# De-pyritization of Tailings: Experiences from Three Copper Mines in Scandinavia

**Presentation prepared for:**

**24rd ANNUAL BRITISH COLUMBIA-MEND ML/ARD WORKSHOP**

***"Challenges and Best Practices in Metal Leaching and Acid Rock Drainage"***

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Nils Eriksson, Boliden Environmental Staff
Seth Mueller, Boliden Environmental Staff
Ulla Syrjälä, Boliden Kevitsa
Kari Janhunen, Boliden Kylylahti
Åsa Sjöblom, Boliden Aitik


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# Definition and legal aspects

**Definition of de-pyritization according to the EU:**

- *"Separation of pyrite from the tailings and separate discharge of the pyrite"*

**EU- legal requirements:**

- The management of extractive waste should be based, *inter alia*, on the concept of BAT

**BAT on ARD management:**

- Characterization of extractive waste and determination of the acid-forming potential.
- If ARD-forming potential exists:

1. Prevent the generation of ARD (de-pyritization is listed as a prevention option),
2. Control ARD
3. Apply treatment options.

Often a combination is used.

- The de-pyritization technique is well known. The pyritic product has a high reactivity and therefore carefully designed measures for deposition are required.

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# General objectives

**General objectives of performing de-pyritization are often:**

- Avoid/lower ARD potential in the de-pyritized tailings
- Concentrate potentially economically recoverable substances
- Legal requirements
- Permit requirements

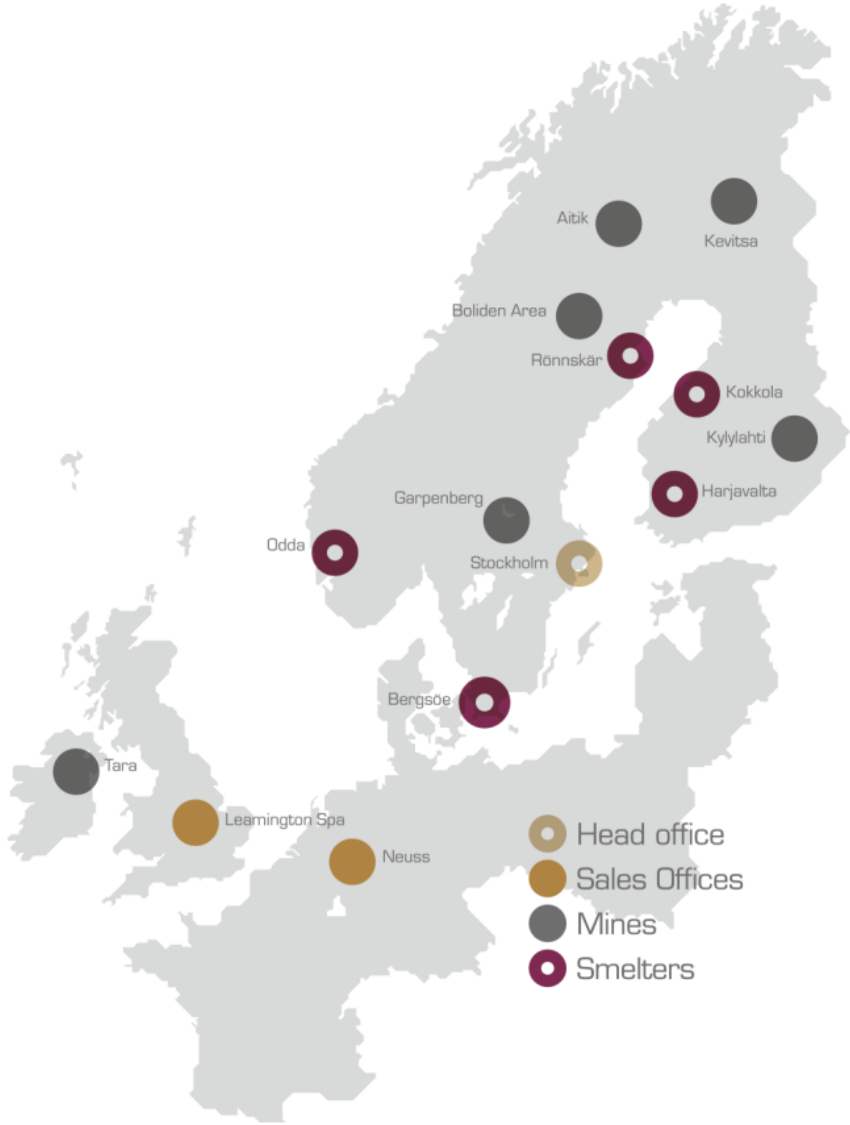
**Potential benefits:**

- Minimize long-term risks
- Recover more from the ore
- Lower closure costs
- Alternative closure options
- Permitting

# Boliden sites

The following Boliden sites perform de-pyritisation:

- Kevitsa, Finland
- Kylylahti, Finland
- Aitik, Sweden

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# KEVITSA

- Finnish nickel-copper-gold-Platinum Group Metals (PGM) mine
- Milled tonnage: 7 -9 Mtonnes
- Waste-rock to ore ratio: 5:1
- Number of employees 380 and 200 contractors

