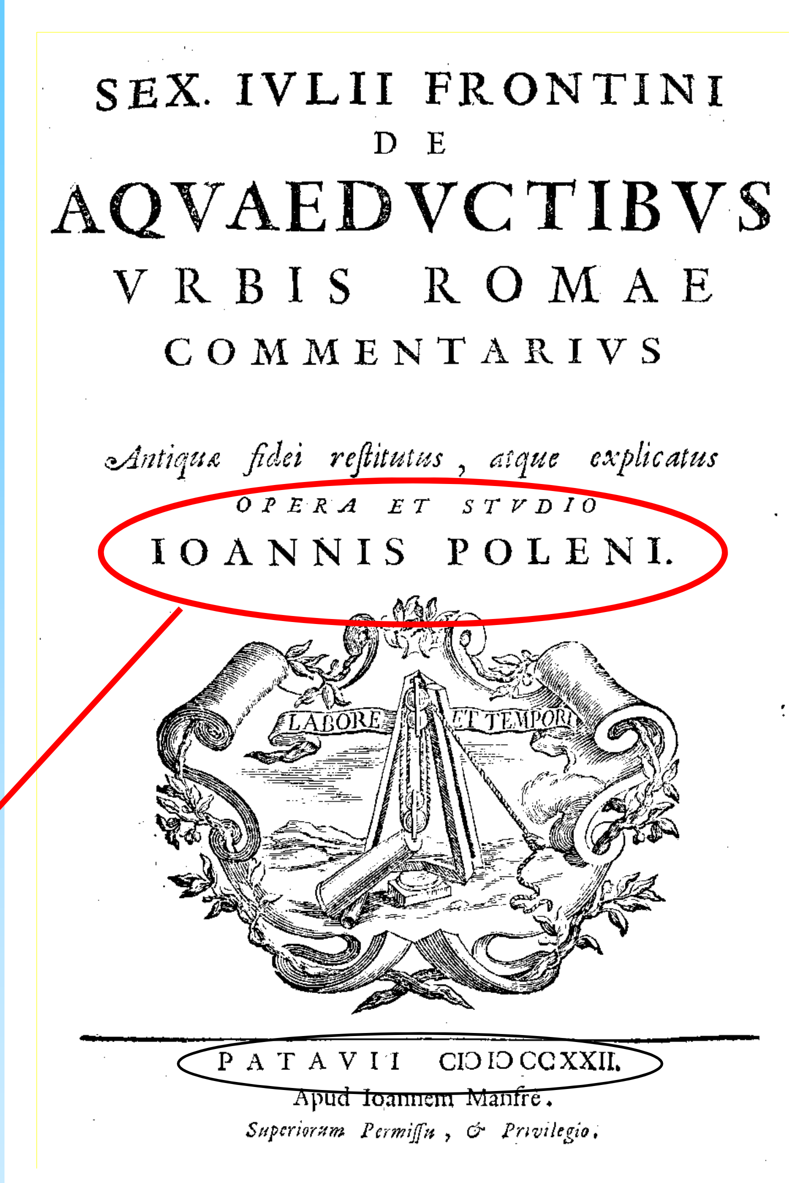
Stadtentwässerung in Deutschland

Geschichte, Statistik, Regenwasserbehandlung, Entwurf und Bemessung von Regenbecken, Technische Ausrüstung

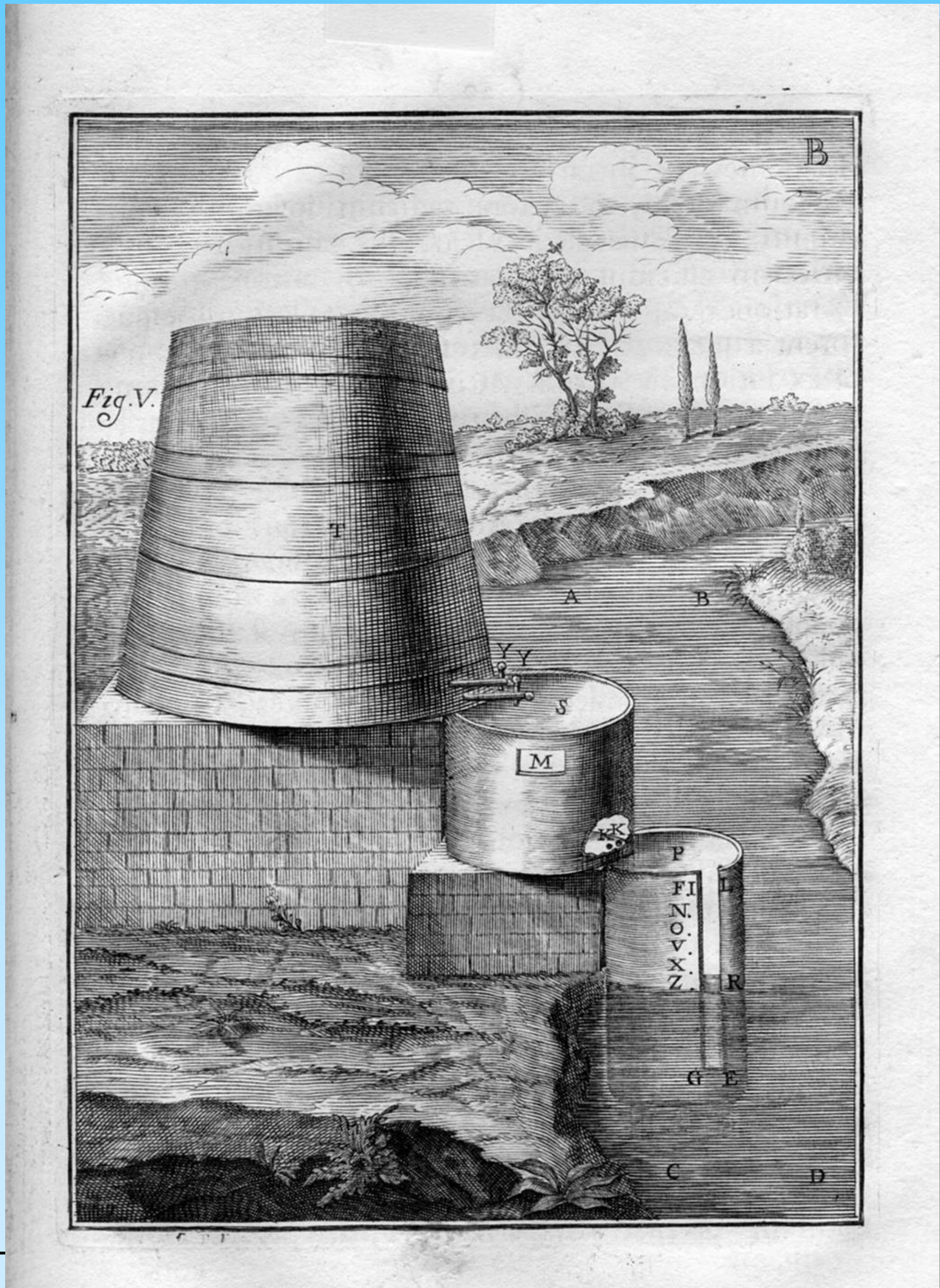
Prof. Dr.-Ing. habil. Hansjörg Brombach,
Bad Mergentheim, Deutschland

VORTRAGSREIHE DONNERSTAG 17 UHR
22. Januar 2009, PORR Hörsaal
Fakultät für Bauingenieur-Wissenschaften
Österreichischer Ingenieur- und Architektenverein
Technische Universität Graz
ÖSTERREICH

Sextus Iulius Frontini
*40 ✝103
De Aquaeductibus
Urbis Romae



Worked over and comments from Ioannis Poleni, 1722



Experiments from Ioannis Poleni

Ord. Prof. et Scient. Societatum Regalium

Motu Aquae Mixtro

Patavii 1717

Universität Stuttgart
Zentrum für Infrastruktur Planung
University of Stuttgart
Centre for Infrastructure Planning

Hansjörg Brombach
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Von-Berlichingen-Str. 21
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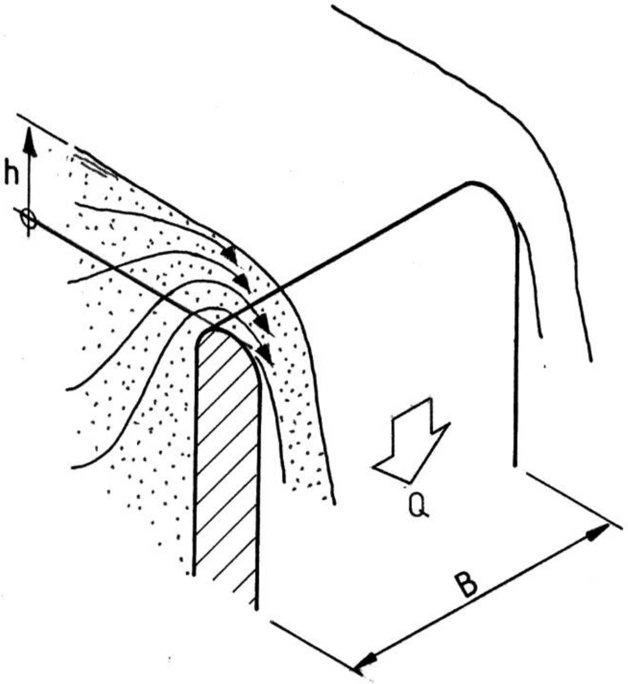
Poleni's Law

Flow over Weirs



Marchese Giovanni Poleni (1683–1761)

$$Q_{ü} = \mu \frac{2}{3} B \cdot \sqrt{2g} \cdot h^{3/2}$$

h = overflow height in m
B = width in m
g = gravity in 9.81 m/s^2
Q = volume flow in m^3/s
μ = flow coefficient, dimless

Max von Pettenkofer 1818 – 1901

Foto: München

Brombach

Erster deutscher Professor für Hygiene, München verdankt Pettenkofer die Kanalisation.

Stritt sich mit Robert Koch über die Ursache von Cholera, er und seine Studenten schluckten zum Gegenbeweis Cholera-Bakerien – und starben nicht!

Robert Koch 1843 – 1910

Foto: WIKIPEDIA

Nobelpreisträger (1905)

Entdecker des Milzbrand- (1876), Tuberkulose- (1882) und Cholera-Bakteriums (1884)

William Lindley

(1808-1900)

Planungsarbeiten Eisenbahn, Wasserversorgung und Kanalisation, später mit seinen Söhnen, für:

Wien 1849 - 1895

Hamburg 1833 – 1859

Frankfurt 1865 – 1897

Düsseldorf 1868 – 1882

Königsberg 1887

London 1830 – 1853

Prag 1892 – 1909

Warschau 1876 – 1896

Würzburg 1897 – 1905

Hanau 1888 - 1911

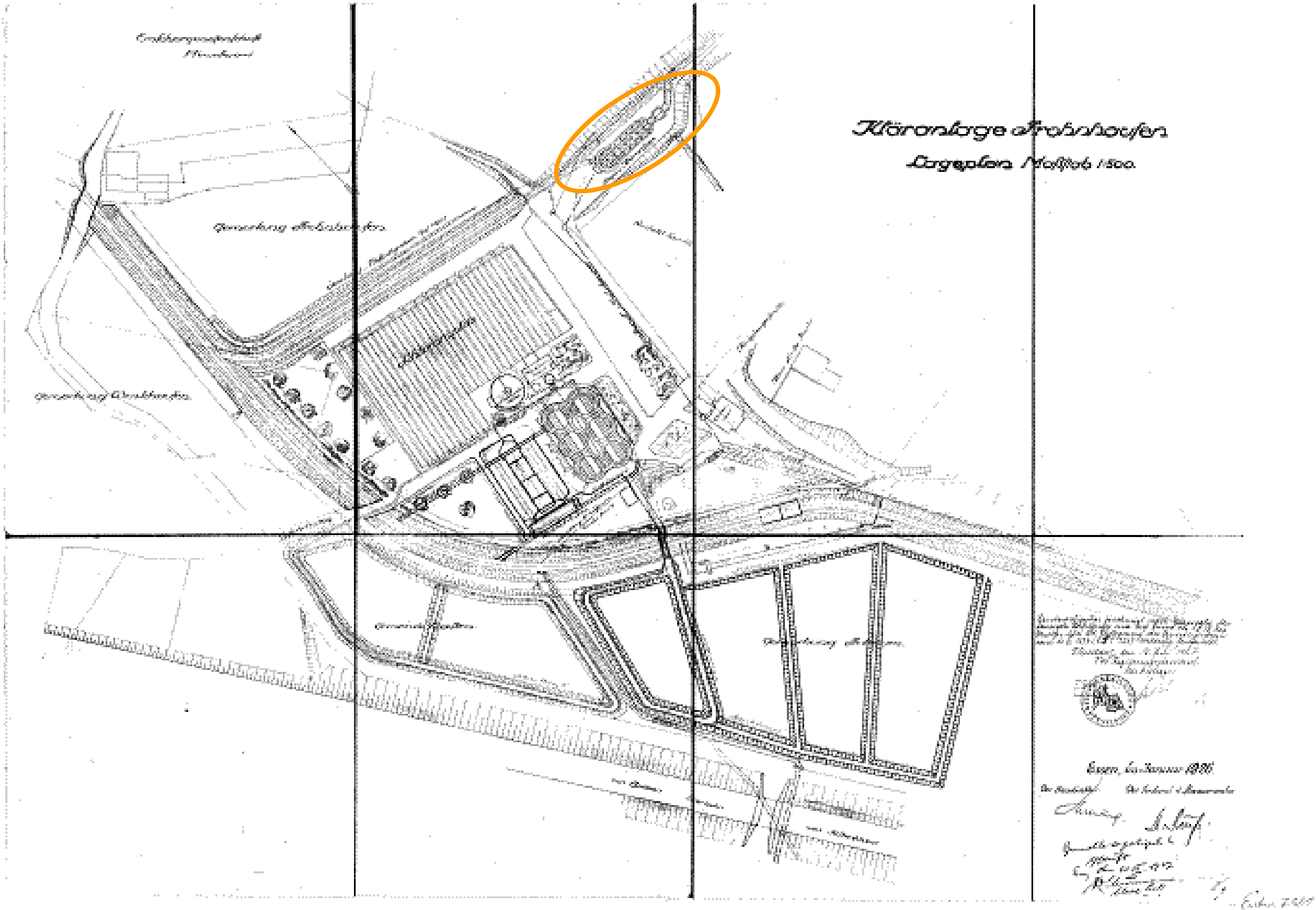
Bukarest 1885 – 1896

u.v.a.m.!!!

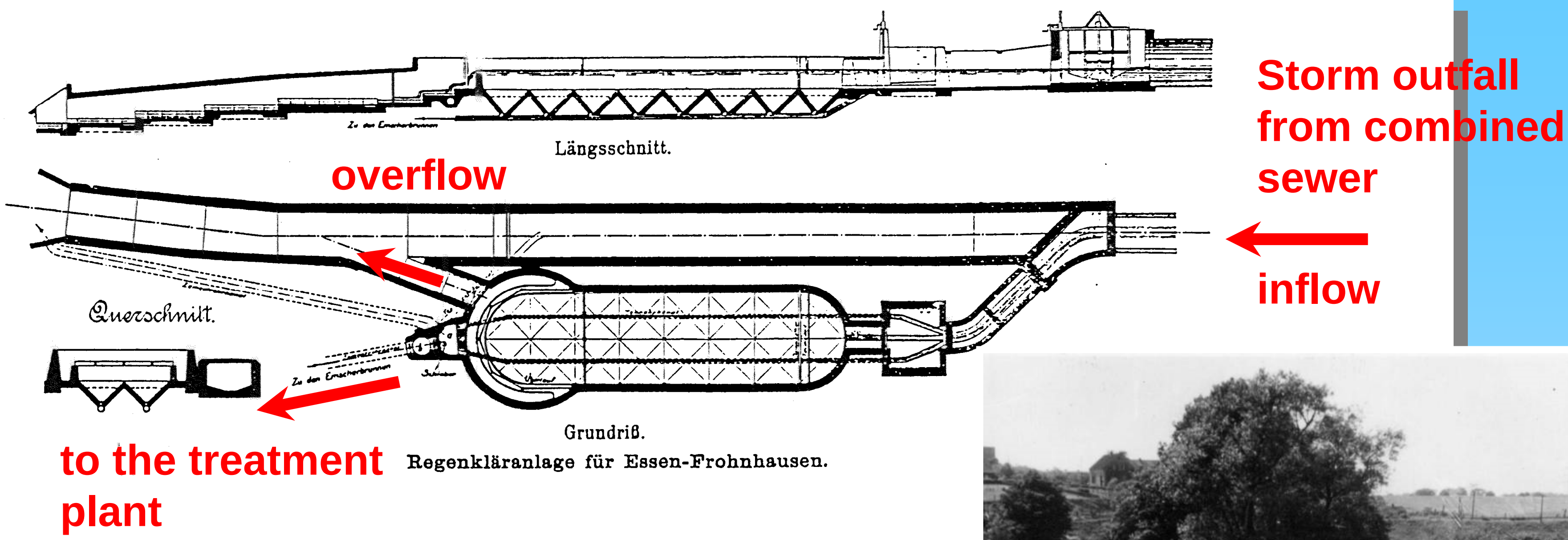
Brombach besucht seinen Freund Lindley am Denkmal im Hamburger Hafen, 2006

Gordon M. Fair and Karl Imhoff (1876-1965)

Erstes Regenüberlaufbecken der Welt? Essen - Frohnhausen



Zeichnung des Ruhrverbandes von 1926



First CSO tank in Germany, built 1913

Essen-Frohnhausen (Engberding 1915), off-line tank with clarifier overflow

Bad Mergentheim Seat of our company

Graz

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000

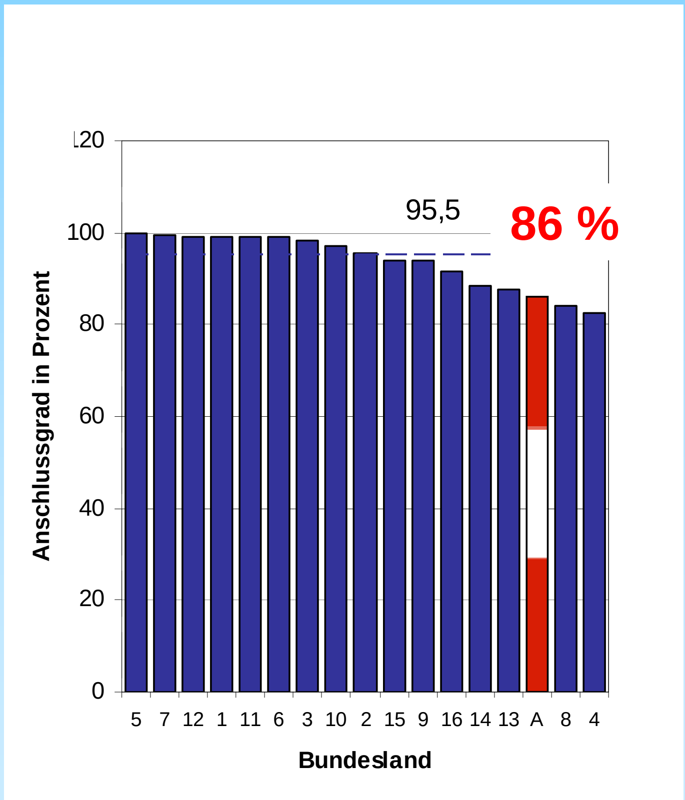
„Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such.“

