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 **Port of
Rotterdam**

12th International SedNet Conference

**Session 4 – Sediment assessment and
management, concepts and policies**

**Use of rare earth elements and optical cable to
quantify the sedimentation from different sediment
sources in Port of Rotterdam**

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Introduction – SURICATES

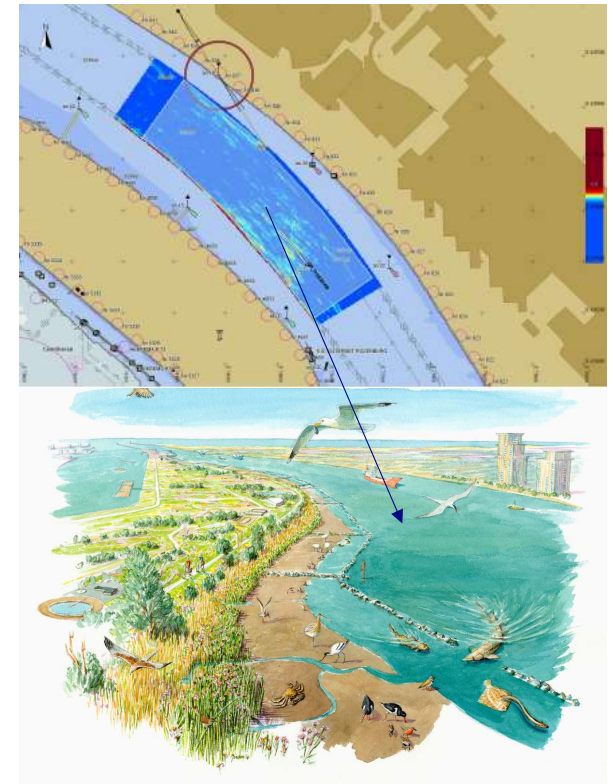
SURICATES stands for Sediment Uses as Resources In Circular And Territorial EconomieS.

SURICATES aim is to increase sediment reuse for erosion and flood protection.

Dutch Pilot: Sediment reallocation within Port of Rotterdam

One such application is the reallocation of 580.000 m³ sediment in the Nieuwe Waterweg (NWW) within the Port of Rotterdam.

The aim is to make a constructed wetland at the river bank more resilient by increasing the sedimentation.



Sediment reallocation within Port of R'dam - assessment

The impact on the systems resilience has been assessed by:

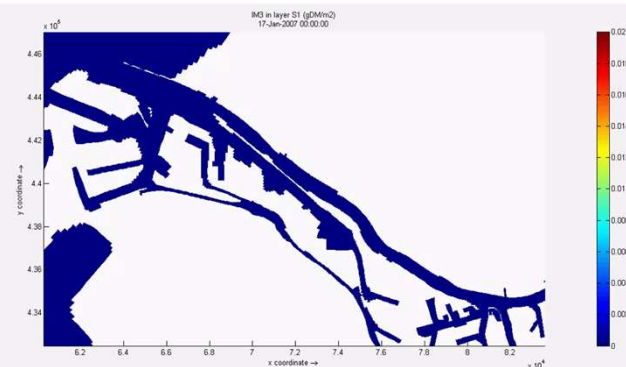
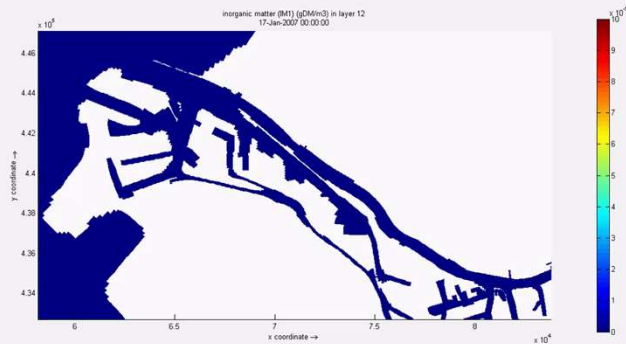
1. The change in **bathymetry** in the main shipping channel, is there extra siltation?
2. The **nourishment** of the constructed wetland, is sediment entrapped?
3. The **sedimentation balance**, is there an observed increase in the amount of fluvial sediments?
4. The **turbidity** in the channel, how is the sediment transported?

