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AEC RESEARCH AND DEVELOPMENT REPORT

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HANFORD TECHNICAL RECORD

RADIOACTIVE CONTAMINATION IN THE HANFORD ENVIRONS

FOR THE PERIOD

OCTOBER, NOVEMBER, DECEMBER

1957

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M. W. McCONIGA, J. M. SELBY and J. K. SOLDAT

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Health and Safety
(M-3679, 21st Ed.)

This document consists of 41 pages. [redacted]

RADIOACTIVE CONTAMINATION IN THE HANFORD ENVIRONS FOR THE PERIOD OCTOBER, NOVEMBER, DECEMBER 1957

DECLASSIFICATION REVIEWED BY: [signature] AUTHORITY CANCELLED AND CHANGED TO UNCLASSIFIED OR ☐ UPGRADED TO CLASSIFICATION [signature] DATE 4-4-73 CLASS. OFFICER 1-3-58

Classification Cancelled (Change to UNCLASSIFIED)
By Authority of Doc
May 1973
By L. Pope 7/13/73

By

M. W. McConiga, J. M. Selby
and
J. K. Soldat

Regional Monitoring
Radiation Protection Operation

[redacted] OF REPORT [redacted] CLASSIFICATION ALTHOUGH [redacted] ADDED TO ALL PAGES.

February 28, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Work performed under Contract No. W 31-109-Eng-52 between the Atomic Energy Commission and General Electric Company

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[redacted]	[redacted]	[redacted]	JUN 12 1958	[redacted]
[redacted]	533	[redacted]	4-6-65	[redacted]

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ABSTRACT

SECTION I: RADIOACTIVE CONTAMINATION IN EFFLUENT GASES

Total average I^{131} emission from A-plant and S-plant stacks this quarter was 0.9 curie per day, compared to 1.0 curie per day during the previous quarter. Approximately 60 per cent of the I^{131} was emitted from A-plant stack this quarter. The average ruthenium emission increased over the previous quarter, with a maximum emission in October of 0.65 curie per day.

During the quarter, a significant decrease occurred in trituum oxide emissions from all reactor area stacks. The total average emission was 1.0 curie per day, compared to 1.9 curies per day last quarter. Increases up to factors of 10 and 7, respectively, occurred during the quarter in C^{14} and S^{35} emission rates.

No significant changes were noted in the alpha particle emitters from reactor stack gases through the quarter. Filterable gross beta emitters increased by a factor of 10 and the concentrations of radioactive particles increased by a factor of 4.

SECTION II: RADIOACTIVE CONTAMINATION ON VEGETATION

Average I^{131} and "FP-I^{131}" activity density on vegetation increased significantly this quarter at all locations sampled due to bomb debris from nuclear tests. Localized increases were also noted after an unusually high emission of I^{131} from Redox in December.

Significant increases in alpha activity density on vegetation were noted at all locations sampled this quarter.

SECTION III: RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE

The average dosage rates measured on integrons and HM chambers in the Tri-City Area and the 300 Area decreased slightly over the previous quarter's values.

The concentration of radioactive particles and the radio-iodine activity density in the atmosphere showed a small increase in the vicinity of the project. Lewiston, Idaho, had a six-fold increase in concentration of radioactive particles; while Great Falls, Montana, showed a five-fold increase. A decrease in concentration was noted at Boise, Idaho; however, the concentration was still almost twice as high as at the other two locations.

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SECTION IV: RADIOACTIVE CONTAMINATION IN HANFORD WASTES

Gross beta activity in reactor cooling water discharged to the Columbia River averaged 1.8×10^4 curies per day this quarter, compared to 1.5×10^4 curies per day last quarter. A summary of activity in liquid wastes discharged to open swamps and ditches is tabulated. Results of ground surveys on the project and in nearby residential areas are illustrated in Appendix B.

Ground surveys of Richland in October revealed one particle in 32,000 square feet surveyed. The particle concentration around Purex and Redox stacks decreased to 33 per cent of the last quarter's concentration.

SECTION V: RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER AND RELATED WATERS

Beta emitter concentrations in Columbia River water and mud, from the reactors to McNary Dam, were on the order of twice the previous quarterly level, mainly attributable to a decrease to half the previous river flow.

All alpha particle emitter concentrations were below the reporting limit.

SECTION VI: RADIOACTIVE CONTAMINATION IN DRINKING WATER

The 100 Area drinking waters reflected the increased beta emitter activities of Columbia River raw waters with the decrease in river flow. The 100-F Area drinking water (1.8×10^{-5} μc/cc) had the highest average measurement. Ingestion of 100-F raw water would contribute about four per cent, and sanitary water about 1.7 per cent of permissible occupational GI exposure from drinking water.

Kennewick composite sanitary samples contained about three times the beta emitter concentrations of Pasco composites and contributed the same exposure as Pasco raw waters.

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INTRODUCTION

This document summarizes the results obtained from monitoring the Hanford environs for radioactive contamination during the period October, November, December, 1957. Samples were collected by Regional Monitoring forces according to procedures previously outlined in documents of this series.(1) These samples were analyzed by Radiological Chemical Analysis forces according to procedures and techniques described in a previously published laboratory manual.(2)

Counting rates obtained from these analyses were corrected for geometry, backscatter, air-window absorption, source size, self-absorption, chemical yield, and collection efficiency by Radiological Chemical Analysis forces using factors described in previous reports.(3, 4, 5) Additional corrections for decay were applied to those samples in which significant amounts of short half-life beta particle emitters were found. The findings obtained from analyzing the direct samples were supplemented with readings obtained from portable and fixed instrumentation.

The results obtained from the described efforts are presented in Sections I through VI. These sections discuss the amounts of active material discharged from plant facilities and their effect on the contamination of vegetation, air, soil, and water.

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SECTION I

RADIOACTIVE CONTAMINATION IN EFFLUENT GASES

Radioactive contaminants in the separations and reactor area effluent gases released to the Hanford environs were sampled at the stacks and the stack breechings. Daily filter and scrubber samples from the separations areas were analyzed for I^{131}, $Ru^{103-106}$, and filterable total beta activity. Semi-weekly filter samples and monthly tritium oxide and C^{14}-S^{35} samples were taken from the reactor area stacks. The results obtained are discussed below and summarized in Table I through V in Appendix A.

SEPARATIONS AREAS

Slight changes in the I^{131} emission rates from the A-plant (Purex) stack this quarter were within the range of fluctuations normally observed at this facility. The average daily emission of filterable gross beta emitters remained at the level observed during the last quarter (Table I).[8]

The average daily emission rate of I^{131} from S-plant (Redox) was still increasing over the low value noted during the second quarter. Average values of 0.13, 0.41, and 0.54 curie per day were noted during the second, third, and fourth quarters[6, 7, 8], respectively (Table II). Average ruthenium emission rates from the S-plant stack were above the detection limit this quarter. The maximum measurement was 0.65 curie per day, compared to a maximum of 0.04 curie per day last quarter.

