended as of 1977 by the U.S. Geological Survey and the U.S. Environmental Protection Agency for parameters commonly included in ground-water monitoring are summarized in table 8. These methods are periodically revised as research continues on the sample-preservation problem.

Monitoring Results

The initial product of a state-wide monitoring program will be a large volume of diverse types of data. Raw data residing in files, whether the files are plain manila or impressive bound computer printouts, do little to protect the ground-water resource. A primary function of the monitoring agency will be to review, interpret, analyze, and disseminate the results of monitoring.

Monitoring results should be reviewed promptly to provide the necessary feedback to maintain an efficient network. Preliminary results in the form of summary tables or graphs, or both, should be made available to State, Federal, and local management and regulatory agencies interested in water resources. Results should be summarized at least annually for release to the general public, and more often if of particular local significance. The U.S. Environmental Protection Agency (EPA) requires that ground-water monitoring data be made available to that agency within 90 days of collection (40 CFR 35, Subpart B); monitoring-site inventories and summary reports are required annually.

TABLE 8.—*Recommended methods for preserving samples for water-quality analyses*

[Methods compiled from available USGS and EPA publications; may vary with receiving laboratory and are subject to change with improving methodologies. Preservative effects: $CuSO_4$, bacteriocide; HNO_3, dissolves metals; $HgCl_2$, bacteriocide; H_2SO_4, bacteriocide; H_3PO_4, forms salts with organic bases; NaOH, forms salts with volatiles; cooling or freezing, retards biologic activity]

Parameters	Filtration recommended	Preservative	Maximum holding time	Remarks
<u>Inorganic</u>				
Cations: Calcium, magnesium, sodium, potassium, iron, manganese, arsenic, other metals	X	HNO_3 to pH <2 [1]	6 months	—
Anions:				
Bicarbonate, carbonate		—	—	Field analyses preferred
Sulfate, chloride, fluoride	[2]X	None required	—	—
Nutrients: Nitrogen and phosphorus species	X	Cool to <4°C, add 40 mg $HgCl_2$ per liter	7 days	Ammonia, organic N, NO_2-N are unstable
Dissolved solids	X	None required	—	—
<u>Organic</u>				
BOD	—	Cool to <4°C	6 hours	—
COD	—	H_2SO_4 to pH <2	7 days	—
Carbon, organic	X	Cool to <4°C	7 days	—
Cyanide	—	NaOH to pH 12, cool to <4°C	24 hours	—
MBAS (detergents)	—	Cool to <4°C	—	—
Oil and grease	—	H_2SO_4 to pH <3, cool to <4°C	24 hours	—
Pesticides: Organochlorines, organophosphates, Chlorophenoxy acids	—	Cool to <4°C	—	—
Phenolics	—	1.0 gm $CuSO_4$ per liter, H_3PO_4 to pH <4	24 hours	—

[1] HNO_3 used to preserve trace constituents must be of very high purity.

[2] Do not filter, or use only inert gases or non-contaminating pumps to provide pressure for filtration.

The preferred format for reporting raw data to EPA is in a format compatible with the STORET data system. The potential variety and number of data parameters to be generated by a long-term statewide monitoring network necessitates an automated data-handling system for efficient operation. An ideal system would do more than store and retrieve numbers; its capabilities should include:

1. Satisfaction of EPA reporting requirements.
2. Generation of tables of publication quality to speed data dissemination.
3. Generation of graphical output for data reduction and analysis.
4. Statistical reduction and analyses of raw data.
5. The ability to manipulate other ground-water data such as water levels, aquifer characteristics, well construction, and geologic logs as well as water quality.

These needs are discussed in more detail in a later section of this report.

A REVIEW OF MONITORING FOR GROUND-WATER QUALITY IN NEVADA AS OF 1978

Data on ground-water quality have been collected in Nevada in a variety of programs ranging from the random submission of samples by private individuals for analysis of domestic water supplies to a specialized statewide network for the systematic monitoring of radionuclides in ground water. These efforts have generally had one of three principal objectives: (1) To describe the ambient quality of ground water areally or regionally; (2) to monitor the quality of ground water at points of withdrawal in relation to intended uses; or (3) to monitor the effects of point or nonpoint sources of pollution on the quality of ground water. Most published data fall in the first category and were collected in the course of areal studies on the general hydrology or ground-water resources of one or more hydrographic basins. As an initial step in organizing data on ground-water quality in Nevada on a statewide basis, published reports (through 1978) containing data on ground-water quality are indexed by hydrographic area in table 9.

Agencies involved in the collection and analysis of data on the quality of ground water in Nevada as of about 1977 include: The Nevada Consumer Health Protection Services (CHPS); Clark County District Health Department; Washoe County District Health Department; Nevada Division of Environmental Protection (DEP); the Nevada State Engineer; Desert Research Institute, University of Nevada System (DRI); Cooperative Extension Service, College of Agriculture, University of Nevada at Reno; U.S. Bureau of Land Management (BLM); U.S. Bureau of Reclamation (USBR); U.S. Geological Survey (USGS); and the Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA). Locations of sites sampled by these agencies are shown on plate 1 and are discussed below.

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*

Hydrographic areas		Reference number in Bibliography
Number	Name	
1--NORTHWEST REGION		
1	Pueblo V.	--
2	Continental Lake V.	80, 81, 125
3	Gridley Lake V.	--
4	Virgin V.	--
5	Sage Hen V.	--
6	Guano V.	--
7	Swan Lake V.	--
8	Massacre Lake V.	122
9	Long V. (Washoe Co.)	122
10	Macy Flat	--
11	Coleman V.	--
12	Mosquito V.	--
13	Warner V.	--
14	Surprise V.	--
15	Boulder V.	--
16	Duck Lake V.	123
2--BLACK ROCK DESERT REGION		
17	Pilgrim Flat	--
18	Painters Flat	--
19	Dry V. (Washoe Co.)	--
20	Sano V.	--
21	Smoke Creek Desert	51
22	San Emidio Desert	51
23	Granite Basin	--
24	Hualapai Flat	55, 80, 81, 121
25	High Rock Lake V.	--
26	Mud Meadow	80, 81
27	Summit Lake V.	--
28	Black Rock Desert	80, 81, 87, 91, 124
29	Pine Forest V.	80, 81, 119
30A	Kings River V., Rio King Subarea	79, 146
30B	Kings River V., Sod House Subarea	79, 146
31	Desert V.	120
32	Silver State V.	--
33A	Quinn River V., Orovada Subarea	63, 87, 129, 135
33B	Quinn River V., McDermitt Subarea	63, 87, 129, 135

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas Number	Name	Reference number in Bibliography
3--SNAKE RIVER BASIN		
34	Little Owyhee River Area	--
35	South Fork Owyhee River Area	--
36	Independence V.	27, 80, 81
37	Owyhee River Area	80, 81
38	Bruneau River Area	--
39	Jarbidge River Area	--
40	Salmon Falls Creek Area	80, 81, 87
41	Goose Creek Area	80, 81
4--HUMBOLDT RIVER BASIN		
42	Marys River Area	80, 81, 87
43	Starr Valley Area	87
44	North Fork Area	80, 81, 87
45	Lamoille V.	87
46	South Fork Area	87
47	Huntington V.	87, 109
48	Dixie Creek, Tenmile Creek Area	87
49	Elko Segment	80, 81, 87
50	Susie Creek Area	87
51	Maggie Creek Area	80, 81, 87
52	Marys Creek Area	87
53	Pine V.	23, 80, 81, 87
54	Crescent V.	80, 81, 87, 144, 145
55	Carico Lake V.	43, 87, 137
56	Upper Reese River V.	38, 53, 87, 98, 118, 137
57	Antelope V. (Lander Co.)	17, 53, 87, 137
58	Middle Reese River V.	17, 53, 87, 137
59	Lower Reese River V.	53, 87, 137
60	Whirlwind V.	80, 81, 87
61	Boulder Flat	87, 137
62	Rock Creek V.	87
63	Willow Creek V.	87
64	Clovers Area	80, 81, 87
65	Pumpernickel V.	80, 81, 87
66	Kelly Creek Area	87
67	Little Humboldt V.	80, 81, 87
68	Hardscrabble Area	87
69	Paradise V.	60, 73, 80, 81, 87

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
4--HUMBOLDT RIVER BASIN--Continued		
70	Winnemucca Segment	9, 10, 12, 15, 80, 81, 87
71	Grass V. (Pershing-Humboldt Co.)	11, 80, 81, 91, 100
72	Imlay Area	25
73	Lovelock V.	42, 99
73A	Oreana Subarea	99
74	White Plains	--
5--WEST CENTRAL REGION		
75	Brady's Hot Spring Area	91
76	Fernley Area	--
77	Fireball V.	--
78	Granite Spring V.	56
79	Kumiva V.	--
6--TRUCKEE RIVER BASIN		
80	Winnemucca Lake V.	145
81	Pyramid Lake V.	80, 81, 87
82	Dodge Flat	--
83	Tracy Segment	--
84	Warm Springs Area	111
85	Spanish Springs V.	--
86	Sun V.	--
87	Truckee Meadows	8, 14, 16, 45, 87, 126, 131, 133, 141
88	Pleasant V. (Washoe Co.)	45, 80, 81
89	Washoe V.	45, 87, 102
90	Lake Tahoe Basin	45
91	Truckee Canyon Segment	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
7--WESTERN REGION		
92A	Lemmon V., Western Part	58, 111
92B	Lemmon V., Eastern Part	58, 111
93	Antelope V. (Washoe Co.)	--
94	Bedell Flat	--
95	Dry V. (Washoe Co.)	87
96	Newcomb Lake V.	--
97	Honey Lake V.	--
98	Skedaddle Creek V.	--
99	Red Rock V.	--
100	Cold Spring V.	--
8--CARSON RIVER BASIN		
101	Carson Desert	50, 80, 81, 87, 89, 91, 127, 128, 131
101A	Packard V.	50
102	Churchill V.	50, 61, 131
103	Dayton V.	50, 131
104	Eagle V. (Carson City)	45, 50, 87, 131, 143
105	Carson V.	45, 50, 80, 81, 87, 131
9--WALKER RIVER BASIN		
106	Antelope V. (Douglas Co.)	49, 90
107	Smith V.	71, 80, 81, 87
108	Mason V.	64, 80, 81, 87
109	East Walker Area	49
110A	Walker Lake V., Schurz Subarea	44, 87
110B	Walker Lake V., Lake Subarea	44, 87
110C	Walker Lake V., Whiskey Flat-Hawthorne Subarea	39, 44, 87

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
10--CENTRAL REGION		
111A	Alkali V., Northern Part	--
111B	Alkali V., Southern Part	--
112	Mono V.	--
113	Huntoon V.	--
114	Teels Marsh V.	--
115	Abode V.	--
116	Queen V.	--
117	Fish Lake V.	21, 87, 113
118	Columbus Salt Marsh V.	132
119	Rhodes Salt Marsh V.	--
120	Garfield Flat	--
121A	Soda Springs, Eastern Part	80, 81, 132
121B	Soda Springs, Western Part	132
122	Gabbs V.	28, 87
123	Rawhide Flats	--
124	Fairview V.	13, 89
125	Stingaree V.	--
126	Cowkick V.	--
127	Eastgate V. Area	--
128	Dixie V.	13, 80, 81, 87, 89
129	Buena Vista V.	72, 80, 81, 87
130	Pleasant V. (Pershing Co.)	--
131	Buffalo V.	80, 81, 91
132	Jersey V.	80, 81
133	Edwards Creek V.	40
134	Smith Creek V.	41, 80, 81, 87
135	Ione V.	41, 87
136	Monte Cristo V.	--
137A	Big Smoky, Tonopah Flat	46, 53, 86, 87, 98, 115
137B	Big Smoky, Northern Part	46, 53, 80, 81, 86, 87, 98, 115, 118
138	Grass V. (Lander-Eureka Co.)	43, 46, 80, 81, 98
139	Kobeh V.	46, 98, 108, 118
140A	Monitor V., Northern Part	18, 46, 80, 81, 87, 98, 108, 118
140B	Monitor V., Southern Part	18, 46, 87, 98, 108, 118
141	Ralston V.	29, 46, 53, 87, 96, 98, 118
142	Alkali Spring V.	53, 86
143	Clayton V.	53, 86, 87, 103

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
10--CENTRAL REGION--Continued		
144	Lida V.	--
145	Stonewall Flat	103
146	Sarcobatus Flat	77, 87
147	Gold Flat	3, 106, 118
148	Cactus Flat	106, 118
149	Stone Cabin V.	29, 46, 98, 118
150	Little Fish Lake V.	18, 46, 67, 98, 110, 118
151	Antelope V. (Eureka-Nye Co.)	46, 80, 81, 98, 108, 118
152	Stevens Basin	--
153	Diamond V.	26, 54, 87, 98, 118
154	Newark V.	22, 98
155A	Little Smoky V., Northern Part	18, 46, 98, 110, 118
155B	Little Smoky V., Central Part	18, 46, 98, 110
155C	Little Smoky V., Southern Part	18, 46, 98, 118
156	Hot Creek V.	18, 46, 67, 80, 81, 87, 98, 110, 118
157	Kawich V.	3, 106
158A	Emigrant V., Groom Lake V.	6, 106, 116, 117, 142
158B	Emigrant V., Papoose Lake V.	106, 116, 117, 142
159	Yucca Flat	6, 106, 116, 117, 142
160	Frenchman Flat	6, 106, 116, 117, 142
161	Indian Springs V.	5, 6, 53, 84, 85, 87, 88, 97, 106, 116, 117
162	Pahrump V.	53, 76, 87, 88, 97, 138, 142
163	Mesquite V.	47, 87, 138
164A	Ivanpah V., Northern Part	47, 53, 138
164B	Ivanpah V., Southern Part	47, 53, 138
165	Jean Lake V.	--
166	Hidden V. (South)	--
167	Eldorado V.	112
168	Three Lakes V. (Northern)	106
169A	Tikapoo V., Northern Part	106
169B	Tikapoo V., Southern Part	106
170	Penoyer V.	134
171	Coal V.	32
172	Garden V.	32
173A	Railroad V., Southern Part	46, 53, 87, 98, 118, 134
173B	Railroad V., Northern Part	46, 53, 87, 98, 118, 134
174	Jakes V.	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
10--CENTRAL REGION--Continued		
175	Long V. (White Pine Co.)	24
176	Ruby V.	80, 81
177	Clover V. (Elko Co.)	--
178A	Butte V., Northern Part	48, 87
178B	Butte V., Southern Part	48, 87
179	Steptoe V.	7, 36, 53, 87
180	Cave V.	30
181	Dry Lake V.	31, 87
182	Delamar V.	31
183	Lake V.	107
184	Spring V. (White Pine Co.)	87, 114
185	Tippett V.	--
186A	Antelope V., Southern (White Pine-Elko Co.)	87
186B	Antelope V., Northern (White Pine-Elko Co.)	87
187	Goshute V.	37, 87
188	Independence V. (Elko Co.)	--
11--GREAT SALT LAKE BASIN		
189A	Thousand Springs V., Herrill Siding-Brush Creek Area	87, 104
189B	Thousand Springs V., Toano-Rock Springs Area	87, 104
189C	Thousand Springs V., Rocky Butte Area	87, 104
189D	Thousand Springs V., Montello-Crittenden Creek Area	--
190	Grouse Creek V.	--
191	Pilot Creek V.	57
192	Great Salt Lake Desert	87
193	Deep Creek V.	--
194	Pleasant V. (White Pine Co.)	--
195	Snake V.	62
196	Hamlin V.	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas: Number	Name	Reference number in Bibliography
12--ESCALANTE DESERT		
197	Escalante Desert	--
13--COLORADO RIVER BASIN		
198	Dry V. (Lincoln Co.)	1
199	Rose V.	1
200	Eagle V. (Lincoln Co.)	1
201	Spring V. (Lincoln Co.)	1
202	Patterson V.	1
203	Panaca V.	95
204	Clover V. (Lincoln Co.)	1, 53
205	Lower Meadow V. Wash	1, 53, 87, 101
206	Kane Springs V.	1, 34, 35
207	White River V.	1, 35, 53, 82, 87
208	Pahroc V.	1, 33, 35
209	Pahranagat V.	1, 33, 35, 53, 87
210	Coyote Spring V.	1, 34, 35
211	Three Lakes V., Southern Part	--
212	Las Vegas V.	2, 4, 5, 19, 20, 53, 65, 66, 68, 70, 74, 75, 83, 84, 85, 87, 92, 93, 94, 97, 106, 139, 140, 142
213	Colorado River V.	5, 70
214	Piute V.	87, 112
215	Black Mountains Area	1, 5, 105
216	Garnet V.	1
217	Hidden V. (North)	1
218	California Wash	1
219	Muddy River Springs Area	1, 34, 53, 87
220	Lower Moapa V.	1, 53, 105
221	Tule Desert	1
222	Virgin River V.	1, 52, 53, 87
223	Gold Butte Area	105
224	Greasewood Basin	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
14--DEATH VALLEY BASIN		
225	Mercury V.	6, 53, 88, 106, 142
226	Rock V.	88, 106, 116, 117
227A	Forty Mile Canyon, Jackass Flats	6, 88, 106, 116, 117, 142
227B	Forty Mile Canyon, Buckboard Mesa	3, 6, 88, 106, 116, 117, 142
228	Oasis V.	3, 6, 77, 78, 88, 97, 142
229	Crater Flat	88, 106
230	Amargosa Desert	53, 69, 87, 88, 97, 116, 117, 130, 136, 142
231	Grapevine Canyon	97
232	Oriental Wash	--

State Agencies

Nevada Consumer Health Protection Services

Ground-water monitoring activities of the CHPS include (1) transmission of water samples from private domestic wells to the Nevada Bureau of Laboratories and Research in Reno for analysis, (2) monitoring of public water supplies, and (3) investigations of ground-water quality in relation to the approval of facilities for water supply and wastewater disposal for subdivisions and developments.

No State requirement exists in Nevada for the submission of water samples from private domestic wells for chemical or bacteriological analyses; however, many homeowners do submit such samples after drilling a new well, renovating an old well, or upon purchase of property with a private well. In addition, analyses of private water supplies are generally made during property sales involving Veterans Administration (VA) or Federal Housing Administration (FHA) loans. Since 1930, an estimated 13,000 samples have been submitted to the State laboratory for domestic supply analyses; as of 1977, samples are being submitted at the rate of about 200 per month.

Parameters included in a routine domestic supply analysis by the Bureau of Laboratories and Research are those listed on the preprinted transmittal and reporting forms shown in figure 10. Chemical and bacteriological data laboratory procedures follow those recommended in "Standard Methods" (American Public Health Association and others, 1976). Samples are generally taken in the field by the homeowner or other individual concerned with the quality of the well water; sampling techniques thus are highly variable, with the point of sampling often being determined by convenience.

IN TRIPLICATE
(PLEASE PRINT)

BUREAU OF LABORATORIES AND RESEARCH
NEVADA DIVISION OF HEALTH
790 Sutro Street
Reno, Nevada 89502

7530

WATER CHEMISTRY:

WELL WATER: Pump should be delivering clear water before sampling.

Date sampled .... Date submitted ....

Owner ....

Report to:

Name ....

Address ....

City .... State ....

County ....

Township ....

Range .... Section ....

Area ....

WATER SOURCE:

Well .... Spring .... Surface ....

Hot .... Cold .... Depth .... Ft.

Casing diameter .... in depth .... Ft.

Now in use .... Yes ☐ No ☐ ....

ROUTINE DOMESTIC ANALYSIS PLEASE CHECK BOX		FOR PARTIAL ANALYSIS CIRCLE CONSTITUENT DESIRED			FOR CONSTITUENTS NOT LISTED BELOW PRINT IN CONSTITUENT DESIRED IN SPACE BELOW			
Constituent P.P.M.	Constituent P.P.M.	Constituent P.P.M.			Constituent	P.P.M.	Constituent	P.P.M.
T.D.S.	Chloride	Iron						
Hardness	Nitrate	Manganese						
Calcium	Alkalinity	Color						
Magnesium	Bicarbonate	Turbidity						
Sodium	Carbonate	pH						
Potassium	Fluoride							
Sulfate	Arsenic							

Remarks ....

Chemical analysis

BUREAU OF LABORATORIES AND RESEARCH
NEVADA DIVISION OF HEALTH
790 Sutro Street, Reno, Nevada 89502
625 Shadow Lane, Las Vegas, Nevada 89106

DO NOT USE

SAMPLED BY ________ DATE ________ HOUR ________

LOCATION ________ COUNTY ________

SAMPLE IS:

DRINKING ________, RAW SURFACE ________, SEWAGE ________, OTHER ________

MEMBRANE FILTER METHOD USED

NAME ________

ADDRESS ________

WATER BACTERIOLOGY

THIS SPACE FOR LAB USE ONLY RESULTS:

COLIFORMS ________/100 ML.; FECAL COLI ________/100 ML.

OTHER ________

NOTE: IF ABOVE COLIFORMS IS O, THE SAMPLE IS CONSIDERED AS MEETING USPHS BACTERIOLOGICAL STANDARDS FOR DRINKING WATER.

OTHERWISE

CALL YOUR AREA SANITARIAN AT ________ FOR INTERPRETATION.

7325

Bacteriological analysis

FIGURE 10.--Examples of transmittal and analytical-reporting forms used by the Nevada Bureau of Laboratories and Research for water-quality samples.

Samples are not treated or preserved in any manner prior to shipment (usually by mail) to the laboratory; thus, the reported values for pH and unstable constituents such as iron, manganese, bicarbonate, carbonate, calcium, and magnesium may reflect equilibrium conditions in the bottle on the laboratory bench rather than being representative of the chemical environment in the native ground water. Given the uncertain collection procedures, and unknown storage and transit times, the results of bacteriological analyses of domestic wells are particularly suspect.

The utility of these analyses for defining ground-water quality is further impaired by site-location data that may be inaccurate or absent. Space is provided on the sample-transmittal forms to indicate the site location by township, range, and section and to provide data on well diameter and depth; however, these data may be unknown to the collector of the sample, and thus are often either missing from the submitted forms or supplied in the form of approximations or guesses.

If interpretations are made with full recognition of the limitations described above, the large number of historical analyses and relatively broad areal coverage within the inhabited parts of the State result in a potentially valuable data base for determining the background quality of Nevada ground water. The utility of these data could be enhanced by modifying the sample transmittal forms to include more specific descriptions of the sampling point and site location. For example, check-off boxes could be added to indicate whether the sample was from the well head, a line preceding or following the storage tank, filter, or softener. Options for site location should include the street address of the site, if available, and the subdivision name and lot number. Space should be provided for owner's comments and a location sketch to refine the site description. An example format is shown in figure 11.

Public water supplies in Clark and Washoe Counties are monitored under the authority of the respective local Distric Health Departments; the CHPS has responsibility for the remainder of the State. Responsibility for sample collection and transmittal is left to the operator of the water supply. Sampling frequencies for chemical analyses have been approximately annual in theory, but intermittent in practice; bacteriological analyses have been requested quarterly for non-community supplies and bimonthly to daily (dependent upon population served) for community supplies.

An estimated 350 community public supplies and 600 to 700 non-community public supplies are served by ground water in Nevada. Approximate locations of the community supply well or springs are shown on plate 1. These sites have potential for monitoring long-term changes in water quality in areas of relatively intense pumping. Evaluation of the historical records in the files of the CHPS and local health departments is beset by the same difficulties as for the domestic-water analyses; unstandardized sample-handling techniques, lack of specific site documentation, and degradation and alteration of unstable constituents during sampling and transportation. Nevada Water Supply regulations as of 1977 require monitoring of all public ground-water supplies at approximately 3-year intervals (table 2).

To be completed by party collecting sample: Samples will not be analysed without adequate location

Date sampled ____________ Date submitted ________
Owner ____

County ______________________
Township ____________________
Range ____________ Section ____________
Area ________________________

Report to:
Name ________________________________
Address ______________________________
City __________________ State __________

Sample collected by: ___________________
|_| Owner |_| Tenant |_| Driller ______________

Reason for sample collection:
____

WATER SOURCE:
Surface ____________ Spring ____________
Hot ____________ Cold ____________
Now in use ____________ Yes _ No _ ________
Sewage ____________ Other ____________

WELLS:
Date drilled ____________

SITE LOCATION--Please identify the location as accurately as possible:

Street address ______________________________
Nearest town ______________________________
Location sketch: Owner's well no. _____

Depth ________ ft, Casing diameter ______ in
Perforated zone(s) ______ ft to ________ ft
______ ft to ________ ft
______ ft to ________ ft

Sampled at:
|_| faucet in house |_| outside faucet
|_| storage tank |_| well head

Equipment between site and sampling point:
|_| storage tank |_| iron filter
|_| water softener |_| ________________

For office use only: | Location checked by ______ Date ______ Office check |_| Field check |_| Revised |_|
Remarks:

For laboratory use only: | Lab log no. and date received
Sample condition upon receipt ____________________

ROUTINE DOMESTIC ANALYSIS PLEASE CHECK BOX		FOR PARTIAL ANALYSIS CIRCLE CONSTITUENT DESIRED				FOR CONSTITUENTS NOT LISTED BELOW PRINT IN CONSTITUENT DESIRED IN SPACE BELOW			
Constituent	P.P.M.	Constituent	P.P.M.	Constituent	P.P.M.	Constituent	P.P.M.	Constituent	P.P.M.
T.D.S.		Chloride		Iron					
Hardness		Nitrate		Manganese					
Calcium		Alkalinity		Color					
Magnesium		Bicarbonate		Turbidity					
Sodium		Carbonate		p.H.					
Potassium		Fluoride							
Sulfate		Arsenic							

Summary of results:
|_| The above water meets all current drinking-water standards.
|_| Concentrations of the following exceed recommended limits for drinking waters:
____

FIGURE 11.--Examples of sample—transmittal form with more descriptive information.

The designated sampling point is at a tap supplying treated water representative of water in the distribution system. The analyses of these samples, however, are likely to provide little utility to an effective ground-water monitoring program because:

1. The quality of finished waters in a distribution system may not be representative of water in the source aquifers.
2. No documentation is provided of quality changes in water from individual wells supplying a system with multiple sources.
3. A 3-year sampling frequency is inadequate to define seasonal or periodic variations in water quality.
4. Monitoring of public supplies can only document the occurrence of contamination; effective monitoring to forecast or provide warning of contamination requires sampling at points between the sources of contamination and the supply wells.

Data on the quality of ground water are also collected by CHPS staff in the course of site studies for approval of water-supply or sewage-disposal systems. Parameters analyzed are generally the same as for routine domestic analyses, and the same qualifications as to the use of the data generally exist. Results of chemical analyses are kept in the CHPS files in Carson City.

Clark County District Health Department

The District Health Department in Las Vegas has been delegated responsibility to monitor the quality of public water supplies in Clark County. Public community water supplies are scheduled for annual chemical analysis and monthly to quarterly bacteriological analyses. Historical data indicate that chemical analyses were made intermittently more commonly than annually. Chemical analyses include the parameters for routine domestic analysis previously described and are made in the Bureau of Laboratories and Research in Reno. Bacteriological analyses are made by the District Health Department in Las Vegas. In addition to the regularly scheduled analyses of public supplies, an attempt has been made to sample, once, the water of each private domestic well in the county for a routine chemical analysis. During 1975-77, such samples were collected at the time of residential sales involving VA or FHA loans. Analytical results are kept in files at Las Vegas. The historical domestic analyses provide a potential data base for documentation of areal water chemistry in the developed areas of the valley. Continuing periodic analyses of public supplies will document temporal changes in quality in the highly stressed zones of the deeper aquifer system. The interpretation of these data is likely to be subject to the same limitations as for the other analyses performed by the State laboratory.

Washoe County District Health Department

The activities of the Washoe County District Health Department within its jurisdiction parallel those of the Clark County District. Samples for bacteriological analyses have been collected monthly on public supplies; sampling for chemical analyses has been intermittent in the past and will become annual under adjustment to provisions of the Safe Drinking Water Act. Samples have been collected from private domestic wells in response to individual requests or in conjunction with VA or FHA loans. Analyses for both chemical and bacteriological parameters are made by the Bureau of Laboratories and Research in Reno. Analytical results are filed in the county offices in Reno and the CHPS offices in Carson City.

Nevada Division of Environmental Protection

The Nevada DEP is not engaged in the direct collection of data on ground-water quality as of 1977. Some analyses of ground water are generated by point-source pollution monitoring required by individual Pollution Discharge Elimination Permits. Responsibility for sample collection and analysis is left to the permittee, with collection frequencies and parameters to be analyzed following individual permit requirements. Results are in the files of the DEP in Carson City.

Nevada State Engineer

The office of the Nevada State Engineer, in the course of operating a network of observation wells for water-level measurements, has collected field measurements of specific conductance in areas of intensive irrigation pumping. This effort spanned the years 1967 to 1973, with annual sampling in some areas and one-time sampling in others. Data are filed in the office of the Nevada State Engineer, Carson City. Hydrographic areas covered and the amount of available data are summarized below:

Hydrographic area		Number of wells	Period of record	Remarks
24	Hualapai Flat	22	1968-69	Generally one-time
31	Desert Valley	19	1968-75	Intermittent
57	Antelope Valley	16	1967-69	Generally one-time
58	Middle Reese River valley	26	1967	One-time
128	Dixie Valley	13	1968-70	Generally one-time

Desert Research Institute

The Water Resources Research Center of the DRI has collected considerable data on ground-water quality in conjunction with various hydrologic research projects throughout the State. These data have been published in various reports (included in table 9) and a large amount of data are stored in computer data bases maintained by DRI in Las Vegas. Analytical support for DRI water projects is provided by DRI laboratories in Reno and Boulder City and by the Nevada Bureau of Laboratories and Research in Reno. The parameters analyzed and the sample collection, preparation, and preservation techniques used differ from project to project. The Center is not engaged in any long-term monitoring of ground-water quality in Nevada as of 1977.

Cooperative Extension Service

The Cooperative Extension Service, College of Agriculture, University of Nevada, Reno, monitors ground water for pesticide residues at four pesticide disposal sites in Churchill, Humboldt, Lander, and Pershing Counties (pl. 1). These sites are operated for the disposal of contaminated containers and excess stocks of pesticides used in agricultural operations by licensed pesticide applicators. Samples are collected from the soil and representative vegetation immediately surrounding each site and are analyzed for chlorinated hydrocarbon and organophosphate insecticides and herbicides to monitor possible movement of pesticides from the sites; water samples are collected from the nearest existing well or spring. Samples are taken each spring and fall to bracket the active season of pesticide use. Analyses are made in the laboratories of the College of Agriculture at the University of Nevada, Reno.

The approximate location of the four disposal sites and the ground-water sampling points used for monitoring each one are shown on plate 1 and in figures 12-15. Available information on the monitoring points is summarized in table 10. Ground-water monitoring points were chosen on the basis of accessibility of existing wells and springs more than by position in the hydrologic system. As a result, few of the sampling points appear to be effectively placed with respect to potential ground-water movement from the disposal sites.

Quinn River valley site (Humboldt County).--The disposal site is on an alluvial fan at the west side of the valley (fig. 12). Ground-water samples are collected at a windmill well about 2-1/2 miles southeast of the site and at a springfed stock-watering facility about 1-3/4 miles south of the site. Neither site is on a probable path of ground-water flow from the disposal site.

TABLE 10.—*Ground-water monitoring at pesticide disposal sites*

[Site use: S, stock]

Site type	Local site number	Owner	Site use	Land-surface altitude (feet)	Total depth (feet)[1]	Casing diameter (inches)	Representative depth to water: Feet	Representative depth to water: Date	Remarks
Quinn River Valley (Orovada Subarea) Disposal Site, Humboldt County; location 33A N43 E36 18DDD									
Well	33A N43 E36 27CAAA1	McErguiaga	S	4155	—	—	3	2-64	Not effective site: too distant and off probable flow path from disposal area.
Spring	33A N43 E36 29C	—	—	—	—	—	—	—	Location uncertain: not effective site; upgradient from disposal area.
Middle Reese River Valley Disposal Site, Lander County, location 58 N25 E42 18DB									
Well	58 N25 E42 20AAD1	Powers	S	4907	110	6	87	2-63	Not effective site: off probable flow path from disposal area.
Lovelock Valley Disposal Site, Pershing County, location 73 N27 E31 30B									
Well	73 N27 E31 29BDDC1	Powers	S	3960	—	—	—	—	Not effective site: too distant and off probable flow path from disposal area.
Well	73 N27 E31 30ADDC1	—	—	3980	—	—	—	—	Not effective site: off probable flow path from disposal area.
Carson Desert Disposal Site, Churchill County, location 101 N20 E28 24CB									
Well	101 N20 E28 24BC1	—	—	3960	10	32	28	12-76	Dug well made from 2 oil drums. Appears to be downgradient and flow path from disposal site.

[1] No information available regarding perforated or screened intervals.

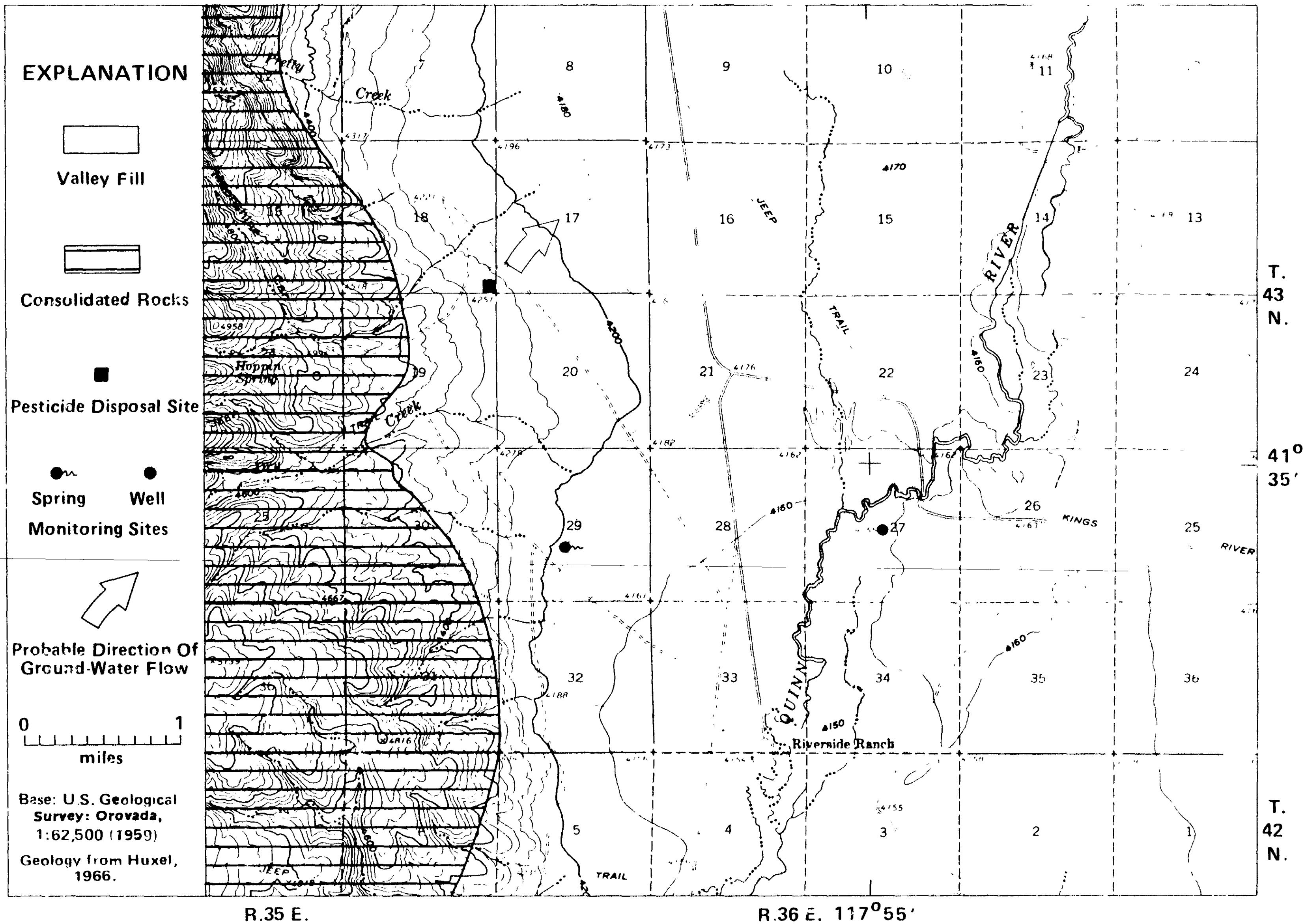


FIGURE 12.--Pesticide-disposal and monitoring sites, Quinn River Valley (Orovada subarea).

Middle Reese River valley site (Lander County).--The disposal site is on alluvium at the point of ground-water underflow from Antelope Valley to the Middle Reese River Valley (fig. 13). Crosthwaite (1963, p. 15) estimated that the hydraulic gradient from Antelope Valley to Middle Reese River Valley is approximately 30 feet per mile and that the volume of underflow between valleys is about 6,000 acre-feet per year. Depths to ground water at the site probably range from 70 to 90 feet. Ground-water samples are collected at a well about 1.5 miles southeast of the disposal site, off the probable path of ground-water flow from the site.

Lovelock valley site (Pershing County).--The Lovelock Valley disposal site lies on alluvium on the southwest flank of a bedrock outcrop about 3.5 mi west of Lovelock (fig. 14). Probable paths of shallow ground-water flow from the site are downslope to the south, then curving southwest to a possible discharge along the east half of section 31. Sample points are two wells east of the site; neither is along a probable flow path.

Carson Desert site (Churchill County).--The disposal site is on a series of lakebed deposits in the Carson Desert about 7.5 mi north of Fallon (fig. 15). Depth to water at the site is about 28 ft; the shallow ground-water system flows to the northeast with a gradient of about 1.7 feet per mile (Olmsted and others, 1975, p. 105). Near-surface upward vertical gradients may exist because the area discharges ground water by open-water and bare-soil evaporation. Ground water is monitored at a shallow dug well about 0.5 mile east of the disposal pit, which is off probable flow paths from the disposal area.

