TECHNICAL REPORT

ABLE UK LTD

FURTHER MODELLING OF HYDRODYNAMICS FROM DEVELOPMENTS AT THE TERRC SITE - SCENARIO 11

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DET NORSKE VERITAS

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TECHNICAL REPORT

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Client: Able UK Ltd	Client ref.: Glyn Wheeler

Summary:

On the request from Able UK, DNV presents results from modelling of effects on hydrodynamics from development Scenario 11, where Seaton Channel is constricted to 85 m width, dredged to -9.5 m LAT, and the spit of intertidal area between Quay 10/11 and the cooling water intake for Hartlepool Nuclear Power Station is on level with the cooling water intake channel.

The deepening of Seaton Channel and the closure of the dry dock decreases tidal velocities, lowering the shear stress acted upon the bed. The erosion potential will therefore decrease, and the sedimentation potential will increase especially in the deepwater parts of the channel.

The predictions match those presented in earlier reports, both with and without the cooling water abstraction. The narrowing and deepening of the channel has little overall impact, whilst the deepening of the area to the west of the cooling water intake, adjacent to the proposed deepwater pocket at Quay 10&11, shows a local effect by lowering velocities and shear stresses in the area.

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Work carried out by: Christopher Garmann	
Work verified by: Thomas Møskeland	

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River Tees

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1 INTRODUCTION

In 2004, DNV carried out a predictive study of the effects on hydrodynamics and sediment transportation in the Tees estuary as a result of the proposed developments at the TERRC site owned by Able UK. The study included numerical modelling of hydrodynamics and sediment transportation. This work was reported in DNV Report 2004-1387.

The model was updated with a cooling water abstraction at the Hartlepool Nuclear Power Station, and with the dredged area of Seaton Channel re-aligned. This work was reported in DNV Report 2006-0315.

This report is an Addendum to DNV Report 2006-0315, with a new proposed Scenario 11. In this scenario, the dry dock is closed, the holding basin dredged to -9.5 m, Seaton Channel dredge area is realigned with an 85 m wide channel deepened to -9.5 m, Quays 10 and 11 are dredged to -14.5 m, with the "tongue" of shallow area between Quay 10/11 and the cooling water intake adjusted to the level of the cooling water intake channel. The modelling approach in general is described in Report 2006-0315.

2 VELOCITIES

The predicted water velocities at observation point 1 Hartlepool nuclear power station cooling water intake, point 2 Seal Sands, point 3 Seaton Channel and point 4 Tees channel is shown in Figure 1. The velocities at observation points 2, 3 and 4 are clearly driven by tidal forces, whilst the velocities at point 1 are influenced to a large degree by the the cooling water intake. At point 1, the velocities increase on a low tide and decrease on a high tide, corresponding to the change in the cross-sectional conveyance area in the cooling water intake channel.

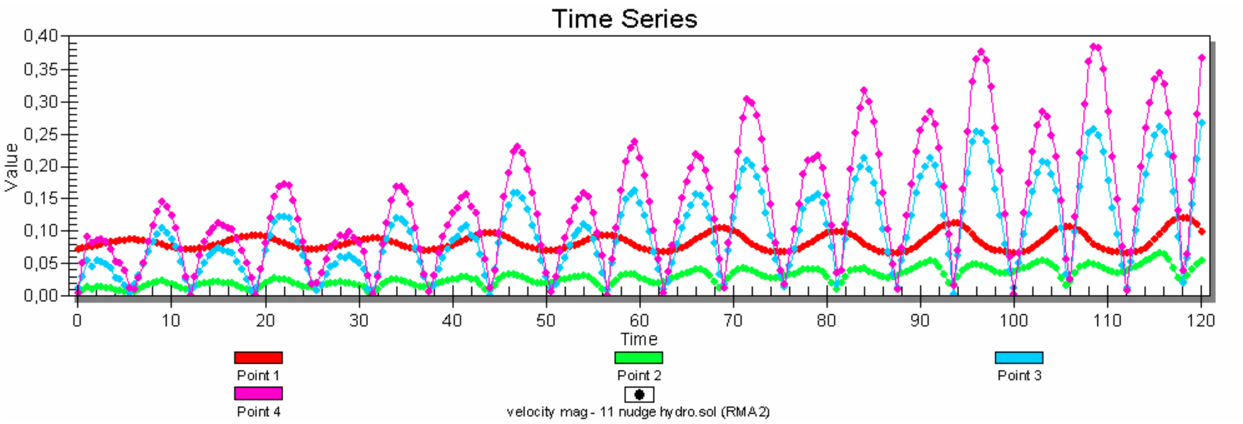

Figure 1 - Velocity magnitude (m/s) for points 1, 2, 3 and 4 for Scenario 11

The velocities immediately in front of the cooling water intake vary from 0.06 to 0.12 m/s. Velocities are lower than predicted for Scenario 0, 8 and 10 due to the widening of the conveyance area following the removal of the intertidal spit to the west of the cooling water intake channel. More detailed information can be found in Table 1.

2.1 Incoming tide

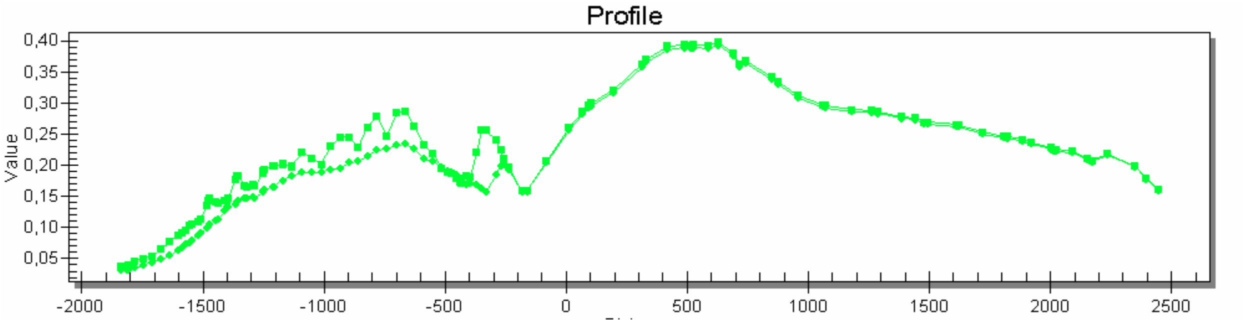

Figure 2 - Velocity (m/s) transect at max. incoming tide t = 108.5

Figure 2 shows a transect of the maximum velocities at incoming tides for t = 108.5. The left end of the graph represents the holding basin immediately in front of the dry dock, the cooling water intake is located approximately at -1400, the Tees turning circle is located at 0 and the seaward end of Tees estuary is at 2500. Both Scenario 0 (upper line) and Scenario 11 (lower line) are presented.

