FILTER CAKE WASHING

FOR CYANIDE REMOVAL

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Filter Cake Washing For Cyanide Removal

The purpose of this presentation is to stress the importance of effectively removing cyanide from the cyanided tailings filter cake, by washing with water, in gold mills which rely principally on the destruction of cyanide in their waste barren solution, e.g., by alkaline chlorination, to produce an acceptable effluent for discharge to the environment.

In the standard gold milling process (Merrill Crowe) as shown in Figure 1, gold is recovered from a clear pregnant solution by zinc precipitation. Filtering of the cyanide leach slurry, usually preceded by thickening, is practiced to separate the pregnant solution from the leached solids. The solution is then clarified and deaerated prior to gold precipitation. Vacuum drum filters are most commonly used for the filtration step but belt type filters are beginning to gain wider acceptance due to their superior cake washing ability. Practice in Canadian gold mills varies between one stage and two stages of filtering and cake washing. Washing of the filter cake is considered vital to decrease losses of gold, and to some extent cyanide, from the process with the tailings. Barren solution is the principal, and in some cases only, wash solution used on the filters. However, some fresh water is also used, particularly when two stages of filtering-washing are employed. In mills which do not have a cyanide destruction system it is unnecessary from the point of view of cyanide destruction to remove cyanide from the filter cake.

Although, in my presentation today I will address one or two flowsheet configurations of filter circuits in gold mills, it is recognized that these do not represent the many arrangements which actually exist in mills. Examples will be presented which are based on the most common gold milling practice, i.e., where all the mill feed is cyanided. However, there are other situations where only flotation concentrates, flotation tailings or roaster calcines and dusts are cyanided, rather than the entire mill feed. Also variations in thickener and filter combinations, wash waters used and routing of filtrate discharge exist.

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In these days of increased awareness of the need for protection of the environment and the availability of treatment methods for destroying cyanide in gold mill effluents one must identify those streams discharged from a gold mill which contain cyanide. There are two main flows involved: the waste barren solution and the final filter cake or more precisely, the moisture in the filter cake. If cyanide losses with the filter cake are to be avoided, or at least reduced substantially, the importance of thoroughly washing the filter cake must be fully realized.

Example 1 - Single stage filtering with barren solution wash

Let us consider an example to show the relative amounts of cyanide which might be discharged with either the waste barren solution or with the filtered solids from a mill using only single stage filtration and a barren solution wash as practiced in some mills. (See Figure 1) The following conditions are assumed based on typical mill operation:

Mill feed	- 500 tpd
Sodium cyanide (NaCN) addition (53% CN)	- 1.0 #/ton feed
Cyanide (CN) equivalent	- 0.53 #/ton feed
Moisture in filter cake	- 20%
Cyanide in pregnant solution	- 300 mg/l
Cyanide in barren solution wash	- 300 mg/l

In this case 500 #/day of sodium cyanide (NaCN) containing 265 #/day of cyanide (CN)are added in cyanidation. From this point on the word "cyanide" will denote CN, not NaCN, unless otherwise noted. The solution retained in 500 tpd of filter cake at 20% moisture will contain 75 #/day of cyanide. Therefore if 75 #/day of cyanide leaves the mill with the filter cake then only 190 #/day of cyanide leaves in the barren solution. Calculations for this example and others to follow are given in Appendix 1.

In other words 28.3% of the cyanide entering the mill leaves with the tailing solids and not with the waste barren solution. This is an important but often unappreciated situation. It is important because many mills have already installed, or are planning to install treatment systems, e.g., alkaline chlorination, to remove cyanide from their waste barren solutions and may not realize the amount of cyanide retained with the tailing solids which can escape treatment. Fortunately a tailings pond does exhibit some ability to naturally degrade cyanide to less objectionable forms, particularly during the warmer months.

There are alternatives to address the problem of the cyanide with the filter cake, including:

(1) washing the solids free of the cyanide bearing solution with water (or perhaps treated barren solution) and routing this cyanide to treatment

(2) treating the slurry directly for cyanide removal, e.g., chlorination in pulp

(3) performing the solid-liquid separation in the tailings pond and treating the tailings pond overflow. Giant Yellowknife Mines follows this practice.

