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Centre Suisse d'écotoxicologie appliquée

Implications for the sediment compartment of the Proposal for a Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental Quality Standards directive with special focus on the proposed EQS for sediments for Priority Substance No. 30 Tributyltin compounds

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With scientific contribution of Dr Marion Junghans

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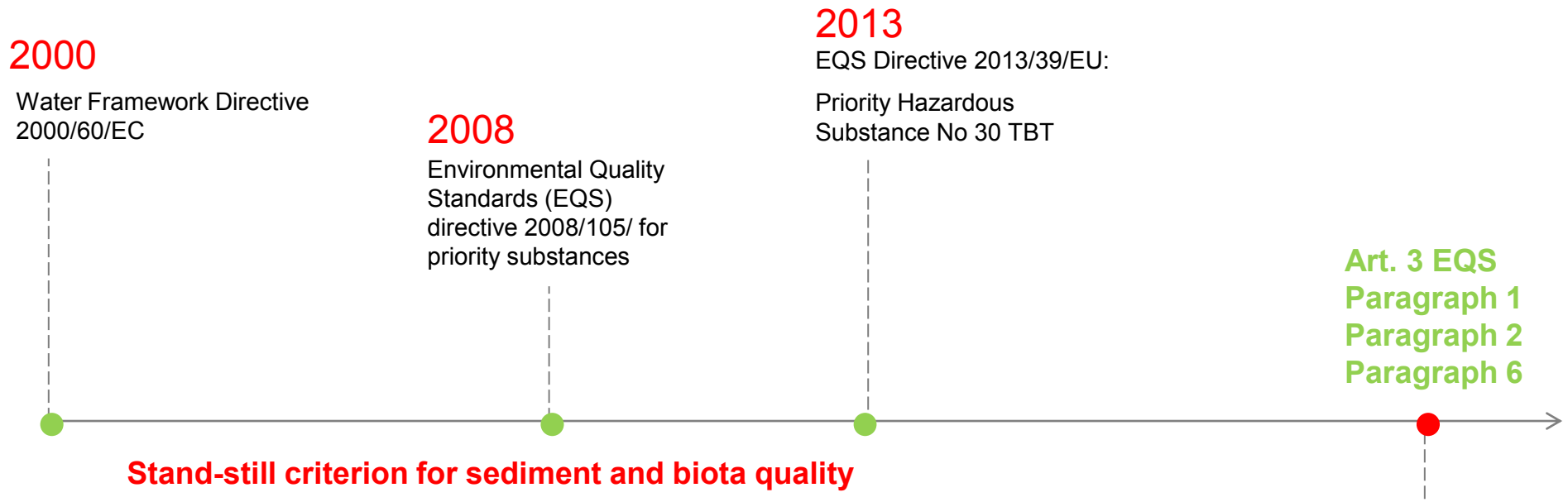
Hamburg, 4th June 2024

Content

- Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy”
- Derivation of the first proposal for sediment EQS in the EQSD: Tributyltin compounds

Background



Monitor the progressive reduction in contamination of **Priority Substances** in sediments. In other words, help demonstrate conditions of no deterioration in sediment quality

COM(2022) 540 final 2022/0344 (COD)
Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy, following Art. 8 of the EQSD requiring the Commission to review Annex X to the WFD (the list of priority substances)

Article 3 Environmental quality standards, Paragraph 1

‘*1. Without prejudice to paragraph 1a, Member States shall apply the EQS laid down in Part A of Annex I for bodies of surface water, and shall apply those EQS in accordance with the requirements laid down in Part B of Annex I.*

1a. Without prejudice to the obligations arising under this Directive in the version in force on 13 January 2009 and in particular the achievement of good surface water chemical status in relation to the substances and the EQS listed therein, Member States shall implement the EQS laid down in Part A of Annex I as regards:

(i) the substances numbered 2, 5, 15, 20, 22, 23, 28 in Part A of Annex I, for which revised EQS are set, with effect from 22 December 2015, with the aim of achieving good surface water chemical status in relation to those substances by 22 December 2021 by means of programmes of measures included in the 2015 river basin management plans produced in accordance with Article 13(7) of Directive 2000/60/EC; and

(ii) the newly identified substances numbered 34 to 45 in Part A of Annex I, with effect from 22 December 2018, with the aim of achieving good surface water chemical status in relation to those substances by 22 December 2027 and preventing deterioration in the chemical status of surface water bodies in relation to those substances. For this purpose, Member States shall, by 22 December 2018, establish and submit to the Commission a supplementary monitoring programme and a preliminary programme of measures covering those substances. A final programme of measures in accordance with Article 11 of Directive 2000/60/EC shall be established by 22 December 2021 and shall be implemented and made fully operational as soon as possible after that date and not later than 22 December 2024

*(iii) the substances numbered 5, 9, 13, 15, 17, 21, 23, 24, 28, **30**, 34, 37, 41, 44 in Part A of Annex I, **for which revised EQS are set**, and the newly identified substances numbered 46 to 70 in Part A of Annex I, with effect from … [OP please insert the date = the first day of the month following 18 months after the date of entry into force of this Directive], with the aim of preventing deterioration in the chemical status of surface water bodies and of achieving good surface water chemical status in relation to those substances.’;*

EQS Directive 2013/39/EU

- *"Art. 4. For substances for which an EQS for sediment and/or biota is applied, Member States shall monitor the substance in the relevant matrix at least once every year, unless technical knowledge and expert judgment justify another interval."*

- *"Art. 6. Member States shall arrange for the long-term trend analysis of concentrations of those priority substances listed in Part A of Annex I that tend to accumulate in sediment and/or biota, giving particular consideration to the substances numbered 2, 5, 6, 7, 12, 15, 16, 17, 18, 20, 21, 26, 28, 30, 34, 35, 36, 37, 43 and 44 listed in Part A of Annex I, on the basis of the monitoring of surface water status carried out in accordance with Article 8 of Directive 2000/60/EC. Member States shall take measures aimed at ensuring, subject to Article 4 of Directive 2000/60/EC, that such concentrations do not significantly increase in sediment and/or relevant biota. Member States shall determine the frequency of monitoring in sediment and/or biota so as to provide sufficient data for a reliable long-term trend analysis. As a guideline, monitoring should take place every three years, unless technical knowledge and expert judgment justify another interval."*

No	Name of substance	CAS number (1)	AA-EQS (2) Inland surface waters (3)	AA-EQS (2) Other surface waters	MAC-EQS (4) Inland surface waters (3)	MAC-EQS (4) Other surface waters	EQS Biota (5)
(30)	Tributyltin compounds (Tributyltin cation)	36643-28-4	0.0002 µg/L	0.0002 µg/L	0.0015 µg/L	0.0015 µg/L	

(1) CAS: Chemical Abstracts Service. (2) This parameter is the EQS expressed as an annual average value (AA-EQS). Unless otherwise specified, it applies to the total concentration of all isomers. (3) Inland surface waters encompass rivers and lakes and related artificial or heavily modified water bodies. (4) This parameter is the EQS expressed as a maximum allowable concentration (MAC-EQS). (5) Unless otherwise indicated, the biota EQS relate to fish. An alternative biota taxon, or another matrix, may be monitored instead, as long as the EQS applied provides an equivalent level of protection.

The value of the EQS for surface waters was so low that implementation of the EQS was problematic due to analytical issues. No EQS was included for biota or sediments.

Article 3 Environmental quality standards, Paragraph 2

2. For the substances numbered 5, 15, 16, 17, 21, 28, 34, 35, 37, 43 and 44 in Part A of Annex I, Member States shall apply the biota EQS laid down in Part A of Annex I.

For substances other than those referred to in the first subparagraph, Member States shall apply the water EQS laid down in Part A of Annex I.

*2. With regard to substances for which a biota EQS or a sediment EQS is laid down in Part A of Annex I, Member States **shall apply** such biota EQS or **sediment EQS**.*

With regard to substances other than those referred to in the first subparagraph, Member States shall apply the water EQS laid down in Part A of Annex I.'

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
[Entry] N°	Name of substance	Category of substances	CAS number (1)	EU number (2)	AA-EQS (3) Inland surface waters (4) [µg/l]	AA-EQS (3) Other surface waters [µg/l]	MAC-EQS (5) Inland surface waters (4) [µg/l]	MAC-EQS (5) Other surface waters [µg/l]	EQS Biota (6) [µg/kg wet weight] or EQS Sediment [µg /kg dry weight] where so indicated	Identified as a priority hazardous substance	Identified as an Ubiquitous Persistent, Bioaccumulative and Toxic (uPBT) substance	Identified as a substance that tends to accumulate in sediment and/or biota
(30)	Tributyltin compounds (18) (Tributyltin-cation)	Biocides	36643-28-4	not applicable	0,0002	0,0002	0,0015	0,0015	1.6	X	X	X

Sediment EQS

- It is noted that the legislation currently provides member states with a period of time to comply with the newly listed substances and the modified TVs, going beyond the 2027 deadline for achieving good chemical status set in the WFD. For revised surface water EQS this additional time was set at 6 years (2021, plus 12 more years in case of technical infeasibility or disproportionate cost).

Article 3 Environmental quality standards, Paragraph 6

"6. Member States shall arrange for the long-term trend analysis of concentrations of those priority substances listed in Part A of Annex I that tend to accumulate in sediment and/or biota, giving particular consideration to the substances numbered 2, 5, 6, 7, 12, 15, 16, 17, 18, 20, 21, 26, 28, 30, 34, 35, 36, 37, 43 and 44 listed in Part A of Annex I, on the basis of the monitoring of surface water status carried out in accordance with Article 8 of Directive 2000/60/EC. Member States shall take measures aimed at ensuring, subject to Article 4 of Directive 2000/60/EC, that such concentrations do not significantly increase in sediment and/or relevant biota."

*'Member States shall arrange for the long-term trend analysis of concentrations of those priority substances identified in Part A of Annex I as substances that tend to accumulate in sediment and/or biota, **on the basis of monitoring in sediment** or biota as part of the monitoring of surface water status carried out in accordance with Article 8 of Directive 2000/60/EC. Member States shall take measures aimed at ensuring, subject to Article 4 of Directive 2000/60/EC, that such concentrations do not significantly increase in sediment and/or relevant biota.'*

Substances identified as tending to accumulate in sediment and/or biota

Anthracene	Hexachlorocyclohexane	Cypermethrin	Diclofenac
Cadmium and its compounds	Isoproturon	Azythromycin	Erythromycin
C10-13 Chloroalkanes	Lead and its compounds	Bifenthrin	Esfenvalerate
Chlorpyrifos	Pentachlorobenzene	Chlarithromycin	Ibuprofen
DEHP	Quinoxyfen	Deltamethrin	Permethrin

What is expected according to the Impact Assessment Report

- *Tributyltin among the top 15 most frequently reported priority substances causing failure to achieve good chemical status in surface water bodies (1988 water bodies from 18 different member states have reported EQS exceedances, with a range of measured concentrations of 0.261 (0-100) µg/L (mean(min-max)).*

- *The distance to target is large in scale and medium in magnitude. An increase in distance to target is expected for the newly proposed EQS, but the overall distance to target is medium and for these substances only limited or no additional measures are expected.*

It is stated that the distance to target is assessed based on data from JRC substance dossiers submitted to the SCHEER. However, the update data sheet for this substance does not include monitoring data for sediments.

The cost-benefit analysis concluded that amendment is preferable due to no or limited impacts (benefits of an EQS amendment outweigh the costs).

What is expected according to the Impact Assessment Report

- Sediments are mentioned 12 times in the Impact Assessment Report accompanying the proposal:
  - Presence of microplastics in EU rivers and lakes
  - The potential increase of concentrations of pharmaceuticals from wastewater in sediment among other environmental compartments
  - The accumulation of silver (p. 28) and nano silver
  - The potential use of dredging for the removal of substances bound to sediments in waterbodies, which can be relatively cheap or very costly, depending on the level of after treatment required".
- In addition, the environmental benefits of the proposed amendments include: "Cleaner sediments should result in less potential for re-dissolution of pollutants in the water column and reduced uptake of harmful substances by plants and animals.", with the economic benefit of "Cleaner sediment negating the need for remediation or dredging. This recognises that a number of the candidate substances are less soluble and likely to concentrate within suspended solids, and then within sediments and biota in the natural environment."

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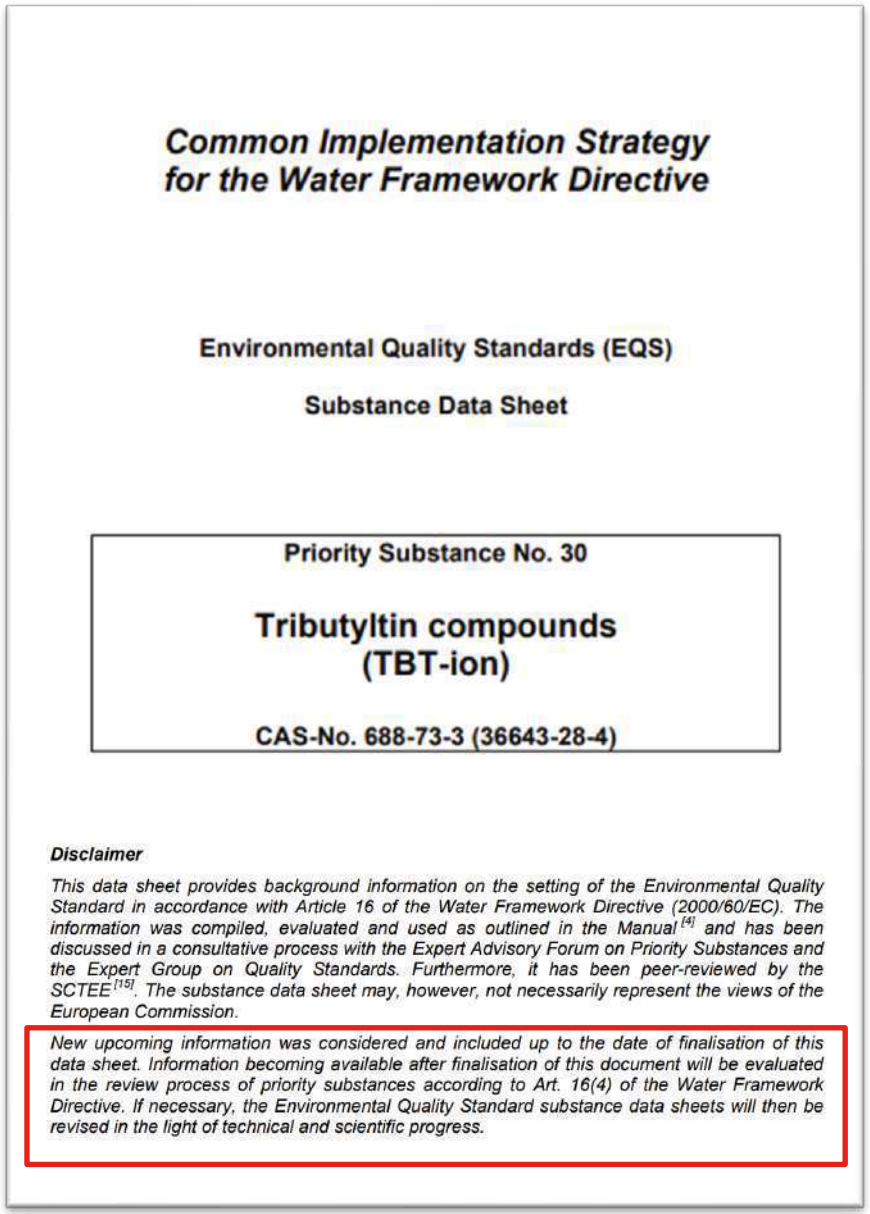
How was the sediment EQS for TBT compounds derived?

How was the TBT sediment EQS derived?



Common Implementation Strategy for the Water Framework Directive

Environmental Quality Standards (EQS)

Substance Data Sheet

Priority Substance No. 30

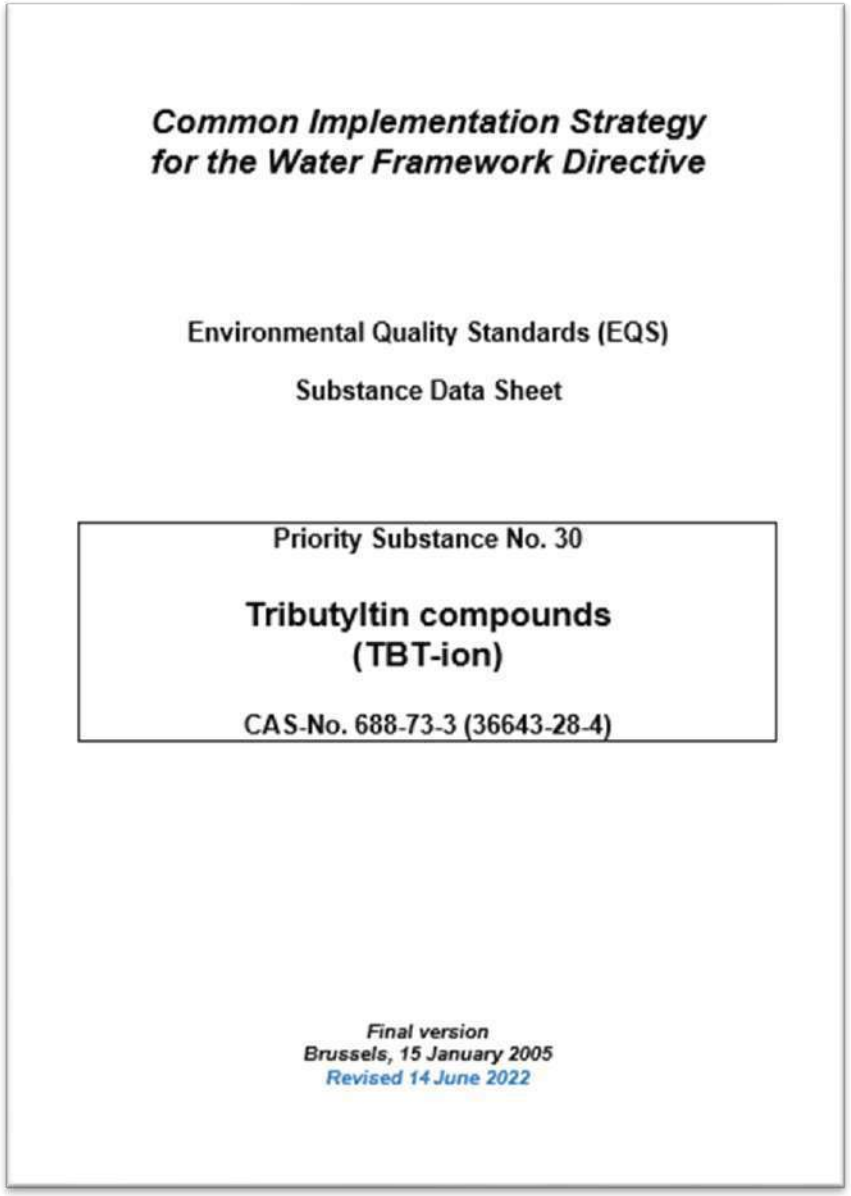
Tributyltin compounds
(TBT-ion)

CAS-No. 688-73-3 (36643-28-4)

Disclaimer

This data sheet provides background information on the setting of the Environmental Quality Standard in accordance with Article 16 of the Water Framework Directive (2000/60/EC). The information was compiled, evaluated and used as outlined in the Manual[4] and has been discussed in a consultative process with the Expert Advisory Forum on Priority Substances and the Expert Group on Quality Standards. Furthermore, it has been peer-reviewed by the SCTEE[15]. The substance data sheet may, however, not necessarily represent the views of the European Commission.

