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NORTHERN WEST VIRGINIA WATER TREATMENT FACILITY

John Owsiany

Director-Water Systems and Operations

The Problem

- West Virginia Department of Environmental Protection new regulations on chlorides in discharges to receiving streams
- Three mines discharge conventionally treated mine drainage from six different locations
- Current treatment for pH, metals, and TSS removal at the points of discharge does not remove Chloride
- Reduce liability for disposal of treatment residuals

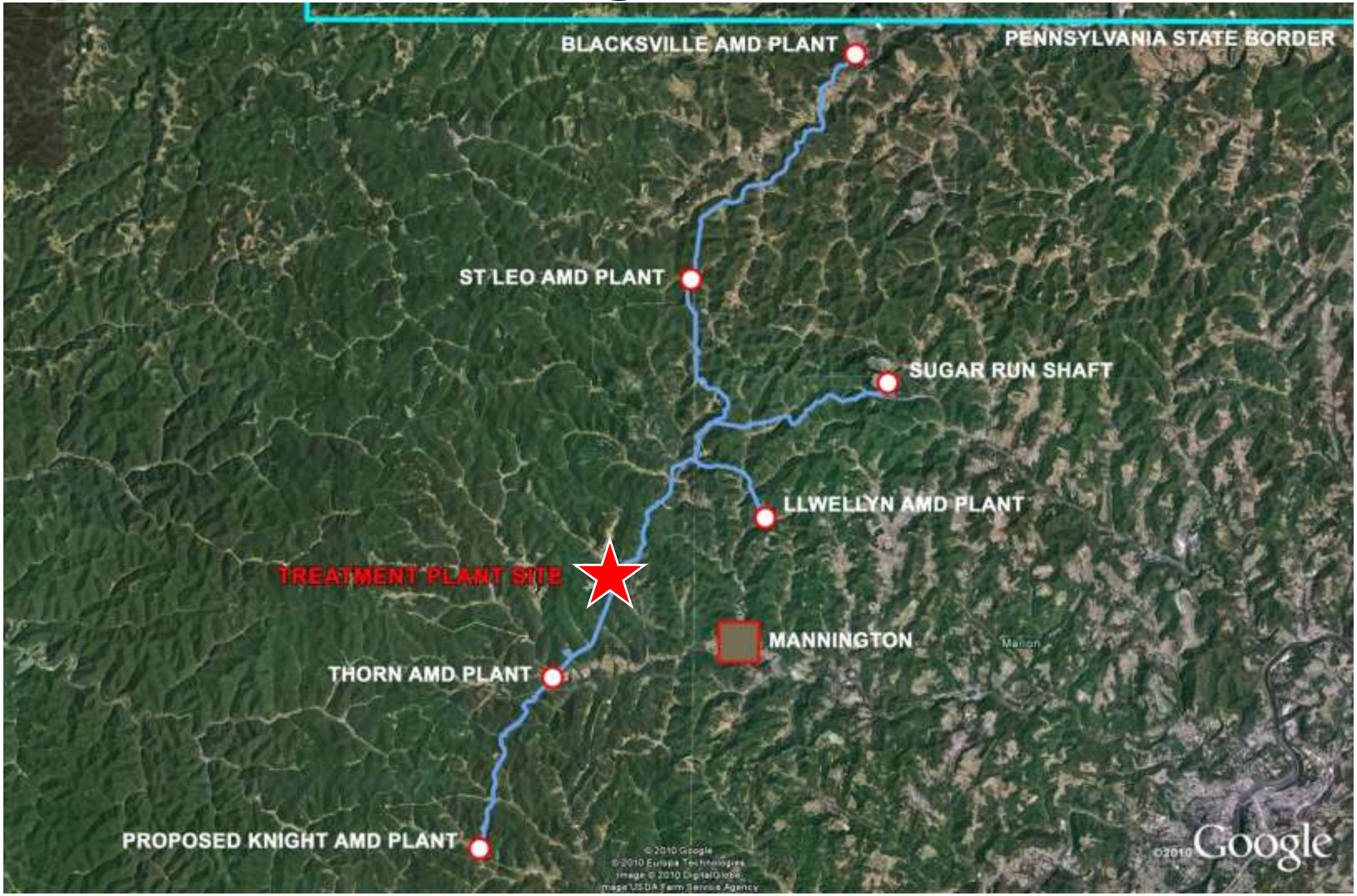
The Solution - ZLW

- A centralized treatment facility that creates Zero Liquid Waste (ZLW)
- The ZLW concept differs from ZLD in that a large quantity of water is discharged, however this water is compliant with environmental discharge requirements
- Waste residuals are condensed into a solid that is properly disposed in an on-site landfill
- No liquid waste from the water treatment operation leaves the site

The Project

- Northern West Virginia Water Treatment Facility (NWVWTF) will treat 5 MGD of mine water
- Mine water, pretreated for metals removal where needed, will be conveyed from six source points to the facility through 34 miles of pipeline
- Executed through a Design-Build-Operate contract with Veolia including 10-year operations term and renewal option for subsequent 5-year periods

