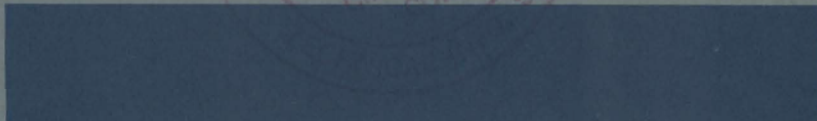


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RADIOLOGICAL STATUS
OF THE GROUND WATER
BENEATH THE HANFORD PROJECT
JULY-DECEMBER, 1968

May 1969



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RADIOLOGICAL STATUS OF THE GROUND WATER
BENEATH THE HANFORD PROJECT
JULY-DECEMBER, 1968

By

D. H. Denham

Radiation Protection Department
Technical Services Division

May 1969

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RADIOLOGICAL STATUS OF THE GROUND WATER
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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 the report were collected during the last six months of 1968; the previous report in this series was BNWL-984.⁽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 $^{106}\text{Ru-Rh}$ 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

^{*} *The term Concentration Guides, as defined in the latest edition of the Appendix to AEC Manual Chapter 0524, replaces the terminology "Maximum Permissible Concentration (MPC)" used in previous reports in this series.*

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 ^3H concentrations measured in the ground water during the last half of 1968 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 respective CG's for ^{106}Ru and ^3H were all within either the 200-E or 200-W Areas or their respective fenced disposal sites. No radioactivity was detected consistently during this report period in any confined ground water aquifer more than 5 miles down-gradient from the 200 Area disposal sites. The highest-average measured concentration in unconfined ground water within or near the 100 Areas (Well 699-71-77) was less than 10% of the CG for ^{51}Cr (2000 pCi/ml).⁽³⁾

Some nitrate ion (NO_3^-) concentrations were above the Public Health Service recommended drinking water limit⁽⁴⁾ of 45 ppm (NO_3^-).

The most probable ground-water flow paths as of March 1968 are shown in Figure 3.⁽⁵⁾ This figure was produced by the Water Resources Systems Section, Battelle-Northwest, using field-measured ground water potentials. In general, ground water flow is from the Chemical Separation Areas to the Columbia River.

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. However, they 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 $^{106}\text{Ru-Rh}$, since radiochemical analyses have shown that these radionuclides account for most of the radioactivity* in this ground water zone. Ground water samples from selected disposal sites (Table 1) are analyzed for total alpha, ^{60}Co , ^{90}Sr , and ^{137}Cs , in addition to total beta, ^3H and NO_3^- . Observed concentrations of ^{90}Sr and ^{137}Cs were below their respective detection limits (0.02 and 0.2 pCi/ml) during the last half of 1968.

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

TABLE 1. *Activity in the Ground Water at Major Disposal Sites from Wells Having the Highest Activity Level at Each Site*

Crib	Waste	Well No. (299-)	Average Conc, pCi/ml, (July-December, 1968)		
			Total β	Total α	^{60}Co
Analytical Limit ^(a)			0.16	0.01	
<u>Purex</u>					
216-A-8	Tank Farm Cond.	E25-7	0.49	-	NA
216-A-10	Process Cond.	E24-2	5.7	-	NA
216-A-27	Lab. and Stacks	E17-3	5.9	-	0.52
216-A-30	Steam Cond.	E16-2	0.38	-	NA
216-A-31	Organic Waste	E24-9	12.	-	0.33
216-A-36B	Scrubber Waste	E17-5	39.	-	0.23
<u>B Plant</u>					
216-B-12	Process Cond.	E28-16	0.19	-	NA
216-B-50	Cond. from ITS#1	E33-23	1.8	-	NA
216-B-55	Steam Cond.	E28-13	-	-	NA
<u>Redox</u>					
216-S-9	Process Cond.	W22-26	17,000	-	<2.1
216-S-20	Lab. Wastes	W22-20	0.42	-	<0.05
216-S-21	Tank Farm Cond.	W23-4	0.17	0.09	NA
<u>T Plant</u>					
216-T-19	Evaporator Cond.	W15-4	2.9	NA	NA
216-T-35	300 Area Waste	W11-17	20.	-	0.12
216-T-36	Decon. Facility	W10-2	0.52	0.07	<0.05
<u>U Plant</u>					
216-U-12	Process Cond.	W22-22	10.	-	NA
<u>Z Plant</u>					
216-Z-1Ac	Recovery Process Waste	W18-7	NA	-	NA
216-Z-7	300 Area Waste (ret.)	W15-7	290.	-	33.
216-Z-12	Pro. and Lab. Waste	W18-5	NA	-	NA