Generally, in Seaton Channel the velocities are lower for Scenario 11, following the lowering of the channel floor. In Tees channel the differences are negligible.

Figure 3 shows the maximim incoming tidal velocities at t = 108.5. Within the Seaton area, the velocities are highest in the constricted part of Seaton Channel, at 0.25-0.3 m/s, and the velocities diminish as the tidal volume is dispersed.

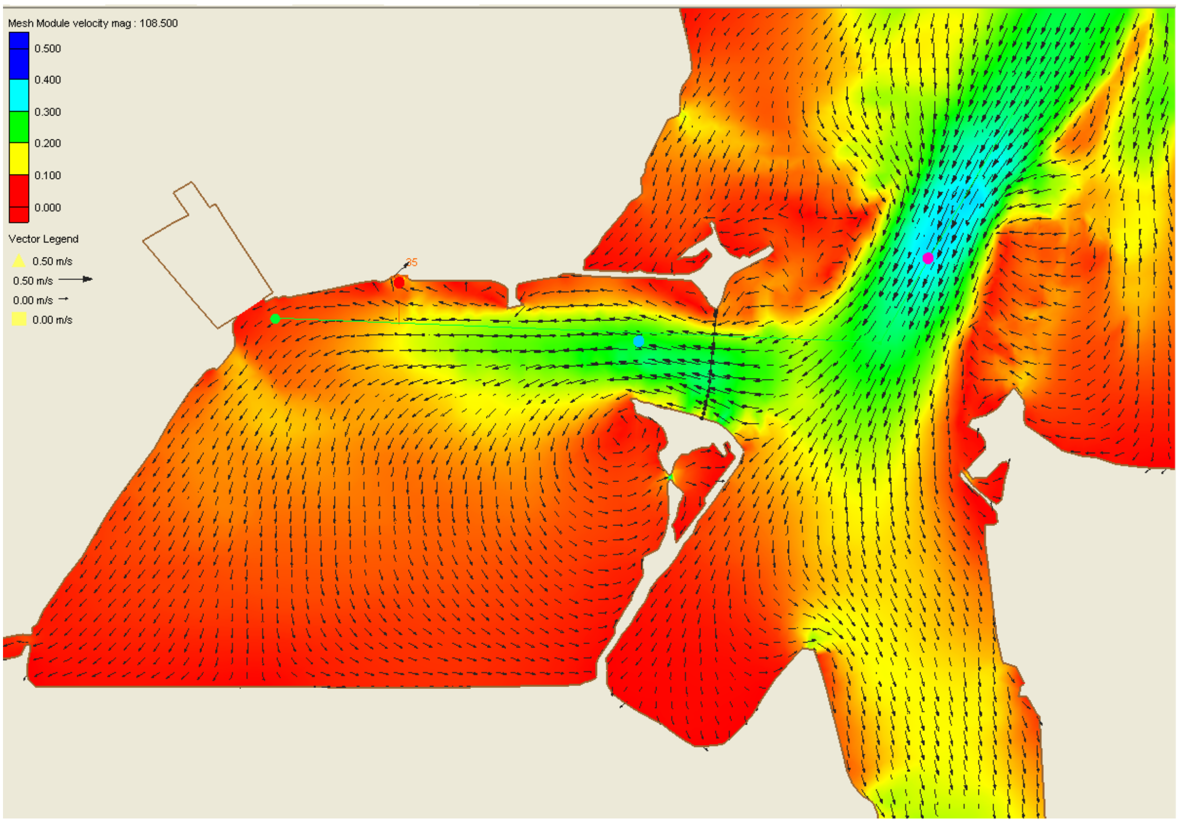

Figure 3 - Scenario 11 maximum incoming tidal velocities at t = 108.5

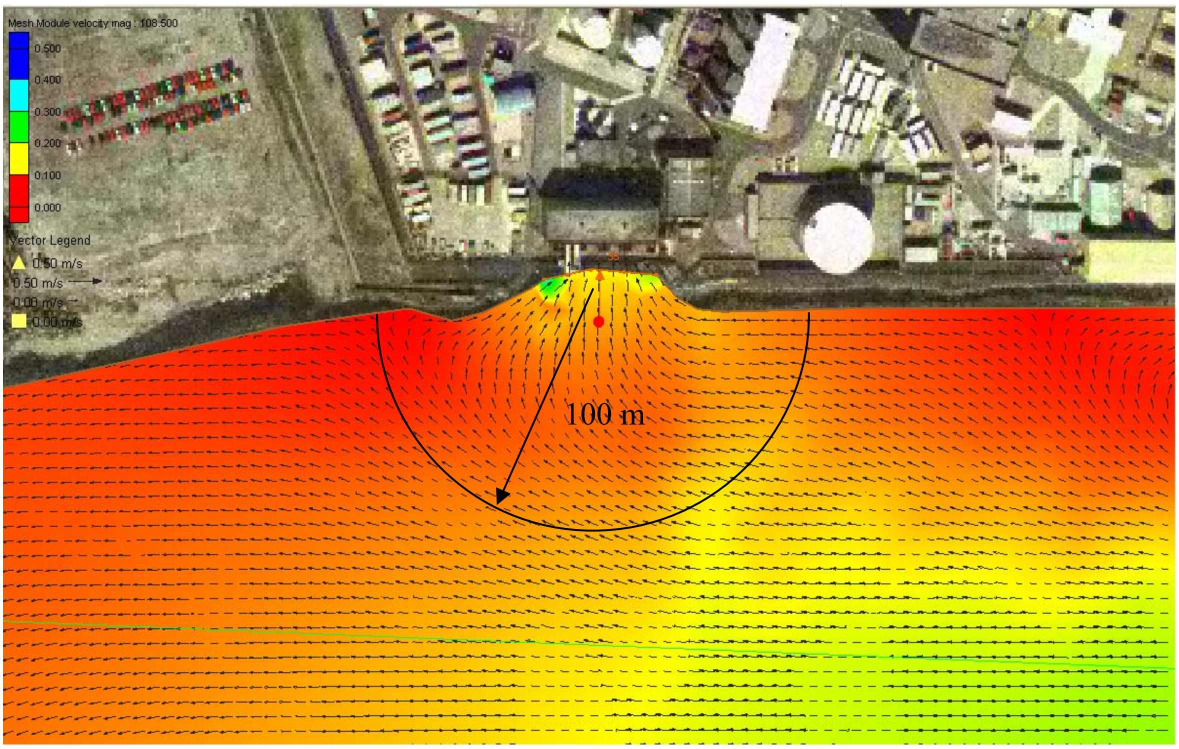

Figure 4 - Scenario 11, zoom in on area immediately in front of CW intake at t = 108.5

