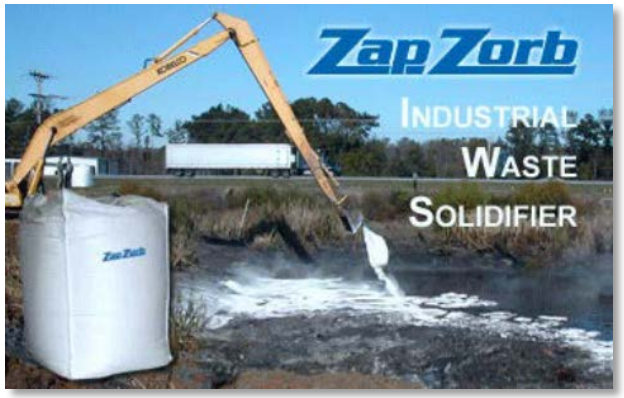
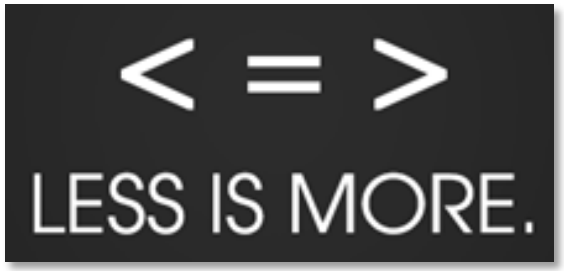
Rapid Solidification of Coal Combustion Residuals (CCR) Dredge Slurries & Wet Ash Wastes

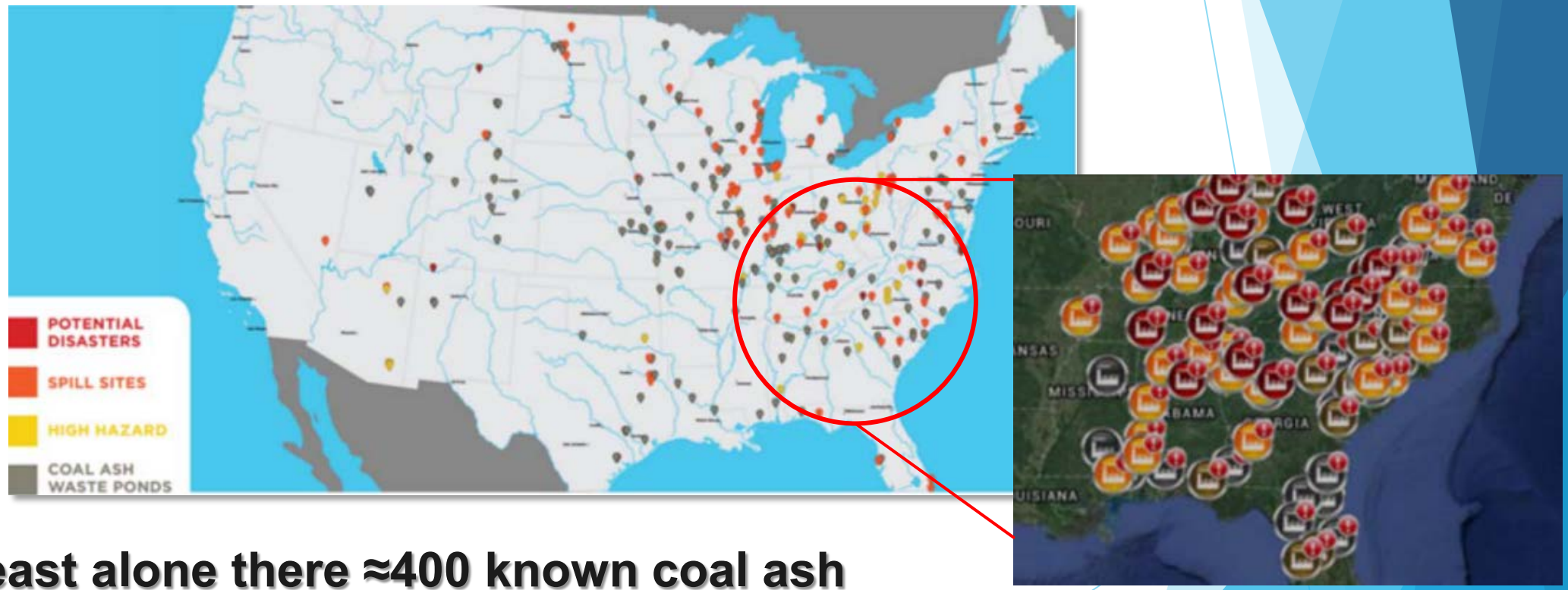




Richard P. Traver, PE – Principal Consultant, Pace Engineering, LLC

Extent of the CCR Remediation Challenge

Coal combustion residuals (CCRs) include fly ash, bottom ash, boiler slag and flue gas desulfurization, or scrubber, materials such as synthetic gypsum, which are produced when coal is burned for electricity generation. CCRs are one of the largest industrial waste streams generated in the United States. ***In 2012, more than 470 coalfired electric utilities burned over 800 million tons of coal, generating approximately 140 million tons annually of CCRs in 47 states and Puerto Rico.***



In the Southeast alone there ≈400 known coal ash storage facilities with a total capacity to hold over 584,234,000 Cys of ash

The "typical" CCR Waste Impoundment Site

Fun Facts!

CCR disposal currently occurs at more than 310 active onsite landfills, averaging more than 120 acres in size with an average depth of over 40 feet, and at more than 735 active onsite surface impoundments, averaging more than 50 acres in size with an average depth of 20 feet with ≈1.6 MCys/ea.

Examples of a "bad day at the CCR office".....

Saturated CCR waste is "thixotropic" and will "liquefy" and flow when agitated/vibrated from rehandling or machine operations

Nolan Run Slurry Impoundment

Catastrophic Slope Failure

Nolan Run Surface Impoundment Facility Dam Failure Accident (Drowning) November 30, 2012

A CATD6 LGP bulldozer was blading CCR waste along the bank of an impoundment. Without warning a slope failure *≈200 feet wide and ≈850 feet long* occurred carrying the dozer and operator into the pool area where it went 25' beneath the liquidized CCR slurry. Commercial divers recovered the operator's body 14 days later.

http://www.wvalways.com/story/20228623/update-missing-consol-miners-body-recovered-from-bulldozer-cab

Superabsorbents versus Absorbents

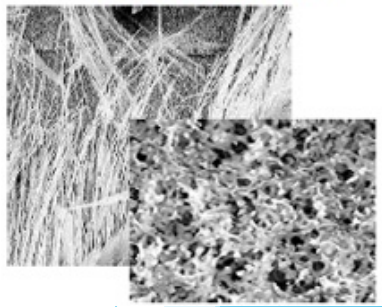
- Super Absorbent Polymers (SAP – Sodium Polyacrylate) developed in 1960's
- Used predominantly child (85%) & adult (10%) diapers, feminine hygiene products
- Only 2% is used to solidify:
  - Meat packaging
  - Medical bio wastes (blood, body fluids, etc.)
  - liquid industrial /radioactive waste streams
  - dredge sediments
  - biosolids and sludges

SAPs reduce waste transportation and disposal costs from these operations by solidifying liquid waste while minimizing an increase in weight and volume. With the capability of solidifying up to ***300x its weight in water, 1# of SAP can solidify ≈36 gallons of water (2,500#).***

