The science behind success

Modular Water Treatment

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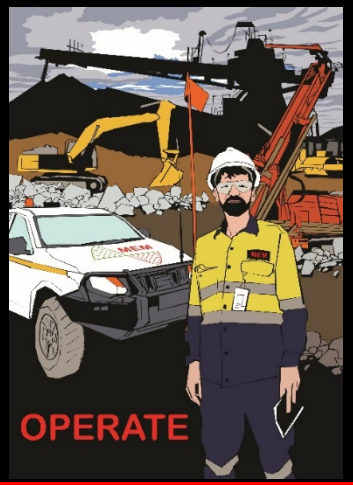


Modular water treatment

- Passive vs active treatment typical discussion points
- Passive treatment
  - Not really passive, need maintenance
  - Viewed as “research project” in many cases i.e. not proven
  - Not standardised
- Active treatment
  - Typically based on large fixed plant approach for industrial or process water treatment
  - Large capital investment
  - Use “proven” technology
  - Not designed for AMD, rather used for AMD
- **Not passive vs active rather sustainable vs not sustainable**

AMD treatment challenges

- No one hit solution as variety of treatment issues
  - High suspended solid content, clogging and passivation impacts
  - High acidity levels, requires neutralisation but this produces sludge and increases suspended solids
  - High metals content, metals soluble at various pH range and REDOX conditions, difficult to remove all in one go
  - Non metal species such as sulfate and ammonia difficult to remove
- Site conditions change
  - Flow rates and concentrations change month to month, during project development
- Location of treatment
  - Often treatment completed in one location, but may not be optimal
  - Multiple sources contribute different issues, metals from one location TSS from another

Modular approach

- Standardised components (off the shelf technology)
- Compatible fittings and flow rates matched between components
- Fitted into shipping containers
- Can be combined in any combination
- System configuration adaptable i.e. can be run in parallel (higher flow) series (higher concentration)
- Automated control systems
- Combine passive and active components

Sonico reactor

Soneco DB Reactor Tank

- Ultra compact electrochemical + ultrasonic treatment unit
- Control pH and removes metals, sulfate, phosphorous, ammonia
- Only input is power: can be run of solar, batteries, hydro, generator

Mobile skid design

Soneco – Stage 2 Design

Power & Water

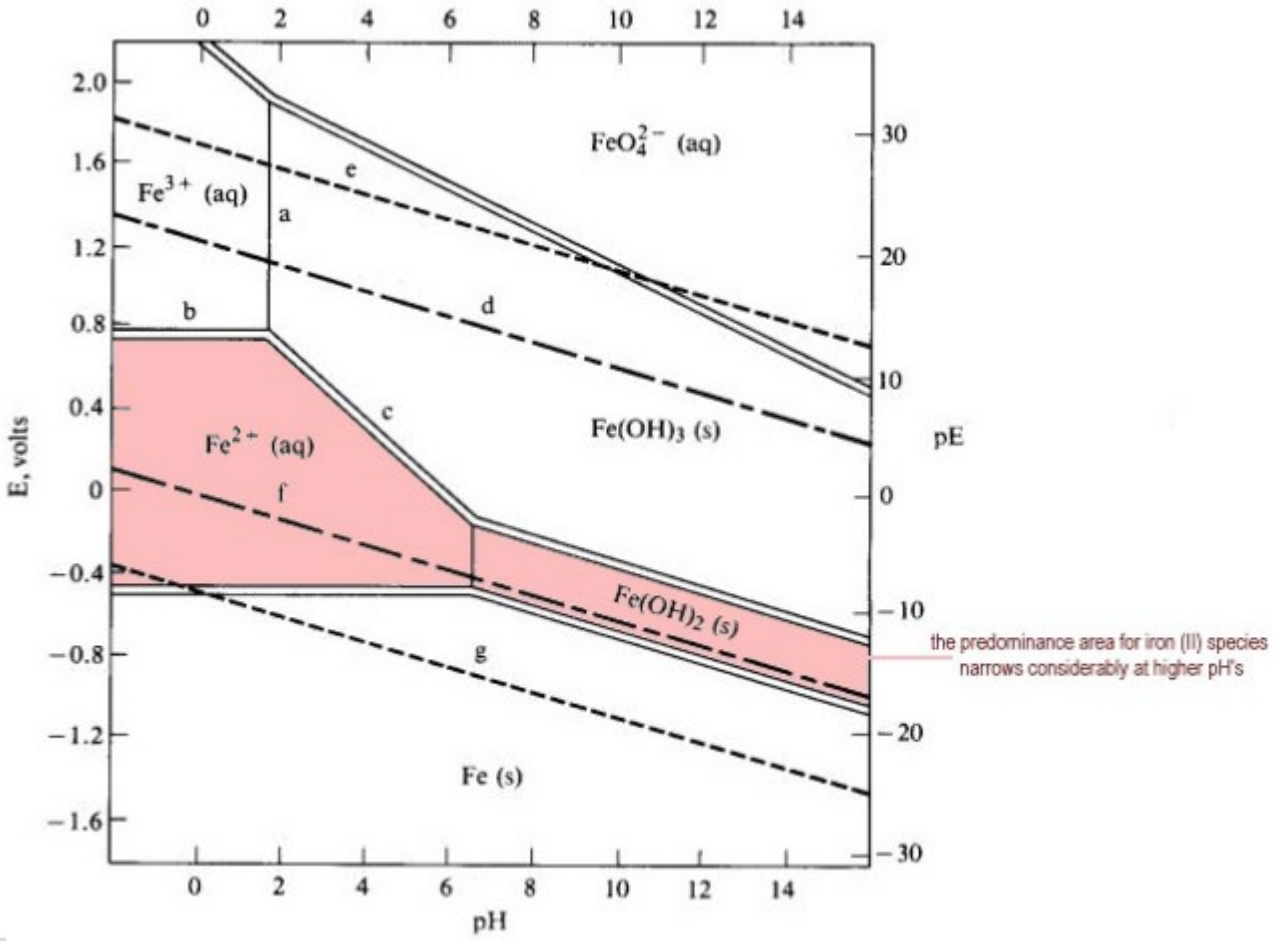
Clarifier Tank
(sludge pump not shown)

