REINHOLD ENVIRONMENTAL Ltd.

2017 NOx-Combustion-CCR Round Table Presentation

February 27 & 28, 2017, in Cleveland, OH / Hosted by FirstEnergy

Coal Combustion Residuals Impoundment Closure Dewatering

and

Wastewater Characterization and Treatment Evaluation

Jeff Heyman, P.E., R.G.
Senior Engineer – Water/Power Group

Stephen Couture, P.E., DEE, BCEE
Principal Water/Wastewater Engineer
Industrial Water/Wastewater Technology Practice Group

Reinhold Environmental

NO_x–Combustion-CCR/PCUG Seminar
Cleveland, OH

February 27, 2017

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Presentation Overview

– <u>Background</u>

- The New Rules – CCR Disposal and Effluent Guidelines
- What are CCR?
- Closure of CCR Impoundments Under New Rules

– <u>CCR Impoundment Closure Dewatering</u>

- Approach and Methods of Free Water and Interstitial (pore) Water Removal
- Planning and Site Investigation

– <u>Characterization of CCR Dewatering Discharges</u>

- Free Water
- Interstitial (ash entrained) Water

– <u>Summary Guidance</u>

- Impoundment Closure Wastewater Management

New Rules for Coal Combustion Waste Streams – Solids Disposal and Effluent Limitations

– **New Rule for Disposal of Coal Combustion Residual (CCR) Disposal**

- Effective on October 19, 2015
- Disposal under Subtitle D of RCRA (40 CFR Parts 257 and 261)
- Established Siting, Groundwater, Engineering Design, Inspection, Operation, Closure/Post-Closure Requirements

– **New Rule for Effluent at Coal-burning Plants**

- Effective on January 4, 2016
- Effluent Limitation Guidelines under CWA (40 CFR Part 23)
- Establishes Effluent Limits for CCR transport water - NPDES

EPA Rules for Coal Combustion Waste Streams – Solids Disposal and Effluent

– CCR Disposal - Final Rule and the Compliance Details - See Final Rule and Rule Summary Documents on EPA website:

https://www.epa.gov/coalash/coal-ash-rule

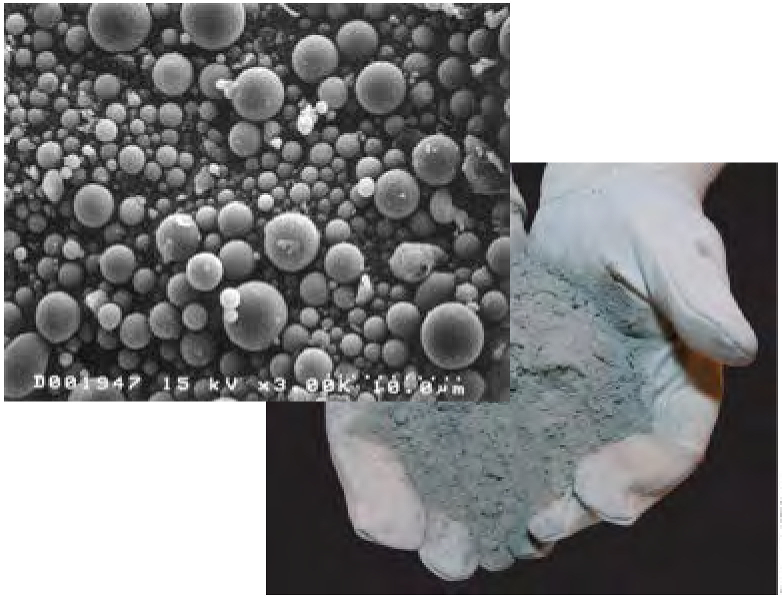
– ELG for Steam Electric Power Generating - Final Rule and the Compliance Details - See Final Rule and Rule Summary Documents on EPA website:

https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines-2015-final-rule

What Are CCRs?

– Fuel byproducts produced from the combustion of coal (from the steam generation of electric power)

– ***Fly Ash (small spherical particulate) =>***



– ***Bottom Ash (larger angular particles)***

– ***FGD Solids (SO_2 air pollution control system solids)***

Closure of CCR Impoundments Under the New CCR Rules

– Existing CCR Impoundments Will Require Closure if Non-compliant

– Closure In-place or Closure-by-Removal

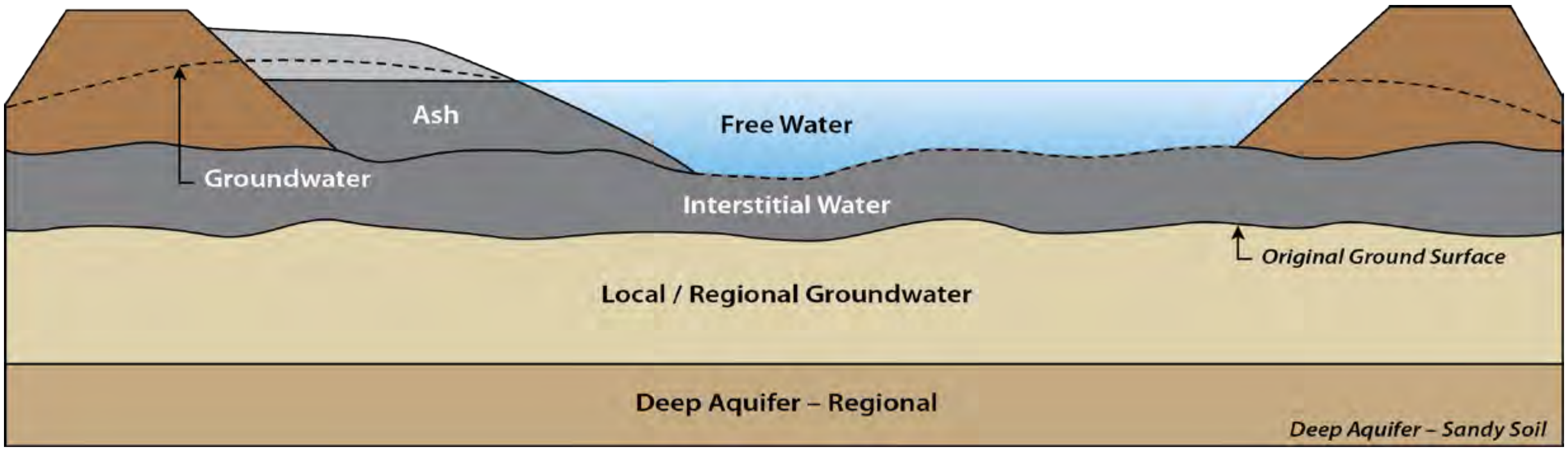
– Remove Free Liquids and Stabilize Impoundment for Closure
  - Decant the Free Water and
  - Lower Phreatic in the CCR sufficient to facilitate construction equipment support and excavation of CCR and to create stable surface for cover (if Closure In-place).

