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PART I

RADIOLOGICAL CONSIDERATIONS OF OPENING THE COLUMBIA RIVER FOR PUBLIC ACCESS UPSTREAM FROM 100-F AREA PART I

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This report is intended primarily for internal use by the sponsoring organization and Battelle-Northwest.

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INTRODUCTION

At the request of the Richland Operations Office of the United States Atomic Energy Commission, a study of radiological conditions on and along the Columbia River from Ringold to 100-F Area was performed in the fall of 1969. The completed study, which furnished radiological information prerequisite to deciding whether that portion of the river should be opened for public access, was transmitted to the Atomic Energy Commission on December 29, 1969. In January 1970, a similar study was requested concerning the portion of the river upstream from 100-F Area. This document summarizes that study. Detailed descriptions, observations, and calculations related to the study are contained in Part II of this document.

This summary document considers the following radiological risks to persons utilizing the river and its adjacent land:

- Exposure of the public to radiation as a consequence of hunting, fishing, swimming, picnicking, and searching for artifacts.
- Exposure of the public while in boats or on water skis in the immediate vicinity of reactor effluent plumes.
- Exposure of the public from eating fish, game, or gamebirds harvested in the vicinity of the operating reactors.
- Radioactive contamination on the surfaces of boats, water skis, fishing gear, and other equipment used in the vicinity of the operating reactors.
- Exposure that could result from dredging the river.
- Exposure of persons in the vicinity of the operating reactors in the event of major accident.

Nearly all the data described in this document were obtained with KE and N reactors in service. Most of the radioactivity in the river and along its shoreline during the measurements resulted from KE effluent. The shutdown of these reactors, KE in particular, virtually eliminates the river, its fish, game, and wildfowl, and its shoreline as sources of radiation exposure. With N reactor only in operation, radioactivity in the N springs and along the N shoreline would result from N coolant released to the crib and trench. Although the Concentration Guides for several nuclides as given in AEC Manual Chapter 0524, Table II, Col. B, might be temporarily exceeded in the spring water, no significant dose to the public should result.

SUMMARY

HUNTING, FISHING, SWIMMING, PICNICKING, AND SEARCHING FOR ARTIFACTS

The main attractions of the river upstream from 100-F appear to be hunting, fishing, and searching for artifacts. Shallow water, swift current, and unappealing terrain make this portion of the river an unlikely location for swimming or picnicking. Nevertheless, radiation dose* estimates have been made for typical examples of persons engaged in all such activities. Selected examples and resultant dose estimates are described briefly in the following statements, which are based on conditions existing with KE and N reactors operating. The shutdown of KE would result in virtual elimination of the river as a source of exposure.

1. An avid hunter spending 10 hours on each of 10 occasions yearly along the D Island shoreline could receive a whole-body dose on the order of 10 mrem/yr.

2. An avid steelheader standing in waist-deep water 5 hours on each of 20 occasions yearly along the plant shore above D Island could receive a whole-body dose on the order of 7 mrem/yr.

3. An avid teenage swimmer spending 40 hours yearly in the water and 80 hours yearly out of the water at D Island could receive a whole-body dose on the order of 10 mrem/yr.

4. A picnicker spending 7 hours yearly on the D Island shoreline could receive a whole-body dose on the order of 1 mrem/yr. In addition,

* *For purposes of this study, "exposure" is considered to be numerically equivalent to "dose equivalent," which is referred to simply as "dose."*

3 hours of wandering through burial grounds, 107 Basins, and other such areas could result in a whole-body dose on the order of 30 mrem.

5. An archaeologist camping on Locke Island for 100 days, during which he spends 2 hours daily along the shoreline, spends one hour daily in the water, uses river water for cooking and drinking, and eats one quarter pound of Columbia River fish per day, could receive a whole-body dose on the order of 60 mrem. From ingestion, he could receive a bone dose of about 50 mrem, and GI Tract and thyroid doses less than 1 mrem.

BOATING AND WATER-SKIING

Although boating and water-skiing are not expected to be popular activities in this stretch of the river, due mainly to fast water and unpredictable river depth, doses have been estimated for the following very conservative cases:

1. A boater spending 100 hours yearly on this portion of the river could receive a whole-body dose on the order of 3 mrem/yr.
2. A person water-skiing for 20 hours yearly on this portion of the river could receive a whole-body dose on the order of 0.5 mrem/yr.

EATING FISH, GAME, AND GAMEBIRDS

Since hunting and fishing are expected to be two of the more popular activities in this portion of the river, radiation dose from eating fish, game, and gamebirds could be significant. Conservative assumptions have been made in estimating doses as described below:

1. The avid steelheader described earlier is assumed to eat 50 pounds of fish, which could result in a whole-body dose less than 1 mrem/yr and a bone dose on the order of 100 mrem/yr.
2. The avid hunter is assumed to eat 50 pounds of gamebirds, which could result in a whole-body dose on the order of 0.2 mrem/yr and a bone dose on the order of 40 mrem/yr.

