AN IN-PLANT EVALUATION OF FROTH WASHING ON CONVENTIONAL FLOTATION CELLS FOR COAL

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ABSTRACT

Column flotation cells have become increasingly popular in the coal industry due to their ability to improve flotation selectivity. The improvement can be largely attributed to the use of froth washing, which minimizes the nonselective entrainment of ultrafine minerals matter into the froth product. Unfortunately, the practice of adding wash water in conventional flotation machines has been largely unsuccessful in industrial trials. In order to better understand the causes of these failures, a detailed in-plant test program was undertaken to evaluate the use of froth washing at an operating coal preparation plant. The tests included detailed circuit audits (solid and liquid mass balances), salt tracer studies, and release analyses. The data collected from these tests have been used to develop criteria that describe when and how froth washing may be successfully applied in industrial flotation circuits.

A second series of tests was developed to look at other alternatives to froth washing and their effectiveness. This involved two-staged flotation circuitry. A two-staged approach was developed because the existing flotation cells did not have enough residence time to support froth washing. The process owner wanted to evaluate possible alternatives to column cell flotation. The testing included release analysis testing as well as a detailed series of tests with percent solids control to the secondary flotation unit.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1.1 - Background

There are two primary mechanisms by which particles may be recovered in a froth product during flotation. These are (i) *direct attachment* to air bubbles and (ii) *hydraulic entrainment* in the froth product water. Direct attachment is a selective process that occurs as a result of differences in the wettability between coal (which dislikes water) and mineral matter (which likes water). Although this phenomenon is a selective process, composite (middlings) particles containing both coal and mineral matter can be recovered by this mechanism due to the presence of the coal inclusions.

The recovery of particles by hydraulic entrainment is a nonselective process resulting from the carryover of fine particles with the water that reports to the froth launder and is an inherent problem in froth flotation. Studies have shown that the rate at which ash reports to the froth product is directly related to the mass rate of froth water (Lynch *et al.*, 1981). In the mineral industry, hydraulic entrainment has traditionally been minimized using multiple stages of cleaner flotation to dilute the concentration of the impurities in the flotation feed. This approach is generally not practical in the coal industry due to the large capital costs of multi-stage circuits. Consequently, column flotation has become the preferred alternative to multi-stage cleaning for the coal industry. Column cells are able to significantly reduce the entrainment problem through the addition of a counter-current flow of wash water to the top of the froth. Studies suggest that less than 1% of the feed pulp (and associated fine clay) will report to the froth product in a well-operated column (Luttrell *et al.*, 1999). Consequently, the wash water allows column cells to produce a high-grade concentrate in a single stage of flotation.

Although many column installations now exist, the coal industry has been rather hesitant in adopting the column flotation technology. One of the major reasons for this reluctance is the comparatively low market value of fine coal. This situation makes it difficult for operators to justify the higher capital and operating costs for columns, particularly if the expenditure is for the replacement of existing conventional cells. In addition, many coal operators generally have the perception that columns are more difficult to operate, entail greater amounts of maintenance, and require complicated ancillary systems for compressed air and wash water.

A less costly alternative to the installation of column cells is to adapt the froth-washing concept to existing conventional flotation machines. This approach has already been evaluated in pilot-scale and industrial circuits in the mineral industry (Kaya and Laplante, 1990). Unfortunately, attempts to apply this approach in the coal industry have been largely unsuccessful. Studies suggest that conventional froths are generally too shallow to allow the wash water to be effective. Furthermore, coal recovery is often adversely impacted by attempts to deepen the froth by lowering the pulp level. The recovery loss can be attributed to increased particle detachment (due to froth instability) and lower bubble-particle attachment (due to less pulp volume and shorter residence time). This suggests that wash water can be effectively applied only to conventional flotation systems that have sufficient excess capacity to offset the recovery problems created by the lower froth stability and shorter residence time. Stronger frothing agents may also be required to produce froths capable of withstanding the washing process without collapsing.

1.2 - Objective

The primary objective of this present investigation was to evaluate the potential benefits of froth washing in conventional flotation circuits. To achieve this objective, a detailed experimental study was conducted at an industrial coal preparation plant. The study included size-by-size analysis of cell performance with and without the addition of wash water. Several important operating parameters were also evaluated including froth depth (pulp level), water distributor location, water addition method, and froth removal method (with and without froth paddles). Salt tracer studies and flotation release analyses were also performed in select cases to provide additional insight into the effects of water addition on flotation cell performance.

Chapter 2

LITERATURE REVIEW

2.1 - Overview

In froth flotation there are many interactions that govern how particles are recovered in the froth. Two distinct groups of particles are present in froths generated by flotation. The first is the particles that are the target of the flotation process for recovery, and the second is any other particle that is recovered, although not desired, and, for this review, will be termed gangue. This review is focusing on the mechanics of how gangue particles are recovered, and ways others have tried to prevent or remove them from froths.

This literature review uses the following organization:

- Overview of How Particles Enter Froth
- Entrainment
  - Size Effects
  - Frother Effects
  - Liquid Lamella Effects
  - Froth Depth
- Froth Drainage
- Froth Residence Time
- Prevention of Entrainment
- Froth Washing
  - Size Effects of Froth Washing on Coal Flotation

2.2 - Overview of How Particles Enter Froth

Material enters the froth by two main effects: true flotation, and mechanical means. A floatable particle's principle means of reporting to the froth is by true flotation, caused by bubble attachment and levitation, although any hydrophobic particle may report to froth by the same means as a hydrophilic particle would (Kaya *et al*., 1990). For nonfloatable (hydrophilic) particles, hydraulic entrainment, such as carryover by wake, mechanical entrainment due to turbulence, or slime coatings are possible means of transportation to the froth phase (Jowett, 1966). All particles in a conventional froth, either hydrophobic or hydrophilic, may leave the froth by two means: drainage back into the pulp or removal in the concentrate (Bisshop and White, 1976).

Similarly, Kaya *et al.*, (1990) distinguished the way that water enters the froth into three categories. The first route is one in which the water is entrained by a boundary layer around each bubble, which is described as the bubble walls dragging the water with it. The second form of water entrainment is in the wakes of bubble clusters. The third method of water carryover into the froth is by entrapment of water between bubble clusters (Smith and Warren, 1989). Unfortunately, little information is available about mechanisms such as entrapment (Gaudin, 1957) and carrier flotation (Greene and Duke, 1962), (Subrahmanyam and Forssberg, 1988b). For the rest of this discussion, the term entrainment will be used to describe all mechanical (i.e. nonselective) processes for both water and particles.

2.3 - Entrainment

2.3.1 – Overview

Finch *et al.*, (1989) showed that entrained particles and water recovery have a proportional relationship for conventional mechanical cells. The thickness of the liquid films that surround bubbles was proposed by Klassen and Tikhonov (1964) to directly correlate to the amount of entrainment. Warren(1985) expanded this to say that recovery of floatable components will vary linearly with the amount of water recovered. When these lines were extrapolated, they intercepted the mineral recovery axis at a positive value, depending on the material being studied. However, when lines of nonfloatable material were plotted, the extrapolation showed an intercept at the origin. Others such as Lynch *et al*. (1981) also observed this trend (Warren, 1985).

Studies on the effect of particle densities on entrainment were conducted by Kirjavainen (1989). They showed that, for particles that could be assumed spherical (quartz and chromite), hydraulic entrainment will increase as material density decreases. Material mass was found to determine the degree of entrainment, whereas pulp density was found to have no bearing on degree of entrainment. For materials with different shape factors, such as phlogopite, the degree of entrainment was found to increase strongly with pulp densities over 10%. Regardless of pulp density, the phlogopite was found to have a higher degree of entrainment than the quartz or chromite. Kirjavainen (1989) concluded that the principle difference was due to the hydrodynamic response of the material shape.

From this study, it was proposed that the hydraulic entrainment of nonfloatable material was a statistical phenomenon. The nonfloatable recovery could then be described by a simple probability model where no other assumptions are needed (Kirjavainen, 1989).

Other work, such as Subrahmanyam and Forssberg (1989b), agreed with Kirjavainen, and represented the process by the equation: $R_g = e_g R_{water}$. R_g is the recovery of fine gangue, and R_{water} is the recovery of water, each of which is for a given time, and R_g is for a given size. The degree of entrainment e_g, is the slope of the plot of the recovery of water versus the recovery of solids (Subrahmanyam and Forssberg, 1988b).

When considering particles that are neither gangue nor floatable material but are locked, limited flotation can occur. These particles can be recovered due to incomplete liberation, incomplete depression of the gangue, or by coflocculation with other floatable particles (Coburn, 1985). From this, Szatkowski (1987) concluded (in contrast to Kirjavainen (1987)) that the amount of gangue reporting to concentrate is a function of the concentration in the pulp.

2.3.2 - Size Effects

Numerous studies have been conducted on the effect of size on entrainment of nonfloatable material. Jowett (1966) found that fine free gangue recovery is proportional to its concentration in the pulp; similarly Kaya *et al.*, (1990) pointed out that as fineness increases, gangue recovery increases. Others correlated fineness to decreased selectivity (Kirjavainen, 1989).

Work by Bisshop and White (1976) found that particle drain-back into the pulp at any size is directly related to the froth residence time. Kirjavainen (1989) further broke down gangue recovery into 1-micrometer-size intervals to determine the differences.

Recovery in any size class is proportional to the amount of floated water, with the finest particles closely reflecting the water flow.

Mechanical separation of particles without the addition of collectors was found to be more active in particles with less than 3-5 micron diameters. From this work, it is assumed that the mechanical separation of fine particles is due to their very slow settling rates in water (Klassen and Tikhonov, 1964). Others pointed out that, with increases in recovery in the coarsest particles in coal feeds, there is a corresponding progressive increase in recovery of ultrafine particles (Miller, 1969).

