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RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT JANUARY-JUNE, 1969

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RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT JANUARY-JUNE, 1969

By

D. H. Denham

Radiation Protection Department
Technical Services Division

November 1969

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RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT JANUARY-JUNE, 1969

D. H. Denham

INTRODUCTION

This report is prepared semi-annually to provide an evaluation of the status of ground water contamination resulting from disposal of plant effluents. The data presented in this report were collected during the first six months of 1969; the previous report in this series was BNWL-1047.[1]

Of the wells that have been drilled to ground water on the Hanford project, about 250 are used for the routine surveillance of radionuclide movement through the sediments both above and below the regional water table. Approximately half of the surveillance wells are located at disposal sites situated on the interior plateau 12 to 15 miles up-gradient from the nearest domestic water supply. Data obtained from these wells are used to determine when a disposal facility is to be retired. All other surveillance wells are sampled to determine the status of contaminants within the general ground water flow network. The locations of wells referred to in this report may be found by referring to the latest Hanford Wells document.[2]

Tritium and ^{106}Ru are used to trace the ground-water flow paths away from the major chemical processing disposal sites because these nuclides move at essentially the same rate as ground water and can be detected in the ground water at concentrations which are small relative to their respective

Concentration Guides (CG's). In addition, ground water quality measurements reflect the changes in water quality that are attributable to the concentrations of salts in the wastes. All ground water samples were analyzed by the Technical Analysis Section, Battelle-Northwest.

SUMMARY

An evaluation of ^{106}Ru and ^{3}H concentrations measured in the unconfined ground water during the first half of 1969 shows that the zones of detectable contamination extend in a southeasterly direction from 200-E Area (Figures 1 and 2) as observed in the past.[1] The few locations from which ground water samples exceeded the CG for ^{106}Ru were all within either the 200-E or 200-W Areas. Only one well located outside of the 200 Area fences (#699-35-70) indicated a ^{3}H concentration greater than its CG. The highest-average measured concentration of ^{51}Cr in unconfined ground water within or near the 100 Areas (Well 199B-5-1) was less than 5% of the CG for ^{51}Cr (2000 pCi/ml).[3] Primarily uranium was observed in 300 Area ground water at average concentrations below 0.5 pCi/ml (<3% CG).

No total beta concentrations were detected during this report period in any confined ground water aquifers. The highest average ^{3}H concentration observed in a confined ground water zone was 360 pCi/ml (12% CG for ^{3}H) from Well 699-42-42-P.

Much of the area surrounding the 200 Area disposal sites is contaminated with nitrates (Figure 3). Some nitrate ion (NO_3^-) concentrations were above the Public Health Service recommended drinking water limit of 45 ppm,[4] especially around the disposal sites and the 300 Area.

However, none of the ground water from these contaminated areas is being consumed by humans or is used for irrigation or consumption by cattle.

EVALUATION OF GROUND WATER SURVEILLANCE DATA

Radionuclide concentrations in the ground water beneath Hanford are evaluated in terms of their respective Concentration Guides (CG's). It is recognized that these CG's are only intended for evaluating radioactivity in drinking water and at present no ground water from the contaminated zones (Figures 1-3) is used for human or animal consumption. However, the CG's do provide a rapid, meaningful method of evaluating the potential radiological significance of most water-borne radionuclides. The CG's used in this report are those which apply to individuals of the general public.[3]

The ground water contamination pattern beneath Hanford can be logically divided into three zones, based on the kinds and quantities of waste disposed to ground at each area:

200 Area (chemical processing areas) and associated 600 Area wells

100 Area (production reactor areas) and associated 600 Area wells

300 Area (fuel fabrication and laboratory area) wells.

Ground water concentration data for these three zones are presented in this report.

