[redacted] UNCLASSIFIED

~~UNCLASSIFIED~~
(CLASSIFICATION)

DOCUMENT NO.
BNWL-CC-1352

ISSUING FILE

COPY NO. [redacted]

DATE
September 19, 1967

PROJECT

BATTELLE-NORTHWEST
RECEIVED
JAN 15 1968
REFERENCE COPY
TECHNICAL INFO. SECTION

REFERENCE COPY

BATTELLE-NORTHWEST
RICHLAND, WASHINGTON

TITLE

GROUND DISPOSAL OF REACTOR COOLANT EFFLUENT

AUTHOR

J. R. Eliason and B. F. Hajek

BEST AVAILABLE COPY

DISTRIBUTION

NAME	BUILDING	AREA	NAME	BUILDING	AREA
Battelle-Northwest			Douglas-United Nuclear		
G. J. Alkire			R. G. Geier (5)		
B. L. Carlile					
J. P. Corley					
J. R. Eliason					
R. F. Foster					
B. F. Hajek					
W. A. Haney					
R. T. Jaske					
K. C. Knoll					
J. L. Nelson					
C. J. Touhill					
300 Files					
Extras (10)					

10/09/2014
Approved for Public Release;
Further Dissemination Unlimited
J. D. Aardal, LM-RIM

ROUTE TO	PAYROLL NO.	LOCATION	FILES ROUTE DATE

THIS DOCUMENT IS PUBLICLY AVAILABLE

UNCLASSIFIED

~~UNCLASSIFIED~~ [redacted]
(CLASSIFICATION)

(TO BE USED ON UNCLASSIFIED AND OFFICIAL USE ONLY DOCUMENTS)

[redacted]

UNCLASSIFIED

GROUND DISPOSAL OF REACTOR COOLANT EFFLUENT

By

J. R. Eliason and B. F. Hajek

September 19, 1967

INFORMATION CONCERNING USE OF THIS REPORT

PATENT STATUS

This document copy, since it is transmitted in advance of patent clearance, is made available in confidence solely for use in performance of work under contracts with the U. S. Atomic Energy Commission. This document is not to be published nor its contents otherwise disseminated or used for purposes other than specified above before patent approval for such release or use has been secured, upon request, from the Chief, Chicago Patent Group, U. S. Atomic Energy Commission. 9800 So. Cass Ave., Argonne, Illinois.

PRELIMINARY REPORT

This report contains information of a preliminary nature prepared in the course of work under Atomic Energy Commission Contract AT(45-1)-1830. This information is subject to correction or modification upon the collection and evaluation of additional data.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

UNCLASSIFIED

54-1100-057 (6-65)
AEC-RLOO RICHLAND, WASH.

GROUND DISPOSAL OF REACTOR COOLANT EFFLUENT

J. R. Eliason and B. F. Hajek

INTRODUCTION

The concept of reactor effluent disposal to the ground in infiltration trenches was proposed by Nelson and Alkire in 1963.[5] At that time the available data indicated that infiltration rates were probably adequate for trench disposal and that decontamination factors (DF's) of 10 to 100 should be obtainable. The need for more quantitative information on infiltration rates and radionuclide adsorption over a relatively long period of time was recognized and field tests were proposed.

A field test using an existing trench at 100-F Area was conducted in 1964-65.[4] The data obtained in the 100-F study showed that 1530 gal/day/ft^2 could be infiltrated; however, structural failures, flooding and frequent reactor down periods prevented sustained disposal at this rate.

The purpose of this report is to present the results of a field test designed to determine the infiltration rate of reactor coolant effluent disposed to an existing trench at 100-D Area for a four-month period. In addition, the effects of this system on groundwater elevations and temperatures in surrounding wells, and radionuclide concentrations reaching the river were determined.

SUMMARY

A study in which reactor coolant effluent was disposed to an existing trench at 100-D Area was conducted for a four-month period, March - June, 1967. During this time 3.367 x 10^9 gallons of effluent were infiltrated at an average rate of 1277 gal/day/ft^2. Groundwater elevations and temperatures increased in the vicinity of 100-D; however, no significant decrease in infiltration rate occurred. Decontamination factors ranged from 2.5 for ^{51}Cr to >276 for ^{65}Zn. These are probably minimum decontamination factors since the route followed by wastes moving from the trench to the springs is considered to be the path having the shortest travel time. Groundwater elevations quickly returned to near pre-test levels upon termination of disposal; however, groundwater temperatures are decreasing slowly.

This study showed that large volumes of reactor coolant effluent can be disposed to the ground for significant periods of time. The decontamination achieved is probably greater than could be obtained by any other treatment process.

METHODS

Personnel of the Research and Engineering Department of Douglas-United Nuclear designed a system which transported 100-D reactor coolant effluent at a rate of 27,000 gpm from the 107-DR basin to the 100-D emergency crib trench. The location of the trench is shown on the map in Figure 1. The trench was 490 feet long and about 90 feet wide (top width). The bottom width varied from essentially a "V" bottom to a flat bottom about 40 feet wide. The volume capacity when filled two feet below the lowest surface point was 1,367,000 gallons.

Groundwater elevations and temperature were obtained from well measurements prior to the test (February, 1967) and at one week intervals during the test. Samples of reactor coolant effluent and effluent from river bank springs were collected for radionuclide analysis. Effluent samples were collected prior to the test and bi-weekly during the four-month study period. Sampling well and spring locations are shown on Figure 4.

RESULTS AND DISCUSSION

Decontamination

Table I gives the average relative concentrations of selected radionuclides in effluent collected during and before the test at spring sampling sites SP-1 and SP-4. The data show that activity increased as a result of the test.

TABLE I

Radionuclide Concentrations of Spring Effluents
Relative to the Average Concentration in the Basin

	^{131}I	^{32}P	^{65}Zn	^{51}Cr
Pretest				
SP-1	0.88×10^{-2}	1.18×10^{-3}	$<3.8 \times 10^{-3}$	4.7×10^{-1}
SP-4	1.33×10^{-2}	0.57×10^{-3}	$<4.1 \times 10^{-3}$	2.8×10^{-1}
Test				
SP-1	8.82×10^{-2}	3.82×10^{-3}	$<3.68 \times 10^{-3}$	4.2×10^{-1}
SP-4	8.90×10^{-2}	5.6×10^{-3}	$<3.6 \times 10^{-3}$	3.9×10^{-1}
Hold-up time (days)	28	110	>1863	36
DF	10	210	>276	2.5

In addition to concentrations, Table I also gives the average decontamination factors obtained and hold-up times between the trench and riverbank springs. These data agree well with laboratory adsorption results[3] and anticipated DF's reported by Nelson and Alkire.[5]

Figures 1, 2, and 3 show relative concentration data obtained from samples collected at SP-1. The data presented in the figures suggest that ^{51}Cr and ^{131}I have reached a new steady-state level; however, ^{32}P concentrations were increasing when the test was terminated. There are many uncertainties in the ^{32}P determinations resulting in "less than" values. If "less than" values were omitted, ^{32}P would appear to be at a steady-state level. The concentration increases observed between +25 and +30 days are probably due to a decrease in travel time caused by the increased ground water gradient.

Ground Water Level Measurements

Ground water levels were measured in all available wells near the 100-D trench during and after the test to determine the response of the aquifer to the disposal of large quantities of reactor effluent. The initial groundwater elevations (February, 1967) plotted in Figure 4 show that a groundwater mound did exist under 100-D Area prior to the test due to leakage from the retention basins and effluent lines. Prior to the test, springs had developed along the river due to this leakage.

