Deloitte & Touche

Water Treatment Costs

Prepared for:

DELOITTE & TOUCHE INC.
Interim Receiver of Anvil Range Mining Corporation
Suite 1900, 79 Wellington Street West
Toronto, Ontario, M5K 1B9

Prepared by:

SRK Consulting
Engineers and Scientists

Web Address: http://www.srk.com
e-mail: vancouver@srk.com

Project Reference Number:
SRK 1CD003.32

June 2004

Water Treatment Costs

Deloitte & Touche

Interim Receiver of Anvil Range Mining Corporation
Suite 1900, 79 Wellington Street West
Toronto, Ontario, M5K 1B9

SRK Consulting (Canada) Inc.
Suite 800, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

SRK Project Number 1CD003.32

June 2004

Prepared by:

J.T. Chapman, P.Eng.

Reviewed by:

D.E. Hockley, P.Eng

Table of Contents

1 Introduction ... 1
1.1 Terms of Reference ... 1
1.2 Background ... 1
1.3 Objectives ... 1
1.4 Scope of Work ... 1

2 Current Water Treatment Costs ... 3
2.1 System Descriptions ... 3
2.2 Current Operating Conditions ... 3
2.2.1 Vangorda/Grum ... 3
2.2.2 Faro Mill ... 4
2.2.3 Down Valley ... 5
2.3 Estimated System Performance ... 6
2.4 Estimated Operating Costs ... 7

3 HDS Water Treatment ... 9
3.1 Vangorda/Grum Water ... 9
3.2 Faro Mill Water ... 10
3.3 Down Valley Water ... 10

4 Conclusions ... 12

5 References ... 14

List of Tables

Table 2.1: Summary of Vangorda/Grum Water Treatment Plant Influent Water Quality Monitoring Results ... 4
Table 2.2 Summary of Faro Pit Lake Water Quality Monitoring Results ... 5
Table 2.3: Summary of Down Valley Treatment System Influent Water Quality ... 6
Table 2.4: Calculated Lime Utilizations ... 6
Table 2.5: Calculated Lime Utilization Including Magnesium Removal ... 7
Table 2.6: Summary of Calculated Operating Costs ... 8
Table 3.1: Summary of HDS Treatment Plant Operating Costs Treating Vangorda/Grum Water ... 9
Table 3.2: Summary of HDS Treatment Plant Operating Costs Treating Faro Water ... 10
Table 3.3: Summary of HDS Treatment Plant Operating Costs Treating Faro Water ... 11

List of Appendices

Appendix A Operating Cost Calculations
Appendix B HDS Treatment System Modelling

1 Introduction

1.1 Terms of Reference

This project was initially conceived in program planning sessions carried out in a June 2003 planning workshop (Deloitte & Touche, 2003). A scope of work for the assessment of current water treatment costs at Anvil Range was presented in a letter from SRK to Deloitte & Touche, dated September 8, 2003. The scope of work was authorized later in September 2003.

1.2 Background

Three water treatment systems are being operated at the Anvil Range complex, comprising:

- The Vangorda/Grum water treatment plant, which is a purpose designed system,
- The Faro Mill water treatment system, which utilizes pre-existing mill equipment, and,
- The Down Valley water treatment system, which consists of a slaking plant and an in-line system to mix the lime slurry with tailings pond water.

Detailed descriptions of each of these facilities have been prepared by EBA Engineering Consultants (2003). That report included descriptions of the water management systems, but did not address water treatment costs.

1.3 Objectives

The primary objectives of this study were to:

- Develop updated water treatment performance and cost estimates based on the 2003 water treatment operations.
- Estimate sludge generation and disposal requirements that could be used to evaluate intermediate and long term water treatment cost implications for different closure scenarios.

1.4 Scope of Work

The water quality data for 2003 were compiled and reviewed to assess the water treatment system performance. For each system, chemical consumption rates and unit water treatment costs were assessed.

To provide a basis for comparison with standard High Density Sludge (HDS) water treatment performance and costs, Canadian Environmental & Metallurgical Inc. (CEMI) of Vancouver was commissioned to estimate feasibility level capital and operating costs, and sludge generation rates for the average water quality and flow rates for each of the three treatment systems.

Finally, the unit operating costs obtained from current water treatment practices, together with those from the HDS system modelling were summarised in a format suitable for direct use in the computer program AMD TREAT, developed by the U.S. Office of Surface Mine Reclamation and Enforcement. The computer program has a cost modeling capability which can be used to predict the future costs associated with water treatment requirements under various closure scenarios.

2 Current Water Treatment Costs

2.1 System Descriptions

The existing water treatment facilities at the Anvil Range Mining Complex comprise:

- The Vangorda/Grum water treatment plant;
- The Faro Mill water treatment system; and,
- The Down Valley water treatment system (currently located at the Intermediate Impoundment Spillway.

Detailed descriptions of these facilities are available in EBA Engineering Consultants (EBA, 2003) and are not repeated here. The reader is referred to that document for complete descriptions.

2.2 Current Operating Conditions

2.2.1 Vangorda/Grum

The Vangorda/Grum water treatment plant was operated for a total of 45 days during the summer of 2003. The system was down from June 28th to July 7th while awaiting laboratory test results before discharge could commence. Repositioning of the barge required that the system be shut down for 1 day on the 21st of July, and for 2 days on the 11th and 12th of August. On the 17th and 18th of August a further 2 days of operation were lost due to repairs to a faulty motor on the barge pump, as well as repositioning the barge.

During the operational period the average water treatment rate was 2,000 USgpm. Over the 45 days, a total of about 436,000 m^3 was treated in the system.

A total of 140 short tons of quick lime were used during this period and the average power consumption was about 700 kW. Staffing comprised a total of 8 operators, 2 operators per shift, working on a 4x4 -12 hr shift rotation.

The available influent water quality monitoring results are provided in Table 2.1. Acidity was not monitored but was calculated from the dissolved metal concentrations. As shown, dissolved zinc and manganese were elevated while the pH decreased slightly over the period, but remained near neutral. Iron increased marginally toward the end of the summer. This is likely a result of the draw-down of the Vangorda pit to an elevation where more reducing conditions were encountered.

Table 2.1: Summary of Vangorda/Grum Water Treatment Plant Influent Water Quality Monitoring Results

Date	Units	2003 Water Quality Results		
		Mar	Jun	Sep
Alkalinity*	mg/L	71	37	46
Acidity**	M`4L	149.8	109.5	168.2
pH		7.4	7.0	6.9
Al	mg/L	0.029	0.001	0.019
Fe	mg/L	0.116	0.334	1.55
Mn	mg/L	20.4	16.5	29.2
Zn	mg/L	73.3	51.3	72.5
SO_4	mg/L	808	635	1041
Ca	mg/L	179	146	262
Mg	mg/L	71.6	52.3	82.8
Na	mg/L	10.1	3.5	6.1
K	mg/L	4.9	3.0	4.7

Notes: * Acidity and Alkalinity in units of CaCO3 eq
** Acidity calculated from metal concentrations.

2.2.2 Faro Mill

The Faro Mill water treatment system was operated for a total of 66 days during the summer of 2003, with no down time during this period.

Water was treated in the system at an average flow rate of about 5,300 USgpm. An estimated total volume of 1,906,000 m^3 of water was treated during the operational period of the system, using a total of 240 short tons of quicklime.

The average power consumption during this period, which included the lighting circuit, was about 800 kW. Staffing comprised a total of 4 operators, 1 operator per shift, working on a 4x4 -12 hr shift rotation.

The available water quality monitoring results are shown in Table 2.2. Again, the acidity was not monitored but was calculated from the dissolved metal concentrations. The results indicated that the pH remained slightly alkaline through the treatment period.

Table 2.2 Summary of Faro Pit Lake Water Quality Monitoring Results

Date	Units	2003 Monitoring Results				
		May	Jun	Jul	Aug	Sep
Acidity	mg/L	11.2	23.8	21.2	21.9	26.8
pH		7.8	7.4	7.4	7.6	7.7
Al	mg/L	0.109	0.007	0.022	0.024	0.060
Fe	mg/L	0.058	0.139	0.103	0.226	0.265
Mn	mg/L	0.465	2.807	2.717	2.508	2.617
Zn	mg/L	6.273	11.980	10.379	10.873	13.751
SO_4	mg/L	132	647	657	574	588
Ca	mg/L	34.0	160.2	159.6	144.5	147.2
Mg	mg/L	13.4	60.2	60.1	56.6	60.5
Na	mg/L	3.5	24.6	23.1	19.6	20.1
K	mg/L	1.9	14.9	14.3	11.7	12.1

Notes: * Acidity calculated form metal concentrations in units of CaCO3 eq.

2.2.3 Down Valley

The Down Valley water treatment system was operated for a total of 54 days during the summer of 2003. The system experienced no down time during the treatment period. Water was siphoned and treated in the system at an average flow rate of 1,500 USgpm, which resulted in the treatment of approximately 442,000 m^3 of water. A total of 220 short tons of quick lime were used to treat the water.

Power for operating the treatment system was generated with a CAT 350 kW generator set. Actual power draw was approximately 175 kW. Diesel fuel consumption was about 200 US gallons per day.

The system was run using 4 operators, 1 operator per shift, rotated on a 4x4 -12 hr shift rotation.

The available influent water quality monitoring results are provided in Table 2.3. Compared to the water treated in the Faro Mill and Vangorda/Grum treatment systems, the water treated in Cross Valley dam initially contained elevated iron concentrations. The iron concentration gradually decreased to below 1 mg/L by July. Since the pH did not decrease over this period, the results indicate that excess alkalinity was present in the water to neutralize the acidity associated with the iron.

Table 2.3: Summary of Down Valley Treatment System Influent Water Quality

Parameter	Units	2003 Monitoring Results								
		Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct
Acidity*	mg/L	78.6	93.8	84.1	87.2	41.8	36.1	37.7	38.9	40.5
pH		7.5	7.3	7.3	7.4	7.5	7.5	7.3	7.5	7.4
Al	mg/L	0.049	0.062	0.076	0.242	0.051	0.022	0.060	0.074	0.010
Fe	mg/L	10.9	19.1	15.9	17.0	1.3	0.19	0.39	0.28	0.12
Mn	mg/L	12.9	13.2	14.4	14.1	9.1	10.2	11.2	10.9	11.5
Zn	mg/L	16.7	11.9	9.7	9.4	14.1	11.0	10.4	11.7	12.5
SO_4	mg/L	799	727	649	652	656	719	720	759	740
Ca	mg/L	202	199	211	207	163	184	185	184	201
Mg	mg/L	56.2	46.1	45.6	42.9	44.0	50.7	51.5	53.7	56.0
Na	mg/L	18.1	16.6	18.3	16.5	11.5	13.1	13.5	13.5	14.1
K	mg/L	6.5	6.1	7.0	6.9	4.7	5.2	5.3	5.2	5.6

Notes: * Acidity in units of CaCO3 eq calculated from metal concentrations.

2.3 Estimated System Performance

The lime efficiencies for each of the three current systems were calculated from the total lime consumed and the calculated acidity in the treatment system influent. The calculation accounts for the lime equivalent required to increase the pH above 9.5 to achieve zinc removal. The results, as shown in Table 2.4, indicate that the lime utilization is highest for the Vangorda/Grum water treatment plant, and lowest for the Down Valley system. This is not unexpected since the Vangorda/Grum treatment plant is a purpose designed and built system. In the Down Valley system, the contact time is very short and the amount of agitation is very limited, which explains the lower utilization. Lime utilization in the Faro Mill system is better than that of the Down Valley system, but remains low at about 15 %.

Table 2.4: Calculated Lime Utilizations

Parameter	Units	Faro Mill	Vangorda	Down Valley
Volume Treated	m^3	1,906,550	436,032	441,482
Average Acidity	mg $CaCO_3$ eq/L	27.9	142.5	59.8
Equiv. to pH 9.5	mg $CaCO_3$ eq/L	1.6	1.6	1.6
Total Acidity Equivalent	**mg $CaCO_3$ eq/L**	**29.5**	**144.1**	**61.4**
Lime consumed	short tons	240	140	220
Acidity equivalent	mg $CaCO_3$ eq/L	204	520	807
Lime Utilization	%	14.5	27.7	7.6

The water quality monitoring results also indicate a reduction in magnesium concentrations during treatment. Therefore, a proportion of the lime is consumed by the precipitation of magnesium hydroxide. Accounting for the precipitation of magnesium from solution the lime utilizations were recalculated as shown in Table 2.5. These calculations assume that all of the dissolved magnesium is removed as hydroxide precipitates. However, in reality, only a proportion of the magnesium will be removed and the actual proportion that is removed would depend strongly on the actual pH achieved in the effluent water. The expected actual utilization is likely to fall somewhere between those shown in Table 2.4 and those shown in Table 2.5.

Table 2.5: Calculated Lime Utilization Including Magnesium Removal

Parameter	Units	Faro Mill	Vangorda	Down Valley
Volume Treated	m^3	1,906,550	436,032	441,482
Average Acidity	mg $CaCO_3$ eq/L	27.9	142.5	59.8
To pH Endpoint 9.5	mg $CaCO_3$ eq/L	1.6	1.6	1.6
Mg removal	mg $CaCO_3$ eq/L	27	84	12
Total Acidity Equivalent	**mg $CaCO_3$ eq/L**	**56**	**228**	**74**
Lime consumed	short tons	240	140	220
Acidity equivalent	mg $CaCO_3$ eq/L	204	520	807
Lime Utilization	%	27.5	43.9	9.1

In the lime neutralization testing completed by Gartner Lee Limited (GLL, 2003), Grum water was treated with both lime and sodium hydroxide. A comparison of these results suggests that, at pH 9.5, the lime is only about 70% available under ideal conditions. The estimated lime utilization for the Vangorda/Grum plant is lower than the availability indicated by the GLL testing due to inefficiencies in the operating conditions. This likely represents an upper bound for the lime delivered to site.

