[redacted]

RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT, JULY-DECEMBER, 1967

T. H. Essig

JUNE 5, 1968

[redacted]

AEC RESEARCH & DEVELOPMENT REPORT

BATTELLE NORTHWEST
BATTELLE MEMORIAL INSTITUTE PACIFIC NORTHWEST LABORATORY
BATTELLE BOULEVARD, P. O. BOX 999, RICHLAND, WASHINGTON 99352

BNWL-835

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

PRINTED BY/FOR THE U. S. ATOMIC ENERGY COMMISSION

54-1950-015 (4-68)
AEC-RL RICHLAND, WASH

UNCLASSIFIED

BNWL-835
UC-70
Special Distribution

RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT, JULY - DECEMBER, 1967

by

T. H. Essig
Evaluations and Measurements Unit
Environmental Studies Section
ENVIRONMENTAL HEALTH DEPARTMENT

June 5, 1968

UNCLASSIFIED

TABLE OF CONTENTS

RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT

July - December, 1967

INTRODUCTION

The Hanford Project has over 500 wells which are used for the surveillance of radionuclides in the ground water. Some wells are also located at disposal sites to monitor the migration of radionuclides in the soil and to determine when a disposal facility is to be abandoned. Outside of the immediate disposal areas, wells are sampled to determine the movement of contaminants in the ground water zone.

This report is prepared semi-annually to provide an evaluation of the status of ground water contamination resulting from disposal of plant effluents. All ground water samples were analyzed by the Radiological Analysis Unit. The data presented in this report were collected during the last six months of 1967; the preceding report in this series is BNWL-687[1], "Earth Sciences Waste Disposal Investigations, January - June, 1967". Previous reports were prepared by the Hydrogeology Unit and its organizational predecessors. This responsibility has now been assumed by the Evaluations & Measurements Unit. The change in responsibility has been accompanied by changes in report format with the object of putting greater emphasis on potential exposure to people. As a result, the contaminated zones delineated on the groundwater maps show changes which are more apparent than real.

Total beta concentrations in the unconfined and confined ground water aquifers are presented in Tables B and C respectively. Results are tabulated for well-water samples in which the total beta concentration exceeded the analytical limit. The average concentrations for the previous report period are listed for comparison. The locations of wells referred to in this report may be found by referring to the well-location maps published in the latest Hanford Wells document.

EVALUATION OF GROUND WATER SURVEILLANCE DATA

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. The total beta activity is calculated as ^{106}Ru-Rh, since radiochemical analyses have shown that these radionuclides account for most of the radioactivity (other than ^{3}H) in ground water. Other routine groundwater analyses (beyond total β, ^{3}H, and NO_3^-) include total α, ^{90}Sr, and ^{137}Cs which are determined at specific disposal sites (Table A).

Beginning with this report, radionuclide concentrations are evaluated in terms of their respective MPC_w (Maximum Permissible Concentration in Water). It is recognized that the MPC_w is only intended for evaluating radioactivity in drinking water. While recognizing the limitations of the MPC_w values, they

are still considered a rapid, meaningful method of evaluating the radiological significance of water-borne radioactivity. At present no water from the contaminated zone (Figures 1 and 2) is being consumed by humans or is used for irrigation or consumption by cattle. The latter two pathways need to be examined in more detail in the event of such use.

The MPC_W used in this report (10 pCi ^{106}Ru/ml and 3000 pCi ^{3}H/ml) are those which apply to individuals of the general public, i.e. 1/10 of the 168-hr. occupational MPC_W. An evaluation of the radioactivity in groundwater outside of exclusion areas by this method indicated consistently potable water.

Ruthenium-106 Concentrations Beneath the Hanford Project

Ruthenium-106 concentrations are shown in Figure 1 for 2-10%, 10-100%, and >100% MPC_W (1/10 168 hr. occupational). The lowest level shown (2% MPC_W) corresponds to a total beta concentration of 0.2 pCi/ml. This level was chosen because it is immediately above fluctuations in the detection limit; i.e. although a rigorous statistical treatment of count-rate data yields a detection limit of 0.08 pCi/ml, the actual statistical method used yields a detection limit of about twice this value.