During the test the flow rate of the Columbia River in this reach fluctuated from approximately 40,000 cfs to 110,000 cfs daily, because of power generation at Priest Rapids Dam, until the end of May when the total flow rate exceeded the regulatory capacity of the dam. High water stage was reflected in wells near the river and complicated the interpretation of data collected during that period. Figure 5 shows maximum groundwater elevations measured before the high water period. These maximum groundwater elevations indicate that a significant change in the size of the groundwater mound occurred due to the trench test. Initial to maximum groundwater elevation differences, plotted in Figure 6, show the ground water level changes caused by the test. The storage volume based on the change in groundwater elevations and a porosity of 30 percent is approximately 8×10^8 gallons. The average discharge rate during the test was 3×10^7 gal/day, and the total discharge was 3.4×10^9 gallons. This indicates that during the test approximately 30 percent of the volume discharged, prior to high water, was accounted for in the ground water mound which formed; the remaining 70 percent flowed into the River. Ground water elevations measured on September 11, 1967 (Figure 7) show that the mound under the trench subsided appreciably, and the groundwater contours have only a slight distortion which may have been caused by the trench test.

During the test the trench had an average infiltration rate of 1277 gal/day/ft^2 and a maximum of 1654 gal/day/ft^2.

The average permeability of the material from the trench to the river was calculated using the equation $P = \frac{7.48\ pu}{I}$ [1] where P is the permeability (gpd/ft^2), p is the porosity, u is the groundwater velocity (ft/day) and I is the hydraulic gradient (ft/ft). The permeability was found to be 3740 gpd/ft^2 using a ground water velocity of 50 ft/day determined by correcting the ^{131}I travel time (28 days) calculated by decay for the 25 percent lag which had been observed in 100-N Area tests.[2]

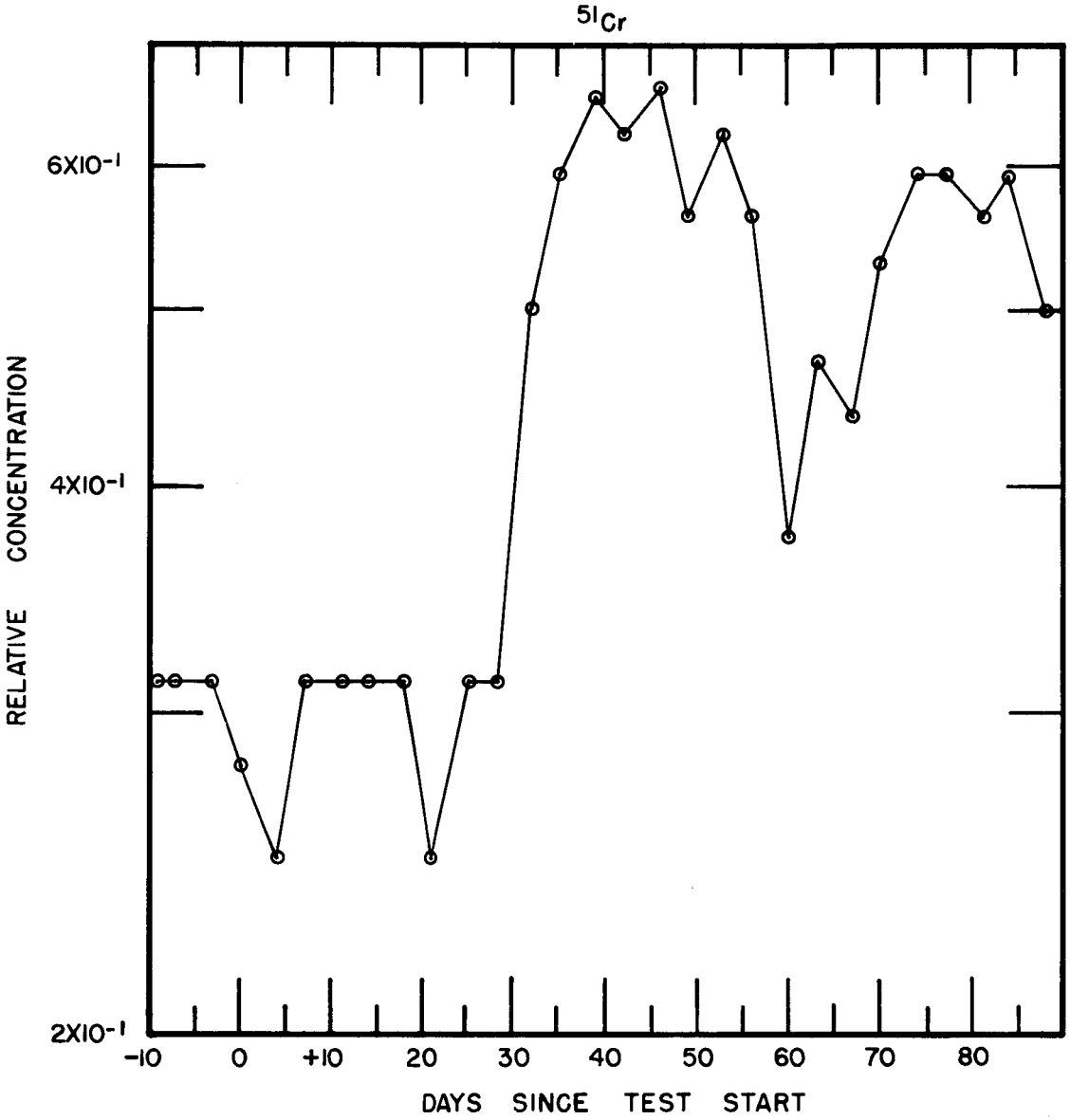

Figure 1. Riverbank spring (SP-1) ^{51}Cr concentrations relative to the average basin concentration.