NA - Not analyzed.

a. A (-) indicates that the concentration was less than the analytical limit. No analytical limit is listed for ^{60}Co because (although such a limit can be established) it would fluctuate over a wide range with the background count rate.

Ruthenium-106 Concentrations (unconfined aquifer)

Ruthenium-106 concentrations are shown in Figure 1 for zones of 2 to 10%, 10 to 100%, and >100% of the CG (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. Although in previous reports total beta concentrations between 0.08 and 0.16 pCi/ml were reported as positive values, these are no longer considered statistically significant for single samples. Therefore, only those total beta concentrations exceeding the analytical limit of 0.16 pCi/ml are tabulated in this report (Tables 1, 2, and 5).

A comparison of contamination contours for the six-month periods ending June and December, 1968, indicates that the inner and outer contours (100% and 2% of the CG, respectively) have not changed significantly over the past year. The middle contour (10% CG) has shifted northward and no longer includes Well 699-15-26.

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.

Tritium Concentrations (unconfined aquifer)

Tritium concentrations are shown in Figure 2 for zones from the analytical limit ($\sim 0.1\%$) to 10%, 10 to 50%, 50 to 100% and >100% of the CG (3000 pCi/ml).⁽⁴⁾ The outer boundary of each zone is the down-gradient edge and represents $\sim 0.1\%$, 10%, 50%, and 100% CG, respectively.

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

Well No.	Units of pCiβ/ml			
	July-December, 1968			Jan.-June, 1968
	Avg Conc	Max. Conc	Conc in Latest Sample	Avg Conc
Analytical Limit ^(a)	0.16			
<u>200-E Area</u>				
<u>216-A Disposal Facilities</u>				
299-E16-2	0.37	1.1	-	0.22
299-E17-1	4.9	6.1	3.6	7.4
299-E17-2	2.9	4.7	3.2	6.4
299-E17-3	5.9	7.5	4.6	11
299-E17-5	39	69	35	26
299-E17-7	18	37	13	20
299-E24-2	5.7	6.6	3.1	18
299-E24-9	12	16	9.0	24
299-E25-2	1.5	7.6	-	1.2
299-E25-3	1.9	5.0	-	1.8
299-E25-5	0.31	0.37	0.27	0.30
299-E25-6	0.43	0.95	0.32	0.38
299-E25-7	0.49	1.9	0.20	0.51
<u>216-B Disposal Facilities</u>				
299-E28-13	-	-	-	0.26
299-E33-23	1.8	2.0	1.4	1.8
<u>Outside Specific Disposal Sites</u>				
299-E19-1	-	-	-	-
299-E24-7	-	-	-	-
299-E26-1	-	0.20	0.20	-
299-E27-3	0.62	0.96	0.23	0.81
299-E28-4	-	-	-	-
299-E32-1	-	-	-	0.19
299-E34-1	-	-	-	-
<u>200-W Area</u>				
<u>216-S Disposal Facilities</u>				
299-W22-20	0.42	1.2	0.17	0.82
299-W22-25	15,000	19,000	19,000	3,800
299-W22-26	17,000	21,000	16,000	23,000
299-W23-2	0.37	0.93	-	0.34
299-W23-3	0.25	0.74	-	0.51
299-W23-4	0.17	0.32	-	0.16

TABLE 2. (contd)

