SCREEN PERFORMANCE OPTIMIZATION
PART 2A: SMART SCREEN SYSTEMS

COLERAINE MINERALS RESEARCH LABORATORY

September 3, 2003

By _____
Thomas R. Larson, Research Fellow

Approved by _____
David W. Hendrickson, Director
Coleraine Minerals Research Laboratory

CMRL/TR-03-04
NRRI/TR-2003/22

University of Minnesota Duluth
Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, Minnesota 55811

Coleraine Minerals Research Laboratory
P O Box 188
One Gayley Avenue
Coleraine, Minnesota 55722

Screen Performance Optimization

Part 2a: Smart Screen Systems

Introduction:

A Smart Screen Systems screening device was installed in the pilot plant at the Coleraine Mineral Research Laboratory. As installed, the machine holds one pre-tensioned panel at 25-degrees from horizontal. Currently, single or two panel machines are available, and can be manufactured at the deck angle required for optimum performance. The effective screen cloth surface area on the pre-tensioned panels was 43" wide by 34" long, and the feed stream was distributed evenly along the 43" wide surface. The panel installation system was very simple, consisting of six cams used to hold an edge bracket onto the panel. A single individual can change a panel in just a few minutes.

The scope of work for this project follows the pattern set in Part 1, in which five tests were completed on each of two feed samples, one from Hibbing Taconite, and one from Northshore Mining. The scope of work for Part 2 also includes silica and magnetic iron assays on head samples as well as on each size fraction. Otherwise, the test plan was identical to the previous part.

For each material, initial tests were completed to achieve the established separation criteria as in Part 1. These criteria were to achieve a split at near 100 microns for the Hibbing Taconite material, and to achieve an undersize grade close to 90% –325 mesh for the Northshore Mining material. Once the panel was selected and other operating issues were resolved, a formal test sequence was conducted using two values for feed rate and two values of feed solids that were just higher and just lower than in the initial tests. The idea was to bracket the optimum separation and measure the variation in screen performance as these two parameters varied. As seen in Table 1, the four tests were completed in a 2x2 pattern, and a fifth test was a repetition of one of the first four in order to measure experimental error.

Results:

Test results are summarized in Table 1 on Page 3, and Figures 1 and 2, on pages 4 and 5 respectively. All of the raw data and balanced data can be found in Appendix A, and Figure 3 on page 6 is a graph of the feed size distributions for each test.

Discussion:

During Hibbing Taconite tests, a few issues are noteworthy. In the initial tests, the precise target of 100 microns appeared to fall in between two panels that were on hand. One panel split on the fine side, and the other split on the coarse side. Because of project timing, the finer panel was used. After completing the test sequence, the split was found to be suitably close to the target split. However, the Smart Screen system can be fitted with any frame mounted or pre-tensioned panels using screen cloth of the appropriate mesh. Second, the screen capacity was much higher than the pump capacity for Hibbing Taconite feed. Therefore, the full capacity of the machine for Hibbing Taconite could not be determined. Once again, project timing dictated that the tests be completed, as a larger pump was not available.

The material balance was calculated within Microsoft EXCEL, using a weighted linear regression to first calculate the global mass split and then using the LaGrange formulation to calculate the balanced assays. The balance calculations used both the head assays and the silica and magnetic iron assays of each size fraction, but the two were included as if they were independent of each other. In this way, the mathematical error minimization technique applies to all the data instead of forcing the error to accumulate in the minus 500 mesh data. As in Part 1, the presence of small amounts of material in the coarsest size fractions challenges the agreement between the measured head assays and the head assays calculated from the size fractions. These particles do not have a strong impact on the final weight split calculations due to their small mass, but they can result in insignificant but unusual values for percent recovery to the coarse stream in coarse particle sizes.

Table 1: Test Results Overview

Test Plan			Actual Conditions			
Material	Feed Solids	Oversize Flow Rate	Oversize Flow (GPM)	Feed Solids	Tested Feed Rate (ltph) *	Machine Feed Rate (ltph) *
Hibbing Taconite	High	High	1.16	49.8%	*(8.47)*	*(n/a)*
Hibbing Taconite	High	Low	1.01	49.5%	*(6.79)*	*(n/a)*
Hibbing Taconite	Low	Low	0.66	42.3%	*(5.42)*	*(n/a)*
Hibbing Taconite	Low	High	1.58	42.8%	*(6.76)*	*(n/a)*
Hibbing Taconite	Low	Low	0.75	42.8%	*(5.77)*	*(n/a)*
Northshore	High	High	18.7	49.3%	7.73	15.5
Northshore	High	Low	9.80	49.3%	4.95	9.89
Northshore	Low	Low	10.8	40.7%	4.68	9.35
Northshore	Low	High	16.1	40.6%	5.71	11.4
Northshore	Low	Low	12.9	41.0%	5.00	10.0

** Hibbing Taconite Feed Rates were limited by pump capacity, not by screen capacity.*

Test Plan			Test Results			
Material	Feed Solids	Oversize Flow Rate	Wgt % to Oversize	Fines Bypass	Partition Slope	Delta Silica
Hibbing Taconite	High	High	7.19%	2.32%	1.31	1.21%
Hibbing Taconite	High	Low	8.19%	2.76%	1.21	1.32%
Hibbing Taconite	Low	Low	5.83%	1.64%	1.69	1.26%
Hibbing Taconite	Low	High	9.51%	2.74%	1.42	2.16%
Hibbing Taconite	Low	Low	5.73%	1.42%	1.58	1.35%
Northshore	High	High	62.4%	43.8%	1.51	20.83%
Northshore	High	Low	57.1%	35.2%	1.78	20.97%
Northshore	Low	Low	56.2%	29.1%	2.04	23.00%
Northshore	Low	High	58.1%	36.6%	1.65	21.35%
Northshore	Low	Low	56.6%	32.7%	1.82	20.40%

Test Plan			Specific Objectives		
Material	Feed Solids	Oversize Flow Rate	d50	Undersize % Silica	Undersize % - 325 Mesh
Hibbing Taconite	High	High	101	3.64%	88.5%
Hibbing Taconite	High	Low	97.6	3.68%	88.2%
Hibbing Taconite	Low	Low	103	3.82%	87.9%
Hibbing Taconite	Low	High	98.0	3.86%	87.2%
Hibbing Taconite	Low	Low	104	3.63%	87.9%
Northshore	High	High	31.8	8.99%	90.7%
Northshore	High	Low	37.5	8.76%	90.5%
Northshore	Low	Low	43.0	9.54%	88.2%
Northshore	Low	High	40.8	10.4%	87.7%
Northshore	Low	Low	42.1	10.0%	87.5%