3. A big game hunter is assumed to eat 50 pounds of venison, which could result in a bone dose of about 150 mrem/yr, a whole-body dose of about 8 mrem/yr, and a GI Tract dose of about 5 mrem/yr. (The bone dose estimate is based on the greatest concentrations of radiophosphorus and radiostrontium shown in Part II, Table X.)

RADIOACTIVE CONTAMINATION ON EQUIPMENT

Radioactive contamination on the surfaces of boats, water skis, fishing gear, and other equipment used in the vicinity of the operating reactors is limited to extremely small quantities of short-lived radionuclides directly related to the amount of foam, algae, and other debris in the water. Such contamination does not constitute a source of measurable radiation dose to the public.

DREDGING A NAVIGATION CHANNEL

The dredging of a navigation channel would provide several opportunities for exposure of the public. The following dose estimates have been made using very conservative assumptions:

1. The whole-body dose to a hunter or fisherman spending 100 hours/yr near a spoil pile should not exceed 1 mrem/yr.
2. The external whole-body dose to a person living in a house built on a spoil pile should not exceed 40 mrem/yr.
3. The whole-body inhalation dose to a person living in a house built on a spoil pile should not exceed 0.001 mrem/yr.
4. The whole-body dose from ingesting food raised on dredging spoils should not exceed 0.1 mrem/yr.
5. The whole-body dose from drinking Richland or Pasco water originating in the river during dredging should not exceed 0.001 mrem/yr.

REACTOR ACCIDENTS

Under certain very unlikely circumstances, significant doses could result from a major reactor accident. The probability of such doses being received by members of the public can be reduced essentially to zero by the installation of an evacuation signal system.

DISCUSSION

DESCRIPTION

Columbia River

Much of the river above 100-F Area (Figure 1) is shallow at low flow rates. In certain areas which have no clearly discernible channel, such as near the upper end of Locke Island, motorboat passage upstream is nearly impossible at the lowest flow rates. Shorelines are generally very rocky, but contain occasional coves or short beaches of silt or fine, silty sand. Shoreline rocks are mostly coated with silt or algae.

The main attractions of this portion of the river appear to be hunting, fishing, and searching for artifacts. Although upland gamebirds are generally scarce, migratory waterfowl are fairly abundant in certain areas. Panfish are abundant in or near the sloughs, and the river should provide good steelhead fishing. Shallow water, swift current, and unappealing terrain make this portion of the river an unlikely location for water-skiing, swimming, or picnicking. However, the fact that it has been closed for many years undoubtedly will attract many people for those purposes. Such use should drop off rapidly as the river, which is quite treacherous at low water, takes its toll of equipment. Steelheading from both boat and shore will draw many avid fishermen, who will quickly become familiar with the river and will proceed to spend many days steelheading each year. Artifact hunting is expected to be another important activity.

Waterborne radionuclides originating at 100-K and 100-N Areas disperse and move slowly across the river, generally reaching the far shore downstream

