Lecture 8

Types, Quantities and Collection of Waste Water

Part: Type and Quantity

Types of Waste Water [ATV-A 118E]

- **Domestic waste water** *(häusliches Schmutzwasser)* from households, offices, hotels, restaurants, small business‘ operations (**Index d**)

- **Commercial waste water** *(betriebliches Schmutzwasser)* from business and industry operations, big hospitals, senior‘s homes, schools, barracks, etc. (**Index c**)

- **Sewer infiltration water** *(Fremdwasser)* from diffuse sources (**Index iw**)
  Penetrating groundwater into drains through leakages, through mistaken pipe connections (e.g. drain or rain water) as well as superficial water from a waste water channel (e.g. over drain covers).

- **Precipitation water** *(Niederschlagwasser)* - rain and melt water (**Index s**)

Types of Waste Water [ATV-A 118E]

Waste water discharge *(Schmutzwasserabfluss)*: $Q_{ww} = Q_d + Q_c$

Dry weather discharge *(Trockenwetterabfluss)*: $Q_{dw} = Q_{ww} + Q_{iw}$

Total discharge:

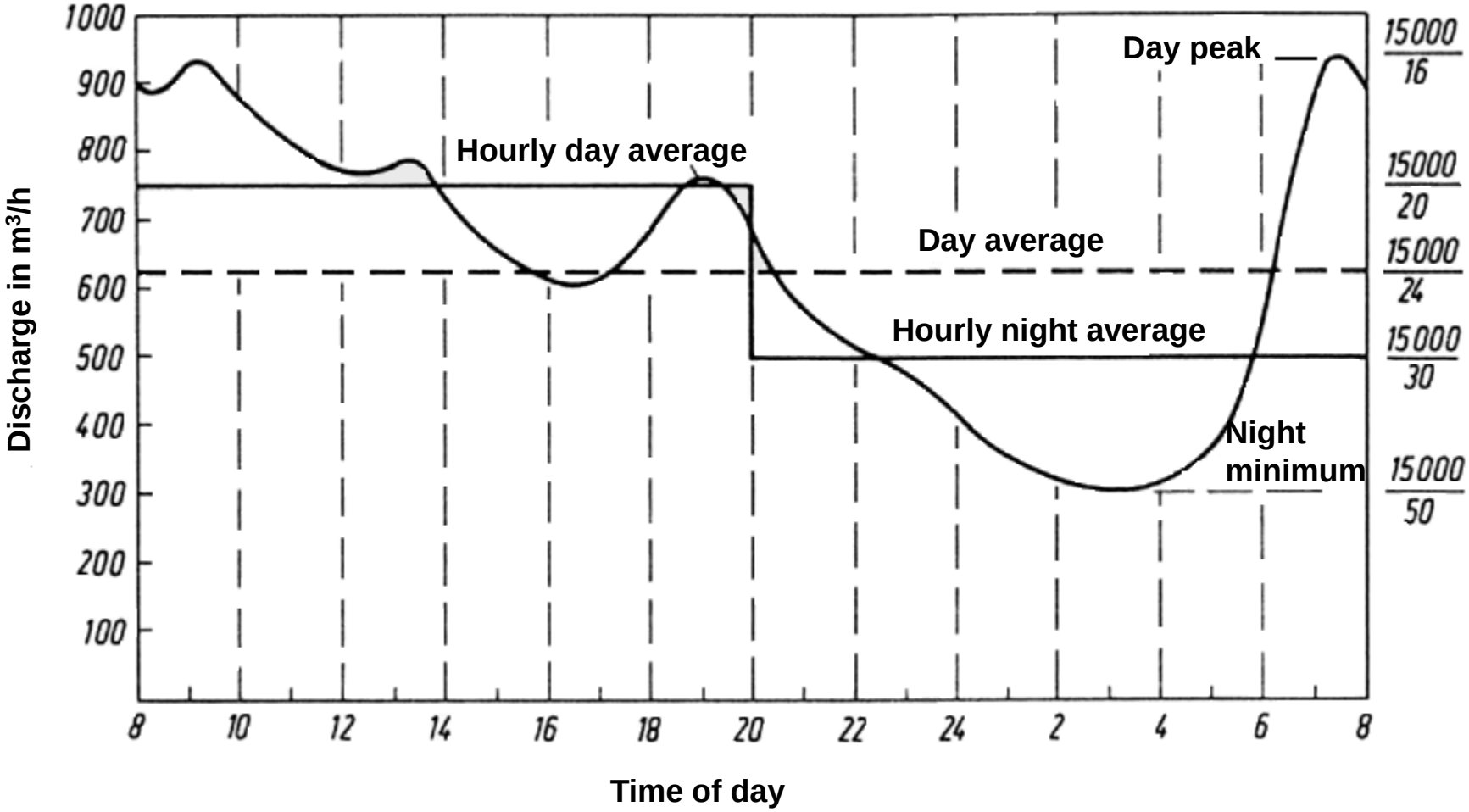
Combined sewer system *(Mischsystem)*: $Q_{tot} = Q_{dw} + Q_s$

Separate sewer system *(Trennsystem)*:

- storm water sewer $Q_{tot} = Q_s$
- wastewater sewer $Q_{tot} = Q_{dw} + Q_{s,S}$

$Q_{s,S}$ is the unavoidable storm water discharge into the sewer (e.g. from the surface via manhole covers)

Daily dry weather discharge fluctuation (85,000 inhabitants including industry)



Domestic wastewater discharge Q_d

The **domestic wastewater discharge Q_d** is calculated with the following formula:

$$Q_d = \frac{q_d \cdot ID \cdot A_{C,s1}}{1000} \left[\frac{l}{s}\right]$$

with:

q_d Specific daily amount of domestic waste water per Inhabitant [l/(s*1000 I)]
q_d = 4 l/(s·1000 I) suggested if there is no available measuring data

$A_{C,s1}$ Surface area of the residential area covered by the sewer system [ha]

ID Population density of the catchment area [I/ha]

Commercial wastewater discharge Q_C

The **commercial wastewater discharge Q_c** is calculated as follows:

$$Q_c = q_c \cdot A_{c,s2} \left[\frac{l}{s}\right]$$

with:

q_c Commercial wastewater discharge rate [l/(s·ha)]

Company with low water consumption q_c = 0.2 to 0.5 l/(s·ha)

Company with average to high water consumption q_c = 0.5 to 1.0 l/(s·ha)

$A_{C,s2}$ Surface area of the commercial and industrial area covered by the sewer system [ha]

Water demand related to industry products

Industry	Specific water demand	Reference year
Textile Industry:		
Cotton	100-120m³/t Material	1980
Wool	80-120m³/t Material	1980
Synthetic fibers	40-90m³/t Material	1980
Refinement processes:		
Bleaching	91-151m³/t Textile goods	
Dyeing	118-221m³/t Textile goods	1982
Washing	129-230m³/t Textile goods	
Mercerising	about 80m³/t Textile goods	
Malt house	1,2-5,5m³/t Barley	1981
	1,5-6,8m³/t Malt	
Brewery	4-8hl/hl Beer	1991
	6-8hl/hl Beer	1983
Bottle cleansing	0,3-0,5l/0,5l Bottle	1979
	ca. 0,15l/0,5l Bottle	1980/82

Possible sewer infiltration water sources depending on the type of sewer

Combined sewer *(Mischwasserkanal)*	**Storm water sewer** *(Regenwasserkanal)*	**Waste water sewer** *(Schmutzwasserkanal)*
Infiltrating groundwater (leakages)	**Infiltrating groundwater (leakages)**	**Infiltrating groundwater (leakages)**
Inflowing drain- and spring water	**Inflowing drain-, spring and rainwater**	**Inflowing drain- and spring water**
	Inflowing waste water (incorrect discharge)	**Inflowing waste water (via manhole cover, incorrect discharges)**

Infiltration water discharge Q_{iw} during dry weather

The **infiltration water discharge Q_{iw}** during dry weather is determined as follows:

$$Q_{iw} = q_{iw} \cdot A_{C,s} \left[\frac{l}{s}\right]$$

with:

q_{iw} Infiltration water discharge rate (during dry weather) [l/(s·ha)]

q_{iw} from 0.05 to 0.15 l/(s·ha) for new designs

$A_{C,s}$ Surface area of the catchment area covered by the sewer system [ha]

Infiltration water discharge Q_{iw}

Alternatively the infiltration water discharge (with normal sewers consisting of dry and wet weather components) can be determined globally as multiple m of the normal wastewater discharge:

The **infiltration water discharge Q_{iw}** results in:

$$Q_{iw} = m \cdot (Q_d + Q_c) \left[\frac{l}{s} \right]$$

m = 0.1 to 1.0 (in justified cases even > 1)

Additional infiltration water $Q_{s,S}$

The **unavoidable storm water runoff $Q_{s,S}$ in separate sewer-systems** is defined as follows :

$$Q_{s,S} = q_{s,S} \cdot A_{C,s3} \left[\frac{l}{s} \right]$$

Additional consideration for infiltrating storm water (e.g. from the surface via manhole covers) besides the infiltration water discharge during dry weather

with:

$\mathbf{q_{s,S}}$ Infiltration rate of storm water into the sewer [l/(s·ha)]

$q_{s,S}$ = 0.2 to 0.7 l/(s·ha) (in justified situations even more)

$\mathbf{A_{C,s3}}$ Catchment area connected to sewer system [ha]

Precipitation water Q_S

From the different precipitation types that exist, like rain, haze, snow, dew and hailstorm, only **rain and occasionally melted snow discharge** result in the **precipitation runoff Q_P**.

For the determination of **Q_P**, it must be analysed whether a precipitation event, **from a short and strong summer thunderstorm** or **a long lasting steady rain**, will result in the largest possible volume of water discharge in the sewer.

Lecture 8

Part:

Waste Water Collection and Sewer Systems

Sewer System

Sewer and drainage system *(Leitungssystem)* for buildings and properties are standardised in DIN 1986 and can be classified as follows:

- **Connecting sewer** *(Anschlusskanal):*

Channel from the public sewer *(öffentlicher Straßenkanal)* to the property‘s limits or to the first cleaning hole *(Reinigungsöffnung)* on the property.

