

# Mobile processing plant to reinvigorate small capital gold mining

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MetFest 2017

MINERAL RESOURCES  
[www.csiro.au](http://www.csiro.au)



# Outline

1. CSIRO overview
2. Thiosulfate as an alternative to cyanide
3. Mobile low capex gold processing demonstration project

# Who we are

People ~5000

Sites 55

Business Units 9


Budget \$1B+

We develop ~750 postgraduate research students with our university partners










# World-class facilities and connections






The map shows Australia with several circular icons placed across its geographical regions. In the southwest, there are icons for a radio telescope, a computer monitor, and crossed hammers. In the southeast, there are icons for a forklift, a medical cross, a leaf, and a ship. In the south, there is an icon for a leaf. In the east, there is an icon for a beaker. Dashed lines indicate state boundaries.

## GLOBAL PRECINCTS

-  **NATURAL & ENVIRONMENTAL SCIENCES**  
CANBERRA | ACT
-  **NATIONAL RESOURCE SCIENCES PRECINCT**  
PERTH | WA
-  **ECOSCIENCES**  
BRISBANE | QLD
-  **HUMAN LIFE SCIENCES**  
PARKVILLE | VIC
-  **MANUFACTURING & MATERIALS INNOVATION PRECINCT**  
CLAYTON | VIC

## MAJOR INFRASTRUCTURE

-  **MARINE RESEARCH VESSEL**  
HOBART | TAS
-  **ASKAP RADIO TELESCOPE**  
MURCHISON | WA
-  **THE PAWSEY SUPERCOMPUTING CENTRE**  
PERTH | WA

# Mineral Resources

## CSIRO's R&D in the minerals domain:

- Budget ~\$70m pa (~\$30m pa external sources)
- Involves about 250 scientists and engineers
- 12 sites located in 5 states;
- Collaboration with >50 universities and other institutions, nationally and internationally;
- Engagement with >300 companies across the value chain; and
- Based on a technology vision for where the sector is going.



# Mineral Resources - Our purpose...



## Growing Australia's Resource base

How do we find it ?

How do we process it ?



## Improving productivity

Improve unit operations (brownfield)

Design of new process options



## Driving environmental performance

Low energy processing

Reduce C footprint in metal production

AMD, tailings & rehabilitation



## Resources supporting society

Community attitudes and buy-in

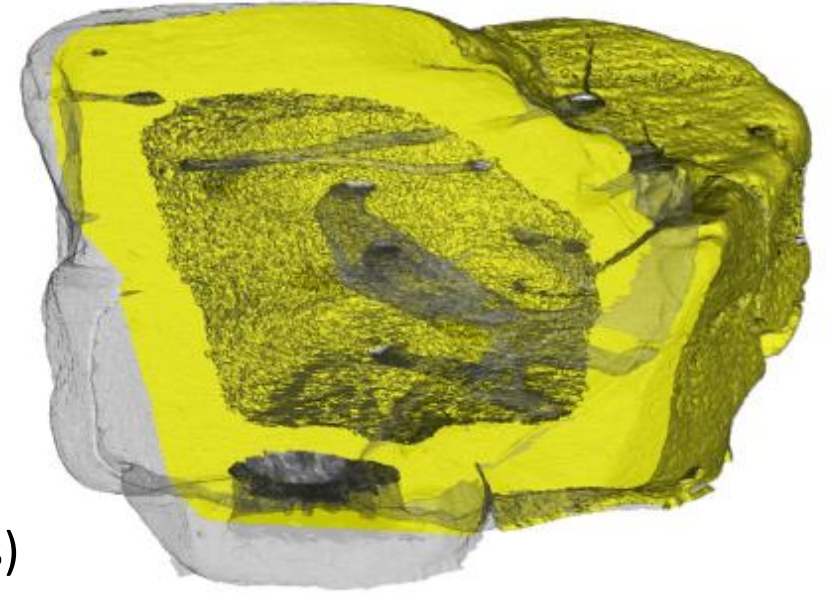
# Gold Processing Technologies

## Cyanidation

- Cyanide speciation analysis and management
- Complex ores – characterisation and leaching
- Carbon management
- Cyanide destruction evaluations (Caro's acid, Inco & H<sub>2</sub>O<sub>2</sub>)
- Cyanide recovery & recycle (SART and IX resin/carbon based processes)
- Trace element department (eg. mercury)

## Thiosulfate based process development

- Alternative to cyanide
- New market opportunities



Micro CT scan of gold loaded activated carbon particle



# Thiosulfate processes for gold recovery

# Thiosulfate based leach systems

Many different thiosulfate based systems

Often classified by oxidant:

- Copper-ammonia
- Oxygen (+ copper)
- Other metal complexes
  - Metals such as copper, iron and nickel
  - Ligands such as organic amines, oxalate

Catalysts/additives

- Thallium and lead
- Thiourea
- sulfite

**Thiosulfate  
consumption typically  
proportional to  
gold leach rate**

# Application developments

## Barrick Goldstrike

- Calcium thiosulfate + copper
- Process development and on-site demonstration
- Commercial implementation in 2014

