



Kidd Operations

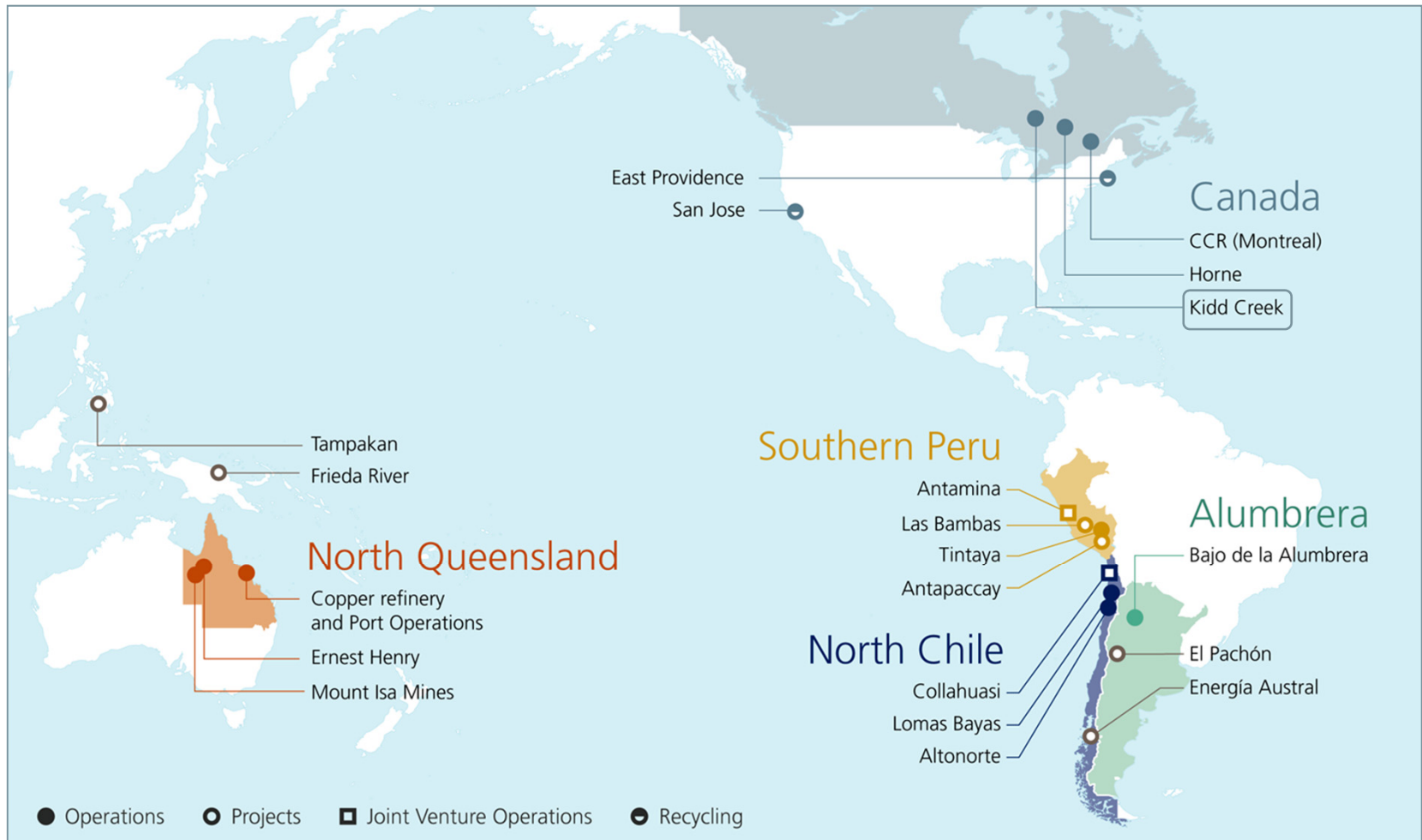
“Managing Thiosalts at Xstrata Copper - Kidd Operations” by: David Yaschyshyn

