UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROGRESS TOWARD A GROUND-WATER-QUALITY MONITORING NETWORK FOR IDAHO

Open-File Report 78-786

Prepared in cooperation with the
Idaho Department of Health and Welfare

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By R. L. Whitehead

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Boise, Idaho

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CONVERSION FACTORS

For the convenience of those who prefer to use International System (SI) units, rather than U.S. Customary units, the conversion factors for terms used in this report are listed below.

Multiply U.S. Customary Unit	By	To Obtain SI Unit
	Length	
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
acre	4047	square meter (m^2)
	Volume	
acre-foot (acre-ft)	1233	cubic meter (m^3)

PROGRESS TOWARD A GROUND-WATER-QUALITY MONITORING NETWORK FOR IDAHO

By

R. L. Whitehead

ABSTRACT

A ground-water-quality monitoring network is being designed for Idaho. The primary objectives of the network are to (1) determine the present quality of the State's ground water, (2) provide continual monitoring of ground-water quality for water-management purposes, and (3) serve as a warning system of undesirable changes in ground-water quality.

Data are compiled for geohydrologic conditions, ground-water quality, cultural elements, and pollution sources. A "Hydrologic Unit Priority Index" is calculated from these data to select priority areas for monitoring purposes.

New ground-water-quality data were collected where existing data were lacking and at some sites that were previously sampled. Old and new data at common sites correlated well, indicating that the water quality has not changed significantly. Most ground water in Idaho is of good quality for common uses; however, water quality may pose problems in local areas. The problems result from both natural and human causes.

The potential for pollution of the aquifers is expected to be greatest in areas of greatest development. In Idaho, population centers and industries tend to be in areas of privately owned irrigated and arable land. Therefore, these areas are of primary concern for monitoring ground-water quality. Other areas requiring monitoring include those with second-home development, mining and its related processes, and radioactive-waste disposal.

INTRODUCTION

Purpose and Scope

The use of ground water for public and private supplies, industry, and irrigation is increasing in Idaho. Some aquifers (water-bearing formations) are being stressed by poor waste-disposal practices and heavy withdrawals. Therefore, it is important that a network to monitor ground-water quality in Idaho be established and maintained. The EPA (U.S. Environmental Protection Agency), in compliance with Section 208 of the Federal Water Pollution Control Act of 1972 (Public Law 92-500), requires States to establish water-quality-management plans. The IDHW (Idaho Department of Health and Welfare) is responsible for the "208 program" in Idaho and in October 1976, requested the USGS (U.S. Geological Survey) to design a ground-water-quality monitoring network that would fulfill the State's needs. This report presents the first year's progress in a 2-year study being made to accomplish the requested task.

The primary objectives of the planned network are to (1) determine the current quality of the State's ground water, (2) provide continual monitoring of ground-water quality for water-management purposes, and (3) serve as a warning system of undesirable changes in ground-water quality.

Because of the broad (statewide) scope of the planned network and the lack of quantitative data, it was necessary to make rough estimates and first approximations for certain geographic areas and hydrologic characteristics. The values determined for these, although adequate for purposes of this study, should not be used otherwise without careful evaluation of their accuracy, particularly for the following: (1) Population figures, (2) acreage of privately owned irrigated and arable land, (3) comparative water-yield potential, (4) quantities of ground-water use, and (5) distribution of mean annual precipitation.

Site-Numbering System

The site-numbering system used by the USGS in Idaho for wells and springs indicates the location, within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two segments of the number designate the township and range. The third segment gives the section number, followed by three letters and a numeral, which indicate the quarter section, the 40-acre tract, the 10-acre tract, and the serial number of the site within the tract, respectively. Quarter sections are lettered a, b, c, and d, in counter-clockwise order from the northeast quarter of each section (fig. 1). Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. Well 2N-37E-14ccc1 is in the SW¼SW¼SW¼, sec. 14, T. 2 N., R. 37 E., and was the first well inventoried in that tract. Springs are designated by the suffix "S"--for example, 14ddd1S.

In addition, a unique identification number is assigned to each site. This number is based on the site's location with respect to latitude and longitude. For example, well 2N-37E-14ddd1 is at latitude 43°29'52" and longitude 112° 04'53". Therefore, its unique identification number is 432952112045301. If more than one site falls within this location, the sequential code 01 (the last 2 digits) is assigned in ascending order to sites within this location.