Figure 1: Partition Curves, Hibbing Taconite Feed

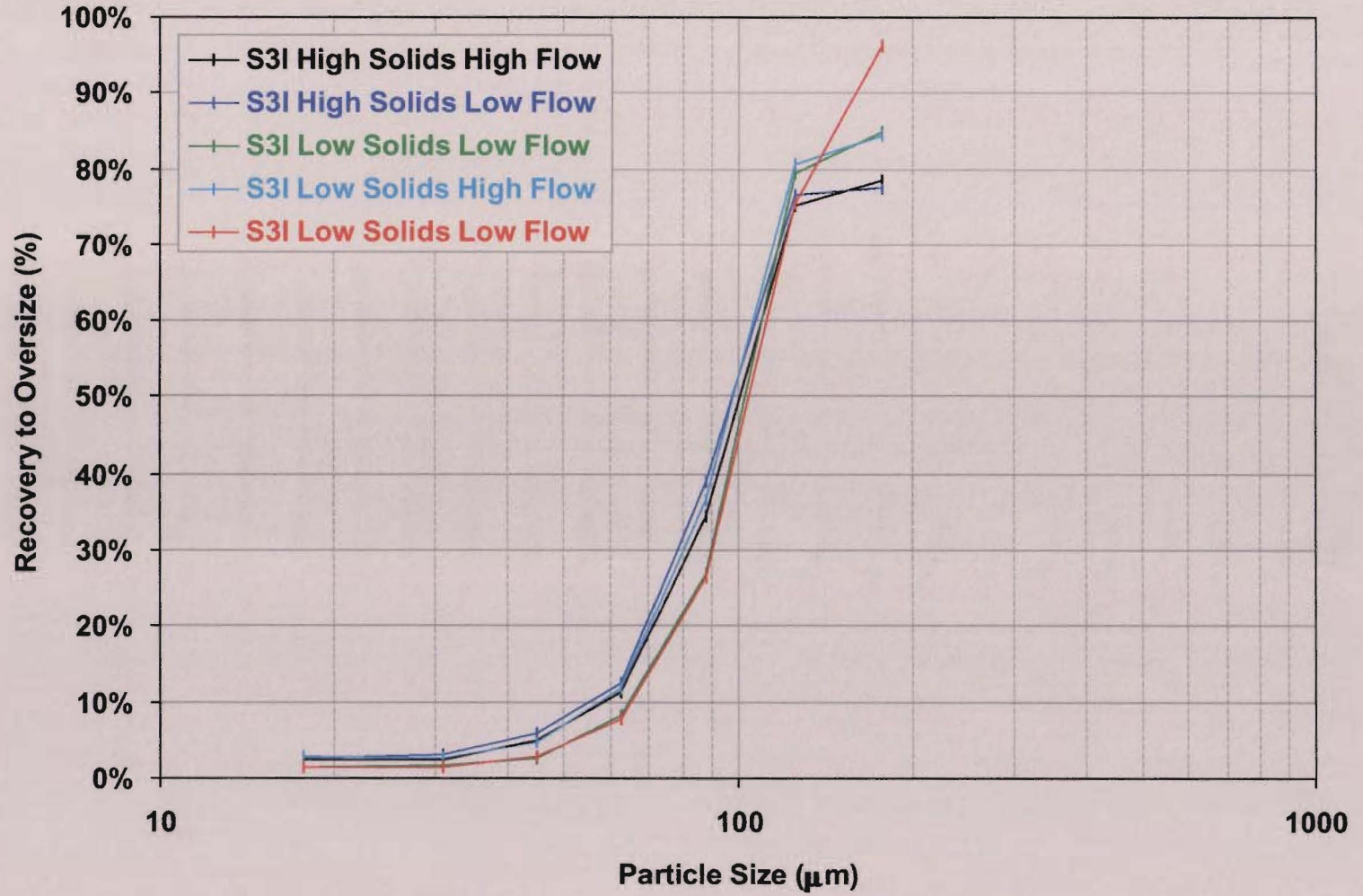


Figure 2: Partition Curves, Northshore Feed

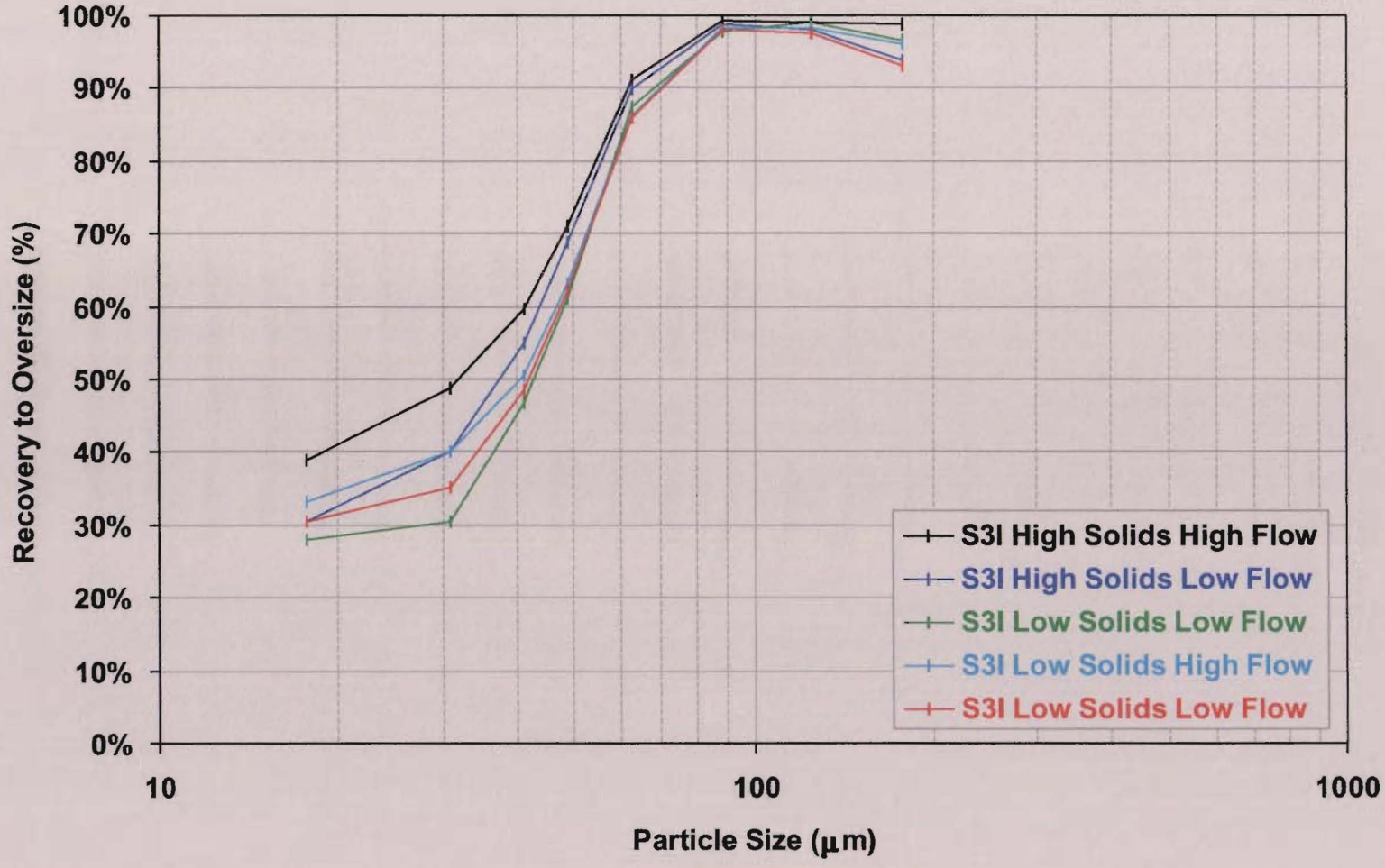
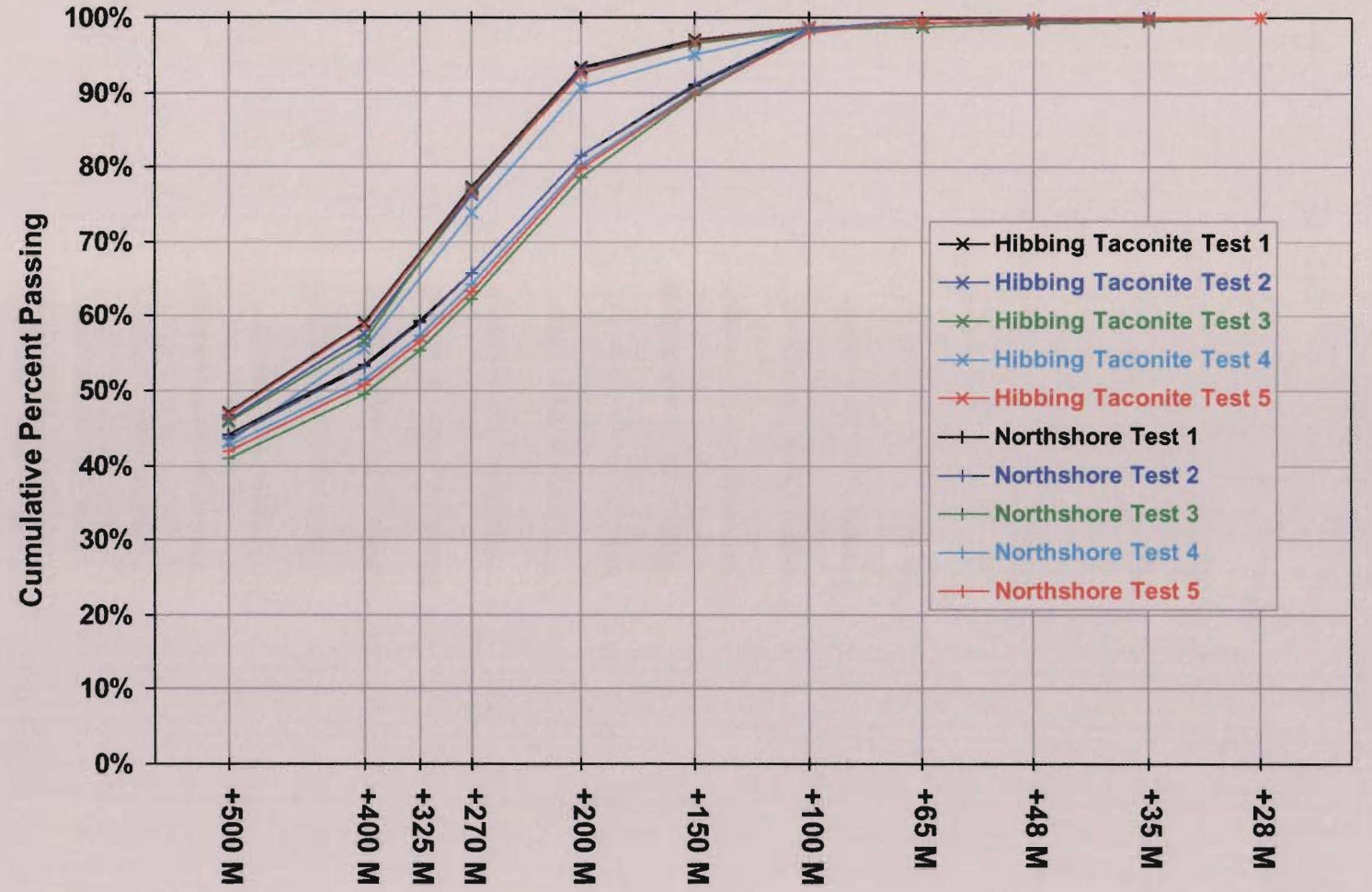


Figure 3: Size Distribution Curves for the Two Feed Samples



In this case, the insignificance of these values was emphasized simply by not including them in Figures 1 and 2. The assays of these particles are also the primary explanation for variances between the measured head assays and the calculated head assays.

Figures 1 and 2 show the separation results for the Hibbing Taconite tests and Northshore tests respectively. The charts show the percent recovered in the coarse stream as a function of the particle size. Three important types of information can be readily seen from this chart.

First, the slope of the line represents the cleanness of the separation, since a vertical line would mean all of the particles coarser than that size would be sent to the coarse stream, and all of the particles below that size would report to the fine stream. Obviously, the slope is a measure of both the amount of fines in the coarse, and the amount of coarse in the fines, in the particle sizes nearest the split size. The higher the slope value, the better the separation.

Secondly, the size at which 50% of the feed reports to the coarse and 50% of the feed reports to the fines can easily be read from the chart. Since real separations are not vertical lines, this point (called the d_{50}) is an overall indication of the size where the vertical line would be if the separation were perfect. From a practical standpoint, the assay by size data in Appendix A shows how this number can be important. The Hibbing Taconite feed stream shows pronounced silica assay changes starting from 5% at 53 microns, tripling to near 15% at 75 microns and then more than doubling again at 105 microns up to values near 40% silica. This is an eight-fold increase in silica in two size fractions. This reveals the importance of the separation at approximately 100 microns.

Finally, the amount of the finest material that reports to the coarse stream is presented by observing the value at which the line flattens out on the fine end. These particles do not belong in the coarse stream, but are there due to various inefficiencies in the separation, including water flow rates, or even water entrainment effects.