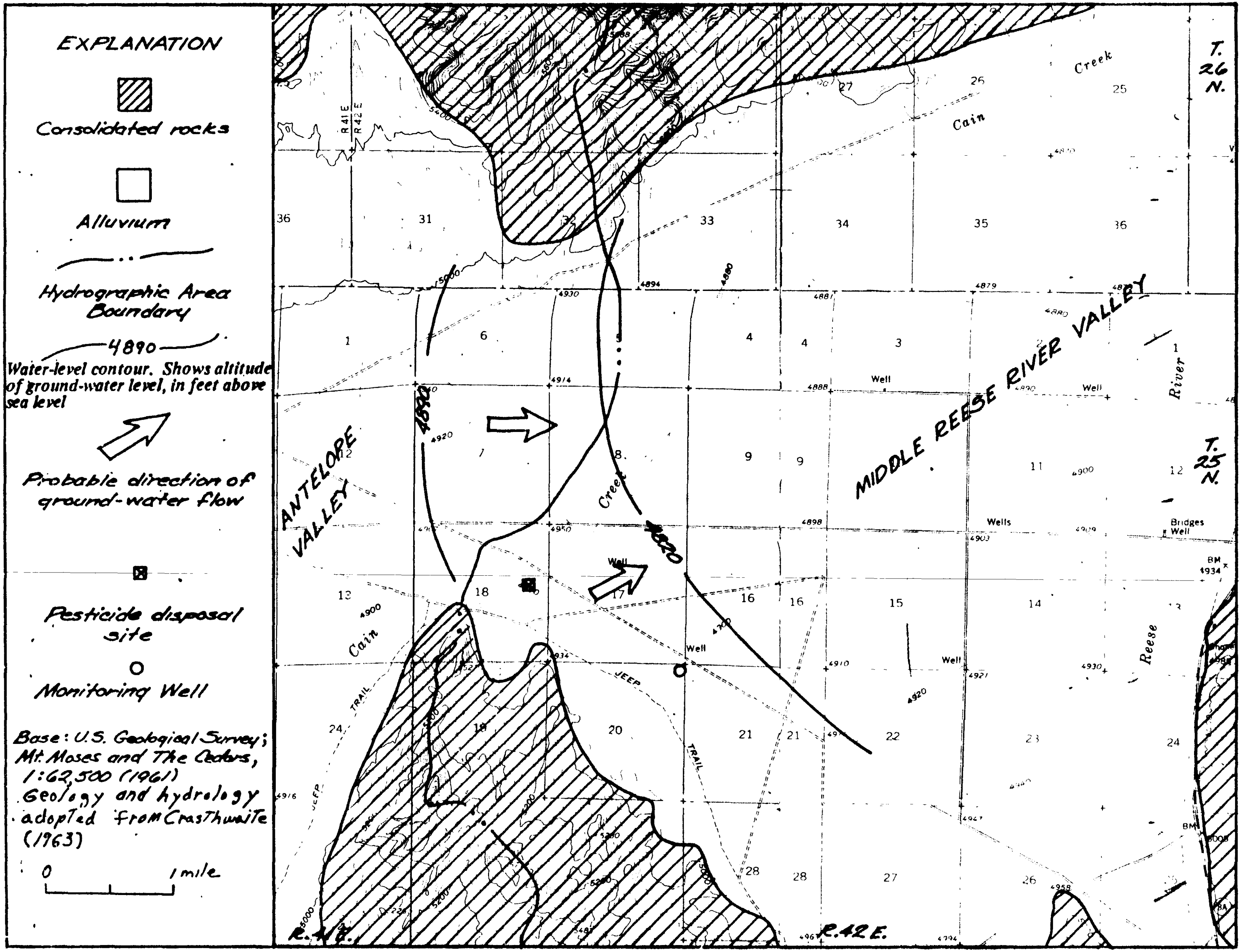


FIGURE 13.--Pesticide-disposal and monitoring sites, Middle Reese River Valley.

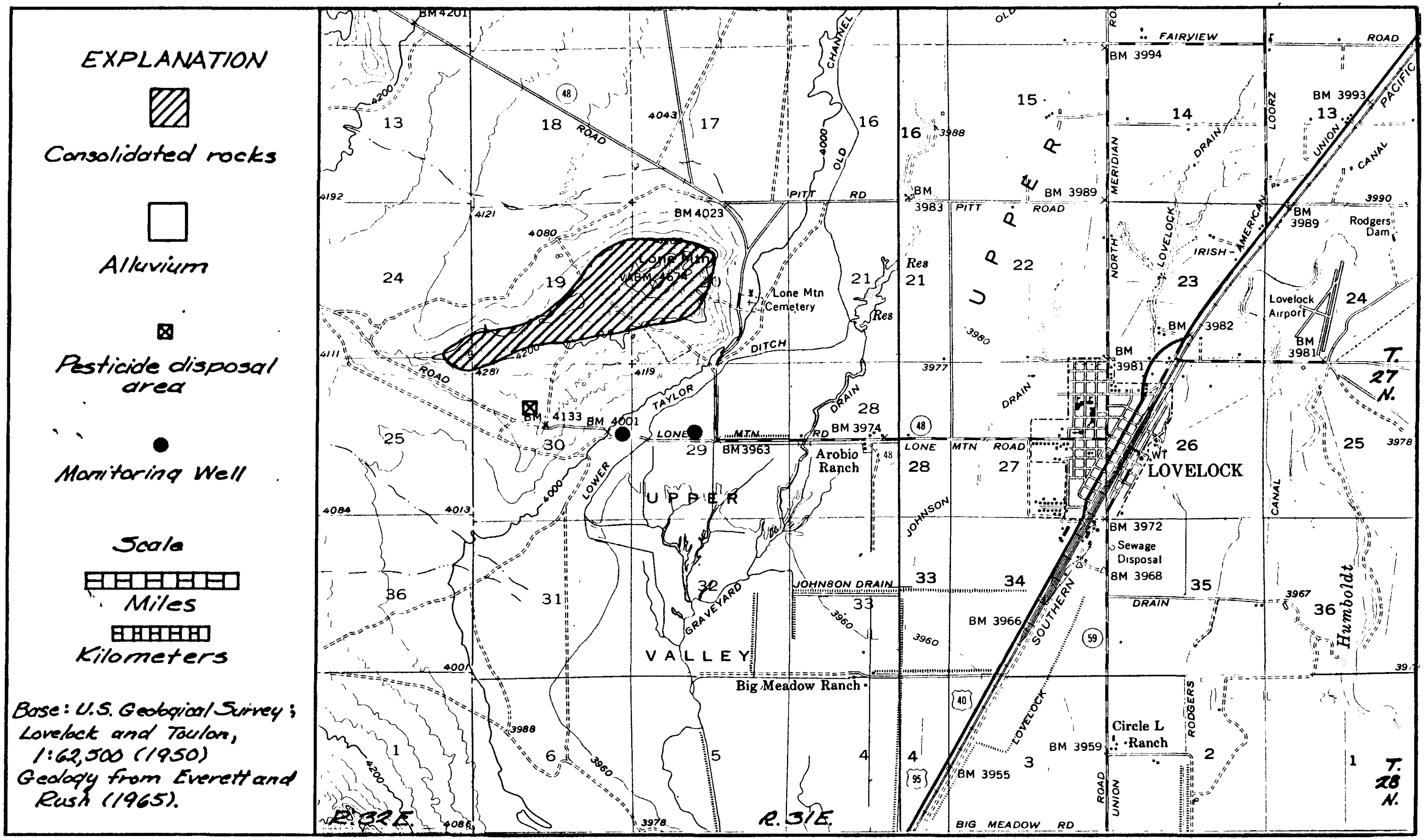


FIGURE 14.--Pesticide-disposal and monitoring sites, Lovelock Valley.

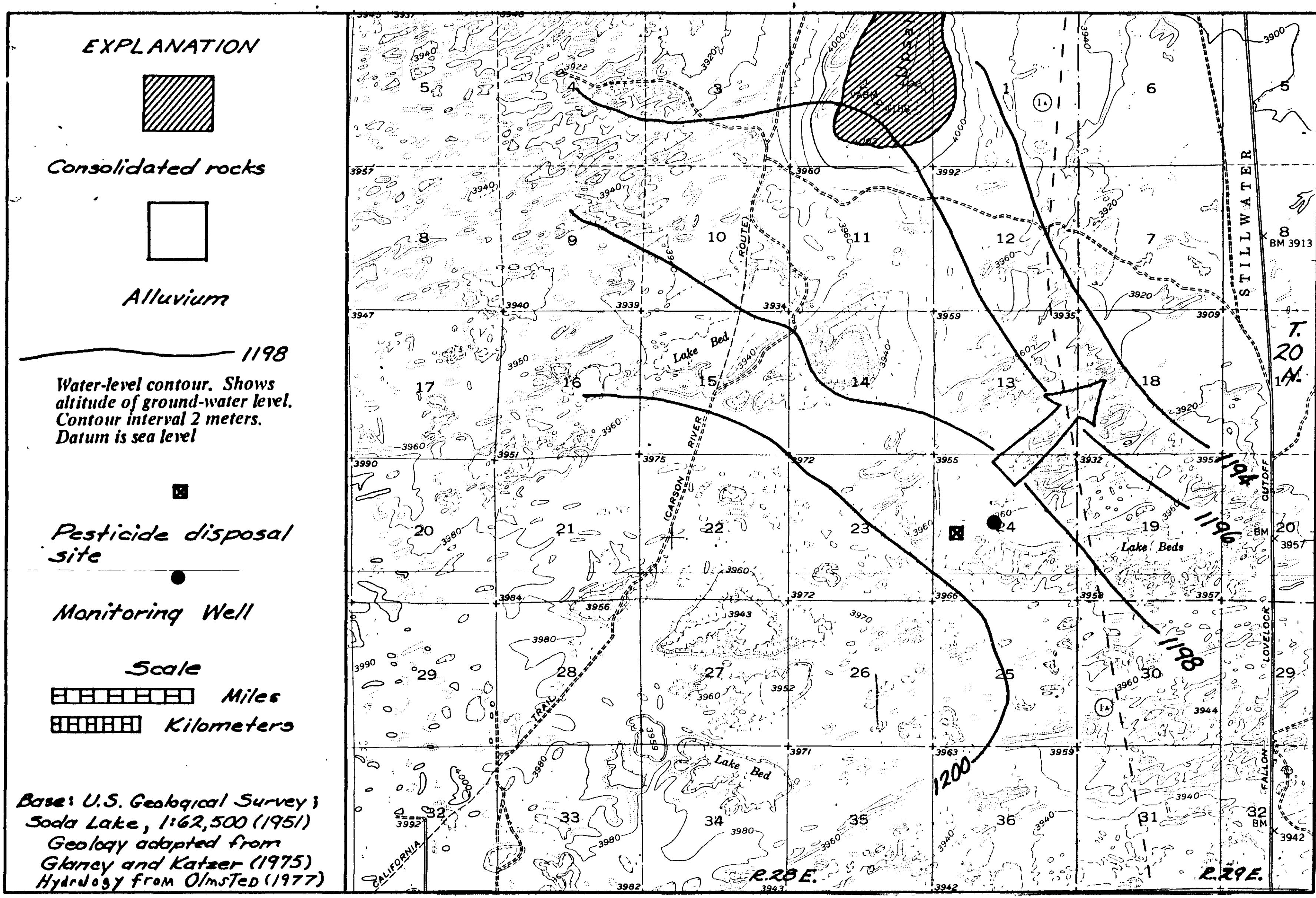


FIGURE 15.--Pesticide-disposal and monitoring sites, Carson Desert.

The probability of significant contamination of ground water beneath or adjacent to the four pesticide disposal sites is quite low. Many organic pesticides are only slightly soluble in water, and most soils have a high absorption capacity for commonly used pesticides; thus, the concentration of pesticides in percolating waters is likely to be greatly attenuated in moving through the unsaturated zone. The expected rates of transport of organic pesticides in the saturated zone are likely to be low; for example, one study involving the injection of DDT into a sand aquifer failed to detect any breakthrough of DDT in an observation well 33 feet from the injection well (Scalf and others, 1968). Points at which ground water is being monitored as of 1977 are too far-removed from the actual disposal grounds to permit the detection of any potential pesticide movement, and the sample points are not on probable flow paths from the disposal sites. Effective monitoring of these sites would require the drilling of observation wells to provide an early warning of pesticide movement. Provisions should be made to collect samples both in the unsaturated zone and at the top of the first saturated zone underlying each site. In addition to the present analyses for organic pesticides, samples should also be analyzed for other possible contaminants such as arsenicals and mercury compounds that might be associated with agricultural use of pesticides. A properly designed monitoring program for each site would be expensive, and perhaps would not be warranted by the low risk of contamination.

Federal Agencies

U.S. Bureau of Land Management

As of 1977, BLM had no ongoing program for monitoring ground water on the public lands in Nevada. Environmental assessments of BLM Planning Units as of 1977 are being made as part of a review of land-management practices; these assessments include a one-time sampling of well and spring water on the public lands. Samples are collected by BLM personnel and are analysed under contract by a private laboratory. Analyses include the following:

- alkalinity (carbonate/bicarbonate)
- arsenic*
- calcium
- chloride
- copper*
- dissolved solids
- fecal coliform
- fecal streptococcus
- iron*
- manganese
- nitrate/nitrite
- pH
- phosphate, ortho
- potassium
- sodium
- sulfate
- total coliform
- turbidity
- zinc*

Asterisks indicate analyses included only if site is associated with mine drainage.

Data will be published in a summary report on each Planning Unit. These data will form a valuable addition to the available water-quality data base for sparsely populated areas of the State. The utility of the data is enhanced by the uniformity of sampling and analytical procedures.

U.S. Bureau of Reclamation

The Lower Colorado Regional Office of the U.S. Bureau of Reclamation is supervising monitoring of surface and wastewater at the Mohave Generating Station in the Colorado River Valley, Clark County. The facility is on a dissected alluvial fan on the west side of the Colorado River about 2 miles south of Davis Dam. Alluvium at the site consists of nearly horizontal interbedded deposits of gravel, sand, and clay. The pre-operational ground-water level was about 210 feet below land surface (August 1970). The station consists of two 755-megawatt steam-generating units using coal fuel delivered in a water slurry via a 275-mile pipeline from Black Mesa, Ariz. Process water is disposed of in five evaporation ponds; fly ash is disposed of in a small isolated drainage network blocked at the lower end by a retention dam. Excess coal slurry is stored in two circular ponds adjacent to the plant. All ponds are lined either with soil cement or asphalt.

Four sources of potential ground-water contamination exist at the site: (1) Leakage from evaporation ponds, (2) leakage from the coal-slurry storage ponds, (3) percolation of leachate from the ash-disposal area, and (4) accidental spills from operational problems. Two networks of monitoring wells are operated at the site (fig. 16): (1) An on-site network of 30 wells sampled monthly by the plant operator, Southern California Edison, and (2) an off-site network of five wells sampled quarterly by the U.S. Geological Survey (table 11).

On-site wells 3 and 12 monitor background quality upgradient from the plant; the remainder of the on-site wells monitor the hydrologic system downgradient from various potential sources of contamination. The following hydrologic and water-quality data are obtained for on-site wells:

Monthly		Annually
water level*	nitrate	aluminum
calcium*	fluoride	arsenic
magnesium*	boron	chromium
sodium*	pH*	copper
potassium*	specific conductance*	iron
carbonate*	dissolved solids	lead
bicarbonate*		manganese
sulfate*		tin
chloride*		zinc

Off-site wells monitor background quality of public and private domestic supplies at the periphery of the facility. Quarterly measurements are made of water levels and samples are analyzed for the items indicated by asterisk in the tabulation above, as well as silica and nitrate plus nitrite. Analytical results are on file at the Bureau of Reclamation office in Boulder City.

TABLE 11.—*USGS monitoring wells at Mohave Generating Station*

Site use: H, private domestic supply; P, public supply.
Aquifers: 110VLFL, Pleistocene series, valley-fill deposits; 111FLDP, Holocene series, flood-plain deposits.

Local site number	Owner	Site use	Land-surface altitude (feet)	Total depth (feet)	Casing diameter (inches)	Perforated or screened interval (feet)	Representative depth to water: Feet	Representative depth to water: Date	Aquifer tapped	Remarks
213 S32 E66 13CDD1	Nevada Club	P	520	64	6	--	23	2-75	111FLDP	Downgradient from evaporation ponds 1 and 2.
213 S32 E66 13DBB1	Riverside Trailer Court	P	521	92	6	84-89	24	5-74	111FLDP	Downgradient from evaporation ponds 1 and 2.
213 S32 E66 24BBA1	Sundance Shores	P	727	480	11	240-480	227	2-75	110VLFL	Downgradient from evaporation ponds 1 and 2.
213 S32 E66 33AAA1	John Knight	H	507	50	—	--	26	4-76	111FLDP	West of probable flow path from site.
213 S32 E66 33BBB1	Cromer	H	511	96	—	90-96	21	11-74	111FLDP	West of probable flow path from site.

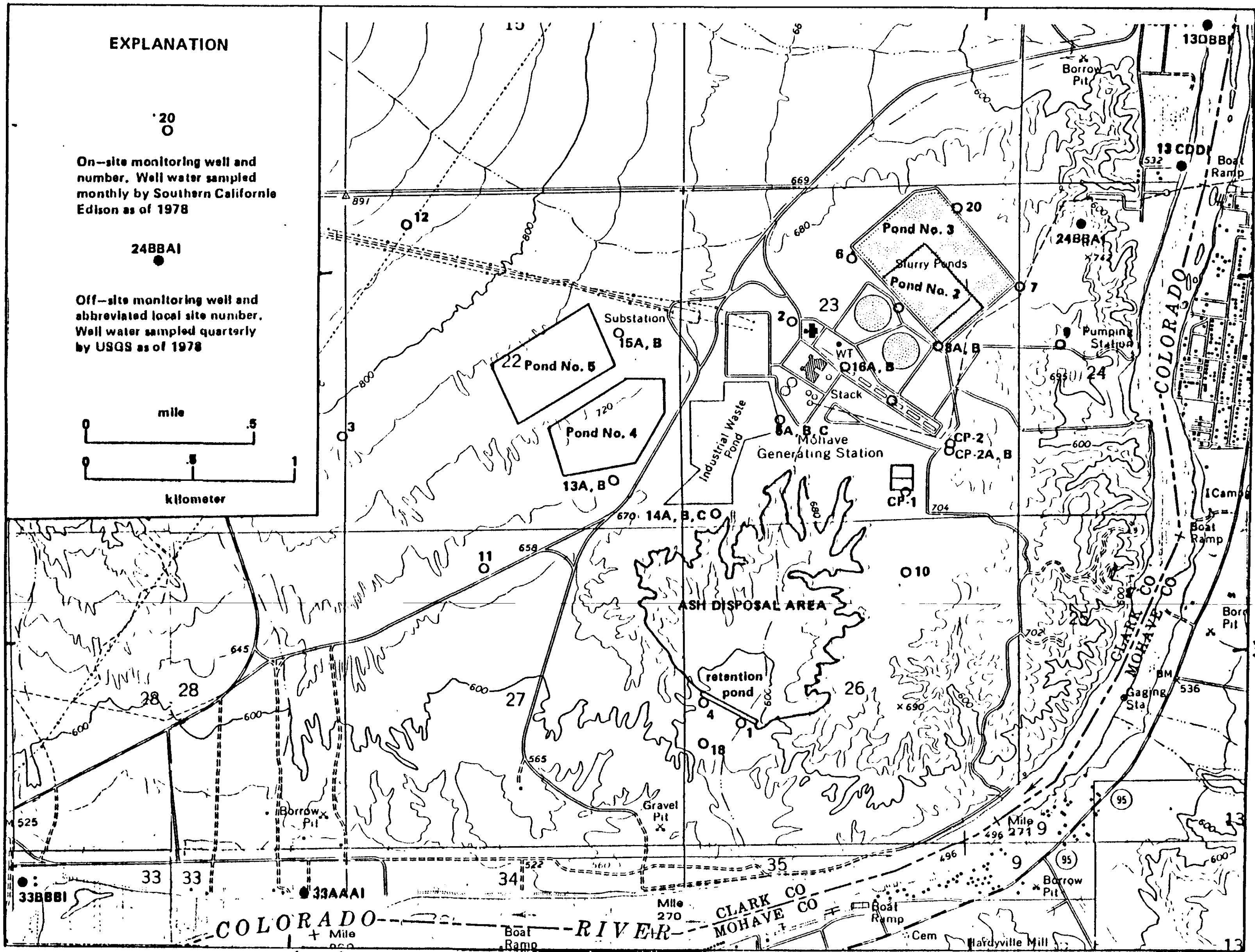


FIGURE 16.--Monitoring wells at Mohave Generating Station, 1978

On-site sampling points appear to be well located with respect to the monitoring targets and the hydrologic system. The effectiveness of the off-site wells in detecting potential movement of contaminants from the site is questionable. Well 24BBA1 probably would be affected by plumes moving downgradient from the number 2 and 3 evaporation ponds. The remaining wells are close to the river and producing from zones more likely to reflect the quality of recharge from the river than contamination from the site.

U.S. Geological Survey

Water-quality data for Nevada ground water have been collected from many of the valleys in the State during a series of water-resource studies by the USGS. These data have been published in individual project reports (see table 9) and are on file in the USGS Nevada office in Carson City. Beginning in 1976, data on ground-water quality and water levels collected by the Nevada office have also been summarized by water year (October through September) in the annual series of data reports entitled "Water Resources Data for Nevada." An intensive data-collection program by the USGS Nuclear Hydrology Program has been underway since 1956 in central Nevada and at the Nevada Test Site and vicinity. Water-quality data collected as part of these projects have been released in a series of administrative reports and are on file in the Nuclear Hydrology Program office in Denver, Colo. Since about 1972, water-quality data collected by both USGS offices also have been stored in the USGS WATSTORE computer files.

The sampling and analysis of ground water by the USGS generally have followed a standard set of procedures presented largely by Rainwater and Thatcher (1960), Brown and others (1970), Fishman and Downs (1966), and Skougstad and others (1979). The standardization of procedures greatly enhances the utility of these ground-water analyses as part of a statewide historical data base.

Ground-water sampling by the USGS in Nevada has, for the most part, been done on a one-time basis in the course of areal water-resources investigations. Repetitive sampling in a monitoring context has been done only at the Mohave Generating Station in the Colorado River Valley (table 11). Other USGS projects include three that involved documentation of the subsurface transport of contaminants: (1) An evaluation of the effect of seepage from tailings ponds at Weed Heights in Lyon County (Seitz and others, 1982); (2) an investigation of the potential for transport of radioactive wastes in the unsaturated zone at the low-level radioactive-waste-disposal facility at Beatty in Nye County (Nichols, 1986), and (3) a study of contamination by effluents from septic tanks at Topaz Lake (Nowlin, 1976; 1982). Long-term monitoring is not a design function of any of these projects.

U.S. Environmental Protection Agency

Under a Memorandum of Understanding with the U.S. Department of Energy (DOE), EPA's Environmental Monitoring Support Laboratory in Las Vegas has been operating a long-term Hydrological Monitoring Program since 1972 to evaluate the possible movement of radionuclides from the Nevada Test Site (NTS) and other areas of DOE nuclear testing in Nevada. The development of this network was discussed in reports by the U.S. Geological Survey (1972) and Humphrey (1976); analytical procedures and results of sampling were discussed in annual summary reports (U.S. Environmental Protection Agency, 1974; 1976a). This network is the only effectively designed long-term program for monitoring ground-water quality in operation within Nevada as of 1977, and as such, it warrants a more detailed discussion than the previously described programs.

Stations in the network are classified by sampling frequency into three groups: (1) Monthly stations, (2) semi-annual stations, and (3) annual stations. The 1977 network consists of 56 stations (49 wells and 7 springs): 11 monthly, 23 semi-annual, and 22 annual. Locations of stations in the network are shown on plate 1 and in more detail in figures 17-19; sampling and analytical schedules are presented in table 12, and information on specific network sites in table 13. Monthly stations were selected to monitor potential movement of radionuclides in ground water within and out of the NTS to provide warning of any increase in radioactivity in public supply wells at the NTS and to provide early warning for movement of contaminated water along most probable paths of flow leaving the NTS. Semi-annual sites include industrial supply wells within the NTS, representative sites along potential but less probable flow paths downgradient from the NTS, and control stations that are sufficiently far from probable flow paths to preclude the likelihood of contamination. Annual stations include: (1) monitoring at locations of two off-NTS nuclear tests, and (2) monitoring of background quality at 10 sites around the NTS.

Sampling locations were selected for each monitoring area to meet the objectives of one of the three classes described above. Data on the geology and hydrology of the area surrounding each target were examined, probable paths of ground-water flow were defined, major areas of ground-water withdrawals were identified, and selection of each site was based on its position in the geohydrologic system relative to the particular monitoring objective.

TABLE 12.--*Sampling schedule for DOE/EPA long-term Hydrological Monitoring Network*

Month	Chemical analyses[1]	Radiological analyses (A)[2]	Radiological analyses (B)[3]	Radiological analyses (C)[4]	Field parameters[5]
		Monthly sites			
January	X	X	X	X	X
February		X		X	X
March		X		X	X
April		X		X	X
May		X		X	X
June		X		X	X
July	X	X	X	X	X
August		X		X	X
September		X		X	X
October		X		X	X
November		X		X	X
December		X		X	X
		Semi-annual sites			
January	X	X	X	X	X
July		X	X	X	X
		Annual sites			
Spring	X	X	X	X	X

[1] Chemical analyses include: Dissolved (filtered sample) silica, calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, ammonia, phosphorus, aluminum, iron, lithium, manganese, strontium; total (unfiltered sample) nitrate plus nitrite, alkalinity; dissolved solids by summation.

[2] Group A analyses include: Gross alpha and beta, gamma scan, tritium.

[3] Group B analyses include: Isotopes of plutonium and uranium.

[4] Group C analyses include: Radium-226 (when gross alpha >3 pCi/L), strontium-89 and strontium-90 (when gross beta >3 pCi/L); in January and July, strontium-89 and strontium-90 are determined regardless of gross-beta concentration.

[5] Field parameters include: Water level (when practical), water temperature, specific conductance, pH.

TABLE 13.--*DOE/EPA long-term hydrologic monitoring sites*

Sampling frequency: A, annual; S, semi-annual, M, monthly, Parameters analyzed as specified in table 12.
Site use: H, domestic supply; I irrigation; N, commercial or industrial; O, observation; P, public-supply; T, test.
Aquifer tapped: 100VLFL, Quaternary System, valley-fill deposits; 110ALVF, Holocene Series, alluvial fan

Map No.	Local site number; (latitude/longitude); Nevada coordinates, Central Zone	Site name; (STORET No.)	First year of record	Monitoring target	ground-water flow system	Sam-pling fre-quency	Owner	Site use	Land-surface altitude (feet)
1	101 N16 E31 36CDB1 (391208/1182710)	Hunts Station, DRI 1 (023293)	1972	Shoal Event	Four-Mile Flat	A	P. Cushman	S	4,192.7
2	101 N16 E32 18CCA1 (391440/1182620)	Flowing well, DRI 2 (023291)	1972	Shoal Event	Four-Mile Flat	A	P. Cushman	S	3,900
3	101 N16 E32 29ACD1	Well H-3	1972	Shoal	Four-Mile	A	DOE	T	4,232
4	124 N16 E33 03CBD1 (391630/1181615)	Frenchman Sta-tion (023004)	1972	Shoal Event	Fairview Valley	A	E. Weyher	P	4,153.3
5	124 N16 E33 32CBC1 (391230/1181830)	Well HS-1 (023285)	1972	Shoal Event	Fairview Valley	A	DOE	T	4,243.76
6	141 N04 E44 08CC1 (381230/1170430)	Tonopah City Supply (083131)	1975	Back-ground	Ralston Valley	A	Tonopah Water Co.	P	—
7	146 S09 E46 35A1 (370700/1164740)	Road D Windmill (992579)	1974	Back-ground W of NTS	Sarcobatus Flat	S	BLM	S	4,100
8	147 S07 E50 (372030/1162208) N93138 E587843	Well UE19 GS (991473)	1973	NTS	Pahute Mesa	M	DOE	N	6,719
9	147 S08 E51 06DAC1 (371300/1161500)	Well UE19 C (991581)	1975	NTS Area 19	Pahute Mesa	M	DOE	T	6,919
10	148 S02 E47 07AA1 (374630/1164400)	Tonopah Test Range well 6 (083182)	1975	Back-ground	Sarcobatus Flat	A	—	O	5,510
11	156 N09 E52 (381230/1161030)	Warm Springs: Twin Springs Ranch (083051)	1975	Faultless Event	Hot Creek Valley	A	Twin Springs Ranch	S	5,150
12	156 N06 E51 15A1 (382210/1161310)	Bluejay Maint. Sta. well (073052)	1972	Faultless Event	Hot Creek Valley	A	State of Nevada	H	5,360
13	156 N07 E50 24DB1 (382700/1161735)	Bluejay Spring (073403)	1972	Faultless Event	Hot Creek Valley	A	—	S	5,350
14	156 N08 E50 29DA3 (383110/1162215)	Hot Creek Ranch Spring (073084)	1972	Faultless Event	Hot Creek Valley	A	Hot Creek Ranch	S	—
15	156 N08 E51 34CDD1 (373015/1161315)	6-Mile well (073415)	1972	Faultless Event	Hot Creek Valley	A	Hutchinson	S	5,500
16	156 N09 E51 (373834/1161245)	Test Well HTH-1 (073405)	1972	Faultless Event	Hot Creek Valley	A	DOE	T	6,011

TABLE 13.—*DOE/EPA long-term hydrologic monitoring sites*—Continued

deposits; 112ALVFO, Pleistocene Series, alluvial-fan deposits; 112LKBP, Pleistocene Series, lake-bed deposits; 120VLCC, Tertiary System, volcanic rocks; 200GRNC, Mesozoic Era, granitic rocks; 300CCSM, Paleozoic Era, clastic rocks; 300CRBN, Paleozoic Era, carbonate rocks; 340DVMP, Mississippian-Devonian Series, undifferentiated rocks.

	Site construction									
			Casing				Representative depth to water			
Map No.	Year com-pleted	Total depth (feet)	Diameter (inches)	Depth (feet)	Perforated interval (feet)	Aquifer tapped	Feet	Date	Rep-resent-ative yield (gal/min)	Remarks
1	—	315	6	—	—	112LKBP	205	6-62	7	SW of probable flow path from ground zero.
2	—	—	4	—	—	112LKPB	flows	6-62	4	do.
3	1962	480	16	0-212	—	—	—	—	—	do.
			10 3/4	0-373	258-358	112ALVFO	328	7-76	33	
			8 5/8	0-458	322-455	200GRNC				
4	—	280	—	—	—	112LKBP	224	4-62	5	do.
5	1962	699	10 3/4	0-520	415-510	112ALFO	300	2-62	66	do.
			8 5/8	510-685	560-675					
6	—	—	—	—	—	110ALVF	—	—	—	—
7	—	—	10	—	—	100VLFL	96	2-62	—	—
8	1965	7,500	13 3/8	0-2,650	none	120VLFL	2,045	5-65	221	—
			8 5/8	4,113-4,349	none					
9	1964	8,489	—	—	—	—	—	—	—	—
10	1963	743	8	—	—	100VLFL	351	2-63	90	—
11	—	—	—	—	—	100VLFL	—	—	—	—
12	—	—	10	—	—	100VLFL	43	10-65	—	—
13	—	—	—	—	—	100VLFL	—	—	5	—
14	—	—	—	—	—	300CRBN	—	—	—	—
15	1948	195	5	—	—	—	100	1948	—	Log No. 973.
16	1967	3,704	13 3/8	0-3,704	—	—	—	—	—	—
			9 5/8	0-3,704	700-850	—	533	8-67		
					950-1,150	—				
					1,400-1,500	—				
					1,660-1,770	100VLFL				
					1,850-1,980	—				
					2,200-2,300	—				
					2,400-2,460	—				
					2,640-2,710	—				
					2,950-3,010	—				

Map No.	Local site number; (latitude/longitude); Nevada coordinates, Central Zone	Site name; (STORET No.)	First year of record	Monitoring target	Ground-water flow system	Sampling frequency	Owner	Site use	Land-surface altitude (feet)
17	156 N09 E51 (383734/116/245)	Test well HTH-2 (073406)	1972	Faultless Event	Hot Creek Valley	A	DOE	T	6,011
18	158A S08 E54 (372545/1154954) N914990 E742272	Well Water-town 3 (992495)	1973	Background adjacent to NTS	Ash Meadows	S	USAF	P	4,446
19	159 S08 E53 34 (371230/1160215) N895709 E682084	Well UE15D (992475)	1973	NTS Area 15	Ash Meadows	S	EPA	P	4,586
20	159 S09 E52 (370945/1160529) N880000 E668720	Well 2 (991477)	1974	NTS Area 2	Ash Meadows	S	DOE	P,N	4,470
21	159 S10 E52 (370418/1160445) N846600 E672600	USGS Test Well D (992479)	1976	NTS Area 3	Ash Meadows	S	DOE	O	4,150
22	159 S10 E52 (370148/1160510) N837000 E666000	Well UE1C (992481)	1976	Old surface-shot area	Ash Meadows	S	DOE	O	4,202
23	159 S10 E53 24BAB1 (370320/11601200) N841255 E687998	Well U3CN-5 (991456)	1972	NTS Area 3, Bilby Event	Ash Meadows	M	DOE	O	4,012
24	159 S10 E53 26BC1 (370142/1160211) N833000 E684000	Well A (991458)	1972	NTS Area 3	Ash Meadows	M	DOE	P,N	4,006
25	159 S11 E53 (365848/116008) N812500 E693010	USGS Test Well B (992485)	1976	NTS Area 6	Ash Meadows	S	DOE	O	3,929
26	159 S12 E53 06CCB1 (365500/1160039) N79083 E692061	Well C (991460)	1972	NTS Area 6	Ash Meadows	M	DOE	N,P	3,921
27	159 S12 E53 06 (365500/1160039) N790011 E692132	Well C-1 (992487)	1973	NTS Area 6	Ash Meadows	S	DOE	P	3,921
28	160 S13 E53 (364915/1155840) N760133 E700997	Well UE5C (992489)	1973	NTS Area 5	Ash Meadows	S	DOE	N,P	3,216
29	160 S13 E53 (364730/1155805) N747359 E704263	Well 5 B (992491)	1973	NTS Area 5	Ash Meadows	S	DOE	N,P	3,092
30	160 S13 E54 31BAA1 (364030/1155730) N741644 E706305	Well 5 C (991462)	1972	NTS Area 5	Ash Meadows	M	DOE	N,P	3,081
31	160 S14 E52 03DD1 (364500/1160700) N731853 E661153	USGS Test Well F (992493)	1976	NTS Area 410	Ash Meadows	S	DOE	T	4,143
32	161 S16 E56 08D1 (364440/1154030) N668000 E790000	USAF No. 1 (992280)	1973	Background, SE of NTS	Ash Meadows	S	USAF	P	3,118

TABLE 13.—*DOE/EPA hydrologic monitoring sites*—Continued

Map No.	Year completed	Total depth (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Perforated interval (feet)	Aquifer tapped	Representative depth to water: Feet	Representative depth to water: Date	Representative yield (gal/min)	Remarks
17	1967	1,000	—	0-1,000	500-1,000	100VLFL	—	—	—	—
18	1959	371	10 3/4	0-366	160-170 195-200 243-302 312-322 346-366	100VLFL do. do. do. do.	107	11-59	180	—
19	1962	5,940	12 8 5/8 7 4 1/4	0-24 0-763 0-1,784 1,667-5,400	— — — —	— — -- 300CRBN	667	10-63	211	Public supply for EPA expiramental farm.
20	1962	3,422	11 3/4 8 5/8 6 5/8	0-1,465 0-2,550 2,500-3,422	— — 2,700-2,950 3,164-3,412	— — 300CRBN —	2,054	3-62	144	Public supply for Area 2 camp.
21	1961	1,950	12 3/4 10 3/4	0-1,700 1,650-1,900	— 1,773-1,882	— 300CCSM	1,732	1-61	—	Upper clastic aquitard.
22	1964	1,880	10 3/4	0-70	none	120VLCC 300CRBN	1,294	10-71	—	Upper carbonate aquifer.
23	1966	3,026	13 3/8 9 5/8 6 5/8	0-1,418 0-2,385 2,321-2,832	— — —	300CRBN — —	1,625	4-66	—	—
24	1960	1,870	12 3/4 10 3/4	0-1,555 1,547-1,870	— 1,608-1,870	— 100VLFL	1,620	11-71	129	—
25	1961	1,675	12 3/4 10 3/4	0-1,539 1,365-1,675	1,432-1,452 1,512-1,656	120VLCC do.	1,507	10-71	—	—
26	1962	1,701	12 3/4 10 3/4	0-1,373 1,381-1,621	— 1,281-1,621	— 300CRBN	1,543	10-71	459	Alternate public supply.
27	1962	1,650	24	0-924 850-1,650	— 1,560-1,650	-- 300CRBN	1,543	8-63	300	Public supply for CP area.
28	1964	2,682	20 13 3/8	0-77 0-1,682	— 1,000-1,3000	— 100VLFL	806	10-71	335	Backup public supply for Area 11.
29	1951	900	12 3/4 10 3/4	0-460 440-900	— 700-900	-- 100VLFL	683	10-71	234	Public supply for Area 11, backup supply for Mercury.
30	1954	1,200	12 3/4 10 3/4	0-20 0-1,187	— 887-1,1187	— 100VLFL	689	5-61	310	do.
31	1962	3,400	12 3/4 8 5/8	0-1,200 0-3,140	— —	— 300CRBN	1,736	10-71	—	—
32	1942	604	8	0-304	245-304	100VLFL	34	3-63	300	Public supply for Indian Springs AFB.

