FIELD EVALUATION OF GROUND DISPOSAL OF REACTOR EFFLUENT - 1301-N CRIB

by

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REACTOR EFFLUENT - 1301-N CRIB

J. R. Eliason

INTRODUCTION

The 1301-N crib, which receives reactor effluent from the N-Reactor on the Hanford Project, has been in service since 1964. In recent months the average flow rate to the facility has been 2300 gallons per minute. The crib, located north of 100-N area, has a bottom area of 37,800 square feet with an overflow trench that adds about 3000 square feet of infiltration area (Figure 1).

Radionuclide concentrations in the wastes discharged to the crib fluctuate measurably. Correlations of concentration peaks at the crib with the subsequent appearance of corresponding peaks in downgradient monitoring wells and in the riverbank springs, which have developed, provide a means for making field measurements of tritium and iodine-131 travel times. Samples were collected laterally along the river and at various depths from shoreline wells to determine variations in travel times in the system. This report presents the results of these recent flow system investigations and also relates these results to predicted travel times for several biologically-important radionuclides.

SUMMARY AND CONCLUSIONS

The minimum travel time of 79 days observed for H^3 at the point of maximum flow along the riverbank spring-front gives a minimum decay time which can be also applied to other radioisotopes discharged to the crib.

Actual travel times of isotopes discharged to the site are dependent on the interaction of the isotopes with the sediments (ion-exchange, chemical, adsorption, etc.). A travel time of 101 days observed for I^{131} is an indication of the dependence of actual migration rates on the isotope's interaction with the soil materials. The interaction of most isotopes with sediments is significantly greater than that of iodine. Therefore, most isotopes will have much longer travel times.

Evaluation of the flow system revealed that >70 percent of the waste discharged to the crib has longer travel times to the river than those shown in Figure 5. Significant quantities of the waste appear to be flowing northeast from the site into the Columbia River below 100-D Area. This would increase the length of flow path and travel times to the river by a factor of 10.

Estimates of the distribution of long-lived isotopes at the site are based on laboratory measurements. Field evaluations of the actual distributions of long-lived isotopes are in progress. This study involves drilling and sampling of the sediments in and near the crib. Analyses of radiocontaminants in these samples will provide an even more accurate field-scale evaluation of disposal at the 1301-N crib than has heretofore been made.

DISCUSSION

Site Characterization

The site was characterized by studying the hydrologic and geologic characteristics of the aquifer. This particular site was evaluated using the data made available since 1960, much of which is contained in a series of reports (1-5). Also, nine exploratory-monitoring wells were drilled in

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the immediate vicinity of the crib, and several outcrops were accessible for study. The well log and outcrop data have made possible the development of a fairly detailed evaluation of the site.

The disposal site is located in glacial outwash gravels, here referred to as the "Pasco gravels," which are unsorted and were deposited while ice moving down the Columbia River was grounded in this area and the irregular "Kame and Kettle" topography developed. The glacial outwash gravels average approximately 20 feet in thickness in the vicinity of the disposal site. Figure 2 shows a typical outcrop of the Pasco gravel deposits near the disposal site. Boulders of from 10 to 20 inches are common, and the upper 2 feet of the Pasco gravels deposit contains much silt and sand which appear to have been deposited as the glacial meltwater velocity and volume decreased. Eolian material deposited on the surface and carried down into the outwash gravels may also account for part of the silt and sand near the surface. The unsorted glacial outwash gravels overlay approximately 85 feet of early Pasco gravels and upper Ringold sands and gravels which are shown in Figure 3. These sands and gravels are unconsolidated in most areas, but locally they may be cemented by calcium carbonate and iron oxides. The gravels and cobbles were deposited with silts, sand, and some clay as shown in Figure 4. The Pasco gravels and upper Ringold sands and gravels (Figure 3) exhibit deltaic bedding which is characteristic of the early Pasco gravels and upper Ringold. The upper Ringold sand and gravels are underlain by clay which is considered to be the bottom of the unconfined aquifer in this area due to the permeability difference which is $>100^{(6)}$. A 425-foot thick bed of clay overlies the Columbia River Basalt at this site.

Before the disposal site was used, the saturated ground water level at low river stage ranged from 380 to 390 feet mean sea level which is 30 to 40 feet above the Ringold clay. A cross section of the disposal site showing the relationship of the Ringold clay, upper Ringold, Pasco gravels, and water table is presented in Figure 5.