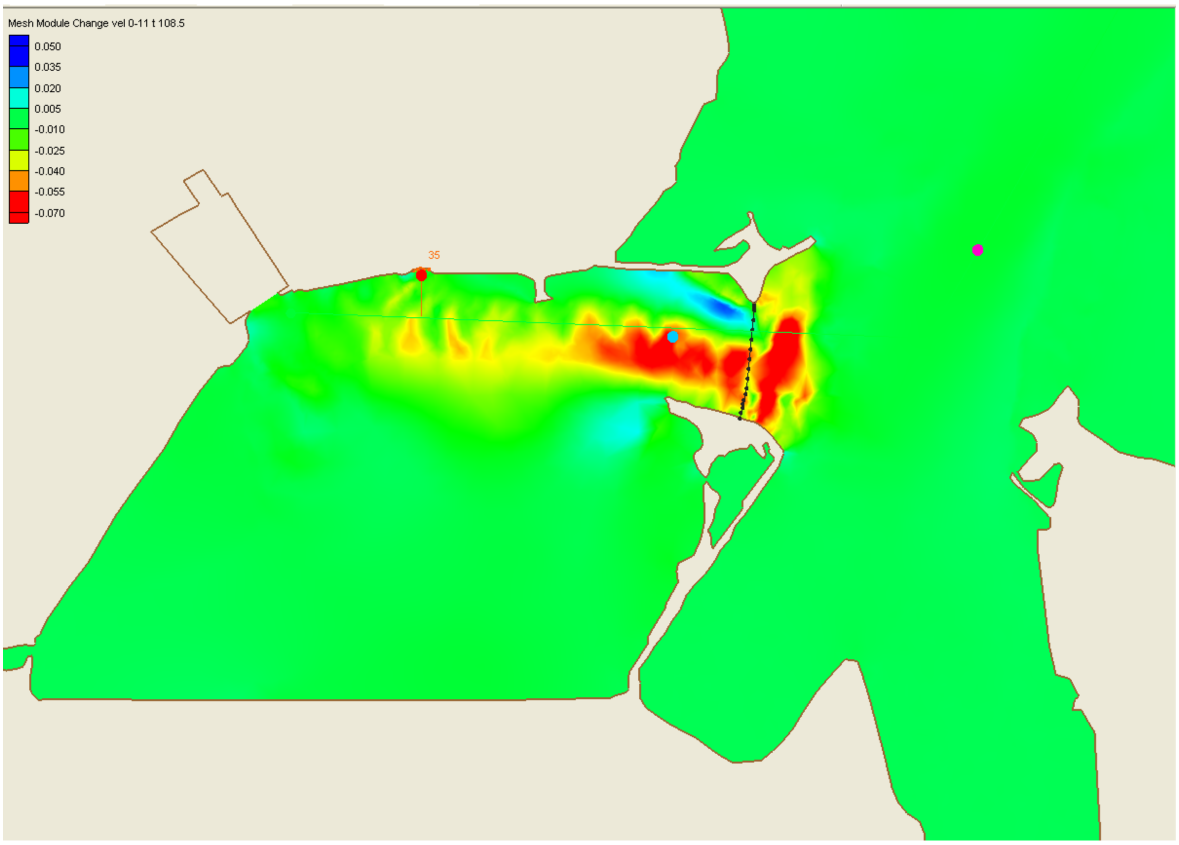

Figure 5 - Differences in velocities between scenario 0 and 11 at max incoming tide at t = 108.5

Figure 4 shows a close view of the velocities and current directions immediately in front of the cooling water intake at the maximum incoming tide. A zone of 100-150 m is influenced by the abstraction. The area immediately to the west of the cooling water intake show low velocities in the area of 0.02-0.04 m/s, lower than today's 0.03-0.07 m/s as a result of levelling the area in alignment with the cooling water intake channel.

This slight drop in velocities can also be seen in Figure 5 where the differences in velocities between scenario 0 and 11 can be seen. The main change is lowering of the velocities in Seaton Channel by 0.05-0.1 m/s

2.2 Outgoing tide

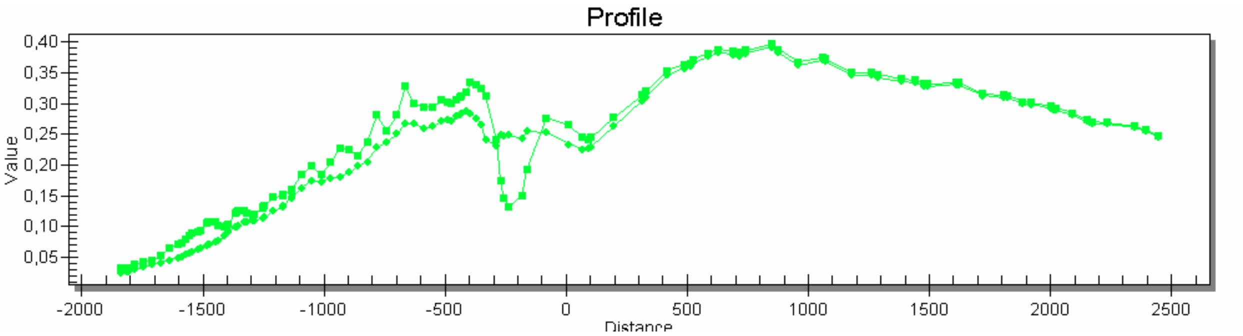

Figure 6 - Velocity (m/s) transect at max. outgoing tide t = 115.5

Figure 6 shows a transect of the maximum velocities at outgoing tides for t = 115.5. Scenario 11 (lower line) shows a slight drop in velocities from Scenario 0 (upper line).

