Wastewater Treatment of high total dissolved solids and acidity in Cerro de Pasco mining wastewater

Presented by

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Presentation Outline

Project Overview

Influent Design Basis

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Project Overview

Project Overview

Project Goals

- Meet LMP standards
- Expand treatment plant capacity
- Reduce operating costs

Project Overview

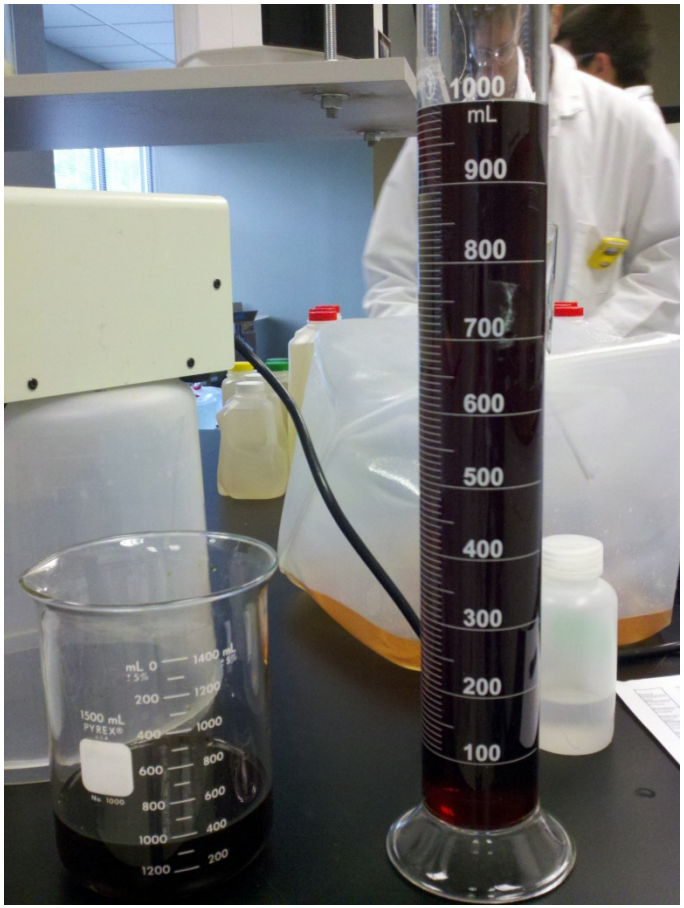
Water Quantity

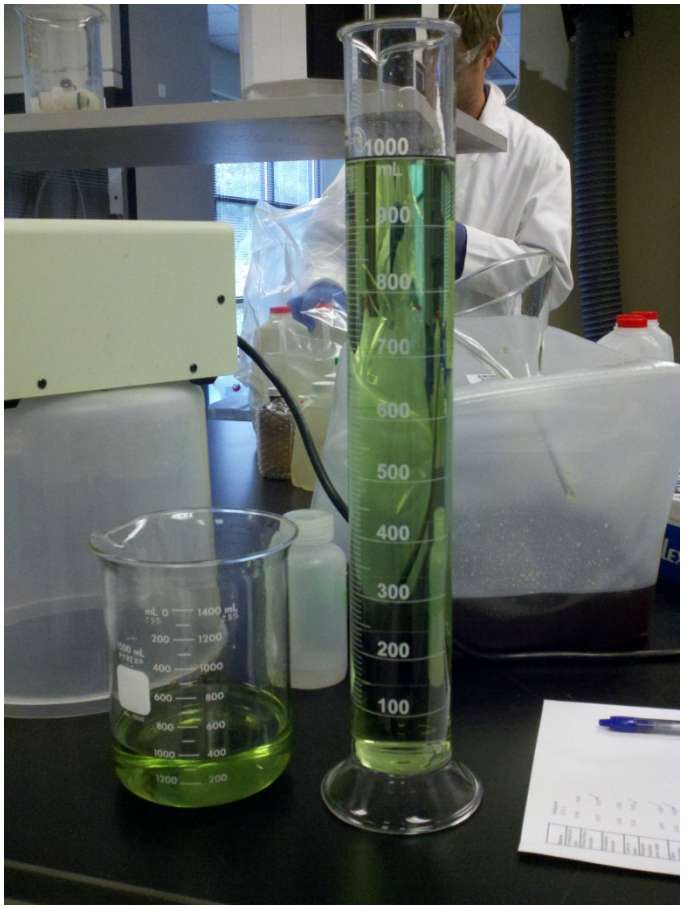
Source	% of Total Flow	
	Current Flow	*Expected Future Flow*
Underground mine	85.7%	49.8%
Pampa Seca stockpile	1.7%	1.8%
Rumiallana stockpile	5.7%	13.1%
Open pit	1.2%	2.6%
Paragsha industrial zone	5.7%	5.2%
Other stockpiles	0.0%	2.6%
Quiluacocha tailings pond / Excelsior stockpile	0.0%	24.8%

