PUBLIC WORKS DEPARTMENT, N.S.W.

Port Hacking: Tidal Data
3rd. - 4th. June 1981

Report No. 316 September 1981

Manly Hydraulics Laboratory

PUBLIC WORKS DEPARTMENT, N.S.W.

DC!DC (L.O.) P13

DATA COLLECTION : PORT HACKING

Attached for your records is the final copy of the report on the tidal discharge observed at Port Hacking on the 3rd/4th June 1981. This is Manly Laboratory No.316 dated September 1981.

P.B.Stone,
Supervising Engineer,
Manly Laboratory.
3-3-83

1. Principal Engineer,
   Rivers and Ports Branch.
   Attn. B.Druery.

2. District ~~Engineer,~~
   ~~Metropolitan~~ District Office.

S.O. 3677 D. West, Government Printer

PUBLIC WORKS DEPARTMENT N.S.W.

MANLY HYDRAULICS LABORATORY

Port Hacking

Tidal Discharge Measurements - June 3/4, 1981

PWD Report No. 81013
Report No. 316

September 1981

FOREWORD

A considerable amount of observational work has already been carried out by the Coastal Engineering Branch in relation to the complex shoaling problems which occur in Port Hacking as outlined in the Departmental Progress Report issued September 1980.

As part of the second stage of the Port Hacking Study, tidal discharges were observed across a profile between Burraneer Point and Deeban Spit; the work was specified by the Estuaries Investigation Section, Coastal Engineering Branch and carried out by the Data Collection Section of the Hydraulics Laboratory, Manly Vale.

Original data, recorded observations and computer reduction records are on file at the Hydraulics Laboratory and may be inspected on application to the Data Collection Section Engineer at the Laboratory.

Reproduction of information from records belonging to the Australian Bureau of Meteorology and the Maritime Services Board of N.S.W. and map detail from the Central Mapping Authority is hereby acknowledged.

SUMMARY

Water velocity measurements for tidal discharge were made between Deeban Spit and the Burraneer peninsula during June 3rd/4th, 1981. Tideboards were monitored at Turriel Point, Burraneer Point and Bundeena and these locations together with that of the metering line are shown in Figure 1.

Resultant computed figures are as follows:

Deeban Spit Profile:

Max. Recorded Velocity (m/s) -

Ebb	1.40
Flood	0.96

Volume* (m3) -

Ebb	14.4×10^6
Flood	8.0×10^6

Max. Discharge (m3/s) -

Ebb	760 at 2345 hrs
Flood	680 at 0750 hrs

* See Section 8.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF DEFINITIONS

The following terms are used in connection with the measurement of liquid flow in open channels. They have been extracted from the International Standard (ISO 772), "Liquid flow measurement in open channels - Vocabulary and symbols", 1973, and the U.S. Army Corps of Engineers C.E.R.C. Shore Protection Manual, 1977, Vol.III, App. A. Glossary of Terms.

LEFT (RIGHT) BANK: The bank to the left (right) of an observer looking downstream.

EBB TIDE: The occurrence of falling water surface of a tide.

EBB CURRENT: The seaward movement of water along a tidal channel.

FLOOD TIDE: The occurrence of rising water surface of a tide.

FLOOD CURRENT: The landward movement of water along a tidal channel.

TIDAL PERIOD: The interval of time between two consecutive like phases of the tide.

1. INTRODUCTION

As mentioned in the Foreword, investigation work is continuing in the Port Hacking area and has now entered the second stage. This tidal discharge measurement is aimed to provide further information for use in the determination of management methods for the problems in the area.

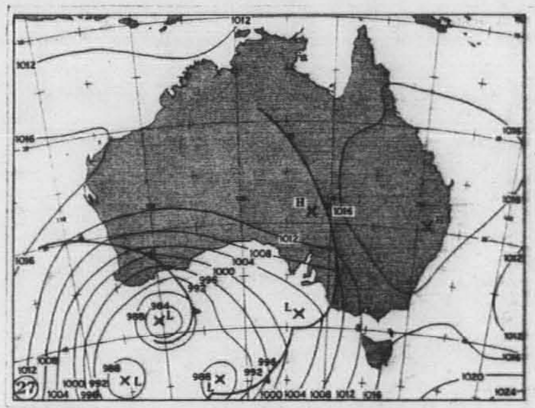
Although originally intended as a flood flow/ebb flow monitoring commencing with the low water predicted at 1436 on Wednesday, June 3rd 1981, logistical and buoy position stability problems reduced the frequency of velocity readings during the flood flow period before high water at 2100 on June 3rd, 1981. Observations were therefore continued for a further half tidal cycle beyond that originally intended, that is until flow reversal after the high water occurring at 1000 on June 4th, 1981. The locations of monitoring stations used in the exercise are shown in Figure 1. Although some tidal height and velocity information is available for the first flood flow, the tidal cycle between 2100 on June 3rd and 1000 on June 4th, 1981 has been accepted as the observational period and reduced accordingly for tidal volume.

2. WEATHER AND SEA STATE

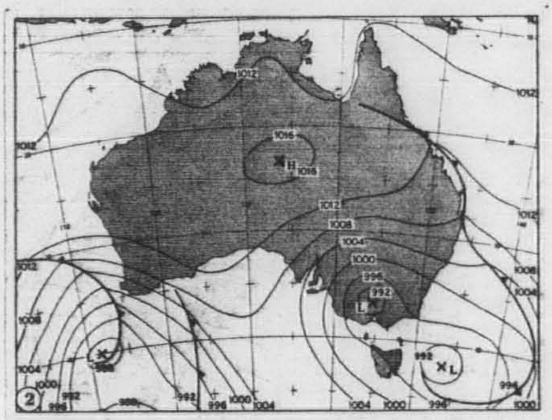
Weather conditions in the Sydney area were stable during the period of observation. Some cloud was in evidence during the evening of June 3rd and the pressure gradient during this time gave rise to moderate winds from the west, gusting to strong on occasions as can be seen from Table 2.1. Conditions became calmer during the early hours of June 4th and continued so until the end of the observations. No rainfall was recorded during this time.

Sea state was not significant during the metering period, wave height offshore Sydney ranged between less than 1 m up to 1.3 m, with a period of between 8 and 9 seconds. Swell was not appreciable at the metering profile position.

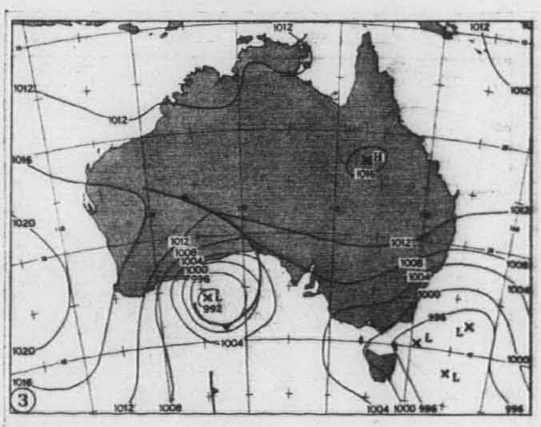
TABLE 2.1 : SURFACE SYNOPTIC CHARTS AT 1000 hrs EST



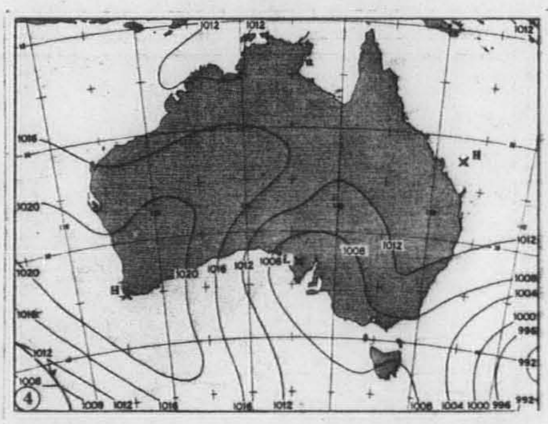
27 MAY'81



2 JUN'81



3 JUN'81



4 JUN'81

TABLE 2.2 : GENERAL WEATHER CONDITIONS AT OBSERVATORY HILL, SYDNEY

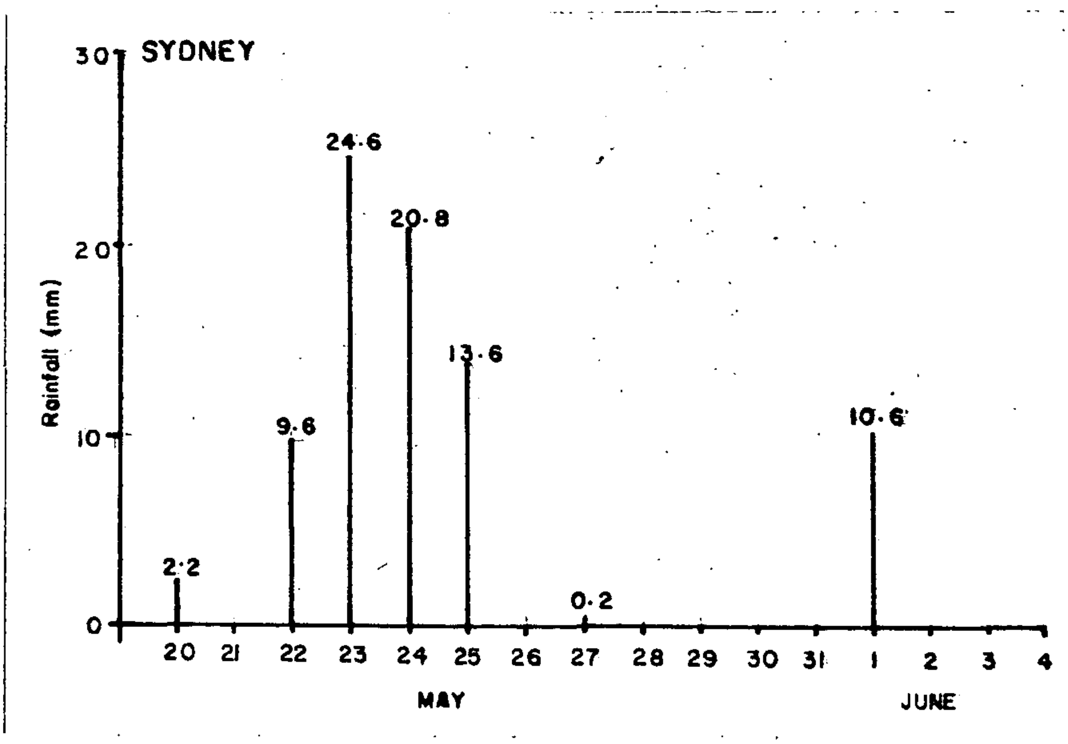
Date: June 3rd, 1981

Time	0300	0900	1500	2100
Atmospheric Pressure	998.4	1002.1	1001.3	1006.8
Temperature °C	15.0	16.0	18.2	14.0
Wind Speed km/h	W 20.3	W 27.6	W 42.4	W 20.3

Date: June 4th, 1981

Time	0300	0900	1500	2100
Atmospheric Pressure	1008.0	1009.9	1007.1	1008.3
Temperature °C	11.8	13.5	18.1	14.6
Wind Speed km/h	WSW 7.4	WNW 11.1	WNW 11.1	W 4.0

TABLE 2.3: RAINFALL RECORD



3. FRESHWATER FLOW

Other than a low priority gauge in the vicinity of Audley on the Hacking River, no flow monitoring systems are in operation within the Port Hacking catchment area. No reliable flow figures could be obtained from this gauge to cover the period applicable to the tidal monitoring reported herein.

As can be seen from the rainfall figures for the period before June 3rd/4th (Table 2.2), substantial rain fell in the Sydney area up to a week and a half beforehand and a significant fall occurred on June 1st, which would still have been influencing flow in the system on the metering days.

4. WATER LEVELS

Tideboard locations established for the metering period included Tideboard 3 on the southern rock face of Burraneer Point, approximately 200 m west from the entrance to Gunnamatta Bay, and Tideboard 2 situated on the jetty of No.12 Wallendbeen Avenue, Little Turriel Point (called Linder's Wharf). As the current metering profile was situated approximately half way between these two water level recording points, a median water level curve (Figure 12) has been derived based on the observations at these two locations and used in the determination of the profile cross sectional area.