Fine particles have been shown to be transported into the froth not only by entrainment but also as slime coatings on the surface of valuable minerals (Waksmundzki *et al.*, 1972). The degree of entrainment depends on the size of the material being entrained. As a particle size decreases, the degree of entrainment increases (Warren, 1985). Also, as the particle size becomes coarser, not only is the degree of entrainment lessened, but the correlation is not always linear (Engelbrecht and Woodburn, 1975). For ultrafine particles, test work has shown the degree of entrainment for some hydrophobic particles to be very close to that of hydrophilic gangue (Warren, 1985).

2.3.3 - Frother Effects

Frothers have been studied for many effects such as recovery, froth stability, and product grade. Frothers also play an important role in the nonselective entrainment of particles. The degree of entrainment of slime particles depends not only on the concentration of the frother but also on its nature (Klassen and Tikhonov, 1964). Subrahmanyam and Forssberg (1988a) concurred and added that the characteristics of frother usage control the water recovery and, therefore, indirectly control entrainment.

Work done by Szatkowski (1987) with hematite ore found that average bubble size strongly affects the selectivity of the flotation. Other factors include the standard deviation of the bubble size as well as particle size. For these tests, frother concentration was used to control the average bubble size. Frother concentration also influenced froth formation rate. As the froth formation rate was increased, the amount of gangue recovered also increased (Szatkowski, 1987).

Similar testing by Laplante *et al.* (1983) showed that the overall transfer selectivity will be maximum when the rate limiting factor is the transfer from the slurry to the froth. Conversely, overall selectivity will be minimized when the transfer from the froth cell lip is rate limiting.

2.3.4 - Liquid Lamella Thickness Effects

Liquid lamella thickness is the thickness of the water layers that separate individual bubbles in a froth. Their thickness determines the carrying capacity of entrained particles, as well as the stability of the froth. As a lamella thickness approaches the size of the particles attached to the bubbles, the amount of drainage reaches its maximum without causing bubble coalescence. For incomplete drainage, the lamella thickness will be greater than that of the particles held by the bubbles (Flynn and Woodburn, 1987).

As the particles being held by bubbles decrease in size, the corresponding well-drained lamella thickness decreases. Heram (1981) proposed the froth liquid lamella thickness theory to explain low selectivity in separating ultrafine particles. The theory states that the grade of concentrate attainable is related to the water recovered in the froth. The amount of water recovered is determined by the liquid lamella thickness. Using this as a basis, the maximum acceptable lamella thickness required for ultrafine separation is 10 micrometers. This is due to the non-settling nature of ultrafine particles and their ease of entrainment.

Others concurred with the liquid lamella theory that, as the liquid lamella increases, so also does the probability of recovering entrained material (Subrahmanyam and Forssberg, 1988b). The thickness of the liquid lamella was found to be in direct correlation to the amount of frother used in the system. Therefore using excess frother lessens the efficiency of the flotation process (Waksmundzki *et al.*, 1972).

2.3.5 - Froth Depth

Between the flotation rate coefficient and froth depth, there exists a linear relationship that has a negative gradient. Simply put, as froth depth increases, flotation rate decreases. This was documented by Engelbrecht and Woodburn (1975), and Laplante *et al.* (1983). Feteris *et al.*, (1987) both confirmed these results and added that the probability of drainage depends linearly on froth depth.

Deep froths have been found to promote selectivity in flotation due to increased coalescence. The coalescence causes the particles to detach as well as reattach to bubbles below (Finch *et al.*, 1989). Distribution studies within deep froths have led to stressing the importance of both mobility and drainage (Cutting *et al.*, 1981). Gangue entrainment has been linked with shallow froth depth as well as increased gas rate (Kaya *et al.*, 1990).

2.4 - Froth Drainage

Froth drainage is known to be one of the irreversible processes that occur in all froths. This is facilitated by capillary suction created by pressure differentials as well as gravity (Kaya *et al.*, 1990). Szatkowski (1987) described these capillaries as channels between the mineralized bubbles, the length and diameter of which determine the rate that gangue is drained. Effective drainage can only occur from the froth layers close to the froth pulp interface.

Cutting *et al.* (1986) split drainage into two categories: film drainage and column drainage. Film drainage is defined as the drainage of water and solids around the air bubble and is characterized as a slow process that occurs over the entire froth volume. Column drainage is described as an area of rapid descent of material in a single vertical zone, which is started by an accumulation of solids that invert the hydraulic gradient in the froth, is usually limited to about 1 cm^2 in area, and may start at any point in the froth column. Column drainage is often initiated by froth mobility, whereas tranquil conditions encourage steady (film) drainage. Through these studies, it was determined that the drainage rate of water always exceeds that of the solids (Cutting *et al.*, 1982).

The amount of froth drainage is highly dependant upon the froth residence time as shown by Bisshop and White (1976) and Cutting *et al.* (1986). Both agreed that the amount of recovery of material by the froth is governed by the residence time of the froth. The effects of drainage as well as residence time are greater for coarse particles (Bisshop and White, 1976).

High particulate solids in the froth were found to significantly reduce the drainage rate of water from a froth, creating a stabilizing effect (Engel and Smitham, 1987). Wash water has been found to reduce overloading, which can increase drainage without reducing froth stability (Kaya *et al.*, 1990).

Comparing the work of Cutting *et al.* (1986), Moys (1978, 1984), Kuzkin *et al.* (1983), and Subrahmanyam and Forssberg, (1988b), all agreed that, while froth drainage is good, it can lead to instability. Well-drained froths also do not flow well, requiring the use of mechanical means of removal (i.e. paddles). This in turn greatly increases the losses of recovery. Therefore, any removal of well-drained froths should target removal of only the upper layers of froth to minimize any losses.

2.5 - Froth Residence Time

Most agree that froth residence time plays a vital role in froth drainage as well as recovery of mineral. Bisshop and White (1976) labeled it as the single most important factor in drainage from the froth. Others listed it as a controlling factor along with drainage rate in maximizing gangue rejection (Kaya *et al.*, 1990), (Szatkowski, 1987). Only Miller (1969) preferred a short residence time coupled with froth washing as a means of cleaning coal froth.

In general, the froth residence time depends on two factors: froth depth and rate of froth formation (Szatkowski, 1987).

2.6 - Prevention of Entrainment

Several alternate methods of reducing entrainment with wash waterless systems have been made. One such system was a froth vibration system (Kaya, *et al*., 1990). The system induced vibrations into the froth column to stimulate drainage. Although the system did aid in drainage, it did so at the expense of recovery. The system was compared to a wash water system and the benefits were less than that of wash water. The vibratory system did have an additive effect when coupled with the wash water system (Kaya *et al.*, 1990). Other systems tested include rod barriers in the froth phase (Degner and Sabey, 1988), or ultrasonic vibrations to encourage coalescence and slow the froth phase (Kaya and Laplante, 1988).

A second such wash waterless system included adding a baffle grid below the base of the froth. This system aimed at reducing turbulence between the pulp and the froth, reducing the likelihood of entrainment. There were positive results; however, operating difficulties outweighed the benefits (Moys, 1978).

2.7 - Froth Washing

2.7.1 – Overview

Several wash water systems have been tried in the past for both coal and mineral flotation systems. All agree that the wash water should be added as a light rain, and not a jet (Finch *et al.*, 1989), (Kaya *et al.*, 1990).

Kaya *et al.* conducted test work with a wash water system that targeted metallic minerals. In this system, wash water rates were varied. At the lowest rate, recovery of mineral increased over no washing due to better froth stability. At the medium rate, both an added recovery and an increase in product grade were observed. At the highest wash water rate, more entrainment of gangue particles occurred than at the medium rate. The explanation was that at the higher wash water rates, mixing occurred within the froth, and the wash water was not as effective. For all of the tests conducted, wash water rates were only 7 to 12% of the feed water. Wash water was shown to increase bubble coalescence while increasing froth drainage.

Some guidelines for placement of wash water were also given. In general, wash water should be distributed evenly across the entire cell. However, to save water requirements, wash water should be at least added to the cell lip adjacent to the overflow weir (Kaya *et al.*, 1990). Adding it to the cell lip is one of the most crucial places for wash water because the entrainment is most severe at that point (Moys, 1978). Adding wash water above the froth decreases gangue entrainment at higher water recovery, while adding wash water at the froth pulp interface decreases gangue entrainment. Adding wash water above the froth also increases the chance of water short-circuiting to the concentrate. The height of the wash water addition above the froth should be minimized to increase froth stability (Kaya *et al.*, 1990).

Test work showed that adding wash water at rates above 0.4 cm/s was detrimental to the system due to excessive mixing of the upper froth, as well as loss of cleaning. The same phenomenon was observed with lower rates and shallower froths, masking any selectivity increases created by the wash water (Finch *et al.*, 1989)

One system studied employed booster plates and raising the cell weirs to change the froth velocity profile to stabilize the froth. This reduces the froth residence time as well as the distribution; however it allows for incorporation of wash water easily (Koivistoinen *et al*, 1991), (Heiskanen and Kallioinen, 1993). Miller (1969) compared the flotation product created by adding wash water to a single stage with that of the standard rougher-cleaner system and found that the single stage addition of wash water is a viable alternative to roughing and cleaning.

2.7.2 - Size Effects of Froth Washing on Coal Flotation

Froth sprinkling was compared on three size fractions of coal feed by Miller (1969). The coarse fraction (14X48 Mesh) seemed to see little improvement from the froth sprinkling. Only modest gains in product ash and recovery were found. For the mid-size region (48X150 Mesh), both an increase in purity as well as a modest increase in recovery were realized, with the 48X65 Mesh size fraction benefiting the most. For the smallest size class (150X0 Mesh), no benefit in either quality or recovery was found. In fact, the product quality was found to be worse than without froth sprinkling. In each test, the best tests were considerably inferior to that obtained from the washability curves (Miller, 1969).

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Chapter 3

IN-PLANT TESTING

3.1 - Circuit RDT

3.1.1 - Residence time tests:

Residence time studies are an important tool in optimizing a plant's performance. Efficiency of separation depends on the physical differences between what is being separated and how long the separation process has to occur. If the process is optimized to maximize the physical differences between the different particles to be separated, yet does not have sufficient time for the separation to occur, then the separation will be less efficient. If, however, the separation is not utilizing the differences between the minerals to its benefit, yet has ample time, the separation will not be efficient either. Being able to measure the residence time of a process provides important clues as to the areas to maximize the efficiency.