– Treatment of decanted/pumped ponded water and interstitial water to meet existing or new NPDES permit requirements

CCR Impoundment Closure Dewatering

General Approach

Dewatering for Closure of CCR Impoundments - Approach



– Decant or Pumping of Free Water to Outfall

- Re-route inflows of other wastewater

– Drain and/or Pump interstitial water (pore-water) to lower phreatic levels within impounded CCR to stabilize.

- 2 to 5 feet lowering for Bottom Ash and 10+ feet for Fly Ash (below excavation)

– Treatment of Free Water and/or Interstitial Water – Active Treatment

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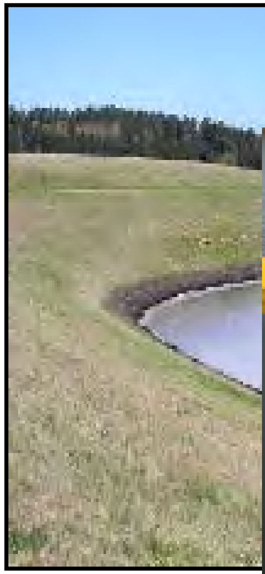
CCR Impoundment Closure Dewatering

Free Water Removal (Ponded Water Removal) Methods

CCR Impoundment Closure Dewatering – Free Water Removal



– Gravity OR Pumping System?

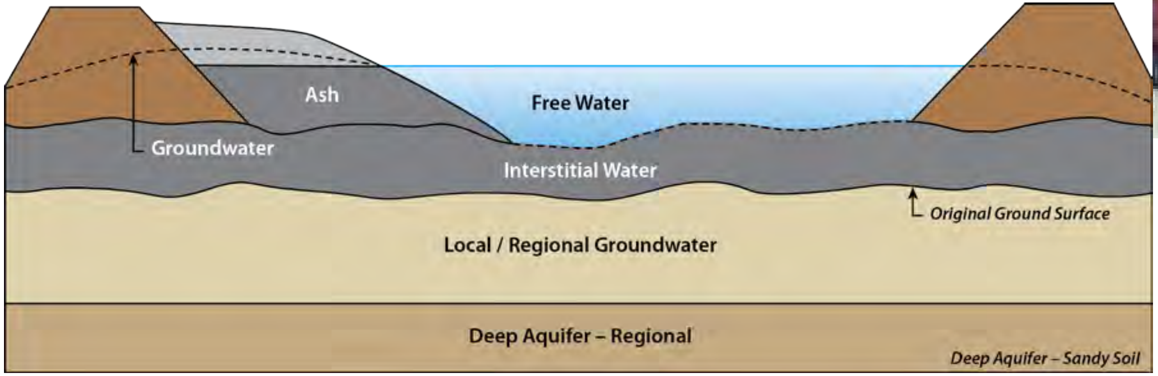
– Pumping Systems

- Suction Pumps or Submersible
  - o Pump Locations (pumps, generators, etc..)

– Discharge Pipe Route and Outfall

- NPDES Requirements
- Treatment Plan

– May Lower Phreatic Level in CCR



CCR Impoundment Closure Dewatering

Interstitial Dewatering Methods - Our "Toolbox" for CCR Dewatering

Experienced Team – Engineer and Contractor

CCR Impoundment Closure – Interstitial Dewatering

– Open Dewatering Methods (Effective Dewatering Depth - 3 to 10 feet)

– Dewatering Well Methods (Effective Dewatering Depth – 10 to 100+ feet)

– Mechanical / Chemical Stabilization and Dredging

– Open or Dewatering Well Methods – Similar Initial Analytical Approach

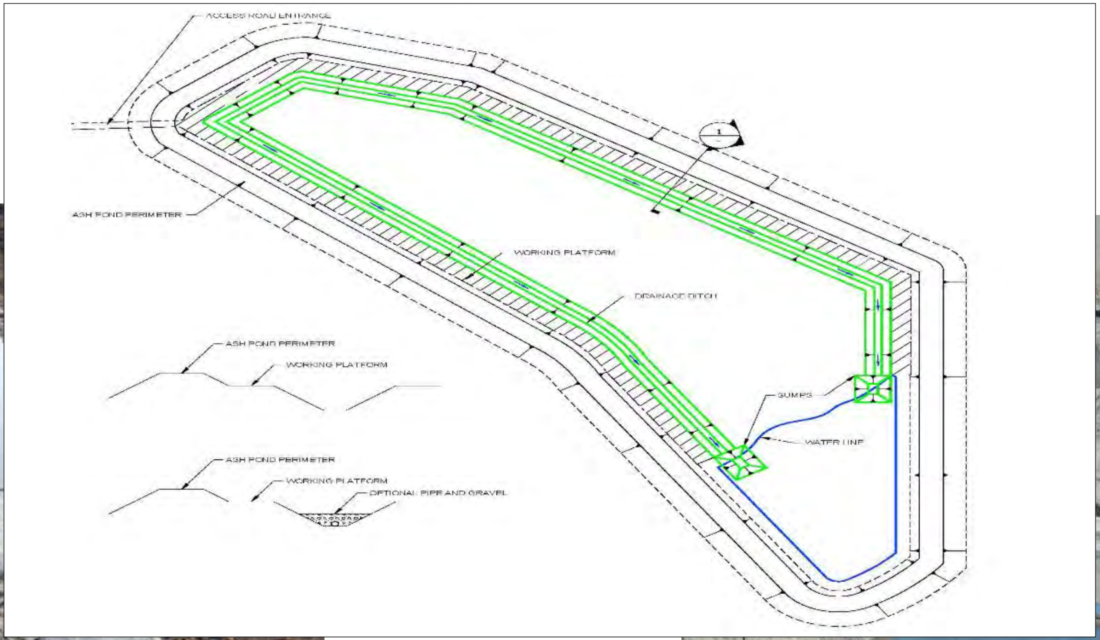
- Line Sink Analytical Methods and/or Empirical Drainage Trench Equation