Design Flow

568 m^3/hr

Water Quality





Water Quality

Parameters	Units	Influent Sources						
		Underground Mine	Pampa Seca	Rumiallana	Open Pit	Paragsha	Other Stockpiles	Quilulacocha
General Chemistry								
pH	-	2.28	0.75	2.44	6.26	2.5	2.09	2.4
TSS	mg/L	68	110	18	14	6	97	18
TDS	mg/L	10,000	180,000	17,000	1,300	11,000	170,000	26,000
Acidity	mg/L	4,500	170,000	1,500	190	3,000	4,300	8,500
Sulfate	mg/L	8,300	200,000	13,000	890	9,400	190,000	30,000

Water Quality

Parameters	Units	Influent Sources						
		Underground Mine	Pampa Seca	Rumiallana	Open Pit	Paragsha	Other Stockpiles	Quilulacocha
Metals (Dissolved)								
Arsenic	mg/L	6	850	0.084	0.093	0.083	220	2.1
Cadmium	mg/L	0.69	12	0.42	0.17	1.3	12	1.6
Chromium	mg/L	0.09	2.4	*0.01*	*0.01*	0.014	0.62	0.026
Copper	mg/L	87	1,200	0.28	0.16	23	2,500	19
Iron	mg/L	1,200	41,000	250	4.7	660	55,000	2,900
Lead	mg/L	0.042	6	0.63	0.015	0.25	0.97	0.27
Manganese	mg/L	140	1,300	520	45	600	3,500	930
Mercury	mg/L	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*
Nickel	mg/L	0.22	1.4	0.18	*0.04*	0.32	4.3	0.28
Zinc	mg/L	400	3,700	420	44	530	7,200	810

Water Quality

Parameter		Unit	Influent Water	LMP Standards	ECA Standards
General Chemistry	Sulfate	mg/L	27,000	-	500
	TSS	mg/L	120	50	
	Conductivity	µS/cm	-	-	-
	pH	-	1.92	6.0 - 9.0	-
Dissolved	Arsenic	mg/L	30	0.1	-
	Copper	mg/L	130	0.5	-
	Iron	mg/L	3,300	2	-
	Manganese	mg/L	420	-	0.2
	Lead	mg/L	0.3	0.2	-
	Zinc	mg/L	730	1.5	-
	Nickel	mg/L	0.52	-	-
	Aluminum	mg/L	230	-	-

Treatment Technology

- Lime precipitation (High Density Sludge)
- Limestone/Lime Two-stage neutralization
- Metals recovery pre-treatment (sulfide precipitation)

Treatment Technology

Lime Precipitation (High Density Sludge)

- Relies on insolubility of heavy metals in the presence of elevated hydroxide ions
- Minimum solubility pH varies by metal ion
- Widely implemented and established solution for ARD waters dominated by Fe chemistry