(greyed out: discussed in another session)

The focus is on new monitoring techniques (optical cables and rare earth elements as tracer) as sedimentation assessment tools.

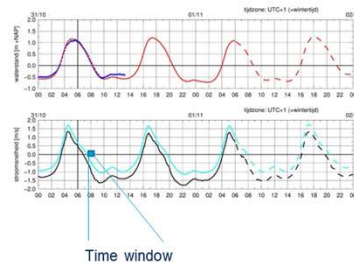
Sediment reallocation within Port of R'dam – site selection

A model study helped to define the reallocation site position and tidal time window and gave a baseline prediction on the amount of siltation (when and where) due to the reallocation of 580.000 m³ sediment.

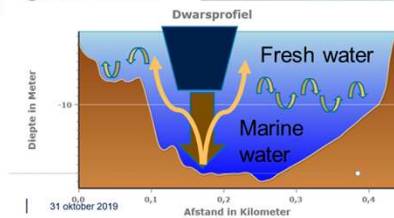


Time window: up to 1 hour after turning tide.

Based on operational tidal model Rotterdam



Actuele bodemligging
Invoer
Beweeg de muis over of klik op het kaart te tonen.
Dwarsprofiel informatie



Sediment reallocation within Port of R'dam - monitoring

The assessment of the impact of the sediment reallocation consisted of several monitoring techniques. The focus here is on the monitoring of the intertidal changes in bathymetry at the reallocation site and the overall system sediment balance.

Main tools:

- Passive optical cable along and across the channel
- Actively heated optical cable for sediment profiles
- Sediment grab sampler and rare earth lab analyses

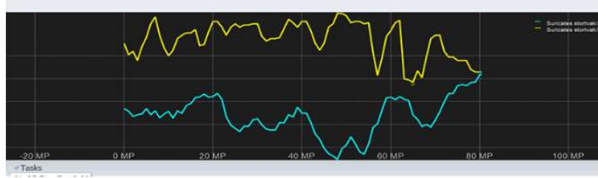


Sediment reallocation within Port of R'dam - bathymetry

Assessment with multibeam surveys

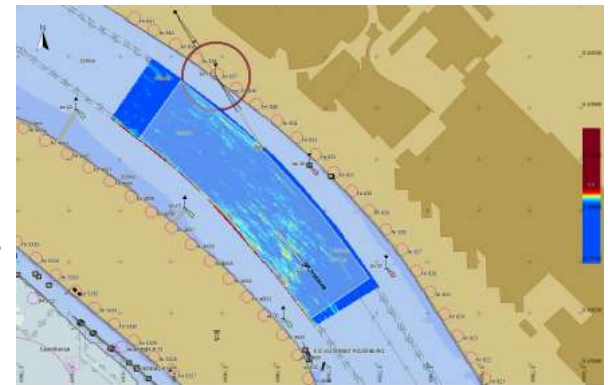
Surveys at the site during the reallocation and a weekly multi beam surveys of the channel showed:

- A decrease in the amount of sediment at the reallocation site direct after reallocation (erosion due to impact of sediment flume)



Bed level difference before and after reallocation by opening barge doors.

- Netto no sedimentation at the reallocation site over a one year period.



