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SUBJECT: Investigation of Radioactivity Releases to White Oak Creek

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FROM: J. F. Manneschmidt

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INTRODUCTION

One of the responsibilities of the Laboratory Facilities Department is to safely dispose of the radioactive liquid waste generated by the Laboratory and, in so doing, to account for any quantities of activity which may be discharged to the nearby creeks and streams. Bethel and Melton Valleys are naturally drained by White Oak Creek and several subsidiary branches which eventually flow into the Clinch River below White Oak Dam, and radioactive substances released to these bodies of water leave the AEC controlled area and enter the public domain. It is important, therefore, that the amounts of radioactivity involved be accurately measured for purposes of control.

The only radioactive discharge routinely and knowingly made to White Oak Creek is from the Settling Basin and consists of the effluent from the Process Waste Treatment Plant. The flow rate of this discharge is continuously monitored and a proportional sample is taken. Approximately 1 1/2 miles downstream at the point where White Oak Creek enters the lake bed a second monitor and sampling station is located. Samples from these two stations are composited monthly, and results of the analyses are used to compute the total quantity of radioactivity transported by the creek during the period. The station at the lake bed not only samples, for the second time, the settling basin discharge but also monitors any release from nearby burial ground seeps, storm sewers, and other influents which, though normally uncontaminated, could accidentally release activity to the environment.

These two monitoring stations have been in operation since early 1961, and examination of the data acquired in the subsequent 3 1/2 years indicates that the amount of strontium activity measured at the lake bed station has exceeded the amount released at the settling basin nearly every month. (Strontium is of particular interest since it is the controlling activity in determining the MPC_w in the Clinch River.) Based on the quantity of activity measured at the lake bed, an average discrepancy of 45% has been experienced over the 42-month period.

Other investigators noting a similar unidentified influx of activity into the stream have suggested that scouring of the stream bed causes long-deposited radioactive materials to be leached out or transported as solid material to the lake bed and that this scouring process seems to cause a greater movement of activity during periods of heavy rainfall and when there are greater quantities of sediment in the water. Figure 1 is a plot of monthly rainfall versus the difference in activities measured at the two monitoring points and illustrates the effect of heavy rainfall on the movement of activity during the years 1961, 1962, 1963, and the first half of 1964. Examination of the plot does not indicate that the effect of rainfall is clear-cut. Some months having heavier rainfall did experience greater activity transport; however, the reverse is true in other months. This data is averaged and presented in Table 1. One sees here that although the average monthly rainfall during 1961 and 1962 was the same the average difference in transported activity varied greatly. The object, then, of the sampling program described in this report was to determine if a discrete source or sources of activity did exist which might be contributing strontium activity to White Oak Creek in a more or less continuous fashion. If such a source could be located, steps could be