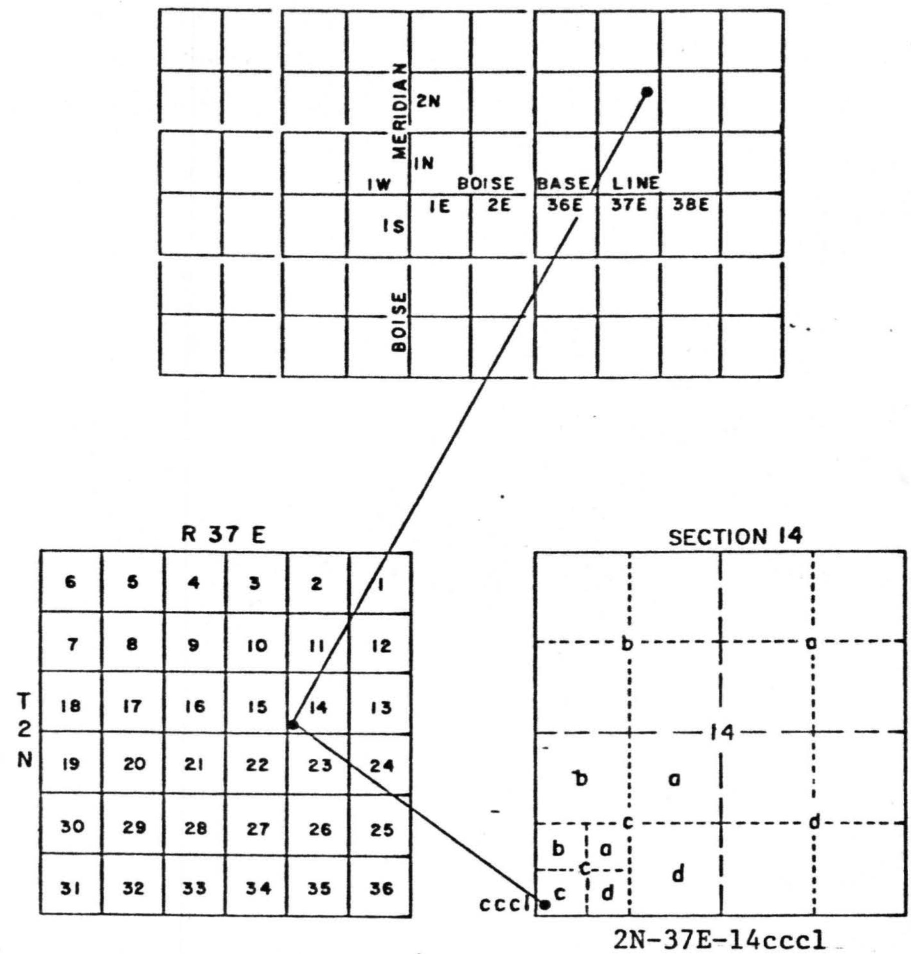

FIGURE 1. Diagram showing site-numbering system.

Once this identification number is assigned to a site, it should not be changed, even if more accurate maps permit a different latitude-longitude assignment.

GROUND-WATER-QUALITY DATA AND MONITORING IN IDAHO

Data for ground-water quality in Idaho are relatively sparse, and monitoring networks are few. The closest program to statewide coverage is that of the IDHW, who requires that each public water-supply system provide samples for water-quality analysis upon initial installation and repeated periodic surveillance.

In the late 1960's, the USGS began annual quality monitoring of selected spring discharges from the Snake Plain aquifer in the Snake River Canyon between Twin Falls and Bliss. Twenty-seven sites are presently (1977) included in this annual sampling. The most intensive program of ground-water-quality monitoring in the State is being done by the USGS as part of the research on effects of waste disposal at INEL (Idaho National Engineering Laboratory). In addition, numerous one-time ground-water samples are analyzed as part of cooperative water-resources studies made by the USGS and IDWR (Idaho Department of Water Resources) in widespread parts of the State.

Other State and Federal agencies also analyze ground-water samples as part of their related water-resources studies. Among these are the IDWR, EPA, USBR (U.S. Bureau of Reclamation), and DOE (U.S. Department of Energy).

Short-term monitoring has been done by private consultants and other governmental agencies, but the data are generally restricted to local areas and are not readily available.

The existing ground-water-quality data are largely inadequate to meet the needs of a statewide ground-water-quality monitoring network for several reasons:

1. Inadequately located sampling sites
2. Lack of hydrogeologic information at the sampling site
3. Lack of information on quality control of data collection, preservation, and analytical methods
4. Lack of trace elements and radiochemical data
5. Inadequate seasonal data

However, in spite of the above deficiencies, the existing data serve as preliminary water-quality indicators and give a general picture of the State's ground-water quality.

NETWORK DESIGN

Planning for a successful ground-water-quality monitoring network includes definition of objectives, aquifers, stresses on aquifers, current water-quality conditions, and present and potential pollution sources.

The network design is being done in the following phases, some of which may be concurrent: (1) Definition of aquifers and flow systems, (2) cataloging and location of sources of pollution, (3) definition of current ground-water quality, (4) assignment of priority indexes, (5) selection of sites and sampling schedules, (6) development of a data file and reporting system, and (7) preparation of a final project report.

Because monitoring must be concentrated where it will be most needed, a method was devised to assign priorities to separate HU's (hydrologic units) of the State. Separation of the State into 84 HU's was done in accordance with the Hydrologic Unit Map for Idaho (U.S. Geol. Survey, 1974). Data used chiefly for the priority-rating system were compiled from a variety of sources that include many private, city, county, State, and Federal organizations. Many of the data are from published reports but are in formats different than those used in this study. Thus, it is necessary to adjust the data to conform to the HU's used herein.

AQUIFERS IN IDAHO

The major aquifers in Idaho are composed of one of two general rock types--volcanic or sedimentary. The rock types and generalized extent of the aquifers and the hydrologic units in which they occur are shown in figure 2. Delineation of the aquifers and designation of rock types are based on several published reports, including USGS Water-Supply Papers and IDWR Water Information Bulletins.

The ultimate design of the water-quality-monitoring network for Idaho will focus on protection of the drinking water in these major aquifers by providing early warning of changes in ground-water quality.

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Table 1. Summary of the physical and hydrologic characteristics of rock units