Map No.	Local site number; (latitude/longitude); Nevada coordinates, Central Zone	Site name (STORET No.)	First year of record	Monitoring target	Ground-water flow system	Sampling frequency	Owner	Site use	Land-surface altitude (feet)
33	161 S16 E56 16 (363500/1150000)	Sewer Co., Inc. well no. 1	1973	Background, SE of NTS	Ash Meadows	S	Indian Springs Sewer Co.	P	3,200
34	162 S20 E53 14 (361230/1155930)	Pahrump Calvada no. 3	1975	Background, S of NTS	Pahrump Valley	A	—	P	—
35	172 N03 E57 07 (380830/1153630)	Adaven Spring (083056)	1975	Background, NE of NTS	—	A	—	—	—
36	173A N01 E53 32DBB1 (375330/1160230)	Diablo Maintenance Sta. (0835053)	1975	Background, N of NTS	—	A	State of Nevada	H	—
37	173B N05 E55 34ABA1 (381500/1154330)	Nyala, Sharps Ranch	1975	Background, N of NTS	—	A	Sharp	S	—
38	209 S05 E60 10D1 (373200/1151400)	Hiko, Crystal Springs (083034)	1975	Background, NE of NTS	—	A	—	—	—
39	209 S07 E61 05CC1 (372200/1152500)	Alamo	1975	Background, NE of NTS	—	A	—	—	—
40	212 S20 E60 11CAAA1 (361030/1151130)	Las Vegas Valley Water Dist. well 28 (083580)	1975	Background, SE of NTS	Las Vegas Valley	A	—	P	2,287
41	225 S16 E53 05ACA1 (363538/1160107) N670902 E684772	Well Army no. 1 (991464)	1972	NTS Area 22	Ash Meadows	M	DOE	P	3,154
42	227A S13 E50 (364557/1162325)	Well J-13 (991577)	1974	NTS Area 25	Pahute Mesa	M	DOE	P	2,390
43	227A S14 E50 06ACC1 (364557/1162325) N733509 E581011	Well J-12 (991454)	1972	NTS Area 18	Pahute Mesa	S	DOE	P,N	3,128
44	227B S08 E50 (370942/1161730) N907395 E571439	Well U-20A-2 (991450)	1973	NTS Area 20	Pahute Mesa	M	DOE	N	6,472
45	227B S09 E50 (370800/1162700) N868100 E564700	Well UE 18R (992471)	1976	NTS Area 10	Pahute Mesa	A	DOE	O	5,570
46	277B S09 E51 (370942/1161730) N879468 E609999)	Well 8 (991452)	1973	NTS Area 18	Pahute Mesa	M	DOE	P,N	5,695
47	228 S11 E47 10CCB1 (370000/1164220)	Goss Springs (992571)	1973	Flow W of NTS	Pahute Mesa	S	—	N	3,800
48	228 S11 E48 01DD1 (370050/1163318)	Coffers Windmill (991466)	1972	Flow W of NTS	Pahute Mesa	M	G. Coffer	S	4,390

TABLE 13.—*DOE/EPA hydrologic monitoring sites*—Continued

Map No.	Site construction: Year completed	Total depth (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Perforated interval (feet)	Aquifer tapped	Representative depth to water: Feet	Representative depth to water: Date	Representative yield (gal/min)	Remarks
33	1963	590	10 3/4	0-550	60-550	100VLFL	54	6-63	—	Public supply for Indian Springs.
34	—	—	—	—	—	—	—	—	—	No well-construction data available.
35	—	—	—	—	—	—	—	—	—	—
36	1957	292	8	0-292	245-292	100VLFL	225	5-57	—	Log No. 3772.
37	—	75	6	0-75	35-75	100VLFL	—	—	—	—
38	—	—	—	—	—	—	—	—	—	—
39	—	—	—	—	—	—	—	—	—	—
40	1964	1,003	20	0-160	—	100VLFL	246	3-75	3,500	Log No. 8033.
			16	0-1,000	307-965	do.				
41	1962	1,946	13 3/8	0-611	—	—	785	11-63	450	Public supply for Mercury.
			10 3/8	0-1,263	800-1,050	300CRBN				
			7 5/8	1,197-1,360	—	—				
42	1963	3,488	18	0-435	—	—	2,390	2-64	688	—
			13 3/8	0-1,301	996-1,301	122VLCC				
			11 3/4	1,301-1,546	1,301-1,386	do.				
			5 1/2	1,484-3,385	2,690-3,312	do.				
43	1968	1,139	12 3/4	0-887	793-868	120VLCC	741	1-60	821	—
44	1964	4,500	18	0-80	—	120VLCC	2,066	2-65	168	—
			13 3/8	0-860	—	—				
			8 5/8	0-2,356	—	—				
45	1967	5,004	10 3/4	0-1,629	none	120VLCC	1,372	1-68	—	—
46	1963	5,490	11 3/4	0-2,031	1,250-1,300	122VLCC	1,068	1-63	580	—
					1,450-1,500	do.				
					1,630-1,780	do.				
			7 5/8	1,942-2,936	2,038-2,070	do.				
					2,137-2,170	do.				
47	—	—	—	—	—	100VLFL	—	—	50	—
48	—	500	—	—	—	—	350	1970	0.5	—

TABLE 13.—*DOE/EPA long-term hydrologic monitoring sites*—Continued

Map No.	Local site number; (latitude/longitude); Nevada coordinates, Central Zone	Site name (STORET No.)	First year of record	Monitoring target	Ground-water flow system	Sampling frequency	Owner	Site use	Land-surface altitude (feet)
49	228 S12 E47 07DBD1 (365420/1164530)	Beatty City well (992569)	1973	Flow W of NTS	Pahute Mesa	S	Beatty Water Co.	P	2,788
50	230 S13 E47 35BAD1 (364600/1164110)	NECO well (992407)	1973	Flow SW of NTS	Pahute Mesa	S	Nuclear Engineering Co.	N	—
51	230 S15 E50 18CDC1 (363840/1162350)	Lathrop Wells (992465)	1976	Flow S of NTS	Pahute Mesa (discharge area)	S	Lathrop Wells	P	2,665
52	230 S17 E50 09AD1 (362930/1162030)	Fairbanks Springs (992567)	1973	Flow S of NTS	Ash Meadows (discharge area)	S	—	P	2,280
53	230 S17 E50 14CAC1 (362822/1161938)	Well 17S/50E-14CAC (992565)	1973	Flow S of NTS	Ash Meadows (discharge area)	S	Spring Meadows Farms	I	2,340
54	230 S18 E50 03A1 (362510/1161920)	Crystal Pool Spring (992561)	1973	Flow S of NTS	Ash Meadows (discharge area)	S	—	P,N	2,197
55	230 S18 E51 07DB1 (362403/1161608)	Well 18S/51E-7DB (992563)	1973	Flow S of NTS	Ash Meadows (discharge area)	S	Spring Meadows Farms	O	2,315
56	N22 E07 30 (355850/1161620)	Shoshone Spring (992461)	1973	Background S of NTS	Amargosa Desert	S	—	P,N	1,620

TABLE 13.—*DOE/EPA hydrologic monitoring sites*—Continued

Map No.	Year com- pleted	Total depth (feet)	Site construction: Casing: Diameter (inches)	Casing: Depth (feet)	Perforated interval (feet)	Aquifer tapped	Representative depth to water: Feet	Date	Rep- resent- ative yield (gal/ min)	Remarks
49	1965	300	8	—	—	100VLFL	282	7-62	2	Public supply for Beatty.
50	1961	575	8	0-573	—	100VLFL	—	—	—	—
51	1955	507	10 3/4	0-507	—	100VLFL	347	6-62	20	—
52	—	—	—	—	—	100VLFL/ 300CRBN	—	—	—	Public supply for about 10 persons.
53	—	92	6 5/8	92	—	300CRBN	flows	—	24	Log No. 10137.
54	—	—	—	—	—	100VLFL/ 300CRBN	—	—	2,824	Public supply for about 100 persons.
55	1969	282	14 3/4 10 3/4	0-242 240-282	40-242 242-282	100VLFL/ 300CRBN	flows inter- mittently		—	Log No. 10542.
56	—	—	—	—	—	100VLFL/ 300CRBN	flows	—	450	Public supply for Shoshone, Calif.

Shoal Event.--Project Shoal involved the detonation in 1963 of a 12-kiloton nuclear device at a depth of 1,200 ft; ground zero for the event is in Churchill County about 28 miles southeast of Fallon at a point near the topographic divide between Fourmile Flat in the Carson Desert and Fairview Valley (fig. 17). The geology and hydrology of the area surrounding ground zero was discussed in detail by Nevada Bureau of Mines and others (1962); the geohydrology of Fairview Valley and the Carson Desert was covered at a reconnaissance level by Cohen and Everett (1963) and Glancy and Katzer (1975), respectively. The 1962 study concluded that radionuclides from the test shot would have a low probability of moving out of granite surrounding ground zero, and that any contamination leaving the granite aquifer would be fixed in the alluvial aquifers within a short distance of the front of the Sand Springs Range. Water samples are collected at five monitoring stations annually to access results of the Shoal Event; the stations comprise three existing private wells and two test holes drilled for the 1962 study (table 13). Well H-3 and the "Flowing Well" (map nos. 3 and 2) monitor points in the bedrock aquifer and valley-fill sedimentary deposits downgradient along potential paths of flow from ground zero in Fourmile Flat. The Hunts Station well (no. 1) monitors ground water in the valley-fill of Fourmile Flat downgradient and off the probable flow path from ground zero. Well HS-1 (no. 5) monitors ground water in the valley-fill of Fairview Valley downgradient from ground zero along potential paths of flow. The Frenchmens Station well monitors a noncommunity public-supply well downgradient from ground zero.

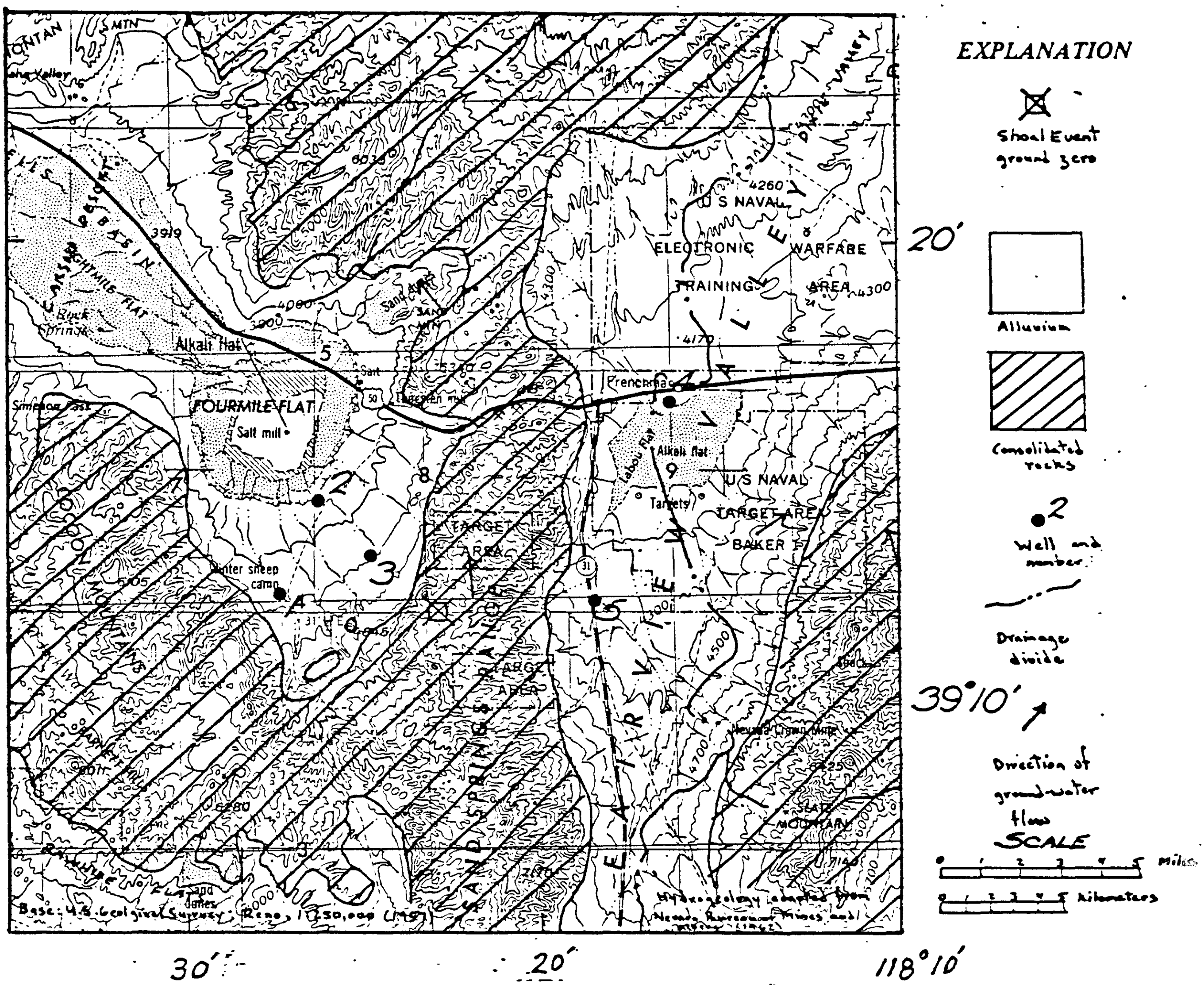


FIGURE 17.–DOE/EPA monitoring sites, Shoal Event, Churchill County.

Faultless Event.—The Faultless Event was a weapons test in 1968 involving the detonation of a 200- to 1,000-kiloton nuclear device at a depth of 3,000 feet; ground zero was about 60 miles east of Tonopah (Nye County) in the northern third of Hot Creek Valley (fig. 18). Reports on the geology and hydrology of Hot Creek Valley include those of Rush and Everett (1966), Dinwiddie (1970), and Dinwiddie and Schroder (1971). Logs of holes drilled near ground zero show 2,400 feet of poorly sorted alluvial materials, underlain by tuffaceous sediments to depths exceeding 3,700 feet. Permeabilities of both the valley-fill and the tuff are reported to be low, except for thin beds of sand and gravel in the valley fill and for fracture zones in the volcanic rocks. Static water levels in test holes HTH-1 and HTH-2 (fig. 18) are about 550 feet below land surface. Dinwiddie and Schroder (1971) hypothesized two components to the ground-water flow system in northern Hot Creek Valley: a shallow component (upper 1,000 ft) flowing to the south and southeast and a deep component (5,000-7,000 ft) moving northeastward and eastward toward Little Smoky Valley.

Seven stations are sampled annually to monitor the Faultless Event (table 13). Test holes HTH-1 and HTH-2 monitor water quality immediately downgradient from ground zero. The Blue Jay Maintenance Station and 6-Mile wells monitor shallow valley-fill ground water downgradient along probable flow paths from ground zero. The Hot Creek Ranch and Blue Jay Springs monitor background quality in ground-water discharge from the carbonate rocks on the eastern flank of the Hot Creek Range. The station at Twin Springs Ranch monitors ground water at an area where an estimated 700 acre-ft per year of subsurface outflow discharges to Railroad Valley (Rush and Everett, 1966).

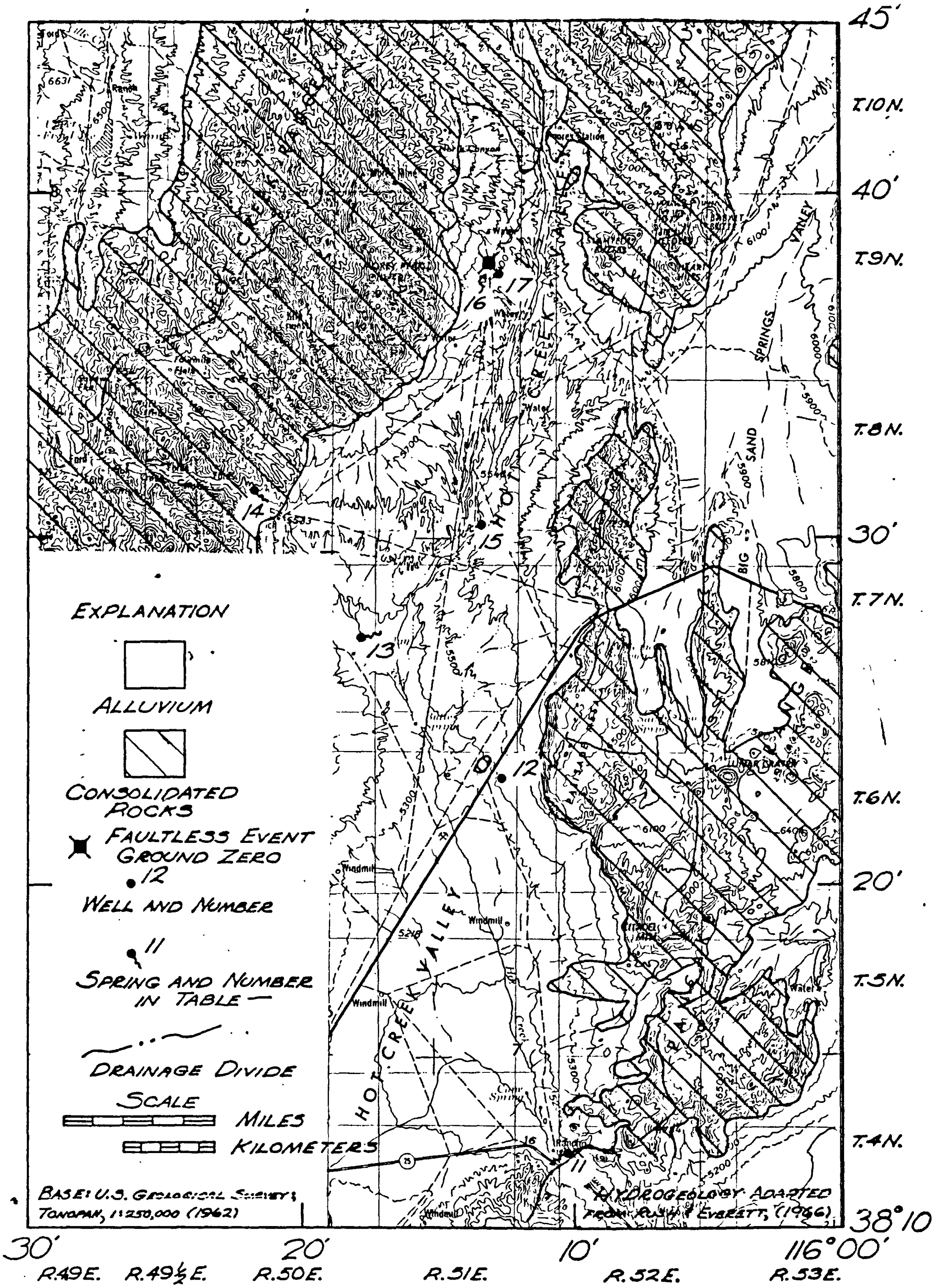


FIGURE 18.--DOE/EPA monitoring sites, Faultless Event, Nye County.

Nevada Test Site events.--Monitoring in and adjacent to the NTS includes sampling at 11 monthly and 23 semi-annual stations and at 10 annual "background" stations (fig. 19).

Geologic and hydrologic studies have been made on and adjacent to the NTS since 1956 by the USGS and other agencies. Geology of the area was summarized at a reconnaissance level by Rush (1970) and discussed in detail by Blankennagel and Weir (1973) and Winograd and Thordarson (1975). Of ten geohydrologic units defined in the area, the valley fill and the deepest of two Paleozoic carbonate-rock aquifers have the widest areal extent and are the prinicipal aquifers in the area (Winograd and Thordarson, 1975, p. 14). Four interbasin regional ground-water flow systems have been identified in the area (Rush, 1970) and are shown in figure 19. The NTS is enclosed within two of these systems: Ground water in the eastern section of the NTS moves in the Ash Meadows system from Yucca Flat (hydrographic area 159) through Frenchman Flat (160) into Mercury Valley (225) and then southwestward towards the Ash Meadows discharge area in the Amargosa Desert (230). Ground water in the northwestern section of the NTS flows in the Pahute Mesa system from the southern ends of Gold Flat (147) and Kawich Valley (157) through Buckboard Mesa (227B) and Jackass Flat (227A) to the Ash Meadows discharge area.

The monitoring network for the NTS and vicinity consists of 10 on-site test holes or wells sampled monthly to provide early warning of the movement of contaminants within NTS and to monitor the quality of on-site domestic water supplies, and one monthly off-site well on a flow path downgradient from NTS in the Pahute Mesa flow system (table 13). Monitoring at 12 sites semiannually provides data on potential movement of contaminants along less probable paths of flow off the NTS and documents the quality of water from

(Figure 19 is in pocket at back of report) on-site industrial supply wells. Four of these sites are in Ash Meadows to provide data at the point of final discharge from that flow system. Six of the semiannual sites provide data on points adjacent to or downgradient from NTS but off probable flow paths from test areas. Nine of the 10 annual stations document background quality at points surrounding NTS at such distance as to preclude any contaminations from NTS activities.

Data handling.—Data generated by the long-term hydrological monitoring network are entered into EPA computer files for analysis and storage. Upper limits for expected values of critical constituents are determined by reviewing historical data and an automatic flagging system tabulates all data in the file for a station when an individual laboratory result exceeds the predetermined limit.

Utility of Past Data-Collection Efforts to a Statewide Monitoring Program

With the exception of the DOE/EPA hydrological monitoring and the point-source monitoring at the Mohave Generating Station, the existing ground-water sampling efforts fulfill few of the requirements for a statewide program to monitor ground-water quality. Data collected in the course of hydrogeologic investigations by the USGS, DRI, and other agencies and the large number of available domestic water analyses potentially contribute toward a data base on the background quality of ground water in Nevada. Full utilization of this information will require: (1) Collation of data from the various source agencies, (2) checking the data for analytical balance between the principal positive and negative ions and uniformity of units of measure, (3) matching the available water-quality data with drillers' well logs and other geohydrologic information, and (4) developing or adopting an efficient data-storage and retrieval system. Analyses of public water supplies could provide monitoring of ground water at points of major withdrawal. The objective of public-supply sampling, however, has been to measure quality at the point of use rather than at the point of withdrawal, and historical data suffer from poor documentation of the exact sampling points and nonuniform sample-collection techniques. Point-of-use samples commonly are composites of water from more than one well or spring and, in some instances, may include contributions from surface-water sources as well. Monitoring of public water supplies for the Safe Drinking Water Act will require sampling at points that provide treated water to the public; these samples may not be representative of source water in the ground-water systems.

Past attempts at monitoring pollution sources generally have suffered from insufficient knowledge of the local hydrologic systems and the necessity to use existing wells for sampling. Crucial points for ground-water monitoring are the unsaturated zone (to follow downward movement of contaminants) and the upper part of the saturated zone (to monitor the arrival and dispersion of contaminants in the native water). In addition, multiple zones in the aquifer may have to be monitored if the specific gravity of the contaminant differs from that of the native water. These monitoring needs are not served by existing supply wells. Supply wells generally are drilled deep enough to allow for anticipated drawdowns during pumping and the upper part of the saturated zone may be cased off. Many supply wells are finished in multiple aquifers, and control is thus lost as to the exact point of sampling in the vertical section. Also, samples collected at different times after pumping began may have different proportions of water from different aquifers. Of all the efforts, the Hydrologic Monitoring Network operated by EPA at the NTS and the on-site monitoring at the Mohave Generating Station best exemplify the use of adequate geohydrologic data in the design and operation of ground-water monitoring systems in Nevada.

SUGGESTED PROGRAM FOR GROUND-WATER MONITORING

Approach

The suggested ground-water monitoring program has the following objectives:

1. Provide data that can be used to meet statutory requirements for ground-water management.
2. Support the State's historical goals of protecting the limited water resource for beneficial uses.
3. Allocate monitoring resources on the basis of greatest need.
4. Encourage interagency participation in the management of ground-water quality.

Summary of Program Elements

The proposed ground-water monitoring program has five main elements:

1. Background-Quality Network.--An active file on the background quality of ground water statewide.
2. Contamination-Source Inventory--An inventory by hydrographic area of known or potential sources of ground-water contamination.
3. Surveillance Network--Monitoring within selected hydrographic areas to document long-term changes in water quality for major aquifers. Emphasis is to be placed on monitoring highly stressed aquifers, with control wells in representative unstressed areas.
4. Intensive Surveys--Case studies of areas with known or potential ground-water quality problems, with the objective of defining the nature and extent of present or probable contamination and providing a basis for management action.

5. Ground-Water Data File—A data base containing input from the preceding elements with provisions for

   (a) interfacing with EPA's STORET data-storage system,

   (b) statistical reduction of data, and

   (c) user-oriented output to provide graphical and tabular material for monitoring reports.

The interaction of the program elements is illustrated by figure 20; the four program activities are interconnected by the common data base. This division of the program effort is intended to be functional rather than formal; operation of the program will require intensive interaction among all four program activities, the supportive data files, management and regulatory agencies, and the public.

Setting Monitoring Priorities

Development of a rational monitoring program statewide requires a means of assigning priorities for the areas to be monitored and for the intensity of monitoring efforts within given areas. The annual monitoring work load must be commensurate with the available funds and work force; consequently, monitoring efforts need to be directed toward areas where they will be most effective in providing information for proper management of the ground-water resource, for both existing and potential uses.

Priorities for ground-water monitoring in Nevada can be most logically assigned areally on the basis of the 255 individual hydrographic areas. One approach to rank the hydrographic areas in order of priority is to synthesize available data on the hydrologic and demographic environments of the valleys into general index numbers reflecting various aspects of monitoring needs.

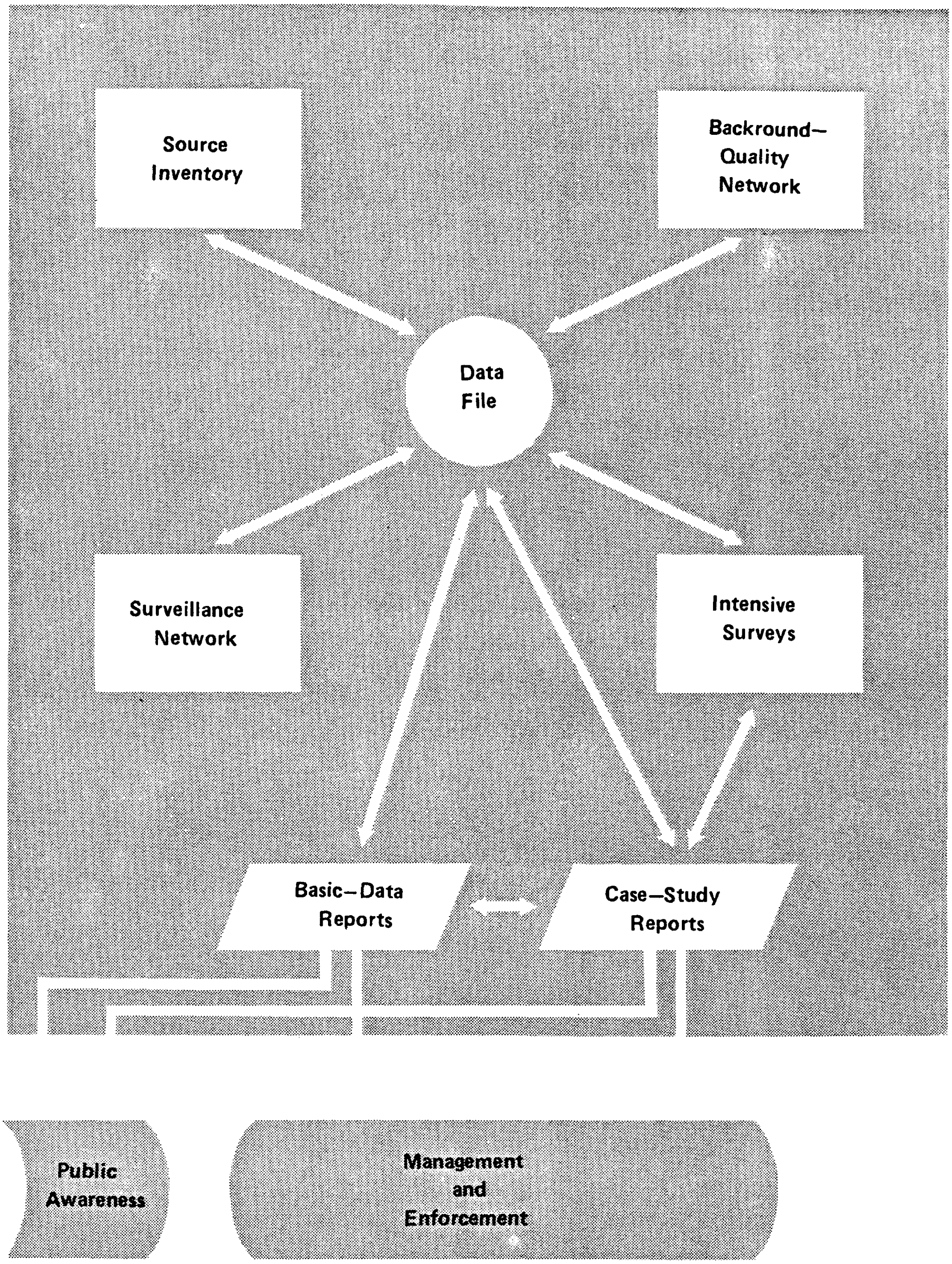


FIGURE 20.--Elements of the proposed monitoring program.

Hydrographic-Area Priority Indices

Use of Environmental Indices

Environmental indices have been used in three basic areas of water-quality management to: (1) Rank management priorities; (2) provide a yardstick for measuring water-quality changes; and (3) assess the potential impact of a particular activity or development. The development and use of indices to optimize surface-water quality management programs have been discussed by Zoeteman (1973), Chamberlain and others (1974), and Truett and others (1975); the concept of developing a comprehensive water-quality index has been discussed by Brown and others (1970; 1973), and Dee and others (1973). Typical uses of indices to evaluate the potential environmental impact of waste-disposal activities were treated by Pavoni and others (1972) and Oleckno (1976).

Potential applications of indices to ranking ground-water monitoring needs include: (1) Characterization of existing ground-water quality; (2) characterization of the existing or potential value of the ground-water resource that is to be protected; and (3) determination of the relative potential for ground-water contamination.

Available Data

Hydrologic, demographic, and agricultural statistics have been compiled by hydrographic regions and areas in a series of reports entitled "Water for Nevada," published by the Nevada State Engineer. Selected data from these publications have been compiled (and in some instances revised) in a computer data base maintained by the Planning Section of the Nevada Division of Water Resources; other data are available in USGS files. The sources of available information are summarized by type of data in table 14.

TABLE 14.--*Inventory of available data on Nevada hydrographic regions and areas*[1]

Parameter	"Water for Nevada" series, report number: 2[a]	3[b]	5[c]	8[d]	Computer file, Nevada State Engineer[e]	USGS files
Hydrographic						
Square-mile area		A		A	A	
Altitude		A				
Precipitation		A				
Growing season		A			A	
Hydrologic						
Ground water						
Recharge		A				
Interbasin flow		A				
Evapotranspiration		A				
Storage		A				
Yield		A			A	
Surface water						
Runoff		A				
Interbasin flow		A				
Evaporation		A				
Water use						
Public supply	R					A
Industrial/institutional	R					A
Rural/domestic	R					
Stock	R					A
Irrigation	R					A
Population			R		A	
Agriculture						
Irrigated area				A	A	A
Irrigable area				A		
Land ownership				A		
Crop inventories				R		
Stock inventories				R		
Good soil					A	

[1] Data reported for: A, hydrographic areas; R, hydrographic regions.
[a] Smales and Harrill, 1971.
[b] Scott and others, 1971.
[c] Hill, 1973.
[d] McNeely and Woernar, 1974.
[e] Nevada Division of Water Resources, Planning Section, unpublished computer file, April 1975.

Of the readily available data, 18 characteristics have been initially compiled by hydrographic area into a data base for setting monitoring priorities. A complete listing of these data may be found in the data supplement at the end of this report (tables 25 and 26).

Seven of the 18 characteristics chosen on the basis of reliability and interbasin-transfer value for use in computing indices for monitoring priorities:

1. Population (P).--The estimated 1970 population for each valley.
2. Perennial yield (Y).--The estimated maximum annual rate at which ground water may be withdrawn and consumed over an indefinite period without appreciably depleting the resource.
3. Ground-water use (U).--The estimated total withdrawal of ground water for each valley as of 1970.
4. Domestic water use (DU).--The sums of estimated ground-water withdrawals for private domestic and public water supplies as of 1970. Quality requirements for drinking water are generally more stringent than for other water uses; thus, rates of withdrawal for this purpose give an indication of the level of protection needed for the water resource.
5. Irrigable area in private ownership (PA).--The area of irrigable soil (based on soil types and land slopes) in private (nonfederal) ownership in each valley. Land- and water-use stresses may be quantified by computing population densities and water-use intensities on the basis of quantities per unit area. Calculations based on total land areas in each valley would be misleading, as approximately 87 percent of the State consists of

Federally owned land unavailable for intensive development. Of the available private land, development concentrates on the "good" soils, first with agricultural use, which is usually followed, and often replaced, by urban development.

6. Irrigated acres (IA).--The 1970 estimates of the amount of irrigated land in each valley.

7. Growing season (G).--Average frost-free growing season, as an indicator of climatic favorability for agricultural development as well as potential residential development.

Normalization of Data

The natural and cultural resources of Nevada have very uneven areal distributions. Consequently, statistical parameters for characteristics such as population, water use, and areas of good soils have broad ranges of values and highly skewed frequency distributions. Reduction of data for use in developing composite indices requires that values for individual characteristics be normalized to produce comparable ranges and more "normal" frequency distributions. Logarithmic transformations were arbitrarily chosen to normalize data for the following index computations. The effects of the normalization process upon selected input parameters are illustrated by the histograms in figure 21. The histograms divide the data for each of the index parameters into 11 equal classes, and show the percentage and number of hydrographic areas having values in the range represented by each class. Whereas, the raw data are skewed to the lower ranges of values (many hydrographic areas have small values), the logarithmic transformations tend to produce a more even distribution of values to be used in the index computations.

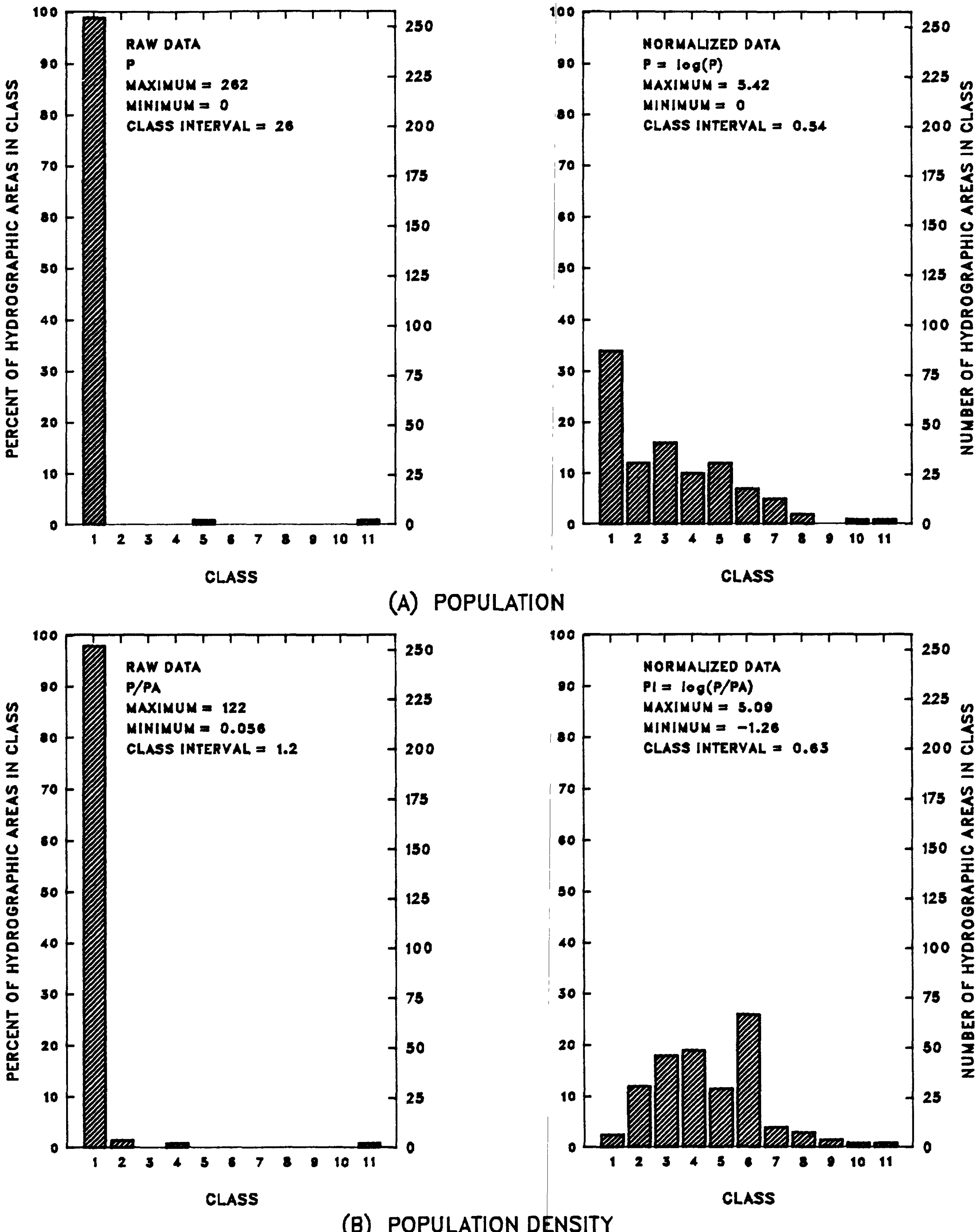
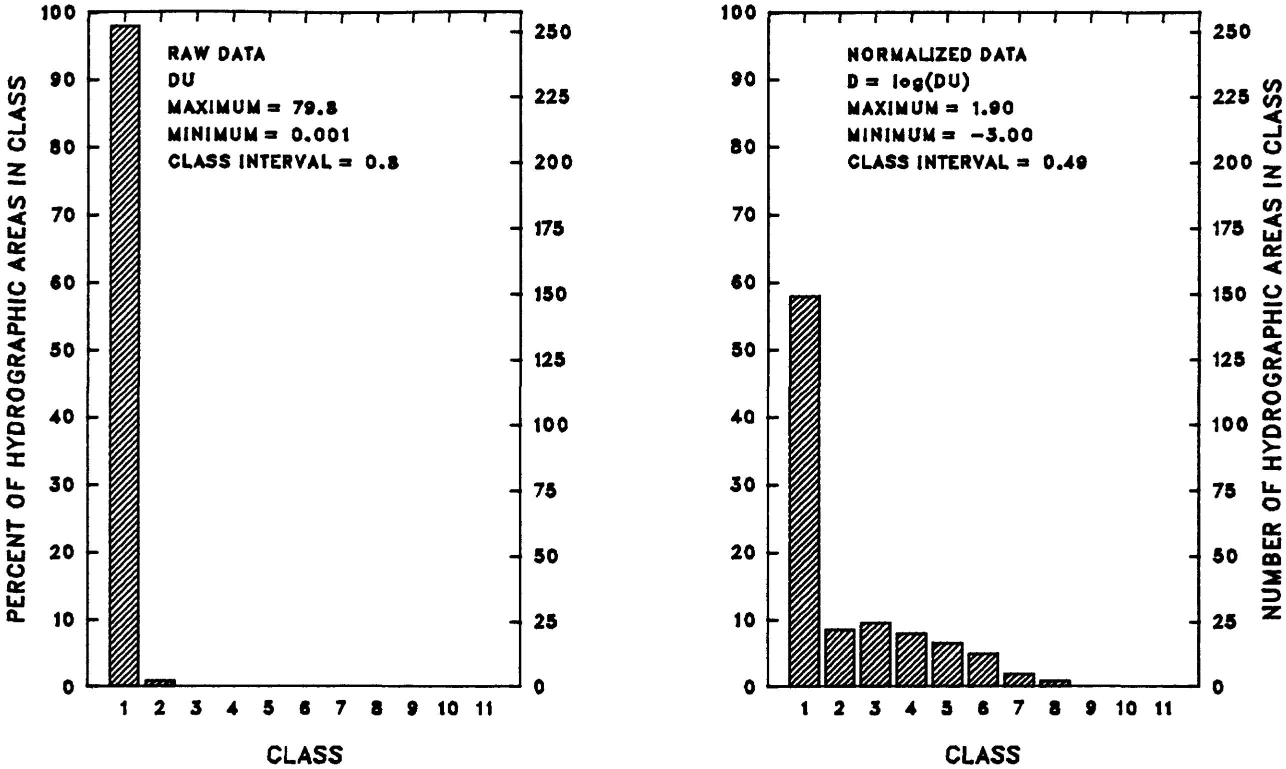
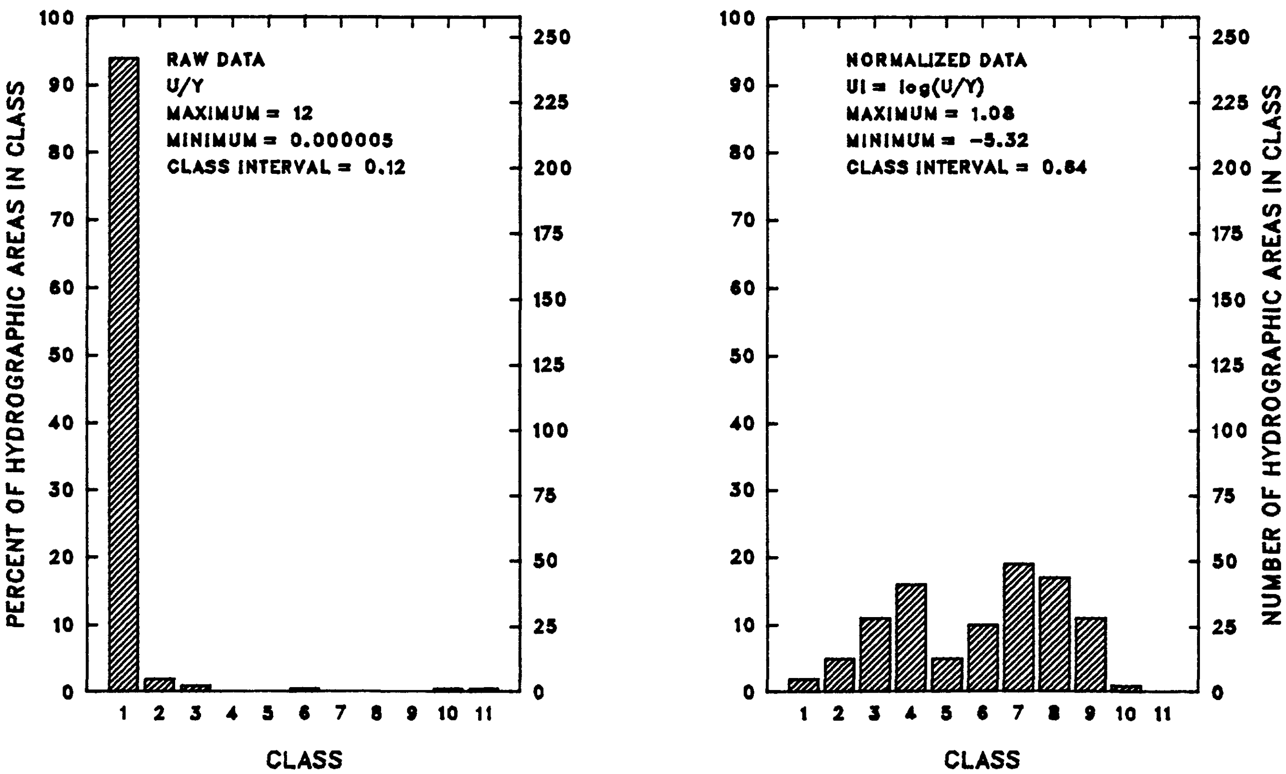


FIGURE 21.—–Frequency distributions for raw and normalized parameters used in index calculations.