New upcoming information was considered and included up to the date of finalisation of this data sheet. Information becoming available after finalisation of this document will be evaluated in the review process of priority substances according to Art. 16(4) of the Water Framework Directive. If necessary, the Environmental Quality Standard substance data sheets will then be revised in the light of technical and scientific progress.



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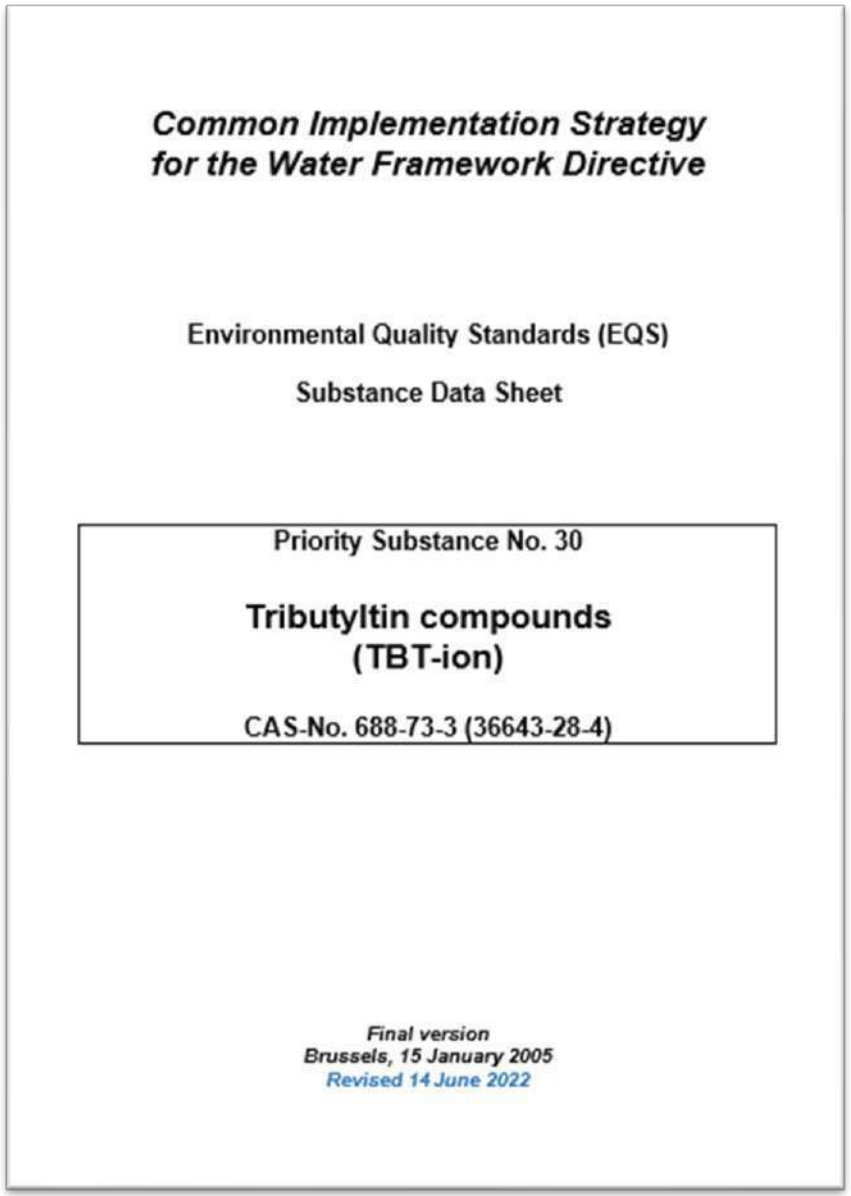
Final version
Brussels, 15 January 2005
Revised 14 June 2022

How was the TBT sediment EQS derived?



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- K_{oc} = 320-1,500,000, log Kp_{susp} 1.5-5.2

  "the trigger for the derivation of a sediment quality standard is met, although not unequivocally."

Log K_{OW} > 3, Log K_{OC} = 4.62 (n=33 values, assessed for reliability and relevance by RIVM ("Environmental risk limits for organotin compounds", Van Herwijnen 2012).

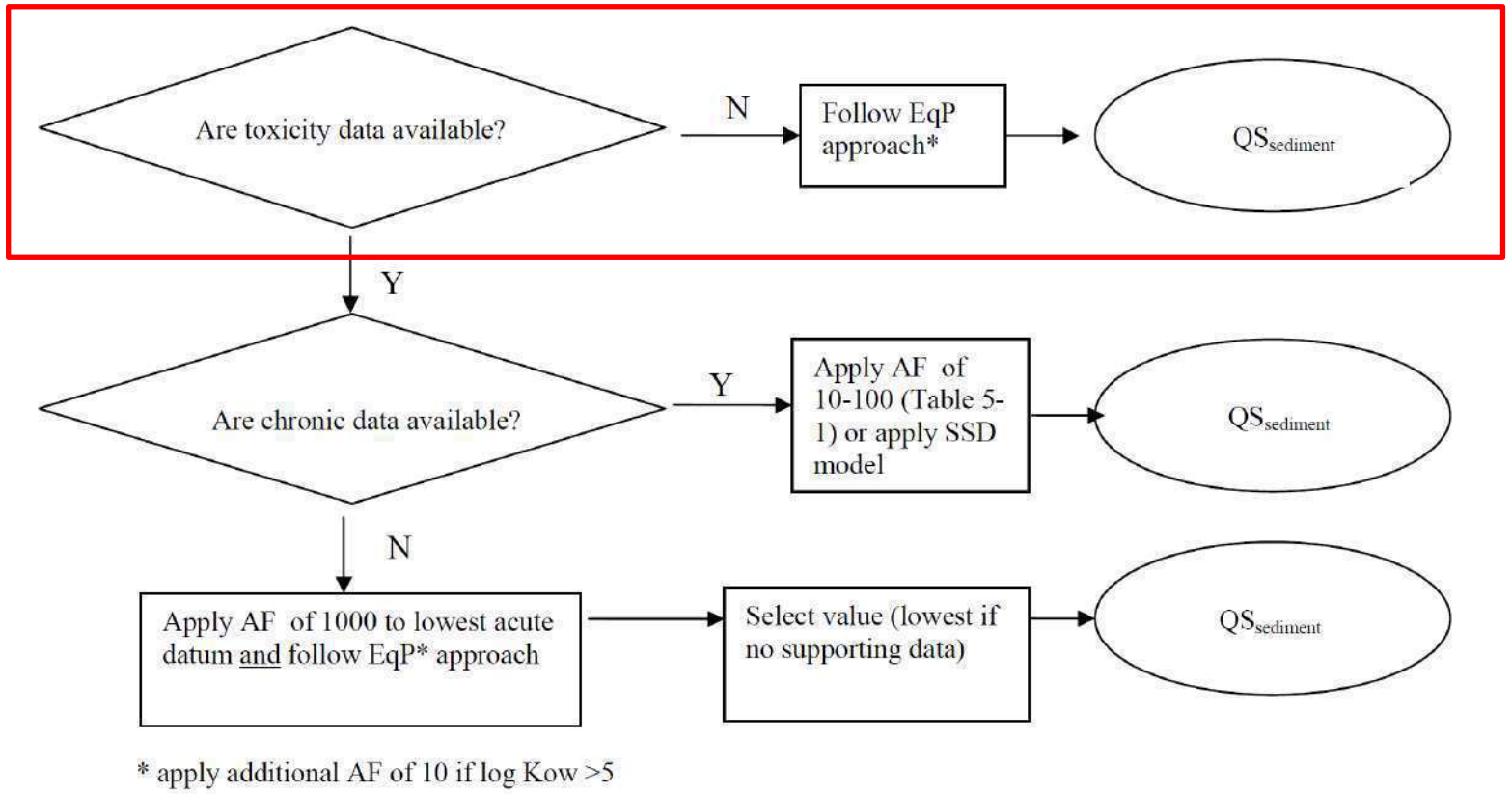
"tributyltin fits the criteria reported in the EQS TGD for the sediment toxicity assessment."

How was the TBT sediment EQS derived?

Standards to protect benthic (sediment dwelling) organisms

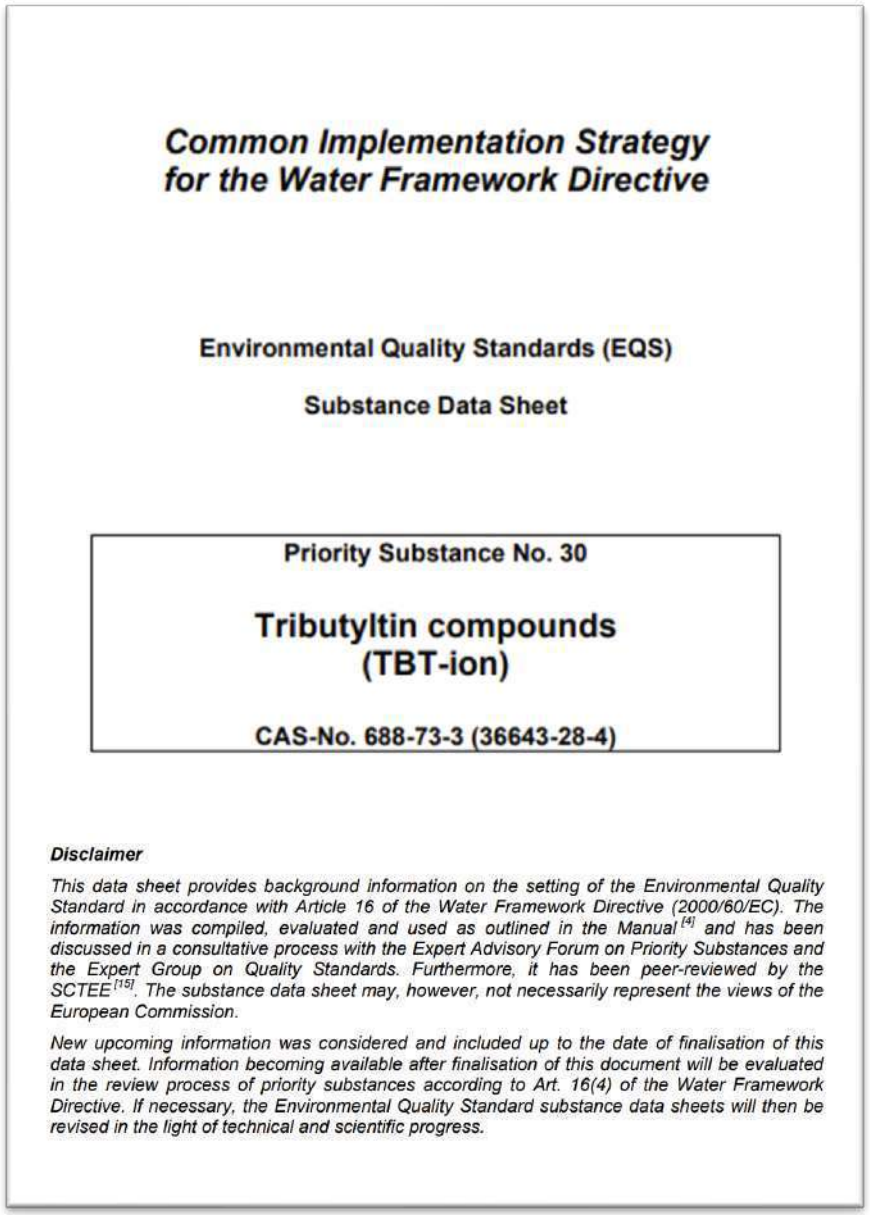
Sediment ecotoxicity data are preferred

2005 Data sheet



Derivation of $QS_{sediment}$ according to the EC Technical Guidance Document

How was the TBT sediment EQS derived?



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- $PNEC_{sediment}$ (≈ $QS_{sediment}$) = 0.02 µg/kg d.w.

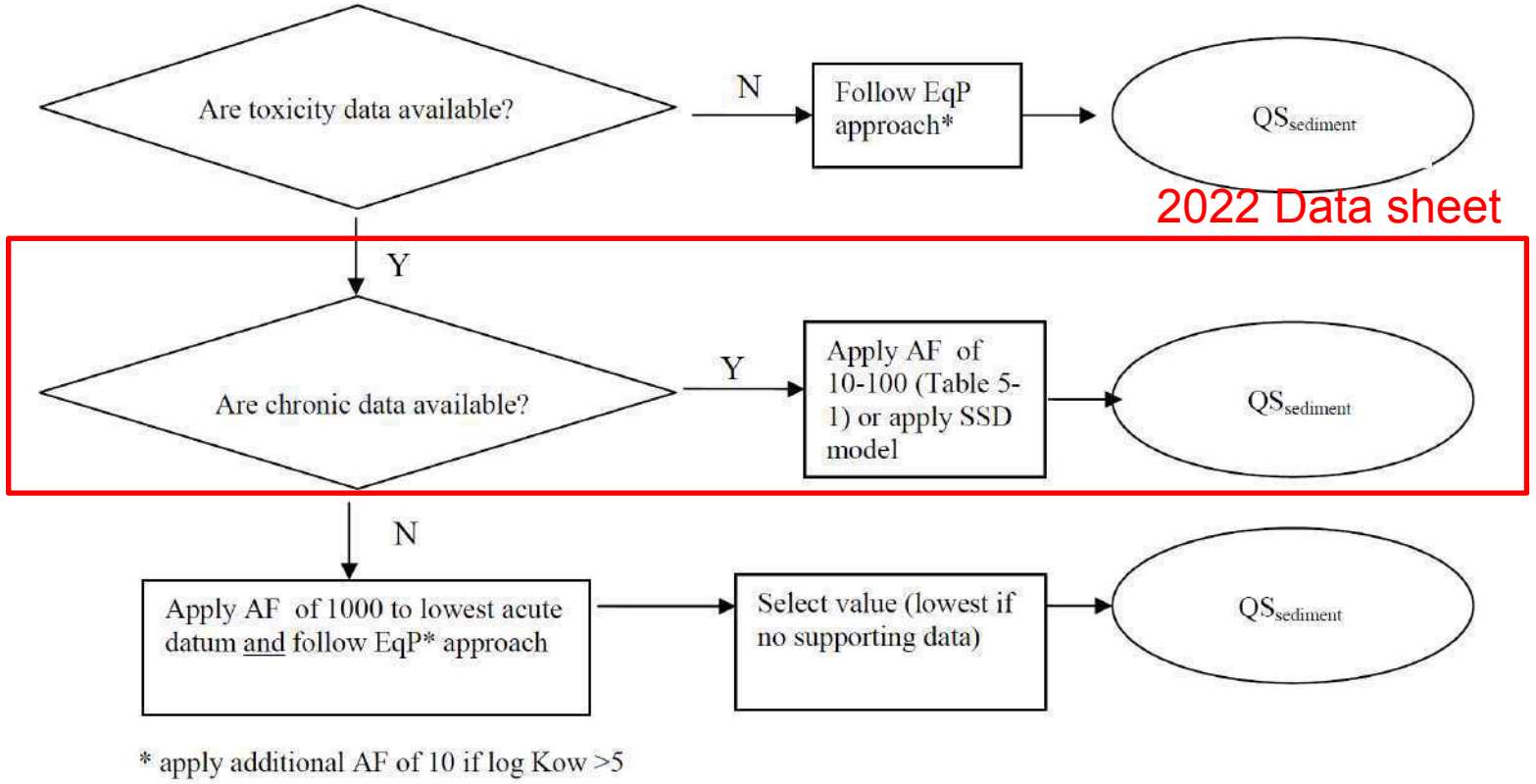
$PNEC_{sed} = Kp_{sed\text{-}wat}$ x $PNEC_{water}$

"The values derived by the EP-method should only be considered as **tentative standards**. In order to refine the quality standards for the sediment compartment long term tests conducted with benthic organisms are required. For the time being no reliable effects based $QS_{sediment}$ can be derived."

How was the TBT sediment EQS derived?

