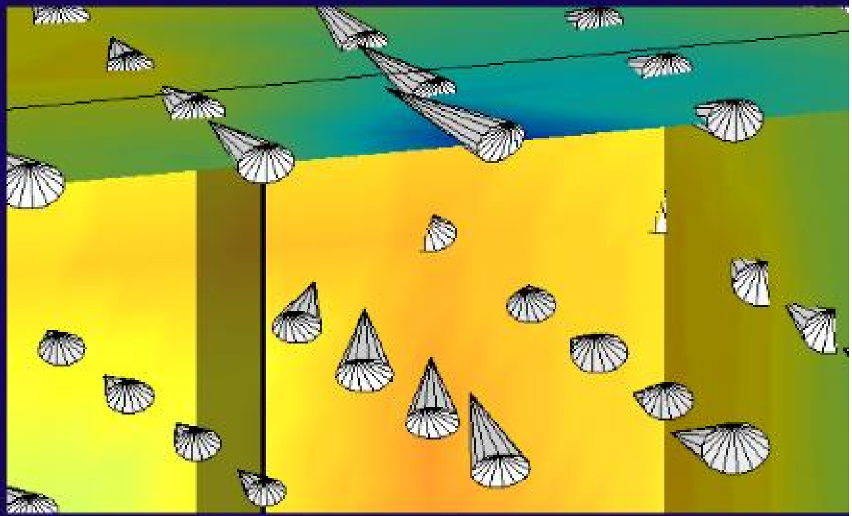

Experimental research on the effects of surface screens on a mobile bed

S.T. Troost

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TU Delft
Delft University of Technology

APPENDICES

Experimental research to the effects of surface screens on a mobile bed

MSc. Thesis

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Figure 2 Overview flume, seen from downstream boundary, with division wall

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Figure 4 Upstream boundary condition in front of perforated plate

Figure 5 Overview dune structure, looking from downstream in upstream direction

Figure 6 Sediment weir on bed level at the downstream boundary

B PREDICTED FLUME PARAMETERS

Input

Chezy	C	25	m^0.5/s		
Discharge	Q	0.0295	m^3/s	29.5	l/s
Width flume	b	0.6	m		
	q	0.049166667	m^2/s		
Gravity	g	9.81	m/s^2		
Bottom slope	i	1.40E-03	m/m		
Grain diameter	D10	0.164	mm	0.000164	m
	D50	0.238	mm	0.000238	m
	D90	0.337	mm	0.000337	m
Drag coeff	Cd	4.82	-		
Density water		1000	kg/m^3		
Density sediment		2650	kg/m^3		
Rel.density		1.65	-		
Length flume	L	21	m		

Calculations

Equilibrium depth	he	0.1403	m
Velocity	u	0.3504	m/s
Froude number	Fr	0.2987	
Settling velocity	ws	0.0326	m/s
	u*	0.0439	
Shields parameter	theta	0.5002	
	C90	66.576	m^0,5/s
	mu	0.2301	

Checks

mu*theta	0.1151	
ws/u*	0.7436	-
D50	0.238	mm

Transport

Engelund Hansen	S	8.33E-06	m^3/s	excl pores
		0.72	m^3/day	
		262.65	m^3/year	
	qs	3.47E-05	m^2/s	incl pores
	Qs	2.08E-05	m^3/s	
		22.07	g/s	
		0.74	g/l	
		1906.90	kg/day	
		696019	kg/year	

Meyer-Peter-Muller	S	2.10E-06	m^3/s	excl pores
		0.18	m^3/day	
		66.25	m^3/year	
	qs	8.75E-06	m^2/s	incl pores
	Qs	5.25E-06	m^3/s	
		5.57	g/s	
		0.19	g/l	
		480.96	kg/day	
		175549	kg/year	

C EQUIPMENT

Flow velocity

ADV Vectrino

The Vectrino is used to measure the flow velocity just behind the screen with great accuracy. The device was mounted on the measure chart to be able to move it along the flume.

Figure 7 Vectrino mounted on measuring chart

EMS

The EMS is used to measure the upstream boundary condition after the perforated plate was added to smoothen the flow. The EMS measures flow velocities in two direction, the x-direction and the y-direction in the chosen coordinate system. The zero-value of the EMS is calibrated using a bucket with non-moving water.

Figure 8 The EMS velocity measurement device

Discharge

The Proline Prosonic is calibrated for the diameter of the pipe which it is mounted on. This value can be programmed to the device, calibration factors are automatically included. The acoustic sensors are mounted on the return pipe, measuring trough the steel part of the pipe.

Figure 9 Display of discharge measurement device

Figure 10 Acoustic sensors of the Proline Prosonic

Sediment and transport

Return flow

The sediment tap in return flow was initially used to determine the transport. A measure duration of 60 hours was taken. Every 10 minutes a bucket of 10 liters of mixture was taken from the return pipe. The 6 buckets including the water have been weighted. Thereafter the water is filtered out of the mixture.

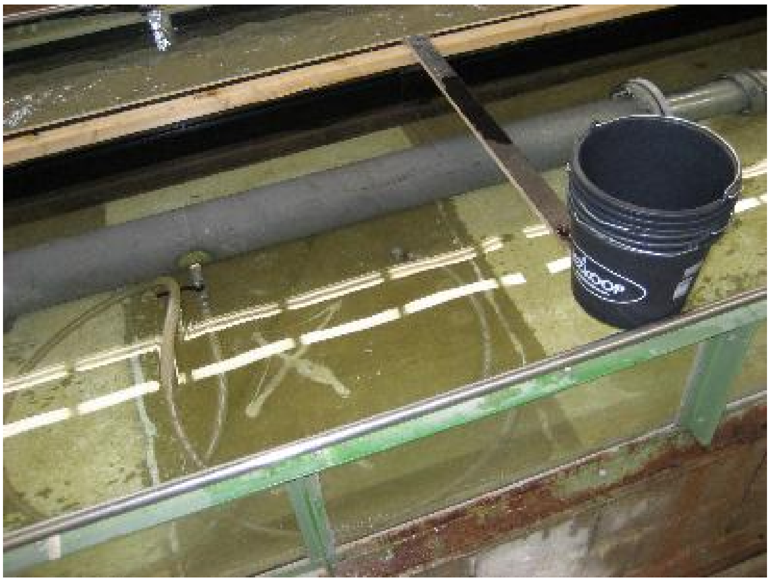

Figure 11 Sediment tap in return pipe

Sediment trap

Figure 12 Sediment trap at the downstream boundary

Vacuum filter

The vacuum filter for sediment is used to separate water and particles from the taken sample. After the water had been filtered from the mixture, the remaining sediment is dried in an oven at constant temperature. After drying for 12 hours, the relative small samples completely dried. After acclimatizing in a glass bell with special vapor attracting material, the sediment was weighted.

Figure 13 Vacuum filter for separating the water-sediment mixture

Water level, bottom profile

Lasers where used to measure the bottom profile and the water level. As can be seen in Figure 14, the measurements are taken simultaneously. One laser is located under water and it is packed in plastic to prevent it getting wet. The other laser is located above a sheet of paper in order to get a reflection surface. If the sheet of paper was not mounted, the laser would just penetrate the water surface in about 90% of the measurements.