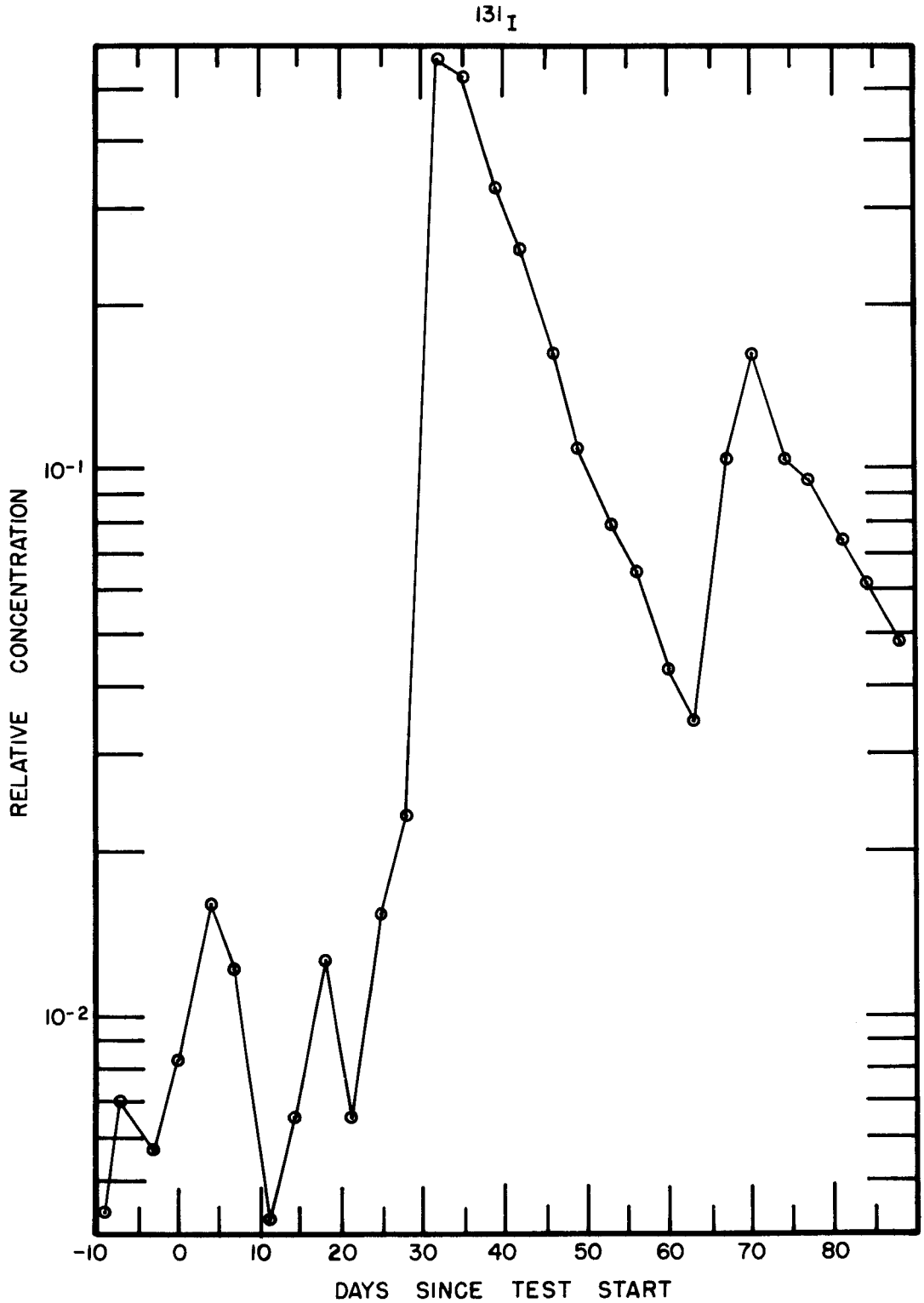

Figure 2. Riverbank spring (SP-1) ^{131}I concentrations relative to the average basin concentration.

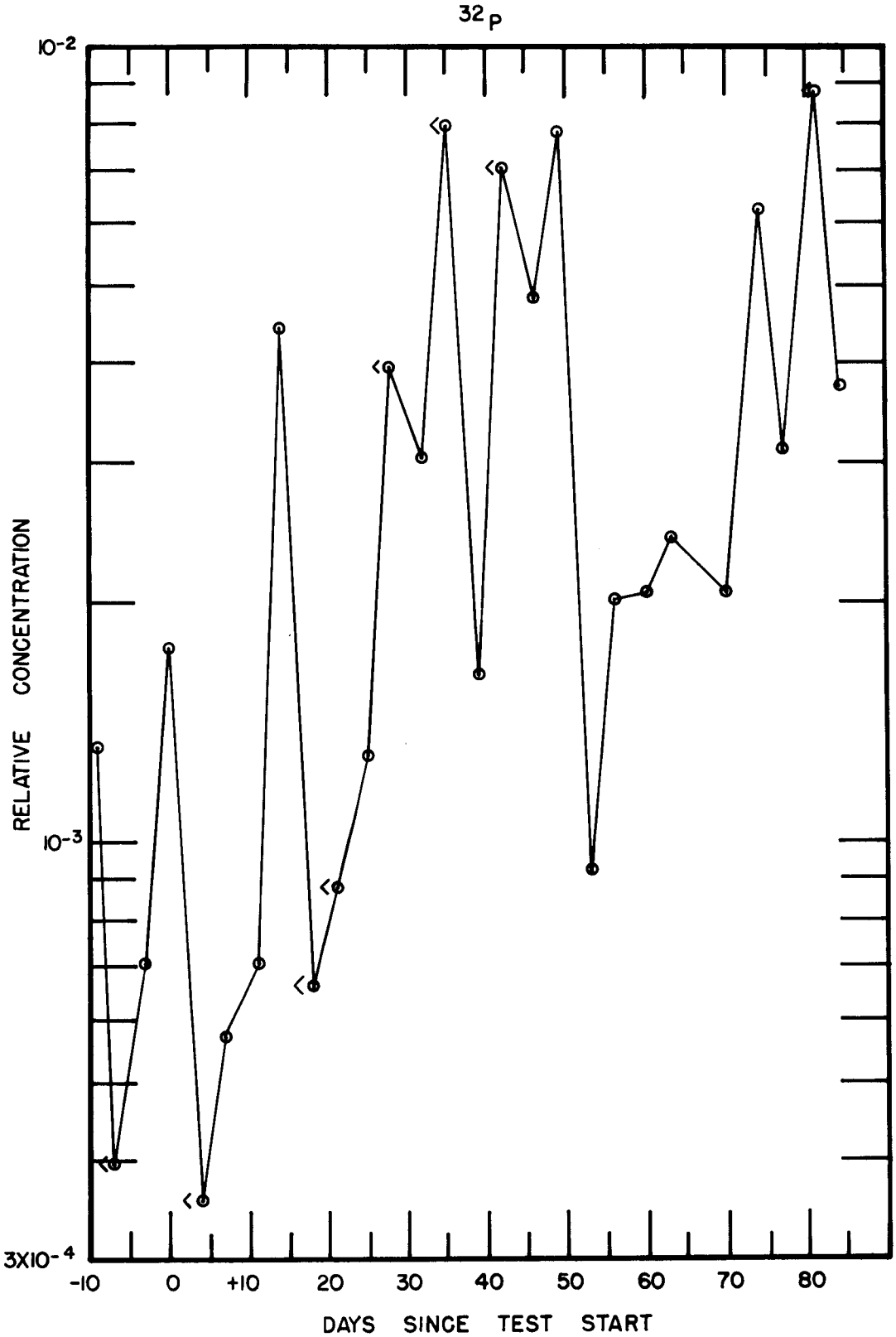

Figure 3. Riverbank spring (SP-1) 32P concentrations relative to the average basin concentration.

Transmissibility coefficients calculated for several wells are listed in Table II. The values were obtained by using a non-equilibrium method of calculating transmissibility described by L. K. Wenzel.[6] Transmissibility measurements made in wells which intercept the Pasco Gravels (Glaciofluviatile) here ranged from 380,000 to 3,000,000 gpd/ft[1] which bracket the 523,000 to 860,000 gpd/ft measurement obtained during this test.

TABLE II

Coefficients of Transmissibility

Well	Distance from Trench (feet)	Direction	Transmissibility gal/day/ft.
699-97-51	3000	N28°E	860,000
699-96-49	3200	N55°E	777,000
699-93-50	2700	S50°E	573,000
199-D5-12	2600	S14°W	523,000

Ground Water Temperature Measurements

Ground water temperatures were measured in all available wells near the 100-D trench during and after the test on a weekly basis to determine the changes in the temperature patterns due to the test. Pre-test temperature measurements (February, 1967) show the influence of the leakage of reactor effluent to the ground (Figure 8). The maximum ground water temperatures plotted in Figure 9 show that a significant increase in the overall temperature pattern occurred due to the test. Figure 10 is a plot of temperature change (ΔT) from the initital to the maximum. An elongated pattern is quite noticeable, particularly for the 10° ΔT contour. The temperature contours and transmissibilities indicate that more groundwater moved to the northeast from the trench than to the southeast. Groundwater temperatures collected September 11, 1967 (Figure 11) show a slight decrease from the maximum, but the same general pattern persists. This pattern is expected to return slowly to somewhat near initial conditions over a significant period of time. The groundwater mound, in contrast, has nearly completely subsided.

