RADIONUCLIDE CONCENTRATIONS IN STREAMS IN THE UPPER BLACKFOOT RIVER BASIN, SOUTHEASTERN IDAHO

By Walton H. Low

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations

Open-File Report 81-142

March 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

Water-Resources Investigations/Open-File Report 81-142

For additional infomation, write to:

District Chief
U.S. Geological Survey, WRD
Box 036, Federal Building
550 W. Fort St.
Boise, ID 83724

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For the convenience of those who prefer to use the SI (International System of Units) rather than the inch-pound system, conversion factors for terms used in this report are listed below. Chemical data for concentrations are given in mg/L (milligrams per liter) or μg/L (micrograms per liter), which are, within the range of values presented, equal to ppm (parts per million) or ppb (parts per billion), respectively. Specific conductance is expressed in μmho/cm (micromhos per centimeter at 25 degrees Celsius). Radionuclide concentrations are expressed in pCi/L (picocuries per liter), or pCi/g (picocuries per gram). One picocurie equals 0.037 disintegrations per second.

Multiply inch-pound unit	By	To obtain SI unit
	Area	
square mile (mi^2)	2.590	square kilometer
acre	4047	square meter
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
	Mass	
ton per day (ton/d)	0.9072	metric ton per day

TEMPERATURE

Conversion of °C (degrees Celsius) to °F (degrees Fahrenheit) is by the equation °F = (1.8)(°C) + 32. Water temperatures are reported to the nearest one-half degree.

RADIONUCLIDE CONCENTRATIONS IN STREAMS IN THE UPPER BLACKFOOT RIVER BASIN, SOUTHEASTERN IDAHO

By
Walton H. Low

ABSTRACT

Data on radionuclide concentrations in water and sediment material in the phosphate-mining area of the upper Blackfoot River basin were collected from May to October 1979. Maximum measured uranium and radium-226 concentrations dissolved in water were 3.7 micrograms per liter and 1.8 picocuries per liter, respectively. Maximum measured uranium and radium-226 concentrations in stream-bottom material were 5.5 micrograms per gram and 1.8 picocuries per gram, respectively. Maximum measured uranium and radium-226 concentrations on bottom material were 9.9 micrograms per gram and 3.9 picocuries per gram, respectively, in sediment-retention ponds, and 17 micrograms per gram and 3.5 picocuries per gram, respectively, in a mine pit. Maximum observed radon-222 concentration was 120 picocuries per liter in surface water and averaged 550 picocuries per liter at Formation Springs (site 10). All radionuclide concentrations were within existing State and Federal water-quality standards. Radionuclide concentrations were not significantly increased downstream from active mining sites.

INTRODUCTION

An important land-use activity in the upper Blackfoot River basin in Caribou County, Idaho, is open-pit phosphate mining. During mining of the phosphate ore, the carbonate and mudstone rock overburden is removed and deposited in large waste piles for later reclamation. The rock overburden contains an average of 20-30 ppm uranium (U.S. Department of the Interior and U.S. Department of Agriculture, 1977). The uranium contained in the overburden may, under certain geochemical conditions, enter the stream environment through erosion and subsequent deposition into streams. Surface-water samples previously collected in the Blackfoot River basin contained 0.4 to 3.3 μg/L uranium and 0.10 to 0.78 pCi/L radium-226 (L.L. Thatcher, written commun., 1978).

The purpose of this study was to provide data on the concentration and distribution of uranium, radium, and radon in the 350-mi^2 basin, where expansion of phosphate mining on about 16,000 acres of Federal land is planned within the next 20 years. The U.S. Geological Survey, Conservation Division, which supervises the phosphate-mining leases, requested that a reconnaissance study be undertaken to provide radionuclide data necessary to monitor effects of mining activities on the concentration of radionuclides in the environment.

Radionuclide data were collected once during May, June, August, and October 1979. Data collection was attempted during storm runoff in August and October but was unsuccessful due to the variability of summer precipitation in the basin. Locations of sampling sites are described in table 1 and are shown on plate 1. Samples of water, suspended sediment, and bed material were collected at eight stream sites and were analyzed for uranium, radium-226, and radon-222. Water samples were collected at Formation Springs (site 10) and were analyzed for dissolved uranium, radium-226, and radon-222. Samples for determination of suspended-sediment concentrations were collected at nine stream sites. Bed-material samples from sediment-retention ponds near active mines were collected for uranium and radium-226 analyses. In addition, water discharge, water temperature, specific conductance, and pH were determined at each stream-sampling site.

Sampling sites on Angus and Maybe Creeks and Little Blackfoot River below ponds (sites 2, 3, and 9, respectively) were located immediately below active phosphate-mining sites. Sampling sites on Diamond Creek, Little Blackfoot River above ponds, and Formation Springs (sites 1, 8, and 10, respectively) were located where there is no active mining. Dry Valley and Trail Creeks (sites 4 and 6, respectively) were sampled at the mouth to determine existing radionuclide concentrations in anticipation of future expansion of mining activity. The Blackfoot River at Allen Ranch (site 5) was sampled only for suspended-sediment concentration, and water discharge was measured to determine the sediment-discharge contribution of sites 1 through 4 and Lanes Creek. Blackfoot River above Blackfoot Reservoir (site 7) represents the cumulative contribution of all tributaries in the upper Blackfoot River basin.

