Water Management in Mining Operations



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Hatch Water

Agenda

- Overview of Water in Mining
- Water Supply
- Process Optimization
- Effluent Treatment

Agenda

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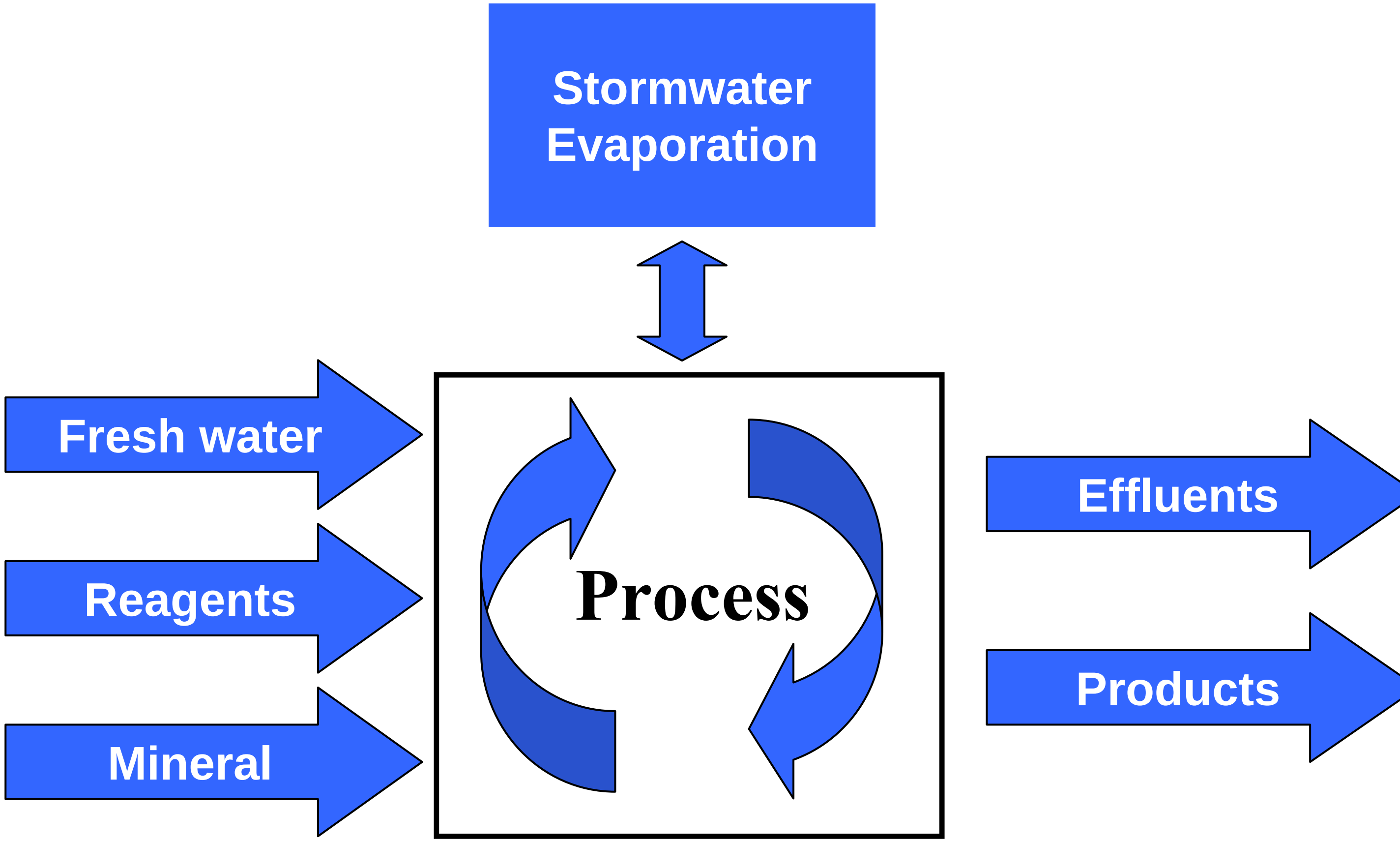
Mining Water Cycle



Water Usage

Water Scarcity in Mining?

