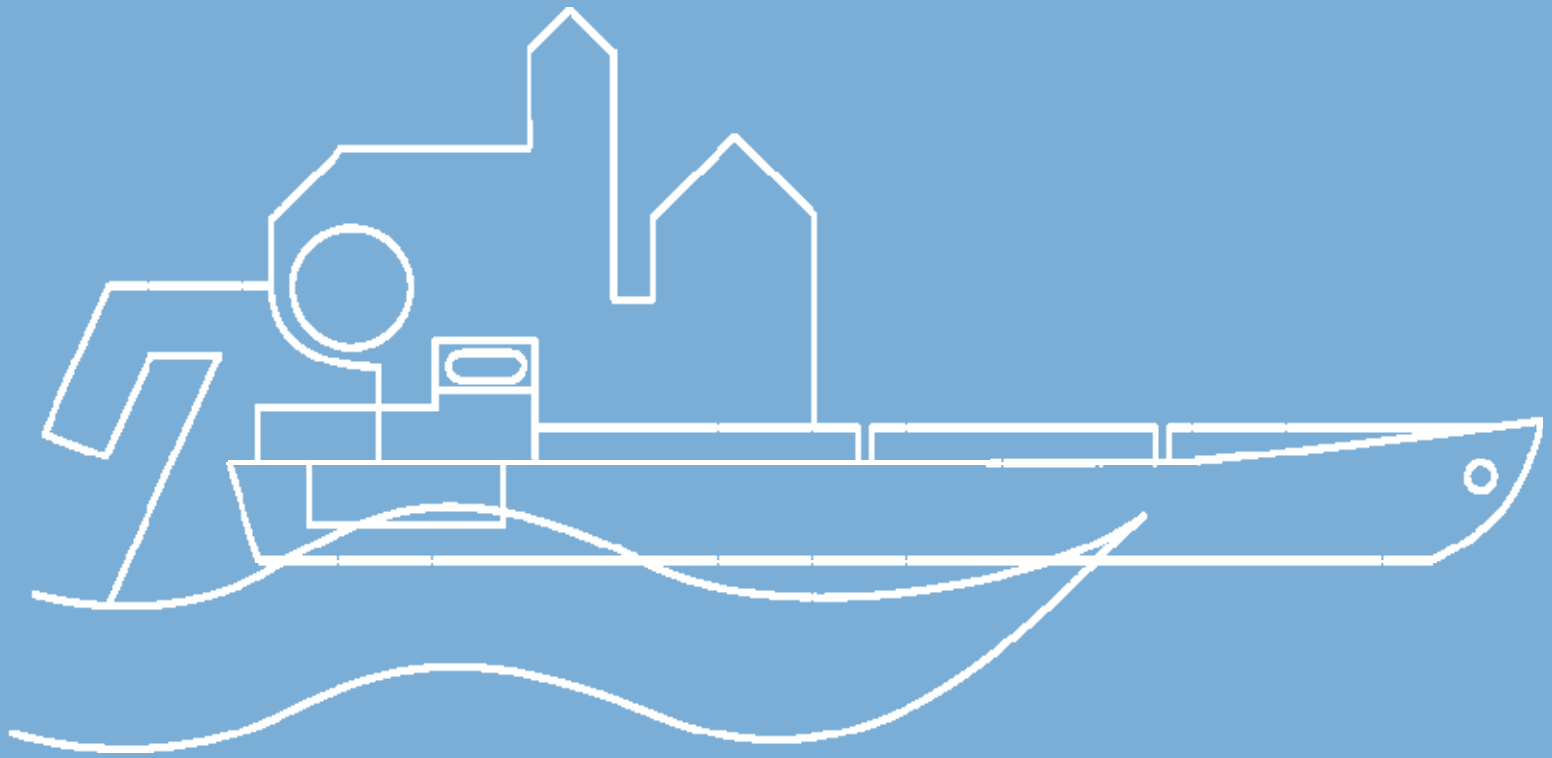

ALAMO (alarm model) – a flow time model used at the river Elbe

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Seminar on the occasion of the 25th anniversary of the Sandoz accident
Bonn, 09th November 2011

1. Background for operational contaminant transport modelling

Legal framework

➢ Water Framework Directive (article 11 (3) l)

Each Member State shall ensure the establishment
for **each river basin** district, …
of a **programme of measures**,

Each **programme of measures** shall include
the **basic measures** …

Basic measures are …

any measures required to …
to **reduce the impact of accidental pollution** incidents …
including … **systems to** detect or **give warning** … and …
measures to reduce the risk to aquatic ecosystems.

photo: River Labe near Nymburk, Czech Republic (13.01.2006)

➢ International warning and emergency plan for the Elbe River, IWAPE (2004)

... to refine the alarm messages described in IWAPE the results of the alarm model Elbe (ALAMO) are used … in case of accidental pollution of water bodies.

1. Background for operational contaminant transport modelling

Organisational framework / alerting mechanism

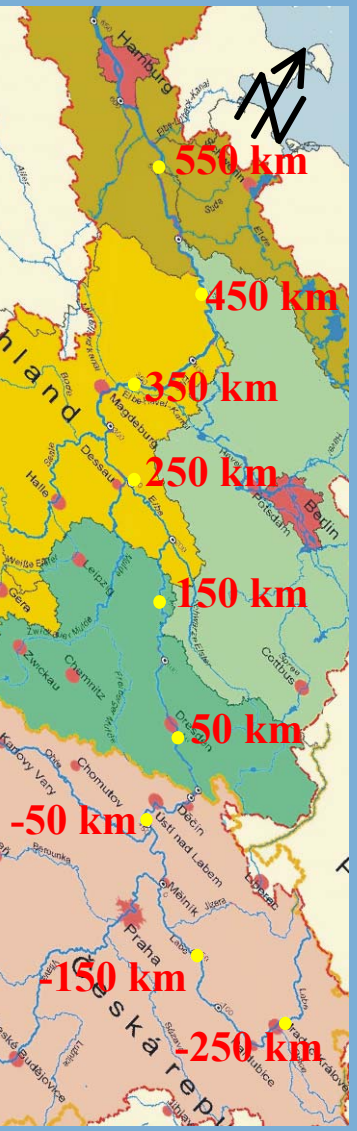
- **countries along the Elbe /Labe**
  Czech Republik
  Saxony (Germany)
  Saxony-Anhalt (Germany)
  Brandenburg (Germany)
  Lower Saxony (Germany)
  Schleswig-Holstein (Germany)
  Hamburg (Germany)

