

Improvements in Gravity and Overall Gold Recovery at NVI Mining Ltd. Myra Falls Operation

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ABSTRACT

NVI Mining's Myra Falls Operation is a 4,000 mtpd copper/zinc flotation circuit with by product gold of ~28,000 ounces per year. Gold recovery has historically averaged 40-55%, however, a portion of this was recovered in the zinc concentrate and received poor payment. Two Knelson CD-30 Concentrators have been operating in the grinding circuit since 1992, with gravity recovery averaging about 2-5% over that time period.

The Myra Falls gravity circuit was one of the very first hard rock mining installations operating in the world with automated Knelsons. The mine has employed a unique and unusual upgrading method for the Knelson concentrate that had never been evaluated as to its efficiency. Recent Gravity Recoverable Gold Testing by McGill University, and mathematical modelling of the Gravity Circuit by Knelson Gravity Solutions indicated the gravity circuit was not living up to its potential. The upgrade system operating regime was changed by Myra Falls Personnel, and a complete gravity audit of the grinding circuit was carried out, with the results confirming the initial suspicions. Gravity recovery increased from 5% to 15%, with overall gold recovery improving by 5%.

INTRODUCTION

NVI Mining operates a 4000 tpd mine and mill complex on Vancouver Island. The milling circuit consists of open circuit rod milling, closed circuit ball milling, gravity recovery, copper flotation, zinc flotation, and tails disposal. There are two milling circuits, "A" circuit, and "B" circuit.

The gravity circuit consists of two Knelson CD-30 concentrators, one on each milling circuit. Historical gold recovery has been via gravity (~3-5% of the total, with high payment), with copper concentrate (~20-30% of the total, slightly lower payment), with zinc concentrate (~13-23%, with low payment), with ~50-60% of the gold going to final tails. Mineralogy (Chryssoulis and Khou, 1998) indicates approximately 70-80% of the gold should be recoverable, thus there is very significant economic incentive for additional gold recovery.

The Myra Falls Operation uses an unusual upgrade system in which Knelson concentrate collected is then run once again through the "A" Circuit Knelson as an upgrade step. The final concentrate is collected in a potable hopper, dewatered, dried and shipped as a separate precious metals concentrate.

The upgrade step at Myra Falls is unique, and no data was available to determine if this was an efficient way to upgrade the primary Knelson concentrate. Since the gravity circuit was installed, the two Knelson CD-30 Concentrators had generally been operating on very long (6 hour) concentrating cycles, and the upgrade step was being carried out on a weekly basis.

INITIAL GRAVITY CIRCUIT CHANGES

It was thought by the Myra Falls staff that Gravity recovery could be improved, and that this may

have a positive effect on overall gold recovery. One area suspected of causing reduced gravity recovery was the long cycle times, and the infrequent upgrading. The two parameters are linked, as shorter Knelson cycle times produce more Knelson concentrate, and with a fixed capacity in the two concentrate hoppers, more frequent cleaning is required.

Initially, the mill staff started to decrease the Knelson cycle time, and started to increase the cleaning cycle accordingly. This had an immediate and positive effect on both gravity and overall recovery. Figure 1 shows the relationship between Knelson weight recovery and gravity recovery.

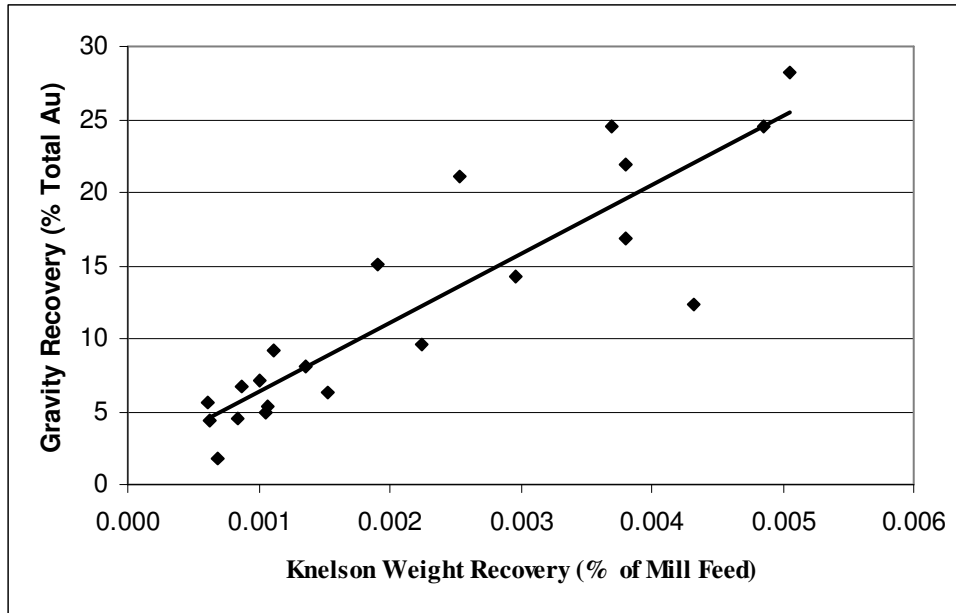


Figure 1 – Gravity Recovery as a Function of Knelson Weight Recovery

Once it was determined that there was a relationship between Knelson concentrate weight (as determined by Knelson cycle time) it was decided to investigate this further. In January 2005, Knelson Gravity Solutions was contracted to carry out an audit of the gravity circuit.

MYRA FALLS GRAVITY CIRCUIT AUDIT

In March 2005, a detailed gravity audit was carried out to provide data to answer several questions with respect to gravity recovery, generally in the following order of importance:

1. How can primary (grinding circuit) gravity recovery be maximized, with the existing Knelson Concentrators
2. What are the losses associated with the upgrade step used at Myra Falls
3. Would a tabling operation or intensive cyanidation system improve overall gravity recovery, and by how much.
4. What is the effect of cycle time on Knelson unit recovery and overall gravity recovery
5. What is the practical upper limit of gravity recovery at Myra Falls, and what additional

equipment might be required.

The goal was to produce data whereby the current circuit performance could be modeled, and changes to the gravity circuit could be simulated. The following sample streams were audited.

Cyclone Samples

Samples of cyclone feed, overflow, and underflow of both “A” and “B” circuit were collected. The goal of this sampling was to characterize GRG behavior in the cyclone (GRG recovery to underflow), as this has a significant effect on overall gravity recovery. Obviously, if GRG has exited the grinding circuit via the cyclone, it is no longer available for gravity recovery. Characterizing the GRG cyclone partition curve is one key parameter required to mathematically model a gravity circuit.

To determine the GRG behavior in the cyclones, the samples were shipped to Knelson and processed in the Knelson MD-3 Laboratory Concentrator. The GRG was characterized on a size-by-size basis for the three streams, and results balanced to produce the GRG partition curve of the cyclone.

In addition, samples of cyclone overflow were collected just prior to, and just after the upgrading step. The goal was to determine if the GRG lost during the upgrading step would show up as additional GRG exiting the grinding circuit.

