MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

M E S II
MEGHNA ESTUARY STUDY

TECHNICAL NOTE MES-046
Brief Note on Surveys in the Meghna Estuary

December 2000

DHV CONSULTANTS BV

in association with

DEVCON SULTANTS LTD
SURFACE WATER MODELLING CENTRE

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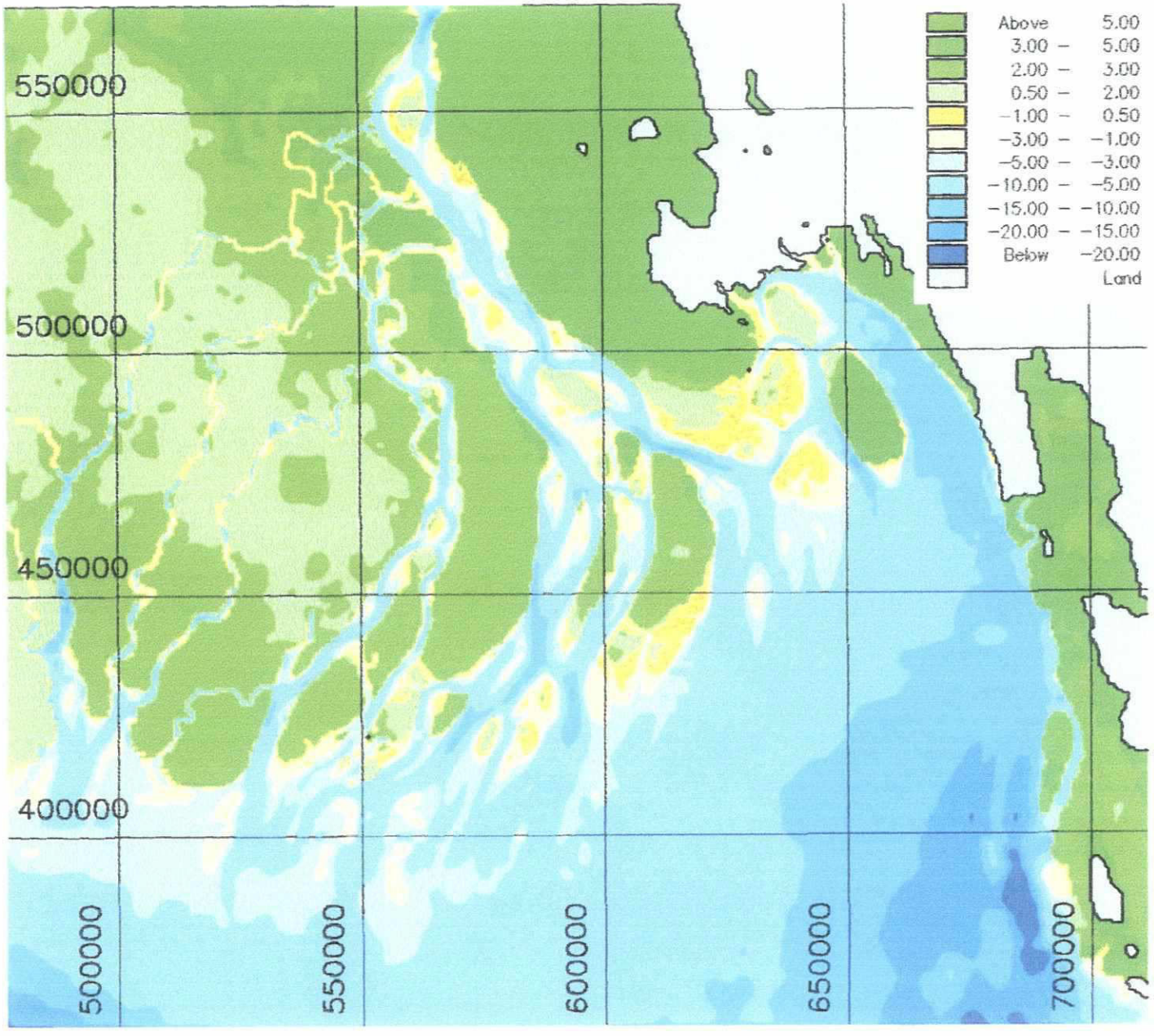


Bathymetric map of Meghna Estuary

(based on 1999/2000 surveys)

1. VESSELS

1.1 Anwesha

Since very limited accommodation and repair facilities are available along the Lower Meghna and none in the coastal zone, a mother ship is required to facilitate survey operations in this vast area and to ensure that the surveys will be executed efficiently.

The Anwesha serves as the mother ship providing accommodation and catering facilities for all personnel involved in the surveys. The ship also provides storage for equipment and repair facilities, the support vessels and survey equipment. It also has the facilities to communicate with the outside world.

Anwesha is normally not engaged in survey works. The movements of the Anwesha are very limited because of shallow waters while sailing the ship is costly because of high fuel consumption.

During the Meghna Estuary Study Anwesha only participated in bathymetric surveys in the open bay area where the depth is adequate for Anwesha and long lines could be surveyed. Otherwise Anwesha would remain at anchor until shifting to a new position was needed.

In the main river system during the monsoon and in the North-east part of the estuary the currents may be too strong for proper operation of the tender boats. Under these conditions it is almost impossible to follow the survey lines with the tender boats and progress will be very slow. In these circumstances Anwesha has to be used to carry out ADCP measurements.

Sediment sampling, in particular pump sampling, is to be carried out from Anwesha because the winch requires a permanent set-up.

Anwesha was also required to participate in the surveys for the Gorai off-take where the currents during the monsoon were too strong for local engine boats.
For Shell route surveys (for the drilling rig) have been carried out by side scan sonar. This equipment, including data recording equipment, could only be operated from Anwesha.

1.2 Tender boats and country boats

The two tender boats are engaged in bathymetric surveys as well as ADCP measurements. These boats are equipped with jet propulsion and can operate in very shallow water as well as in rather wavy conditions. However it is difficult to survey exactly along the survey line in particular at low speed, strong cross currents or wind.

In order to maximize output of the Survey Unit Anwesha two local country boats should be hired during routine survey campaigns in the winter season. One boat will be engaged in survey work besides the two tender boats. The second boat serves as a spare in case one of the tender boats (or the first country boat) breaks down and can not be used for more than a day.

1.3 Hovercraft

The bathymetric survey of shallow areas and emerging chars is either very time consuming or impossible with the tender boats or a country boat. Only at high water spring tide the boats can move into part of the shallow areas for a couple of hours and survey a few lines before the depth becomes too shallow again.

In order to be able to survey shallow areas and emerging chars efficiently and completely a small hovercraft has been procured in 1997. The performance of this craft has been disappointing for various reasons:

- It took a lot of time to develop an arrangement to measure accurately over the whole depth range (from 0 m to 10 m) without hampering the movement of the craft because of the risk of damaging the echo-sounder transducer.

- The hovercraft is powered by diesel engines because high-octane fuel is not readily available in the market and diesel fuel is always available on Anwesha. However it was not possible to maintain maximum power of the two engines. Therefore the speed of the engines falls 10 % short of the required 3500 rpm and as a result insufficient lift and thrust slow down the hovercraft to a few knots while flying above water. After a year the hovercraft has become very inefficient.

- The hovercraft is quite sensitive to windy conditions, this also reduces the efficiency. More over this may lead to dangerous situations in case the craft cannot return and the winds get stronger

- Measurement of the bottom levels in shallow water or on the chars requires accurate positioning of the GPS antenna in vertical direction. In actual practice it was observed that this accurate positioning was available for limited periods only and sometimes even the accurate mode appeared to become inaccurate or jumpy.

Although a substantial shallow and char area has been surveyed with the hovercraft initially, the deterioration of the engine speed has closed down the craft for the moment.
A more powerful lift motor would be required to solve the speed problem. Even then the hovercraft can only be operated in the quiet winter months and for limited periods because of less accurate positioning.