(C) DOMESTIC WATER USE



(D) INTENSITY OF GROUND-WATER USE

FIGURE 21.--Continued.

The relative effect of individual characteristics upon the resultant index value may be adjusted by use of weighting factors. The final index computation then assumes the form:

$$I = c_1 i_1 + c_2 i_2 + c_3 i_3 \ldots + c_n i_n ,$$

where I = the composite index,

c_n = weighting factor for parameter (n), and

i_n = normalized value of parameter (n).

Assignment of weighting factors requires a value judgement for the relative importance of each parameter, a process which is often rather arbitrary. Such factors were not assigned in the preliminary development of the indices used in this study.

Selection of Indices

The uneven distribution of population and development in Nevada necessitates consideration of two different schemes for assigning monitoring priorities. In terms of priority for management of the ground-water resource, the hydrographic areas may be divided into three classes: (1) Those that are already in a state of moderate to intensive development; (2) those that are undeveloped as of 1977 but have high potentials for future development; and (3) those that have low potential for future development. Hydrographic areas in the first class need to be ranked for inclusion into the Surveillance and Intensive-Survey monitoring programs, to evaluate the effects of recent stresses on the ground-water resource and to provide early warning of future contamination. Undeveloped hydrographic areas with high potentials for future development need to be ranked for inclusion into the Background-Quality Network to establish base-line measurements of ground-water quality against which impacts of future development might be compared. High-quality aquifers in valleys with little development need to be identified and protected for future uses. Many hydrographic areas in the State have little potential for intensive development and, thus, a low probability of need for future monitoring.

Hydrographic-Area Priority Index (HPI)

The hydrographic-area priority index is designed to rank the State's 255 hydrographic areas for inclusion in the Surveillance Network by integrating the effects of current development on the ground-water resource. The effects of man's activities on a valley-wide basis are assumed to be a function of the population density and the intensity of ground-water use. The importance of the water resource to be protected is assumed to be a function of water availability and the intensity and type of water use. These factors are combined to form the HPI as follows:

$$HPI = p + PI + UI + D,$$

where $p = \log(P)$, the population factor,

$PI = \log(P/PA)$, the population-intensity factor,

$UI = \log(U/Y)$, the use-intensity factor, and

$D = \log(DU)$, the quality-of-use factor.

Values for the HPI and its components are listed in table 15 and are summarized below; their frequency distribution is shown in figure 22.

	HPI	P	PI	UI	D
Maximum	12.2	5.4	5.1	1.1	1.9
Minimum	-8.4	.0	-1.2	-5.3	-3.0
Mean	-1.6	1.3	1.3	-1.9	-2.2
			Percentiles		
95	5.6	3.5	3.4	0.3	-0.2
90	4.1	3.1	2.7	- .1	- .7
85	2.9	2.7	2.4	- .3	-1.1
80	1.9	2.5	2.3	- .5	-1.4
75	1.1	2.2	2.2	- .7	-1.6
70	.4	2.0	2.1	- .9	-1.9
60	-1.1	1.5	1.8	-1.2	-2.5
50	-2.4	1.2	1.2	-1.6	—
30	-4.1	—	.6	-3.0	—
10	-6.0	—	- .21	-4.0	—

TABLE 15.--*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*

[Hydrographic areas were excluded from consideration where components A_Y and AL were negative, where depths to ground water are generally >500 ft, and where the quality of available ground water is known to be generally fair to poor, or worse.]

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
212	Las Vegas Valley	12.212	5.419	4.340	0.552	1.902
87	Truckee Meadows	9.218	5.032	3.437	-0.325	1.073
104	Eagle Valley	7.229	4.177	3.273	-0.509	0.287
52	Marys Creek Area	7.159	3.087	5.087	-0.658	-0.357
49	Elko Segment	6.486	3.919	2.501	-0.453	0.519
92B	Lemmon Valley-Lemmon Subarea	6.380	3.653	2.773	0.176	-0.222
101	Carson Desert	6.373	4.016	2.131	-0.012	0.238
110C	Walker Lake Valley-Whisky Flat-Hawthorne Subarea	6.288	3.776	3.495	-0.736	-0.248
179	Steptoe Valley	6.231	3.979	2.233	-0.548	0.568
205	Lower Meadow Valley Wash	5.751	3.071	2.895	0.173	-0.387
161	Indian Springs Valley	5.420	3.069	3.313	-0.105	-0.857
108	Mason Valley	5.310	3.713	1.927	-0.274	-0.056
90	Lake Tahoe Basin	5.222	3.694	3.217	-0.842	-0.848
70	Winnemucca Segment	5.195	3.652	2.018	-0.590	0.114
105	Carson Valley	5.131	3.558	1.793	-0.106	-0.114
22	San Emidio Desert	5.048	2.682	2.682	0.081	-0.397
121A	Soda Spring Valley-Eastern Part	4.829	2.639	3.639	-0.599	-0.851
89	Washoe Valley	4.718	3.298	2.306	-0.535	-0.352
86	Sun Valley	4.699	3.398	3.097	-0.097	-1.699
122	Gabbs Valley	4.551	2.968	2.277	-0.299	-0.395
162	Pahrump Valley	4.435	3.124	1.608	0.530	-0.827
228	Oasis Valley	4.422	2.888	3.019	-0.647	-0.839
76	Fernley Area	4.381	3.248	2.241	-0.523	-0.585
73	Lovelock Valley	4.266	3.367	1.606	-1.128	0.421
214	Piute Valley	4.115	2.422	3.944	-1.015	-1.237
192	Great Salt Lake Desert	4.030	1.949	3.949	-1.284	-0.585
92A	Lemmon Valley-Silver Lake Subarea	3.897	3.398	2.315	-0.449	-1.367
220	Lower Moapa Valley	3.882	3.211	2.733	-1.280	-0.783
71	Grass Valley	3.841	3.261	1.700	-0.430	-0.690
203	Panaca Valley	3.789	2.750	1.844	0.091	-0.896

Footnote at end of Table

TABLE 15.—*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*—Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
30A	Kings River Valley-Rio King Subarea	3.635	1.851	0.427	0.445	0.913
83	Tracy Segment	3.552	2.447	1.794	0.780	-1.469
91	Truckee Canyon Segment	3.359	2.890	2.890	-1.362	-1.060
202	Patterson Valley	3.102	2.705	2.520	-1.388	-0.735
209	Pahranagat Valley	2.906	2.594	1.681	-0.188	-1.180
59	Lower Reese River Valley	2.858	3.096	1.508	-0.892	-0.854
64	Clovers Area	2.784	2.992	1.342	-1.082	-0.467
225	Mercury Valley	2.752	2.000	4.000	-1.289	-1.959
107	Smith Valley	2.731	2.846	1.286	-0.292	-1.108
103	Dayton Valley	2.584	2.985	1.687	-0.770	-1.319
153	Diamond Valley	2.493	2.698	1.340	-0.064	-1.481
143	Clayton Valley	2.398	2.179	2.373	-0.455	-1.699
42	Marys River Basin	2.361	3.154	1.214	-1.531	-0.476
222	Virgin River Valley	2.327	2.965	2.472	-2.473	-0.638
110A	Walker Lake Valley-Schurz Subarea	2.240	2.740	2.091	-1.384	-1.208
37	Owyhee River Area	2.233	2.983	1.837	-1.620	-0.967
33B	Quinn River Valley-McDermitt Subarea	2.150	2.815	1.187	-0.834	-1.018
207	Smith Valley	2.078	2.533	1.071	-0.106	-1.420
230	Amargosa Desert	2.053	2.678	1.098	-0.486	-1.237
33A	Quinn River Valley-Orovada Subarea	1.969	2.515	0.778	0.108	-1.432
218	California Wash	1.927	2.000	2.000	-0.416	-1.658
164A	Ivanpah Valley-Northern Part	1.671	2.274	2.518	-1.483	-1.638
88	Pleasant Valley	1.632	2.477	2.357	-1.733	-1.469
106	Antelope Valley	1.570	2.179	1.366	-0.205	-1.770
219	Muddy River Springs Area (Upper Moapa Valley)	1.546	1.477	1.436	-1.085	-0.281
1	Pueblo Valley	1.542	1.982	1.514	0.004	-1.959
200	Eagle Valley	1.503	1.785	1.922	-0.049	-2.155
167	Eldorado Valley	1.309	3.720	3.288	-2.699	-3.000
54	Crescent Valley	1.307	2.484	1.197	-0.906	-1.469
142	Alkali Spring Valley (Esmeralda)	1.230	2.377	2.570	-2.097	-1.620

TABLE 15.--*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*--Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
137A	Big Smoky Valley- Tonopah Flat	1.211	3.311	1.964	-1.385	-2.678
215	Black Mountains Area	1.179	2.646	4.646	-3.114	-3.000
69	Paradise Valley	1.127	2.425	0.378	-0.153	-1.523
40	Salmon Falls Creek Area	1.072	2.675	1.319	-1.947	-0.975
56	Upper Reese River Valley	1.030	2.610	1.086	-1.246	-1.420
81	Pyramid Lake Valley	1.005	2.522	1.823	-2.089	-1.252
102	Churchill Valley	0.928	2.433	1.111	-1.196	-1.420
117	Fish Lake Valley	0.897	2.167	0.995	-0.496	-1.770
128	Dixie Valley	0.846	2.064	1.062	-0.395	-1.886
173B	Railroad Valley- Northern Part	0.732	2.233	1.108	-0.887	-1.721
141	Ralston Valley	0.720	1.531	0.919	-1.254	-0.476
45	Lamoille Valley	0.612	2.489	0.692	-1.250	-1.319
137B	Big Smoky Valley- Northern Part	0.562	2.228	0.871	-0.936	-1.602
213	Colorado River Valley	0.466	2.124	1.990	-1.824	-1.824
114	Teels Marsh valley	0.437	1.826	2.173	-1.465	-2.097
84	Warm Springs Valley	0.423	2.064	0.704	-0.460	-1.886
183	Lake Valley	0.247	1.724	0.868	-0.123	-2.222
24	Hualapai Flat	0.206	1.792	0.425	0.144	-2.155
46	South Fork Area- Humbolt River Basin	0.191	2.188	1.057	-1.284	-1.770
163	Mesquite Valley (Sandy Valley)	0.182	1.301	1.523	0.057	-2.699
216	Garnet Valley (Dry Lake Valley)	0.182	1.415	3.415	-2.125	-2.523
156	Hot Creek Valley	0.148	1.431.	1.356	-0.843	-1.796
189D	Thousand Springs Valley- Montello Crittenden Creek Area	-0.036	2.236	0.674	-1.558	-1.387
176	Ruby Valley	-0.054	2.220	0.452	-1.005	-1.721
36	Independence Valley	-0.138	2.114	0.527	-0.955	-1.824
129	Buena Vista Valley	-0.176	1.851	0.503	-0.434	-2.097
85	Spanish Springs Valley	-0.188	2.176	1.044	-1.638	-1.770
32	Silver State Valley	-0.248	1.431	1.324	-0.481	-2.523
31	Desert Valley	-0.308	1.732	0.705	-0.649	-2.097
149	Stone Cabin Valley	-0.327	1.255	1.094	0.023	-2.699

TABLE 15.—*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*—Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
72	Imlay Area	-0.387	2.179	0.594	-1.391	-1.770
193	Deep Creek Valley	-0.458	1.771	2.227	-2.301	-2.155
155A	Little Smoky Valley-Northern Part	-0.730	1.146	0.988	-0.165	-2.699
144	Lida Valley	-0.850	1.342	1.661	-1.699	-2.155
53	Pine Valley	-0.888	1.820	0.665	-1.218	-2.155
131	Buffalo Valley	-0.892	1.398	0.824	-0.591	-2.523
28	Black Rock Desert	-0.928	1.531	0.746	-0.808	-2.398
146	Sarcobatus Flat	-1.032	1.255	0.810	-0.398	-2.699
184	Spring Valley	-1.054	1.886	0.321	-1.215	-2.046
58	Middle Reese River Valley	-1.114	1.204	-0.084	-0.138	-2.097
29	Pine Forest Valley	-1.146	1.568	0.222	-0.549	-2.387
41	Goose Creek Area	-1.340	1.114	0.772	-0.526	-2.699
189A	Thousand Springs Valley-Herrell Siding-Brush Creek Area	-1.361	1.176	0.159	0.002	-2.699
79	Kumiva Valley	-1.426	1.398	3.398	-3.222	-3.000
166	Hidden Valley (South)	-1.445	1.176	0.776	-0.699	-2.699
187	Goshute Valley	-1.469	1.491	0.134	-0.697	-2.398
177	Clover Valley	-1.555	1.716	0.121	-1.155	-2.237
43	Starr Valley Area	-1.567	1.826	0.377	-1.674	-2.097
35	South Fork Owyhee River Area	-1.606	2.009	0.396	-2.052	-1.959
133	Edwards Creek Valley	-1.634	1.146	0.818	-0.899	-2.699
195	Snake Valley	-1.648	2.104	1.102	-3.000	-1.854
99	Red Rock Valley	-1.663	1.000	0.296	0.041	-3.000
21	Smoke Creek Desert	-1.695	1.415	0.564	-1.151	-2.523
47	Huntington Valley	-1.731	1.929	0.283	-1.943	-2.000
199	Rose Valley	-1.753	0.0	0.167	1.079	-3.000
73A	Lovelock Valley-Oreana Subarea	-1.841	1.505	0.429	-1.377	-2.398
109	East Walker Area	-1.926	1.820	0.973	-2.564	-2.155
140A	Monitor Valley-Northern Part	-1.932	1.146	0.567	-0.947	-2.699
154	Newark Valley	-2.077	1.255	0.038	-0.671	-2.699
132	Jersey Valley	-2.088	0.699	1.119	-0.907	-3.000

TABLE 15.--*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*--Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
2	Continental Lake Valley	-2.115	1.176	0.349	-0.941	-2.699
61	Boulder Flat	-2.208	1.643	-0.389	-1.161	-2.301
118	Columbus Salt Marsh Valley	-2.217	1.380	1.800	-3.000	-2.398
227A	Fortymile Canyon-Jackass Flats	-2.250	1.176	3.176	-3.602	-3.000
178A	Butte Valley-Northern Part (Round Valley)	-2.251	1.079	0.759	-1.089	-3.000
130	Pleasant Valley	-2.288	1.230	0.583	-1.402	-2.699
223	Gold Butte Area	-2.301	0.699	2.699	-2.699	-3.000
198	Dry Valley	-2.312	0.0	0.086	0.602	-3.000
138	Grass Valley	-2.332	1.301	0.390	-1.324	-2.699
51	Maggie Creek Area	-2.402	1.322	0.155	-1.180	-2.699
136	Monte Cristo Valley	-2.426	0.699	2.699	-2.824	-3.000
173A	Railroad Valley-Southern Part	-2.447	1.000	3.000	-3.447	-3.000
126	Cowkick Valley	-2.464	0.301	1.097	-0.862	-3.000
189C	Thousand Spring Valley-Rocky Butte Area	-2.522	0.778	0.363	-0.663	-3.000
201	Spring Valley	-2.524	0.602	0.270	-0.396	-3.000
135	Ione Valley	-2.535	1.431	1.477	-2.921	-2.523
44	North Fork Area-Humboldt River Basin	-2.569	1.740	-0.191	-1.896	-2.222
124	Fairview Valley	-2.592	0.602	2.602	-2.796	-3.000
63	Willow Creek Valley	-2.616	1.431	0.267	-1.792	-2.523
151	Antelope Valley (Eureka & Nye)	-2.719	1.041	0.539	-1.299	-3.000
127	Eastgate Valley Area	-2.772	1.114	2.114	-3.301	-2.699
119	Rhodes Salt Marsh Valley	-2.814	1.114	1.470	-2.699	-2.699
158B	Emigrant Valley-Papoose Lake Valley	-3.000	0.0	2.000	-2.000	-3.000
74	White Plains	-3.000	0.0	2.000	-2.000	-3.000
7	Swan Lake Valley	-3.000	0.0	2.000	-2.000	-3.000
48	Dixie Creek-Tenmile Creek Area	-3.195	1.322	-0.040	-1.779	-2.699
121B	Soda Spring Valley-Western Part	-3.204	1.000	1.097	-2.301	-3.000
204	Clover Valley	-3.219	1.114	0.764	-2.097	-3.000
178B	Butte Valley-Southern Part	-3.249	1.000	0.807	-2.056	-3.000
170	Penoyer Valley (Sand Spring Valley)	-3.292	0.699	-0.170	-0.821	-3.000

TABLE 15.--*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*--Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
20	Sano Valley	-3.301	0.0	2.000	-2.301	-3.000
217	Hidden Valley (North)	-3.301	0.0	2.000	-2.301	-3.000
100	Cold Spring Valley	-3.431	0.0	-0.265	-0.166	-3.000
3	Gridley Lake Valley	-3.452	0.301	0.319	-1.072	-3.000
9	Long Valley	-3.600	1.176	-0.308	-1.770	-2.699
38	Bruneau River Area	-3.616	1.230	0.648	-2.796	-2.699
93	Antelope Valley	-3.637	1.041	0.497	-2.176	-3.000
139	Kobeh Valley	-3.694	0.699	-0.152	-1.241	-3.000
110B	Walker Lake Valley-Lake Subarea	-3.748	0.699	1.620	-3.067	-3.000
66	Kelly Creek Area	-3.773	0.903	-0.551	-1.125	-3.000
26	Mud Meadow	-3.787	1.041	0.165	-1.993	-3.000
60	Whirlwind Valley	-3.831	1.079	0.567	-2.477	-3.000
4	Virgin Valley	-3.840	1.000	0.824	-2.664	-3.000
134	Smith Creek Valley	-3.849	1.176	0.975	-3.301	-2.699
165	Jean Lake Valley	-3.914	0.699	0.308	-1.921	-3.000
189B	Thousand Springs Valley-Toano-Rock Spring Area	-3.969	0.477	-0.522	-0.925	-3.000
206	Kane Springs Valley	-4.000	0.0	2.000	-3.000	-3.000
145	Stonewall Flat	-4.000	0.0	2.000	-3.000	-3.000
125	Stingaree Valley	-4.000	0.0	2.000	-3.000	-3.000
152	Stevens Basin	-4.000	0.0	2.000	-3.000	-3.000
77	Fireball Valley	-4.000	0.0	2.000	-3.000	-3.000
65	Pumpernickel Valley	-4.009	0.778	-0.588	-1.200	-3.000
68	Hardscrabble Area	-4.041	0.0	2.000	-3.041	-3.000
174	Jakes Valley	-4.051	1.204	1.222	-3.778	-2.699
229	Crater Flat	-4.051	0.301	2.301	-3.653	-3.000
57	Antelope Valley	-4.092	1.398	0.288	-3.255	-2.523
172	Garden Valley	-4.100	1.301	1.076	-3.477	-3.000
194	Pleasant Valley	-4.148	0.602	1.125	-2.875	-3.000
232	Oriental Wash	-4.176	0.0	2.000	-3.176	-3.000
115	Adobe Valley	-4.176	0.0	2.000	-3.176	-3.000
16	Duck Lake Valley	-4.229	0.602	-0.715	-1.116	-3.000
180	Cave Valley	-4.243	0.0	-0.547	-0.697	-3.000
17	Pilgrim Flat	-4.301	0.0	2.000	-3.301	-3.000
23	Granite Basin	-4.301	0.0	2.000	-3.301	-3.000
96	Newcomb Lake Valley	-4.301	0.0	2.000	-3.301	-3.000

TABLE 15.—*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*—Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
98	Skedaddle Creek Valley	-4.301	0.0	2.000	-3.301	-3.000
39	Jarbidge River Area	-4.347	0.954	1.477	-3.778	-3.000
5	Sage Hen Valley	-4.398	0.0	2.000	-3.398	-3.000
164B	Ivanpah Valley (Southern Part)	-4.398	0.0	2.000	-3.398	-3.000
148	Cactus Flat	-4.477	0.0	2.000	-3.477	-3.000
112	Mono Valley	-4.477	0.0	2.000	-3.477	-3.000
111A	Alkali Valley (Mineral) Northern Part	-4.477	0.0	2.000	-3.477	-3.000
224	Greasewood Basin	-4.477	0.0	2.000	-3.477	-3.000
188	Independence Valley (Pequop Valley)	-4.513	0.0	-0.958	-0.555	-3.000
190	Grouse Creek Valley	-4.544	0.0	2.000	-3.544	-3.000
159	Yucca Flat	-4.544	0.0	2.000	-3.544	-3.000
155B	Little Smoky Valley (Central Part)	-4.602	0.0	1.398	-3.000	-3.000
231	Grapevine Canyon	-4.602	0.0	2.000	-3.602	-3.000
123	Rawhide Flats	-4.699	0.0	2.000	-3.699	-3.000
8	Massacre Lake Valley	-4.724	0.0	-0.423	-1.301	-3.000
19	Dry Valley	-4.778	0.0	1.222	-3.000	-3.000
116	Queen Valley	-4.778	0.0	2.000	-3.778	-3.000
27	Summit Lake Valley	-4.784	0.903	0.359	-3.046	-3.000
111B	Alkali Valley (Mineral) Southern Part	-4.845	0.0	2.000	-3.845	-3.000
97	Honey Lake Valley	-4.903	0.0	-1.255	-0.648	-3.000
226	Rock Valley	-4.903	0.0	2.000	-3.903	-3.000
55	Carico Lake Valley	-4.981	0.0	-0.493	-1.488	-3.000
13	Warner Valley	-5.000	0.0	2.000	-4.000	-3.000
221	Tule Desert	-5.000	0.0	2.000	-4.000	-3.000
18	Painters Flat	-5.079	0.0	2.000	-4.079	-3.000
211	Three Lakes Valley (Southern Part)	-5.097	0.301	2.301	-4.699	-3.000
169A	Tikapoo Valley (Tickaboo Valley) Northern Part	-5.114	0.0	2.000	-4.114	-3.000
186B	Antelope Valley (White Pine & Elko) Northern Part	-5.230	0.0	2.000	-4.230	-3.000
50	Susie Creek Area	-5.246	0.301	0.796	-3.342	-3.000
147	Gold Flat	-5.279	0.0	2.000	-4.279	-3.000

TABLE 15.—*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*—Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
196	Hamlin Valley	-5.329	0.699	0.893	-3.921	-3.000
157	Kawich Valley	-5.342	0.0	2.000	-4.342	-3.000
67	Little Humboldt Valley	-5.409	0.845	-0.373	-2.881	-3.000
158A	Emigrant Valley (Groom Lake Valley)	-5.447	0.0	2.000	-4.447	-3.000
169B	Tikapoo Valley (Tickaboo Valley) Southern Part	-5.477	0.0	2.000	-4.477	-3.000
182	Delamar Valley	-5.477	0.0	2.000	-4.477	-3.000
175	Long Valley	-5.551	0.477	1.273	-4.301	-3.000
82	Dodge Flat	-5.553	0.301	0.009	-2.845	-3.000
227B	Fortymile Canyon-Buckboard Mesa	-5.556	0.0	2.000	-4.556	-3.000
168	Three Lakes Valley (Northern Part)	-5.602	0.0	2.000	-4.602	-3.000
171	Coal Valley	-5.778	0.0	2.000	-4.778	-3.000
62	Rock Creek Valley	-5.779	0.477	-0.381	-2.875	-3.000
140B	Monitor Valley (Southern Part)	-5.797	0.954	0.249	-4.000	-3.000
25	High Rock Lake Valley	-5.797	0.699	0.425	-3.921	-3.000
186A	Antelope Valley (White Pine & Elko) Southern Part	-5.806	0.301	0.495	-3.602	-3.000
191	Pilot Creek Valley	-5.977	0.903	-0.527	-3.352	-3.000
10	Macy Flat	-6.041	0.0	0.357	-3.398	-3.000
185	Tippett Valley	-6.049	0.0	0.796	-3.845	-3.000
12	Mosquito Valley	-6.051	0.0	-0.176	-2.875	-3.000
11	Coleman Valley	-6.176	0.0	-0.176	-3.000	-3.000
160	Frenchman Flat	-6.204	0.0	2.000	-5.204	-3.000
34	Little Owyhee River Area	-6.243	0.301	0.301	-3.845	-3.000
120	Garfield Flat	-6.259	0.0	-0.083	-3.176	-3.000
14	Surprise Valley	-6.389	0.0	-0.292	-3.097	-3.000
94	Bedell Flat	-6.574	0.0	-0.097	-3.477	-3.000
6	Guano Valley	-6.602	0.0	0.699	-4.301	-3.000
197	Escalante Desert	-6.602	0.0	0.398	-4.000	-3.000
113	Huntoon Valley	-6.650	0.0	-0.474	-3.176	-3.000
75	Bradys Hot Springs Area	-6.773	0.477	-0.330	-3.921	-3.000
80	Winnemucca Lake Valley	-6.899	0.0	0.620	-4.519	-3.000

TABLE 15.—*Hydrographic areas sorted by the Hydrographic-Area Priority Index (HPI)*--Continued

Hydrographic area			Index components[1]			
No.	Name	HPI	P	PI	UI	D
181	Dry Lake Valley	-7.161	0.0	0.237	-4.398	-3.000
95	Dry Valley	-7.343	0.0	-0.644	-3.699	-3.000
155C	Little Smoky Valley (Southern Part)	-7.401	0.0	-0.401	-4.000	-3.000
101A	Carson Desert	-7.491	0.0	-0.792	-3.699	-3.000
15	Boulder Valley	-7.787	0.0	-0.486	-4.301	-3.000
78	Granite Springs Valley	-8.061	0.0	-0.408	-4.653	-3.000
210	Coyote Spring Valley	-8.185	0.0	0.071	-5.255	-3.000
208	Pahroc Valley	-8.322	0.0	0.0	-5.322	-3.000
30B	Kings River Valley-Sod House Subarea	-8.369	0.0	-0.670	-4.699	-3.000
150	Little Fish Lake Valley	-8.382	0.0	-0.382	-5.000	-3.000

[1] See report section titled "Hydrogaphic-Area Priority Index (HPI)" for definition of index-component abbreviations.

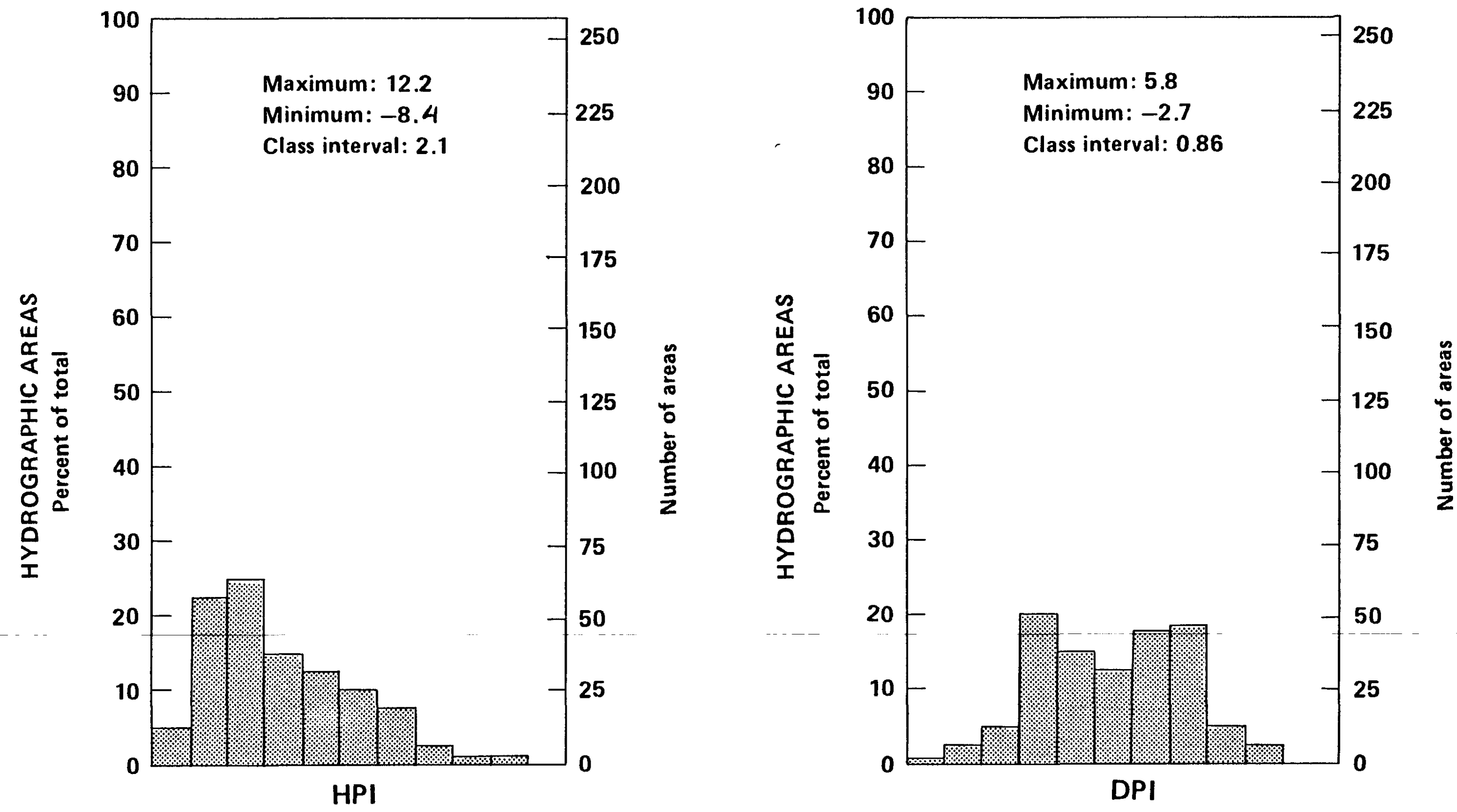


FIGURE 22.—Frequency distributions for the hydrographic—area indices.

Figure 23 shows the 255 hydrographic areas in Nevada ranked by the HPI with regard to their priority for the establishment of monitoring programs, on the basis of existing development. Five classes, based on the 95, 90, 85 and 75 percentiles, are shown. Because the index is a semiquantitative tool at best, management judgment will be required to select individual valleys for monitoring among the general classes shown.

Development-Potential Index (DPI)

The development-potential index is designed to rank the hydrographic areas for priority of consideration for background monitoring. The State's ground water must be protected for future as well as current uses; thus, undeveloped areas which may have potentials for future ground-water development should be evaluated. Development potential is assumed to be directly proportional to the amount of available (and usable) ground water, the area of unused good private land, and the favorableness of the climate, and inversely proportional to the degree of development as of 1977. The DPI is calculated by:

$$DPI = AY + AL + g + d$$

where $AY = \log [(Y-U) + 1]$, available ground water

$AL = \log [(PA-IA) + 1]$, available good land,

$g = \log (G)$, climate factor, and

$d = \log (1/PI)$, current development factor.

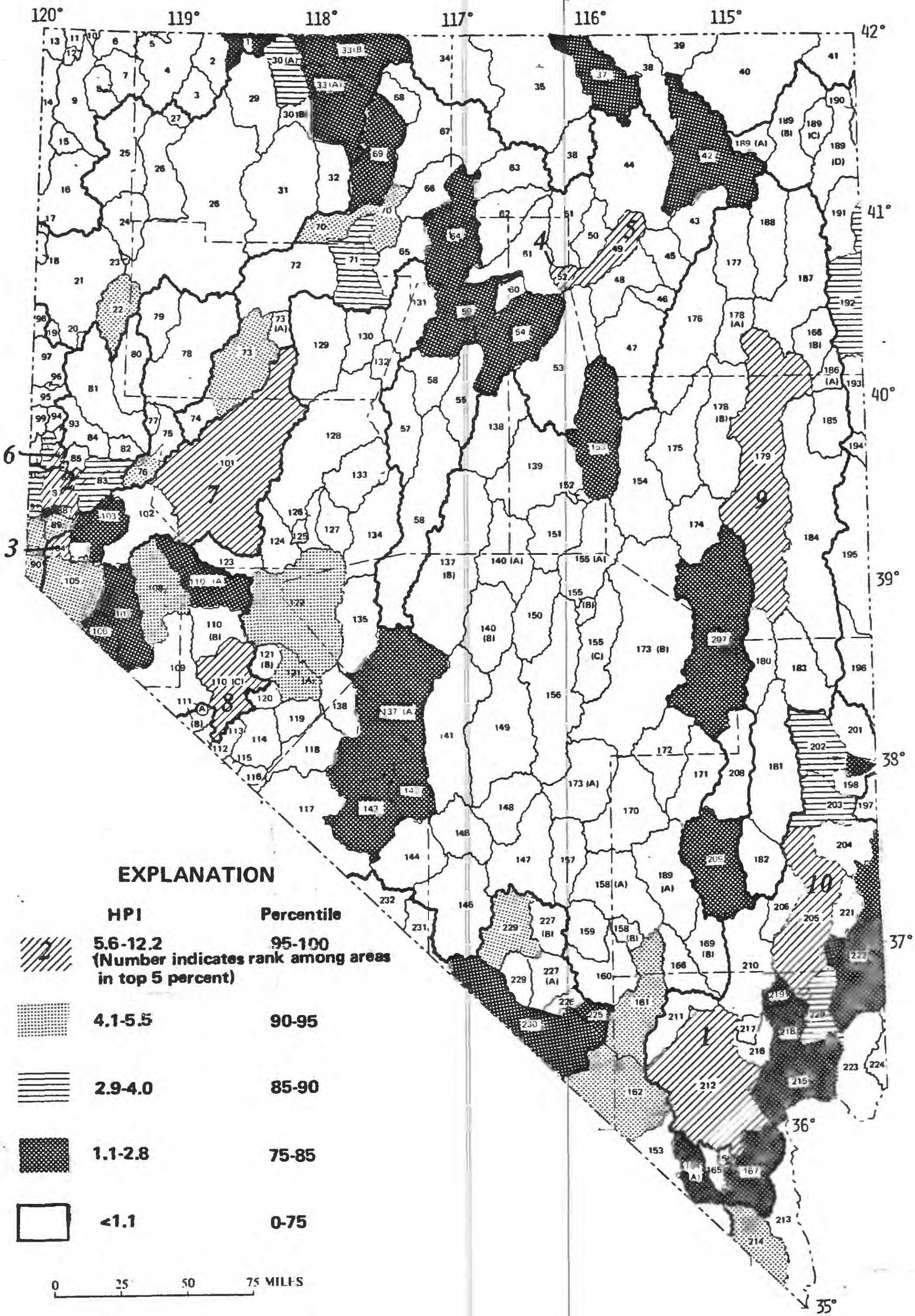


FIGURE 23.--Priority for surveillance and intensive monitoring of hydrologic areas as indicated by the index HPI.