Field Evaluation

Wells and riverbank springs have been sampled extensively over the past two years, and travel times have been determined by correlating low but distinguishable activity peaks at the river and in the wells with those at the crib. Sampling points were established at 100-foot intervals along the 1000 feet of spring front. These sampling stations are located at the points of apparent maximum riverbank discharge. Figure 6 shows a sampling station at the riverbank which is 12 feet above the average low river stage. A series of wells, equipped with 2-foot screened sections, was drilled at appropriate locations near the river to depths of 100, 60, 50, 40, 30 and 20 feet to determine the waste travel time distribution with depth. The locations of the riverbank wells with respect to the disposal site and the average ground-water level contours in the vicinity of the crib are shown in Figure 7.

The analytical results of samples taken at the maximum riverbank discharge point are plotted in Figure 8. Travel times of 79 days for Tritium and 101 days for Iodine-131 were determined from these correlations. The movement of trace ions through soils has been studied comprehensively; and iodine in particular, when in extremely low concentrations (ppb), has been shown to significantly lag other tracers⁽⁷⁾. The movement of tritium should represent the true travel time of the water unless some isotopic

exchange effect could be causing it to be delayed; even then such an effect would be of very minor magnitude and insignificant insofar as this study is concerned. The variations in travel times with depth and width from the point of maximum riverbank discharge are shown in Figures 9 and 10, respectively. The values in Table I, calculated from the travel times determined by field measurements, illustrate the lateral and vertical flow distribution in the system. An effective porosity of 30 percent was used in calculating flow rates with the following equation.

$$Q = \frac{Lp}{T} 7.48$$

where: Q is the flow per unit area of front (gpd/ft²), p is the porosity, T is the travel time (days), and L is the length of the flow path (ft.).

Table I

LATERAL AND VERTICAL FLOW DISTRIBUTION

<u>Lateral Flow Distribution</u> (ft. north or south of Point 0)	<u>Flow</u> (gpd/ft ²)	<u>Vertical Flow Distribution</u> <u>At Lateral Point 0</u> (Ft. below water table)	<u>Flow</u> (gpd/ft ²)
500'N	21.98	0'	24.1
400'N	22.57	5'	24.04
300'N	22.82	10'	23.88
200'N	23.64	15'	23.56
100'N	23.84	20'	23.08
0	24.1	25'	21.91
100'S	23.93	30'	17.17
200'S	23.85		
300'S	23.66		
400'S	23.6		
500'S	23.6		

The average permeability of the material at the site was calculated using the equation,

$$P = \frac{7.48}{I} pu$$

where: P is the permeability (gpd/ft^2), p is the porosity, u is the ground-water velocity (ft/day) and I is the hydraulic gradient (ft/ft)⁽⁶⁾. The permeability was found to be $1,165 \text{ gpd}/\text{ft}^2$ which is somewhat higher than that usually associated with Ringold sand and gravel deposits. This may be accounted for by the lack of cementing in this material compared to the cementing normally found in Ringold deposits.

Discharge to the crib averages 2,300 gallons per minute with about 600 gallons per minute of this going to the overflow trench. The infiltration rate in the crib, is $65 \text{ gpd}/\text{ft}^2$, based on 1700 gallons per minute infiltrating evenly over the $37,800 \text{ ft}^2$. The overflow trench (3000 ft^2) receives 600 gallons per minute for an average infiltration rate of $288 \text{ gpd}/\text{ft}^2$. The wide variation in infiltration rates between the crib and the overflow trench is probably due to surface channeling in the crib which would greatly reduce the effective infiltration area, Figure 11.

The maximum ground water velocity in the system, based on the minimum observed travel time of 79 days, is $10.8 \text{ ft}/\text{day}$ which is a relatively high velocity when compared to most other ground water systems. However, this velocity does not exceed the settling velocity of fine silt particles with diameters $>0.007 \text{ mm}$, and transport of particles greater than this size would be unlikely. Deposited fine silt particles would in turn serve as an effective filter for much smaller particles. Particle-size distributions of sediments typical of the site were determined⁽⁸⁾. The values are presented in Table II.

Table II

GRAIN SIZE ANALYSIS

<u>Particle Size</u>	<u>Weight %</u>
>2 mm Gravel and Cobbles	40
2-1.05 mm Sand	43
0.05-0.002 mm Silt	15
<0.002 mm Clay	2

The average dry density value for 12 samples taken from 1 to 66 feet below the surface at the site is $124 \text{ lbs/ft}^{3(10)}$. This density gives a loading of 6200 lbs/ft^2 at 50 feet, the average saturated groundwater depth. With this high loading pressure, the calculated groundwater velocity, and large percentage of material with grain sizes $>0.002 \text{ mm}$, it is extremely difficult to visualize any significant channeling of the sediments at the site, and no channeling has been observed during the past 2 years of crib use.