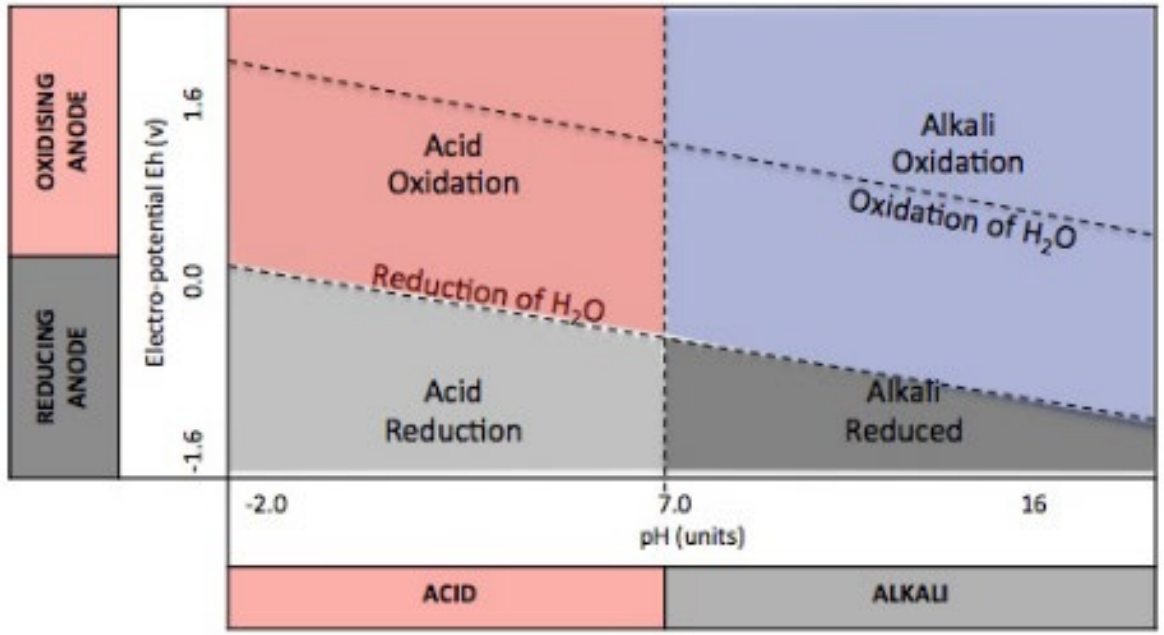
Flocculator Tank
(VSD stirrers not shown)

Soneco Reactor Tank

Power need:
0.5kw/m3

How it works


0 2 4 6 8 10 12 14
2.0
1.6
1.2
0.8
0.4
0
−0.4
−0.8
−1.2
−1.6
E, volts
FeO_4^{2-} (aq)
Fe^{3+} (aq)
a
e
b
d
c
Fe^{2+} (aq)
f
$Fe(OH)_3$ (s)
$Fe(OH)_2$ (s)
g
Fe (s)
30
20
10
0
−10
−20
−30
pE
0 2 4 6 8 10 12 14
pH
the predominance area for iron (II) species
narrows considerably at higher pH's