Figure 14 Lasers for water level and bed level measurement

D INITIAL RUN

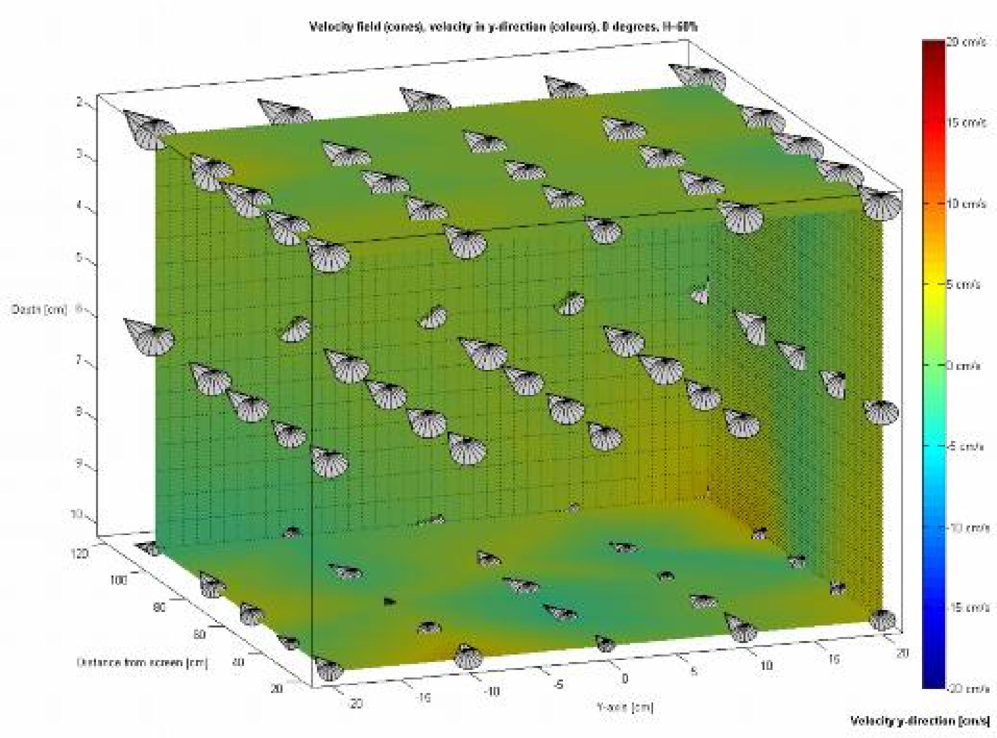

Figure 15 General stream pattern, 0 degrees, H=60%

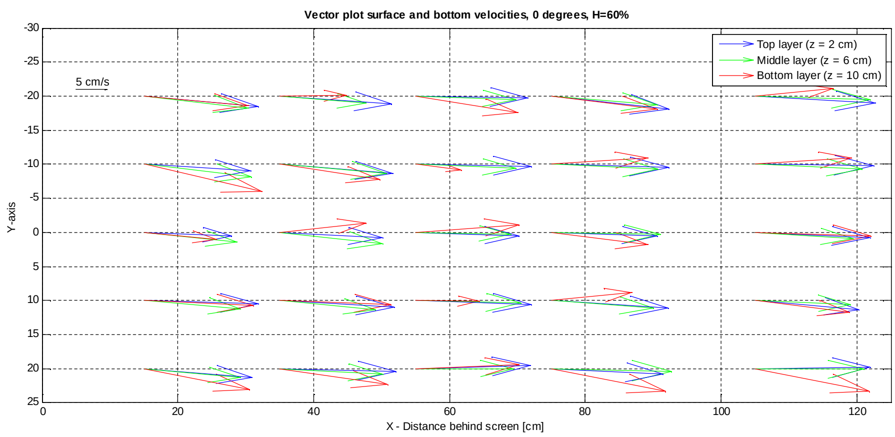

Figure 16 Top view velocity vectors behind the screen, 3 layers

E RESULTS A-SERIES

E.1 15 degrees, H=20%

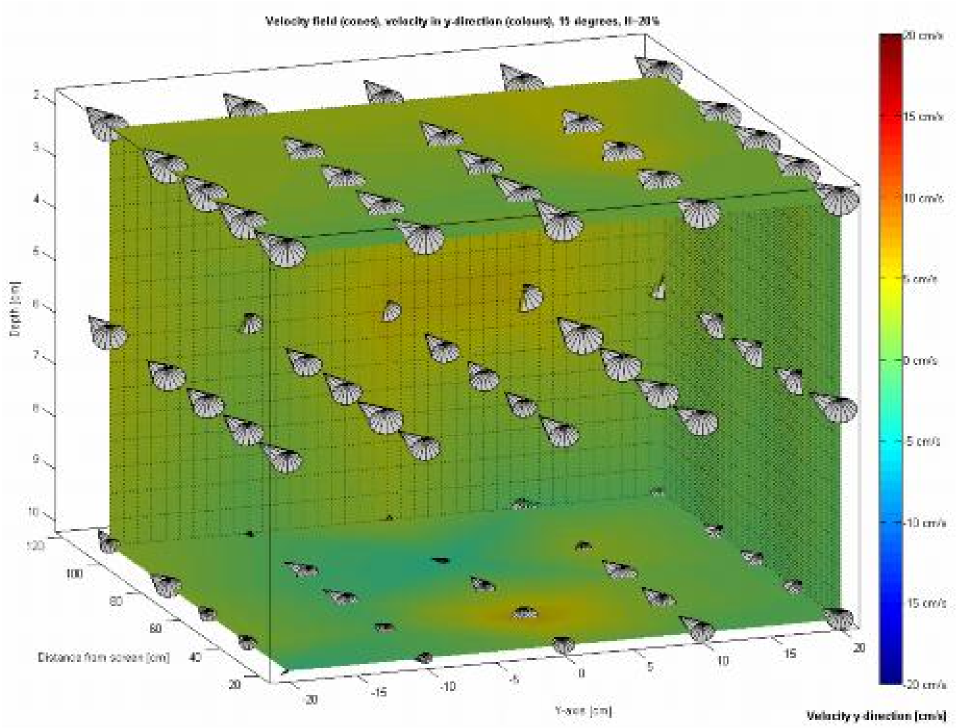

Figure 17 General stream pattern 15 degrees, H=20%

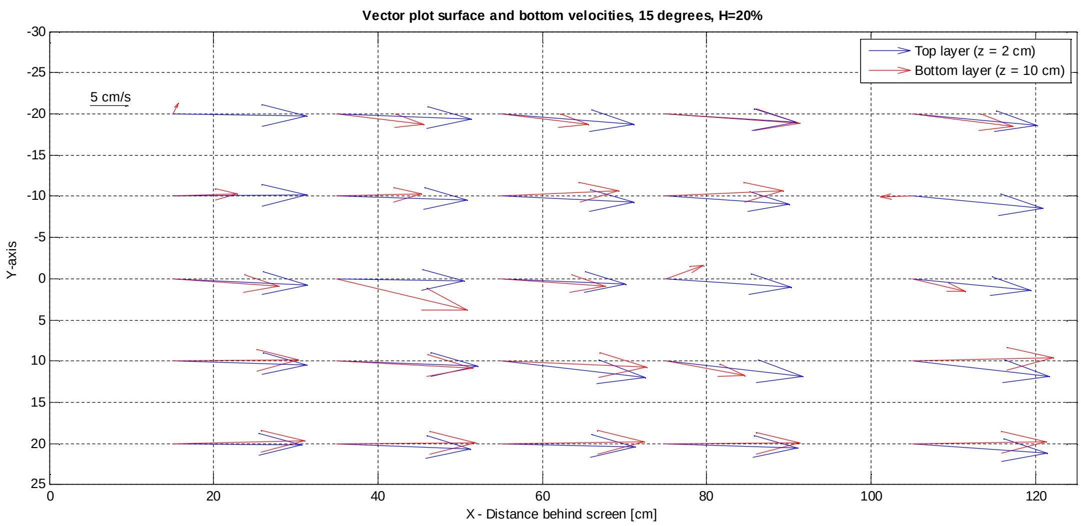

Figure 18 Top view velocity vectors behind the screen

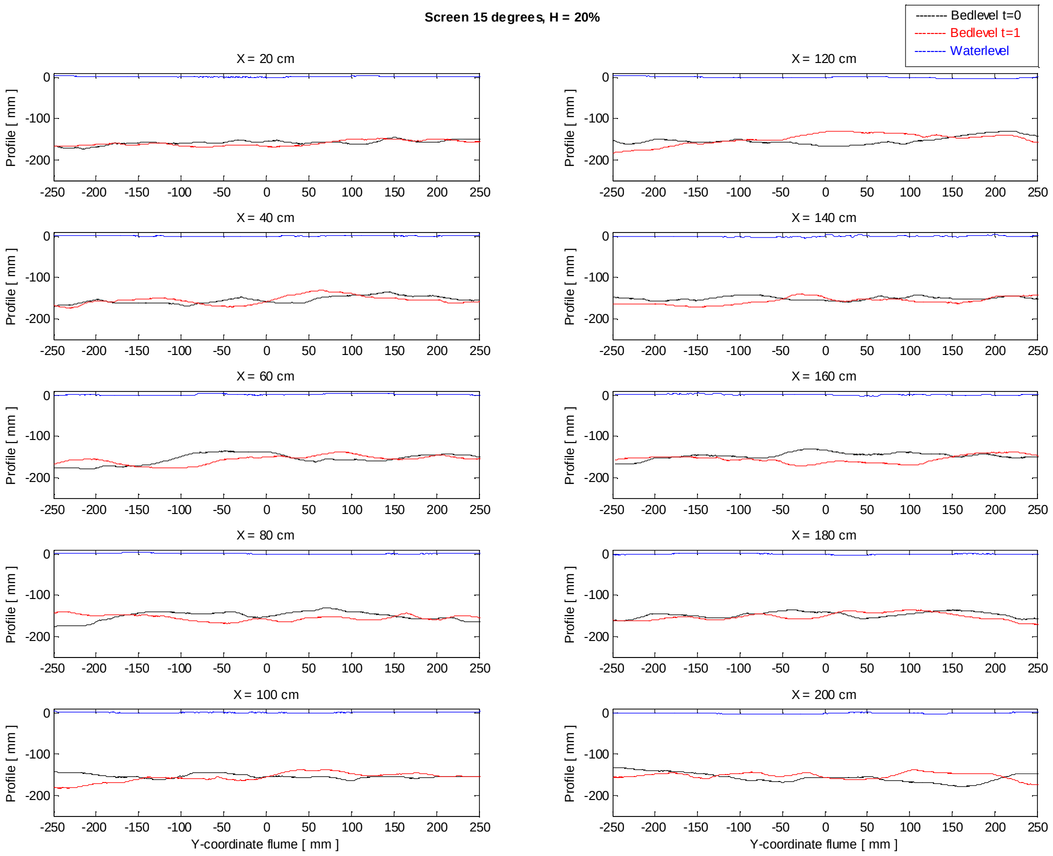

Figure 19 Morphological development, 15 degrees, H=20%

E.2 15 degrees, H=40%

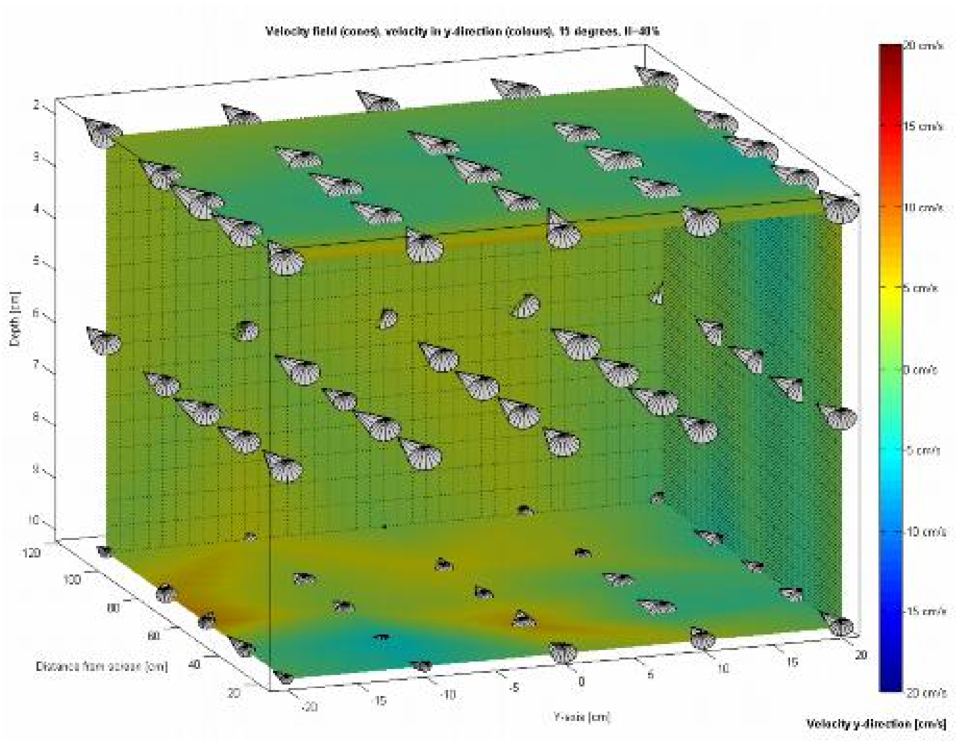

Figure 20 General stream pattern, 15 degrees, H=40%

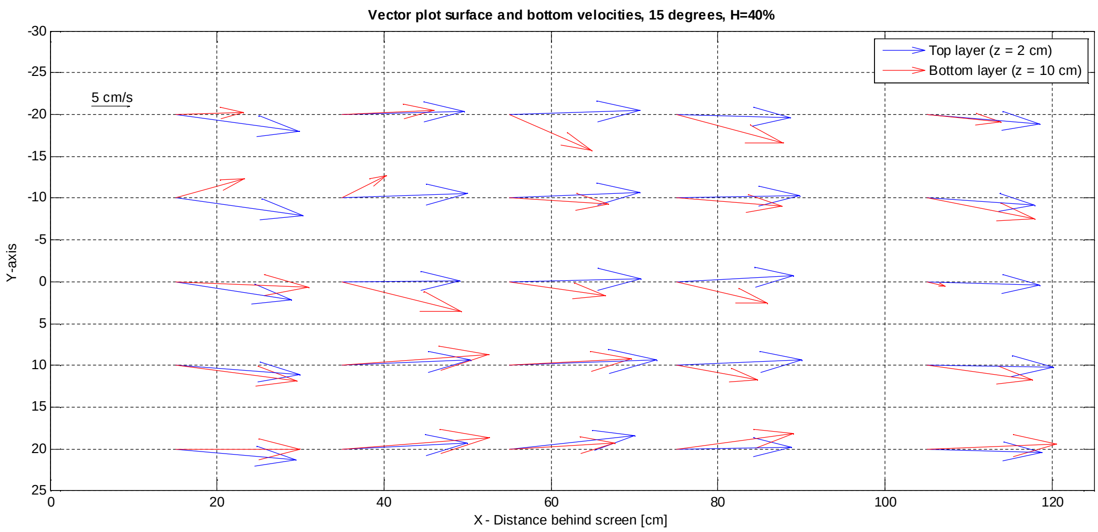

Figure 21 Top view velocity vectors behind the screen

E.3 15 degrees, H=60%

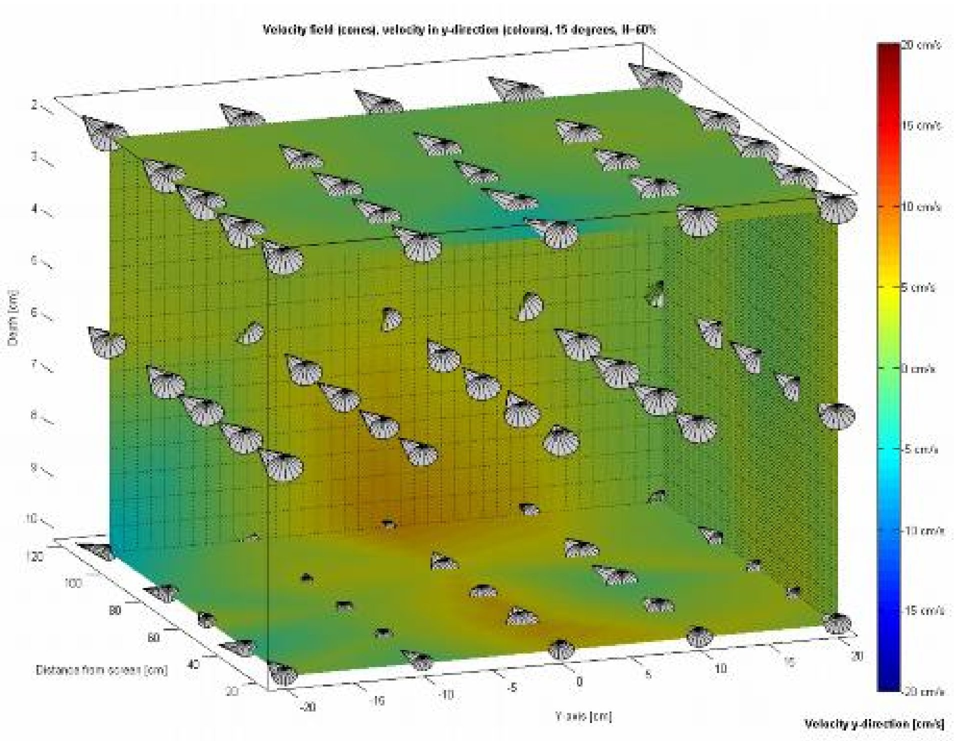

Figure 22 General stream pattern, 15 degrees, H=60%

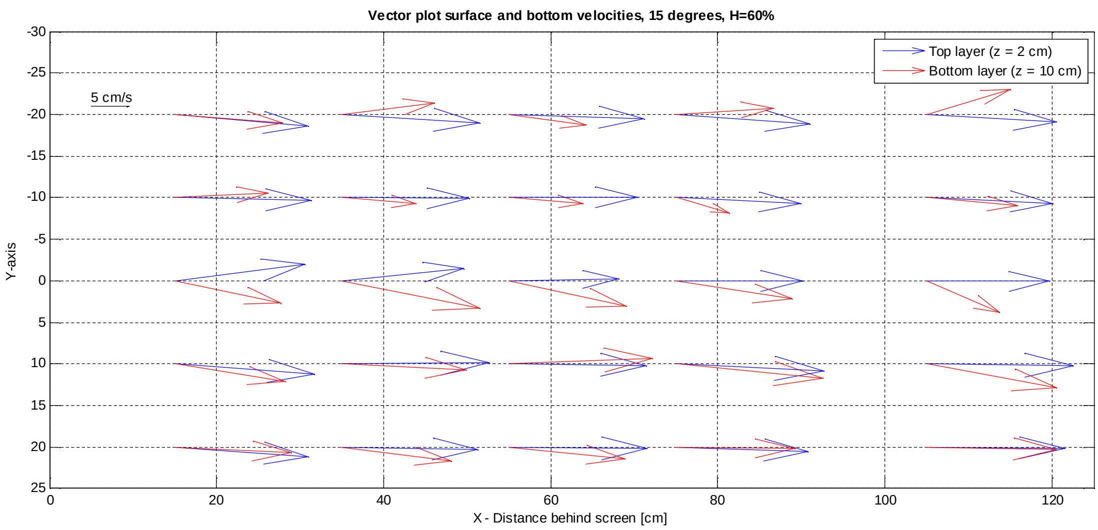

Figure 23 Top view velocity vectors behind the screen

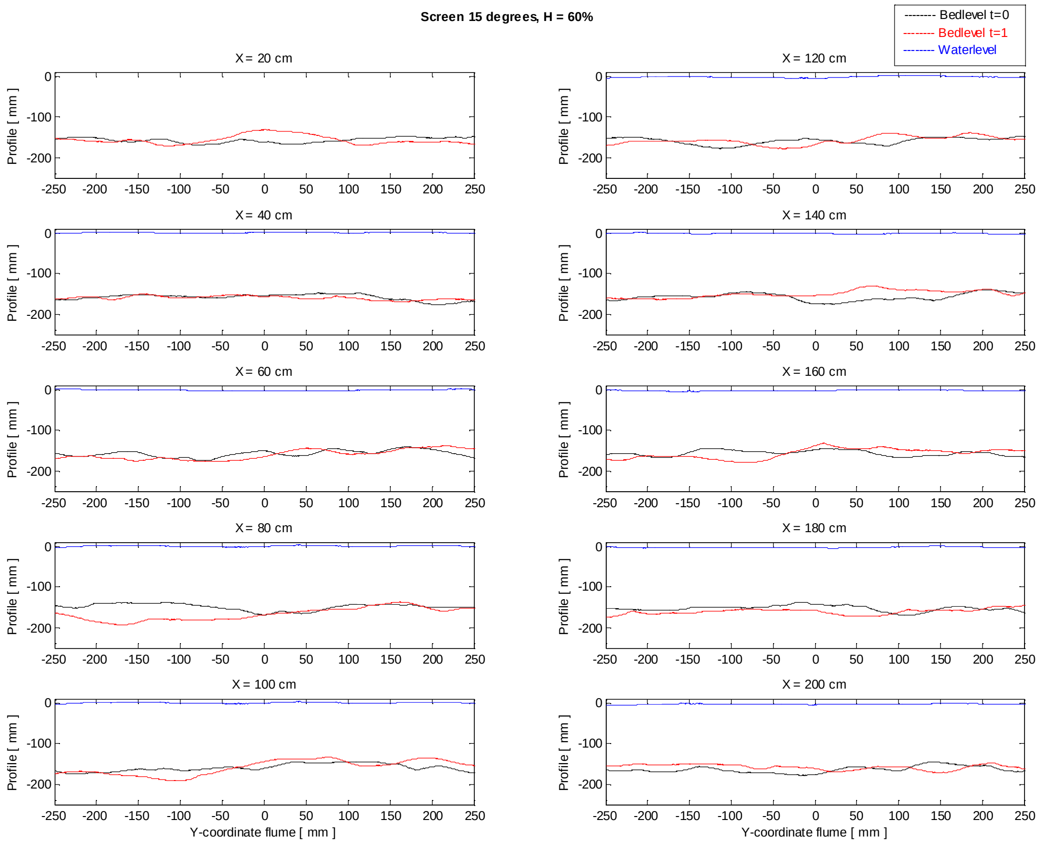

Figure 24 Morphological development, 15 degrees, H=60%

E.4 20 degrees, H=20%

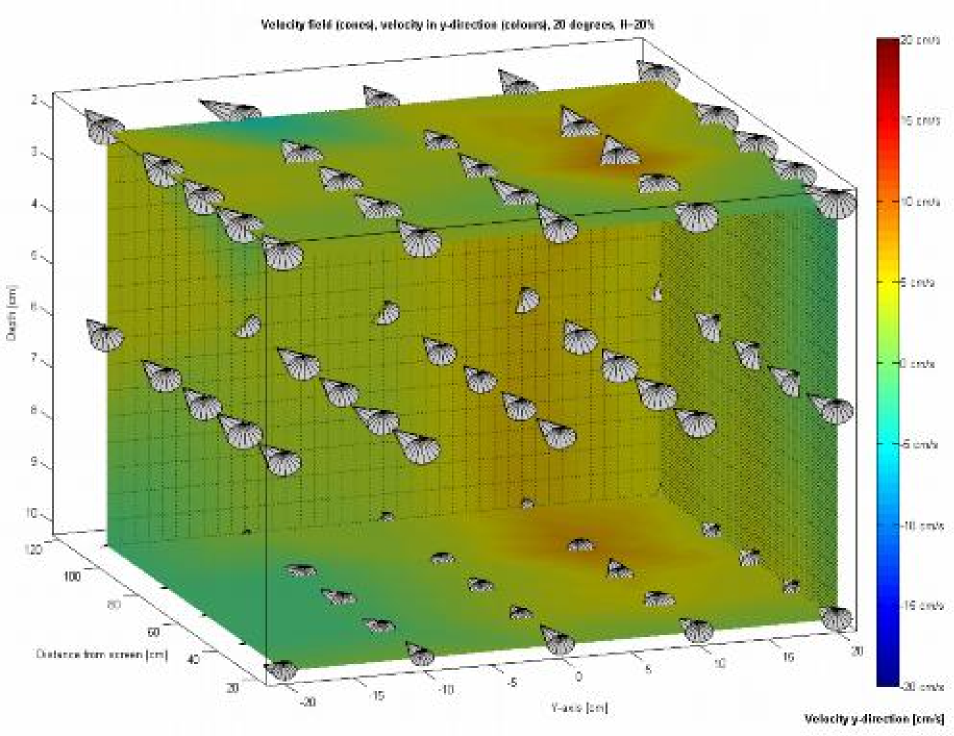

Figure 25 General stream pattern, 20 degrees, H=20%

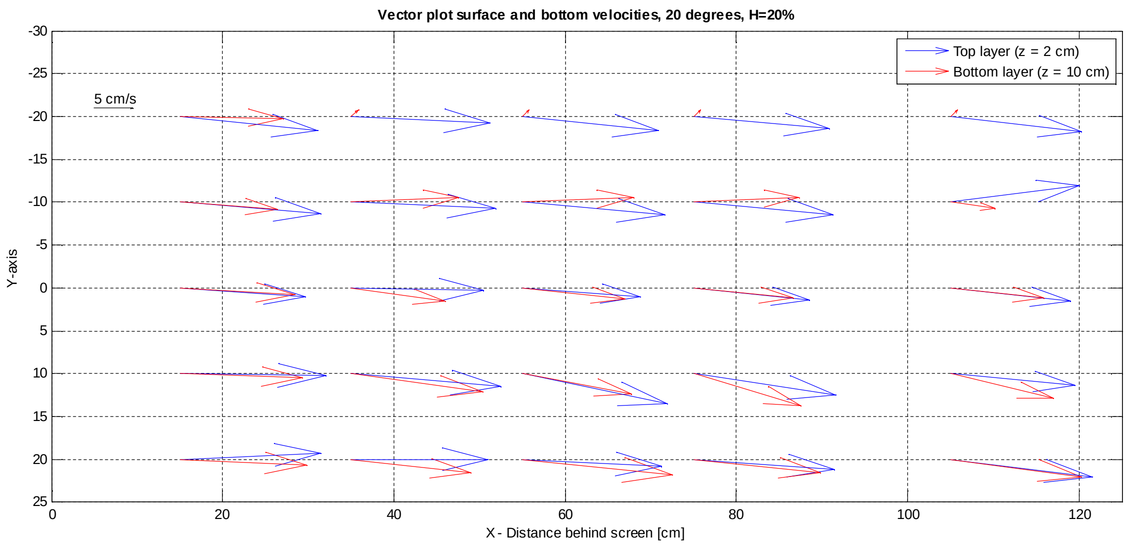

Figure 26 Top view velocity vectors behind the screen