17th Annual BC MEND ML/ARD Workshop



December 1, 2010

Xstrata Copper – diverse copper assets and projects

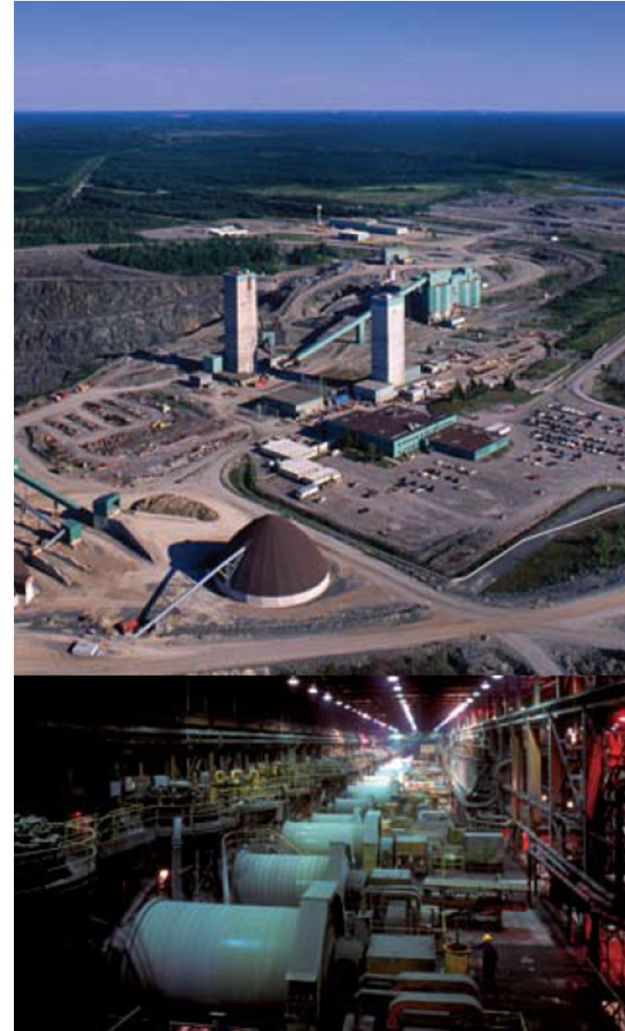




Kidd Operations

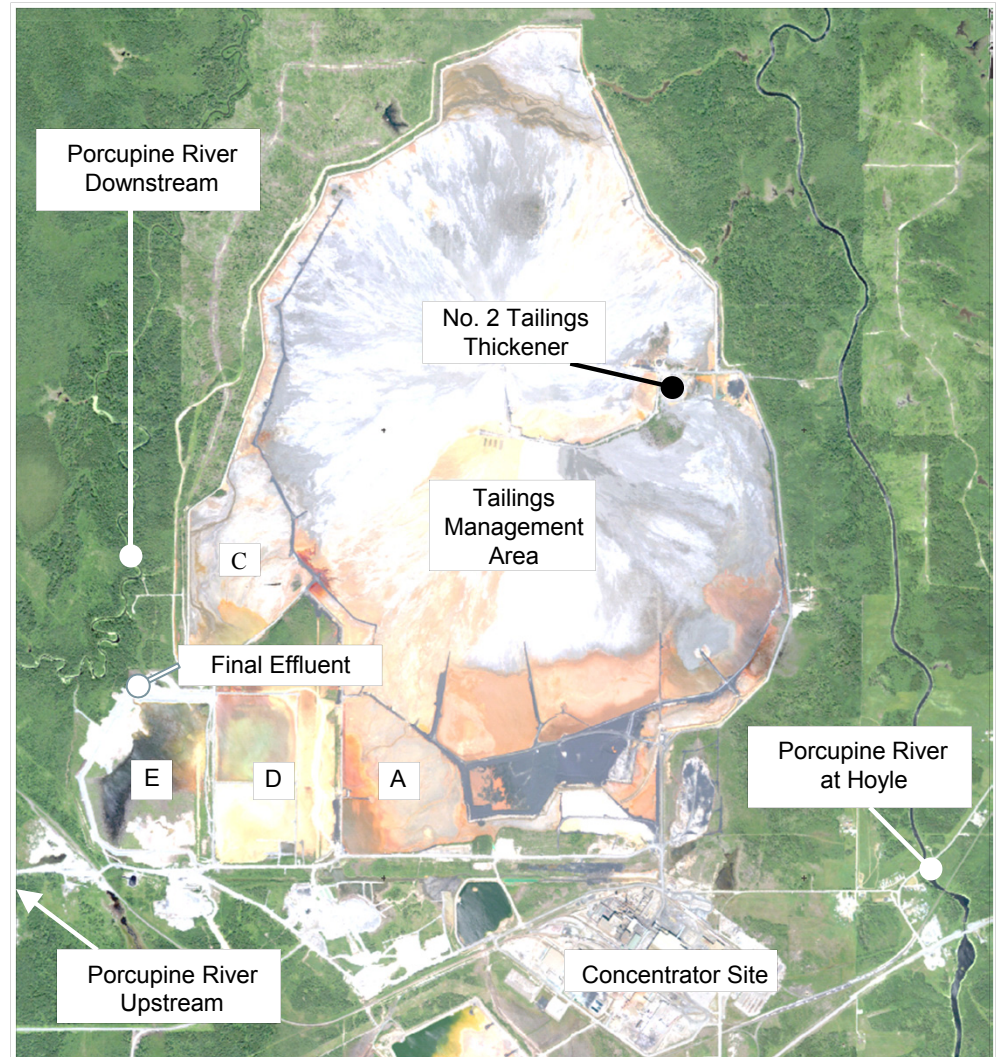


- Located in Timmins, Ontario
- Kidd Mine and Kidd Concentrator
- Copper/zinc mined since 1966
- Production reached 9,200 feet (2,800m) in 2009, making the operation the deepest base metal mine in the world
- Projected mine life to 2017
- Ore processed at Kidd Concentrator using conventional flotation techniques
- Copper and zinc concentrates dewatered and shipped for further refinement in Canada



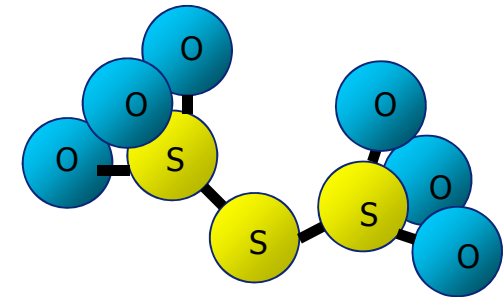
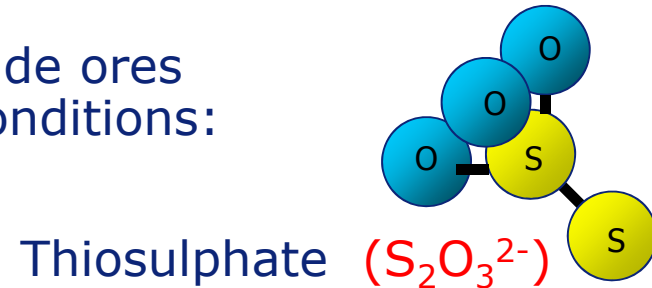
Kidd Concentrator, Tailings Management Area

- Conventional slurry tailings discharge started in 1966
- Thickened tailings discharge since 1973
- Lime Treatment at Pond A and C
- Settling Pond D, water recycled for milling
- Polishing Pond E
- Treated Final Effluent discharged to Porcupine River



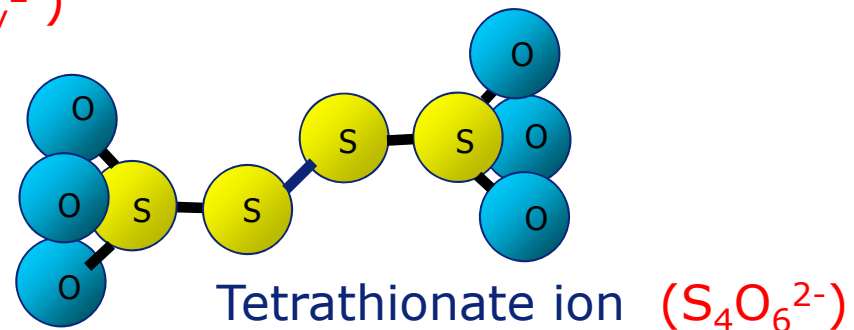
Where/When Thiosalts Occur?