## Gravity concentrates

- Copper-ammonia system able to achieve acceptable leach rates
- Developed to the pilot plant stage

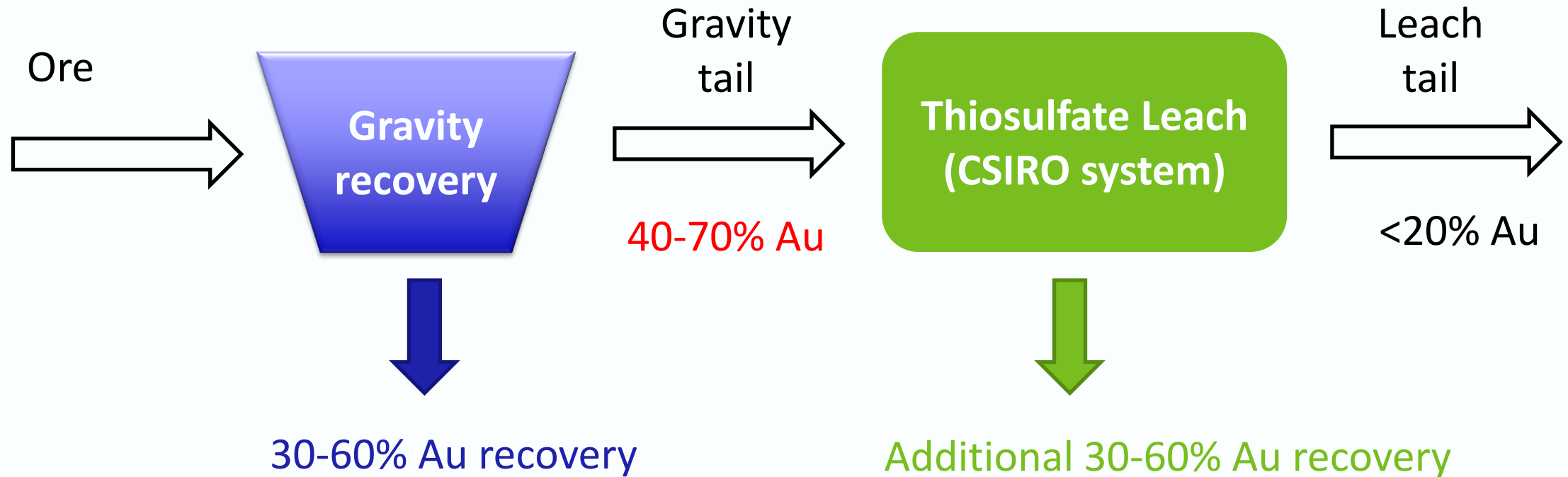
## In-situ (the future)

- Laboratory column evaluations conducted for specific deposits / companies
- Field trials under consideration