Press Releases:

….. Completes Acquisition of Water Rights….

….. the Company entered into a letter agreement to acquire water rights, at a total volume of … litres per second

Water supply problem resolved?

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Historical Water Management

- Water quantity not quality
- Most current mineral process designs date from the days when:
  - Environmental regulations were relaxed
  - Water was readily available
- As a result no real water management
  - i.e. no recycle/reuse practiced

Water Usage

Water qualities

	TDS ppm	Cl ppm	SO_4 ppm
Seawater	35,000	20,000	2,700
Brackish (Well) water	1,000 - …	250 -	500 – …
Desalinated Seawater	350	150	<10
Municipal Waste water	COD (organic matter, foaming agents, bacteria, P, etc.)		

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Water Usage

Required water quality depends on application

Water Quality	Flotation	Oxide Leach	Sulphide Leach
Seawater	√	√	No
Brackish (well) water	√	√	Maybe
Desalinated Seawater	√	√	√
Municipal Wastewater	Maybe	Maybe	√
Low chloride (1 or 2 pass RO)	√	√	√

Agenda

- Overview of Water in Mining
- **Water Supply**
  - **Aquifers**
  - **Muncipal**
  - **Seawater**
  - **Desalinated Seawater**
    - **Project Components**
- Process Optimization
- Effluent Treatment

Aquifers

- Wells were traditional source
- Environmental and/ or political pressure in many parts of the world (competition with urbanization)
- Limited access for expansion of mining operations

Water supply

Municipal water source

- Mining operation must be close to major city
- Depending on intended use advanced treatment required
  - affects process efficiency
- Municipal water reuse not practiced in most parts of the world