- Typically during grinding or flotation of sulphide ores containing pyrite and pyrrhotite in alkaline conditions:

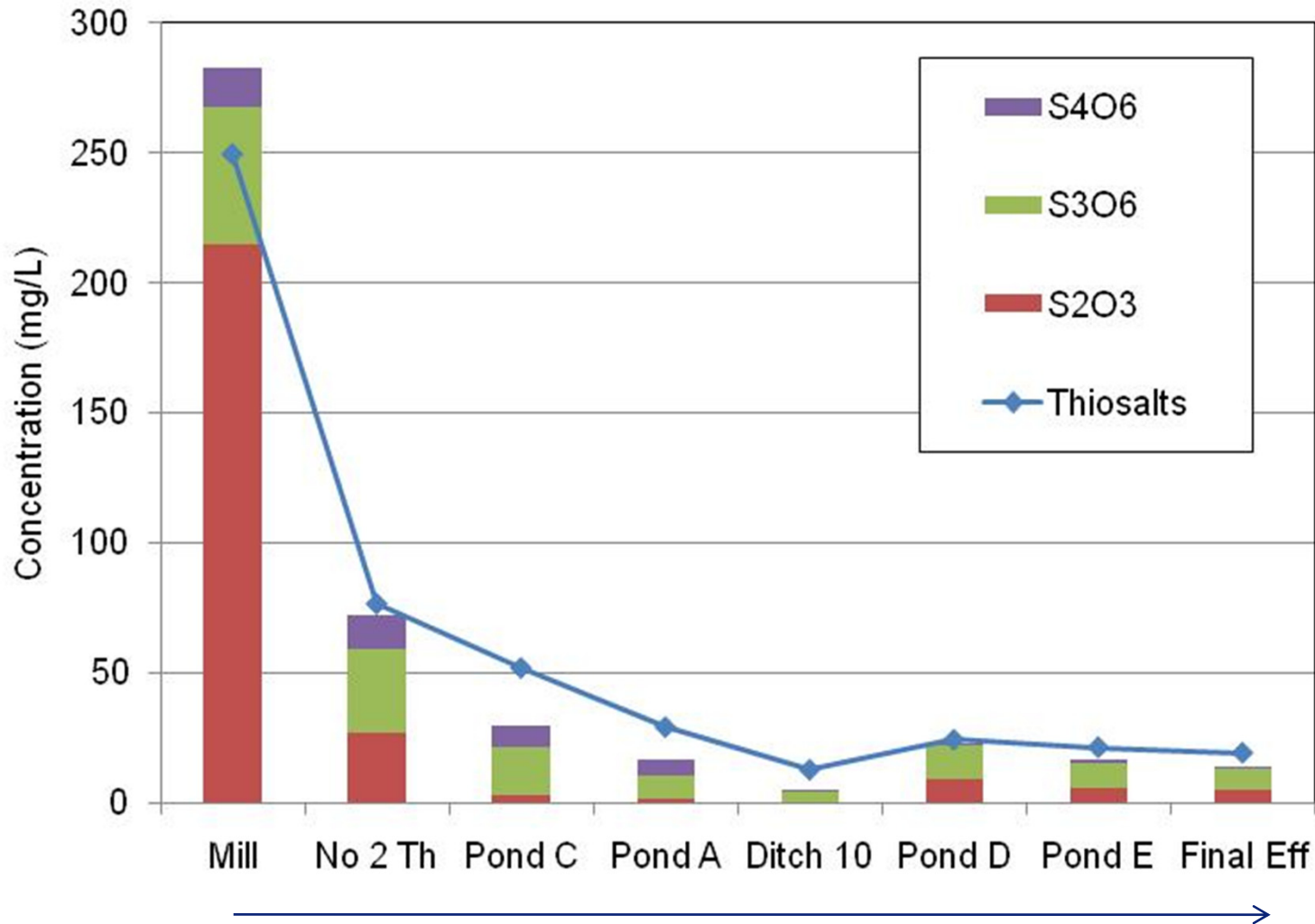


- Thiosalts are a series of partially oxidized sulphur oxyanions ($\text{S}_x\text{O}_y^{2-}$)

- Thiosalts generation tends to be site-specific



Thiosalts Speciation (2009-2010)



Why Thiosalts May Require Management?

- They typically oxidize until end product sulphate (SO_4^{2-}) is reached
- During oxidation reactions, proton (H^+) is produced. This represents delayed acidity with potential to drop pH in treatment ponds, and effluents which could cause aquatic toxicity



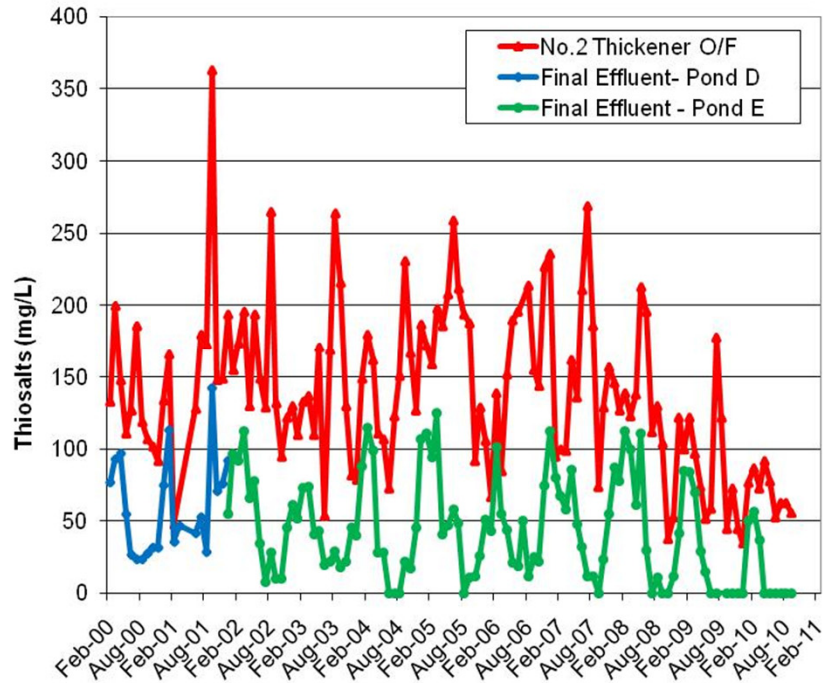
or by iron oxyhydroxides (FeOOH):