➢Chemically bond with water ➢Don't biodegrade ➢Minimize waste volume increase

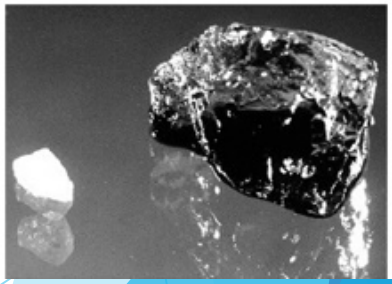
Difference between Superabsorbents & Absorbent Material

Absorbent



Fluff-pulp, wood chips, sawdust, sponge, corncobs, shredded paper, kitty litter, etc.
Absorbs Liquids Only

Superabsorbent



Super Absorbent Polymer (SAP)
Absorbs & Retains Liquids

Application of Super Absorbent Polymer for Sediment Water Locking

Past SAP Application Practices

Since it's development in the 1960's, SAP has been used for over *55 years* in solidification of industrial, radioactive waste streams, slurries, drilling muds and sediments. Means & Methods for

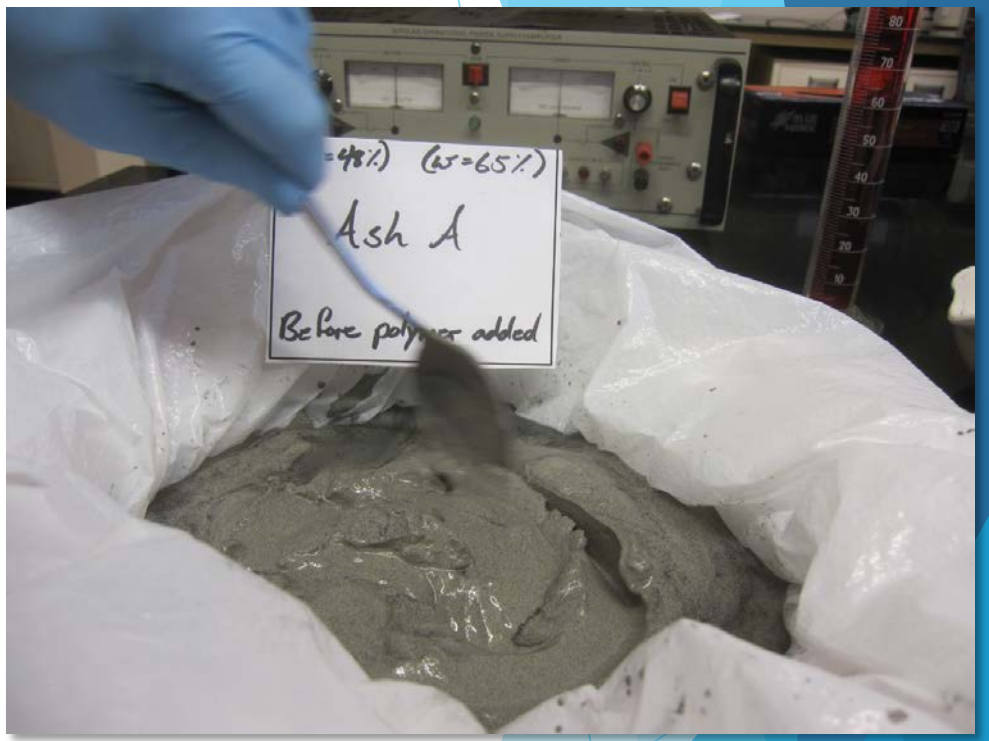
SAP application has been typically "broadcasting" the SAP on top of the waste matrix at application rates of 2 – 5%, dependent upon how careful the operator was and how cost-conscious the superintendent was.

The CALM CCR/SAP solidification treatability results have shown:

Bench-Scale Moisture & Strength Evaluation of Ponded CCR Ash Using ZapZorb SAPs
Phase I - Screening Key Objectives

1. ***Coal Ash & Liquid Management Office - UNC*** **secured 5 CCR Ash samples from 4 different power utilities within the SE Region**

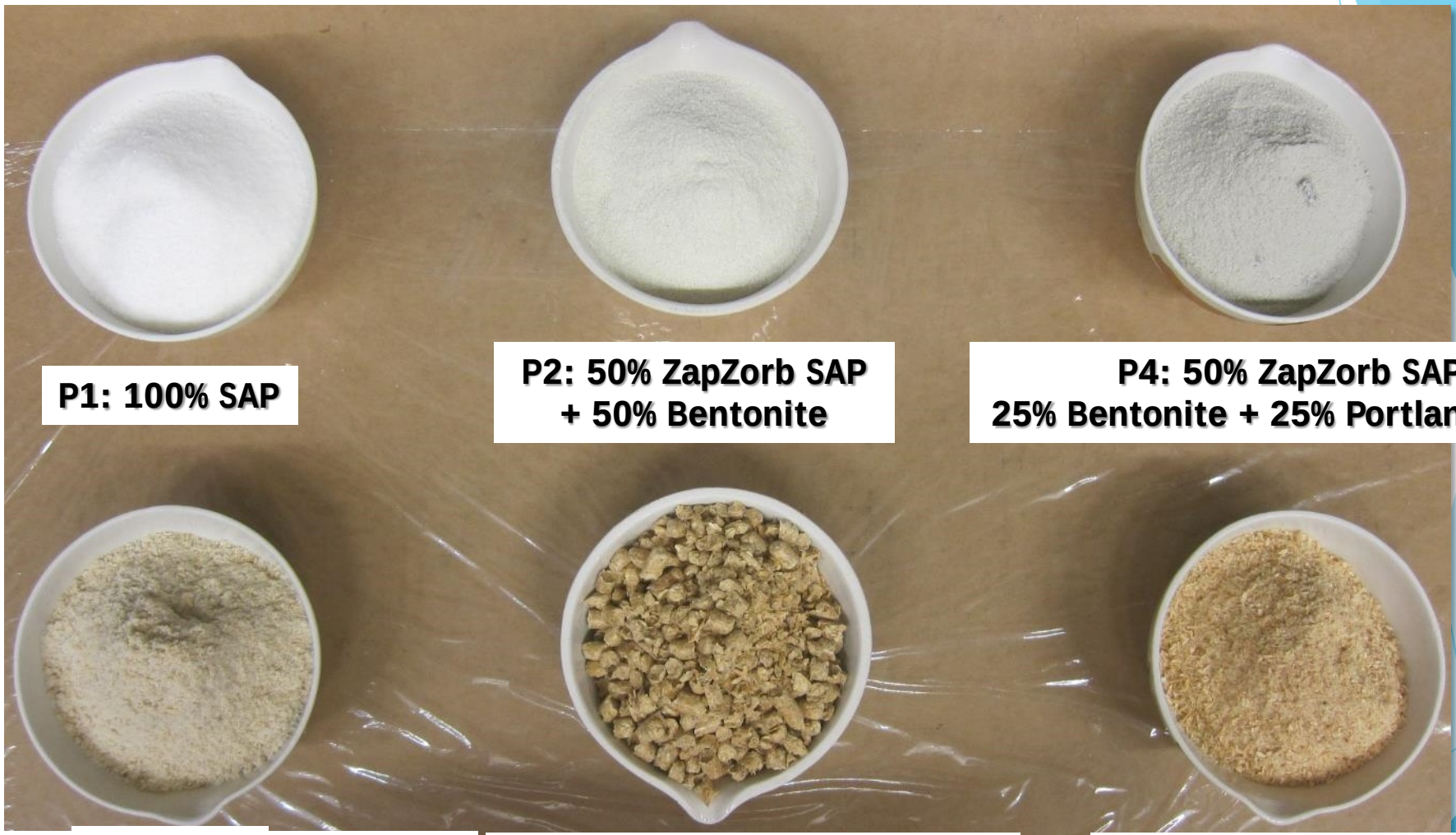
2. **Establish a water content at which each of the ash samples fail the Paint Filter Test**



