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MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MES II
MEGHNA ESTUARY STUDY

TECHNICAL NOTE MES-035

ANALYSIS OF CROSS-SECTIONAL PROPERTIES OF CHANNELS IN THE MEGHNA ESTUARY

June 2001

DHV CONSULTANTS BV

in association with

DEVCONSULTANTS LTD
SURFACE WATER MODELLING CENTRE

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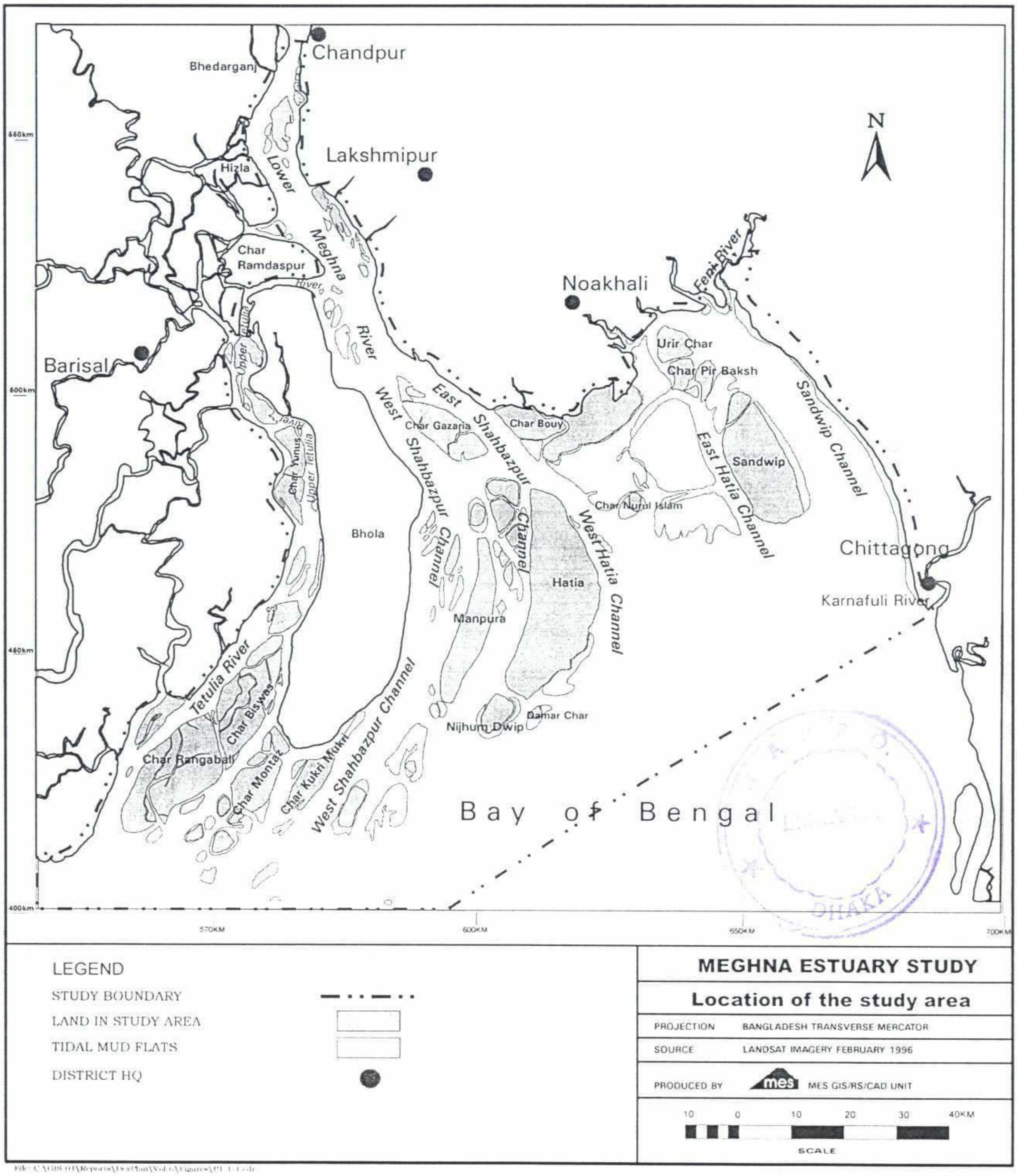
1. INTRODUCTION

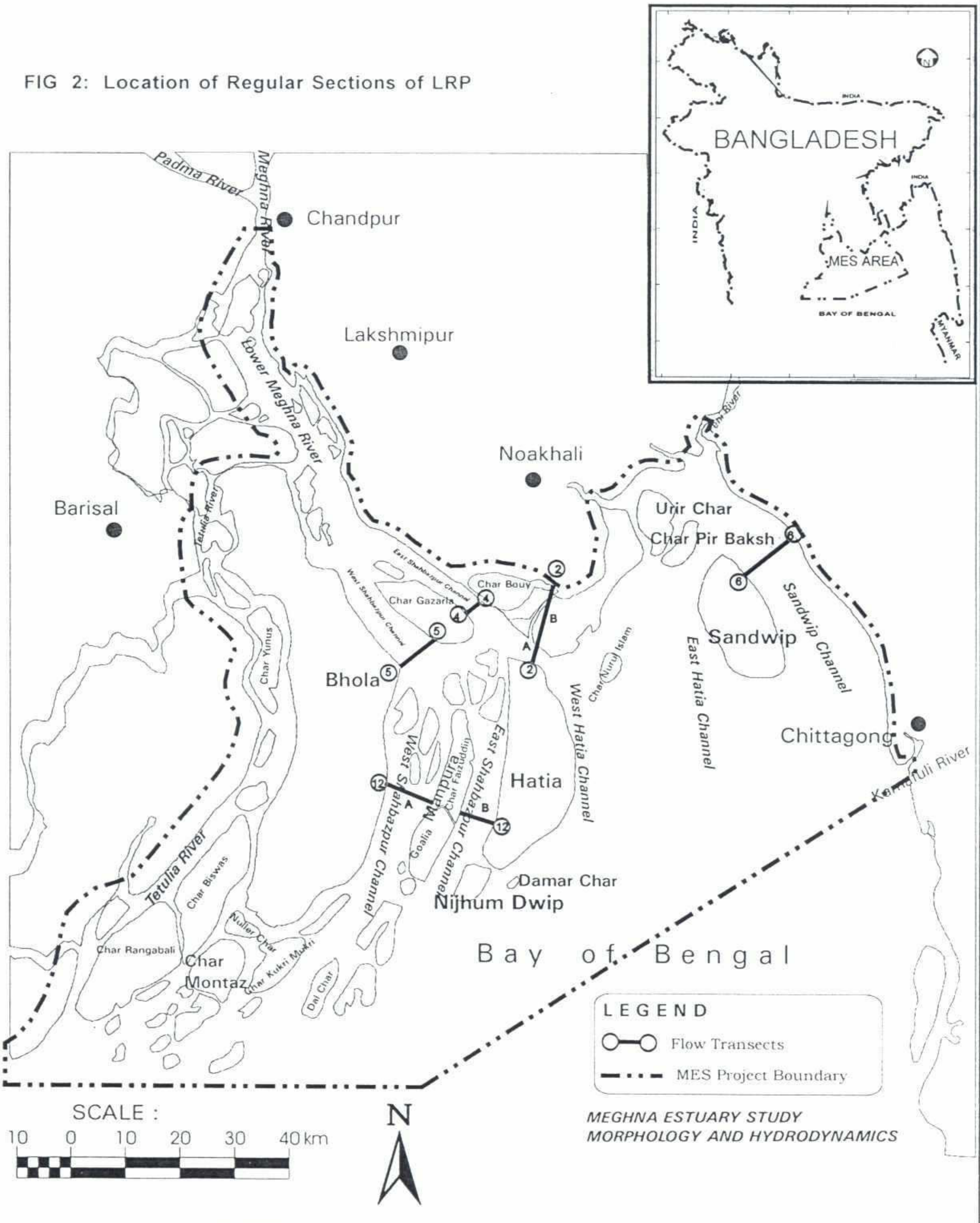
The Lower Meghna Estuary consists of many channels, which are either tide and river flow dominated. Here 'dominance' means the direction of residual (i.e., net) flow during a tidal cycle of 12.4 hours. Figure 1 shows the locations of channels, islands and mud flats in the estuary and figure 2 shows the locations of 'regular' cross-sections. Figure 3 shows the locations of cross-sections drawn from bathymetric echosoundings.

Figure 1: Location Map of Meghna Estuary



The purpose of this note is to study the change in area and conveyance ($A*R^{0.66}$ in Manning's formulation, where A is the cross-sectional area and R is the hydraulic radius) of selected cross-sections in the estuary.

FIG 2: Location of Regular Sections of LRP



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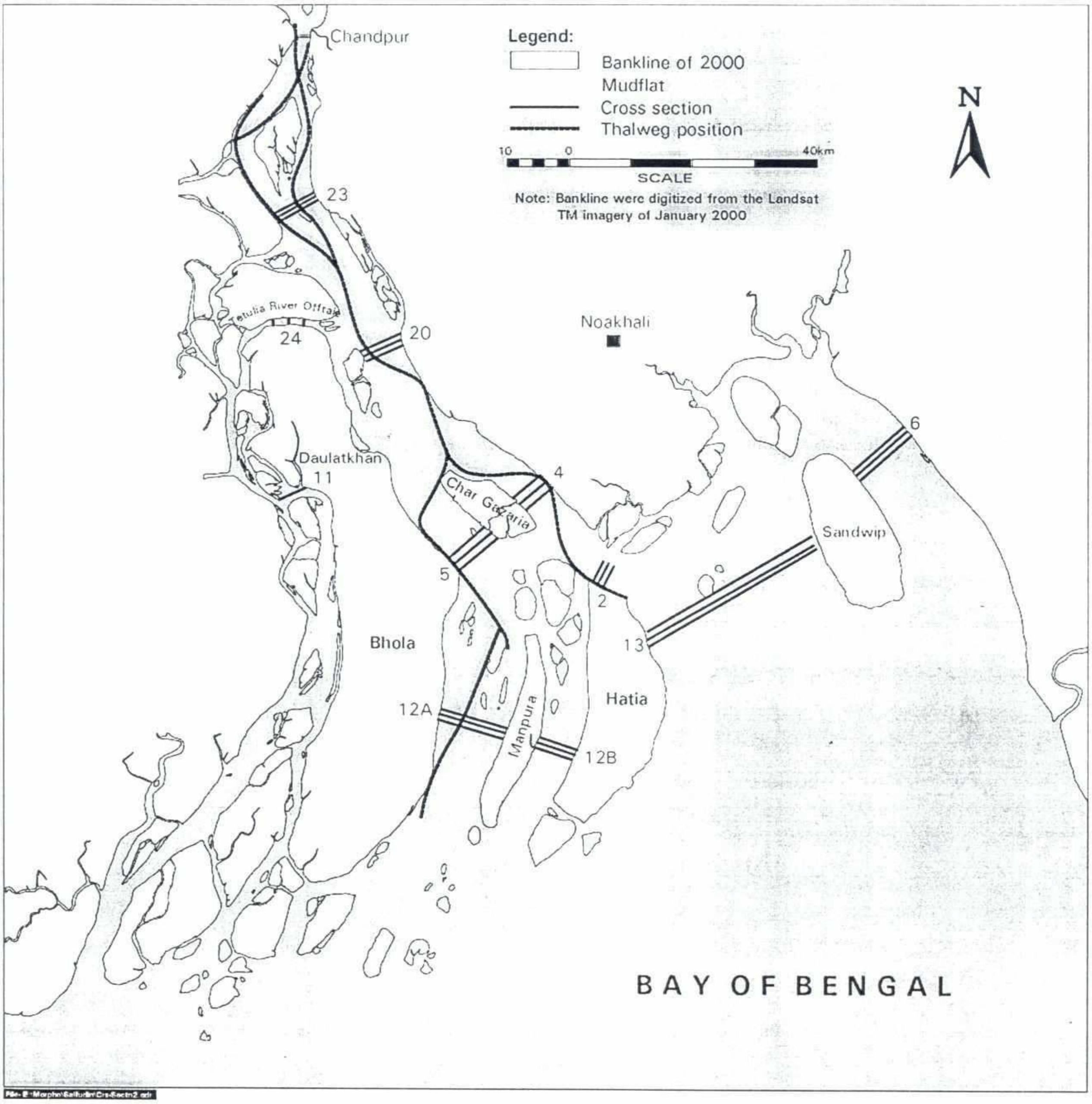
Conveyance is the most important geometric property of a channel as it determines the capacity of a channel to convey flow through it. So, during flows higher (e.g., during high floods) than normal, the channel will adjust its cross-sectional properties to convey the flood flows. Conveyance is the result of interaction of flow and sediment that are carried by an alluvial channel. Morphologically dynamic portions of the estuary, thalweg, and bankline migration can be identified by studying the shape of cross-sections. For navigational purposes, the location of main flow channel i.e., the location of the area of greater depths is also important. Significant change in cross-sectional area and conveyance would mean that major morphological changes took place. When conveyance of a cross-section of different dates are compared, it has been assumed the roughness around the cross-section in the channel has not changed between the period(s) of investigation.

Fig 3 : Locations of cross-sections drawn from bathymetric echosoundings and thalweg



2. APPROACH

One way of studying the variation in area and conveyance in time and space is the plotting of these parameters by any standard software like EXCEL and MIKE11. The processed cross-sectional database menu in MIKE 11 gives ten vertical levels for a cross-section and the corresponding area, hydraulic radius, width and conveyance for each level.

3. EROSION AND ACCRETION PROCESS

Bankline migration is caused by change in cross-sectional area, which occurs due to bank erosion and accretion. Cross-sectional area also changes due to a change in riverbed level.

The rate of bank erosion is determined by the strength of the bank on the one hand and the fluid forces on the other hand. Often a distinction is made between noncohesive and cohesive banks.

Bank erosion can be due to fluvial entrainment of individual particles (mainly by large velocities and shear stress on the banks), undermining the toe of the bank and subsequent soil-mechanical failure or liquefaction by overpressure in fine sand during falling water levels. Coleman (1969) observed that for the Brahmaputra (Jamuna) River, the majority of bank failures were due to current undermining and subsequent failure of levee deposits. For the toe erosion of lower portion of banks, it holds that the material, which enters into the river by the slumping of top portion of bank, has to be eroded. This same failure mode was observed in the channels in the Lower Meghna Estuary. Hence, bank erosion is controlled on the one hand by the instability of the banks and on the other hand by the sediment transport capacity of the flow near the bank.

4. METHODOLOGY

Some cross-sections are termed 'regular' (figure 2) in this analysis in the sense that these cross-sections were taken at the same position many times to monitor morphological and planform changes and to measure discharge. These cross-sections cover the whole channel width from one bank to the other and are of pre-1996 period and were echosounded during Land Reclamation Project period.

The cross-sections that are not regular are referred to as 'bathymetric sections' (figure 3) in this note and they were composed from the contours (done by 'surfer' software) of bathymetric echosoundings for this analysis. These echosoundings were usually carried out during the dry season of any year to avoid windy and unworkable monsoon climate. When comparisons are made between 'bathymetric sections' (for areas, conveyance and shape) of different years, it was ensured that these cross-sections are processed from exactly the same locations for consistency. Bathymetric sections are of post-1996 period. In the enclosed figures, all regular and bathymetric sections were drawn from left to the right of channels when looking from north to south.

All pre-1996 cross-sections have only one profile of the same date. But most of the post-1996 cross-sections i.e., 'bathymetric sections' have 3 transverse profiles spaced equally within a 1 km reach – one is located 500 meter upstream (denoted 'us' in the drawings) and the other is located 500 meter downstream (denoted by 'ds' in the drawings) and the third one is located midway between the 'us' and 'ds' cross-sections. The three cross-sections were profiled by processing the bathymetric data with the help of MES inhouse software and 'surfer' linear interpolation. Then these cross-sections were put into the MIKE11 database mainly for calculating cross-sectional areas and conveyances. The three cross-sections were taken to visualize the change in shape of channel bed within a 1 km range, which in some cases is quite significant from morphological point of view.

It is assumed that each regular section (pre-1996) was measured at the same location several times during discharge measurements. Also, each 'bathymetric section' was profiled at the same location in different years for consistency and for comparing cross-sectional properties such as area and conveyance. Cross-sectional area and conveyance of a section were compared below a certain level (0.0 m PWD) for different dates.

Regular sections have one advantage over bathymetric sections – regular sections were measured from bank to bank i.e., they cover the whole width of a channel but bathymetric sections do not cover the whole width of the channel as the survey vessel could not echosound the channel up to the top of bank line and a little bit into the land side beyond the channel bank or natural levee. In sum, bathymetric sections are incomplete. Bathymetric sections are shorter in width than the regular sections – the amount depend on the type of bank line. For the same width of a channel, when the bankline is steep, the bathymetric sections are wider than when the bankline is mildly sloping (for the same top width of a cross-section) i.e., a bankline having mudflats e.g. the north bank of cross-section 2 at Bouer Char along Noakhali mainland. Usually, bathymetric sections echosounded during high water levels are wider than those echosounded during low water levels. As cross-sectional properties of bathymetric sections should not be compared with those of regular cross-sections because most of the bathymetric sections were not profiled up to the bank top level, they were compared in this report to get 'global' estimates.

The cross-sectional shapes, areas and conveyances are plotted in drawings 1 through 76.

Area and conveyance of cross-sections are given in table 1.

5. ANALYSIS OF CROSS-SECTION PROFILES

5.1 The Lower Meghna River, East and West Shahbazpur Channel

5.1.1 The Lower Meghna River

In this analysis, the Lower Meghna River is defined as the river from the confluence of the Padma (Ganges) and the Meghna River located upstream of Chandpur to Daulatkhan in Bhola (about 20 km downstream of northeast corner of Bhola island (figure 1)).

Drawings 1 through 9 show the shape of the cross-section, cross-sectional area and the conveyance of the cross-section profiles at Chandpur. The only available regular x-section (drawing 1) at Chandpur was profiled on 5/10/97 and bathymetric sections were echosounded on 18/5/2000 (drawing 4) and 7/01/98 (drawing 7). The locations of the regular and bathymetric sections at Chandpur are not the same and this is evident from drawings 1, 4 & 7. Profiles of 2000 were taken probably close to the location of a submerged transverse spur of Chandpur Town Protection Project as the bed level is close to -30 m PWD. So, the variation of cross-sectional area and conveyance cannot be compared between 1997 and 2000. Bathymetric sections of 2000 are wider by about 500 m than those of 1998 and their area and conveyance are more than those of 1998. Profiles of CHAND-US and CHAND-DS of 2000 show slight variation in area and conveyance within the 1 km reach. Profiles of 1998 show almost no variation.

Table 1 : Area and conveyance of cross-sections

Cross-section ID	Date of Survey	Area below 0.0 m PWD m^2	Conveyance below 0.0 m PWD $AR^{2/3}$
CHAND2LM	05/10/97	31470	145675
CHANDPUR	18/05/2000	46340	377930
	07/01/98	39555	353970
CHAND-DS	18/05/2000	43000	332330
	07/01/98	39535	343130
CHAND-US	18/05/2000	49230	418320
	07/01/98	40406	363200
CS23	17/05/2000	41280	161740
	10/01/98	48000	209150
CS23-DS	17/05/2000	38010	147390
	10/01/98	43040	183620

Cross-section ID	Date of Survey	Area below 0.0 m PWD m^2	Conveyance below 0.0 m PWD $AR^{2/3}$
CS23-US	17/05/2000	41900	172650
	10/01/98	60440	282180
CS20	29/04/2000	40830	150430
	15/01/98	36352	139130
CS20-DS	29/4/2000	40360	147430
	15/01/98	36620	138215
CS20-US	29/4/2000	39780	150850
	15/01/98	36185	148490
CS-4	03/05/83	16760	53955
	25/09/85	16840	56890
	06/10/87	16490	48666
	28/07/90	20090	65360
	17/04/2000	29318	111825
CS4-DS	17/04/2000	32283	124680
CS4-US	17/04/2000	31143	124012
CS-5	23/08/83	31265	184840
	16/09/87	46805	213325
	06/10/87	35860	144265
	26/02/90	40185	171615
	17/04/2000	46275	204295
CS5-DS	17/04/2000	38535	186025
CS5-US	17/04/2000	44670	204965
CS-12B	23/04/84	22520	63070
	14/12/86	35585	120420
	04/08/90	44235	161115
	21/04/2000	32105	100610
NH2ESHA1 (CS-12B)	11/09/97	43075	142635
CS12B-DS	21/04/2000	30120	92640
CS12B-US	21/04/2000	31255	97375
CS-2	11/05/83	44165	158045
	17/07/85	45452	171650
	07/01/87	48565	196096
	05/03/89	40095	147605
	14/09/90	39555	148460
	16/02/94	35000	136780
	25/04/2000	37570	194300
CS2-DS	25/04/2000	37200	197253
CS2-US	25/04/2000	34000	173000
CS6	06/04/82	78170	278345
	12/09/85	107060	483180
	05/09/90	97290	402226
	21/02/94	103740	464290
	26/12/99	104360	481057

Cross-section 23 is located at about 25 km downstream of Chandpur which was profiled from bathymetric soundings of 2000 (drawing 10) and 1998 (drawing 13). No regular cross-section is available at this location. There was no significant change in the cross-sectional area and conveyance during 2000 within 1 km reach. Profiles of 'us' and 'ds' of 1998 show about 10% variation in area and cross-section.

No regular cross-section at the location of section 20 is available as well. No significant change in area and conveyance is visible between the 3 profiles of 1998 (drawings 20 & 21). If we compare the drawings 16 & 19, we can see that between 1998 and 2000, the channel has widened by the deepening of right bank and the left bank conveyance section accreted to some extent. Cross-sectional area and conveyance increased by about 10% and 6% respectively at 0.0 m PWD level between 1998 and 2000.

5.1.2 The East and West Shahbazpur Channels

The end of Lower Meghna River at Daulatkhan in figure 1 is the starting point of East and West Shahbazpur Channels and these two channels continue up to the south of Nijhum Dwip island.

Pre-96 cross-sections 4 & 5 (figure 2 and drawings 22 & 23) are located at the head of East and West Shahbazpur Channels.

Cross-section 4 is located in the East Shahbazpur Channel at the downstream end of Char Gazaria. There are 4 regular profiles of cross-section 4 which were echosounded in '83, '85, '87 and '90. There is a slight variation in shape and but very insignificant variation in area and conveyance took place between '83 and 87 (drawings 24 & 25). This section increased by about 20% in area and conveyance between 1983 & 1990 (table 1). Cross-section 4 has increased in area and conveyance by about 50% and 70% respectively between 1990 and 2000 if we compare the area below 0.0 m PWD and it also deepened.

There is almost no change in area of section 5 between 09/87 and '90 profiles at 0.0 m PWD level (table 1). Prior to 1990, the main conveyance section was on the Char Gazaria side but 2000 profiles show that it is along the Bhola side. 1983 profile (drawing 23) of section 5 seems unreliable. 2 profiles of monsoon 1987 (drawing 23 and table 1) show significant variation in area (30%) and conveyance (48%). 1990 regular and 2000 bathymetric profiles of section 5 show more than 15% increase in area and conveyance and also the main conveyance channel deepened. Although profiles of 2000 are incomplete (drawing 26), these do not show any significant variation in area and conveyance. CS5-DS (drawing 26) has either processing error or sounding error. The coastline is retreating i.e., it is being eroded at the Bhola side but the rate of retreat is insignificant.

It is evident from regular sections of cross-section 12A (drawing 29) that the profiles were not echosounded at the same location because satellite image suggest that bankline cannot shift by 3km between 90 and 91. It is also doubtful whether 84 and 90 profiles of section 12A were echosounded at the same location. 1997 & 2000 profiles of 12A are incomplete (drawings 32 through 37). So, no conclusion can be drawn from the regular and bathymetric sections of section 12A.

The area and conveyance of cross-section 12B (figure 2) increased significantly by about 100% between 1984 and 1990 (drawings 39 & 40 and table 1) but the same during 1990 and 1997 did not change significantly (drawings 39, 40, 45 & 46 & table 1). The profiles of 2000 are incomplete.

5.2 Hatia Channel

Regular cross-section 2 (figure 2 and drawings 47 thru' 49) falls in the West Hatia Channel. Prior to 1994, the section was a composite one having two conveyance channels-the main one along the bank of North Hatia and other one on the Bouer Char side along the Noakhali main land. Area and conveyance increased slightly from '83 to '85 (table 1) after which these decreased up to 1994 and increased again in 2000. There is about 20% reduction in area and conveyance between 1985 & 1994 (drawing 48 & 49 and table 1). This section has been reducing in width and deepening along the Noakhali mainland side near Bouer Char and is deepening and widening on the North Hatia side. Bathymetric sections of 1997 are incomplete (drawing 53) i.e., during the survey, whole width of the cross-section was not sounded. Profiles of 2000 of are also somewhat incomplete (drawing 50) along the north Hatia bank as the bankline is steep here. Accretion along Noakhali coast seems to be more than the erosion along North Hatia coast and that's why the width of bathymetric section of 2000 is about half of that of pre-96 regular sections but North Hatia side and the Bouer Char side along the Noakhali mainland deepened also in comparison with pre-1994 cross-sections. Because of this deepening of both banks, there is an increase in area (5%) and conveyance (40%) between 1994 and 2000. The conveyances of 1987 & 2000 are close (table 1) although cross-sectional area was much higher in 1987. This is due to the less hydraulic radius in 1987 than in 2000. Although new land is emerging along the Noakhali main land side, it will take about many years when these lands would be ready for agricultural purposes and would be above the high water level for practical uses.

Bathymetric section 13 (figure 2 & drawings 56 through 61) covers the whole East and West Hatia Channel-about 30 km wide. There was significant variation in shape between the 'us' and 'ds' section within a reach of 1 km in 1997-specially between 5th km and 20th km of width which suggests the existence of some dunes. There are dunes of about 5 m height between 8th km and 16th km of width. These silt dunes contribute significantly to the bed load transport and also to bed roughness. This cross-section increased in size between 1997 and 2000. If we compare the 'us' section of 1997 and 2000, we find that East Hatia side deepened quite a lot.

5.3 Sandwip Channel

In the Sandwip Channel, regular section 6 spreads from northeast Hatia to Chittagong mainland, and about 11 km wide.

All the regular sections of section 6 are approximately 12 km wide (drawing 62) but the bathymetric sections are about 11 km (drawings 65 & 68) wide. Bottom levels of 1982 & 1994 cross-sections show that the cross-section deepened by about 3 meters in 12 years. Bottom levels of 1994 & 1999 are more or less the same. Chittagong bankline is much steeper than the Sandwip east bankline. Drawings 63 & 64 and table 1 show insignificant variation in area and conveyance between 1994 and 1999 and also between 1985 & 1999. Comparison of properties in bathymetric sections of 1997 & 2000 show that there is slight increase in area and conveyance during this period but as these are bathymetric sections which were not sounded up to the top of banklines, this conclusion should be taken very cautiously.

5.4 Offtake of the Tetulia River

There are no regular sections here except the bathymetric sections.

The right bank (north) is eroding while the left bank (south) is accreting. Bathymetric sections of 1997 (drawing 74) and 2000 (drawing 71) show that there is insignificant change in area and conveyance.

5.5 Position of Thalweg

The position of thalweg (i.e., the line of maximum depth along a channel, figure 3) was determined by comparing the change in bed level between the bathymetric surveys of 1997 & 2000.

It is observed that in the course of some years, a few channels in the project area shifted their main conveyance section from one bank to the other (or from one channel to another channel in case of composite cross-sections) due to changes in the hydraulic and morphological regime. Consequently, the position of thalweg also shifted and this was the most significant change observed within the channel systems in the sense that the rate of channel bank erosion and accretion will change and even an eroding bank may change to an accreting or stable bank. A sudden increase in bankline migration rate reveals that the thalweg has either deepened or the thalweg migrated from another location to the bankline under investigation or both. It is important to know the position of thalweg in the sense that e.g., sometimes, it can be used to ascertain the setback distance of embankments in coastal areas in conjunction with the bankline migration rate and also to locate a navigation route for vessels that have a large draft.

7. CONCLUSION

Change in area and conveyance over time and space for all important locations in the estuary could not be ascertained adequately for the lack of required number of regular i.e, bank to bank cross-sections but a methodology has been established to analyze the necessary data. As bathymetric sections were not measured from bank to bank and as regular sections were not interpolated by 'surfer' software as were done for bathymetric sections, comparison of cross-sectional properties of regular and 'bathymetric' sections gave global estimates.

Available bathymetric sections show that no significant change in area and conveyance of the whole Lower Meghna River between Chandpur and Char Gazaria during 1997 and 2000 took place.

The East Shahbazpur Channel from the east of Char Gazaria to the south of Manpura island increased in size significantly. The East Shahbazpur Channel at the east of Char Gazaria increased in area and conveyance by about 50% between 1990 and 2000. There is no significant change between 1990 and 1997 at section 12(B) between South Hatia and Manpura.

The West Shahbazpur Channel at the west of Char Gazaria increased by more than 15% in area and conveyance between 1990 and 2000.

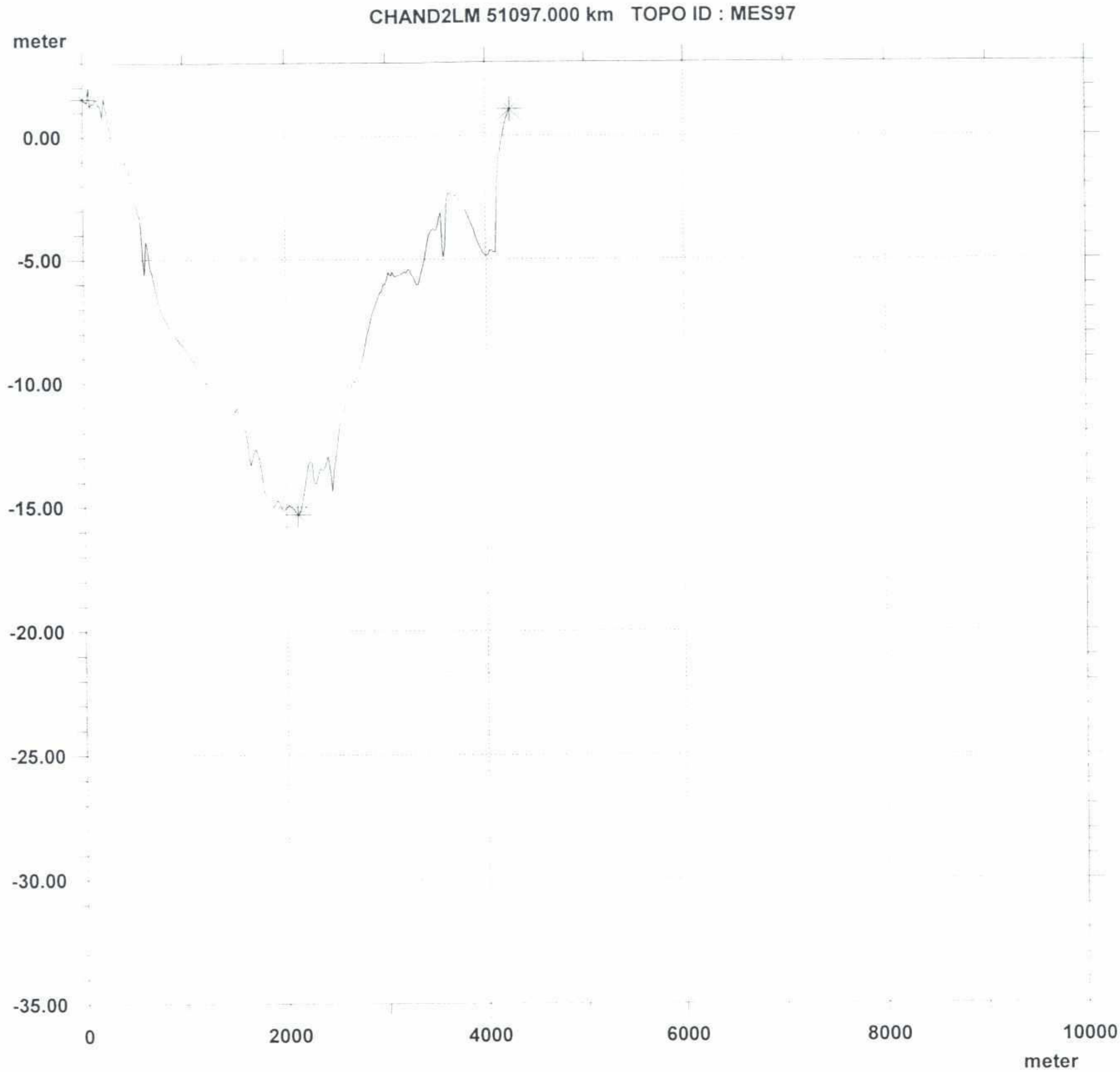
Area and conveyance of section 2 in West Hatia Channel increased insignificantly from '83 till '85 and were almost same between 85 to '87 after which these decreased in size till 1994 and again increased before 2000. There is about 20% reduction in area and conveyance of section 2 between 1985 & 1994. Between 1994 & 2000, the area and conveyance increased by about 5% & 40% respectively due to the deepening along the both banks of section 2.

The East and West Hatia Channels along section 13 increased slightly between 97 and 2000.

The Sandwip Channel along section 6 shows slight variation in size.

8. RECOMMENDATION

Whenever possible, such analyses should be carried out with adequate number of bank to bank cross-sections spaced equally over time at the same locations.



MIKE 11

DATA BASE : MES97

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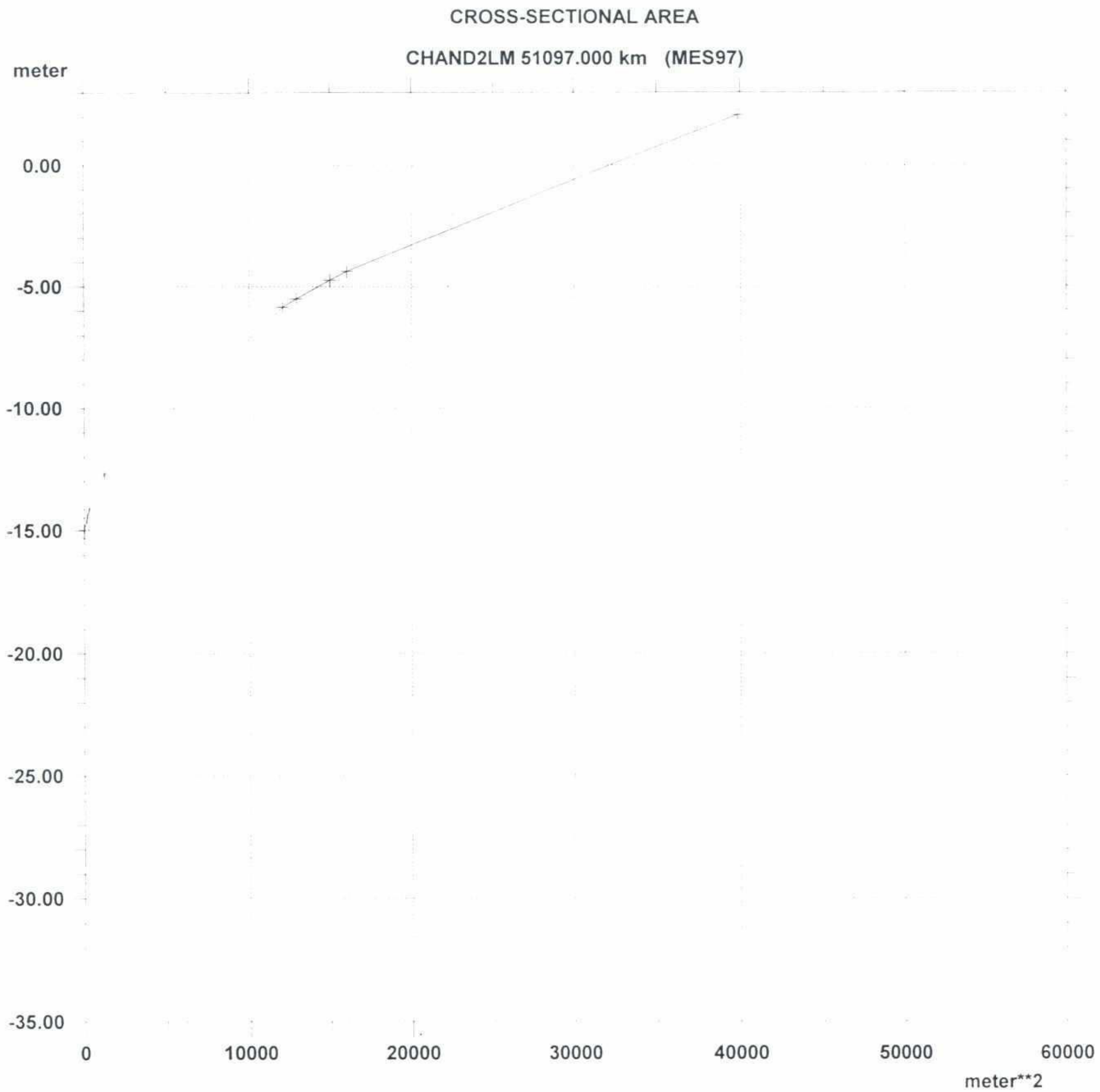

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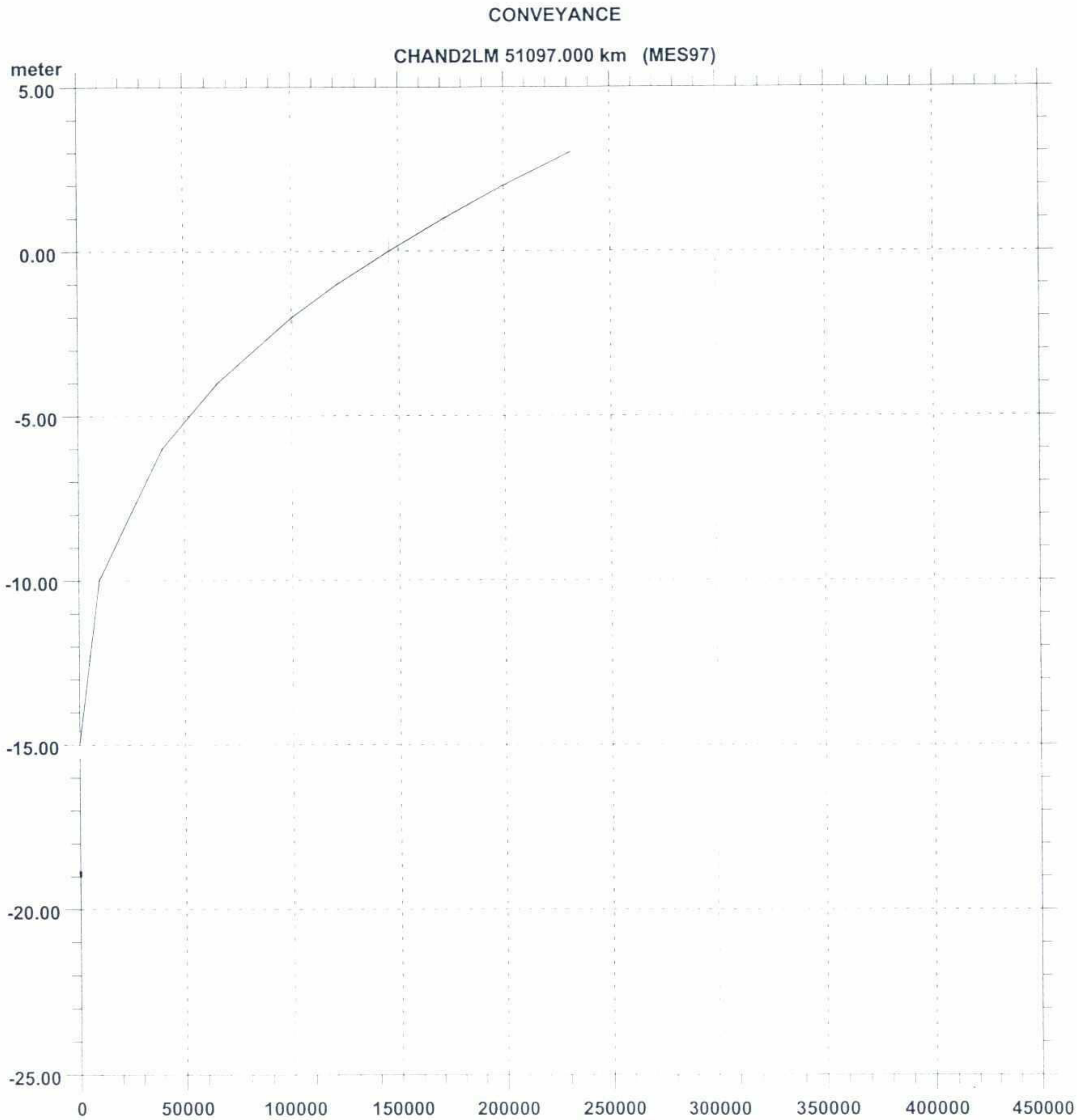

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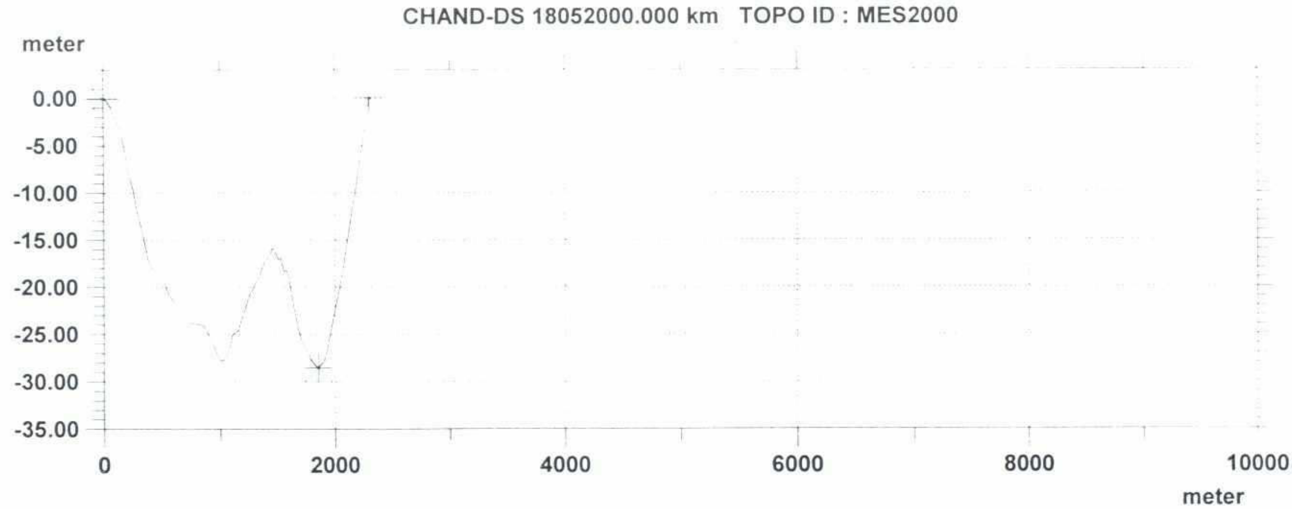

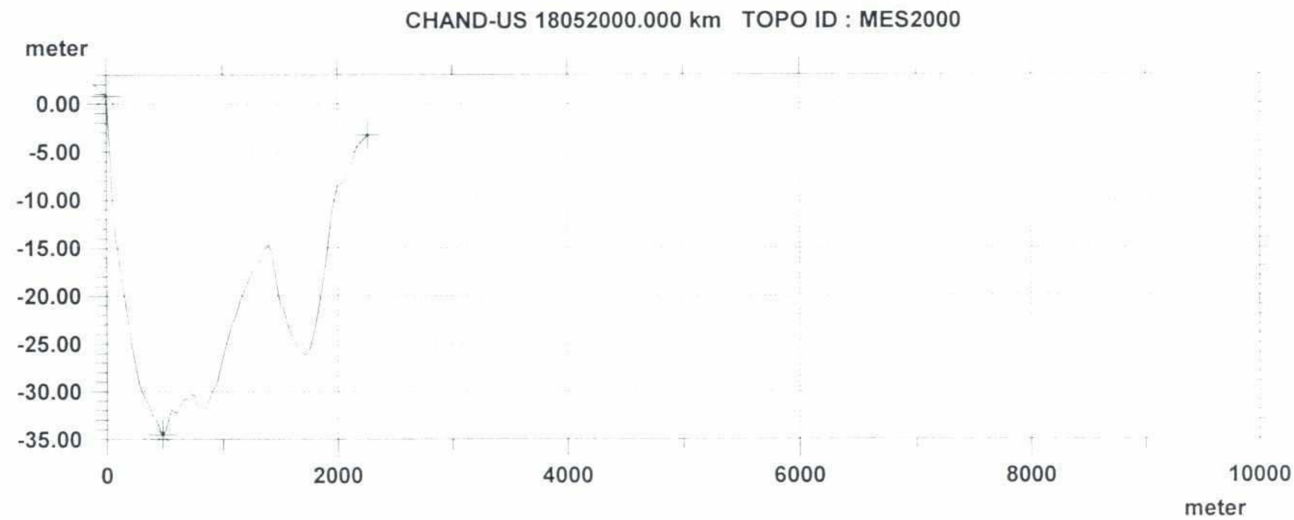

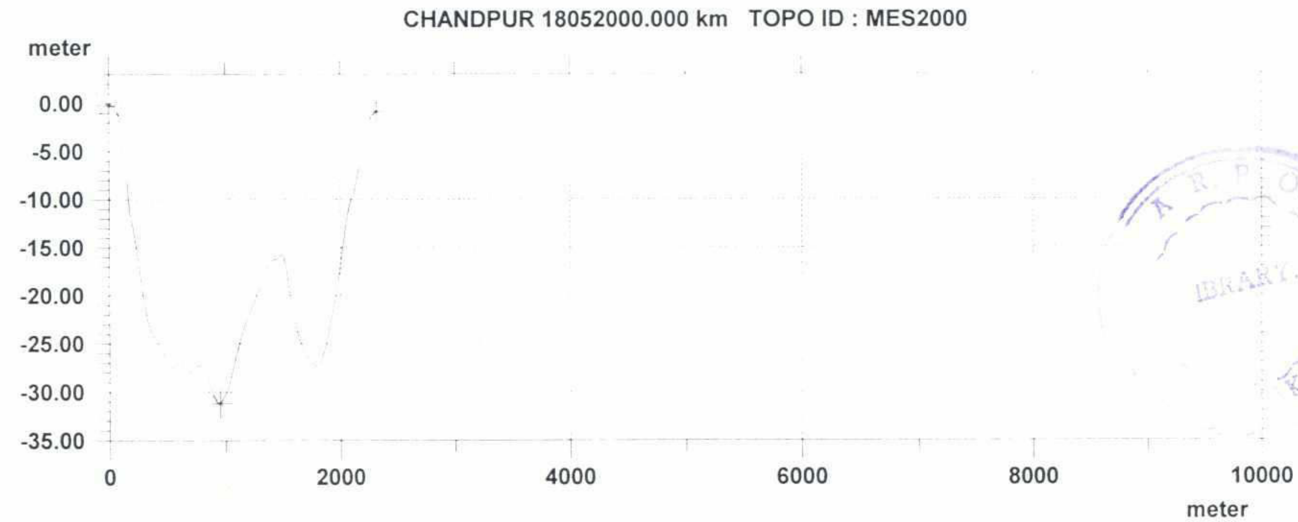

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CROSS-SECTIONAL AREA

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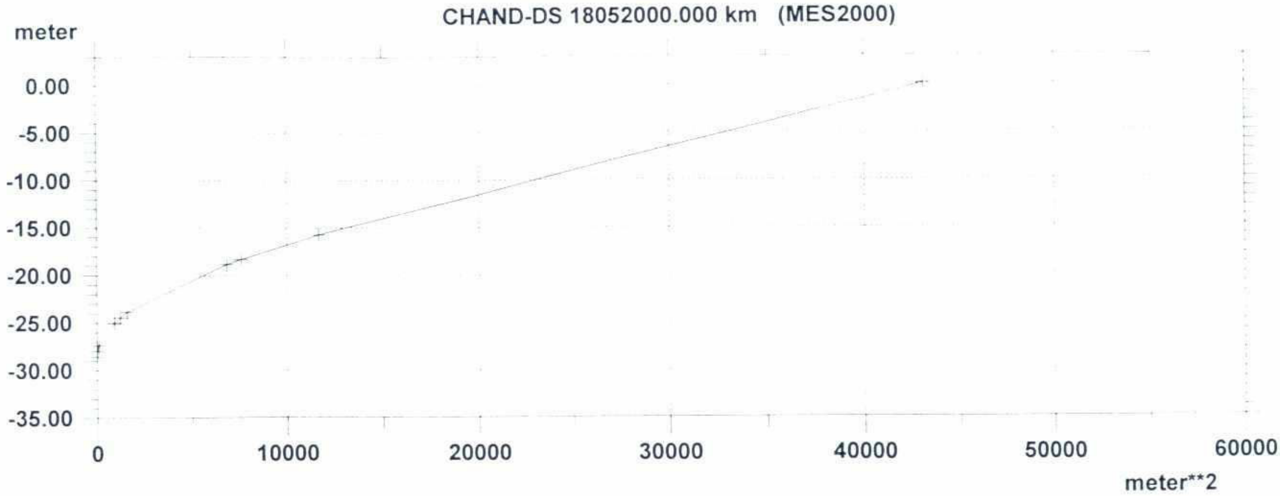

CROSS-SECTIONAL AREA

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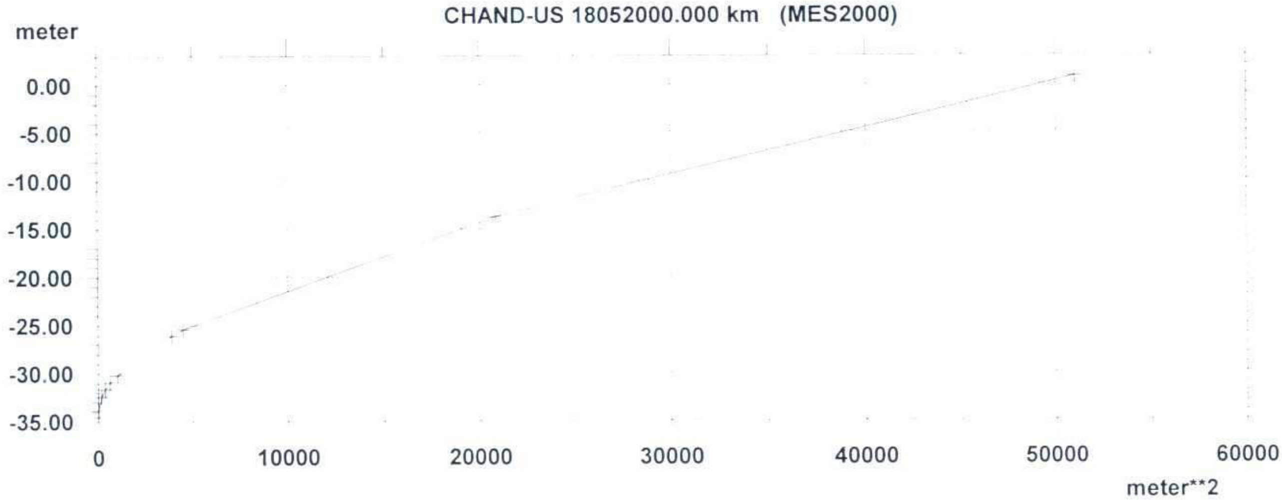

CROSS-SECTIONAL AREA

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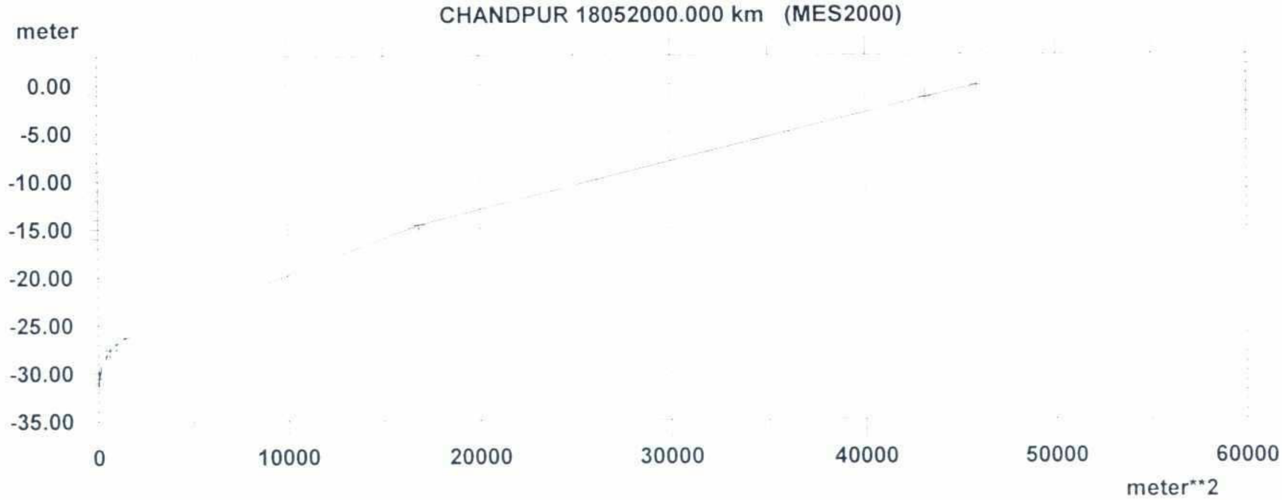

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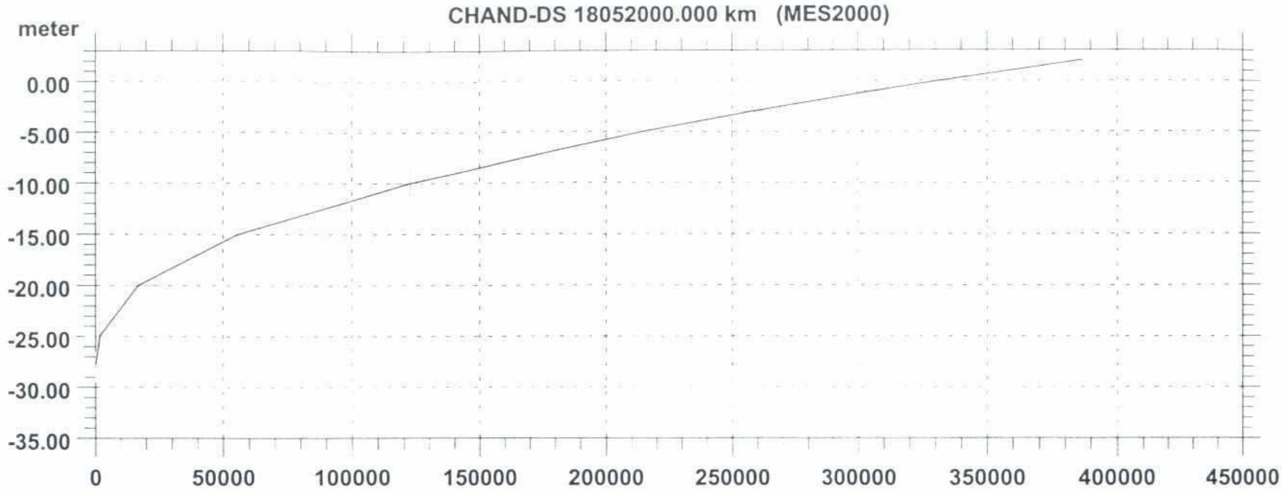
CONVEYANCE

CHAND-DS 18052000.000 km (MES2000)



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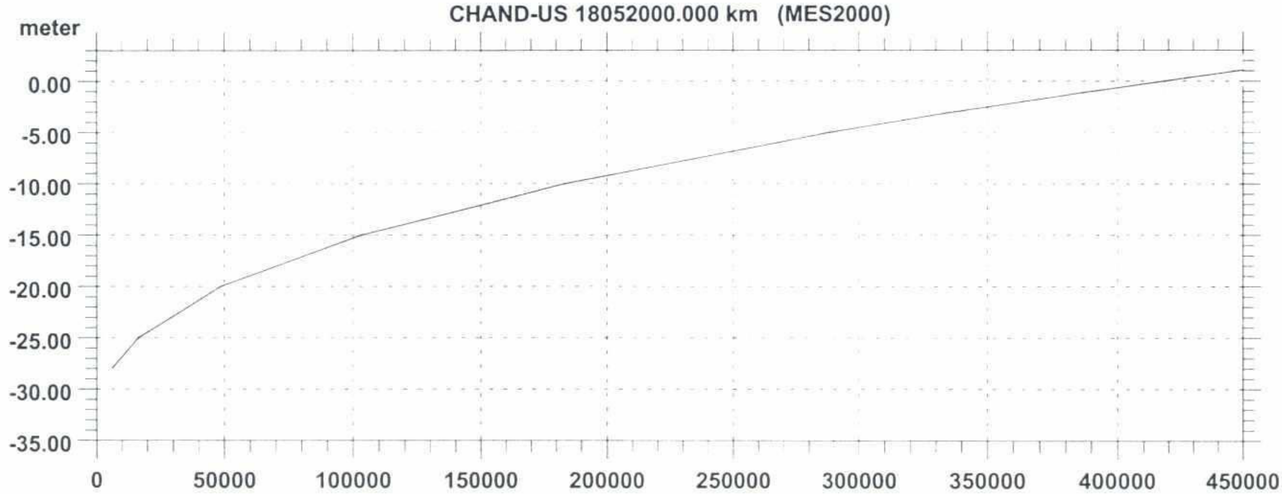

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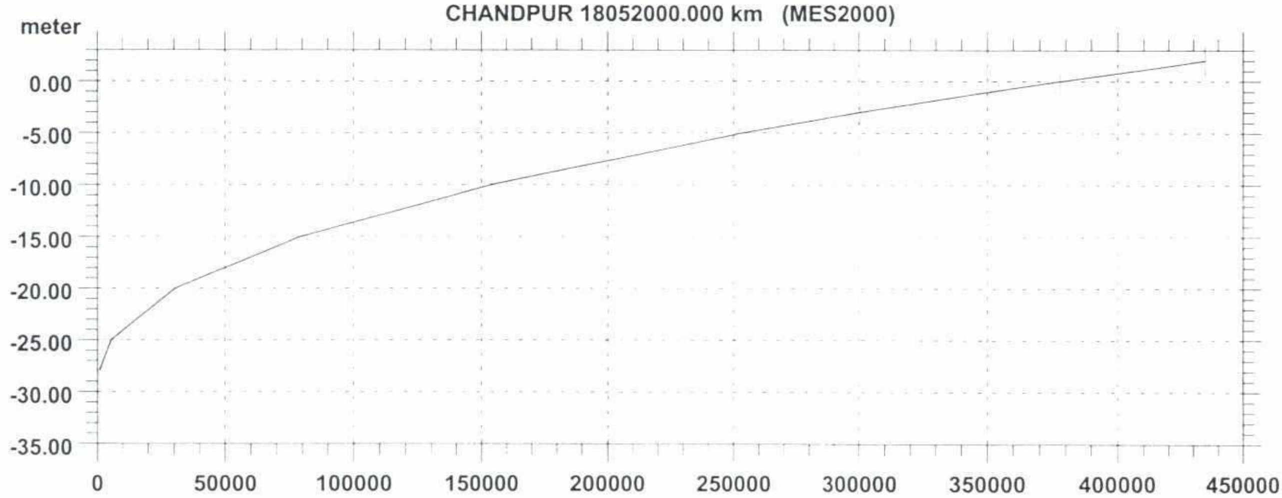

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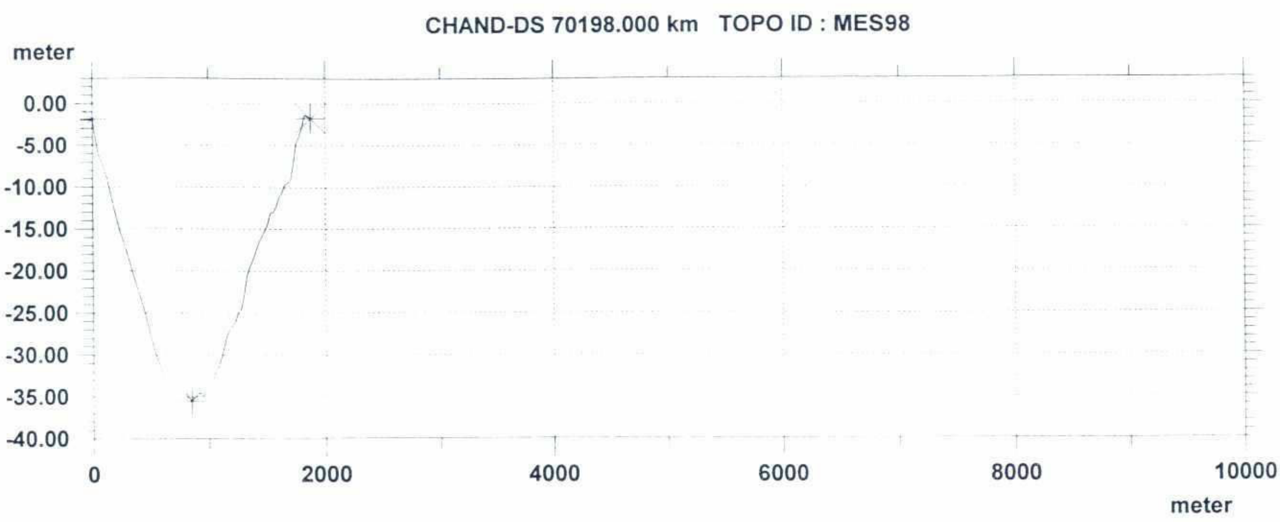

