Gesellschaft für Grundbau
und Umwelttechnik mbH

Verification of groundwater influence of sealing clays by a modified testing method

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Who and what is GGU mbH ?

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  - Environmental Engineering

- Accredited Laboratories
  - Soil Mechanics
  - Polymer Technology

- Materials Testing
  - Landfill Engineering
  - Recycling Technology
  - Product Development

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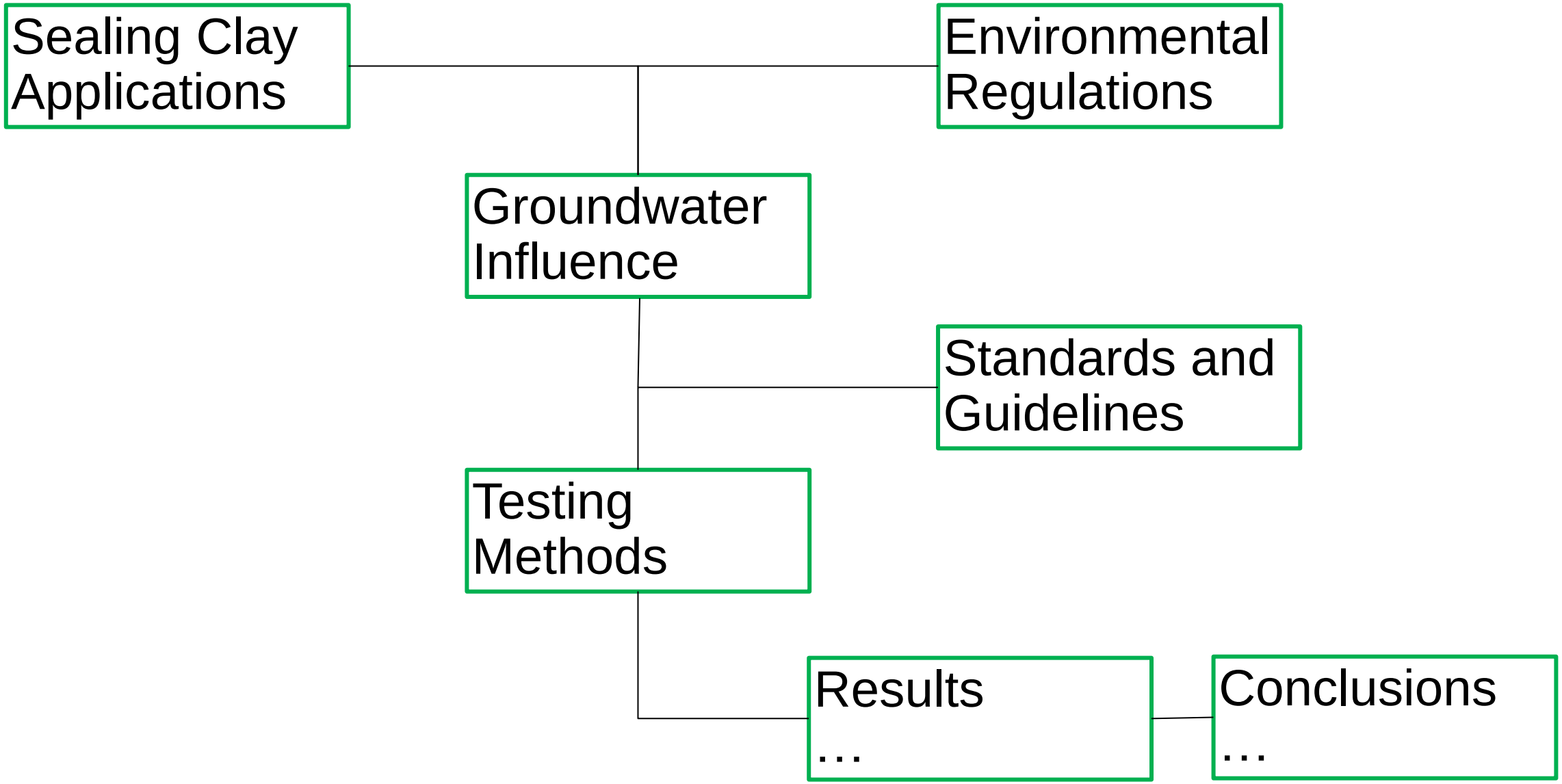
Introduction

