

# **Gravity Gold Recovery at President Steyn Mine**

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## **Introduction**

President Steyn Gold Mine (Freestate) (Pty) Ltd (PSGM) is a privately owned mine acquired from AngloGold and Avmin (a result of restructuring within the group) and has been in operation since the early 1950's. The reduction plant currently treats between 70 000 and 95 000 tpm (metric) of ore, consisting of a blend of waste rock, clean up and underground ore. In the latter part of 1999 and in the first quarter of 2000, modifications and upgrades were implemented in the milling circuit and new technology was introduced. In short, two mills (#'s 1 & 3) were converted to fully autogenous mills (previously SAG), the mill liners were rubber injected and a third mill (# 2) was re-commissioned (also with the new liners). Three Knelson Concentrators (KC-CD20 ICSjr) were installed, one per milling circuit. The engineering, design and project management was done by Time Mining (Pty) Ltd. This paper focuses on the overall impact that the Knelson Concentrators (KC's) have had on the performance of the reduction plant and also has a brief look at the project financials.

## **Test work**

As is usually the case, Knelson Concentrators Africa (Pty) Ltd were approached (along with other competitors) to do test work on various streams within the milling circuit, asked to present the results and assist with the project justification.

In order to remain conservative and realistic, KCA looked at the long term benefits of KC's by testing fresh ore feed to the mill, determining the % gravity recoverable gold (GRG) by Knelson Concentrator. The answers from such test work could then form the basis of performance guarantees and also result in realistic expectations from PSGM's side. Gold is removed from lock-up and circulating loads shortly after installation of gravity concentration should be seen as a once-off, short-term cash flow enhancement to boost payback of, but not necessarily cover, the project costs.

Test work on fresh ore feed indicated that GRG by KC would be 30-32% with the most appropriate feed to the machine being the primary cyclone u/flow (screened at 3mm) in order to achieve the desired the mass throughput due to high densities, and to take advantage of slight pre-concentration (higher grade) that is commonly seen with cyclones. Cyclone overflow, underflow and mill discharge were tested.

Project justification was based on the following :

- Lower residue grades
- Removal of severe spikes in the solids (washed) residue
- Reduced leach feed grade and residence time requirement
- 1 to 2% increase in overall plant recovery
- Reagent savings
- More effective security
- Improved cash flow (earlier dispatch of a large portion of the gold)

Based on the realistic (conservative) approach by Knelson staff and the results from the test work that followed, the contract was awarded for the installation of the first two KC-CD20ICSjr's, on #'s 2 and 3 mills.

## **Installation and Circuit Description**

The first machine was installed on #3 Mill, which at that stage, had been running with the old liners, and it was commissioned on the 15<sup>th</sup> of November 1999. By the end of the month, Pres Steyn had smelted approximately 62 kg fine Au over call. The additional gold could only have come from the mill lock-up and circulating gold. On the 15<sup>th</sup> of December 1999 the second machine was commissioned on #2 Mill, which was being re-commissioned with new liners. As a pre-commissioning exercise, #2 Mill was run on waste rock for 3 days. At the same time #1 Mill was stopped for re-lining with the new rubber injected liners. No “loss” of gold was experienced; something which was anticipated due to a portion of incoming gold locking up in the new mill liners of #2 Mill. It is apparent that the Knelson catches circulating gold before it is given the opportunity to go behind the mill liners.

The installation was very simple. The primary cyclone was lifted and the underflow box modified by adding a 6” outlet at the base through which the screen would be fed via an actuated valve. The valve is actuated by a signal from the ICSjr control system fitted to the Knelson Concentrator. The screen undersize (-3mm) gravitates into the Concentrator and the oversize is gravity fed to the mill feed. The tailings from the KC join the screen over size as transport fluid back into the mill feed. Pumping is avoided.