An evaluation of total beta concentrations in terms of the ^{106}Ru MPC_W shows a more highly contaminated zone (10-100% MPC_W) extending in a southeasterly direction from 200-E Area, as has been the case in the past.[1] There were few locations which exceeded the MPC_W, all of which were either within 200 E or 200 W Areas. For the most part, the zones of interest could be reasonably well defined. However, inconsistent data were obtained from samples from wells 699-24-1-T, 699-14-E6-I, and 699-S3-E12. There was insufficient evidence from well surveillance data to justify relating these results to 200 E Area effluents.

Tritium Concentrations Beneath the Hanford Project

Tritium concentrations are shown in Figure 2 for zones from the analytical limit (~0.1%) to 10%, 10-50%, 50-100% and >100% MPC_W. The outer boundaries of the two zones shows in Figure 2 represent "lines of detectability", i.e. tritium concentrations in well samples outside of these zones were reported as "less than" values (which varied from 1.5 to about 4 pCi/ml).

An evaluation of tritium concentrations in terms of the ^{3}H MPC_W shows the more highly contaminated zones extending in a southeasterly direction from 200 E Area, as has been the case in the past.[1] As was the case with ^{106}Ru, there were few locations which exceeded the MPC_W, all of which again were within either 200 E or 200 W Areas. Similarly for tritium contaminated zones, there was insufficient evidence from well surveillance data to support connection of the two zones shown in Figure 2 into one continous zone.

CONTAMINATION IN CONFINED AQUIFERS

Total beta concentrations in samples taken at various depths (in some instances from confined aquifers) below the water table are listed in Table C.

Depth sampling in wells and samples taken from specific aquifers over the past years indicate that some radioactive materials possibly are entering the confined aquifers beneath the project. The extent to which waste appears in confined or semi-confined aquifers is difficult to evaluate because of the limited number of points at which these aquifers can be sampled. The maximum six-month average beta activity in well water from a confined zone was 0.36 pCi/ml in well 699-30-31R in a zone 333 feet below the water table. The maximum six-month average tritium activity in well water from a confined zone was 360 pCi/ml at the same location (well 699-30-31R).

GROUND WATER QUALITY

The disposal of wastes to the ground has caused measurable changes in ground water quality near disposal sites. 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 D shows concentrations of radioactive and non-radioactive materials in the ground water near disposal sites and down-gradient from the sites. Concentrations of the non-radioactive materials in the ground water are below the Public Health Service recommended drinking water limits except for nitrate which is above the recommended 45 ppm (NO_3^-) limit in several wells.