In addition to the above, a third tideboard was independently read at Bundeena.

The tideboards monitored were all fitted with a damped sensor and each reading is considered to be accurate to within +/- 5 mm. Actual data points, reduced to datum, and a fitted curve are presented for each tideboard monitored at Figures 14 to 16.

The water level recorded at Fort Denison gauge has been used as ocean tide for comparison purposes and the derived water level curve has been included in Figure 17 with the other tideboard curves for comparison.

Tideboard locations are shown in Figure 1.

5. LEVEL DATUM

Tideboards 2 and 3 were levelled from temporary bench-marks established in their immediate vicinity, whilst Tideboard 4 was levelled from a Departmental permanent mark PWD 486. Descriptions of these marks are as follows:

TABLE 5.1 :

Marks	Description	Reduced Level (A.H.D.)
1/CK	9.5 mm Dynabolt set into top of rock with red paint surround	2.094 m
2/CK	Knob of rock with red paint surround on waterfront below level of swimming pool of 12 Wallendbeen Avenue	2.894 m
PWD 486	Brass survey plaque grouted flush with concrete surface of concourse adjacent to Bundeena Ferry Wharf	2.636 m (prov.)

The temporary marks were derived from Metropolitan Water Sewerage and Drainage Board benchmarks: 1/CK from BM 19 situated at Rutherford Avenue, Burraneer Point and 2/CK from BM 29 Wallendbeen Avenue, Turriel Point. These marks have values based on Standard Datum and the values of the temporary bench-marks have been reduced from this to Australian Height Datum using the difference between Standard Datum as applied in relation to the Fort Denison Tide Gauge, that is:

Australian Height Datum	=	0.925 m
Standard Datum	=	0.890 m
Fort Denison Gauge '0'	=	0.000 m

Whilst the relative accuracy of the Water Board Bench Marks is unknown, the levelling from these Bench Marks to the Tideboard Marks is accurate to within +/- 2 mm, and from the Tideboard Marks to the tideboards to within +/- 1 mm.

PWD 486 originated from a State permanent mark (PM 45279) situated in Loftus Street, Bundeena and was established by Departmental surveyors. Connecting levelling between PWD 486 and Tideboard 4 was +/- 1 mm.

6. CROSS SECTION

As shown in Figure 1, the metering line was established between the seaward face of the ruined sandstone baths down from Loch Lomond Crescent, Burraneer Point and the refuse bins at the tip of Constables Point on Deeban Spit. This location is approximately 50 m further west than the profile monitored in previous work.

Four metering points were established by attaching buoys by line to anchors on the bed. The length of line, whilst as short as possible, does allow the buoys a certain degree of freedom and the metering line is therefore a metering band. Judicious choice of line normally obviates the problem of a varying cross section. However from the Manly Hydraulics Laboratory Report 305 of February 1981, it was noted that the bed form in this area is subject to migration under tidal influences and consequently the metering line was echo-sounded on two occasions. Echo-sounding across the profile was carried out at 0630 on June 4th, 1981 across the line of buoys when the flood flow had been established, and again downstream within 20 m of the first sounding line at 1120 on the same day.

Both sections were related to datum via the median tide curve mentioned in Section 4 and are shown in Table 6.1. Also shown is the profile derived from these two soundings and field observations, which was accepted as the cross sectional bedform for computer calculations. An order of accuracy of +/- 5% is thereby indicated in the cross sectional area.

During the measuring period prior to the high water at 2100 on June 3rd, Buoys C and D dragged offline and had to be relocated, but apart from minor movement in Buoy D the buoy positions were substantially maintained throughout the tidal cycle adopted for computer processing. Buoy positions prior to 2100 may be seen in Figure 3, while buoy positions during the observed tidal cycle may be seen in Figure 2. The initial buoy positions were determined by electronic distance measuring equipment when the cross section was measured and the buoys first laid. The latter buoy positions were determined by use of the fathometer fix line as each buoy was passed during each of the echo soundings of the cross section.

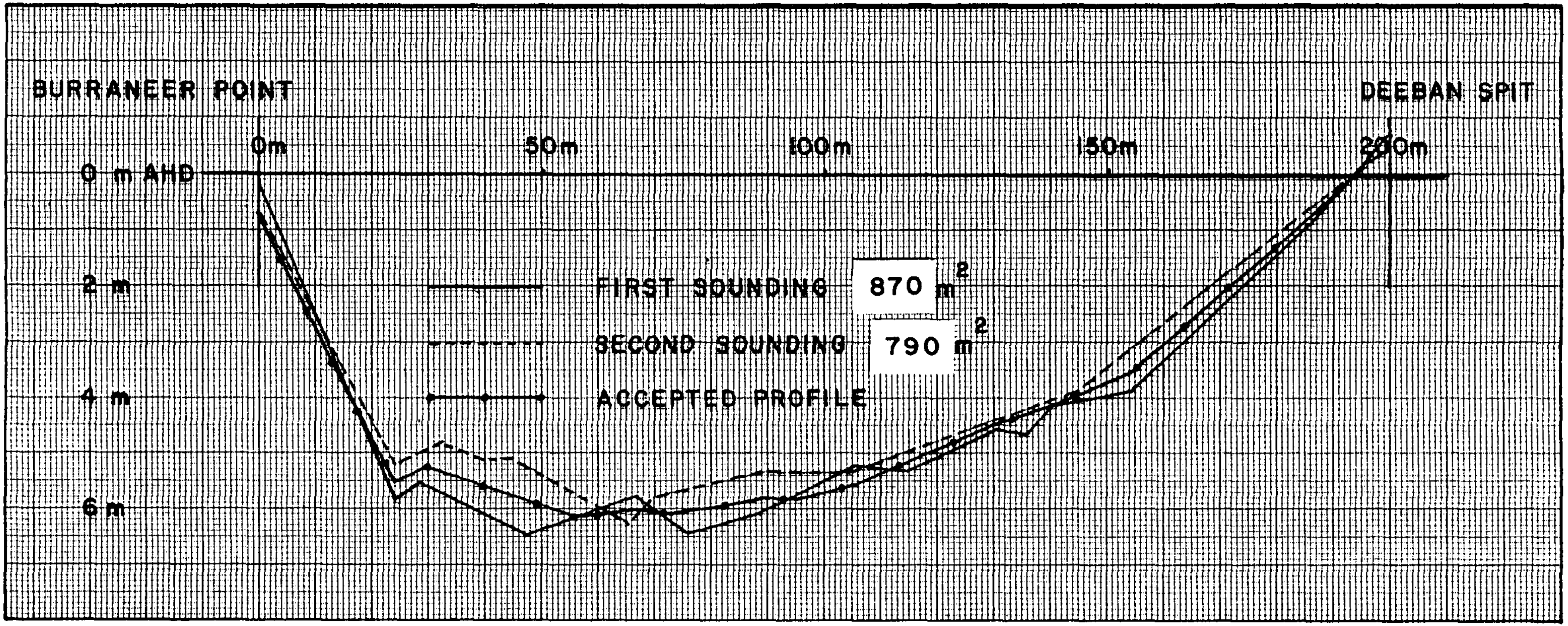


TABLE 6.1 : CROSS SECTIONAL COMPARISON BETWEEN TWO SOUNDING RUNS WITH ACCEPTED PROFILE RELATIVE TO A.H.D.

7. WATER VELOCITY READINGS

The recording of water velocities began before the high water at 2100 on June 3rd, 1981 and continued throughout the night until after high water at 1000 on June 4th, 1981, when reversal of flow had been recorded on all four buoys.

At each of these four recording locations, a directional Braystoke current meter was deployed from a moored boat at depths determined by Table 7.1.

TABLE 7.1 : METERING DEPTHS

Depth of Water (D)	Metering Depth Below Surface
< 1.0 m	0.5D
1.0 m to 2.0 m	5/6D, 0.5D, 1/6D
> 2.0 m	0.9D, 0.7D, 0.5D, 0.3D, 0.1D

The Braystoke Directional current meter aligns itself with the current and the number of revolutions of the impeller over a time interval (30 secs) is noted. These meters have in-built compasses and thus the orientation of the current meter in the water gives the direction of flow.

At each metering buoy, the current meter was lowered to the bed and the depth of water recorded. Some disparity occurs between this measured depth and the depth obtained for the same time from the measured cross section and the tide curve, and is occasioned by boat movement, bed form irregularities and departure of the current metering cable from the vertical as a result of current drag. With a view to assessing the effect of current drag, a tabulation of depths for the Buoy B and Buoy C positions may be seen in Table 7.2. At these two positions, depth variation as a result of boat movement and bed form irregularities is in the order of +/- 1 m.

As can be seen from Table 7.2, maximum disparity occurs during peak flow, the largest difference being 0.75 m at Buoy B during the peak flood velocity. This difference is approximately 12% of the water level depth. When current velocities are strong, Columbus weights are added to the current meter to damp out this error. However this action was not considered necessary for this metering.

TABLE 7.2: DIFFERENCE BETWEEN ACTUAL AND INDICATED CROSS SECTION DEPTHS WITH RESPECT TO CURRENT

BUOY B - Accepted Cross Sectional Depth on AHD 6.15 m (K)

MEAN TIME	WATER LEVEL CURVE VALUE (V)m	WATER LEVEL DEPTH (K+V)m	CURRENT METER MEASURED DEPTH (m)	DIFFERENCE (m)	AVERAGE VECTOR CURRENT VELOCITY (m/s)	
2126	1.19	7.34	7.20	-0.14	-0.074	Ebb
2342	0.56	6.71	7.40	+0.69	-0.982	
0035	0.23	6.38	6.40	+0.02	-1.088	
0137	-0.12	6.03	5.80	-0.23	-0.875	
0248	-0.43	5.72	5.50	-0.22	-0.740	
0421	-0.59	5.56	5.50	-0.06	-0.380	
0538	-0.43	5.72	5.40	-0.32	+0.410	Flood
0648	-0.10	6.05	6.40	+0.35	+0.720	
0811	0.30	6.45	7.20	+0.75	+0.730	
0927	0.55	6.70	7.10	+0.40	+0.400	
1026	0.57	6.72	6.30	-0.42	-0.170	
BUOY C - Accepted Cross Sectional Depth on AHD 5.55 m (K)						
2145	1.16	6.71	7.10	+0.39	-0.570	Ebb
2353	0.50	6.05	6.40	+0.35	-0.906	
0102	0.07	5.62	5.60	-0.02	-0.910	
0205	-0.26	5.29	5.00	-0.29	-0.810	
0307	-0.50	5.05	4.70	-0.35	-0.660	
0439	-0.58	4.97	4.60	-0.37	-0.280	
0556	-0.36	5.19	5.00	-0.19	+0.440	Flood
0704	-0.02	5.53	5.20	-0.33	+0.820	
0840	0.43	5.98	5.80	-0.18	+0.810	
0940	0.57	6.12	5.90	-0.22	+0.380	
1042	0.54	6.09	6.40	+0.31	-0.380	

After the current meter was lowered to the bed and the depth of water recorded, the meter was then successively raised to each metering depth in turn, the time noted and the revolutions recorded. The direction of flow was recorded prior to and following each reading of impeller revolutions. During the reduction of field data, the readings in each vertical profile are fed into a computer where the revolutions of the impeller are converted to velocities by using a calibration curve. The velocities are then vector corrected normal to the metering cross section and an arithmetic average of velocity and time for the vertical profile at the buoy is tabulated.

The average velocity values are plotted for each metering point, then a curve is smoothed through these points. A composite graph of velocity curves for each buoy is presented at Figure 4. The actual average velocity points are shown in order to indicate the accuracy of the curve fitting. It is not intended that the curve pass through all the points. The curve is fitted so that irregularities are not completely disregarded, but their effect on the final answer is damped. The maximum flood and ebb velocities are tabulated on the velocity graphs. These values are actual velocities at any depth and not vector adjusted.