Myra Falls also experiences “grind outs” on occasion. As such, samples of cyclone overflow were collected during grind-out, and by coincidence, just prior to a grind-out. These were characterized for GRG content.

Upgrade System Samples

Historically, Myra Falls operated on 6 hour concentrating cycles, with the concentrate being “upgraded”, by taking the “A” Circuit Knelson off line, and processing the primary concentrate individually from both the “A” and “B” Knelson through the “A” Knelson. The goal was to reduce the weight of con, and increase the grade, as the concentrate was shipped off site, and the smelter had minimum grade targets. This had unknown gold losses associated with it. While the Knelson was operating as an upgrade unit, samples of feed and tails were collected. These samples were shipped to Knelson for size-by-size characterization. The results were roughly balanced to determine the upgrade efficiency.

Primary Knelson Unit Recovery, 60 Minute Concentrating Cycle

The “A” Knelson was characterized as to unit recovery by size, that is, single pass GRG recovery. This was accomplished by collecting the full flush of the “A” Circuit CD-30 and sampling the “A” Circuit CD-30 tails over a complete concentrating cycle. The concentrate sample was dried, split, and assayed on a size-by-size basis. The tails sample was processed in the Knelson MD-3 Laboratory Concentrator. The GRG in the tails was characterized on a size-

by-size basis, and results balanced to produce the GRG unit recovery of the Knelson CD-30. For balancing purposes, the feed rate to the unit was measured using a Marcy Scale and by collecting a timed sample of slurry in a large bin.

Primary Knelson Unit Recovery, 240 Minute Cycle

As the Knelsons at Myra Falls historically were operated on very long (6 hour) concentrating cycles, it was thought that this might have been an area of high gold losses. A batch Knelson has an upper limit (ore and application specific) of concentrate grade, and since this is a batch process, the grade rises from feed grade at the start of the concentrating cycle to some maximum theoretical level over time. Longer cycles produce higher grade concentrate (at lower mass yield) but at some point the unit recovery of the concentrator is diminished, as the recovery rings get “full” of GRG. The “A” Circuit CD-30 feed and tails were collected over a 4 hour cycle and characterized for GRG content. The goal was to determine if the unit recovery was severely diminished by using a long concentrating cycle.

GRAVITY AUDIT RESULTS

Cyclone Partition Curve

The cyclone partition curves of the two circuits were determined, and are shown in Figure 2.

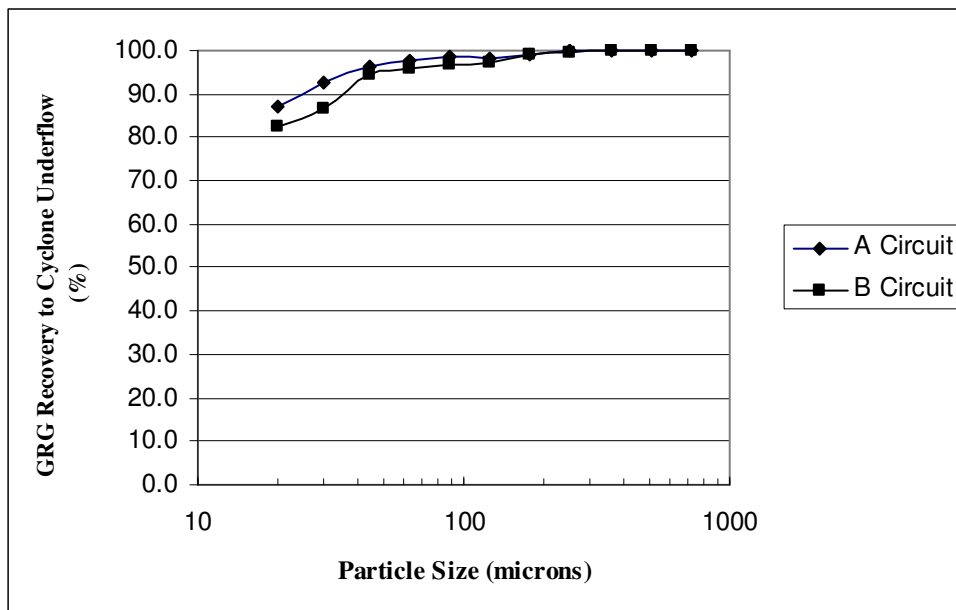


Figure 2 – GRG Recovery to Cyclone Underflow as a Function of Particle Size

As can be seen, the recovery to underflow is slightly better for “A” circuit than for “B” circuit. Of interest is the recovery to underflow at coarser sizes (>75 microns). Typically, GRG recovery to underflow approaches 100% for fine grind circuits at sizes above 75 microns. An examination

of the GRG partition curve yields recoveries at somewhat lower than this. This allows a certain portion of fine GRG to exit the grinding circuit, where it may or may not be recovered effectively downstream. This is an area of further study at Myra Falls.

Cyclone Overflow During Grind Out

The cyclone overflow was characterized before and during a grind out. By coincidence, the cyclone overflow was sampled during “normal” operation, and immediately after this, a grind out occurred due to a plugged feed chute, allowing a window of opportunity to sample the effect. The cyclone overflow was characterized for GRG content using the Knelson MD-3. The results are shown in Figure 3.

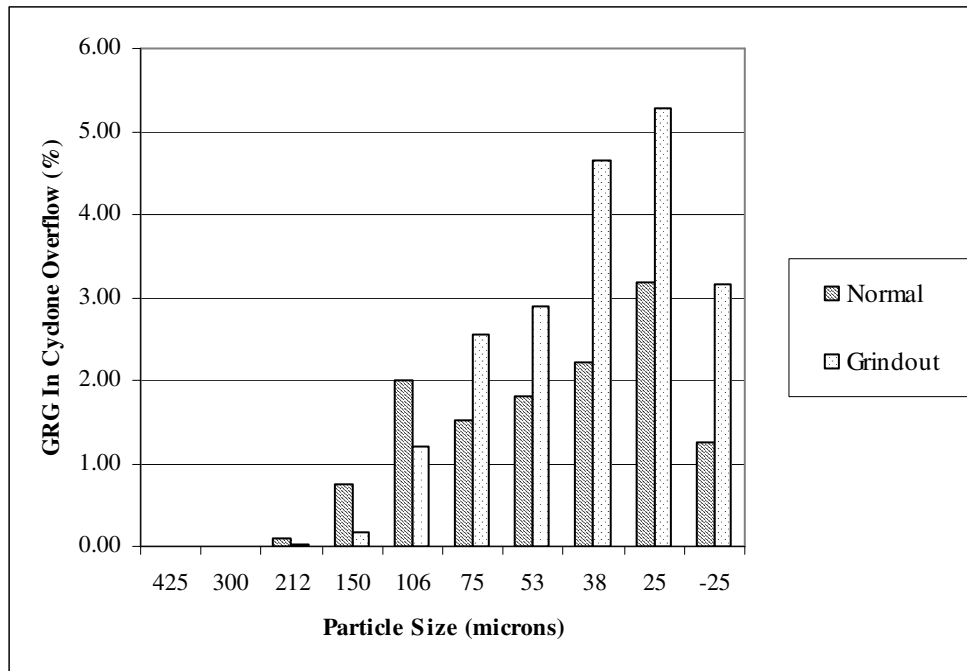


Figure 3 – GRG Content of Cyclone Overflow as a Function of Particle Size

As can be seen, GRG exiting the circuit increases during a grind out. This is not unexpected as cyclone performance would deteriorate under these conditions. The coarse GRG exiting grinding under both normal and grind out conditions can also be seen.

