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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS
APRIL, MAY, JUNE, 1959

Prepared by Members of the
Chemical Effluents Technology Operation

Edited by: W. H. Bierschenk

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MASTER

CHEMICAL RESEARCH AND DEVELOPMENT OPERATION
HANFORD LABORATORIES OPERATION

HANFORD ATOMIC PRODUCTS OPERATION
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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS APRIL, MAY, JUNE, 1959

INTRODUCTION

The Chemical Effluents Technology Operation performs research to investigate the chemical and physical aspects of environmental contamination resulting from plant effluents or from potential process incidents. This report is primarily concerned with plant assistance research in the field of waste disposal during the quarter April, May, June, 1959.

The ground-water monitoring data utilized in this report were obtained from well-water samples. These samples are collected routinely by the Regional Monitoring Operation and analyzed by the Radiological Chemical Analysis Operation.

I. INTERPRETATION OF GROUND-WATER MONITORING DATA (D. J. Brown)

Inasmuch as laboratory data indicate that the radioisotope mainly found in the ground water is Ru^{106}, the analytical detection limit for gross beta in ground-water samples is 1.5×10^{-7} µc/cc. Figure 1 is a map of the separation areas showing the extent of detectable ground-water contamination during the period April-June, 1959. In addition, contaminated ground water was ✓ detected in three wells not shown on this map; wells 699-34-39A, 699-31-30, ✓ and 699-24-33. It must be emphasized that the boundaries of the contaminated ✓ zones shown on the map (Fig. 1) are rather indefinite because of the limited number of monitoring wells.

Water samples from monitoring wells are analyzed for specific radioisotopes depending on the composition of waste going to the crib and the gross beta