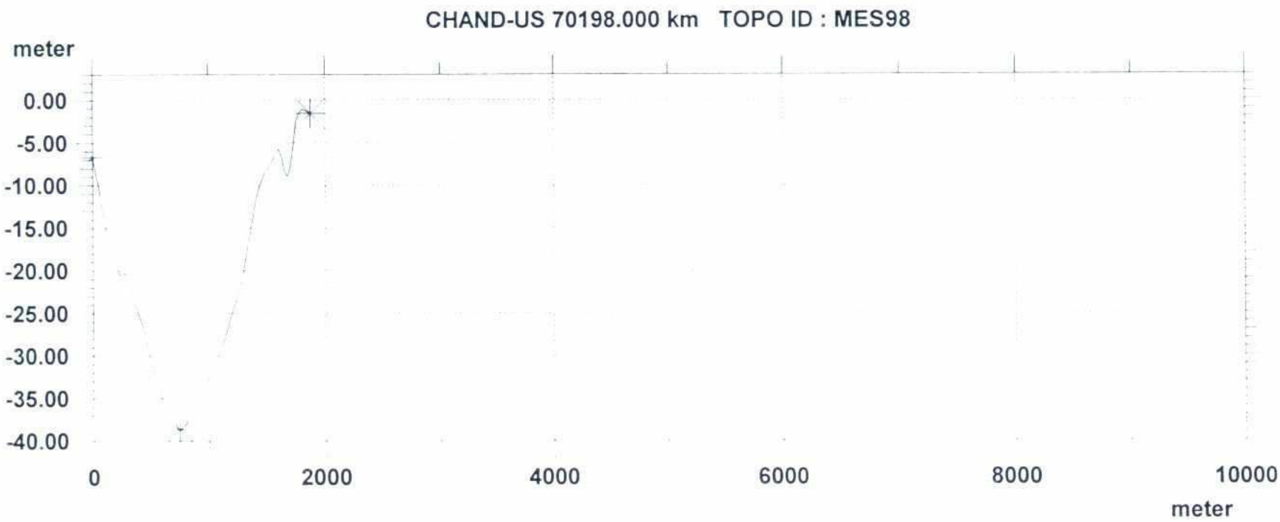

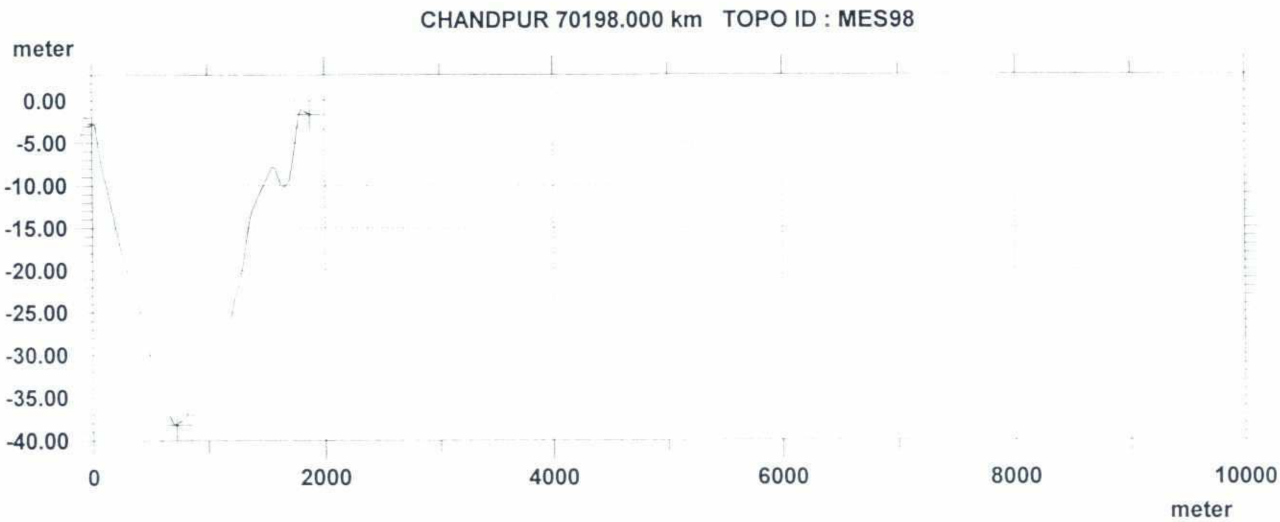

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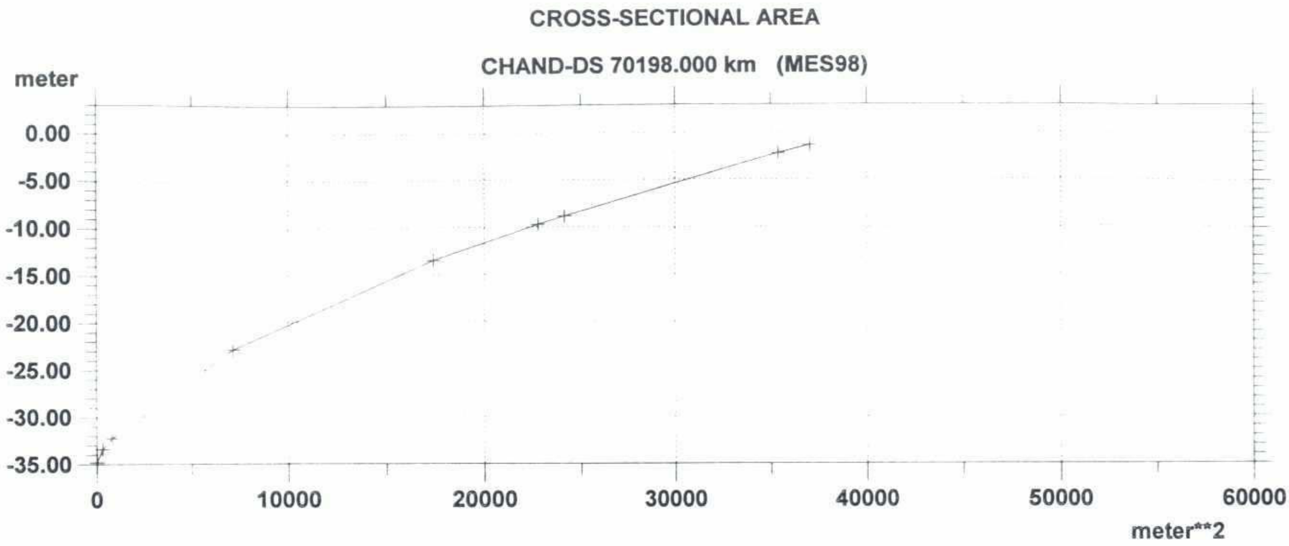

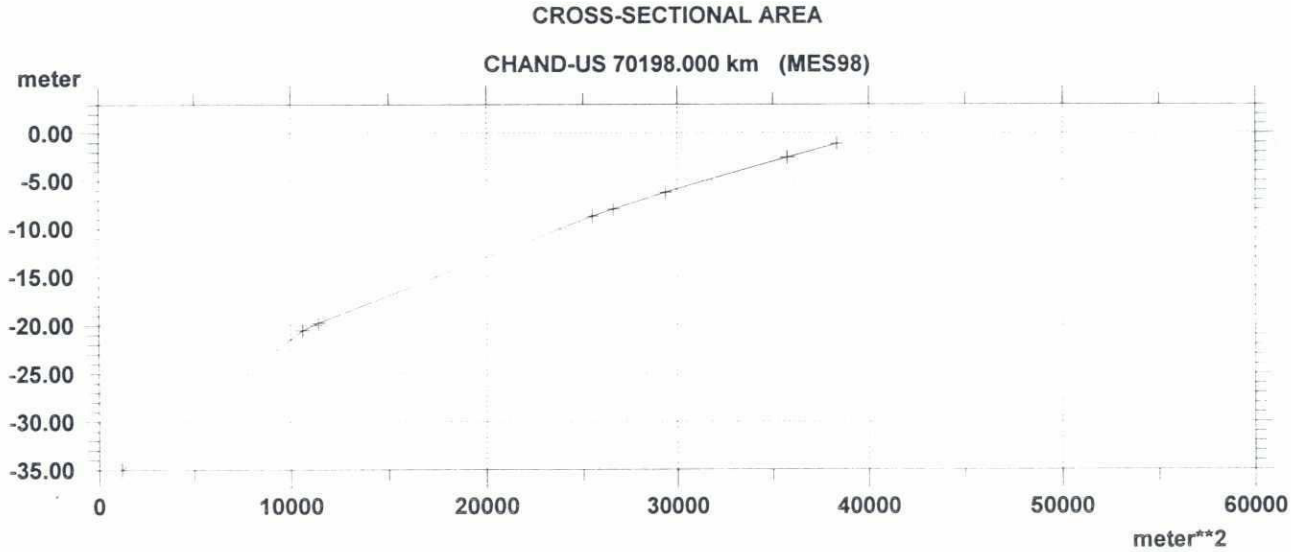

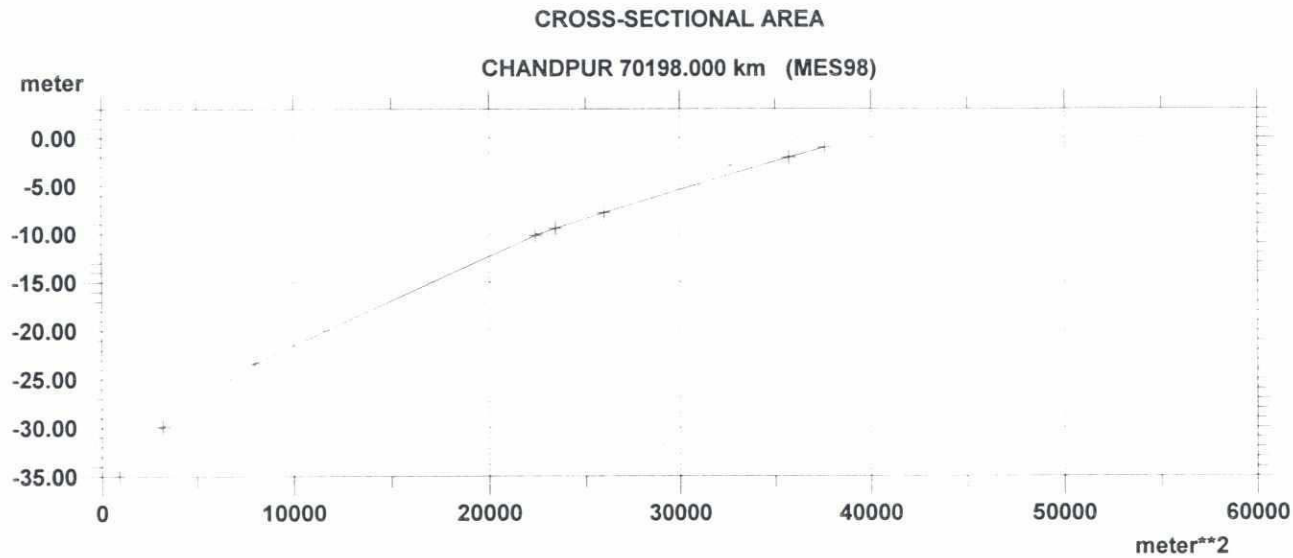

MIKE 11

DATA BASE : MES97

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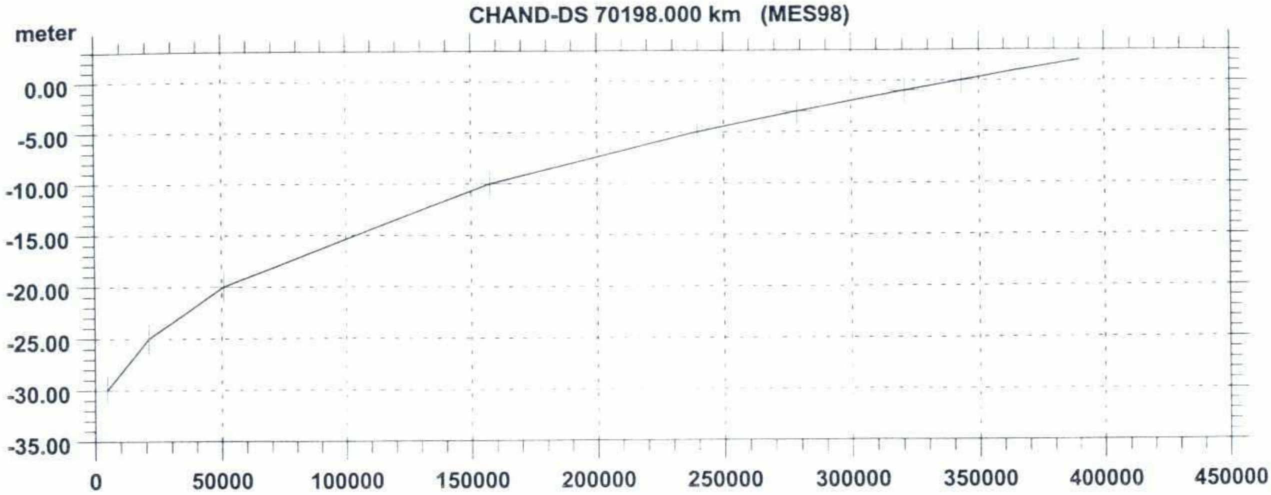
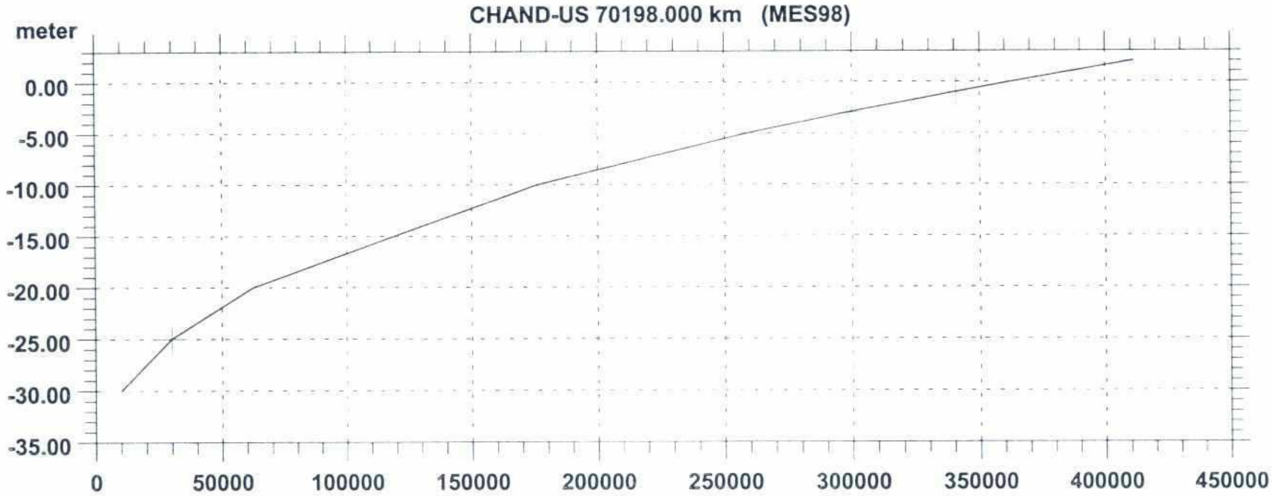
CONVEYANCE

CHAND-DS 70198.000 km (MES98)



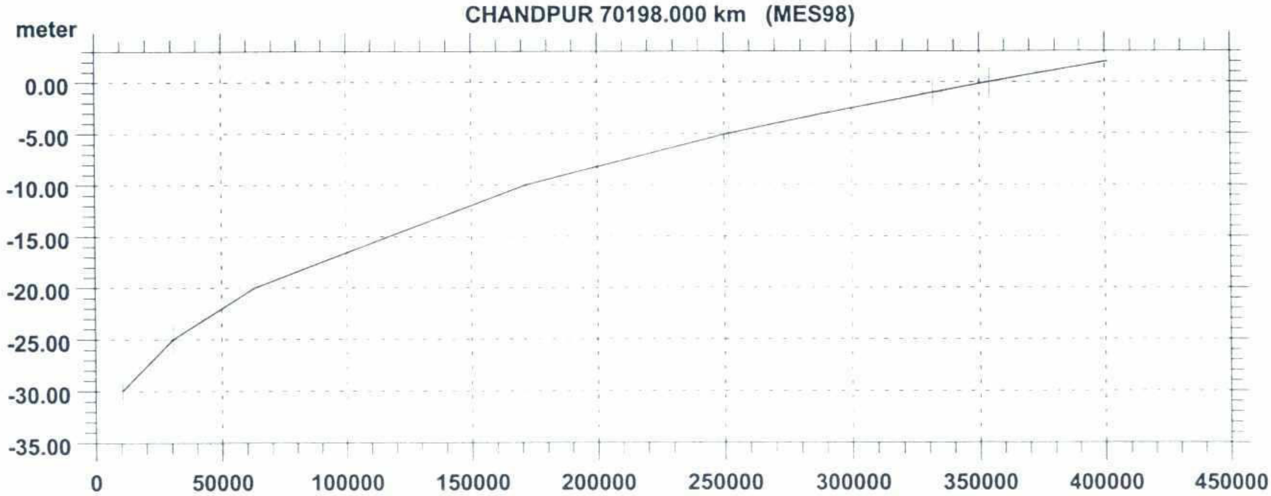
CONVEYANCE

CHAND-US 70198.000 km (MES98)



CONVEYANCE

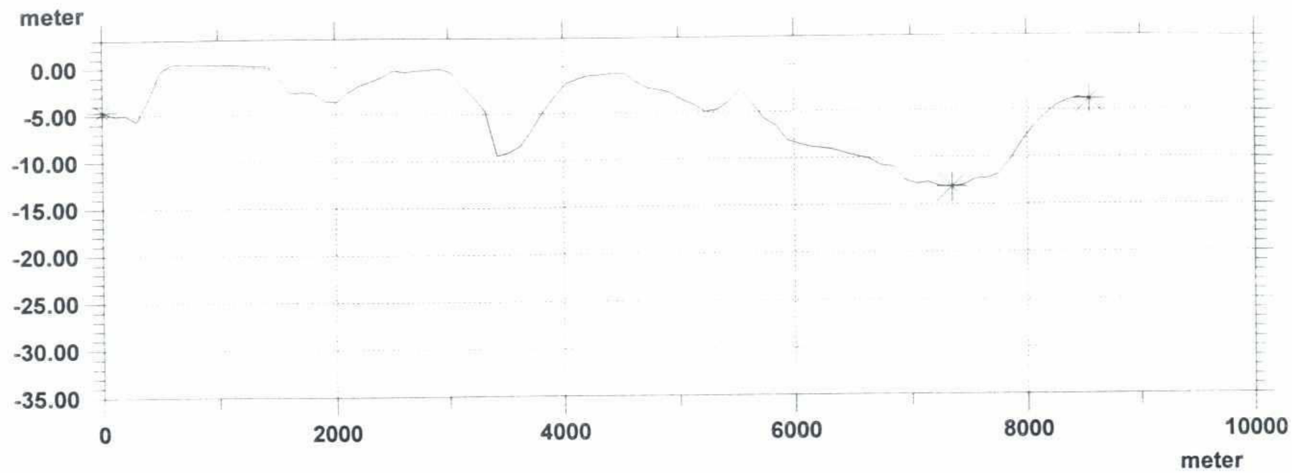
CHANDPUR 70198.000 km (MES98)



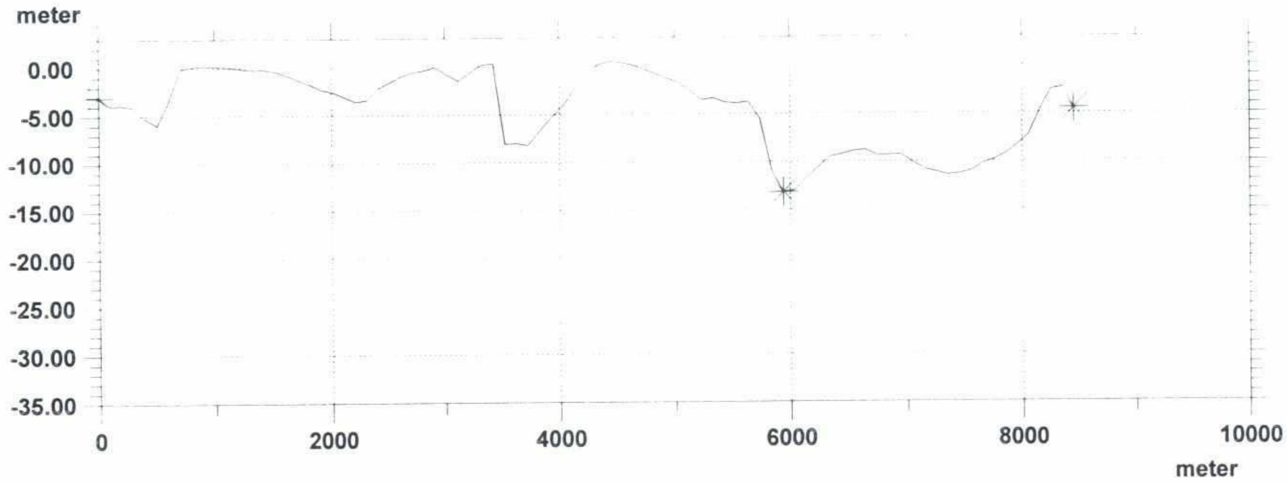
DATA BASE : MES97

MIKE 11

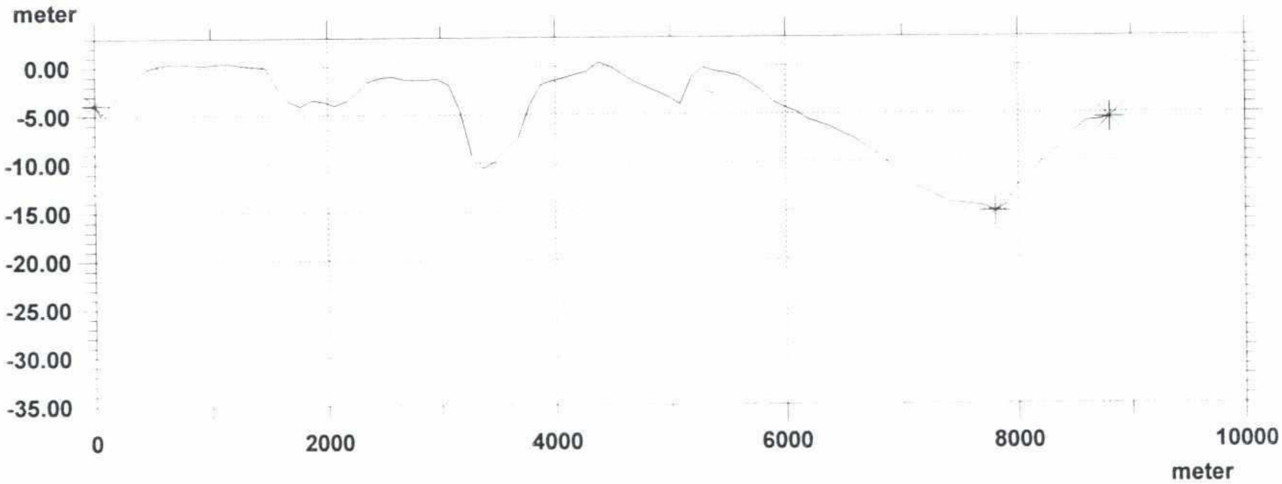
CS23 17052000.000 km TOPO ID : MES2000



CS23-DS 17052000.000 km TOPO ID : MES2000



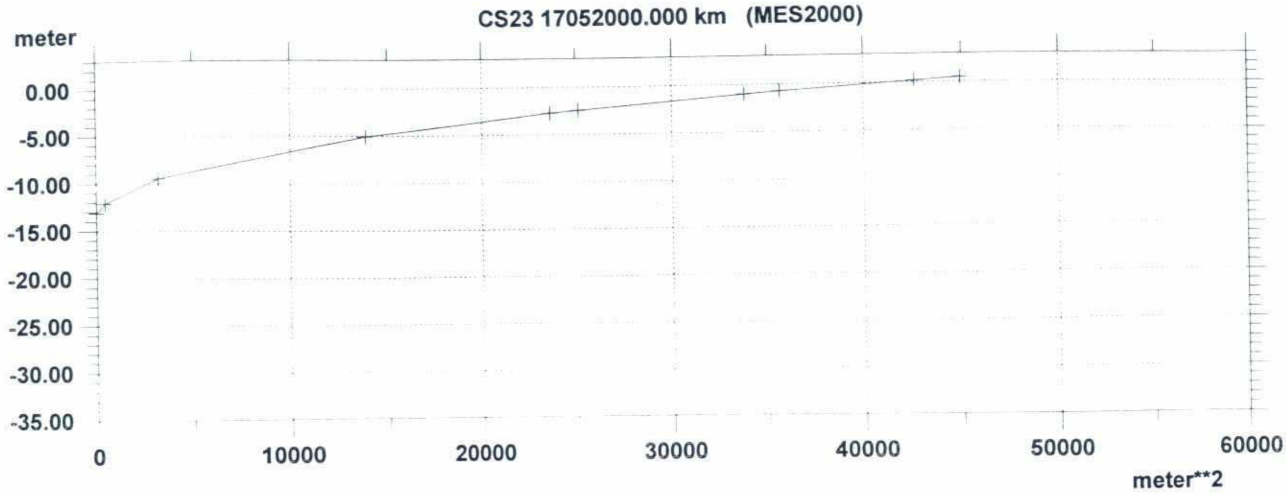
CS23-US 17052000.000 km TOPO ID : MES2000



2G

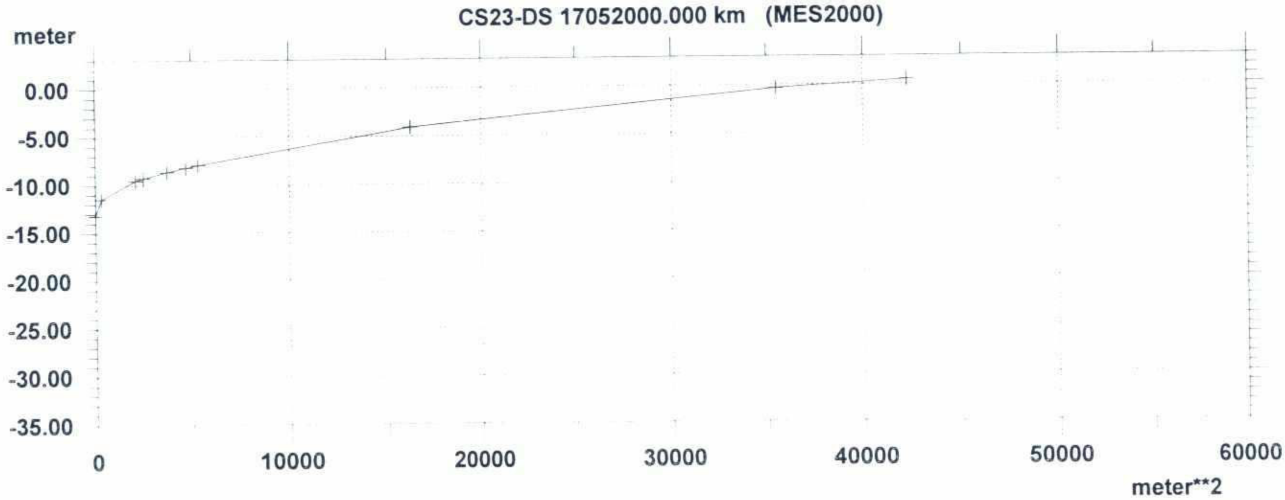
CROSS-SECTIONAL AREA

CS23 17052000.000 km (MES2000)



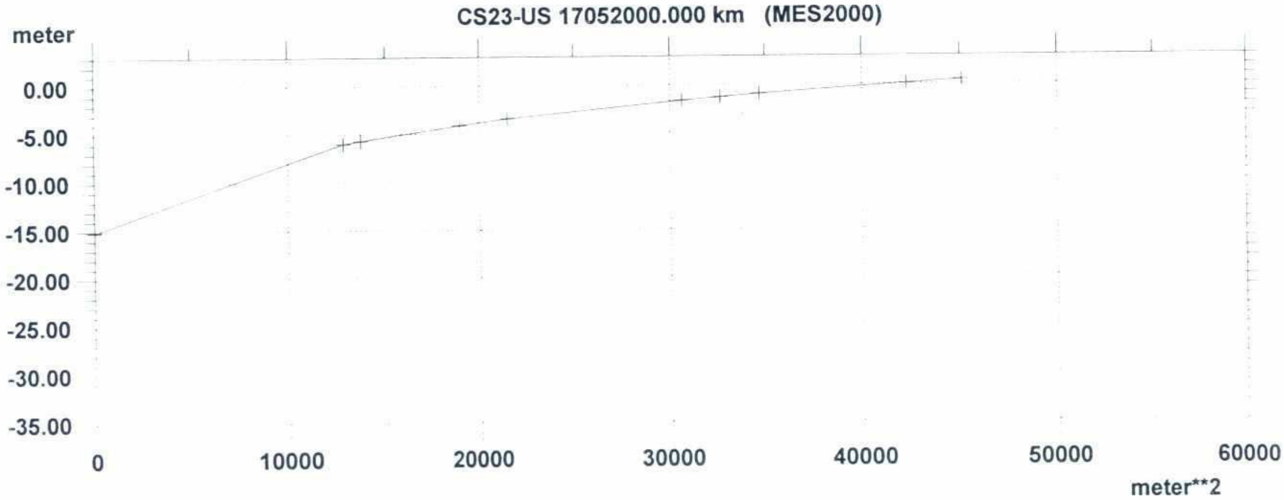
CROSS-SECTIONAL AREA

CS23-DS 17052000.000 km (MES2000)



CROSS-SECTIONAL AREA

CS23-US 17052000.000 km (MES2000)

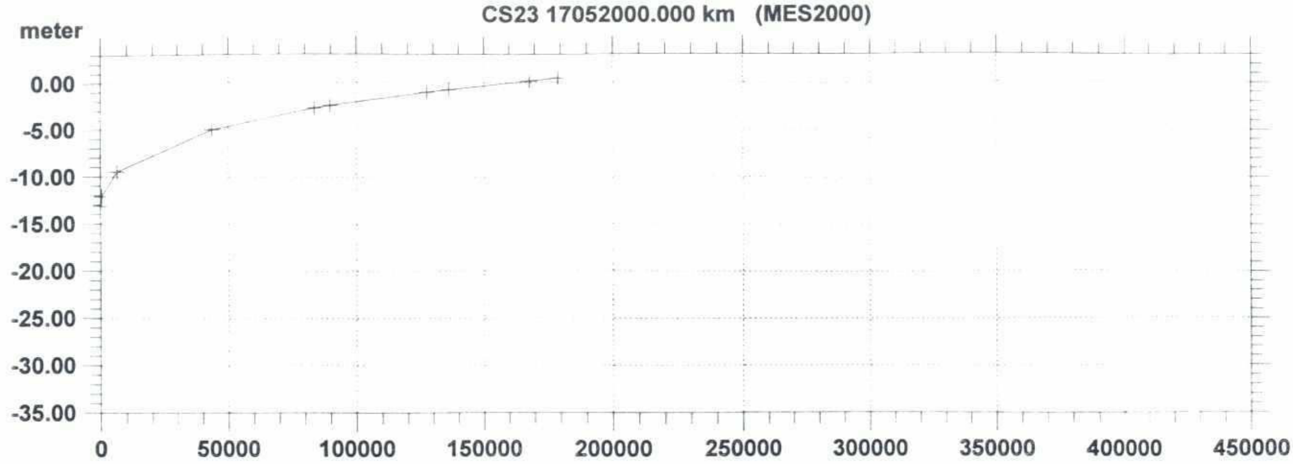


MIKE 11

DATA BASE : MES2000

CONVEYANCE

CS23 17052000.000 km (MES2000)



CONVEYANCE

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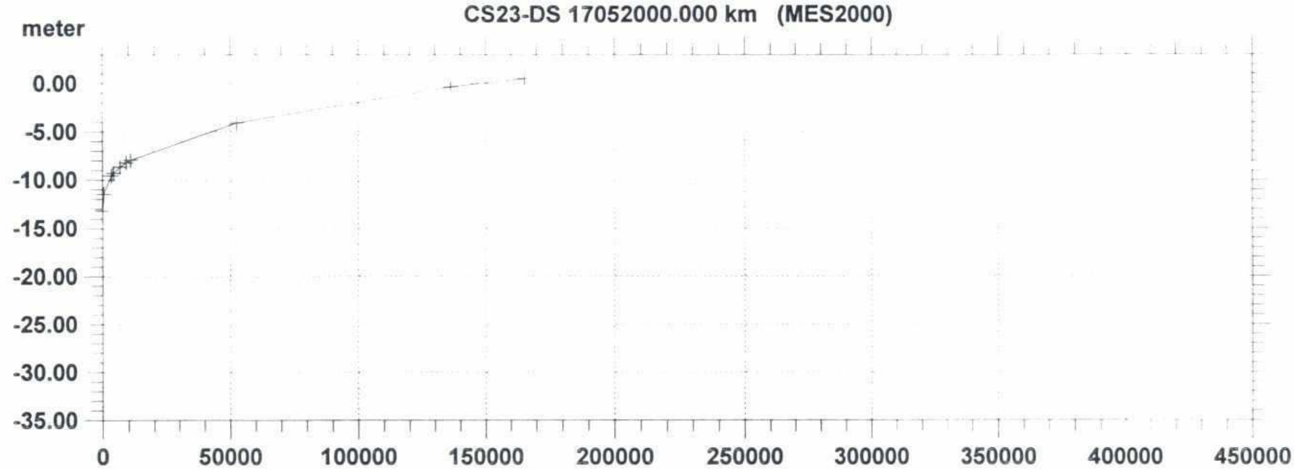
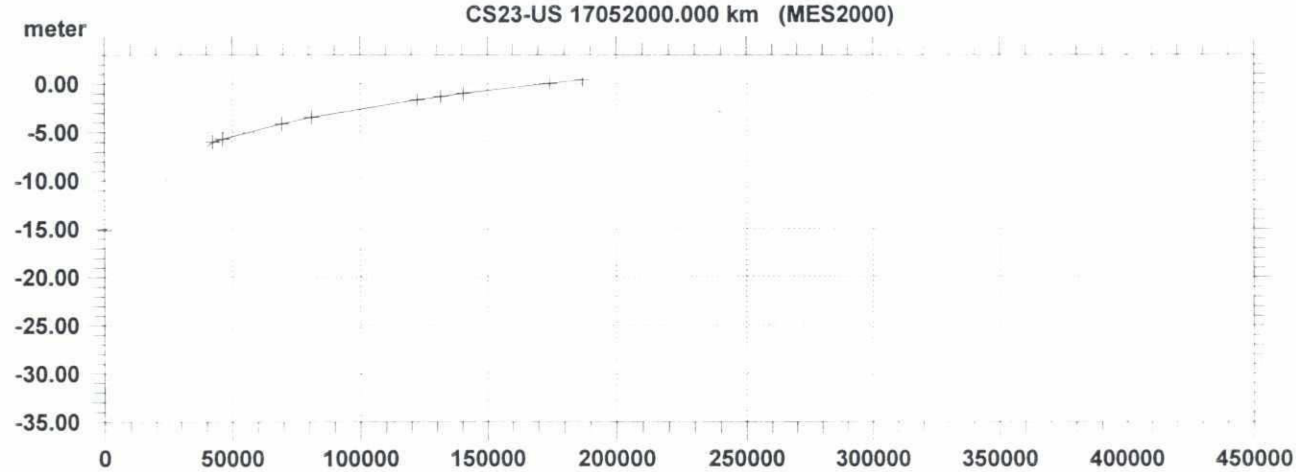


CONVEYANCE

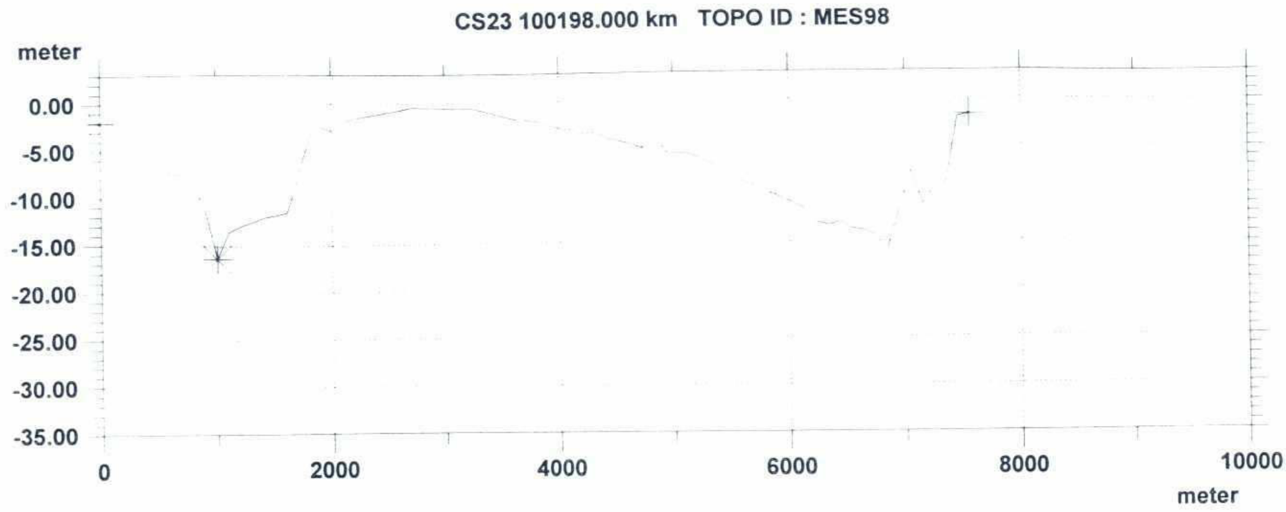
CS23-US 17052000.000 km (MES2000)

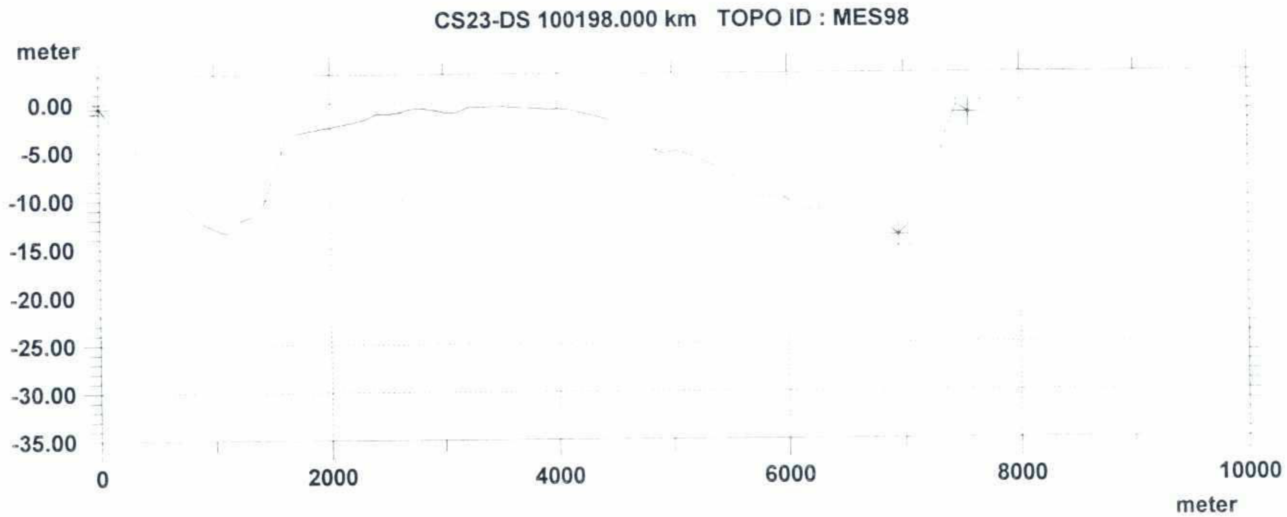


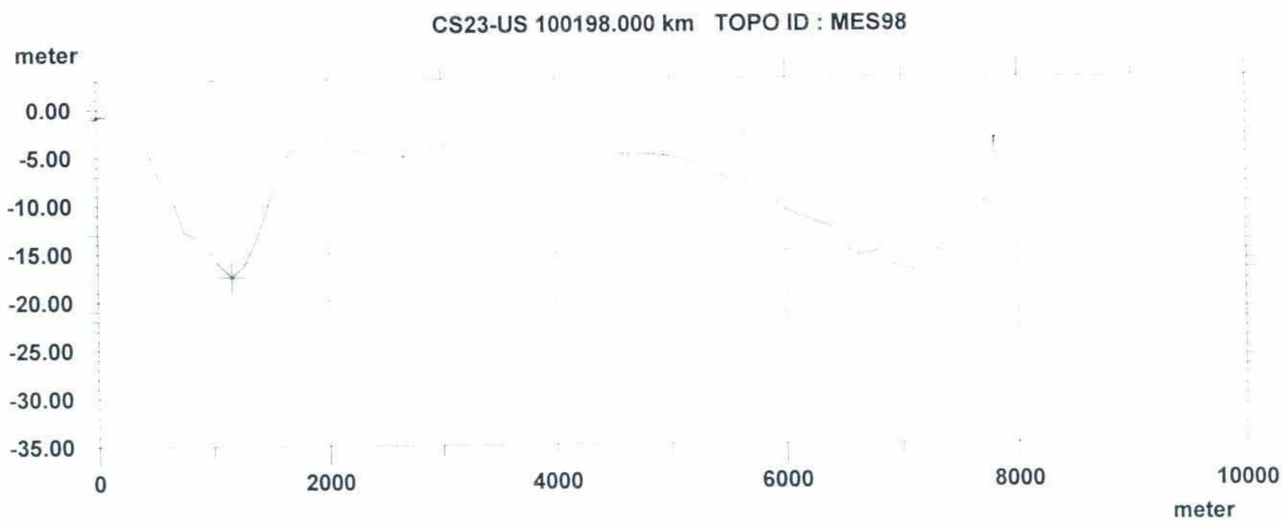
MIKE 11

DATA BASE : MES2000

20



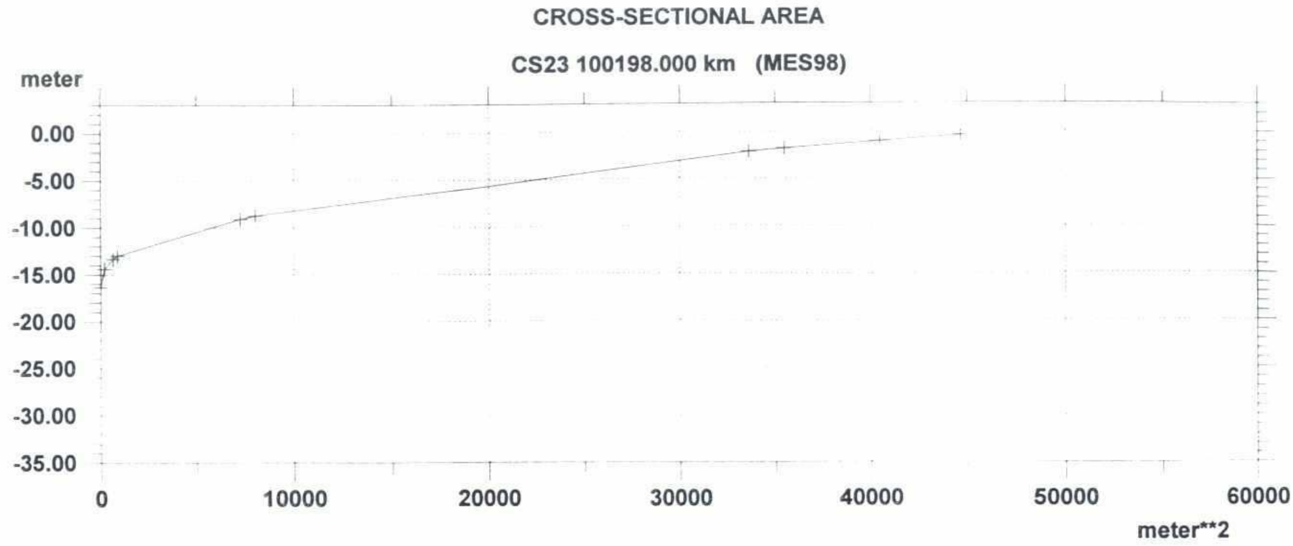


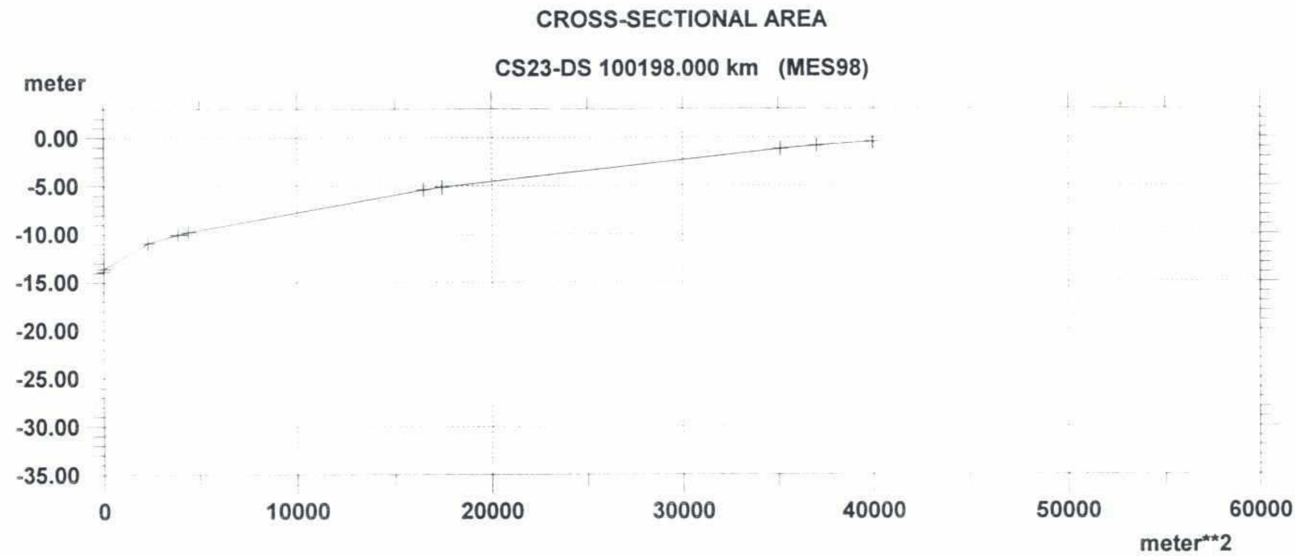


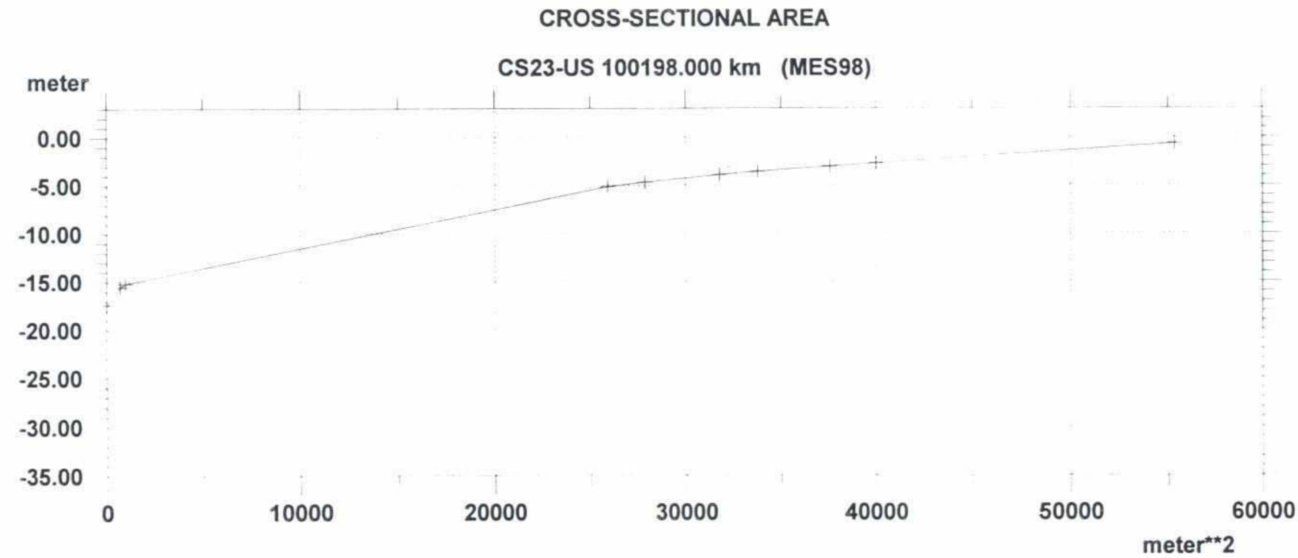
MIKE 11

DATA BASE : MES97

13





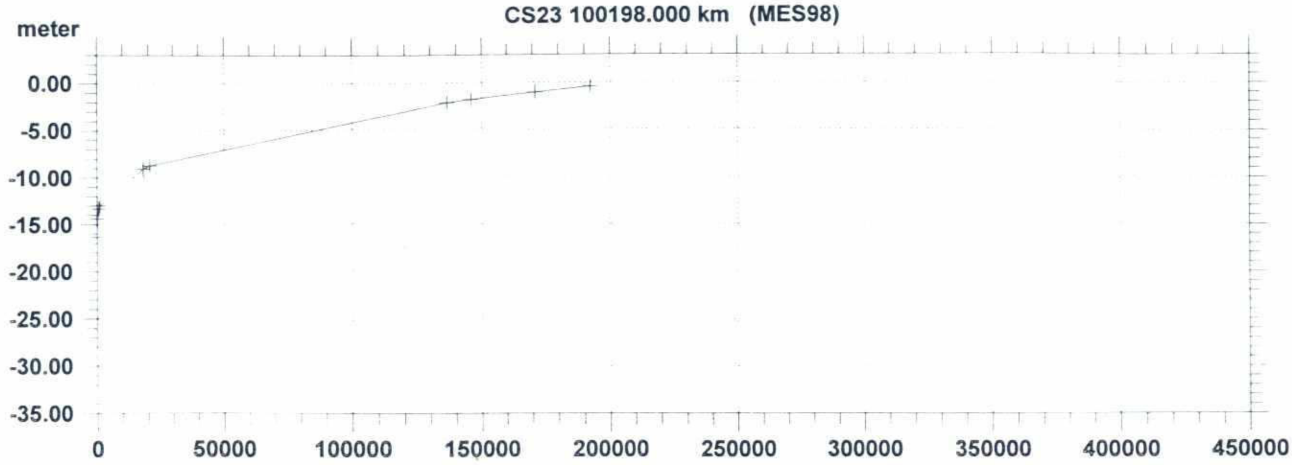


MIKE 11

DATA BASE : MES97

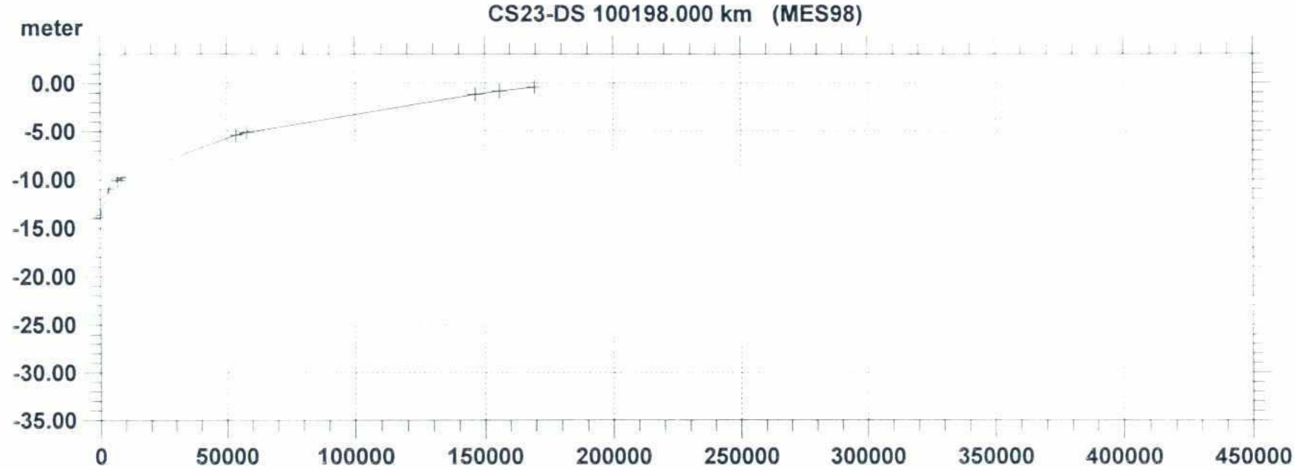
CONVEYANCE

CS23 100198.000 km (MES98)



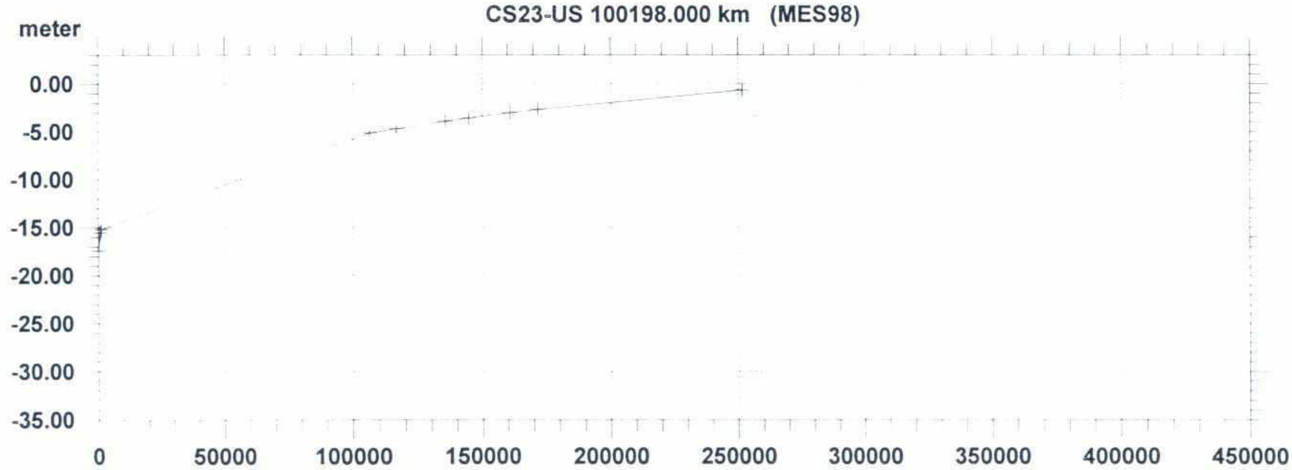
CONVEYANCE

CS23-DS 100198.000 km (MES98)

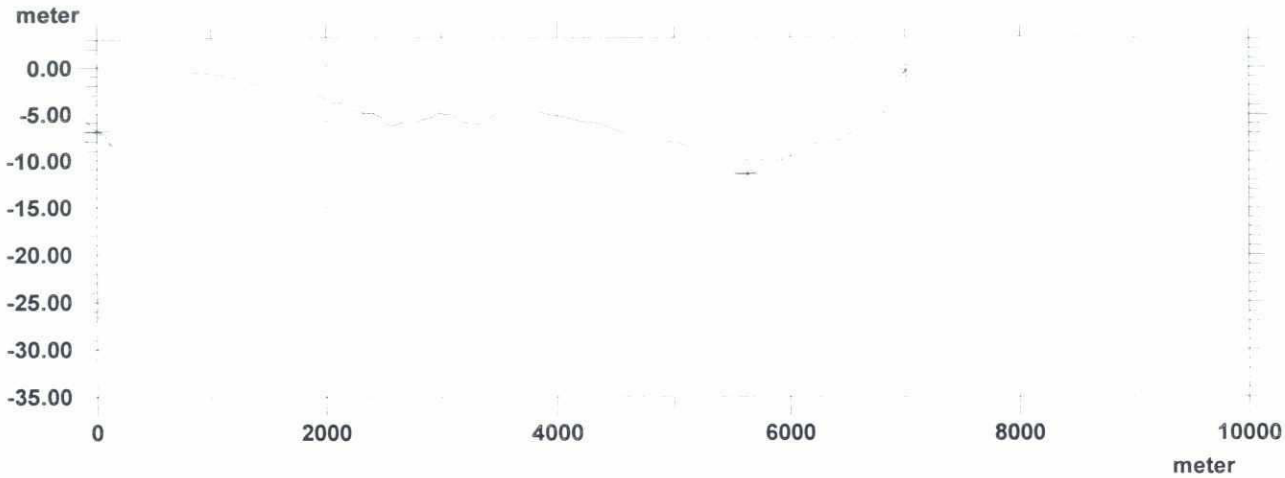


CONVEYANCE

CS23-US 100198.000 km (MES98)



CS20 29042000.000 km TOPO ID : MES2000



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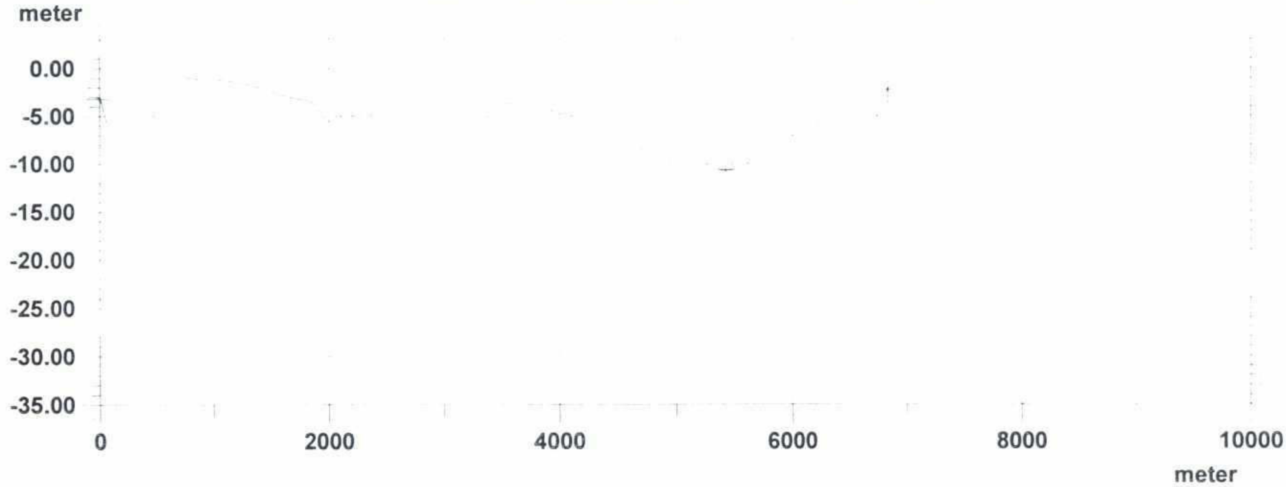
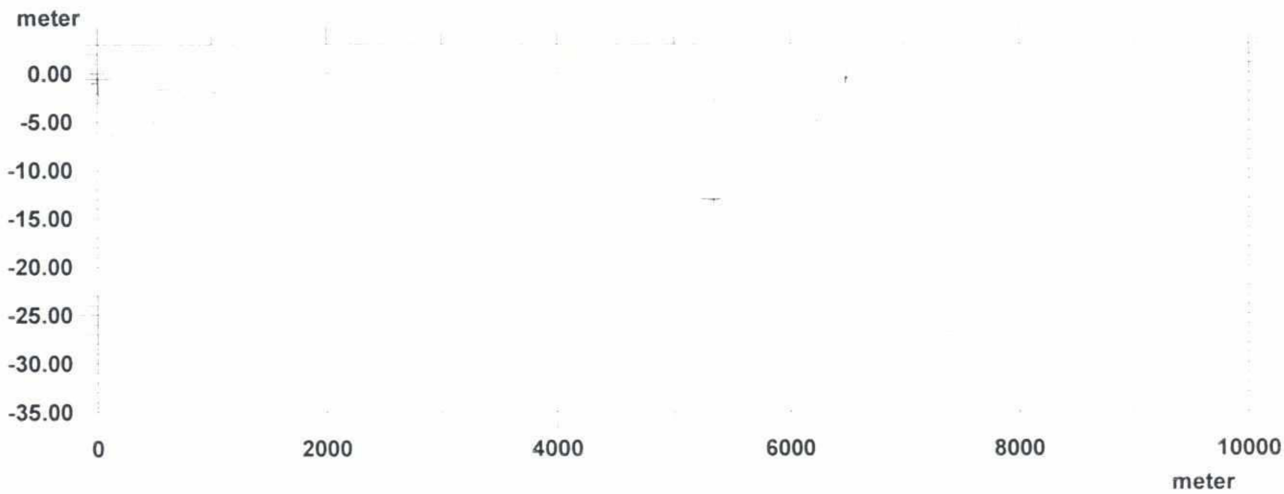


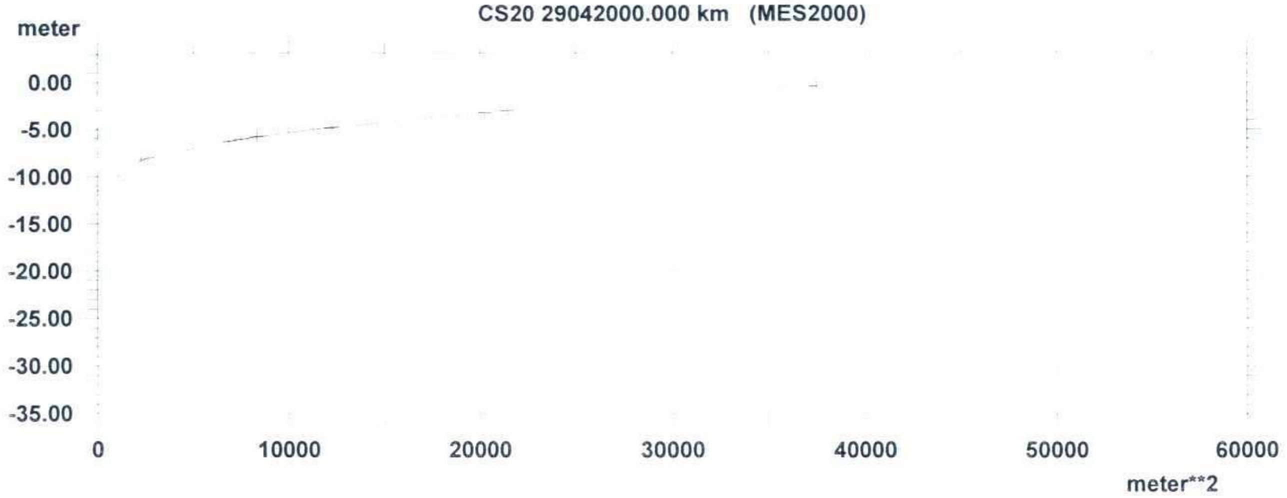
CS20-US 29042000.000 km TOPO ID : MES2000