Values for the index DPI and its components are summarized below; their frequency distribution is shown in figure 23.

	DPI	AY	AL	g	d
Maximum	5.8	2.0	2.0	2.3	1.2
Minimum	-2.7	-1.8	-5.4	1.8	-5.1
Mean	1.9	.8	-.3	2.0	11.3
			Percentiles		
95	4.5	1.5	1.5	—	0.5
90	4.0	1.2	1.4	2.2	.2
85	3.8	1.2	1.3	2.2	.1
80	3.5	1.2	1.1	2.2	-.2
75	3.3	1.1	1.0	2.2	-.4
70	3.0	1.1	.9	2.1	-.6
60	2.6	1.0	.6	2.1	-.9
50	2.0	.9	.4	2.0	-1.2
30	.7	.7	.1	1.9	-2.1
10	-.1	.2	-.2	1.9	-2.7

Two important factors affecting the potential for ground-water development are not considered in the DPI: (1) The depth to ground water and (2) the quality of the ground water. Table 16 lists the valleys ranked in order by the DPI, however, an initial screening was rejected from consideration in those valleys where (1) the depth to ground water is generally more than 500 ft below land surface, (2) the known water quality is fair to poor, (3) the index for available ground water (AY) is zero or less, and (4) the index for available good land (AL) is zero or less.

TABLE 16.--*Hydrographic areas sorted by the Development Potential Index (DPI)*

[Hydrographic areas were excluded from consideration where components AY and AL were negative, where depths to ground water are generally >500 ft, and where the quality of available ground water is known to be generally fair to poor, or worse.]

Hydrographic area			Index components			
No.	Name	DPI	AY	AL	g	d
61	Boulder Flat	5.84	1.46	1.99	2.00	0.389
44	North Fork Area	5.44	1.53	1.84	1.89	.191
97	Honey Lake Valley	5.38	.86	1.26	2.00	1.26
65	Pumpernickel Valley	5.17	1.20	1.38	2.00	.59
66	Kelly Creek Area	5.14	1.20	1.39	2.00	.55
184	Spring Valley	5.12	1.98	1.46	2.00	-.32
9	Long Valley	4.78	1.11	1.48	1.89	.31
191	Pilot Creek Valley	4.71	.74	1.44	2.00	.53
67	Little Humboldt Valley	4.70	1.3	1.13	1.89	.37
188	Independence Valley	4.68	.87	.96	1.89	.96
177	Clover Valley	4.58	1.29	1.48	1.93	-.12
47	Huntington Valley	4.40	1.20	1.55	1.93	-.28
30B	Sod House Subarea	4.20	.78	.75	2.00	.67
48	Dixie Creek-Tenmile Creek Subarea	4.20	.95	1.28	1.93	.04
154	Newark Valley	4.18	1.18	1.11	1.93	-.04
187	Goshute Valley	4.12	.99	1.37	1.89	-.13
139	Kobeh Valley	4.09	1.21	.80	1.93	.15
58	Middle Reese River Valley	3.99	.68	1.17	2.06	.08
170	Penoyer Valley	3.94	.64	.91	2.22	.17
55	Carico Lake Valley	3.90	.94	.46	2.00	.49
35	South Fork Owyhee River Area	3.89	.95	1.45	1.89	-.40
150	Little Fish Lake Valley	3.88	1.04	.53	1.93	.38
26	Mud Meadow	3.86	1.14	.93	1.95	-.16
189B	Toano-Rock Spring Area	3.86	.52	.93	1.89	.52
57	Antelope Valley	3.85	1.00	1.14	2.00	-.29
208	Pahroc Valley	3.79	1.34	.30	2.15	.00
95	Dry Valley	3.74	.30	.73	2.06	.64
210	Coyote Spring Valley	3.73	1.28	.26	2.26	-.07
43	Starr Valley Area	3.73	1.03	1.15	1.93	-.38
78	Granite Springs Valley	3.70	.74	.55	2.00	.41

TABLE 16.—*Hydrographic areas sorted by the Development Potential Index (DPI)*—Continued

Hydrographic area			Index components			
No.	Name	DPI	AY	AL	g	d
62	Rock Creek Valley	3.60	.40	.89	1.93	.38
180	Cave Valley	3.60	.42	.64	2.00	.55
138	Grass Valley	3.55	1.13	.88	1.93	-.39
51	Maggie Creek Area	3.53	.66	1.10	1.93	-.16
21	Smoke Creek Desert	3.51	1.20	.81	2.06	-.56
2	Continental Lake Valley	3.46	1.03	.85	1.93	-.35
15	Boulder Valley	3.42	.48	.61	1.84	.49
8	Massacre Lake Valley	3.41	.58	.55	1.84	.42
140B	Monitor Valley, Southern Part	3.40	1.04	.68	1.93	-.25
113	Huntoon Valley	3.28	.06	.60	2.15	.47
195	Snake Valley	3.24	1.42	.93	2.00	-1.10
14	Surprise Valley	3.15	.54	.42	1.89	.29
63	Willow Creek Valley	3.08	.36	1.10	1.89	-.27
73A	Oreana Subarea	2.98	.46	.88	2.06	-.43
82	Dodge Flat	2.89	.49	.33	2.06	.01
140A	Monitor Valley, Northern Part	2.86	.91	.58	1.93	-.57
201	Spring Valley	2.84	.84	.33	1.93	-.27
100	Cold Spring Valley	2.80	.06	.42	2.06	.26
12	Mosquito Valley	2.77	.40	.30	1.89	.18
11	Coleman Valley	2.76	.30	.35	1.93	.18
130	Pleasant Valley	2.75	.54	.73	2.06	-.58
25	High Rock Lake Valley	2.70	.78	.46	1.89	-.42
151	Antelope Valley	2.68	.68	.61	1.93	-.54
178B	Butte Valley, Southern Part	2.67	1.17	.37	1.93	-.81
181	Dry Lake Valley	2.65	.54	.20	2.15	-.24
94	Bedell Flat	2.62	.11	.35	2.06	.10
165	Jean Lake Valley	2.55	.02	.54	2.30	-.31
120	Garfield Flat	2.55	.06	.34	2.06	.08
60	Whirlwind Valley	2.53	.60	.44	2.06	-.57
27	Summit Lake Valley	2.44	.30	.65	1.84	-.36
38	Bruneau River Area	2.36	1.04	.12	1.84	-.65
178A	Butte Valley, Northern Part	2.34	.81	.36	1.93	-.76
134	Smith Creek Valley	2.34	1.04	.34	1.93	-.98
172	Garden Valley	2.33	.84	.41	2.15	-1.08
189C	Rocky Butte Area	2.32	.32	.47	1.89	-.36

TABLE 16.--*Hydrographic areas sorted by the Development Potential Index (DPI)*--Continued

Hydrographic area			Index components			
No.	Name	DPI	AY	AL	g	d
3	Gridley Lake Valley	2.31	.57	.16	1.89	-.32
93	Antelope Valley	2.28	.06	.65	2.06	-.50
34	Little Owyhee River Area	2.27	.38	.30	1.89	-.30
197	Escalante Desert	2.19	.30	.14	2.15	-.40
80	Winnemucca Lake Valley	2.16	.63	.09	2.06	-.62
196	Hamlin Valley	2.16	.78	.21	2.06	-.89
204	Clover Valley	2.15	.30	.47	2.15	-.76
174	Jakes Valley	2.11	1.11	.29	1.93	-1.22
109	East Walker Area	2.07	.81	.30	1.93	-.97
186A	Antelope Valley, Southern Part	1.90	.26	.21	1.93	-.49
185	Tippett Valley	1.84	.65	.05	1.93	-.80
10	Macy Flat	1.74	.10	.16	1.84	-.36
50	Susie Creek Area	1.65	.50	.05	1.89	-.80
175	Long Valley	1.56	.84	.06	1.93	-1.27
121B	Soda Spring Valley, Western Part	1.45	.08	.25	2.22	-1.10
135	Ione Valley	1.34	.54	.28	2.00	-1.48
126	Cowkick Valley	1.25	.23	.06	2.06	-1.10
132	Jersey Valley	1.24	.09	.13	2.15	-1.12
19	Dry Valley	.90	.04	.02	2.06	-1.22

Figure 24 shows those valleys not eliminated by the above criteria, ranked by the DPI for evaluation of the need for background monitoring. Five classes are shown, on the basis of the 95, 90, 85, and 75 percentiles. The DPI is, by its construction, biased towards agricultural development. Historical land-development patterns have consisted of agricultural development followed by urbanization. Exceptions exist in Nevada in valleys where the dominant industry is mineral oriented; however, this type of development is, to a large extent, unpredictable.

Application of the Indices

The two indices developed above are intended to be no more than guides for management decisions. The indices offer the manager objective means of quickly preparing a "menu" of targets for two different types of areal monitoring. The selection of characteristics used in the development of the indices was largely arbitrary; the original data base is readily available for modifying the indices as deemed advisable. Water-use and population values used were based on 1970 data; these values should be updated with more recent data. Other values may also be readily updated as necessary.

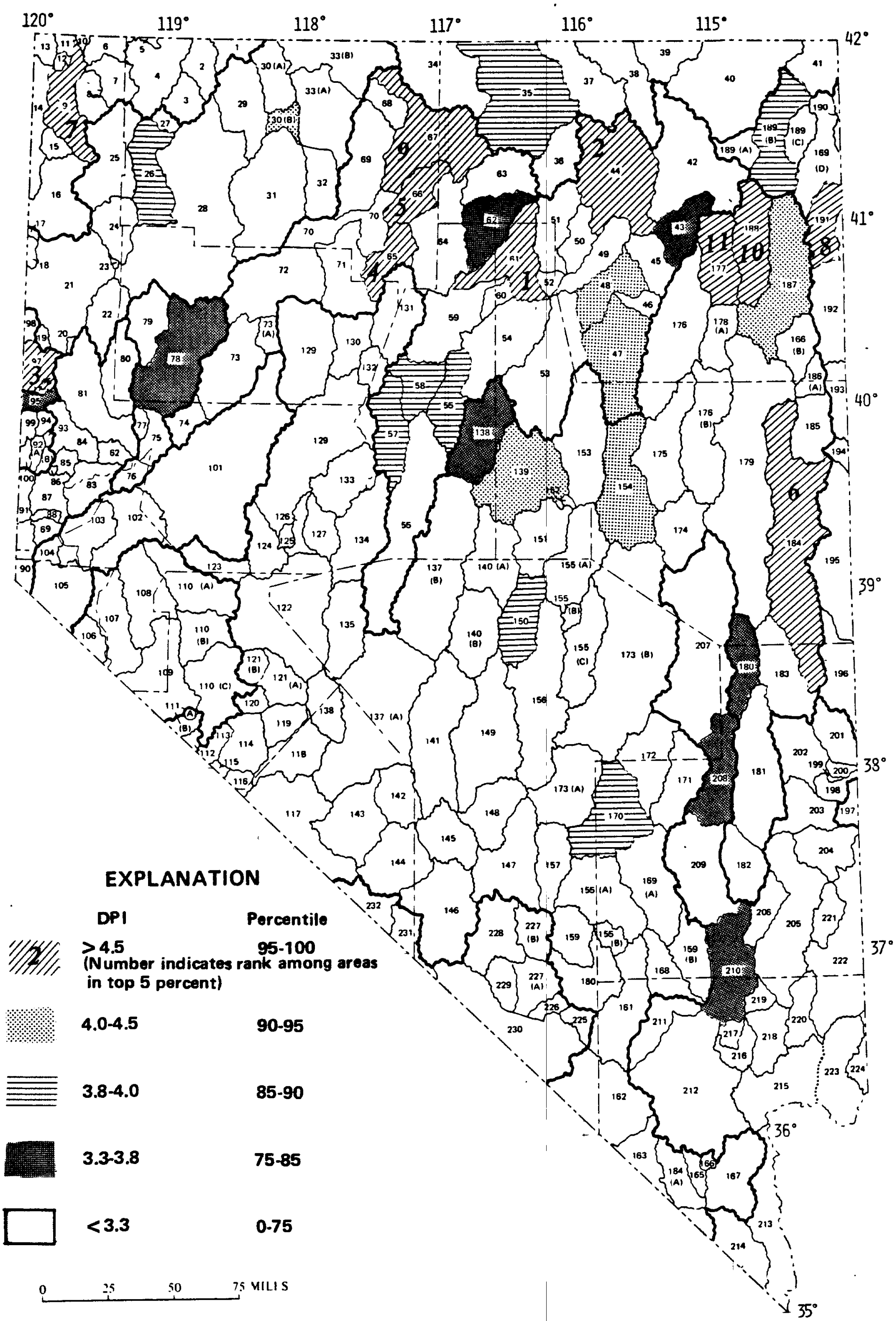


FIGURE 24.--Priority for background monitoring of hydrographic areas as indicated by the index DPI.

Background-Quality Network

The Background-Quality Network is intended to supply reconnaissance-level data on the existing quality of water in Nevada's major aquifers. The function of background monitoring is to document existing water-quality conditions, to establish a background against which current anomalies or future changes can be measured. In areas of light development, the background ground-water quality may be the result of natural long-term processes, and may be documented by available historical data. In more intensely developed areas the background quality may be the result of more dynamic interactions between natural conditions and the effects of development. In these areas, historical data may not be adequate to define current conditions accurately.

The availability of historical water-quality data for ground water in Nevada is discussed in preceding sections of this report; one of the first functions of the monitoring program should be to collate and review these data and assemble them into a central file. This assemblage of data would be the initial contribution to the Ground-Water Data File. Preliminary steps towards this end have been taken and are discussed in a following section on the Ground-Water-Monitoring Data File.

The compilation of historical data should include an evaluation of the reliability of reported values. Data will first have to be screened for consistency of reporting units. Approximate checks of data reliability may be made for most chemical analyses by examining the cation-anion balance, the ratio of dissolved-solids concentration by evaporation to that computed from the sum of the ions, and the ratio of the sum of the anions to the specific conductance. Data not meeting limits defined for these reliability checks should be flagged for the benefit of subsequent users of the data base.

Once the initial compilation of historical data is complete, a summary report could be produced describing the general quality of Nevada's ground water as presently known. An example of such a report was that done by Swain (1973) for Hawaii. The report would summarize the available information on ground-water quality for each of the 255 hydrographic areas. The most efficient approach might be a statistical summary showing the frequency distribution for the more significant water-quality characteristics in the initial data base. Data could be displayed graphically on a regional basis and by individual hydrographic areas for those valleys with sufficient data. An example of one format for displaying such data is shown in figure 25. The summary report should, where possible, discuss the relationship of ground-water quality to individual aquifer units; the minimum detail would be to compare the water quality in bedrock and valley-fill aquifers, where known. The report might conclude with an analysis of deficiencies in the data base in terms of reported constituents and areal coverage. For example, very few data are available on background concentrations of metals or organics in Nevada ground water. Recommendations could be made for systematic collection of data to correct the deficiencies.

The Development-Potential Index discussed in a preceding section may be used as a guide in assigning priorities for acquiring background data in valleys with little development. The 90th percentile of hydrographic areas as ranked by the DPI is listed in table 17, along with the number of analyses available for each valley in the prototype water-quality data base and summary comments on the available published data. Minimum action to document the background quality in high-priority valleys would include:

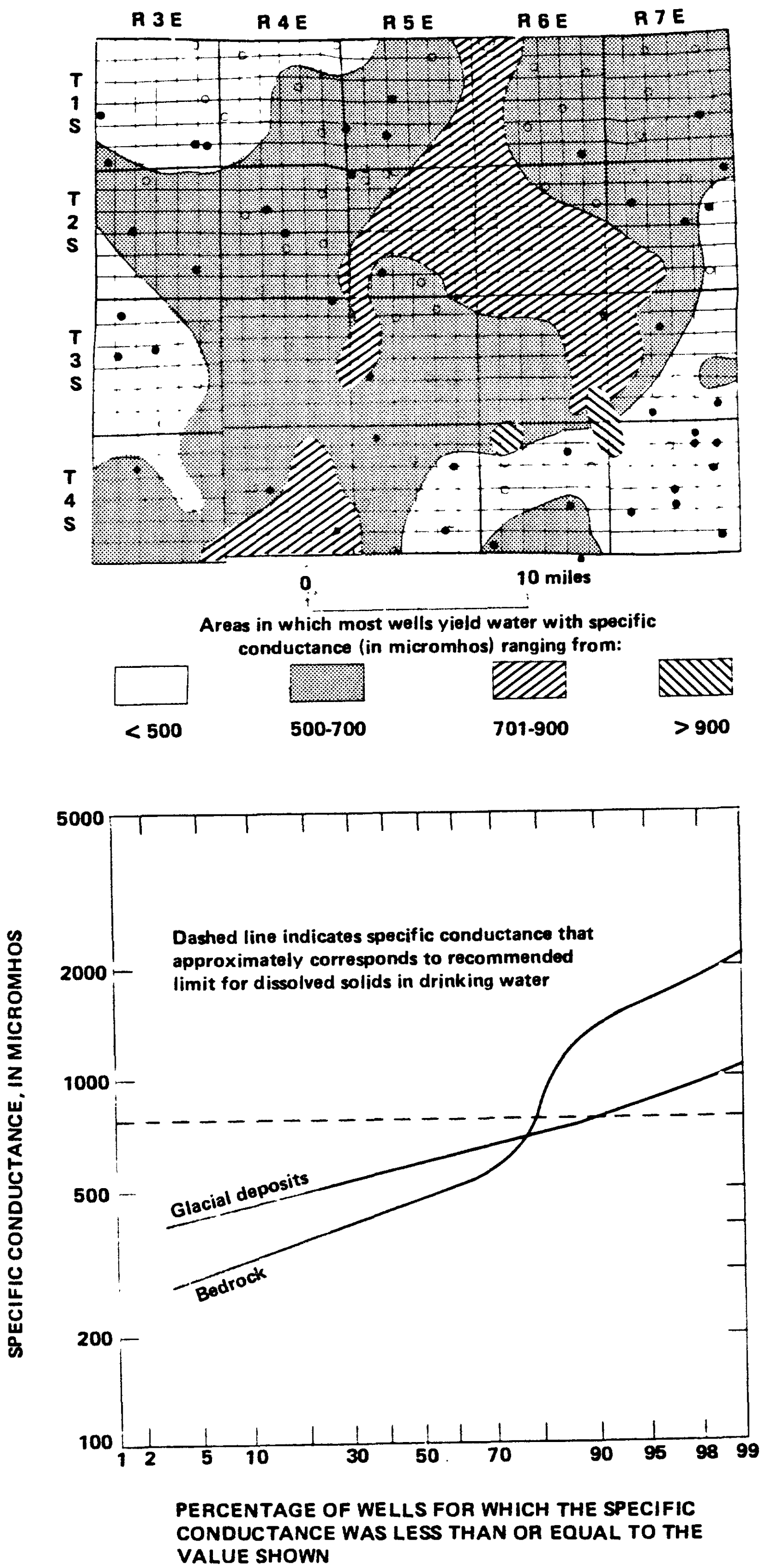


FIGURE 25.--Example of technique for presentation of summary data on background water quality (modified from Twenter and others, 1976).

TABLE 17.—*Available background data for valleys with high potentials for ground-water development*

Hydrographic area No.	Hydrographic area Name	Number of analyses in prototype data base (see text)	Published references (number in Bibliography)	Remarks
61	Boulder Flat	5	87, 137	Very little data on ground-water quality.
44	North Fork Area	1	80, 81, 87	Do.
96	Honey Lake Valley	6	111	Ground-water quality appears to be marginal for irrigation.
65	Pumpernickel Valley	1	80, 81, 87	Very little data on ground-water quality.
66	Kelly Creek Area	4	87	Do.
184	Spring Valley	5	87, 114	Limited water-quality data; ground-water quality appears suitable for most purposes.
9	Long Valley	4	120	Limited data.
191	Pilot Creek Valley	0	57, 87	Ground-water quality highly variable.
67	Little Humboldt Valley	12	80, 81, 87	Very little data.
188	Independence Valley	1	--	--
177	Clover Valley	4	87	Very little data.

1. A brief assessment of the potential for ground-water development and delineation of probable areas of future development.
2. An inventory of readily available well-construction and water-quality data.
3. An evaluation of the adequacy of existing data to describe the background quality of ground water.
4. Collection of the minimum necessary field data to meet any deficiencies in item 2, including water-level data.
5. Preparation of a brief report describing the background conditions in the target valley and recommending any subsequent data collection needed at further stages of development.

Background monitoring could be begun on the basis of a few valleys per year, the actual number depending upon the available staff and funding. The summary reports would be brief but would provide valuable data against which to measure any effects of future development.

Contamination-Source Inventory

The function of the Contamination-Source Inventory is to document known or potential sources of ground-water contamination; the detail of that documentation will depend upon the intended level of monitoring. Background monitoring will require a screening of potential sources to insure that the data collected are truly representative of background quality and not influenced by local sources of contamination. Surveillance monitoring will require a more detailed evaluation of potential sources of contamination, including a study of the hydrologic environment, an inventory of types and quantities of contaminants, and a prediction of the ultimate effect on the ground-water resource. Intensive studies will require even more source detail, including the monitoring of individual waste outputs. Many municipal and industrial waste-disposal practices in Nevada involve routing the wastes to unlined percolation or evaporation ponds or ditches for ultimate disposal. In many instances, these practices probably result in some degree of contamination to the local subsurface environment. Given practical limitations on finances and manpower, however, monitoring such systems is not justifiable if no productive aquifer is currently or potentially affected because (1) the yield or quality of the receiving hydrologic system is too poor to be of beneficial use or (2) the point of recharge is so far upgradient from productive aquifers as to minimize the possibility of their contamination (effective distance will depend upon the nature of the wastes and the local hydrologic system).

A preliminary inventory of potential contamination sources is presented in table 18 as a general guide to more detailed investigations. Known mining activities, industrial operations, municipal waste-disposal systems, and landfills (point sources), along with areas of non-sewered urbanization and intensive irrigation (diffuse sources), were compiled and indexed by hydrographic area. Readily available data on the hydrologic flow system and existing ground-water uses were examined to select the sources most likely to affect beneficial uses of ground water. Those sources are summarized in the table for each hydrographic area.

Compilation and review of the Contamination-Source Inventory should be a continuing function of the monitoring program. An operational inventory of point sources for ground-water contamination might be maintained as part of the State Program of Pollution Discharge Elimination Permits. The potential of an activity for ground-water contamination can be evaluated as part of the permit-issuance process, and ground-water monitoring provisions could be

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*

Hydrographic areas: Asterisk indicates area designated for control of ground-water withdrawals by State Engineer.
Major aquifers: a, alluvium; c, carbonate rocks; v, volcanic rocks; n, no major aquifer with potable water.
Native ground-water quality: e, excellent; g, good; f, fair; p, poor; s, satisfactory for most uses; u, unsatisfatory for most uses; ?, unknown.
Potentially affected uses: D, esixting domestic supplies; Dp, probable future domestic supplies; I, irrigaton; In, industrial; N, none known; P, community public supplies; S, stock watering; SW, affects quality of receiving surface water.

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
NORTHWEST REGION									
1	Pueblo Valley	—	—	2,100	a	s-u	Septic-tank effluents	D	At Denio
2	Continental Lake V.	—	—	1,200	a	s-u			
3	Gridley Lake Valley	—	—	450	a	s-u			
4	Virgin Valley	—	minor	—	a	s-u			
5	Sage Hen Valley	—	—	—	a	s-u			
6	Guano Valley	—	—	—	a	s-u			
7	Swan Lake Valley	—	—	—	n	s-u			
8	Massacre Lake Valley	—	—	150	a	s-u			
9	Long Valley	—	—	200	a	s-u			
10	Macy Flat	—	—	—	a	s-u			
11	Coleman Valley	—	—	—	a	s-u			
12	Mosquito Valley	—	—	—	a	s-u			
13	Warner Valley	—	—	390	a	s-u			
14	Surprise Valley	—	—	—	a	s-u			
15	Boulder Valley	—	—	—	a	s-u			
16	Duck Lake Valley	—	—	1,200	a	f-u			
BLACK ROCK DESERT REGION									
17	Pilgrim Flat	—	—	—	a	—			
18	Painters Flat	—	—	—	a	—			
19	Dry Valley	—	—	—	n	—			
20	Sano Valley	—	—	—	n	—			
21	Smoke Creek Desert	—	—	1,110	a	s-u			
22	San Emidio Desert	62	207	—	a	s-u			
23	Granite Basin	—	—	—	n	s-u			
24	Hualapai Flat	—	—	10,480	a	s	Irrigation-return flows	I	Intermittent monitoring by State Engineer
25	High Rock Lake Valley	—	—	—	a	—			
26	Mud Meadow	—	—	1,900	a	p-u			
27	Summit Lake Valley	—	—	—	a	p			
28	Black Rock Desert	—	—	4,800	a	p-u	Irrigation-return flows	I	
29	Pine Forest Valley	—	—	13,580	a	s-u	Irrigation-return flows	I	
30a	Rio King Subarea	—	—	39,100	a	s	Irrigation-return flows	I	
30b	Sod House Subarea	—	—	—	a	s-u			
*31	Desert Valley	—	—	12,000	a	s-u	Irrigation-return flows	I	Intermittent monitoring by State Engineer
*32	Silver State Valley	—	—	9,900	a	s	Irrigation-return flows	I	Do.
*33a	Quinn River Valley: Orovada Subarea	—	—	57,900	a	p-u	Septic-tank effluents	D	At Orovada: abandoned mine shaft used for effluent disposal
							Irrigation-return flows	I	
							Pesticide disposal site	N	Monitored by Coop. Ext. Service
*33b	McDermitt Subarea	106	—	1,170	a	p			

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
SNAKE RIVER BASIN									
34	Little Owyhee River Area	—	—	—	a	s			
35	South Fork Owyhee River Area	—	—	—	a	s			
36	Independence Valley	17	3	1,300	a	s			
37	Owyhee River Area	120	—	—	a	s			
38	Bruneau River Area	—	—	—	a	s			
39	Jarbidge Area	—	—	—	a	s			
40	Salmon Falls Creek Area	100	—	1,200	a	s			
41	Goose Creek Area	—	—	500	a	s			
HUMBOLDT RIVER BASIN									
42	Marys River Basin	890	—	600	a	?			
43	Star Valley Area	—	—	200	a	?			
44	North Fork Area	—	—	400	a	?			
45	Lamoille Valley	12	—	400	a	?	Septic-tank effluents?	D	At Lamoille
46	South Fork Area	—	—	—	a	g			
47	Huntington Valley	—	—	—	a	g			
48	Dixie-Tenmile Creek Area	—	—	100	a	g			
49	Elko Segment	4,300	—	300	a	?	Septic-tank effluents	D	At Spring Creek
50	Susie Creek Area	—	—	—	a	?			
51	Maggie Creek Area	—	397	—	a	?			
52	Marys Creek Area	260	—	—	a	?			
53	Pine Valley	—	4	1,000	a	s-u			
54	Crescent Valley	4	4	4,500	a	s-u	Irrigation-return flows	I	
55	Carico Lake Valley	—	—	250	a	g-p			
56	Lower Reese River Valley	12	—	3,270	a	s-u			
*57	Antelope Valley	—	—	3,300	a	s-u	Irrigation-return flows	I	Intermittent monitoring by State Engineer
*58	Middle Reese River Valley	—	—	10,900	a	s-u	Irrigation-return flows	I	do.
							Pesticide disposal site	N	Monitored by Coop. Ext. Service
59	Lower Reese River V.		2,480	4,000	a	?			
60	Whirlwind Valley	—	—	—	a	?			
61	Boulder Flat	—	16	2,500	a	?			
62	Rock Creek Valley	—	—	—	a	?			
63	Willow Creek Area	1	—	—	a	?			
64	Clovers Area	327	—	3,100	a	?			
65	Pumpernickel Valley	—	—	1,600	a	?			
*66	Kelly Creek Area	—	—	2,480	a	f-u			
67	Little Humboldt V.	—	—	—	a	g			
68	Hardscrabble Area	—	—	—	a	g			
*69	Paradise Valley	—	—	54,000	a	g	Irrigation-return flows Septic-tank effluents	I D	
*70	Winnemucca Segment	1,870	524	12,500	a	g-p	Irrigation-return flows Food processing wastes	I,D	

TABLE 18.--*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
* 71	Grass Valley	—	12	11,400	a	g-p	Irrigation-return flows	I	
72	Imlay Area	25	—	—	a	g-u			
73	Lovelock Valley	—	170	—	a	g-u	Pesticide disposal site	N	Monitored by Coop. Ext. Service
* 73a	Oreana Subarea	950	—	660	a	g-u			
74	White Plains	—	—	—	n	?			
WEST CENTRAL REGION									
75	Bradys Hot Springs	—	—	—	a	p-u			
76	Fernley Area	240	524	—	a	p-u			
77	Fireball Valley	—	—	—	n	?			
78	Granite Springs V.	—	2	—	a	s-u			
79	Kumiva Valley	—	—	—	a	s			
TRUCKEE RIVER BASIN									
80	Winnemucca Lake V.	—	—	—	a	?			
81	Pyramid Lake Valley	50	—	—	a	p-u			
82	Dodge Flat	—	—	—	a	?			
83	Tracy Segment	20	239	—	a	?	Septic-tank effluents	D	
* 84	Warm Springs Valley	—	—	2,200	a	s-u	High nitrate	Dp	Source of nitrate not established
* 85	Spanish Springs V.	—	—	—	a	s-u			
86	Sun Valley	—	—	—	n	s-u	Septic-tank effluents	D	Most water for public supplies imported
87	Truckee Meadows	7,185	436	—	a	e-p	Septic-tank effluents, urban wastes	D,P	Local problems with excessive arsenic
88	Pleasant Valley	—	—	—	a	g-p	Septic-tank effluents	D, SW	
89	Washoe Valley	—	—	—	a	e-g	Septic-tank effluents	D	Locally excessive flourides
90	Lake Tahoe Basin	90	—	—	a	e			
91	Truckee Canyon Segment	—	320	—	a	?			
WESTERN REGION									
* 92a	Lemmon Valley: Silver L. Subarea	15	—	400	a	g-p			
* 92b	Lemmon Subarea	935	—	—	a	g-f	Septic-tank effluents	D	
93	Antelope Valley	—	—	—	a	g-f			
94	Bedell Flat	—	—	—	a	g-f			
95	Dry Valley	—	—	—	a	g-f			
96	Newcomb Lake Valley	—	—	—	a	g-f			
97	Honey Lake Valley	—	—	1,200	a	s-u	Irrigation-return flows	I	
98	Skedaddle Creek V.	—	—	—	a	?			
99	Red Rock Valley	—	—	600	a	g-f			
*100	Cold Springs Valley	—	—	210	a	g-f	Septic-tank effluents	D	

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
CARSON RIVER BASIN									
101	Carson Desert	1,240	52	—	a,v	g-u	Irrigation-return flow & septic-tank effluents	D	Locally excessive arsenic
							Pesticide disposal site	N	Monitored by Coop. Ext. Service
							Shoal Nuclear Event	S	Monitored by DOE/EPA
102	Churchill Valley	62	—	120	a	g-u			
*103	Dayton Valley	110	—	3,700	a	g-u	Septic-tank effluents	D	
*104	Eagle Valley	3,645	—	—	a	e-f	Septic-tank effluents	Dp	Overland acres area
							Sewage irrigation	D	Golf course needs monitoring
105	Carson Valley	782	—	5,000	a	e-f	Irrigation-return flow, septic-tank effluents	Dp I	
							Large landfill	I	Dump refuse includes liquid wastes from Lake Tahoe Basin
WALKER RIVER BASIN									
106	Antelope Valley	156	—	850	a	e-f	Septic-tank effluents	D	
*107	Smith Valley	—	—	20,170	a	s-u	Irrigation return flow	I	
*108	Mason Valley	1,085	10,100	8,000	a	s-u	Mining & milling wastes		
							Septic-tank effluents	D	
							Irrigation-return flow	I	
109	East Walker Area	—	—	—	a	e-f			
110a	Walker Lake Valley:								
	Schurz Subarea	—	—	—	a	s-u			
110b	Lake Subarea	45	—	—	a	s-u			
110c	Whiskey Flat-Hawthorne Subarea	558	47	960	a	s-u	Industrial waste disposal	N	
CENTRAL REGION									
111a	Alkali Valley:								
	Northern Part	—	—	—	a	s-u			
111b	Southern Part	—	—	—	a	s-u			
112	Mono Valley	—	—	—	a	s-u			
113	Huntoon Valley	—	—	—	a	s-u			
114	Teels Marsh Valley	—	—	—	a	s-u			
115	Adobe Valley	—	—	—	a	s-u			
116	Queen Valley	—	—	—	a	s-u			
117	Fish Lake Valley	—	—	12,000	a	s-u	Irrigation-return flows	I	
118	Columbus Salt Marsh	—	11	—	a	f-u			
119	Rhodes Salt Marsh	—	—	—	a	f-u			
120	Garfield Flat	—	—	—	a	s-u			
121a	Soda Springs Valley:								
	Eastern Part	81	—	—	a	s-u			
121b	Western Part	—	—	—	a	s-u			
122	Gabbs Valley	330	480	1,000	a	f-u			
123	Rawhide Flats	—	—	—	a	s-u			
124	Fairview Valley	—	2	—	a	s-u	Shoal Nuclear Event	D	Monitored by DOE/EPA
125	Stingaree Valley	—	—	—	n	s-u			

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
126	Cowkick Valley	—	—	2	a	s-u			
127	Eastgate Valley Area	—	—	—	a	s-u			
128	Dixie Valley	—	—	6,600	a	s-u	Irrigation-return flows	I	Intermittent monitoring by State Engineer
129	Buena Vista Valley	—	1	2,460	a	s-u	Irrigation-return flows	I	
130	Pleasant Valley	—	—	1,000	a	s-u			
131	Buffalo Valley	—	—	1,050	a	s-u			
132	Jersey Valley	—	—	30	a	s-u			
133	Edwards Creek Valley	—	—	2,100	a	s-u			
134	Smith Creek Valley	—	—	—	a	s-u			
135	Ione Valley	—	—	—	a	g-u			
136	Monte Cristo Valley	—	—	—	a	s-u			
137a	Big Smoky Valley: Tonopah Flat	—	—	260	a	s-u			
137b	Northern Part	13	2	7,500	a	s-u	Irrigation-return flows	I	
138	Grass Valley	—	—	600	a	g-p			
139	Kobeh Valley	—	—	600	a	s-p			
140a	Monitor Valley: Northern Part	—	—	300	a	s-p			
140b	Southern Part	—	28	—	a	s-p			
141	Ralston Valley	—	—	—	a	s			
142	Alkali Spring Valley	11	—	—	a	f-u			
143	Clayton Valley	32	14,000	—	a	s-u			
144	Lida Valley	—	—	—	a	s-u			
145	Stonewall Flat	—	—	—	n	s-u			
146	Sarcobatus Flat	—	—	—	a	s-u			
147	Gold Flat	—	—	—	a	?	Nevada Test Site	N	Monitored by DOE/EPA
148	Cactus Flat	—	—	—	a	?			
149	Stone Cabin Valley	—	—	520	a	s			
150	Little Fish Lake V.	—	—	240	a	s			
151	Antelope Valley	—	—	200	a	s			
152	Stevens Basin	—	—	—	n				
*153	Diamond Valley	49	10	40,200	a	s-u	Irrigation-return flows	I	
154	Newark Valley	—	—	5,600	a	s-u	Irrigation-return flows	I	
155a	Little Smoky Valley: Northern Part	—	—	—	a	s			
155b	Central Part	—	—	—	n	?			
155c	Southern Part	—	—	—	a	?			
156	Hot Creek Valley	—	16	2,680	a,c	s-u	Faultless Nuclear Event	D	Do.
157	Kawich Valley	—	—	—	a	?			
158a	Emigrant Valley: Groom Lake Valley	—	—	—	a	?			
158b	Papoose Lake V.	—	—	—	n	?			
159	Yucca Flat	—	1,100	—	a,c,v	?	Nevada Test Site	I,P	Do.
160	Frenchman Flat	—	—	—	a,c	?	do.		Do.

