PARSONS

40 YEARS OF SOIL BENTONITE SLURRY WALL RESEARCH & EXPERIENCE: PRACTICAL IMPLICATIONS FOR WASTE CONTAINMENT

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PRESENTATION OUTLINE

1. Cutoff wall deployment in waste containment
2. Soil-bentonite (SB) slurry wall construction
3. Properties of SB
   - Consolidation
   - State of stress
   - Hydraulic conductivity
   - Wet/dry durability
   - Compatibility
4. Design of SB cutoff walls
5. Summary

1. FUNCTIONS OF CUTOFF WALLS IN WASTE CONTAINMENT

1. Reduce off site contaminant transport
2. Reduce seepage quantity into or out of contaminated area

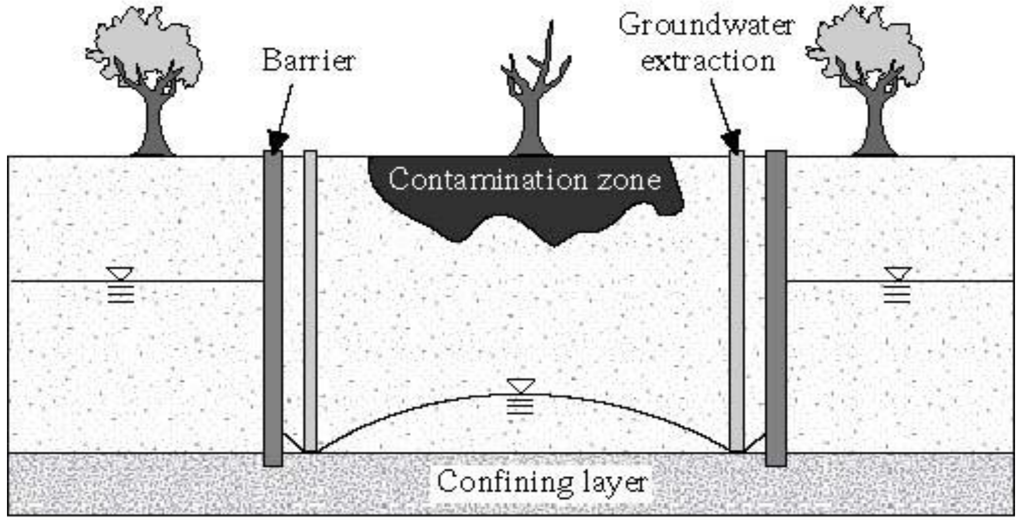
Also:

3. Add strength
4. Walls as flow control, e.g., PRBs and collection trenches

Note: In most cases, cutoff walls are used in conjunction with a low permeability cover and modest in-board pumping to produce an effective hydraulic control system.

