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Departement Leefmilieu en Infrastructuur
Afdeling Waterwegen en Zeewezen
Afdeling Waterbouwkundig Laboratorium en Hydrologisch Onderzoek

STUDIE DENSITEITSSTROMINGEN IN HET KADER VAN LTV

STROOM- EN SALINITEITSMETING TE OOSTERWEEL UITGEVOERD OP 05/06/2002

I/RA/11216/02.039/CMA
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en i.s.m.

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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 take n 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-assig nment 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 Oosterweel 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 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.

Table 1 gives a survey 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 measurement locations.

This report is the factual data report of the through tide current and salinity measurements at Oosterweel 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 salinity measurement	I/RA/11216/02.038/CMA
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 Lillo-Ponton Deurganckdok Schelle Oosterweel Petroleum steiger	June 2002	Long term current and salinity measurement	I/RA/11216/02.046/FDK
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 and Interpretation of the Measurement 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 Oosterweel on june 5th 2002 from 5:00 MET until 19:00 METand was conducted by Afdeling Maritieme Toegang.

The purpose of the measurements was to determine the variation in the vertical structure of the velocity distribution from neap to spring tide as well as the variation of the salinity during successive tidal cycles.

From the survey vessel Parel ADCP and CTD measurements were conducted. The measurements followed a cyclic pattern. At the start of every half hour an ADCP measurement was conducted (sailing from the left bank towards the right bank of the river). While sailing back to the starting point of the ADCP measurement track, CTD profiles were measured in the 3 measurement points.

Appendix 4 is a survey 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 positions 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
Oan	595770.4	5677260	595803.7	5677676	422.5	4.6

Table 2 Average start and endpoint of ADCP measurement tracks

Measurement point	Easting	Northing	Bottom depth (mTAW)
Oc1	595775.1	5677337	-11.9
Oc2	595759	5678241	-12
Oc3	595797.7	5677591	-7.9

Table 3 Average positions of the CTD measurement points

2.2 The equipment

The current measurements were conducted with the help of a RDI 1200Khz ADCP apparatus which had been fixed onto the vessel PAREL. Appendix 2 gives the technical details for the ADCP.
The apparatus was set so as to realize an average of one ensemble every 5 seconds. The vertical resolution ("bin size") was 0.5 m.

The conductivity and temperature profiling measurements were conducted with the help of a Valeport 602 device, which was attached to a winch and lowered manually. Appendix 2 gives the technical details for the equipment used.

A DGPS was used for the positioning.

3 PROCEEDINGS OF THE MEASUREMENTS

3.1 Measurement periods

3.1.1 ADCP measurements

In all, 29 ADCP measurements have been conducted along the measurement track. All measurement tracks were sailed from the left bank of the river to the right bank of the river, the average course was 5° with respect to North. 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

In three CTD measurement points measurements were conducted during 29 cycles. The measurements were conducted as profiling measurements. A Valeport 602 CTD sensor attached to a david was lowered to the bottom . While the sensor was being raised from the bottom to the water level, temperature and conductivity were measured at regular distances above the bottom.

Appendix 6 gives the X and Y coordinates (UTM-ED50) of the every measurement point , the bottom depth in mTAW, the maximum and minimum depth on which measurements took place and the depth averaged 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 Oosterweel tidal measurement 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 Hansweert on the day of the measurements

	Time (hh:mm MET)	Water level (mTAW)
LW (1)	5:45	0.27
HW (2)	11:50	4.94
LW (3)	18:15	0.45
HW (4)	23:55	4.83

Table 4 high tide and low tide at Oosterweel on 5/06/2002

In Table 5 the tidal characteristics of the measurement day are compared to the average tide over the decade 1981-1990 (Claessens and Meyvis, 1994) .
The tidal coefficient of 0.84 to 0.90 for the tidal data of 05/06/2002 indicates a neap tide with a tidal difference that is slightly higher than the average neap tide.

Oosterweel	**Neap tide (‘81-’90)**	**Average Tide (‘81-’90)**	**Spring Tide (‘81-’90)**	**Tide 05/06/2002**
Water level (mTAW)				
LW (1)	0.38	0.05	-0.17	0.27
HW (2)	4.69	5.24	5.20	4.94
LW (3)	-	-	-	0.45
HW (4)	-	-	-	4.83
Tidal difference (m)				
Rising(1→2)	4.20	5.19	5.87	4.67
Falling (2→3)	4.20	5.19	5.87	4.49
Rising (3→4)	-	-	-	4.38
Duration (hh:mm)				
Rising (1→2)	05:54	05:22	05:00	6:05
Falling (2→3)	06:48	07:03	07:20	6:25
Rising (3→4)	-	-	-	6:40
Tide (1→3)	12 :42	12:25	12:20	12:30
Tide (2→4)	-			12:05
Tidal coefficient				
Rising (1→2)	0.81	1	1.14	0.90
Falling (2→3)	0.81	1	1.14	0.86
Rising (3→4)	-	-	-	0.84

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 decade 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 DATASETS

4.1 Methodology of processing

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

4.1.1 Processing of the ADCP dataset

A survey of the ADCP measurements has already been given in Table 2.
The results of the ADCP measurements can be found in Appendix 9. The acquisition as well as a part of the processing of the ADCP data was conducted by AMT.

In the processing of the ADCP data, the bottom track information collected by the ADCP was used.
The displacement 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 that was 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.
The values for the bottom depth were deduced from the adcp measurements. In case where no bottom depth value was available a dummy value is given.

Further processing of the ADCP data included :

- Drawing a contouring map over the section of the perpendicular velocity
- Drawing a contourig map over th e section of the parallel velocity
- Drawing the variation in depth averaged velocity and the discharge along the measurement line
- Drawing the velocity magnitude and direction along the measurement line
- Calculation of the total discharge over the sailed section
- Calculation of the area of the sailed cross-section
- Calculation of the cross-sectional averaged velocity over the sailed cross-section

For the processing of the ADCP data, all measured data were projected on an “theoretical measurement track”, in order to make comparisons between the different measurement cycles more straightforward. This “theoretical measurement track” was calculated from the averaged measurement tracks coordinates and runs from the left bank top of the dike to the right bank top of the dike. . Table 6 gives the coordinates of start and ending point of the track.

	Start Easting	Start Northing	End Easting	End Northing
	595777.64	5677181.9	595801.15	5677852.32

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

The velocity measurements have been extrapolated upwards and downwards.

The upward extrapolation was done using a constant extrapolation. In the downward direction, a region of approximately 1.5 meters was extrapolated, in the upward direction, around 1 – 1.5 m was extrapolated. The downward extrapolation was conducted using Equation 4-1(Van Rijn, 1993).

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

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. The bathymetry used in the presentation was derived from bathymetric surveys, carried out by AMT.

The current velocities are negative in the flood direction and positive in the eb direction. The discharge was calculated by multiplying the depth-averaged velocity per ensemble with the distance to the following ensemble, multiplied by the thickness 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 that showed 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 when possible, the depth averaged values for salinity, temperature and conductivity are given.

4.2 Storage of the data

The contents of the folder “Oosterweel 1206” in the CDROM 11216-1 are the following

-RA02039-Oosterweel05062002 : de electronic version of this report

-“processed adcp data”

Oa*n.txt : validated data, in the agreed format

-“processed ctd data” :

Oc*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
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