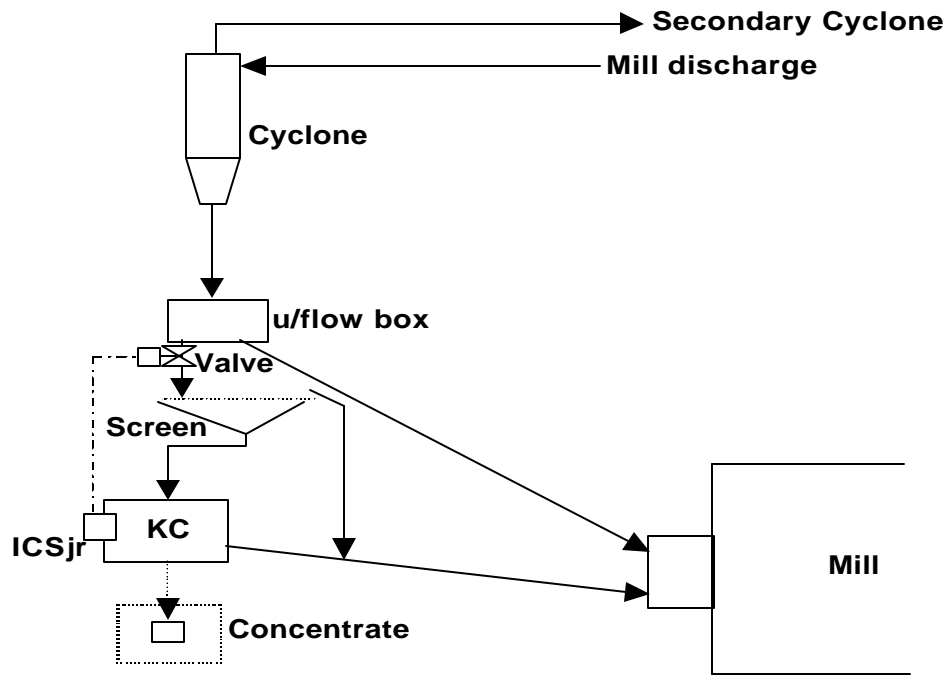
The results from the 2 KC’s spoke for themselves and a third KC was installed on #1 Mill and commissioned on the 15<sup>th</sup> of March 2000. A dedicated compressor supplies the KC circuit and clean potable water is used for fluidization.

Each KC flushes its concentrate into its own secure collection hopper, which is locked up in a cage. The hoppers are removed each day and transported to the smelt house for further processing and replaced with a second set of empty hoppers from the previous day’s activities in the gold room.

The concentrate is pre-screened at 1mm and fed over a Gemeni Table. Table middlings are re-circulated and the tails from that are combined with the screen o/size and returned to the mills with the first-pass tailings. Concentrate is calcined and smelted. The secondary concentrate treatment circuit is estimated to be approximately 85% efficient.

## **Engineering**

The circuit layout and engineering are as important as the KC itself. Generally, the machines are dependent on the reliability of any system designed to transport slurry to them and/or tailings back to the milling circuit. In the case of PSGM, availability was maximized by sizing the screens carefully, by avoiding pumps and by keeping things as simple as possible. The diagram (below) illustrates the simplicity of the KC circuit.



