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Modeling Consolidation of Slurries: A Water Balance Approach

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Agenda

1. Safety Moment
2. Consolidation Theory (We will Keep it Simple!)
   - Consolidation Basics
   - Laboratory Testing for Consolidation Properties
   - Modeling Slurry Deposition
3. Water Balance Modeling Considerations

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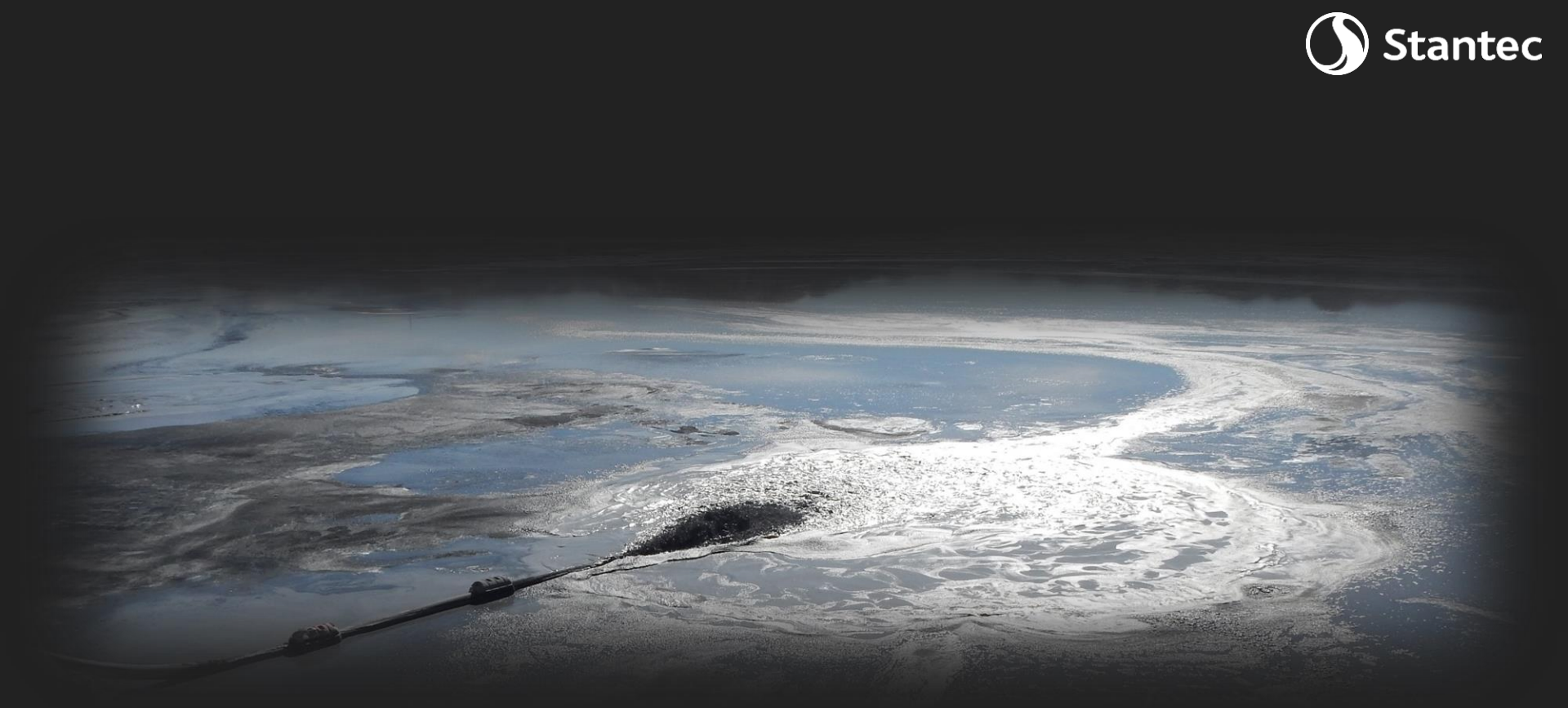
Safety Moment

Springtime means more bikes on the road:

- Bikers – use caution around intersections and use appropriate hand signals always
- Motorists – Keep a close eye out for bikes and give them some space