55 - 60% Moisture CCR Ash Fails Paint Filter Test

3. **Add pre-determined mass fractions of SAPs and evaluate for the *Paint Filter Test*, *Undrained Cohesion* and *Shear Strengths* of the CCR SAP solidified samples.**

Phase I - SAP Material Blends Evaluated



P1: 100% SAP

P2: 50% ZapZorb SAP + 50% Bentonite

P4: 50% ZapZorb SAP + 25% Bentonite + 25% Portland Cement

P6: 75% ZapZorb SAP + 8% Portland + 8% Bentonite + 8%wood flour

Power Pellets - 5% ZapZorb SAP + 95% wood pellets

P7: 25% ZapZorb SAP + 75% wood fiber

Example of Pre- & Post SAP Addition

CCR Ash at 70% Water Content
Failing Paint Filter Test

CCR Ash at 70% Water Content +1% SAP
Passing Paint Filter Test

Phase I Screening of ZapZorb Super Absorbent Polymer Formulations for Wet CCR Waste Solidification

TESTING PROTOCOL:

Once the CCR samples are characterized, they were amended with the SAPs and the following tests performed before and after amending the samples.

1. Pre- and post-moisture content
2. Specific gravity
3. Bulk density
4. Pocket Penetrometer;
5. Pocket Vane Shear (Torvane)
6. Unconfined Compression Test
7. Paint Filter

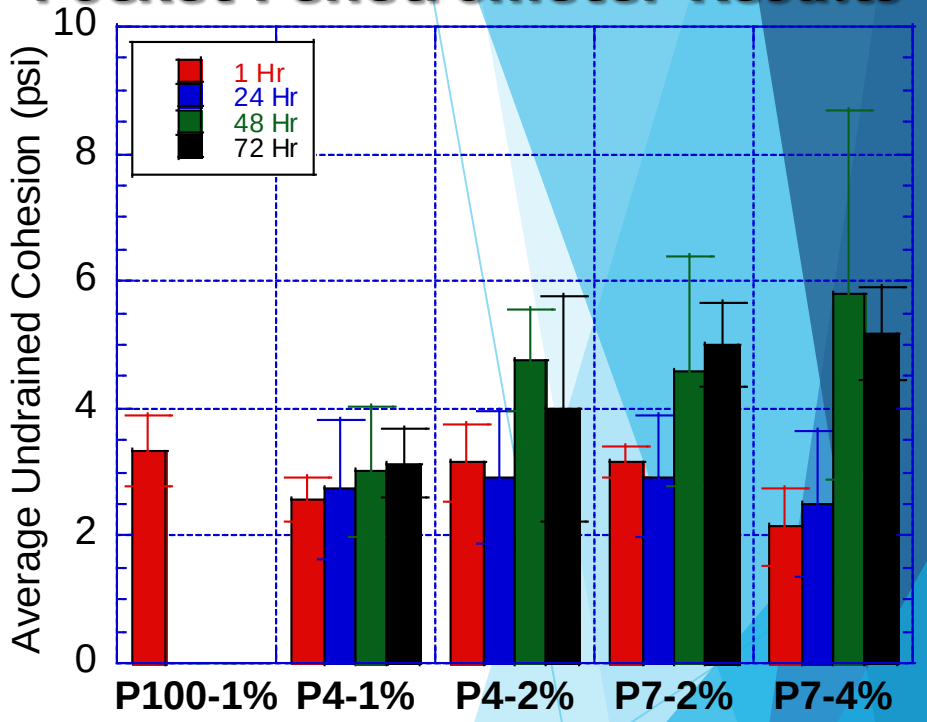
Phase I - Summary Conclusions

1. As little as 0.5% of SAP by dry weight was sufficient to stabilize the moisture in fly ash containing as high as 70% water
2. All polymers stabilized free water and the strength improved from a material that is at liquid limit to a material that can stand at undrained shear strength ranging from 2 to 10 psi.

CATD6 LGP Dozer needs 5.1 psi bearing capacity.

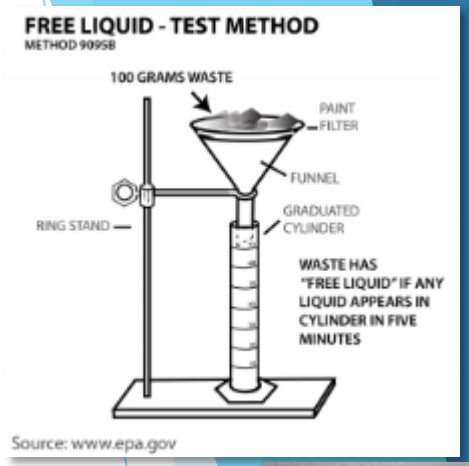
3. P2, P-4 and P-7 provided the most strength for the amount of SAP they contained.

CCR Ash M1, M2, and U Effect of P100, P4 & P7 Pocket Penetrometer Results



MGP Waste - Summary Conclusions

KEMRON ENVIRONMENTAL SERVICES



In March 2015, Kemron Environmental Services, using a Manufactured Gas Plant (MGP) waste, performed a comprehensive study that demonstrated the SAP passed the Paint Filter Test (EPA Method 9095) and the Liquid Release Test (EPA Method 9096) at 50 psi. Moreover, the leachable organic constituents testing demonstrated the following outcomes:

As stated in the Kemron report, *"A 96% reduction in leachable PAH compounds is considered comparable to other reagents such as Portland cement which are commonly used as solidification agents."*

A comprehensive review of the criteria set forth by ODNR and the generated data leads Kemron to conclude *"that the SAP has the potential to receive approval from ODNR as a solidification agent utilized to treat various waste streams produced in the oil and gas exploration sector."*

Material	Test Method	Results
SAP	TCLP VOC's EPA Method 1311	54.5% Reduction
SAP	TCLP PAH's EPA Methods 8260/8270	96% Reduction

SmartFeed™ Sequential Mixer/Blending of ZapZorb Amendments with CCR High-solids Content Dredge Slurry