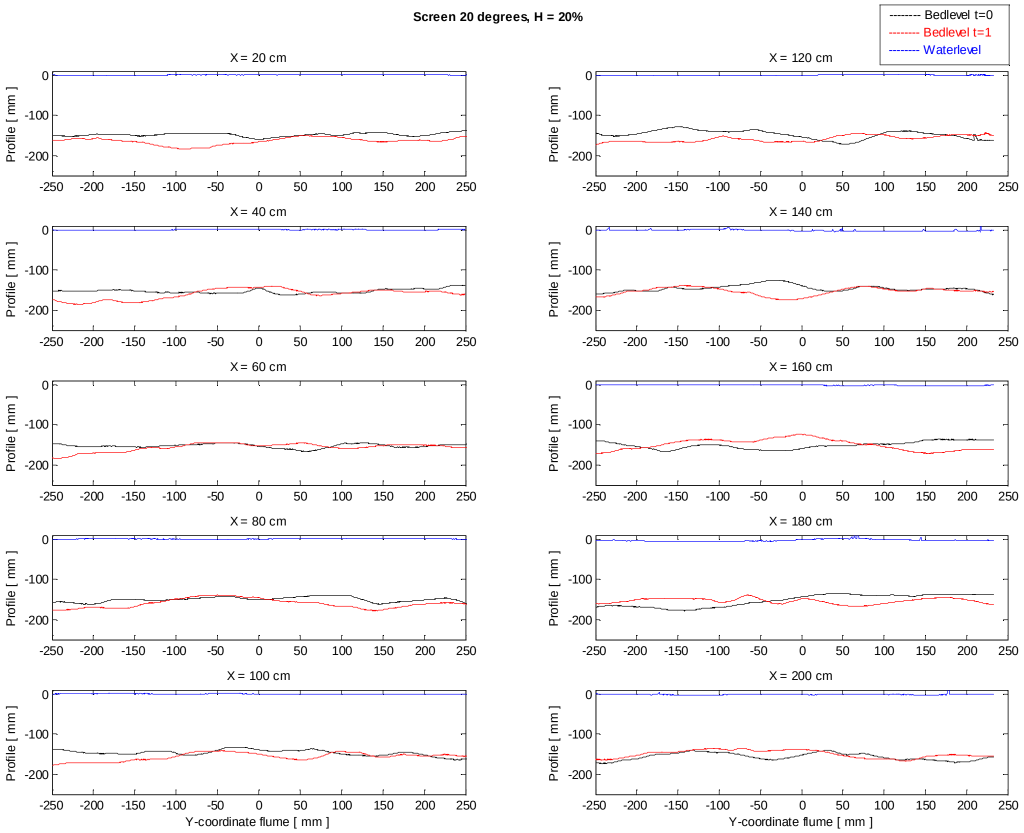

Figure 27 Morphological development, 20 degrees, H=20%

E.5 20 degrees, H=40%

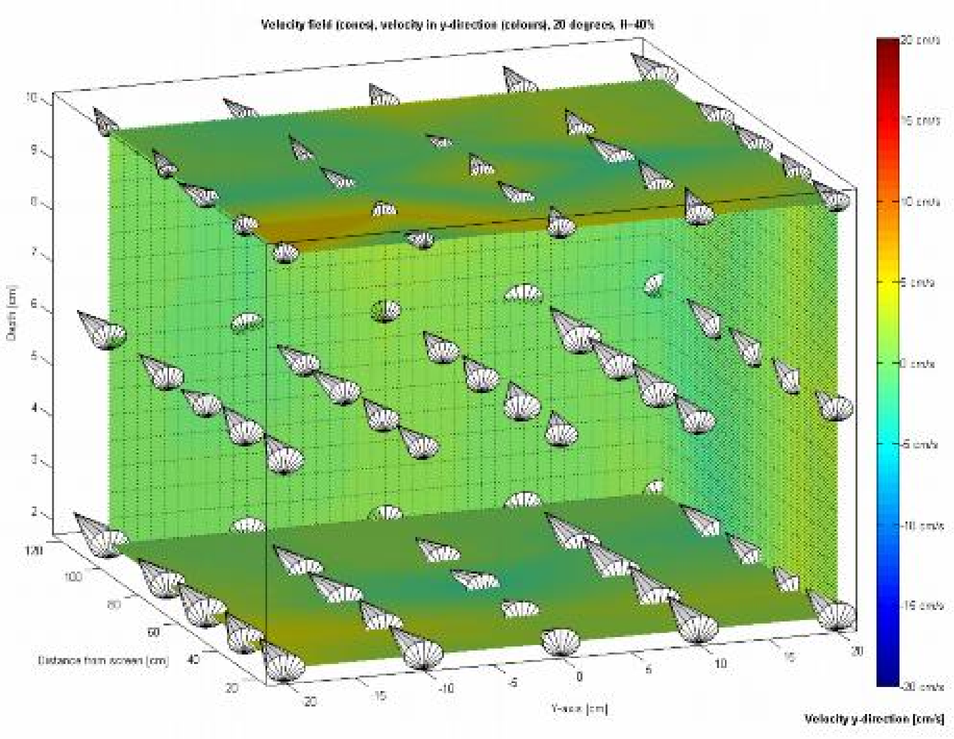

Figure 28 General stream pattern, 20 degrees, H=40%

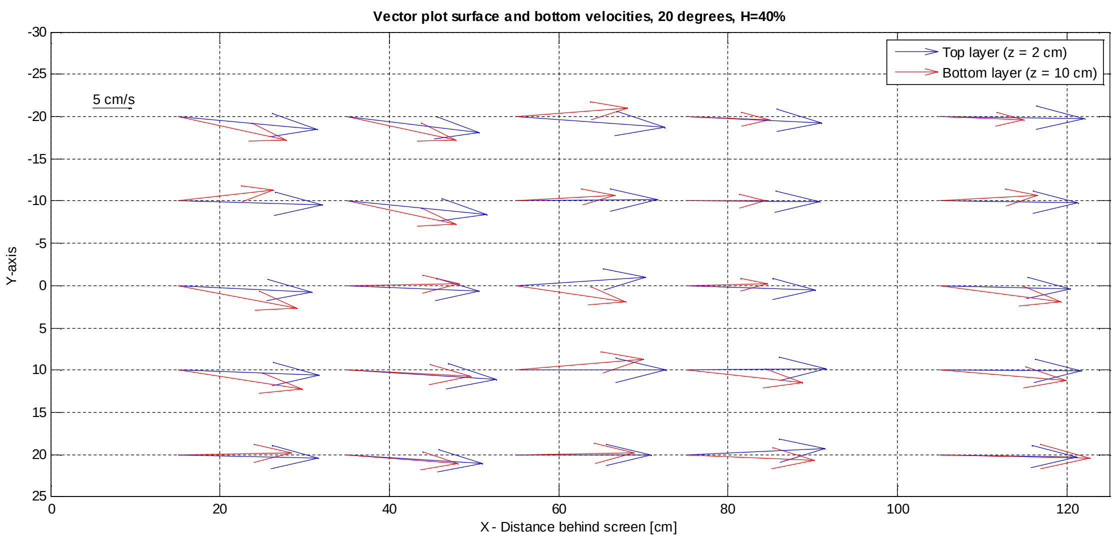

Figure 29 Top view velocity vectors behind the screen

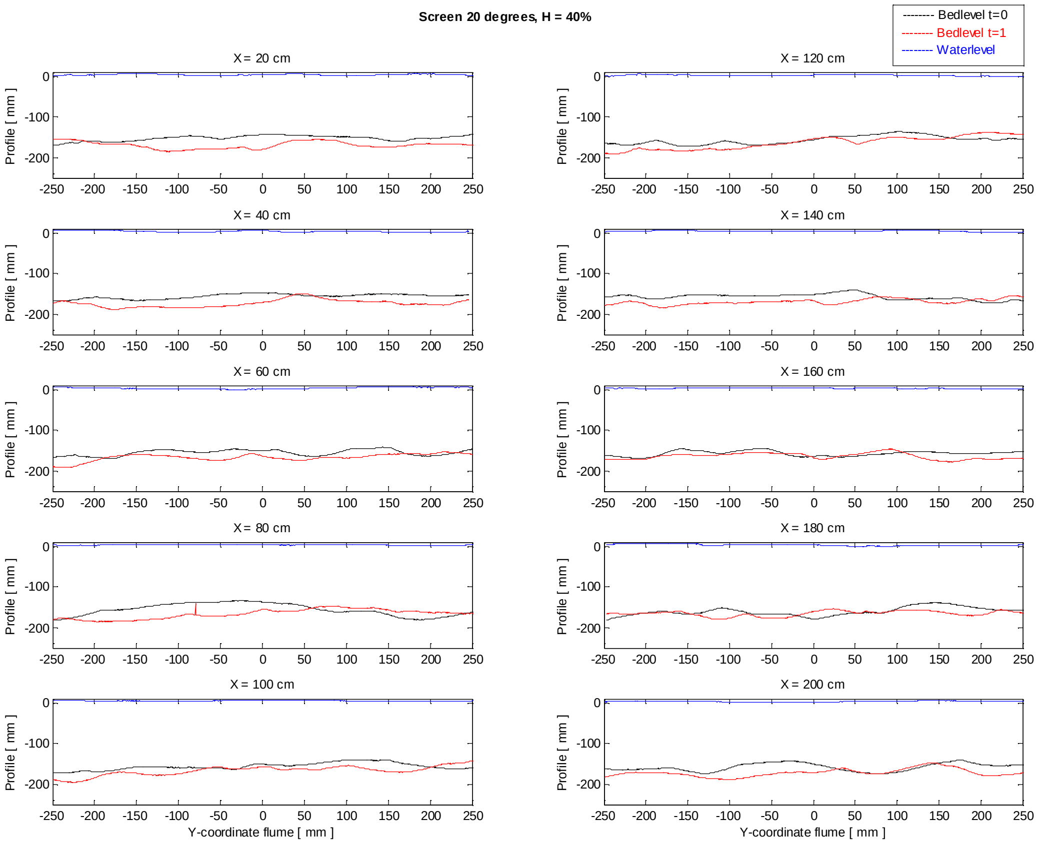

Figure 30 Morphological development, 20 degrees, H=40%

E.6 20 degrees, H=60%

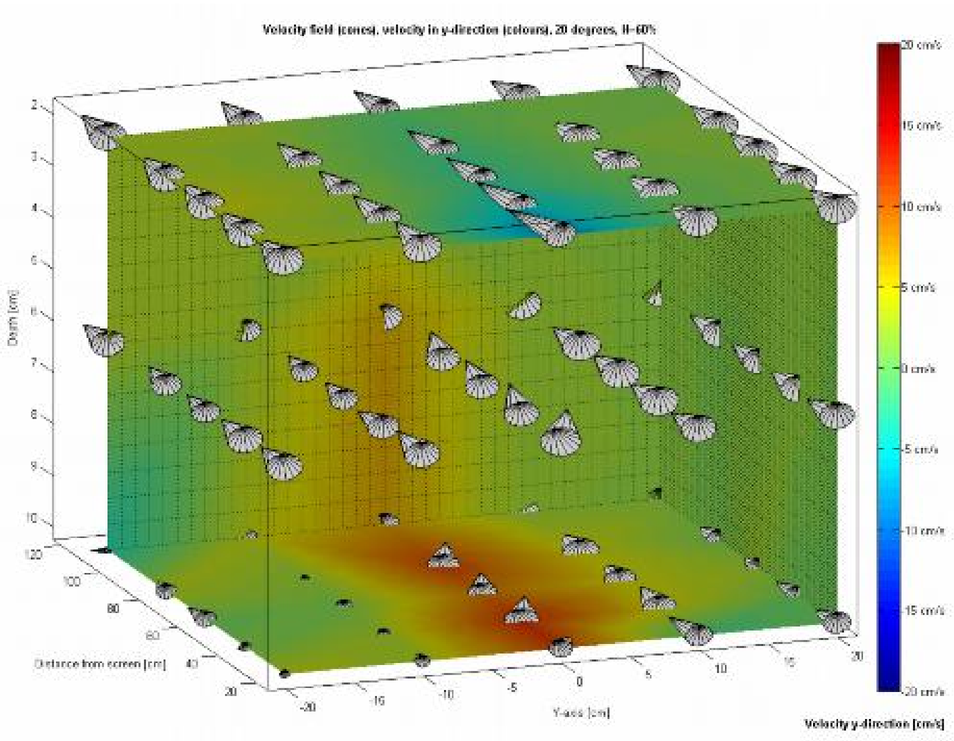

Figure 31 General stream pattern, 20 degrees, H=60%

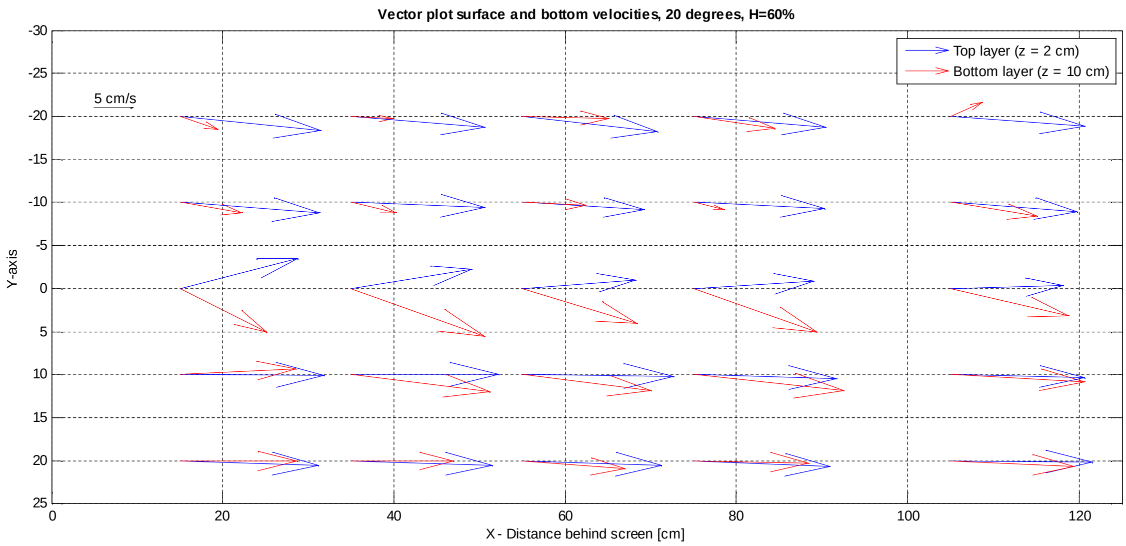

Figure 32 Top view velocity vectors behind the screen

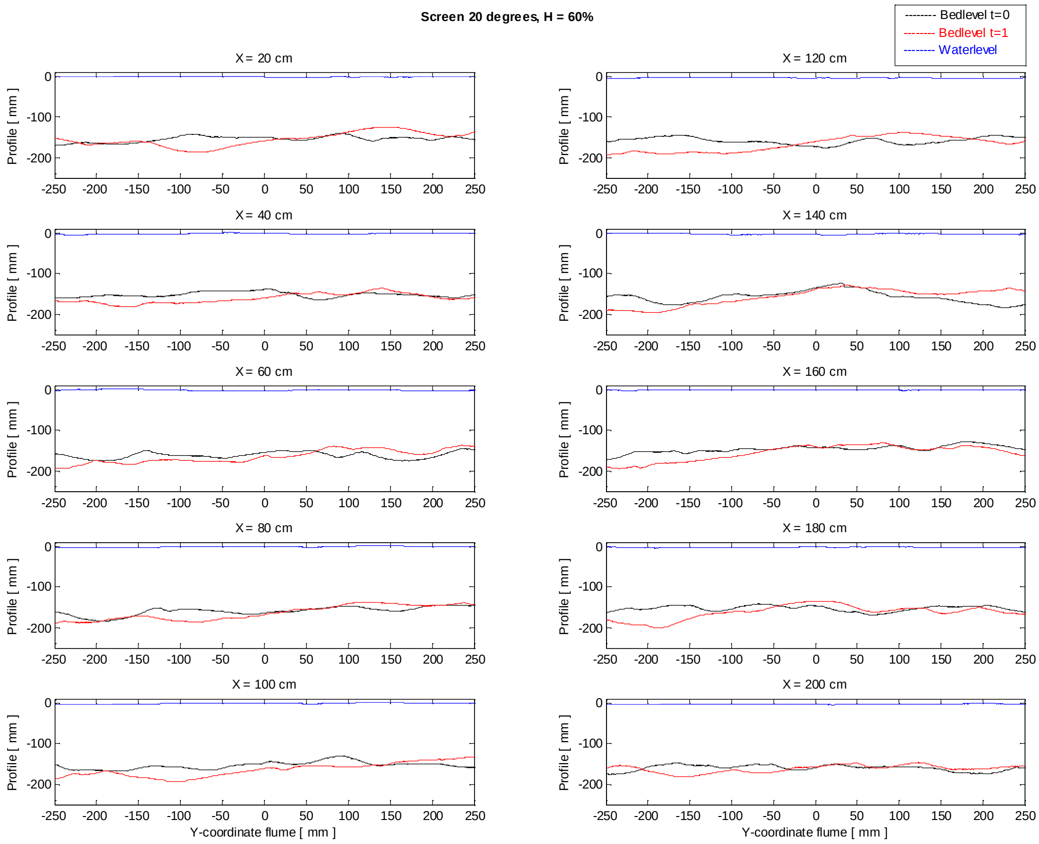

Figure 33 Morphological development, 20 degrees, H=60%

E.7 25 degrees, H=20%

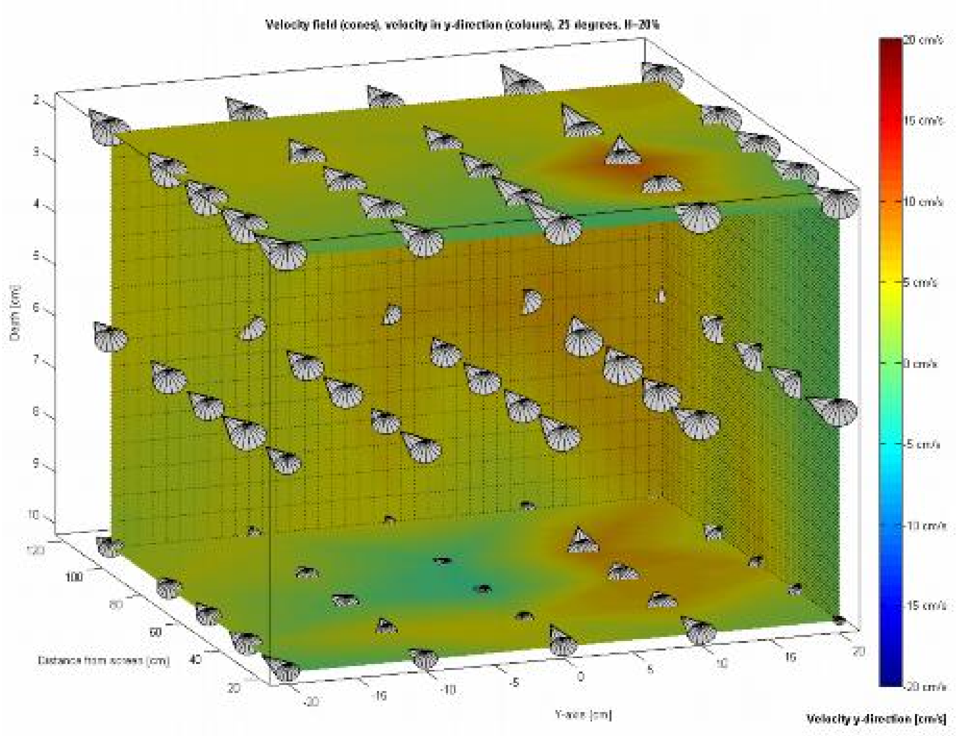

Figure 34 General stream pattern, 25 degrees, H=20%

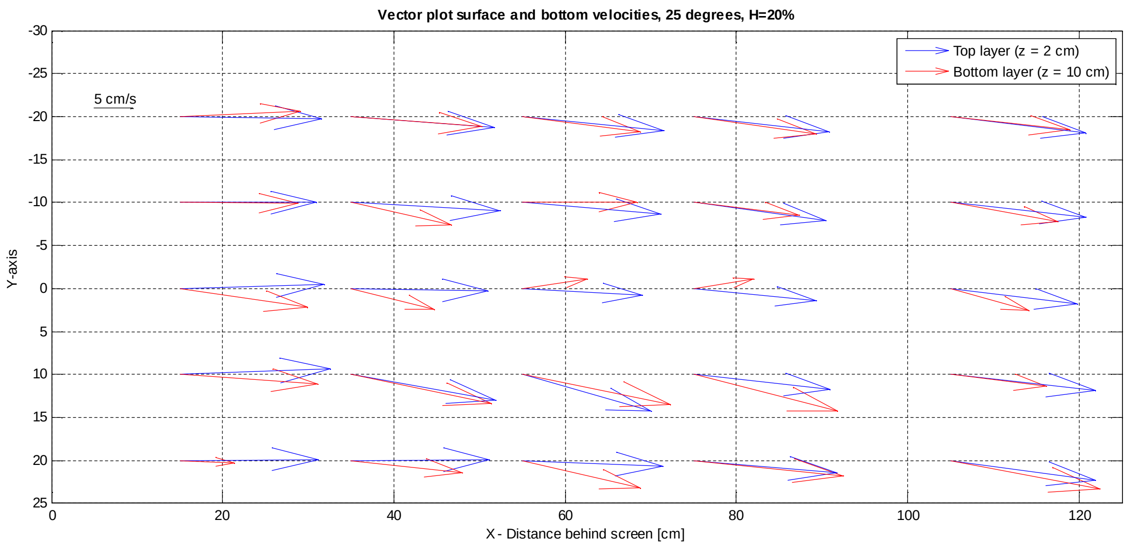

Figure 35 Top view velocity vectors behind the screen

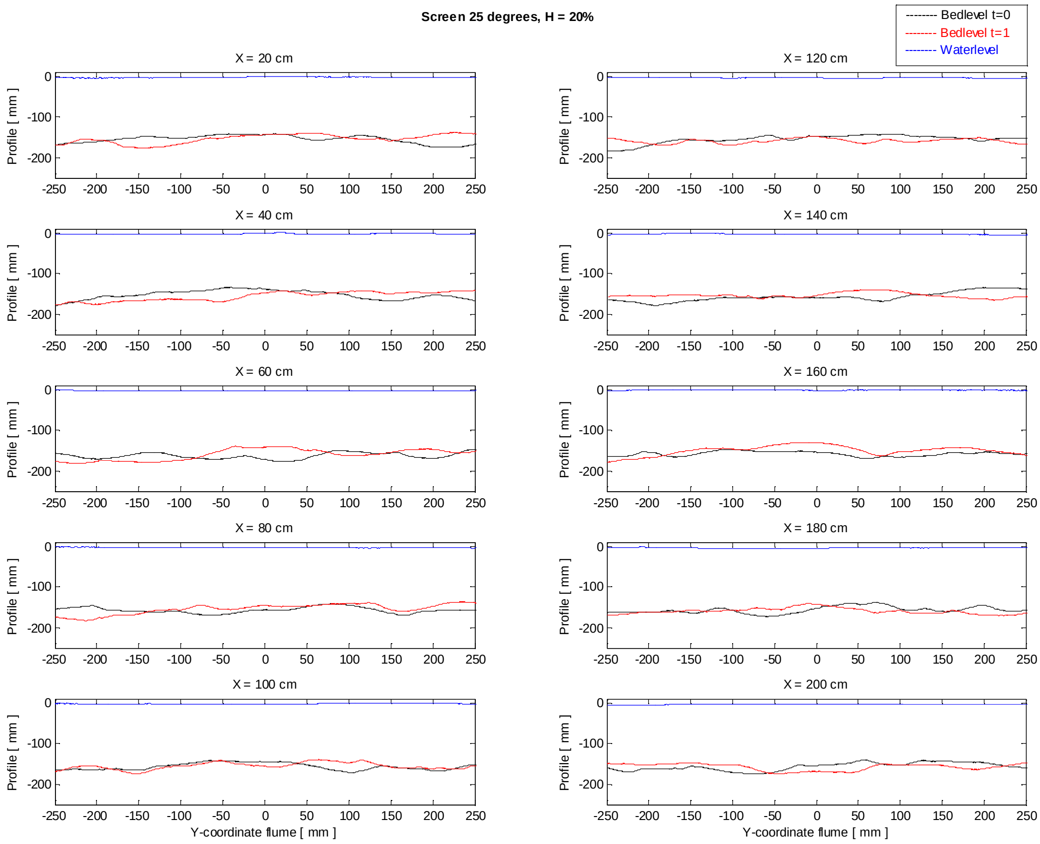

Figure 36 Morphological development, 25 degrees, H=20%

E.8 25 degrees, H=40%

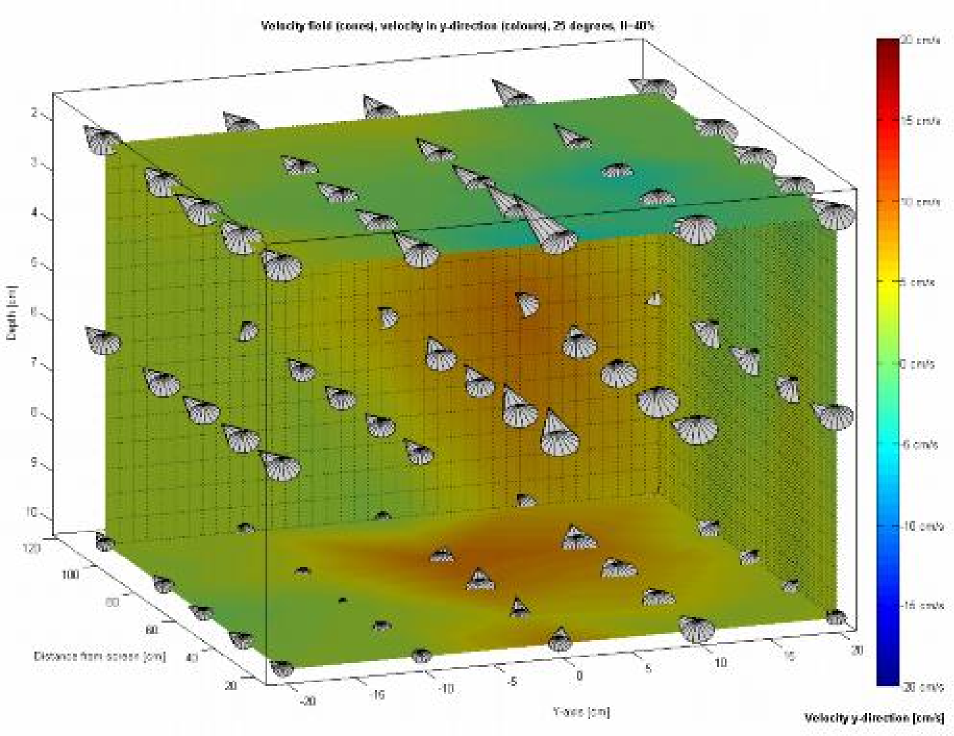

Figure 37 General stream pattern, 25 degrees, H=40%

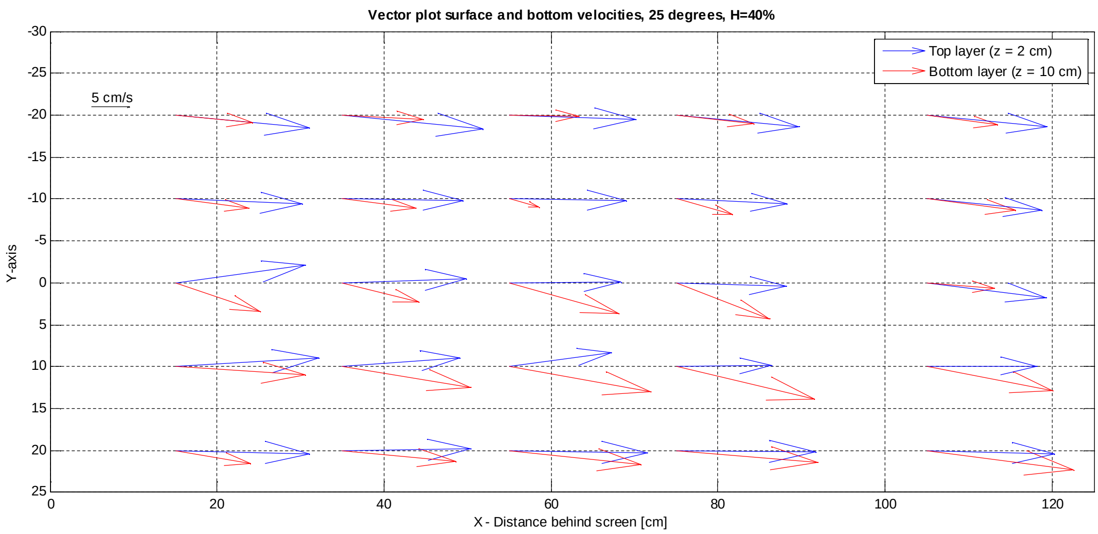

Figure 38 Top view velocity vectors behind the screen

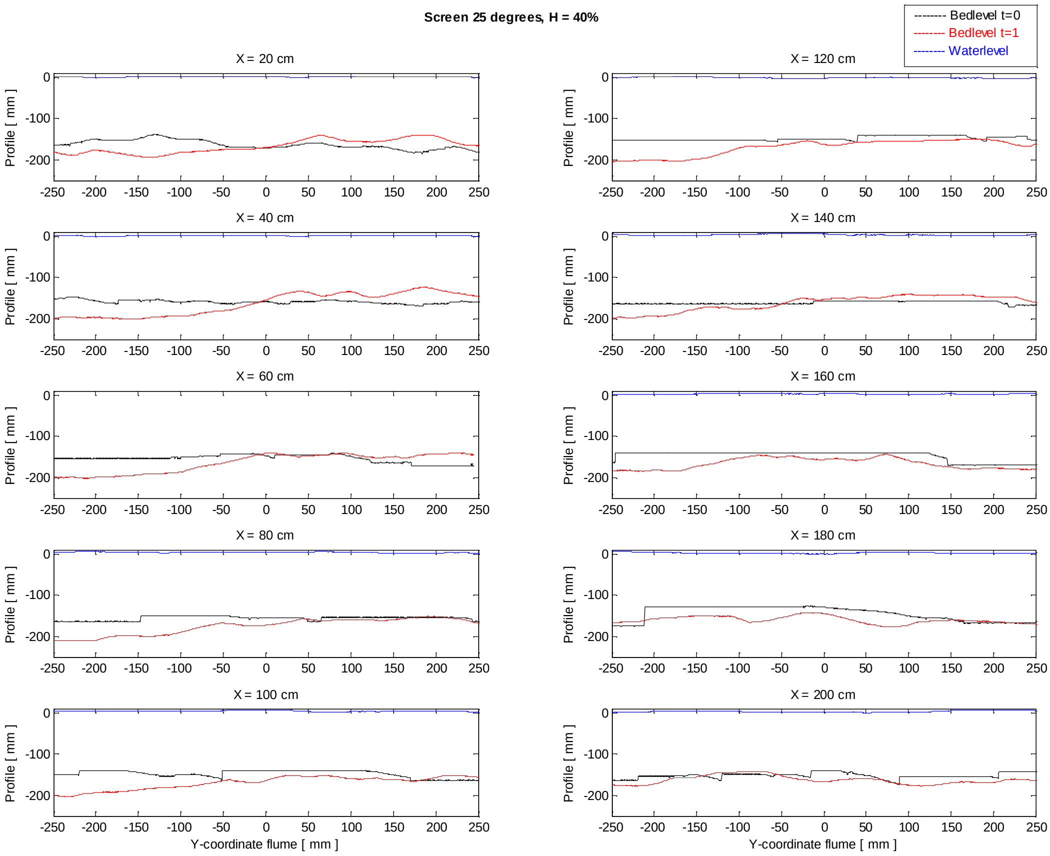