Barrick Gold's thiosulfate demonstration plant at the Goldstrike

# Additional gold recovery (small gold miners)



## Combined process benefits

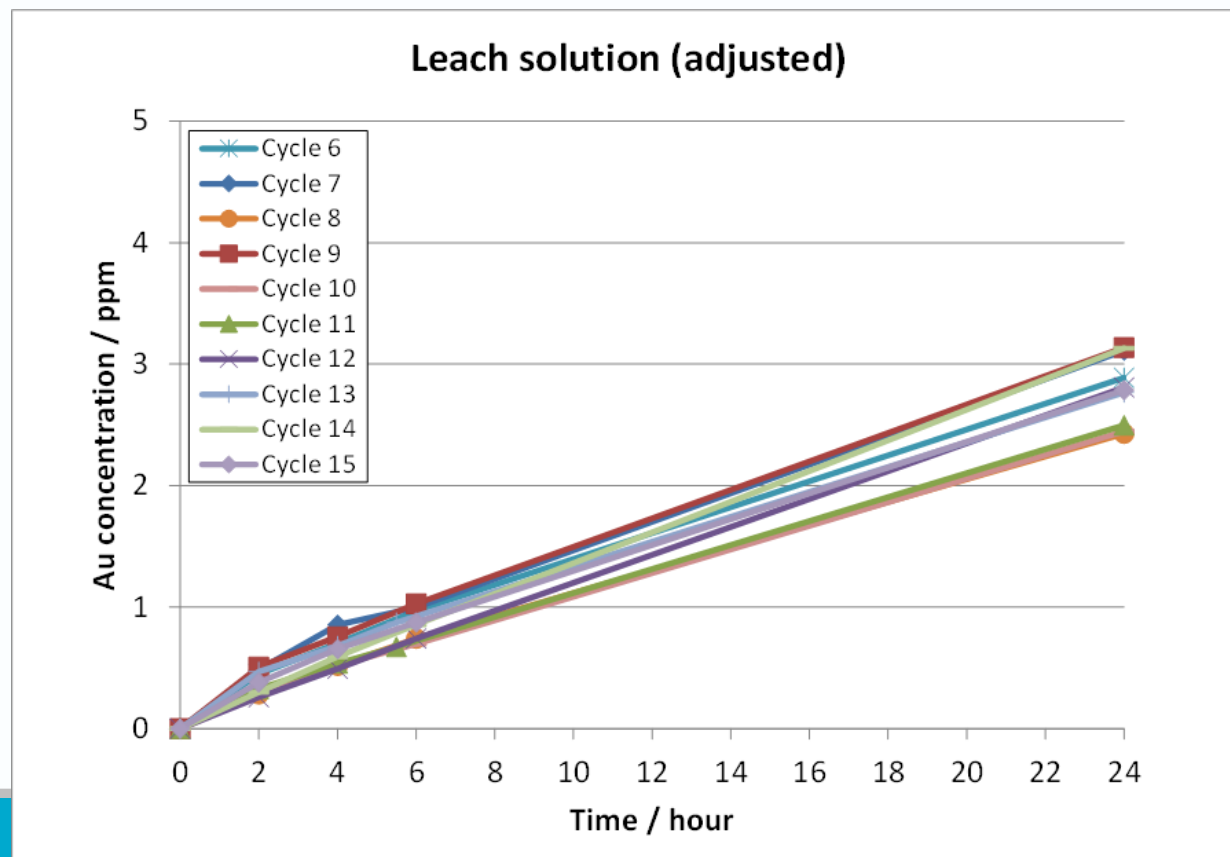
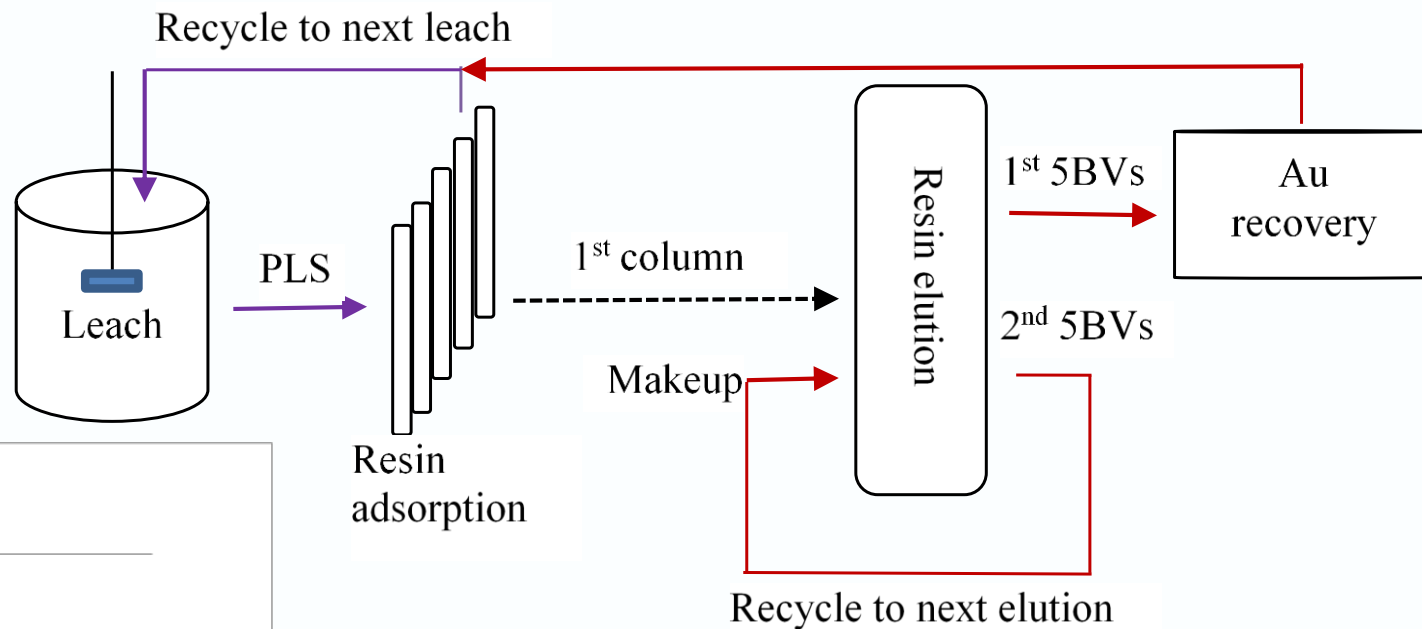
- High and predictable overall gold recovery
- Gold recovery risk lower – robust leach process captures gold not recovered by gravity
- Gravity recovery doesn't have to chase the fine gold – optimise for recovery of the coarse gold

# Performance of CSIRO product (thiosulfate system)

Sample	Description	Size ( $\mu\text{m}$ )	Head grade ( $\text{g t}^{-1}$ )	NaCN leach recovery	CSIRO product leach recovery	Thiosulfate consumption ( $\text{kg t}^{-1}$ )
A	Low sulfide ore	P <sub>90</sub> - 74	0.9	90% @ 24 hrs	90% @ 24 hrs	2.2
B	Carbonaceous ore; gold partially encapsulated	P <sub>80</sub> - 75	1.9	51% @ 24 hrs	70% @ 24 hrs	1.6
C	Aged sulfide ore gravity tails	< 2000	1.2	73% @ 24 hrs	67% @ 24 hrs	1.1
D	Oxide ore	< 10000	1.4	59% @ 24 hrs	56% @ 2 days	1.5
E	Oxide ore gravity tails	< 1000	2.1	80% (intensive cyanidation with LeachWell)	76% @ 7 days	< 0.2
F	Oxide ore; potential ISR candidate	< 4000	~5	38% @ 24 hrs; 81% @ 7 days	79% @ 2 days	1.3