At the beginning of this study on froth washing, the idea of adding wash boxes to more than one plant was discussed, assuming the testing showed that the wash boxes provided a reduction in ash for the product. It was known from previous experience that adding wash water reduced the recovery of coal in flotation cells. It has also been shown that residence times of 3.5 to 4 minutes are necessary for high coal recovery. So before wash boxes were ordered and installed in several plants, a series of residence time studies were conducted to determine which plants were best suited for wash water systems.

For all of the residence time studies conducted for this research, a tracer of potassium chloride salt solution was used. Depending on the volume flow of slurry through the froth cells, 15 to 30 gallons of tracer solution would be used. The solution was made by fully dissolving deicing salt. Care was taken so that no undissolved pieces were left in the solution. While the salt was dissolving, a series of samples would be taken of the tailings. A total dissolved solids (TDS) meter was used to measure the salinity of the tailings. Conductivity meters can also be used; however for the plants being tested, the background conductivity was too high to detect a difference made by the tracer, so total dissolved solids was measured instead. Due to plant fluctuations as well as meter adjustments, the process of determining the baseline concentration of TDS usually took 10 minutes to establish. The length of time was purposefully long so that any shifts due to cycling of plant water could be seen. This would determine the baseline salinity of the tailings. The total tracer concentration would then have the baseline level subtracted from it to determine the increment of added salinity.

The test was timed starting with the addition of tracer to the feed of the froth cells. The tracer was added as rapidly as possible so that a single spike in salinity could be traced. Samples from the tailings were drawn off every thirty seconds, and the TDS was measured in parts per trillion. Values ranged from 0.320 ppt. to 0.700 ppt. Each test was completed when the salinity of the tailing samples stabilized to an approximate value of the base line. The reason this is approximate is because plant chemistry can change depending on how quickly recycled water is returned to the froth cell feed. Baseline drifts of as high as 0.021 ppt. have been observed.

For this work all residence times mentioned are the entire bank's mean residence time.

3.1.2 – Plant 1

During the initial circuit audit at Plant 1, two residence time tests were completed to help determine the potential that the froth cells had for adding a wash water system. Because the system had originally been designed to handle all of the minus 100 mesh coal, but later had the minus 325 fraction removed from the feed, it was believed that there was ample residence time. Hence the reason for starting the work at Plant 1. The first test was on the froth cell system with no wash water added to any of the cells. This test showed an ample mean residence time of 8.7 minutes. The second test was conducted with the wash water added to the last three cells (cells 3-5). This test showed a residence time of 7.4 minutes.

After the wash boxes were added to the primary cells, a third test was completed to see what the effect of having wash water on all of the cells (1-5). This test showed a mean residence time of 6.3 minutes. Although this test showed a considerable loss of residence time due to the wash water addition, there was still ample residence time for the coal to be recovered. Figure 3.1 shows the normalized distributions of the three tests at Plant 1. A normalized distribution curve was used when comparing the three curves because differences in baseline concentrations as well as total concentration are present when comparing the raw data.

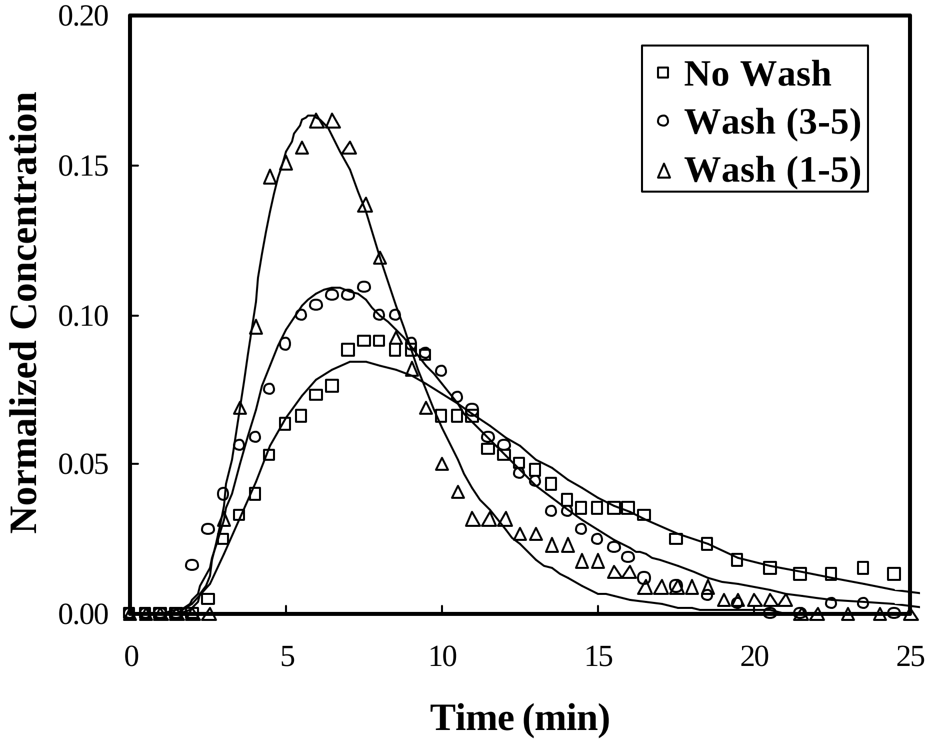


Figure 3.1 – Residence time distributions obtained with and without froth washing.

3.1.3 - Plant 2

Plant 2 was the second plant that was considered for wash water systems. Two tests were performed on the existing froth cells at Plant 2. For both of these tests, no wash water systems had been added to the cells. The first test was conducted with bank 1 having a mean residence time of 2.5 minutes, and bank 2 having a mean residence time of 3 minutes, which Figure 3.2 illustrates. Because the froth cell circuit at Plant 2 has the ability to vary the percent solids of the feed by adding or removing dilution water, a second set of tests were conducted at Plant 2. The goal of this second test set was to see if by removing all dilution water from the cells, there might be enough residence time to warrant adding wash boxes to the cells. Then the wash water could act as the dilution water for the cells. For the second series of tests, bank 1 had a mean residence time of 4.3 minutes while bank 2 had a mean residence time of only 2.5 minutes, shown in Figure 3.3. Although the residence time measured in bank 1 increased by over a minute, the residence time to bank 2 was decreased by half a minute. This suggests that the distribution to both froth cells is uneven as well as sporadic. Besides the uneven feed problems, the lack of ample residence time in the froth cells suggests that adding wash water would have detrimental effects on the recovery of coal in that circuit.

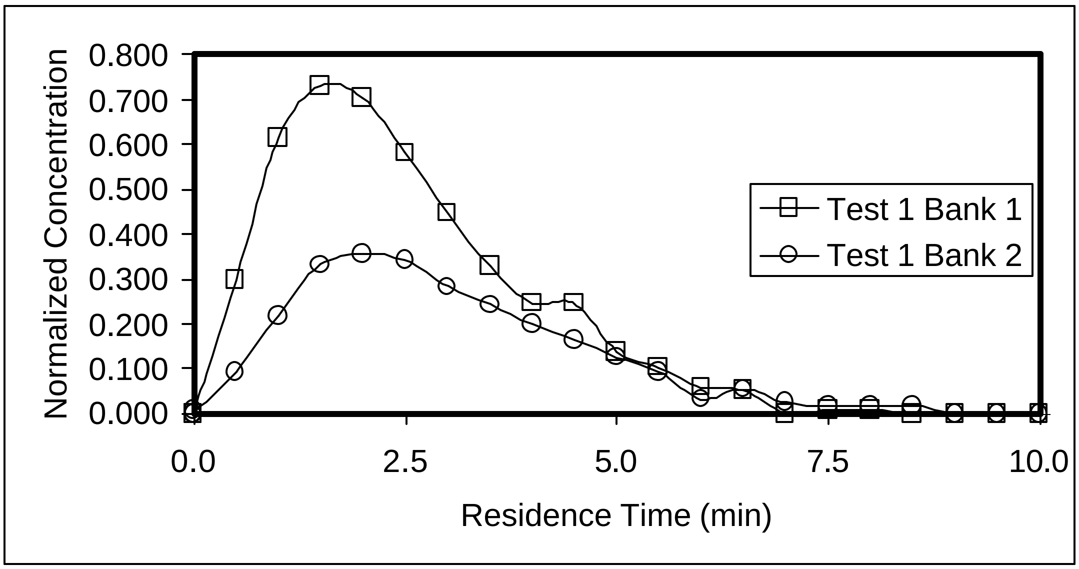


Figure 3.2 - Residence time distributions for Plant 2 Test 1.

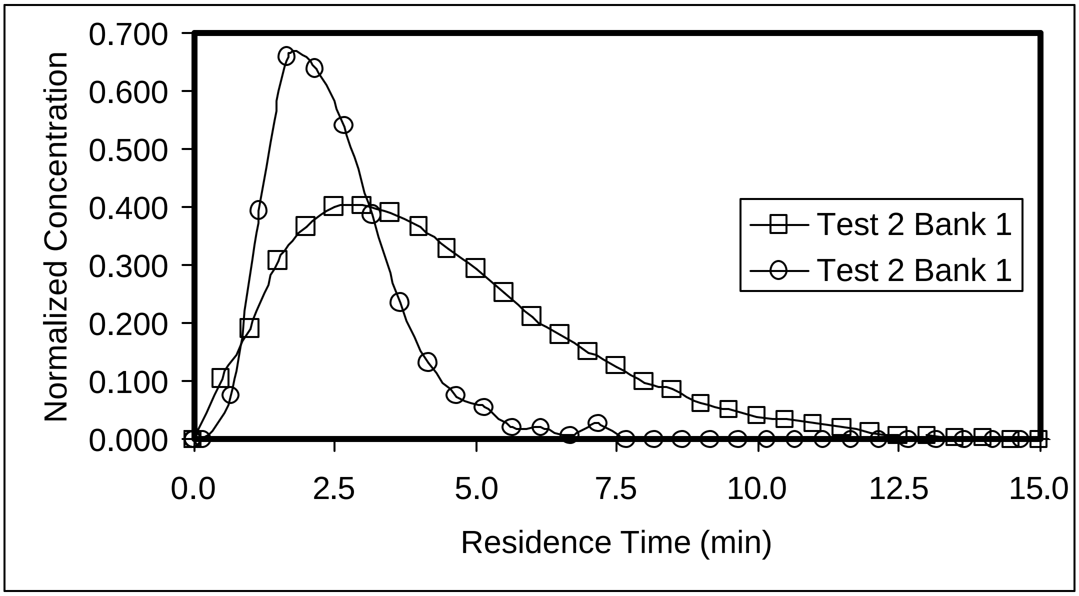


Figure 3.3 - Residence time distribution for Plant 2 Test 2.