- **Building drain** *(Grundleitung):*

Pipelines that lie under the property´s ground and under the building, that supply the connection channel with waste water.

- **Down spot** *(Fallleitung):*

Vertical pipeline that goes through one or more floors. It is ventilated over the roof and the waste water is routed to the building drain.

Drainage system

- **Vent pipe** *(Lüftungsleitung):*

Pipeline that ventilates the drainage area *(Entwässerungsanlage)*, but does not transport any waste water.

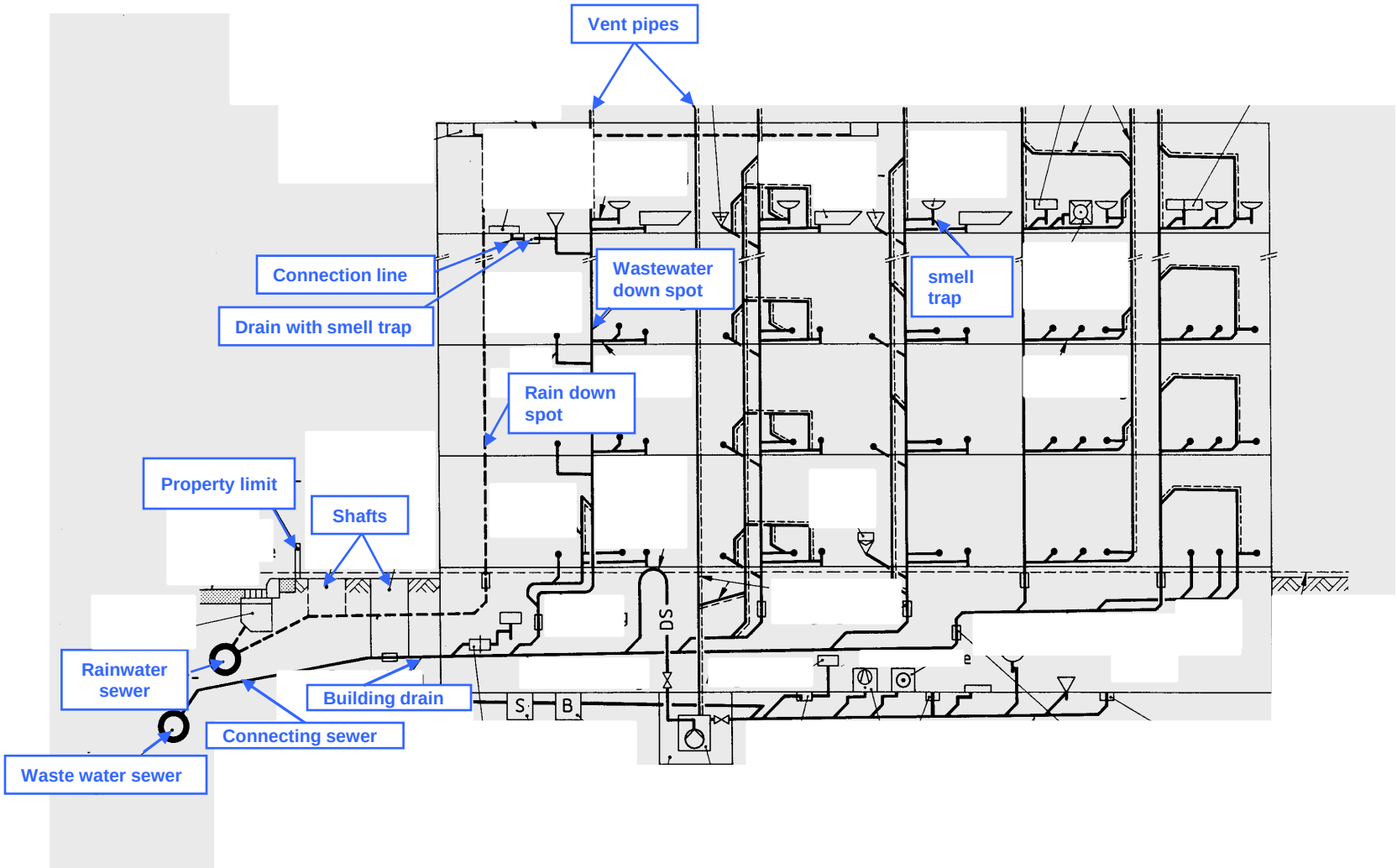
- **Connecting pipe** *(Anschlussleitung):*

Connection from smell drain trap *(Geruchsverschluss)* to the down spot.

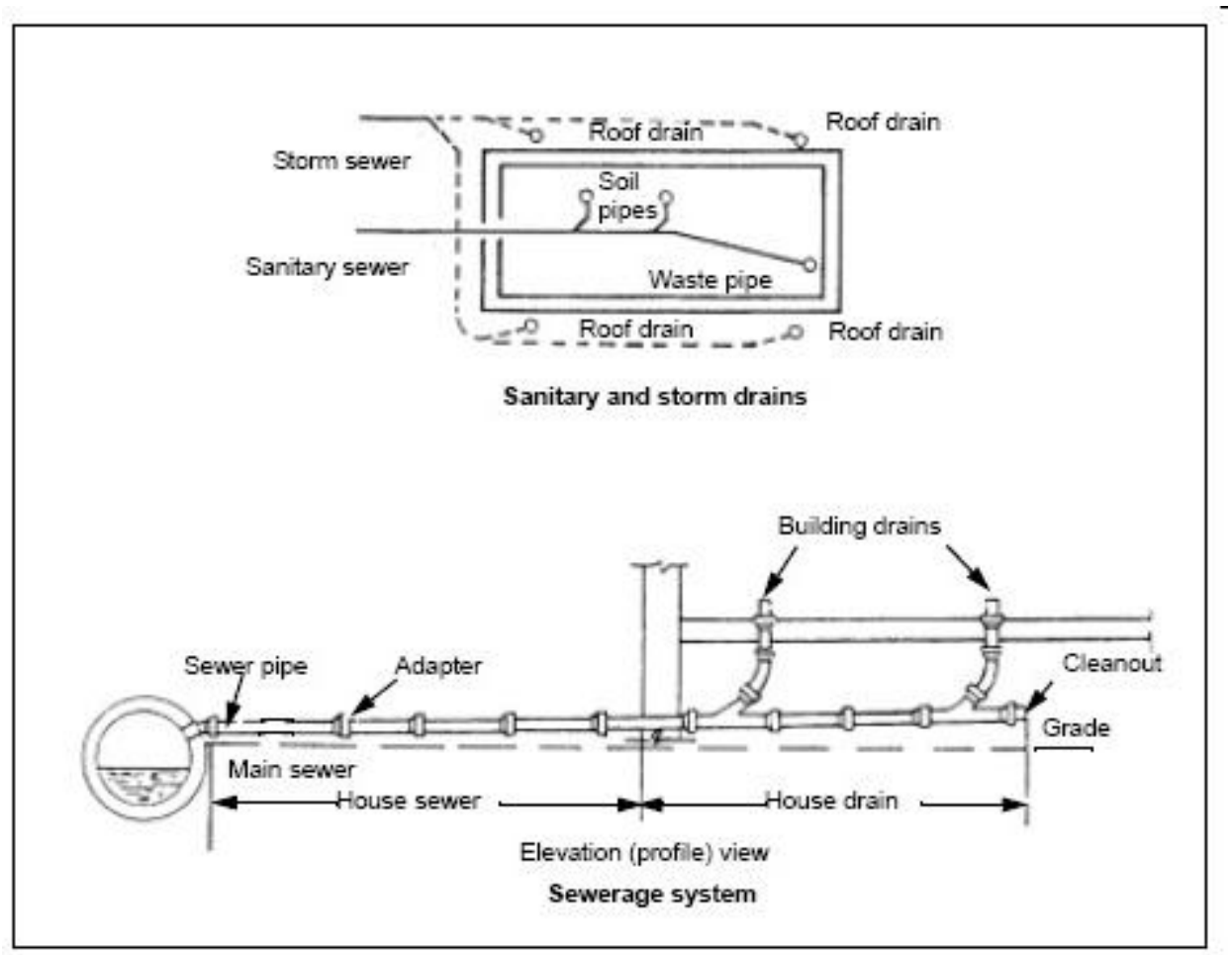
- **Rainwater pipe** *(Regenfallleitung):*

Internal or external laying pipe for the rainwater discharge from roofs, balconies, etc.