2.4 Estimated Operating Costs

The 2003 operating costs were calculated for each of the systems and are shown in Table 2.6. Complete calculations are provided in Appendix A. The calculations utilized a unit cost for lime FOB the site of $320 per short ton, power at $0.13 per kWh and labour at $21.03 per hour. The costs for commissioning and mothballing the systems are not included in the operating cost summary.

As shown in Table 2.6, the power costs represent the major proportion of the overall operating costs for the Faro Mill system. The power cost of the Faro Mill system is also significantly higher than for the other systems. In the case of the Vangorda/Grum plant, labour costs are disproportionately high compared to the other systems. For the Down Valley system, the lime costs are disproportionately high due to the low lime utilization rate.

Table 2.6: Summary of Calculated Operating Costs

Parameter	Faro Mill	Vangorda	Down Valley
Overall Operating Costs			
Quick Lime	$76,800	$44,800	$70,400
Power	$164,736	$87,360	$29,484
Labour	$33,312	$45,425	$27,255
Total	$274,848	$177,585	$127,139
Unit Operating Costs ($/m^3)			
Quick Lime	0.040	0.103	0.159
Power	0.086	0.200	0.067
Labour	0.017	0.104	0.062
Total	0.144	0.407	0.288

3 HDS Water Treatment

The current water quality and flow rates were input to a numerical model that simulates a high density sludge (HDS) treatment system to provide a direct comparison with current operating strategies, and allow projection of potential future water treatment capital and operating costs. The modelling results are presented in Appendix B, and key estimated operating and capital costs are summarised below. It should be noted that the HDS water treatment modelling assumes that the systems would be operated year round. Therefore, the capital costs for these systems are not directly comparable to those of the current systems. Operating costs, however, can be compared.

The estimated sludge generation rates in these calculations also assume that only 20 % of the magnesium would be precipitated from solution.

3.1 Vangorda/Grum Water

The HDS plant modelling indicates that the normalised operating costs for an HDS treatment plant treating Vangorda/Grum water will be about $0.21 per m^3. The current normalised treatment costs are about $0.407 per m^3. The primary reason for this is that the current Vangorda treatment system is operated with two operators. A modern HDS system generally is fully automated, and can be operated by a single operator working an 8 hour day.

The estimated operating costs are shown in Table 3.1. The estimated capital cost for a treatment plant treating 7,571 L/min (2,000 USgpm) is about $4,670,000.

The modelling also indicated that the sludge generation from this water would be expected to be about 0.23 g/L of water treated, which can be used to project future sludge generation rates. The sludge that would be generated is expected to be at about 20% solids.

Table 3.1: Summary of HDS Treatment Plant Operating Costs Treating Vangorda/Grum Water

Item	Units	Consumption	Unit Cost (CDN$)	Annual Cost (CDN$/year)
Quicklime	tonnes/year	784*	320	$ 251,000
Flocculant	tonnes/year	12	6,000	$ 71,000
Electric Power	million kW-hours	2.42	0.13	$ 314,000
O & M Capital	% of capital cost	3	4,670,000	$ 140,000
O & M Manpower	man-hours per day	8	21.03	$ 61,000
Annual Operating Costs				**$ 837,000**
Normalized Annual Operating Cost:				**$ 0.21 /m^3**

Note: *Based on average water quality for 2003

3.2 Faro Mill Water

The HDS plant modelling suggests that the normalised operating costs for an HDS treatment plant used to treat water currently treated in the Faro Mill treatment system will be about \$0.14 per m^3. This compares well with the current normalised treatment cost of about \$0.144 per m3 for the existing system.

The similarity in costs is partly due to the allowance for flocculant and an operating and maintenance (O and M) which is not accounted for in the existing treatment system operating costs.

The estimated operating costs are shown in Table 3.2. The estimated capital cost for an HDS treatment plant treating 20,062 L/min (5,300 USgpm) is about \$8,790,000.

The estimated rate of sludge generation for this water is expected to be about 0.10 g/L. The sludge that would be generated is expected to be at about 20% solids.

Table 3.2: Summary of HDS Treatment Plant Operating Costs Treating Faro Water

Item	Units	Consumption	Unit Cost (CDN\$)	Annual Cost (CDN\$/year)
Quicklime	tonnes/year	1,294*	320	\$ 414,000
Flocculant	tonnes/year	32	6,000	\$ 191,000
Electric Power	million kW-hours	4.57	0.13	\$ 594,000
O & M Capital	% of capital cost	3	8,790,000	\$ 264,000
O & M Manpower	man-hours per day	8	21.03	\$ 61,000
Annual Operating Costs				**\$ 1,524,000**
Normalized Annual Operating Cost:				**\$ 0.14 /m^3**

Note: * based on worst water quality encountered during 2003.

3.3 Down Valley Water

The HDS plant modelling indicates that the normalised operating costs for an HDS treatment plant treating water currently treated in the Down Valley treatment system will be about \$0.21 per m3. The estimated current normalised treatment cost is about \$0.29 per m^3.

The estimated operating costs are shown in Table 3.3. The estimated capital cost for an HDS treatment plant treating 5,678 L/min (1,500 USgpm) is about \$3,870,000.

The estimated rate of sludge generation for this water is expected to be about 0.15 g per litre of water treated. The sludge that would be generated is expected to be at about 20% solids.

Table 3.3: Summary of HDS Treatment Plant Operating Costs Treating Faro Water

Item	Units	Consumption	Unit Cost (CDN$)	Annual Cost (CDN$/year)
Quicklime	tonnes/year	429*	320	$137,000
Flocculant	tonnes/year	8.9	6,000	$53,660
Electric Power	million kW-hours	2.03	0.13	$263,000
O & M Capital	% of capital cost	3	3,870,000	$116,000
O & M Manpower	man-hours per day	8	21.00	$61,000
Annual Operating Costs				**$631,000**
Normalized Annual Operating Cost:				**$0.21 /$m^3$**

Note: * Based on average water quality encountered during 2003.

4 Conclusions

The assessment of the existing Anvil Range water treatment systems has indicated that the lime utilization ranges from about 9.1 percent for the Down Valley water treatment system, to about 44 percent for the purpose designed and built Vangorda/Grum water treatment plant. The lime utilization in the Faro Mill treatment system is about 28 percent. These estimates were derived based on the available influent water quality monitoring data, which is limited and is typically collected on a monthly basis. Variability in the water quality will have a significant impact on the estimated utilizations. The estimated utilizations are also dependent on the proportion of magnesium removed. Nonetheless, the results indicate a significantly improved utilization for the purpose built Vangorda/Grum system over the Faro Mill and Down Valley systems.

Unit operating costs were derived for each of the treatment systems, and water quality types treated in the systems. CEMI was also commissioned to model HDS treatment systems and to estimate the expected performance, operating and capital costs. The unit costs are as follows:

		Faro Mill	Vangorda	Down Valley
Existing System				
Flow	US gpm	5,300	2,000	1,500
Lime consumption	g/L as CaO	0.114	0.291	0.452
Lime utilization	%	27.5	43.9	9.1
Unit Operating Cost	$/m^3$	0.144	0.407	0.288
HDS System				
Flow	US gpm	5,300	2,000	1,500
Lime consumption	g/L as CaO	0.123	0.197	0.144
Lime utilization	%	87	87	87
Sludge generation	g/L	0.097	0.228	0.151
Capital Cost	$	8,790,000	4,670,000	3,870,000
Unit Operating Cost	$/m^3$	0.144	0.210	0.211

As shown in the table above, the HDS system lime consumption is expected to be significantly lower than for the Vangorda and Down Valley systems. For these calculations, the average water quality was used in all calculations. In contrast, the estimates for the Faro Mill are very similar. The reason for this is that the HDS system calculations were based on the peak worst water quality encountered over the treatment period rather than the average water quality as was the case for the other two systems. Hence, higher lime consumption resulted, even though higher lime utilization was assumed for the HDS system.

The lower unit operating costs estimated for the Vangorda and Down Valley HDS systems are primarily a result of the improved lime utilization and the lower labour costs anticipated for a fully automated treatment system.

In conclusion, the estimated operating and capital costs provide a range of rates for various conditions that can be used to assess post closure treatment costs. Furthermore, these unit operating costs and estimated capital costs can be utilized directly in the computer program AMD TREAT, developed by the U.S. Office of Surface Mine Reclamation and Enforcement. The computer program has a forward cost modeling capability which can be used to predict the water treatment costs associated with the various closure measures that will be considered over the next several months.

5 References

EBA Engineering Consultants Ltd., 2003. Anvil Range Mine Complex, Existing Water Treatment Facilities. Prepared for Deloitte & Touche, October 2003.

Deloitte & Touche Inc., 2003. Supplementary Sheet for 2003-2004 Projects, July 2003.

Gartner Lee Ltd. (2003). Anvil Range Mine, 2003 Studies of Care and Maintenance Management Alternatives for Grum Pit, Ref. GLL 23-586, October 2003.

Appendix A

Operating Cost Calculations

	Unit Costs	
Lime	$ 320.00	per short ton
Power	$ 0.13	per kWh
Labour	$ 21.03	per hour

Parameter	Units	Faro Mill	Vangorda	Down Valley
Operating Period	days	66	45	54
Downtime	days	0	5	0
Flow Rate	USgpm	5300	2000	1500
	L/s	334	126	95
Volume Treated	m3	1,906,550	436,032	441,482
Lime consumption				
Consumed	short tons	240	140	220
	kg CaO	217,723	127,005	199,580
	mgCaO/L	114	291	452
	mg CaCO3 eq/L	204	520	807
Power				
Draw	kWh	800	700	175
Consumed	kWh	1267200	672000	226800
Genset Fuel	gals/day	n/a	na	200
Shift	hr	12	12	12
Rotation		4x4	4x4	4x4
Operators	Total	4	8	4
Operators/shift		2	4	2
Operating Costs				
Quick Lime		$ 76,800	$ 44,800	$ 70,400
Power		$ 164,736	$ 87,360	$ 29,484
Labour		$ 33,312	$ 45,425	$ 27,255
Total		$ 274,848	$ 177,585	$ 127,139
Unit Operating Costs				
Quick Lime	$/m3	0.040	0.103	0.159
Power	$/m3	0.086	0.200	0.067
Labour	$/m3	0.017	0.104	0.062
Total	$/m3	0.144	0.407	0.288

Appendix B

HDS Treatment System Modelling

APPENDIX B

HDS Treatment System Modelling

HDS Process Design

Faro Mill
5300 usgpm

14 December, 2003
Conceptual Design
Rev. 1

General Design Information

Design Flowrate:	20,062	L/min
Solids Generation	0.10	g/L plant feed
Recycle Ratio	69.9	(?:1)
Solids SG	2.8	
Feed pH	7.3	
Reactor pH	9.3	pH Units
Lime Sludge Mix Tank pH	13.5	pH Units
Clarifier U/F Density	20	%
Clarifier Overflow Solids	0	mg/L

Aeration Requirements

Feed Iron Content	0.3	mg/L
Percentage Ferrous Iron	100	%
Average Density of Air	1.201	kg/m^3
Oxygen Transfer Efficiency	20	%

Vessel Residence Times:

Reactor Residence Time	60	minutes
Lime Sludge Mix Tank	5	minutes
Clarifier Upflow Ratio	1.200	$(m^3/hr)/m^2$
Recycle Water Tank	0.5	minutes

Flocculant Dosing System

Flocculant Dose Rate	440	mg floc/kg solids (range from 50 to 200)
Flocculant Addition Rate	3.0	mg floc/L plant feed (range from 1 to 10)
Undiluted Floc Concentration	0.5	%

Lime Dosing System

Lime Addition Rate (as $Ca(OH)_2$)	0.15	g lime/L plant feed
Lime Slurry Concentration	12	%
Slurry pH	14	pH Units
Solids SG	2.4	
Storage Requirements	24	hours
Available CaO	92.0	%
Lime use	0.12	g lime (CaO)/L plant feed

Operating Costs

Lime Cost	320	CDN$/tonne		
Flocculant Cost	6000	CDN$/tonne		
Power Cost	700	hp	0.13	CDN$/kw-hour
Manpower Cost	8	man-hours/day	21.03	CDN$/man-hour
O&M Capital	3	% of capital cost	8,790,000	CDN$ total capital

