TRITIUM CONCENTRATIONS IN FLOW FROM SELECTED SPRINGS THAT DISCHARGE TO THE SNAKE RIVER, TWIN FALLS-HAGERMAN AREA, IDAHO

By

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CONVERSION FACTORS

For readers who prefer to use International System (SI) units rather than units used in this report, the following conversion factors may be used:

Multiply	By	To obtain
foot (ft)	0.3048	meter
acre	0.4047	hectare
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
picocurie per milliliter (pCi/mL)	0.037	becquerel per milliliter
curie (Ci)	3.70×10^{10}	becquerel
millirem	0.01	millisievert

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ABSTRACT

Concern has been expressed that some of the approximately 30,900 curies of tritium disposed to the Snake River Plain aquifer from 1952 to 1988 at the INEL (Idaho National Engineering Laboratory) has migrated to springs that discharge to the Snake River in the Twin Falls-Hagerman area. To document tritium concentrations in springflow, 17 springs were sampled in November 1988 and 19 springs were sampled in March 1989. Analyses showed that the tritium concentrations were less than the minimum detectable concentration of about 0.5 pCi/mL (picocuries per milliliter) in November 1988 and less than the minimum detectable concentration of about 0.2 pCi/mL in March 1989; the minimum detectable concentration was smaller in March 1989 owing to a longer counting time in the liquid scintillation system. For comparison, the maximum contaminant level of tritium in drinking water as established by the U.S. Environmental Protection Agency is 20 pCi/mL.

Samples analyzed by the U.S. Environmental Protection Agency indicate there has been a subtle decrease in tritium concentrations in the Snake River near Buhl since the 1970's owing to the radioactive decay of tritium that was produced by atmospheric testing of nuclear weapons in the 1950's and 1960's. In 1974-79, the concentrations were less than 0.3±0.2 pCi/mL in 3 of 20 samples, whereas, in 1983-88, 17 of 23 samples contained less than 0.3±0.2 pCi/mL of tritium; the minimum detectable concentration is 0.2 pCi/mL. On the basis of these findings, aqueous waste disposal of tritium at the INEL has had no measurable effect on tritium concentrations in the springflow discharging from the Snake River Plain aquifer and in the Snake River near Buhl. This conclusion is supported by the distribution of tritium in the Snake River Plain aquifer as delineated by Pittman and others

(1988, Hydrologic conditions at the Idaho National Engineering Laboratory, 1982 to 1985: U.S. Geological Survey Water-Resources Investigations Report 89-4008, 73 p.).

INTRODUCTION

In 1988, ground-water discharge along the north side of the Snake River between Milner and King Hill (fig. 1) was about 4.3 million acre-ft (L.C. Kjelstrom, U.S. Geological Survey, oral commun., 1989). Part of the ground water is discharged to springs near the channel of the Snake River and part is discharged directly to the river channel. The flow of the springs is an important source of water for irrigated agriculture, commercial fisheries, hydroelectric-power generation, recreation, and fish and wildlife. The springflow is ground-water outflow from the Snake River Plain aquifer that underlies the eastern part of the Snake River Plain, an area of about 10,800 mi^2 in southeastern Idaho (fig. 1).

Because of the importance of the springflow to local and downstream users, there is concern that tritium and other waste constituents generated and disposed of at the INEL (Idaho National Engineering Laboratory) have migrated or may migrate from the INEL to the Snake River. Tritium is a naturally occurring radioisotope of hydrogen and has a half-life of 12.26 years. It is naturally produced by reaction of cosmic ray neutrons with nitrogen in the upper atmosphere. Tritium is also a radioactive waste product from nuclear power plants and from fuel-processing and weapons-production activities. Tritium is the most mobile constituent in wastewater at the INEL, and since disposal began in 1952, has migrated about 9 mi south of the points of disposal (Pittman and others, 1988). From 1952 to 1988, about 30,900 Ci of tritium were contained in wastewater disposed to deep wells and infiltration ponds at the INEL.

To determine whether the disposal of tritium in wastewater at the INEL has had a measurable effect on tritium concentrations in springflow discharged from the Snake River Plain aquifer to the Snake River, water samples from 19 springs were collected and analyzed for tritium. In