- **4 warning centres at the river Elbe / Labe in**
  Hradec Králové (L1)
  Dresden (E1)
  Magdeburg (E2)
  Hamburg (E3)

ALAMO (alarm model) – a flow time model used at the river Elbe

1. Background for operational contaminant transport modelling

Organisational framework / alerting mechanism



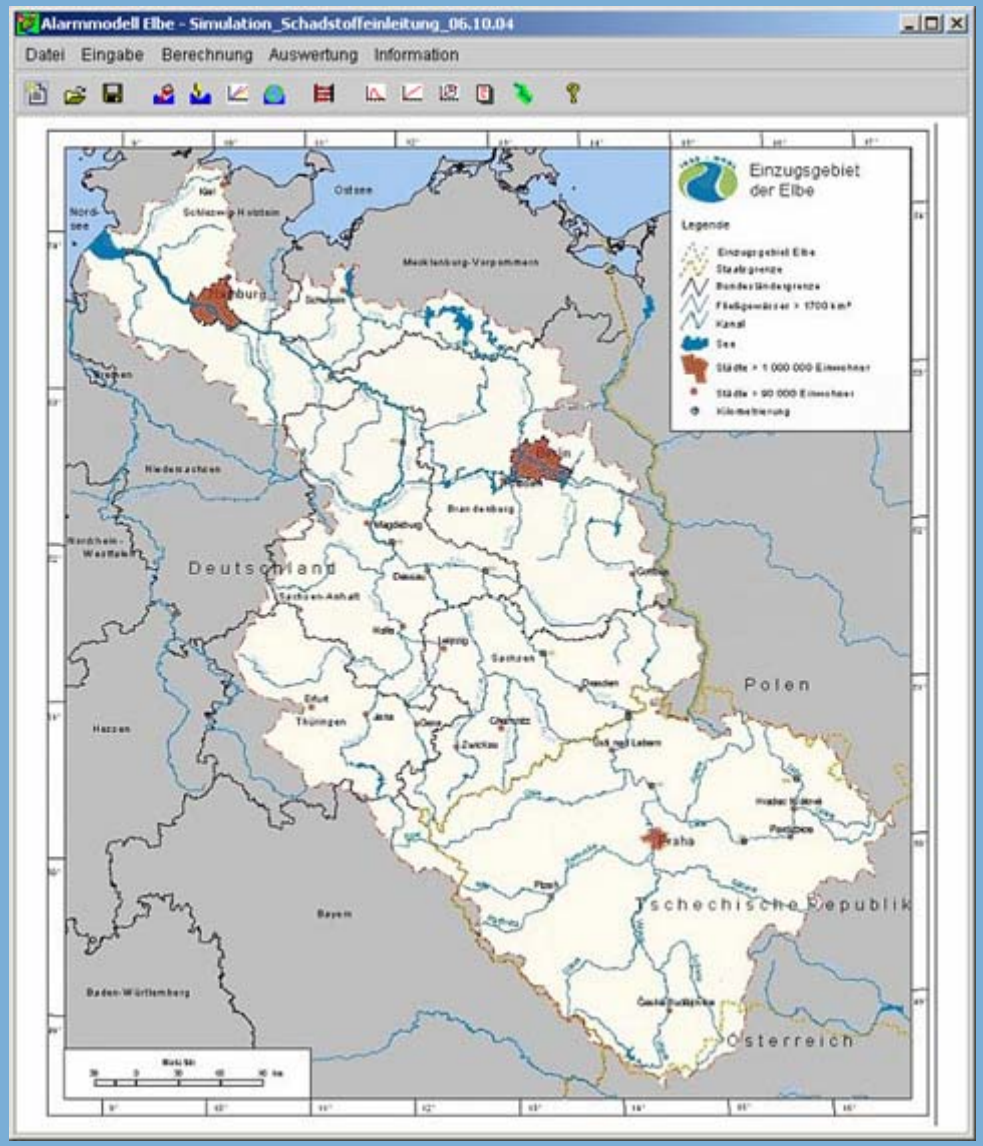
characteristics of the river Elbe:

- from the source to the city of Usti nad Labem **regulated river** (by weirs)
- downstream Usti nad Labem **free flowing river regulation by groynes**

Usage of water of the river Elbe:

- **abstraction of drinking water** (water barrage / bank filtration)
- **abstraction of process water**
- **hydropower**
- **transportation / traffic**

2. Requirements for operational contaminant transport models



➢ALAMO - demands

simple model (user friendly)

applicability on PC

low run-time requirements (< 1 min)

➢ALAMO - realisation

1-dimensional numerical model

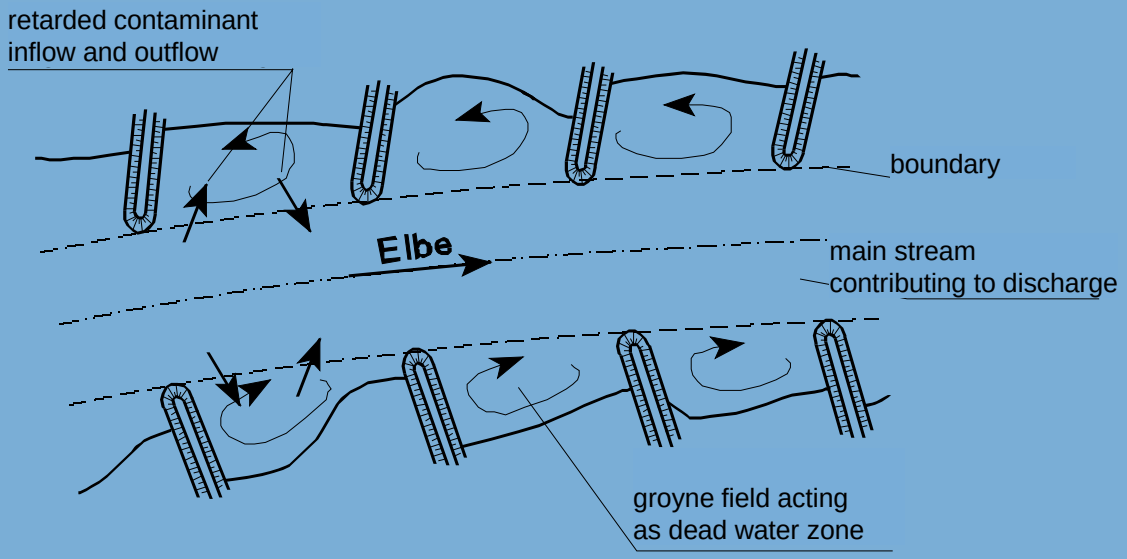
empirical approach to model the longitudinal und latitudinal mixing of contaminants in the river