Buoy D gave persistent flood or counter flow readings during the general ebb run and, in fact, a shear line was observed to lie on the water surface between Buoy C and Buoy D at an approximate direction of 330°M to 150°M. The metering line lies 033°M to 213°M.

The brief period of monitoring during the preceding and succeeding ebb flows also showed a tendency towards rotational currents near Buoy D. A shear line in this general location has been noticed on subsequent occasions and it seems as though the presence of an eddy in this area is not an unusual phenomenon.

On each metering of Buoy D between 2200 and 0500 hrs, velocities varied significantly with depth in both magnitude and direction. Whilst the average velocity component normal to the metering line during this period was only approx. 0.05 m/sec, actual velocities up to 0.25 m/sec were recorded, albeit often at acute angles to the metering line.

To indicate total mass water transport, curves have been drawn which show velocity vectors averaged through depth at each buoy. These curves are presented at Figures 6 and 7.

In order to give a better appreciation of velocities affecting the bedform, curves have been drawn showing magnitude and direction of the uncorrected velocities at 0.9 depth for all buoys. These may be seen at Figures 8, 9 and 10.

An overall appreciation for the water velocities and their vector directions throughout the discharge cycle may be gathered from the isometric illustration at Figure 11.

8. FLOW CURVES

The discharge at any time, t, is calculated using the following equation:

$$Q(t) = \sum_{i=1}^{N} Ai(t)Vi(t)$$

where

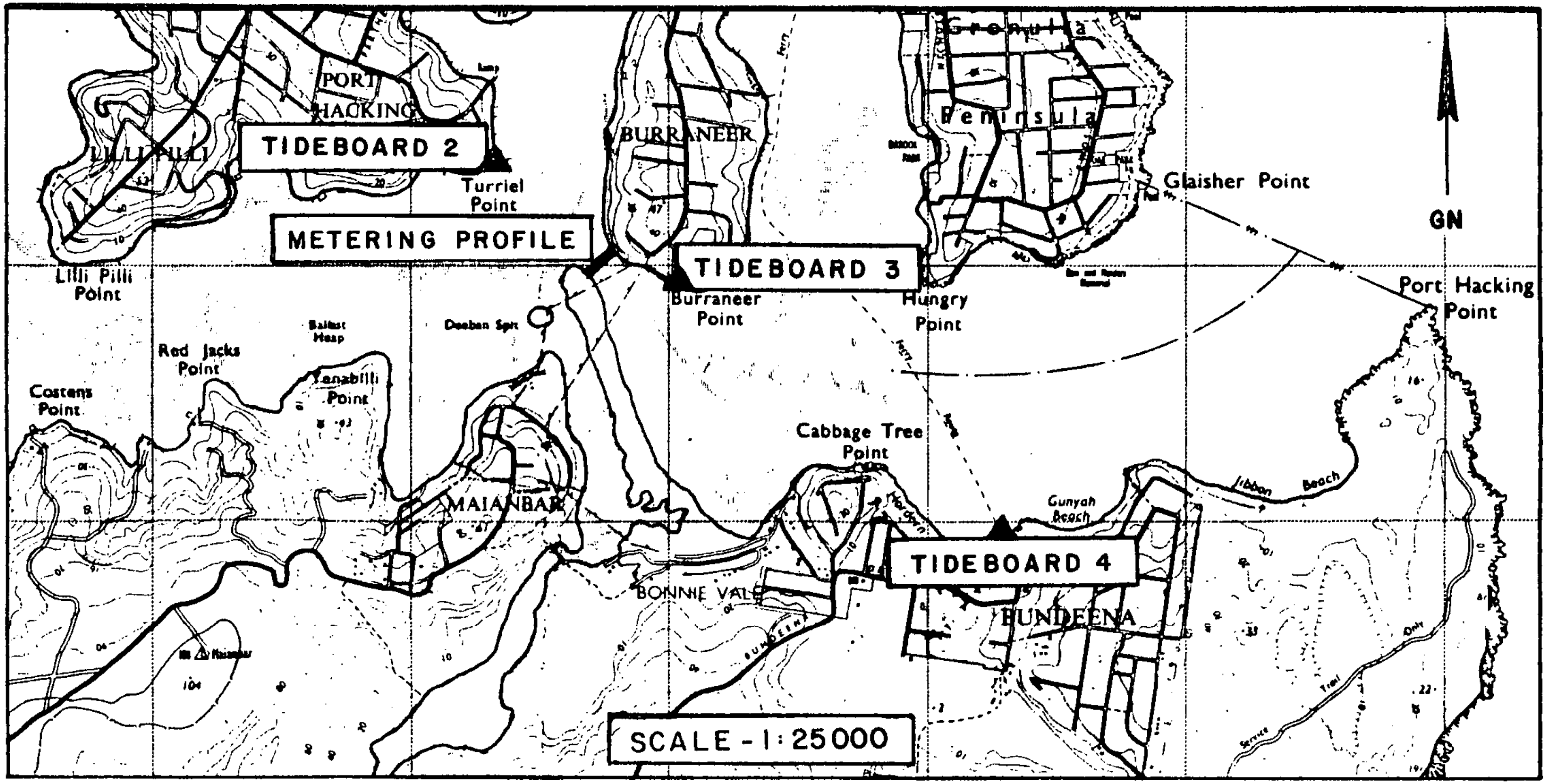
N = number of metering areas
Q(t) = discharge at time t
Ai(t) = metering area i at time t
Vi(t) = velocity at metering area i at time t

The values for discharge obtained from the application of this equation are summed to give total volume of flow in both the flood and ebb directions. The eddying noted towards the right bank and which was referred to in Section 7 will have an adverse effect on total flow calculations, in that the extent and magnitude of the reverse flow could not be adequately monitored. However the nett flow in the Buoy D region would appear to be quite low. The main source of error to the total ebb volume would then be delineation of the shear line between Buoy C, where flow was high, and Buoy D, where flow was in the order of 1/10th lower. Imprecise observations of the shear line when it was noticeable would indicate confidence limits due to this component alone of +/- 5% on total ebb volume.

Confidence limits of normal flow metering cross sections are generally in the order of +/- 5%. In view of the unstable bed mentioned in Section 6, this figure is considered to be +/- 7% for the flood flow but should be further adjusted in accordance with the above for ebb flow.

The flow curve, together with the water level curve obtained for the metering line, are plotted on the Discharge and Water Level graph at Figure 12 to show their inter-relationship.

Due to infrequent velocity readings at the beginning of ebb flow, the line of the ebb discharge curve has been estimated and extended backwards to the time of reversal. The volume given by this calculation was 2.9% of the total ebb volume quoted in this report.



LOCATION DIAGRAM

PORT HACKING
3 AND 4 JUNE 1981

FIG.1

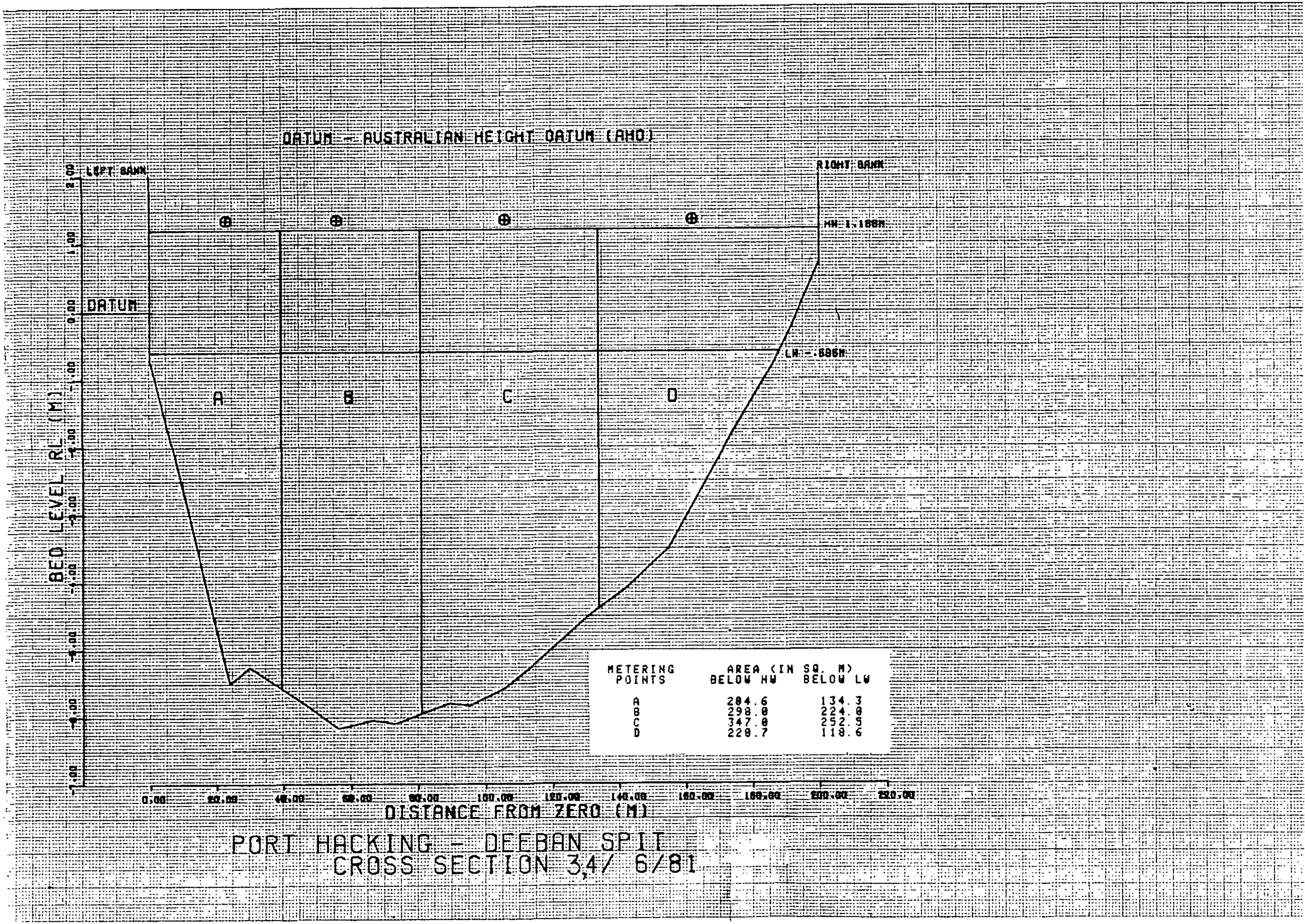
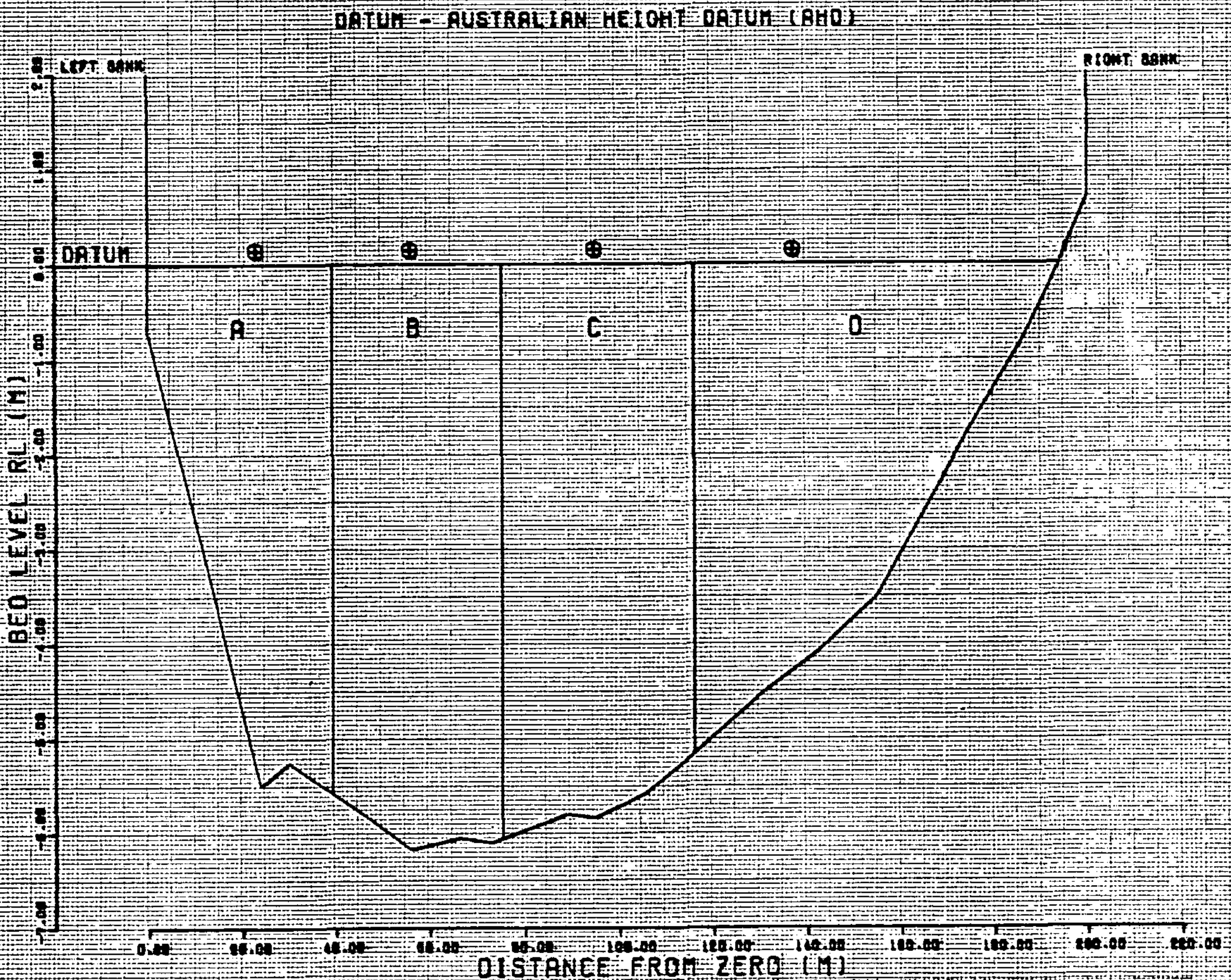