Water supply

Raw Seawater

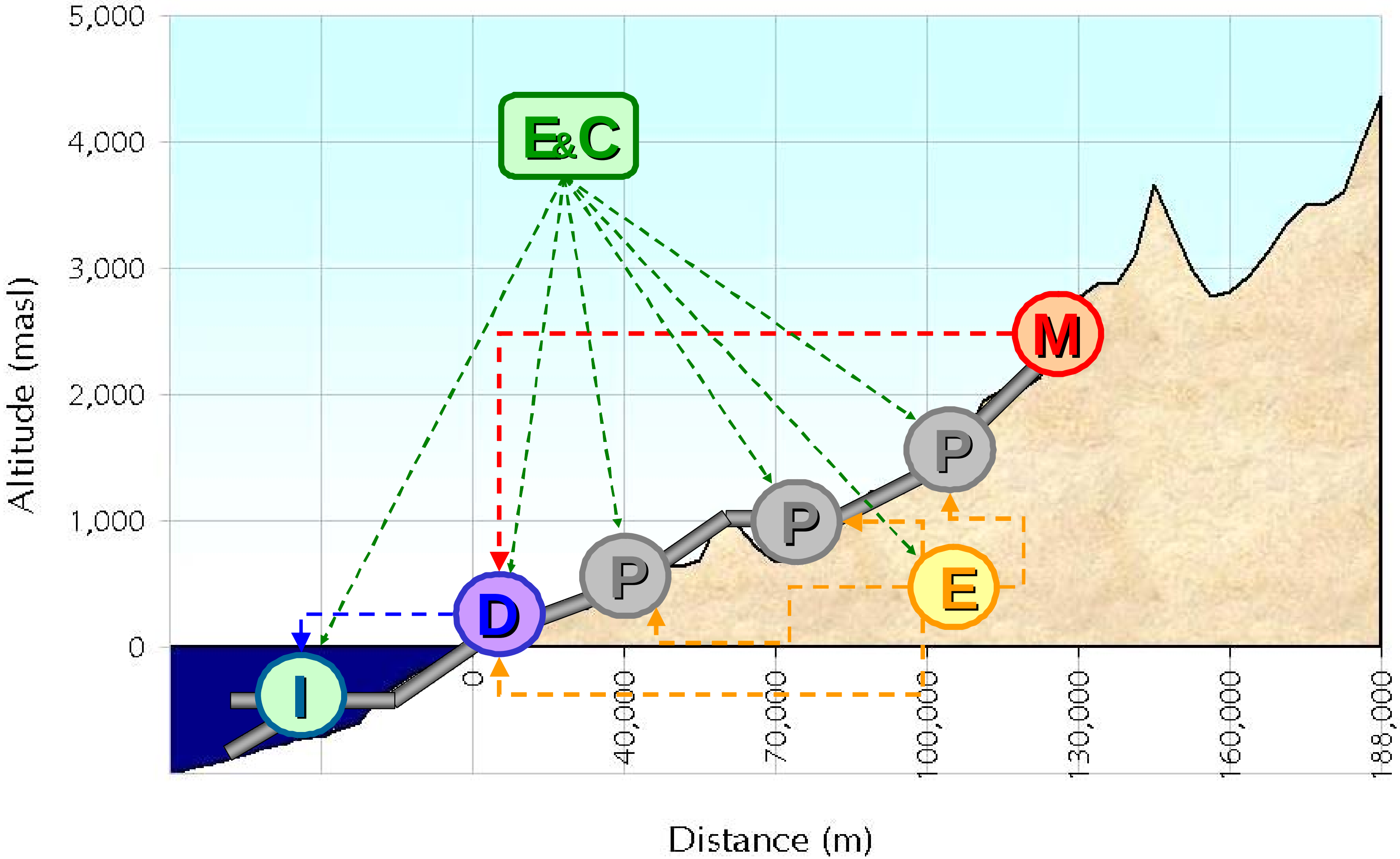
- Industry experience with salt water
  - Historically: smaller operations
- Several operations are already using direct seawater in copper leaching and/or flotation
- Corrosion management (Conveyance/Process)
- Metallurgical Process efficiency issues
- Requires partially desalination on site
- Gypsum scaling (salt build-up)

Water supply

Desalinated Seawater

- For many projects, seawater seems to be the only available (sustainable) water source
- Most mining companies in Chile are considering (desalinated) seawater as their sole source of sustainable water supply

Project Components



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CAPEX

- Most significant items in the overall project are the pipeline and pumping stations
- CAPEX depends on pipeline routing characteristics
  - Site conditions
  - Soil mechanics
  - Constructability aspects
  - Market conditions (commodity/materials prices)
- Pipeline protection and coating (internal and external)

OPEX

- Energy largest percentage of overall OPEX
- For desalination plants, between 50% and 80% of OPEX
- For the water conveyance system, over 90% of OPEX
- Substations and transmission lines are often part of overall water supply projects