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area		Estimated ground-water withdrawals in 1975 (acre-feet)							
No.	Name	Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
161	Indian Springs V.	117	--	--	a				
*162	Pahrump Valley	43	200	38,000	a	s-u	Irrigation-return flows	I, Dp	Locally excessive nitrate
163	Mesquite Valley	--	--	600	a	s-u			
164a	Ivanpah Valley:								
	Northern Part	30	--	--	a	s-u			
164b	Southern Part	--	--	--	a	?			
165	Jean Lake Valley	--	--	--	n	?			
166	Hidden Valley (South)	--	--	--	n	?			
167	Eldorado Valley	--	--	--	a	s-u			
168	Three Lakes Valley	--	--	--	--	?			
169a	Tikapoo Valley:								
	Northern Part	--	--	--	a	?			
169b	Southern Part	--	--	--	a	?			
170	Penoyer Valley	--	1	--	a	s-u			
171	Coal Valley	--	--	--	a	?			
172	Garden Valley	--	--	--	a	?			
173a	Railroad Valley:								
	Southern Part	--	--	--	--	?			
173b	Northern Part	14	--	16,000	a	s-u	Irrigation-return flows	I	
							Oil fields	I	Few wells likely to be affected
174	Jakes Valley	--	--	--	a	?			
175	Long Valley	--	--	--	a	s-u			
176	Ruby Valley	--	7,500	5,000	a	s-u	Irrigation-return flow	I	
177	Clover Valley	--	--	2,700	a	?			
178a	Butte Valley:								
	Northern Part	--	--	300	a	s			
178b	Southern Part	--	--	300	a	s			
179	Steptoe Valley	3,370	5,958	10,000	a	e-u	Mining and milling wastes	P	At McGill
180	Cave Valley	--	--	--	a	?			
181	Dry Lake Valley	--	--	--	a	?			
182	Delmar Valley	--	--	--	a	?			
183	Lake Valley	--	--	9,000	a	e-u	Irrigation-return flows	I	
184	Spring Valley					s-u			
185	Tippet Valley	--	--	--	a	s			
186a	Antelope Valley:								
	Southern Part	--	--	--	a	s			
186b	Northern Part	--	233	--	a	s			
187	Goshute Valley	190	--	800	a	s-u			Ground water exported to H.A. 192 for public supply
188	Independence Valley	--	--	--	a	s			
GREAT SALT LAKE BASIN									
189a	Thousand Springs V.: Herrell Siding-Brush Creek Area	--	--	1,800	a	e-f			
189b	Tosno-Rock Spring Area	--	--	300	a	e-f			
189c	Rocky Butte Area	--	--	300	a	e-f			
189d	Montello-Critenden Creek Area	40	--	300	a	f-p			

TABLE 18.—*Preliminary inventory of potential sources of ground-water contamination in Nevada as of 1977*—Continued

Hydrographic area No.	Hydrographic area Name	Estimated ground-water withdrawals in 1975 (acre-feet): Community public supplies	Industrial supplies	Irrigation supplies	Major aquifers[2]	Native ground-water quality[3]	Potential sources of ground-water contamination[3]	Potentially affected downgradient ground-water uses	Remarks
190	Grouse Creek Valley	—	—	—	a	e-f			
191	Pilot Creek Valley	—	—	—	a	s-u			
192	Great Salt Lake	—	—	—	a	p-u			Public supply imported from H.A. 187
193	Deep Creek Valley	—	—	—	a	s			
194	Pleasant Valley	—	—	—	a	e-g			
195	Snake Valley	—	—	3,500	a	e-f	Septic tanks, cesspools	D	Reported bacteriological contamination at Baker
196	Hamlin Valley	—	—	—	a	e-f			
ESCALANTE DESERT REGION									
197	Escalante Desert	—	—	—	a	?			
COLORADO RIVER BASIN									
198	Dry Valley	—	—	4,000	a	g	Irrigation-return flow	I	
199	Rose Valley	—	—	600	n	g-p			
200	Eagle Valley	—	—	—	a	g-p			
201	Spring Valley	—	—	4,400	a	e-f	Irrigation-return flows	I	
202	Patterson Valley	190	1	—	a	e-g			
203	Panaca Valley	172	37	900	a	g-p			
204	Clover Valley	—	—	—	a	e-f			
205	Lower Meadow Valley Wash	470	—	7,500	a	g-p	Irrigation-return flows	I	
206	Kane Spring Valley	—	—	—	n	?			
207	White River Valley	—	—	28,800	a	?	Irrigation-return flows Septic-tank effluents	I D	 At Preston, Lund
208	Pahroc Valley	—	—	—	a	?			
209	Pahranagat Valley	78	1	17,000	a	s-u			
210	Coyote Spring Valley	—	—	—	a	?			
211	Three Lakes Valley	—	—	—	a	?			
*212	Las Vegas Valley	49,300	1,660	3,800	a	g-u	Urban and irrigation return flows, recharge with sewage effluent, industrial waste	P, D, In, SW	
213	Colorado River Basin	1	1	—	a	s-u			
214	Piute Valley	150	—	—	a	s-u			
215	Black Mountains Area	—	—	—	a	p-u			
216	Garnet Valley	—	—	—	a	?			
217	Hidden Valley	—	—	—	a	?			
218	California Wash Area	31	3	800	a	f-u			
*219	Muddy R. Springs Area	—	—	2,500	a	f-p	Irrigation-return flows	I	
220	Lower Moapa Valley	—	155	—	a	f-u			
221	Tule Desert	—	—	—	a	?			
222	Virgin River Valley	231	—	—	a	f-u			
223	Gold Butte Area	—	—	—	a	f-p			
224	Greasewood Basin	—	—	—	a	f-p			
225	Mercury Valley	—	400	—	a,c	?	NTS	In, P	Monitored by DOE/EPA
226	Rock Valley	—	—	—	a	?	NTS		Do.
227a	Fortymile Canyon: Jackass Flats	—	—	—	a	v	NTS	In, P	Do.
227b	Buckboard Mesa	—	—	—	a	v	NTS		Do.
228	Oasis Valley	120	—	300	a	s-u	Low-level radioactive waste disposal		Do.
229	Crater Flat	—	—	—	s	?	NTS		Do.
230	Amargosa Desert	—	—	8,000	a,c	s-u	NTS		Do.
231	Grapevine Canyon	—	—	—	a	s			
232	Oriental Wash	—	—	—	a	s-u			

included in the permit stipulations. Potential diffuse sources of ground-water contamination may be identified by a continuing review of patterns of agricultural, urban, and industrial development. Areas of known or suspected problems may be designated for initiation of surveillance or intensive monitoring efforts as appropriate.

Surveillance Network

Surveillance monitoring is to be done on an areal basis to document long-term trends in ground-water quality. The long-term Hydrologic Monitoring Network operated by EPA for DOE is a good example of ground-water monitoring at the surveillance level.

Effective evaluation of long-term monitoring data requires high-quality data and continuity of record. A considerable effort in evaluating the target areas and selecting monitoring sites, on the basis of the previously discussed principles, is generally warranted. Effective location of monitoring sites commonly will require the drilling of special observation wells for that purpose.

Allocation of the limited funds available for surveillance monitoring can be made by conducting the monitoring on a valley-by-valley basis, depending on need. Hydrographic areas in Nevada have been ranked for monitoring priority on the basis of estimated stress on the ground-water resources as of 1977 (table 15, fig. 23).

Development of a monitoring scheme at the surveillance level is illustrated by an example. Las Vegas Valley was ranked number one by the HPI index and was chosen by the Nevada DEP as the first valley for surveillance monitoring. A proposed monitoring network and the process by which it was developed are discussed by Van Denburgh and others (1982).

The output from surveillance monitoring will be raw data. These data could be compiled annually in reports that would include graphs showing time trends of water quality, maps showing areal distribution of concentrations, and tables summarizing the data. The raw data should be reviewed regularly and promptly to provide feedback to the monitoring effort, and appropriate regulatory authorities should be notified of significant anomalies as they are observed.

Intensive Surveys

Intensive surveys document specific known or suspected instances of contamination. The surveys would be conducted as case studies with specific goals. Data would be collected in sufficient detail to define the hydrologic flow system, describe the quality of the native water and contaminants in question, document existing contamination, and predict future movement of contaminants. Output would be technical reports of the results of the study and suggestions for appropriate control measures. If needed, sites would be established for long-term monitoring, as part of the statewide surveillance program.

Targets for intensive-survey monitoring range in scale from industrial point sources to urban or agricultural return flows. Examples of this program element include investigations of ground-water quality by DRI at the Gilcrease Ranch area of Las Vegas Valley (Patt and Hess, 1976) and at Fort Churchill (Hess and Mifflin, 1976), and a study by the USGS the disposal of wastes associated with the mining and milling of copper ore at Weed Heights (Seitz and others, 1982). On a larger scale, the EPA/DRI study of shallow ground-water quality in Las Vegas Valley (Kaufman, 1978; Patt, 1978) would be an example of an intensive survey of areal contamination from diffuse sources.

The Hydrographic-Area Priority Index and Contamination-Source Inventory may be used in conjunction to select candidates for additional intensive studies. For example, Truckee Meadows (H.A. 87) is ranked number two by the Hydrographic-Area Priority Index. Intensive studies are needed in that valley to examine the natural occurrence of arsenic in ground water and to evaluate the potential for ground-water contamination by rapidly intensifying urban development.

Ground-Water-Monitoring Data File

Section 108 of Public Law 92-500 includes a mandate for data processing as well as data collection in monitoring programs: "***the establishment and operation of appropriate devices, methods, systems, and procedures to monitor, and to compile and analyze data***and provision for annually updating such data***" (Sec. 108e). The existing data on ground-water quality in Nevada are quite extensive and are distributed among manual and computer files of several agencies. Initiation of a formal statewide program for monitoring ground-water quality will require an efficient organization and compilation of the existing data and a systematic procedure for adding to the data base as new information is collected. The following section describes the requirements of a central data file for ground-water information and gives an overview of existing data-management systems that could be adopted to meet those needs.

Functions of the Data File

Each of the major components of the monitoring program will require data exchanges with other components. For example, data on potential sources of contamination compiled for the Source Inventory will need to be analyzed in the process of selecting sites for inclusion in the Surveillance Network. Water-quality data from Surveillance-Network sites will have to be evaluated along with background data and Source-Inventory data in the process of conducting an Intensive Survey. In addition to internal data exchanges between program components, external data exchanges will be required to input information on aquifer hydraulics, well construction, water use, and water quality. Output of monitoring data will be required in formats ranging from raw data to statistical summaries and reports.

The Ground-Water Data File is proposed as the fifth major component of the total monitoring program, to expedite both internal and external flows of data. Options for data management range from manual files and simple data-processing systems to large-scale computer-based data-management systems. The volume of existing data related to ground water in Nevada is large. For example, the number of domestic-water analyses processed by the Nevada Bureau of Laboratories and Research is estimated at 13,000. The manual files containing these analyses are growing at a rate of about 2,400 per year. Drillers' logs reporting details of well construction and aquifer lithology on file with the Nevada State Engineer number about 16,000 as of 1977, with about 950 new logs being received each year. Monitoring of public water supplies under provisions of the Safe Drinking Water Act of 1974 will generate water-quality data at frequencies ranging from daily to annually for an estimated 350 community public water systems in Nevada, supplied wholly or in part by ground-water sources. Monitoring at less frequent intervals will be required for an estimated 600 to 700 non-community public water systems, most of which are served by wells or springs. In addition to these background data, more localized data on ground-water quality are being generated by a variety of State and Federal agencies. Integrating these data with the output from elements of the monitoring program will be a major task, the magnitude of which can only increase with growing demands on the ground-water resource. With the ever increasing volume of data to be managed, efficient management of the Data File for the monitoring program presumably will require some sort of automated system or systems.

Information-Management Requirements

General data requirements and information flows between elements of the monitoring program are summarized in table 19. The information to be managed may be grouped by type into seven general categories:

1. Site identification.
2. Geologic framework.
3. Hydrologic framework.
4. Site construction.
5. Recharge water.
6. Water-levels.
7. Water-quality data.

Information-management techniques are governed by the mode of occurrence of the data entries for each category. Data occurrences may be classified as unique, with only one entry made per site for a given property, or variable, with multiple entries allowed. An example of a unique item would be the site-identification number, which uniquely distinguishes a site from other sites in a file or data base. Variable data entries must be associated with a control value to establish uniqueness. For example, a county code would be variable within the data base; that is, many occurrences are allowable. However, when combined with a site-identification number as a control, the code becomes unique, describing the specific county in which the given site may be found. Another example of variable data being made unique by an associated control would be multiple values for a water-quality property

TABLE 19.--*Data-management requirements for elements in the monitoring program*

	Data input		Data output		
Program element	Type of data	Update frequency (per data item per site)	Type of data	Update frequency (per site)	Typical formats
Background Quality Network	Site identification	One-time	Water-quality data	Intermittent	Tabular, statistical
	Geologic framework	Do.			
	Site construction	Do.			
Surveillance Network	Site identification	Do.	Water-quality data	Periodic	Tabular, statistical, graphical
	Geologic framework	Do.			
	Aquifer hydraulics	Do.	Water levels	Do.	Tabular, statistical, graphical
	Site construction	Infrequent			
	Recharge	Periodic			
	Water withdrawals	Do.			
Intensive Surveys	Site identification	One-time	Water-quality data	Periodic to continuous	Tabular, statistical, graphical
	Geologic framework	Do.			
	Aquifer hydraulics	Do.	Water levels	Do.	Tabular, statistical, graphical
	Site construction	Do.			
	Recharge	Periodic to continuous			
	Water withdrawals	Do.			
Contamination Source Inventory	Site identification	One-time	Water-quality data	Periodic	Tabular
	Geologic framework	Do.	Site-identification data	Intermittent	Tabular
	Aquifer hydraulics	Do.			
	Recharge	Periodic			

such as temperature. For a given site, many entries may be made for temperature measurements. The uniqueness of each value would be defined by a temporal control such as date of sampling. If multiple samples are expected within a given day, a more specific control such as time of day must be given in addition to the date to preserve uniqueness.

The size and complexity of a data base are functions of (1) the number of discrete entries, (2) the number of variable characteristics, and (3) the frequency of entries for each variable. The general requirements of the Ground-Water Data File presented in table 19 are grouped by the seven categories of information defined above and expanded into a more detailed list of requirements in table 20. Included for each category are major elements or subtypes and typical specific characteristics. The approximate frequency of entry is given for variable properties along with the parameter controlling the uniqueness of each variable.

Site identification.--Site-identification data provide a unique identifier for the site, locate the site geographically and politically within the State, provide descriptive information as to site name, type, and purpose, and describe the monitoring activity and responsible agency. Site-identification data tend to be discrete, unique to the given site, or, if variable due to changes in time, to have low frequencies of occurrence with few expected updates.

TABLE 20.—*Types of data processed by a ground-water monitoring program*

DATA CATEGORY / Major elements / Typical parameters	Probable number of discrete data entries per site: One	Few	Many	Unlimited	Parameter controlling uniqueness of individual values	Remarks
SITE IDENTIFICATION						Identifies, locstes, and describes s discrete,
Site number (unique identifier)	X				site	Unique to each site; once assigned, not changed
Site location						
Latitude-longitude	X				site number	Provides geodesic coordinates
Landline	X				do.	Township, range, section, quarters. Provides simple legal and map reference
State	X					
County	X				do.	Geographic and political retrieval key
Hydrographic area or bssin	X				do.	Retrieval key
Site name						
Owner's name		X			date acquired	Multiple ownership probable
Date acquired by owner		X			date	
Owner's designation or number		X			date acquired	Changes in numbering probable
Date assigned by owner						
Site type						
Well, spring, pit, shaft, etc.	X					
Site use						
Water withdrawal, water recharge, waste disposal, observation point, etc.		X			dates	Multiple uses probable
Agency operating						
Period of record: Begin and end dates		X			data types	
Principal agency: Agency codes		X			dates	Agency or agencies collecting data
Data available: Type codes		X			agency code	Category of data collected
GEOLOGIC FRAMEWORK						
Vertical section		X				Unique position in 3rd dimension
Section number			X			Sequential from land surface
Depth to top, depth to bottom			X		section number	
Stratigraphy						Establishes position in stratigraphic sequence
AAPG stratigraphic codes or equivalent[1]			X		do.	
Lithology						Describes potential geologic controls on water movement
Rock types: Ssnd, gravel, bssalt, etc.			X		do.	Descriptive terms or codes
Modifiers: Coarse, fine, hard, red, etc.			X		do.	Descriptive terms or codes
Mineralogy						
Minerals present: Names or codes			X		do.	Describes potential controls on water quality
HYDROLOGIC FRAMEWORK						Describes hydrologic controls on water movement
Vertical section	X					Same as above
Aquifer description			X		do.	
Aquifer name			X		do.	May be combined with stratigraphic code
Aquifer type: Confined, unconfined, semiconfined		X			do.	Affects degree of communication between aquifers
Hydrologic zone: Recharge, discharge		X			do.	Position in aquifer relative to water movement
Saturation zone: Vadose, capillary, saturation		X			do.	Affects rate and direction of water movement

TABLE 20.—*Types of data processed by a ground-water monitoring program*—Continued

DATA CATEGORY Major elements typical parameters	Probably number of discrete data entries per site: One	Few	Many	Unlimited	Parameter controlling uniqueness of individual values	Remarks
HYDROLOGIC FRAMEWORK--Continued						
Aquifer hydraulics					do.	
Permeability or infiltration rate					do.	
Porosity		X			do.	
Particle-size distribution		X			do.	
Transmissivity		X			do.	
Storage coefficient		X			do.	
Field capacity		X			section number, date determined	Applies to unsaturated zone; variable with time
Aquifer chemistry						
Ion-exchange capacity		X			do.	Variable with time
SITE CONSTRUCTION						Describes physical installation at the site
Date constructed	X					Unique key to a given activity
Log number	X					Unique to a given activity
Method of construction: Dug, bored, cable tool, hydraulic rotary, etc.		X			date constructed	
Hole specifications						
Depth to top, bottom			X		do.	
Diameter			X		depth	
Casing specifications						
Diameter	X					
Depth to top, bottom		X			diameter	
Finish specifications						
Type: Gravel pack, screen, gallery, etc.		X			depth	
Depth to top, bottom	X					
RECHARGE WATER						
Type of water: Precipitation, industrial waste, domestic waste, irrigation return, etc.		X				
Permit numbers: State permits for waste discharge						
Type and degree of treatment: Settling ponds, aeration, Imhoff tanks, etc.		X			permit number	
Application rates					application rate	
Date determined			X		type	
Method: measured, estimated, reported			X		date	
Rate, in inches per year			X		do.	
Infiltration or recharge rates						
Date determined			X		rate of recharge	
Method: measured, estimated, reported			X		type	
Rate, in inches per year			X		date	
Recharge quality				X		Most efficiently stored with other water-quality data

TABLE 20.--*Types of data processed by a ground-water monitoring program*--Continued

DATA CATEGORY Major elements Typical parameters	Probsble number of discrete data entries per site				Parameter controlling uniqueness of individual values	Remarks
	One	Few	Many	Unlimited		
WATER LEVELS						
Descriptive parameters						
Period of record	X					
Frequency of measurement		X			period of record	May vary from once per site to continuous
Measuring-point datum:		X				
Date established	X					
Elevation		X			date established	
Description		X			do.	
Water levels						
Date/time measured				X		
Water level or altitude				X	date/time	
WATER-QUALITY DATA						
Date/time measured	X					
Descriptive parameters				X	date/time	
Agency collecting						
Agency analyzing						
Laboratory number						
Collection method: Pumped, bailed, etc.						
Site status: Pumping, flowing						
Discharge or pumping rate at sampling						
Water level at sampling						
Sampled depth or interval						
Sample source: Tap, bore, pressure tank						
Sample condition: Raw, filtered, treated						
Sample preservation: Raw, filtered, acidified, etc.						
Water-quality parameters				X	date/time	
Individual data items						Parameters should be both method- snd water-phase-specific

[1] AAPG: American Association of Petroleum Geologists

Geologic framework.--Geologic data define the stratigraphy and lithology of the recharge or production medium. Depth below land surface is the control for variables such as stratigraphy, lithology, and mineralogy. The number of entries to be stored for each variable will depend upon the detail of the source logs. Stratigraphic codes should follow an accepted standard to facilitate the exchange of data among agencies.

Hydrologic framework.--Hydrologic data define the physical influences on water occurrence and movement. Depth below land surface is the control for the variables. Aquifer names could be combined with the stratigraphic codes used for the geologic data. Provisions should be made for the storage and recall of quantitative descriptors of aquifer chemistry, such as the ion-exchange capacity.

Site construction.--Site-construction data define the physical installation (withdrawal or injection well, spring structure, and so forth) at a site. The completion date of a given construction activity provides a control allowing the unique recording of well modifications following the original construction. Controls are also needed for the hole diameters (which may differ with depth) and for casing depths (multiple strings of casing can be present in a given interval of depth).

Recharge water.--Recharge data define the nature, quantity, and quality of recharge at a site. The recharge fluid may be natural (precipitation or infiltrating surface water), cultural (waste effluents), or a combination of both. Primary control on entries of variables should be the type of recharge, as there may be more than one source at a given site. Multiple entries may be expected for rates of recharge and infiltration, with date of measurement as the control. Water-quality analyses of recharge waters may also have multiple entries.

Water levels.--Water-level data may be added to the data base at collection intervals ranging from one-time or intermittent to hourly or more frequently, depending upon the nature of the monitoring activity.

Water-quality data.--Water-quality variables will be added at widely differing frequencies, with date and time of collection as the control. The number of variables of water-quality data to be stored for a ground-water monitoring station can be large, and will vary widely with the particular monitoring effort. For example, more than 700 individual parameters exist for water analyses performed routinely by USGS laboratories. Water-quality data are commonly method-specific with respect to collection and analytical techniques, requiring each data item to have an identifier or qualifier attached denoting specific methodologies.

In addition to actual physical or chemical measurements, descriptive data must also be stored for individual samples specifying the point of collection in the vertical profile, the water discharge at the time of sampling, antecedent pumping time, sample condition, and other environmental variables that could affect interpretation of the analytical data. As an example of the potential complexity of a water-quality file, more than 2,000 individual parameter codes are used by the EPA STORET and USGS WATSTORE systems to identify water-quality data as of 1977.

Available Systems for Managing Ground-Water Data

Three basic options exist to establish the Ground-Water Data File: (1) Conception and development of the necessary resources locally, (2) purchase or lease of one or more commercially available general data systems, with subsequent adaptation to the specific monitoring needs, or (3) participation in an existing system for managing water-related data. The first option would be time-consuming and expensive, and would of necessity duplicate or parallel previous efforts by other agencies. The second option would be less time consuming than the first, although lead times of months to years might be required to adapt available commercial systems to the requirements outlined in the preceding section. The third option appears to be the most attractive; advantages of using existing systems include the availability of fully developed applications programs and a reduction in the required commitment of local fiscal and manpower resources. Disadvantages may include greater operational costs for individual components owing to overhead charges imposed by the parent agency, a lack of response to local needs because of inertia in the parent system, and the imposition of standards and system requirements more demanding than the local needs.

Three general systems are in use as of 1977 for storing water-related data in Nevada: (1) STORET, a national data-storage system operated by a commercial contractor for EPA; (2) the DRI hydrologic data banks, a local data-storage system operated by DRI at Las Vegas; and (3) WATSTORE, a national data-storage system operated by the USGS. The amount of data in each system on the quality of Nevada ground water is summarized in table 21. A fourth system, USGS' NAWDEX, is available as a directory of available water data.

STORET.--STORET (Storage and Retrieval System) is a national water-quality data system managed by EPA with operation by a private contractor. The system is accessed through remote terminals of member organizations, one of which is the Nevada Division of Environmental Protection in Carson City. Three types of data are stored in STORET: (1) Station descriptions, (2) parameter-code identifications, and (3) water-quality values. Individual data values are controlled by associated five-digit parameter codes that denote the parameter

TABLE 21.--*Inventory of data in major computer files as of October 1977 pertaining to Nevada ground-water quality*

Parameter (units are mg/L except as noted)	STORET code	EPA STORET[1]	USGS WATSTORE	DRI WADS[2]
Total analyses	--	369	1,550	11,608
Total number of parameters	--	60	119	36
Collection depth (ft)	00003	--	108	3,987
Analysis number	00008	369	602	2,600
Water temperature (°C)	00010	327	538	2,333
Collection agency	00027	--	178	11,608
Analysis agency	00028	--	179	11,608
Well yield (gal/min)	00058	--	14	--
Discharge (ft^3/s)	00060	--	33	--
Stage (ft above datum)	00065	--	3	--
Turbidity (JTU)	00070	--	222	--
Color (platinum-cobalt units)	00080	--	176	--
Specific conductance (umhos/cm at 25°C)	00095	364	793	2,303
Sample treatment code	00115	--	177	11,608
pH (units)	00400	11	440	10,281
Lab pH (units)	00403	354	--	--
Carbon dioxide	00405	--	437	10,123
Alkalinity, total as $CaCO_3$	00410	10	551	10,814
Bicarbonate	00440	341	551	10,814
Carbonate	00445	12	439	1,132
Residue, total filtrable (at 105°C)	00515	--	199	7,986
Residue, total nonfiltrable (105°C)	00530	--	22	--
Nitrogen, total as N	00600	--	24	--
Organic nitrogen, total as N	00605	--	24	--
dissolved as N	00607	--	8	--
Ammonia, dissolved as N	00608	7	21	--
total as N	00610	--	34	--
Nitrite, dissolved as N	00613	--	35	--
total as N	00615	--	33	--
Nitrate, dissolved as N	00618	--	125	7,890
total as N	00620	--	33	--
Kjeldahl nitrogen, dissolved as N	00623	--	8	--
total as N	00625	--	24	--
Nitrate + Nitrite, total as N	00630	6	33	--
dissolved as N	00631	--	231	--
Phosphate, total as PO_4	00650	--	216	313
Orthophosphate, dissolved as PO_4	00660	331	213	--
Phosphorus, total as P	00665	--	1	--
dissolved as P	00666	--	2	--

TABLE 21.--*Inventory of data in major computer files as of October 1977 pertaining to Nevada ground-water quality*--Continued

Parameter (units are mg/L except as noted)	STORET code	EPA STORET[1]	USGS WATSTORE	DRI WADS[2]
Orthophosphate, dissolved as P	00671	10	134	--
Carbon, dissolved organic, as C	00681	--	48	--
Aluminum, total (ug/L)	01105	--	125	--
dissolved (ug/L)	01106	10	147	--
Gallium, dissolved (ug/L)	01120	--	101	--
Germanium, dissolved (ug/L)	01125	--	100	--
Lithium, dissolved (ug/L)	01130	10	226	--
total (ug/L)	01132	--	1	--
Rubidium, dissolved (ug/L)	01135	--	15	--
Selenium, dissolved (ug/L)	01145	--	117	--
Titanium, dissolved (ug/L)	01150	--	102	--
Zirconium, dissolved (ug/L)	01160	--	99	--
Alpha, dissolved (pc/L)	01503	19	--	--
counting error (pc/L)	01504	14	--	--
Alpha, gross, dissolved (pc/L)	01515	--	5	--
Beta, dissolved (pc/L)	03503	19	--	--
counting error (pc/L)	03504	17	--	--
Beta, gross, dissolved as Cs-137	03515	--	44	--
suspended as Cs-137	03516	--	22	--
Tritium, total (pc/L)	07000	--	627	--
Tritium, total (tritium units)	07017	19	596	--
counting error (tritium units)	07019	4	--	--
Radium-226, total (pc/L)	09501	12	--	--
counting error (pc/L)	09504	3	--	--
Radium-226, radon method	09511	3	--	--
Strontium-90, dissolved (pc/L)	13503	12	--	--
counting error (pc/L)	13504	1	--	--
Strontium-89, dissolved (pc/L)	15503	12	--	--
Plutonium-238, dissolved (pc/L)	22001	10	--	--
Plutonium-239, dissolved (pc/L)	22010	10	--	--
Uranium-238, dissolved (pc/L)	22603	10	--	--
counting error (pc/L)	22604	10	--	--
Uranium-234, dissolved (pc/L)	22610	10	--	--
counting error (pc/L)	22611	10	--	--
Uranium-235, dissolved (ug/L)	22620	10	--	--
counting error (pc/L)	22621	10	--	--
Coliform, total, MF (colonies/100 mL)	31501	--	8	--
Suspended solids (at 110°C)	70299	--	3	--
Dissolved solids (at 180°C)	70300	--	212	1,941

TABLE 21.--*Inventory of data in major computer files as of October 1977 pertaining to Nevada ground-water quality*--Continued

Parameter (units are mg/L except as noted)	STORET code	EPA STORET[1]	USGS WATSTORE	DRI WADS[2]
Dissolved solids, sum	70301	354	340	1,346
Dissolved solids (tons per day)	70302	--	29	--
Dissolved solids (tons per acre-ft)	70303	--	219	1,941
Ammonium, total as NH_4	71845	--	20	--
Ammonia, dissolved as NH_4	71846	--	21	--
Nitrate, total as NO_3	71850	352	178	--
Nitrate, dissolved, as NO_3	71851	--	152	7,948
Nitrite, dissolved, as NO_2	71856	--	33	--
Hardness, total as $CaCO_3$	00900	--	551	10,701
Hardness, noncarbonate, as $CaCO_3$	00902	--	550	10,550
Calcium, dissolved	00915	10	551	10,637
total	00916	354	--	--
Magnesium, dissolved	00925	10	551	10,400
total	00927	352	--	--
Sodium, total	00929	354	--	--
dissolved	00930	10	808	1,941
Sodium-adsorption ratio, SAR (units)	00931	--	457	1,884
Sodium, percent	00932	--	464	1,819
Sodium plus potassium, dissolved	00933	--	19	8,649
Potassium, dissolved	00935	10	467	1,821
Sodium plus potassium, total	00937	354	--	--
Chloride, dissolved	00940	364	877	10,823
Sulfate, dissolved	00945	364	543	10,854
Fluoride, dissolved	00950	10	424	6,074
total	00951	353	3	--
Silica, dissolved	00955	10	352	1,871
total	00956	10	--	--
Arsenic, dissolved (ug/L)	01000	--	85	4,103
total (ug/L)	01002	1	130	--
Barium, dissolved (ug/L)	01005	--	101	--
Beryllium, dissolved (ug/L)	01010	--	103	--
Bismuth, dissolved (ug/L)	01015	--	100	--
Boron, dissolved (ug/L)	01020	6	272	399
total (ug/L)	01022	8	--	--
Cadmium, dissolved (ug/L)	01025	--	103	--
Cobalt, dissolved (ug/L)	01035	--	103	--
Copper, dissolved (ug/L)	01040	--	104	--
Iron, total (ug/L)	01045	1	212	--
dissolved (ug/L)	01046	10	232	--

TABLE 21.--*Inventory of data in major computer files as of October 1977 pertaining to Nevada ground-water quality*--Continued

Parameter (units are mg/L except as noted)	STORET code	EPA STORET[1]	USGS WATSTORE	DRI WADS[2]
Lead, dissolved (ug/L)	01049	--	101	--
Manganese, total (ug/L)	01055	1	126	--
dissolved (ug/L)	01056	10	--	227
Molybdenum, dissolved (ug/L)	01060	--	102	--
Nickel, dissolved (ug/L)	01065	--	103	--
Silver, dissolved (ug/L)	01075	--	102	--
Strontium, dissolved (ug/L)	01080	10	291	--
total (ug/L)	01082	--	1	--
Vanadium, dissolved (ug/L)	01085		102	--
Zinc, dissolved (ug/L)	01090	--	182	--
Antimony, dissolved (ug/L)	01095	--	11	--
Tin, dissolved (ug/L)	01100	--	101	--
Bromide, dissolved	71870	--	15	--
Manganese, in solu. at analysis (ug/L)	71883	--	111	535
Iron, in solution at analysis (ug/L)	71885	--	137	8,117
Phosphorus, total as PO_4	71886	--	22	--
Nitrogen, total as NO_3	71887	--	24	--
Mercury, dissolved (ug/L)	71890	--	11	--
Mercury, total (ug/L)	71900	--	1	--
Elevation of land-surface datum (ft. above sea level)	72000	--	411	--
Sample source code	72005	--	189	--
Depth of well, (ft)	72008	--	349	--
Top of sampled interval (ft)	72015	3	--	--
Water level, (ft blw. land-surf. datum)	72019	2	182	--
Water level (ft above sea level)	72020	--	128	--
Uranium, dis.fluorometric (ug/L)	80020	--	6	--
Alpha, gross, dissolved (ug/L)	80030	--	44	--
suspended (ug/L)	80040	--	22	--
Beta, gross as St-Yt-90, (ug/L)	80050	--	44	--
suspended as St-Yt-90 (ug/L)	80060	--	22	--

[1] STORET data from open file. Data from DOE/EPA Hydrologic Monitoring Network not included.

[2] Summary count based on data transferred to the prototype ground-water quality file; includes some data for bordering States for interstate valleys.

being measured and, for some, the specific analytical method used. Up to 100,000 individual parameter codes may be uniquely identified in STORET; about 2,000 are in use as of 1977, with 85 percent of the data stored under about 190 parameter codes (Hampton, 1976, p. 44). The uniqueness of an individual analysis in the file is controlled by a date-time parameter. Historical data in STORET for ground-water-related sites in Nevada are summarized in table 21. As of 1977, data are being entered for the EPA Hydrological Monitoring Network, but are controlled by a unlocking key code so that the data may be retrieved only by EPA in Las Vegas. The only other ground-water data in STORET as of 1977 are those analyses entered into the USGS WATSTORE system and passed to STORET by the automatic transfer option of the WATSTORE water-quality file.

Data may be retrieved from STORET by specifying individual or groups of station numbers, agency codes, State codes, station types, areal boundaries (latitude-longitude verticies), time periods, and ranges of values for individual parameters. Output may be tabular, graphic (line-printer or continuous plots), or machine readable (punch-card or magnetic tape). Readily available applications programs include routines for tabular, graphical, and statistical output.

DRI hydrologic data banks.--Hydrologic data are maintained in several files by DRI in Las Vegas. The basic system is the Hydrologic Data Storage and Retrieval System administered for DOE by DRI, with the system installed on a CDC 6400 Computer. Development of the system was described by Crouse and Maxey (1967) and Friesen (1972). Requests for data from the Hydrologic Data Storage and Retrieval files must be made through DOE, data maintained by DRI in parallel DRI files may be obtained directly from DRI. Data management is achieved by using a management system called OMNIANA, developed by the USGS

New Mexico District office and obtained by DRI in 1971. Data are also stored in the format of modified "ABC-card" images formerly used by the USGS for storing ground-water data (Lang and Leonard, 1967). In addition to the data maintained for DOE, statewide ground-water and water-quality data are maintained for Nevada by DRI. These files include: (1) A statewide well and lithologic-log file containing historical driller's-log data for about 85 percent of the State, (2) a Geothermal Data File containing chemical and temperature data for geothermal sites, (3) miscellaneous project files custom-designed to project needs, and (4) WADS, a master file of chemical analyses of water for Nevada.

The WADS file includes about 11,500 chemical analyses for ground water gathered from reports of analyses made by the Bureau of Laboratories and Research in Reno, the DRI laboratories in Reno and Boulder City, and a search of published reports on Nevada water resources. Although copies of analyses from the State laboratory are still received by DRI, the WADS file has not been updated owing to funding limitations. Except for a few areas with ongoing DRI research projects, data for most parts of the State end with analyses made in 1973.

Parameters are stored in a fixed-field matrix in the WADS system; thus, values are identified by their position in the input data fields rather than by associated parameter codes, which greatly limits the total number of parameters that can be stored.

Data in WADS are retrievable in three basic tabular formats. Applications programs for the DRI data files consist mainly of STATPAC programs obtained from the USGS (Berry and Sower, 1972; Computer Sciences Corporation, 1972) and individual specialized programs developed in the course of projects and research investigations.

WATSTORE.--The USGS maintains a group of computer files and programs for hydrologic data cumulatively called WATSTORE (National Water Data Storage and Retrieval System). Data are maintained on an Amdahl computer at the USGS National Center in Reston, Va. Access is via one or more remote terminals maintained in 46 Water Resources Division offices, or through terminals of other authorized WATSTORE users. Major WATSTORE files are listed in table 22. Detailed descriptions of individual files and programs may be found in volumes 1-6 of the USGS WATSTORE User's Guide.

The USGS Ground-Water File can store geologic and hydrologic data generated by ground-water monitoring activities. As of 1977, the file is currently composed of two subfiles, the Ground-Water Site Inventory (GWSI) Data Base and the Water Levels Data Base. Data may be retrieved from the Ground-Water File by submitting a listing of retrieval criteria either as an individual job for batch processing or in an interactive time-sharing mode whereby a one-to-one dialog is constructed between the user and the computer to manipulate data.

Operational applications programs for the USGS Ground-Water File as of 1977 consist of tabling routines for the GWSI and Water-Levels data bases, line-printer graphical and contouring routines, and interfaces to other WATSTORE files and programs.

The USGS Header File contains basic site-description data shared by other USGS files. Data pertinent to ground-water applications include: Site-identification number, latitude and longitude, local site number, site type, Hydrologic Unit Code, site elevation, well depth, Geologic Unit (aquifer) Code, and aquifer-type code.

TABLE 22.--*USGS WATSTORE Computer Files*

File	Function	Application programs
Ground-Water File	Storage of site construction, hydraulic, lithologic, and water-level data for ground-water sites	Tabulation (2 formats of publication quality); map plots (line printer and pen-plotter); statistical and Water-Quality File interfaces
Station-Header File	Station location and description; provides such data to other WATSTORE programs	Tabulations (3 formats); pen-plotter and line-printer maps
Water-Quality File	Storage of water data collected at less than daily frequencies. Any data identified by USGS parameter codes may be stored	Tabulations (3 formats of publication quality); graphical (line-printer or pen-plotter) programs for mapping, contouring temporal plots, regression analyses, Stiff, Piper, Collins, and irrigation classification diagrams; frequency analyses, geochemical ratios; interface for all current statistical programs
Satellite Data Collection File	Storage of water data relayed from data-collection platforms via satellites. Any water data capable of digital monitoring and identified by USGS parameter codes may be stored	Data reduction and transfer to Unit Values or Daily Values Files as appropriate
Unit Values File	Storage of water data collected more frequently than once daily. Any data identified by USGS parameter codes may be stored	Computations of daily discharges or loads and input to Daily Values File; reduction of digital monitor records
Daily Values File	Storage of water data collected on a daily to continuous basis. Any data identified by USGS parameter codes may be stored	Tabulations (publication quality); inventory lists; temporal plots pen plotter; monthly and annual statistics; duration tables; log-Pearson type-III frequency analyses and plots (line printer); data reduction from digital monitors
Peak Flow File	Storage of summary peak flow discharge data for gaging stations	Tabulations; flood-frequency analyses
Streamflow/Basin Characteristics File	Contains summary of basin physiographic data for gaging stations	Statistical interfaces

The USGS Water Quality File (QW File) stores intermittent to periodic (less than daily frequency) water-quality data in a manner similar to EPA's STORET. Data values are identified by five-digit USGS parameter codes, which are compatible with STORET. Data entered into the QW File are copied monthly onto magnetic tape and automatically transferred into STORET. QW-File applications programs include three basic tabling formats, which produce copy suitable for direct photo-offset publication. Statistical routines are available for direct reduction of data as well as interfaces that pass retrieved data to statistical routines known as STATPAC (Sower and others, 1971) and SAS (Barr and others, 1976). Graphical programs are available for producing plots and contours of data, water-quality hydrographs, and graphical regression analyses (arithmetic, semi-log, or log-log plots). Special graphical programs have been developed for use in the interpretation of ground-water quality data: these include trilinear, pattern, bar, line, and irrigation-classification diagrams. General discussions of the applications of water-quality diagrams may be found in Hem (1970, p. 257-272) and Todd and others (1976, p. 68-76). Examples of applications involving the use of computer-generated diagrams and geochemical tables are presented in McNellis and others (1969).