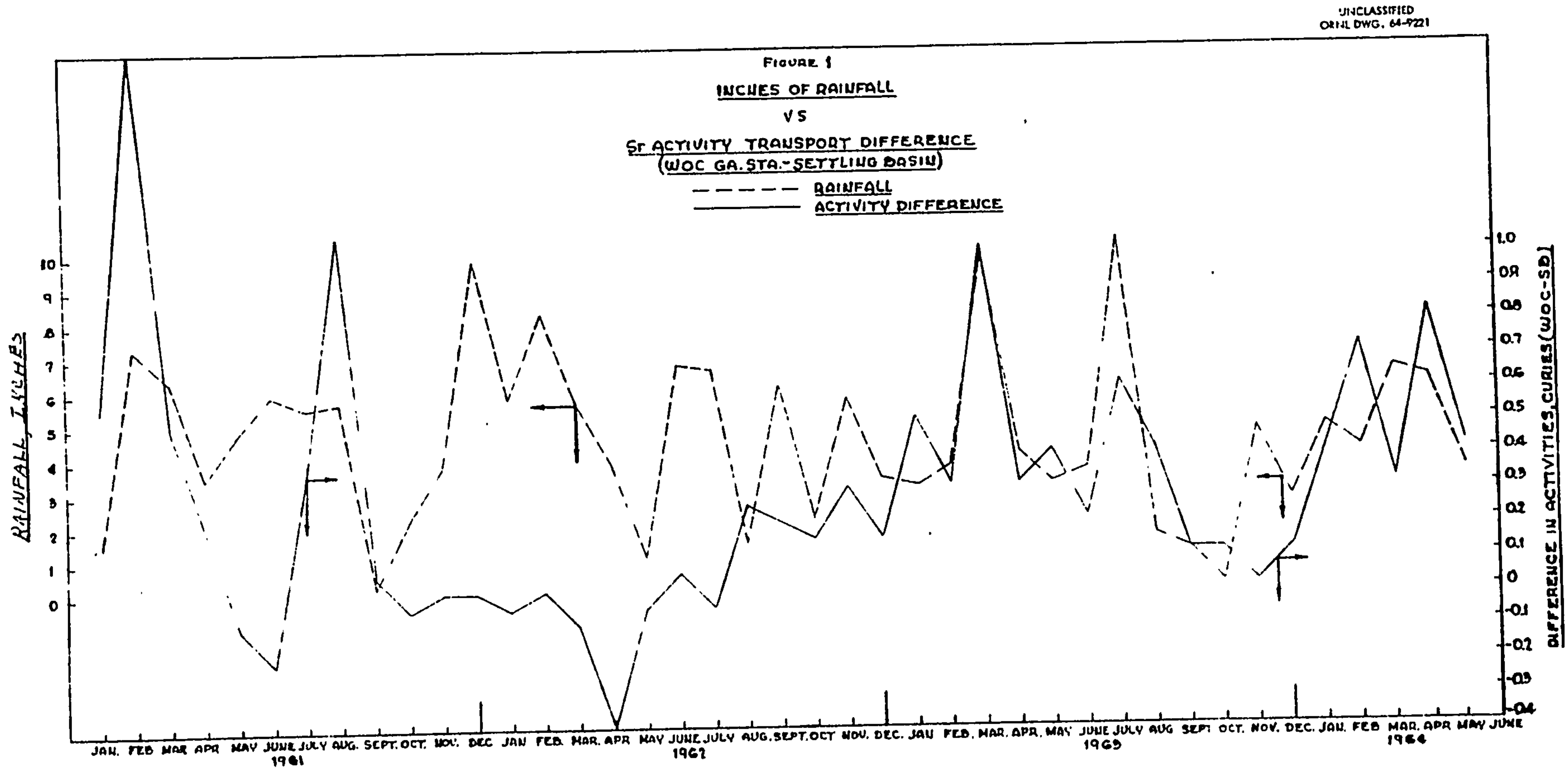

FIGURE 1
INCHES OF RAINFALL
VS
Sr ACTIVITY TRANSPORT DIFFERENCE
(WOC GA. STA.-SETTLING BASIN)

taken to correct the condition and thereby reduce considerably the Laboratory's release of this nuclide to the environment.

TABLE 1

RAINFALL AND ACTIVITY DIFFERENCES IN WHITE OAK CREEK

Year	Average Monthly Rainfall (Inches)	Average Strontium Transport Difference (Curies)
1961	4.69	0.8
1962	4.67	0.1
1963	3.85	0.3
1964 (Jan.-June)	4.25	0.5

SAMPLING

In the past unidentified pickup in activity, as much as 0.5 curies/month, has been attributed to miscellaneous drainage from burial grounds which lie along the course of the stream; from contaminated storm sewers discharging into the creek; and from various other sources such as the sewage treatment plant, laundry, and abandoned, but contaminated, leaking process lines lying near the stream. Much "spot" sampling has been carried out in an effort to pinpoint the source of the activity but without success.

A more intensive sampling program was initiated wherein White Oak Creek was sampled on a daily basis at six points located as shown in Figure 2 (Stations 1-6). During the first sampling period (May) the locations were more or less equally spaced between the point where the settling basin discharges into the stream and the USGS gaging station immediately above the confluence of Melton Branch and White Oak Creek in Melton Valley. Areas of interest near these samplers included Burial Ground No. 4 and the abandoned ILW Disposal Trench No. 6. Station No. 3 was not located in White Oak Creek but slightly upstream in North Fork, a tributary joining White Oak Creek near the 1000 Area. Samplers were not located east of the inlet from the settling basin since monitoring and sampling have indicated only negligible activity levels in that area.

In June the samplers were relocated at positions nearer the Laboratory in Bethel Valley. These changes were made after examination of the earlier data, as noted below. Sampling was discontinued at