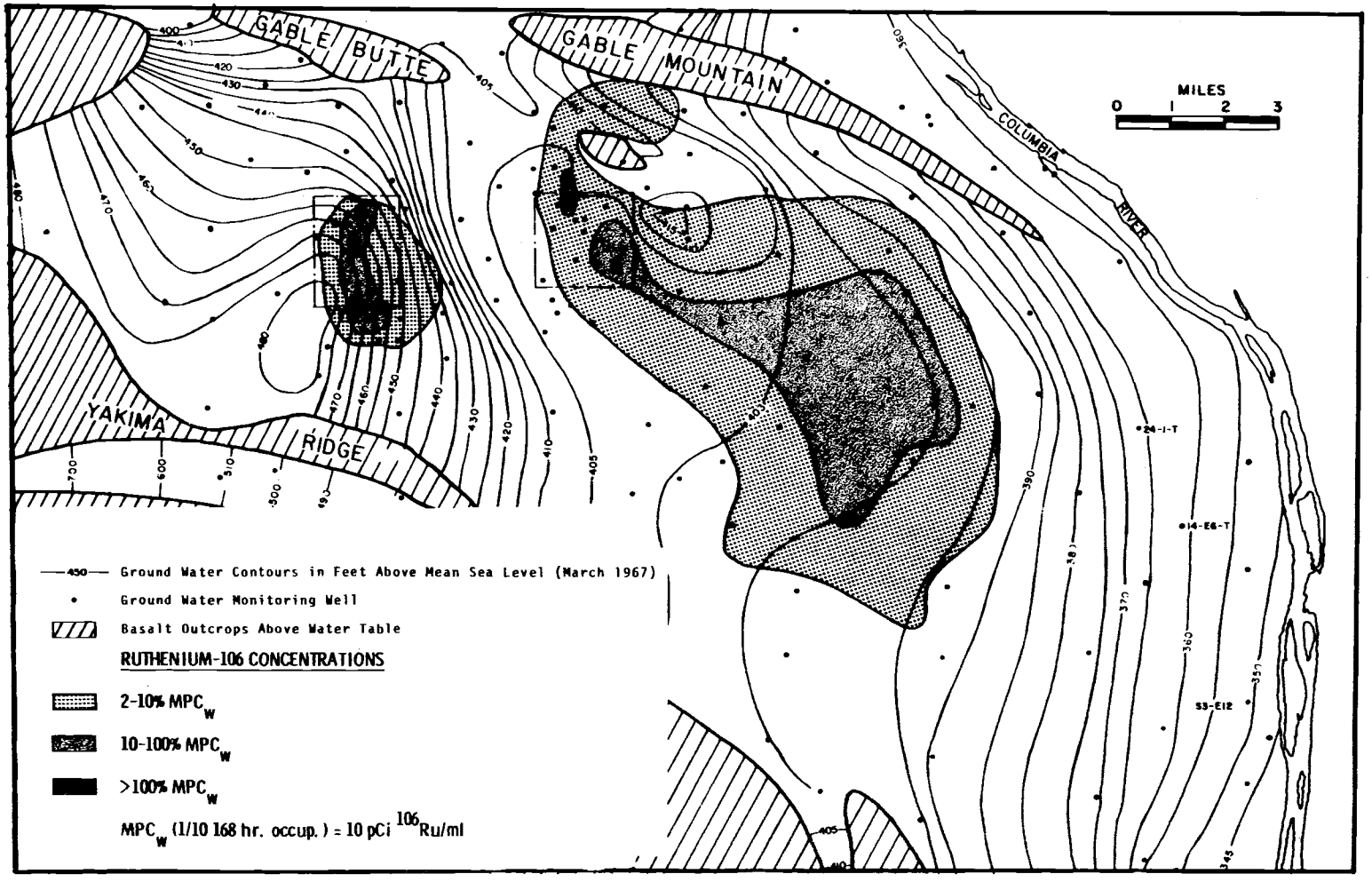

FIGURE 1
Ruthenium-106 Concentrations Beneath the Hanford Project

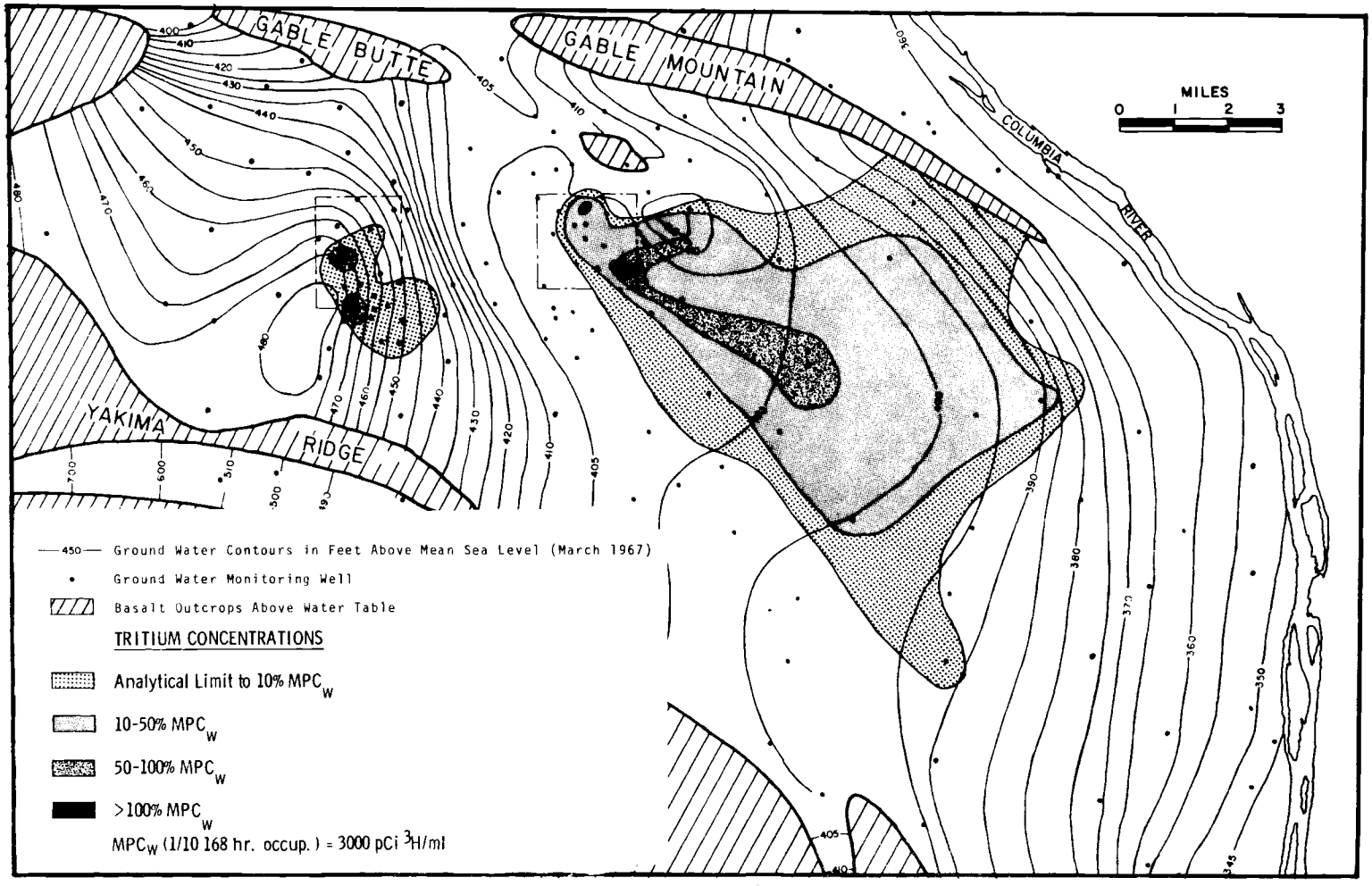

FIGURE 2
Tritium Concentrations Beneath the Hanford Project

REFERENCES

1. J. R. Eliason, "Earth Sciences Waste Disposal Investigations, January-June, 1967", BNWL-687. December 27, 1967

2. R. C. Newcomb and J. R. Strand, "Geology and Ground Water Characteristics of the Hanford Reservation of the Atomic Energy Commission, Washington", USGS-W-P-8. December, 1953.

TABLE A

Activity in the Ground Water at Major Disposal Sites
From Wells Having the Highest Activity Level at Each Site

