DGIS/DANIDA

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MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

TECHNICAL NOTE MES-015

SURVEYS IN BAY OF BENGAL

August 1998

DHV CONSULTANTS BV

in association with

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DANISH HYDRAULIC INSTITUTE

DEVELOPMENT DESIGN CONSULTANTS
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Technical Note on:

SURVEYS IN BAY OF BENGAL
WATER LEVEL AND BATHYMETRIC MEASURENTS

Dhaka, December 1997

Project Name	:	Meghna Estuary Study (MES)
Location	:	Bay of Bengal inside MES Project Area
Key words	:	Water levels measured with sensors
		Prediction of water levels throughout the survey area
		Calculation and interpolation of bed levels

TABLE OF CONTENTS

1 INTRODUCTION

The survey ship "the Anwesha" carried out cruise 3 from the first of January until the thirteenth of January. It was not possible to measure the bottomlevel in respect to PWD, because there are no reference stations in this area. The survey ship "the Anwesha" measured only the waterdepth during cruise 3. If the waterlevel in respect to PWD is known, the bottomlevel in respect to PWD can be calculated. This report describes:

- the long term waterlevel measurements at seven locations;
- and the analysis of four waterlevel sensors, which are used to calculate the bottomheight in respect to PWD at the location of cruise 3.

The locations of the four sensors, mes1, mes2, mes4 and se, are given in figure 1. The data of the bottomheight at the location of cruise 3 will used to setup a hydrodynamical model of the MES area (Meghna Estuary Study area).

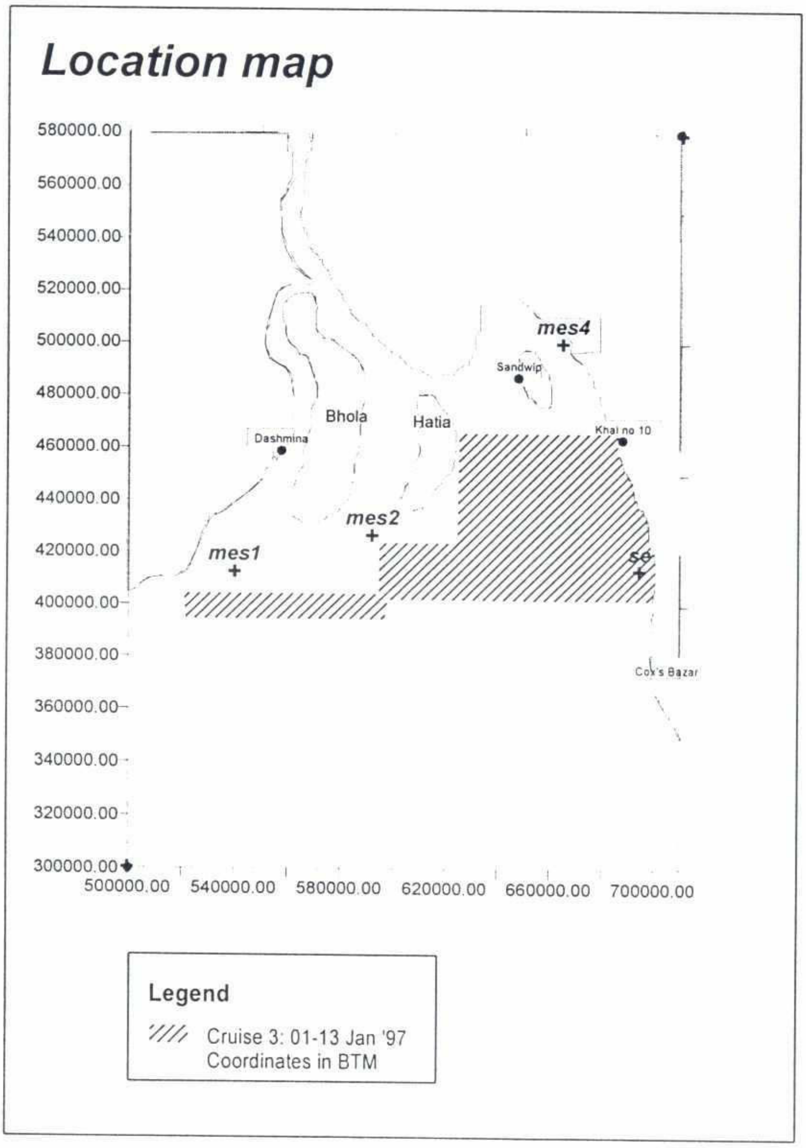
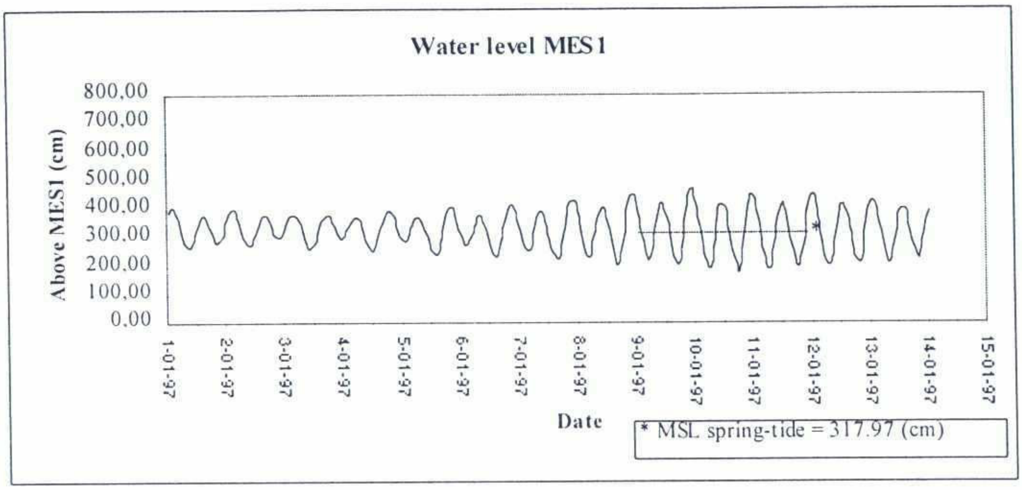
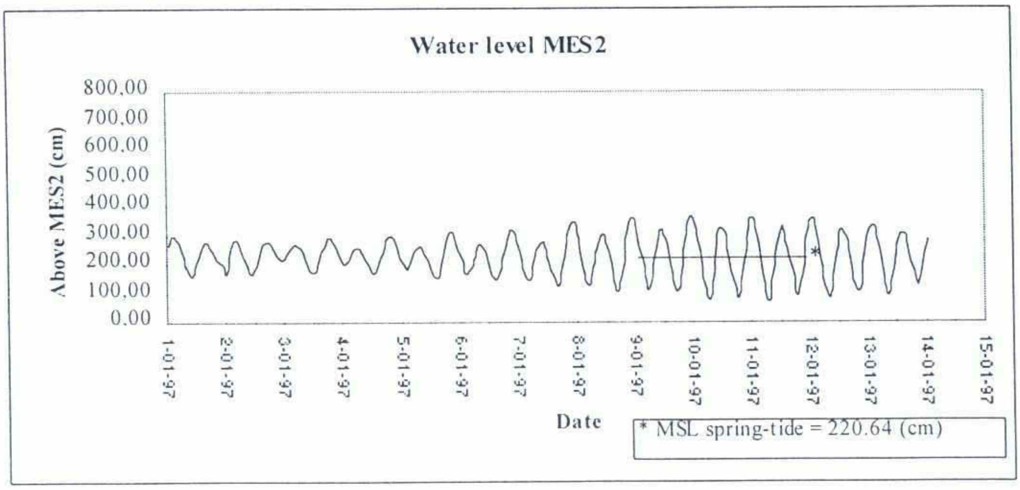


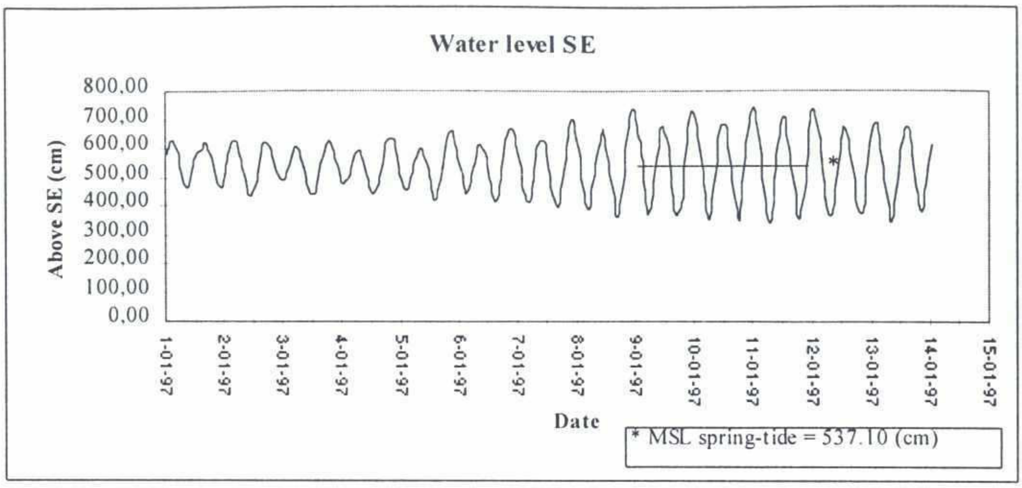
Figure 1: location map.

2 THE MEASUREMENTS OF THE WATERLEVEL SENSORS

After every two hours a measurement with a duration of ten minutes and a frequency of 2 Hz was carried out by the sensors. Because we are only interested in the tidal waterlevel variation, the average over that ten minutes measurement has been calculated. This value has been corrected for the air pressure, because the sensor registers the pressure above it and that includes the air pressure. Two different air pressure stations have been used, the Feni regulator and the Nijhum Dwip station. The results of the measurements are given in annex 6. The Nijhum Dwip station has been used for the air pressure correction at sensor Mes1, Mes2 and Se. The Feni regulator has been used for sensor Mes4. After this analysis the waterlevel above the sensor is known for every two hours. The results are given in figure 2.







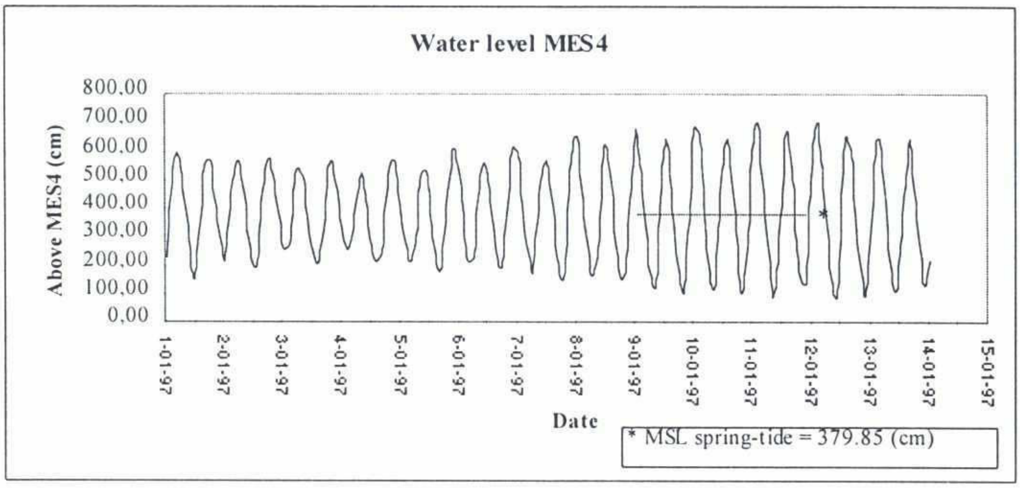


Figure 2: waterlevel above the sensor.

Figure 2 represents the waterlevel above the sensor at the location of the sensor. For further analysis it is necessary to know the waterlevel at the location of the sensor in respect to the reference level PWD. Because the sensor height in respect to P.WD is not known or not accurate enough, an interpolation has been used. Some data were available of some reference stations in the neighbourhood. The reference stations are represented by a dot in figure 1. The waterlevels have been measured in respect to Chart datum at the location of the reference stations. To compare the waterlevels of the reference stations with the waterlevels of the sensors, the waterlevels have been converted to PWD datum. The correction factors to convert the waterlevels from Chart datum to PWD datum are given in annex 1. The waterlevels at the location of the reference stations are all converted to PWD. After that the average was calculated over a three day period, 9-11 January. This value is the mean sea level during spring-tide in respect to PWD. In figure 3 the waterlevel above sensor mes1 is given and the waterlevel in respect to PWD is given for the reference station Dashmina. The two straight lines represent the mean sea level during spring-tide. The mean sea level of Dashmina is given in respect to PWD. The mean sea level of sensor mes1 is a mean sea level above sensor mes1.

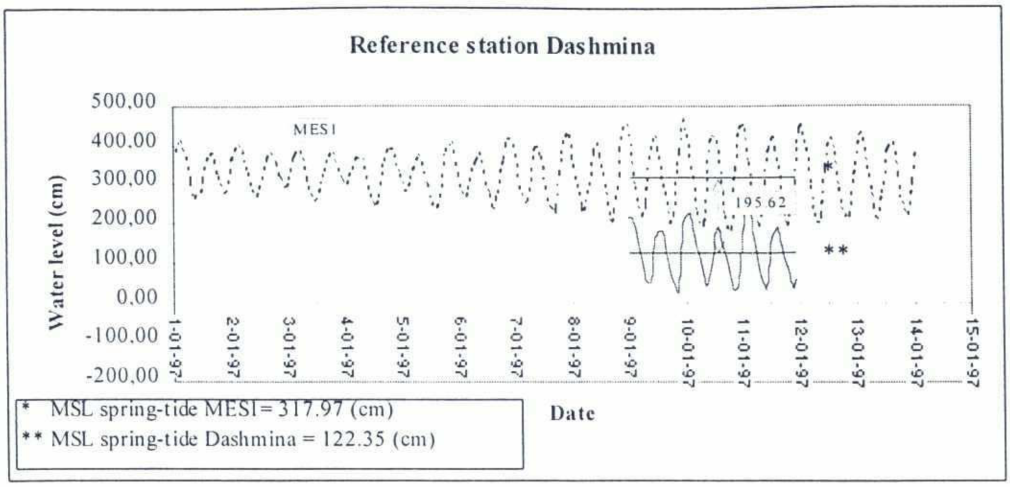


Figure 3: waterlevel above sensor mes1 and the waterlevel at Dashmina in respect to PWD.

By using the values of the mean sea level during spring-tide of the four reference stations, the value of the mean sea level in respect to PWD at the location of the sensors could be predicted. The mean sea level of the four reference stations during spring-tide are given in table 1.

Reference stations	
	Mean sea level during spring tide (cm, PWD)
Chandpur	161.00
Khal no. 10	84.1
Sandwip	122.97
Dashmina	122.35

Table 1: mean sea level at the reference stations (9-11 January).

Between those four reference station a mean sea level plane has been interpolated by using a Kriging interpolation method. This method is distance weighted method. That means that a reference station far away from a point is less important to predict the value of that point than a reference station in the direct environment of that point. It was also possible with the Kriging interpolation method to search datapoints in an ellipse and not in a circle. This results in a pattern similar with the pattern of the tidal waves. The choice for a ellipse search radius has been made because the tidal waves approach from one direction, namely from the South. The result of the Kriging anisotropy interpolation is given in figure 4, assuming a mean sea level far in the sea (South) of 46 cm. Now it is possible to read down the mean sea level in respect to PWD at the location of the four sensors. Those values are also given in figure 4.