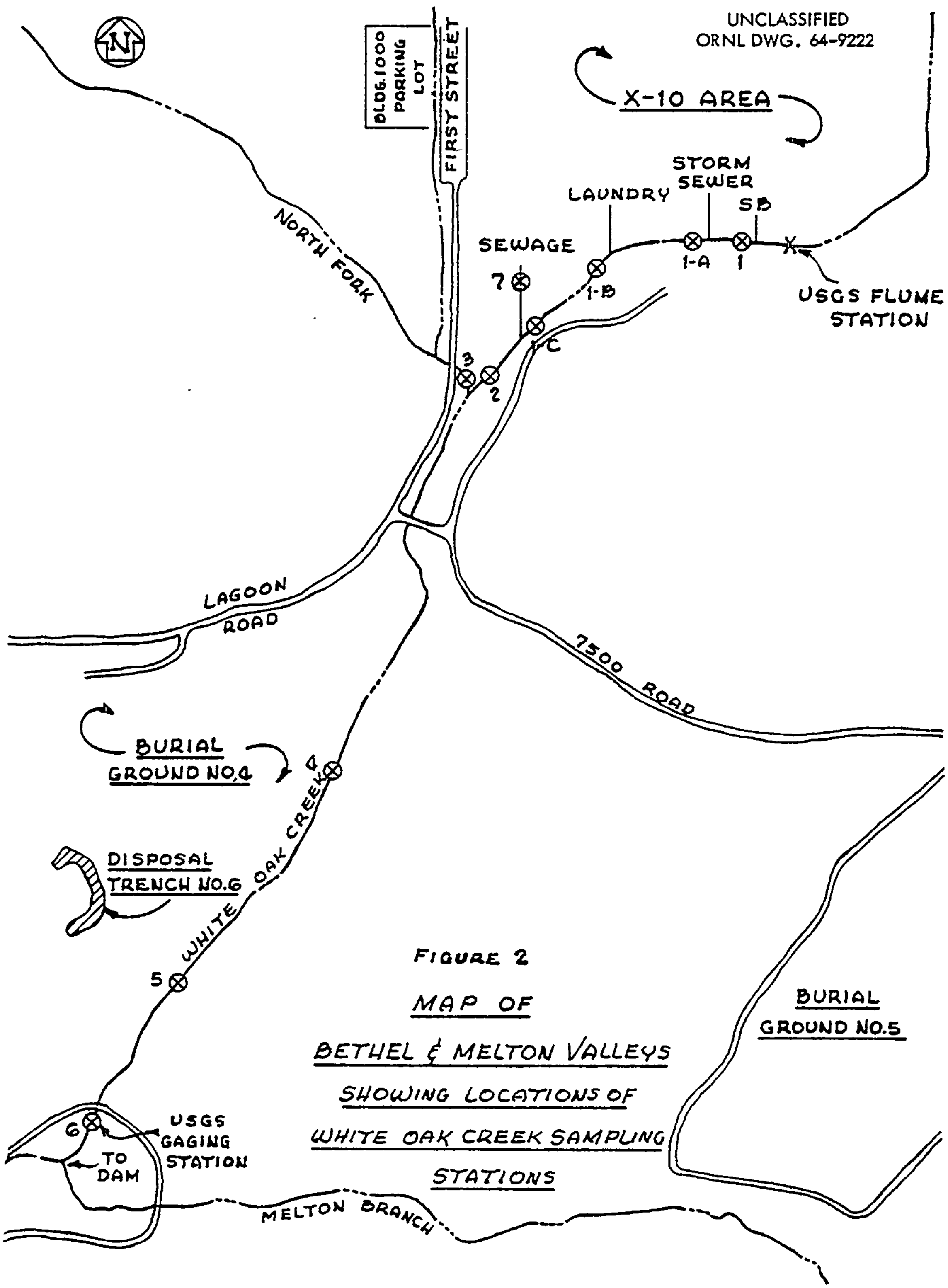

FIGURE 2

MAP OF BETHEL & MELTON VALLEYS SHOWING LOCATIONS OF WHITE OAK CREEK SAMPLING STATIONS

Stations 3, 5, and 6. Sampling was begun at Stations 1-A (near a storm sewer discharge draining the South Tank Farm area down Third Street); 1-B (downstream of the Decontamination Laundry influent); and 1-C (upstream of the Sewage Treatment Plant influent). Sampling was continued at Stations 1, 2 and 4. A seventh sampler (Station 7) was placed in the discharge sump at the Sewage Treatment Plant.

The sampler employed was a modification of a continuous-leak sampler developed at Paducah[1] and is shown in Figure 3. A 2-liter aspirator bottle with a bottom opening was weighted with about an inch of fine lead shot in epoxy resin. A length of copper tubing extended through the epoxy to a side opening at the bottom of the bottle to which was attached, by a short piece of rubber tubing, a section of perforated tubing which served as a strainer. A length of 6-mil nickel capillary tubing, potted in a piece of 3/8-in. tubing for protection, was connected with rubber tubing to a stopper in the top of the bottle. In operation the bottle was submerged in the stream and the capillary tube was fastened to a stake on the bank. Water flowed into the bottle through the strainer tube at a rate controlled by the venting of air through the capillary.

In several cases the surface of the water being sampled was only 4 or 5 inches above the strainer tube (which was taped to the side of the bottle); in other locations, or when the stream flow was greater, the level of water was perhaps 6 or 8 inches above the top of the bottle.

