REINHOLD ENVIRONMENTAL Ltd.

2016 APC-Wastewater Round Table & Expo Presentation

July 18 & 19, 2016 in Dearborn, MI / Hosted by DTE Energy

July 18 -19, 2016 APC Wastewater Round Table Workshop

Options and Opportunities for Eliminating Wastewater Discharges Through Solids Fixation

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Agenda

- Fixation Options
- Testing
- Equipment
- Project examples
- Conclusions
- and then a……..

VIDEO!

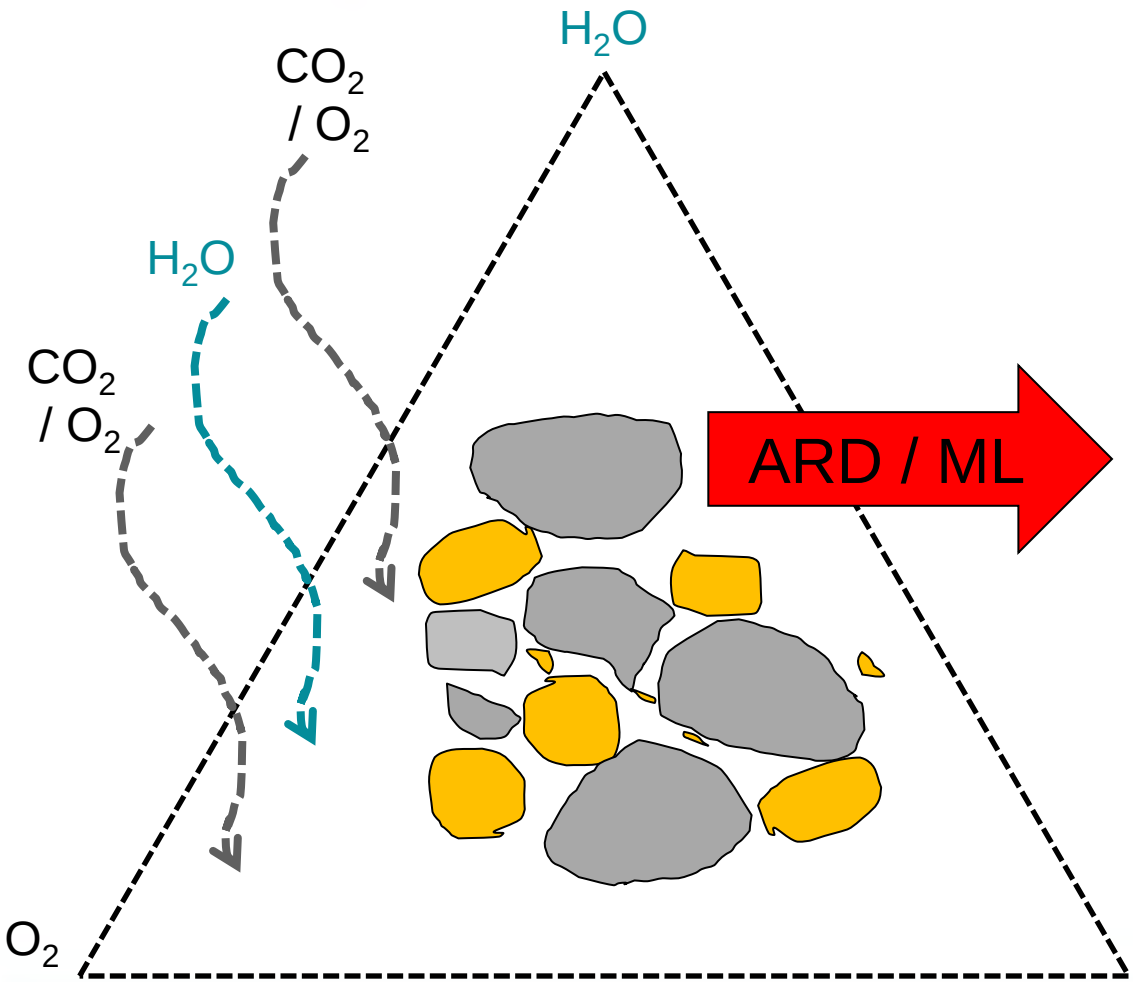
What is Fixation?

- Fixation
- Sequestration
- Solidification
- Encapsulation
- Stabilization

- All of these terms have been used to describe the desired end state for both CCR materials and wastewater treatment residuals/streams
- What do they all mean?
  - Technical definition is the action of making something firm or stable
  - Ultimately looking for long term immobility (geotechnically and geochemically)

The importance of Yield Stress for Geotechnical Immobility

The importance of Permeability for Geochemical Immobility

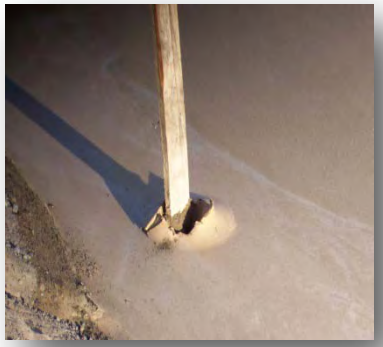


Reactive Material

How do we get stability / immobility?

Paste

What is “Paste”?