The author wishes to thank Mr. David Farnsworth and Mr. Ronald W. Ferrel of Monsanto Chemical Company; Mr. Larry Kelsey of Beker Industries Corporation; Mr. Wendell E. Johnson of Stauffer Chemical Company; and Mr. Calvin L. Bennett, Mr. Paul Keetch, Mr. Keith Hunsinger, and Mr. Fred Hagius for their help in gaining access to the sampling sites.

Table 1. Location of sampling sites

Site No.	Latitude	Longitude	Station name
S1	42°48'12"	111°16'43"	Diamond Creek above Timothy Creek
S2	42°51'06"	111°24'40"	Angus Creek near Wooley Valley Unit 3 Mine
S3	42°44'47"	111°18'03"	Maybe Creek near South Maybe Canyon Mine
S4	42°47'03"	111°23'10"	Dry Valley Creek near mouth
S5	42°47'04"	111°23'13"	Blackfoot River at Allen Ranch
S6	42°45'52"	111°26'57"	Trail Creek near North Trail Mine
S7	42°49'00"	111°30'35"	Blackfoot River above reservoir[1]
S8	42°54'01"	111°29'37"	Little Blackfoot River above retention ponds
S9	42°53'49"	111°29'37"	Little Blackfoot River below retention ponds
S10	42°41'42"	111°32'30"	Formation Springs near Soda Springs
			Sediment-Retention Pond and Mine Pit Sampling Sites
P1	42°42'39"	111°29'03"	North Trail Mine lower retention pond
P2	42°44'47"	111°18'14"	Maybe Canyon Mine upper retention pond
P3	42°44'47"	111°18'25"	Maybe Canyon Mine lower retention pond
P4	42°50'50"	111°25'01"	Wooley Valley Unit 3 Mine upper retention pond
P5	42°51'06"	111°25'02"	Wooley Valley Unit 3 Mine lower retention pond
P6	42°51'44"	111°26'15"	Henry Mine pit
P7	42°53'49"	111°29'06"	Henry Mine upper retention pond
P8	42°53'49"	111°29'19"	Henry Mine lower retention pond

[1]U.S. Geological Survey gaging station No. 13063000

METHODS OF COLLECTION AND ANALYSIS

Water samples were collected for determination of suspended-sediment, uranium, and radium-226 concentrations by using the equal width increment method (formerly called the equal transit rate method) described by Guy and Norman (1970). Samples of sediment material from the streambed and sediment-retention ponds were collected in acid-rinsed plastic bottles for uranium and radium-226 analyses. Samples for dissolved radon-222 analysis were collected in glass radon bubblers under vacuum.

One-liter water samples for dissolved uranium and radium-226 determinations were filtered through a 0.45-micron membrane filter at the collection site. Concentrated hydrochloric acid (10 milliliters) was added to each 1-liter filtered sample to minimize loss of solutes by oxidation, precipitation, or adsorbtion onto the sample containers.

All samples were sent to the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo., for analysis. Concentrations of dissolved uranium and radium-226 were determined from the filtered water sample, and recoverable uranium and radium-226 were determined from the suspended-sediment and bottom-sediment material. The fluorimetric direct analytical method was used for determination of uranium and is inclusive for all uranium isotopes. The method's precision is approximately ±0.3 µg/L. The radon emanation analytical method was used for determination of radium-226 and radon-222. The method's precision is ±20 percent for concentrations less than 0.10 pCi/L and ±10 percent for concentrations greater than 0.10 pCi/L. Sediment material was digested on a steam bath in a 5-percent hydrochloric acid solution to extract all adsorbed uranium and radium-226 on the sediment particle. The filtered extract was then analyzed for uranium and radium-226. Detailed laboratory analytical methods are described by Skougstad and others (1979), and Thatcher, Janzer, and Edwards (1977). Suspended-sediment concentration was determined in accordance with methods described by Guy (1969). All water data and analytical results collected for this study are presented in tables 2 and 3.