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[1]K. K. Mitchell and R. C. Baker, Continuous Leak Water Sampler, KY-423 (November 30, 1962)

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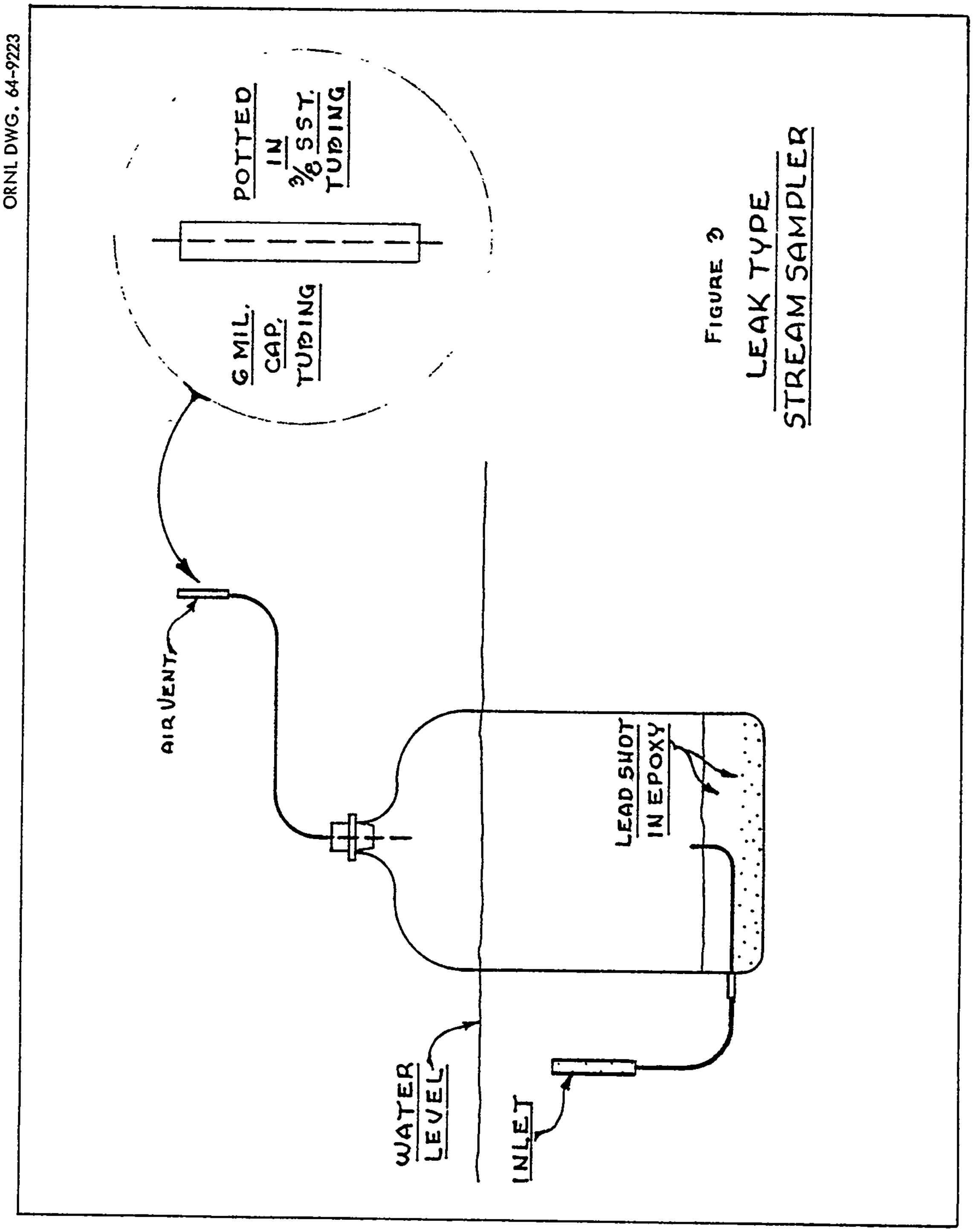

FIGURE 3
LEAK TYPE STREAM SAMPLER

The capillary length required to permit filling of the bottle once each day was calculated initially, assuming an average water depth; however, the lengths of the capillaries on the individual samplers were adjusted until a daily sample rate of from about 800 ml to 1200 ml was obtained. The bottles were emptied each afternoon, Monday through Friday, and the contents, up to 1000 ml, were submitted to the Analytical Chemistry Division for total strontium analysis.

RESULTS

Analytical data were treated in two manners. First, a plot was made which shows the change in activity (strontium) concentration along the course of White Oak Creek. This may be seen in Figure 4. These curves resulted from plots of data obtained from 87 samples taken over a period of 16 sample days during the first sampling period. The upper and lower curves are the maximum and minimum activities detected; the center line is the average. Data from the North Fork samples is represented by the small envelope below the White Oak Creek curves. The upward slope of the curves indicates that there is an increase in total strontium transport as one moves downstream. This would be indicated by any curve having a zero or positive slope. If there were no influx of activity the increase in flow would cause the downstream concentrations to decrease.

