“ RECURRENT ”. A RECORDING CURRENT METER DATA ANALYSIS SYSTEM

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INTRODUCTION

In recent years recording current meters have become available for use on commercial surveys which are capable of recording months of data at one deployment. This has made possible lengthy and very detailed tidal flow studies to provide information for use in the design of marine structures. This paper describes a data processing system known as RECURRENT, developed to analyse and report findings from up to one month's records from the N.B.A. — DNC2 or DNC2A recording current meters. The data from other meters could also be analysed if a pre-processing conversion was carried out to produce the required data format for the system.

It has been found in commercial survey applications that clear graphical presentation of current meter results is needed because survey reports are very often read and used by people who are unfamiliar with tidal work. The aim in developing RECURRENT was largely one of simplifying and clarifying the data obtained. The scatter plot diagram (figure 1) for example is designed to be useful in the consideration of alignments for jetties or perhaps bridge piers and shows clearly any predominant flow directions at a particular point. The system is thought to present data from places with mainly semi-diurnal tides quite comprehensively. The question now arises as to how best to present data for places with predominantly mixed and diurnal tides while at the same time keeping the layout simple and direct. The full graphical presentation of all results (figure 2) and the scatter plot could still be usefully presented. The vector diagram of average stream velocities and directions (figure 3) cannot, however, be used. This diagram shows average directions and velocities related to tides of specific range type and with times related to High Water. Both these concepts become confused in situations of mixed tides and a satisfactory, simple presentation has yet to be devised.

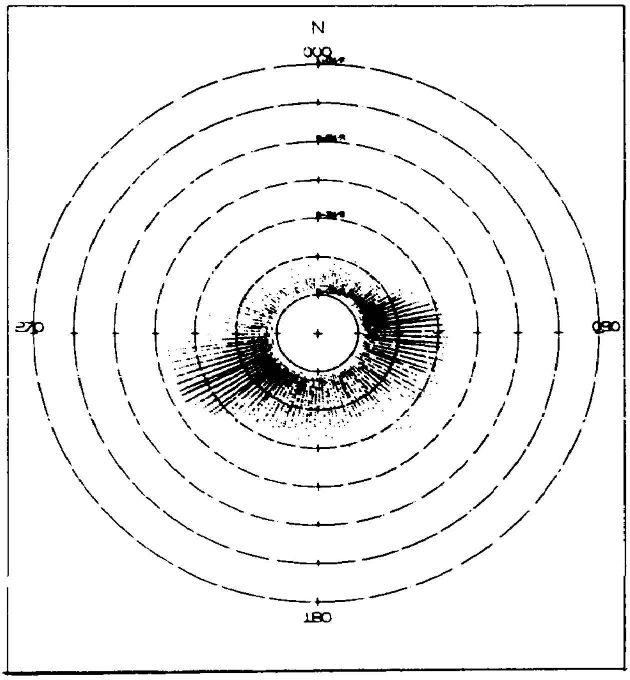


FIG. 1. — A Scatter Plot Diagram.

THE RECORDING CURRENT METER

Recording current meters generally record on magnetic tape. The DNC2 or DNC2A meters take tape reels of 13 cm and play at a speed of 2.54 cm/sec. Depending on the tape used (i.e. single, double or triple play tape) and the interrogation period, the meter can record between 30 hours (at 15-second intervals on single play tape) and 450 days (at 30-minute intervals on triple play tape), the maximum number of records being 21600. The readings contain 38 data bits divided into an 8-bit serial number (4 bits at each end of the record), a 10-bit velocity measurement, a 7-bit direction measurement and a 12-bit reading number. The 38th bit is a parity bit set for even parity (an even number of data bits to each message). This is used as a validity check on replay. The velocity measurement count has a maximum limit of 1023, but by scaling this with factors of 1, 2, 4, 8, etc., to 64, a larger number of velocity pulses may be stored.

The magnetic tape is first translated into a decimal coded paper tape containing a validity digit, reading number, instrument serial number, direction in degrees and the number of velocity pulses counted. This paper tape then becomes the main input to the RECURRENT system. The system also requires an input of tidal height data. Currently this information is provided in the following choice of ways:

(1) A manually punched paper tape containing tidal heights from observations or predictions.