Changes in concentrations of filterable radioactive materials discharged from the U-plant stack this quarter were insignificant when compared with previous fluctuations (Table III).

REACTOR AREAS

Tritium oxide emission rates showed a significant decrease in all reactor areas, except 100-B and 100-KW. Total emission from the eight

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reactor areas combined was less than 1.0 curie per day this quarter, compared to 1.9 curies per day last quarter. The maximum measurement was 0.4 curie per day at 100-B Area in November, and also at 100-KW Area in December.

Increases up to a factor of ten were noted in C^{14} emission rates this quarter. The maximum C^{14} value occurred at 100-D Area in October when 0.14 curie per day was emitted. Daily average S^{35} emission rates increased up to a factor of seven this quarter, although the maximum of 1×10^{-2} curie per day occurring at 100-B Area in October was below the last quarter maximum (Table IV).

The average activity density of alpha particle emitters discharged from the reactor stacks remained below the detection limit of 6×10^{-8} curie per day again this quarter. The maximum value this quarter was 3.1×10^{-7} curie per day at 100-C Area, compared to the last quarter maximum of 1.1×10^{-7} curie per day at 100-KW Area. Increases up to a factor of nine were noted in the gross beta particle emitter activity density; maximum value was 2.6×10^{-3} curie per day occurring at 100-KE Area. The concentration of radioactive particles showed increases up to a factor of four with the maximum of 1.1×10^{3} particles per day occurring at 100-C Area (Table V).

300 AREA - 327 BUILDING

Weekly filter and scrubber samples collected from the plenum of the 327 Building stack were analyzed for gross beta particle emitters. The emission rates from the stack were in the expected range of values this quarter following the unusually high measurements obtained last quarter. The present quarter average was less than 4×10^{-5} curie per day; the average last quarter was 4×10^{-3} curie per day.

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SECTION II

RADIOACTIVE CONTAMINATION ON VEGETATION

Determination of the radioactive contamination on vegetation in the environs was made by gamma spectrometric analysis for Zr^{95}-Nb^{95}, Ru^{103}-Ru^{106}, I^{131}, Ba^{140}-La^{140}, and Ce^{141}-Ce^{144}-Pr^{144}. Approximately 130 composite samples were collected from the project and about 100 composite samples from off-project locations in Washington and Oregon. Analysis for alpha particle emitters on vegetation was made on 25 gram samples of vegetation collected from selected locations in and near the project. The results of these vegetation measurements are summarized in Tables VI and VII in Appendix A.

I^{131} deposition on vegetation increased nearly ten-fold at Hanford and throughout the Pacific Northwest in October as a result of deposition of bomb debris from nuclear tests. Fission products minus I^{131} ($FP\text{-}I^{131}$) increased three-fold. Activity density of I^{131} and "$FP\text{-}I^{131}$" on vegetation returned to normal in November.

The high I^{131} emission from Redox stack in November (Section I) resulted in increased deposition on vegetation in residential areas. Maximum I^{131} activity density was 3×10^{-5} $\mu c/gm$ at Benton City and Richland. Figures 1 through 3 illustrate the patterns of I^{131} activity density on vegetation during October, November and December.

Average alpha emitter activity density on vegetation this quarter increased up to a factor of six at locations near the separations areas. These significant increases are a continuation of a long-term increasing trend. Five-fold increases were noted in alpha activity on vegetation sampled from nearby residential areas this quarter.

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SECTION III

RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE

The magnitude and extent of airborne contamination in the Hanford environs were determined from analyses of filter and scrubber samples and from data recorded in the operation of Victoreen Integrons, HM Chambers, and Detachable Ionization Chambers. The results obtained by each of these monitoring methods are summarized in Tables VIII through X in Appendix A.

The quarterly average dosage rates in the Tri-City Area and in the vicinity of 300 Area were slightly lower than those noted last quarter.[8] The quarterly average in the Tri-City Area was still about twice as high as that in the 300 Area and Vicinity. A slight increase was noted in the dosage rates measured at Benton City this quarter. The 100 Area and Vicinity readings have increased considerably over the last three quarters[6, 7, 8] from a reading of 2.7 mrad per day during the second quarter to 6.2 mrad per day for the present quarter. The reading of 2.9 mrad per day for 200 Areas and Vicinity was approximately two-thirds of last quarter's reading.

The average alpha particle emitter activity density in the atmosphere was above the detection limit of 2×10^{-15} μc/cc at eight scattered locations. In each case, one extremely high sample occurred during the quarter. If these high samples were omitted, the average of the other samples would have been below the detection limit.

Filterable beta particle emitters and radioactive particle concentrations in the atmosphere increased on the project and in the Tri-City Area. The quarterly average radioactive particle concentration showed a six-fold increase at Lewiston, Idaho. A five-fold increase was measured at Great Falls, Montana; and a decrease from 0.6 to 0.36 particle per cubic meter occurred at Boise, Idaho. The highest monthly average this quarter (0.9 particle/m^3) occurred at Boise, Idaho, during bomb fallout in October.

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The quarterly average radio-iodine activity density in the atmosphere increased up to three times the previous quarterly average (Table X). The weekly maximum of 6.2×10^{-12} $\mu c/cc$ occurred in 200 West Area during the week ending November 25, co-incident with the high emission of 13 curies of I^{131} per day from the S-plant stack.

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SECTION IV

RADIOACTIVE CONTAMINATION IN HANFORD WASTES

The magnitude and extent of radioactive contamination in Hanford wastes were determined from the results of over 2600 measurements. Solid and liquid samples obtained from open waste areas were analyzed radiochemically for gross alpha and beta particle emitters. Specific isotopic analyses were also performed for certain other contaminants. These measurements were supplemented with data obtained from portable instrument surveys at various locations on the plant.

100 AREA WASTES

Radioactive contamination discharged to the Columbia River from the reactor areas was determined by analyzing samples collected daily from the outlets of the effluent water retention basins and correcting the results for decay. A summary of the activity of beta particle emitters discharged to the river per unit of time, not corrected for periods of reactor outage (when no samples were taken) is given in Table XI in Appendix A.

The average total beta activity in cooling water discharged to the river from all reactors increased from 1.5×10^4 curies per day last quarter[8] to 1.8×10^4 curies per day during the current quarter.

The activity density of I^{131} in waste discharged to the Columbia River from the Biology Farm at 100-F Area was measured by analyzing composite samples collected from the sump in the waste discharge line. An average of 110 μc/day was discharged to the river from this source during the quarter.