# Cyclic testing

- Batch leaching of gold RDE
- Tetrathionate added to mimic ore leaching

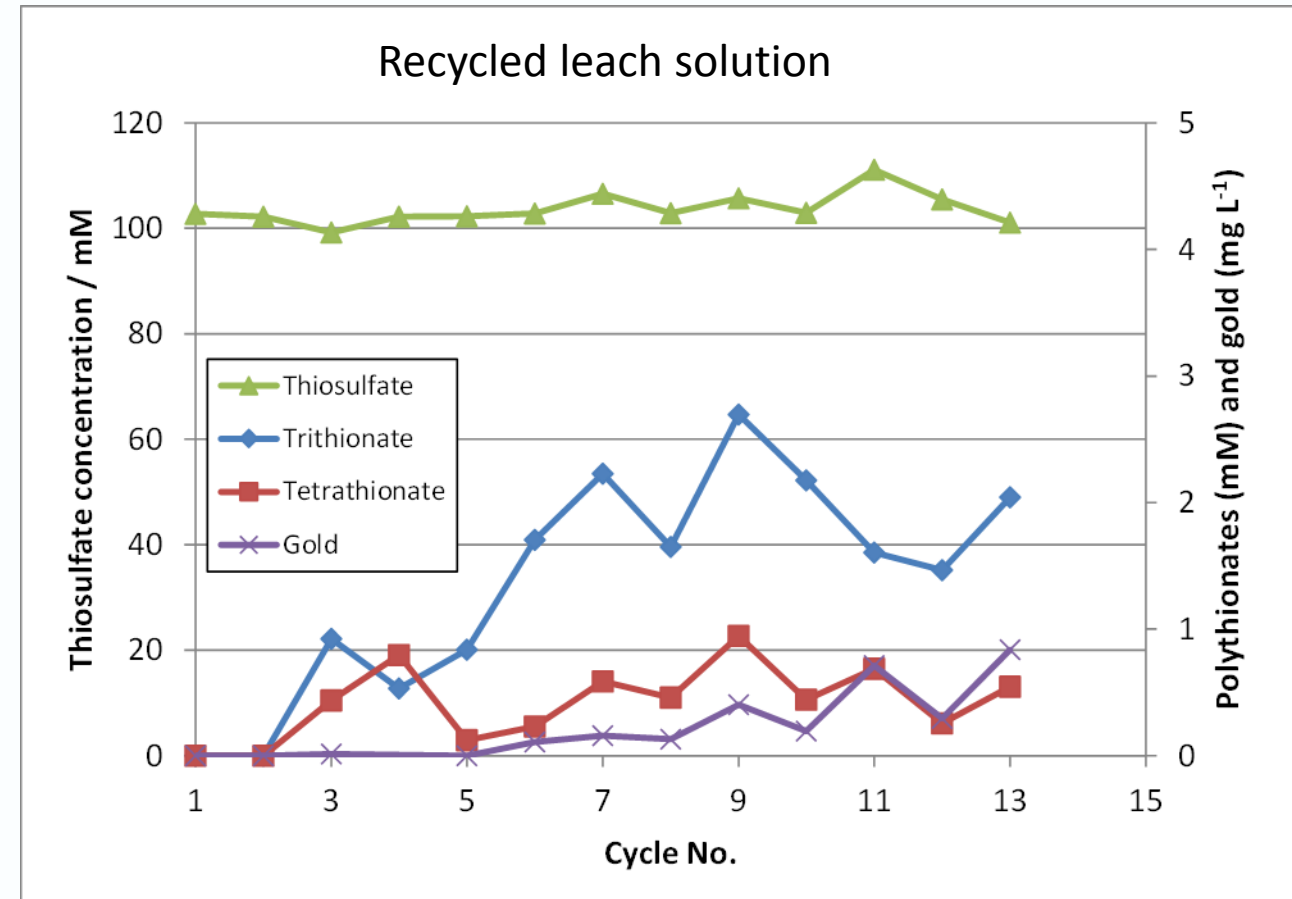
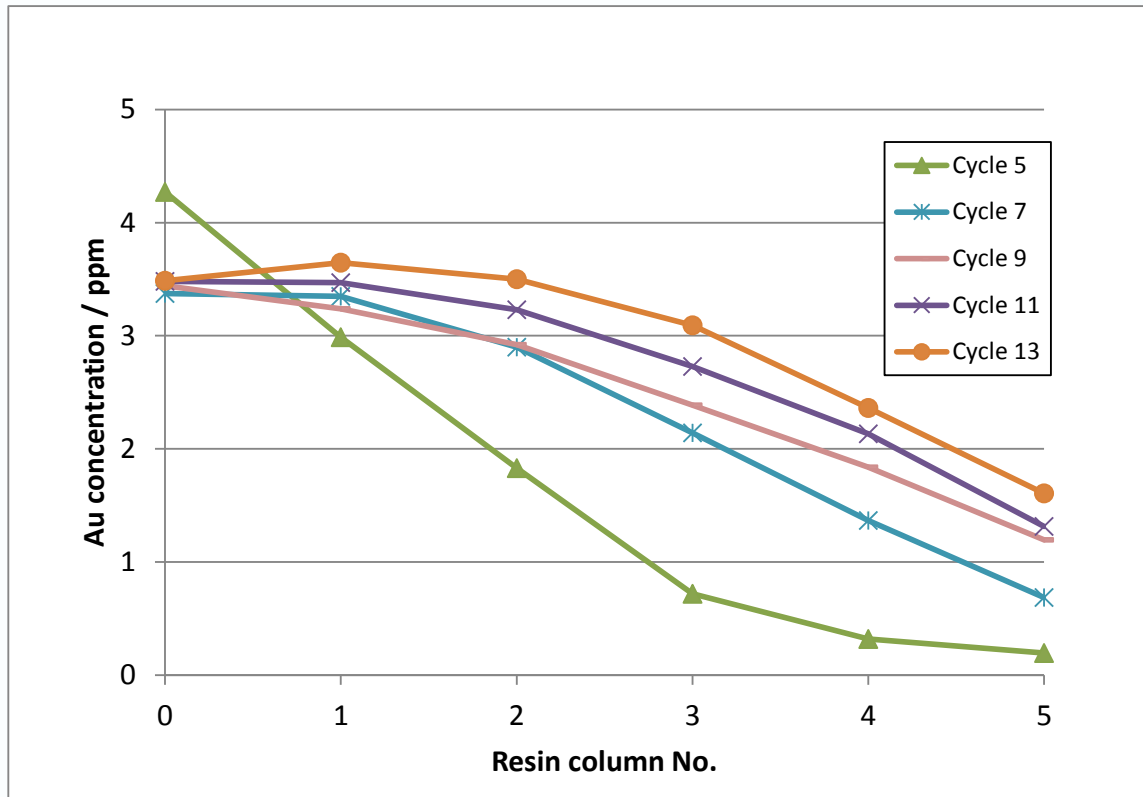