Sewer and drainage systems in buildings



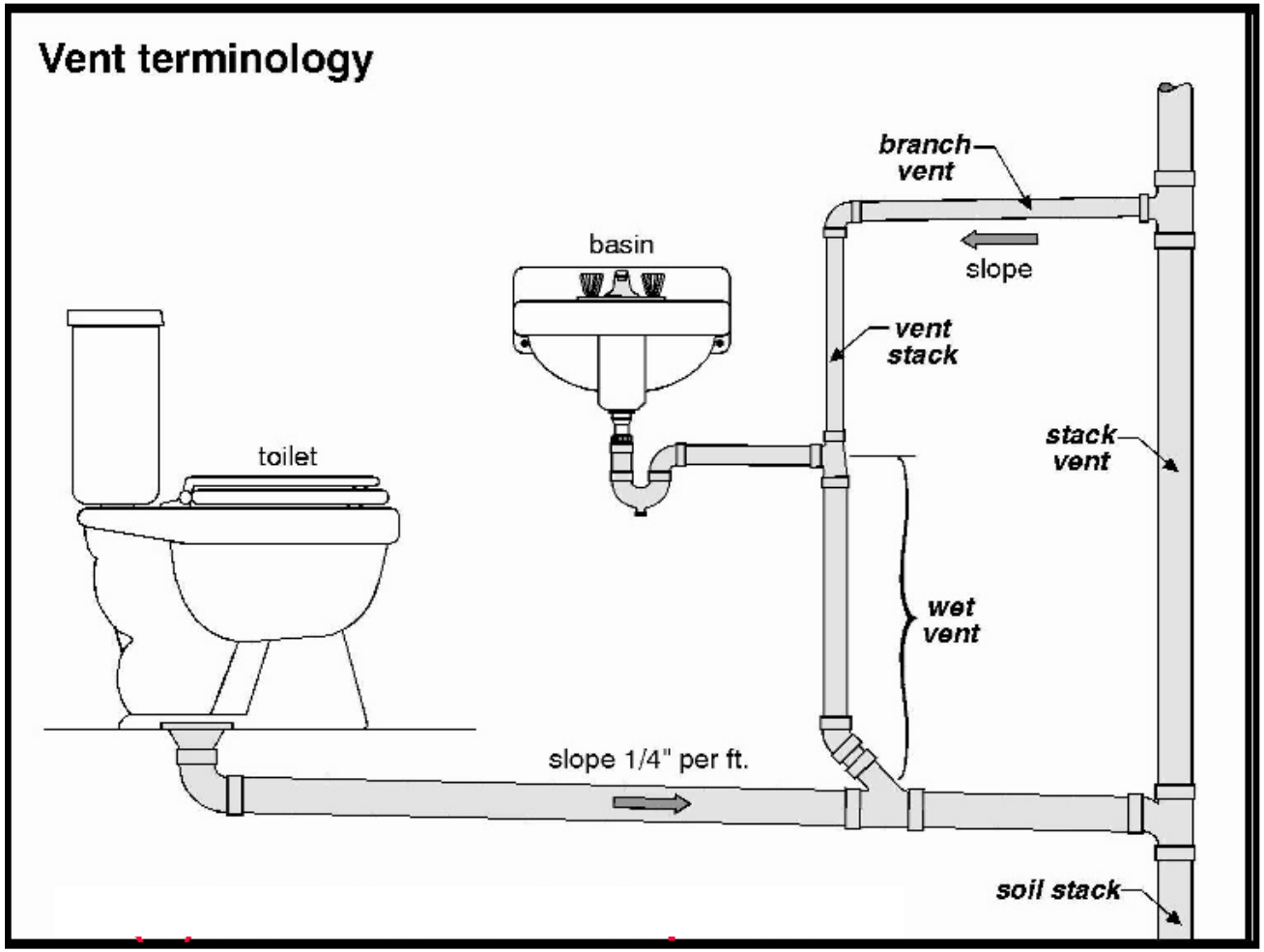
Sewer and drainage systems in buildings



Sewer and Drainage Systems

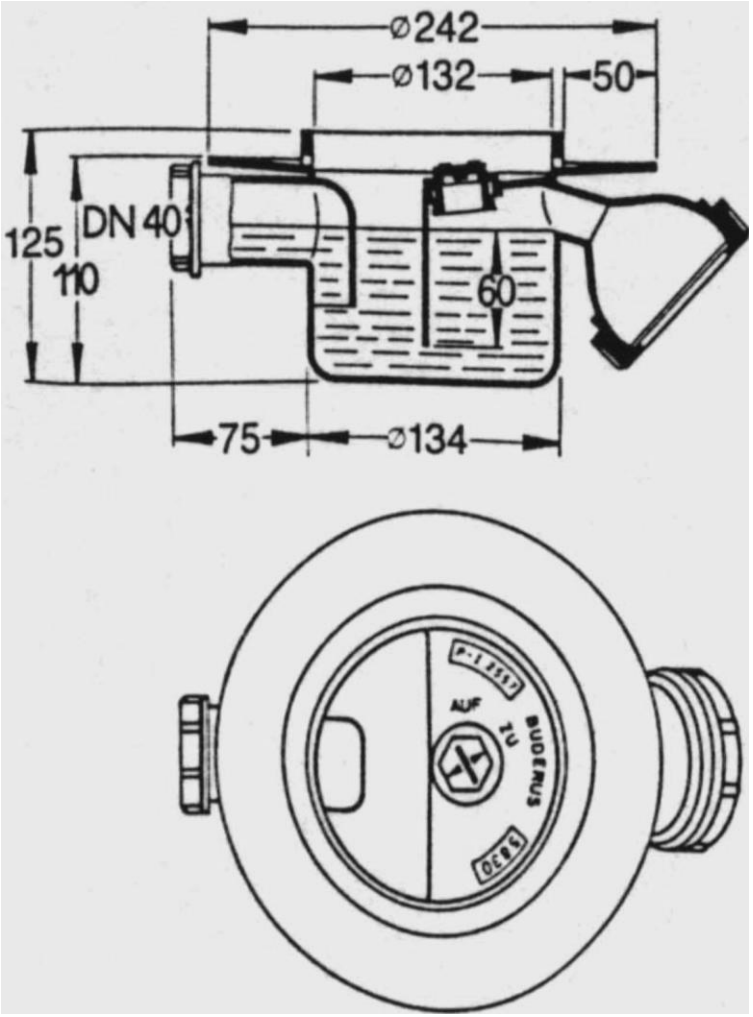
[Headquarters, Department of the Army (2001). Plumbing, pipe fitting and sewerage. Field Manual No. 3-34.471]

Vent terminology



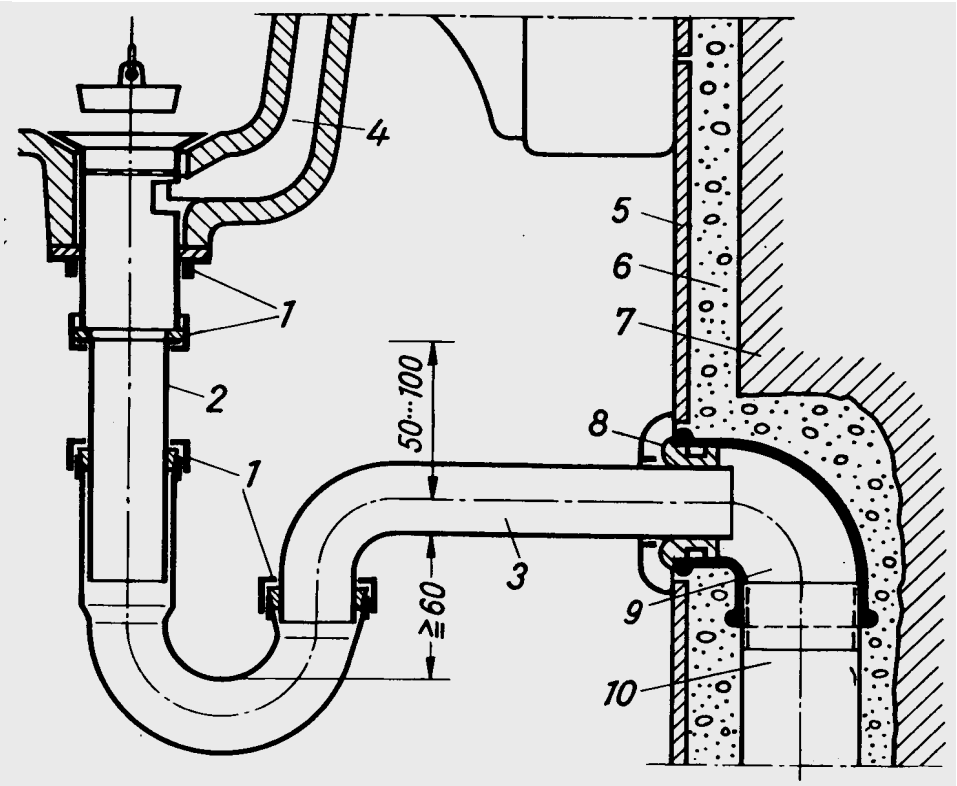
[http://www.inspectapedia.com/plumbing/Plumbing_Vent_Definitions.htm]

Roof gutter and basement drain inflow (DIN 4284) *(Decken- und Kellereinläufe)*

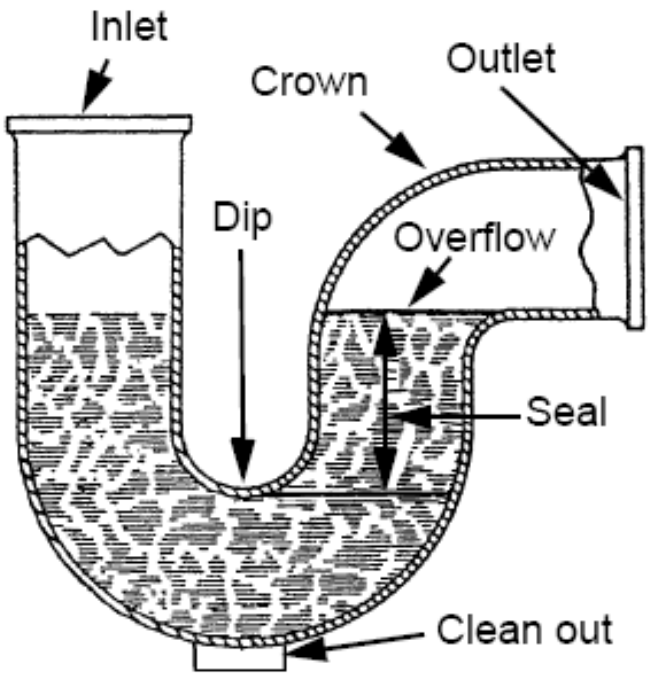


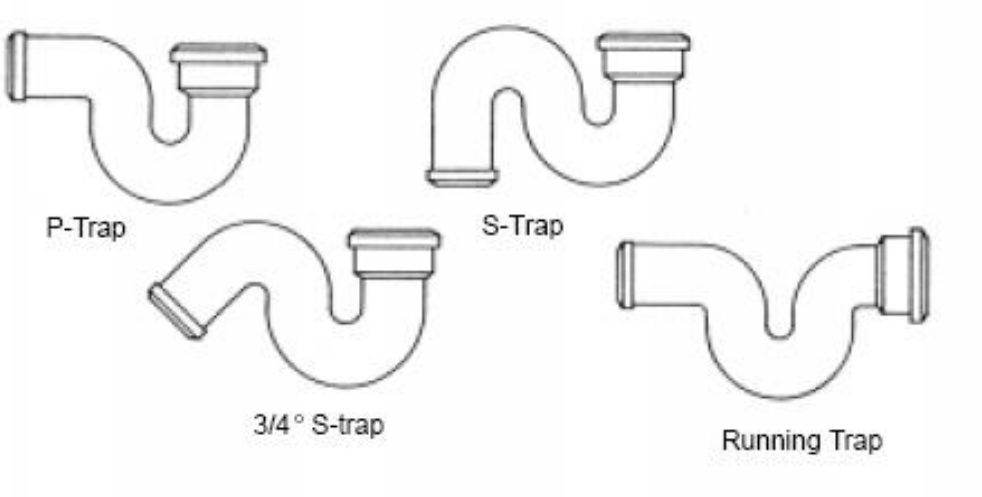
Drain smell trap *(Rohrgeruchsverschluss)*

