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BIOPHYSICS SECTION

RADIOLOGICAL SCIENCES DEPARTMENT

RADIOACTIVE CONTAMINATION IN THE ENVIRONS OF THE HANFORD WORKS

FOR THE PERIOD
JULY, AUGUST, SEPTEMBER
1951

December 29, 1951

GENERAL ELECTRIC

NUCLEONICS DIVISION

HANFORD WORKS RICHLAND, WASHINGTON

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Radiological Safety

AEC RESEARCH AND DEVELOPMENT REPORT

RADIOACTIVE CONTAMINATION IN THE ENVIRONS OF THE HANFORD WORKS FOR THE PERIOD JULY, AUGUST, SEPTEMBER, 1951

wo 21141

by

H. J. Paas

December 29, 1951

NUCLEONICS DIVISION
RICHLAND, WASHINGTON

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RADIOACTIVE CONTAMINATION IN THE ENVIRONS OF THE HANFORD WORKS FOR THE PERIOD JULY, AUGUST, SEPTEMBER, 1951

SECTION I - RADIOACTIVE CONTAMINATION IN EFFLUENT GASES:

A significant reduction in the amount of I-131 discharged to the atmosphere occured during the latter part of July after the silver reactors in the off-gas lines of the 200 West Area dissolvers were replaced. Daily emission dropped from an average of 535, 206, and 162 curies/day during the three weeks preceeding the replacement to an average of 7.7, 2.7, and 1.3 curies/day during the three weeks following the replacement. Maximum daily emission from the 200 West Area was 815 curies/day. Daily monitoring indicated about 5 curies of I-131 were emitted from the sand filter with maximum emission from this source on the order of 30 curies. Addition of mercuric salts in concentrations of 1×10^{-3} molar resulted in a 10% decrease in emission thru the sand filter. Daily monitoring at the 200 East Area was inaugurated in September. Results showed that from 10 to 100 curies I-131/day were emitted from this area; regeneration of the reactor during the week of September 15 resulted in a significant decrease in I-131 emission and a reactor efficiency which was comparable to that of the 200 West Area during the latter part of the quarter. Trace quantities of tritium oxide were detected leaving the 105-D and 105-F stacks; maximum measurements showed values on the order of 2×10^{-7} µc/cc with mean values over the three-month period ranging from 2 to 3×10^{-8} µc/cc. Spot measurements for S-35 leaving the pile stacks showed negligible activity from this source.

SECTION II - RADIOACTIVE CONTAMINATION ON VEGETATION:

During July, tha amount of I-131 deposited on vegetation remained at the high levels noted toward the end of the previous quarter. Significant decreases approaching a factor of 10 were observed for this activity around July 25, after the silver reactors were regenerated and replaced. The measurements obtained during the month of September indicated the activity density from I-131 was comparable in magnitude to values obtained during the same period in 1950. Maximum deposition from I-131 was found in an area extending southeast from the 200 West Area gate; the activity density from I-131 averaged over 2.5×10^{-3} µc/gm in a region about ½ mile wide and atleast 3 miles long. Decreases, by a factor of 10 in isolated cases and more normally by a factor of 3 to 4 were observed in the activity density from I-131 on vegetation collected from off-area locations after July 15. During early July, this activity averaged between 2 and 6×10^{-5} µc/cc over an area bounded by Patterson, Dodge, Othello, and Sunnyside. Trace deposition was detected as far east as Kellogg, Idaho, and as far west as Bonneville Dam. Surveys in the Spokane and Bonneville area toward the later part of the quarter showed negligible activity from I-131. Estimated iso-activity maps showing the extent and magnitude of the deposition during each month of the quarter along with tabular summaries for representative sampling locations are included in the text.

SECTION III - RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE:

Average dosage rates as computed from recorded integron readings and detachable "C" type ionization chambers were comparable to previous data. Small decreases in air borne radiation levels near the 200 Areas were associated with the replacement of faulty silver reactors. Maximum radiation levels were detected ½ mile southeast of the 200 East area where the three month average was 3.5 mrep/24 hours. Decreases which in extreme cases approached a factor of 50 were noted in the mean activity density from beta emitters in the atmosphere. Maximum measurements obtained near the 200 West Area during July ranged from 2 to 3.5 $x 10^{-11}$ µc/cc over one week periods. Although trace quantities of alpha emitters were detected at nearly all on-area locations, the average activity density from this source was less than 8×10^{-15} µc/cc at 21 out of 30 locations. The average activity density from I-131 near the 200 Areas decreased by a factor of from 2 to 5 during late July and through August; small increases observed during September were associated with meteorological conditions. Maximum concentrations of I-131 were detected in the 200 East Area where the average activity density was 1.9×10^{-9} µc/cc over a one week period. I-131 in air averaged on the order of 10^{-12} µc/cc in residential regions adjacent to the plant. Spot samples obtained during periods of maximum deposition on the ground showed a mean value of 1.6×10^{-8} µc I-131/cc. The number of radioactive particles in the atmosphere showed a general increase by a factor of 2 during July with isolated stations showing increases by factors of 10 to 12. Comparable increases noted at remote locations in Oregon, Washington, Idaho and Montana indicated that the cause for this increase was a source other than the Hanford Works. Detailed summaries of these data are presented in the text.

SECTION IV - RADIOACTIVITY CONTAMINATION IN HANFORD WASTES:

The increase in the activity density from gross beta emitters in the effluent water at the 107 basins noted during the previous period, continued throughout this quarter. The average activity density from this source at the five pile areas ranged from 1 to 1.4×10^{-3} µc/cc with maximum measurements on the order of 5 to 6×10^{-3} µc/cc. Nearly all of the high measurements were obtained during the month of September when mean values ranged from 1.3 to 2.0×10^{-3} µc/cc. Analysis for the alpha emitters of uranium, plutonium, and polonium showed negligible activity from these sources in the pile effluent water. Approximately 0.5 mc of I-131 was discharged from the Biology Farm to the Columbia River daily. The mean activity density from I-131 in biology farm waste was 3.3×10^{-6} µc/cc; this value represented a significant decrease when compared to measurements obtained during the previous quarter. Direct sampling from open waste ponds and ditches in the 200 and 300 areas and subsequent analysis for the activity density from alpha and beta emitters showed no change or trend compared to previous measurements. Tabular summaries of these analysis are presented in the text.

SECTION V - RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER:

A significant decrease in the flow rate of the Columbia River from 2,665,000 gallons per second on June 27 to 547,000 gallons per second on September 25 caused on over-all increase in the activity density of gross beta emitters at monitoring locations in the Columbia River during this period. Maximum activity prevailed immediately below the 100-F area and in the vicinity of the Hanford Ferry; average values in this region were on the order of 3 to 4×10^{-6} µc/cc with maximum measurements of 1.1×10^{-3} µc/cc at the Hanford Ferry during September. Samples from Bonneville Dam showed no indication of beta emitters. The activity density from alpha emitters averages less than 5 dis/min/liter at all monitoring locations on the river. The results obtained from the analysis of mud samples for the activity density of alpha and beta emitters were not indicative of any trend or change from previous measurements. Raw water samples obtained at the Hanford areas showed negligible alpha activity although the activity density from beta emitters showed an increase which was associated with the higher activity density of the Columbia River. Maximum activity in raw water was detected at the 100-F area where the three-month average was 2.6×10^{-7} µc/cc including one measurement of 9.0×10^{-7} µc/cc.

SECTION VI - RADIOACTIVE CONTAMINATION IN RAIN:

The activity density from gross beta emitters in rain collected in the 200 West Area was about 10 to 20 times greater than that detected during the previous quarter; increases by a factor of 5 to 10 were noted when analyzing samples from residential areas and perimeter locations. I-131 was the predominant contaminant, accounting for about 80% of the total activity detected.

SECTION VII - RADIOACTIVE CONTAMINATION IN DRINKING WATER SUPPLIES AND TEST WELLS:

Trace quantities of alpha emitters, identified as uranium, were detected in the Benton City and Richland wells. The activity density from beta emitters in drinking water averaged less than 5×10^{-8} μc/cc at all locations except those which depend on the Columbia River for their supply. Small increases in the activity measured at the later locations was attributed to the lower flow rate of the river during the quarter.

[redacted]

SECTION I

RADIOACTIVE CONTAMINATION IN EFFLUENT GASES

200 AREAS:

The amount of I-131 discharged to the atmosphere from the separations and dissolving processes in the 200 Areas was measured by obtaining samples from the 50' level of the stacks. The source of the I-131 passing through the stack was determined by measuring the amount passing through the down stream side of the sand filter and then determining the contribution from the dissolving process by difference. Monitoring methods were comparable to those described in previous reports (HW-22313); however, constant monitoring apparatus was employed in the 200 West Area during the major portion of the current period. The majority of samples were collected over a 24 hour period, with some sampling intervals extended to 48 and 72 hours in isolated cases and over week ends. These measurements were obtained throughout the entire period at the 200 West Area and were started routinely on September 7 at the 200 East Area. Monitoring at the latter location included evaluation of the effect of the addition of mercuric salts for the purpose of retaining the radioactive I-131 in solution during subsequent separation processes.

200 WEST AREA

A summary of the results obtained from monitoring the 200 West stack are presented in Table I.

TABLE I
SUMMARY OF RESULTS FROM STACK MONITORING
200 WEST AREA STACK
JULY, AUGUST, SEPTEMBER
1 9 5 1

Month	Curies of I-131 Dissolved per 24 hrs Maximum	Average	Curies I-131 Emitted Daily Maximum	Average	Curies Emitted Through Sand Filter Daily Maximum	Average
July	3133	1178	815	232	12	3.7
Aug.	3584	1431	12	3.0	2.6	0.1
Sept. (1)	3219	1194	20	7.8	28.5	8.2

A significant reduction in the amount of I-131 discharged to the atmosphere during the latter part of July was a result of the replacement of the silver reactors in the off gas lines from the dissolvers. The reactor from cell 4-5L was replaced on July 13 and 3-5R was replaced on July 24. A comparison of measurements obtained during the 3 weeks previous to the reactor replacement with similar measurements obtained immediately after the new reactors were employed indicated that the daily emission dropped from an average of 535, 206, and 162 curies/day to 7.7, 2.7, and 1.3 curies/day. The latter value represents the daily emission during the week ending August 11, 1951. Maximum daily emission previous to replacement was 815 curies/day as compared with a maximum emission of 12.0 curies/day during the 3 weeks following the installation of new reactors. Measurements obtained through the remainder of August and September indicated that the average daily emission remained on the order of 1.0 to 15 curies with maximum emission of 20 curies/day in an isolated case during the latter part of September. The daily emission after July 24 represented a highly significant reduction when compared to measurements during the previous quarter, whereas the data obtained during the early part of July represented values which were

(1) Discrepancy between total emission and sand filter emission during September was due to difference in periods covered by each type of monitoring.

comparable to those found during the latter part of the previous quarter. It is interesting to note that the cooling period of the irradiated metal remained relatively constant throughout the 3 month period; the range of the interval was 38 to 50 days with a average on the order of 43 days.

Monitoring at the downstream side of the sand filter indicated that an average of from 4 to 7 curies/day came from this source during the early part of July. On July 17 a program designed to hold the I-131 in solution and reduce the amount of I-131 emitted via the ventilation air and sand filter was innaugurated by adding mercuric salts to the dissolver cells after metal dissolution had ceased. A mercuric concentration of 1×10^{-3} molar was added during the initial tests and caused the emission through the sand filter to drop to approximately 10 percent of the previous monthly average daily emission. Daily emission through the sand filter ranged from 0.05 curies to 0.6 curies during the period when the 1×10^{-3} molar concentration was used. On August 27 the concentration of mercury was reduced to 1×10^{-4} molar and as a result the I-131 emitted through the sand filter increased to a value on the order of magnitude to that found when no mercury was added.

A graph showing the week to week trend of the measurements preformed at the 200 West Area is presented in Figure I. The trend of the average cooling period along with the calculated amount of I-131 available in the dissolution process is included for comparison.

200 EAST AREA

Table II summarizes the results obtained from the stack monitoring program at the 200 East Area.

TABLE II
SUMMARY OF I-131 MEASUREMENTS AT 200 EAST (2)
MAXIMUM AND AVERAGE DAILY EMISSION BY WEEKS

Week Ending		Cooling Times (Days)	Calculated I-131 Dissolved (Curies/24 hr)	I-131 Emitted per day (Curies/24 hours) Stack	I-131 Emitted per day (Curies/24 hours) Sand Filter	Percent of Dissolved I-131 Emitted Stack	Percent of Dissolved I-131 Emitted Sand Filter
Sept. 8, 1951	Ave.	48	1049	135.2	0.77	12.9	0.07
Sept. 15, 1951							
	Ave.	63	216	58.4	0.68	47.0	1.1
	Max.	53*	482	105	1.66	73.7	3.15
Sept. 22, 1951							
	Ave.	42	1894	18.3	7.02	1.38	0.41
	Max.	41*	3046	22.3	12.6	3.65	0.70

* Indicates the minimum cooling period which effectively represents the maximum available I-131.

Although the monitoring program at the 200 East Area represents only the condition during the latter part of the quarter, the preliminary measurements indicate that the daily emission from the 200 East Area stack is considerably higher than that found at the 200 West Area. The measurements also show that the amount of I-131 passing through the sand filter in the 200 East Area was comparable to that found in the 200 West Area and thereby indicates that the efficiency of the 200 East Area reactors was not as great as that in the 200 West Area during the latter part of the quarter. The high results obtained during the week ending September 8 were due to reactor failure in the 4-5L line. Regeneration of the reactor on the week end of September 15 resulted in a significant

(2) The calculated amount of I-131 dissolved represents mean value for entire week and the emission figures represent values obtained for monitoring periods only.

[redacted]

reduction in the emission from this source and if these data were isolated from the over all average, the efficiency of the regenerated reactor would be comparable to that of a replaced sliver reactor.

The monitoring facilities currently employed at the 200 East Area will be continued in a manner and at a frequency comparable to that currently observed in the 200 West Area.

REDOX AREA

Considerable effort during the period was devoted to the design and installation recommendations for adequate sampling facilities at the Redox Area. Facilities are being provided for monitoring all known sources which may contribute to the atmospheric activity.

100 AREAS

The program inaugurated during the previous quarter to determine the activity density of tritium oxide in the atmosphere at environmental locations was enlarged to include monitoring at perimeter locations and construction areas located in the vicinity of the 100-B and 100-C Areas. Aerosol concentrations were evaluated by propelling an air flow of 0.5 to 1.0 cfm through a cylindrical metal container containing dehydrated silica gel. The activity density of the oxide was determined according to standard laboratory procedures and techniques (HW 20136.) A total of 871 samples were collected from 18 representative locations during the 3 month period. Table III summarizes the results obtained from these determinations. A map showing the locations at which the monitoring equipment was operated is presented in Figure 2.

TABLE III

SUMMARY OF TRITIUM OXIDE MEASUREMENTS
JULY AUGUST SEPTEMBER
1 9 5 1

Location	ACTIVITY DENSITY x 10^9 μc/cc July Average	August Average	September Average	Quarter Average	Maximum Measurement	Date Measured
Pistol Range	7	6	5	6	77	8/16
105-F Stack	9	26	37	26	180	8/16
White Bluffs	10	7	<5	7	94	6/28
105-D Stack	26	24	53	34	200	8/9
100-D SE	5	9	<5	6	130	8/16
Richland	8	7	<5	<5	48	7/23
Riverland	6	11	12	9	29	8/20
C. Area #1	*	5	<5	<5	25	8/17
C Area #2	*	7	<5	<5	61	8/12
C Area #4	*	7	<5	6	34	8/26
100-B 614 SW	*	6	<5	<5	34	8/3
100-B 614 SE	*	6	<5	<5	46	8/16
100-B 614 NE	*	<5	<5	<5	27	7/25
151-B NE corner	*	7	8	7	22	8/20
183 B SE corner	*	<5	<5	<5	14	8/16
1701 B Main Gate	*	7	<5	<5	48	8/16
107-B Inlet End	*	6	<5	<5	34	8/20
131-B Roof	*	7	<5	<5	46	8/16

* Monitoring facilities were not extablished at these locations during July.

A review of the data summarized above indicates very little change or trend occuring during the period. In general, the activity density averaged less than 5×10^{-9} μc/cc at nearly all outside monitoring locations; trace quantities of tritium oxide were detected in the 105-D and 105-F stacks throughout the entire period. The magnitude of the latter measurements was comparable to preliminary results obtained during June when the concentration was on the order of 2×10^{-8} μc/cc.

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One hundred and thirty-nine samples obtained from the 105-D and 105-F Areas were analyzed for the activity density of S-35. Only three of these samples showed detectable activity from this source (detection limit arbitrarily established at 5 c/m.) Two samples from 105-D collected on August 11 and September 5 showed 4.5 and 1.6 x 10^{-10} $\mu c/cc$, respectively. One sample from 105-F obtained on September 15 indicated a value of 1.1 x 10^{-10} $\mu c/cc$.

The activity density from C-14 admitted to the atmosphere was measured at the 105-D and 105-F stacks. Sixteen out of one hundred and twenty-three samples showed detectable quantities of this activity; average values for the positive measurements ranged from 7.0 x 10^{-10} $\mu c/cc$ to 1.3 x 10^{-8} $\mu c/cc$; the latter value was exceptionally high as the majority of the positive samples ranged from 1.0 x 10^{-9} $\mu c/cc$ to 4.0 x 10^{-9} $\mu c/cc$. Six of the positive values were obtained at the 105-F Area and ten were obtained at the 100-D Area. There was no difference in the number of positive measurements obtained during any month or week during the quarter.