Resin columns cycled after every 2 batch leaches

# Cyclic testing

## Gold breakthrough

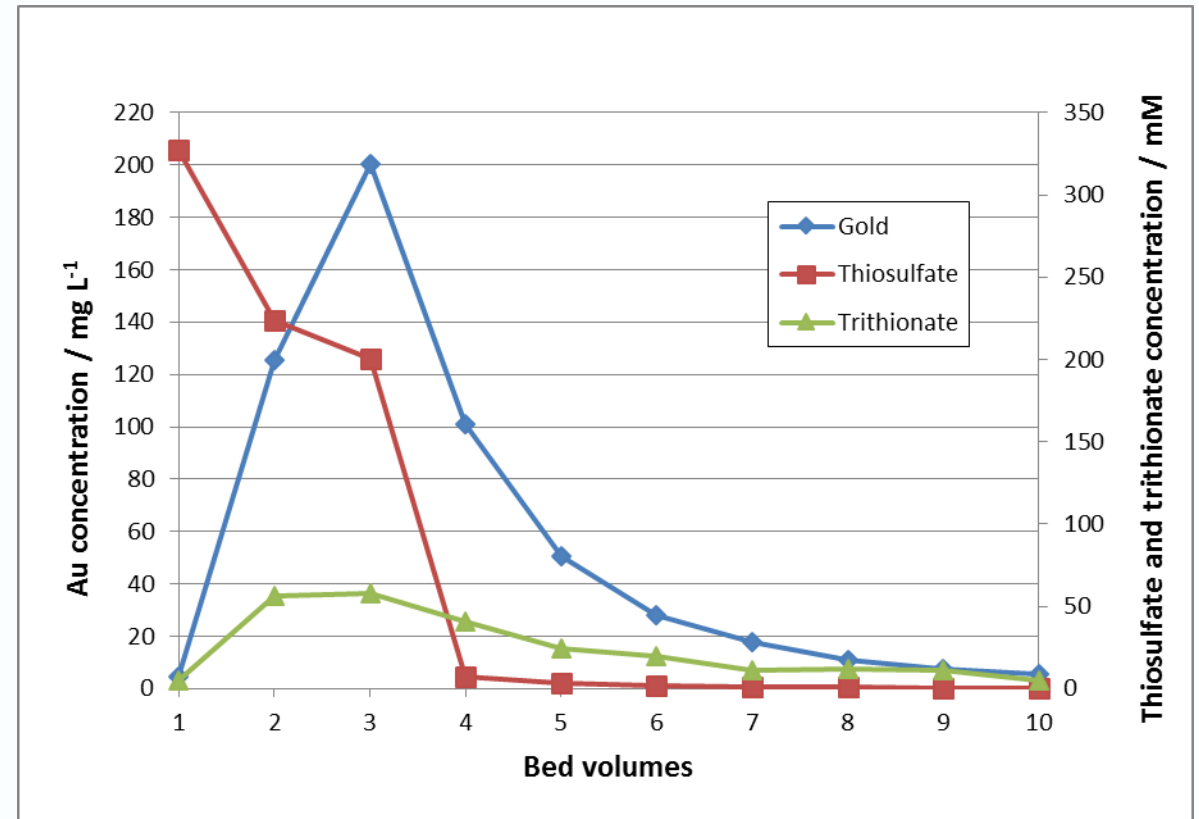
- Required resin columns to be cycled faster



