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TITLE

MAPPING OF A REACTOR COOLANT EFFLUENT GROUND DISPOSAL TEST USING AN INFRARED IMAGING SYSTEM AND GROUND WATER POTENTIAL AND TEMPERATURE MEASUREMENTS

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**MAPPING OF A REACTOR COOLANT EFFLUENT GROUND DISPOSAL TEST USING AN INFRARED
IMAGING SYSTEM AND GROUND WATER POTENTIAL AND TEMPERATURE MEASUREMENTS**

SPECIAL RE-REVIEW
FINAL DETERMINATION
Declassification Confirmed
By: S. P. Sydesen
Re-Reviewed 8/37/80
Date
By: W. A. Snyder
Re-Reviewed 1/24/80
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by
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April 10, 1969

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MAPPING OF A REACTOR COOLANT EFFLUENT GROUND
DISPOSAL TEST USING AN INFRARED IMAGING SYSTEM
AND GROUND WATER POTENTIAL AND TEMPERATURE MEASUREMENTS

J. R. Eliason

INTRODUCTION

The concept of reactor effluent disposal to ground in infiltration trenches was proposed by Nelson and Alkire in 1963.⁽⁵⁾ At that time the available data indicated that radionuclide infiltration rates were probably adequate for trench disposal and that decontamination factors (DF's) of 10 to 100 should be obtainable. Field tests at 100-F Area 1965⁽⁴⁾ and 100-D Area 1967⁽³⁾ have indicated that the infiltration rates are adequate and DF's of from 2.5 for ⁵¹Cr to 7276 for ⁶⁵Zn were obtained during the 100-D test.

The purpose of this report is to present the results and interpretations of data from studies conducted over a reactor coolant effluent disposal test site. Data presented in this report were collected over the 100-C Area test in which a significant percentage of the reactor coolant effluent was disposed to an existing trench for a five-month period. Results of infrared thermal surveys and ground water temperature and potential measurements collected during this test are presented.

SUMMARY

Reactor coolant effluent from 100-C reactor was discharged into an existing trench at the average rate of 35,000 gpm from November 15, 1967 to March 20, 1968. Ground water elevations and temperatures increased in the vicinity of the disposal trench and river bank seepage volume and temperatures also increased significantly during the test. River temperature patterns below Coyote Rapids, which is approximately 1.4 miles downstream from the test site, did not appear to be influenced by the river bank seepage upstream.

An infrared imaging system which is capable of determining detailed thermal patterns over water bodies with an accuracy of $\pm 0.5^{\circ}\text{C}$ has successfully been used in this study to map river temperature patterns and river bank seepage distribution over a reactor coolant effluent disposal test site. Infrared

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surveys were conducted prior to disposal and at the completion of the test to determine the overall thermal influence of the test on the Columbia River and ground water system. These studies have shown the value of using an infrared imaging system to evaluate the thermal influence of a large scale ground disposal test on the local river and ground water systems. Temperature patterns obtained from the infrared imaging system over the test site clearly reveal the influence of the test on the river and river bank seepage patterns.

METHODS

The infrared imagery used in this study was collected by an aerial line scanning system from approximately 2000 feet altitude with the data being recorded on magnetic tape. These data were reduced to isothermal plots by techniques described by Eliason, 1967⁽¹⁾ and Eliason, Foote and Taylor, 1968.⁽²⁾ Imagery was collected over the test site prior to the test, (river flow rate 80,000 cfs), and at the completion of the test, (river flow rate 41,000 cfs). The initial imagery was collected at the 80,000 cfs river stage because an imaging system was available for a test over the area for only a short period, and lower flow rates did not occur during this test period. Imagery collected at the completion of the test at 41,000 cfs was planned to provide data on river thermal patterns at a low river stage which should reveal the maximum influence of the ground disposal test on the river.

A portion of the 100-C Area reactor coolant effluent was discharged into the 100-C crib trench at an average rate of 35,000 gallons per minute from November 15, 1967 to March 20, 1968 with a total of 6.33×10^9 gallons being discharged. Figure 1 is a bar graph of the effluent disposed throughout the test period based upon available records provided by Douglas United Nuclear. Ground water elevations and temperatures were measured in all available well structures near the test site prior to the test and at regular intervals during the test. Temperature measurements were collected in the river and at selected river bank springs at the time the infrared imaging flights were made over the test area. The data were used to correlate with the aerial imagery to obtain the quantitative evaluations presented in this report.

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RESULTS AND DISCUSSION

Intensity Modulated Infrared Imagery

Infrared imagery collected over the test site prior to and at the completion of the test has been reproduced as intensity modulated imagery with warmer objects being light and cool objects dark (Figure 2). This display of the imagery shows the obvious increase in hot spring activity both upstream and downstream from the disposal test site. The influence of the spring discharge on the river is more pronounced in the post-test imagery than in the pre-test imagery. This can be accounted for by the pronounced increases observed in river bank spring discharge volume and temperature; also the post-test imagery was collected at a 41,000 cfs river flow versus 80,000 cfs flow in the pre-test imagery. The smallest gray shade differences which can be discriminated in the imagery represent temperature differences on the order of 0.5°C . The influence of the hot springs on river temperatures on the south or reactor side of the river below Coyote Rapids cannot be detected in the pre- or post-test imagery which indicates that the influence of the test should not be detectable ($\ll 0.5^{\circ}\text{C}$) in downstream reactors, even under low river flow conditions. This is due primarily to the influence of Coyote Rapids which directs the warmer shoreline water from 100-C Area out into the center of the channel. The effect of Coyote Rapids on the river bank discharges from 100-BC Area were observed in both the pre- and post-test imagery.