Period	Epoch	Rock unit	Physical characteristics and areal distribution	Water-bearing characteristics
Quaternary	Holocene and Pleistocene	Alluvium, lake beds, windblown deposits, glacial outwash, and terrace gravels. (Qs)	Clay, silt, sand, gravel, and boulders; unconsolidated to well compacted; not bedded to well bedded. Alluvium floors the tributary valleys and flood plains of the main rivers and forms fans at mouths of some valleys. Lake beds formed behind basalt dams near Rupert, American Falls, Roberts, Mud Lake, and other areas. Windblown deposits mantle much of the lowland areas; glacial debris, talus, and landslide material are coalesced with alluvium at many places; terrace gravel occurs locally along streams.	Sandy and gravelly alluvium; an important aquifer; yields considerable ground water to wells; lake beds yield only small amounts of water because of low hydraulic conductivity. Windblown deposits mostly occur above the water table; terrace gravel locally yields moderate to large supplies of water to wells, but in many areas, the gravel occurs above the water table.
Quaternary	Holocene and Pleistocene	Basalt of the Snake River Group (Qb)	Olivine basalt, dense to vesicular, aphanitic to porphyritic; irregular to columnar jointing; thickness of flows variable; includes beds of basaltic cinders, rubbly basalt, and interflow sedimentary rocks. Crops out over much of the Snake River Plain; mantled in many places with alluvium, terrace gravel, and windblown deposits; locally intertongued with deposits of Pleistocene and Holocene age; overlies the Idaho Group, silicic-volcanic and sedimentary rocks, and basalt of the Columbia River Basalt Group.	Hydraulic conductivity highly variable; formational hydraulic conductivity high because of jointing and rubbly contacts between flows; rock hydraulic conductivity low. One of the more important aquifers in Idaho. Yields large amounts of unconfined ground water to wells where it lies below the water table; receives and transmits recharge readily.
Quaternary and Tertiary	Holocene to Paleocene(?)	Silicic-volcanic rocks (QTsv)	Rhyolitic, latitic, and andesitic rocks; massive and dense; jointing ranges from platy to columnar; occurs as thick flows and blankets of welded tuff with associated fine- to coarse-grained ash and pumice beds (commonly reworked by running water) and as clay, silt, sand, and gravel; locally folded, tilted, and faulted. Includes the Challis Volcanics (extensive rocks ranging in composition from rhyolite to basalt, which crop out in the foothills and mountains along the north side of the Snake River Plain).	Joints and fault zones in flows and welded tuff and interstices in coarse-grained ash, sand, and gravel beds yield small to moderate, and rarely large, amounts of water to wells. Commonly contain warm water under confined conditions. An important aquifer in places. The Challis Volcanics generally have low hydraulic conductivity and are not an important aquifer.
Quaternary and Tertiary	Pleistocene to Miocene	Sedimentary rocks, undifferentiated (QTs)	Subaerial and lake deposits of clay, silt, sand, and some gravel (includes Idaho Group and Payette and Salt Lake Formations). Compacted to poorly consolidated; poorly to well stratified; beds somewhat lenticular and intertongued; contains beds of ash and intercalated basalt layers. Widespread in the southern part of the State.	Porosity and hydraulic conductivity highly variable; generally contain water under confined conditions; yields to wells range from a few gallons per minute from clayey beds to several hundred gallons per minute from sand and gravel. An important aquifer in places, especially in southwestern Idaho. Water is warm at some places.
Tertiary	Miocene	Basalt of the Columbia River Basalt Group (Tb)	Flood-type basalt, dense, rude columnar jointing at many places; folded and faulted; may include some rhyolitic and andesitic rock types; exposed near the Snake River in western and west-central Idaho.	Locally yields small to moderate amounts of confined and unconfined water to wells from fractures, faults, and related sedimentary zones. Hydraulic conductivity is highly variable. An important aquifer.
Tertiary and Cretaceous		Granitic rocks, undifferentiated (TKi)	Intrusive granitic rocks and related rocks of comparable age. Chiefly includes granitic rocks of the Idaho batholith, which are exposed in the central part of the State.	Generally yields only small amounts of water to wells where fractured. Not an important aquifer.
Pre-Cretaceous		Pre-Cretaceous rocks, undifferentiated (Mzp€)	Well-indurated sedimentary and metamorphic rocks that have been folded, faulted, and intruded by granitic rocks. Crop out in the mountainous areas. Include extrusive rocks of Permian and Triassic age in the western part of the State. May include some younger sedimentary rocks.	Hydraulic conductivity generally low, except where jointed. Not an important aquifer.

Recharge to Aquifers

For purposes of this study, and unless data indicate otherwise, the source of most recharge to each HU is assumed to be precipitation that falls within the drainage basin of the HU (see table 2). Part of the precipitation runs off in streams; part, in some HU's, is stored in reservoirs; part is lost by evapotranspiration; and the remainder percolates through the ground to recharge the aquifers. Most of the precipitation that recharges the aquifers falls as snow during winter. Additional recharge to aquifers may occur in some HU's as a result of one or more of the following: leakage from canals or ditches that import irrigation water from adjacent areas, leakage from reservoirs, percolation of applied irrigation water, and ground-water underflow from aquifers in adjacent HU's.

Table 2. Mean annual precipitation in hydrologic units

[Data based on maps prepared for the Pacific Northwest River Basins Commission (1970) and Pacific Southwest Interagency Committee, Water Resources Council (1971)]

HU	Precipitation (in)	HU	Precipitation (in)	HU	Precipitation (in)
1	20	29	19	57	37
2	20	30	17	58	35
3	18	31	9	59	22
4	37	32	17	60	33
5	20	33	16	61	29
6	17	34	10	62	23
7	47	35	12	63	25
8	36	36	18	64	15
9	24	37	17	65	31
10	44	38	21	66	22
11	35	39	25	67	29
12	39	40	22	68	26
13	40	41	22	69	24
14	51	42	18	70	21
15	49	43	15	71	31
16	32	44	10	72	31
17	44	45	11	73	29
18	28	46	12	74	36
19	27	47	15	75	22
20	34	48	11	76	32
21	22	49	10	77	45
22	28	50	15	78	48
23	9	51	16	79	50
24	26	52	42	80	31
25	16	53	25	81	28
26	17	54	31	82	28
27	16	55	12	83	54
28	10	56	12	84	46

Discharge From Aquifers

Natural discharge from aquifers occurs as evapotranspiration, discharge in springs, discharge to streams or water bodies, and underflow to adjacent aquifers. Ground-water underflow accounts for appreciable discharge from some HU's, particularly those surrounding the Snake River Plain. Except for areas where previous data indicate appreciable underflow, it is assumed that evapotranspiration, discharge through springs, and ground-water discharge to streams account for most of the natural discharge.

Man's activities in an area also account for discharge from aquifers, as water is withdrawn by pumping. Much ground water is used for public supply, domestic, stock, industrial, agricultural, and mining purposes. Generally, only a small part of that withdrawn is returned to the aquifer within its respective HU.

Present Ground-Water-Quality Conditions in Idaho

Present (1978) ground-water quality may be determined in a general way by examination of existing data. Files of IDHW, IDWR, USBR, and USGS are chief sources for these data. Most of the data are for inorganic chemical constituents and many are, in general, indicative of natural conditions. Concentrations of certain constituents are high in places. Some suggest effects of human activities; others reflect geologic environments. The high concentrations may exceed those desired for particular uses and may be troublesome in local areas. However, most of the ground water is satisfactory for common uses. Locations of wells or springs that have been sampled are shown in figure 4.

During this study, water samples were collected at selected sites to define the ground-water quality in areas where existing data were lacking or where comparison with existing data was desired. Generally, close correlation was found between the old and new data, indicating that the water quality has changed little with time.

Data concerning short-term and seasonal changes in ground-water quality are lacking in the State. Collection of these data would add greatly to the knowledge of the State's ground-water quality and may be essential to adequately monitor certain types of contamination.