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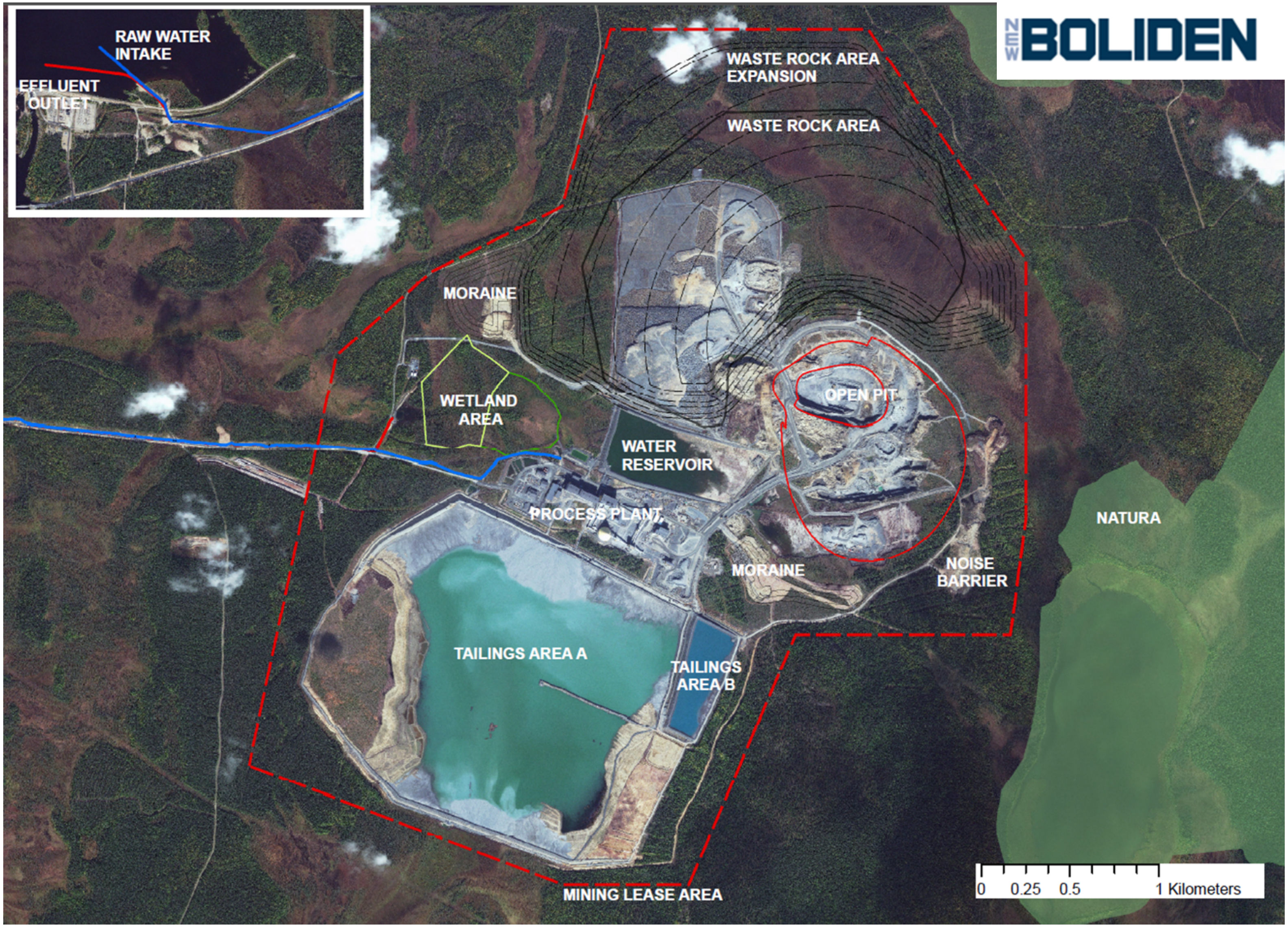
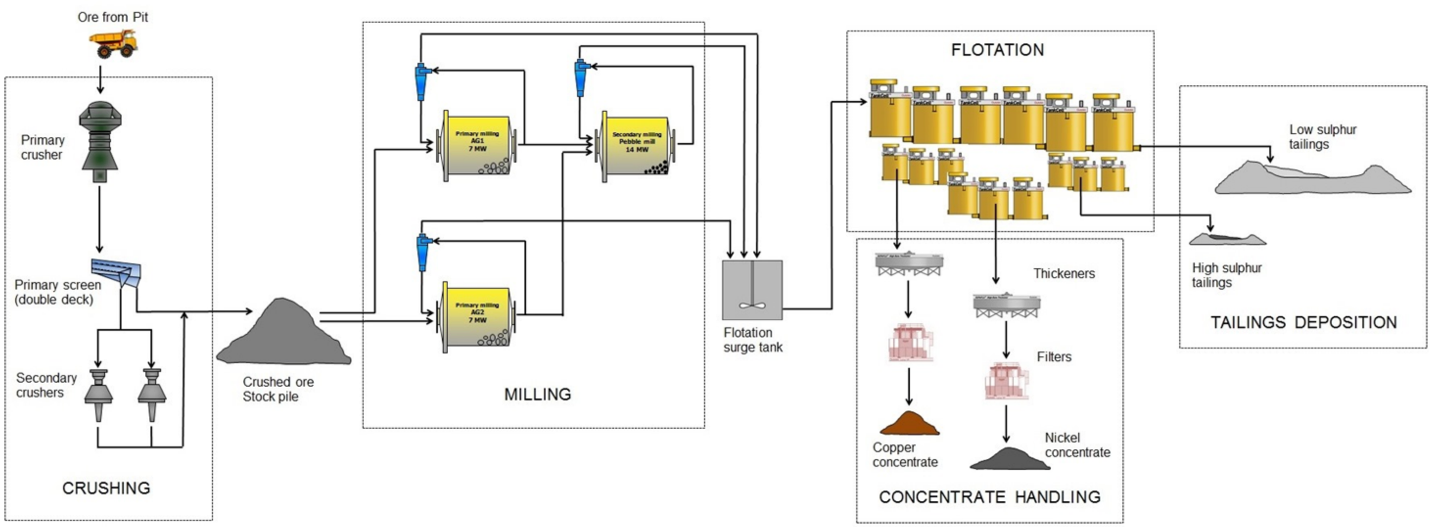
# Kevitsa