1	Squeeze screwed joint
2	Adjustable torque tube 32/30 mm, yellow brass – chrome-plated
3	Pipe 32/30 mm, yellow brass – chrome plated
4	Washbasin overflow drain
5	Wall tile 150 x 150 mm
6	Mortar
7	Masonry
8	Elastic pipe connection with H-rubber nipple
9	Fitting, Elbow, DN 40
10	Downspot - Steel pipe DN 40, galvanized



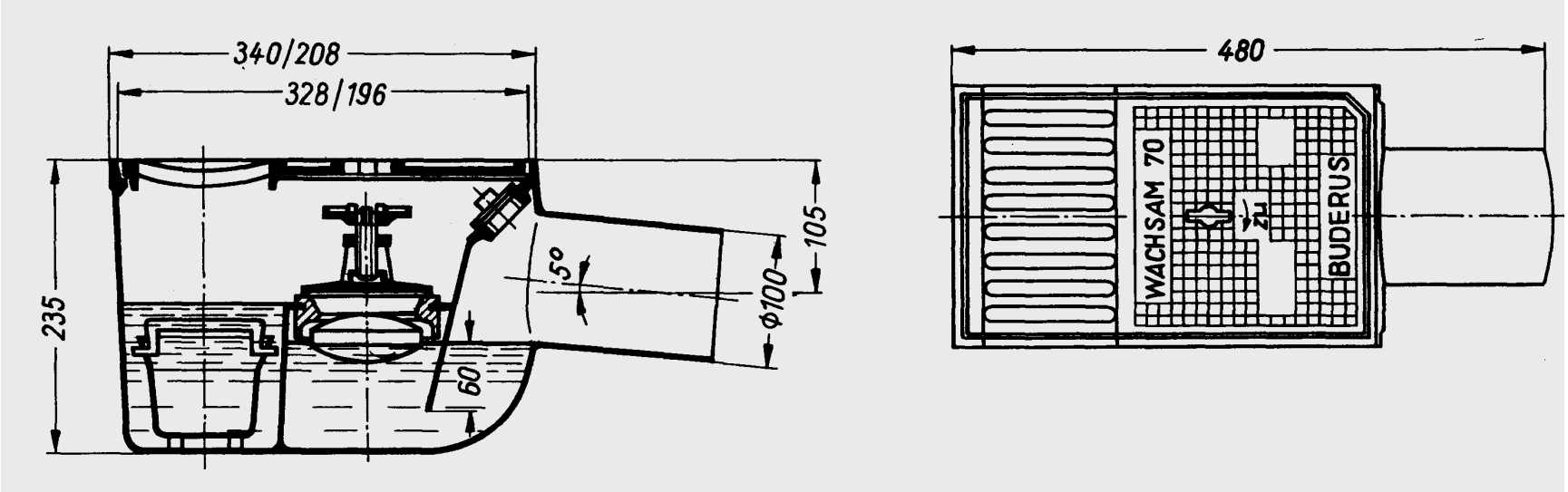
Drain smell trap



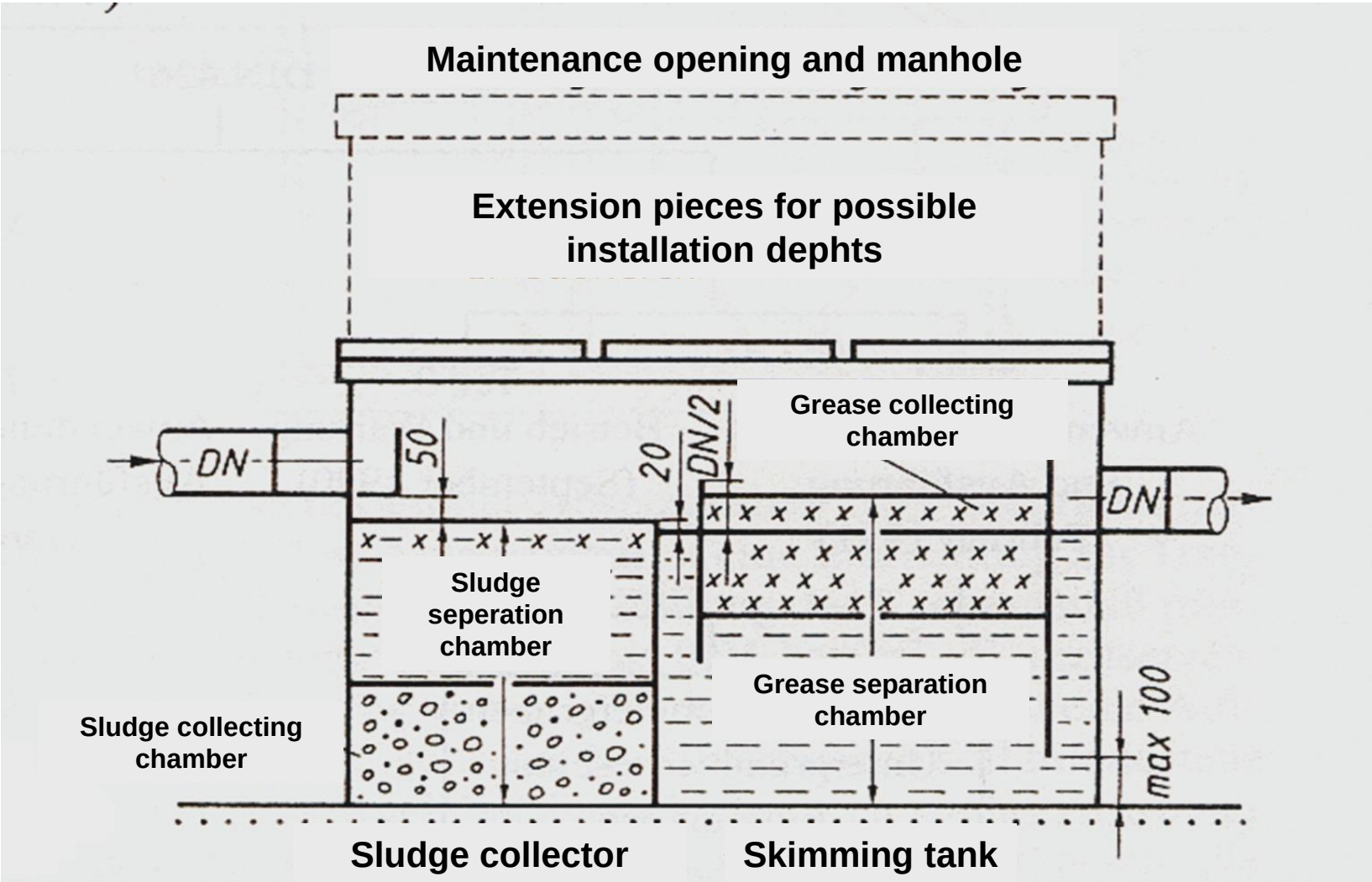


[Headquarters, Department of the Army (2001). Plumbing, pipe fitting und sewerage. Field Manual No. 3-34.471]

Basement drain outflow with double backflow seal *(Kellerablauf mit doppeltem Rückstauverschluss)*



Grease skimming tank *(Fettabscheider)*



Drainage treatment, -techniques and -systems according to DIN 4045

Drainage treatment	Combined system and variants	Separate sewage system and variants
Drainage techniques	Gravity sewer system	Pressure drainage system, vacuum drainage system
Drainage systems	Drainage systems, for example: infiltration basin, sewer line, storm water tank	

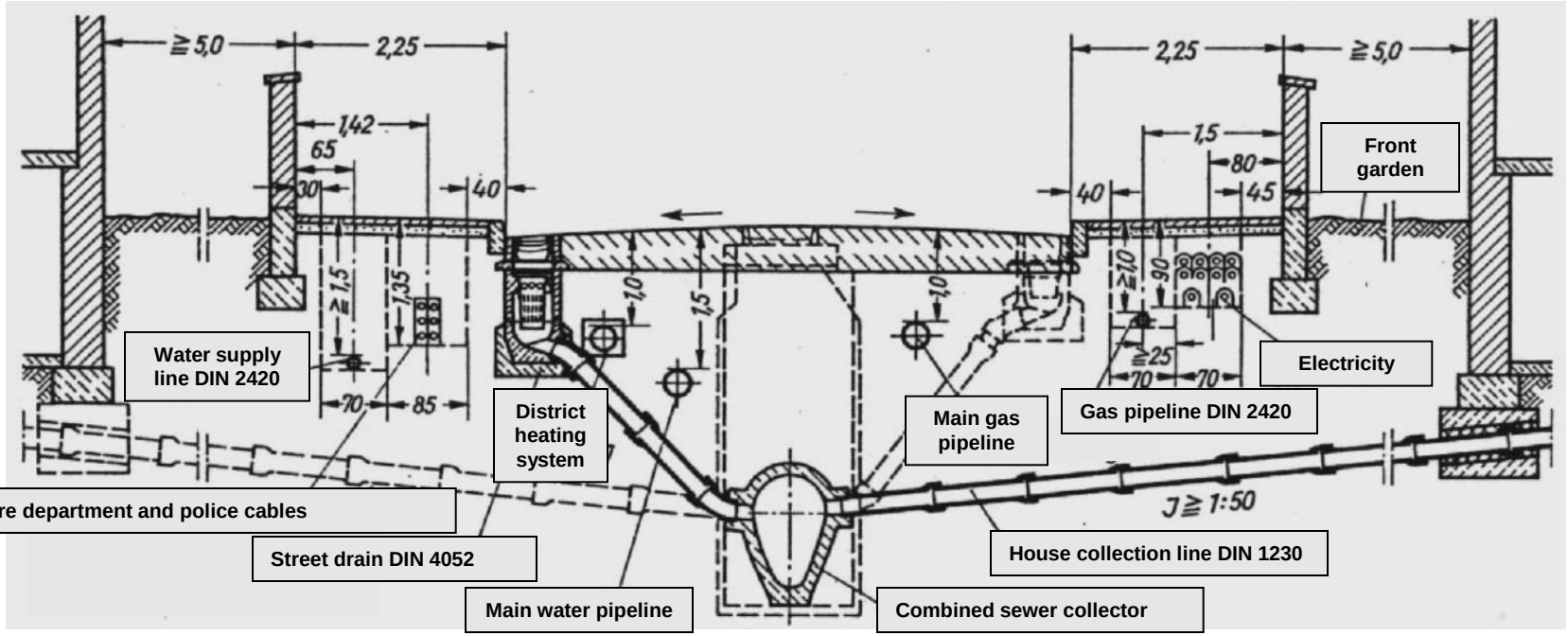
[Geiger,W.F., 2003]