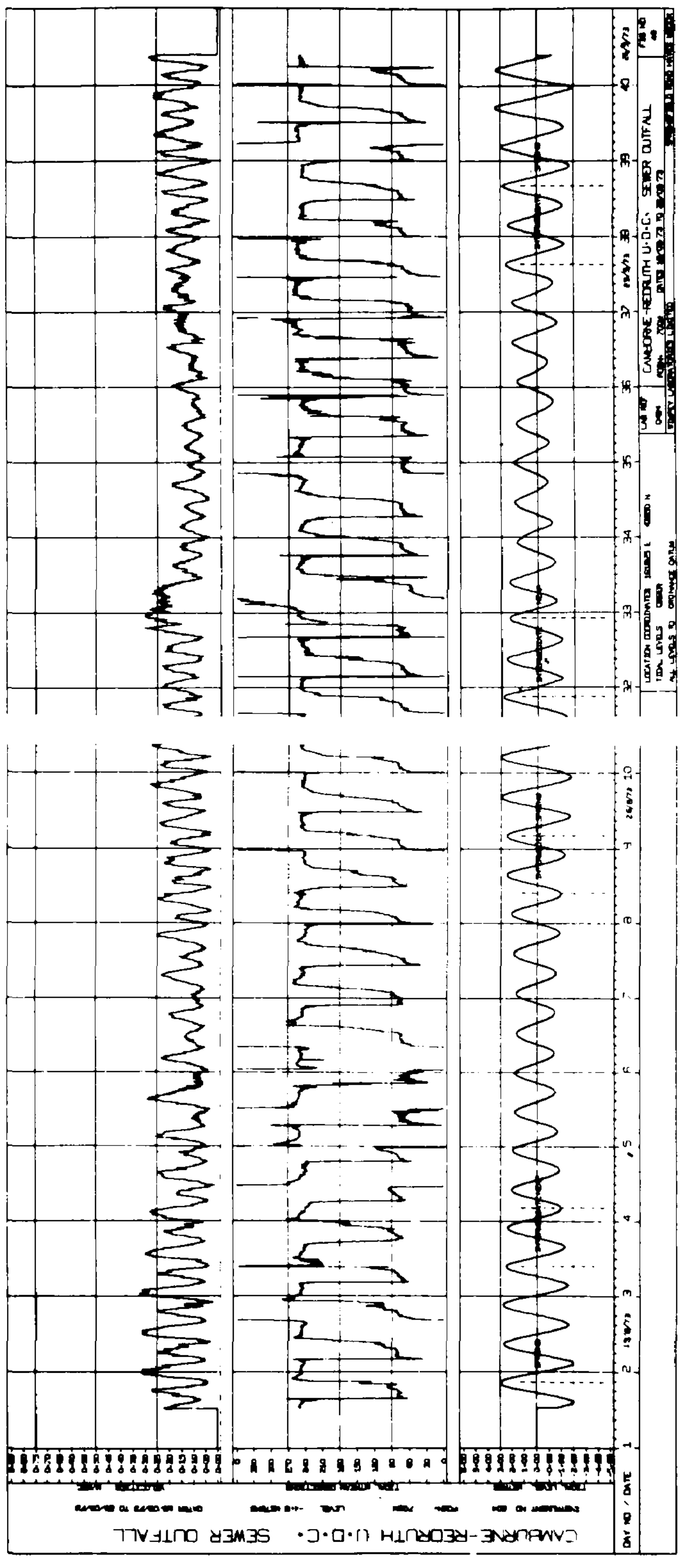
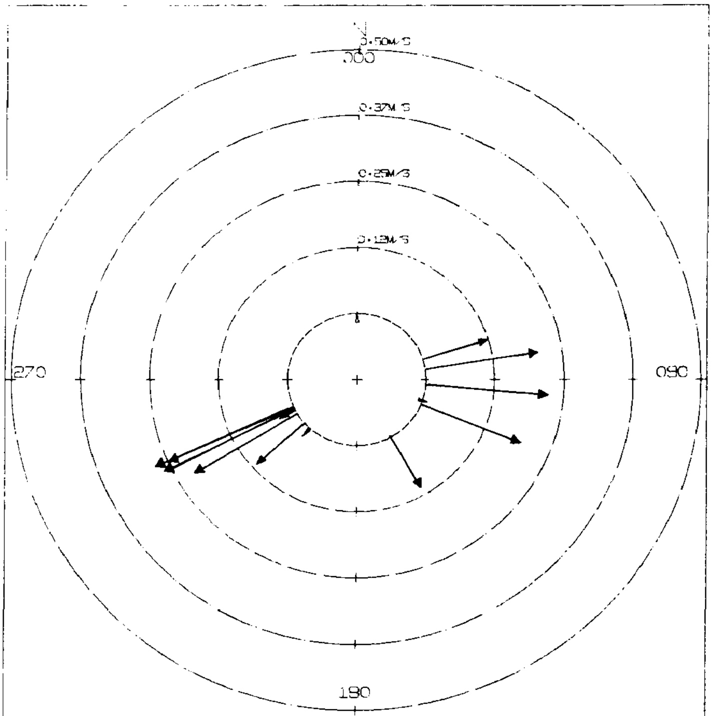


FIG. 2. — Full graphical presentation of all results.