Cyclone Overflow During Knelson Concentrate Upgrading

The GRG content of the cyclone overflow was characterized before and immediately after the upgrading step. The results are shown in Figure 4, below.

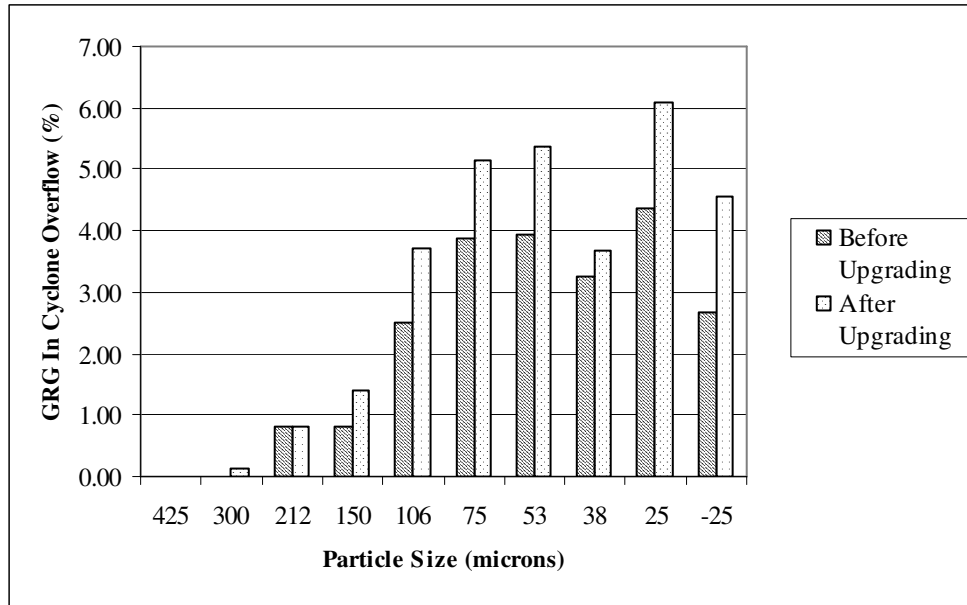


Figure 4 – GRG Content of Cyclone Overflow Before and After Upgrading

As can be seen, GRG exiting the circuit increases during the upgrading step. This is GRG that had already been recovered by the Knelson, but is lost back to the grinding circuit during the upgrading process.

Upgrade System Results

During the audit, the upgrade system feed and tails (CD-30 feed and tails while upgrading) were sampled for both A and B Circuit. The sampling was split loosely into two parts, the first part of the cycle, and the second part of the cycle. This was done to determine if the tails grade increased as more concentrate was processed through the Knelson. These samples were screened, with each screen fraction assayed to extinction. It was not possible to collect two feed samples from A circuit, as the upgrading time was unexpectedly short, however, two tails samples at least were obtained.

Table 1 shows the individual grades of the samples on a size-by-size basis.

Table 1 – “A” Circuit Knelson Feed and Tails Grade While Operating as an Upgrade Device for Primary “A” and “B” Circuit Knelson Concentrates

Microns	A Circuit			B Circuit			
	Feed Au g/t	Tails 1 Au g/t	Tails 2 Au g/t	Feed 1 Au g/t	Tails 1 Au g/t	Feed 2 Au g/t	Tails 2 Au g/t
1700	1204						
1180	1123			3469	0	340	0
850	713	397	456	1831	2	5157	186
600	1317	791	1197	1318	3	1800	431
425	1911	1220	1467	1410	94	1687	604
300	2702	1054	1333	1289	54	1503	878
212	3138	1203	1893	1041	85	1227	640
150	2741	1199	1778	922	42	996	278
106	2134	754	1370	556	37	798	139
75	1598	381	847	477	42	749	60
53	1992	257	734	599	46	961	84
38	3010	374	965	846	78	1377	146
25	4962	874	2100	1234	84	1897	349
-25	4143	1421	1918	1039	352	1554	748
Total	1481	807	1305	1292	44	1364	343

As can be seen, for the “A” circuit primary concentrate, the tails grades rose to values approaching the feed grade, indicating a quite severe loss of recovery very rapidly as more material is fed to the CD-30. The upgrade cycle for the “A” circuit primary concentrate on this day was only a few minutes, so this occurred very rapidly. Upgrading the “B” circuit results showed better performance, but still a significant increase in grade.

A rough balance was determined for the CD-30 operating in upgrade mode. The unit recoveries showed a large amount of scatter, but this was normalized to produce the unit recovery curves shown in Figure 5.

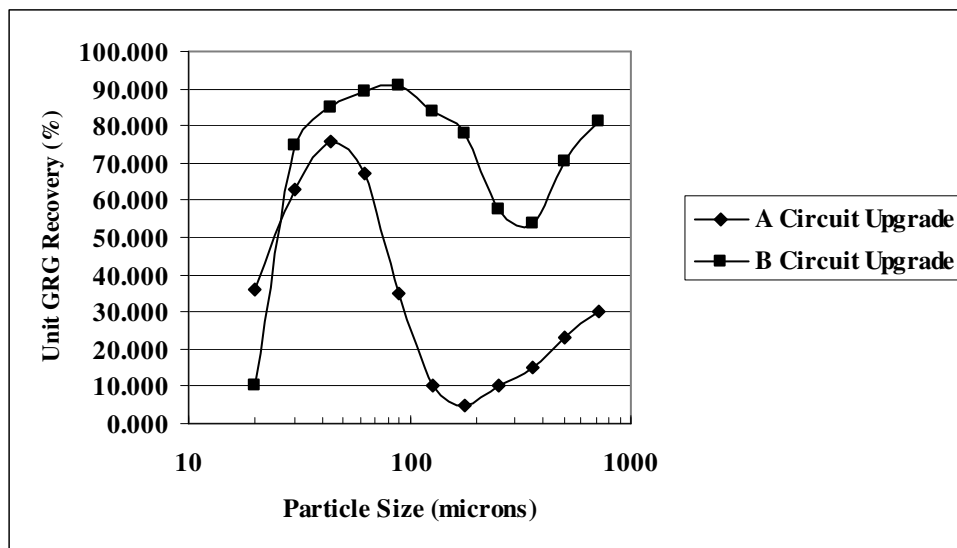


Figure 6 – Upgrade System Unit Recovery as a Function of Particle Size

The shape of the curves is remarkably similar, as were the feed grades, yet the B circuit results are quite significantly better. There are two likely possible reasons for this:

- The feed rate to the “A” Circuit CD-30 was much higher (as observed visually). Unit recovery is quite feed rate dependent.
- The quantity of concentrate from the “A” circuit was much larger, and the CD-30 realized more GRG units, “loading” the concentrate bed more rapidly.