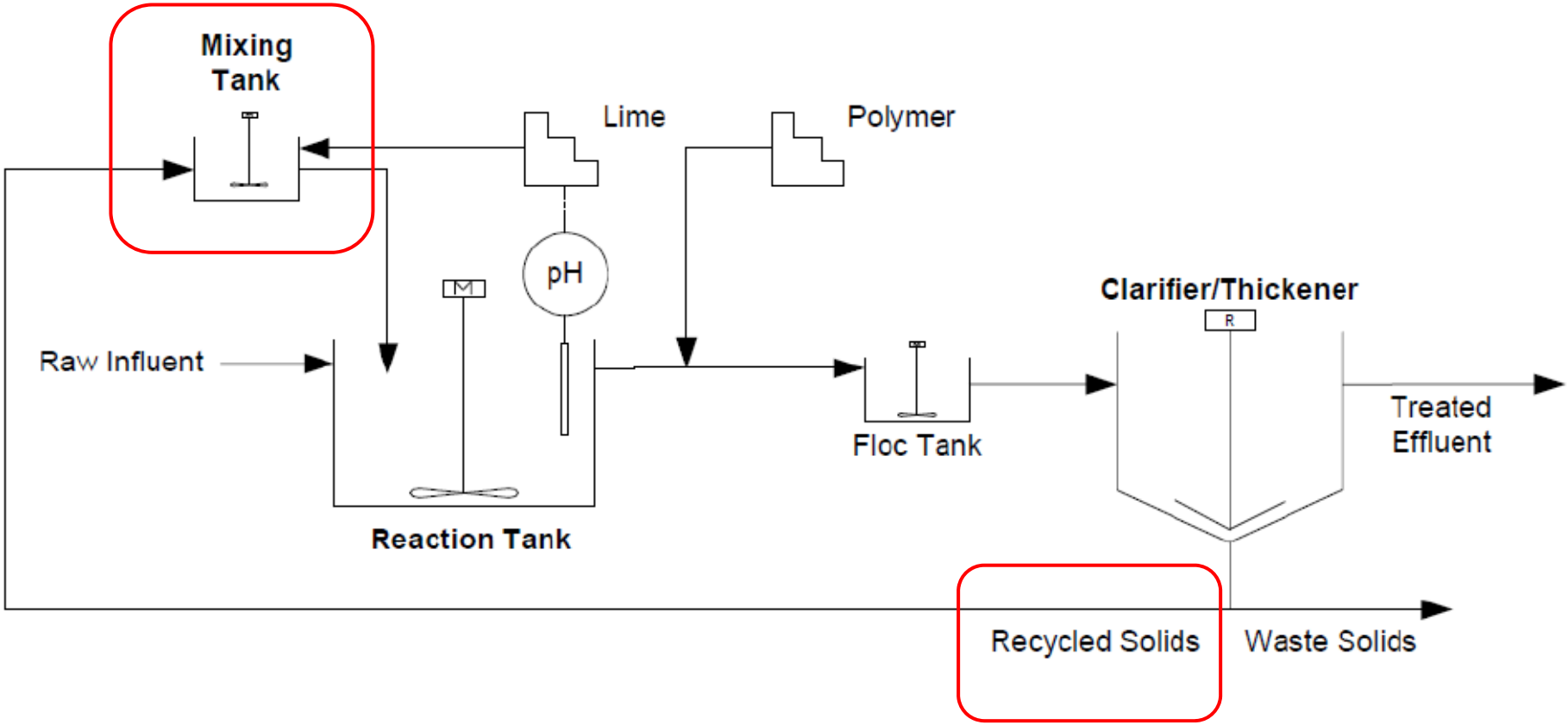
$$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$$

$$Me^{2+} + 2\ OH^- \rightarrow Me(OH)_2\,(s)$$

(Metal hydroxide precipitation)

Treatment Technology

Lime High Density Sludge (HDS)



Treatment Technology

Limestone/Lime Two-Stage Neutralization

- Advantages
  - Lower material costs
  - Can create denser sludge
- Disadvantages
  - Longer reaction times
  - Low utilization due to sulfate armoring
  - Inability to raise pH above 6.0

$$H^+ + CaCO_3 \rightarrow Ca^{2+} + HCO_3^-$$

$$HCO_3^- \rightarrow OH^- + CO_2^-$$

(Limestone dissolution)