Waste discharged to the crib contains low concentrations of long-lived isotopes; Sr^{90} and Cs^{137} are probably the critical isotopes from the radiological standpoint. The relative migration rates of Sr^{90} and Cs^{137} have been predicted based on laboratory research with soil samples from the crib site⁽⁸⁻⁹⁾. Migration rate of about $1/100$ and $1/1000$ the rate of groundwater movement were determined for Sr^{90} and Cs^{137} , respectively. These are the average migration rates of the radionuclides through soil. Low but detectable concentrations of Sr^{90} and Cs^{137} may exist at greater distances downgradient from where the maximum concentrations occur. In laboratory studies, after the disposal of 12 column volumes of simulated waste, detectable concentrations of Sr^{90} ($\sim 0.01 \text{ C/C}_0$) were observed at approximately 0.7 of the column length⁽⁸⁾. The crib to date has received approximately 11.5 column volumes of waste; therefore, detectable concentrations of Sr^{90} ($\sim 0.01 \text{ C/C}_0$) may be expected on the soil as far as 600 feet downgradient from the crib. Lines indicating the approximate location of the average migration fronts of Sr^{90} and Cs^{137} based on the laboratory-determined rates are shown in Figure 5.

An estimate of the flow volume per linear foot along the 1000-foot sampling section of the unconfined aquifer was made based on the flow distributions observed at the riverbank. Because of the small variations observed in the lateral flow distribution along the sampling front, these were neglected and the estimate was based on an unconfined aquifer 36 feet thick with a vertical flow distribution as observed at wells near the river. The estimated flow is 750 gpd/ft., which if applied to the 1000-foot sampling front would give a total discharge of 750,000 gpd. The discharge to the crib averages 3,370,000 gpd which would indicate that only 22 percent of the flow from the crib was intercepted by the 1000-foot sampling front. The remaining 78 percent of the flow has considerably long travel times to the river, which would result in additional decay of radioisotopes before release to the river.

Several ground-water flow directions and velocities from the crib are shown in Figure 7. These estimates are based on the permeability previously determined for this site and the ground water gradient at the point indicated.

Samples were taken from the riverbank springs and analyzed for gamma, beta and alpha-emitting isotopes which were expected to be in the wastes in measurable quantities. The results of one samples are given in Table III. Average concentrations of radionuclides in other samples collected and analyzed were generally lower than the concentrations shown in Table III.

Table III

ISOTOPIC ANALYSIS OF A RIVERBANK SPRING SAMPLE*

<u>Radioisotope</u>	<u>Concentration</u> (pCi/ml)	<u>10 CFR 20 Limit for</u> <u>Unrestricted Discharge</u> <u>(Soluble)</u> (pCi/ml)
Np ²³⁹	0.09	100
Mo ⁹⁹	0.77	40
Cr ⁵¹	12.80	2000
Ru ¹⁰³	0.10	10
As ⁷⁶	0.66	20
Cs ¹³⁷	0.03	20
Zr-Nb ⁹⁵	0.02	6
Mn ⁵⁴	0.02	100
Zn ⁶⁵	0.04	100
Fe ⁵⁹	0.05	50
Co ⁶⁰	0.10	50
Na ²⁴	0.03	200
I ¹³¹	1.68	0.3
Sr-Y ⁹⁰	0.012	0.3
H ³	70.00	3000

*Taken at the point of maximum concentration and at a time of peak H³ concentration.

Further reduction of the concentration of radionuclides released to the 1301-N crib occurs by dilution with the Columbia River water. Significant dilution in the river occurs before N-Reactor effluent reaches the first water intake point at downstream reactors.

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FIGURE 1
The 1301-N Crib Site

FIGURE 2
Pasco Gravel Near The 1301-N Crib Site

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FIGURE 3
Outcrop of Pasco Gravels and Upper Ringold Formation Showing Deltaic Bedding

FIGURE 4
Outcrop Showing a Typical Distribution of Material Size in Sediments at the 1301-N Crib Site

FIGURE 5
Cross Section of the 1301-N Crib Site

FIGURE 6
Riverbank Spring Sampling Point

FIGURE 7
Average Ground Water Contours near the 1301-N Crib

FIGURE 8
Activity Concentrations at the Maximum Riverbank Discharge Point

FIGURE 9
I¹³¹ Arrival at the Riverbank Wells with Depth

FIGURE 10
 I^{131} Arrival Front at the River

FIGURE 11
Crib Channeling at the Discharge Point to the Overflow Trench