Sustainability Webinar Series

Part 3: Managing Water Resources
Sustainability Series

Part 1: Managing Mining’s Waste
31 July 2019

Part 2: Renewable Energy’s Role in Mining’s Future
22 August 2019

Part 3: Managing Water Resources
12 September 2019

Part 4: Creating Sustainable Communities & Partnerships
10 October 2019

Part 5: Rethinking Remediation & Rehabilitation
5 November 2019
Part 2: Renewable Energy’s Role in Mining’s Future

- Hybrid microgrids and battery storage are creating a revolution for energy in the mining industry.

- Electrification of the mining industry is being driven by license to operate, costs and collaboration.

- The business case of renewables and integrated energy solutions is growing, and there are a variety of emerging examples of success across the global mining industry.

View Recording
Today’s Speakers

• Duane Thompson, Regional Sales Manager - Water Division, Minetek

• Eduardo DeSousa, Principal Groundwater Modeller, DHI Group

• Brett Harries, Technical Lead, Interlate
Global Water Management Solutions
Clients Objectives:

- Manage Impacted & Process Water
  - Cost Effectively
  - Minimal Production Interruption
- Minimise Capital Cost Exposure
- Sustainable Solution
- Short, Medium & long term Security
Minetek’s water management solutions help our clients focus more on production and profit.

Our approach is based on a deep understanding of our clients’ needs combined with a practical approach that delivers results.

Successful mine water management has a direct impact on our clients bottom line, and Minetek’s aim is to provide solutions that lower costs while effectively managing water quality and quantity in the face of environmental and site challenges.
Tailings dams have a long history of ruptures and collapses. In this century alone, there has now been 11 dangerous dam failures. This number also appears to be on the rise.
On the 25th of January 2019. This Brazil Tailings Dam collapsed and unleashed a tidal wave of waste and mud that engulfed homes, businesses, and residents in its path. It killed at least 237 people;

Eight employees of the Brazilian mining company were arrested over this deadly dam collapse.
Clients Storage & Management Risks:

1. Spill – Release of Fluids
2. Impact Production (lack of storage capacity) – Lost Revenue
3. Excessive Ongoing Operating Cost
4. Safety
Options to Manage Fluids:

1. Water Treatment
2. Large Evaporation ponds / compounds / dam
3. Larger pit storage facilities
4. Minetek Evaporation System
Minetek Evaporation solution:

- The Minetek evaporation technology has been implemented around the globe as a cost effective solution to water management challenges.

- This solution has the proven ability to meet a complex range of water management challenges and has enabled many sites to achieve operational & environmental compliance.

- Unique Ability to handle broad range of water qualities and volumes

- Utility, Mining & industrial operations have implemented the Patented Minetek water evaporation solution when confronted with one or more of the following critical risks;
Challenges we **Help solve:**

- Process & produced water disposal
- Tailings & storage dam overloading increasing risk of catastrophic failure and collapse.
- Legacy & mine closure site waste water issues.
- Landfill water management
- Closure of ash basins, dewatering
- Leachate water management
- Uncontrolled release of contaminated mine water causing environmental harm.
- Flooding of pits impacting the production.
- Extreme rainfall events causing wide spread flooding and inundation of operations.
How Does The Minetek Water Evaporation Process Work?
See The Magic Happen
Iron Ore Mine
WA, Australia
630m³/hr (2800 GPM) Capacity
Gold Mine
Nunavut, Canada
450m³/hr (2000 GPM) Capacity
Who Is Minetek?

35 - Years of Experience
2,800 - Completed Projects
100 - % Project Success
60 - Countries
Case Study: Colstrip Power Plant

**Client:** Talen Energy Colstrip Plant

**System Configuration:** 10 x Model 400/200 Evaporators, stainless steel

**Automation:** Fully Automated design

**System Capacity:** 250 L/sec pumped (10 units) (Average efficiency of 50% +

**Water Quality:** Coal ash pond water
Case Study: South32 Coal South Africa

**Client:** South 32 Energy Coal South Africa

**System Configuration:** 24 x Model 400/200 Evaporators

**Automation:** Climate Controlled automated System

**System Capacity:** 600 L/sec (24 units) @ 2 locations.
Case Study Data: Mount Morgan

Client: Australian Government
Queensland Mt Morgan Mine

System Configuration: 3 x Model 400/200 Evaporators

System Capacity: Pump 75 L/sec

Task: Evaporate acid water from abandoned gold mine

Features: Full stainless steel construction
Thank You for Your Time

Website: www.minetek.com
Email: sales@minetek.com
Integrated modelling of Pit lakes and groundwater environments