Figure 12 shows thermal profiles observed in Well 699-96-49 which is 3200 feet northeast of the 100-D trench. The well penetrates approximately 50 feet of Pasco Gravels that overly the Ringold Formation. The contact is reflected by a temperature break which is caused by the permeability difference in the materials. An initial increase in temperature at depth observed May 8, 1967, is difficult to explain, but may be due to loss of heat to the ground surface from the upper part of the aquifer, a zone of more permeable material, or a combination of these considerations. A more normal pattern existed on June 26, 1967 when a maximum temperature of $\sim$ 52°C was noted at the water table surface. The temperature profile on September 9, 1967 indicates that warmer water from the trench area is still moving through this well at several depths.

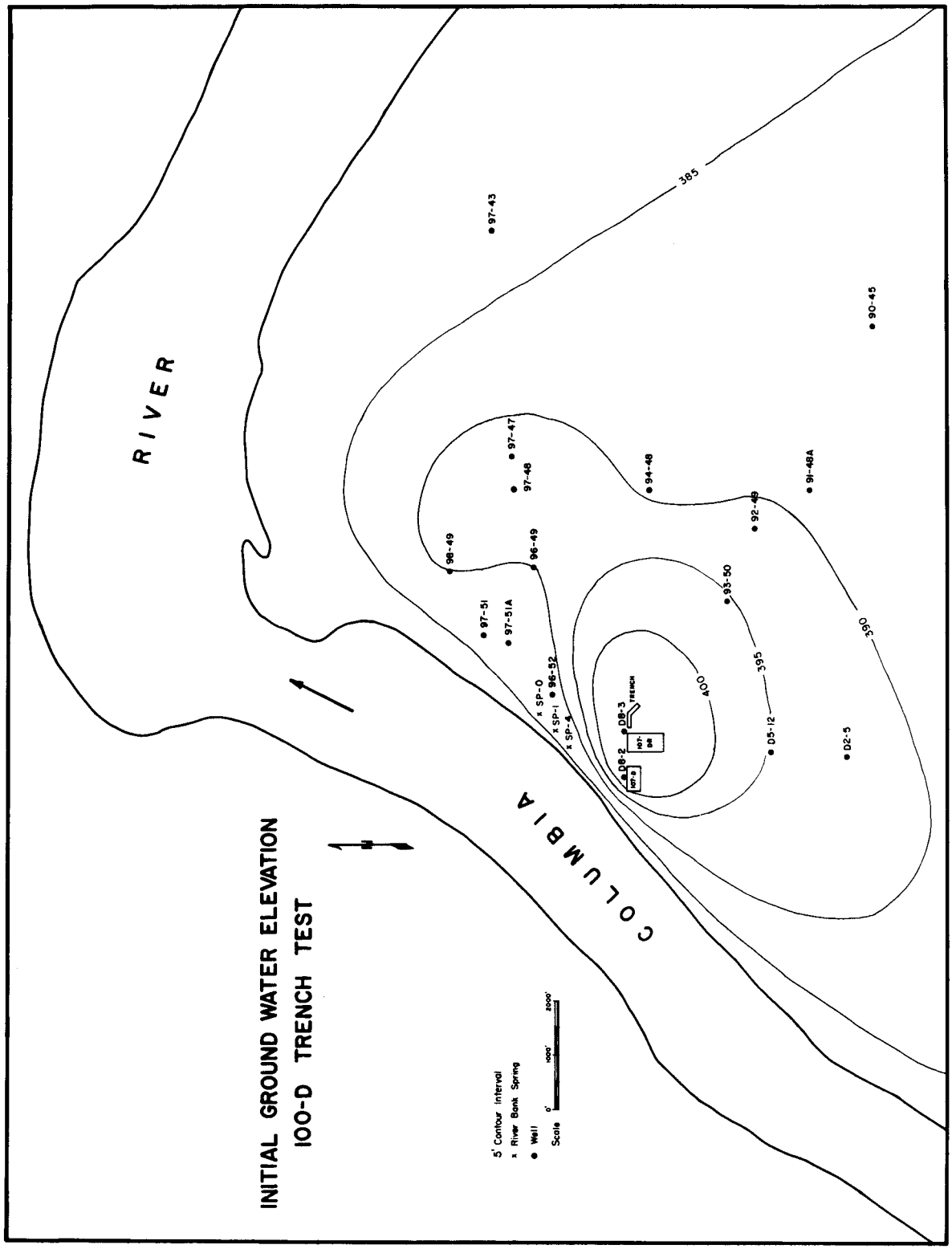

Figure 4. Initial ground water elevation 100-D trench test February, 1967.