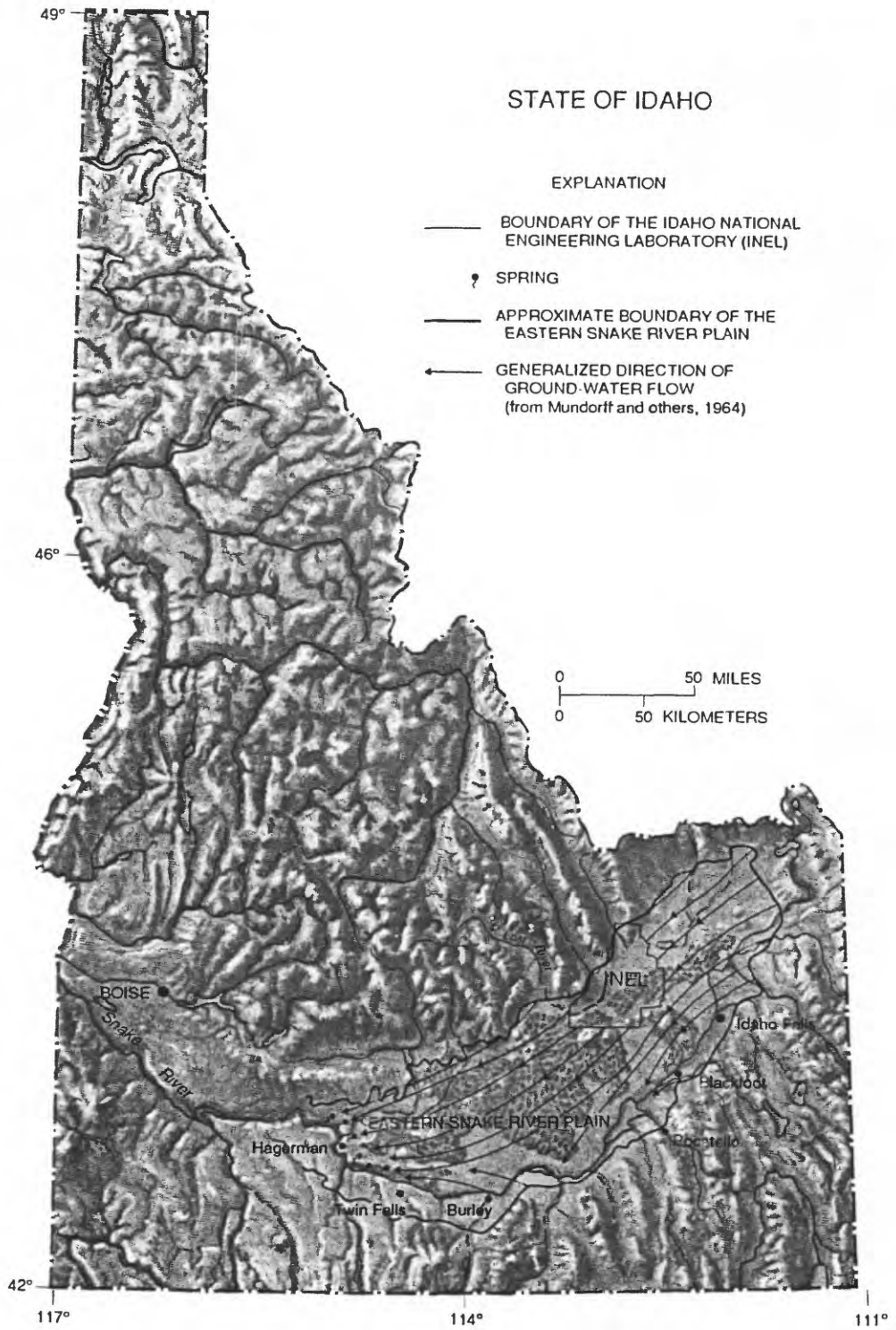

Figure 1.--Locations of eastern Snake River Plain, Twin Falls-Hagerman area and the INEL, and generalized direction of ground-water flow in the Snake River Plain aquifer.

November 1988, water from 17 of the springs accounted for about 77 percent of the ground-water discharge along the north side of the Snake River between Milner and King Hill (G.F. Lindholm, U.S. Geological Survey, written commun., January 1989). The predominant spring discharge area is the reach of the river in the Twin Falls-Hagerman area (fig. 1). The sampling program was conducted in the Twin Falls-Hagerman area by the U.S. Geological Survey in cooperation with the U.S. Department of Energy's Idaho Operations Office. This report presents the results of the sampling program; data collected and compiled as part of this study are included in tables 2 and 3 at the end of this report.

Geohydrologic Setting and Waste-Water Disposal at the INEL

The eastern Snake River Plain is a northeast-trending structural basin about 200 mi long and 50 to 70 mi wide. The plain is underlain by a layered sequence of basaltic lava flows and cinder beds intercalated with alluvium and lakebed sedimentary deposits. Individual lava flows generally range from 10 to 50 ft in thickness, although the average thickness may be from 20 to 25 ft (Mundorff and others, 1964, p. 143). The sedimentary deposits consist mainly of lenticular beds of sand, silt, and clay with lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are exposed at the land surface or occur at depth. The basaltic lava flows and intercalated sedimentary deposits combine to form the Snake River Plain aquifer, which is the main source of ground water on the plain.

The Snake River Plain aquifer is recharged by the infiltration of precipitation and irrigation water, and by underflow from tributary valleys on the perimeter of the plain. Water recharged to the aquifer generally moves to the southwest along the axis of the plain and is discharged to springs along the Snake River.

In 1980, about 1.33 million acres of land were irrigated on the eastern Snake River Plain (Garabedian, 1986, p. 7). About 8.3 million acre-ft of water were diverted from the Snake River and its tributaries for irrigation. From 1902 to 1980, springflow discharge to the Snake River increased from

about 3.1 million acre-ft/year to about 4.3 million acre-ft/year as a result of increased recharge to the Snake River Plain aquifer from the infiltration of irrigation water.

The INEL includes about 890 mi^2 of the northeastern part of the eastern Snake River Plain. The general direction of ground-water movement in the Snake River Plain aquifer is southwestward from the INEL to the springs in the Twin Falls-Hagerman area (fig. 1). The INEL is about 100 mi northeast of Twin Falls and about 110 mi northeast of Hagerman.

