Ministerie van de Vlaamse Gemeenschap
Departement Leefmilieu en Infrastructuur
Afdeling Waterwegen en Zeewezen
Afdeling Waterbouwkundig Laboratorium en Hydrologisch Onderzoek

STUDIE DENSITEITSSTROMINGEN IN HET KADER VAN LTV SCHELDE

STROOM- EN SALINITEITSMETING T.H.V. DEURGANCKDOK UITGEVOERD OP 05/06/2002

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1 INTRODUCTION

1.1 The assignment

On March 1, 2002 the study " Densiteitsstromingen Schelde in het kader van LTV" (16EB/01/01), assigned by WLHO (Departement Leefmilieu en Infrastructuur, Afdeling Waterwegen en Zeewezen, Afdeling Waterbouwkundig Laboratorium en Hydrologisch Onderzoek) to WL | Delft Hydraulics in association with IMDC has started.
The study consists of the following parts:

- The set up and execution of an extensive measurement campaign
- The building of a physical model, including the access channel to a sluice
- The building of a 3D numerical model
- The writing of a report on future possible actions that can be t aken in order to obtain a better understanding of the functioning of sedimentation and silt transport in the Lower Scheldt
- The transfer of the numerical models to the WLHO, including the necessary training sessions.

This report is written as part of sub-assignment 1: the set up and execution of an extensive measurement campaign.

1.2 Purpose of the measurement campaign

The through tide measurement campaign conducted at Deurganckdok is part of the extensive measurement campaign in the study on density currents in the river Scheldt, in the framework of the Scheldt Long Term Vision (LTV). In addition to long term measurement campaigns at certain designated tidal posts along the river Scheldt, the measurement plan also covered two series of through tide measurements at different locations on June 5th and 12th 2002.

The purpose of the measurement campaign was to supply a coherent set of data which will be not only be applied in the calibration and validation of the numerical models and the physical model that are being developed in the framework of the study on density currents on the one hand, but which could also contribute to the knowledge of the behaviour of density currents in the river Scheldt, and more specifically around the areas of the Kallo Lock and the future Deurganckdock.

The measurement at the Deurganckdok area were carried out in order to characterize the flow pattern and the salinity distribution in the vicinity of the future Deurganckdok.

Table 1 gives an overview of the measurement campaign and the resulting factual data reports. Appendix 4 is a survey of the entire measurement plan, with the locations of the through tide measurement campaigns and the long term measu rement locations.

This report is the factual data report of the through tide current and salinity measurements at Deurganckdok on June 5th 2002 . An interpretation and analysis of the measurement data will be made in the data analysis report (I/RA/11216/02.045/CMA), which is in preparation.

Measurement Location	Measurement Period	Type of Measurement	Report number
Waarde	5/06/2002	Through tide current and salinity measurement	I/RA/11216/02.037/CMA
Waarde	12/06/2002	Through tide current and	I/RA/11216/02.038/CMA

		salinity measurement	
Oosterweel	5/06/2002	Through tide current and salinity measurement	I/RA/11216/02.039/CMA
Oosterweel	12/06/2002	Through tide current and salinity measurement	I/RA/11216/02.040/CMA
Deurganckdok	5/06/2002	Through tide current and salinity measurement	I/RA/11216/02.041/CMA
Deurganckdok	12/06/2002	Through tide current and salinity measurement	I/RA/11216/02.042/CMA
Kallo	5/06/2002	Through tide current and salinity measurement	I/RA/11216/02.043/CMA
Kallo	12/06/2002	Through tide current and salinity measurement	I/RA/11216/02.044/CMA
Zandvliet	June 2002	Long term current and salinity measurement	I/RA/11216/02.046/FDK
Lillo-Ponton			
Deurganckdok			
Schelle			
Waarde Petroleum steiger			
Kallo	June 2002	Long term current and salinity measurement	I/RA/11216/02.047/FDK
Merelbeke	June 2002	Discharge measurement	I/RA/11216/02.029/CMA
Analysis of the data			I/RA/11216/02.045/CMA

Table 1 : survey of the measurement campaigns that have been conducted for the study on density currents in the river Scheldt.

