

CHAPTER 51

PROCESSING AND ANALYSIS OF RADIOISOTOPIC SAND TRACER (RIST) STUDY DATA*

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ABSTRACT

Data collected during the Radioisotopic Sand Tracer (RIST) field tests are processed through digital computers. Data treatment requires computing and plotting the detector position and correcting the corresponding radiation count rates for radioactive decay. The field data are recorded on punched paper tape which is then edited and transferred to magnetic tape for input to data reduction programs. The navigation data, which are in the form of distances to shore-based microwave responder beacons, are tested for spurious values by comparison with the theoretical maximum travel distances of the survey vehicle between successive fixes. The navigation ranges are then converted to rectangular geographical coordinates.

Present emphasis is in the development of computer programs to construct a count rate surface from data collected along track lines. This technique facilitates machine contouring and enables numerical integration of the count rate surface. The ultimate goal is to obtain an estimate of mean direction and volume of littoral transport and a radiation material balance to be used to check the results. Several programs required to accomplish these tasks are operating at the Coastal Engineering Research Center (CERC) and the Oak Ridge National Laboratory (ORNL).

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Data processing for the Radioisotopic Sand Tracer (RIST) Study is computer oriented to handle the large volume of collected data which are digital in form and represent parameters that must be correlated to obtain sand transport rates. Figure 1 enumerates the objectives of the computer programs.

Fig 1 Objectives of Computer Programs

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- 1 Assembling the data in graphical form
 - 2 Interpolation to establish the count rate surface within the survey area
 - 3 Computation of the surface rate and direction of the sand movement
 - 4 Correlation of other data with survey data to calculate volume rate of sand transport
 - 5 Correlation of the volume rate of sand transport with ocean conditions for fundamental studies in sand transport
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To accomplish the first objective of assembling the data in geographical form, two programs are operational one at the Coastal Engineering Research Center and the other at the Oak Ridge National Laboratory. The data collection system¹ shown in Fig 2 illustrates the automatic correlation of three parameters necessary in assembling the data in graphical form.

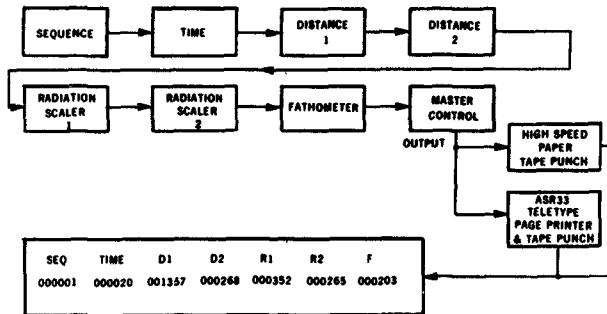


Fig 2 Data Collection System

¹An Underwater Survey System for Radionuclide-Tagged Sediment Tracing
E H Acree, F N Case, and H R Brashear

The data are collected on punched paper tape in a serial fashion to form a line of data. Each line of data consists of numbers which represent time, tow vehicle position, radiation count rate, and water depth. Time and radiation units have buffers so the data can be recorded while new data are being taken. These buffers permit data to be taken at 2-sec intervals with no instrument dead time due to readout. Tow vehicle position is represented by D1 and D2, the distances between the tow vehicle and two fixed shore stations. The distances are measured at the same time that the time and radiation values are transferred to the buffers for readout. Water depth measurements are near the first part of each data cycle, but are not as precisely timed.

One survey may have up to 2000 lines of data, which is approximately the capacity of one roll of paper tape. A normal survey consists of 1700 lines of data. An average of four surveys are made each day, producing 47,600 six-digit numbers, an average field test yields a total of 380,800 six-digit numbers.

Data stored on punched paper tape are copied onto magnetic tape for computer input. The tow vehicle positions are calculated from D1 and D2, using either the law of cosines or the intersection of two circles, depending upon which coordinate system is desired. The law of cosines is used to place the tow vehicle on a geographical grid, and the intersection of two circles is used for placement on an arbitrary x-y coordinate grid. The validity of each location is checked by comparison with the previous location. If the separation distance between the two locations is greater than the theoretical distance possible, the location is changed. This change is based on the average velocity and direction of the tow vehicle.