➢Needs

calibration of model parameters describing mixing processes

➢Tracer experiments

3. Physical fundamentals of contaminant transport



relevant processes in:

- **main stream**
  - advection
  - diffusion/ dispersion
  - decay
  - exchange with dead water zones

- **dead water zones**
  - decay
  - exchange with main stream

ALAMO (alarm model) – a flow time model used at the river Elbe

3. Physical fundamentals of contaminant transport

equation for main stream:

$$\frac{\partial c}{\partial t} = -v\frac{\partial c}{\partial x} + D_L\frac{\partial^2 c}{\partial x^2} - \ldots$$

$$\ldots \varepsilon D_s(c-s) - k\,c$$

equation for dead water zone:

$$\frac{\partial s}{\partial t} = D_s(c-s) - k\,s$$

- c: contaminant concentration (main stream)
- v: flow velocity (main stream)
- D_L: coefficient of diffusion / dispersion
- s: contaminant concentration (dead water zone)
- D_S: coefficient of exchange
- ε: ratio of dead water zone to main stream
- k: coefficient of decay

➢ **advanced Taylor-model**

processes:
advection
diffusion/ dispersion
decay

➢ **1.5-dimensional approach**

exchange between main stream and dead water zones

no Transport in dead water zones

➢ **calibration needed for**

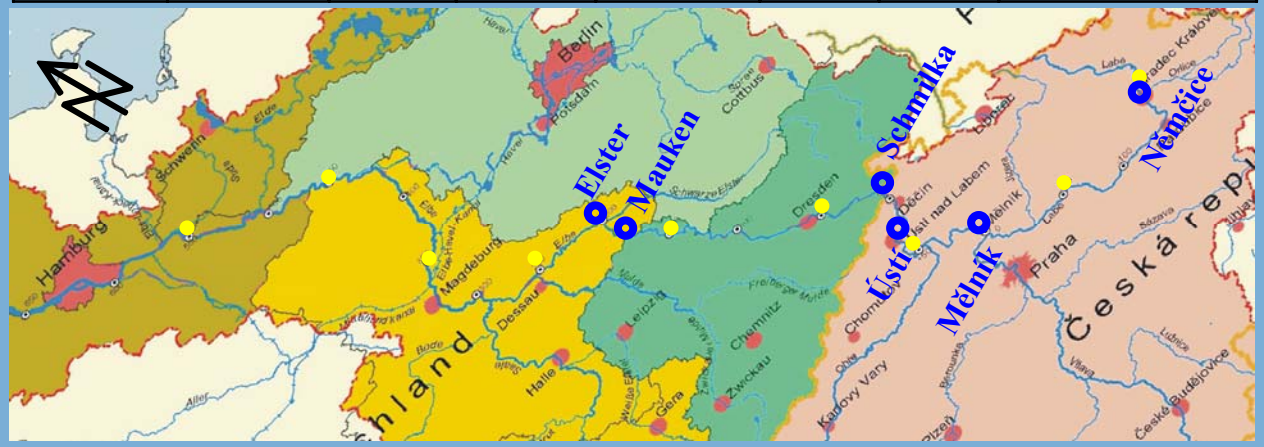
coefficients D_L, D_S

4. Tracer experiments for the calibration of the model

- overview over experiments
- realisation and measuring devices
- results

4. Calibration of ALAMO – tracer experiments

date	location of tracer input	river-km [km]	mass of tracer [kg]	discharge Q [m³/s]	MNQ [m³/s]	MHQ [m³/s]	authors
29/11/99	Němčice	-249,2	2,0	16	12	309	Dostál et al.
02/05/05	Němčice	-249,2	8,0	52	12	309	
26/04/99	Mělník	-104,8	24,0	255	76	1324	Dostál et al.
30/11/97	Ústí	-37,0	12,1	130	91	1430	Dostál et al.
15/07/97	Schmilka	4,1	33,5	330	102	1480	Hanisch et al.
29/03/01	Schmilka	4,1	75,8	912	102	1480	Hanisch et al.
06/10/04	Mauken	184,5	20,0	136	114	1380	Lippert et al .
11/10/99	Elster	200,4	26,0	160	130	1490	Hanisch et al.
27/10/98	Elster	200,4	26,4	265	130	1490	Hanisch et al.



- **overview over experiments**
- realisation and measuring devices
- results

Input of tracer

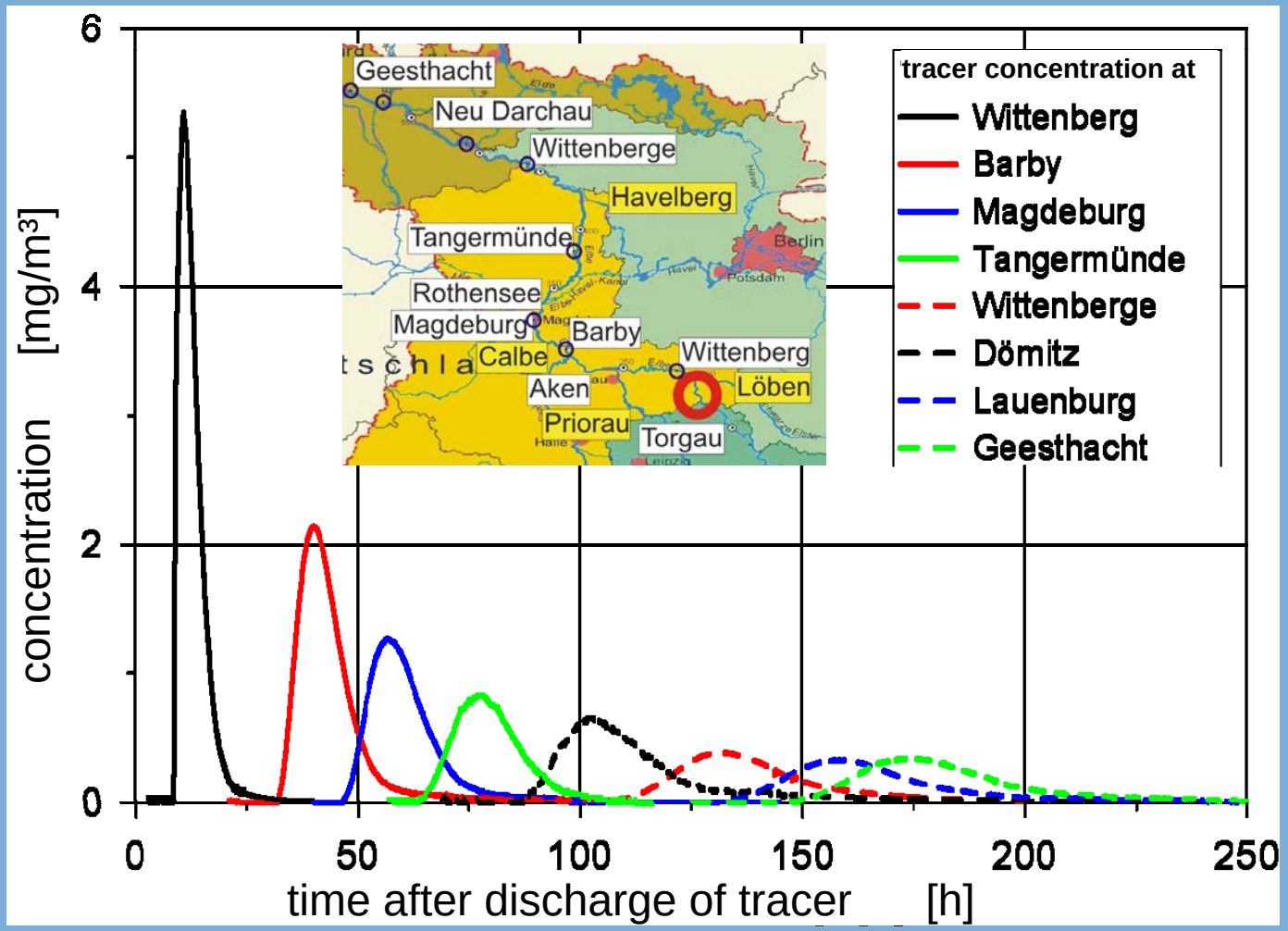
- ► at different locations along the river
- ► at different discharge conditions