SOURCES OF POLLUTION

Sources of Data

The sources of potential pollution to the State's aquifers were compiled chiefly from published reports and the files of the IDHW, IDWR, and USGS.

Sources and Types of Waste

Sources of ground-water pollution can be classified as line, point, or nonpoint (diffuse), but in many places, the distinction is not clear. Line and point sources (direct sources of pollution) generally can be identified. However, in designing a statewide network to monitor ground-water quality, some generalizations must be made. For example, waste-disposal wells and individual septic tanks generally can be classified as point sources, and leakage along sewerage lines can be classified as a line source; but where these sources are concentrated, their wastes may merge and become a nonpoint source before affecting the aquifer. Therefore, with a few exceptions, most sources will be considered as nonpoint for this study.

Water enriched in selected constituents may percolate to the aquifer from any of the following sources: (1) Pesticides, fertilizers, and waste products applied to soils; (2) stockpiles of industrial, mining, or agricultural wastes; (3) landfills, sewerage ponds, septic-tank systems, and sewerage lines; (4) recharge in urban and suburban areas; (5) construction areas that have disturbed the land surface; (6) leakage or spillage of pollutants; (7) percolation of excess irrigation water; and (8) waste-disposal wells. In addition to the above potential sources of pollution, geologic formations with which the ground water comes in contact contain soluble minerals that can concentrate in the water. Thus, anomalously high mineral concentrations in ground water do not necessarily indicate a manmade source. Major ground-water use and potential pollution sources are shown in table 3.

The general locations of pollution sources and amounts and types of wastes released to the environment have not yet been tabulated. A compilation of these data, obtained from other agency files, will be made in subsequent phases of the study.

Table 3. Major ground-water use in and potential ground-water pollution source(s) in hydrologic units

Use:

A - Domestic, stock, and public supply
B - Irrigation
C - Industrial

Pollution sources:

D - Septic-tank systems, sewerage leakage, sewerage ponds, and landfills
E - Waste-disposal wells
F - Agricultural and livestock waste
G - Mining and related activities
H - Industrial processing
J - Recharge in urban areas
K - Known pollution minor

HU	Use	Source	HU	Use	Source	HU	Use	Source
1	A,B	D,F	29	A,B,C	D,F,G,H	57	A	D,G
2	A,B,C	D,F,H,J	30	A,B,C	D,E,F,G,H,J	58	A	D
3	A,B,C	D,F,H,J	31	A,B,C	D,E,F,H,J	59	A,B,C	D,F,H,J
4	Minor	K	32	A,B	D,F	60	A,B	D,F,J
5	A,B	D,F	33	A,B	D,F	61	A,B	D,F,J
6	A,B	D,F	34	A,B,C	D,E,F,G,H,J	62	A,B	D,F,J
7	Minor	K	35	A,B	D,E,F	63	Minor	K
8	A	D,F,J	36	A,B	D,F	64	A	D
9	A	D	37	A,B	D,E,F	65	A	D,F,J
10	Minor	D	38	A,C	D,E,H	66	A	K
11	A	D,H	39	A,B,C	D,F	67	A	D,F,G
12	A	D	40	A,B,C	D,E,F,G,H,J	68	A,B,C	D,F
13	Minor	K	41	A,B,C	D,E,F,H	69	A,B,C	D,F,G,H,J
14	A	D,G	42	A,B,C	D,E,F,H	70	A,B	D,F
15	A	D,G,H	43	A,B,C	D,E,F,H	71	A	K
16	A	D,G,J	44	A,B,C	D,F,H,J	72	Minor	K
17	A	D,G	45	A,B	D,F	73	A	D
18	A,B,C	D,F,H,J	46	A,B	D,E,F	74	A	D,G
19	A	D	47	A	K	75	A	D,F
20	Minor	D	48	Minor	K	76	A,B	D,F
21	A,B	D,F	49	Minor	K	77	Minor	K
22	A	D,F	50	Minor	K	78	Minor	K
23	A,B,C	D,E,F,G,H,J	51	A,C	D,H	79	Minor	K
24	A,B	D,F	52	A	D	80	A	D
25	A,B,C	D,E,F,H,J	53	A	D	81	A,B	D,F,J
26	A,B,C	D,E,F,H,J	54	A	D	82	A,B,C	D,F,H,J
27	A	D,F	55	A,B,C	D,F,H,J	83	Minor	K
28	A,B,C	D,E,F,G,H,J	56	A,B	D,F	84	A	D

Data compiled chiefly from published reports of IDHW, IDWR, and USGS.

PRIORITY RATING OF AREAS

Knowledge of the occurrence and characteristics of aquifers in relation to the relative position of pollution sources and water-supply systems is paramount in design of a viable ground-water-quality monitoring network. In addition, the network planner's judgment is important in selection of monitoring sites, frequency of monitoring, and types of analyses to be made. To aid in making this judgment, a priority-rating system or HPI (Hydrologic Unit Priority Index) is used in this study, based chiefly on intensity of ground-water development. The system was modified from one developed by the USGS in planning a ground-water-monitoring program for Nevada (Nowlin, 1978).

The HU's of the State, intended for reporting and management purposes, were ranked in order of priority. Selected geohydrologic and cultural elements within each HU were determined for use in the priority rating. The elements are:

1. IA, privately owned irrigated and arable land--Most of the population and resulting development generally tend to concentrate in these areas. A land-status map (U.S. Bureau of Land Management, 1968) was updated to 1975 and was used as the basis for determining landownership. Idaho com-

Table 4. Total area and privately owned arable land in hydrologic units
(In thousands of acres)