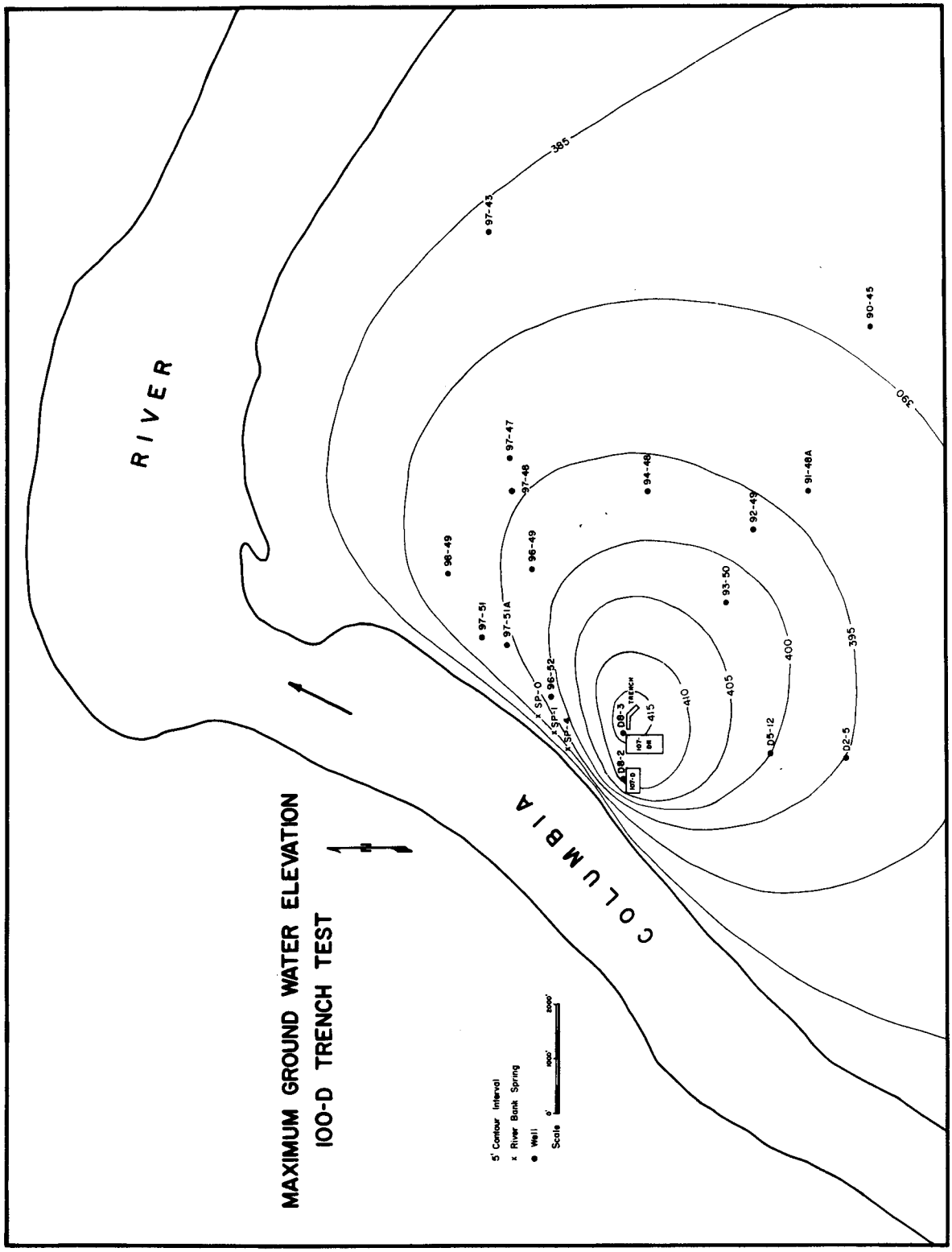

Figure 5. Maximum ground water elevation 100-D trench test.

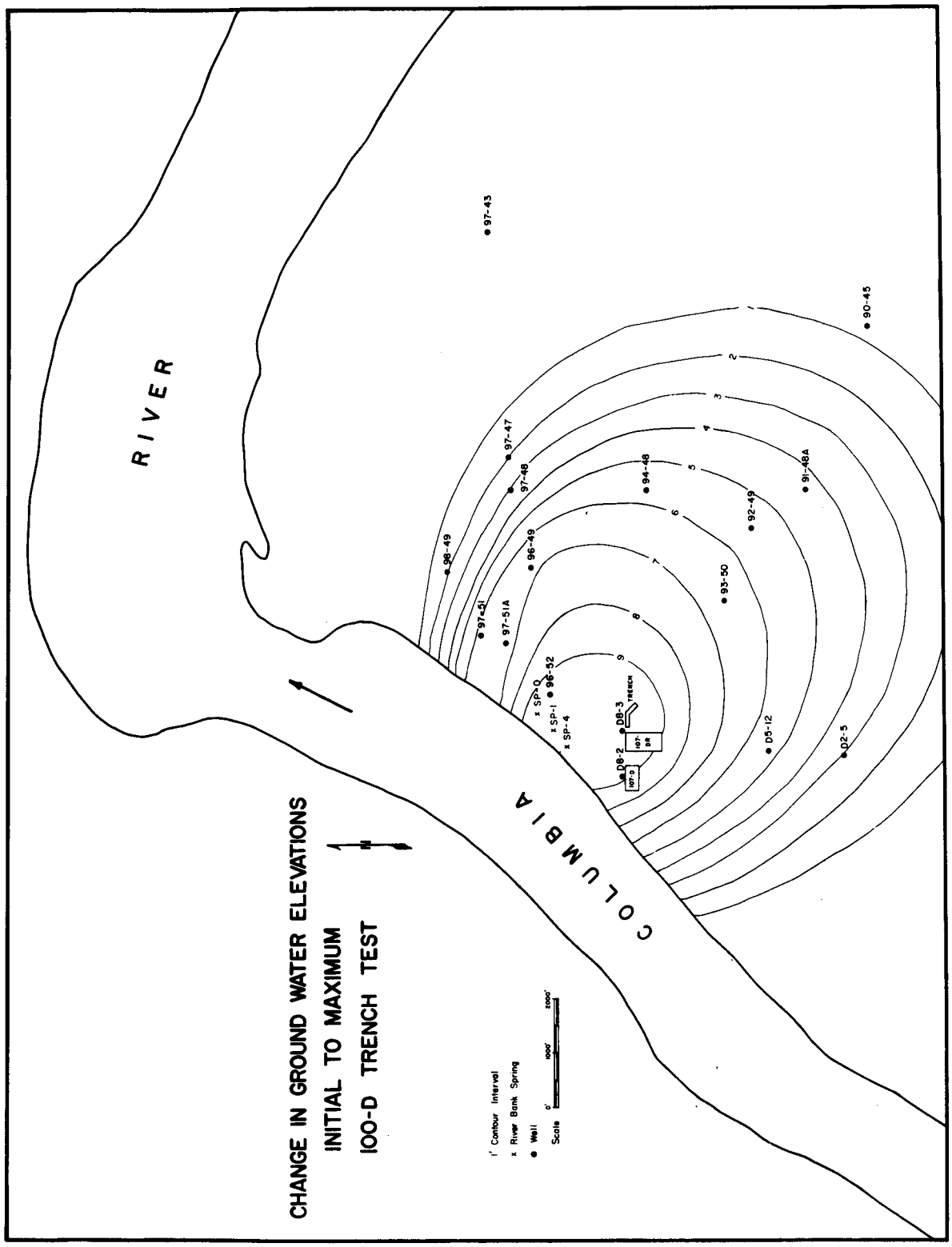

Figure 6. Change in ground water elevations initial to maximum 100-D trench test.