Standards to protect benthic (sediment dwelling) organisms

Sediment ecotoxicity data are preferred



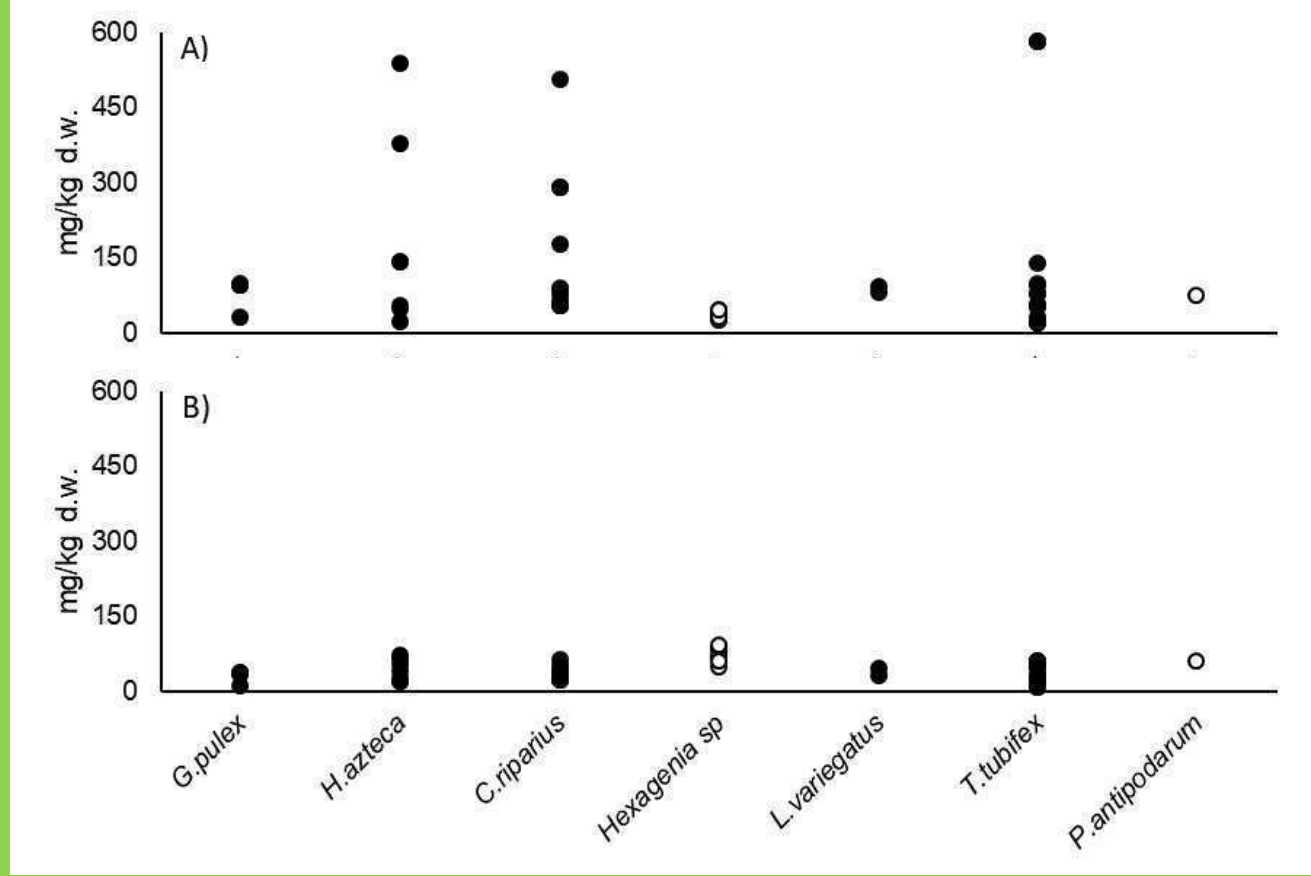
Derivation of $QS_{sediment}$ according to the EC Technical Guidance Document

Lowest chronic sediment ecotoxicity data EU standard normalised according to the EQS TGD

Taxonomic group	Organism	Toxicity effect	Endpoint /Duration (days)	TOC	EU standardised (µgTBT/kg)(5%OC)	Reference	Reliability
FRESHWATER							
Crustaceans							
Amphipod	Hyalella azteca	Reproduction	EC_{10} 70 d	2%	976	Bartlett et al. 2004 [23]	2
Amphipod	Monoporeia affinis	Reproduction	NOEC 35 d	4.4%	80.5	Jacobson et al. 2011 [32]	2
Insects							
Diptera	Chironomus riparus	Development	NOEC 15 d	2.32 %	25.62	Lilley et al. 2012 [33]	2
Ephemeroptera	Hexagenia spp.	Survival	NOEC 21 d	1.49%	1007	Day et al. 1998 [25]	2
Mollusc							
Snail	Potamopyrgus antipodarum	Development (unshelled embryos)	EC_{10} 56 d	2.3%	15.86	Duft et al. 2003 [26]; Duft et al. 2005 [27]	1
MARINE WATER							
Crustacean							
Amphipod	Corophium volutator	Survival	NOEC 10 d	2%	6972	Stronkhorst et al. 1999 [28]	1
Annelida							
Worm	Armandia brevis	Growth	EC_{10} 42 d	0.58%	292.3	Meador and Rice 2001 [30]	1
Worm	Tubifex tubifex	Reproduction	NOEC 28 d	1.49%	5731.6	Day et al. 1998 [25]	2
Echinodermata							
Urchin	Echinocardium cordatum	Survival	NOEC 28 d	2%	6864	Stronkhorst et al. 1999 [28]	1
Higher plants							
	Ruppia marittima	Growth	EC_{10} 21 d	1.09%	31.72	Jensen et al. 2004 [34]	2

When is TOC normalisation performed?

For substances for which the bioavailability is dependent on the TOC content of the sediment: Example for Copper and its compounds



Effect concentrations for different benthic organisms

Before TOC normalisation

After TOC normalisation

Tributyltin bioavailability is dependent on the organic carbon content of the sediment. Therefore, according to the EQS Technical Guidance, the effect concentrations should be normalised.

How was the TBT sediment EQS derived?

- Derivation of $QS_{sediment}$ according to the EC Technical Guidance Document

$$QSsediment = \frac{Lowest\ effect\ datum}{Assessment\ factor}$$

Available data	Assessment factor
One long term test (NOEC or EC10)	100
Two long term tests (NOEC or EC10) with species representing different living and feeding conditions	50
Three long term tests (NOEC or EC10) with species representing different living and feeding conditions	10

Lowest chronic sediment ecotoxicity data EU standard normalised according to the EQS TGD

Taxonomic group	Organism	Toxicity effect	Endpoint /Duration (days)	TOC	EU standardised (µgTBT/kg)(5%OC)	Reference	Reliability
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Critical study

How was the TBT sediment EQS derived?

- Derivation of $QS_{sediment}$ according to the EC Technical Guidance Document

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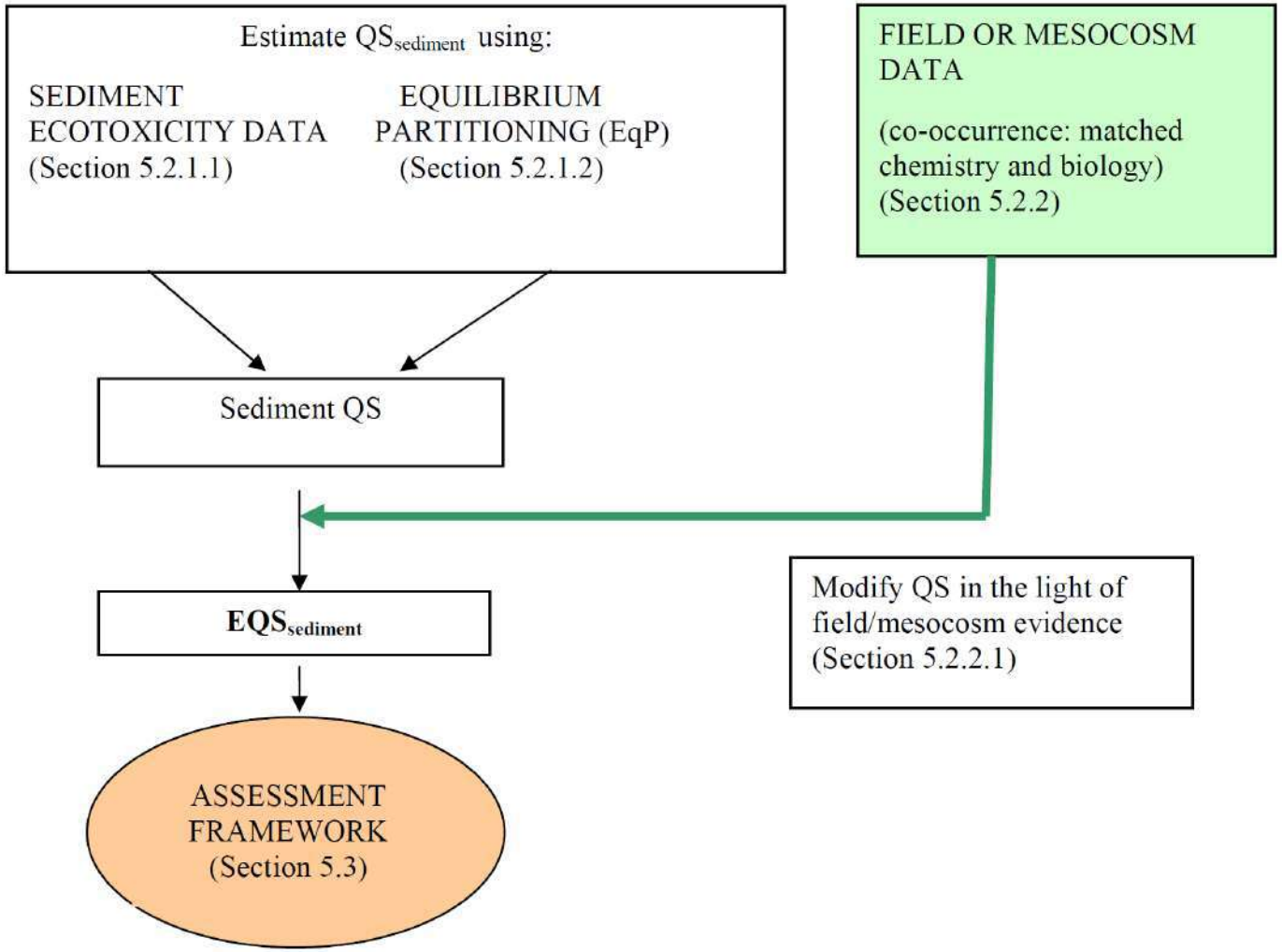
Available data	Assessment factor
One long term test (NOEC or EC10)	100
Two long term tests (NOEC or EC10) with species representing different living and feeding conditions	50
Three long term tests (NOEC or EC10) with species representing different living and feeding conditions	10

$$QSsediment = \frac{15.86}{10}$$ = 1.6 µg/kg d.w. (5% TOC)

Marine and freshwater sediment toxicity data may be pooled unless it can be documented that differences in toxicity exist between freshwater and saltwater sediments. The data indicate a lower sensitivity of marine test systems because of a reduced bioavailability in marine systems. This prohibits, in principle, the pooling of data from freshwater and marine systems.

No data are available for benthic marine mollusks (most likely the most sensitive taxonomic group), which renders the marine dataset unsuitable on its own for deriving a valid QS for marine sediments. The effect data for freshwater snail is used in the derivation, emphasizing in the final TBT dossier that this value is preliminary and that toxicity data for marine sediment-dwelling mollusks are needed.

How was the TBT sediment EQS derived?



Recommendations for use in EU TGD for EQS development

Pass/fail approach is not always appropriate, especially as residual uncertainties in sediment standards can be high making compliance assessment difficult

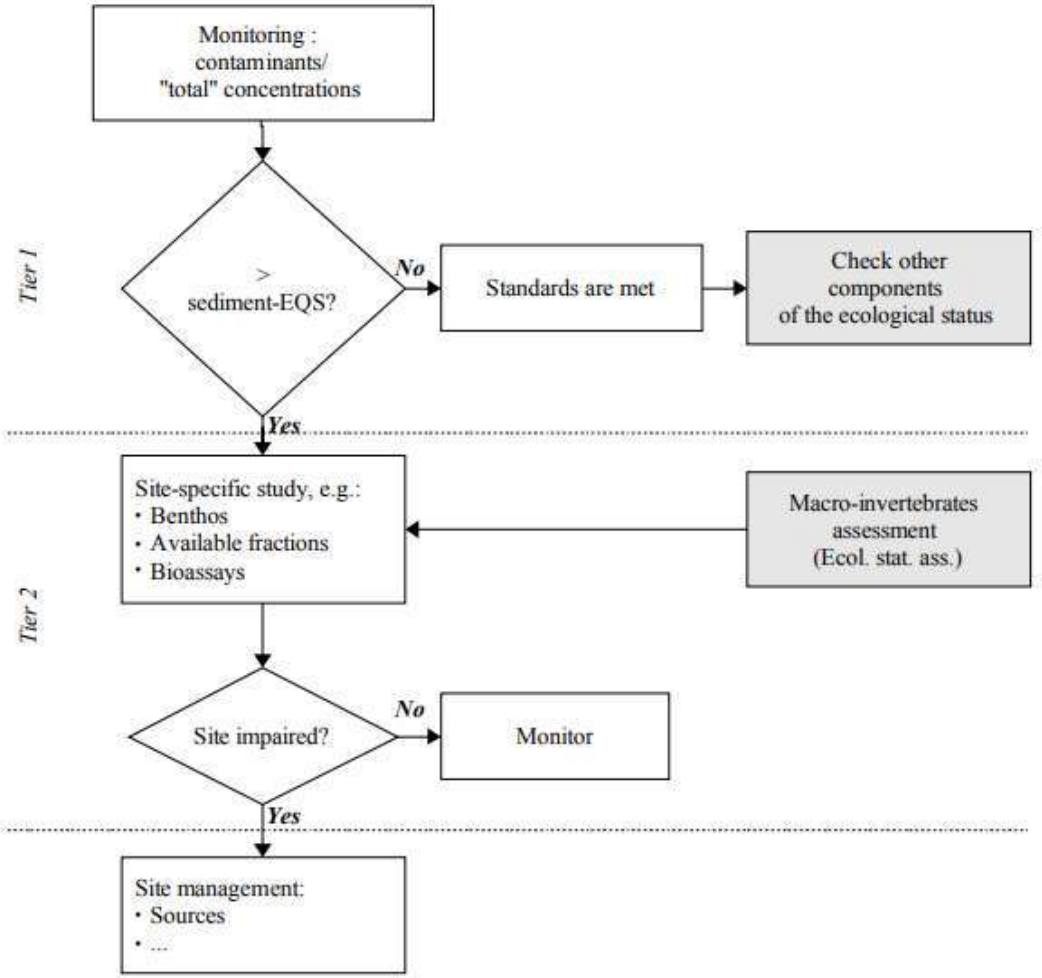


Figure 5.3 Tiered assessment framework for sediments

THE ESTABLISHMENT OF STRICTER EQS ACCORDING TO THE PROPOSAL FOR THE DIRECTIVE AMENDING THE WFD AND ITS POSSIBLE CONSEQUENCES FOR DREDGING AND DISPOSAL FOR THE PORT OF HAMBURG

SedNet| 4.6.2024| Hamburg

Maja Karrasch, Frank Krüger (WI23) | Hamburg Port Authority

Proposal for a Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental Quality Standards Directive

- **Addition of 24 Substances/-groups**: Pesticides and their metabolites, pharmacologically active substances in human and veterinary pharmaceutical products and industrial chemicals (including a group of 24 PFAS substances)
- **Amendment of existing EQS for 16 substances**, 14 substances more stringent, 2 substances less stringent EQS
- Preparation for the future inclusion of **microplastics** and **antimicrobial-resistance genes** (inclusion in the next watchlist)

Amendments in the Proposal

Surface water	
Addition to PS list as an individual substance with EQS set for each individually (23 Substances)	17-beta estradiol (E2), Acetamiprid, Azithromycin, Bisphenol A, Carbamazepine., Clarithromycin, Clothianidin, Deltamethrin, Diclofenac, Erythromycin, Esfenvarlerate, Estrone (E1), Ethinyl estradiol (EE2), Glyphosate, Ibuprofen, Imidacloprid, Nicosulfuron, Permethrin, Thicloprid, Thiamethoxam, Triclosan, Silver
Addition to PS list as a group with EQS set for „sum of“	PFAS (sum of 24 named substances)
Amendment of existing EQS: 14 substances more stringent	Chlorpyrifos, Cypermethrin, Dicofol, Dioxins, Diuron, Fluoranthene, HBCDD, Hexachlorbutadiene, Mercury, Nickel, Nonyl Phenol, PAH, PBDE, TBT
Amendment of existing EQS: 2 substances less stringent	Heptachlor, Hexachlorbenzene
Deselection of 4 substances	Alachlor, Carbon tetrachloride, Chlorfenvinphos, Simazine

New / changed EQS in the Proposal for the new Directive

(1)	(2)	RL 2008 vs. new	RL 2008 vs. new	(10) new	(11)	(12)	(13)
No	Name of Substance	AA-EQS [in µg/l] Inland / Other Surface Water	MAC-EQS [in µg/l] Inland / Other Surface Water	EQS Sediment [µg /kg dry weight] where so indicated	Identified as priority hazardous substance	Identified as Ubiquitous Persistent, Bioaccumulative and Toxic (uPBT) substance	Identified as substance that tends to accumulate in sediment and/or biota
		No Change!	No Change!	New!			
(30)	Tributyltin-Compound (TBT cation)	0,0002	0,0015	1,6	X	X	X

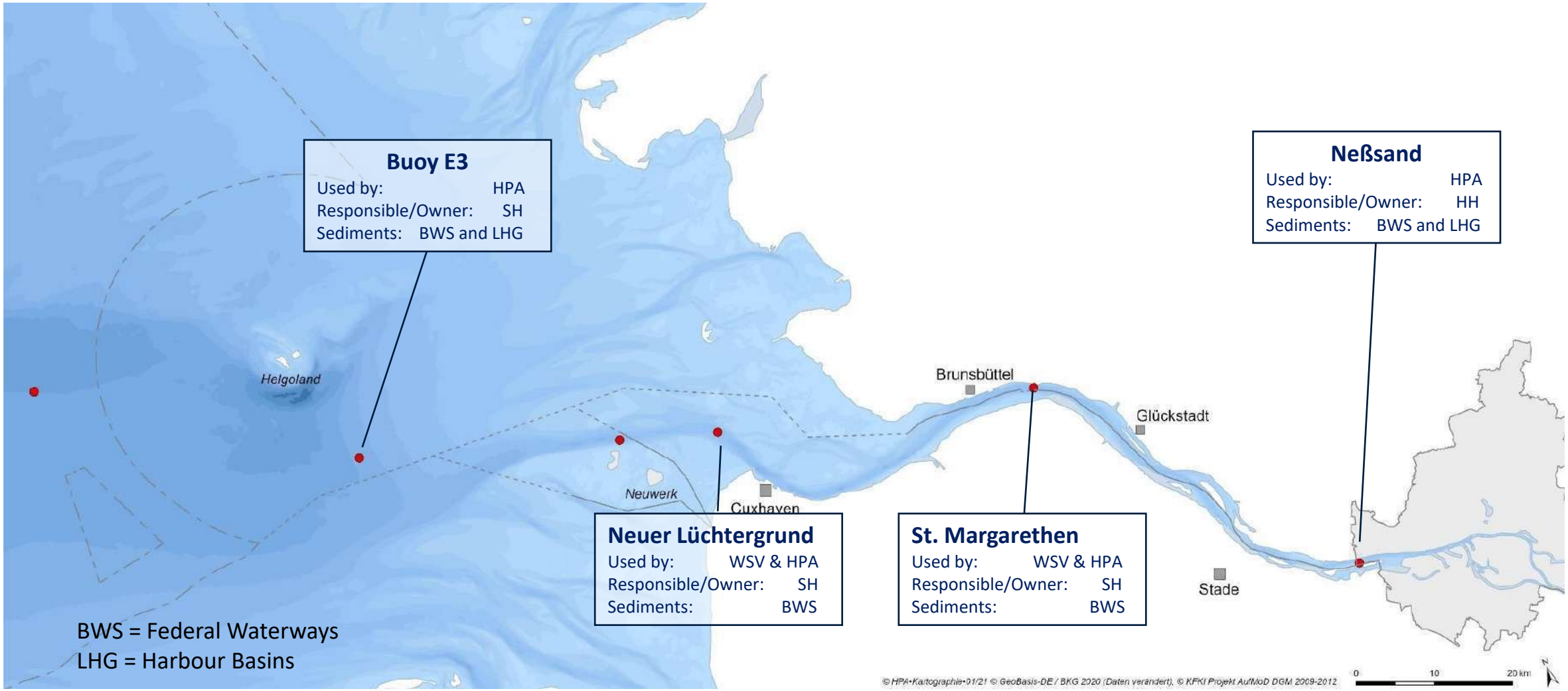
Only Sediment EQS!