The concentrate grade fed to the machine was of moderate grade for Knelson concentrate (~1,200-1,500 g/tonne), yet even after a very short period of time, recovery already was diminished. The Knelson Concentrator was not designed to be an upgrade device for primary Knelson concentrates, thus its performance in this duty is poor. It should be noted that the performance measured was for the already reduced (60 minute) primary concentrator cycle time, and increased frequency of upgrading (once per shift, taking only a few minutes per circuit). It is not unreasonable to assume that the previous practice of 6 hour primary Knelson cycle times, and weekly cleaning of this concentrate taking a reported 45 minutes, would have given dismal upgrade performance.

This data very strongly supported the recently adopted practice of short cycles and frequent cleanings.

Primary Knelson Unit Recoveries

Knelson unit recoveries were characterized for both short (60 minute) and long (240 minute) concentrating cycles using “A” Circuit Knelson.

The short cycle recoveries were characterized by collecting a composite of Knelson tails over the 60 minute cycle, and collecting the full flush of the CD-30. The tails and concentrate were then characterized for GRG on a size-by-size basis.

The long cycle recovery was characterized by collecting individual Knelson feed and tails samples over each 60 minute period of the 240 minute concentrating cycle. The goal was to determine the size-by-size GRG of the feed and tails each hour to determine if the size-by-size recoveries trended downwards. Unfortunately, during processing at Knelson the four samples were combined, thus it was only possible to determine the size-by-size recoveries for the overall four hour cycle.

The results are shown in Figure 7.

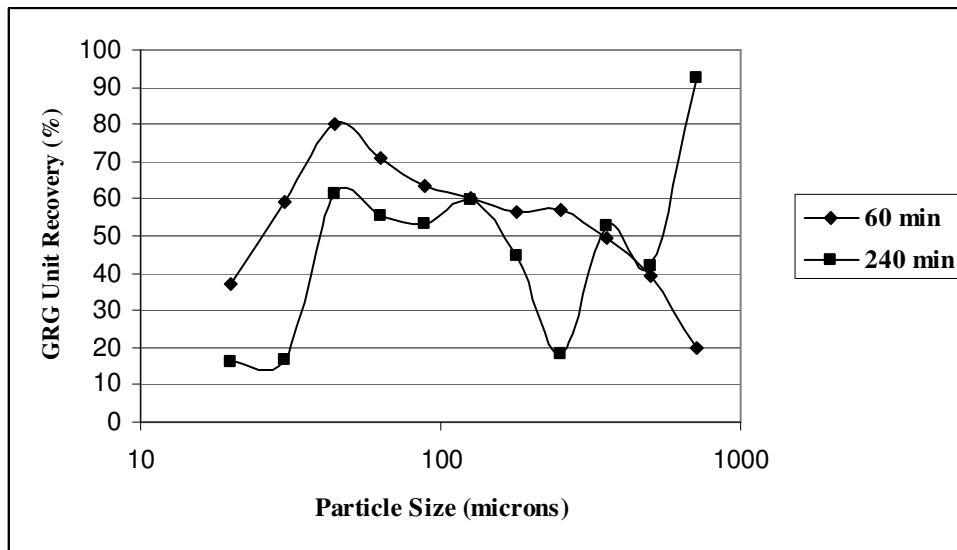


Figure 7 – Primary GRG Recovery of the “A” Circuit Knelson

The long cycle data exhibits more scatter as would be expected from not having the final Knelson concentrate available to “smooth” out the GRG balance.

The shape of the two curves are quite similar, but also quite unusual. They are also somewhat similar to the upgrade recovery curves. Typically, Knelson unit recovery starts at about 80% for coarse (1 mm) particles, and trends downwards to approximately 20% unit recovery at -25 microns. Note this is unit (single pass) recovery, not overall gravity recovery. As can be seen, the coarse recoveries appear to be low (40% range), increasing to 60-80% in the 38-53 micron size class, then dropping to 20-35% in the -25 micron size class. This shape of curve has been noted at least two other sites (Laplante, 2003) and is theorized to be related to particle interference of similar sized GRG and gangue particles (Laplante, 2005) however, this has not been proven.

It should also be noted that the 240 minute cycle actually yielded an implied concentrate grade of only approximately 700 g/tonne, as compared with the 60 minute cycle time concentrate grade of 4,200 g/tonne. The sampling was carried out on different days, thus the operating conditions of the grinding circuit may be quite different. An upset in the circuit, or period of off line time for the Knelson would have had a profound influence on the circulating load of gold and GRG. This cast doubt on any conclusion that could be drawn with respect to Knelson Concentrator cycle time.

MATHEMATICAL MODELLING OF THE GRAVITY CIRCUIT

Gravity Recoverable Gold Data

A report on the GRG content of Myra Falls ore (Laplante, 2004) was supplied by Myra Falls staff. The GRG is well described in the report.

The GRG, as tested, was determined to be 43.5% at a grind p80 of 81.3% minus 75 microns. The sample size was ~65 kg. The cumulative GRG is shown graphically in Figure 8.

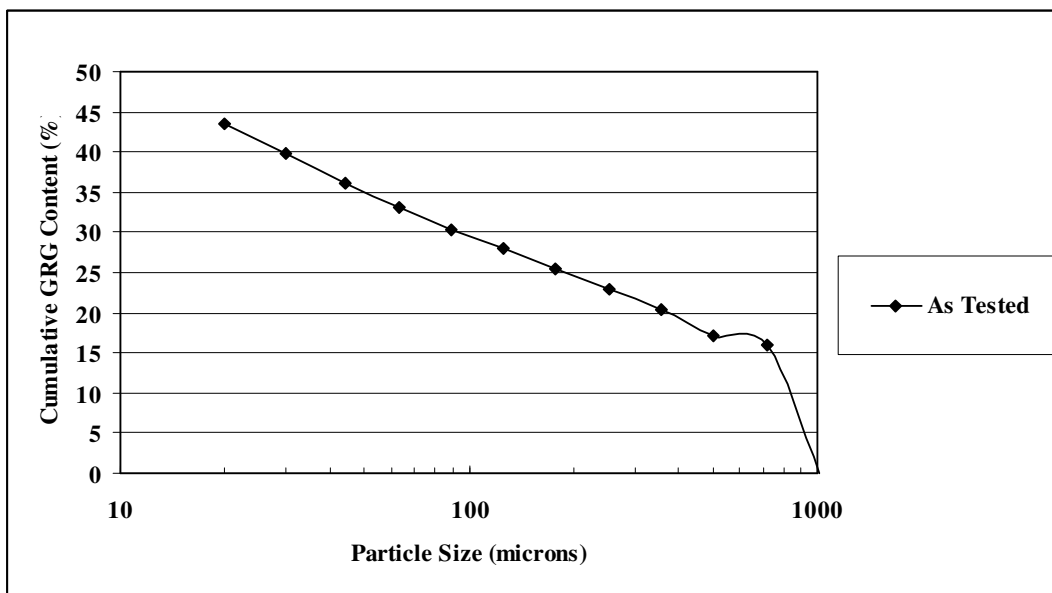


Figure 8 – Cumulative GRG as a Function of Particle Size

The GRG is moderate, and generally coarser than average. It liberates particularly well, with 32% of the total gold (equating to 73% of the total GRG) recovered to the first stage concentrate. Of note, and also noted in the report, is that there is a large “bump” in the curve at the coarse end. This indicates that a few very coarse flakes generated a high assay in the +600 micron fraction of the first stage KC MD-3 concentrate. An argument can be made that this would not be typical of every 65 kg feed sample. The GRG test allows us to “normalize” these assays spikes and take out the coarse “flakes”, or at least a portion of them. The normalized GRG distribution is shown in Figure 9.