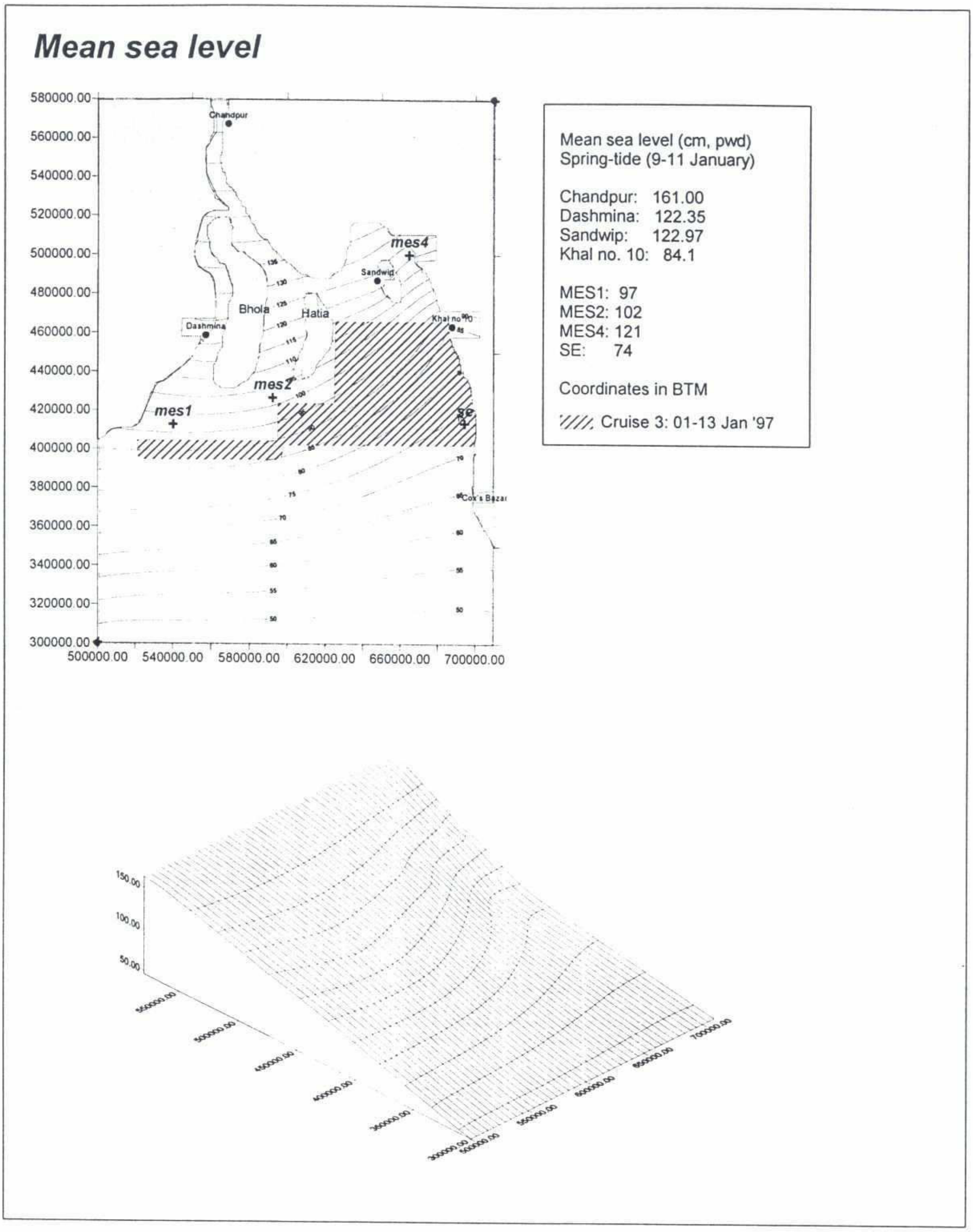


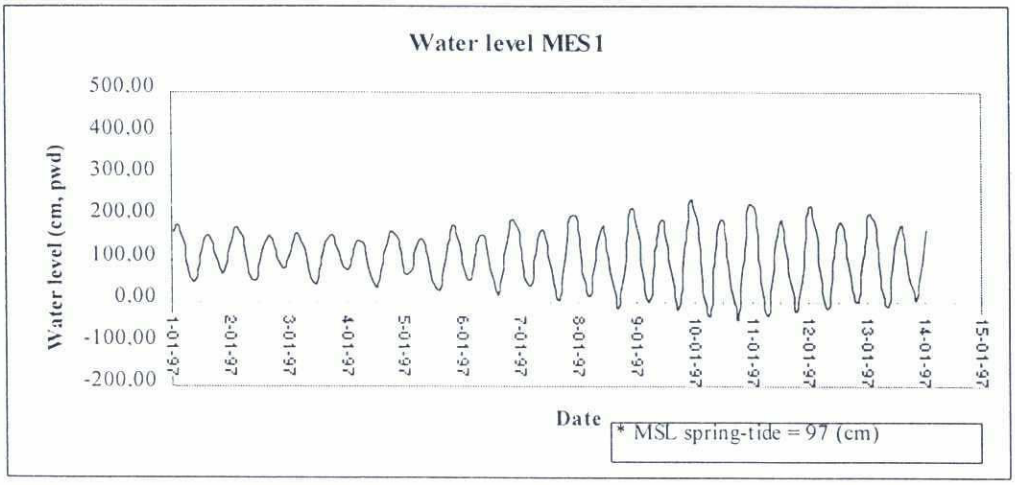
Figure 4: the interpolation of mean sea level plane between the four reference stations during spring-tide.

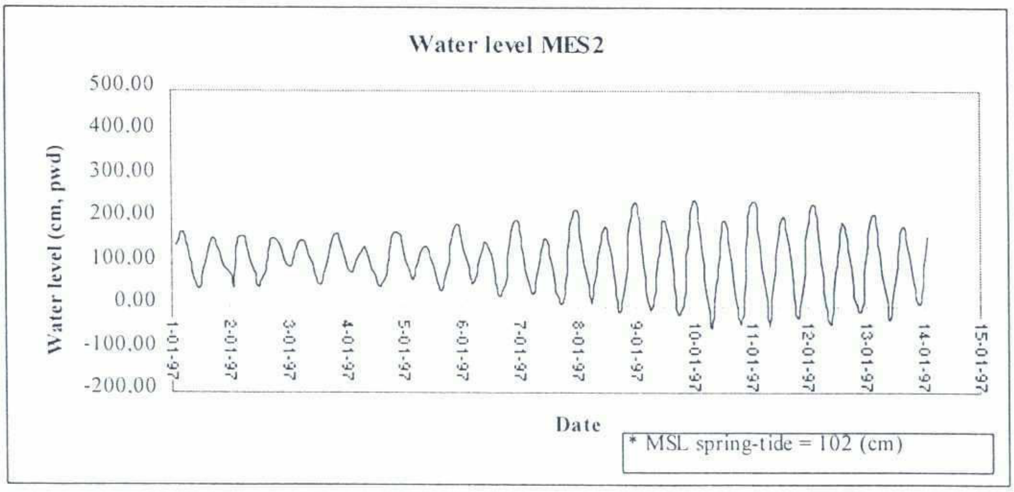
Due to this interpolation the mean sea level at the location of the four sensors is known in respect to PWD. The mean sea level above the sensor was already calculated, see figure 3. This has been done for all the four sensors and the results are given in table 2. Table 2 contains also the results of the interpolation, this is the mean sea level at the location of the sensor in respect to PWD. The fourth column represents the correction value to calculate the waterlevels from waterlevels above the sensor to waterlevels in respect to PWD at the location of the sensor.

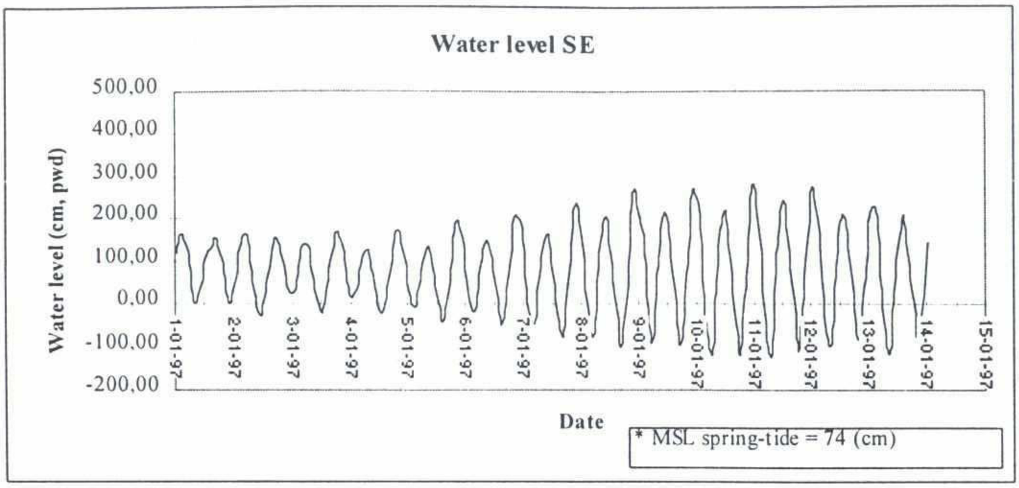
Mean sea level sensor (MSL)			
	MSL above sensor (cm)	*MSL in respect to PWD (cm)*	*Correction (cm)*
MES1	317.97	97	-220.97
MES2	220.64	102	-118.64
SE	537.10	74	-463.10
MES4	379.85	121	-258.85

Table 2: the mean sea level above the sensor and in respect to PWD at the location of the sensors.

After this analysis the waterlevel at the locations of the four sensor is known for every two hours in respect to PWD. The results are given in figure 5.







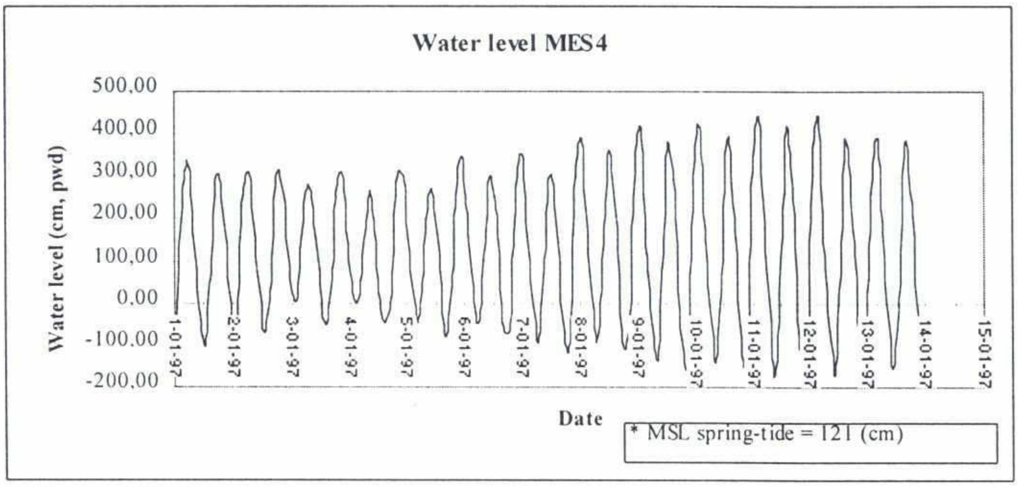


Figure 5: the waterlevels at the locations of the four sensors in respect to PWD.

3 THE PREDICTION OF THE WATERLEVELS AT THE LOCATION OF THE SURVEY AREA

Because the survey ship "the Anwesha" measured every second the waterdepth in the survey area, it was necessary to calculate the waterlevel at the location of the four sensors for every second. By fitting a polynomial function through the curve of the waterlevels in respect to PWD, the waterlevel could be calculated for every second. The polynomial coefficients and the results of the fits are given in annex 2.

After doing this the waterlevel in respect to PWD at the location of the four sensors is known for every second. A program has been written to calculate the waterlevel in respect to PWD at the location of the ship at a particular time. This was done by using an interpolation method between the four waterlevel sensors. An inverse distance interpolation has been used. That means that a sensor far away from the ship is less important than a sensor in the direct environment of the ship,see annex 3. For example the ship was at one time (2-1-97, 14.32.05) at one place (654735.78 E, 448734.34 N). The program calculates the waterlevel in respect to PWD at the location of the four sensors at that time by using the polynomial coefficients. The value of the waterlevel at the location of the ship at that time was calculated by using the interpolation method between the values of the waterlevels at the location of the four sensors. After one second the ship is on another place and the waterlevels at the location of the four sensors have been calculated and interpolated again.

Annex 3 gives a illustration of the waterlevel at the location of the sensors and the predicted waterlevel at the location of the ship. Two files are analysed, one in the South and one in the North of the survey area of cruise 3. The first graph represents the location of the ship in the South and the four sensors. The second graph represents the distance from the ship to the four sensors changing in time. The third graph represents the waterlevel at the location of the four sensors and the waterlevel at the location of the ship, varying in time. The last three graphs in annex 3 represent the analysis of the file located in the North of the study area. Obvious is that, when the distance from ship to sensor is small, the waterlevel at the location of the ship is nearly the same as the waterlevel at the location of the sensor. This means that a sensor close to the ship is more important than a sensor far away.

Figure 6 gives a illustration of the measured waterlevel at Khal no. 10 and the predicted waterlevel at Khal no. 10 by using the inverse distance interpolation method between the sensors. The predicted waterlevel at Khal no. 10 is given at the time of the measurements. This graph gives a illustration of the accuracy of the interpolation method. The mean inaccuracy of the interpolation method is 13 cm over three days with a standard deviation of 42 cm.

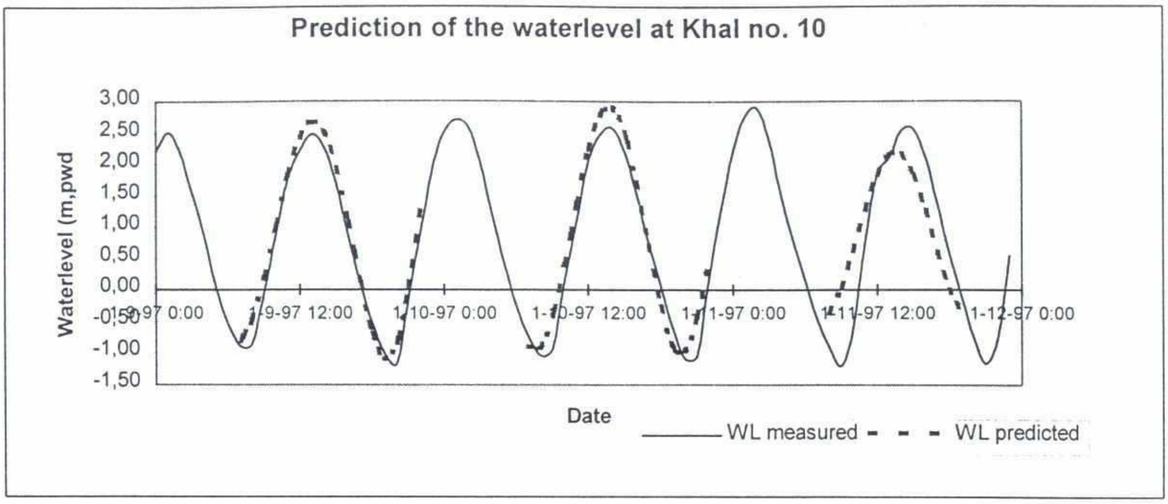


Figure 6: The measured and the predicted waterlevel at Khal no. 10

4 THE CALCULATION OF THE BOTTOMHEIGHT AND THE INTERPOLATION OF THE RESULTS

Because the waterdepth was measured by the "Anwesha" and the waterlevel in respect to PWD has been calculated, it is easy to calculate the bottomheight in respect to PWD. Subtract the waterdepth from the waterlevel in respect to PWD and the bottomheight in respect to PWD is remaining. This has been done for all the measurements carried out by the survey ship "the Anwesha". The measurements are carried out in lines from East to West or from West to East. The bottomheight between the lines has been calculated by using a kriging interpolation method in the program surfer. A gridsize of 1000 meter has been used. A map with the results from the interpolation is given in annex 4. The map includes also the bathymetry measurements of cruise 4, 5, 6, 7, 11, 12 and 13.

5 LONG TERM WATERLEVELMEASUREMENTS

Six waterlevel sensors carried out measurements at seven locations from December 1996 until February 1997. One sensor, sensor Mes4, measured from December 1996 until April 1997. The values from the measurements are corrected for the varying air pressure. The air pressure station at Nijhum Dwip has been used for the correction at the location of sensor Mes1, Mes2, Mes3 and Se. For the sensors Mes4, Mes5 and Mes6 the air pressure station at the Feni regulator has been used for the correction. The results are given in annex 5. Annex 5 includes also a map with the location of the six sensors. Sensor Mes3 was located at the location of Mes3 until January 1997. And was replaced to the location of SE at 1/1/97.
Obvious is that the tidal range at the location of sensor Mes1 and Mes2 is much lower than the tidal range at the location of sensor Mes4 and Mes5.