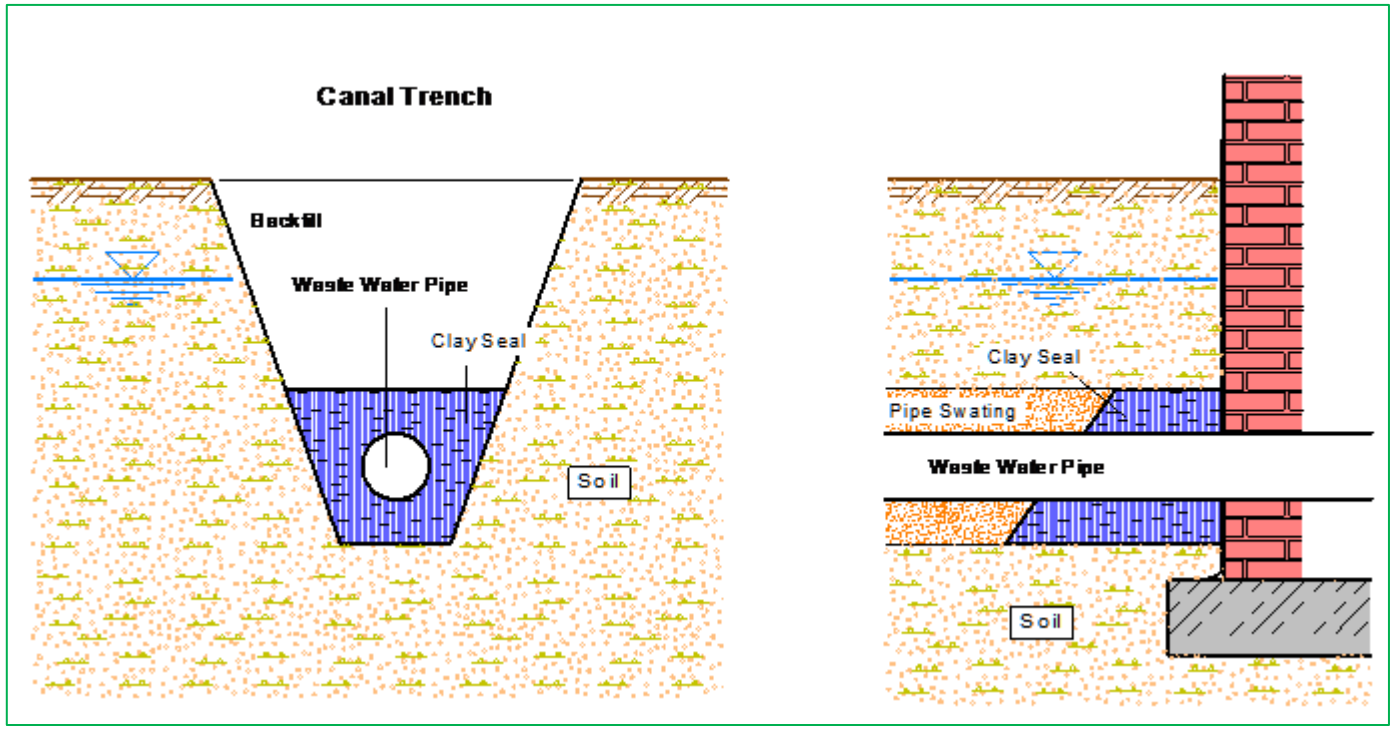


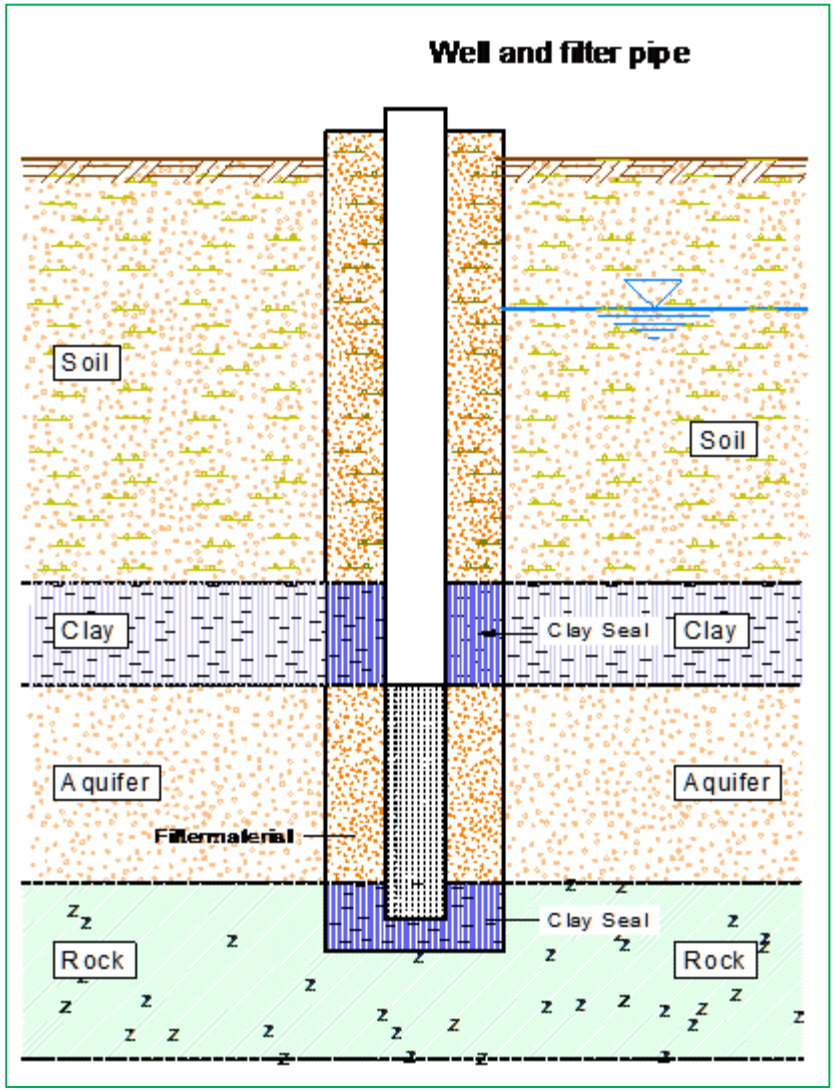
Rules and Regulations . Standards and Guidelines

- LAWA 2002 Principles of precautionary groundwater protection in waste recycling and product use, GAP Paper
  (Grundsätze des vorsorgenden Grundwasserschutzes bei Abfallverwertung und Produkteinsatz)
- DIBT 2011 Principles for the Evaluation of the effects of Products on soil and groundwater
- LAWA 2016 Derivation of threshold values of significance for groundwater
  (Ableitung von Geringfügigkeitsschwellenwerten für das Grundwasser)
- BBodSchV Federal Soil Protection and Contaminated Sites Decree
- LAGA EW 98 T Guideline for the procedure for physical and chemical analysis of waste, contaminated soil and materials from contaminated areas, Creation and analysis of aqueous eluates
- EN 1744-3:2002 Tests for chemical properties of aggregates-Part 3: Preparation of eluates by leaching of aggregates
- DIN 4904 Poured sealing clay for well construction, Requirements and testing

Sealing Clay Applications

- Pipes and Wells
  - Placement and controlled compaction
  - Uncompacted Insertion
  - Self compaction and self sealing properties