SURFACE-WATER HYDROLOGY

Figure 1 is a streamflow hydrograph for gaging station 13063000, Blackfoot River above Blackfoot Reservoir near Henry, Idaho (site 7), water year 1979 (October 1, 1978,

Table 2. Results of radionuclide and onsite water-quality analyses for water and sediment samples collected from streams and a spring in the upper Blackfoot River basin

[-- = No data available; < = less than]

Stream site	Stream name and location	Date	Instantaneous discharge (ft^3/s)	Specific conductance (µmhos)	pH (units)	Temperature, air (°C)	Temperature, water (°C)	Radon-222, dissolved (pCi/L)	Radium-226, dissolved (pCi/L)	Radium-226, suspended recoverable (pCi/L)	Radium-226, recoverable from bottom material (pCi/g)	Uranium, dissolved (µg/L)	Uranium, suspended recoverable (µg/L)	Uranium, recoverable from bottom material (µg/g)	Sediment, suspended (mg/L)	Sediment discharge (ton/d)
S1	Diamond Creek	5-10-79	28	320	8.1	8.5	9.5	8	0.05	--	0.56	<0.5	--	0.71	88	6.6
	above Timothy	6- 6-79	40	340	8.4	--	15.0	--	.06	0.06	.40	.7	0.06	.72	78	8.4
	Creek	8- 9-79	15	356	8.4	19.0	11.0	<2	.04	<.03	.30	1.1	<.01	.98	29	1.2
		10- 3-79	11	360	8.4	4.0	3.0	<5	.15	.02	.46	.7	.01	.77	[1]<1	--
S2	Angus Creek	5- 9-79	8.5	244	8.1	3.0	8.0	37	.13	--	.48	1.1	--	1.0	125	2.9
	near Wooley	6- 7-79	2.2	343	8.1	7.0	6.5	--	.05	.25	.82	1.1	.60	1.1	47	.28
	Valley unit 3	8- 8-79	.39	352	7.7	19.0	20.0	34	.03	<.06	1.3	.7	.10	1.3	19	.02
	mine	10- 3-79	.38	244	8.1	3.0	8.0	44	.06	.05	1.2	.6	.09	1.1	40	.04
S3	Maybe Creek	5- 8-79	.69	285	8.2	3.5	3.0	120	.22	--	1.3	2.1	--	2.0	17	.03
	near South	6- 6-79	.42	426	8.0	13.0	5.5	--	.12	.15	1.3	2.8	.42	2.9	35	.04
	Maybe Canyon	8- 7-79	.12	485	7.7	19.5	8.0	97	.11	.05	1.7	3.5	.10	2.1	22	.01
	mine	10- 3-79	.09	533	8.2	3.5	3.0	8	.14	.22	1.1	3.7	.04	1.1	37	.01
S4	Dry Valley	5- 8-79	15	260	8.3	7.5	5.5	77	.08	--	.95	<.4	--	2.2	19	.77
	Creek near	6- 6-79	1.7	383	8.0	13.5	13.5	--	.06	<.04	1.0	.8	.03	1.9	60	.28
	mouth	8- 9-79	.54	415	8.3	25.5	22.0	3	.08	<.06	.74	.9	.04	.87	33	.05
		10- 3-79	.66	404	8.6	15.5	14.0	6	.06	.03	.98	.8	.04	1.6	48	.09
S5	Blackfoot River	5- 3-79	575	--	--	--	--	--	--	--	--	--	--	--	81	126
	at Allen Ranch	5- 8-79	415	--	--	--	--	--	--	--	--	--	--	--	55	62
		6- 6-79	192	--	--	--	--	--	--	--	--	--	--	--	74	38
		8- 9-79	60	--	--	--	--	--	--	--	--	--	--	--	11	1.8
		10- 3-79	47	--	--	--	--	--	--	--	--	--	--	--	37	4.7
S6	Trail Creek	[2]5- 8-79	3.9	354	8.3	4.0	10.0	15	.09	--	.37	.4	--	.42	11	.12
	near North	6- 5-79	5.9	366	8.7	--	22.0	--	.09	.03	.36	.6	.02	.36	42	.67
	Trail mine	8- 7-79	[1]2.7	365	8.5	24.0	20.0	--	.04	<.05	.45	<.7	.06	.86	17	.12
		10- 2-79	3.1	398	8.3	15.0	11.5	9	.03	--	.44	.6	--	.43	[1]<1	--
S7	Blackfoot River	5- 3-79	687	--	--	--	--	--	--	--	--	--	--	--	19	35
	above reservoir	5-10-79	495	282	8.3	5.0	6.5	20	.11	--	1.1	.5	--	5.4	32	43
		6- 5-79	191	346	8.4	--	16.0	--	.24	<.05	1.8	.7	.09	5.5	78	40
		8- 8-79	60	296	8.5	25.0	20.0	4	.06	.07	1.5	.9	.02	4.3	7	1.1
		10- 2-79	45	340	8.3	25.0	11.5	6	.08	<.04	1.4	.8	.01	3.2	26	3.2
S8	Little Black-	5- 9-79	29	477	8.2	3.0	6.0	--	.07	--	.03	.7	--	.37	19	1.5
	foot River	6- 5-79	4.4	787	8.6	24.0	15.0	--	.05	<.07	.58	1.4	<.01	1.7	36	.43
	above ponds															
S9	Little Black-	5- 9-79	27	473	8.4	5.0	7.0	17	.05	--	.97	.7	--	3.9	31	2.3
	foot River	6- 5-79	5.2	739	8.9	--	16.5	--	.04	<.04	.36	1.3	.04	1.1	13	.18
	below ponds	8- 8-79	3.6	1,030	8.4	20.5	7.0	7	.04	<.02	.59	1.6	<.01	1.9	12	.12
		10- 2-79	3.2	832	8.3	15.0	9.5	<4	.06	--	.62	1.5	--	1.8	--	--
S10	Formation	5-10-79	4.9	--	--	13.0	12.5	660	1.7	--	--	1.9	--	--	--	--
	Springs	6- 6-79	3.7	934	7.2	--	15.0	--	--	--	--	--	--	--	--	--
		8- 7-79	2.4	941	7.3	20.0	14.0	460	--	--	--	--	--	--	--	--
		10- 3-79	2.4	937	7.3	16.0	13.0	540	1.8	--	--	2.0	--	--	--	--