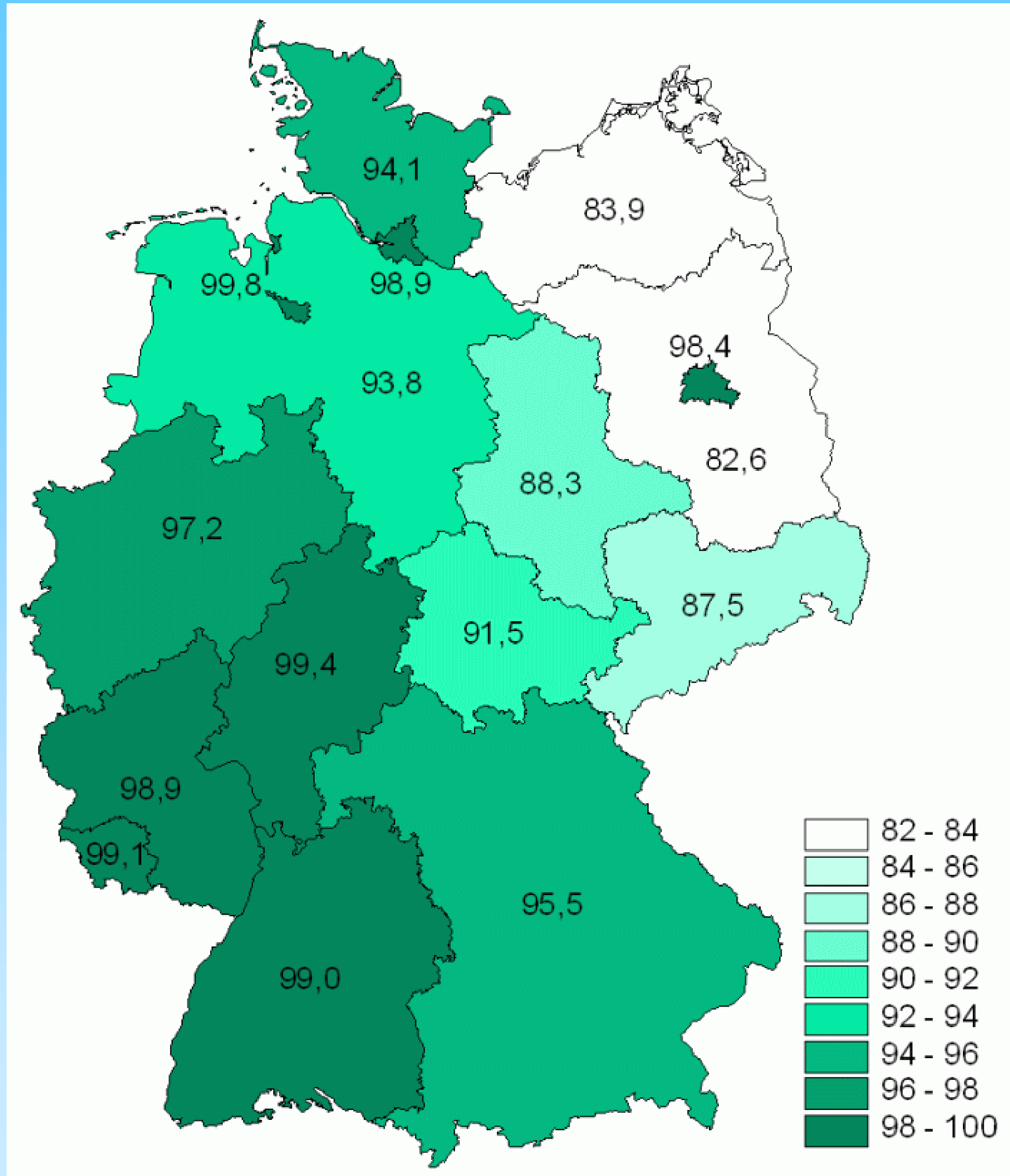
„Wasser ist kein übliches Handelsgut, sondern ein ererbtes Gut, das geschützt, verteidigt und entsprechend behandelt werden muss“

Statistische Vergleichszahlen zur Kanalisation in ausgewählten Ländern

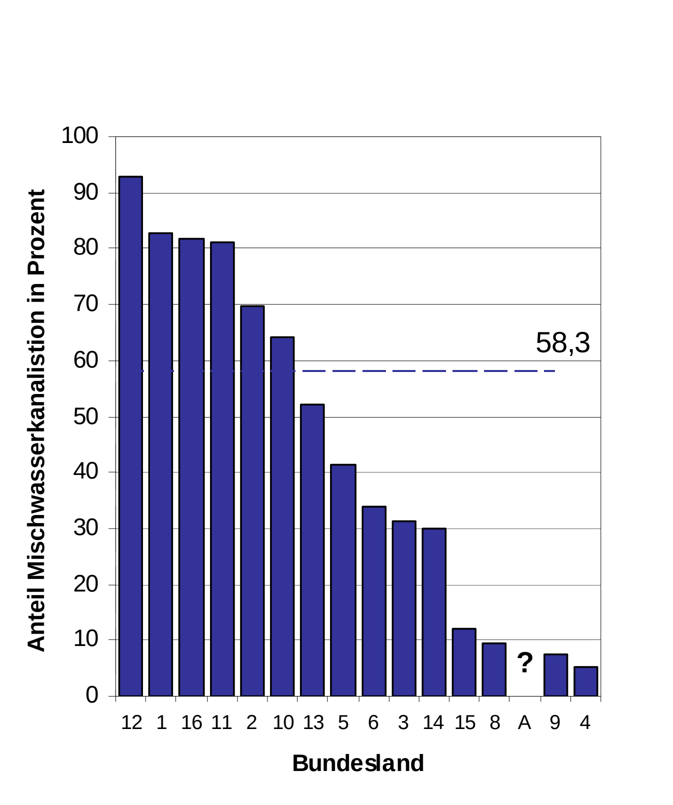
Country	Total area in 1000 km^2 °	Population in million people °	Average population density in heads/km^2 °	Connection to public sewers in % of population	Connection to public WWTP in % of population	Connection to combined sewerage in % of population
Netherlands	42	17	484	99	88	85
Belgium	31	11	345	60	46	70
United Kindom	245	61	246	98	82	70
Germany**	357	82	230	98,6	94,2	58,3
Italy §§§	301	59	196	95	89	
Luxembourg***	2,6	0,5	187	96	91	> 90
Switzerland §§§§	41	7,6	184	96,7	97	85
Denmark §§	43	5,5	129	94	92	49,1
Poland	312	38	122	59	58	23
Austria	84	8	99	86	86	> 50 ?
Spain	505	46	91	100	60	88
France	544	62	88	97	73	45
Morocco	447	32	67	?	?	?
Tunesia	164	10	61	?	?	?
USA*	9.826	304	31	70	70	15
Algeria	2.381	(32) 34,8	14	86	< 10	73
Norway ****	385	4,8	12	81	76	40 §
Lybia	1.776	6,2	3,3	?	?	?

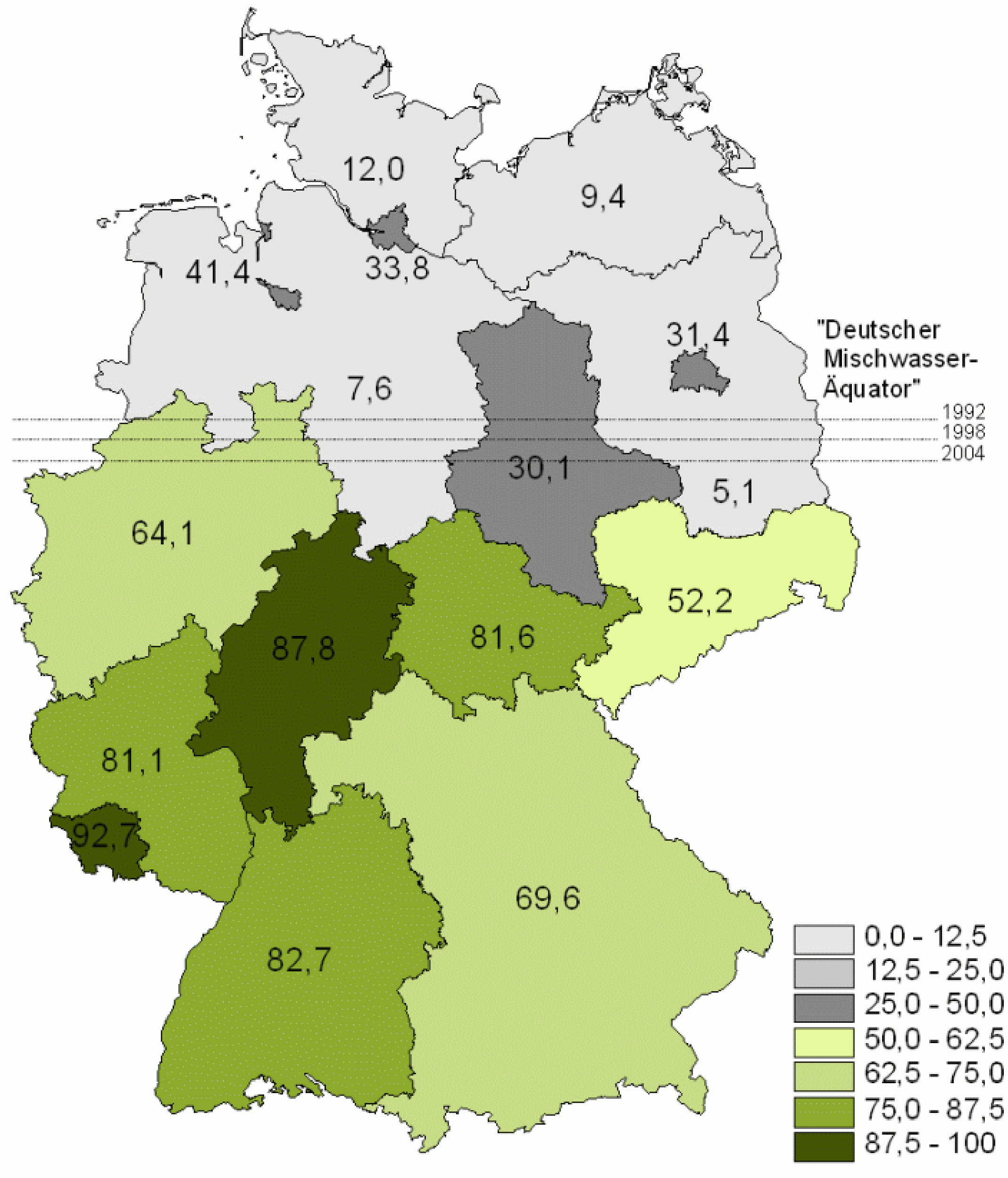
Share of people connected to public collection system in %



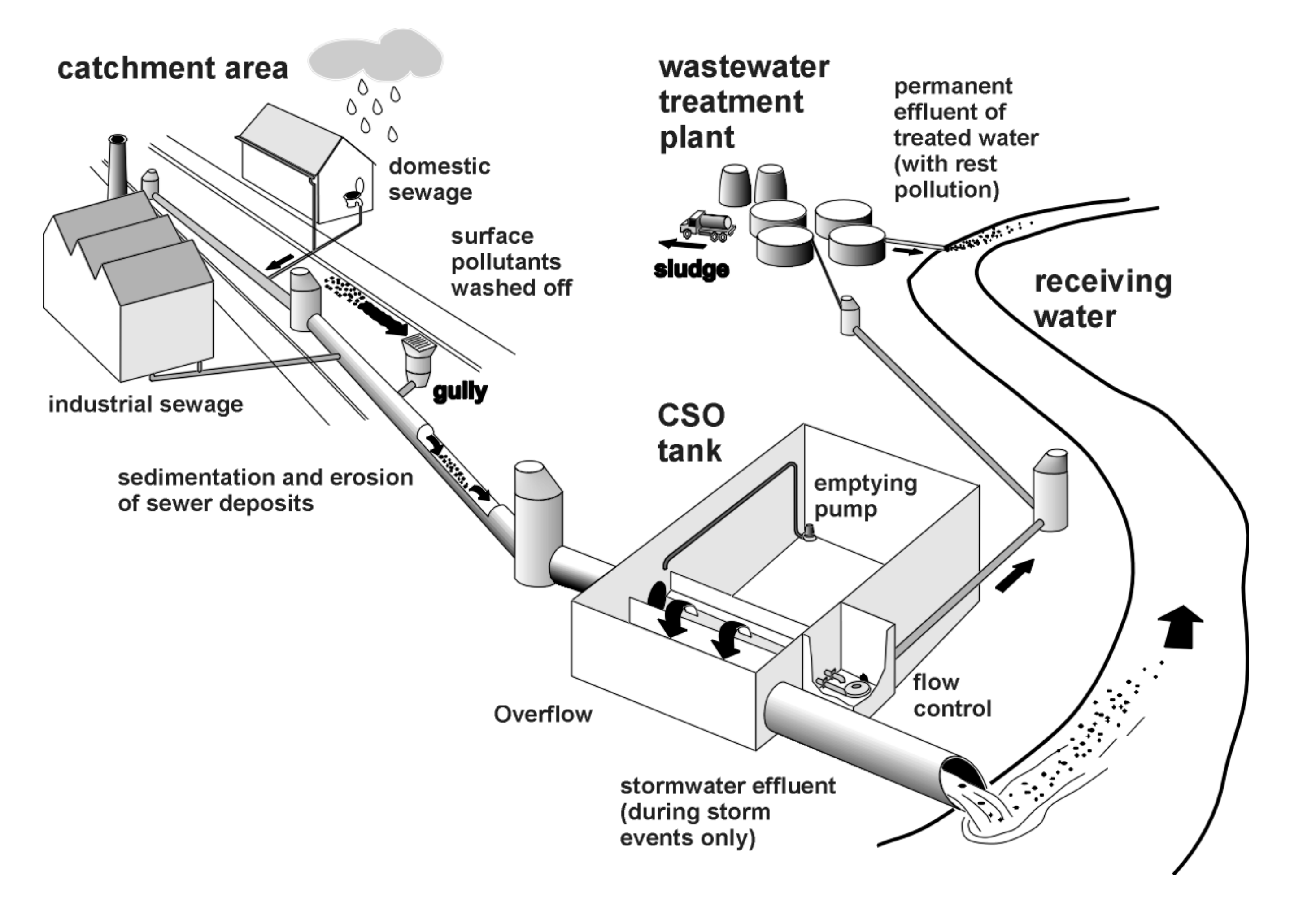


Connection to combined sewerage in % of population





Typical Combined Sewer System

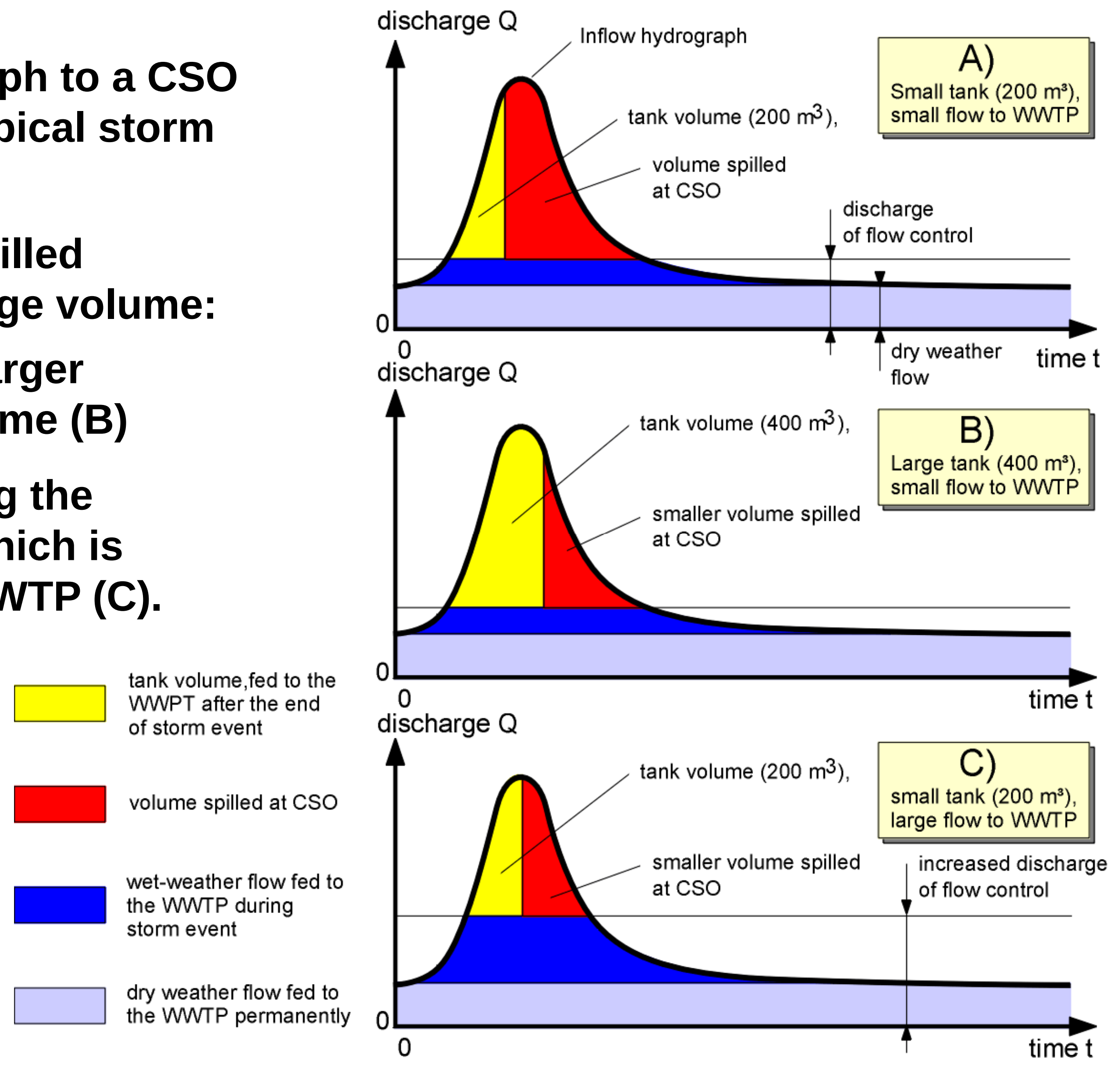


Inflow hydrograph to a CSO tank due to a typical storm event.