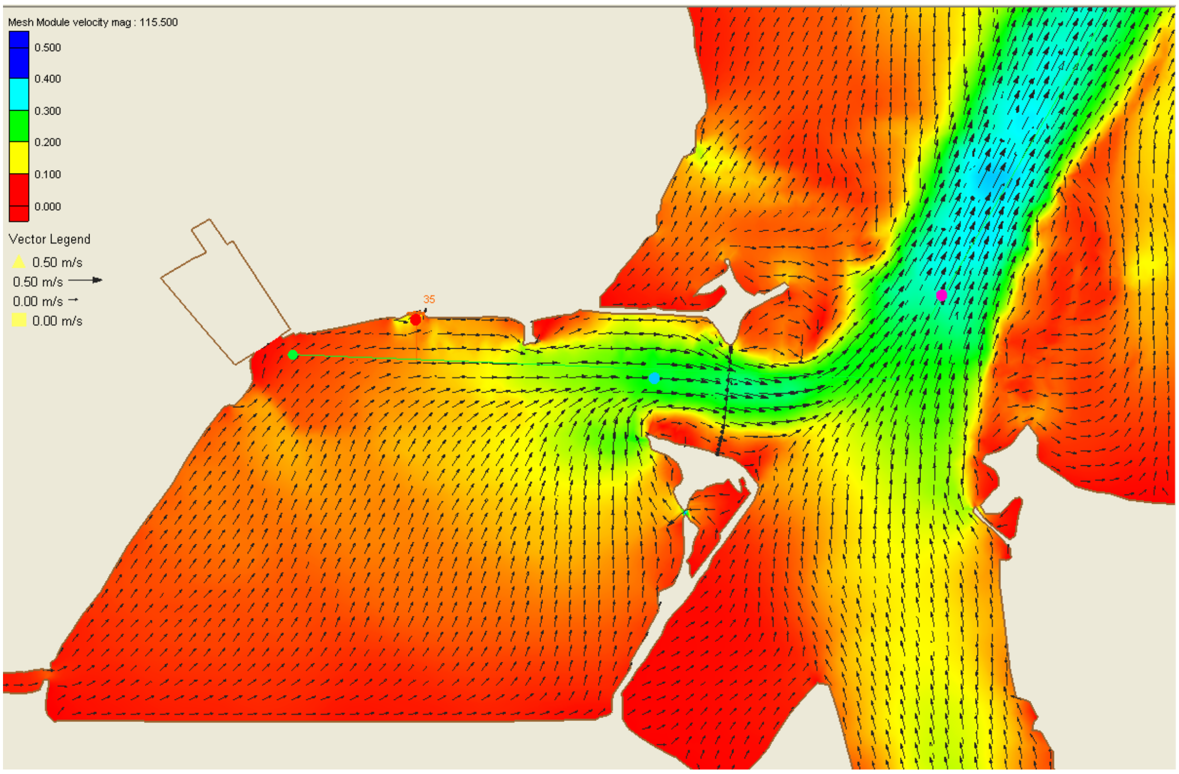

Figure 7 - Scenario 11 maximum outgoing tidal velocities at t = 115.5

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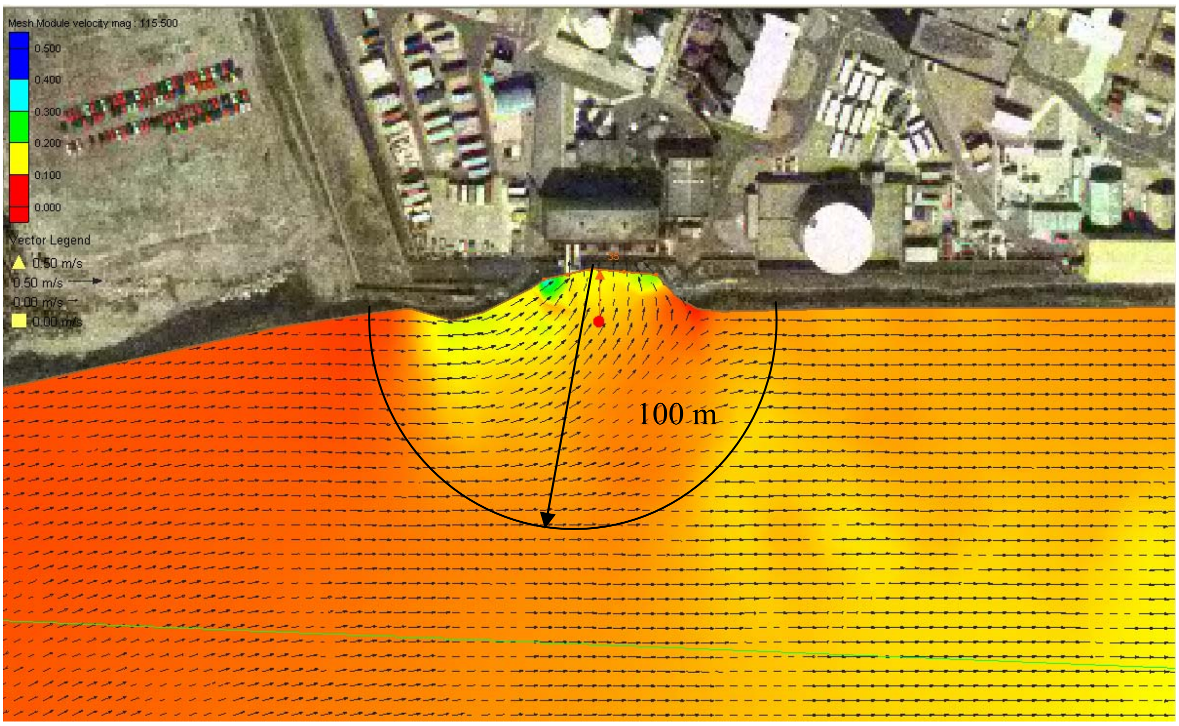

Figure 8- Scenario 11, zoom in on area immediately in front of CW intake at t = 115.5