[1]Estimated value
[2]Samples collected approximately 3,000 feet downstream

Table 3. Results of radionuclide analyses of sediment samples collected from sediment-retention ponds and a mine pit

[-- = No data available]

Sediment-retention pond or mine pit site number	Site name	Date	Radium-226 recoverable from bottom material (pCi/g)	Uranium recoverable from bottom material (μg/g)
P1	North Trail mine lower pond	6- 7-79	0.02	0.66
		8- 7-79	.11	.15
P2	Maybe Canyon mine upper pond	5- 8-79	1.9	4.4
		6- 6-79	1.8	4.4
		8- 7-79	.56	1.0
		10- 3-79	1.3	4.9
P3	Maybe Canyon mine lower pond	5- 8-79	--	--
		6- 6-79	1.1	1.5
		8- 7-79	1.1	2.5
		10- 3-79	.02	.48
P4	Wooley Valley unit 3 mine upper pond	5- 9-79	1.6	9.9
		6- 7-79	2.5	6.0
		8- 8-79	.54	2.9
		10- 3-79	.63	6.3
P5	Wooley Valley unit 3 mine lower pond	5- 9-79	--	--
		6- 7-79	1.2	3.6
		8- 8-79	1.2	2.5
		10- 3-79	.13	.80
P6	Henry Mine pit	6- 5-79	3.5	17
P7	Henry Mine upper pond	5- 9-79	.48	1.3
		6- 5-79	.53	.25
		8- 8-79	3.9	6.7
		10- 2-79	.43	.81
P8	Henry Mine lower pond	5- 9-79	.63	1.8
		6- 5-79	.02	.46
		8- 8-79	.82	1.1
		10- 2-79	.58	1.0