**Diagram : Knelson Concentrator installation at PSGM**

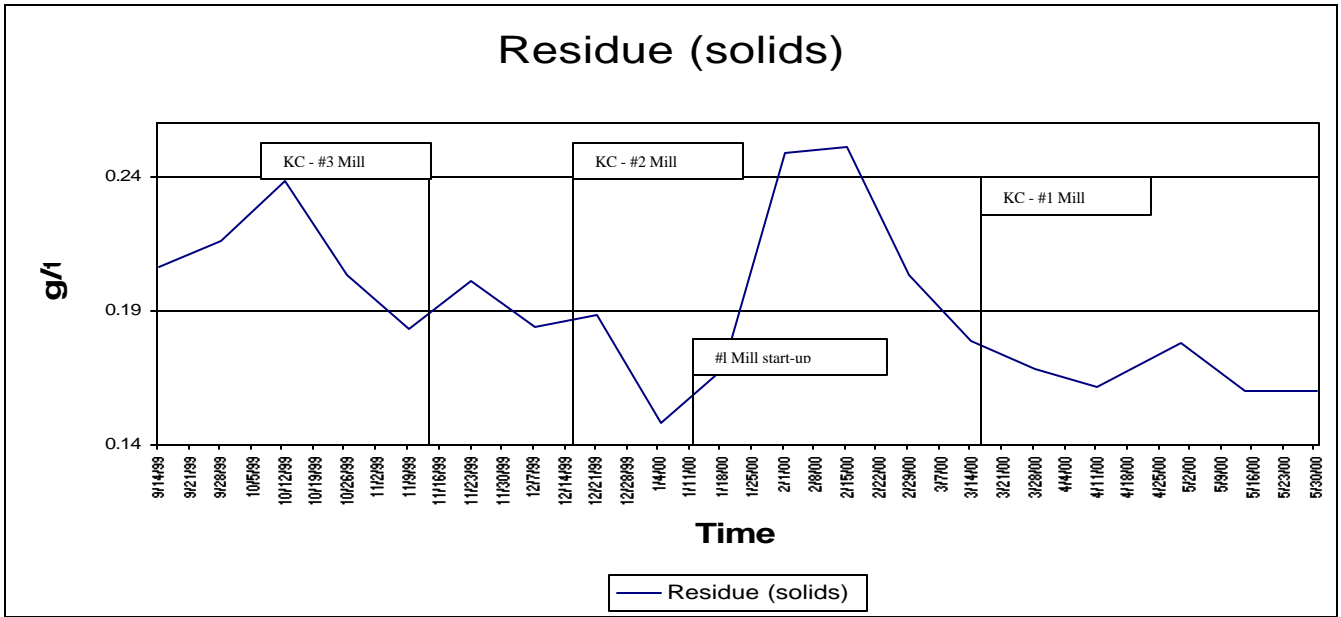
### Process Water Supply and Start-up of #1 Mill

From roughly the end of January to mid March 2000 a spike in the solids residue caused concern. Solids residues had previously dropped down to 0.16 g/t, but were now peaking at values of up to 0.26 g/t. This was due to two reasons.

1. Process water, supplied from underground settlers acted like a “preg robber”. It was discovered that the mine had been experimenting with additives to accelerate water clarification u/ground. These chemicals apparently did the job underground but effected recovery in the reduction plant adversely. This was soon stopped (mid March)
2. The abovementioned was exacerbated by the start-up of #1 Mill at the beginning of January. #1 Mill had no KC installed in its circuit. The net result was that a third of the material treated by the plant was escaping gravity concentration.

### Residues

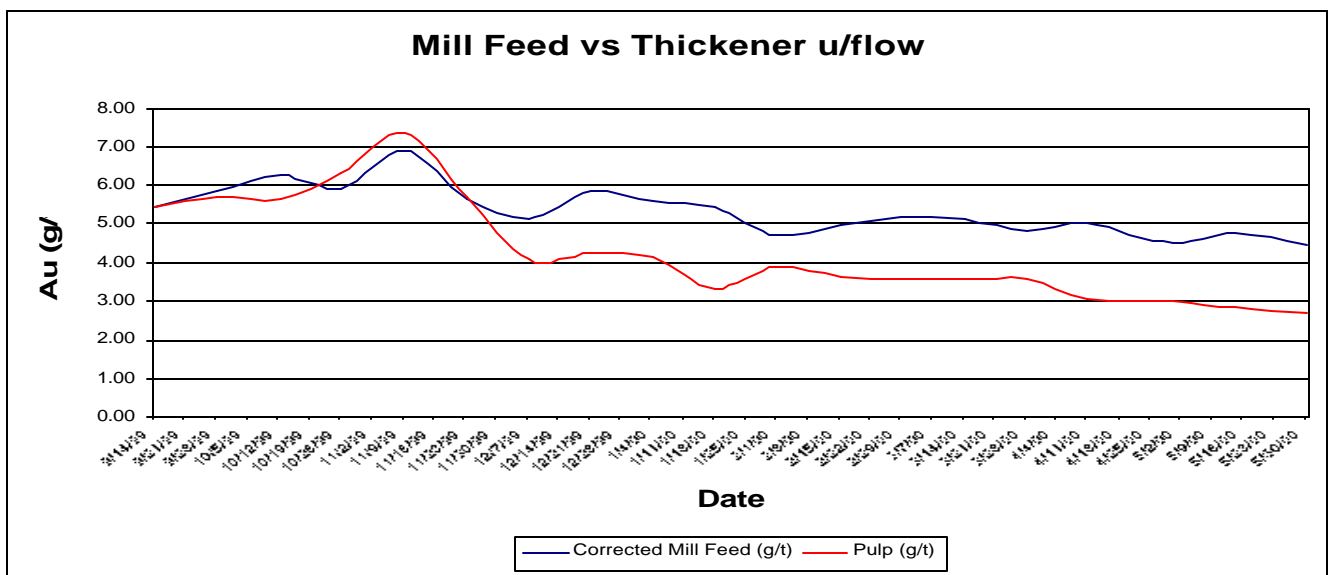
From Figure 1, the effect of the KC's on the solids residue can be seen. From a historical average of 0.22 g/t, the residues have dropped to and settled on 0.16 g/t and occasionally even drop to levels as low as 0.11 g/t. It has to be borne in mind that the above chart was compiled, using two-week averages in order to eliminate noise and, at the same time, keeping it as representative as possible. The plant operating data shows that the residue fluctuates far less than before and the calculations show that an average of 5.4 kg fine Au less per month reporting to the tailings dam.