April, May, June 1959

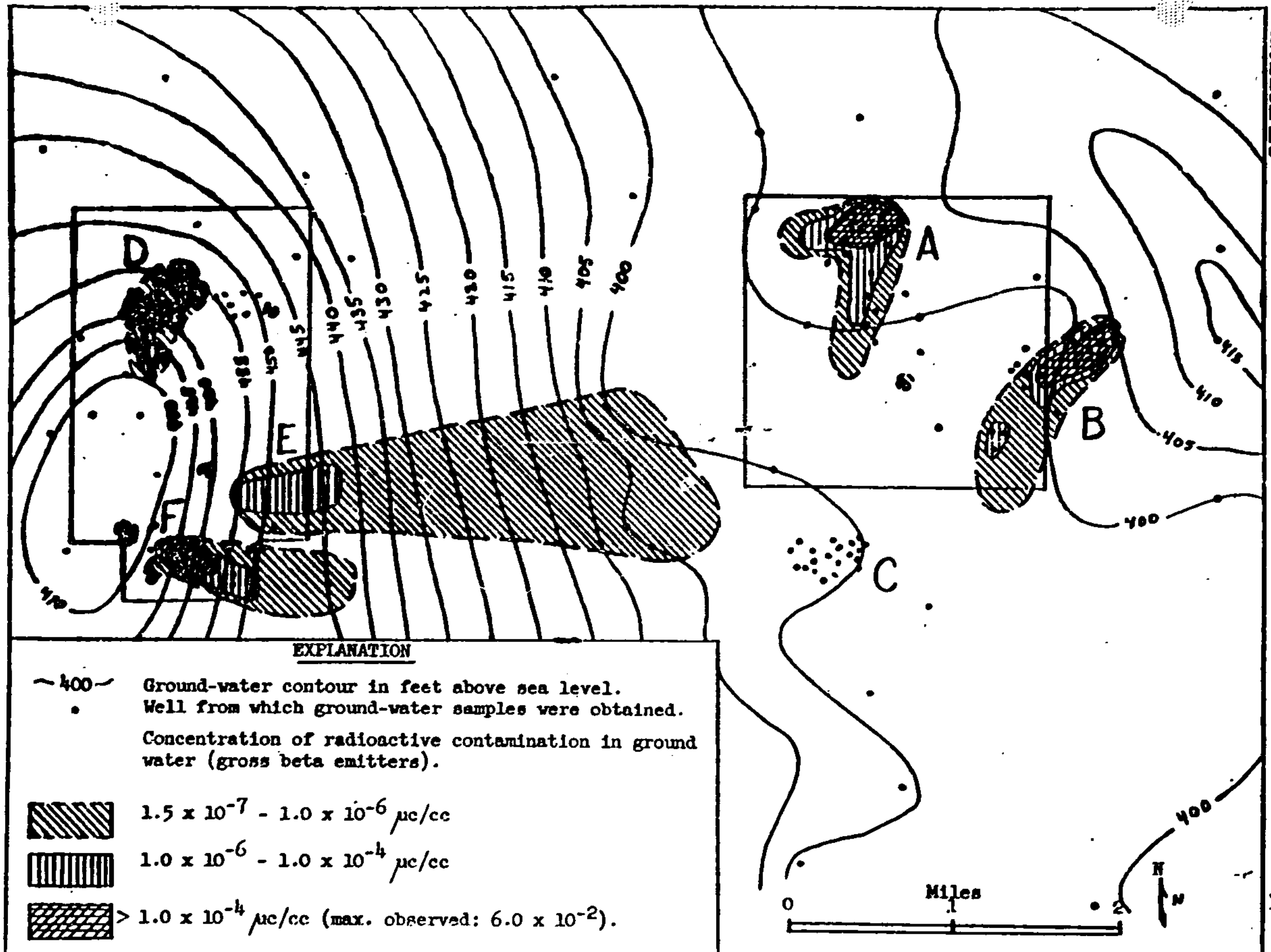

Figure 1. - Map of Separations Area showing probable extent of ground-water contamination and contours on the water table, June 1959.

activity found in the well samples. In general, when the gross beta activity in a well exceeds 1.0×10^{-4} μc/cc, the samples are analyzed for Co^{60}, Sr^{90}, and Cs^{137}. The routine analytical detection limit for these isotopes in such ground-water samples is 4×10^{-7}, 7×10^{-8}, and 5×10^{-7} μc/cc, respectively.

Figure 1 also shows the ground-water contours as of June 1959. The general direction of ground-water movement is normal to the contour lines in the direction of the downward slope. Any waste, therefore, that infiltrates to the water table will take the same general course as that of the ground water.

200-East Area

In the 200-East Area there are three major crib sites to which liquid radioactive wastes have been discharged. (See Figure 1, A, B, and C). The earth materials through which these wastes percolate are for the most part sands and gravels with minor amounts of silt and clay. The depth to ground water ranges from about 200 feet in the northeast part of the area to about 350 feet in the southwest part.

(1) 216-BY and 241-B cribs. -- Both of these crib sites are inactive. (See A, Fig. 1). The 241-B cribs were taken out of service in 1953 when the B-Plant was shut down and the 216-BY cribs were taken out of service in 1956 when radiocesium was detected in the ground water beneath the site. The gross beta concentrations in the ground water have remained fairly constant since these cribs were removed from service. Several wells in the BY-crib site were reperforated to determine whether the water samples taken from the wells were representative of the true ground-water

concentrations. Analyses received this quarter indicate that the same level of contamination is present as was observed prior to the reperforating work. The highest concentration of gross beta activity reported in the wells at this disposal site this quarter was 7.2×10^{-3} μc/cc. Isotopic analyses showed seven wells with Co^{60} concentrations above the 1/10 MPC value of 4×10^{-5} μc/cc. The maximum observation was 2.1×10^{-4} μc/cc in well 299-E33-3. Radiostrontium and radiocesium concentrations were below the analytical detection limits.

The unusual two-pronged shape of the contaminated ground-water pattern is probably caused by the fine Ringold sediments which rise above the water table just southwest of the crib sites and the coarser glaciofluviatile sands and gravels which occur just north and east of the Ringold beds. The more permeable glaciofluviatile materials are transmitting the contaminated ground water at a much faster rate.

One monitoring well south of this disposal site shows a detectable concentration of beta emitters. This radioactivity is probably the movement into the well of residual contamination from the soil immediately surrounding it.