200 AREA WASTES

The results of liquid and solid samples collected from waste sources in the separations areas are summarized in Tables XII and XIII in Appendix A.

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The beta activity density in T-swamp and U-swamp remained at the level observed last quarter.

The alpha activity density increased up to a factor of ten in the laundry ditch, the 231 ditch and the 234-5 ditch; however, the U-swamp (where the ditches discharge) had almost a fifty per cent reduction in concentration. Mud samples from the 234-5 ditch showed a five-fold increase in alpha activity. A four-fold increase in alpha concentration occurred in water samples from the 222-S swamp this quarter. The alpha and beta activity densities in the remaining locations were within the range of fluctuations expected.

Portable instrument surveys using GM and CP meters were performed at the perimeter of all open waste zones in the separations areas. Counting rates obtained over mud and water at the B-ditch and B-swamp in 200 East Area this quarter ranged from background to 300 c/m above background. These readings were comparable to those noted last quarter. Counting rates observed at the T-swamp and T-ditch were similar to those noted last quarter. Maximum readings were obtained in November, when 20,000 c/m and 15,000 c/m were observed over the ditch and the swamp, respectively. Laundry ditch readings continued to range from background to a few hundred counts per minute. Maximum readings were again obtained at the U-swamp inlet, where one reading of 40,000 c/m was found during the quarter.

300 AREA WASTES

Radioactive contamination in waste water entering the 300 Area North pond was measured in bi-weekly composite samples collected by Fuels Preparation Department personnel (Table XIV). Slight increases in both uranium and gross beta activity density were noted in the waste stream during the quarter.

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ENVIRONS - GROUND CONTAMINATION

One radioactive particle was detected when portable instrument surveys of 32,000 square feet were performed in Richland during October. The surface reading obtained on this particle was 30,000 c/m, on a Thyac GM meter.

Surveys of ground adjacent to the project roadways and inside of areas revealed 0 to 2 particles per 1000 square feet, except in the vicinity of 100-B Area, 100-K Area, and around 200 West Area. A concentration of 10 to 30 particles per 1000 square feet surveyed was found in and around 100-B Area as a result of the 107-C basin dryout in December. In October, concentrations of 0 to 32 particles per 1000 square feet surveyed were found in 100-K Area. This contamination occurred when an experimental facility was removed from the 105-KE reactor. Approximately four square miles in and around 200 West Area, were contaminated with 5 to 1000 particles per 1000 square feet during burial of grossly contaminated equipment in November.

Surveys of 400 square foot plots around Redox during the quarter disclosed an average deposition of 2 particles per plot. This is one-third the concentration found during the last quarter. The maximum concentration found during the quarter was 9 particles per plot. Particle deposition around Purex decreased during the quarter with a maximum of 4 particles found in one plot during December. The average concentration of 53 plots surveyed during the quarter was 0.6 particle per plot, compared to an average of 2 particles per plot during the last quarter.

Figure 4 (Appendix B) illustrates the ground contamination pattern found during November.

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SECTION V

RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER AND RELATED WATERS

The approximately 500 water samples taken from the Columbia, Yakima, and Snake Rivers were analyzed to determine the concentration of their radioactive contaminants. All river locations sampled this quarter indicated alpha particle emitter concentrations below the reporting limit of 5×10^{-9} μc/cc.

The average beta particle emitter activity densities of Columbia River water (Table XV) were generally on the order of twice the third quarter[8] average of 1957. This can be attributed mainly to the change in river flow, which was 9.3×10^{5} gps in the third quarter and 4.7×10^{5} gps in the fourth.

Monthly one-liter samples collected from the Columbia River between McNary Dam and Portland indicated a two to three-fold increase in beta emitters immediately below the dam, but only slight increases at monitoring sites farther down stream. The highest monthly average was 2.7×10^{-6} μc/cc below the dam in December, 1957.

The average I^{131} activity density of 13 water samples from the Hanford Ferry was 1.1×10^{-7} μc/cc, about twice the average of analyses for the third quarter.

All alpha particle emitter concentrations of mud samples from the Columbia River and nearby tributaries were below the reporting limit of 3×10^{-6} μc/gm. The gross beta activity in Columbia River mud increased in about the same ratio as did the river water, up to twice the levels of the previous quarter. Yakima and Snake River mud samples showed no change.

The activity density from gross alpha emitters was below the detection limit for all samples of raw water collected from the 183 and 283 Buildings in the reactor and separations areas (Table XVI). The beta emitters in raw water at the 100 Area intake buildings were on the order of two to three times more concentrated than last quarter, the highest average being 4.2×10^{-5} μc/cc at 181-F.

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Beta emitters in 283-East and West raw waters showed an increase from 2×10^{-7} μc/cc in the third quarter to 6×10^{-6} μc/cc in the fourth, but are still lower than all but two of the 100 Area raw water average concentrations.

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SECTION VI

RADIOACTIVE CONTAMINATION IN DRINKING WATER

Drinking water in the 100 Areas was approximately three times higher in beta emitter concentrations than in the third quarter of 1957,[8] reaching 1.8×10^{-5} μc/cc at 100-F Area. The per cent of maximum permissible continuous occupational GI exposure from ingestion of these waters, calculated from isotopic analyses, is about 1.7 per cent, and from 100-F raw water, about 4 per cent. Ten per cent of permissible exposure is the limit which can be contributed by drinking water.

The increase in 100 Area drinking water contamination is approximately the same factor of increase observed in the raw water, which is mainly the result of a drop to less than half the previous quarterly river flow.

The 200 Area drinking water also showed increases in beta emitters by 10 to 20 times, but still remained in the 10^{-6} μc/cc range. The White Bluffs Fire Hall drinking water, which recently showed an unexplained increase, is now also in the 10^{-6} μc/cc range.

The Kennewick composite drinking water sample contained about three times the beta emitter concentration of the Pasco composite. Samples taken at each end of the Pasco-Kennewick Bridge indicated that the raw water taken in for processing was nearly equal in beta emitter concentrations. The Pasco floculation-filtration treatment process of water purification is evidently superior to the Ranney collection system used by Kennewick. The Ranney system depends on the filtration efficiency of river bed sediments, the fine constituents of which have evidently been removed by development of the system.

Percents of permissible continuous occupational exposure to the GI tract from ingestion of raw water from Pasco and Kennewick were calculated from isotopic analyses of the raw water. At Pasco, per cent of permissible

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exposure increased from 0.6 per cent in September to 0.8 per cent in October, 1.0 per cent in November, and 1.7 per cent in December.