CIRCUMFERENTIAL BARRIER WALL

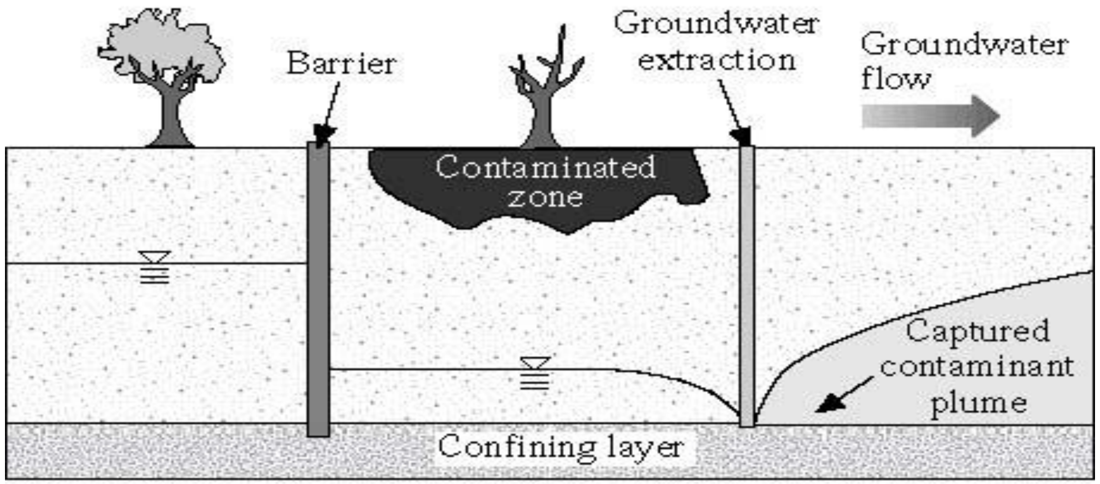
Plan view



Section

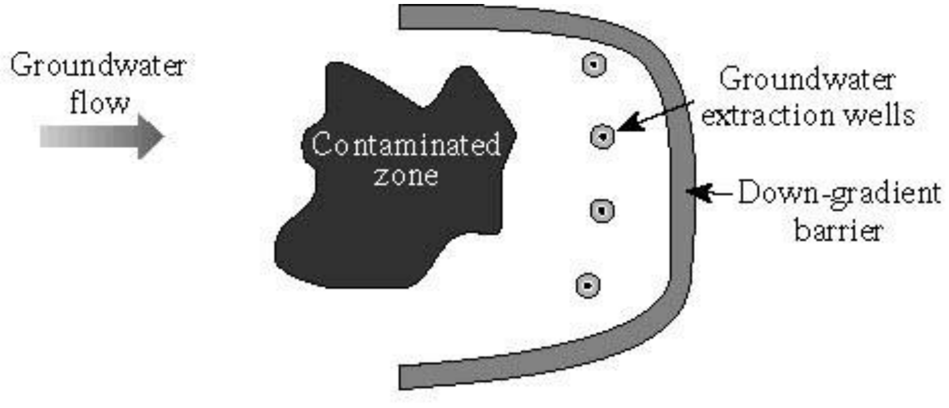
UP-GRADIENT BARRIER WALL

Plan view

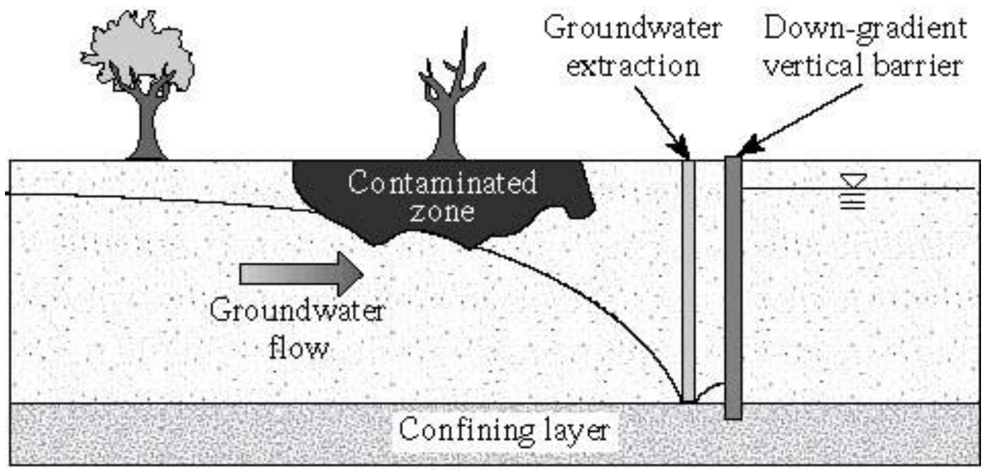


Section

DOWN-GRADIENT BARRIER WALL



Plan view



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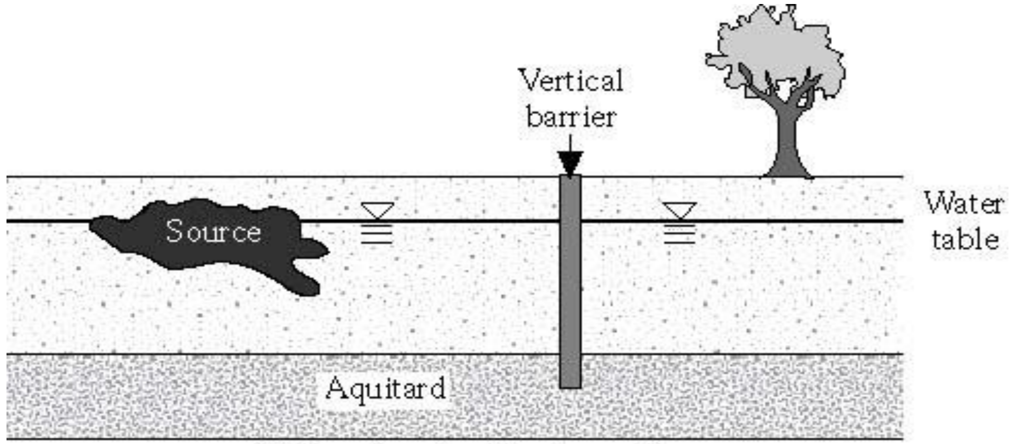
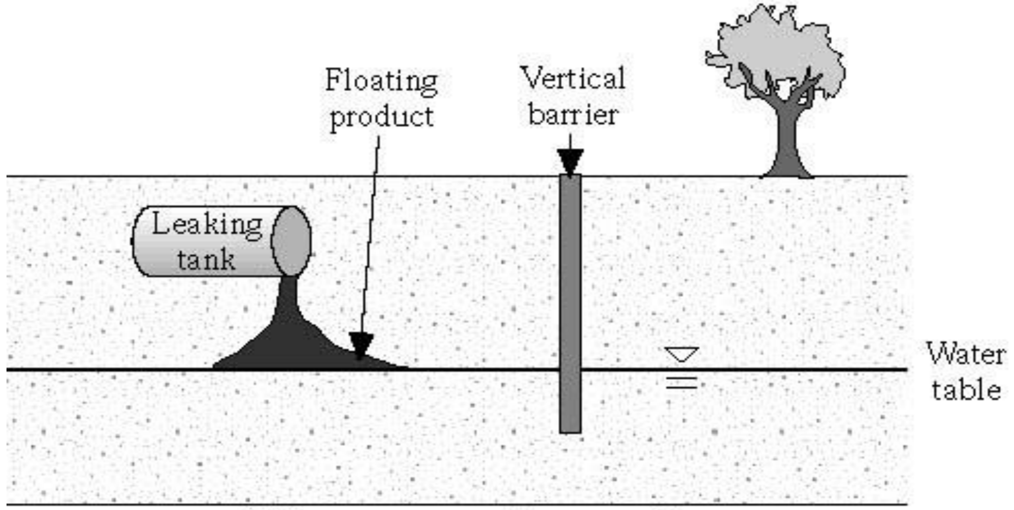
EMBEDMENT OF VERTICAL BARRIER WALLS

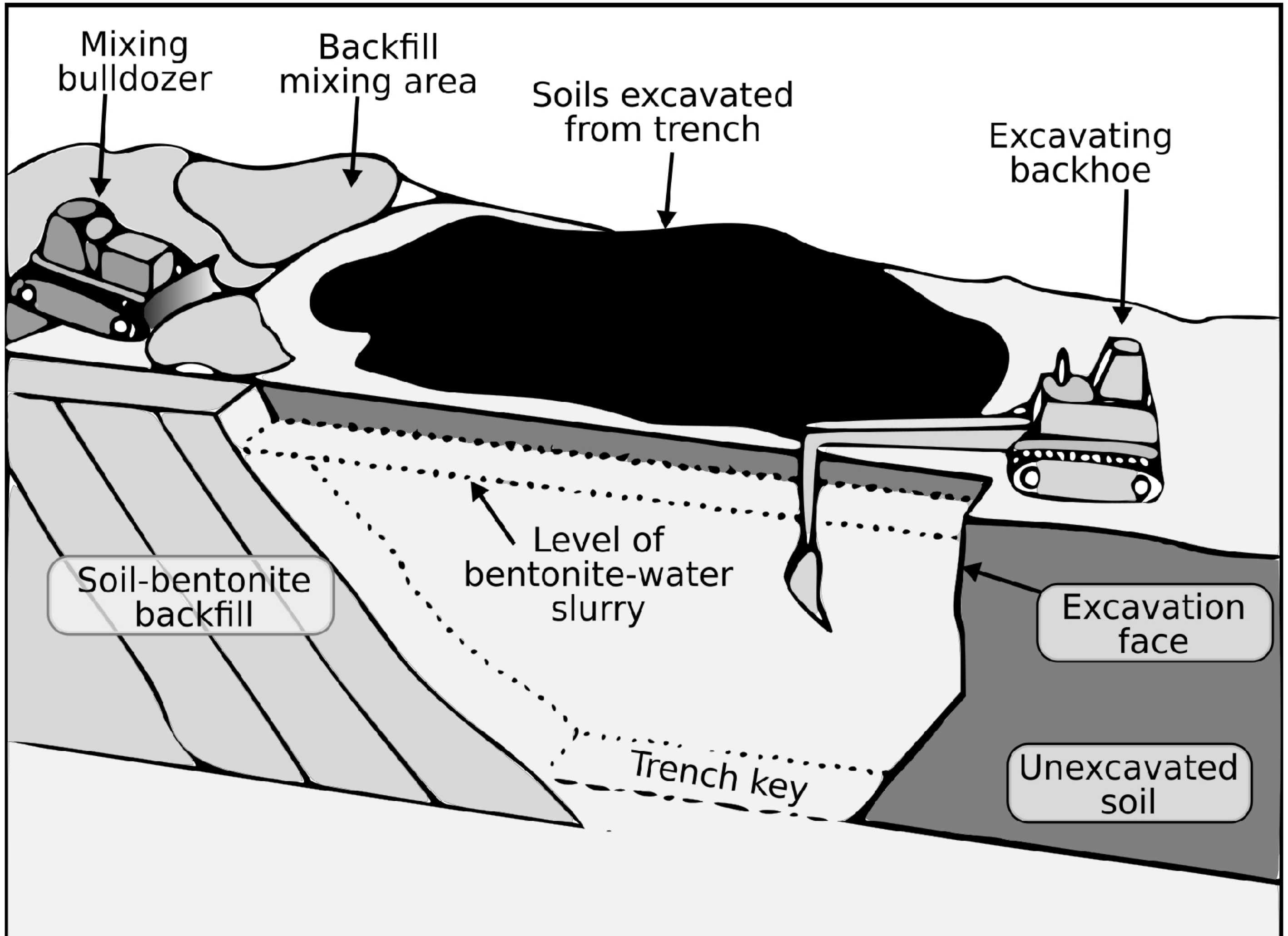


(a) Keyed vertical barrier wall



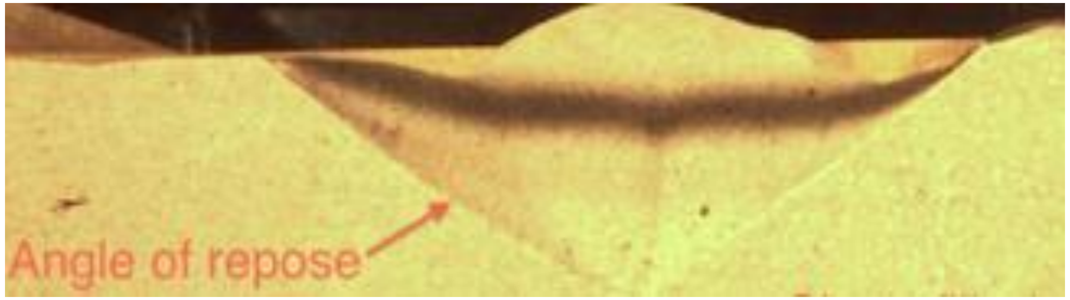
(b) Hanging vertical barrier wall

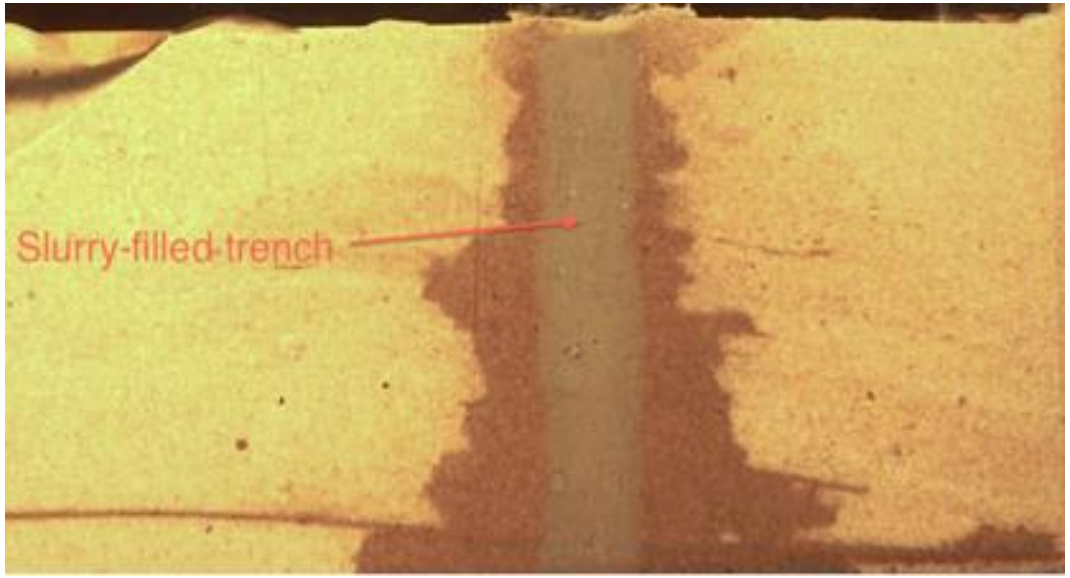
2. SB CUTOFF WALL CONSTRUCTION: SCHEMATIC