1.3 The report

The first chapter forms the introduction, with a short description of the measurement campaign. Chapter 2 describes the measuring equipment used. Chapter 3 includes the proceedings of the measurement campaign. In chapter 4 the processing of the data set and the measurement results are presented.

2 THE MEASUREMENT CAMPAIGN

2.1 Description of the measurement campaign

The current and salinity measurement took place at Deurganckdok on June 5th 2002 from 5:00 MET until 19:20 MET and was carried out by Afdeling Maritieme Toegang (AMT).

From the survey vessel Veremans ADCP and CTD measurements were conducted. The measurements sequence relative to the tidal cycle : depending of wether it was eb of flood ctd profiling took place at the 2 downstream or 2 upstream locations, respectively. At a central point, ctd profiling was conducted throughout the entire measurement campaign. Three ADCP tracks were sailed. At the start of every hour the downstream track was sailed, followed by the entrance and upstream tracks. The CTD measurements sequence was relative to the tidal cycle : depending of wether it was eb of flood ctd profiling took place at the 2 downstream or 2 upstream locations, respectively. At one central point, ctd profiling was conducted throughout the entire measurement campaign.

Appendix 4 is gives an overview of the entire measurement plan, with the locations of the through tide measurement campaigns and the long term measurement locations.
Appendix 7 offers a survey of the measurement location with sailed ADCP tracks, whereas Appendix 8 gives a survey of the location where CTD profiles were measured.
Table 2 displays the average start and end point of the ADCP measurement tracks and the average length and course of the tracks.
Table 3 gives the average position of the CTD measurement points and the bottom depth at those locations.

name	Start easting	Start northing	End easting	End northing	Average length	Average course
DAD	589189.9	5684751	588599.3	5685057	668.89	117.34
DAE	588587.2	5685073	589113.4	5684175	1059.61	329.62
DAU	589107.1	5684176	589223.4	5684728	582.37	11.90

Table 2 Average start and endpoint of ADCP measurement tracks

name	Easting	Northing	Bottom depth (mTAW)
Dc3	589211.07	5319278.86	-8.79
Dc1u	589114.58	5684192.25	-7.96
Dc2u	589142.17	5710641.83	-13.53
Dc1d	588627.50	5685030.00	-15.81
Dc2d	588904.17	5684897.50	-12.48

Table 3 Average positions of the CTD measurement points

2.2 The equipment

The current measurements were conducted with the a RDI 600 KHz ADCP apparatus which had been fixed onto the vessel Veremans.
The apparatus was set so as to realize one ensemble per 5 seconds. The bin size was set to 0.5 m.

The conductivity and salinity profiling measurements were conducted with a Valeport 602 device, coupled with a measurement fish. While the fish was raised from the bottom to the water level, temperature and conductivity were measured at regular intervals, with a higher measurement frequency near the bottom. A configuration file was recorded at the start of the measurements.

Positioning was determined by a DGPS.

Appendix 3 gives the technical details for the equipment used.

3 THE MEASUREMENTS

3.1 Measurement periods

3.1.1 ADCP measurements

16 series of a ADCP measurements tracks have been conducted. Series 1-15 comprise all three tracks (downstream, upstream an entrance). A 16th serie has only data collected for the downstream track. All measurement series started with the downstream track (dad), followed by the entrance (dae) and upstream (dau) tracks. Appendix 7 gives a graphic survey of the sailed ADCP tracks, Appendix 5 gives the start and end points of the tracks, the sailed length and the course.

3.1.2 CTD measurements

As was already mentioned in § 3.1.2 not all 5 ctd measurement points were measured during all measurement cycles. Only at point dc3 (located centrally) ctd profiling measurements were conducted during 14 measurement cycles. At the points dc1d and dc2d (downstream location) profiling took place during flood, at the points dc1u and dc2u (upstream location) during ebb.

Appendix 6 gives the X and Y coordinates (UTM-ED50) of every measurement point, the bottom depth in mTAW, the maximum and minimum depth on which measurements took place and the depth average temperature and salinity.
Appendix 8 is a graphic overview of the locations of the CTD measurements.