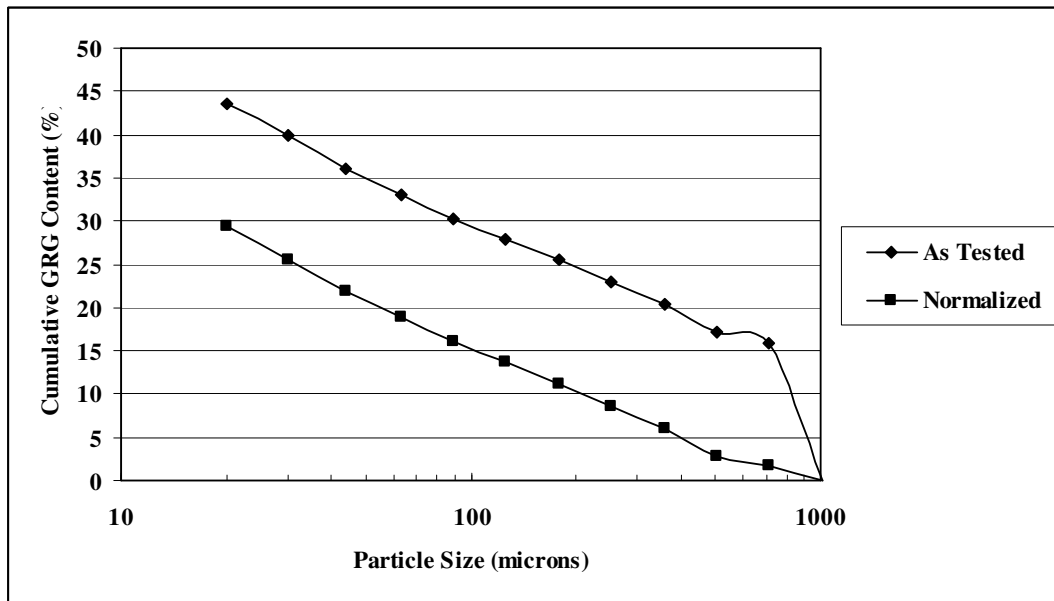


Figure 9 – Cumulative GRG as a Function of Particle Size

Mathematical Modelling of The Myra Falls Gravity Circuit

Knelson has developed a mathematical model to predict gravity recovery within a grinding circuit, called *KC MOD*Pro* (Grewal and Fullam, 2004). This has been used numerous times for both Greenfield simulations, as well as for operating plants, which allow us to compare predicted results with actual. The model is also a very powerful tool for determining the dominant factor(s) affecting gravity performance, and for troubleshooting to improve gravity circuit results.

The model simply calculates a GRG population balance in the grinding circuit, as well as in the gold room or upgrading circuit if it exists. Under any set of operating conditions, GRG is either ground into non-GRG within the grinding circuit, exits the grinding circuit via the cyclone overflow, or if a gravity circuit is present, is recovered to gravity, and may or may not end up in the final product, as determined by the upgrade circuit.

Preliminary modelling was carried out prior to auditing the gravity circuit. This indicated that the gravity circuit (historically) was not living up to its potential.

The gravity audit provided more comprehensive data that could be used to “calibrate” the model to the circuit.

The “normalized” GRG value of 29.3% was used for the modelling. Under the current operating conditions (60 minute concentrating cycle, upgrade once per shift) the model results returned a

result of 14.6% of total gold recovery by gravity, or about one half of the GRG.

Using the “long cycle” (240 minute) unit recoveries had a relatively small impact on gravity recovery. Gravity recovery dropped slightly from 14.6% to 13.0%.

One possible option at Myra Falls would be the replacement of the existing upgrading circuit with a shaking table. Shaking table recoveries are notoriously unpredictable and typically will vary from one operator to another. Having said this, there is enough data available from other audits to at least provide some indication of what might be expected.

Gold rooms are generally set up as “simple” systems with the Knelson concentrate passing over the table, with final table concentrate cut off for sale or smelting according to grade, table middlings recycled to the concentrate tank, and table tails returned to grinding. Alternatively, more complex tabling circuits incorporates a Knelson Concentrator to scavenge the table tails, and this concentrate re-tabled separately for higher upgrade recoveries.

Modelling gravity recovery with a simple gold room yields a predicted 15.2% gravity recovery, and 17.5% with the more complex gold room. This does not tell the whole story however.

The existing upgrade system is operated once per shift, with at least one hour of down time for each cycle. The net effect is that of the 48 hours of operating time of the 2 CD-30's per day, 3 hours are lost on the “A” circuit Knelson as the CD-30 must be off line to accomplish the upgrading step. This in itself equates to a loss of gravity recovery of 6% relative.

Another potential option would be the use of a ConSep Acacia Reactor (Campbell and Watson, 2003) to intensively leach the gold. The Acacia simply puts the gold into solution, where it can be electrowon onto gold cathodes, with the cathode sludge smelted into dore bars. Acacia recoveries typically run in the high 90's, averaging about 98% in the 27 operating global installations.

Modelling using a ConSep Acacia yields an increase in gravity recovery from 14.6% to 18.7%, plus the 6% relative increase (overall 1.1%) due to increased on line time of the “A” circuit Knelson.

This does not seem intuitively correct. Taking the existing upgrade system, which operates at overall low efficiency and replacing it with a system that operates at near 100% efficiency, one would expect a very large increase in gravity recovery. The two mitigating factors are the relative coarse nature of the GRG, and the relatively high recovery of this gold to cyclone underflow once it is rejected from the existing upgrade system. The net result is the majority of the gold lost in the upgrading process is recovered again in the primary gravity circuit. If the GRG were fine, and the cyclone recovery to underflow lower, the benefit of an Acacia would be much more pronounced.

Modelling Increased Feed Rate

The Knelson CD-30 was originally introduced in 1992 as a 40 mtpH concentrator. This was before it was possible to predict the effect and the general benefit of increasing feed rate on gravity recovery in closed circuit grinding were not well understood. Over the years, the CD-30 has had feed rates (and nameplate capacity) increased to 100 mtpH. This decreases the unit recovery, but since a larger portion of the circulating load is treated, gravity recovery typically is increased.

If it were possible to increase the feed rate to each CD-30, gravity recovery would increase to 16.7%, or a relative increase of 14.4% from the base case.

