TIDE
Tidal River Development

Project part-financed by the European Union (European Regional Development Fund)

The Interreg IVB North Sea Region Programme

'Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg'

Measure analysis 04
in the framework of the Interreg IVB project TIDE

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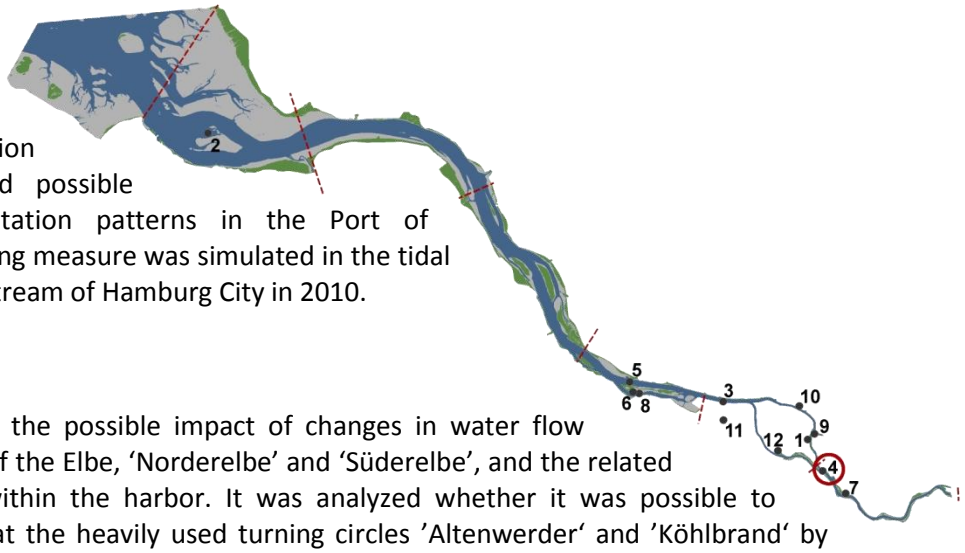
Part 1: Measure description

measure category	hydrology, morphology
estuary	Elbe
salinity zone	freshwater
pressure	gross change in morphology and hydrographic regime
status	Finished in 2010
river km	609
country/location	Germany, Hamburg Bunthaus on the island of Wilhelmsburg
responsible authority	Hamburg Port Authority

1.1 Introduction

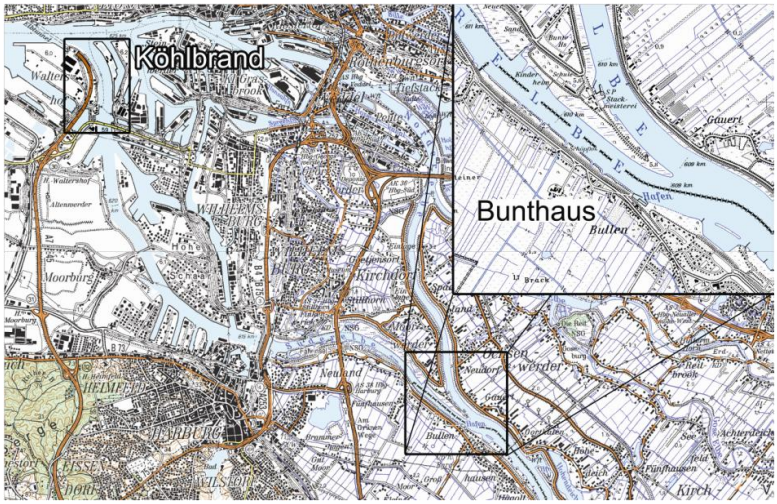


In the study "Investigation on freshwater current direction control at 'Bunthaus' and possible impacts on the sedimentation patterns in the Port of Hamburg", a river engineering measure was simulated in the tidal influenced Elbe estuary upstream of Hamburg City in 2010.

1.2 Objectives

The study should calculate the possible impact of changes in water flow through the two branches of the Elbe, 'Norderelbe' and 'Süderelbe', and the related sedimentation processes within the harbor. It was analyzed whether it was possible to reduce the sedimentation at the heavily used turning circles 'Altenwerder' and 'Köhlbrand' by controlling the direction and strength of the currents at 'Bunthäuser Spitze'.

1.3 Background and side conditions



Anthropogenic and natural changes along the estuary resulted in a strong upstream sediment transport which finally led to high sedimentation rates in the area of Hamburg. The amount of dredged material increased during the last years.

Figure 1: Port of Hamburg with 'Bunthaus' in detail

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Adjustments of the inner areas of Hamburg harbor resulted in changes in current velocities and influenced sedimentation and erosion processes in harbor basins. At conditions of low freshwater discharge a silting up tendency is observed in the 'Süderelbe' which is the area where the container terminal 'Altenwerder' and the bifurcation channel 'Köhlbrand' are located.

The intention of the measure was to control the amount of freshwater at Bunthaus that runs either in the 'Norderelbe' or in the 'Süderelbe' by installing a movable construction.