3.1.4 - Plant 3

A third plant for which wash water systems were considered was Plant 3. The froth cell system consisted of one bank of five 500-cubic-foot cells. The purpose for this test was to see if the cells had enough residence time to warrant adding a wash water system. Two tests were conducted on two different feed rates of the same coal, their residence times are plotted in Figure 3.4. The first test was conducted with the plant feed rate at 570 tph and the froth cell residence time was 3.6 minutes. The second test was conducted a few hours later at a feed rate of 750 tph. The second test showed a mean residence time of 5.2 minutes. The difference seen between the two tests could be partly explained by differences in how quickly the salt tracer was added to the cells; however, this does not account for more than a few tenths of a minute difference.

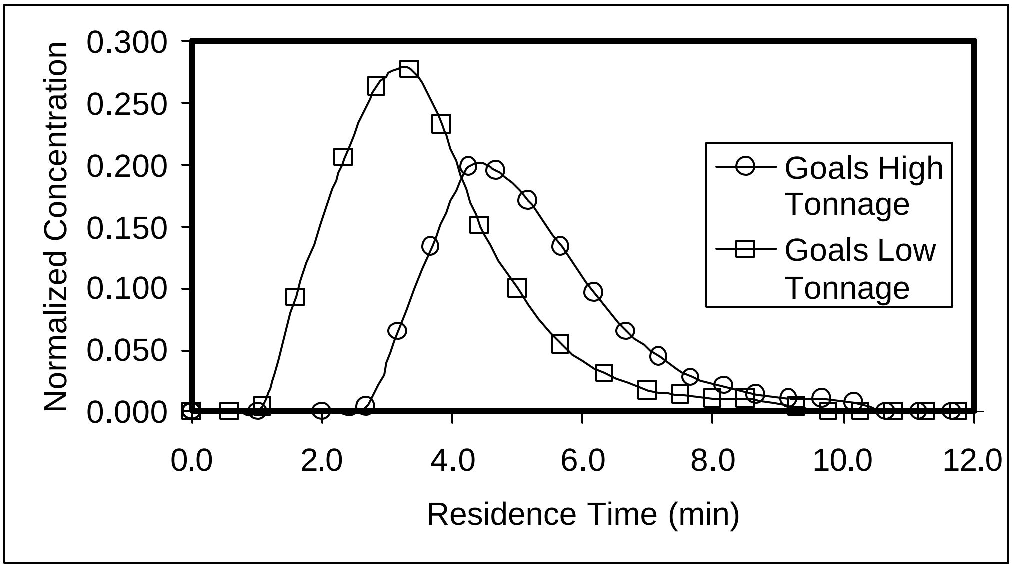


Figure 3.4 - Residence time distributions obtained at two tonnages.

3.1.4.1 Observations:

One of the interesting findings from these residence time studies is that low tonnage to a plant does not necessarily mean longer residence time for the froth cells. For the Plant 3, running at a lower feed rate lowered the residence time in the froth cell. The major contributing factor to residence time changes would be the flow rate of water coming into the froth cells. The feed is dry coming into the plant. The amount of water available for the plant is fixed and dictated by the system's carrying capacity. If the amount of coal coming into the plant is reduced, but the water addition stays the same, then the water to coal ratio will increase. This would increase the water going to the fine coal circuit, and possibly reduce the residence time of the froth cells.

Another observation is that different coals entering a plant will have different residence times, even though the entire plant feed is remaining the same. This is probably due to different mass splits of coals through the plants.

Adding wash water reduces the amount of residence time in the cells because wash water increases the flow rate through the cells. (Note: if the wash water is not being effective in washing the water out of the cells, and the water is just being carried over with the froth, then the effect of wash water on residence time will be minimal.)

Wash water when added correctly adds a net volume flow into the bank of cells. Normal froth cells have a net volume flow out of the froth cells, created by the removal of froth from the cell. By adding water to the cells, the total throughput is increased. This decreases the amount of time available for a piece of coal to report to the froth. If the froth washing is not very effective, and the added wash water is being carried over with the froth, then the residence time that the cells have would not be reduced as much. This might eventually become a way of measuring the effectiveness of froth washing. If the total volume flow of feed, froth, wash water, and cell volume is known, then a theoretical residence time can be calculated. If the residence time is longer than the estimated residence time, then it may be an indication that the froth washing did not have a net downward flow.

3.2 - Circuit Audit

3.2.1 - Overview

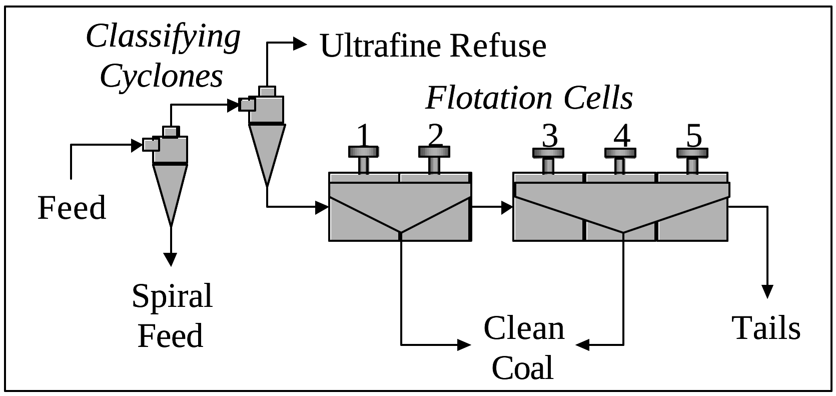


Figure 3.5 - Simplified flotation circuit flowsheet.

Figure 3.5 shows the layout of the industrial flotation circuit evaluated in the test program. The flotation circuit consists of five 1000 ft^3 Wemco cells arranged in series as primary (two cells) and secondary (three cells) banks. The flotation bank was originally designed to process minus 100-mesh feed from a single bank of classifying cyclones. The classifying circuit was later reconfigured with a second stage of classifying cyclones that was designed to operate at a nominal cut size of 325 mesh. The additional stage of classification improved the performance of the flotation circuit by removing a large portion of the fine clay slimes from the flotation feed. This configuration also reduced the total volumetric flow of slurry that entered the flotation circuit. As a result, the flotation bank has excess volumetric capacity that is currently not being utilized.

The plant operators had started to implement a wash water system but had not determined the best way of running the system. The testing that they had conducted showed low ash concentrate reporting from the first cell and increasing ash down the bank. With this information, the plant installed a wash water system on the last three cells. The plant hoped that by attacking the higher ash contributors, the greatest reduction in ash could be realized. The goal of this test work was to first determine the circuits' capability, identify any opportunities for improvement, and implement the most effective wash water system.

The water for the wash water system was gravity-fed from the clarified makeup water head tank on the floor above which provides 8 ft of head to the system. The first two series of tests (1 & 2) were completed using the wash water system on the last three cells that the plant operators had designed. All subsequent tests utilized a set of wash boxes on the primary cells as well. The piping for the final system was split into two sections with the primary cells being fed first, and the remainder of the cells fed next. The piping branched to provide water for the wash boxes on both sides of the cells. The individual wash boxes were open on the top, and the water would flow from the pipe into the box (Figure 3.6).

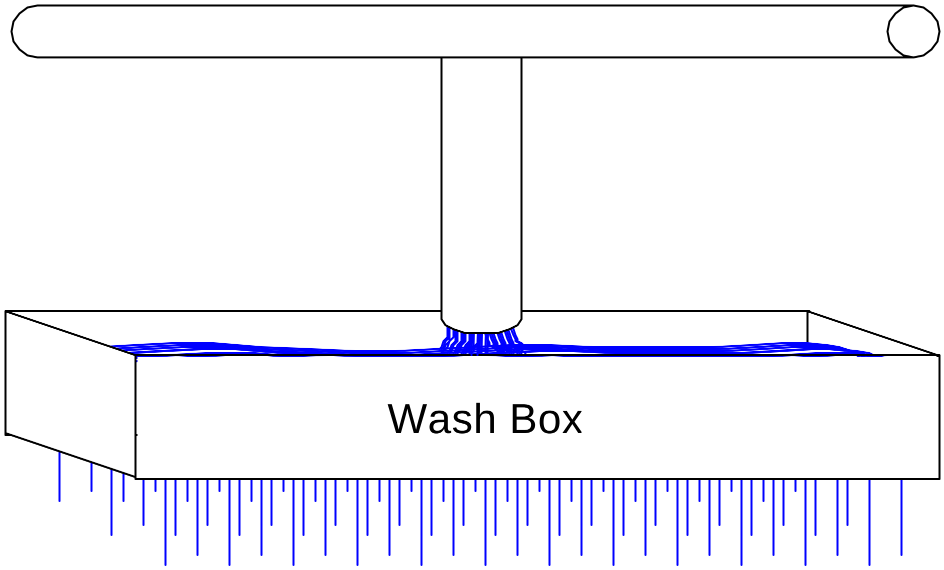
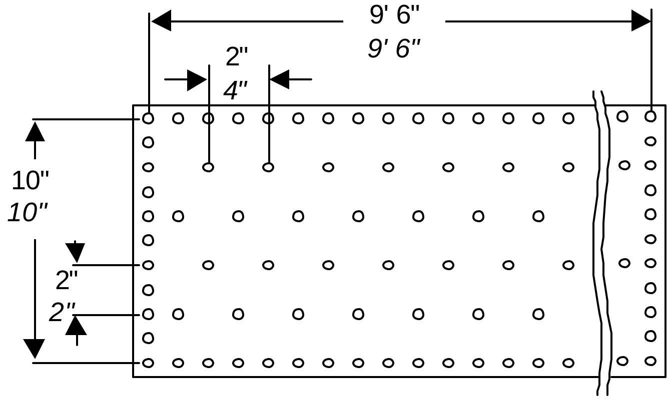


Figure 3.6 – Wash box.