(2) <u>216-A cribs.</u> -- There are five important cribs in this area which have received wastes from the Purex operation (See B, Fig. 1). Of these five, three are still in use. The maximum gross beta concentration reported at this site was 5.6×10^{-4} μc/cc. Isotopic analyses of samples from wells in this area show no concentrations of Co^{60}, Sr^{90}, and Cs^{137} above the analytical detection limits.

The contaminated ground-water pattern shows little change from that of the previous quarter. The wastes continue to move to the west and thence in a southerly direction to the vicinity of the southern boundary of the 200-East Area. Results from all wells further to the south and east of the 200-East Area show gross beta concentrations below the detectable limit, except in the three wells previously mentioned. These wells, 699-34-39A, 699-31-30, and 699-24-33, have all shown a twofold increase in gross beta concentrations over the previous quarterly average. (The wells are not located on the map in Figure 1 but are approximately three miles southeast of the 200-East Area). The source of this contamination is not definitely known, but is probably residual contamination remaining in the soil after contaminated ground water from the BY crib site moved through this area early in 1956. After the buildup of the 200-East ground-water mound in 1956, the movement of these wastes through this region stopped. The gross beta concentrations slowly dropped to below the detectable concentrations of beta emitters in the ground water but the occurrences are generally sporadic and inconsistent. Detectable concentrations of beta activity have been reported continuously in well 699-34-39A for over a year and in wells 699-31-30 and 699-24-33 for the past six months. A special sampling program will be established to determine what other factors may be causing this observed increase in concentration.

(3) 216-BC cribs and trenches. -- No wells monitoring the 216-BC cribs and trenches consistently show concentrations of gross beta activity above the detectable limit (1.5×10^{-7} μc/cc). (See C, Fig. 1).

200-West Area

The rate and direction of contaminated ground-water movement beneath the 200-West Area largely depend on the shape and height of the artificial ground-water mound which has been formed on the original water table. During the past 12 years the rates and directions have changed significantly several times. Consequently, contaminated ground water has moved through much of the soil which intercepts the water table beneath the 200-West Area. At present the apex of the ground-water mound beneath the 200-West Area is located to the southwest of the area. The principal directions of ground-water movement beneath the three major disposal sites in the area are southeast, east and northeast. The depth to ground water ranges from 190 feet to 280 feet. The earth materials through which the wastes filter to the water table include beds that are much finer than any located beneath the 200-East Area and probably cause significant lateral spreading. This is especially true in the southern part of the area where wastes have been detected above the water table several hundred feet from the site where they were sent to the ground. These fine materials also reduce the rate of movement of the ground water beneath this area.

There are three general areas where ground water is contaminated to detectable concentrations. These areas are shown on the map in Figure 1 near the letters D, E, and F. Other small isolated areas also appear on the map. These areas are contaminated by small cribs in the locality of the monitoring well or they are presumably the result of residual radioactive material washing into the well from the soil adjacent to it.

(1) T-Plant cribs and trenches. -- In the north of the 200-West Area is the T-Plant and its associated cribs and trenches. (See D, Fig. 1). These disposal facilities are no longer in use but wastes from several of these cribs continue to drain into the ground water accounting for the continued high concentrations of beta emitters found there. The highest concentration reported this quarter was 2.7 x 10^{-5} μc/cc. Water samples from critical monitoring wells were analyzed for Sr^{90} and Cs^{137} but no concentrations above the detectable limit were reported.

(2) 216-WR cribs. -- An area of contaminated ground water extends from the 216-WR cribs approximately three miles to the east. (See E, Fig. 1). It is believed that most of this radioactive material originated from the T-Plant cribs when the hydraulic gradient was toward the southeast. At a later time the gradient of the 200-West ground-water mound was changed in the T-Plant region and the movement of the wastes from this site was altered to the north and northeast. Much of the contaminated ground water which had moved to the southeast was unaffected by the local gradient change and continued to move in an easterly direction. The 216-WR cribs are now believed to be the major source of contamination in this area. The maximum concentration detected in the ground water this quarter was 1.1 x 10^{-5} μc/cc in well 299-W19-2 located just east of the 216-WR-1 crib. No detectable concentrations of Sr^{90} or Cs^{137} were found in the wells at this site.