Regarding the Hibbing Taconite separation, the data in Table 1 shows several interesting features. First, the slope of the partition curve appears to be

inversely related to the feed solids, indicating that a cleaner split is available at the lower feed solids values. A small average shift in d_{50} to the coarse side is also apparent at the lower feed solids, as shown in Figure 1, but the d_{50} depends more on the combination of feed solids and feed flow rate. Interestingly, at high solids, the d50 follows the oversize flow rate directly, but at low solids, the relationship is reversed. On the other hand, the weight percent reporting to the oversize shows an increased sensitivity to feed flow rate when the solids are at the lower value. Since this stream can result in lost productivity, the low feed solids needs to be coupled with the lower feed rate. The silica in the undersize stream does not appear to have a strong relationship with the controlled variables, although each of the values is quite low.

Northshore data also shows significant relationships between the controlled variables and the measured responses. In particular, the weight split and the fines bypass values follow each other, and average higher with higher feed solids, and lower at the low feed solids, coupled with a similar relationship with feed flowrate. The weight split and fines bypass data associates with higher values at higher oversize flow rates, and likewise lower values with the lower flow rates. The undersize target of 90% - 325 mesh was successfully bracketed by these tests conditions, but appears related to the feed solids more than to the feed flowrate. In this case, however, the finer underflow size values correspond to the higher solids values. Just as with the Hibbing data, the partition curve slopes follow the feed solids values relatively well, showing that lower slopes correspond to the higher solids.

Figure 3 is included simply to check on possible drift of the feed size distributions. As each slurry sample was used in five continuous tests, there was a possibility that the first sample might be coarser than the fifth sample due to the number of trips it made through the feed pump. This condition was checked mathematically for the - 270 mesh data, and no association was found to exist between this size and the test order, nor between this size and the feed solids or feed flowrate inputs.

Conclusion and Recommendation:

As supported by the data in this report, the Smart Screen Systems product has been shown to be a viable candidate for screening applications on the Minnesota Iron Range. It is hoped that performance details presented here will be used by mine managers and technical staff in determining the best size separation device for their plant. To better characterize the application of this device for any given separation, additional tests are recommended following one of two methods. First, a machine can be placed in the appropriate plant and plumbed in using a slip stream, or secondly, several 55 gallon drums of feed sample can be collected and shipped to the Coleraine Minerals Research Laboratory pilot plant for more detailed optimization tests.

Appendix A: Raw and Balanced Data:

Hibbing Taconite Test 1 *High Solids High Flow*		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			4.78%	63.37%		3.58%	64.60%		20.36%	47.39%
Head Assays Calculated from Size:		100.0%	4.79%	65.83%	92.81%	3.64%	67.11%	7.19%	19.68%	49.33%
Balanced % Solids:			49.78%			48.32%			81.49%	
Water Weight Split:			100.0%			98.4%			1.6%	
					Calculated Data					
Dry Massflow (ltph):			8.47			7.86			0.61	
Water (ltph):			8.54			8.40			0.14	
Volumetric flow (GPM):			45.78			44.62			1.16	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35	425	99.9	0.00%	0.00%	99.9	0.00%	0.00%	99.8	0.00%	0.00%
48	297	99.7	26.64%	0.00%	99.5	26.10%	0.00%	99.5	37.47%	0.00%
65	212	99.4	38.70%	0.00%	99.2	26.71%	0.00%	98.6	60.12%	0.00%
100	149	99.3	39.68%	26.88%	99.1	25.43%	38.65%	94.4	63.94%	14.24%
150	105	97.4	39.81%	26.79%	98.6	24.57%	39.50%	74.8	47.38%	22.81%
200	74	93.9	15.94%	48.75%	96.0	14.75%	50.02%	57.4	24.75%	40.24%
270	53	77.9	4.97%	64.31%	80.3	5.05%	65.04%	31.7	6.78%	61.48%
400	38	59.9	2.90%	68.70%	61.9	2.99%	68.93%	19.0	3.49%	68.29%
500	25	47.2	2.28%	70.43%	49.7	2.29%	70.34%	15.1	2.54%	69.85%
	Pan		2.91%	67.92%		2.89%	68.50%		3.51%	66.60%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
35	425	99.9%	0.00%	0.00%	99.9%	0.00%	0.00%	99.8%	0.00%	0.00%
48	297	99.6%	26.64%	0.00%	99.6%	25.97%	0.00%	99.5%	37.73%	0.00%
65	212	99.3%	35.02%	0.00%	99.3%	28.30%	0.00%	98.6%	60.31%	0.00%
100	149	98.9%	53.34%	15.42%	99.2%	18.46%	19.47%	94.4%	62.95%	14.30%
150	105	97.0%	40.93%	26.80%	98.7%	21.34%	38.92%	74.8%	47.37%	22.81%
200	74	93.4%	17.14%	47.63%	96.2%	13.12%	51.54%	57.5%	24.74%	40.25%
270	53	77.2%	5.12%	64.49%	80.8%	4.91%	64.88%	31.8%	6.77%	61.47%
400	38	59.2%	2.96%	68.81%	62.3%	2.93%	68.83%	19.0%	3.48%	68.28%
500	25	47.1%	2.29%	70.38%	49.6%	2.28%	70.39%	15.1%	2.54%	69.87%
	Pan		2.91%	68.36%		2.90%	68.41%		3.51%	66.50%

Appendix A: Raw and Balanced Data:

Hibbing Taconite Test 2										
High Solids Low Flow		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			4.96%	63.19%		3.65%	64.55%		19.71%	48.01%
Head Assays Calculated from Size:		100.0%	5.01%	65.66%	91.81%	3.68%	67.10%	8.19%	20.02%	49.58%
Balanced % Solids:			49.51%			47.80%			82.92%	
Water Weight Split:			100.0%			98.3%			1.7%	
					Calculated Data					
Dry Massflow (ltph):			6.79			6.23			0.56	
Water (ltph):			6.92			6.80			0.11	
Volumetric flow (GPM):			37.01			36.00			1.01	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35	425	99.9	0.00%	0.00%	99.9	0.00%	0.00%	99.8	0.00%	0.00%
48	297	99.6	32.67%	0.00%	99.7	28.28%	0.00%	99.6	38.47%	0.00%
65	212	99.3	36.64%	0.00%	99.4	28.28%	0.00%	98.6	59.64%	0.00%
100	149	99.0	49.23%	21.07%	99.3	33.56%	31.41%	94.1	66.12%	13.66%
150	105	97.0	38.25%	27.43%	98.8	28.72%	35.54%	75.8	48.68%	22.75%
200	74	93.4	15.66%	47.66%	96.1	14.35%	50.49%	57.7	23.33%	40.82%
270	53	76.2	4.84%	64.84%	80.4	5.59%	65.62%	31.7	8.19%	61.80%
400	38	57.7	2.97%	68.80%	61.4	2.90%	69.23%	18.2	3.61%	67.86%
500	25	45.7	2.32%	70.71%	49.2	2.30%	70.34%	13.9	2.68%	69.71%
	Pan		2.68%	68.40%		3.22%	67.51%		3.91%	65.98%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
35	425	99.9%	0.00%	0.00%	99.9%	0.00%	0.00%	99.8%	0.00%	0.00%
48	297	99.6%	31.13%	0.00%	99.6%	30.45%	0.00%	99.6%	38.51%	0.00%
65	212	99.3%	36.26%	0.00%	99.4%	28.45%	0.00%	98.6%	59.67%	0.00%
100	149	98.9%	58.01%	15.65%	99.3%	23.07%	21.05%	94.3%	68.09%	14.09%
150	105	96.9%	41.36%	26.51%	98.8%	17.63%	38.75%	75.9%	48.65%	22.76%
200	74	93.1%	16.82%	47.21%	96.3%	12.65%	51.31%	57.9%	23.32%	40.82%
270	53	76.2%	5.42%	64.99%	80.2%	5.02%	65.46%	31.8%	8.16%	61.80%
400	38	57.7%	2.95%	68.99%	61.2%	2.91%	69.06%	18.4%	3.61%	67.84%
500	25	46.0%	2.32%	70.50%	48.8%	2.30%	70.53%	14.0%	2.68%	69.76%
	Pan		2.99%	68.01%		2.97%	68.07%		3.79%	65.47%

Appendix A: Raw and Balanced Data:

Hibbing Taconite Test 3										
Low Solids Low Flow		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			5.50%	62.84%		4.24%	64.12%		25.83%	42.07%
Head Assays Calculated from Size:		100.0%	5.14%	65.48%	94.17%	3.82%	66.84%	5.83%	26.50%	43.34%
Balanced % Solids:			42.35%			41.17%			78.72%	
Water Weight Split:			100.0%			98.8%			1.2%	
					Calculated Data					
Dry Massflow (ltph):			5.4			5.1			0.32	
Water (ltph):			7.4			7.3			0.1	
Volumetric flow (GPM):			37.9			37.2			0.7	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35	425	99.5	35.24%	0.00%	99.6	31.10%	0.00%	99.8	43.79%	0.00%
48	297	99.2	34.42%	0.00%	99.2	30.67%	0.00%	99.4	43.79%	0.00%
65	212	98.9	37.79%	0.00%	98.9	30.88%	0.00%	98.1	62.36%	0.00%
100	149	98.5	52.35%	19.46%	98.8	32.35%	32.40%	91.2	64.50%	13.57%
150	105	96.7	41.35%	25.51%	98.2	30.64%	33.84%	64.2	51.21%	21.27%
200	74	93.1	16.94%	46.70%	95.0	14.85%	49.67%	46.3	26.57%	38.78%
270	53	77.1	5.22%	65.02%	80.3	5.76%	65.44%	24.4	7.05%	61.01%
400	38	57.0	2.88%	69.22%	58.7	2.83%	69.13%	15.1	3.74%	67.36%
500	25	45.7	2.13%	70.60%	47.8	2.17%	70.45%	11.9	2.62%	69.34%
	Pan		2.71%	68.30%		2.73%	68.30%		3.83%	66.08%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
35	425	99.6%	33.39%	0.00%	99.6%	33.15%	0.00%	99.8%	43.95%	0.00%
48	297	99.2%	32.81%	0.00%	99.2%	32.19%	0.00%	99.4%	43.89%	0.00%
65	212	98.9%	37.94%	0.00%	98.9%	29.88%	0.00%	98.1%	62.39%	0.00%
100	149	98.4%	62.06%	18.63%	98.9%	46.80%	46.91%	91.3%	64.76%	13.64%
150	105	96.4%	43.77%	22.67%	98.4%	15.01%	28.04%	64.2%	51.20%	21.28%
200	74	92.6%	17.45%	46.80%	95.5%	14.07%	49.78%	46.4%	26.57%	38.77%
270	53	77.0%	5.55%	65.04%	80.3%	5.42%	65.40%	24.4%	7.03%	61.01%
400	38	56.6%	2.87%	69.15%	59.1%	2.84%	69.19%	15.2%	3.74%	67.36%
500	25	45.7%	2.15%	70.51%	47.8%	2.15%	70.53%	11.9%	2.61%	69.37%
	Pan		2.73%	68.28%		2.71%	68.32%		3.82%	65.91%

Appendix A: Raw and Balanced Data:

Hibbing Taconite Test 4 *Low Solids High Flow*		Screen Feed			Screen Undersize			Screen Oversize		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			5.79%	62.62%		3.63%	64.66%		26.32%	43.27%
Head Assays Calculated from Size:		100.0%	5.64%	65.25%	90.49%	3.86%	67.55%	9.51%	22.64%	43.38%
Balanced % Solids:			42.81%			40.99%			74.07%	
Water Weight Split:			100.0%			97.5%			2.5%	
					Calculated Data					
Dry Massflow (ltph):			6.8			6.1			0.64	
Water (ltph):			9.0			8.8			0.2	
Volumetric flow (GPM):			46.5			44.9			1.6	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35	425	100.0	28.68%	0.00%	99.7	32.54%	0.00%	99.7	40.27%	0.00%
48	297	99.8	28.68%	0.00%	99.4	31.67%	0.00%	99.4	40.27%	0.00%
65	212	99.4	28.68%	35.57%	99.1	29.91%	34.48%	97.9	29.56%	15.74%
100	149	99.1	45.50%	23.17%	98.9	31.36%	33.22%	91.1	33.10%	13.51%
150	105	96.9	39.19%	28.80%	98.2	27.47%	36.69%	63.3	47.47%	20.85%
200	74	92.5	15.95%	48.24%	94.9	14.80%	49.18%	45.8	23.68%	38.33%
270	53	75.4	4.87%	65.20%	79.0	4.82%	64.88%	25.2	7.68%	61.04%
400	38	56.3	2.99%	68.86%	60.3	2.95%	69.19%	16.1	3.72%	68.01%
500	25	43.8	2.15%	70.33%	46.9	2.20%	70.38%	12.6	2.52%	69.92%
	Pan		3.15%	68.21%		2.91%	68.62%		3.65%	67.03%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3	6700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
35	425	99.8%	32.67%	0.00%	99.8%	31.65%	0.00%	99.8%	40.68%	0.00%
48	297	99.6%	31.64%	0.00%	99.6%	30.11%	0.00%	99.4%	40.40%	0.00%
65	212	99.2%	29.32%	31.40%	99.3%	29.20%	39.62%	97.9%	29.54%	15.82%
100	149	98.4%	29.00%	15.09%	99.2%	6.38%	23.37%	91.2%	33.21%	13.54%
150	105	95.2%	43.57%	21.95%	98.5%	27.44%	26.30%	63.5%	47.45%	20.90%
200	74	90.6%	17.08%	46.59%	95.3%	13.27%	51.37%	46.0%	23.66%	38.36%
270	53	73.9%	5.03%	64.78%	79.0%	4.68%	65.28%	25.3%	7.66%	61.08%
400	38	55.6%	2.99%	69.00%	59.7%	2.95%	69.05%	16.2%	3.71%	67.99%
500	25	43.1%	2.18%	70.35%	46.3%	2.17%	70.36%	12.7%	2.51%	69.91%
	Pan		3.07%	69.41%		3.06%	69.49%		3.67%	66.65%