The wash boxes were constructed of 3/4-inch thick plastic sheet, connected by mechanical fasteners and sealed with silicone. The wash boxes were rectangular (1 ft wide x 1 ft deep x 10 ft long), and were drilled with ¼ inch holes. Each wash box throughout the testing held between 3 and 6 inches of water, depending on the demands of the plant for the clarified water. The holes were drilled in an offset pattern so as to provide even distribution. The hole spacing was as shown in the Figure 3.7.



Primary cell wash box drill pattern 302 holes
Secondary cell wash box drill pattern 150 holes

Figure 3.7 – Wash box hole pattern.

These wash boxes covered most of the length of the cell lip and provided a steady "rain" of clarified water to the cells. The wash boxes on the secondary cells provided approximately 1.5 gpm/ft^2. Later, wash boxes were added to the primary cells and were drilled on a tighter spacing to provide double the wash water. The wash water system was limited to 1050 gpm mainly due to piping flow constraints, but also because of other plant needs. (Note: Any attempts to increase this flow would require either a pump added to the existing piping, or larger diameter pipe.)

The wash boxes were located on racks just behind the froth overflow lip of each cell. This arrangement allowed the froth to be rinsed just before discharge from the cell (Figures 3.8 and 3.9).

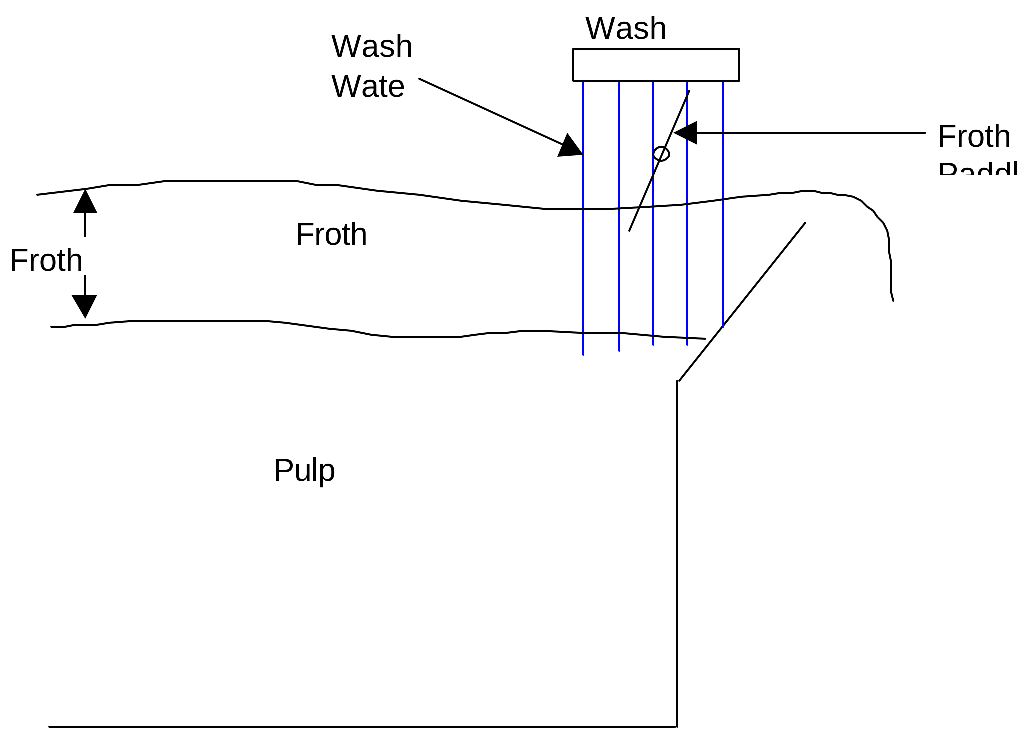


Figure 3.8 – Wash box placement over froth cells.

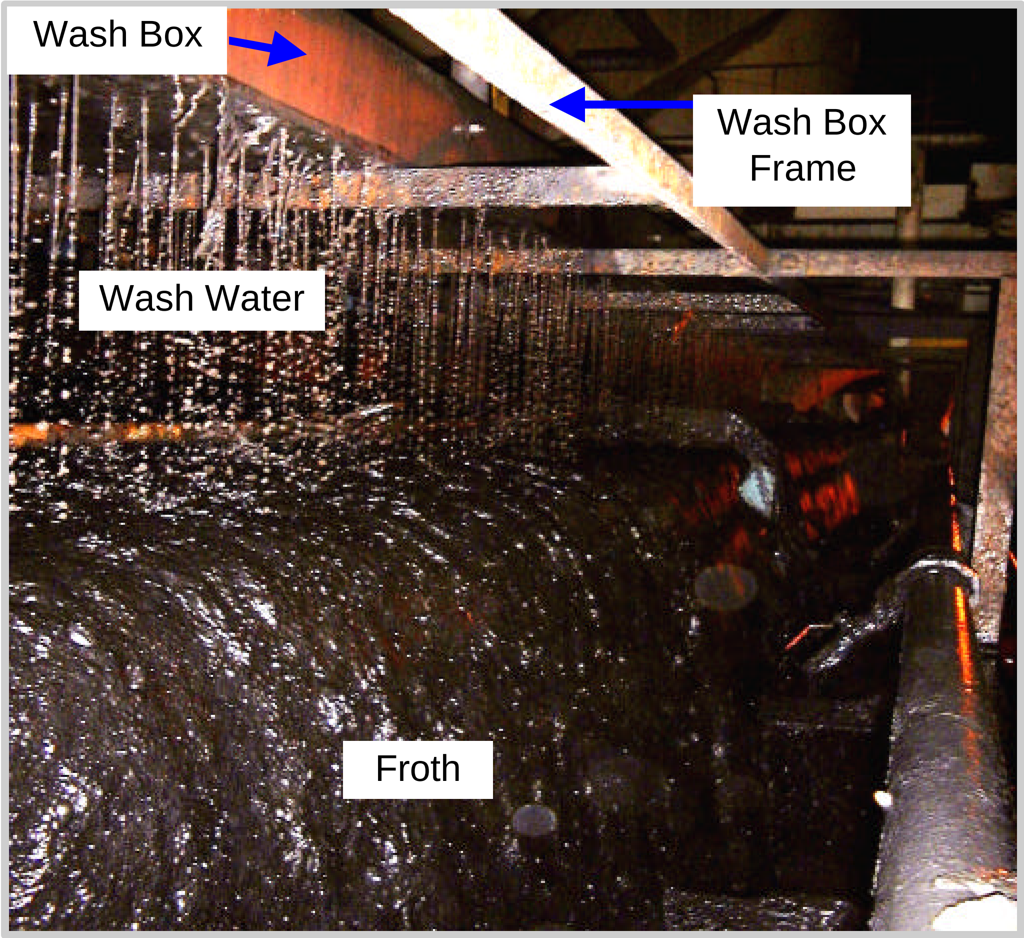


Figure 3.9 - Wash boxes over primary cells (paddles taken off).

3.2.2 - Experimental

Test samples were collected from each of the three primary streams around the flotation bank, i.e., feed, clean coal and tails. These composite samples were collected using an automatic sampling system located downstream from the flotation bank. In addition, a manual sample cutter was fabricated so that timed samples of the froth concentrate could be collected from the launders of each of the five flotation cells. The froth samples were taken from both sides of the flotation cell and combined to create a composite sample for each cell. This technique made it possible to directly measure the mass flow of clean coal produced by each cell. All experimental values were evaluated using a mass balance program and mathematically adjusted to obtain an internally consistent set of data. Flow rates or assay values that required substantial adjustment were deemed unreliable and were eliminated from the data set.

3.2.2.1 – FLOW

A PVC sample container was constructed with an opening of 5 inches that could be placed in such a way so as to catch an entire segment of the stream. Knowing that the entire length of one cell was 120 inches, an approximate flow rate for each side could be calculated. Edge effects were minimal in part due to the long length of the cell, and partly because the paddles pushed the froth. The samples were taken at multiple points along the edge of the cell. A minimum of 5 seconds was used for all samples to accurately calculate a flow rate. The paddles had a cycle time of 5 seconds and were used as a gauge of time for sample collection. Typical sample times and mass flow were as follows (Table 3.1).

Table 3.1 - Median flow rate by cell.

	Median Values	
Cell	Number of Paddles Rotations	Wet Sample Weight (g)
1	2	9410
2	2	7925
3	4	6400
4	4.2	4060
5	6.25	2725

When the froth was heavily loaded with coal, the sample easily flowed into the sample collector, such as with the first three cells. If, however, the froth was not heavily loaded, the froth bubbles were much larger and would not flow down into the sampler easily. This effect was compounded when no wash water was used. Often, filling the sample container multiple times was needed in order to collect a representative sample.

3.2.2.2 - Sample Collection

The method for collecting samples during a test was as follows: first, all of the buckets with the appropriate labels were set beside each cell. Then the sampler was used to collect the first timed sample on the first cell. This sample was collected and poured into the bucket. The sampler was quickly rinsed out and moved to the next cell. The second cell's sample was taken and placed into its designated bucket. This was repeated down one side of the bank of cells. Then the buckets were quickly moved to the other side of the cells. There the same procedure was used to collect the samples. The same number of paddle turns per sample were kept constant for each side, to reduce biasing one side or the other. Sample collection time took about seven minutes per side with about one minute delay in the middle for switching buckets, giving the total sample collection time at 15 minutes, or about 2 times the residence time. By going down the bank at the equivalent rate of one residence time, the samples from each cell represented the same segment of feed as it traveled down the bank, reducing the effects of feed variations.