DATUM - AUSTRALIAN HEIGHT DATUM (AHD)
LEFT BANK
RIGHT BANK
DATUM
A
B
C
D
BED LEVEL RL (M)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
DISTANCE FROM ZERO (M)
METERING POINTS
AREA (IN SQ. M)
BELOW HW
BELOW LW
A 204.6 134.3
B 298.0 224.0
C 347.0 252.5
D 220.7 110.6
PORT HACKING - DEEBAN SPIT
CROSS SECTION 3,4/ 6/81

FIG.2

CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA

CHART No. H/F/M/P



PORT HACKING - DEEBAN SPIT 3/6/81

BUOY POSITIONS PRIOR TO DISCHARGE CYCLE

FIG.3

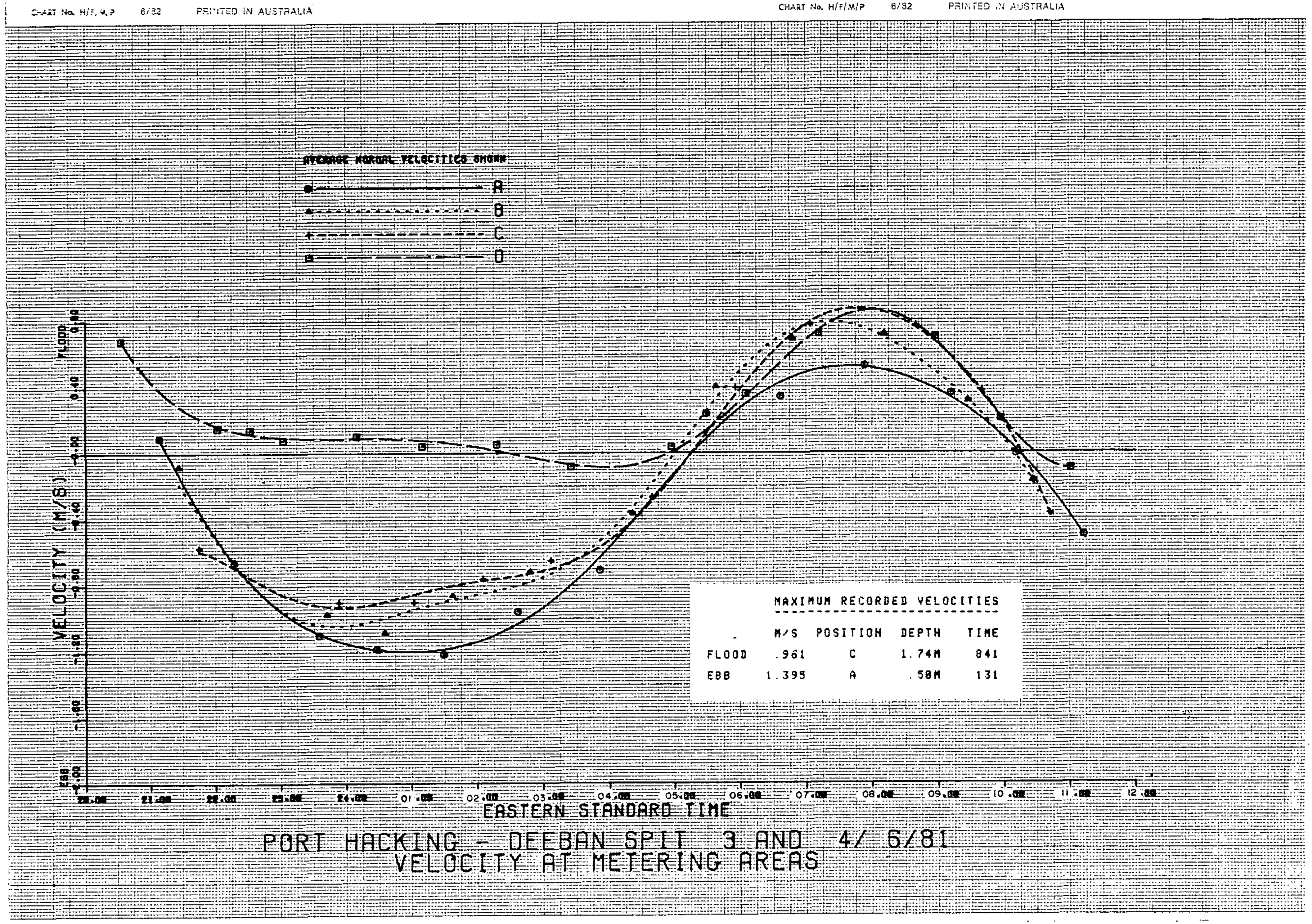


CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA
CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA
AVERAGE NORMAL VELOCITIES SHOWN
A
B
C
D
VELOCITY (M/S)
FLOOD
EBB
MAXIMUM RECORDED VELOCITIES
M/S POSITION DEPTH TIME
FLOOD .961 C 1.74M 841
EBB 1.395 A .58M 131
EASTERN STANDARD TIME
PORT HACKING - DEEBAN SPIT 3 AND 4/ 6/81
VELOCITY AT METERING AREAS

FIG.4

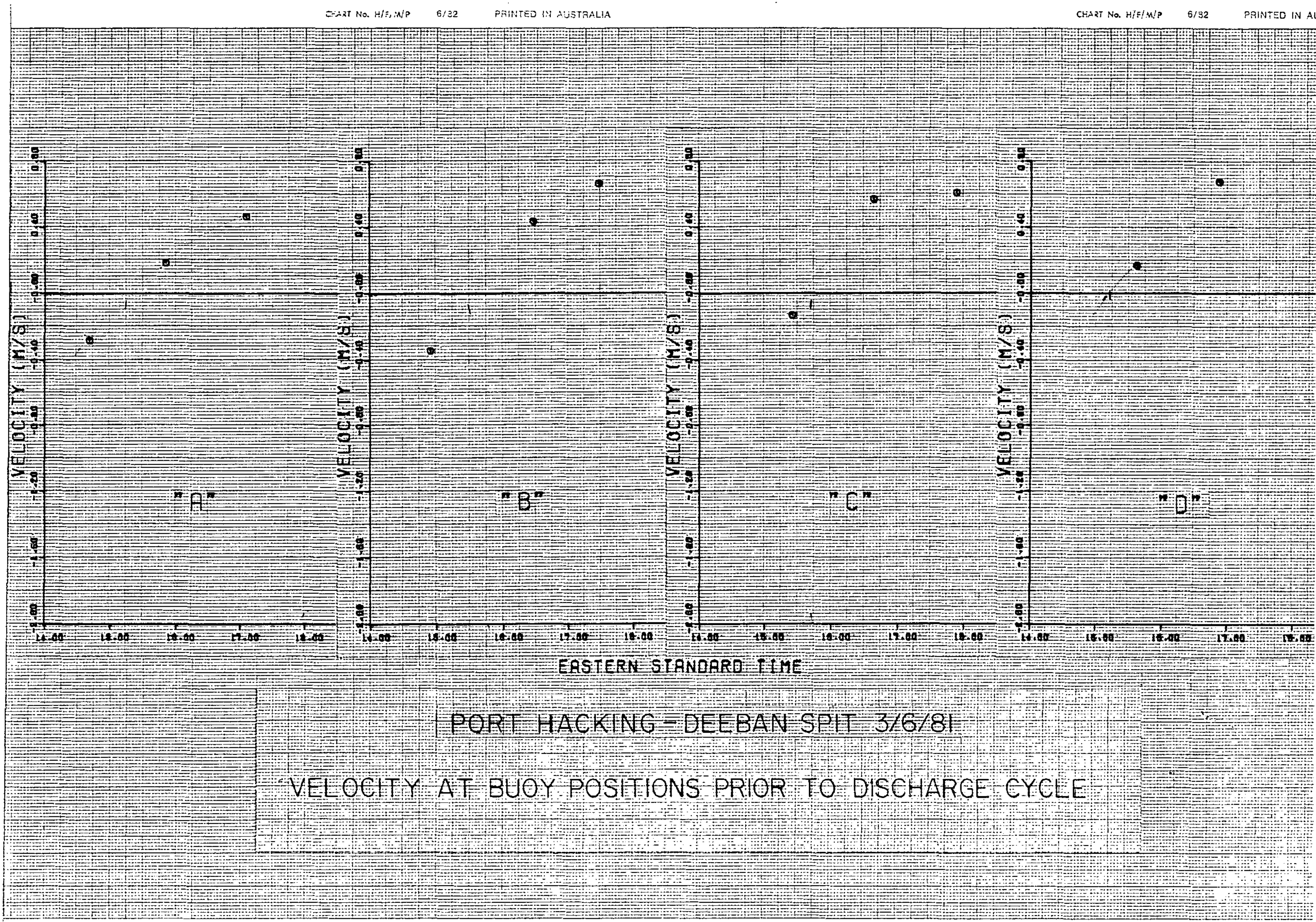


CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA
VELOCITY (M/S)
"A"
"B"
"C"
"D"
EASTERN STANDARD TIME
PORT HACKING – DEEBAN SPIT 3/6/81
VELOCITY AT BUOY POSITIONS PRIOR TO DISCHARGE CYCLE