Another alternative is to simply add another CD-30 to each circuit, but at the current feed rate of 45 mtpH to each unit. The effect would be to increase gravity recovery to 20.1%, or a relative increase of 37.7% from the base case.

THE UPPER LIMIT OF GRAVITY RECOVERY

Assuming a GRG value of 29.3%, there is a practical upper limit to gravity recovery. This would require Intensive Cyanidation, and two additional CD-30 Concentrators (one for each circuit), in addition to maximizing the feed rate to each concentrator (100 mtpH each unit). Gravity recovery under this scenario would increase to 23.0%, or a relative increase from the base case of 57.5%.

The summary of gravity circuit modelling results is shown in Table 24.

Table 3 – Modelling Outcomes

Scenario	Gravity Recovery (%)			Relative Change (%)
	A Circuit	B Circuit	Total	
60 Minute Concentrating Cycle	12.8	16.4	14.6	0
240 Minute Concentrating cycle	11.1	14.9	13.0	-11.0
Upgrade with Basic Gold Room	16.2	14.2	15.2	4.1
Upgrade with Complex Gold Room	18.5	16.4	17.5	19.9
Upgrade with ConSep Acacia	19.0	18.4	18.7	28.1
Increased Feed Rate to Gravity	14.4	18.6	16.7	14.4
Add More Knelsons	19.6	20.6	20.1	37.7
Upper Practical Limit	25.6	23.9	23.0	57.5

The modelling exercise indicated very strongly that additional gravity recovery was available. The task now was to link the increased gravity recovery to overall gold recovery and select the most appropriate outcome(s).

Based on the modelling results, as well as an economic analysis of the various options, a table has been purchased and is being installed. The mill also has a small grinding mill available, and once the table is installed, tests will be carried out to determine if the table tails can be ground and simply added to the copper flotation concentrate. Intensive Cyanidation, although attractive from a technical standpoint, would require the addition of cyanide to the process. The feed rate

to the gravity circuit will be increased, with the combined effect projected to increase gravity recovery to ~20% of total gold production.

THE EFFECT OF GRAVITY RECOVERY ON OVERALL GOLD RECOVERY

It had been known from previous observation at Myra Falls that gravity gave a benefit to overall gold recovery. This was in fact, why the concentrators were installed in the first place. The recent process change of the shorter primary concentrating cycles, and more frequent upgrade regime allowed an opportunity to determine if more gravity recovery equated to more overall gold recovery. A simple plot of the relationship between overall gravity recovery and gold recovery for 2004/2005 YTD is shown in Figure 10.

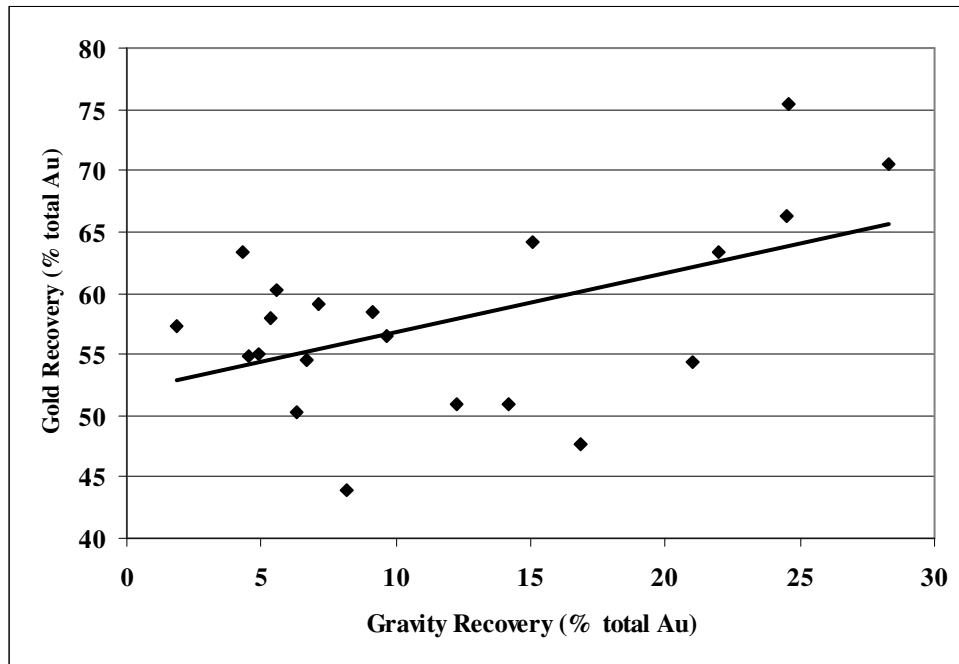


Figure 10 – Overall Gold Recovery as a Function of Gravity Recovery

Although gravity recovery appeared to provide a benefit, it was difficult to quantify exactly how much, as the data exhibited considerable scatter. An examination of the overall gold deportment in the gravity, copper flotation, and zinc flotation circuits started to shed more light on what might be occurring.

Gold Recovery to Base Metal Concentrates

Gravity gold that survives as GRG in the grinding circuit, but does not get recovered by the gravity circuit, exits to copper flotation. Presumably, if gravity recovery is lower than optimum, some, if not most, of this GRG will be recovered in the copper circuit. If the copper flotation circuit fails to recover the gold, it may exit via the rougher tails or copper cleaner scavenger tails, be activated in the zinc circuit and report to the zinc concentrate. Failing this, gold will report to

final tails. A week-by-week examination of the gold department for the two flotation circuits is shown in Figure 11.