However the hovercraft is the only means to survey such shallow area and it may be worthwhile to refurbish the craft at a later stage to enhance the survey capability of the Survey Unit Anwesha

1.4 Speed boats

A single-outboard engine Sillinger rubber boat is available for communication between Anwesha, the tender boats, the country boat and the hovercraft during surveys as well as for other errands that require more speed than the tender boats can reach.

A twin- outboard engine speed boat (E-vessel) is available for longer trips and more passengers. The E-vessel can also be equipped with a set of positioning/echo-sounding equipment for far away bathymetric surveys. However the cost of running the E-vessel is quite high compared to the tender boats and country boat. Provided that the sea or river is relatively calm the E-vessel can be used for salinity measurement

1.5 Communication facilities

The Anwesha is equipped with a Philips SAFECOM satellite transceiver that allows direct sending and receiving of text messages as well as fax and email text messages that contain plain text. Two additional units are available, one for use in the office and one as spare.
It is essential that during surveys the SAFECOM installed on the Anwesha is operating properly because it is the only means to communicate with the outside world. Therefore the spare unit of the SAFECOM should be kept on Anwesha.
Through the provider EIK it can be arranged that faxes and email can be sent directly to the SAFECOM of the Anwesha if the SAFECOM installed in the office doesn't function properly.

For communication between Anwesha and the tender boats/country boat/E-vessel during survey UHF radio are included in the survey set.

Additionally three sets walky-talky are available for communication with the rubber boat etc.

2. SURVEY EQUIPMENT

2.1 General

The survey equipment on board Anwesha is state-of-the art and as such sturdy and reliable. However proper handling and maintenance remain a prerequisite for uninterrupted service of this highly sophisticated electronic equipment and computers. Although much care is taken to keep the equipment in good condition, accidents can happen and mistakes may be made.

Many problems can be solved on board Anwesha but certain problems or damage have to be solved or repaired by experts. If possible by local engineers or otherwise expatriate expertise has to be involved.

2.2 Positioning system

When the positioning system, including a fixed reference station on land, is operational the following modes will be possible:

- Fix RTK

  Fix RTK is the most accurate mode of operation both in position as well as in levels. However depending on the presence and position of satellites fix RTK may be available or not. And although the readings are generally stable it may also happen that the readings temporarily jump decimeters and back again. So thorough checking of the correctness of the recorded positional data is always needed.

- Float RTK

  The float RTK may appear when the satellite configuration is not optimal or some of the satellite cannot be received due to an obstruction like trees. The accuracy of the horizontal position (x and y) may still be adequate but the vertical position (z) will not be sufficiently accurate for reliable map preparation.

- Autonomous fix

  When the distance to the reference station becomes too large the x,y,z data will be recorded in the less accurate autonomous fix.

As will be discussed later on the problems with the vertical position will be solved by a combination of water level recording and water level simulation

2.3 Reference stations

All over the estuary reference stations have been installed, the coordinates of the benchmarks have been established by accurate measurements and mathematical adjustment in 1997.
In 2000 most of the reference stations have been upgraded by installing more permanent benchmarks.

However fresh measurements and adjustment have to be included in the survey program of the estuary. Some stations may be lost for various reasons for instance riverbank erosion or willful destruction. Another reason for re-determination of the coordinates is the subsidence within the estuary that could occur because of geological changes or for geo-technical reasons.

The reference station established at Char Nurul Islam (located about 15 km to the West of Sandwip) requires special attention. This reference station is very important because it covers a large part of the shallow areas in between Sandwip and Hatia. The island is not habituated and

guarding is very difficult because of the isolation of the island. Recently dacoits threatened the survey crew when they wanted to set up their equipment at the reference station.
A permanent solution has to be found in order to ensure accurate surveys in this area.

2.4 Echo sounders

The echo sounders are functioning properly. However calibration of these instruments should be done as a matter of routine and not haphazardly.

2.5 ADCP

The ADCP is in good operational condition. Careful checking of the data collected by this sensitive instrument is required even during the surveys to avoid invalid data. As a matter of routine a transect has to be surveyed in both directions and the calculated discharges have to be compared immediately.

2.6 S4 and RCM-9

Both instruments are in good conditions. The S4 requires 6 batteries that have to be pre-connected; this appears to be old fashioned and a bit cumbersome.

The software for processing of the data collected by the RCM-9 has to be re-installed in a computer. During installation a key has to be obtained from the manufacturer.

2.7 Pressure transducers

The pressure transducers used during MES surveys are simple, versatile and relatively cheap devices to measure water levels in tidal areas for a short period or long period if a permanent structure is available.

Since the instrument has to be installed below the lowest water level, a diver will be required to do this job. The nominal ranges of the instruments are 5, 10 and 30 m, however the effective ranges are 4, 9 and 29 m only. To avoid stunted records care should be taken to select the proper range for the diver. In the Sandwip area use of the 10 m range transducer should be checked because of the large tidal range.

During MES a number of instruments stopped functioning because of faulty wiring and subsequent loss of battery power. However this problem has not occurred in later models.

Although the manufacturer cautions against use in salty water because of its effect on the sensitive membrane of the pressure transducer, during MES no problems with the membrane have been encountered. The reason may be that the salinity of the water in the near coastal zone is not that high. Maybe packing of the instrument in geotextile or cloth also helps.

2.8 Sediment samplers

The sediment samplers and the winches on board Anwesha require checking and repair. The umbilical hose pipe of the pumped sampler has to be replaced, a spare hose is in stock.

2.9 Salinometers

The salinometers are in good condition; these instruments always require calibration before use.

3. EXECUTION OF SURVEYS

3.1 Timing of the execution of surveys

Surveys like current and salinity measurements, sediment sampling will be needed year round to cover the whole range of annual fluctuations. Routine bathymetric surveys in the southern river channels and in the coastal zone have to be planned in the winter season between mid November and mid March when the wind speeds are low and rain is unlikely.

Special (detailed) bathymetric may be needed outside this season. In case of inclement weather conditions these surveys should be postponed or interrupted for a couple of days until the situation improves

3.2 Inclement weather conditions

As mentioned, during the winter season the weather in the estuary is very stable, only foggy conditions may hamper survey works.

During the pre-monsoon, from April until June nor'westerns, strong winds of short duration may occur within less than an hour's notice. If these conditions appear to develop survey work should be halted and the tender and country boats should seek shelter immediately.

In the Bay of Bengal steady strong winds may prevail in the pre-monsoon season from mid March. Under such conditions only Anwesha can carry out surveys as has been done for Shell. However in estimating the time required for a certain job, an ample allowances for unworkable conditions should be included. Similar conditions may occur in the post-monsoon season.

Cyclones may occur before and after the monsoon. Cyclone warning will be given well ahead of the arrival of the event. The Anwesha must seek shelter in time before a cyclone arrives in the coastal zone.

3.3 Keeping logs of survey operations

Detailed logs have to be kept in a diary of all survey operations. This is a very important task of the chief hydrographer in charge of the survey works. Besides filling in a standard form, records of all relevant events should be entered into the diary.

3.4 Water level recording during surveys

As mentioned the positioning system usually is operating in fix RTK mode during part of the time only and even height data in RTK mode may not be reliable at time. The only way to obtain reliable and accurate bed level data is to determine the water level at the location and time of the measurement of the water depth by echo sounder. Since the water levels vary with the tidal cycle throughout the estuary the water level at a specific location and time can only be determined by interpolation from a measured tidal levels recorded simultaneously with the surveys.

During the 1999/2000 bathymetric survey campaign a number of pressure transducers have been installed at strategic locations for a period of 3 - 4 months. The main problem is where and how to install the instruments and how to find the instruments back when the surveys have been completed. Very few permanent structures are found in deep water that could be used to install a pressure transducer. Most of the installations for automatic water level recording established by BWDB have disappeared or are located in shallow areas and thus unusable.

In actual practice anything that is visible for some time will be taken away by local people or fishermen even guarding during the day may not prevent unauthorized loss of instruments.

Installation completely under water or in a remote place, provided that the installation is visible for a short time only during low water spring, may be a solution.

