Experiences with severe corrosion of condensate systems of juice heaters and evaporators

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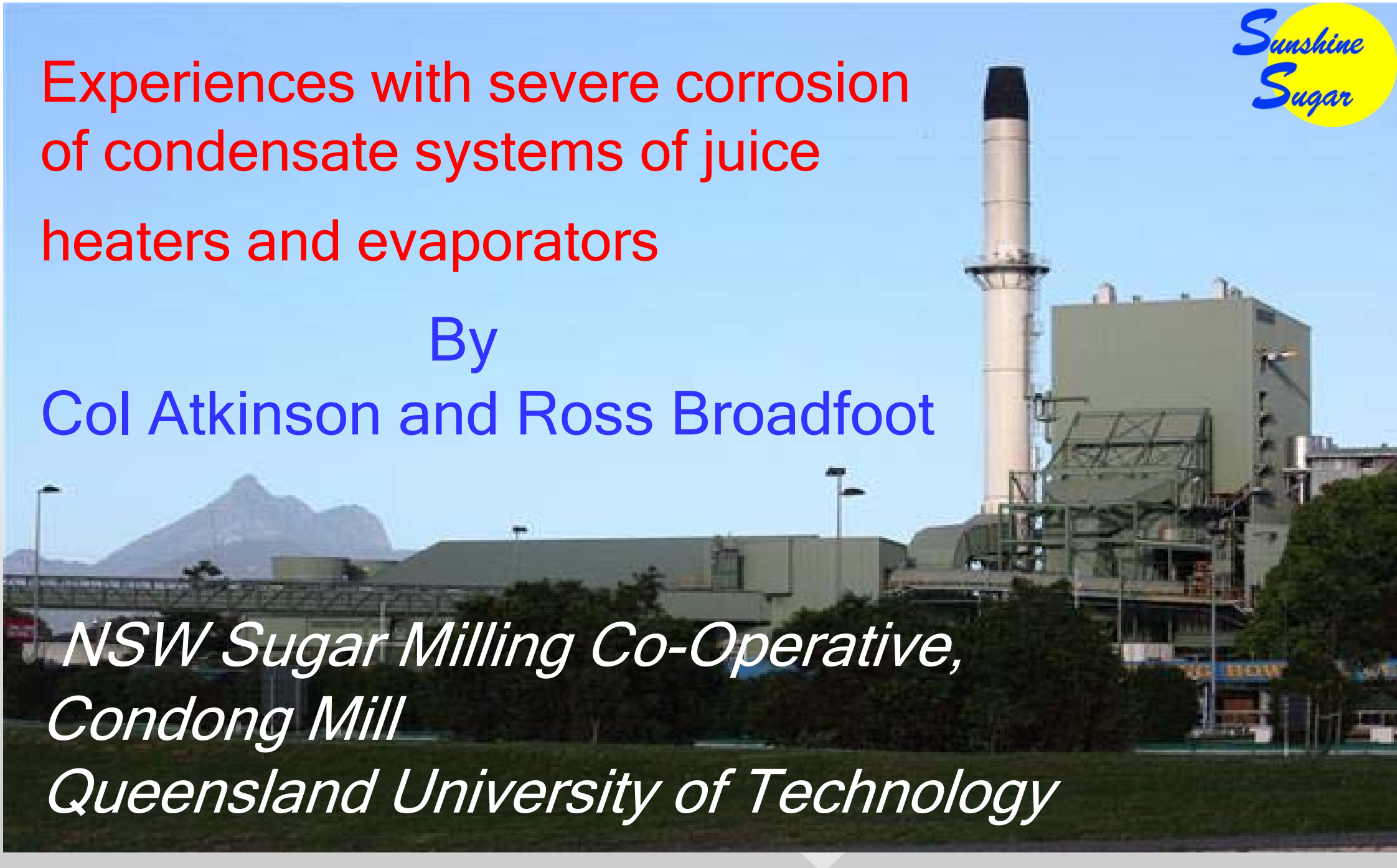
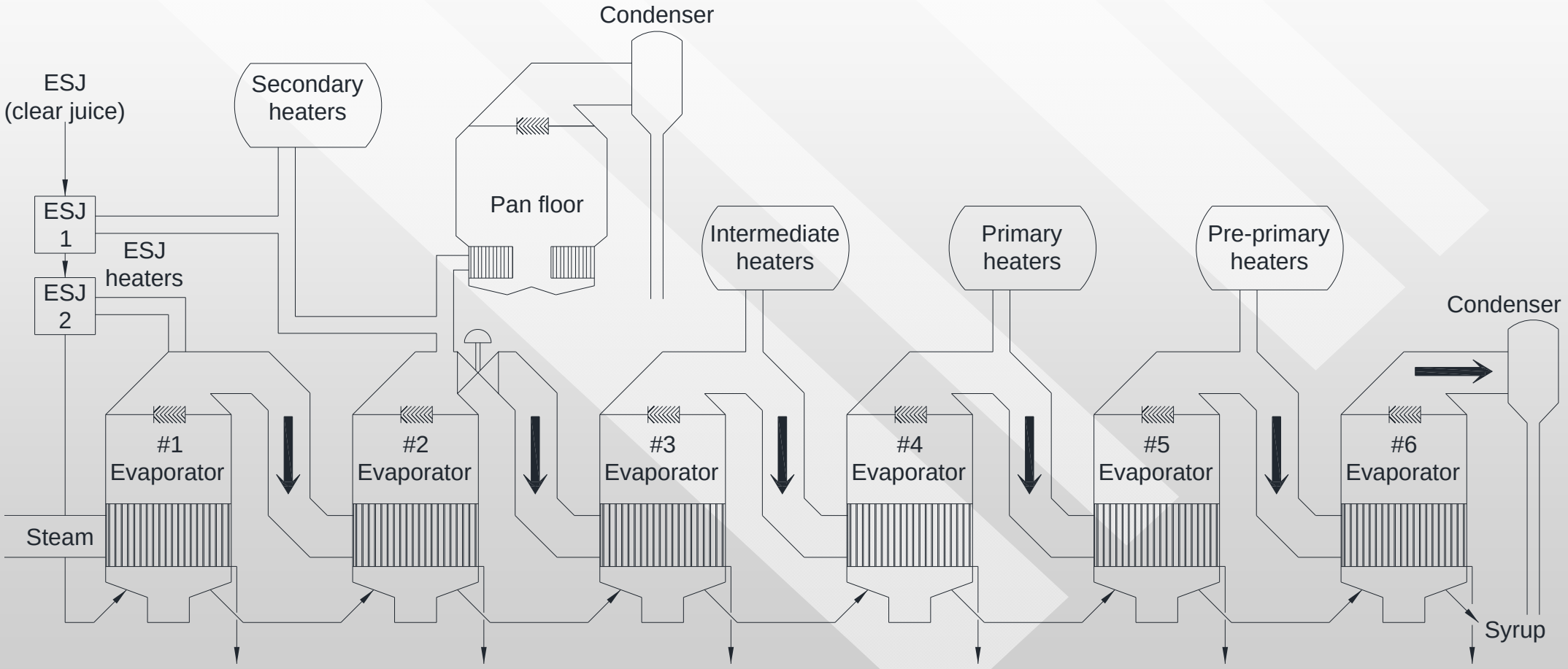