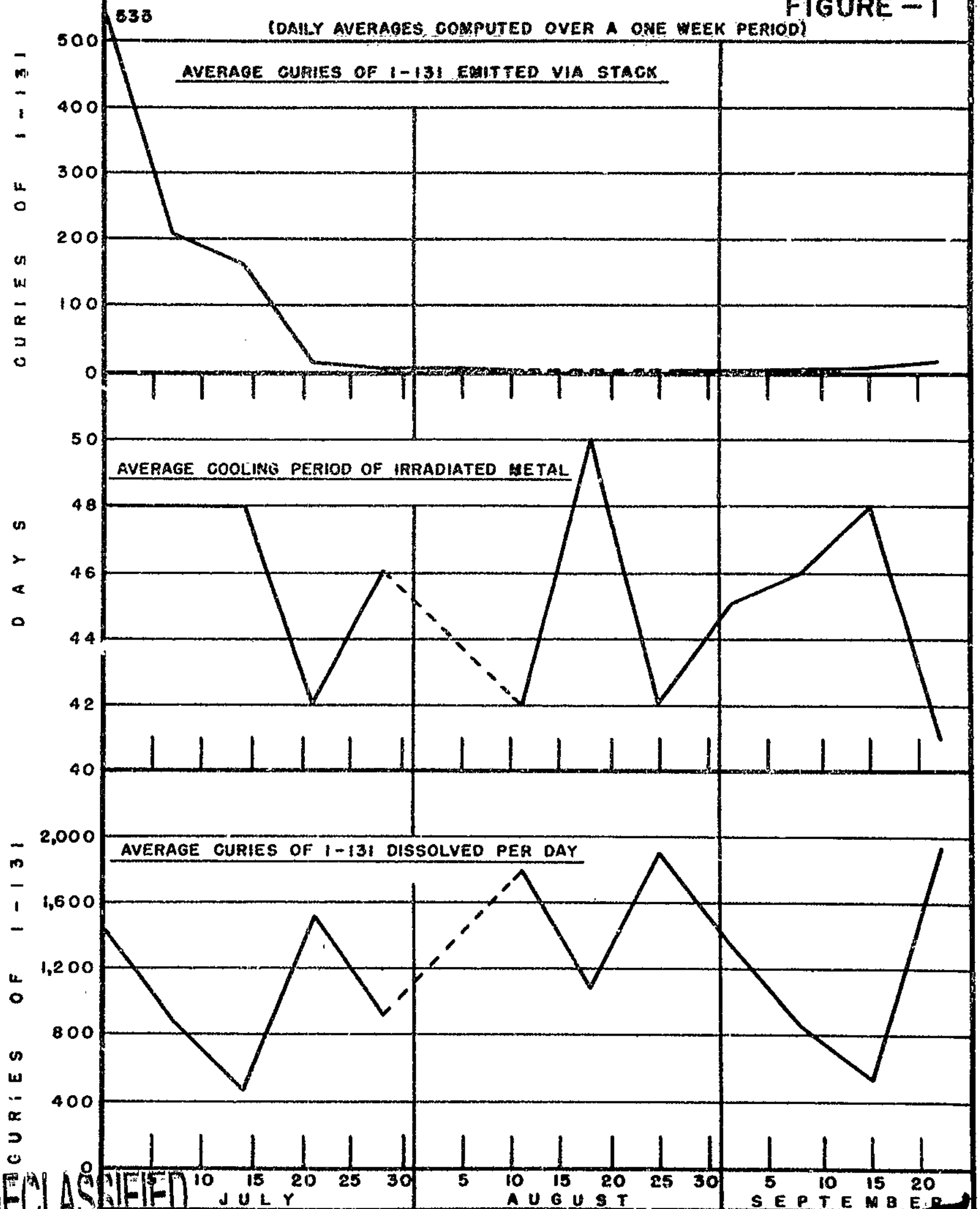
SECTION I

(Please refer to Figure 1 and 2)

STACK MONITORING RESULTS — 200 WEST AREA
JULY, AUGUST, SEPTEMBER, 1951

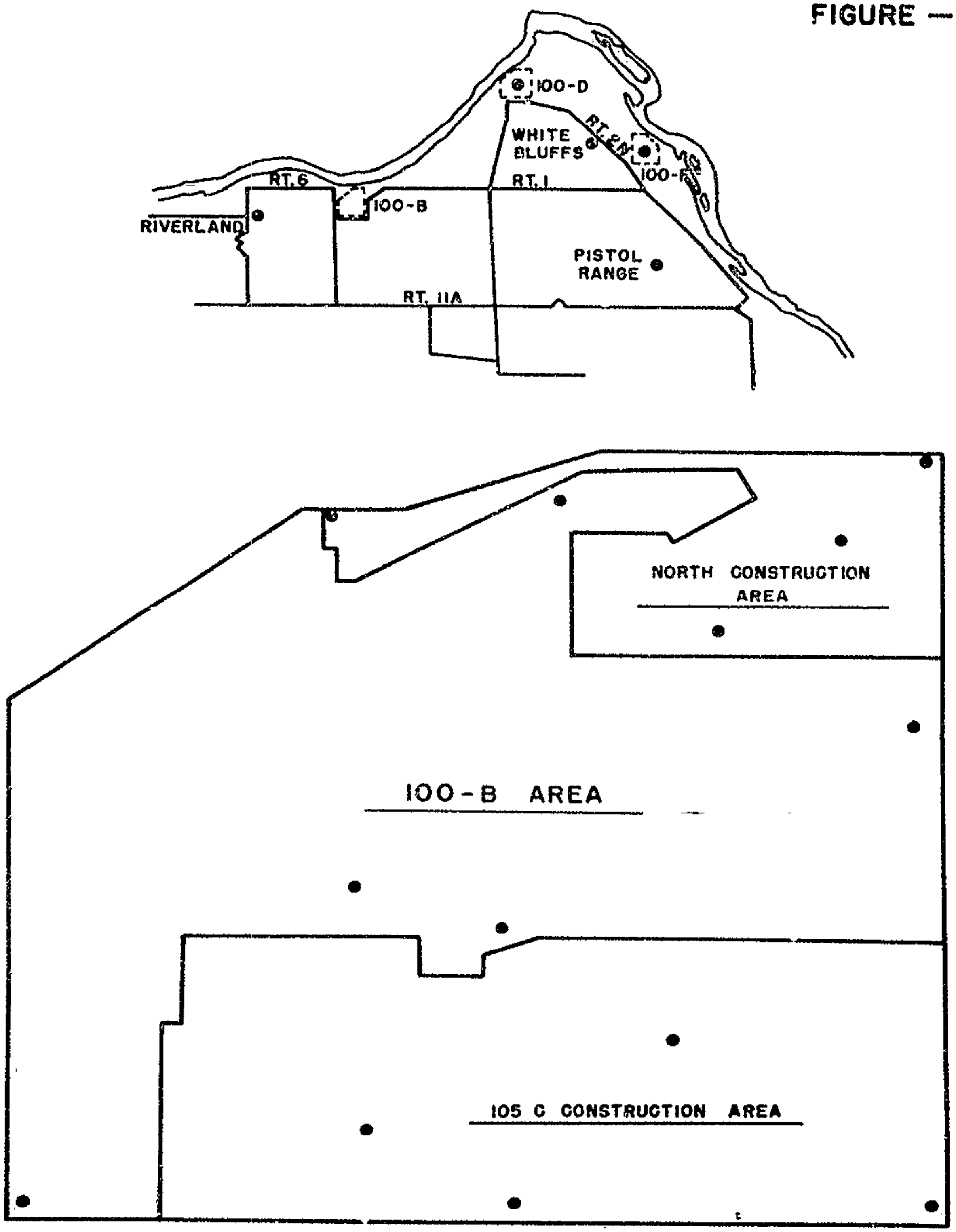
FIGURE — I

(DAILY AVERAGES COMPUTED OVER A ONE WEEK PERIOD)



LOCATIONS OF AIR MONITORING EQUIPMENT USED FOR MEASUREMENT FOR TRITIUM OXIDE

FIGURE — 2



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SECTION II

RADIOACTIVE CONTAMINATION ON VEGETATION

I-131 deposited on vegetation in the environs of Hanford Works was measured by analyzing over 3500 samples of vegetation collected from the region during the three month period. Nearly one-thousand of these samples were collected from locations outside the project perimeter: 2600 samples were obtained from nearby locations and from communities adjacent to the project. A map showing the locations from which the latter samples were obtained may be reviewed in a previous publication of this series. (HW-21214.)

The vegetation samples were analyzed according to standard procedures and techniques (HW-20136) used at the control laboratory. The subsequent counting rates were corrected for counting efficiency, decay, and weight using correction factors normally applied to this calculation (HW-22682.) In addition to the analysis for the activity density from I-131, the majority of samples were also analyzed for activity density from "non-volatile" beta particle emitters which includes the potassium-40, and uranium that occur naturally in vegetation. Several spot samples were also analyzed for the activity density from alpha particle emitters.

A summary of the results obtained from the measurements for the activity density from I-131 is presented in Table I: average values from the previous quarter are included for comparison.

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TABLE I
RADIOACTIVE CONTAMINATION ON VEGETATION
JULY - AUGUST - SEPTEMBER
1 9 5 1

Location	No. Samples	I-131 Activity Density x 10^6 µc/gm Maximum	Average	Previous Average	Non-volatile Activity Density x 10^6 µc/gm Maximum	Average	Previous Average
North of 200 Areas	204	330	26	36	51	15	20
Near the 200 Areas	185	380	87	200	55	20	25
Route 3	13	2100	400	4400	180	33	100
200 West Gate	132	5100	1000	6900	970	120	350
200 East Tower #16	132	2500	220	550	110	27	48
Batch Plant	132	2400	370	1400	200	34	64
Meteorology Tower	13	1200	290	1000	93	33	30
South of 200 Areas	292	3100	53	86	80	16	23
Richland	211	400	29	60	88	16	17
Pasco Sacajawea PK.	76	140	16	44	69	16	20
Kennewick, Kenn. Highlands	117	220	17	32	100	14	14
Benton City - Cobb's Corner	39	540	36	28	42	15	19
Richland "Y"	13	100	14	18	29	15	10
Hanford	25	100	25	54	40	17	16
200 East Area	48	1200	150	250	72	24	25
200 West Area	66	4600	280	5000	250	37	130
Redox Construction Area	88	7600	600	1200	330	48	79
Wahluke Slope	286	600	25	56	36	11	24
Goose Egg Hill	57	2500	140	330	220	24	31
Rattlesnake Mountain	92	150	27	400	33	17	26
PSN - 300 - 310 - 320	33	300	35	80	300	44	29
Adjacent Area Sampling							
Pasco to Ringold	106	310	18	19	23	13	11
Prosser-Patterson-Plymouth							
McNary-Plymouth-Kennewick	246	240	12	20	51	14	15
Benton Gap	140	27	8	14	76	16	16

A comparison of the results summarized in Table I with the results of similar measurements obtained during the previous period (HW-22313) indicate a highly significant decrease, ranging from two to six times, in the amount deposited. The deposition pattern is presented in Figure 3 as an iso-activity map showing the estimated average deposition over the three month period.

A review of independent surveys performed during the three month period shows that the maximum measurements were obtained during the month of July when

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the amount of I-131 emanating from the 200 West Area Stack was exceptionally high due to the failure of the silver reactor in the off-gas line. The high levels experienced during the early part of the quarter were a continuation of an upward trend that started during the early part of May, 1951 and terminated about July 25, 1951 when the reactors were regenerated and/or replaced. The significance of the reduction in the amount of I-131 deposited on vegetation may be appraised by reviewing average values for each of the months during the period: these data are summarized in Table II.

TABLE II
ACTIVITY DENSITY FROM I-131 ON VEGETATION
JULY - AUGUST - SEPTEMBER
1 9 5 1

	Activity Density x 10^6 μc/gm					
	July		August		September	
Location	Maximum	Average	Maximum	Average	Maximum	Average
North of 200 Areas	190	44	110	7	330	24
Near 200 Areas	2300	150	120	19	110	32
Route 3	2100	950	140	62	120	53
200 West Gate	5100	2400	1000	240	180	88
200 East Tower #16	2500	290	340	140	590	240
Batch Plant	2400	930	200	71	59	31
Meteorology Tower	1200	680	140	55	71	40
South of 200 Areas	3100	120	52	9	170	12
Richland	390	68	12	3	24	6
Pasco Environs	140	36	17	4	15	5
Kennewick Environs	220	37	9	<3	16	5
Benton City	540	87	4	<3	17	6
Richland "Y"	100	32	<3	<3	7	4
Hanford	100	35	14	6	81	34
200 East Area	1200	270	150	42	440	140
200 West Area	4600	680	10	<3	120	29
Redox Construction Area	7600	1500	200	48	60	31
Wahluke Slope	600	33	7	<3	270	45
Goose Egg Hill	2500	350	380	71	18	7
Rattlesnake Mountain	150	70	29	4	11	5

In addition to the above summary, estimated iso-activity maps, based on individual values for the months of July, August, and September may be referred to in Figure 4, 5, and 6. Results obtained during the month of September (Figure 6 and Table II) were comparable to levels experienced during the same period during 1950 (HW-20700.)

A detailed survey was conducted on June 30 for the purpose of determining the exact location of the maximum I-131 deposition. Vegetation samples were collected at ½ mile intervals in a 32 square mile area which surrounded the 200 East and 200 West Areas. The maximum activity was found in an elongated area which extended southeast from the 200 West Area gate. This area was about ½ mile wide and atleast 3 miles long. (The southeast extremity of this area of higher deposition was not determined from this survey.) The activity density from I-131 averaged over 2.5×10^{-3} μc/gm in this region with maximum individual samples showing values on the order of 3.5×10^{-2} μc/gm. The latter measurement represented the highest activity detected on vegetation during this quarter. Activity from I-131 exceeded 1.0×10^{-4} μc/gm at all locations in the 32 square mile area and between 5.0×10^{-4} μc/gm and 2.5×10^{-3} μc/gm over approximately 1/3 of the area surveyed. Figure 7 is an estimated iso-activity map showing the deposition pattern based on the results of this survey.

As the above described survey represented the period during the emission of significant quantities of I-131 from the 200 West Area stack, a comparable survey was performed on August 1 when measurements performed at the base of the stack indicated I-131 emission to be normal. The area in which the maximum deposition was observed was in reasonable agreement with that noted in the previous survey, however the magnitude of the activity in the maximum deposition region was lower by a factor of 5 when compared to June 30 results; maximum measurements during the latter survey were on the order of 4 to 5×10^{-4} μc/gm as compared to values exceeding 2.5×10^{-3} μc/gm during the earlier survey. Figure 8 may be referred to as an estimated deposition map based on the results from the August 1 survey.

Decreases, in extreme cases by a factor of 10, but more normally by a factor of 3 to 4 were also observed in the activity density of I-131 measured on vegetation collected from off-area locations after July 15. During the early part of

 [redacted]

July the activity density from I-131 averaged between 2.0 and 6.0 x 10^{-5} μc/cc in the area bounded by Patterson (south), Dodge (east), Othello (north), and Sunnyside (west). Average values ranging between 1.0 and 2.0 x 10^{-5} μc/gm were found in a region extending as far as Lewiston and Kelogg, Idaho; Spokane and Lind, Washington, at this time. Trace deposition (between 5 x 10^{-6} and 1 x 10^{-5} μc/gm was detected along the gorge of the Columbia River between Umatilla, Oregon and Bonneville, Dam. Surveys over most of this same region completed after July 15, showed trace deposition on the order of 5 x 10^{-6} μc/gm in a region bounded by Patterson, Dodge, and Burke. No activity was detected in the Lewiston and Spokane areas and average values obtained from samples collected along the Columbia River gorge between Wallula and Bonneville Dam showed less than 3 x 10^{-6} μc/cc. Surveys extended to locations which were not covered during the early part of July showed the activity density from I-131 to average less than 3 x 10^{-6} μc/cc at Meacham, Oregon; New Meadows, Idaho; and Grangeville, Idaho. Figure 9 and Figure 10 show the estimated deposition pattern from I-131 at off-area locations based on results of the two surveys discussed above. A tabular summary of these results for locations which were sampled during each of the two periods under discussion is presented in Table III.

[redacted]

TABLE III
ACTIVITY DENSITY FROM I-131 ON VEGETATION
OFF AREA LOCATIONS
JULY - AUGUST - SEPTEMBER

units of 10^{-6} µc/cc

Location	Before July 15, 1951		After July 15, 1951	
	Average	Maximum	Average	Maximum
Wallula, Wn.	22	25	<3	<3
Touchet, Wn.	19	26	<3	<3
Lowden, Wn.	12	16	<3	<3
Walla Walla, Wn.	14	18	<3	<3
Dixie, Wn.	28	30	32	33
Waitsburg, Wn.	16	21	<3	<3
Dayton, Wn.	12	17	<3	<3
Dodge, Wn.	18	19	<3	<3
Pomeroy, Wn.	10	16	16	33
Lewiston, Idaho	8	18	<3	3
Union Town, Wn.	14	20	<3	<3
Pullman, Wn.	11	19	<3	<3
Colfax, Wn.	16	22	<3	3
Steptoe, Wn.	16	23	<3	<3
Rosalia, Wn.	8	10	<3	<3
Spangle, Wn.	12	15	<3	<3
Cheney, Wn.	11	15	<3	4
Sprague, Wn.	9	13	4	8
Ritzville, Wn.	14	17	<3	4
Lind, Wn.	16	20	<3	4
Connell, Wn.	20	24	7	10
Union Gap, Wn.	8	14	<3	<3
Wapato, Wn.	11	26	<3	<3
Toppenish, Wn.	10	16	<3	4
Goldendale, Wn.	10	18	<3	<3
Dalles, Ore.	8	10	<3	3
Mosier, Ore.	12	17	<3	<3
Hood River, Ore.	8	12	<3	<3
Bla Lock, Ore.	17	24	<3	<3
Arlington, Ore.	11	13	<3	<3
Heppner Jct., Ore.	12	13	<3	<3
Boardman, Ore.	26	36	<3	<3
Umatilla, Ore.	13	17	6	14
Ellensburg, Wn.	11	18	<3	<3
Zillah, Wn.	16	20	<3	<3
Buena, Wn.	9	12	<3	<3
Yakima, Wn.	9	12	<3	<3
Sunnyside, Wn.	16	30	<3	<3

In addition to measuring the activity density from I-131 on predominant vegetation, spot samples were obtained from various commercial crops and fruits. Detectable quantities of I-131 were found on samples of wheat collected during the latter part of June: samples obtained from Patterson, Ritzville, and Connell showed average values ranging from 8 x 10^{-6} µc/gm to 2.9 x 10^{-5} µc/gm with [redacted] maximum measurements on the order of 3.8×10^{-5} μc/gm in the Patterson Area. Samples of wheat, apricots, hops, grapes, and corn which were collected during July, August, and September showed negligible activity (less than 3×10^{-6} μc/gm) in nearly all cases. Table 4 summarizes the results obtained from analyzing samples of common crops during this period.