In selecting a site for installing a pressure transducer the possibility of accretion or erosion has to be taken into account. In both cases the instrument may not be found back as happened several times during the MES surveys. The latest bathymetry as well as simulated flow patterns and water levels may be studied to determine the most favorable location for installing a pressure transducer.

The exact location of the installation should be determined using the positioning system with fix or float RTK. If this is not possible a simple GPS can be used. In that case the area to be searched will be 30 m x 30 m. Installation and searching should be planned during low water spring. Some techniques have been developed to find pipes or poles under water, the diver on board Anwesha knows how to do it.

See also ANNEX A for possible ways to install pressure transducers.

In addition to long term measurements pressure transducers should also be installed at the boundaries of the area where surveys are being carried out so that interpolation becomes more accurate. The instruments should be shifted when the surveys in a certain area have been completed.

These temporary arrangements can be quite simple. Pressure transducers have been successfully attached to fishermen's poles or dropped in the river attached to a locally manufactured anchor with buoy. In all cases it should be avoided that the instrument is stolen or swept away by drifting fishing nets. For some ideas see ANNEX A.

Some time between installation and removal of a pressure transducer the water level should be recorded in fix RTK mode. This may be carried out as part of the survey or separately when good fix RTK is available. It is very important to ensure that water levels at the location of the pressure transducer are recorded for some time in fix RTK mode otherwise the data recorded by the pressure cells can not directly be reduced to PWD datum.

3.5 Bathymetric surveys

Bathymetric surveys have to be carefully planned to ensure the most efficient use of the boats and equipment. In particular the planning of the surveys of shallow areas should take into account the timing of spring tide high water to cover as much as possible of these areas.
The deeper parts of the area or channel may be surveyed at low water. It is acceptable that the output of the Survey Unit Anwesha is reduced when shallow areas are included in the area t be surveyed.

Before a cruise a detailed survey plan has to be prepared by the hydrographers in close cooperation with the data processing section. Survey lines should as much as possible run perpendicular to the course of the channel. A special program has been prepared in EXCEL to plan these perpendicular lines with the proper spacing and orientation. See ANNEX B.
In other areas a specific orientation of the lines may be preferred. By jointly preparing the detailed survey plan for a cruise, the quality of the data set can be optimized.

At the end of each survey day all lines have to be entered in an EXCEL file and shown on a chart so that any gaps in the survey made visible and filled in before the survey activities are shifted to an other area.

3.6 Land surveys

Land surveys have not been executed during MES. In case the need arises, a combination of a simple GPS and accurate barometer (with stationary reference barometer) may be used or a combination of GPS and land leveling.

3.7 Current meter measurements

No comments

3.8 Float tracking

Since the hand held GPS has become much more accurate (after removal of the selective availability) these instruments can be used for float tracking. Float tracking is a relatively cheap method to measure surface currents simultaneously in a number of points in a river section.

Only a speedboat and a country boat are required to drop the instruments at pre-determined points and pick up after a couple of minutes. During windy periods with waves float tracking may have to be interrupted because of difficult retrieval of the instruments.

Depending on the width of the river the measurements can be repeated every hour or every two hours. Anyone with a basic computer training can be trained to use the GPS, including downloading in a computer.

A basic set-up of the GPS with float and some samples of the results are given in ANNEX C.

3.9 Detailed surveys

No comments

3.10 Sediment sampling

No comments

4. MISCELLANEOUS ARRANGEMENTS

4.1 Daily management of survey operations

During the MES surveys one of the very experienced hydrographer of SSD has been in charge of the daily management of the survey operations. A second experienced hydrographer of SSD is also permanently involved in the marine survey works and could take over the daily management at least for a limited period of time.

Other SSD staff have received training during MES but are not available for marine survey work except in case of emergency because of their designation within SSD or simply because they are not interested in this type of work.

4.2 Additional surveyors

For detailed or special surveys the two hydrographers permanently assigned to the Survey Unit Anwesha are adequate.

However during the routine bathymetric surveys the two tender boats and one country boat have to be engaged for efficient execution of the survey program. This requires 4 or 5 additional surveyors to ensure that the surveys can be carried out from dawn to dusk.

These additional surveyors may be hired from a local firm as per requirement. It is advisable to ensure that two or three of these additional surveyors have previous experience with the equipment used for marine surveys. Others may be trained, a basic requirement is sufficient background education as well as computer training and a few years experience with computers.

4.3 Vessel

The skipper of the Anwesha is in charge of the ship and its crew. An engineer takes care of the machinery of the ship. The permanent crew of SSD is sufficient to sail the ship for a pleasure trip but not adequate for carrying out an extensive survey program. In particular additional tender boat operators are required as well as a diver to remove fishing nets from the propellers of Anwesha.

Sufficient number of crew should also be available for guard duties. It may even be required to employ professional guards in certain areas because of piracy threat.

4.4 Equipment repair

The hydrographers on the ship can remedy minor breakdowns of survey equipment. Other problems have to be solved by specialized engineers, either local or expatriate. Since it has to be avoided as much as possible that a survey cruise has to be ended prematurely or that the output of the Survey Unit is reduced because of equipment problems, it is essential that a specialist can be called in at short notice or can be consulted to solve the problem.

4.5 Maintenance and overhauling of vessels

Since the vessels are relatively old, breakdowns occur regularly. Most minor problems can be solved while at sea. Sometimes repairs can be postponed until the end of the cruise, other problems may require immediate attention and outside engineers or technicians have to be sent to the ship as soon as possible to ensure that the survey program can be completed as planned.

Routine maintenance appears to be well established on the ship. Annual overhauling should be planned well in advance. At an early stage a decision has to be taken what type of overhauling is needed. Guidelines for overhauling are provided in a report prepared during MES:
Technical Report Survey Vessel "M.V. Anwesha" with tenders and survey equipment, prepared by BVS, the Netherlands April 1998.

The engineer has to prepare a list of spare parts required for overhauling and check the availability of these spares in the store or in the local market. It will take at least 4 months to procure and import spares from abroad following normal procedures and shipment by sea. In case of shipment by air 2 to 4 weeks will be required depending on availability of the spares and customs clearance.

4.6 Data processing and presentation

Processing and presentation of bathymetric, ADCP and other data has been well established during MES. Transfer of these data to the National Water Sector Database has to be done in close consultation with WARPO experts.

Processing of data for other Clients may follow their special requirements.

4.7 Overall management and supervision

Overall management and supervision of the survey operations is required to ensure that the survey works are carried out efficiently as per plan by the Survey Unit Anwesha,.

In principle this is the task of the Survey and Study Division of BWDB. However at the start of the survey works in 1996 the division was not in position to take care of managing the survey works. Therefore it was agreed with the Project Director of BWDB that during MES this management and supervision would be the responsibility of the consultant of MES.

It was agreed by the Ministry of Water Resources that a special separate survey unit would be created within the BWDB as recommended by a Donor's Review Mission in 1997. This was even a condition for continued financial support by the Donors at that time.
Due to unavoidable circumstances such a unit has not yet been established by BDWB.

Since the Executive Engineer in charge of SSD has to abide fully by the rules and regulations of the BWDB, the SSD will not be able to manage the Survey Unit Anwesha in a manner that ensures smooth and efficient survey operations. Because of lots of red tape, not the least around financing of the survey works, it has to be feared that only a very small part of the planned survey program would be carried out under the management of SSD.

In addition, even if sufficient funds are available for this purpose, it is very doubtful that SSD/BDWB would be in a position to provide for the necessary maintenance of both vessels and equipment as is deemed essential for sustainable operation of the Survey Unit Anwesha.

Therefore, in order to ensure smooth and efficient execution of marine surveys in the (near future) the present arrangement of leaving the management to a consultant should be continued. In order to ensure that the survey program is executed efficiently and accurately the Consultant shall appoint the following staff:

4.7.1 Senior hydrographer (expatriate)

The responsibilities of the senior hydrographer will be:

- Overall management and quality control of the survey works
- Preparation of the detailed survey program in close cooperation with the chief hydrographer and the software engineer
- Overall management of the Anwesha including
- Arranging for maintenance, repair and annual overhauling including spare parts from abroad
- Contact with other Clients to acquire additional survey jobs for the Survey Unit Anwesha
- Coordination with other Clients during the execution of their job

4.7.2. Instrument specialist (Expatriate)

This specialist (preferably of the Danish Hydraulic Institute DHI) will be required on short term basis in case survey instruments can not be repaired locally or cannot be sent abroad for repairs. If possible the instrument specialist should check the survey instruments before the start of a survey campaign.