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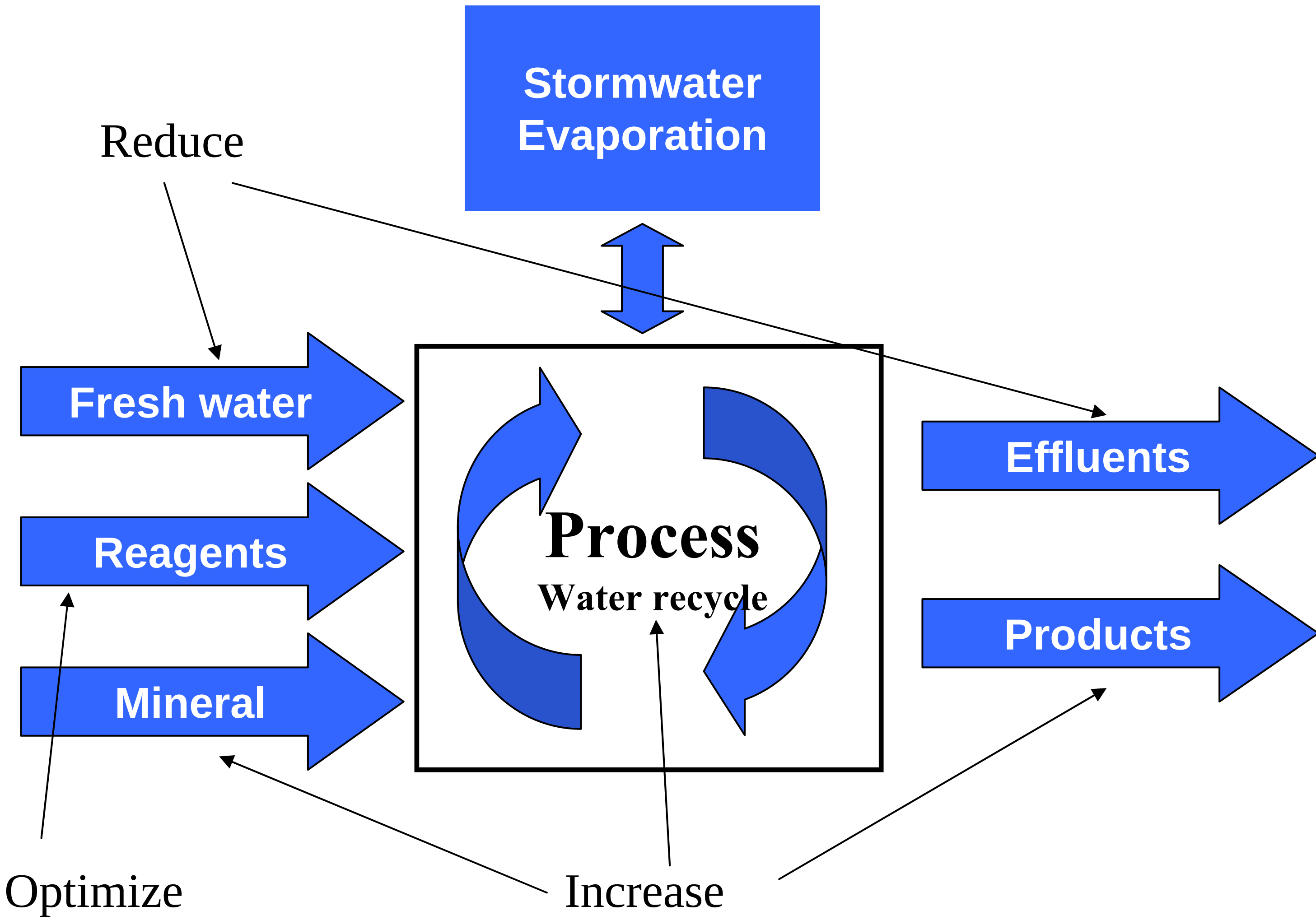
- **Process Optimization**
  - **Recycle/reuse**
- Effluent Treatment

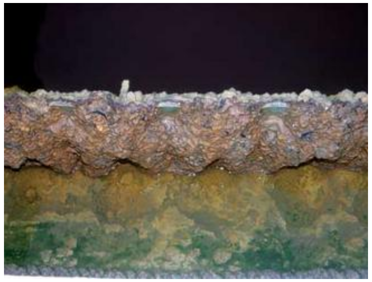
Optimization – Water Recycle



Water balance

Consequences of Optimization

- Scaling and corrosion issues with process
- Increased ion concentrations (e.g. sulfate) in the discharge



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Agenda

- Overview of Water in Mining
- Water Supply
- Process Optimization
- **Effluent Treatment**
  - **Overview**
  - **Critical Elements**
  - **Typical Treatment Methods**
  - **Sulphate removal**
  - **Advanced Treatment Example**