Aqueous chemical and radioactive wastes generated at the INEL were discharged to ponds and wells from 1952 to 1983. Since 1983, most of the aqueous wastes have been discharged to unlined infiltration ponds. Many of the constituents contained in the wastewater enter the aquifer indirectly following percolation through the unsaturated zone; prior to 1984, much of the waste was injected directly into the aquifer through a deep disposal well at the Idaho Chemical Processing Plant.

The chemical and radioactive wastes have migrated from less than 1 to about 9 mi southwest of the disposal areas at the INEL (Pittman and others, 1988). Tritium, which is the most mobile constituent in wastewater entering the aquifer, was detected periodically at concentrations of 3.4±0.2 pCi/mL or less in water from two wells along the southern boundary of the INEL in 1983-86. Since April 1986, tritium concentrations in water from wells along the southern boundary have been less than the minimum detectable concentration of 0.5 pCi/mL.

Acknowledgments

The author gratefully acknowledges the employees of the U.S. Geological Survey and the U.S. Department of Energy's Radiological and Environmental Sciences Laboratory who aided in the collection and analysis of the water samples described in this report. R.L. Backsen, T.S. Brennan, M.D. Campbell, L.C. Davis, K.L. Hein, and S.J. Wegner of the U.S. Geological Survey collected the water samples and made field measurements of pH,

specific conductance, temperature, and dissolved oxygen, and measurements of the springflow. R.B. Randolph of the Radiological and Environmental Sciences Laboratory analyzed the water samples for tritium.

Tritium analyses for samples from the Snake River near Buhl for 1974-88 were provided by J.A. Broadway of the U.S. Environmental Protection Agency's Office of Radiation Programs in Montgomery, Alabama. The samples were collected by personnel with the Idaho Department of Health and Welfare and sent to the U.S. Environmental Protection Agency for analysis.

METHODS AND QUALITY ASSURANCE

The methodology used to collect water samples for tritium analyses generally followed guidelines established by the U.S. Geological Survey (Wood, 1976; Thatcher and others, 1977; and Skougstad and others, 1979). Slight modifications have been incorporated into the sampling procedures for tritium resulting from recommendations of the Radiological and Environmental Sciences Laboratory. Sampling methods used in the field and quality assurance practices are outlined in the following sections.

Sample Collection

Water samples for tritium analyses were collected in 500-mL (milliliter) polyethylene bottles and were not treated prior or subsequent to being bottled in the field. Water from the springs was collected as close as reasonably possible to the spring orifices. Some springs had multiple orifices or the springflow was diverted for use by fish hatcheries. Where possible, the samples were collected upstream from diversions. A 500-mL polyethylene bottle was lowered by hand in the area of the orifice or in the channel downstream from the orifice(s); where flow was channeled, care was taken to sample moving water instead of water in eddies and ponded areas. The bottle was rinsed at least three times with springwater prior to sample collection. The bottle was capped immediately, and the exterior dried; laboratory film was placed around the cap and a label, which included

identification information for the sample, was attached to the bottle. Duplicate samples were collected at each site so that a second sample was available in the event that the first sample was destroyed inadvertently during transport or storage. The samples were placed in a secured vehicle or in the U.S. Geological Survey Project Office at the INEL until they were hand delivered to the analyzing laboratory on November 14, 1988 and March 24, 1989, 2 to 7 days after collection.

Physical conditions at the springs during sample collection were recorded in a field logbook and a chain-of-custody record was used to track samples from the time of collection until delivery to the analyzing laboratory. These records are available for inspection at the U.S. Geological Survey Project Office at the INEL.

Analytical Methods

Springflow samples were analyzed for tritium by the Radiological and Environmental Sciences Laboratory by means of the direct liquid scintillation counting method described by Bodnar and Percival (1982). This method is applicable for the determination of tritium introduced artificially into water by nuclear power and waste-disposal facilities, but is not sufficiently sensitive to determine small natural tritium concentrations.

The direct liquid scintillation counting method uses the conversion of energy emitted by a radioactive nucleus to light energy in a scintillating chemical. Tritium scintillations are beta-particle emissions that are detected by a photo-multiplier tube and amplified through a multichannel analyzer. The water samples are dispersed in a standard volume of organic solvent containing the scintillating chemical. The scintillating chemical is a proprietary mixture of organic solvent and a strong liquid detergent.

Seventy milliliters of each water sample were counted for gross gamma radioactivity prior to addition of the scintillator to determine potential interferences from other radionuclides. Those samples having greater than

100 counts per minute above background were distilled before addition of the scintillating chemical.