Appendix A: Raw and Balanced Data:

Hibbing Taconite Test 5 *Low Solids Low Flow*	Screen Feed			Screen Undersize			Screen Oversize		
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:		5.00%	63.09%		3.65%	64.38%		27.20%	41.91%
Head Assays Calculated from Size:	100.0%	4.59%	65.67%	94.27%	3.63%	67.10%	5.73%	20.47%	42.12%
Balanced % Solids:		41.93%			40.81%			76.67%	
Water Weight Split:		100.0%			98.7%			1.3%	
				Calculated Data					
Dry Massflow (ltph):		5.8			5.4			0.33	
Water (ltph):		8.0			7.9			0.1	
Volumetric flow (GPM):		40.9			40.2			0.7	
mesh ***microns***				**Measured Size and Assay Data**					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3 6700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
4 4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6 3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8 2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10 1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14 1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20 850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28 600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35 425	99.7	35.88%	0.00%	99.9	30.63%	0.00%	99.8	41.41%	0.00%
48 297	99.4	35.65%	0.00%	99.5	30.63%	0.00%	99.5	41.41%	0.00%
65 212	99.2	0.00%	0.00%	99.3	0.00%	0.00%	98.0	0.00%	0.00%
100 149	99.0	0.00%	0.00%	99.1	0.00%	0.00%	91.0	0.00%	0.00%
150 105	97.1	42.79%	25.54%	98.5	29.00%	35.28%	63.6	48.42%	21.11%
200 74	93.2	16.26%	48.09%	95.3	14.58%	50.36%	45.3	24.09%	39.30%
270 53	77.3	4.87%	64.89%	79.8	4.85%	64.93%	23.8	8.11%	61.18%
400 38	59.1	2.76%	68.84%	61.3	2.91%	68.77%	14.9	3.92%	67.56%
500 25	47.2	2.18%	70.46%	48.6	2.24%	70.36%	12.0	2.71%	69.10%
Pan		2.82%	68.83%		2.70%	68.23%		3.71%	66.50%
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
3 6700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
4 4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6 3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8 2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10 1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14 1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20 850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28 600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
35 425	99.8%	34.21%	0.00%	99.8%	33.89%	0.00%	99.8%	41.39%	0.00%
48 297	99.5%	33.04%	0.00%	99.5%	32.55%	0.00%	99.5%	41.61%	0.00%
65 212	99.2%	0.00%	0.00%	99.3%	0.00%	0.00%	98.0%	0.00%	0.00%
100 149	98.8%	0.00%	0.00%	99.3%	0.00%	0.00%	91.0%	0.00%	0.00%
150 105	96.7%	42.90%	25.28%	98.7%	26.02%	38.04%	63.6%	48.42%	21.11%
200 74	92.7%	16.68%	47.78%	95.6%	14.02%	50.82%	45.3%	24.09%	39.30%
270 53	76.9%	4.99%	64.76%	80.1%	4.73%	65.06%	23.8%	8.10%	61.19%
400 38	58.8%	2.85%	68.79%	61.5%	2.82%	68.82%	14.9%	3.91%	67.57%
500 25	46.8%	2.22%	70.40%	48.9%	2.21%	70.42%	12.1%	2.70%	69.11%
Pan		2.77%	68.59%		2.75%	68.62%		3.72%	66.56%

Appendix A: Raw and Balanced Data:

Northshore Test 1 *High Solids High Flow*	Screen Feed			Screen Undersize			Screen Oversize		
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:		29.71%	43.68%		8.88%	59.79%		42.28%	33.97%
Head Assays Calculated from Size:	100.0%	28.76%	45.30%	37.63%	8.99%	62.47%	62.37%	40.69%	34.94%
Balanced % Solids:		49.25%			37.95%			60.05%	
Water Weight Split:		100.0%			59.7%			40.3%	
				Calculated Data					
Dry Massflow (ltph):		7.7			2.9			4.82	
Water (ltph):		8.0			4.8			3.2	
Volumetric flow (GPM):		42.5			23.9			18.7	
mesh ***microns***				**Measured Size and Assay Data**					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4 4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6 3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8 2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10 1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14 1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20 850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28 600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
35 425	99.9	0.00%	0.00%	99.9	0.00%	0.00%	99.9	0.00%	0.00%
48 297	99.9	0.00%	0.00%	99.9	0.00%	0.00%	99.9	0.00%	0.00%
65 212	99.6	69.94%	0.00%	99.8	50.74%	0.00%	99.6	76.22%	0.00%
100 149	98.4	80.64%	6.95%	99.7	48.99%	25.80%	97.3	76.80%	5.13%
150 105	90.9	82.66%	6.04%	99.5	45.23%	28.90%	85.6	78.36%	5.88%
200 74	81.5	74.66%	9.37%	99.3	48.76%	25.98%	70.6	72.76%	9.01%
270 53	66.0	53.07%	20.61%	95.5	33.28%	39.30%	47.6	54.02%	21.34%
325 45	59.4	27.15%	45.90%	90.6	18.53%	53.83%	40.4	31.13%	39.69%
400 38	53.4	16.05%	55.89%	84.3	12.48%	60.20%	34.8	16.61%	52.73%
500 25	44.1	10.91%	62.55%	71.6	8.37%	63.64%	27.4	11.31%	61.10%
Pan		6.58%	64.41%		6.24%	64.76%		6.77%	64.24%
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4 4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6 3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8 2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10 1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14 1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20 850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28 600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
35 425	99.9%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
48 297	99.9%	0.00%	0.00%	99.9%	0.00%	0.00%	99.9%	0.00%	0.00%
65 212	99.6%	70.36%	0.00%	99.8%	51.52%	0.00%	99.6%	75.74%	0.00%
100 149	98.3%	77.44%	6.08%	99.7%	43.76%	59.31%	97.4%	77.88%	5.39%
150 105	90.9%	79.70%	6.06%	99.5%	94.27%	24.29%	85.7%	79.55%	5.87%
200 74	81.4%	73.28%	9.23%	99.3%	71.58%	29.96%	70.6%	73.30%	9.07%
270 53	65.7%	52.46%	22.16%	95.6%	34.00%	37.09%	47.7%	54.28%	20.68%
325 45	59.4%	27.36%	44.53%	90.7%	18.51%	54.42%	40.5%	30.97%	40.51%
400 38	53.4%	15.33%	55.80%	84.3%	12.75%	60.21%	34.8%	17.07%	52.82%
500 25	44.1%	10.19%	62.45%	71.6%	8.56%	63.67%	27.5%	11.89%	61.17%
Pan		6.49%	64.51%		6.26%	64.74%		6.86%	64.14%