Modified from Marchiori et al 2019
https://www.mdpi.com/2412-3811/4/1/5

2. SB CUTOFF WALL CONSTRUCTION: EXCAVATION



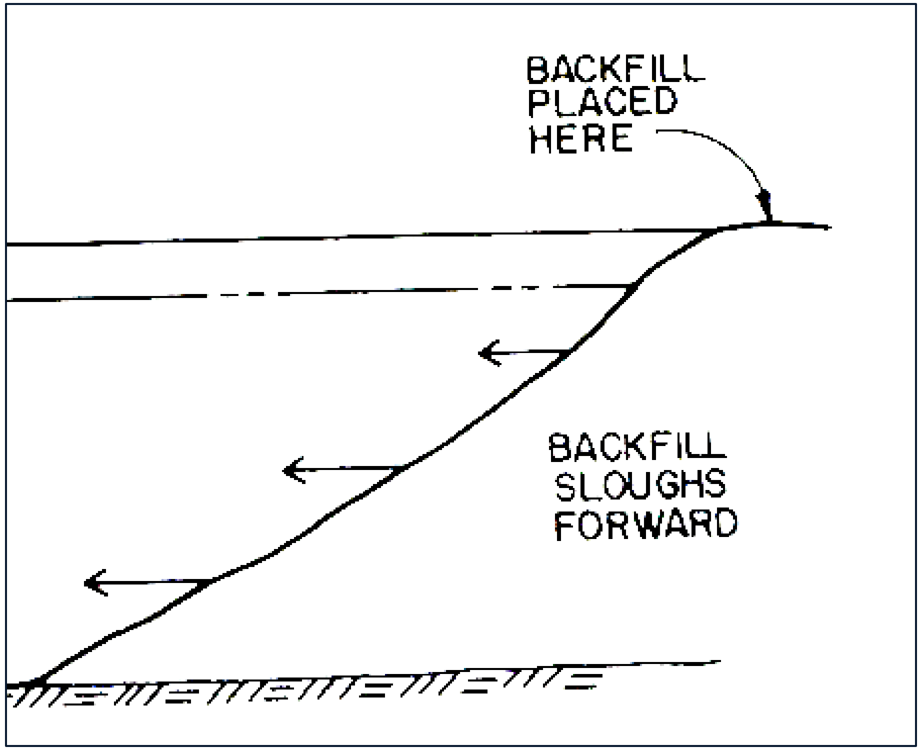


- Excavation under a head of bentonite-water slurry
- SB: Soil-bentonite denotes the backfill i.e the in-place barrier

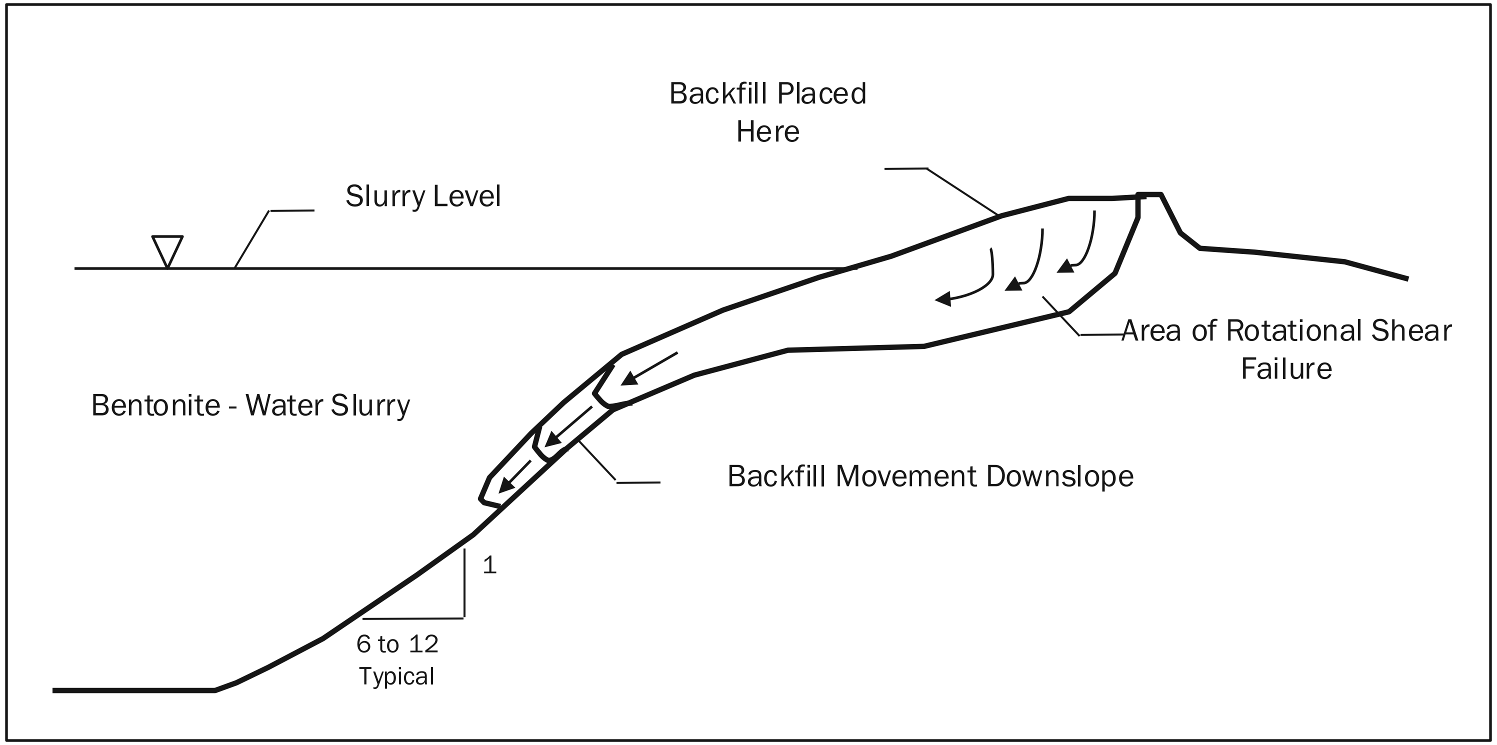
2. SB CUTOFF WALL CONSTRUCTION: BACKFILLING

Backfill is made from bentonite-water slurry, soil (termed base soil) and, as needed, dry bentonite.

2. BACKFILL MOVEMENT BENEATH THE SLURRY



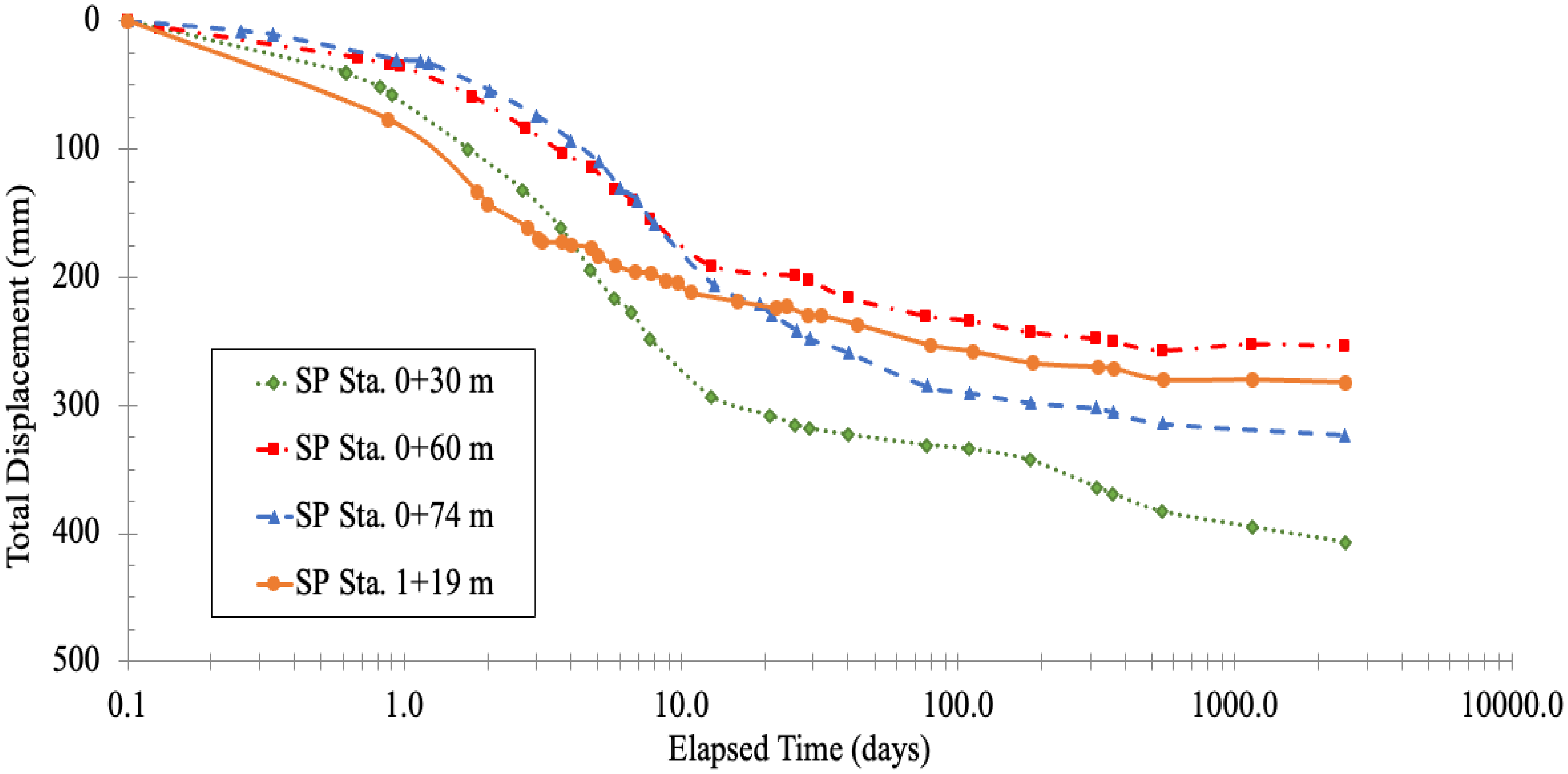
Ref: Ryan, June 1985



Ref: Evans et al. Nov. 1985 (redrawn)