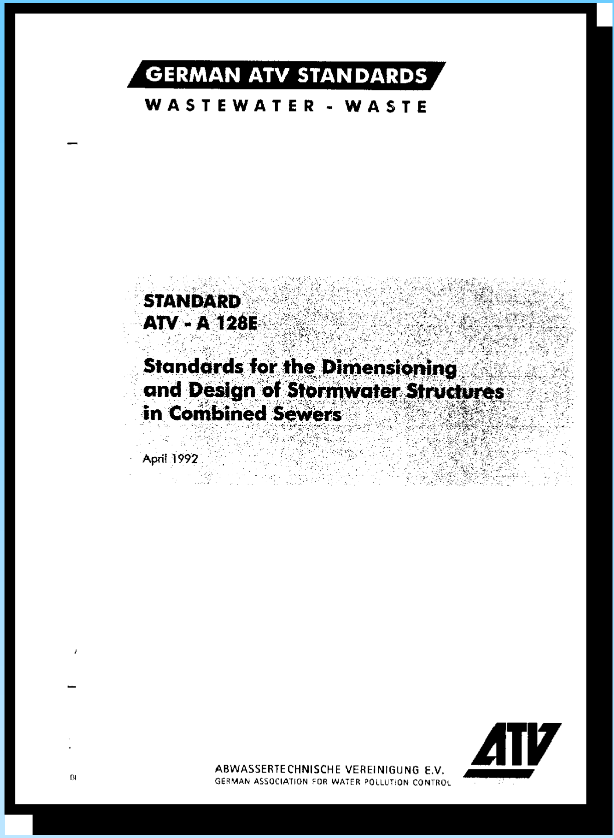
Reduction of spilled combined sewage volume:

- **by using a larger storage volume (B)**
- **by increasing the discharge which is fed to the WWTP (C).**

Effect of in-sewer storage



ATV-A 128 (1992): German Standard for Dimensioning of CSO-tanks (Combined Sewer Overflow Tanks, Regenüberlaufbecken)


GERMAN ATV STANDARDS
WASTEWATER - WASTE

STANDARD
ATV - A 128E

Standards for the Dimensioning and Design of Stormwater Structures in Combined Sewers

April 1992

ATV
ABWASSERTECHNISCHE VEREINIGUNG E.V.
GERMAN ASSOCIATION FOR WATER POLLUTION CONTROL

- „cooking recipe“ yields necessary CSO tank volume
- Typical: Tanks of specific volume of
- 20 ... 30 m³/ha,
- small flow to WWTP of 2 to 4 times DWF

Some other German Standards for CSO tanks:

ATV-A 166 (1999)
ATV-M 176 (2001)
ATV-M 177 (2001)
ATV-A 198 (2003)

WASSER ÖWAV ABFALL

REGELWERK

UFT
30. JAN. 2008
Gesehen:
Weiter an:
EINGANG
Bad Mergentheim

■ REGELBLÄTTER

des Österreichischen Wasser- und Abfallwirtschaftsverbandes (ÖWAV)

ÖWAV-Regelblatt 19

Richtlinien für die Bemessung von Mischwasserentlastungen

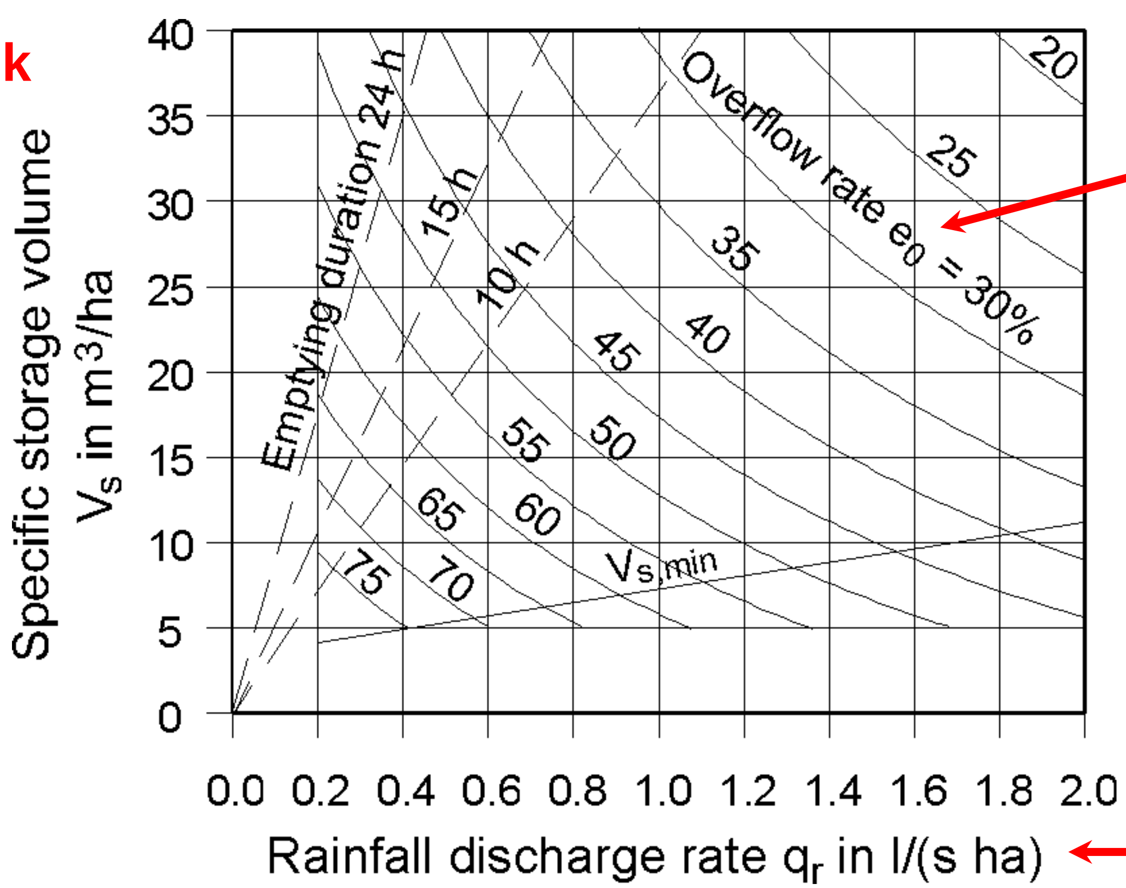
2., vollständig überarbeitete Auflage

Wien 2007

In Kommission bei:
ON Österreichisches Normungsinstitut
A-1020 Wien, Heinestraße 38

Interdependence of storage volume and wet-weather CSO tank outflow (from A 128)

Necessary specific CSO tank volume



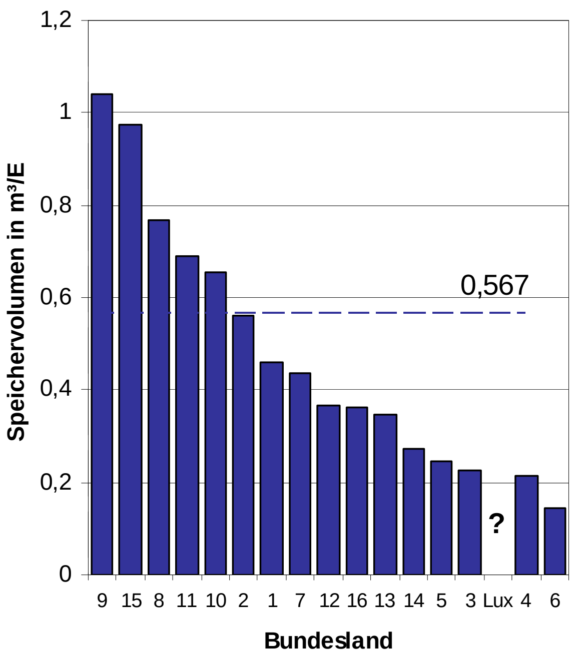
Permissible longterm percentage of stormwater to be spilled into the receiving waters

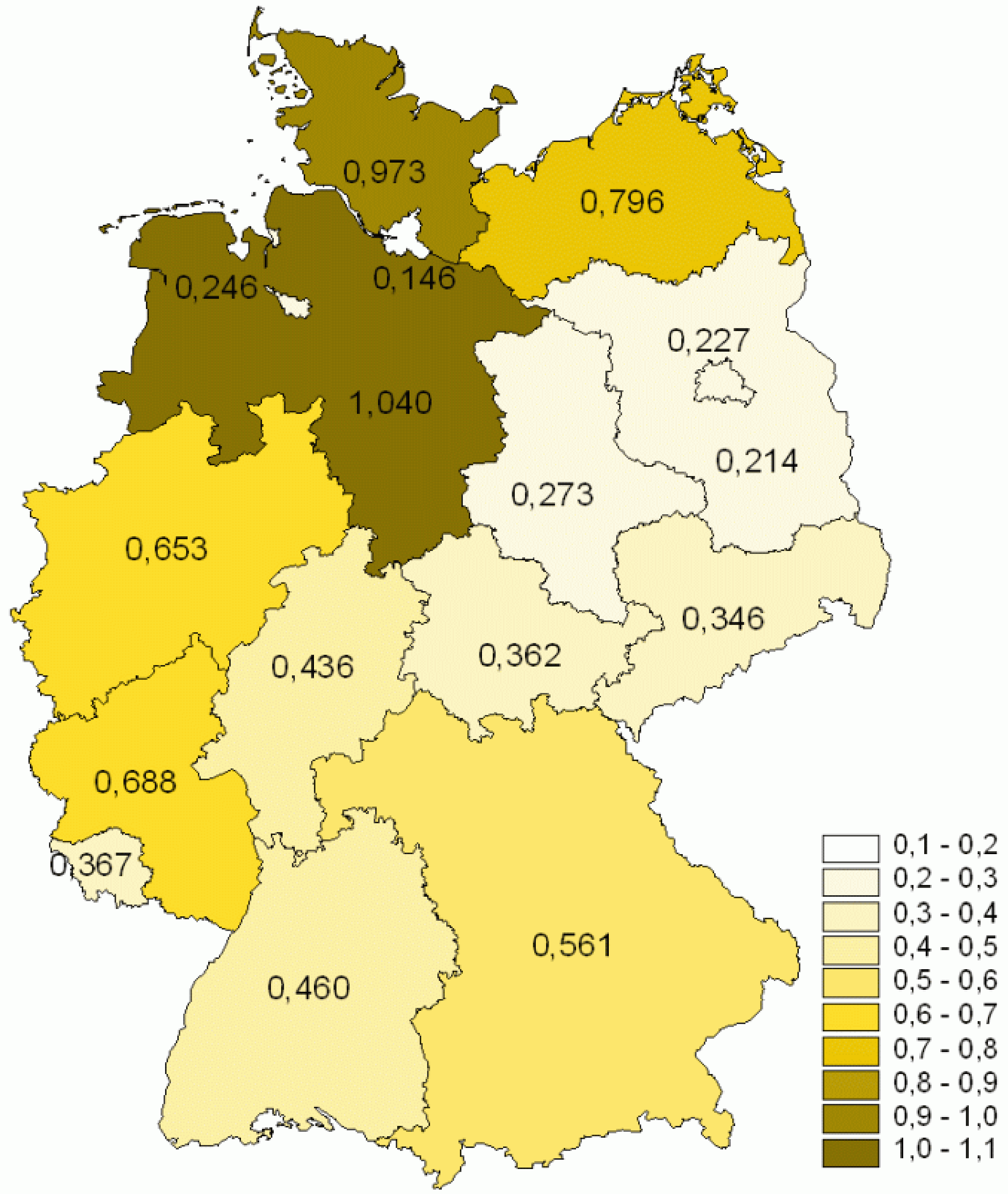
Dependent on outflow control setting

Tabelle 2: In Betrieb befindliche Regenwasserbehandlungsanlagen in Deutschland, auf der Grundlage der Erhebungen des Statistischen Bundesamtes, Stand Jahresende 2004

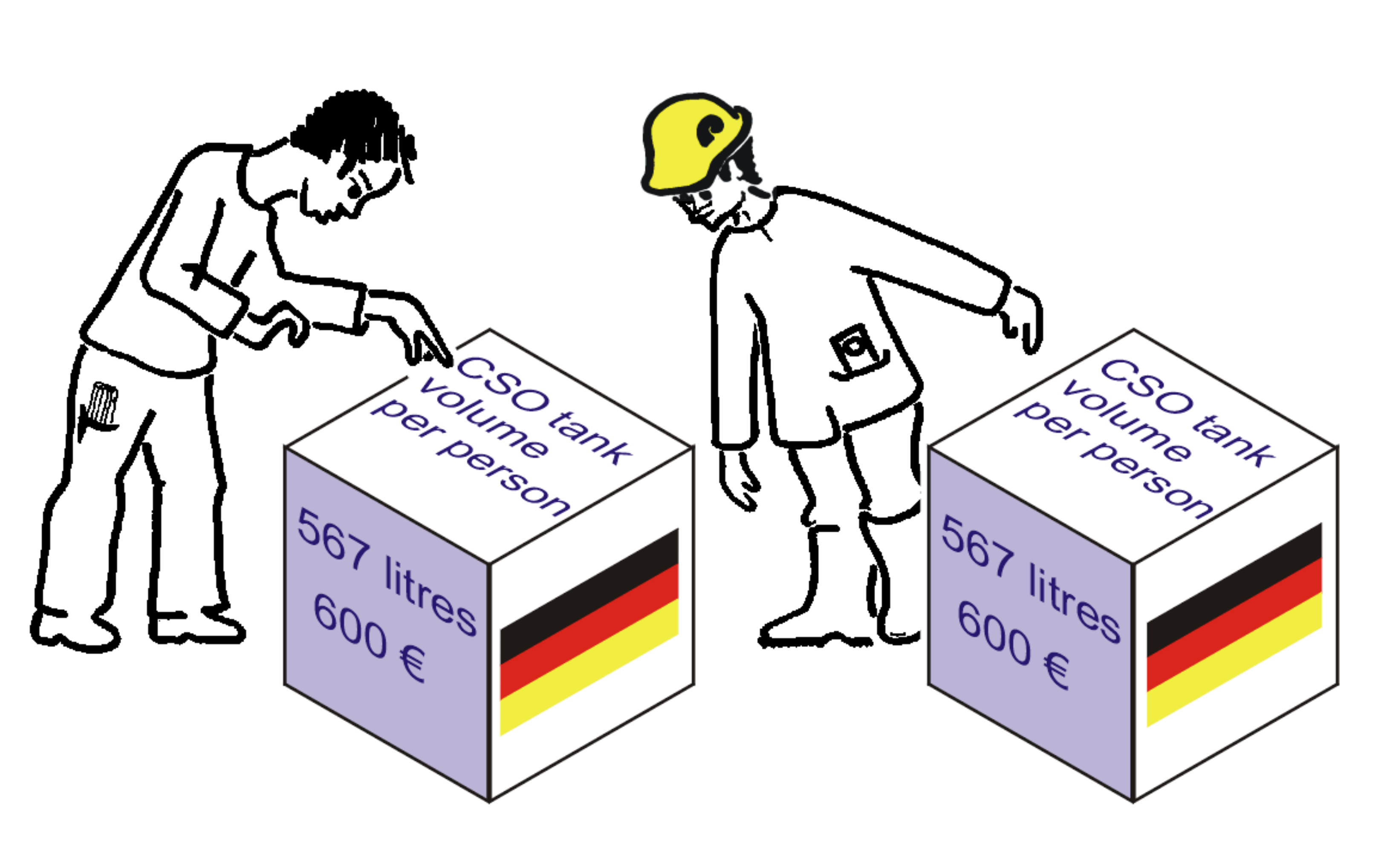
Typ Regenwasser-behandlungsanlage	Stück	Volumen in 1000 m^3	durchschnitt-liche Größe	Ausbau-grad in %
Kläranlagen, KA	**9.444**	-	**8.266** Einwohner pro Anlage	**94,2**
Regenüberlaufbecken und Stauraumkanäle im Mischsystem, RÜB und SK, MS	**23.311**	**14.938**	**641** m^3/pro Becken	**71?**
Regenrückhalteanlagen im Misch- und Trennsystem, RRA, MS+TS	**15.408**	**29.223**	**1.897** m^3/pro Becken	**?**
Regenklärbecken im Trennsystem, RKB, TS	**2.850**	**2.592**	**909** m^3/pro Becken	**?**
Regenüberläufe im Mischsystem, RÜ, MS	**21.454**	**0**	**0**	**?**
Summe	**72.467**	**46.753**		**?**