<u>216-U Disposal Facilities</u>				
299-W21-1	0.38	0.64	0.64	0.27
299-W22-22	10	30	7.0	3.2
<u>216-T Disposal Facilities</u>				
299-W6-1	-	-	-	0.11
299-W10-2	0.52	0.86	0.48	0.51
299-W10-3	0.38	0.74	-	0.29
299-W10-4	0.43	0.81	0.23	0.40
299-W11-18	11	15	11	14
299-W12-1	-	-	-	-
299-W15-4	2.9	8.3	2.4	1.2
299-W11-17	20	38	16	9.9
<u>216-Z Disposal Facilities</u>				
299-W15-2	-	-	-	-
299-W15-7	290	500	110	710
299-W19-4	-	-	-	-
299-W22-4	0.22	0.80	-	0.15
<u>600 Area Wells</u>				
699-S12-29	-	-	-	-
699-S8-19	-	-	-	-
699-S6-E14	-	-	-	-
699-S3-E12	-	-	-	-
699-8-17	-	-	-	-
699-10-E12	-	-	-	-
699-14-E6T	-	0.17	-	-
699-15-26	0.68	1.0	-	1.2
699-19-58	-	0.30	-	0.10
699-20-E5T	-	-	-	-
699-20-20	0.55	0.71	0.41	0.48
699-24-1T	-	-	-	-
699-24-33	-	0.28	-	0.19
699-26-15	1.9	2.1	1.9	1.5
699-27-8	-	-	-	-
699-28-40	-	-	-	-
699-29-78	-	0.17	-	-
699-31-31	1.3	2.5	1.4	2.2
699-31-53B	-	-	-	-
699-31-65	-	-	-	-
699-32-62	-	-	-	-
699-33-56	-	-	-	-
699-34-39A	0.39	0.68	-	1.2
699-34-88	-	-	-	-

TABLE 2. (contd)600 Area Wells (contd)

699-35-70	0.31	0.44	0.35	0.30
699-36-46R ^(b)	1.1	1.1	1.1	0.40
699-37-82A	-	0.18	-	-
699-38-65	-	-	-	-
699-38-70	-	0.18	-	-
699-40-1	-	-	-	-
699-41-23	0.63	0.67	0.62	0.67
699-42-42	-	-	-	-
699-44-64	-	-	-	-
699-45-69	-	-	-	-
699-47-35	-	-	-	-
699-47-46	-	-	-	-
699-50-53	1.7	5.0	0.22	1.6
699-50-85	-	-	-	-
699-52-47	-	-	-	0.16
699-53-55	-	-	-	0.20
699-54-57	-	-	-	-
699-55-50A	-	0.30	-	0.15
699-55-76	-	0.17	0.17	-
699-55-89	-	-	-	-

-
- (a) A (-) indicates that the concentration was less than the analytical limit.
- (b) Single sample during six-month period.

A comparison of concentration contours for the six-month periods ending June and December, 1968, indicates that the following changes have occurred: a) the outermost contour ($\sim 0.1\%$ CG) has shifted slightly in an easterly direction and has expanded to include three additional wells, 699-8-17, 699-20-39, and 699-47-35; and b) the northwest portion of the 10 to 50% contour has shifted in a south-easterly direction, the principle direction of flow.

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 more 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 last six months of 1968. The maximum six-month average tritium concentration in well water from a confined zone was 1200 pCi/ml (40% of the CG for ^3H) in Well 699-42-42-P in a zone 98 ft below the water table. The well most remote from the disposal sites showing ^3H concentrations above the detection limit was 699-42-12, and it was 1.5 miles from the river.

Ground Water Quality

The disposal of liquid wastes to the ground has caused measurable changes in ground water quality near disposal sites. Table 3 shows nitrate (NO_3^-) ion concentrations in the ground water down-gradient from the disposal sites.