Introduction and Overview

- Install Cogen Plant in 2007. 30 MW generators
- Reconfigure evaporators (Quin to Sextuple; extensive vapour bleed system; exhaust steam 150 kPag)
- Significant energy savings and increase in revenue
- BUT…….

CORROSION!!

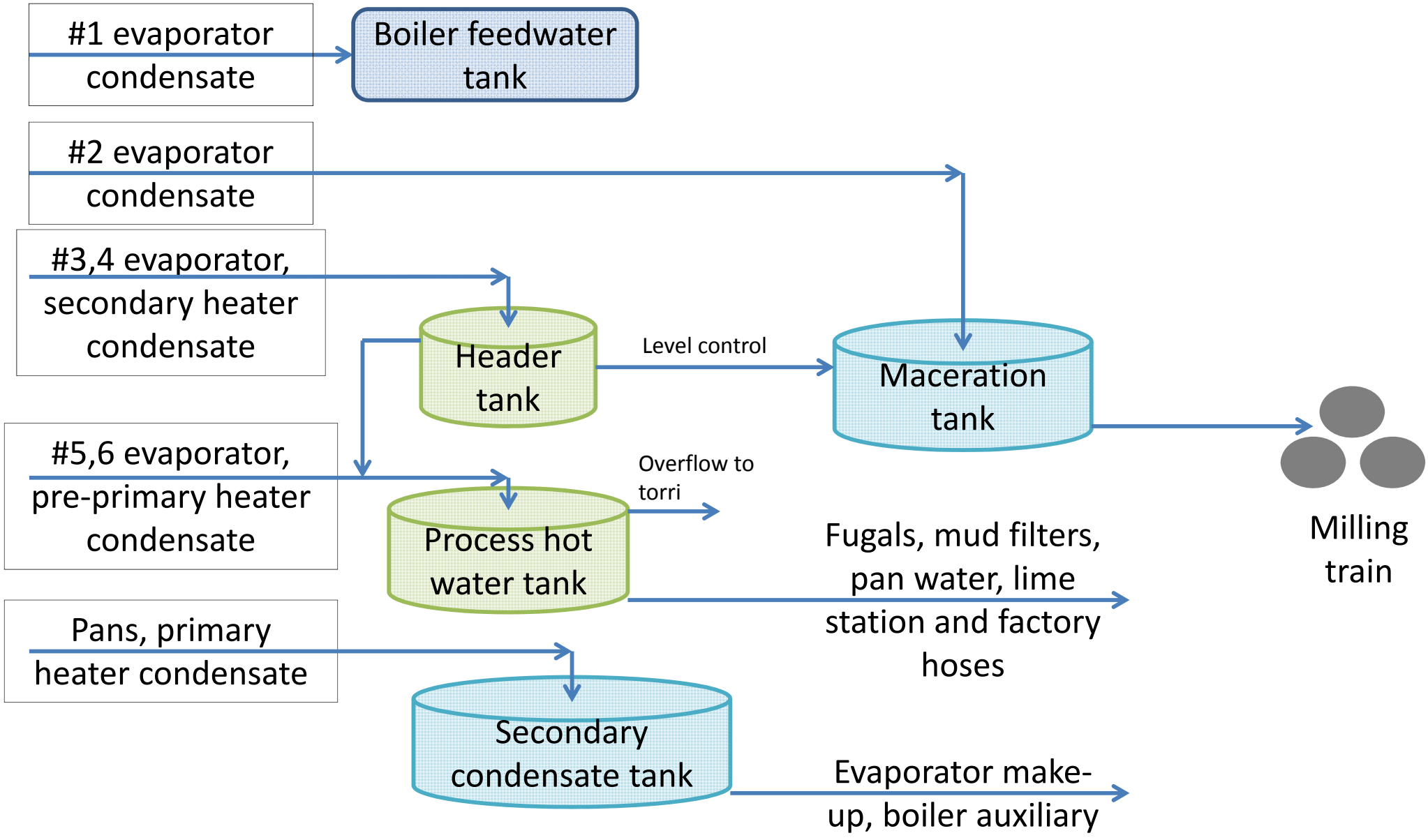
Condong evaporation plant



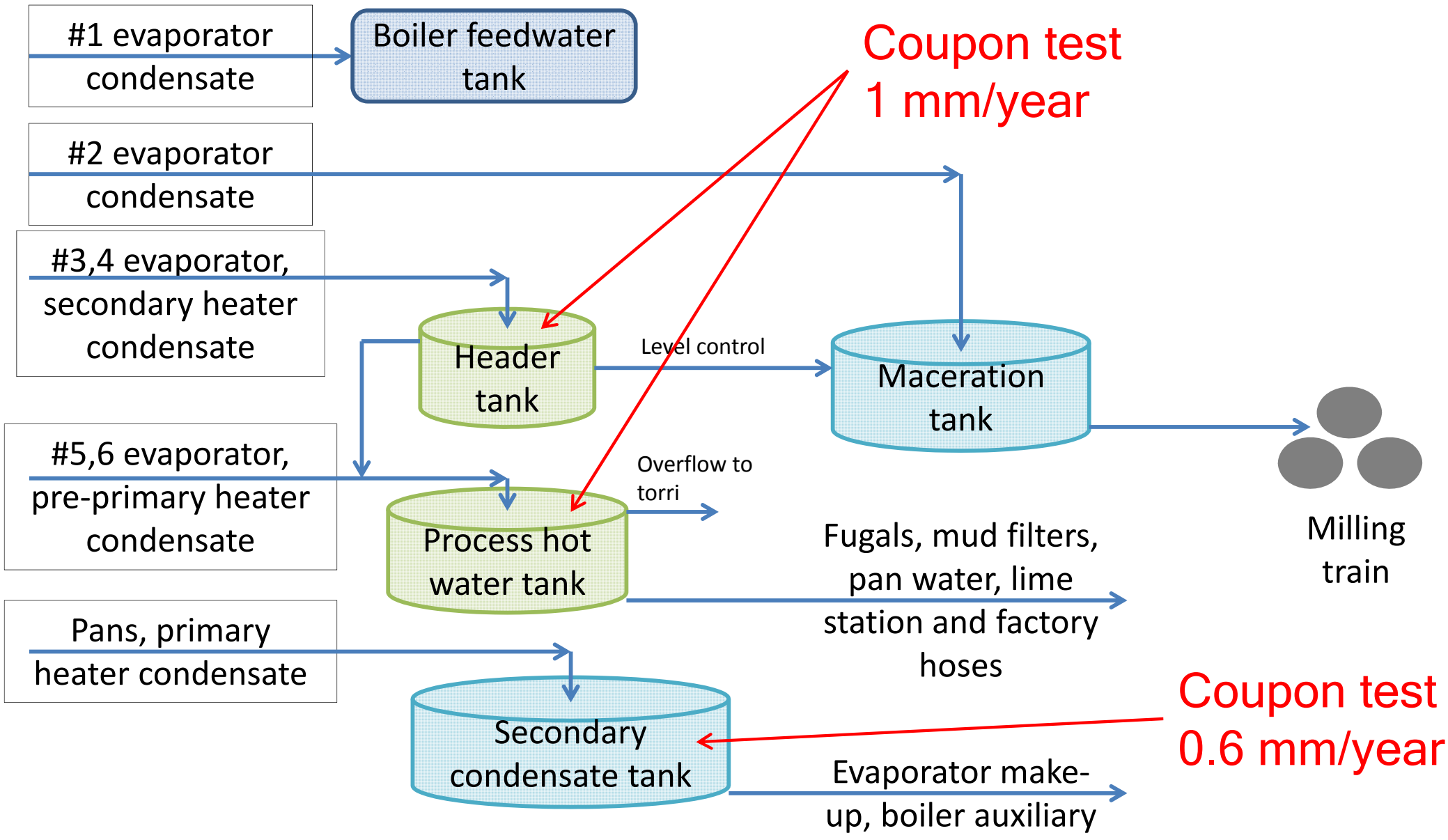
Evidence of high corrosion rates

- Replacement of vapour 2 main (2012)
- Replacement of condensate pumps (2012)
- Replacement of #6 evaporator and primary heater condensate pipes (2012)
- Corrosion of valves
- Pin hole leaks in heater and evaporator tubes
- Coupon tests in condensate tanks of >40 mpy (1.0 mm/year). Life expectancy < 2 years