**Figure 1 : Washed Residue – Sept 99 to May 00**

**Reduced Leach Feed Grade and Residence Time**

It is necessary to qualify the term “Corrected Mill Feed” first. From historical information it was calculated that the mill feed belt grades were an average of 13.23% higher than the thickener u/flow grades (leach feed). All the graphs are represented using corrected mill feed, which is the sample grade less 13.23%. The effect of removing gold using KC’s on leach feed grade is clearly illustrated in fig. 2. Note : PSGM does not mill in cyanide.

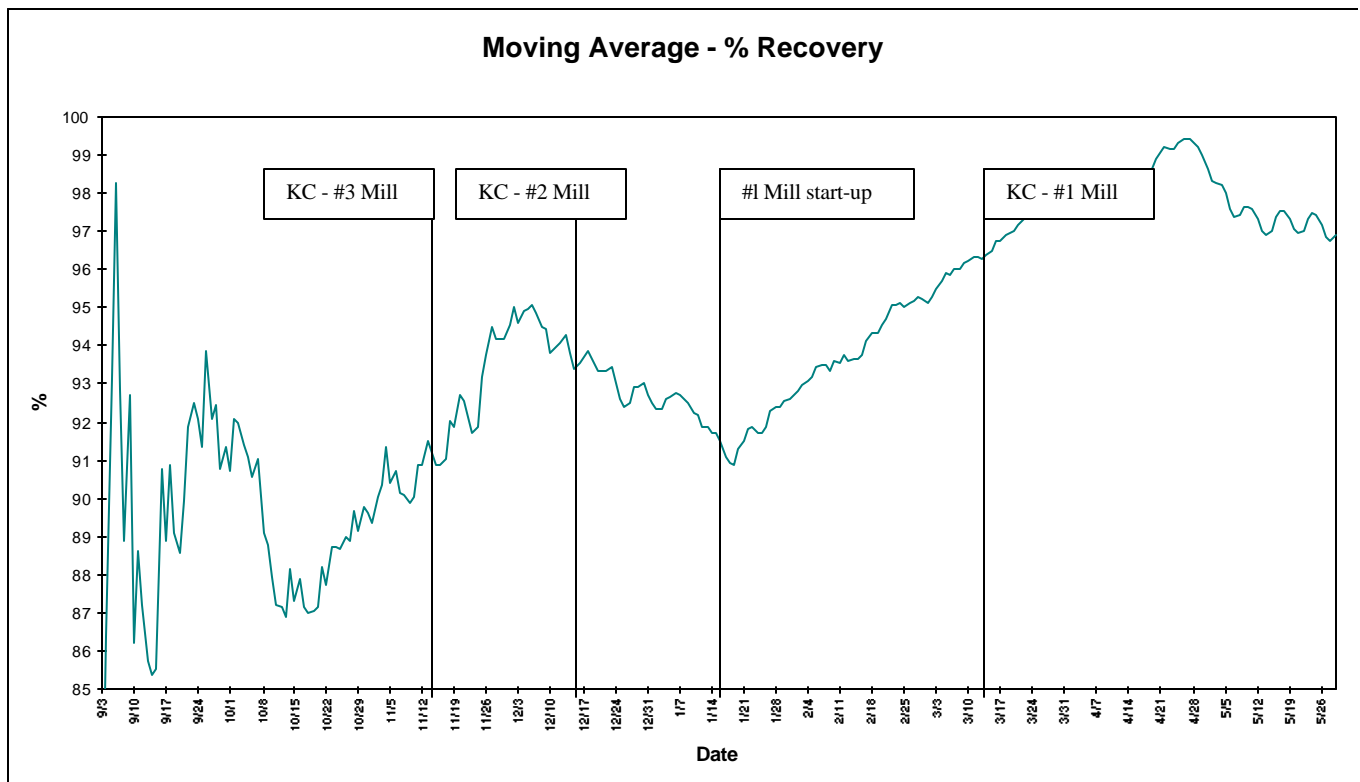


**Figure 2 : Reduction of Leach Feed Grade – Sept 99 to May 00**

The grade to leach reduced from values that should have ranged between 4.5 to 5 g/t to grades ranging 2.7 to 3 g/t. As a result, 2 of 6 leach tanks were taken off line due to less residence time needed to achieve dissolution. Cyanide addition was cut by 10% (a saving of R47 000 per month), and lime addition remained constant.

### Plant Recovery

Before the installation of KC's, the daily (and even weekly) plant recoveries varied widely between 85 and 98%. The sensitivity towards variances in ore characteristics was high and the process was very quick to react to these. The average monthly recoveries were however always between 94% and 95%. Once the KC's were installed, recovery numbers went up drastically and at one stage 114% was achieved – obviously due to GRG being pulled out of the mill lock up and circulating loads. Daily and weekly spikes in the recovery figures were smoothed out significantly. This is clearly visible from Figure 3 below. Note the dip in the graph caused by the process water quality and the start up of #1 Mill without a KC in its circuit.