20

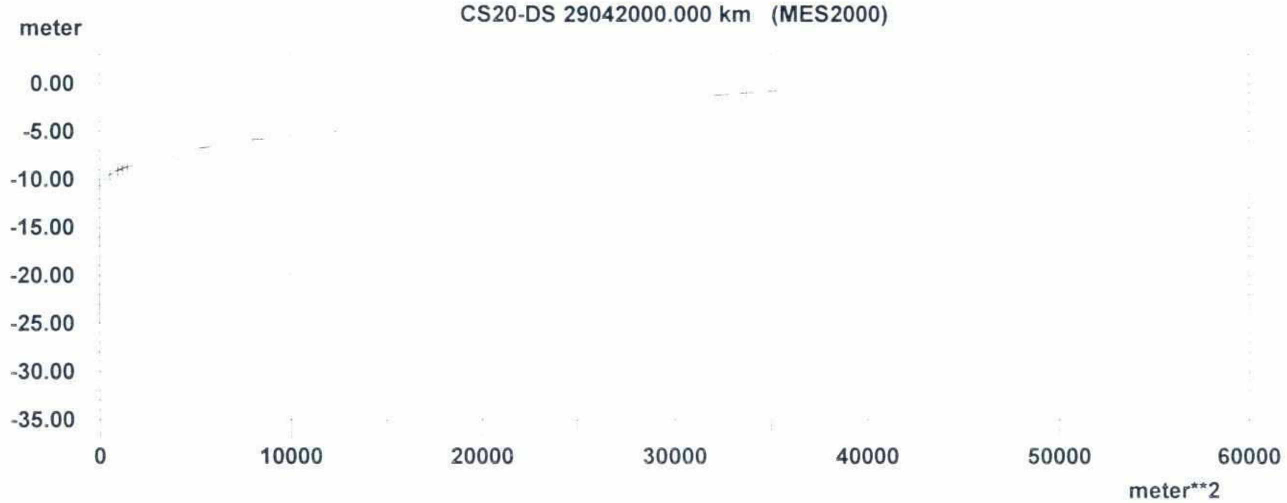
CROSS-SECTIONAL AREA

CS20 29042000.000 km (MES2000)



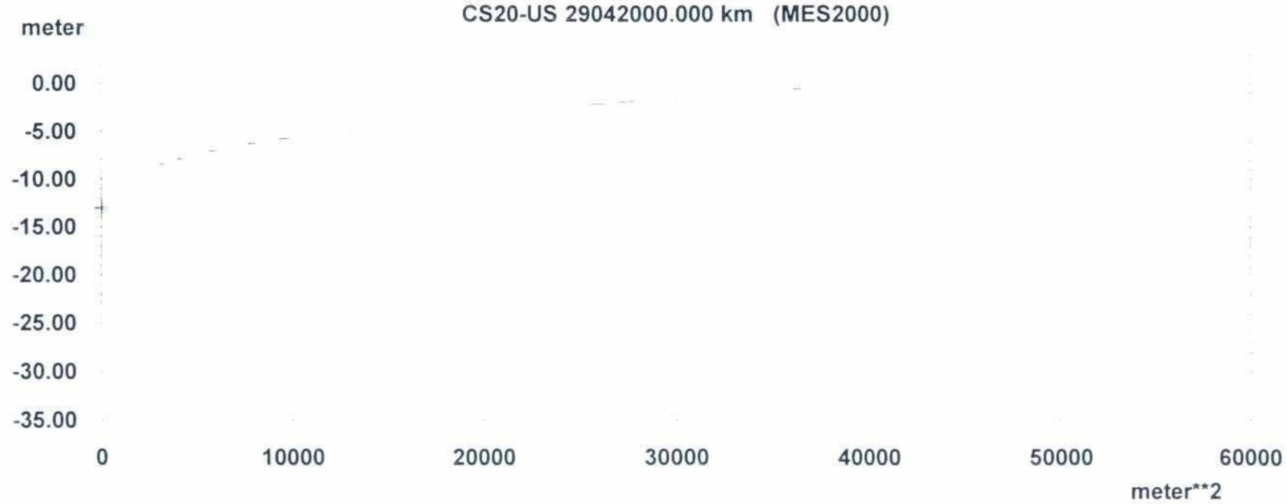
CROSS-SECTIONAL AREA

CS20-DS 29042000.000 km (MES2000)



CROSS-SECTIONAL AREA

CS20-US 29042000.000 km (MES2000)

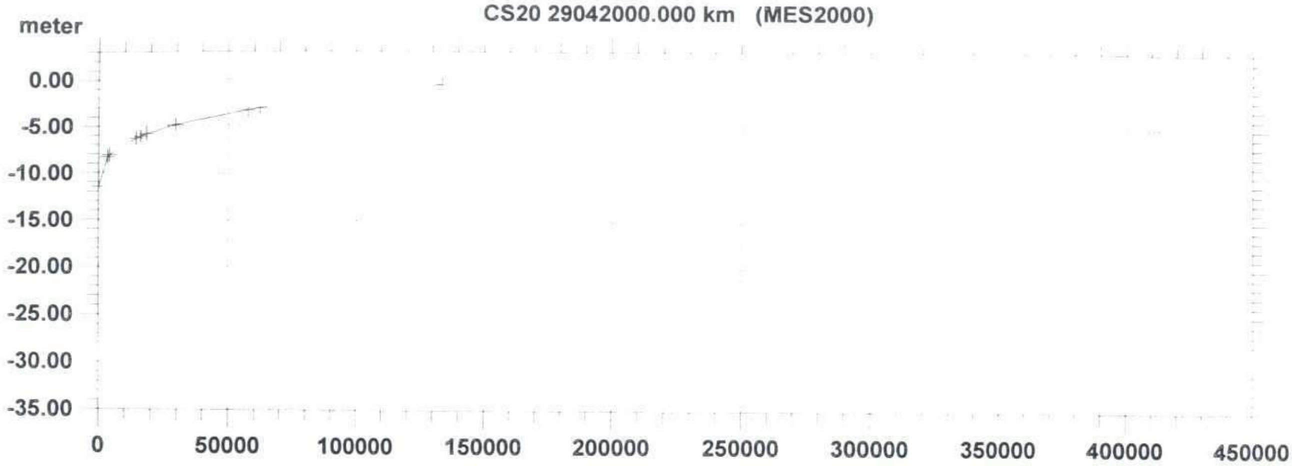


MIKE 11

DATA BASE : MES2000

CONVEYANCE

CS20 29042000.000 km (MES2000)



CONVEYANCE

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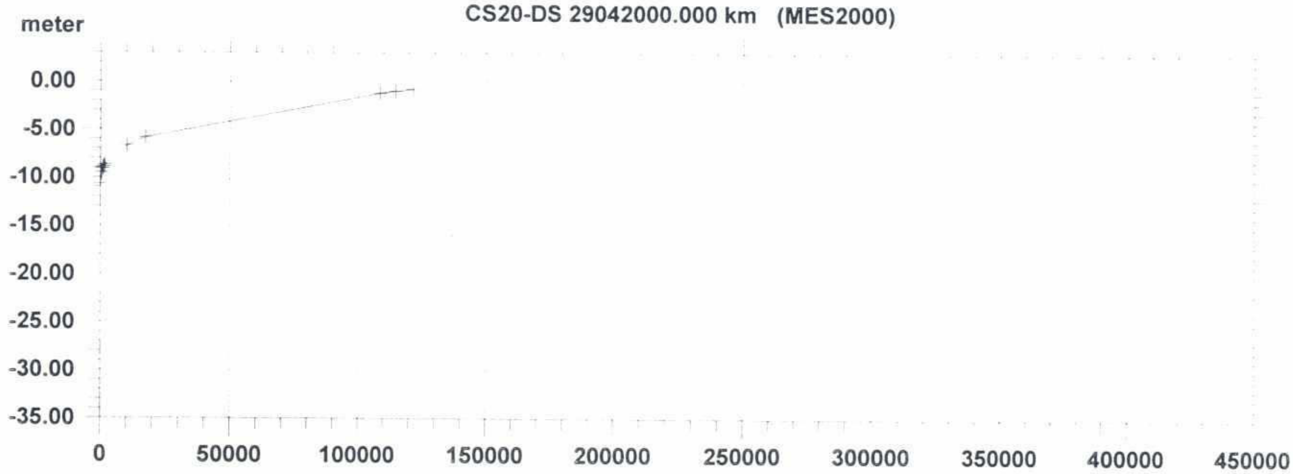
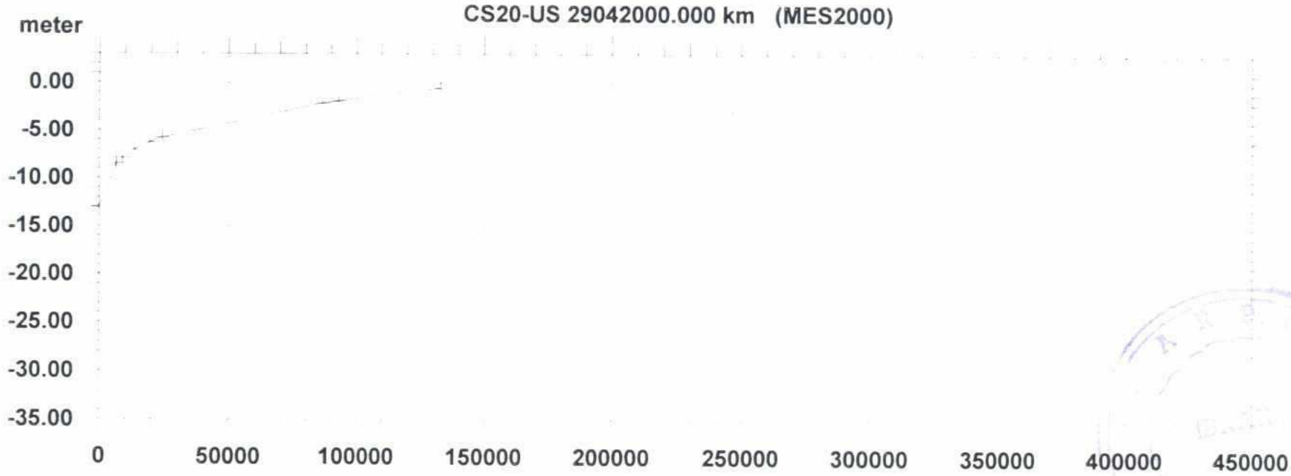


CONVEYANCE

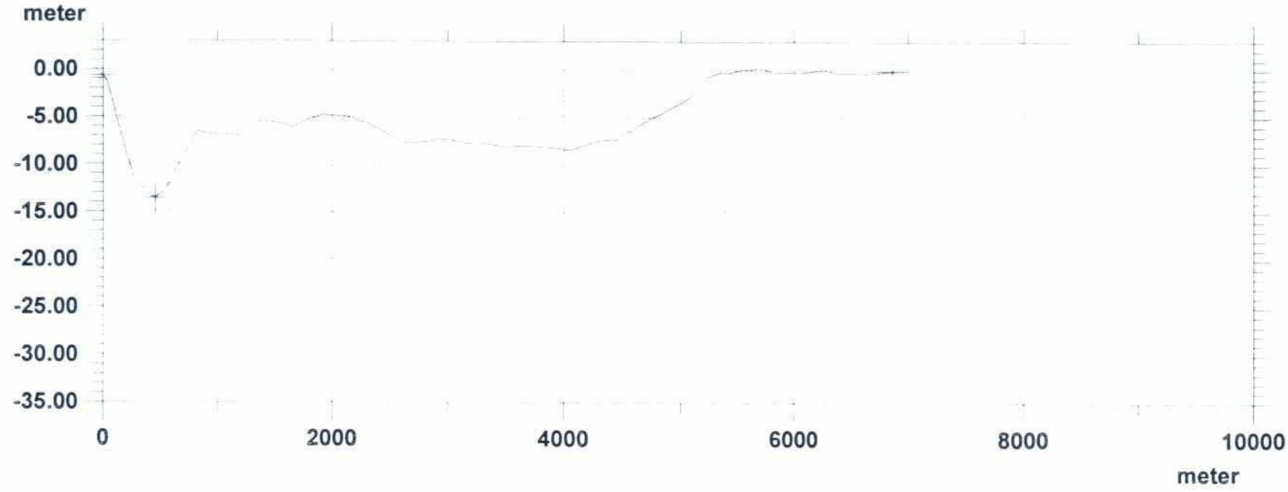
CS20-US 29042000.000 km (MES2000)



MIKE 11

DATA BASE : MES2000

CS20 150198.000 km TOPO ID : MES98



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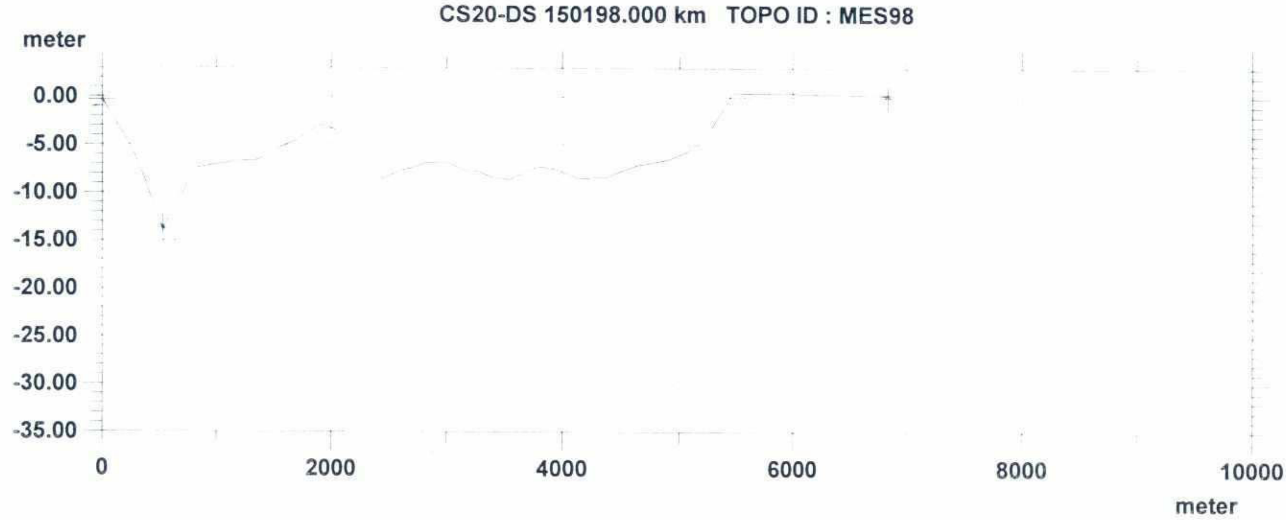

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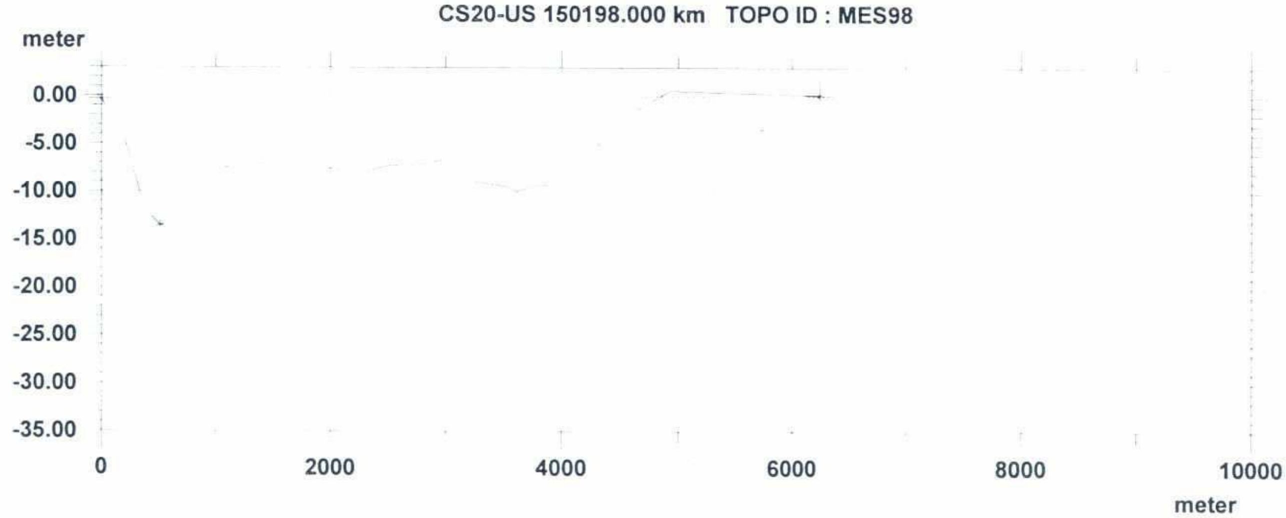
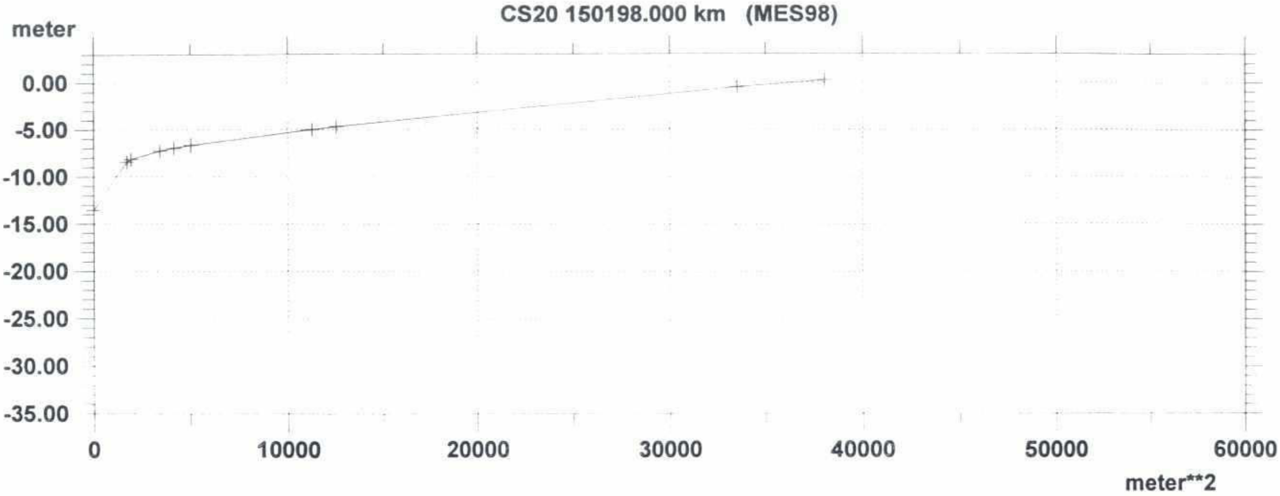


MIKE 11

DATA BASE : MES97

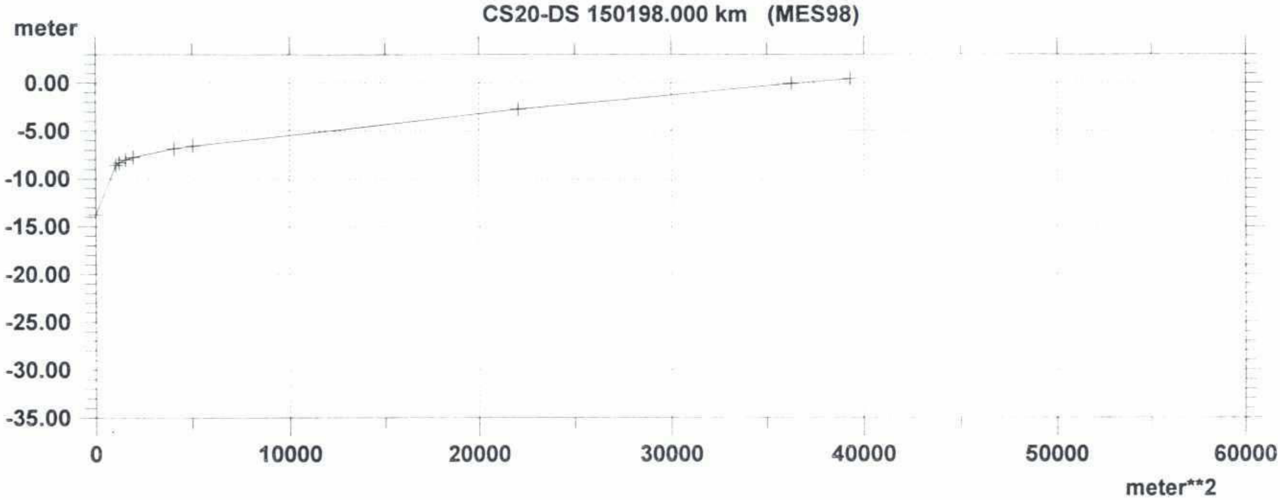
CROSS-SECTIONAL AREA

CS20 150198.000 km (MES98)



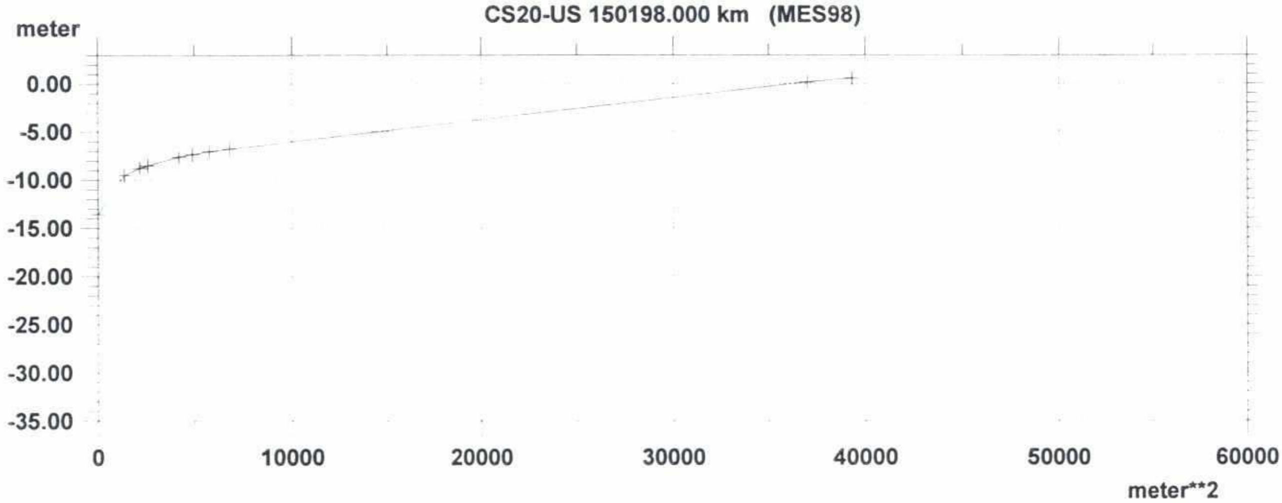
CROSS-SECTIONAL AREA

CS20-DS 150198.000 km (MES98)



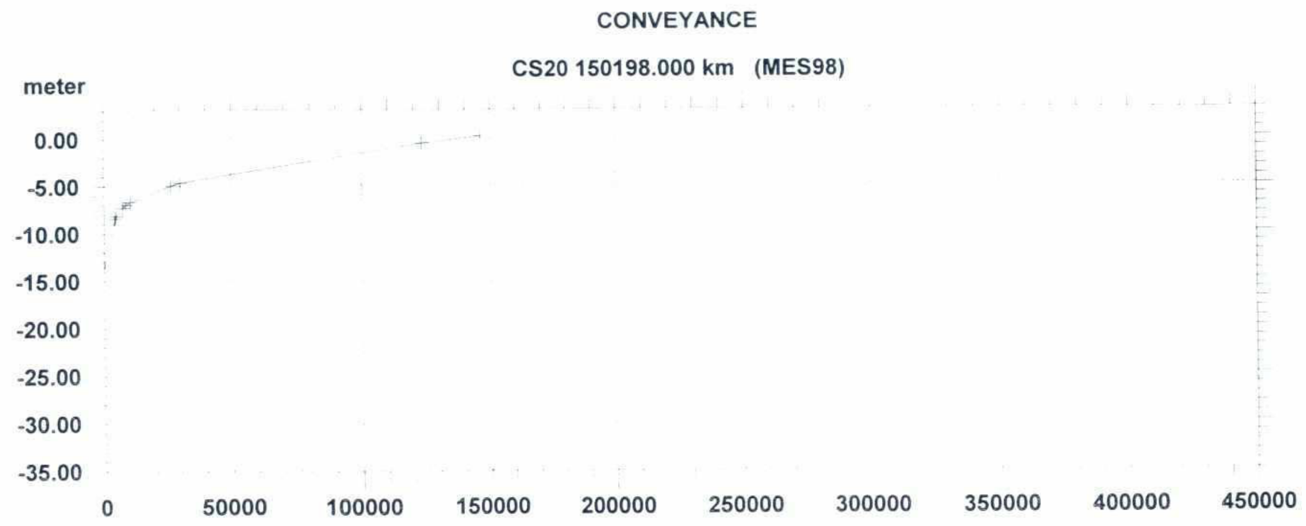
CROSS-SECTIONAL AREA

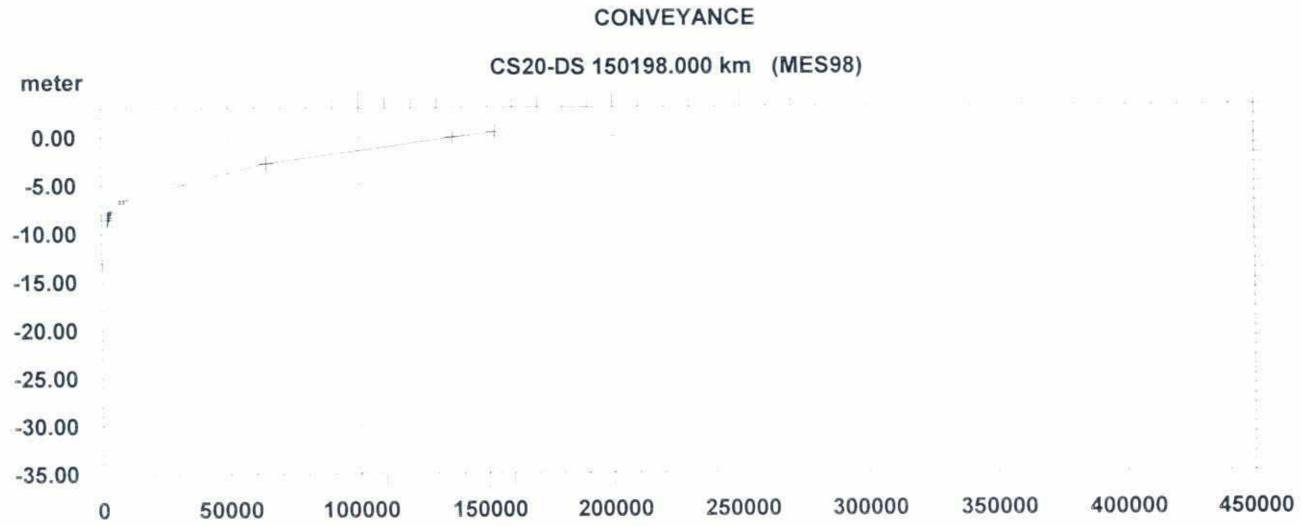
CS20-US 150198.000 km (MES98)

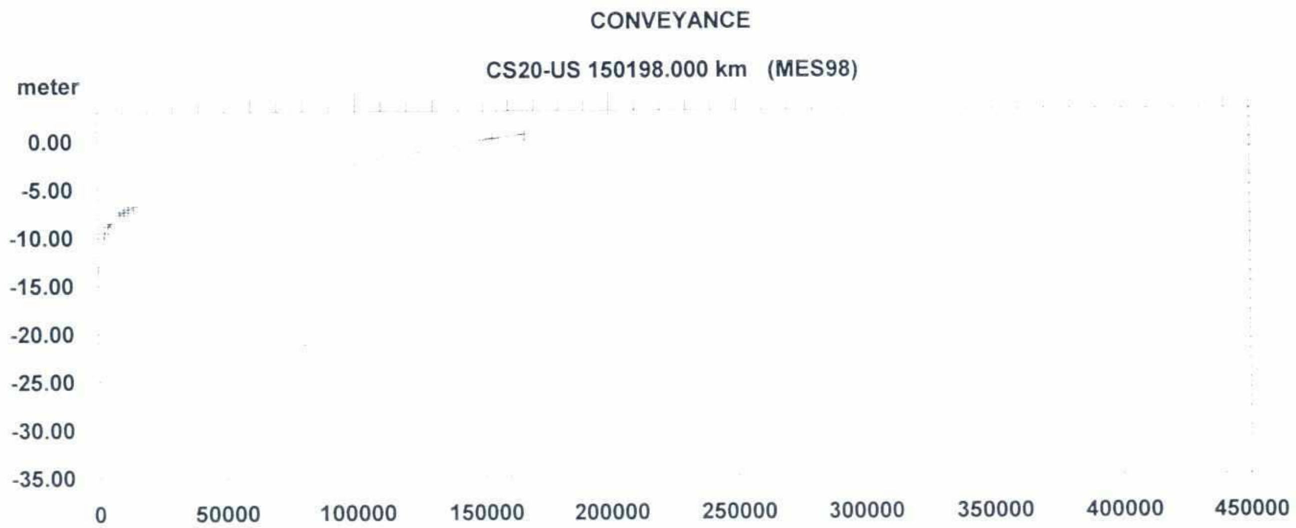


MIKE 11

DATA BASE : MES97



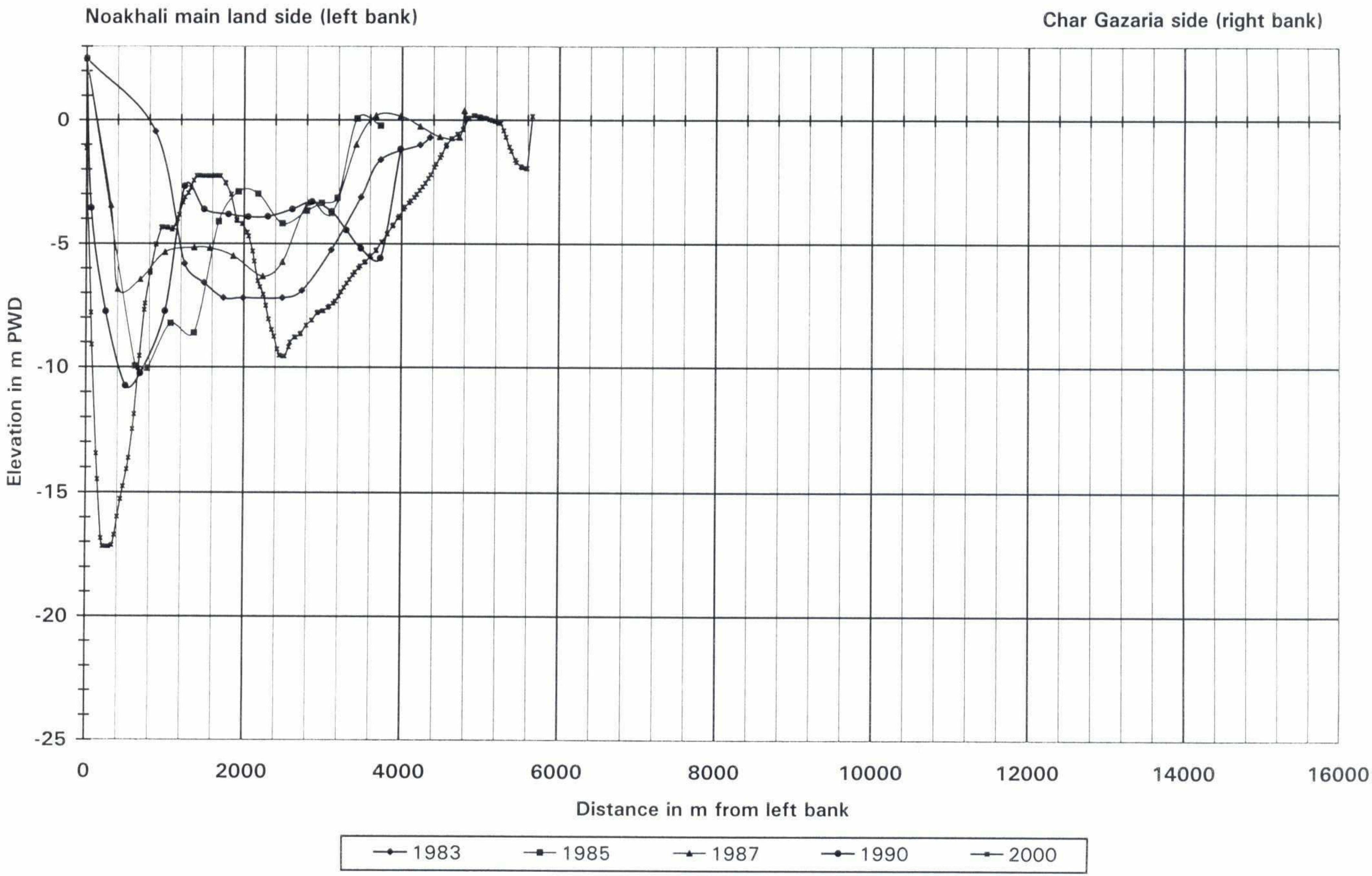




MIKE 11

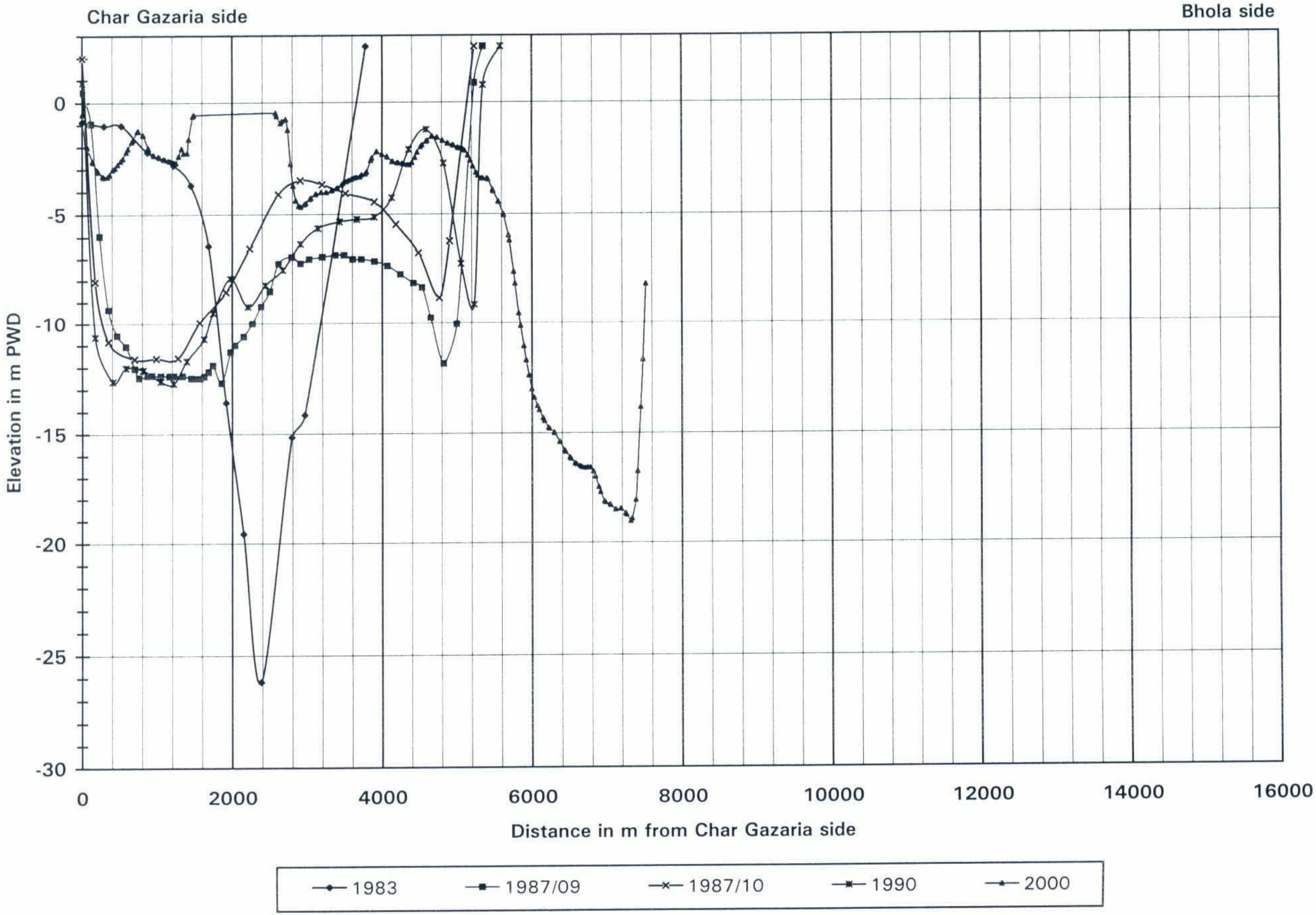
DATA BASE : MES97

Drawing 22 : Cross-section 4 at the East of Char Gazaria in the East Shahbazpur Channel



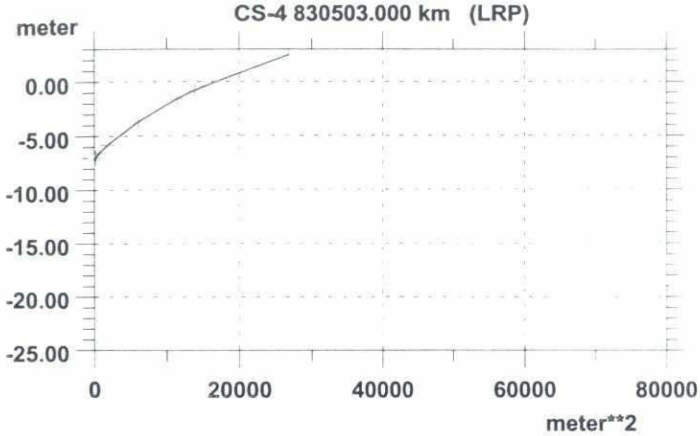
6a

Drawing 23 : Cross-section 5 at the West of Char Gazaria in the West Shahabzpur Channel



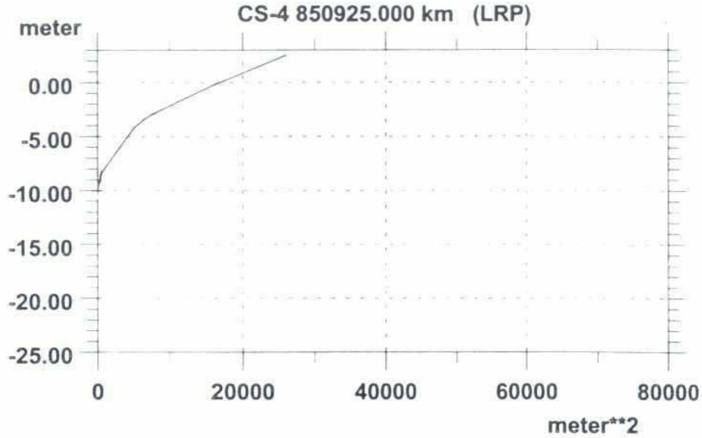
CROSS-SECTIONAL AREA

CS-4 830503.000 km (LRP)



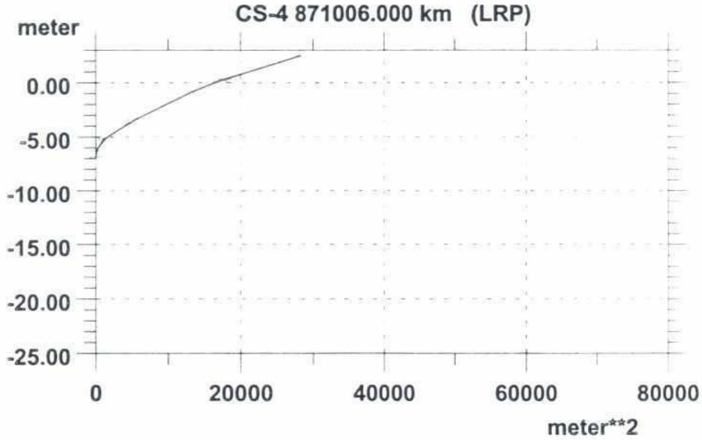
CROSS-SECTIONAL AREA

CS-4 850925.000 km (LRP)



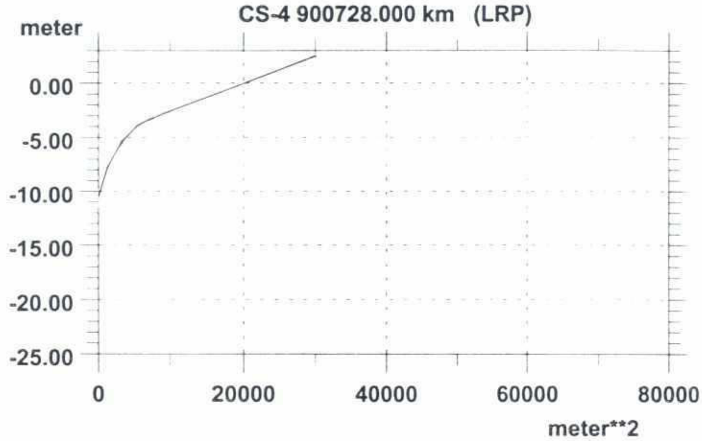
CROSS-SECTIONAL AREA

CS-4 871006.000 km (LRP)



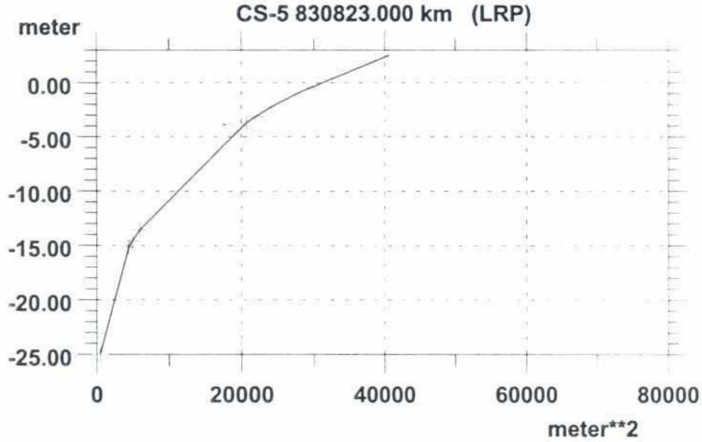
CROSS-SECTIONAL AREA

CS-4 900728.000 km (LRP)



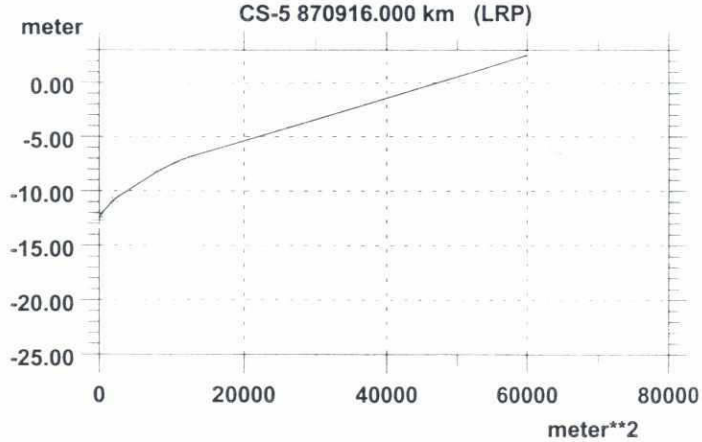
CROSS-SECTIONAL AREA

CS-5 830823.000 km (LRP)



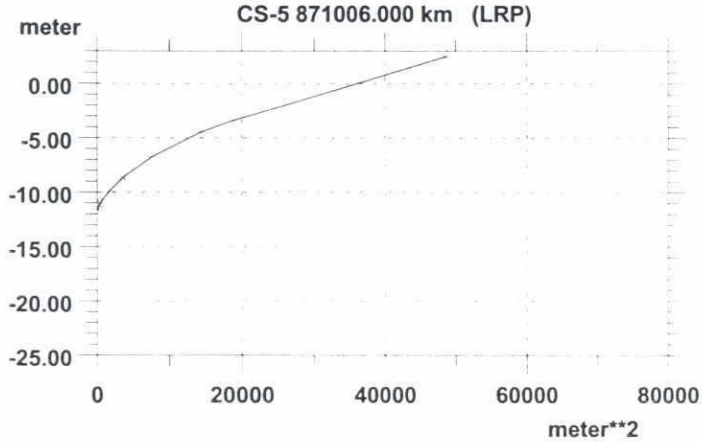
CROSS-SECTIONAL AREA

CS-5 870916.000 km (LRP)



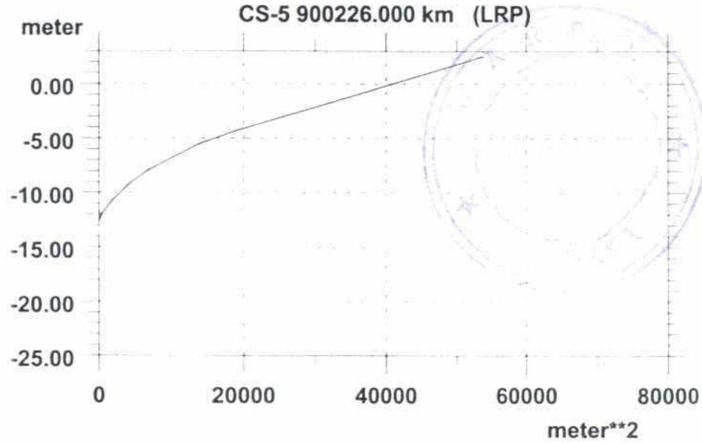
CROSS-SECTIONAL AREA

CS-5 871006.000 km (LRP)



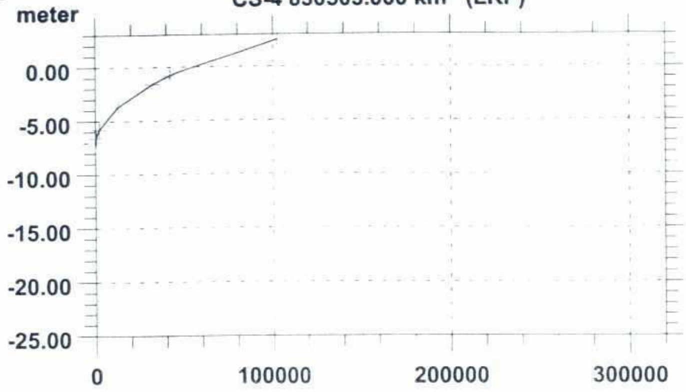
CROSS-SECTIONAL AREA

CS-5 900226.000 km (LRP)



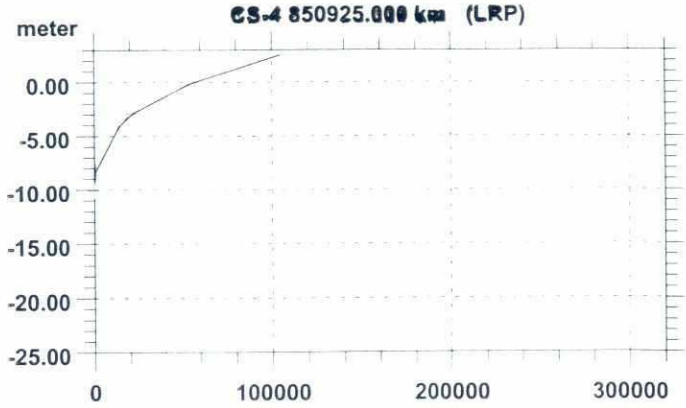
CONVEYANCE

CS-4 830503.000 km (LRP)



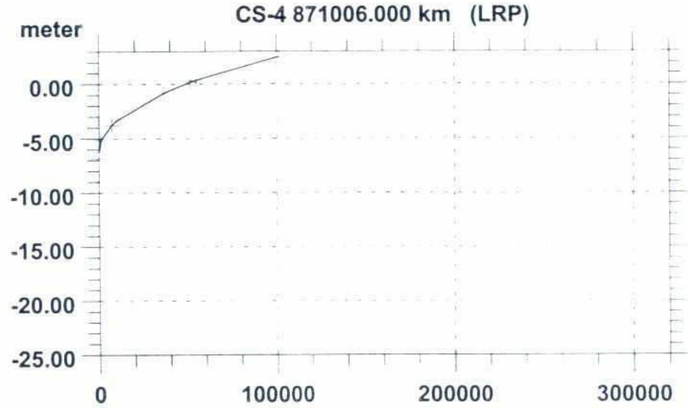
CONVEYANCE

CS-4 850925.000 km (LRP)



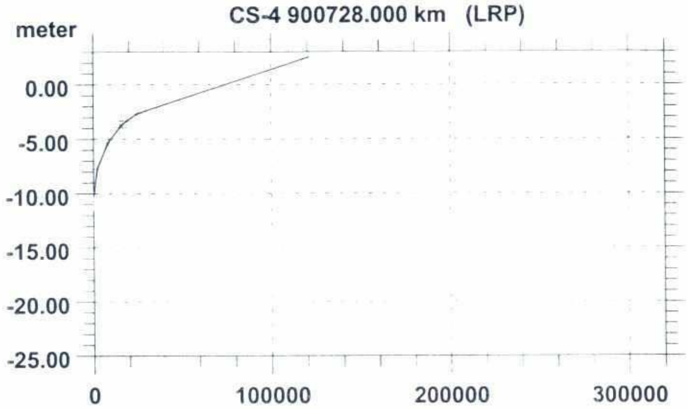
CONVEYANCE

CS-4 871006.000 km (LRP)



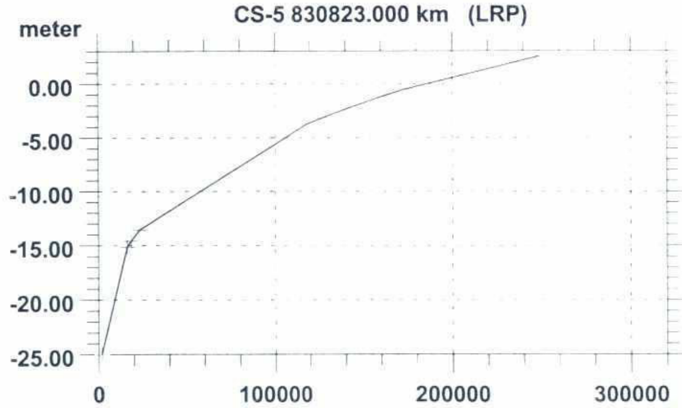
CONVEYANCE

CS-4 900728.000 km (LRP)



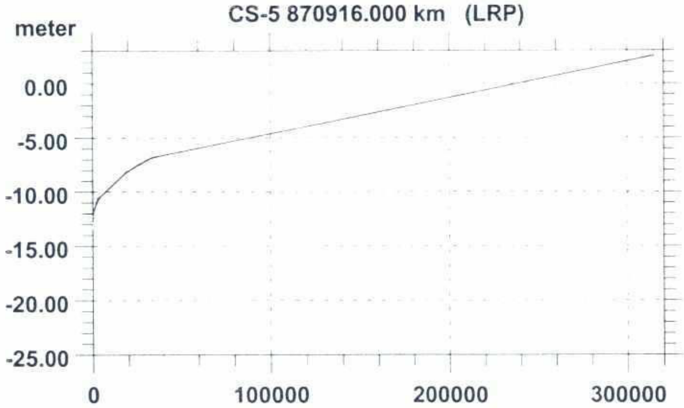
CONVEYANCE

CS-5 830823.000 km (LRP)



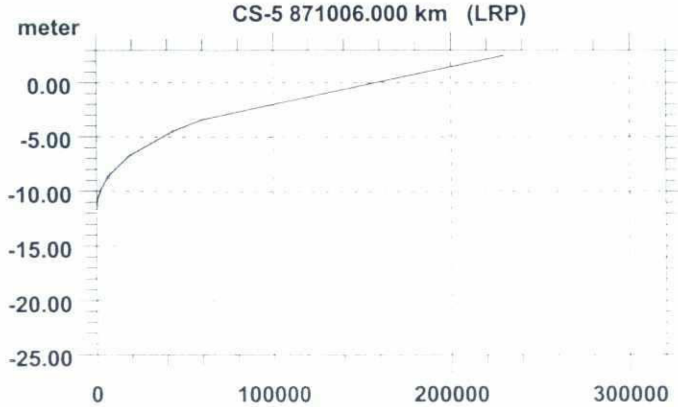
CONVEYANCE

CS-5 870916.000 km (LRP)



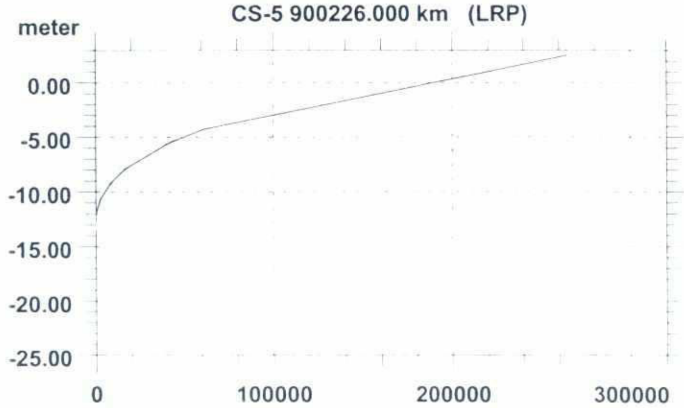
CONVEYANCE

CS-5 871006.000 km (LRP)

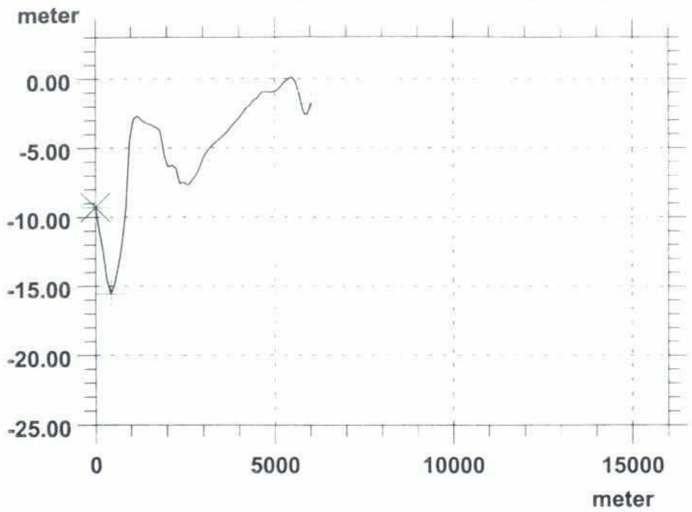


CONVEYANCE

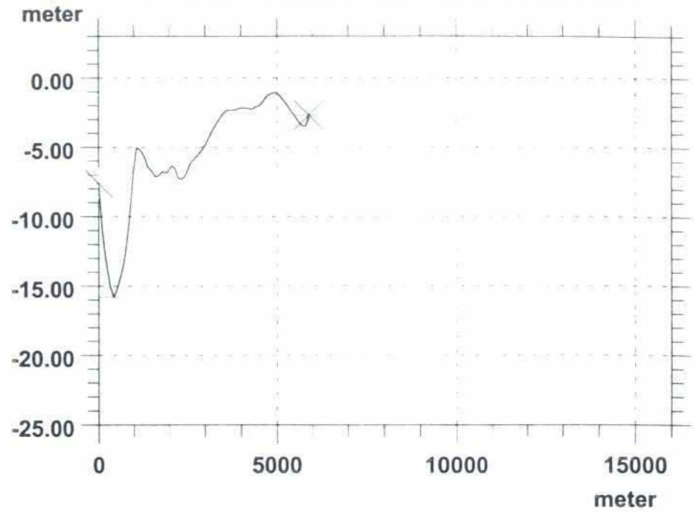
CS-5 900226.000 km (LRP)



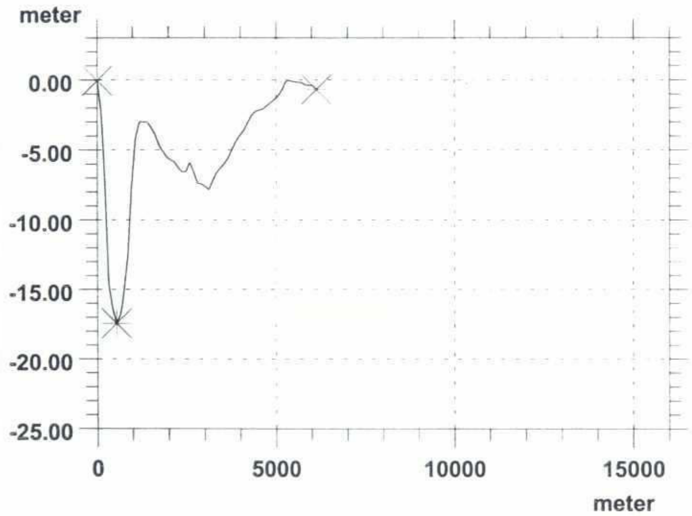
CS4 17042000.000 km TOPO ID : MES2000



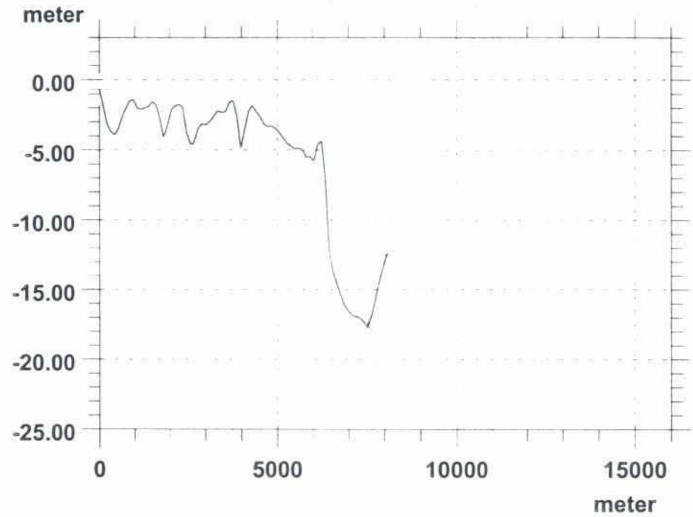
CS4-DS 17042000.000 km TOPO ID : MES2000



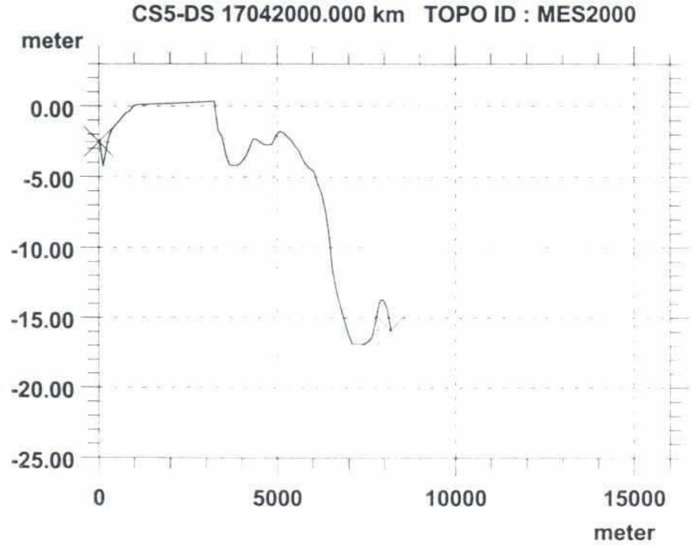
CS4-US 17042000.000 km TOPO ID : MES2000



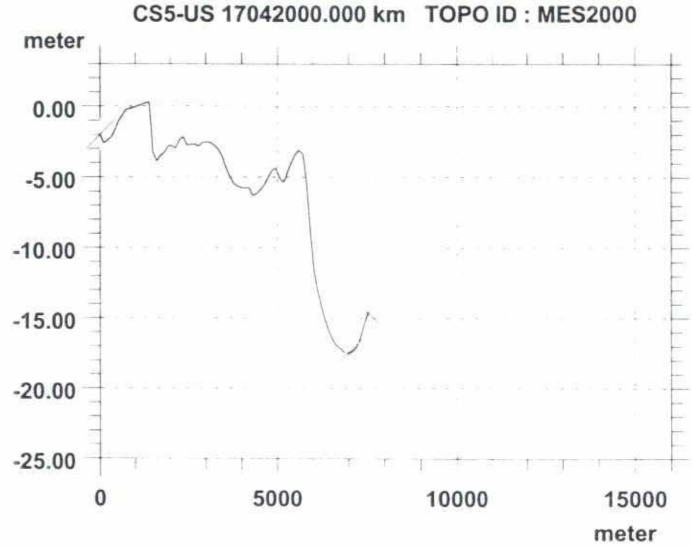
CS5 17042000.000 km TOPO ID : MES2000



CS5-DS 17042000.000 km TOPO ID : MES2000

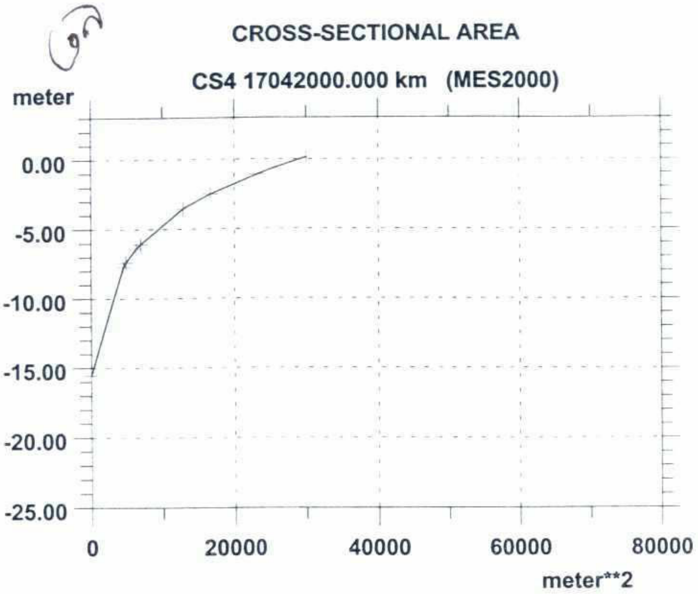


CS5-US 17042000.000 km TOPO ID : MES2000

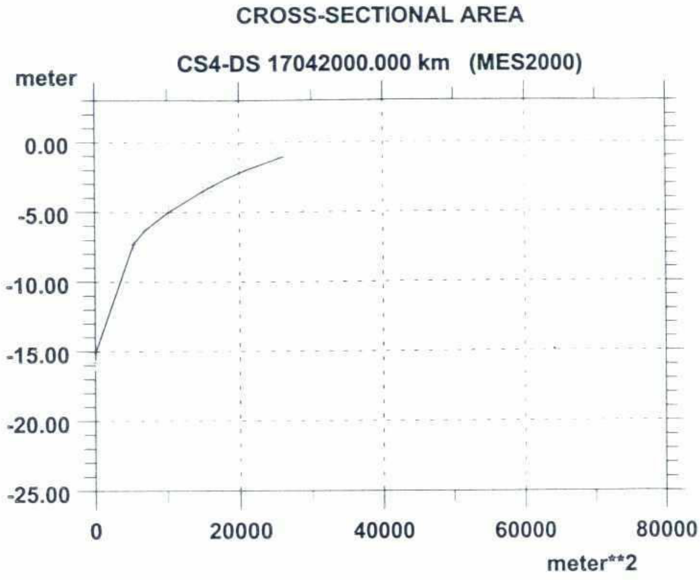


DATA BASE : MES2000

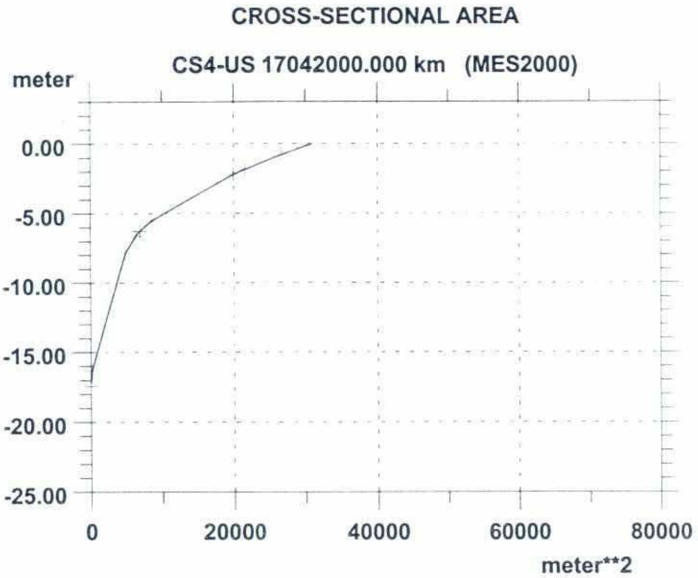
MIKE 11



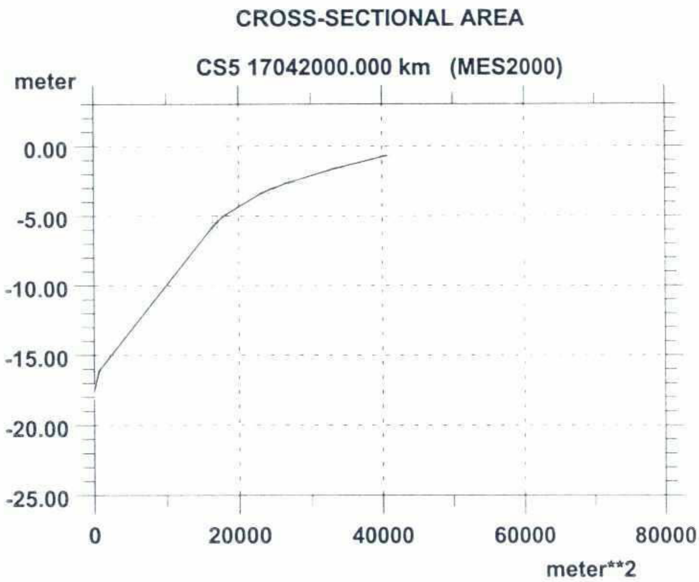
CROSS-SECTIONAL AREA
CS4 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2