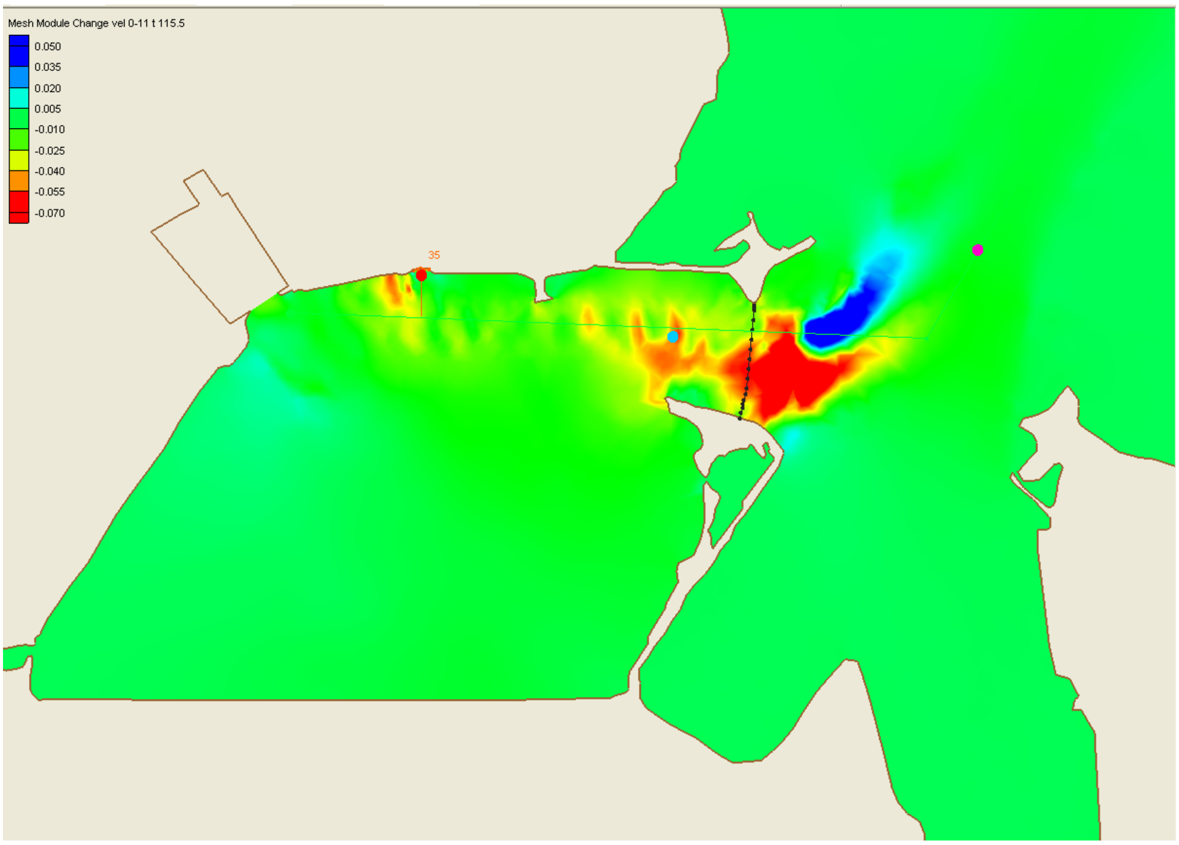

Figure 9 - Differences in velocities between scenario 0 and 11 at max outgoing tide at t = 115.5

Figure 7 shows that the maximum outgoing tidal velocities are in the order of 0.2-0.3 m/s in Seaton Channel. Figure 8 shows the local effects in the area of the cooling water intake. Compared to Scenario 10 (DNV Report 2006-0315 fig. 10) the velocities in the area immediately to the west if the intake channel drop from 0.12-0.18 to 0.08-0.12 m/s.

2.3 Velocity differences

Table 1 shows the changes in velocities from Scenario 0 to Scenarios 8, 10 and 11. For the cooling water intake, the average velocities drop by 0.1% both for Scenario 8 and Scenario 10, but by 10.4% for Scenario 11 as the intertidal spit on the western border of the intake channel is lowered to the level of the intake channel.

The original modelling presented in DNV Report 2004-1387 predicted that for Scenario 8 the drop in velocities would be 6.6% for Pt 2, 17.9% for Pt 3 and 1.4% for Pt 4. The predictions correspond well to those presented in this study.

Table 1 – Velocity difference maxima in % (depth averaged) between baseline scenario (0) and scenarios 8, 10 and 11. With cooling water abstraction.

Scenario	m/s	Pt 1 CW intake	Pt 2 Seal Sands	Pt 3 Seaton Channel	Pt 4 Tees Channel
0	Max	0.146	0.0709	0.347	0.390
	Min	0.0674	0.0330	0.00151	0.00118
	Average	0.0932	0.0311	0.123	0.1412
8	Max	0.146	0.0657	0.276	0.385
	Min	0.0679	0.00431	0.00163	0.00128
	Average	0.0931	0.0288	0.100	0.139
	Average diff	-0.0000884	-0.00230	-0.00222	0.001844
	Avg diff %	-0.1%	-7.4%	-18.1%	-1.3%
10	Max	0.146	0.0652	0.264	0.385
	Min	0.0683	0.00444	0.00158	0.00120
	Average	0.0931	0.0284	0.0975	0.140
	Average diff	-0.00119	-0.003	-0.0250	-0.00194
	Avg diff %	-0.1%	-8.6%	-20.4%	-1.4%
11	Max	0.122	0.0663	0.266	0.385
	Min	0.0659	0.00444	0.00172	0.00122
	Average	0.0835	0.0286	0.0987	0.140
	Average diff	-0.00970	-0.00254	-0.0238	-0.00199
	Avg diff %	-10.4%	-8.2%	-19.4%	-1.4%

3 SHEAR STRESS

The predicted shear stress distribution at points 1, 2, 3 and 4 for Scenario 11 are shown in Figure 10. The shear stress at point 1, the cooling water intake, varies from 0.015-0.055 N/m^2, slightly lower than that predicted for Scenario 10 in DNV Report 2006-0315.

Figure 11 shows the distribution of shear stress in N/m^2 along the transect from the Holding basin to the sea through Seaton Channel (left to right) at maximum incoming tide at t = 108.5 for Scenario 0 (upper line) and 11 (lower line). The shear stress drops significantly within the deepwater part of Seaton Channel in Scenario 11.

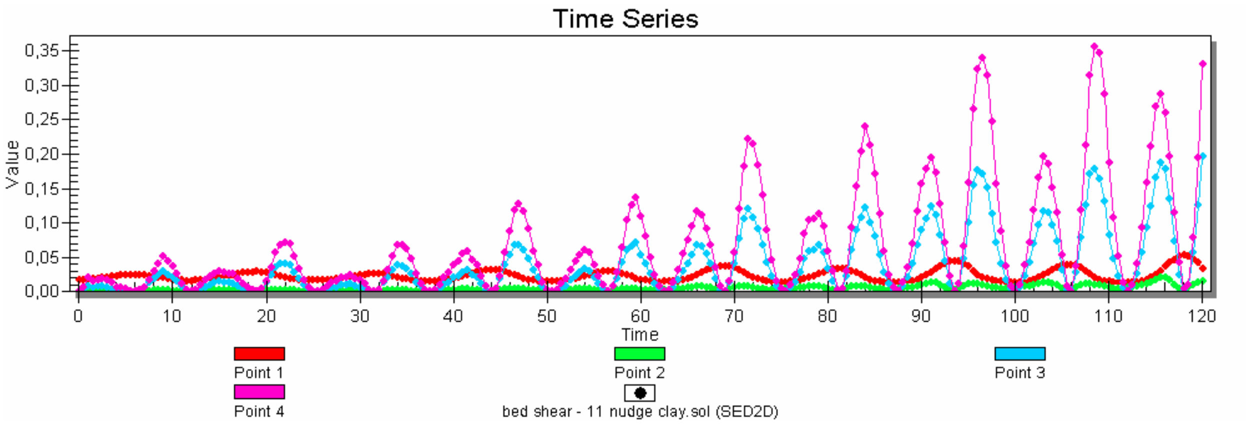

Figure 10 - Shear stress magnitude (N/m^2) for points 1, 2, 3 and 4 for Scenario 11