A second plot was made to better show the increase in transport. This is shown in Figure 5. The flow line was made by connecting with a straight line known flows at either end of the stream. Points along the abscissa of these plots were laid out in the same ratio that exists

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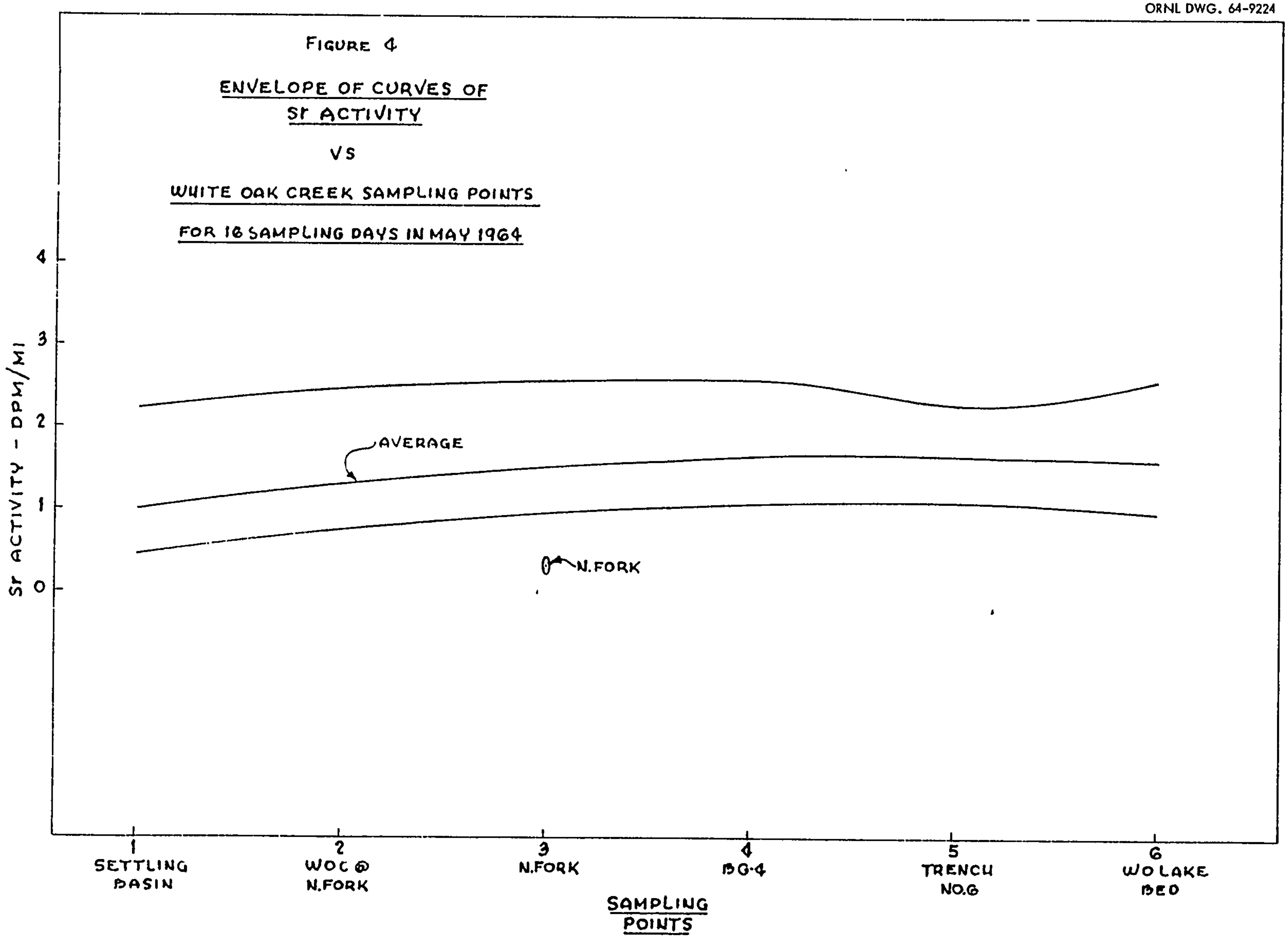