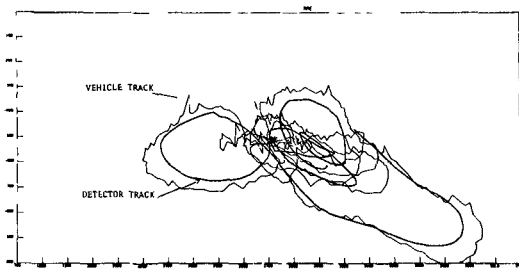


Fig 3 Plot of Tow Vehicle and Detector Path

Figure 3 is a computer-directed machine plot of a tow vehicle path and detector vehicle path with no corrections for the tow vehicle locations. The irregularities are due to errors from the range-finding equipment in measuring the distances.

from the tow vehicle to each shore station. The location of the detector vehicle, which is towed approximately 100 ft behind the tow vessel, must be calculated by performing a series of approximations. These approximations are quite accurate due to the frequency of obtaining tow vehicle position. The initial detector vehicle position is determined on an arbitrary basis. The second position is determined by computing the equation of the line which connects the first detector vehicle position with the second tow vehicle position. The actual length of the tow cable, minus any correction due to water depth, is used as the distance from the tow vehicle (along the computed line) to the second detector vehicle position. Subsequent detector vehicle positions are determined in a similar manner. As each detector vehicle position is calculated, the corresponding time and radiation count rates are assigned to that position. In Fig. 3, the paths of both vehicles are drawn by straight lines connecting successive calculated positions.

Radiation data are scanned to obtain an average radiation background count rate (due to natural radioactive material). All radiation count rates are adjusted by subtracting the average background, and the adjusted count rates which are equal to or greater than the background are corrected for radioactive decay by the following formula:

$$R_{CD} = \frac{R}{E^{-\lambda t}}$$

where R_{CD} = radiation counts corrected for decay (counts/sec)

R = radiation counts $\geq 2 \times$ average background (counts/sec)

E = base of natural logarithm

λ = decay constant of isotope used in test

t = time from tagged sand insertion (unit)

Figure 4 is a machine plot of numbers which represent ranges of corrected count rates calculated from data obtained at Point Mugu, California, in September, 1969.

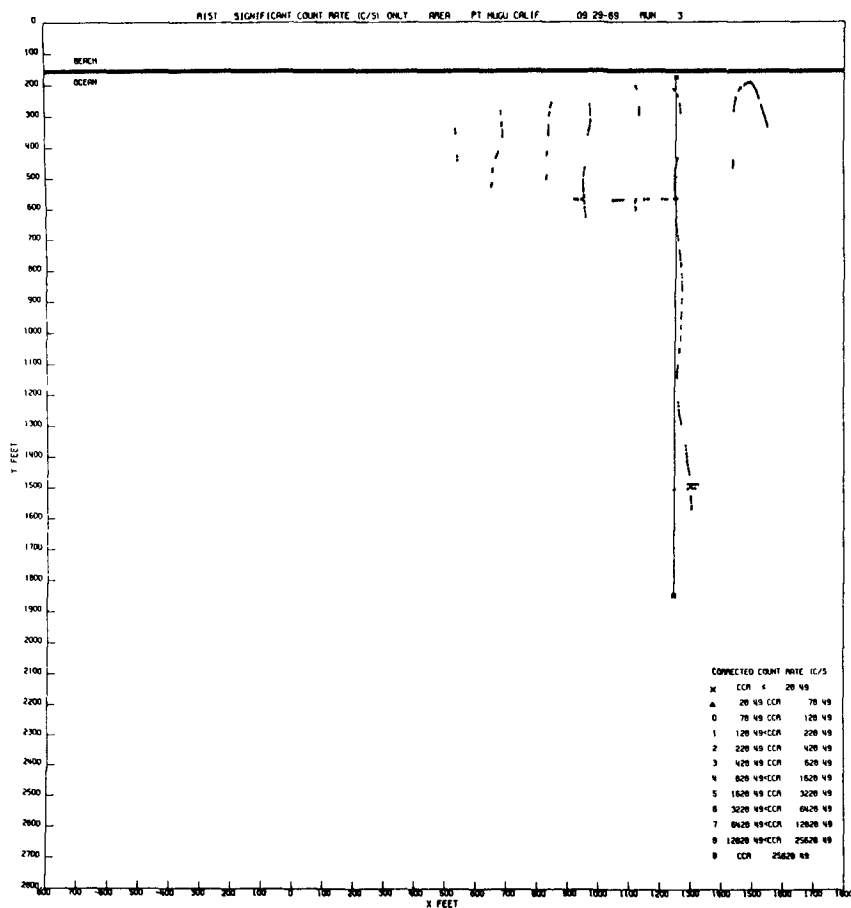


Fig 4 Calculated Radiation Count Rate Ranges Over Detector Track

Figure 5 is an enlargement of Fig 4 in the area of significant radiation count rates. All background count rates have been omitted to make the trend of sand movement more apparent. The computer programs allow more than one survey to be plotted on a single map to enhance the distribution pattern as it develops.