However, today I will address the first alternative only, i.e., thorough washing of cyanide from the filter cake. A number of mills are equipped to do this to varying degrees.

The purpose of an alkaline chlorination system in most gold mills is to remove cyanide and metals from the waste barren solution. Obviously such a system cannot destroy cyanide which by-passes the system and does not go for treatment, e.g., cyanide in the water with the filter cake. Suppose, that in the example just given, it is possible to reduce the cyanide in the treated barren solution by alkaline chlorination from 300 mg/l to 1 mg/l. This would result in the discharge of a treated barren solution containing only 0.63 # cyanide/day while 75# cyanide/day would be discharged in the tailings slurry. This is hardly a suitable answer to the problem.

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If the cyanide in the solution retained in the filter cake is to be treated as part of the waste barren solution, obviously it must be washed free from the solids by displacement with fresh water, recycled tailings pond water or perhaps treated barren solution. Any water or solution used for for washing should be free of suspended solids to avoid clogging the filter cake wash pipes. This would not be necessary if the water or solution was added to a filter cake repulper.

The more stages of washing performed, the more complete the removal of cyanide from the filter cake will be, but accordingly, at progressively greater capital and operating costs.

Example 2 - Single stage filtering with water wash

Now examine what would result in single stage filtration if fresh water instead of barren solution was used for washing the filter cake, assuming the following conditions:

Weight of solids in filter feed	- 500 tpd
Cyanide concentration in pregnant solution	- 300 mg/l
Final filter cake moisture	- 20%
Washing efficiency (% cyanide removal)	- 75%

Based on the above assumptions the weight of cyanide retained in the filter cake before washing is 84.6 #/day. (Calculations are given in Appendix 1) With a 75% washing efficiency 63.4# cyanide/day would be recovered and 21.2# cyanide/day would remain with the filter cake. This would lower the concentration of cyanide in the filter cake solution from 300 mg/l to 84.6 mg/l.

If the filter cake was reslurried in water and pumped to the tailings pond at 40% solids, the water would contain 14.1 mg/l cyanide.

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Example 3 - Two stage filtering with water wash

However, if a second stage of filtration was added with water repulping between stages and a water wash added on the filter as shown in Figure 2, an even greater decrease would result in the amount of cyanide in the tailings slurry.

Assuming for the second stage of filtration:

Solids from the lst filter are repulped with water to	- 55% solids
Final filter cake moisture	- 20%
Washing efficiency	- 75%

In this case an additional 19.35# cyanide/day would be removed from the filter cake and only 1.8# cyanide/day would be discharged with the filter cake. The overall recovery of cyanide in the filter circuit would be 97.6% and would lower the concentration of cyanide in the filter cake moisture to 7.2 mg/l cyanide. If the filter cake was further diluted to 40% solids with water before pumping to the tailings pond then the cyanide concentration in the water portion of the tailings slurry would be only 1.2 mg/l.

The results obtained from these various filter-wash scenarios are summarized in Table 1.

TABLE 1

Filter Stages	Wash Solution	#CN Retained In Filter Cake	(1) % CN Loss With Filter Cake	(2) CN Recovery From Filter Cake #/Day	%
1	Barren	75.0	28.3	0	0.0
1	Water	21.2	8.0	53.8	75.0
2	Water	1.8	0.7	73.2	97.6

(1) % loss of cyanide through the filter-wash circuit based on 265#/day cyanide (500#/day NaCN) added to the cyanidation circuit

(2) Base condition is that of a filter cake washed with barren solution. Recovery of cyanide from the filter cake increases with successive water washes.

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If less water and more barren solution is used for washing then, of course, more cyanide will be discharged to the tailings pond with the filter cake.

From this summary it is evident that the discharge of cyanide with the tailings solids can be reduced with single stage filtration from 28.3% of the cyanide entering the mill when a barren solution wash is used to 8.0% when a water wash is substituted. By adding a second stage of filtering and a water wash, preceded by repulping with water, the retention of cyanide with the solids can be reduced to 0.7%. The recovered cyanide can then be directed to the cyanide removal system rather than be allowed to enter the tailings pond untreated. It is necessary to realize that the treatment system must be sized adequately to allow for the additional volume of cyanide containing streams coming from the filters.