FIGURE 4

ENVELOPE OF CURVES OF Sr ACTIVITY VS WHITE OAK CREEK SAMPLING POINTS FOR 16 SAMPLING DAYS IN MAY 1964

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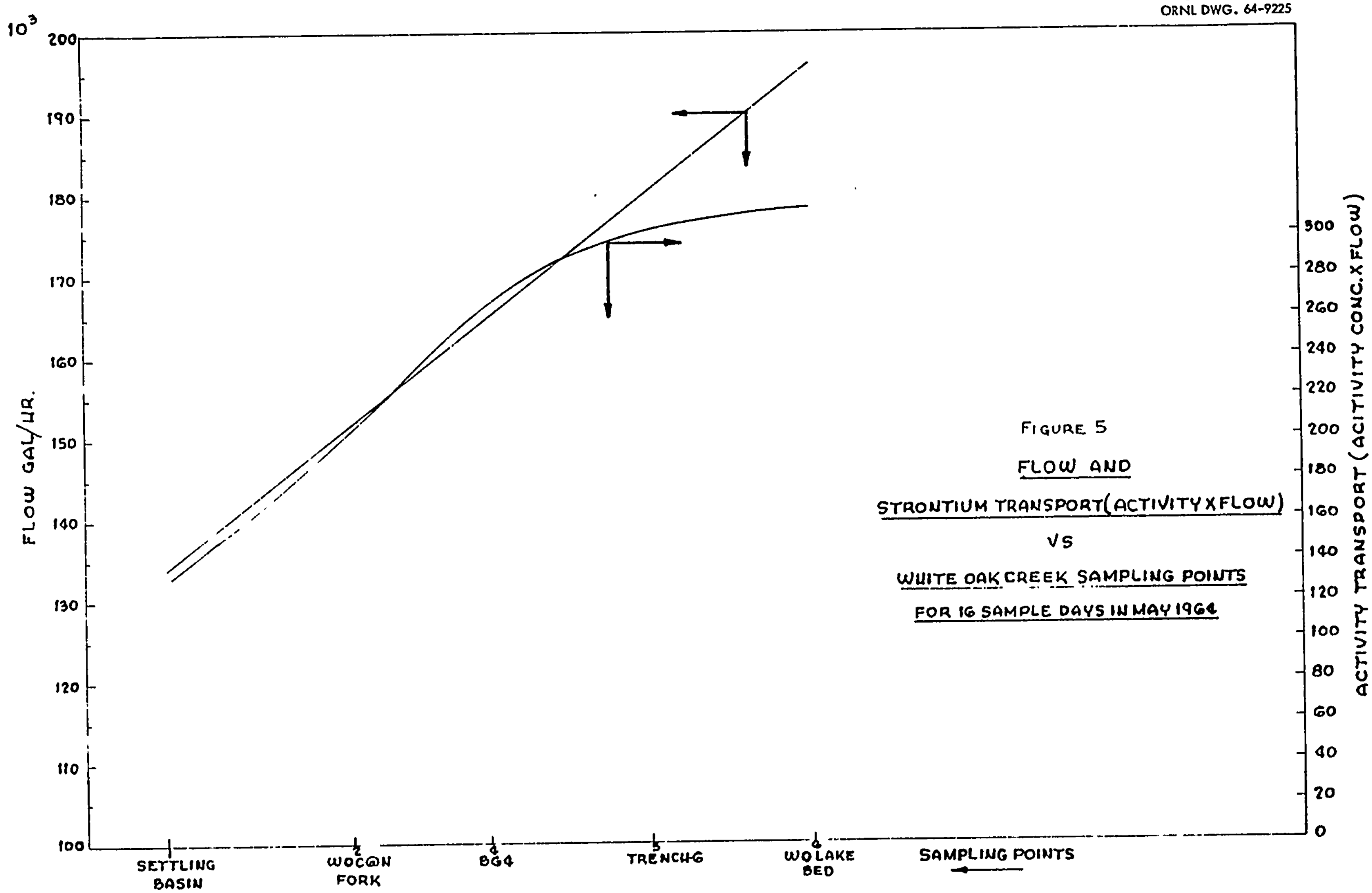

FIGURE 5

FLOW AND

STRONTIUM TRANSPORT (ACTIVITY X FLOW)

VS

WHITE OAK CREEK SAMPLING POINTS

FOR 16 SAMPLE DAYS IN MAY 1964

between the actual distances involved. In reality the flow probably did not increase in straight-line fashion; however, more accurate data is not available. From this plot the flows at each sample point are gotten. The product of this flow value and the average strontium concentration is a number which is indicative of the total transport of strontium activity past the point. If these numbers are plotted for each of the six locations, the curved line results. From the shape of this curve it appears that the greatest pickup of activity by the stream occurs between the settling basin and Burial Ground No. 4. There is, however, no discrete source indicated but rather a steady increase in transport.

On the basis of these findings it was decided to relocate the samplers in the upstream area, as described above, placing them near incoming streams which could be identified. Sampling was carried out at these locations for 24 days in the month of June. The data were treated in the same manner as the earlier results and the first plot of concentrations is seen in Figure 6. The peculiar dip in the curve with its low point at about station 1B cannot now be explained. Plotted to the right of these curves is the envelope of data from the sewage effluent samples. The average activity level experienced here is five times greater than that measured in White Oak Creek at the Station No. 2; however, the total quantity of strontium contributed by this stream to the creek is so small as to be insignificant because of the low flow rate.