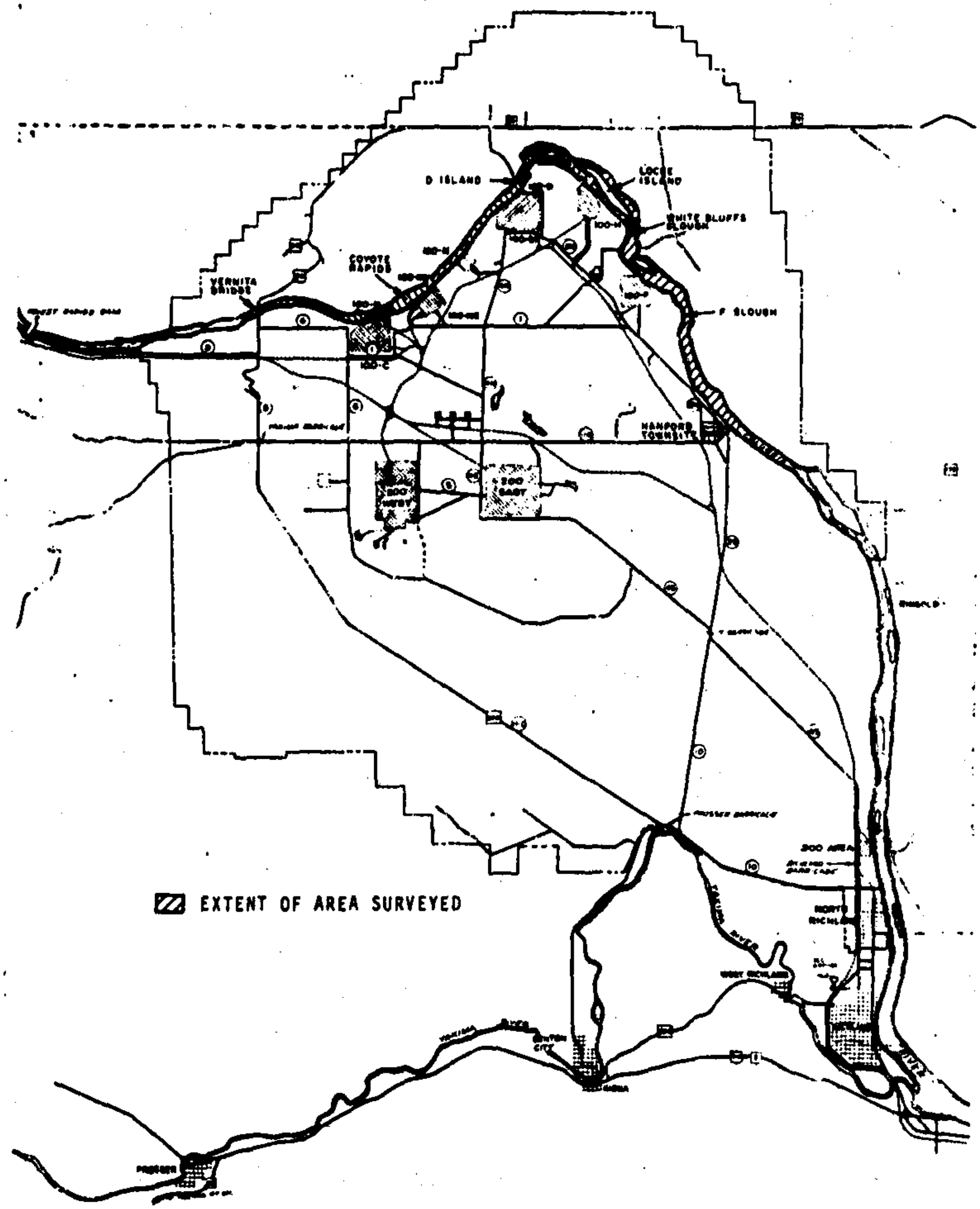

Figure 1. Portion Of The River Surveyed And Its Relation To The Hanford Environs

from D Island. Thorough mixing does not occur for many miles--at least as far as 100-F Area. As the river rises and falls, it removes and deposits contaminated algae and other debris unpredictably, such that spotty contamination can be found from time to time along the shoreline. Generally, however, shoreline contamination is reasonably uniform, the greatest variation probably resulting from the decay of short-lived radionuclides with transport downstream. The flow time of water from 100-K to 100-F Area ranges from about three and one half hours at high flow rates to six hours at low flow rates.

The Far Shore*

The far shore throughout much of this area is not very attractive. Downstream from H Island the shore is dominated by high bluffs. The land upstream becomes more gentle, but is quite desolate.

The Plant Shore*

Having at one time been populated, the plant shore is a little more attractive than the far shore. Although years without water have reduced once-cultivated land to cheat grass and Russian thistle, trees still find enough water to grow and provide cover for game and gamebirds in the lowlands near the river. Numerous domestic and irrigation wells at old farmsteads and townsites are a safety, though not radiological, hazard.

Radioactivity In And Around The 100 Areas

Since it is possible, even likely, that some persons using this stretch of the river would enter the 100 Areas for one reason or another, the radiological aspects of such entry should be considered in determining whether or

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* *The term "far shore" as used in this document means the left bank. "Plant shore" means the right bank (i.e., the one on which the 100 Areas are located).*

under what conditions to open the river for public access. Outside the existing exclusion or area perimeter fences, accessible* radioactivity is virtually nonexistent in most locations, but is significant in some others. Accessible radioactivity includes large masses of soil slightly contaminated (less than 2 nCi/g)** by reactor effluent leakage, highly radioactive materials contained in cribs and burial grounds covered by several feet of soil, and significant and easily accessible contamination and radiation fields in currently used burial grounds and other disposal sites. In general, the slightly contaminated soil presents little risk of public exposure. Buried, higher level radioactivity also would be of little concern if the material were to remain buried. However, it would be no great task to either inadvertently or intentionally dig through the covering soil to reach material that could deliver a significant radiation dose.

At 100-F, the termination of disposal sites is generally assumed complete, except for the exclusion area and those locations presently in use by Battelle-Northwest's Biology Department. Radiation surveys have shown in most portions of the 100-F Area that GM count rates measured near the surface of the ground are hardly distinguishable from normal background. However, significant count rates and exposure rates have been found in a few locations, such as the Number 1 and Number 2 burial grounds.