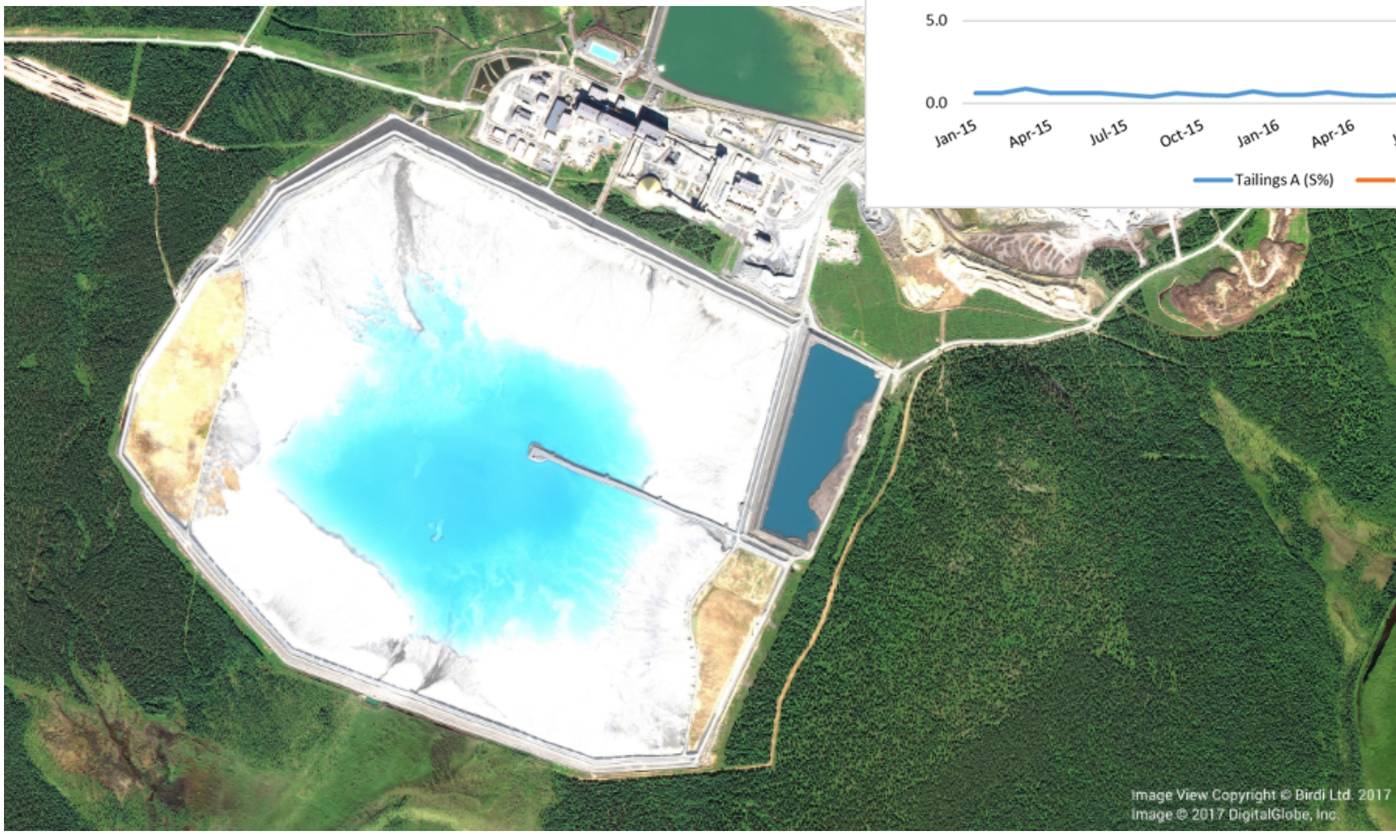


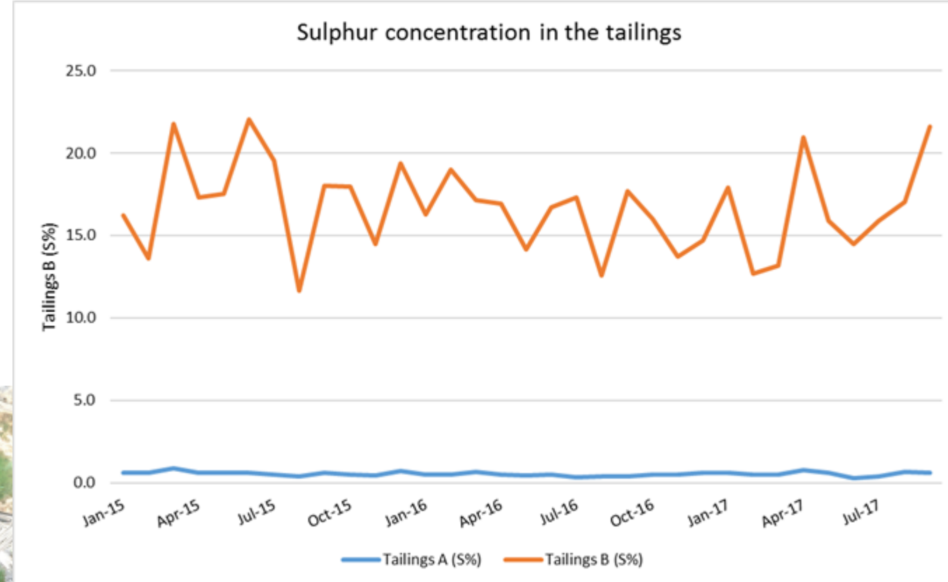
RAW WATER INTAKE
EFFLUENT OUTLET
WASTE ROCK AREA EXPANSION
WASTE ROCK AREA
MORAINE
WETLAND AREA
OPEN PIT
WATER RESERVOIR
PROCESS PLANT
NATURA
MORAINE
NOISE BARRIER
TAILINGS AREA A
TAILINGS AREA B
MINING LEASE AREA
0 0.25 0.5 1 Kilometers