4. Calibration of ALAMO – tracer experiments

- overview over experiments
- **realisation and measuring devices**
- results

4. Calibration of ALAMO – tracer experiments

time concentration curves
in the river Elbe (discharge Q = 150 m³/s)

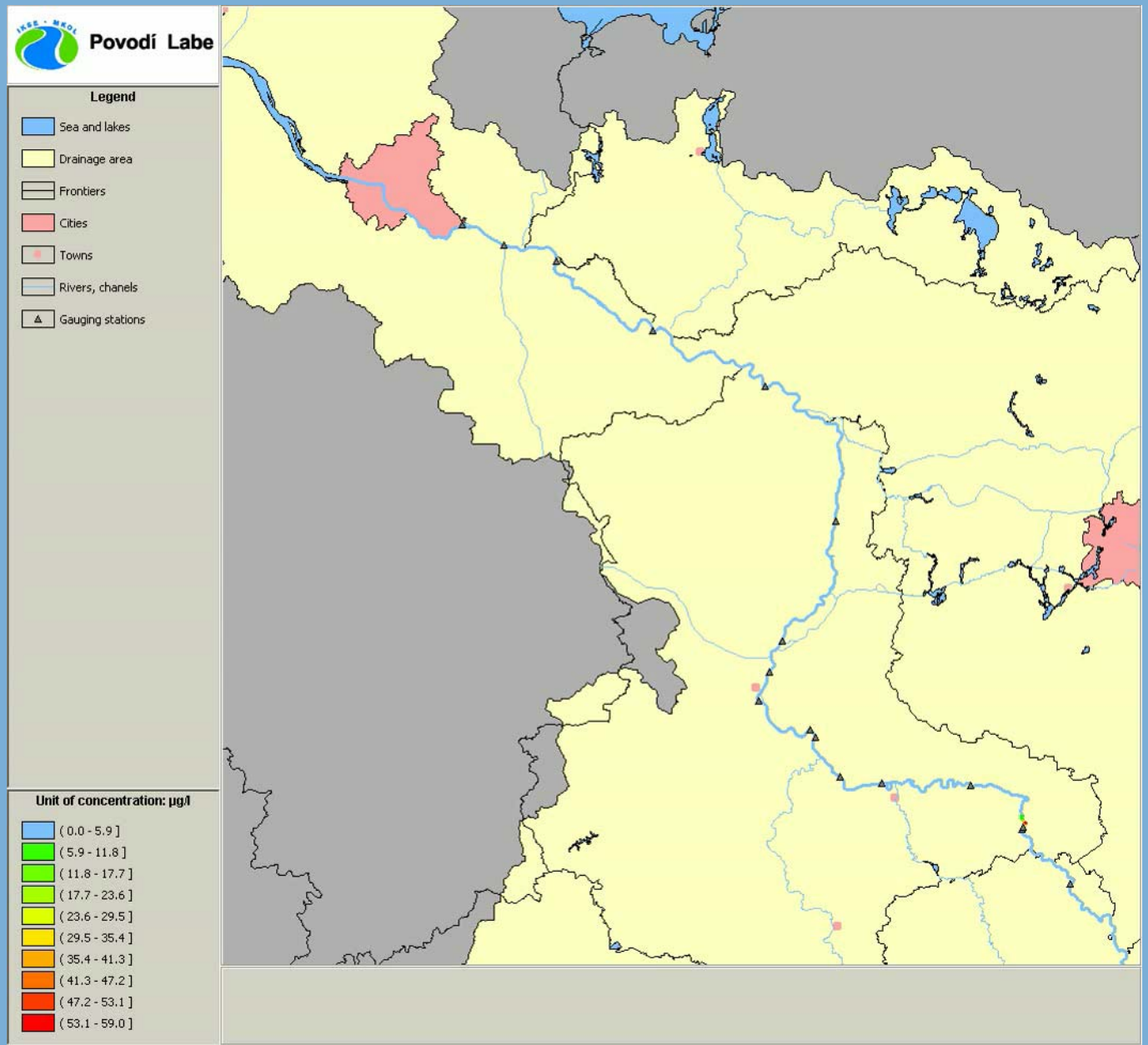


- overview over experiments
- realisation and measuring devices
- **results**

characteristic parameter:

- ► time of travel
  - start of tracer transit
  - peak of tracer transit
  - end of tracer transit
- ► maximum concentration of tracer transit
  - in main stream
  - at the river bank