Condensate storage at Condong



Condensate storage at Condong



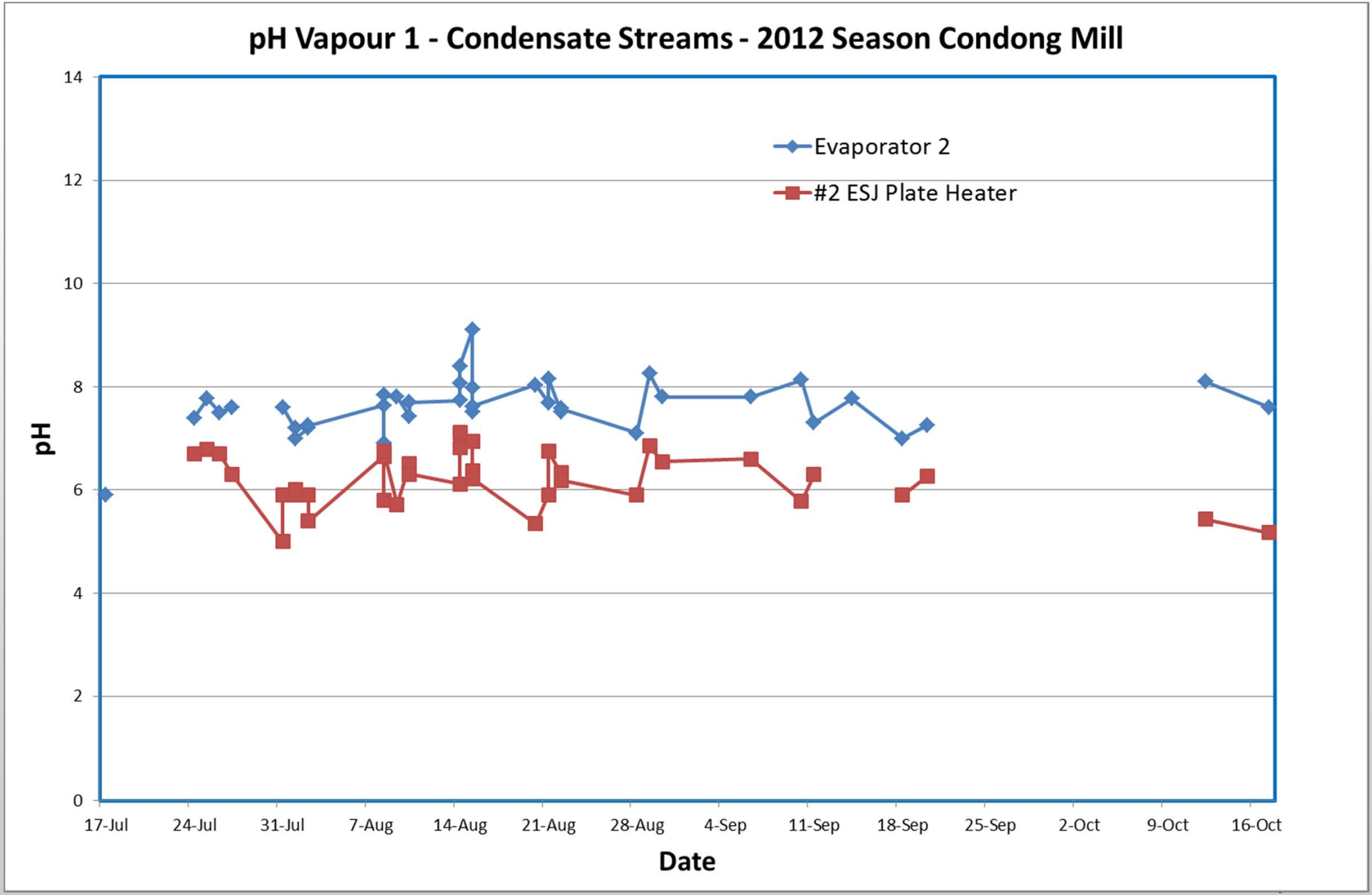
Evidence of Corrosion

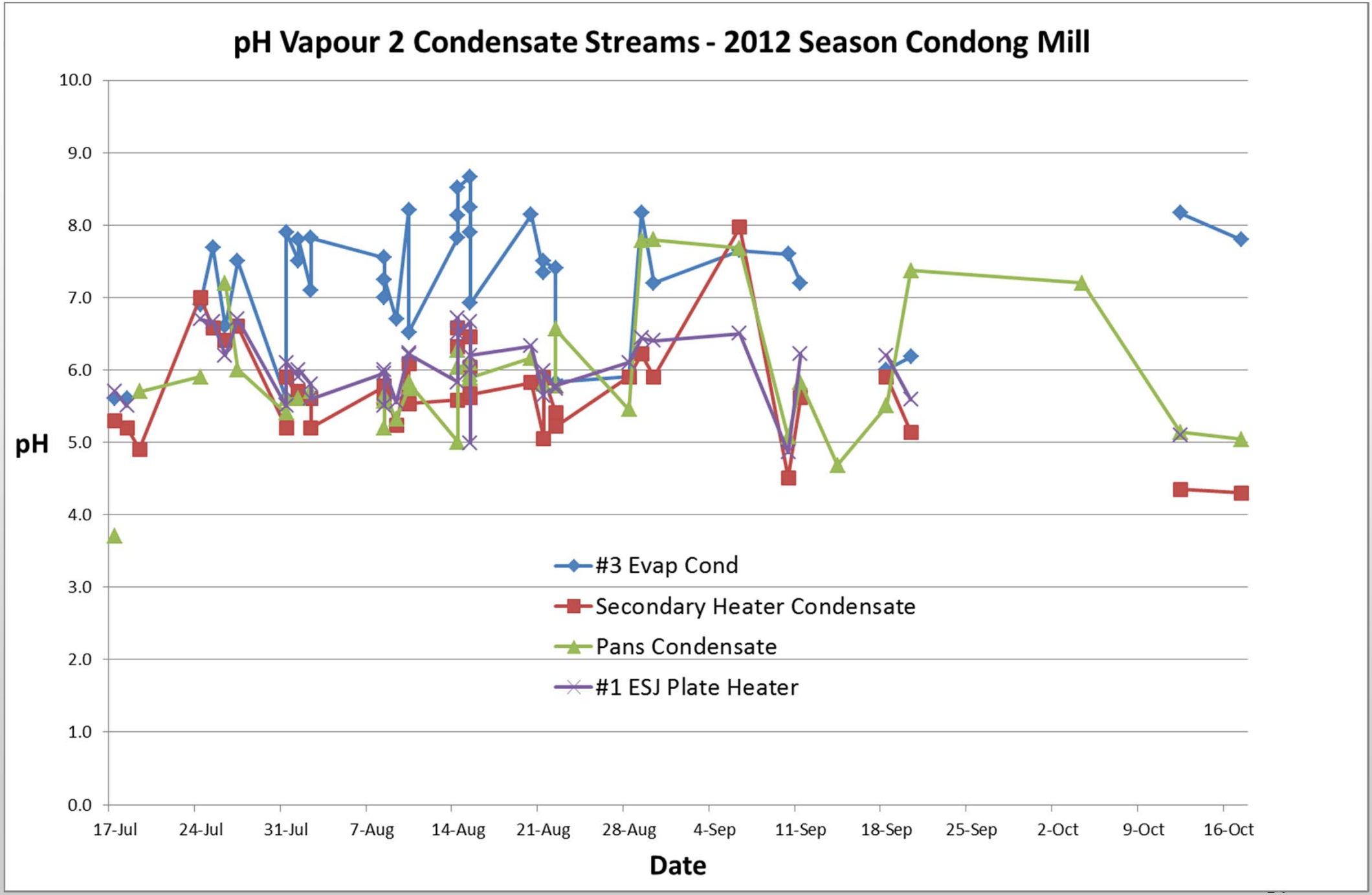
#6 Evaporator Condensate Valve