**Figure 3 : Plant Recovery % – Sept 99 to May 00**

Percentage recovery has not dropped below 97% since the 15<sup>th</sup> of March 2000, when the third KC was commissioned. Average monthly recovery in the past was generally never higher than 95%, which means that the gravity recovery circuit has improved overall plant recovery by a minimum of 2%!

### Gravity Gold Production

Test work indicated that 30 to 32% of the mines total gold production would come from the Knelsons. This can be a dangerous prediction because it is not only dependant on the effectiveness of the KC's (circuit availabilities, efficiencies etc) but also is tied to the secondary concentrate treatment efficiencies in the gold room. As described earlier the Gemeni circuit efficiency is estimated at no more than 85%. This means that if 32% is recovered by Knelson, only  $0.85 \times 32\%$  will eventually report to smelt. With start up however, it was found that smelted gold equaled between 30 and 35% of total production (the KC's were running on 1 hour cycles). This means that the KC's were actually achieving 35 to 41% - way beyond prediction.

An optimization exercise was undertaken by the mine personnel, whereby KC cycle times were varied in order to find optimum recovery. It was found that 45-minute cycles achieved the maximum. PSGM now produces 44 to 45% of its gold (smelted) from the KC circuits! This means that the KC's before secondary concentrate treatment, are achieving an actual recovery of between 51% and 53%.

It was also discovered that the KC's were treating more than the rated tonnages. A 20" G5 Knelson Concentrator Cone is rated at 25tph at 47% solids. Throughput at PSGM is estimated to be somewhere between 30 and 35tph at densities in the region of 70% solids, with no detrimental effects on the machines.