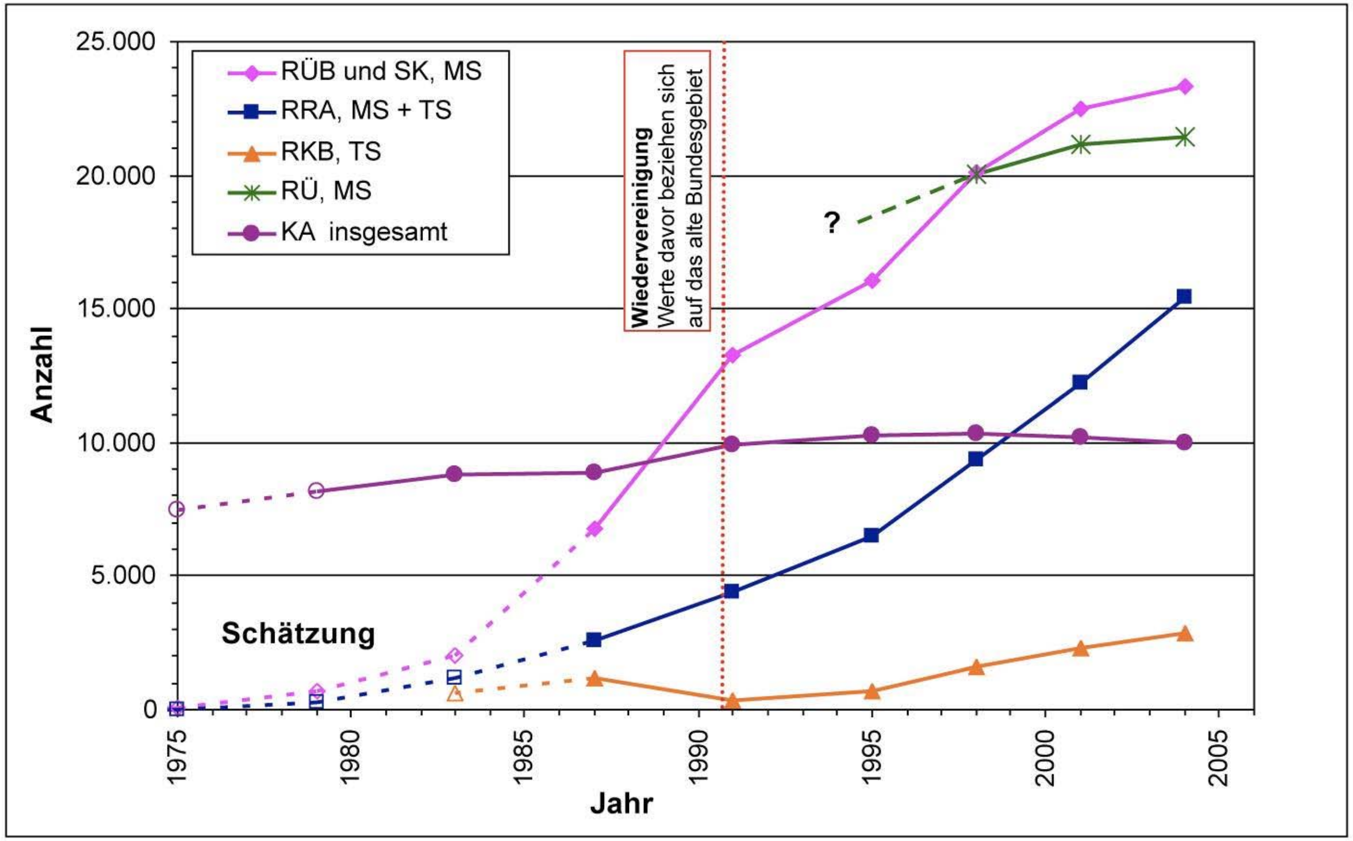
Existing additional storm-water storage volume in the public collection system of Germany in m³ per head, status 2004





Two Germans inspecting their average extra sewer storm storage volume in public sewers

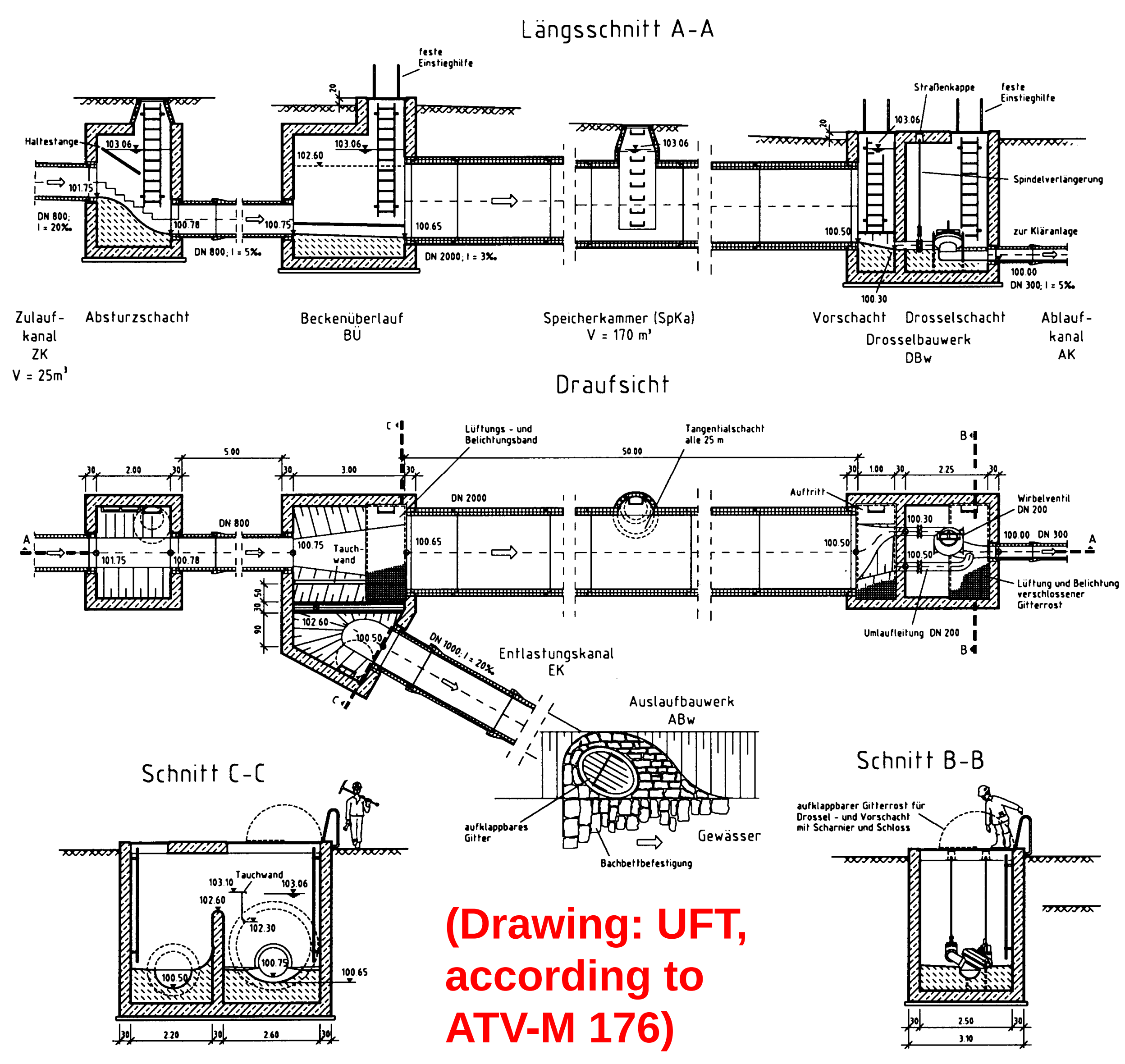




Status 2004:
Summe aller Regenbecken: 41.569 Stück
Gesamtvolumen: 46,7 Mio m³
mittleres Speichervolumen pro Kopf der Bevölkerung: 567 Liter/Einwohner

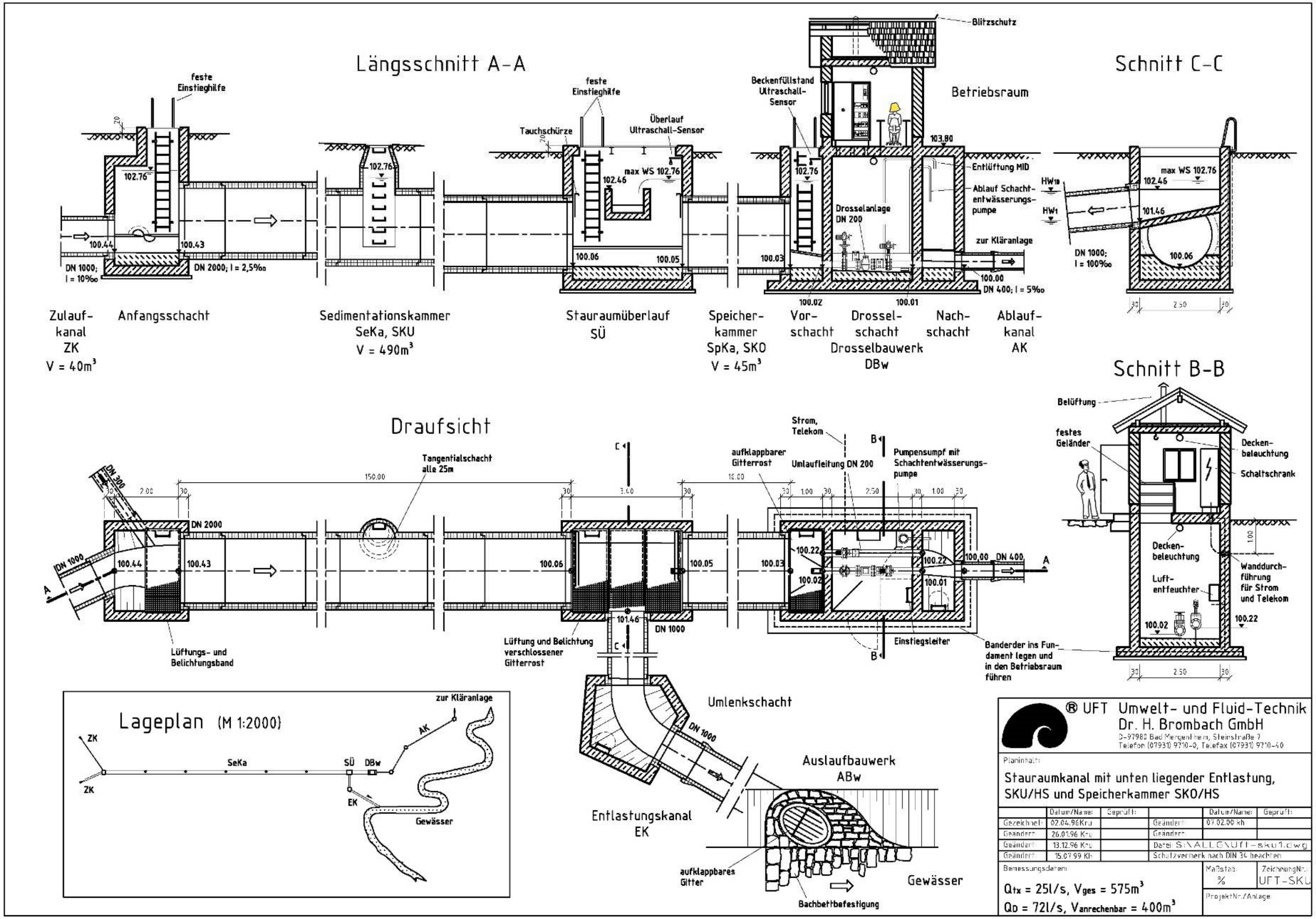
CSO Tank Designs

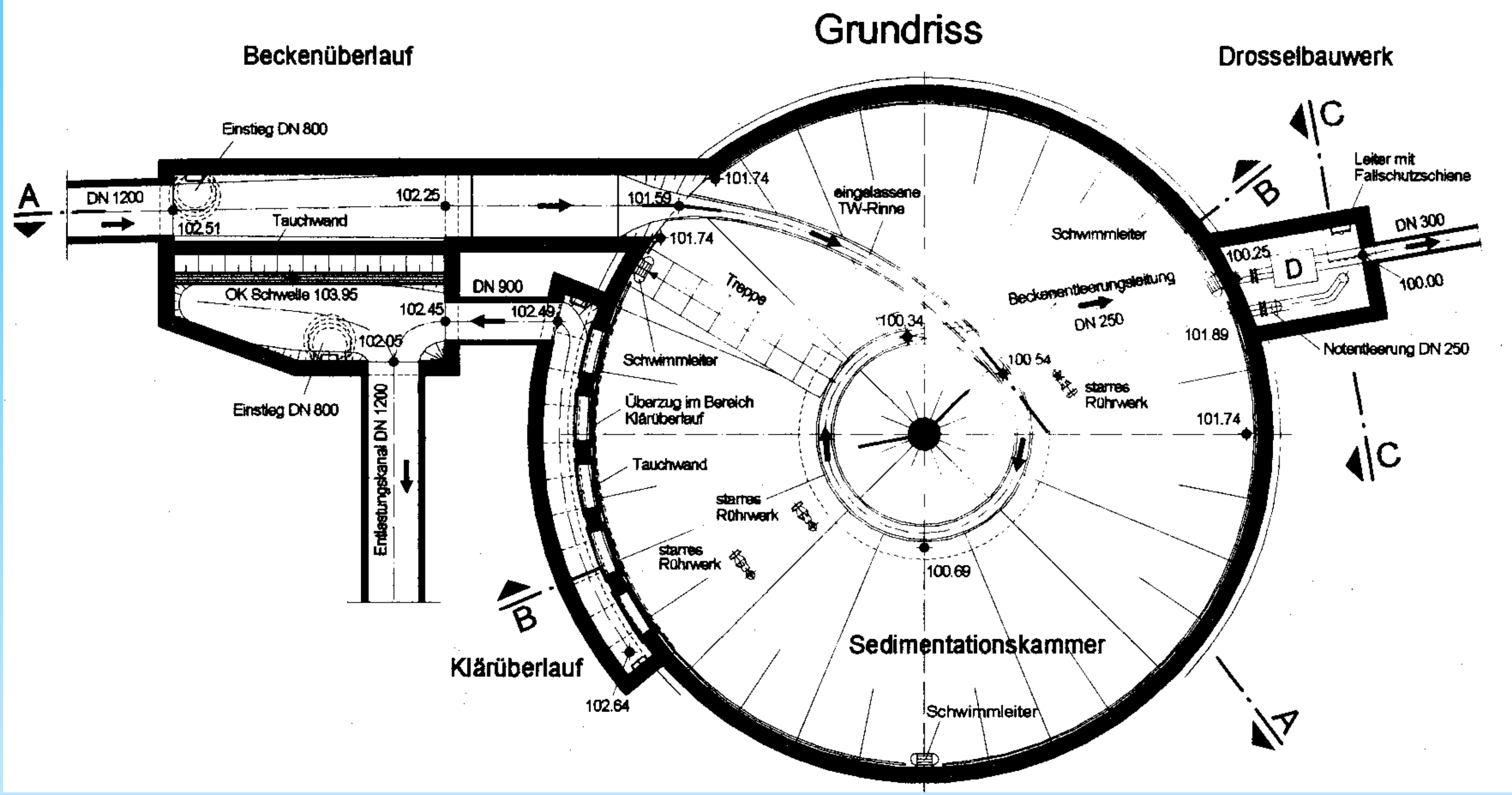
First-flush CSO tank with upstream overflow, arranged in-line, storage in an oversized sewer, storage volume 170 m³



(Drawing: UFT, according to ATV-M 176)

Kanalstauraum mit untenliegender Entlastung nach DWA-M 176





CSO tank designs

In-line circular CSO tank with upstream overflow and clarifier overflow, storage volume 500 m³

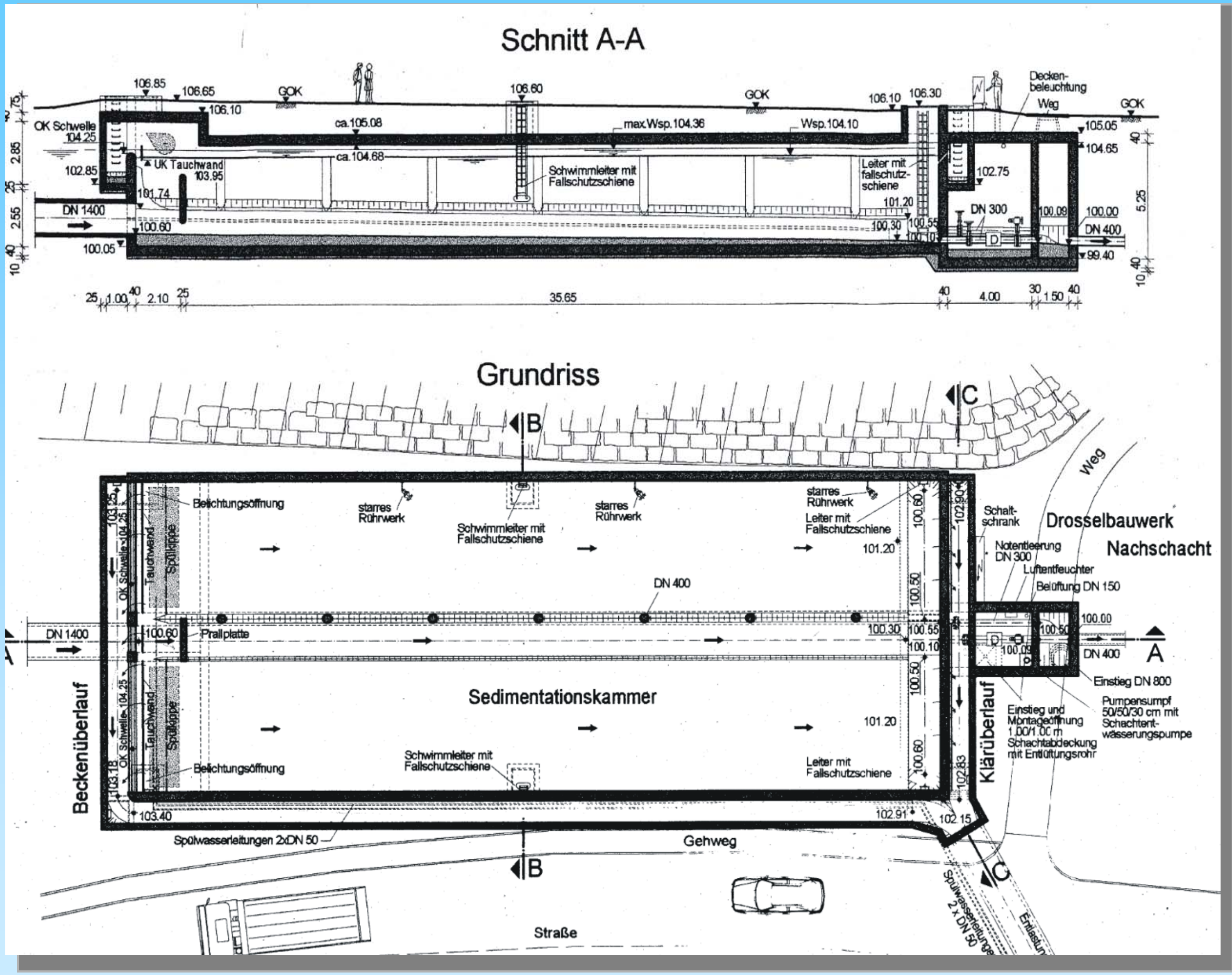
(Drawing: ATV-M 176)