Appendix A: Raw and Balanced Data:

Northshore Test 2 *High Solids Low Flow*	Screen Feed			Screen Undersize			Screen Oversize		
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:		29.45%	42.81%		8.47%	59.83%		45.18%	30.03%
Head Assays Calculated from Size:	100.0%	30.10%	45.62%	42.86%	8.76%	62.65%	57.14%	46.11%	32.85%
Balanced % Solids:		49.29%			37.99%			63.46%	
Water Weight Split:		100.0%			68.0%			32.0%	
				Calculated Data					
Dry Massflow (ltph):		4.9			2.1			2.83	
Water (ltph):		5.1			3.5			1.6	
Volumetric flow (GPM):		27.2			17.4			9.8	
mesh ***microns***				**Measured Size and Assay Data**					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4 4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6 3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8 2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10 1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14 1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20 850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28 600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
35 425	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
48 297	99.9	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
65 212	99.6	72.90%	0.00%	99.8	52.94%	0.00%	99.7	78.92%	0.00%
100 149	98.5	83.98%	5.52%	99.7	52.70%	22.87%	98.0	88.16%	5.15%
150 105	90.6	78.96%	6.28%	99.5	52.71%	22.86%	85.1	86.54%	5.68%
200 74	81.1	75.94%	9.48%	99.3	51.45%	23.84%	68.7	77.84%	9.13%
270 53	65.6	54.14%	23.09%	95.5	33.12%	40.64%	43.8	58.78%	21.17%
325 45	59.0	25.54%	46.37%	90.5	17.39%	54.61%	35.7	29.50%	42.19%
400 38	53.0	15.45%	57.19%	84.2	12.51%	60.68%	29.9	20.33%	53.15%
500 25	43.6	10.09%	63.33%	70.9	8.96%	63.89%	23.2	13.03%	60.18%
Pan		6.57%	64.27%		6.46%	64.86%		7.74%	63.77%
				Balanced Data					
	Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4 4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6 3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8 2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10 1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14 1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20 850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28 600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
35 425	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
48 297	99.9%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
65 212	99.7%	72.62%	0.00%	99.8%	56.50%	0.00%	99.6%	78.40%	0.00%
100 149	98.6%	85.52%	5.85%	99.7%	54.56%	18.27%	97.9%	87.53%	5.04%
150 105	91.0%	83.62%	6.03%	99.3%	17.16%	19.16%	84.8%	84.89%	5.77%
200 74	81.6%	77.01%	9.35%	99.1%	34.73%	25.46%	68.5%	77.49%	9.17%
270 53	65.9%	55.48%	23.14%	95.4%	30.11%	41.02%	43.7%	58.32%	21.14%
325 45	59.1%	25.66%	46.17%	90.5%	17.27%	54.78%	35.6%	29.47%	42.26%
400 38	53.1%	16.36%	56.75%	84.1%	12.13%	60.87%	29.8%	19.82%	53.38%
500 25	43.6%	10.42%	62.71%	70.9%	8.85%	64.08%	23.1%	12.78%	60.66%
Pan		6.75%	64.44%		6.41%	64.81%		7.54%	63.59%

Appendix A: Raw and Balanced Data:

Northshore Test 3										
Low Solids Low Flow		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			30.99%	41.31%		7.99%	58.73%		48.90%	27.75%
Head Assays Calculated from Size:		100.0%	33.02%	43.28%	43.77%	9.54%	62.22%	56.23%	51.30%	28.53%
Balanced % Solids:			40.74%			29.44%			58.10%	
Water Weight Split:			100.0%			72.1%			27.9%	
					Calculated Data					
Dry Massflow (ltph):			4.7			2.0			2.63	
Water (ltph):			6.8			4.9			1.9	
Volumetric flow (GPM):			34.6			23.8			10.8	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
35	425	99.9	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
48	297	99.9	0.00%	0.00%	100.0	0.00%	0.00%	99.9	0.00%	0.00%
65	212	99.7	82.86%	0.00%	99.9	47.22%	0.00%	99.4	83.64%	0.00%
100	149	98.3	86.50%	6.24%	99.8	48.00%	26.60%	97.0	88.28%	4.72%
150	105	89.7	85.20%	6.53%	99.5	49.14%	25.67%	81.7	85.48%	6.04%
200	74	78.2	77.32%	9.50%	99.3	52.50%	23.02%	63.1	78.06%	9.39%
270	53	62.9	51.90%	22.10%	94.0	36.26%	38.91%	36.9	62.12%	16.88%
325	45	56.3	25.78%	46.30%	87.8	18.91%	53.82%	29.3	28.77%	41.46%
400	38	50.5	16.17%	56.62%	80.8	12.94%	60.16%	24.5	20.62%	51.55%
500	25	42.1	10.96%	62.62%	66.6	8.98%	64.33%	19.5	13.60%	59.72%
	Pan		6.78%	64.74%		6.59%	64.61%		8.06%	63.28%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
35	425	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
48	297	99.9%	0.00%	0.00%	100.0%	0.00%	0.00%	99.9%	0.00%	0.00%
65	212	99.6%	80.34%	0.00%	99.9%	43.34%	0.00%	99.4%	84.56%	0.00%
100	149	98.2%	86.73%	5.74%	99.8%	44.40%	30.62%	97.0%	88.21%	4.88%
150	105	89.6%	85.11%	6.35%	99.6%	44.68%	32.45%	81.8%	85.51%	6.10%
200	74	78.7%	77.61%	9.53%	99.1%	62.10%	16.14%	62.8%	77.95%	9.38%
270	53	62.2%	56.53%	20.55%	94.3%	27.53%	43.07%	37.2%	60.70%	17.31%
325	45	55.4%	25.21%	46.28%	88.2%	19.07%	53.96%	29.8%	29.12%	41.38%
400	38	49.6%	16.41%	56.30%	81.2%	12.85%	60.28%	25.0%	20.47%	51.75%
500	25	40.8%	10.59%	62.81%	67.2%	9.06%	64.30%	20.2%	14.10%	59.40%
	Pan		6.92%	64.42%		6.55%	64.69%		7.86%	63.70%