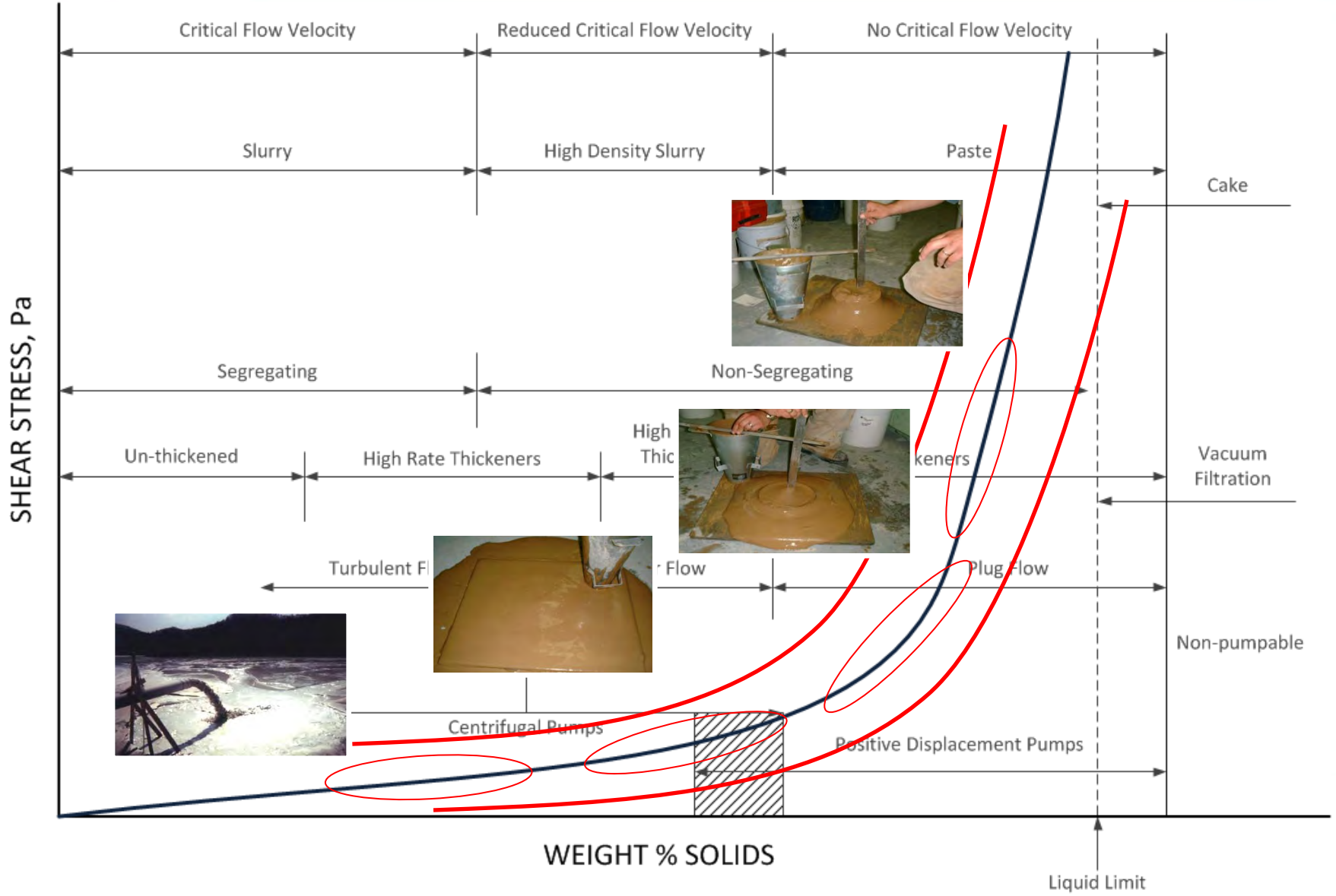


- Simply dewatered material (generally tailings or other mineral wastes i.e. ash) that is an engineered mixture of solids and water
- Possesses a yield stress
- Produces a measurable slump and has a maximum slump of ~10 inches
- Has a homogenous appearance i.e. no segregating of coarse to fine particles

What is “Paste”?

- Is normally free standing when deposited
- Has low or no critical flow velocity
- Uses pumps or gravity to move through a pipeline
- Exhibits low permeability upon deposition and after desiccation
- Exhibits plug flow characteristics
- Exhibits little to no water bleed during transport or placement

Solids Content Continuum



How do we move along the continuum?

- Process
  - Slurry → Thickened Ash → Paste → Filter Cake
    - Mechanically
      - Thickeners, filters, cyclones, centrifuges, mixers
    - Chemically
      - Flocculants, admixtures, retarders etc either pre-pipeline or in-line
    - Other options
      - Electro-kinetics
- Transportation
  - Slurry → Thickened Ash → Paste → Filter Cake
    - Pumps and pipelines (centrifugal vs positive displacement)
    - Conveyors
    - Trucks

How do we move along the continuum?

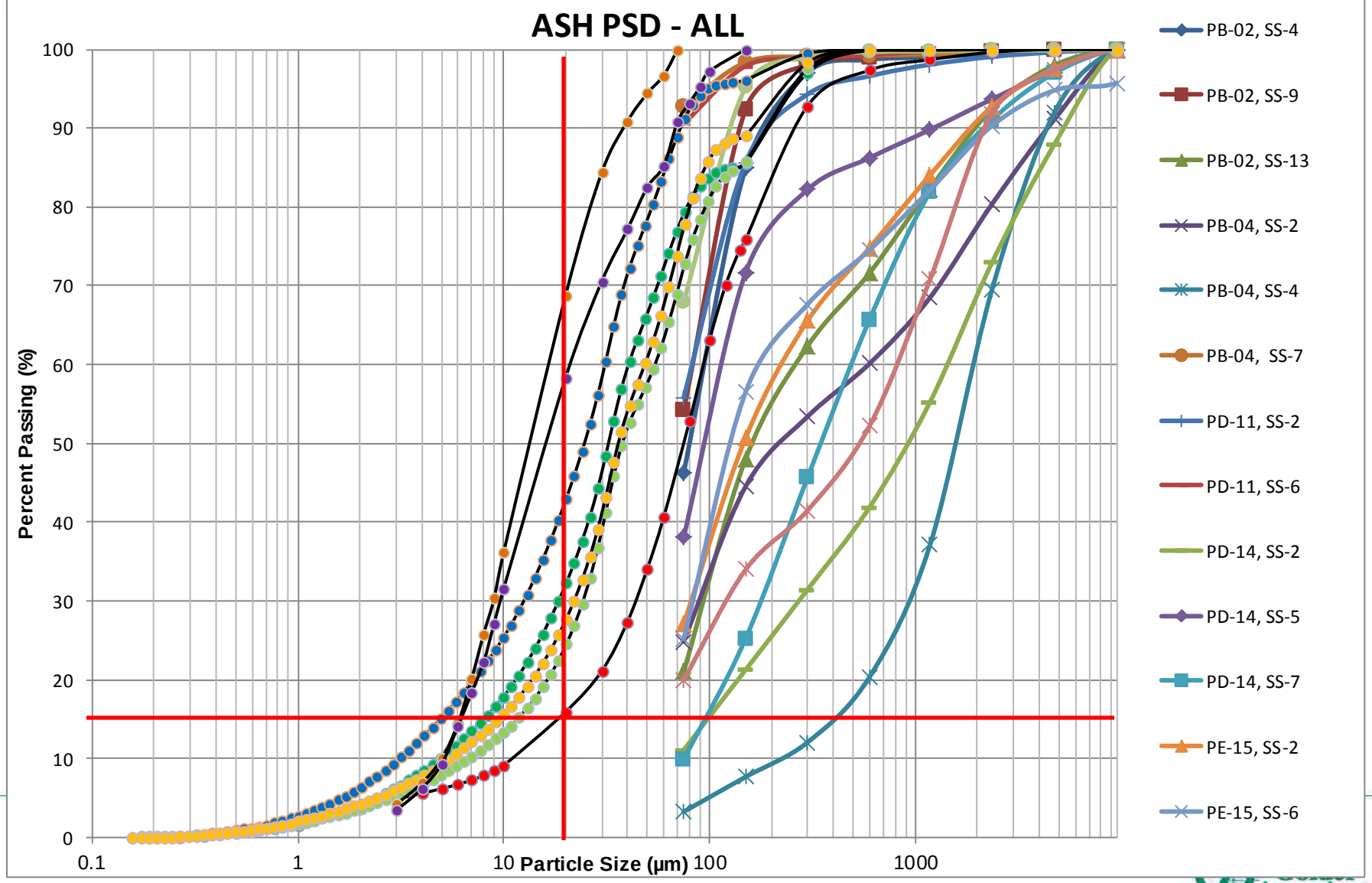
- Deposition
  - Slurry → Thickened Ash → Paste → Filter Cake
    - Single point discharge
    - Multi-spigot
    - Perimeter discharge
    - Cell construction