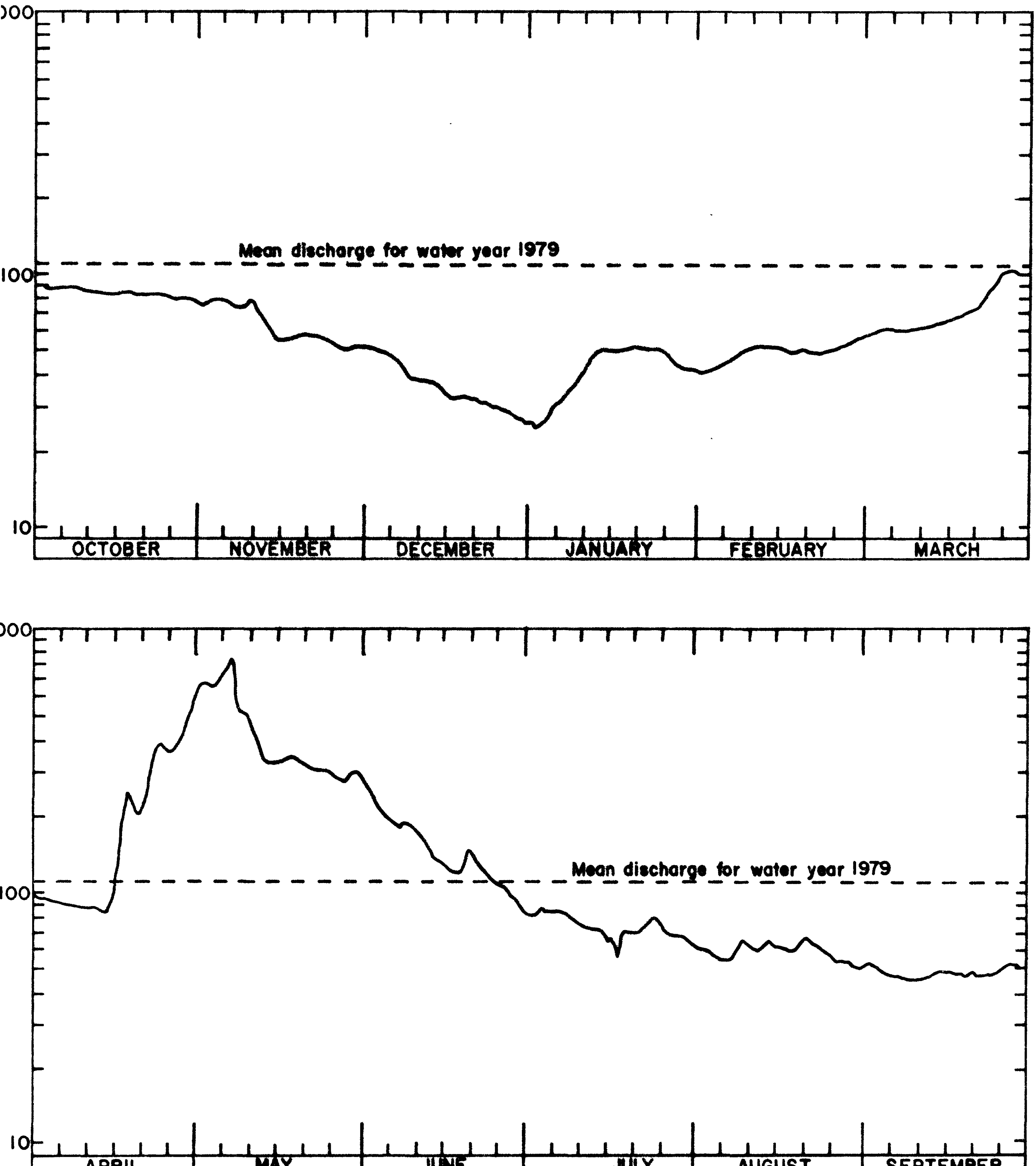

Figure 1.--Streamflow hydrograph, water year 1979, Blackfoot River above Blackfoot Reservoir near Henry, Idaho.

through September 30, 1979). The mean annual discharge from the upper Blackfoot River basin was 168 ft^3/s (U.S. Geological Survey, 1979) for 13 years of streamflow record (1915, 1968-79) collected at this gaging station. Peak flow for this same period was 2,150 ft^3/s, which occurred on April 26, 1974. Peak flow for water year 1979 was 937 ft^3/s, which occurred on May 7, 1979. The mean discharge for water year 1979 was 110 ft^3/s.

Figure 2 shows flow duration for the 13-year period of streamflow record. The flow-duration curve is a cumulative frequency curve that shows the percentage of time that specified discharges were equaled or exceeded. The curve applies only to the period for which data were used to develop the curve and represents an average for the period considered, rather than the distribution of flow within a single year.

RADIONUCLIDE WATER-QUALITY STANDARDS

Current radionuclide water-quality standards, established by the Idaho Department of Environmental and Community Services (1973a and 1973b), as amended by the U.S. Environmental Protection Agency (1976) standards, are summarized in table 4 for uranium, radium-226, and radon-222.

The Idaho water-quality standards express a dual limiting radium concentration, depending upon the intended use of the receiving water. The 5 pCi/L radium standard applies for water used for domestic purposes. The 10 pCi/L radium standard applies for effluent discharged into any receiving water.

RADIONUCLIDE CONCENTRATIONS

Principal rocks in the overburden overlying the Permian Phosphoria Formation are carbonate and mudstone. Average uranium concentrations in these rocks are 20 and 30 ppm, respectively, compared to an average continental crust concentration of 2.7 ppm (U.S. Department of the Interior and U.S. Department of Agriculture, 1977). When the overburden is removed and placed in large waste piles, uranium ions, under certain geochemical conditions, may be available to more rapidly enter the environment through transport in the dissolved or suspended state due to water erosion and subsequent deposition into streams. In the radioactive