Water Quality and Sludge Generation Prediction

HDS Process Design
Faro Mill
5300 usgpm
14 December, 2003

Ion	Ion Wt. (g/mol)	Hydroxide Formula	Hydroxide Weight (g/mol)	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)
Al	26.98	$Al(OH)_3$	78.01	0.12	0.23	0.35
Ag	107.87	AgOH	124.88	0.00	0.00	0.00
As	74.92	$As(OH)_3$	125.95	0.00	0.00	0.00
Bi	208.98	$Bi(OH)_3$	260.01	0.00	0.00	0.00
Ca	40.08	$Ca(OH)_2$	74.1	160.20	0.00	0.00
Cd	112.41	$Cd(OH)_2$	146.43	0.00	0.00	0.00
Cu	63.55	$Cu(OH)_2$	97.57	0.00	0.00	0.00
Fe	55.85	$Fe(OH)_3$	106.88	0.30	0.27	0.57
Pb	207.2	$Pb(OH)_2$	241.22	0.00	0.00	0.00
Mg	24.31	$Mg(OH)_2$	58.33	12.94	18.11	31.05
Mn	54.94	MnO_2	86.94	2.80	0.00	4.43
Ni	58.71	$Ni(OH)_2$	92.73	0.00	0.00	0.00
S*	32.06	$CaSO_4.2H_2O$	172.18	0.00	0.00	0.00
Sb	121.75	$Sb(OH)_3$	172.78	0.00	0.00	0.00
Se	78.96	$Se(OH)_4$	147	0.00	0.00	0.00
Si	28.09	$Si(OH)_2$	62.11	0.00	0.00	0.00
Zn	65.38	$Zn(OH)_2$	99.4	28.50	14.83	43.33
SO_4^{2-}*	96.06	$CaSO_4.2H_2O$	172.18	657.00	0.00	0.00
CO_3^{2-}	59.98	$CaCO_3$	100.06	0.00	0.00	0.00
TSS	n/a	n/a	n/a	n/a	n/a	0.00
Total					**33.44**	**79.73**

Residual SO_4^{2-} concentration 1800 mg/L (pure solubility range from 1240 - 1435 mg/L)

*** Use either (S) or (SO4).**

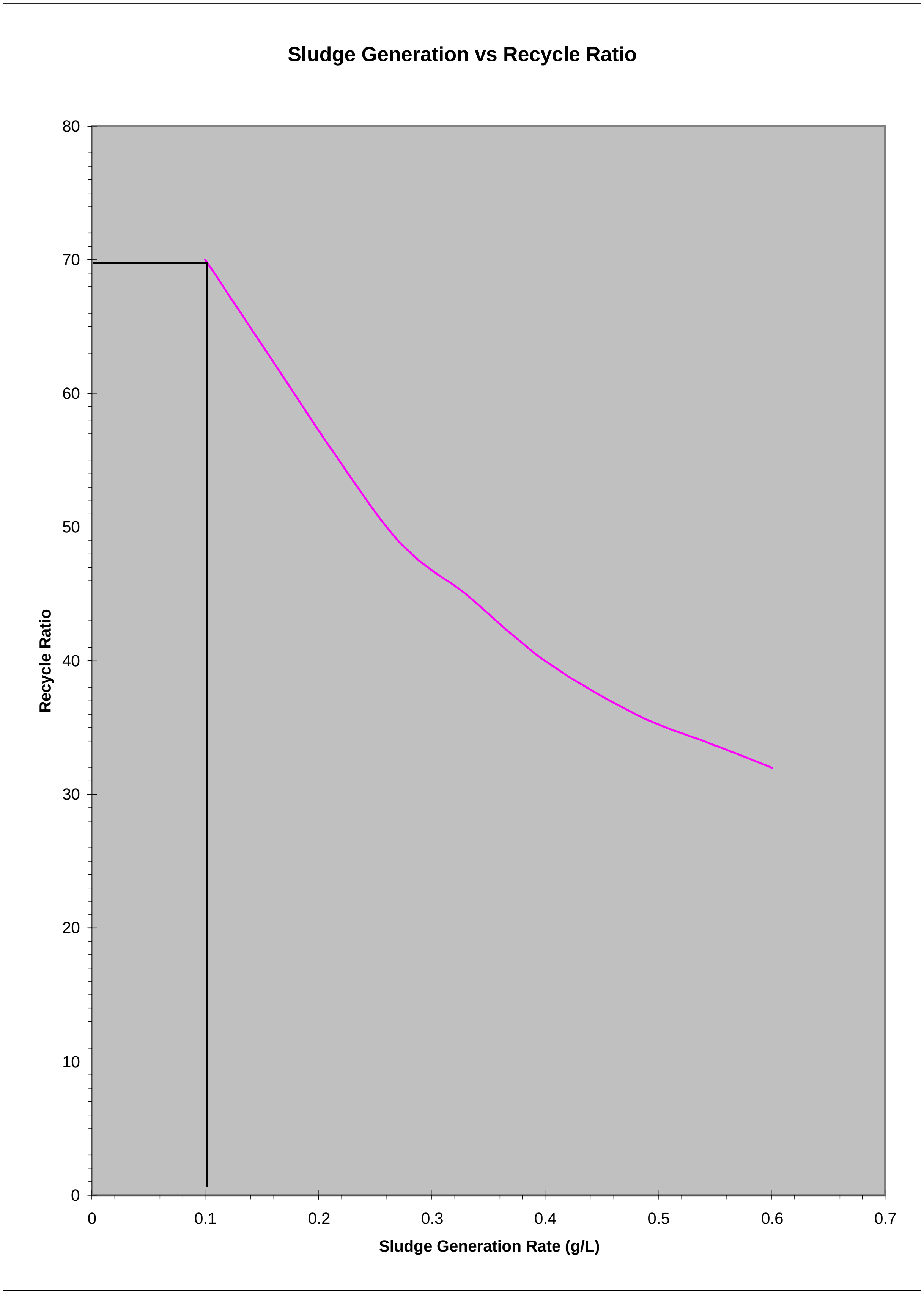
Solids Generation = 0.10 g/L
(includes 8.0 % lime enerts)
(includes 5.0 % unreacted lime solids)

<u>Lime Requirements</u>

Based on calcium requirements	0.21	g Ca(OH)2/L effluent	**OR**	(SO_4^{2-} based)
	0.00	g Ca(OH)2/L effluent		(S based)
Based on hydroxide requirements	0.07	g Ca(OH)2/L effluent		

Lime Utilization = 95.0 %
Available CaO = 92.0 %

Lime use = 0.15 g $Ca(OH)_2$/L effluent
Lime use = 0.12 g lime (CaO)/L effluent


Sludge Generation vs Recycle Ratio
Recycle Ratio
Sludge Generation Rate (g/L)
0
10
20
30
40
50
60
70
80
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Sludge Quality Prediction

HDS Process Design
Faro Mill
5300 usgpm
14 December, 2003

Ion	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)	Mass of Metal (mg/L)	Sludge Composition (%)
Al	0.12	0.23	0.35	0.12	0.12
Ag	0.00	0.00	0.00	0.00	0.00
As	0.00	0.00	0.00	0.00	0.00
Bi	0.00	0.00	0.00	0.00	0.00
Ca	160.20	0.00	0.00	0.00	0.00
Cd	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	0.00	0.00	0.00
Fe	0.30	0.27	0.57	0.30	0.31
Pb	0.00	0.00	0.00	0.00	0.00
Mg	12.94	18.11	31.05	12.94	13.34
Mn	2.80	0.00	4.43	2.80	2.89
Ni	0.00	0.00	0.00	0.00	0.00
$CaSO_4.2H_2O$	0.00	0.00	0.00	n/a	0.00
Sb	0.00	0.00	0.00	0.00	0.00
Se	0.00	0.00	0.00	0.00	0.00
Si	0.00	0.00	0.00	0.00	0.00
Zn	28.50	14.83	43.33	28.50	29.38
$CaSO_4.2H_2O$	657.00	0.00	0.00	n/a	0.00
$CaCO_3$	0.00	0.00	0.00	n/a	0.00
TSS	n/a	n/a	0.00	n/a	0.00
Lime Inerts	n/a	n/a	17.28	n/a	17.81
Total		**33.44**	**97.01**	**44.66**	**63.85**

Balance Check: 100.00 %

Solids generation =	0.1 g/L	
Ultimate drained percent solids =	50 %	
Sludge pond lifetime =	20 years	

Annual Average Data:

Operating days =	365 days/year	
Plant feed rate =	20,062 L/minute	
Total dry solids production =	2.8 tonnes/day	1023.0 tonnes/year
Sludge volume purged =	12.2 m^3/day	4457.2 m^3/year
Volume at ultimate density =	3.8 m^3/day	1388.3 m^3/year
Pond volume required =	27,770 m^3	

Vessel Sizes

				Tank Dimensions (no freeboard included)		aspect ratio
Lime Sludge Mix Tank:	3 m^3 =	816 USgal	D =	1.7 m or 5.6 ft	H = 1.4 m or 4.5 ft	1.25
Reactor Vessels:	1241 m^3 =	327785 USgal	D =	12.9 m or 42.2 ft	H = 9.5 m or 31.3 ft	1.35
Clarifier Diameter:	36 m =	118 ft				
Lime Storage Tank:	36 m^3 =	9592 USgal	D =	3.8 m or 12.5 ft	H = 3.2 m or 10.5 ft	1.19
Recycled Water Tank:	10 m^3 =	2669 USgal	D =	2.5 m or 8.2 ft	H = 2.1 m or 6.8 ft	1.21

Aeration Requirements

Total Iron Content =	0	mg/L
Percent Ferrous Iron =	100	%
Oxygen Transfer Efficiency =	20	%
Total Flow In =	20062	L/min
Total Ferrous Iron =	0.0	kg/min
=	0.4	kg/hr
Aeration required =	**1.0**	m^3/hour
=	**0.6**	SCFM

Sludge and Reagent Flowrates

Sludge Purge and Recycle

Sludge Purge Data

Sludge Purge = Solids Generation =	2	kg/min =	4	lbs/min
Solids Volume =	1	L/min =	0	USgpm
Water Flow =	8	L/min =	2	USgpm
Total Flow =	8	L/min =	2	USgpm
SG Slurry =	1.15			
pH Slurry =	9.3	pH Units		
SG Solids =	2.8			
Slurry % Solids =	20.00	%		

Sludge Recycle Data

Solids Recycled =	136	kg/min =	300	lbs/min
Solids Volume =	49	L/min =	13	USgpm
Water Flow =	544	L/min =	144	USgpm
Total Flow =	593	L/min =	157	USgpm
SG Slury =	1.15			
pH Slurry =	9.3	pH Units		
SG Solids =	2.8			
Slurry % Solids =	20.00	%		

Lime Circuit

Lime Dosing

Solids Mass =	3	kg/min =	7	lbs/min
Solids Volume =	1	L/min =	0	USgpm
Water Flow =	24	L/min =	6	USgpm
Total Slurry Flow =	25	L/min =	7	USgpm
Slurry SG =	1.08			
pH Slurry =	14	pH Units		
SG Solids =	2.4			
Slurry % Solids =	12.00	%		

Lime Loop Out Of Storage Tank

Solids Mass =	13	kg/min =	29	lbs/min
Solids Volume =	5	L/min =	1	USgpm
Water Flow =	95	L/min =	25	USgpm
Total Slurry Flow =	101	L/min =	27	USgpm
Slurry SG =	1.08			
pH Slurry =	14	pH Units		
SG Solids =	2.4			
Slurry % Solids =	12.00	%		

Lime Loop Return To Storage Tank

Solids Mass =	10	kg/min =	22	lbs/min
Solids Volume =	4	L/min =	1	USgpm
Water Flow =	72	L/min =	19	USgpm
Total Slurry Flow =	76	L/min =	20	USgpm
Slurry SG =	1.08			
pH Slurry =	14	pH Units		
SG Solids =	2.4			
Slurry % Solids =	12.00	%		

Flocculant Dosing

Floc Dosing Rate =	3	mg/L effluent treated		
Flow Into Floc Tank =	20680	L/min =	5463	USgpm
Undiluted Floc Flowrate =	13	L/min =	3	USgpm
Diluted Floc Flowrate =	125	L/min =	33	USgpm
Floc Consumption =	90	kg/day =	199	lbs/day

Lime Dosing

Lime Dosing Rate =	0.1	g lime/L effluent treated
Lime Dosing Rate =	0.1	g lime (CaO + inerts)/L \treated
Average Plant Feed =	20062.25	L/minute
Daily Consumption =	3.5	tonnes/day
Annual Consumption=	1294	tonnes/year quicklime

Tank Flows

Out Of Lime/Sludge Mix Tank

Solids Mass =	139	kg/min =	307	lbs/min
Solids Volume =	50	L/min =	13	USgpm
Water Flow =	568	L/min =	150	USgpm
Total Slurry Flow =	618	L/min =	163	USgpm
Slurry SG =	1.14			
pH Slurry =	13.5	pH Units		
SG Solids =	2.79			
Slurry % Solids =	19.69	%		

Out Of Reactor Tank

Solids Mass =	138	kg/min =	304	lbs/min
Solids Volume =	49	L/min =	13	USgpm
Water Flow =	20630	L/min =	5450	USgpm
Total Slurry Flow =	20680	L/min =	5463	USgpm
Slurry SG =	1.00			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	0.66	%		

Into Clarifier

Solids Mass =	138	kg/min =	304	lbs/min
Solids Volume =	49	L/min =	13	USgpm
Water Flow =	20755	L/min =	5483	USgpm
Total Slurry Flow =	20805	L/min =	5496	USgpm
Slurry SG =	1.00			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	**0.66**	%		

Clarifier Flows

Clarifier Overflow

Solids Mass =	0	kg/min =	0	lbs/min
Solids Volume =	0	L/min =	0	USgpm
Water Flow =	20203	L/min =	5337	USgpm
Total Slurry Flow =	20203	L/min =	5337	USgpm
Slurry SG =	1			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	0	%		

Clarifier Underflow

Solids Mass =	138	kg/min =	304	lbs/min
Solids Volume =	49	L/min =	13	USgpm
Water Flow =	552	L/min =	146	USgpm
Total Slurry Flow =	601	L/min =	159	USgpm
Slurry SG =	1.15			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	20.00	%		

Balance Check (Overall)

Total Solids In =	1.95	kg/min	Total Water In =	20211	L/min
Total Solids Out =	1.95	kg/min	Total Water Out =	20211	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Balance Check (Clarifier)