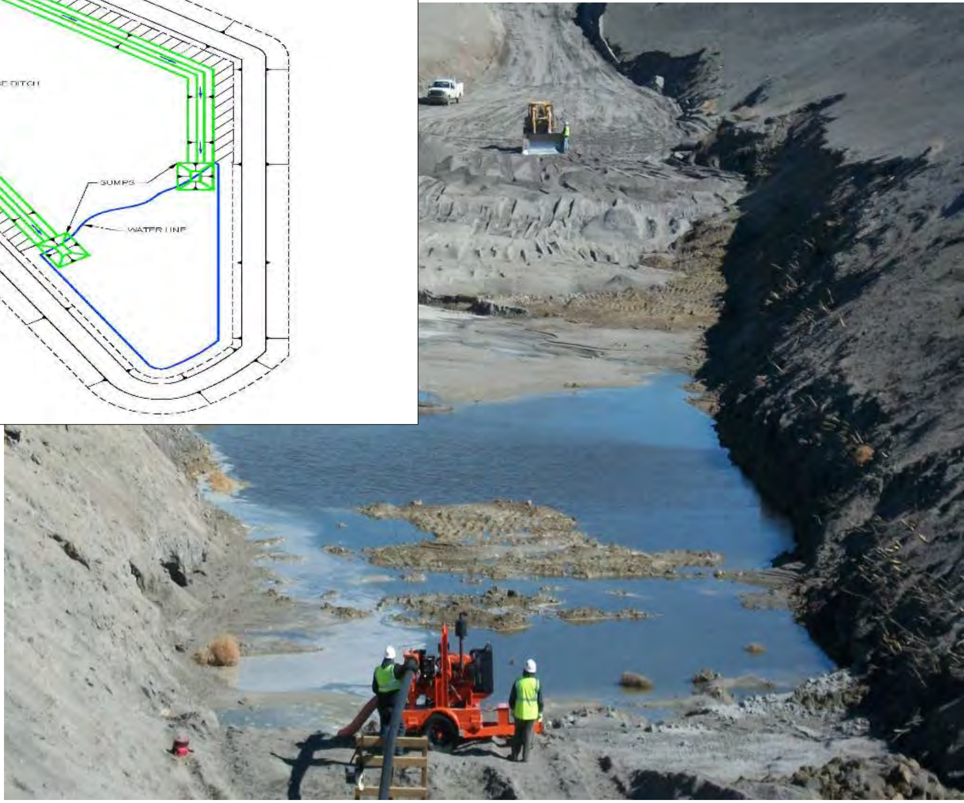
$Q = [x \cdot K \cdot (H^2 - h^2)] / 2 \cdot (R_0 \text{ or } 2L)$ - Powers (2007) **AND/OR** $T=(2 \cdot t \cdot k_h \cdot H)/(c \cdot n_e \cdot L^2)$ - Casagrande/Shannon (1951)