200 AREA AND ASSOCIATED 600 AREA WELLS

Ground water samples collected from wells within and near the zone in which 200 Area effluents are present are analyzed for total beta, tritium, and nitrate ion. The total beta activity is calculated as ^{106}Ru, since radiochemical analyses have shown that it accounts for most of the

radioactivity* in this ground water zone. Ground water samples from beneath some inactive and all of the active disposal sites (Table 1) are analyzed for total alpha, ^{60}Co, ^{90}Sr, and ^{137}Cs, in addition to total beta, ^{3}H and NO_3^-.

TABLE 1. Active Disposal Sites.

200 East Area		200 West Area	
Crib	Waste	Crib	Waste
Purex		Redox	
216-A-8	Tank Farm Cond.	216-S-6	Steam Cond.
216-A-10	Process Cond.	216-S-23	Process Cond.
216-A-27	Lab. and Stacks	T Plant	
216-A-30	Steam Cond.	216-T-19	Evaporator Cond.
216-A-31	Organic Waste	216-T-35	300 Area Waste
216-A-36B	Scrubber Waste	216-T-36	Decon. Facility
B Plant		U Plant	
216-B-12	Process Cond.	216-U-12	Process Cond.
216-B-55	Steam Cond.	Z Plant	
216-B-61	Cond. from ITS#1	216-Z-12	Pro. and Lab. Waste
		216-Z-16	231-Z Lab. Waste
		216-Z-18	Recovery Process Waste

Observed ground water concentrations of ^{90}Sr and ^{137}Cs were below their respective detection limits (0.03 and 0.3 pCi/ml) for the 200-East and -West disposal areas during the first half of 1969. Ground water samples near only one crib site (216-T-36) indicated alpha activity (0.05 pCi/ml) above the

* *Not including ^{3}H, whose low energy beta emission does not contribute to the total beta activity measured.*

0.01 pCi/ml detection limit during the first half of 1969. Low but detectable concentrations of ^{60}Co were observed beneath the 216-A-31 crib (0.45 pCi/ml) and the 216-A-36B crib (0.64 pCi/ml). The highest average total beta concentrations beneath active disposal sites were observed at the 216-A-36B crib (50 pCi/ml) in 200 East Area and at the 216-T-35 crib (20 pCi/ml) in 200 West Area. (The 216-S-9 crib, which has been used for process condensate, but was recently retired from service, indicated an average total beta concentration of 9,400 pCi/ml.)

Total Beta Concentrations (unconfined aquifer)

Total beta concentrations are shown in Figure 1 for zones of 2 to 10%, 10 to 100%, and >100% of the CG for ^{106}Ru (10 pCi/ml).[3] The outer boundary of each zone is the down-gradient edge and represents 2%, 10% and 100% CG, respectively. The lowest level shown (2% CG) corresponds to a total beta concentration of 0.2 pCi/ml. Data for individual wells appear in Table 2.

A comparison of contamination contours for the six-month periods ending December 1968 and June 1969, indicates that the following changes have occurred: 1) the outer contour (2% of the CG) around the 200-West Area has shifted eastward to include Well 699-38-70; 2) the outer contour (2% CG) around the 200-East Area has shifted southward and no longer includes Well 699-37-43; and 3) the inner contour (10% CG) has shifted northward to include Well 699-50-53, but no longer includes Well 699-36-46. For the most part, these zones were reasonably well defined. However, inconsistent data were obtained from samples from the following 699- wells: 24-1T, S6-E14, and 32-43. There was insufficient evidence from well

TABLE 2. Total Beta Activity in Unconfined Ground Water (200 Area and Associated 600 Area Wells)*