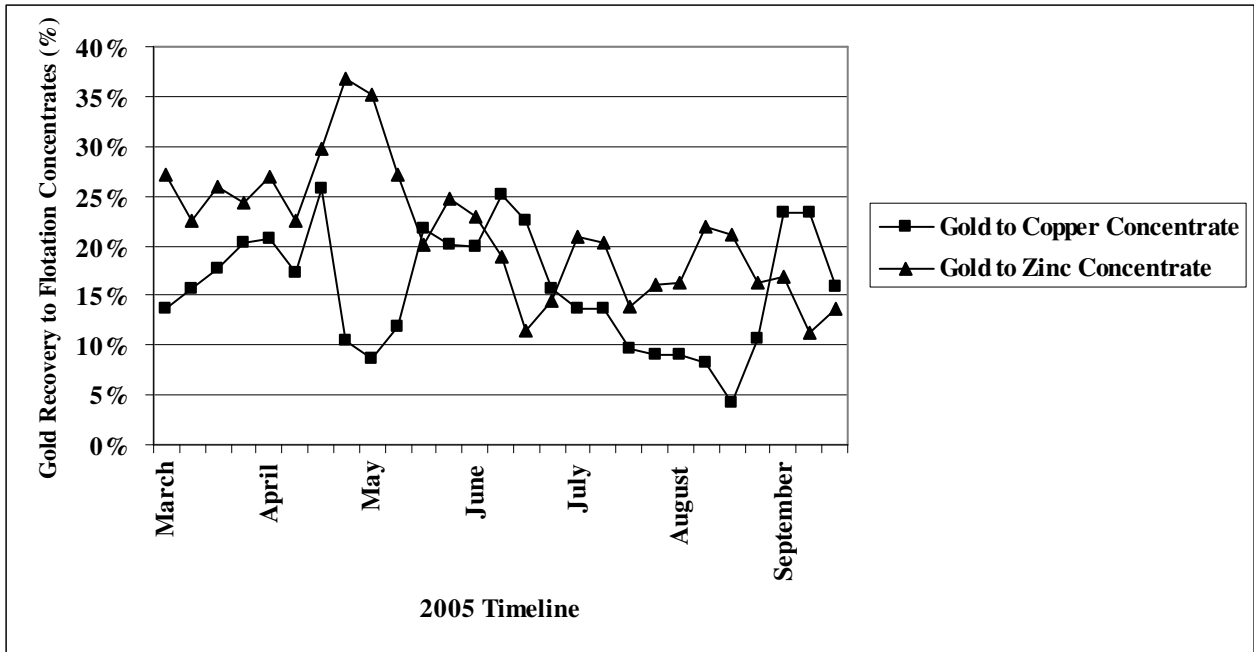


Figure 11 – Gold Recovery to Copper and Zinc Concentrates

The data shows a somewhat loose inverse relationship between gold recovery to the two metal concentrates. Reduced gold recovery to copper concentrate sometimes increased gold recovery to the zinc concentrate. Due to payment issues, it was highly desirable to have as much gold as possible report to either gravity concentrate or copper concentrate. It was less desirable to have gold report to zinc concentrate, and undesirable to have gold report to final tails.

The next relationship to be studied was that of gravity recovery to gold recovery of the copper concentrate, as shown in Figure 12.

Some periods of high gravity recovery “stole” gold from the copper concentrate, but again, with a somewhat loose correlation. By combining the gold recoveries to the gravity and copper concentrate, a strong correlation was found to overall gold recovery. This relationship is shown in Figure 13.

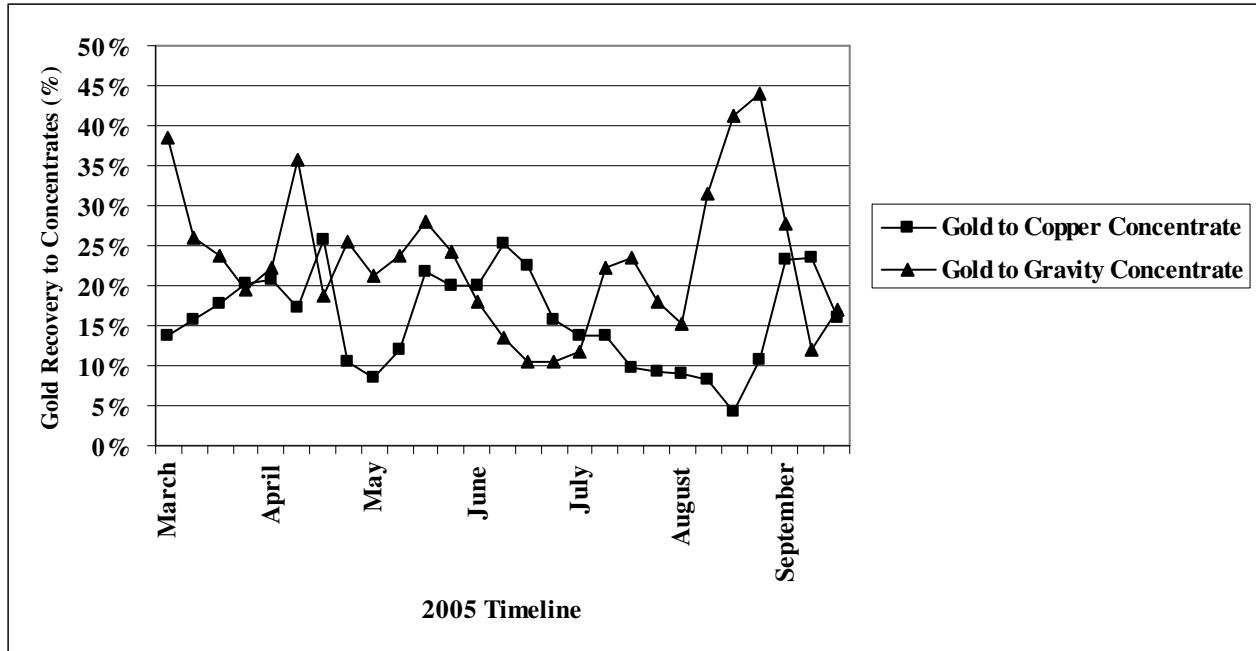


Figure 12 – Gold Recovery to Copper and Gravity Concentrates

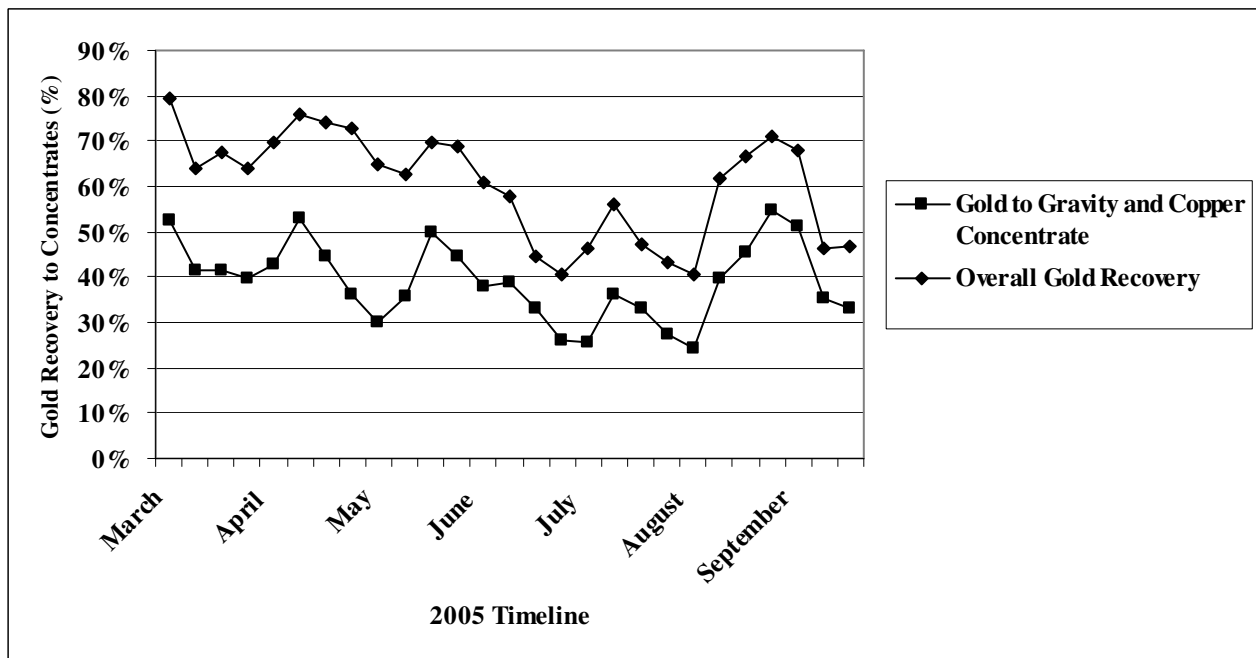


Figure 13 – Combined Gold Recovery to Copper and Gravity Concentrates

Clearly, a correlation exists between combined gold recovery to the gravity and copper concentrates, and overall gold recovery. More importantly, higher gold payment was being realized by recovering as much gold as possible to the gravity and copper concentrates.