Overview

- Neutralization of acidity
- Removal of regulated elements primarily metals and metalloids
- Control toxicity

Overview

- Effluent has complicated Chemistry
  - Scale forming
  - Corrosive
  - Organics
- Variable flow rates

Elements

Some Critical Elements in water

Cations	Anions
H^{+} (pH 6-8.5)	OH^{-} (pH 6-8.5)
Na^{+}	SO_4^{-2} (1000 ppm)
Ca^{+2}	Cl^{-}(400 ppm)
Mg^{+2}	F^{-} (1.5 ppm)
K^{+}	CN^{-} (0.2 ppm)
Metals (Al, Fe, Cu, As, Zn, Pb, etc.)	
Metalloids (As, Mn, Mo, Se etc.)	

Treatment

Typical treatment for Metals

- Active metals removed from solution by precipitation or adsorption onto solids
- Solids are separated from solution
- Waste generated for disposal or re-use

- Other methods:
  - Passive biological treatment
  - Active biological
  - Evaporation
  - Ion Exchange
  - Reverse Osmosis/Nanofiltration

Sulphates

Sulphate Discharge Regulations

- International standards
- Local standards
- Special situations
- Discharge limits
  - Directly as $[SO_4]^{-2}$
  - Indirectly as TDS (Total Dissolved Solids) or Electrical Conductivity
  - Limits depend on final use of water and the body of water receiving the discharge