4. Calibration of ALAMO – tracer experiments



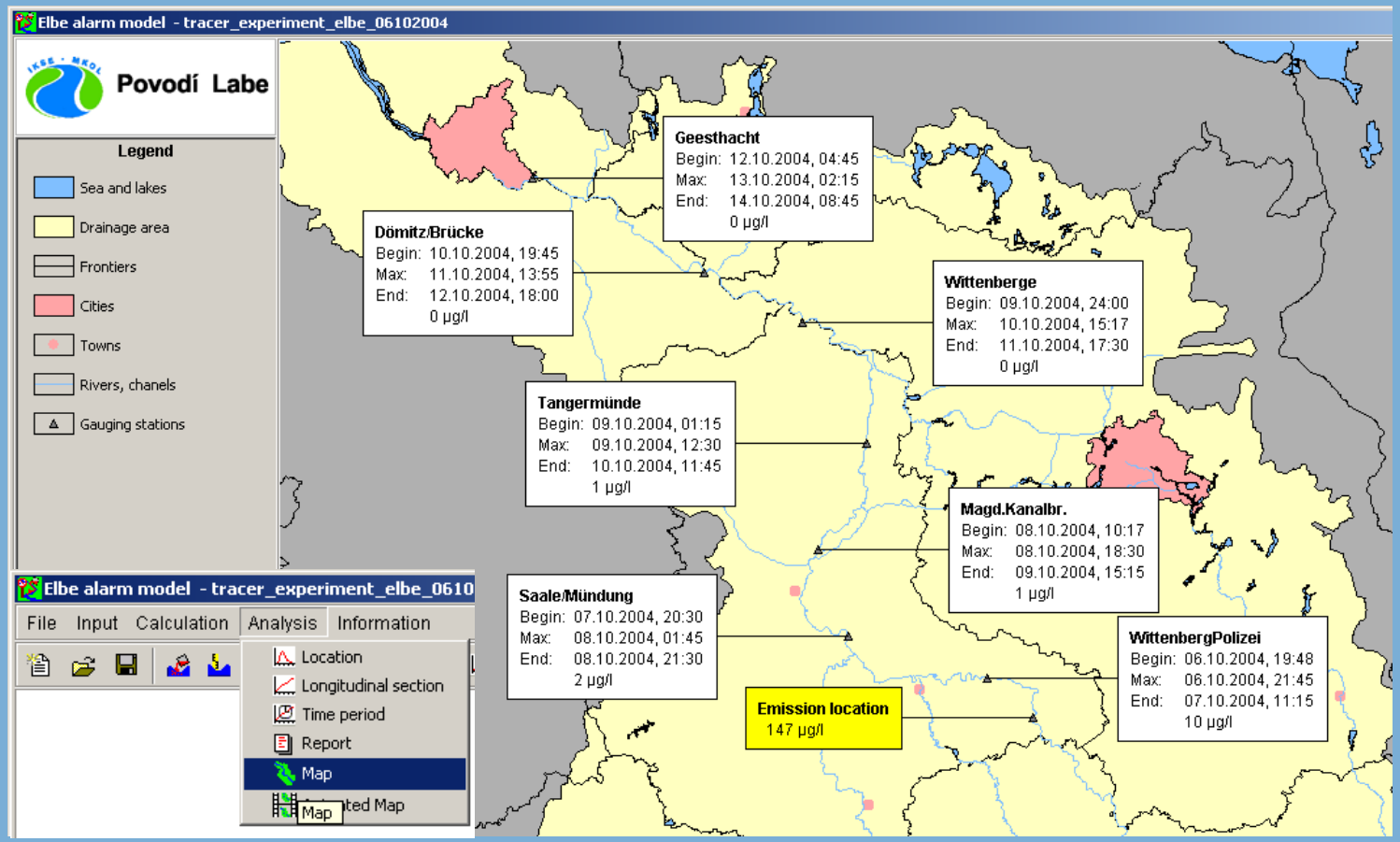
- overview over experiments
- realisation and measuring devices
- **results**

animated results
of the model ALAMO
in the river Elbe
(discharge Q = 150 m³/s)

animated time interval: 7 days

4. Calibration of ALAMO – tracer experiments

characteristics of tracer transport along
the river Elbe (discharge Q = 150 m³/s)



- overview over experiments
- realisation and measuring devices
- **results**

characteristic parameter:

- time of travel
  - start of tracer transit
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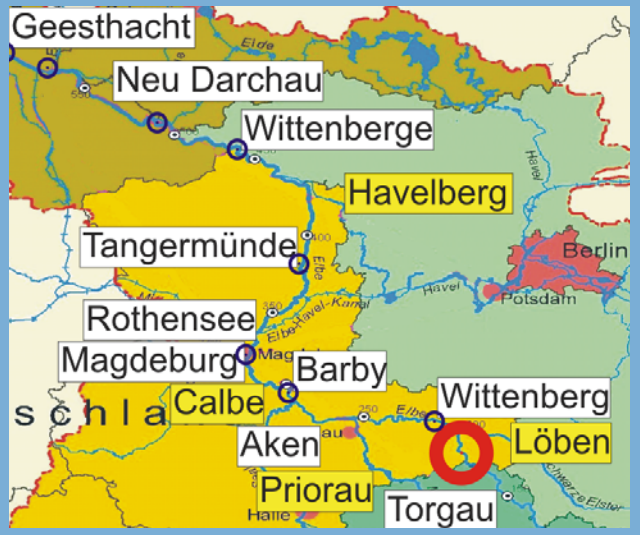
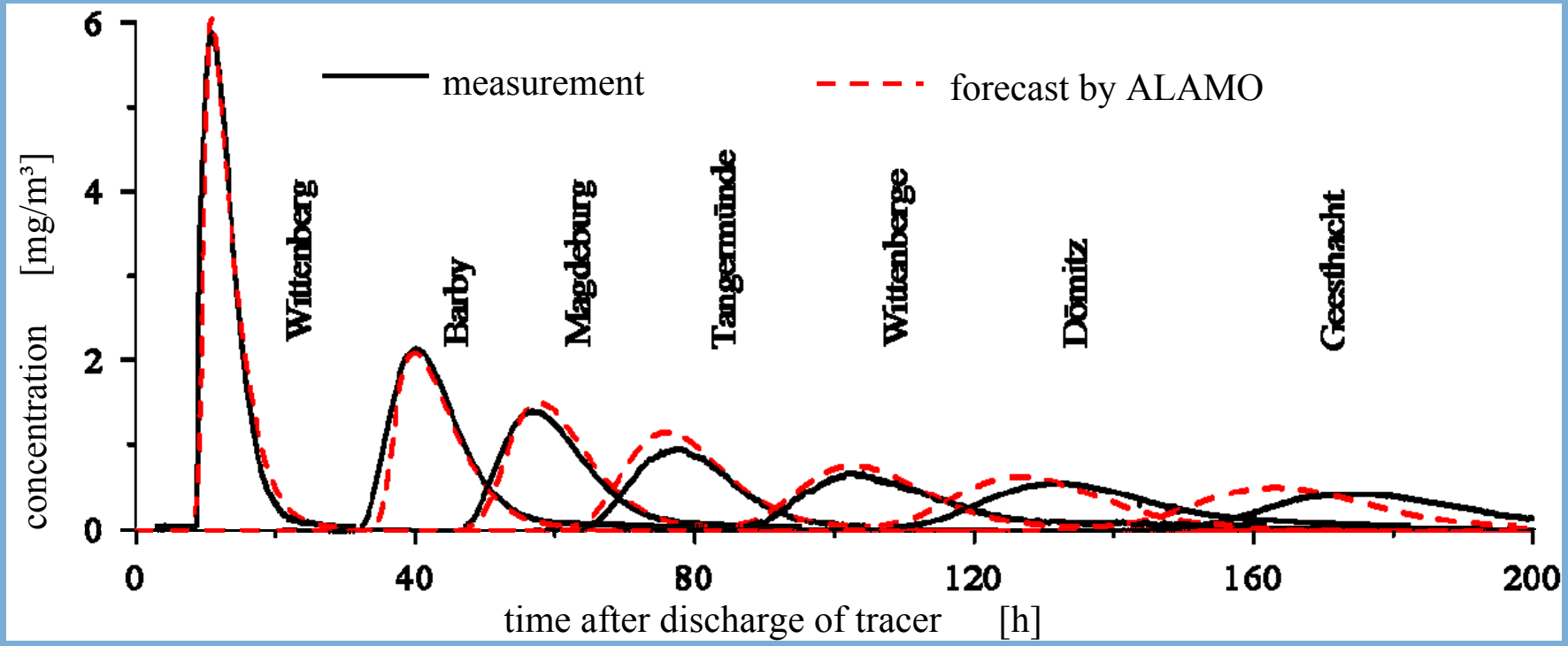
  - end of tracer transit
- maximum concentration of tracer transit
  - in main stream
  - at the river bank