During the sample collection from the individual cells, composite samples were taken of the feed, the product, and the tails from the entire bank of cells. These samples were collected from the automatic sampler on the floor below. The sampling rate was set at three sample cuts per minute.

3.3.2.3 - Chemical Dosages

All of the chemical dosages were measured at the end of the last test. This was so as not to interrupt the flow of frother and diesel to the cells while sampling was being done. Diesel was added at the classifying cyclone overflow on the floor above. This allowed more mixing time with the coal. The frother was added to the feed tank next to the first cell.

3.3.2.4 - General Observations

A useful aid in determining the effectiveness of wash water is the hand drain test (Davis, 1999). This test is a quick way of determining what the froth water is carying. The first step is to collect a handful of froth entering a product launder. The water portion of the froth is allowed to drain out of the first hand into the second, cupped below. This water is examined in good light. If the water has a lot of clays in it, then the wash water is not being effective. If the water has almost no clays in it, then the wash water is being effective at removing clay from the product.

This method was used throughout the testing process to make a visual assessment of the wash water effectiveness. Some tests seemed to have less clay than others, but none of them seemed to remove all of the clays. Some tests the product contained a lot of water, while others seemed to have less water. Each test seemed to have a similar amount of clays left behind. One other observation is that the clays seemed to be coagulated. This may be a function of the fact that the wash water is from the thickener overflow, and probably still had coagulant and flocculent in it.

3.2.3 - Results

3.2.3.1 - Initial Tests (1-A, B)

As part of the initial circuit audit conducted, two tests (1-A, 1-B) were conducted on the system to establish a baseline of where the plant was performing. Test series 1 used Powellton coal seam as the plant feed. This set of tests was a comparison of the circuit's performance with and without wash water on the last three cells. The entire circuit was tested rather than only the cells with wash water. This allowed us to determine the total impact of the wash water. The objective of this test was to determine (1) if the wash water was effective (2) where the ash was coming from, and (3) how the system could be improved. It was decided to conduct size by size analysis of all of the streams to pinpoint the major contributors of ash. Also, a residence time test was conducted with no wash water as well as with wash water added to the last three cells.

Some observations of test series 1. The first observation was that visually most of the coal was being floated in the first two cells, and the last two cells had hardly any coal recovery. The second observation was that the wash water was being added above the paddles. This meant that during part of a cycle of the paddles the water was being deflected and a section of froth was not being washed very well (Figure 3.10). Bubble size also was much smaller where the water was being added. This raised some questions as to the method that the wash water was being added. Was the wash water being added in a less than ideal way? Was the height of the rain boxes too high, so that it caused the bubbles to be broken readily? Should the flotation cells be run with no paddles? Should water be added to the first two cells as well? Was there too much coal being recovered in the first two cells, and if so how should the coal be pushed down the bank of cells without losing recovery?

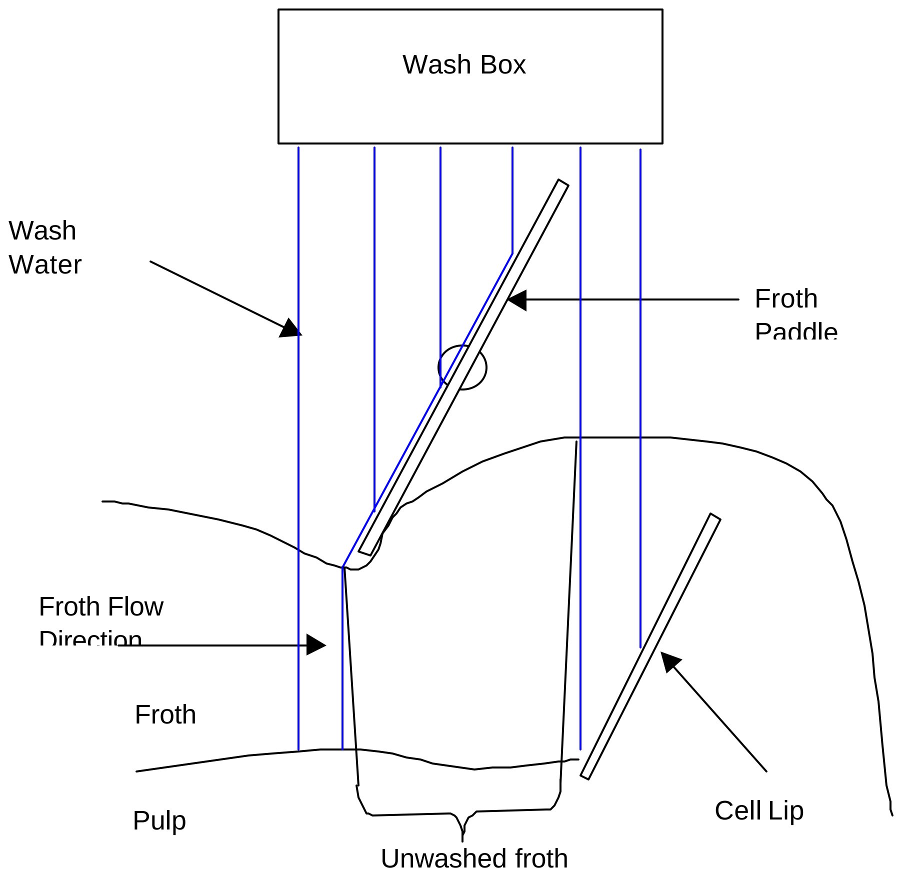


Figure 3.10 - Paddle deflected wash water.

For series 1, the froth cell bank was sampled as part of the initial circuit audit. The overall concentrate ash for test 1-A was found to be 10.48%, with a combustible recovery of 97.4%. This test showed that over 93% of the coal was being recovered in the first two cells.

With wash water (test 1-B) the product ash was 10.45% with a combustible recovery of 95.8%. Because the wash water was being added only to the last three cells where only 6 percent of the coal was being recovered, the effectiveness of the wash water was negligible. Using this information, it was recommended that wash water be added to the first cells. It was also recommended that the wash boxes added to the first two cells be made with double the hole density because of the amount of coal being recovered in these first two cells. This would double the wash water provided to the first two cells. The reduction of ash from a 10.48% to a 10.45% is statistically no reduction in ash. The recovery was reduced by the wash water, by reducing the ability of the last three cells to recover high ash as well as larger coal particles.

Looking at the distribution of the coal, Table 3.2, one can see that the wash water had little impact on the performance of the system.

Table 3.2 - Product mass by cell.

	% of Product Mass	
	No Wash	With Wash
Cell 1	57.1	55.2
Cell 2	36.7	36.9
Cell 3	4.5	5.8
Cell 4	1.2	1.6
Cell 5	0.6	0.5

The mass percentage as well as the percent ash for each size is shown in Tables 3.3, 3.4, and 3.5. For both tests the feed remained relatively constant, which is to be expected because the time between tests was less than an hour. The concentrate analysis with wash water is very similar to the concentrate without wash water. This can be explained by the fact that only six percent of the concentrate was being washed.

Table 3.3 - Size by size ash and mass percentages for feed tests 1-A, B.

Feed size analysis	Mean particle size	Without wash-water		With wash-water	
Mesh	Microns	Weight %	Ash %	Weight %	Ash %
Plus 48 M	351	2.27	5.72	2.76	10.35
48 x 65 M	248	6.82	4.63	6.44	5.58
65 x 100 M	175	11.33	5.05	11.07	5.17
100 x 325 M	81	37.95	14.10	35.70	15.20
Minus 325 M	41	41.63	55.64	44.03	53.22

Table 3.4 - Size by size ash and mass percentages for concentrate tests 1-A, B.

Concentrate size analysis	Mean particle size	Without wash-water		With wash-water	
Mesh	Microns	Weight %	Ash %	Weight %	Ash %
Plus 48 M	351	2.82	3.04	3.16	2.87
48 x 65 M	248	8.80	3.82	8.38	3.66
65 x 100 M	175	14.60	4.09	14.68	4.14
100 x 325 M	81	45.09	6.37	43.23	6.69
Minus 325 M	41	28.70	22.94	30.55	21.45

Table 3.5 - Size by size ash and mass percentages for tailings tests 1-A, B.

Tailings size analysis	Mean particle size	Without wash-water		With wash-water	
Mesh	Microns	Weight %	Ash %	Weight %	Ash %
Plus 48 M	351	0.46	59.10	1.60	53.04
48 x 65 M	248	0.33	75.08	0.80	63.86
65 x 100 M	175	0.58	84.60	0.59	78.40
100 x 325 M	81	14.52	92.96	13.87	92.04
Minus 325 M	41	84.11	92.30	83.14	88.73

The tailings analysis shows a slight difference as seen in Figure 3.11. Notice that all of the size ranges other than 100 x 325 are slightly lower in ash for the test with the wash water. Because these are tailings, a lower ash indicates lower recovery in that size range. What this is saying is that wash water has a greater effect on the recovery of all size ranges other than 100 x 325, Table 3.6.