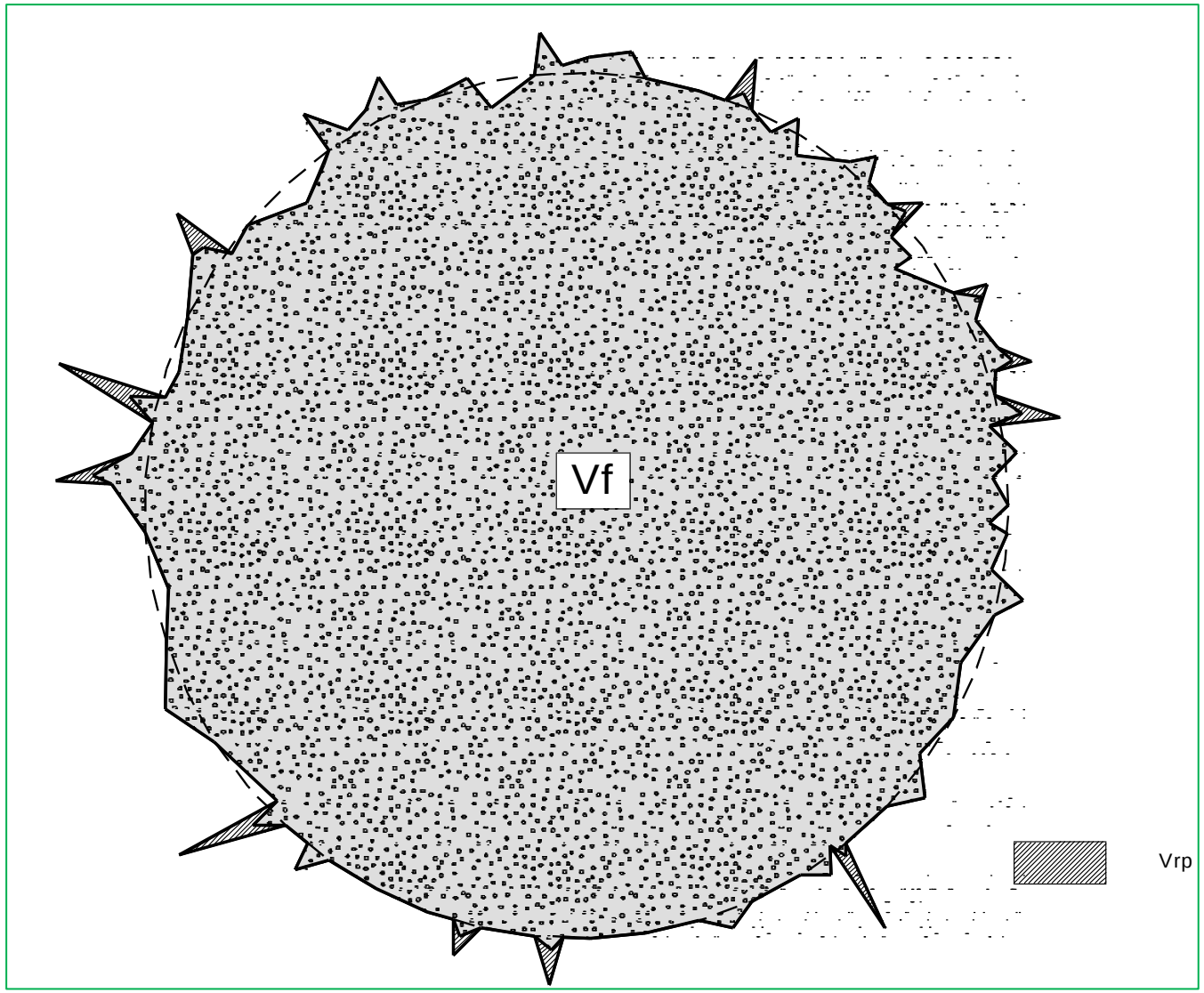




Sealing Clay Applications

- Mine Shaft (vertical)
- Vertical Mine Deposits
  - Placement under water
  - Self compaction properties
  - Self sealing properties

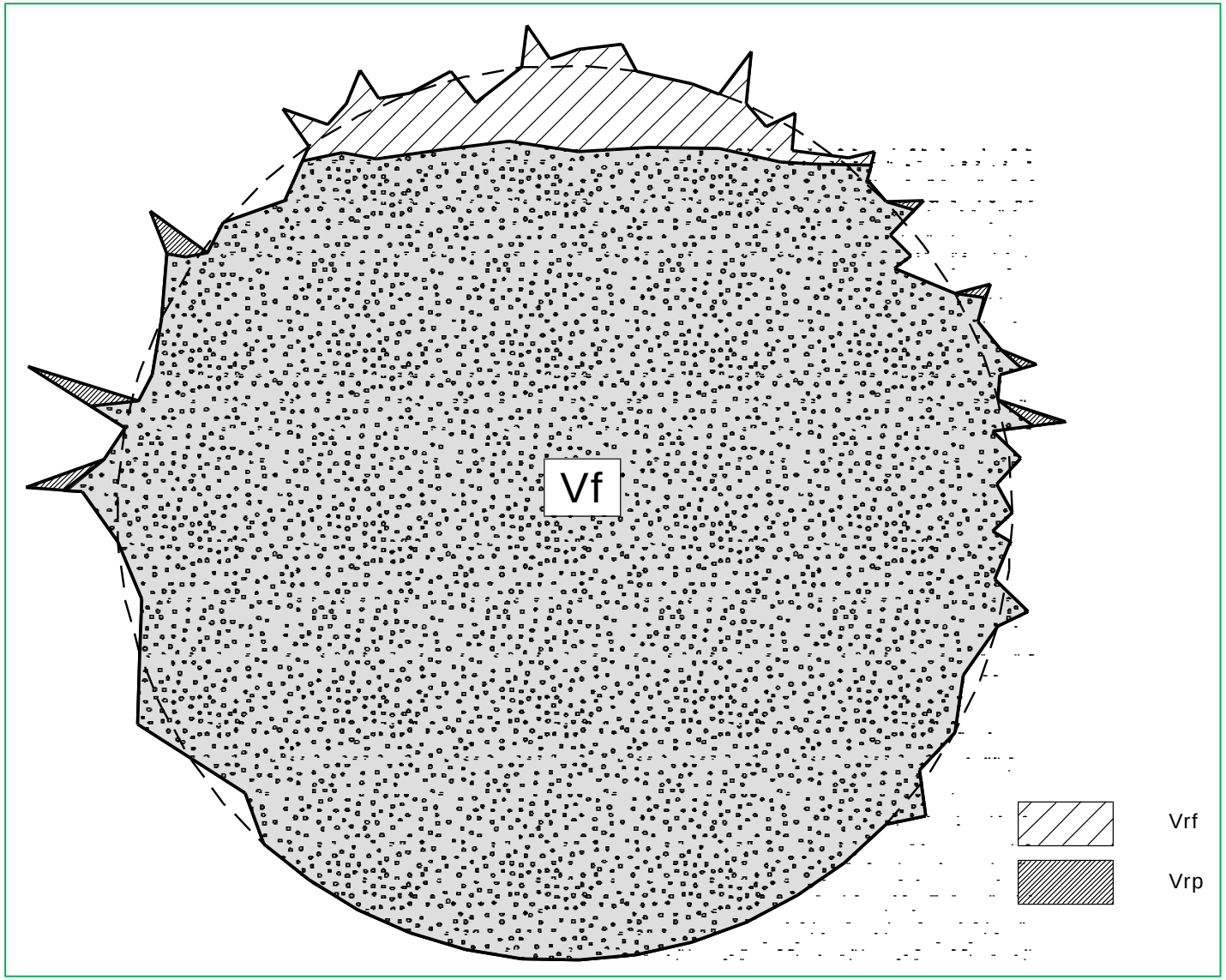
- Permeability ?
- Groundwater Exposition ?