Examining gold recovery to gravity and copper concentrate and comparing to gold reporting to tails yields two curves that are near mirror images. This is shown in Figure 14. Clearly, gravity recovery plays an important role in overall gold recovery, as well as improving gold payment.

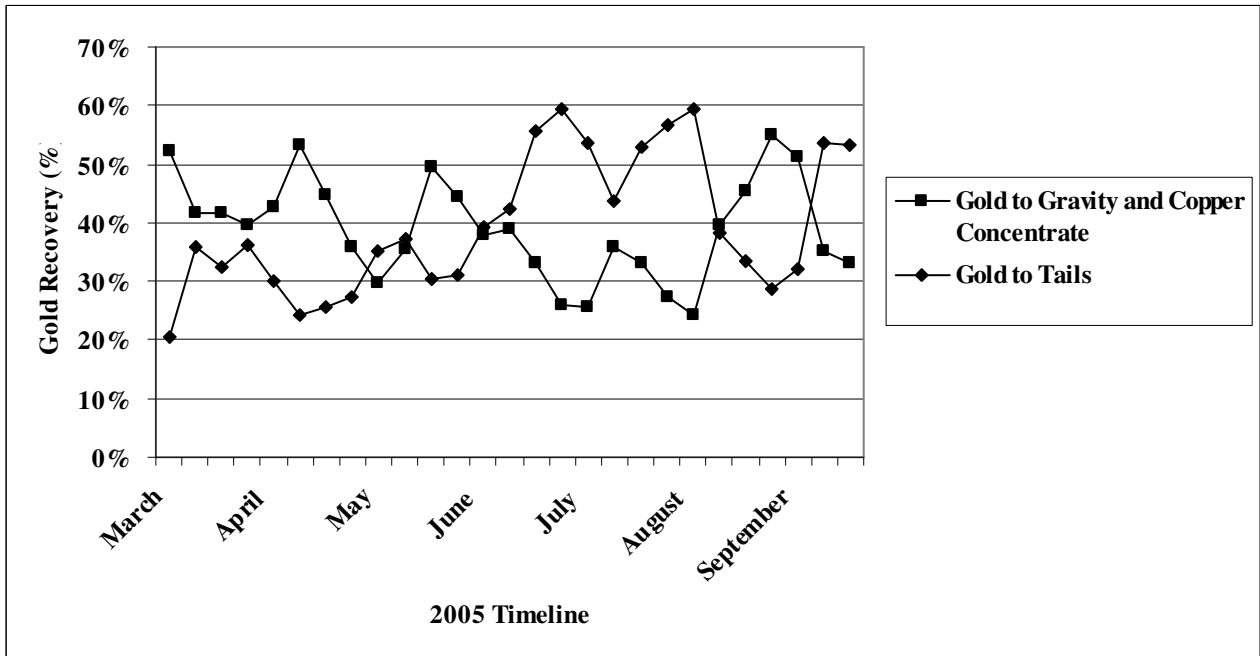


Figure 14 – Combined Gold Recovery to Copper/Gravity Concentrates and Tails

By taking into account periods prior to the gravity circuit changes in late 2004, it was possible to develop a relationship between gold recovered to gravity/copper concentrate, and overall gold recovery. This is shown in Figure 15.

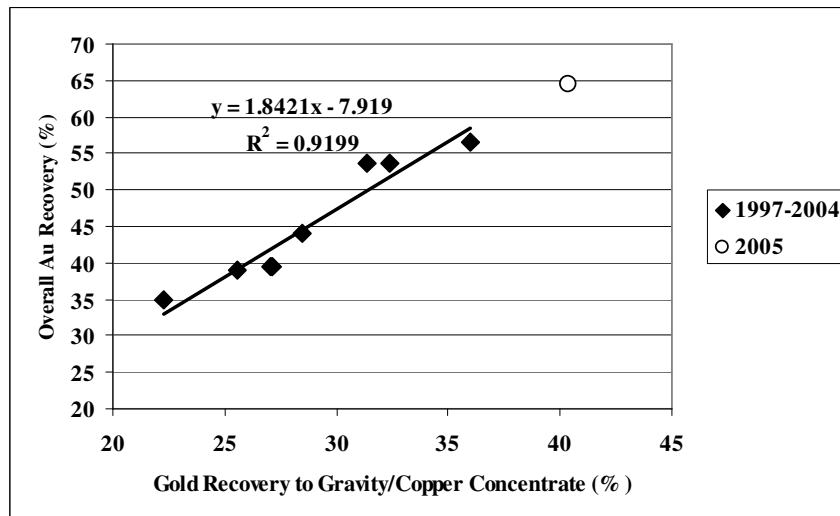


Figure 15 – Overall Gold Recovery as a Function of Gold Recovery to Copper and Gravity Concentrates

The data over the longer term indicates that for every 1% gain in gold recovery to Knelson/copper concentrate, a gain of 0.84% is being achieved overall.

The initial change to the gravity circuit operating regime was carried out in late 2004. Gravity recovery has increased, gold recovery to the copper concentrate has decreased, but overall gold recovery has increased by approximately 5%. This suggests that for every 1% gain in gravity recovery, a 0.5% gain in overall recovery is realized. This must be taken into context with other changes that affect both gravity and overall recovery, such as ore changes, mill availability, gold grade, etc.

SUMMARY

By increasing gravity recovery from 5% to 15%, approximately 5% additional gold recovery was realized. This was by implementing a very simple change to operating procedure, and apart from some minor labour costs required to “clean” the Knelson Concentrate more frequently, almost all of this additional recovery reported to the bottom line. With the additional changes to the gravity circuit, another 2.5% gain in overall gold recovery is expected. This has some capital requirements for the gold room, but payback is expected in the range of 6 months.

References

Chryssoulis, S., and Khou, Y, ‘Department of Gold in the Myra Falls Copper Circuit’, Amtel, January 21 1998.

Laplante, A.R., ‘Marvel Loch Site Visit Report’, www.p420b.parkercentre.crc.org.au, November 2003

Laplante, A.R., personal communication, 2005

Laplante, A.R., ‘Report on the Characterization of Gravity Recoverable Gold in a Sample of Myra Falls Ore’, October 2003

Campbell, J., and Watson, B., ‘Gravity Leaching with the ConSep ACACIA Reactor - Results from Anglogold Union Reefs’, August 2003, www.consep.com.au

Grewal, I., and Fullam, M, ‘Gravity Circuit Optimisation via Mathematical Modelling by Particle Size Classes’, April, 2004, www.knelsongravitysolutions.com