# Kevitsa performance

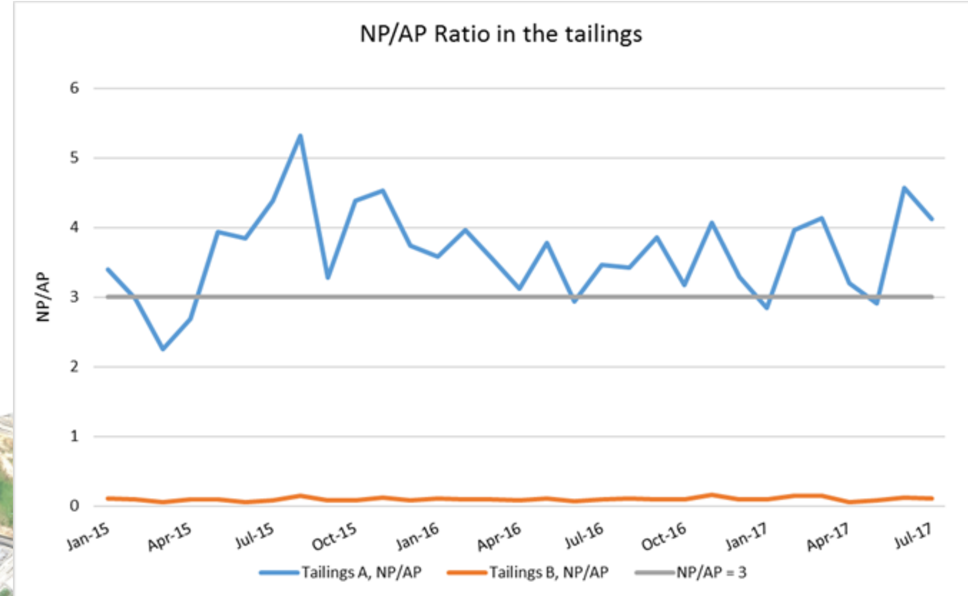


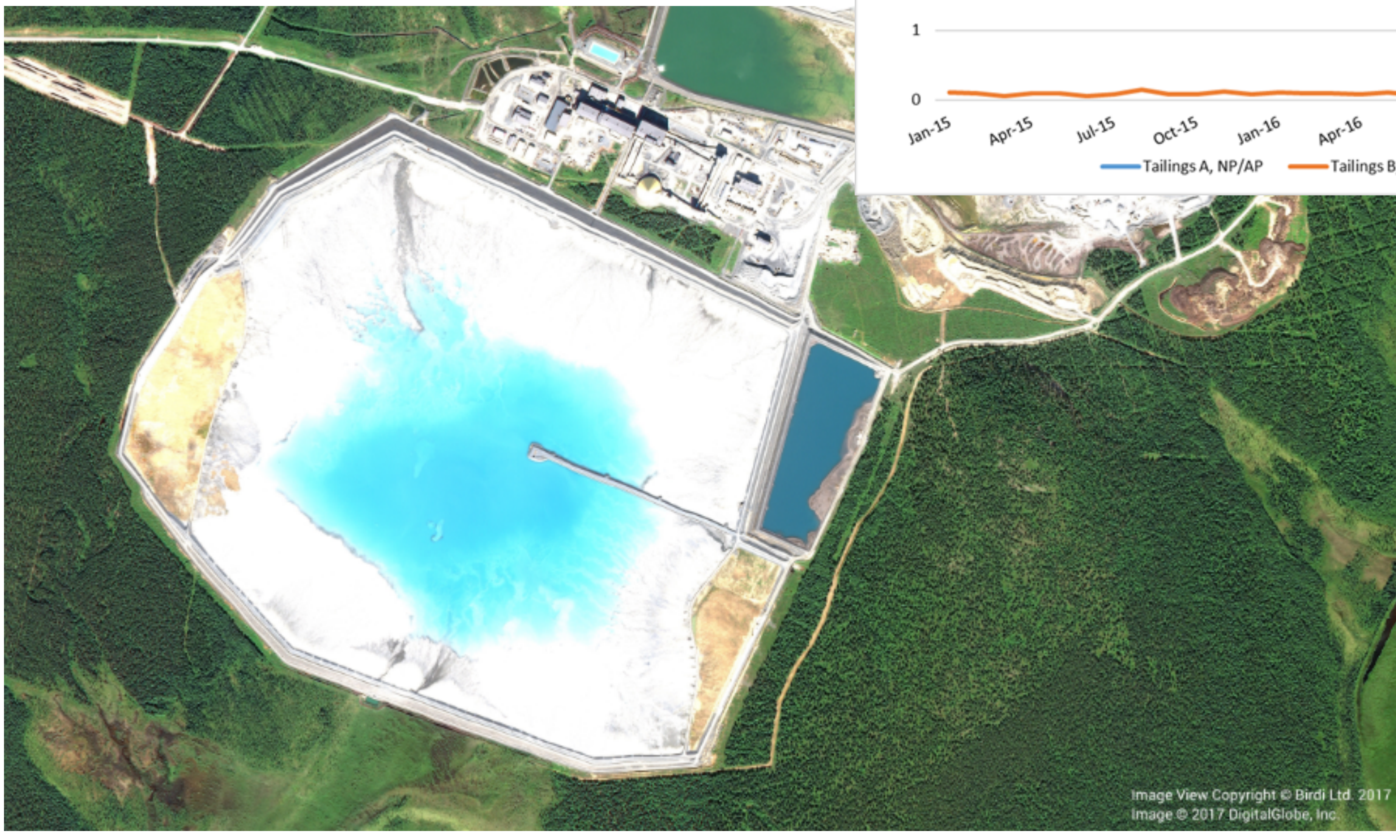
# Kevitsa performance



# Kevitsa performance

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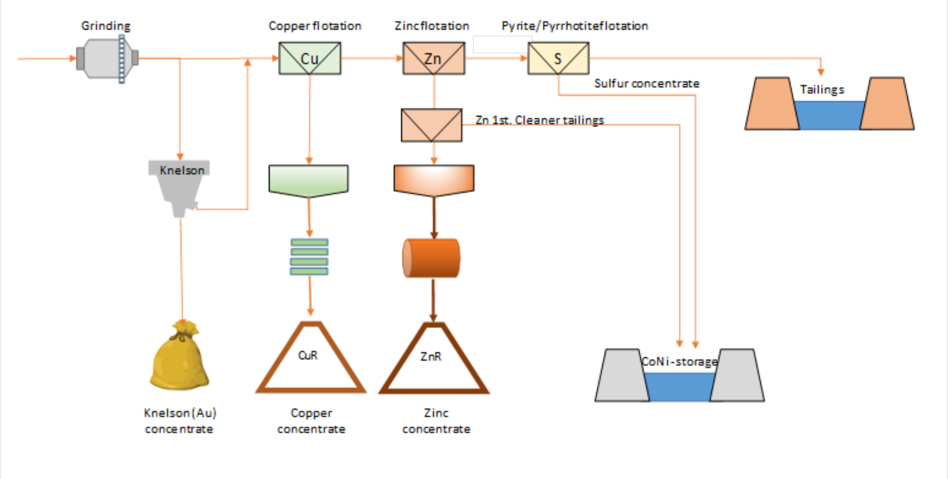
# KYLYLAHTI – Copper mine

- Finnish copper, gold, zinc and silver underground mine
- Exploration rights in the surrounding Outokumpu field
- Milled tonnage: 800 Ktonnes
- Number of employees 110