The use of fresh water only for washing may require undue amounts of such water, however, these amounts may be reduced by using other sources of water for washing, either alone or in combination. For example, counter-current washing could be used in a two stage filter circuit, i.e., the filtrate from the second filter could be used as wash water on the first filter. Other sources of wash water could be treated waste barren solution, mine water or recycle water from the tailings pond.

If this presentation has conveyed or reinforced the importance of washing to remove cyanide from the cyanidation circuit tailings, so that the cyanide may be treated before discharge, then its purpose has been served.

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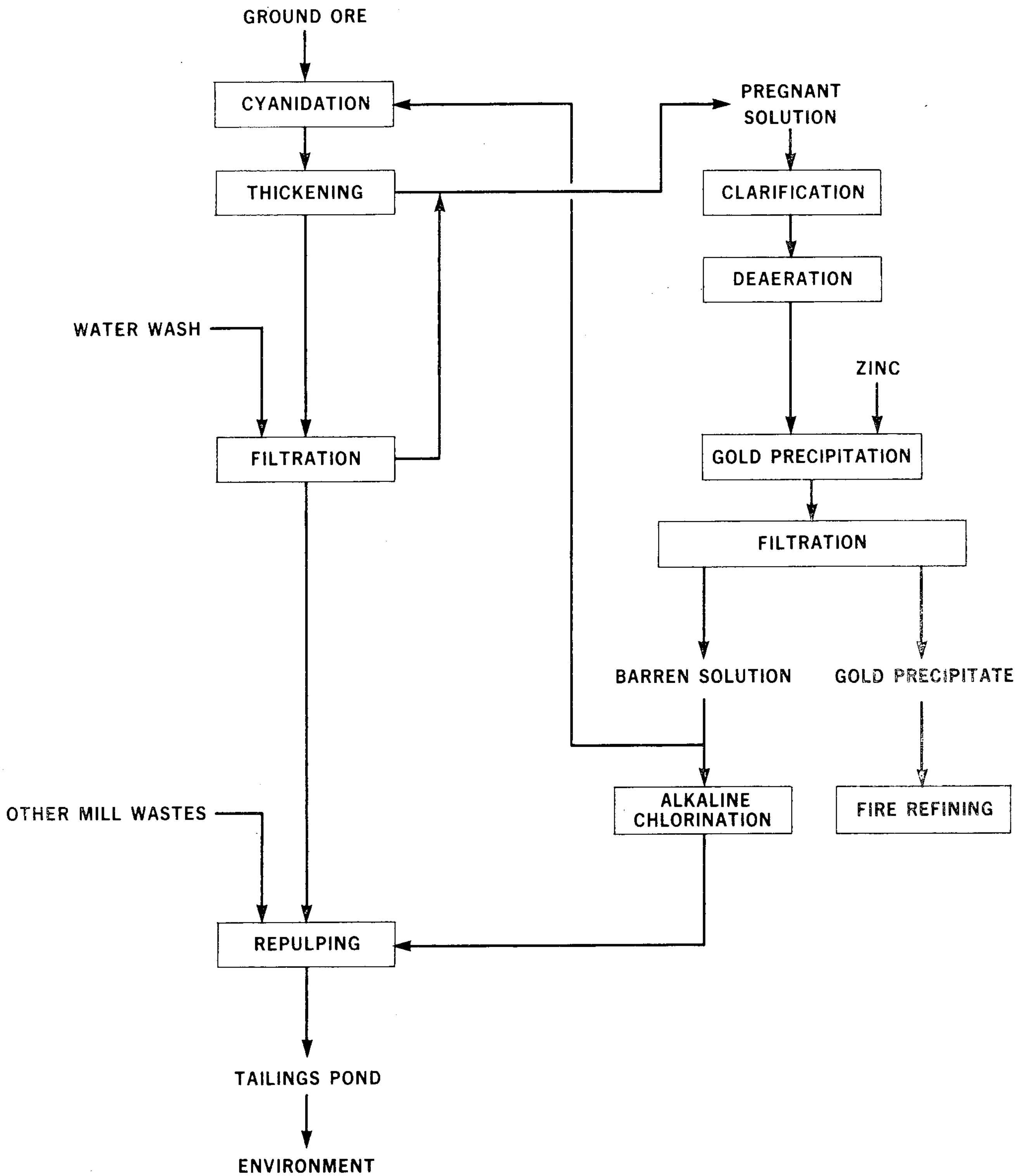
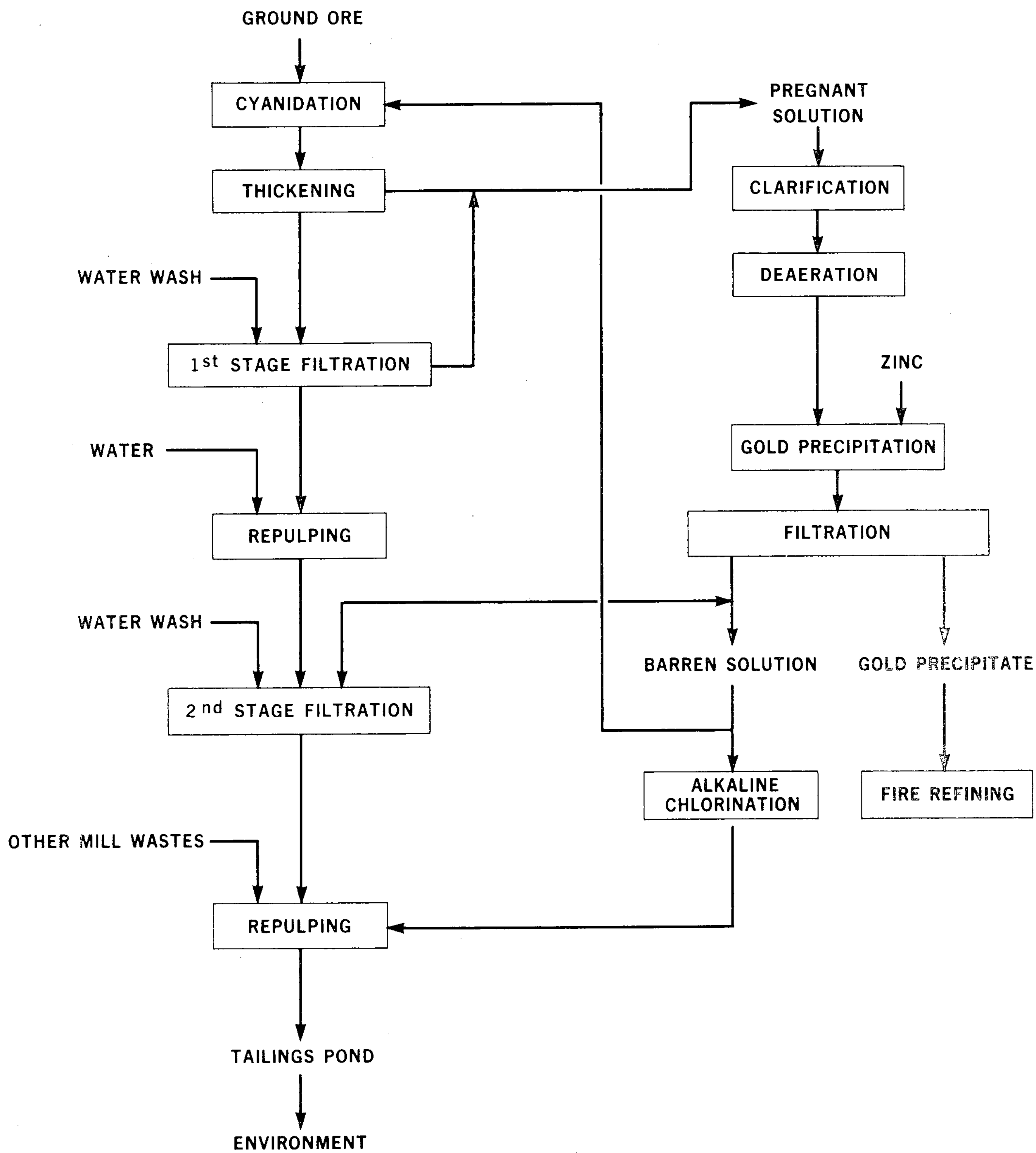
CYANIDATION FLOWSHEET - FIGURE 1