(2) A paper tape digitized from a tide gauge chart using a digital trace table.

(3) Data from a tidal prediction programme, predicting from constituents.



FLOOD

HRS BEFORE HW	DIRN	VEL
-7	0	0·00
-6	222	0·01
-5	111	0·19
-4	34	0·22
-3	81	0·20
-2	72	0·12
-1	105	0·00
HW	150	0·10

EBB

HRS AFTER HW	DIRN	VEL
HW	150	0·10
+1	229	0·11
+2	238	0·21
+3	243	0·26
+4	245	0·27
+5	245	0·24
+6	241	0·03
+7	0	0·00

FIG. 3. — A vector diagram of average stream velocities and directions.

SYSTEM OPERATION

The RECURRENT system can be broken down into three main operations: checking of data, analysis of data, and plotting of results. The checking of data can be further sub-defined into checking and correction of format errors in the paper tape, and editing the data of grossly erroneous values. (See figure 5, Flow Chart). The first part of the system reads the paper tape and produces a list of format errors for correction by the next program (Flow Chart, Ref 1). A paper tape of corrections is then fed to this program and the disc file is amended as appropriate (Flow Chart, Ref 2). The tidal data is treated in a similar manner except that in the

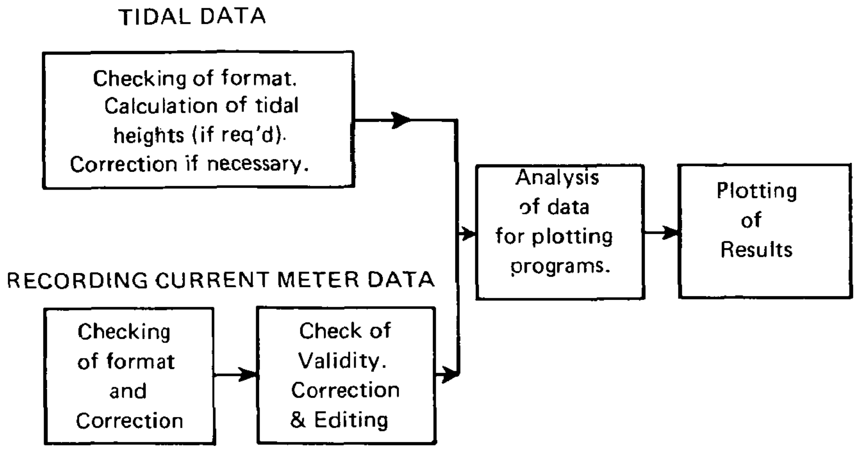


FIG. 4. — Recording Current Meter System — Block Diagram.

case of digitised tide readings an intermediate program converts data into height and times. If any serious mistake is made in the data the program reports a fatal error, does not compute the tidal values and thus saves valuable computer time (Flow Chart, Ref. 3). The data is then in a valid form for acceptance by the next stage of the system.

All of the current meter records are then plotted by line printer in graphical format to show up any grossly erroneous values. At this stage the surveyor can examine his data easily and rapidly and decide on any editing required (Flow Chart, Ref 4). Bad readings occur occasionally due to poor recording on the magnetic tape and editing is necessary because, later in the system, wild values would lead to a distortion of the results. Editing can be done in two ways, one is to assess the probable value for the reading from adjacent readings, the other is to replace the error with a zero value. The first method is generally adopted as being the most practical approach. An editing tape is then prepared consisting of corrections and any headings required on the plotted output. The line printer plot can then be re-run to output an improved version of the graphic format showing date and times of observations. This can be used as a preliminary report document to indicate general flow directions and velocities, as well as being useful for re-checking (Flow Chart, Ref 5).

Similarly, tidal data is listed and a further program is available to edit this data. New values may also be added at this stage if it is seen that the data does not adequately represent the tidal heights for the survey area (Flow Chart, Ref 6).

Some of the foregoing editing process may seem unnecessary but it has been found in practice that good results are obtained more speedily by following through this process thoroughly. The increase in computer usage time and cost is far outweighed by its usefulness in the process of carefully checking data.