Sediment reallocation within Port of R'dam - bathymetry

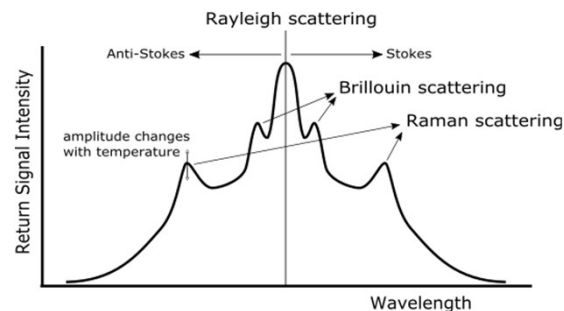
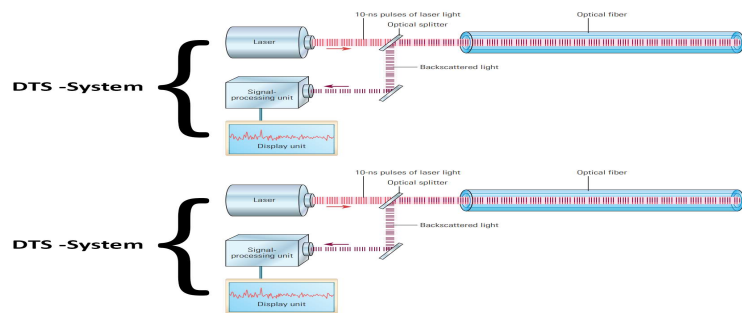
Sedimentation assessment with passive optical cable

The optical cable with DTS detects variation in temperature over the cable.

The water temperatures varies over the tide (river versus sea water).

If the cable gets covered by siltation, the temperature fluctuation is 'out of phase' with the water temperature due to the time needed to transfer heat.

This phase shift can be used to monitor sediment coverage (4x a day).

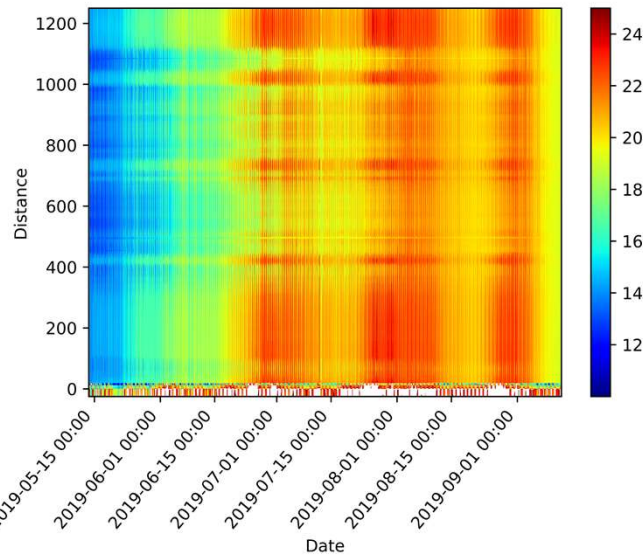


Sediment reallocation within Port of R'dam - bathymetry

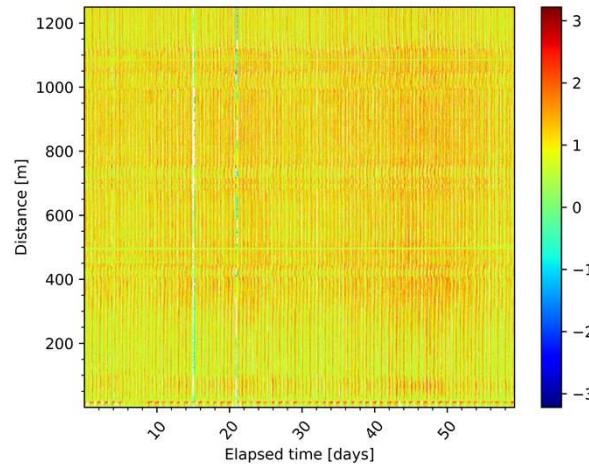
Sedimentation assessment with passive optical cable

Heat maps for the green cable.