3. CONSOLIDATION SETTLEMENT: VERTICAL

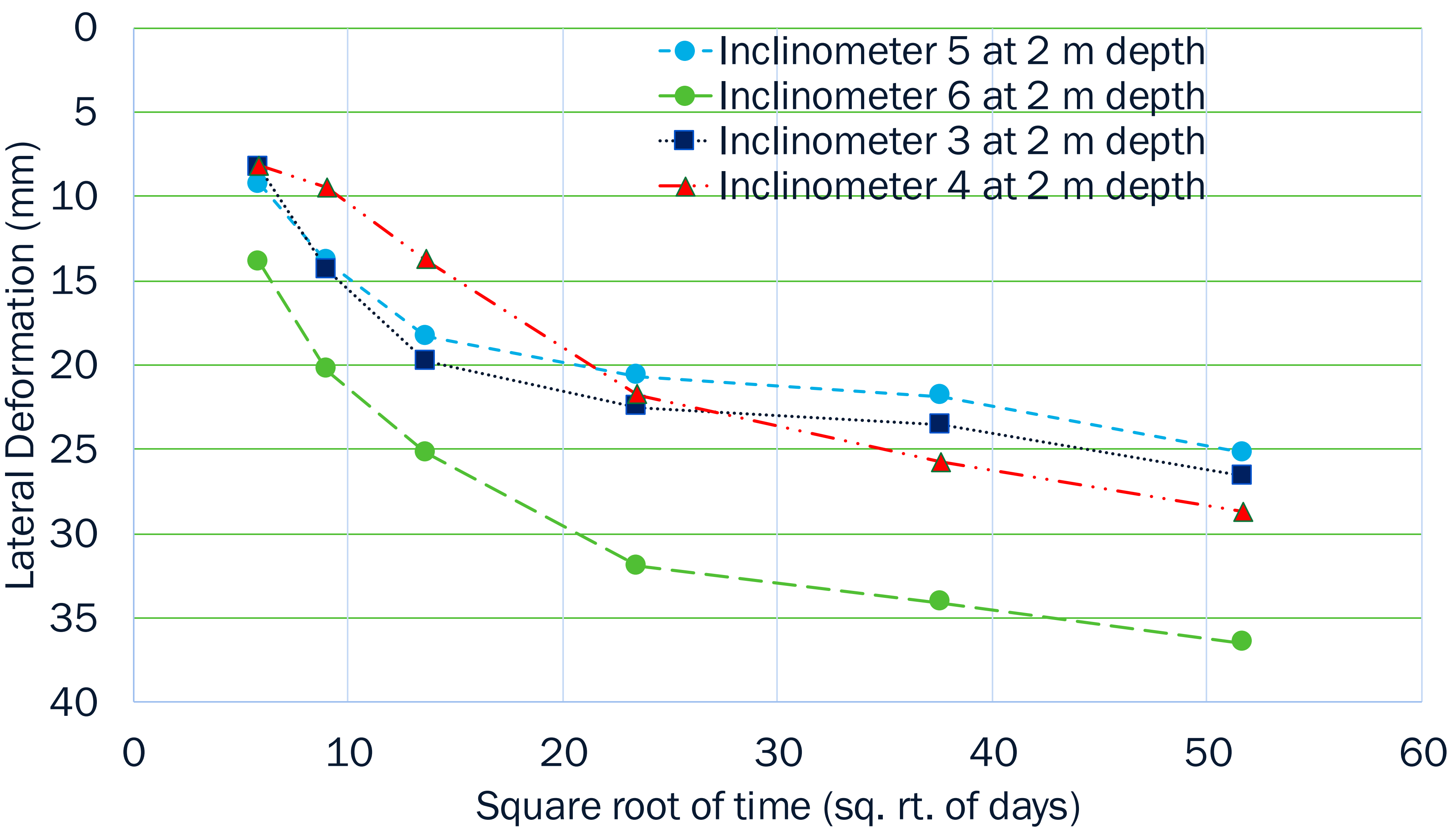
Vertical movement



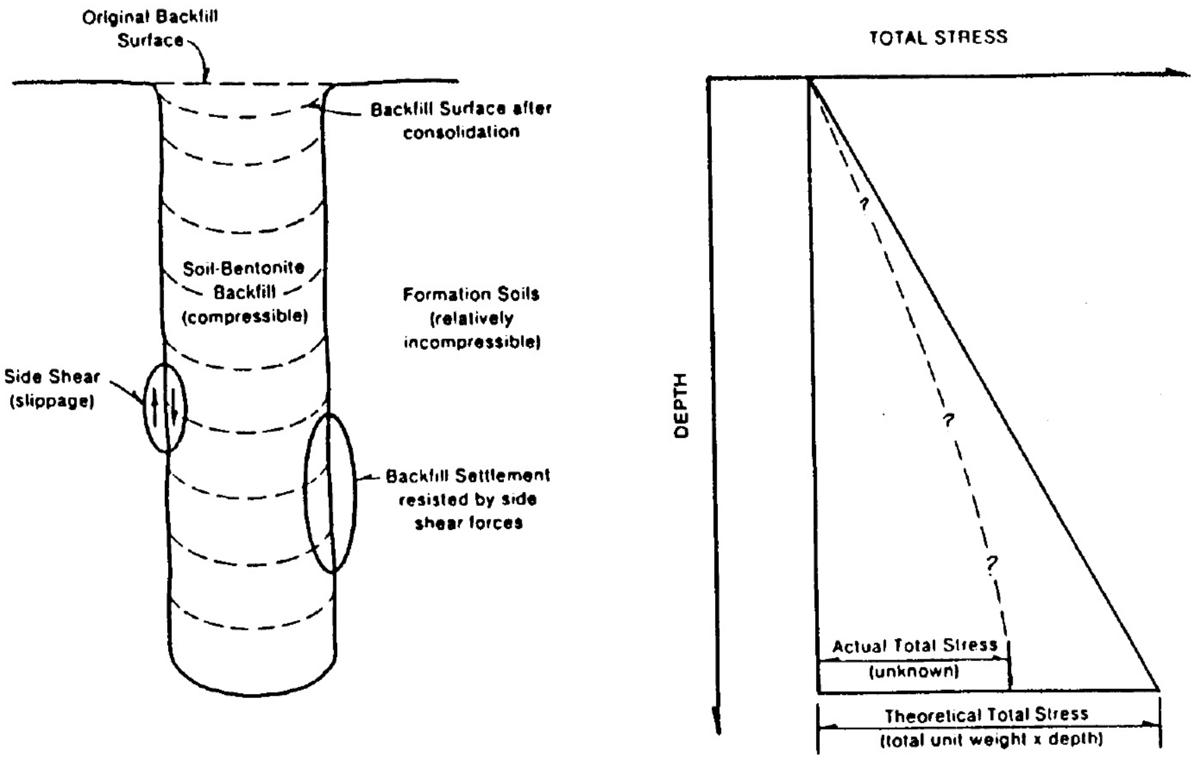
*Settlement Plate at Sta. 1+19 was installed 24 hours after the backfill was placed, thus the initial 24 hours of settlement were not measured.