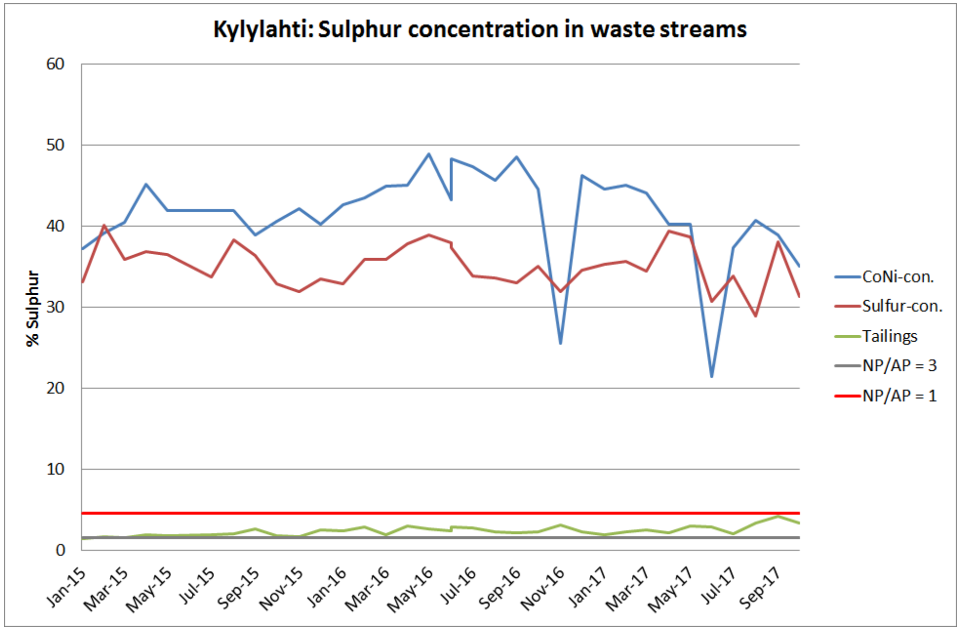
# Kylylahti

- General
  - Underground copper mine in eastern Finland. Luikonlahti concentrator.
  - Annual production 800 kton.
  - Cu, Zn and Au concentrates.
  - 470 kton tailings, 35 kton CoNi tails and 230 kton S-tails
- Objectives
  - To reduce S-concentration to acceptable level
  - To concentrate Co, Ni for future process
- Permit requirements
  - Tailings should not be significantly acid forming (not non-acid forming)
  - CoNi+S tailings to lined facility
- Closure
  - Dry cover
  - Closure Plan under revision

Schematic Process layout



# Kylylahti performance

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# AITIK –open-pit copper mine

- Swedish copper, gold, silver open pit mine
- Large-scale operations
- Milled tonnage: 39,000 Ktonnes
- Waste-rock to ore ratio: 1:1
- Number of employees 700

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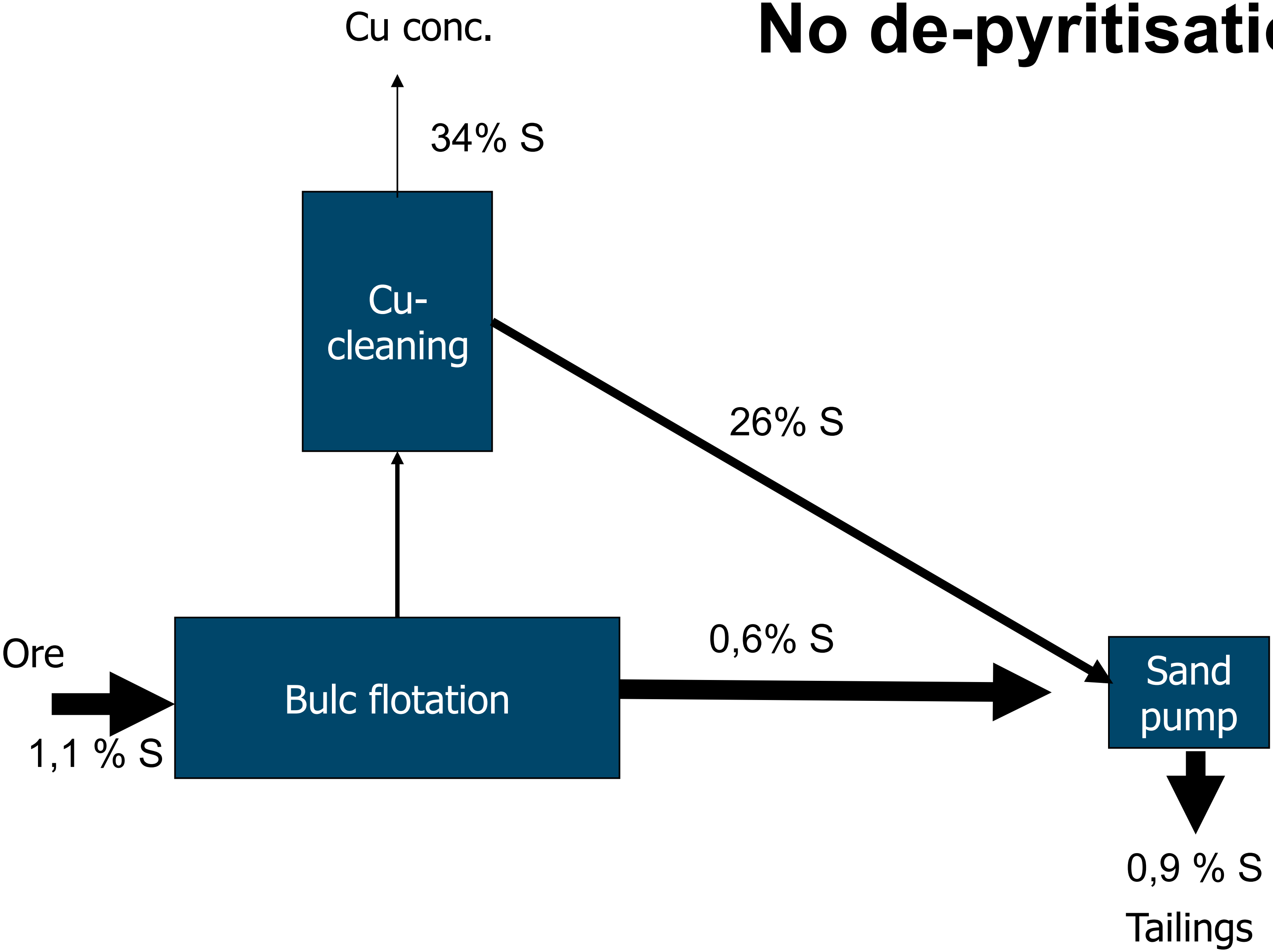
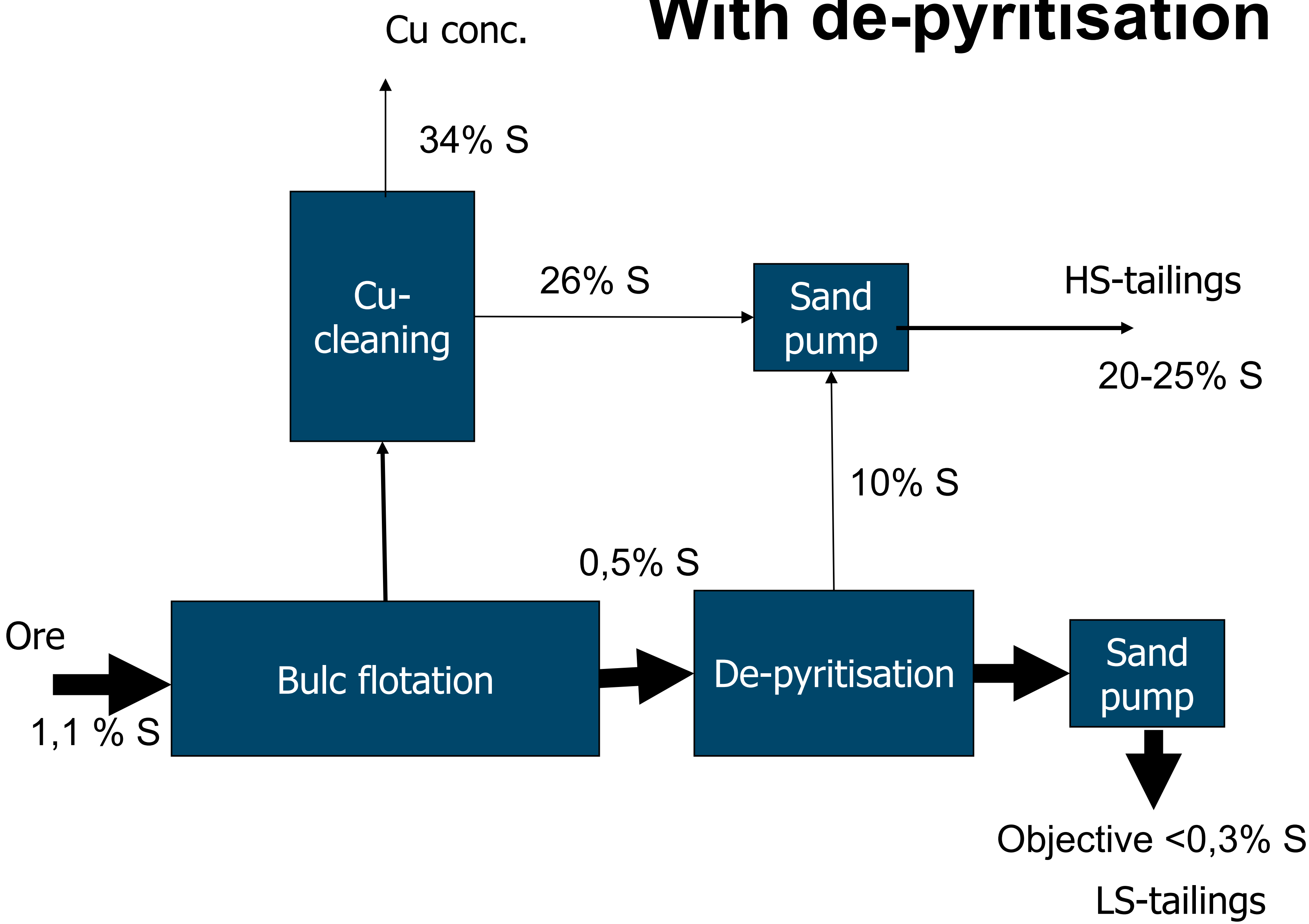
# Aitik