Total Solids In =	138	kg/min	Total Water In =	20755	L/min
Total Solids Out =	138	kg/min	Total Water Out =	20755	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Operating Cost Estimate

Faro Mill
5300 usgpm
14 December, 2003

Reagent	Dose Rate (mg/L plant feed)	Annual Average Plant Flow Rate (L/min)	Annual Reagent Consumption (tonnes/year)	Reagent Unit Cost (CDN$/tonne)	Annual Reagent Cost (CDN$/year)
Quicklime	123	20,062	1294	320	414,000
Flocculant	3	20,062	32	6000	191,000
				Sub-total:	**$605,000**

Item	Annual Consumption	Unit Cost (CDN$)	Annual Cost (CDN$/year)
Electric Power	4.57 million kW-hours	0.13	594,000
O & M Capital	3 % of capital cost	8790000	264,000
O & M Manpower	8 man-hours per day	21.03	61,000
		Sub-total:	**$919,000**

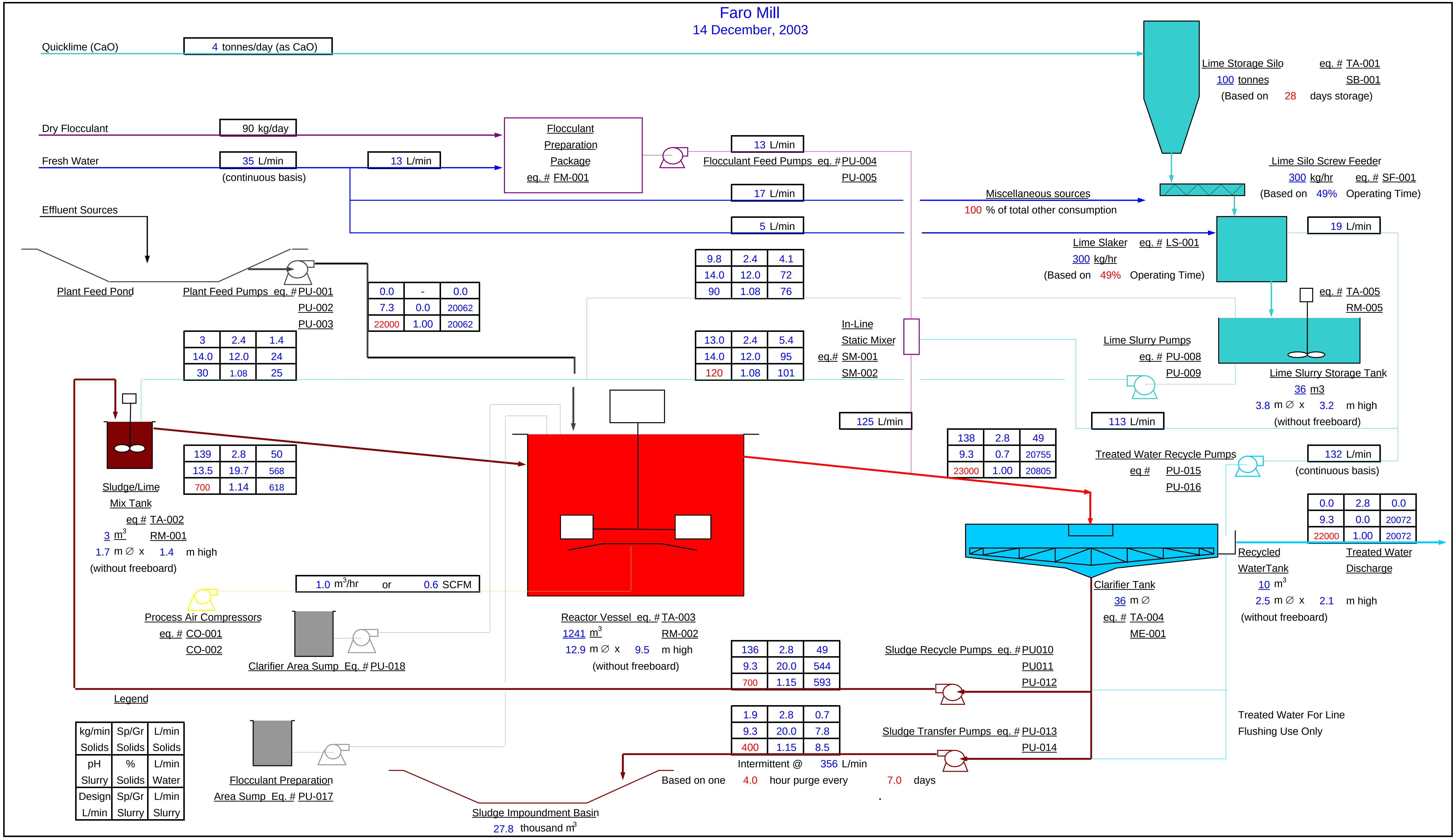
Total Annual Operating Cost:	**$1,524,000**	**/year**	(CDN dollars)
Normalized Annual Operating Cost:	**$0.14**	**/m^3**	(CDN dollars)
	$0.55	**/1000 USgal**	(CDN dollars)

Discount Interest Rate:	10%	
Expected Plant Lifetime:	20	years
Present Value of Plant Operating Costs:	**$12,975,000**	**CDN dollars**
Net Present Value of Plant:	**$21,765,000**	**CDN dollars**

Mechanical Equipment List

Faro Mill
5300 usgpm

Equipment Number	Description	Motor hp	Type	Capacity/Size	Material
FM-001	Flocculant Preparation System	** AMP	Vendor Package	180 kg/day	
SM-001	Flocculant Static Mixer			188 L/min	
SM-002	Flocculant Static Mixer			188 L/min	
TA-001	Lime Storage Silo	** HP		100 tonnes	c.s.
SB-001	Lime Silo Baghouse				
SF-001	Lime Silo Screw Feeder	** HP		300 kg/hour	c.s.
LS-001	Lime Slaker	* HP + ** HP		300 kg/hour	
CO-001	Process Air Compressor #1	** HP		1 m^3/hour	
CO-002	Process Air Compressor #2	** HP		1 m^3/hour	
RM-001	Sludge/Lime Mix Tank Agitator	** HP			c.s.
RM-002	Lime Reactor #2 Tank Agitator	** HP			c.s.
ME-001	Clarifier Rake Mechanism	** HP + ** HP			c.s.
RM-005	Lime Slurry Storage Tank Agitator	** HP			c.s.
PU-001	Plant Feed Pump #1 V.S.D.	** HP	Vertical Turbine	11000 L/min	
PU-002	Plant Feed Pump #2 V.S.D.	** HP	Vertical Turbine	11000 L/min	
PU-003	Plant Feed Pump #3 V.S.D.	** HP	Vertical Turbine	11000 L/min	
PU-004	Flocculant Feed Pump #1	** HP	Prog. Cavity	19 L/min	
PU-005	Flocculant Feed Pump #2	** HP	Prog. Cavity	19 L/min	
PU-008	Lime Slurry Pump #1	** HP	Cantilever	120 L/min	
PU-009	Lime Slurry Pump #2	** HP	Cantilever	120 L/min	
PU010	Sludge Recycle Pump #1 V.S.D.	** HP	Centrifugal	350 L/min	
PU011	Sludge Recycle Pump #2 V.S.D.	** HP	Centrifugal	350 L/min	
PU-012	Sludge Recycle Pump #3 V.S.D.	** HP	Centrifugal	350 L/min	
PU-013	Sludge Transfer Pump #1	** HP	Centrifugal	400 L/min	
PU-014	Sludge Transfer Pump #2	** HP	Centrifugal	400 L/min	
PU-015	Treated Water Recycle Pump #1	** HP	Centrigugal	263 L/min	
PU-016	Treated Water Recycle Pump #2	** HP	Centrigugal	263 L/min	
PU-017	Flocculant Preparation Area Sump Pump	** HP	Cantilever	400 L/min	
PU-018	Clarifer Area Sump Pump	** HP	Cantilever	400 L/min	
TA-002	Sludge/Lime Mix tank			2 m ∅ x 1 m High (w/o F/B)	c.s.
TA-003	Lime Reactor Tank			13 m ∅ x 10 m High (w/o F/B)	c/s
TA-004	Clarifier Tank			36 m ∅	c/s
TA-005	Lime Slurry Storage Tank			4 m ∅ x 3 m High (w/o F/B)	c/s


Faro Mill
14 December, 2003
Quicklime (CaO)
4 tonnes/day (as CaO)
Lime Storage Silo eq. # TA-001
100 tonnes SB-001
(Based on 28 days storage)
Dry Flocculant
90 kg/day
Fresh Water
35 L/min
(continuous basis)
13 L/min
Flocculant Preparation Package eq. # FM-001
13 L/min
Flocculant Feed Pumps eq. # PU-004
PU-005
Lime Silo Screw Feeder
300 kg/hr eq. # SF-001
(Based on 49% Operating Time)
Miscellaneous sources
100 % of total other consumption
17 L/min
5 L/min
Effluent Sources
19 L/min
Lime Slaker eq. # LS-001
300 kg/hr
(Based on 49% Operating Time)
Plant Feed Pond
Plant Feed Pumps eq. # PU-001
PU-002
PU-003
0.0 | - | 0.0
7.3 | 0.0 | 20062
22000 | 1.00 | 20062
9.8 | 2.4 | 4.1
14.0 | 12.0 | 72
90 | 1.08 | 76
eq. # TA-005
RM-005
3 | 2.4 | 1.4
14.0 | 12.0 | 24
30 | 1.08 | 25
In-Line Static Mixer
eq.# SM-001
SM-002
13.0 | 2.4 | 5.4
14.0 | 12.0 | 95
120 | 1.08 | 101
Lime Slurry Pumps
eq. # PU-008
PU-009
Lime Slurry Storage Tank
36 m3
3.8 m ∅ x 3.2 m high
(without freeboard)
125 L/min
113 L/min
138 | 2.8 | 49
9.3 | 0.7 | 20755
23000 | 1.00 | 20805
Treated Water Recycle Pumps
eq # PU-015
PU-016
132 L/min
(continuous basis)
139 | 2.8 | 50
13.5 | 19.7 | 568
700 | 1.14 | 618
Sludge/Lime Mix Tank
eq # TA-002
RM-001
3 m3
1.7 m ∅ x 1.4 m high
(without freeboard)
0.0 | 2.8 | 0.0
9.3 | 0.0 | 20072
22000 | 1.00 | 20072
Recycled WaterTank
10 m3
2.5 m ∅ x 2.1 m high
(without freeboard)
Treated Water Discharge
Clarifier Tank
36 m ∅
eq. # TA-004
ME-001
1.0 m3/hr or 0.6 SCFM
Process Air Compressors
eq. # CO-001
CO-002
Clarifier Area Sump Eq. # PU-018
Reactor Vessel eq. # TA-003
1241 m3 RM-002
12.9 m ∅ x 9.5 m high
(without freeboard)
136 | 2.8 | 49
9.3 | 20.0 | 544
700 | 1.15 | 593
Sludge Recycle Pumps eq. # PU010
PU011
PU-012
Legend
kg/min Solids | Sp/Gr Solids | L/min Solids
pH Slurry | % Solids | L/min Water
Design L/min | Sp/Gr Slurry | L/min Slurry
1.9 | 2.8 | 0.7
9.3 | 20.0 | 7.8
400 | 1.15 | 8.5
Sludge Transfer Pumps eq. # PU-013
PU-014
Treated Water For Line Flushing Use Only
Flocculant Preparation Area Sump Eq. # PU-017
Intermittent @ 356 L/min
Based on one 4.0 hour purge every 7.0 days
Sludge Impoundment Basin
27.8 thousand m3

HDS Process Design

Grum/Vangorda Pit
2000 usgpm

14 December, 2003
Conceptual Design
Rev. 1

General Design Information

Design Flowrate:	7,571	L/min
Solids Generation	0.23	g/L plant feed
Recycle Ratio	53.3	(?:1)
Solids SG	2.8	
Feed pH	6.9	
Reactor pH	9.3	pH Units
Lime Sludge Mix Tank pH	13.5	pH Units
Clarifier U/F Density	20	%
Clarifier Overflow Solids	0	mg/L

Aeration Requirements

Feed Iron Content	1.5	mg/L
Percentage Ferrous Iron	100	%
Average Density of Air	1.201	kg/m^3
Oxygen Transfer Efficiency	20	%

Vessel Residence Times:

Reactor Residence Time	60	minutes
Lime Sludge Mix Tank	5	minutes
Clarifier Upflow Ratio	1.200	$(m^3/hr)/m^2$
Recycle Water Tank	0.5	minutes

Flocculant Dosing System

Flocculant Dose Rate	240	mg floc/kg solids (range from 50 to 200)
Flocculant Addition Rate	3.0	mg floc/L plant feed (range from 1 to 10)
Undiluted Floc Concentration	0.5	%

Lime Dosing System

Lime Addition Rate (as $Ca(OH)_2$)	0.2	g lime/L plant feed
Lime Slurry Concentration	12	%
Slurry pH	14	pH Units
Solids SG	2.4	
Storage Requirements	24	hours
Available CaO	92.0	%
Lime use	0.2	g lime (CaO)/L plant feed

Operating Costs

Lime Cost	320	CDN$/tonne		
Flocculant Cost	6000	CDN$/tonne		
Power Cost	370	hp	0.13	CDN$/kw-hour
Manpower Cost	8	man-hours/day	21.03	CDN$/man-hour
O&M Capital	3	% of capital cost	4,670,000	CDN$ total capital