Testing

Laboratory Suite of Tests

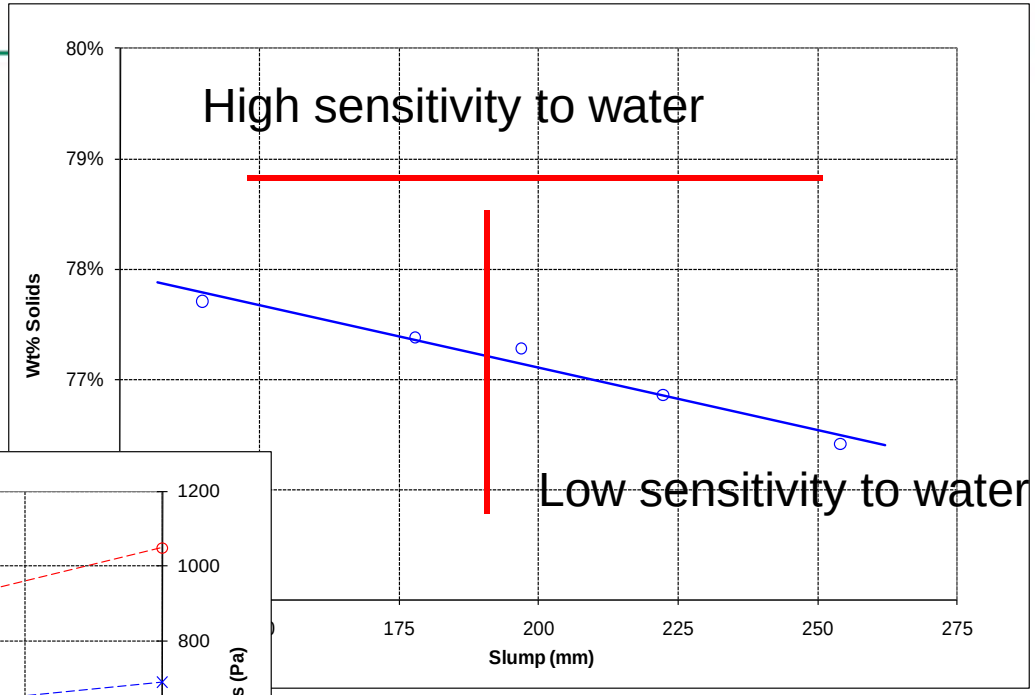
- Index Testing
  - PSD – governs the dewatering, mixing and transport behaviour
  - SG – governs the processing options and the m^3 throughput
  - pH – affects process-ability and strength performance
  - Mineralogy and chemistry – affects all of the above
- Rheology – measures the flowability and behaviour of material
- Flocculant screening – identifies chemical compatibility
- Settling tests – measures dewatering performance
- Filtration / Centrifuge tests – measures ultimate dewatering performance
- UCS – strength profiles with each recipe
- Water chemistry – secondary mineral formation
- Temperature – overarching consideration

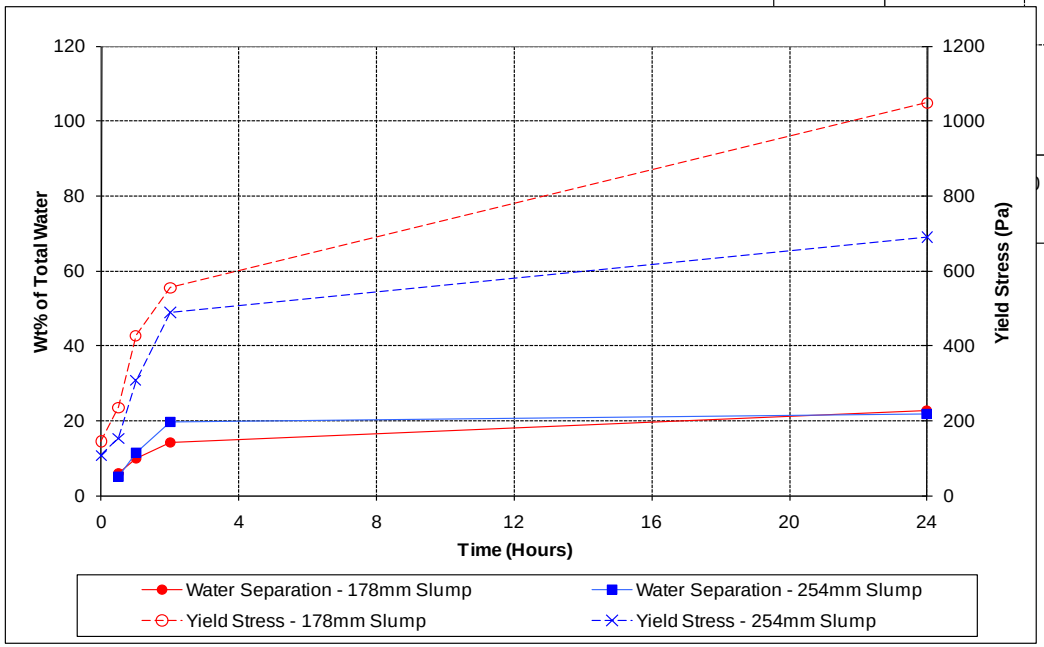
Ash PSD's


ASH PSD - ALL
Percent Passing (%)
Particle Size (µm)
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10
100
1000
PB-02, SS-4
PB-02, SS-9
PB-02, SS-13
PB-04, SS-2
PB-04, SS-4
PB-04, SS-7
PD-11, SS-2
PD-11, SS-6
PD-14, SS-2
PD-14, SS-5
PD-14, SS-7
PE-15, SS-2
PE-15, SS-6