# No de-pyritisation



# With de-pyritisation

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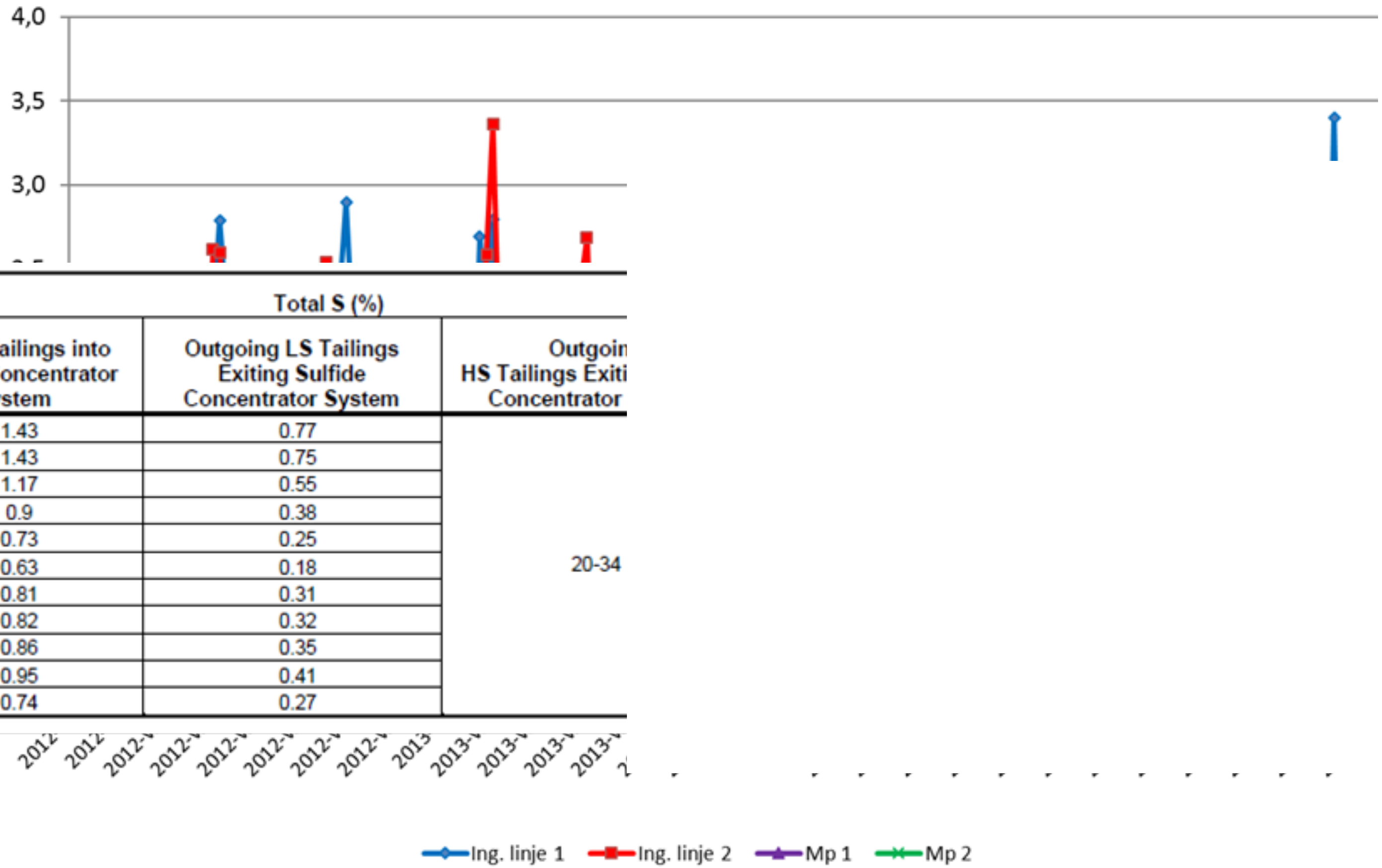
# Aitik performance