Absolute temperature



v.s. ΔT over a tide

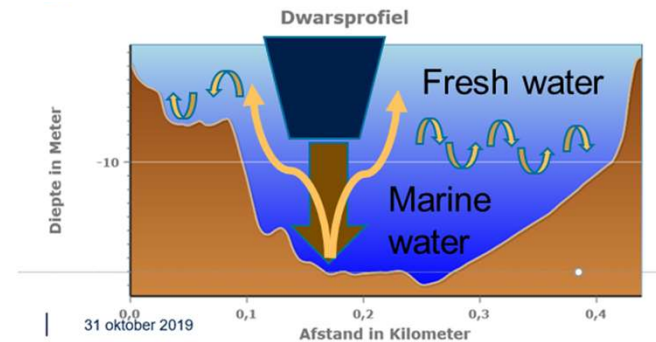


Sediment reallocation within Port of R'dam - nourishment

Assessment of Wetland nourishment with active optical cable

The hopper reallocated 580.000 m³ at the doorstep of the constructed wetland.

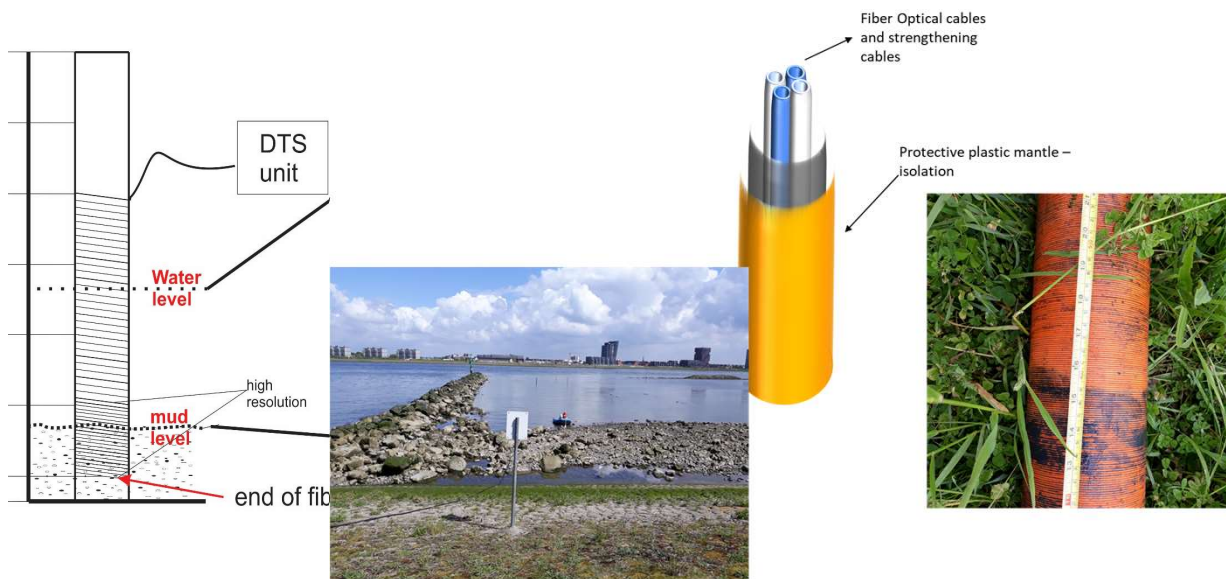
Did this help to increase the sedimentation rate within the wetland?



Sediment reallocation within Port of R'dam - nourishment

Assessment of Wetland nourishment with active optical cable

This was assessed with actively heated optical cables. The advantage is that there is no need for a natural source for heat fluctuation. Also the heat mass balance can be refined to calculate the sediment/water ratio and therefore the density of the sediment.