The only changes from the previous values in alpha particle emissions in Table XVIII are slightly higher average values in Columbia Field sanitary and Paterson Store water samples. These appear to be influenced by one high maximum value.

In Table XIX, Pasco Filter Plant samples were only slightly higher than for the previous quarter. The recent policy, with the installation of a new water superintendent, is to frequently drain the filter basins, clean them, and wash the walls with a fire hose. This may lower the values on filter bed materials.

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APPENDIX A

Tables I through XIX

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TABLE I

IODINE-131 AND FILTERABLE BETA PARTICLE EMITTERS
DISCHARGED FROM THE A-PLANT STACK
OCTOBER, NOVEMBER, DECEMBER
1957

Units of Curies Per Day

Month	I-131		Filterable Total Beta	
	Maximum	Average	Maximum	Average
October	0.7	0.25	0.012	0.005
November	1.3	0.68	0.034	0.010
December	0.68	0.20	0.066	0.011
Quarter	1.3	0.38	0.066	0.009
Last Quarter	4.6	0.64	0.035	0.010

TABLE II

IODINE-131 AND RUTHENIUM DISCHARGED
FROM THE S-PLANT STACK
OCTOBER, NOVEMBER, DECEMBER
1957

Units of Curies Per Day

Month	I-131		Ruthenium	
	Maximum	Average	Maximum	Average
October	0.7	0.16	0.65	0.05
November	13	0.64	0.08	0.02
December	9.5	0.81	0.03	0.01
Quarter	13	0.54	0.65	0.03
Last Quarter	2.1	0.41	0.04	0.01

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TABLE III

RADIOACTIVE PARTICULATE MATERIALS DISCHARGED FROM THE U-PLANT STACK OCTOBER, NOVEMBER, DECEMBER 1957

Month	Alpha Particle Emitters, Units of 10^{-8} curie/day		Beta Particle Emitters, Units of 10^{-5} curie/day		Radioactive Particle Concentrations, Units of 10^{4} Particles/day	
	Max.	Avg.	Max.	Avg.	Max.	Avg.
October	1.4	0.4	0.13	0.08	1.5	0.5
November	1.8	0.8	0.49	0.12	2.0	0.4
December	0.7	0.4	0.05	0.03	1.0	0.4
Quarter	1.3	0.5	0.22	0.08	2.0	0.4
Last Quarter	3.2	1.0	0.15	0.09	2.6	0.3

TABLE IV

QUARTERLY SUMMARY OF TRITIUM OXIDE, CARBON-14, SULFUR-35 DISCHARGED FROM REACTOR STACKS OCTOBER, NOVEMBER, DECEMBER 1957

Stack	Tritium Oxide, Units of curie/day		Carbon-14, Units of 10^{-3} curie/day		Sulfur-35, Units of 10^{-4} curie/day	
	Maximum	Average	Maximum	Average	Maximum	Average
100-B	0.4	0.2	15	12	100	61
100-C	0.1	<0.1	24	23	< 6	<6
100-KW	0.4	0.2	19	9.9	< 6	<6
100-KE	0.1	<0.1	23	12	13	6.3
100-D	0.3	0.1	140	55	12	8.8
100-DR	<0.1	<0.1	14	8.8	13	6.1
100-H	< 0.1	<0.1	13	7.9	< 6	<6
100-F	0.1	<0.1	14	7.2	24	13

TABLE V

QUARTERLY SUMMARY OF
RADIOACTIVE PARTICULATE MATERIALS DISCHARGED
FROM THE REACTOR STACKS
OCTOBER, NOVEMBER, DECEMBER
1957

Stack	Alpha Particle Emitters, Units of 10^{-7} curie/day		Beta Particle Emitters, Units of 10^{-5} curie/day		Radioactive Particle Concentrations, Units of 10^{5} Particles/day	
	Maximum	Average	Maximum	Average	Maximum	Average
100-B	0.6	<0.6	17	1.9	25	1.3
100-C	3.1	<0.6	140	26	110	15
100-KW	1.3	<0.6	21	7.4	4.3	0.3
100-KE	0.9	<0.6	260	84	5.2	0.3
100-D	<0.6	<0.6	9.4	1.6	1.8	0.2
100-DR	0.8	<0.6	28	3.8	0.9	0.1
100-H	0.9	<0.6	10	2.4	1.3	0.1
100-F	0.9	<0.6	92	8.6	25	2.7

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TABLE VI

SUMMARY OF VEGETATION MEASUREMENTS

OCTOBER, NOVEMBER, DECEMBER

1957

Units of 10^{-6} μc/gm

Locations	Zr-95 Nb-95	Ru-103 Ru-106	I-131	Ba-140 La-140	Ce-141 Ce-144	Fission Products Less I-131
Separations Areas	51	52	12	34	116	245
Project	44	13	6.1	26	87	167
Wahluke Slope	35	12	4.7	20	64	132
Residential Areas	34	15	10	38	96	175
Eastern Wash.	36	20	6.8	39	86	182
So. Central Wash. and No. Oregon	21	8.1	5.3	22	101	135

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TABLE VII

RADIOACTIVE CONTAMINATION FROM ALPHA PARTICLE EMITTERS ON VEGETATION OCTOBER, NOVEMBER, DECEMBER 1957

Units of 10^{-7} μc/gm

Location	October Average	November Average	December Average	Quarter Maximum	Quarter Average
Near Separations Areas					
200 West Gate	41	100	20	110	54
Meteorology Tower	5.3	17	13	19	12
Batch Plant	16	23	29	34	23
Rt. 4S, Mi. 4	8.4	12	6.4	18	8.8
Rt. 4S, Mi. 6	2.4	4.3	9.1	12	5.3
Residential Areas					
Pasco	0.4	2.4	2.0	3.3	1.6
Benton City	0.4	2.2	1.2	3.3	1.3

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TABLE VIII

AVERAGE DOSE RATES MEASURED BY IONIZATION CHAMBERS
OCTOBER, NOVEMBER, DECEMBER
1957

Units of mrad per day

Location	Integrons and HM Chambers		Detachable Chambers	
	Quarterly Average	Average Last Quarter	Quarterly Average	Average Last Quarter
100 Areas and Vicinity	6.2	5.8	1.1	0.8
200 Areas and Vicinity	2.9	4.0	1.3	0.8
300 - 3000 Areas and Vicinity	0.5	0.8	1.4	0.9
Benton City	0.7	0.5	---	---
Tri-City Area	0.9	1.5	0.9	0.7