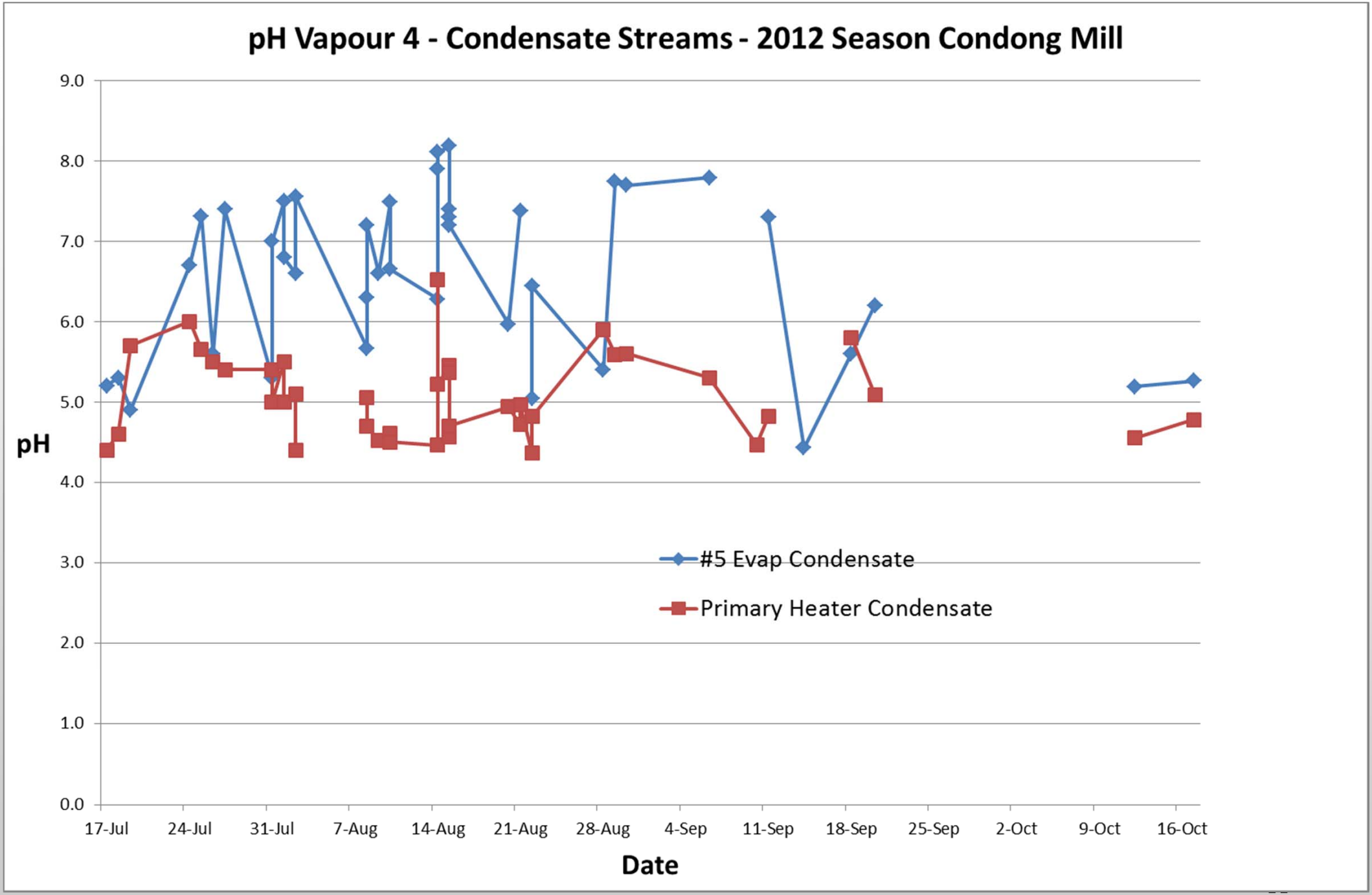
High Corrosion around Valve Seating

Investigations by Condong

- Extensive literature survey related to the possible cause(s) of corrosion
- pH measurements of condensates from evaporators, heaters and pans
- Analyses of condensates (organic acids, carbonic acid, ammonia)
- Coupon tests on condensate tanks, pipes