3. CONSOLIDATION SETTLEMENT: TRANSVERSE

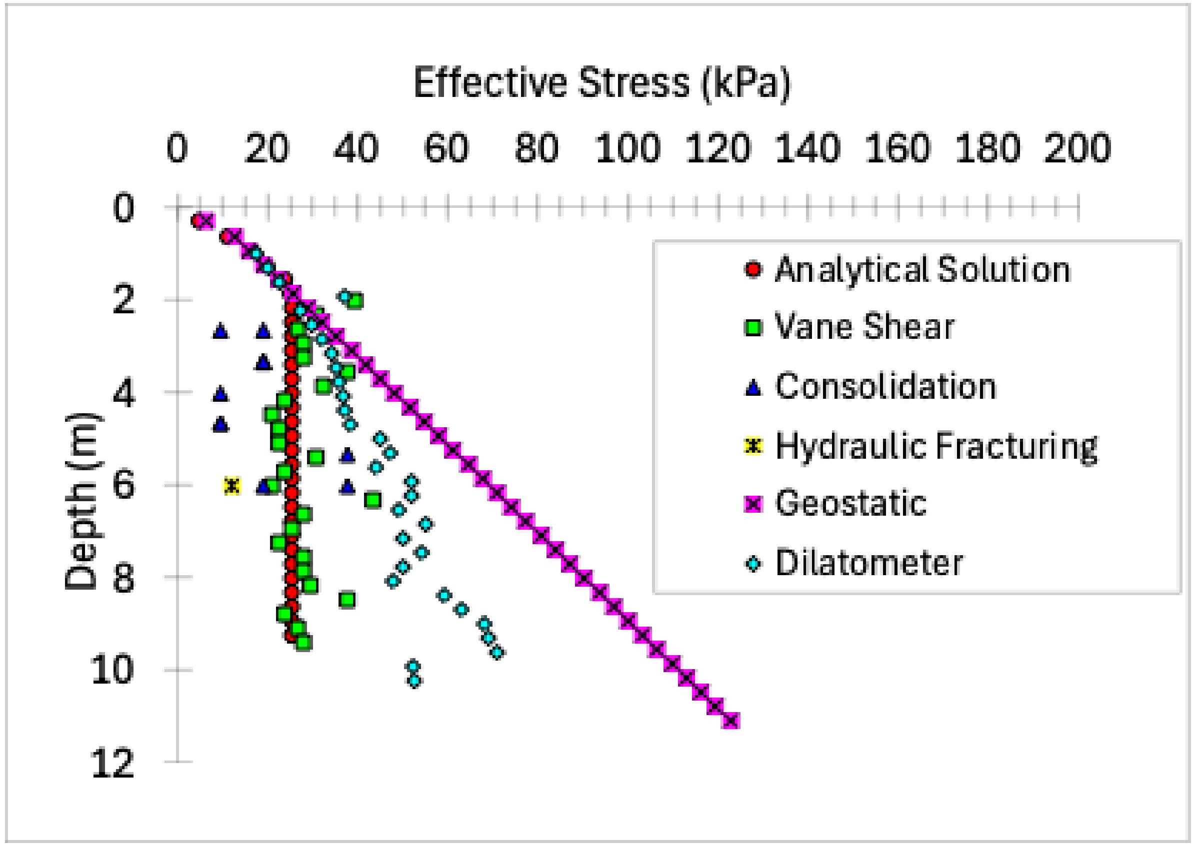
Transverse movement (perpendicular to the long axes of the wall)