An arrangement is required with DHI to allow the chief hydrographer of the Survey Unit Anwesha to obtain advise from a DHI specialist in Denmark in case of problems that cannot be resolved on the spot.

4.7.3. Vessel manager (local)

The vessel manager, appointed by the Consultant, will be in charge of all activities in relation to the survey works as well as the vessel operation.

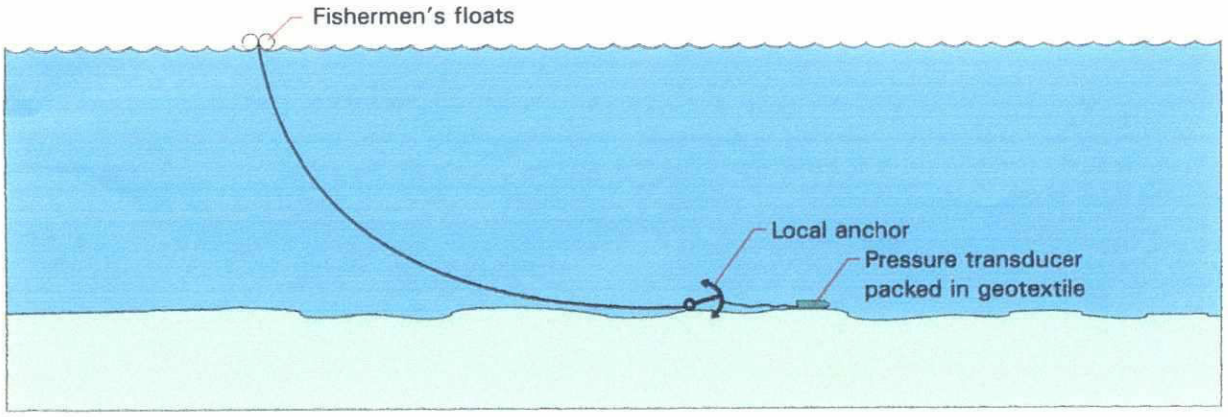
The main tasks and responsibilities of the vessel manger will be:

- During surveys give follow-up on all requests from the chief surveyor in relation to personnel and equipment so that the surveys can proceed without delay or loss of quality
- During surveys give follow-up on all requests from the skipper or engineer of Anwesha to ensure that all vessels remain in operation
- Arrange procurement of locally available spare parts and other necessities for smooth and uninterrupted surveys
- Prepare list of spare parts and cost estimate for overhauling of Anwesha, tender boats and other vessel as required
- Coordinate repair work and annual overhauling of the vessels belonging to the Survey Unit Anwesha with the dockyard
- Handle the accounts of the Survey Unit Anwesha

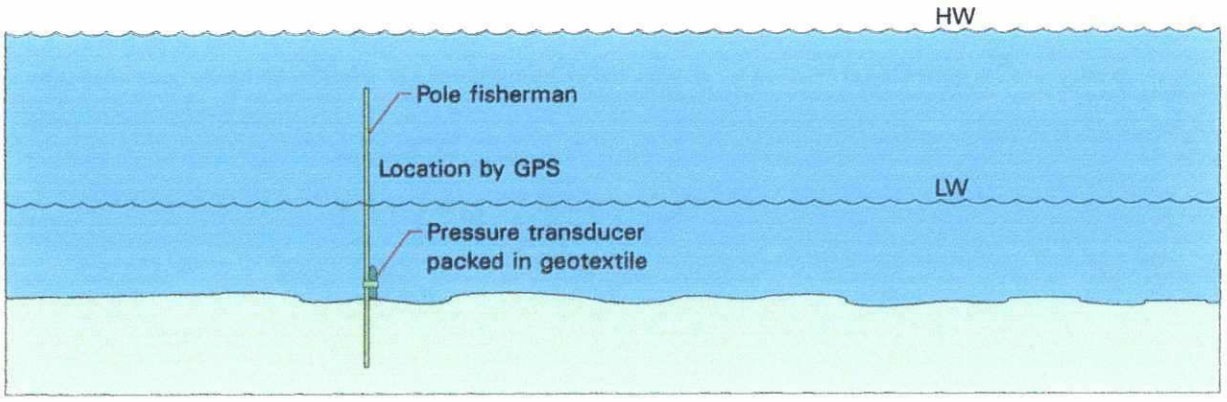
ANNEX A

SURVEYS IN THE MEGHNA ESTUARY

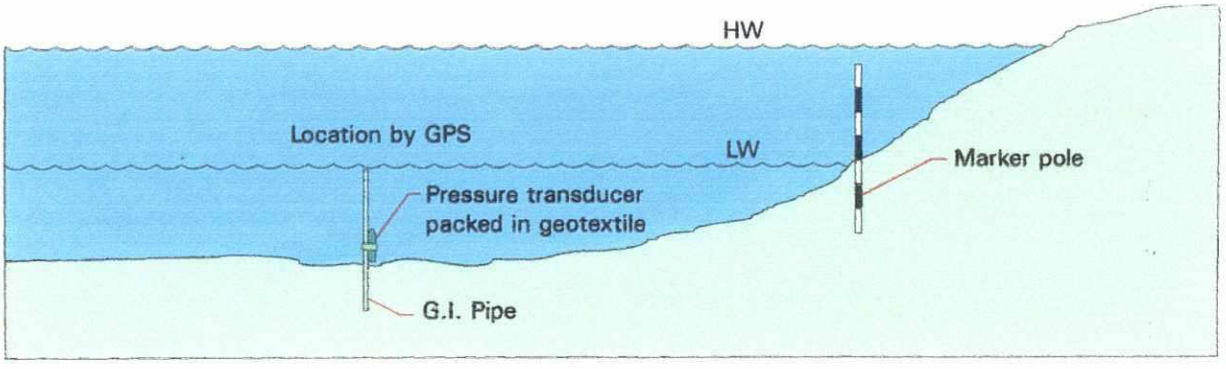
INSTALLATION PROCEDURES FOR PRESSURE TRANSDUCERS



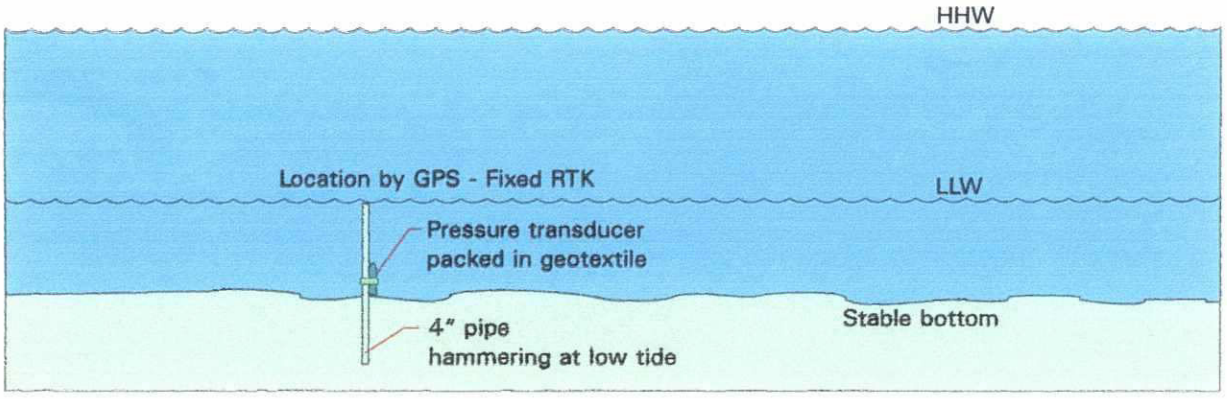
Temporary installation
(few days)