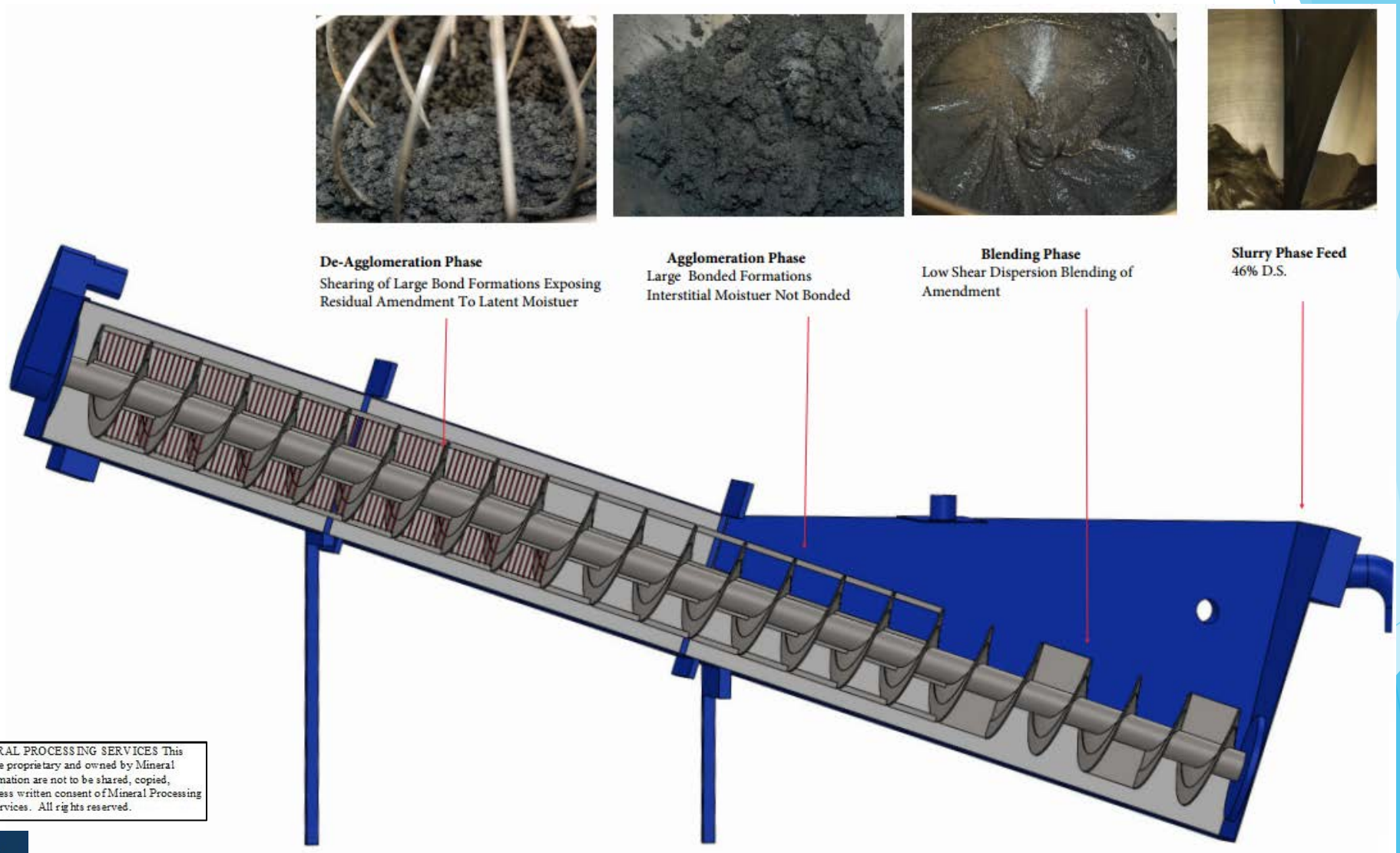
Mineral Processing Services (www.mpsmaine.com) bench-scale evaluation of Sequential Mixer/Blending of ZapZorb Amendments with wet CCR (64% moisture) slurry showed SAP CCR solidification effective at addition dosages as low as 0.3% (wet weight) with amended CCR stackable and passing EPA Paint Filter criteria for no free liquids in 3 minutes of blending.

< = >
LESS IS MORE.

MPS
MINERAL PROCESSING SERVICES, LLC

WEDA Western Dredging Association

MPS Bench-scale evaluation of SmartFeed™ Sequential Mixer/Blending of 0.3% ZapZorb SAP with wet CCR (64% moisture) paste sludge for 180 Second Contact Time



High Solids Production Dredging of CCR wastes

Application for high-solids dredging within Pits, Ponds, Lagoons and Dam impoundment areas

JAVELER DP-150

3,000 GPM @ ≈ 175 - 200 Cys/hr

- Discharge Diameter: **10”**
- Standard Motor HP: **150**
- Depth Range: **0’-150’**
- Capacity BEP (gpm@head): **3,200 @ 72’**
- Production (yd3/hr.): **0-250+**
- Power Source: **300kW Generator**
- Electric Cable Length: **220’**
- Max Soild: **4.5”**
- Pump Weight: **8,000 lbs.**

High Solids Production Dredging of CCR wastes

Application for 70% high-solids dredging of CCR solids from Power Plant Impoundment

1991 YouTube Video Clip showing TOYO Pumping 70% CCR Solids Sludge:

http://www.toyopumps.com/toyo_html/dp-submersible-video1.html

Eric Wingate, President
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Specialized Dredging Solutions
11106 LA-14
Delcambre, LA 70528
337-364-5841 Office
337-257-9071 Cell
ewingate@javeler.com
www.javeler.com

High Solids Production Dredging of CCR

Pump Model	TO-15	TO-75	TO-150	TO-400
Discharge (in)	4	6 or 8	10	16
Weight (lbs)	1100	3500	10,000 w/ rigging	25,000 w/ rigging
Motor HP	15	178 cc	500 cc	1000 cc
Capacity (usgpm)	480	1,600	3,200	7,200
Head (ft)	70	95	75	65
Production (yd^3/hr)	20 - 45	50 - 150	150 - 300	300 - 600
Hydraulic Flow Rate	15	55	85	110
Hydraulic Power Unit	14 gpm @ 3000 psi	55 gpm @ 3000 psi	85-115 gpm @ 3000 psi	100-160 gpm @ 3000 psi