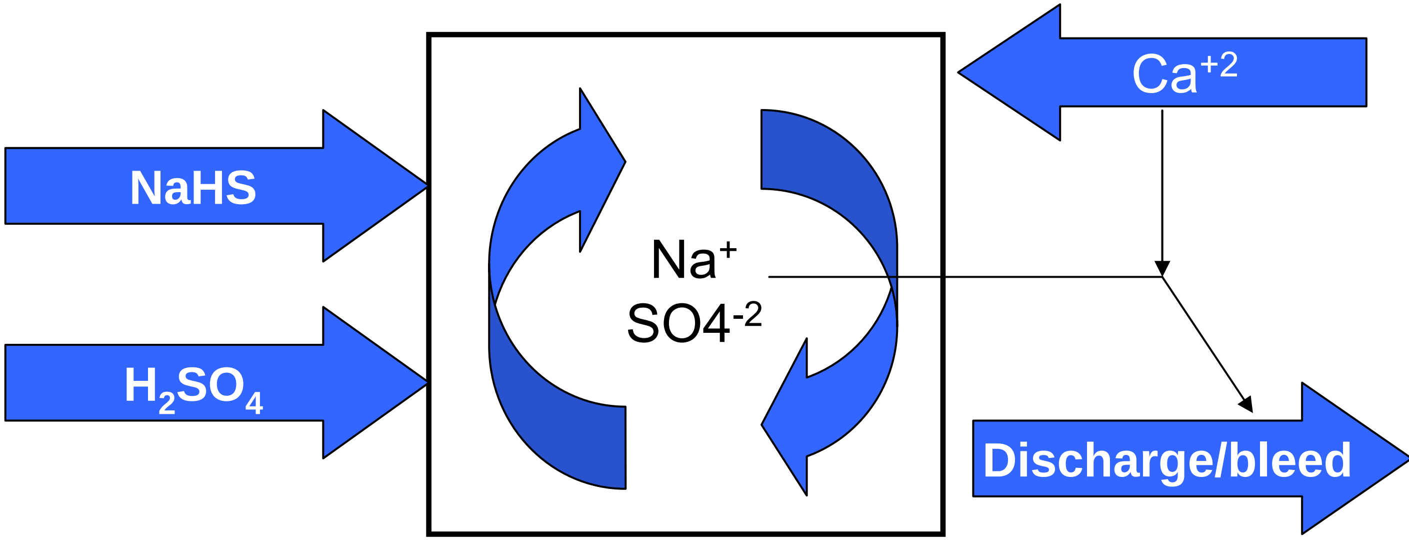
Sulphates

Effluent Discharge Regulations

Country	Legal Instrument	$[SO_4]^{-2}$ mg/l	TDS mg/l	Conductivity mS/m
Chile	DS90 DS46 NCh1333	1000-2000 250-500		
Peru	DS-002-2008-MIN	300 (Cat 3)	500 (Cat 4)	
Ecuador	NCADE Lib VI, 1	1000	3000	
Brazil	Resolution 357	250 (Class 1-	500	
South-Africa	Water Act 1998	-	-	70 - 150
Australia	ANZECC 2000/	1000	2400	

Sulphates

Mo/Cu flotation process using NaHS



Issues:

- Build-up of Na^+ and SO_4^{-2} in solution
- Scaling
- Effluent treatment

Definition of sulphate treatment

- Removal of sulphate ions from the aqueous phase, to a concentration compliant with discharge regulations

How:

- Reduction of SO_4 to S°↓
- Precipitation of SO_4 with reagent
- Precipitation of SO_4 as product of evaporation

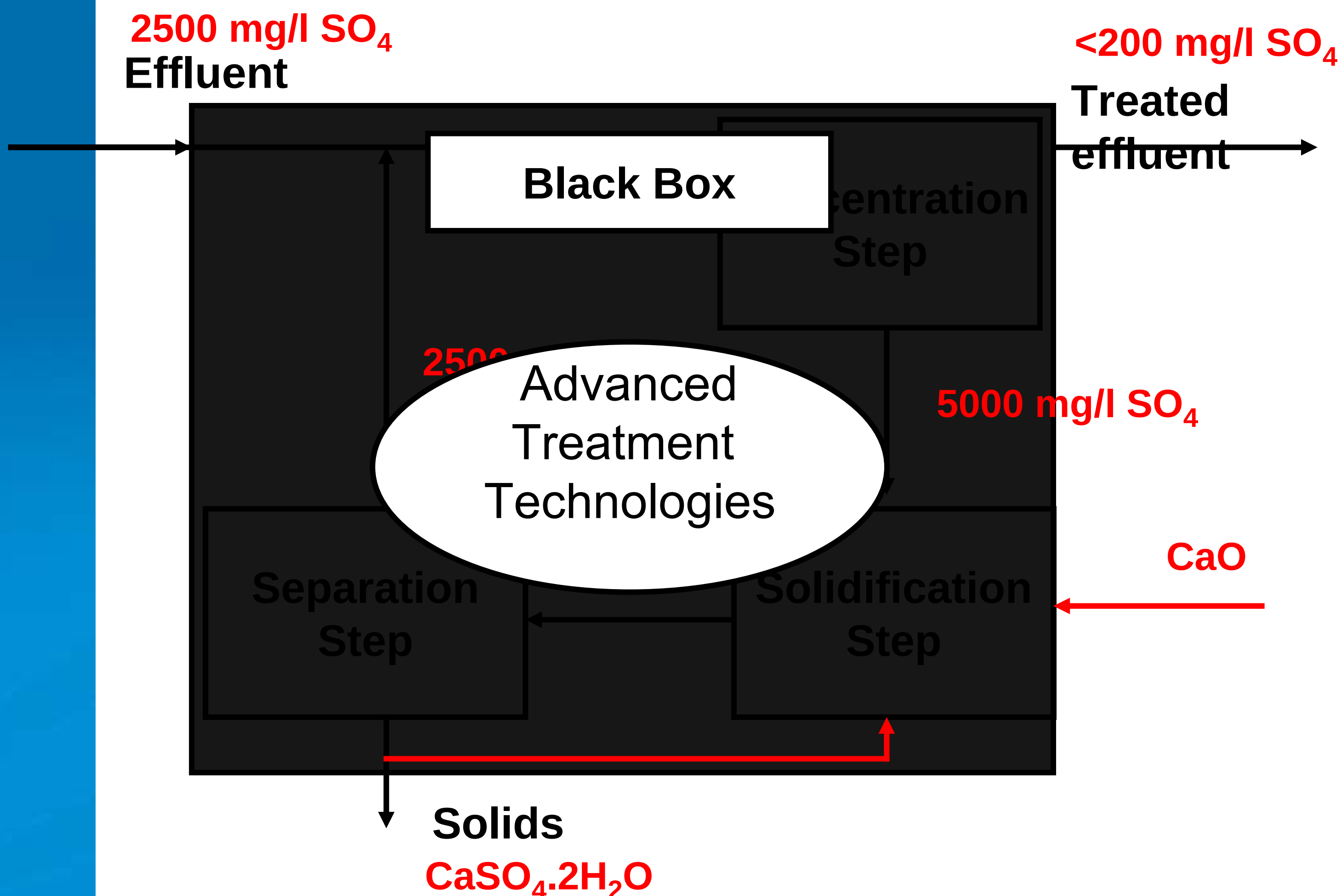
- *Retention of a concentrated effluent within process inventory (to avoid effluent generation)*