(changed from 1,3 in first draft)

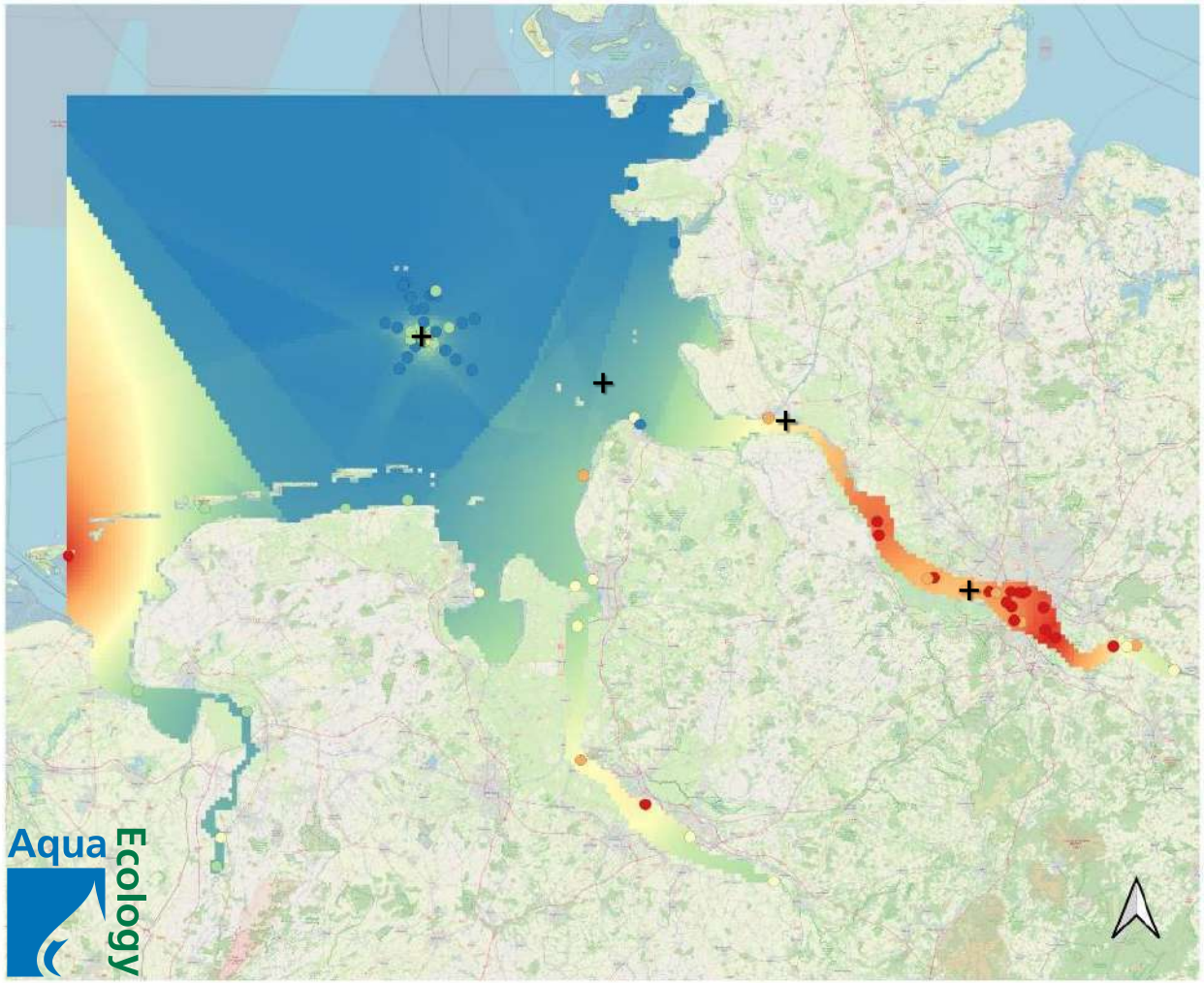
New Sediment EQS for TBT:

- How are the current concentrations in the Port of Hamburg and in the German Bight?
- Is TBT still a problem (Imposex)?
- When will we reach the proposed EQS value?
- Consequences for Dredging und Disposal?

Disposal Sites in the Tidal Elbe and German Bight



TBT: Distribution in the German Bight and in the Elbe Estuary



TBT Concentration – Values at stations and Interpolation (Ordinary Kriging)

TBT Concentration in µg/kg DM

- 0 - 2
- 2 - 5.5
- 5.5 - 12.3
- 12.3 - 29.5
- 29.5 - 66.2

Co-Kriging Ergebnis

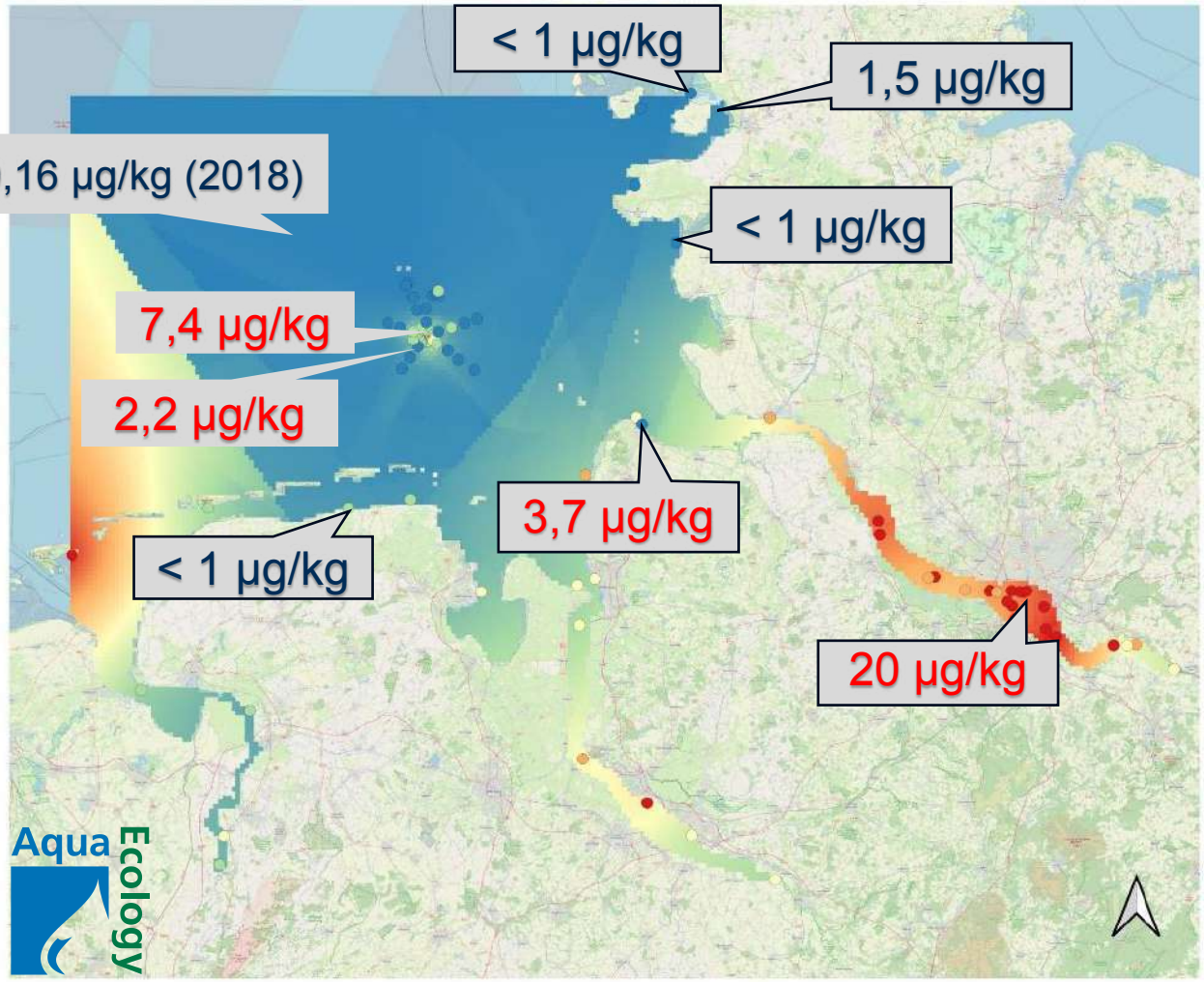
- 0.1694
- 10.8983
- 21.6272
- 32.3561
- 43.0850

OSM Standard

0 25 50 km

Source of the Map: „Bewertung von vorhandenen Monitoringdaten ausgewählter Indikatoren für D8C1 als Entscheidungsgrundlage" (Report, 2022)

TBT: Distribution in the German Bight and in the Elbe Estuary 2022



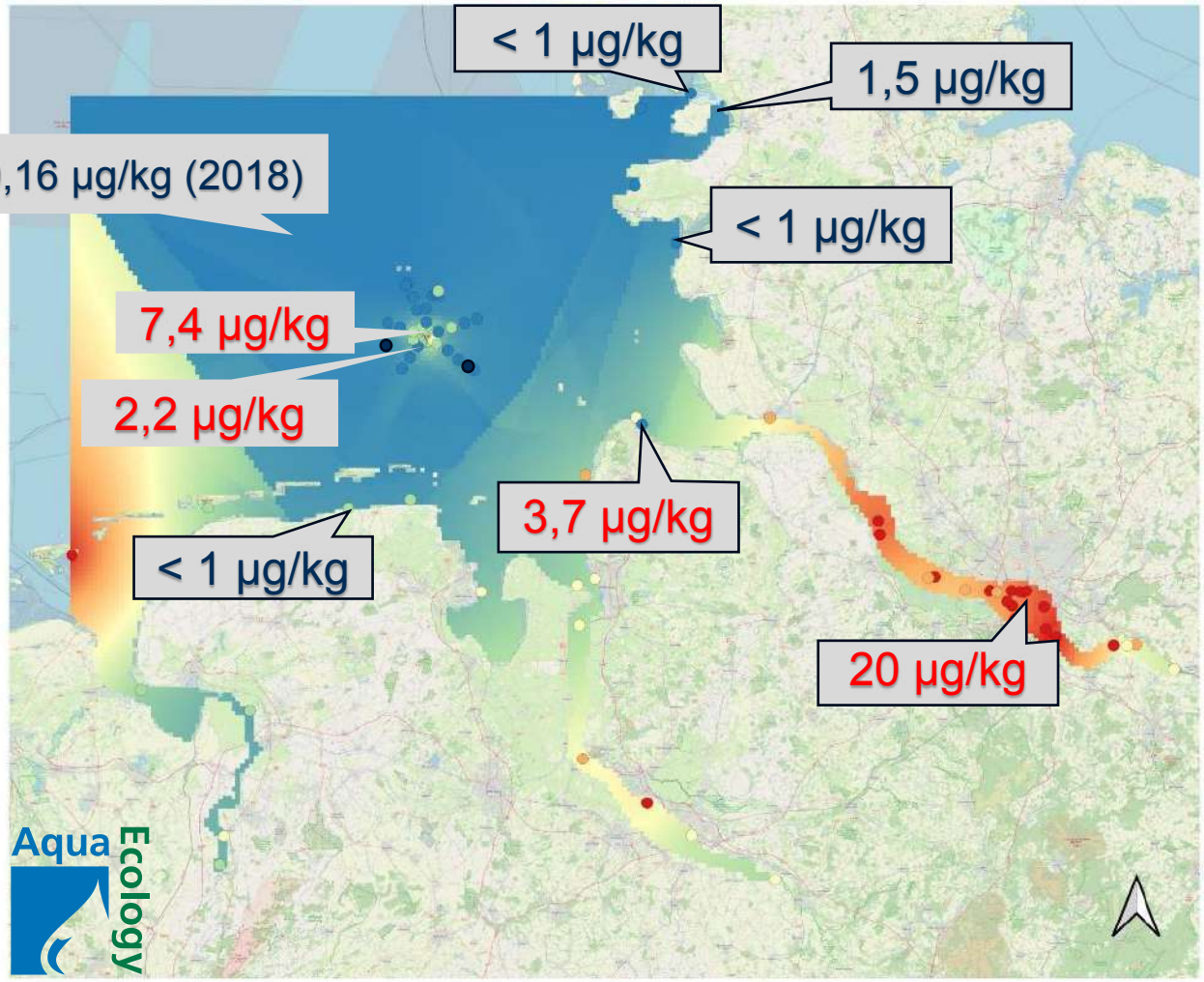
TBT Concentration – Values at stations and Interpolation (Ordinary Kriging)

HPA / BfG Monitoring Values for 2022 (Annual Mean)

Red: Above EQS 1,6 µg/kg

Source of the Map: „Bewertung von vorhandenen Monitoringdaten ausgewählter Indikatoren für D8C1 als Entscheidungsgrundlage" (Report, 2022)

TBT: Distribution in the German Bight and in the Elbe Estuary 2022

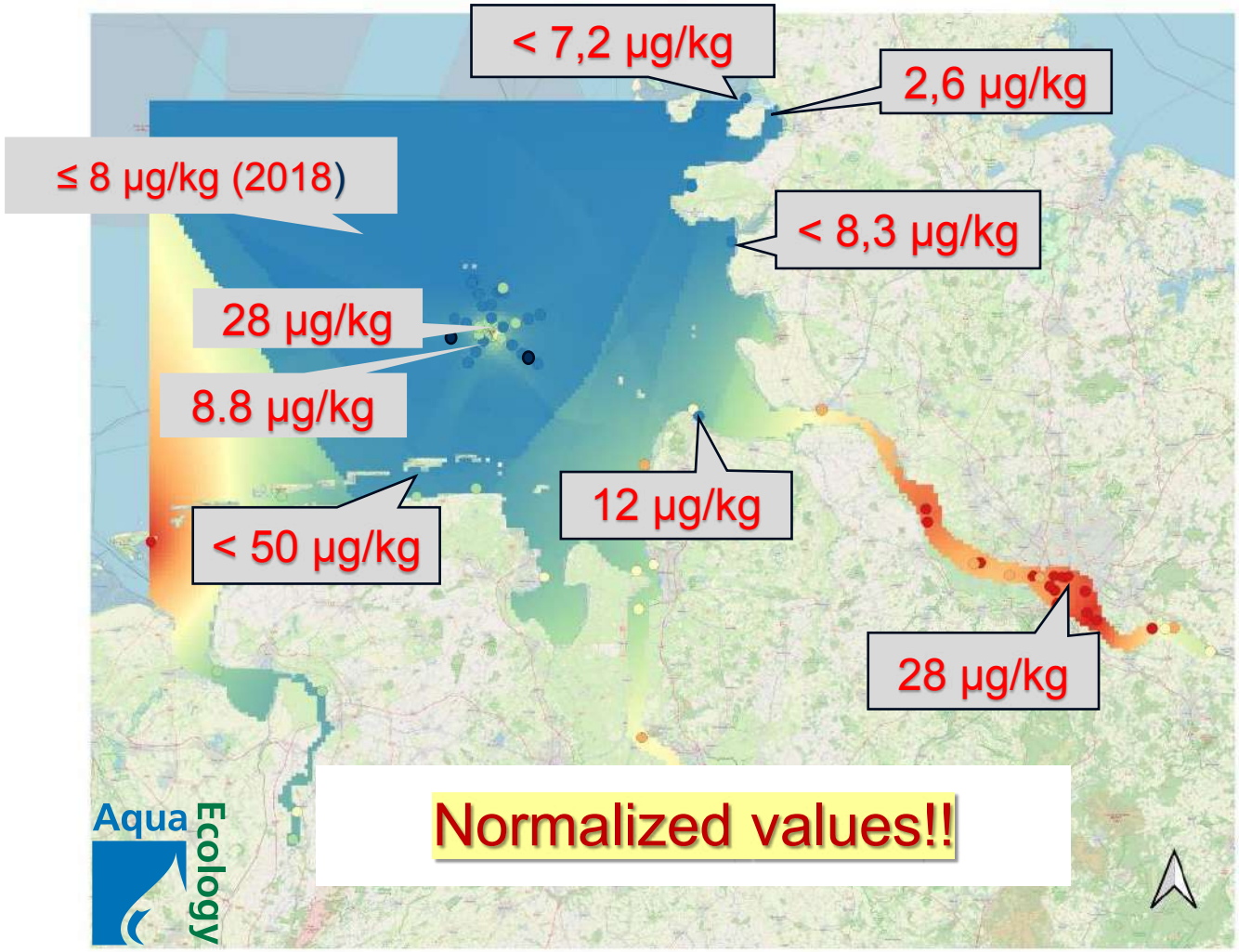


TBT Concentration – Values at stations and Interpolation (Ordinary Kriging)

Normalisation with 5 % TOC and 1,6 µg/kg is mandatory for comparability according to SCHEER!!