3.1 Incoming tide

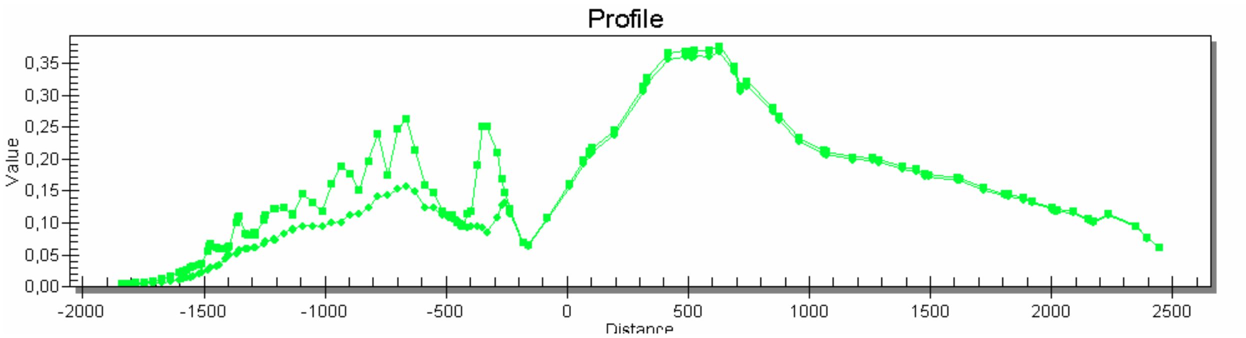

Figure 11 – Shear stress (N/m^2) transect at max. incoming tide t = 108.5

Figure 12 shows the maximum shear stress distribution at the maximum incoming tide. The shear stress in Seaton Channel reaches 0.2-0.25 N/m^2 at the eastern constriction towards Tees channel, dropping steadily towards the west. The area to the west of the cooling water intake channel experiences 0.005-0.01 N/m^2.

Figure 13 shows the change in shear stress from the baseline scenario to Scenario 11 at the time of maximum incoming tide. In Seaton Channel the drop is about 0.15 N/m^2, on Seal Sands less than 0.0001 N/m^2, and to the west of the intake channel the drop is 0.001-0.015 N/m^2 due to lowering of the bed to the level of the intake channel.

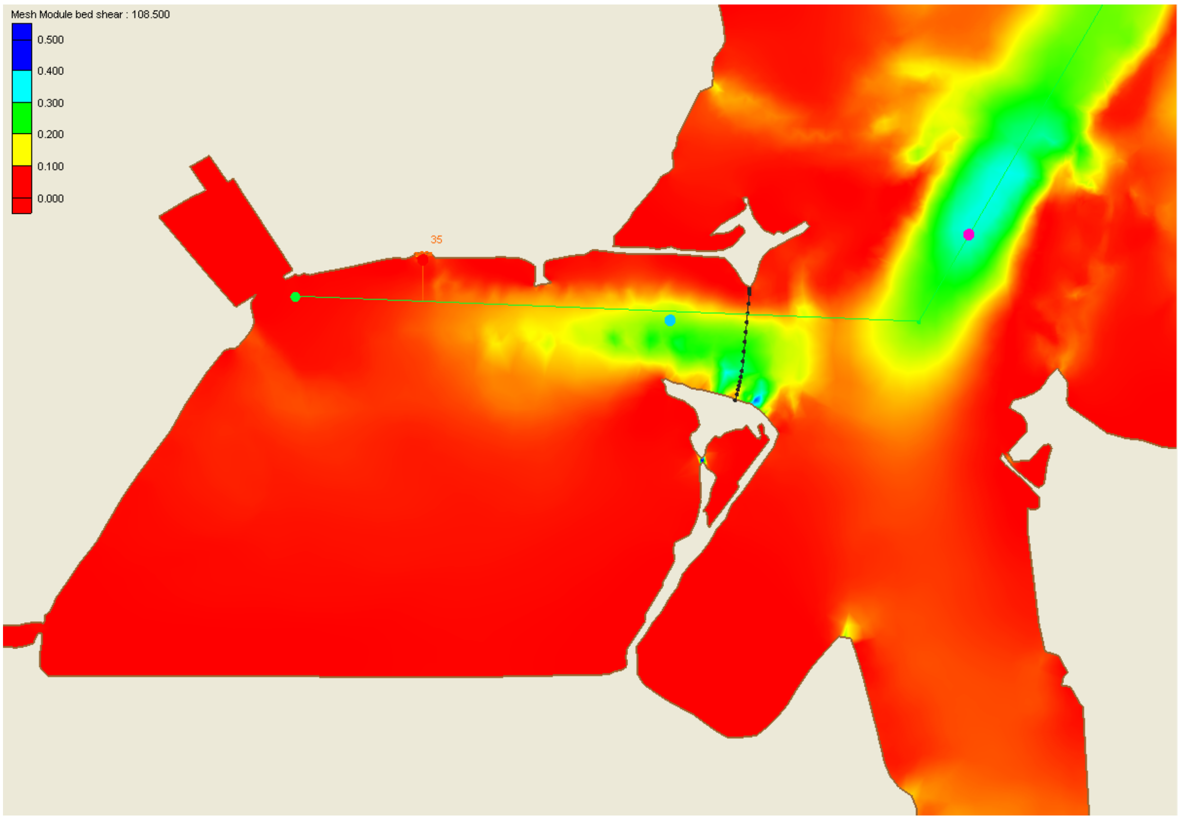

Figure 12 - Scenario 11 maximum shear stress (N/m^2) at incoming tide at t = 108.5