HU	Total area	Privately owned arable land[1]	HU	Total area	Privately owned arable land[1]	HU	Total area	Privately owned arable land[1]
1	147.8	37	29	688.6	150	57	527.4	3.8
2	627.8	210	30	847.4	370	58	214.4	4.5
3	613.1	300	31	2,344.3	600	59	798.1	160
4	30.7	[2].01	32	773.1	210	60	585.0	68
5	326.4	130	33	471.0	120	61	1,068.8	120
6	457.0	130	34	1,562.9	640	62	416.0	20
7	49.3	[2].01	35	590.7	88	63	215.0	10
8	531.8	65	36	636.2	120	64	130.6	27
9	120.3	1.3	37	617.6	130	65	332.2	160
10	133.1	3.2	38	449.9	5.1	66	14.7	3.8
11	739.8	75	39	618.9	47	67	1,568.0	19
12	481.3	[2]12	40	1,226.2	120	68	533.1	41
13	11.5	1.3	41	936.3	130	69	1,155.2	[2]30
14	586.9	1.9	42	434.6	140	70	816.6	59
15	188.2	[2]110	43	727.0	120	71	962.6	1.3
16	413.4	53	44	1,374.1	240	72	891.5	[3].3
17	1,181.4	47	45	1,597.4	32	73	1,086.1	[3]1.7
18	243.2	120	46	1,260.2	250	74	838.4	[3].6
19	151.7	95	47	987.5	30	75	798.1	90
20	16.0	7.7	48	163.2	1.3	76	373.8	18
21	535.7	63	49	57.6	1.3	77	627.8	[3].3
22	258.6	28	50	185.6	5.8	78	658.6	.01
23	737.3	430	51	389.8	19	79	739.2	[3].1
24	688.0	59	52	529.3	[3].3	80	137.0	[3]4.5
25	458.9	180	53	396.2	[3]3.2	81	748.8	110
26	547.8	350	54	837.1	1.3	82	1,476.5	630
27	417.3	90	55	873.0	550	83	828.8	[3].06
28	1,846.4	550	56	83.8	45	84	734.1	5.1

[1] Includes irrigated land (U.S. Bureau of Land Management, 1968, and Idaho Water Resources Board, 1970).
[2] Estimated; value less than shown.
[3] Developed area other than agricultural; value represents 1 percent of HU population in thousands of acres.

prises 64 percent federally owned land. Because landownership can be shown on the map only generally, some small parcels of privately owned land (particularly in National Forest areas) are not shown. Areas of IA were obtained by planimetry from a map (Idaho Water Resources Board, 1970), updated to 1972 conditions (table 4 and fig. 5).

2. P, population--The greatest pollution potential is likely to occur where population is greatest (1975 census data were used). However, there are exceptions. Where no people were listed for an HU area, an arbitrary value of 1 was assigned to facilitate priority calculations (table 5).
3. U, ground-water use--Estimated annual ground-water use for each HU is based on data from files of the USGS and IDWR. Data are adjusted to 1975 conditions (table 6).
4. C, comparative water-yield potential--This indicates, for general comparative purposes only, the volume of ground water that may be stored in rock units having the specified thicknesses and estimated specific yields (table 7).

Table 5. Population in hydrologic units
(An arbitrary value of 1 is assigned to unpopulated HU's)

HU	Population	HU	Population	HU	Population
1	200	29	5,000	57	200
2	9,800	30	58,420	58	100
3	10,000	31	37,190	59	22,050
4	1	32	1,000	60	4,260
5	2,850	33	1,500	61	8,890
6	150	34	66,100	62	2,090
7	1	35	300	63	1
8	6,550	36	1,000	64	2,500
9	450	37	600	65	22,540
10	500	38	50	66	40
11	18,600	39	300	67	1,400
12	1,800	40	4,575	68	395
13	1	41	10,100	69	4,650
14	300	42	920	70	1,500
15	17,500	43	6,350	71	25
16	8,200	44	19,130	72	50
17	7,150	45	400	73	270
18	37,500	46	9,480	74	90
19	750	47	20	75	1,110
20	200	48	1	76	1,030
21	800	49	1	77	40
22	80	50	10	78	1
23	69,830	51	40	79	20
24	2,000	52	50	80	700
25	8,400	53	500	81	7,340
26	19,000	54	200	82	50,200
27	150	55	207,060	83	10
28	30,085	56	5,350	84	800

Table 6. Comparative water-yield potential[1] and annual ground-water use in hydrologic units

(In thousands of acre-feet)

HU	Comparative water-yield potential	Ground-water use	HU	Comparative water-yield potential	Ground-water use	HU	Comparative water-yield potential	Ground-water use
1	350	9.7	29	3,800	4.2	57	650	0.02
2	2,900	37	30	4,100	510	58	190	.01
3	3,700	56	31	13,000	1,000	59	3,400	6.3
4	33	.0001	32	5,000	190	60	1,900	.01
5	1,800	31	33	2,000	200	61	2,600	11
6	2,700	19	34	8,100	870	62	370	.70
7	25	.0001	35	2,200	9.7	63	110	.0001
8	1,200	.28	36	3,500	29	64	78	.46
9	320	.02	37	3,600	280	65	170	5.0
10	110	.0001	38	2,500	5.8	66	7	.03
11	2,000	.42	39	2,700	51	67	2,400	1.9
12	1,400	.02	40	4,800	100	68	2,200	11
13	24	.0001	41	2,900	21	69	860	1.9
14	620	.01	42	2,100	10	70	2,600	.45
15	250	.61	43	2,700	80	71	910	.01
16	580	1.1	44	11,000	84	72	600	.0001
17	830	.34	45	7,500	5.9	73	730	.01
18	1,400	39	46	7,800	56	74	1,100	.01
19	250	.04	47	4,300	.01	75	580	.24
20	63	.0001	48	920	.0001	76	390	.94
21	1,500	.26	49	240	.0001	77	310	.0001
22	630	.42	50	440	.0001	78	330	.0001
23	4,600	850	51	1,100	.01	79	69	.0001
24	2,700	.54	52	260	.01	80	68	.15
25	3,100	80	53	460	.04	81	740	7.6
26	2,500	290	54	800	.04	82	790	34
27	2,100	.01	55	6,900	210	83	460	.0001
28	11,000	1,000	56	840	7.6	84	370	.04

[1]Values shown are intended only for relative comparison of HU's and should not be used otherwise or assumed to replace previously determined values.

Table 7. Specified thickness and estimated specific yield for selected rock units

Rock unit[1]	Specified thickness[2] (ft)	Estimated specific yield[2] (percent)
Qs	50	20
Qb	100	5
QTsv	100	1
QTs	100	10
Tb	50	1
TKi	50	1
MzpЄ	50	[3] 1 (2)

[1]Refer to table 1 for description of rock units.

[2]Modified from Pacific Northwest River Basins Commission (1970, p. 200) and Pacific Southwest Interagency Committee, Water Resources Council (1971, p. 48).