At 100-H, termination of disposal sites is nearly complete, except for the exclusion area. Radiation surveys have shown in most parts of the 100-H Area that GM count rates measured near the surface of the ground are hardly distinguishable from normal background. However, significant count rates and exposure rates have been found in a few locations, such as the terminated

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* *As used here, the term "accessible" does not mean uncovered or unposted. Rather, it means reachable, either by accident or intent, by persons using the river.*

** *A concentration of 2 nCi/g has been used at Hanford as an unconditional release limit. This value is believed to have been obtained from the International Atomic Energy Agency's definition of "radioactive material" as ".... any material of which the specific activity is greater than 0.002 μCi/g."*

Number 1 burial ground, in which small pieces of irradiated metal were discovered on the surface of the ground in the spring of 1970. The 107 Basin and other portions of the effluent system also contain significant contamination levels and exposure rates.

At 100-D-DR, GM count rates are more easily distinguishable from normal background. Since the D and DR reactor systems have been maintained on standby status, burial grounds and effluent basins have been kept available for reactivation. Thus, little effort has been put into terminating burial grounds and covering contamination. Radiation surveys have shown in most parts of the 100-D-DR Area that GM count rates measured near the surface of the ground are generally 100 to 400 c/m, as compared to a 100 to 200 c/m normal background. Greater count rates were found in many locations, the most significant being the 107 Basins, other effluent system structures, and the burial grounds.

At 100-BC, GM count rates measured near the surface of the ground were generally 100 to 300 c/m, barely distinguishable from normal background. However, since the 100-BC Area reactors have been kept in standby condition, only one burial ground and one 107 Basin have been terminated, and significant surface contamination and external radiation levels can still be found in several locations. Many accessible disposal sites have not been adequately prepared from a radiological standpoint to permit uncontrolled access. The most significant are the burial grounds, one of which is still in use, and the 107 Basins and associated effluent systems.

From the standpoint of this study, the radiological significance of the F, H, D-DR, and BC Areas results at least partly from removal of area perimeter fences, which once would have prevented access by the public. The remaining areas, 100-N and 100-K, present a slightly different situation, since fences have not been removed. At 100-N, liquid waste empties into a rock-filled crib and then overflows into a trench. At present, these two structures contain the only significant source of accessible radioactivity, except for the riverbank springs, which are discussed under "Riverbank Springs." At 100-K, the most significant sources of accessible radioactivity are the K trench and the small burial ground located between the main burial ground and the liquid waste basin. At both 100-N and 100-K, large masses of slight, generally underground soil contamination exist between the trenches and the river.

OBSERVATIONS AND DATA

Shoreline Exposure Rates

Radioactive material along the river shoreline and, to a lesser extent, in the river provides one of the more important sources of radiation exposure to persons using the river. Gamma exposure to the gonads or whole body of a standing person and beta exposure to the skin of a person lying or sitting on the shoreline are of major interest. The measurement of shoreline gamma exposure rates and surface contamination levels has long been a part of the routine environmental surveillance program. Until recent years, however, most shoreline measurements were made below Ringold, because the public did not have access generally to the shoreline upstream from that point.

In January 1970, a number of new routine shoreline survey locations were established between Ringold and Vernita in order to provide information for this study. In addition, three special shoreline surveys were made for purposes of better describing the shoreline exposure rate and trend with distance downstream and for purposes of searching the shoreline for spotty contamination. The averages of measured exposure rates at various locations are shown in Table I. Annual averages for locations routinely surveyed during 1967, 1968, and 1969 are included to show that shoreline exposure rates generally have decreased at those locations. (Similar reductions are assumed to have occurred at all other shoreline locations.) As expected, the greatest decrease occurred in 1970 following the shutdown of K-West. As a result of this decrease, the highest average in 1970 (i.e., on D Island) is not greatly different from the 1967, 1968, and 1969 averages at Powerline Crossing, which has been open to the public for many years. Exposure rates measured during the 1970 special shoreline surveys are plotted in Figure 2 along with those from three earlier surveys for comparison. Although shoreline exposure rates may fluctuate considerably, due to variations in the concentration of stable nuclides that

Table I

Summary Of Routine Measurements Along
The Columbia River Shoreline - 1967 Through 1970