OXIDISING ANODE
REDUCING ANODE
Electro-potential Eh (v)
1.6
0.0
-1.6
Acid
Oxidation
Alkali
Oxidation
Oxidation of H_2O
Reduction of H_2O
Acid
Reduction
Alkali
Reduced
-2.0
7.0
16
pH (units)
ACID
ALKALI

Treatment process

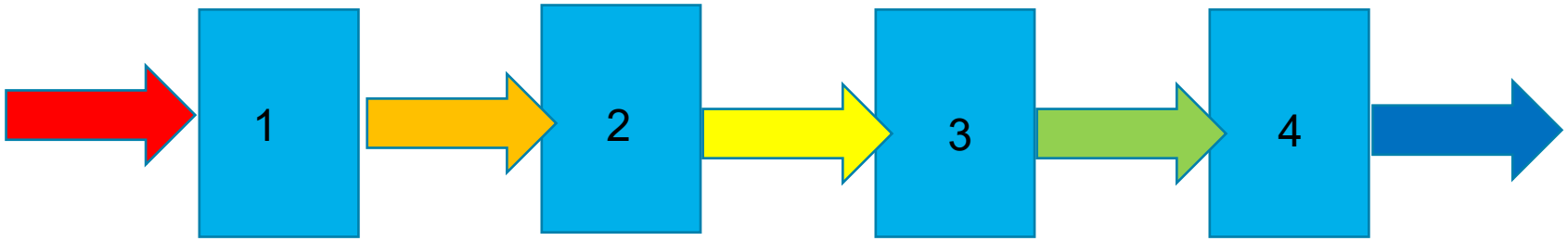
- If mine water is aerated (EH > 0.0) and pH corrected to < pH 6.5 iron will precipitate as insoluble orange/brown ferric hydroxide [Fe(OH)3].
- Under an oxygen reduced state (EH < 0.0) the iron will precipitate as green ferrous hydroxide [Fe(OH)2].
- Similar reactions can be achieved within an electrochemical treatment process by selecting appropriate electrode materials and applying a voltage across the anode and cathode electrodes to control current density (Amps/Electrode area [Am-2])
- By employing a voltage to an alkaline earth metal anode in water, the water becomes reduced and alkaline due to the formation of the hydroxide Mg(OH)2.
  - Mg2+ (anode) + 2OH- (cathode) = Mg(OH)2

Treatment process

- Once magnesium hydroxide is generated it operates by the principal of ion exchange, where a magnesium ion (Mg2+) exchanges with a metal ion (M2+) as shown by the following equation:
  - Mg(OH)2 (adsorbent) + M2+ (aq.) = M(OH)2 (adsorbent) + Mg2+
- The magnesium ions (Mg2+) may further react with sulphate ions (SO42-) to produce insoluble magnesium sulphate.
  - Mg2+ + SO42- = MgSO4
- **Electro-generate magnesium hydroxide in-situ: more efficient than adding it as a chemical**
- Overcome passivation: using power ultrasound simultaneously with electrolysis removes the ionic boundary and passivation layers