Sewer system

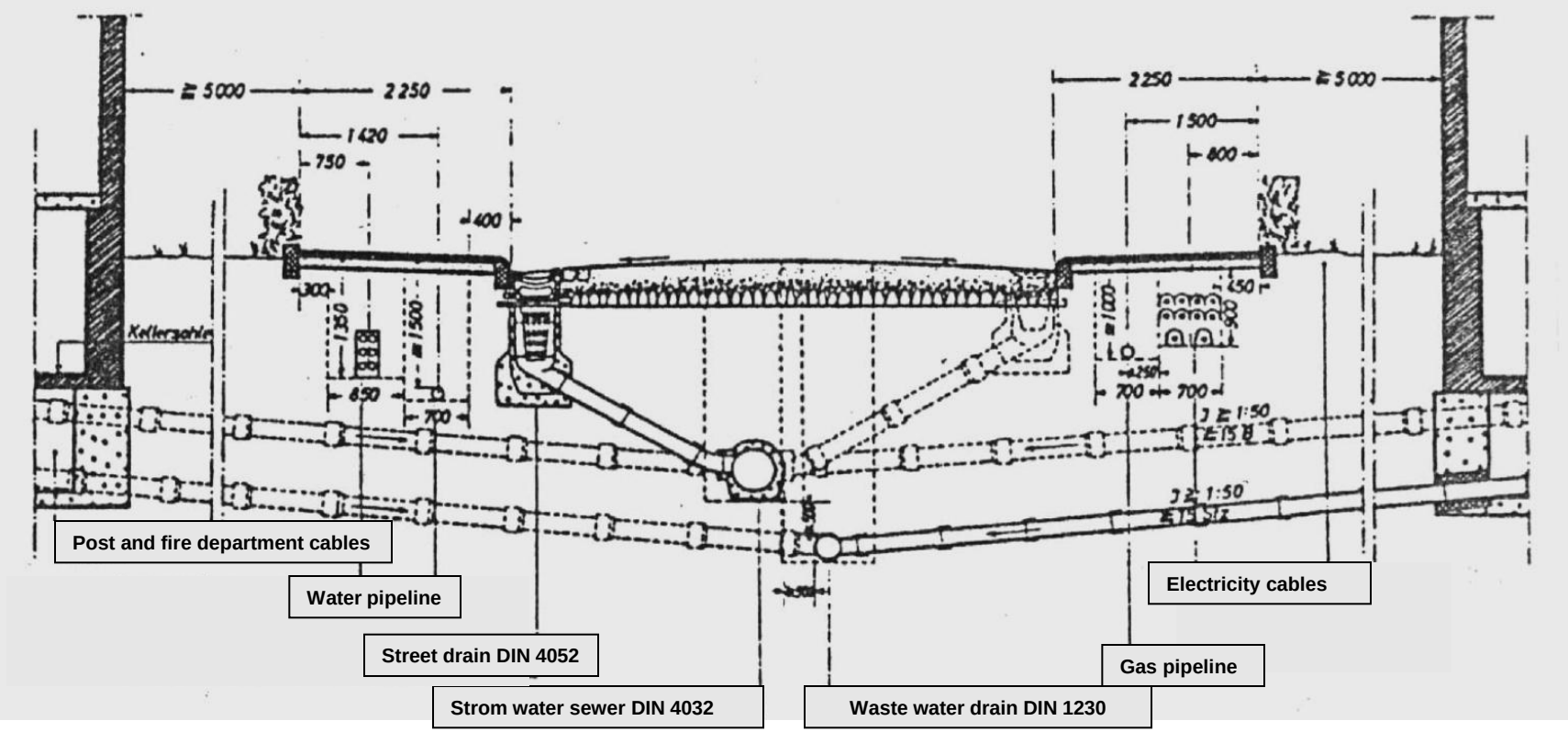
The local sewer system‘s *(Ortsentwässerung)* **objective and purpose** is the fast, flawless and perfect removal of all types of waste water from households, businesses and industries as well as the removal of precipitation water *(Niederschlagswässer)* from parcels and streets.

A **good operating local sewer system** is a prerequisite for a flawless hygiene, a good life standard, a necessary water pollution control *(Gewässerschutz)* as well as a healthy economical development.

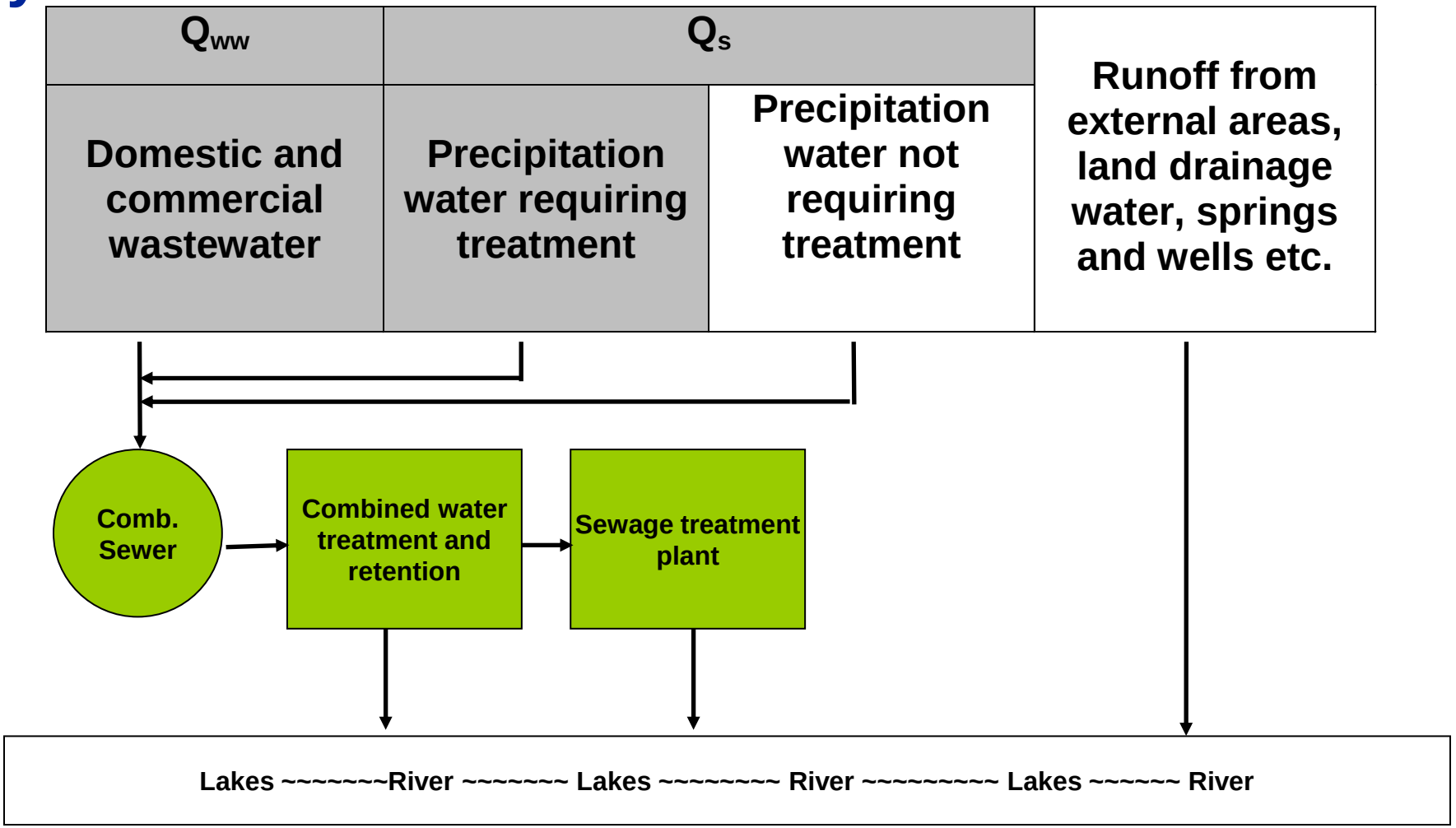
Sewer's position in road cross section for a combined system