Water Quality and Sludge Generation Prediction

HDS Process Design
Grum/Vangorda Pit
2000 usgpm
14 December, 2003

Ion	Ion Wt. (g/mol)	Hydroxide Formula	Hydroxide Weight (g/mol)	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)
Al	26.98	$Al(OH)_3$	78.01	0.03	0.06	0.09
Ag	107.87	AgOH	124.88	0.00	0.00	0.00
As	74.92	$As(OH)_3$	125.95	0.00	0.00	0.00
Bi	208.98	$Bi(OH)_3$	260.01	0.00	0.00	0.00
Ca	40.08	$Ca(OH)_2$	74.1	262.00	0.00	0.00
Cd	112.41	$Cd(OH)_2$	146.43	0.00	0.00	0.00
Cu	63.55	$Cu(OH)_2$	97.57	0.00	0.00	0.00
Fe	55.85	$Fe(OH)_3$	106.88	1.50	1.37	2.87
Pb	207.2	$Pb(OH)_2$	241.22	0.00	0.00	0.00
Mg	24.31	$Mg(OH)_2$	58.33	16.56	23.17	39.73
Mn	54.94	MnO_2	86.94	29.20	0.00	46.21
Ni	58.71	$Ni(OH)_2$	92.73	0.00	0.00	0.00
S*	32.06	$CaSO_4.2H_2O$	172.18	0.00	0.00	0.00
Sb	121.75	$Sb(OH)_3$	172.78	0.00	0.00	0.00
Se	78.96	$Se(OH)_4$	147	0.00	0.00	0.00
Si	28.09	$Si(OH)_2$	62.11	0.00	0.00	0.00
Zn	65.38	$Zn(OH)_2$	99.4	73.30	38.14	111.44
SO_4^{2-}*	96.06	$CaSO_4.2H_2O$	172.18	1041.00	0.00	0.00
CO_3^{2-}	59.98	$CaCO_3$	100.06	0.00	0.00	0.00
TSS	n/a	n/a	n/a	n/a	n/a	0.00
Total					**62.74**	**200.34**

Residual SO_4^{2-} concentration 1800 mg/L (pure solubility range from 1240 - 1435 mg/L)

*** Use either (S) or (SO4).**

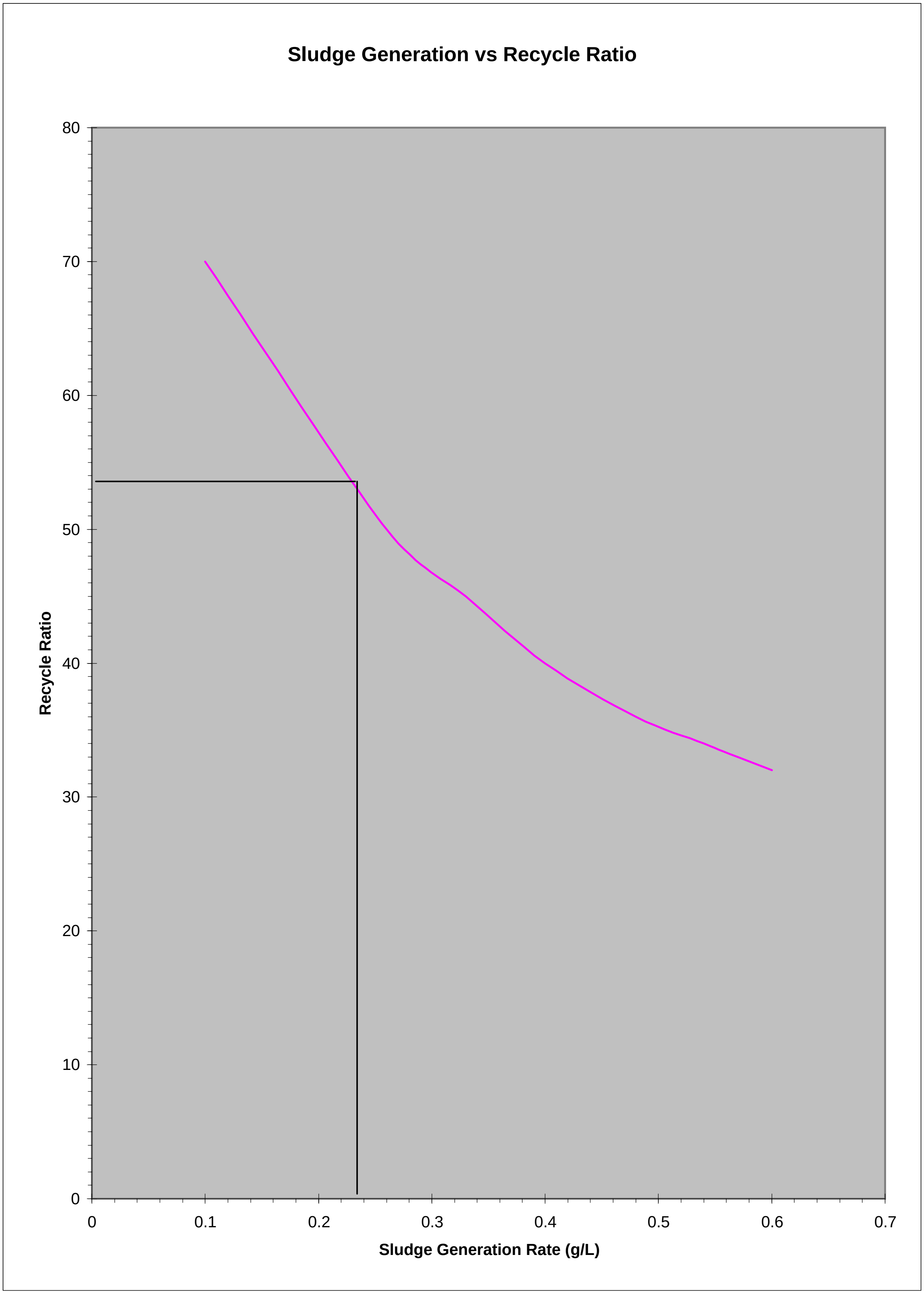
Solids Generation = 0.23 g/L
(includes 8.0 % lime enerts)
(includes 5.0 % unreacted lime solids)

Lime Requirements

Based on calcium requirements	0.32	g Ca(OH)2/L effluent	**OR**	(SO_4^{2-} based)
	0.00	g Ca(OH)2/L effluent		(S based)
Based on hydroxide requirements	0.14	g Ca(OH)2/L effluent		

Lime Utilization = 95.0 %
Available CaO = 92.0 %

Lime use = 0.24 g $Ca(OH)_2$/L effluent
Lime use = 0.20 g lime (CaO)/L effluent


Sludge Generation vs Recycle Ratio
Recycle Ratio
Sludge Generation Rate (g/L)
0
10
20
30
40
50
60
70
80
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Sludge Quality Prediction

HDS Process Design
Grum/Vangorda Pit
2000 usgpm
14 December, 2003

Ion	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)	Mass of Metal (mg/L)	Sludge Composition (%)
Al	0.03	0.06	0.09	0.03	0.01
Ag	0.00	0.00	0.00	0.00	0.00
As	0.00	0.00	0.00	0.00	0.00
Bi	0.00	0.00	0.00	0.00	0.00
Ca	262.00	0.00	0.00	0.00	0.00
Cd	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	0.00	0.00	0.00
Fe	1.50	1.37	2.87	1.50	0.66
Pb	0.00	0.00	0.00	0.00	0.00
Mg	16.56	23.17	39.73	16.56	7.26
Mn	29.20	0.00	46.21	29.20	12.80
Ni	0.00	0.00	0.00	0.00	0.00
$CaSO_4.2H_2O$	0.00	0.00	0.00	n/a	0.00
Sb	0.00	0.00	0.00	0.00	0.00
Se	0.00	0.00	0.00	0.00	0.00
Si	0.00	0.00	0.00	0.00	0.00
Zn	73.30	38.14	111.44	73.30	32.14
$CaSO_4.2H_2O$	1041.00	0.00	0.00	n/a	0.00
$CaCO_3$	0.00	0.00	0.00	n/a	0.00
TSS	n/a	n/a	0.00	n/a	0.00
Lime Inerts	n/a	n/a	27.75	n/a	12.17
Total		**62.74**	**228.09**	**120.59**	**65.04**

Balance Check: 100.00 %

Solids generation =	0.2 g/L
Ultimate drained percent solids =	50 %
Sludge pond lifetime =	20 years

Annual Average Data:

Operating days =	365 days/year	
Plant feed rate =	7,571 L/minute	
Total dry solids production =	2.5 tonnes/day	907.6 tonnes/year
Sludge volume purged =	10.8 m^3/day	3954.6 m^3/year
Volume at ultimate density =	3.4 m^3/day	1231.8 m^3/year
Pond volume required =	24640 m^3	

Vessel Sizes

				Tank Dimensions (no freeboard included)											aspect ratio
Lime Sludge Mix Tank:	2 m^3 =	550	USgal	D =	1.5	m	or	4.9	ft	H =	1.2	m	or	3.9 ft	1.27
Reactor Vessels:	479 m^3 =	126596	USgal	D =	9.0	m	or	29.5	ft	H =	7.5	m	or	24.7 ft	1.19
Clarifier Diameter:	22 m =	72	ft												
Lime Storage Tank:	22 m^3 =	5814	USgal	D =	3.3	m	or	10.8	ft	H =	2.6	m	or	8.4 ft	1.28
Recycled Water Tank:	4 m^3 =	1007	USgal	D =	1.8	m	or	5.9	ft	H =	1.5	m	or	4.9 ft	1.20

Aeration Requirements

Total Iron Content =	2	mg/L
Percent Ferrous Iron =	100	%
Oxygen Transfer Efficiency =	20	%
Total Flow In =	7571	L/min
Total Ferrous Iron =	0.0	kg/min
=	0.7	kg/hr
Aeration required =	**1.9**	m^3/hour
=	**1.1**	SCFM

Sludge and Reagent Flowrates

Sludge Purge and Recycle

Sludge Purge Data					Sludge Recycle Data				
Sludge Purge = Solids Generation =	2	kg/min =	4	lbs/min	Solids Recycled =	92	kg/min =	203	lbs/min
Solids Volume =	1	L/min =	0	USgpm	Solids Volume =	33	L/min =	9	USgpm
Water Flow =	7	L/min =	2	USgpm	Water Flow =	368	L/min =	97	USgpm
Total Flow =	8	L/min =	2	USgpm	Total Flow =	401	L/min =	106	USgpm
SG Slurry =	1.15				SG Slury =	1.15			
pH Slurry =	9.3	pH Units			pH Slurry =	9.3	pH Units		
SG Solids =	2.8				SG Solids =	2.8			
Slurry % Solids =	20.00	%			Slurry % Solids =	20.00	%		

Lime Circuit

Lime Dosing					Lime Loop Out Of Storage Tank					Lime Loop Return To Storage Tank				
Solids Mass =	2	kg/min =	4	lbs/min	Solids Mass =	8	kg/min =	17	lbs/min	Solids Mass =	6	kg/min =	13	lbs/min
Solids Volume =	1	L/min =	0	USgpm	Solids Volume =	3	L/min =	1	USgpm	Solids Volume =	2	L/min =	1	USgpm
Water Flow =	14	L/min =	4	USgpm	Water Flow =	58	L/min =	15	USgpm	Water Flow =	43	L/min =	11	USgpm
Total Slurry Flow =	15	L/min =	4	USgpm	Total Slurry Flow =	61	L/min =	16	USgpm	Total Slurry Flow =	46	L/min =	12	USgpm
Slurry SG =	1.08				Slurry SG =	1.08				Slurry SG =	1.08			
pH Slurry =	14	pH Units			pH Slurry =	14	pH Units			pH Slurry =	14	pH Units		
SG Solids =	2.4				SG Solids =	2.4				SG Solids =	2.4			
Slurry % Solids =	12.00	%			Slurry % Solids =	12.00	%			Slurry % Solids =	12.00	%		

Flocculant Dosing					**Lime Dosing**		
Floc Dosing Rate =	3	mg/L effluent treated			Lime Dosing Rate =	0.2	g lime/L effluent treated
Flow Into Floc Tank =	7987	L/min =	2110	USgpm	Lime Dosing Rate =	0.2	g lime (CaO + inerts)/L \treated
Undiluted Floc Flowrate =	5	L/min =	1	USgpm	Average Plant Feed =	7570.66	L/minute
Diluted Floc Flowrate =	47	L/min =	13	USgpm	Daily Consumption =	2.1	tonnes/day
Floc Consumption =	34	kg/day =	75	lbs/day	Annual Consumption=	784	tonnes/year quicklime

Tank Flows

Out Of Lime/Sludge Mix Tank

Solids Mass =	94	kg/min =	207	lbs/min
Solids Volume =	34	L/min =	9	USgpm
Water Flow =	383	L/min =	101	USgpm
Total Slurry Flow =	416	L/min =	110	USgpm
Slurry SG =	1.14			
pH Slurry =	13.5	pH Units		
SG Solids =	2.79			
Slurry % Solids =	19.72	%		

Out Of Reactor Tank

Solids Mass =	94	kg/min =	207	lbs/min
Solids Volume =	33	L/min =	9	USgpm
Water Flow =	7953	L/min =	2101	USgpm
Total Slurry Flow =	7987	L/min =	2110	USgpm
Slurry SG =	1.01			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	1.17	%		

Into Clarifier

Solids Mass =	94	kg/min =	207	lbs/min
Solids Volume =	33	L/min =	9	USgpm
Water Flow =	8001	L/min =	2114	USgpm
Total Slurry Flow =	8034	L/min =	2122	USgpm
Slurry SG =	1.01			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	**1.16**	%		