Sulphur content in ore and LS-tailings:
Weekly averages

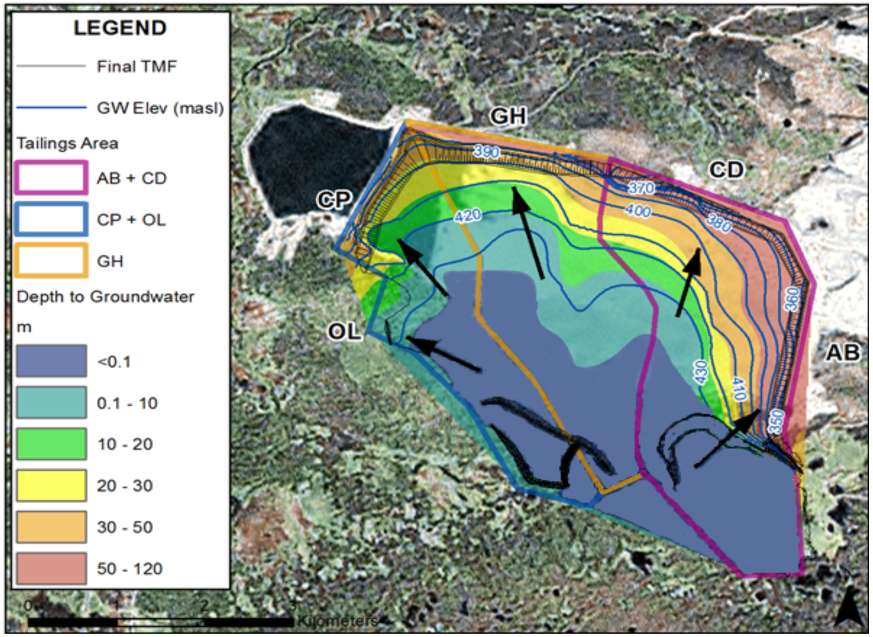



| Year* | Total S (%) | | |
| --- | --- | --- | --- |
| | Whole Tailings into Sulfide Concentrator System | Outgoing LS Tailings Exiting Sulfide Concentrator System | Outgoin HS Tailings Exiti Concentrator |
| 2015 | 1.43 | 0.77 | |
| 2016 | 1.43 | 0.75 | |
| 2017 | 1.17 | 0.55 | |
| 2018 | 0.9 | 0.38 | |
| 2019 | 0.73 | 0.25 | |
| 2020 | 0.63 | 0.18 | 20-34 |
| 2021 | 0.81 | 0.31 | |
| 2022 | 0.82 | 0.32 | |
| 2023 | 0.86 | 0.35 | |
| 2024 | 0.95 | 0.41 | |
| 2025 | 0.74 | 0.27 | |

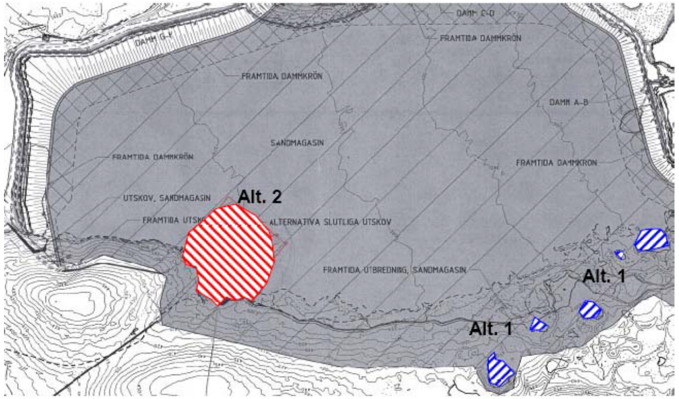
# Aitik – site evolution

Changing conditions over time:

- Dam construction methods
- Hydro-geology
- Potential thiosalt generation in HS-pond
- Permitting process