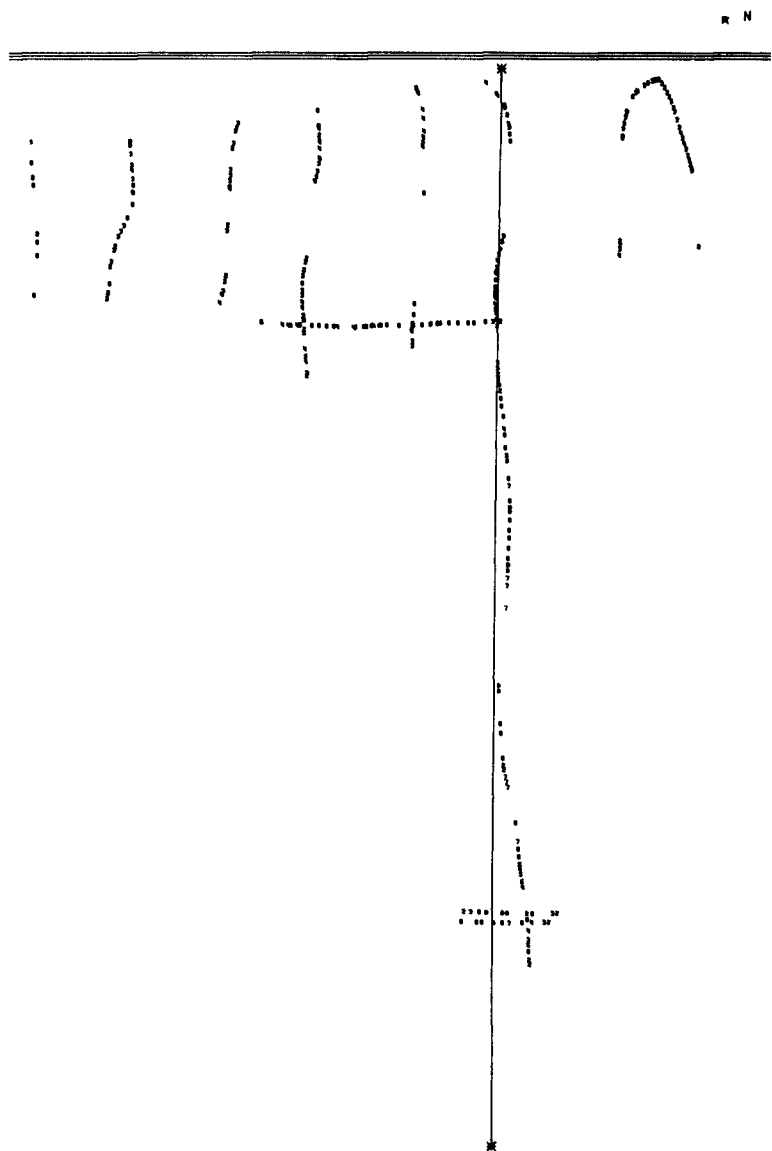


Fig 5 Section of Fig 4, Area of Significant Count Rates

The second objective, interpolation of data, is required because it is physically impossible to sample every square foot of the study area. Several programs are either operational or near operational to complete the count rate surface and machine draw radiation intensity contours. One of the programs is a linear interpolation technique. This program divides the x-y coordinate system into a grid adjacent to the x and y axes having square areas of 25 ft on a side. In general the x-axis lies parallel with the beach. In the studies to date the predominate directions of sand movement have been parallel or perpendicular to the beach. The interpolation is done in either or both directions depending on the preliminary indication of sand movement direction.

The second step in this program is to assign all square areas which have radiation count rates within an area a single count rate, which is the average of all radiation count rates within that area. Figure 6 is the result of the second step of the program. The results here are much like the data display of radiation count rates along the detector vehicle track of the first program, but somewhat simpler due to a grouping of numbers.