Eduardo de Sousa
DHI
Introduction
We’re on a quest
to help solve the world’s toughest challenges in water environments

Mines  Groundwater  Oceans  Coastlines  Cities  Rivers
DHI in short

We are a leader in water modelling and technologies

21% of our resources are allocated to R&D to further our knowledge

Our people are highly qualified
80% of our 1,100 employees hold an MSc or a PhD degree

We’re global
We have more than 30 offices worldwide and experience from projects in over 140 countries (Mining focused staff in Canada, USA, Peru, Australia, Sweden, Germany)

We’re an independent, private and not-for-profit organisation
Current Focus Areas (mining)

- **Mine Dewatering**
  - High-resolution geologic framework models
  - Wellfield optimization
  - Cost optimization
  - Facilitated uncertainty analysis (FePEST)

- **Mine Water Operational Planning System**
  - MIKE MIKE

- **Tailings Dam Break Outflow Modeling**
  - Non-Newtonian flow code

- **Physically Based Water Balance Modeling**
  - Success where and when simplified probabilistic models fail
Pit lakes and mine voids

- Pit lakes form when open pits extend below groundwater level, following cessation of mining and/or dewatering activities.
- Currently there are over 1800 mine voids in Western Australia.
- There is a potential for environmental impacts.
- Long term planning (closure) for management of these areas is required.
Conceptual model

Johnson and Wright (2003)
Conceptual model

Johnson and Wright (2003)
Simulation of pit lakes

- Usually undertaken from different perspectives
  - Groundwater
    - High resolution 3d groundwater flow and solute
    - Simplified representation of pit lake boundary conditions
  - Pit lake
    - Detailed pit lake water/salt balance
    - Simplified exchange relations between the lake and surrounding aquifers
FEFLOW

What is FEFLOW?
- Commercial “All-in-One” Surface/Subsurface (FE) Simulator
- Qt/OpenGL Graphical User Interface
- Density-Coupled Flow/Mass/Heat
- Uncertainty Analysis / Model Calibration

Regional Groundwater Management
- Natural groundwater resources
- Artificial recharge
- Aquifer storage and recovery
- Bank filtration
- Dewatering systems
- Drawdown assessment
- Interaction with surface water
- Pipe, karstic and fracture flow

Water-Supply Management
- Capture-zone delineation
- Particle-tracking, Random-Walks
- Exit-probability and travel time analyses
- Well-field management
- Contamination-risk analysis

© DHI
Mine Hydrology using MIKE SHE:
Spatial and Dynamic water balance, distributed Recharge, ground and surface water interactions, stream flow, solutes and geochemistry.

Hydrogeological model FEFLOW:
Groundwater flow modeling, transport and density dependent flow, geochemistry.

Geological model using LEAPFROG Parameters zone and Faults Representation.

Mine Closure – Pit Rebound.
## Mine closure – Pit lakes

<table>
<thead>
<tr>
<th>MODEL</th>
<th>SIMULATED PROCESSES</th>
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<tbody>
<tr>
<td></td>
<td>3D GROUNDWATER FLOW</td>
</tr>
<tr>
<td>MODFLOW LAK3 (Merrit and Konokow, 2000)</td>
<td>YES</td>
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<tr>
<td>GSFLOW (Markstrom et al., 2008)</td>
<td>YES</td>
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<tr>
<td>MODFLOW-WETLAND (Restrepo, 1998)</td>
<td>YES</td>
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<tr>
<td>MODHMS (Pandoy and Huyakorn, 2004)</td>
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<td>MIKE-SHE (Graham and Refsgaard, 2001)</td>
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<tr>
<td>FEFLOW-IFMLAKE (Monninkhof and Li, 2009)</td>
<td>YES</td>
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<tr>
<td>FEFLOW – PIT LAKE (Wingle and Sinton, 2015)</td>
<td>YES</td>
</tr>
<tr>
<td>FEFLOW-GOLDSIM (Thornburrow et al., 2013)</td>
<td>YES</td>
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<tr>
<td>PARFLOW (Kollet and Maxwell, 2000)</td>
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<tr>
<td>MODFLOW OWHM (Hanson et al., 2014)</td>
<td>YES</td>
</tr>
<tr>
<td>MODFLOW-SWR (Hughes et al., 2012)</td>
<td>YES</td>
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</tbody>
</table>
Environmental – Surface-groundwater interactions