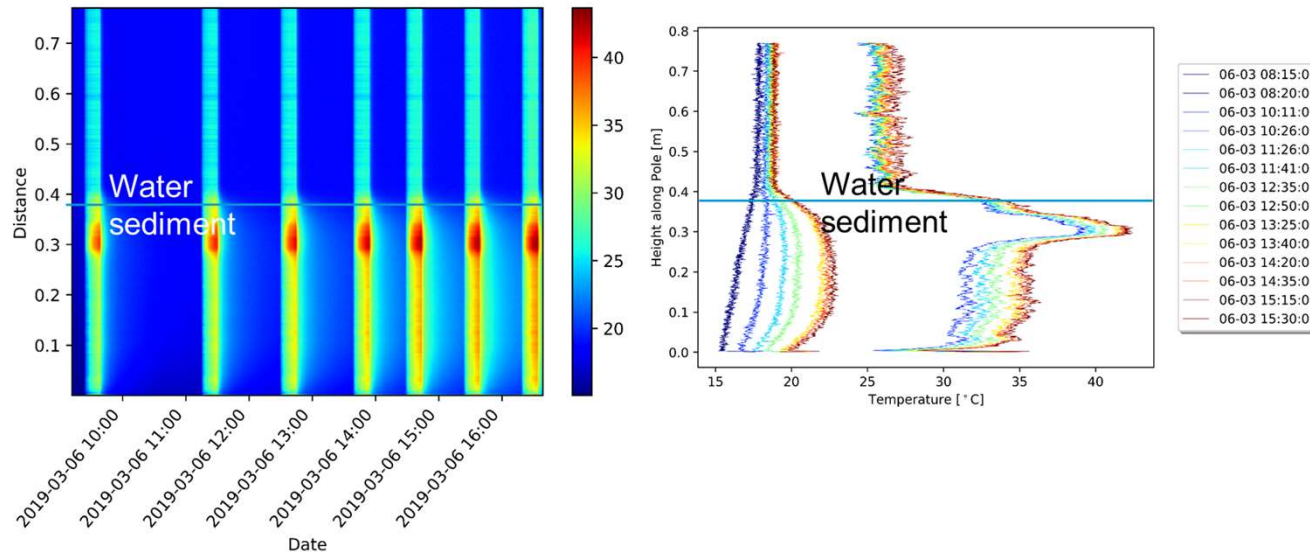


Sediment reallocation within Port of R'dam - nourishment

Assessment of Wetland nourishment with active optical cable

The technique works to establish the sediment/water boundary on a scale of 1 mm.

Cable temperature as function of time and distance (heatmap and line graph)



Question 2: Suitability for local impact assessment of sedimentation: Yes.

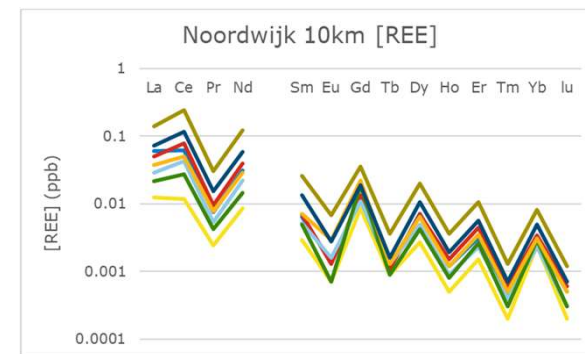
Sediment reallocation within Port of R'dam - balance

Assessment of sediment balance with rare earth elements

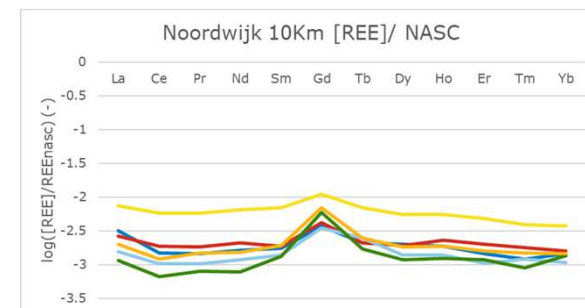
Group of rare earth elements

1	Periodiek systeem																18	
1	2																	0
1	2																	2
3	4																	10
11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Na	Mg	IIIb	IVb	Vb	VIb	VIIb	VIIIb	VIIIb	VIIIb	IIb	IIb	Al	Si	P	S	Cl	Ar	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
55	56	↓	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
87	88	↓↓	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og	
Lanthaniden		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71		
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
Actiniden		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103		
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