Contributing Mine Sources



Project Schedule

- June 2010 - Request for proposals issued
- April 2011 - Project awarded
- July 2011 - Construction began
- October 2012 - System start-up
- January 2013 - Design-Build project completion
- May 2013 - Full operation

Project Components

- Water Conveyance Systems
- Treatment Facility
- Onsite Landfill

Water Conveyance Systems

Pipelines

Pump Stations

Pipeline / Pump Station Information

- Pipelines
  - Spans from the Pennsylvania border near Blacksville, WV south to nearly Folsom, WV spanning virtually three counties.
  - Consists of approximately 34 miles of HDPE pipeline with sizes ranging from 10” to 18”.

- AMD Collection Locations / Pump Stations / New AMD Treatment Facilities
  - Mine water will be collected from (4) existing and (2) proposed AMD treatment plants. Mine Water will be conveyed via (7) pump stations with capacities ranging from 1,000 to 4,000 gpm.
    - Blacksville
    - St. Leo
    - Sugar Run Settling Ponds (New AMD)
    - Llewellyn
    - Thorne
    - Knight AMD (New AMD)

Treatment Facility

Design Criteria

Influent Water Quality

Parameters	Maximum
Design Flow, GPM	3500 max (1750 min)
pH, S.U.	5 – 10
Temperature, deg F	38 – 85
Chlorides, mg/L	1,500
Sulfates, mg/L	5,500
Iron, mg/L	150
Manganese, mg/L	2
Aluminum, mg/L	8
TDS, mg/L	10,000
TSS, mg/L	150