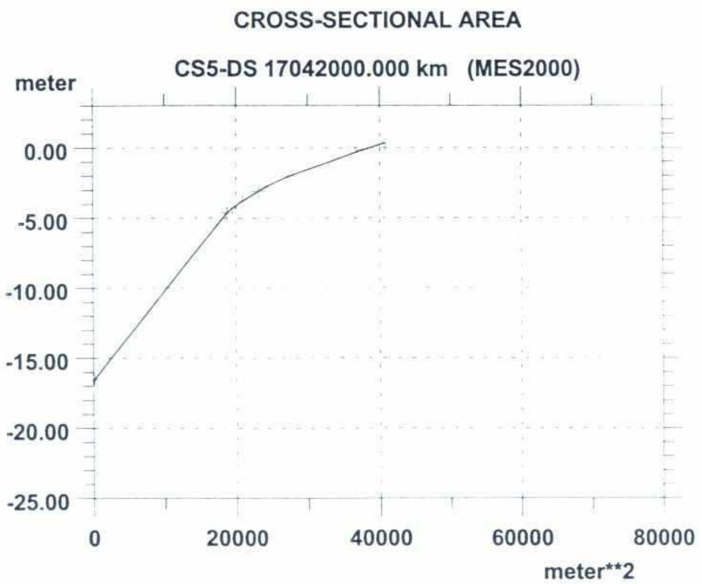
CROSS-SECTIONAL AREA
CS4-DS 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2



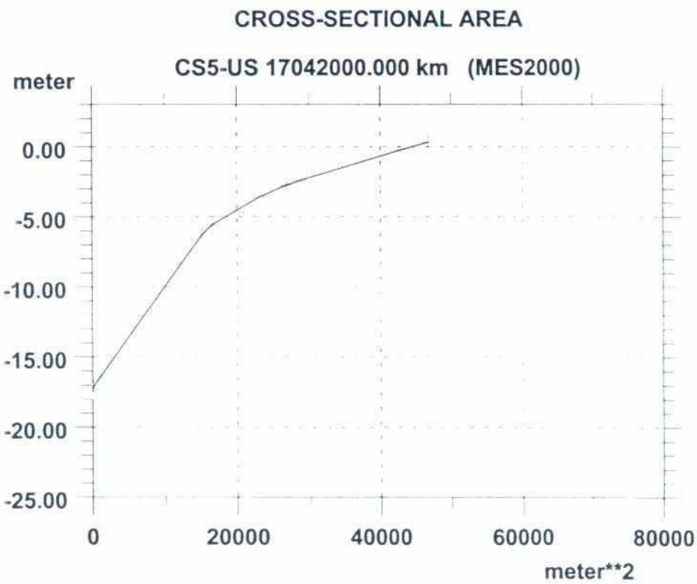
CROSS-SECTIONAL AREA
CS4-US 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2



CROSS-SECTIONAL AREA
CS5 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2



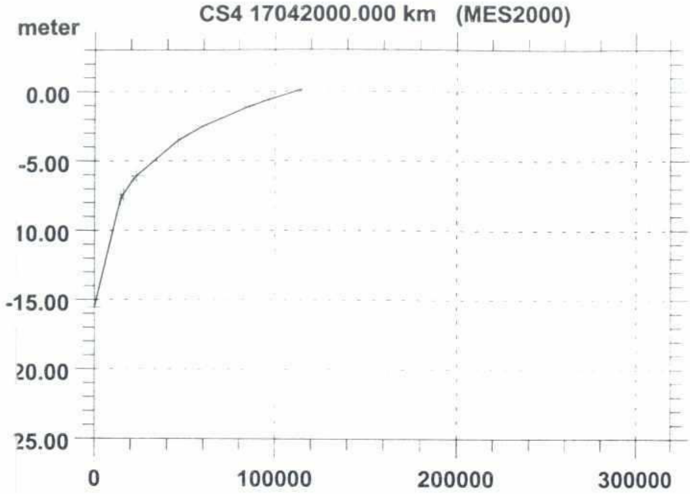
CROSS-SECTIONAL AREA
CS5-DS 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2



CROSS-SECTIONAL AREA
CS5-US 17042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
meter**2

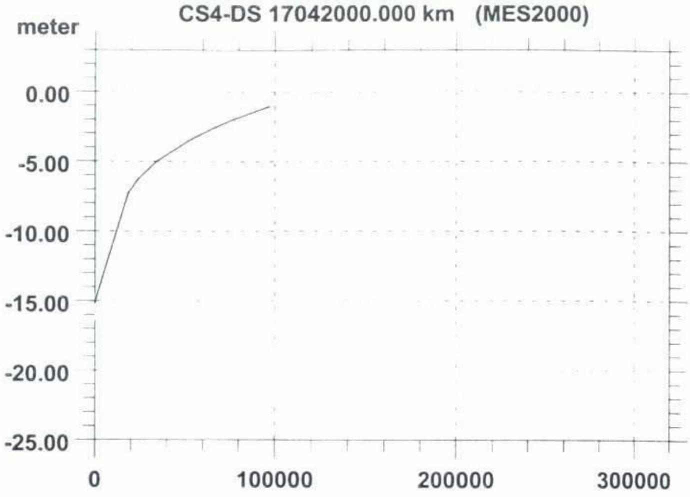
CONVEYANCE

CS4 17042000.000 km (MES2000)



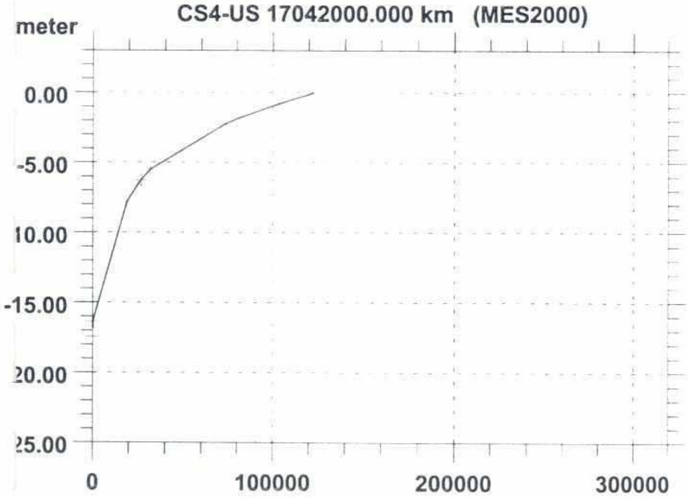
CONVEYANCE

CS4-DS 17042000.000 km (MES2000)



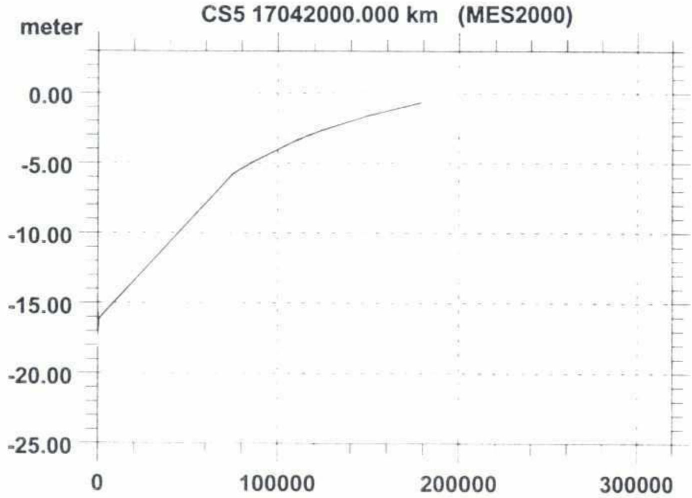
CONVEYANCE

CS4-US 17042000.000 km (MES2000)



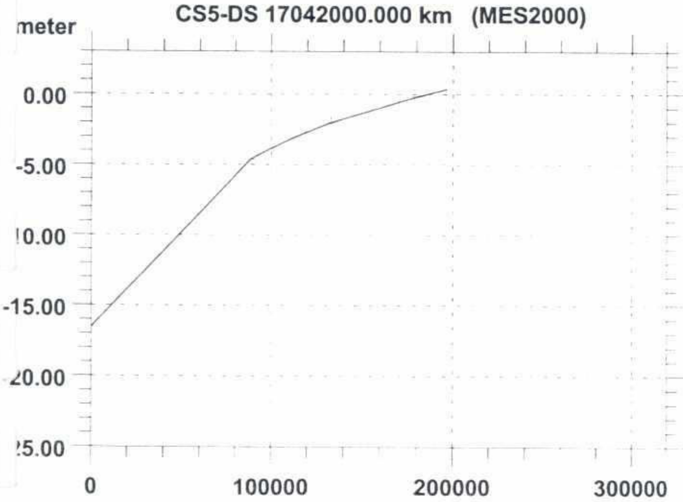
CONVEYANCE

CS5 17042000.000 km (MES2000)



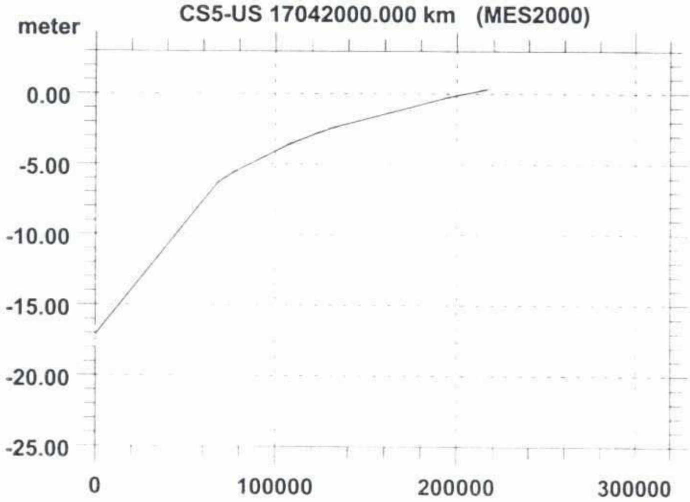
CONVEYANCE

CS5-DS 17042000.000 km (MES2000)

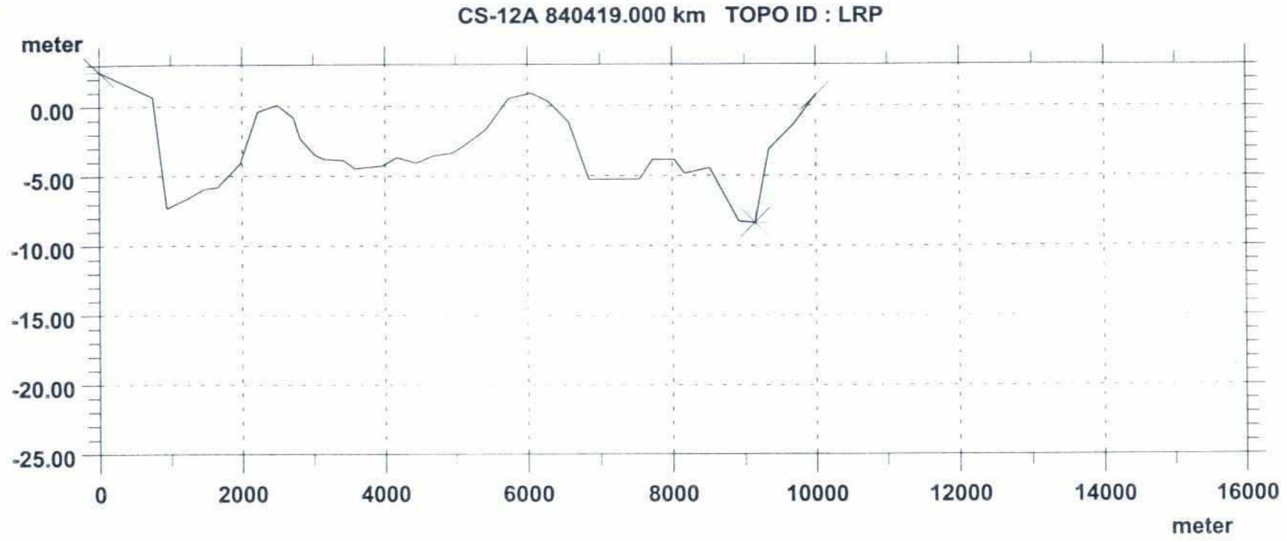


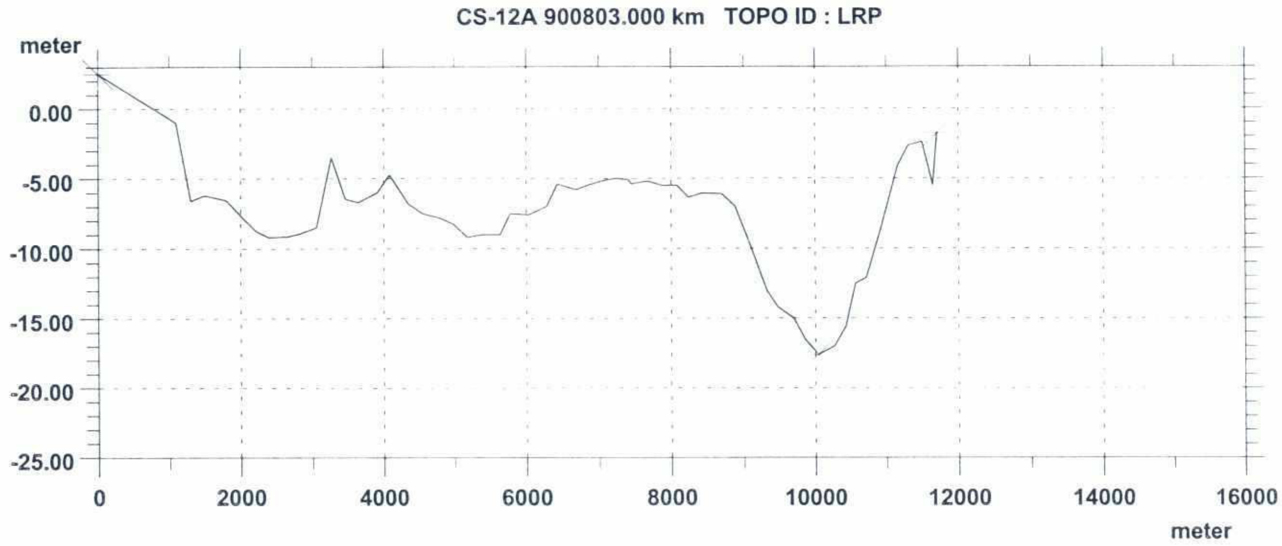
CONVEYANCE

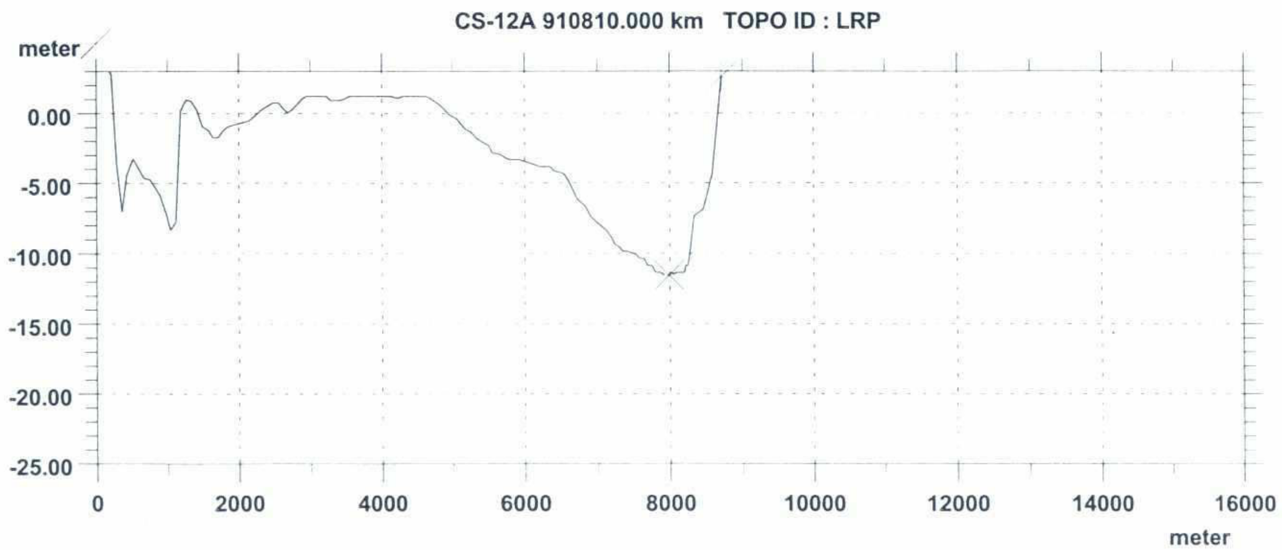
CS5-US 17042000.000 km (MES2000)



DATA BASE : MES2000	MIKE 11
	28



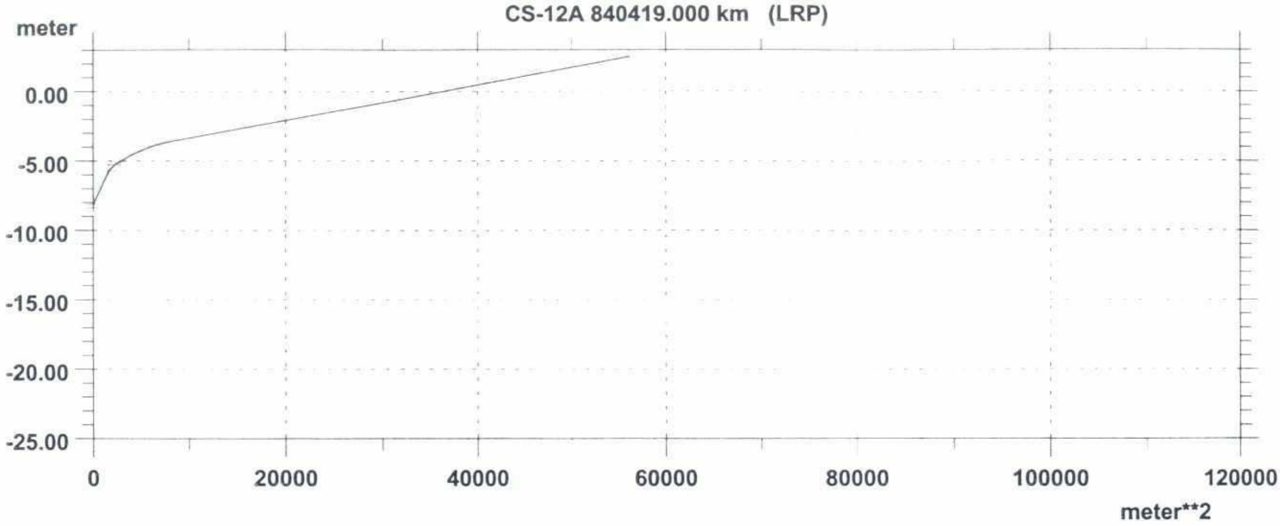




DATA BASE : LRP	MIKE 11
	29

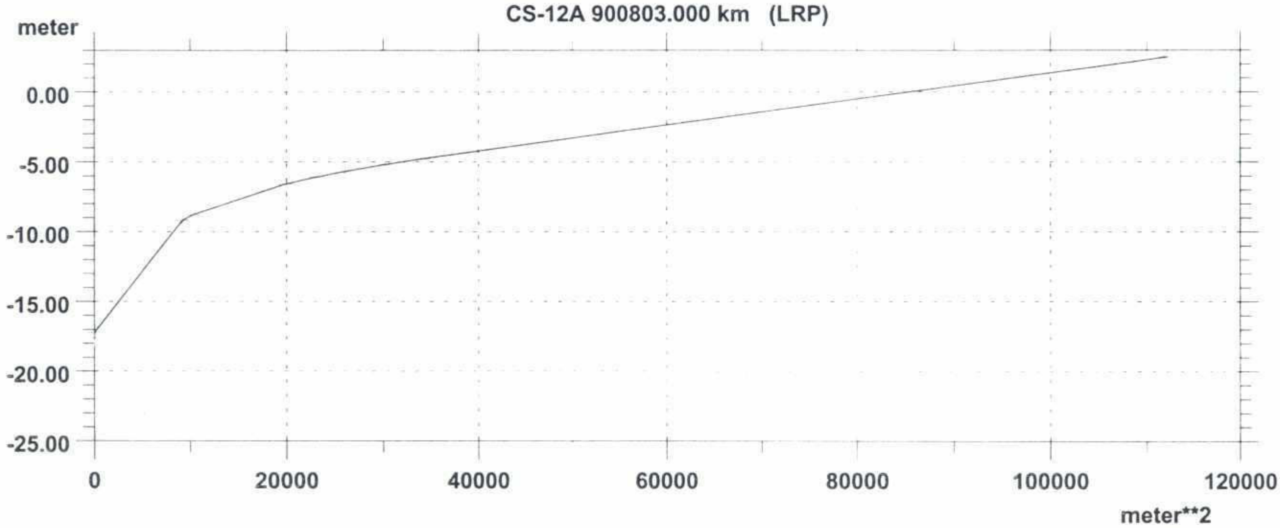
CROSS-SECTIONAL AREA

CS-12A 840419.000 km (LRP)



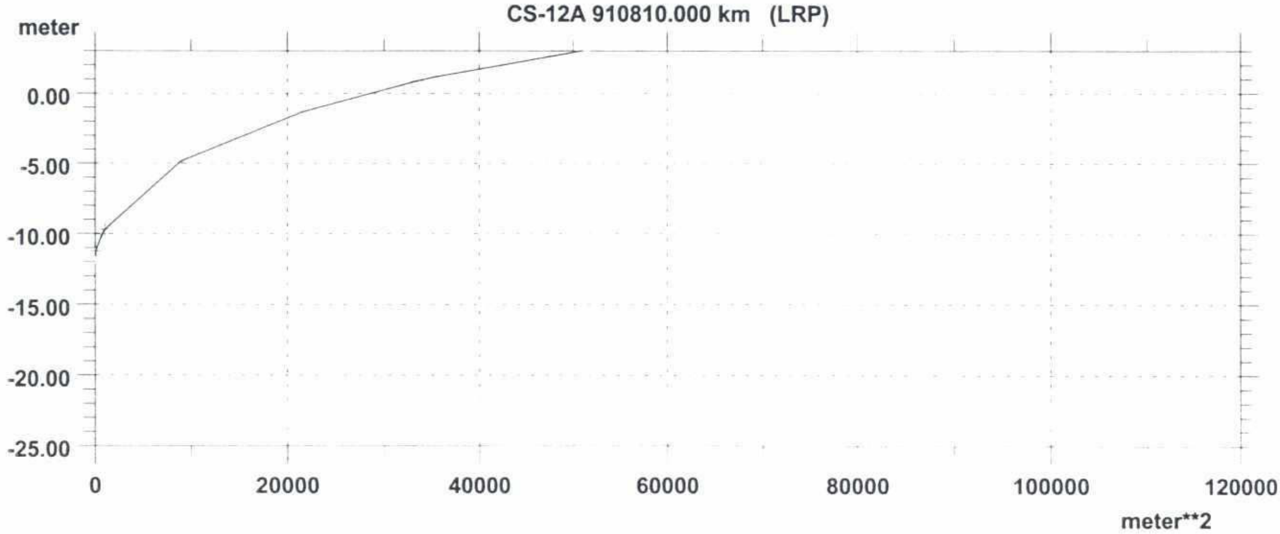
CROSS-SECTIONAL AREA

CS-12A 900803.000 km (LRP)



CROSS-SECTIONAL AREA

CS-12A 910810.000 km (LRP)

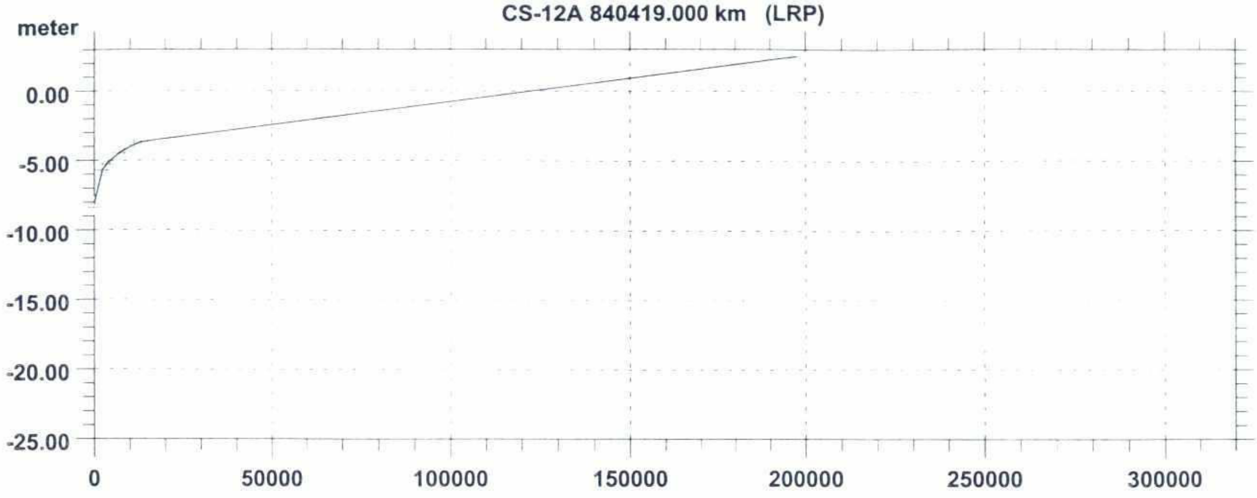


DATA BASE : LRP	MIKE 11
	30

86

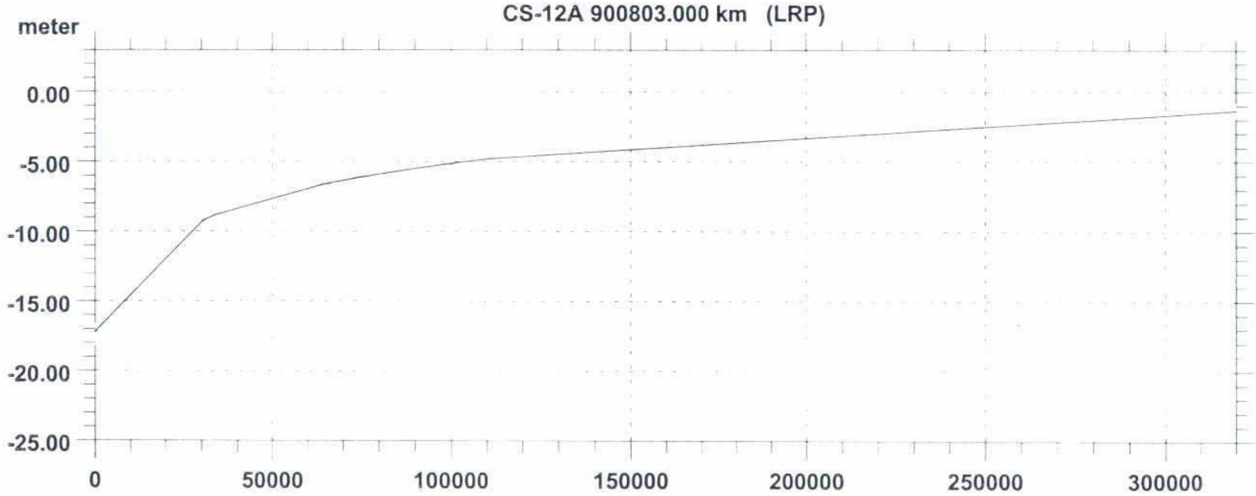
CONVEYANCE

CS-12A 840419.000 km (LRP)



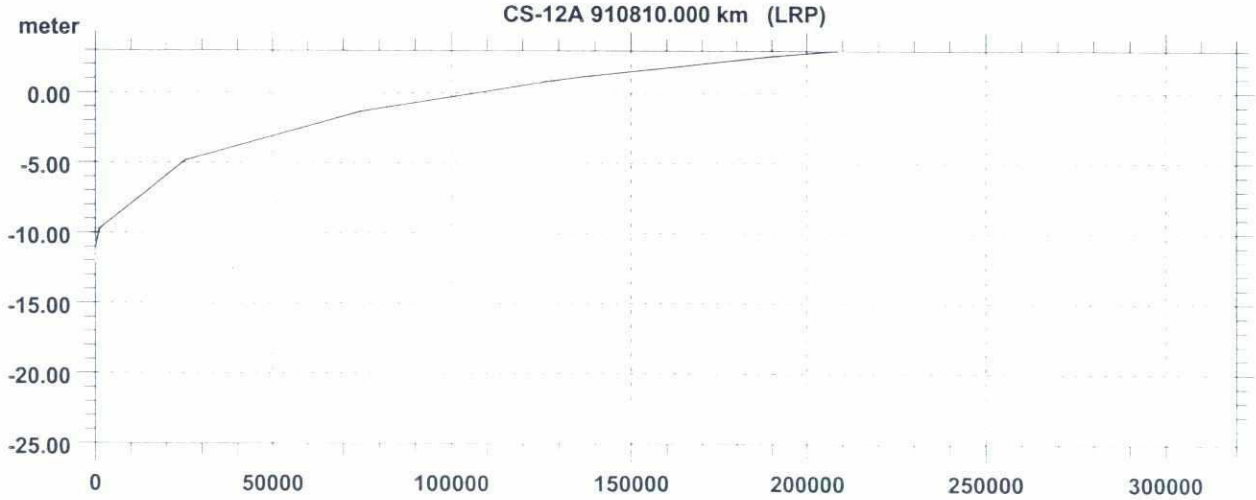
CONVEYANCE

CS-12A 900803.000 km (LRP)



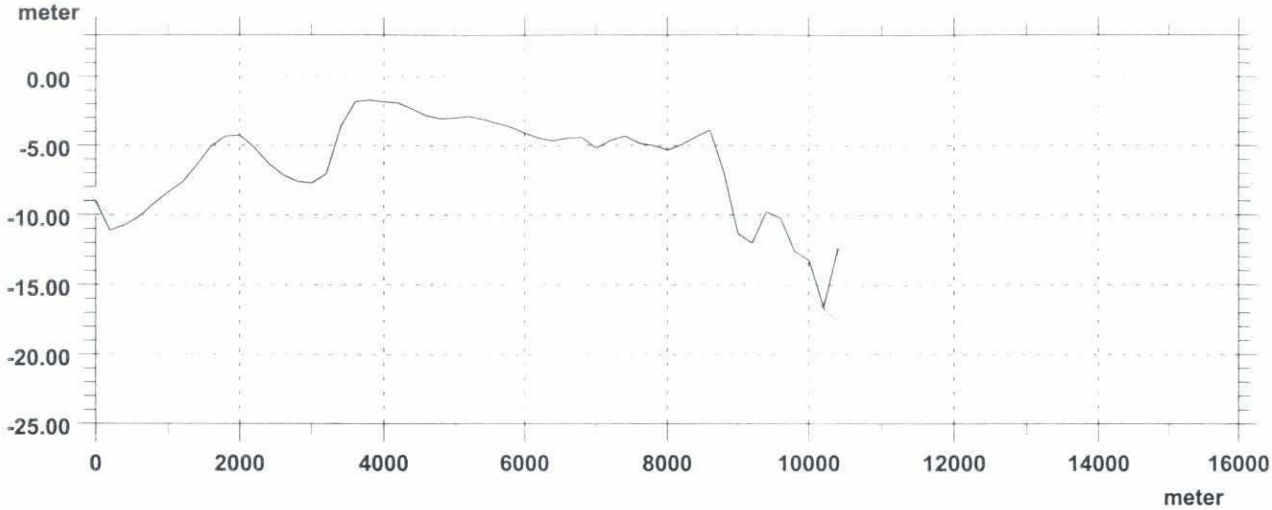
CONVEYANCE

CS-12A 910810.000 km (LRP)

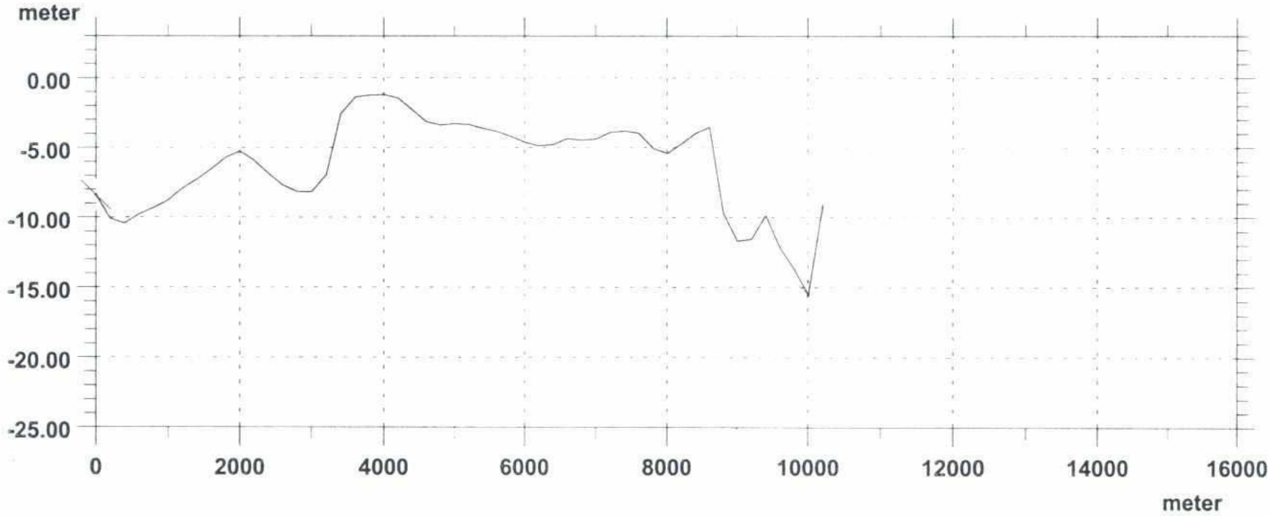


DATA BASE : LRP	MIKE 11
	31

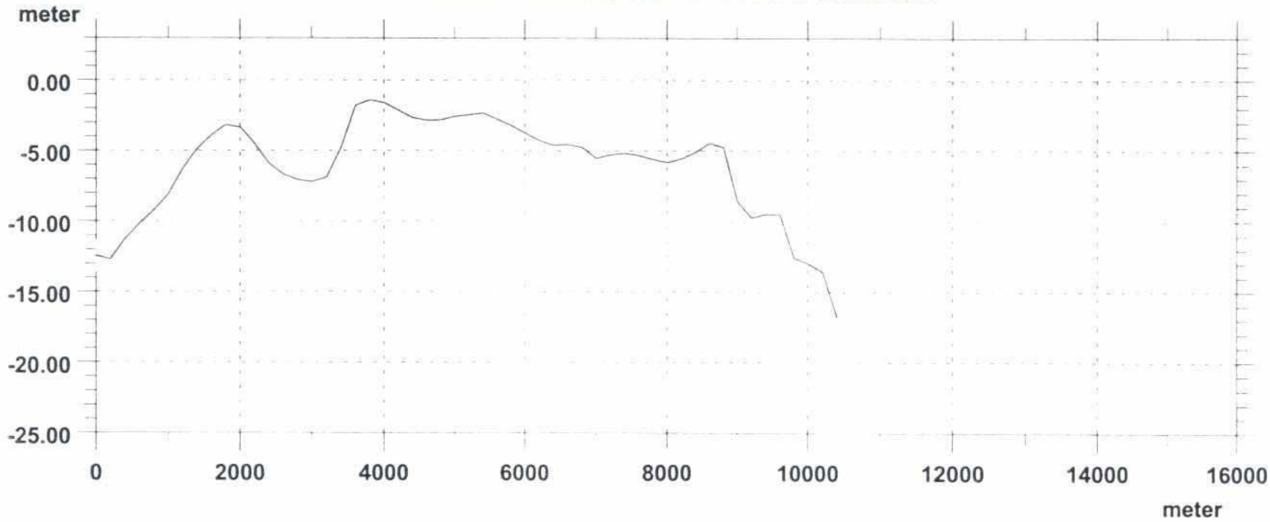
CS12A 14042000.000 km TOPO ID : MES2000



CS12A-DS 14042000.000 km TOPO ID : MES2000

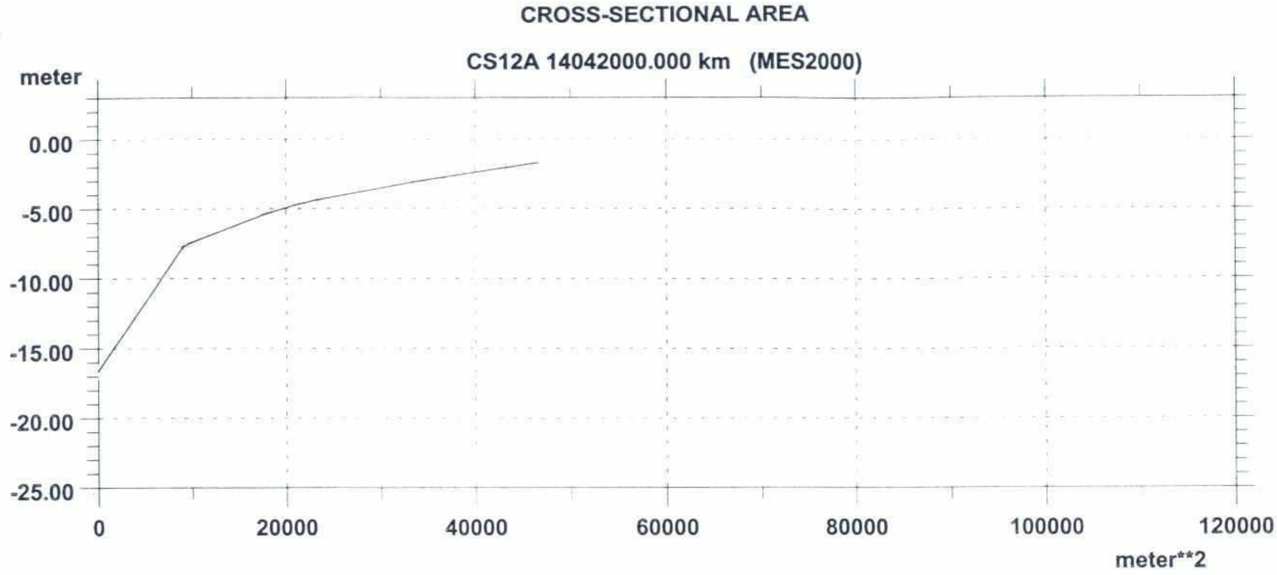


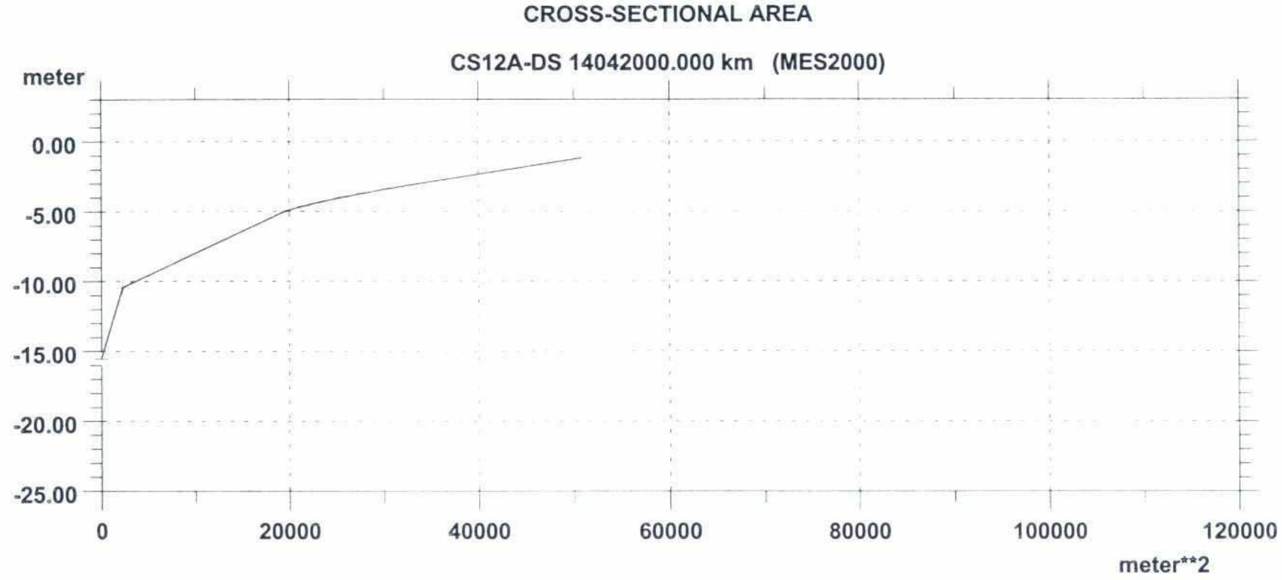
CS12A-US 14042000.000 km TOPO ID : MES2000

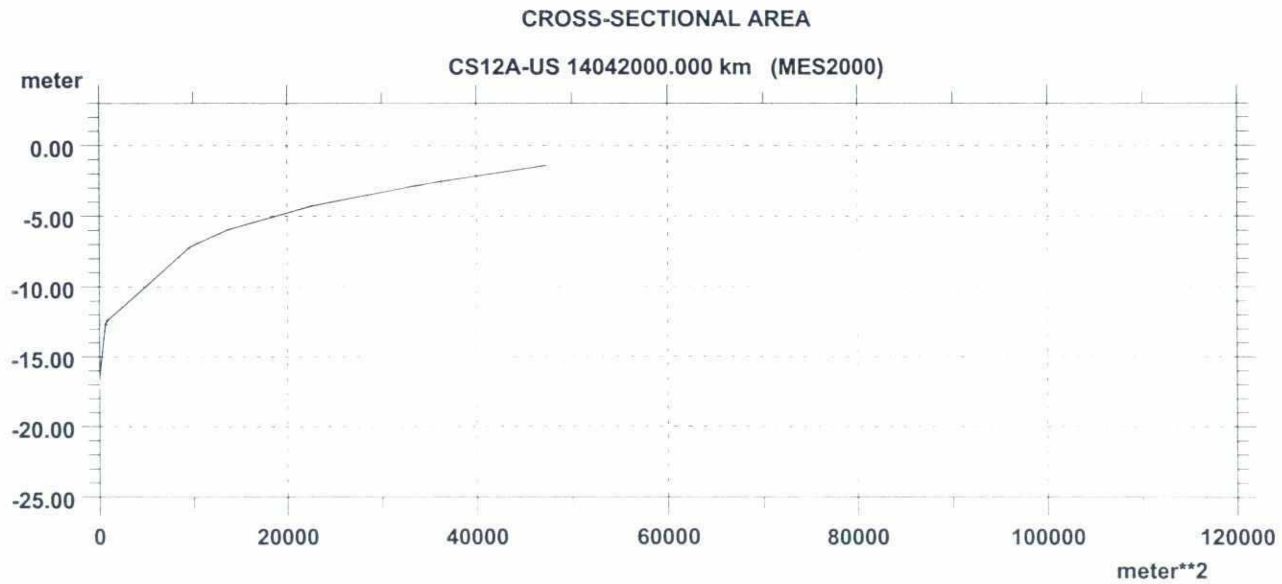


MIKE 11

DATA BASE : MES2000

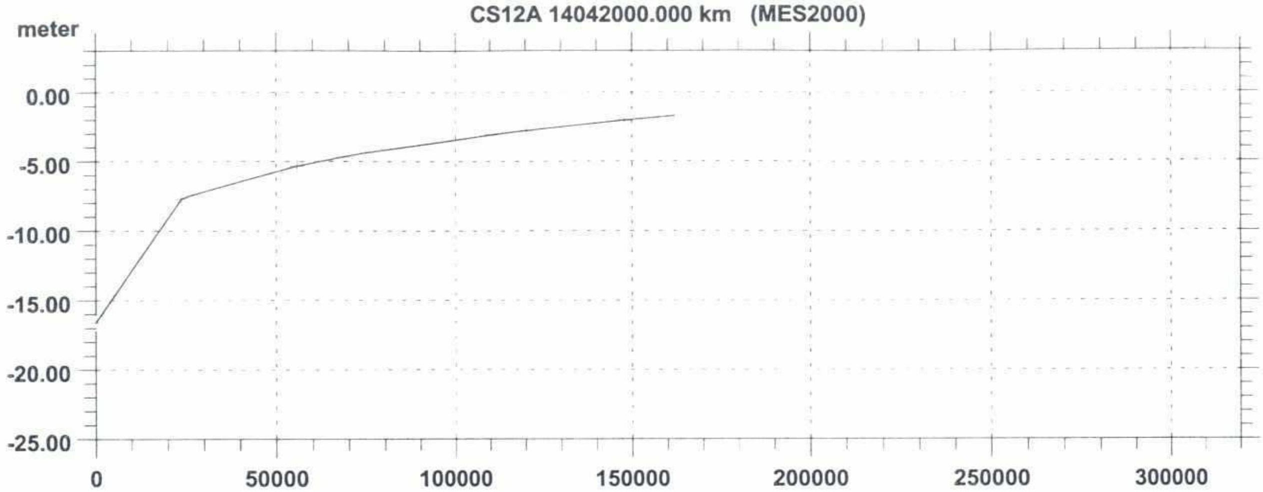

CROSS-SECTIONAL AREA
CS12A 14042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
100000
120000
meter**2


CROSS-SECTIONAL AREA
CS12A-DS 14042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
100000
120000
meter**2


CROSS-SECTIONAL AREA
CS12A-US 14042000.000 km (MES2000)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
20000
40000
60000
80000
100000
120000
meter**2

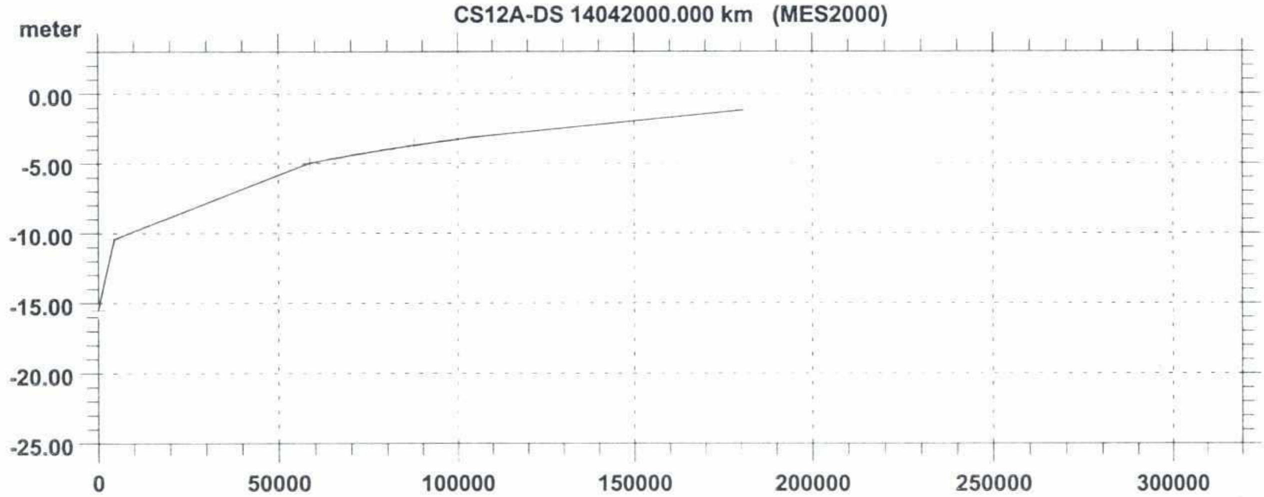
CONVEYANCE

CS12A 14042000.000 km (MES2000)



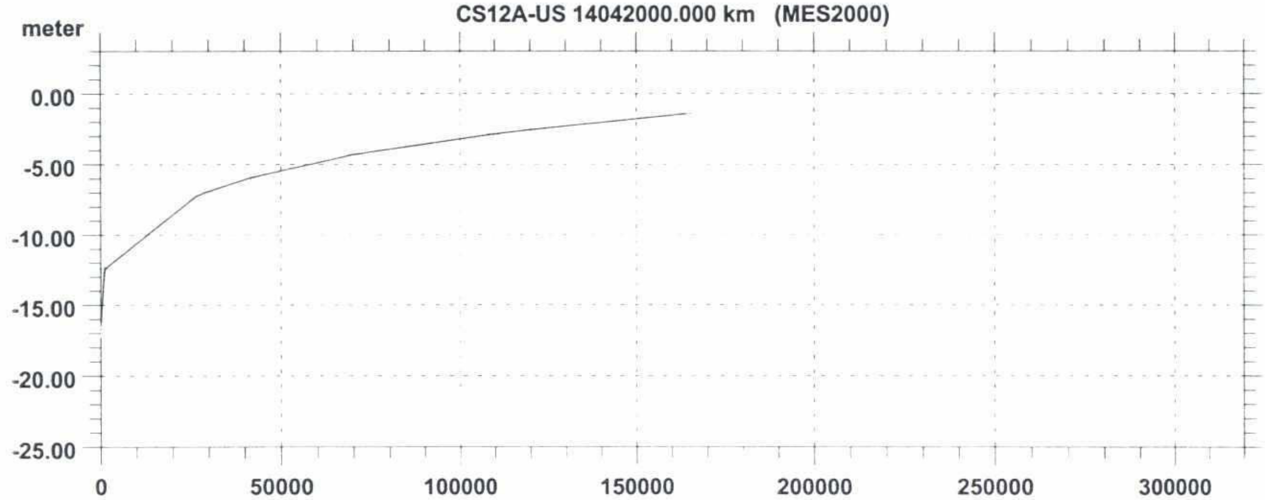
CONVEYANCE

CS12A-DS 14042000.000 km (MES2000)

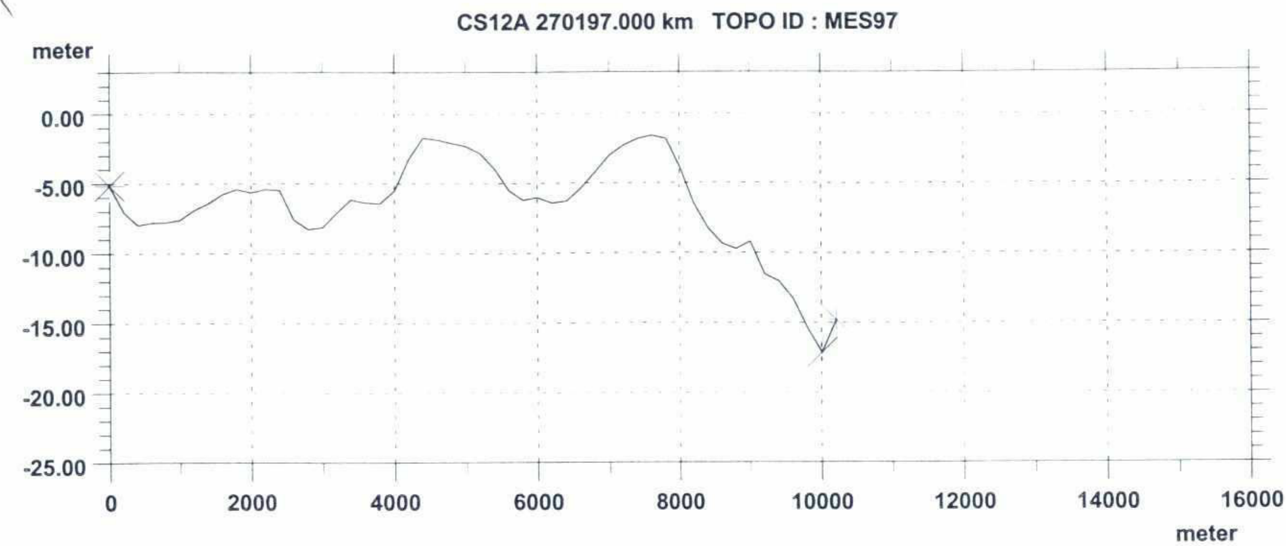


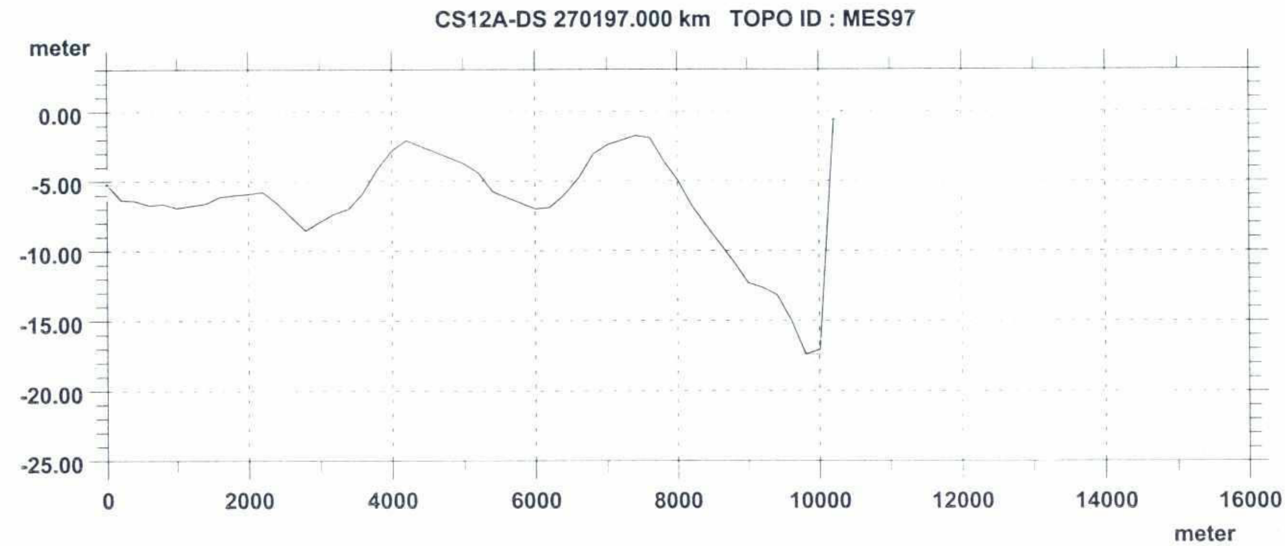
CONVEYANCE

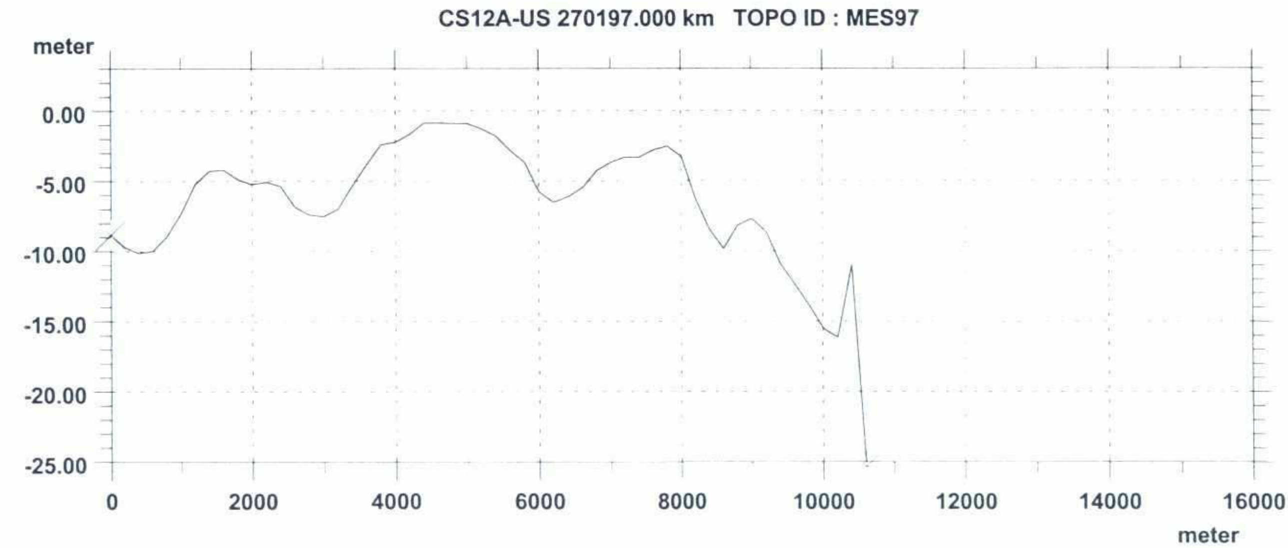
CS12A-US 14042000.000 km (MES2000)