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TABLE IX

RADIOACTIVE PARTICULATE MATERIALS FILTERED FROM AIR

OCTOBER, NOVEMBER, DECEMBER

1957

Location	Beta Particle Emitters Units of 10^{-14} μc/cc		Concentration of Radioactive Particles Units of 10^{-3} Particles/m^3	
	Quarterly Average	Average Last Quarter	Quarterly Average	Average Last Quarter
100 Areas and Vicinity	57	31	16	18
200 Areas and Vicinity	52	44	34	27
300 - 3000 Areas and Vicinity	49	34	31	15
Benton City	59	43	21	13
Tri-City Area	15	18	18	16
Seattle, Washington	--	--	27	14
Spokane, Washington	--	--	23	19
Walla Walla, Washington	--	--	63	27
Yakima, Washington	--	--	16	18
Boise, Idaho	--	--	360	600
Lewiston, Idaho	--	--	160	24
Great Falls, Montana	--	--	200	41
Meacham, Oregon	--	--	25	7
Klamath Falls, Oregon	--	--	67	30

TABLE X

CONCENTRATIONS OF IODINE DETECTED BY AIR SCRUBBERS
OCTOBER, NOVEMBER, DECEMBER
1957

Units of 10^{-12} μc/cc

Location	October	November	December	Qtrly. Avg.	Wkly. Max.	Avg. Last Qtrly.
100 Areas and Vicinity	0.3	0.1	0.1	0.1	0.5	0.1
200 Areas and Vicinity	0.6	0.2	0.6	0.5	6.2	0.3
300 Area and Vicinity	0.2	0.1	0.1	0.1	0.4	0.1
Benton City	0.4	0.1	0.2	0.2	0.8	0.1
Tri-City Area	0.4	0.1	0.3	0.3	1.8	0.1

TABLE XI

BETA PARTICLE EMITTERS DISCHARGED TO RIVER
IN REACTOR EFFLUENT WATER
OCTOBER, NOVEMBER, DECEMBER
1957

Units of 10^{3} μc/sec

Location	No. Samples	October		November		December		Quarterly	
		Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.
100-B	58	30	23	33	23	51	27	38	24
100-C	53	56	40	44	23	66	47	55	37
100-KW	56	77	44	75	40	90	41	81	42
100-KE	55	70	43	63	40	45	28	59	37
100-D	59	28	19	28	20	39	22	32	20
100-DR	61	22	16	25	16	26	14	24	15
100-H	58	22	13	31	19	25	17	26	16
100-F	58	28	16	28	14	34	15	30	15

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TABLE XII

RADIOACTIVE CONTAMINATION IN 200 AREA WASTE SYSTEMS

OCTOBER, NOVEMBER, DECEMBER

1957

Liquid Samples

Location	Alpha Particle Emitters Units of 10^{-8} μc/cc			Beta Particle Emitters Units of 10^{-7} μc/cc		
	Maximum	Average	Average Last Quarter	Maximum	Average	Average Last Quarter
T-Ditch	< 0.5	< 0.5	< 0.5	35	8	< 5
T-Swamp	< 0.5	< 0.5	< 0.5	5	< 5	< 5
Laundry Ditch	19	2.6	1.3	36	10	< 5
U-Ditch Inlet	6.0	1.3	2.2	46	15	< 5
231 Ditch	970	130	46	23	< 5	< 5
234-5 Ditch	580	110	11	15	< 5	< 5
U-Swamp	170	45	79	46	18	14
B-Ditch	< 0.5	< 0.5	< 0.5	< 5	< 5	< 5
B-Swamp	< 0.5	< 0.5	< 0.5	47	10	< 5
Purex	< 0.5	< 0.5	< 0.5	67	17	< 5
222-S Swamp	380	70	18	14	6	< 5
Redox Swamp	15	2.2	2.3	57	19	12

Solid Samples

	Units of 10^{-6} μc/gm			Units of 10^{-5} μc/gm		
T-Ditch	9.3	3.8	5.1	1300	330	950
Laundry Ditch	25	13	9.9	140	46	100
234-5 Ditch	26000	7100	1400	9.3	4.2	3.1
B-Swamp	1.9	0.7	1.3	40	8.1	5.8
Purex	1400	370	970	570	160	5.8
222-S Swamp	400	270	160	170	100	81
Redox Swamp	1700	560	970	16000	3900	3200

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TABLE XIII

RADIOACTIVE CONTAMINATION IN 200 AREA WASTE SYSTEMS

OCTOBER, NOVEMBER, DECEMBER

1957

Liquid Samples

	Uranium Units of 10^{-9} μc/cc		
Location	Maximum	Average	Average Last Quarter
U-Swamp	1800	690	1300
Laundry Ditch	240	15	10
U-Ditch	29	4.5	2.6
222-S Swamp	4400	780	130

Solid Samples

	Units of 10^{-6} μc/gm		
Laundry Ditch	51	19	8
222-S Swamp	240	69	68

TABLE XIV

RADIOACTIVE CONTAMINATION IN 300 AREA POND INLET

OCTOBER, NOVEMBER, DECEMBER

1957

Units of 10^{-7} μc/cc

Liquid Samples	Maximum	Average	Average Last Quarter
Beta Particle Emitters	9.8	3.1	2.7
Alpha Particle Emitters	< 1.5	< 1.2	< 1.3
Uranium	21.7	7.3	4.7
Plutonium	< 1.8	< 1.7	< 1.2

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TABLE XV

CONCENTRATIONS OF BETA PARTICLE EMITTERS IN RIVER WATER

OCTOBER, NOVEMBER, DECEMBER

1957

Units of 10^{-8} μc/cc

Location	October Average	November Average	December Average	Quarter Average	Average Last Quarter
Columbia River					
Will's Ranch	<5	<5	<5	<5	<5
181-B	8	---	---	8	<5
181-C	7	---	---	7	<5
181-KW	760	---	---	760	220
181-KE	780	---	---	780	350
181-D	2700	---	---	2700	890
181-H	3640	---	---	3640	1390
Below 100-H	2990	3980	2790	3250	1740
181-F	4170	---	---	4170	1420
Below 100-F	3740	4250	2680	3560	2410
Hanford	4810	5050	5350	5070	2440
300 Area	1250	1430	1420	1370	960
Byer's Landing	710	1360	1970	1340	630
Richland	980	1170	1410	1190	830
Kennewick Highlands Pumping Station	750	950	1180	960	430
Pasco Bridge (Kennewick side)	680	810	630	710	430
Pasco Bridge (Pasco side)	670	800	640	700	460
Pasco Filter Plant Pumping Station	880	820	920	870	750
Sacajawea Park	440	530	440	470	270
Below McNary Dam	180	80	270	180	46
Paterson	130	80	80	96	51
Snake River					
Mouth	7	<5	<5	<5	<5
Yakima River					
Prosser	8	<5	<5	<5	9
Shore	<5	<5	<5	<5	<5
Horn	<5	9	6	6	<5