Figure 39 Morphological development, 25 degrees, H=40%

E.9 25 degrees, H=60%

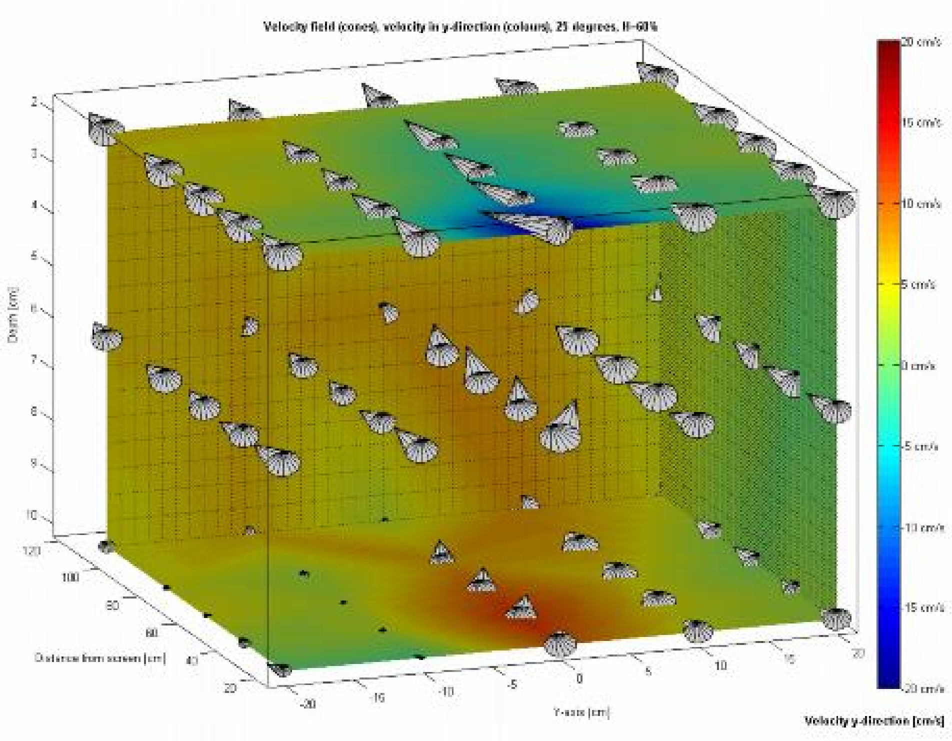

Figure 40 General stream pattern, 25 degrees, H=60%

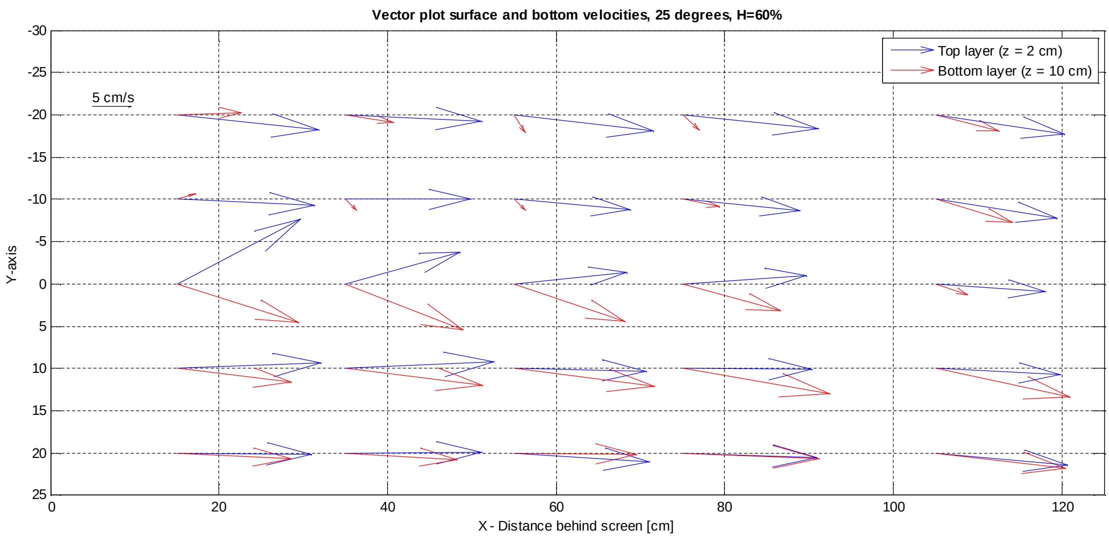

Figure 41 Top view velocity vectors behind the screen

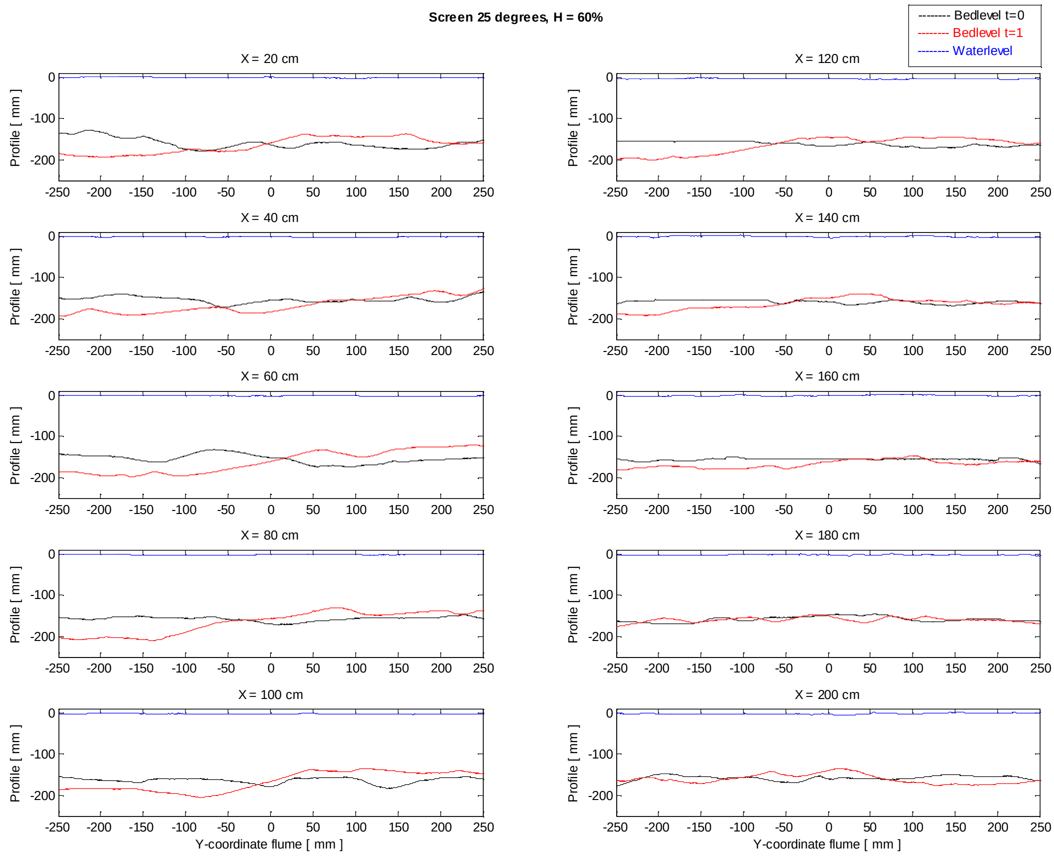

Figure 42 Morphological development, 25 degrees, H=60%

F RESULTS B-SERIES

F.1 15 degrees, H=40%

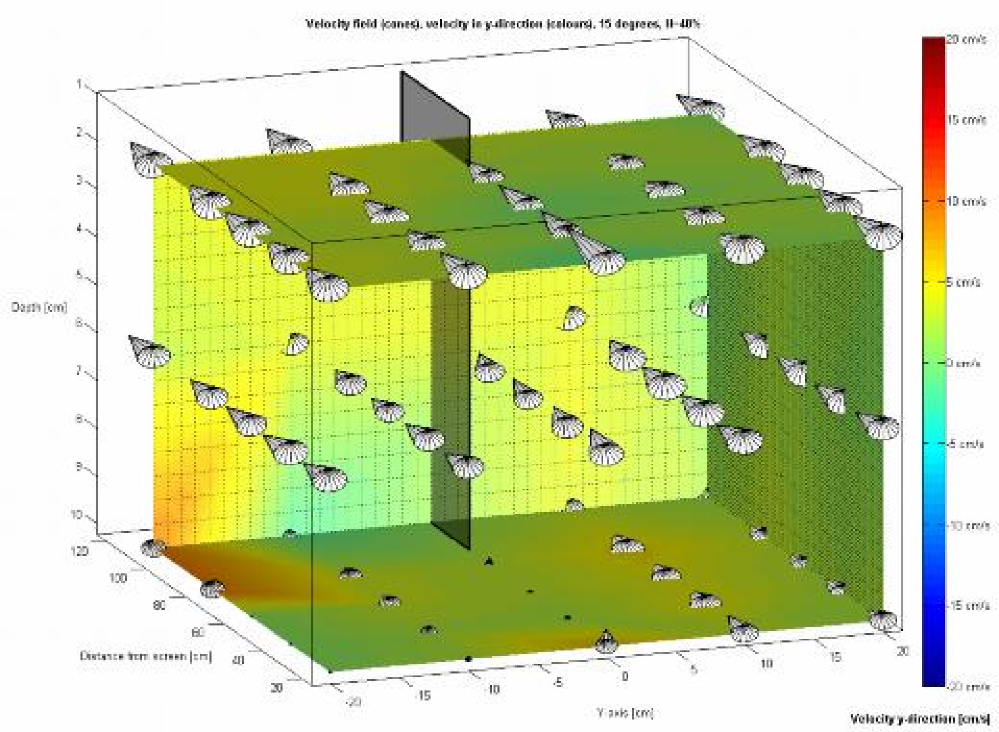

Figure 43 General stream pattern, 15 degrees, H=40%

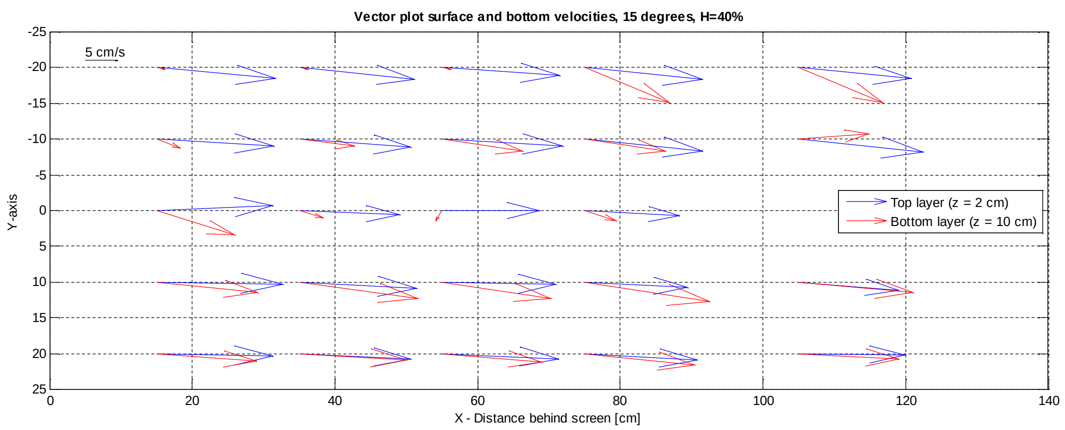

Figure 44 Top view velocity vectors behind the screen

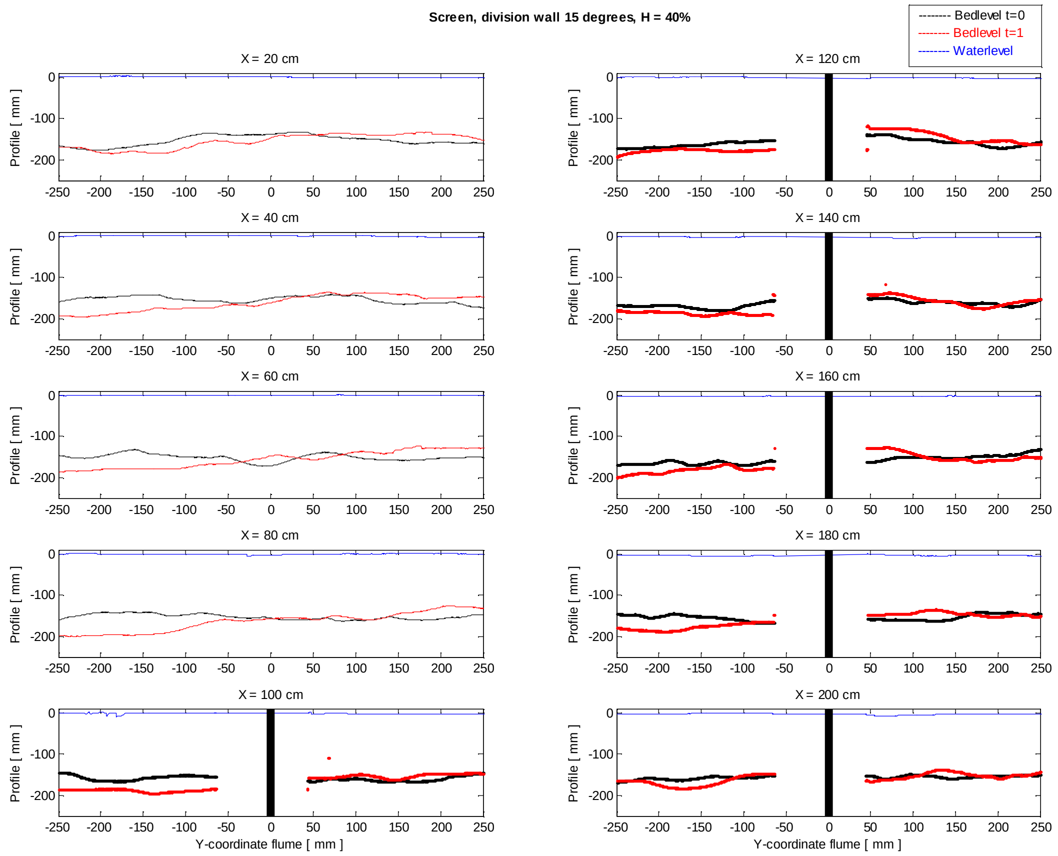

Figure 45 Morphological development, 15 degrees, H=40%

F.2 15 degrees, H=60%

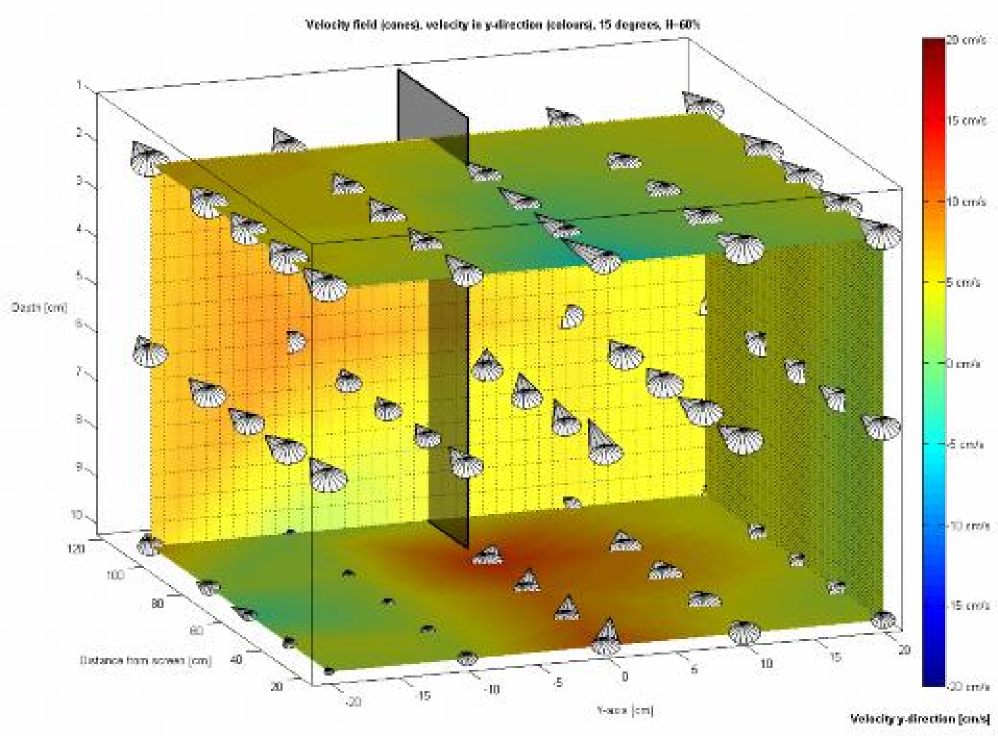

Figure 46 General stream pattern, 15 degrees, H=60%

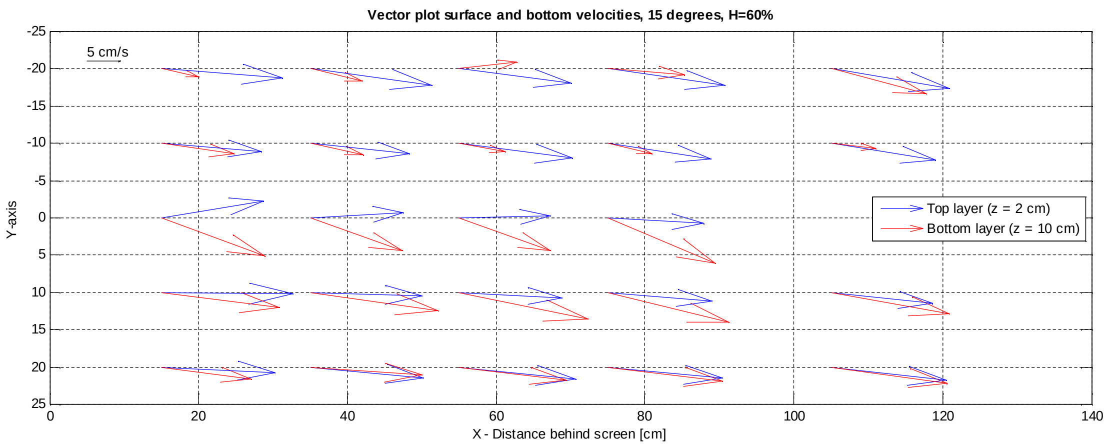

Figure 47 Top view velocity vectors behind the screen

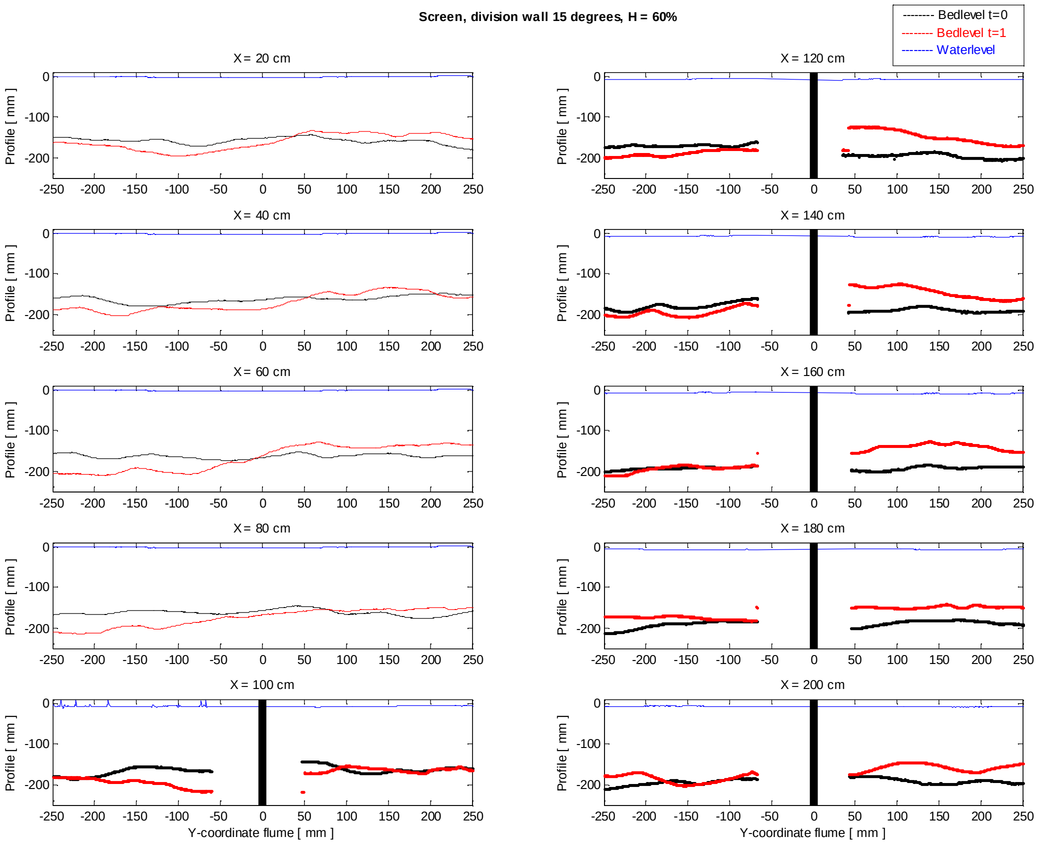

Figure 48 Morphological development, 15 degrees, H=60%

F.3 20 degrees, H=40%

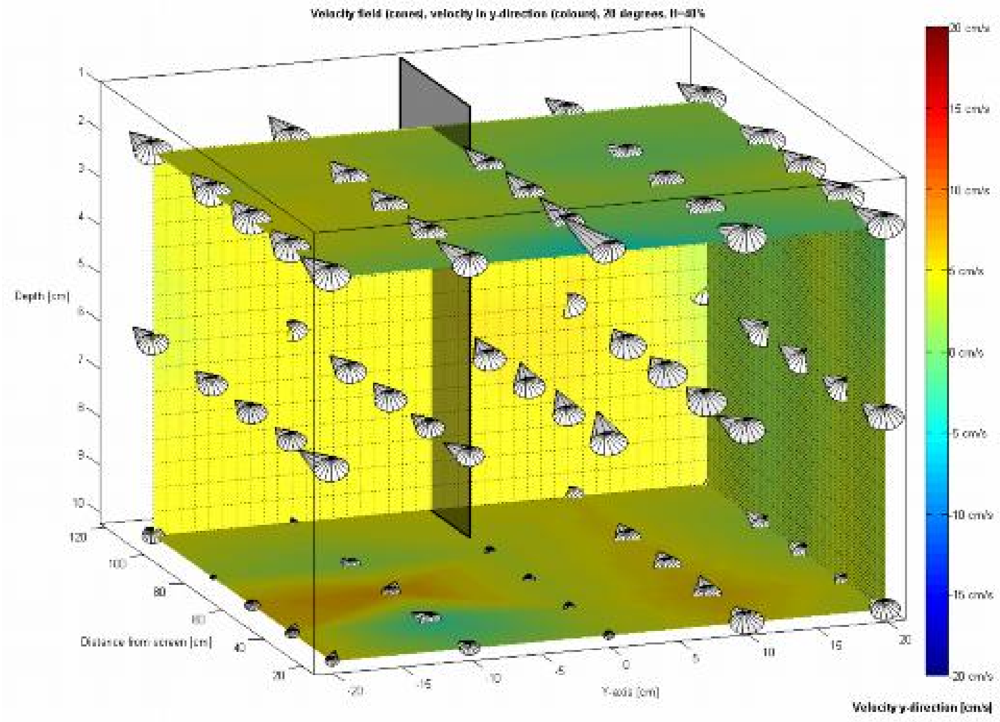

Figure 49 General stream pattern, 20 degrees, H=40%

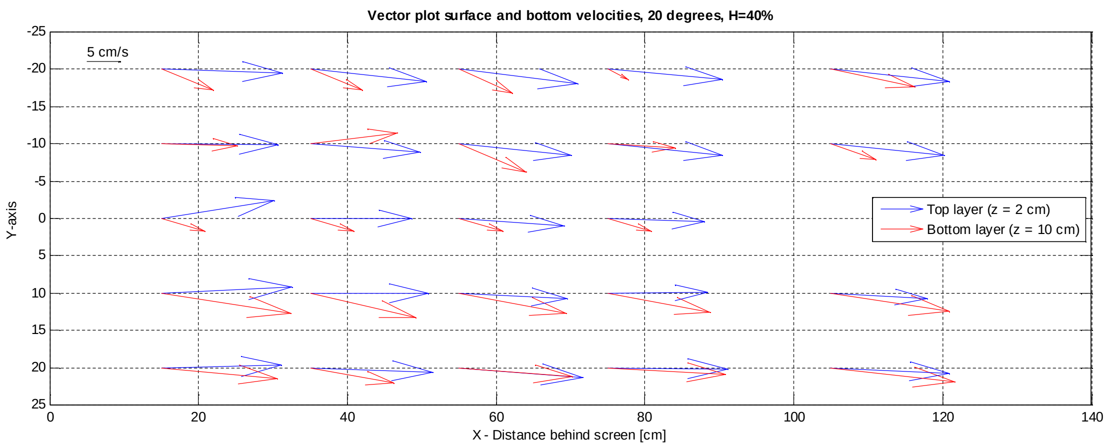

Figure 50 Top view velocity vectors behind the screen

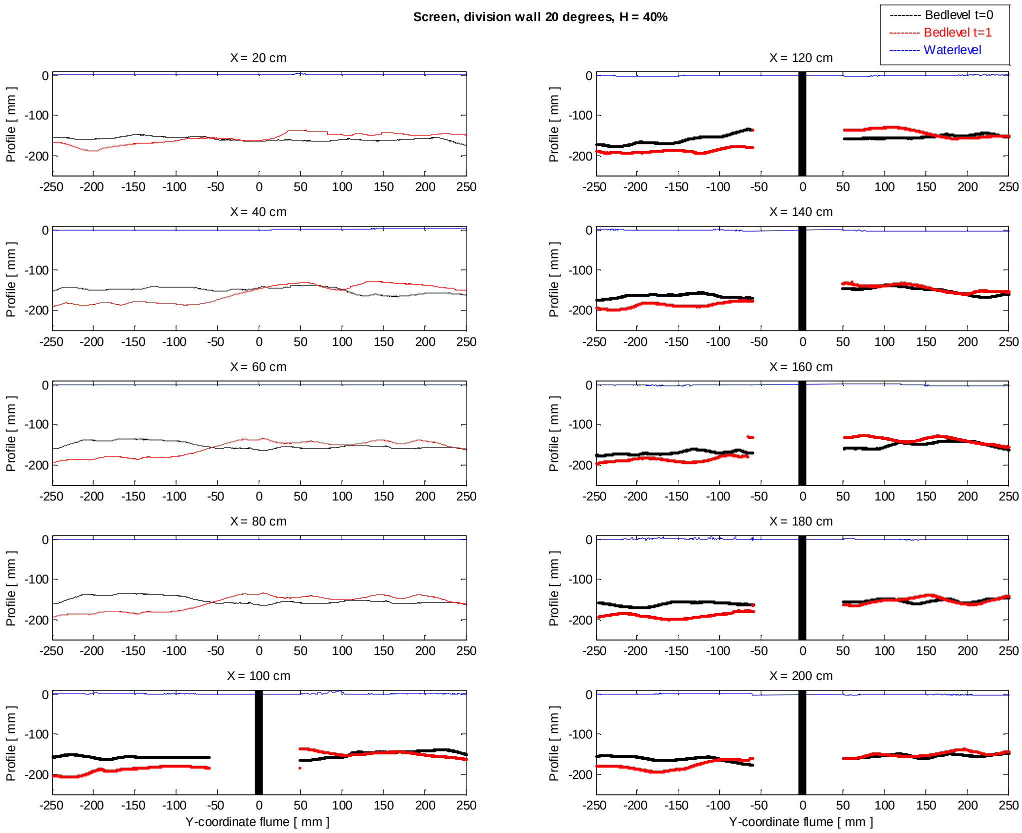

Figure 51 Morphological development, 20 degrees, H=40%