Crib	Waste	Well # (299-)	Average Conc. (pCi/ml), July-Dec., 1967 Total β	Total α	^{60}Co	^{90}Sr	^{137}Cs
Analytical Limit**			0.02	0.02		0.02	
Purex							
216-A-9	N Reactor*	E24-4	0.36	-	0.15	-	<0.55
216-A-10	Process Cond.	E24-2	29	-	0.14	-	<0.55
216-A-24	Tank Farm Cond.	E26-5	0.50	-	<0.11	-	<0.58
216-A-27	Lab. & Stacks	E17-3	15	-	0.23	-	<0.62
216-A-30	Steam Cond.	E16-2	0.99	-	<0.11	-	<0.58
216-A-31	Organic Waste	E24-9	23	-	0.13	-	<0.54
216-A-36B	Scrubber Waste	E17-5	31	-	0.16	-	<0.55
B Plant							
216-B-12	Process Cond.	E28-9	-	-	NA	-	NA
216-B-50	Cond. from ITS#1	E33-4	17	-	12	-	<0.55
216-B-55	Steam Cond.	E28-12	0.52	-	<0.01	0.02	<0.56
Redox							
216-S-6	Steam Cond.	W26-3	6.8	-	<0.06	-	<0.54
216-S-9	Process Cond.	W22-26	14,000	-	<22	-	<0.47
216-S-20	Lab. Wastes	W22-20	0.40	-	<0.11	-	<0.47
216-S-21	Tank Farm Cond.	W23-4	0.38	0.25	<0.11	-	<0.47
T Plant							
216-T-19	Evaporator Cond.	W15-4	4.1	-	<0.06	-	<0.41
216-T-34	300 Area Waste	W11-15	9.3	-	<0.08	-	<0.55
216-T-35	300 Area Waste	W11-18	64	-	<0.11	-	<0.55
216-T-36	Decon. Facility	W10-2	1.6	0.12	<0.05	-	<0.50
U Plant							
216-U-12	Process Cond.	W22-22	24	-	<0.11	-	<0.46
Z Plant							
216-Z-12	Pro. & Lab. Waste	W18-4	17	-	<0.08	-	<0.52

NA - Not analyzed.

* The 216-A-9 Crib formerly received wastes from the Purex plant.

** A (-) indicates that the concentration was less than the analytical limit. No analytical limits are listed for ^{60}Co and ^{137}Cs because, although such limits can be established, they fluctuate over a wide range with the background count rates.

TABLE B

Total Beta Activity in Unconfined Ground Water
(in units of pCiβ/ml)

Well No.	July - December, 1967 Avg. Conc.	Max. Conc.	Conc. in Latest Sample	Jan - June, 1967 Avg. Conc.
200-E Area				
216-A Disposal Facilities				
299-E16-2	1.0	2.9	0.24	0.17
299-E17-1	14	18	13	33
299-E17-2	12	15	9.9	14
299-E17-3	15	20	18	25
299-E17-4	40	46	32	55
299-E17-5	31	42	33	62
299-E17-6	0.13	0.2	<0.08	0.78
299-E24-2	29	39	39	58
299-E24-4	0.36	0.56	0.37	7.5
299-E24-9	23	40	28	51
299-E25-2	<0.08	0.17	<0.08	4.8
299-E25-3	0.27	0.44	0.21	32
299-E25-5	0.32	0.32	0.32	2.4
299-E25-7	0.52	0.85	0.60	2.0
299-E25-11	0.35	0.68	0.26	1.6
299-E25-12	0.63	1.8	0.15	0.40
299-E26-4	0.23	0.50	0.17	5.5
216-B Disposal Facilities				
299-E27-5	1.0	3.8	0.38	0.5
299-E33-3	12	14	7.7	20
299-E33-18	2.8	3.4	3.4	1.8
216-BC Disposal Facilities				
299-E13-20	0.10	0.14	0.08	0.34
Outside Specific Disposal Sites				
299-E19-1	<0.08	0.08	<0.08	0.09
299-E24-7	<0.08	0.14	<0.08	0.20
299-E28-4	<0.08	0.16	<0.08	0.20

TABLE B (Continued)

Total Beta Activity in Unconfined Ground Water
(in units of pCiβ/ml)