Data in the USGS QW File for ground-water sites in Nevada through 1977 consist of analyses of samples collected in the course of water-resources investigations by the USGS Nevada Office in Carson City or the USGS Nuclear Hydrology Program staff in Denver, Colo. Data have been automatically stored in the QW File since 1971 for all routine analyses performed by the USGS Central Laboratory System. Some data from analyses by the Nevada Bureau of Laboratories and Research in Reno have also been entered on a project basis, to make the data available for analysis by the USGS applications programs.

Other WATSTORE files with potential applications to ground-water monitoring are the Unit Values File, the Daily Values File, and the Satellite Data-Collection File. The Unit-Values File is organized for efficient processing of data from analog or digital instruments such as water-level recorders, flow meters, and multiparameter water-quality monitors. The Daily Values File is used to store water data summarized at a daily frequency. The Satellite Data-Collection File processes data relayed by satellite from remote data-collection platforms.

USGS WATSTORE programs are generally accessible to Nevada State agencies by one or more of the following means:

1. Input by cooperative agreement through the USGS Nevada office terminal.
2. By the State agency (or agencies) becoming WATSTORE members and having direct access through State facilities.
3. By acquiring USGS nonproprietary programs for direct use on State-owned and managed computer facilities.

NAWDEX.—The National Water Data Exchange (NAWDEX) is a coalition of Federal, State, and local member organizations established to assist users of water data in identifying, locating, and aquiring needed data. The objectives of NAWDEX are to define available types of water data, where and how the data are stored, and how they may be obtained. An overview of the history and structure of NAWDEX has been published by Edwards (1976). Details of the operational procedures are given in the NAWDEX Policies and Procedures Manual (U.S. Geological Survey, 1976).

The design goal of NAWDEX is not to store individual data values but to index their location, type, and mode of occurrence. The NAWDEX Program Office is administered by the USGS to provide this service. Two computer files are maintained: (1) a Water Data Sources Directory (WDSD) identifying over 300 organizations nationwide that collect water data, and (2) a Master Water Data Index (MWDI) identifying over 61,000 data sites (as of 1976) at which water data are collected. Both files are still in the formative stages with a great deal of future expansion expected. Interfaces are being developed to automatically index data contained in STORET, WATSTORE, and other data systems of member agencies. Most components in the files may be used as sort or retrieval keys by employing a "natural-language" series of retrieval commands, input through a batch terminal or in an interactive mode. NAWDEX may be accessed either through terminals in USGS Water Resources Division offices or through terminals of other member organizations.

NAWDEX offers the agency responsible for ground-water monitoring a powerful tool for indexing available ground-water data. Use of the Master Water-Index File would provide a running inventory of the location and type of ground-water data sites, the agencies involved in the data collection, the purpose of data collection, and the parameters, period of record, and frequency of collection for the available data.

Summary of major available data systems.--Capabilities of the three major existing data systems maintained by DRI, EPA, and USGS are compared with the previously outlined requirements for a data file for general ground-water monitoring in table 23. Each of the systems has some unique capabilities; as of 1977, none meets all the potential requirements of the complete

TABLE 23.--*Summary of capabilities of major data systems for processing ground-water monitoring data*

DATA CATEGORY Major element Typical parameter	EPA STORET	DRI data bases	USGS WATSTORE
SITE IDENTIFICATION			
Site number (unique identifier)	X	X	X
Site location			
Latitude-longitude	X	X	X
Landline	X	X	X
State	X	X	X
County	X	X	X
Hydrographic area or basin	X	X	X
Site name			
Owner's name	X	X	X
Date acquired by owner	--	--	--
Owner's designation or number	X	X	X
Date assigned by owner	--	--	--
Site type			
Well, spring, pit, shaft, etc.	X	X	X
Site use			
Water withdrawal, water recharge, waste disposal, observation point, etc.	X	X	X
Agency operating			
Period of record: Begin and end dates	--	--	X
Principal agency: Agency codes	X	X	X
Data available: Type codes	--	--	X
GEOLOGIC FRAMEWORK			
Vertical section	X[1]	X	X
Section number	--	--	X
Depth to top, depth to bottom	X[1]	X	X
Stratigraphy			
AAPG stratigraphic codes or equivalent	X[1]	X	X
Lithology			
Rock types: Sand, gravel, basalt, etc.	--	X	X
Modifiers: Coarse, fine, hard, red, etc.	--	X	X
Mineralogy			
Minerals present: Names or codes	--	--	--

TABLE 23.--*Summary of capabilities of major data systems for processing ground-water monitoring data*--Continued

DATA CATEGORY Major elements typical parameters	EPA STORET	DRI data bases	USGS WATSTORE
RECHARGE WATERS			
Type of water: Industrial waste, domestic waste, irrigation return, etc.	--	--	--
Permit numbers: NPDES permit for waste discharge	--	--	--
Type and degree of treatment: Settling ponds, aeration, Imhoff tanks, etc.	--	--	--
Application rates			
Date determined	--	--	--
Method: Measured, estimated, reported	--	--	--
Rate, in inches per year	--	--	--
Infiltration or recharge rates			
Date determined	--	--	--
Method: Measured, estimated, reported	--	--	--
Rate, in inches per year	--	--	--
Recharge quality	X	X	X
WATER LEVELS			
Descriptive parameters			
Period of record	--	--	X
Frequency of measurement	--	--	X
Measuring-point datum: Date	--	--	X
established, elevation, description	--	--	X
Water levels			
Date/time measured	X	X[2]	X
Water level or altitude	X	X[3]	X

TABLE 23.--*Summary of capabilities of major data systems for processing ground-water monitoring data*--Continued

DATA CATEGORY Major elements typical parameters	EPA STORET	DRI data bases	USGS WATSTORE
WATER-QUALITY DATA			
Date/time measured	X	X	X
Descriptive parameters			
Agency collecting	X	X	X
Agency analyzing	X	X	X
Laboratory number	X	X	X
Collection method: Pumped, bailed, etc.	X	X	X
Site status: Pumping, flowing	X	--	X
Discharge or pumping rate at sampling	X	--	X
Water level at sampling	X	--	X
Sampled depth or interval	X	--	X
Sample source: Tap, bore, pressure tank	X	--	X
Sample condition: Raw, filtered, treated	X	X	X
Sample preservation: Raw, filtered, acidified, etc.	X	X	X
Water-quality parameters			
Individual data items	X	X[4]	X

[1] Occurrence controlled by date; must be reenterd with each analysis.
[2] Date stored to nearest month.
[3] Only one value may be stored.
[4] Limited number of parameters may be stored.

Ground-Monitoring Data File. Of the systems described, WATSTORE has the greatest capability to handle the diverse types of water data potentially generated by a large-scale ground-water monitoring program.

Both WATSTORE and the DRI data bases have capabilities to store and retrieve geohydrologic and lithologic data for ground-water sites. The DRI data bases contain more well-inventory and lithologic data for Nevada than WATSTORE; however, the WATSTORE Ground-Water File is more flexible in terms of storage and retrieval capabilities and has more on-line applications programs for data reduction and analysis. The WATSTORE Ground-Water File also has the advantage of being more readily accessible to State agencies in Carson City, either through the terminal in the USGS Office or by having one or more State agencies become a WATSTORE member and gain direct access through State computer facilities. Recommendations have been made to add more parameter codes to provide for the inclusion of ground-water data in STORET (Hampton, 1976, p. 54-56). As of 1977, STORET has no efficient way to store lithologic or site-inventory data which are not logically time-dependent. Expansion of STORET to efficiently include ground-water data would require a major committment of resources to design an independent data file cross-linked to the STORET water-quality data.

DRI has been a leader in Nevada in attempting to systematically store ground-water data on a statewide basis. The WADS file represents an initial step in the endeavor to collate historical water-quality data into a unified data base. As presently constructed, however, the WADS file is not flexible enough to store the large number of parameters that a full-scale monitoring program would generate. The WADS file is also limited in the number of available applications programs.

Both the WATSTORE and STORET systems offer a large number of "canned" applications programs for the reduction and analysis of water-quality data. STORET applications programs reflect a historic orientation toward surface-water monitoring; WATSTORE Water-Quality file programs include a variety of packages specifically designed for the analysis of water quality in ground-water systems. The automated interfaces developed to link the WATSTORE Ground-Water and Water-Quality files allow an extension of the powerful retrieval techniques available for the Ground-Water file to include water-quality data. Because WATSTORE water-quality data are automatically transferred to STORET, all STORET applications programs will also be available for use on WATSTORE data, and the depositing of data in STORET would automatically satisfy EPA requirements for reporting raw data.

NAWDEX is a potential "housekeeping" tool for indexing a large number of water-data activities. Its powerful sorting and retrieval techniques offer a quick method of producing automated summary reports of monitoring activities.

Prototype Ground-Water Quality File

As an initial step in developing a demonstration component to the Ground-Water Monitoring Data File, DRI WADS analyses for ground-water sites were obtained on magnetic tape in a format compatible with those of WATSTORE. The data were then processed to create files that as of 1977 are maintained in WATSTORE format on the USGS computers in Reston, Va. Because these data are maintained separately from the national WATSTORE system, the analyses have not been transferred into STORET. Data included in this prototype file are summarized in table 24. All USGS Water-Quality File applications programs are available to process these files; however, plotting routines dependent upon latitude-longitude coordinates will be ineffective as these data were not available in the DRI WADS data base.

TABLE 24.--*Summary of data contained in the prototype ground-water quality file*

Parameter (chemical symbol in parantheses)	Parameter code	Number of analyses for indicated parameters					
		Nevada (32)	Arizona (04)	California (06)	Oregon (41)	Utah (49)	Total
Sample depth	00003	3,977	1	9	—	—	3,987
Collection agency	00027	10,870	1	717	4	16	11,608
Analysis agency	00028	10,870	1	717	4	16	11,608
Sample treatment code	00115	10,870	1	717	4	16	11,608
Sample number	00008	2,212	1	387	—	—	2,600
Silica (SiO_2)	00955	1,207	—	664	—	—	1,871
Calcium (Ca)	00915	9,910	1	709	4	13	10,637
Magnesium (Mg)	00925	9,674	1	708	4	13	10,400
Sodium (Na)	00930	1,247	1	689	4	—	1,941
Potassium (K)	00935	1,131	1	689	—	—	1,821
Sodium plus Potassium (Na+K)	00933	8,612	—	22	—	15	8,649
Bicarbonate (HCO_3)	00440	10,080	1	716	4	13	10,814
Carbonate (CO_3)	00445	1,117	—	11	4	—	1,132
Carbon Dioxide (CO_2)	00405	9,394	1	713	4	11	10,123
Alkalinity (as $CaCO_3$)	00410	10,080	1	716	4	13	10,814
Sulfate (SO_4)	00945	10,125	1	709	4	15	10,854
Chloride (Cl)	00940	10,091	1	711	4	16	10,823
Fluoride (F)	00950	5,929	1	139	—	5	6,074
Nitrate (NO_3)	71851	7,745	1	191	—	11	7,948
Nitrate (as N)	00618	7,731	1	147	—	11	7,890
Phosphate (PO_4)	00650	181	—	132	—	—	313
Dissolved solids (residue on evap. at 180°C)	70300	1,671	—	256	—	14	1,941
Dissolved solids (residue on evap. at 105°C)	00515	7,948	1	36	—	1	7,986
Dissolved solids (sum)	70301	686	—	660	—	—	1,346
Dissolved solids, tons/ac-ft	70303	1,671	—	256	—	14	1,941
Hardness, total as $CaCO_3$	00900	9,974	1	709	4	13	10,701
Hardness, noncarbonate	00902	9,823	1	709		13	10,550
Sodium-adsorption ratio (SAR)	00931	1,192	1	687	4	—	1,884
Percent sodium	00932	1,129	1	689	—	—	1,819
Specific conductance, umhos	00095	1,608	—	680	4	11	2,303
pH	00400	9,553	1	712	4	11	10,281
Temperature, deg. Celsius	00010	1,658	—	669	—	6	2,333
Arsenic (As)	01000	4,090	1	12	—	—	4,103
Boron (B)	01020	369	—	28	—	2	399
Iron (Fe)	71885	8,086	1	29	—	1	8,117
Manganese (Mn)	71883	532	1	2	—	—	535
Total number of analyses:		10,870	1	717	4	16	11,608

Dummy identifiers and locators in the prototype file were assigned sequentially as the analyses were read in the transfer process.

This effort is merely a preliminary step in creating a functional data base. The following work needs to be done to refine the raw data: (1) Identify repetitive analyses at the same site and combine the data under one site identification number, (2) match analyses where possible to sites in the WATSTORE Ground-Water File and the DRI ground-water data bases, and update the dummy site identifier with a more correct latitude-longitude identifier, (3) process the data through an editing program to flag analyses with obvious analytical errors, (4) merge data from other sources of background water-quality data, and (5) transfer the refined data to the final system chosen to contain the Ground-Water Monitoring Data File.

Suggestions for Establishing the Ground-Water-Monitoring Data File

The ultimate Ground-Water-Monitoring Data File should be an operating system containing several subfiles chosen for their efficiencies in processing the particular types of data stored. Links should exist between the subfiles, to facilitate the retrieval of data from one file on the basis of selection criteria applied to another. Application programs must be available that will facilitate rapid data reduction and analysis without involving the skills of an experienced programmer.

The requirements for an efficient data system are diverse enough to warrant participation by more than one agency. Components of the system managing site-inventory and lithologic data would be of use to the Nevada

State Engineer in storing and retrieving drillers' logs, well-permit data, water-level data, and pumpage inventories. Components of the system managing water-quality data would be of use to the Nevada Bureau of Laboratories and Research in providing quality-control checks on water analyses, and to DEP in reduction and analysis of data on surface-water quality. Station-indexing, water-quality, and site-inventory components would be of use to the CHPS and local health departments in monitoring public water supplies.

In light of the above, the following suggestions are made:

1. That interagency support be recruited among State agencies using water data for the establishment of an integrated water-data automation system for Nevada.
2. That a joint effort be sponsored by DEP and CHPS to develop the prototype Water-Quality File into a usable data base that could be incorporated into an overall State water-data system.
3. That a joint effort be sponsored by the DEP, CHPS, and the State Engineer to develop a data base for site-inventory and lithology data for ground-water sites, to be incorporated into an overall State water-data system.

Of the available data processing systems as of 1977, the DRI Hydrologic Data Banks contain the most raw data for Nevada ground water. USGS WATSTORE programs, however, offer capabilities for processing a wider variety of data types and have more readily available programs for data reduction and display. The WATSTORE Water-Quality File also has an advantage in the option to transfer water-quality data automatically to EPA STORET. As of 1977 EPA STORET has the capability to process only a limited number of ground-water variables other than water-quality data.

State options for participation in the above data systems vary with the system chosen. As of 1977, the DRI systems are operated out of the DRI Water Data Center in Las Vegas. Data files are on tape; access to data for input and output must be made through DRI personnel in the Las Vegas office. State participation could be implemented through financial support for system operation and by supplying raw data.

State use of the WATSTORE systems may be obtained in one of three ways: (1) By cooperative agreement with the USGS office in Carson City, (2) by WATSTORE membership, or (3) by acquisition of many of the WATSTORE programs for use on State computer facilities. With the first option, data input to and output from WATSTORE would be made through the USGS terminal in either batch or timesharing modes. Data input may be prepared on State facilities and transmitted by direct telephone link to the terminal for relay to WATSTORE. Data may be retrieved from WATSTORE and relayed to State facilities, or may be printed out by the USGS terminal. Under the second option, WATSTORE access would be direct via State terminal facilities. Under the third option, desired WATSTORE programs would be obtained from USGS for installation on the State IBM computer system; support and maintenance would be performed by State personnel.

As of 1977, STORET is accessed via a low-speed teletype terminal at DEP. Retrievals of STORET data are made on EPA facilities and mailed to DEP. STORET use could be expanded to include data on ground-water quality; however, data-processing needs for site-inventory, water-level, and lithologic information would not be satisfied, nor would full requirements for efficient support of monitoring reports be met.

Although copies of analyses from the State laboratory are still received by DRI, the WADS file has not been maintained on an up-to-date basis as of 1977 owing to funding limitations. Except for a few areas with ongoing DRI research projects, data for most areas of the State end with analyses made in 1973.

Parameters are stored in a fixed-field matrix in the WADS system, thus, values are identified by their position in the input data fields rather than by associated parameter codes, which greatly limits the total number of parameters that can be stored.

Data in WADS are retrievable in three basic tabular formats; applications programs for the DRI data files consist mainly of STATPAC programs obtained from the USGS (Berry and Sower, 1972; Computer Sciences Corporation, 1972) and individual specialized programs developed in the course of projects and research investigations.

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SUPPLEMENT

Basic Data in the

Hydrographic-Area Data Base

TABLE 25.--*Parameters in Hydrographic-Area Data Base*[1]

Parameter	Units	Column heading	Source of data[2]
Perennial yield	acre-ft x 10^3	P YIELD	a, e
Ground-water storage	do.	STORAGE	a, e
Altitude of valley floor	feet above sea level, x 10^3	ALTITUDE	a
Basin area	acres x 10^3	TOTAL A	c
Irrigable area	do.	IRRIG A	b
Growing season	days	GROWING	c
Mean precipitation	feet	PRECIP	a
Population	number of people	POPULAT	c, e
Area irrigated	acres x 10^3	AREA IRR	c
Irrigable area in private ownership	do.	PRIV A	b
Average depth to ground water	classes: 1= 0-200 feet 2= 200-500 feet 3= 500-1,000 feet 4= >1,000 feet	GW DEPTH	f
Ground-water withdrawals:			
Irrigation	acre-feet x 10^3	IRRIG U	g
Stock	do.	STOCK U	h
Industrial/institutional	do.	IND U	g, d
Public supplies	do.	PUB SUP	g
Rural-domestic	do.	RUR-D U	g, i
Total	do.	TOTAL U	sum
Ground-water quality	classes: blank = insufficient data 1 = generally suitable 2 = variable; locally poor 3 = fair 4 = fair to poor 5 = poor 6 = unsuitable	QUALITY	g

[1] Remarks symbols used on printouts: L, less than value shown; G, greater than value shown; H, source value prorated into subareas by ratios of irrigated lands; B, blank-no data available.

[2] Sources of data: a, Scott and others, 1971; b, McNeely and Woerner, 1974; c, Nevada Division of Water Resources, Planning Section, computer file, 1975; d, Holmes, 1966; e, original source modified by author; f, Rush and Cardenalli, 1974; g, USGS files, 1969 state-wide inventory; h, from available published estimates, or computed by author [irrigated acres x regional rate of ground-water use for stock (from McNeely and Woerner, 1974)]; i, rural population estimate x 100 gallons per capita per day.

Table 26.--*Basic data in the Hydrographic-Area Data Base*
[Refer to table 25 for explanation of headings and qualifying codes]

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
1	2.000	2.700	4.2	88.3	20.0	85	1.0	96	0.69	2.94
2	11.000	3.800	4.2	137.0	27.5	85	1.0	15	0.70	6.72
3	3.000	2.300	4.5	124.8	7.0	78	1.9	2	0.50	0.96
4	6.000	0.420	4.8	316.2	1.5	78	0.8	10	2.00	1.50
5	0.250	0.010L	5.6	14.1	0.1L	70	0.9	1 L	0.01L	0.01L
6	2.000	0.120	5.4	94.1	9.0	70	0.9	1 L	0.20	0.20
7	0.010L	0.010L	5.7	144.6	0.1L	70	0.9	1 L	0.35	0.01L
8	3.000	1.400	5.7	112.6	7.5	70	0.8	1 L	0.08	2.65
9	12.000	10.000	5.6	277.1	71.5	78	0.9	15	1.40	30.46
10	0.250	0.300	5.8	17.3	2.5	70	0.9	1 L	0.01L	0.44
11	1.000	0.350	4.8	32.6	2.5	85	0.9	1 L	0.24	1.50
12	1.500	0.470	5.7	20.5	2.0	78	0.8	1 L	0.50	1.50
13	1.000	0.010L	5.3	52.5	0.1L	70	0.8	1 L	0.01L	0.01L
14	2.500	0.520	4.5	137.0	9.5	78	0.9	1 L	0.30	1.96
15	2.000	0.600	5.7	56.3	9.6	70	0.9	1 L	0.01L	3.06
16	8.000	5.600	4.7	341.1	36.5	78	0.8	4	2.00	20.75
17	0.200	0.060	6.4	7.7	0.1L	85	1.1	1 L	0.01L	0.01L
18	1.200	0.140	5.7	19.8	0.1L	85	0.9	1 L	0.01L	0.01L
19	0.100	1.000	4.2	25.0	4.5	115	0.5	1 L	0.01L	0.06
20	0.020	0.200	4.0	7.7	0.1L	115	0.4	1 L	0.01L	0.01L
21	16.000	20.000	3.9	627.2	22.0	115	0.6	26	1.60	7.10
22	2.500	8.400	4.0	195.2	38.0	115	0.5	481	1.00	1.00
23	0.200	0.050	5.0	5.8	0.1L	115	1.0	1 L	0.01L	0.01L
24	6.700	3.500	4.1	201.6	24.5	115	0.8	62	3.62	23.31
25	5.000	0.610	5.0	425.6	10.0	78	0.8	5	0.01L	1.88
26	13.000	8.500	4.0	316.8	30.0	90	0.7	11	0.05	7.52
27	1.000	0.630	5.9	38.4	6.0	70	1.2	8	0.01L	3.50
28	30.000	56.000	4.0	1394.0	164.0	100	0.6	34	4.57	6.10
29	11.000	18.000	4.0	337.9	112.0	100	0.8	37	5.04	22.21
30	17.000	20 000	4.2	264.3	103.5	100	1.0	71	12.70	31.26
30A	12.000	14.000	4.3	192.0	88.0H	100	1.0	71	12.70H	26.58H
30B	5.000	6.000	4.2	72.3	15.5H	100	1.0	1 L	0.01L	4.68H
31	9.000	40.000	4.2	673.3	302.5	100	0.6	54	2.80	10.64
32	5.900	16.000	4.2	200.3	95.5	100	0.7	27	0.64	1.28
33	60.000	42.000	4.3	783.4	265.5	85	1.0	992	39.00	96.94
33A	40.000	26.000	4.2	404.5	149.5H	90	0.9	327	21.96H	54.54H
33B	20.000	16.000	4.5	378.9	116.0H	78	1.1	653	17.04H	42.50H
34	1.400	0.010L	5.1	458.2	60.5	78	0.8	2	0.01L	1.00
35	8.000	3.600	5.0	838.4	91.0	78	0.9	102	14.00	41.00
36	12.000	5.200	5.7	220.8	52.0	78	1.4	130	22.64	38.61
37	7.000	2.200	5.3	341.1	53.0	78	1.4	961	14.00	14.00

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
1	1	2.ØØØ	Ø.Ø13ØØ	Ø.Ø	Ø.Ø	Ø.Ø11ØØ	2.Ø2ØØØ	2
2	1	1.25Ø	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	1.26ØØØ	2
3	1	Ø.25Ø	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.254ØØ	2
4	1	Ø.Ø	Ø.Ø12ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø13ØØ	2
5	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
6	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
7	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
8	1	Ø.15Ø	Ø.ØØØ3Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.15ØØØ	2
9	1	Ø.2ØØ	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.2Ø4ØØ	2
1Ø	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
11	1	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	2
12	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ2ØØL	2
13	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
14	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	2
15	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
16	1	Ø.6ØØ	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ4Ø	Ø.612ØØ	4
17	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
18	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
19	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
2Ø	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
21	1	1.12Ø	Ø.ØØ6ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	1.13ØØØ	2
22	1	2.5ØØ	Ø.Ø14ØØ	Ø.Ø94	Ø.36Ø	Ø.Ø41ØØ	3.Ø1ØØØ	2
23	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
24	1	9.28Ø	Ø.Ø46ØØ	Ø.Ø	Ø.Ø	Ø.ØØ7ØØ	9.33ØØØ	2
25	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ6Ø	Ø.ØØØ6Ø	Ø B
26	1	Ø.13Ø	Ø.ØØ7ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.132ØØ	Ø B
27	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ9Ø	Ø.ØØØ9Ø	Ø B
28	1	4.64Ø	Ø.Ø22ØØ	Ø.ØØ1	Ø.Ø	Ø.ØØ4ØØ	4.67ØØØ	5
29	1	3.Ø8Ø	Ø.Ø28ØØ	Ø.Ø	Ø.Ø	Ø.ØØ41Ø	3.11ØØØ	1
3Ø	1	33.2ØØ	Ø.15ØØØ	Ø.Ø	Ø.Ø	8.18ØØØ	33.39999	1
3ØA	1	33.2ØØ	Ø.15ØØØ	Ø.Ø	Ø.Ø	8.18ØØØ	33.39999	1
3ØB	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	1
31	1	2.ØØØ	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.ØØ8ØØ	2.Ø2ØØØ	2
32	1	1.92Ø	Ø.Ø26ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	1.95ØØØ	1
33	1	52.8ØØ	Ø.23ØØØ	Ø.Ø16	Ø.Ø51	Ø.Ø82ØØ	55.2ØØØØ	5
33A	1	51.ØØØ	Ø.22ØØØ	Ø.Ø	Ø.Ø	Ø.Ø37ØØ	51.3ØØØØ	5
33B	1	2.8ØØ	Ø.Ø14ØØ	Ø.Ø16	Ø.Ø51	Ø.Ø45ØØ	2.93ØØØ	5
34	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØØ2Ø	1
35	1	Ø.Ø	Ø.Ø6ØØØ	Ø.Ø	Ø.Ø	Ø.Ø11ØØ	Ø.Ø71ØØ	1
36	1	1.3ØØ	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.Ø15ØØ	1.33ØØØ	1
37	1	Ø.Ø	Ø.Ø6ØØØ	Ø.Ø	Ø.Ø	Ø.1Ø8ØØ	Ø.168ØØ	1

Table 26.—*Basic data in the Hydrographic-Area Data Base*—Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
38	10.000	0.270	5.0	329.0	8.3	70	1.5	17	3.50	3.82
39	12.000	0.010L	5.0	177.9	0.3	70	1.9	9	0.50	0.30
40	10.000	3.100	5.2	779.5	89.5	78	1.3	473	14.00	22.68
41	1.700	0.680	5.2	202.2	3.0	70	1.0	13	2.20	2.20
42	32.000	19.000	5.6	686.7	142.5	78	1.0	1424	18.00	86.90
43	10.000	5.900	6.0	212.5	54.5	85	1.1	67	15.00	28.10
44	33.000	20.000	5.4	710.4	146.0	78	1.1	55	18.00	85.39
45	8.000	4.600	5.4	164.4	74.0	85	1.1	308	28.10	62.64
46	2.000	1.800	5.6	63.4	13.5	85	1.5	154	14.50	13.50
47	15.000	14.000	5.5	503.7	161.4	85	1.1	85	10.00	44.35
48	8.000	7.000	5.4	250.9	23.0	85	0.9	21	5.00	23.00
49	11.000	5.600	5.1	201.0	49.0	85	0.9	8292	12.00	26.17
50	2.200	4.000	5.0	142.7	5.0	78	0.9	2	0.20	0.32
51	3.800	7.000	5.3	253.4	19.5	85	0.9	21	3.10	14.69
52	2.000	1.100	5.2	39.0	3.5	85	0.8	1221	0.01L	0.01L
53	20.000	17.000	5.4	641.3	114.0	85	1.0	66	7.00	14.26
54	17.000	13.000	5.0	481.3	128.0	100	0.9	305	1.80	19.37
55	8.000	6.600	5.1	240.6	43.5	100	0.7	1 L	1.20	3.11
56	37.000	20.000	5.8	728.3	129.5	85	0.9	407	5.63	33.35
57	9.000	8.000	5.0	289.3	72.0	100	0.9	25	0.10	12.87
58	14.000	5.700	4.9	204.2	37.0	115	0.8	16	5.66	19.42
59	17.000	10.000	4.7	376.3	142.0	115	0.8	1247	0.80	38.70
60	3.000	1.600	4.8	60.2	6.5	115	0.8	12	1.50	3.25
61	30.000	9.600	4.7	348.2	129.0	100	0.7	44	11.50	107.87
62	1.500	7.900	4.9	284.2	39.5	85	0.8	3	0.40	7.22
63	1.300	7.100	5.1	259.2	19.0	78	1.0	27	3.00	14.59
64	40.000	13.000	4.5	460.8	235.0	100	1.0	981	11.68	44.64
65	16.000	5.200	4.5	191.4	56.5	100	0.7	6	0.42	23.22
66	16.000	5.300	4.4	192.6	96.5	100	0.7	8	4.84	28.44
67	19.000	14.000	4.6	624.0	47.0	78	0.9	7	4.00	16.54
68	3.300	2.400	5.2	106.9	0.1L	78	1.1	1 L	0.05	0.01L
69	11.700	8.900	4.5	384.0	172.0	100	0.7	266	31.40	111.38
70	17.000	6.400	4.4	278.4	82.0	100	0.6	4488	12.00	43.03
71	13.000	7.600	4.4	332.8	89.5	115	0.8	1825	3.30	36.40
72	3.000	11.400	4.2	493.4	159.0	100	0.6	151	0.40	38.45
73	43.000	9.300	4.0	406.4	108.6H	140	0.6	2329	25.70H	57.70H
73A	2.000	2.200	4.3	62.7	22.4H	115	0.7	32	5.30H	11.92H
74	0.010L	4.200	3.9	105.0	9.5	140	0.5	1 L	0.01L	0.01L
75	2.500	3.500	4.2	113.9	14.0	140	0.5	3	0.01L	6.41
76	0.600	4.200	4.2	76.8	18.5	140	0.6	1770	4.50	10.16
77	0.100	1.300	4.7	37.1	10.0	115	0.6	1 L	0.01L	0.01L

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
38	1	Ø.Ø	Ø.Ø14ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø16ØØ	1
39	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø.ØØ2ØØ	1
4Ø	1	1.2ØØ	Ø.ØØ7ØØ	Ø.Ø	Ø.Ø	Ø.1Ø6ØØ	Ø.113ØØ	1
41	1	Ø.5ØØ	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.5Ø6ØØ	1
42	1	Ø.6ØØ	Ø.ØØ9ØØ	Ø.Ø	Ø.32Ø	Ø.Ø14ØØ	Ø.943ØØ	Ø B
43	1	Ø.2ØØ	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØ8ØØ	Ø.212ØØ	Ø B
44	1	Ø.4ØØ	Ø.Ø13ØØ	Ø.Ø	Ø.Ø	Ø.ØØ6ØØ	Ø.419ØØ	Ø B
45	1	Ø.4ØØ	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø27	Ø.Ø21ØØ	Ø.45ØØØ	Ø B
46	1	Ø.4ØØ	Ø.Ø87ØØ	Ø.Ø	Ø.Ø	Ø.Ø17ØØ	Ø.1Ø4ØØ	1
47	1	Ø.1ØØ	Ø.Ø61ØØ	Ø.Ø	Ø.Ø	Ø.Ø1ØØØ	Ø.171ØØ	1
48	1	Ø.1ØØ	Ø.Ø31ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.133ØØ	1
49	1	Ø.5ØØ	Ø.Ø76ØØ	Ø.Ø	3.3ØØ	Ø.ØØ1ØØL	3.88ØØØ	Ø B
5Ø	1	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØ1ØØ	Ø B
51	1	Ø.Ø	Ø.Ø19ØØ	Ø.23Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.251ØØ	Ø B
52	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.44Ø	Ø.Ø	Ø.44ØØØ	Ø
53	1	1.ØØØ	Ø.2ØØØØ	Ø.Ø	Ø.Ø	Ø.ØØ7ØØ	1.21ØØØ	Ø
54	1	1.5ØØ	Ø.Ø29ØØ	Ø.55Ø	Ø.Ø	Ø.Ø34ØØ	2.11ØØØ	2
55	1	Ø.25Ø	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.26ØØØ	2
56	1	2.Ø3Ø	Ø.Ø34ØØ	Ø.Ø	Ø.Ø2Ø	Ø.Ø18ØØ	2.1ØØØØ	2
57	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	Ø.ØØ5ØØ	2
58	1	1Ø.1ØØ	Ø.Ø34ØØ	Ø.Ø	Ø.Ø	Ø.ØØ8ØØ	1Ø.2ØØØØ	2
59	1	Ø.Ø	Ø.ØØ5ØØ	2.Ø3Ø	Ø.Ø	Ø.14ØØØ	2.18ØØØ	Ø B
6Ø	1	Ø.Ø	Ø.ØØ9ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø1ØØØ	Ø B
61	1	2.ØØØ	Ø.Ø69ØØ	Ø.Ø	Ø.Ø	Ø.ØØ5ØØ	2.Ø7ØØØ	Ø B
62	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ3Ø	Ø.ØØ2ØØ	Ø B
63	1	Ø.Ø	Ø.Ø18ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	Ø.Ø21ØØ	Ø B
64	1	2.1ØØ	Ø.Ø7ØØØ	Ø.Ø	Ø.34Ø	Ø.ØØ1ØØL	3.31ØØØ	Ø B
65	1	1.ØØØ	Ø.ØØ8ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ7Ø	1.Ø1ØØØ	Ø B
66	1	Ø.64Ø	Ø.Ø29ØØ	Ø.52Ø	Ø.Ø	Ø.ØØØ9Ø	1.2ØØØØ	Ø B
67	1	Ø.Ø	Ø.Ø24ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ8Ø	Ø.Ø25ØØ	1
68	1	Ø.Ø	Ø.ØØ3ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	1
69	1	8.ØØØ	Ø.19ØØØ	Ø.Ø	Ø.Ø	Ø.Ø3ØØØ	8.22ØØØ	2
7Ø	1	4.ØØØ	Ø.Ø72ØØ	Ø.Ø	1.3ØØ	Ø.ØØ1ØØL	4.37ØØØ	2
71	1	4.6ØØ	Ø.Ø2ØØØ	1Ø.ØØØ	Ø.Ø	Ø.2Ø4ØØ	4.83ØØØ	2
72	1	Ø.1ØØ	Ø.ØØ5ØØ	Ø.Ø	Ø.Ø	Ø.Ø17ØØ	Ø.122ØØ	2
73	1	Ø.25ØH	Ø.16ØØØH	Ø.17Ø	2.6ØØ	Ø.Ø37ØØ	3.2ØØØØ	2
73A	1	Ø.Ø5ØH	Ø.Ø3ØØØH	Ø.Ø	Ø.Ø	Ø.ØØ4ØØ	Ø.Ø84ØØ	Ø B
74	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
75	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ3Ø	Ø.ØØØ3Ø	6
76	1	Ø.Ø	Ø.Ø24ØØ	Ø.Ø	Ø.14Ø	Ø.12ØØØ	Ø.18ØØØ	Ø B
77	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
78	4.500	26.000	4.0	618.9	187.0	100	0.6	1 L	0.01L	2.56
79	0.500	10.000	4.5	213.1	61.0	100	0.6	25	0.01L	0.01L
80	3.300	9.600	3.8	237.4	12.5	115	0.6	1 L	0.01L	0.24
81	7.000H	19.000	3.8	430.1	17.0	115	0.6	333	0.30	5.00
82	2.100H	2.600	4.2	58.9	11.5	115	0.7	2	0.88	2.04
83	9.000H	1.000	4.3	182.4	4.5	115	2.3	280	0.70	4.50
84	3.000	4.200	4.3	158.1	30.0	115	0.8	116	0.34	22.91
85	1.000	1.700	4.5	48.6	14.0	115	0.6	150	1.70	13.57
86	0.025	0.200	4.7	6.4	2.5	115	0.6	2500	0.01L	2.00
87	30.000H	4.500	4.5	129.9	39.5	115	1.2	107700	18.00	39.37
88	2.000H	0.300	4.5	25.0	1.5	115	2.0	300	1.00	1.32
89	5.000	2.700	5.1	52.5	10.5	115	1.8	1987	4.00	9.82
90	1.000L	0.300	6.2	89.0	4.0	85	2.1	4944	0.59	3.00
91	2.000H	0.400	4.9	53.8	4.0	115	2.3	777	0.01L	1.00
92	1.300	2.300	5.0	59.4	20.5	115	0.8	7000 H	0.01L	19.69
92A	0.900	1.100	5.0	33.9	12.6H	115	0.8	2500 H	0.01L	12.10H
92B	0.400	1.200	5.0	25.6	7.9H	115	0.8	4500 H	0.01L	7.59H
93	0.150	0.470	5.2	11.5	5.5	115	0.8	11	0.01L	3.50
94	0.300	0.790	5.0	33.9	11.5	115	0.8	1 L	0.01L	1.25
95	1.000	1.100	4.6	51.2	7.5	115	0.8	1 L	0.02	4.41
96	0.200	0.034	5.2	5.8	0.1L	115	0.9	1 L	0.01L	0.01L
97	8.000	5.500	4.0	123.5	23.0	100	0.7	1 L	0.72	18.00
98	0.200	0.100L	4.8	27.5	0.1L	85	0.7	1 L	0.01L	0.01L
99	1.000	0.640	4.9	37.1	8.0	115	0.8	10	0.30	5.06
100	0.500	0.450	5.1	19.2	3.5	115	0.9	1 L	0.24	1.84
101	2.500H	80.000	3.9	1283.0	194.5	140	0.5	10378	90.00	76.70
101A	0.500	5.000	4.2	113.0	17.1H	140	0.5	1 L	0.01L	6.20H
102	1.600	7.400	4.4	307.2	30.0	165	0.8	271	2.50	20.99
103	7.000	4.400	4.7	236.1	21.0	140	1.3	965	5.80	19.82
104	7.000	2.000	4.7	44.2	10.0	115	1.3	15039	0.50	8.02
105	8.000H	7.000	4.8	268.2	76.0	115	1.0	3616	45.00	58.26
106	2.600	2.000	5.0	73.6	7.5	115	1.0	151	0.91	6.50
107	10.000H	9.800	4.7	306.6	57.5	100	0.9	701	22.00	36.30
108	25.000H	29.000	4.5	330.2	95.5	115	0.5	5163	39.30	61.11
109	5.500	8.000	6.8	375.0	9.5	85	0.7	66	6.00	7.02
110	6.200	25.000	4.3	863.8	212.5	148	0.0	6531	6.10	6.49
110A	1.500H	15.000	4.2	321.3	146.2H	140	0.5	550	4.20H	4.46H
110B	0.700	1.000	4.0	196.5	4.1H	165	0.0	5	0.17H	0.12H
110C	5.000	9.000	4.8	346.2	62.2H	140	0.6	5976	1.73H	1.91H
111	1.000	1.400	6.9	53.1	1.0	85	0.0	1 L	0.01L	0.01L
111A	0.300	0.400	7.0	11.5	0.2H	85	0.8	1 L	0.01L	0.01L