Figure 7 shows the flow and transport curves for this set of data. The plot of flows was handled somewhat differently here because of the

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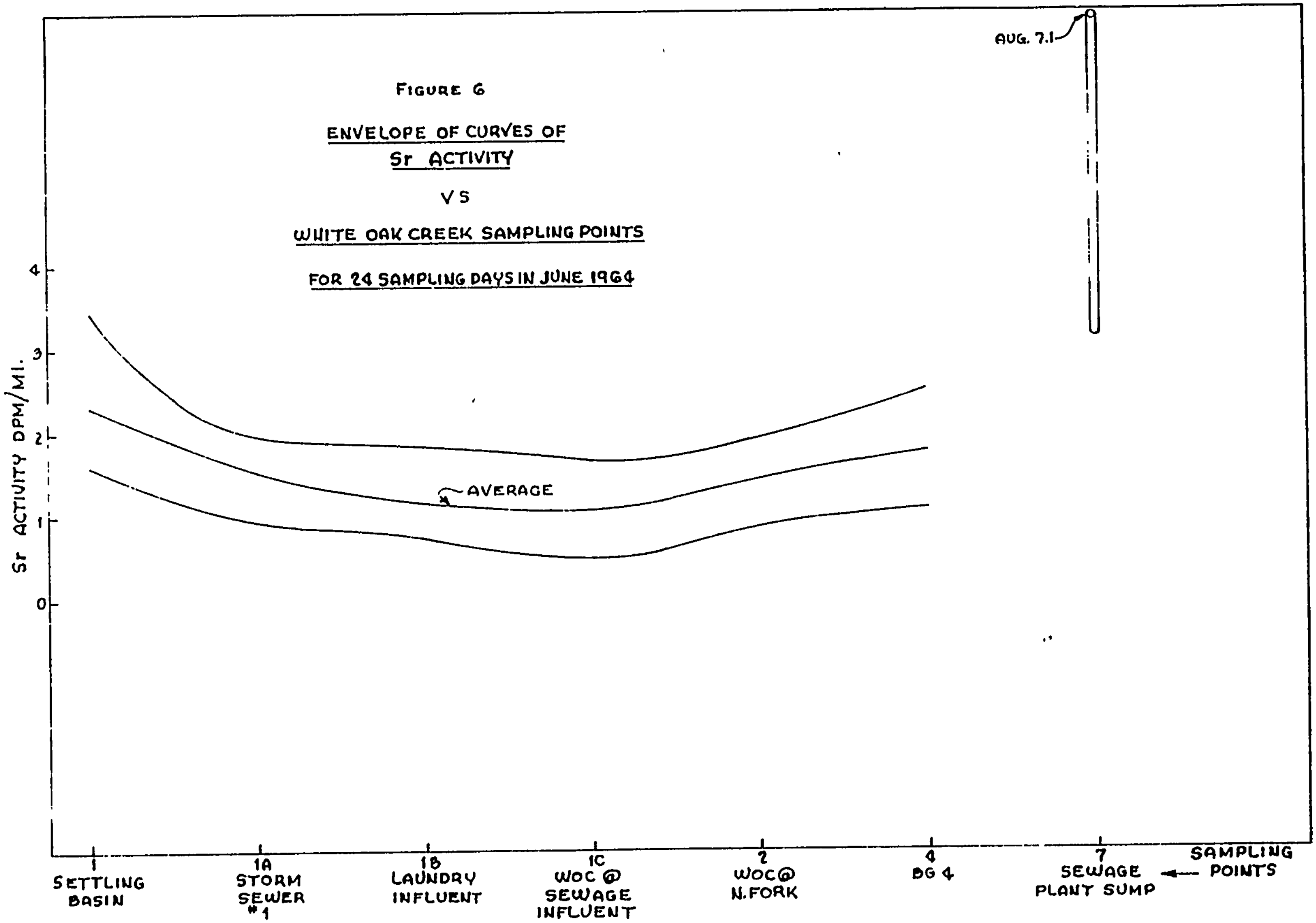