Sewer's position in road cross section for a separate sewer system

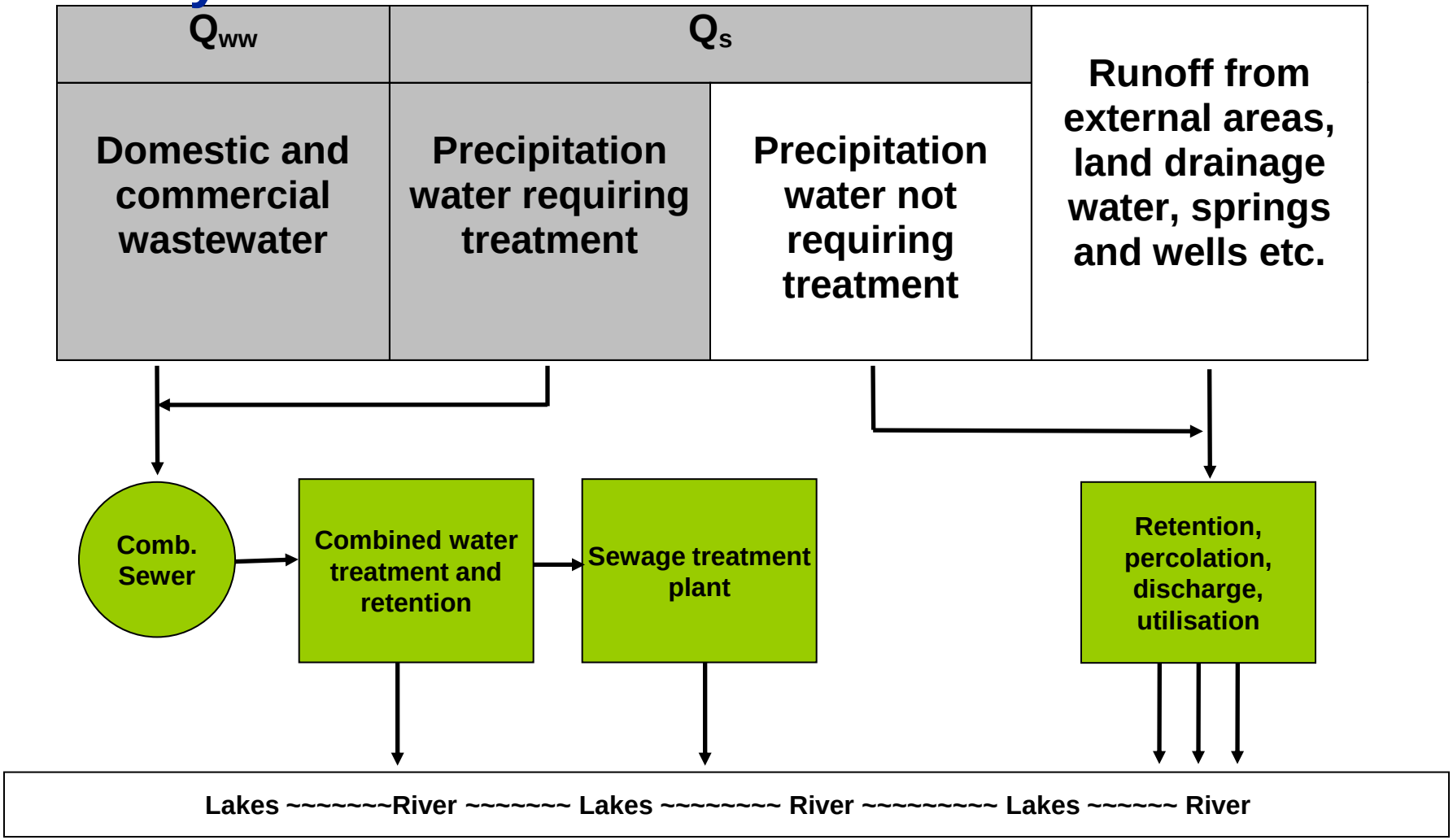


Schematic diagram of combined sewer system



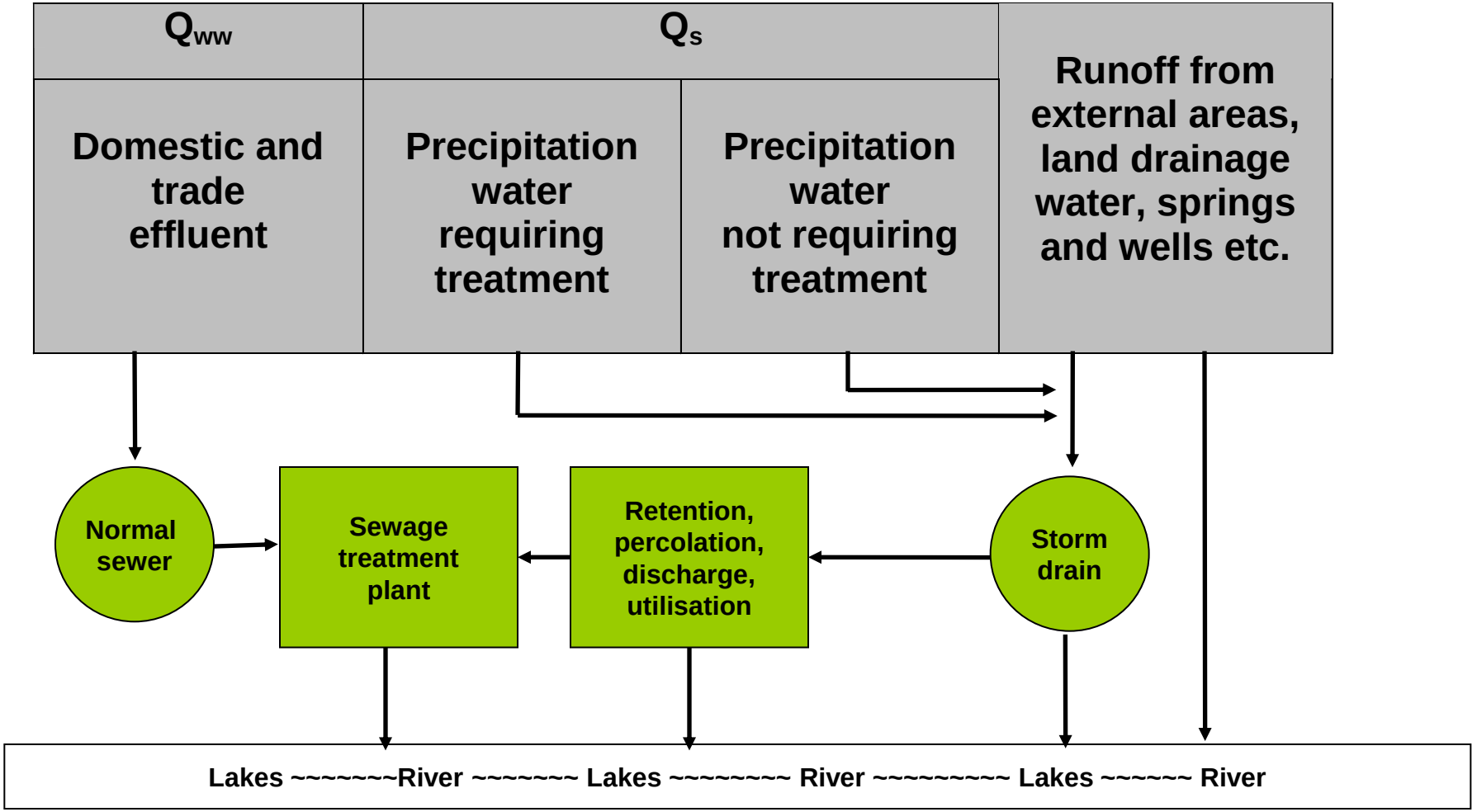
[Geiger,W.F., 2003]

Schematic diagram of modified combined sewer system



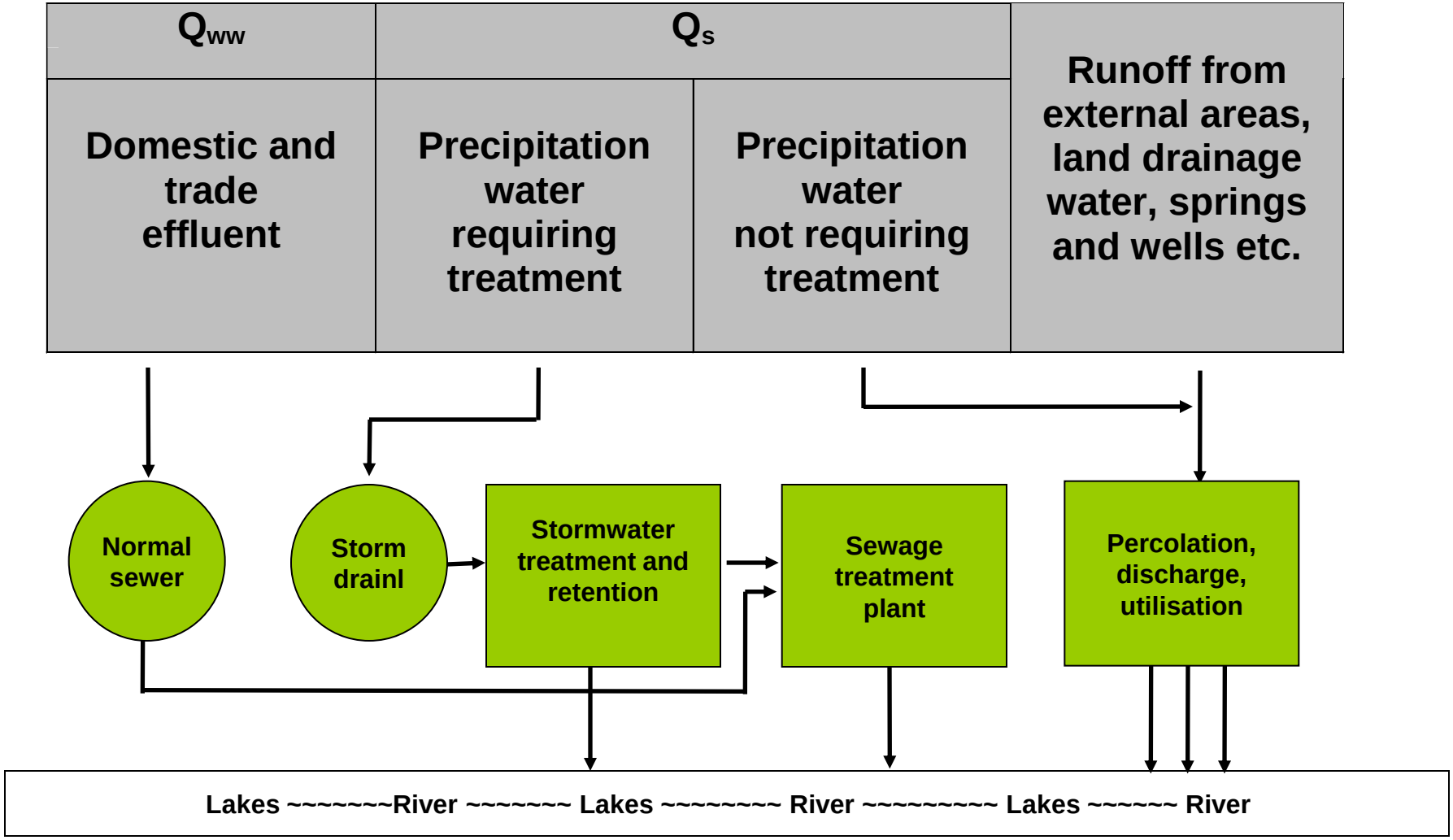
[Geiger,W.F., 2003]