TOYO DP400

Hydraulically Pump up to 70% Solids Slurries

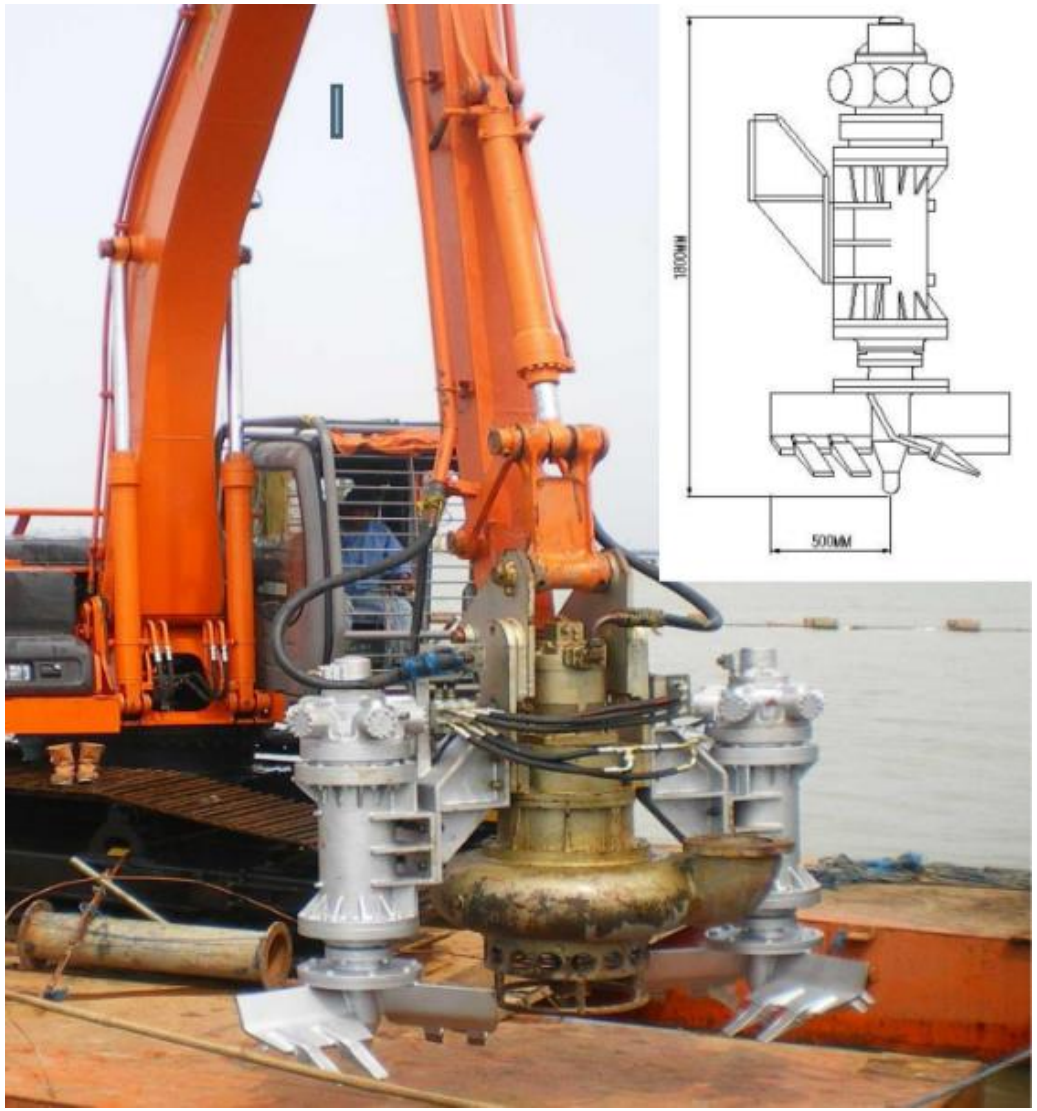
TOYO TO-150 Pump dredging of CCR solids from Impoundment

AEP AMERICAN ELECTRIC

3,000 GPM @
≈ 175 - 200 Cys/hr

Rusty Reeves
Toyo Pumps North America, LLC
Phone: 601-497-1404
E-mail: rreeves@toyopumps.com
Web: www.toyopumps.com
www.hevvypumps.com

Hydraulically Pump up to 70% Solids Slurries

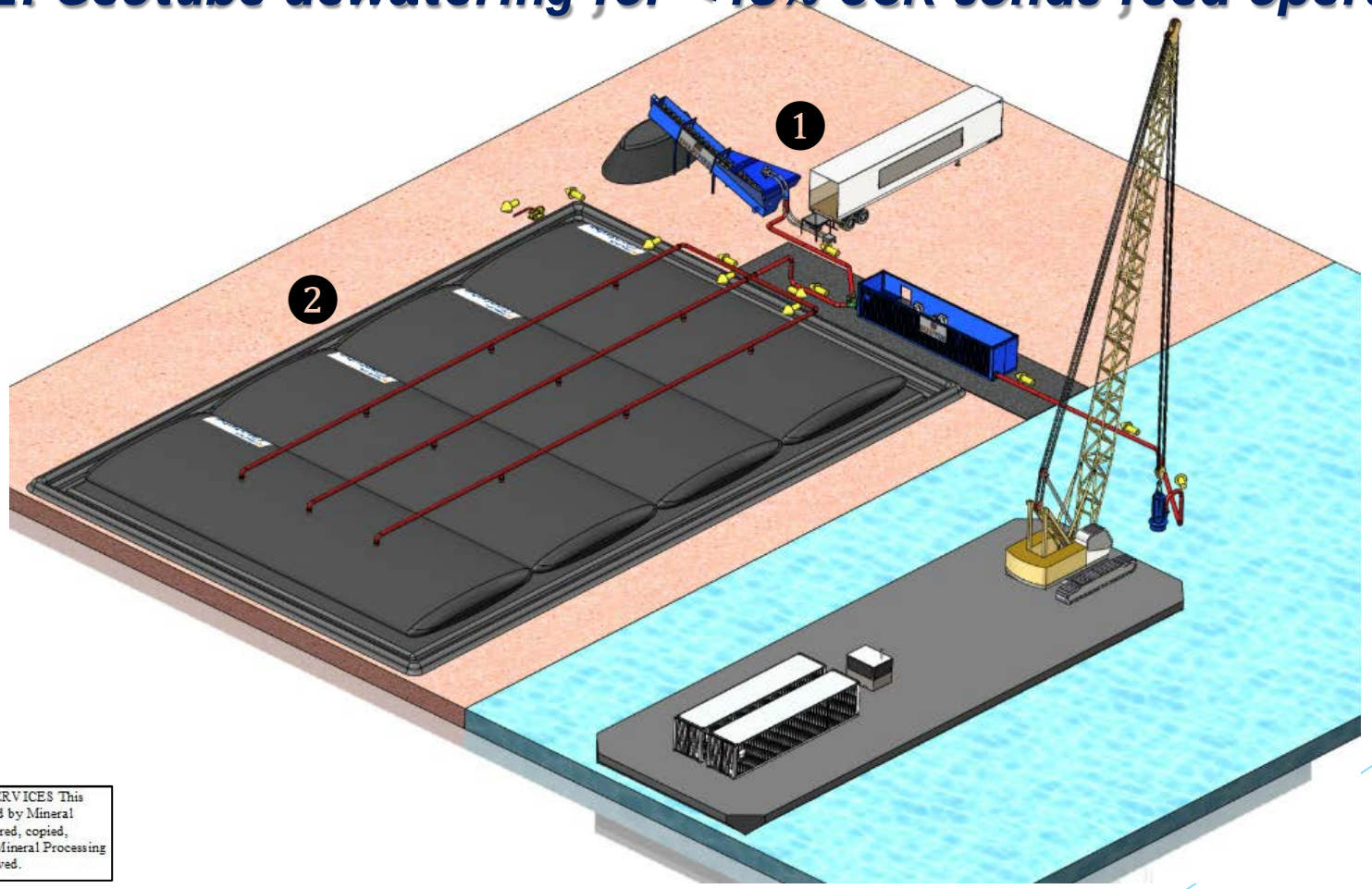


Hydraulic Cutter Assemblies for Homogenization / Liquefaction of CCR Wastes

Dual Processing Operations:

1. SmartFeed™ Sequential Mixer for Blending of ZapZorb Amendments with TOYO Pump high-solids CCR dredged waste materials for >45% CCR solids feed