FIG.5

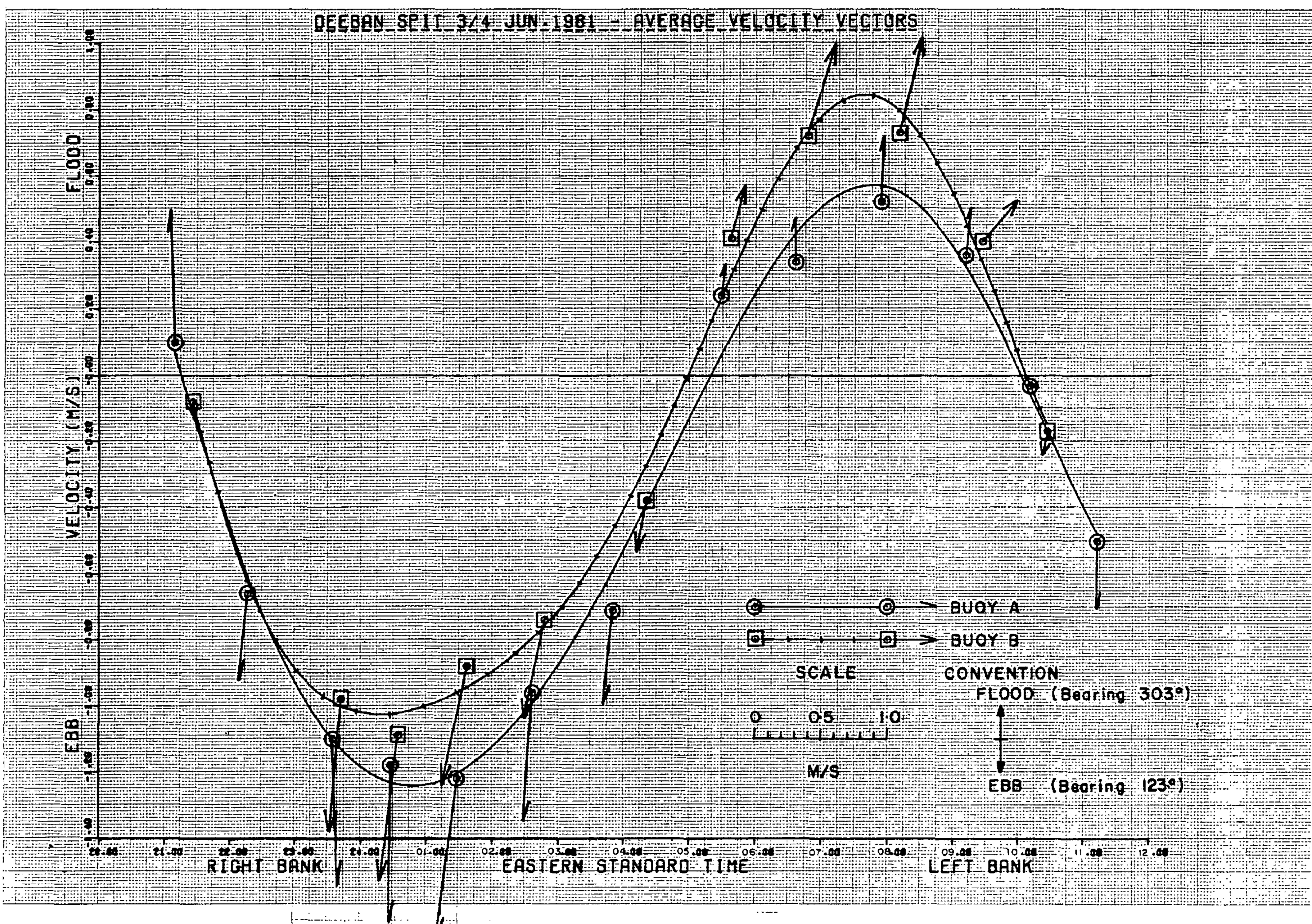
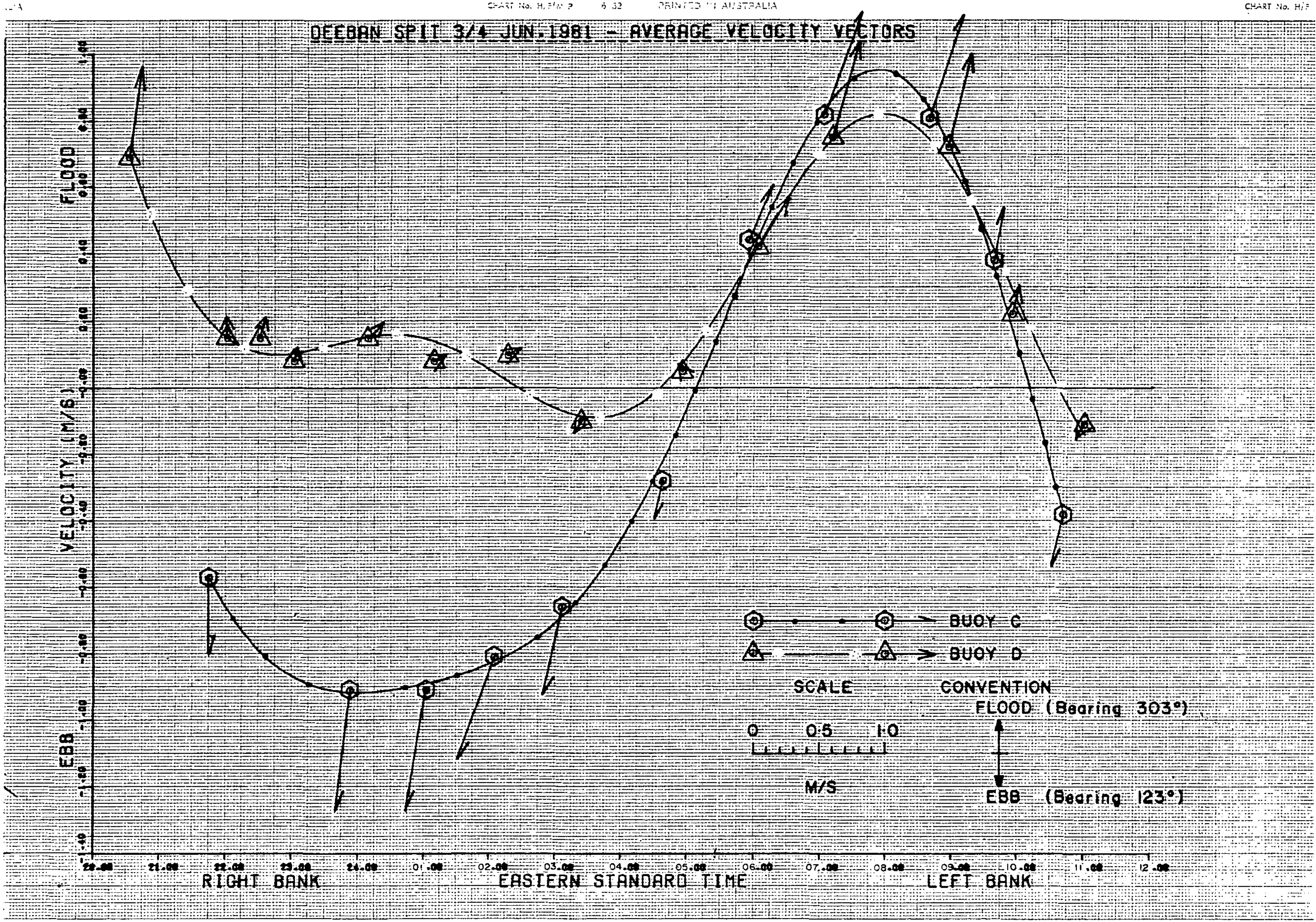

DEEBAN SPIT 3/4 JUN 1981 - AVERAGE VELOCITY VECTORS
FLOOD
VELOCITY (M/S)
EBB
RIGHT BANK
EASTERN STANDARD TIME
LEFT BANK
BUOY A
BUOY B
SCALE
0 0.5 1.0
M/S
CONVENTION
FLOOD (Bearing 303°)
EBB (Bearing 123°)

FIG.6



PRINTED IN AUSTRALIA
DEEBAN SPIT 3/4 JUN.1981 - AVERAGE VELOCITY VECTORS
FLOOD
VELOCITY (M/S)
EBB
BUOY C
BUOY D
SCALE
0 0.5 1.0
M/S
CONVENTION
FLOOD (Bearing 303°)
EBB (Bearing 123°)
21.00
22.00
23.00
24.00
01.00
02.00
03.00
04.00
05.00
06.00
07.00
08.00
09.00
10.00
11.00
12.00
RIGHT BANK
EASTERN STANDARD TIME
LEFT BANK

FIG.7

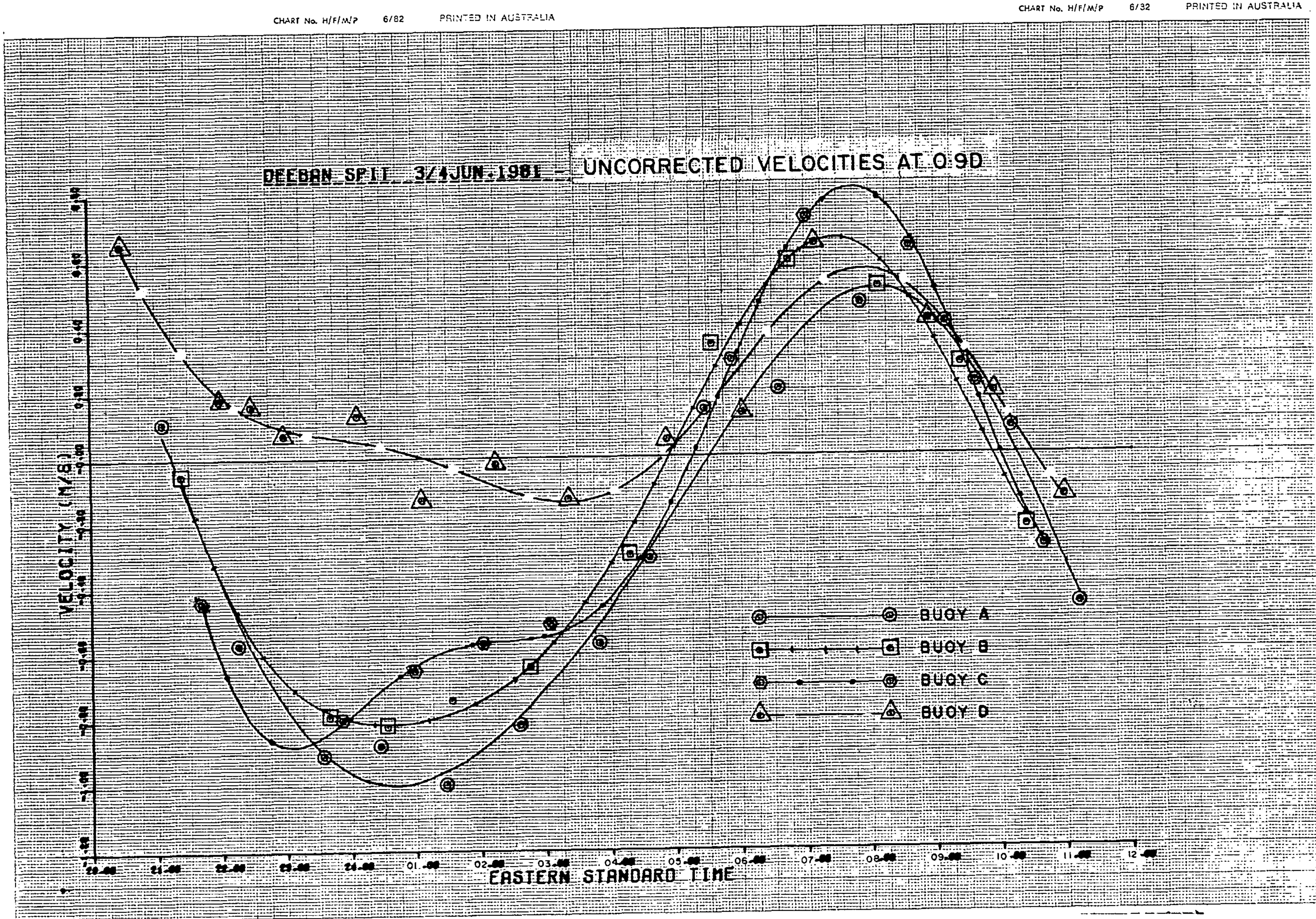


CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA
DEEBAN SPIT 3/4JUN.1981 - UNCORRECTED VELOCITIES AT 0.9D
VELOCITY (M/S)
EASTERN STANDARD TIME
BUOY A
BUOY B
BUOY C
BUOY D