Source of the Map: „Bewertung von vorhandenen Monitoringdaten ausgewählter Indikatoren für D8C1 als Entscheidungsgrundlage" (Report, 2022)

TBT: Distribution in the German Bight and in the Elbe Estuary (2022)

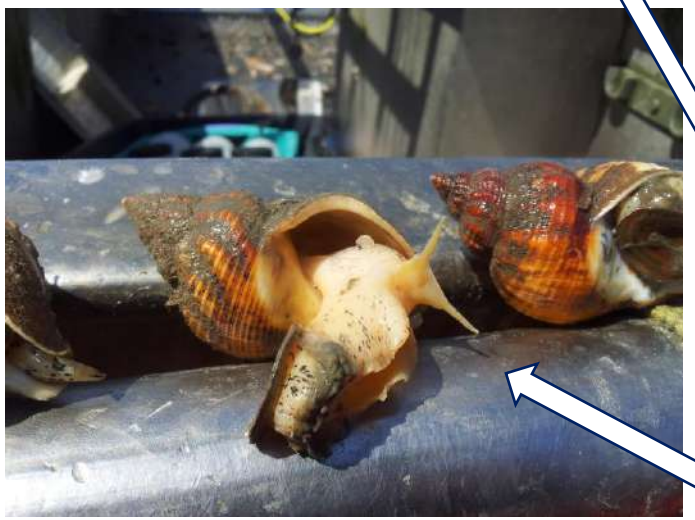


TBT Concentration – Values at stations and Interpolation (Ordinary Kriging)

Normalisation with 5 % TOC and 1,6 µg/kg is mandatory for comparability according to SCHEER!!

Source of the Map: „Bewertung von vorhandenen Monitoringdaten ausgewählter Indikatoren für D8C1 als Entscheidungsgrundlage" (Report, 2022)

TBT: Imposex in Common Whelk (*Buccinum undatum*)

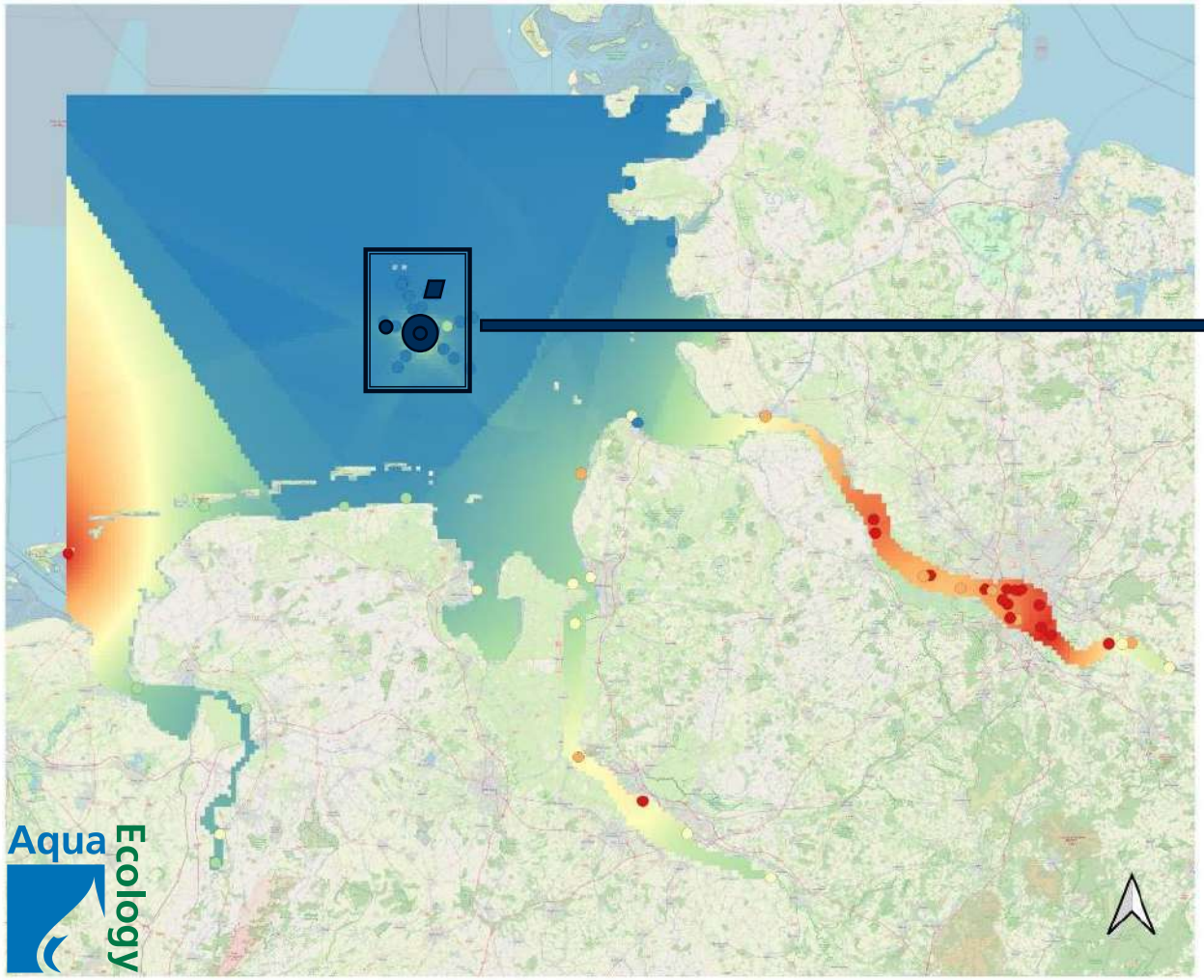


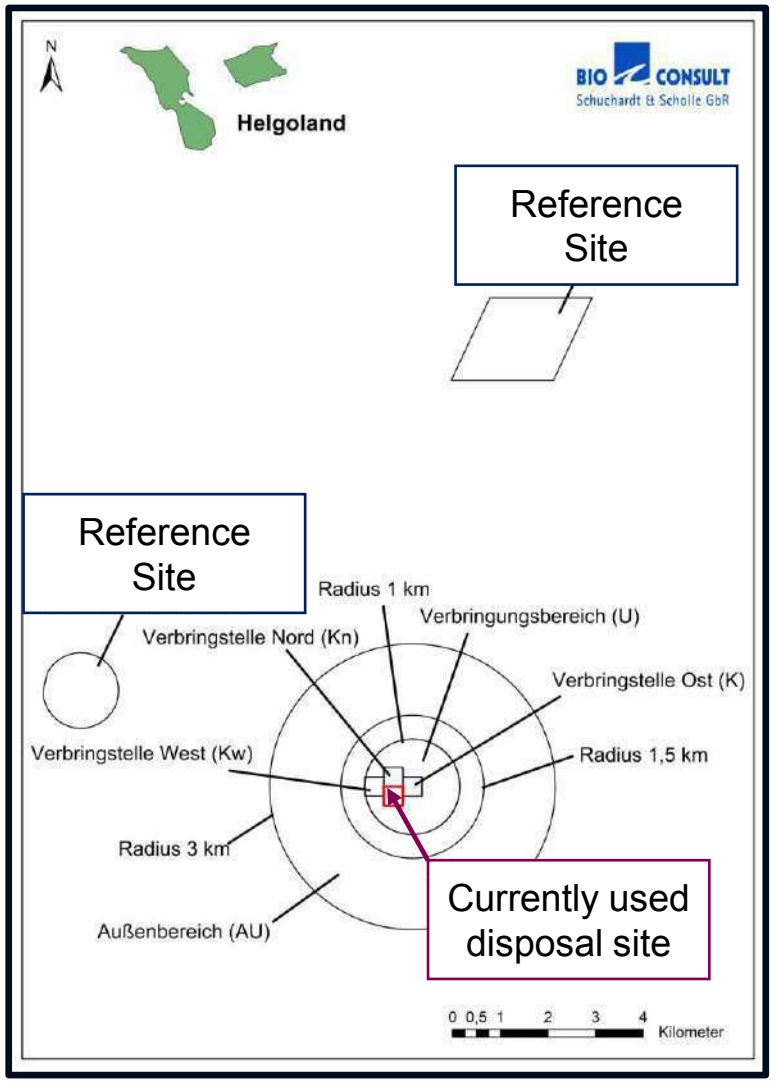
Stage 1

Stage 2

Stage 3

TBT: Monitoring of Imposex in the Common Whelk (*Buccinum undatum*)





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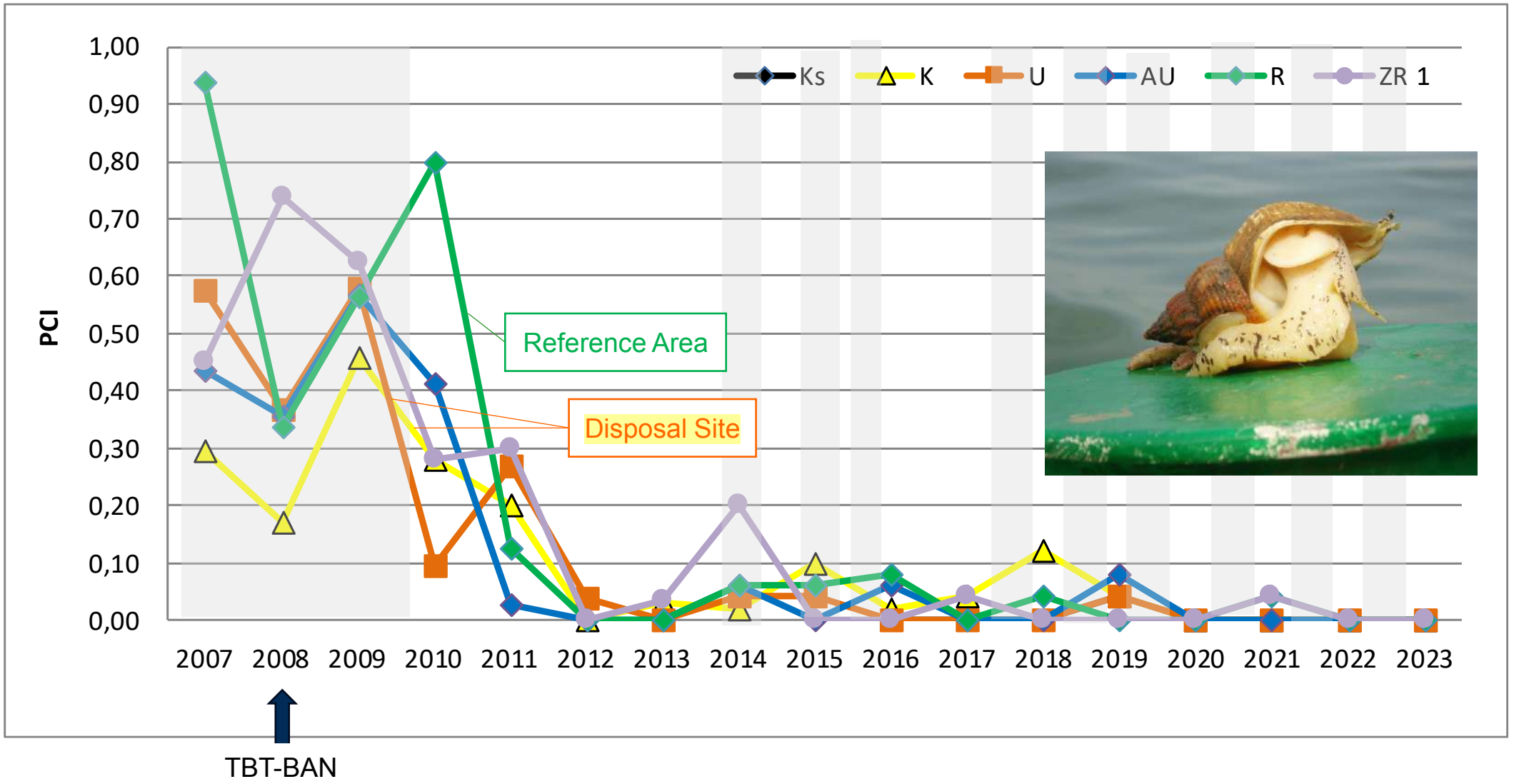
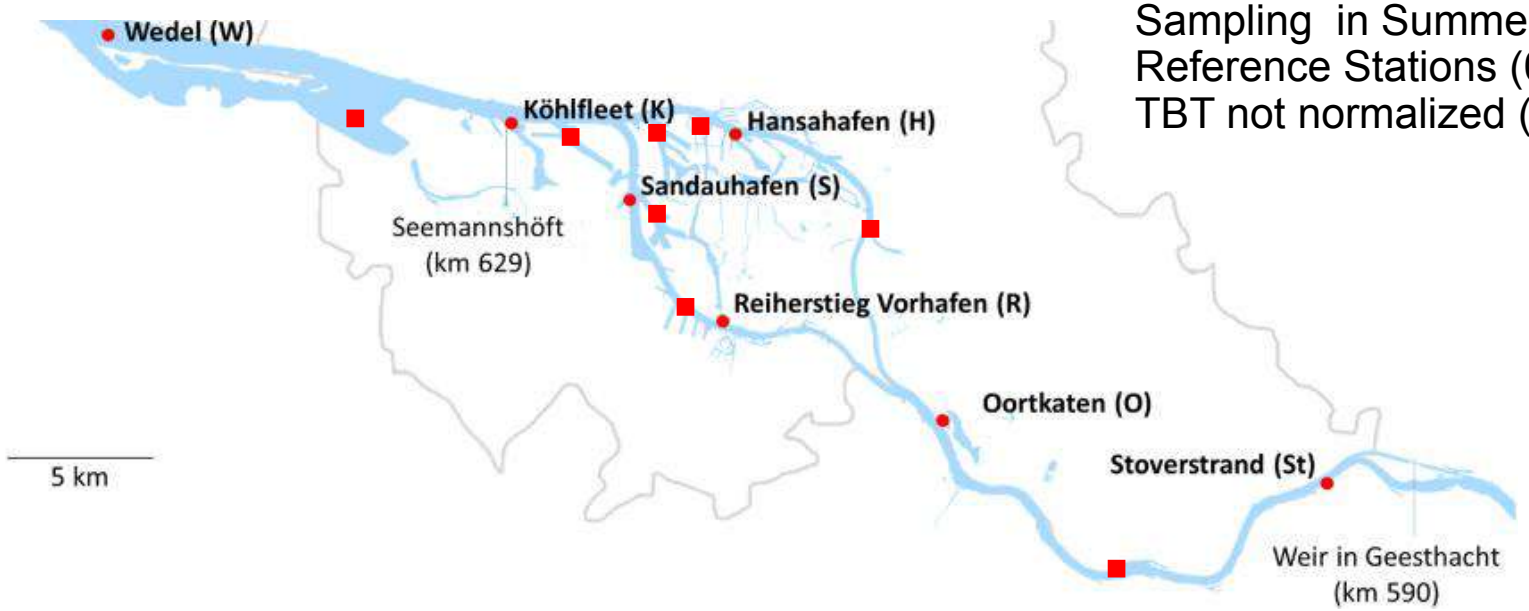


TBT in the Port of Hamburg

Sampling in Summer
Reference Stations (0-5 cm)
TBT not normalized (µg/kg)