(3) Redox cribs. -- There are seven cribs in this area which are potential sources of ground water contamination. (See F, Fig. 1). The 216-S-1 and 2 cribs, however, have been inactive since January of 1956. This area is underlain

by extensive deposits of fine material which have caused the wastes going to these cribs to spread considerably. The small hook at the west end of the contaminated ground-water pattern is probably the result of some wastes spreading laterally in the soils above the water table in this direction. The general movement to the southeast shows little change over that of the previous quarter. The maximum concentration of beta activity reported was 6.0×10^{-2} µc/cc in well 299-W22-14.

Well 299-W22-2 continues to show detectable concentrations of Sr^{90} in the ground water. Sr^{90} has continuously appeared in this well for the past 26 months, the present concentration averaging 1.7×10^{-6} µc/cc for the quarter. All other wells in this area were below the detectable limit for Sr^{90} and Cs^{137}.

II. PLANT WASTE DISPOSAL PRACTICE

Chemical Processing Department (W. A. Haney)

Disposal to ground. -- Geological, well-probe, ground-water sampling, and waste disposal data have been utilized in determining well-drilling locations that should yield maximum information on the distribution and concentration of radioisotopes under selected 200-Area disposal sites. Optimum well locations for investigating five facilities have been determined. These twenty-four wells represent about fifty percent of the anticipated drilling footage requirements for a program under consideration to investigate the distribution of radioactive materials in the vadose zone under 200-Area ground disposal facilities.

HW-59916, "Phase I Program -- Effects of a Proposed Dam at Columbia River Mile 348 on Radioisotopes Stored in Ground" by D. W. Pearce, was issued May 1, 1959. The report outlines a program to study the distribution and concentrations of radioisotopes in 200-Area soils above the ground-water table. The program is the result of concern over the effect a higher and fluctuating water table might have on past, present, and future disposals of radioactive liquid wastes in the 200-Areas.

Recommendations were forwarded to the Chemical Processing Department that the abandoned 216-T-19 crib and tilefield not be used for disposal of wastes from the T-Plant decontamination facility. Uncertainties relative to the present contamination status of this facility and inadequate monitoring well coverage make it inadvisable to reactivate this disposal site. The effect of combining decontamination waste with UO_3 plant condensate on the capacity of the unused 216-R-27 and 28 cribs is being investigated as a possible alternate solution to this disposal problem.

HW-60115, "Exploratory Field Study of a Ground Waste Disposal Facility," by W. A. Haney and C. E. Linderoth, was issued May 15, 1959. This report presents studies of waste dispersal and radioisotope distribution in soils beneath the abandoned Redox 216-S-1 and 2 cribs. The bases for these studies were radioanalytical results and sediment characteristics of soil samples obtained from wells drilled in the vicinity of the crib site after abandonment in 1956. Good correlation exists between geological formation characteristics and directions of waste movement. Furthermore, the preferential uptake of Cs^{137}, relative to Sr^{90}, was evidenced by the absence of Cs^{137} in samples from all but two nearby wells, and there only in low concentrations.

Irradiation Processing Department (W. N. Koop)

Decontamination of reactor coolant. -- The engineering study to determine feasibility of a Chemical Research Operation proposal for decontaminating spent coolant was continued. The proposal involves passage of effluent through beds of aluminum turnings prior to river release. Experiments to date have been limited to scrap aluminum which was obtained from the manufacture of reactor fuel elements. Results from pressure drop tests, conducted by Chemical Development Operations personnel, indicate favorable characteristics at low effluent velocities such as those found across reactor retention basins. However, prohibitive pressure drops occurred at higher velocities of the magnitude of those found across outfall structures. Preliminary data from glass column experiments also indicate more effective coolant decontamination at low velocities. Surface areas of material were measured by a gas adsorption technique after samples had been immersed in H-Area retention basin water. These immersion results confirmed to some extent the relationship between surface area and the ability of corroded aluminum to adsorb radioisotopes from the water. The immersion experimental method appears promising for evaluating other bed materials.