[3]Two percent was used for HU's 1-6.

The thickness and specific yields (table 7) were derived from a wide range of conditions and, as such, are only general estimates that may not be completely representative of actual conditions in each HU (refer to Pacific Northwest River Basins Commission, 1970, p. 82, and Pacific Southwest Interagency Committee, Water Resources Council, 1971, p. 46).

The areal distribution of rock units in each HU was planimetered from a 1:500,000-scale map (Ross and Forrester, 1947). The above values for thickness and specific yield were used with the areas to determine volumes. Because some amount of ground water occurs in most rock units in Idaho, if only in small amounts suitable for use, the distribution of all rock units in each HU was planimetered.

As mentioned previously, the comparative water-yield potential does not indicate the total amount of ground water available. It is used only as an index for comparison of HU's for the specified thickness of rock units and should not be used otherwise or assumed to replace former values determined for some other purpose.

Calculation of the Hydrologic Priority Index

The HPI is designed to rank the effects of man's activities on the quality of the ground water in each HU, particularly with respect to major ground-water uses. The population element, P, (table 5), of each HU was normalized to obtain an index component, PL, by using logarithms:

$$PL = \log P$$

Idaho has a large percentage of federally owned land, and most of the population tends to concentrate largely in IA areas, rather than being spread over the entire HU; therefore, a PI (population density component) is derived for each IA area. PI is the ratio of P to IA and is normalized by using logarithms:

$$PI = \log \frac{P}{IA}$$

The intensity of ground-water use in an area also determines the need to protect the resource against contamination. The intensity of use is quantified by using the ratio of U (ground-water use) to C (comparative water-yield potential) and is normalized by using logarithms:

$$UI = \log \frac{U}{C}$$

The hydrologic priority index for each HU is defined as the sum of the three components (table 8).

$$HPI = PL+PI+UI$$

The greatest value of HPI indicates the highest priority for ground-water monitoring (table 9).

Table 8. HPI[1] components used for priority rating
(Refer to text for description of components)

HU	PL	PI	UI[2]	HU	PL	PI	UI[2]	HU	PL	PI	UI[2]
1	2.30	0.73	1.56	29	3.70	1.52	2.96	57	2.30	1.72	4.51
2	3.99	1.67	1.89	30	4.77	2.20	.91	58	2.00	1.35	4.28
3	4.00	1.52	1.82	31	4.57	1.79	1.11	59	4.34	2.14	2.73
4	0	2.00	5.52	32	3.00	.68	1.42	60	3.63	1.80	5.28
5	3.45	1.34	1.76	33	3.18	1.10	1.00	61	3.95	1.87	2.37
6	2.18	.06	2.15	34	4.82	2.01	.97	62	3.32	2.02	2.72
7	0	2.00	5.40	35	2.48	.53	2.36	63	0	-1.00	6.04
8	3.82	2.00	3.63	36	3.00	.92	2.08	64	3.40	1.97	2.23
9	2.65	2.54	4.20	37	2.78	.66	1.11	65	4.35	2.15	1.53
10	2.70	2.19	6.04	38	1.70	.99	2.63	66	1.60	1.02	2.37
11	4.27	2.39	3.68	39	2.48	.81	1.72	67	3.15	1.87	3.10
12	3.26	2.18	4.85	40	3.66	1.58	1.68	68	2.60	.98	2.30
13	0	-.11	5.38	41	4.00	1.89	2.14	69	3.67	2.19	2.66
14	2.48	2.20	4.79	42	2.96	.82	2.32	70	3.18	1.41	3.76
15	4.24	2.20	2.61	43	3.80	1.72	1.53	71	1.40	1.28	4.96
16	3.91	2.19	2.72	44	4.28	1.90	2.12	72	1.70	2.22	6.78
17	3.85	2.18	3.39	45	2.60	1.10	3.10	73	2.43	2.20	4.86
18	4.57	2.49	1.56	46	3.98	1.58	2.14	74	1.95	2.18	5.04
19	2.88	.90	3.80	47	1.30	-.18	5.63	75	3.05	1.09	3.38
20	2.30	1.41	5.80	48	0	-.11	6.96	76	3.01	1.76	2.62
21	2.90	1.10	3.76	49	0	-.11	6.38	77	1.60	2.12	6.49
22	1.90	.46	3.18	50	1.00	.24	6.64	78	0	2.00	6.52
23	4.84	2.21	.73	51	1.60	.32	5.04	79	1.30	2.30	5.84
24	3.30	1.53	3.70	52	1.70	2.22	4.41	80	2.85	2.19	2.66
25	3.92	1.67	1.59	53	2.70	2.19	4.06	81	3.87	1.82	1.99
26	4.28	1.73	.94	54	2.30	2.19	4.30	82	4.70	1.90	1.37
27	2.18	.22	5.32	55	5.32	2.58	1.52	83	1.00	2.22	6.66
28	4.48	1.74	1.04	56	3.73	2.08	2.04	84	2.90	2.20	3.97

[1]HPI = PL+PI+UI.
[2]Negative values.

Table 9. Priority and ranking of hydrologic units

Rank	HU	HPI	Rank	HU	HPI	Rank	HU	HPI
1	55	6.38	29	11	2.98	57	6	.09
2	23	6.32	30	17	2.64	58	38	.06
3	30	6.06	31	62	2.62	59	19	-.02
4	34	5.86	32	80	2.38	60	14	-.11
5	18	5.50	33	37	2.33	61	73	-.23
6	31	5.25	34	29	2.26	62	52	-.49
7	82	5.23	35	32	2.26	63	57	-.49
8	28	5.18	36	8	2.19	64	22	-.82
9	26	5.07	37	76	2.15	65	74	-.91
10	65	4.97	38	67	1.92	66	58	-.93
11	44	4.06	39	36	1.84	67	10	-1.15
12	25	4.00	40	39	1.57	68	20	-2.09
13	43	3.99	41	1	1.47	69	79	-2.24
14	15	3.83	42	42	1.46	70	71	-2.28
15	2	3.77	43	68	1.28	71	77	-2.77
16	41	3.75	44	24	1.13	72	72	-2.86
17	59	3.75	45	84	1.13	73	27	-2.92
18	56	3.73	46	9	.99	74	51	-3.12
19	3	3.70	47	53	.83	75	7	-3.40
20	81	3.70	48	70	.83	76	83	-3.44
21	40	3.56	49	75	.76	77	4	-3.52
22	61	3.45	50	35	.65	78	47	-4.51
23	46	3.42	51	45	.60	79	78	-4.52
24	16	3.38	52	12	.59	80	50	-5.40
25	33	3.28	53	66	.25	81	13	-5.49
26	69	3.20	54	21	.24	82	49	-6.49
27	64	3.14	55	54	.19	83	63	-7.04
28	5	3.03	56	60	.15	84	48	-7.07