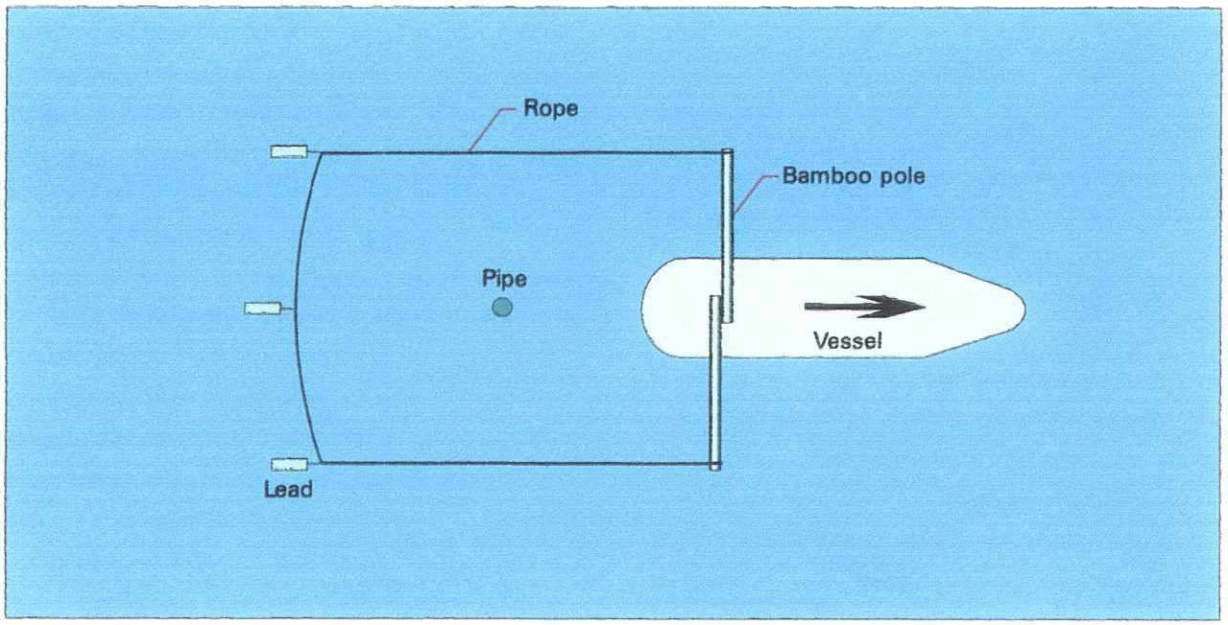
Temporary installation
(1-2 week)



Temporary installation
(1-3 months)



Temporary open water installation
(1-3 months)



Temporary open water installation
(Searching arrangement)

ANNEX B

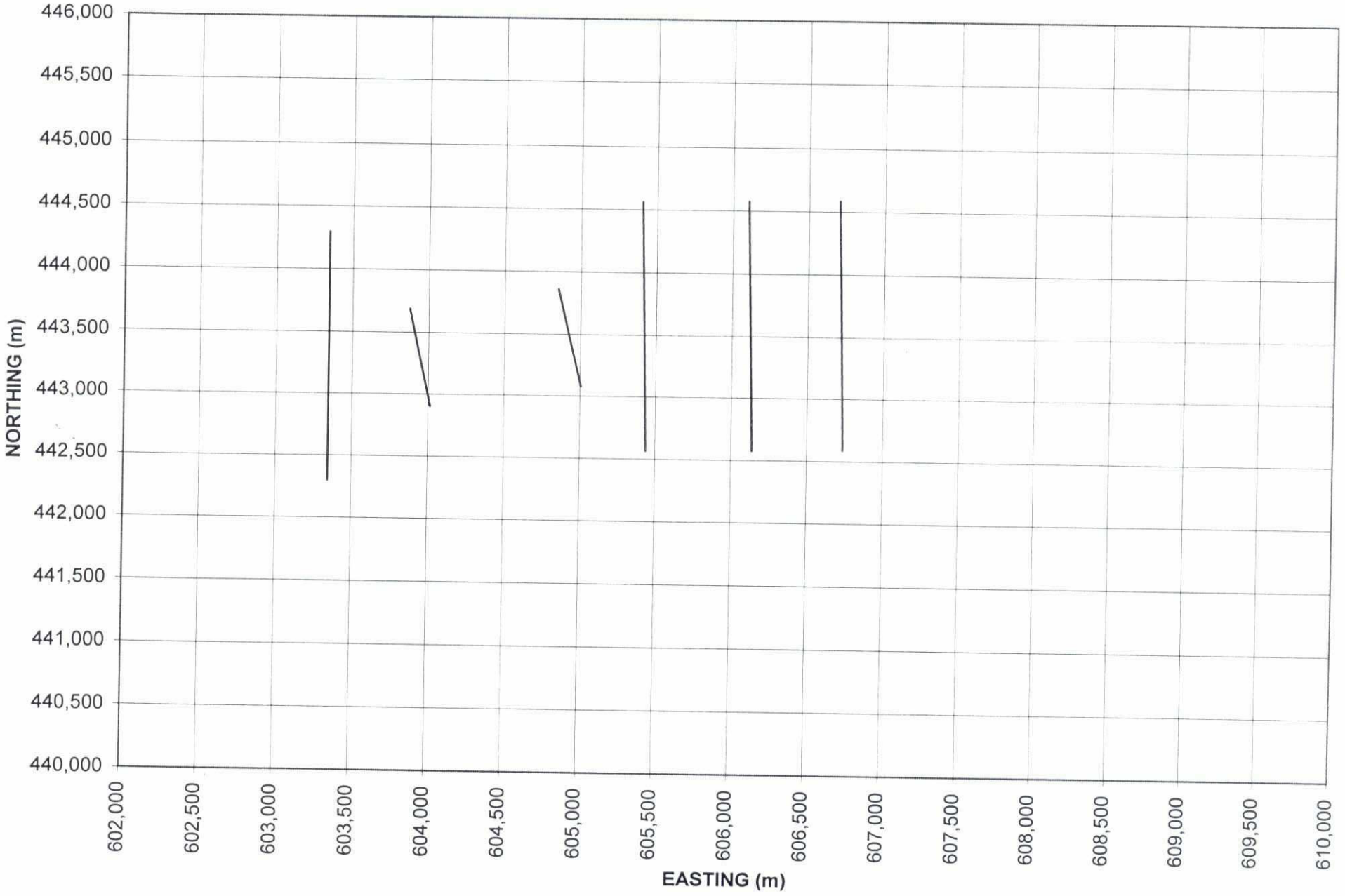
SURVEYS IN THE MEGHNA ESTUARY

PREPARATION OF SURVEY LINES BEFORE SURVEYS

PLANNED LINE		
NO	EASTING (m)	NORTHING (m)
1	603,344 603,344	442,294 444,294
2	604,013 603,875	442,900 443,688
3	605,005 604,852	443,075 443,860
4	605,437 605,402	442,563 444,563
5	606,137 606,102	442,575 444,575
6	606,737 606,702	442,586 444,586

MIDPOINT OF LINE		LINE SPACING	LENGTH FROM MIDPOINT		ORIENTATION	CHANGE IN ORIENTATION	LENGTH OF LINE
NORTHING (m)	EASTING (m)	(m)	(m)	(m)	(0)	(0)	(m)
443,294	**603,344**		1000	1000	90		2,000
443,294	603,944	600	400	400	100	10	800
443,468	604,929	1,000	400	400	101	1	800
443,563	605,420	500	1000	1000	91	-10	2,000
443,575	606,120	700	1000	1000	91	0	2,000
443,586	606,719	600	1000	1000	91	0	2,000