F.4 20 degrees, H=60%

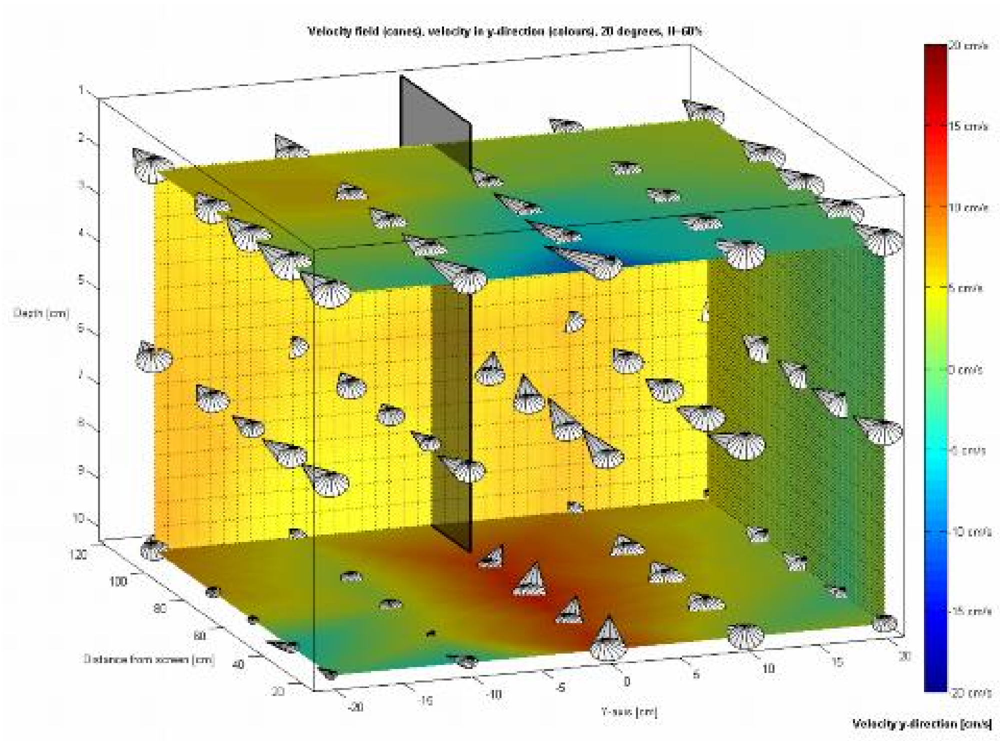

Figure 52 General stream pattern, 20 degrees, H=60%

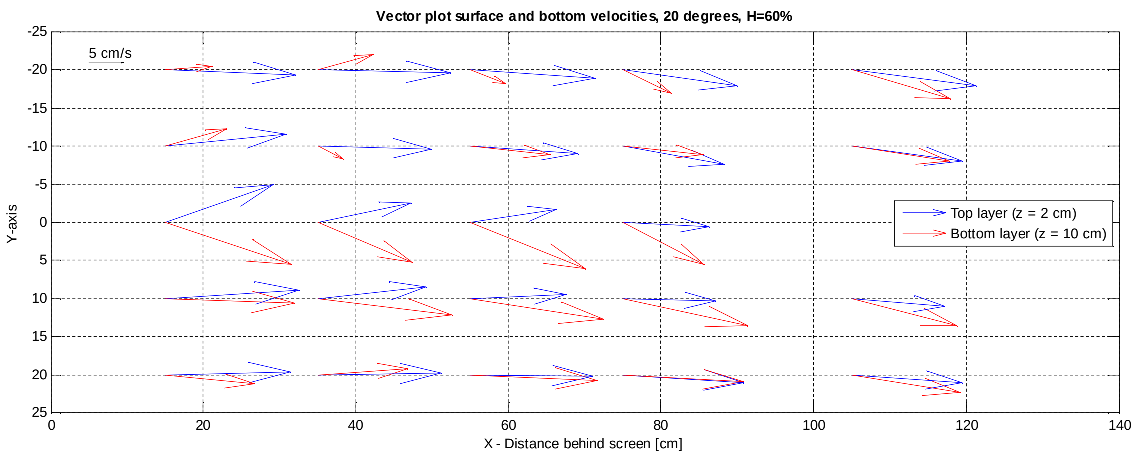

Figure 53 Top view velocity vectors behind the screen

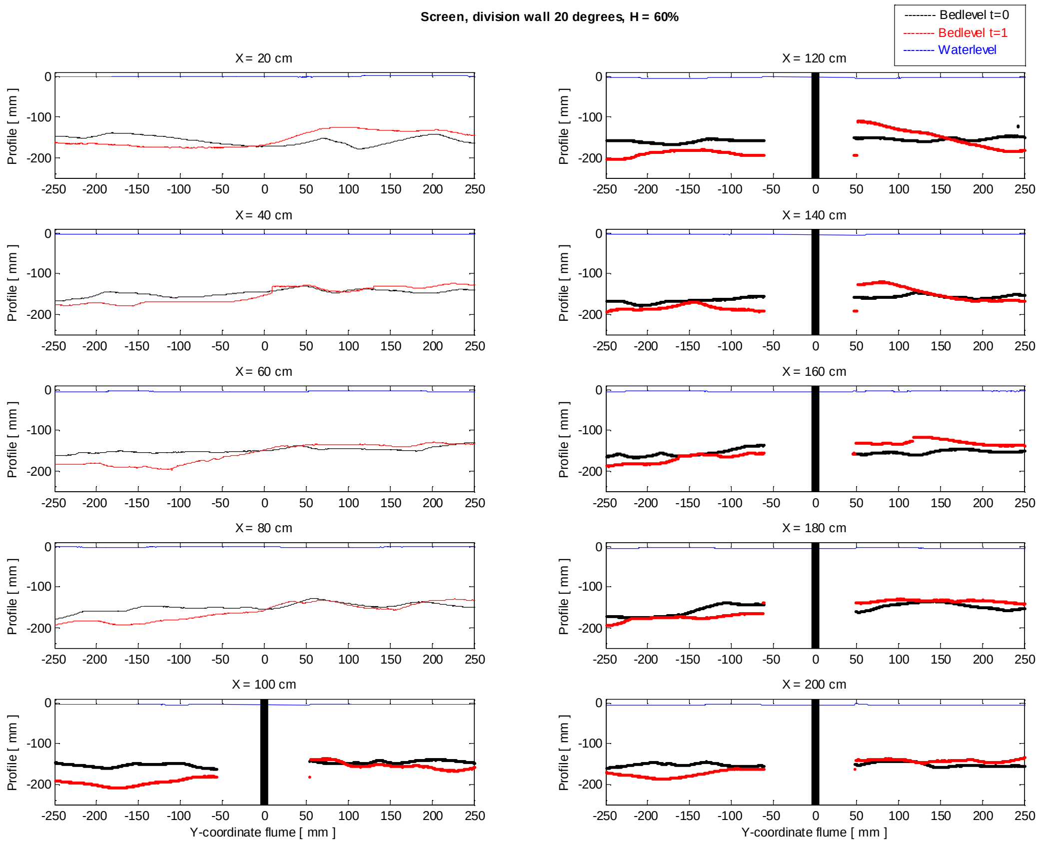

Figure 54 Morphological development, 20 degrees, H=60%

F.5 25 degrees, H=40%

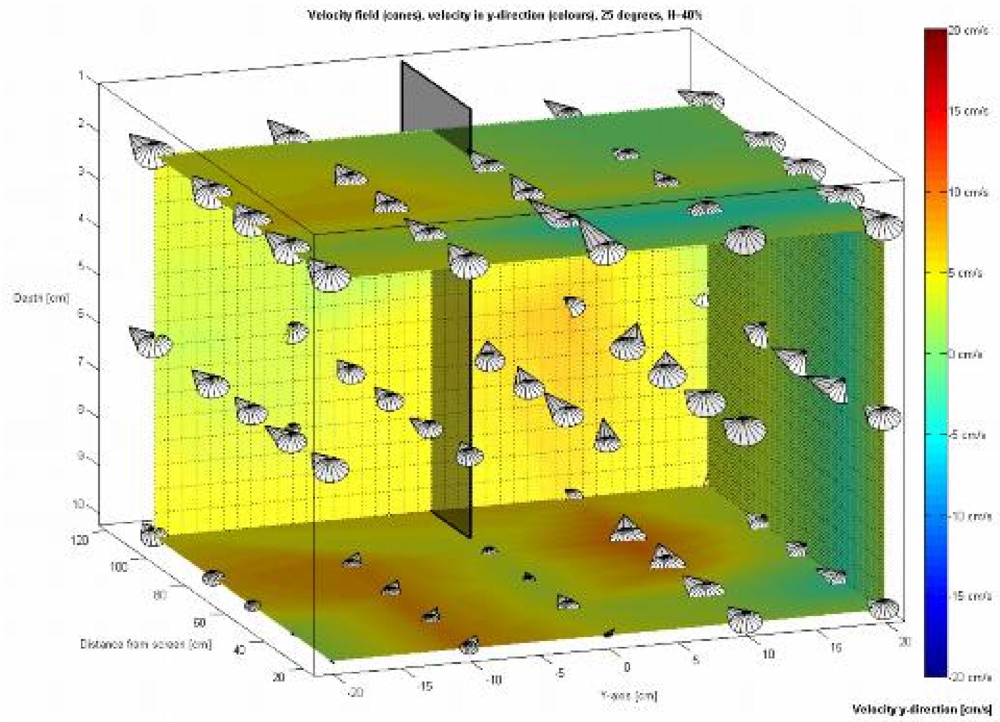

Figure 55 General stream pattern, 25 degrees, H=40%

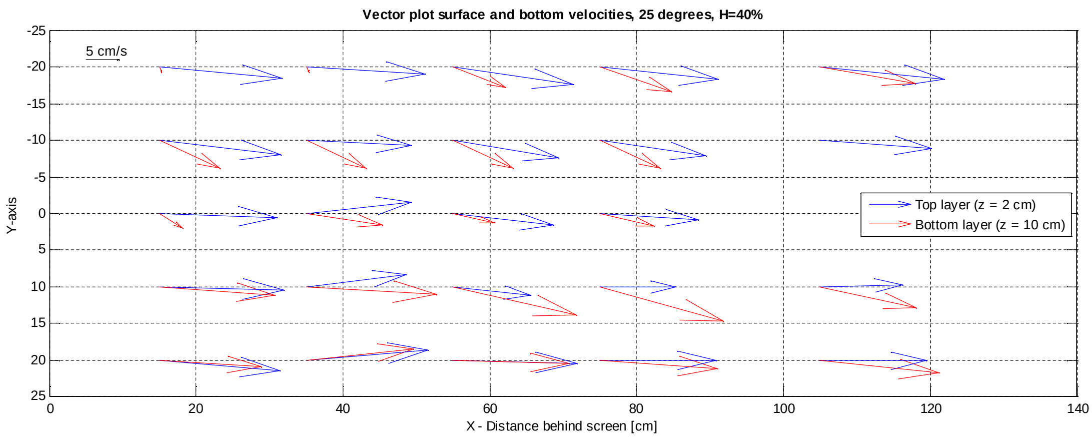

Figure 56 Top view velocity vectors behind the screen

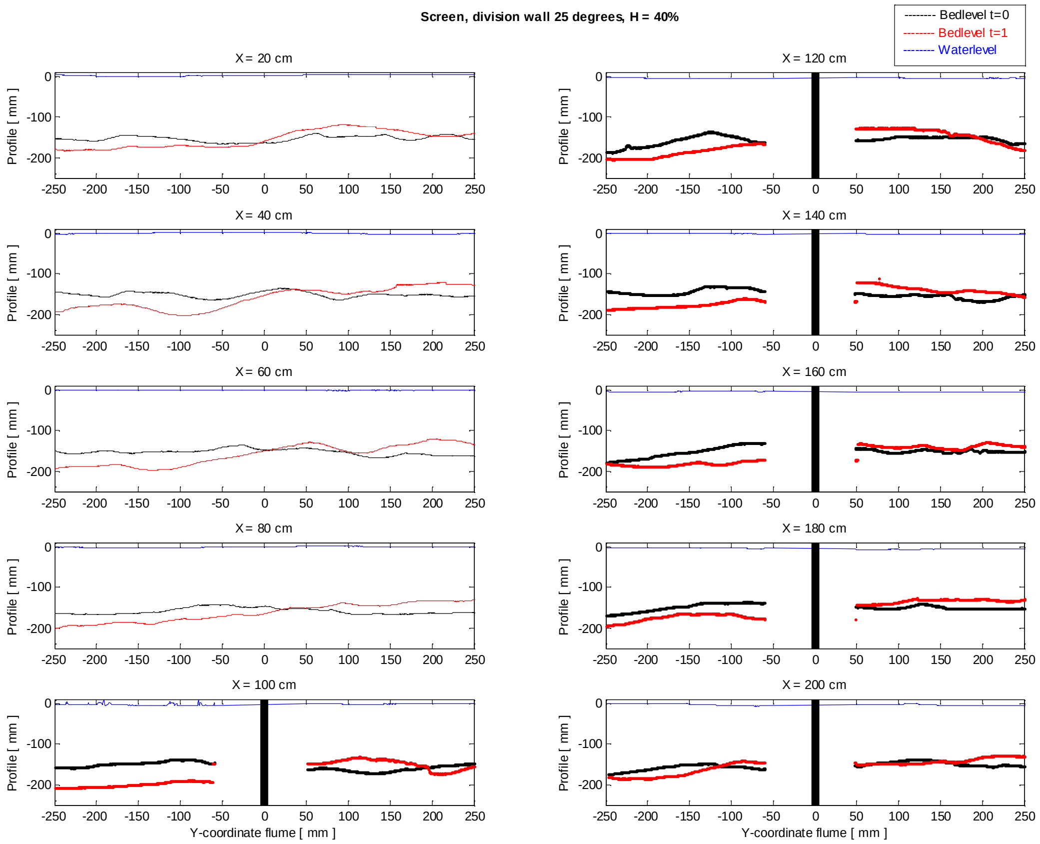

Figure 57 Morphological development, 25 degrees, H=40%

F.6 25 degrees, H=60%

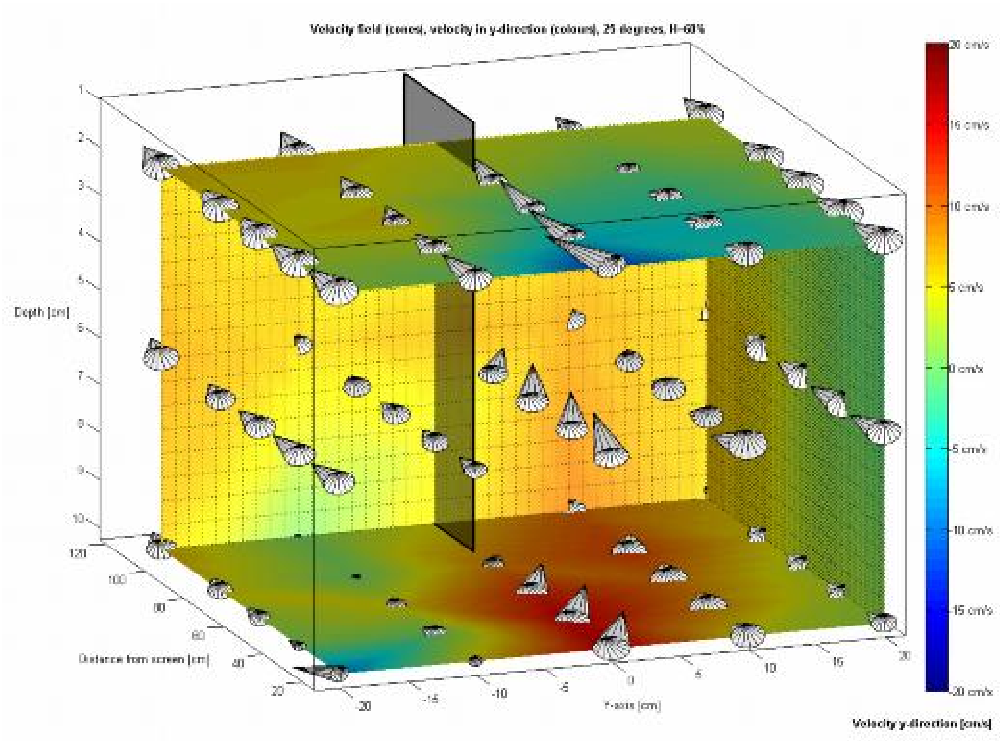

Figure 58 General stream pattern, 25 degrees, H=60%

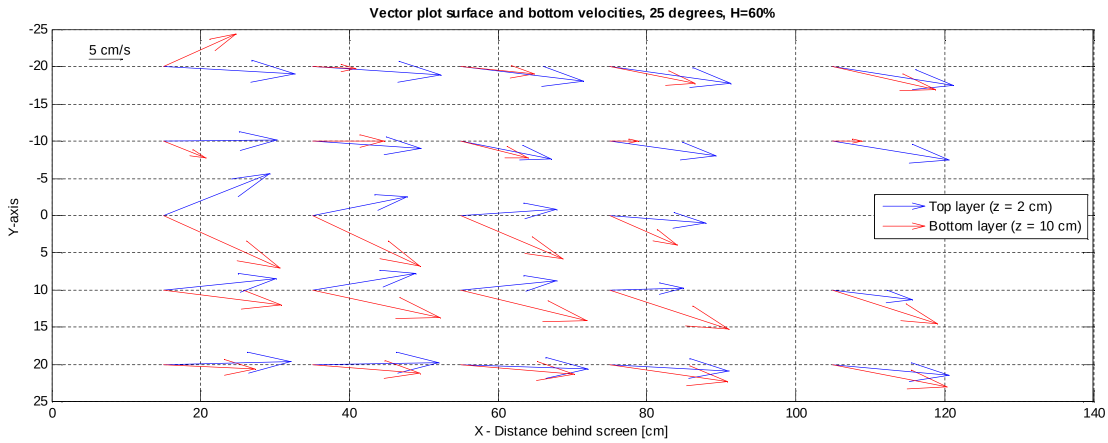

Figure 59 Top view velocity vectors behind the screen

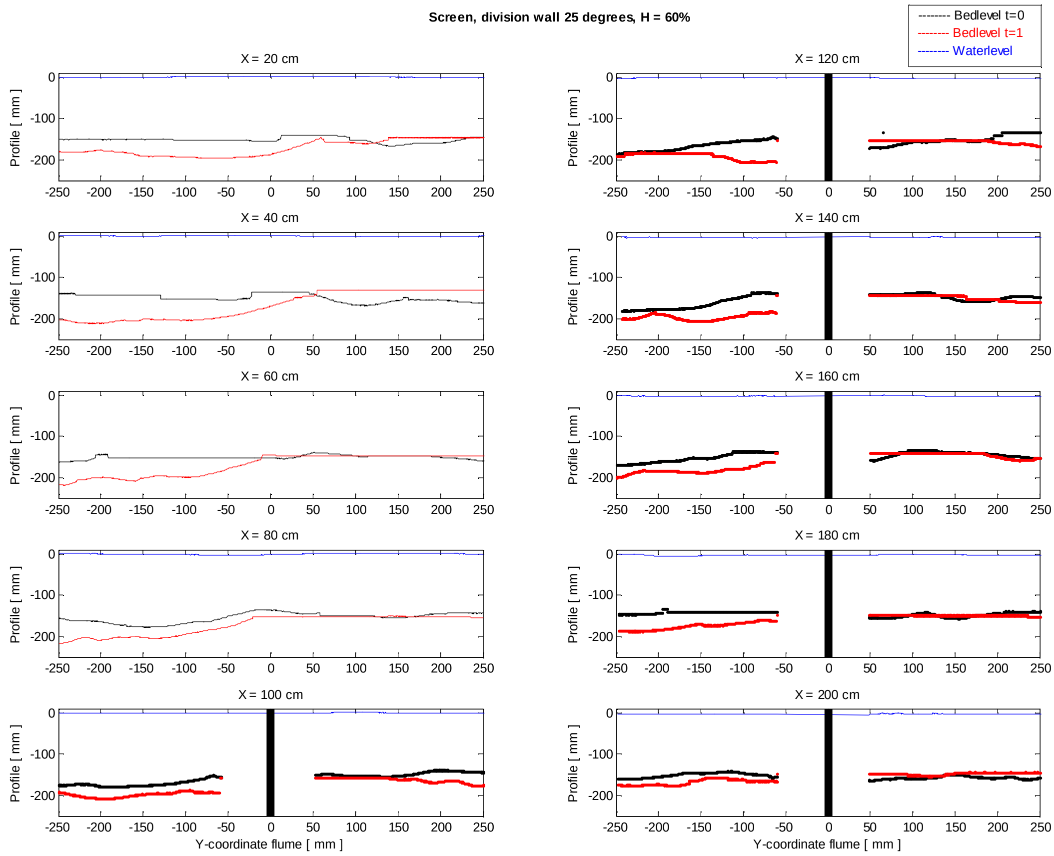

Figure 60 Morphological development, 25 degrees, H=60%

F.7 25 degrees, H=60%, long run

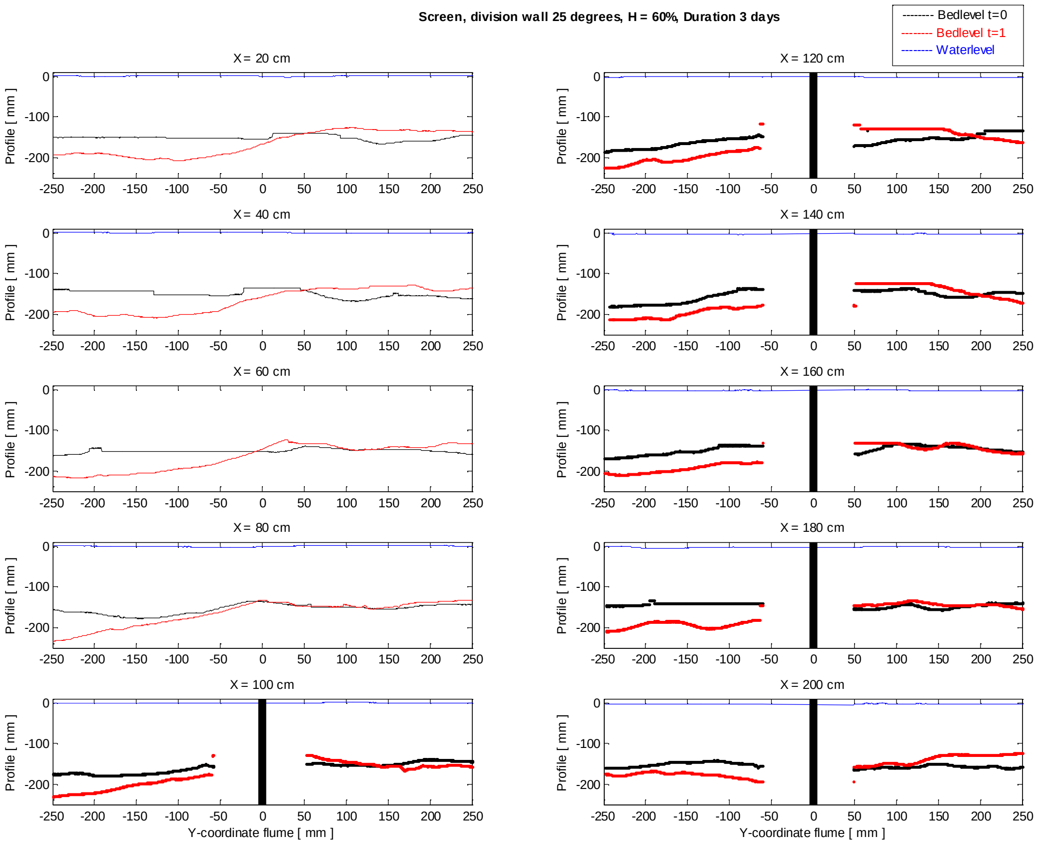

Figure 61 Morphological development, 25 degrees, H=60%, long run

G ACTUAL FLUME PARAMETERS, WITHOUT WALL

Input

Chezy	C	21	m^0.5/s		
Discharge	Q	0.0295	m^3/s	29.5	l/s
Width	b	0.6	m		
	q	0.0492	m^2/s		
Gravity	g	9.81	m/s^2		
Bottom slope	i	1.40E-03	m/m		
Grain diameter	D10	0.164	mm	0.000164	m
	D50	0.238	mm	0.000238	m