Rheology

- Solids versus Slump
- Water bleed versus time
- Yield stress versus time

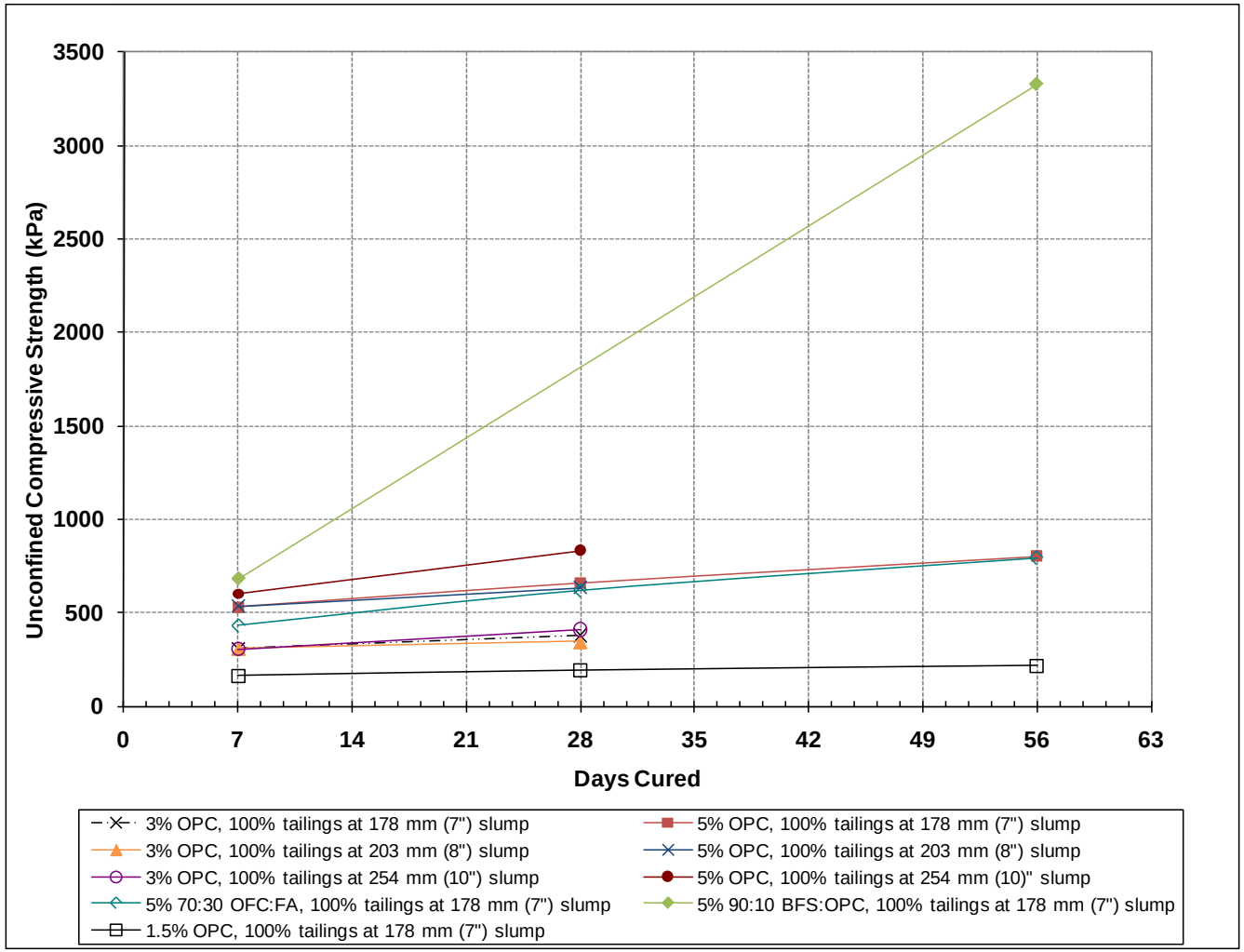




Flocculant Screening

- Flocculant Types
  - Anionic
  - Cationic
  - Organic
  - Inorganic
- Other Admixtures
  - Coagulants
  - Dispersants
  - Retardants
- Screening Program can include
  - Single floc
  - Double floc
  - Floc + admixtures

UCS Test Results

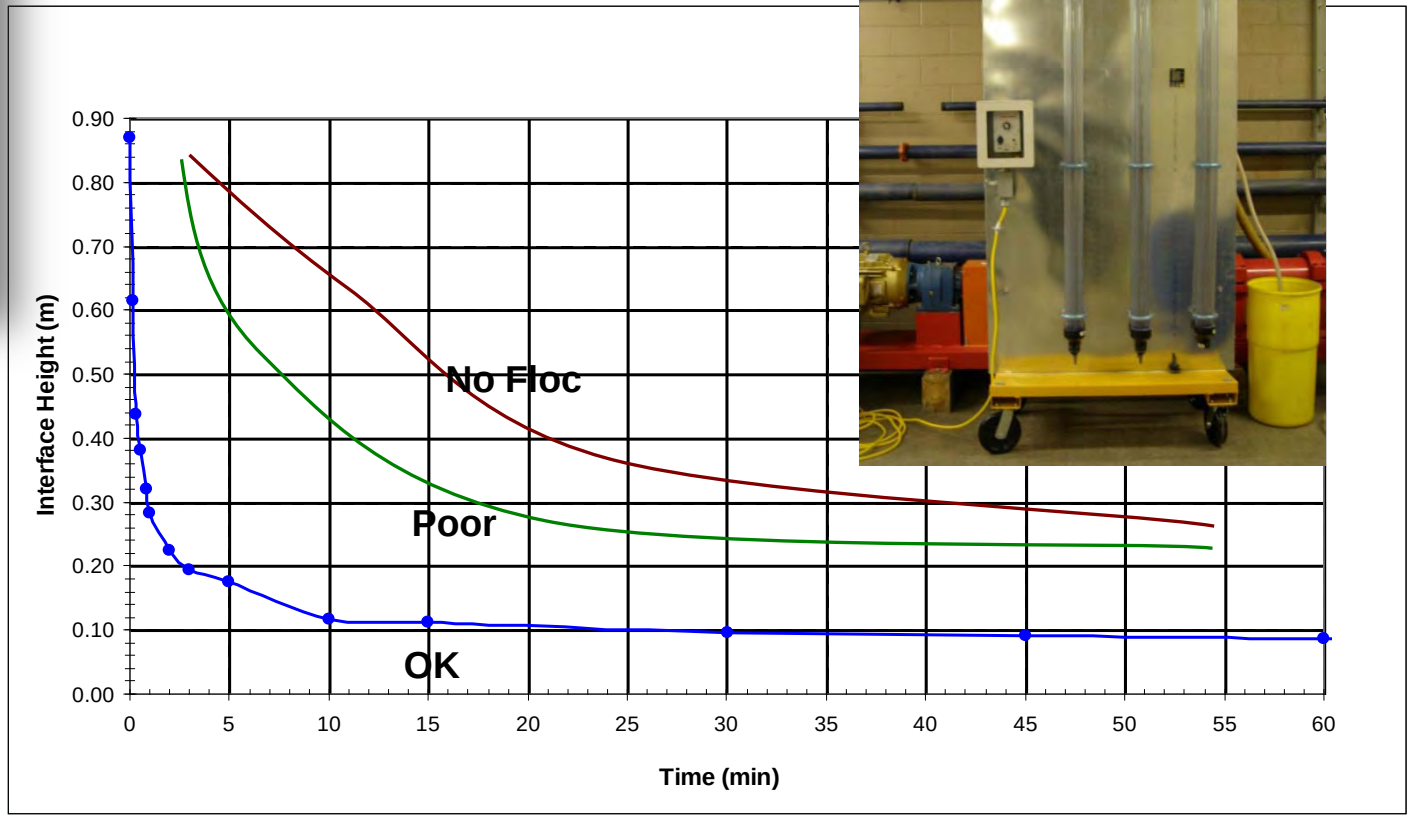


Bench Scale versus Pilot

- Bench scale is the foundation of a program
  - Identification of your ‘book ends’
  - Covers multiple process scenarios