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ANNEX 1

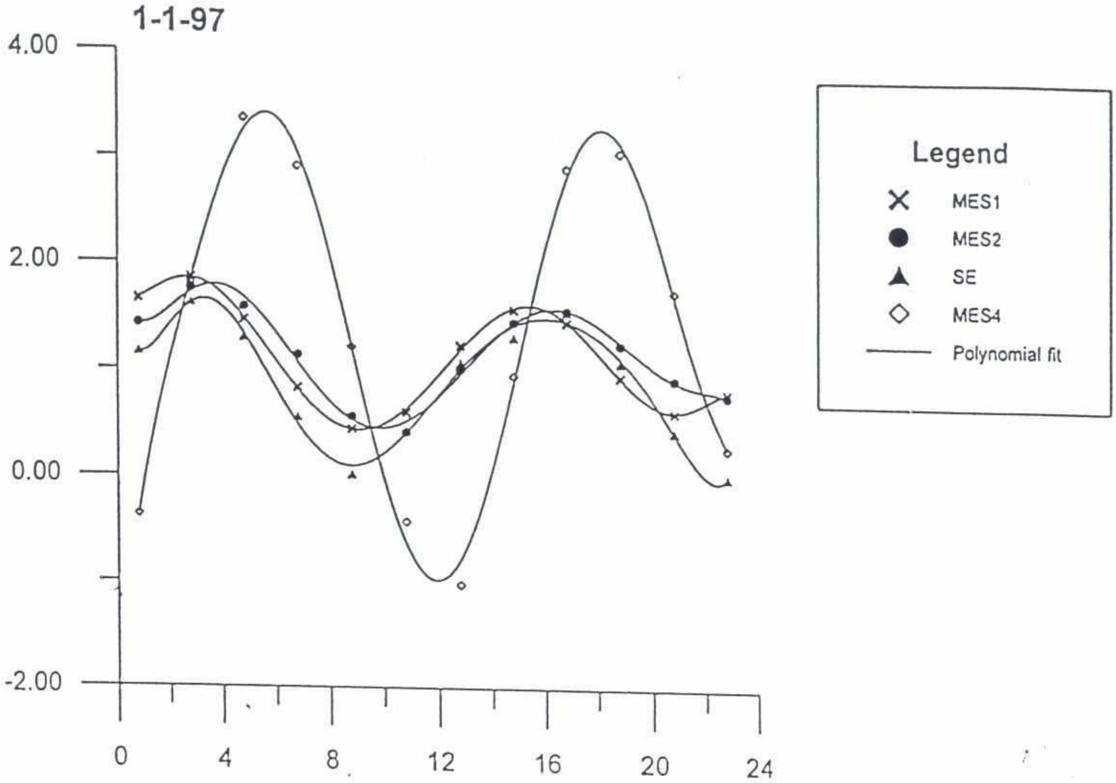
The correction factors to calibrate the waterlevels from Chart datum to PWD:

Reference stations			
	Chart datum (CD)	*PWD*	*Correction factor*
	meter below benchmark	*meter below benchmark*	
Chandpur	5.81	6.06	+0.25
Khal no. 10	6.48	5.14	-1.35
Sandwip	6.93	5.22	-1.71
Dashmina	given in PWD		

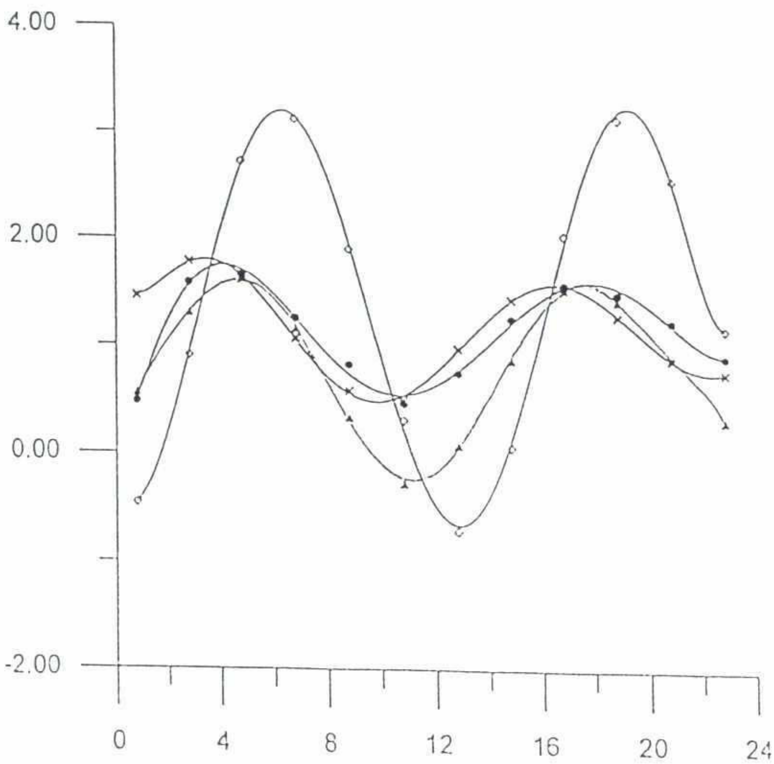
ANNEX 2

The fitting of the polynomial function.

1-1-97



2-1-97



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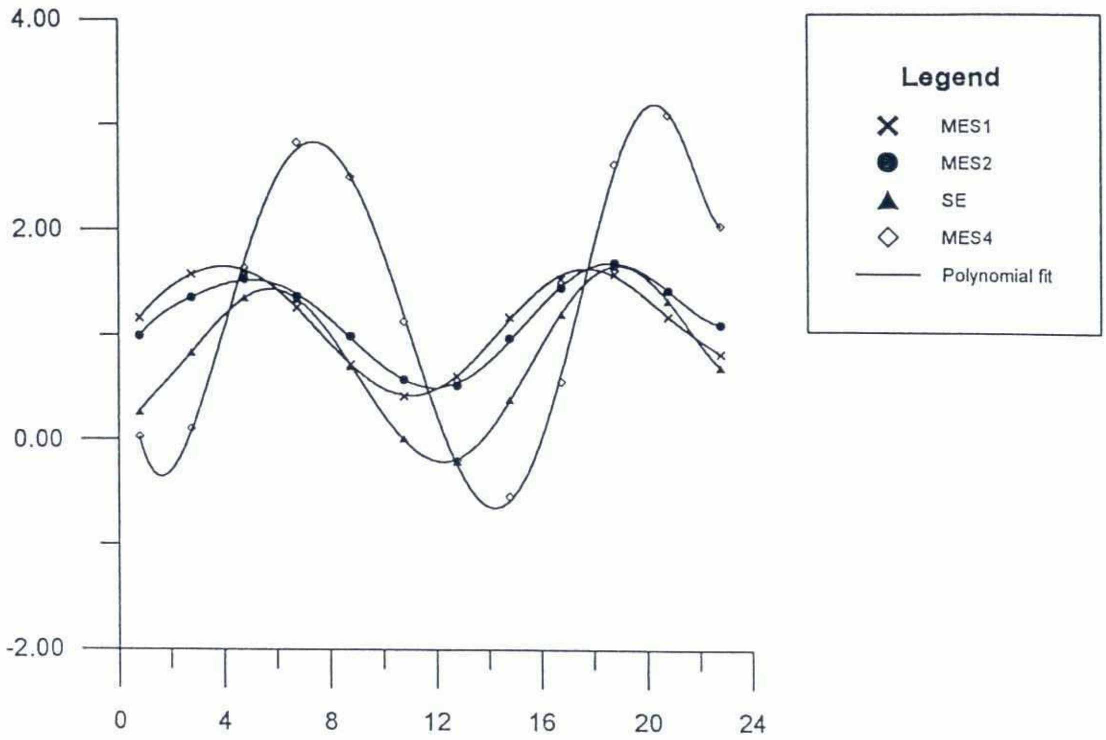
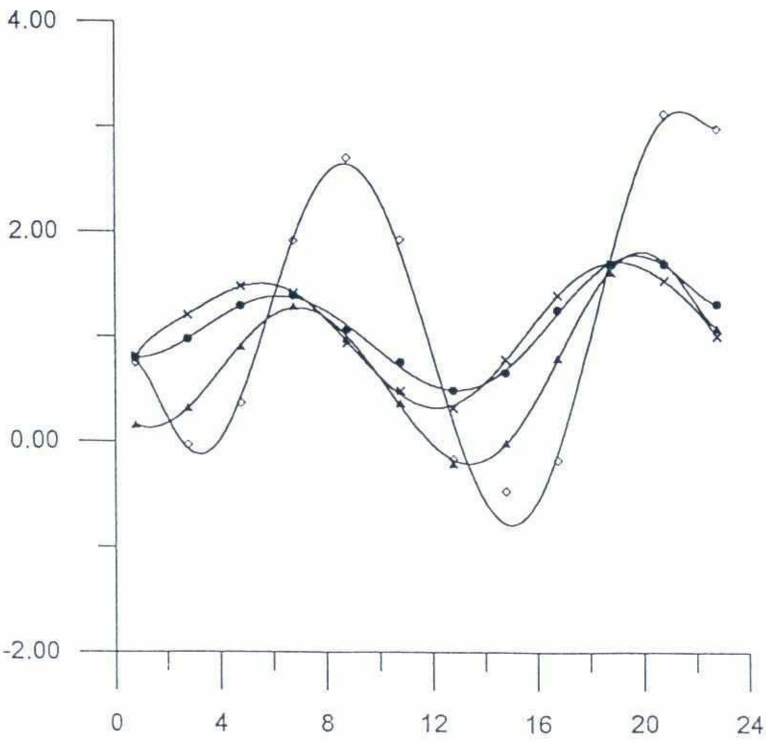
3-1-97



4.00
2.00
0.00
-2.00
0
4
8
12
16
20
24
Legend
MES1
MES2
SE
MES4
Polynomial fit

4-1-97



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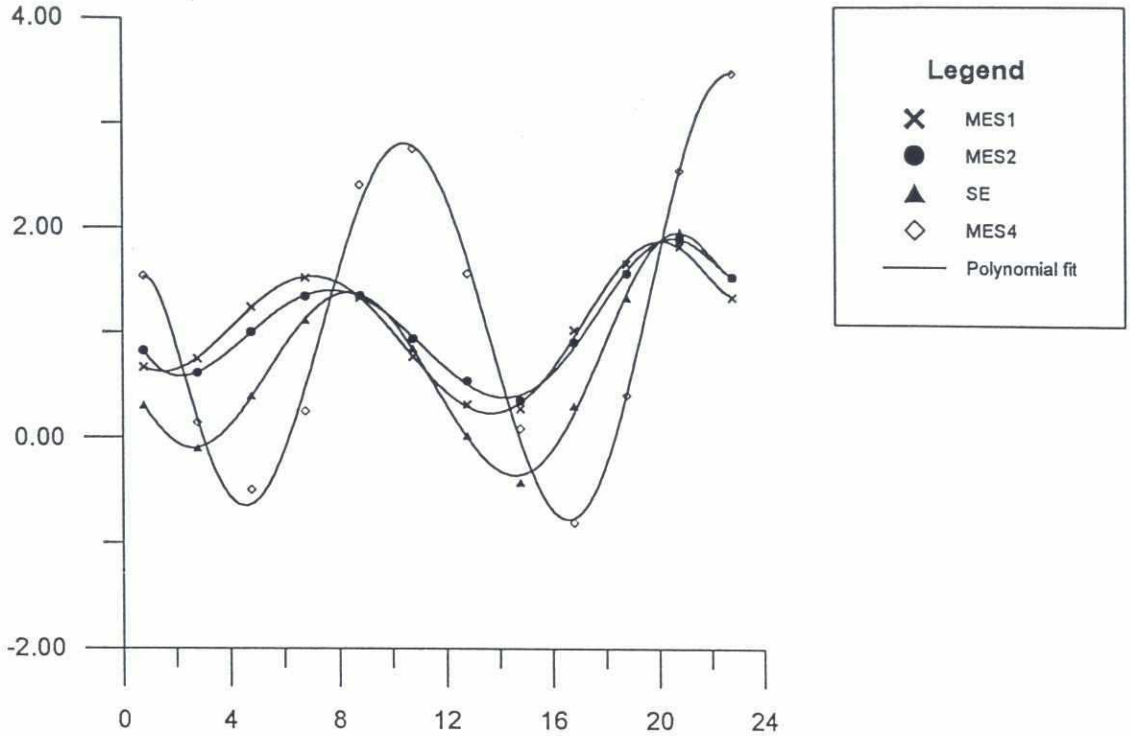
5-1-97


4.00
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0.00
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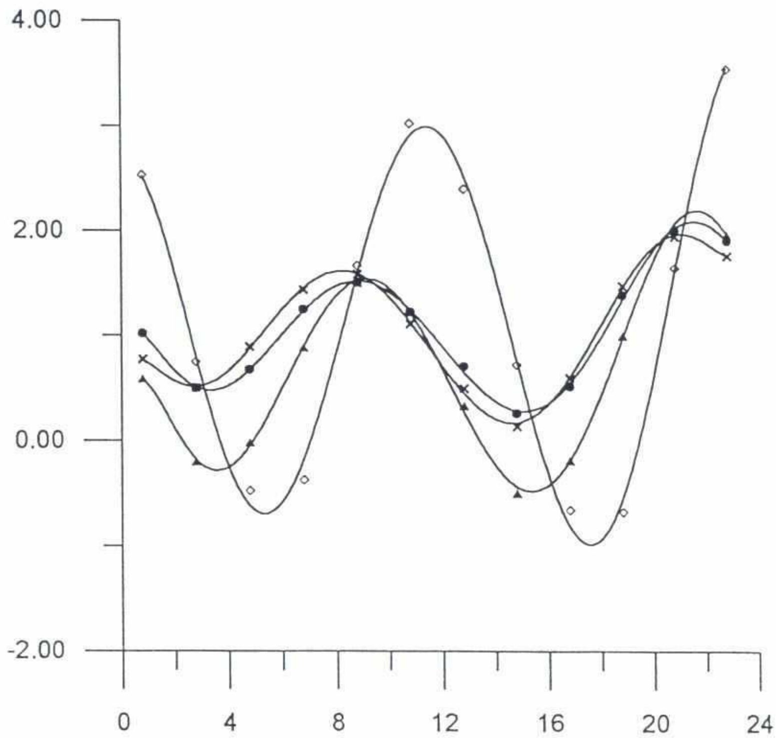
Legend
MES1
MES2
SE
MES4
Polynomial fit

6-1-97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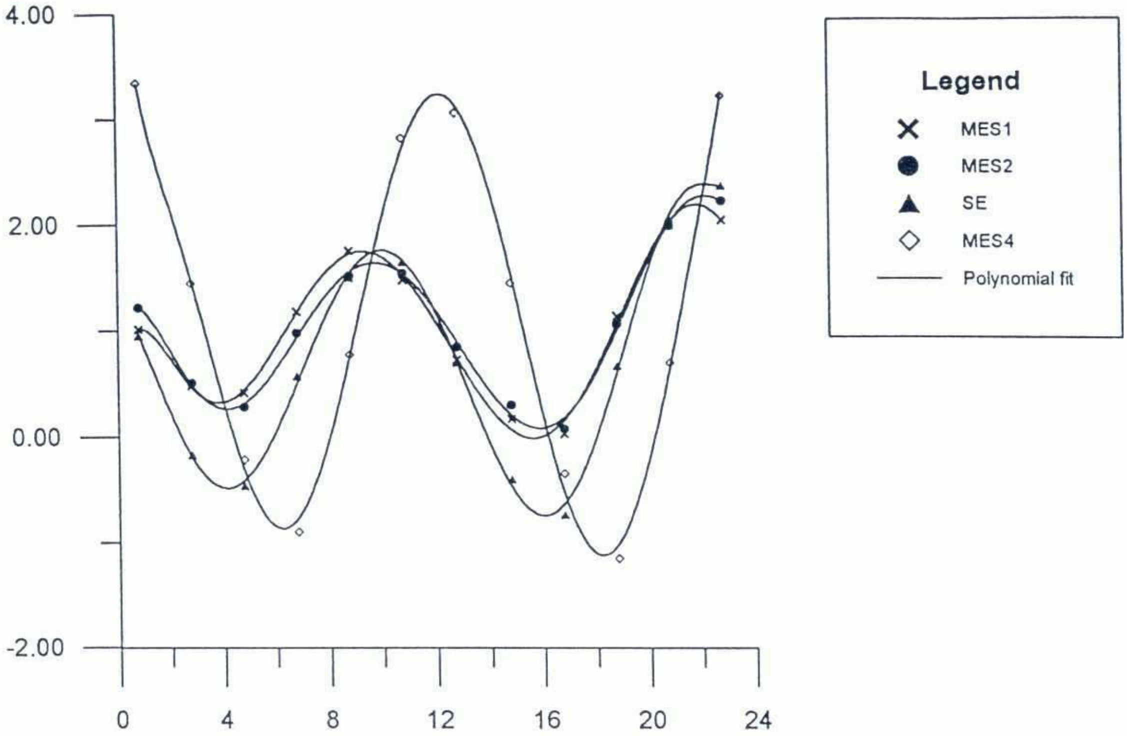
7-1-97



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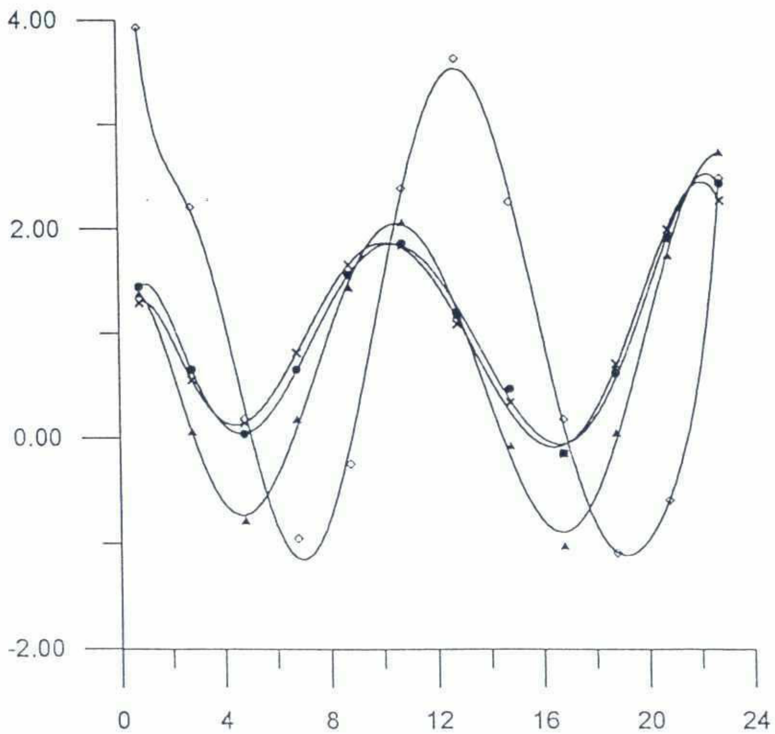
Legend
MES1
MES2
SE
MES4
Polynomial fit