TABLE IV
ACTIVITY DENSITY FROM I-131 ON CROPS & FRUITS
JULY - AUGUST - SEPTEMBER
1 9 5 1

Location	Type Sample	Date Sampled	units of 10^{-6} μc/gram Maximum	Average
Connell, Wn.	Wheat	June 28	9	8
Ritzville, Wn.	Wheat	June 28	15	15
Patterson, Wn.	Wheat Stem	June 28	27	23
Patterson, Wn.	Wheat Head	June 28	38	29
4 Mi. So. Prosser	Wheat	July 6		5
9 Mi. So. Prosser	Wheat	July 6		<3
14 Mi. So. Prosser	Wheat	July 6		<3
5 Mi. So. Prosser	Wheat	July 12		<3
Hanford	Apricots	July 20		<3
Rattlesnake Area	Wheat	August 15	<3	<3
Kennewick Highlands	Wheat	August 17	<3	<3
Moxee Valley	Hops	August 30	<3	<3
Hanford Area	Grapes	September 21	3	<3
Prosser Area	Corn	September 28	<3	<3

The majority of samples collected from on-area locations were also analyzed for the activity density from non-volatile emitters. A review of the results obtained from these measurements (summarized in Table I) shows no significant change or trend when comparing current measurements with those obtained during previous periods. Small decreases in this activity were noted near the 200 West Area but were not significant when compared statistically with the over-all data. Small insignificant increases of this activity at random locations as the Military Encampments and the Richland Y were also observed. Spot analysis on some of the samples collected from remote off-area locations showed that the activity density from non-volatile beta emitters was on the order of that expected from the naturally occuring uranium and potassium (1×10^{-5} μc/gm.)

SECTION II

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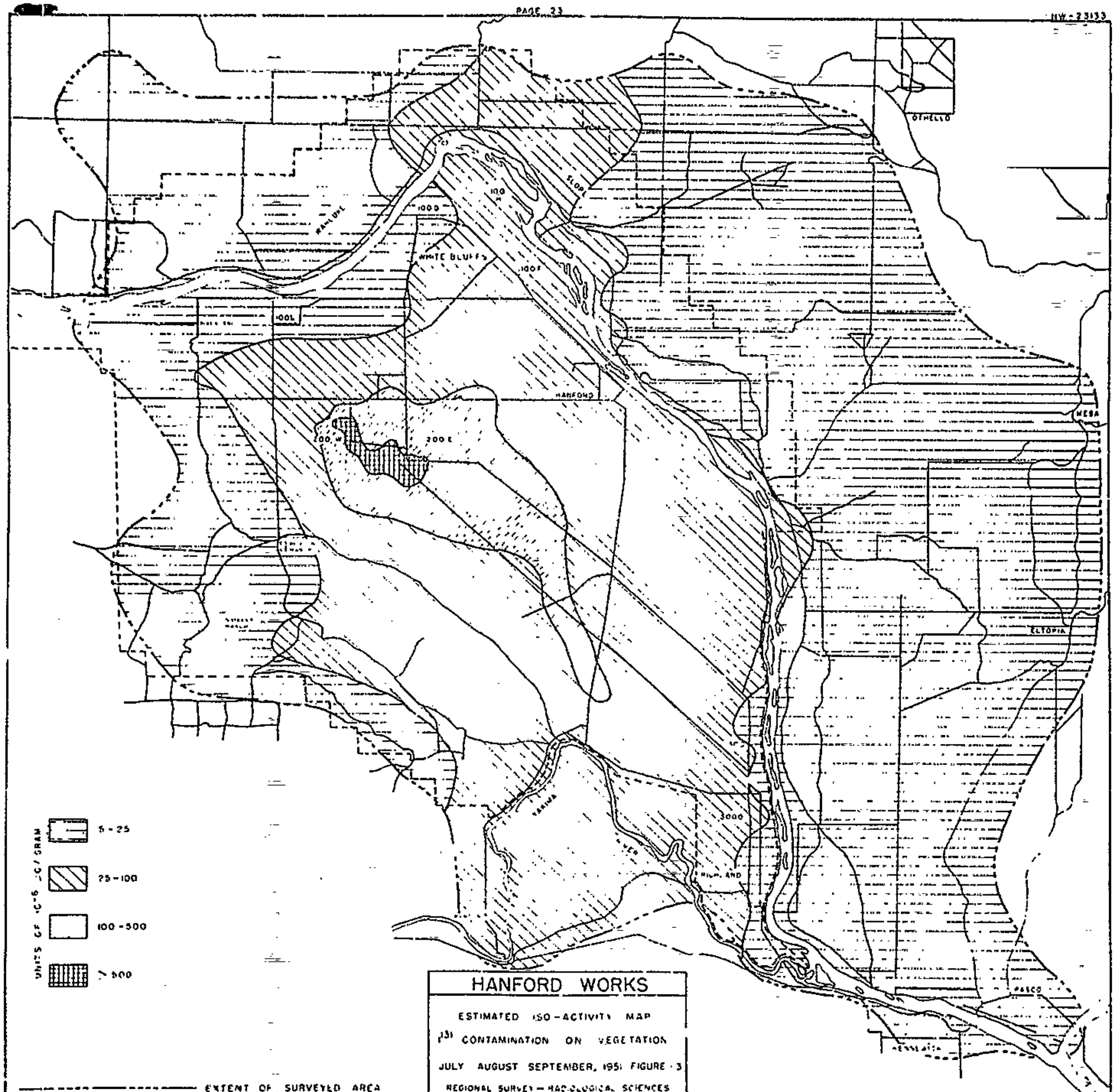


HANFORD WORKS

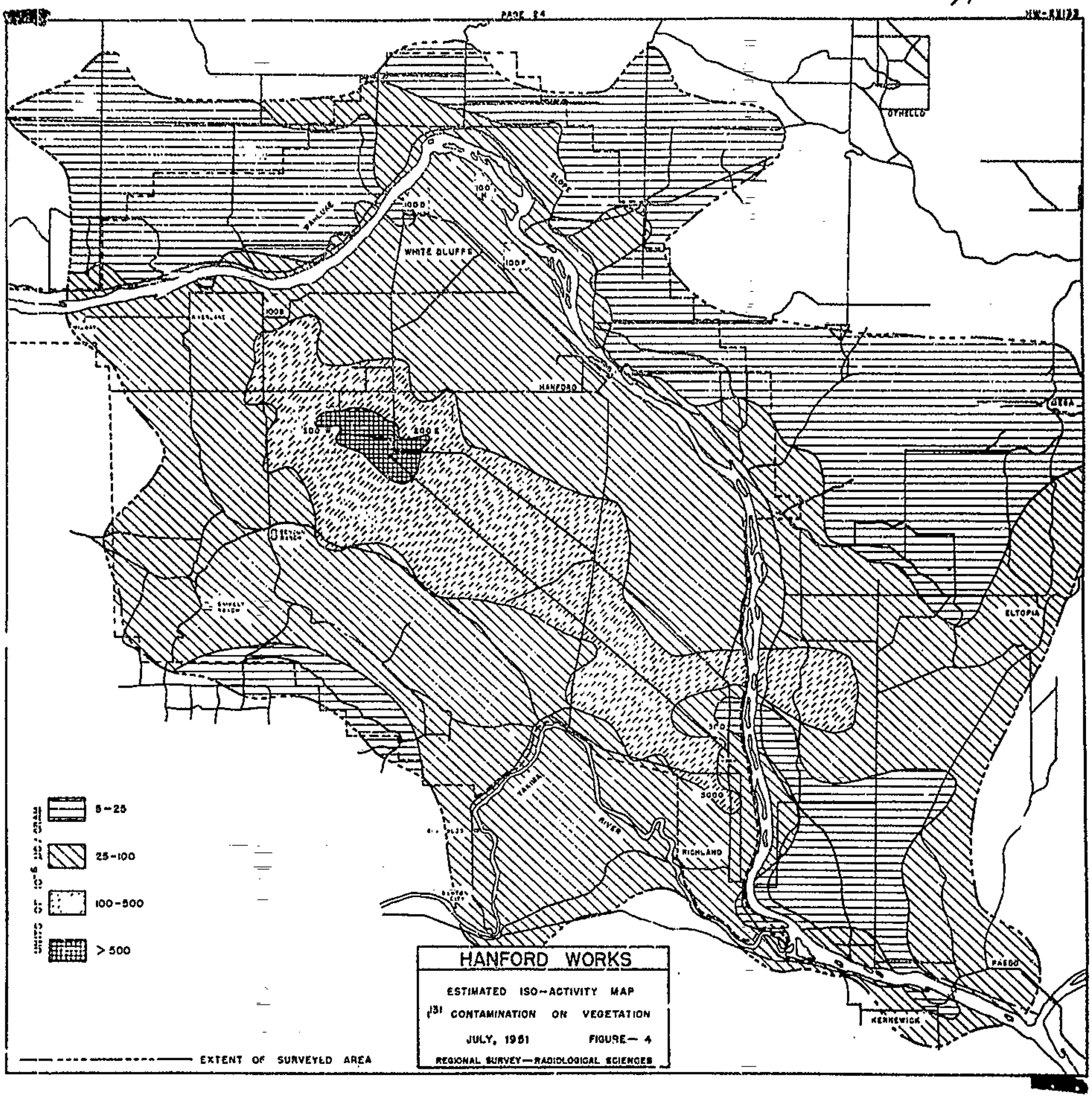
ESTIMATED ISO-ACTIVITY MAP

I^{131} CONTAMINATION ON VEGETATION

JULY AUGUST SEPTEMBER, 1951 FIGURE - 3

REGIONAL SURVEY — RADIOLOGICAL SCIENCES

HW-23133


PAGE 24
OTHELLO
WAHLUKE
SLOPE
100 D
100 H
WHITE BLUFFS
100 F
100 B
HANFORD
200 W
200 E
MESA
ELTOPIA
300
3000
YAKIMA
RIVER
RICHLAND
PASCO
KENNEWICK
5–25
25–100
100–500
> 500
EXTENT OF SURVEYED AREA
HANFORD WORKS
ESTIMATED ISO–ACTIVITY MAP
I131 CONTAMINATION ON VEGETATION
JULY, 1951
FIGURE— 4
REGIONAL SURVEY—RADIOLOGICAL SCIENCES

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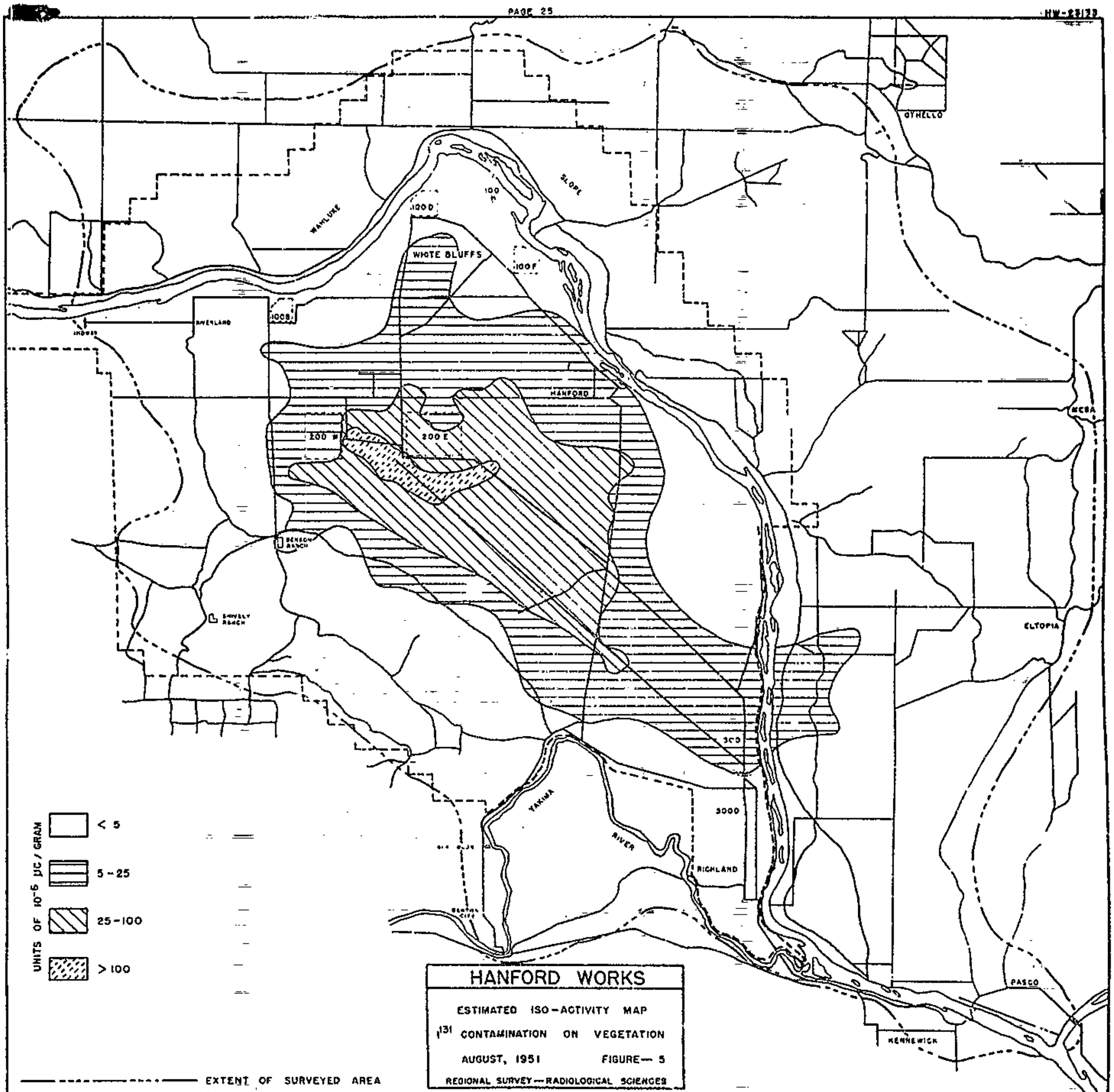
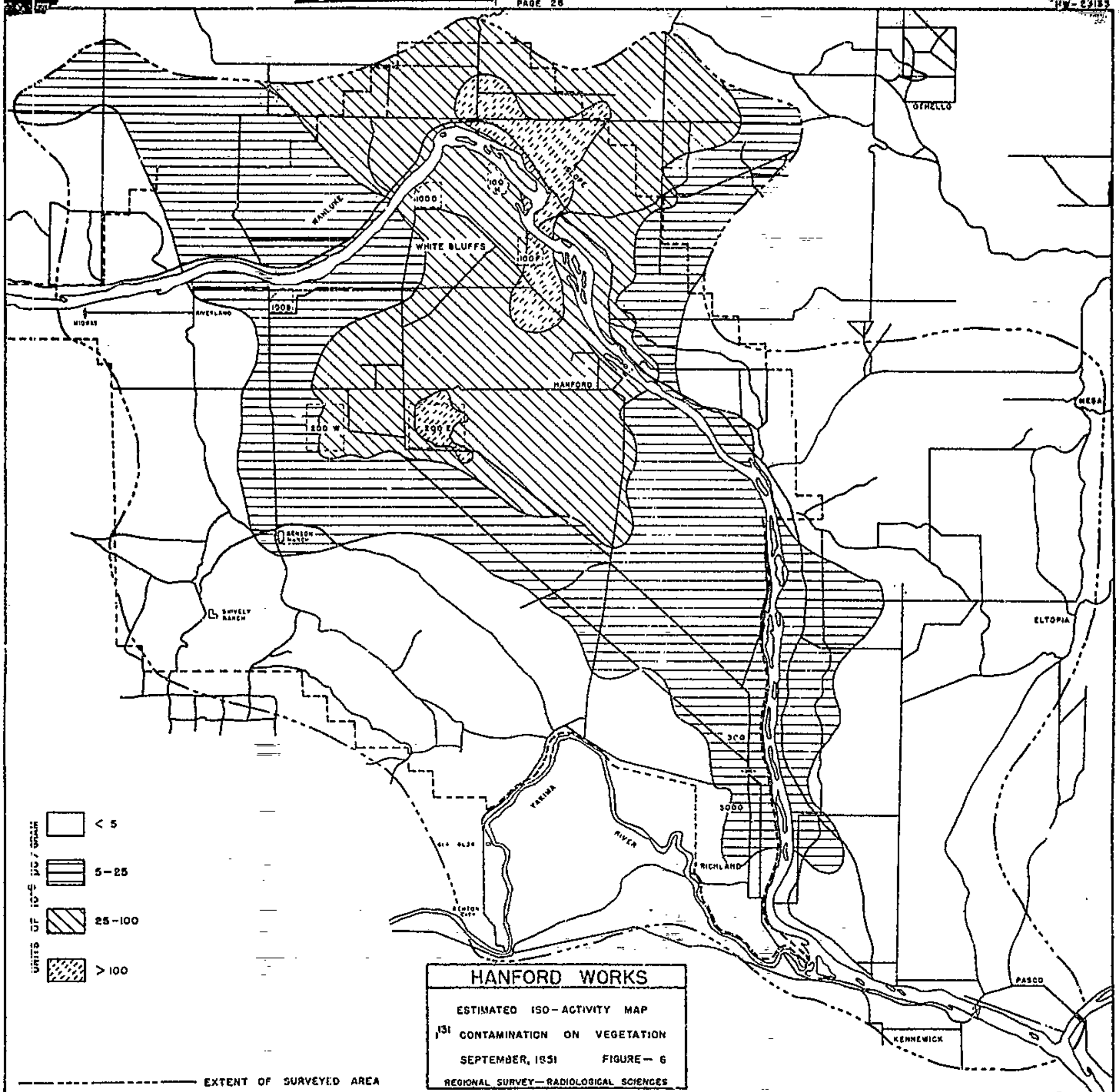
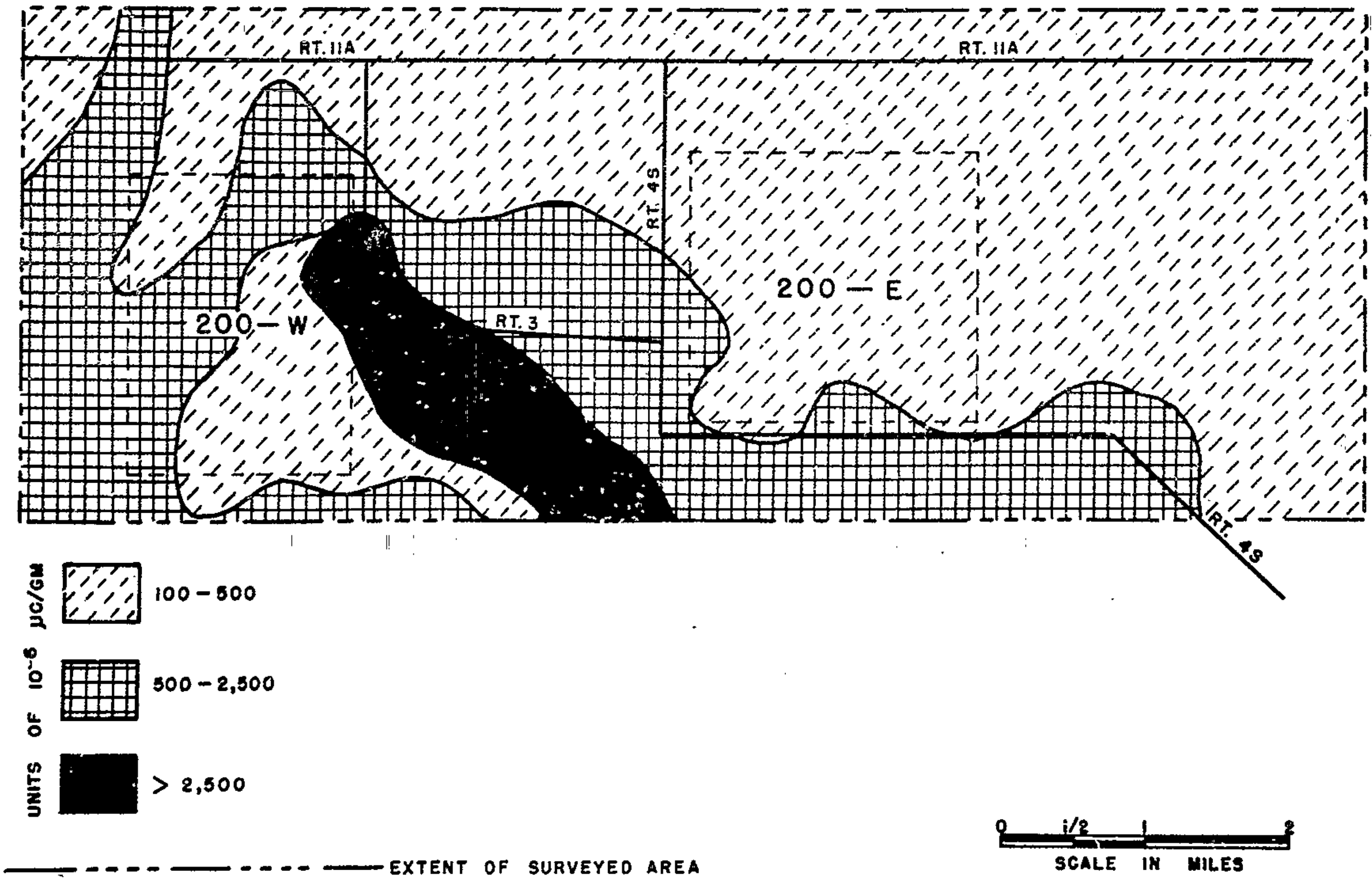