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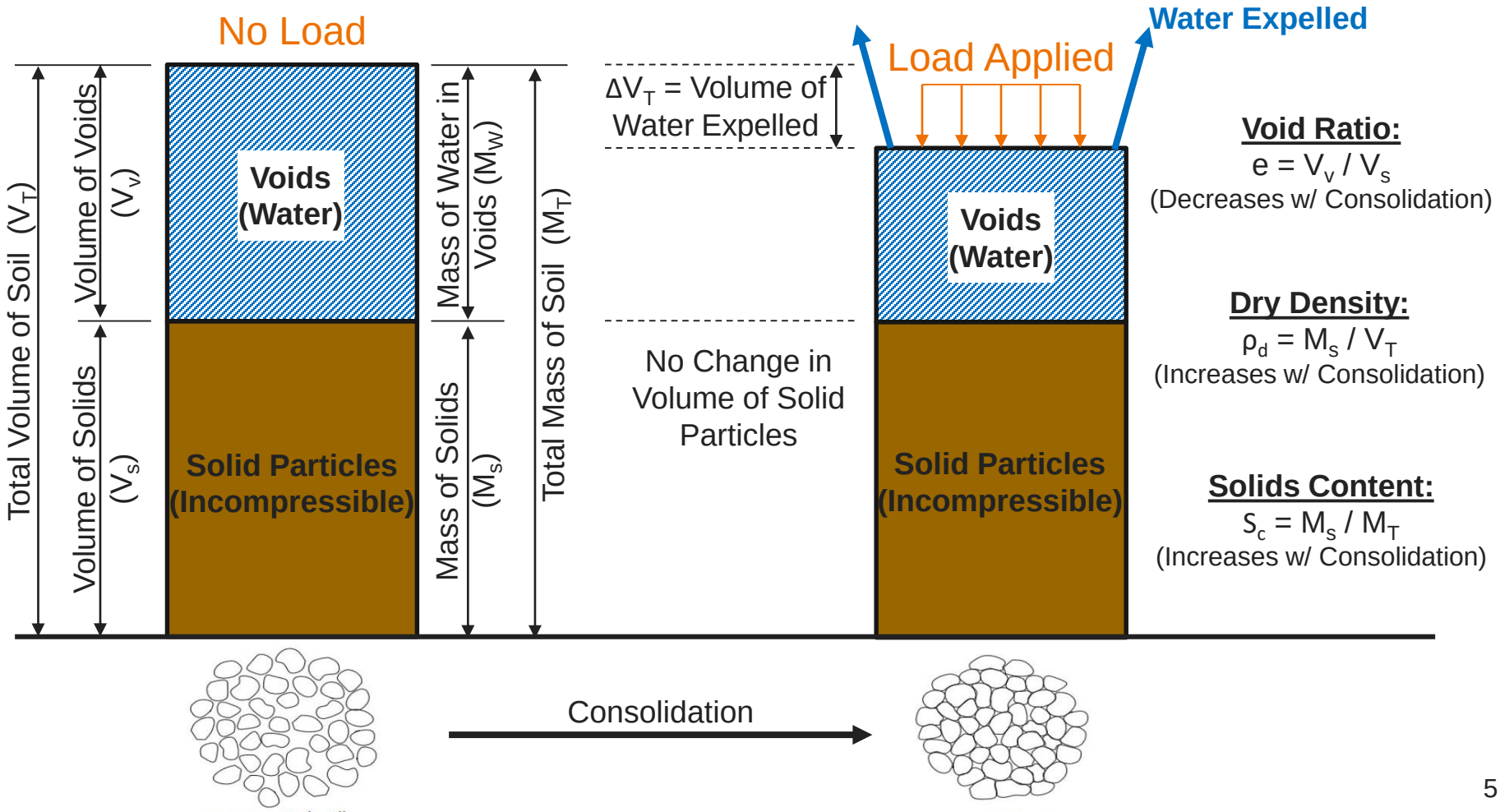
Consolidation Theory

What is Consolidation?

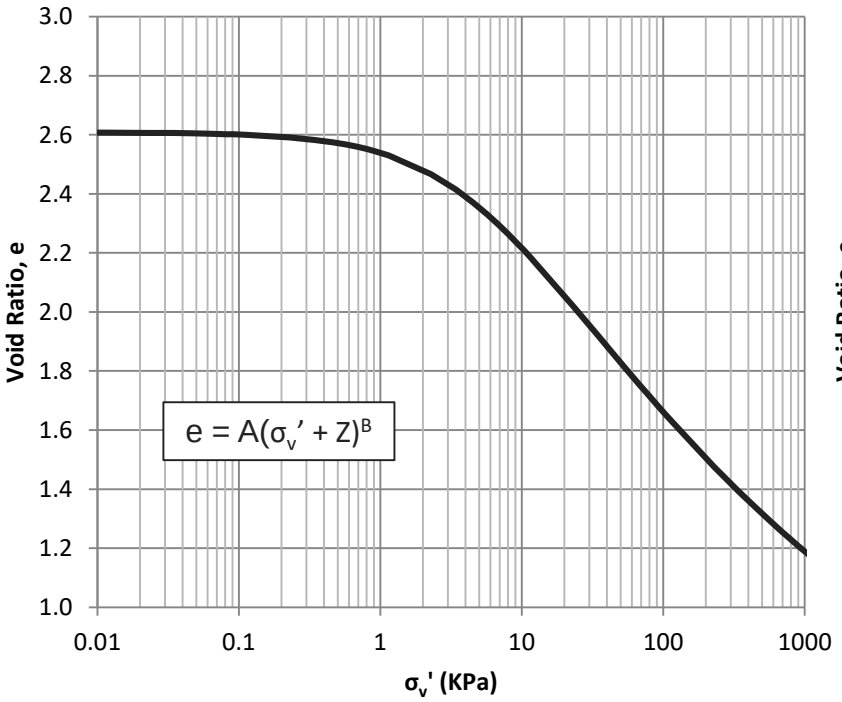
- Consolidation is defined as volume change in saturated soils resulting from expulsion of pore water, driven by application of a load.