The two data files — one containing direction and velocities of flow, and the other tidal heights and times — are now combined. This was in practice the most difficult of all the operations to develop. The only common factor between the two data files is "time". In the case of the

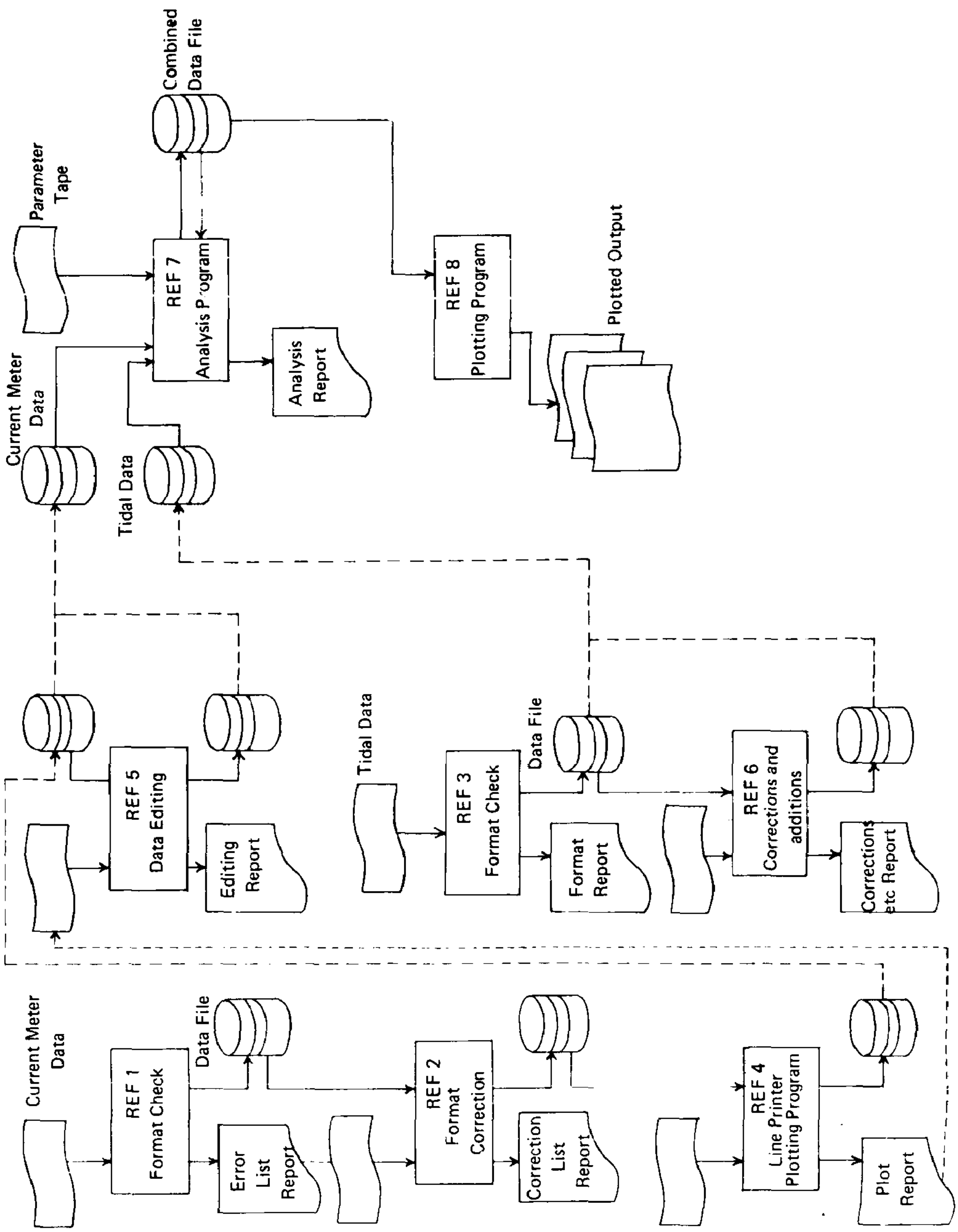


FIG. 5. — RECURRENT System Flow Chart.

current meter, the starting time of the instrument is known, and successive readings occur at the interrogation interval set by the operator. The difficulty lies in determining the time corresponding to the first acceptable reading on the data tape. If the instrument is started before being put in the water, and this is often done for test purposes, the number of readings before the instrument has settled down on its mooring must be determined. An error of one interrogation interval can easily occur here. One way to overcome this is to use a diver to start the instrument and note the start time when it has been deployed. Another method, presently under development, is to use a surface interrogation unit which will examine a particular recording cycle so that the exact reading number can be established. The latter method once successfully developed would appear to be the most useful.