8-1-97



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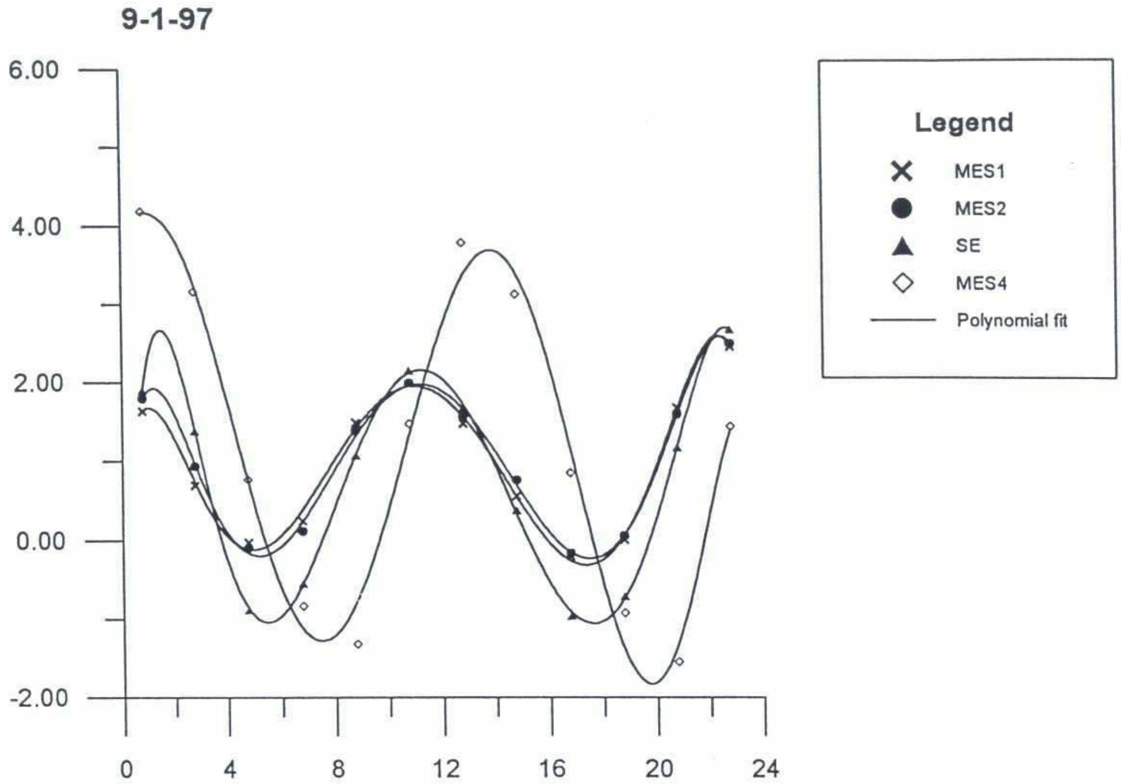
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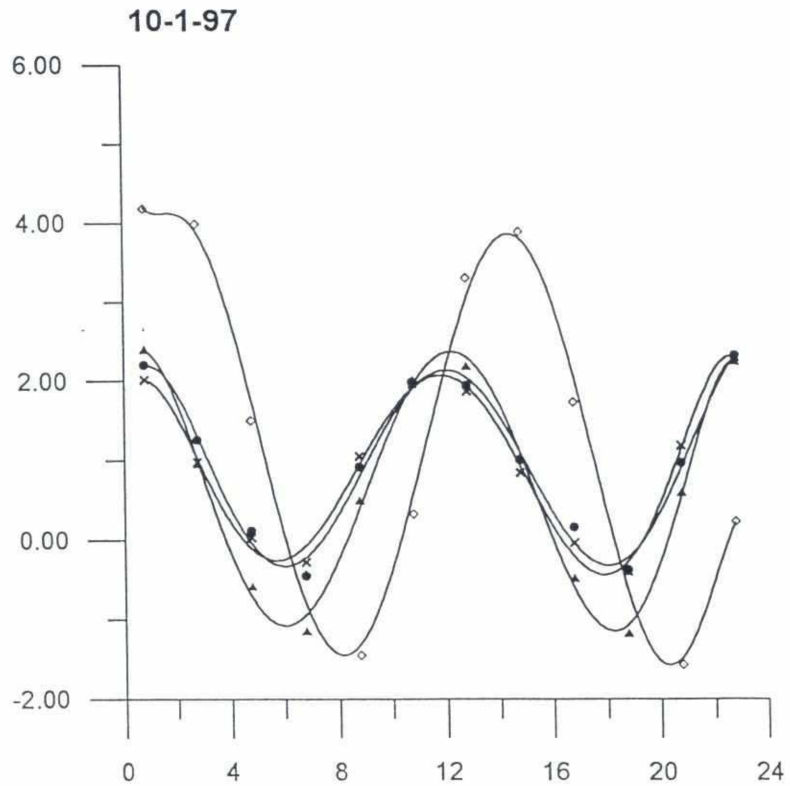
Legend
MES1
MES2
SE
MES4
Polynomial fit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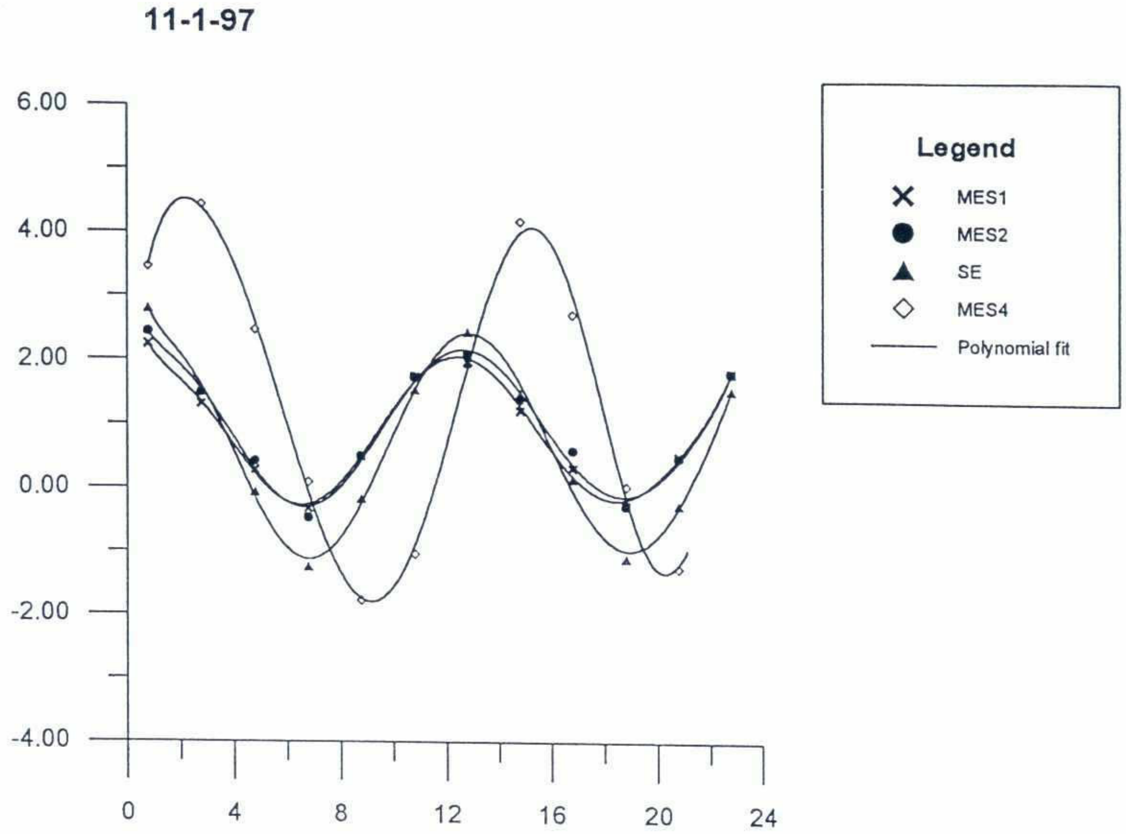
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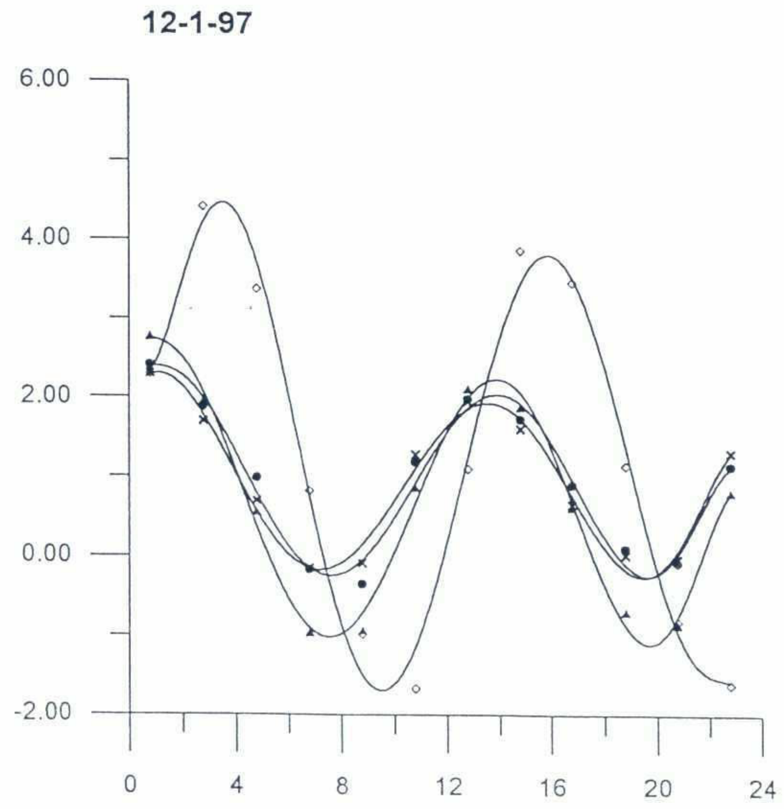
MES1
MES2
SE
MES4
Polynomial fit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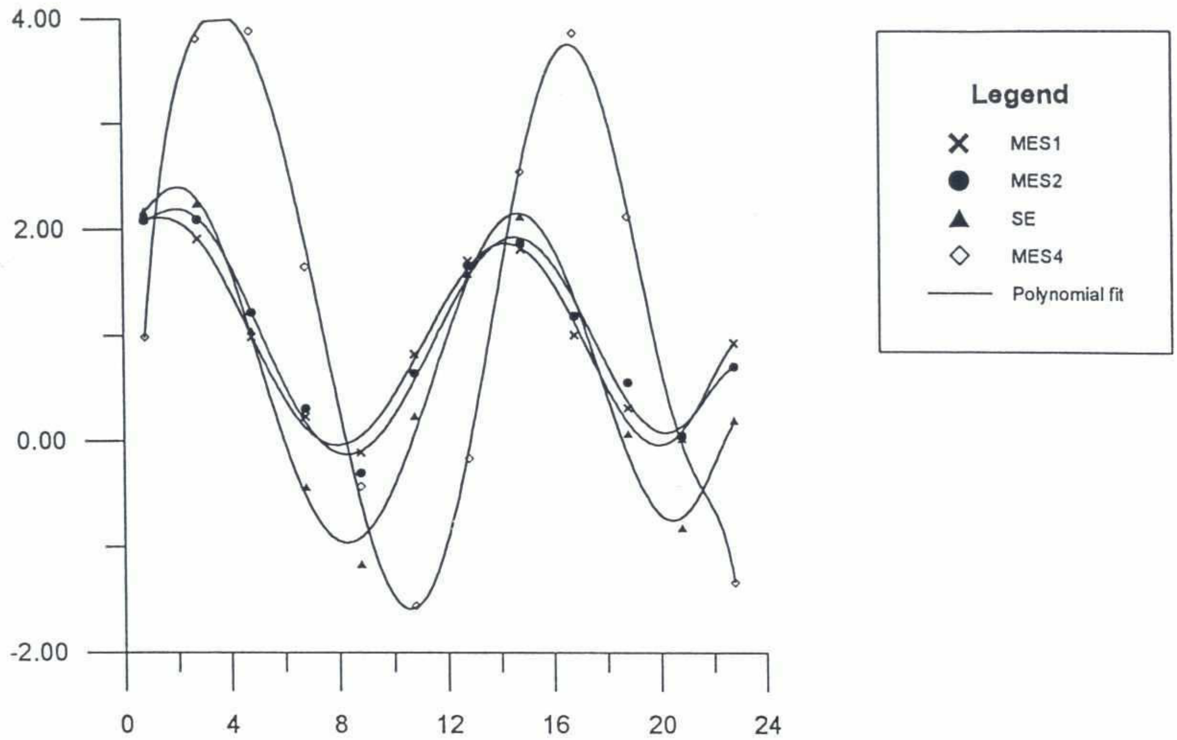
13-1-97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Legend
MES1
MES2
SE
MES4
Polynomial fit

Polynomial function:	$Y = a_0+a_1X+a_2X^2+...a_nX^n$ Y: water level X: time a: polynomial coefficient							
	MES1		MES2		MES4		SE	
		coefficient		coefficient		coefficient		coefficient
Day	1-1-97		1-1-97		1-1-97		1-1-97	
Number of coefficients (n)	9		8		9		9	
Coefficient number (a_n)	0	1.6112000000	0	1.7410800000	0	-2.1352900000	0	1.6582700000
	1	-0.0594958000	1	-0.7731770000	1	3.0939000000	1	-1.3506400000
	2	0.1990790000	2	0.5976320000	2	-1.3850200000	2	1.1741500000
	3	-0.0766980000	3	-0.1620220000	3	0.4674360000	3	-0.3775030000
	4	0.0098928800	4	0.0195353000	4	-0.0866511000	4	0.0574817000
	5	-0.0005081050	5	-0.0011689700	5	0.0084095300	5	-0.0047169700
	6	0.0000057950	6	0.0000341452	6	-0.0004332870	6	0.0002161770
	7	0.0000003112	7	-0.0000003893	7	0.0000112751	7	-0.0000052380
	8	-0.0000000075			8	-0.0000001168	8	0.0000000525
Number of datapoints (N)		12		12		12		12
R^2		0,9981		0,9856		0,9940		0,9884
Day	2-1-97		2-1-97		2-1-97		2-1-97	
Number of coefficients	8		8		9		9	
Coefficient number	0	1.5816000000	0	-0.1084430000	0	-0.5315900000	0	0.0748531000
	1	-0.4110670000	1	0.7576720000	1	-0.0949150000	1	0.8019300000
	2	0.4094380000	2	0.0254417000	2	0.2034980000	2	-0.3092280000
	3	-0.1205220000	3	-0.0446640000	3	0.0490115000	3	0.1184270000
	4	0.0148961000	4	0.0063329300	4	-0.0208858000	4	-0.0262155000
	5	-0.0008928280	5	-0.0003686490	5	0.0023299700	5	0.0029023500
	6	0.0000258057	6	0.0000097079	6	-0.0001149310	6	-0.0001653130
	7	-0.0000002889	7	-0.0000000949	7	0.0000025881	7	0.0000046736
					8	-0.0000000211	8	-0.0000000521
Number of datapoints (N)		12		12		12		12
R^2		0,9974		0,9867		0,9983		0,9990
Day	3-1-97		3-1-97		3-1-97		3-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	0.8517460000	0	0.6272790000	0	1.3245900000	0	-0.0645529000
	1	0.5004720000	1	0.6487140000	1	-2.4327500000	1	0.5826320000
	2	-0.1652920000	2	-0.2987970000	2	1.1354200000	2	-0.2773050000
	3	0.0509167000	3	0.0926420000	3	-0.1994450000	3	0.1154300000
	4	-0.0110097000	4	-0.0162698000	4	0.0217741000	4	-0.0231792000
	5	0.0012305800	5	0.0015216900	5	-0.0018586100	5	0.0022787400
	6	-0.0000702871	6	-0.0000757635	6	0.0001095200	6	-0.0001155900
	7	0.0000019746	7	0.0000019012	7	-0.0000035206	7	0.0000029204
	8	-0.0000000217	8	-0.0000000189	8	0.0000000450	8	-0.0000000292
Number of datapoints (N)		12		12		12		12
R^2		0,9984		0,9982		0,9983		0,9997