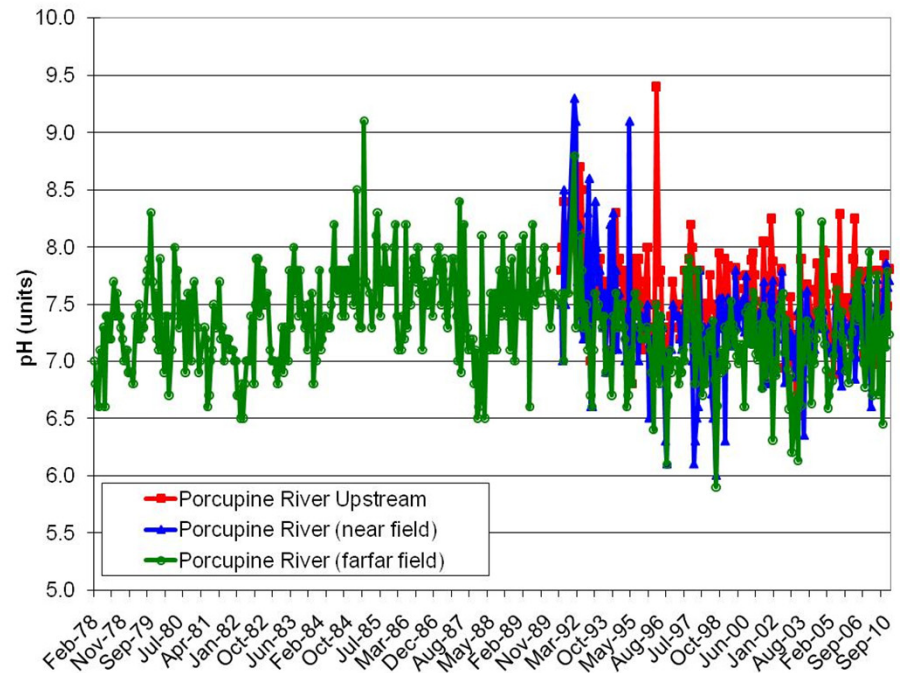
or simply disproportionate:



Thiosalts Monitoring and Receiving Environment pH



- Monitoring thiosalts within treatment system for 11 years
- Seasonal trend evident, peaks lowered, more periods when final effluent at 0 mg/L

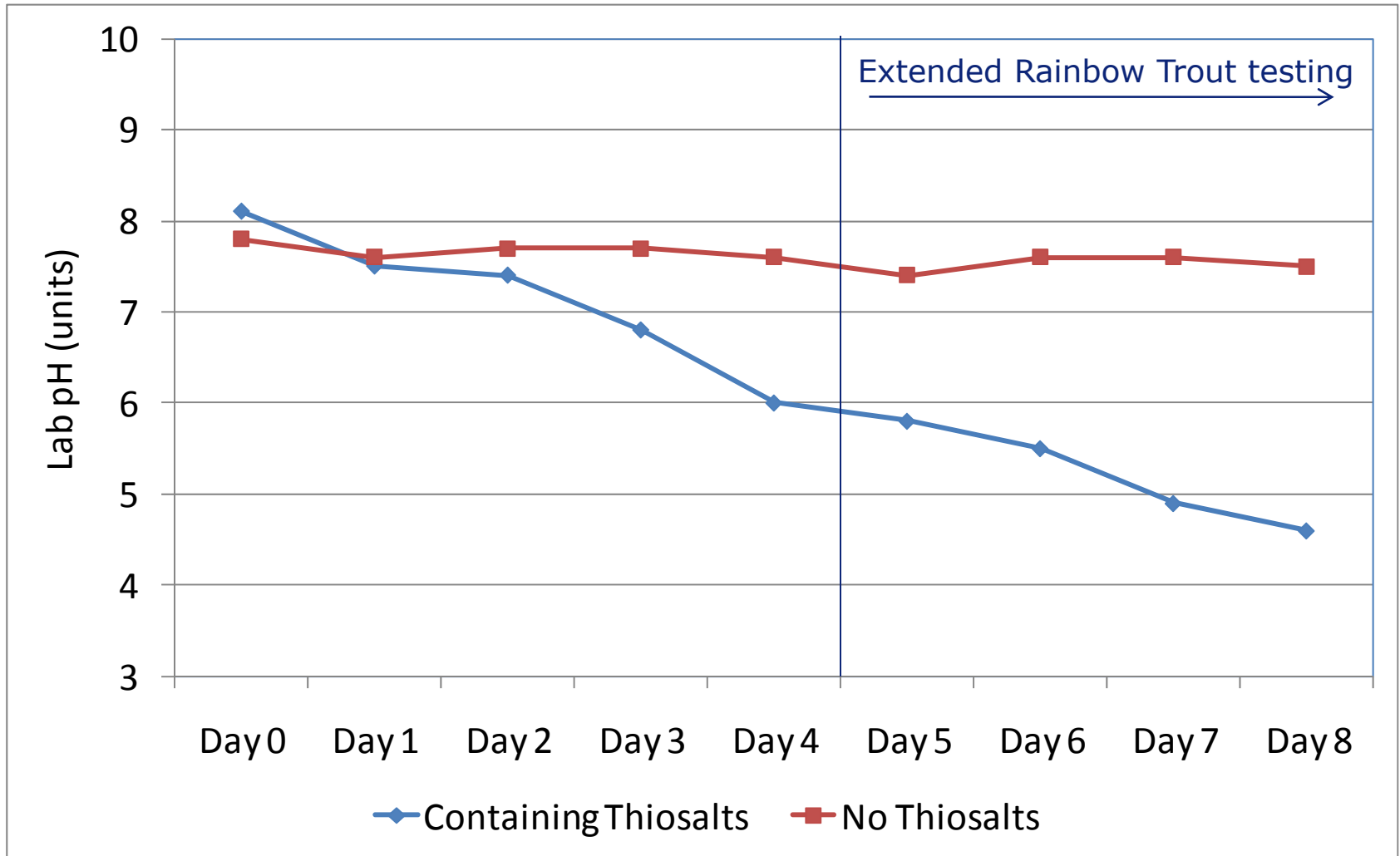


- Receiving environment pH monitoring since 1970's
- No significant pH depression observed downstream