Key Effluent Requirements

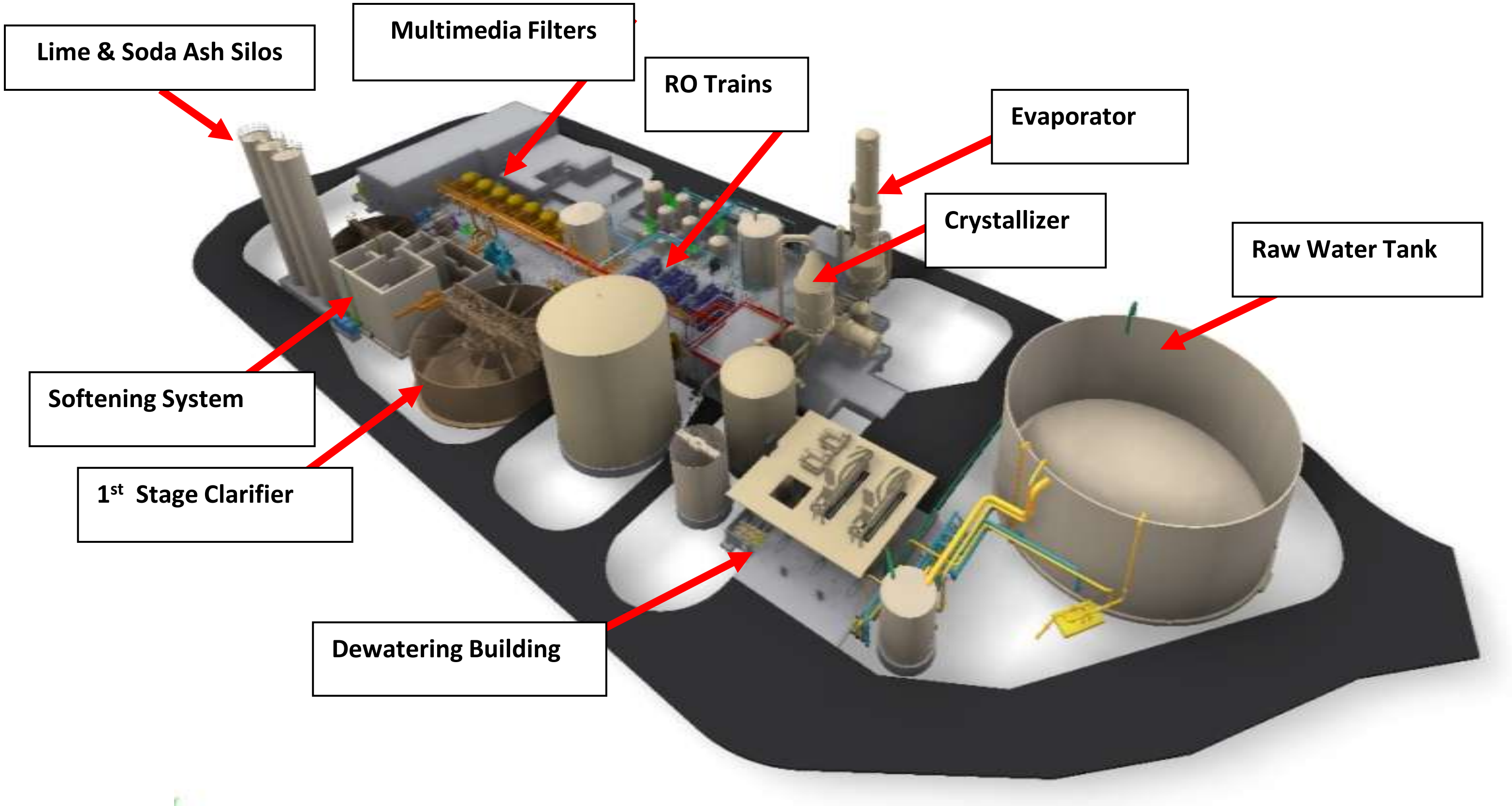
Parameters	Maximum Effluent Concentration
Chlorides, mg/L	< 218
TDS, mg/L	<150*
pH, S.U.	6 to 9

*Applied to RO permeate prior to re-mineralization

Additional Requirements by CONSOL

- Zero liquid waste discharge
- Turndown capacity of 50%
- 98% system availability
- Minimum operational life of 25 years, excluding major equipment replacement or retrofit
- Planned maintenance shutdowns not to exceed one calendar week per year
- Minimum 10-day chemical storage
- Treatment plant wastes to be non-hazardous