Sealing Clay Applications

- Mining Tunnels
- Deposit Chambers
  - Placement by pneumatic methods
  - Self compaction properties
  - Self sealing properties

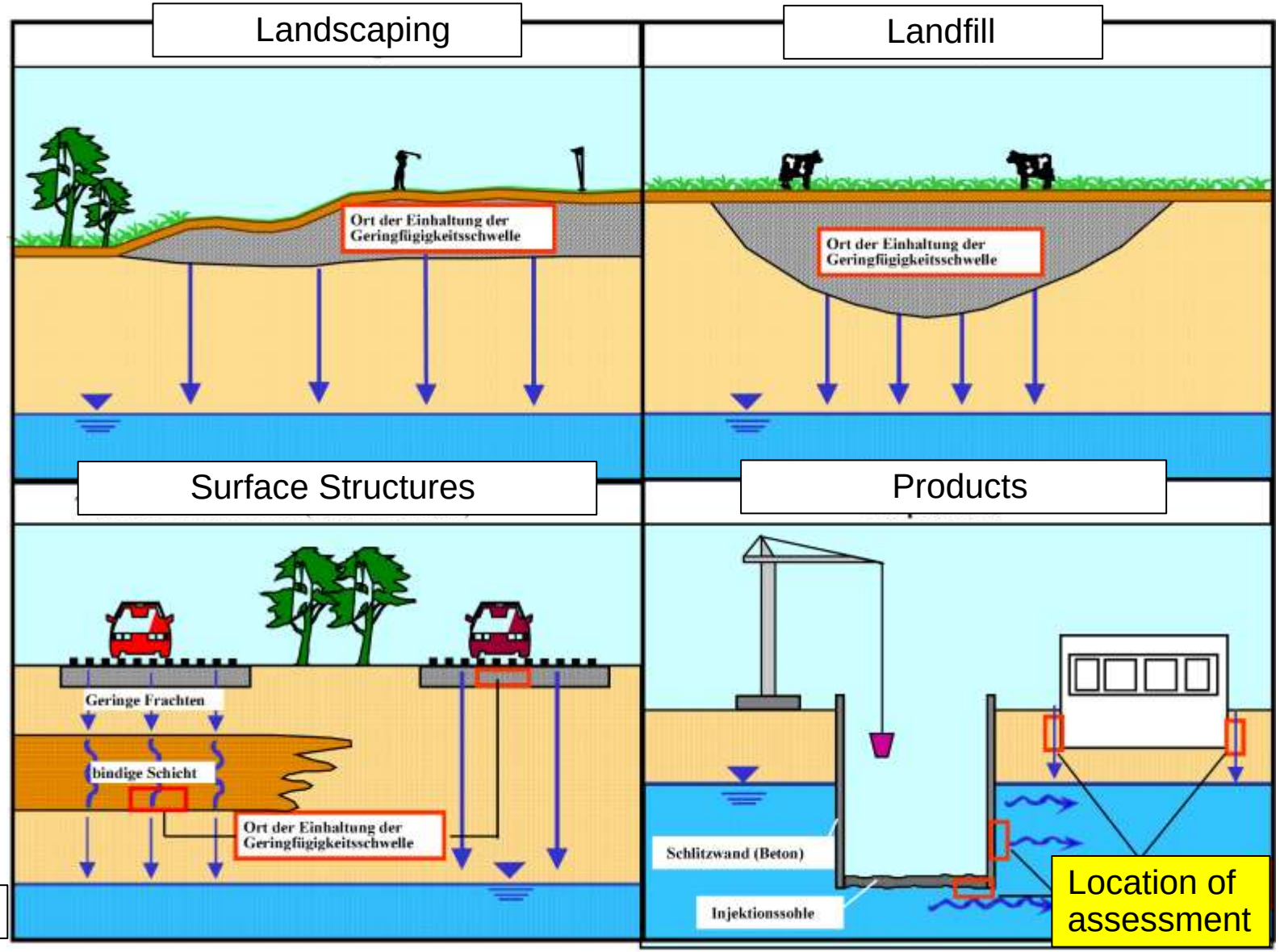
- Permeability ?
- Groundwater Exposition ?