All data submitted to RECURRENT is stored on disc files so that it is easy for the operator, through instructions on a Parameter Tape, to run the system several times (Flow Chart, Ref 7). The first run uses the two corrected files (velocities/directions and tide heights) as input. The combined data — i.e. Reading Number, Time and Velocity, Direction, and Tidal Height — are stored on a new file. This file can then be accessed without reference to the other two on any subsequent runs. The data combination is achieved by interpolating the tidal data to give heights corresponding to each current meter record. At present a linear interpolation on the tide curve is used, because sample intervals are normally of the order of 5-15 minutes. Obviously, the facility to increase the tidal data described earlier (predictions and digitised records as opposed to manually-punched input) allows more tidal data to be input for more complex curves, thus increasing the accuracy of the interpolation.

ANALYSIS

Two types of analysis can be performed, dependent on the parameters requested. The first is a calculation of the residual flow, and the second is the average flow at fixed times related to high water. The residual flow is calculated by algebraically summing the vector components for each reading for a period of twenty-eight days, i.e. fifty-six cycles of a semi-diurnal tide. The first requirement of both types of analysis is the determination of the exact times of High Water and Low Water on each cycle. To determine the limits of a cycle, an estimate of the ebb and flood durations are input as part of the parameter data. From these times, the expected number of readings for the average flood and ebb can be calculated. The approximate position of the first High Water reading is calculated from the start of the instrument recording by input of the approximate time of the first High Water after the start. A curve is fitted to a number of readings on either side of this calculated position, and the maximum or minimum height (and hence the reading) is determined. If the maximum or minimum occurs at the beginning or end of the curve being considered, this reading is taken as the middle of another set of

Table showing method by which readings are selected for averaging hourly tidal stream values related to high water

Day	Tide	Reading at time	
1	LW (2325)	2330	
		2340	
		2350	
	−6	0000	Average for value at 6 hrs before H W
2		0010	
		0020	
		0030	
		0040	
		0050	
	−5	0100	Average for value at 5 hrs before H W
		0110	
		0120	
		0130	
		0140	
		0150	
	−4	0200	Average for value at 4 hrs before H W
		0210	
		0220	
		0230	
		0240	
		0250	
	−3	0300	Average for value at 3 hrs before H W
		0310	
		0320	
		0330	
		0340	
		0350	
	−2	0400	Average for value at 2 hrs before H W
		0410	
2		0420	
		0430	
		0440	
		0450	
	−1	0500	Average for value at 1 hr before H W
		0510	
		0520	
		0530	
		0540	
		0550	
	H W	0600	Used
	(0603)	0610	
		0620	
		0630	
		0640	
		0650	
	+ 1	0700	Average for value at 1 hr after H W
		0710	
		0720	
		0730	
		etc	

readings and the process repeated, thus allowing for the fact that the time inputs for flood and ebb are only estimates and so will not cover every case. The reading so determined is then taken as the start for the calculation of the position of the next High Water or Low Water reading. A list of each High Water reading number and Low Water reading number is then stored.

Each reading from the first High Water is split into two vector components, one north the other east. The algebraic sum of these is taken for fifty-six tide cycles and the resultant vectors combined to give a residual flow. If insufficient data is present for this calculation to be completed, this is reported. A list of the vectors, the sum for each cycle and the total are printed. If more than fifty-six cycles are present, the entire data is used with a residual being computed for each set of fifty-six cycles.

Two further parameters are supplied to the program. These specify the lower limit of a given tide range and the upper limit of another — e.g. lower limit of spring range and upper limit of neap range. These two values are used in the computation of average flows at fixed times related to High Water. The previously computed positions of Low and High Water readings are used to first categorize each half tide cycle by type (neap, intermediate, or spring). For each range type the average flows are computed in the following manner.

If the recording interval on the current meter is set at say ten minutes, then six readings cover each hour. For High Water the velocity and direction readings of the nearest record to the actual time of High Water are taken. Two readings either side of High Water are skipped, then the next seven readings are vectored and algebraically summed. (See the tabular example opposite).

The last of the seven is then taken as the first of the next seven and the same process is repeated. A maximum of seven of these sums before and after High Water are stored for each range. When all the data has been processed, the vector sums are divided by the number of readings making up this sum, giving the average vectors. From these vectors the average velocity and direction for each hourly period is computed.

Example of average hourly flow analysis

Half tidal cycle of flood : 6 hours 30 minutes.

At a recording interval of 10 minutes there are six readings to each hour. If Low Water is at, say, 2325 hours on Day 1 and High Water at, say, 0603 hours on Day 2, then see the table opposite.

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The results of averaging these selected readings are also printed and stored for use in plotting. Any further analysis of the data has not as yet been undertaken, but could obviously be catered for if required.