FIG.8

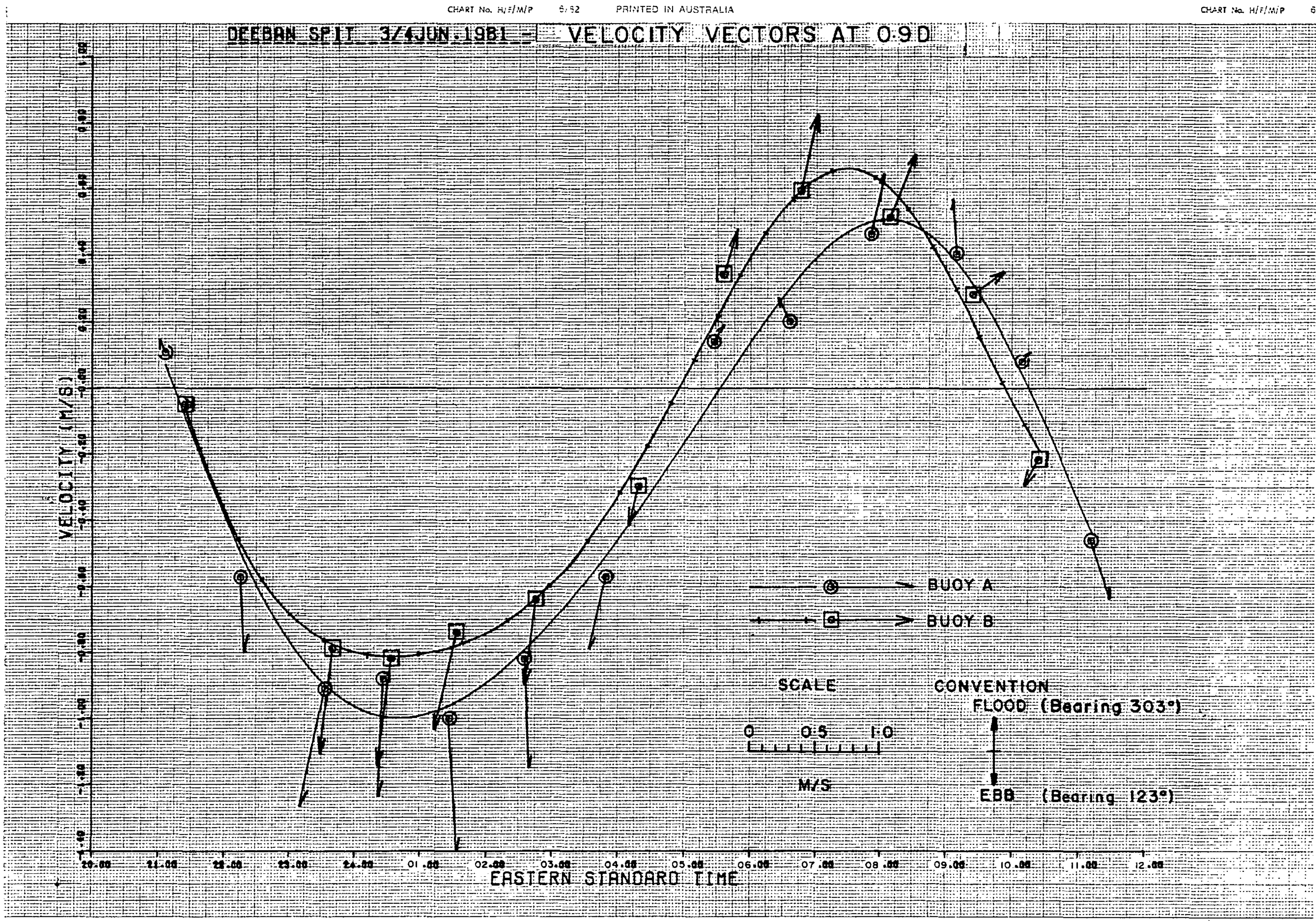


CHART No. H/F/M/P 6/62 PRINTED IN AUSTRALIA
DEEBAN SPIT 3/4JUN.1981 - VELOCITY VECTORS AT 0.9D
VELOCITY (M/S)
EASTERN STANDARD TIME
BUOY A
BUOY B
SCALE
0 0.5 1.0
M/S
CONVENTION
FLOOD (Bearing 303°)
EBB (Bearing 123°)