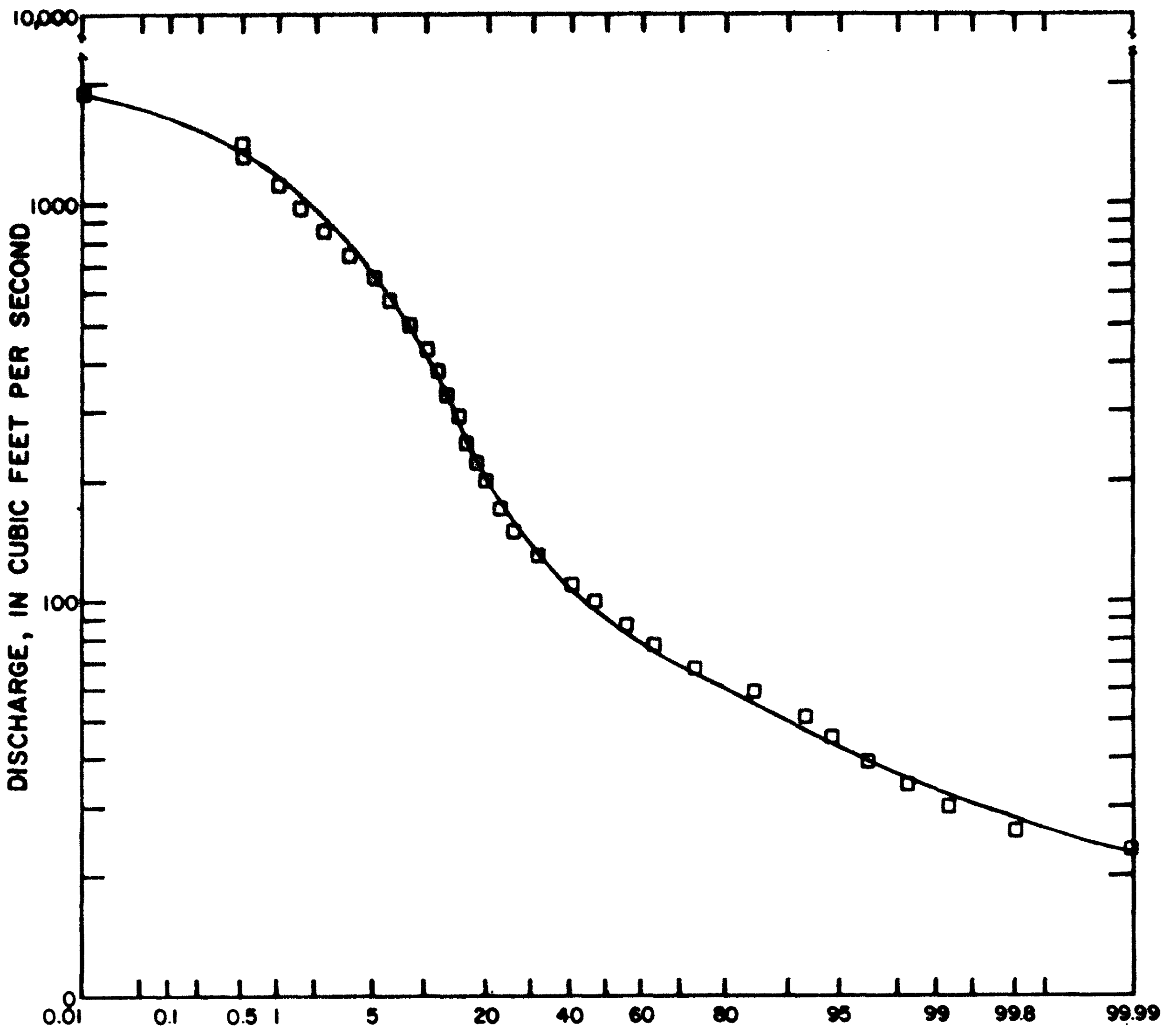

Figure 2.--Flow-duration curve for gaging station at Blackfoot River above Reservoir near Henry, Idaho.

Table 4. Radionuclide water-quality standards and concentrations in the upper Blackfoot River basin

Concentrations reported in picocuries per liter;
[-- = no data available; < = less than]

Radionuclide (dissolved)	Maximum permissible concentration			Range of concentrations in the upper Blackfoot River basin
	Idaho water quality standards[1]	Idaho radiation control regulations[2]	U.S. EPA national interim primary drinking water regulations[3]	
Uranium (natural)[4]	6,667	20,000	--	<0.27 - 2.52
Radium-226	[5]5/10	30	5	.03 - 1.8
Gross alpha radioactivity[6]	15	--	15	--
Radon-222 (in air)[7]	--	3	--	--

[1]Idaho Department of Environmental and Community Services (1973a). Standards apply to surface and ground waters within the State.
[2]Idaho Department of Environmental and Community Services (1973b). Standards apply to unrestricted receiving waters.
[3]U.S. Environmental Protection Agency (1976).
[4]Uranium conversion factor: pCi/L x 1.471 = μg/L (Thatcher, Janzer, and Edwards, 1977).
[5]The 5 pCi/L standard applies for water used for domestic purposes; the 10 pCi/L standard applies to effluent discharged into any receiving water. Concentrations are for combined radium-226 and radium-228.
[6]Includes radium-226 but excludes radon and uranium.
[7]Maximum permissible concentration per liter of air from unrestricted sources.

decay scheme of naturally occurring uranium (uranium-238 comprises 99.3 percent of natural uranium), the uranium disintegration products of most environmental concern are radium-226 and radon-222 gas.

Uranium

The geochemical mechanism for mobilization and immobilization of uranium is primarily dependent on the solution oxidation-reduction conditions and pH of water (Ames and Rai, 1978). The pH of streams in the Blackfoot River basin ranged from 7.2 to 8.9 (table 2). Studies of water from waste piles in the study area show that pH ranges from near neutral to about 8.3 (Ralston and others, 1980). Within the observed pH range of water in the Blackfoot River basin, uranium ions would not be readily leachable. The dissolved uranium ions that are present probably are negatively charged phosphate and carbonate complexes and, hence, may not be associated with the cation exchange of sediment. A more detailed discussion of uranium ions, complexes, and solubilities is given by Langmuir (1978).