- Pilot
  - Confirms behaviour and performance at a larger scale
  - A planned program that pushes the book ends established in bench scale

Bench Scale – Dewatering and/or Mixing



Pilot Dewatering and/or Mixing

Bench Scale Rheology - Slump Test, Viscosity

Pilot Scale Flow Loop

Bench Scale Deposition – Consolidation, Water Bleed

Pilot Scale Deposition - Beach Slope, Solids content

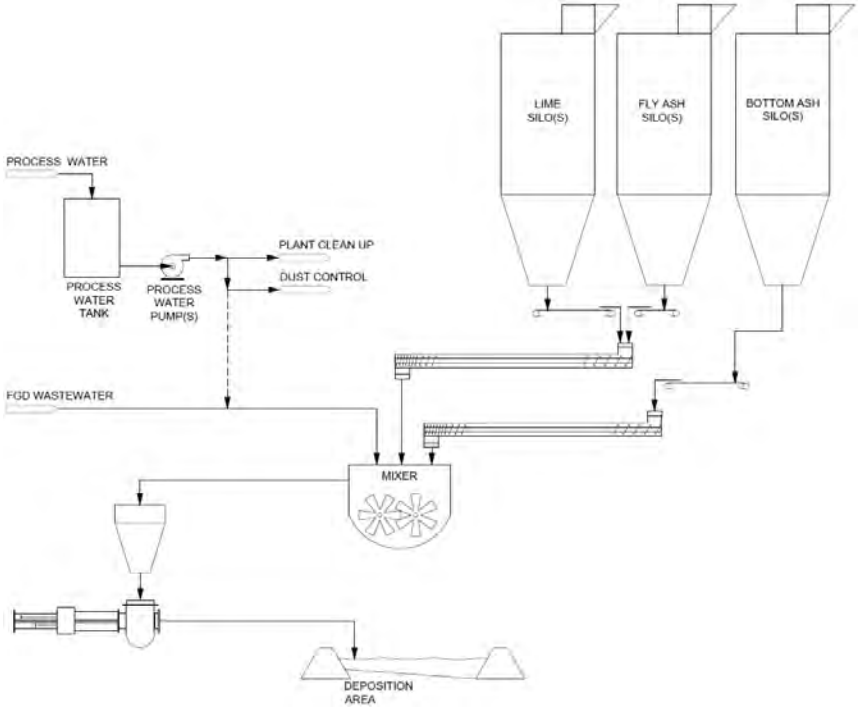
Testing Summary

- Bad news
  - Every site / material is unique so you must undertake a testing program to confirm behaviour and performance
- Good news
  - Lots of different fly ash and bottom ash materials have been tested from around the world
    - South Africa
    - Brazil
    - USA
    - Canada
  - And they all make pretty good pastes
  - There are two full scale fly ash paste plants in operation and approximately 50 full scale paste plants in operation
    - Paste works in general and fly ash works in particular

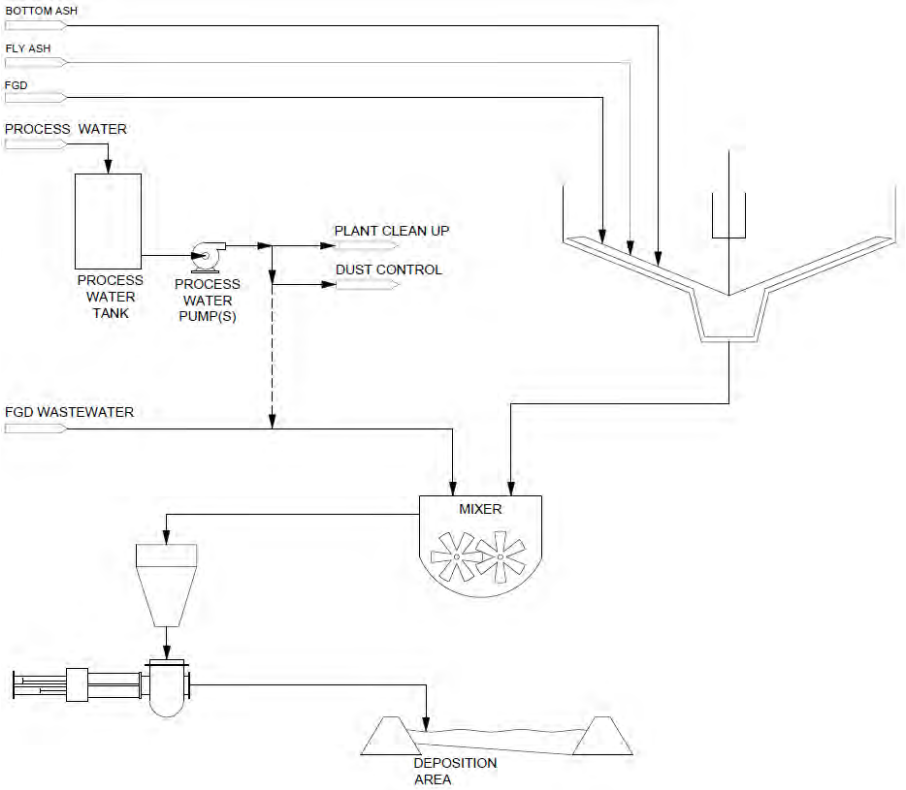
Equipment

Fly ash + bottom ash + water (FGD)

Dry Feed Materials



Wet Feed Materials



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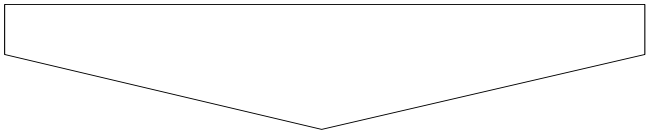
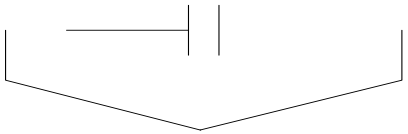
Thickener Technology Development