SURVEY LINE PLAN



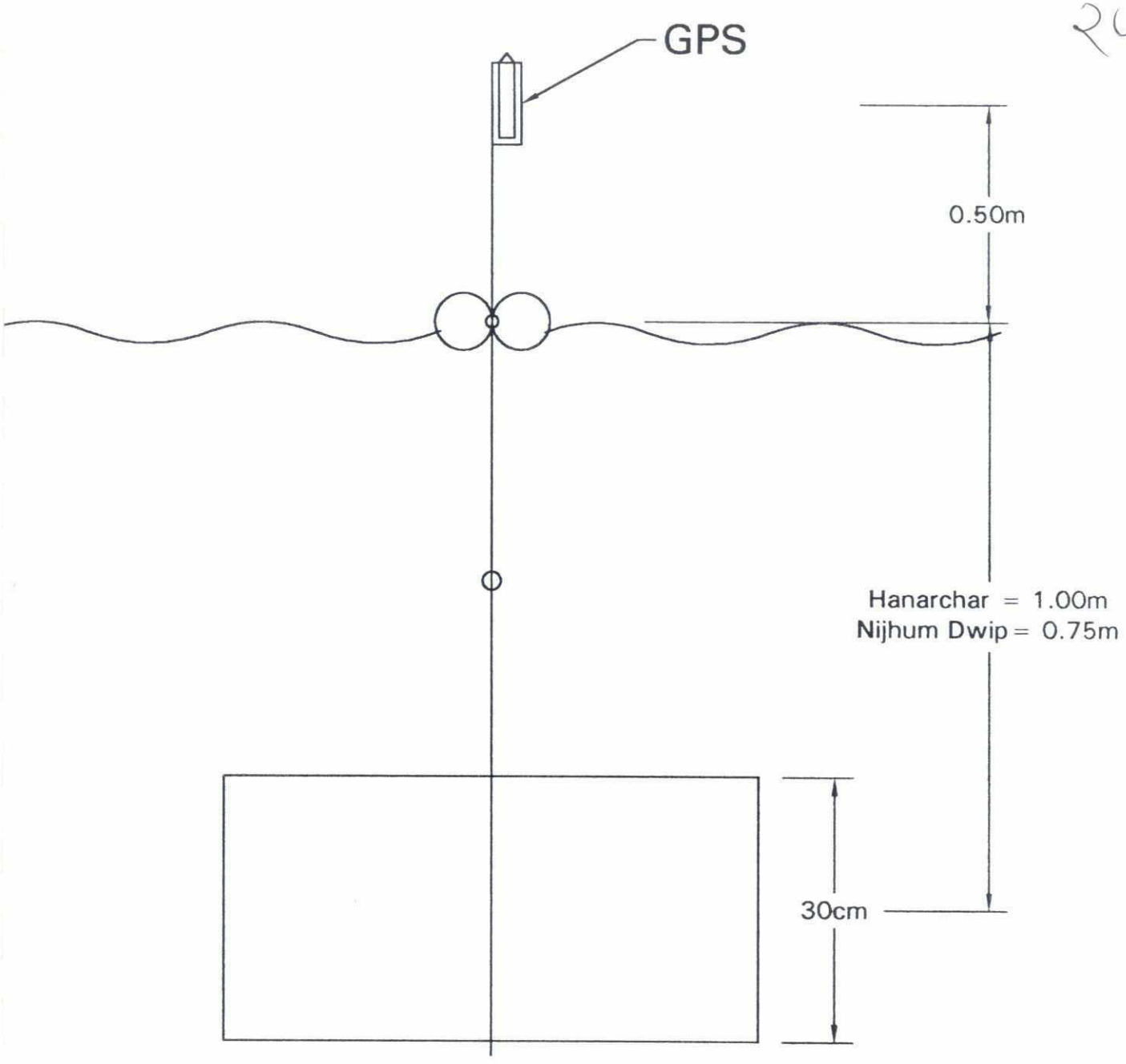
FORMULAS USED IN LINE PLANNING

	PLANNED LINE				MIDPOINT OF LINE	
	NO	EASTING (m)	NORTHING (m)		NORTHING (m)	EASTING (m)
6	1	=F6-H6*COS(J6/180*PI())	=E6-H6*SIN(J6/180*PI())		**443294**	**603344**
7		=F6+I6*COS(J6/180*PI())	=E6+I6*SIN(J6/180*PI())			
8						
9	2	=F9-H9*COS(J9/180*PI())	=E9-H9*SIN(J9/180*PI())		=(C6+C7)/2-G9*COS(J6*PI()/180)	=(B6+B7)/2+G9*SIN(J6*PI()/180)
10		=F9+I9*COS(J9/180*PI())	=E9+I9*SIN(J9/180*PI())			
11						
12	3	=F12-H12*COS(J12/180*PI())	=E12-H12*SIN(J12/180*PI())		=(C9+C10)/2-G12*COS(J9*PI()/180)	=(B9+B10)/2+G12*SIN(J9*PI()/180)
13		=F12+I12*COS(J12/180*PI())	=E12+I12*SIN(J12/180*PI())			
14						
15	4	=F15-H15*COS(J15/180*PI())	=E15-H15*SIN(J15/180*PI())		=(C12+C13)/2-G15*COS(J12*PI()/180)	=(B12+B13)/2+G15*SIN(J12*PI()/180)
16		=F15+I15*COS(J15/180*PI())	=E15+I15*SIN(J15/180*PI())			
17						
18	5	=F18-H18*COS(J18/180*PI())	=E18-H18*SIN(J18/180*PI())		=(C15+C16)/2-G18*COS(J15*PI()/180)	=(B15+B16)/2+G18*SIN(J15*PI()/180)
19		=F18+I18*COS(J18/180*PI())	=E18+I18*SIN(J18/180*PI())			
20						
21	6	=F21-H21*COS(J21/180*PI())	=E21-H21*SIN(J21/180*PI())		=(C18+C19)/2-G21*COS(J18*PI()/180)	=(B18+B19)/2+G21*SIN(J18*PI()/180)
22		=F21+I21*COS(J21/180*PI())	=E21+I21*SIN(J21/180*PI())			