The Kidd Experience

- Natural thiosalt oxidation in the Tailings Management Area (TMA) created the following issues:
 - Drops in pH after lime addition points
 - Lime addition set-points increased to compensate for pH reduction
 - Increased lime costs and sludge generation
 - Risks to Final Effluent compliance for pH and Acute Toxicity
 - Indirect toxicity in acute lab samples for *Daphnia magna* and Rainbow Trout, downstream monitoring has confirmed no effects
- Assessed Potential Treatment Options in 2004
- Highest Ranked Options included
 - Increased/Enhanced Natural Degradation (first-order rate)
 - Chemical Oxidation with Hydrogen Peroxide (H_2O_2)
 - Buffering addition using sodium carbonate (CO_3^{2-}) and/or sodium bicarbonate (HCO_3^-)

Acute Toxicity Testing, Variation in Lab pH



Hydrogen Peroxide Pilot Plant Studies in 2007

Peroxide Tanker

Dosing System

Dosing Location
(North Overflow
Collection Box)

Safety Shower



- Trials investigated peroxide dosage rates, dosing locations at No.2 Tailings Thickener Overflow which is <1 mg/L iron, ferric iron as catalyst, % thiosalts degradation, acute toxicity.

Hydrogen Peroxide Pilot Plant Studies + Ferric Sulphate



- Discovered iron concentrations in the 15-30 mg/L range resulted in complete thiosalt destruction within minutes of peroxide addition
- Repeated pilot trial with H_2O_2 and Ferric Sulphate $\text{Fe}_2(\text{SO}_4)_3$
- Achieved 100% thiosalt destruction in <5 minutes downstream of peroxide addition point
- Maximum H_2O_2 requirement with $\text{Fe}_2(\text{SO}_4)_3$ determined to be only 50% of the theoretical requirement

Chemistry of Iron Catalyzed Peroxide Oxidation



“Modified” Fenton’s Reagent (from FMC Environmental Solutions website)

- Chemical oxidation is a proven water treatment technology
- Hydrogen peroxide is a powerful oxidant, but at low concentrations reaction kinetics maybe too slow to degrade many contaminants of concern
- Addition of ferrous (II) or ferric (III) iron dramatically increases the oxidative strength of peroxide. This increase is attributed to the production of hydroxyl radicals (OH*) and initiation of a chain reaction causing the formation of new radicals
- The reaction of iron catalyzed peroxide oxidation at pH 3-5 is called “Fenton’s Chemistry” after its discoverer H.J.H. Fenton. The iron/peroxide combination is known as “Fenton’s Reagent.” If the pH is less than 5, the iron (III) is reconverted to iron (II), via a side cyclic reaction, and the iron remains in solution to sustain the initiation of hydroxyl radical production.
- The basic reaction for the application of Fenton’s Reagent is:

Radical initiation



Radical Propagation

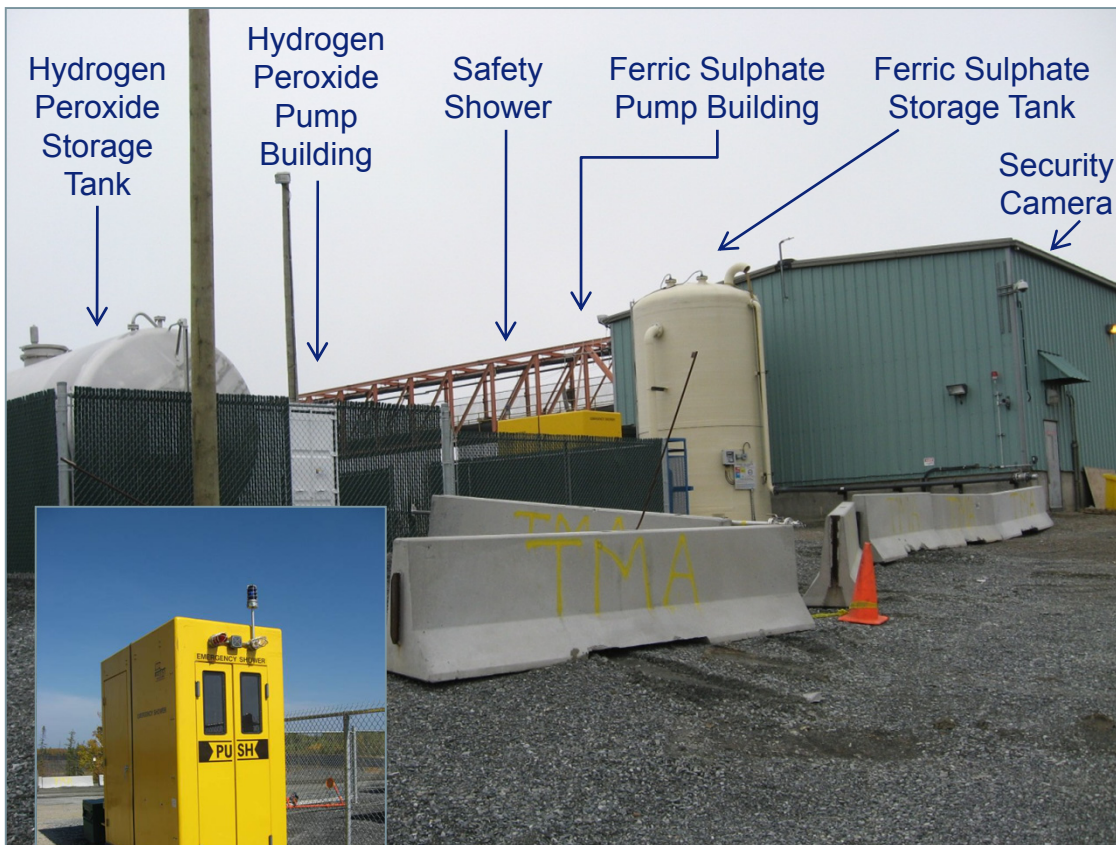


Thiosalt Treatment System Design Criteria (2008)