Sulphate Treatment

Sulphate Treatment Process

- **Traditional/Conventional**
  - Lime/limestone
  - Proven
- **Advanced Treatment**
  - Consist of three specific processes:
    - Concentration
    - Solidification
    - Solid/Liquid separation

Advanced Sulphate Treatment Concept



BHP Billiton Kwinana Nickel Refiner
Chloride, Sulfate Removal, water reu

Sulphates

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Sulphate Treatment

Concentration Processes

- **Evaporation (Solar, Mechanical)**
  - Location (climate/environment)
- **Ion Exchange (Sulf-IX)**
  - In general, minimum pretreatment required
  - Process in combination with lime precipitation
- **Membranes (Reverse Osmosis, nanofiltration)**
  - Proven: Industrial experience
  - Pretreatment (scaling, solids)

Solidification Processes

- **Lime precipitation**
  - Requires sulphate concentrations above saturation
  - Scaling issues
  - Well known process (LDS, HDS)
- **Barium precipitation**
  - Costs/ reagent availability
  - Pilot test stage

Sulphate Treatment

Solidification Processes

- **Ettringite (SAVMIN, CSER)**
  - Precipitation of sulphate as CaO.3CaSO4.Al2O3.31H2O
  - Al2O3 availability
- **Biological processes (Biosure, Sulfateq)**
  - (Bio) Conversion of SO4 to S° (or S-2)
  - Industrial scale proven
  - Electron/carbon source availability
- **Crystallization**

Selecting Sulphate Treatment Process

- **Key Criteria**
  - Effluent characterization
  - Environmental regulations
  - Reuse requirements
  - Sludge disposal
  - Plant Locatin
  - Logistics
  - Reagents

Examples of Advanced Sulphate Treatment Operations

Operation	Country	Technology	Q (m3/h)	Year	SO_4 mg/l
eMalahleni (BHP/Anglo	SA	RO & Lime	830	2007	<200
Ancor Works	SA	Biosure	416	2006	<200
Kwinana Nickel (BHP)	Aus	NF&RO&evap	120	1994	< 10
ERA Ranger	Aus	Lime & NF & RO	290	2005	< 95 (200µS/cm)
Collahuasi	Chile	NF/RO&evotr	235	2008	<500
[illegible] Florida	[illegible]	[illegible]	[illegible]	[illegible]09	<30