Open circular CSO tank

CSO Tank Designs

On-line rectangular CSO tank with clarifier overflow, storage volume 1.400 m³

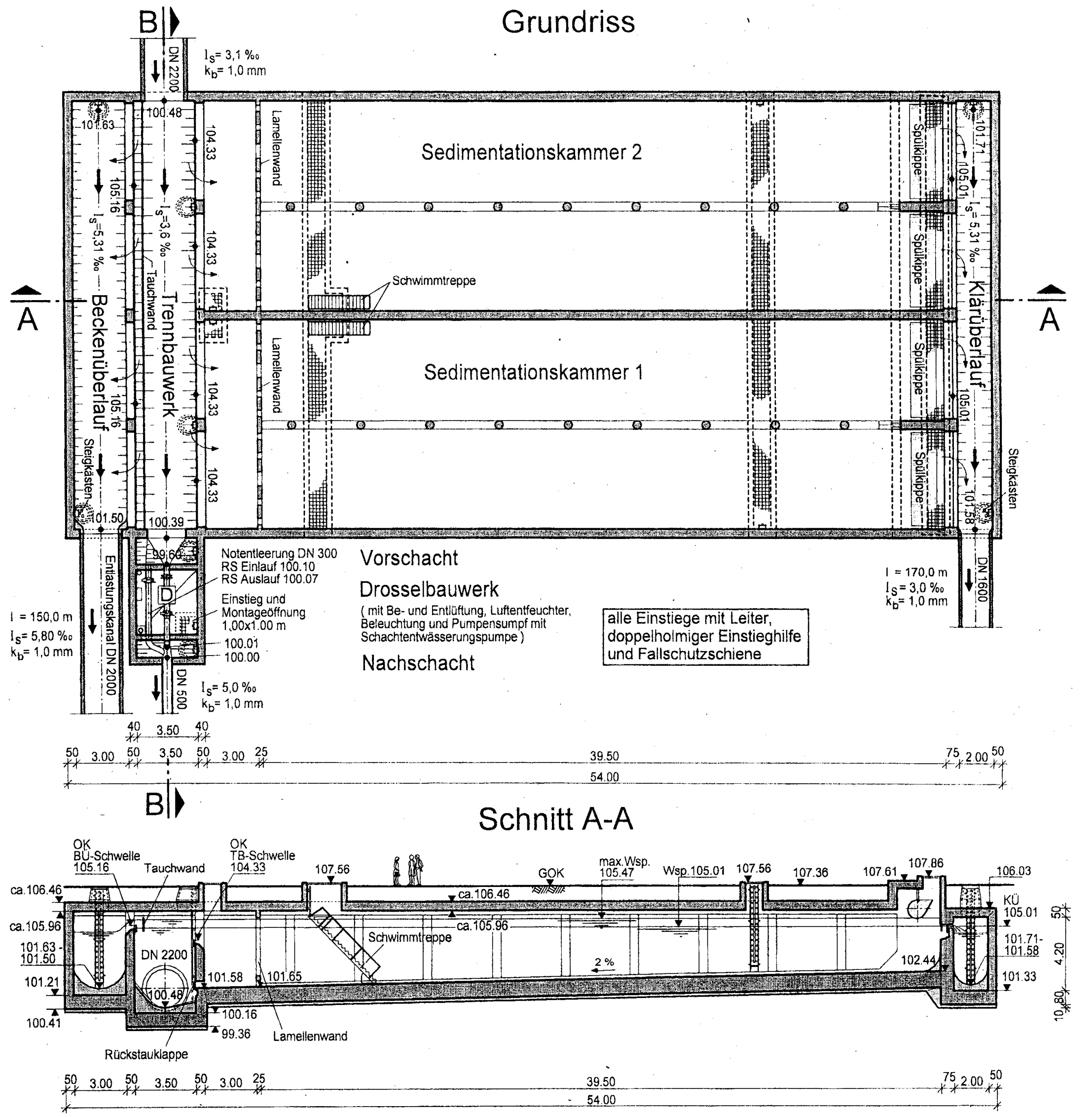
(according to ATV-M 176, Bild D.1.3.1)



CSO Tank Designs

Off-line rectangular CSO tank with clarifier overflow, storage volume 3.000 m³

(according to ATV-M 176, Bild C.1)



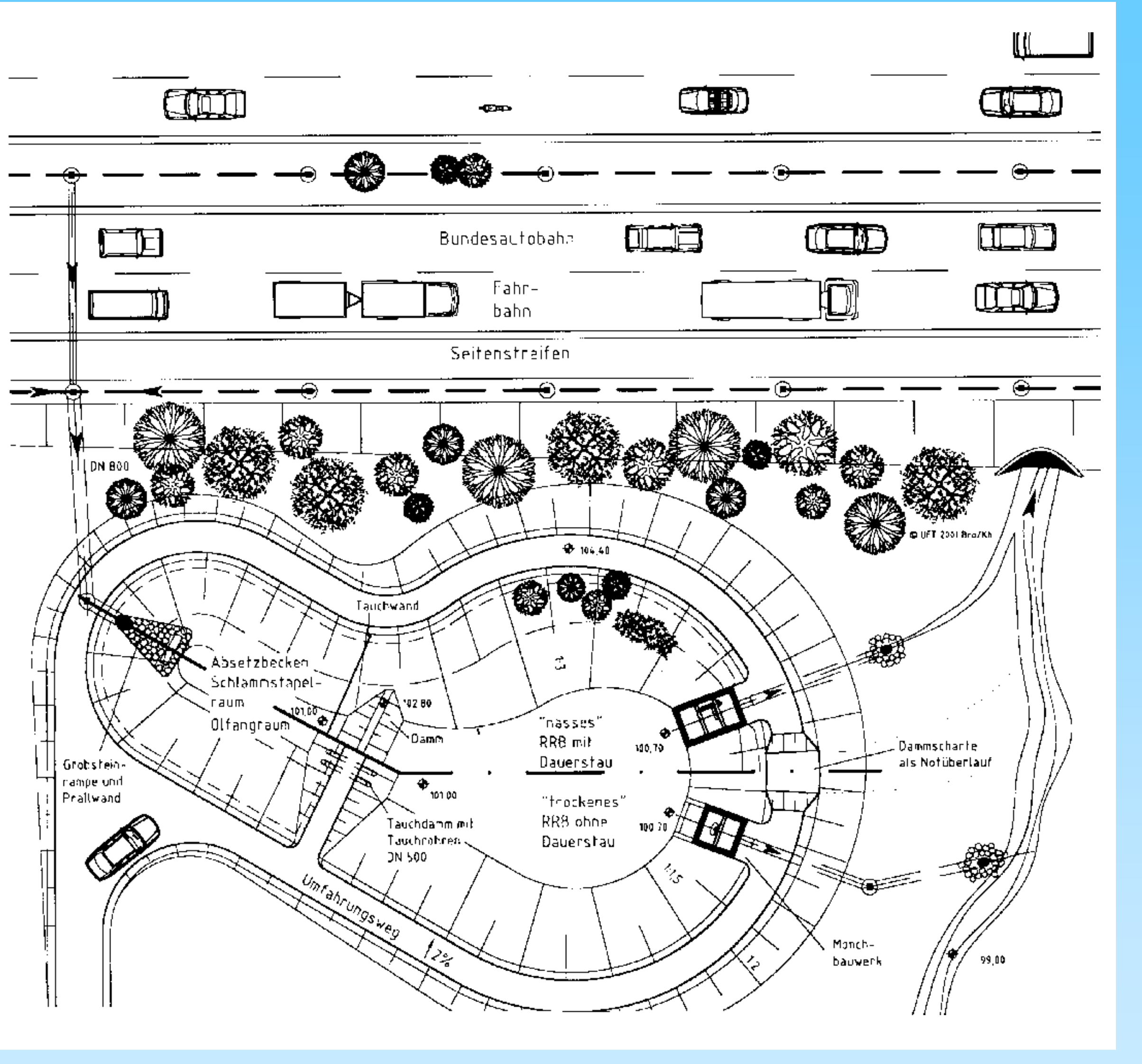
4-lane rectangular CSO tank with tipping flusher buckets

Stormwater retention pond design

Retention pond for motorway storm runoff, „wet“ or „dry“ pond design

Storage volume 3.000 m³

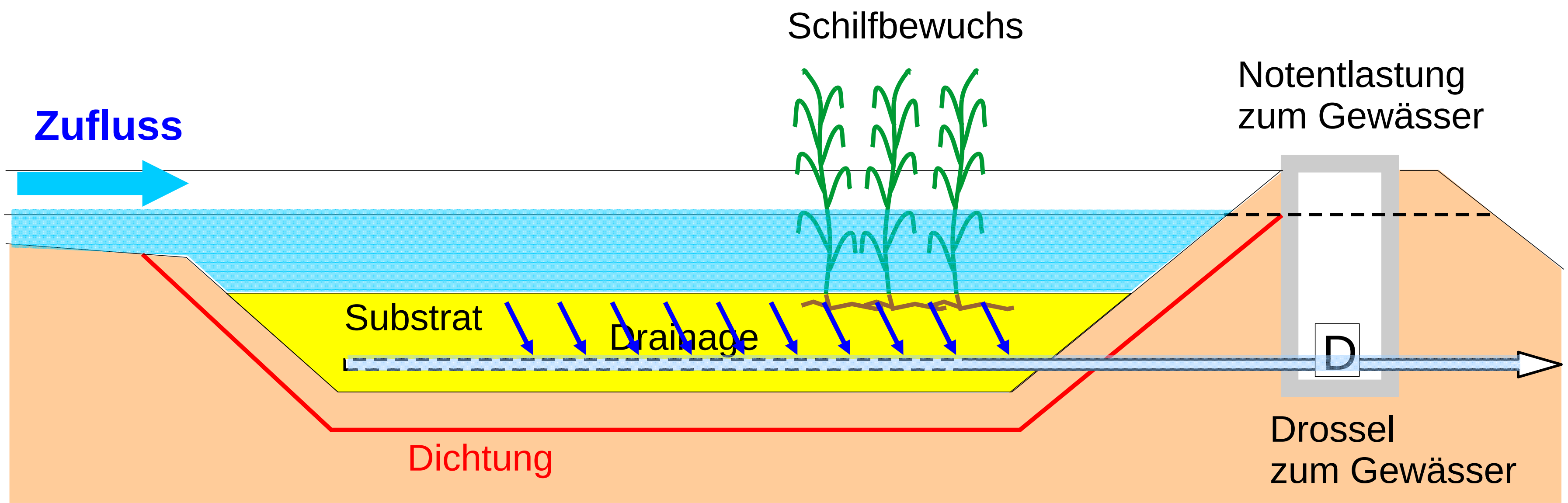
Design: UFT



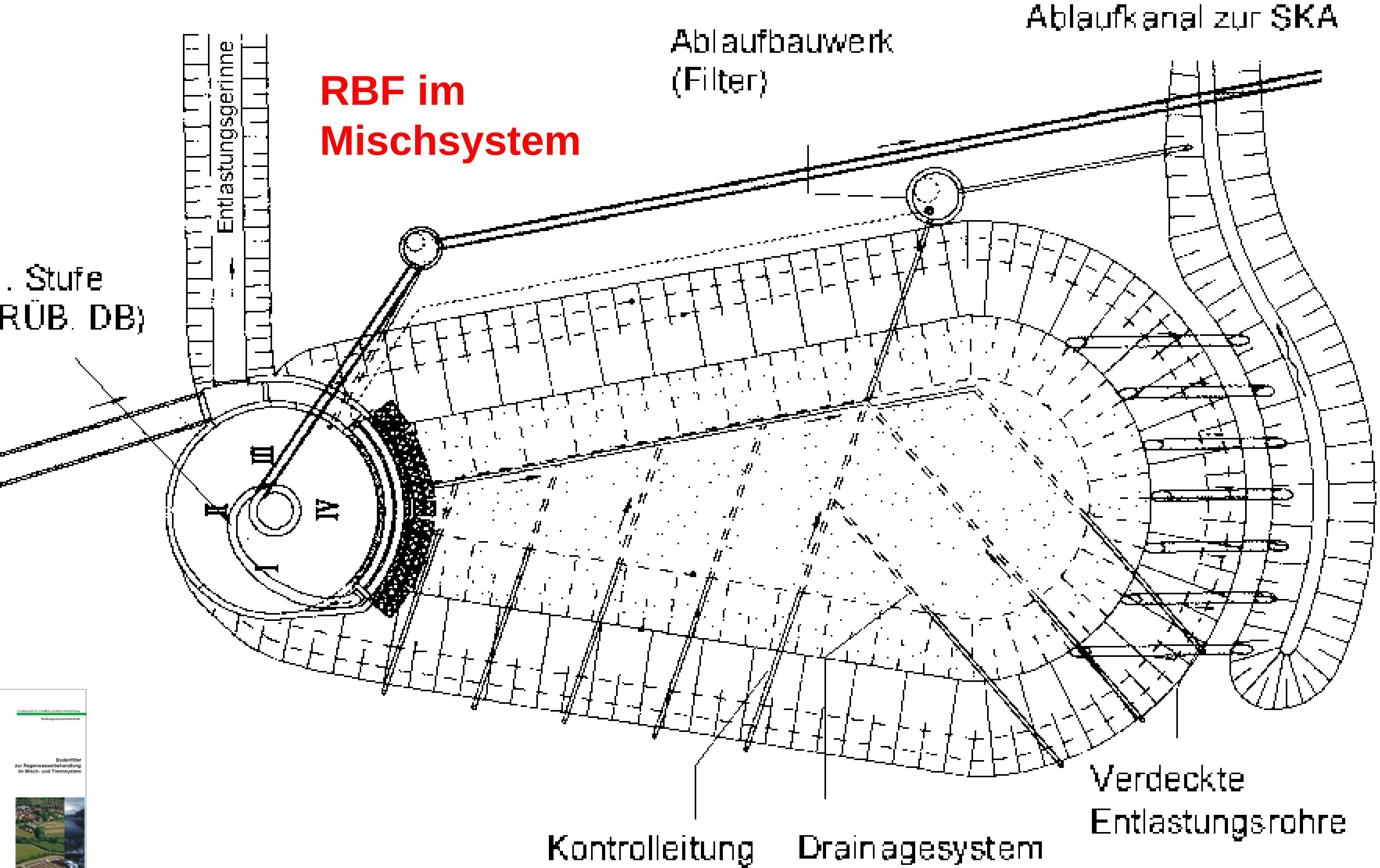
Was ist ein Retentionsbodenfilter?

What is a constructed wetland?

- Offenes Regenbecken
- Rückhalt von Abflusspitzen
- Filterung des Abflusses zum Gewässer



RBF im Mischsystem



RBF Mörsch


Zulauf
24/10/2005

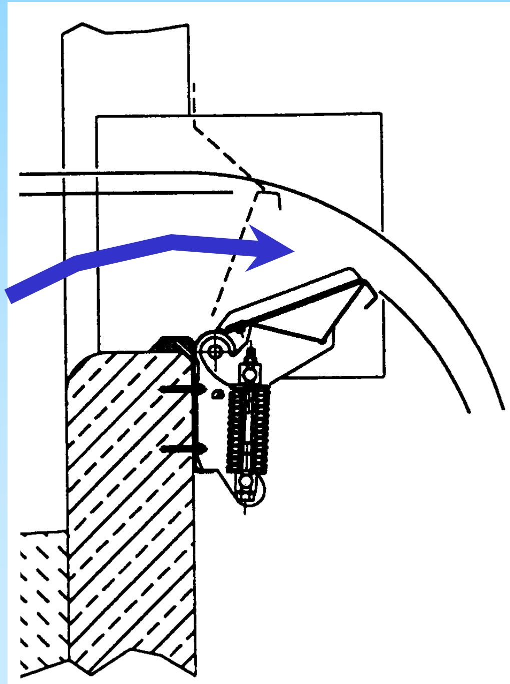

Ansicht
in Fließrichtung
24/10/2005

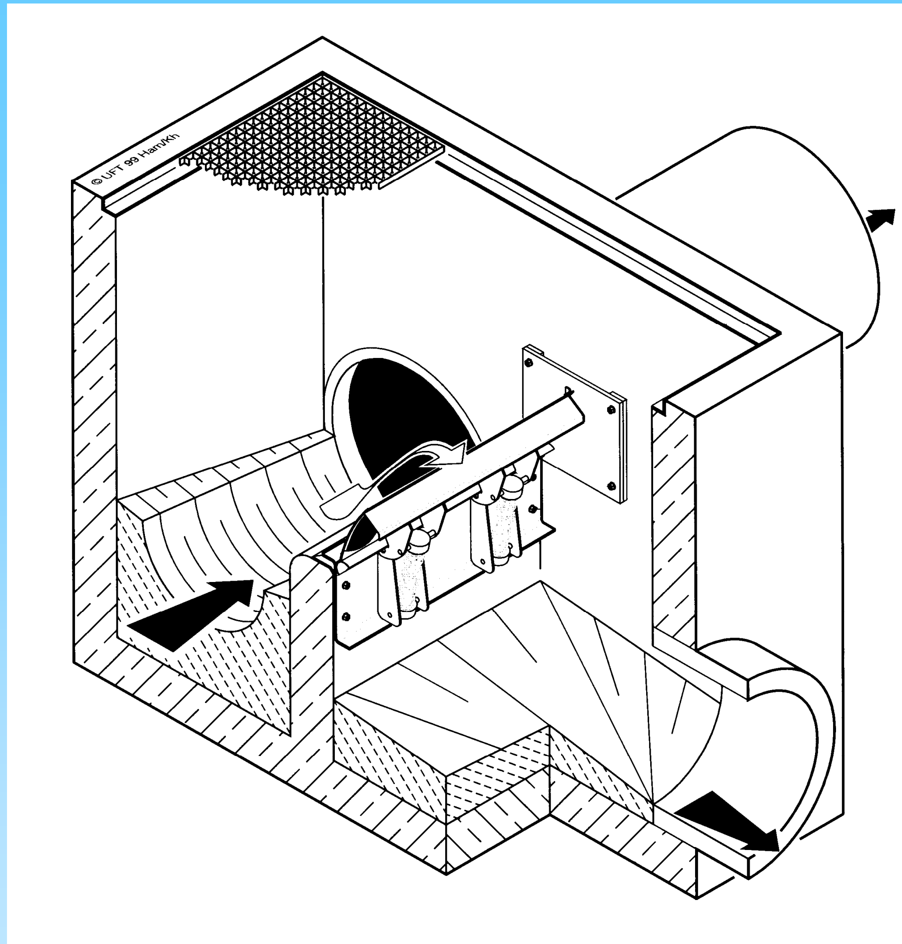

Filterüberlauf
24/10/2005

New developments in CSO tank equipment

Water level control

- Self-regulating overflow weir with support spring mechanism

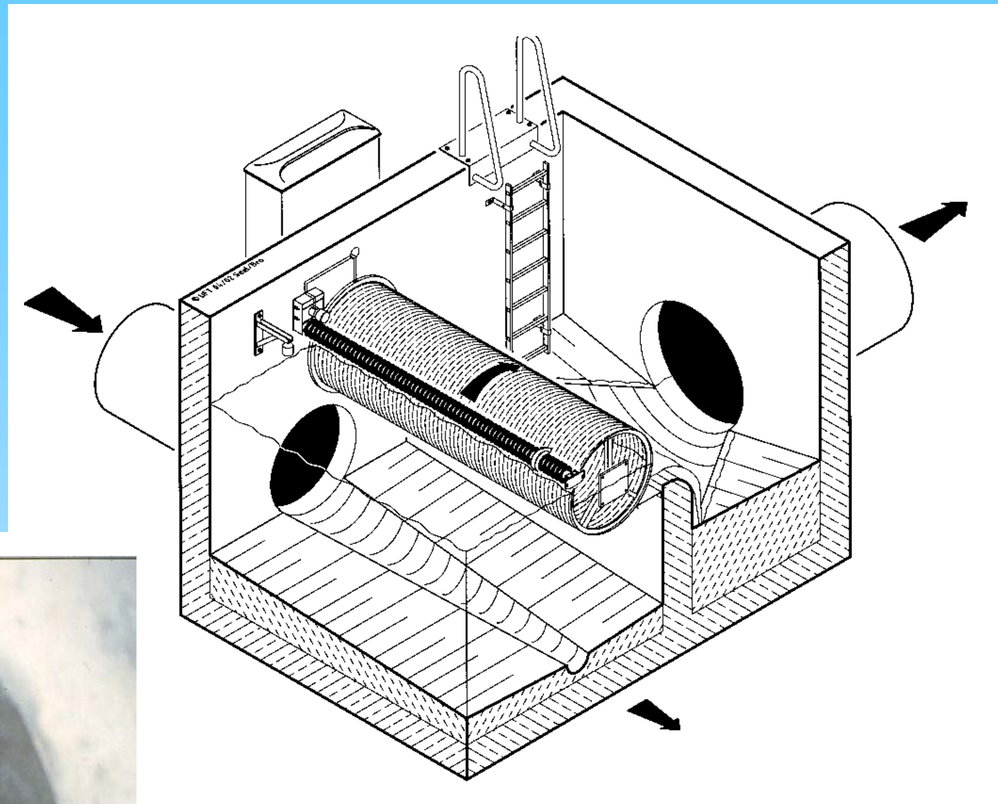




- Allows large overflows over a short weir with small increase of water level
- Optional with backflow prevention