- Thiosalt concentration = 217 mg/L at No. 2 tailings thickener
- Flow rate = 44,000 m³/day at No.2 tailings thickener
- H₂O₂ addition rate = 0.00105 mL H₂O₂/mg thiosalts
 - 50% of theoretical requirement from reaction stoichiometry
- Fe₂(SO₄)₃ addition rate = 0.09 mL 55% Fe₂(SO₄)₃/L No. 2 thickener O/F
 - Theoretical requirement to achieve a minimum concentration of 20 mg/L Fe in the No. 2 thickener overflow

Thiosalt Treatment Plant (2009)



- One all weather safety shower and eyewash station
- One 40 m³ fibreglass ferric sulphate storage tank
- 3 ferric sulphate metering pumps housed in an 8' x 8' building
 - Owned by Kidd
- One 50 m³ stainless steel H₂O₂ storage tank
- 4 H₂O₂ metering pumps housed in a 15' x 8' sea container
 - Leased from Arkema

Thiosalt Treatment System



Ferric sulphate metering pumps (2 operating 1 spare)

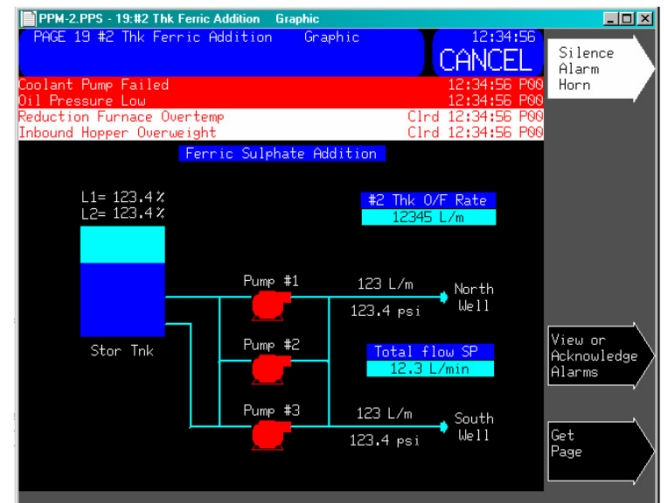
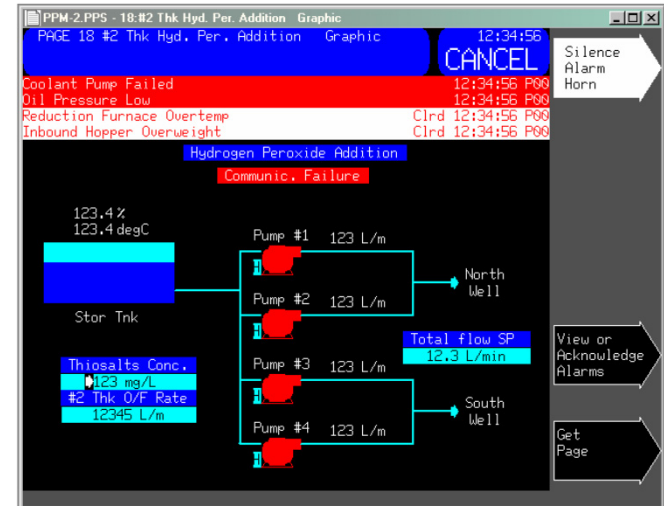
Hydrogen peroxide metering pumps (2 operating 2 spare)



Thiosalt Treatment System Control

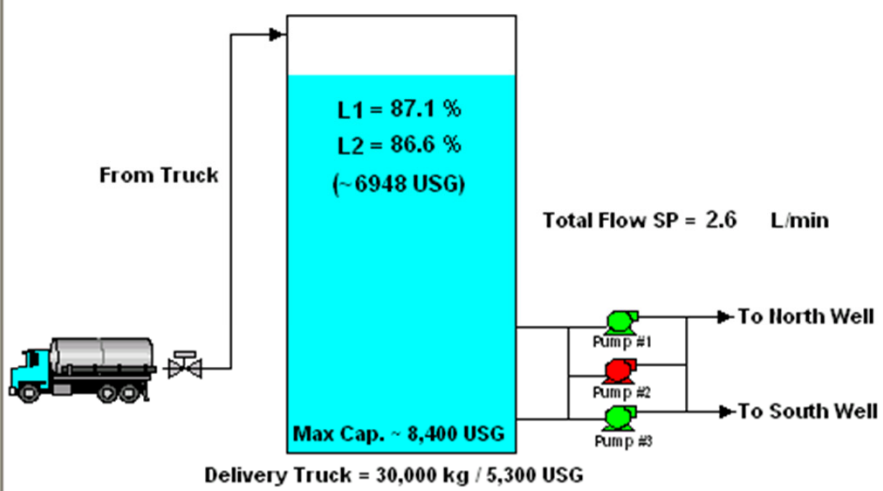


- Hydrogen peroxide and ferric sulphate addition rates automatically controlled by the PLC
 - Adjusted continuously based on the calculated No. 2 thickener overflow rate
- Operator is only required to enter a “pre-treatment” thiosalt concentration once per day, which is obtained from a sample of the No. 2 thickener overflow that is submitted to our onsite Analytical Lab each morning
- Pre-A, Pre-C, and Pre-D samples also collected daily to determine treatment effectiveness
- Opportunity identified to optimize reagent addition rates by incorporating natural degradation within existing system