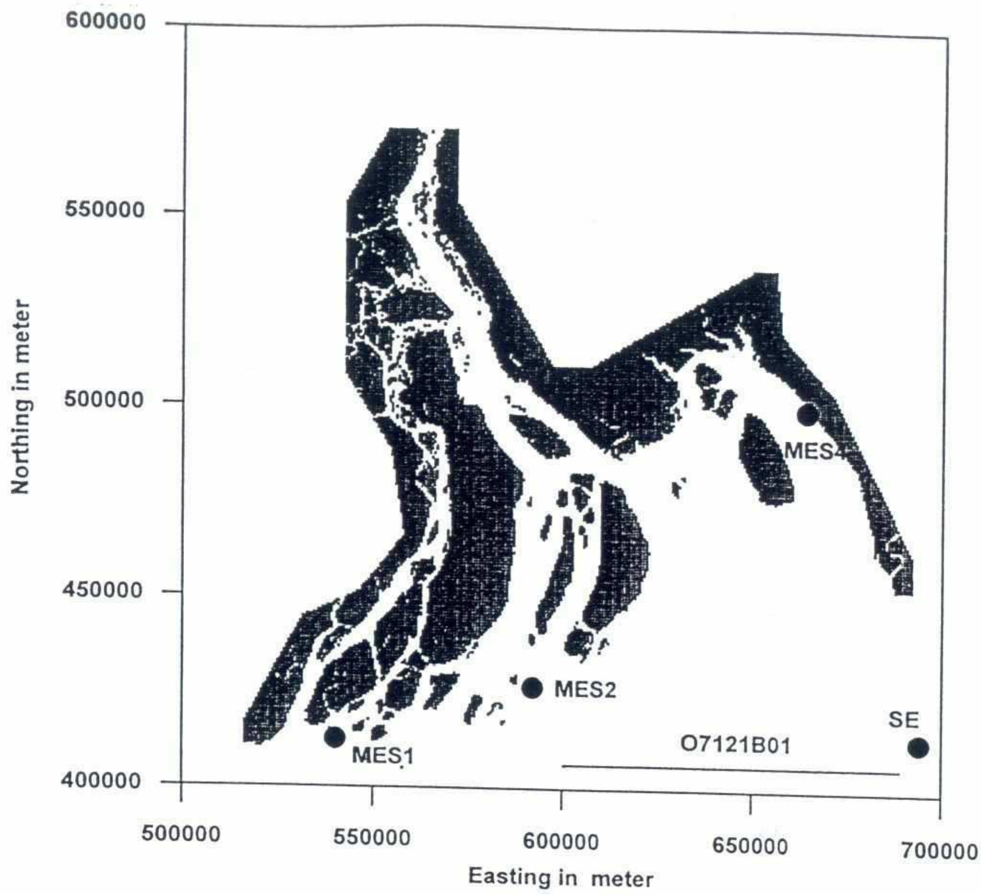
Day	4-1-97		4-1-97		4-1-97		4-1-97	
Number of coefficients	9		8		8		8	
Coefficient number	0	0.3687550000	0	0.8383180000	0	0.4240150000	0	0.2936420000
	1	0.8196230000	1	-0.0978015000	1	1.1625600000	1	-0.2170150000
	2	-0.4303640000	2	0.0531304000	2	-1.2182200000	2	0.0358849000
	3	0.1409160000	3	0.0067433900	3	0.3835010000	3	0.0352517000
	4	-0.0247146000	4	-0.0032871800	4	-0.0511208000	4	-0.0087997800
	5	0.0023000600	5	0.0003323820	5	0.0032961600	5	0.0007600050
	6	-0.0001149780	6	-0.0000133160	6	-0.0001020080	6	-0.0000281691
	7	0.0000029281	7	0.0000001893	7	0.0000012175	7	0.0000003815
	8	-0.0000000299						
Number of datapoints (N)		12		12		12		12
R^2		0,9987		0,9959		0,9872		0,9990
Day	5-1-97		5-1-97		5-1-97		5-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	0.8102360000	0	1.2656800000	0	0.9693240000	0	0.6102560000
	1	-0.2295040000	1	-0.7408880000	1	1.5434700000	1	-0.3617620000
	2	0.0505826000	2	0.2570220000	2	-1.2501300000	2	-0.0796026000
	3	0.0213449000	3	-0.0332842000	3	0.2646110000	3	0.0651341000
	4	-0.0056221500	4	0.0030865100	4	-0.0184363000	4	-0.0092367800
	5	0.0004469200	5	-0.0003296270	5	-0.0001720250	5	0.0004030310
	6	-0.0000129144	6	0.0000248692	6	0.0000762646	6	0.0000055555
	7	0.0000000203	7	-0.0000009168	7	-0.0000032245	7	-0.0000008024
	8	0.0000000033	8	0.0000000126	8	0.0000000430	8	0.0000000148
Number of datapoints (N)		12		12		12		12
R^2		0,9963		0,9967		0,9927		0,9979
Day	6-1-97		6-1-97		6-1-97		6-1-97	
Number of coefficients	8		8		9		8	
Coefficient number	0	0.8158320000	0	1.1320800000	0	2.7554200000	0	0.4641380000
	1	0.1036240000	1	0.0300459000	1	-0.0804404000	1	0.6208650000
	2	-0.2830620000	2	-0.3066430000	2	-0.2623960000	2	-0.7663550000
	3	0.1125000000	3	0.1140400000	3	-0.0348832000	3	0.2365200000
	4	-0.0166482000	4	-0.0158210000	4	0.0260213000	4	-0.0304347000
	5	0.0011395500	5	0.0010254500	5	-0.0036296000	5	0.0018916300
	6	-0.0000366486	6	-0.0000314082	6	0.0002200550	6	-0.0000564047
	7	0.0000004491	7	0.0000003676	7	-0.0000062350	7	0.0000006480
					8	0.0000000677		
Number of datapoints (N)		12		12		12		12
R^2		0,9986		0,9978		0,9940		0,9987

Day	7-1-97		7-1-97		7-1-97		7-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	0.6587210000	0	1.1352700000	0	5.0023600000	0	1.3180400000
	1	0.9747850000	1	0.4599310000	1	-3.1438000000	1	-0.3489320000
	2	-0.8283650000	2	-0.5518820000	2	1.7143100000	2	-0.1830930000
	3	0.2290860000	3	0.1470960000	3	-0.6107380000	3	0.0347246000
	4	-0.0280398000	4	-0.0153008000	4	0.1105220000	4	0.0057279500
	5	0.0016970900	5	0.0006211820	5	-0.0104076000	5	-0.0015600700
	6	-0.0000501347	6	-0.0000000749	6	0.0005234350	6	0.0001219210
	7	0.0000005919	7	-0.0000006178	7	-0.0000133803	7	-0.0000040689
	8	-0.0000000005	8	0.0000000114	8	0.0000001369	8	0.0000000501
Number of datapoints (N)		12		12		12		12
R^2		0,9928		0,9941		0,9964		0,9972
Day	8-1-97		8-1-97		8-1-97		8-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	0.7631320000	0	0.7058210000	0	7.4487400000	0	1.1816500000
	1	1.3486100000	1	1.7639000000	1	-7.1644900000	1	0.8201060000
	2	-1.0411400000	2	-1.2728800000	2	4.3339600000	2	-0.8465420000
	3	0.2586830000	3	0.3088490000	3	-1.3564300000	3	0.1752180000
	4	-0.0287583000	4	-0.0346477000	4	0.2189040000	4	-0.0097961000
	5	0.0015913400	5	0.0020171900	5	-0.0191806000	5	-0.0005076850
	6	-0.0000432742	6	-0.0000624050	6	0.0009265060	6	0.0000758448
	7	0.0000004860	7	0.0000009706	7	-0.0000232601	7	-0.0000028722
	8	-0.0000000009	8	-0.0000000061	8	0.0000002376	8	0.0000000365
Number of datapoints (N)		12		12		12		12
R^2		0,9968		0,9960		0,9971		0,9965
Day	9-1-97		9-1-97		9-1-97		9-1-97	
Number of coefficients	9		9		8		9	
Coefficient number	0	0.8084650000	0	0.4596580000	0	4.1495900000	0	-1.7788200000
	1	1.9651200000	1	2.9337400000	1	-0.0404816000	1	7.4545300000
	2	-1.3968300000	2	-1.8820700000	2	0.2182450000	2	-4.1654800000
	3	0.3331230000	3	0.4373430000	3	-0.2039570000	3	0.9246530000
	4	-0.0377977000	4	-0.0499904000	4	0.0395272000	4	-0.1043170000
	5	0.0023560800	5	0.0032019800	5	-0.0031249400	5	0.0066522200
	6	-0.0000861135	6	-0.0001209450	6	0.0001105520	6	-0.0002477860
	7	0.0000018207	7	0.0000026054	7	-0.0000014536	7	0.0000051414
	8	-0.0000000178	8	-0.0000000253			8	-0.0000000468
Number of datapoints (N)		12		12		12		12
R^2		0,9945		0,9954		0,9778		0,9994

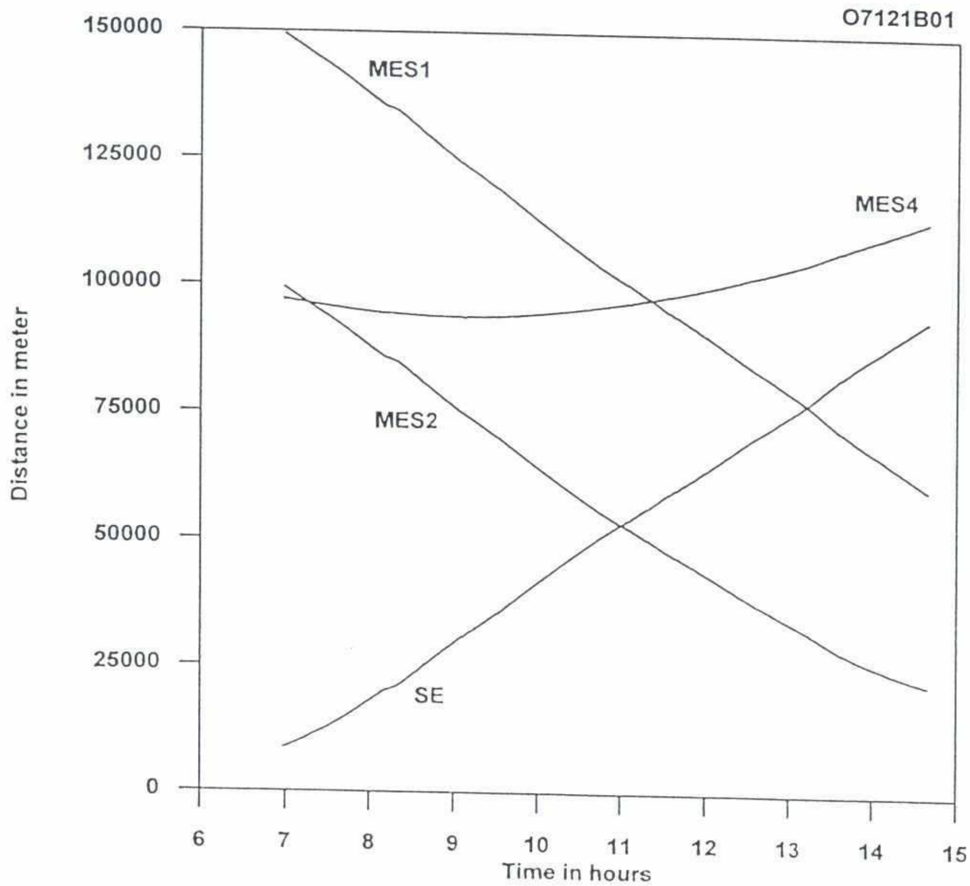
Day	10-1-97		10-1-97		10-1-97		10-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	1.8377900000	0	1.9383400000	0	5.0297100000	0	2.3533100000
	1	0.5424570000	1	0.5851770000	1	-2.0394800000	1	0.3041640000
	2	-0.4404330000	2	-0.3252470000	2	1.6495100000	2	-0.3010940000
	3	0.0395758000	3	-0.0273151000	3	-0.5802480000	3	-0.0388563000
	4	0.0071641800	4	0.0206152000	4	0.0875309000	4	0.0233092000
	5	-0.0013749600	5	-0.0027111800	5	-0.0064919500	5	-0.0029028100
	6	0.0000854571	6	0.0001568540	6	0.0002452000	6	0.0001586300
	7	-0.0000023070	7	-0.0000042797	7	-0.0000043698	7	-0.0000040323
	8	0.0000000228	8	0.0000000450	8	0.0000000268	8	0.0000000387
Number of datapoints (N)		12		12		12		12
R^2		0,9863		0,9822		0,9888		0,9936
Day	11-1-97		11-1-97		11-1-97		11-1-97	
Number of coefficients	9		9		9		9	
Coefficient number	0	3.1861000000	0	3.2229200000	0	1.2606100000	0	3.9915600000
	1	-1.8866800000	1	-1.5976400000	1	4.0580500000	1	-2.4209900000
	2	1.1419300000	2	0.9969280000	2	-1.9155900000	2	1.5096700000
	3	-0.4106270000	3	-0.3786490000	3	0.4913890000	3	-0.5516750000
	4	0.0732104000	4	0.0688249000	4	-0.0881903000	4	0.0969423000
	5	-0.0068174100	5	-0.0064275800	5	0.0096553600	5	-0.0087941800
	6	0.0003414400	6	0.0003206600	6	-0.0005836200	6	0.0004270620
	7	-0.0000087463	7	-0.0000081581	7	0.0000178227	7	-0.0000105835
	8	0.0000000902	8	0.0000000834	8	-0.0000002147	8	0.0000001054
Number of datapoints (N)		12		12		12		12
R^2		0,9939		0,9844		0,9961		0,9950
Day	12-1-97		12-1-97		12-1-97		12-1-97	
Number of coefficients	8		8		8		8	
Coefficient number	0	2.0477200000	0	2.0477200000	0	2.9145700000	0	2.7736600000
	1	0.4656420000	1	0.4656420000	1	-2.1485900000	1	-0.0824303000
	2	-0.2067610000	2	-0.2067610000	2	2.2751600000	2	0.1546250000
	3	-0.0185675000	3	-0.0185675000	3	-0.6816130000	3	-0.1366470000
	4	0.0094805200	4	0.0094805200	4	0.0861518000	4	0.0263363000
	5	-0.0009263750	5	-0.0009263750	5	-0.0052951600	5	-0.0020806600
	6	0.0000360926	6	0.0000360926	6	0.0001571300	6	0.0000737105
	7	-0.0000005021	7	-0.0000005021	7	-0.0000018074	7	-0.0000009719
Number of datapoints (N)		12		12		12		12
R^2		0,9758		0,9654		0,9815		0,9655

Day	13-1-97		13-1-97		13-1-97		13-1-97	
Number of coefficients	8		8		9		8	
Coefficient number	0	2.0970900000	0	2.0970900000	0	-2.5753500000	0	2.0328300000
	1	-0.1188310000	1	-0.1188310000	1	6.3115200000	1	-0.0432556000
	2	0.2191500000	2	0.2191500000	2	-2.7464800000	2	0.4033160000
	3	-0.1156350000	3	-0.1156350000	3	0.7367750000	3	-0.2006670000
	4	0.0194034000	4	0.0194034000	4	-0.1248430000	4	0.0320195000
	5	-0.0014318100	5	-0.0014318100	5	0.0122249000	5	-0.0022739700
	6	0.0000486081	6	0.0000486081	6	-0.0006609690	6	0.0000748305
	7	-0.0000006219	7	-0.0000006219	7	0.0000183044	7	-0.0000009324
					8	-0.0000002028		
Number of datapoints (N)		12		12		12		12
R^2		0,9875		0,9796		0,9971		0,9880