	D90	0.337	mm	0.000337	m
Drag coeff	Cd	4.82	-		
Density water		1000	kg/m^3		
Density sediment		2650	kg/m^3		
Rel.density		1.65	-		
Length flume	L	21	m		

Calculations

Equilibrium depth	he	0.1576	m
Velocity	u	0.3119	m/s
Froude number	Fr	0.2509	
Settling velocity	ws	0.0326	m/s
	u*	0.0465	
Shields parameter	theta	0.5619	
	C90	67.485	m^0,5/s
	mu	0.1736	

Checks

mu*theta	0.0975	
ws/u*	0.7016	-
D50	0.238	mm

Transport

Engelund Hansen	S	7.86E-06	m^3/s	excl pores
		0.68	m^3/day	
		247.82	m^3/year	
	qs	3.27E-05	m^2/s	incl pores
	Qs	1.96E-05	m^3/s	
		20.82	g/s	
		0.69	g/l	
		1799.24	kg/day	
		656721	kg/year	

Meyer-Peter-Muller	S	1.34E-06	m^3/s	excl pores
		0.12	m^3/day	
		42.34	m^3/year	
	qs	5.59E-06	m^2/s	incl pores
	Qs	3.36E-06	m^3/s	
		3.56	g/s	
		0.12	g/l	
		307.42	kg/day	
		112210	kg/year	

H ACTUAL FLUME PARAMETERS, WITH WALL

Input

Chezy	C	20	m^0.5/s		
Discharge	Q	0.0288	m^3/s	28.8	l/s
Width	b	0.6	m		
	q	0.0480	m^2/s		
Gravity	g	9.81	m/s^2		
Bottom slope	i	1.40E-03	m/m		
Grain diameter	D10	0.164	mm	0.000164	m
	D50	0.238	mm	0.000238	m
	D90	0.337	mm	0.000337	m
Drag coeff	Cd	4.82	-		
Density water		1000	kg/m^3		
Density sediment		2650	kg/m^3		
Rel.density		1.65	-		
Length flume	L	21	m		

Calculations

Equilibrium depth	he	0.1602	m
Velocity	u	0.2996	m/s
Froude number	Fr	0.2389	
Settling velocity	ws	0.0326	m/s