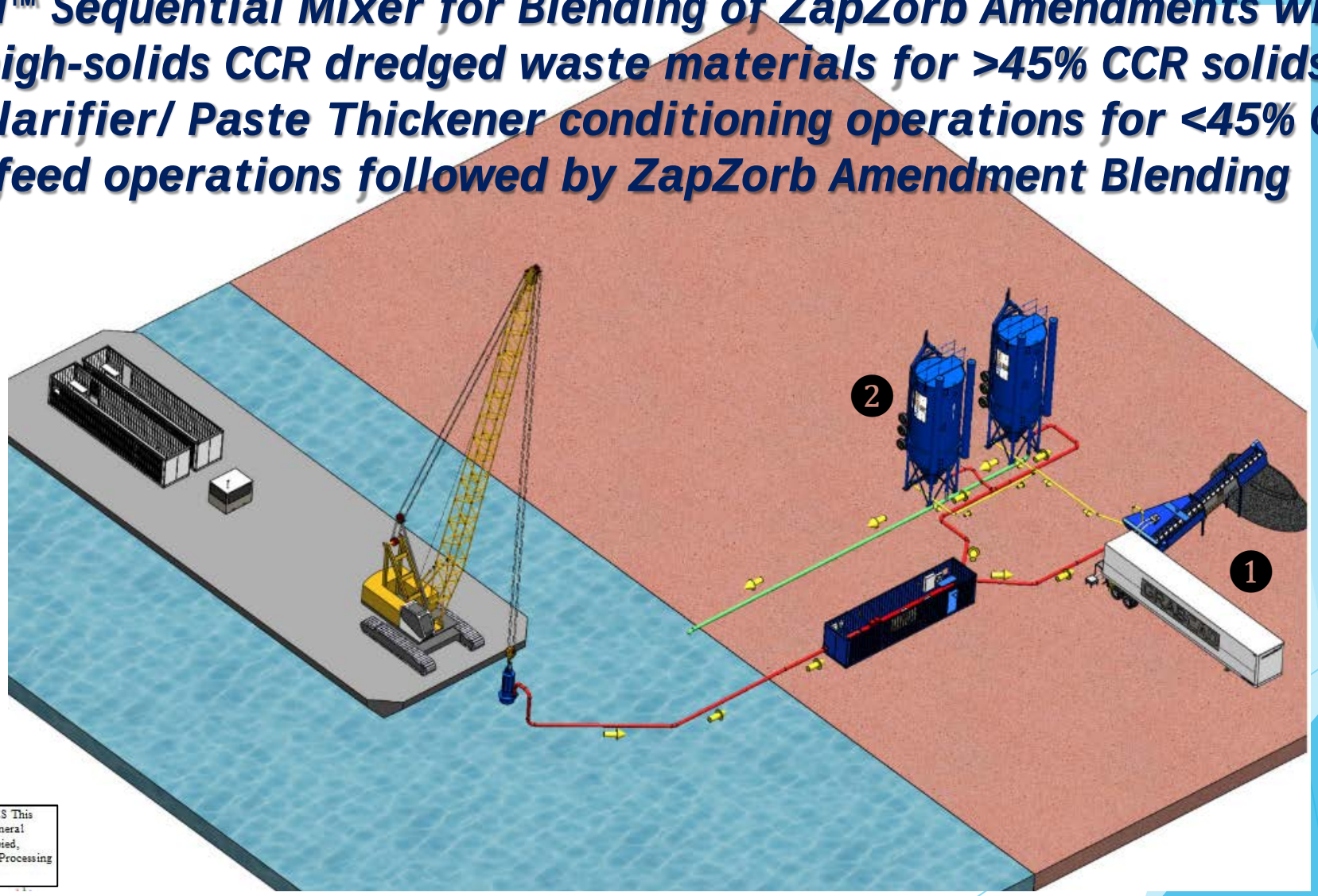
2. Geotube dewatering for <45% CCR solids feed operations



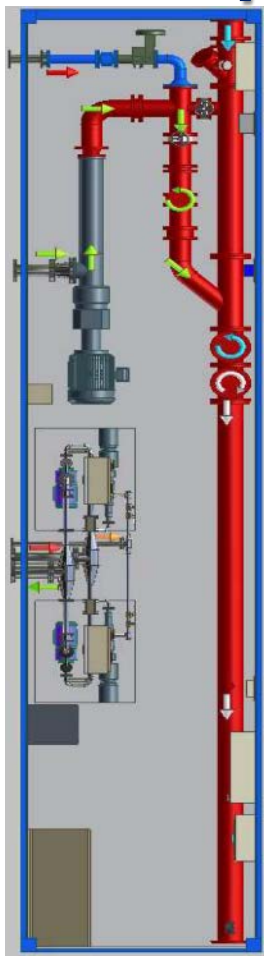
Dual Processing Operations:

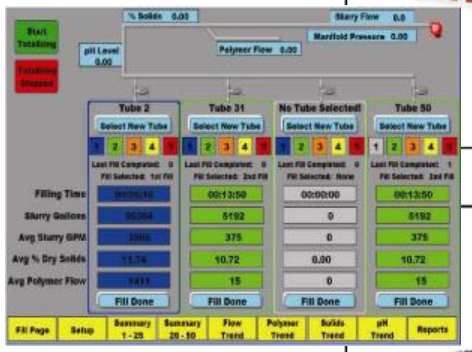
1. SmartFeed™ Sequential Mixer for Blending of ZapZorb Amendments with TOYO Pump high-solids CCR dredged waste materials for >45% CCR solids feed

2. High-rate Clarifier/ Paste Thickener conditioning operations for <45% CCR solids feed operations followed by ZapZorb Amendment Blending



Controlled Metering of ZapZorb Amendments into Modified SmartFeed™ Sequential Mixer /Blending for CCR wet paste sludge





Model 2500 EM

* Treats up to 2,500 gpm slurry flow
* Process slurry up to 12% d.s
* Can deliver up to 400 gpm of .5% polymer dilution

Site Requirements

* 8" pipe connection for slurry feed
* 4" pipe connection 400 gpm @ 80 psi
* Power 100 amps 480 volts 3 phase
* Lay-down area 40' x 30'

Model 4000 EM

* Treats up to 4,000 gpm slurry flow
* Process slurry up to 25% d.s.
* Can deliver up to 1,200 gpm .5% polymer dilution

Site Requirements

* 12" pipe connection for slurry feed
* 4" pipe connection 600 gpm @ 100 psi "dilution water"
* 4" pipe connection 600 gpm @ 100 psi "post dilution"
* Power 200 amps 480 volts 3 phase
* Lay-down area 80' x 40'

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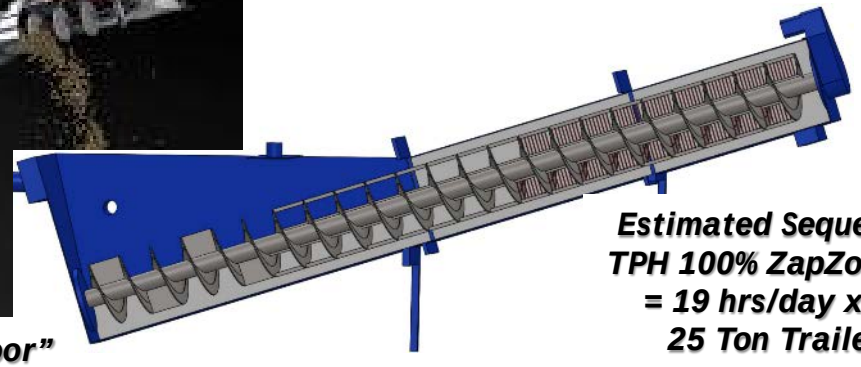
Controlled Metering of ZapZorb Amendments into Modified SmartFeed™ Sequential Mixer /Blending for CCR wet paste sludge solidification