Average Of Shoreline Exposure Rates
At 3 Feet Above The Ground*

μR/hr

Location	River** Mile	1967	1968	1969	1970
Vernita†	388.0 P	(18)	(15)	(13)	(18)Jan-April 14 Aug-Dec
Above 181 KW	382.5 P	--	--	--	20
Below 181 KE	381.5 P	--	--	--	99
Below 181 KE	381.0 F	--	--	--	16
Below N Trench	379.7 P	--	--	--	59
Below 100 N	379.0 P	--	--	--	59
Above 181 D	378.4 F	--	--	--	20
D Island	377.4 IP	--	--	--	140
E Island	375.8 IF	--	--	--	40
Locke Island	373.4 IP	--	--	--	100
Locke Island	371.1 IP	--	--	--	43
White Bluffs Ferry	369.7 P	200	160	75	64
White Bluffs Ferry	369.8 F	84	64	56	25
Upper End 100-F Slough	368.3 P	--	--	--	64
100-F Slough	367.0 IF	--	--	--	110
Hanford	362.0 P	110	130	88	71
Hanford	362.0 F	88	130	100	59
Savage Island	359.1 F	--	--	--	44
Ringold	355.7 IP	--	--	--	68
Ringold	354.7 F	63	78	45	36
Powerline Crossing	350.4 P	120	150	110	51
Powerline Crossing	350.4 F	130	120	72	38
Byers Landing	345.2 F	57	80	63	44
300 Area	344.5 P	88	82	60	--
Richland	340.5 P	(31)††	(54)	(26)	(20)Jan-April [17]Aug-Dec

* *From weekly surveys when in parentheses and from semiweekly when in brackets. Otherwise, from monthly surveys. Data from May through July excluded.*

** *P-Plant shore, F-Far shore, IP-Plant shore of island, IF-Far shore of island.*

† *Surveys made near Vernita Bridge (plant shore), except from July, 1968 to December, 1969 when made at the Priest Rapids Dam gauge station.*

†† *Average of weekly data at Sacajawea Park (∿13 miles downstream of Richland).*

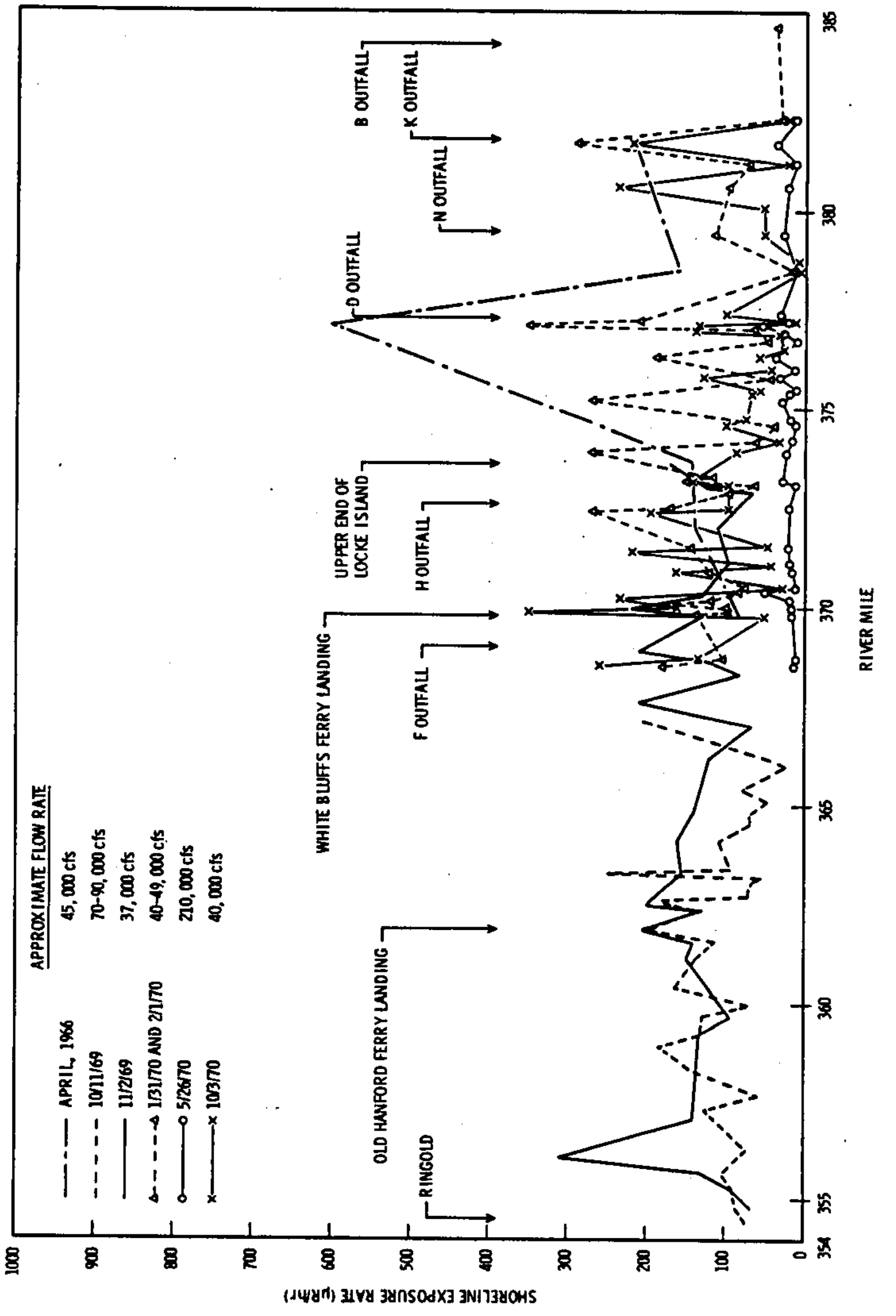

Figure 2. River Shoreline Exposure Rates Measured With A 40-Liter Chamber At 3' Above The Ground