Open Dewatering Methods

– Rim Ditch or Channel Excavation

– Sump Pits

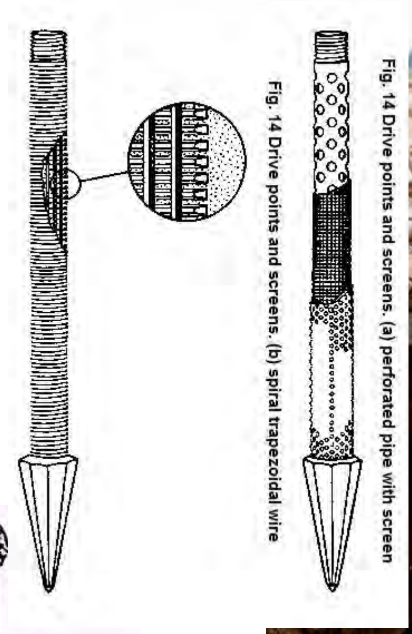




Dewatering Well Methods

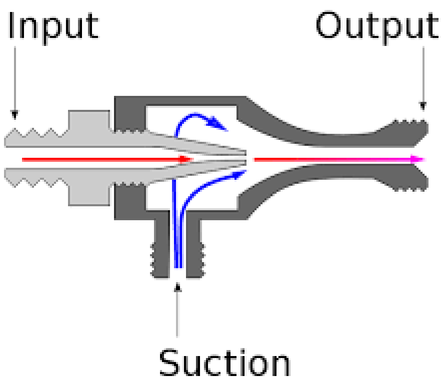
– Wellpoints

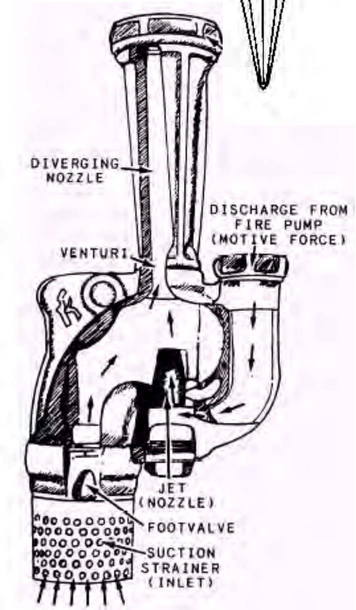
- Effective to 18 feet



– Jet-eductor wells

- Effective to 100+ feet

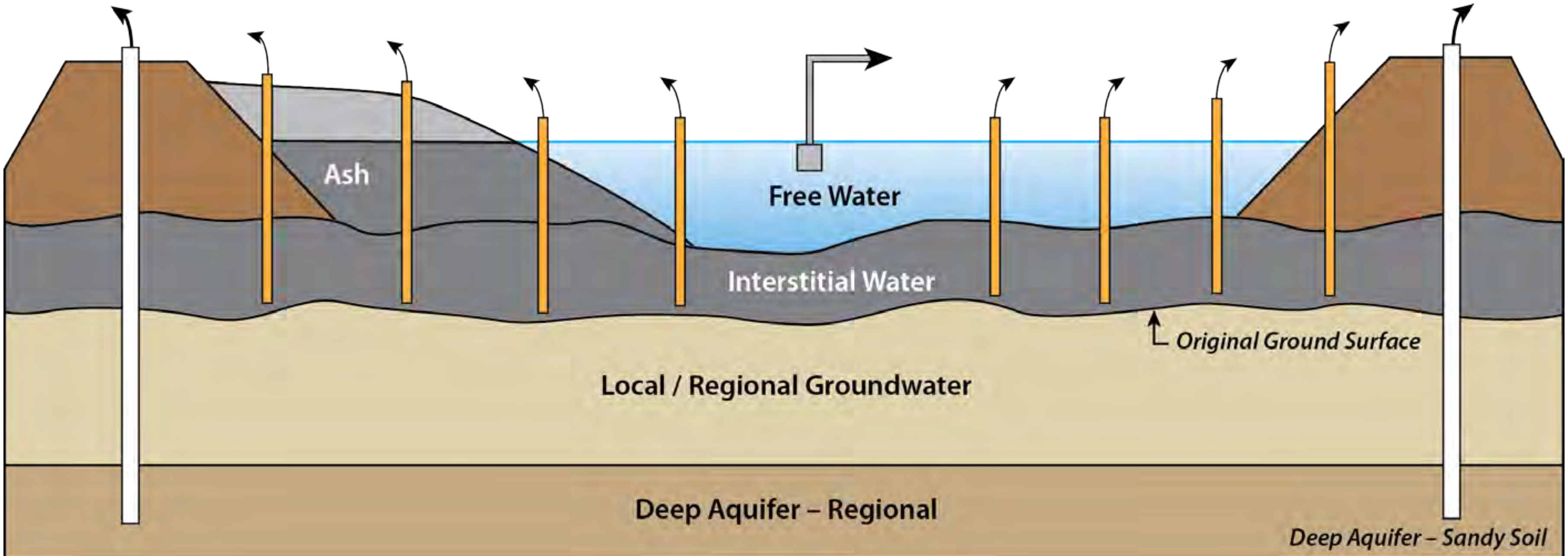


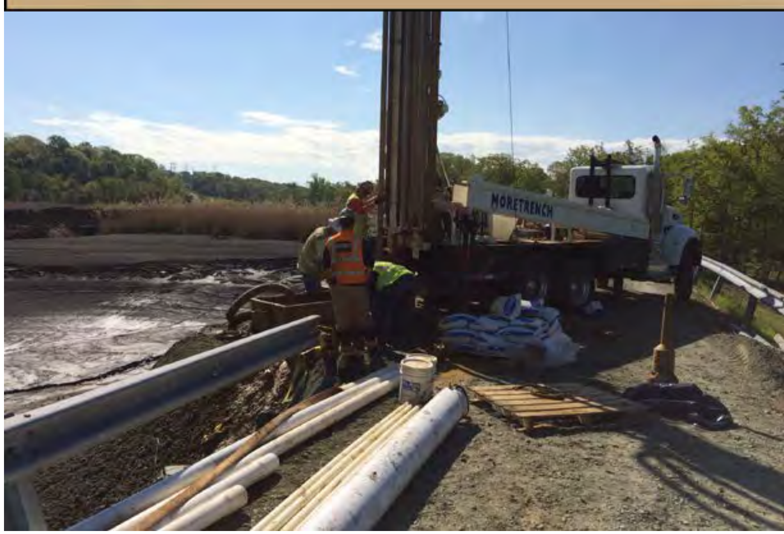


– Deep wells (submersible)

- Effective to 100+ feet

Dewatering Plan – Dewatering Well Methods
(Wellpoints and Deep Wells)





Chemical /Mechanical Stabilization and Dredging – Mixing

Dredging

Photo – Piranha Dredge

Shallow Mixing

Photo – Recon

Deep Mixing

CCR Impoundment Closure Dewatering

Planning and Site Investigation

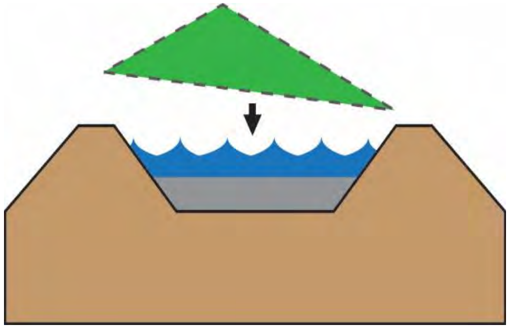
CCR Impoundment Closure Dewatering – Planning

– **Schedule for Closure:**

- When must you close (what will be trigger)? - Rule 40 CFR -257.101 or 102
- How many years to close (5 yrs.)? Should you plan a time extension?

– **Closure Method**

- Closure by Removal or In-place Closure



– **Pond Site Investigation**

- Historical and Current Operation
- Site conditions
  - o Geotechnical/Hydrogeological
  - o Pilot Testing – part of exploration (prove-out dewatering plan and const. equip.)
  - o Water Chemistry – Surface and interstitial (pore-water)

– **Discharge limitations? Where do you send the water? Monitoring?**

Open Dewatering Methods Planning

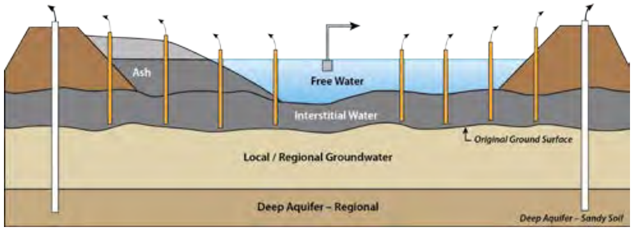
– Sizing of Open Dewatering
  - Number and Spacing of Ditches and Sumps
  - Pump Sizing
  - Room Required for Construction Equipment (Excavator and Haul Trucks)

– Depth of Excavations for Ditches and Sumps
  - Stability of Slopes
  - Equipment Limitations

– Water Quality
  - Sediment Control (sizing and design of sump pits – BMPs?)
  - Active Treatment System

– Small Scale Test Excavation and Sump Pumping ("Pilot" Testing)

Dewatering Well Methods Planning



– Design of well screens and filters and deterioration of well efficiency

- Filter compatibility – current state-of-the-art methods are applicable to CCR
- Precipitation of dissolved solids in groundwater in filters, geotextiles, well and wellpoint screens, pumps, and piping.
- Bacterial activity and biofilms – another unknown at all sites

– Water Quality

- Active Treatment System

– **Small Scale Evaluation or "Pilot" of Dewatering Methods**

- Pumping testing at multiple locations to confirm dewatering plan
- Focus these pumping tests in both the "good" areas and in the less drainable areas.