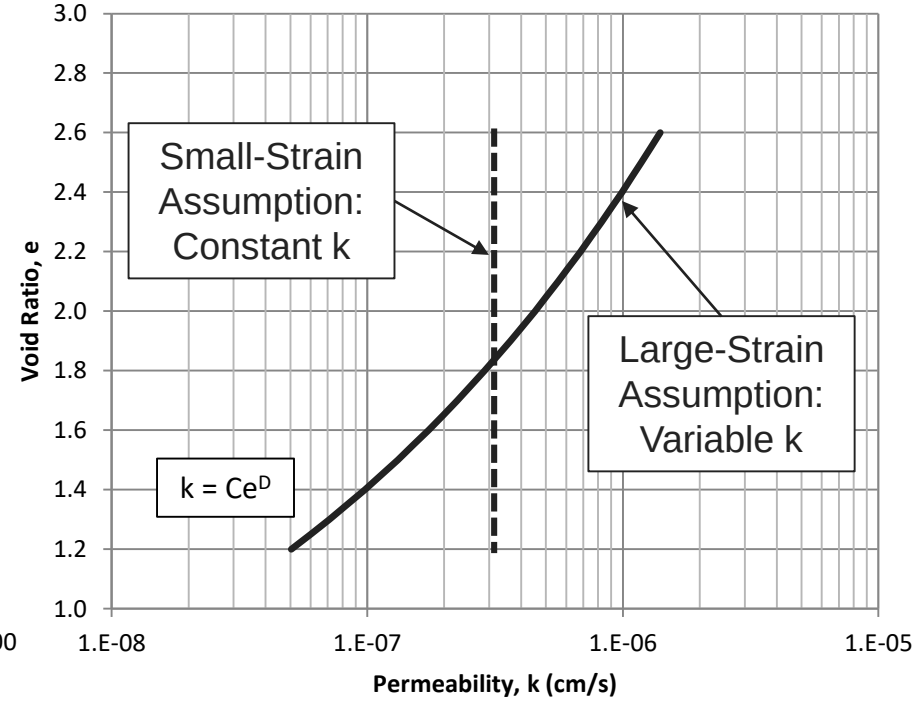
How do we Represent Consolidation?

- Large-strain theory accounts for the reduction in soil permeability as the voids shrink – applicable for small or large strains.

Compressibility: controls magnitude of volume change



Permeability: controls rate of volume change



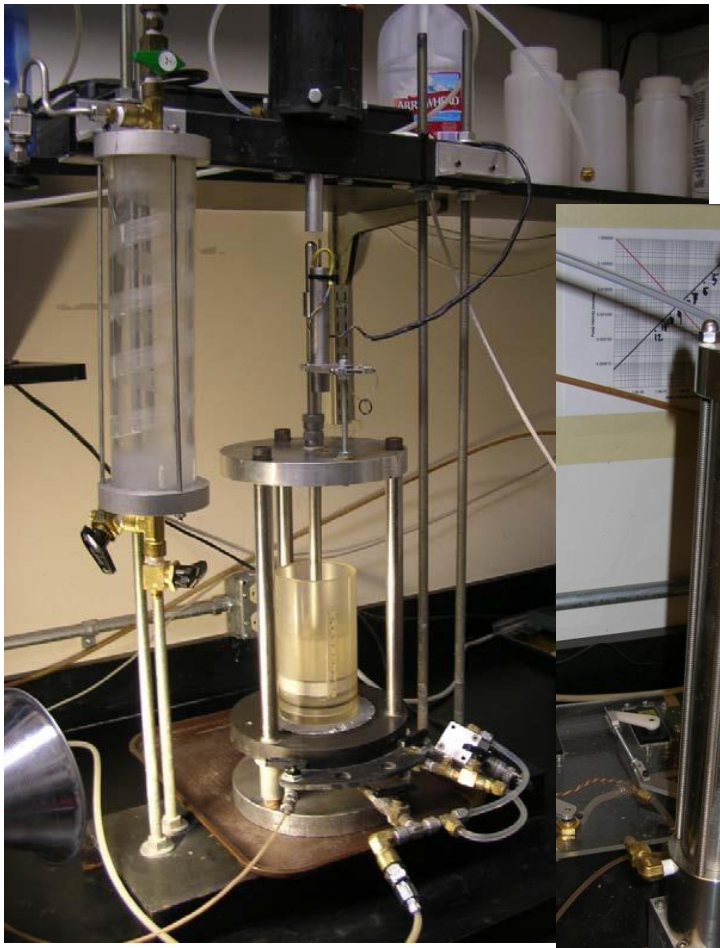
Figures show test results from a kaolinite slurry