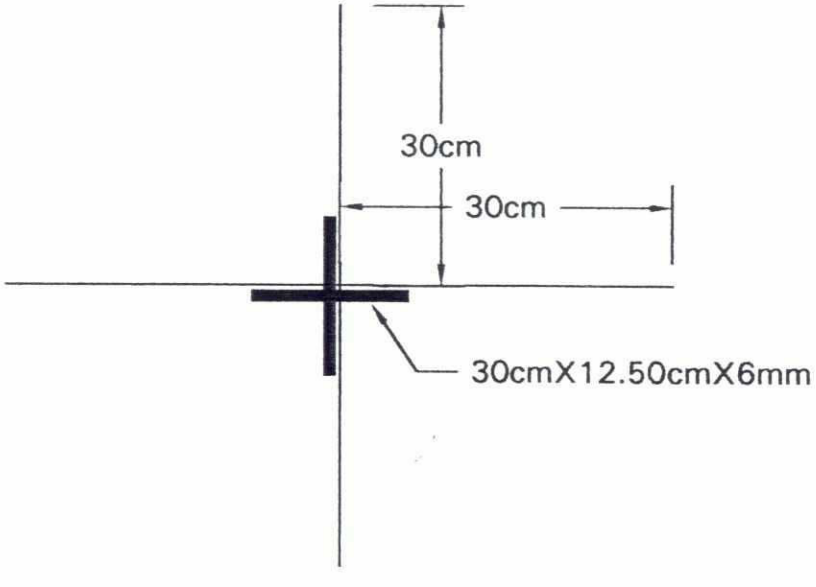
ANNEX C

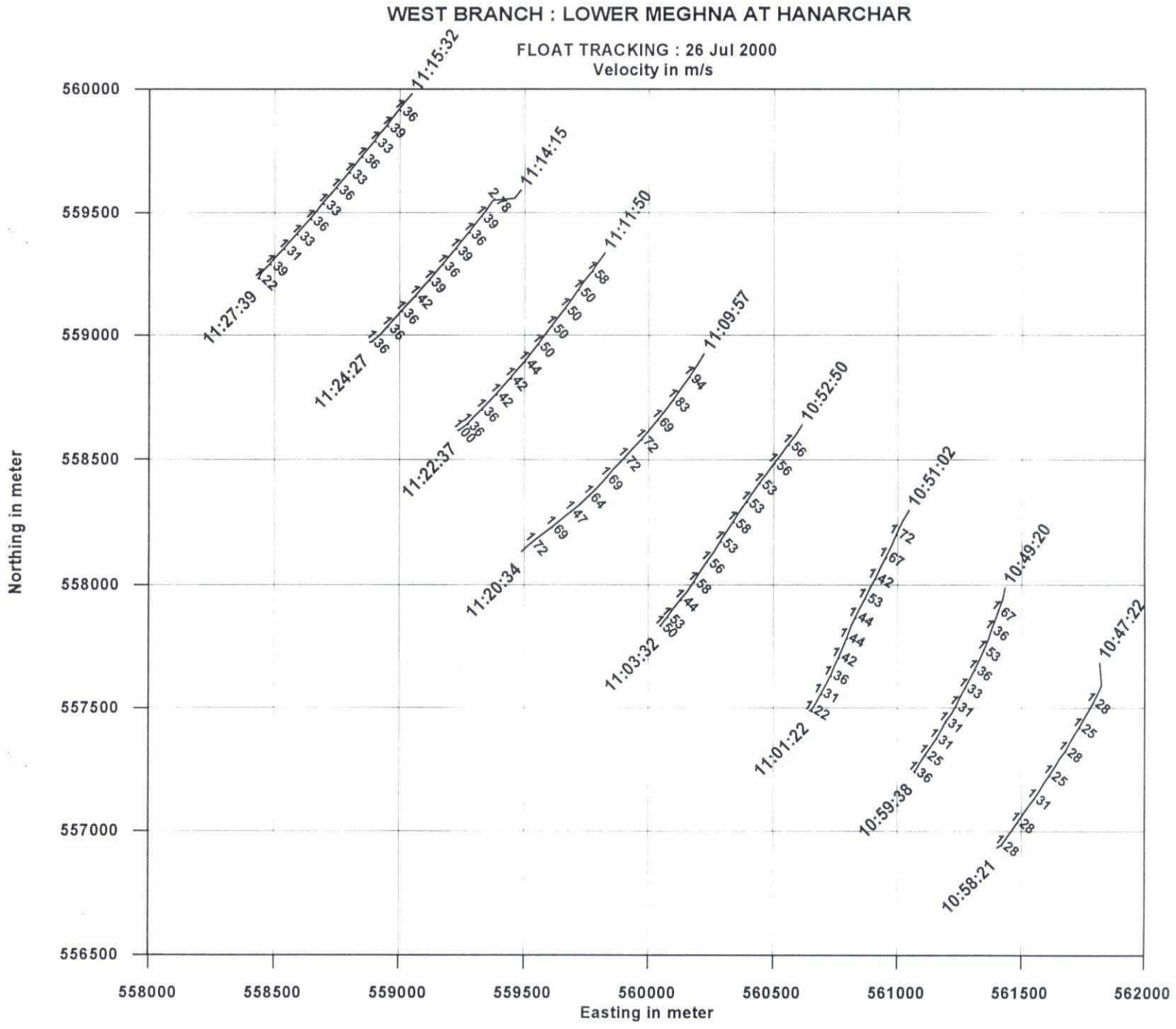
SURVEYS IN THE MEGHNA ESTUARY

SET UP OF GPS AND FLOAT FOR TRACKING
EXAMPLE OF RESULTS


GPS
0.50m
Hanarchar = 1.00m
Nijhum Dwip = 0.75m
30cm

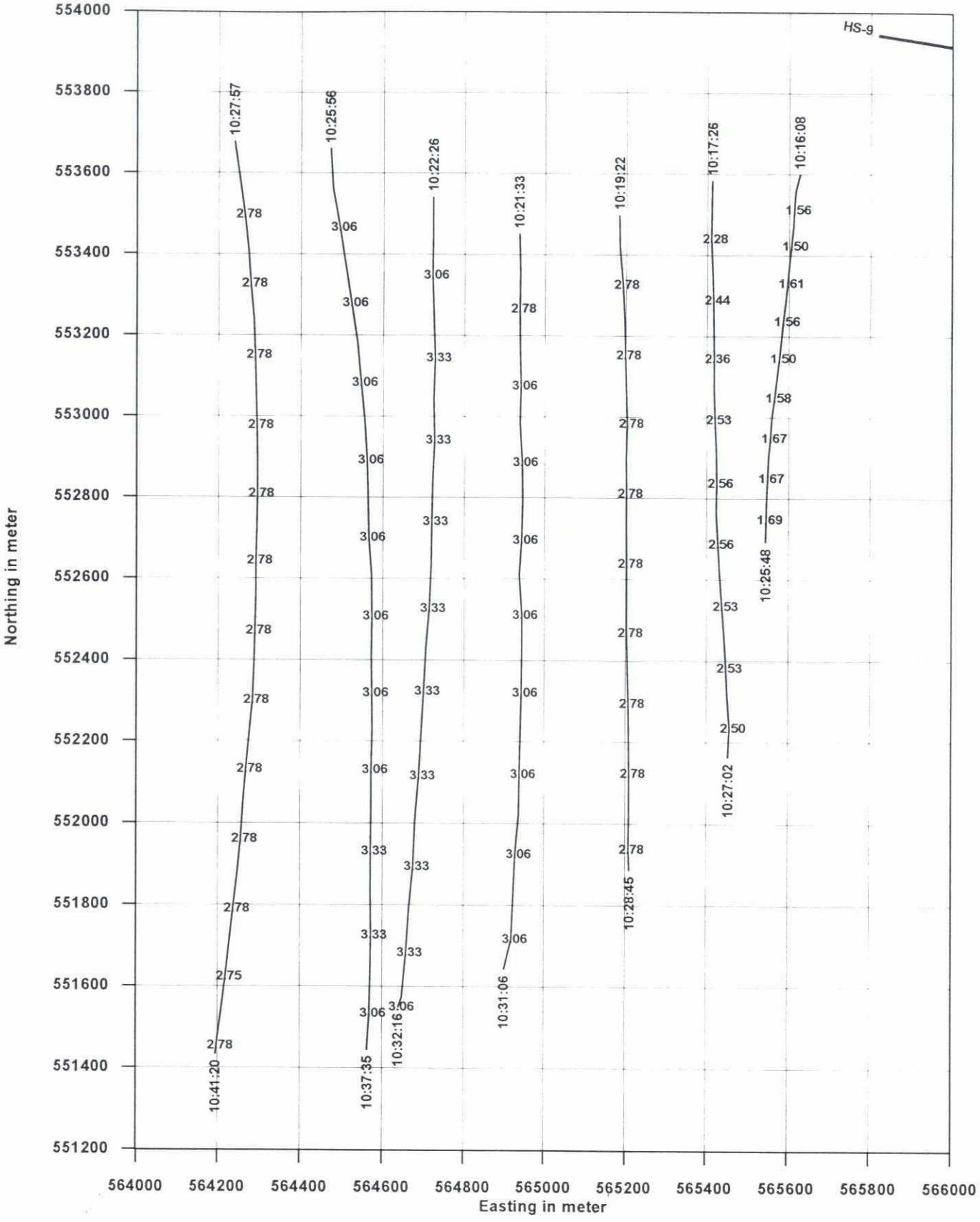
Float


30cm
30cm
30cmX12.50cmX6mm

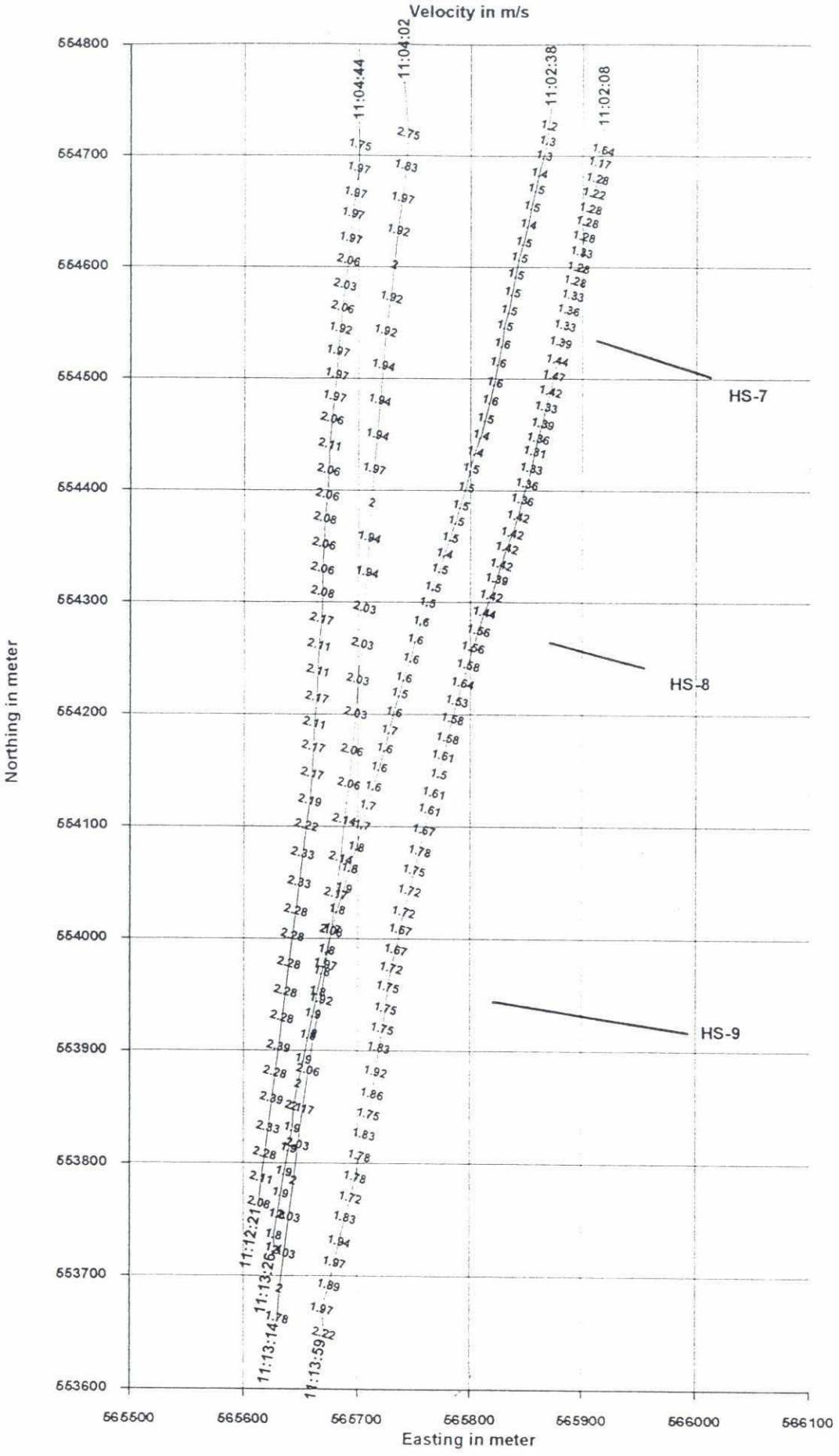

WEST BRANCH : LOWER MEGHNA AT HANARCHAR
FLOAT TRACKING : 26 Jul 2000
Velocity in m/s
Northing in meter
Easting in meter
560000
559500
559000
558500
558000
557500
557000
556500
558000
558500
559000
559500
560000
560500
561000
561500
562000
11:27:39
11:15:32