3. STATE OF STRESS IN SB WALLS



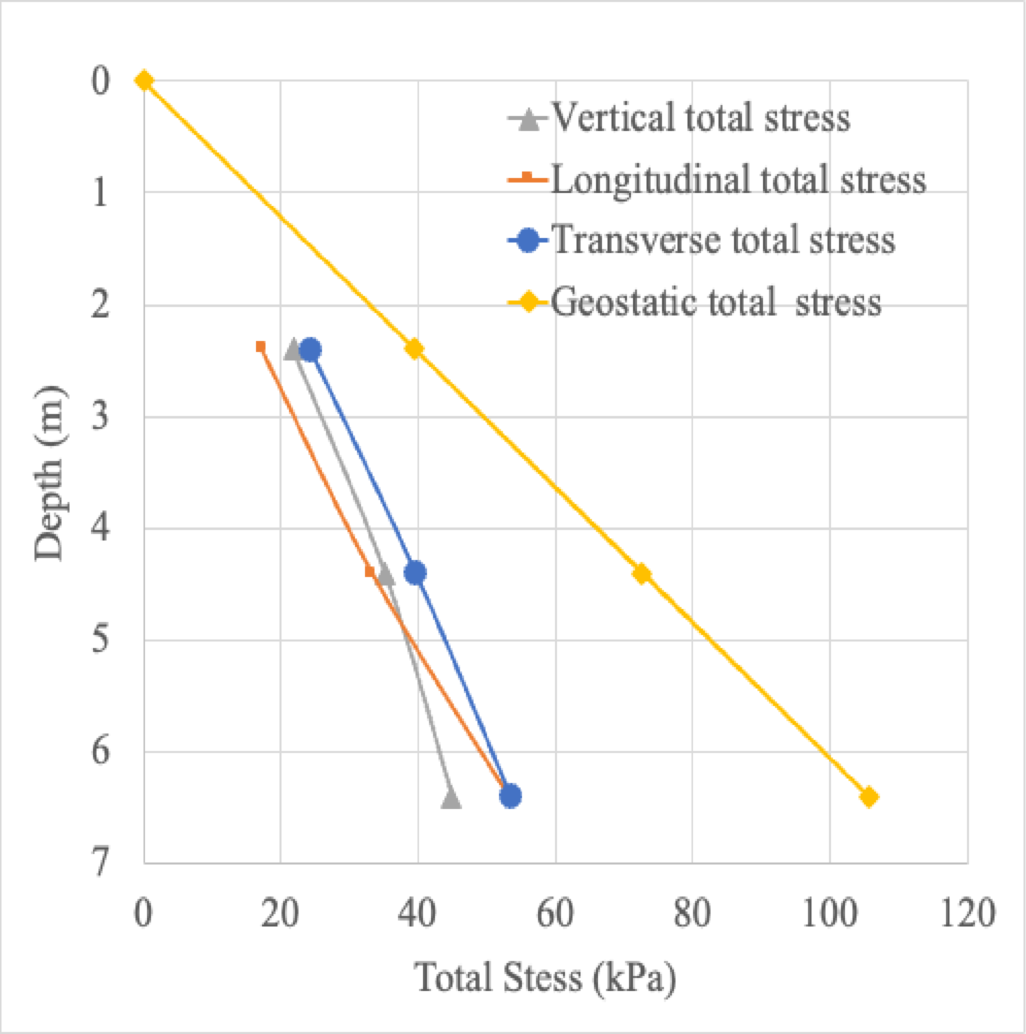
Evans et al. 1985

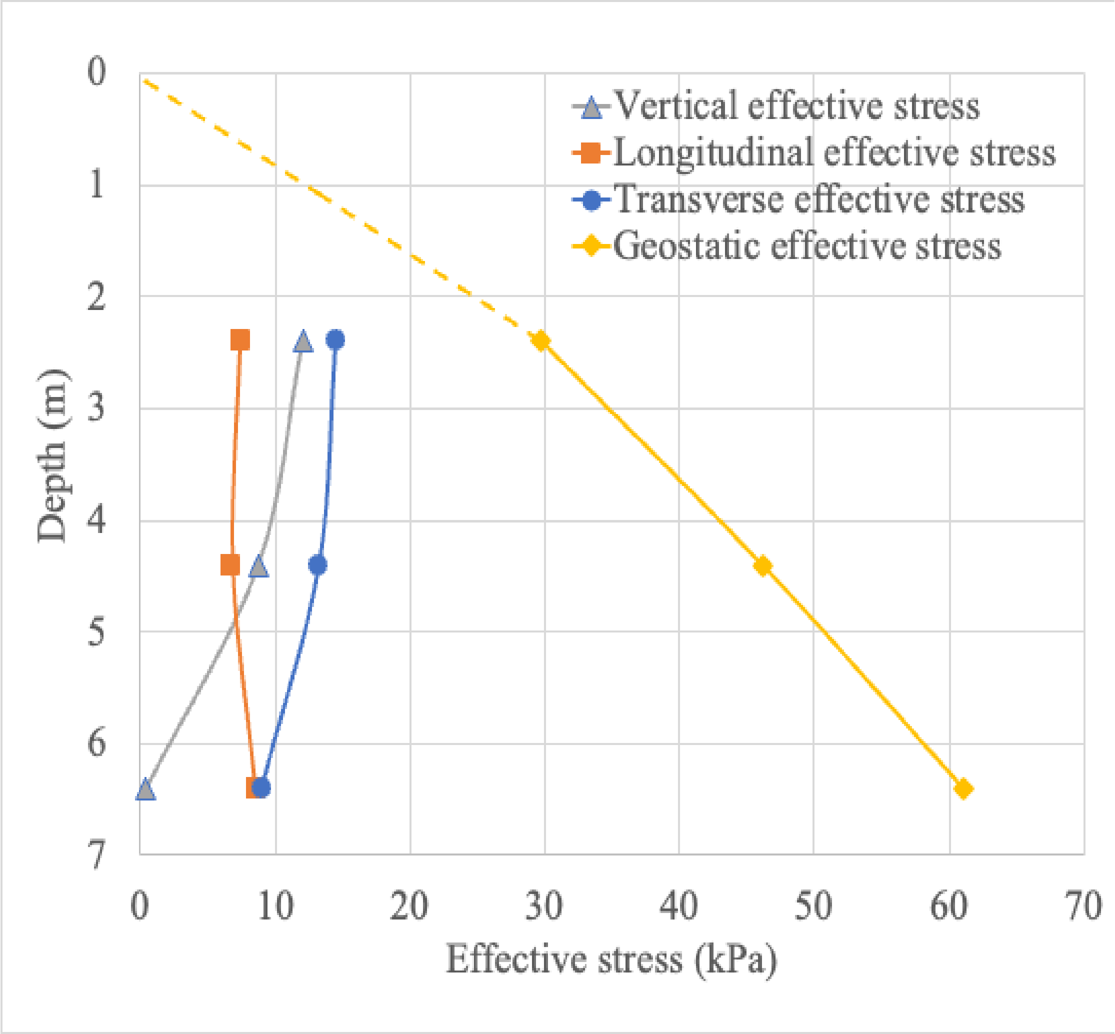


Evans et al. 1995

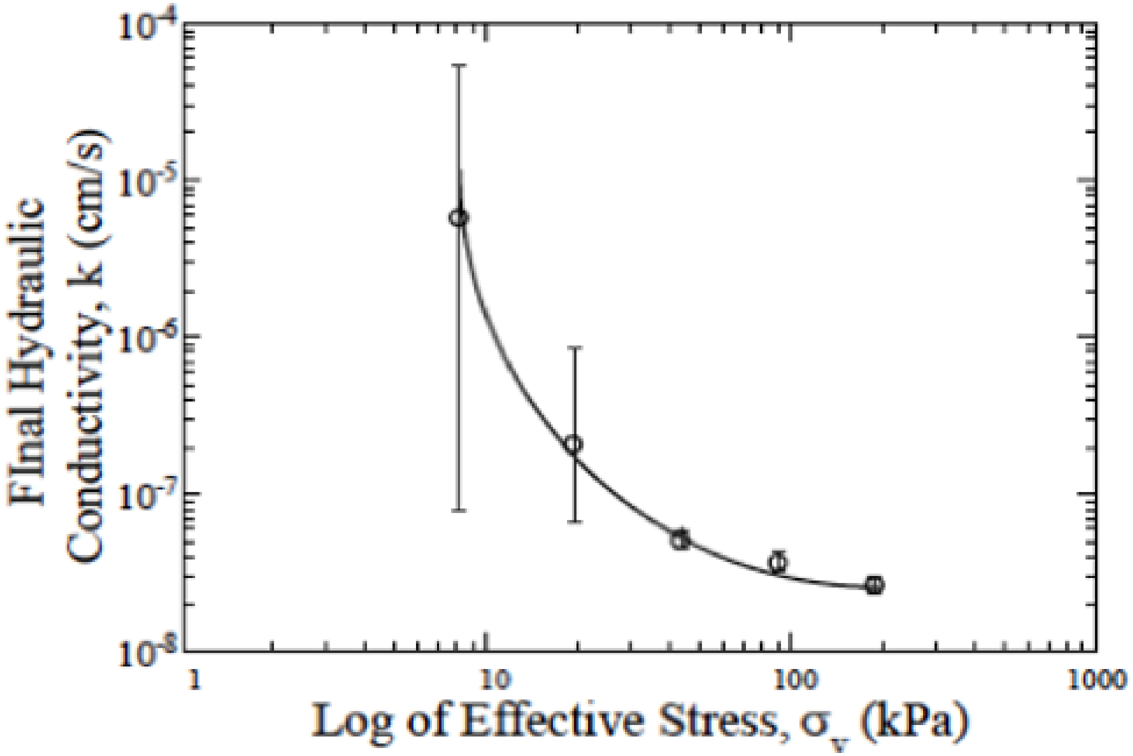
Geostatic stress are due to the weight of the soil above.
Stresses in SB walls are lower than geostatic.