3.2 Hydro-meteorological conditions during the measurement campaign.

3.2.1 Vertical tide during the measurement

The vertical tide was measured at the Liefkenshoek tidal measuring station A graphical representation of the tide, together with the tidal registrations for the other measurement locations of the through tide measurements can be found in Appendix 1.
Table 4 gives the most important characteristics (high and low tide) of the tide at Liefkenshoek on the day of the measurements

	Time (hh:mm MET)	**Water level (mTAW)**
LW (1)	5:30	0.29
HW (2)	11:35	4.81
LW (3)	17:50	0.4
HW (4)	23:45	4.68

Table 4 high tide and low tide Liefkenshoek on 5/06/2002

Table 5 compares the tidal characteristics of the measurement day to the average tide, the neap tide and the spring tide over the decade 1981-1990 (Claessens and Meyvis, 1994).

The tidal coefficient of 0.85 to 0.9 for the tidal data of 05/06/2002 indicates a neap tide with a tidal difference that is slightly higher to slightly lower than the average neap tide.

Liefkenshoek	**Neap tide ('81-'90)**	**Average Tide ('81-'90)**	**Spring Tide ('81-'90)**	**Tide 05/06/2002**
Water level (mTAW)				
LW (1)	0.43	0.1	-0.12	0.29
HW (2)	4.55	5.14	5.61	4.81
LW (3)	-	-	-	0.4
HW (4)	-	-	-	4.68
Tidal difference (m)				
Rising(1→2)	4.12	5.04	5.73	4.52
Falling (2→3)	4.12	5.04	5.73	4.41
Rising (3→4)	-	-	-	4.28
Duration (hh:mm)				
Rising (1→2)	5:59	5:33	05:16	6:05
Falling (2→3)	6:43	6:53	07:04	6:15
Rising (3→4)	-	-	-	5:55
Tide (1→3)	12:42	12:26	12:20	12:20
Tide (2→4)	12:42	12:26	12:20	12:10
Tidal coefficient				
Rising (1→2)	0.81	1	1.14	0.9
Falling (2→3)	0.81	1	1.14	0.88
Rising (3→4)	-	-	-	0.85

Table 5 Comparison of the tidal characteristics of 5/06/2002 with the average tide, the average neap tide and the average spring tide over the peroide 1981-1990.

3.2.2 Meteorological data

The wind velocity and direction was measured at Deurne meteorological station. On the 5th of June, the wind was blowing in an SSW-SSE direction, with velocities from daily average11 to maximum 40 km/h.

The average air temperature was 18.9°.(KMI maandbericht, 2002)

3.3 Naval Traffic

A survey of the naval traffic is given in Appendix 3.

4 PROCESSING OF THE DATA SETS

4.1 Methodology of processing

In the following chapter the results of the ADCP and CTD measurements will be discussed, as well as the processing of the data.

4.1.1 Processing of the ADCP data set

An overview of the ADCP measurements has already been given in Table 2.
The results of the ADCP measurements can be found in Appendix 9. The processing of the data was carried out by IMDC.

The software package TRANSECT was used to process the raw data.
The movement of the ADCP sensor during the recording has been calculated with the "bottom track" information. This " bottom track" information is recorded by the ADCP itself during the measurements. Flow velocity and direction were calculated with the help of the "bottom track" information.
The validation of the ADCP data has been conducted on a visual basis and on the basis of the calculated discharge data per measured cel ("bin"): in cases where the value given for this discharge was the dummy value, it was supposed that the velocity information for this particular cel was unreliable. Cells with unreliable data were deleted.

Further processing of the ADCP data included (for the downstream (dad) and upstream (dau) measurements):

- Drawing a contouring map over the section of the perpendicular velocity
- Drawing a contouring map over the section of the parallel velocity
- Drawing the variation in depth average perpendicular and parallel velocity along the measurement line
- Drawing the velocity magnitude and direction along the measurement line
- Calculation of the cross-sectional averaged velocity over the sailed cross-section

Further processing of the ADCP data included (for the entrance (dae) measurements) :

- Drawing a contouring map over the section of the u velocity
- Drawing a contouring map over the section of the v velocity
- Drawing the variation in depth average u and v velocity along the measurement line
- Drawing the velocity magnitude and direction along the measurement line

For the processing of the ADCP data, the data measured along the dad and dau (upstream and downstream tracks) were projected on an "theoretical measurement track", in order to make comparisons between the different measurement cycles more straightforward. This "theoretical measurement track" was defined as the track between the two outermost measurement points. Table 6 gives the coordinates of start and ending point of the track.
The data collected along the dae track were not projected on an average track. The shape of the track was such that projection would have affected the presentation and understanding of the data in a negative way. Therefore no projection has been applied on the dataset.