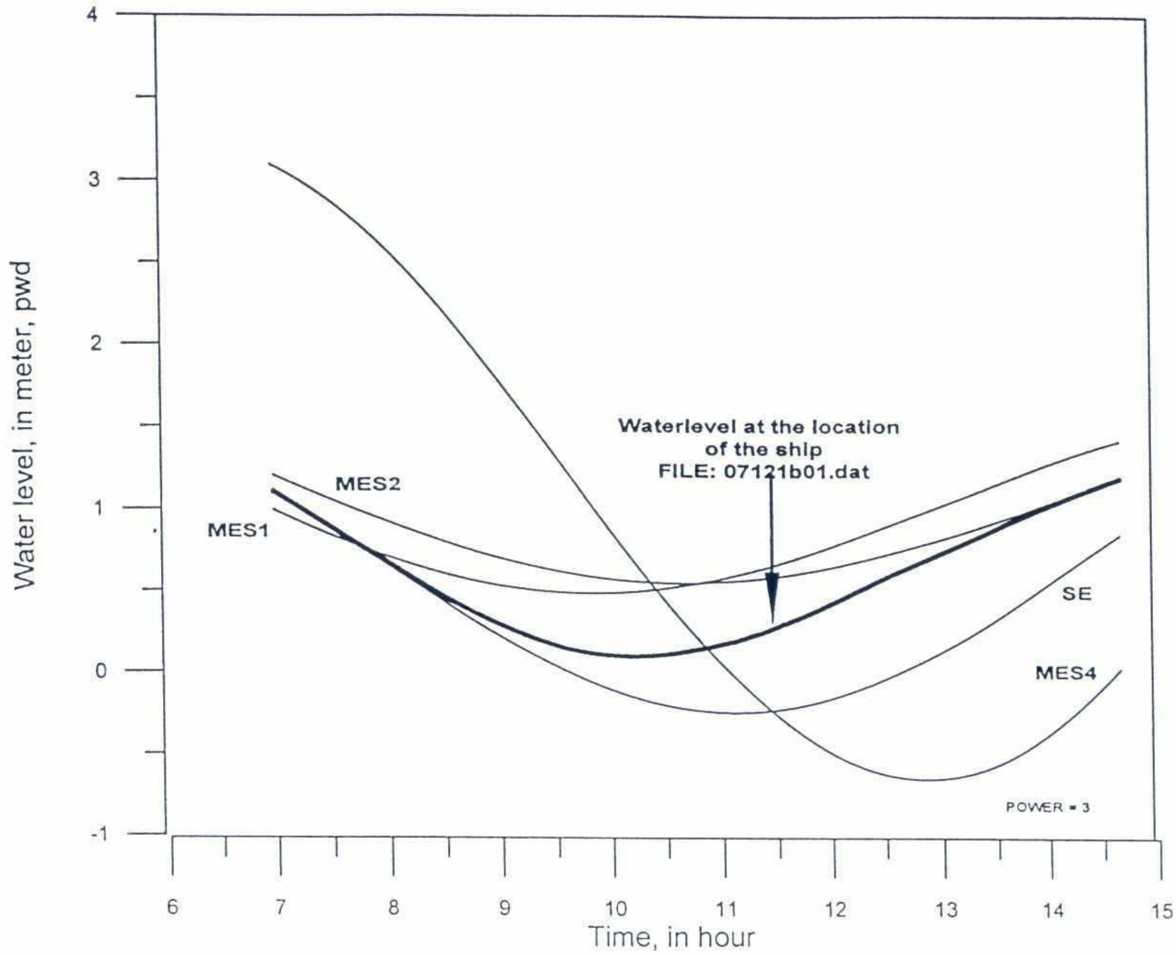
ANNEX 3



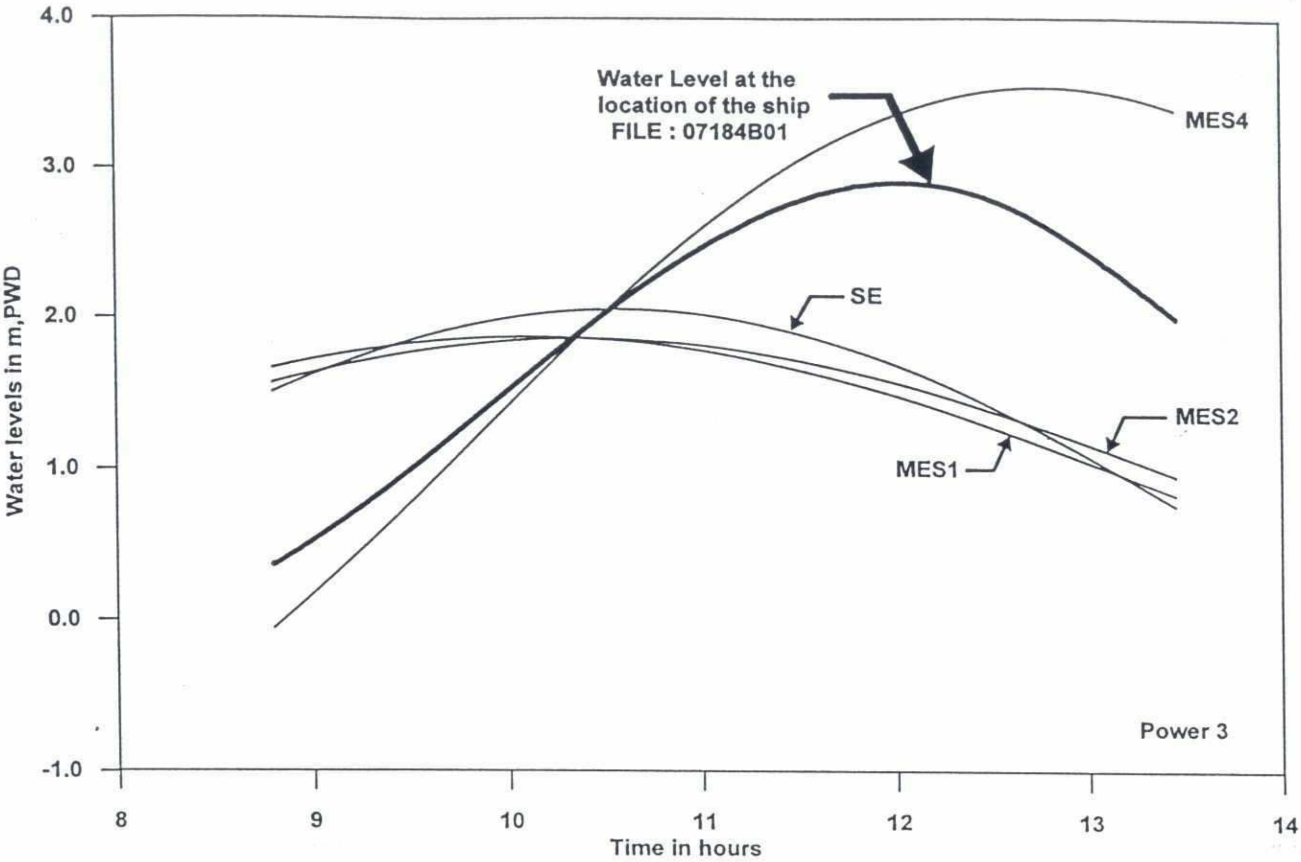
600000
550000
500000
450000
400000
Northing in meter
MES4
MES2
SE
O7121B01
MES1
500000
550000
600000
650000
700000
Easting in meter

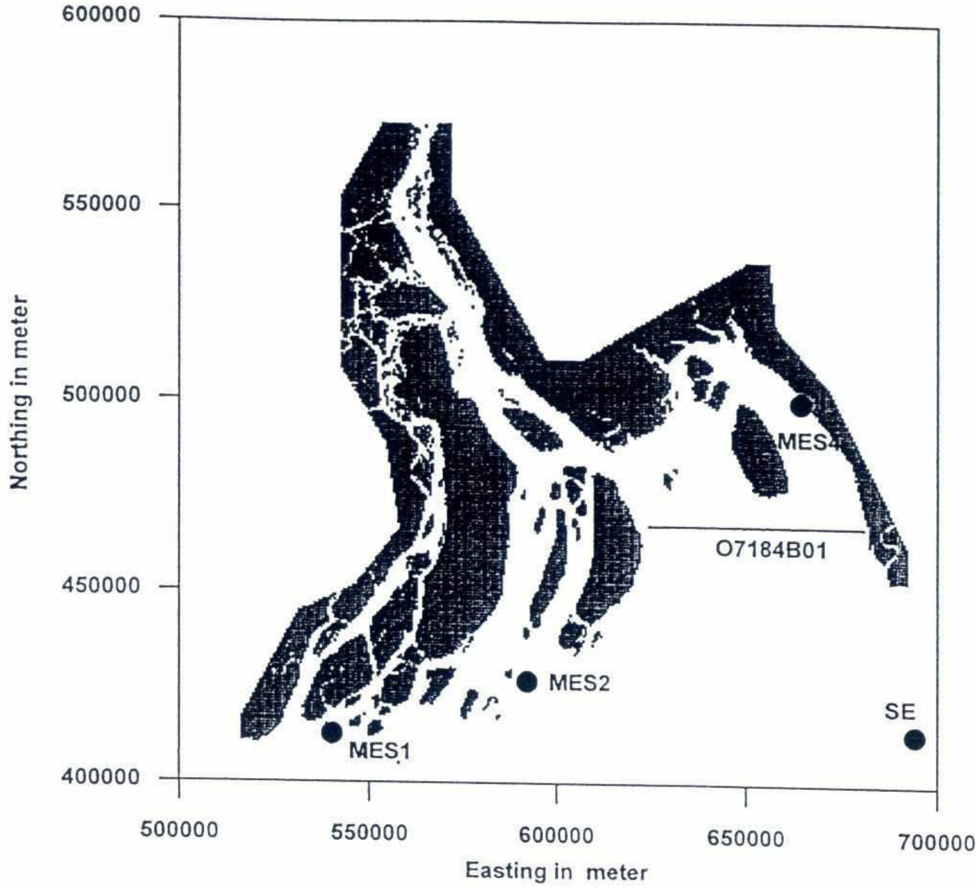


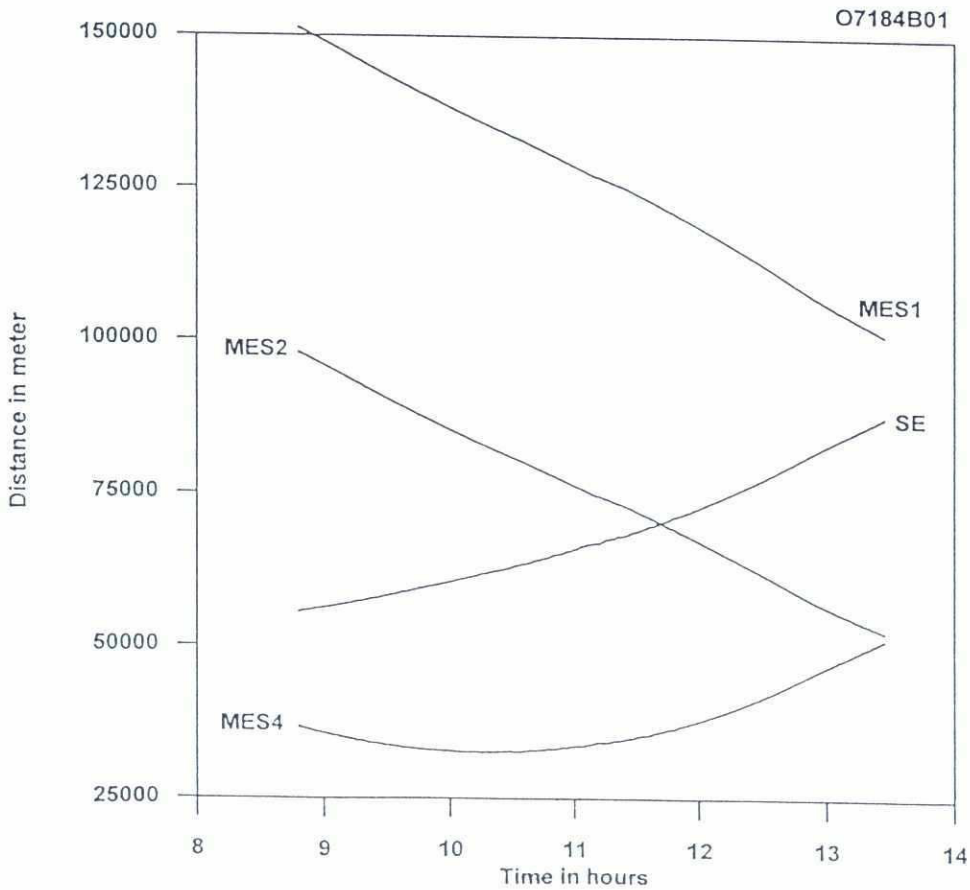
O7121B01
150000
125000
100000
75000
50000
25000
0
Distance in meter
MES1
MES4
MES2
SE
6
7
8
9
10
11
12
13
14
15
Time in hours



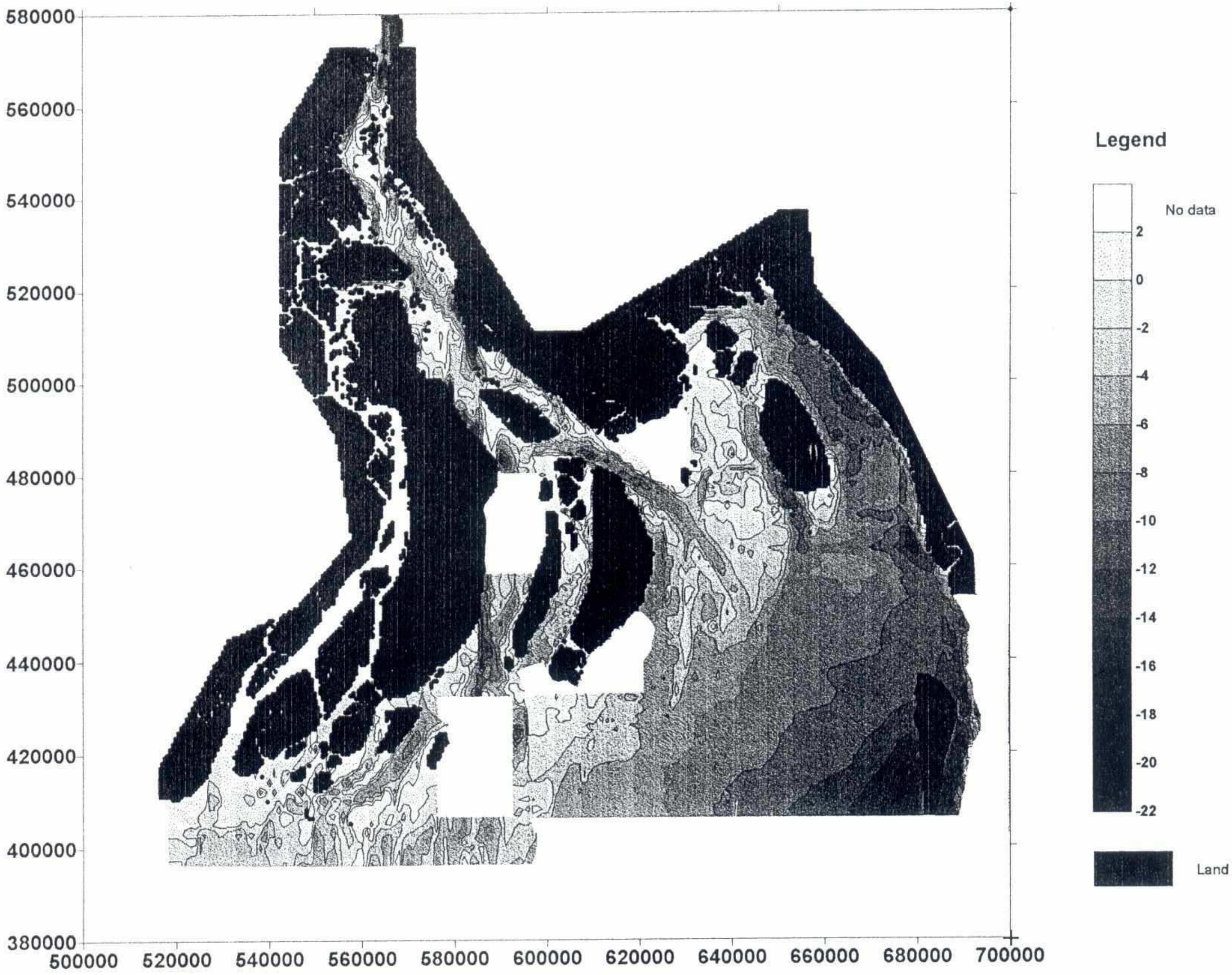
Water level, in meter, pwd
Time, in hour
Waterlevel at the location
of the ship
FILE: 07121b01.dat
MES2
MES1
SE
MES4
POWER = 3


Water Level at the
location of the ship
FILE : 07184B01
MES4
SE
MES2
MES1
Power 3
4.0
3.0
2.0
1.0
0.0
-1.0
Water levels in m,PWD
8
9
10
11
12
13
14
Time in hours


600000
550000
500000
450000
400000
Northing in meter
500000
550000
600000
650000
700000
Easting in meter
MES4
O7184B01
MES2
SE
MES1

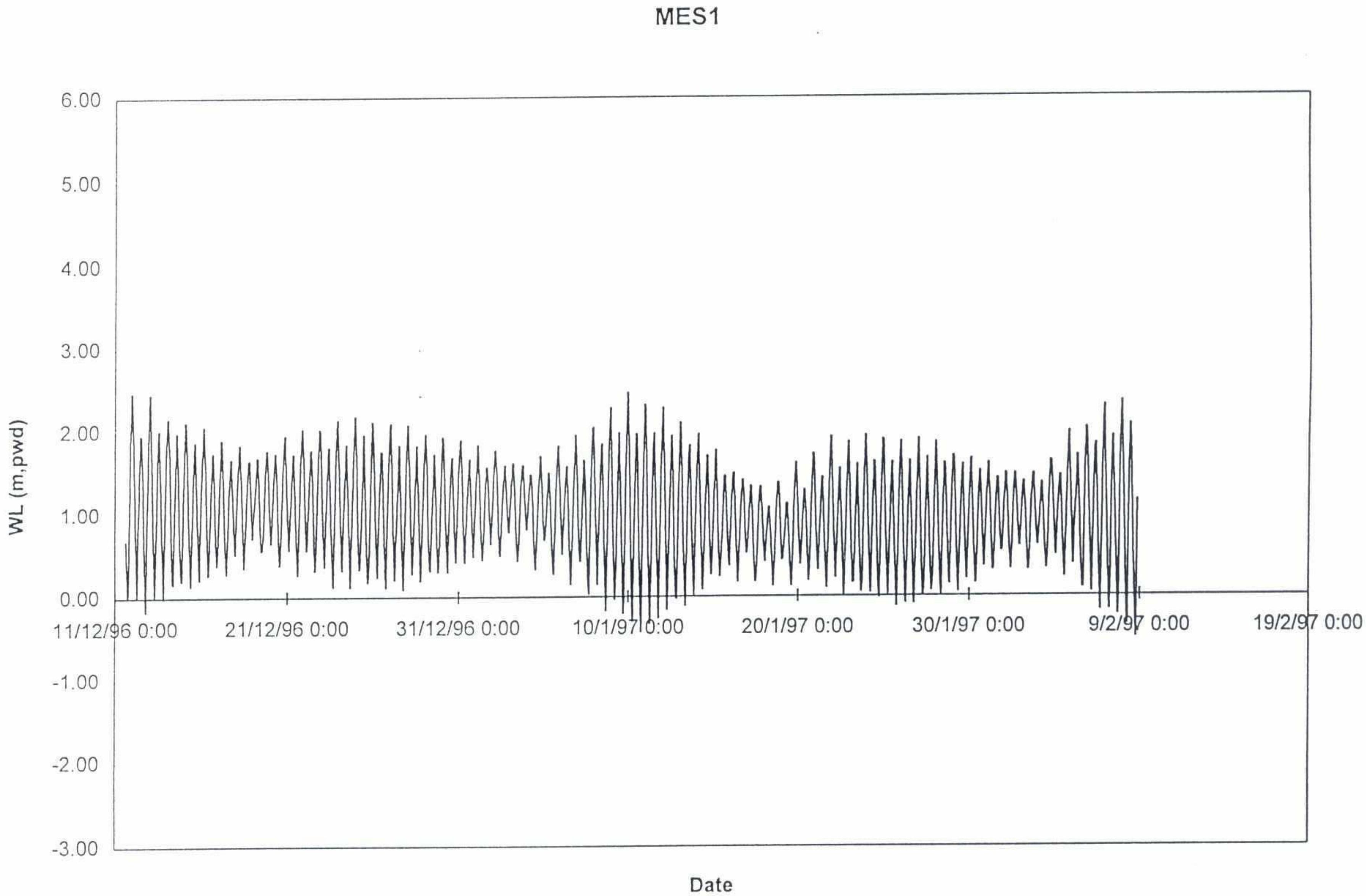

O7184B01
150000
125000
100000
75000
50000
25000
Distance in meter
8
9
10
11
12
13
14
Time in hours
MES1
MES2
SE
MES4