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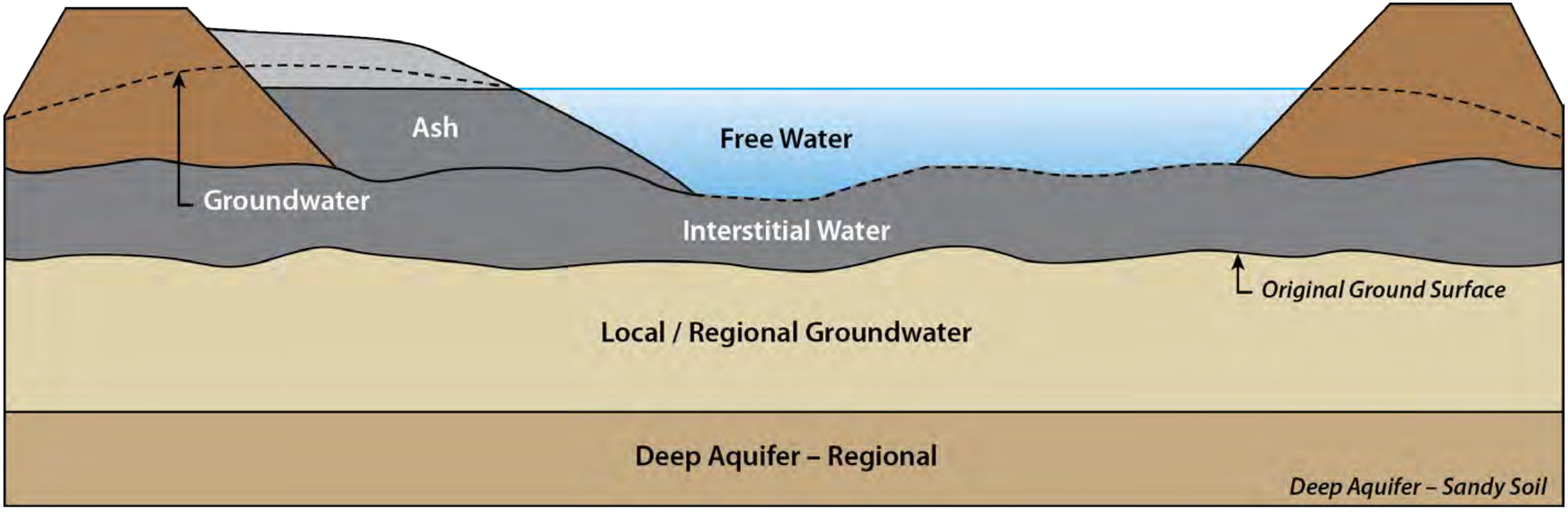
CCR Impoundment Closure Dewatering – Planning



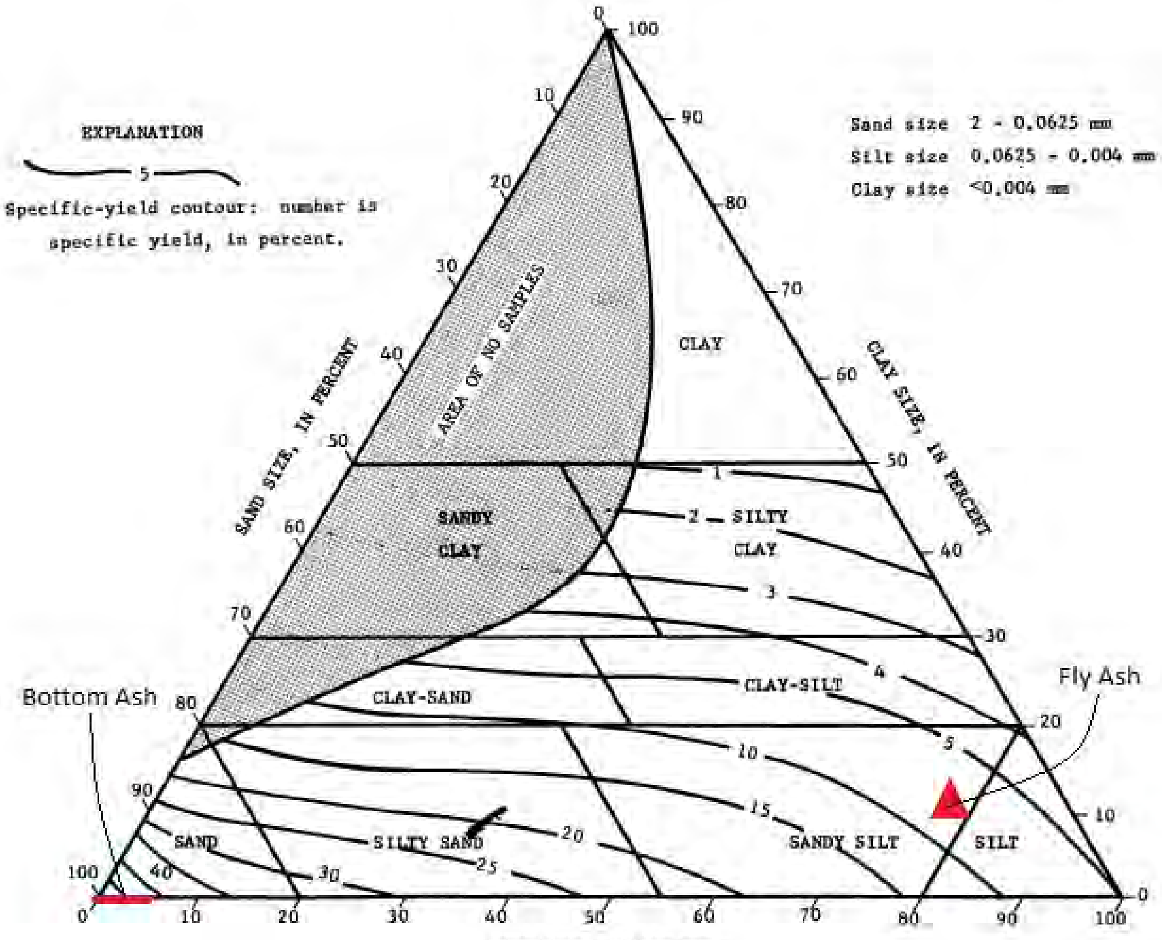
– **<u>Review Historical Information:</u>**