FIGURE 6

ENVELOPE OF CURVES OF Sr ACTIVITY VS WHITE OAK CREEK SAMPLING POINTS FOR 24 SAMPLING DAYS IN JUNE 1964

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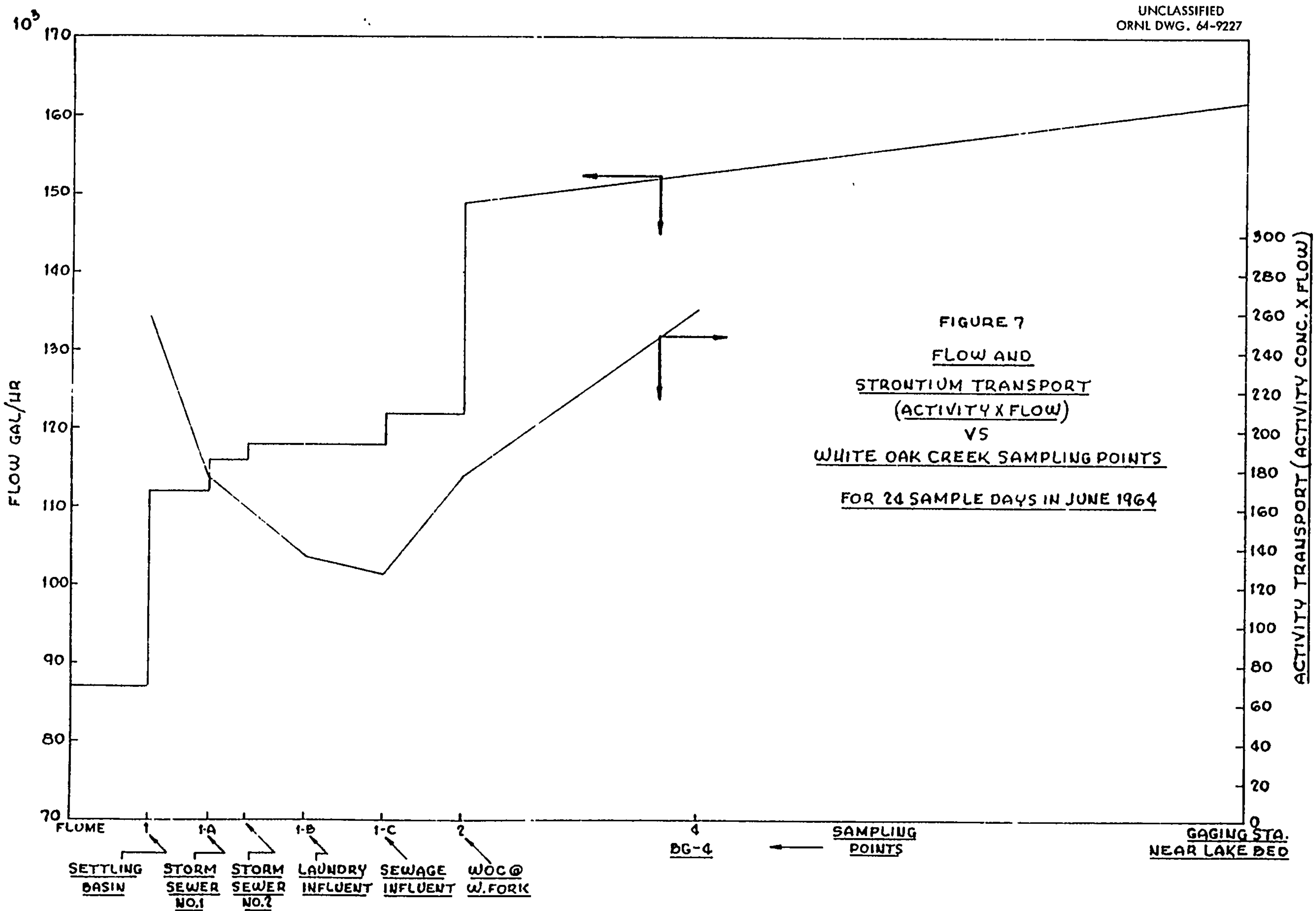

FIGURE 7
FLOW AND
STRONTIUM TRANSPORT
(ACTIVITY X FLOW)
VS
WHITE OAK CREEK SAMPLING POINTS
FOR 24 SAMPLE DAYS IN JUNE 1964

generally dry weather experienced in June. The lack of rain resulted in little run-off or seepage into White Oak Creek from swampy areas which normally drain into the creek in this manner. It appeared, therefore, that the creek flow was increasing more nearly stepwise, at least to the North Fork junction. The stream was explored rather carefully down to this point and naturally occurring seeps or drainage were not to be found. The plot then was constructed by adding to the average flow measured at the USGS flume station the individual discharges into the stream until the North Fork junction had been reached and then assuming a straight line increase beyond that point. As in the previous flow curve the sampling stations are located on the abscissa in direct ratio to the distances involved; however, in this plot this is not important except with respect to where the Burial Ground No. 4 station is placed. The resultant plot of the product (concentration X flow) versus sample station gives a curve which, once again, defies reasonable explanation. It indicates that the average total transport of strontium past the laundry or sewage influent streams for a given day was less than the amount approaching or leaving those points. Obviously, this is an impossible conclusion which only points out the need for more intensive study.

CONCLUSIONS

On the basis of the results obtained, as interpreted above, it appears that more accurate data is needed which must be gathered over a longer period of time. Also, there is a strong need for better sampling equipment and more abundant flow data. Sampling stations with permanently established flow measuring devices and proportional samplers would certainly give more meaningful information if operated over a substantial period of time. Costs of such a program are not insignificant. A permanent monitoring station costs from $6,000 to $8,000. Analytical costs, based on individual determination at $10 each, would be about $1,500 per month for a five-station system sampled daily. Even if such a program were carried out using the best equipment and techniques there is no positive assurance that the findings would indicate a situation which could be corrected. As noted earlier, previous studies have indicated that the errant activity finding its way into White Oak Creek comes, not from point sources which can be dammed, dug up, or diverted, but rather from the creek bed itself which has become contaminated over the years and is slowly releasing that contamination. Continuation of these studies should be contingent on careful consideration of these factors.