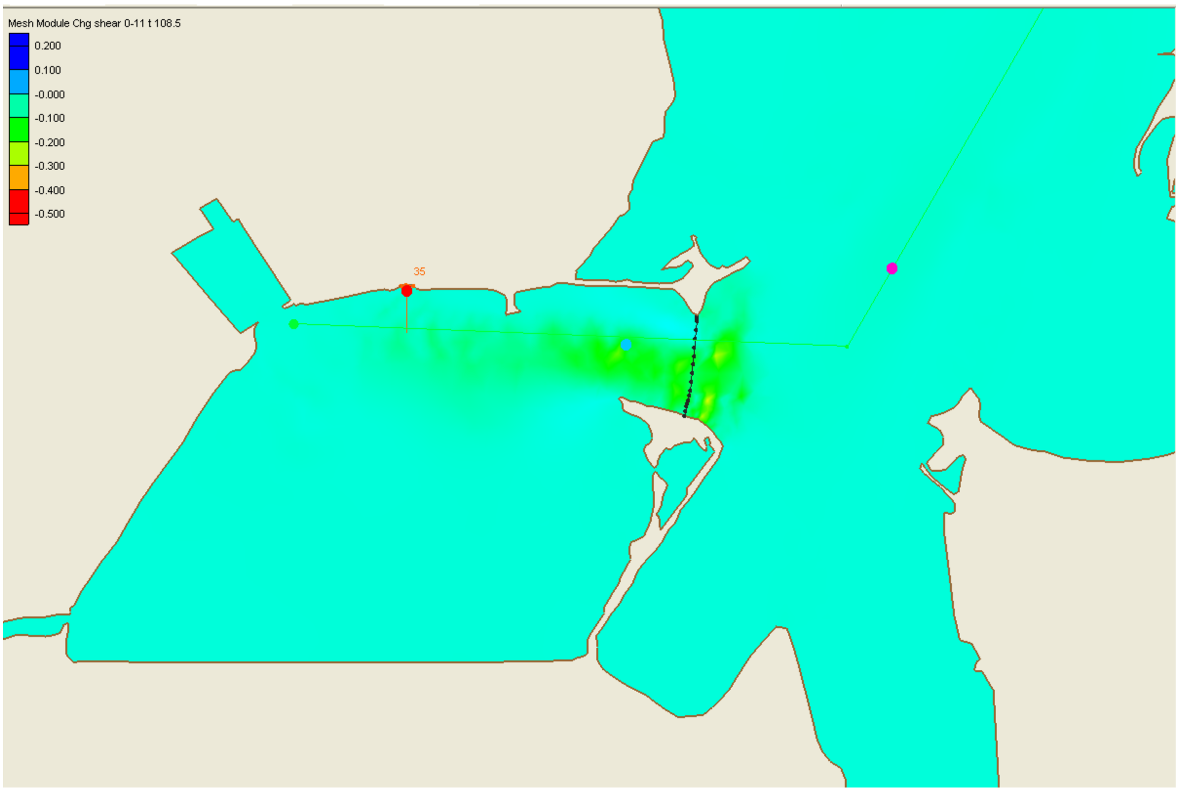

Figure 13 – Differences in shear stress scenario 0 to 11 at max incoming tide t = 108.5

3.2 Outgoing tide

Figure 14 shows the shear stress in N/m^2 along the transect from the holding basin (left end of graph) through Seaton Channel towards the sea at the maximum outgoing tide, t = 115.5 for Scenario 0 (upper line) and 11 (lower line). Shear stress drops to a certain degree in Seaton Channel as a result of the lower channel floor.

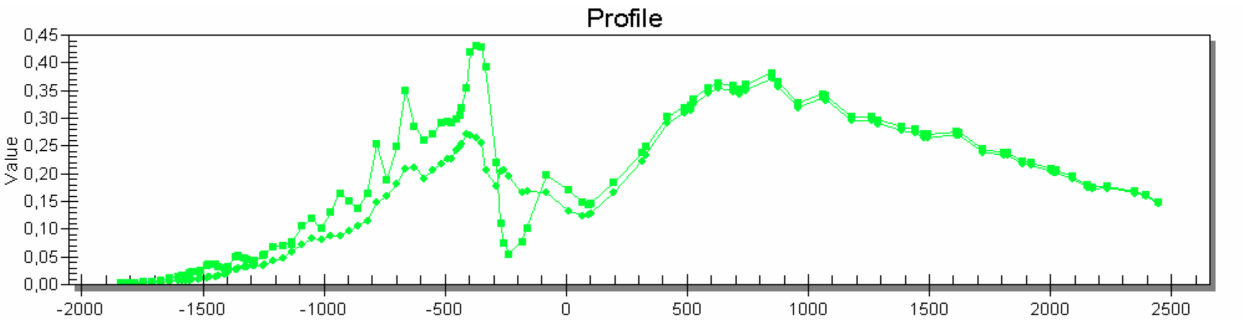

Figure 14 – Shear stress (N/m^2) transect at max. outgoing tide t = 115.5

Figure 15 shows the shear stress distribution for the outgoing tide. Seaton Channel experiences 0.25 N/m^2 at the eastern border towards Tees turning circle, dropping steadily westwards. The area to the west of the cooling water intake channel is subjected to about 0.02-0.07 N/m^2, with 0.05-0.07 N/m^2 adjacent to the deepwater pocket at Quay 10&11.

The change in shear stress from Scenario 0 to Scenario 11 at the maximum outgoing tide is presented in Figure 16. The largest drops are experienced in the deepwater parts of Seaton Channel with a drop of 0.05-0.1 N/m^2. The area to the west of the cooling water intake channel experiences a drop of about 0.05 N/m^2, which represents a drop in the order of 50%.

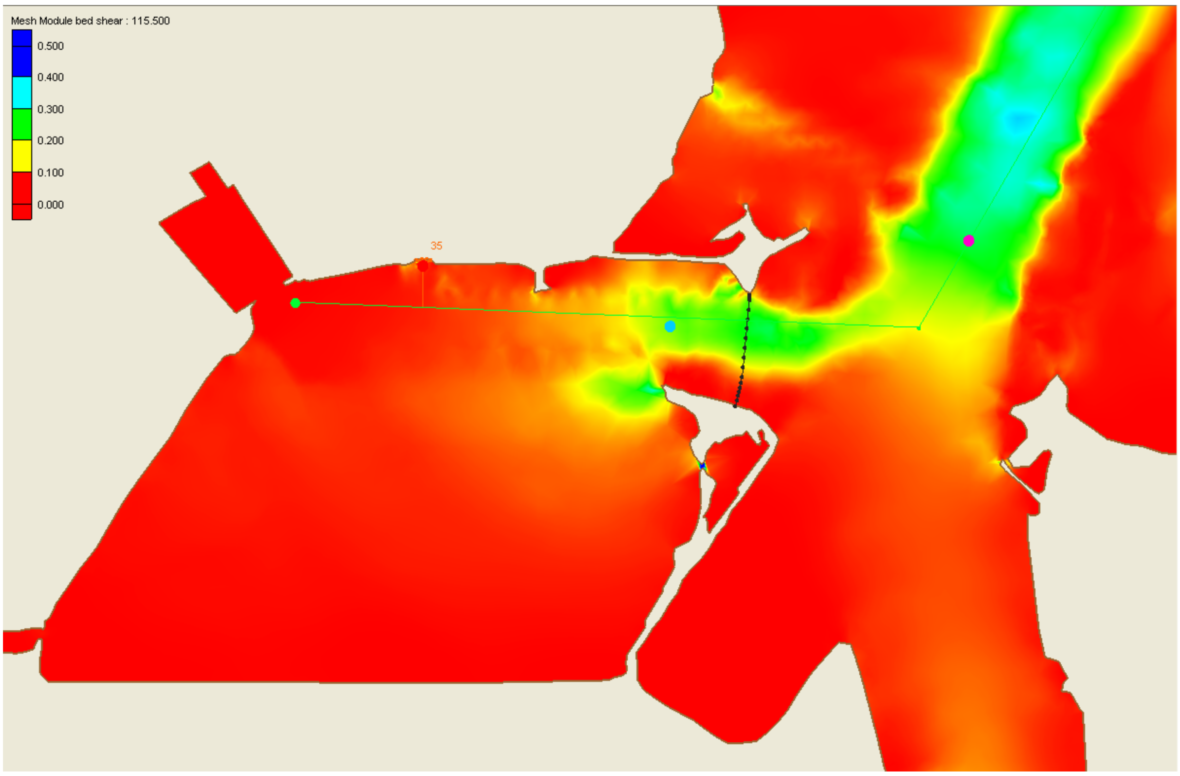

Figure 15 - Scenario 11 maximum shear stress (N/m2) at outgoing tide at t = 115.5