Treatment Facility Overview



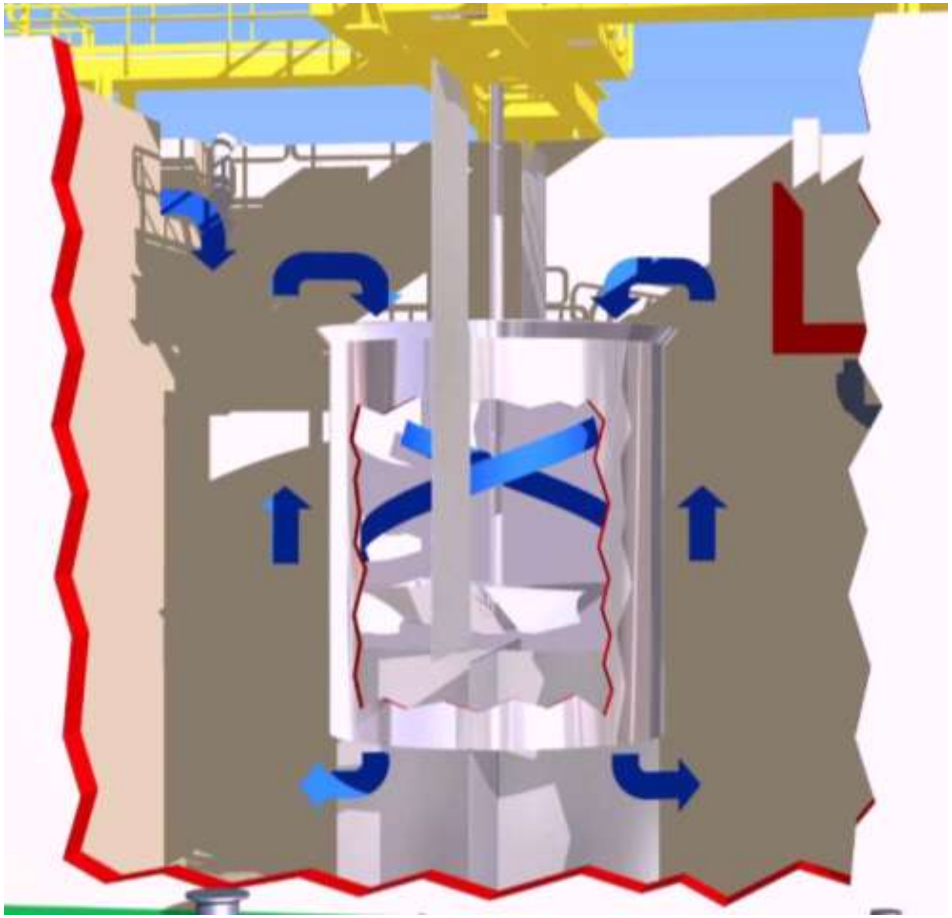
The Process: 3 Primary Components

- Raw Water Pretreatment System
- Reverse Osmosis System
- Thermal Brine Management System

The Process Flow - Pretreatment

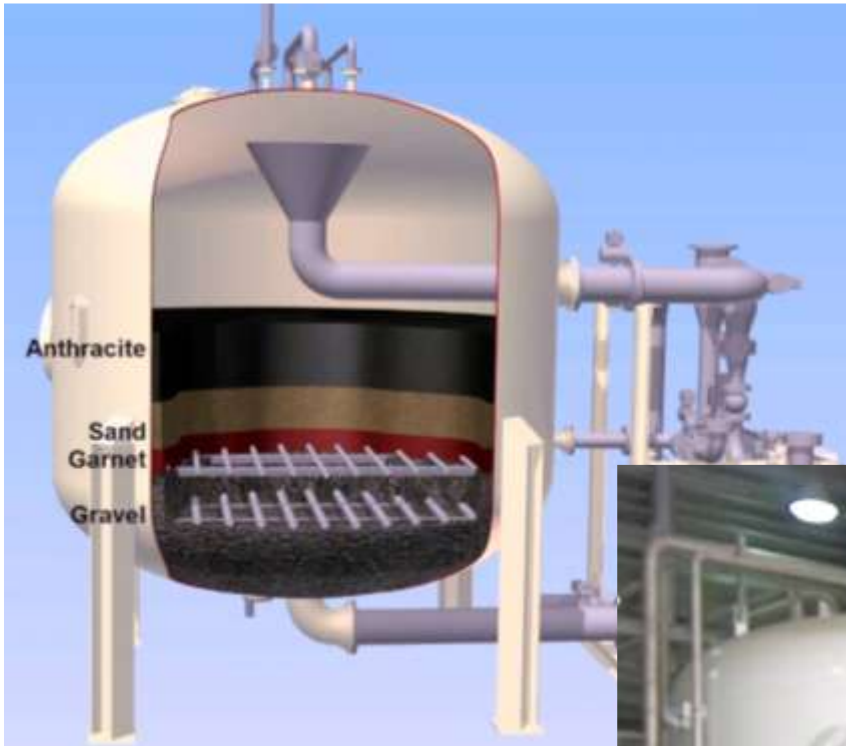
- Raw Water Pretreatment
  - Raw Water Feed Tank with Mixing Grid
  - Chemical Softening System
  - Clarifier
  - Aluminum precipitation tank – a critical step to prevent downstream membrane fouling
  - Multimedia Filtration System
    - 7 filter vessels 12 feet in diameter, 6 feet high with 3-foot bed of garnet, sand, anthracite