# Cyclic testing

## Resin elution

- Sharp gold elution profile
- > 99% Au recovery
- Tetrathionate converted to trithionate



Sample	Au		Thiosulfate (mM)	Trithionate (mM)	Tetrathionate (mM)	Pentathionate (mM)
	(g t <sup>-1</sup> )	Efficiency (%)				
Preg. resin	3186	99.81	62	142	229	111
Barren resin	6		2	101	0	0



# Hurdles in adoption of new lixiviants for gold recovery

## Proof at scale a process can economically recover gold

- Leaching and gold recovery R&D conducted but limited process development
- Reagents require recovery and recycle due to the concentrations used
  - More complex / undeveloped circuits
- Risks with scaling laboratory / pilot plant data

## Process is practical and robust

- Low impact (economic and physical), including operability of the process and resources
- Able to cope with typical ore variability
- Applicable to a range of ores

# Addressing the challenges

## Research facility in the field

- End user / operator involvement to ensure the technology is practical and robust
- Pilot / demonstration information attained in conjunction with development at scale

## Process development

- Vat leach with cyclone to remove fines
- Tank leach with thickener / filter as parallel circuit to treat fines
- Nano-filtration to aid reagent recovery and minimise water use
  - Evaporation will be adopted initially to maintain the water balance
- Plug and play modules allowing testing and development of alternative flowsheets

# Mobile low capex gold processing demonstration at Menzies



# Key Project Collaborator – Nu-Fortune Gold

## Menzies stamp battery site

- Existing mill and gravity plant operating at 200 t/d
- Existing infrastructure
- Central location at Menzies
- Site leased from the Perth Mint
- No hurdles with approvals

## Nu-Fortune Gold

- Shared vision and Entrepreneurs
- Experience in mineral processing



# Demonstration Plant

## Process

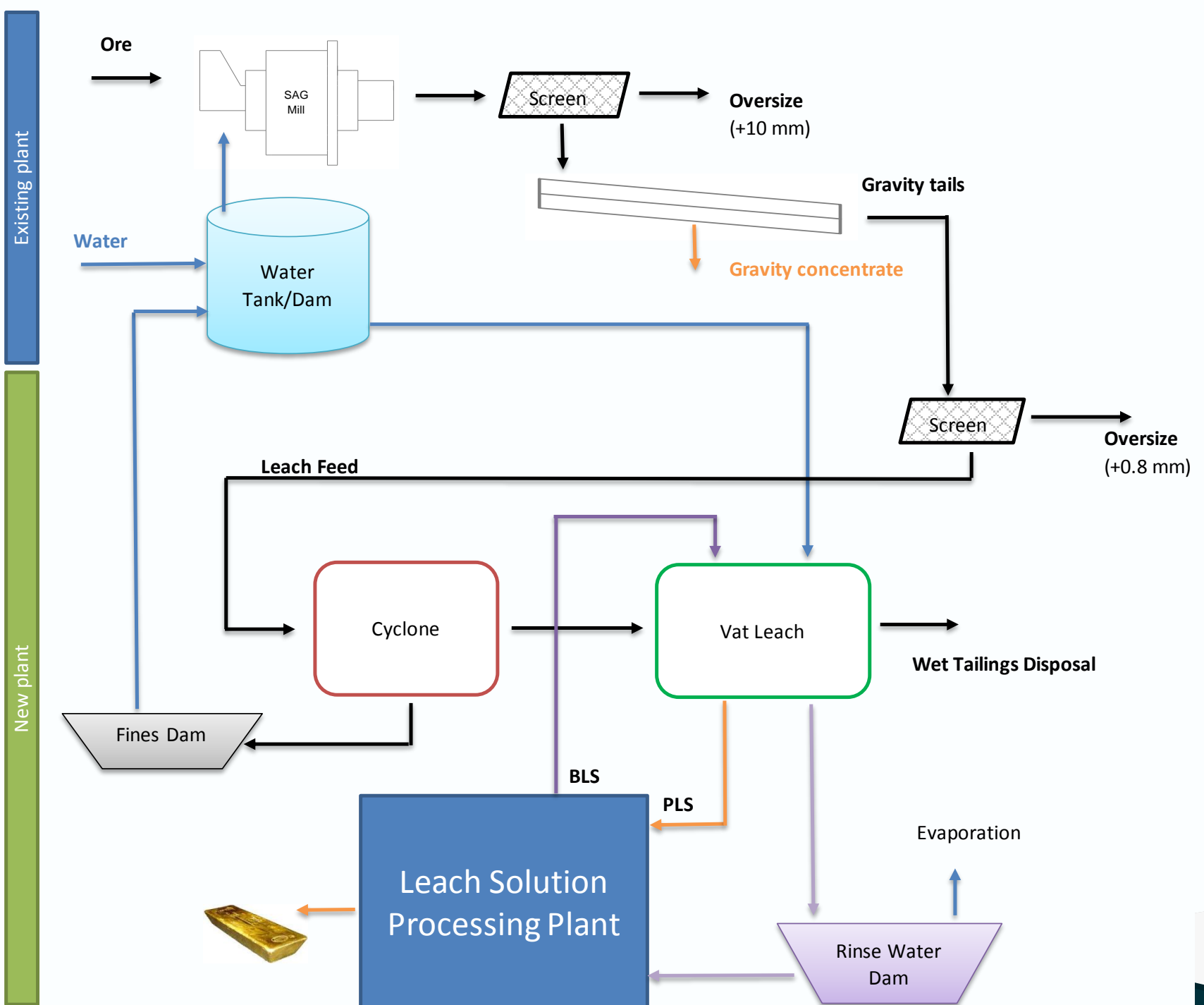
- Thiosulfate system developed with high reagent stability and moderate gold leach rate
- Low capex vat leach application
- 100 t/d demonstration plant
  - Construction underway and commissioning to commence soon
  - Operational January 2018 (seeking process technicians/metallurgists)
  - Multiple ore feeds, including gravity tails and battery sands