For each set of analyses performed in the laboratory, a reagent blank and internal standard were prepared in addition to the target samples. The reagent blank was prepared by pipetting 10 mL of water with no measurable tritium concentration. Reagent-blank water was distilled to remove dissolved salts and particles and placed in a 22-mL counting vial with 10 mL of the scintillating chemical. The internal standard was prepared by pipetting 9 mL of the reagent blank and 1 mL of standard tritiated water into a counting vial with 10 mL of the scintillating chemical. Each target sample was prepared by pipetting 10 mL of water into a counting vial with 10 mL of the scintillating chemical. All counting vials were capped securely and shaken until the water sample and scintillating chemical formed a gel. The reagent blank, standard, and samples were placed in the automatic counter of a commercially available liquid scintillation system. Scintillations of the reagent blank, standard, and samples collected in November 1988 were counted for 20 minutes. Counting time for the March 1989 samples, however, was 100 minutes. A tritium counting efficiency curve was obtained and tritium concentrations for each sample were calculated.

Field Quality Assurance

Quality assurance procedures instituted for the sampling program consisted of four blind replicates--duplicate samples with different sample identification numbers sent to the same laboratory. One of the two equal volumes from each replicate was retained by the U.S. Geological Survey as a backup sample in the event additional samples were needed. The analyses of the replicate samples are included on table 2 at the end of this report.

Reporting of Data

For each tritium concentration, an associated analytical uncertainty, **s**, is calculated such that there is a 67 percent probability that the true

tritium concentration in a sample is in the range of the reported concentration plus or minus the analytical uncertainty; analytical uncertainties for analysis by the U.S. Environmental Protection Agency and those reported by Hawkins and Schmalz (1965) are given as 2**s** (see section entitled "Tritium in flow from selected springs and the Snake River"). For example, given an analytical result of 1.0±0.2 pCi/mL, there is a 67 percent probability that the true concentration is in the range of 0.8 to 1.2 pCi/mL; at 2**s** or 1.0±0.4 pCi/mL, there is a 95 percent probability that the true concentration is in the range of 0.6 to 1.4 pCi/mL. The following guidelines for interpreting analytical results are based on an extension of the method described by Currie (1968).

In the analysis for tritium, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and the blank vary randomly. Therefore, it is essential to distinguish between two key aspects of the problem of detection: (1) The instrument signal for the sample must be greater than the signal observed for the blank to make the decision that tritium was detected; and (2) an estimation must be made of the minimum concentration that will yield a sufficiently large observed signal to make the correct decision for detection or nondetection of tritium most of the time. The first aspect of the problem is a qualitative decision based on an observed signal and a definite criterion for detection. The second aspect of the problem is an intuitive estimation of the detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level to make the qualitative decision whether tritium was detected. Tritium concentrations that equal 1.6**s** meet this criterion; at 1.6**s**, there is a 95 percent probability that the correct decision--not detected--will be made. Given a large number of samples, up to 5 percent of the samples with measured concentrations greater than or equal to 1.6**s**, which were concluded as being detected, might not contain tritium. These measurements are referred to as false positives and are errors of the first kind in hypothesis testing.

Once the critical level of 1.6σ has been defined, the minimum detectable concentration may be established. Tritium concentrations that equal 3σ represent a measurement at the minimum detectable concentration. For true concentrations of 3σ or greater, there is a 95 percent or more probability of correctly concluding that tritium was detected in a sample. Given a large number of samples, up to 5 percent of the samples with true concentrations greater than or equal to 3σ, which were concluded as being non-detected, could contain tritium at the minimum detectable concentration. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing.

True tritium concentrations between 1.6σ and 3σ have larger errors of the second kind. That is, there is a greater than 5 percent probability of false negative results for samples with true concentrations between 1.6σ and 3σ and, although tritium might have been detected, such detection may not be considered reliable; at 1.6σ, the probability of a false negative is about 50 percent.

These guidelines are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values, 1.6σ and 3σ, vary slightly with background or blank counts, and with the number of gross counts for individual analyses. The use of the critical level and minimum detectable concentration aid the reader in the interpretation of analytical results and do not represent absolute concentrations of radioactivity which may or may not have been detected.

TRITIUM IN FLOW FROM SELECTED SPRINGS AND IN THE SNAKE RIVER

Tritium is a naturally occurring isotope of hydrogen with a 12.26 year half-life. Tritium is produced by reaction of cosmic ray neutrons with nitrogen in the upper atmosphere. It is also a radioactive waste product from nuclear power plants, fuel processing, and weapons production activities. Prior to atmospheric weapons tests, the average background tritium concentration in environmental waters due to natural tritium production by cosmic rays was less than 0.016 pCi/mL (National Council on

Radiation Protection and Measurements, 1979). Atmospheric weapons tests in the 1950's and 1960's markedly increased background tritium concentrations in surface waters. The average concentration in surface water of the United States was about 3.5 pCi/mL in 1963, but by the mid 1970's the tritium concentration averaged about 0.15 pCi/mL.

Selected springs that discharge water from the Snake River Plain aquifer in the Twin Falls-Hagerman area were sampled for tritium (for locations and names of springs see figure 2 and table 1). Water samples were collected in November 1988, when 17 springs were sampled subsequent to the 1988 irrigation season; and in March 1989, when 19 springs were sampled prior to the 1989 irrigation season. The combined flow of 16 of the springs sampled in November 1988 was about 77 percent of the ground-water discharge to the Snake River from springs along the north side of the river between Milner and King Hill; the discharge of Blue Heart Spring could not be measured. Because flow from the springs represents at least 77 percent of the water discharged from the aquifer, radiochemical analyses of the spring-flow provide documentation of the tritium concentrations in water from the aquifer in a large part of the Twin Falls-Hagerman area. The discharge of each spring or group of springs, selected chemical and physical characteristics of the springflow, and tritium concentrations in the springflow are given in table 2.