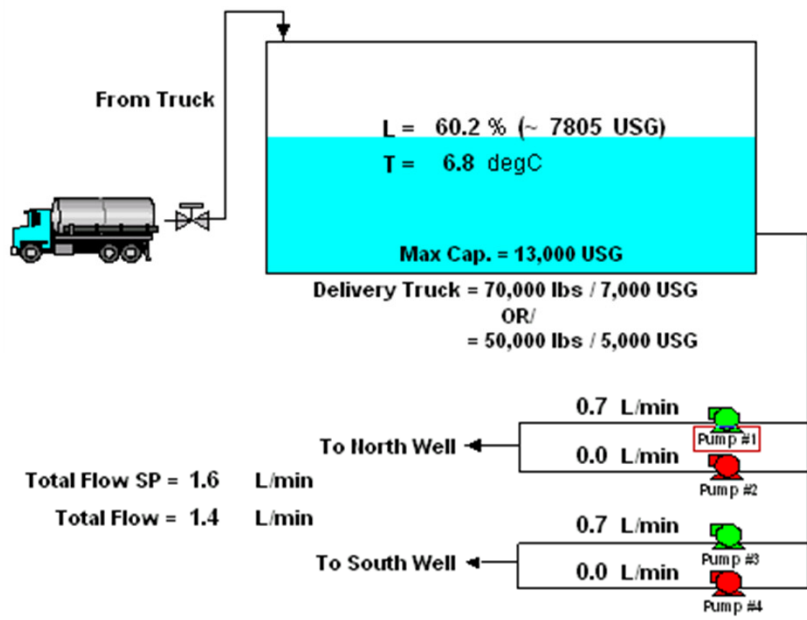


new! Thiosalt Treatment System

Ferric Sulphate



Hydrogen Peroxide



Ferric Sulphate Tank Approx. Time to Empty = 6.16 days
 Ferric Sulphate Approx. Daily Consumption Rate = 988 USG/day

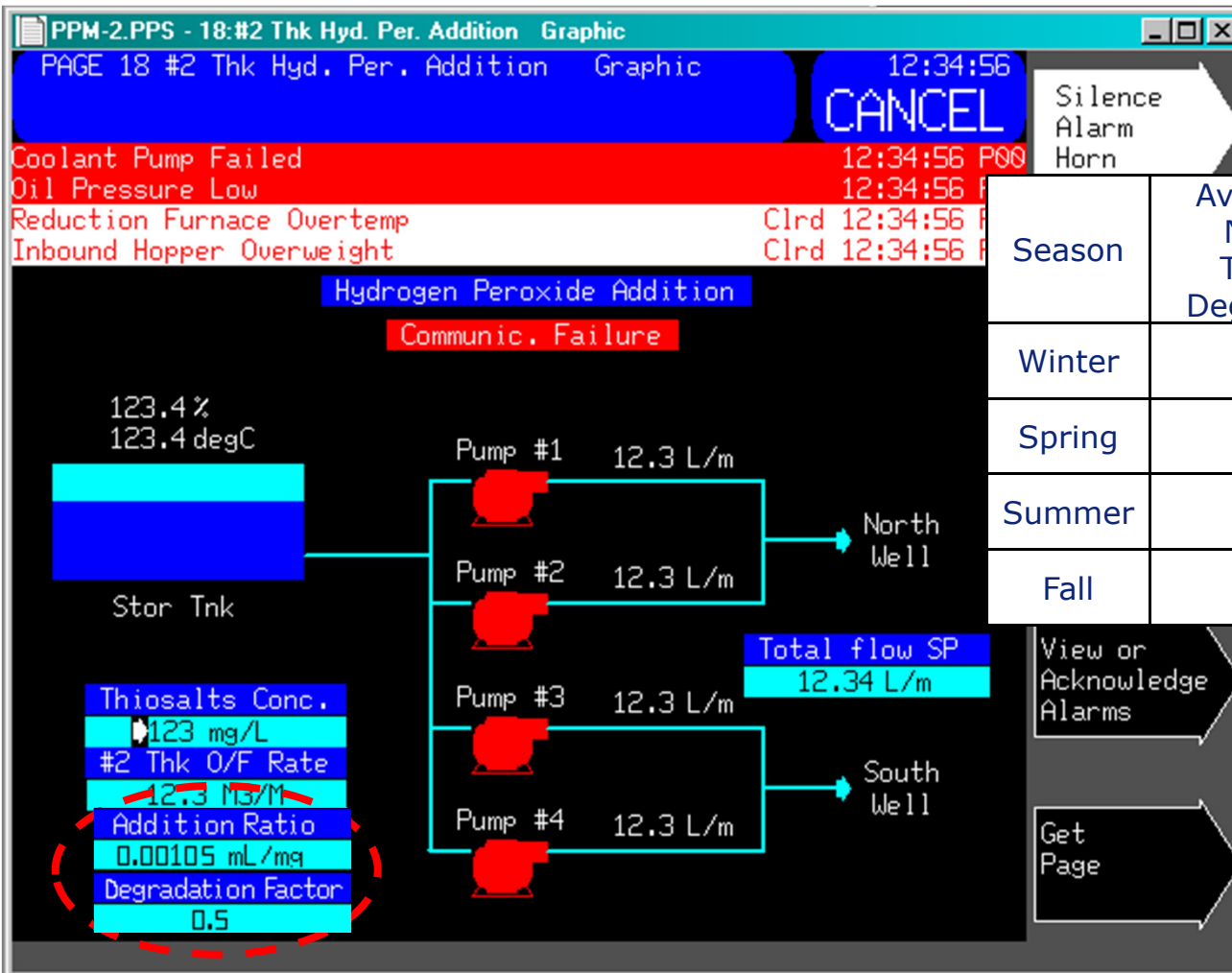
Hydrogen Peroxide Tank Approx. Time to Empty = 13.9 days
 Hydrogen Peroxide Approx. Daily Consumption Rate = 540 USG/day

Estimated No. 2 Thickener O/F Rate = 28869 L/min
 No. 2 Thickener O/F Thiosalts Concentration = 52 mg/L