Groundwater influence

- Protection of Groundwater
- Product introduction
- Location of assessment
- Saturated / unsaturated zone
- Seepage water / Percolation water
- Contact groundwater

  - DIBT 2011
  - LAWA 2002



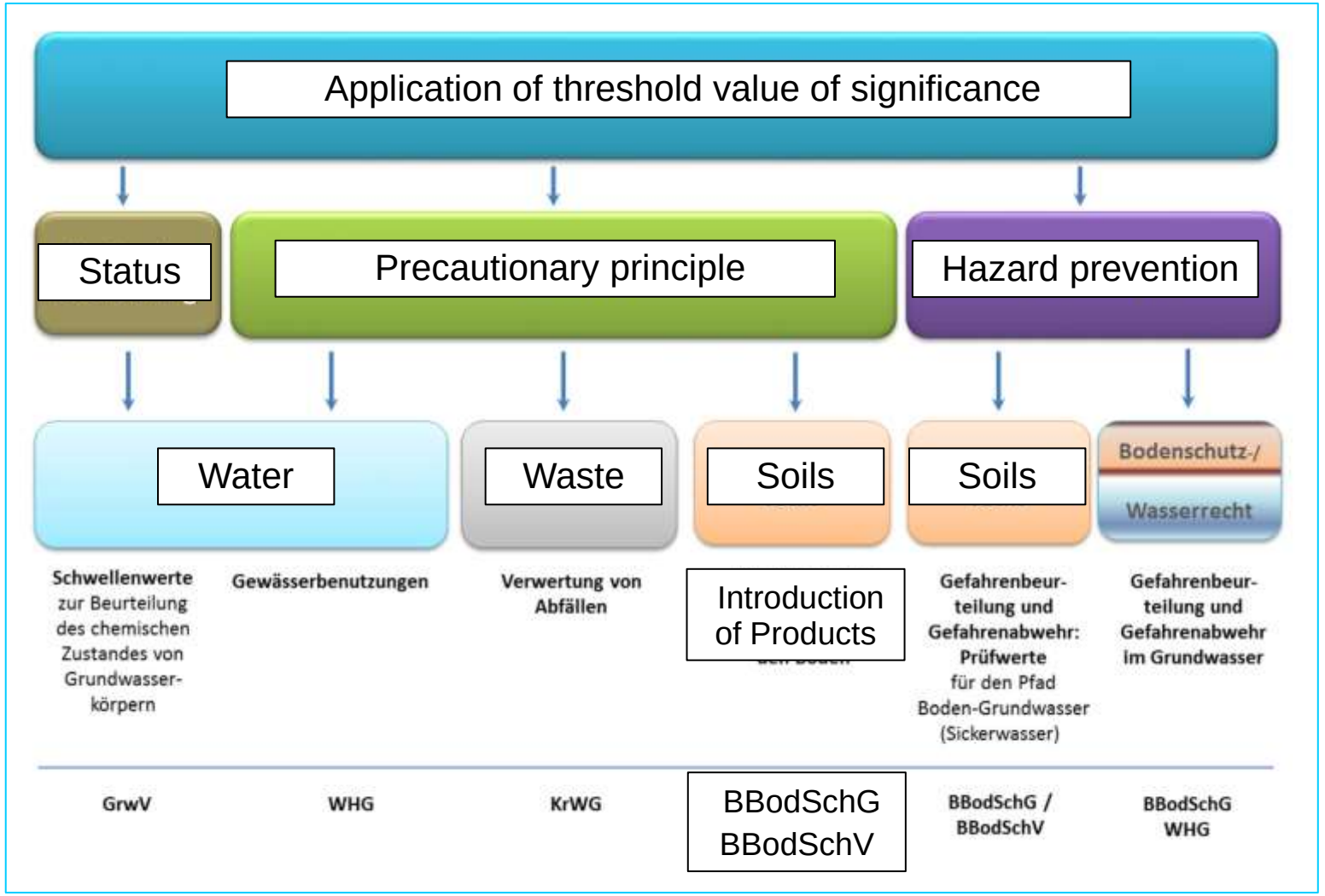
GAP, LAWA 2002)

Groundwater influence

- Seepage water / Percolation water
  - Leachate LAGA EW 98 S -> DIN EN 12457
    Product Matrix / Soil Matrix is destroyed → „Standard Leachate method“
- Surface / Contact groundwater
  - Lechate LAGA EW 90 T -> EN 1744-3
    Product Matrix / Soil Matrix /
    Product Properties are preserved → „Trough Leachate Method“
- Precautionary principle: Threshold value of significance

Groundwater influence

- Precautionary Principle
- Applicable Environmental Regulations
  - Groundwater LAWA 2016
  - Soils Law Soils Decree BBodSchV