Columbia River Navigation Channel. -- Chemical Effluents Technology cooperated with the Irradiation Processing Department in reviewing the effects of a navigation channel on Hanford operations. Opinions and comments of other interested components of Hanford Laboratories Operation were composited and sent to Irradiation Processing Department for inclusion in a document that updates information in the 1958 report on this subject.

Tritium injection. -- At the request of Irradiation Processing Department and in cooperation with Radiation Protection Operation, a working limit of 20 curies/day as a maximum injection rate for tritium was derived and recommended. This was done in order that river pollution aspects might be included along with other considerations in the development of a tritium tracer technique for locating process tube leaks during reactor operation. This limit provides a rate of tritium injection that is known to have an insignificant effect on the potential internal exposure of the general public. The restrictive criteria for the working limit is justified, since a deliberate routine addition of radioactive materials to the river, other than reactor coolant contamination, is contrary to the disposal philosophy at Hanford. However, the potential reduction of outage time for locating tube leaks appeared to warrant consideration of limited tritium injection.

Reactor confinement. -- The design of the cribs for waste streams from the proposed reactor confinement buildings was reviewed. Relocating the 100-F crib 170 feet south of the originally selected site was recommended to minimize leaching of radionuclides from other nearby disposal facilities. Monitoring well locations and specifications were also recommended.

Fission Product Release Experiments (R. K. Hilliard and A. J. Scott)

Air atmospheres. -- Six additional experiments were performed this quarter for a total of twenty-nine tests on the release of fission products from low-level irradiated uranium heated in air atmospheres. This completed the first phase of the fission product release study and a topical report will be issued in July as HW-60689. In these experiments the fraction of seven fission product isotopes released from small uranium specimens was measured at various conditions and a correlation made as functions of temperature, time, and air flow rate. Xenon, iodine, and tellurium were found to be quite volatile, being released in proportion to the extent of uranium oxidized. Strontium, cesium, ruthenium, and barium were found to be relatively non-volatile. The fraction released was independent of time and extent of oxidation, but somewhat dependent upon temperature of oxidation. The release of the volatile elements during a steady temperature increase of 10° C/min compared closely with that predicted by graphical integration of isothermal data. The release rate during thermocycling conditions showed fluctuations corresponding to the thermal peaks. A helium atmosphere gave a lower release of iodine, xenon, tellurium, and ruthenium, and a higher release of strontium than with air under otherwise similar conditions. Cesium and barium release was the same as in an air atmosphere.

Aluminum jackets pressed around the uranium specimen caused a rapid and large temperature excursion when exposed to air at high temperature. In one case a cloud of fine aluminum oxide particles was emitted which passed through several traps.

Planning was started on a test facility for fission product release experiments utilizing fully irradiated specimens.

Steam atmospheres. -- Studies of the release of fission products from low-level irradiated uranium heated to high temperatures in steam atmospheres are progressing satisfactorily. The combustion apparatus used is a modification of equipment applied to fission product release experiments in air. Steam flow used to date is 2300 cc/min at one atmosphere pressure. Helium is used for protecting the specimen while in the combustion train prior to and following introduction of steam.

A series of experiments with unirradiated uranium, using 1/4" diameter by 3/4" long specimens, was made in order to assure adequacy of the combustion equipment and to provide oxidation rate information for representative temperatures. Linear oxidation rates were obtained for these runs. Ten experimental runs utilizing low-level irradiated uranium oxidized by steam have been completed. Fission product release data obtained through radiochemical analyses of samples collected from the combustion apparatus are not yet complete. However, data to date indicate that the release of I^{131}, Te^{132}, Ru^{103}, and Xe^{133} is greatly suppressed in steam as compared to air atmosphere for similar oxidation temperatures and time. Measurements have shown that the 1/4" x 3/4" specimens used in these studies of both unirradiated and irridated metal oxidize at the same rate. This permits use of unirradiated uranium results in correlation of irradiated specimen data.