OTHELLO
WAHLUKE
SLOPE
100 H
100 D
WHITE BLUFFS
100 F
100 B
RIVERLAND
MIDWAY
HANFORD
200 W
200 E
BENTON RANCH
SHIVELY RANCH
MESA
ELTOPIA
300
3000
RICHLAND
YAKIMA
RIVER
BENTON CITY
PASCO
KENNEWICK
UNITS OF 10^{-6} µc / GRAM
< 5
5–25
25–100
> 100
EXTENT OF SURVEYED AREA
HANFORD WORKS
ESTIMATED ISO-ACTIVITY MAP
I^{131} CONTAMINATION ON VEGETATION
SEPTEMBER, 1951 FIGURE — 6
REGIONAL SURVEY — RADIOLOGICAL SCIENCES

ACTIVITY DENSITY FROM I-131 ON VEGETATION
IN AND NEAR THE 200 AREAS
JUNE 30, 1951

FIGURE — 7



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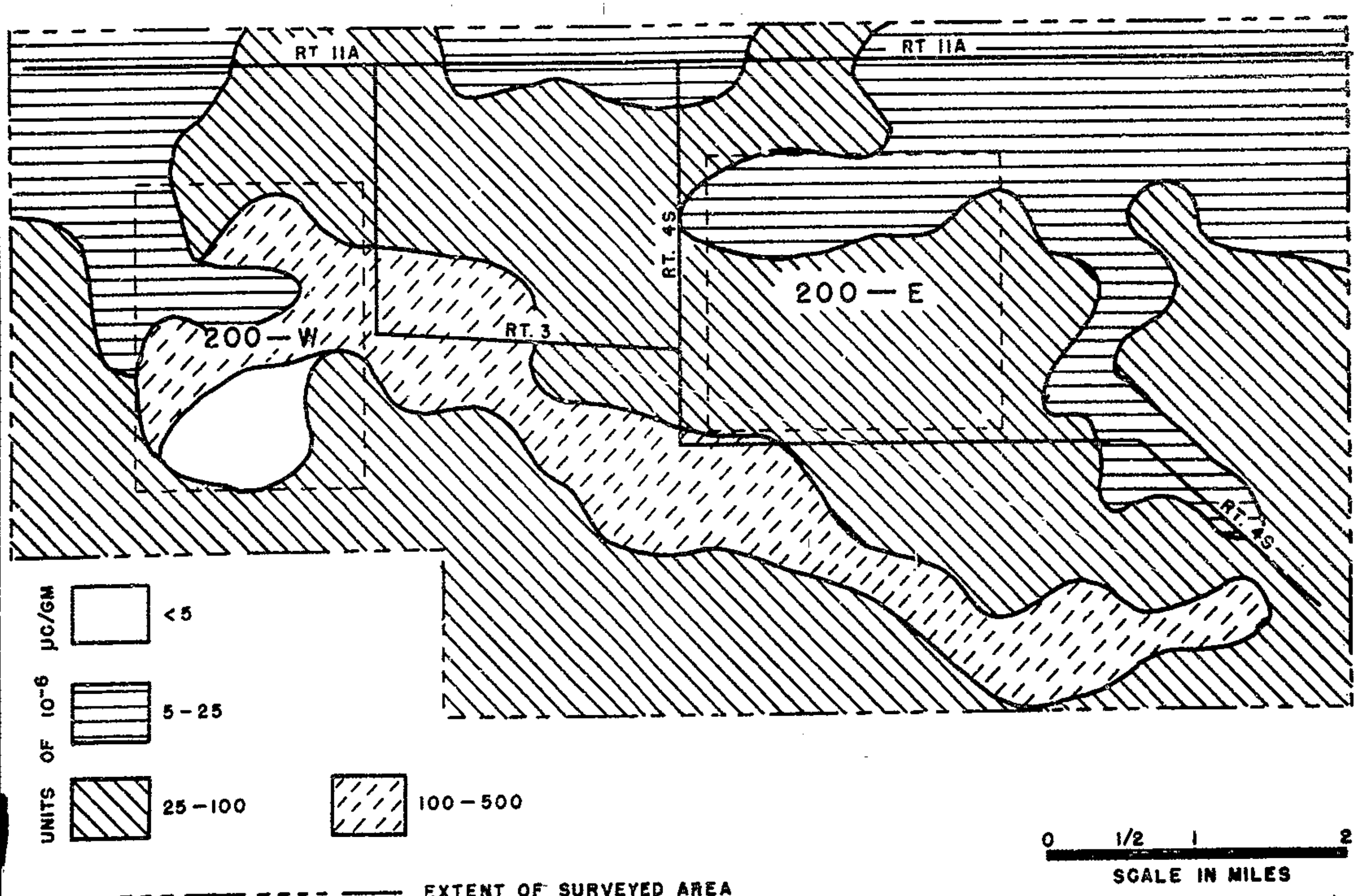
ACTIVITY DENSITY FROM I-131 ON VEGETATION
IN AND NEAR THE 200 AREAS
AUGUST 1, 1951

FIGURE — 8



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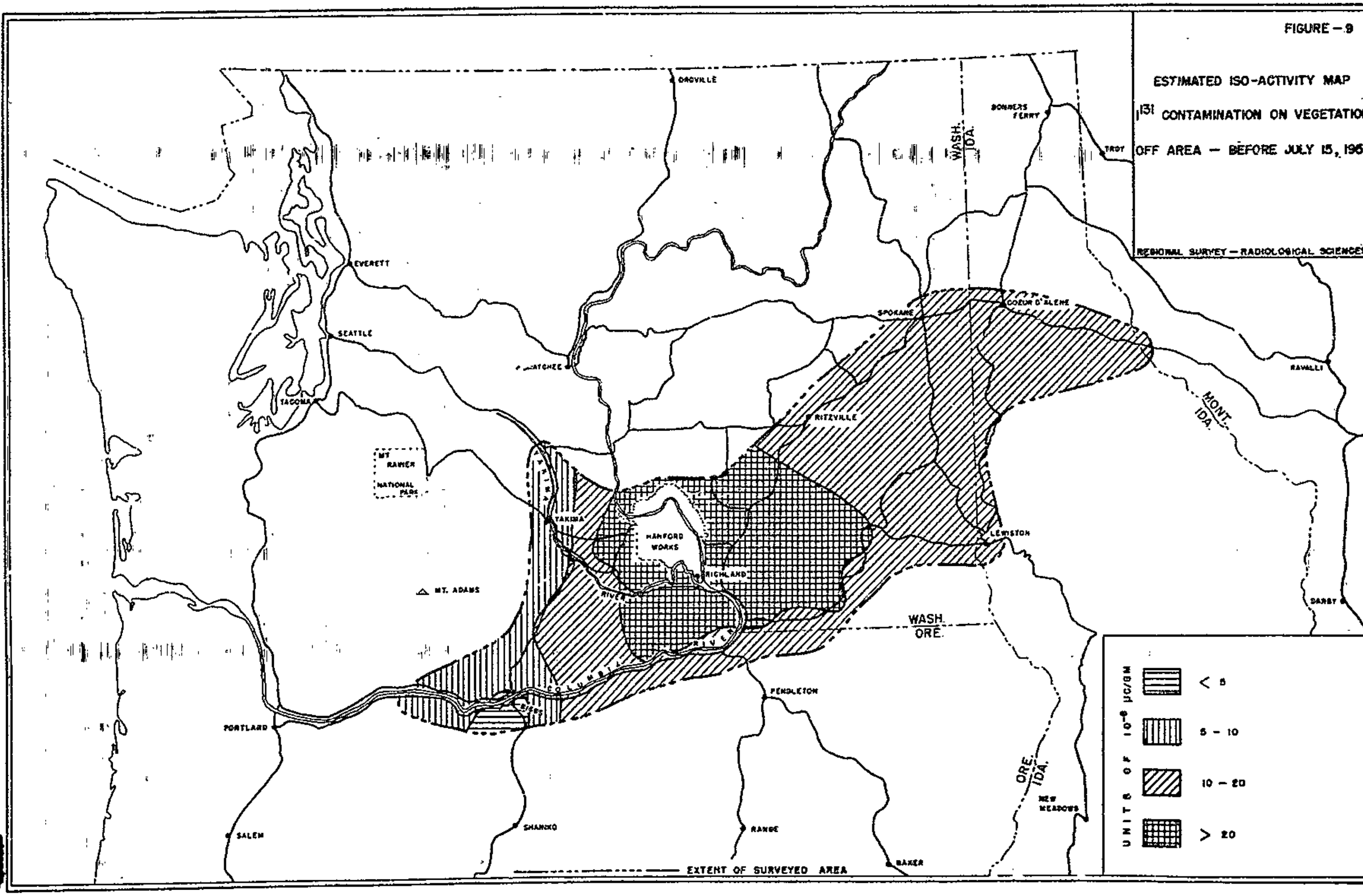

FIGURE – 9

ESTIMATED ISO-ACTIVITY MAP

I^{131} CONTAMINATION ON VEGETATION

OFF AREA – BEFORE JULY 15, 1961

REGIONAL SURVEY – RADIOLOGICAL SCIENCES

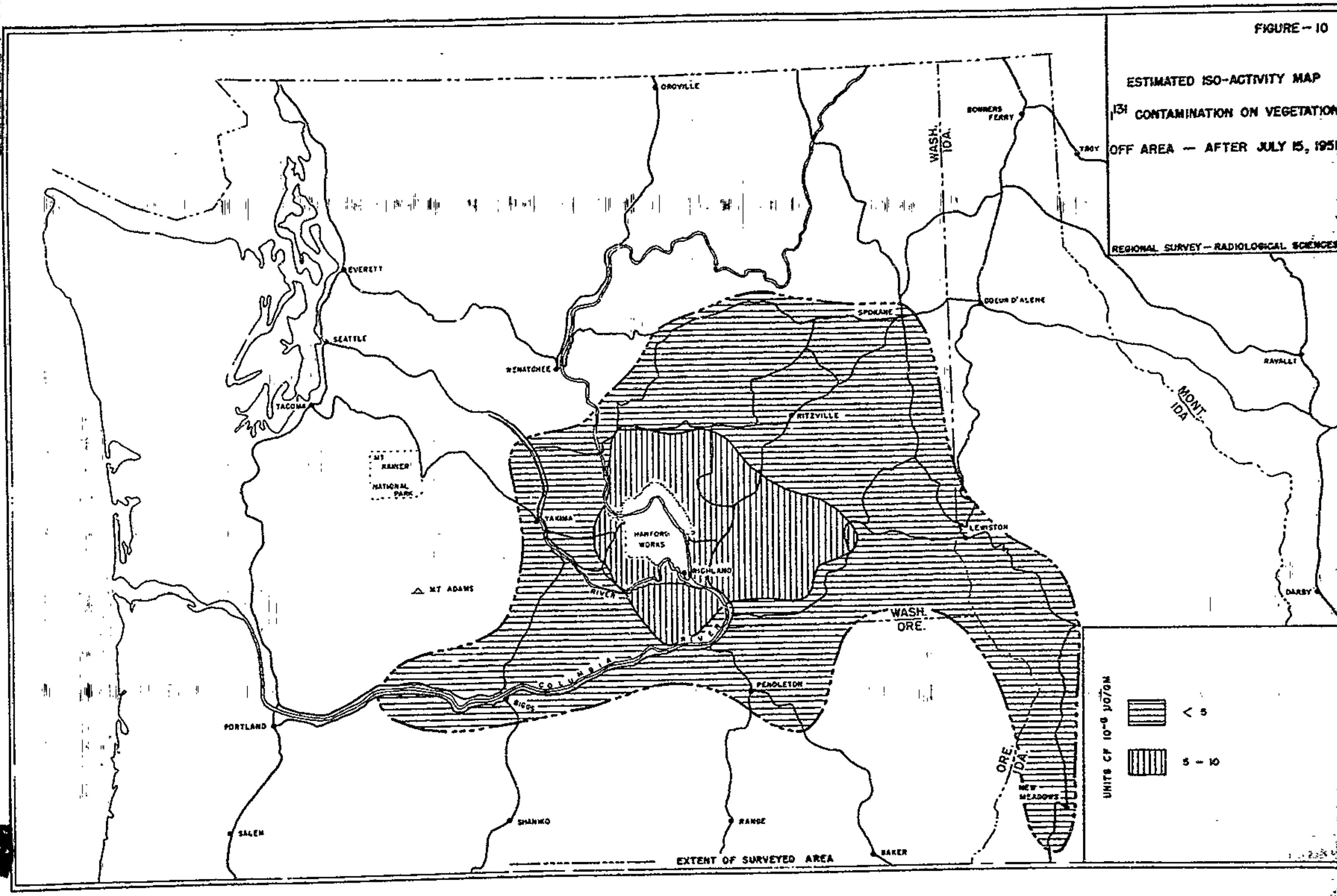

FIGURE – 10

ESTIMATED ISO-ACTIVITY MAP

I^{131} CONTAMINATION ON VEGETATION

OFF AREA — AFTER JULY 15, 1951

REGIONAL SURVEY – RADIOLOGICAL SCIENCES

SECTION III

RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE

Atmospheric radiation dosage rates and magnitude and extent of radioactive contamination in air were determined by evaluating readings obtained from various types of fixed instrumentation and from operating air filters and air scrubbing devices. The bulk of this equipment was operated within the confines of the Hanford Works Project; however, monitoring stations were also operated in the nearby communities of Benton City, Pasco, and Kennewick and at several remote locations in the states of Washington, Oregon, Idaho, and Montana. The latter units were primarily used for determining fluctuations in natural background and identifying activity which may originate from a source other than the Hanford Works. A map showing the location of the air monitoring stations employed in this program may be referred to in a previous publication of this series. (HW 21214.) Results from this monitoring program are discussed separately for each type of equipment in the following paragraphs.