- Drawings and Aerial Photos (Google Earth)
- Discuss Operational History with Power Plant Operations and/or Engineering
- Review/evaluate piezometric and local/regional hydrogeologic information

<u>Focus Geotechnical Exploration to Find "Sweet Spots"</u>

Dewatering Methods – Applicability to Soil Types (CCR Materials)

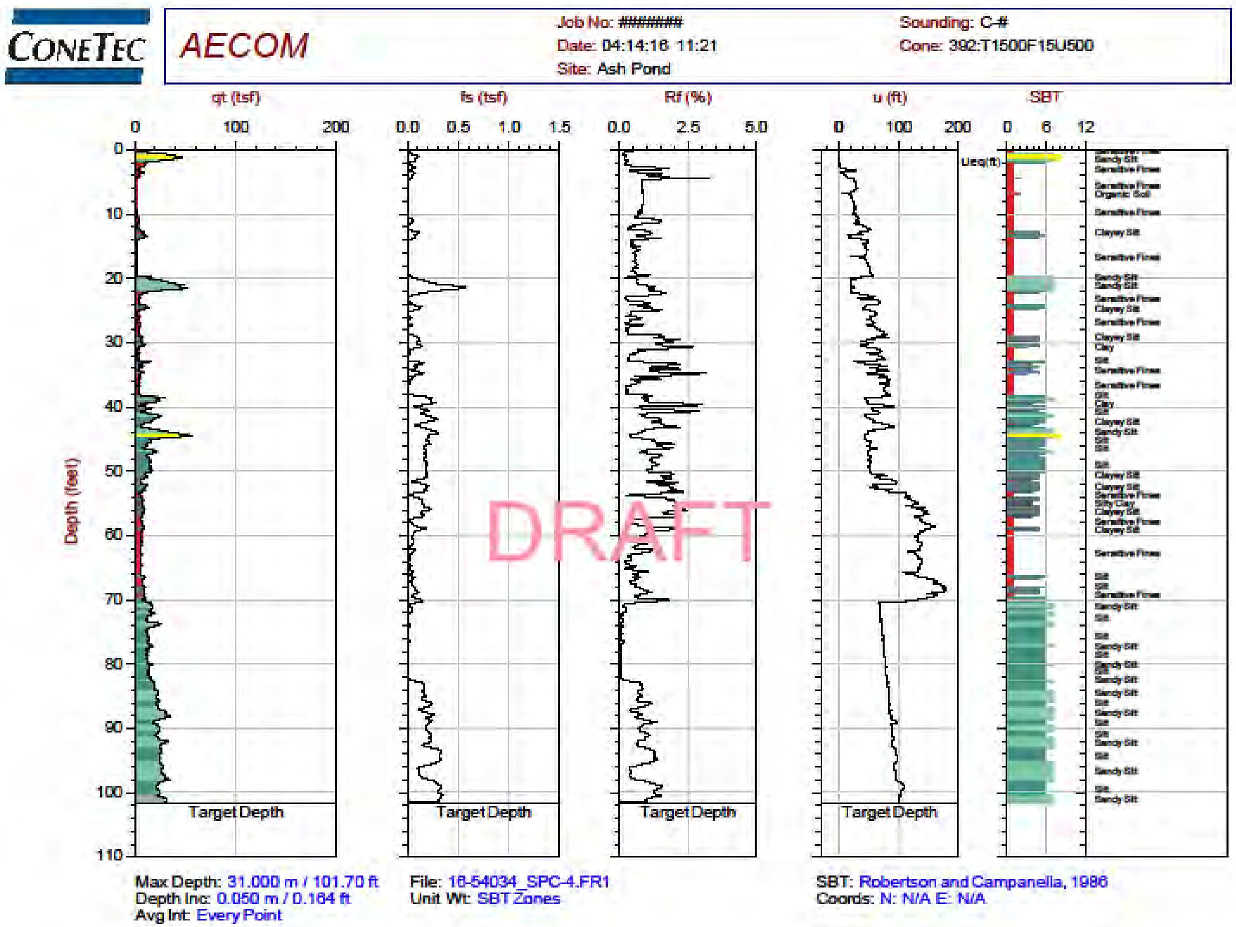
Specific Yield of Soils and Plot of Average Fly Ash and Bottom Ash Soil Classifications