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TABLE XVI

CONCENTRATIONS OF BETA PARTICLE EMITTERS IN RAW WATER

RIVER EXPORT LINE

OCTOBER, NOVEMBER, DECEMBER

1957

Units of 10^{-8} $\mu c/cc$

Location	October Average	November Average	December Average	Quarter Average	Average Last Quarter
183-B	17	8	7	11	8
183-C	17	9	8	11	10
183-KW	880	740	1280	970	240
183-KE	1450	1110	1430	1330	380
183-D	2680	2770	2780	2750	770
183-Dr	3400	2810	4460	3550	930
183-H	3520	2040	4490	3350	1570
183-F	3310	3220	4110	3550	1560
283-East	16	460	1360	610	16
283-West	24	570	1340	650	25

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TABLE XVII

CONCENTRATIONS OF ALPHA AND BETA PARTICLE EMITTERS IN WATER SUPPLIES OCTOBER, NOVEMBER, DECEMBER 1957

Location	No. Samples	Alpha Particle Emitters Units of 10^{-9} $\mu c/cc$ Max.	Alpha Particle Emitters Units of 10^{-9} $\mu c/cc$ Avg.	Beta Particle Emitters Units of 10^{-8} $\mu c/cc$ Max.	Beta Particle Emitters Units of 10^{-8} $\mu c/cc$ Avg.
Mattawa Chev. Station	13	<5	<5	<5	<5
Midway and Vicinity	23	<5	<5	6	<5
100-B Area	13	<5	<5	150	21
100-C Area	12	<5	<5	19	10
100-K Area	26	<5	<5	1320	570
100-D Area	12	<5	<5	2590	1230
100-DR Area	12	<5	<5	1980	1180
100-H Area	12	<5	<5	2060	870
100-F Area	12	<5	<5	5970	1850
White Bluffs Fire Hall	13	<5	<5	390	110
251 Building	12	<5	<5	90	30
200 East Area	30	<5	<5	1070	100
200 West Area	52	<5	<5	550	130
300 Area, 3000 Area (San)	23	5	<5	9	<5
Byer's Landing Pump Station	9	<5	<5	290	32
Larson Farm	12	<5	<5	5	<5
Richland	24	<5	<5	7	<5
Prosser	12	<5	<5	<5	<5
Benton City	37	17	11	11	<5
Headgate Well	13	<5	<5	5	<5
Enterprise	11	<5	<5	5	<5
Kennewick	43	<5	<5	800	250
Pasco	26	<5	<5	630	220
Sacajawea	8	14	8	<5	<5
McNary	22	<5	<5	6	<5
Paterson Store	12	5	<5	<5	<5
Pasco Composite	8	<5	<5	150	95
Kennewick Composite	8	<5	<5	440	270

TABLE XVIII

CONCENTRATIONS OF ALPHA PARTICLE EMITTERS
IN DRINKING WATER
OCTOBER, NOVEMBER, DECEMBER
1957

Location	Alpha Particle Emitters			Uranium		
	No. Samples	Units of 10^{-9} μc/cc		No. Samples	Units of 10^{-9} μc/cc	
		Max.	Avg.		Max.	Avg.
Columbia Field (San)	12	<5	<5	12	8	3
Lee Blvd. (San)	12	<5	<5	12	5	4
Benton City Store	13	17	11	13	14	10
Benton City Water Company	12	15	11	12	14	10
Sacajawea	8	14	8	9	11	9
Paterson Store	12	5	<5	12	8	5

TABLE XIX

CONCENTRATIONS OF BETA PARTICLE EMITTERS
AT THE PASCO FILTER PLANT
OCTOBER, NOVEMBER, DECEMBER
1957

Type Sample	No. Samples	Maximum	Average
Water Entering Plant From River	28	1.5×10^{-5} μc/cc	8.7×10^{-6} μc/cc
Filter Bed Material	12	1.3×10^{-3} μc/gm	6.2×10^{-4} μc/gm
Backwash Activity (Soluble)	11	6.9×10^{-6} μc/cc	3.8×10^{-6} μc/cc
Backwash Activity (Insoluble)	11	5.6×10^{-1} μc/gm	2.8×10^{-1} μc/gm
Foam From Filter Beds	1	4.2×10^{-2} μc/gm	4.2×10^{-2} μc/gm
Water Leaving Plant	21	6.3×10^{-6} μc/cc	3.3×10^{-6} μc/cc

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APPENDIX B

Figures 1 through 4

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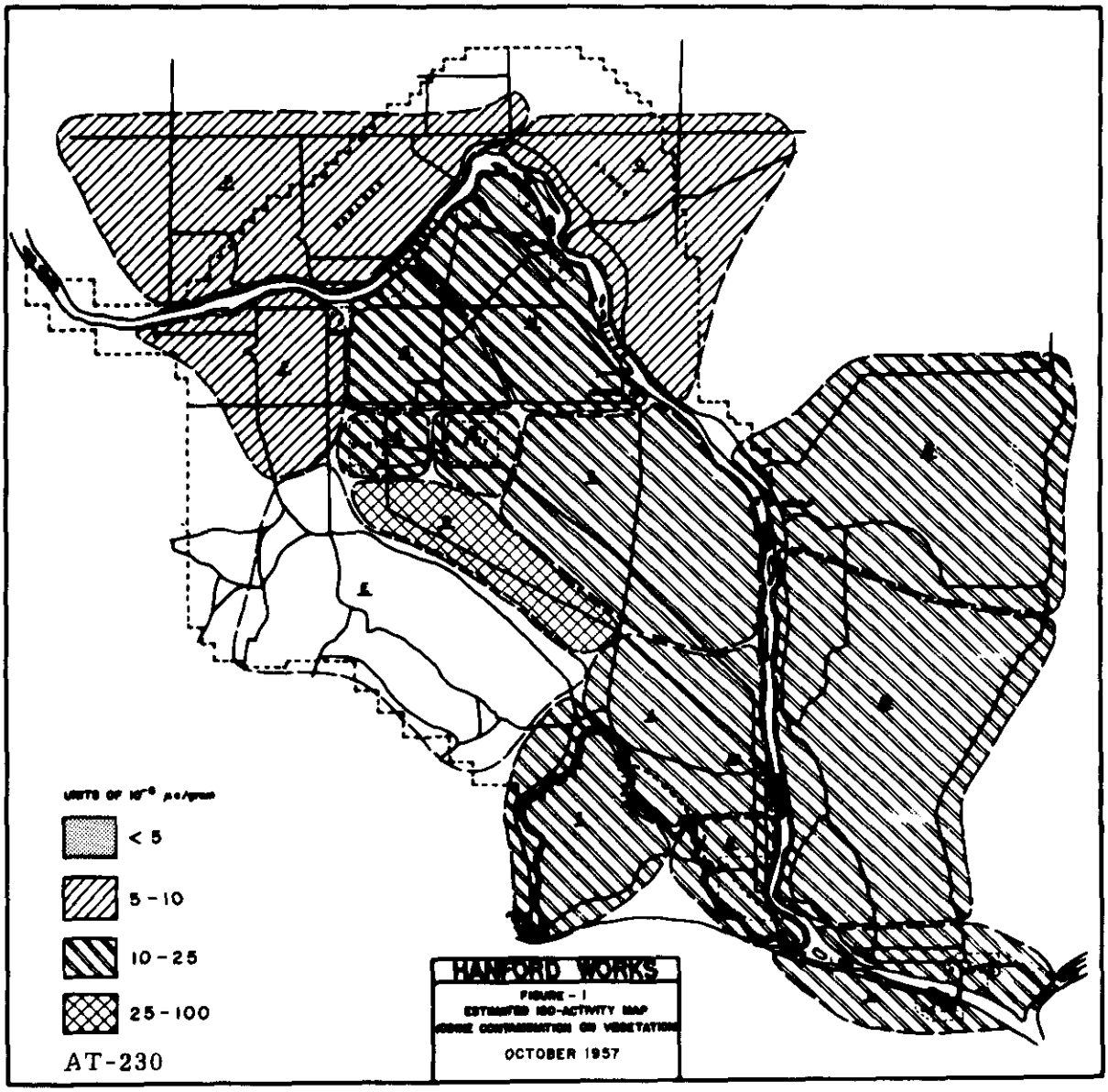