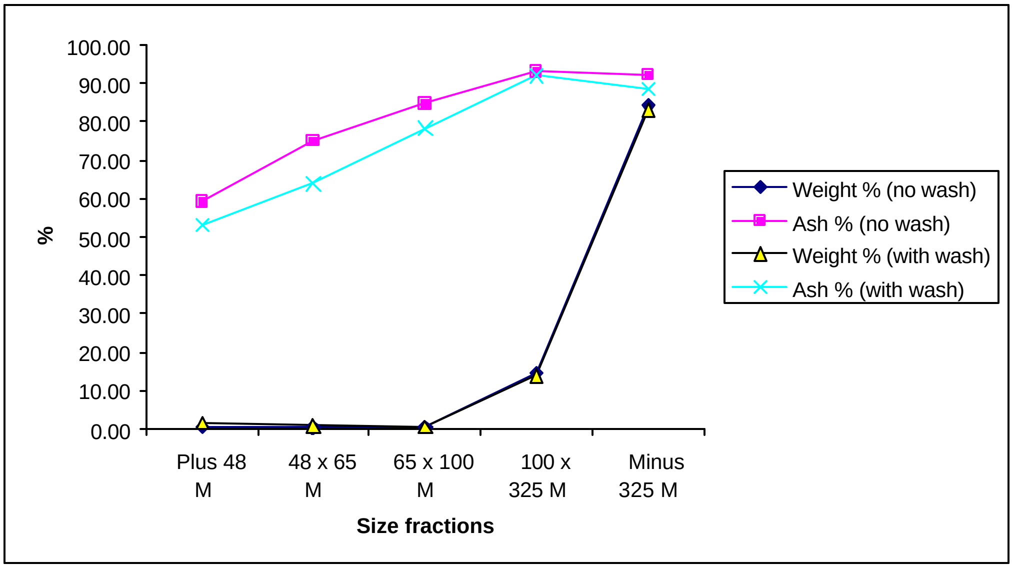


Figure 3.11 - Comparison of tailings size and ash for tests 1-A, B.

Table 3.6 - Combustible recovery by size.

Mesh	Microns	Combustible Recovery No Wash	Combustible Recovery Wash	Difference
Plus 48 M	351	97.93	92.19	5.74
48 x 65 M	248	99.70	98.78	0.93
65 x 100 M	175	99.81	99.69	0.12
100 x 325 M	81	99.27	99.06	0.21
Minus 325 M	41	91.82	88.62	3.20

When comparing the effects of each size class on the total ash of the cell's concentrate, it is easy to see that the smaller size classes especially the minus 325 contributes most of the ash. Figure 3.12 compares each of the last three cells performance by size. The biggest difference can be seen in the performance of cell 5.

This is due in part to the wash water on that cell, but it is also due to the cumulative effect of all of the cells with wash water. In the last cell the difference in ash in the minus 325 fraction is over 30 percent. In comparison the difference in ash on the minus 325 ash for the fourth cell is 27 % and for the third cell there is no difference.

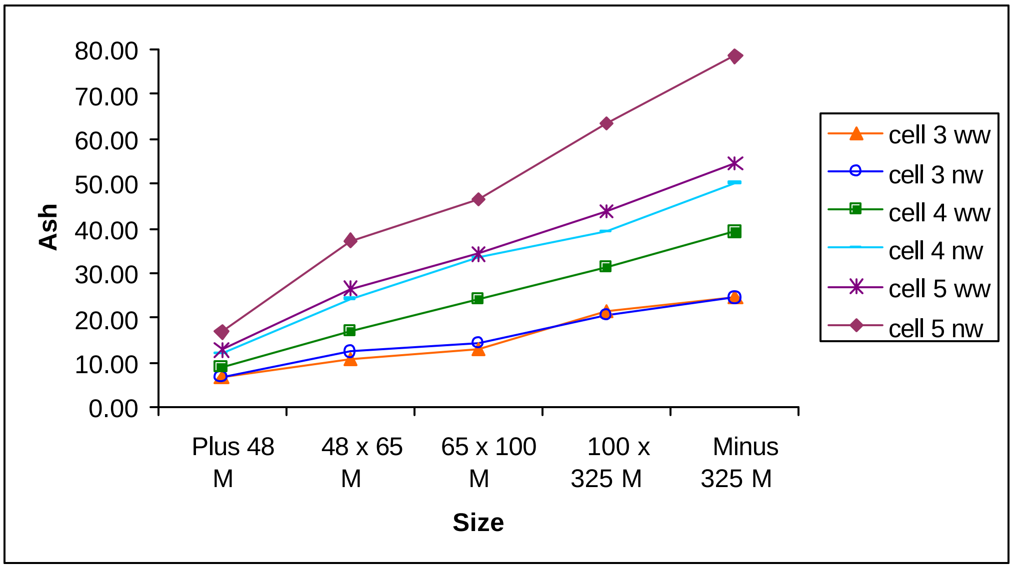


Figure 3.12 - Size by Ash plot for tests 1-A, B.

The purpose of the size analysis was to confirm that the ash was coming from the high ash clay component and that the wash water was washing out the clay component (in the minus 325 fraction). A secondary purpose was to see what size fractions the wash water had an adverse affect on.

3.2.3.2 - Staged Frother Addition (Test 2-A, B)

In the initial tests, the effectiveness of the wash water was limited by the amount of froth product it washed. So a second test to was used to see the results of distributing the recovery of the bank to the cells with the wash water (cells 3-5). The plant was very interested in this test to see how the wash water would work before spending more money on the primary cells. The two tests that were performed compared the cells with wash water on the last three cells, to no wash water on any of the cells. These two tests were conducted with a mixture of 80% Eagle and 20% Powellton coal seams feeding the plant.

There were several methods to choose from to redistribute the froth recovery. Weir bars, staged frother addition, reducing air consumption in the primary cells as well as lowering pulp level in the primaries were discussed. Because the primary cells already had the air intake openings only ¼ open, the plant operators were hesitant to reduce the air much more. They were afraid that lowering the intake of air would end up collapsing the froth and not allow the first two cells to recover enough coal. Lowering pulp level was not chosen because of concerns that the combustible recovery would not be as good. Adding weir bars were chosen, because this maintains pulp level (which keeps the same cell volume and therefore residence time, see Figure 3.13), but it also increases the froth depth, which increases froth drain back into the pulp. Six inches of weir bars were added to the primary froth cells. Note adding six inches of weir bars does not increase the froth depth by six inches due to the angle that the weir bars are added at. After the weir bars were added and the system was allowed to stabilize, it was decided to also use a staged frother addition in conjunction with the weir bars. Although the weir bars had moved some of the recovery down the bank, most of the coal was still being recovered in the first two cells.

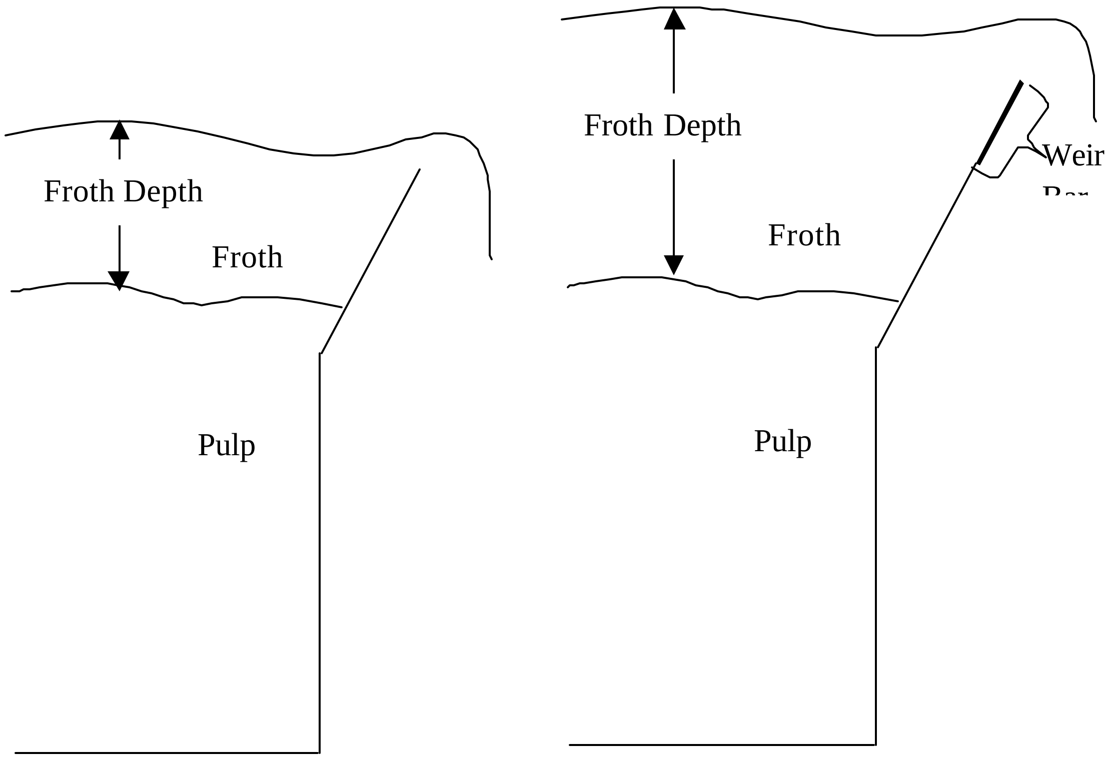


Figure 3.13 - Illustration of the effects of weir bars.

The frother amount being added to the feed was reduced until visually enough froth was being washed in the secondary cells. Then frother was added to the secondary cells until there was no visual loss of recovery in the tailings, Table 3.7 shows the frother addition amounts.

Table 3.7 - Frother addition rates.

Frother addition (ml/minute)	3/10/00	3/29/00
Primary cells	260	170
Secondary cells	0	120

For the unwashed product (test 2-A), a combustible recovery of 95.1 was achieved with a product ash of 9.14 %. When wash water was added (test 2-B) with the same system settings, the product ash was reduced to 8.08, for only a 0.5 percentage point drop in recovery.

The effect of wash water can be seen on the recovery of coal in Table 3.8. Wash water was added to cells three four and five. In cell three, the amount of coal recovered was reduced from 20% to 12%, similarly cell 4 had a slight decrease in coal recovery, and cell five's percent of product mass recovered was increased. This shows that as wash water is added, less coal is recovered in that cell. The benefit of shifting the coal recovery to the cells with wash water is that the tons of water recovered vs. the tons of water used to wash the coal becomes more evenly balanced. With the recovery of product shifted to be more evenly distributed by staged frother addition the effect of the wash water was increased compared to the previous tests. The product ash was reduced from 9.14% to 8.08%, a reduction of 11.6%.

Table 3.8 - Product mass split by cell with and without wash water.