TABLE 3. *Ground Water Quality - July-December, 1968*

<u>Well No.</u>	<u>Distance from Processing Facility, miles</u>	<u>NO_3^- ppm</u>
(699-)		
42-42	<1	29
34-39A	2.0	24
40-33	3.0	1
31-31	3.8	8
24-33	4.0	8
46-21	5.5	7
15-26	6.1	47
20-20	6.4	33
26-15	6.9	35
42-12	7.1	9
35-9	7.5	6
15-15	7.7	30
27-8	8.0	0.7
8-17	8.2	14
1-18	9.2	4
17-5	9.2	8
24-1	9.4	1
40-1	9.4	0.1
S8-19	10	3
2-3	11	4
9-E2	11	1
14-E6	11	8
<u>Columbia River</u>		
Richland - Average for same period		0.3
Average Concentration in Ground Water Prior to Significant Plant Disposal. ⁽⁶⁾		2.2

100 AREA AND ASSOCIATED 600 AREA WELLS

The presence of radioactivity in the ground water beneath the 100 Areas is due to disposal of wastes to trenches and to leaks in reactor effluent systems. Well-water samples were collected from within and near the 100 Areas and were analyzed for total beta. Because preliminary data have shown that ^{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 .

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

Well No.	Units of pCi/ml			
	July-December, 1968			
	Avg. Conc.	Max. Conc.	Conc. in Latest Sample	Jan.-June, 1968 Avg. Conc.
Analytical Limit(a)	1.6			
199B-4-4	56.	100.	17.	220.
199B-5-1	68.	130.	79.	170.
199D-2-5	-	-	-	-
199D-5-12	2.4	3.5	-	3.6 ^(b)
199K-11	-	-	-	-
199N-3 O	23.	110.	6.3	34.
199N-8 U	8.6	12.	9.3	68. ^(b)
699-67-86	-	2.0	-	-
699-69-45	-	-	-	-
699-70-68	-	2.4	-	6.8
699-71-77	89.	300.	10.	130.
699-71-84	23.	49.	11.	38.
699-72-73	14.	33.	6.8	50.
699-81-58	-	-	-	2.4
699-86-60	3.2	3.8	2.3	4.1
699-96-49	-	-	-	2.2

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

(b) Results of single sample analyses during the six-month period.

The estimated extent of detectable 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 (i.e. 100-D is the lowest of the three areas since the D Area reactor is no longer in operation).

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.

If the Public Health Service drinking water limits⁽⁴⁾ are used as a base for comparison with the concentrations of non-radioactive contaminants, much of the ground water beneath the 300 Area is above the recommended limits,* especially for nitrate ion (Table 5). Sampling of the river adjacent to the disposal sites has shown measurable increases in nitrate, fluoride, and chromate ion concentrations only at seepage locations along the riverbank.