Tube Chain Conveyor YouTube Video Clip http://i.imgur.com/w5bRn71.gif

Estimated Sequential Mixer Rate: 50 TPH x 24 Hr/day ops @ 80% online = 19 hrs/day = 950 TPD/SmartFeed™ Sequential Mixer



Estimated Sequential Mixer Rate: 50 TPH using .25 TPH 100% ZapZorb SAP. 24 Hr/day ops @ 80% online = 19 hrs/day x .25 TPH SAP = 4.75 tons/day SAP 25 Ton Trailer Load of SAP used in 5.26 days

ZapZorb Amendment Delivered in 50 CY "walking floor" bulk material trailers (max. weight 25 tons/load) for metered delivery to SmartFeed™ Sequential Mixer via VFD-controlled Tube Chain Conveyor

50 tons SAP ZapZorb Amendment metered at 0.5% delivered to SmartFeed™ Sequential Mixer via VFD-controlled Tube Chain Conveyor would solidify 10,000 tons wet CCR Waste at ≈$10/ton SAP/ton CCR solidified

WEDA Western Dredging Association

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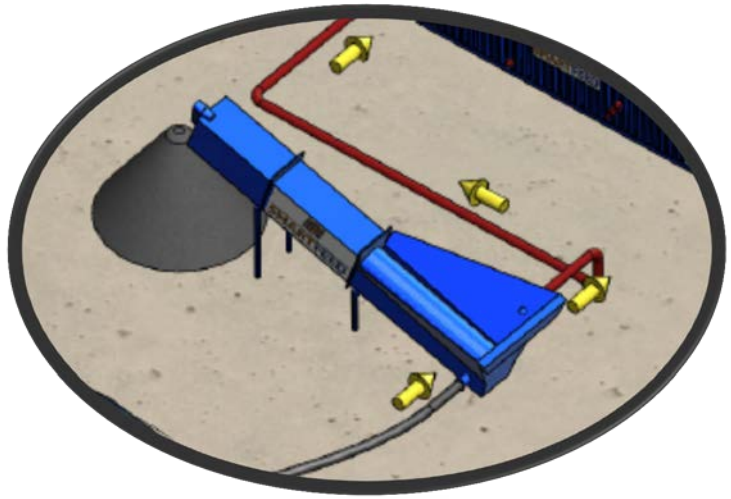
MPS SmartFeed™ Sequential Blending Modules



300 GPM TOYO Hydraulic Pump high solids slurry @ 45% Solids will process ≈88 Cys/hr (≈83 tons/hr) Solidified CCR in 3 minutes

2,000 GPM TOYO Hydraulic Pump high solids slurry @ 45% Solids will process ≈600 Cys/hr (≈570 tons/hr) Solidified CCR in 5 minutes

WEDA Western Dredging Association

MPS MINERAL PROCESSING SERVICES, LLC

MPS SmartFeed Portable Clarifier/Paste Thickener

Clarifier Influent
1,500 gpm @ 3 – 12% d.s.
(30,000 – 120,000 ppm TSS)

Flocculated
Feed to Clarifier

Clarifier Overflow
<30 ppm TSS
99.975% removal efficiency

Clarifier/Thickener Underflow: 45% D.S.

Entergy Corporation Power Generation Facility
Raw Water Intake Structure Diver/Dredging Project
Cesium Contaminated Sediment/Water Processing

Contact Information:
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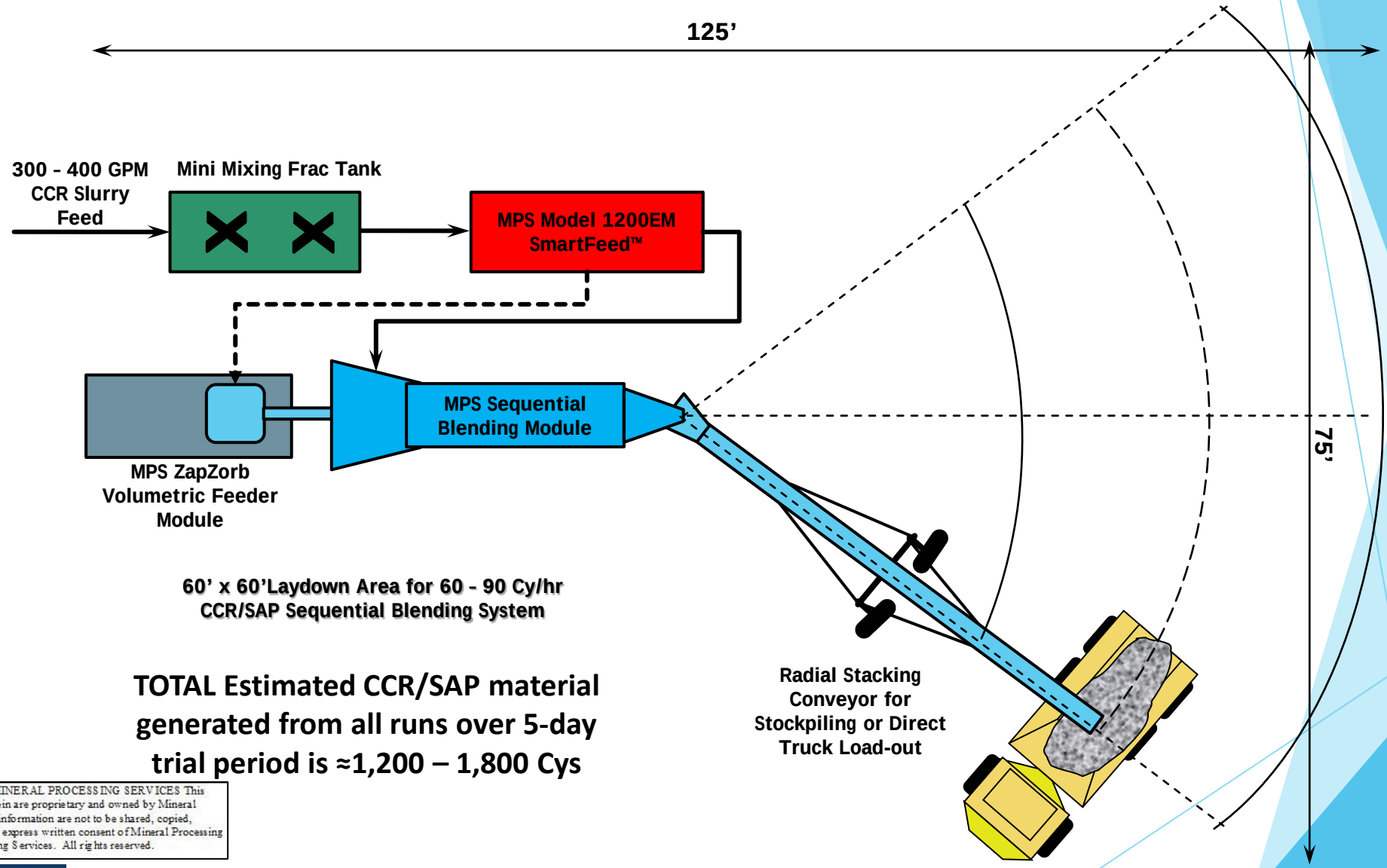
Estimated Laydown Area for 60 – 90 Cy/hr CCR/SAP Sequential Blending System