Natural concentrations in earth crust



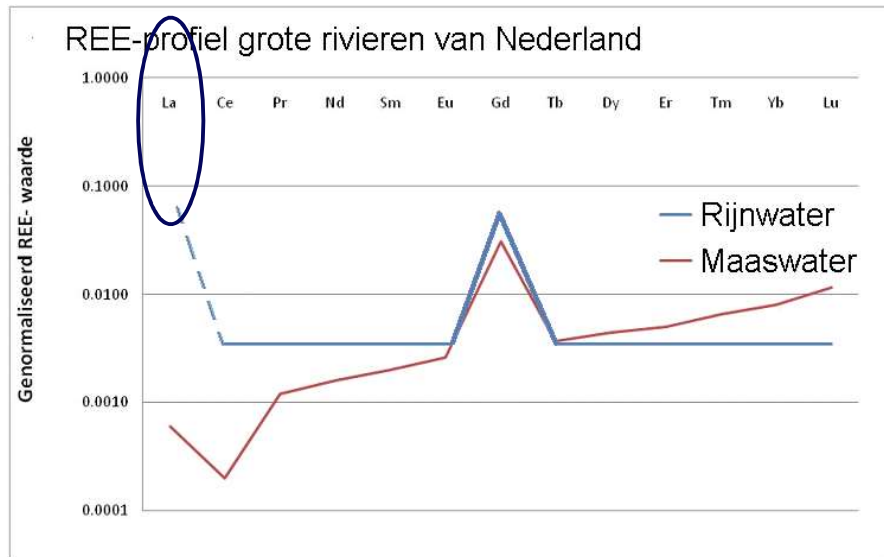
... making normalization possible.



Sediment reallocation within Port of R'dam - balance

Assessment of sediment balance with rare earth elements

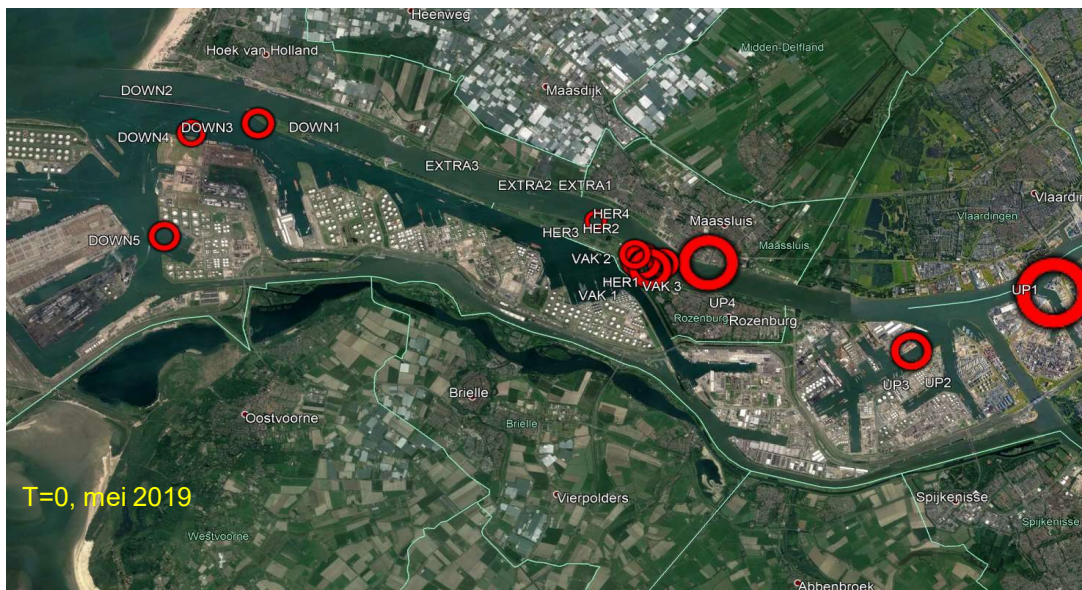
If there are anthropogenic sources of rare earth elements the rare earth fingerprint will shift. For Rhine sediment we have such a source (La). Therefore the reallocated sediment (fluvial source) can be distinguished from the local sediment (mostly from the sea).