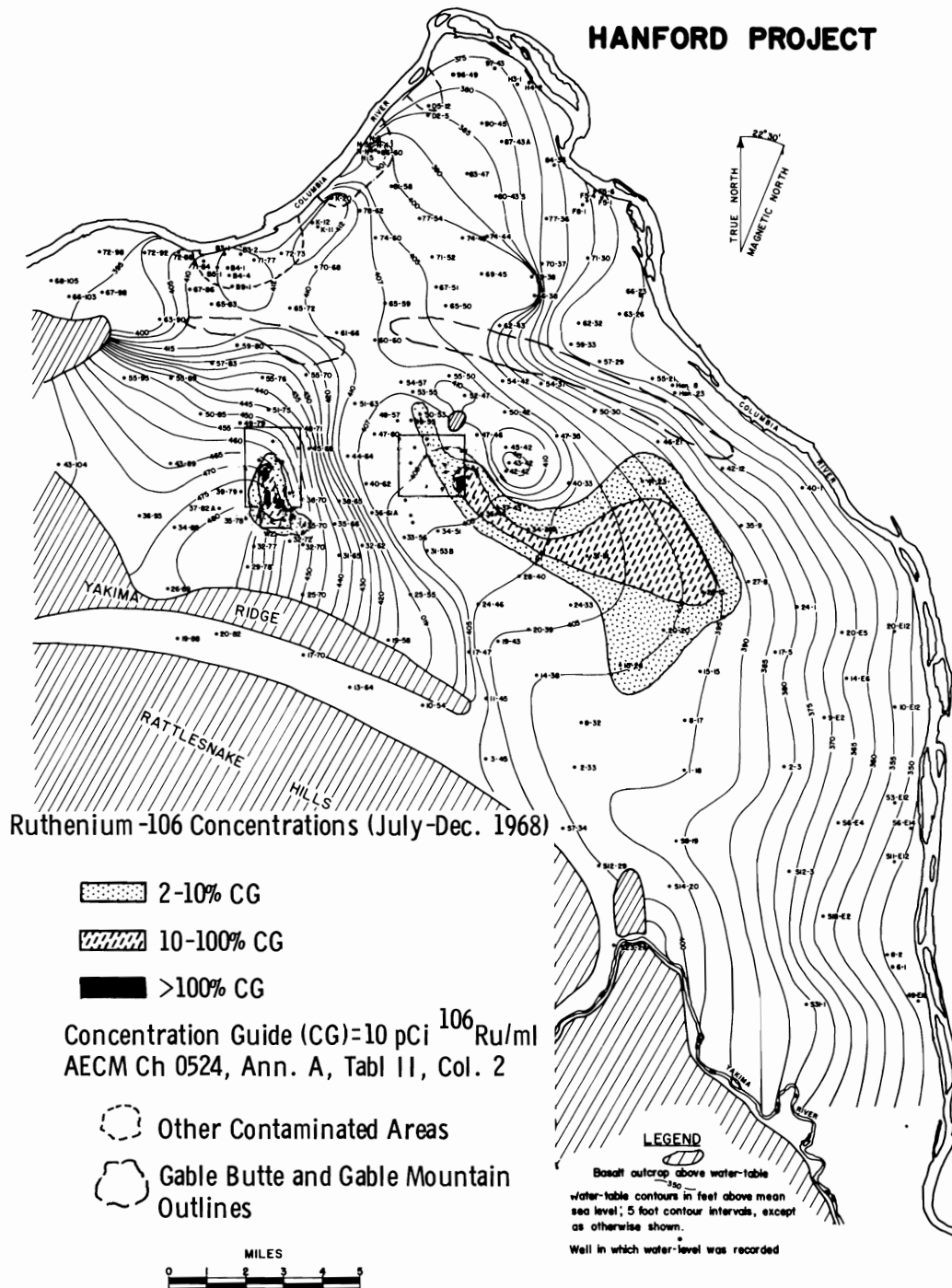
* The recommended limits are: NO_3^- , 45 ppm; Cr^{+6} , 50 ppb; and F^- , 1.4-2.4 ppm (depending on the ambient air temperature).

TABLE 5. *Analytical Data - 300 Area Wells
July-December, 1968 Averages*

<u>Well No.</u>	<u>Alpha, pCi/ml</u>	<u>Beta, pCi/ml</u>	<u>NO₃⁻ ppm</u>	<u>Cr⁺⁶, ppb</u>	<u>F⁻, ppm</u>
Analytical Limit(a)	0.01	0.16			
399-1-1	0.38	0.30	103	<1	1.8
399-1-2	0.26	0.23	63	NA	NA
399-1-3	0.31	0.22	79	NA	NA
399-1-4	0.21	0.20	46	NA	NA
399-3-1	0.27	0.20	57	2	1.1
399-4-1	0.28	0.21	59	NA	NA
399-4-7	0.20	0.19	64	NA	NA
399-5-1	0.03 ^(b)	-	17	1.0 ^(b)	0.5 ^(b)
399-5-2	-	-	0.2 ^(b)	1.3	1.1
399-6-1	0.03 ^(b)	-	16	1.5 ^(b)	0.2 ^(b)
399-8-1	0.06 ^(b)	-	16	3.0 ^(b)	0.3 ^(b)
399-8-2	-	-	12	1.7 ^(b)	0.3 ^(b)
399-8-3	0.12 ^(b)	-	18	NA	NA