The used river engeneering model was commisioned by Hamburg Port Authority (HPA) and the Administration of Waterways and Navigation (WSA Nord). The company DHI WASY GmbH set up the model and carried out the calculations.

1.4 Measure

Numeric modeling was used to investigate how sedimentation processes in the harbor – especially within the area 'Köhlbrand' and the connected parts of the 'Norderelbe' – can be influenced by a river engineering measure at 'Bunthäuser Spitze'.

The hydrodynamic numerical model considered the area between the City of Geesthacht (upstream end) and the island 'Stadersand' (downstream end) having a length of 69 km. In order to model the bathymetry of the Elbe estuary, soundings of HPA-surveys were used.

Several scenarios with different loads of suspended matter from upstream and downstream were analyzed, in order to calibrate and validate the model with results from nature. In the model the impact of changes in water flow through the 'Norderelbe' and the 'Süderelbe' was studied by processing it in four different cases:

1. Current and sediment transport without structural alteration.
2. Reduction of the water amount (40%) in the 'Norderelbe' by a piling wall.
3. Reduction of the water amount (40%) in the 'Süderelbe' by a piling wall.
4. Variable gates were set in the Norderelbe and the 'Süderelbe' in order to influence the freshwater discharge. The gate in the 'Süderelbe' was closed during the period from low tide to high tide. The gate in the 'Norderelbe' was closed in the period from high tide to low tide.

1.5 Expected effect

The hydrodynamic and morphological quality of the model was approved. Both, silty sediments from upstream and sandy sediments from downstream are transported to the harbor at the investigated headwater levels.

Results of scenario 2: (Adjustment of the 'Norderelbe'): a higher sedimentation rate in the 'Norder-' and 'Süderelbe' occurred. The material originated mostly from a part of the 'Norderelbe' in between

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'Köhlbrand' and the turning radius of the 'Hansahafen'. The strong erosion at this place was caused by the strong beginning state of the flood current which was a result of the adjustment of the 'Norderelbe'.

Results of scenario 3: (Adjustment of the 'Süderelbe') higher erosion rates in large parts of the 'Norderelbe' occurred. In most parts higher sedimentation was expected as well as between 'Köhlbrand' and the turning radius of the 'Hansahafen' and in the 'Süderelbe' at the turning circles 'Sandauhafen' and 'Altenwerder'.
Results of scenario 4: (Controlled gates in the 'Norder'- and 'Süderelbe'): A clear decrease of the flow through took place during the single tidal phases, as well as a higher sedimentation at the turning radius southward of the container-terminal 'Altenwerder'. The sedimentation rates in the 'Norderelbe' clearly decreased.

As a final result no scenario could influence the sedimentation in a positive manner in the 'Norderelbe' and 'Süderelbe'. By controlling both gates in the 'Norder-' and 'Süderelbe' a decrease in the sedimentation process could be reached in the 'Norderelbe'. Unfortunately, sedimentation in the 'Süderelbe' increased.

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Part 2: Execution of the main effectiveness criteria

2.1 Effectiveness according to development targets of measure

Definition of development targets

- Finding a possibility to affect the sedimentation patterns within the harbor of Hamburg by using a current direction control at the “Bunthäuser Spitze”.
- Find a possibility to reduce the sedimentation at the highly frequented turning circle “Altenwerder” and the “Köhlbrand turn”.
- Find a possibility to reduce the sedimentation within the Port of Hamburg.

Achievement of development targets

- The results of the numeric modeling showed that it is possible to influence long established sedimentation patterns within the Port of Hamburg only to a certain degree. The sediment load appeared elsewhere within the harbor.
- In conclusion the degree of reaching the development targets is rather low.

2.2 Impact on ecosystem services

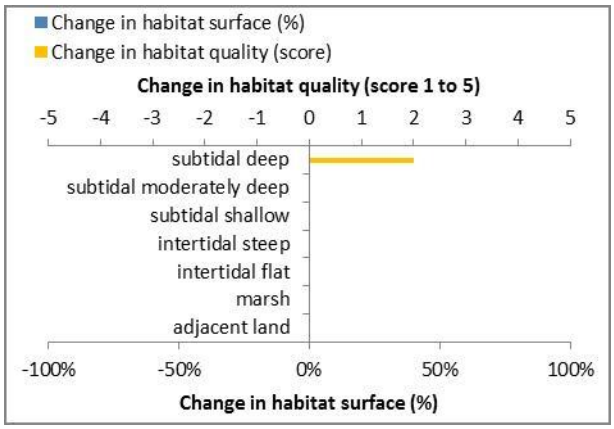

Figure 2: Ecosystem services analysis for Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´: Indication of habitat surface and quality change, i.e. situation before versus after measure implementation.