become activated upon passage through a reactor and due to scouring and intermittent deposition of river sediments at high flow rates, a general downward trend of shoreline exposure rates with time is apparent in this figure. The January 31 and February 1, 1970 survey represents essentially a "two operating K reactor" situation. The May 26, 1970 survey probably represents something less than a "one operating K reactor" situation, since the extended shutdown during the winter and spring reduced the shoreline concentration of some of the longer-lived radionuclides. High flow rate (210,000 cfs) undoubtedly accounts to a great extent for the low exposure rates measured on this occasion. The October 3, 1970 survey probably is more typical of what one would find with a single K reactor operating and the river flow rate low.

Shoreline Mud and Foam

Shoreline contamination fluctuates somewhat, due to variations in the concentration of stable nuclides that become activated upon passage through a reactor and due to scouring and intermittent deposition of river sediments at high flow rates. Spotty contamination sometimes results from accumulations of algae or other debris along the shoreline. While it is generally-distributed contamination that gives rise to the gamma exposure rates discussed in the preceeding section, spotty contamination is of interest from the standpoint of gonad exposure to those lying or sitting on the shoreline. Spotty contamination also is of interest from an internal dose standpoint.

During 1970, no spots located during routine or special shoreline surveys were significant from either an external or internal dose standpoint. The maximum exposure rate measured three feet above such a spot in 1970 was 350 μR/hr, while the maximum surface measurement with a thin-walled GM detector was 20,000 c/m, probably corresponding to a surface absorbed dose rate of several mrad/hr. The maximum concentration measured was 2500 pCi/g of $^{46}Sc+^{65}Zn$ in mud. Spots of this sort are transient and somewhat uncommon. Changes in river flow rate can cause such spots to be deposited and then removed in a single day.

Riverbank Springs

The radionuclide content of groundwater emerging as riverbank springs was briefly investigated during this study. Springs existed in at least one location along this portion of the river long before the Hanford plant was constructed. However, ground disposal of reactor effluents and other liquids in the 100 Areas has created additional riverbank springs, at least some of which contain measurable radioactivity of Hanford origin. Riverbank springs were located during this study in five locations--near 181-BC, near 107-KW, near the downstream end of 100-K trench, near the 100-N effluent crib, and near the Hanford Townsite. The Hanford Townsite springs, which predate the Hanford plant, appear to contain no radioactivity of Hanford origin. This cannot be said, however, of the other springs, some or all of which result from ground disposal of reactor effluents and other liquids in the 100 Areas. Except for those at 100-N, radioactivity in riverbank springs seems unlikely to result in a significant dose to any member of the public. At the concentrations found in a single 100-N spring sample on December 16, 1970, however, ^{90}Sr, ^{131}I, and ^{133}I concentrations were estimated at 0.2, 0.5, and 2.5 times their respective Concentration Guides for individuals in uncontrolled areas.

Exposure Rates At The Surface Of The River

During the monthly shoreline surveys, exposure rate measurements were made while traveling by boat from one shoreline location to the next. Although single measurements are of questionable accuracy, due to the difficulty of using 40-liter ionization chambers in a moving boat, several such measurements viewed together provide a fair estimate of the average exposure rate over a given stretch of the river. Unsteady exposure rates up to about 10 mR/hr exist directly over the operating KE effluent plume, but measured "river surface" exposure rates from 100-K to 100-F average from about 25 to 50 μR/hr with KE operating. With no reactors operating, exposure rates measured over this portion of the river typically have averaged about 15 to 25 μR/hr, while exposure rates from 100-F to Richland have generally ranged from 10 to 15 μR/hr. River surface exposure rates normally are a factor of two or more below the adjacent shoreline exposure rates.

Immersion Exposure Rates In The River

Exposure rates in the river have been measured in various ways and locations for a number of years. Changes in detector type and location make difficult the observation of long-term trends. The occasional loss of detectors during high river flow rates also has complicated the measurement and evaluation of immersion exposure rates. However, enough data have been obtained and evaluated to make possible the following statements. Immersion exposure from Coyote Rapids upstream, and along the far shore from Coyote Rapids downstream to D Island, is unaffected by reactor operating conditions. Exposure rates in effluent plumes reach hundreds of mR/hr at the point where the effluent enters the river. Due to plume turbulence, however, it would not be possible to remain in the highest concentrations of effluent plumes, which porpoise sporadically for hundreds of yards. Farther downstream, where the effluent plume is less turbulent but is still fairly narrow, it is unlikely that a significant fraction of a person's time would be spent in the plume. Using such reasoning, an immersion exposure rate of 65 μR/hr has been assumed to apply to the portion of the river between Coyote Rapids and D Island (except for the far shore as discussed earlier). Exposure rates of 40 and 20 μR/hr, respectively, have been assumed for the portions of the river from D Island to 100-F and from 100-F to Richland.