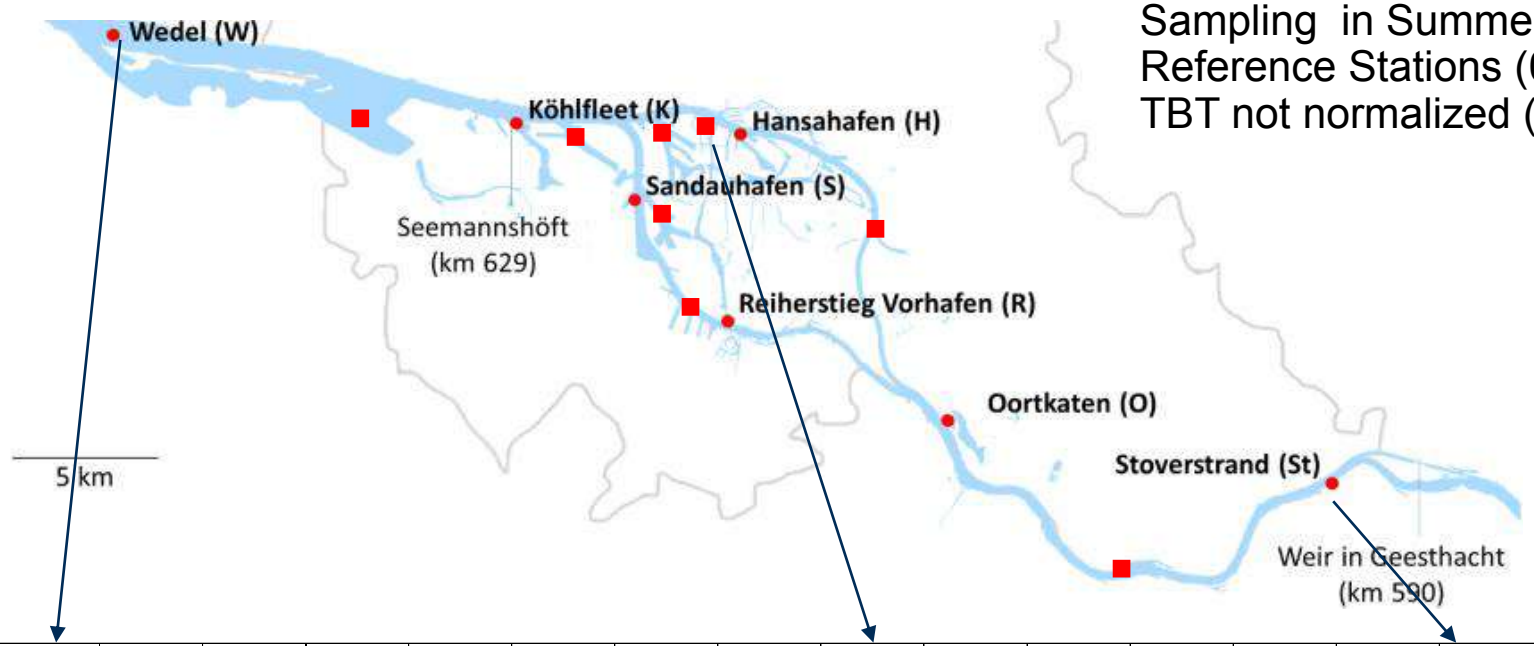


Tributylzinn		Sedifa	Ref 1	Ref 3	Ref 4	Ref 10	Ref 15	Ref 13	Ref 5	Ref 6	Ref 7	Ref 8	Ref 11	Ref 12	R9/20	R14/22
		FS/DS	1_AußenEste	3_Köhlfleet	4_Parkhafen	10_Sandauh.	15_Rethe Bl.3	13_Rethe Bl.2	5_Vorhafen	6_Reiherst.	7_Hansah.	8_NE6-SH	11_Seehaf. 4	12_ReiV	20_Dove/Oortk	22_Bull/Stove
2000	Juni		193.0	338.0	244.0	232.0	324.0	286.0	349.0	2180.0	547.0	297.0	156.0	97.6	360.0	45.8
2001	Juni		194.0	362.0	173.0	284.0	338.0	277.0	607.0	4440.0	1230.0	915.0	160.0	80.8	314.0	49.9
2002	Juni		156.0	450.0	362.0	337.0	425.0	333.0	670.0	12633.0	1770.0	815.0	148.0	63.8	163.0	36.4
2003	Juni		35.0	170.0	140.0	170.0	190.0	300.0	250.0	2800.0	510.0	260.0	88.0	110.0	160.0	8.0
2004	Juni		130.0	241.0	106.0	86.5	136.0	148.0	188.0	1330.0	248.0	399.0	62.0	34.6	114.0	25.9
2005	Juni		58.9	151.0	155.0	113.0	79.4	216.0	176.0	353.0	197.0	166.0	108.0	44.3	187.0	31.9
2006	Juni		92.0	240.0	69.0	100.0	110.0	130.0	150.0	280.0	260.0	150.0	67.0	46.0	180.0	29.0
2007	Juli		32.6	77.4	66.6	51.0	71.9	92.3	89.7	205.0	162.0	73.4	52.9	21.3	76.8	28.6
2008	Juni		90.0	93.0	110.0	49.0	160.0	180.0	83.0	110.0	230.0	76.0	52.0	27.0	54.0	23.0
2009	Juni		63.0	126.0	85.0	113.0	23.0	87.0	222.0	243.0	92.0	114.0	59.0	36.0	73.0	12.0
2010	Juni		25.0	110.0	46.0	85.0	44.0	109.0	61.0	929.0	99.0	51.0	61.0	36.0	49.0	12.0
2011	Juni		47.0	95.0	63.0	68.0	43.0	60.0	152.0	309.0	143.0	101.0	31.0	19.0	42.0	19.0
2011	Juli		34.0	83.0	57.0	39.0	54.0	76.0	101.0	306.0	106.0	105.0	35.0	22.0	48.0	28.0
2011	Sept		27.0	66.0	37.0	43.0	33.0	18.0	85.0	288.0	94.0	54.0	29.0	18.0	31.0	9.9
2012	Mai	59.0	40.0	93.0	59.0	61.0	148.0	77.0	92.0	187.0	82.0	76.0	84.0	27.0	32.0	17.0
2012	Juli	32.0	45.0	61.0	54.0	53.0	57.0	62.0	75.0	135.0	83.0	62.0	38.0	23.0	50.0	18.0
2012	Okt	24.0	37.0	60.0	55.0	51.0	69.0	54.0	72.0	105.0	80.0	52.0	30.0	23.0	48.0	16.0
2013	Juni	34.0	150.0	110.0	36.0	43.0	44.0	100.0	75.0	730.0	330.0	84.0	55.0	31.0	55.0	29.0
2014	Juli	19.0	29.0	35.0	27.0	32.0	35.0	24.0	35.0	65.0	43.0	38.0	21.0	6.9	11.0	5.1
2015	Juni	20.0	29.0	55.0	31.0	44.0	30.0	46.0	38.0	68.0	130.0	33.0	24.0	11.0	16.0	10.0
2016	Juni	15.0	36.0	61.0	30.0	31.0	39.0	39.0	37.0	71.0	49.0	42.0	31.0	27.0	25.0	12.0
2017	Juli	21.0	11.0	50.0	20.0	52.0	24.0	38.0	37.0	45.0	38.0	31.0	33.0	44.0	76.0	73.0
2018	Juli	11.0	19.0	48.0	33.0	26.0	26.0	42.0	30.0	40.0	30.0	38.0	39.0	17.0	38.0	12.0
2019	Juli	16.0		34.0	25.0	25.00	26.00	27.00	32.0	35.0	33.0	24.0	23.00	20.00	32.00	11.00
2020	Juni	15.0	8.6	20.0	20.0	16.00	24.00	21.00	22.0	28.0	27.0	21.0	20.00	18.00	37.00	9.10
2021	Juni	21.0	9.7	21.0	20.0	15.00	15.00	16.00	16.0	19.0	17.0	17.0	10.00	7.80	110.00	16.00
2022	Juli	10.0	6.3	14.0	15.0	14.00	15.00	17.00	12.0	18.0	17.0	16.0	11.00	9.70	59.00	11.00
2023	Juli	7.3	12.0	18.0	10.0	12.0	13.0	22.0	16.0	17.0	37.0	14.0	14.0	4.6	21.0	8.8

2000 2005 2010 2013 2018 2023

TBT in the Port of Hamburg

Sampling in Summer
Reference Stations (0-5 cm)
TBT not normalized (µg/kg)



Above Weir Geesthacht:
11 µg/kg Schnackenburg
2021 annual mean

Tributylzinn		Sedifa	Ref 1	Ref 3	Ref 4	Ref 10	Ref 15	Ref 13	Ref 5	Ref 6	Ref 7	Ref 8	Ref 11	Ref 12	R9/20	R14/22
		FS/DS	1_AußenEste	3_Köhlfleet	4_Parkhafen	10_Sandauh.	15_Rethe Bl.3	13_Rethe Bl.2	5_Vorhafen	6_Reiherst.	7_Hansah.	8_NE6-SH	11_Seehaf. 4	12_ReiV	20_Dove/Oortk	22_Bull/Stove
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2006	Juni		92.0	240.0	69.0	100.0	110.0	130.0	150.0	280.0	260.0	150.0	67.0	46.0	180.0	29.0
2007	Juli		32.6	77.4	66.6	51.0	71.9	92.3	89.7	205.0	162.0	73.4	52.9	21.3	76.8	28.6
2008	Juni		90.0	93.0	110.0	49.0	160.0	180.0	83.0	110.0	230.0	76.0	52.0	27.0	54.0	23.0
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2015	Juni	20.0	29.0	55.0	31.0	44.0	30.0	46.0	38.0	68.0	130.0	33.0	24.0	11.0	16.0	10.0
2016	Juni	15.0	36.0	61.0	30.0	31.0	39.0	39.0	37.0	71.0	49.0	42.0	31.0	27.0	25.0	12.0
2017	Juli	21.0	11.0	50.0	20.0	52.0	24.0	38.0	37.0	45.0	38.0	31.0	33.0	44.0	76.0	73.0
2018	Juli	11.0	19.0	48.0	33.0	26.0	26.0	42.0	30.0	40.0	30.0	38.0	39.0	17.0	38.0	12.0
2019	Juli	16.0		34.0	25.0	25.00	26.00	27.00	32.0	35.0	33.0	24.0	23.00	20.00	32.00	11.00
2020	Juni	15.0	8.6	20.0	20.0	16.00	24.00	21.00	22.0	28.0	27.0	21.0	20.00	18.00	37.00	9.10
2021	Juni	21.0	9.7	21.0	20.0	15.00	15.00	16.00	16.0	19.0	17.0	17.0	10.00	7.80	110.00	16.00
2022	Juli	10.0	6.3	14.0	15.0	14.00	15.00	17.00	12.0	18.0	17.0	16.0	11.00	9.70	59.00	11.00
2023	Juli	7.3	12.0	18.0	10.0	12.0	13.0	22.0	16.0	17.0	37.0	14.0	14.0	4.6	21.0	8.8

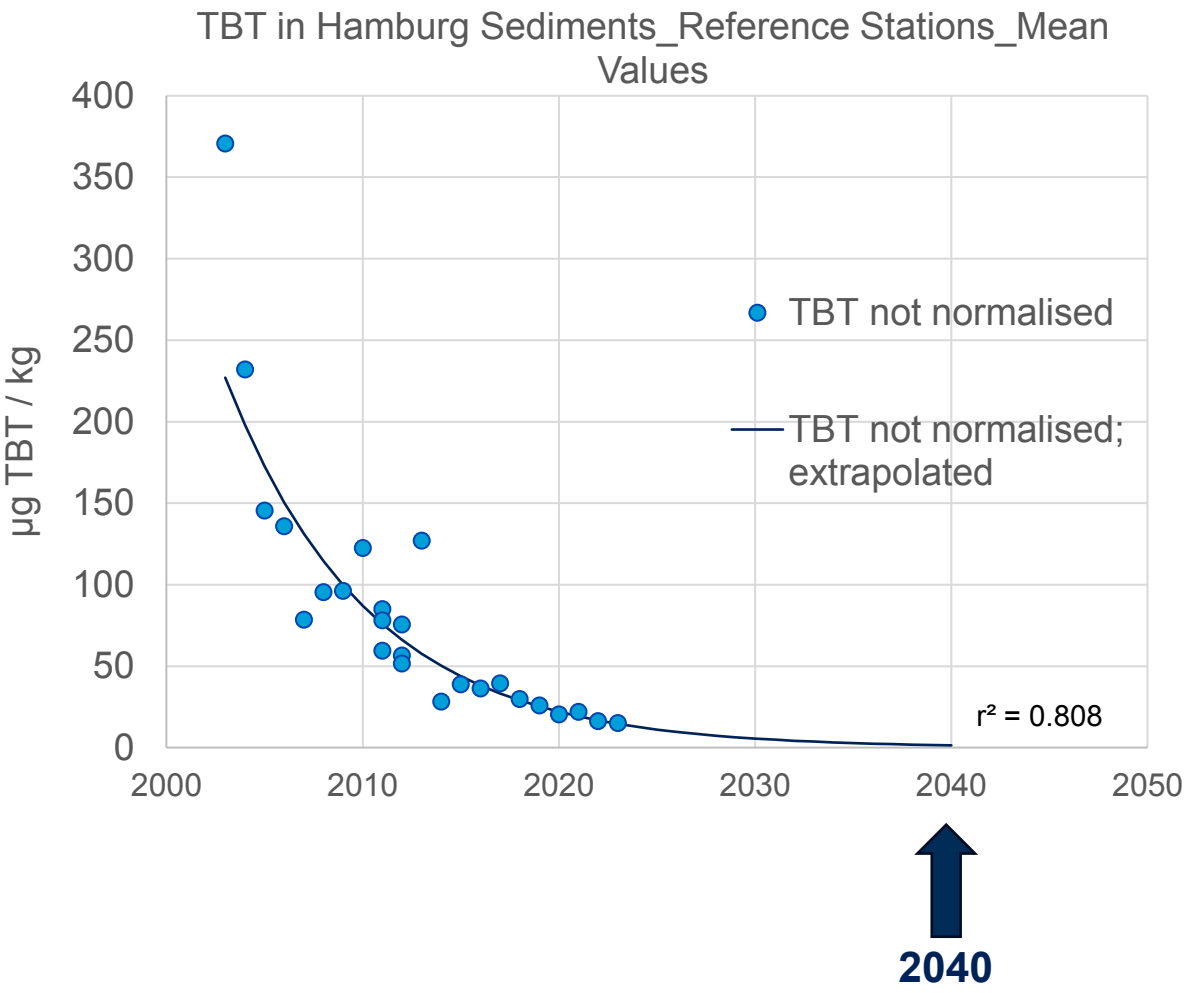
2000 2005 2010 2013 2018 2023

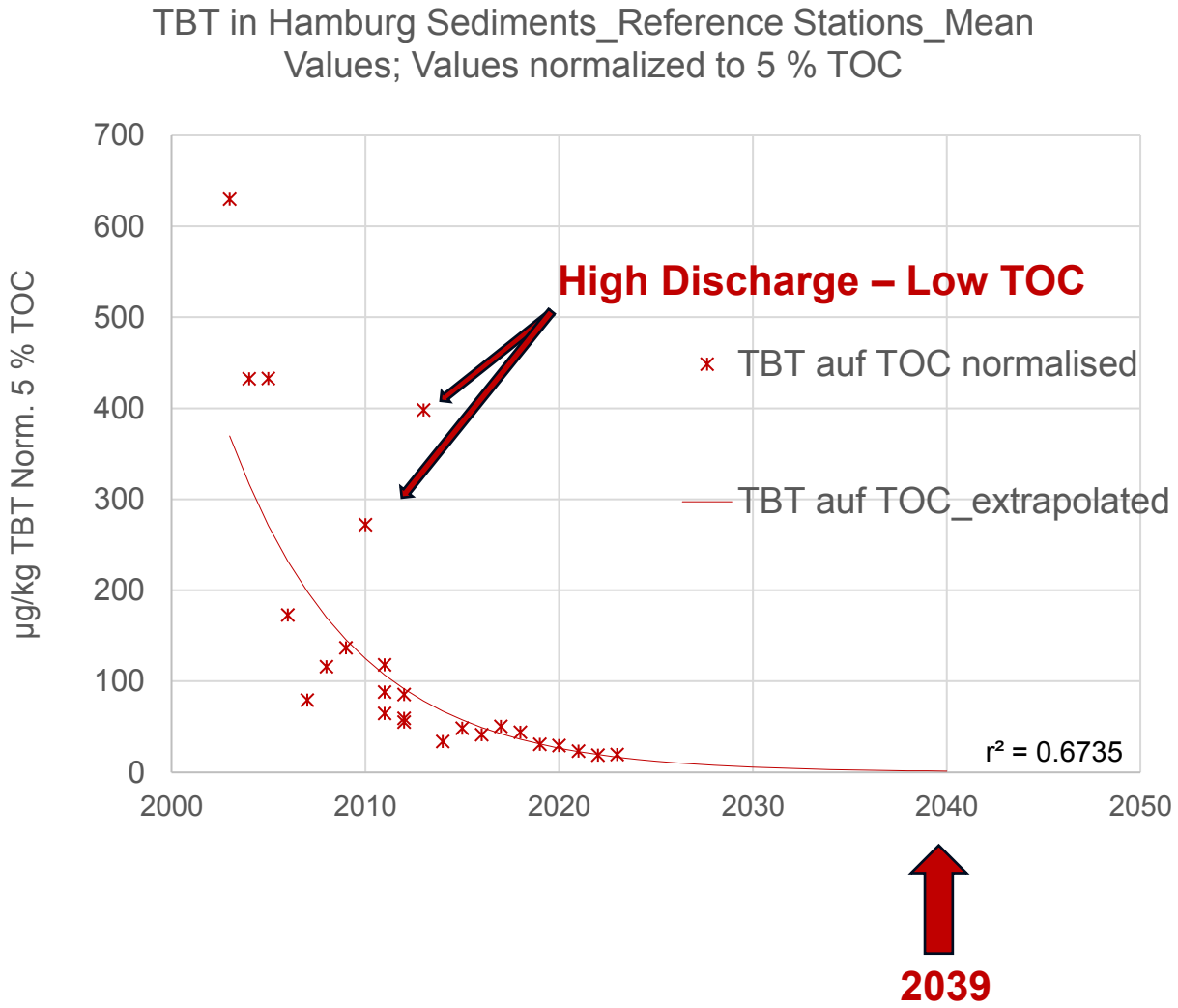
X=400 µg/kg

X=15 µg/kg

7.3 µg /kg 22 µg /kg 37 µg /kg 8.8 µg /kg

TBT in the Port of Hamburg: When will the new EQS be reached?!





Consequences for Dredging and Disposal:

- TBT Concentration has already decreased since 2008
- Sediment EQS 1,6 µg/kg TBT will be reached around 2040.
- If EQS will be a strict threshold value for Disposal: NO DREDGING UNTIL 2040!!
- If EQS at reference stations must be monitored: No observable or measurable change allowed.
  - Depends on current concentrations at reference stations (partly unknown)
- If EQS has to be normalized to 5 % TOC: In the German Bight it cannot be checked for compliance if normalized with a current detection limit of 1 µg TBT/kg. (< 8 to < 50 µg/kg norm. 5 % TOC)

High Risk not to comply with non-deterioration principle in estuaries and ports!