- From the ES assessment it is concluded that this measure generates overall a slightly positive expected impact for several ES, mainly for:
  - “biodiversity”
  - Cultural services
  - Some regulating services: Erosion and sedimentation regulation (by water bodies); Water quality regulation: transport of polutants and excess nutrients; Water quantity regulation: transportation
  - Some provisioning services: Water for industrial use; Water for navigation
- The expected impact for the development target (“Water for navigation”) is slightly positive.
- The expected impact for the different beneficiary groups is limited, with a slightly positive expected impact for indirect and future use and for local and region use.

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Table 1: Ecosystem services analysis for Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´: (1) expected impact on ES supply in the measure site and (2) expected impact on different beneficiaries as a consequence of the measure.

Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´

Cat.	Ecosystem Service	Score
S	"Biodiversity"	1
R1	Erosion and sedimentation regulation by water bodies	1
R2	Water quality regulation: reduction of excess loads coming from the catchment	0
R3	Water quality regulation: transport of polutants and excess nutriënts	1
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	0
R6	Water quantity regulation: transportation	0
R7	Water quantity regulation: landscape maintenance	0
R8	Climate regulation: Carbon sequestration and burial	0
R9	Water quantity regulation: dissipation of tidal and river energy	0
R10	Regulation extreme events or disturbance: Wave reduction	0
R11	Regulation extreme events or disturbance: Water current reduction	0
R12	Regulation extreme events or disturbance: Flood water storage	0
P1	Water for industrial use	1
P2	Water for navigation	1
P3	Food: Animals	0
C1	Aesthetic information	1
C2	Inspiration for culture, art and design	1
C3	Information for cognitive development	1
C4	Opportunities for recreation & tourism	1

Beneficiaries:	
Direct users	0
Indirect users	1
Future users	1
Local users	1
Regional users	1
Global users	0

X Targeted ES

Legend: expected impact*	
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative socio-economic conclusions require local supply and demand data to complement this assessment.

The screening of the ecosystem services (ESS) that were effected by the measure `Current direction control` showed no clear results. Some ESS will be influenced positively, and also the targeted ESS will slightly be effected. This outcome made clear that the screening of the effects on the ESS is not applicable on every type of measure executed in the TIDE project

2.3 Degree of synergistic effects and conflicts according the uses

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Part 3: Additional evaluation criteria in view of EU environmental law

3.1 Degree of synergistic effects and conflicts according WFD aims

Table 2: Effect of the measure concerning the main pressures in the freshwater zone of the Elbe estuary

Indicator Group	Code	Main pressures freshwater zone Elbe	Effect?					Description: Aim of the measure current control at Bunthaus
			- -	-	0	+	+ +	
S.I.	-	Habitat loss and degradation during the last about 100 years: Subtidal			0			
S.I.	1.1	Habitat loss and degradation during the last about 100 years: Intertidal			0			
S.I.	1.4/ 1.5	Gross change in morphology/hydrographic regime during the last about 100 years			0			
S.I.	3.1/3. 2	Decrease of water and sediment chemical quality			0			
D.I.	2.3	Discharge of nutrients or harmful substances			0			
D.I.	1.3	Land claim during the last about 100 years			0			
D.I.	2.6	Capital dredging			0			

S.I. = state indicator; D.I. = driver indicator

The aim and the effect of the measure ‘current control at Bunthaus’, has neither positive nor negative effect on the main pressures of the freshwater zone of the Elbe estuary.

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3.2 Degree of synergistic effects and conflicts according NATURA 2000 aims

Table 3: Effect of the measure concerning the main conservation objectives in the operational area 2

Operational area (zone)	Natura 2000 conservation objectives	Effect of Measure on conservation objectives			Description
2		Positive	No effect	Negative	
2	Prevention of further increase and/or reduction of tidal range (energy)		+		
2	Conservation and development of primarily floodplain/alluvial forest (*91E0)		+		
2	Conservation and improvement of alluvial meadows of river valleys (6440) and lowland and hay meadows (6510)		+		
2	Conservation of the primarily 'Elbe Water Dropwort' (*Oenanthe conioides*) with species specific dynamic, development of further habitats to improve the habitat network		+		
2	Conservation and development of spawn and growth habitats for asp, ensuring the habitat potential for the twaite shad		+		
2	Conservation and development of the transition functionality between the Middle Elbe and the Estuary downstream for migratory fish species of Annex II BHD		+		

The management targets concerning the BHD were not considered in this theoretical study.

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Part 4: Crux of the matter

The idea of regulating the sedimentation within the Port of Hamburg by the use of a well directed controlled headwater discharge through the two branches of the Elbe estuary had a lot of maintainers and opponents.

The feasibility study showed the possibility of affecting the sedimentation patterns by regulating the discharge through the branches of the Norder- and 'Süderelbe'. The benefits regarding the dredging needs were however rather low, because of the new (only shifted) sedimentation that occurs elsewhere in the port of Hamburg. An overall reduction of sedimentation within the port could not be achieved by regulating the freshwater current in the described way.

This study can be seen as a necessary step in enhancing the knowledge on the interrelation between sedimentation and headwater discharge. The idea will not be pursued furthermore.

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