FIG.9

PRINTED IN AUSTRALIA CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA

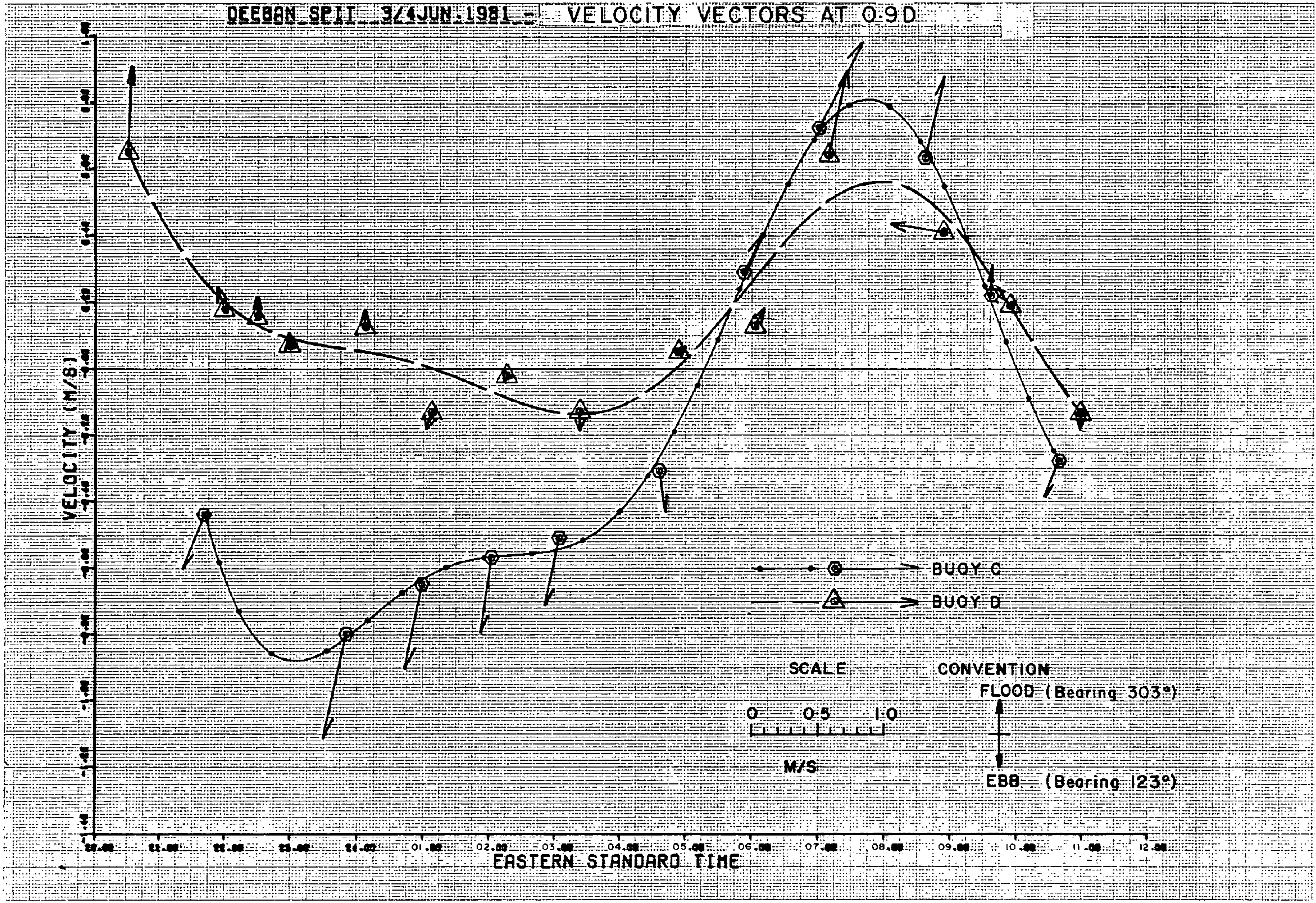


FIG.10

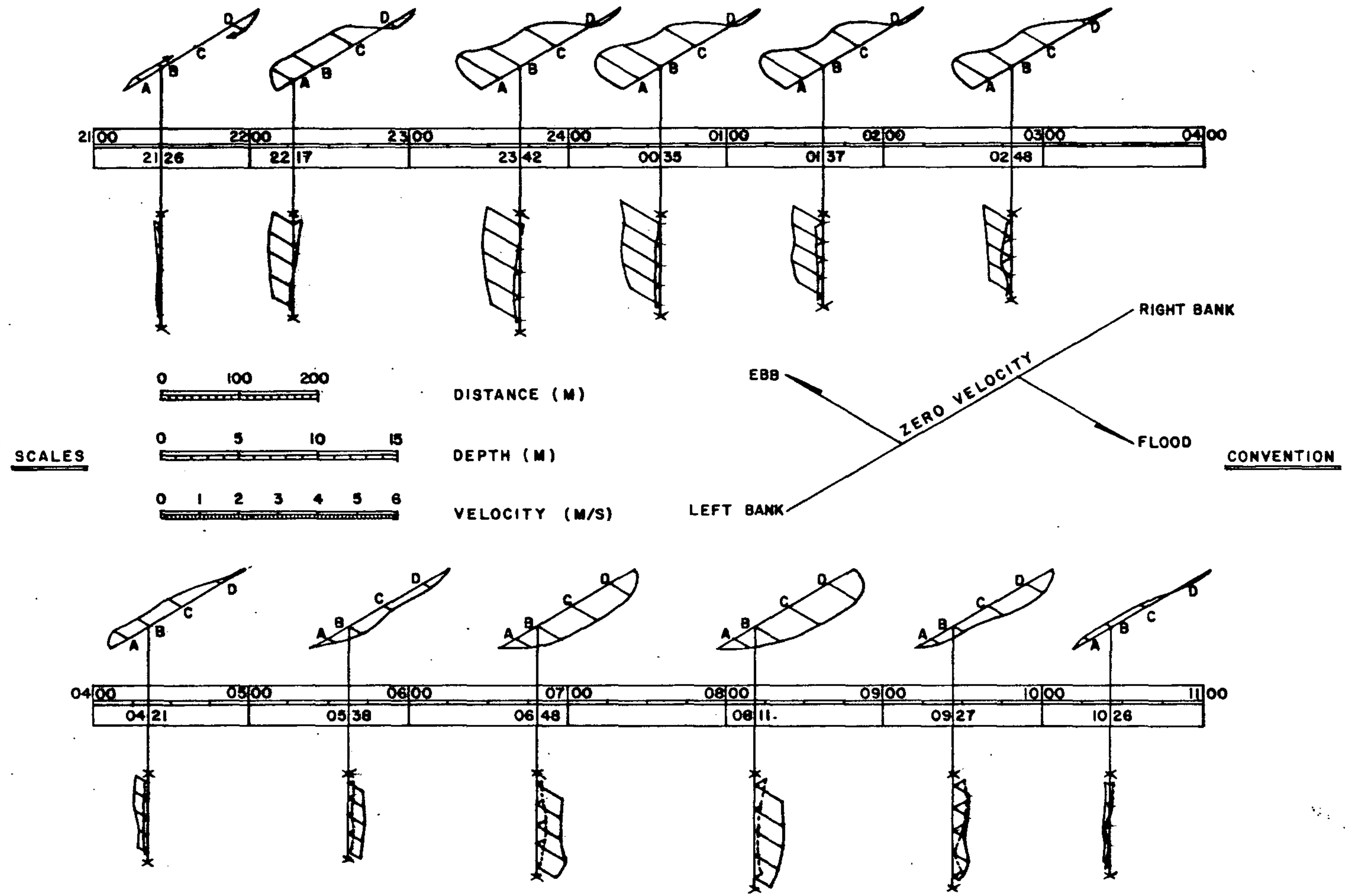


FIG.11

DEEBAN SPIT
PORT HACKING 3, 4 JUNE 1981 E.S.T.
INSTANTANEOUS VELOCITY PROFILES

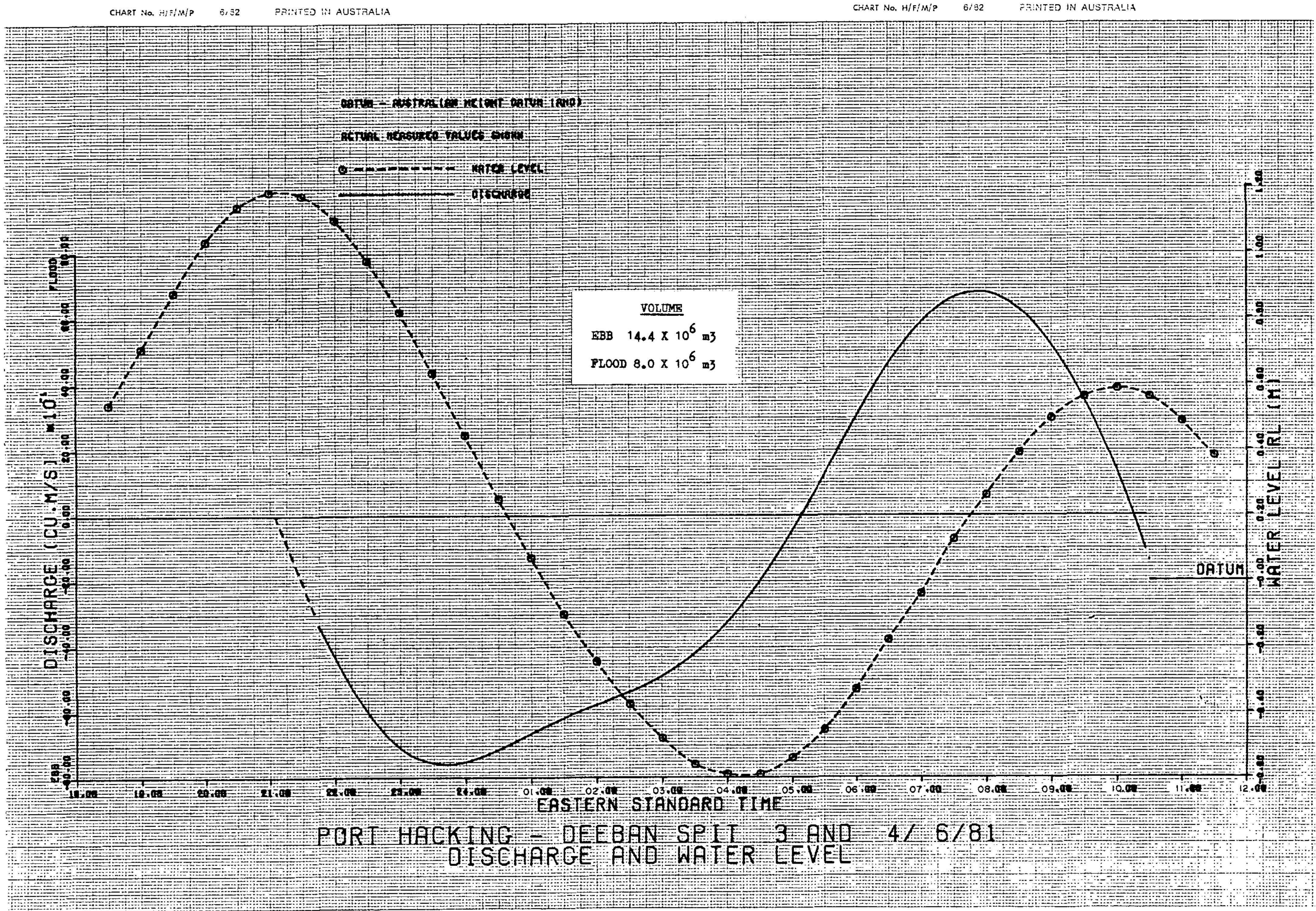


CHART No. H/F/M/P 6/82 PRINTED IN AUSTRALIA
DATUM - AUSTRALIAN HEIGHT DATUM (AHD)
ACTUAL MEASURED VALUES SHOWN
WATER LEVEL
DISCHARGE
VOLUME
EBB 14.4 X 10^6 m3
FLOOD 8.0 X 10^6 m3
DISCHARGE (CU.M/S) x10^1
FLOOD
WATER LEVEL RL (M)
DATUM
EASTERN STANDARD TIME
PORT HACKING - DEEBAN SPIT 3 AND 4/ 6/81
DISCHARGE AND WATER LEVEL

FIG.12

— Camp Cove.

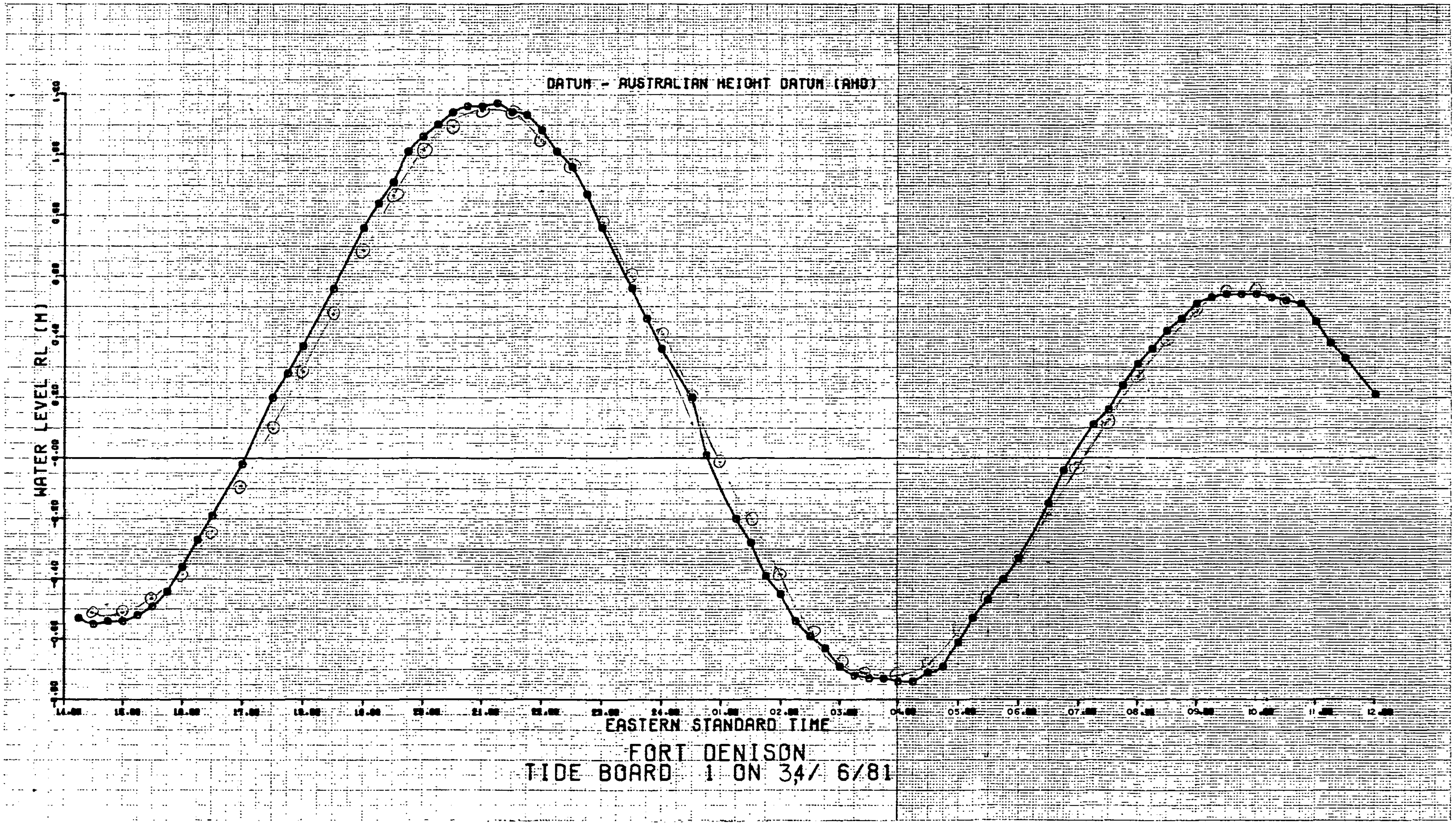
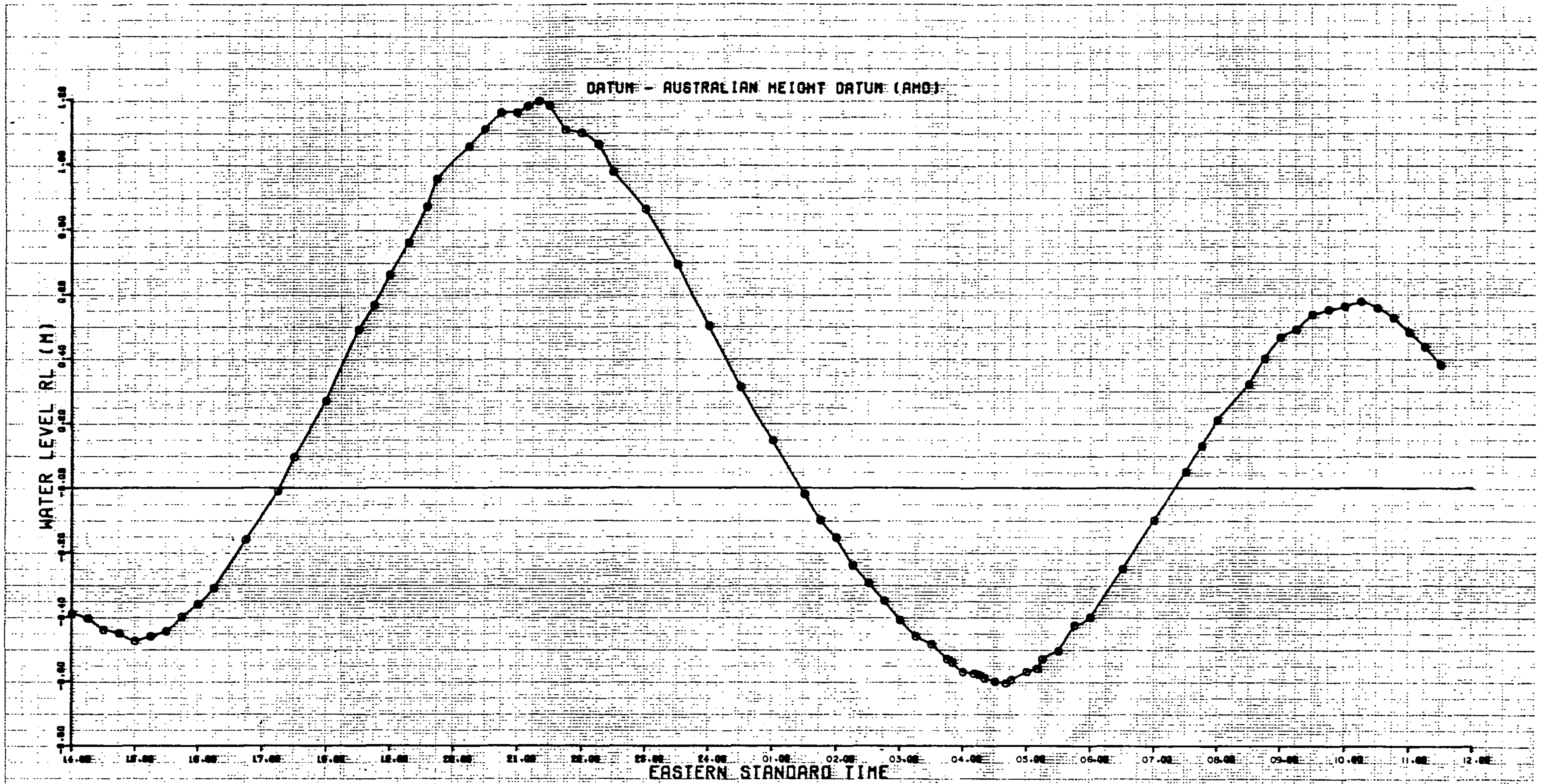