Priority Ranking of Hydrologic Units

Calculation of the HPI gives values for priority ranking of HU's in Idaho. Those HU's having the greater HPI values are ranked beginning with 1 and will receive early attention for monitoring. Because of other factors not considered in the priority rating, such as special geohydrologic conditions or particular pollution sources, a final judgmental assessment must be made. For the most part, the rankings indicate higher priority areas, even where special conditions apply.

The ranking of HU's resulting from the priority rating is listed in table 9, and the ranked distribution within the State is shown in figure 6.

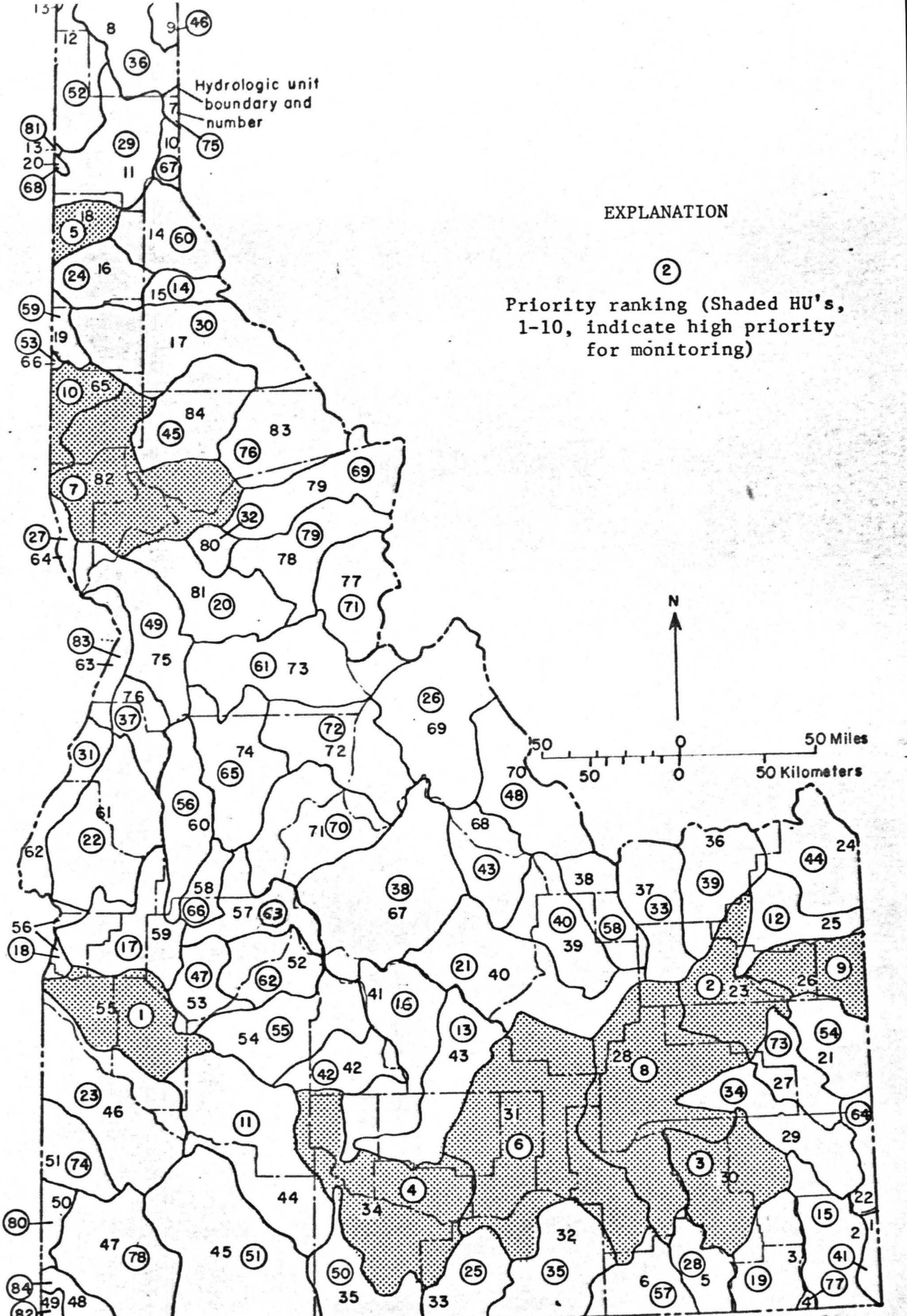

FIGURE 6. Priority ranking of hydrologic units for ground-water-quality monitoring.

WORK TO BE DONE

Work to be done for the study consists chiefly of the following:

1. Collect current data. This part of the study is nearly completed. Only about 12 wells or springs where data are lacking remain to be sampled.
2. Establish a ground-water-quality data base. Selected data from the USGS, IDHW, and IDWR files are being assigned location numbers and coded for entry into the USGS WATSTORE (National Water Data Storage and Retrieval System) computer system. These data will serve as a base from which future changes in ground-water quality can be measured.
3. Select sampling sites and sampling horizons in the aquifer(s). Selection of sites for monitoring has begun. Site selection is not an exact procedure because of the many complexities involved in the subsurface systems. However, knowledge of the occurrence and flow of ground water, aquifer geometry, sources of pollution, and patterns of ground-water use enable reasonable selection of monitoring sites and vertical sampling positions. The priority-rating system is used only to delineate HU's needing most attention for monitoring. Within each HU, areas prone to pollution

comprise privately owned irrigated and arable land, including industrial processing plants, nonsewered first-home development, mining and related processing, second-home development, and radioactive-waste disposal (fig. 7). These areas will receive the most attention for monitoring, although some monitoring sites will be in remote areas specifically to establish data for near-natural conditions and to document any naturally caused ground-water-quality changes. Every effort will be made to select existing wells and springs for monitoring sites. However, in some areas, drilling new wells may be necessary.