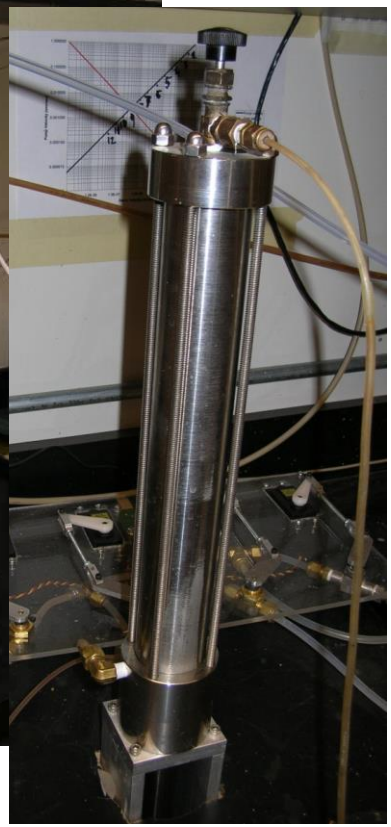
Laboratory Testing for Consolidation Properties

Classical Consolidation

Source: U-Test, Inc.

Seepage-Induced Consolidation





Consolidation during Deposition (Another Complicating Factor)

- Deposition of a slurry over a long period of time is common practice for mine tailing, and for other slurry applications.
- Slurry is deposited into an impoundment, and the impoundment is represented by a stage/storage curve.

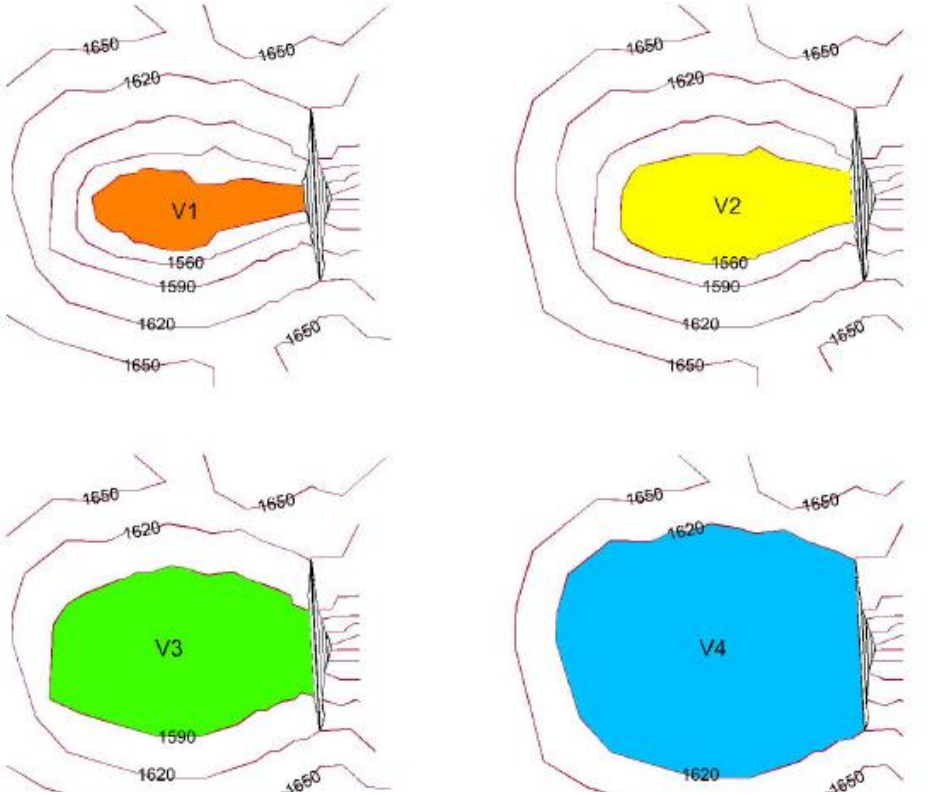
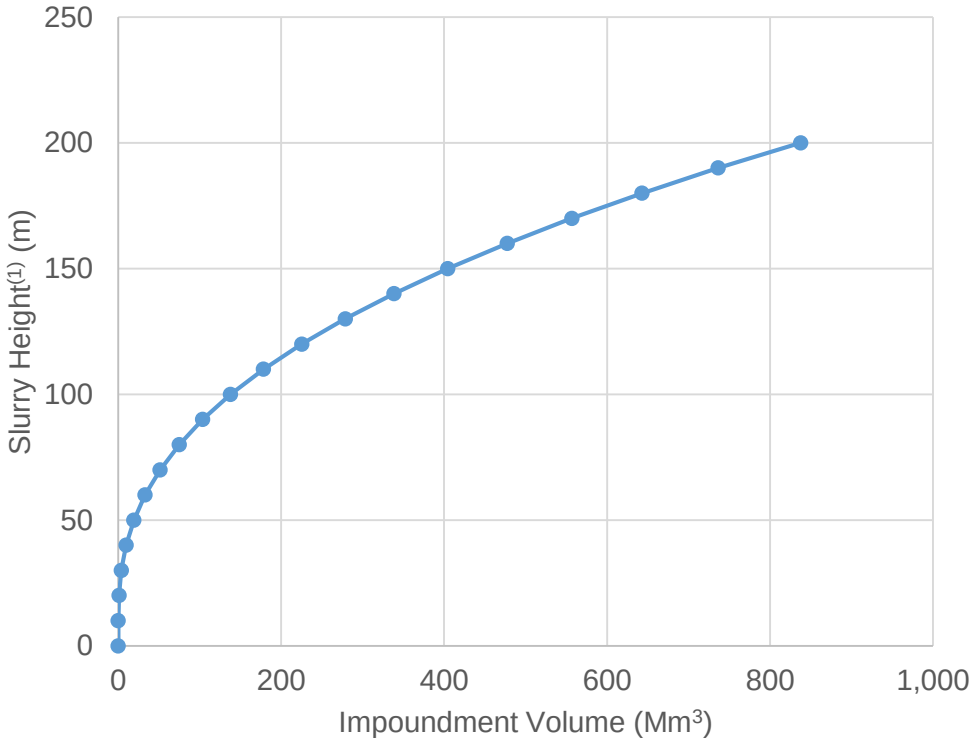