Consequences for Measures:

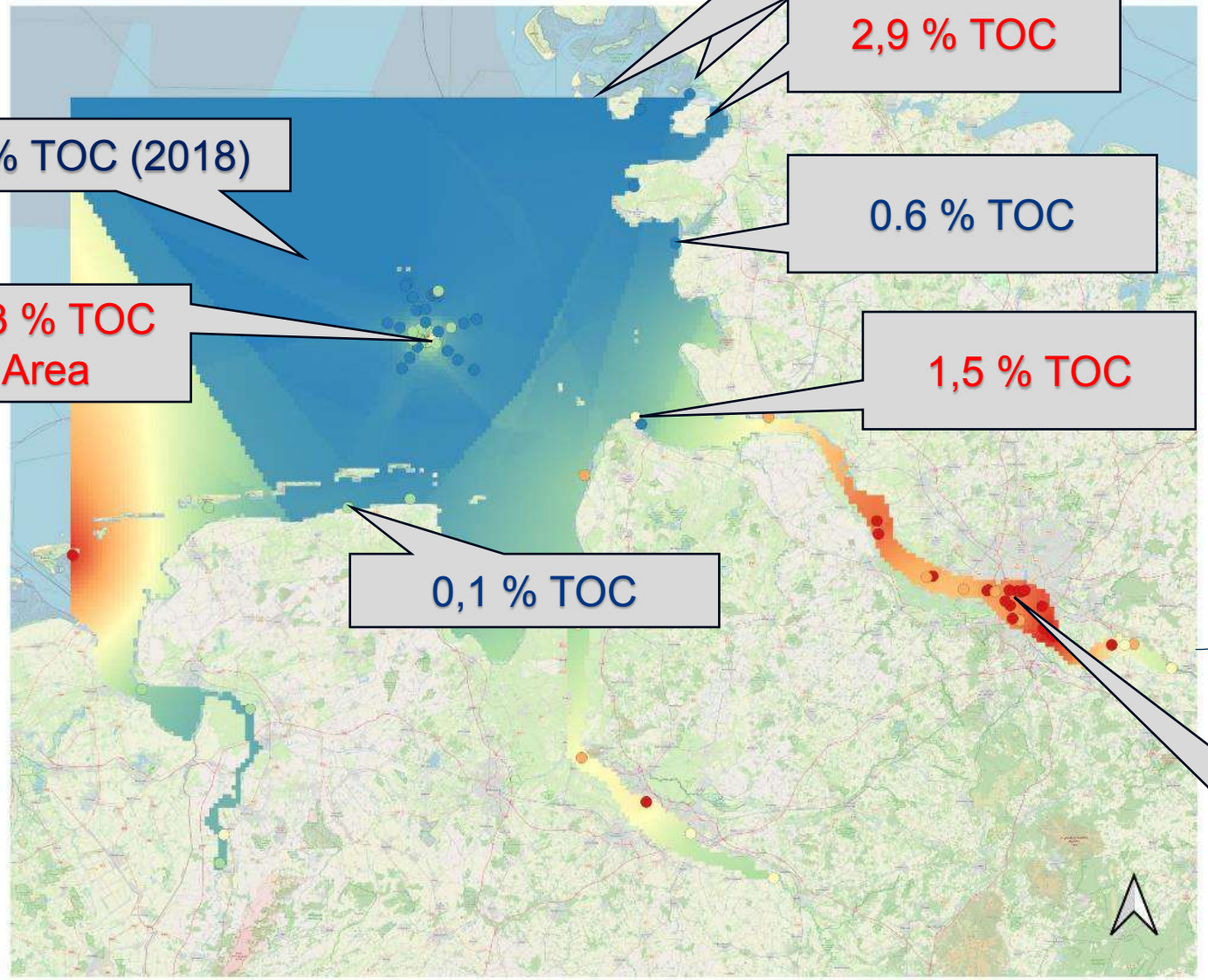
- No more known remediation measures / point sources in the Port of Hamburg
- Natural attenuation…We can only wait? But this is what we do!

HPA
Hamburg Port Authority

Hamburg Port Authority AöR

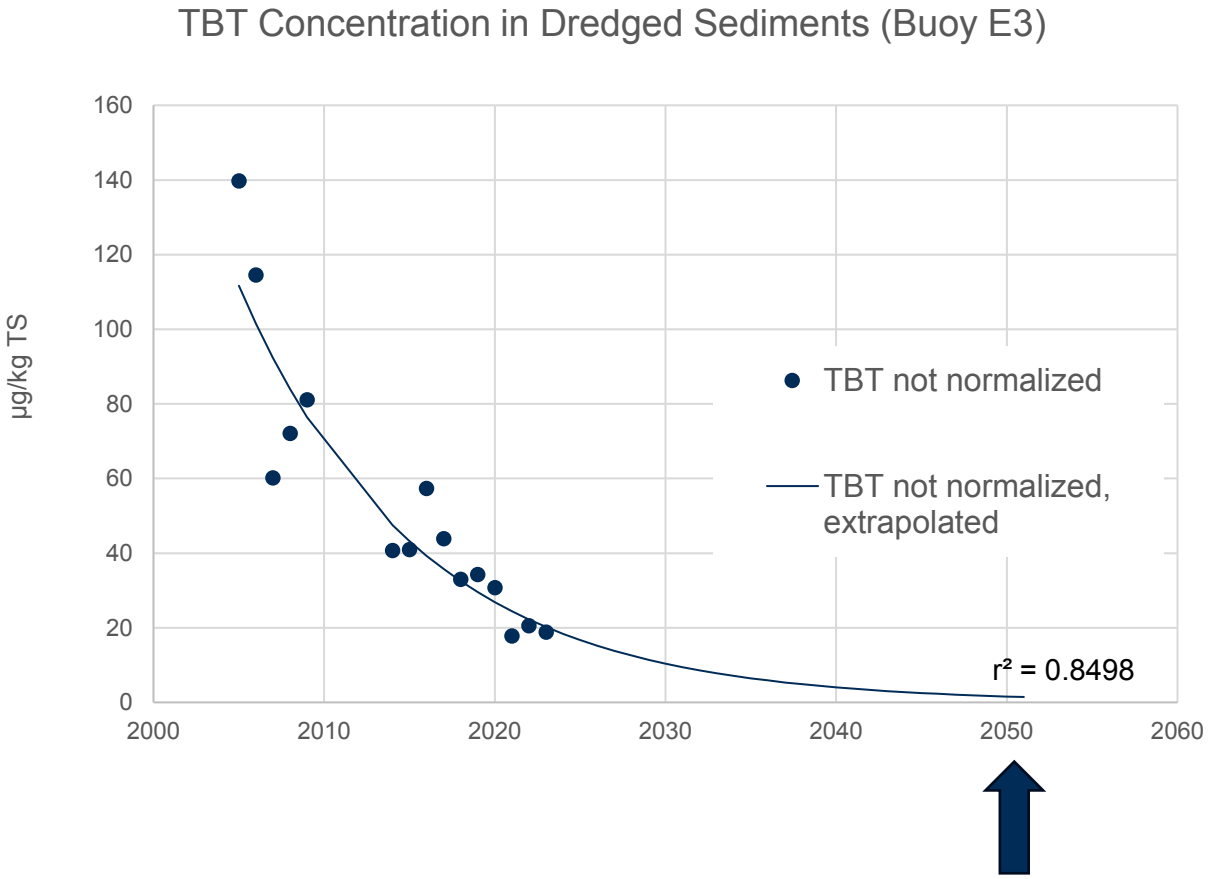
Neuer Wandrahm 4
20457 Hamburg
Tel.: +49 40 42847-2432

TOC in the Sediments (2022)

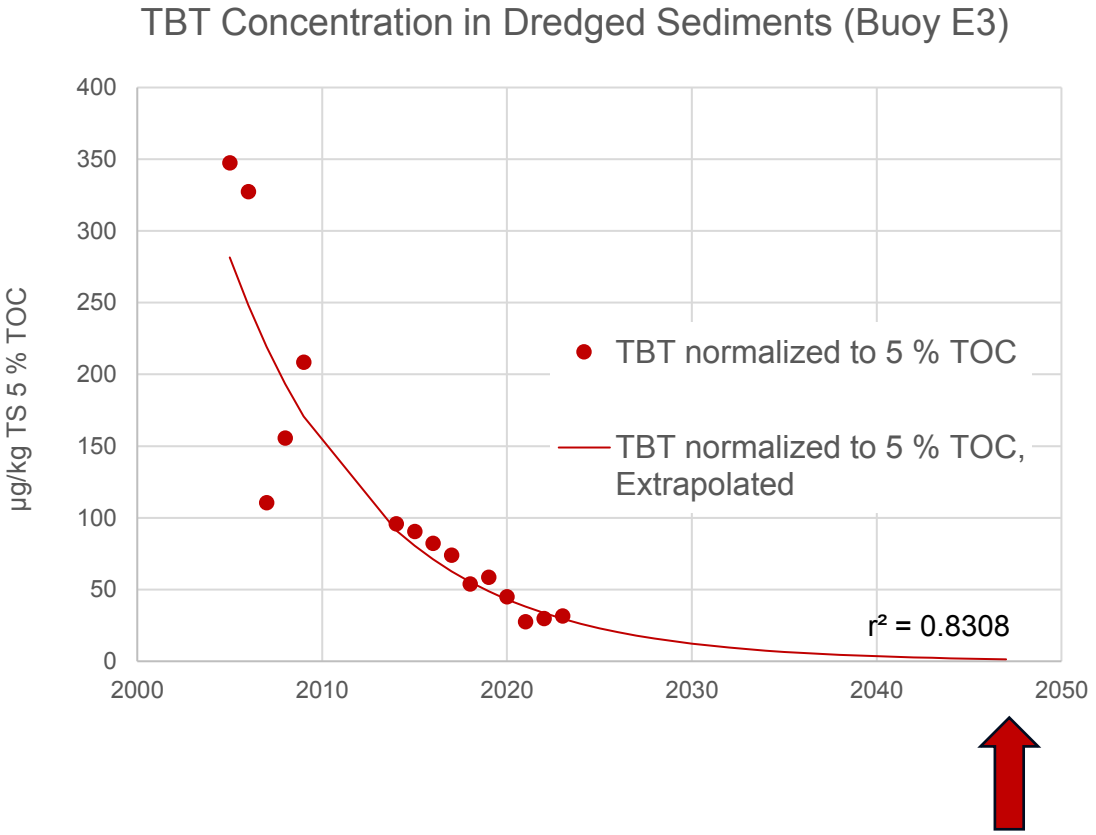


Wadden Sea Stations: Only for fine grained sediments

TBT in the Port of Hamburg:
When will the new EQS be reached? Disposed Sediments



2050



2047

How to overcome rigid quality standards to enhance beneficial use:

A case study on risk-based assessment for waste bodies in the Netherlands

Julia Gebert[1] & Joris Dijkstra[2]

[1]Delft University of Technology (TU Delft)

[2]Netherlands Organization for Applied Scientific Research (TNO)

Contact: j.gebert@tudelft.nl

The problem with waste bodies (landfills)

- Large volumes (millions of tons) of waste, over large areas (easily > 100 ha): MSW, commercial, industrial, construction & demolition waste
  → risk of contaminant leaching to the underlying soil, ground- and surface waters
- Sealing systems at base and at top (today!), but 10000s of non-sanitary sites per country
- Sealing systems have a limited life-time
- The money is made during the few years of operation
- BUT: The law requires “eternal aftercare”…. i.e. monitoring, treatment and remediation into eternity. There are no financial provisions for this.

TU Delft

Landfill closure and aftercare:
European landfill directive Article 13 c

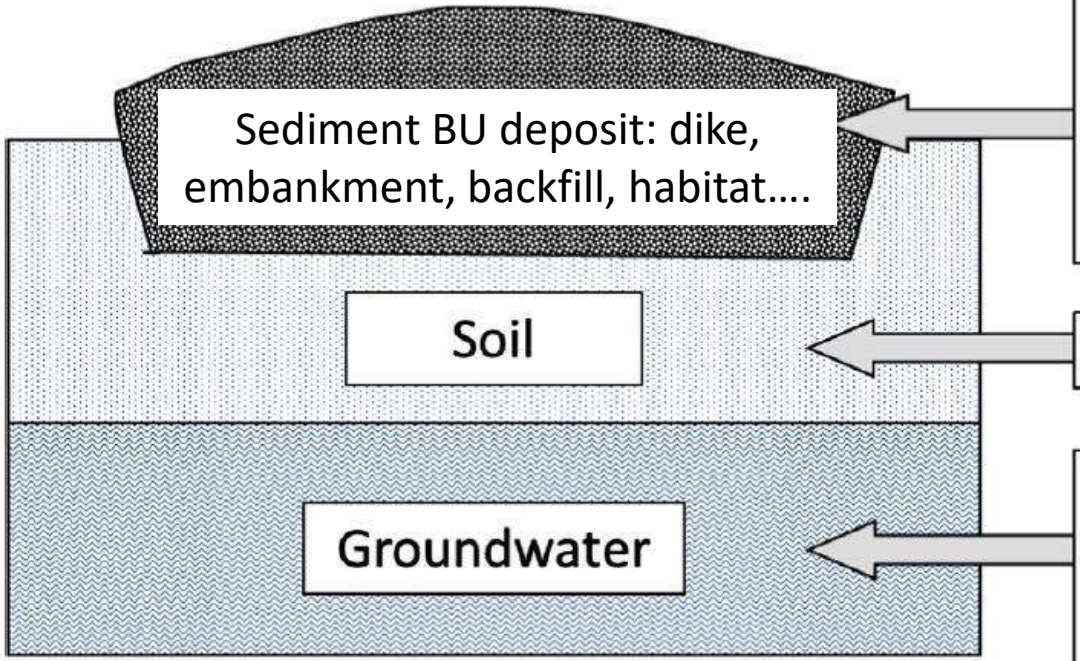
… after a landfill has been definitely closed, the operator shall be responsible for its maintenance, monitoring and control in the after-care phase **for as long as may be required by the competent authority, taking into account the time during which the landfill could present hazards**.

Never so far has any landfill been released from aftercare!

Eternal aftercare

- violates the principles of sustainable development
- creates huge financial uncertainties for operators and competent authorities in the very long term
- risk and cost are transferred to future generations

EU and national frameworks regarding landfilling of waste



- EU: Directive on Landfilling of Waste (1999/31/EC)
- EU: Landfill Directive (2003/33/EC)
- NL: Decree on Landfills and Landfill Bans
- NL: Decree on Landfilling and Soil Protection

- NL: Soil Quality Decree

- EU: Waterframework directive (2000/60/EC)
- EU: Groundwater Directive (2006/118/EC)
- NL: Water Decree

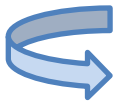
From current beliefs to a paradigm shift

Current landfill beliefs:

- Environmental protection relies on isolation (impermeable sealing systems), but ...
- … eternal functional isolation seems unrealistic

Paradigm shift:

- New approach based on intrinsic safety of the landfill
- Leaching to a large extent determined by dissolved organic matter that mobilises contaminants: organic matter in the landfill needs to be stabilized
- Contaminants emitted in case of seal failure must not pose any threat to HHE



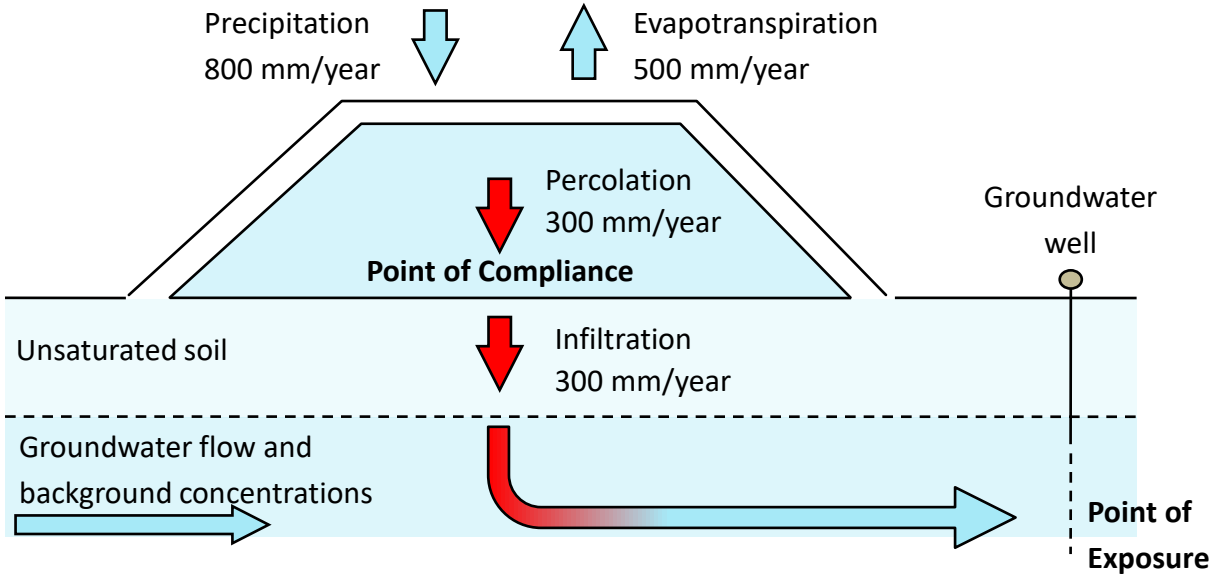
Case analogy to risk of leaching from sediment BU deposits

End of aftercare: Conceptual model

End of aftercare means no more isolation. The landfill is in equilibrium with the environment and remaining emissions cause no hazard to HHE.