Well No. (299-)	Units of pCi/ml			
	Jan-June, 1969			July-Dec., 1968
	Avg Conc	Max Conc	Conc in Latest Sample	Avg Conc
Analytical Limit[a]	0.16			
200-E Area				
216-A Disposal Facilities				
E17-1	3.9	5.6	2.7	4.9
E17-2	2.4	3.0	2.1	2.9
E17-3[b]	6.1	6.1	6.1	5.9
E17-5	50.	57.	51.	39.
E17-7	37.	50.	23.	18.
E24-2	5.7	8.0	4.6	5.7
E24-9	7.8	9.9	7.5	12.
E25-2	0.66	2.2	-	1.5
E25-3	0.18	0.25	-	1.9
E25-5	0.29	0.57	0.30	0.31
E25-6	0.26	0.34	0.21	0.43
216-B Disposal Facilities				
E33-23	1.4	1.8	1.6	1.8
200-W Area				
216-S Disposal Facilities				
W22-25	7,900	18,000	1,800	15,000
W22-26	9,400	13,000	6,300	17,000
216-T Disposal Facilities				
W6-1	0.19	2.3	2.3	-
W10-2	0.38	0.99	0.25	0.52
W10-3	0.28	0.77	-	0.38
W10-4	0.26	0.57	0.17	0.43

TABLE 2. (contd)

Well No. (299-)	Avg Conc	Max Conc	Conc in Latest Sample	July-Dec., 1968 Avg Conc
200-W Area (contd)				
W11-17	20.	24.	18.	20.
W11-18	7.4	9.6	5.6	11.
W15-4	2.3	2.9	2.5	2.9
216-U Disposal				
W21-1	1.8	2.8	2.8	0.38
W22-22	7.2	7.9	7.9	10.
216-Z Disposal				
W15-7	71.	160.	34.	290.
W22-4	0.27	0.85	-	0.22
600 Area Wells (No. 699-)				
S6-E14[b]	0.47	0.47	0.47	-
15-26	0.68	0.75	0.75	0.68
20-20	0.58	0.97	0.62	0.55
24-1T	0.20	0.25	0.16	-
26-15	1.8	2.0	1.6	1.9
31-31	1.4	1.9	0.92	1.3
32-43	0.90	0.91	0.68	NS[c]
34-39A	0.72	1.8	0.25	0.39
35-70	0.36	0.63	0.24	0.31
36-46R	0.75	1.0	0.57	1.1
38-70	0.23	0.39	0.39	-
41-23	0.67	0.82	0.67	0.63
50-53	1.2	3.2	1.2	1.7

* *Calculated as* ^{106}Ru.

(a) *A (-) indicates that the concentration was less than the analytical limit.*

(b) *Single sample during six-month period.*

(c) *Not sampled (New well).*

TABLE 2. (contd)

The following wells were sampled routinely, however, the average total beta concentration was below the analytical limit of 0.16 pCi/ml:

Well No. (299-)	Well No. (699-)	Well No. (699-)	Well No. (699-)
E-16-2	S3-E12	25-70	45-69
E-17-6	S6-E4C	26-89	46-21
E-19-1	S7-34	27-8	47-35
E-24-7	S8-19	28-40	47-46
E-25-7	S11-E12	28-52	47-60
E-26-1	S12-3	29-78	48-71
E-27-3	S12-29P	31-53B	49-55
E-28-4	S14-20P	31-65	49-57
E-28-9	S18-E2	32-42	49-79
E-28-12	S27-E14	32-62	50-28
E-28-13	S31-1P	32-70	50-30
E-28-16	1-18	32-72	50-42
E-32-1	2-3	32-77	50-85
E-34-1	2-33	33-42	51-63
	8-17	33-56	51-75
	8-32	34-51	52-47
W-10-1	9-E2	34-88	53-55
W-12-1	10-E12	35-9	54-37
W-15-2	10-54	35-66	54-42
W-19-4	11-45	35-78	54-57
W-22-20	14-E6T	36-61B	55-50A
W-23-2	14-38	36-93	55-70
W-23-3	15-15	37-43	55-76
W-23-4	17-5	37-82A	55-89
	17-47	38-65	57-83
	19-43	39-79	59-80B
	19-58	40-1	60-60
	20-E5T	40-33	61-66
	20-E12	40-62	63-90
	20-39	42-12	65-50
	24-33	42-42	65-59
	24-46	44-64	65-72
	25-55	45-42	67-51
			69-45

surveillance data to justify relating these results to 200 East Area effluents.