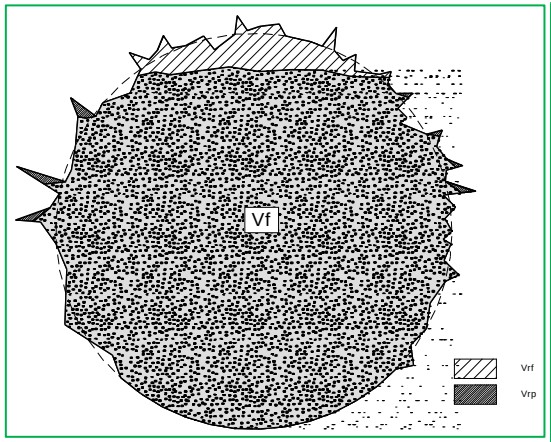


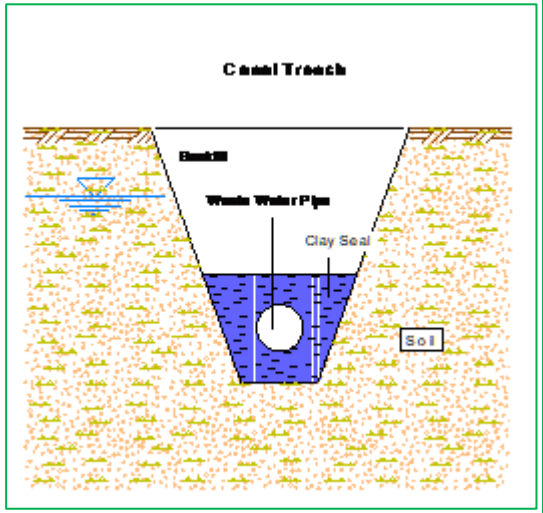
LAWA 2016

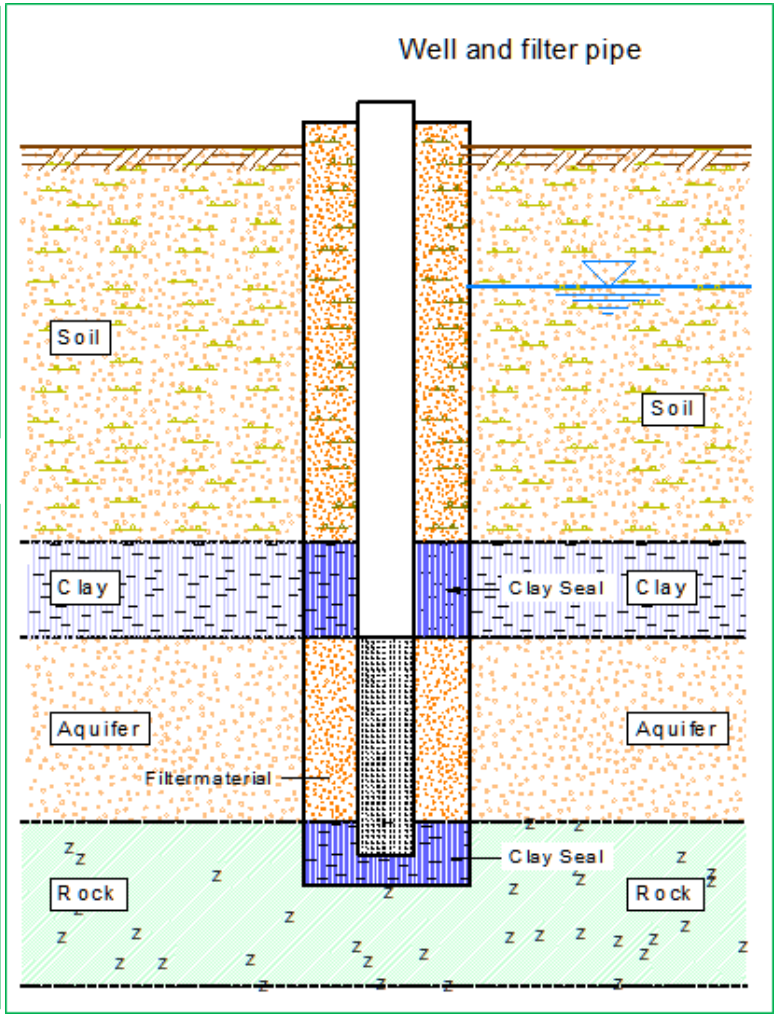
Product Properties

- Introduction of an impervious Product into the Environment
- Properties influenced by the placement procedure
- Groundwater Influence: Contact Groundwater
- Testing: Trough Leachate

- Principle:
  Preserving the properties of the product in
  <u>its installed condition !</u>







Product Properties

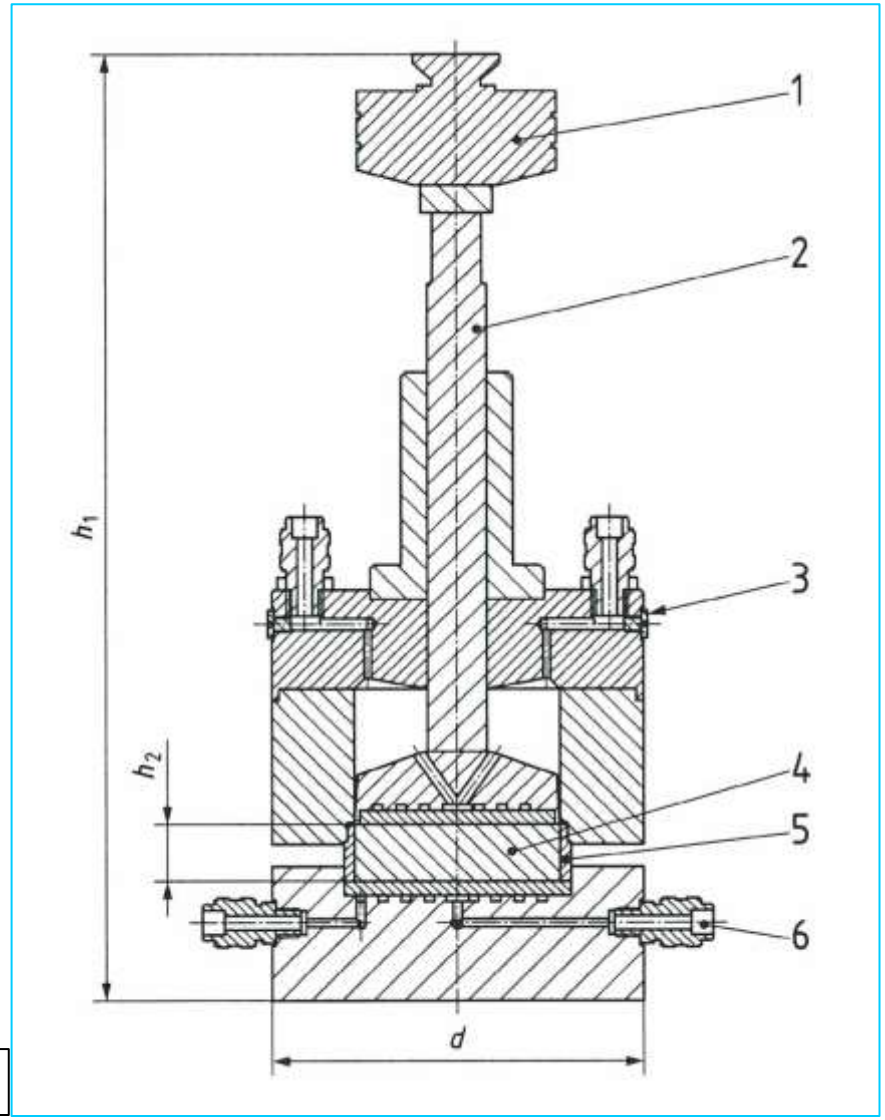
- Well construction
  - Phase 1, settling phase
    Pellets sink to the installation location, surrounded by water go into suspension, structural stability (DIN 4904)
  - Phase 2a, installed state
    Pellets have settled, self compacted, not covered, constant volume
  - Phase 2b, installed state in permanent condition
    Volumetric stability, self compacted and self sealed pellets,
    Swollen final state with constant volume
    Permanent condition of the installed material

  - Phase 2b: State of assessment and location of assessment !