Sediment reallocation within Port of R'dam - balance

Assessment of sediment balance with rare earth elements

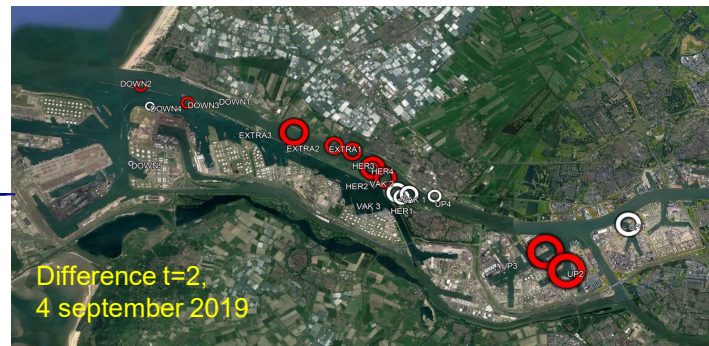
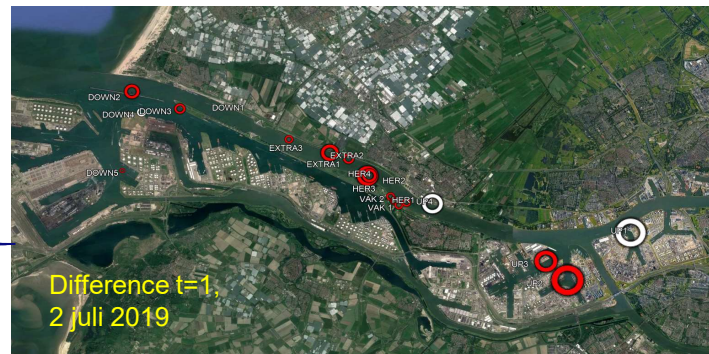
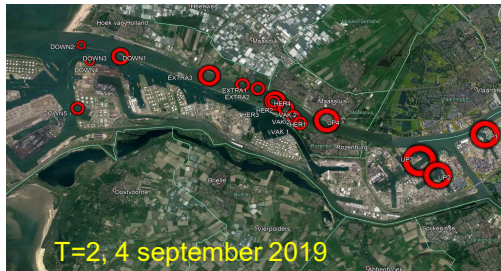
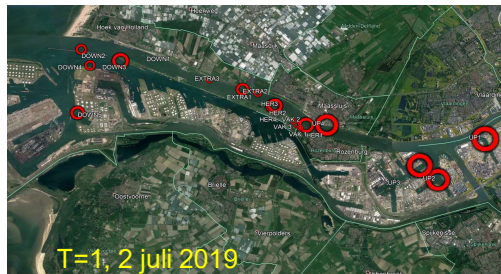
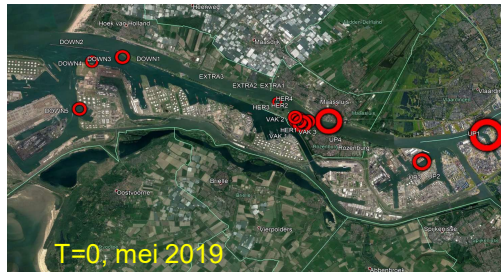
T₀, percentage of Rhine sediment (range 0,16 % at HER_2 up to 27,0% at UP1)