Well No.	July - December, 1967 Avg. Conc.	Max. Conc.	Conc. in Latest Sample	Jan - June, 1967 Avg. Conc.
200-W Area				
216-S Disposal Facilities				
299-W22-1	120	190	190	310
299-W22-14	8.1	16	6.2	17
299-W22-19	0.94	2.2	0.44	12
299-W22-20	0.40	0.58	0.33	2.3
299-W22-21	2.5	120	0.14	4.8
299-W22-25	6,100	19,000	4,500	23,000
299-W22-26	14,000	36,000	34,000	74,000
299-W22-27	470	640	380	420
299-W23-2	0.56	1.7	0.44	0.54
299-W23-3	0.40	1.0	0.16	0.70
299-W23-4	0.38	0.56	0.53	2.4
216-U Disposal Facilities				
299-W21-1	0.13	0.20	0.16	0.10
299-W22-22	24	80	3.6	0.60
216-T Disposal Facilities				
299-W6-1	<0.08	0.15	<0.08	0.20
299-W11-15	9.3	14	12	6.7
299-W11-16	0.20	0.29	0.10	1.1
299-W12-1	0.08	0.24	<0.08	0.13
299-W14-1	61	120	49	310
299-W14-2	1,800	3,900	2,000	4,400
299-W14-3	280	380	190	660
216-Z Disposal Facilities				
299-W15-7	3,200	4,600	4,600	8,400
299-W18-1	0.62	1.5	0.43	0.50
299-W18-5	2.6	2.9	1.5	4.4
600 Area Wells				
699-S12-19	<0.08	0.15	<0.08	0.16
699-S8-19	0.13	0.57	<0.08	0.23
699-S6-E14	<0.08	0.12	<0.08	0.10
699-S3-E12	0.65	2.8	<0.08	0.17

TABLE B (Continued)

Total Beta Activity in Unconfined Ground Water
(in units of pCiβ/ml)

Well No.	July - December, 1967 Avg. Conc.	Max. Conc.	Conc. in Latest Sample	Jan - June, 1967 Avg. Conc.
600 Area Wells				
699-8-17	<0.08	0.19	<0.08	0.23
699-10-E12	0.13	0.25	<0.08	0.70
699-14-E6T	0.74	1.4	<0.08	0.40
699-15-26	1.3	1.5	1.2	1.5
699-19-58	0.10	0.20	<0.08	0.40
699-20-E5T	0.10	0.40	<0.08	0.38
699-20-20	0.27	0.74	0.74	0.30
699-24-1T	0.44	1.2	0.14	0.63
699-24-33	0.49	0.86	0.12	1.2
699-26-15	0.87	3.4	0.75	2.9
699-27-8	<0.08	0.09	<0.08	0.08
699-28-40	0.23	0.35	0.11	0.75
699-29-78	0.14	0.43	<0.08	0.38
699-30-31	3.5	4.7	4.2	5.9
699-31-53B	<0.08	0.12	0.11	0.33
699-31-65	<0.08	<0.08	<0.08	0.34
699-32-62	0.11	0.22	0.14	1.1
699-33-56	0.08	0.13	<0.08	<0.08
699-34-39A	3.0	5.5	5.5	4.4
699-34-38	0.13	0.28	0.11	3.8
699-35-70	0.27	0.33	0.33	0.32
699-36-46R	0.32	0.48	0.30	0.68
699-38-65	<0.08	0.09	<0.08	0.17
699-38-70	<0.08	0.10	<0.08	0.09
699-40-1	<0.08	<0.08	<0.08	<0.08
699-41-23	0.92	2.5	0.72	0.60
699-42-42	0.25	0.33	0.33	2.5
699-44-64	<0.08	0.18	0.18	0.08
699-45-69	<0.08	0.16	<0.08	<0.08
699-47-35	0.12	0.19	0.08	0.11
699-47-46	<0.8	0.25	<0.08	0.43
699-50-53	2.3	3.5	1.5	3.5
699-50-85	<0.08	0.14	<0.08	0.23
699-53-55	0.20	0.56	<0.08	0.43
699-54-57	<0.08	<0.08	<0.08	<0.08
699-55-50A	0.31	0.48	0.17	1.4
699-55-76	0.09	0.32	<0.08	0.08
699-55-89	<0.08	0.14	<0.08	<0.08

Total beta concentrations for other 699 wells were below the analytical limit of 0.08 pCi/ml.