## Evaluation of ores to be demonstrated

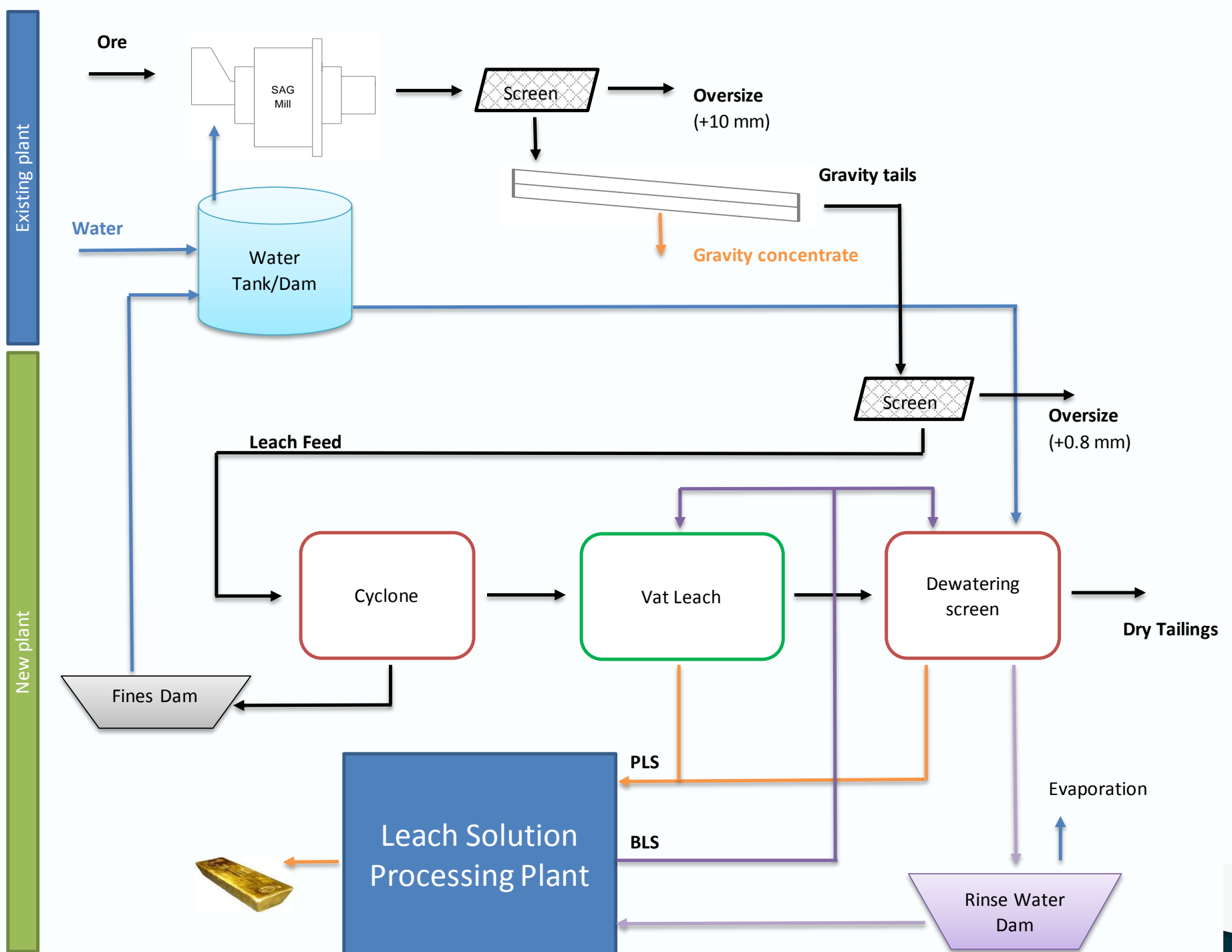
- Cyclic column leach testing and resin adsorption
- Benchmarking data for comparison with plant performance