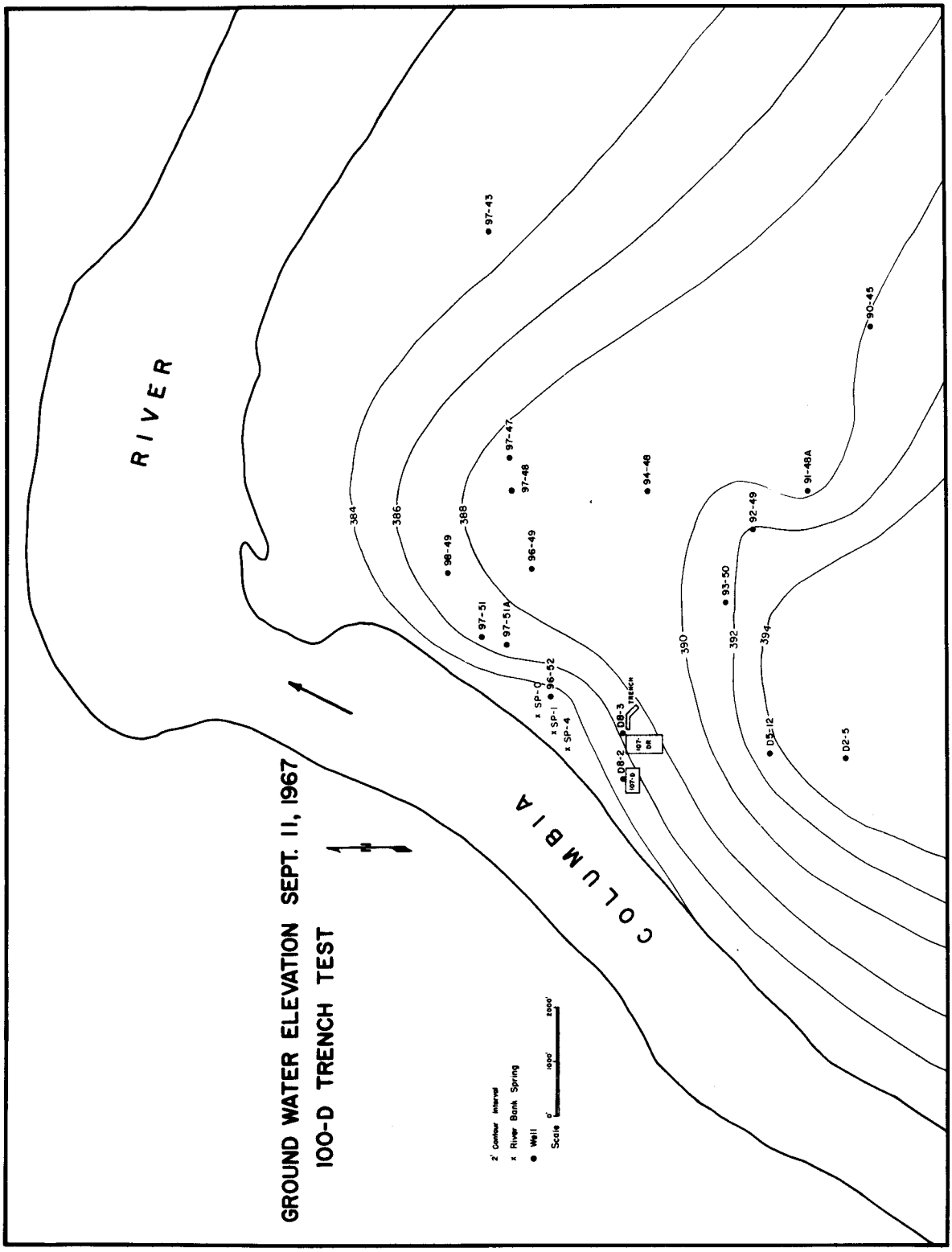

Figure 7. Ground water elevation September 11, 1967 100-D trench test.

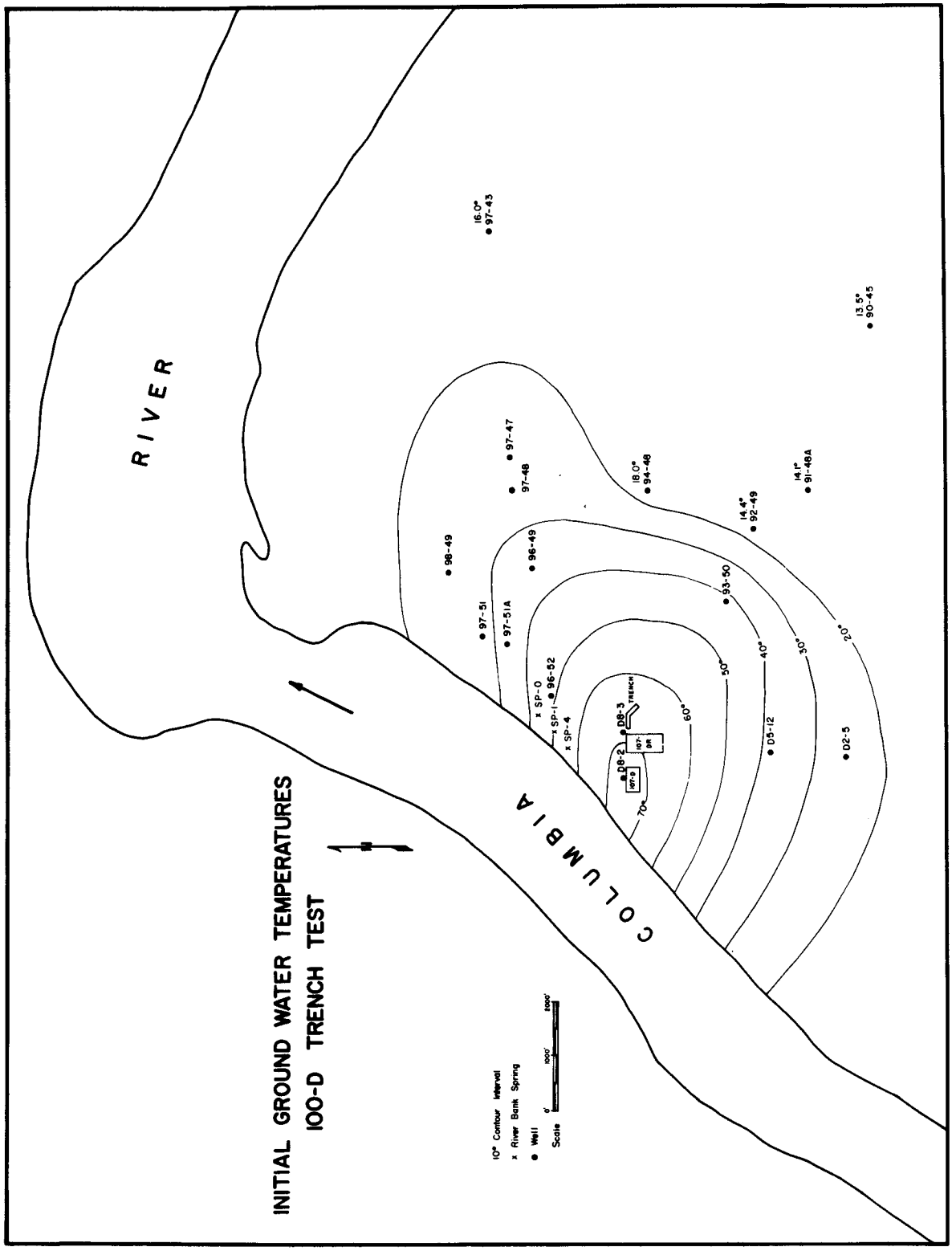

Figure 8. Initial ground water temperature 100-D trench test.