Dissolved uranium concentrations in the upper Blackfoot River basin ranged from about 0.4 to 3.7 μg/L (table 2). The highest concentrations occurred at site 3 on Maybe Creek, which flows directly from an active mining site. The next highest concentrations occurred, respectively, at site 10 (Formation Springs) and at sites 9 and 8 on the Little Blackfoot River. The relatively high concentrations in the Little Blackfoot River may be caused by mineralized groundwater inflow into this river reach (Ralston and others, 1980). In the main-stem drainage, dissolved uranium concentrations in two streams (sites 2 and 3) immediately below active mining sites averaged 2.0 μg/L. Concentrations in streams not near active mining sites (sites 1, 4, 6, and 7) averaged about 0.6 μg/L. In the Little Blackfoot River, such a relation was not found; concentrations at site 8, above an active mining area, were as great as at site 9, just below the active mining area. Samples were not collected at site 8 during August or October, so no comparison could be made for these dates. Concentrations at the two sites were virtually identical in May and June.

Dissolved uranium concentrations in the upper Blackfoot River basin were generally in agreement with the 0.1 to 1 μg/L background range in water of the United States (Livingstone, 1963) and are considerably lower than the uranium concentration in the overburden (less than one-tenth of one percent). Fix (1956) indicated that surface water contains 1 to 10 μg/L of uranium in uranium-rich areas of the United States. All observed concentrations of dissolved uranium in in the upper Blackfoot River basin were within the limits of existing water-quality standards (table 4).

Uranium adsorbed on bottom material occurred in higher concentrations than dissolved uranium, particularly at the mine site sediment-retention ponds and at site 7 on the Blackfoot River. Uranium concentrations averaged 1.8 μg/g (ppm) in stream-bottom material and 2.7 μg/g in sediment-retention pond material. These concentrations are considerably less than the 20-30 ppm uranium contained in the overburden and are close to uranium's crustal abundance of 2.7 ppm (Parker, 1967). Generally, uranium minerals are extremely insoluble within the pH range of water in the river basin (Langmuir, 1978). Under the pH conditions in the river basin, and particularly in the overburden waste piles (Ralston and others, 1980), the leaching of uranium from the mineral phase appears to be very slow and yields only trace concentrations of the ion.

Radium-226

Radium-226 is a disintegration product of uranium and has a (2+) oxidation state. Chemistry of radium-226 resembles that of barium, and radium compounds, except radium sulfate, are highly water soluble (Landa, 1980). Radium interaction in natural water is related to the cation exchange capacity of sediment, and radium will probably substitute for other divalent cations on the sediment particles (Ames and Rai, 1978). Thus, radium is not expected to exist in high concentrations in the dissolved state, except in highly acidic waters.

Concentrations of dissolved radium-226 in samples from streams in the upper Blackfoot River basin ranged from 0.03 to 0.24 pCi/L (table 2). Concentrations in water from Formation Springs (site 10) averaged about 1.8 pCi/L. In the main stem, dissolved radium-226 in two streams (sites 2 and 3) immediately below active mining sites averaged 0.11 pCi/L; concentrations in streams not near active mining sites (sites 1, 4, 6, and 7) averaged 0.08 pCi/L.

Higher concentrations (up to 3.9 pCi/g) were observed in bottom material from sediment-retention ponds than in bottom material from streams. The maximum observed suspended-radium concentration was 0.25 pCi/L. All concentrations of radium-226 were within the permissible limits of the most stringent existing water-quality standards (table 4).

Radon

Radon-222, a radioactive noble gas, is a disintegration product of radium-226. The solubility of dissolved radon-222 in surface and ground water depends largely upon temperature-pressure relations. Dissolved concentrations are higher in ground water than in surface water. Concentrations of radon-222 in surface water are site specific and change immediately upstream or downstream from the sampling point.

Radon concentrations in surface water in the upper Blackfoot River basin ranged from less than 2 to 120 pCi/L (table 2). Sites 2 and 3, where the stream discharge is mostly from springs, showed high concentrations of radon. Samples collected at Formation Springs (site 10) had the highest concentrations of radon; yet, they were within the lower concentration range observed by J. K. Felmlee, U.S. Geological Survey, Denver, Colo. (written commun., 1980) for radon in ground-water samples collected throughout the western United States.

The radon standard listed in table 4 is expressed as radon concentration per liter of air and is not related to dissolved radon in water. There are no existing standards or criteria for radon in water.

SUSPENDED-SEDIMENT CONCENTRATIONS

Instantaneous suspended-sediment concentration and discharge from the upper Blackfoot River basin are given in table 2. The suspended-sediment discharge is computed from the following relation:

$$Qs = Qw \times Cs \times 0.0027$$

where,

Qs = sediment discharge, in tons per day,
Qw = water discharge, in cubic feet per second, and
Cs = concentration of suspended sediment, in milligrams per liter.