Sediment reallocation within Port of R'dam - balance

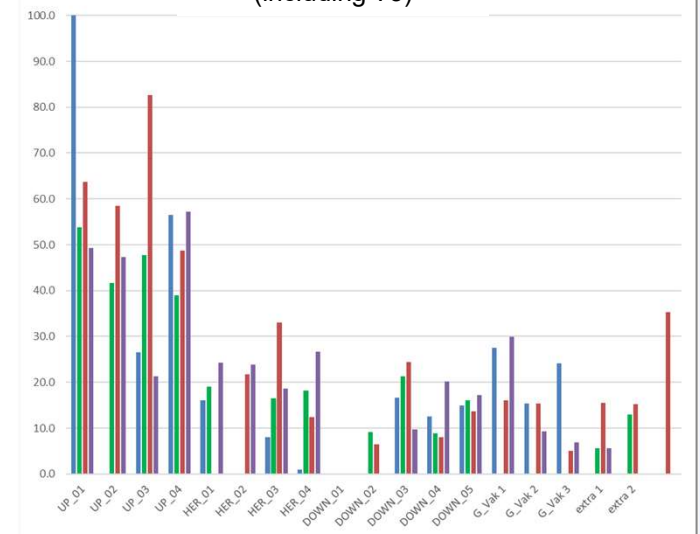
% Rhine sediment

Difference with T_0 (ranging from an increase with 7.6% for UP_03 to a decrease with 18.6% for UP_01).



Trends in fluvial sediment contribution

(including T3)



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Sediment reallocation within Port of R'dam - balance

Assessment of sediment balance with rare earth elements

System sediment balance, main results:

- The most impacted location has an increase of +7.6% in the Rhine sediment fraction.
- The river bank next to the reallocation site (the constructed wetland) has a slight decrease of -1.3%.
- On average the increase in the Rhine sediment fraction in the studied area (40 km) due to the reallocation is +0.2% (+1.200 m³).

In conclusion, there is no significant system impact based on the reallocation of 580.000 m³ within the harbor.

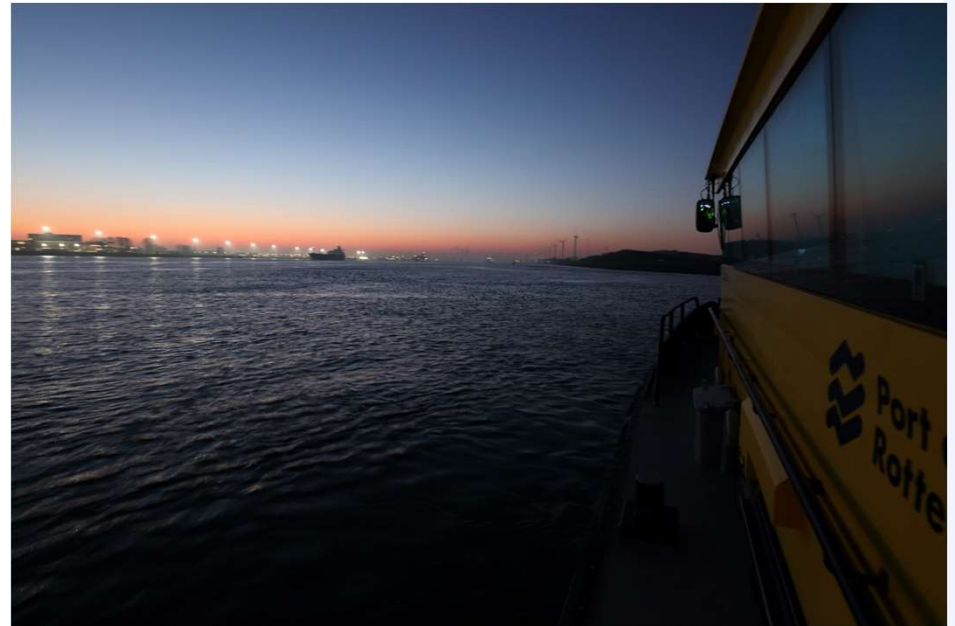
Question 3: Suitability for impact assessment of the system sedimentation balance:

Rare earth elements are suitable for finger printing sources, especially when integrated in routine monitoring.

Sediment reallocation within Port of R'dam – questions



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