Tritium Concentrations (unconfined aquifer)

Tritium concentrations are shown in Figure 2 for zones of 0.3 to 1%, 1 to 10%, 10 to 100% and >100% of the CG (3000 pCi/ml).[4] The outer boundary of each zone is the down-gradient edge and represents 0.3%, 1%, 10%, and 100% CG, respectively. These new boundary zones (i.e. addition of a 1% and deletion of the 50%) were chosen so that order-of-magnitude differences in ground water contamination would be readily discernible and also so that the contamination "zones" on both the ^{106}Ru and ^{3}H maps would be consistent.

A comparison of concentration contours for the six-month period ending June 1969 indicates that the following changes have occurred since the previous report period ending December 1968: East Area - The outermost contour (0.3% CG) has expanded to include six additional wells, (699-) 2-3, 35-9, 49-57, 50-42, 54-57, and 60-60; and the northeast portion of the 10 to 100% contour has shifted to include well 699-45-42. West Area - The outer boundary (0.3%) includes three new wells, (699-) 29-78, 32-77, and 38-65, but no longer includes 31-65.

The concentration zone boundaries shown in Figures 1 and 2 should not be interpreted as indicating that no radioactivity is present in the ground water beyond these outer boundaries. It is probable that some radionuclides do in fact reach the river, but because of dilution and decay, the

concentrations are too low to be measured in the ground water or in the river.

Contamination in Confined Ground Water

Samples taken from wells penetrating specific aquifers in past years have indicated that some radioactive wastes may be entering the confined aquifers beneath the project. The extent to which such wastes appear in confined or semi-confined aquifers is difficult to evaluate because of the limited number of points at which these aquifers can be sampled with the present well system.

Water samples from specific aquifers are obtained from either vertically-separated tubes (piezometers) contained within a single well or from piezometer tubes drilled as separate wells. Admittedly, there is no certainty that the vertical separation of piezometer tubes is infallible since the possibility of inter-aquifer transfer within a well may exist.

Total beta concentrations in samples taken at various depths (in some instances from confined aquifers) below the water table were all at or below the detection limit (<2% CG for ^{106}Ru) for the first six months of 1969. The maximum six-month average tritium concentration in well water from a confined zone was 360 pCi/ml (12% of the CG for ^{3}H) in Well 699-42-42-P in a zone 98 ft below the water table.

Ground Water Quality

The disposal of liquid wastes to the ground has caused measurable changes in ground water quality surrounding the disposal sites (Figure 3). The changes in water quality are attributable directly to the concentrations

of salts in the wastes and indirectly to the degradation of minerals in the soil by the wastes. Table 3 shows concentrations of contaminants in the ground water near disposal sites and down-gradient from the sites.

TABLE 3. Ground Water Quality.

Well No.	Distance From Processing Facility (miles)	pH*	NO_3^- (ppm)	$SO_4^=$* (ppm)	Na^+* (ppm)	Ca^{++}* (ppm)
(299-)						
E17-2	<1	8.1		80	49	106
E24-2	<1	8.2		56	36	62
(699-)						
34-39A	2	8.2	24	65	35	17
31-31	4	8.2	65	46	43	17
41-23	5		37			
15-26	6	8.2	17	61	26	38
26-15	7		36			
Average Conc. in Ground Water Prior to Significant Plant Disposal.(5)		7.9	2.2	22	19	29
Columbia River (Average for same period)						
100-F				15		23
Richland		7.8	0.3			

* *Results of single analyses during 6 month period.*

A blank in the table indicates that the analysis was not made.

The extent of nitrate ion (NO_3^-) contamination in the ground water is shown in Figure 3. Much of the ground water within the area shown in Figure 3 has detectable (0.2 ppm) NO_3^- concentrations, probably as a result of previous farming and the use of fertilizers in addition to the disposal of wastes in the 200 Areas. However, only those wells

having average NO_3^- concentrations above 5 ppm are included within the contamination zones since these are most probably from waste disposal in the 200 Areas. Although a rather large portion of the contaminated area has ground water concentrations above the Public Health Service recommended drinking water limit[4] of 45 ppm, no water from this area is being consumed by humans or is used for irrigation or consumption by cattle.