	u*	0.0469	
Shields parameter	theta	0.5713	
	C90	67.614	m^0,5/s
	mu	0.1609	

Checks

mu*theta	0.0919	
ws/u*	0.6959	-
D50	0.238	mm

Transport

Engelund Hansen	S	7.43E-06	m^3/s	excl pores
		0.64	m^3/day	
		234.26	m^3/year	
	qs	3.10E-05	m^2/s	incl pores
	Qs	1.86E-05	m^3/s	
		19.68	g/s	
		0.66	g/l	
		1700.76	kg/day	
		620776	kg/year	

Meyer-Peter-Muller	S	1.12E-06	m^3/s	excl pores
		0.10	m^3/day	
		35.46	m^3/year	
	qs	4.69E-06	m^2/s	incl pores
	Qs	2.81E-06	m^3/s	
		2.98	g/s	
		0.10	g/l	
		257.45	kg/day	
		93969	kg/year	

I TURBULENCE ANALYSES

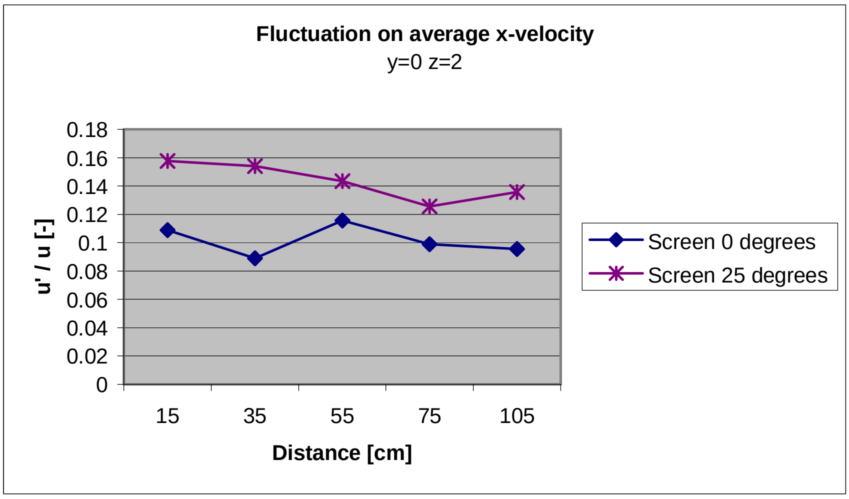

Figure 62 Turbulence different angles, z=2

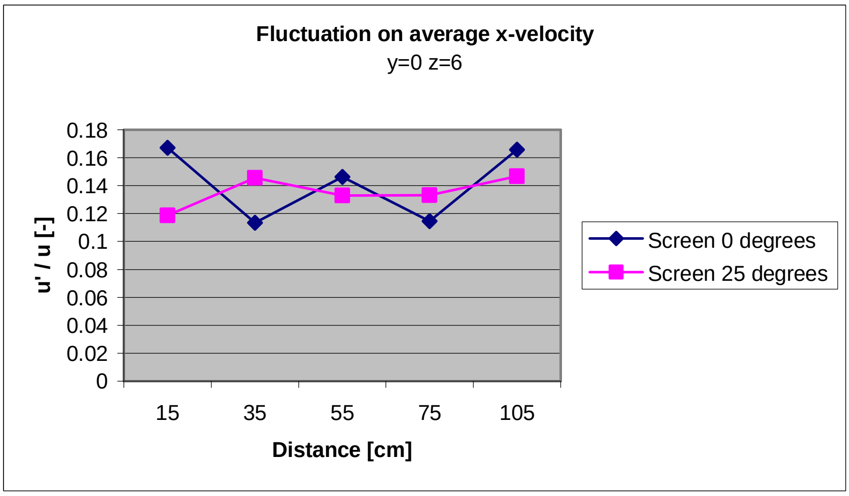

Figure 63 Turbulence different angles, z=6

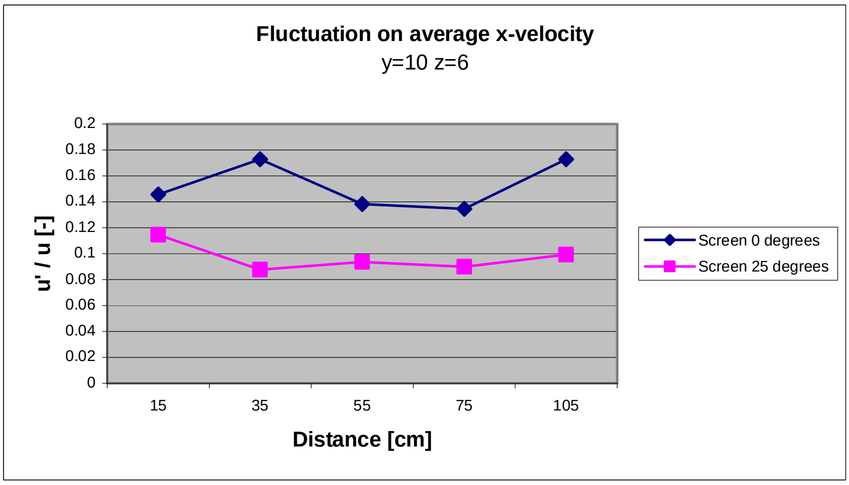

Figure 64 Turbulence different angles, y=10, z=6

J OVERVIEW MATLAB SCRIPTS

Name	Purpose	Input	Output	Remarks
Add_All_in_set2.m	Adding mean velocities of different location in 1 file	Velocity measurements	Set with all mean velocities and standard deviations	Developed
Bepaling meetinterval.m	Determination of measure duration	Measurements	Relative error as function of duration	Developed
deltazb.m	Visualize bed level change on a constant location	Files bed level measurements	Bed level on a constant location	Developed