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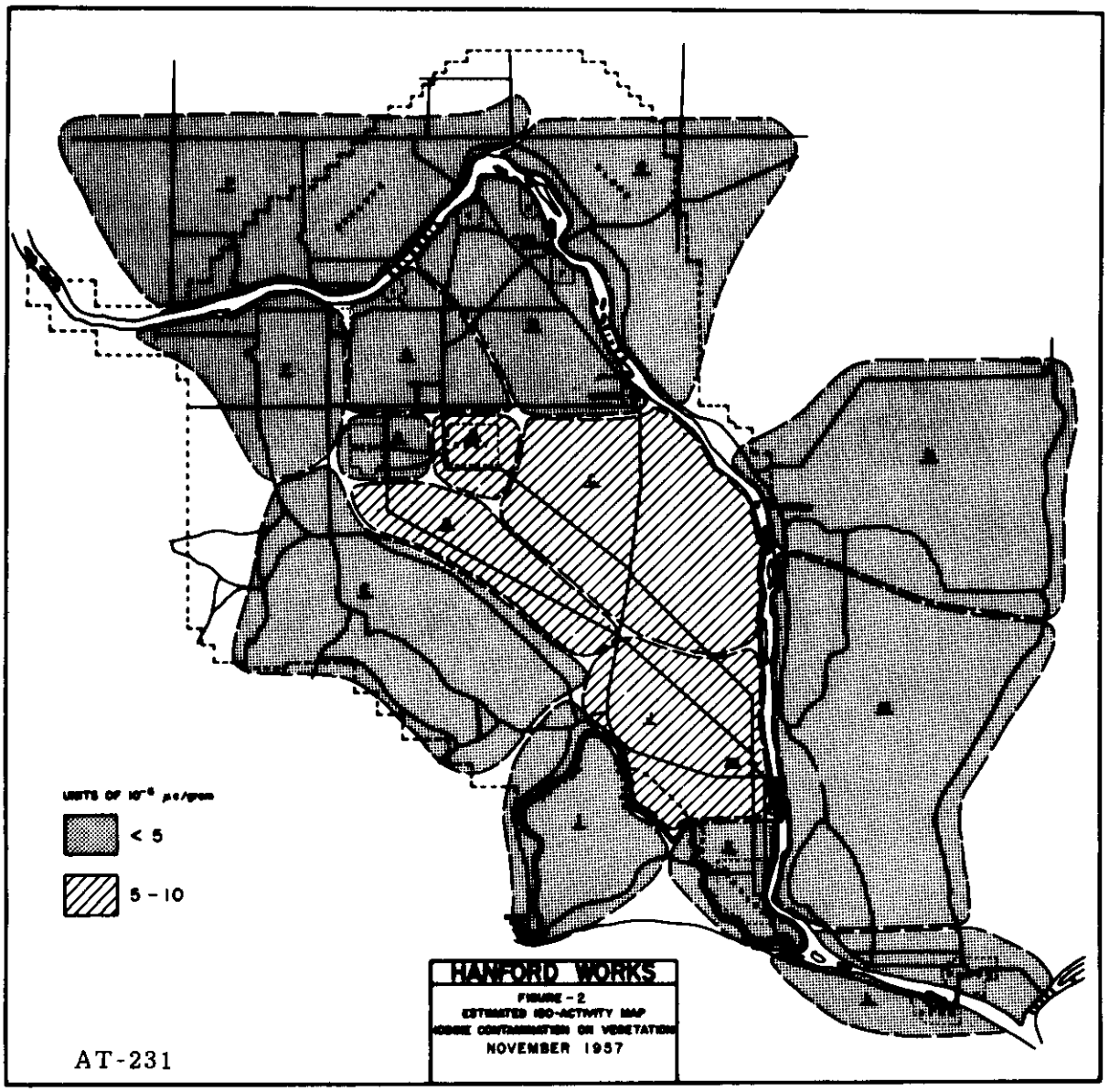