E. Brand, T. De Nijs, J. Claessens, J. Dijkstra, R. Comans, R. Lieste, 2014, Development of emission testing values for pilot landfills for sustainable landfill practices - Phase 2: Proposals for testing values, RIVM Report 607710002/2014, RIVM, Bilthoven, Netherlands

http://www.rivm.nl/en/Documents_and_publications/Scientific/Reports/2014/mei/Development_of_emission_testing_values_to_assess_sustainable_landfill_management_on_pilot_landfills_Phase_2_Proposals_for_testing_values



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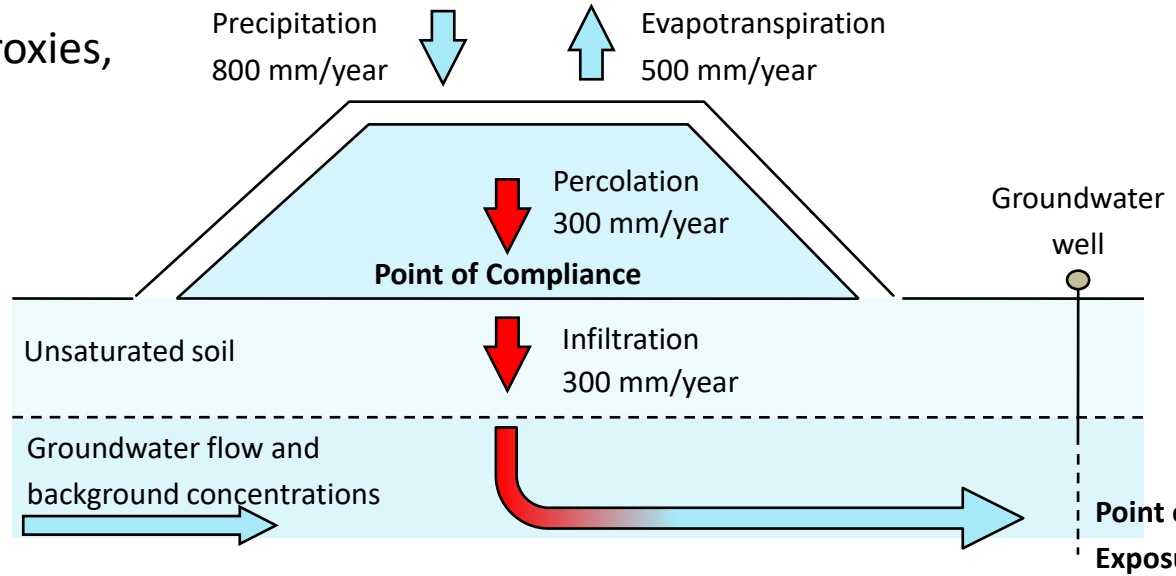
Approach to site-specific risk assessment

- **Emission target values (ETV) for a wide range of contaminants** calculated for Point of Compliance (concentration)
- ETV ensure target values at Point of Exposure for 500 years, considering soil-specific factors (organic matter, Fe-oxides/hydroxies, clay, pH) and dilution
- Models were iterated until groundwater quality criteria at PoE were met



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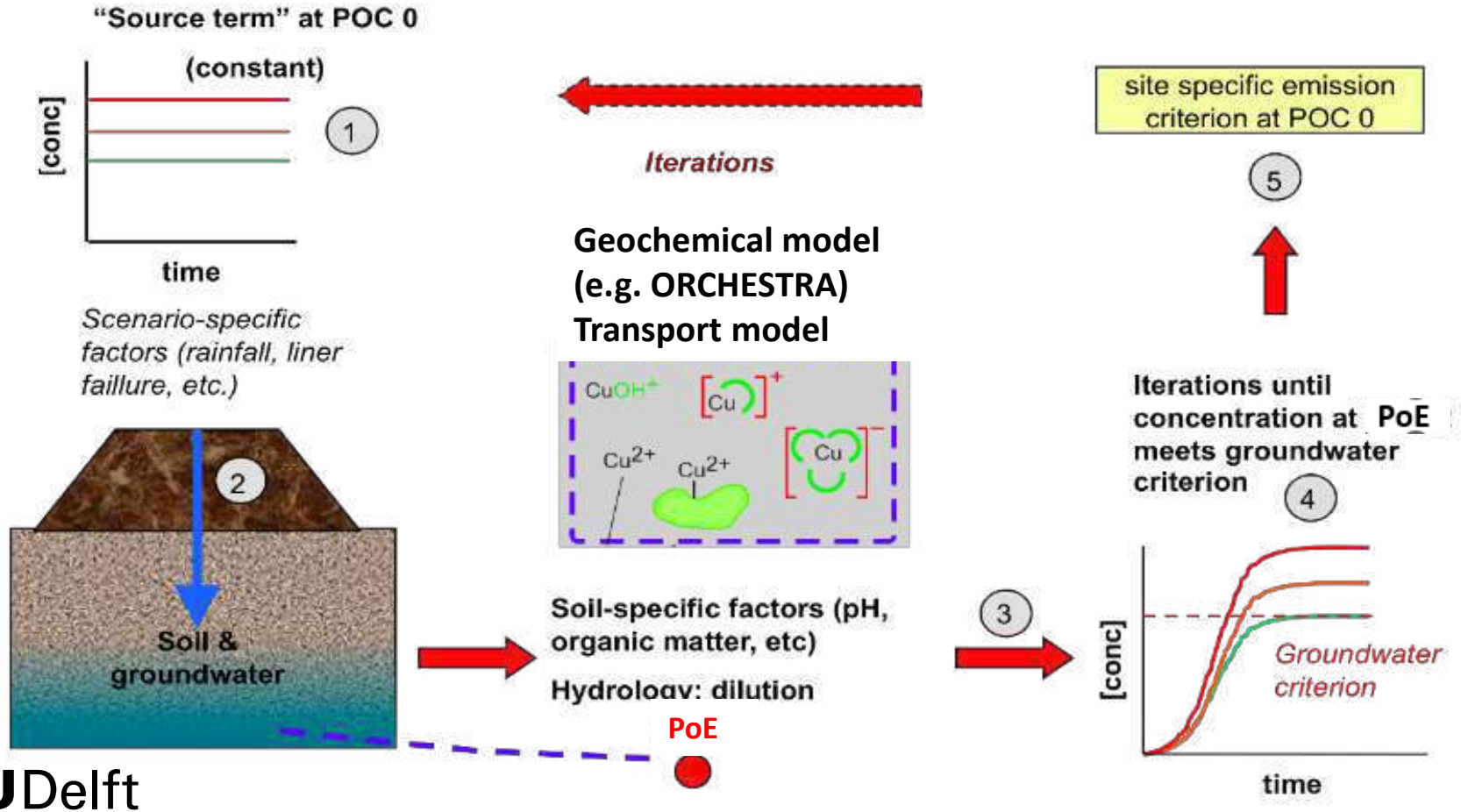
Determining emission target values



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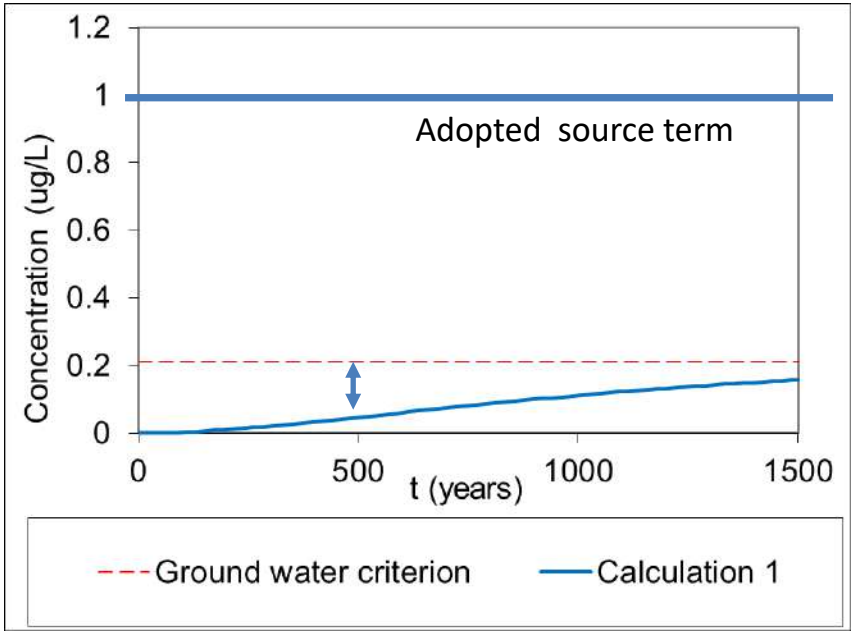
Brand et al. 2016 http://dx.doi.org/10.1016/j.wasman.2016.07.038

Example of iteration process

- Moderately mobile substance (Cd, Cu, Ni)
- Initial source term estimation
- Source term increased to meet criterion at t = 500 y



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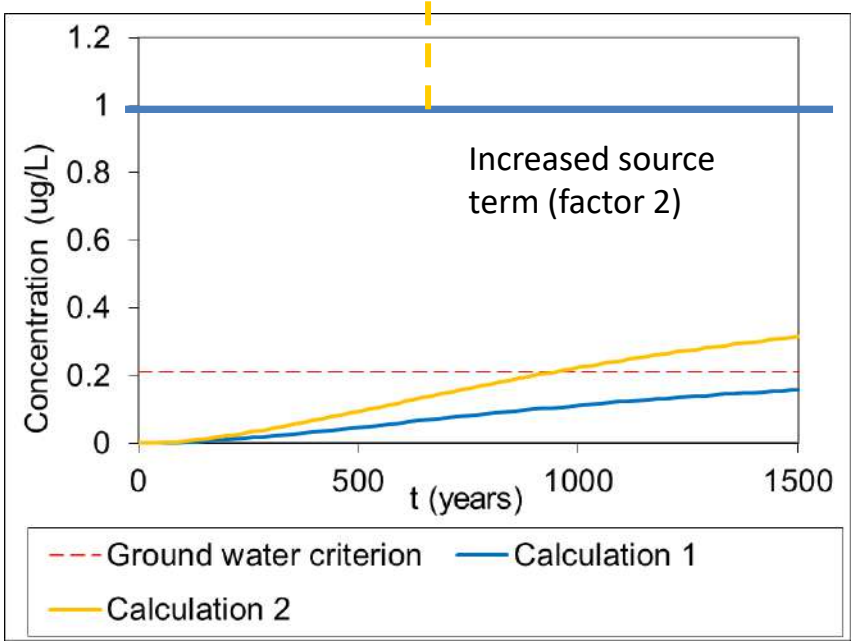
Example of iteration process



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Example of iteration process

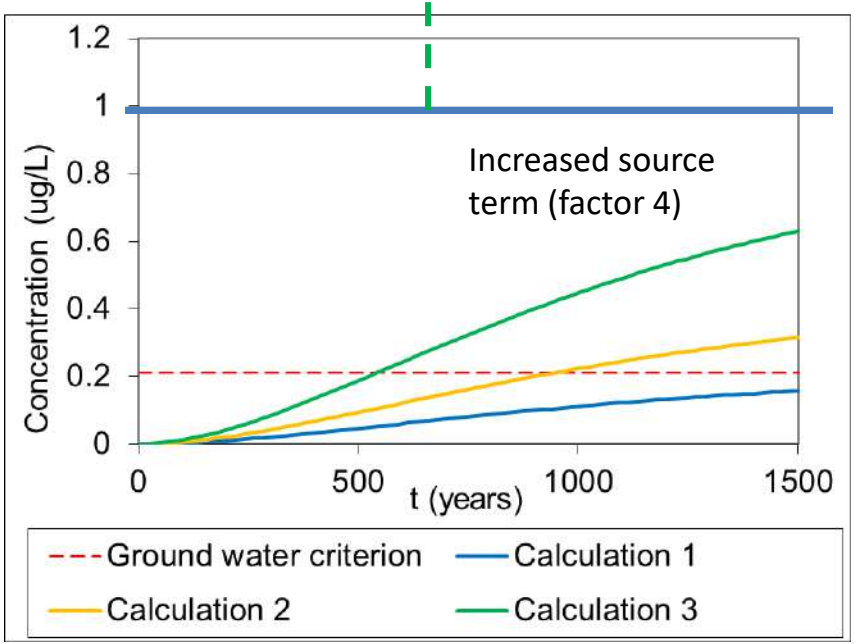

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Table 1 https://doi.org/10.1016/j.wasman.2018.02.002

Modelling results (EPC values) for metals, macroparameters and organic compounds for three pilot landfills. Compounds marked with an '*' required special attention and between brackets policy-based adjusted values are presented. For the underlying modelling details, see also Dijkstra et al. (2016).

Compounds	EPC Pilot 1 Braambergen	EPC Pilot 2 Kragge	EPC Pilot 3 Wieringermeer
Inorganic parameters (µg/L)			
Arsenic	190	100	190
Cadmium	6.4	3.6	1.3
Chromium	210	140	37
Copper	50	64	19
Mercury	5.8	4.1	1
Lead	60,000*/(130)	130	25,000*/(130)
Nickel	21	47	21
Zinc	160	120	39
Free cyanides	61	6.8	35
Macroparameters (mg/L)			
Ammonium	1.8*/(50)	1.1* (50)	50
Chloride	450	160	2400
Sulphate	700	200	1400
Organic contaminants (µg/L)			
Mineral oil sum EC10-EC40	470	270	100
VOX			
Vinyl chloride	0.047*/(0.2)	0.014*/(0.2)	0.01*/(0.2)
Dichloromethane	0.047*/(0.2)	0.014*/(0.2)	0.01*/(0.2)
1,1 dichloroethane	4.7	1.4	1
1,2 dichloroethane	14	4.1	3
1,1 dichloroethene	0.047*/(0.1)	0.014/(0.1)	0.01/(0.1)
1,2 dichloroethene	0.047*/(0.1)	0.014/(0.1)	0.01/(0.1)

Emission Target Values (ETV or EPC)

- 53 substances were regulated
- Concentrations for some differ up to a factor 45 between sites
- Local dilution factors and specific soil properties differ per location
- Local background concentrations and criteria at POC are different

Modelling exercise shows that ETVs are mostly determined by the site-specific soil properties: pH, dissolved organic matter, Fe-oxides/hydroxides, clay!

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Policy

A novel approach in calculating site-specific aftercare completion criteria for landfills in The Netherlands: Policy developments

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ABSTRACT

As part of a more circular economy, current attention on waste is shifting from landfilling towards the prevention, re-use and recycling of waste materials. Although the need for landfills is decreasing, there are many landfills around the world that are still operational or at the point of starting the aftercare per-

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Model

Site-specific aftercare completion criteria for sustainable landfilling in the Netherlands: Geochemical modelling and sensitivity analysis

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ABSTRACT

A novel, regulatory accepted approach is developed that enables competent authorities to decide whether landfill aftercare can be reduced or terminated. Our previous paper (Brand et al., Waste Management 2016, 56, 255–261, https://doi.org/10.1016/j.wasman.2016.07.038) outlines the general approach, that consists of a 10-year treatment phase (e.g. aeration, leachate recirculation) in combination with site-

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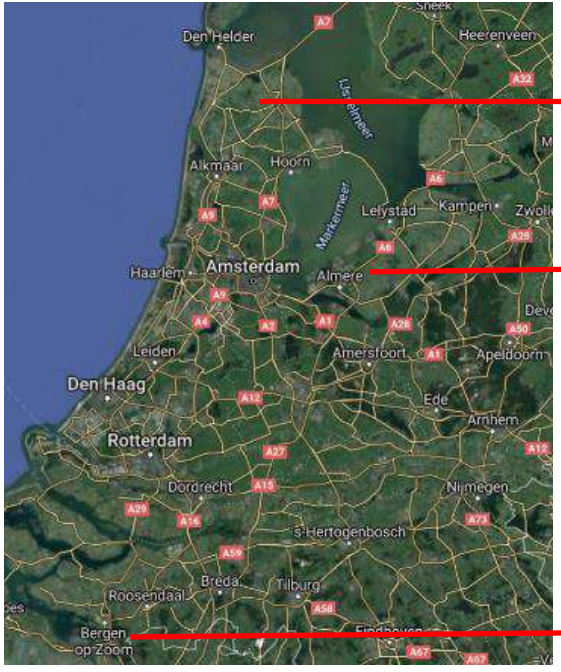
Green deal between Dutch government and landfill operators successful!

- ✓ Approach accepted
- ✓ Emission target values accepted
- ✓ Experiment to enhance organic matter decay started in 2017: projects iDS and CURE



Over-extraction

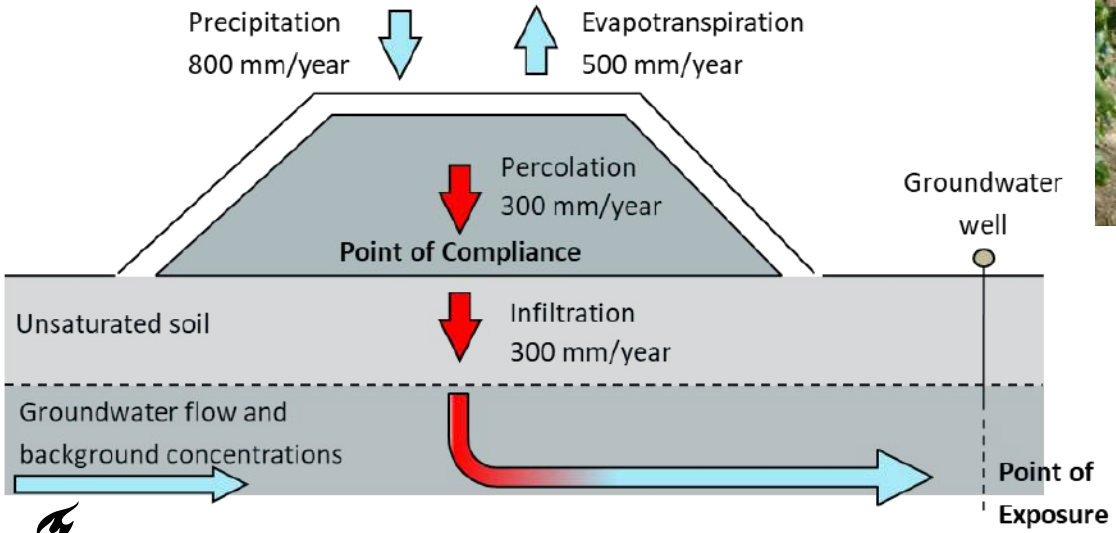
Combi-aeration
Over-extraction

Leachate recirculation

CURE
Coupled multi-process research for reducing landfill emissions

iDS
Introductie Duurzaam Stortbeheer

BU as analogy to the landfill case



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The approach by which the emission criteria were derived is sufficiently protective → Accepted by all parties involved

A way forward to enhance sediment BU projects?

Discussion

1. How can we develop enhanced EQS for sediments?
2. What strategies can be employed to minimize risks from circular economy applications?
3. How do strict standards limit BU in Europe and what measures can be taken to overcome these limitations?