100 AREA AND ASSOCIATED 600 AREA WELLS

The presence of radioactivity in the ground water beneath the 100 Areas is due to leaks in reactor effluent systems and to disposal of wastes to trenches. Well-water samples were collected from within and near the 100 Areas and were analyzed for total beta and ^{51}Cr. Since ^{51}Cr was the only gamma-emitting radionuclide present in quantities detectable by routine methods, the concentrations shown in Table 4 are reported as ^{51}Cr.

The estimated extent of detectable total beta radioactivity in the ground water beneath the 100 Areas is shown as a short-dashed line in Figure 1. Three contaminated zones can be distinguished: 100-B, 100-K--100-N, and 100-D, with the radioactivity level decreasing in that order.

300 AREA WELLS

The presence of radioactive and nonradioactive contaminants in the ground water beneath the 300 Area arises from the disposal of wastes to two process ponds located north and east of the 300 Area. Results of samples collected from 300 Area ground water show that the radioactivity is primarily due to uranium, although ^{51}Cr (for which the river is the source) has also been identified.

TABLE 4. ^{51}Cr Concentrations in Unconfined Ground Water (100 Area and Associated 600 Area Wells)

	Units of pCi/ml			
	Jan-June, 1969			Jul-Dec. 1968[a]
Well No.	Avg Conc	Max Conc	Conc in Latest Sample	Avg Conc
Analytical Limit[b]	0.3			
199B-3-2	0.9	1.7	-	NA[c]
199B-4-4	19.	37.	1.2	56.
199B-5-1	41.	79.	3.3	68.
199B-9-1	3.6	7.0	-	31.
199K-20	20.	40.	0.6	33.
199N-8 U	0.9	1.0	1.0	8.6
699-71-77	27.	51.	2.5	89.
699-71-84	7.6	14.	1.2	23.
699-72-73	0.5	0.9	-	14.
699-86-60	1.1	2.1	-	3.2

No detectable ^{51}Cr was observed in any of the samples from the following wells:

199D-2-5	199K-11	699-65-83	699-70-68	699-81-58
199D-5-12	199K-25	699-67-86	699-74-60	699-96-49
	199N-3 0	699-68-72	699-78-62	

(a) *The average total beta concentrations for this period were multiplied by a factor of 10 to obtain these equivalent ^{51}Cr concentrations.*
(b) *A (-) indicates that the concentration was less than the analytical limit.*
(c) *NA - Not Analyzed.*

Much of the ground water beneath the 300 Area is above the Public Health Service drinking water limit[4] (Table 5) of 45 ppm nitrate (NO_3^-). Sampling of the river adjacent to the disposal sites has shown measureable increases in nitrate ion concentrations only at seepage locations along the riverbank.

TABLE 5. Analytical Data - 300 Area Wells

Well No. (399-)	Average Concentrations Jan-June, 1969 Alpha, pCi/ml	Beta, pCi/ml	NO_3^- ppm
Analytical Limit*	0.01	0.16	1
1-1	0.33	0.32	86
1-2	0.40	0.30	122
1-3	0.44	0.32	48
1-4	0.41	0.23	88
3-1	0.29	0.26	58
4-1	0.34	0.32	52
4-7	0.40	0.28	42
5-1	0.42	-	17
6-1	0.28	-	18
8-1	0.50	-	46
8-2	-	-	8
8-3	0.31	-	19