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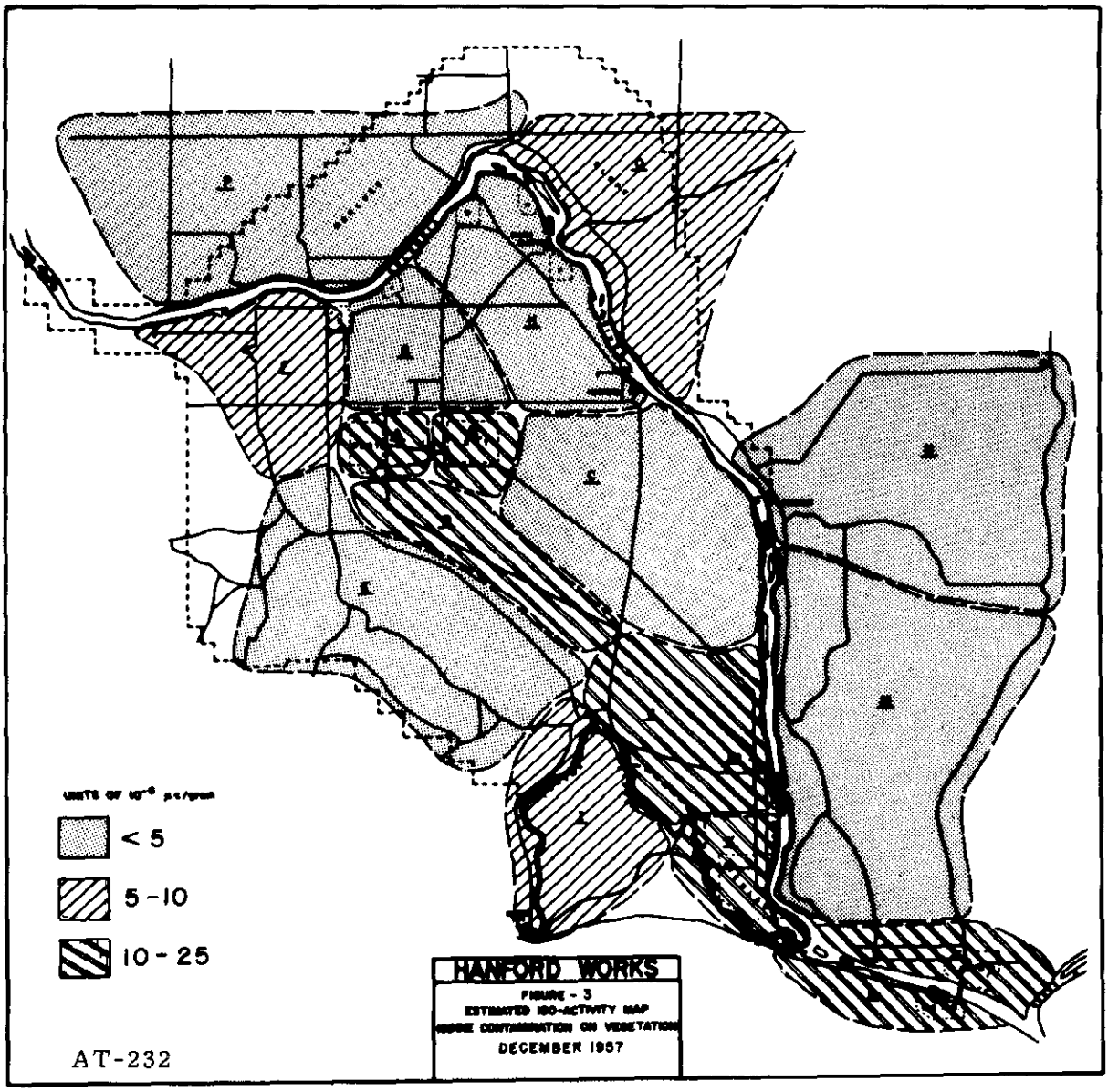

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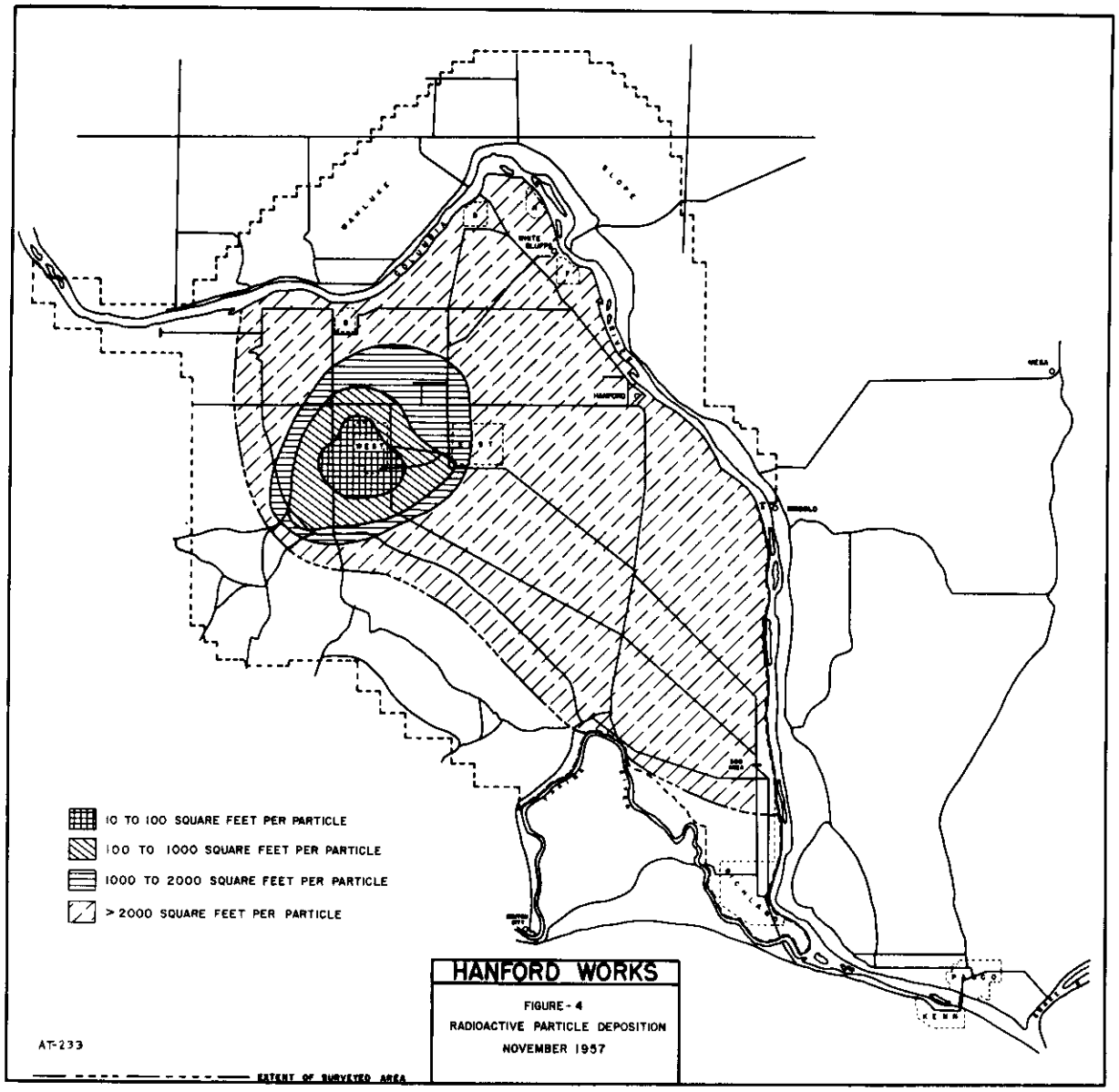

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