Schematic diagram of separate sewer system



[Geiger, W.F., 2003]

Schematic diagram of modified separate sewer system



Comparison between separate sewer system and combined system

Element	Separate sewer system	Combined sewer system
Wastewater treatment plant	• Only receives wastewater, thereby has an even inlet. • Good wastewater treatment technique. • Storm-water tanks are not necessary. • Road salt is kept away. • Small design values, low cost operation.	• Because of dry and rainy weather inflow uneven water loads. Bad wastewater treatment technique. • Storm-water tank necessary. • Road salt is added, interference with water treatment (biology and sludge digestion • Bigger design values, expensive operation.
Receiving body	• Untreated effluent of rainwater. • No waste water flows into the receiving water.	• By heavy rain combined sewage outflow. • During light rain small loading of the receiving water.
Wastewater elevation	• Mostly only necessary for wastewater, small pump stations. • Low cost operation	• Besides the dry weather pumps, big rainy weather pumps are necessary too, which only work some hours/year. • Big stations, expensive operation.
House connection line	• Two connecting sewers necessary. • Possible errors in the sewer connections. • Basement backwater because of rainwater and receiving body not possible.	• One connecting sewer enough. • Errors in the sewer connections not possible. • Possible backwater flow back into the basement.
Street sewage system	• Two street sewers with the necessary manhole structure necessary, higher construction costs. • Bad accommodation by the lack of space in the road bed. • Minimum downward gradient for wastewater sewer must be complied, otherwise sedimentation/deposits • Ground and cooling water collection only possible in the rainwater sewer. • Resistant pipeline materials (stoneware) can be-installed cost effective because of the small wastewater sewer profiles.	• One street sewer enough. • By equal wastewater connecting sewer level bigger sole depth. • Little space requirements in road bed. • Gradient can be smaller than in the wastewater sewer. The hydraulic radius is for the dry weather flow good too. High scavenging while rainy weather. • Ground and cooling water can be collected. • The lining with profiled shells or cement clinker and the application of concrete-ceramic pipes is expensive. • Discharge structure is necessary
Sewage system maintenance	• Sedimentation in the first section of the sewer and because of small gradients in the wastewater sewer. • Long-sized sewer because of the double pipeline	• Rinsing from rainy weather flow reduces the maintenance costs. • Pipe longitudes are only half as long as the ones from separate sewage system

Pressure sewer system

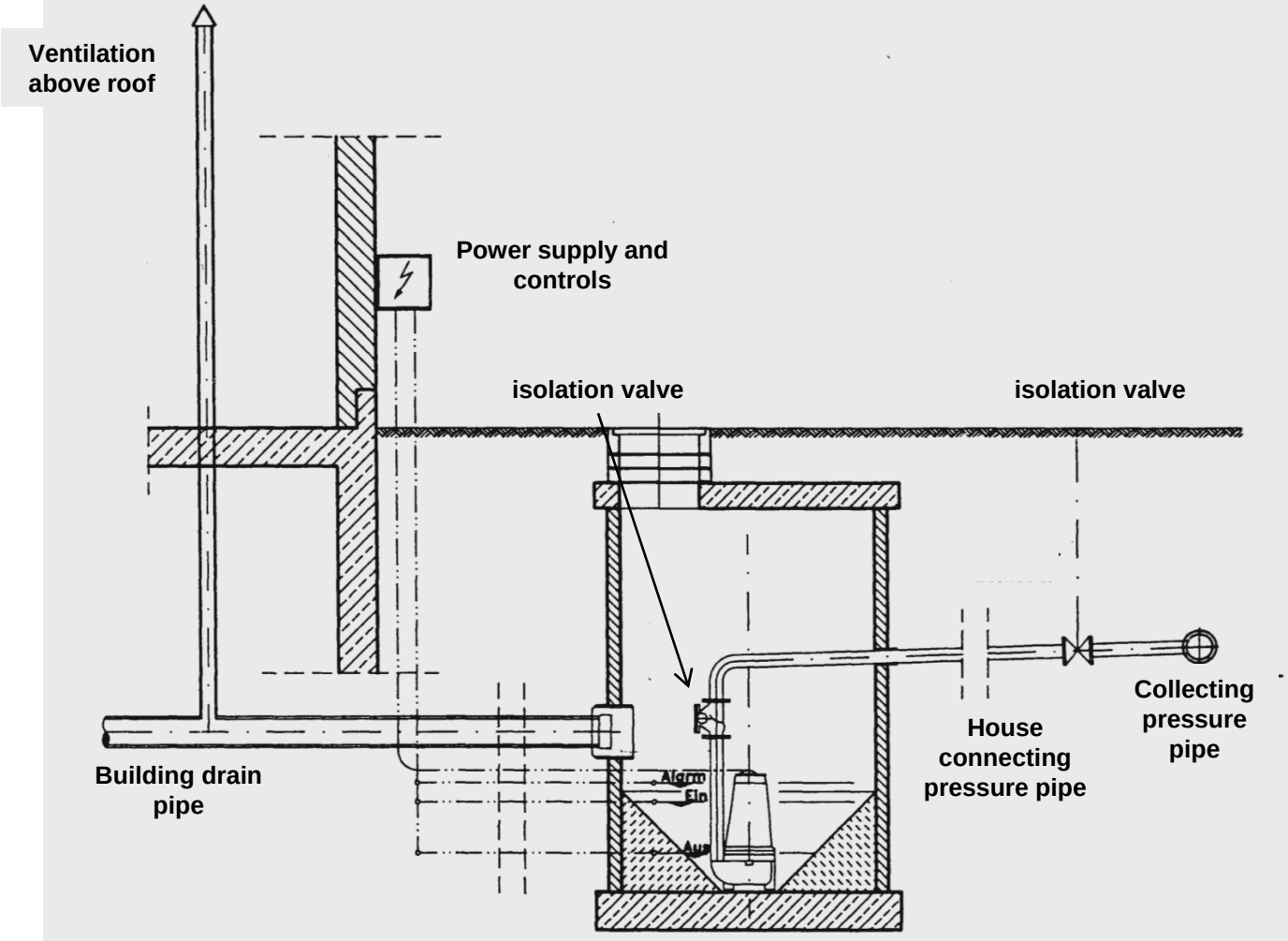
Pressure sewer system (PSS) ATV A 116, DIN EN 1671

High pressure ≥ 2 bar, pneumatic; low pressure: submersible motor *(Niederdruck Tauchmotor)*.

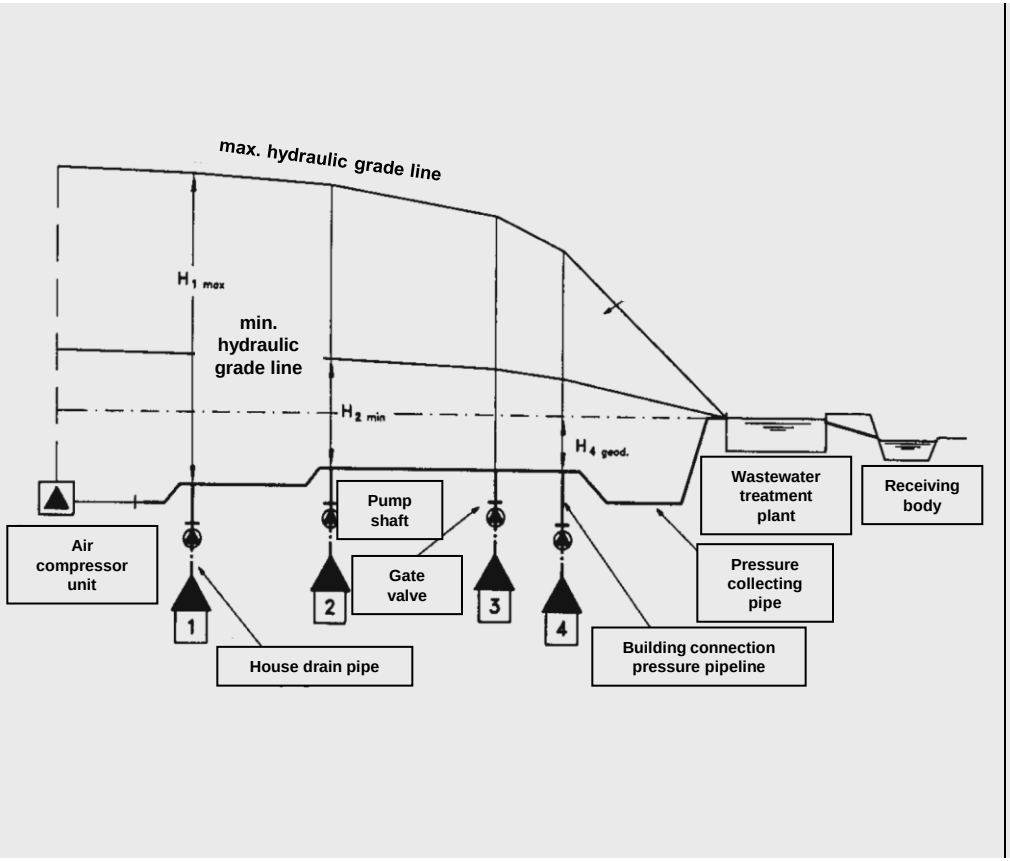
A pressure sewer system consists mostly of the following substantial components:

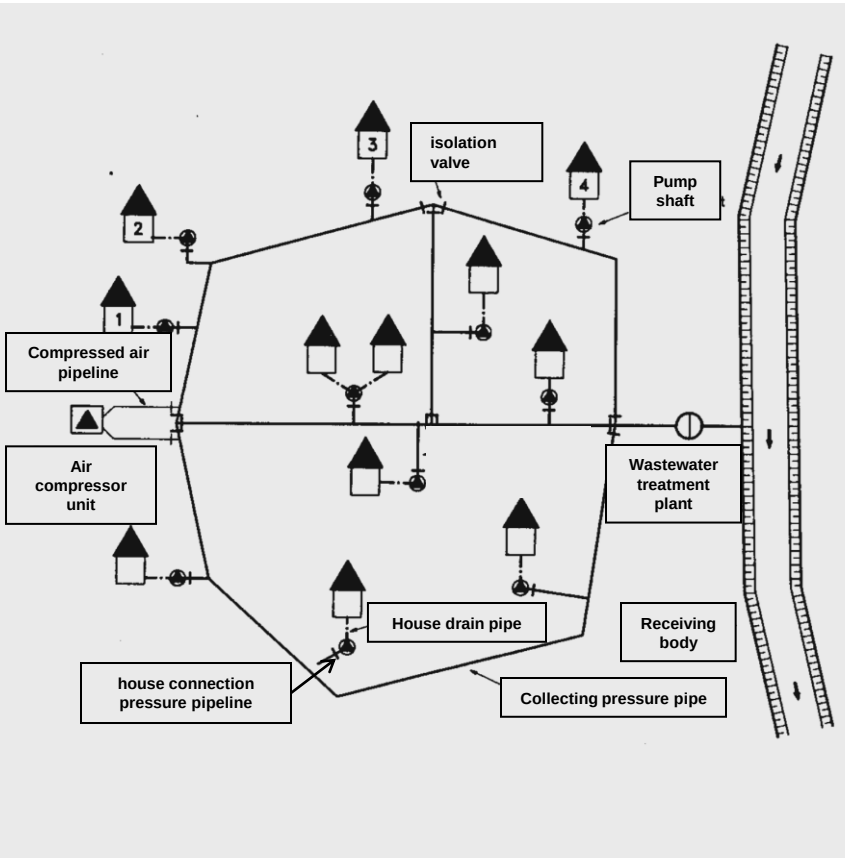
- Gravity building drains
- Waste water collecting chamber *(Schmutzwassersammelschacht)* with submersible motor
- House connecting pressure pipe *(Anschlussdruckrohrleitungen)*
- Pressure main *(Sammeldruckrohrleitung)* ≥ 100
- Air compressor unit *(Druckluftspülstationen)*

Scheme of a pressure sewer



Scheme of a pressure drainage system



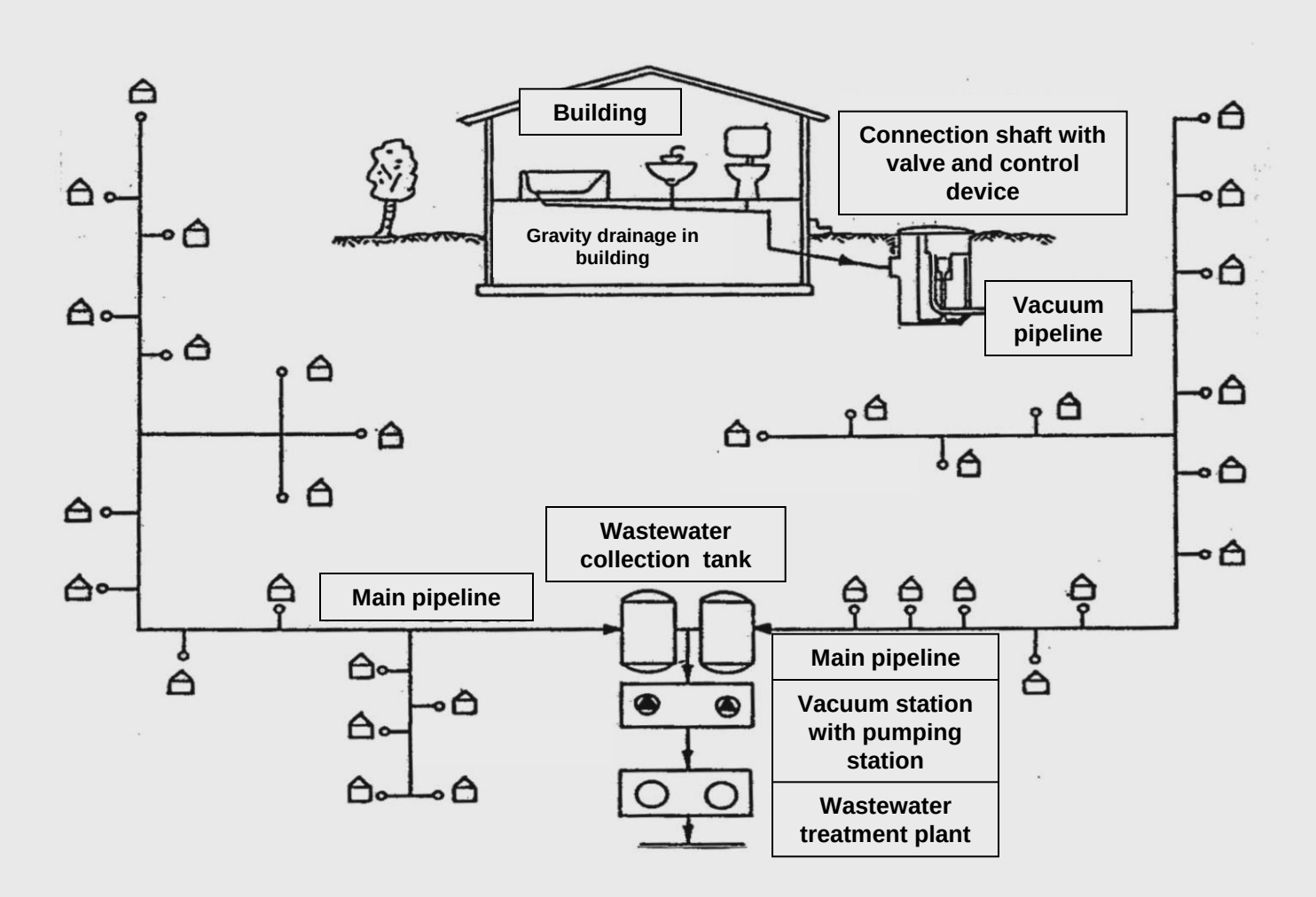


Vacuum sewer systems

A **vacuum sewer systems** *(Vakuumentwässerung)* consists basically of the following system parts:

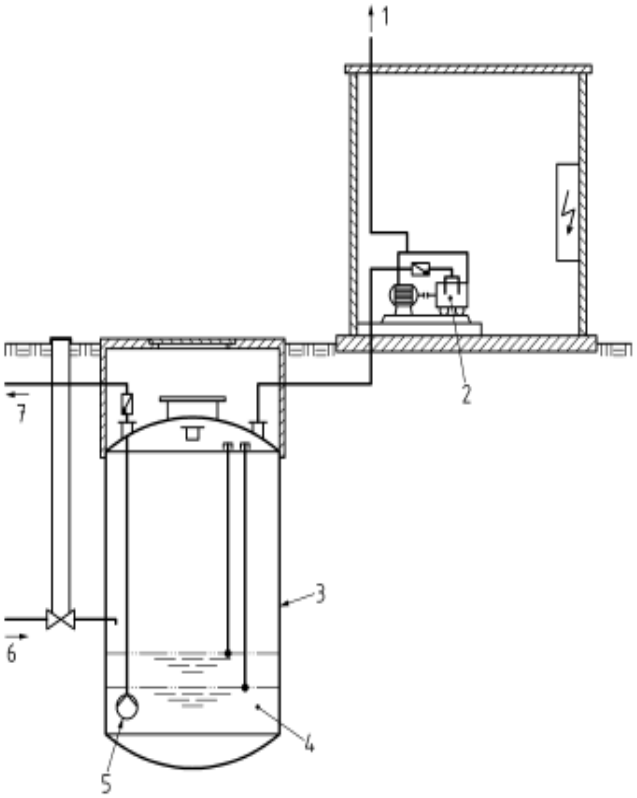
- Domestic connection with delivery valve *(Übergabeventilen)*.
- Vacuum toilets (with own valve possible), 1.2 l water and 100 l air
- Piping network: Minimum nominal size DN 65, max. ΔH 1 - 4 m, every 40 - 60 m low-points are necessary.
- Vacuum station that generates 0.6 – 0.7 bar sub pressure.
- Pumping station for conveyance *(Weiterförderung)* (hydraulic or pneumatic).

Scheme of a vacuum sewer system



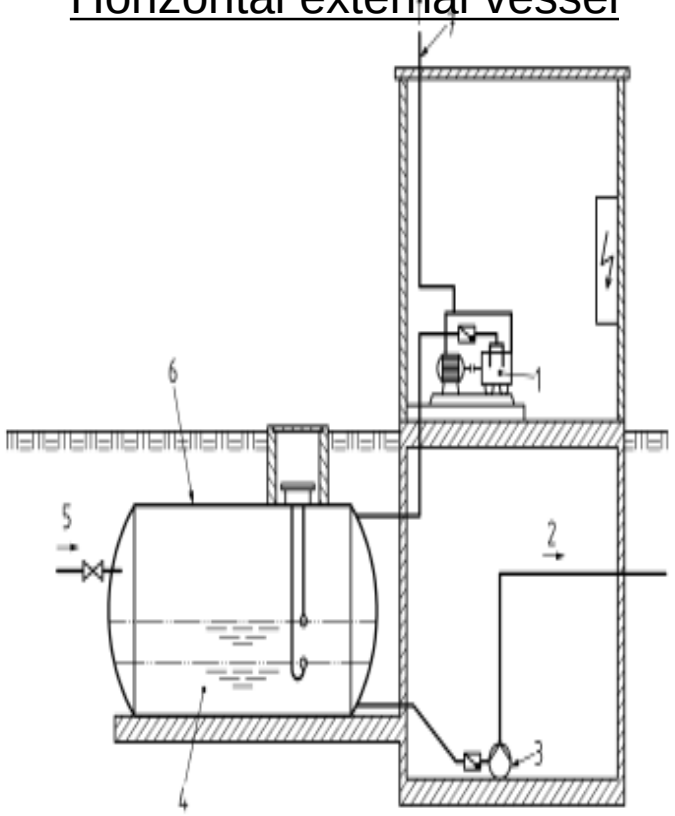
Scheme of a vacuum station with hydraulic conveyance

Vertical external vessel



1 vent
2 vacuum pumps
3 vacuum vessel
4 sewage
5 submersible forwarding pumps
6 from vacuum sewer
7 rising main

Horizontal external vessel



1 vacuum pumps
2 rising main
3 forwarding pumps
4 sewage
5 vacuum sewer
6 vacuum vessel
7 vent

Elevation profile of a vacuum sewer