Self-regulating overflow weir, view from the back side

Rotating drum sieve

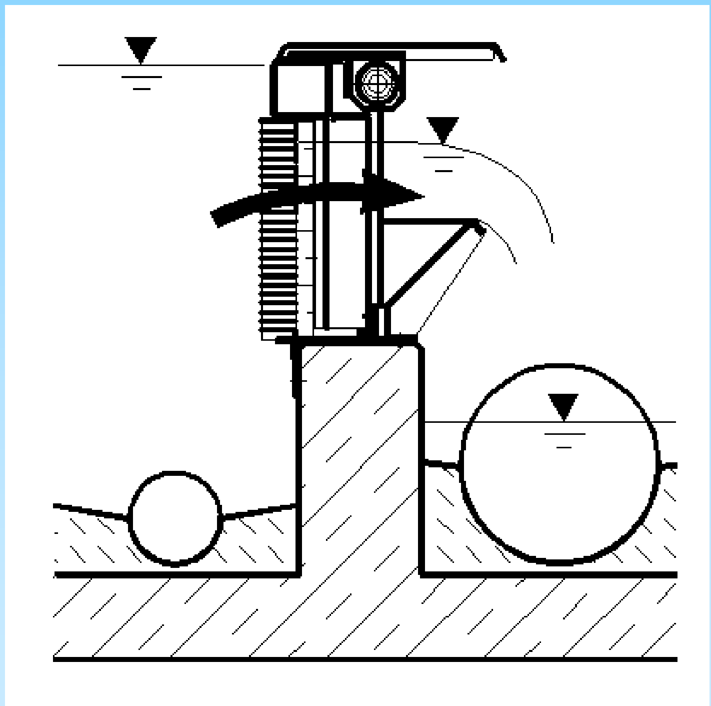


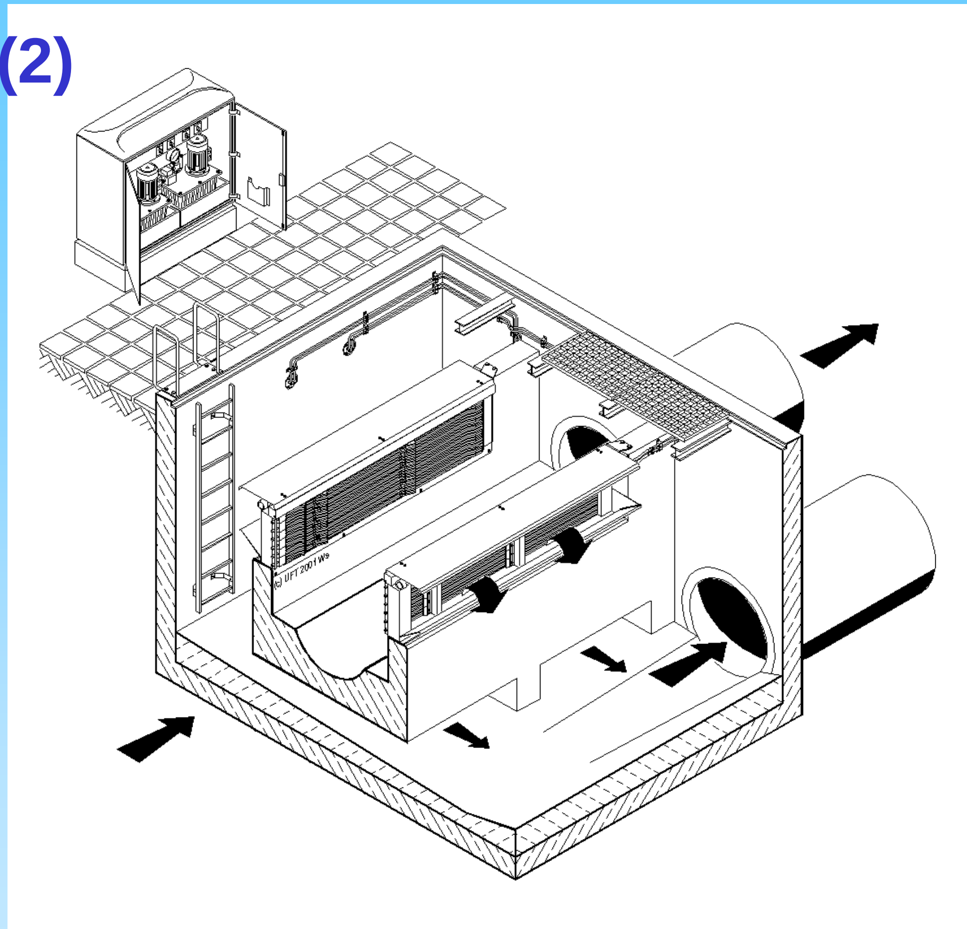
- Rotating brush removes screenings above water level

Rotating drum sieve

New developments in CSO tank equipment (2)

Removal of unaesthetic gross solids from overflowing combined sewage



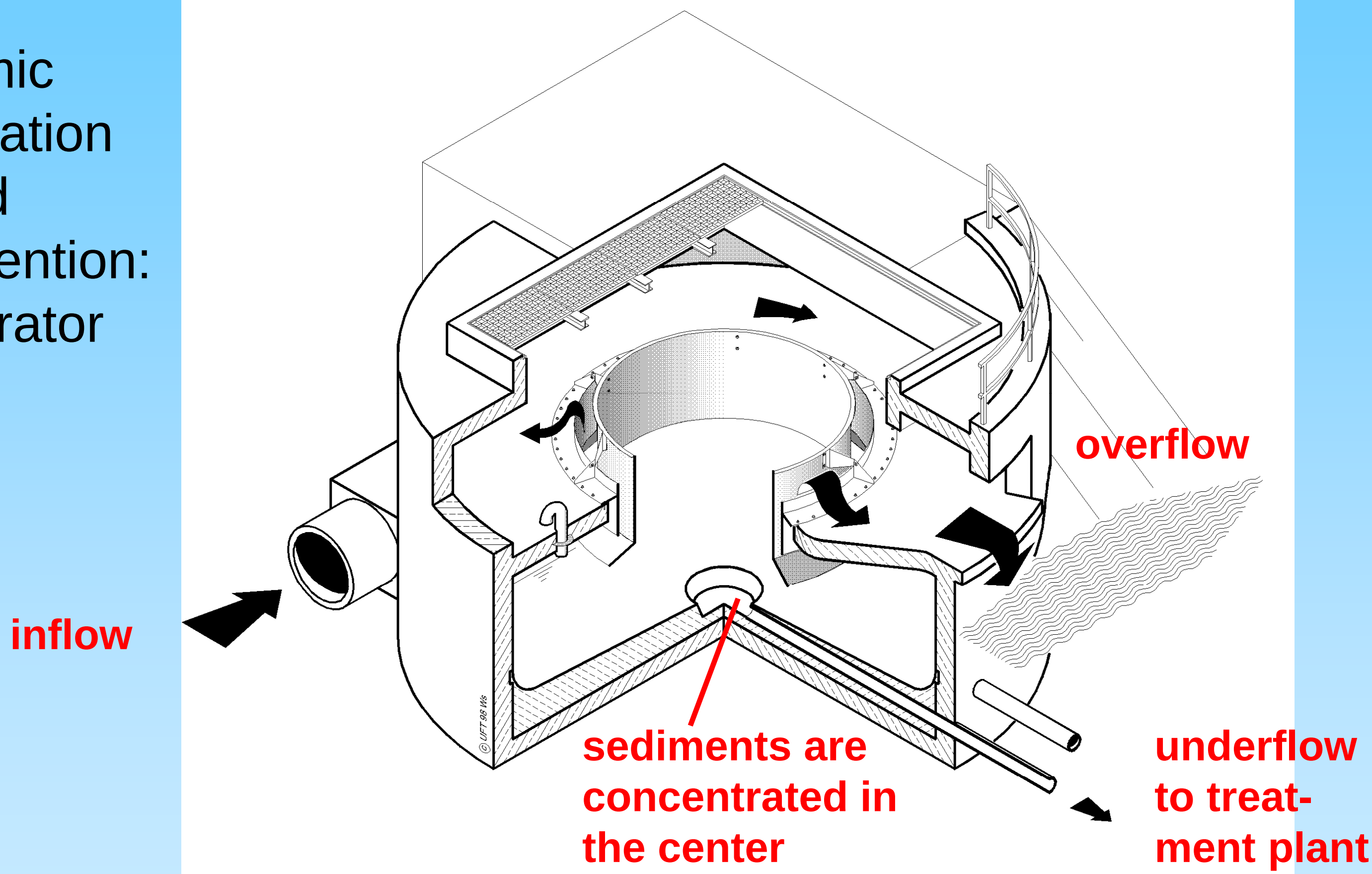


- Fine bar screen with automatic cleaning

Large screen installation (Photo: ROMAG)

New developments in CSO tank equipment (3)

- Hydrodynamic solids separation for improved pollutant retention: Vortex separator



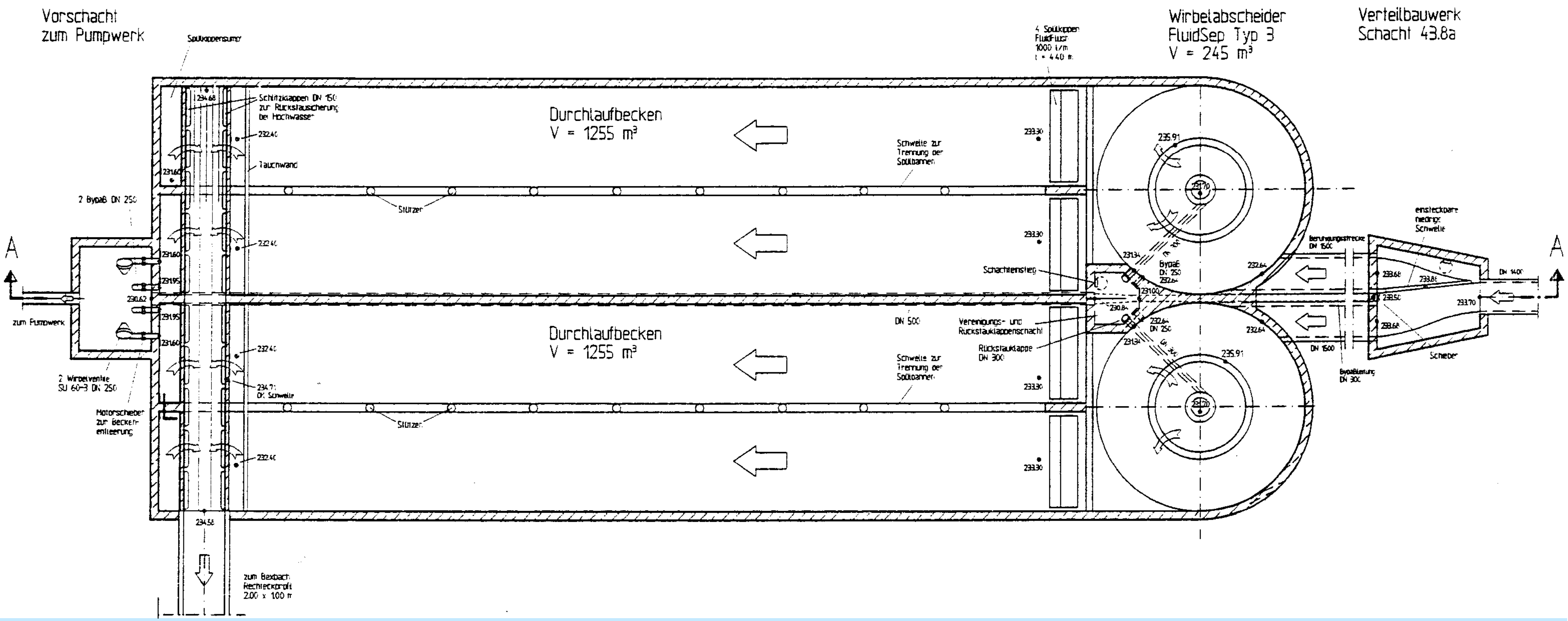
Vortex separator *FluidSep* Type 3, D = 8,0 m
Schematic section of concrete structure with steel baffles

Vortex separators

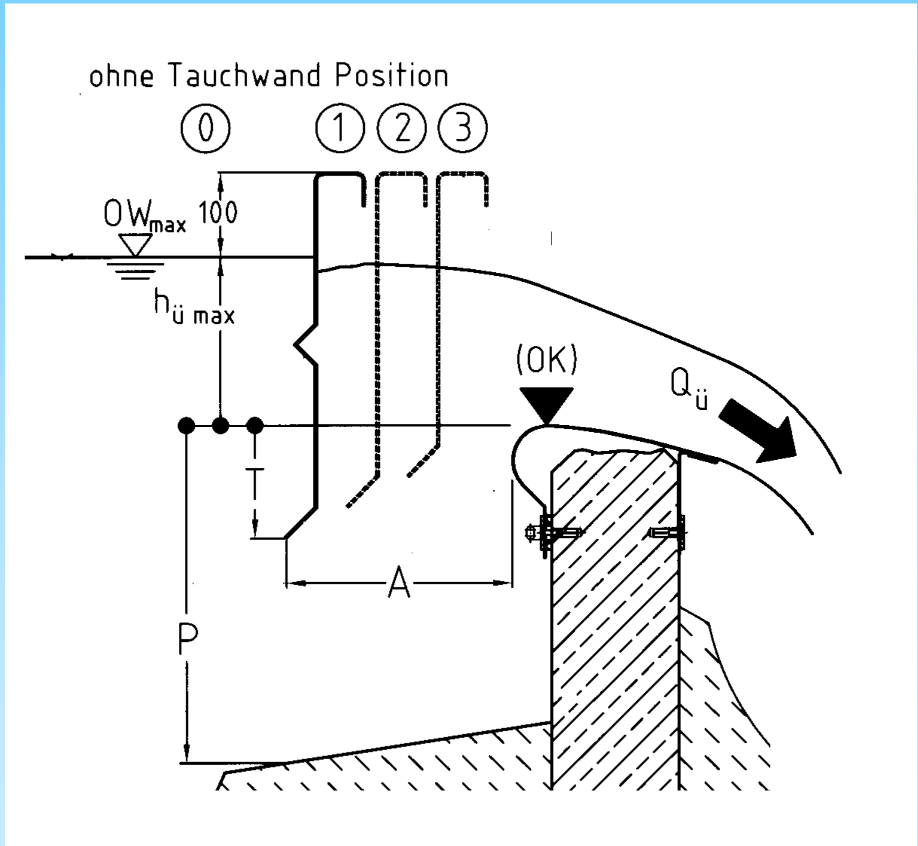
Concrete structure with steel baffles

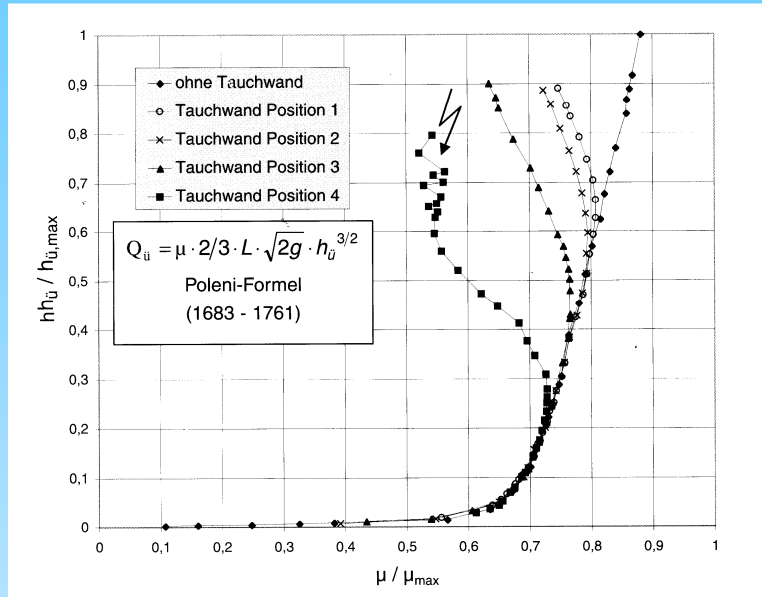
Turn-key prefabricated unit from high-density polyethylene