Without exception, tritium concentrations in samples collected in November 1988 and March 1989 were less than the minimum detectable concentrations. In November 1988, tritium concentrations in flow from 17 selected springs were equal to or less than 0.16±0.16 pCi/mL. In March 1989, tritium concentrations in 19 springs, including those sampled in November 1988 and 2 other springs, were equal to or less than 0.13±0.07 pCi/mL. The analytical uncertainty for the November 1988 samples was ±0.15 or ±0.16 pCi/mL. The minimum detectable concentration is three times the analytical uncertainty or about 0.5 pCi/mL (see section entitled "Reporting of Data" and table 2). The analytical uncertainty for the March 1989 samples was about ±0.07 and, because of a longer counting time, the minimum detectable concentration was about 0.2 pCi/mL. For purposes of comparison, the maximum contaminant level, based on the average annual tritium concentration assumed to produce

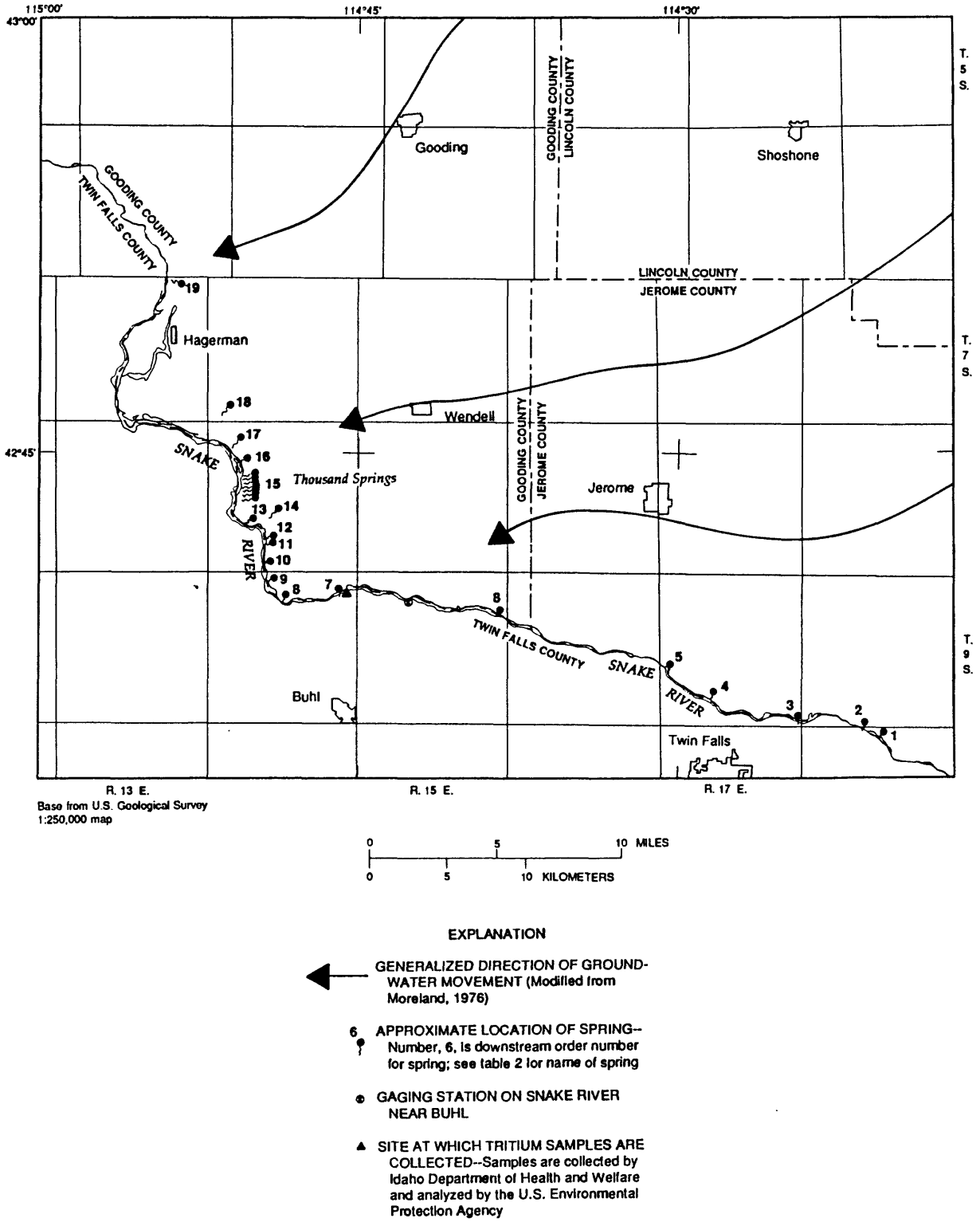

Figure 2.--Locations of springs at which water samples were collected for tritium analyses.