Hot Spring Distribution

The distribution of river bank hot springs, that are producing water at a rate and temperature which allows them to maintain a surface temperature greater than 25°C , has been plotted from the pre- and post-test imagery, Figure 3 and 4 respectively. The 25°C temperature was selected because it was definitely above the $16\text{-}17^{\circ}\text{C}$ normal ground water temperature in this area, and in evaluating the imagery this level appeared to discriminate the primary hot spring areas. It is evident from the distributions of these springs that the disposal of reactor coolant effluent has significantly influenced

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the ground water system. Several new springs downstream and upstream from the test site have surface temperatures $>25^{\circ}\text{C}$ in the post-test imagery. The increased hot spring activity which is evident in the post-test imagery has been confirmed by field inspection to be new or increased seepage due to the test and not due to river stage difference from the pre- to post-test conditions. Hot springs along the river bank near the test site had pre-test temperatures of approximately 60°C , measured by a recording thermograph, and post-test temperatures of $>80^{\circ}\text{C}$. Temperature measurements collected on springs which were initially $>25^{\circ}\text{C}$ along the 100-C Area ranged from 42 to 60°C . Post-test temperatures of these springs ranged from 55 to 81°C .

River Surface Temperature Patterns

To evaluate the thermal influence of the test on downstream facilities it is necessary to obtain a detailed quantitative picture of the thermal patterns in the river caused by the river bank seepage. Quantitative evaluations of the imagery have been obtained from computer plots of the imagery; Figures 5 and 6 present these data. The pre-test imagery collected at a river flow rate of 80,000 cfs shows very little influence on river thermal patterns due to the shoreline discharge. Areas in which changes can be detected do not appear to be discharging quantities which cause detectable temperature changes downstream along the shoreline. The post-test imagery which was collected at a river flow rate of 41,000 cfs shows significant temperature patterns in the river due to the shoreline discharge. This influence on the river persists at detectable levels downstream to Coyote Rapids where it appears to dissipate and be directed out into the center of the river channel. The temperature patterns observed immediately downstream from Coyote Rapids in the pre- and post-test imagery indicate that no detectable influence of the test on river temperatures can be discerned beyond the rapids area.

Ground Water Level Measurements

Ground water levels were measured in all available wells near the 100-C trench before and during the test to determine the response of the aquifer to the disposal of large quantities of reactor effluent. The initial ground

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water elevations plotted in Figure 7 show that a ground water mound existed under 100-C Area prior to the test due to leakage from the retention basins and effluent lines. Prior to the test, springs developed along the river due to this leakage as indicated in the pre-test infrared imagery.

Ground water elevations measured near the time the test was terminated are plotted in Figure 8 and the initial to maximum ground water elevation differences are plotted in Figure 9. The storage volume based on the change in ground water elevations and a porosity of 30 percent is approximately 4.29×10^9 gallons. The average discharge rate during the test was approximately 5.0×10^7 gallons per day, and the total discharge was 6.33×10^9 gallons. This indicates that during the test a maximum of 68 percent of the volume discharged could be accounted for in the ground water mound which developed.

Ground Water Temperature Measurements

Ground water temperatures were measured in all available wells near the 100-C trench before and during the test to determine changes in the temperature patterns due to the test. Pre-test temperature patterns plotted in Figure 10 show the influence of leakage of reactor effluent from retention basins and effluent lines. Ground water temperatures measured near the time the test was terminated are plotted in Figure 11. These show a significant increase in temperature due to the test. Figure 12 is a plot of temperature change (ΔT) from the initial to the final temperature patterns observed. This plot indicates that changes in ground water temperature due to the test were observed as far as 2.5 miles from the test site. A discrepancy in the ΔT pattern within the 100-C Area was observed where a negative ΔT of 10°C exists. This is probably due to a repair of a leaky effluent line or the shutdown of B Reactor.

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FIGURE 1. Reactor effluent disposed to ground during test period.

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Post-Test 41,000 cfs

Pre-Test 80,000 cfs

FIGURE 2. Infrared Imagery of the C Trench Area

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DISTRIBUTION OF SPRINGS $>25^{\circ}\text{C}$
80,000 cfs RIVER FLOW
PRE-TEST

FIGURE 3. Pre-test distribution of hot springs 25°C .

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FIGURE 4. Post-test distribution of hot springs 25°C .

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FIGURE 5. Pre-test Columbia River surface temperature patterns 80,000 cfs.

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FIGURE 6. Post-test Columbia River surface temperature patterns 41,000 cfs.

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FIGURE 7. Pre-test ground water contours.

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POST TEST
GROUND WATER CONTOURS
100-C TRENCH TEST

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FIGURE 9. Change in ground water elevations initial to maximum.

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FIGURE 10. Pre-test ground water temperatures.

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FIGURE 12. ΔT ground water initial to maximum.

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