# Initial facility set-up

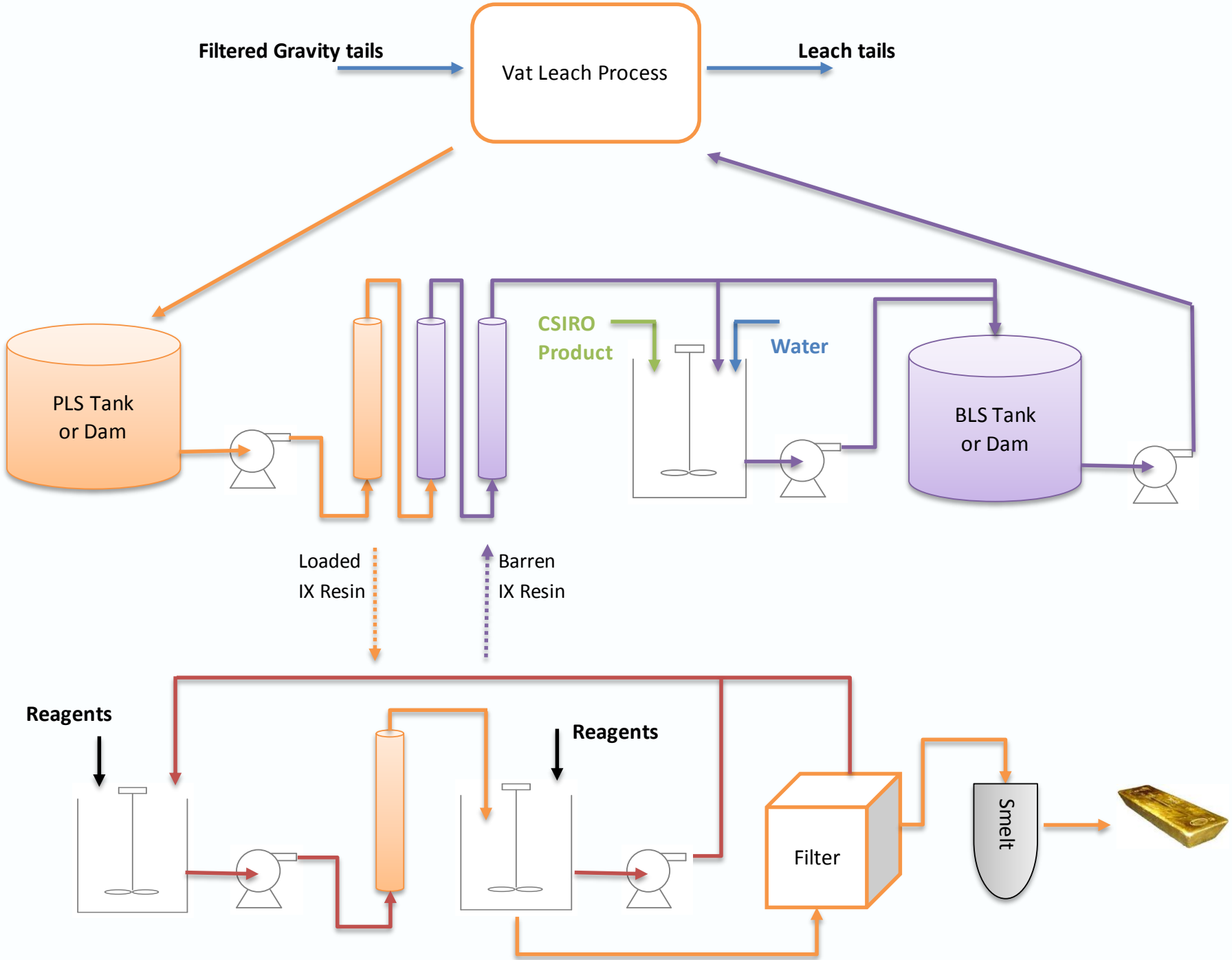
Key aspect is recovery and recycle of reagents from the leach tail



# Improved facility set-up



# Leach Solution Processing Plant





# R&D activities

## Lixiviant recovery/recycle

- Optimisation of tails washing
- Process modelling to optimise washing to minimise gold and lixiviant losses within constraint of maintaining the water balance
- Monitor build-up of any potential deleterious species in the leach solution with recycle/reuse and impact on gold recovery

## Gold recovery rate

- Lixiviant concentration (impacts also lixiviant recovery/recycle)
- Vat leach solution circulation rate

# Bigger Vision

## Research facility that allows in the field

- Development of alternative lixiviant systems
  - Various thiosulfate based
  - Glycine
  - Iodine/Iodide
- Testing and development of
  - Process flowsheets for a greater range of ores
  - Unit operations
- Application to
  - Tank leaching to treat fines
  - Vat, heap, dump, in-place and in-situ leaching
  - Combinations

# Bigger Vision

## Enabling / improving uptake of new technologies

- Mets sector able to test/develop innovations to improve productivity
- Researchers able to test/develop alternative lixiviants and process flowsheets
- Gold miners able to test and evaluate processes to treat their ore

# Questions?

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