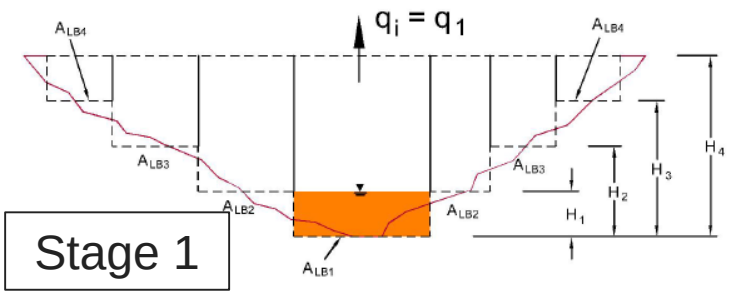
Illustration by Dr. Dobroslav Znidarcic, University of Colorado Boulder

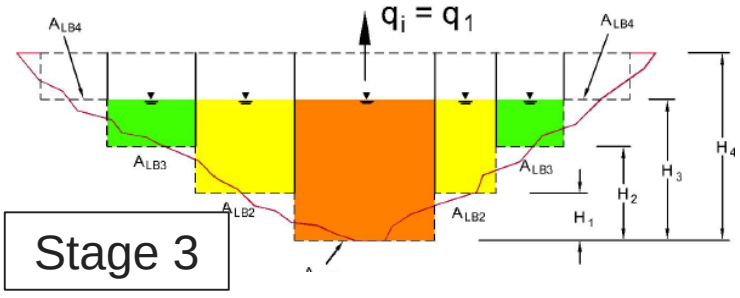


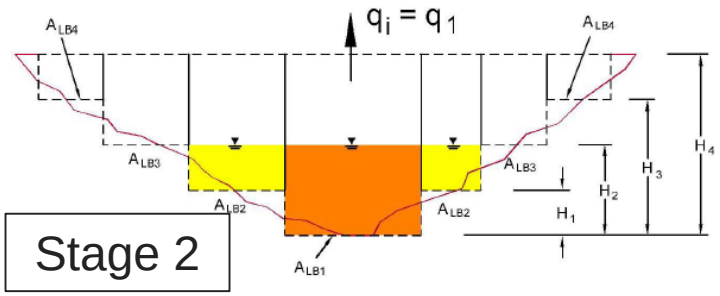
Note 1: Slurry height is measured vertically from the low-point of the impoundment foundation to the high-point of slurry surface.

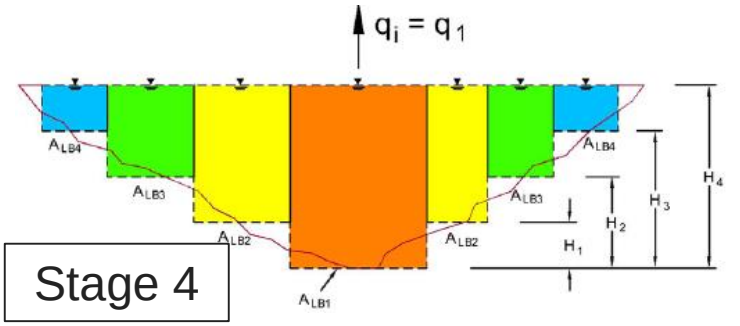
Consolidation during Deposition (Another Complicating Factor) – Ctd.

- Each discrete element of slurry/soil exists in a unique state, and this state is constantly changing as new material is deposited above it:
  - Experiencing a unique state of stress,
  - Exists at a unique density and thus has a unique permeability,
  - Has a unique drainage path (i.e. rate of consolidation is different than for adjacent materials)
- How do we handle this situation? Numerical modeling is required.