Product Properties

- Self-compaction
  - Granular material „Pellets“
    - Optimum Bulk Density dry
    - Optimum Buoyant Density after Sink Phase
  - Bimodal material „Pellets“ + „Filler“
    - Intergranular voids fill

- Self sealing
  - Clay mineralogy (Smektites, Montmorillonites)
  - Swelling behaviour with water access
    - Swelling volume change (Softening, NO !)
    - Swelling pressure (Self Sealing, YES !)



DIN 4904

Product Properties

- Pellets Water Placement: Swelling and Self Sealing

Dry Placement

Self Sealing after water access. Constained volume change

Product Properties

- Bimodal Products Pellets and Filler
  - Self-Compaction
  - Swelling and Self Sealing

Dry Placement

Sample for Permeability Testing

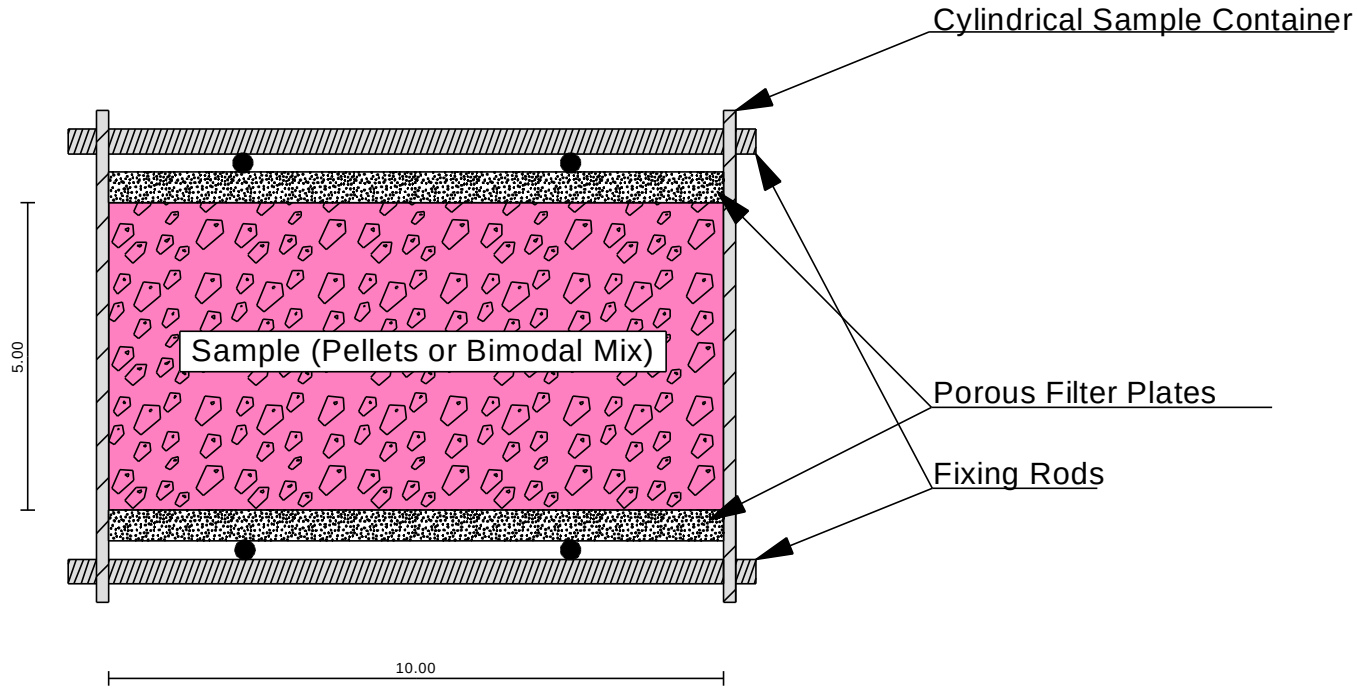
Sample after removal

Testing Methods

- Principle:
  Preserving the properties of the Product in its installed condition
  - Unrestricted water access but volumetric stability
  - Trough leachate method