4. Calibration of ALAMO – tracer experiments

comparison of measurement and model

- **good reproduction of the time of travel of the pollutant (± 5%)**
- **good reproduction of maximum concentration of the pollutant**

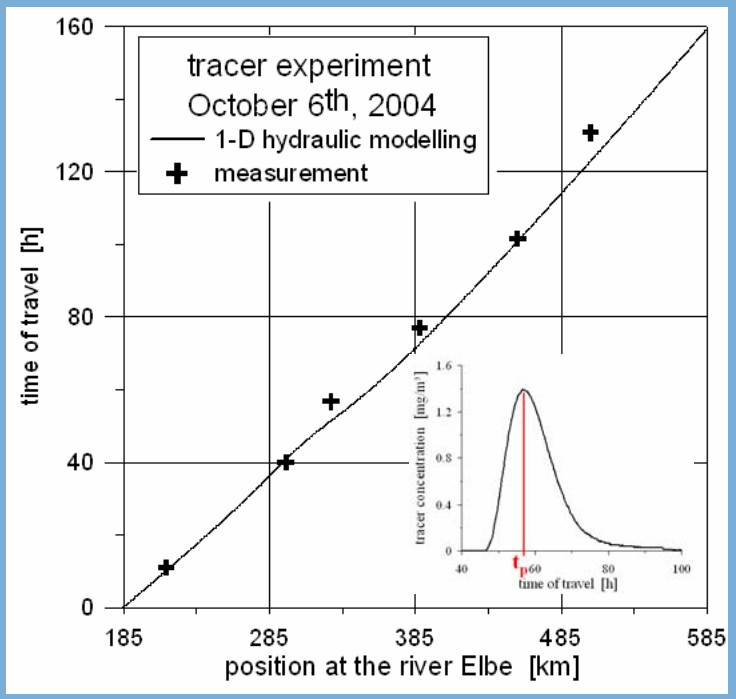




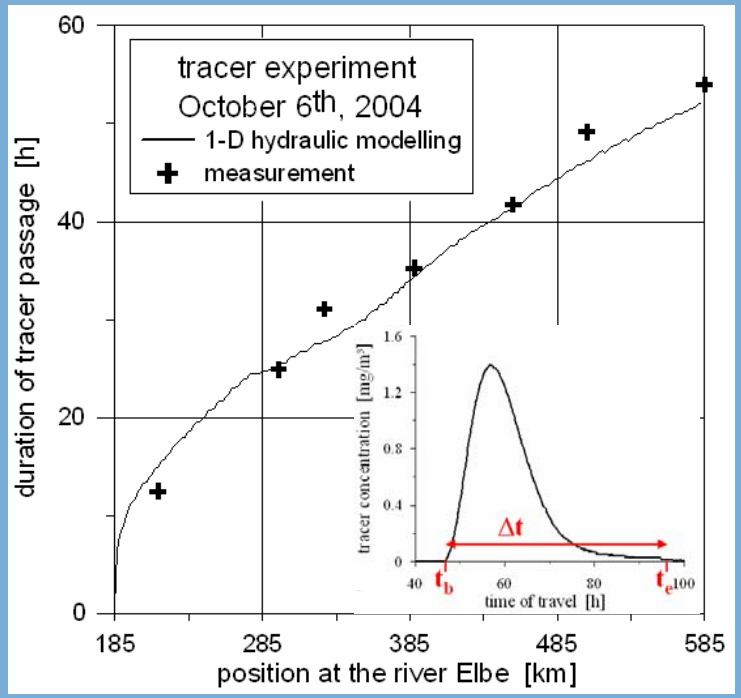
4. Calibration of ALAMO – tracer experiments