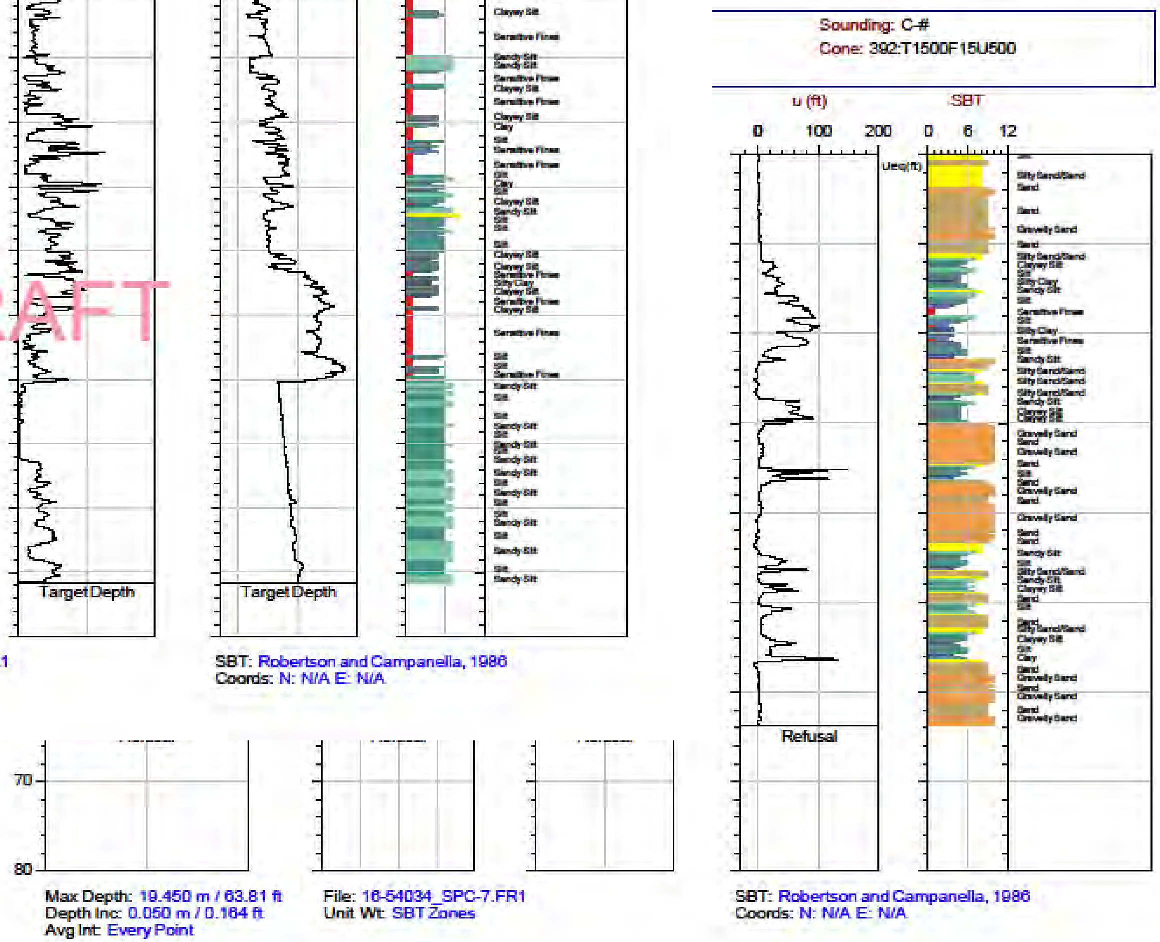


Courtesy of Moretrench

Approach to CCR Pond Dewatering – Operational History & Site Condition Review - Every Pond is Different!

Geotechnical Exploration Data – Piezocone Penetrometer Testing





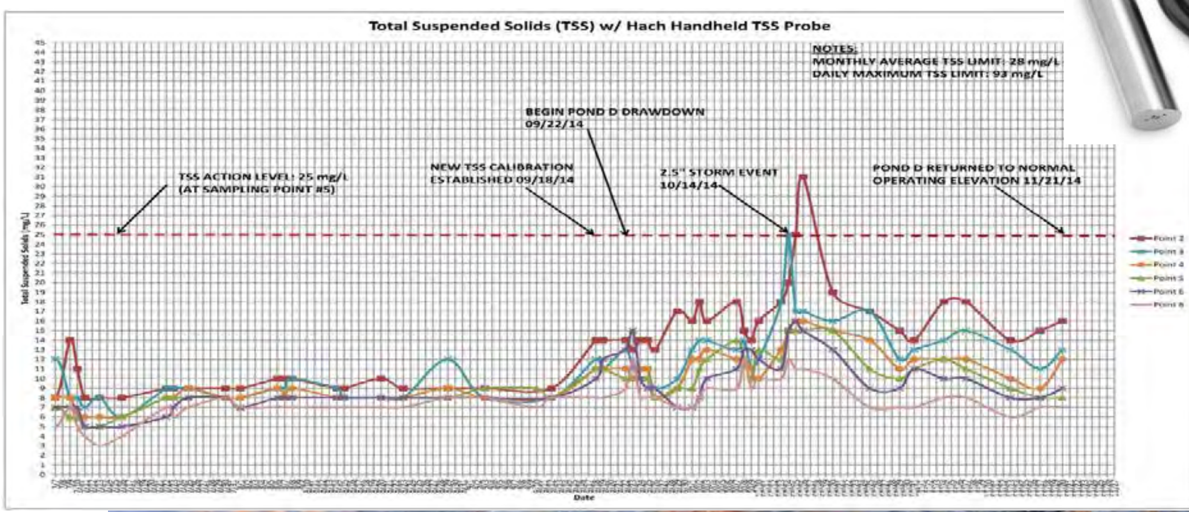
CCR Impoundment Closure Dewatering – Discharge Water Quality

– Identify Discharge Route and Outfall

– Identify Free Water and Interstitial Water Effluent Limitations (NPDES)

– Evaluate Character of Free Water and Interstitial Water to Identify if Active Treatment System is Necessary

– Plan for Monitoring



Characterization of Free and Interstitial Waters

– Physical/Conventional Chemical Parameters:

- pH
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Oil & Grease
- Turbidity

Characterization of Free and Interstitial Waters (Continued)

– Metals (Total and Dissolved):

- Arsenic (As)
- Selenium (Se)
- Mercury (Hg)
- Copper (Cu)
- Iron (Fe)

– Nutrients:

- Nitrate (NO_3)
- Nitrite (NO_2)
- Total Kjeldahl Nitrogen (TKN)
- Phosphorus

Characterization of Free and Interstitial Waters (Continued)

– Collect samples at various depth in free water and accumulated ash

– Perform metals and TSS analyses on raw (unfiltered) samples and on serial filtrations of samples (i.e., 20µ and 10µ and 0.45µ)