Twin Vortex Separators and Rectangular Tanks in Series, Storage Volume 3.000 m³



Latest invention: Wing-shaped CSO measuring weir plus variable scumboard

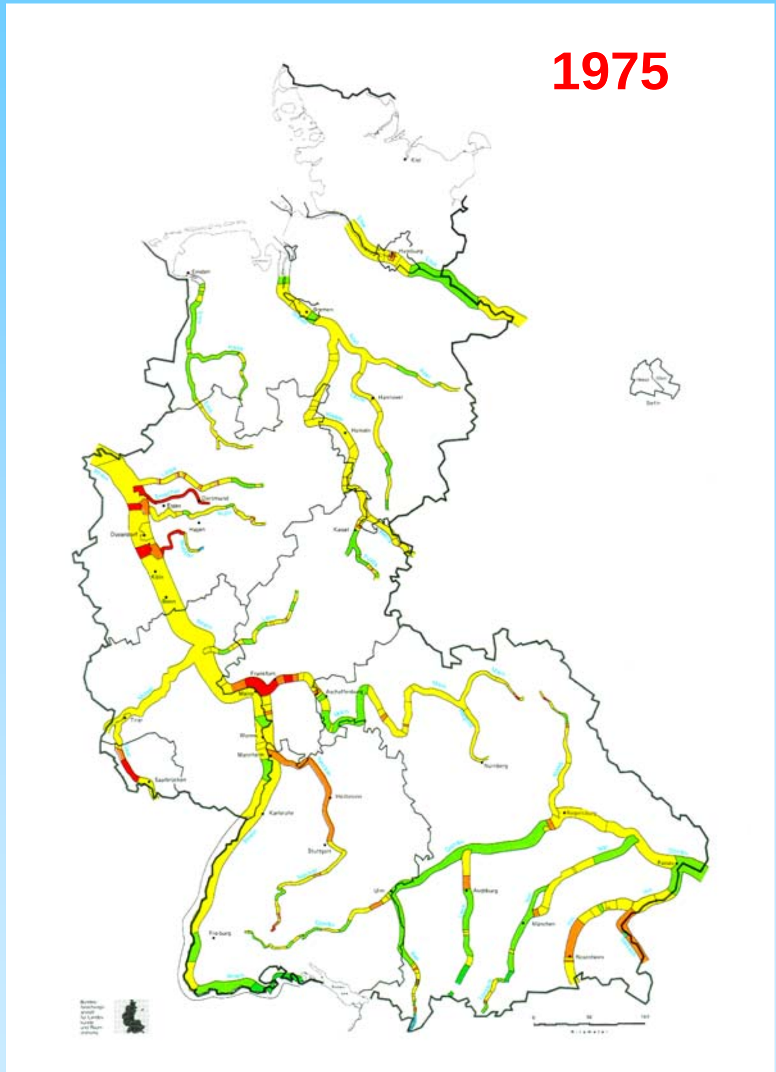


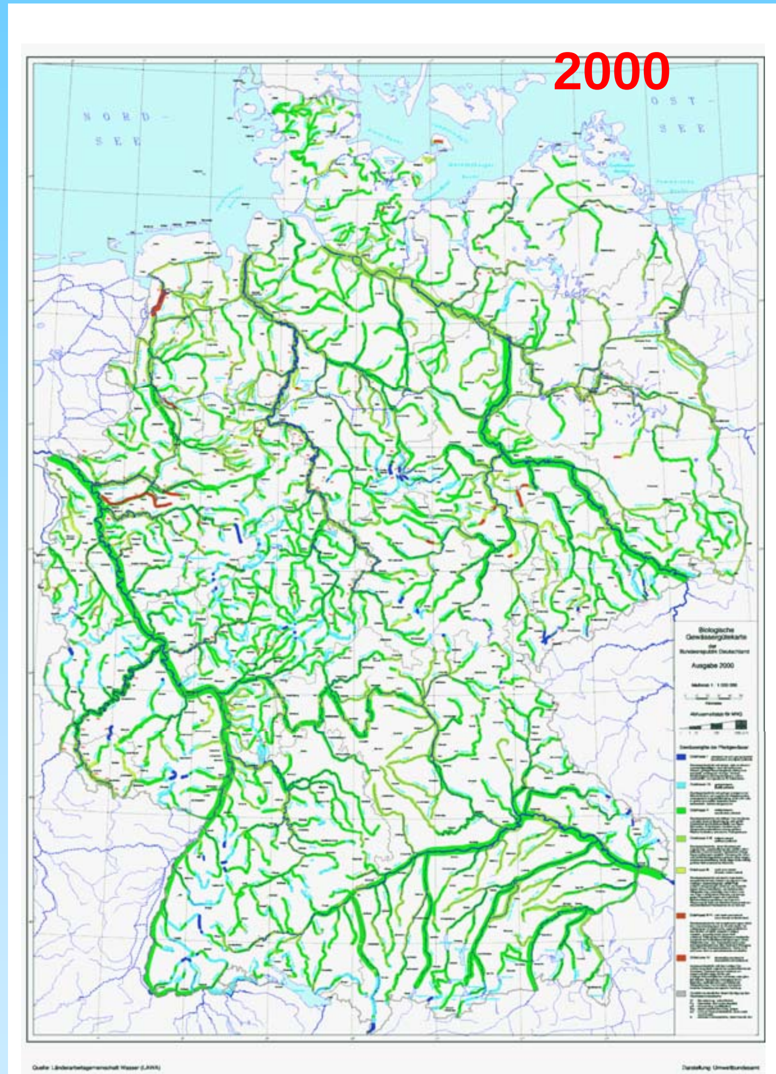


Remember 1722?

Wing-shaped CSO measuring weir

Improvement of Biological River Quality due to WWTPs and Storm Water Management in Germany





Averaged overall costs of water supply and sewage treatment in Germany (2007)

Water supply Sewage fee	1,85 € 2,78 €	per m³ per m³
Sum	**4,63 €**	**per m³**
Water consumption	126 litres	per capita and day
Overall costs	**0,58 €**	**per capita and day**

=1


Fine

Reservefolien für Diskussion

Einzugsgebiet 1

$A_{E,b}$ = 8,5 ha
EZ = 850 E
$Q_{S,aM}$ = 1,18 l/s
Q_F = 1,18 l/s

Stauraumkanal

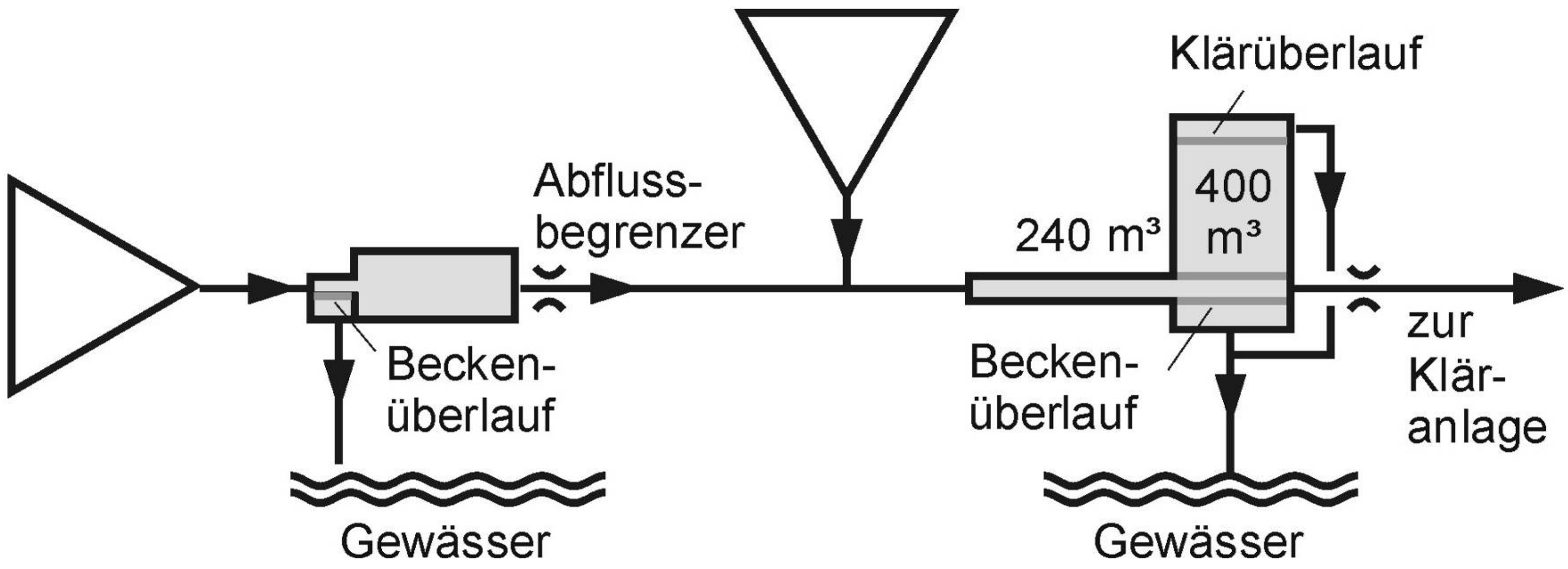
Q_{Dr} = 10,0 l/s
V = 150 m³

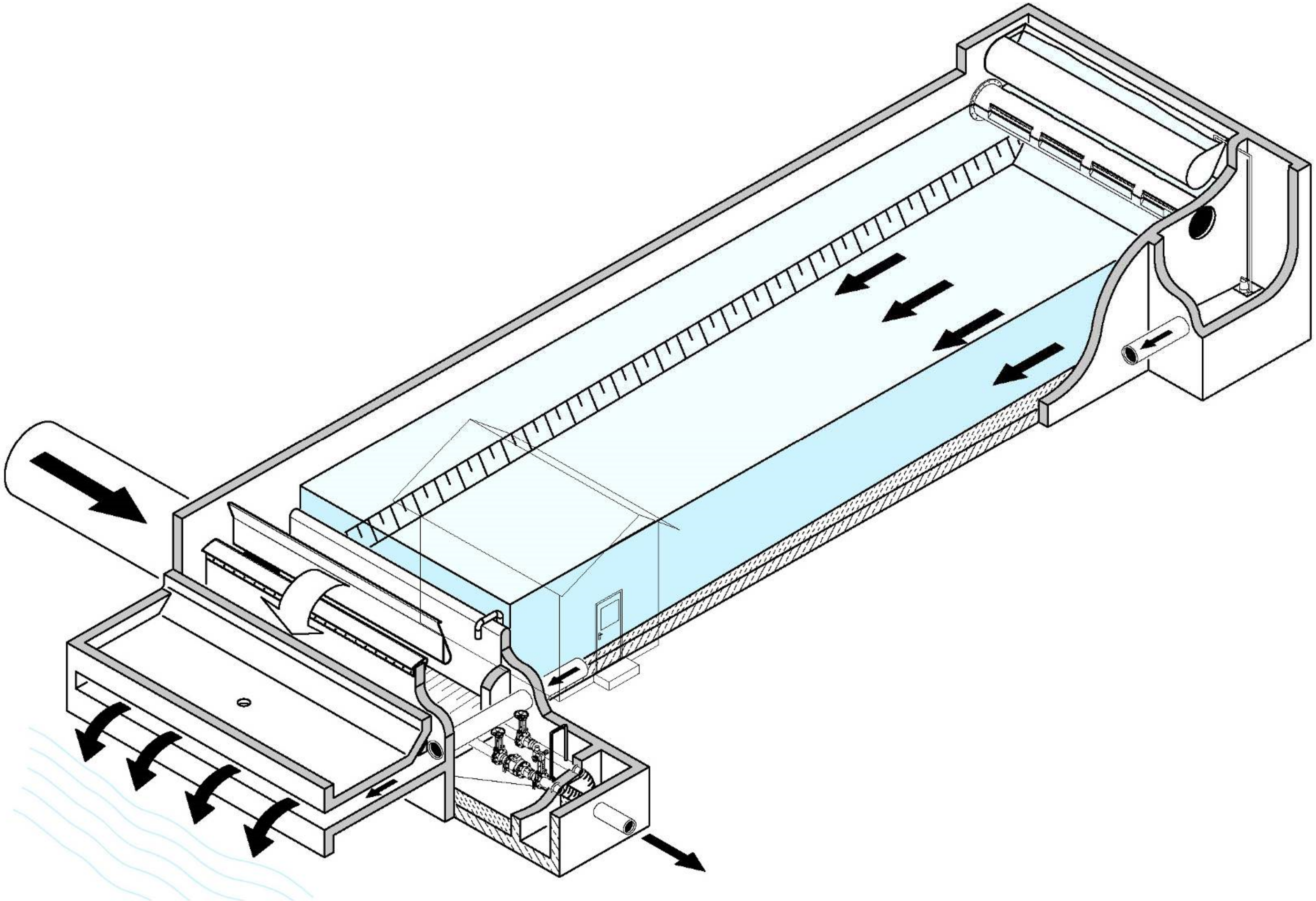
Einzugsgebiet 2

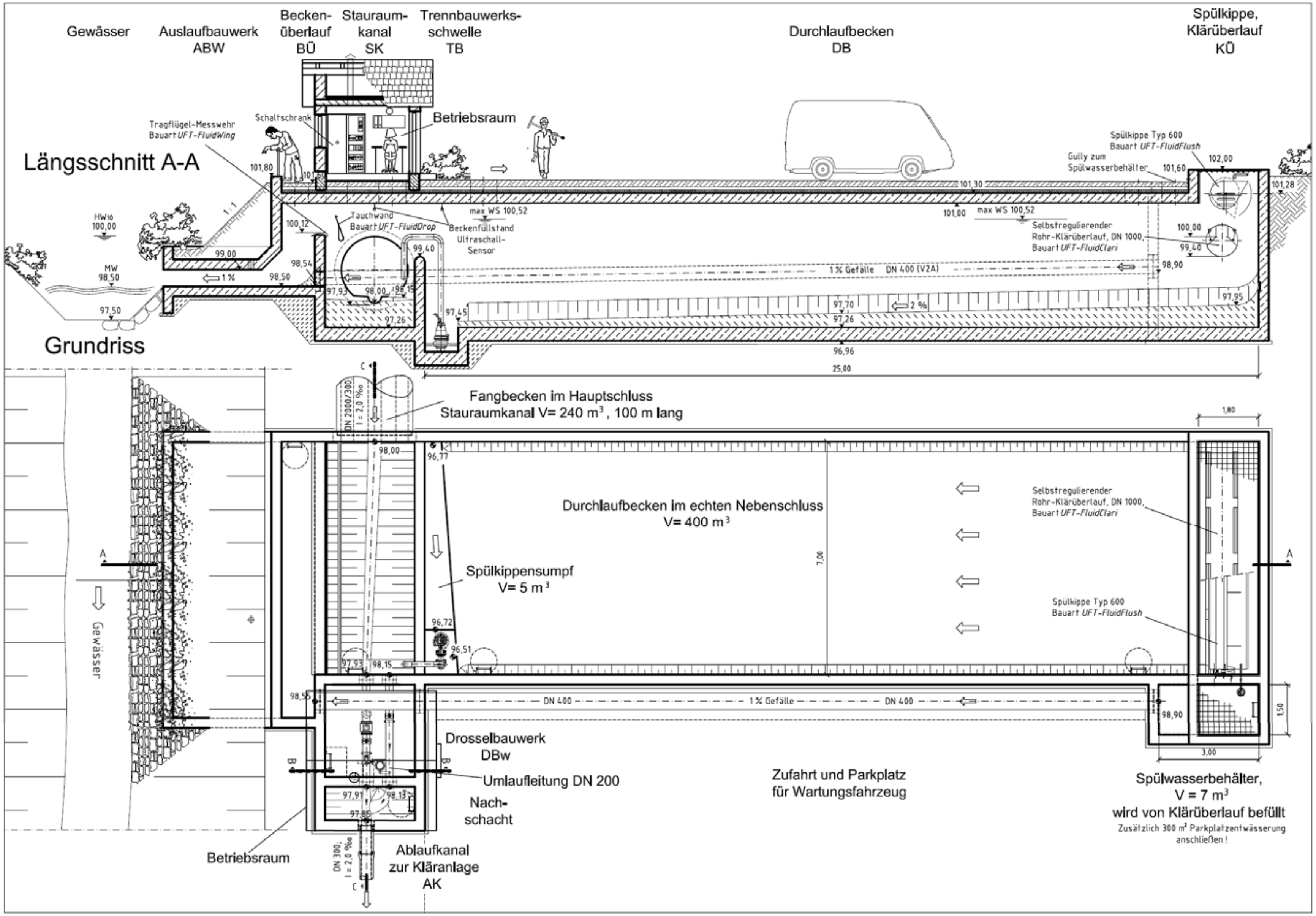
$A_{E,b}$ = 25,6 ha
EZ = 2 560 E
$Q_{S,aM}$ = 3,56 l/s
Q_F = 3,56 l/s

Verbundbecken (Musterentwurf)