11:24:27
11:14:15
11:22:37
11:11:50
11:20:34
11:09:57
11:03:32
10:52:50
11:01:22
10:51:02
10:59:38
10:49:20
10:58:21
10:47:22

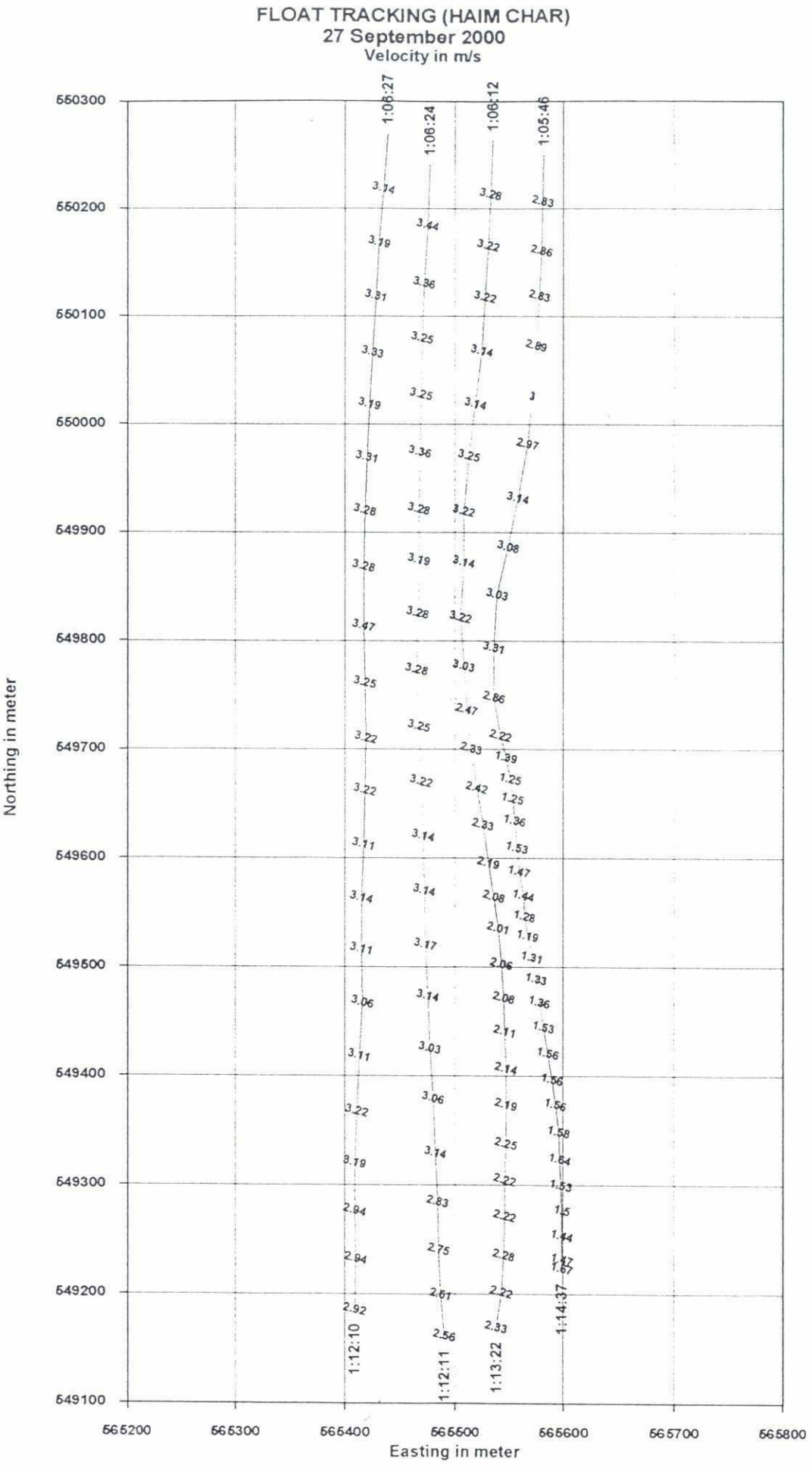
EAST BRANCH : LOWER MEGHNA AT HANARCHAR

FLOAT TRACKING
11 August 2000
Velocity in m/s



FLOAT TRACKING (HANAR CHAR)
21 September 2000




FLOAT TRACKING (HAIM CHAR)
27 September 2000
Velocity in m/s
1:08:27
1:06:24
1:06:12
1:05:46
1:12:10
1:12:11
1:13:22
1:14:37
550300
550200
550100
550000
549900
549800
549700
549600
549500
549400
549300
549200
549100
Northing in meter
565200
565300
565400
565500
565600
565700
565800
Easting in meter