Table 1--Springs at which water samples were collected for tritium analyses
[Springs are numbered in downstream order; see figure 2 for locations]

	Name of spring(s)		
1	Devils Washbowl	10	Spring (unnamed)
2	Devils Corral (upper)	11	Blind Canyon
3	Spring (unnamed)	12	Box Canyon
4	Blue Lakes	13	Blue Heart
5	Warm Creek	14	Sand
6	Crystal	15	Thousand
7	Clear Lakes	16	Bickel
8	Briggs Creek	17	Riley Creek
9	Banbury	18	Billingsley Creek
		19	Birch Creek

a total body dose of 4 millirem/year, is 20 pCi/mL (U.S. Environmental Protection Agency, 1983, p. 236).

Some of the springs sampled in 1988-89 also had been sampled for tritium in 1956 and 1980. In 1956, the tritium concentrations in flow from Blue Lakes, Clear Lakes, Crystal, Sand, and Thousand Springs were 0.065, 0.10, 0.087, 0.078, and 0.22 pCi/mL, respectively (Hawkins and Schmalz, 1965, p. 18). An uncertainty was not reported for each analysis, but for these 5 analyses plus 27 other analyses of surface water in Idaho the uncertainty averaged ±0.08 pCi/mL at the 2**s** level. In 1980, the tritium concentration in Blue Lakes Springs was 0.0±0.4 pCi/mL at the 2**s** level. Except for Thousand Springs, the tritium concentrations were less than the minimum detectable concentration. If the average analytical uncertainty of ±0.08 pCi/mL at the 2**s** confidence level is applicable, the 1956 tritium concentration of 0.22 pCi/mL in water from Thousand Springs exceeded the minimum detectable concentration of 0.12 pCi/mL.

The fact that tritium concentrations in springflow were less than about 0.2±0.2 pCi/mL in March 1989 is supported by tritium analyses for the Snake River near Buhl (see figure 2 for location). Since 1974, tritium samples from the Snake River have been collected by the Idaho Department of Health

and Welfare and analyzed by the U.S. Environmental Protection Agency; the tritium concentrations are shown on table 3.

From 1974 to 1988, tritium concentrations in the Snake River near Buhl ranged from 0.1±0.2 to 0.9±0.2 pCi/mL and averaged 0.3±0.2 pCi/mL (table 3). A subtle, yet distinguishable, qualitative trend in tritium concentrations is recognized by comparing concentrations for three periods; a quantitative estimate of the amount of decrease cannot be made because of the small concentration of tritium when compared with the minimum detectable concentration of 0.2 pCi/mL (U.S. Environmental Protection Agency, 1988, p. xi). From 1974 to 1979, the tritium concentrations in 3 of 20 samples, or 15 percent, were less than 0.3±0.2 pCi/mL. From 1980 to 1982, tritium concentrations in 3 of 11 samples, or 27 percent, were less than 0.3±0.2 pCi/mL. From 1983 to 1988, tritium concentrations in 17 of 23 samples, or 74 percent, were less than 0.3±0.2 pCi/mL. The increase in number of samples with tritium concentrations less than 0.3±0.2 pCi/mL is consistent with the expected reduction in tritium from radioactive decay, given the 12.26 year half-life of tritium. For example, in the 12-year period from 1976 to 1988, tritium in surface and ground water resulting from the atmospheric testing of nuclear weapons in the 1950's and 1960's would have been reduced by about 50 percent owing to radioactive decay of tritium. The greater number of samples that contained less than 0.3±0.2 pCi/mL of tritium demonstrates a decreasing rate at which tritium has been added to the Snake River from atmospheric testing since at least 1974.

Tritium concentrations in the Snake River near Buhl are small when compared with concentrations in surface water at other sites in the United States. From April to June 1988, tritium concentrations in surface water samples from 60 sites in the United States, including the Snake River near Buhl, ranged from 0.1±0.2 to 5.0±0.3 pCi/mL and averaged about 0.5±0.2 pCi/mL (U.S. Environmental Protection Agency, 1988, p. 18). Of the 60 sites, the tritium concentrations equaled or exceeded 1.0±0.2 pCi/mL at 5 sites, equaled or exceeded 0.5±0.2 pCi/mL at 9 sites, equaled or exceeded 0.3±0.2 pCi/mL at 19 sites, and equaled or were less than 0.2±0.2 pCi/mL at 41 sites. Concentrations in the Snake River near Buhl were 0.2±0.2 pCi/mL.

SUMMARY AND CONCLUSIONS

Tritium concentrations in flow from 17 selected springs in the Twin Falls-Hagerman area were less than or equal to 0.16±0.16 pCi/mL in November 1988. In March 1989, tritium concentrations in these 17 springs and in 2 others were less than or equal to 0.13±0.07 pCi/mL; the minimum detectable concentration was about 0.5 pCi/mL for the analyses of samples collected in November 1988 and about 0.2 pCi/mL for those collected in March 1989. For the purpose of comparison, the maximum contaminant level, which is based on an average annual tritium concentration assumed to produce a total body dose of 4 millirem/year, is 20 pCi/mL.