Chemical Softening System



- Multi-stage process
- Two aeration tanks for precipitation of metals such as manganese and iron
- Crystallization tank for removal of alkalinity and hardness
- Draft-tube reactor design
  - Solids recycle
  - Reduce chemical consumption
  - Enhance particle growth and settling characteristics
- Conventional circular clarifier design

Multimedia Filter System



- Removes residual suspended solids in the effluent from upstream clarification and aluminum precipitation processes
- Backwash water is returned to the Raw Water Feed Tank
- Filtrate is conveyed to the RO System

The Process Flow – RO System

- Reverse Osmosis System
  - RO Feed Tank, followed by Cartridge Filtration
  - RO Skids designed to achieve chloride and TDS specifications while operating at a high recovery rate
    - Five parallel skids, each sized to handle 25% of the design flow, 1 standby
    - 31 pressure vessels per skid, each with 7 seawater RO membrane elements
  - Permeate flows to Product Water Tank, which also collects distillate from Brine Management System
    - Prior to discharge, the Product Water Tank effluent is re-mineralized using carbon dioxide and lime water, to protect aquatic life
    - Discharged to Hibbs Run, a tributary to Buffalo Creek, which flows into the Monongahela River OR to a truck loading station for reuse in energy-related operations
  - Reject is sent to the thermal Brine Management System

Reverse Osmosis System

The Process Flow – Brine Management

- Brine Management System enables Zero Liquid Waste
  - Consists of Reject Conditioning, Evaporation, Crystallization
- Brine (RO Reject) Conditioning
  - Chemical softening of the brine in a second Crystallization Tank is necessary to prevent fouling of the surfaces in the Evaporator
  - Reject conditioning consists of:
    - Softening in a draft-tube reactor
    - Clarification
    - pH adjustment
    - Preheating
    - Deaeration/Decarbonization

Brine Management System

Crystallizer

Evaporator

Preheater

Evaporation

- Evaporator
- Concentric falling film unit is divided into two sections with a low concentration side and a high concentration side
    - Split design to reduce overall power consumption by allowing a portion of the evaporation to occur at a lower boiling point rise than the final concentration
  - Evaporator operates as a Mechanical Vapor Recompression System
    - Recycle of hot vapor in the system; minimize auxiliary steam
  - Distillates from the Evaporator and Crystallizer are pumped through a Feed Preheater for heat transfer to the incoming brine,
    - Heat exchanger for efficient energy utilization

Evaporator Design (HPD)