comparison of measurement and model – separation of transport processes

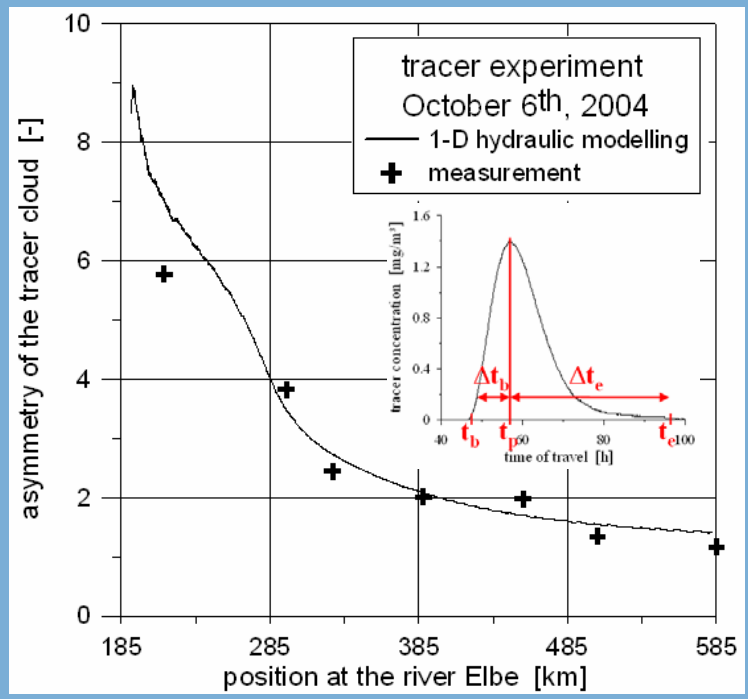
advection



diffusion / dispersion

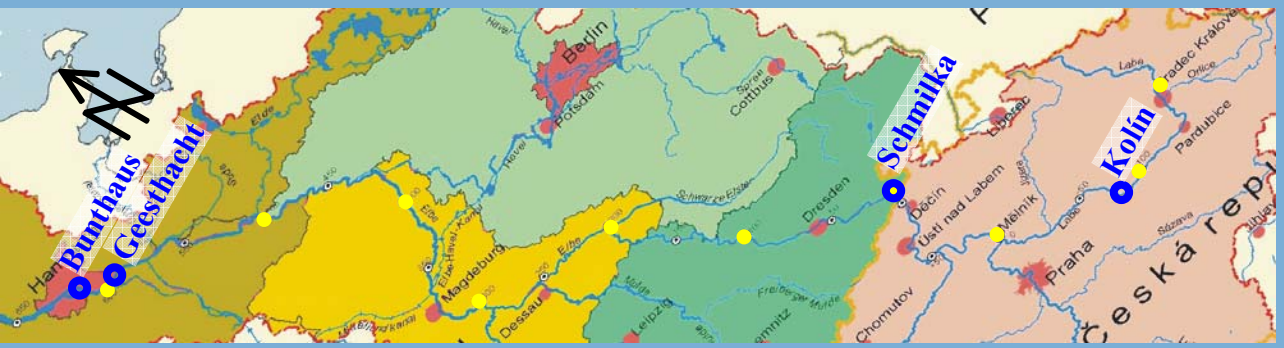


exchange with dead water zones



5. Verification of ALAMO – accidental river pollution

discharge of cyanide into Labe near Nymburk, 2006



➢river pollution

contaminant: cyanide

location: Kolín

time: 09.01.2006

concentration: >500 µg/l

mass: > 100 kg

polluter: LZ Draslovka

first warning: 16.01.2006

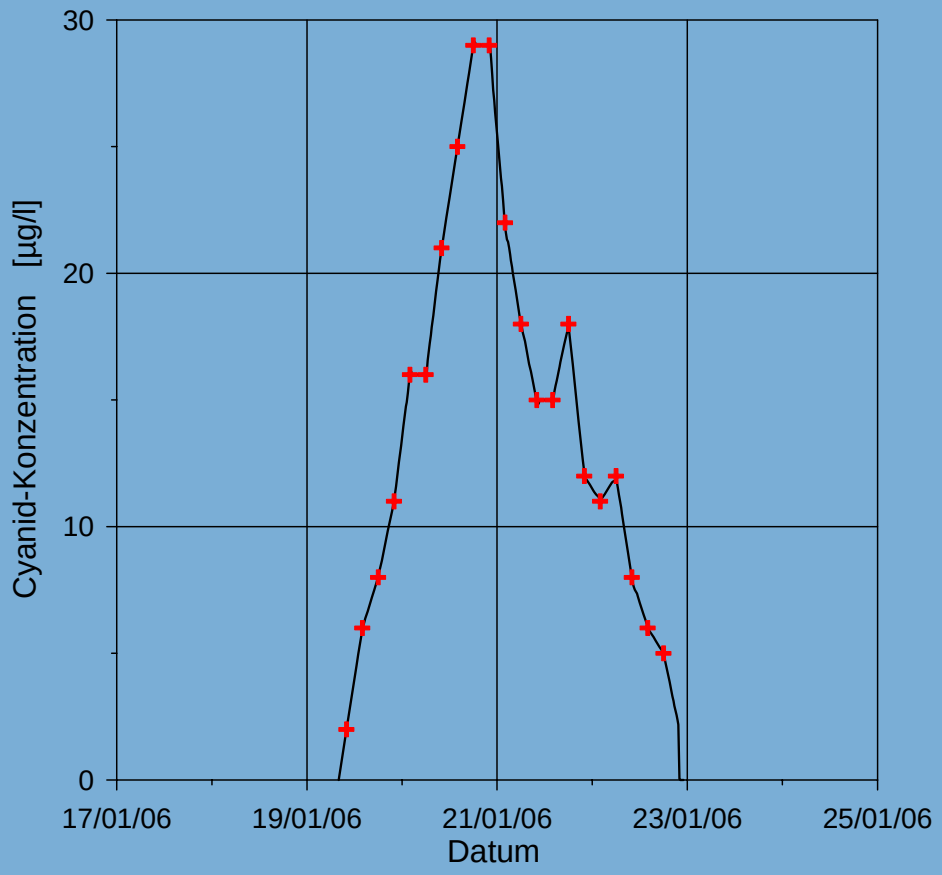
➢problem

no detailed information
on the input of the pollutants

➢solution

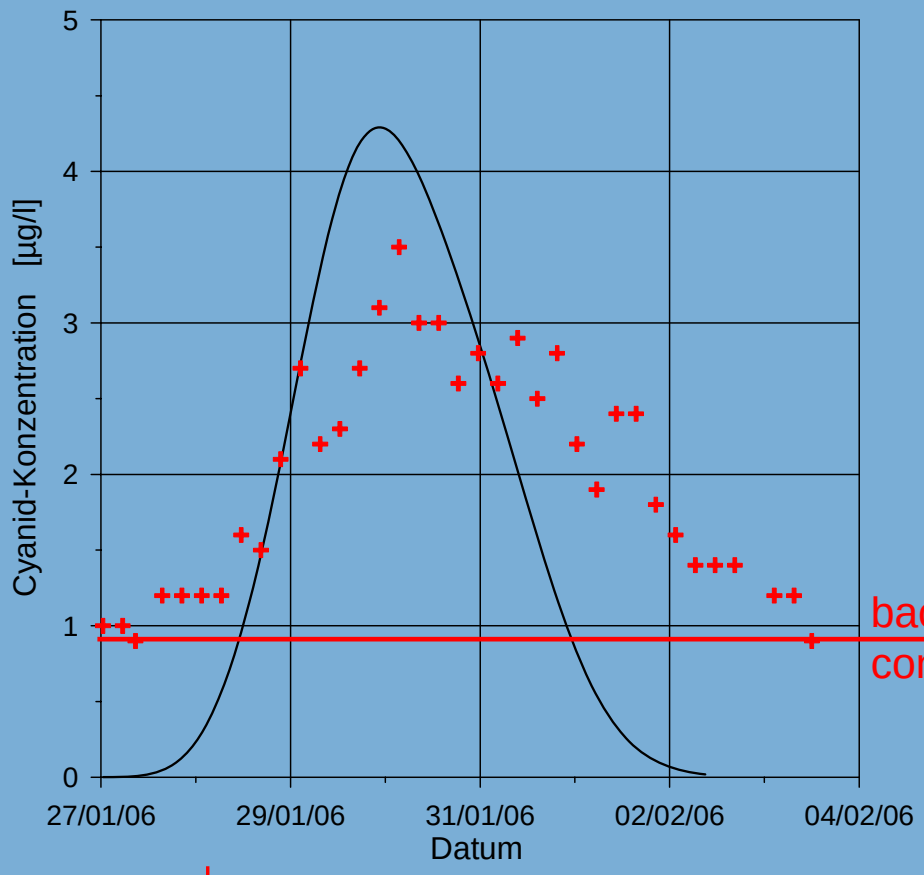
using measurement of cyanide concentration at Schmilka

5. Verification of ALAMO – accidental river pollution



+ measurement (at Schmilka)

——— input concentration for ALAMO (at Schmilka, km 0)



+ measurement [influenced by tides] (at Bunthaus, km 609)