Radiation dosage rates in the immediate environs were computed from recorded readings from Victoreen integrons. These units were located around the perimeter of the various operating areas and in the residential communities of Richland, Benton City, and Pasco. Two or three units were operated near each area and one unit was maintained at the residential locations. Individual readings were obtained for each 8 hour interval throughout the period and the averages as presented in Table I represent the mean dosage rate tabulated from these accumulated readings. (Table I is shown on the following page)

The average dosage rates tabulated in Table I were comparable to similar measurements recorded during 1950 and the early part of 1951. A small decreasing trend was observed at several locations when comparing the individual monthly averages during this period. Higher readings recorded during July were attributed to the large amount of I-131 admitted to the atmosphere from the 200 West Area dissolvers prior to July 24 (refer to Section I.) The radiation levels recorded during July were comparable to those measured during June when the same condition existed at the 200 West Area. Average values recorded during the latter part of the quarter were generally comparable to natural background (0.3 to 0.5 mrep/24 hours) in this region.

Radiation levels were also evaluated at each of the integron stations by exposing "C" type detachable chambers. Two chambers were placed at each location and the reading which indicated the minimum discharge was used to evaluate the radiation level. Results from this monitoring program for the period July, August, and September are presented in Table II.

TABLE I

AVERAGE DOSAGE RATES AS MEASURED BY VICTOREEN INTEGRONS

JULY - AUGUST - SEPTEMBER

1 9 5 1

Units of mrep per 24 hours

Location	No. of units	July	August	September	Quarterly Average
100-B Area	3	0.8	0.4	0.3	0.5
100-D Area	3	0.3	0.3	0.1	0.2
100-F Area	3	0.2	0.2	0.2	0.2
100-H Area	3	0.4	0.5	0.4	0.4
200 West Area	2	0.9	0.4	0.3	0.5
200 East Area	4	0.1	0.1	0.2	0.1
Riverland	1	0.5	0.8	1.1	0.8
300 Area	1	1.0	0.7	0.7	0.8
Richland	1	1.1	1.6	*	1.4
Pasco	1	0.8	0.6	*	0.7
Benton City	1	0.3	0.3	0.3	0.3
North Richland North	1	0.2	0.3	0.5	0.3
North Richland South	1	0.3	0.5	0.6	0.5
Hanford	1	0.2	0.1	0.1	0.1

* Instrument readings at this location were erroneous due to faulty equipment.

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TABLE II
"C" TYPE DETACHABLE IONIZATION CHAMBERS
JULY - AUGUST - SEPTEMBER
1951

mrep per 24 hours

Location	July	August	September	QUARTERLY AVERAGE
Within				
100-B Area	0.3	0.3	0.3	0.3
100-D Area	0.4	0.4	0.4	0.4
100-F Area	0.3	0.3	0.4	0.3
200 West Area	0.8	0.5	0.4	0.6
200 East Area	0.7	0.6	0.7	0.7

The average radiation levels at the stations located at the 100 Areas were nearly identical to those measured during previous periods, and were not indicative of any trend or change during the three month period. A decrease was observed at the 200 West Area where average dosage rates were 0.8 mrep/24 hours during July and 0.4 mrep/24 hours during September. This decrease was apparently caused by a significant reduction in the amount of I-131 discharged to the atmosphere from 200 West Area separations process.

Detachable "M" and "C" type ionization chambers were used at intermediate locations between the Hanford Works operating areas and in the residential communities around the project perimeter to determine the air radiation levels. Two chambers were employed at each location and the minimum readings were utilized in a manner similar to that described for the "C" type chamber. These chambers

TABLE III
RADIATION LEVELS OBSERVED WITH
"M" AND "S" TYPE DETACHABLE IONIZATION CHAMBERS
JULY AUGUST SEPTEMBER
1951

Units of mrep/24 hours

Location	July	August	September	Quarterly Average	Group Average
100 Areas and Environs					
Route 1, Mile 8	0.52	0.53	0.51	0.52	
Route 2N, Mile 10	0.43	0.33	0.47	0.41	
Route 2N, Mile 5	0.36	0.32	0.50	0.39	
At White Bluffs	0.36	0.36	0.51	0.41	
Route 11-A, Mile 1	0.58	0.81	1.08	0.82	
Hanford 614 Bldg.	0.44	0.50	0.41	0.45	0.47
Intersection Rt. 1 & Rt. 4N	0.36	0.35	0.40	0.37	
At Hanford 101 Bldg.	0.39	0.35	0.53	0.42	
100-H Area	0.39	0.40	0.48	0.42	
P-11 Area	0.65	0.34	0.50	0.50	
100-B NE	0.38	0.44	0.58	0.47	
100-B SE	0.41	0.35	0.49	0.42	
Within 5 miles of 200 East Area					
Route 4S, Mile 6	1.24	0.74	1.98	1.32	
Batch Plant	1.73	0.58	0.46	0.92	
Route 11-A, Mile 6	0.92	0.95	0.79	0.89	
Route 3, Mile 1	1.91	1.26	0.67	1.28	
Meteorology 200'	2.47	1.15	1.54	1.72	
Route 4S, Mile 2.5	4.08	1.39	0.81	2.09	
Redox Area	2.16	1.10	1.15	1.47	
Route 4S, Mile 4.5	1.68	1.70	2.28	1.89	1.50
Semi-Precess Construction #1	0.81	0.72	2.13	1.22	
Semi-Process Construction #2	3.42	2.07	2.30	2.60	
Military Camp PSN 300	0.74	1.33	0.92	1.00	
PSN 310	0.80	0.79	1.12	0.90	
PSN 320	0.74	0.81	0.92	0.82	
PSN 330 (M)	1.01	0.65	1.10	0.92	
PSN 330 (S)	4.80	2.11	3.50	3.47	
Within 10 miles of 200 East					
Route 4S, Mile 10	1.31	0.89	1.46	1.22	
Route 10, Mile 1	0.93	0.89	1.29	1.04	
Route 10, Mile 3	6.12	1.73	1.87	1.20	1.28
Route 2S, Mile 4	1.70	2.00	1.30	1.67	
Near 300 Area					
Route 4S, Mile 16	4.04	2.48	1.38	2.63	
Route 4S, Mile 22	0.58	0.95	1.37	0.97	
North Richland North	0.43	0.61	0.41	0.48	1.00
North Richland South	0.52	0.51	0.39	0.45	
300 Area	0.50	0.53	0.49	0.51	

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TABLE III, con't
RADIATION LEVELS OBSERVED WITH
"M" AND "S" TYPE DETACHABLE IONIZATION CHAMBERS
JULY-AUGUST-SEPTEMBER
1 9 5 1

Units of mrep/24 hours

Location	July	August	September	Quarterly Average	Group Average
Outlying					
Richland	0.53	0.58	0.55	0.55	----
Benton City	0.48	0.38	0.42	0.43	----
Pasco	0.20	0.29	0.27	0.25	0.40
Kennewick	----	----	0.39	0.39	----
Richland	----	----	0.39	0.39	----

were placed on wooden stands about 5 feet above ground level. Table III summarizes the average radiation levels measured in this manner during the quarter.

A review of the data summarized in Table III shows that mean dosage rates at locations near the 100 Areas and in residential communities around the project perimeter remained essentially the same as in the past. In the environs of the 200 Areas a small decrease was noted during the quarter; the average obtained from 15 stations located within a radius of 5 miles was 1.5 mrep/24 hours as compared with 1.7 mrep/24 hours during the period April, May, and June. Significant decreases during the quarter were observed at several stations immediately adjacent to the separation areas. At Route 3, Mile 1, the July average was 1.9 mrep/24 hours as compared to an average of 1.3 and 0.7 mrep/24 hours during August and September. At Route 4S, Mile 2.5, the average dosage rate decreased from 4.1 to 0.8 mrep/24 hours between July and September. As in the previous period, the maximum radiation level existed at the Military camp PSN 330 where the average over the three month period was 3.5 mrep/24 hours including an average of 4.8 mrep/24 hours during July.

Continuous air samples, drawn through CWS #6 filters, at a flow rate of 2.5 cfm for weekly periods were taken to evaluate activity density from filterable beta emitters in the atmosphere. Several days were allowed between sample removal date and counting to eliminate significant emission from the daughter products of thoron and radon. The results obtained from this monitoring program are summarized in Table IV. (Next page.)

A comparison of the date summarized in Table IV with similar measurements obtained during the previous period indicates that current averages were lower at nearly all monitoring locations. Maximum decreases occurred at the 200 West Area gatehouse where the current average of 2.1×10^{-12} µc/cc represented a decrease by a factor of 50 from the previous quarterly average of 9.7×10^{-11} µc/cc. Maximum measurements over a one week period were obtained in July at the 200 West Area at the Redox Station and 200 West Area gatehouse where values were on the order of 2 to 3.5×10^{-11} µc/cc. These maximum values were significantly lower than the maximum weekly average of 1.3×10^{-9} µc/cc observed during the previous quarter. A review of weekly measurements showed that nearly all higher concentrations occurred early in July, during the same period that the silver reactors at the 200 West Area were not effectively reducing the I-131 emission. In general, the values obtained during the month of September (on the order of 10^{-13} µc/cc) were comparable to averages noted during the month of April when the silver reactors were operating about 99 percent efficiently.

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TABLE IV

AVERAGE FILTERABLE BETA ACTIVITY IN AIR

JULY - AUGUST - SEPTEMBER

1951

Beta Emitters - Average Activity Density x 10^{-14} µc/cc

Location	July	August	September	Quarterly Average	Maximum Weekly
200 Areas and Vicinity					
200 East South East	88	42	48	58	181
200 East Tower #16	93	70	85	81	139
200 East, Semi-Works	119	104	130	118	181
200 West, Tower #4	140	34	35	65	326
200 West Gatehouse	579	31	51	206	1956
200 West Redox Area	1026	9	*	461	3442
Gable Mountain	38	20	24	27	59
200 East Tower #15	85	74	86	81	128
100 Areas and Vicinity					
100-D Area	55	30	51	44	110
100-H Area	63	70	66	66	141
Hanford 101 Bldg.	20	6	34	19	66
Hanford 614 Bldg.	12	19	20	17	31
White Bluffs	40	16	44	32	134
300 Area					
300 Area 614 Bldg.	14	10	13	12	40
Outlying					
Richland	39	12	167	75	356
North Richland	40	14	17	23	100
Pasco	49	18	19	28	134
Benton City	10	6	9	8	13
Riverland	48	13	13	24	99

* Measurements were not obtained during the period due to interupted electrical service.

[redacted]

Additional evaluations of the activity density from filterable beta emitters were obtained by counting the small filters which were removed from dual air monitors located in the 200 Areas and at three elevations on the Meteorology Tower. These filters were exposed over a one week period and counted in a manner similar to that used for locations described in Table IV. The results from this program are summarized in Table V. (Next page.)

The results obtained from counting the filters from the dual air monitors reflects a general decrease comparable to that observed when evaluating the data from the single units. Several of the locations showed values which were slightly higher than expected for the month of September; however, some of the higher concentrations during the latter part of the quarter were associated with meteorological conditions which brought the upper air masses to a ground level in the immediate vicinity of the 200 Areas. Data obtained at the Meteorology Tower showed ground concentrations to be greater than those at elevations of 200, and 400 feet. For the second consecutive quarter, the ground level concentration was approximately twice as great as that observed at the 200 and 400 foot levels, whereas the mean concentrations at the latter two levels was nearly identical during each of the three month periods.

The program inaugurated during the previous quarter to determine the activity density of alpha emitters in the atmosphere by counting the filters obtained from locations listed in Tables IV and V on standard counters was continued during the period. Table VI summarizes the results obtained from this program. (Refer to page 41.)

TABLE V
AVERAGE FILTERABLE - BETA ACTIVITY IN AIR
DUAL AIR MONITORS
JULY - AUGUST - SEPTEMBER
1951

Dual Units Location	Beta Emitters - Average Activity Density x 10^{-14} µc/cc				
	July	August	September	Quarterly Average	Maximum Weekly
200 West East Center #1	2040	86	151	596	4986
200 West East Center #2	304	32	25	114	937
200 East Southeast #1	94	43	42	52	119
200 East Southeast #2	34	40	59	44	87
200 East East Center #1	96	57	82	77	170
200 East East Center #2	62	71	71	68	125
2707 EA #1	126	68	212	130	279
2707 EA #2	127	72	113	102	277
Meteorology Tower					
Ground level	132	676	52	287	2578
200' level	67	57	36	53	164
400' level	99	50	32	59	208

Although trace quantities of alpha emitters were detected at nearly all locations during isolated one week periods, the average activity density from this source was less than 8 x 10^{-15} µc/cc at 21 out of 30 representative locations. Positive averages were on the order of 1 to 3 x 10^{-14} µc/cc and in the majority of instances were weighted by high values obtained from monitoring over one individual weekly period. A comparison of the results summarized in Table VI with similar data from the previous quarter was not indicative of any significant change or trend.

The activity density from I-131 in the atomsphere was measured by passing 2.0 to 2.5 cfm of air through caustic scrubbers for a one week period. The scrubber samples were analyzed according to standard procedures used in the control laboratory (HW 20136.) The results obtained from this monitoring program during the 3 month period are summarized in Table VII. (Next page.)

Although the mean activity density of I-131 in air showed no significant change compared to the average of the last quarter, except at 200 West Gatehouse and the 300 Area, two significant trends were observed. The average concentration showed an overall decrease by a factor of from 2 to 5 in the immediate [redacted]

TABLE VI
AIR FILTER MONITORS
JULY - AUGUST - SEPTEMBER
1951

Location	Number Samples	Alpha Emitters - Activity Density x 10^{15} µc/cc Maximum	Average
200 East Southeast	13	9	<8
200 West Tower #4	13	17	<8
200 East, Semi-Works	12	29	<8
200 East, Tower #16	13	16	<8
Gable Mountain	13	9	<8
Richland	12	219	28
Pasco	12	34	9
300 Area	13	26	9
100-D Area	13	20	8
200 West Gate	12	65	13
Benton City	13	8	<8
Hanford 614 Building	13	14	<8
White Bluffs	13	29	<8
North Richland North	13	10	<8
200 West Redox Area	7	16	<8
100-H Area	13	63	24
Hanford 101 Building	13	<8	<8
Riverland	13	8	<8
200 East Tower #15	13	15	<8
Meteorology Tower, Ground Level	12	35	11
Meteorology Tower, 200' level	13	35	<8
Meteorology Tower, 400' level	13	16	<8
DUAL MONITORING UNITS*			
200 West East Center #1	13	68	31
200 West East Center #2	13	54	13
200 East Southeast #1	11	10	<8
200 East Southeast #2	13	<8	<8
200 East 2707 EA Building #1	13	13	<8
200 East 2707 EA Building #2	13	10	<8
200 East East Center #1	13	11	<8
200 East East Center #2	13	9	<8

* These units are operated alternately at a given location, each unit representing operation during 50 percent of the month.

TABLE VII
AVERAGE ACTIVITY DENSITY OF I-131 DETECTED IN SCRUBBERS
JULY - AUGUST - SEPTEMBER
1951
Activity Density x 10^{-12} µc/cc

Location	July	August	September	Quarterly Average	Maximum Weekly
200 Areas & Vicinity					
200 East Southeast	61.0	26.1	40.9	41.4	165.6
200 East Tower #16	135.5	279.9	102.2	181.0	1939.4
200 West Gatehouse	108.4	2.6	10.6	39.8	188.2
Gable Mountain	15.7	1.4	3.4	6.4	33.9
Outlying Locations					
100-H Area	6.1	0.6	1.2	2.6	10.1
300 Area	2.1	1.4	1.4	1.6	5.9
Richland	7.0	2.3	5.2	4.5	17.5
North Richland	7.2	0.9	17.1	7.8	63.6
Benton City	8.0	-0.3	0.4	2.7	12.8

environs of the 200 Areas during the month of July and continued through August. Concentrations remained essentially the same during July as in June at residential locations but general decreases were observed during August when the activity detected in residential regions was approximately 3 times lower than that observed during July. This decrease was attributed to a reduced amount of I-131 admitted from the stacks. Increases were observed at nearly all locations during the month of September; in general, September averages were from 2 to 5 times greater than those observed during August and was caused by adverse meteorological conditions.