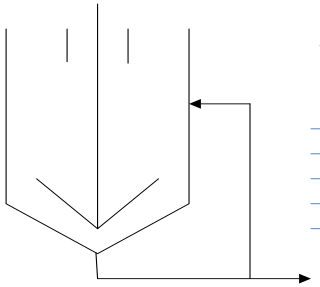
MAJOR Ddensification MILESTONES

CONVENTIONAL – “OLD” THICKENER



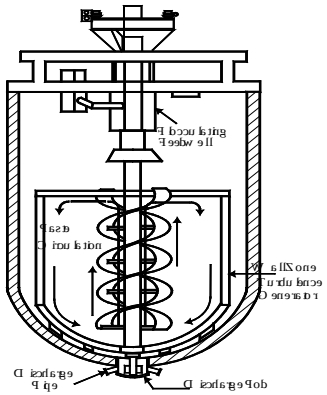
FEEDWELL / FLOCCULENT MIXING



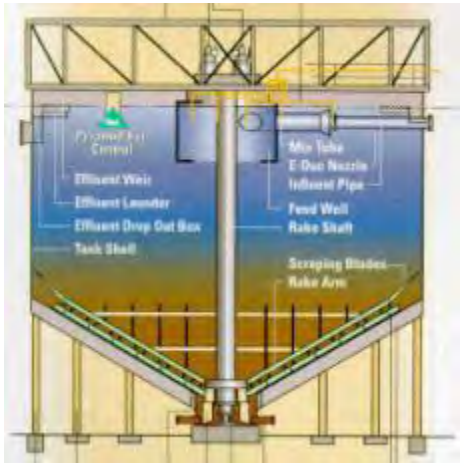


ALCAN

- PACHUCA
- FEEDWELL
- FLOCCULENT
- RECYCLE
- RAKE



PPSM
GL&V/INCO



DTT

Filtration Technology Options

- Vacuum Disc Filters

- Belt Filters

- Pressure Filters

- Rotary Drum Filters

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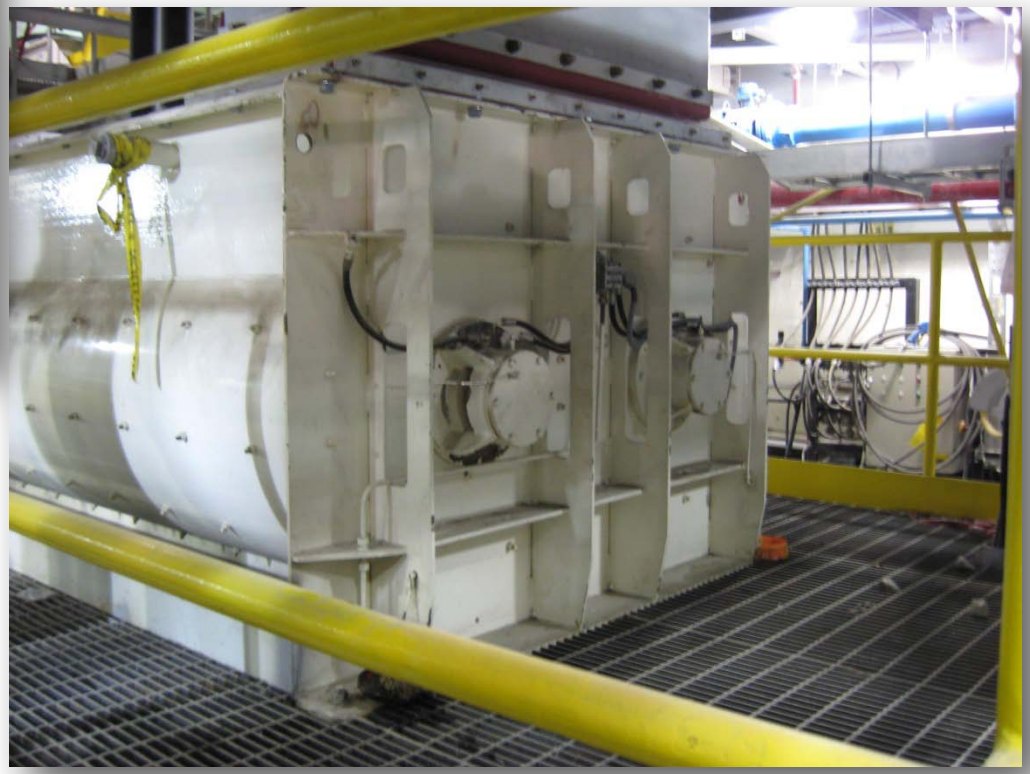
Mixing Technology



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Dewatering versus Pumping System

Slurry Placement			Centrifugal Pump (lower pipeline pressures)
High Density Slurry Placement			Centrifugal or Piston/Diaphragm Pump (high pipeline pressures)
High Slump Paste Placement			Piston/Diaphragm Pump (higher pipeline pressures)
Low Slump Paste Placement			Dual Piston Positive Displacement Pump (high pressure pipelines)