III. LABORATORY EVAOUATION OF WASTES (A. E. Reisenauer).

300 Area Waste and Redox Laboratory Waste

Soil column tests were performed to estimate the expected life of the 216-SL 1 and 2 cribs. The average column capacity for the critical isotope Sr^{90}

in four soil columns using a 9 to 1 mixture of 300 Area waste to Redox laboratory waste was 8.4 column volumes. By the end of May 1959, 7.04×10^6 gallons or 1.37 column volumes of waste had been discharged to this crib. At the present rate (150,000 gal/mo) the crib would be expected to last 20 years. This estimate is based on a flow rate of only 0.35 $gal/ft^2/hr$, and no attempt was made to simulate the batchwise addition of 300 Area waste to this crib. The soil used in the test columns was a composite from drilling samples from well 299-W22-19. A conservative attitude toward this apparently long crib life should be maintained because of the uncertain composition of laboratory wastes and probable increase in their volume and concentration.

224-U Plant Condensate

Four pairs of soil columns were used to investigate the optimum pH to which the 224-UPlant acid condensate should be adjusted with NaOH before ground disposal. The pH points studied were at pH 6,9, 11, and 12. The following results were obtained using waste samples spiked with Sr^{90}, the critical radionuclide.

1. 5% breakthrough of Sr^{90} occurred before 5 column volumes was reached using wastes adjusted to pH 6 and 9.
2. No detectable rise in Sr^{90} activity occurred through 120 column volumes using waste adjusted to pH 11 and 12.

The soil used in these columns was composited from well 299-W14-2, which is situated near the 216-TY crib site.

Purex Ammonia Scrubber and Stack Drain Waste

Soil column tests in progress to estimate the life of the replacement for the 216-A-4 crib indicate that over 40 column volumes of waste may be added with no significant increase in the critical radionuclide Sr^{90} in the effluent. the waste used as influent was combined ammonia scrubber waste and stack drain waste, at present being sent to the 216-A-21 cribs. The soil used in the columns was composited from well 299-E24-1. The present flow rate to the crib is less than 1 column volume per year.

IV. GROUND-WATER HYDROLOGY (W. H. Bierschenk)

All quantitative ground-water data collected to date have been evaluated and compiled and are included in the formal report "Aquifer Characteristics and Ground-Water Movement at Hanford" which will be issued during the third quarter as HW-60601. The hydraulic characteristics of Hanford aquifers were measured and estimated by a variety of field methods. Mutually consistent results show that the permeability of the glaciofluviatile sediments ranges from about 10,000 to more than 60,000 gpd/ft^2, and the permeability of the underlying Ringold deposits ranges from less than 100 to 600 gpd/ft^2. Based on these permeability data, calculations of the average rate of ground-water flow indicate a range from a few inches per day to as much as 160 ft/day.

The hydraulic studies show that wastes which reach the water table beneath disposal sites will potentially move in a general southeastward and eastward direction some 20 miles to the Columbia River. Average rates of ground-water flow indicate that travel along this estimated mean lateral path of ground-water contamination could conceivably be completed in an average time in the order of 180 years. Such factors as heterogeneity and anisotropy of the aquifers, and dispersal of wastes in the ground water, however, assume great importance in determining the path and ultimately the concentration of radioactive wastes in the river. The statistical distribution of velocities indicates some potential for movement at several times the average rate, while other components, particularly those that undergo adsorption reactions with soil surfaces, may move at a minute fraction of the average rate.

V. WELL DRILLING SUMMARY (D. J. Brown)

A contract for construction of research and exploratory wells was awarded to the Bach Drilling Company of Coulee City, Washington. It covers the construction of 16 wells ranging in depth from about 75 feet to over 700 feet. The total footage to be drilled is approximately 3600 feet. The firms which bid on this contract are listed below with their respective estimates.

Western Drilling Co., Tacoma Washington	$93,088
Midland Drilling Co., Walla Walla, Washington	48,265
Hatch Drilling Co., Half Moon Bay, California	52,415
Bach Drilling Co., Coulee City, Washington	40,945
Fair cost estimate	46,060

The work is scheduled to start during the third quarter of 1959 and is to be completed within 240 calendar days after the notice to proceed has been given.