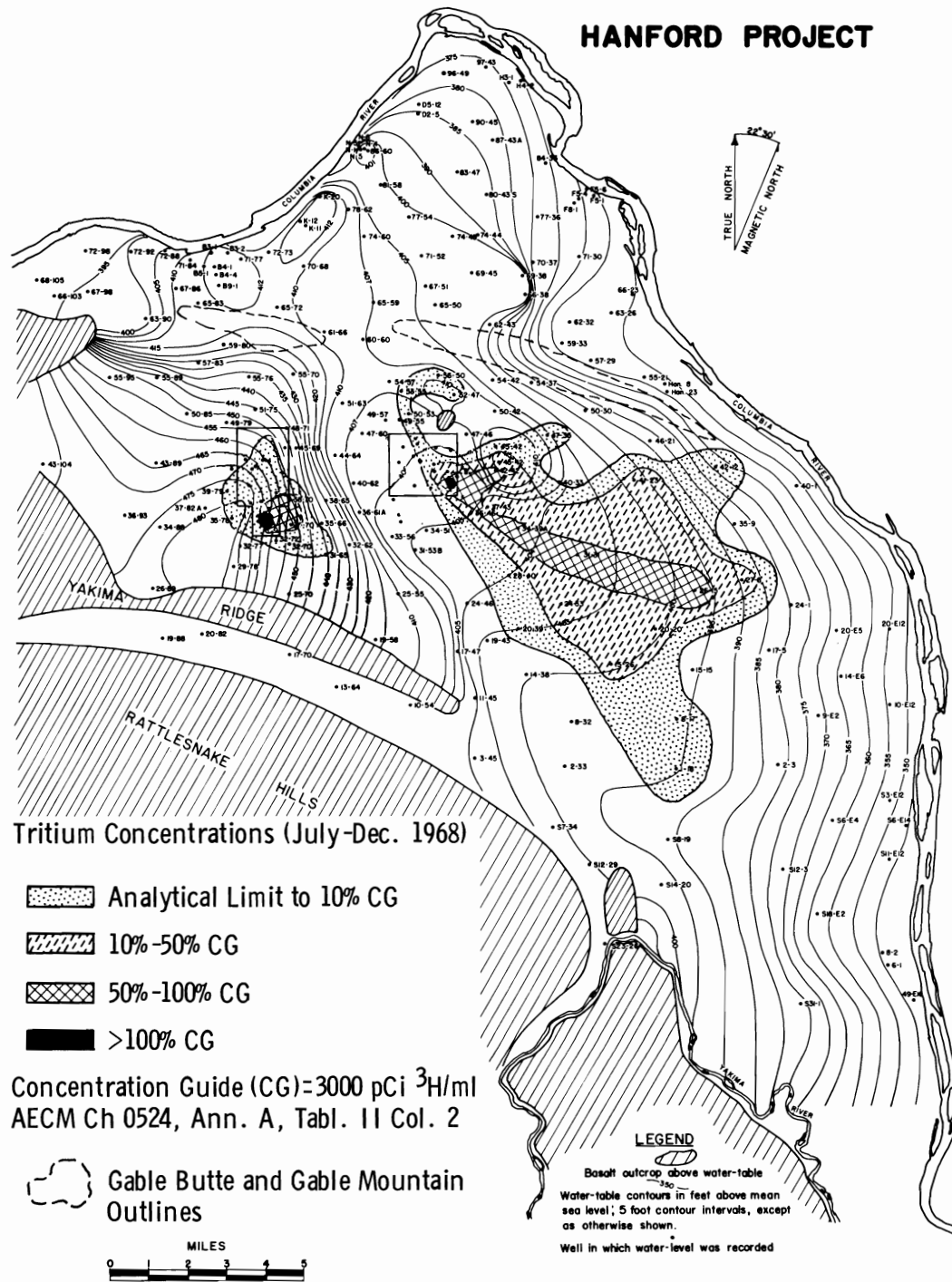
NA - Not analyzed.

-
- a. A (-) indicates that the concentration was less than the analytical limit.
- b. Results of single analyses during the six-month period.