TABLE C

Total Beta Activity in Confined Ground Water
(in units of pCiβ/ml)

Piezometer Tube Designation	Depth Below Water Table (feet)	July - December, 1967			Jan - June 1967
		Avg. Conc.	Max. Conc.	Conc. in Latest Sample	Avg. Conc.
699-S31-1P	141	0.24	0.48	0.14	0.38
699-S18-E2P	168	0.20	0.43	0.14	0.60
699-S14-20P	74	<0.08	0.10	<0.08	0.60
699-S12-29P	84	0.11	0.22	<0.08	0.35
699-S6-E4CP	377	<0.08	0.13	0.13	0.17
699-10-E12P	283	<0.08	0.15	<0.08	0.23
699-20-E12P	260	<0.08	0.17	<0.08	0.22
699-28-40P	313	0.09	0.30	<0.08	0.35
699-30-31P	503	0.12	0.24	0.12	0.23
699-30-31R	333	0.36	0.84	0.15	1.2
699-42-42P	106	0.13	0.41	<0.08	0.20

TABLE D

Ground Water Quality - July-December, 1967

Well No.	Distance From Processing Facility (miles)	Total β (pCi/ml)	Total α (pCi/ml)	pH	$SO_4^=$ (ppm)	NO_3^- (ppm)	Na^+ (ppm)	Ca^{++} (ppm)	Organic (ppm)
200-E Area									
299-E17-1	<1	14	<0.02			120			<0.1
299-E17-2	<1	12	<0.02			87			<0.1
299-E17-5	<1	31	<0.02			200			<0.1
299-E24-2	<1	29	<0.02			300			<0.1
299-E24-9	<1	23	<0.02			480			<0.1
600 Area									
699-36-46R	<1	0.30	<0.02	9.4	16	0.25	4.8	16	<0.1
699-34-39A	2.0	3.0	<0.02	7.5	49	27	32	32	<0.1
699-28-40	2.6	0.23	<0.02	7.3	42	19	20	31	<0.1
699-40-33	3.0	0.08	<0.02	7.6	2.4	<0.1	50	15	<0.1
699-30-31	3.8	3.5	<0.02	7.4	46	25	31	26	<0.1
699-24-33	4.0	0.49	<0.02	7.4	39	5	24	32	<0.1
699-41-23	4.9	0.92	<0.02	7.5	57	35	28	44	<0.1
699-15-26	6.1	1.3	<0.02	7.4	46	41	22	48	<0.1
699-20-20	6.4	0.27	<0.02	7.4	48	48	15	52	<0.1
699-26-15	6.9	0.87	<0.02	8.4	110	19	92	12	<0.1
Columbia River									
Hanford					10	0.30		22	
Average Conc. in Ground Water Prior to Significant Plant Disposal.[3]				7.9	22	2.2	19	29	

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

DISTRIBUTION

Number of Copies

17 ARHCO, Inc.
Richland, Washington 99352

G. E. Backman
D. J. Brown
M. H. Cambell
D. T. Crawley
G. L. Hanson
R. E. Isaacson
L. M. Knights
W. N. Koop
R. W. McCullough
B. J. McMurray
G. C. Oberg
H. C. Rathvon
R. E. Roberts
R. J. Sloat
P. W. Smith
R. E. Tomlinson
File

9 Atomic Energy Commission - Richland Operations Office

A. Brunstad (2)
W. Devine, Jr.
W. E. Lotz
E. B. Jackson (3)
C. L. Robinson
M. W. Tiernan

5 Division of Technical Information Extension

2 AEC, Chicago Patent Group

G. H. Lee
N. K. Sharp

4 Douglas-United Nuclear
Richland, Washington 99352

T. W. Ambrose
C. D. Corbit
R. G. Geier
File

Number of Copies

2 Hanford Environmental Health Foundation

F. E. Adley
D. E. Anderson

40 Battelle-Northwest

R. E. Brown
L. A. Carter
D. B. Cearlock
J. P. Corley
J. R. Eliason
T. H. Essig (15)
R. F. Foster
J. J. Fuquay
B. F. Hajek
R. B. Hall
W. A. Haney
F. E. Holt
J. F. Honstead
W. C. Horton
H. V. Larson
J. M. Nielsen
H. M. Parker
D. W. Pearce
J. R. Raymond
D. D. Tillson
C. J. Touhill
C. M. Unruh
F. W. Woodfield
Technical Information (3)