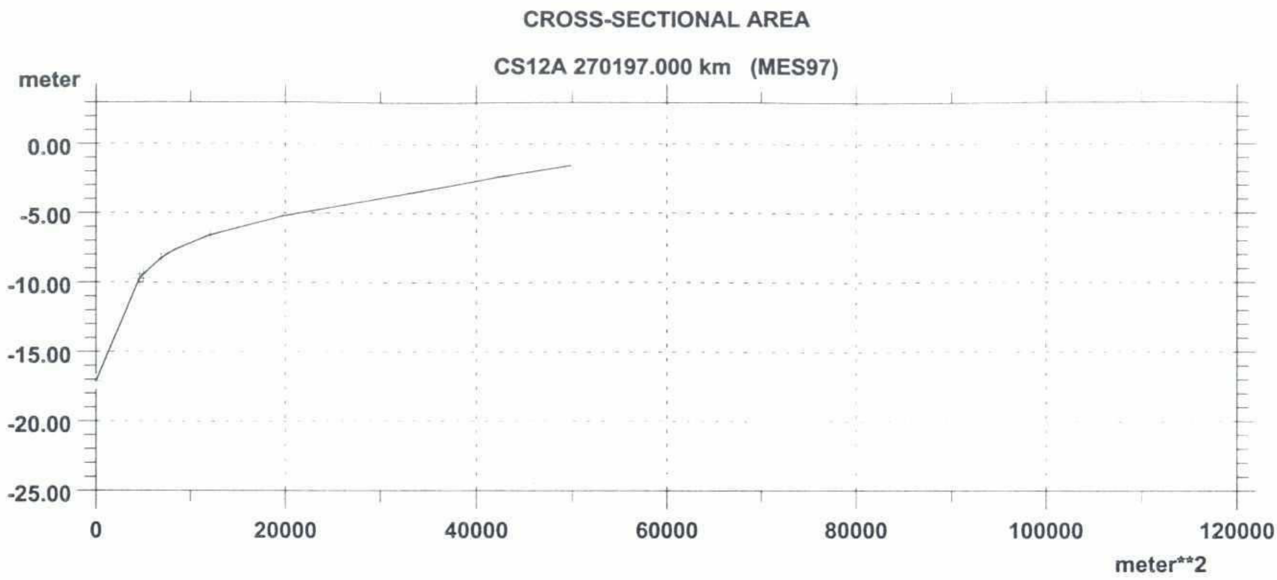
DATA BASE : MES2000	MIKE 11
	34

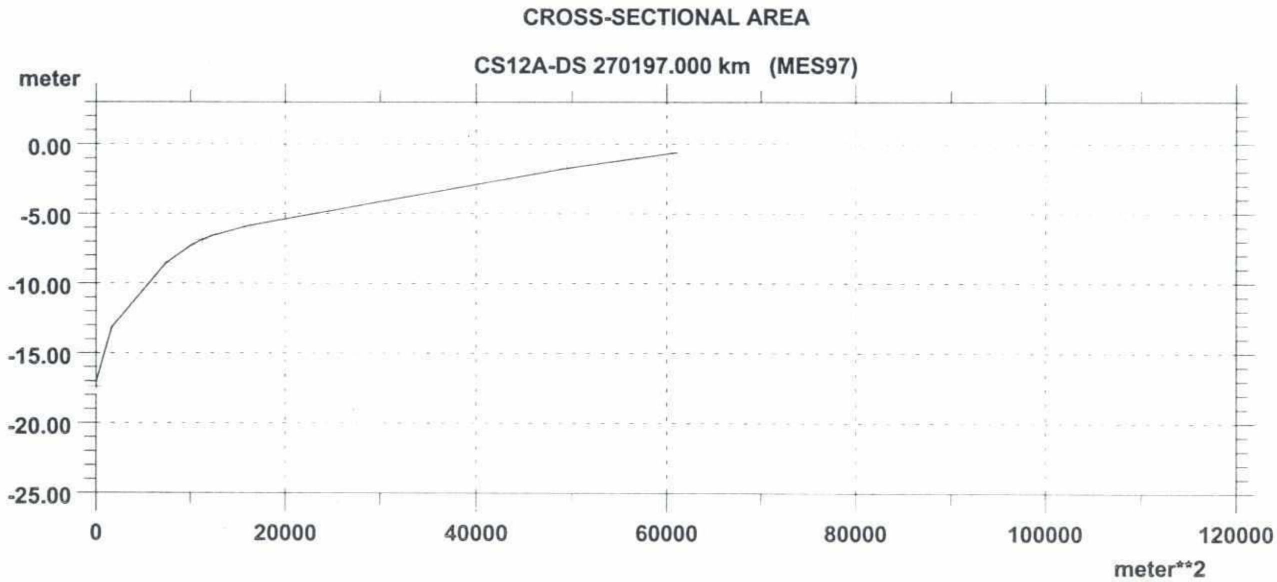


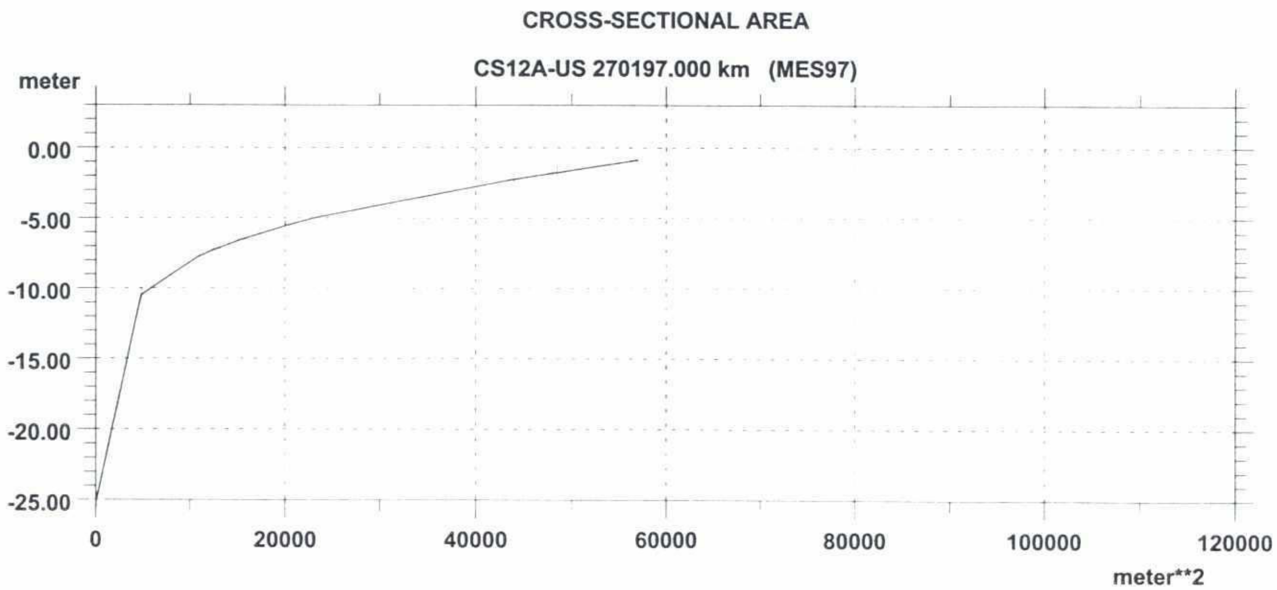




	MIKE 11
DATA BASE : MES97	35





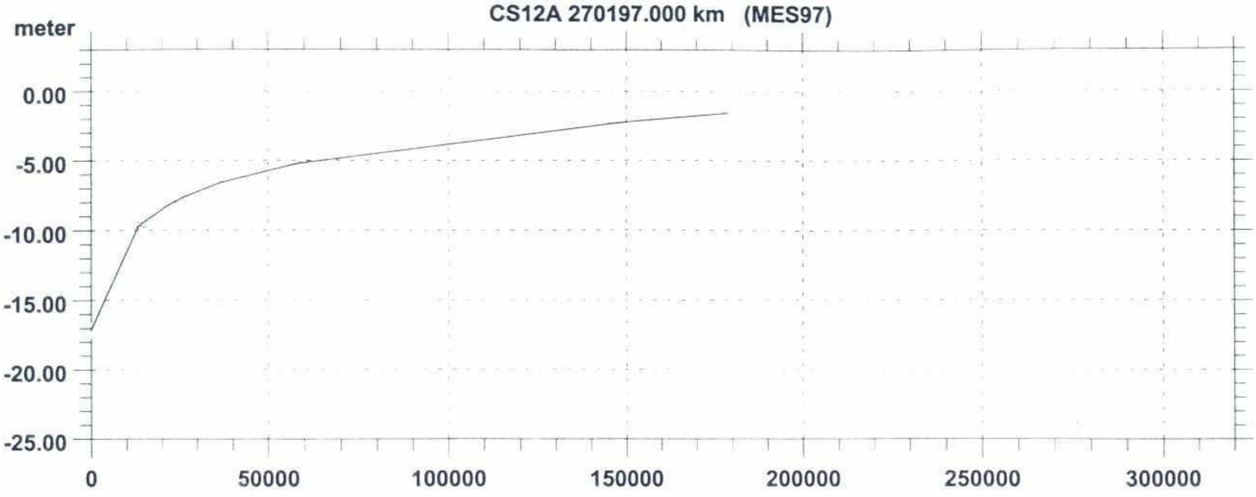


DATA BASE : MES97

MIKE 11

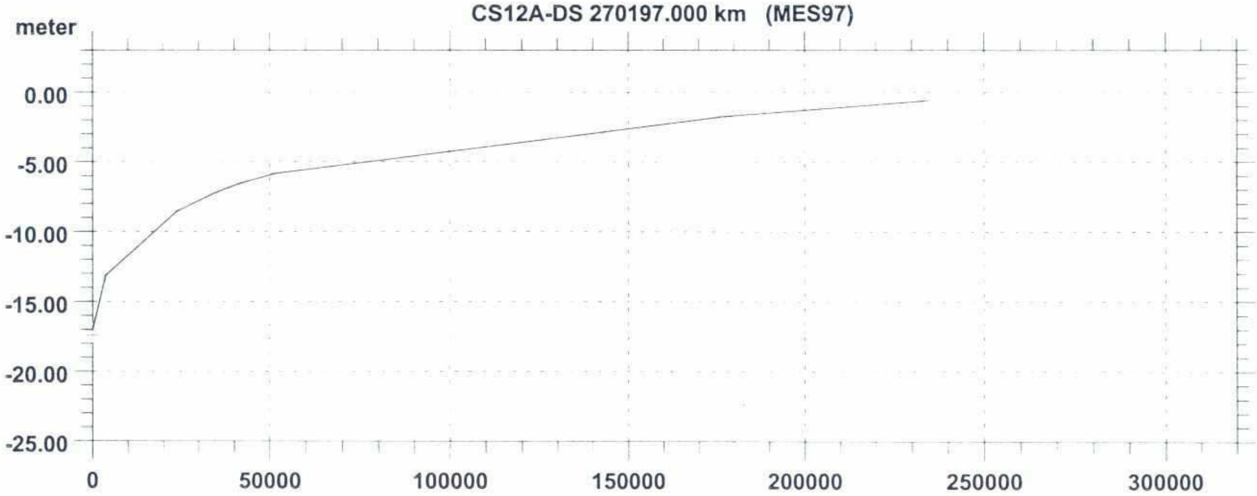
CONVEYANCE

CS12A 270197.000 km (MES97)



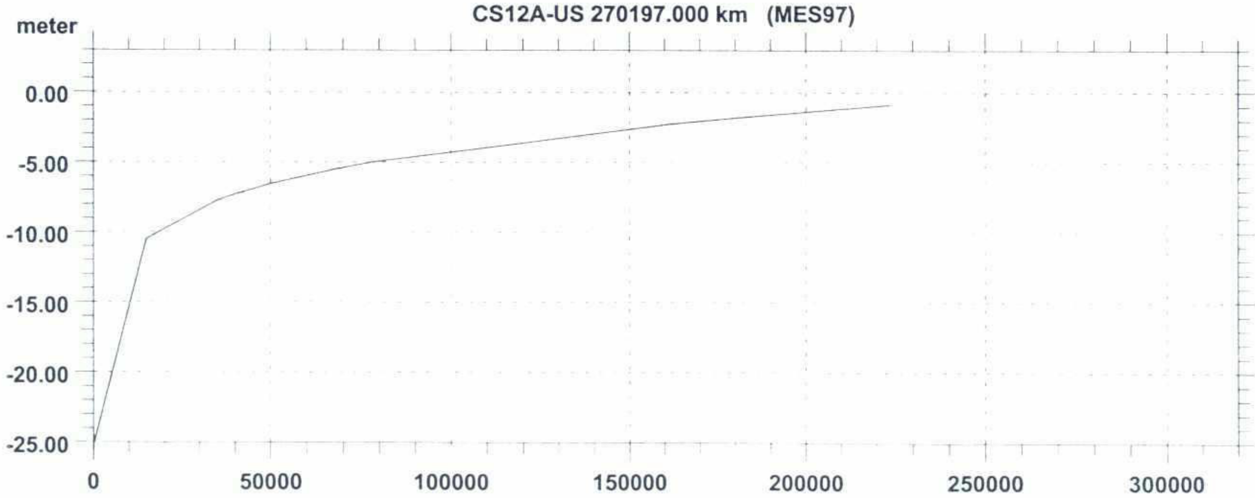
CONVEYANCE

CS12A-DS 270197.000 km (MES97)



CONVEYANCE

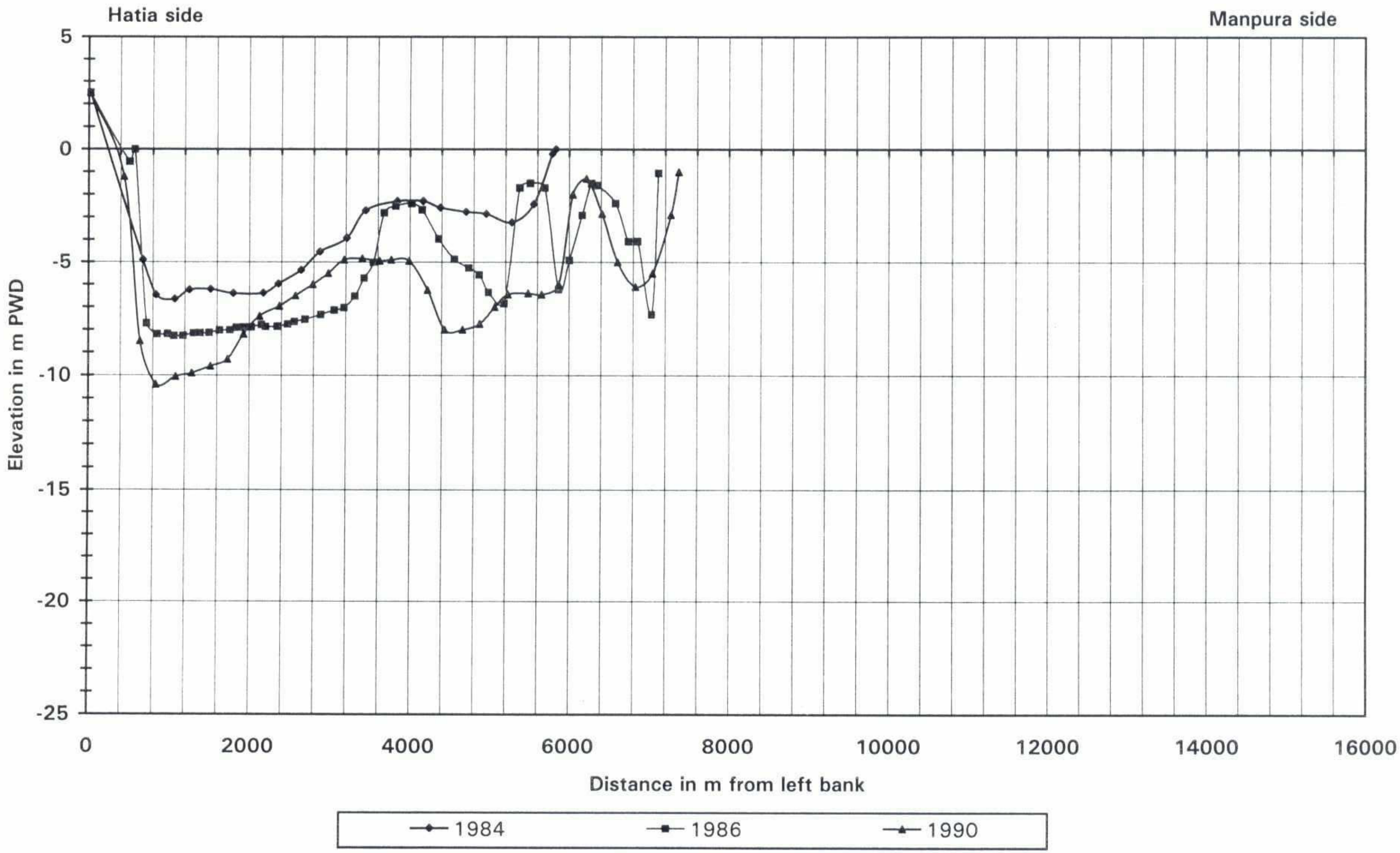
CS12A-US 270197.000 km (MES97)



DATA BASE : MES97

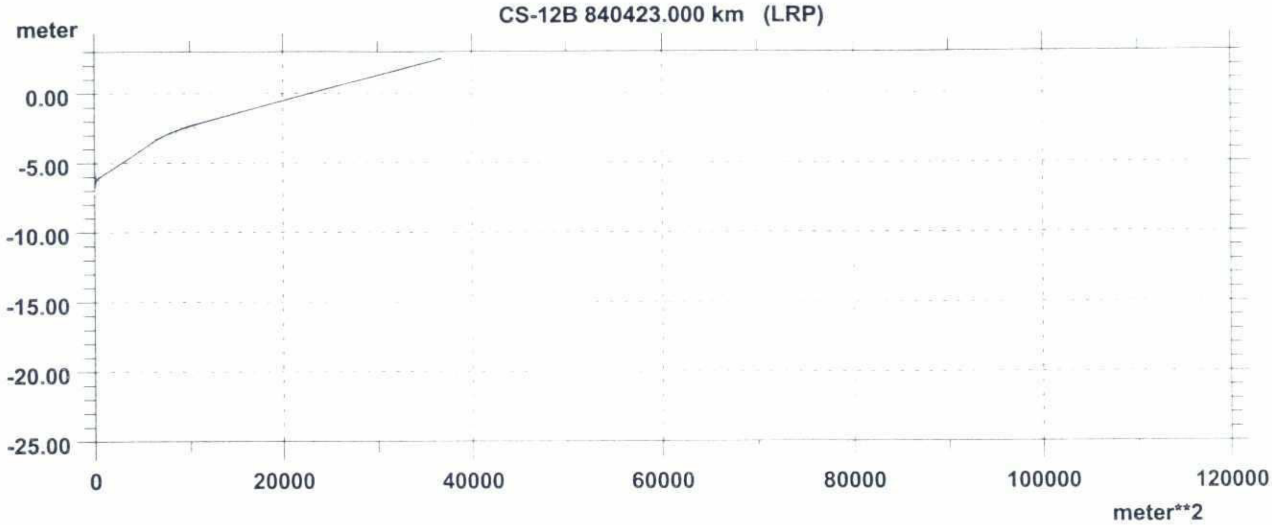
MIKE 11

Drawing 38 : Cross-section 12B in East Shahbazpur Channel in Different Years



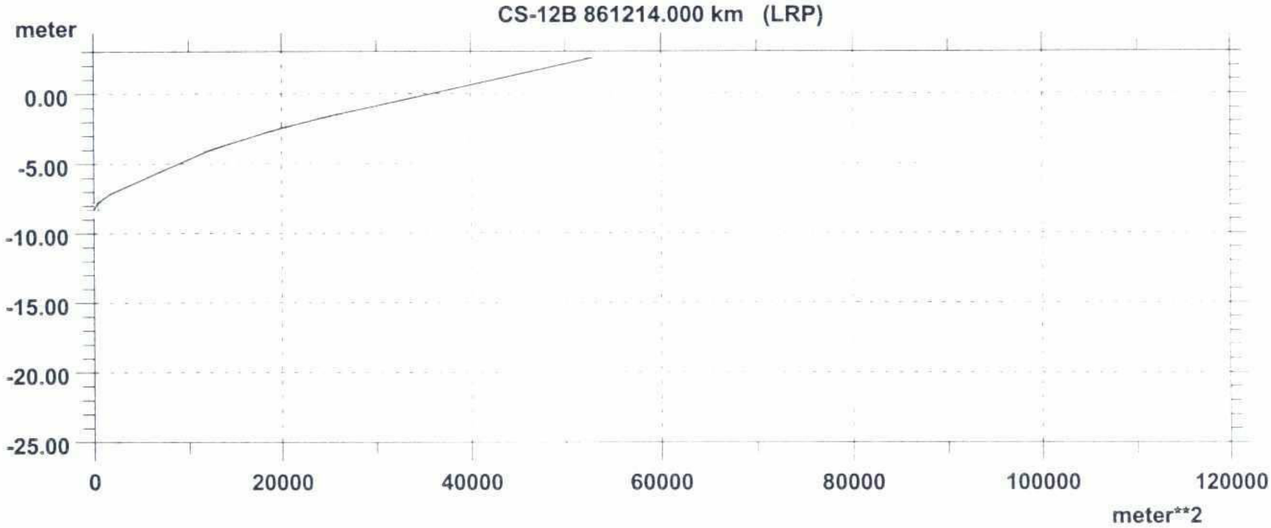
CROSS-SECTIONAL AREA

CS-12B 840423.000 km (LRP)



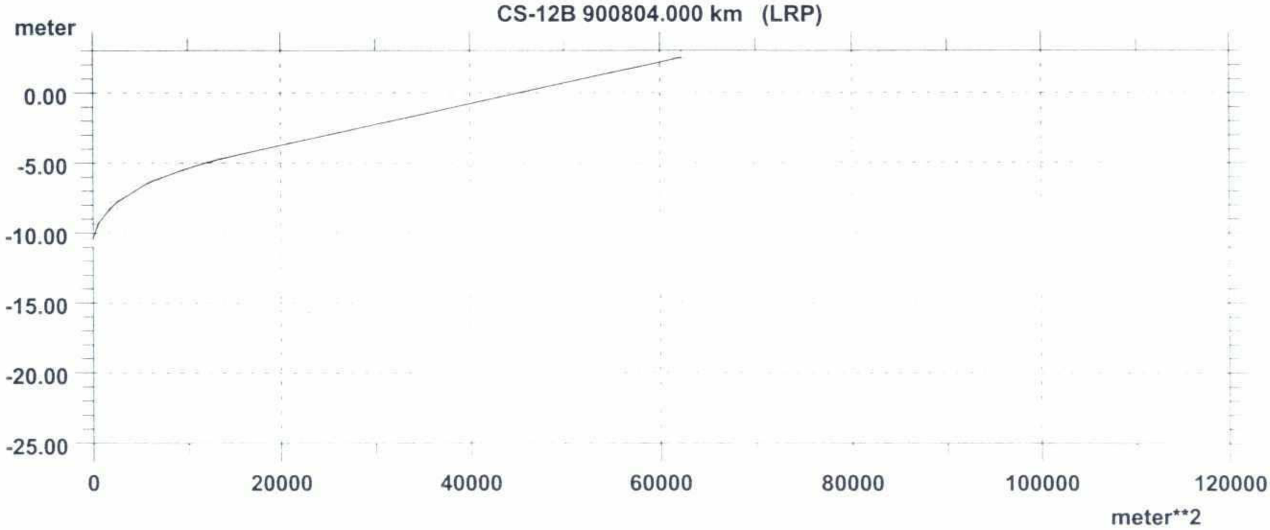
CROSS-SECTIONAL AREA

CS-12B 861214.000 km (LRP)



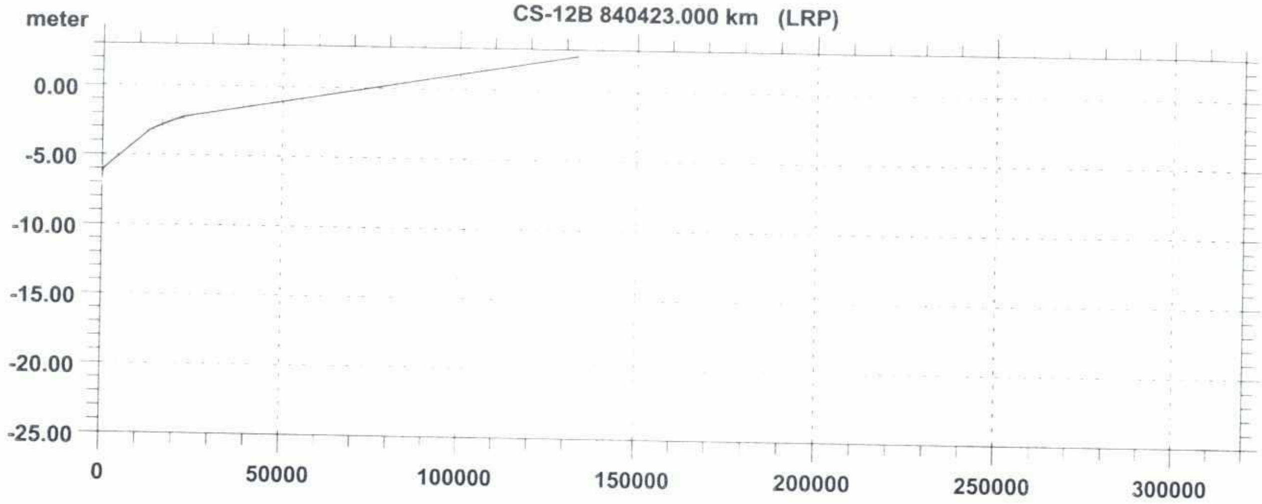
CROSS-SECTIONAL AREA

CS-12B 900804.000 km (LRP)



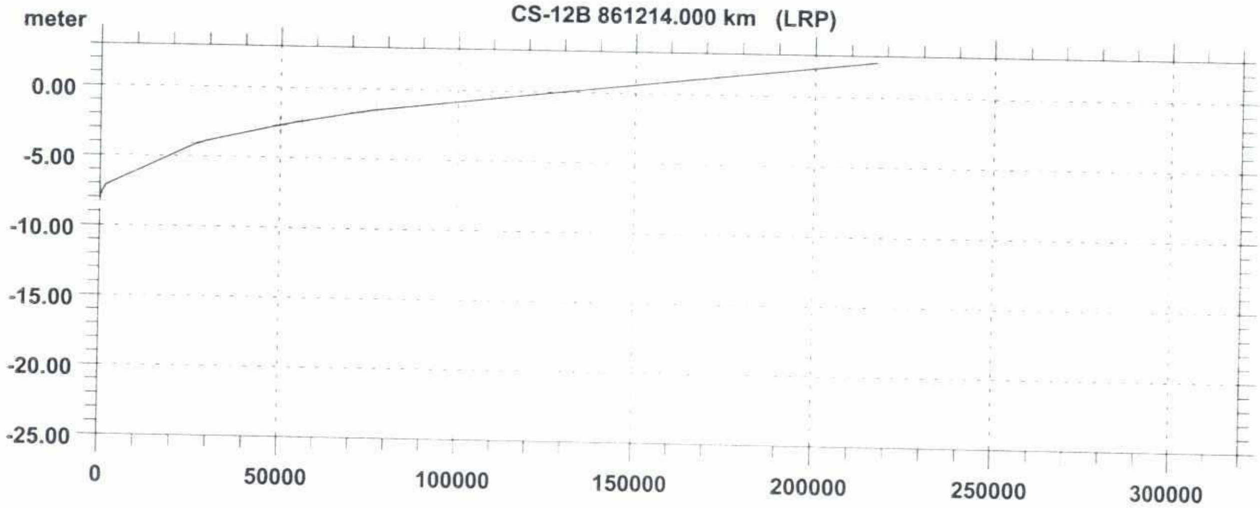
CONVEYANCE

CS-12B 840423.000 km (LRP)



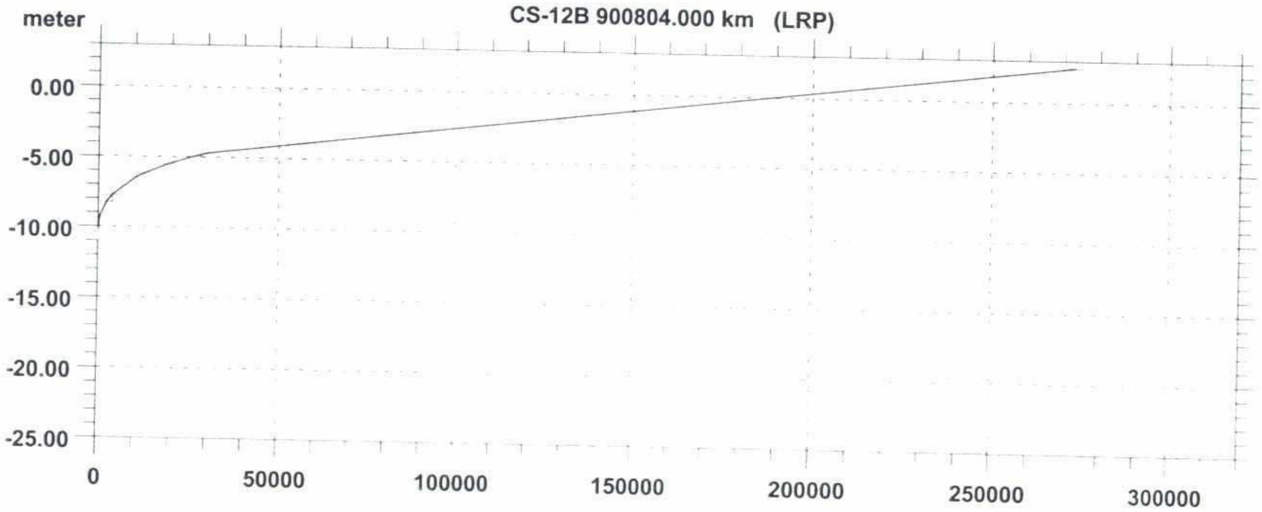
CONVEYANCE

CS-12B 861214.000 km (LRP)



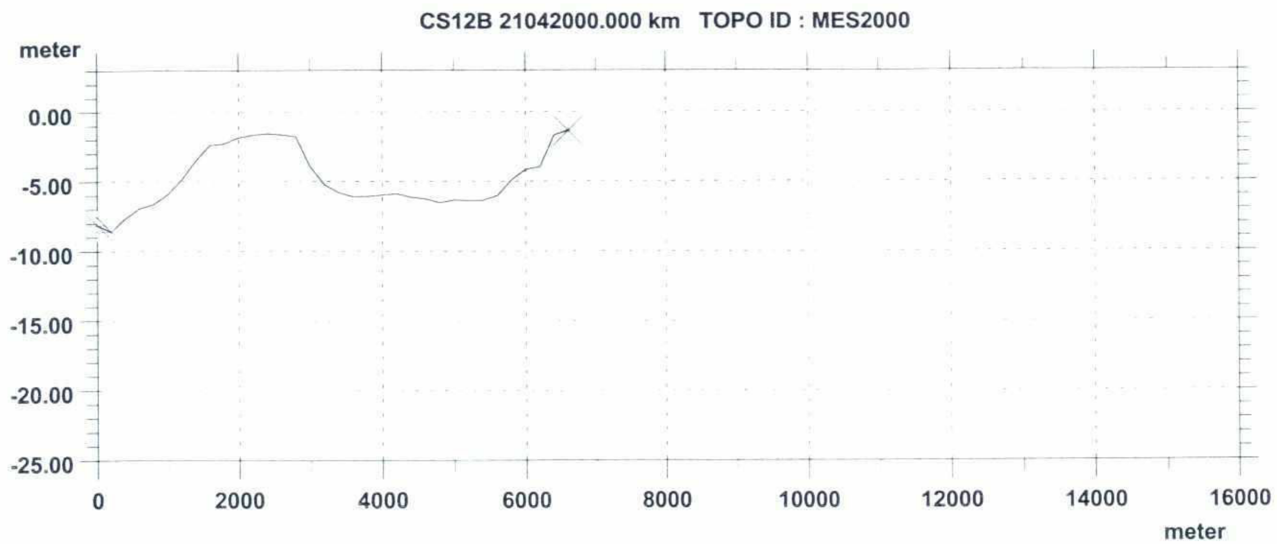
CONVEYANCE

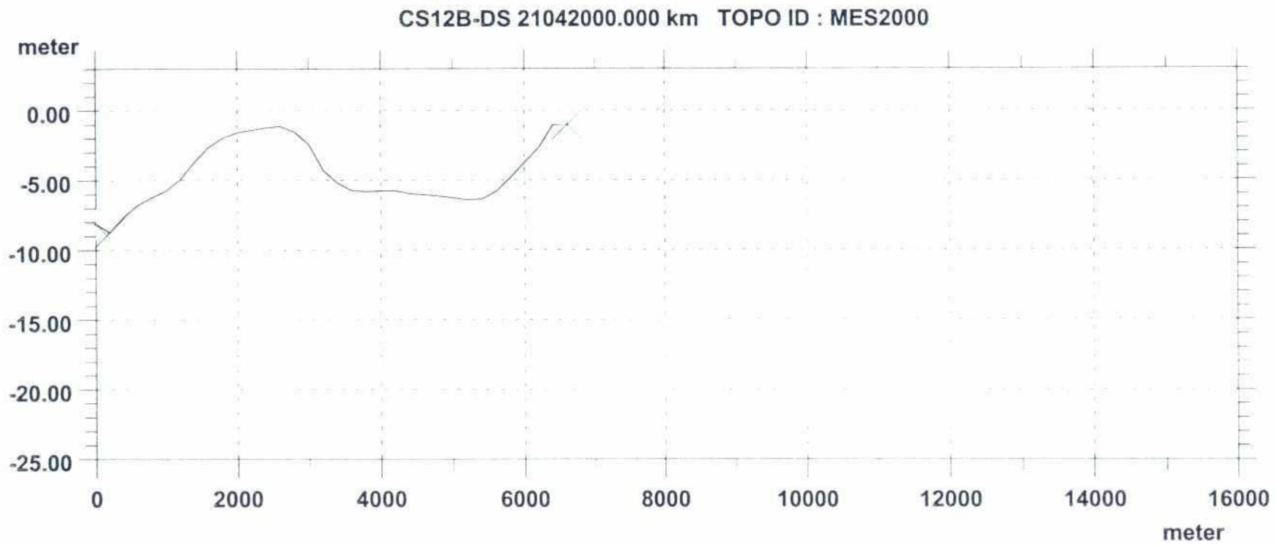
CS-12B 900804.000 km (LRP)

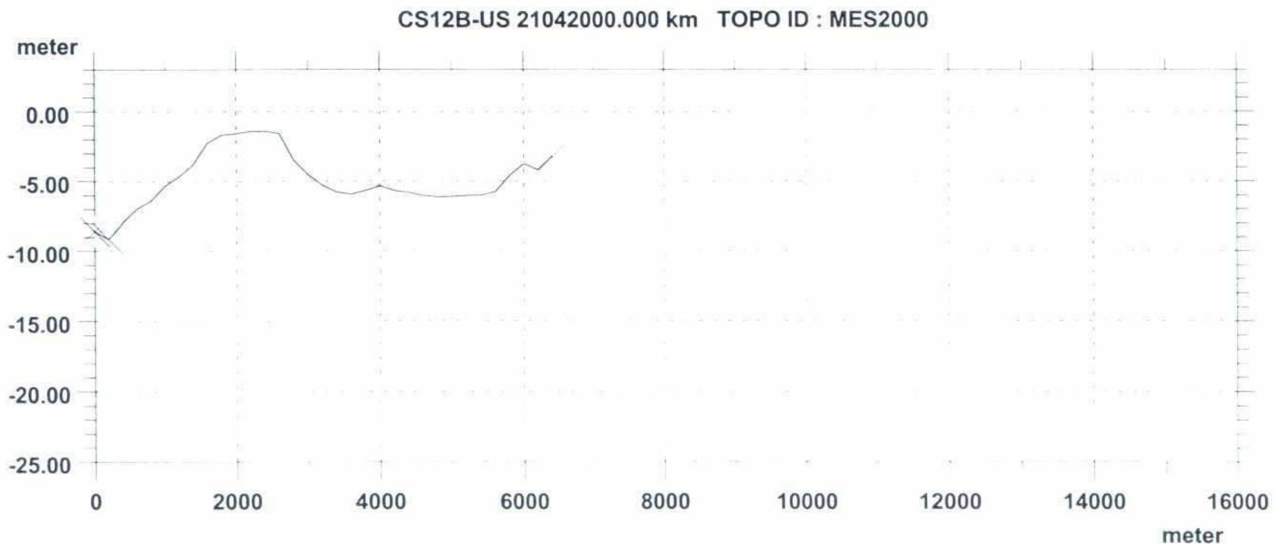


DATA BASE : LRP

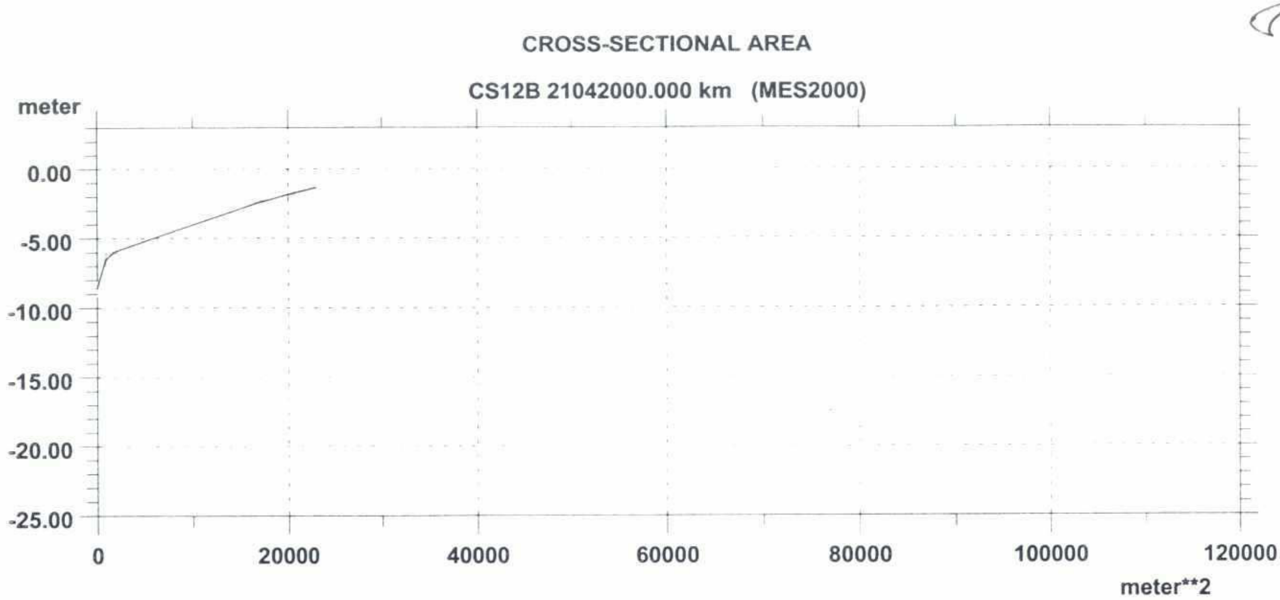
MIKE 11

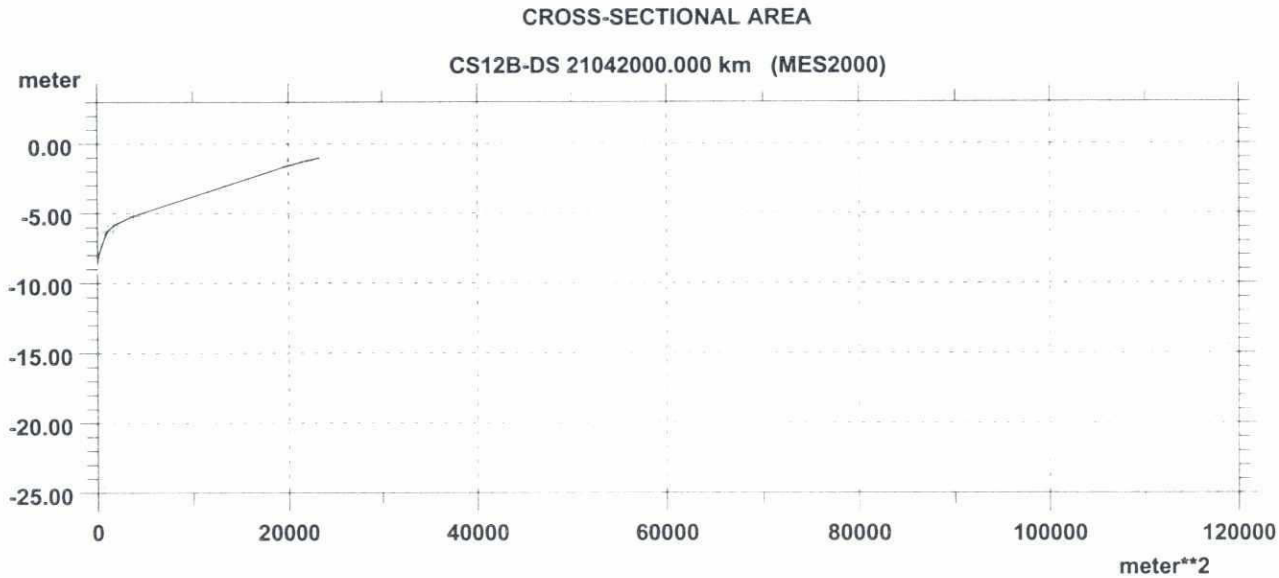


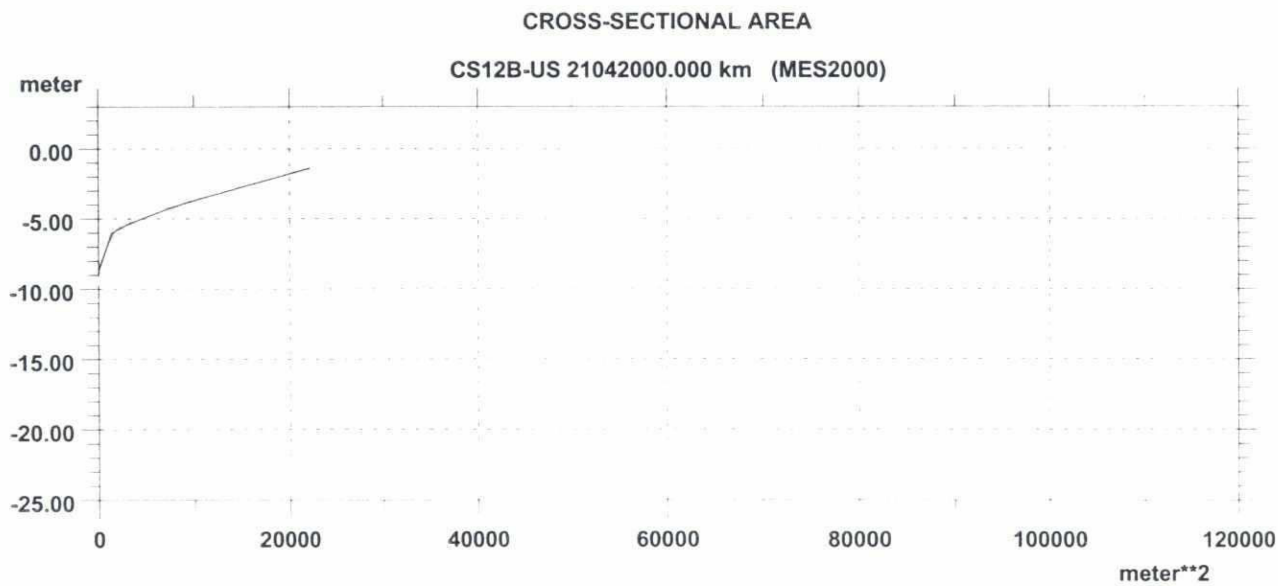




	MIKE 11
DATA BASE : MES2000	41





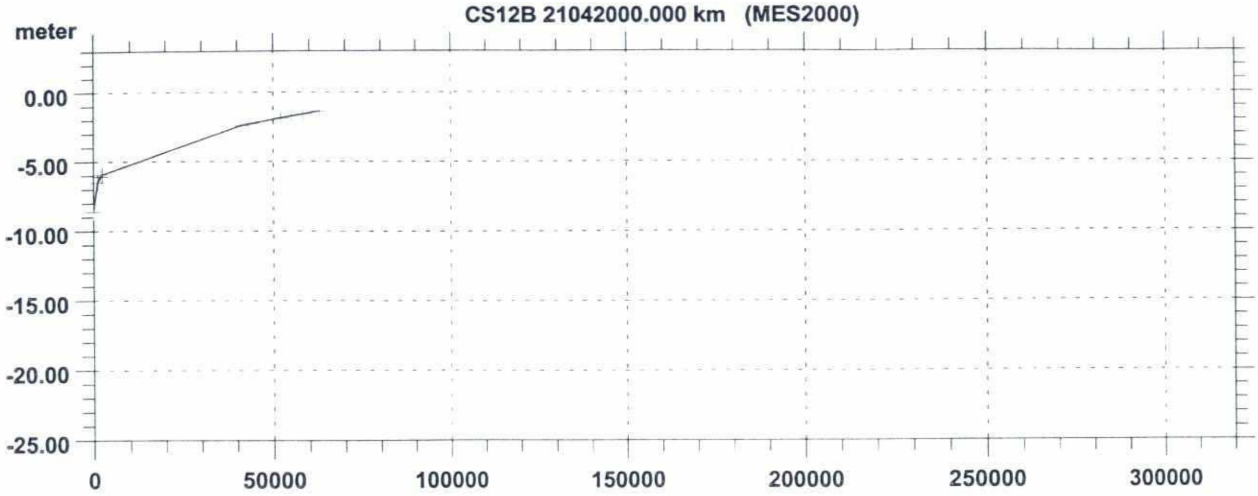


MIKE 11

DATA BASE : MES2000

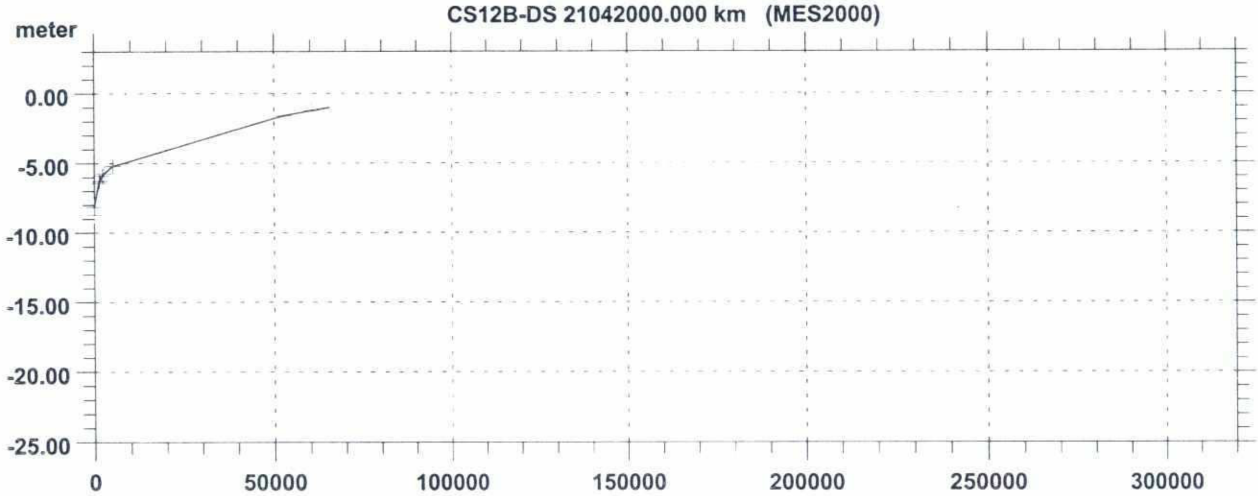
CONVEYANCE

CS12B 21042000.000 km (MES2000)



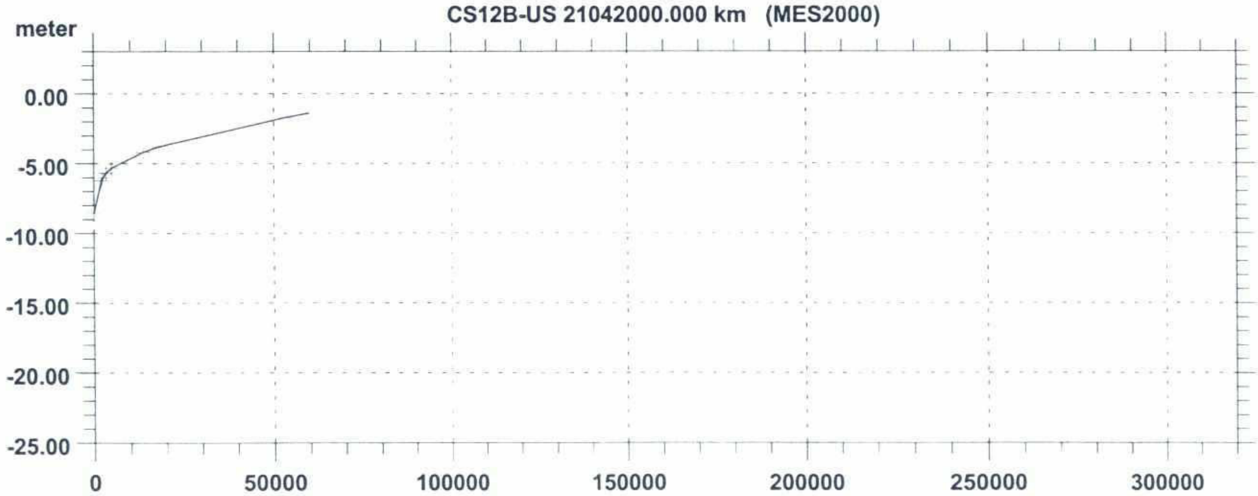
CONVEYANCE

CS12B-DS 21042000.000 km (MES2000)

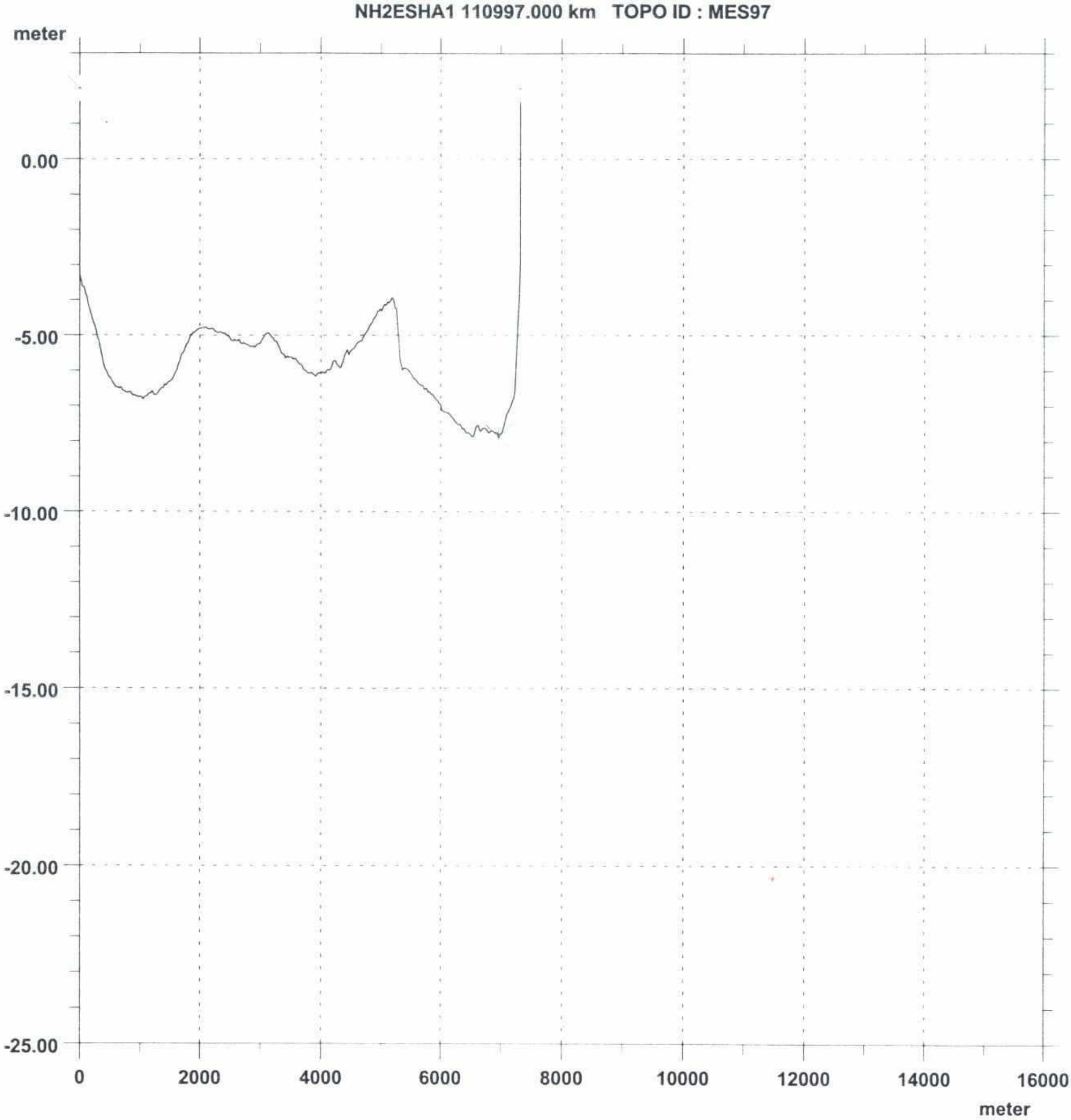


CONVEYANCE

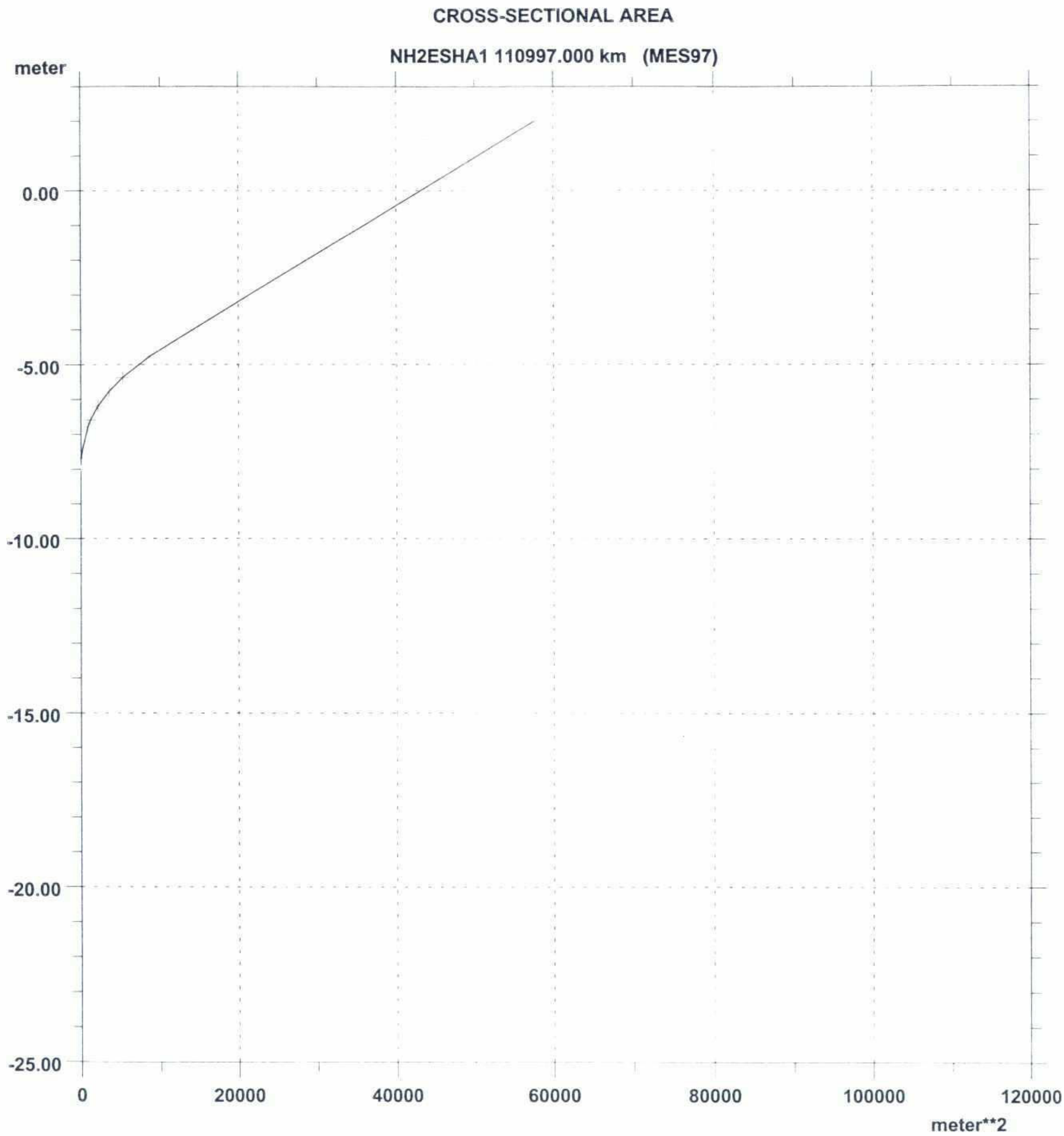
CS12B-US 21042000.000 km (MES2000)



87



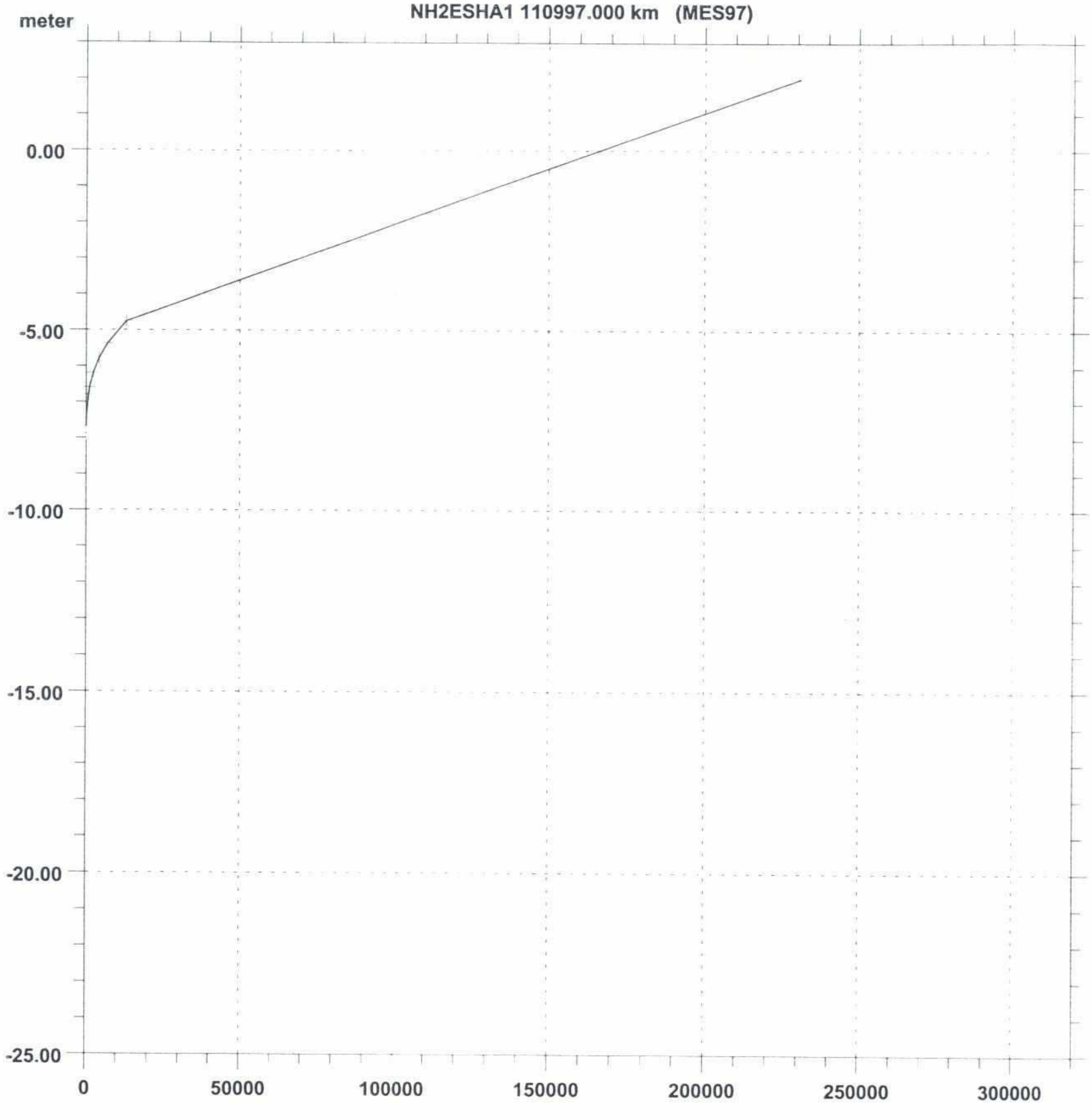
DATA BASE : MES97	MIKE 11 44



DATA BASE : MES97	MIKE 11 45

CONVEYANCE

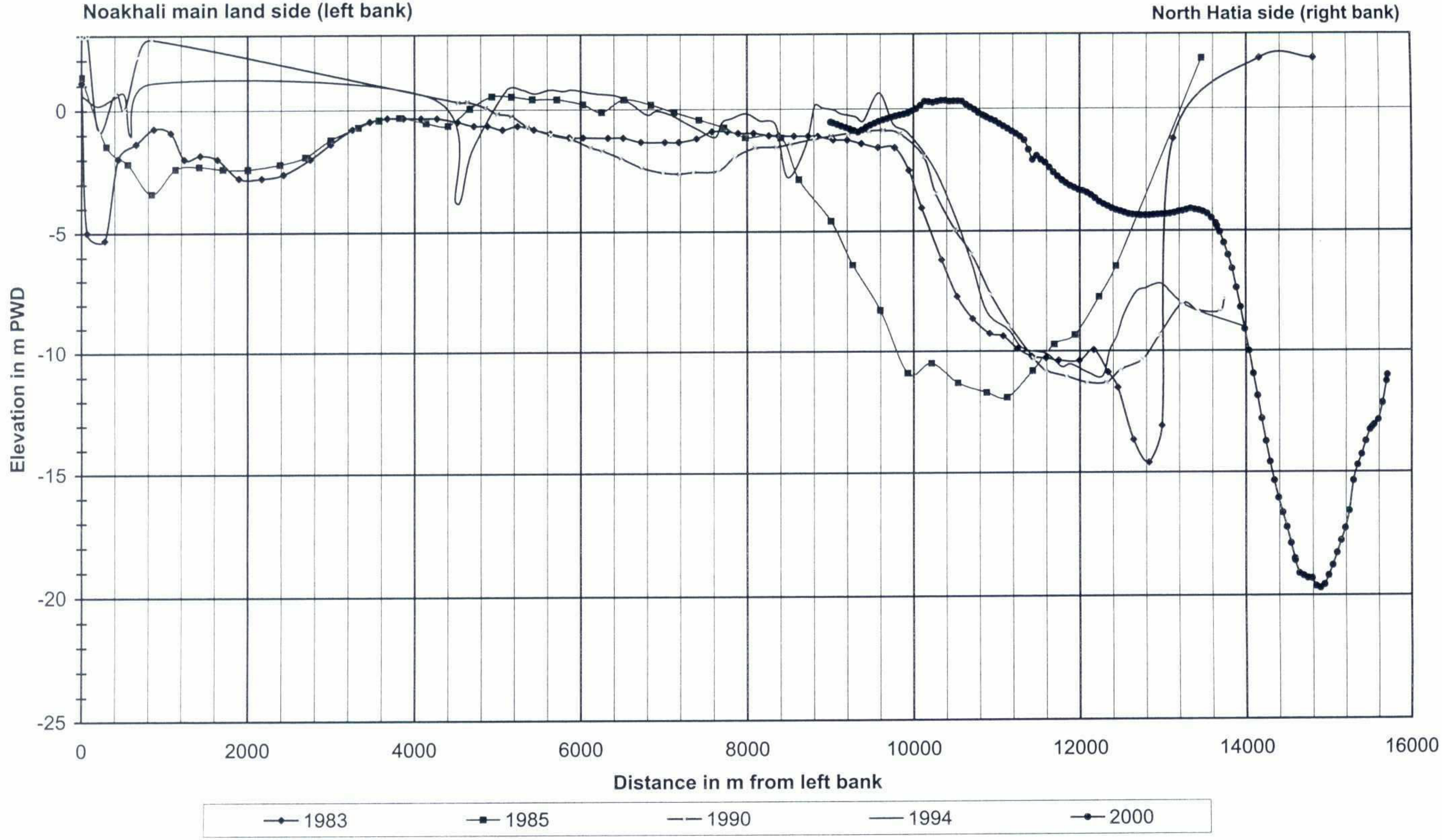
NH2ESHA1 110997.000 km (MES97)



	MIKE 11
DATA BASE : MES97	46

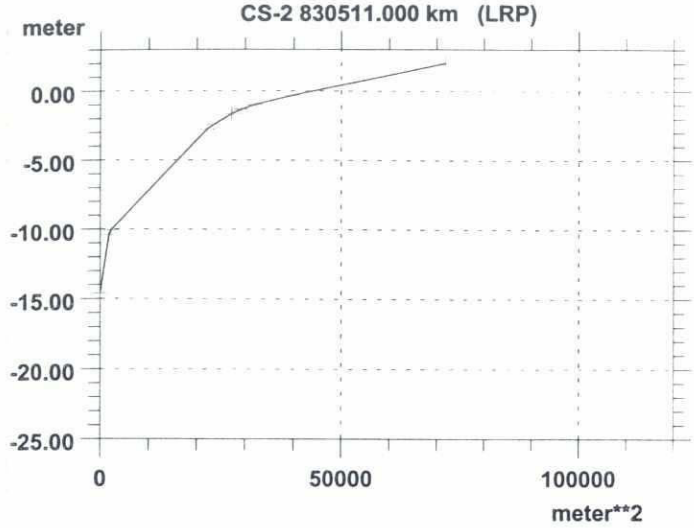
P2

Drawing 47 : Cross-section 2 in the Hatia Channel at North Hatia in Different Years