Clarifier Flows

Clarifier Overflow

Solids Mass =	0	kg/min =	0	lbs/min
Solids Volume =	0	L/min =	0	USgpm
Water Flow =	7626	L/min =	2015	USgpm
Total Slurry Flow =	7626	L/min =	2015	USgpm
Slurry SG =	1			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	0	%		

Clarifier Underflow

Solids Mass =	94	kg/min =	207	lbs/min
Solids Volume =	33	L/min =	9	USgpm
Water Flow =	375	L/min =	99	USgpm
Total Slurry Flow =	409	L/min =	108	USgpm
Slurry SG =	1.15			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	20.00	%		

Balance Check (Overall)

Total Solids In =	1.73	kg/min	Total Water In =	7633	L/min
Total Solids Out =	1.73	kg/min	Total Water Out =	7633	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Balance Check (Clarifier)

Total Solids In =	94	kg/min	Total Water In =	8001	L/min
Total Solids Out =	94	kg/min	Total Water Out =	8001	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Operating Cost Estimate

Grum/Vangorda Pit
2000 usgpm
14 December, 2003

Reagent	Dose Rate (mg/L plant feed)	Annual Average Plant Flow Rate (L/min)	Annual Reagent Consumption (tonnes/year)	Reagent Unit Cost (CDN$/tonne)	Annual Reagent Cost (CDN$/year)
Quicklime	197	7,571	784	320	251,000
Flocculant	3	7,571	12	6000	71,000
				Sub-total:	**$322,000**

Item	Annual Consumption	Unit Cost (CDN$)	Annual Cost (CDN$/year)
Electric Power	2.42 million kW-hours	0.13	314,000
O & M Capital	3 % of capital cost	4670000	140,000
O & M Manpower	8 man-hours per day	21.03	61,000
		Sub-total:	**$515,000**

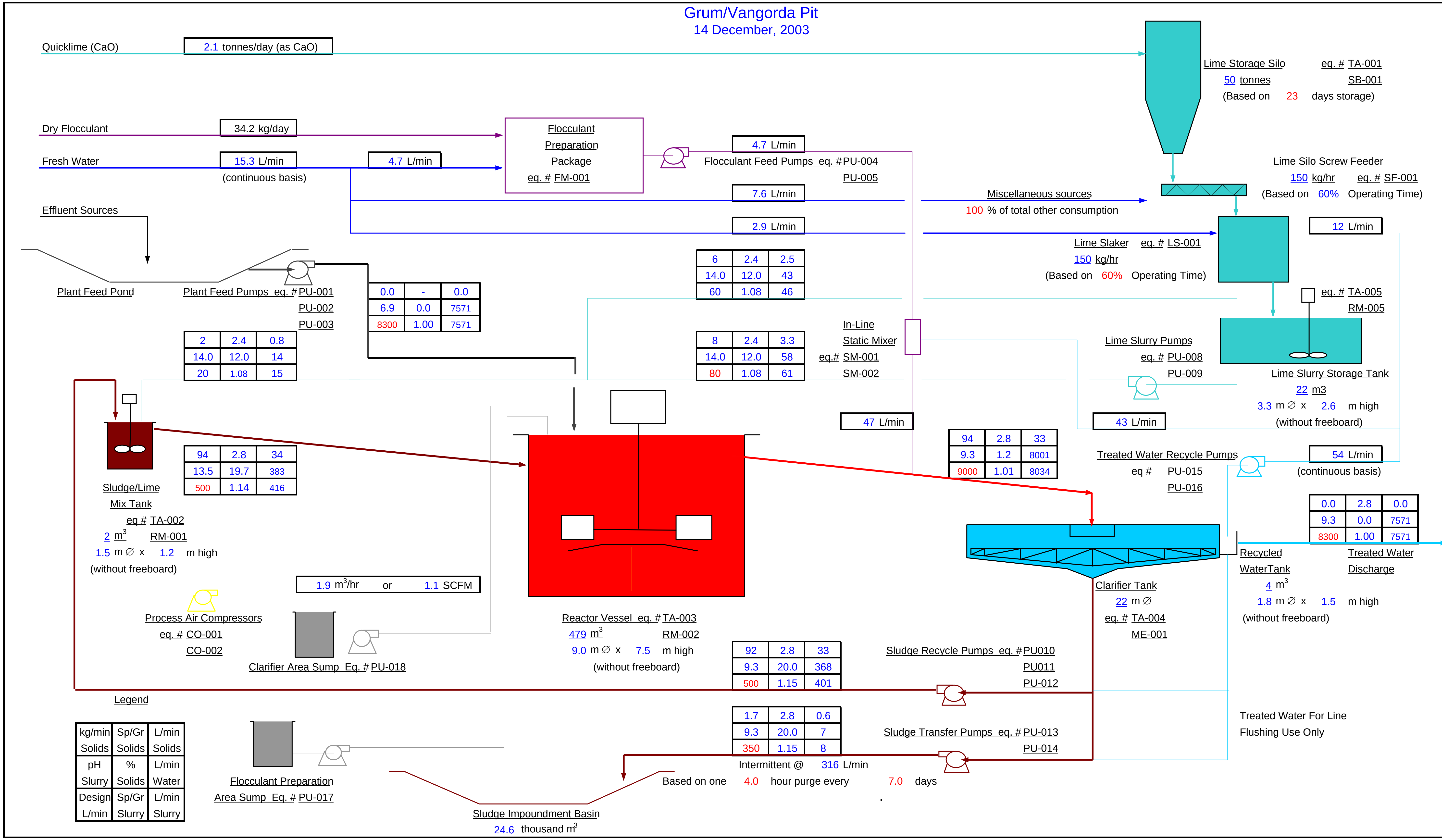
Total Annual Operating Cost:	**$837,000**	**/year**	(CDN dollars)
Normalized Annual Operating Cost:	**$0.21**	**/m^3**	(CDN dollars)
	$0.80	**/1000 USgal**	(CDN dollars)

Discount Interest Rate:	10%	
Expected Plant Lifetime:	20	years
Present Value of Plant Operating Costs:	**$7,126,000**	**CDN dollars**
Net Present Value of Plant:	**$11,796,000**	**CDN dollars**

Mechanical Equipment List

Grum/Vangorda Pit
2000 usgpm

Equipment Number	Description	Motor hp	Type	Capacity/Size	Material
FM-001	Flocculant Preparation System	** AMP	Vendor Package	68 kg/day	
SM-001	Flocculant Static Mixer			71 L/min	
SM-002	Flocculant Static Mixer			71 L/min	
TA-001	Lime Storage Silo	** HP		50 tonnes	c.s.
SB-001	Lime Silo Baghouse				
SF-001	Lime Silo Screw Feeder	** HP		150 kg/hour	c.s.
LS-001	Lime Slaker	* HP + ** HP		150 kg/hour	
CO-001	Process Air Compressor #1	** HP		2 m^3/hour	
CO-002	Process Air Compressor #2	** HP		2 m^3/hour	
RM-001	Sludge/Lime Mix Tank Agitator	** HP			c.s.
RM-002	Lime Reactor #2 Tank Agitator	** HP			c.s.
ME-001	Clarifier Rake Mechanism	** HP + ** HP			c.s.
RM-005	Lime Slurry Storage Tank Agitator	** HP			c.s.
PU-001	Plant Feed Pump #1 V.S.D.	** HP	Vertical Turbine	4150 L/min	
PU-002	Plant Feed Pump #2 V.S.D.	** HP	Vertical Turbine	4150 L/min	
PU-003	Plant Feed Pump #3 V.S.D.	** HP	Vertical Turbine	4150 L/min	
PU-004	Flocculant Feed Pump #1	** HP	Prog. Cavity	7 L/min	
PU-005	Flocculant Feed Pump #2	** HP	Prog. Cavity	7 L/min	
PU-008	Lime Slurry Pump #1	** HP	Cantilever	80 L/min	
PU-009	Lime Slurry Pump #2	** HP	Cantilever	80 L/min	
PU010	Sludge Recycle Pump #1 V.S.D.	** HP	Centrifugal	250 L/min	
PU011	Sludge Recycle Pump #2 V.S.D.	** HP	Centrifugal	250 L/min	
PU-012	Sludge Recycle Pump #3 V.S.D.	** HP	Centrifugal	250 L/min	
PU-013	Sludge Transfer Pump #1	** HP	Centrifugal	350 L/min	
PU-014	Sludge Transfer Pump #2	** HP	Centrifugal	350 L/min	
PU-015	Treated Water Recycle Pump #1	** HP	Centrifugal	109 L/min	
PU-016	Treated Water Recycle Pump #2	** HP	Centrifugal	109 L/min	
PU-017	Flocculant Preparation Area Sump Pump	** HP	Cantilever	400 L/min	
PU-018	Clarifer Area Sump Pump	** HP	Cantilever	400 L/min	
TA-002	Sludge/Lime Mix tank			2 m ∅ x 1 m High (w/o F/B)	c.s.
TA-003	Lime Reactor Tank			9 m ∅ x 8 m High (w/o F/B)	c/s
TA-004	Clarifier Tank			22 m ∅	c/s
TA-005	Lime Slurry Storage Tank			3 m ∅ x 3 m High (w/o F/B)	c/s


Grum/Vangorda Pit
14 December, 2003
Quicklime (CaO)
2.1 tonnes/day (as CaO)
Lime Storage Silo eq. # TA-001
50 tonnes SB-001
(Based on 23 days storage)
Dry Flocculant
34.2 kg/day
Fresh Water
15.3 L/min
(continuous basis)
4.7 L/min
Flocculant Preparation Package eq. # FM-001
4.7 L/min
Flocculant Feed Pumps eq. # PU-004
PU-005
Lime Silo Screw Feeder
150 kg/hr eq. # SF-001
(Based on 60% Operating Time)
7.6 L/min
Miscellaneous sources
100 % of total other consumption
Effluent Sources
2.9 L/min
12 L/min
Lime Slaker eq. # LS-001
150 kg/hr
(Based on 60% Operating Time)
6 2.4 2.5
14.0 12.0 43
60 1.08 46
Plant Feed Pond
Plant Feed Pumps eq. # PU-001
PU-002
PU-003
0.0 - 0.0
6.9 0.0 7571
8300 1.00 7571
eq. # TA-005
RM-005
In-Line Static Mixer
eq.# SM-001
SM-002
Lime Slurry Pumps
eq. # PU-008
PU-009
Lime Slurry Storage Tank
22 m3
3.3 m ∅ x 2.6 m high
(without freeboard)
2 2.4 0.8
14.0 12.0 14
20 1.08 15
8 2.4 3.3
14.0 12.0 58
80 1.08 61
47 L/min
43 L/min
94 2.8 33
9.3 1.2 8001
9000 1.01 8034
Treated Water Recycle Pumps
eq # PU-015
PU-016
54 L/min
(continuous basis)
94 2.8 34
13.5 19.7 383
500 1.14 416
Sludge/Lime Mix Tank
eq # TA-002
2 m³ RM-001
1.5 m ∅ x 1.2 m high
(without freeboard)
0.0 2.8 0.0
9.3 0.0 7571
8300 1.00 7571
Recycled WaterTank
4 m³
1.8 m ∅ x 1.5 m high
(without freeboard)
Treated Water Discharge
Clarifier Tank
22 m ∅
eq. # TA-004
ME-001
1.9 m³/hr or 1.1 SCFM
Process Air Compressors
eq. # CO-001
CO-002
Clarifier Area Sump Eq. # PU-018
Reactor Vessel eq. # TA-003
479 m³ RM-002
9.0 m ∅ x 7.5 m high
(without freeboard)
92 2.8 33
9.3 20.0 368
500 1.15 401
Sludge Recycle Pumps eq. # PU010
PU011
PU-012
Legend
kg/min Solids | Sp/Gr Solids | L/min Solids
pH Slurry | % Solids | L/min Water
Design L/min | Sp/Gr Slurry | L/min Slurry
1.7 2.8 0.6
9.3 20.0 7
350 1.15 8
Sludge Transfer Pumps eq. # PU-013
PU-014
Treated Water For Line Flushing Use Only
Intermittent @ 316 L/min
Based on one 4.0 hour purge every 7.0 days
Flocculant Preparation Area Sump Eq. # PU-017
Sludge Impoundment Basin
24.6 thousand m³

HDS Process Design

Down Valley
1500 usgpm

14 December, 2003
Conceptual Design
Rev. 1

General Design Information

Design Flowrate:	5,678	L/min
Solids Generation	0.15	g/L plant feed
Recycle Ratio	63.2	(?:1)
Solids SG	2.8	
Feed pH	7.3	
Reactor pH	9.3	pH Units
Lime Sludge Mix Tank pH	13.5	pH Units
Clarifier U/F Density	20	%
Clarifier Overflow Solids	0	mg/L

Aeration Requirements

Feed Iron Content	19	mg/L
Percentage Ferrous Iron	100	%
Average Density of Air	1.201	kg/m^3
Oxygen Transfer Efficiency	20	%

Vessel Residence Times:

Reactor Residence Time	60	minutes
Lime Sludge Mix Tank	5	minutes
Clarifier Upflow Ratio	1.200	$(m^3/hr)/m^2$
Recycle Water Tank	0.5	minutes

Flocculant Dosing System

Flocculant Dose Rate	310	mg floc/kg solids (range from 50 to 200)
Flocculant Addition Rate	3.0	mg floc/L plant feed (range from 1 to 10)
Undiluted Floc Concentration	0.5	%