External Radiation On Plant

External radiation on the Hanford plant can originate from several sources. Radionuclides in the river contribute to the exposure of persons along the shoreline and at other locations in view of the river. Effluent vapors from 107 Basins and possibly from disposal trenches contribute to exposure rates near operating reactors. Cribs and burial grounds, both active and retired, and abandoned and standby reactor facilities contribute to external radiation near the 100 Areas. Soil contaminated by effluent system leakage in the 100 Areas, large expanses of soil slightly contaminated through the years by airborne radioactive material, and roads and railroads occasionally contaminated during transportation of radioactive material all contribute slightly to external radiation on plant. Numerous surveys have been conducted to determine the nature and extent of these sources.

In September and October, 1970, a strip of land one half to one mile wide along the plant shore from Vernita to Hanford, a distance of 22 miles (excluding the 100 Areas), was surveyed on foot. This survey, which was intended to locate unknown sources of radiation beyond and between the 100 Areas, was performed with GM survey instruments having thin-walled detectors held near the ground. Since a complete survey of so large an area was impractical, surveyors walked random zigzag patterns at their own discretion in order to survey those areas intuitively felt most likely to contain radioactivity of Hanford origin. This survey revealed that Hanford operations have not added measurably to the natural external radiation background in most locations away from the Columbia River shoreline. During this extensive survey, GM instrument readings away from the 100 Areas seldom reached values twice those obtained between Vernita and 100-BC, a region essentially free of measurable radioactivity of Hanford origin. Only three significant sources, discussed elsewhere under "Radioactive Owl Pellets," were found away from 100 Area disposal sites.

In June 1970 and January 1971, special road monitoring surveys of all major and minor roads and of many trails within about a mile of the river were performed from 100-F to Vernita. As did the foot survey, this road monitoring indicated the only significant sources of external radiation to be those in or very near the 100 Areas. Railroad surveys, control plot surveys, and aerial surveys performed during 1970 also confirm this.

Probably the most meaningful measurements of external radiation on plant are obtained from thermoluminescent dosimeters (TLD) placed at several locations. As measured by such TLD's, average onsite exposure rates measured within about a mile of the river during the last half of 1970 ranged from 6.7 μR/hr at Hanford and Ringold to 11 μR/hr at 100-K Area. By comparison, offsite exposure rates, both along and away from the river, ranged from 5.4 μR/hr at the 700 Area in Richland to 8.3 μR/hr at McNary Dam and other locations.

Radioactivity In Fish

Since fishing is expected to be one of the greatest recreational activities on the river, a limited study of ^{32}P and ^{65}Zn concentrations in whitefish was conducted from May through November 1970. The purpose of this study was to compare concentrations in fish taken at about the same time from three different locations--100-K to White Bluffs, White Bluffs to Ringold, and Ringold to Richland. As expected, there was not a significant reduction in concentration with downstream distance from the reactors. Furthermore, a comparison with past data shows, on a concentration basis, that fish taken near the reactors in 1970 constitute a smaller source of exposure than fish taken below Ringold previously. The average concentrations of ^{32}P and ^{65}Zn in whitefish taken between 100-K and White Bluffs during this special study were 24 and 6 pCi/g, respectively.

Radioactivity In Gamebirds And Game

For many years, radioactivity has been measured in gamebirds taken on or near the river downstream from the reactors. For all species except goose, concentrations of ^{32}P and ^{65}Zn, the only significant radionuclides, were lower in 1970 than in earlier years. The average concentrations in ducks and quail was about 1 pCi/g, while pheasants and geese contained about 2 and 5 pCi/g, respectively. The dose that might be received from eating one or even many of these "typical" birds is negligible when compared to guidelines established by the Federal Radiation Council. On several occasions in 1969 and early 1970, however, gamebirds containing considerably higher than average concentrations were collected on or near liquid waste disposal sites. Although immediate consumption of such a bird could produce a dose approaching the yearly guidelines, this is considered highly unlikely in view of the fact that few birds (out of over 200,000 in the area) would be likely to contain such concentrations of radioactive material.