* *A (-) indicates that the concentration was less than the analytical limit.*

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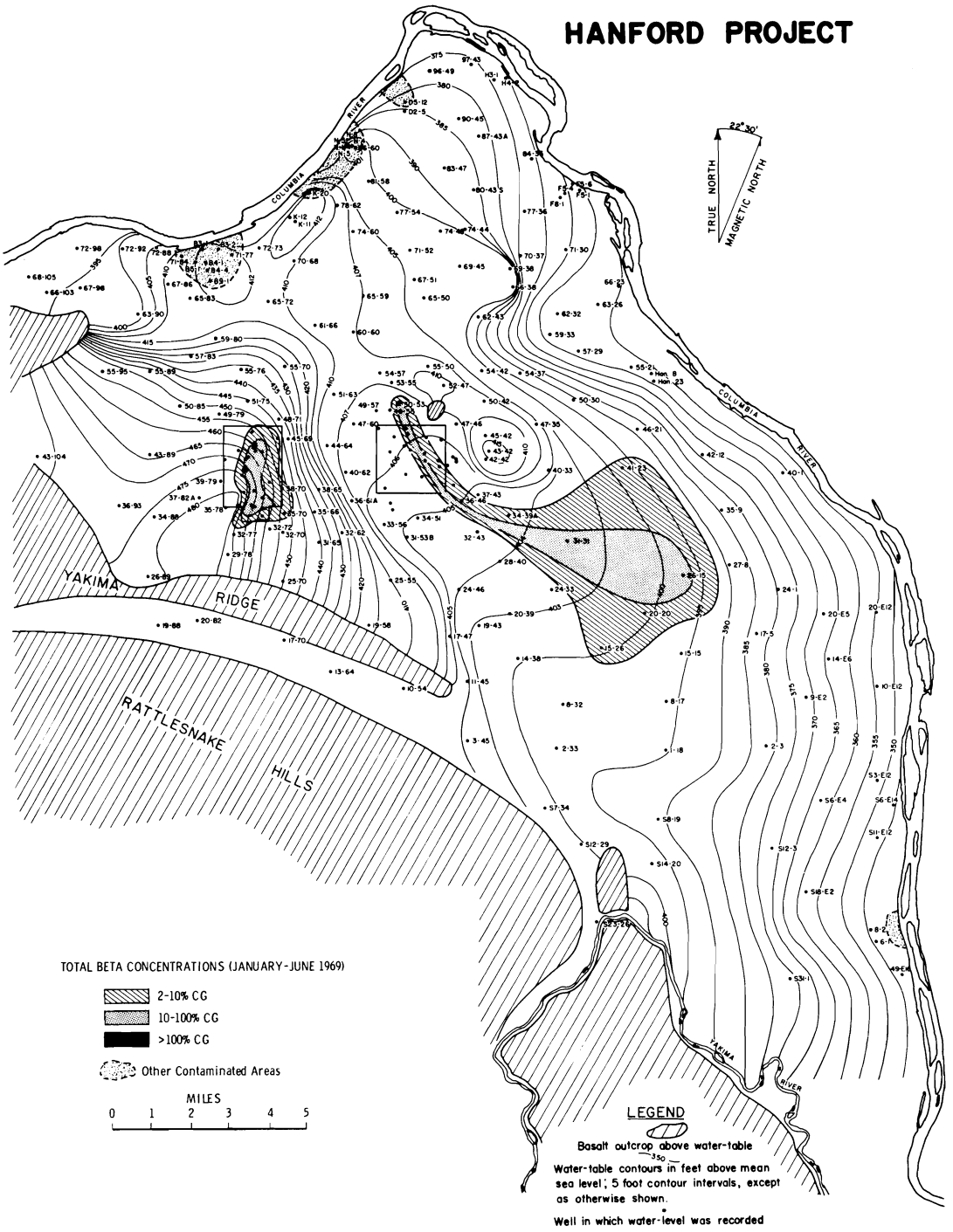

Neg 0694351-1

FIGURE 1. Total Beta Concentrations Beneath the Hanford Project Expressed as Percent of ^{106}Ru Concentration Guide (10 pCi/ml)