Modular treatment train

20-50m3/hr
5,000 mg.l SO4
100 mg/l cu
20g/l TSS



Aeration
Filtration

Removes
TSS, iron

VFR/SRB

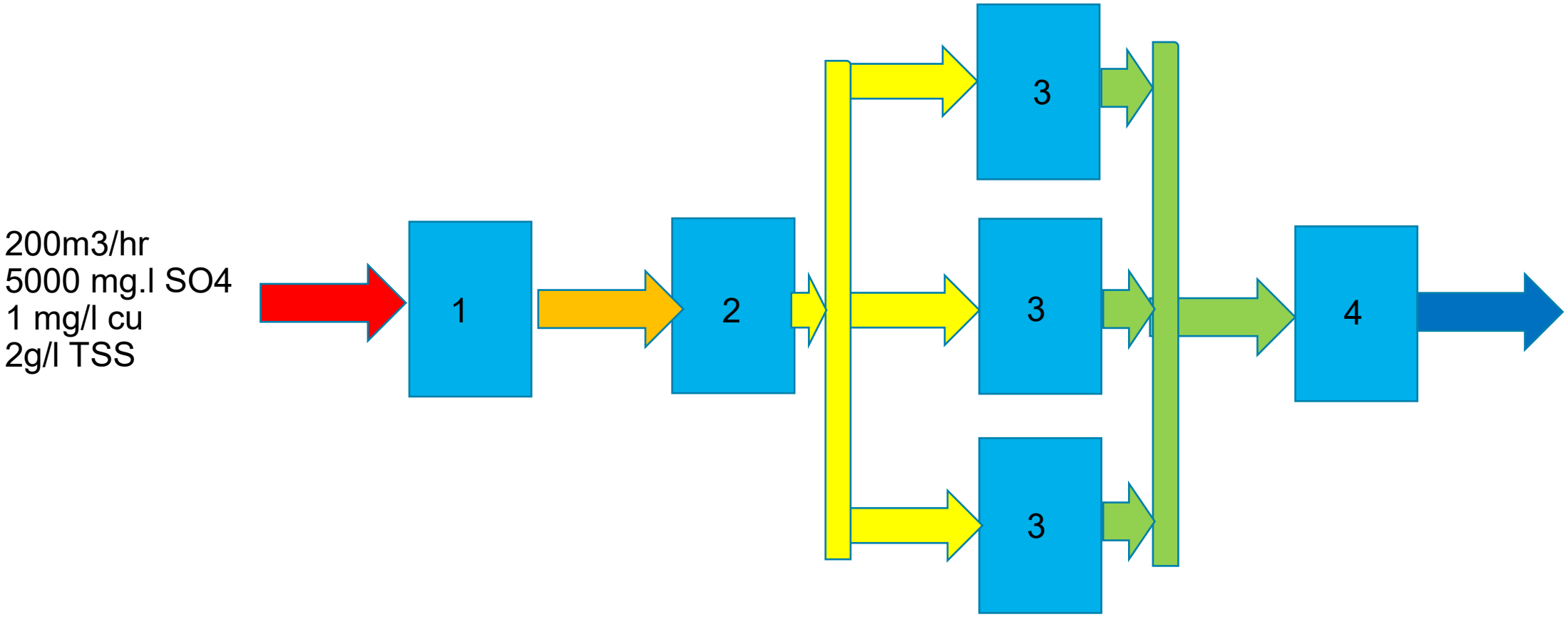
Removes iron,
some metals

Sonico

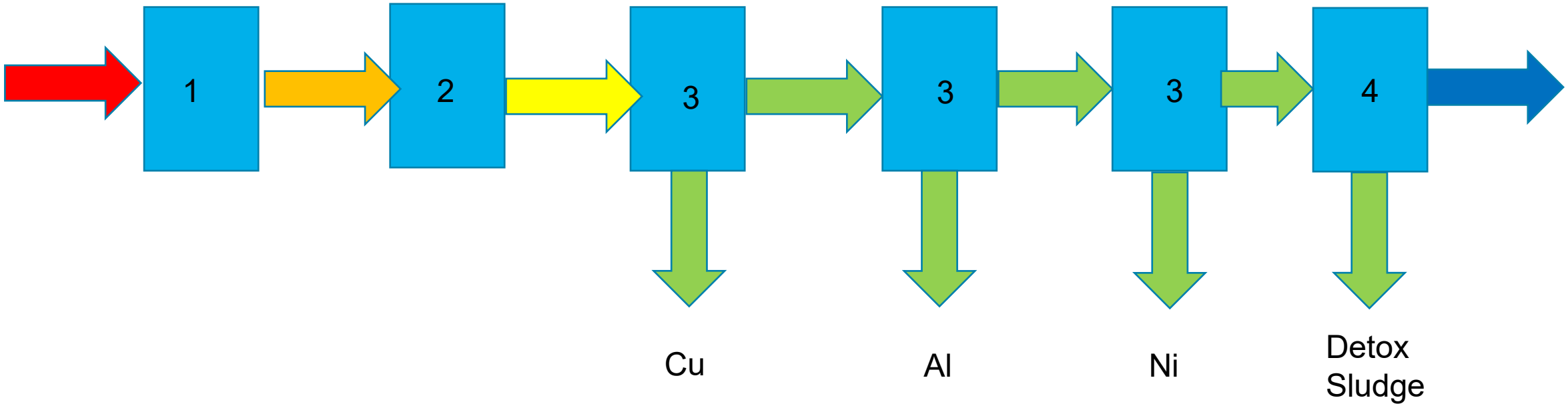
Removes
everything
else

Sludge
treatment

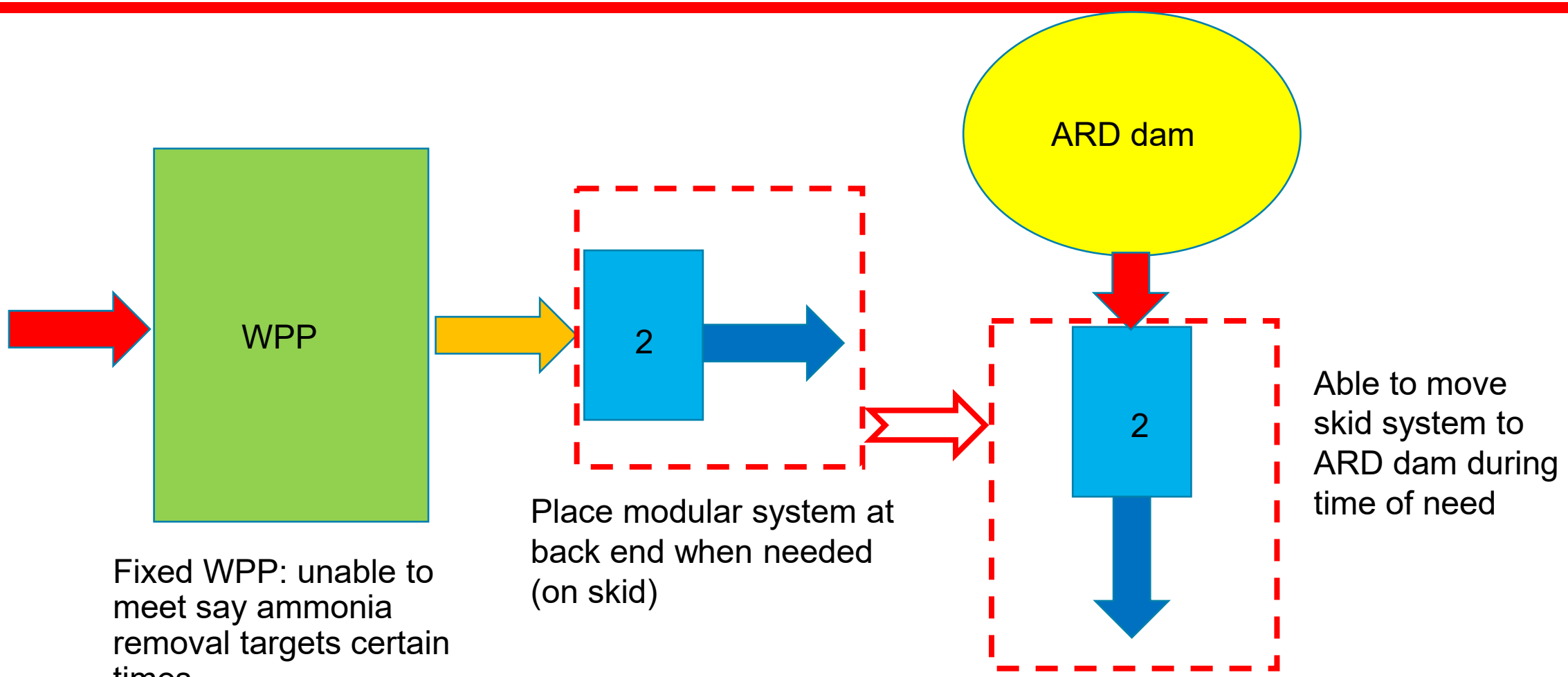
Parallel system to cope with variable flow raes



Series system to remove metals on targeted basis, or reduce toxicity of sludge



Assist other systems and move around site to meet demand



Treatment proven

Soneco – Performance & Results

Power & Water

Average Power - 4m³/hr @ 5Kw = 1.25Kw/m³ treated water

1. Raw Water 2. Precipitate 3. Treated Water

Contaminant	Untreated	Treated	% Removal
pH	3.82	6.55	-
Cadmium	35.88	0.193	99.46
Zinc	17,080	15.85	99.90
Lead	499.2	2	99.59
Iron	7,978	40.2	99.48
Magnesium	11.45	29.32	-154.82

NRW Filtered Results (average)

Average Sludge Concentrations = 5-10% of treated water

Advantages

- Controlled: treatment can be varied depending on the incoming loads
- Scalable: can be scaled up by using parallel reactors
- Targeted: can target specific metal/species
- Mobile: can be moved around a site
- No chemicals: transport, spillage and handling risks avoided
- Automated: web based system
- Sustainable: power is the only input
- Small footprint area: no fixed infrastructure required

Thank you

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