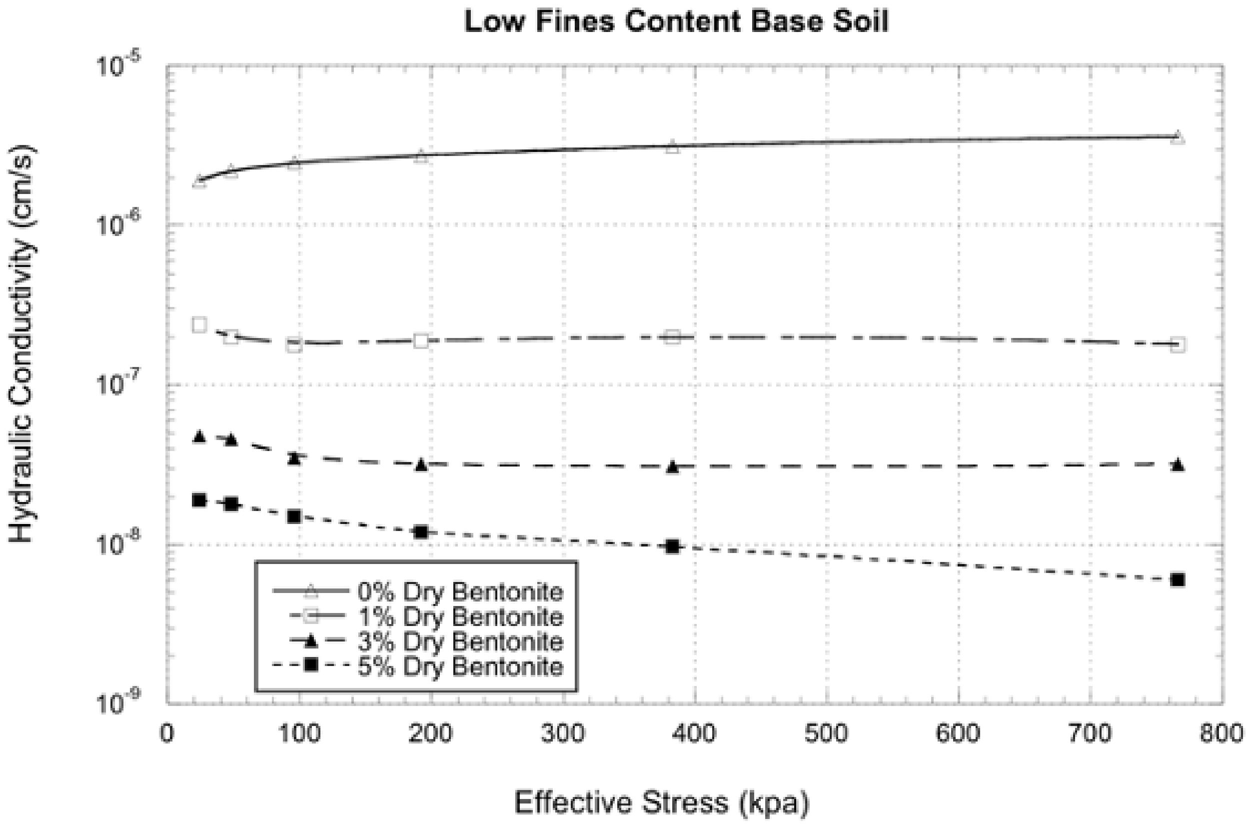
3. STATE OF STRESS





3. HYDRAULIC CONDUCTIVITY: IMPACT OF STRESS



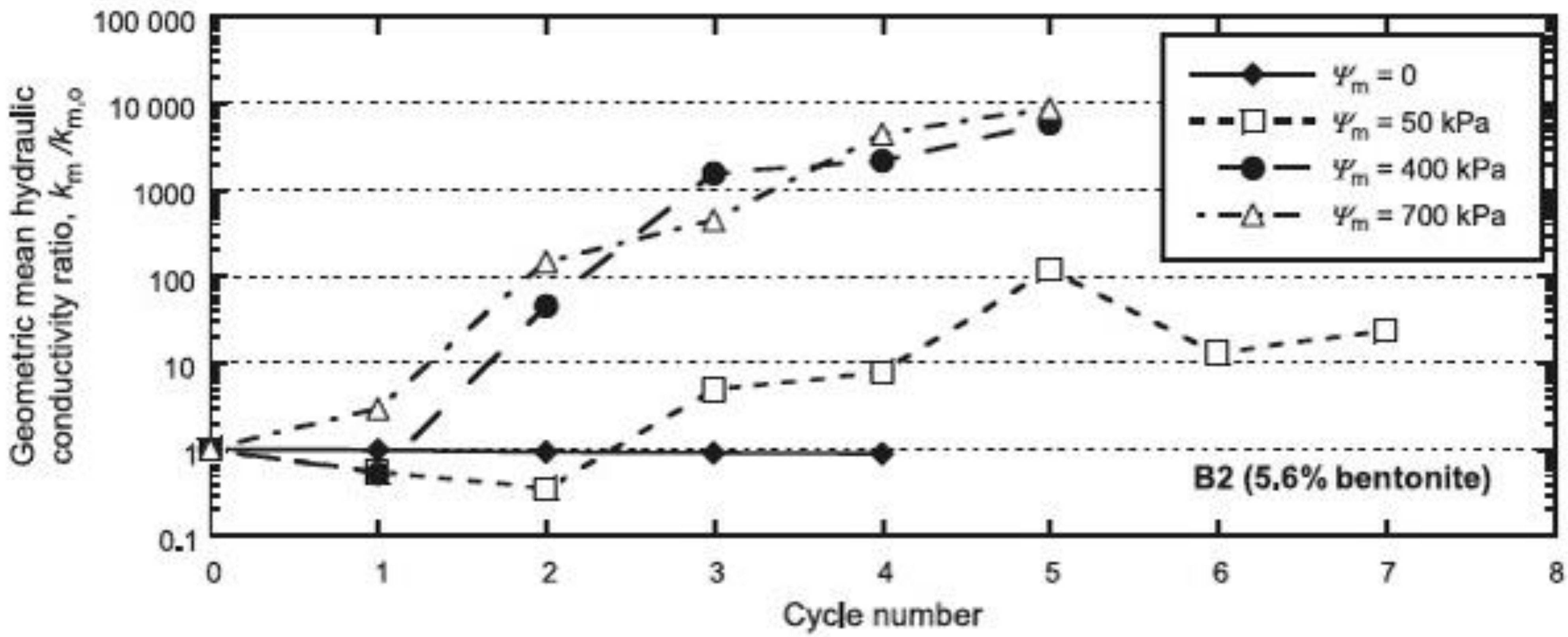


Hydraulic conductivity may be stress dependent, depending upon the base soils and bentonite content.

3. PROPERTIES: IMPACT OF WET/DRY CYCLES ON K OF SB

Wall Construction date	Position of sample relative to water table	Saturated hydraulic conductivity (cm/s)
1981	Above	$1x10^{-3}$
1981	Below	$1x10^{-8}$
1987	Above	$6x10^{-6}$
1987	Below	$1x10^{-7}$

3. WET/DRY DURABILITY

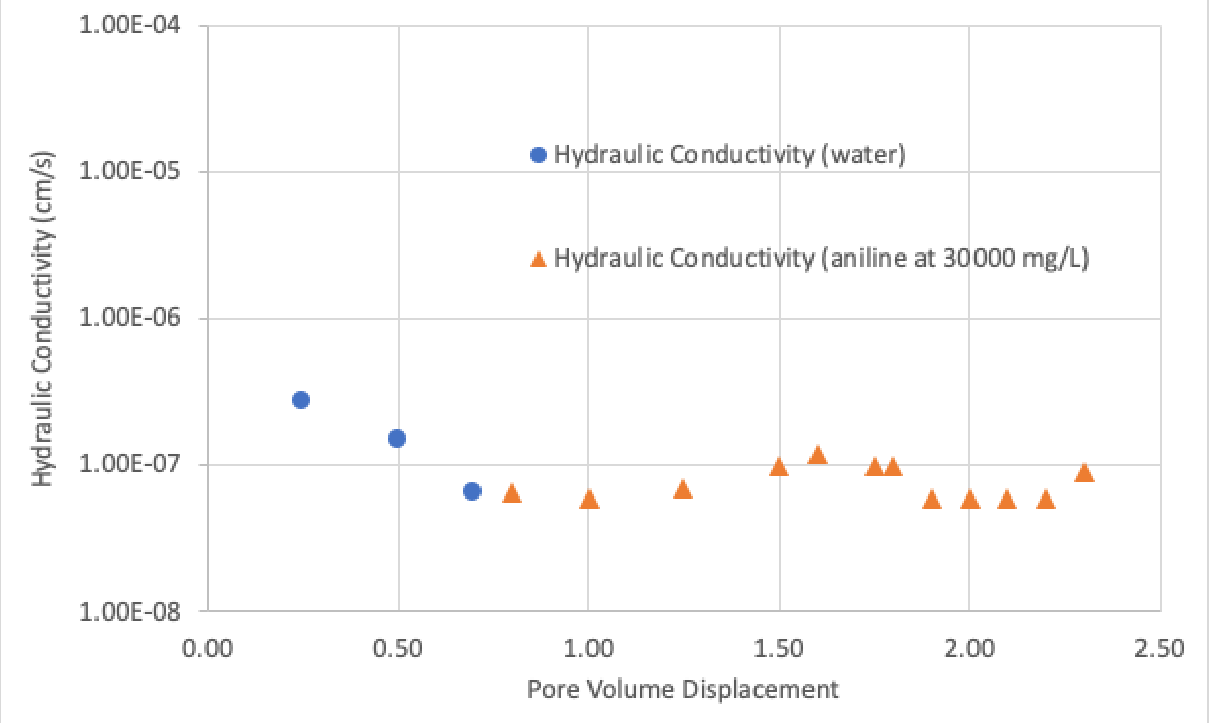


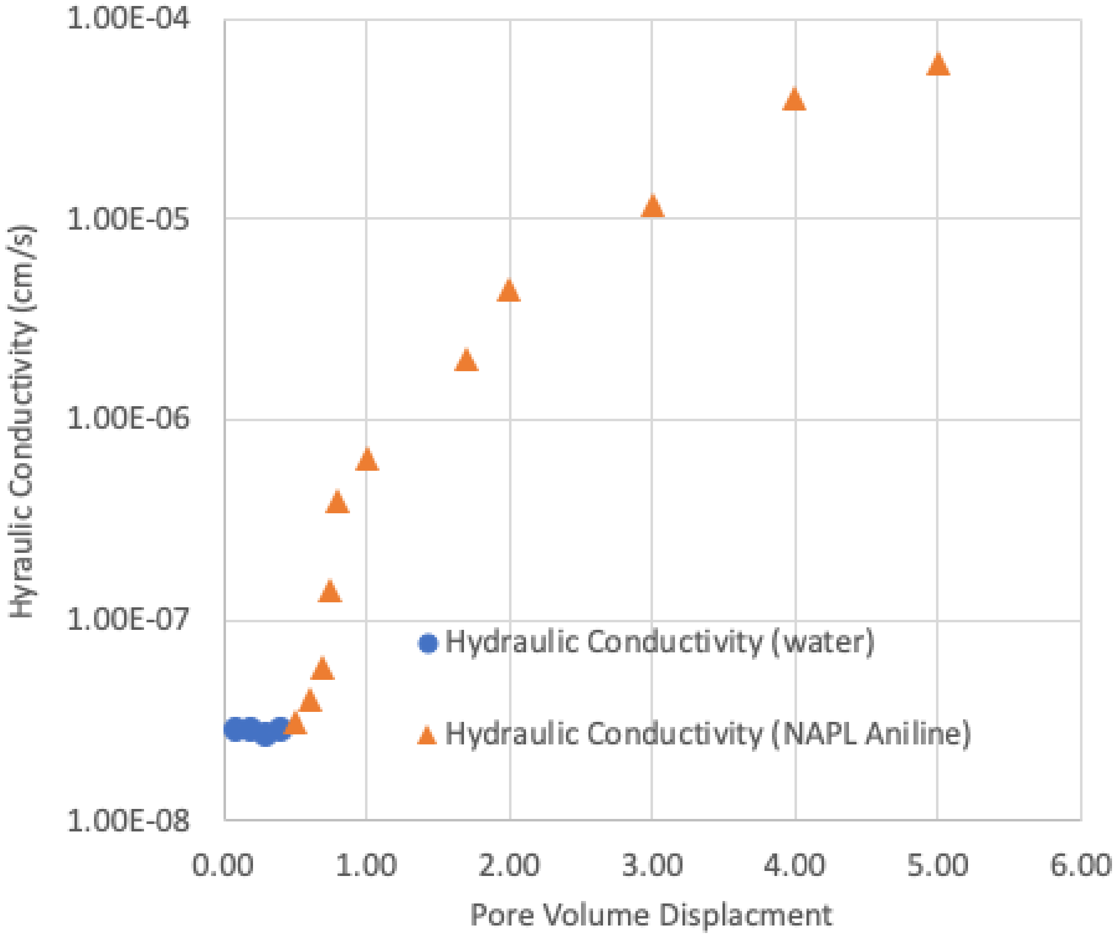
Hydraulic conductivity increase depends upon:

- Number of wet/dry cycles
- Suction pressure
- Bentonite content

Takeaway message: SB cutoff walls need to be covered to prevent desiccation and resulting hydraulic conductivity increases.