Lime Dosing System

Lime Addition Rate (as $Ca(OH)_2$)	0.17	g lime/L plant feed
Lime Slurry Concentration	12	%
Slurry pH	14	pH Units
Solids SG	2.4	
Storage Requirements	24	hours
Available CaO	92.0	%
Lime use	0.14	g lime (CaO)/L plant feed

Operating Costs

Lime Cost	320	CDN$/tonne		
Flocculant Cost	6000	CDN$/tonne		
Power Cost	310	hp	0.13	CDN$/kw-hour
Manpower Cost	8	man-hours/day	21.03	CDN$/man-hour
O&M Capital	3	% of capital cost	3,870,000	CDN$ total capital

Water Quality and Sludge Generation Prediction

HDS Process Design
Down Valley
1500 usgpm
14 December, 2003

Ion	Ion Wt. (g/mol)	Hydroxide Formula	Hydroxide Weight (g/mol)	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)
Al	26.98	$Al(OH)_3$	78.01	0.24	0.46	0.70
Ag	107.87	AgOH	124.88	0.00	0.00	0.00
As	74.92	$As(OH)_3$	125.95	0.00	0.00	0.00
Bi	208.98	$Bi(OH)_3$	260.01	0.00	0.00	0.00
Ca	40.08	$Ca(OH)_2$	74.1	210.80	0.00	0.00
Cd	112.41	$Cd(OH)_2$	146.43	0.00	0.00	0.00
Cu	63.55	$Cu(OH)_2$	97.57	0.00	0.00	0.00
Fe	55.85	$Fe(OH)_3$	106.88	19.10	17.45	36.55
Pb	207.2	$Pb(OH)_2$	241.22	0.00	0.00	0.00
Mg	24.31	$Mg(OH)_2$	58.33	11.24	15.73	26.97
Mn	54.94	MnO_2	86.94	14.40	0.00	22.79
Ni	58.71	$Ni(OH)_2$	92.73	0.00	0.00	0.00
S*	32.06	$CaSO_4.2H_2O$	172.18	0.00	0.00	0.00
Sb	121.75	$Sb(OH)_3$	172.78	0.00	0.00	0.00
Se	78.96	$Se(OH)_4$	147	0.00	0.00	0.00
Si	28.09	$Si(OH)_2$	62.11	0.00	0.00	0.00
Zn	65.38	$Zn(OH)_2$	99.4	28.50	14.83	43.33
SO_4^{2-}*	96.06	$CaSO_4.2H_2O$	172.18	799.00	0.00	0.00
CO_3^{2-}	59.98	$CaCO_3$	100.06	0.00	0.00	0.00
TSS	n/a	n/a	n/a	n/a	n/a	0.00
Total					**48.47**	**130.34**

Residual SO_4^{2-} concentration 1800 mg/L (pure solubility range from 1240 - 1435 mg/L)

*** Use either (S) or (SO4).**

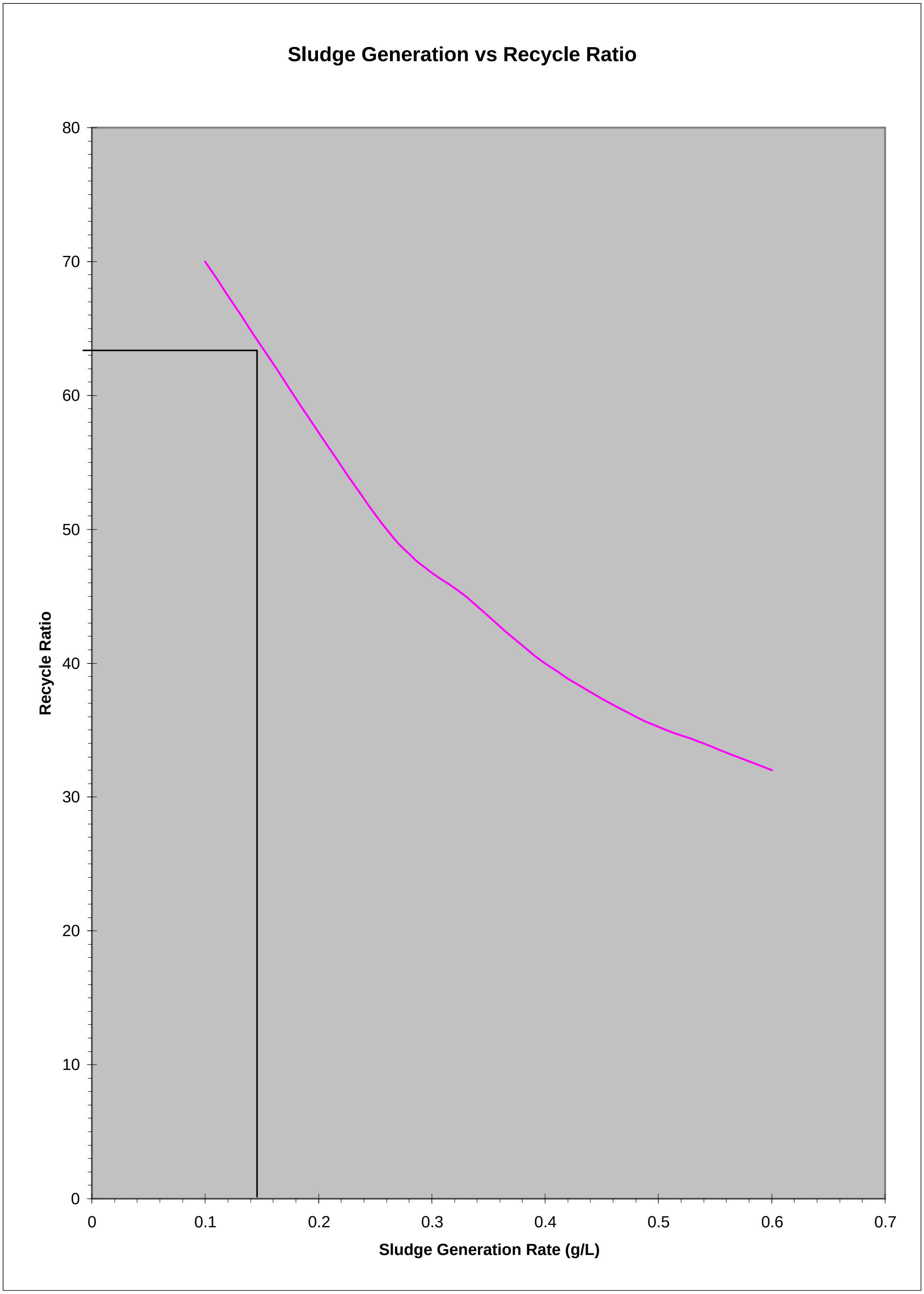
Solids Generation = 0.15 g/L
(includes 8.0 % lime enerts)
(includes 5.0 % unreacted lime solids)

<u>Lime Requirements</u>

Based on calcium requirements	0.23	g Ca(OH)2/L effluent **OR**	(SO_4^{2-} based)
	0.00	g Ca(OH)2/L effluent	(S based)
Based on hydroxide requirements	0.11	g Ca(OH)2/L effluent	

Lime Utilization = 95.0 %
Available CaO = 92.0 %

Lime use = 0.17 g $Ca(OH)_2$/L effluent
Lime use = 0.14 g lime (CaO)/L effluent


Sludge Generation vs Recycle Ratio
Recycle Ratio
Sludge Generation Rate (g/L)
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Sludge Quality Prediction

HDS Process Design
Down Valley
1500 usgpm
14 December, 2003

Ion	Mass of Ion Present (mg/L)	Mass of OH^- (mg/L)	Mass of Precip. (mg/L)	Mass of Metal (mg/L)	Sludge Composition (%)
Al	0.24	0.46	0.70	0.24	0.16
Ag	0.00	0.00	0.00	0.00	0.00
As	0.00	0.00	0.00	0.00	0.00
Bi	0.00	0.00	0.00	0.00	0.00
Ca	210.80	0.00	0.00	0.00	0.00
Cd	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	0.00	0.00	0.00
Fe	19.10	17.45	36.55	19.10	12.68
Pb	0.00	0.00	0.00	0.00	0.00
Mg	11.24	15.73	26.97	11.24	7.46
Mn	14.40	0.00	22.79	14.40	9.56
Ni	0.00	0.00	0.00	0.00	0.00
$CaSO_4.2H_2O$	0.00	0.00	0.00	n/a	0.00
Sb	0.00	0.00	0.00	0.00	0.00
Se	0.00	0.00	0.00	0.00	0.00
Si	0.00	0.00	0.00	0.00	0.00
Zn	28.50	14.83	43.33	28.50	18.93
$CaSO_4.2H_2O$	799.00	0.00	0.00	n/a	0.00
$CaCO_3$	0.00	0.00	0.00	n/a	0.00
TSS	n/a	n/a	0.00	n/a	0.00
Lime Inerts	n/a	n/a	20.25	n/a	13.45
Total		**48.47**	**150.59**	**73.48**	**62.24**

Balance Check: 100.00 %

Solids generation = 0.2 g/L
Ultimate drained percent solids = 50 %
Sludge pond lifetime = 20 years

Annual Average Data:

Operating days =	365 days/year	
Plant feed rate =	5,678 L/minute	
Total dry solids production =	1.2 tonnes/day	449.4 tonnes/year
Sludge volume purged =	5.4 m^3/day	1958.1 m^3/year
Volume at ultimate density =	1.7 m^3/day	609.9 m^3/year
Pond volume required =	12,200 m^3	

Vessel Sizes

					Tank Dimensions (no freeboard included)												**aspect ratio**
Lime Sludge Mix Tank:	1	m^3 =	322	USgal	D =	1.3	m	or	4.3	ft	H =	0.9	m	or	3.0	ft	1.42
Reactor Vessels:	355	m^3 =	93862	USgal	D =	8.2	m	or	26.9	ft	H =	6.7	m	or	22.1	ft	1.22
Clarifier Diameter:	19	m =	63	ft													
Lime Storage Tank:	12	m^3 =	3181	USgal	D =	2.8	m	or	9.2	ft	H =	2.0	m	or	6.4	ft	1.43
Recycled Water Tank:	3	m^3 =	755	USgal	D =	1.7	m	or	5.6	ft	H =	1.3	m	or	4.1	ft	1.35

Aeration Requirements

Total Iron Content =	19	mg/L
Percent Ferrous Iron =	100	%
Oxygen Transfer Efficiency =	20	%
Total Flow In =	5678	L/min
Total Ferrous Iron =	0.1	kg/min
=	6.5	kg/hr
Aeration required =	**18**	m^3/hour
=	**11**	SCFM

Sludge and Reagent Flowrates

Sludge Purge and Recycle

Sludge Purge Data					Sludge Recycle Data				
Sludge Purge = Solids Generation =	1	kg/min =	2	lbs/min	Solids Recycled =	54	kg/min =	119	lbs/min
Solids Volume =	0	L/min =	0	USgpm	Solids Volume =	19	L/min =	5	USgpm
Water Flow =	3	L/min =	1	USgpm	Water Flow =	216	L/min =	57	USgpm
Total Flow =	4	L/min =	1	USgpm	Total Flow =	235	L/min =	62	USgpm
SG Slurry =	1.15				SG Slury =	1.15			
pH Slurry =	9.3	pH Units			pH Slurry =	9.3	pH Units		
SG Solids =	2.8				SG Solids =	2.8			
Slurry % Solids =	20.00	%			Slurry % Solids =	20.00	%		

Lime Circuit

Lime Dosing					Lime Loop Out Of Storage Tank					Lime Loop Return To Storage Tank				
Solids Mass =	1	kg/min =	2	lbs/min	Solids Mass =	4	kg/min =	10	lbs/min	Solids Mass =	3	kg/min =	7	lbs/min
Solids Volume =	0	L/min =	0	USgpm	Solids Volume =	2	L/min =	0	USgpm	Solids Volume =	1	L/min =	0	USgpm
Water Flow =	8	L/min =	2	USgpm	Water Flow =	32	L/min =	8	USgpm	Water Flow =	24	L/min =	6	USgpm
Total Slurry Flow =	8	L/min =	2	USgpm	Total Slurry Flow =	33	L/min =	9	USgpm	Total Slurry Flow =	25	L/min =	7	USgpm
Slurry SG =	1.08				Slurry SG =	1.08				Slurry SG =	1.08			
pH Slurry =	14	pH Units			pH Slurry =	14	pH Units			pH Slurry =	14	pH Units		
SG Solids =	2.4				SG Solids =	2.4				SG Solids =	2.4			
Slurry % Solids =	12.00	%			Slurry % Solids =	12.00	%			Slurry % Solids =	12.00	%		

Flocculant Dosing					Lime Dosing		
Floc Dosing Rate =	3	mg/L effluent treated			Lime Dosing Rate =	0.2	g lime/L effluent treated
Flow Into Floc Tank =	5922	L/min =	1564	USgpm	Lime Dosing Rate =	0.1	g lime (CaO + inerts)/L \treated
Undiluted Floc Flowrate =	4	L/min =	1	USgpm	Average Plant Feed =	5677.995	L/minute
Diluted Floc Flowrate =	35	L/min =	9	USgpm	Daily Consumption =	1.2	tonnes/day
Floc Consumption =	26	kg/day =	56	lbs/day	Annual Consumption=	429	tonnes/year quicklime

Tank Flows

Out Of Lime/Sludge Mix Tank

Solids Mass =	55	kg/min =	122	lbs/min
Solids Volume =	20	L/min =	5	USgpm
Water Flow =	224	L/min =	59	USgpm
Total Slurry Flow =	244	L/min =	64	USgpm
Slurry SG =	1.15			
pH Slurry =	13.5	pH Units		
SG Solids =	2.79			
Slurry % Solids =	19.74	%		