The third step computes radiation count rates for those areas with no count rates assigned. Interpolation is made only between areas which have real data. The interpolation is linear, and the average radiation count rate of two areas is assigned to the area halfway between the two areas. The formula used is

$$R_{1+K,J} = R_{1,u} - \frac{(R_{1,J} - R_{1+L,J})}{L} (L - K)$$

where R = radiation value of the area

1 = x location of area of larger R data

j = y location of area

K = x location of area for R interpolation

L = x location of area of smaller R data

If interpolation is desired in both the x and y direction, the interpolation is done independently in each direction and the average of the two is used as the final value.

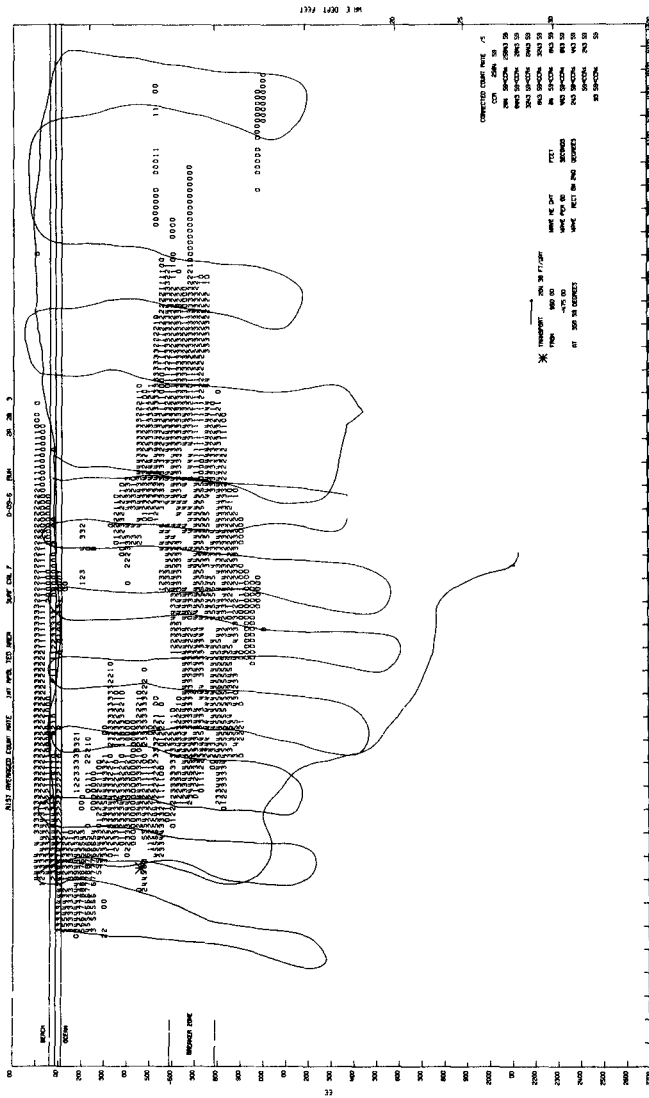


Figure 7 is the completed map using the linear interpolation method. All background radiation count rates have been omitted for clarity.

Beyond the initial plotting of trackline data, present emphasis at CERC is slightly different from that at ORNL. The procedure being tested at CERC for RIST survey data is to use a weighted least-squares fit of a plane through the centroid of each grid cell containing a data point. The area surrounding each grid mesh point is divided into octants, and each octant is searched for the nearest data point to the grid centroid. Once the search is completed, the nearest point in each octant is used to construct a weighted least-square fit of a plane through the centroid. Each data point is assigned a weight which is an inverse function of the distance from the data point to the grid centroid.

This procedure has been tested by generating a random surface with a double Fourier series and evaluating it at 100 randomly distributed points in a plane. When interpolated over a uniform grid, these points produced a surface that appeared similar to the original surface, but with reduced variance. The numerical approximation routine has not been tested yet with a hypothetical trackline superimposed on the random surface. It has already been observed that, in certain instances with real data, the routine produces grid point values that are artifacts of the numerical approximation procedure. Although the result is not as aesthetically appealing as a handdrawn contour map of the data, it does provide a quick first approximation of the survey area. Testing and evaluation of the two approaches is being made at CERC and ORNL, but at present is incomplete.

Correlation of data for fundamental studies and volume-rate of sand transport are in the early stages of development.