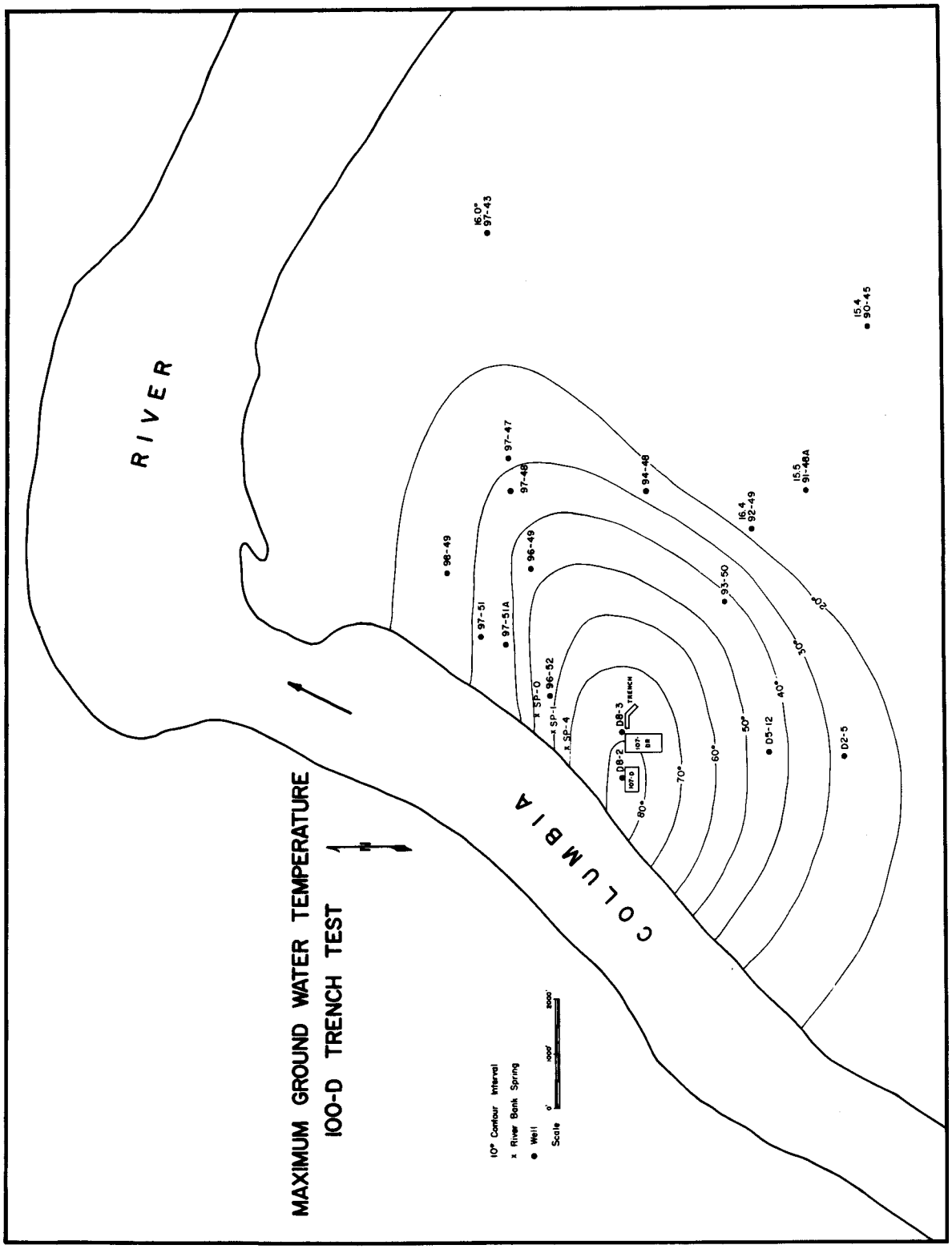

Figure 9. Maximum ground water temperature 100-D trench test.

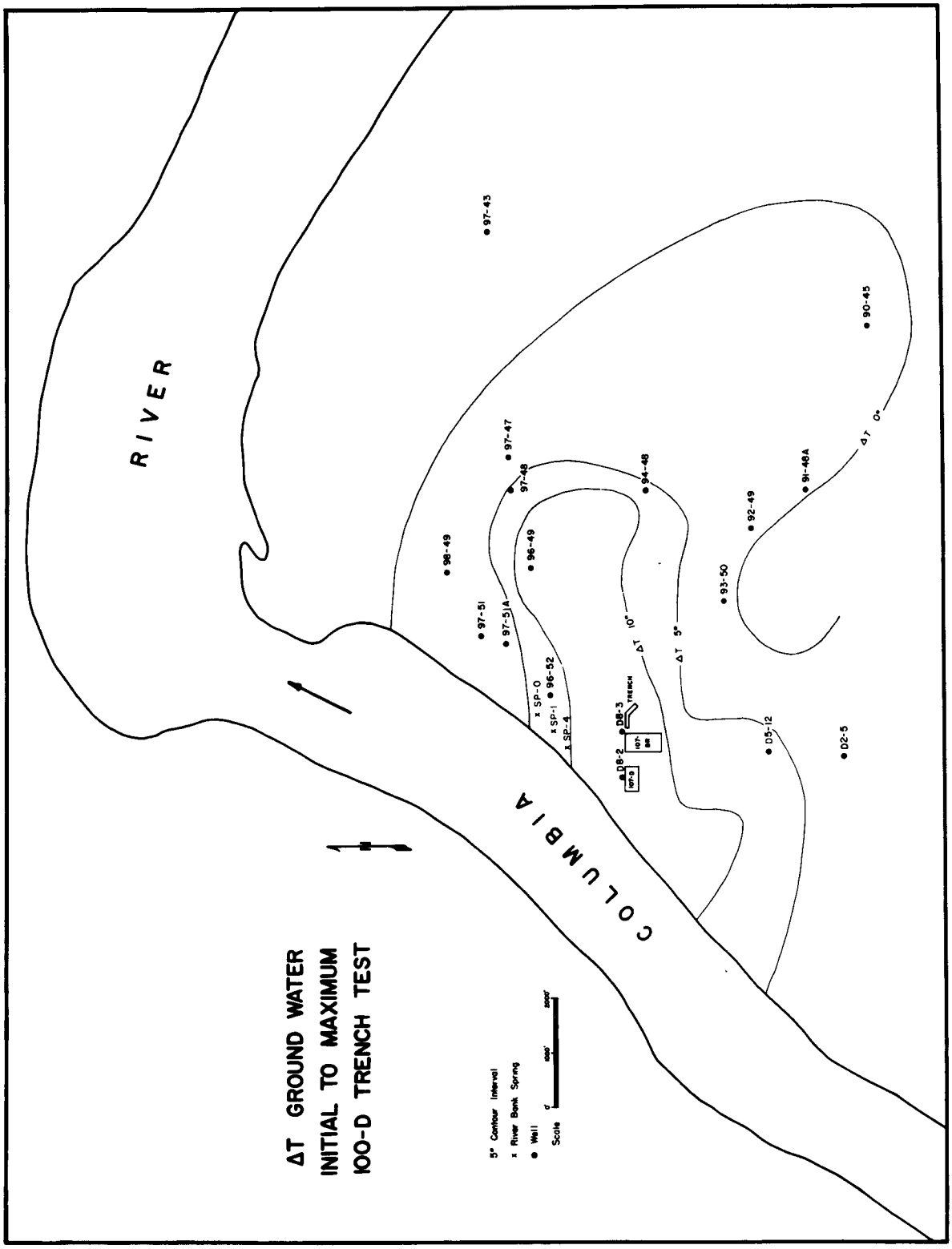

Figure 10. Change in ground water temperature initial to maximum 100-D trench test.