Bathymetry Meghna Estuary Study area, 1997



G2

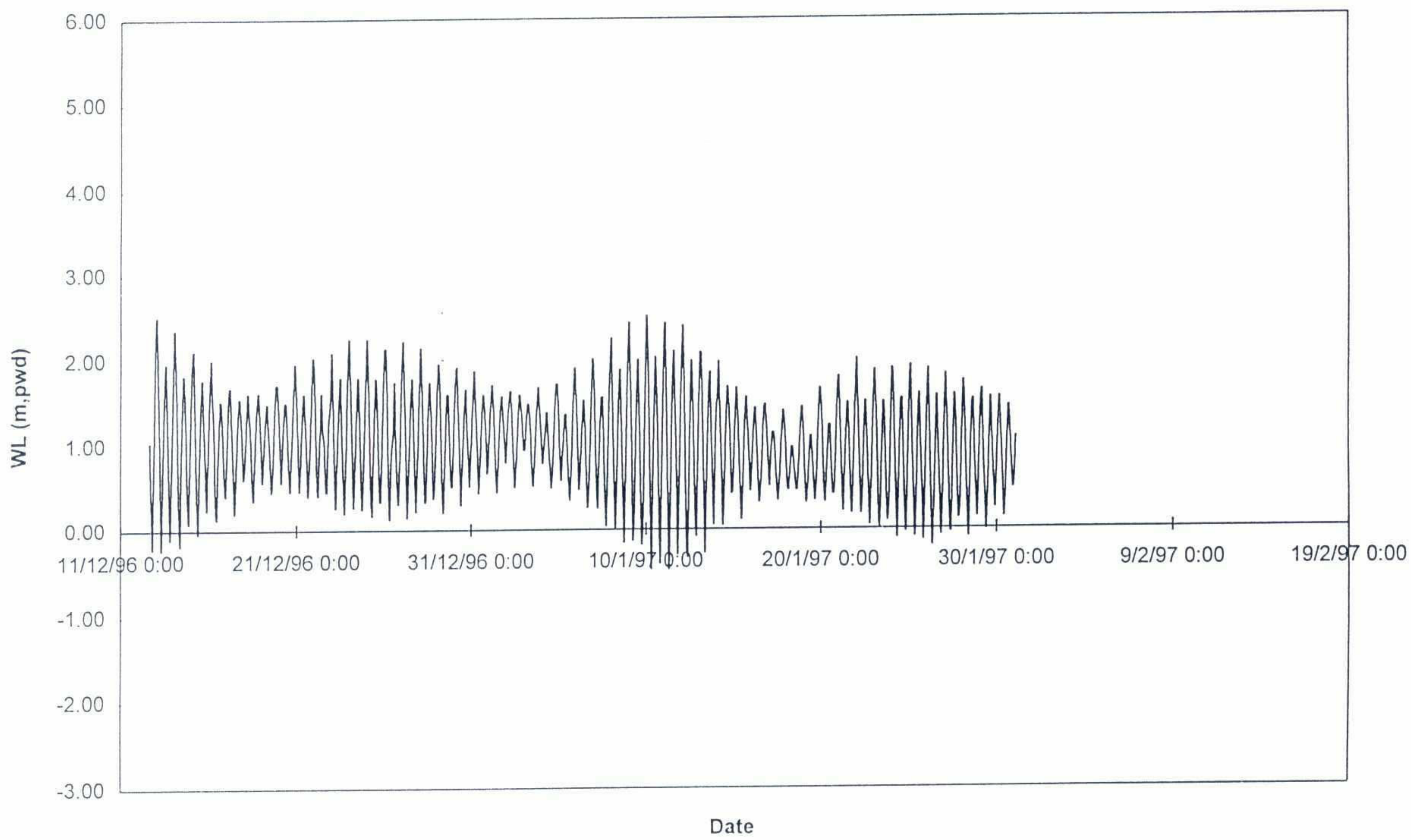
ANNEX 5


MES1
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date

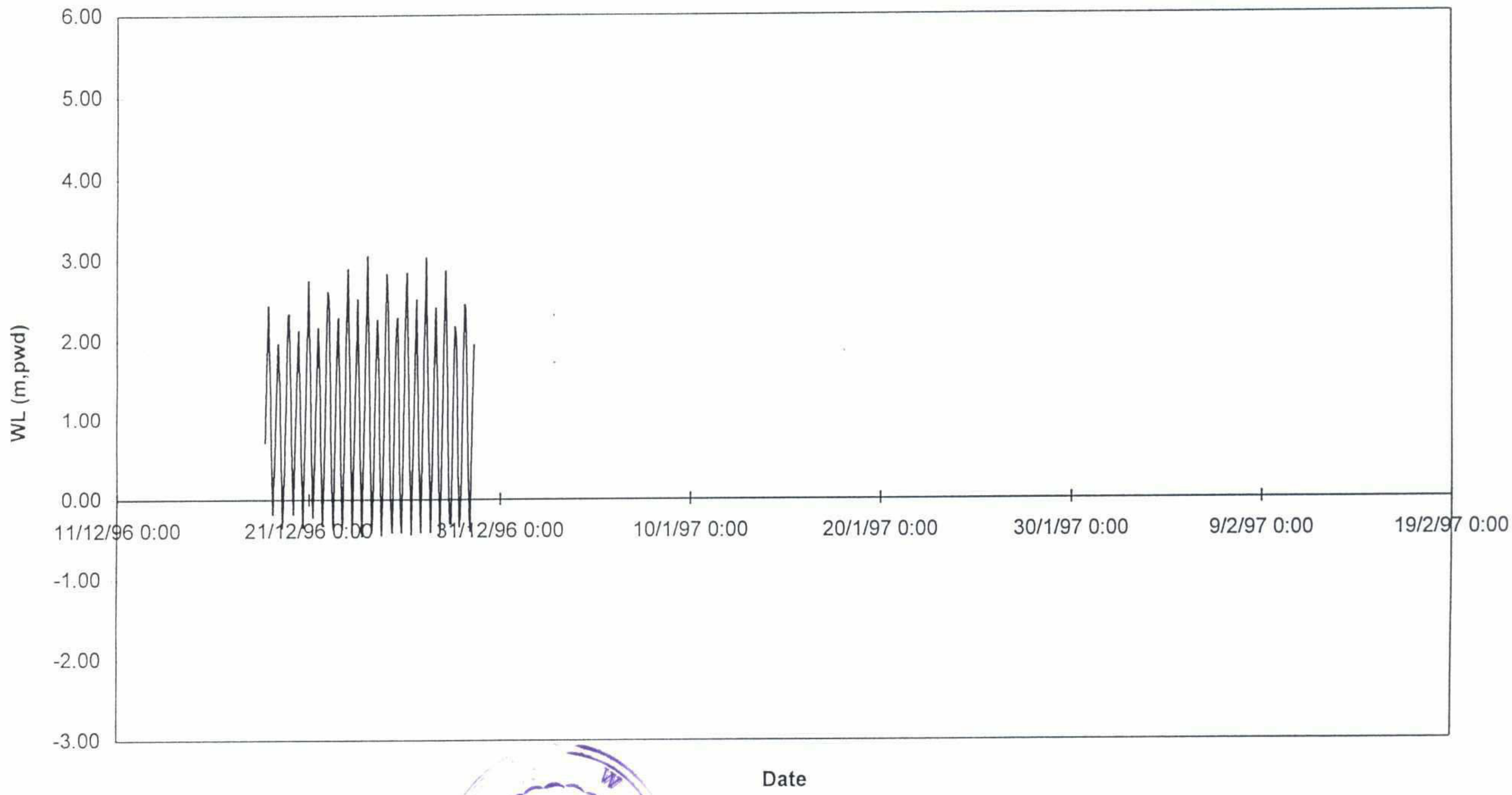
66

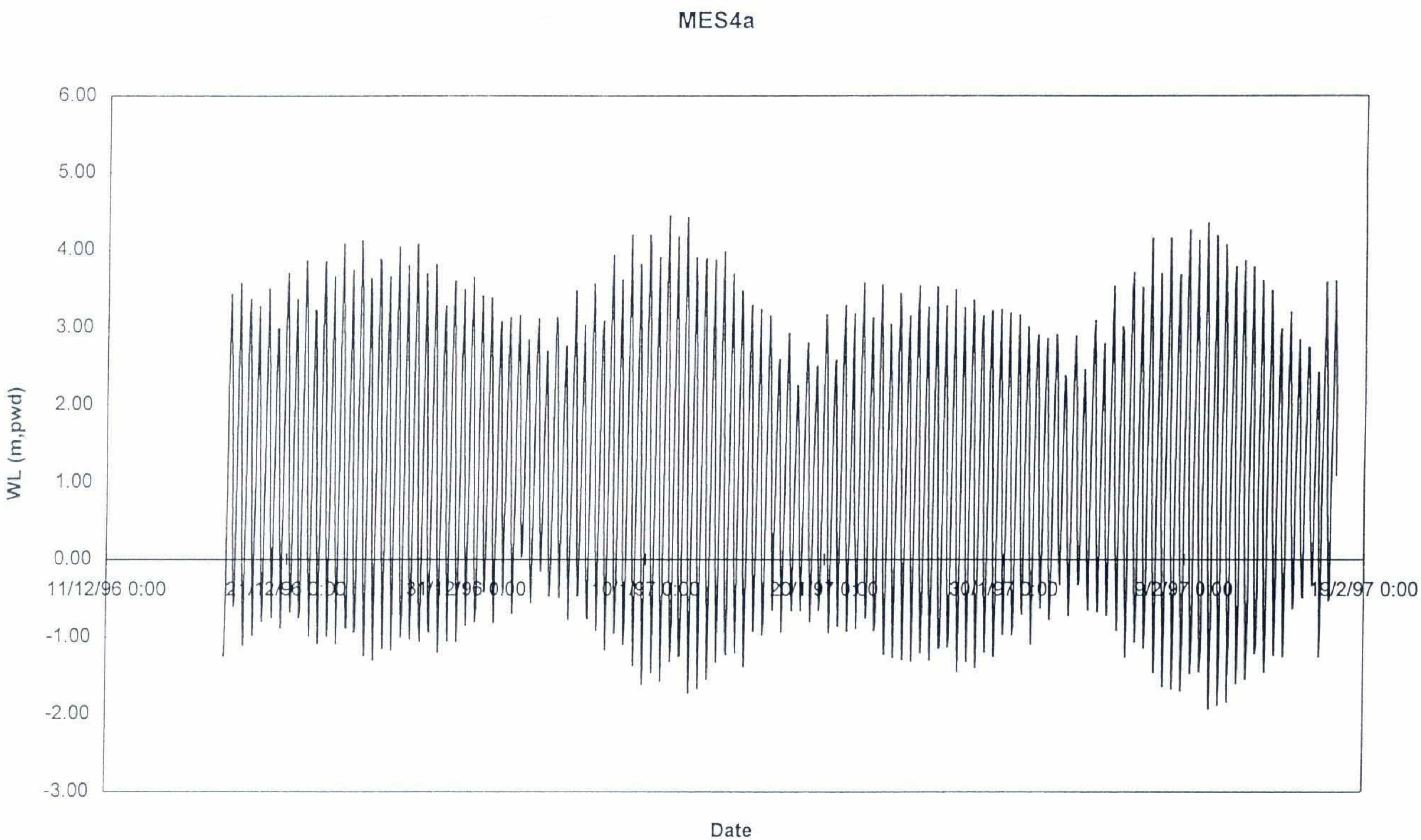
G8

MES 2

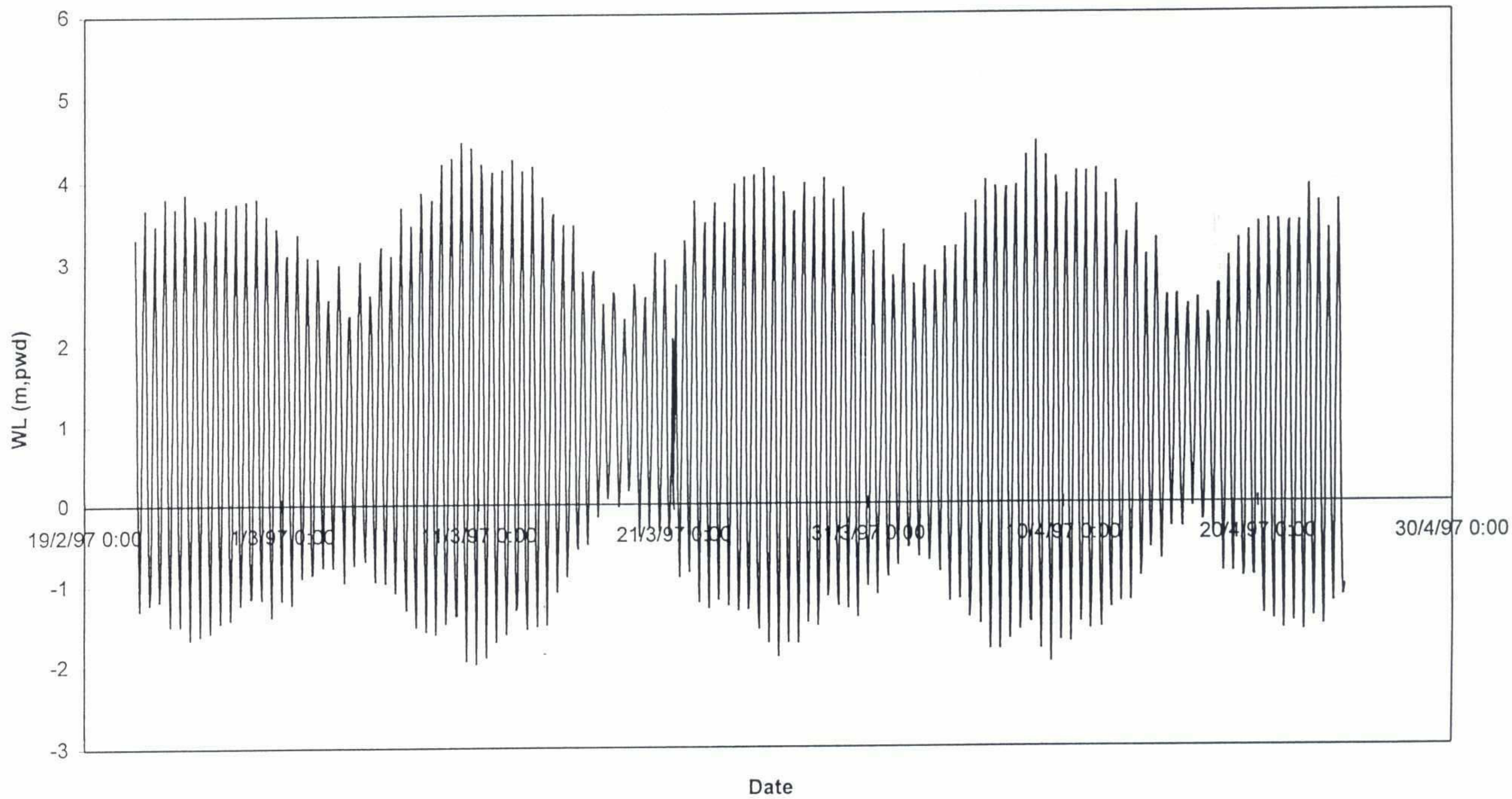

6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date

MES3


6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date


MES4a
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date

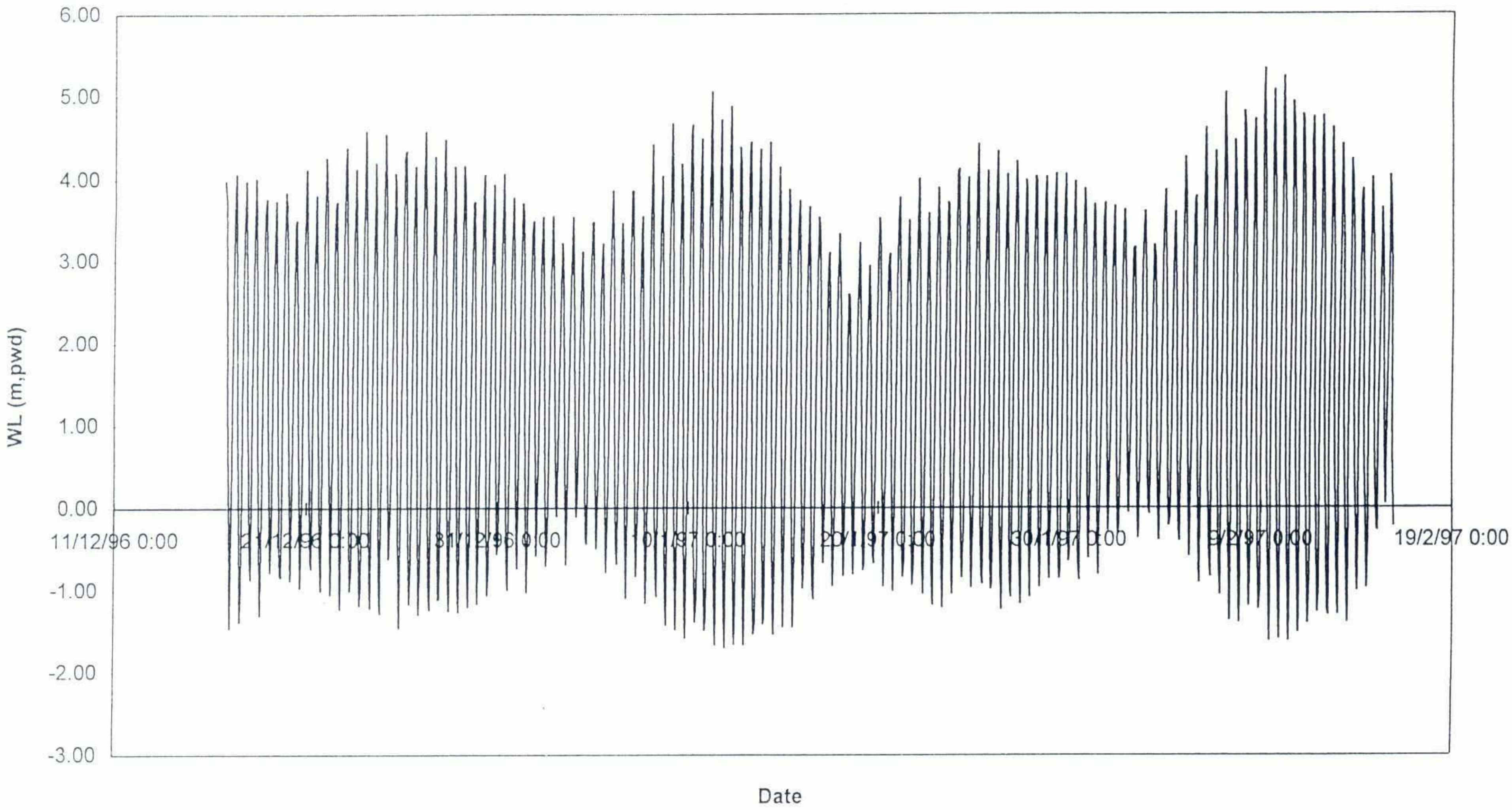
MES4b



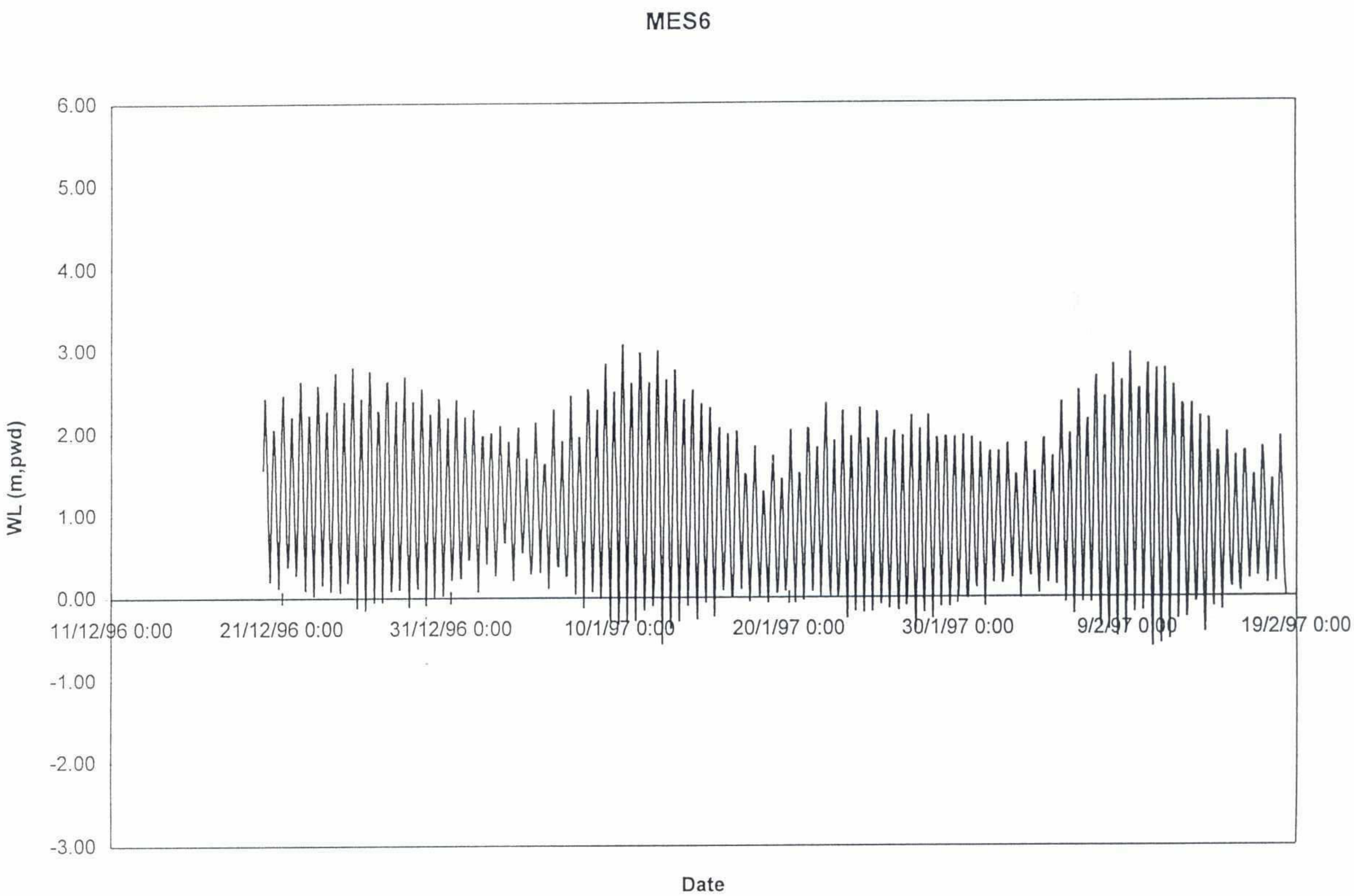
6
5
4
3
2
1
0
-1
-2
-3
WL (m,pwd)
19/2/97 0:00
1/3/97 0:00
11/3/97 0:00
21/3/97 0:00
31/3/97 0:00
10/4/97 0:00
20/4/97 0:00
30/4/97 0:00
Date

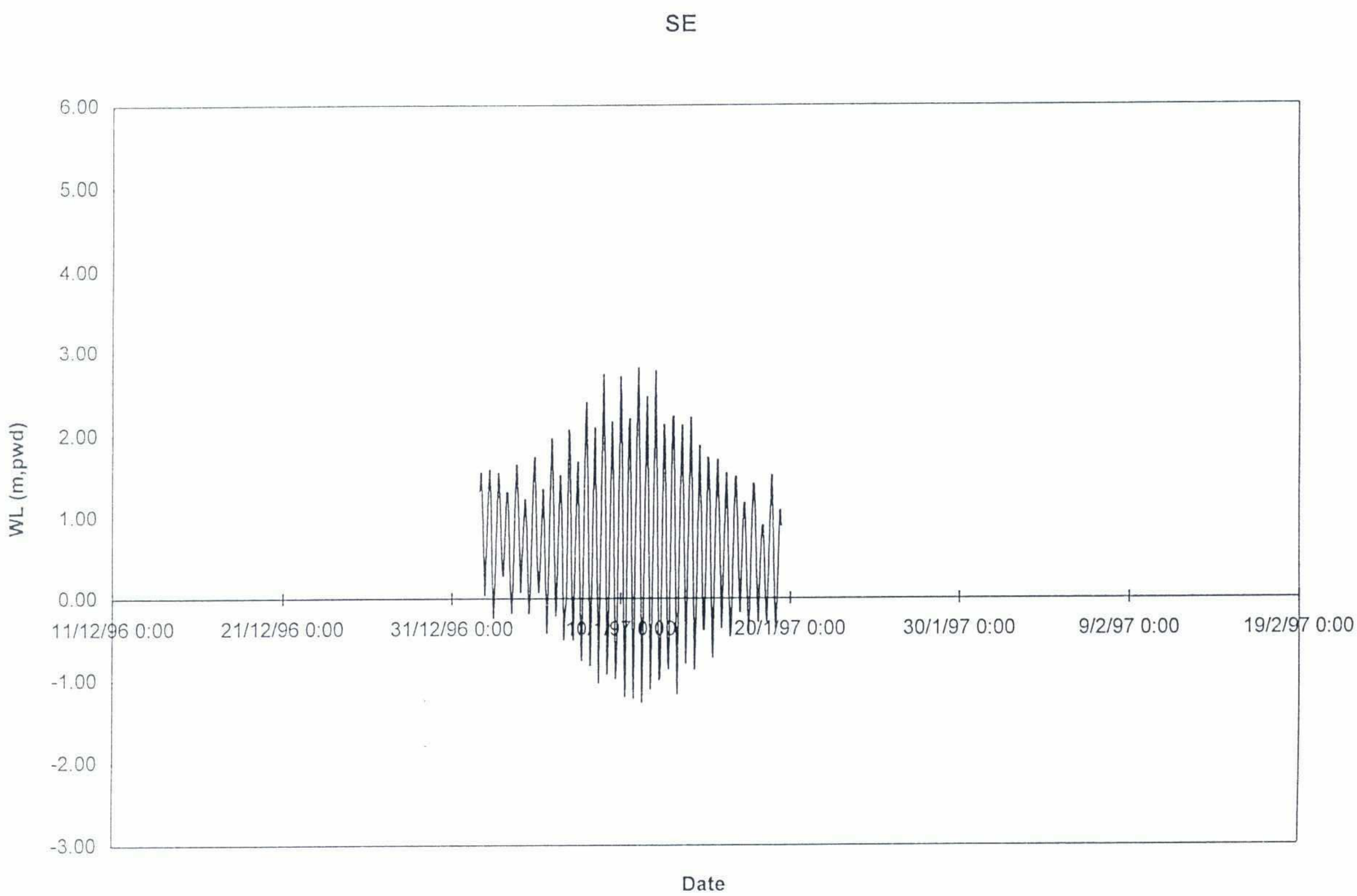
69

MES5

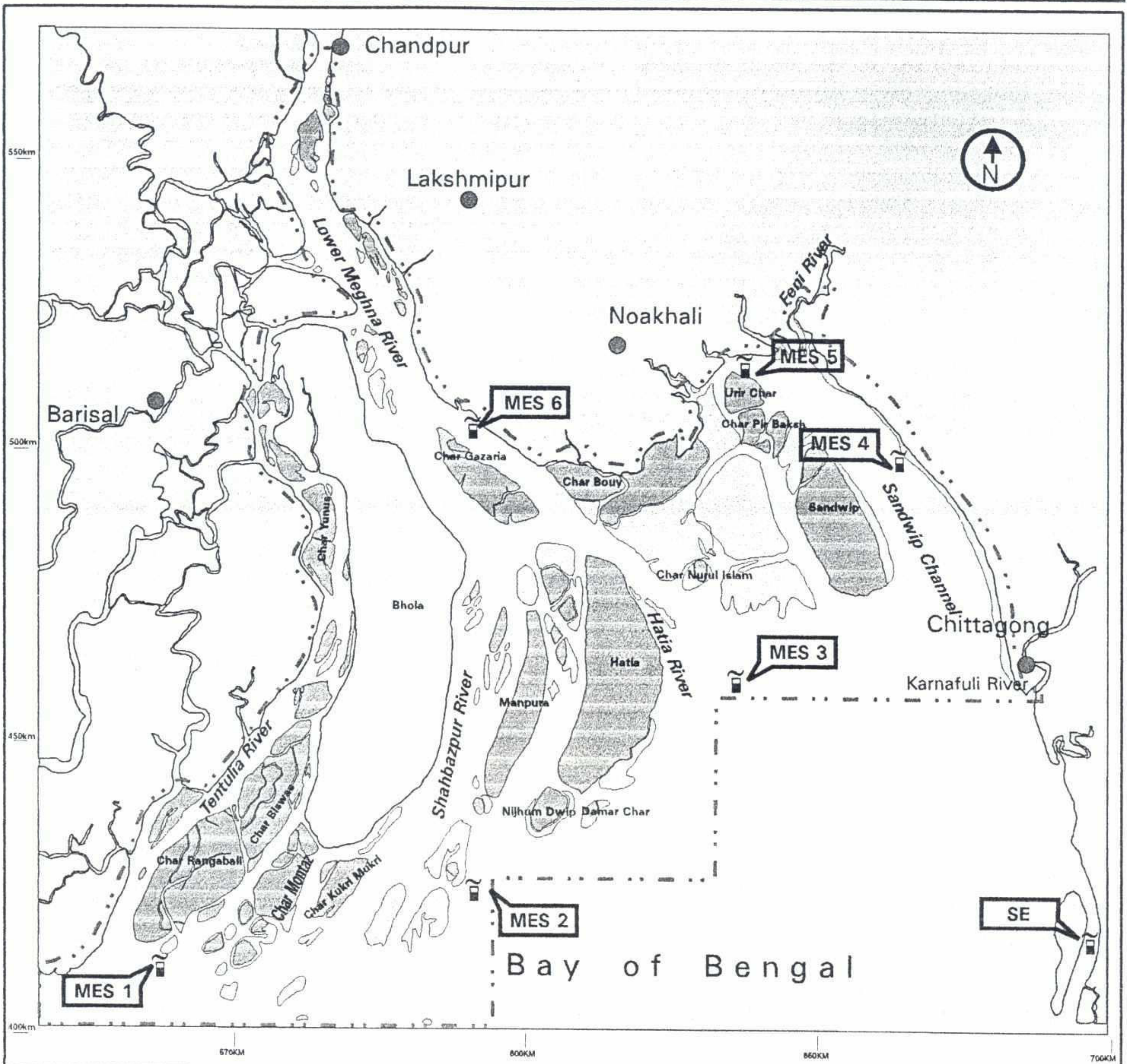


6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date


MES6