Analyses by the U.S. Environmental Protection Agency show that tritium concentrations in the Snake River near Buhl have decreased slightly since the 1970's. A quantitative estimate cannot be made because of the small concentrations of tritium with respect to the minimum detectable concentration. A qualitative estimate can be made, however, by comparing the percentage of reported tritium concentrations less than 0.3±0.2 pCi/mL for different periods. In 1974-79, the concentrations in 3 of 20 samples were less than 0.3±0.2 pCi/mL. In contrast, from 1983 to 1988, 17 of 23 samples contained less than 0.3±0.2 pCi/mL of tritium. This slight decrease is consistent with the reduction in tritium from radioactive decay from the 12.26-year half-life of tritium. For example, from 1976 to 1988, tritium concentrations in the river would be reduced by about 50 percent owing to the radioactive decay of tritium present from the atmospheric testing of nuclear weapons. Furthermore, tritium concentrations in the springflow and river were less than the average of about 0.5±0.2 pCi/mL for the 60 surface-water sites sampled by the U.S. Environmental Protection Agency from April to June 1988; samples from 41 of the surface-water sites, including the Snake River near Buhl, contained 0.2±0.2 pCi/mL or less of tritium. Given these facts and the distribution and concentrations of tritium at the INEL as described by Pittman and others (1988), aqueous waste disposal of tritium at the INEL has had no measurable effect on the concentration of tritium in springflow discharging from the Snake River Plain aquifer in the Twin Falls-Hagerman area or in the Snake River near Buhl.

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Table 2.--Physical and chemical characteristics, and tritium concentrations in flow from selected springs in the Twin Falls-Hagerman area

[Tritium analyses and analytical uncertainties by U.S. Department of Energy's Radiological and Environmental Sciences Laboratory, Idaho Falls, Idaho. Name of springs(s): see figure 2 for locations of spring(s). Remarks: Replicate indicates a second sample submitted for analysis with a different identifier.]

Name of spring(s)	Date sampled (mo/dy/yr)	Discharge (cubic feet per second)	Water temperature (degrees Celsius)	pH (units)	Specific conductance (microsiemens per centimeter at 25 °C)	Dissolved oxygen (milligrams per liter)	Tritium concentration (picocuries per milliliter)	Analytical uncertainty (picocuries per milliliter)	Remarks
Banbury	03/21/89	123	13.5	8.00	405	10.35	0.13	+/- 0.07	
Bickel	11/07/88	19.5	14.6	8.13	259	8.81	-0.05	+/- 0.15	
	03/20/89	18.4	15.6	8.35	344	10.61	0.02	+/- 0.07	
Billingsley Creek	11/07/88	46.7	14.0	7.91	334	7.01	0.14	+/- 0.16	
	03/20/89	31.3	13.8	7.79	368	7.43	0.13	+/- 0.07	
Birch Creek	11/07/88	11.6	13.7	8.15	485	9.08	-0.03	+/- 0.15	
	03/20/89	8.69	13.0	8.09	460	9.03	0.04	+/- 0.07	
Blind Canyon	11/08/88	11.5	14.0	8.20	402	9.33	0.00	+/- 0.16	
	03/21/89	9.92	14.0	8.49	415	11.34	0.03	+/- 0.07	
Blue Heart	11/08/88	--	15.0	8.05	388	8.95	0.11	+/- 0.16	
	03/21/89	--	14.5	8.40	385	8.48	-0.05	+/- 0.07	
Blue Lakes	11/08/88	206	15.1	8.40	620	8.36	0.13	+/- 0.16	
		--	--	--	--	--	-0.07	+/- 0.15	Replicate
	03/21/89	189	15.4	7.98	679	9.01	-0.010	+/- 0.071	
		--	--	--	--	--	-0.02	+/- 0.07	Replicate
Briggs Creek	11/08/88	120	14.2	8.30	432	9.34	-0.01	+/- 0.16	
	03/21/89	103	14.3	7.90	441	8.98	0.08	+/- 0.07	
		--	--	--	--	--	0.014	+/- 0.072	Replicate
Box Canyon	11/09/88	387	14.3	8.40	389	9.37	-0.07	+/- 0.15	
	03/21/89	357	14.4	8.20	395	9.51	0.07	+/- 0.07	
Clear Lakes	11/07/88	528	11.5	8.38	449	9.08	0.02	+/- 0.16	
	03/20/89	478	14.5	8.12	428	9.89	0.11	+/- 0.07	
Crystal	11/09/88	479	14.4	8.17	697	9.51	0.16	+/- 0.16	
		--	--	--	--	--	0.13	+/- 0.16	Replicate
	03/22/89	370	15.0	8.30	655	9.32	0.10	+/- 0.07	
Devils Corral (upper)	11/07/88	39	15.0	8.35	510	9.47	0.07	+/- 0.16	
	03/20/89	37.9	15.5	8.45	600	10.94	0.04	+/- 0.07	
Devils Washbowl	11/07/88	15.8	13.1	8.51	622	9.65	0.15	+/- 0.16	
	03/22/89	12.7	15.2	8.06	658	8.72	0.01	+/- 0.07	

Table 2.--Physical and chemical characteristics, and tritium concentrations in flow from selected springs in the Twin Falls-Hagerman area--Continued