Appendix A: Raw and Balanced Data:

Northshore Test 4 *Low Solids High Flow*		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			30.56%	42.38%		9.21%	59.62%		45.93%	29.97%
Head Assays Calculated from Size:		100.0%	31.00%	44.70%	41.86%	10.37%	61.89%	58.14%	45.85%	32.32%
Balanced % Solids:			40.56%			30.53%			53.13%	
Water Weight Split:			100.0%			65.0%			35.0%	
					Calculated Data					
Dry Massflow (ltph):			5.7			2.4			3.32	
Water (ltph):			8.4			5.4			2.9	
Volumetric flow (GPM):			42.5			26.5			16.1	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
35	425	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
48	297	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
65	212	99.8	97.98%	0.00%	99.9	0.00%	0.00%	99.6	77.58%	0.00%
100	149	98.5	74.06%	5.45%	99.8	54.92%	21.19%	96.8	84.50%	4.46%
150	105	90.1	87.40%	5.68%	99.6	61.68%	16.47%	83.4	82.78%	6.01%
200	74	80.1	81.60%	9.28%	99.2	57.76%	19.14%	66.7	72.98%	9.11%
270	53	64.4	57.60%	23.84%	93.8	37.00%	37.33%	42.7	57.52%	19.72%
325	45	57.6	24.70%	46.24%	87.8	19.69%	52.03%	35.4	26.21%	42.39%
400	38	51.7	16.95%	56.42%	81.0	13.63%	59.30%	30.4	18.72%	53.03%
500	25	42.6	9.87%	62.90%	68.2	9.29%	63.10%	24.3	12.26%	60.37%
	Pan		7.05%	64.68%		6.58%	65.09%		7.37%	63.94%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
35	425	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
48	297	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
65	212	99.7%	75.86%	0.00%	99.9%	0.00%	0.00%	99.6%	85.39%	0.00%
100	149	98.2%	81.53%	5.05%	99.8%	54.40%	18.09%	97.0%	82.63%	4.53%
150	105	90.1%	83.47%	5.96%	99.4%	42.24%	8.87%	83.4%	84.20%	5.91%
200	74	80.2%	75.02%	9.27%	99.1%	60.98%	18.51%	66.7%	75.26%	9.11%
270	53	64.2%	55.62%	22.74%	93.7%	38.95%	39.08%	42.9%	58.30%	20.12%
325	45	57.4%	24.11%	46.05%	87.7%	20.00%	52.08%	35.5%	26.52%	42.52%
400	38	51.6%	16.45%	56.23%	80.9%	13.82%	59.35%	30.5%	19.04%	53.18%
500	25	42.6%	10.27%	62.32%	68.0%	9.18%	63.27%	24.3%	11.90%	60.89%
	Pan		6.92%	64.76%		6.63%	65.20%		7.50%	63.86%

Appendix A: Raw and Balanced Data:

Northshore Test 5 *Low Solids Low Flow*		**Screen Feed**			**Screen Undersize**			**Screen Oversize**		
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
Balanced Head Assays:			31.45%	41.80%		11.05%	59.61%		47.09%	28.15%
Head Assays Calculated from Size:		100.0%	29.58%	43.90%	43.39%	10.05%	61.28%	56.61%	44.55%	30.59%
Balanced % Solids:			41.04%			30.89%			54.86%	
Water Weight Split:			100.0%			67.6%			32.4%	
					Calculated Data					
Dry Massflow (ltph):			5.0			2.2			2.83	
Water (ltph):			7.2			4.9			2.3	
Volumetric flow (GPM):			36.6			23.6			12.9	
mesh	***microns***				**Measured Size and Assay Data**					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
6	3350	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
8	2360	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
10	1700	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
14	1180	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
20	850	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
28	600	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
35	425	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
48	297	100.0	0.00%	0.00%	100.0	0.00%	0.00%	100.0	0.00%	0.00%
65	212	99.7	75.32%	0.00%	99.9	51.14%	0.00%	99.6	79.10%	0.00%
100	149	97.8	75.82%	5.77%	99.6	50.16%	24.86%	96.7	83.96%	4.93%
150	105	89.1	71.10%	6.17%	99.4	52.16%	23.29%	83.0	67.68%	6.04%
200	74	79.0	70.12%	9.64%	99.0	51.78%	23.58%	65.8	74.94%	9.39%
270	53	62.9	55.64%	21.96%	93.6	35.98%	37.40%	40.7	55.60%	18.79%
325	45	56.2	22.81%	45.73%	87.7	18.97%	52.74%	33.2	28.31%	41.19%
400	38	50.3	14.96%	55.81%	80.7	13.84%	59.19%	28.2	19.30%	52.94%
500	25	42.1	10.26%	62.73%	67.2	9.80%	63.59%	22.3	12.81%	60.12%
	Pan		6.80%	63.91%		5.97%	64.53%		7.37%	63.57%
					Balanced Data					
		Weight	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**	**Weight**	**Silica**	**Mag Iron**
4	4750	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
6	3350	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
8	2360	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
10	1700	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
14	1180	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
20	850	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
28	600	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
35	425	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
48	297	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%	100.0%	0.00%	0.00%
65	212	99.7%	73.99%	0.00%	99.8%	53.31%	0.00%	99.6%	79.57%	0.00%
100	149	97.9%	79.73%	6.01%	99.6%	43.93%	21.08%	96.6%	82.44%	4.87%
150	105	89.8%	68.79%	6.22%	99.1%	80.46%	13.98%	82.6%	68.51%	6.03%
200	74	79.8%	73.04%	9.63%	98.7%	26.00%	21.39%	65.3%	73.96%	9.40%
270	53	63.4%	53.75%	21.61%	93.4%	38.03%	38.26%	40.5%	56.31%	18.90%
325	45	56.6%	24.12%	45.62%	87.5%	18.29%	52.84%	33.0%	27.67%	41.22%
400	38	50.7%	15.98%	56.04%	80.5%	13.46%	59.11%	27.9%	18.64%	52.78%
500	25	41.9%	10.69%	62.46%	67.3%	9.67%	63.68%	22.5%	12.57%	60.21%
	Pan		6.53%	64.13%		6.04%	64.47%		7.65%	63.34%