Since ingestion of deer and small game has not been considered a source of internal exposure, game animals have not been routinely sampled as part of the environmental program. During 1970, however, three deer were collected within about a mile of the Columbia River. The major radionuclides and the ranges of concentrations in pCi/g were: ^{32}P (7-15), ^{60}Co (0.04-1), ^{65}Zn (0.8-9.6), ^{106}Ru (0.35), ^{137}Cs (0.05-0.25), ^{144}Ce-Pr (0.05-0.8), and Total Strontium (0.05-0.15). Potential sources of radiostrontium include fallout, separations areas, and 100 Area trenches. For comparison, the maximum concentrations (pCi/g) for four of these radionuclides found in beef cattle raised on irrigated pasture downstream from Ringold during 1970 were: ^{32}P (31), ^{65}Zn (4.6), ^{106}Ru (0.1), and ^{137}Cs (0.04).

Due to its scarcity near the 100 Areas, small game seldom has been sampled. Because of this scarcity and because radionuclide concentrations are expected to be very low, small game is regarded as a less significant source of exposure than deer.

Radioactive Owl Pellets

Although radionuclide concentrations in small game are expected to be very low, some evidence of radionuclide reconcentration by mice was obtained during this study. While performing a land survey between 100-D and 100-H Areas, a great horned owl pellet measuring approximately 200 mrad/hr near the surface was found in a grove of trees upstream from 100-H. On the following day, a pellet containing slightly radioactive (less than 1 mrad/hr near the surface) deer mouse bones was found near 100-F Area in a grove known to be inhabited by a pair of great horned owls. A spot of low-level contamination found on a different occasion at the Hanford Irrigation Project pumping station is also attributed to great horned owls. Extensive owl pellet surveys made since those findings have failed to locate any further evidence of radioactive pellets. Because of their scarcity, such pellets are not considered to present a significant radiological risk.

Contamination Of Boats And Other Equipment

The possibility that boats, water skis, fishing tackle, and other equipment placed in the river might become contaminated by dissolved or suspended radionuclides was investigated by measuring contamination on equipment frequently used in the river as part of the environmental program. Surveys of fishing equipment used in the 100-K to White Bluffs section of the river have shown no detectable contamination. Barely detectable contamination (less than 150 c/m above background with a thin-walled GM detector) has been observed along the waterline of the environmental evaluations fishing boat immediately after use in the 100-K to White Bluffs section of the river. The contamination seems short-lived and directly related to the amount of foam, algae, and other debris in the water. It must be concluded from these surveys that the contamination of boats, water skis, fishing tackle, and other equipment used in the river is not a source of measurable radiation dose to the public.

Radiological Aspects Of Dredging A Navigation Channel

The potential radiological impact on the public of dredging a navigation channel in the Columbia River through the Hanford project has been evaluated briefly as part of this study. Potential sources of radiation exposure to the public include: external from large masses of spoil; internal from inhalation of airborne spoil; internal from ingestion of milk, meat, and crops grown on spoil used as fill; and internal from ingestion of water derived from the Columbia River during dredging operations. In addition, some exposure could occur to workers during the dredging operations, either directly from the spoil or indirectly from contaminated equipment. Using very conservative assumptions, estimates have been made of radiation dose that could be received by the public during the first year of or following (as appropriate) dredging operations. Only in the case of a person residing 24 hours per day over spoil used as land fill is the estimated dose at all significant. Assuming an initial concentration of 40 pCi/g in the spoil, the whole-body dose received by such a person during the first year following dredging operations would be about 40 mrem. Doses calculated for other exposure mechanisms are one to several orders of magnitude smaller than this.

Radiological Consequences Of Reactor Accidents

Persons on or along the Columbia River near the reactors could be subjected to potentially serious radiation exposure in the event of a reactor accident. This exposure potential has been examined as part of this study. Since the KE reactor has been shut down and its fuel discharged, the potential exposure from a postulated K reactor accident has not been considered here.

Two postulated accidents for N reactor, the maximum credible accident (MCA) and the design basis accident (DBA), have been evaluated. Both of these accidents postulate the loss of coolant followed by melting of fuel resulting in a release of fission products to the environs.

For people in boats on the river near the N reactor, the potential modes of exposure are: external from being in or near the radioactive cloud as it passed by; internal from inhalation in the radioactive cloud; external to direct radiation from contamination in the river; and internal from drinking contaminated river water.

The only significant exposure to persons on the river near N reactor would be from a passing cloud of radioactive material. However, even this exposure could be avoided or at least greatly reduced if an evacuation signal were given promptly and if the evacuation were accomplished rapidly. The installation of an evacuation signal system would minimize the potential exposure of people on the river to airborne radionuclides following a major reactor accident. The relatively long delay time between discharging liquid effluents to the crib and the appearance of radionuclides in the river water eliminates contaminated river water as a source of exposure during the first several days following a reactor accident.

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REFERENCE

W. L. Fisher. "Radiological Considerations Of Opening The Columbia River For Public Access Upstream From 100-F Area," BNWL-B-71 Part II. Battelle-Northwest, Richland, Washington, March 1970.

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