Atmospheric evaluations of the maximum concentrations of I-131 at ground level were made by employing portable hand scrubbers at locations where visual observations indicated the possibility of extreme deposition. A total of 90 samples were collected from the immediate vicinity of the 200 Areas during the three month period. Average activity density from I-131 in these samples was 1.6×10^{-8} µc/cc with maximum measurements on the order of 5.7×10^{-7} µc/cc. A comparison of these values with previous measurements indicated that the average activity was lower by a factor of 2 during this period although maximum measurements were 2 to 5 times higher than those observed during the previous

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three month period. The higher concentrations were observed during the month of July at which time the average activity from I-131 in 41 portable scrubbers samples was 3.6×10^{-8} μc/cc. The July measurements were significantly higher than those taken during the following month when the average activity in 40 samples was on 5.3×10^{-10} μc/cc. Twenty-nine of these samples were above tolerance limit of 3×10^{-9} μc/cc during July, whereas only one of the August samples showed a value above tolerance.

Mobile equipment was used on one occasion during August to determine the mean activity from I-131 over a one hour collection period. The activity density averaged 1.0×10^{-8} μc/cc in this instance.

Several spot samples to determine the activity density from filterable beta emitters in the atmosphere were taken by using an air filter in conjunction with a portable hand scrubber. The activity density from filterable beta emitters ranged from 1 to 1.5×10^{-9} μc/cc near the 200 Areas.

The number of radioactive particles in the atmosphere was determined by exposing the small air filters obtained from the locations listed in Tables V, VI, and VII to type K X-ray film. In addition to these filters, a number of air monitoring stations were maintained for the specific purpose of determining the number of radioactive particles in air. The latter stations represented locations in and near the 200 Areas, at various elevations on the Meteorology Tower, at the Plant perimeter, and at remote spots in the states of Washington, Oregon, Montana, and Idaho. Film exposure periods were 168 hours and the number of particles were determined by counting the number of darkened spots on the developed film. Tables VIII, and IX, and X summarize the results from the particle monitoring program for this period.

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TABLE VIII
PARTICLE DEPOSITION - SMALL FILTERS
Units of 10^{-3} particles/meter^3
JULY AUGUST SEPTEMBER
1951

Location	Total Volume of air sampled m^3	July	August	September	Third Quarter 1951 Average	Second Quarter 1951 Average
200 East Area						
Semi-Works	8423	35.0	23.0	9.9	24.0	2.0
200 E Twr. #15	9241	21.0	12.0	9.7	14.0	13.0
200 ESE Decade	7344	22.0	15.0	5.9	15.0	5.5
200 ESE Twin #1	3613	18.0	17.0	9.4	14.0	14.0
200 ESE Twin #2	4989	20.0	12.0	2.8	12.0	17.0
2707EA Scaler #1	4900	31.0	19.0	7.3	19.0	7.4
2707EA Scaler #2	4356	32.0	28.0	38.0	33.0	19.0
200 E Twr. #16	7096	19.0	15.0	15.0	16.0	17.0
200 EEC Dual #1	4070	22.0	15.0	46.0	29.0	54.0
200 EEC Dual #2	4843	33.0	22.0	12.0	22.0	14.0
200 West Area						
200 WEC Decade	7196	22.0	26.0	29.0	26.0	16.0
200 WEC Scaler #1	3622	120.0	68.0	30.0	67.0	24.0
200 WEC Scaler #2	4940	29.0	65.0	3.9	34.0	23.0
Redox	8315	29.0	7.8	0.3	13.0	2.9
200 W Twr. #4	7214	11.0	15.0	7.1	11.0	12.0
200 Area Environs						
Meteorology Tower						
Ground level	9061	21.0	12.0	5.7	13.0	13.0
200' level	8333	33.0	15.0	3.8	19.0	23.0
400' level	9273	25.0	11.0	22.0	20.0	10.0
Gable Mtn. Decade	7475	19.0	8.1	2.1	9.5	5.5
Hanford 101 Bldg.	7561	10.0	8.3	2.6	7.1	3.9
100-H SE	7307	18.0	26.0	14.0	19.0	6.1
100 D Area	9266	5.3	15.0	18.0	13.0	5.1
Hanford 614	7897	3.5	9.3	1.5	4.6	4.5
White Bluffs	6804	33.0	6.2	4.1	17.0	4.2
300 Area	6194	4.8	6.3	6.6	5.8	4.3
Adjacent to Environs						
Benton City	6716	1.7	3.5	0.5	1.9	5.0
Pasco	8447	14.0	7.8	2.6	8.3	1.5
North Richland North	7502	8.3	8.1	1.3	6.0	7.1
Riverland	9118	14.0	9.4	2.4	8.6	5.5
Richland Decade	5480	35.0	1.3	19.0	18.0	3.2

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TABLE IX
SUMMARY OF PARTICLE DEPOSITION
JULY-AUGUST-SEPTEMBER
1951

Units of 10^{-3} particles/meter^3

Location	Total Volume of air sampled m^3	July	August	September	Third Quarter Averages 1951	[illegible]econd Quarter Averages 1951
200 East Vicinity						
2704 Outside	7558	19.0	23.0	12.0	19.0	13.0
H. I. Garden	8275	43.0	45.0	39.0	43.0	26.0
BY SE	9472	58.0	24.0	29.0	17.0	83.0
BY NE	9150	17.0	18.0	20.0	18.0	20.0
"B" Gate	8769	45.0	56.0	43.0	49.0	20.0
222-B Outside	9133	56.0	95.0	120.0	92.0	52.0
2701 Outside	9088	24.0	48.0	17.0	30.0	18.0
2704 Inside	8671	23.0	28.0	34.0	28.0	12.0
221-B	5853	100.0	18.0	25.0	35.0	28.0
222-B Hall	9.67	190.0	140.0	210.0	180.0	110.0
222-B Lab.	5948	840.0	3050.0	1400.0	1200.0	>820.0
2701 Inside	10639	39.0	55.0	14.0	38.0	15.0
200 West Vicinity						
2701 Outside	8598	240.0	180.0	110.0	170.0	35.0
2722	8[illegible]00	83.0	110.0	120.0	100.0	34.0
"T" Gate	8830	67.0	89.0	87.0	82.0	77.0
222-T Outside	9112	190.0	280.0	170.0	220.0	120.0
231	8797	72.0	47.0	42.0	54.0	28.0
South Guard Tower	7935	26.0	41.0	12.0	28.0	11.0
West Guard Tower	8552	28.0	27.0	19.0	25.0	11.0
2701 Inside	10299	190.0	74.0	65.0	120.0	26.0
272	4909	73.0	38.0	51.0	50.0	15.0
222-T Hall	9176	140.0	260.0	180.0	200.0	95.0
222-T Lab.	9.54	810.0	680.0	1100.0	840.0	430.0
Meteorology Tower						
3'	36737	16.0	14.0	11.0	13.0	5.3
50'	36737	[illegible]4.0	11.0	10.0	14.0	4.3
100'	25611	27.0	15.0	7.5	15.0	4.6
150'	23517	41.0	22.0	13.0	24.0	5.5
200'	26474	54.0	19.0	14.0	30.0	10.0
250'	24642	31.0	19.0	5.2	19.0	6.1
300'	20131	41.0	13.0	5.6	18.0	5.9
350'	20853	44.0	19.0	3.1	20.0	4.8
400'	14274	43.0	23.0	9.3	24.0	6.0

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TABLE X
SUMMARY OF PARTICLE DEPOSITION
JULY - AUGUST - SEPTEMBER
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Units of 10^{-3} particles/meters^3

Locations	Total Volume of air sampled m^3	July	August	September	Third Quarter 1951 Average	Second Quarter 1951 Average
Area Locations						
100-B Area	34417	18.0	11.0	1.6	10.0	4.0
100-D Area	7956	0.6	5.5	2.8	2.6	18.0
White Bluffs	29529	18.0	1.2	1.7	6.1	3.1
100-F Area	35955	19.0	13.0	5.7	12.0	6.9
300 Area	37502	17.0	6.8	3.0	8.6	7.2
Hanford 101 Bldg.	33575	3.5	7.8	1.1	4.8	5.2
Off-Area Locations						
Benton City, Wn.	35700	13.0	6.9	0.7	6.7	5.2
Pasco Wn.	37451	20.0	7.1	1.3	9.3	5.3
Richland, Wn.	32147	7.6	6.9	2.5	5.4	6.9
Boise, Idaho	8793	6.9	29.0	4.4	22.0	15.0
Klamath Falls, Ore.	8369	7.8	15.0	1.8	17.0	20.0
Stampede Pass, Wn.	1003	0.5	*	*	*	2.7
Great Falls, Mont.	7133	0.9	10.0	0.4	4.5	6.2
Walla Walla, Wn.	9811	12.0	7.3	0.4	13.0	6.9
Meacham, Ore.	8624	8.2	12.0	3.1	17.0	6.0
Lewiston, Idaho	7429	3.8	27.0	1.3	14.0	8.3
Spokane, Wn.	36142	7.8	9.0	1.4	6.1	4.8
Kennewick, Wn.	**	**	**	**	**	**
Yakima, Wn.	**	**	**	**	**	**

* This data not representative.
** No data available.

[redacted]

A comparison of the results summarized in Tables IX, and X with similar data representing the previous quarter indicates that the number of radioactive particles in the atmosphere showed an overall increase during this period. In general, concentrations during July were approximately 2 times higher than those observed during June, with several of the individual stations showing increases by a factor of 10 to 12 above June measurements. Increases were also observed at all elevations of the Meteorology Tower during July and some particles were detected on the filters received from all remote stations in Washington, Idaho, Montana, and Oregon. These increases during July were significant as compared to data measured during the first two months of the previous quarter and were of questionable significance when compared to June values. Higher concentrations had been observed during the month of June and detailed data analysis indicated that the cause for the excessive number of particles was due to a source other than the Hanford Works. (HW 22072.) The higher levels observed during July were an apparent continuation of the latter source of particle deposition. Small decreases were noted at many of the stations during the month of August; however, the bulk of the data was not significantly different than that of July. In one excepted case at Lewiston, Idaho, the particle concentration averaged 8.4×10^{-2} particles/meter^3 during the week ending August 3. This was an unusually high value for this location. Decreases were observed during September when the average particle concentration was found to be on the order of 1 to 2×10^{-3} particles/meter^3 in the residential areas near the plant. Decreases were observed at remote locations where the average number of particles in the atmosphere toward the latter part of the quarter was comparable to that around the project perimeter.

SECTION III

SECTION IV

RADIOACTIVE CONTAMINATION IN HANFORD WASTES

Over 750 liquid and 200 solid samples were obtained from the various waste zones in the 100, 200, and 300 Areas to determine the activity density of alpha and beta particle emitters in Hanford West sources. These samples were analyzed according to standard control laboratory procedures (HW 20136) and the subsequent counting rates were corrected using standard corrections for geometry, weight and volume, and decay (HW 22682.) The direct measurements were supplemented with portable instrument surveys which were performed around the open waste areas and over the adjoining terrain. Special summaries covering the results of this program for the 100, 200, and 300 Areas follow:

100 AREA WASTES:

Nearly 250 samples were obtained from the outlet side of the 107 effluent basins in the 5 pile areas. The activity measured at these samples represented a direct evaluation of the activity discharged to the Columbia River from the 100 Areas. These samples were analyzed within 16 hours of the time of collection and in all cases the results were corrected for decay to sampling time. A summary of the results obtained from this program is presented in Table I.

 [redacted]

TABLE I
RADIOACTIVE CONTAMINATION IN THE 107 BASINS
DURING PERIODS OF NORMAL PILE OPERATION
JULY - AUGUST - SEPTEMBER
1951

Location	No. Samples	Alpha Emitters Average Activity Density dis/min/liter	Beta Emitters Activity Density x 10^3 µc/cc Maximum	Beta Emitters Activity Density x 10^3 µc/cc Average
100-B Area	44	<8	3.8	1.3
100-D Area	39	<8	1.8	1.0
100-DR Area	53	<8	5.0	1.4
100-F Area	52	<8	6.4	1.4
100-H Area	55	<8	3.1	0.9

The higher levels of contamination observed during the past several months continued and in many cases individual samples exceeded that noted in earlier measurements. Small increases were noted in the average activity density from beta emitters in each basin; maximum measurements also exceeded those measured during the period April, May, and June of 1951. The direct cause of the increased activity was not definitely established, however a partial explanation may be attributed to the operation of the 100 Area piles at higher power levels than those used during the previous period. An examination of the month to month trend within this data indicates that this activity density from beta emitters was lower in the earlier part of July than it was during August and nearly all maximum measurements were obtained during the month of September. Table II summarizes the month to month increase.

TABLE II
AVERAGE RADIOACTIVE CONTAMINATION IN THE 107 BASINS
BETA EMITTERS - ACTIVITY DENSITY X 10^4 µc/cc

Location	July	August	September
100-B Area	9.3	11.7	18.0
100-D Area	7.4	8.9	12.6
100-DR Area	10.9	10.0	19.5
100-F Area	10.5	13.2	16.2
100-H Area	5.9	5.8	14.1

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The activity density from alpha emitters in the effluent water admitted to the Columbia River averaged less than 8 dis/min/liter at all basin outlets. As in the past, trace quantities of alpha emitters were detected in isolated samples but were not confirmed by resample in samples obtained from downstream locations. Values in these isolated cases were essentially on the order of 6 to 20 dis/min/-liter.

All samples collected from the outlet of the basins were analyzed for uranium by a fluorescence method (HW 20136.) The average activity from this source was less than 5 µg/liter at all areas with only one sample collected from the 107-D basin (14 µg U/liter) showing a significant quantity. Plutonium measurements were performed on spot samples from all basins and on all samples which indicated trace quantities of alpha activity. The only significant result obtained from these measurements was from a sample collected on July 17 from 107-F basin which indicated a value of 14 dis/min Pu/liter. As previously stated, this measurement was not confirmed by any other sample. Two one gallon samples were collected from each basin outlet each month and analyzed for the activity density from alpha emitters of polonium. In all cases, the activity from this source was below the detection limit of the measurement.

Eighty-seven samples were collected from the Biology Farm waste in the 100-F Area and analyzed for I-131. The average activity density from this source over the three month period was 3.3×10^{-6} µc/cc (maximum measurements of 2.1×10^{-5} µc/cc) which is equivalent to approximately 0.5 mc of I-131 discharged to the river daily. These values represent a significant decrease when compared to the previous quarters average of 1.5×10^{-5} µc/cc, (maximum measurements during the previous period were on the order of 5×10^{-4} µc/cc) and correspond to the decreased amount of I-131 used for experimentation at the farm. Trace quantities of this activity were detected at a river monitoring location near the Hanford Ferry (refer to Section V.)

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200 AREA WASTES:

Table III summarizes the results obtained from the measurements of the activity density from alpha and beta emitters in liquid and solid samples obtained from the open waste ponds and associated waste ditches in the 200 Areas:

TABLE III
RADIOACTIVE CONTAMINATION IN THE 200 AREA WASTE SYSTEMS
JULY - AUGUST - SEPTEMBER
1951

LIQUID SAMPLES

Location	No. Samples	Alpha Emitters Activity Density dis/min/liter Maximum	Average	Beta Emitters Activity Density x 10^7 µc/cc Maximum	Average
T Swamp	36	31	<6	8.5	2.8
U Swamp	24	17	7	4.3	<1
Laundry Ditch	24	29	10	7.3	2.3
231 Ditch	24	28	10	7.1	1.6
200 E "B" Ditch	39	97	6	35.	9.2
200 E "B" Swamp	26	17	<6	21.	8.1
234-5 Ditch	12	7	<6	4.8	1.0
200 E Retention Pond	50	33	<6	77.	16.
200 W Retention Pond	46	48	<6	12.	3.9
234 Retention Pond	12	96	31	---	---
Redox Swamp *	3	<6	<6	4.4	2.8

SOLID SAMPLES

Location	No. Samples	dis/min/gram Maximum	Average	Activity Density x 10^5 µc/gram Maximum	Average
T Swamp	24	470	34	18	3.5
Laundry Ditch	12	46	15	52	12.
200 E "B" Ditch	39	28	<6	1080	160.
200 E "B" Swamp	26	7	<6	360	98.
234-5 Ditch	12	280	44	23	4.4
Redox Swamp *	3	<6	<6	15	6.6

* Sampled only during the month of September.

A comparison of the results summarized above with similar measurements obtained during the previous 3 month period indicates very little change in the magnitude of activity in 200 Area wastes. The only significant difference occured in measurements which represented the 200 East Area B ditch and B Swamp. Solid samples collected from these sources indicated values exceeding previous

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measurements by a factor of from 2 to 10. High results on the same order of magnitude have been observed in isolated cases during the past two or three years. The direct cause for the higher contamination has not been established, since the process water discharged to the B swamp via the B ditch did not, as judged by spot samples indicate higher than normal activity densities.

Samples of waste from all locations listed in Table II were also analyzed for uranium. Trace quantities of this activity were found in isolated cases at the T and U Swamp, 234-5 ditch, 231 ditch, and laundry ditch. Maximum measurements were noted in the laundry ditch where liquid samples showed values approaching 20 µg U/liter and solid samples obtained from the edge of the ditch showed values of 15 µg U/gm. The average amount was 5 µg U/liter and 9 µg U/gm in the liquid and solid material, respectively.