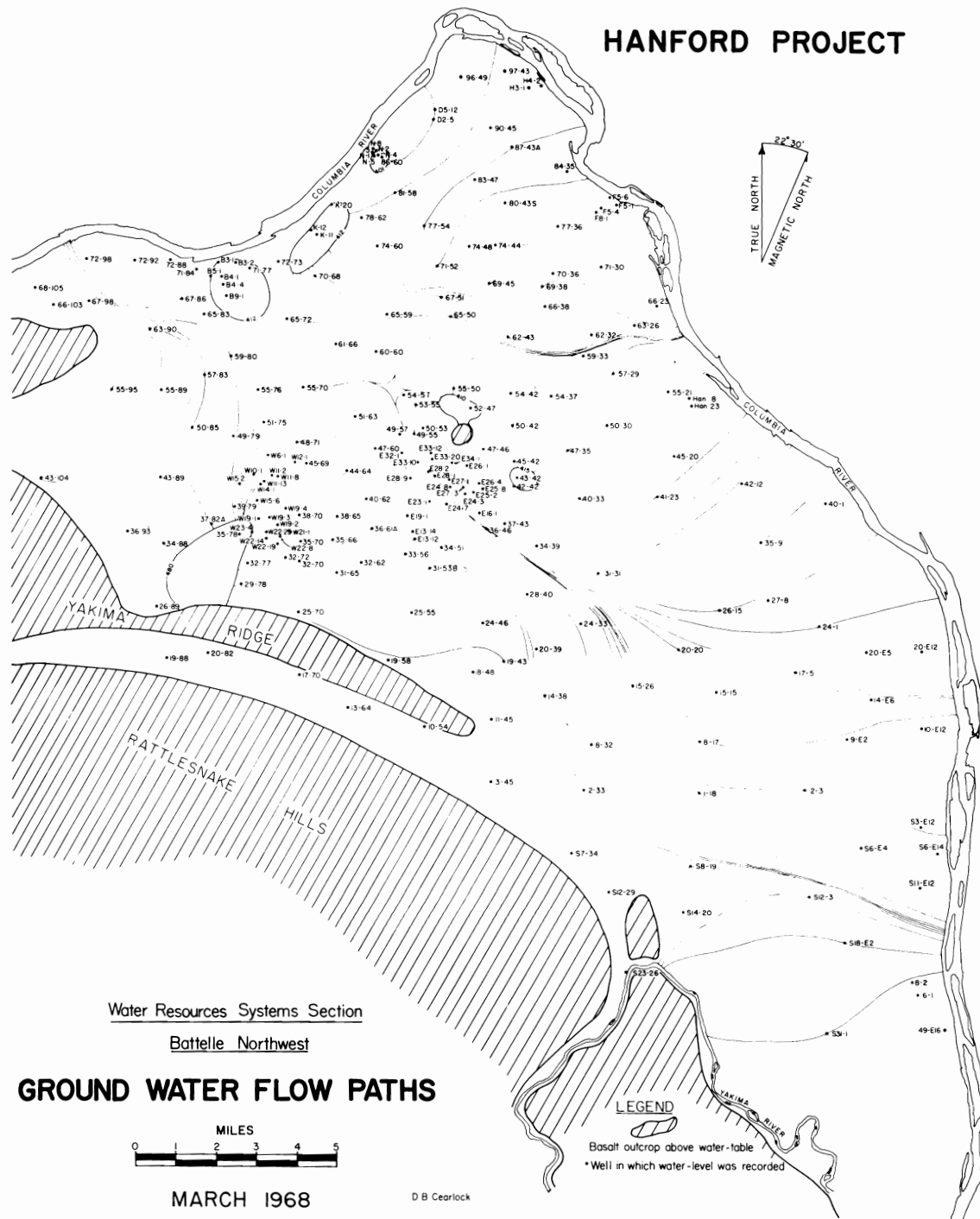
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FIGURE 1. Ruthenium-106 Concentrations Beneath the Hanford Project



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FIGURE 2. Tritium Concentrations Beneath the Hanford Project



Neg 0691265-1

FIGURE 3. Ground-Water Flow Paths (Toward the Columbia River) Beneath the Hanford Project

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