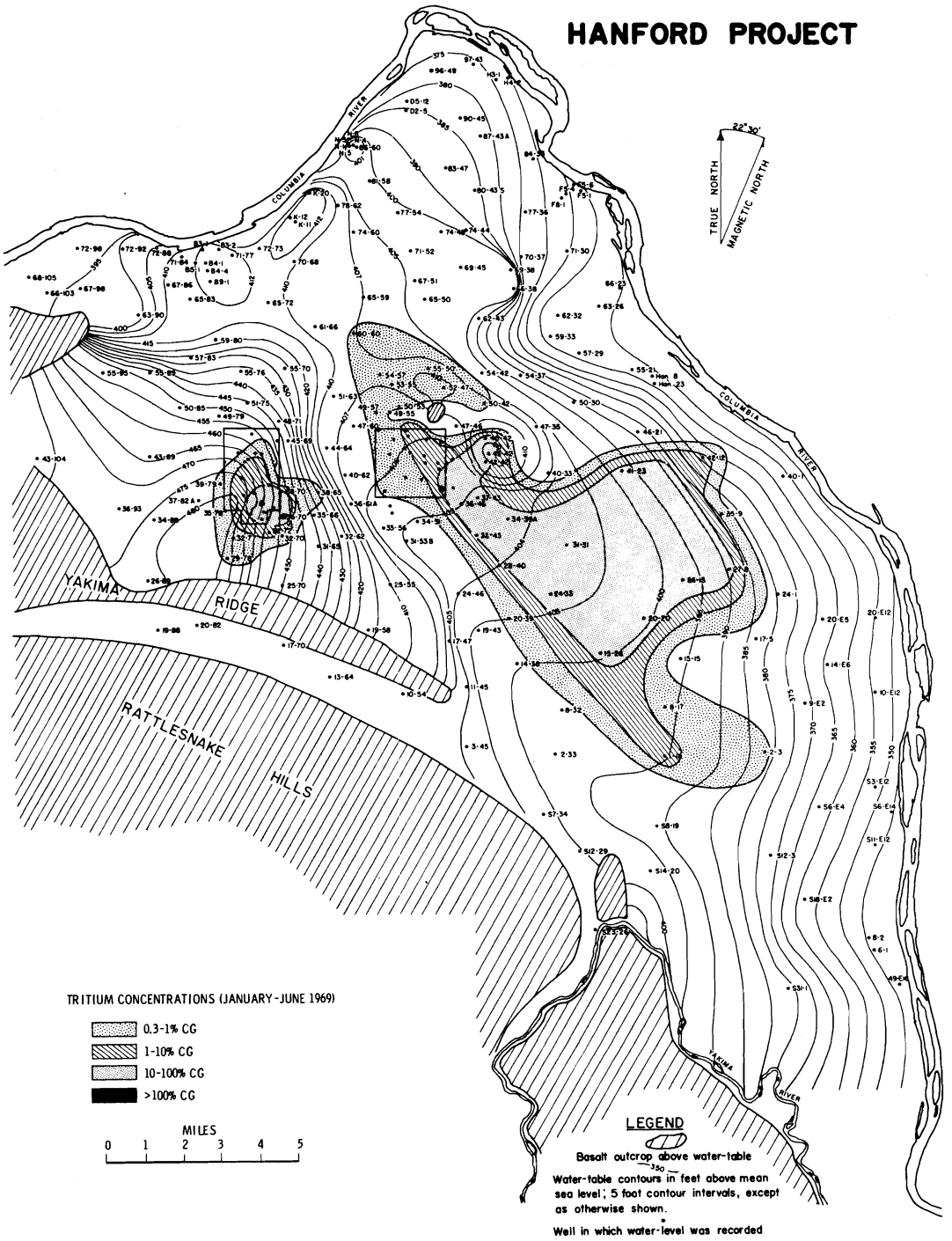

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FIGURE 2. Tritium Concentrations Beneath the Hanford Project Expressed as Percent of ^3H Concentration Guide (3000 pCi/ml)