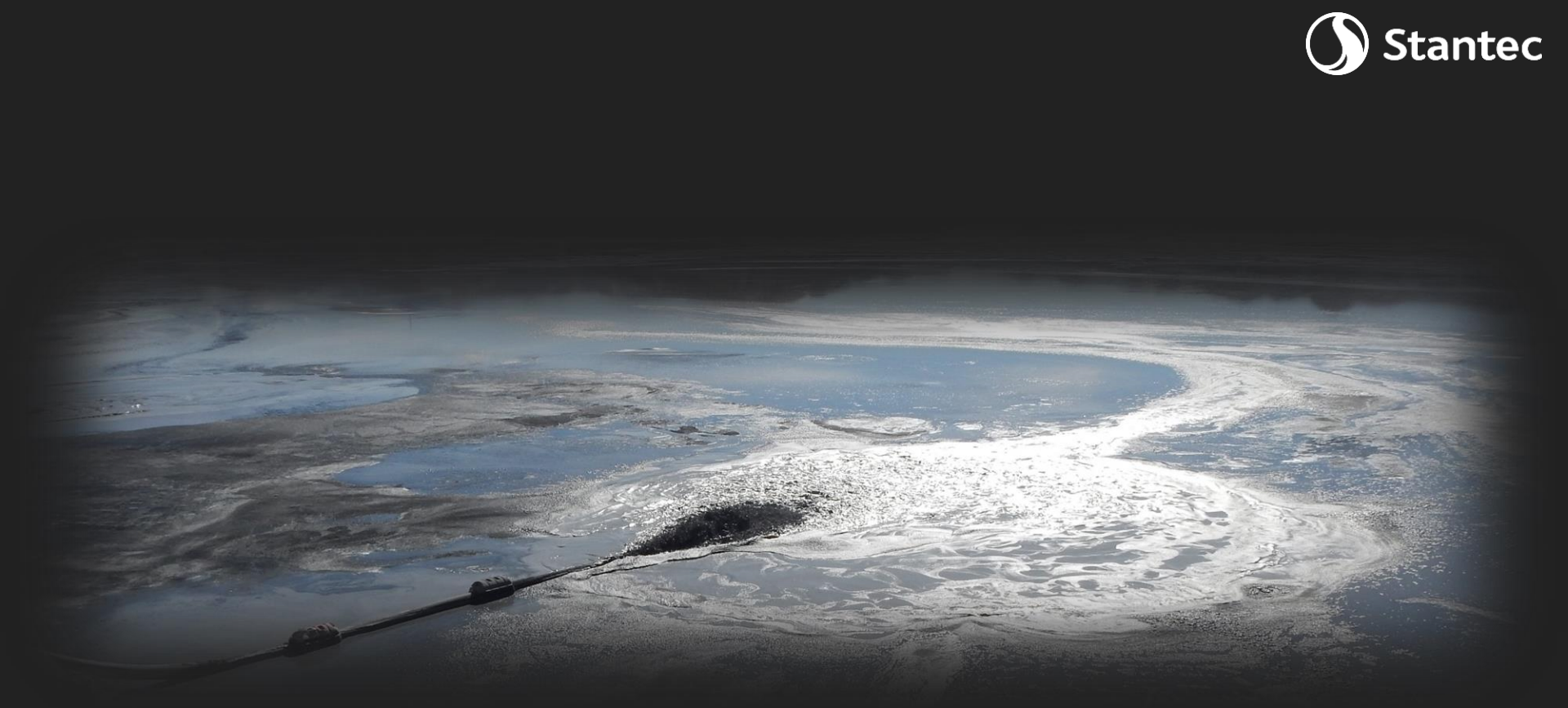








Illustrations by Dr. Dobroslav Znidarcic, University of Colorado Boulder