pH Vapour 1 - Condensate Streams - 2012 Season Condong Mill
Evaporator 2
#2 ESJ Plate Heater
pH
0
2
4
6
8
10
12
14
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug
4-Sep
11-Sep
18-Sep
25-Sep
2-Oct
9-Oct
16-Oct
Date


pH Vapour 2 Condensate Streams - 2012 Season Condong Mill
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pH
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug
4-Sep
11-Sep
18-Sep
25-Sep
2-Oct
9-Oct
16-Oct
Date
#3 Evap Cond
Secondary Heater Condensate
Pans Condensate
#1 ESJ Plate Heater


pH Vapour 4 - Condensate Streams - 2012 Season Condong Mill
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pH
#5 Evap Condensate
Primary Heater Condensate
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug
4-Sep
11-Sep
18-Sep
25-Sep
2-Oct
9-Oct
16-Oct
Date

Observations from pH measurements

- pH of condensate from exhaust steam (No 1 evaporator condensate ~8.0
- pH of condensate from bleed vapour (heaters and pans) always lower than pH of condensate from the evaporator (same vapour source)
  - Suggests volatile acids drawn off in bleed vapour
- pH of condensate is lower in the tail end of the set (sometimes <5 pH)

Other tests

- Condensate chemical analyses
  - High levels of organic acid towards tail end of set
  - Ammonia protection layer in pipework is thin
- Coupon tests
  - Life expectancy of condensate tanks 2 to 3 years
  - Failure of condensate pipes

Possible causes of corrosion

- Hydrolysis of sucrose and decomposition of reducing sugars in evaporators. Expected to be worse at front end (high juice temperatures and longer residence times)
- Large flows of bleed vapour
- Variation in cane quality
- 5 day crushing schedule (due to small crops)

» Production of organic acids, low pH condensates

LOW PH CONDENSATE INVESTIGATION –PROPOSED PROBLEM AND SOLUTION

Problem Identification	Proposed Solution	Benefits	Risks	Comments
Low ammonia levels in juice + elevated boiling temperature (#1 evap) →lack of ammonia in vapour phase to passivate corrosive attack in later stages (heaters, evaps)	Dose ammonia hydroxide in juice (between 3&4 evap) to increase ammonia in vapour phases and provide protection in later stages	Single addition point	Ammonia aggressive to copper alloys (not a function of pH – ammonia dissolves copper oxide) – increased risk of corrosion induced failure in brass pump components and pan tubes	Seek alternative options
High acetic acid levels in juice (whole cane effect?)	Dose volatile amines into 3, 4 and 5 evap condensate catch vessels	Volatile amines less aggressive to copper alloys than ammonia	Very expensive Multiple addition points Detection limits in sugar (HACCP)	Seek alternative options
	Dose filming amines	Provides protection by forming a coating	Difficult to apply (injection into several vapour streams) Expensive	Seek alternative options
Pinhole leaks in heater/evap tubes	Dose caustic into 6 evap, primary heater and pre primary heater condensate catch vessels	Low chemical cost	Multiple injection points Overdosing → river contamination Will not benefit pipework upstream of catch vessel	
	Repair leaks in tubes		Labour intensive Crushing delays while repair leaks	

Summary of solutions

- Upgrade pipework to stainless steel

(but what is happening to tube plates). Need a better solution

- Chemical treatment options. Dosing with

  Caustic soda (into condensate)

  Ammonium hydroxide (into juice)

  Amines (volatile and non volatile)

No cost effective solution yet found!

Acknowledgements

- Other staff at Condong Mill (Brendon Rich, Kent Selby, Phil Scroope)
- Chemical supply companies (Core Water, Nalco)
- TD Chemicals
- Alstom (Chemical analyses of condensates)

References

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Sunshine
Sugar
Discussion Time
Suggestions welcome