Suspended-sediment samples collected during May 1979 are representative of spring-snowmelt runoff for the 1979 water year. The instantaneous sediment discharges computed for Blackfoot River at Allen Ranch (site 5) and Blackfoot River above Blackfoot Reservoir (site 7) on May 3, 1979, were 126 and 35 ton/d, respectively. The sediment and water discharge at site 5 represent the tributary contribution of Diamond, Angus, Maybe, Dry Valley, and Lanes Creeks. Sediment discharge at site 7 is representative of suspended-sediment and water discharge from the entire Blackfoot River basin above the site. The difference in sediment discharge calculated for sites 5 and 7 indicates that the stream reach was aggrading. Whether this aggradation is an annually cyclic event or a long-term trend cannot be determined from the data.

SUGGESTIONS FOR FUTURE STUDIES

The radionuclide and other water-quality data collected in the upper Blackfoot River basin indicate that radionuclides exist only in trace or background concentrations. Water and sediment samples collected immediately below active phosphate-mining sites did not show significant increases in radionuclide concentrations. Further need of radionuclide monitoring appears to be minimal.

As mentioned in the final environmental impact statement by the U.S. Department of the Interior and U.S. Department of Agriculture (1977), the greatest potential impact of increased mining activity in the river basin appears to be increased erosion, which could result in increased sediment discharge to streams. Available data to determine the present sediment discharge from disturbed and undisturbed areas in the basin are inadequate. If the sediment discharge under present land-use conditions can be defined, the impact of increased mining activity may then be compared to future changes in sediment discharge.

SUMMARY

In the upper Blackfoot River basin, maximum measured uranium concentrations were 3.7 µg/L in water, and 5.5 and 9.9 µg/g in bottom material from streams and sediment-retention ponds, respectively, and 17 µg/g in a mine pit. Maximum measured radium-226 concentrations were 1.8 pCi/L in water and 1.8 and 3.9 pCi/g in bottom material from streams and sediment-retention ponds, respectively. Maximum measured radon-222 concentrations were 120 pCi/L in surface water and averaged 550 pCi/L at Formation Springs (site 10). Dissolved radionuclide concentrations in two main-stem streams immediately below active mining sites averaged 0.11 pCi/L radium-226 and 2.0 µg/L uranium. In streams not near active mining sites, dissolved radionuclides averaged about 0.08 pCi/L radium-226 and about 0.6 μg/L uranium. All radionuclide concentrations were within the limits of State and Federal water-quality standards.

Because radionuclides were observed only in trace concentrations, the need for further radionuclide monitoring seems to be minimal. Presently, few suspended-sediment data for the basin are available to assess the impact that increased mining activity may have on sediment discharge.

REFERENCES

Ames, L. L., and Rai, Dahnpat, 1978, Radionuclide interactions with soil and rock media: Las Vegas, Nev., U.S. Environmental Protection Agency, EPA 520/6-78-007A, v. 1, 306 p.

Fix, P. F., 1956, Hydrogeochemical exploration for uranium in Page, L. R., and others, compilers, Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on peaceful uses of atomic energy, Geneva, Switzerland, 1955: U.S. Geological Survey Professional Paper 300, p. 667-671.

Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water Resources Investigations, Book 5, Chapter C1, 58 p.

Guy, H. P., and Norman, V. W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water Resources Investigations, Book 3, Chapter C2, 59 p.

Idaho Department of Environmental and Community Services, 1973a, Water quality standards and wastewater treatment requirements: Boise, Idaho, 19 p.

_____1973b, Idaho radiation control regulations: Boise, Idaho, 98 p.

Landa, Edward, 1980, Isolation of uranium mill tailings and their component radionuclides from the biosphere--some earth science perspectives: U.S. Geological Survey Circular 814, 32 p.

Langmuir, Donald, 1978, Uranium solution-mineral equilibria at low temperatures with applications to sedimentary ore deposits: Geochimica et Cosmochimica Acta, v. 42, p. 547-569.

Livingstone, D. A., 1963, Chemical composition of rivers and lakes in Data of geochemistry, 6th ed.: U.S. Geological Survey Professional Paper 440-G, 64 p.

Parker, R. L., 1967, Composition of the earth's crust in Data of geochemistry, 6th ed.: U.S. Geological Survey Professional Paper 440-D, 19 p.

Ralston, D. R., and others, 1980, Interactions of mining and water resource systems in the southeastern Idaho phosphate field: Moscow, Idaho, Idaho Water Resources Research Institute, 214 p.

Skougstad, M. W., and others, 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter Al, 626 p.

Thatcher, L. L., Janzer, V. K., and Edwards, K. W., 1977, Methods for determination of radioactive substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A5, 95 p.

U.S. Department of the Interior and U.S. Department of Agriculture, 1977, Development of phosphate resources in southeastern Idaho, final environmental impact statement: Washington, U.S. Government Printing Office, v. 1.

U.S. Environmental Protection Agency, 1976, National interim primary drinking water regulations: Washington, U.S. Government Printing Office, 159 p.

U.S. Geological Survey, 1979, Water resources data for Idaho: U.S. Geological Survey Water Data Report ID-78-1, v. 1, 457 p.