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
78	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	1
79	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ3Ø	Ø.ØØØ3Ø	1
8Ø	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
81	1	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø55	Ø.ØØ1ØØL	Ø.Ø57ØØ	Ø B
82	1	Ø.Ø	Ø.ØØ3ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØ3ØØ	Ø B
83	1	Ø.Ø	Ø.ØØ3ØØ	54.2ØØ	Ø.Ø1Ø	Ø.Ø24ØØ	54.2ØØØØ	Ø B
84	1	1.ØØØ	Ø.ØØ1ØØ	Ø.Ø27	Ø.Ø	Ø.Ø13ØØ	1.Ø4ØØØ	2
85	1	Ø.Ø	Ø.ØØ6ØØ	Ø.Ø	Ø.Ø	Ø.Ø17ØØ	Ø.Ø23ØØ	2
86	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.26Ø	Ø.Ø2ØØØ	Ø.28ØØØ	2
87	1	Ø.Ø	Ø.Ø66ØØ	2.27Ø	9.67Ø	2.17ØØØ	14.2ØØØØ	2
88	1	Ø.Ø	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.Ø34ØØ	Ø.Ø37ØØ	Ø B
89	1	1.ØØØ	Ø.Ø15ØØ	Ø.Ø	Ø.Ø	Ø.445ØØ	1.46ØØØ	1
9Ø	1	Ø.Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.12Ø	Ø.Ø22ØØ	Ø.144ØØ	1
91	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø87ØØ	Ø.Ø87ØØ	Ø B
92	1	Ø.28Ø	Ø.Ø	Ø.Ø	Ø.513	Ø.13ØØØ	Ø.92ØØØ	2
92A	1	Ø.28Ø	Ø.Ø	Ø.Ø	Ø.Ø13	Ø.Ø3ØØØ	Ø.32ØØØ	2
92B	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.5ØØ	Ø.1ØØØØ	Ø.6ØØØØ	4
93	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ1ØØ	2
94	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
95	1	Ø.Ø	Ø.ØØØ1Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1Ø	Ø.ØØØ2Ø	2
96	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
97	1	1.8ØØ	Ø.ØØ3ØØ	Ø.Ø	Ø.Ø	Ø.Ø	1.8ØØØØ	2
98	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
99	1	1.1ØØ	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	1.1ØØØØ	2
1ØØ	1	Ø.34Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.341ØØ	2
1Ø1	1	Ø.Ø	Ø.22ØØØ	Ø.48Ø	Ø.9ØØ	Ø.83ØØØ	2.43ØØØ	Ø B
1Ø1A	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	5
1Ø2	1	Ø.Ø	Ø.ØØ6ØØ	Ø.Ø58	Ø.Ø3Ø	Ø.ØØ8ØØ	Ø.1Ø2ØØ	Ø B
1Ø3	1	1.ØØØ	Ø.14ØØØ	Ø.Ø	Ø.Ø	Ø.Ø48ØØ	1.19ØØØ	4
1Ø4	1	Ø.2ØØ	Ø.ØØ1ØØ	Ø.Ø3Ø	1.48Ø	Ø.457ØØ	2.17ØØØ	2
1Ø5	1	5.ØØØ	Ø.5ØØØØ	Ø.Ø	Ø.589	Ø.18ØØØ	6.27ØØØ	2
1Ø6	1	1.6ØØ	Ø.ØØØ4Ø	Ø.Ø	Ø.Ø	Ø.Ø17ØØ	1.62ØØØ	2
1Ø7	1	5.ØØØ	Ø.Ø27ØØ	Ø.Ø	Ø.Ø	Ø.Ø78ØØ	5.1ØØØØ	2
1Ø8	1	1.9ØØ	Ø.Ø48ØØ	13.3ØØ	Ø.766	Ø.113ØØ	13.3ØØØØ	2
1Ø9	1	Ø.Ø	Ø.ØØ7ØØ	Ø.Ø	Ø.Ø	Ø.ØØ7ØØ	Ø.Ø15ØØ	2
11Ø	1	Ø.3ØØ	Ø.ØØ3ØØ	Ø.Ø51	Ø.565	Ø.Ø63ØØ	Ø.982ØØ	2
11ØA	1	Ø.Ø	Ø.ØØØ1Ø	Ø.Ø	Ø.Ø	Ø.Ø62ØØ	Ø.Ø62ØØ	2
11ØB	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ6Ø	Ø.ØØØ6Ø	2
11ØC	2	Ø.3ØØ	Ø.ØØ3ØØ	Ø.Ø51	Ø.565	Ø.Ø	Ø.919ØØ	2
111	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
111A	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
111B	Ø.7ØØ	1.ØØØ	6.8	41.6	Ø.8H	85	Ø.8	1 L	Ø.Ø1L	Ø.Ø1L
112	Ø.3ØØ	Ø.2ØØ	7.Ø	17.3	Ø.1L	115	Ø.9	1 L	Ø.Ø1L	Ø.Ø1L
113	Ø.15Ø	1.2ØØ	5.8	62.1	7.Ø	14Ø	Ø.6	1 L	Ø.Ø1L	2.98
114	1.4ØØ	2.6ØØ	5.Ø	2Ø6.7	1Ø.5	115	Ø.6	67	Ø.Ø1L	Ø.45
115	Ø.15Ø	Ø.Ø2Ø	6.4	9.6	Ø.1L	115	Ø.9	1 L	Ø.Ø1L	Ø.Ø1L
116	Ø.6ØØ	1.ØØØ	6.2	41.6	4.5	115	Ø.9	1 L	Ø.Ø1L	Ø.Ø1L
117	19.ØØØ	16.ØØØ	4.8	451.8	6Ø.Ø	115	Ø.6	147	5.1Ø	14.88
118	4.ØØØ	5.3ØØ	4.6	236.8	8.5	14Ø	Ø.4	24	Ø.Ø1L	Ø.38
119	1.ØØØ	3.4ØØ	4.6	127.4	12.Ø	165	Ø.5	13	Ø.Ø1L	Ø.44
12Ø	Ø.15Ø	1.5ØØ	5.7	58.9	7.Ø	115	Ø.6	1 L	Ø.Ø1L	1.21
121	Ø.8ØØ	7.1ØØ	4.6	24Ø.6	26.5	165	Ø.4	446	Ø.Ø1L	Ø.9Ø
121A	Ø.6ØØ	4.3ØØ	4.6	157.4	2.6H	165	Ø.5L	436	Ø.Ø1L	Ø.1ØH
121B	Ø.2ØØ	2.8ØØ	4.5	83.2	23.9H	165	Ø.4	1Ø	Ø.Ø1L	Ø.8ØH
122	5.ØØØ	16.ØØØ	4.3	817.3	137.Ø	14Ø	Ø.7	93Ø	Ø.6Ø	4.92
123	Ø.5ØØ	Ø.6ØØ	4.Ø	145.3	36.5	14Ø	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
124	Ø.25Ø	7.8ØØ	4.2	182.4	88.6	14Ø	Ø.5	4	Ø.Ø1L	Ø.Ø1L
125	Ø.1ØØL	1.3ØØ	4.4	27.5	12.6	115	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
126	Ø.8ØØL	1.7ØØ	4.7	7Ø.4	21.3	115	Ø.6	2	Ø.Ø1L	Ø.16
127	4.ØØØL	1.9ØØ	4.8	138.2	38.2	115	Ø.8	13	Ø.1Ø	Ø.1Ø
128	15.ØØØ	35.ØØØ	3.6	833.9	348.Ø	14Ø	Ø.6	116	2.7Ø	1Ø.Ø5
129	1Ø.ØØØ	24.ØØØ	4.1	474.9	117.Ø	115	Ø.6	71	1.2Ø	22.28
13Ø	2.6ØØ	6.2ØØ	4.4	182.4	71.Ø	115	Ø.6	17	Ø.1Ø	4.44
131	8.ØØØ	17.ØØØ	4.7	322.6	81.Ø	1ØØ	Ø.7	25	Ø.64	3.75
132	Ø.25Ø	1.6ØØ	4.2	9Ø.9	24.1	14Ø	Ø.6	5	Ø.Ø3	Ø.38
133	8.ØØØ	7.ØØØ	5.2	266.2	59.5	115	Ø.7	14	Ø.7Ø	2.13
134	1Ø.ØØØ	15.ØØØ	6.1	327.5	122.Ø	85	Ø.8	15	Ø.4Ø	1.59
135	2.5ØØ	13.ØØØ	6.Ø	294.4	71.Ø	1ØØ	Ø.7	27	Ø.Ø1L	Ø.9Ø
136	Ø.4ØØ	7.2ØØ	5.4	181.8	25.5	115	Ø.5	5	Ø.Ø1L	Ø.Ø1L
137	71.ØØØ	12Ø.ØØØ	Ø.ØB	1872.7	389.Ø	14Ø	Ø.7	2214	12.Ø7	44.95
137A	6.ØØØ	7Ø.ØØØ	4.8	1Ø26.Ø	192.ØH	1ØØ	Ø.6	2Ø45	6.ØØH	22.22H
137B	65.ØØØ	5Ø.ØØØ	5.5	846.7	197.ØH	85	Ø.9	169	6.Ø7H	22.73H
138	13.ØØØ	16.ØØØ	5.7	38Ø.8	112.5	85	Ø.8	2Ø	1.5Ø	8.14
139	16.ØØØ	27.ØØØ	6.2	555.5	242.5	85	Ø.8	5	1.8Ø	7.Ø9
14Ø	18.ØØØ	2Ø.ØØØ	Ø.ØB	664.4	2Ø3.5	85	Ø.7	23	2.21	8.86
14ØA	8.ØØØ	1Ø.ØØØ	6.5	338.6	87.ØH	85	Ø.7	14	Ø.95H	3.79H
14ØB	1Ø.ØØØ	1Ø.ØØØ	7.Ø	325.8	116.5H	85	Ø.8	9	1.26H	5.Ø7H
141	6.ØØØ	27.ØØØ	5.6	621.4	116.Ø	14Ø	Ø.6	34	Ø.11	4.1Ø
142	3.ØØØ	13.ØØØ	5.Ø	2ØØ.3	63.5	165	Ø.5	238	Ø.Ø1L	Ø.64
143	2Ø.ØØØ	13.ØØØ	4.4	355.2	27.Ø	165	Ø.5	151	Ø.Ø1L	Ø.64
144	Ø.35Ø	15.ØØØ	5.Ø	342.4	84.Ø	165	Ø.5	22	Ø.Ø1L	Ø.48
145	Ø.1ØØ	8.2ØØ	4.8	243.8	42.5	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RURD U	TOTAL U	QUALITY
111B	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
112	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
113	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
114	1	Ø.Ø	Ø.Ø	Ø.Ø4Ø	Ø.Ø	Ø.ØØ8ØØ	Ø.Ø48ØØ	2
115	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
116	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
117	1	6.ØØØ	Ø.Ø47ØØ	1Ø.ØØØ	Ø.Ø	Ø.Ø17ØØ	6.Ø7ØØØ	2
118	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ4	Ø.Ø	Ø.ØØ4ØØ	4
119	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ2	Ø.Ø	Ø.ØØ2ØØ	4
12Ø	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
121	1	Ø.Ø	Ø.Ø	Ø.Ø1Ø	Ø.11Ø	Ø.Ø32ØØ	Ø.152ØØ	Ø B
121A	1	Ø.Ø	Ø.Ø	Ø.Ø1Ø	Ø.11Ø	Ø.Ø31ØØ	Ø.151ØØ	Ø B
121B	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ1ØØ	Ø B
122	1	Ø.96Ø	Ø.ØØ9ØØ	1.14Ø	Ø.4ØØ	Ø.ØØ3ØØ	2.51ØØØ	4
123	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
124	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ4Ø	2
125	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
126	1	Ø.1ØØ	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.11ØØØ	2
127	1	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.ØØ2ØØ	2
128	1	6.ØØØ	Ø.Ø25ØØ	Ø.Ø	Ø.Ø	Ø.Ø13ØØ	6.Ø4ØØØ	2
129	1	3.6ØØ	Ø.Ø11ØØ	Ø.Ø62	Ø.Ø	Ø.ØØ8ØØ	3.68ØØØ	2
13Ø	1	Ø.1ØØ	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.1Ø3ØØ	2
131	1	2.Ø4Ø	Ø.ØØ6ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	2.Ø5ØØØ	Ø B
132	1	Ø.Ø3Ø	Ø.ØØØ2Ø	Ø.Ø	Ø.Ø	Ø.ØØØ6Ø	Ø.Ø31ØØ	2
133	1	1.ØØØ	Ø.ØØ6ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	1.Ø1ØØØ	2
134	2	Ø.Ø	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.ØØ5ØØ	2
135	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	Ø.ØØ3ØØ	2
136	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ6Ø	Ø.ØØØ6Ø	2
137	1	7.7ØØ	Ø.Ø25ØØ	Ø.Ø	Ø.Ø27	Ø.ØØØ1Ø	7.79ØØØ	2
137A	1	Ø.24Ø	Ø.ØØ5ØØ	Ø.Ø	Ø.ØØ2	Ø.ØØØ1Ø	Ø.247ØØ	2
137B	1	7.5ØØ	Ø.Ø2ØØØ	Ø.Ø	Ø.Ø25	Ø.Ø	7.54ØØØ	2
138	1	Ø.6ØØ	Ø.Ø14ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.616ØØ	2
139	1	Ø.9ØØ	Ø.Ø17ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.918ØØ	2
14Ø	1	Ø.9ØØ	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	Ø.9Ø5ØØ	2
14ØA	1	Ø.9ØØ	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.9Ø4ØØ	2
14ØB	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ1ØØ	2
141	2	Ø.Ø	Ø.ØØØ4Ø	Ø.Ø	Ø.33Ø	Ø.ØØ4ØØ	Ø.334ØØ	2
142	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø2Ø	Ø.ØØ4ØØ	Ø.Ø24ØØ	4
143	2	Ø.Ø	Ø.Ø	7.ØØØ	Ø.Ø2Ø	Ø.Ø	7.Ø2ØØØ	Ø B
144	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ7	Ø.Ø	Ø.ØØ7ØØ	2
145	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
146	3.ØØØ	24.ØØØ	4.1	519.7	4Ø.Ø	165	Ø.4	18	Ø.32	2.79
147	1.9ØØ	16.ØØØ	5.2	437.8	83.5	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
148	Ø.3ØØ	14.ØØØ	5.4	257.9	89.Ø	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
149	2.ØØØ	22.ØØØ	5.7	63Ø.4	226.5	14Ø	Ø.6	18	Ø.75	1.45
15Ø	1Ø.ØØØ	8.ØØØ	6.6	277.8	19.5	85	Ø.8	1 L	Ø.Ø1L	2.41
151	4.ØØØ	12.ØØØ	6.2	284.2	1Ø6.5	85	Ø.7	11	Ø.1Ø	3.18
152	Ø.1ØØ	Ø.5ØØ	7.2	1Ø.9	Ø.1L	7Ø	Ø.7	1 L	Ø.Ø1L	Ø.Ø1L
153	3Ø.ØØØ	28.ØØØ	5.9	481.3	136.5	85	Ø.9	499	17.7Ø	22.81
154	18.ØØØ	15.ØØØ	5.9	512.6	194.5	85	Ø.8	18	4.6Ø	16.5Ø
155	6.1ØØ	25.ØØØ	6.Ø	741.1	275.5	85	Ø.6	14	1.7Ø	4.ØØ
155A	5.ØØØ	15.ØØØ	6.1	378.2	99.1H	85	Ø.6	14	1.7ØH	1.44H
155B	Ø.1ØØ	1.ØØØ	6.5	36.5	1.ØH	85	Ø.5	1 L	Ø.Ø1L	Ø.Ø4H
155C	1.ØØØ	9.4ØØ	5.9	326.4	175.1H	1ØØ	Ø.6	1 L	Ø.Ø1L	2.52H
156	5.5ØØ	23.ØØØ	5.3	663.Ø	169.5	14Ø	Ø.6	27	Ø.3Ø	1.19
157	2.2ØØ	9.6ØØ	5.5	224.Ø	55.Ø	14Ø	Ø.7	1 L	Ø.Ø1L	Ø.Ø1L
158	2.8ØØ	16.ØØØ	Ø.ØB	49Ø.9	96.5	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
158A	2.8ØØ	16.ØØØ	4.6	424.3	85.5	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
158B	Ø.Ø1ØL	Ø.1ØØL	4.5	66.6	11.Ø	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
159	Ø.35Ø	5.2ØØ	4.Ø	195.2	26.Ø	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
16Ø	16.ØØØ	7.9ØØ	3.2	296.3	17.5	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
161	Ø.5ØØ	18.ØØØ	3.2	419.2	12.5	165	Ø.6	1171	Ø.Ø1L	Ø.57
162	12.ØØØ	23.ØØØ	2.8	5Ø5.Ø	39.Ø	183	Ø.7	1331	8.6Ø	32.85
163	2.2ØØ	7.ØØØ	2.6	151.Ø	8.Ø	2ØØ	Ø.6	2Ø	Ø.6Ø	Ø.6Ø
164	Ø.95Ø	8.4ØØ	2.7	2Ø9.Ø	8.Ø	2ØØ	Ø.5	188	Ø.Ø1L	Ø.57
164A	Ø.7ØØ	7.4ØØ	2.7	161.9	8.ØH	2ØØ	Ø.5	188	Ø.Ø1L	Ø.57H
164B	Ø.25Ø	1.ØØØ	2.8	46.7	Ø.1L	2ØØ	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
165	Ø.Ø5Ø	3.2ØØ	2.8	61.4	11.Ø	2ØØ	Ø.5	5	Ø.Ø1L	2.46
166	Ø.Ø1ØL	Ø.8ØØ	3.1	21.8	5.5	2ØØ	Ø.5	15	Ø.Ø1L	2.51
167	Ø.5ØØ	14.ØØØ	1.8	339.2	26.Ø	2ØØ	Ø.6	5245	Ø.Ø1L	2.7Ø
168	4.ØØØ	8.3ØØ	3.6	19Ø.7	9.Ø	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
169	4.3ØØ	21.5ØØ	4.Ø	638.7	78.Ø	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
169A	1.3ØØ	14.ØØØ	4.3	395.7	27.1H	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
169B	3.ØØØ	7.5ØØ	3.4	243.Ø	5Ø.9H	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
17Ø	4.ØØØH	22.ØØØ	5.Ø	448.Ø	96.5	165	Ø.6	5	Ø.32	7.39
171	6.ØØØ	15.ØØØ	5.Ø	294.4	99.Ø	14Ø	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
172	6.ØØØ	15.ØØØ	5.5	315.5	81.Ø	14Ø	Ø.7	2Ø	Ø.1Ø	1.68
173	75.ØØØH	8Ø.ØØØ	4.9	1761.3	495.5	14Ø	Ø.6	181	3.5Ø	13.35
173A	2.8ØØH	2Ø.ØØØ	4.9	385.9	166.7	14Ø	Ø.6	1Ø	Ø.Ø1L	Ø.Ø1L
173B	75.ØØØ	6Ø.ØØØ	4.8	1375.4	328.8	14Ø	Ø.7	171	3.5Ø	13.35
174	12.ØØØ	9.8ØØ	6.4	27Ø.1	76.5	85	Ø.9	16	Ø.Ø1L	Ø.96
175	6.ØØØ	16.ØØØ	6.1	416.6	85.Ø	85	Ø.6	3	Ø.Ø1L	Ø.16

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
146	1	1.200	0.00300	0.0	0.0	0.00200	1.20000	2
147	2	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
148	1	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
149	1	2.100	0.00700	0.0	0.0	0.00200	2.11000	1
150	1	0.0	0.0	0.0	0.0	0.0	0.00010L	1
151	2	0.200	0.00010	0.0	0.0	0.00100	0.20100	2
152	2	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
153	1	25.700	0.16400	0.002	0.033	0.0	25.89999	2
154	1	3.800	0.04300	0.0	0.0	0.00200	3.84000	2
155	2	3.400	0.01600	0.0	0.0	0.00200	3.42000	0 B
155A	2	3.400	0.01600	0.0	0.0	0.00200	3.42000	1
155B	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
155C	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
156	2	0.600	0.00300	0.170	0.013	0.00300	0.78900	2
157	2	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
158	4	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
158A	4	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
158B	4	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
159	4	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
160	4	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
161	3	0.0	0.0	0.254	0.072	0.06700	0.39300	0 B
162	2	40.500	0.08000	0.0	0.0	0.14900	40.70000	2
163	1	2.500	0.00600	0.0	0.0	0.00200	2.51000	2
164	2	0.0	0.0	0.0	0.020	0.00300	0.02300	2
164A	2	0.0	0.0	0.0	0.020	0.00300	0.02300	2
164B	2	0.0	0.0	0.0	0.0	0.0	0.00010L	2
165	2	0.0	0.0	0.0	0.0	0.00060	0.00060	0 B
166	3	0.0	0.0	0.0	0.0	0.00200	0.00200	0 B
167	2	0.0	0.0	0.0	0.0	0.00100L	0.00100L	2
168	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
169	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
169A	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
169B	3	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
170	2	0.600	0.00300	0.0	0.0	0.00060	0.60400	2
171	2	0.0	0.0	0.0	0.0	0.0	0.00010L	0 B
172	2	0.0	0.00100	0.0	0.0	0.00100	0.00200	0 B
173	2	9.680	0.03200	0.0	0.0	0.01900	9.74000	2
173A	2	0.0	0.0	0.0	0.0	0.00100	0.00100	2
173B	2	9.680	0.03200	0.0	0.0	0.01900	9.73000	2
174	2	0.0	0.0	0.0	0.0	0.00200	0.00200	0 B
175	2	0.0	0.0	0.0	0.0	0.00030	0.00030	0 B

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
176	53.ØØØ	33.ØØØ	6.Ø	642.6	165.5	85	1.1	166	12.ØØ	58.59
177	2Ø.ØØØ	15.ØØØ	5.7	297.Ø	1Ø8.Ø	85	Ø.9	52	1Ø.2Ø	39.36
178	2Ø.ØØØ	32.ØØØ	6.2	646.4	142.5	85	Ø.8	22	1.ØØ	3.65
178A	6.ØØØ	9.8ØØ	6.1	173.4	27.5	85	Ø.8	12	Ø.8Ø	2.Ø9
178B	14.ØØØ	22.ØØØ	6.3	473.Ø	115.Ø	85	Ø.9	1Ø	Ø.2Ø	1.56
179	7Ø.ØØØ	5Ø.ØØØ	5.9	1242.9	33Ø.5	85	1.Ø	9522	7.ØØ	55.72
18Ø	2.ØØØ	1Ø.ØØØ	6.1	231.7	39.Ø	1ØØ	Ø.9	1 L	Ø.2Ø	3.52
181	2.5ØØ	28.ØØØ	4.8	564.5	1Ø4.5	14Ø	Ø.6	1 L	Ø.Ø1L	Ø.58
182	3.ØØØ	12.ØØØ	4.6	245.1	39.Ø	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
183	12.ØØØ	18.ØØØ	6.Ø	356.5	145.Ø	115	Ø.8	53	3.5Ø	7.19
184	1ØØ.ØØØ	42.ØØØ	5.7	1Ø63.Ø	334.Ø	1ØØ	Ø.9	77	8.7Ø	36.81
185	3.5ØØ	11.ØØØ	5.7	22Ø.8	71.Ø	85	Ø.7	1	Ø.Ø4	Ø.16
186	2.5ØØ	9.9ØØ	5.7	252.8	8Ø.Ø	85	Ø.7	2	Ø.Ø1L	Ø.64
186A	Ø.8ØØ	2.6ØØ	5.9	8Ø.Ø	19.Ø	85	Ø.7	2	Ø.Ø1L	Ø.64
186B	1.7ØØ	7.1ØØ	5.6	172.8	61.Ø	85	Ø.7	1 L	Ø.Ø1L	Ø.Ø1L
187	11.ØØØ	22.ØØØ	5.6	61Ø.6	187.5	78	Ø.7	31	Ø.5Ø	22.76
188	9.ØØØ	18.ØØØ	5.6	359.7	1Ø6.5	78	Ø.8	1 L	1.ØØ	9.Ø8
189	2Ø.ØØØH	38.ØØØ	5.4	925.4	97.Ø	85	Ø.6	196	15.ØØ	59.39
189A	1.8ØØH	4.6ØØ	5.9	1Ø4.3	17.ØH	78	Ø.7	15	2.63H	1Ø.4ØH
189B	2.6ØØH	2Ø.ØØØ	5.6	395.5	16.3H	78	Ø.6	3	2.52H	9.97H
189C	1.4ØØH	3.6ØØ	5.2	117.1	4.2H	78	Ø.6	6	Ø.66H	2.6ØH
189D	14.ØØØH	9.7ØØ	4.9	3Ø8.5	59.5H	1ØØ	Ø.6	172	9.19H	36.42H
19Ø	Ø.35ØL	Ø.17Ø	5.Ø	35.2	Ø.1L	85	Ø.7	1 L	Ø.Ø1L	Ø.Ø1L
191	4.5ØØ	11.ØØØ	4.6	2Ø8.6	49.5	1ØØ	Ø.6	8	Ø.16	26.95
192	5.ØØØ	1Ø.ØØØ	4.3	324.5	14.5	1ØØ	Ø.6	89	Ø.Ø1L	Ø.Ø1L
193	2.ØØØ	2.6ØØ	5.2	133.1	Ø.5	85	Ø.6	59	Ø.8Ø	Ø.35
194	1.5ØØ	Ø.42Ø	6.2	48.Ø	1.Ø	85	1.2	4	Ø.3Ø	Ø.3Ø
195	25.ØØØG	13.ØØØ	5.2	497.3	41.Ø	1ØØ	1.2	127	2.5Ø	1Ø.Ø4
196	5.ØØØ	12.ØØØ	5.8	264.3	63.Ø	115	1.Ø	5	Ø.Ø1L	Ø.64
197	1.ØØØ	1.9ØØ	5.8	67.8	16.Ø	14Ø	1.1	1 L	Ø.Ø1L	Ø.4Ø
198	1.ØØØ	3.6ØØ	5.4	72.3	1Ø.Ø	14Ø	Ø.7	1 L	Ø.7Ø	Ø.82
199	Ø.1ØØL	Ø.8ØØ	5.5	7.7	4.Ø	115	Ø.6	1 L	Ø.35	Ø.68
2ØØ	Ø.3ØØ	1.8ØØ	5.6	33.3	2.5	1ØØ	Ø.8	61	Ø.5Ø	Ø.73
2Ø1	1Ø.ØØØG	8.ØØØ	6.Ø	183.7	12.5	85	1.Ø	4	1.ØØ	2.15
2Ø2	4.5ØØ	18.ØØØ	5.6	267.5	73.5	14Ø	Ø.7	5Ø7	Ø.Ø1L	1.53
2Ø3	9.ØØØ	14.ØØØ	4.8	213.8	43.5	14Ø	Ø.8	562	2.ØØ	8.Ø5
2Ø4	1.ØØØ	6.5ØØ	5.Ø	233.Ø	43.8	14Ø	Ø.6	13	Ø.3Ø	2.24
2Ø5	5.ØØØ	28.ØØØ	2.6	626.6	4.2	183	Ø.5	1177	1.5Ø	1.5Ø
2Ø6	Ø.1ØØL	4.ØØØ	3.3	149.8	Ø.1L	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
2Ø7	37.ØØØ	49.ØØØ	5.4	1Ø28.5	276.Ø	1ØØ	Ø.7	341	6.2Ø	28.94
2Ø8	21.ØØØ	13.ØØØ	5.Ø	325.1	26.5	14Ø	Ø.6	1 L	Ø.Ø1L	1.ØØ

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
176	1	5.ØØØ	Ø.11ØØØ	Ø.Ø	Ø.Ø	Ø.Ø19ØØ	5.24ØØØ	2
177	1	1.3ØØ	Ø.Ø94ØØ	Ø.Ø	Ø.Ø	Ø.ØØ58Ø	1.4ØØØØ	Ø B
178	1	Ø.6ØØ	Ø.ØØ9ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	Ø.612ØØ	1
178A	1	Ø.48Ø	Ø.ØØ7ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.489ØØ	1
178B	1	Ø.12Ø	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.123ØØ	1
179	1	1Ø.2ØØ	Ø.Ø7ØØØ	4.86Ø	3.69Ø	Ø.ØØ6ØØ	19.8ØØØØ	2
18Ø	2	Ø.4ØØ	Ø.ØØ2ØØ	Ø.Ø	Ø.Ø	Ø.Ø	Ø.4Ø2ØØ	Ø
181	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø
182	3	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø
183	1	9.ØØØ	Ø.Ø32ØØ	Ø.Ø	Ø.Ø	Ø.ØØ6ØØ	9.Ø4ØØØ	2
184	1	6.ØØØ	Ø.Ø81ØØ	Ø.Ø	Ø.Ø	Ø.ØØ9ØØ	6.Ø9ØØØ	2
185	2	Ø.Ø	Ø.ØØØ4Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1Ø	Ø.ØØØ5Ø	1
186	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØØ2Ø	2
186A	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØØ2Ø	1
186B	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
187	1	Ø.8ØØ	Ø.ØØ5ØØ	1.4ØØ	Ø.Ø	Ø.ØØ4ØØ	2.21ØØØ	2
188	1	2.5ØØ	Ø.ØØ9ØØ	Ø.Ø	Ø.Ø	Ø.Ø	2.51ØØØ	2
189	1	2.7ØØ	Ø.Ø67ØØ	Ø.Ø	Ø.Ø4Ø	Ø.ØØ4ØØ	2.81ØØØ	2
189A	1	1.8ØØ	Ø.ØØ8ØØ	Ø.Ø	Ø.Ø	Ø.ØØ2ØØ	1.81ØØØ	2
189B	1	Ø.3ØØ	Ø.ØØ9ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ3Ø	Ø.3Ø9ØØ	2
189C	2	Ø.3ØØ	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ7Ø	Ø.3Ø4ØØ	2
189D	2	Ø.3ØØ	Ø.Ø46ØØ	Ø.Ø	Ø.Ø4Ø	Ø.ØØ1ØØ	Ø.387ØØ	4
19Ø	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	2
191	2	Ø.Ø	Ø.ØØØ7Ø	Ø.Ø	Ø.Ø	Ø.ØØØ9Ø	Ø.ØØ2ØØ	2
192	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.26Ø	Ø.Ø	Ø.26ØØØ	5
193	1	Ø.Ø	Ø.ØØ4ØØ	Ø.Ø	Ø.Ø	Ø.ØØ7ØØ	Ø.Ø1ØØØ	1
194	1	Ø.Ø	Ø.ØØ1ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ5Ø	Ø.ØØ2ØØ	1
195	1	Ø.8ØØ	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.Ø14ØØ	Ø.Ø25ØØ	2
196	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ6Ø	Ø.ØØØ6Ø	2
197	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
198	1	4.ØØØ	Ø.ØØ3ØØ	Ø.Ø	Ø.Ø	Ø.Ø	4.ØØØØØ	1
199	1	1.2ØØ	Ø.ØØ8ØØ	Ø.Ø	Ø.Ø	Ø.Ø	1.2ØØØØ	2
2ØØ	1	Ø.25Ø	Ø.Ø11ØØ	Ø.Ø	Ø.Ø	Ø.ØØ7ØØ	Ø.268ØØ	2
2Ø1	1	4.ØØØ	Ø.Ø23ØØ	Ø.Ø	Ø.Ø	Ø.ØØØ4Ø	4.Ø2ØØØ	2
2Ø2	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.184	Ø.Ø	Ø.184ØØ	1
2Ø3	1	1Ø.ØØØ	Ø.Ø46ØØ	Ø.938	Ø.127	Ø.Ø	11.1ØØØØ	2
2Ø4	1	Ø.Ø	Ø.ØØ7ØØ	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ8ØØ	2
2Ø5	1	7.ØØØ	Ø.Ø34ØØ	Ø.Ø	Ø.39Ø	Ø.Ø2ØØØ	7.44ØØØ	2
2Ø6	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
2Ø7	1	28.8ØØ	Ø.14ØØØ	Ø.Ø	Ø.Ø	Ø.038ØØ	29.ØØØØØ	Ø B
2Ø8	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	P YIELD	STORAGE	ALTITUDE	TOTAL A	IRRIG A	GROWING	PRECIP	POPULAT	AREA IRR	PRIV A
2Ø9	25.ØØØ	17.ØØØ	3.7	491.5	32.5	165	Ø.5	393	4.7Ø	8.2Ø
21Ø	18.ØØØ	18.ØØØ	2.5	42Ø.5	1.5	183	Ø.5	1 L	Ø.Ø1L	Ø.85
211	5.ØØØ	8.6ØØ	3.1	199.Ø	5.5	183	Ø.7	2	Ø.Ø1L	Ø.Ø1L
212	25.ØØØ	34.ØØØ	2.Ø	1ØØ1.Ø	13.Ø	183	Ø.7	26226Ø	1.6Ø	12.ØØ
213	1.ØØØH	11.ØØØ	Ø.8	36Ø.3	8.Ø	2ØØ	Ø.4	133	Ø.Ø1L	1.36
214	Ø.6ØØ	12.ØØØ	2.8	216.3	63.5	2ØØ	Ø.5	264	Ø.Ø1L	Ø.Ø3
215	1.3ØØH	15.ØØØ	1.2	4Ø3.2	Ø.1L	2ØØ	Ø.5	443	Ø.Ø1L	Ø.Ø1L
216	Ø.4ØØ	5.ØØØ	2.Ø	99.8	5.Ø	2ØØ	Ø.5	26	Ø.Ø1L	Ø.Ø1L
217	Ø.2ØØ	1.5ØØ	2.7	51.2	3.Ø	2ØØ	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
218	2.2ØØH	1Ø.ØØØ	1.8	2Ø3.5	1.5	2ØØ	Ø.5	1ØØ	1.ØØ	1.ØØ
219	37.ØØØ	2.5ØØ	1.8	58.2	1.9	2ØØ	Ø.5	3Ø	Ø.84	1.1Ø
22Ø	16.5ØØH	8.ØØØ	1.4	161.3	8.5	2ØØ	Ø.5	1624	3.ØØ	3.ØØ
221	1.ØØØ	5.3ØØ	3.2	122.9	7.5	165	Ø.7	1 L	Ø.Ø1L	Ø.Ø1L
222	71.ØØØH	29.ØØØ	1.5	58Ø.5	5.5	183	Ø.6	923	3.2Ø	3.11
223	Ø.5ØØ	1Ø.ØØØ	1.2	341.1	Ø.1L	2ØØ	Ø.5	5	Ø.Ø1L	Ø.Ø1L
224	Ø.3ØØ	2.ØØØ	2.2	69.1	Ø.1L	2ØØ	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
225	8.ØØØ	1.ØØØL	3.2	7Ø.4	Ø.1L	165	Ø.5	1ØØ	Ø.Ø1L	Ø.Ø1L
226	8.ØØØ	1.5ØØ	3.3	52.5	3.Ø	183	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
227	7.6ØØ	7.4ØØ	4.2	332.2	37.Ø	175	Ø.5	15	Ø.Ø1L	Ø.Ø1L
227A	4.ØØØ	7.4ØØ	3.5	178.6	37.ØH	183	Ø.5	15	Ø.Ø1L	Ø.Ø1L
227B	3.6ØØ	1.ØØØL	5.Ø	153.6	Ø.1L	165	Ø.6	1 L	Ø.Ø1L	Ø.Ø1L
228	2.ØØØ	4.ØØØ	3.8	294.4	5.5	165	Ø.5	773	Ø.3Ø	Ø.74
229	Ø.9ØØ	3.5ØØ	3.2	116.5	12.Ø	183	Ø.5	2	Ø.Ø1L	Ø.Ø1L
23Ø	34.ØØØ	35.ØØØ	2.6	573.4	225.5	183	Ø.4	476	2.ØØ	37.95
231	Ø.4ØØ	1.6ØØ	4.2	1Ø3.7	26.Ø	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L
232	Ø.15Ø	3.7ØØ	4.Ø	116.5	6.Ø	165	Ø.5	1 L	Ø.Ø1L	Ø.Ø1L

Table 26.--*Basic data in the Hydrographic-Area Data Base*--Continued

HA NO.	GW DEPTH	IRRIG U	STOCK U	IND U	PUB SUP	RUR-D U	TOTAL U	QUALITY
2Ø9	2	16.ØØØ	Ø.11ØØØ	Ø.Ø	Ø.Ø45	Ø.Ø21ØØ	16.2ØØØØ	2
21Ø	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
211	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
212	2	7.72Ø	Ø.Ø36ØØ	1.53Ø	79.7ØØ	Ø.12ØØØ	89.1ØØØ1	2
213	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø15ØØ	Ø.Ø15ØØ	2
214	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø56	Ø.ØØ2ØØ	Ø.Ø58ØØ	2
215	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ1ØØ	4
216	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ3ØØ	Ø.ØØ3ØØ	Ø B
217	3	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØL	Ø B
218	2	Ø.8ØØ	Ø.Ø23ØØ	Ø.Ø	Ø.Ø2Ø	Ø.ØØ2ØØ	Ø.845ØØ	4
219	1	2.5ØØ	Ø.Ø19ØØ	Ø.Ø	Ø.52Ø	Ø.ØØ3ØØ	3.Ø4ØØØ	4
22Ø	1	Ø.Ø	Ø.Ø68ØØ	Ø.633	Ø.165	Ø.Ø	Ø.866ØØ	4
221	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
222	2	Ø.Ø	Ø.Ø68ØØ	Ø.Ø	Ø.23Ø	Ø.Ø	Ø.239ØØ	4
223	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØ	Ø.ØØ1ØØ	4
224	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	4
225	3	Ø.Ø	Ø.Ø	Ø.4ØØ	Ø.Ø	Ø.Ø11ØØ	Ø.411ØØ	Ø B
226	4	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØL	Ø B
227	3	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØL	Ø B
227A	4	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØ1ØØL	Ø B
227B	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B
228	1	Ø.3ØØ	Ø.ØØ6ØØ	Ø.Ø	Ø.12Ø	Ø.Ø25ØØ	Ø.451ØØ	2
229	3	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ2Ø	Ø.ØØØ2Ø	Ø B
23Ø	1	11.ØØØ	Ø.Ø42ØØ	Ø.Ø	Ø.ØØ5	Ø.Ø53ØØ	11.1ØØØØ	2
231	2	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	1
232	1	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.ØØØ1ØL	Ø B

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