Influent brine flow

Vapor recirculation

Distillate exits the system

Crystallization

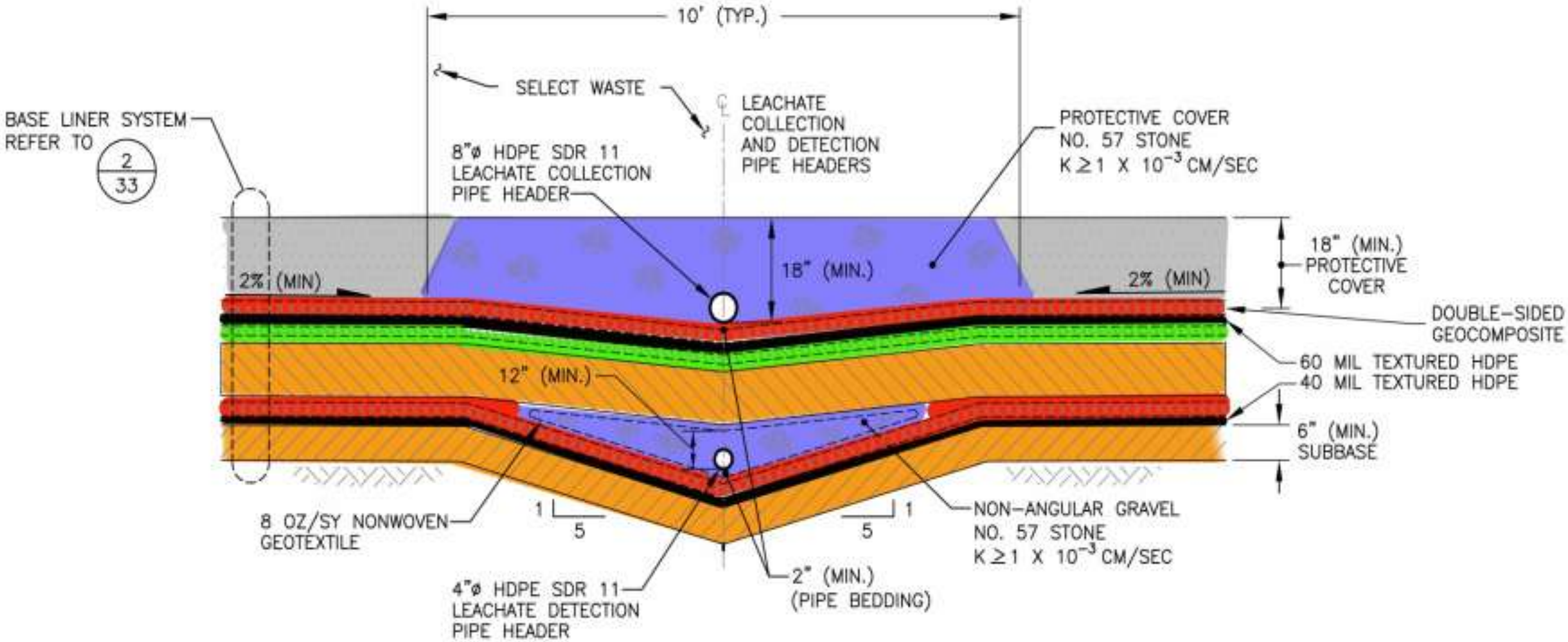
- Crystallizer includes a vapor body, recirculation pump, and forced circulation heat exchanger
  - Vapors created by concentrating the slurry in the Crystallizer are recompressed and recirculated through the heater
  - As the brine concentration increases, the solution becomes supersaturated and salts precipitate, resulting in a brine slurry
  - A slip stream of the crystallizer slurry is sent to centrifuges for dewatering
- The result: Zero Liquid Waste
  - Dewatered salt cake is disposed in the on-site landfill along with the dewatered sludge from the softening processes

Dewatered Filter Cake

Dewatered Mixed Salt

Onsite Landfill

Typical Landfill Liner System



Typical Landfill Liner System

Onsite Landfill

- At average flow conditions the plant will generate approximately 90 tons/day of filter cake and +/-160 tons/day of mixed salt.
- The filter cake and mixed salt wastes will be disposed at an onsite industrial landfill.
- The landfill will consist of a double HDPE liner design.
- All leachate generated in the landfill will be treated at the treatment plant. This creates a totally closed system.
- There are numerous benefits to an onsite landfill including:
  - Not occupying space in existing municipal landfills.
  - Not having additional truck traffic on local roadways.
  - Keeping all wastes contained at a single facility.

Conclusions

- Treatment facility design was driven by regulatory requirements that required advanced treatment technologies to achieve chloride discharge limits
- Project challenges are being overcome to ensure safe, compliant, and reliable mining operations
- CONSOL is leading the industry with development of ZLW facilities
- Chloride, TDS, Conductivity, and other industry discharge requirements may require others to pursue similar ZLW approach for compliance

Acknowledgements

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Questions?