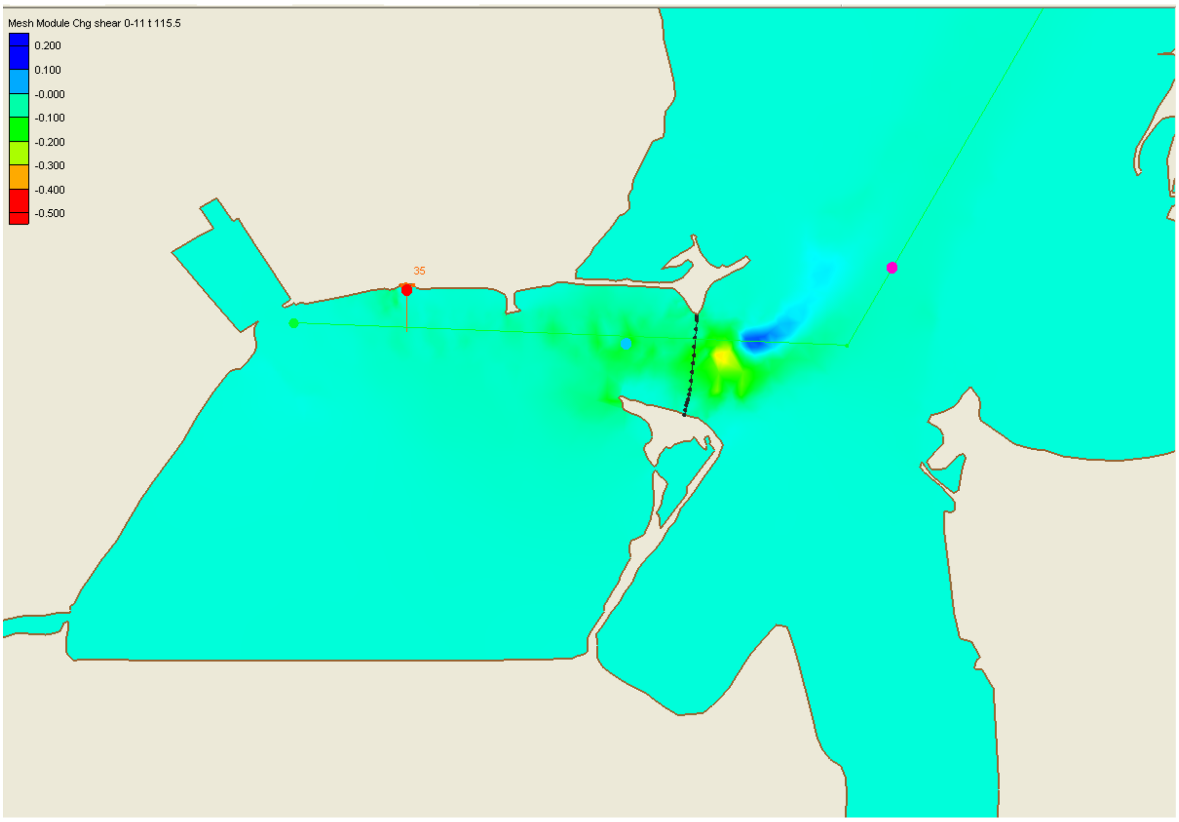

Figure 16 - Differences in shear stress scenario 0 to 11 at max outgoing tide t = 115.5

3.3 Shear stress differences

Table 2 – Shear stress difference maxima in % (depth averaged) between baseline scenario (0) and scenarios 8, 10 and 11. With cooling water abstraction.

Scenario	N/m^2	Pt 1 CW intake	Pt 2 Seal Sands	Pt 3 Seaton Channel	Pt 4 Tees Channel
0	Max	0.0767	0.0236	0.384	0.366
	Min	0.0136	0.000044	0.000004	0.000003
	Average	0.0295	0.00515	0.0672	0.0702
8	Max	0.0767	0.0204	0.219	0.357
	Min	0.0138	0.000075	0.000011	0.000002
	Average	0.0294	0.00445	0.0407	0.0684
	Average diff	-0.000068	-0.000702	-0.0266	-0.00181
	Avg diff %	-0.2%	-13.7%	-39.5%	-2.6%
10	Max	0.0765	0.0202	0.197	0.357
	Min	0.0140	0.000080	0.000010	0.000002
	Average	0.0294	0.00434	0.0378	0.0683
	Average diff	-0.000094	-0.000810	-0.0295	-0.00191
	Avg diff %	-0.3%	-15.7%	-43.8%	-2.7%
11	Max	0.0529	0.0209	0.197	0.357
	Min	0.0129	0.000080	0.000013	0.000002
	Average	0.0233	0.00439	0.0382	0.0683
	Average diff	-0.00621	-0.000753	-0.0291	-0.00297
	Avg diff %	-21.1%	-14.6%	-43.2%	-2.8%

The changes in shear stresses at the observation points from Scenario 0 to Scenario 8, 10 and 11 are summarised in Table 2. For the cooling water intake, the average shear stresses drop by 21.1% in Scenario 11, due to lowering of the bed at the intertidal spit on the western border of the intake channel to the level of the intake channel itself. The shear stress in this area, in the area adjacent to the deepwater pocket, drops from Scenario 0 to Scenario 11, indicating a lower potential for erosion.

The original modelling presented in DNV Report 2004-1387 predicted that for Scenario 8 the drop in shear stresses would be 13% for Pt 2, 39% for Pt 3 and 2.7% for Pt 4. The predictions correspond well to those presented in this study.

4 REFERENCES

/1/ Environmental assessment of dredging operations, changes in hydrodynamics and sediment transport; TERRC facility. DNV Report 2004-1387

/2/ Finalising environmental assessment at the TERRC facility. Addendum to DNV Report 2004-1387. DNV Report 2005-1024

/3/ Further modelling of hydrodynamics and sediment transport from developments at the TERRC site. DNV Report 2006-0315

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