FIG.13



PORT HACKING - TURRIEL POINT
TIDE BOARD 2 ON 3,4/ 6/81

FIG.14

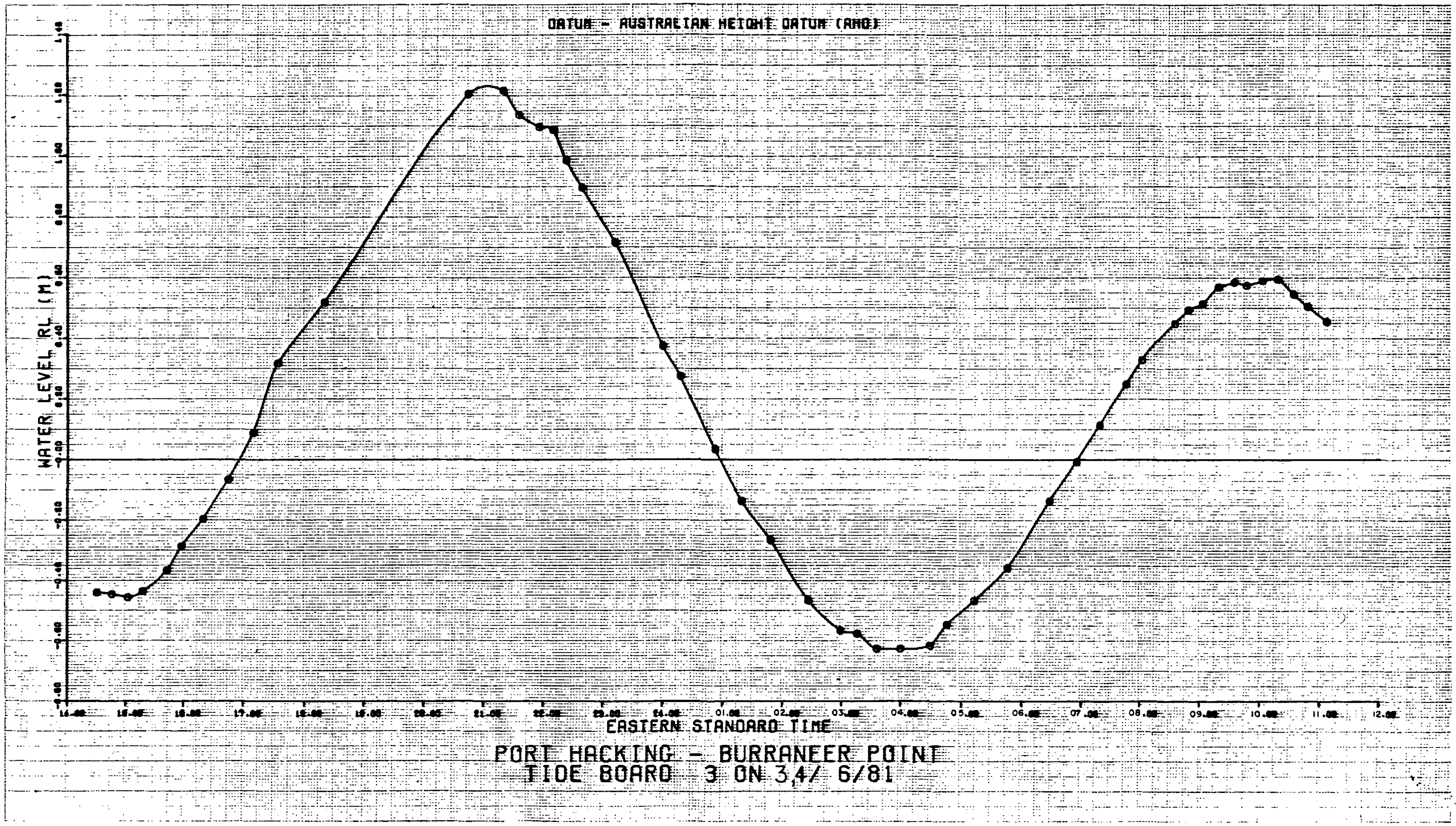

DATUM - AUSTRALIAN HEIGHT DATUM (AHD)
WATER LEVEL RL (M)
EASTERN STANDARD TIME
PORT HACKING - BURRANEER POINT
TIDE BOARD 3 ON 3,4/ 6/81

FIG.15

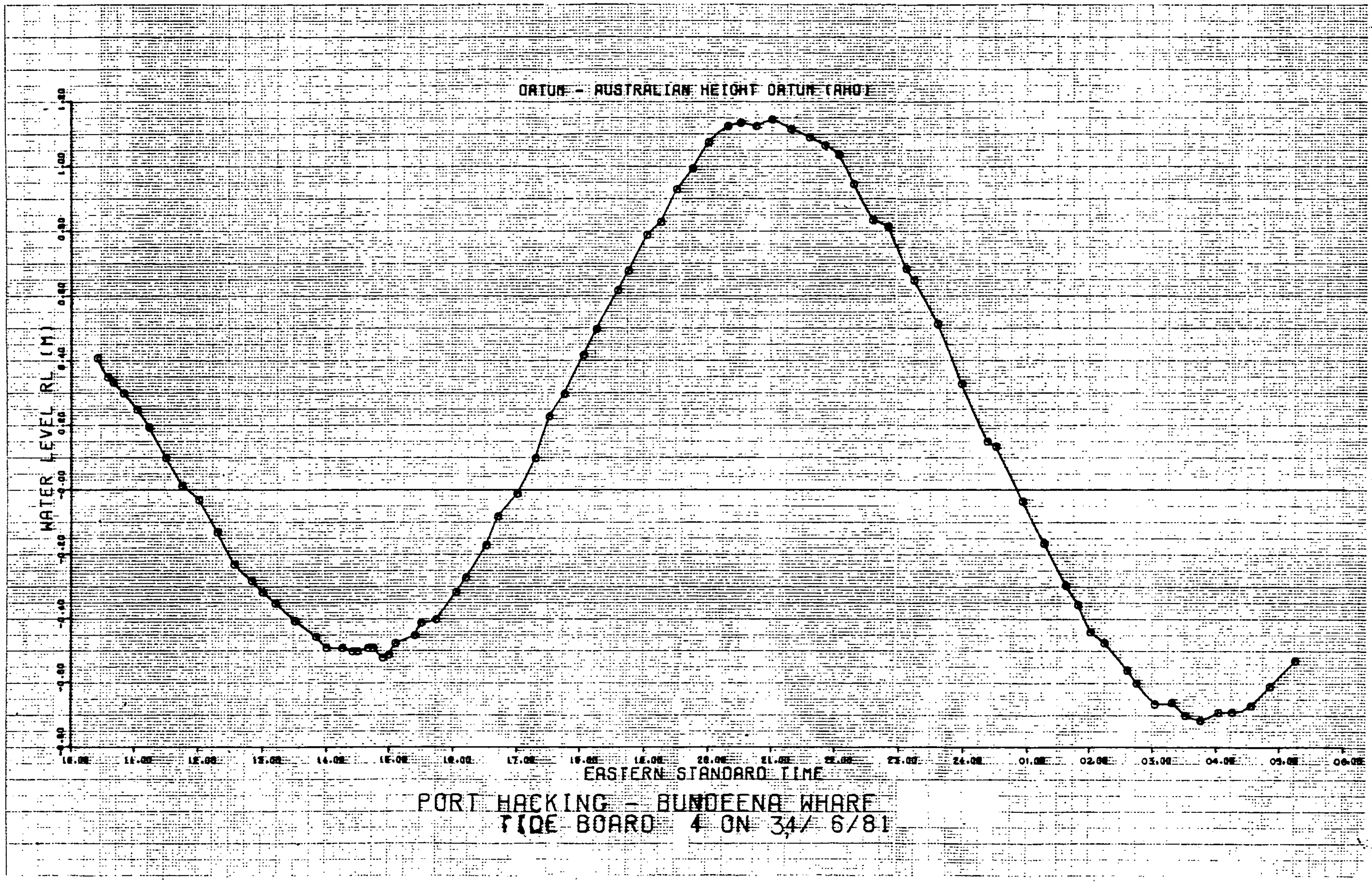
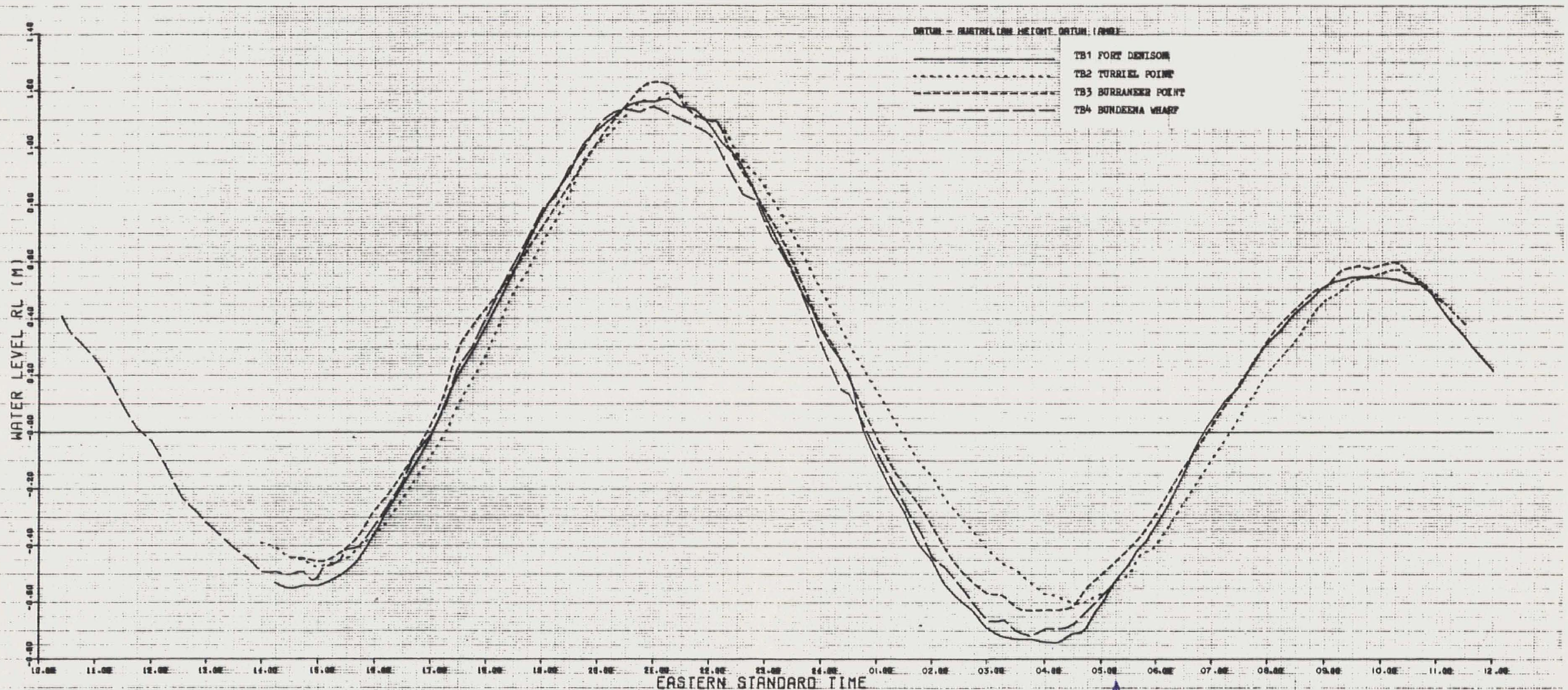

DATUM - AUSTRALIAN HEIGHT DATUM (AHD)
WATER LEVEL RL (M)
EASTERN STANDARD TIME
PORT HACKING - BUNDEENA WHARF
TIDE BOARD 4 ON 34/ 6/81

FIG.16



PORT HACKING 34/ 6/81
COMPARISON OF WATER LEVELS

BUNDEENA WHARF TERMINATES.

FIG.17