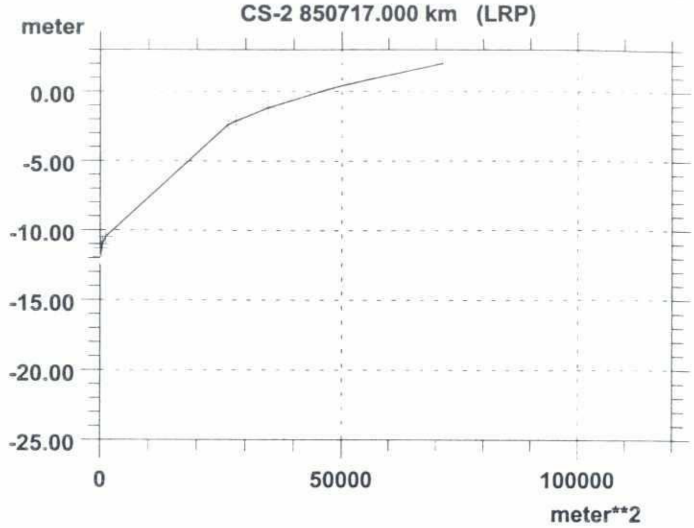
CROSS-SECTIONAL AREA

CS-2 830511.000 km (LRP)



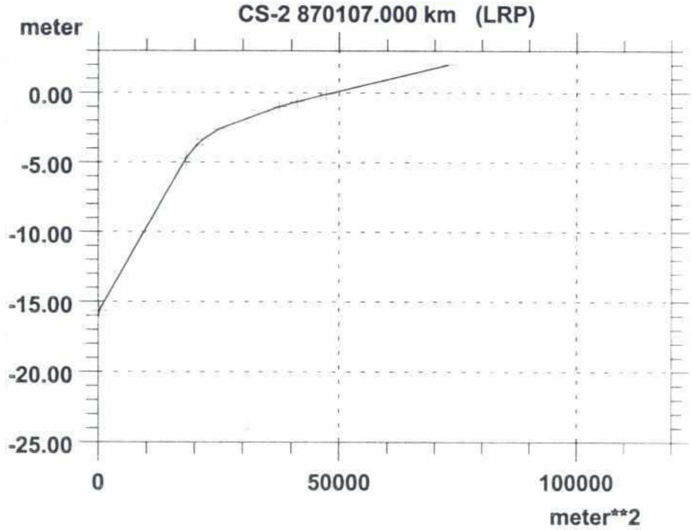
CROSS-SECTIONAL AREA

CS-2 850717.000 km (LRP)



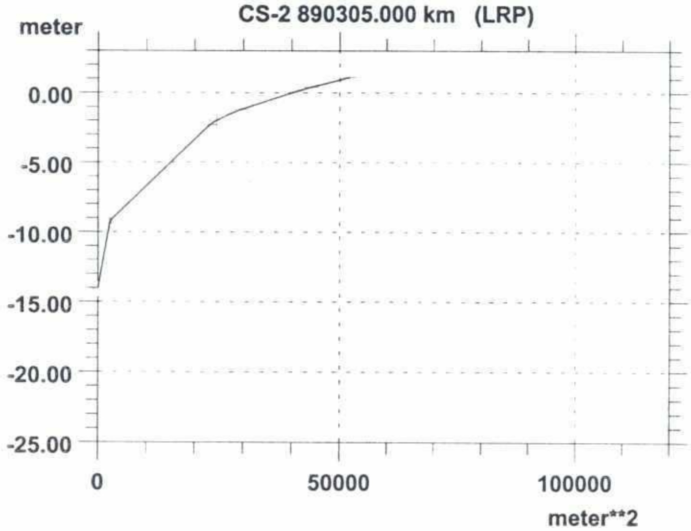
CROSS-SECTIONAL AREA

CS-2 870107.000 km (LRP)



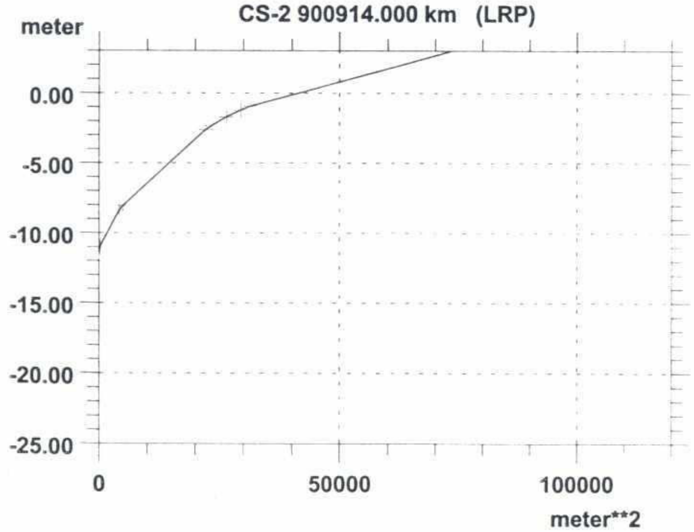
CROSS-SECTIONAL AREA

CS-2 890305.000 km (LRP)



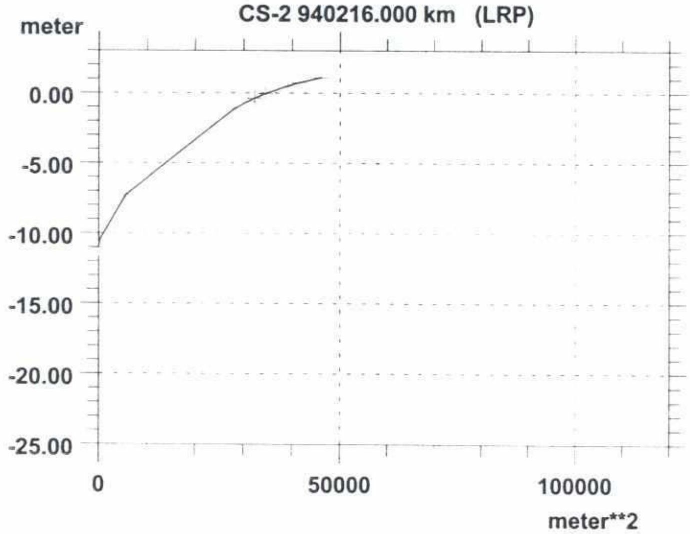
CROSS-SECTIONAL AREA

CS-2 900914.000 km (LRP)



CROSS-SECTIONAL AREA

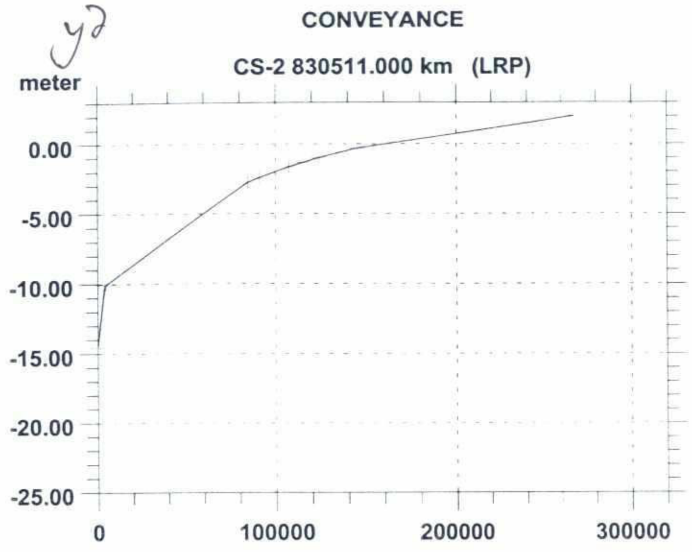
CS-2 940216.000 km (LRP)

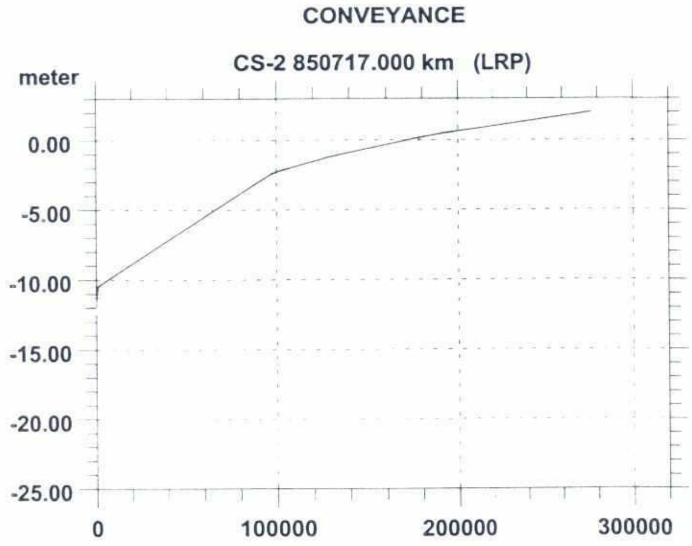


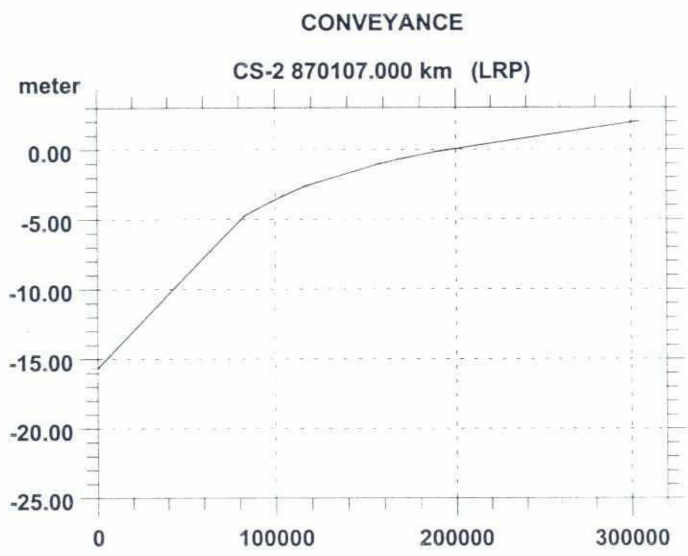
DATA BASE : LRP

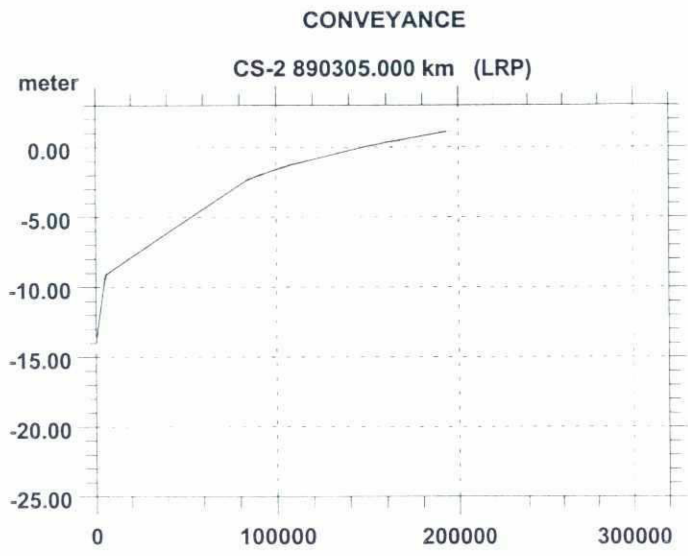
MIKE 11

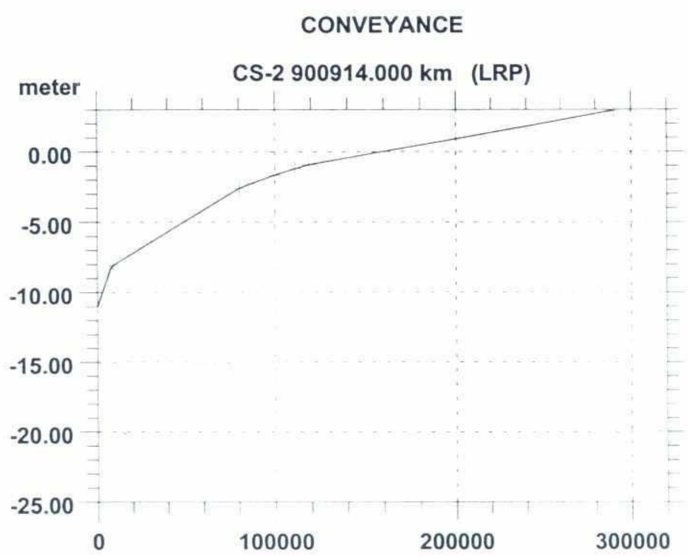
yd

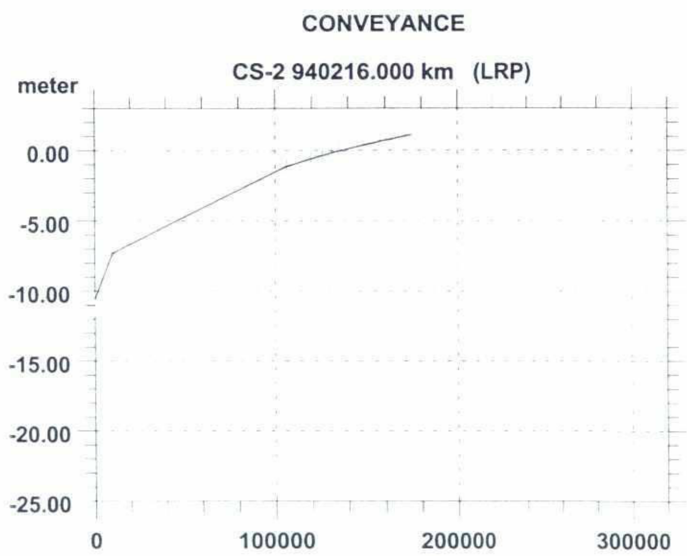

CONVEYANCE
CS-2 830511.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000

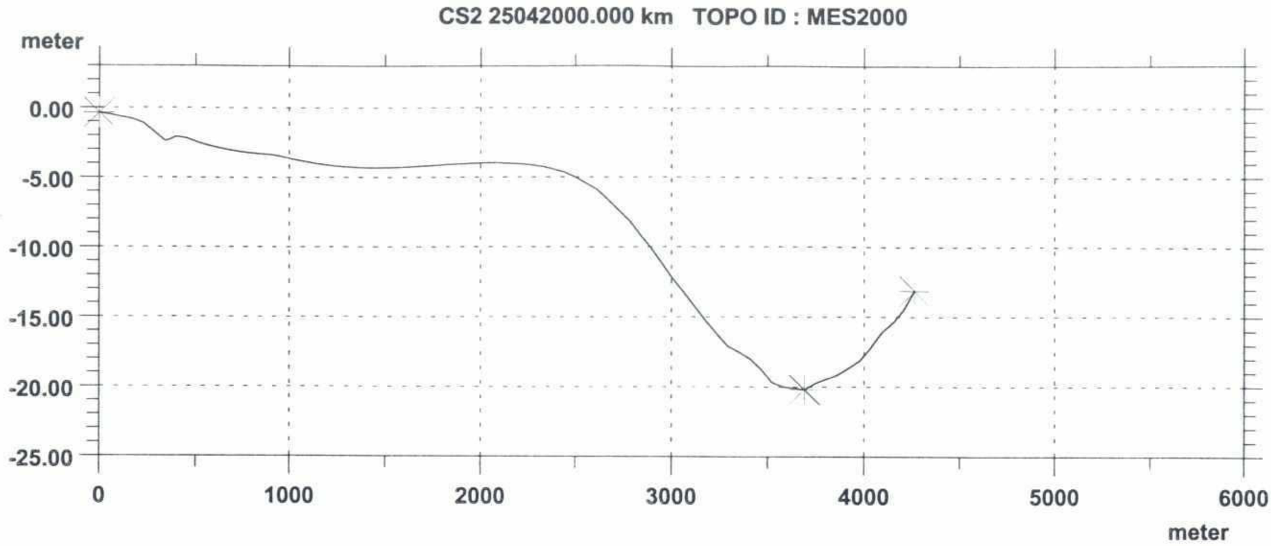

CONVEYANCE
CS-2 850717.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000

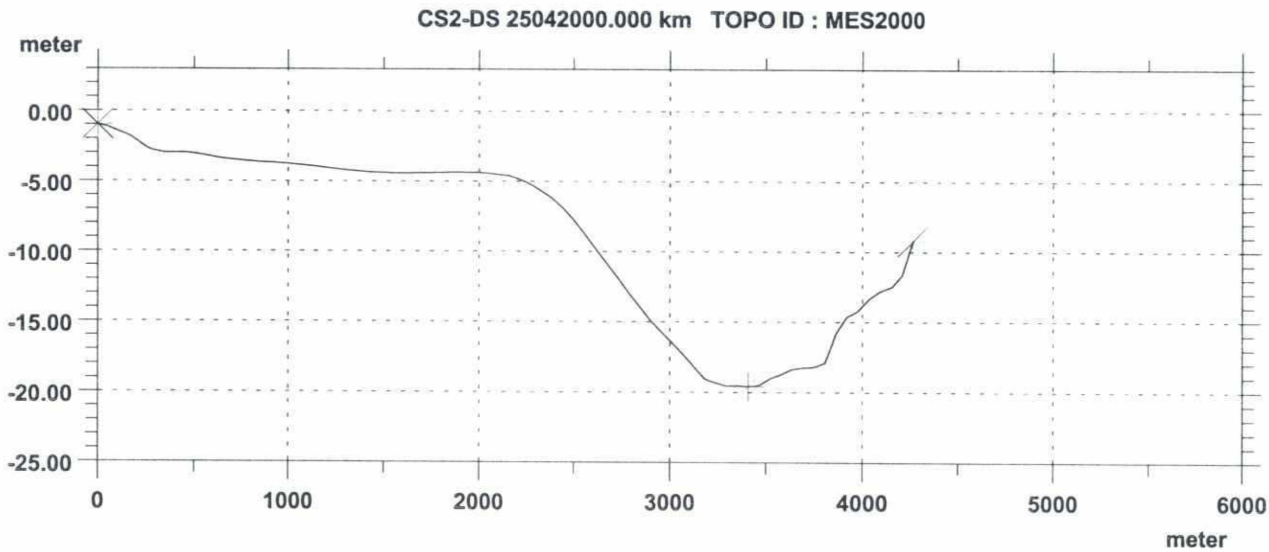

CONVEYANCE
CS-2 870107.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000

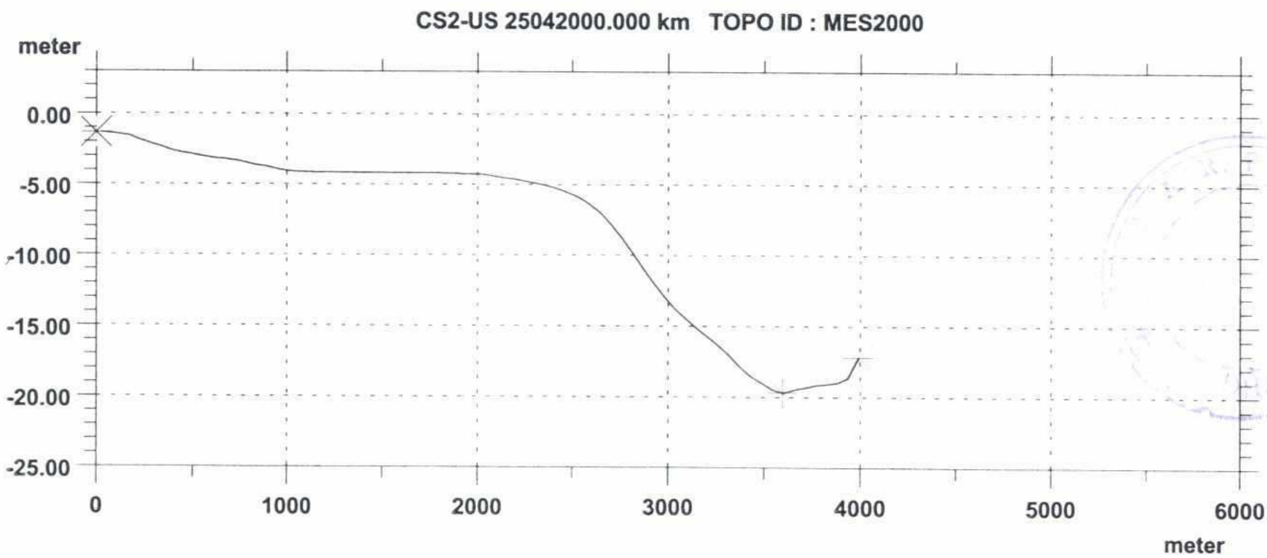

CONVEYANCE
CS-2 890305.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000


CONVEYANCE
CS-2 900914.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000


CONVEYANCE
CS-2 940216.000 km (LRP)
meter
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
0
100000
200000
300000



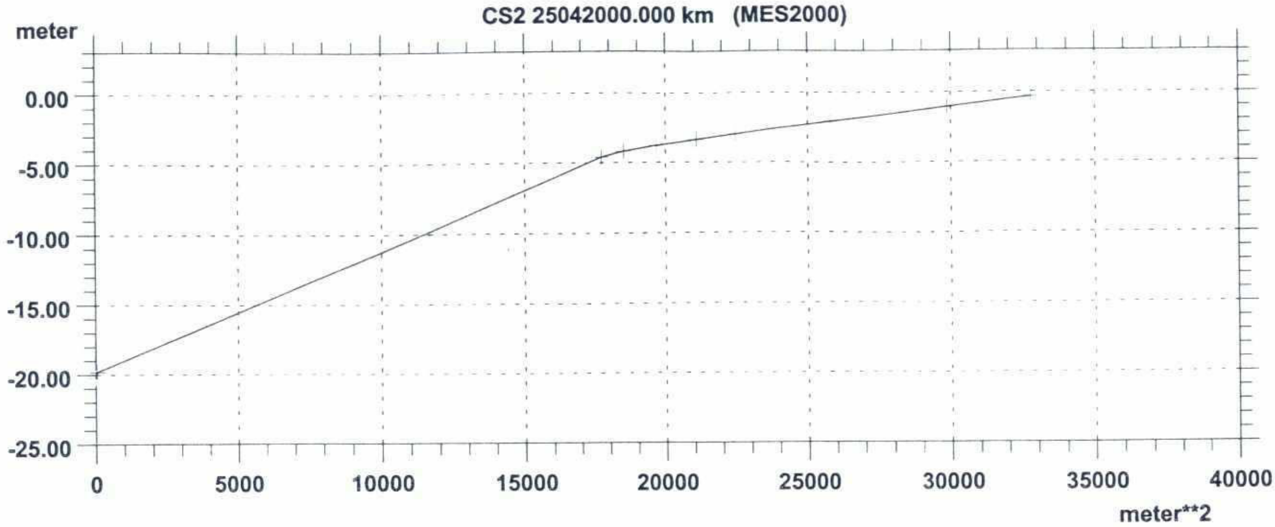




DATA BASE : MES2000	MIKE 11
	Drawing no : 50

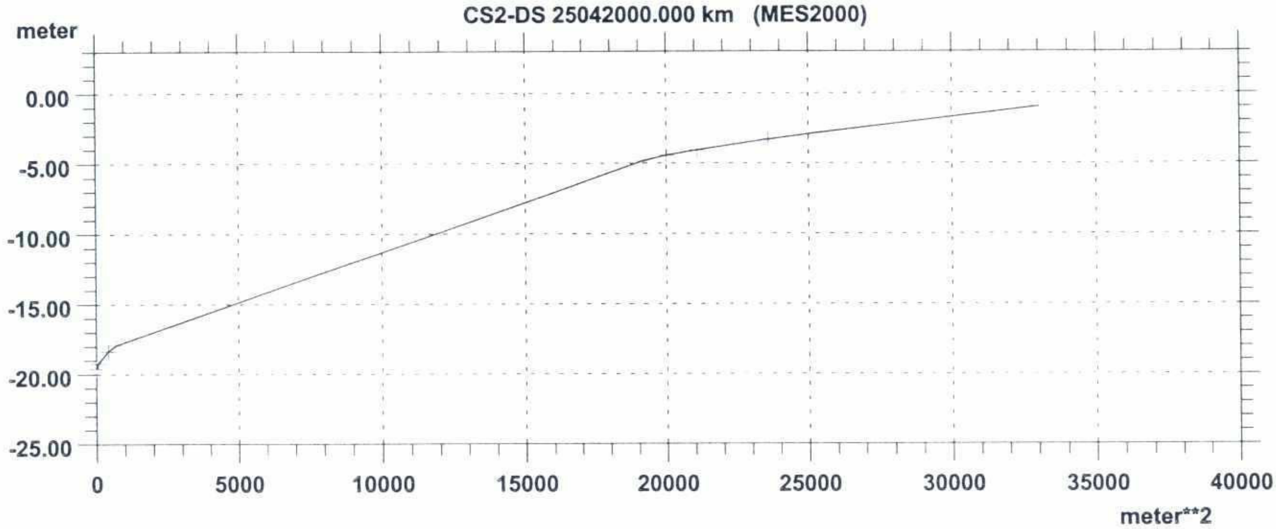
CROSS-SECTIONAL AREA

CS2 25042000.000 km (MES2000)



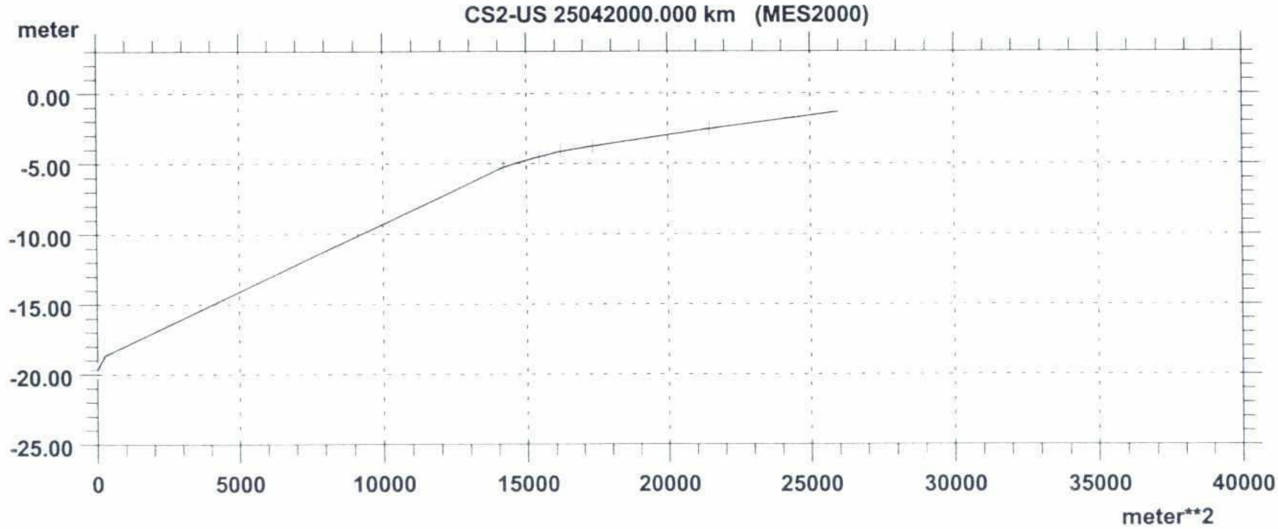
CROSS-SECTIONAL AREA

CS2-DS 25042000.000 km (MES2000)



CROSS-SECTIONAL AREA

CS2-US 25042000.000 km (MES2000)

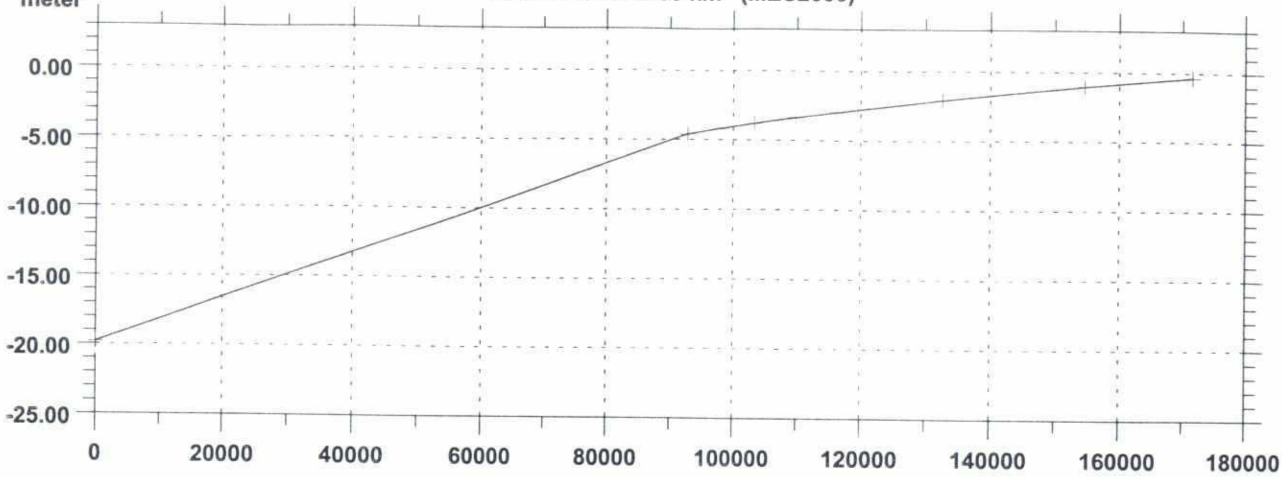


DATA BASE : MES2000	MIKE 11
	Drawing no 51

c8

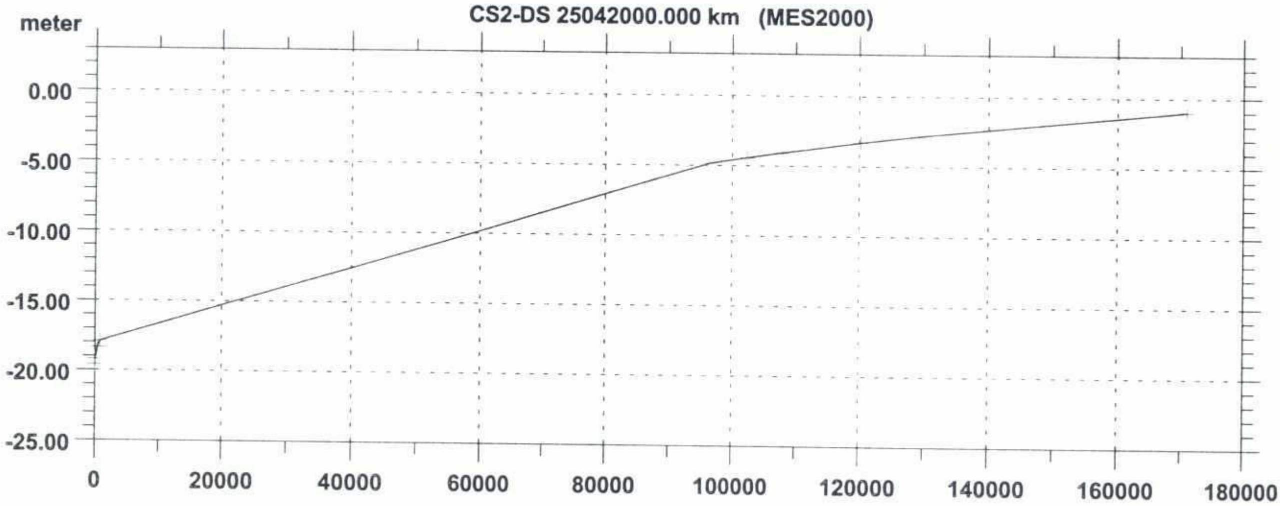
CONVEYANCE

CS2 25042000.000 km (MES2000)



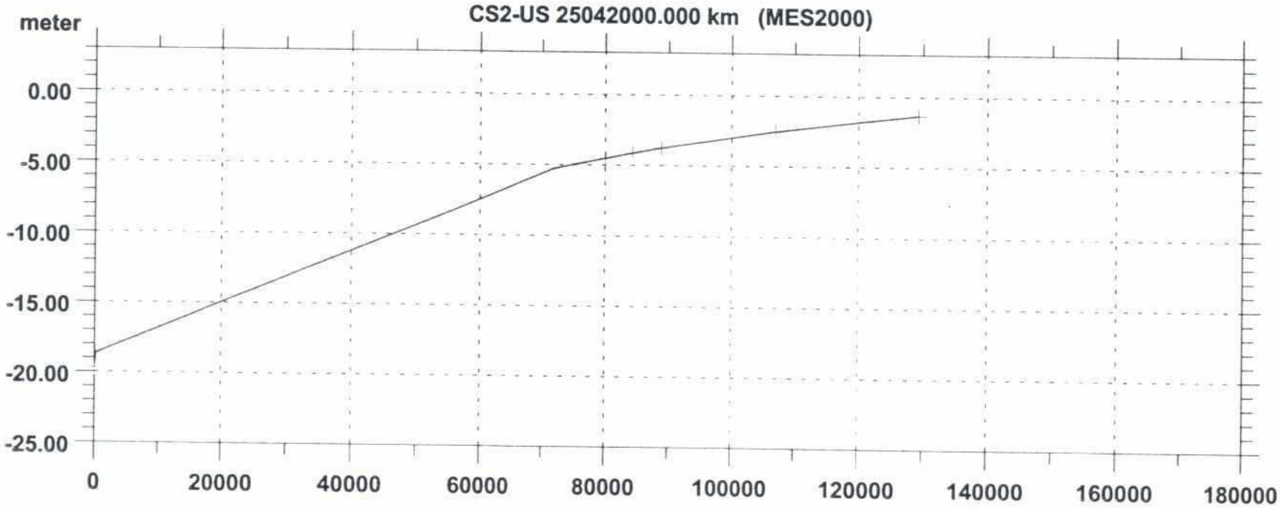
CONVEYANCE

CS2-DS 25042000.000 km (MES2000)

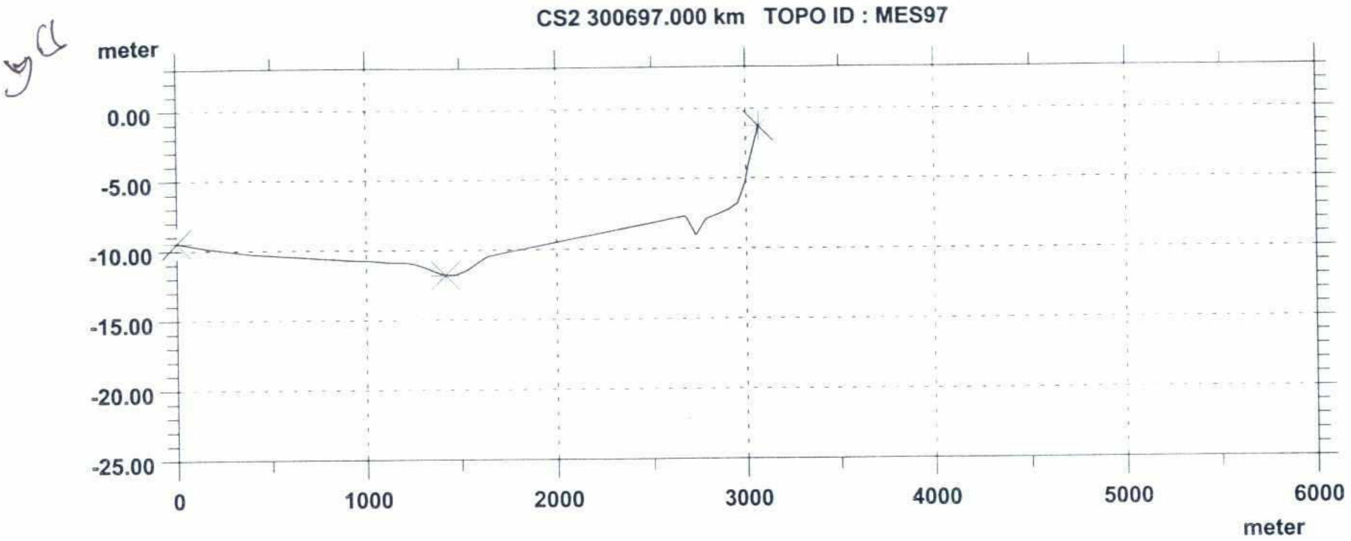


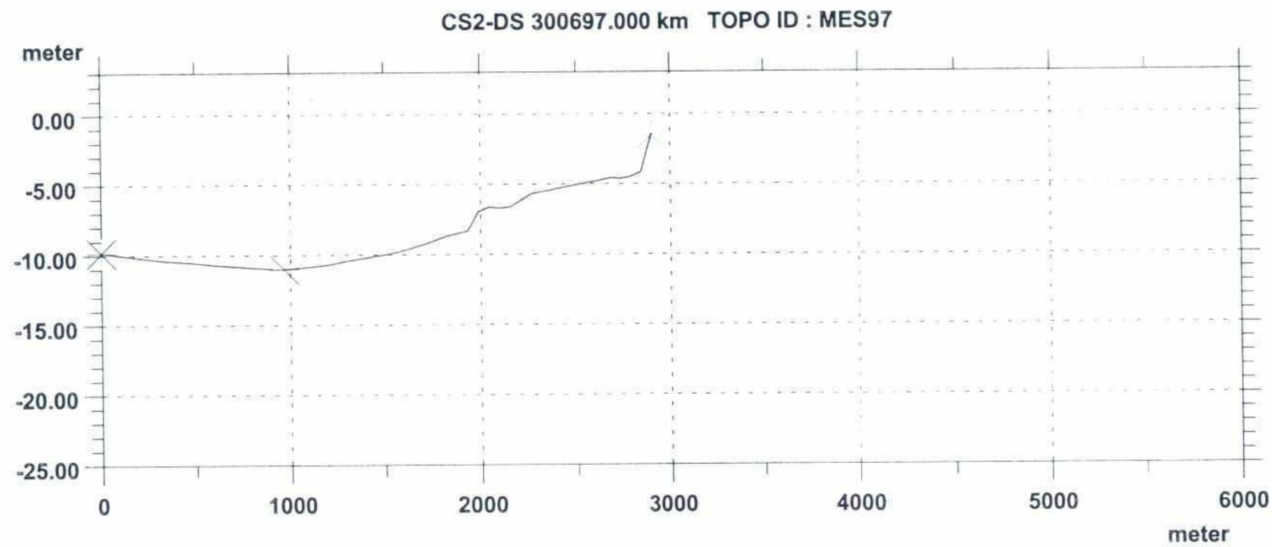
CONVEYANCE

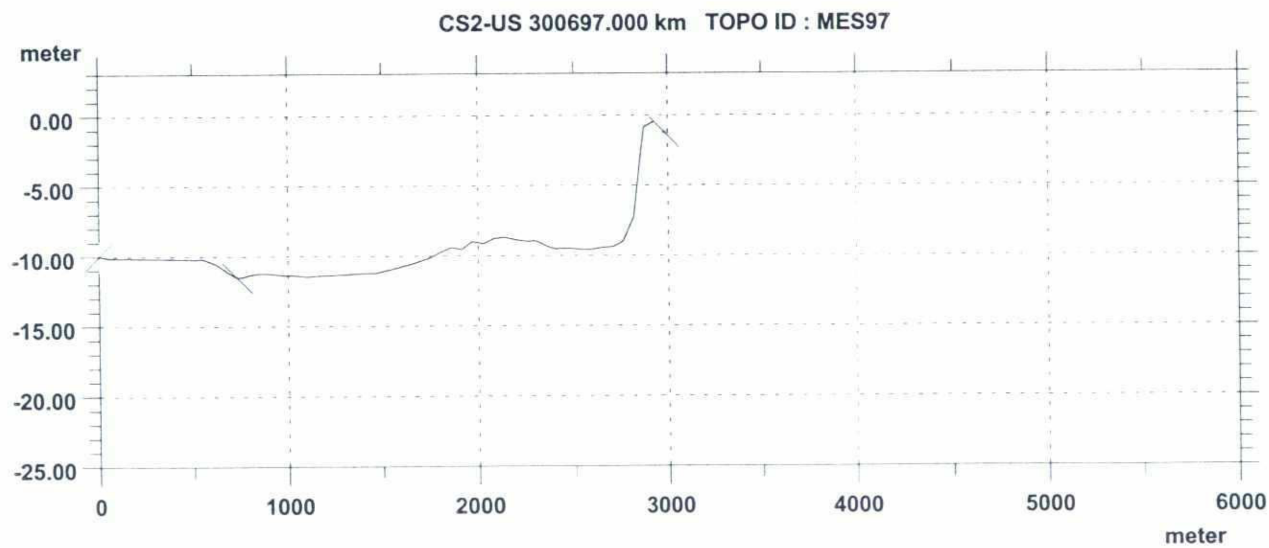
CS2-US 25042000.000 km (MES2000)



DATA BASE : MES2000		MIKE 11 Drawing no 52







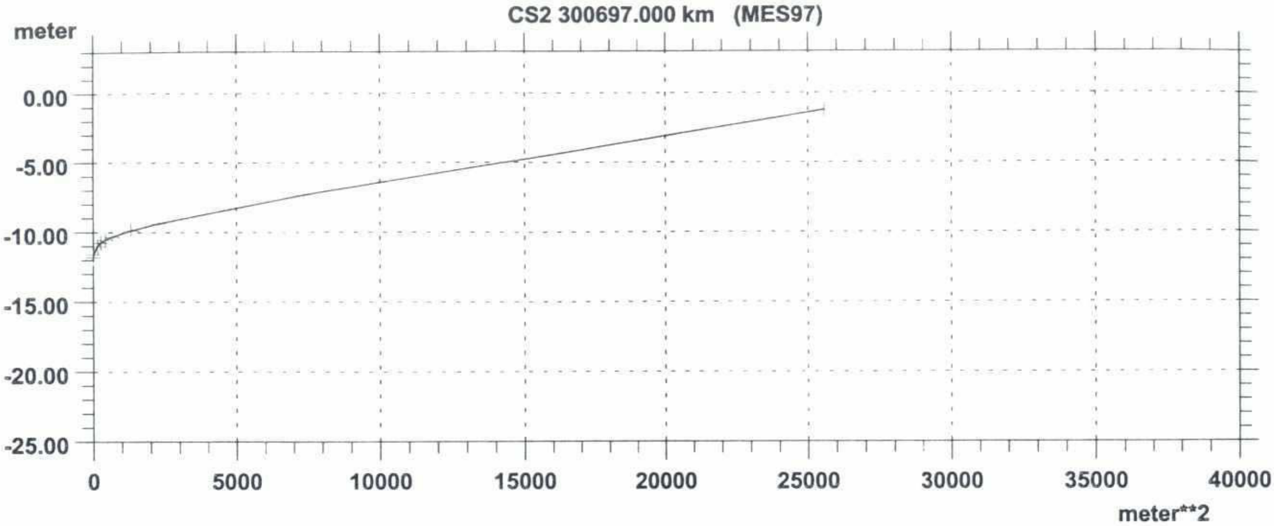
DATA BASE : MES97

MIKE 11

Drawing no 1 53

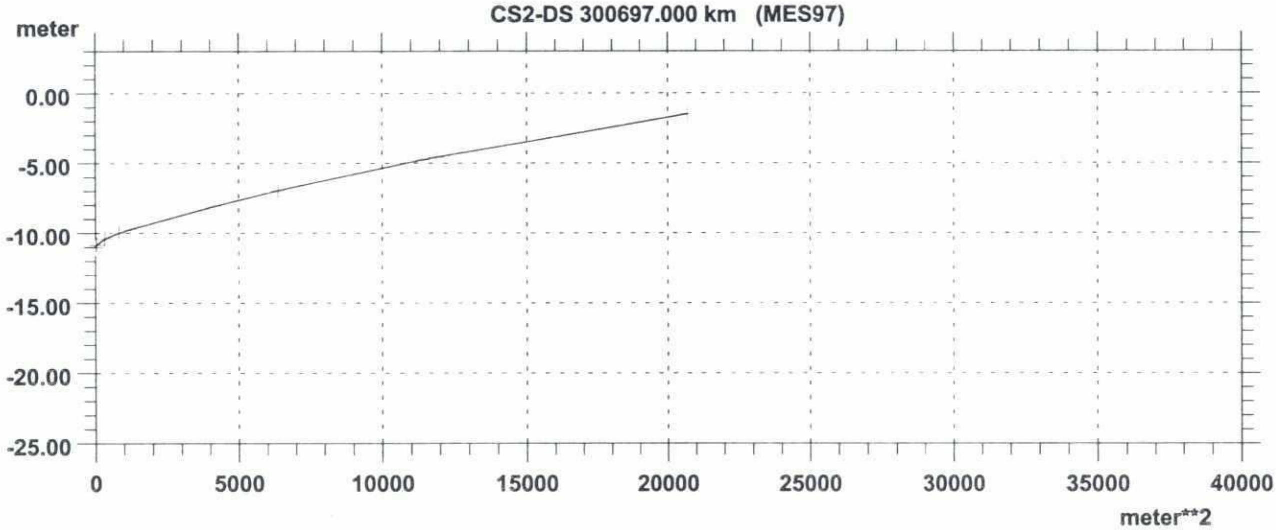
CROSS-SECTIONAL AREA

CS2 300697.000 km (MES97)



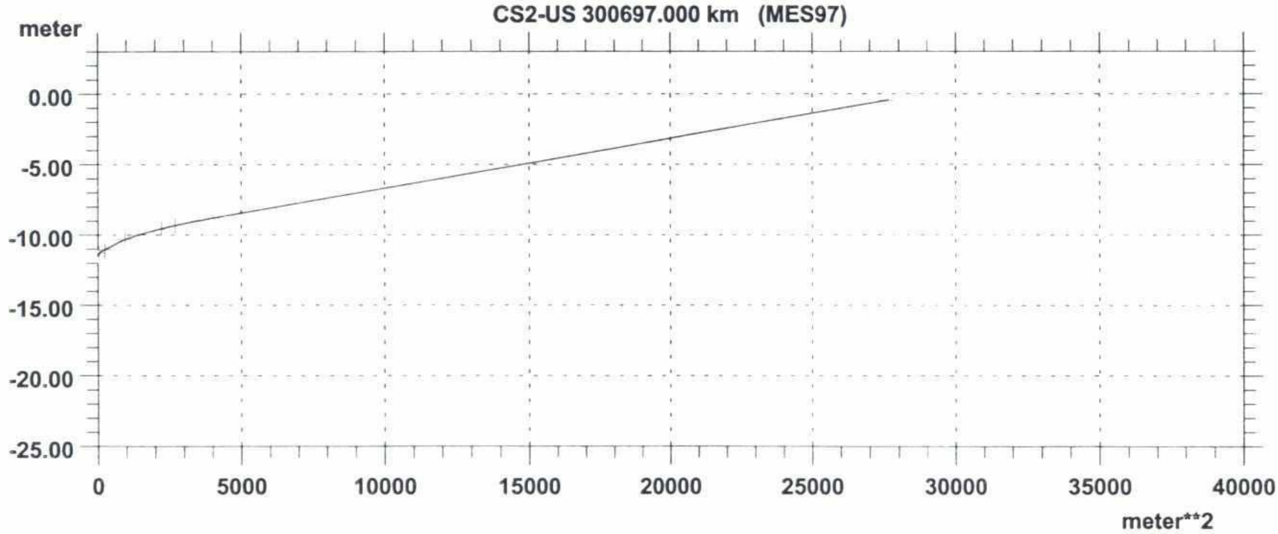
CROSS-SECTIONAL AREA

CS2-DS 300697.000 km (MES97)



CROSS-SECTIONAL AREA

CS2-US 300697.000 km (MES97)

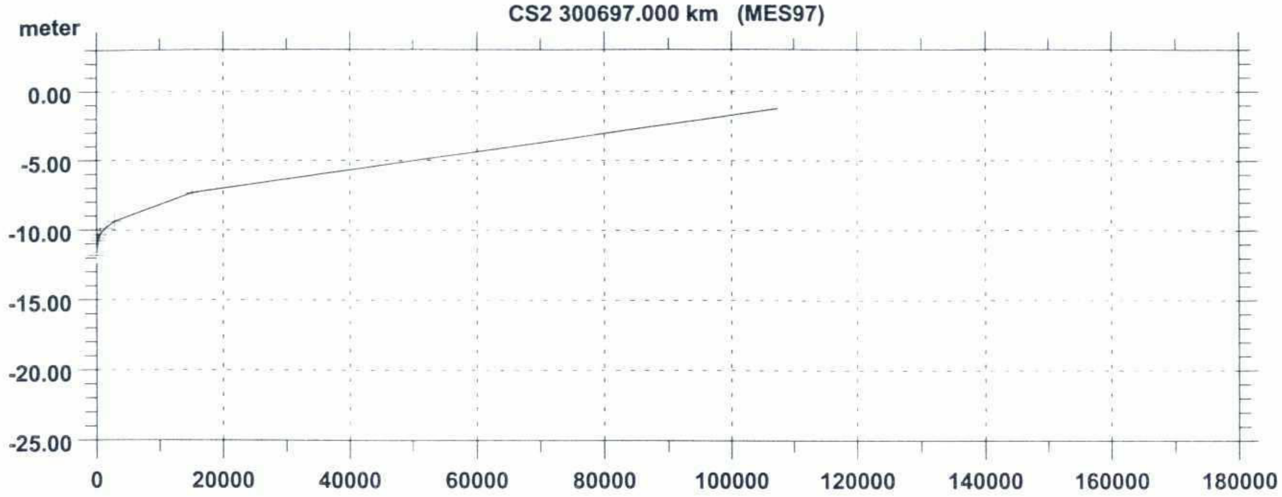


DATA BASE : MES97	MIKE 11
	Drawing no : 57

99

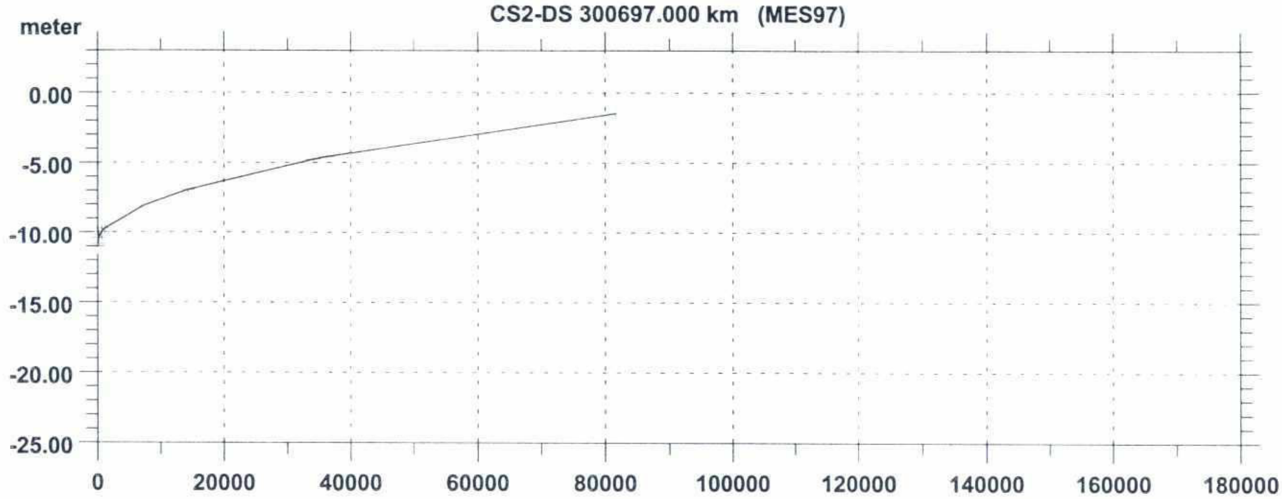
CONVEYANCE

CS2 300697.000 km (MES97)



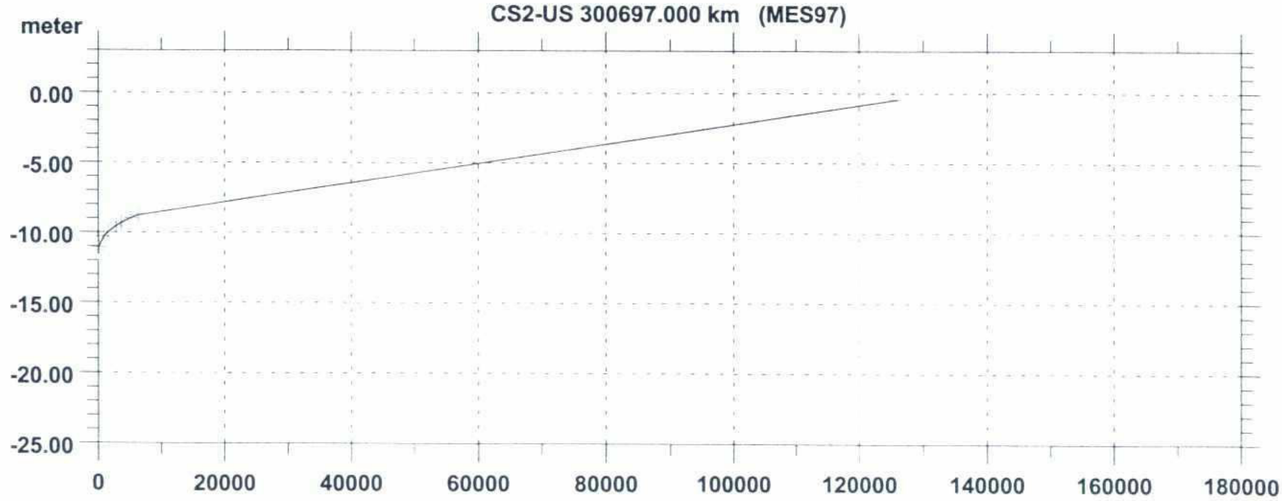
CONVEYANCE

CS2-DS 300697.000 km (MES97)



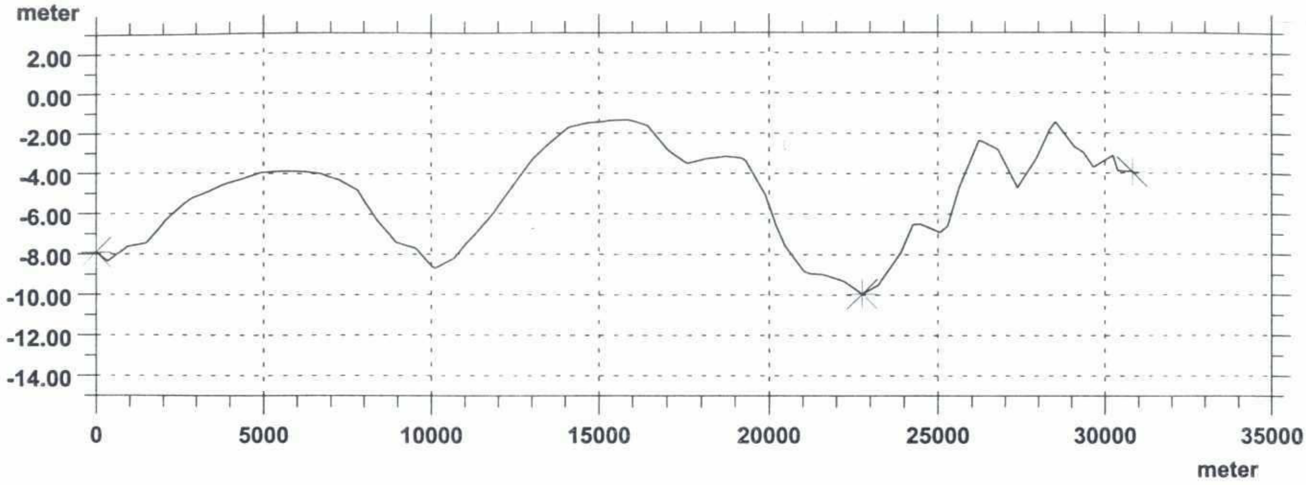
CONVEYANCE

CS2-US 300697.000 km (MES97)

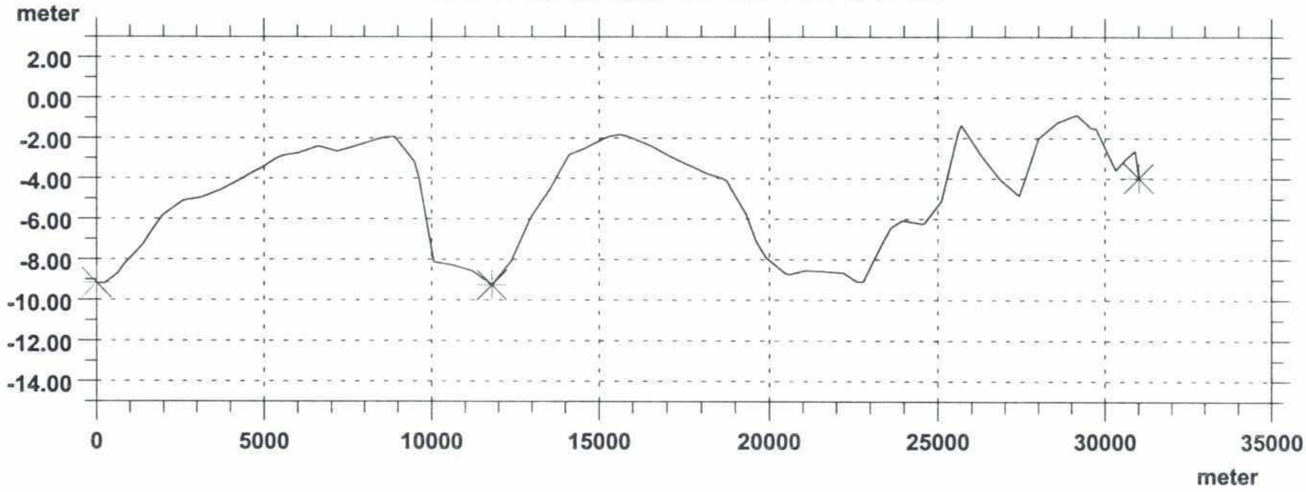


DATA BASE : MES97	MIKE 11
	Drawing no I 55

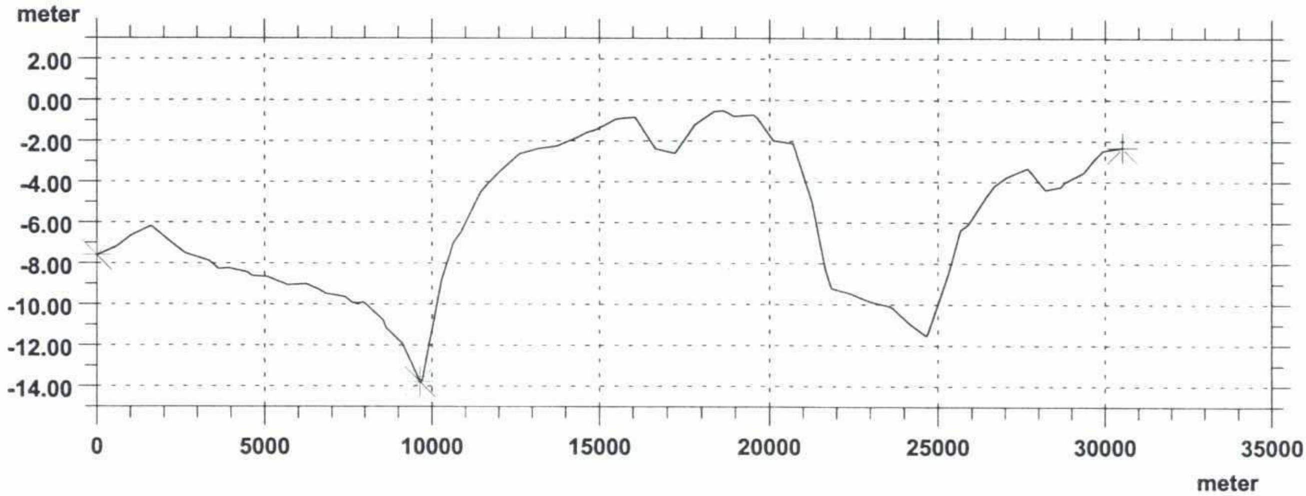
CS13 251299.000 km   TOPO ID : MES2000



CS13-DS 25012000.000 km   TOPO ID : MES2000



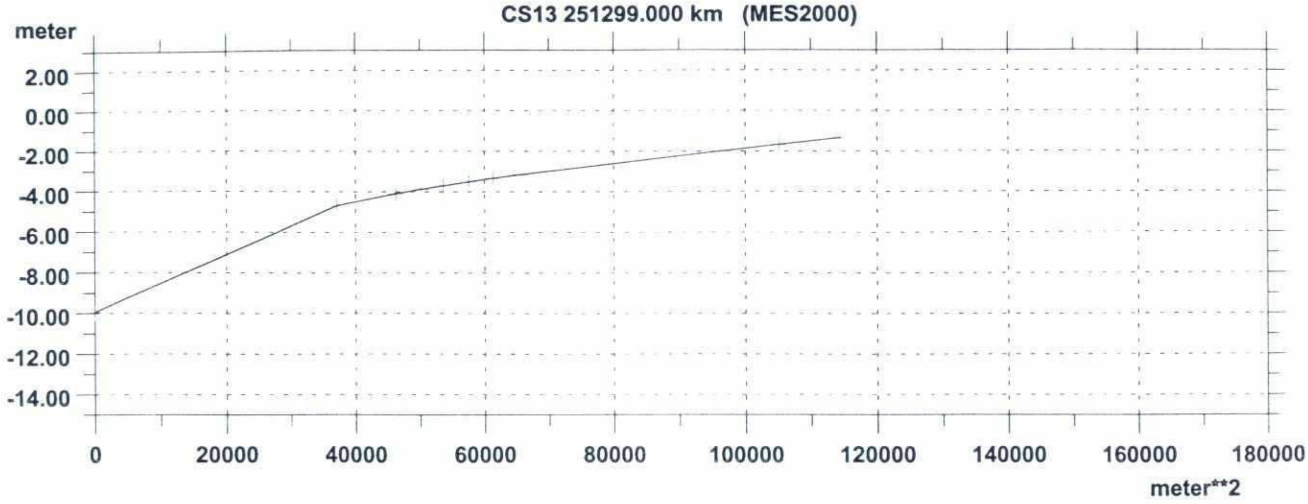
CS13-US 251299.000 km   TOPO ID : MES2000