ONE STAGE FILTRATION



CYANIDATION FLOWSHEET - FIGURE 2

TWO STAGE FILTRATION



Appendix 1

Calculations for this paper are based on the following equations:

1. $\text{tons/day solution} = \dfrac{\text{tons/day solids X \% solution in slurry}}{\text{\% solids in slurry}}$

2. $\text{\#CN/day} = \dfrac{\text{tons/day solution X mg/l(CN)}}{500}$

3. $\text{mg/l (CN)} = \dfrac{\text{500 X \#CN/day}}{\text{tons solution/day}}$

4. $\text{tons solution/day} = \dfrac{\text{500 X \#CN/day}}{\text{mg/l(CN)}}$

Example 1 - Single stage filtering with barren solution wash

Conditions:

Mill feed	- 500 tpd
NaCN addition (53%CN)	- 1.0 #/ton feed
CN equivalent	- 0.53 #/ton feed
Moisture in filter cake	- 20%
CN in pregnant solution	- 300 mg/l
CN in barren solution wash	- 300 mg/l

NaCN added in cyanidation	500X1.0	= 500#/d
CN added in cyanidation	500X0.53	= 265#/d
Dry weight of filter cake		= 500 tpd
Wet weight of filter cake	$\frac{500}{80}$	= 625 tpd
Weight of solution in filter cake	625-500	= 125 tpd
Weight of CN remaining in filter cake =	$\frac{125X300}{500}$	= 75 #/d
Weight of CN recovered	265-75	= 190 #/d

Example 2 - Single stage filtering with water wash

Conditions:

Mill feed	- 500 tpd
NaCN addition (53%CN)	- 1.0 #/ton feed
CN equivalent	- 0.53 #/ton feed
Moisture in filter cake at start of washing	- 22%
Moisture in final filter cake	- 20%
CN in pregnant solution	- 300 mg/l
CN in waste water	- 0 mg/l
Washing efficiency	- 75%

CN added (as in Example 1) - 265 #/d

Weight of solution in filter cake before washing

$\frac{500 \times .22}{.78}$ - 141 tpd

Weight of CN with filter cake at start of washing

$= \frac{141 \times 300}{500}$ - 84.60 #/d

At 75% washing efficiency weight of CN recovered

= 84.6 X .75 - 63.45 #/d

Weight of CN left with filter cake solution

84.6-63.45 - 21.15 #/d

Weight of CN recovered 265.00-21.15 - 243.85 #/d

Weight of solution in final filter cake

$= \frac{500 \times .20}{.80}$ - 125 tpd

Concentration of CN in solution with final filter cake

$= \frac{500 \times 21.15}{125}$ - 84.6 mg/l

If filter cake is diluted to 40% solids with water before pumping to the tailings pond the following would result:

Weight of water with filter cake 500 X $\frac{.60}{.40}$ = 750 tpd

Concentration of CN in water in tailings slurry

$\frac{500 \times 21.15}{750}$ - 14.1 mg/l

Example 3 - Two stage filtering with water wash

Conditions:

Same as Example 2 plus the following:

Filter cake from stage 1 is repulped with water to - 55% solids

Moisture in #2 filter cake at start of washing - 22%

Weight of CN in filter cake to repulper (from Example 2) - 21.15 #/d

Weight of water in feed to #2 filter - 409 tpd

$$= 500 \times \frac{.45}{.55}$$

Concentration CN in this water $\frac{500 \times 21.15}{409}$ - 25.9 mg/l

Weight of water in filter cake at start of washing

$$= 500 \times \frac{.22}{.78}$$ - 141 tpd

Weight CN with filter cake at start of washing - 7.3 #/d

$$= \frac{141 \times 25.9}{500}$$

At 75% washing efficiency, weight of CN recovered - 5.5 #/d

= 7.3 X.75

Weight of CN left in final filter cake solution - 1.8 #/d

= 6,3-5.5

Weight of solution in final filter cake - 125 tpd

$$= 500 \times \frac{.20}{.80}$$

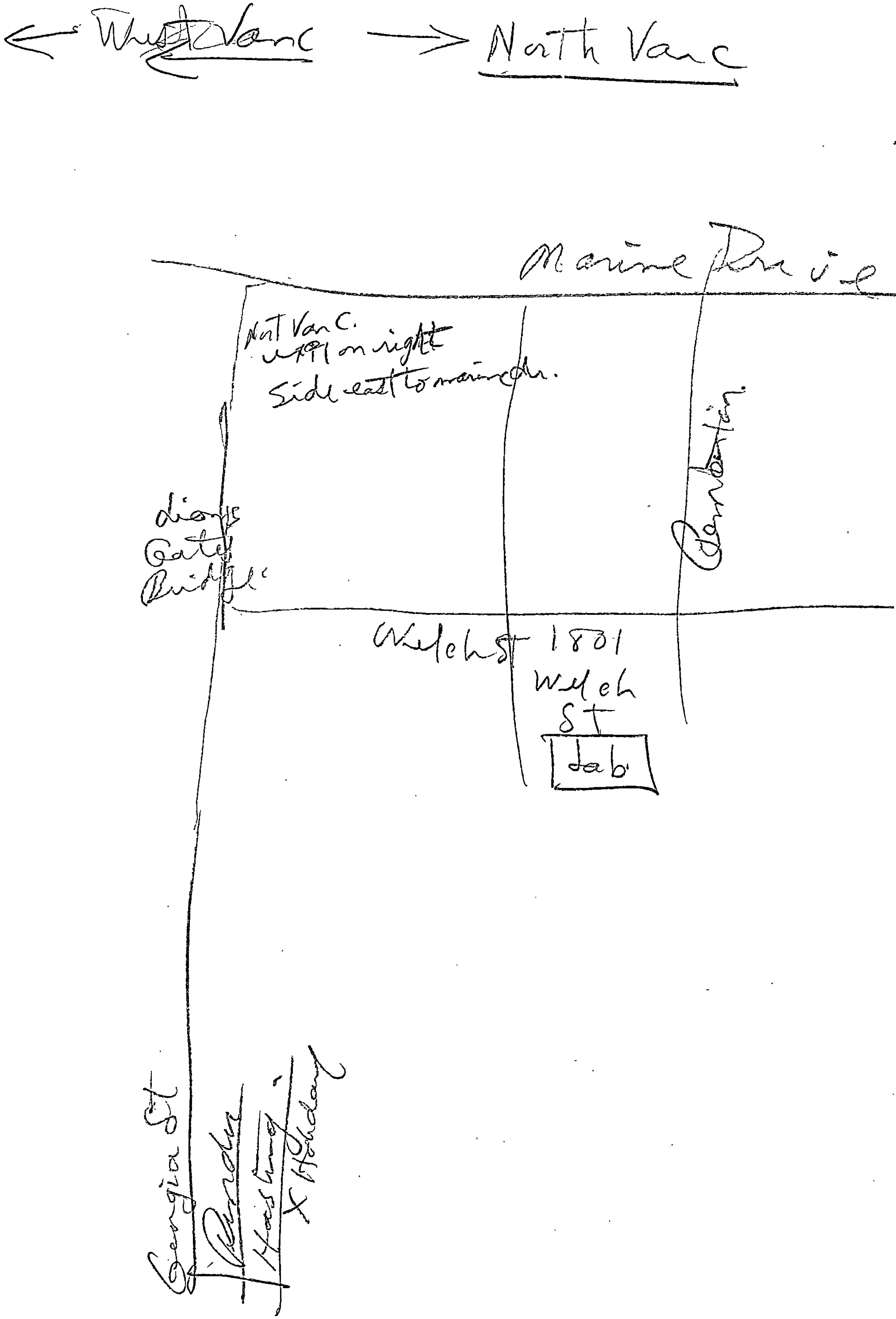
Concentration of CN in solution with final filter cake $= \frac{500 \times 1.8}{125}$ - 7.2 mg/l

If the filter cake is diluted to 40% solids with water before pumping to the tailings pond the following would result:

Weight of water with the filter cake $500 \times \frac{.60}{.40} = 750$ tpd

Concentration of CN in final tailings slurry - 1.2 mg/l

$$= \frac{500 \times 1.8}{750}$$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