From: Hatch, 2015



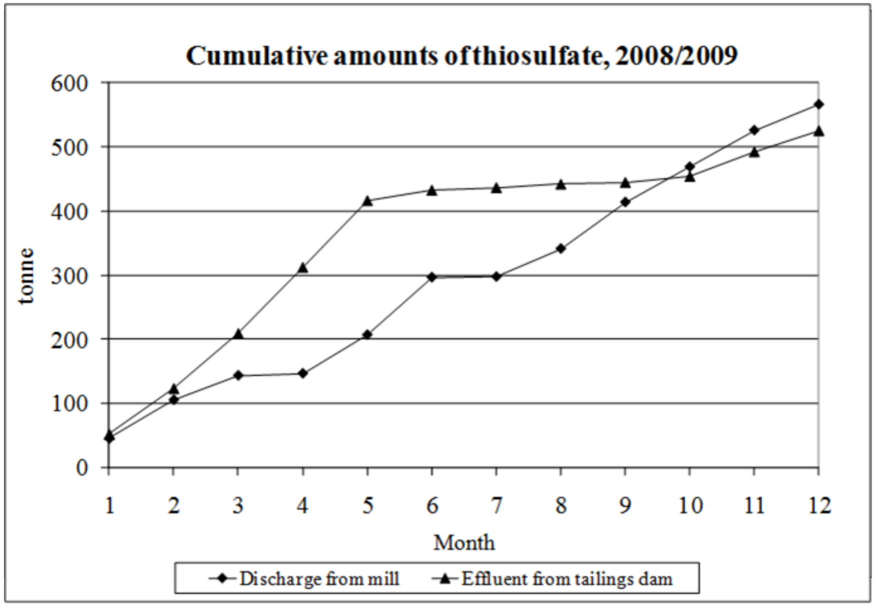

# Discussion

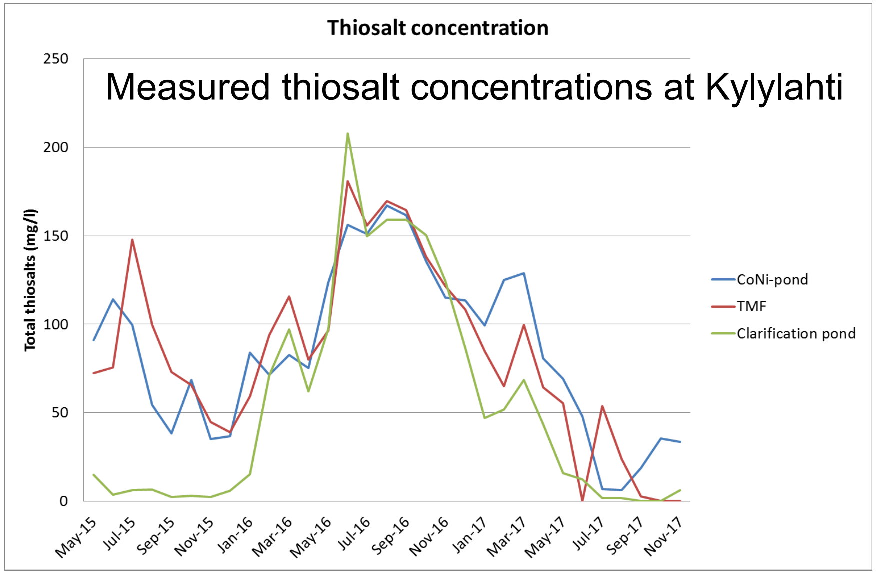
**Overall balance:**

- when and why de-pyritization may be worth while and for which reasons?

# Issues

- Varying performance due to incoming S-grades and production rates
- Objectives – how to evaluate them
- Segregation
- Potential thiosalt generation in high sulphur tailings at high pH
- Closure (both for LS and HS)
- Evolving site
- Evolving environmental requirements – non-ARD not enough
- Increased foot-print
- Re-processing opportunities/problems
- Costs

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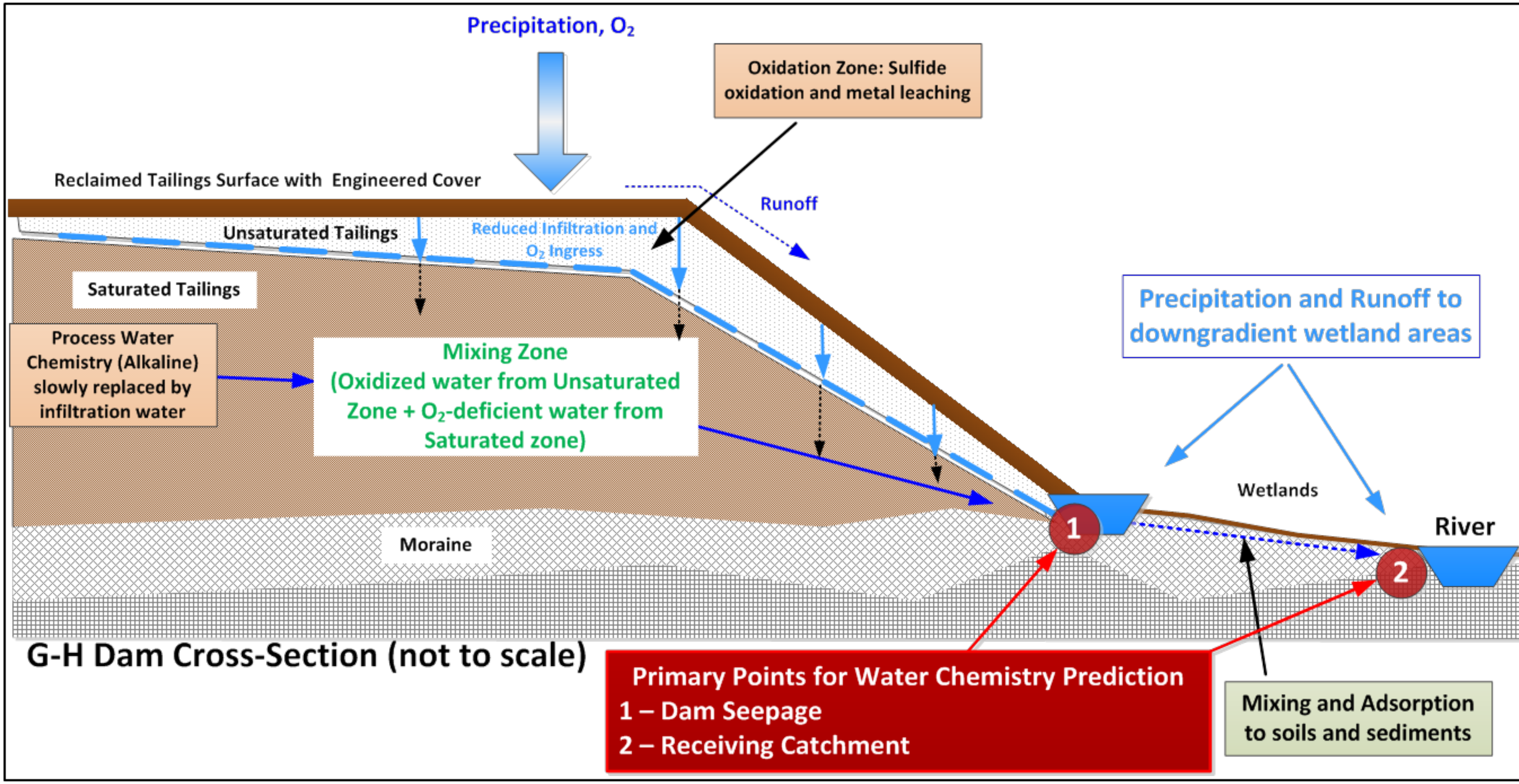
# Thank you!

# Aitik – site evolution




From: Hatch, 2015

# Thiosalts Generation

- **Disproportionation of sulphur by hydroxide ions; dominating in the tailings pond?**

By the action of alkalinity on elemental sulphur (eqs 1-2).

$$4\ S^0 + 4\ OH^- \rightarrow S_2O_3^{2-} + 2\ HS^- + H_2O \qquad (1)$$

$$4\ S^0 + 5\ OH^- \rightarrow SO_4^{2-} + 3\ HS^- + 4\ H_2O \qquad (2)$$

By the action of alkalinity on pyrite (eqs 3-4).

$$4\ FeS_2 + 4\ OH^- \rightarrow S_2O_3^{2-} + 2\ HS^- + H_2O + 4\ FeS \qquad (3)$$

$$4\ FeS_2 + 5\ OH^- \rightarrow SO_4^{2-} + 3\ HS^- + 4\ H_2O + 4\ FeS \qquad (4)$$

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