DATA BASE : MES2000	MIKE 11
	Drawing no # 56

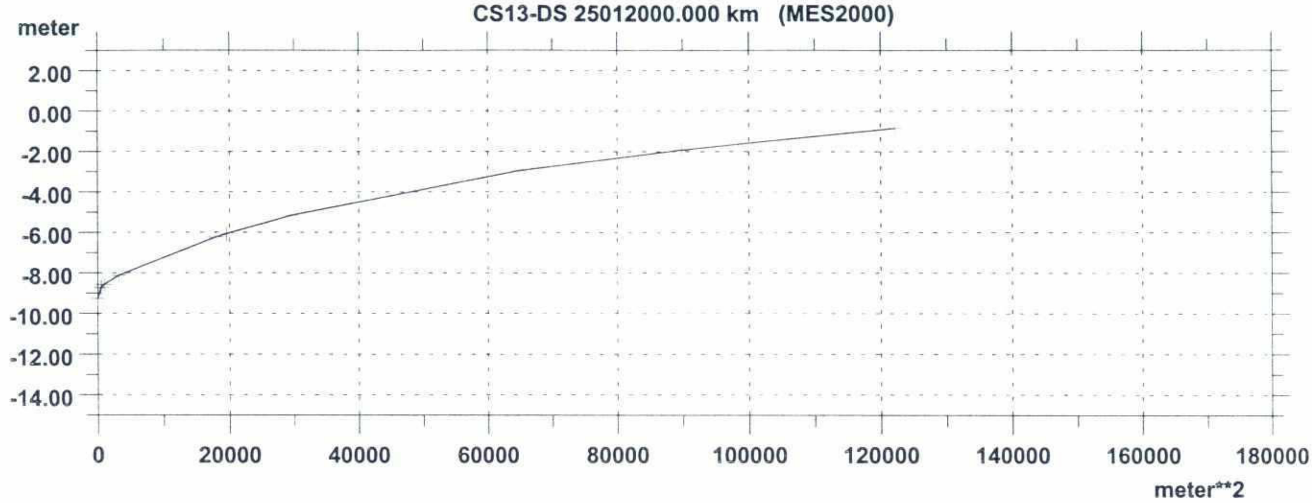
CROSS-SECTIONAL AREA

CS13 251299.000 km (MES2000)



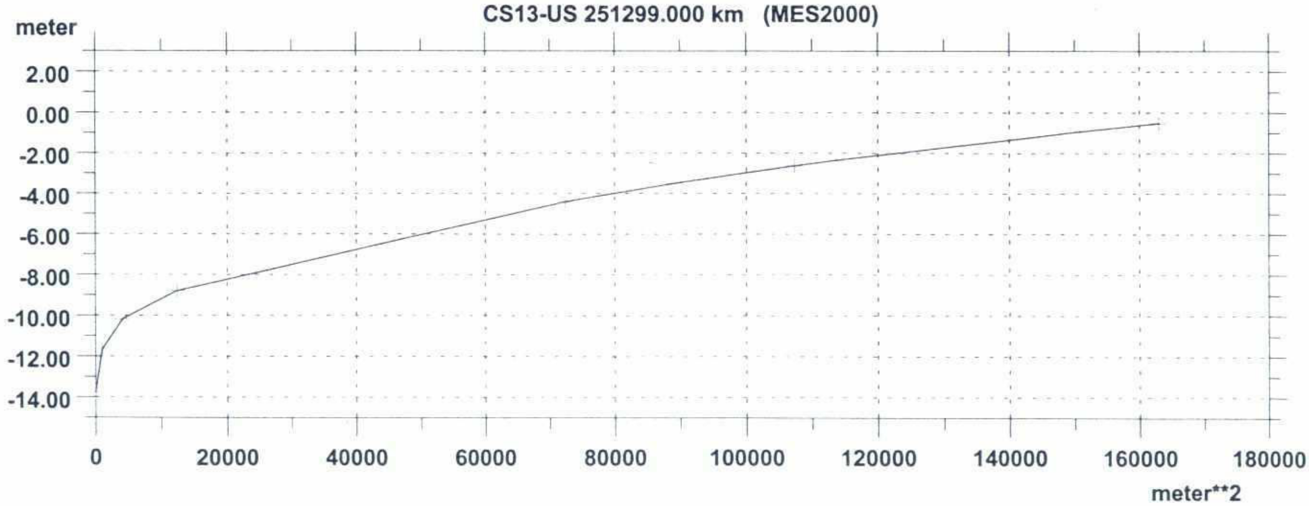
CROSS-SECTIONAL AREA

CS13-DS 25012000.000 km (MES2000)



CROSS-SECTIONAL AREA

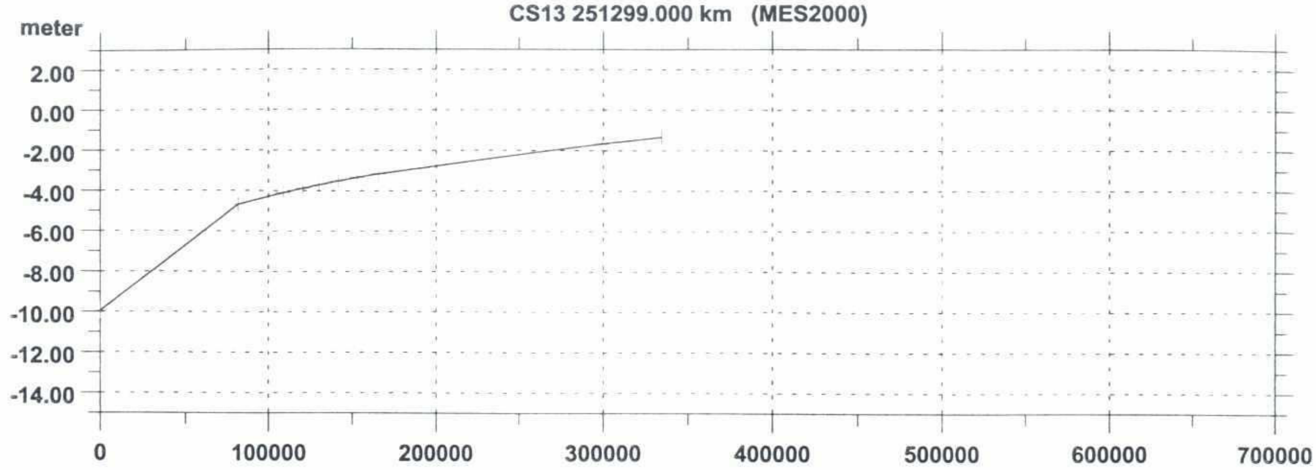
CS13-US 251299.000 km (MES2000)



DATA BASE : MES2000	MIKE 11
	Drawing no 157

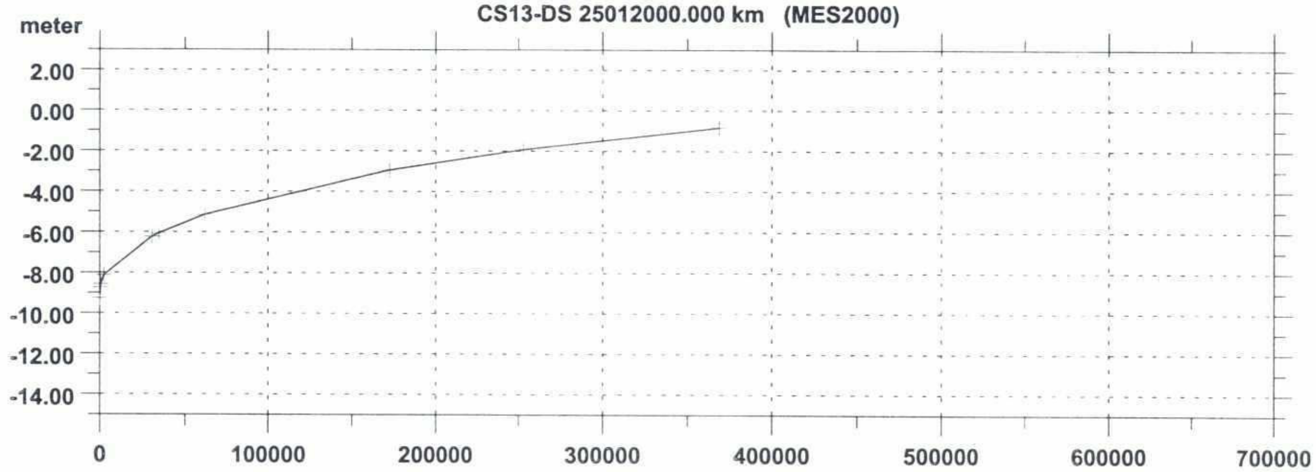
CONVEYANCE

CS13 251299.000 km (MES2000)



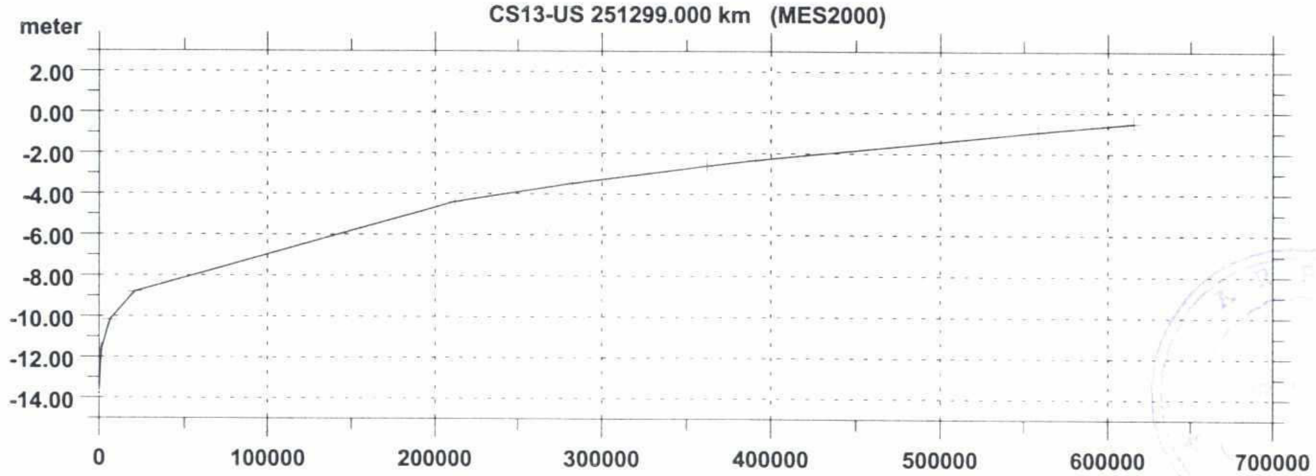
CONVEYANCE

CS13-DS 25012000.000 km (MES2000)



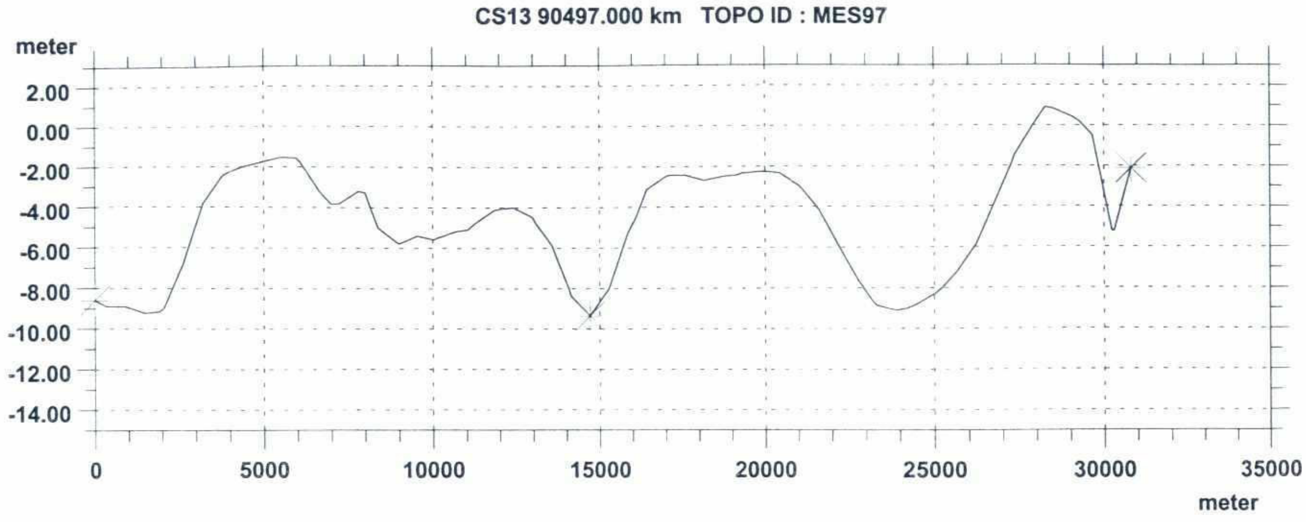
CONVEYANCE

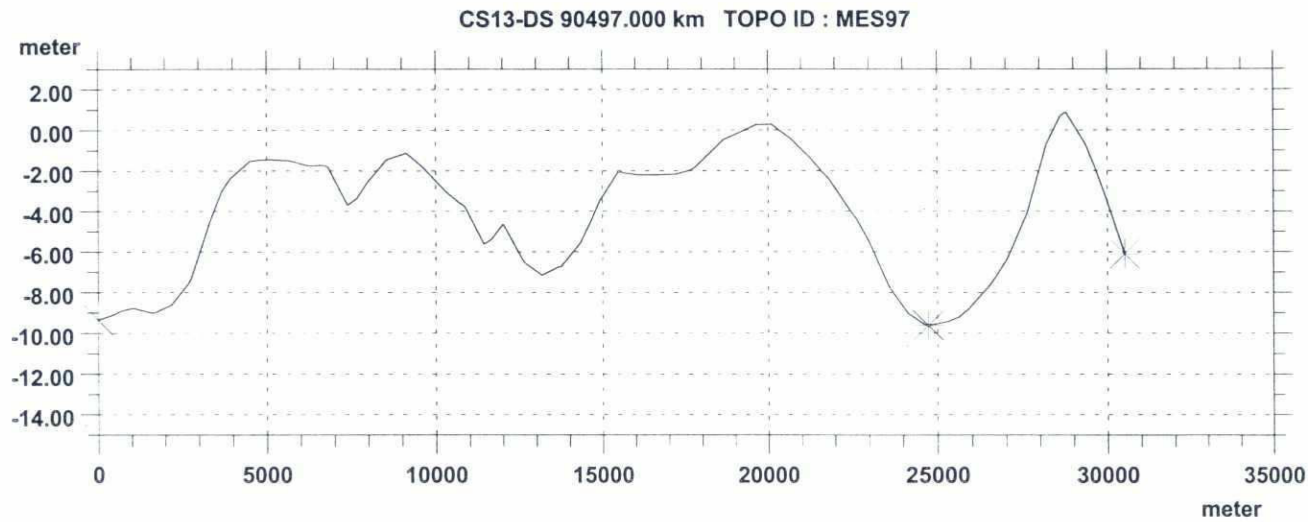
CS13-US 251299.000 km (MES2000)

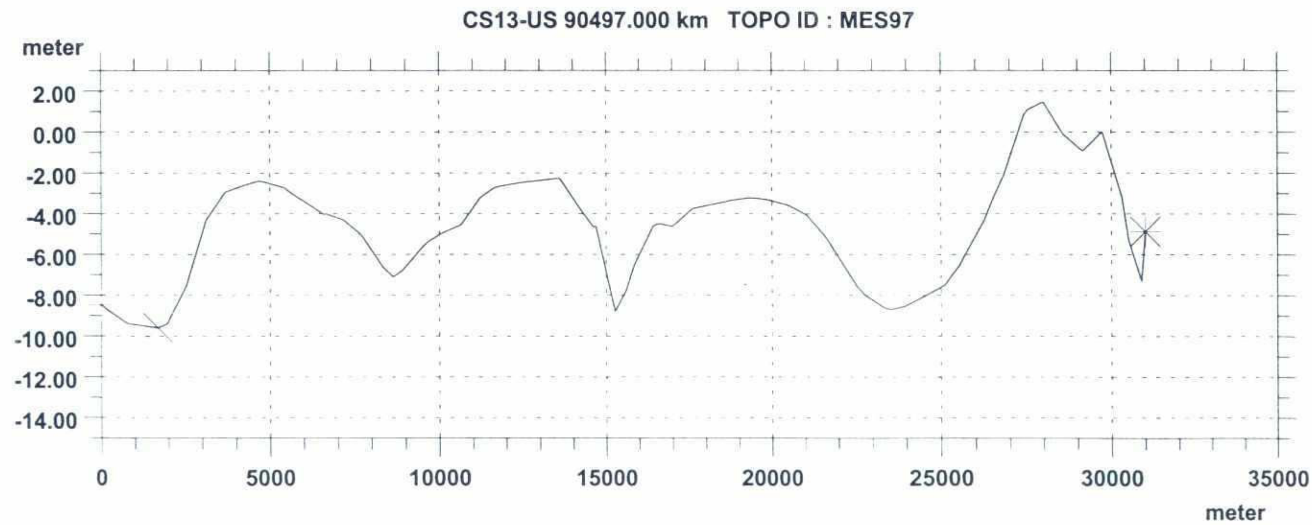


DATA BASE : MES2000	**MIKE 11**
	Drawing no 158

22





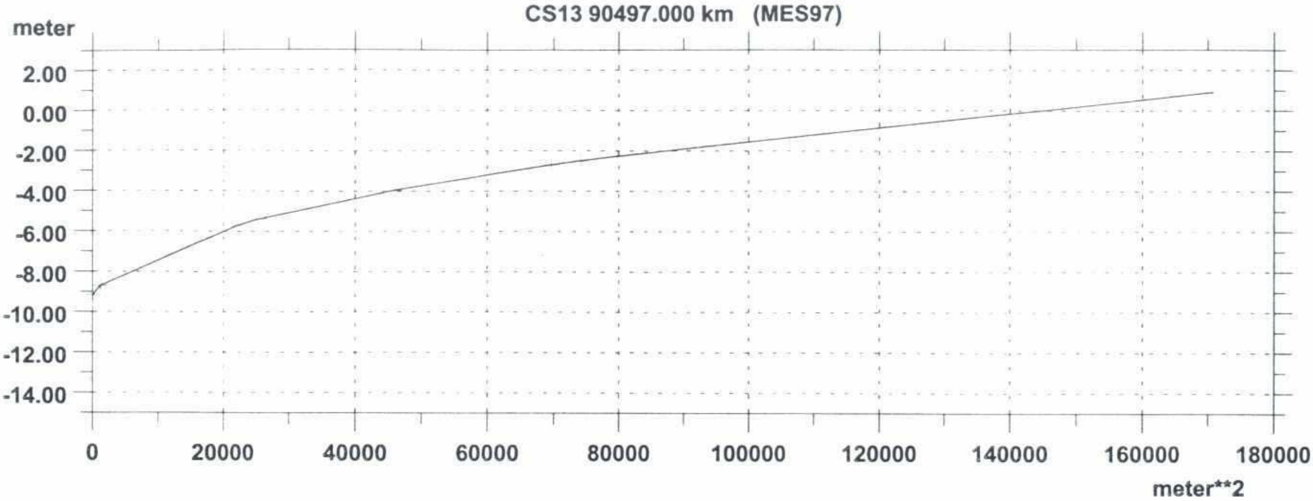


DATA BASE : MES97	**MIKE 11** Drawing no 1 59

92

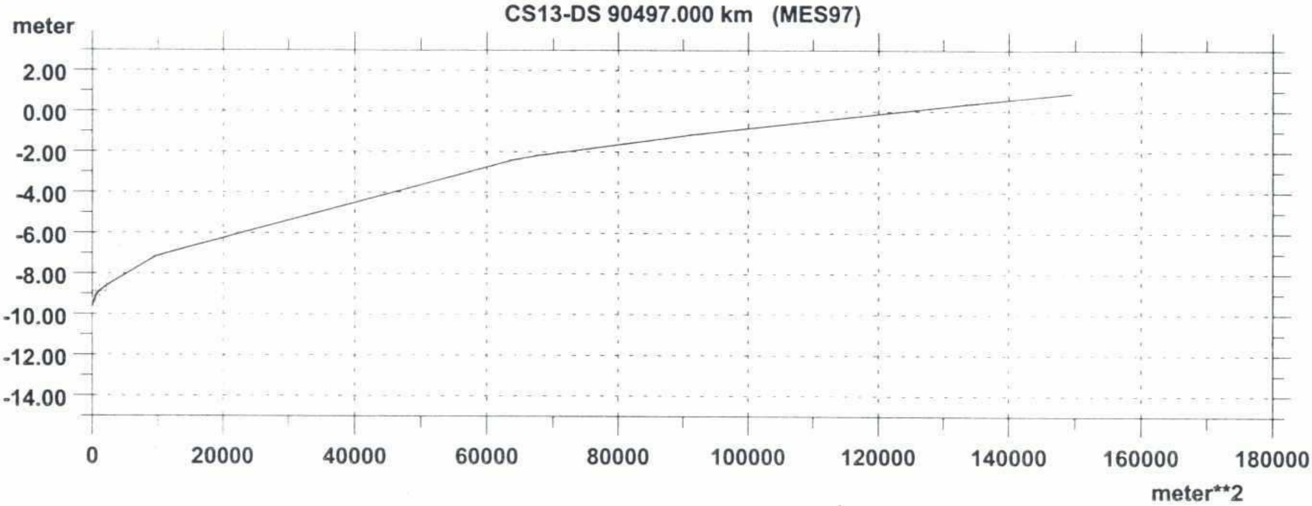
CROSS-SECTIONAL AREA

CS13 90497.000 km (MES97)



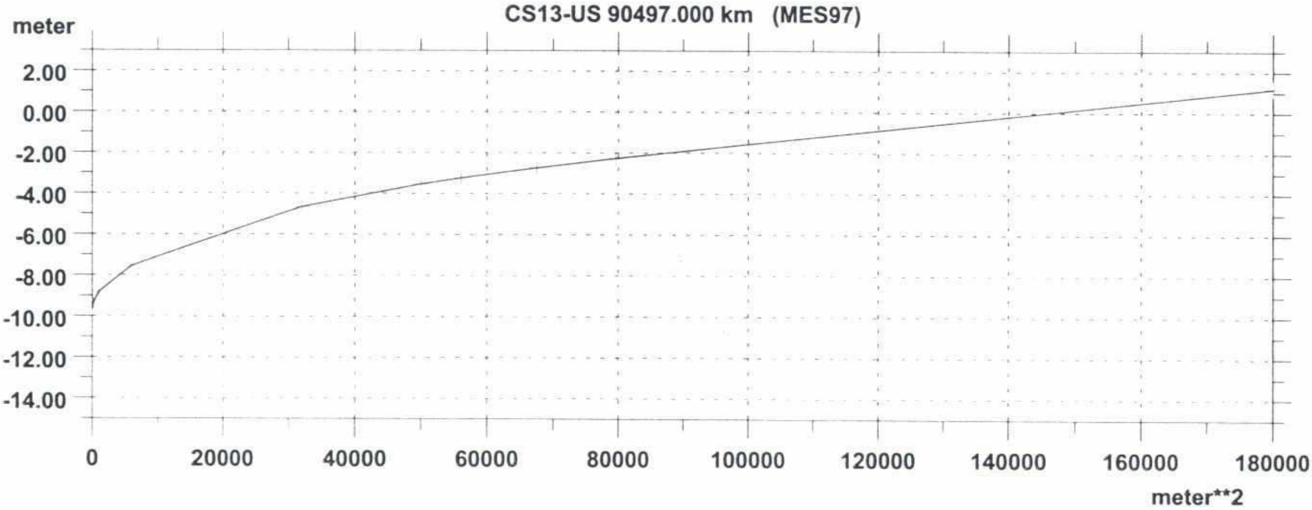
CROSS-SECTIONAL AREA

CS13-DS 90497.000 km (MES97)



CROSS-SECTIONAL AREA

CS13-US 90497.000 km (MES97)

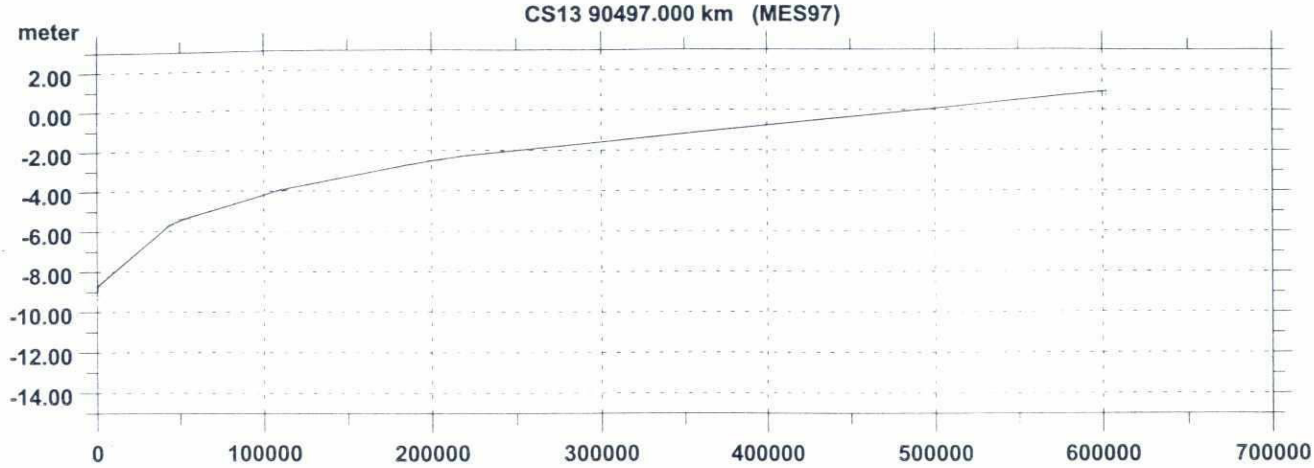


DATA BASE : MES97	MIKE 11
	Drawing no 60

26

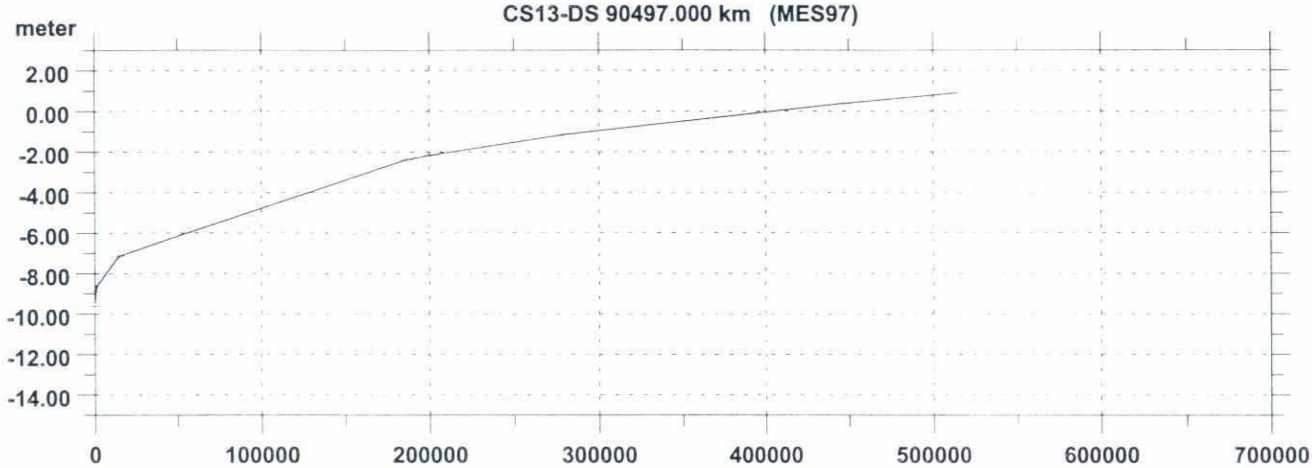
CONVEYANCE

CS13 90497.000 km (MES97)



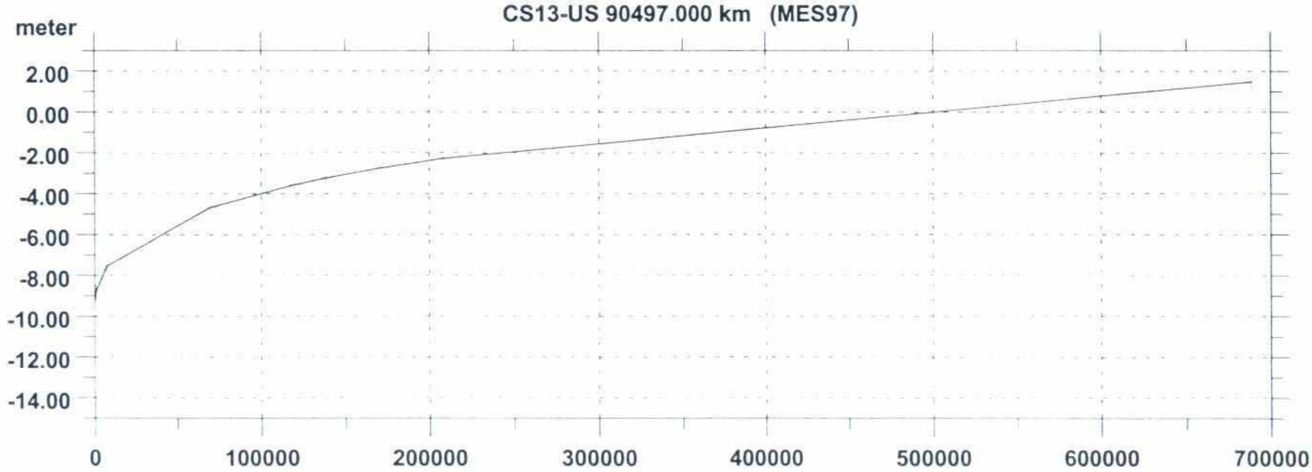
CONVEYANCE

CS13-DS 90497.000 km (MES97)



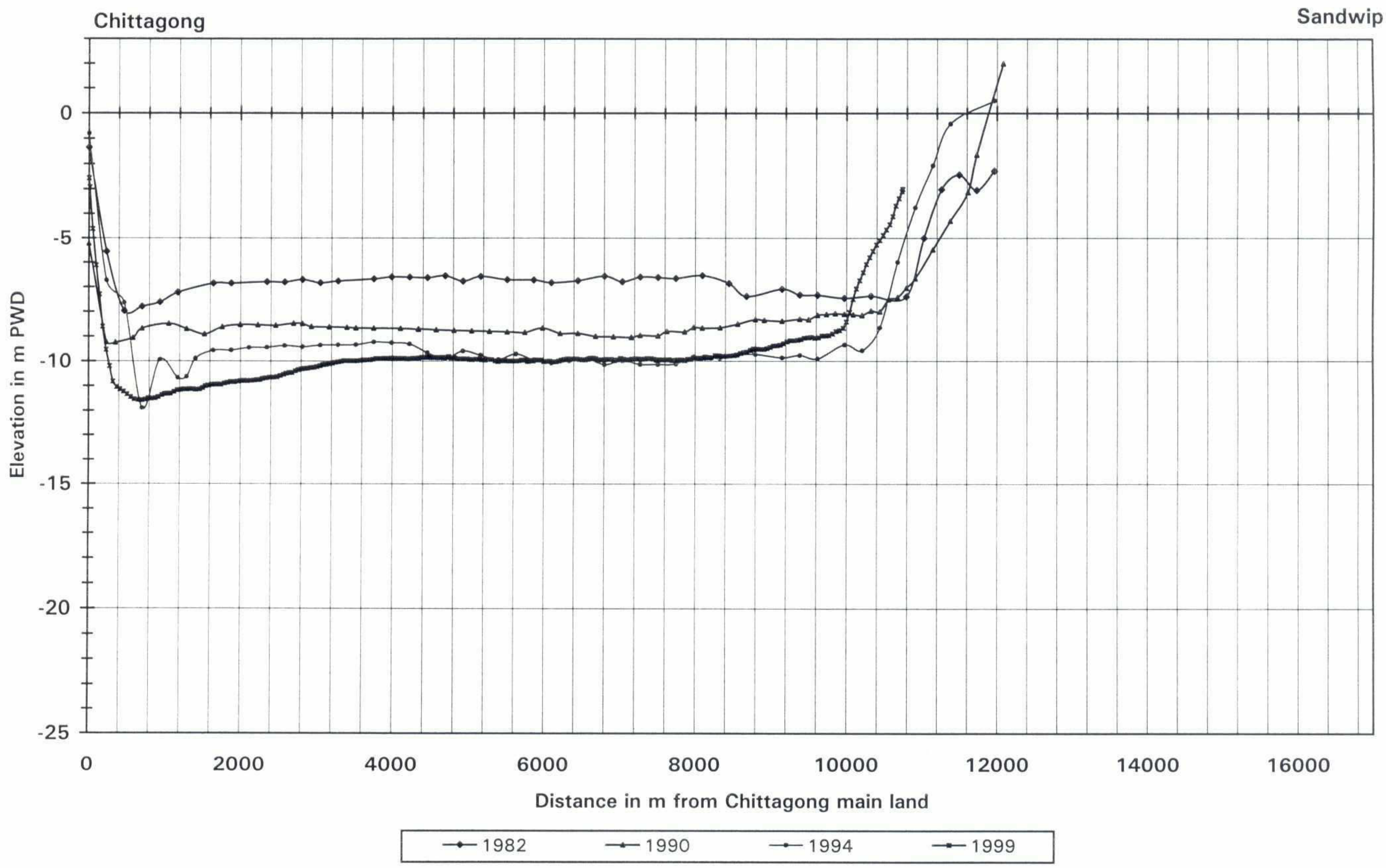
CONVEYANCE

CS13-US 90497.000 km (MES97)



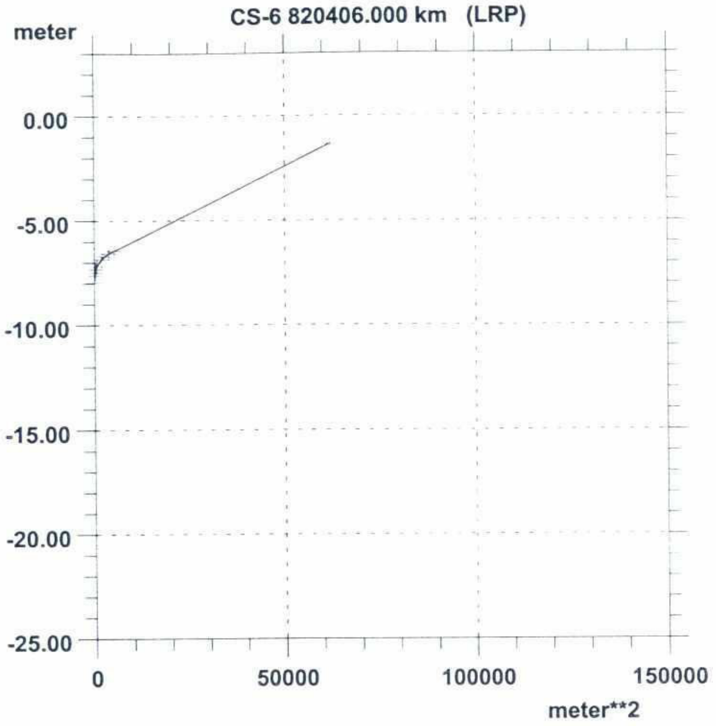
DATA BASE : MES97	**MIKE 11**
	Drawing no : 61

Drawing 62 : Cross-section 6 in Sandwip Channel in Different Years



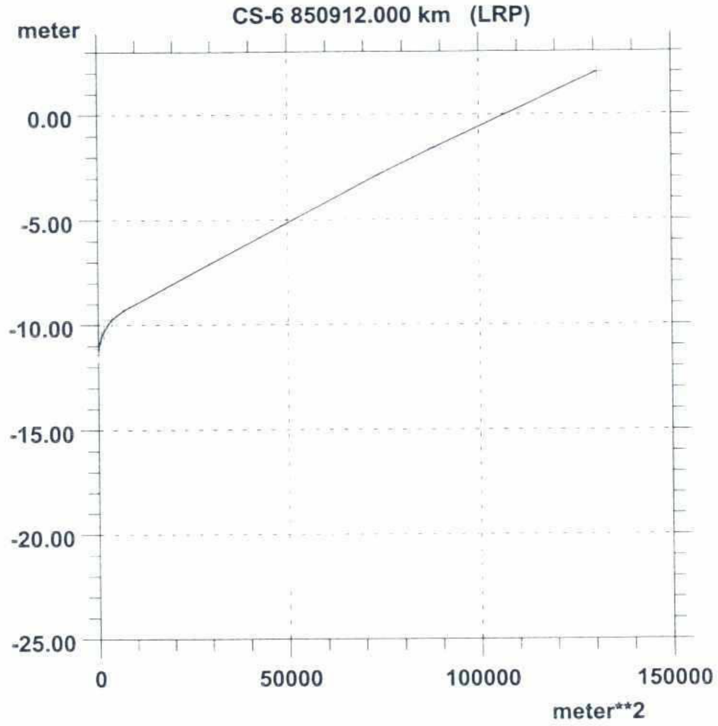
CROSS-SECTIONAL AREA

CS-6 820406.000 km (LRP)



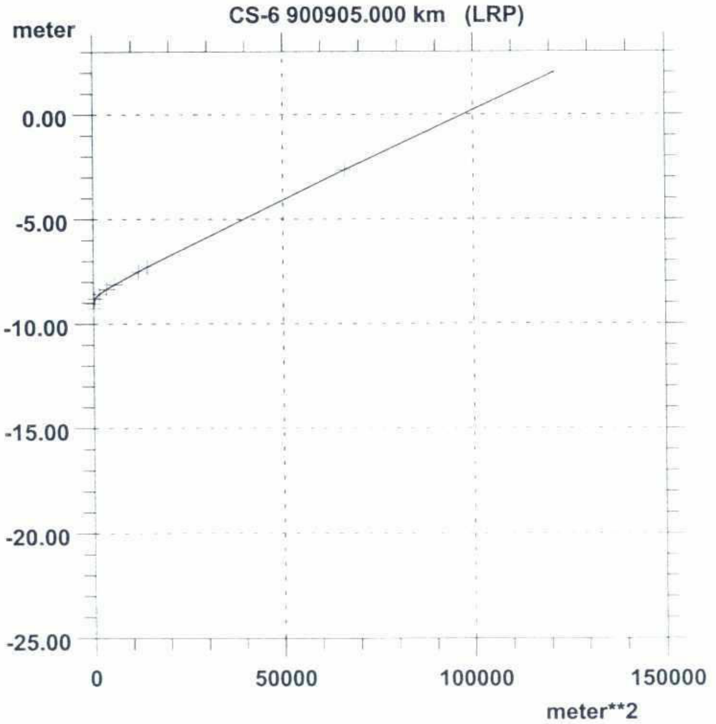
CROSS-SECTIONAL AREA

CS-6 850912.000 km (LRP)



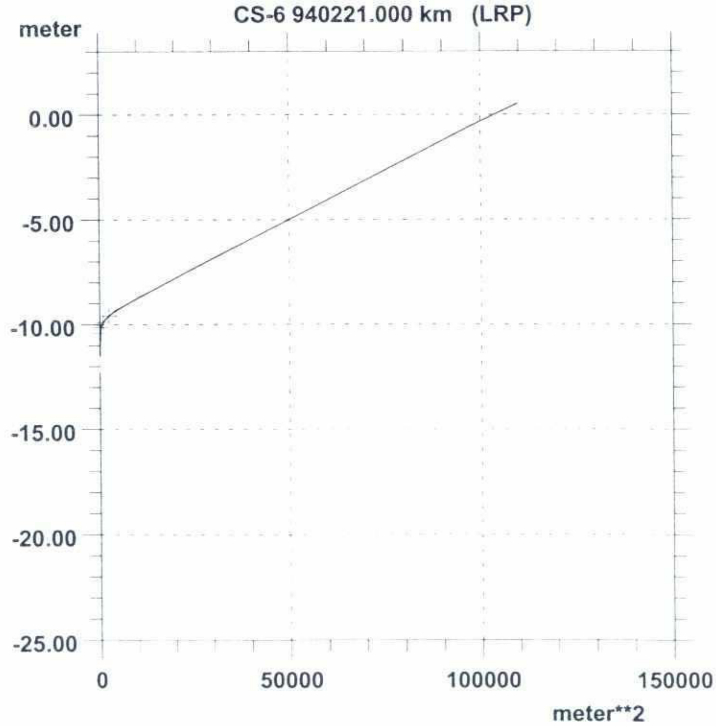
CROSS-SECTIONAL AREA

CS-6 900905.000 km (LRP)

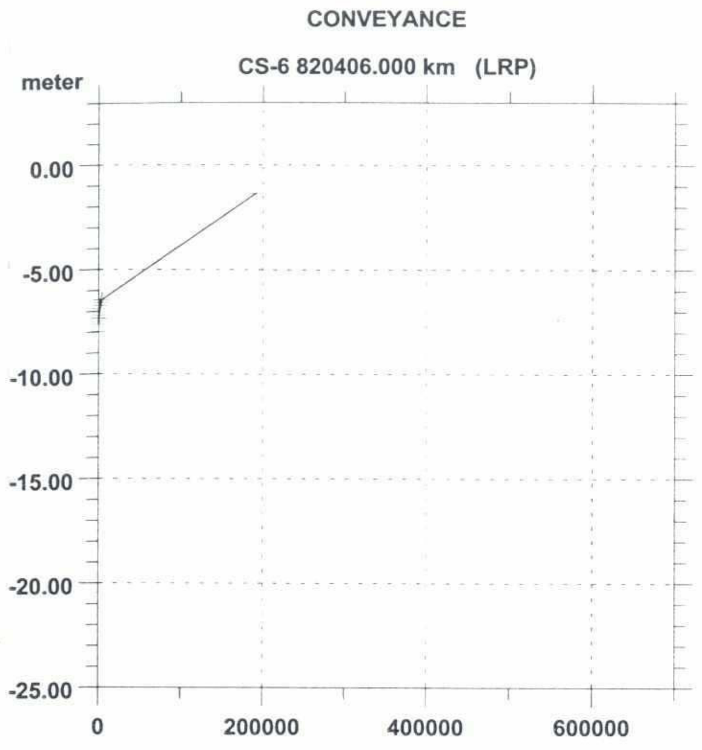


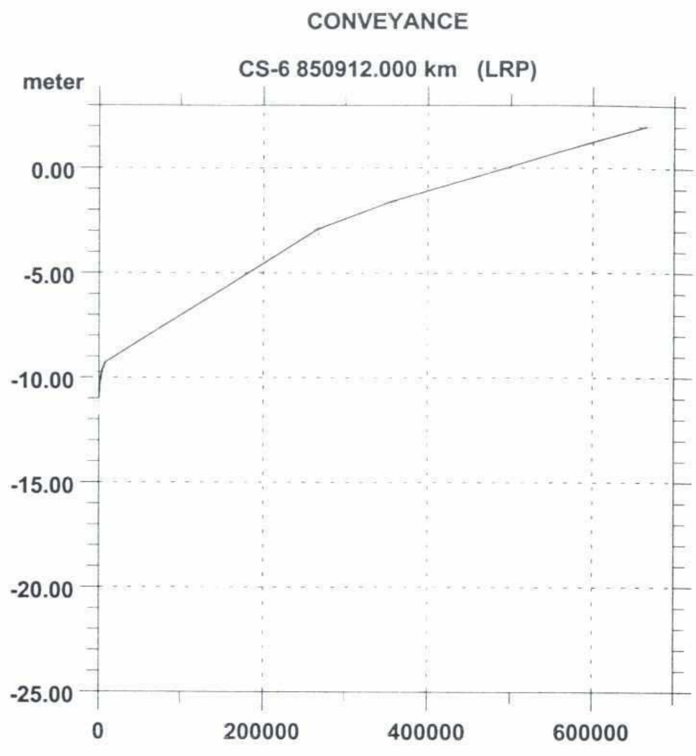
CROSS-SECTIONAL AREA

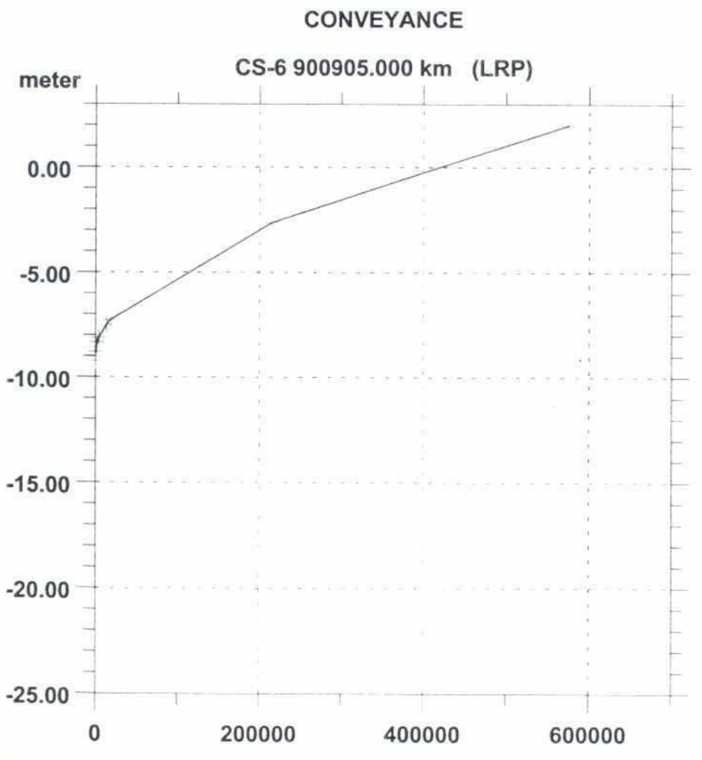
CS-6 940221.000 km (LRP)

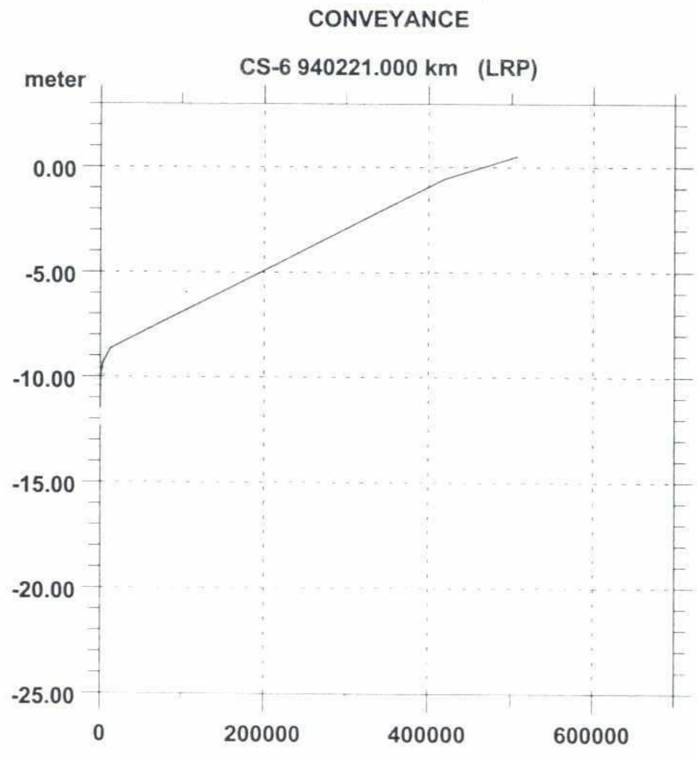


DATA BASE : LRP	MIKE 11
	63



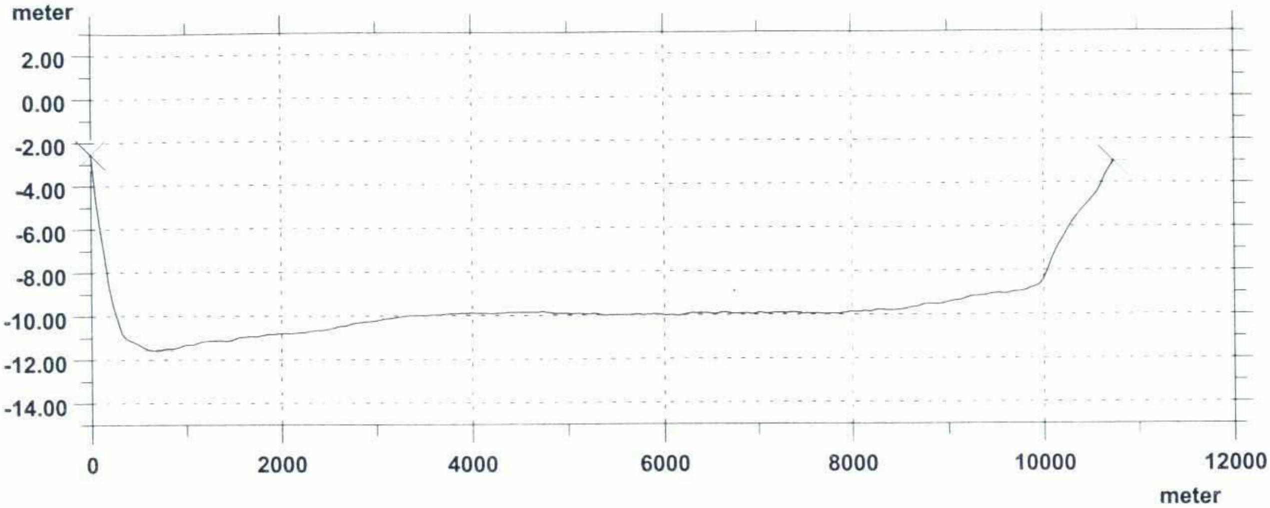




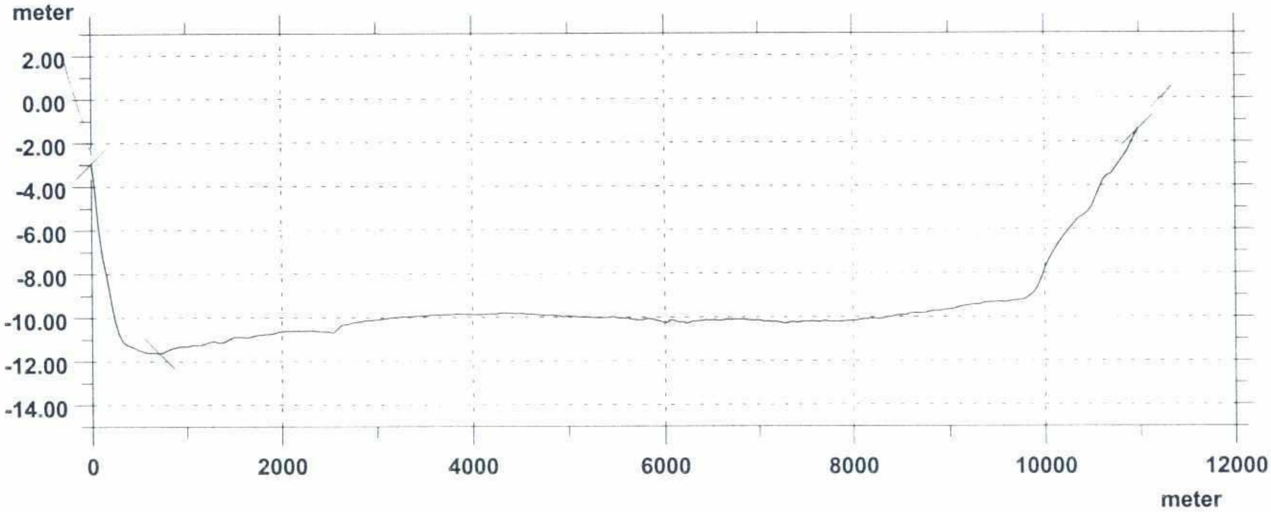


DATA BASE : LRP	MIKE 11
	64

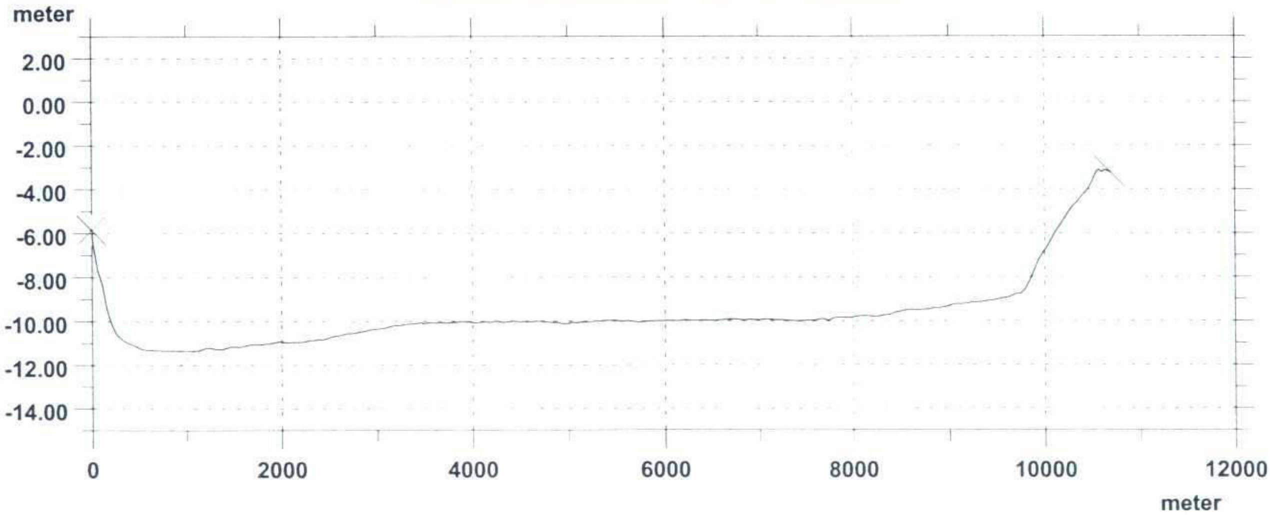
CS6 261299.000 km   TOPO ID : MES2000



CS6-DS 261299.000 km   TOPO ID : MES2000



CS6-US 261299.000 km   TOPO ID : MES2000

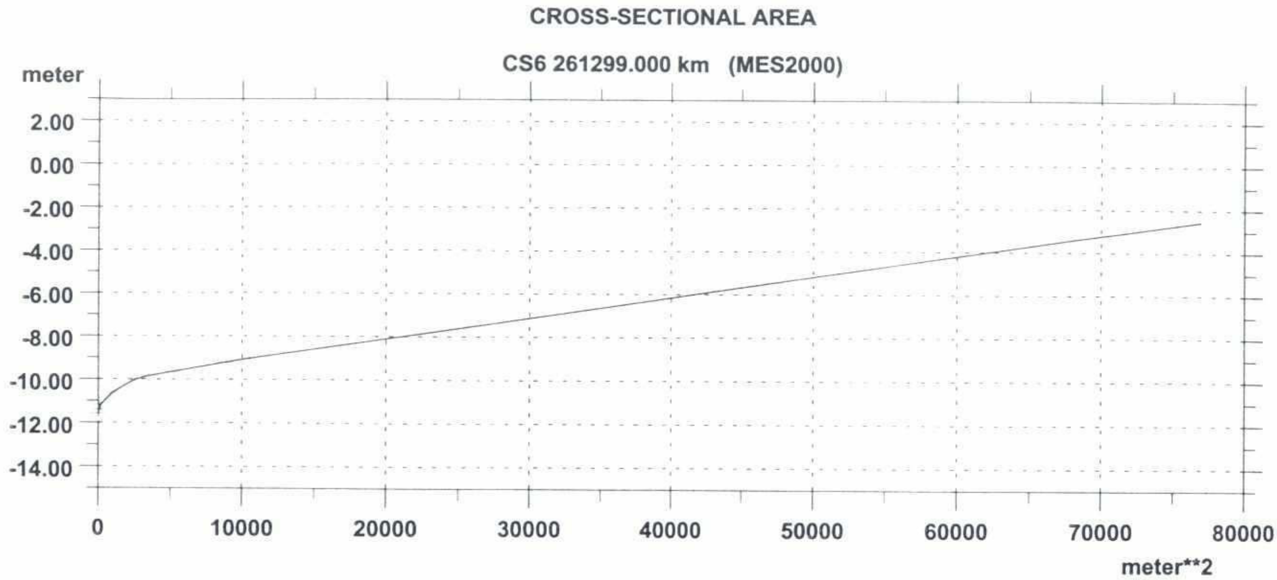


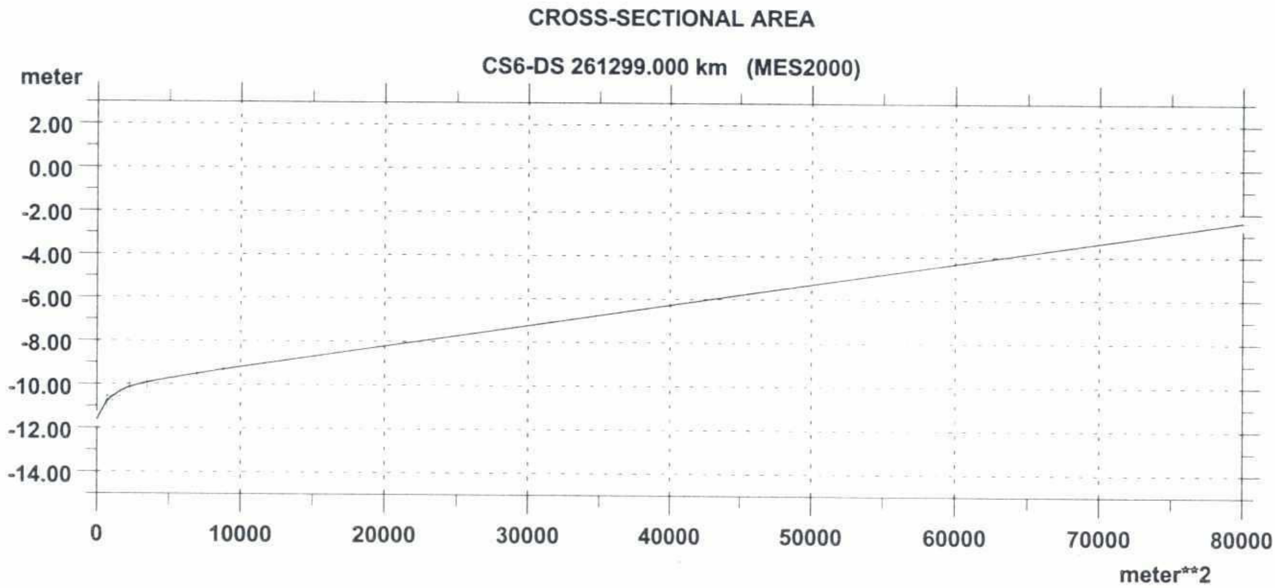
MIKE 11

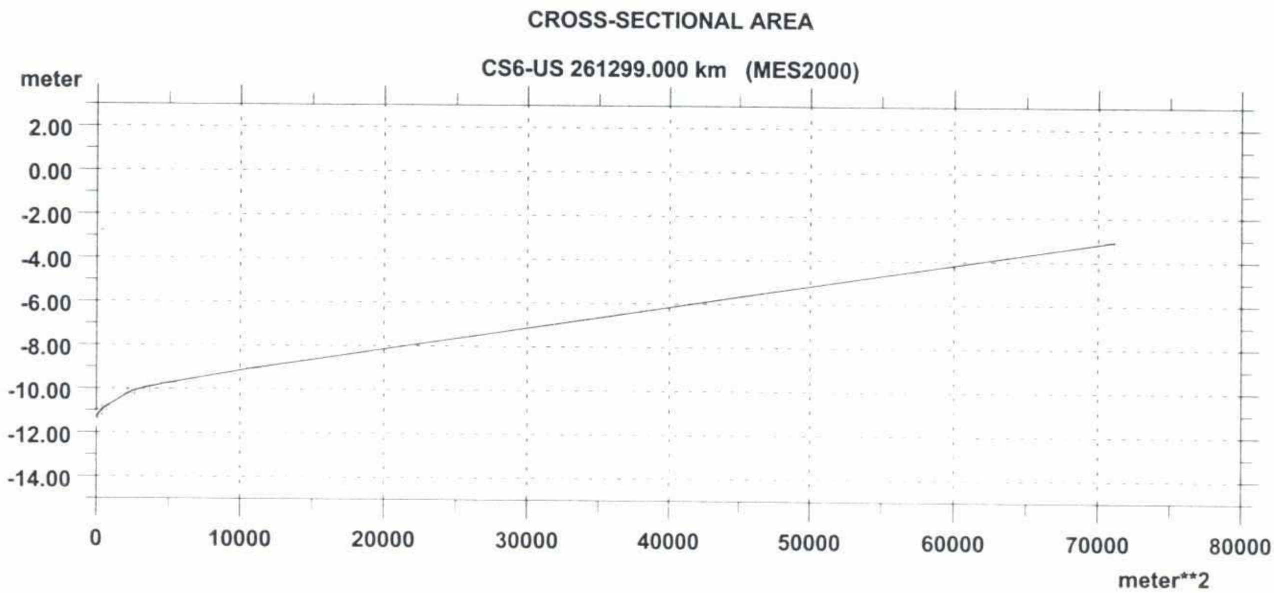
DATA BASE : MES2000

Drawing no 165

98



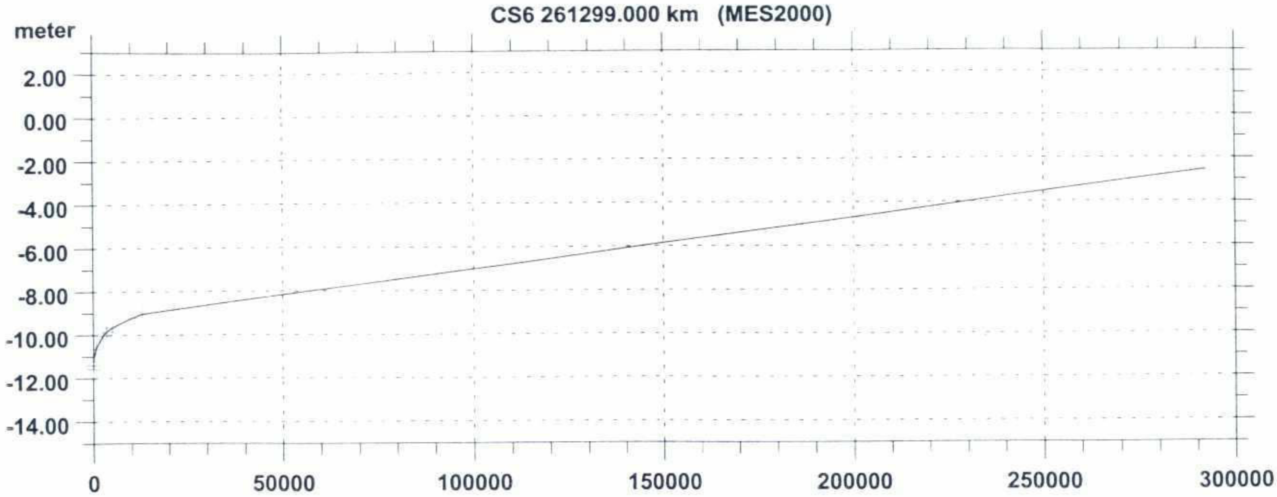




DATA BASE : MES2000	MIKE 11
	Drawing no 1 66

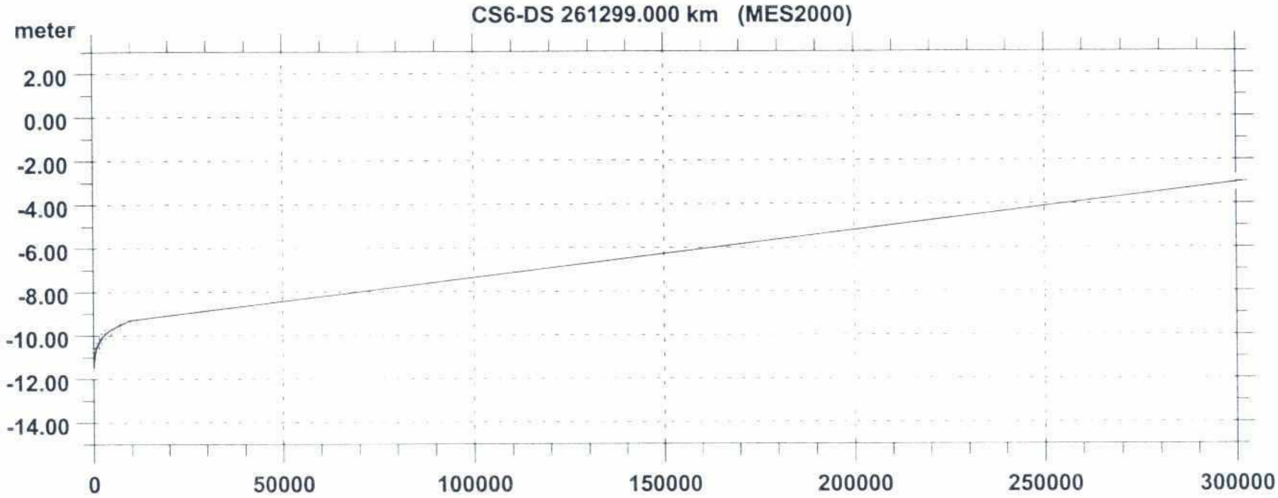
CONVEYANCE

CS6 261299.000 km (MES2000)