Yield Stress versus Slopes

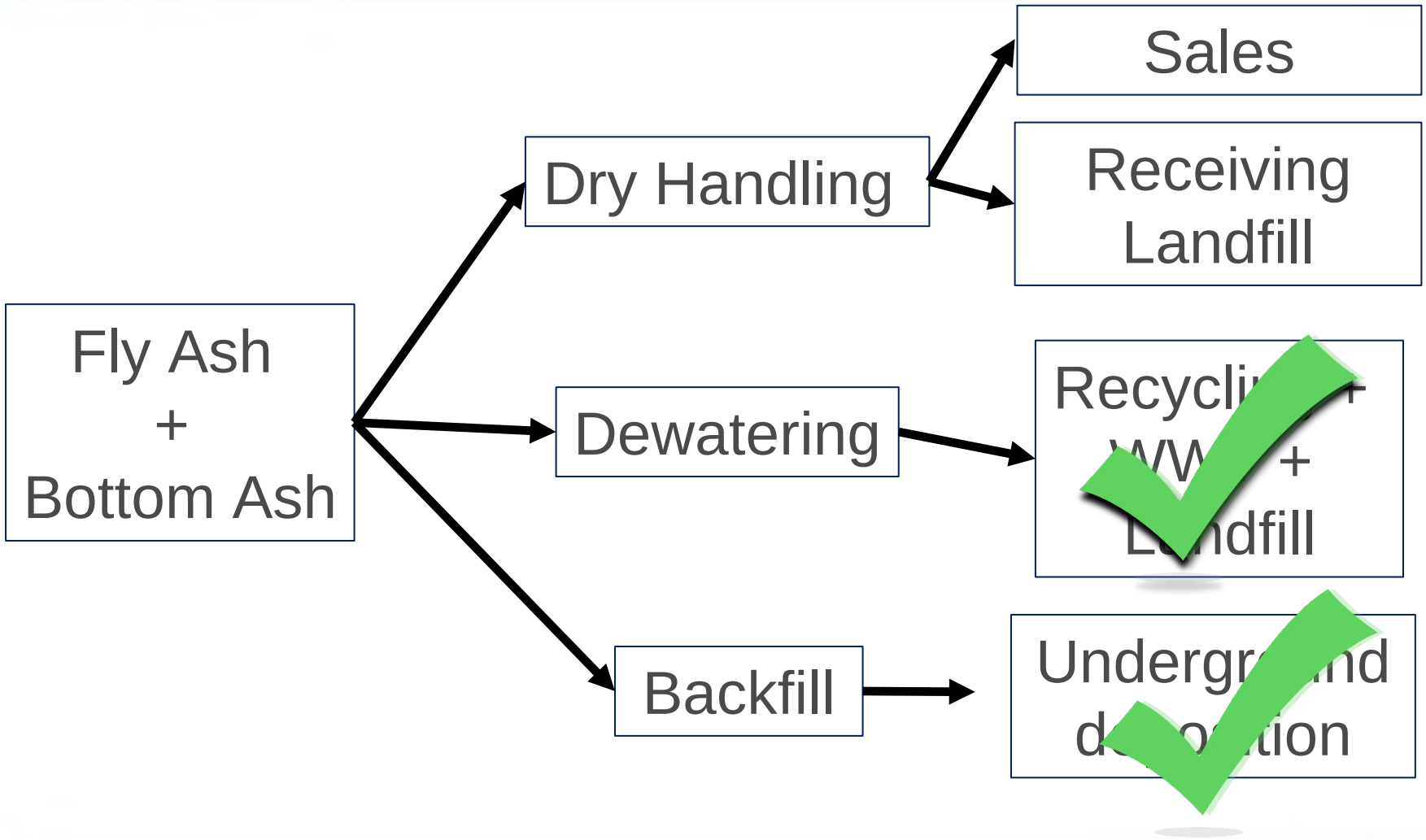
Slurry Placement		0 – 1%
High Density Slurry Placement		1 – 2%
High Slump Paste Placement		2 – 5%
Low Slump Paste Placement		3 – 10%

Project Experience

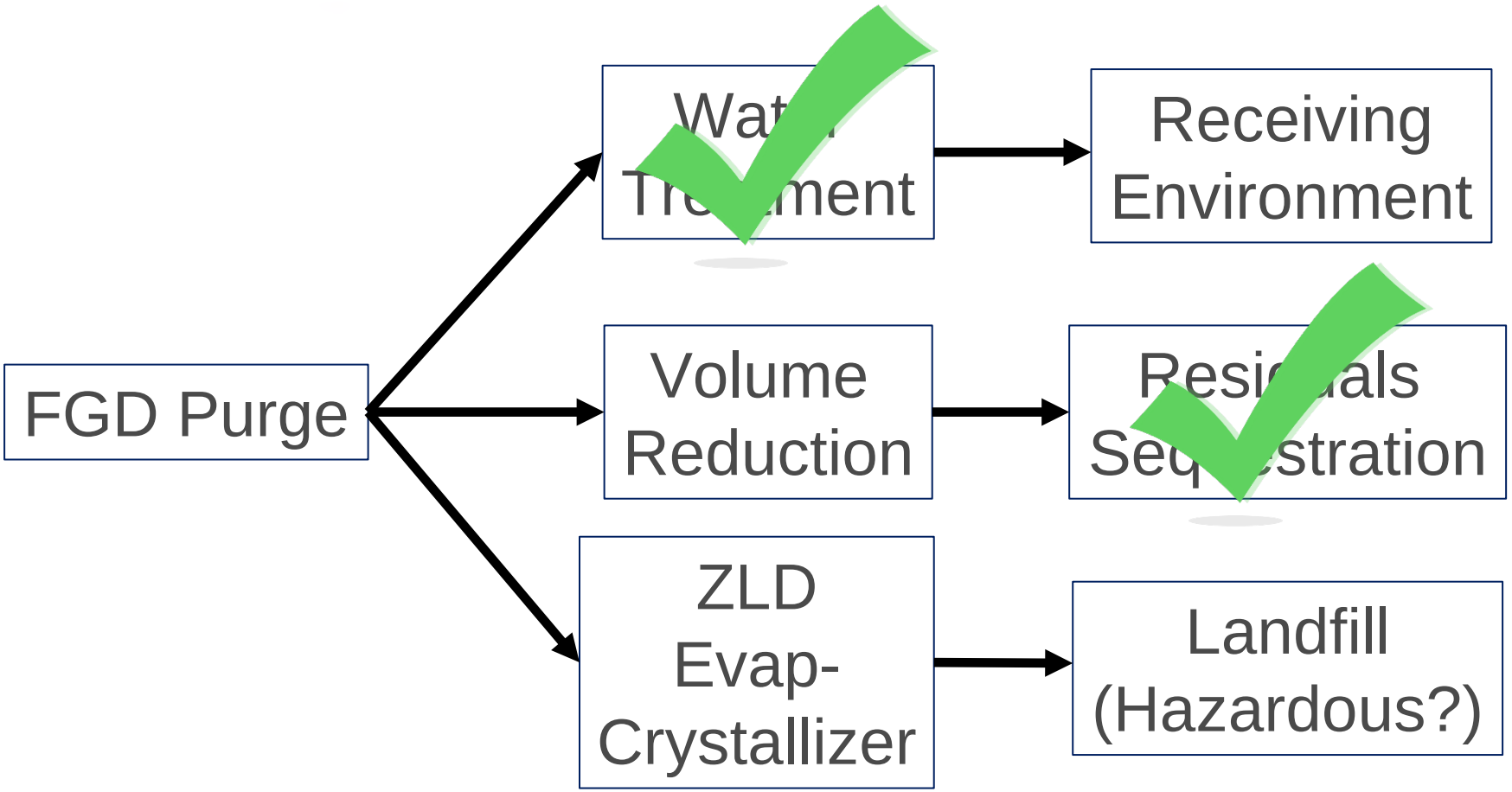
Summary of Paste advantages

- Increased water reuse/recycling
- Smaller surface footprints (stackable)
- Reduces likelihood of seepage/leachate from waste facilities (10^{-6} cm/s or better)
- Smaller containment dikes (not dams)
- Reduces risk of failure of dikes
- Reduces dusting on surface
- Faster reclamation (progressive)
- Potential to put back u/g or in-pit
- Metals / contaminants of concern are encapsulated in the paste matrix
- Co-disposal opportunities (fly ash, bottom ash and FGD)
- Forces holistic discussions between engineering, environmental, regulatory