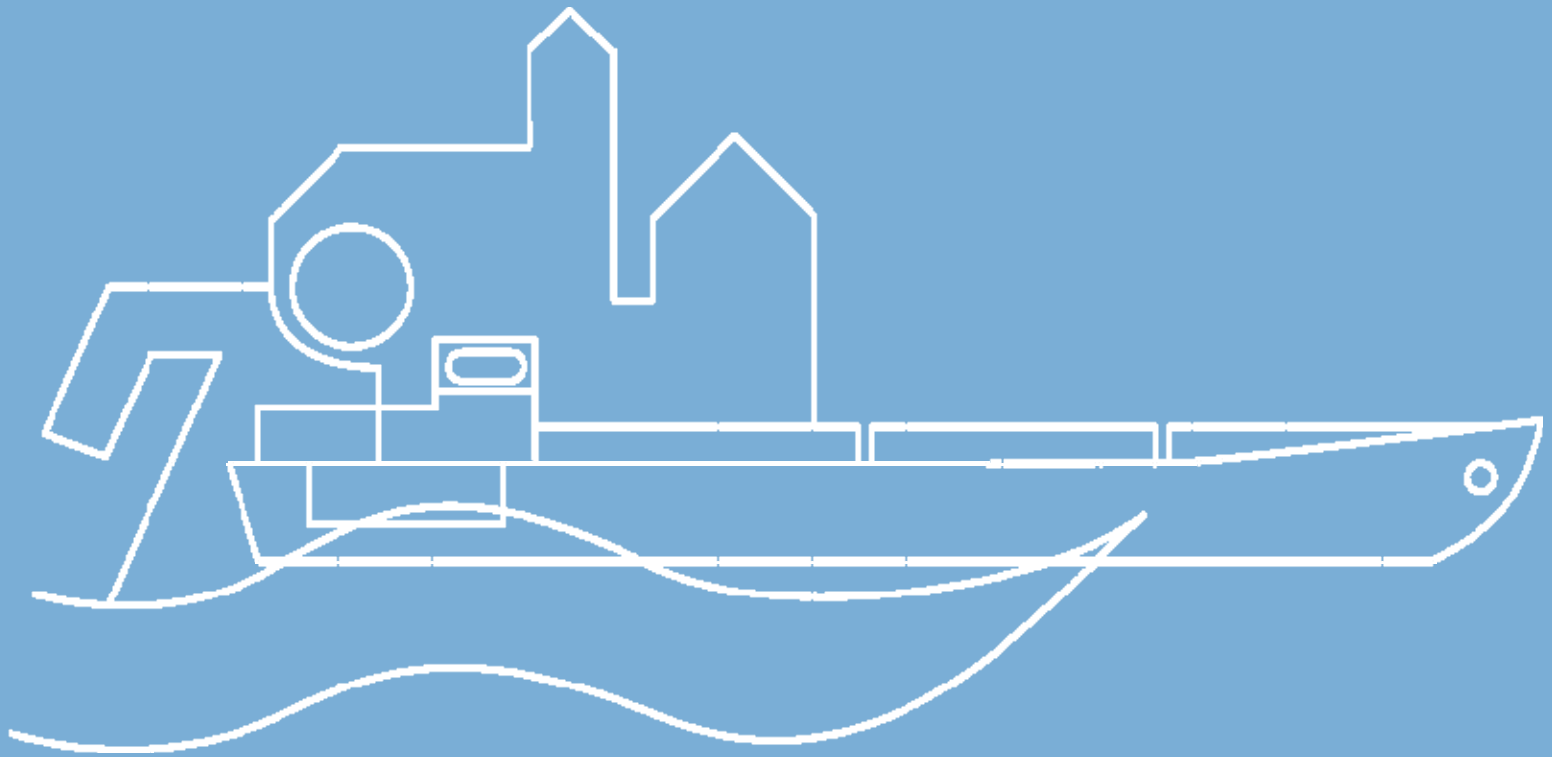
——— forecast of ALAMO (at Geesthacht, km 585)

➢**good reproduction of traveling time**

6. Conclusion and Outlook

- **water framework directive of the EC requires early warning systems for river pollution ► ALAMO**
- **ALAMO is part of the warning and alarming plan for the river Elbe**
- **ALAMO is applicable for the whole river Elbe – the German part and the Czech part as well.**
- **ALAMO is operated by four alarm control units, each responsible for a river section of about 200 km.**
- **ALAMO gives a prognosis of the contaminant transport,** i.e. time of travel, maximum concentration of the contaminant cloud
- **ALAMO is essential for the planning of cross-border measures against river pollution.**

- **future development of ALAMO: inclusion of tributaries into the contaminant transport model (esp. Saale, Moldau)**



Thank you for your attention

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