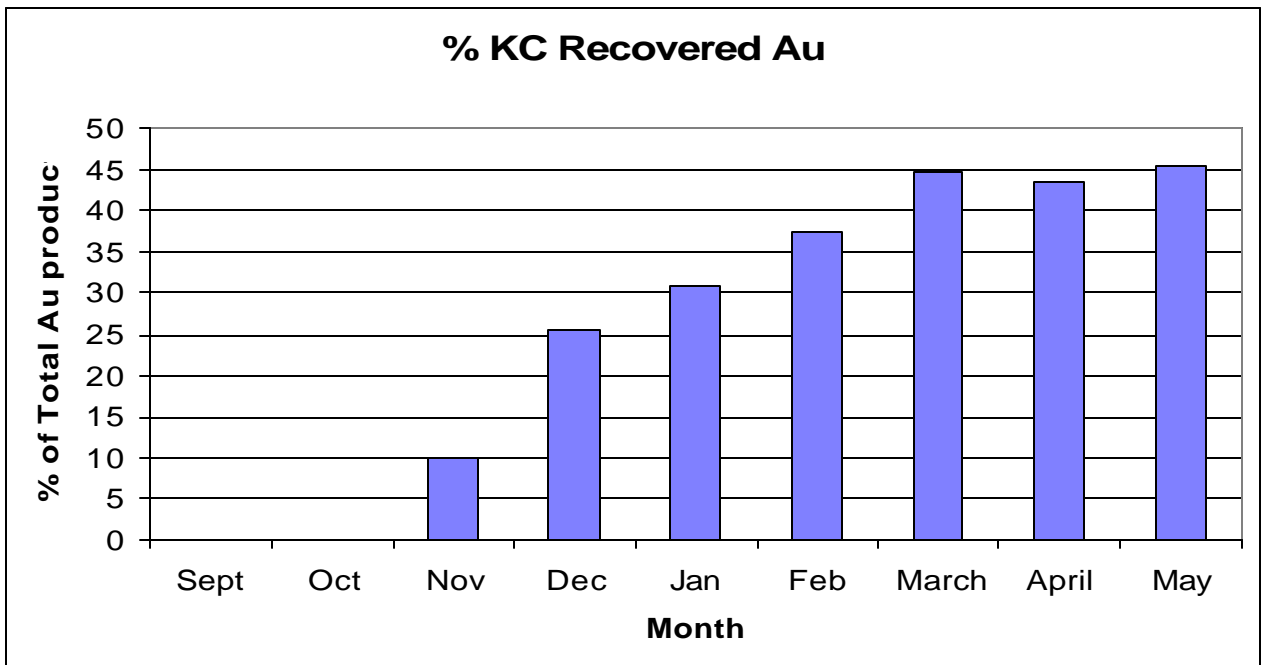


Figure 4 : Knelson Concentrator Gold Production – Sept 99 to May 00

## Financial

	Once-off (ZAR)	Monthly (ZAR)	Annual (ZAR)
<b>Revenue</b>			
Revenue form 62 kg Au (over call)	3720000		
<b>Savings</b>			
Cyanide		47000	564000
Au (less to tailings) (5.4 Kg fine at R60k/kg)		324000	3888000
Additional cashflow - 45% of total Au smelted and despatched 3 days earlier @ 8% return		7988	95856
33% less leach capacity - less air and maint		n/a	n/a
<b>Less Costs</b>			
<b>Capex</b>			
KC and Secondary conc. Installation	2000000		
<b>Opex</b>			
Water		20000	240000
Maintenance entire circuit incl KC's		5000	60000
<b>Totals</b>	R 1720000	353988	4247856

The project cost roughly R2million (including secondary circuit in the gold room). With figures shown above, the payback including interest, was less than 1 month. The installation was, however, phased over a period of time so it would be fair to say that the first 2 KC's (along with installation costs) had paid for themselves before the third was installed and that the third installation had paid for itself in roughly one month.

## Discussion

Although the initial project justification is a tough task, due to the fact that accurate predictions on plant performance are so difficult, and the fact that the recoverable quantity of locked up gold in the mills is not easy to predict, the figures have spoken for themselves and goals have been achieved.

The KC's have also significantly reduced the plant's exposure to theft problems. Far less free and visible gold is locked up in the milling circuits, lying in sumps and in other confined spaces where this kind of material generally tends to accumulate. The operators feel that they have more control over where valuable material ends up and find the additional materials handling and transfer of concentrate hoppers a small price to pay in return for greater peace of mind. Machine availabilities are currently 99%+.

Apart from the small, but not insignificant, benefit from interest on gold gained earlier in the process, the mine claims that there has also been a significant improvement in cash flow as a result. This is a very important factor and perhaps more so in the case of PSGM, who are a privately owned operation.

**Acknowledgement**

KCA thank the management of PSGM for their valuable contribution by supplying all necessary information needed for this document and for opening their doors to visitors interested in viewing the installation.

A special thanks to everyone involved, for taking the time to review this document and for verifying that the facts and figures are accurate.