Portable instrument surveys along the west ditches and ponds in the 200 East Area indicated that the mean radiation levels were above background in the B ditch and B Swamp. Maximum readings were obtained over mud in the vicinity of the inlet to the B swamp where levels showed 10,000 c/m during the latter part of September. During the earlier part of the quarter, instrument readings ranged from 2,000 to 8,500 c/m at this location. Several locations which were surveyed repetitively along the B ditch showed values ranging from 200 c/m above background to 8,000 c/m above background throughout the period. Comparable surveys in the 200 West area at the T ditch and T swamp showed that the radiation levels were on the order of background and maximum readings were about 250 c/m above background. In one isolated case, however a value of 1,200 c/m was detected near the T ditch.

Land surveys performed over the open terrain outside the exclusion area but within the confines of the 200 areas showed general radiation levels to be on the order of background (VGM) in most locations. Maximum values were on the order of 400 to 500 c/m during the earlier part of the quarter when a rather heavy I-131 deposition was detected by direct sampling methods. The instrument readings summarized for waste zones and open terrain do not represent any significant departure from levels observed during previous periods.

Instrument surveys in the N, P, and R ditches in the 200 N Area were limited due to the heavy weed growth along the edge of the ditches. Maximum radiation levels were on the order of 50,000 to 75,000 c/m (VGM) at the P ditch inlet and a maximum dosage recorded throughout the three month period was 25 mrep/hr near the P ditch inlet. Radiation levels were generally less than 6 mrep/hr at spot monitoring locations along the N and R ditches during the quarter.

300 AREA WASTE:

Table IV summarizes the results obtained from the radiochemical analyses of liquid and solid samples obtained from 300 Area waste sources. Considerable fluctuation was observed when reviewing the results obtained from sampling the 300 Area waste sources. A general change in pond usage contributed to some of this variation as the old pond was not used during the latter part of the quarter. Samples obtained from the inlet represented seepage sources rather than the actual waste effluent from the 300 Area process waste line. Samples from the 300 Area waste line showed a general decrease in overall alpha activity with the current maximum measurements being about a factor of 5 lower than those previously observed. Essentially, uranium was found to be the predominant contaminant in all samples that showed detectable quantities of alpha emitters.

The samples obtained from the 300 Area waste line were also analyzed for the activity density of the alpha emitter of plutonium. The mean activity from this source in 55 analyses was 35 dis/min Pu./liter. The latter value was approximately 3 times higher than that normally found; however, the average of 35 dis/min Pu./liter was not significantly different from the previous quarterly average of 27 dis/min/liter.

SECTION VI

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SECTION V

RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER

Nearly 400 samples were collected from representative locations along the Columbia River and analyzed for the activity density from alpha and beta emitters. In general, these samples were obtained from control locations at a frequency of one sample per week and supplemented with special samples from intermediate locations during periods when the mean activity density showed significant changes. A map showing the locations from which the routine samples were obtained may be referred to in a previous document (HW-21214) and the procedure which was used to determine the various activity concentrations appears in the Control Laboratory Standard Procedures Mannual (HW-20136.)

The contamination measurements obtained from the Columbia River were supplemented with background studies, obtained from samples collected above the 100-B Area, and from nearby tributaries such as the Yakima and Snake Rivers. Control sampling was maintained on a daily basis at a location near the Hanford Ferry where the maximum contamination has been found in the past.

A summary of the results obtained from the radiochemical analysis for the activity density from gross beta emitters during the three month period is presented in Table I.

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TABLE I

AVERAGE ACTIVITY DENSITY OF GROSS BETA EMITTERS
IN THE COLUMBIA RIVER
JULY - AUGUST - SEPTEMBER
1951
Activity Density x 10^{-8}
μc/cc

Location	July Average	August Average	September Average	Quarter Average	Last Quarter Average	Maximum Measurement This Quarter
Wills Ranch	<5	<5	<5	<5	[illegible]	<5
100-B 181 Bldg.	<5	<5	<5	<5	<5	<5
Allard Pumping Station	<5	8	<5	6	12	23
100-D 181 Bldg.	15	28	49	30	29	108
100-H 181 Bldg.	22	92	152	89	65	217
Below 100-H	56	170	350	201	156	604
100-F 181 Bldg.	86	174	406	267	134	461
Below 100-F	106	182	328	212	206	448
Foster Ranch	40	61	*	50	62	67
Hanford South Bank	129	384	600	375	475	1135
Hanford Middle	92	199	396	218	192	457
Hanford North Bank	45	90	227	115	95	357
300 Area	77	185	216	168	117	402
Richland	61	113	211	112	95	293
Highland Pump Station	47	83	176	105	69	259
Pasco-Kennewick Bridge						
Kennewick side	40	83	136	86	60	170
Pasco side	34	46	134	69	63	187
Sacajawea Park	24	20	90	43	36	137
McNary Dam	20	32	56	33	25	70
Patterson	14	25	41	25	19	55
Snake River Mouth	<5	<5	<5	<5	<5	7
Yakima River Mouth	<5	<5	<5	<5	<5	8

* Sampling at this location was discontinued during September.

A comparison of the quarterly averages summarized in Table I with the averages representing the previous three month period indicates that the average activity density from beta emitters in the Columbia River increased at nearly all locations during this period. This increase is further reflected when reviewing the individual averages for the three months of the period; the measurements obtained during July were considerably lower than those obtained during August and September. This overall increase was a direct result of a highly significant decrease in the mean flow rate of the Columbia River during the three month period. (Figure 11) Maximum flows were measured during the early

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part of the quarter (2,665,000 gallons/second on June 27) and the minimum flow was observed toward the latter part of September (547,000 gallons/second on September 25.) The respective monthly average flow rates were 2,322,000, 1,270,000, and 705,000 gallons/second during July, August, and September. The lower flow rate of the river caused a reduction in the dilution ratio of river water to pile effluent water and thereby caused an increase in the concentration of the gross beta emitters at locations below the 100-B Area.

A comparison of the current values with those measured durnng the same three month period in 1950 also shows that the magnitude of the contamination in the Columbia River was higher during the year 1951. Three factors which tend to influence the higher readings during 1951 were (1) additional activity was admitted to the Columbia River from the operation of the 105-DR pile in 1951.; (2) the power level of the 5 pile areas was higher during 1951 than it was during 1950; and (3) the minimum flow rate of the Columbia River during the 3 month period was 547,000 gallons/second as compared with a minimum flow on the order of 563,000 gallons/second during the same period in 1950.

A comparison of the magnitude of activity observed at a given location with that observed at any other location on the river indicates that the dispersion and distribution pattern followed by the activity was essentially the same as that noted during previous periods. Maximum measurements continue to prevail in the region immediately below the 100-F Area and in the vicinity of the Hanford Ferry where the bulk of the activity tends to adhere to the south (Benton County shore) bank of the river. The maximum measurements tabulated in Table I represent values which were obtained during the month of September when the flow rate of the Columbia was at the minimum for the period.

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Natural radioactivity from beta emitters in the Columbia River as evaluated from samples obtained at Wills Ranch above the 100-B Area was below the detection limit (5×10^{-8} μc/cc) of this measurement. These values were in good agreement with the background observed in the Yakima and Snake Rivers which also averaged less than 5×10^{-8} μc/cc.

Special samples were obtained twice each week from a location near the Hanford Ferry and analyzed for the activity density from 8-day I-131. One source of I-131 in the Columbia River is the waste discharge at the biology farm at the 100-F Area. The activity density from I-131 in the Columbia River at Hanford averaged about 2.0×10^{-7} μc/cc during the period. Again, minimum mean values were obtained during the month of July when the average activity density was 8.1×10^{-8} μc/cc and maximum measurements were observed during September when the mean activity density was 3.0×10^{-7} μc/cc. Maximum results from individual samples showed the activity density from I-131 to be on the order of 4.0×10^{-7} μc/cc, however, one exceptionally high samples indicated a value of 2.1×10^{-6} μc/cc during September.

The activity density from alpha emitters in the Columbia River averaged less than 6 dis/min/liter at all of the locations listed in Table I. On several occasions individual samples showed trace quantities of this activity on the order of 6 to 15 dis/min/liter; however, these measurements were not confirmed by resample or by samples which were obtained from other downstream locations.

Five samples of river water were obtained from Bonneville Dam during the quarter. The activity density from alpha and beta emitters in these samples was below the detection limit (less than 5×10^{-8} μc/cc) in each sample analyzed.

Mud samples were collected weekly from each of 15 control locations along the Columbia River and from 2 locations on the Yakima and Snake Rivers. Two samples were obtained during each collection; one sample represented the mud at

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the edge of the water and the other sample was obtained from a point below the surface of the water at a distance of about 5 feet from the shore line. These samples were analyzed for the activity density from alpha and beta emitters according to the standard procedures described in HW-20136. A summary of the results obtained from these measurements for the activity density from beta emitters is presented in Table II.

TABLE II
RADIOACTIVE CONTAMINATION IN COLUMBIA RIVER MUD SAMPLES
JULY - AUGUST - SEPTEMBER
1 9 5 1

Beta Emitters - Activity Density x 10^{-5} μc/gram

Location	July Average	August Average	Sept. Average	Quarter Average	Last Quarter Average	Maximum This Quarter
Wills Ranch, Shore	1.4	1.0	2.7	3.4	1.6	6.0
5' out	1.2	<1	2.0	2.9	1.3	3.2
Allard Pumping Sta., Shore	1.3	<1	3.8	3.2	1.4	5.9
5' out	1.6	<1	2.8	3.2	1.4	9.3
100-H Area, shore	<1	1.1	2.5	3.0	1.5	4.4
5' out	2.3	<1	4.9	4.7	1.5	19.3
Below 100-F Area, shore	1.[illegible]	1.7	3.1	6.0	3.3	20.3
5' out	2.[illegible]	1.5	10.8	7.4	6.1	17.1
Richland Dock, shore	1.3	2.6	4.4	5.8	1.8	16.3
5' out	2.[illegible]	2.0	6.6	6.9	1.8	18.1
300 Area, shore	1.6	1.5	4.0	4.6	2.0	8.5
5' out	<1	1.4	5.7	4.2	2.2	9.5
Pasco Bridge (Pasco Side)	1.3	1.6	3.5	4.3	1.4	8.3
5' out	1.2	1.5	2.4	3.9	1.4	8.6
Pasco Bridge (Kenn. Side)	1.0	1.4	3.1	3.7	1.4	7.3
5' out	1.1	1.3	2.9	3.5	1.7	6.4
Hanford Ferry, shore	1.7	1.9	4.5	5.4	1.5	9.0
5' out	2.7	4.1	4.4	9.0	1.7	35.8
Highland Pumping St. shore	<1	1.1	4.5	3.5	2.4	6.9
5' out	1.6	1.4	3.9	4.5	1.2	6.1
Byers Landing	-	1.5	4.8	4.8	-	4.8
Sacajawea Park 5' out	3.[illegible]	1.6	7.7	8.6	1.7	21.6
Patterson, 5' out	2.0	<1	3.4	4.3	1.5	18.4
McNary Dam, 5' out	1.0	<1	2.7	3.0	1.6	5.0
Snake River Mouth, 5' out	1.9	1.1	2.9	4.1	1.2	9.5

The activity density from beta emitters in mud collected during July and August was nearly identical in magnitude to values measured during the previous month of 1951. The values tabulated in Table II for this quarter indicate a higher concentration of radio contaminants but due to a re-evaluation of analytical methods, necessitating larger correction factors to convert to absolute disentegration rates these results actually represent the same concentrations as previously noted. Corrections applied to the data including a re-evaluated self-absorption factor and a spread source factor resulting in a change of about 60% were effected September 1, 1951. If the application of these additional correction factors were considered when comparing all results summarized in Table II the magnitude of beta emitters in mud samples collected along the Columbia River during July, August, and September would be comparable to that observed during nearly all three-month periods in the past.

The activity density of alpha emitters in mud samples collected from the locations shown in Table III averaged less than 4 dis/min/gram at all locations. In isolated cases individual measurements showed values between 4 and 10 dis/min/gram; however these were not confirmed by duplicate or subsequent sampling.

Five mud samples obtained from the base of Bonneville Dam showed values ranging from 4.2×10^{-6} µc/gram to 3.3×10^{-5} µc/gram. These values were not significantly different from those observed at background locations in the upper waters of the Columbia and in the Yakima and Snake Rivers. Alpha activity in mud samples from Bonneville was less than 6 dis/min/gram in all samples analyzed.

Weekly samples were obtained from the raw water in the river export line at each of the Hanford Operating Areas. This water originates from the Columbia River and is consumed as sanitary water in the operating areas after purification and chlorination. Table III summarizes the results obtained from the radiochemical analyses for the activity density of beta emitters in this water.

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TABLE III

RADIOACTIVE CONTAMINATION IN RAW WATER - RIVER EXPORT LINE

JULY - AUGUST - SEPTEMBER

1951

BETA EMITTERS - ACTIVITY DENSITY x 10^8 µc/cc

Location	July Average	August Average	Sept. Average	Quarter Average	Last Quarter Average	Maximum This Quarter
183 Building, 100-B Area	<5	<5	<5	<5	<5	<5
183 Building, 100-D Area	<5	<5	12	6	<5	23
183 Building, 100-DR Area	6	17	44	22	11	66
183 Building, 100-F Area	13	13	54	26	22	90
183 Building, 100-H Area	<5	<5	21	11	<5	46
183 Building, 200 East Area	<5	6	40	16	11	60
183 Building, 200 West Area	<5	10	46	19	6	53

The activity density from beta emitters in raw water fluctuated during the three month period and reflected a trend that was associated to the change in flow rate of the Columbia River. The activity density measured during July represented minimum values at each of the areas whereas the samples collected during the latter part of the period showed values which were among the highest observed during the past 6 months. Again, maximum activity was observed at the most downstream location (100-F) where the maximum concentration of beta activity exists in the Columbia River; conversely, the activity density from beta emitters measured at the farthest upstream area (100-B) remained less than 5 x 10^{-8} µc/cc throughout the quarter. The magnitude of activity measured at each area during the period was not significantly different from the magnitude expected during the period in which the river flow decreased to a value on the order of 550,000 gallons/second.

Samples obtained from the same locations listed in Table III were also analyzed for the activity density from alpha emitters, according to standard procedures and techniques. In all cases, the activity from this source averaged less than 6 dis/min/liter.

Sampling of the raw water supply was supplemented with weekly sampling directly from the retention basins in the 200 East and 200 West Areas. The

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activity density from beta emitters averaged 1.7×10^{-7} μc/cc and 1.4×10^{-7} μc/cc in the 200 East and 200 West Area retention basins, respectively. The maximum measurement from a retention basin sample was 6.4×10^{-7} μc/cc at the 200 West Area. These values represent increases over the measurements obtained during the previous quarter and were in good agreement with increases noted in the raw water monitoring program.

SECTION V

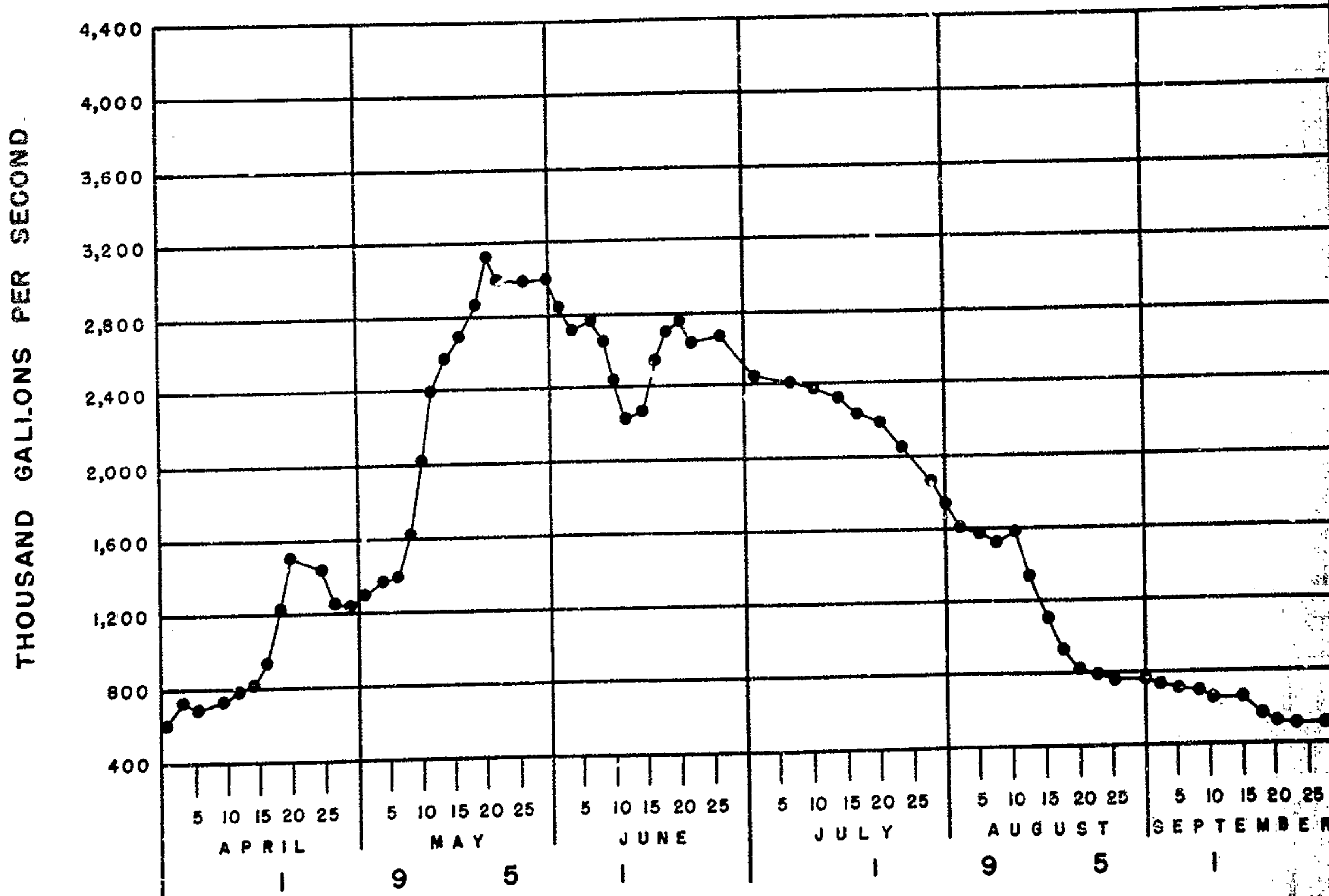
(please refer to Figure 11)

COLUMBIA RIVER FLOW

JULY — AUGUST — SEPTEMBER

1951

FIGURE — 11



SECTION VI

RADIOACTIVE CONTAMINATION IN RAIN

The small amount of precipitation measured in the environs during July, August, and September offered very little opportunity to determine the mean activity density from gross beta emitters in rainfall. Qualitative estimations of this activity were obtained from analyzing 29 samples which were collected from 20 different locations on and adjacent to the Hanford Works. A map showing the locations of the rain collecting stations (HW 21214) and a description of the procedure used for this analysis (HW 20136) may be referred to in previous documents of this series.