- Lake Muir-Unicup
Environmental – Surface-groundwater interactions

Dry season
(lake level at 171.4 mAHD)

Wet season
(lake level at 171.8 mAHD)

Dry lake
(Recharge boundaries + seepage face boundaries)

Wet lake
(Lake level constant heads + zero recharge)

Legend:
- Quaternary sediments
- Tertiary alluvium sediments
- Weathered crystalline basement

© DHI
Mine closure – Pit lakes

- FEFLOW plugin
- Capable of simulating
  - Dynamic lake geometries (and boundaries)
  - Water/Solute/Heat balances
  - Environmental heads
  - GW interactions in 2D/3D
- Flexible to simulate a wide range of environments
  - Lakes
  - Wetlands
  - Pit lakes
Lake water balance

\[ V_t = V_{t-1} + \Delta t \times \left\{ (R - E) \times L_a + G_{\text{inflow}} + G_{\text{outflow}} + Q_{\text{pump}} \right\} \]

- \( V_t \) – Lake volume (m³)
- \( V_{t-1} \) – Lake volume (m³) from previous time step
- \( \Delta t \) – time step length
- \( R \) – Rainfall (mm)
- \( E \) – Evaporation (mm)
- \( L_a \) – Lake area
- \( G_{\text{inflow}} \) – Inflow from FEFLOW mass balance
- \( G_{\text{outflow}} \) – Outflow from FEFLOW mass balance
- \( Q_{\text{pump}} \) – Abstraction/injection rate
How the module works
Main inputs

- Time series (as Power functions)
  - Lake stage curves
  - Rainfall series
  - Evaporation series
  - Pumping series (optional)
- Reference distributions
  - Lake Ids (nodal and elemental)
  - Lake bathymetry
  - Lake wet-dry flag
Main inputs – Stage Curves (DTM based)
Main inputs – Time series

Rainfall

Evaporation
Main inputs – Reference distributions

Lake ID’s

Lake Bathymetry
Sub time-stepping

- If FEFLOW time-step is larger than a day, lake water balance calculations are split into daily sub-time steps
Project 1 – Coal basin

- Use void to store water
- Pump in during wet season
- Pump out during dry season
- Would water be lost to aquifer/evap?
Model results
Model results
Project 2 - Multiple lakes
Coal basin
Multiple lakes
Multiple lakes
Lake levels
Conclusions

- Pit lake dynamics and its interaction with surrounding aquifers is complex
- Most of approaches used to simulate it oversimplify one environment (Pit lake) or another (groundwater)
- The developed FEFLOW add-on allows simulation of detailed lake dynamics coupled with high-resolution 3D groundwater flow fields
Thank you

Eduardo de Sousa
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AGENDA

Introduction

CASE STUDY - Recovery of process water from a concentrator tailings thickener

Results
INTRODUCTION
Brett has 35 years experience in a variety of mining and mineral processing operations in Australia and internationally. Brett has held leadership roles that span across various disciplines including plant operations, engineering, asset management and business development.
Interlate is an industrial productivity improvement specialist that utilizes the power of connected machines and technical innovation to deliver superior value for mining companies.

Operating from a state-of-the-art Operations Intelligence Centre in Brisbane, Interlate’s solutions help natural resource companies reduce operating risk and increase productivity.
CASE STUDY

RECOVERY OF PROCESS WATER FROM A CONCENTRATOR TAILINGS THICKENER
Challenge

For minerals processing operation, managing the regulatory compliance and reputational aspects not to mention cost implication of freshwater consumption is a very topical matters.

For many operations around the globe, freshwater consumption is magnitudes higher than the consumption rates of the adjoining communities. This can become an obvious stressor for all stakeholders. With the rising price of water comes the need for efficient consumption to control operating cost.

Somewhere along the line almost every person associated with the mining and mineral processing industry, regardless of continent around the world, would empathise with this.
Situation

A mine and minerals processing plant operates in a region that experiences an extended dry period, consequently water resources (above and below ground) are very scarce.