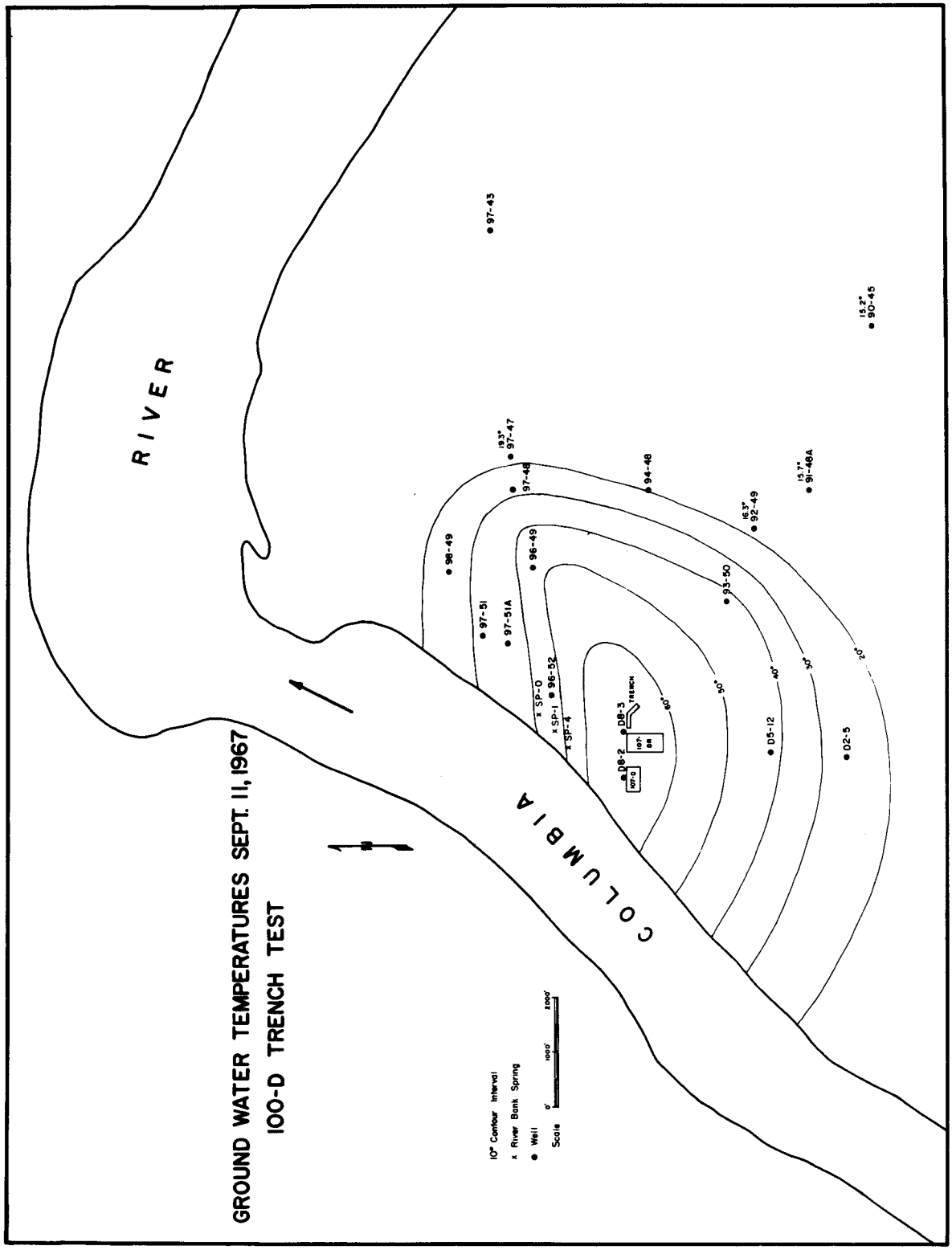

Figure 11. Ground water temperature September 11, 1967 100-D trench test.

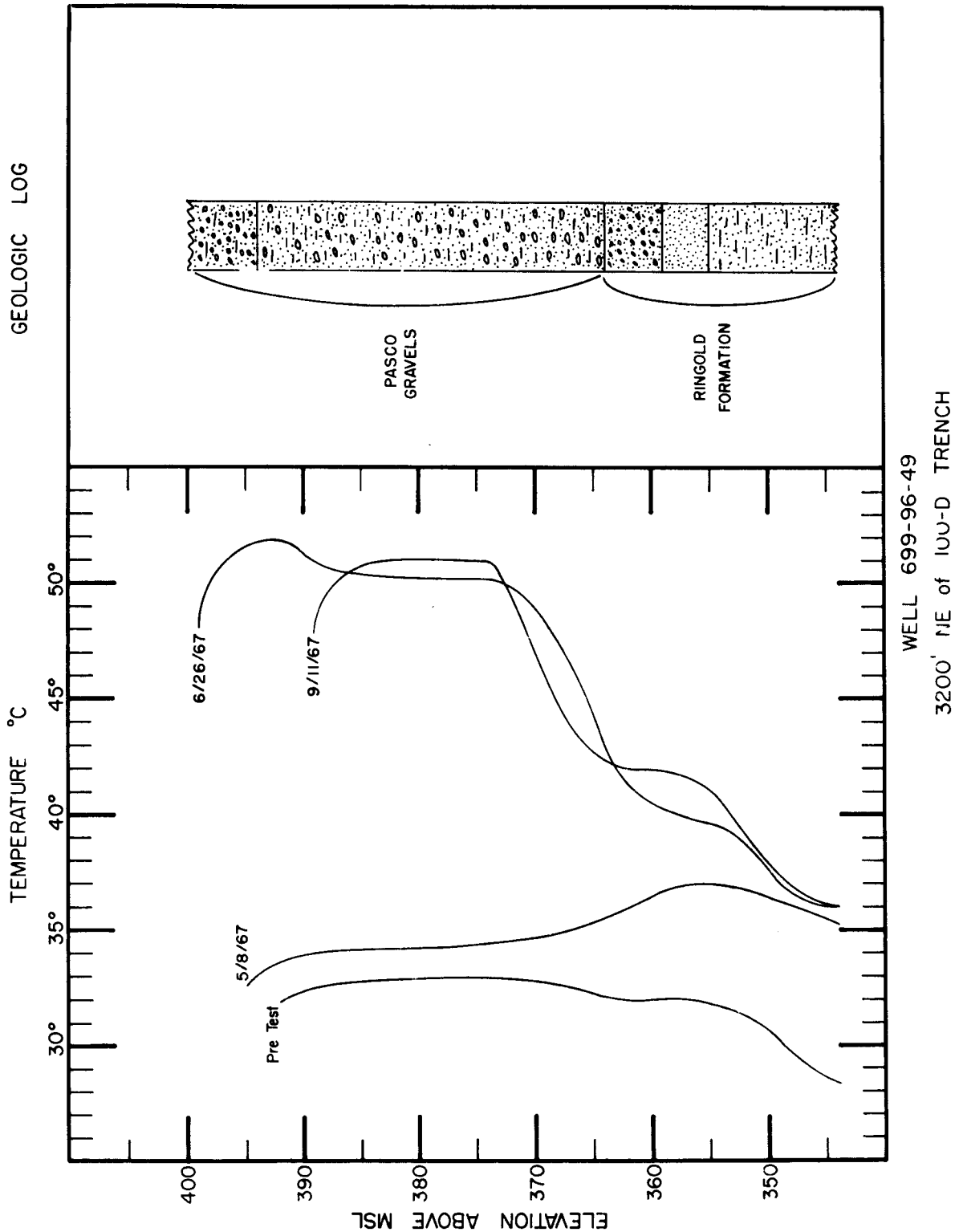

Figure 12. Ground water temperature and geologic logs of well 699-96-46, 3200' NE of 100-D trench.

REFERENCES

1. W. H. Bierschenk, Aquifer Characteristics and Ground-Water Movement at Hanford, HW-60601, June 9, 1959.

2. J. R. Eliason, Field Evaluation of Ground Disposal of Reactor Effluent - 1301-N Crib, BNWL-CC-1032, February 8, 1967.

3. B. F. Hajek, Some Adsorption, Diffusion and Dispersion Characteristics of Anions in Soils, BNWL-36 IV, January 1965.

4. Personal Communication, B. F. Hajek to R. G. Geier, April 14, 1965.

5. J. L. Nelson and G. J. Alkire, A Concept and Proposed Field Test for Decontamination of Reactor Effluent, HW-80022, December 22, 1963.

6. L. K. Wenzel, Methods for Determining Permeability of Water-Bearing Materials, Water Supply Paper 887, 1942.