– Speciation of As and Se

– Whole Effluent Toxicity testing

Total Suspended Solids

	Permit Limits (mg/l)		Impoundment I-1 (mg/l)				Impoundment I-2 (mg/l)			
Free Water TSS (mg/l)	***Monthly Avg.***	***Daily Max***	***I-1 (1ft)***	***I-1 (4ft)***	***I-1 (8ft)***		***I-2 (1ft)***	***I-2 (4ft)***	***I-2 (8ft)***	
	23	75	2.5	2.5	2.5		2.5	2.5	2.5	
Interstitial Water TSS (mg/l)	***Monthly Avg.***	***Daily Max***	***PZ-1***	***PZ-1 (20μ)***	***PZ-1 (10μ)***		***PZ-2***	***PZ-2 (20μ)***	***PZ-2 (10μ)***	
	23	75	2000	96	5		5700	680	66	

Arsenic

	Permit Limits (µg/l)		Impoundment I-1 (µg/l)				Impoundment I-2 (µg/l)			
Free Water As (µg/l)	***Monthly Avg.***	***Daily Max***	***I-1 (1ft)***	***I-1 (4ft)***	***I-1 (8ft)***		***I-2 (1ft)***	***I-2 (4ft)***	***I-2 (8ft)***	
	52.5	72.5	3.05	3.28	3.32		38		38.5	
Interstitial Water As (µg/l)	***Monthly Avg.***	***Daily Max***	***PZ-1***	***PZ-1 (20µ)***	***PZ-1 (10µ)***	***PZ-1 (0.45µ)***	***PZ-2***	***PZ-2 (20µ)***	***PZ-2 (10µ)***	***Z-1 (0.45µ)***
	10.5	14.5	656	386	375	378	71	10.7	1.61	

Selenium

	Permit Limits (µg/l)		Impoundment I-1 (µg/l)				Impoundment I-2 (µg/l)			
Free Water Se (µg/l)	*Monthly Avg.*	*Daily Max*	*I-1 (1ft)*	*I-1 (4ft)*	*I-1 (8ft)*		*I-2 (1ft)*	*I-2 (4ft)*	*I-2 (8ft)*	
	68	127.5	1.96	2.07	1.81		46.9		48.6	
Interstitial Water Se (µg/l)	*Monthly Avg.*	*Daily Max*	*PZ-1*	*PZ-1 (20µ)*	*PZ-1 (10µ)*	*PZ-1 (0.45µ)*	*PZ-2*	*PZ-2 (20µ)*	*PZ-2 (10µ)*	*Z-1 (0.45µ)*
	13.6	25.5	55.7	2.47	1.36	1.53	426	239	229	

Mercury

	Permit Limits (ng/l)		Impoundment I-1 (ng/l)				Impoundment I-2 (ng/l)			
Free Water Hg (ng/l)	*Monthly Avg.*	*Daily Max*	*I-1 (1ft)*	*I-1 (4ft)*	*I-1 (8ft)*		*I-2 (1ft)*	*I-2 (4ft)*	*I-2 (8ft)*	
	47	47	0.25	0.25	0.25		0.941	1.03	0.987	
Interstitial Water Hg (ng/l)	*Monthly Avg.*	*Daily Max*	*PZ-1*	*PZ-1 (20µ)*	*PZ-1 (10µ)*	*PZ-1 (0.45µ)*	*PZ-2*	*PZ-2 (20µ)*	*PZ-2 (10µ)*	*Z-1 (0.45µ)*
	47	47	40.6	16.5	3		76.7	33.2	12.9	

Nitrate-Nitrite

	Permit Limits (mg/l)		Impoundment I-1 (mg/l)				Impoundment I-2 (mg/l)			
Free Water NO_3-NO_2 (mg/l)	***Monthly Avg.***	***Daily Max***	***I-1 (1ft)***	***I-1 (4ft)***	***I-1 (8ft)***		***I-2 (1ft)***	***I-2 (4ft)***	***I-2 (8ft)***	
	0.65	0.85	0.005	0.028	0.018		0.005		0.01	
Interstitial Water NO_3-NO_2 (mg/l)	***Monthly Avg.***	***Daily Max***	***PZ-1***	***PZ-1 (20µ)***	***PZ-1 (10µ)***	***PZ-1 (0.45µ)***	***PZ-2***	***PZ-2 (20µ)***	***PZ-2 (10µ)***	***Z-1 (0.45µ)***
	0.13	0.17	0.005	0.01	0.023	0.016	0.005	0.333	0.317	

Phosphorus

	Permit Limits (mg/l)		Impoundment I-1 (mg/l)				Impoundment I-2 (mg/l)			
Free Water P (mg/l)	***Monthly Avg.***	***Daily Max***	***I-1 (1ft)***	***I-1 (4ft)***	***I-1 (8ft)***		***I-2 (1ft)***	***I-2 (4ft)***	***I-2 (8ft)***	
	Monitor Only		0.01	0.01	0.01		0.01	0.01	0.01	
Interstitial Water P (mg/l)	***Monthly Avg.***	***Daily Max***	***PZ-1***	***PZ-1 (20µ)***	***PZ-1 (10µ)***	***PZ-1 (0.45µ)***	***PZ-2***	***PZ-2 (20µ)***	***PZ-2 (10µ)***	***Z-1 (0.45µ)***
	Monitor Only		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Free Water and Interstitial Water pH

– General observations:

- Neutral to slightly alkaline across all project portfolio impoundments (meeting discharge requirement of pH = 6.0 to 9.0)
- Exception site/interstitial water pH at 5.2 to 5.8 (requiring pH neutralization for discharge)

Wastewater Characterization Treatment Implications

- TSS Treatment of Free Water
  - Not required but implemented as contingency
- TSS Treatment of Interstitial Water
  - Required with likely chemical coagulation
- As and Se
  - Filtration (with/without chemical enhancement, in particulate form)
  - Where in dissolved anionic form
    - Biological (anaerobic) metal reduction
    - Zero Valent Iron media

Wastewater Characterization Treatment Implications (Continued)

- Mercury Treatment of Free Water/Interstitial Water
  - Not required for Free Water
  - Interstitial water/dewatering phase treatment by filtration
- Nitrate-Nitrite
  - Treatment not required
- Phosphorus
  - Treatment not required

Conclusions/Recommendations

- Engage environmental regulators early in the CCR impoundment closure planning process
- Prepare comprehensive free water and interstitial water characterizations including:
  - Analyses on serial filtrations (particularly interstitial water)
  - As and Se speciation
  - Whole Effluent Toxicity Testing
- Treatability testing

Questions