Conventional (lime) treatment:
1600-2000 mg/l SO_4

Acid Mine Treatment Mosaic, Phosphate Mining

Example

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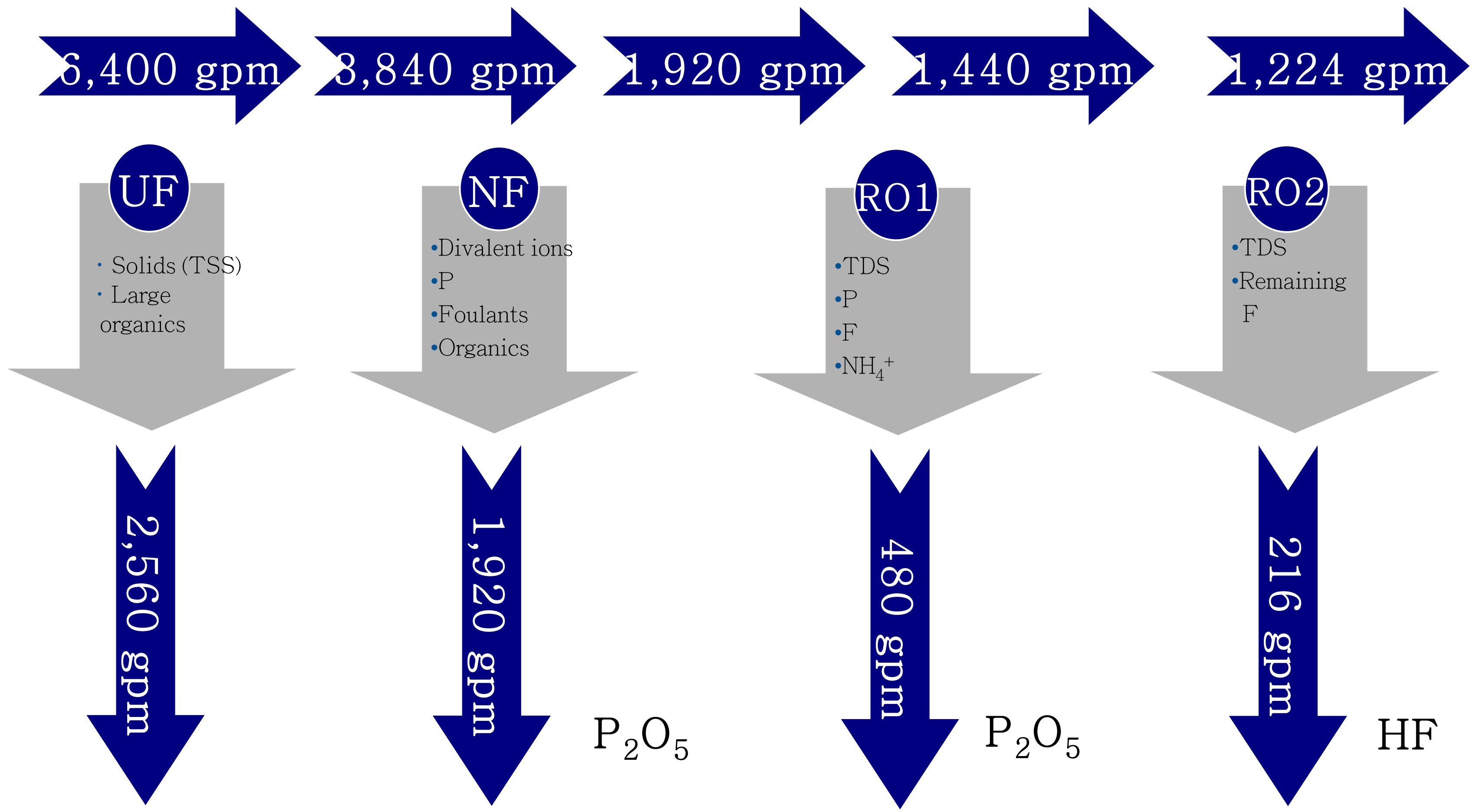
Acid Mine: Key Process Steps



Mosaic- Phosphate- Spent Liquor Treatment Bartow Florida

Questions

Thank you!

Questions or Comments?

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