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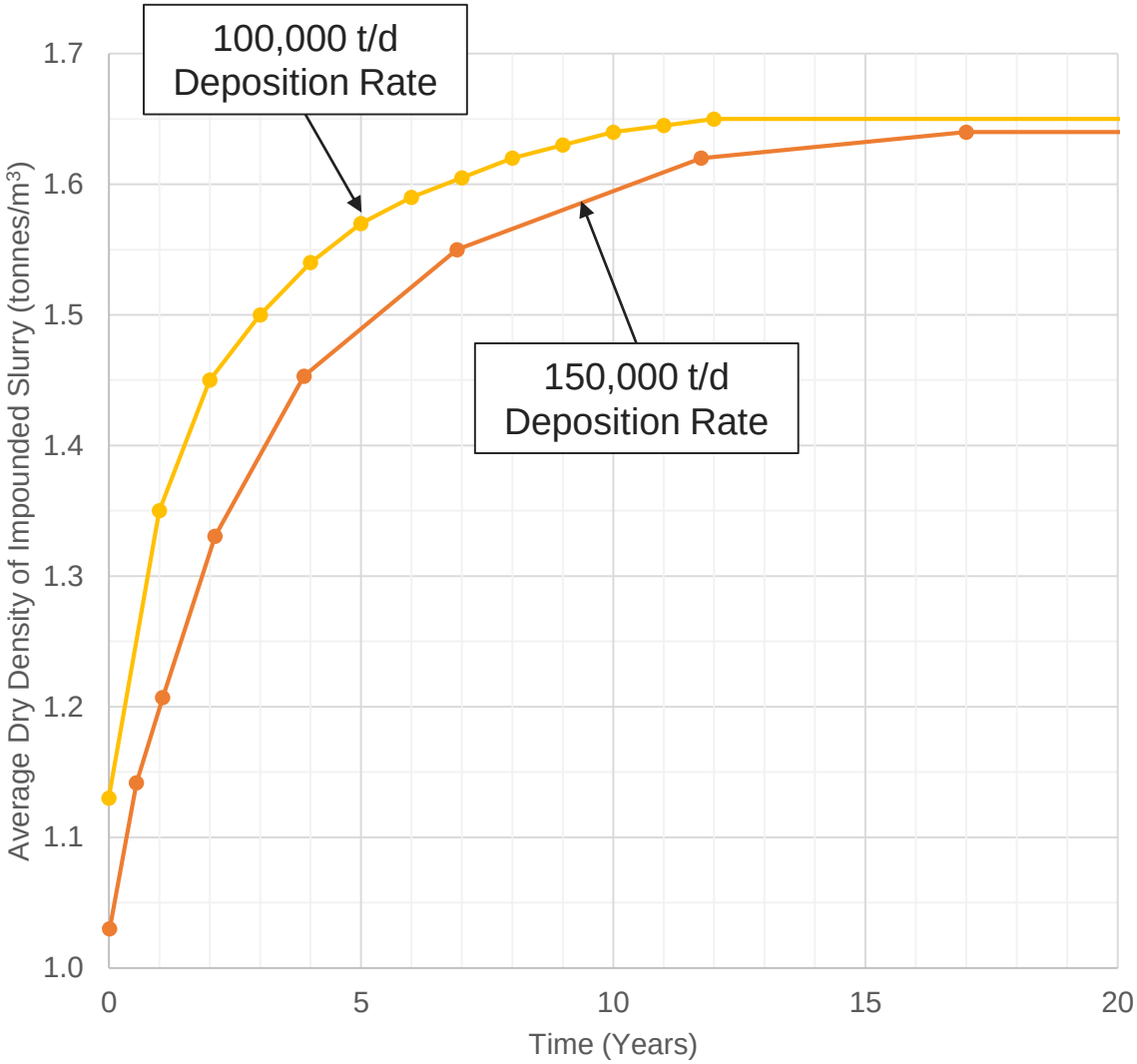
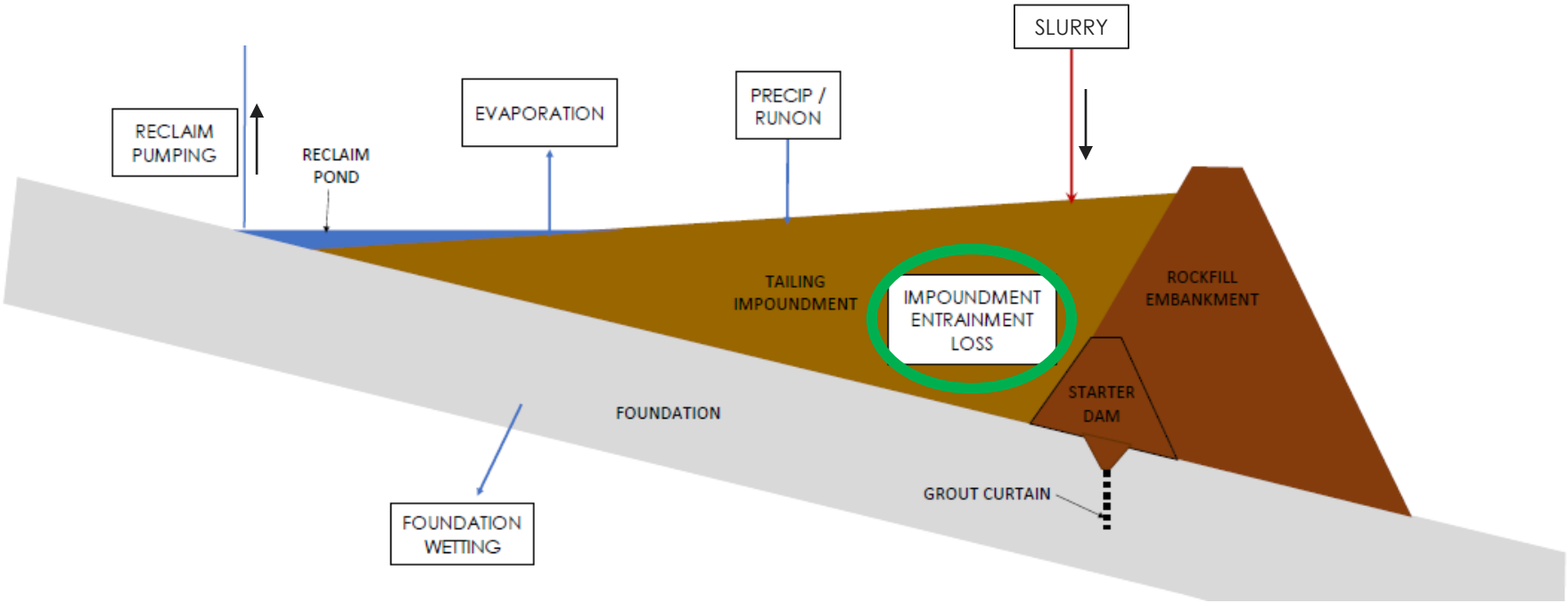
Water Balance Modeling Considerations