Treatment Technology

Metals Recovery Pre-treatment

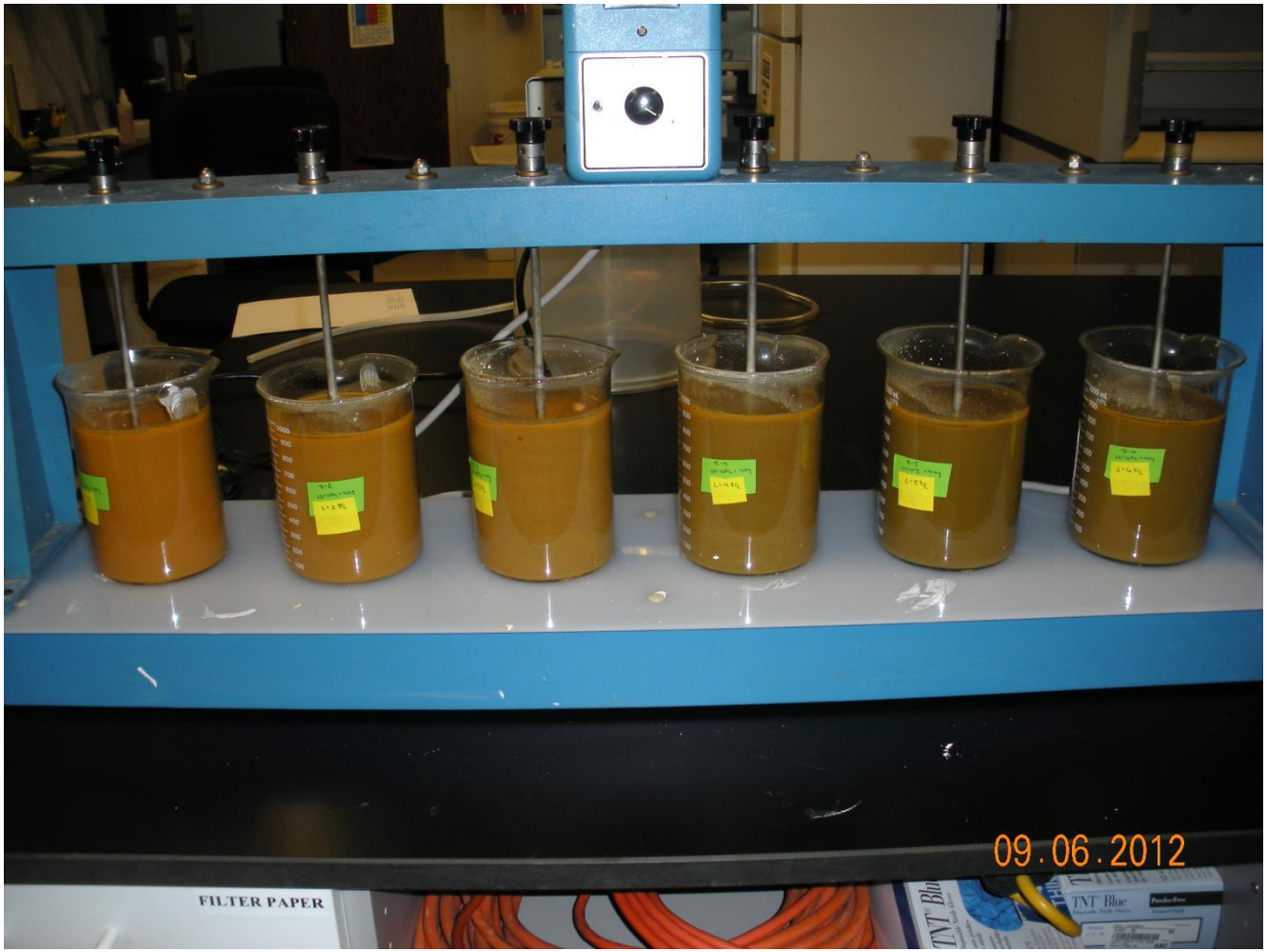
- Advantages
  - Creates saleable product
- Disadvantages
  - Additional equipment

Bench Testing

Primary Objectives

- Lime demand
- HDS performance
- Limestone performance
- Metal recovery performance

Bench Testing



Bench Testing Results

HDS Performance

Parameters	Units	Treatment Goals	Raw Water	HDS Recycle	Oxidation
			Total Blend	Decant #10	with Solids Seeding
pH	-	-	1.92	8.4	9.9
Lime Dose (as $Ca(OH)_2$)	g/L			10	11.2
Sulfate	mg/L	500	27,000	3,100	1,400
Metals (Dissolved)					
Aluminum	mg/L	-	230	*0.1*	*0.1*
Arsenic	mg/L	0.1	30	*0.015*	*0.015*
Cadmium	mg/L	0.05	1.9	*0.005*	*0.005*
Copper	mg/L	0.5	130	*0.015*	*0.015*
Iron	mg/L	2	3,300	*0.1*	*0.1*
Lead	mg/L	0.2	0.28	*0.009*	*0.009*
Manganese	mg/L	0.2	420	7.4	0.013
Nickel	mg/L	0.5 [1]	0.52	*0.04*	*0.04*
Zinc	mg/L	1.5	730	0.072	0.02