High Level Process Alternatives - CCR



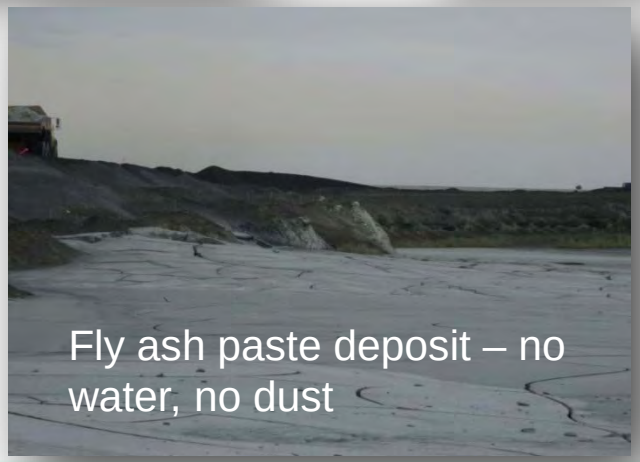
High Level Process Alternatives - ELG



Dewatered and Deposited – Fly Ash

Fly ash paste 5-7 days after deposition

Fly ash paste 2+ weeks after deposition



Fly ash paste deposit – no water, no dust

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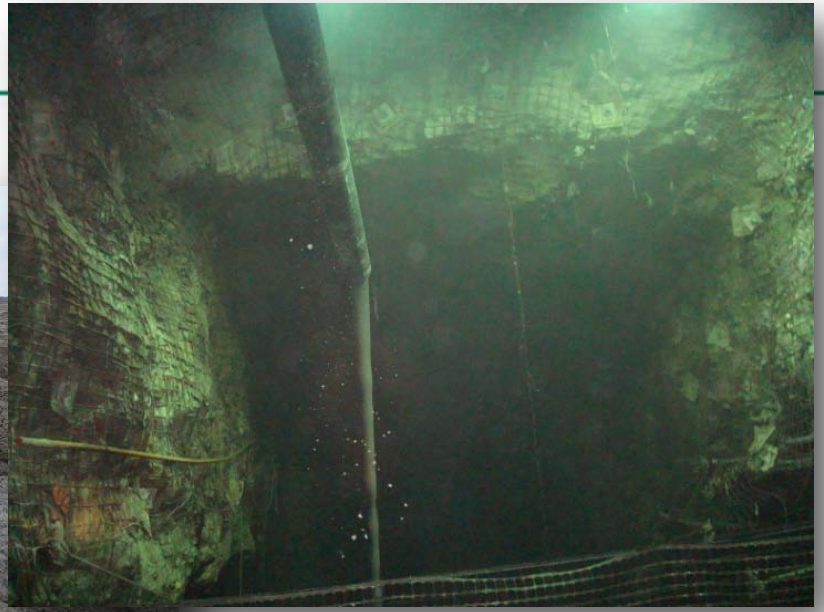
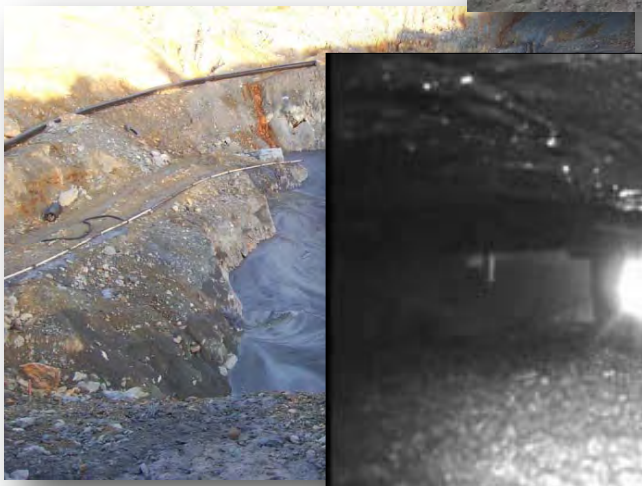
Backfill Applications

- Paste technology began in u/g mining backfill applications
- ~ 2/3 quantity of material extracted can be replaced underground as backfill depending on mineralogy/chemistry and PSD's
- Requires processing and testing to get the hydration process correct and thus the strengths and other properties like hydraulic conductivity
- Key concerns underground are:
  - Excess water (bleed)
  - Transport (pumps and pipeline plugs)
  - Leachate coming out of stack adding to mine water loading

Backfill Photos





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Water Treatment Sludge

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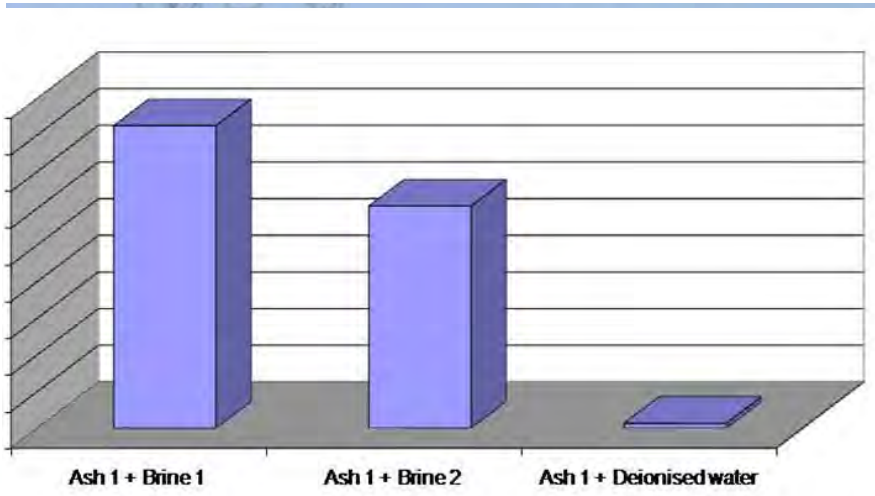
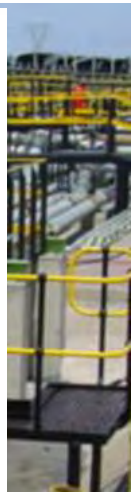
Waste water treatment residual solidification

- Interaction of pozzolanic ash/cement with waste waster residuals to form new solid phases
- High strength/low permeability properties develop
- Concentrated waste water contaminants are solidified
  - Materials formed are much less solubility than e.g. gypsum / NaCl
- Remainder of soluble materials are encapsulated in pore water.





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Conclusion

- End goal is immobility/stability/fixation etc
  - Geotechnical AND geochemical
- Paste is one possible solution
- Testing is critical at bench scale for “book end” identification
- Site specific system design
  - Based on unique properties and circumstances of each site and waste material
  - No one size fits all – no silver bullet
  - Paste is not always the answer but it should always be an option to consider
  - Integrated solutions
    - Process, transport and deposition

Surface disposal

Backfill disposal

THANK YOU