To further exacerbate the situation, a major structural failure occurred to circuit infrastructure, meaning return process water pump sets were out of commission for an extended period.

Normal return process water was not immediately available.

Alternative infrastructure was being engineered, but not in a short time frame and not without considerable cost.

Operations suspended for response and recovery.
An Innovative Approach

- One option for reducing fresh makeup water consumption is to be consistently more efficient at recovery of existing in-circuit process water stocks, prior to sending to tailings storage facility.
  - This is particularly attractive when the solution is achieved very quickly and at NO capital cost.

- In this webinar we will talk about a solution that identifies the operational tactics / parameter set points for a concentrator tailings thickening process to minimise consumption of fresh makeup water.

- **Note:** Thickeners are mechanically continuous process equipment which operates on a particle / floccule sedimentation principle where in simplest terms the solids settle to the bottom of the thickener tank and the process water overflows to a storage tank. Some water is required to convey / pump the sediment in a slurry form from the underflow to a tailing storage facility. % solids in the underflow varies from operation to operation and from design to design (e.g. pump or gravity tailings outfall).
Applying Data-driven Approach

Different classes of process water were created using characteristics (e.g. % solids, reagent content, mineralization, etc). These classifications are referred to as “Productivity Groupings”.

Productivity Groupings are statistically unique both in characteristic and parameter set points.

This was about recognising that different inputs need to be treated differently in the thickener. Similar to different ore feed types into a concentrator.

Productivity Groupings, plant performance / process and other data sources for 12 months of historical data, were fused together in a hyper-variant model.

A visualization interface allowed filtering of data associated with each Productivity Grouping.

Exploratory analysis across all thickener parameters (e.g. flow rate, bed level, flocculate addition, underflow density, etc) simultaneously allowed identification of strongest set point value combinations with respect to recovery of existing in-circuit process water.
Solution

- In the following slide flocculant dosage and dilution water rates are used as example parameters for set point selection.

- The technique generates a binned scatter plots of the parameters which allows selection of data ranges that drive an uplift in process water recovery.

- A clear inflection point is observed on the interface for flocculant dosage rate. The inflection representing highest process water recovery at that dosage rate.

- Operational tactics / parameter setpoints were determined (at 95% statistical C.I.).

- This identified the best past recycle performance and was the new benchmark going forward.

- A region of higher water recovery is also observed at dilution rates of 40-45m³ per hour.

- As the operation continued to tightens up the data around these new target set points, the data density increases and further optimisation occurs.
A clear inflection point is visible in the flocculant dosage data points for highest water recovery.

Similarly region of higher water recovery is also observed at dilution rates of 40-45m³ per hour.

The example below show pre-set point selection average water recovery for the 12 months of data is 59.6%.

Post set point selection of flocculent rate and dilution parameters shows water recovery increase of ~4% from 59.6% up to 63.5%.

E.g. at process water flow rate of ~1000m³ per hour into thickener (i.e. 1300tph @ 30% solids), equates to ~960m³ per day of additional water.
RESULTS
4% REDUCED FRESH WATER CONSUMPTION

- Pre-selection average process water recovery for the 12-months of data was 59.6%.
- Post-selection gave rise to absolute water recovery increase of ~4% from 59.6% up to 63.5%.
- For process water flow rate of ~1000m$^3$ per hour into the thickener (i.e. 1300tph mill throughput @ assumed 30% solids), equates to ~960m$^3$ per day of reduced fresh makeup water consumption.
- Sets of operating tactics that lift water recovery performance are identified in a few seconds.
- In the use case the identified thickener parameters lead to an increased water recovery of 4%:
  - While there may not be a directly tangible financial benefit, water efficiency is an important community matter to manage, in the best of seasons.
  - Assist compliance with increasing regulatory and permitting conditions.
Austmine Webinar Series Special Offer

15 minutes call to discuss your questions about your challenges related to process water recovery in your operations.

FOR FREE

Email to book a call

brett.harries@interlate.com

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Audience Q&A
Sustainability Series

Part 4: Creating Sustainable Communities & Partnerships

10 October 2019, 12.30 – 1.30pm AEDT

• Community engagement plans and procedures
• New partnership models with local communities
• Leaving a legacy beyond the operation of the mine

REGISTER