Table I summarizes the rainfall data for the period July, August, and September; similar data covering the 2 previous years are included for comparison.

TABLE I
PRECIPITATION MEASURED AT HANFORD WORKS
JULY - AUGUST - SEPTEMBER
1 9 5 1
Units-Inches

Year	July	August	September	Quarterly Total
1949	0.01	0.03	0.23	0.27
1950	0.07	Trace	0.01	0.08
1951	0.37	0.15	0.10	0.62

* Trace measurement indicates an amount of precipitation less than 0.01 inches of rainfall.

The total of 0.62 inches of rainfall during the 3 month period is somewhat higher than the amount measured during the same period in 1949 and 1950, however the amount of rainfall during this time of the year is considerably lower than that measured during the remaining 9 months of the year; a total of 2.34 inches of rain fell during the 3 month period April through June, 1951. Correspondingly the volume on the samples collected during this period was less than 50 ml./ sample, as compared with collections which usually ranged between 50 ml. and 500 ml. Also, the number of samples from any given location did not exceed 3 whereas normally, the collection frequency ranges between 2 and 10 samples/-location/quarter.

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The results obtained from the measurement of the activity density from beta emitters during this period are not believed representative of average aerosol concentrations due to the small frequency of collection and the small volume collected for any given rainfall.

Table II summarizes the results obtained from the measurement of the activity density from gross beta emitters in rainfall collected during this period.

TABLE II
ACTIVITY FROM GROSS BETA EMITTERS IN RAIN
JULY - AUGUST - SEPTEMBER
1 9 5 1

Location	Number Samples	Activity Density x 10^6 μc/cc Maximum	Average
200 East Area			
250' E of stack	1	118	118
2000' E of stack	2	287	147
Summary	3	287	137
200 West Area			
8000' SE of stack	1	79	79
4900' SE of stack	1	741	741
Redox Area	1	50	50
Summary	3	741	290
100 Area Environs			
100-B SE	1	5	5
100-F SW	1	1	1
Hanford 614	2	12	6
Hanford 101	1	3	3
White Bluffs	2	3	3
100-H SE	1	4	4
Summary	8	12	3
Perimeter Locations			
700 A 614	1	2	2
Pasco H & R	1	58	58
Benton City	1	15	15
Riverland	3	4	2
North Richland North	1	14	14
Summary	7	58	13
Intermediate Locations			
300 Area 614	2	8	7
200 North 614	1	19	19
Gable Mountain	2	31	19
Batch Plant	1	121	121
622 Building	2	3	2
Summary	8	121	21

In general, the majority of the results summarized above were considerably higher than those noted in the past. The increase in activity density from beta emitters in rainfall was largely attributed to the increase in the amount of I-131 in the atmosphere during the earlier part of the quarter. (Refer to Section I.) As expected, the higher results prevailed at locations in the immediate environs of the 200 Areas where the higher aerosol concentrations of I-131 prevailed. Samples collected within 5000 feet of the 200 West Area stack showed values on the order of 7.4×10^{-4} μc/cc and were approximately 10 to 20 times greater than those normally detected. Samples collected from perimeter locations and residential communities showed values which were 5 to 10 times greater than those during the previous quarter; the maximum activity density in the region adjacent to the plant was detected in a sample collected in Pasco which showed 5.8×10^{-5} μc/cc. The activity density from beta emitters in rainfall at remote locations has seldom exceeded 5×10^{-5} μc/cc during the past 2 years.

Several of the samples which indicated the higher activity density from beta emitters were placed on decay to determine the identity of the contaminant. In all cases the predominant contaminant (approximately 80% of the total activity) was identified as 8 day I-131. In one case I-131 accounted for 95% of the total activity collected in the rain samples. The idenity of the remaining activity has not been established radiochemically; decay studies indicate long life fission products which may be associated with particulate contamination.

Several spot samples were analyzed for the activity density from alpha emitters. As expected, for rain samples in which the volume rain collected was less than 50 ml, the activity density from this source was below the limit of detection.

SECTION VI

SECTION VII

Radioactive contamination in drinking water supplies was measured by analyzing nearly twelve hundred samples for the activity density of alpha and beta emitters. Nine hundred and six of these samples were 500 ml. and the remainder were of 12 liter volume. The large volume samples were used to detect trace quantities of alpha emission (on the order of 2 dis/min/liter) and the small volume samples were analyzed primarily for the activity density of gross beta emitters. Analytical procedures and techniques were identical to those used at Hanford in the past (HW-20136) and the subsequent counting rates were corrected to activity density values by applying correction constant for geometry, absorption, weight, and process efficiency as indicated in the Regional Survey calculation manual (HW-22682).

A summary of results representing all locations at which the activity density from alpha emitters exceeded 6 dis/min/liter over the three month period is presented in Table I.

TABLE I
ACTIVITY DENSITY IN DRINKING WATER
JULY, AUGUST, SEPTEMBER
1 9 5 1
500 ml. samples

Location	No. Samples	Ether Extraction dis/min/liter		No. Samples	Fluorophotometer ug U/liter	
		Maximum	Average		Maximum	Average
Richland Well #2	13	23	13	12	9	6
Richland Well #4	56	21	9	55	9	4
Richland Well #5	12	23	7	11	5	<2
Richland Well #12	13	17	10	13	12	5
Richland Well #14	13	49	13	12	18	6
Richland Well #15	12	19	8	12	60	10
Richland Well #18	12	17	9	12	5	4
North Richland Well C	13	28	6	12	3	<2
North Richland Well D	11	19	8	13	8	<2
Benton City Store	13	46	17	13	18	10
Benton City Water Co.	12	47	30	11	47	16
Cobb's Corner	13	16	7	12	3	<2
Kennewick Std. Station	12	21	7	10	3	<2
White Bluffs Ice House	11	10	7	13	9	3
Pasco Improvement Farm Well	1	11	11	0		
White Bluffs Telephone Exch.	12	11	6	0		
Sacajawea Park	12	36	15	12	18	8
Patterson	12	18	9	9	7	4

The locations at which alpha activity exceeded six dis/min/liter were nearly identical to those which indicated positive activity during the previous quarter. The magnitude of the mean activity was comparable to previous measurements at all locations except Richland Well #18; a decrease from a previous average of 28 dis/min/liter to 9 dis/min/liter was noted at the latter location. The value of 9 dis/min/liter is within the range of normal fluctuation for Richland Wells. Uranium was detected in nearly all wells in the Richland and Benton City region; mean values ranging from 4 to 16 μg U/liter at these locations were comparable to previous values. Spot analysis of Richland and Benton City samples for radium and plutonium indicated negligible activity from these sources. The uranium detected in these supplies presumably occurs naturally in this region.

Trace quantities of alpha activity were detected in individual samples from many wells during the quarter, however, the average activity from this source did not exceed 6 dis/min/liter over the three month period. In many instances the magnitude of this activity barely exceeded the detection limit of the analysis and except for isolated cases, the positive values were not confirmed by resample. Tables II and III summarize the results of measurements obtained from samples of all wells which were sampled repetitively during the quarter. Table II includes this tabulation for 500 ml. samples and Table III summarizes the results from the 12 liter sample measurements. (see following pages)

The activity density from gross beta emitters in drinking water supplies was below the detection limit of the analysis (5×10^{-8} μc/cc) at all locations except those which take water directly from the Columbia River. Maximum values were obtained from samples at Pasco where water leaving the filter plant averaged 1.8×10^{-7} μc/cc including a maximum measurement of 4.3×10^{-7} μc/cc. These values represented a small but non-significant increase over similar measurements obtained during the previous quarter. The small increase was associated with the lower dilution ratio of river water to pile effluent caused by the lower flow rate of the Columbia river during this period. The only other off-area drinking

TABLE II
SUMMARY OF ALPHA AND BETA EMITTERS MEASURED IN WATER SUPPLIES
500 ml. samples
JULY, AUGUST, SEPTEMBER
1951

Location	Number Samples	Alpha Emitters Activity Density dis/min/liter		Beta Emitters Activity Density x 10^8 μc/cc	
		Maximum	Average	Maximum	Average
Richland Well #2	13	23	13	4	<1
Richland Well #4	56	21	9	4	<1
Richland Well #5	12	23	7	3	<1
Richland Well #12	13	17	10	2	<1
Richland Well #13	13	16	6	2	<1
Richland Well #14	13	49	13	1	<1
Richland Well #15	12	19	8	1	<1
Richland Well #18	12	17	9	2	<1
Tract House J-685	13	18	5	2	<1
Foster's Ranch	9	4	3	2	<1
Headgate Well	16	7	3	2	<1
Hanford Well #1	9	10	5	1	<1
Hanford Well #4	9	10	4	1	<1
Hanford Well #7 Sanitary	13	18	5	1	<1
3000 Area Well "A"	13	15	5	2	<1
3000 Area Well "B"	13	16	5	3	<1
3000 Area Well "C"	13	28	6	<1	<1
3000 Area Well "D"	11	19	8		<1
3000 Area Well "E"	12	10	5	2	<1
3000 Durand #5	14	9	3	5	<1
Columbia Field Well "A"	13	15	4	1	<1
Columbia Field Well "B"	12	20	5	1	<1
Columbia Field Well "C"	13	7	2	8	1
1100 Area Well #8	12	14	4	2	<1
Benton City Store	13	46	17	2	<1
Benton City Water Co.	12	47	30	4	<1
Cobb's Corner	13	16	7	3	<1
Enterprise Well	13	8	3	3	<1
Kennewick Standard Station	12	21	7	43	10
Riverland	13	15	4	2	<1
Midway	13	6	<2	2	<1
Lower Knob	13	18	3	5	1
Wills Ranch	13	10	3	3	<1
P-11 Well	10	9	3	2	<1
Pistol Range	13	11	5	2	1
White Bluffs Ice House	11	10	7	20	5
Pasco Drinking Water	13	-	-	43	18
Pasco Improvement Farm	2	11	11	<1	<1
300 Area Sanitary	23	15	3	2	<1
200 East Sanitary	12	8	<2	23	5
200 West Sanitary	12	11	2	35	9
100-B Sanitary	13	7	2	2	<1
100-D Sanitary	13	5	<2	12	3
100-DR Sanitary	14	12	2	15	3

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TABLE II
SUMMARY OF ALPHA AND BETA EMITTERS MEASURED IN WATER SUPPLIES
500 ml. samples
JULY, AUGUST, SEPTEMBER
1951

Location	Number Samples	Alpha Emitters Activity Density dis/min/liter		Beta Emitters Activity Density x 10^8 μc/cc	
		Maximum	Average	Maximum	Average
100-F Sanitary	13	8	2	34	12
100-H Sanitary	13	12	<2	23	9
White Bluffs Tel. Ex.	12	11	6	15	4
Sacajawea Park	12	36	15	3	<1
McNary Dam	13	7	3	10	2
Patterson	12	18	9	<1	<1
Plymouth	13	5	2	<1	<1
Prosser	12	2	<1	1	<1
Redox Add Bldg.	12	7	3	5	2
251 Bldg. Sanitary	12	14	5	1	<1

water supply which indicated measurable beta activity was Kennewick where the activity density averaged 1.0×10^{-7} μc/cc. Drinking water supplies at the Hanford Works operating areas showed detectable activity from beta emitters at all areas during some part of the quarter; average values ranged from 3×10^{-8} μc/cc to 1.2×10^{-7} μc/cc. Maximum activity predominated at the 100-F area which is the most downstream operating area and therefore represents the higher activity concentration from the Columbia river water. General increases in the activity measured in sanitary water at the operating areas were also associated with the lower flow rate of the Columbia river. The results of beta measurements obtained from all wells which were repetitively sampled during the quarter are summarized in Table II.

Samples from various filtering media and backwash processes at the Pasco filter plant were obtained throughout the period. Table IV summarizes the results obtained from the radiochemical analysis of these samples.

TABLE III

SUMMARY OF ALPHA EMITTERS MEASURED IN DRINKING WATER

12 liter samples

Activity Density - Units - dis/min/liter

JULY, AUGUST, SEPTEMBER

1 9 5 1

Location	Number Samples	Maximum	Average
Richland Well #2	6	12	6
Richland Well #4	6	12	5
Richland Well #5	6	3	<2
Richland Well #12	7	8	3
Richland Well #13	5	6	5
Richland Well #14	5	6	4
Richland Well #15	5	10	7
Richland Well #18	5	9	6
Foster Ranch	5	4	2
Hanford Well #1	5	3	2
Hanford Well #4	5	3	<2
3000 Area Well "A"	6	4	2
3000 Area Well "B"	6	2	<2
3000 Area Well "C"	6	4	2
3000 Area Well "D"	6	3	<2
3000 Area Well "E"	6	9	3
3000 Area Duruand #5	7	3	<2
Columbia Field Well "A"	7	2	<2
Columbia Field Well "B"	7	2	<2
Columbia Field Well "C"	7	2	<2
3000 Area Pond Inlet	7	4	3
1100 Area Well #8	7	4	3
Benton City Store	6	22	10
Benton City Water Co. Well	4	25	17
Cobb's Corner	6	4	2
Will's Ranch	7	3	<2
P-11 Well	4	4	<2
Pistol Range	7	17	5
White Bluffs Ice House	6	5	<2
251 Building Sanitary	7	5	2

TABLE IV
RADIOACTIVE CONTAMINATION AT PASCO FILTER PLANT
JULY - AUGUST - SEPTEMBER
1951

Type Sample	Activity Density —— Gross Beta Emitters Maximum	Average
Water Entering Plant From River	1.9×10^{-6} µc/cc	6.9×10^{-7} µc/cc
Sand (surface of sand filter	3.7×10^{-5} µc/gm	1.3×10^{-5} µc/gm
First Backwash Material (liquid)	4.6×10^{-7} µc/cc	2.4×10^{-7} µc/cc
First Backwash Material (solid)	1.8×10^{-2} µc/gm	3.8×10^{-3} µc/gm
Coal (surface of coal filter)	1.2×10^{-4} µc/gm	4.9×10^{-5} µc/gm
First Backwash Material (liquid)	3.4×10^{-7} µc/cc	2.3×10^{-7} µc/cc
First Backwash Material (solid)	6.9×10^{-3} µc/gm	5.0×10^{-3} µc/gm
Water Leaving Plant	4.3×10^{-7} µc/cc	1.8×10^{-7} µc/cc

The measurements summarized above were in reasonable agreement with previous results and the values were well within the range expected for the existing river flow. All maximum measurements were obtained toward the latter part of the quarter when the river flow was at a minimum for the period.

A more detailed survey at the Pasco Filter Plant including direct sampling of the various settling and coagulation basins was completed on August 17. Progressive decontamination through the various treatment processes indicated a decontamination factor of approximately 10 for the processed water and a concentration factor greater than 500 to 1 when comparing the activity in one cc. of inlet water to 1 gram of pressed-dried sludge. A detailed discussion of these results may be referred to in an associated publication (HW-22862).

A summary of the results obtained from the radiochemical analysis of test well samples for all test wells at which the activity density from alpha emitters exceeded 6 dis/min/liter is presented in Table V. The results from uranium measurements are also included.

TABLE V
ACTIVITY DENSITY IN TEST WELLS
JULY, AUGUST, SEPTEMBER
1951

Location	No. Samples	Alpha Activity Density dis/min/liter Maximum	Alpha Activity Density dis/min/liter Average	No. Samples	Uranium Activity Density µg U/liter Maximum	Uranium Activity Density µg U/liter Average
300 Area Well #1	12	679	269	10	322	124
300 Area Well #2	24	598	278	22	268	146
300 Area Well #3	19	428	194	18	251	142
300 Area Well #4	12	457	291	11	322	138
300 Area North Well	8	7004	3900	9	13066	6566
BY Well	13	19	7	13	4	2
200 North Well	9	9	6	1	<2	<2

A comparison of the above measurements with those from the previous quarter shows that the alpha activity in the 300 Area wells increased during this period. This increase was expected as the data obtained over the past several years shows this activity to fluctuate in accord with flow rate of the Columbia River. As in the past, the predominant contaminant in these wells was uranium which apparently originates from an open waste area between the river and the four wells. Highly significant increases were noted at the 300 North Area Well where the average uranium content increased from 1.8×10^3 µg/liter to 6.6×10^3 µg/liter during this quarter. Maximum measurements (1.3×10^4 µg/liter) were three times greater than the maximum measured during April, May and June. This well continued to represent the most contaminated well in the Regional Survey sampling program.

SECTION VII

H. J. Paas
Regional Survey-RADIOLOGICAL SCIENCES

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