Name of spring(s)	Date sampled (mo/dy/yr)	Discharge (cubic feet per second)	Water temperature (degrees Celsius)	pH (units)	Specific conductance (microsiemens per centimeter at 25 °C)	Dissolved oxygen (milligrams per liter)	Tritium concentration (picocuries per milliliter)	Analytical uncertainty (picocuries per milliliter)	Remarks
Riley Creek	11/07/88	85.3	12.9	7.87	327	8.39	0.08	+/- 0.16	
	03/20/89	67.4	15.2	8.03	343	8.49	0.03	+/- 0.07	
Sand	11/07/88	106	14.5	7.88	384	8.95	-0.06	+/- 0.15	
		--	--	--	--	--	-0.04	+/- 0.15	Replicate
	03/20/89	97.2	14.4	7.92	397	8.73	0.05	+/- 0.07	
Spring (unnamed)	11/08/88	4.31	13.5	8.52	429	9.16	0.12	+/- 0.16	Unnamed springs upstream from Blind Canyon Springs
		--	--	--	--	--	0.16	+/- 0.16	Replicate
	03/21/89	3.54	14.0	8.50	415	9.62	0.08	+/- 0.07	
Spring (unnamed)	03/20/89	5.19	15.0	8.15	625	12.64	0.03	+/- 0.07	Unnamed spring upstream from Blue Lakes Springs
Thousand	11/08/88	1,360	14.5	8.28	345	8.97	0.13	+/- 0.16	
	03/21/89	1,350	15.0	7.95	320	9.94	0.05	+/- 0.07	
Warm Creek	11/08/88	11.3	14.5	8.33	562	10.14	0.08	+/- 0.16	
	03/21/89	6.60	15.4	8.34	638	10.67	0.05	+/- 0.07	

Table 3.--Daily mean discharge and tritium concentrations in the Snake River near Buhl, Idaho

[Analyses by U.S. Environmental Protection Agency, Montgomery, Alabama. Analytical results and analytical uncertainties in picocuries per milliliter; analytical uncertainty is reported as 2$. Samples were collected on south bank of river at water's edge--grab samples--by Idaho Department of Health and Welfare, Division of Environmental Quality, Field Office, Twin Falls, Idaho. Daily mean discharge is for a gaging station about 3 miles upstream from sampling site; Discharge records from the U.S. Geological Survey (1975-89). See figure 2 for locations of sampling site and gaging station]

Date sampled (mo/dy/yr)	Daily mean discharge (cubic feet per second)	Tritium concentration	Analytical uncertainty
07/23/74	2,160	0.4	+/-0.2
04/17/75	17,700	0.4	+/-0.2
07/14/75	2,120	0.3	+/-0.2
10/14/75	6,580	0.3	+/-0.2
01/19/76	9,850	0.2	+/-0.2
04/14/76	18,400	0.9	+/-0.2
10/04/76	2,090	0.2	+/-0.2
10/04/76	4,180	0.1	+/-0.2
01/11/77	5,590	0.3	+/-0.2
04/14/77	1,930	0.3	+/-0.2
07/07/77	2,050	0.6	+/-0.2
10/11/77	2,200	0.3	+/-0.2
01/30/78	3,400	0.3	+/-0.2
04/03/78	3,450	0.3	+/-0.2
07/10/78	2,270	0.3	+/-0.2
10/05/78	2,970	0.4	+/-0.2
01/08/79	6,220	0.3	+/-0.2
04/23/79	6,790	0.3	+/-0.2
07/06/79	1,900	0.4	+/-0.2
10/05/79	2,310	0.4	+/-0.2
01/15/80	2,570	0.2	+/-0.2
07/07/80	2,070	0.3	+/-0.2
10/15/80	2,480	0.3	+/-0.2
01/20/81	4,790	0.2	+/-0.2
04/01/81	4,960	0.3	+/-0.2
09/28/81	3,630	0.4	+/-0.2
10/30/81	3,580	0.3	+/-0.2
01/28/82	3,180	0.2	+/-0.2
04/20/82	17,000	0.3	+/-0.2
07/09/82	8,560	0.3	+/-0.2
10/15/82	6,420	0.5	+/-0.2
01/12/83	12,400	0.2	+/-0.2
04/19/83	7,950	0.1	+/-0.2
07/08/83	10,500	0.4	+/-0.2
10/13/83	9,790	0.2	+/-0.2
01/20/84	15,400	0.2	+/-0.2
04/20/84	11,500	0.1	+/-0.2
07/04/84	9,500	0.1	+/-0.2
10/15/84	13,100	0.2	+/-0.2
01/03/85	12,600	0.3	+/-0.2
05/30/85	4,130	0.1	+/-0.2
07/30/85	3,290	0.5	+/-0.2
10/16/85	4,190	0.1	+/-0.2
04/28/86	18,700	0.2	+/-0.2
07/21/86	2,700	0.2	+/-0.2
10/20/86	12,600	0.4	+/-0.2
01/20/87	7,610	0.3	+/-0.2
05/06/87	1,880	0.2	+/-0.2
07/07/87	2,370	0.1	+/-0.2
12/01/87	2,690	0.1	+/-0.2
02/17/88	2,330	0.2	+/-0.2
04/21/88	1,800	0.2	+/-0.2
07/13/88	2,630	0.2	+/-0.2
10/28/88	2,970	0.3	+/-0.2