Q_{Dr} = 37,0 l/s
$Q_{KÜ}$ = 364 l/s
V = 640 m³

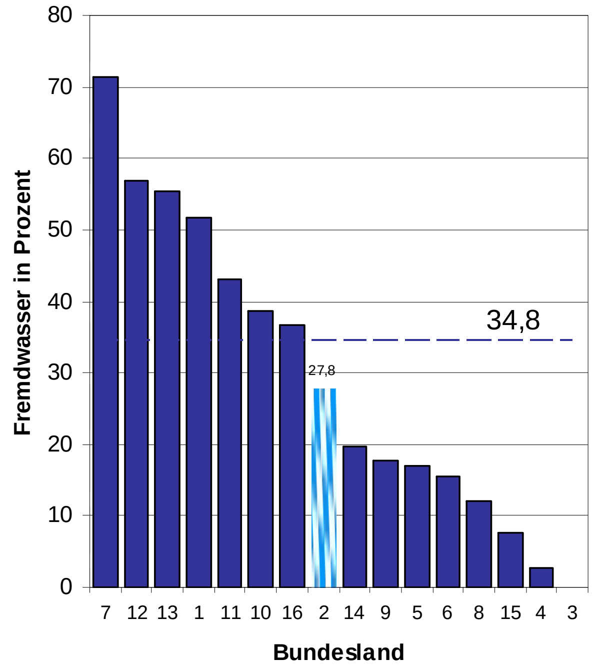


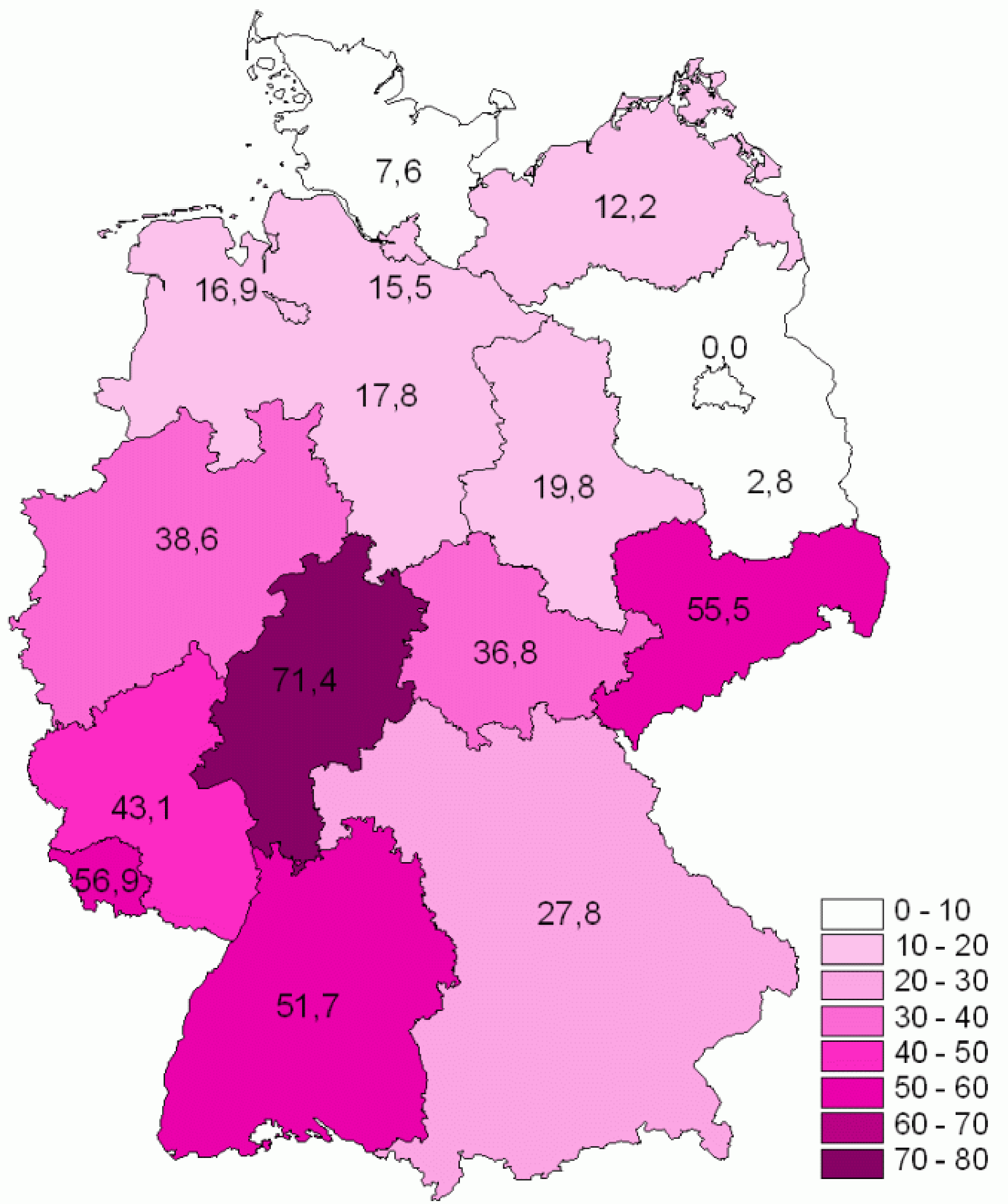




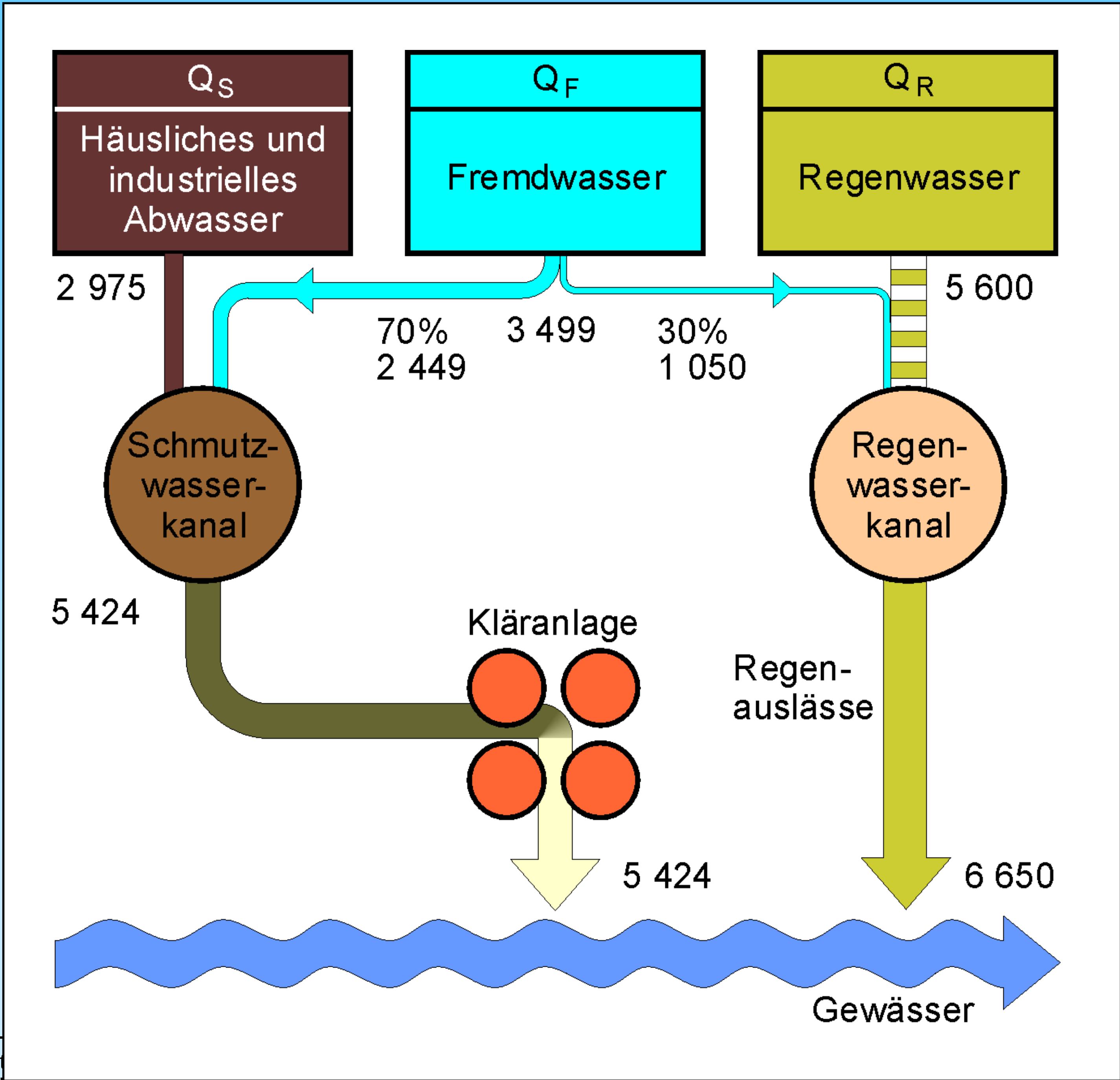
Gewässer
Auslaufbauwerk ABW
Becken-überlauf BÜ
Stauraum-kanal SK
Trennbauwerks-schwelle TB
Durchlaufbecken DB
Spülkippe, Klärüberlauf KÜ
Längsschnitt A-A
Betriebsraum
Grundriss
Fangbecken im Hauptschluss
Stauraumkanal V= 240 m³, 100 m lang
Durchlaufbecken im echten Nebenschluss
V= 400 m³
Spülkippensumpf
V= 5 m³
Drosselbauwerk DBw
Umlaufleitung DN 200
Nach-schacht
Zufahrt und Parkplatz für Wartungsfahrzeug
Spülwasserbehälter,
V = 7 m³
wird von Klärüberlauf befüllt
Betriebsraum
Ablaufkanal zur Kläranlage AK

Mittlerer Fremdwasserzuschlag in Prozent vom Schmutzwasserzufluss während des Jahres 2004

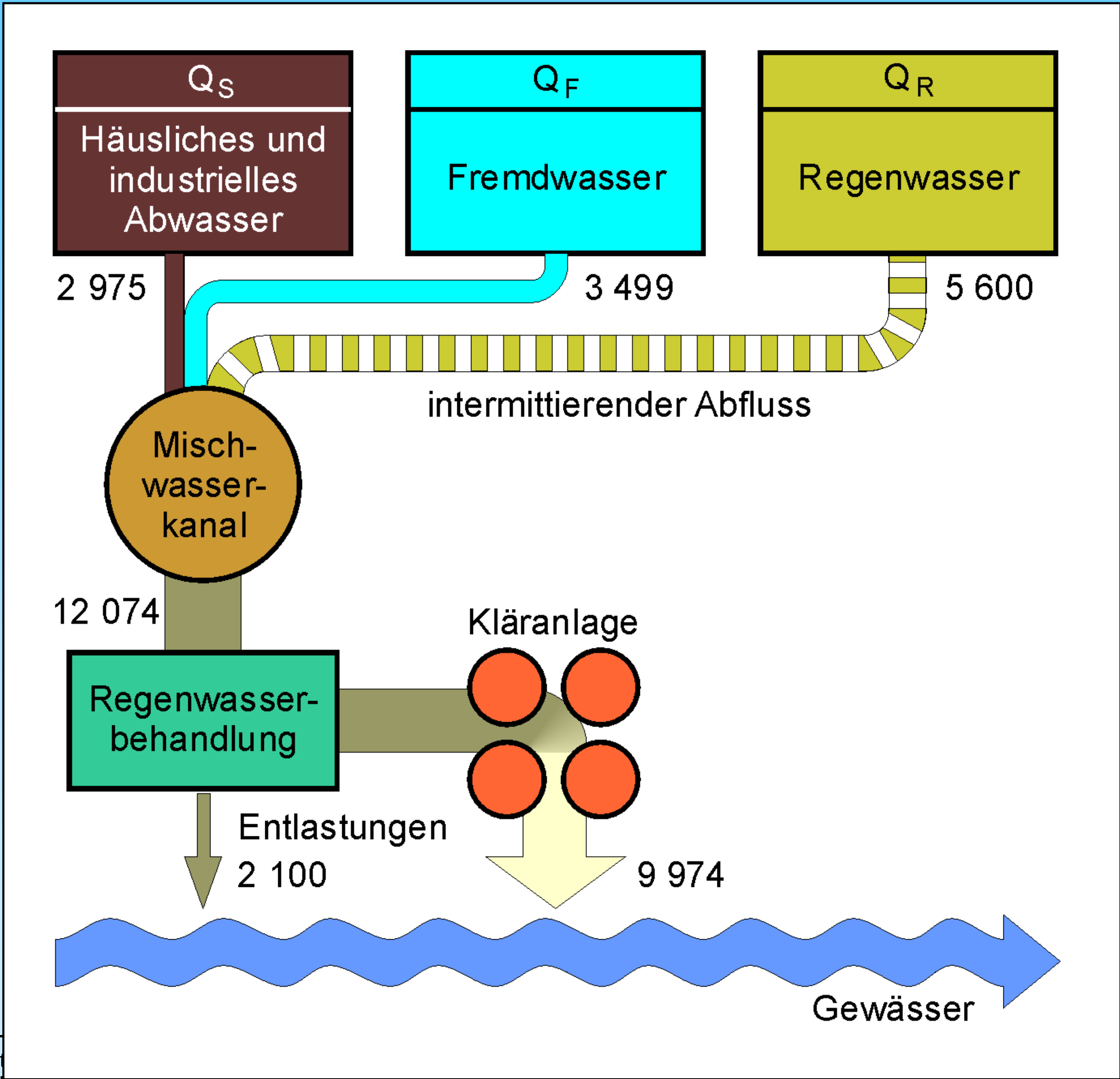




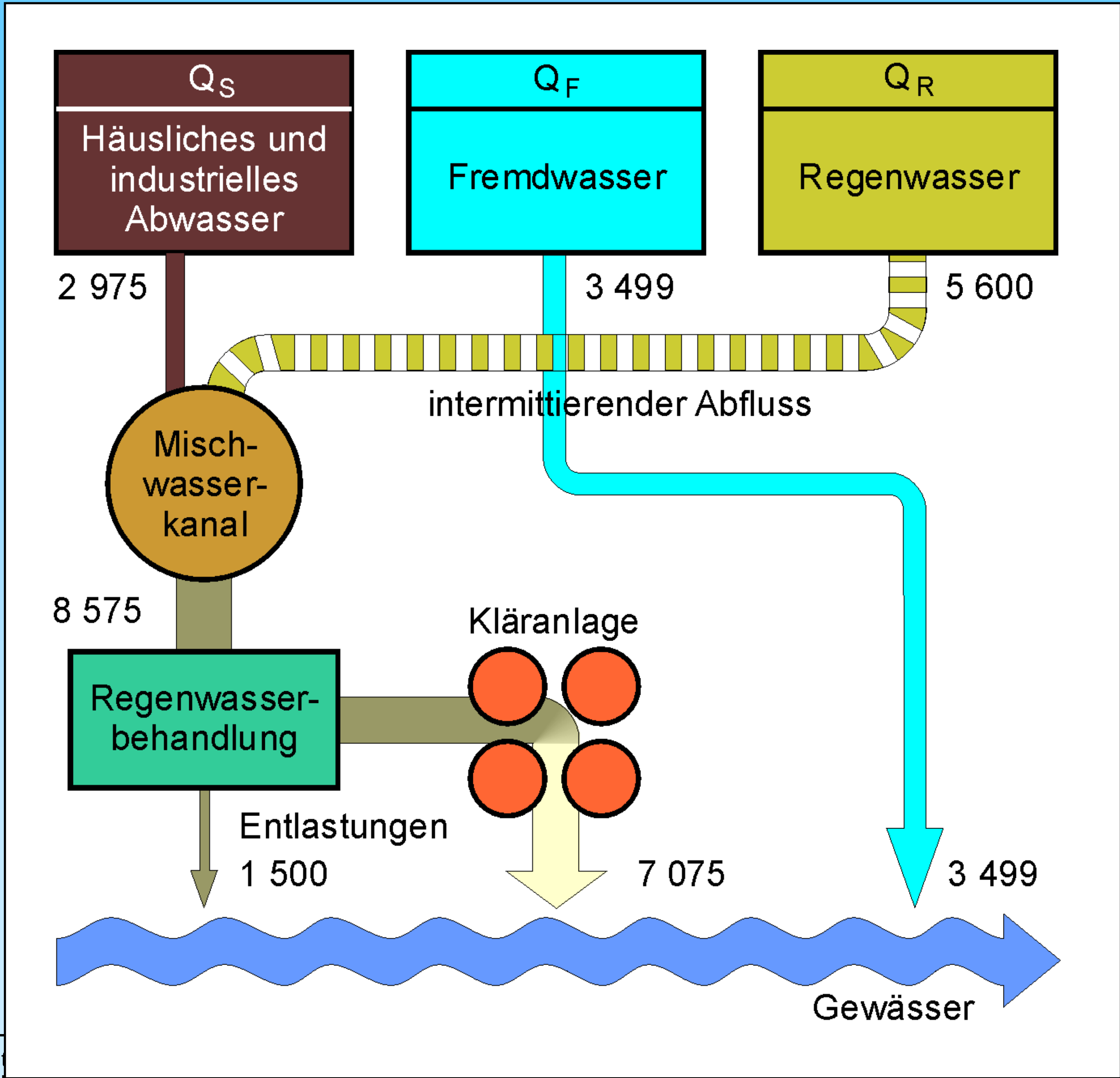
Konventionelles Trennsystem



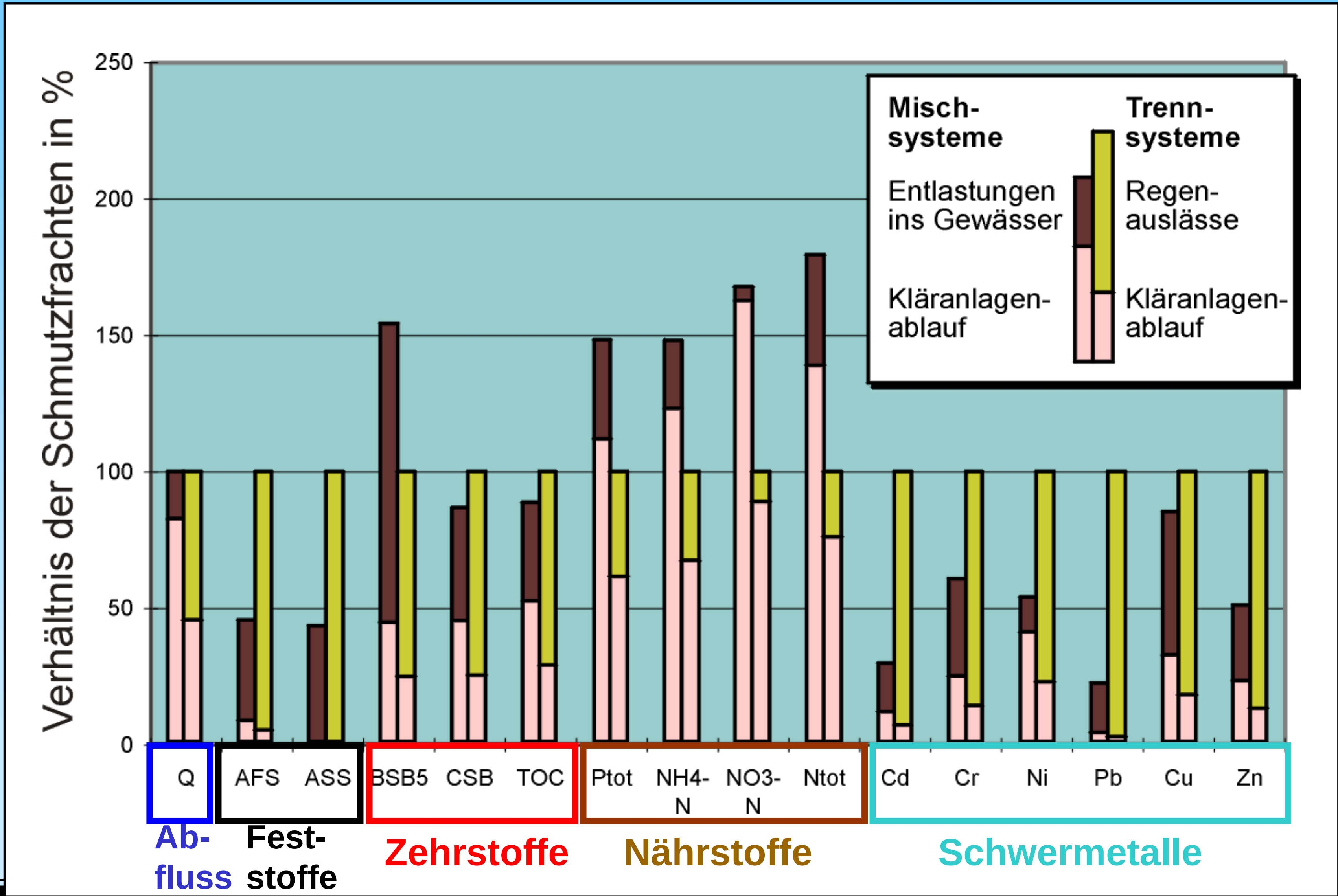
Konven-
tionelles
Mischsystem



Modifiziertes Mischsystem



Ergebnis: Verhältnis der ins Gewässer gelangenden Schmutzfrachten



Kostenvergleich pro Einfamilienhaus