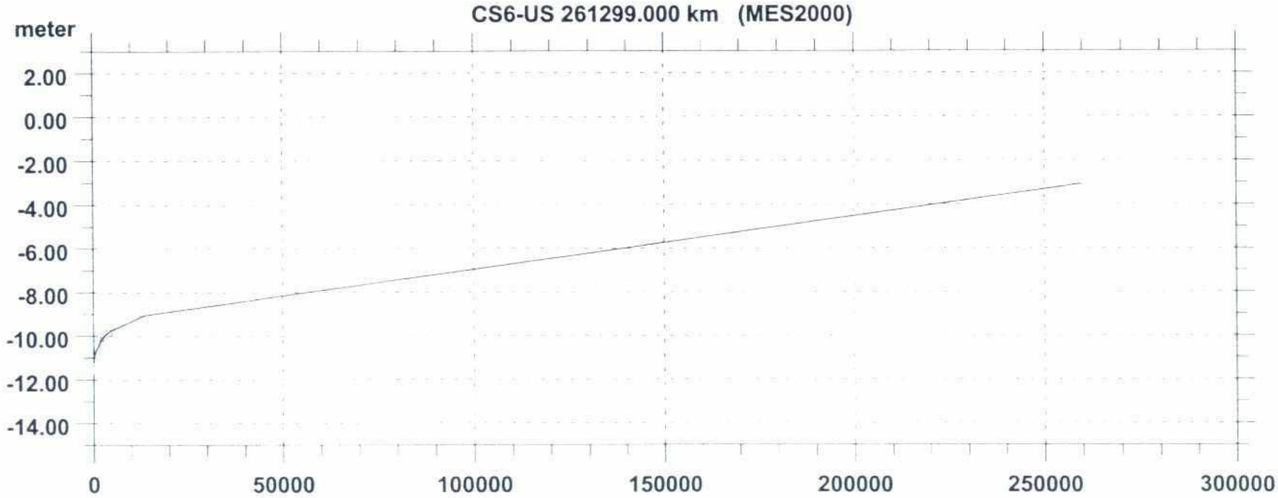
CONVEYANCE

CS6-DS 261299.000 km (MES2000)



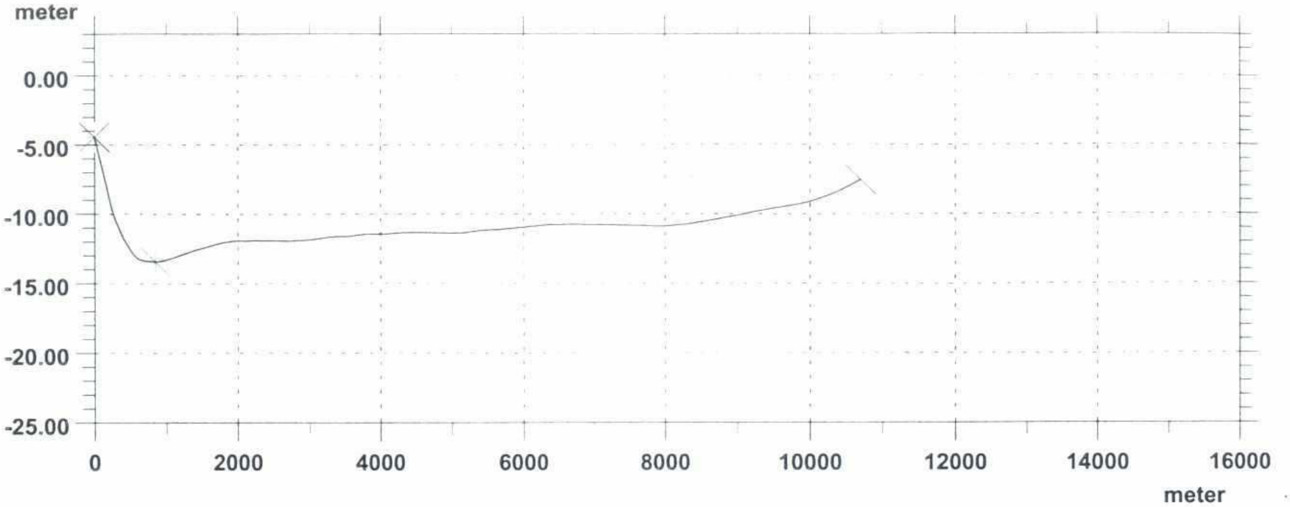
CONVEYANCE

CS6-US 261299.000 km (MES2000)

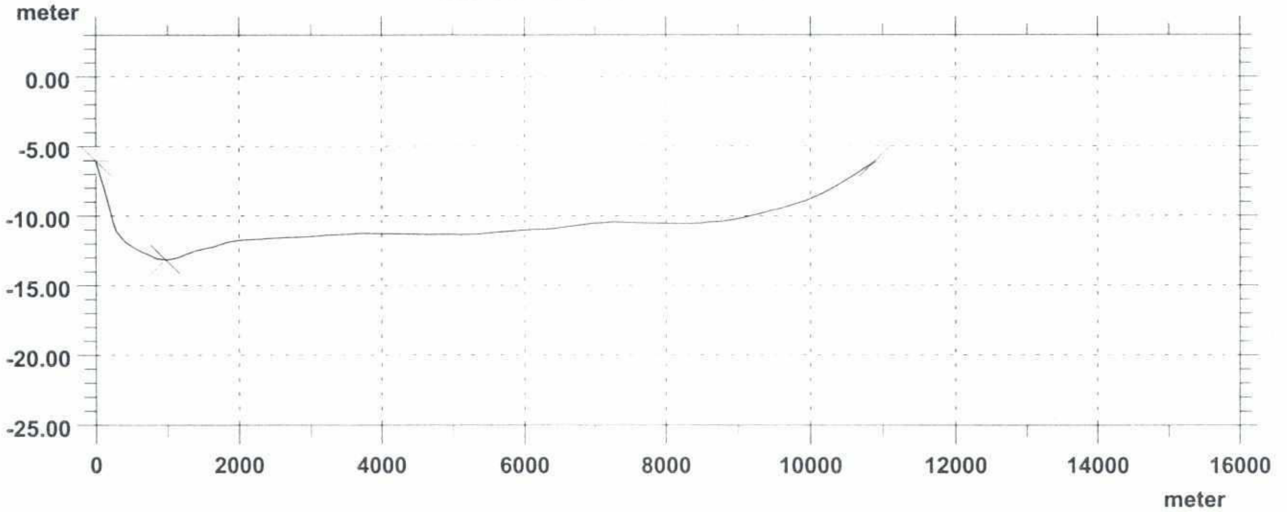


DATA BASE : MES2000	MIKE 11
	Drawing no 67

CS6 190297.000 km TOPO ID : MES97



CS6-DS 190297.000 km TOPO ID : MES97



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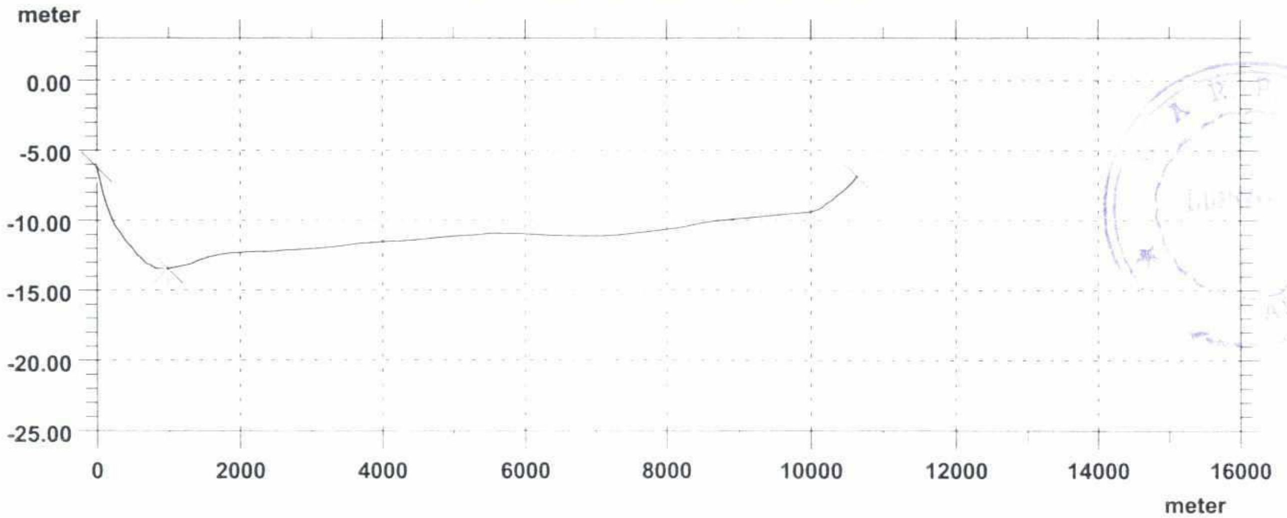
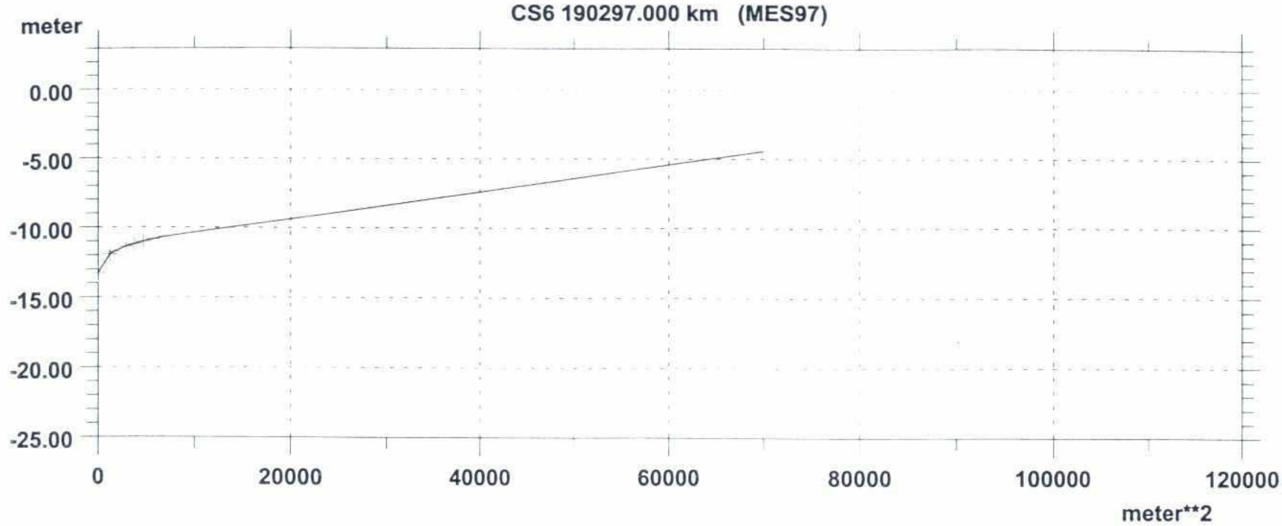


	MIKE 11
DATA BASE : MES97	68

CROSS-SECTIONAL AREA

CS6 190297.000 km (MES97)



CROSS-SECTIONAL AREA

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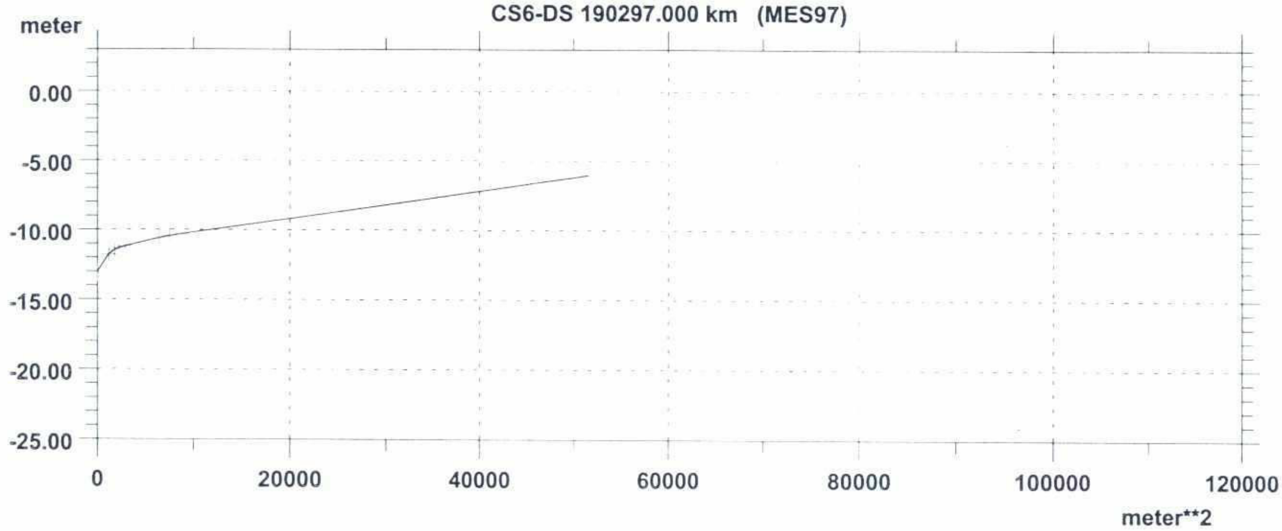
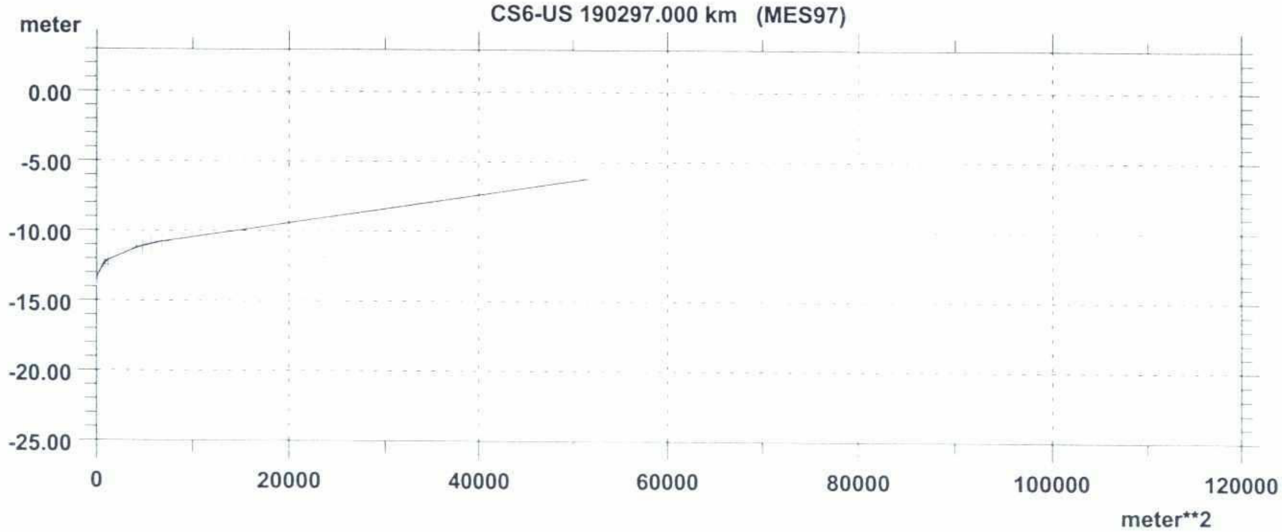
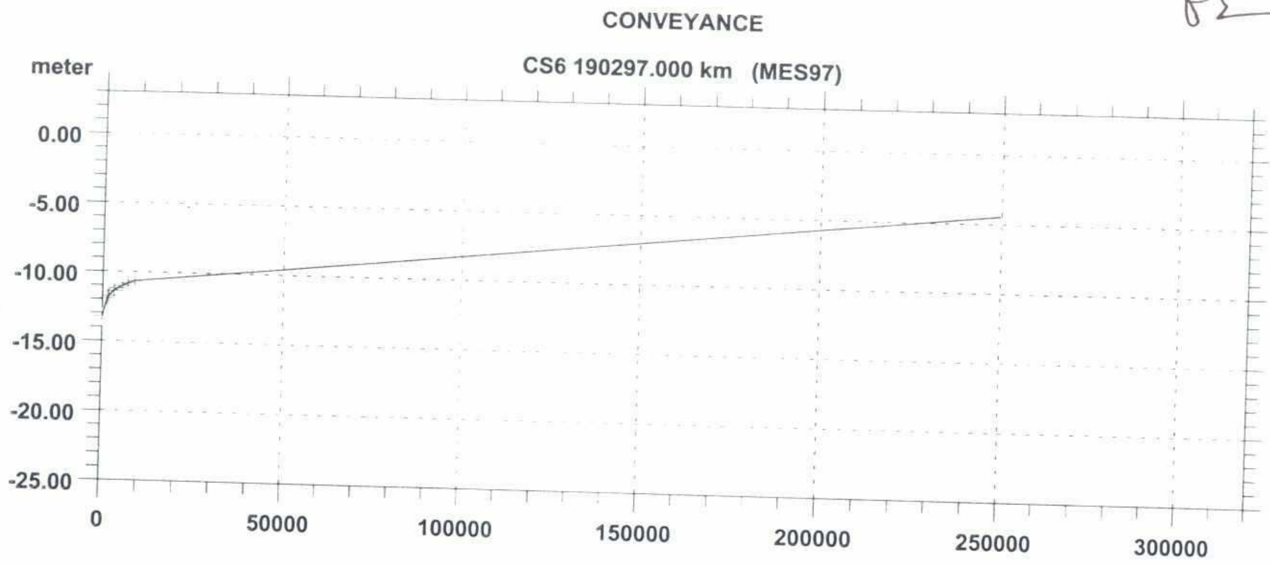
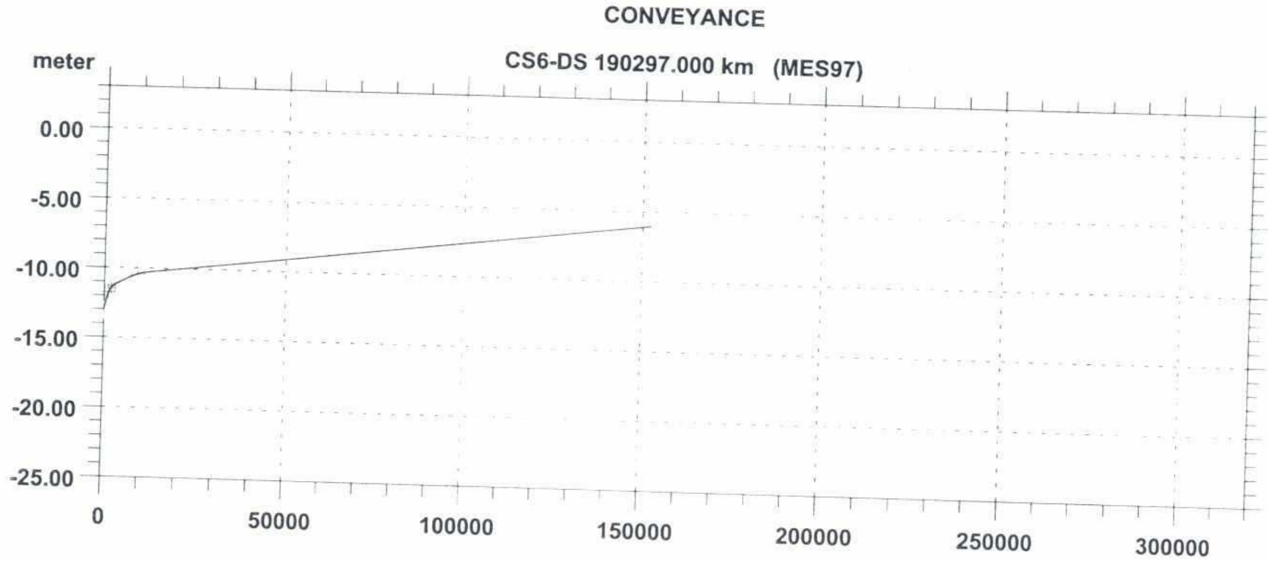


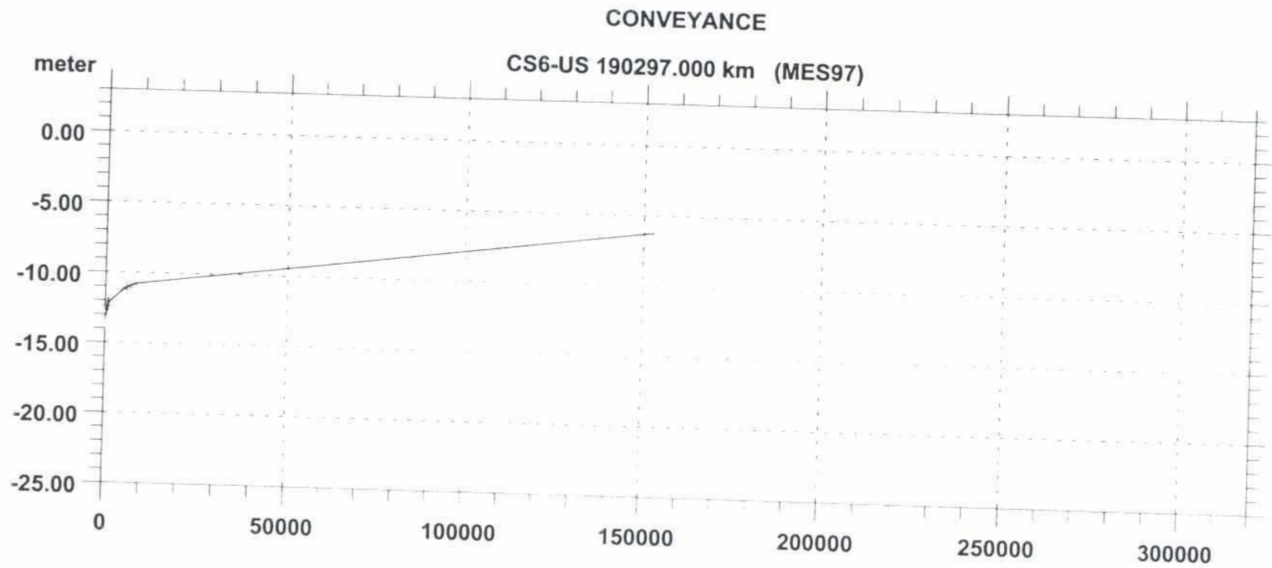
CROSS-SECTIONAL AREA

CS6-US 190297.000 km (MES97)



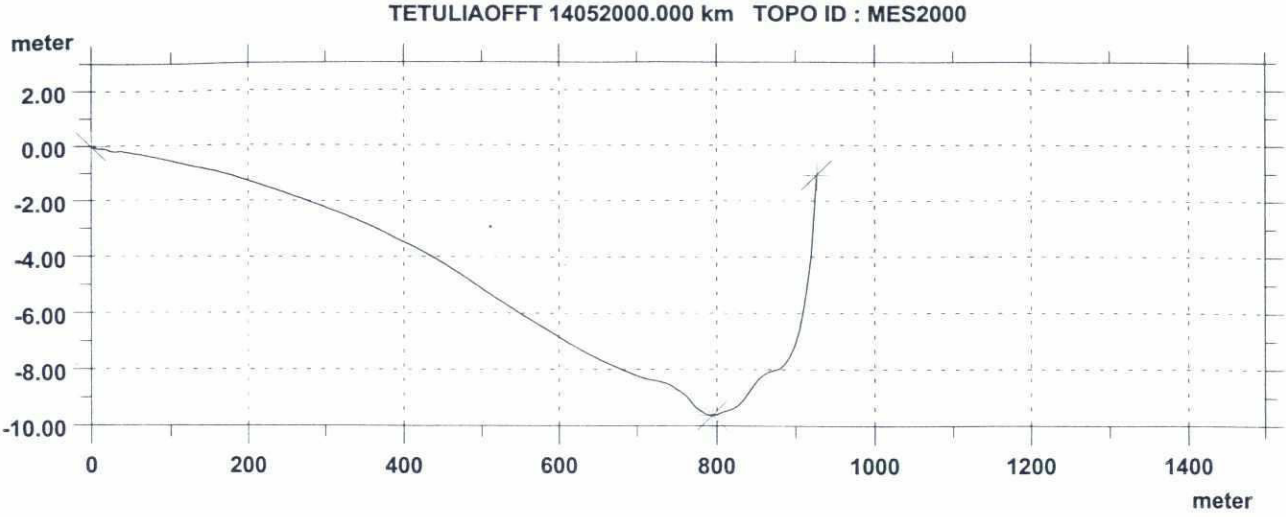


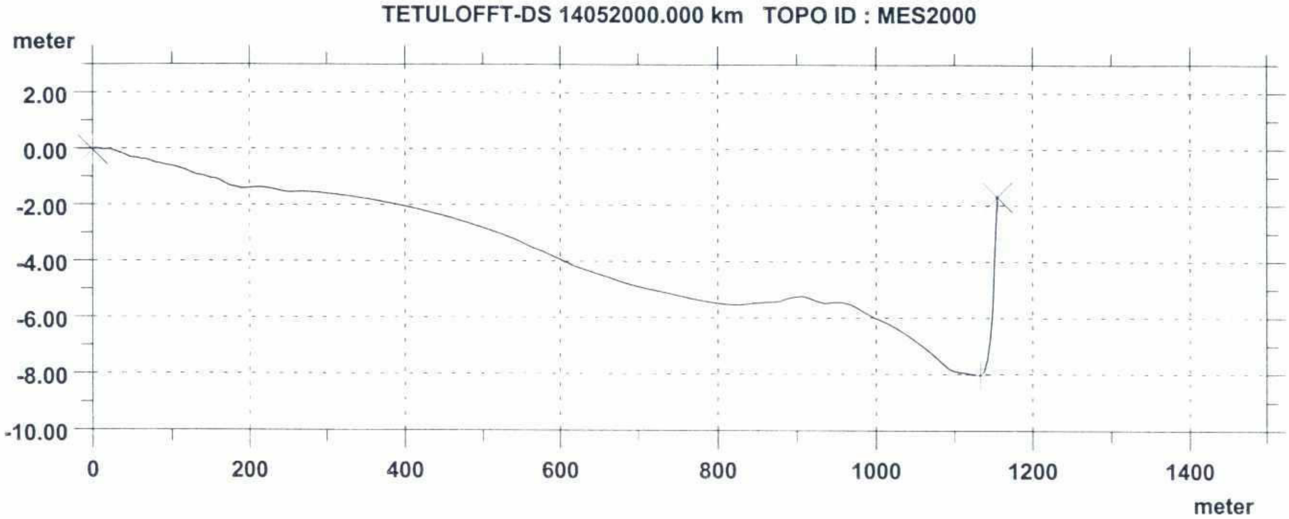


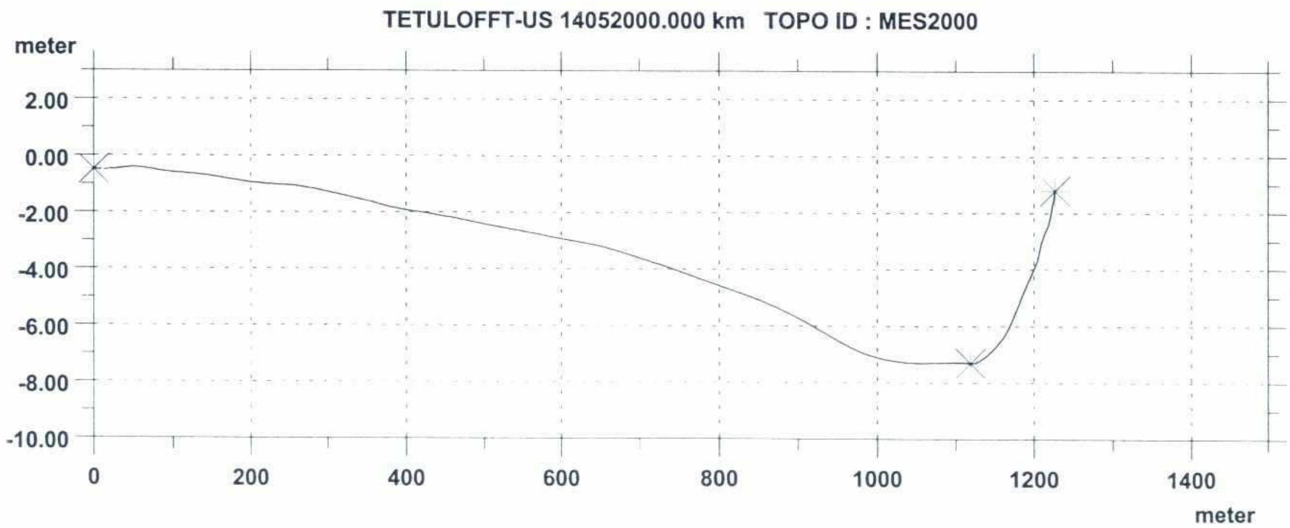


DATA BASE : MES97

MIKE 11

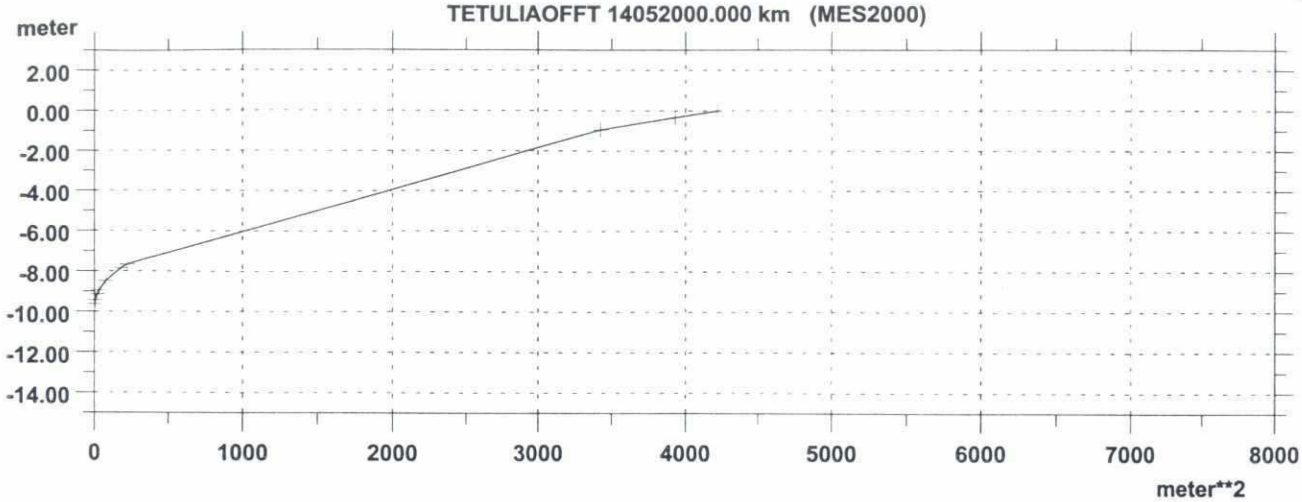




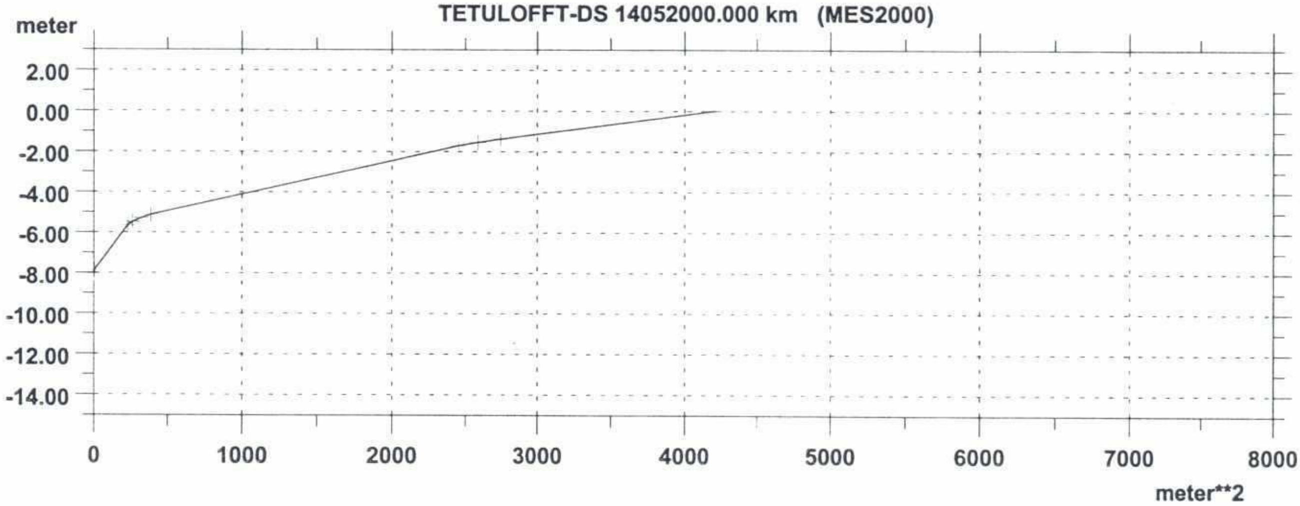


DATA BASE : MES2000	**MIKE 11** Drawing no 171

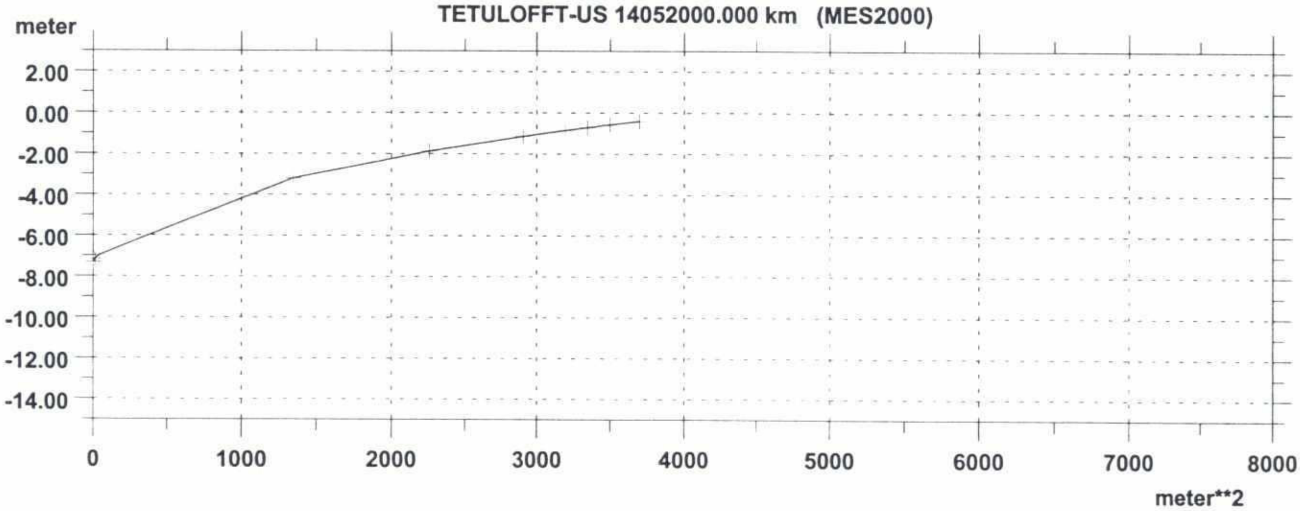
CROSS-SECTIONAL AREA



CROSS-SECTIONAL AREA



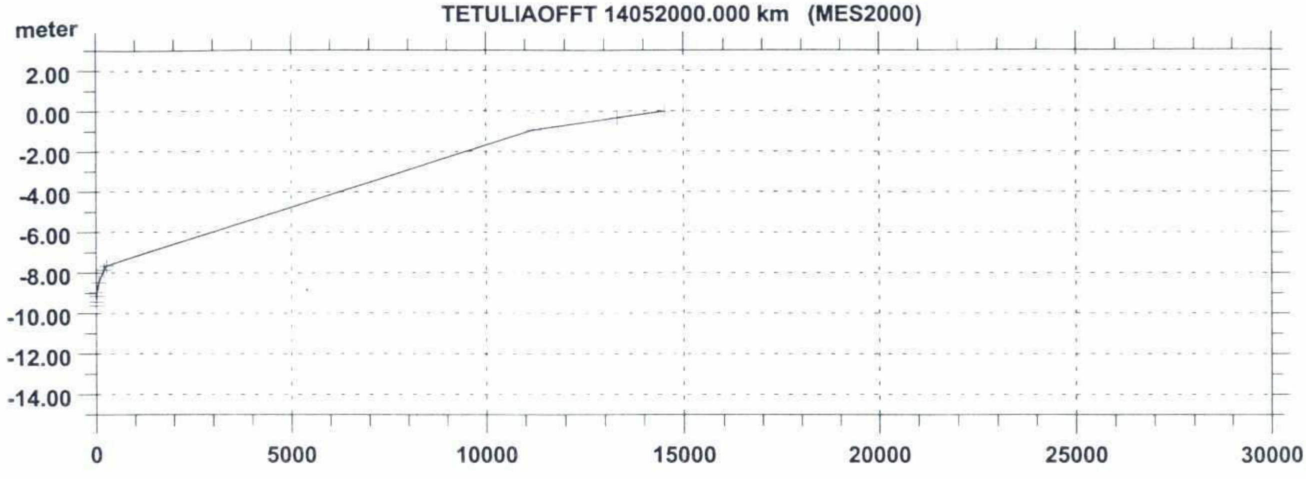
CROSS-SECTIONAL AREA



DATA BASE : MES2000	**MIKE 11** Drawing no 172

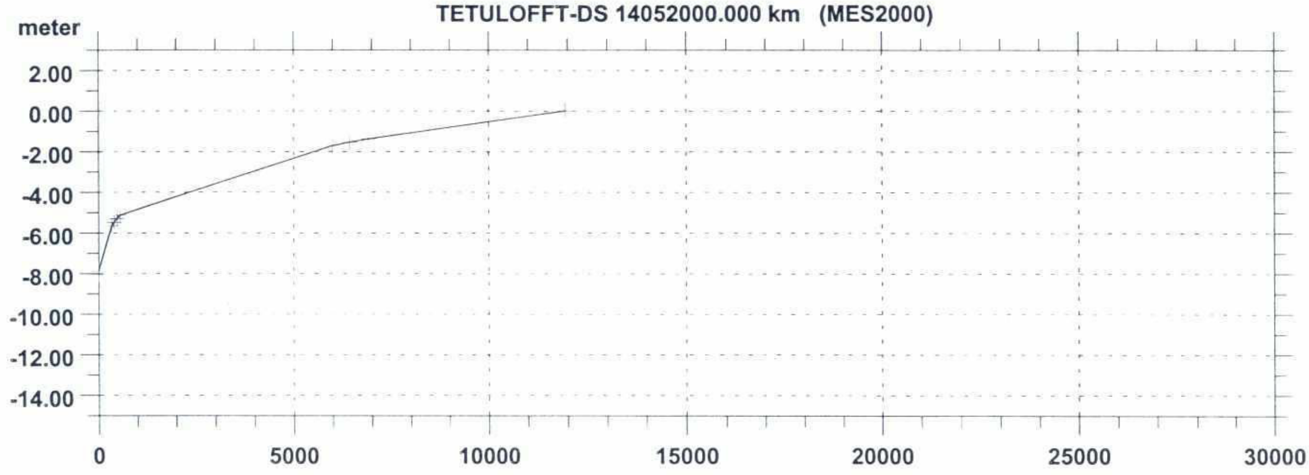
CONVEYANCE

TETULIAOFFT 14052000.000 km (MES2000)



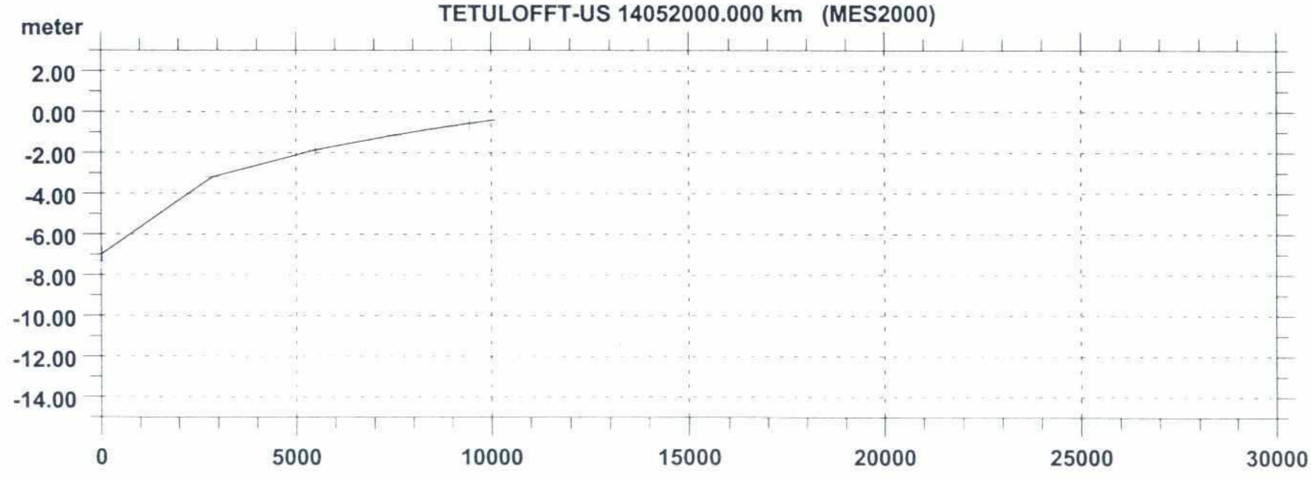
CONVEYANCE

TETULOFFT-DS 14052000.000 km (MES2000)



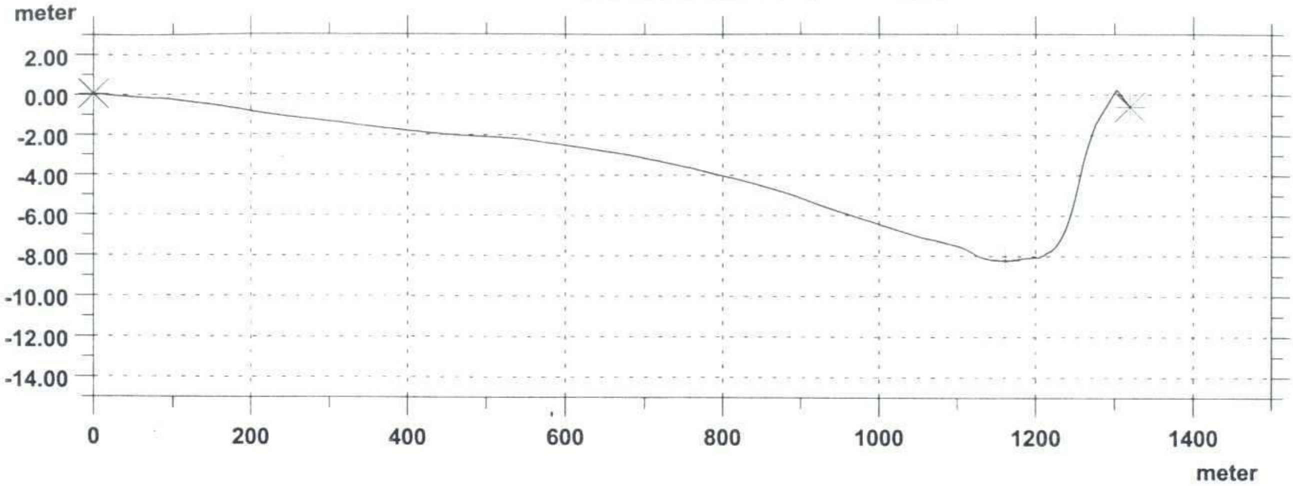
CONVEYANCE

TETULOFFT-US 14052000.000 km (MES2000)



DATA BASE : MES2000	MIKE 11 Drawing no I 73

TETULIAOFFT 290797.000 km TOPO ID : MES97



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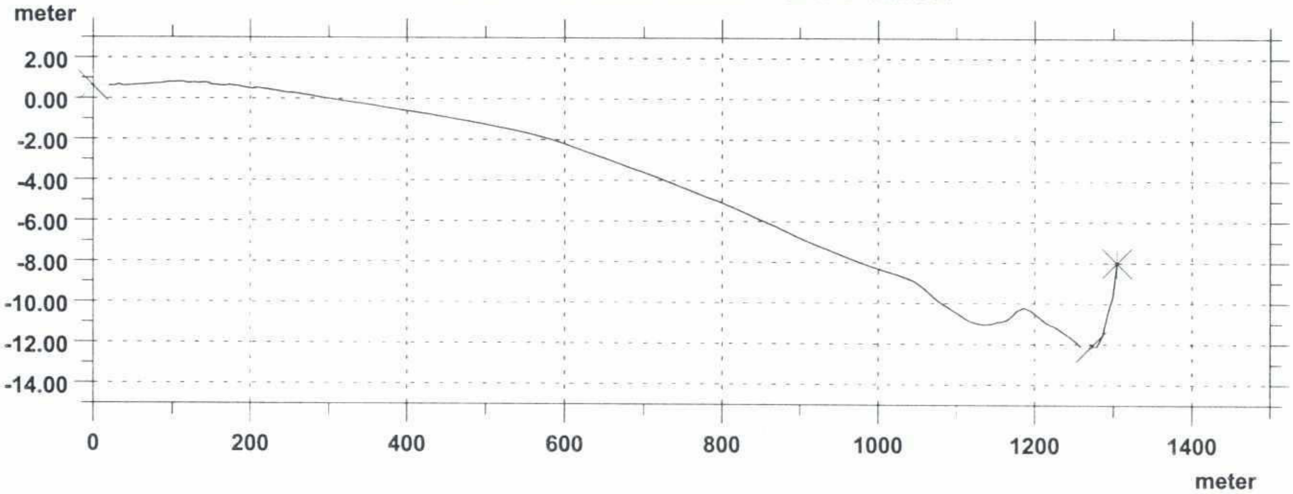

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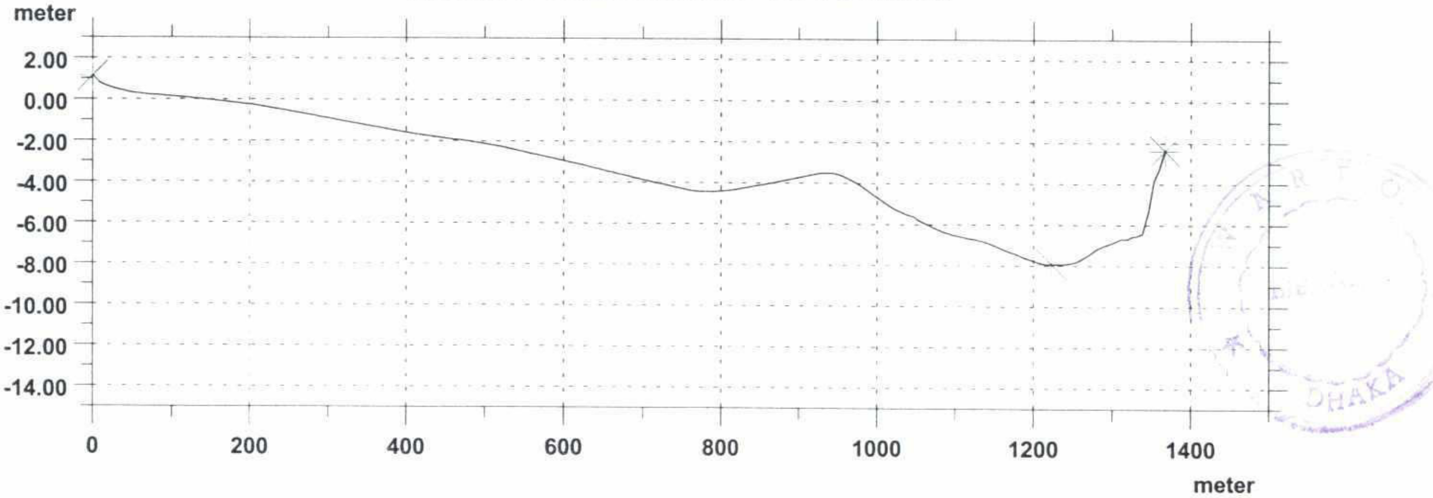
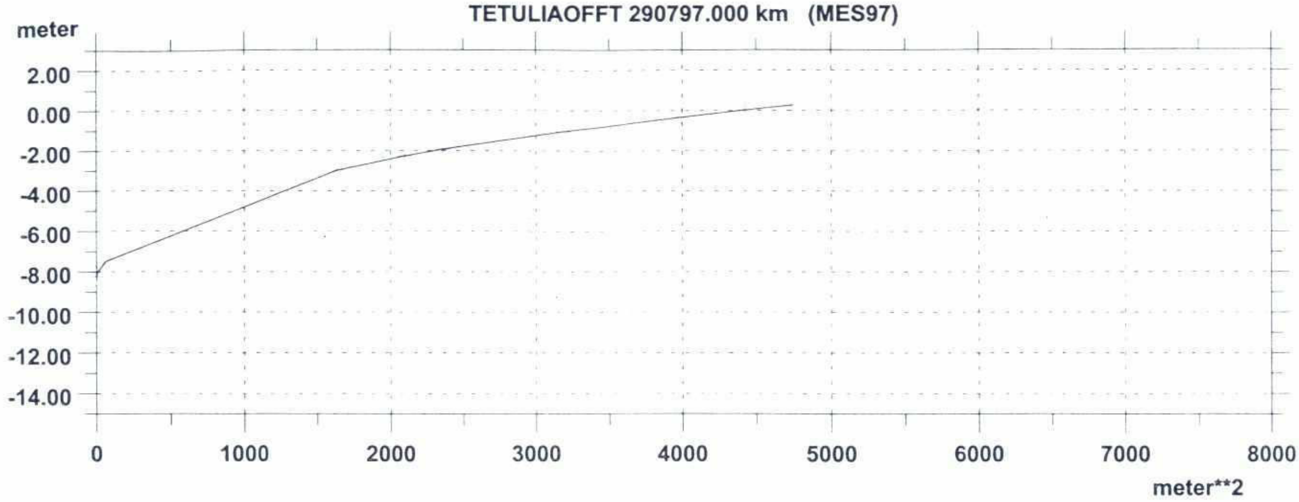


DATA BASE : MES97	MIKE 11
	Drawing no 174

89

CROSS-SECTIONAL AREA

TETULIAOFFT 290797.000 km (MES97)



CROSS-SECTIONAL AREA

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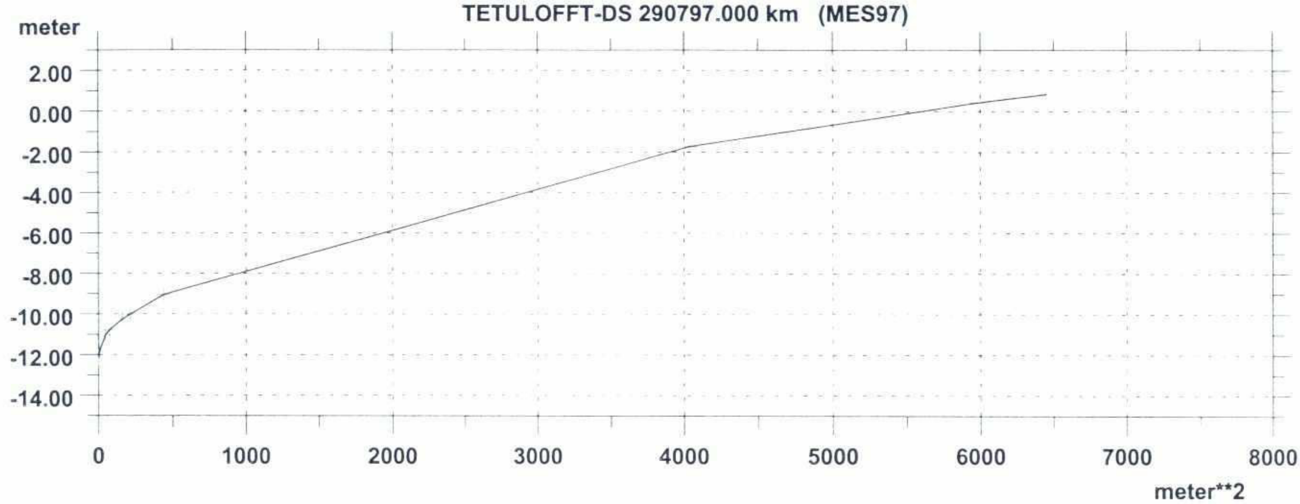
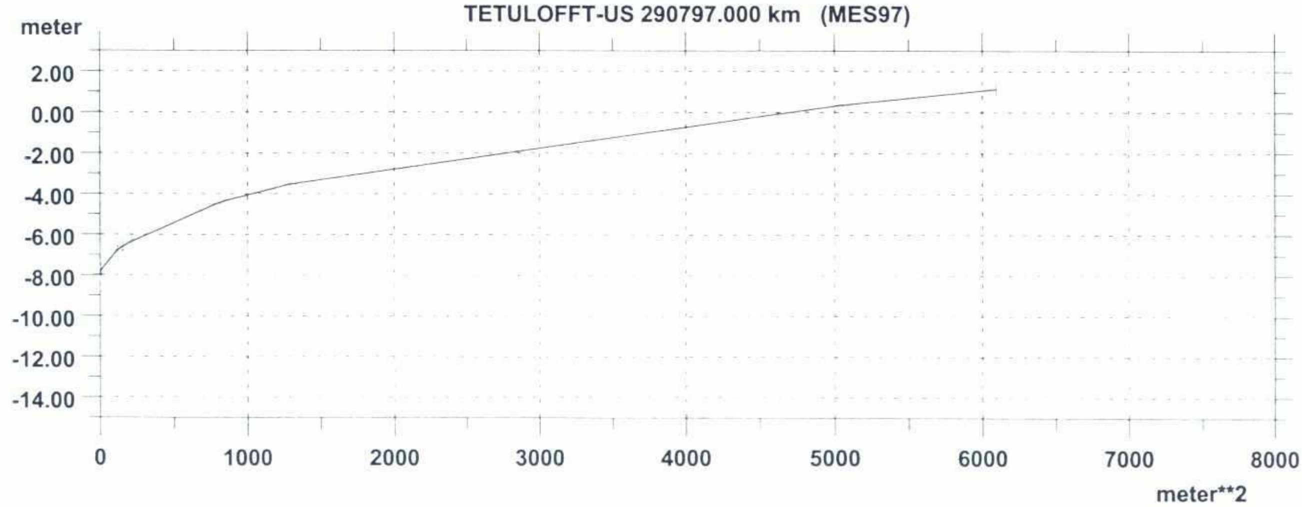


CROSS-SECTIONAL AREA

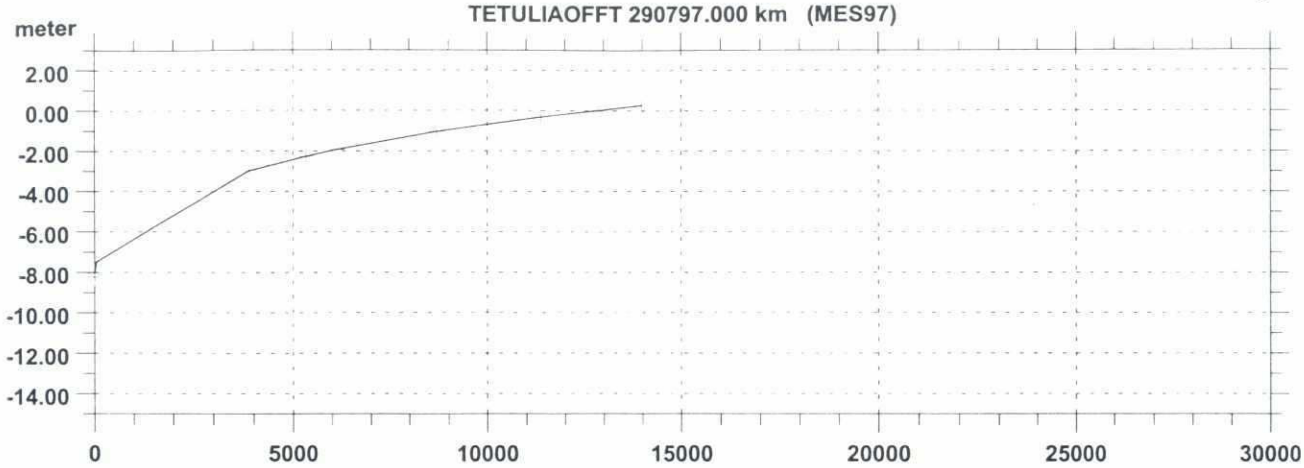
TETULOFFT-US 290797.000 km (MES97)



DATA BASE : MES97	**MIKE 11**
	Drawing no 175

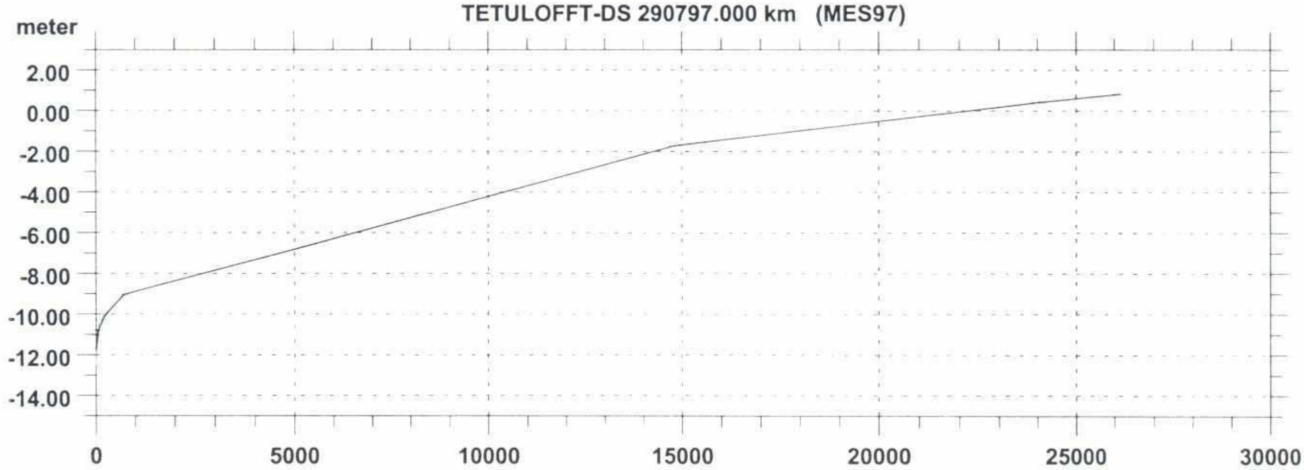
CONVEYANCE

TETULIAOFFT 290797.000 km (MES97)



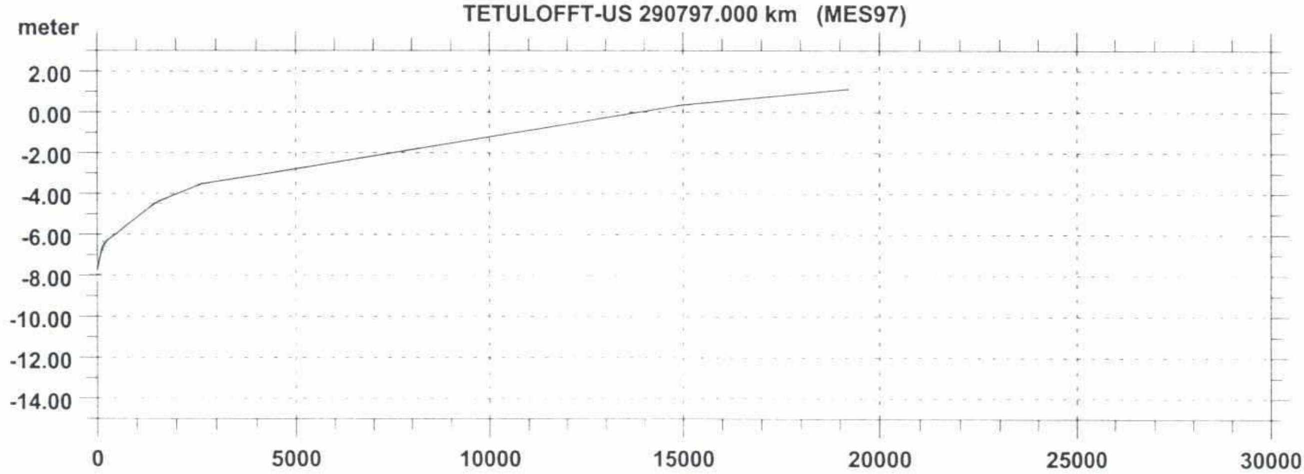
CONVEYANCE

TETULOFFT-DS 290797.000 km (MES97)



CONVEYANCE

TETULOFFT-US 290797.000 km (MES97)



DATA BASE : MES97

MIKE 11

Drawing no 76