Bench Testing Results

Limestone/Lime Performance

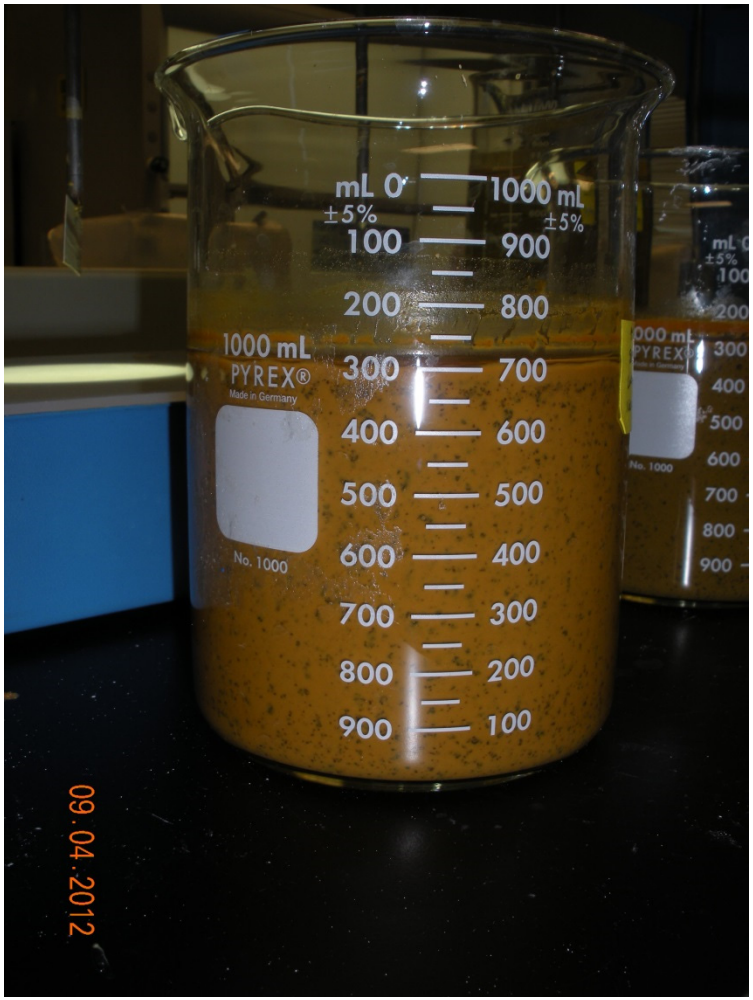
Parameters	Units	Treatment Goals	Raw Water	LS + Lime Titration					
			Total Blend	R-1	R-2	R-3	R-4	R-5	R-6
pH	-		1.92	6.23	6.85	8.2	8.76	8.96	9.48
Limestone Dose (as $CaCO_3$)	g/L			10	10	10	10	10	10
Lime Dose (as $Ca(OH)_2$)	g/L			1	2	3	4	5	6
Sulfate	mg/L	500	27,000	4,700	3,800	3,300	2,600	2,000	1,700
Metals (Dissolved)									
Arsenic	mg/L	0.1	30	0.019	0.02	*0.015*	*0.015*	*0.015*	*0.015*
Cadmium	mg/L	0.05	1.9	0.42	0.085	*0.005*	*0.005*	*0.005*	*0.005*
Copper	mg/L	0.5	130	0.018	*0.015*	*0.015*	*0.015*	*0.015*	*0.015*
Iron	mg/L	2	3,300	260	40	0.15	0.14	*0.1*	*0.1*
Lead	mg/L	0.2	0.28	0.046	0.024	*0.009*	*0.009*	*0.009*	*0.009*
Nickel	mg/L	0.5 [1]	0.52	0.15	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*
Zinc	mg/L	1.5	730	150	17	0.12	0.045	0.027	0.021

Bench Testing Results

Metals Recovery Performance

Parameters	Units	Treatment Goals	Raw Water	Testing			
			Metal Recovery Blend	M-1	M-3	M-4	M-6
pH	-		1.54	4.66	4.98	5.35	5.76
Lime Dose (as $Ca(OH)_2$)	g/L		N/A	75	80	82	88
Sulfate	mg/L	500	194,111	N/A	43,000	40,000	31,000
Metals (Dissolved)							
Arsenic	mg/L	0.1	479	0.43	0.28	0.12	0.094
Cadmium	mg/L	0.05	12	11	11	9.2	6.5
Copper	mg/L	0.5	1,966	12	0.78	0.38	0.15
Iron	mg/L	2	49,244	12,000	5,800	3,300	3,000
Lead	mg/L	0.2	3.04	0.55	0.55	0.49	0.41
Nickel	mg/L	0.5 [1]	3.11	*4*	*4*	*4*	*4*
Zinc	mg/L	1.5	5,761	2,000	670	240	120

Bench Test Results



Bench Testing Results

Conclusions

Project Goals

- Meet LMP standards
  - HDS and Limestone/Lime both meet LMP standards
  - HDS can meet ECA standard for Mn
  - Sulfate minimized to near solubility at end of pipe
- Expand treatment plant capacity
- Reduce operating costs
  - HDS: 10-20% reduction
  - Limestone/Lime: 35% reduction

Thank You!

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