func_despike_phasespace3d.m	Despiking routine	Velocity measurements	Despiked velocity measurements	Taken and optimized
plot_cones_v2	Visualize general stream pattern	Files velocity measurements	3D visualization of velocity field	Developed
plot_cones_v2_met_wand	As plot_cones_v2, including wall	Files velocity measurements	3D visualization of velocity field, incl wall	Developed
plotbodemdef.m	Visualize bed level change on different locations behind screen	Files bed level measurements	Bed level change different locations	Developed
plotbodemdef_wall.m	As plotbodemdef, including wall	Files bed level measurement	Bed level change different locations including wall	Developed
Plotspectra.m	Plotting spectral analyses	Velocity measurements	Energy density spectrum	Taken
samenvoegen.m	Combining bed level measurements of both branches	Bed level measurements	Bed level over width flume	Developed
smooth_v6.m	Despiking routine	Velocity measurements	Despiked velocity measurements	Taken and optimized
Spectra.m	Spectral analysis	Velocity measurements	Dataset as input for plots	Taken
Splitted_averaged_spectrum.m	Averaged spectral analysis of 1/10 of the measurement duration	Velocity measurements	Averaged energy density spectrum	Taken and optimized
Velocity_layers.m	Draw velocity vectors, top view	Files velocity measurements	Vector plot velocity	Developed