4. Select water-quality properties to be monitored. The Idaho Regulations for Public Water Systems (IDHW, 1977) and the Federal Drinking Water Standards (EPA, 1975) will be used as guides for selection of properties for analyses. The properties will differ considerably, depending on aquifer characteristics and pollution sources involved.

5. Establish sampling frequencies for ground-water-quality monitoring. The frequency of sampling at

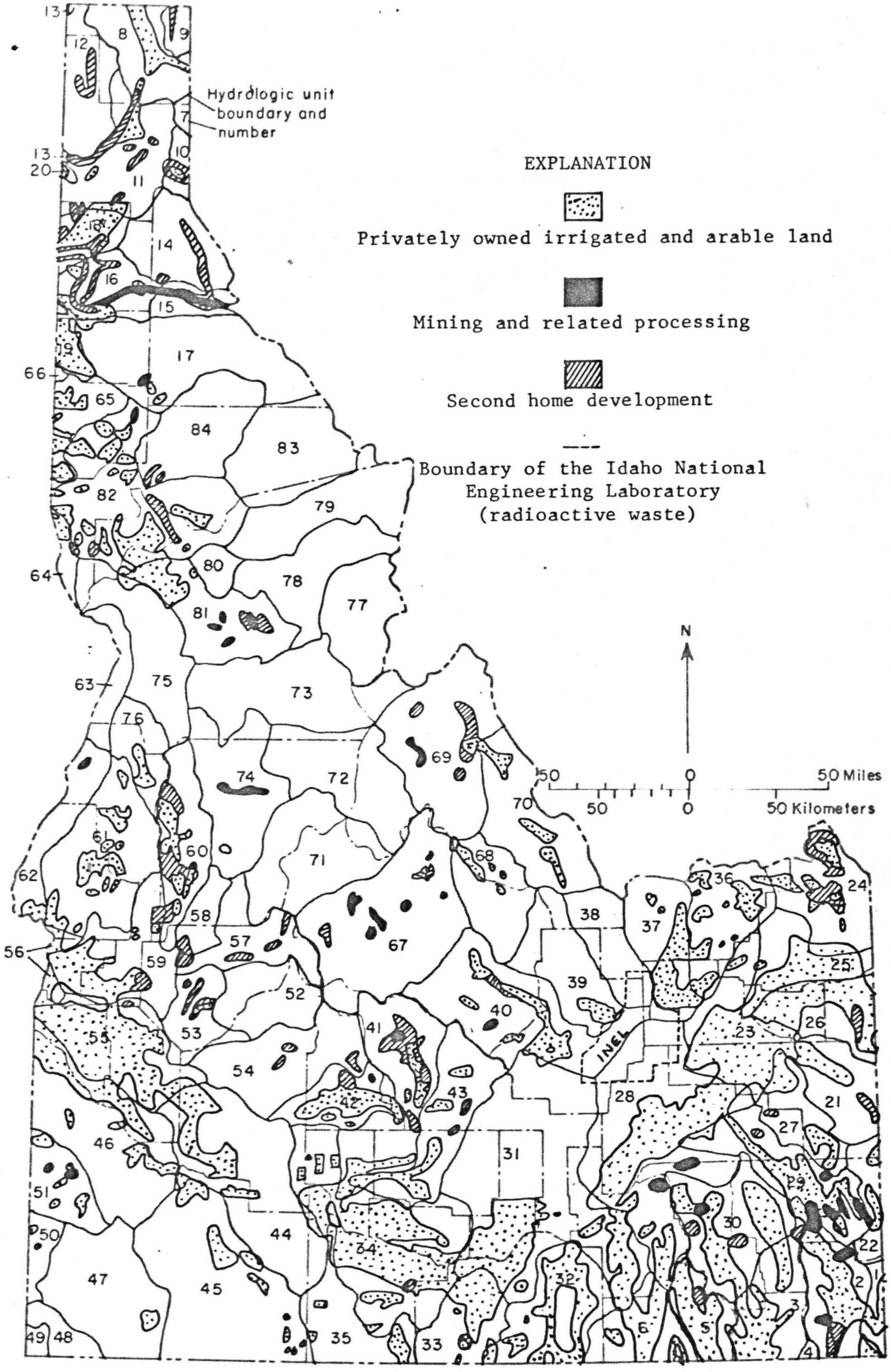

FIGURE 7. Areas of greatest pollution potential within each hydrologic unit.

each site will depend greatly on aquifer characteristics, pollution sources, and types of groundwater use. Sampling may be done monthly, quarterly, semiannually, annually, or only once every several years.

6. Prepare a final report that will include tabulations of monitoring sites and sampling schedules and a text explaining the rationale used for the network design.

REFERENCES CITED

Idaho Department of Health and Welfare, 1977, Idaho regulations for public water systems: Idaho Dept. Health and Welfare, (in press).

Idaho Water Resource Board, 1970, Irrigated and potentially irrigable lands: 1 sheet, 1:750,000.

Nowlin, J. O., 1978, Ground-water-quality monitoring program for Nevada: U.S. Geological Survey Open-File Report 78-768 (in press).

Pacific Northwest River Basins Commission, 1970, Columbia-North Pacific region comprehensive framework study of water and related lands: app. V, v. 1, 543 p.

Pacific Southwest Inter-Agency Committee, Water Resources Council, 1971, Great Basin region comprehensive framework study: app. V, 109 p.

Ross, C. P., and Forrester, J. P., 1947, Geologic map of the State of Idaho: U.S. Geol. Survey, 1 sheet.

Todd, D. K., and others, 1976, Monitoring ground-water quality; monitoring methodology: U.S. Environmental Protection Agency rept. EPA-600/4-76-026, 154 p.

U.S. Bureau of Land Management, 1968, Land status map, State of Idaho: 1 sheet, 1:500,000.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water standards: Federal Register, Pt. IV, v. 40, no. 248, p. 59566-59587.

U.S. Geological Survey, 1974, Hydrologic unit map, State of Idaho: 1 sheet, 1:500,000.