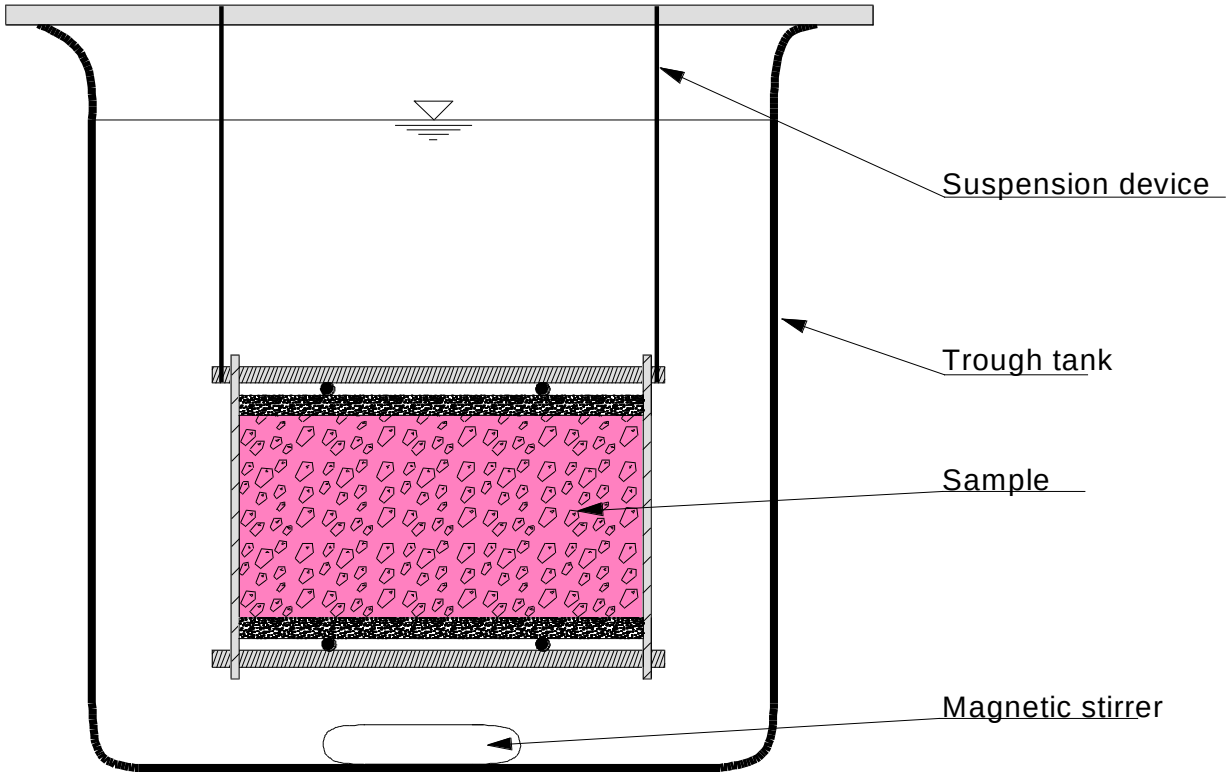
Testing Methods

- Principle:
  Preserving the properties of the Product in its installed condition
  - Constant volume condition



Testing Methods

- Principle:
  Exposing the relevant location / surface
  - Water access + Swelling at constant volume



Testing Methods

- Principle:
  Preserving the properties of the Product
  - Water access + Swelling at constant volume
  - Self-Sealing process

Testing Methods

- Principle:
  - Preserving the properties of the Product in the installed condition
  - Exposing the relevant location / surface to water

- Trough Leachate procedure
  - Swelling at constant volume by water contact
  - Controlled creation of contact groundwater in a trough
  - Chemical analysis of that water (Leachate)
  - 2 Step appoach

- Evaluation

Testing Methods

- Placement of samples in a constant-volume test cylinder enclosed by water-permeable glass filter plates. This accurately resemples the installation condition in the annular space of a well
- Simulation of the initial swelling process by leaving the test cylinder in a trough tank for 24-48 h with water contact. The test volume remains constant. Thus the swelling process is simulated correctly.
- Creation of a first trough leachate in distilled water with magnetic stirrer over a period of 24 h. This results in a short-term, maximum release of adsorbed substances in the clay. A chemical analysis of the leachate is performed (simulation of the installation condition).
- Pollutant contents measured here are short-term and do not correspond to a practical situation. They are for reference purposes only

Testing Methods

- Simulation of the residual conditions by a subsequent swelling process in distilled water by leaving the test cylinder in a trough tank with water contact over 48 h to 72 h
- Creation of a second trough leachate in distilled water with magnetic stirrer over a period of 24 h. A second chemical analysis of the entire leachate is perfomed (simulation of the permanent state).
- The chemical analysis is performed for the entire parameter spectrum according to LAGA 2016 and the evaluation is based on the limit values / threshold values of significance according to . BBodschV. The values determined here can be regarded as long-term values in the contact groundwater.
- These are used for the evaluation of groundwater influence

Results

- Comparision of parameters to threshold values of significance
- Deifferenze between initial state and residual state
  Modelling of permanent condition

Parameter	Einheit	Probenbezeichnung		Threshold Values
Teil 1 anorganisch		Sample initial state	Sample Residual state	
Antimon	µg/l	< 1	< 1	10
Arsen	µg/l	< 1	< 1	10
Barium	µg/l	< 10	< 10	
Blei	µg/l	< 1	< 1	25
Bor	µg/l	< 100	< 100	
Cadmium	µg/l	< 0,3	< 0,3	5
Chrom gesamt	µg/l	8,8	9,3	50
Chrom VI	µg/l	< 30	< 30	
Kobalt	µg/l	< 5	<5	50
Kupfer	µg/l	< 5	< 5	50
Molybdän	µg/l	< 5	< 5	50
Nickel	µg/l	< 1	< 1	50
Quecksilber	µg/l	< 1	< 1	1
Selen	µg/l	3	< 2	10
Thallium	µg/l	< 1	< 1	
Vanadium	µg/l	< 4	< 4	
Zink	µg/l	< 10	< 10	500
Chlorid	mg/l	2,7	1,1	
Cyanid	µg/l	< 5	< 5	50
Fluorid	µg/l	< 500	< 500	750
Sulfat	mg/l	18	6,7	
Teil 2 organisch				
Σ PAK (TVO)	µg/l	0	0	0,2
Anthracen	µg/l	< 0,02	< 0,02	
Benzo[a]pyren	µg/l	< 0,02	< 0,02	
Summe Benzo[b]fluoranthen und Benzo[k]fluoranthen	µg/l	< 0,02	< 0,02	
Summe Benzo[ghi]perylen und Indeno[123-cd]pyren	µg/l	< 0,02	< 0,02	
Dibenz(a,h)anthracen	µg/l	< 0,02	< 0,02	
Fluoranthen	µg/l	< 0,02	< 0,02	
Σ Naphthalin u. Methylnaphthaline	µg/l	0,035	0,053	2
Kohlenwasserstoffe	µg/l	< 120	< 140	200
Phenol	µg/l	< 10	< 10	20

Conclusion

- The Trough Leachate Method
  - Model the groundwater influence of introduced products
  - Product properties in the installed condition
  - Location of assessment by relevant product exposure

- Installation procedure → Product properties / exposure
  - Desired self-compaction resulting in a specific bulk (buoyant) density
  - Subsequent swelling resulting in a the desired self-sealing properties
  - Relevant exposure for leachate creation

- Realistic environmental impact / groundwater influence assessment

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