Out Of Reactor Tank

Solids Mass =	55	kg/min =	121	lbs/min
Solids Volume =	20	L/min =	5	USgpm
Water Flow =	5902	L/min =	1559	USgpm
Total Slurry Flow =	5922	L/min =	1564	USgpm
Slurry SG =	1.01			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	0.92	%		

Into Clarifier

Solids Mass =	55	kg/min =	121	lbs/min
Solids Volume =	20	L/min =	5	USgpm
Water Flow =	5938	L/min =	1569	USgpm
Total Slurry Flow =	5957	L/min =	1574	USgpm
Slurry SG =	1.01			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	**0.92**	%		

Clarifier Flows

Clarifier Overflow

Solids Mass =	0	kg/min =	0	lbs/min
Solids Volume =	0	L/min =	0	USgpm
Water Flow =	5718	L/min =	1511	USgpm
Total Slurry Flow =	5718	L/min =	1511	USgpm
Slurry SG =	1			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	0	%		

Clarifier Underflow

Solids Mass =	55	kg/min =	121	lbs/min
Solids Volume =	20	L/min =	5	USgpm
Water Flow =	220	L/min =	58	USgpm
Total Slurry Flow =	239	L/min =	63	USgpm
Slurry SG =	1.15			
pH Slurry =	9.3	pH Units		
SG Solids =	2.80			
Slurry % Solids =	20.00	%		

Balance Check (Overall)

Total Solids In =	0.86	kg/min	Total Water In =	5721	L/min
Total Solids Out =	0.86	kg/min	Total Water Out =	5721	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Balance Check (Clarifier)

Total Solids In =	55	kg/min	Total Water In =	5938	L/min
Total Solids Out =	55	kg/min	Total Water Out =	5938	L/min
% Deviation =	0.00	%	% Deviation =	0.00	%

Operating Cost Estimate

Down Valley
1500 usgpm
14 December, 2003

Reagent	Dose Rate (mg/L plant feed)	Annual Average Plant Flow Rate (L/min)	Annual Reagent Consumption (tonnes/year)	Reagent Unit Cost (CDN$/tonne)	Annual Reagent Cost (CDN$/year)
Quicklime	144	5,678	429	320	137,000
Flocculant	3	5,678	8.9	6000	53,660
				Sub-total:	**$191,000**

Item	Annual Consumption		Unit Cost (CDN$)	Annual Cost (CDN$/year)
Electric Power	2.03	million kW-hours	0.13	263,000
O & M Capital	3	% of capital cost	3870000	116,000
O & M Manpower	8	man-hours per day	21.03	61,000
			Sub-total:	**$440,000**

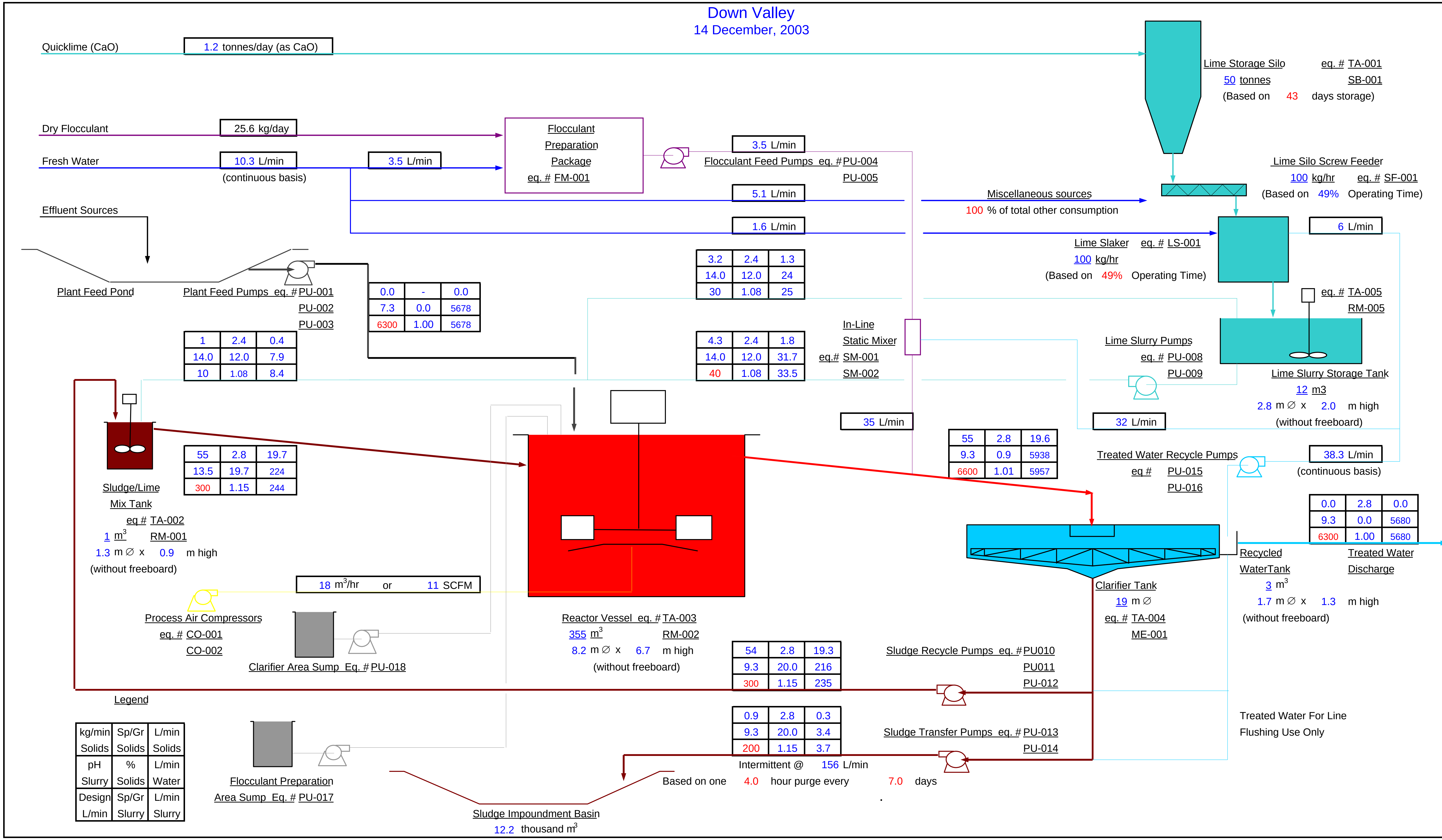
Total Annual Operating Cost:	**$631,000**	**/year**	(CDN dollars)
Normalized Annual Operating Cost:	**$0.21**	**/m^3**	(CDN dollars)
	$0.80	**/1000 USgal**	(CDN dollars)

Discount Interest Rate:	10%	
Expected Plant Lifetime:	20	years
Present Value of Plant Operating Costs:	**$5,372,000**	**CDN dollars**
Net Present Value of Plant:	**$9,242,000**	**CDN dollars**

Mechanical Equipment List

Down Valley
1500 usgpm

Equipment Number	Description	Motor hp	Type	Capacity/Size	Material
FM-001	Flocculant Preparation System	** AMP	Vendor Package	51 kg/day	
SM-001	Flocculant Static Mixer			53 L/min	
SM-002	Flocculant Static Mixer			53 L/min	
TA-001	Lime Storage Silo	** HP		50 tonnes	c.s.
SB-001	Lime Silo Baghouse				
SF-001	Lime Silo Screw Feeder	** HP		100 kg/hour	c.s.
LS-001	Lime Slaker	* HP + ** HP		100 kg/hour	
CO-001	Process Air Compressor #1	** HP		21 m^3/hour	
CO-002	Process Air Compressor #2	** HP		21 m^3/hour	
RM-001	Sludge/Lime Mix Tank Agitator	** HP			c.s.
RM-002	Lime Reactor #2 Tank Agitator	** HP			c.s.
ME-001	Clarifier Rake Mechanism	** HP + ** HP			c.s.
RM-005	Lime Slurry Storage Tank Agitator	** HP			c.s.
PU-001	Plant Feed Pump #1 V.S.D.	** HP	Vertical Turbine	3150 L/min	
PU-002	Plant Feed Pump #2 V.S.D.	** HP	Vertical Turbine	3150 L/min	
PU-003	Plant Feed Pump #3 V.S.D.	** HP	Vertical Turbine	3150 L/min	
PU-004	Flocculant Feed Pump #1	** HP	Prog. Cavity	5 L/min	
PU-005	Flocculant Feed Pump #2	** HP	Prog. Cavity	5 L/min	
PU-008	Lime Slurry Pump #1	** HP	Cantilever	40 L/min	
PU-009	Lime Slurry Pump #2	** HP	Cantilever	40 L/min	
PU010	Sludge Recycle Pump #1 V.S.D.	** HP	Centrifugal	150 L/min	
PU011	Sludge Recycle Pump #2 V.S.D.	** HP	Centrifugal	150 L/min	
PU-012	Sludge Recycle Pump #3 V.S.D.	** HP	Centrifugal	150 L/min	
PU-013	Sludge Transfer Pump #1	** HP	Centrifugal	200 L/min	
PU-014	Sludge Transfer Pump #2	** HP	Centrifugal	200 L/min	
PU-015	Treated Water Recycle Pump #1	** HP	Centrifugal	77 L/min	
PU-016	Treated Water Recycle Pump #2	** HP	Centrifugal	77 L/min	
PU-017	Flocculant Preparation Area Sump Pump	** HP	Cantilever	400 L/min	
PU-018	Clarifer Area Sump Pump	** HP	Cantilever	400 L/min	
TA-002	Sludge/Lime Mix tank			1 m ∅ x 1 m High (w/o F/B)	c.s.
TA-003	Lime Reactor Tank			8 m ∅ x 7 m High (w/o F/B)	c/s
TA-004	Clarifier Tank			19 m ∅	c/s
TA-005	Lime Slurry Storage Tank			3 m ∅ x 2 m High (w/o F/B)	c/s


Down Valley
14 December, 2003
Quicklime (CaO)
1.2 tonnes/day (as CaO)
Lime Storage Silo eq. # TA-001
50 tonnes SB-001
(Based on 43 days storage)
Dry Flocculant
25.6 kg/day
Fresh Water
10.3 L/min
(continuous basis)
3.5 L/min
Flocculant Preparation Package eq. # FM-001
3.5 L/min
Flocculant Feed Pumps eq. # PU-004
PU-005
Lime Silo Screw Feeder
100 kg/hr eq. # SF-001
(Based on 49% Operating Time)
5.1 L/min
Miscellaneous sources
100 % of total other consumption
1.6 L/min
6 L/min
Effluent Sources
Lime Slaker eq. # LS-001
100 kg/hr
(Based on 49% Operating Time)
3.2 | 2.4 | 1.3
14.0 | 12.0 | 24
30 | 1.08 | 25
Plant Feed Pond
Plant Feed Pumps eq. # PU-001
PU-002
PU-003
0.0 | - | 0.0
7.3 | 0.0 | 5678
6300 | 1.00 | 5678
eq. # TA-005
RM-005
In-Line Static Mixer
eq.# SM-001
SM-002
1 | 2.4 | 0.4
14.0 | 12.0 | 7.9
10 | 1.08 | 8.4
4.3 | 2.4 | 1.8
14.0 | 12.0 | 31.7
40 | 1.08 | 33.5
Lime Slurry Pumps
eq. # PU-008
PU-009
Lime Slurry Storage Tank
12 m3
2.8 m ∅ x 2.0 m high
(without freeboard)
35 L/min
32 L/min
55 | 2.8 | 19.6
9.3 | 0.9 | 5938
6600 | 1.01 | 5957
Treated Water Recycle Pumps
eq # PU-015
PU-016
38.3 L/min
(continuous basis)
55 | 2.8 | 19.7
13.5 | 19.7 | 224
300 | 1.15 | 244
Sludge/Lime Mix Tank
eq # TA-002
1 m³ RM-001
1.3 m ∅ x 0.9 m high
(without freeboard)
0.0 | 2.8 | 0.0
9.3 | 0.0 | 5680
6300 | 1.00 | 5680
Recycled WaterTank
3 m³
1.7 m ∅ x 1.3 m high
(without freeboard)
Treated Water Discharge
Clarifier Tank
19 m ∅
eq. # TA-004
ME-001
18 m³/hr or 11 SCFM
Process Air Compressors
eq. # CO-001
CO-002
Clarifier Area Sump Eq. # PU-018
Reactor Vessel eq. # TA-003
355 m³ RM-002
8.2 m ∅ x 6.7 m high
(without freeboard)
54 | 2.8 | 19.3
9.3 | 20.0 | 216
300 | 1.15 | 235
Sludge Recycle Pumps eq. # PU010
PU011
PU-012
Legend
kg/min Solids | Sp/Gr Solids | L/min Solids
pH Slurry | % Solids | L/min Water
Design L/min | Sp/Gr Slurry | L/min Slurry
Flocculant Preparation Area Sump Eq. # PU-017
0.9 | 2.8 | 0.3
9.3 | 20.0 | 3.4
200 | 1.15 | 3.7
Sludge Transfer Pumps eq. # PU-013
PU-014
Treated Water For Line Flushing Use Only
Intermittent @ 156 L/min
Based on one 4.0 hour purge every 7.0 days
Sludge Impoundment Basin
12.2 thousand m³

SRK Report Distribution Record

Complete this form and include it as the final page for each copy of the report produced.

Report No.	
Copy No.	

Name/Title	Company	Copy	Date	Authorised by

Approval Signature:	