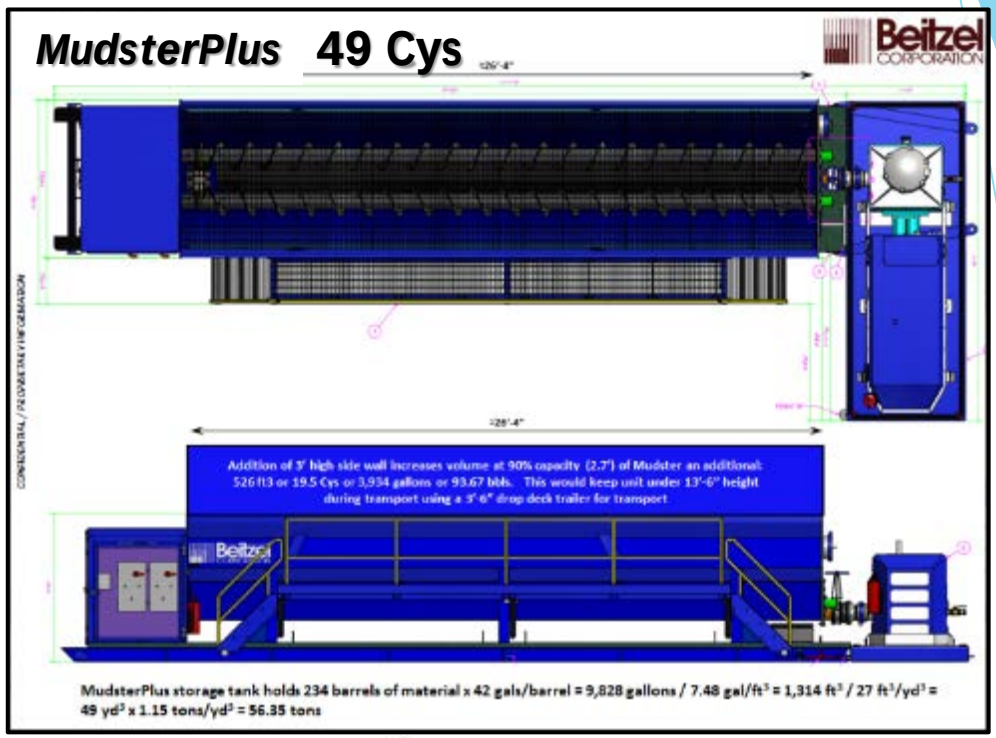


TOTAL Estimated CCR/SAP material generated from all runs over 5-day trial period is ≈1,200 – 1,800 Cys

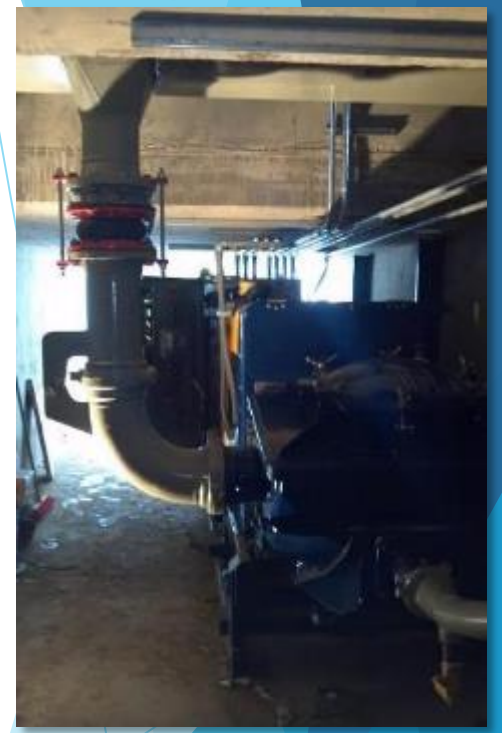
250 CY/Hr CCR/SAP Solidified Waste Positive Displacement Pumping

29 Cys Live Bottom Feeder Module

THE MUDSTER Beitzel CORPORATION



Putzmeister KOS 25150 HP
High Density Solids Pump:
250 yd³ / hr – 3,500'



MegaMudster
100 Cys

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250 CY/Hr CCR/SAP Solidified Waste Positive Displacement Pumping

KOS 25150 HP High Density Solids Pump: 250 yd³ / hr – 3,500'

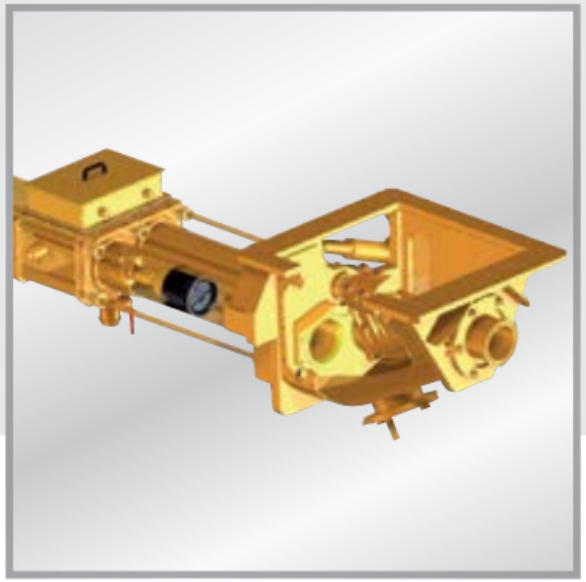
Putzmeister

Economical fly- and bottom-ash transport as high density slurries

After the incineration of coal in coal fuelled power stations the resulting waste ash such as fly-ash from the electrofilters or the bottom-ashes from the boiler have to be disposed of. Most fly and bottom ashes are pumped into embankments.

By using the Putzmeister KOS type piston pumps a mixture of both fly- and bottom-ashes can be transported successfully without operational disturbances. Due to the fact that the Putzmeister KOS piston pump has no valve between the inlet and outlet of the pump even coarse particle can pass the pump without stopping the process.
High dry solid contents can be handled and water content can be reduced to a minimum. Due to the low water content the lifetime of the disposing area can be extended or a smaller disposing area can be de signed. Also the environmental fact of large amount of contaminated water can be reduced to a minimum.

http://www.pmsolid.com/cps/rde/xchg/SID-00B1E1CF-8982832A/psp/hs.xsl/6873_ENU_HTML.htm



Left: KOS series S tube pump
Right: Fly ash hardens within a short time

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www.putzmeisteramerica.com

Application of ZapZorb SAP Blends for wet CCR Waste Solidification

There are three primary areas for the application ZappaTec ZapZorb 100% SAP and engineered blends with CCR impoundment closures:

1. **Ex-situ solidification of CCR with moisture contents of >55% in preparation for off-site transportation and disposal by ensuring compliance with EPA Paint Filter Test criteria a the point of delivery to the disposal facility by either truck or railcar.**
2. **In-situ solidification of CCR to bind excess porewater and increase compressive strength thereby permitting tracked excavation equipment access on top of amended areas of the impoundment;**
3. **Solidification of high-strength (i.e., high Total Dissolved Solids) CCR leachate.**




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