Tails Overview Mill Overview

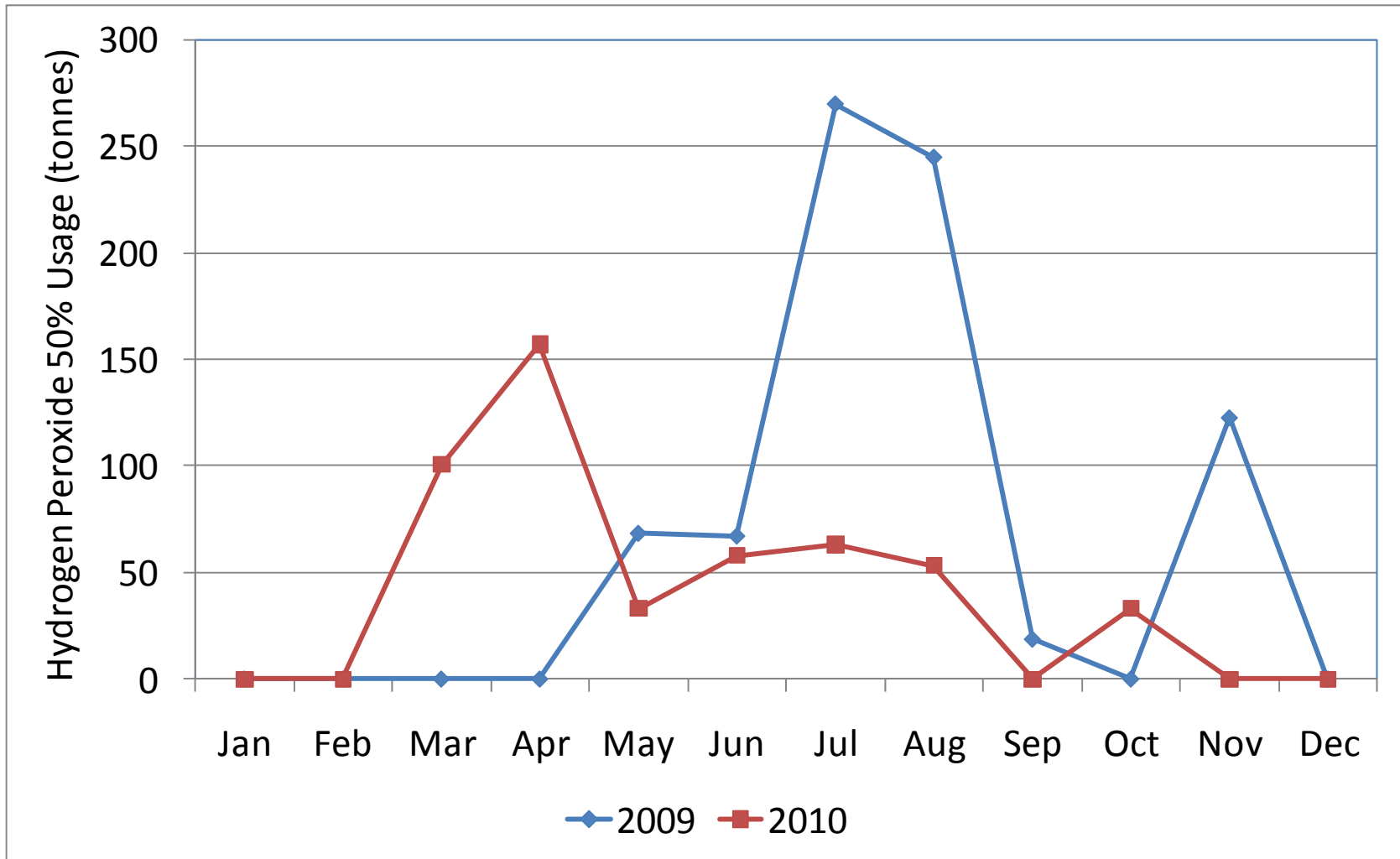
In 2009, hydrogen peroxide and ferric sulphate made up 19% of the site total water treatment reagent costs.

Hydrogen Peroxide Consumption Optimization



Season	Average % Natural Thiosalt Degradation	Natural Thiosalt Degradation Factor
Winter	35.0	0.35
Spring	50.0	0.50
Summer	85.0	0.85
Fall	75.0	0.75

Hydrogen Peroxide Consumption 2009 & 2010 After Optimization



The Kidd Experience (Now)

- Optimization has reduced consumption and costs for peroxide
- No further drops in pH after lime additions points
- Lime addition set-points have now been lowered
- Sludge generation has decreased
- Reduced re-circulating load of thiosalts in recycle water
- No need for non-routine addition of neutralizing agents, safety
- Final effluent in compliance, no pH issues.
- Carbon dioxide consumption has dropped, lower incoming pH's
- No more sporadic acute toxicity tests at the lab for past 2 years
- Reduced residual process reagents (ie: xanthate) in effluent

Other H₂O₂ Treatment Plants for Oxidation of Thiosalts



Location	Ore Type	Install Date	Vendor	Capacity
Apirsa Mine Seville, Spain	Zinc, Lead, Copper	2001	Degussa	50% H ₂ O ₂ , 13000 USG Storage, 750-800 m ³ /h flow rate with 500 mg/L thiosalts, 13 tpd average
Brunswick Mine Bathurst, NB, Canada	Zinc, Lead, Copper, Silver	2004	Degussa	50% H ₂ O ₂ , 9500 USG Storage, 10 tpd average in spring, 30 tpd peak
Kidd Met. Site Timmins, ON, Canada	Zinc, Copper, Silver	2009	Arkema	50% H ₂ O ₂ , 13000 USG Storage, 20 tpd average, 36 tpd peak
Voisey's Bay Mine & Mill Site, NL, Canada	Nickel, Copper, Cobalt	2010	TBD	TBD

Knowledge Sharing

Sudbury 2007 Mining & Environment Conference – Managing Thiosalts in Mill Effluents “Studies Conducted at the Kidd Metallurgical Site” by Nural Kuyucak, David Yaschyshyn



2009 Xstrata Copper Canada Sustainable Development Report – Case Study “Sharing innovative solutions in water treatment with the industry”



42nd Annual CMP Conference (Ottawa) January 2010 – “Development of a Thiosalt Treatment System at Xstrata Copper Kidd Metallurgical Site” by Andréa Lagacé



17th Annual BC/MEND Metal Leaching/Acid Rock Drainage Workshop, Vancouver December 2010 – “Managing Thiosalts at Xstrata Copper, Kidd Operations” by David Yaschyshyn



Knowledge Sharing



CANMET MMSL Thiosalts Consortium 2009 Annual Meeting –
held at Kidd Metallurgical Site with field tour of peroxide plant

Acknowledgements

Thiosalt Treatment Project Team

- Dave Scott, Concentrator Manager
- Andréa Lagacé, Engineer in Training
- Tim Miller, Tailings Metallurgist
- Leah Fedat, Environmental Coordinator
- Brian Raittinen, Project Engineer
- Porcupine Engineering Services
- Arkema (Hydrogen Peroxide)
- Kemira (Ferric Sulphate)

Treatment Optimization

- Juzer Tayabally, Engineer in Training

Thank You. Questions? (dychyshyn@xstratacopper.ca)