	Start Easting	Start Northing	End Easting	End Northing
dad	588606.77	5685068.73	589227.55	5684695.52
dau	589110.56	5684153.71	589230.49	5684740.84
dae	-			

Table 6 coordinates (UTM-ED50) of the "theoretical measurement track"

The velocity measurements have been extrapolated upwards and downwards.. In the downward direction, a region of approximately 2 to 2.5 meters was extrapolated, in the upward direction, around 2 m . The upward extrapolation was done using a constant value .The downward extrapolation was conducted using Equation 4-1 (Van Rijn, 1993).

$$v = v_1 \left(\frac{z}{z_1} \right)^{0.25} \quad (4\text{-}1)$$

in which v_1= current velocity in the first measurement point above the bottom
z_1=height of the first measurement point above the bottom

For the drawing of the contouring maps, the data was interpolated on a regular 40*15 points grid. For the drawing of the contouring plots of the non-projected track (Dae), the data was interpolated at 25 m intervals (horizontally) over 15 points (vertically).

The current velocities are negative in the flood direction and positive in the ebb direction. Or for the tracks with a N-S orientation, positive to the West, negative to the East. The discharge was calculated by multiplying the depth-average velocity per ensemble with the distance to the following ensemble, multiplied by the height of the ensemble.

4.1.2 Processing of the CTD results

In Appendix 6 a survey is given of the CTD measurement points. The results of the CTD processing can be found in Appendix 10.

The salinity was calculated from the temperature and conductivity using the pps-78 formula (UNESCO,1991). Appendix 11 gives the calculation.

The validation of the CTD data was done visually : data showing strong deviations were deleted from the profiles.
The coordinates as well as the values for the bottom depth were deducted from the ADCP measurement that were conducted during the CTD profiling.

For every CTD profile a measurement report was made. Besides general information, this report contains a graphical representation of the conductivity, the temperature and the salinity in function of the depth. The measurement values are represented in a table (in the case of measurements at relatively deep points not all measurement values are notated) and the depth average values for salinity, temperature and conductivity are given.

4.2 Storage of the data

The content of the folder "Deurganckdok 0506" in the CDROM 11216-1 are the following directories :

-RA02041-Deurganckdok05062002 : the electronic version of this report
-“processed adcp data”
    da*n.txt : validated data, in the agreed format
-“processed ctd data” :
    dc*n.txt : validated data

5 REFERENCES

N.P.Fotonoff and R.C.Millard Jr (1983.),'Algorithms for computation of fundamental properties of seawater', N.P.Fotonoff and R.C.Millard Jr., Unesco technical papers in marine science, Unesco 1983.

KMI maandbericht (2002) Klimatologische waarnemingen juni

Meyvis en Claessens (1991) Overzicht van de tijwaarnemingen in het Zeescheldebekken gedurende het decennium 1981-1990

Unesco (1991) Processing of Oceanographic Station Data

Van Rijn, L. (1993) Principles of Sediment Transport in rivers, estuaries and coastal seas.

APPENDICES

Appendix 1 : Tidal data for all through tide measurement locations on 05/06/2002

Appendix 2:The Equipment Used

Appendix 3 : Survey of the naval traffic

Appendix 4: Plan of the measurements

Appendix 5: Start and endpoint of the sailed ADCP lines, sailed length and course

Appendix 6: Coordinates of CTD measurement points, bottom depth, and maximum & minimum measurement depth

Appendix 7: Graphic survey of the sailed ADCP measurement tracks

Appendix 8: Graphic survey of CTD measurement locations

Appendix 9: Processing of the ADCP data set

Appendix 10: Processing of the CTD data set

Appendix 11: Calculation of the salinity (pps-78 formula)

Appendix 12: Organisation of the files