Representing Consolidation in GoldSim

- We use the numerical model results to estimate the AVERAGE density of the impounded slurry with time, resulting in a density curve.
- The density curve is unique to the material AND to the deposition type/environment; it is affected by:
  - Slurry material properties,
  - Deposition rate and/or rate-of-rise in the impoundment,
  - Geometry of the impoundment (i.e. stage/storage curve),
  - Drainage conditions of the substrate beneath the impoundment.



How Does Consolidation Fit in a Water Balance Model?

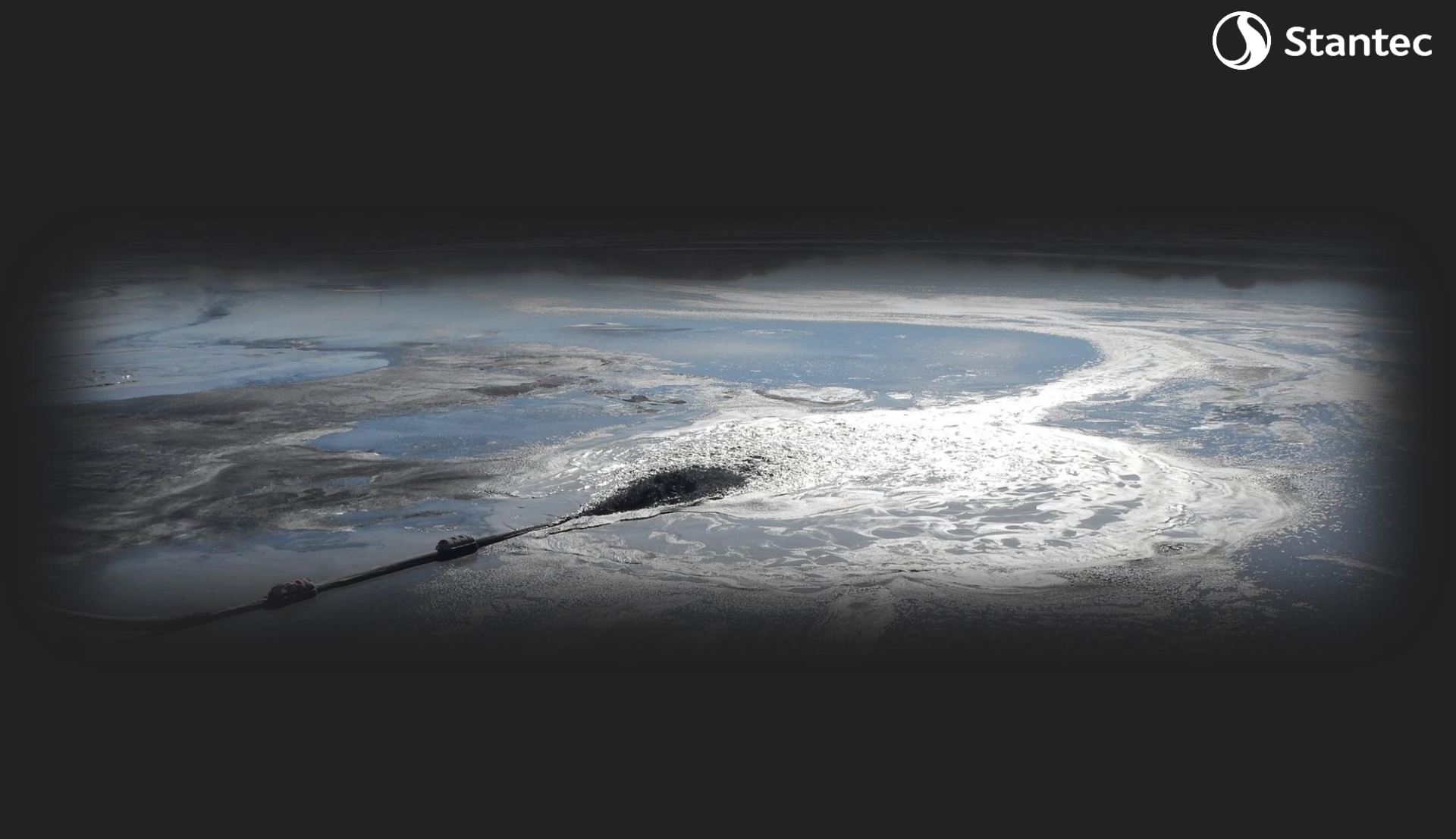


Inflows → **Losses** → **Reclaim**

- Water in the Slurry
- Precipitation/Runon

- Entrainment in Impounded Slurry
- Evaporation
- Foundation Loss

- Calculate: Inflows minus Losses
- Consider change in volume of ponded water, if applicable



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GoldSim Modeling