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
WL (m,pwd)
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date


SE
WL (m,pwd)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
11/12/96 0:00
21/12/96 0:00
31/12/96 0:00
10/1/97 0:00
20/1/97 0:00
30/1/97 0:00
9/2/97 0:00
19/2/97 0:00
Date

Location Map of MES Wave/Tide Recorder Stations



LEGEND

STUDY BOUNDARY

STUDY AREA

SUBMERGED LAND AREA

Wave/Tide Recorder Stations

REMARK: BHOLA IS EXCLUDED FROM THE STUDY AREA

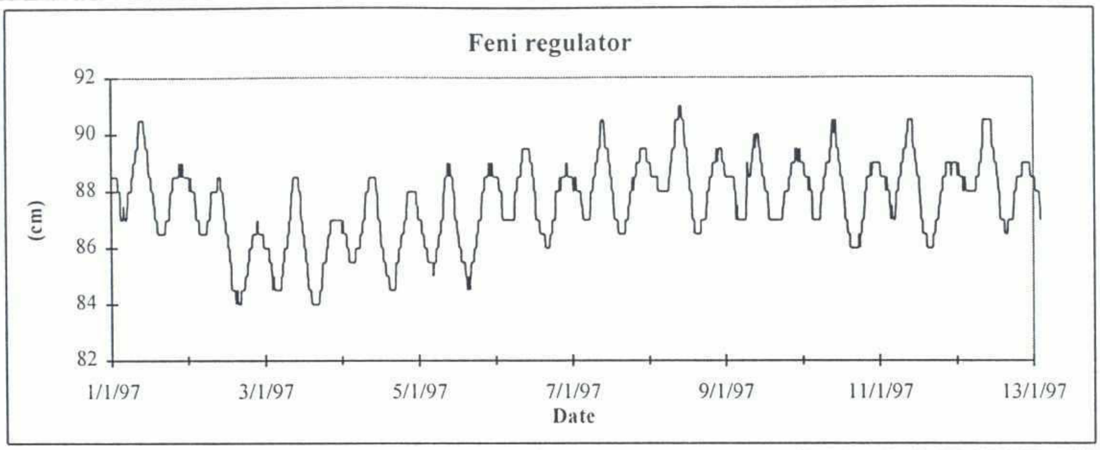
MEGHNA ESTUARY STUDY	
Wave/Tide Recorder Stations	
PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996

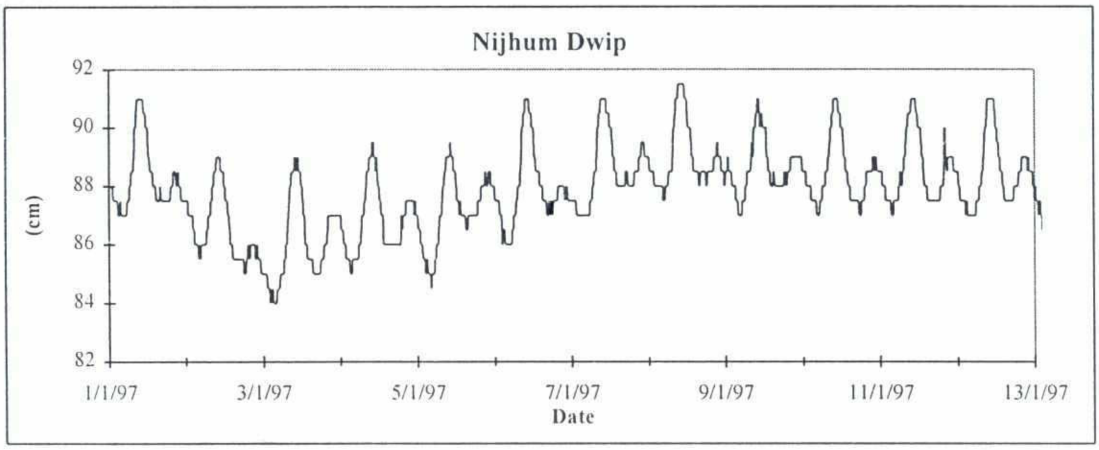
10 0 10 20 30 40KM

SCALE

File (GIS 02)d :\Mahfuz\New\Wv tide.cdr

ANNEX 6


Feni regulator
92
90
88
86
84
82
(cm)
1/1/97
3/1/97
5/1/97
7/1/97
9/1/97
11/1/97
13/1/97
Date


Nijhum Dwip
92
90
88
86
84
82
(cm)
1/1/97
3/1/97
5/1/97
7/1/97
9/1/97
11/1/97
13/1/97
Date