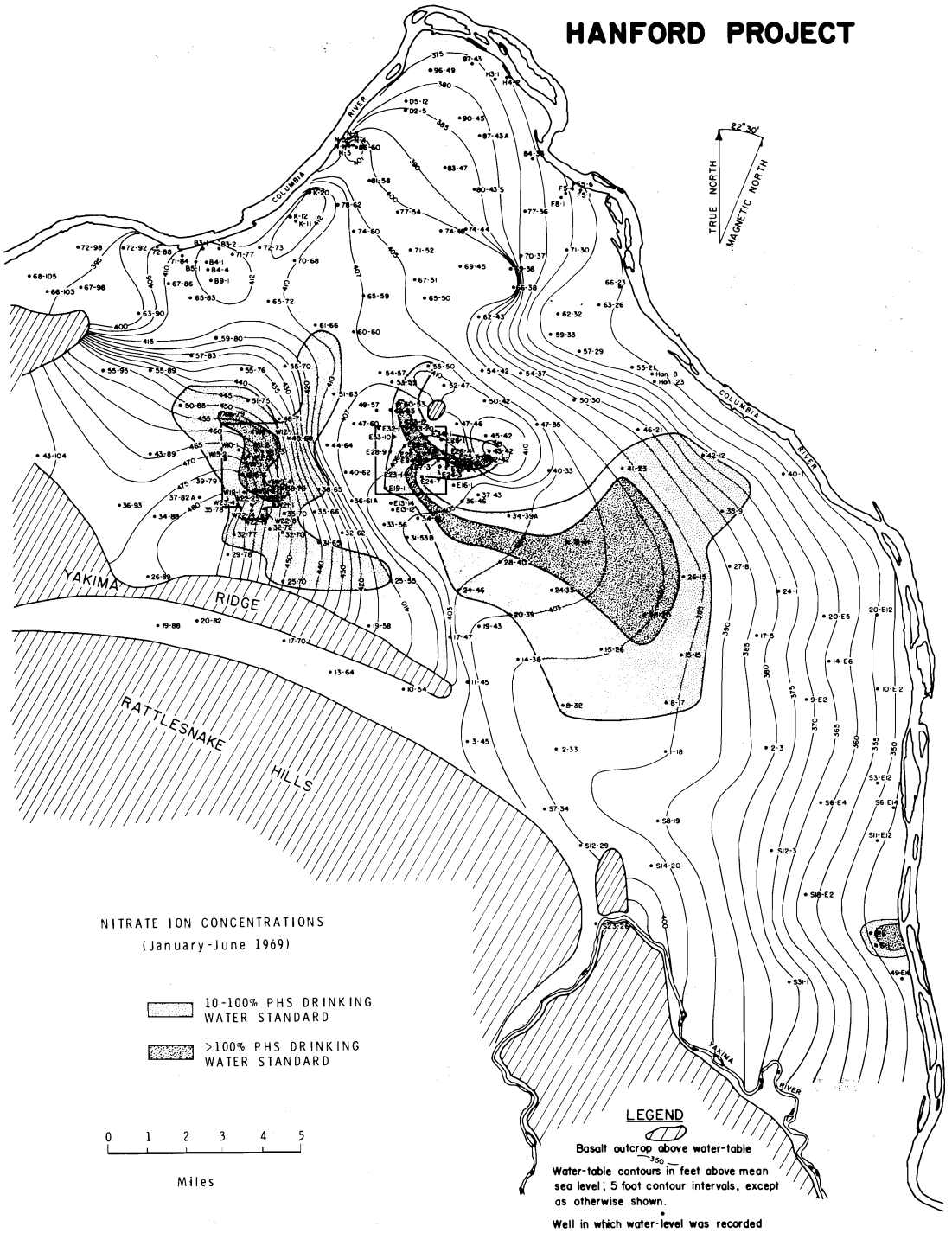

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FIGURE 3. Nitrate Ion Concentrations Beneath the Hanford Project Expressed as Percent of Public Health Service Drinking Water Limit (45 ppm)

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