3: SB COMPATIBILITY WITH ORGANICS





Redrawn from Evans 1985

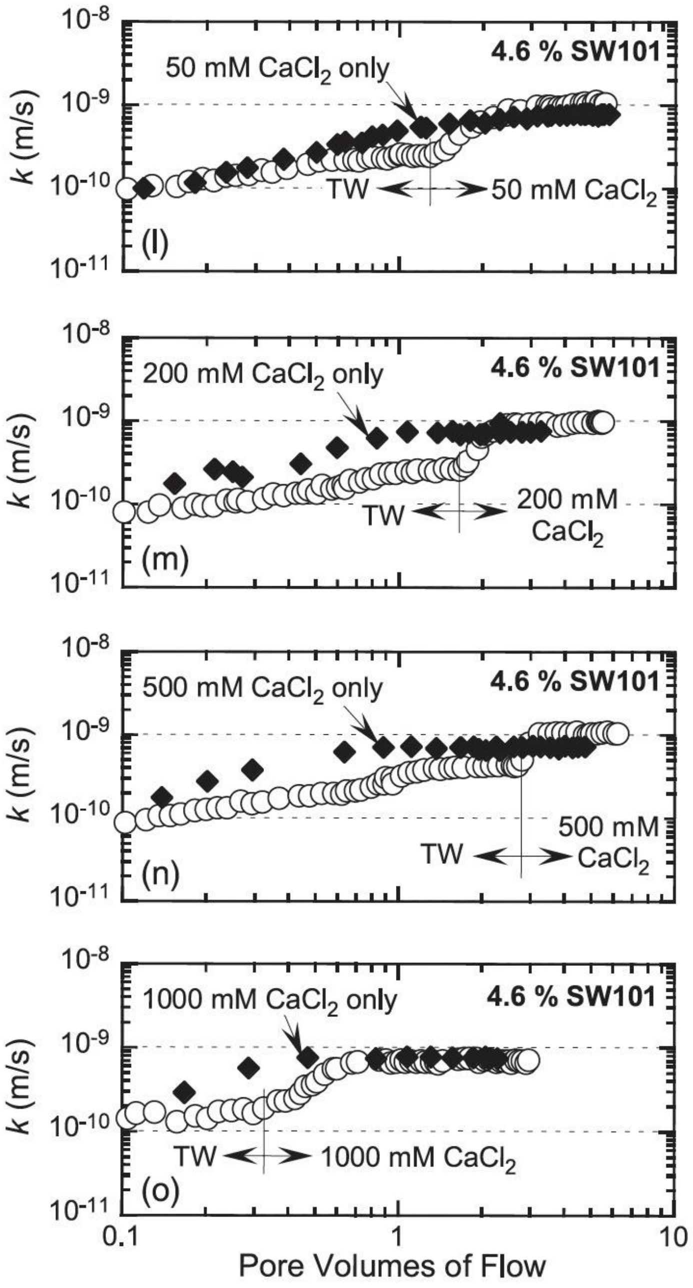
1. Pure NAPL (such as floating products) are a principal concern to SB compatibility
2. Run site specific compatibility tests
3. Magnitude of impact depends on base soil grain size distribution

3: SB COMPATIBILITY WITH INORGANICS

Compound of Concern	Maximum Recommended Conc. in Water for an SB Wall (mg/L)
Chloride	5,000
Calcium	500
Magnesium	150

From Stewart Krause, Wyo-Ben via Paul Boyajian

1. Impact of inorganics is concentration dependent.
2. Magnitude of impact depends upon inorganic valence, concentration and base soil grain size distribution.
3. Run site specific compatibility tests.
4. Behavior understandable in terms of colloidal chemistry expectations.

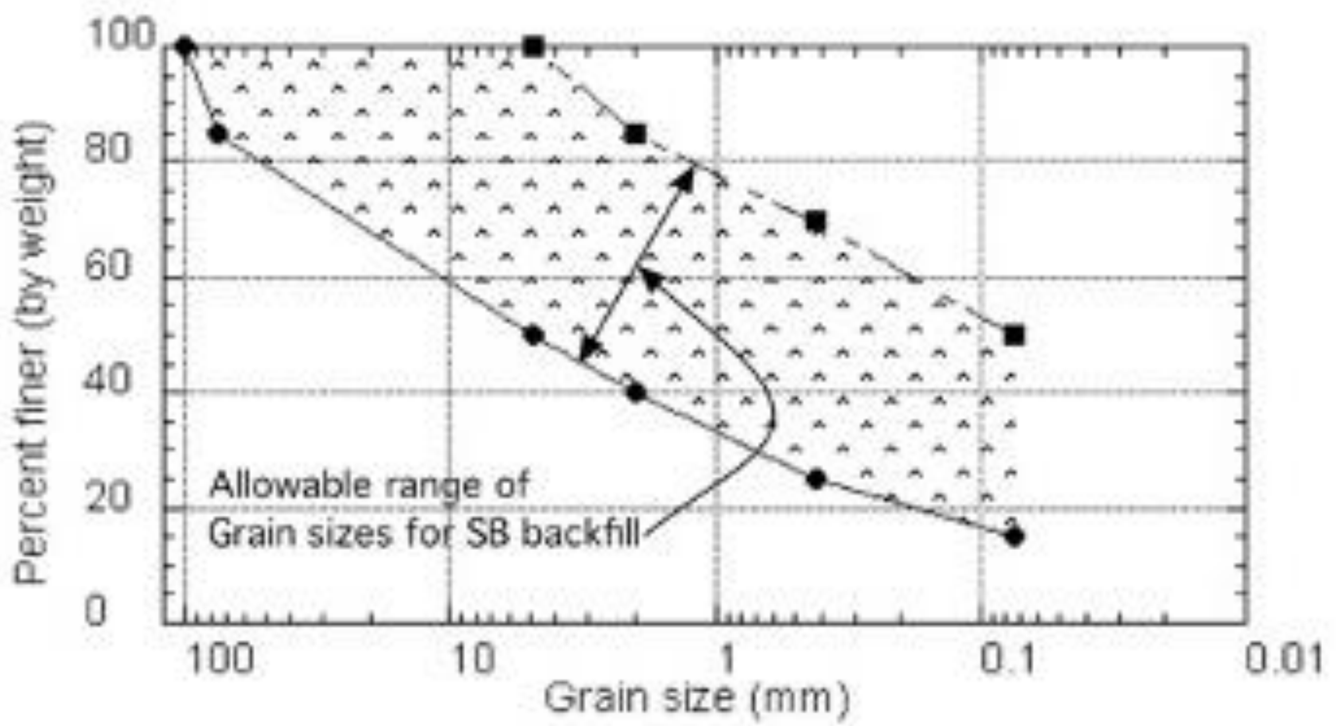


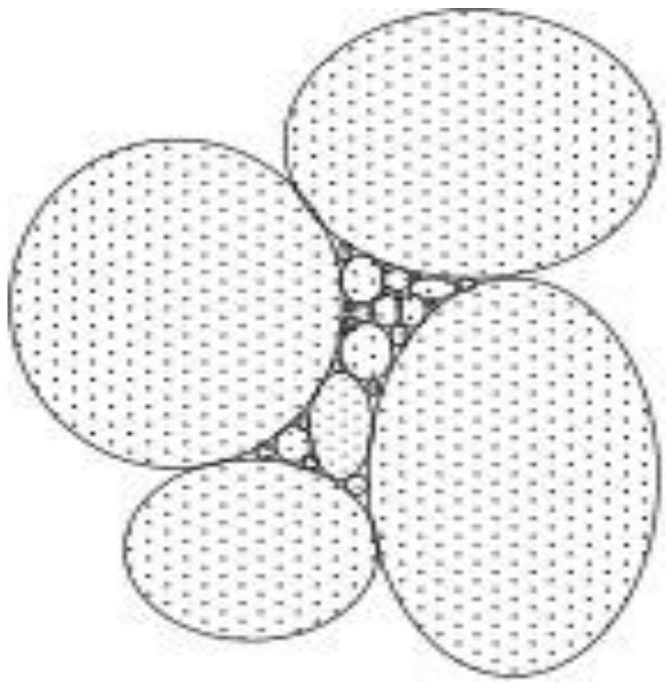
From Malusis and McKeehan 2013

4: SB BACKFILL OPTIMUM DESIGN

- **Well-graded backfill**
- **Natural fines content (20 to 50%)**
- **Low bentonite content (1%)**

Result: Low permeability, low compressibility and least likely to be incompatible





4. SB DESIGN SUMMARY

- SB Hydraulic conductivity is stress dependent and this dependence increases with increasing fines content.
- Mixing bentonite water slurry with base soils to achieve necessary slump adds ~1% bentonite to the mixture.
- SB Hydraulic conductivity of less than $1x10^{-7}$ cm/s can readily be achieved without the use of dry bentonite for many base soils.
- SB Hydraulic conductivity can be reduced to $1x10^{-7}$ cm/s by increasing dry bentonite content (typically 1 to 3% additional dry bentonite).
- For reduced risk of incompatibility, use least amount of bentonite since bentonite swelling is reversable.

5. WE NOW KNOW AFTER 40 YEARS OF SB CUTOFF WALLS

- SB cutoff walls have been in place as successful environmental containment measures since the early 1980s.
- Experience in design and construction of vertical barriers is now widely available.
- Developments in construction means and methods have increased the range of materials and depths to which vertical barriers can be effectively constructed.
- Developments in understanding of stresses and compatibility have improved ability to design vertical barriers for environmental containment.
- Vertical barriers, as a component of site remediation, can achieve long-term protection of the public health and the environment in a more sustainable manner than some more active remediation measures.

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QUESTIONS?

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