	% of Product Mass	
	No Wash	With Wash
Cell 1	27.4	27.6
Cell 2	29.7	34.2
Cell 3	20.2	12.9
Cell 4	18.3	15.7
Cell 5	4.4	9.7

The effect of adding the wash water was increased over test 1 series. The reduction of ash was greater for the overall product not just the cells where the froth was being washed. With the results of this test it was decided to have wash boxes built for the two primary cells. The primary cells would differ in that they would have double the amount of holes as the secondary boxes from 150 to 302 holes. The hole spacing was reduced in hopes that the wash water would be more evenly distributed giving a greater washing effect.

3.2.3.3 - Wash Water on All Cells (Test 3-A, B)

Two tests were conducted with Tunnel Eagle feeding the plant, comparing the froth system with (3-B) and without (3-A) wash water on all of the cells. This was the first test where wash water was added on all of the cells using the new wash boxes on the primary cells. Frother was added in stages as well. The purpose of this test was to see if adding wash water to the primary cells would indeed have the reduction in ash that the plant was looking for. The froth being recovered was unusually wet in appearance in comparison to other tests to that point. The overall effect of adding wash water to all of the cells should have been greater for this test than all of the previous tests. The reduction in ash was far from dramatic: it was as if other factors reduced the ash of the product more than the wash water. The goal for this test was an ash reduction of greater than one percentage point between with wash water and without. For the previous test (test 2) the difference in ash was almost 1 percent. For this test (3) it was about ½ of a percent difference, shown in Table 3.9. Water recovery was a greater issue in this test.

Table 3.9 - Wash water performance for test 3-A, B.

	Concentrate ash	Combustible Recovery
	%	%
With wash	8.56	97.64
No wash	8.98	97.07
Ash reduction (%)	4.7	

3.2.3.3.2 Small Test (Test 3-C)

A small test was used to check the overall effects of reducing the air that the primary cells used and reducing the amount of frother used in the secondary cells. This was a single test, intended to be compared to the test with wash water. The test was in response to a question that the plant had about the increased frother needed to run the cells, because of the staged frother addition. Could less frother be used in the circuit without the performance of the circuit being compromised? The goal was to recover less coal in the primaries thus pushing more coal, and frother, to the secondary circuit. To accomplish this the air was reduced from ¼ to 1/8 of the intake area on the primary circuit. The frother that was added to the secondary circuit was also reduced from 210ml/min to 170 ml/min in the secondary circuit. The frother added to the primary circuit was kept at 206 ml/min. This reduced the amount of coal recovered in the first two cells by a fair amount (visually). Because this was a last minute test, only grab samples were taken of the feed the concentrate and the tailings as well as grab samples for the first two cell concentrates. Although the overall concentrate was less desirable, the recovery was maintained with less frother addition; see Table 3.10 for comparisons. No flow rates or assays were measured for the secondary circuit; therefore it can only be inferred from the data that the performance of the last three cells dropped dramatically. Because the recovery was maintained, the coal previously recovered in the first two cells was shifted to the last three. The amount of coal recovered was probably greater than the wash water could remove, and so the overall clay recovery increased, increasing the product ash.

Table 3.10 - Comparison of test 3-A, B, and C

Test	No Wash	With Wash	Small Test With Wash
Combustible Recovery	97.6	97.1	97.0
Feed (% Ash)	21.79	21.54	22.61
Concentrate (% Ash)	8.98	8.56	9.12
Tails (% Ash)	88.54	86.26	86.50
Cell 1 (% Ash)	7.35	7.27	6.26
Cell 2 (% Ash)	9.58	8.84	6.78

Some benefits from moving the coal down the bank in this manner is that a substantial frother savings can be achieved by pushing the coal down the bank and allowing the frother already in the system to work in other cells.

3.2.3.4 – Comparison Testing with Eagle Coal Seam (Test 4-A, B, C, D, E)

Three tests (4-B, C, & D) were performed with wash water added on all of the cells and frother added in stages. Weir bars were added to the first two cells to help maintain a high froth depth. These weir bars were kept the same for all three tests. Two more tests (4-A & E) were conducted at a later date with the same coal seam, to compare normal pulp level without wash (test 4-A) as well as lower pulp level with wash (test 4-E). A detailed list of the test follows, with Eagle Coal feeding the plant for all tests.

- Test 4-A Primary cell paddles were removed and no wash water was added.
- Test 4-B Primary cell paddles were left on.
- Test 4-C Primary cell paddles were removed.
- Test 4-D Primary cell paddles were removed and froth level was increased on all cells by lowering pulp level in the cells.

- Test 4-E Primary cell paddles were removed and froth level was increased to a high level by lowering the pulp level in the cells.

The purpose of the first three tests was first to assess the impact of removing the paddles on the froth washing. The second purpose was to evaluate how much could be gained by better matching the froth flow to wash water flow and how that would impact coal recovery. Because the goal of reaching a net bias flow of water into the cell was not met, tests 4-A and 4-E were added at a later date to be compared with these tests.

The total test time for the initial tests took about 3 hours from the time the first test was taken until the last test was finished. This was longer than most tests because the paddles had to be removed from the primary cells. (Most of the delay was in taking the paddles off, which took a little over an hour.) Sample time also increased for tests 4-C, and 4-D because flow rate measurements could not be taken using the turn of the paddles for a reference. The flow rate measurements instead had to be timed, which slowed down the sample taking process.

For these three tests there was very little difference between the recovery and the concentrate ash of the test with and without the paddles, Table 3.11. Changing the pulp level created the biggest difference between the tests. For tests 4-A, 4-B and 4-C the froth depth on the primary cells was kept at 14 inches, and the secondary cells at 12 inches. The froth depth was increased to 18 and 22 inches for the primary cells and 16 and 18 inches on the secondary circuit for the low level (4-D) and very low level (4-E) tests respectively.

Table 3.11 - Comparison of test conditions for series 4 tests.

	B	C	D	E	A
Test	With Paddles	No Paddles	Low Pulp Level	Very Low Level	No wash
Combustible Recovery	95.3	95.8	93.1	93.1	96.1
Feed (% Ash)	32.45	30.44	31.44	30.23	31.88
Concentrate (% Ash)	9.23	9.32	8.53	8.30	9.95
Tails (% Ash)	89.02	89.03	84.42	83.43	90.32

3.3 - Discussion

3.3.1 - Water Ash Relationships

For tests 1-A and 1-B, Figure 3.14 shows the overall water ash plots for the two tests. In this plot the tons per hour of ash reporting to concentrate are plotted against the tons per hour of water reporting to concentrate. In an ideal situation the tons of ash reporting to concentrate should only increase as the higher ash coal is recovered. This would produce the shallowest slope. However as water is recovered in a conventional flotation cell entrained particles of ash report to concentrate, this increases the amount of ash that is collected which raises the slope. Notice the negligible difference between the two tests. However if the points of the last three cells are compared to that of the last three cells in the test with no wash water (1-A) the effect of the wash water (1-B) can be seen.

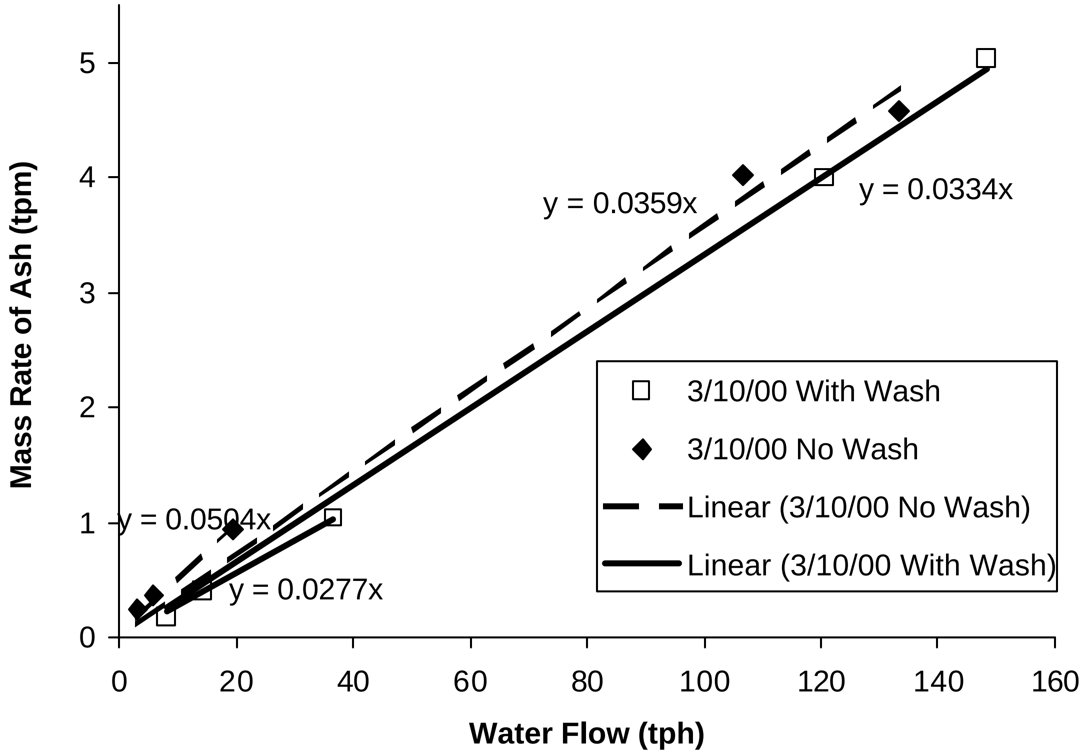


Figure 3.14 - Water ash plot for test series 1, Powellton coal.

Looking at the effectiveness of the wash water for test series 2 can also be seen in the water ash plot, Figure 3.15. Similar to the previous test, the water ash relationship for cells one and two fall in line with those that had no wash water. The last three cells which did have wash water are clearly operating on a different level. The slope for these last three cells are 0.0229, which is far less than the overall from the test without wash water 0.0338. This slope is even lower than that of the last three cells for the previous test with wash water 1-A, 0.0277. The reason for this difference is that the coal recovery was more evenly distributed, so the amount of clay recovered to the amount of low ash coal recovered was less than test series 1.

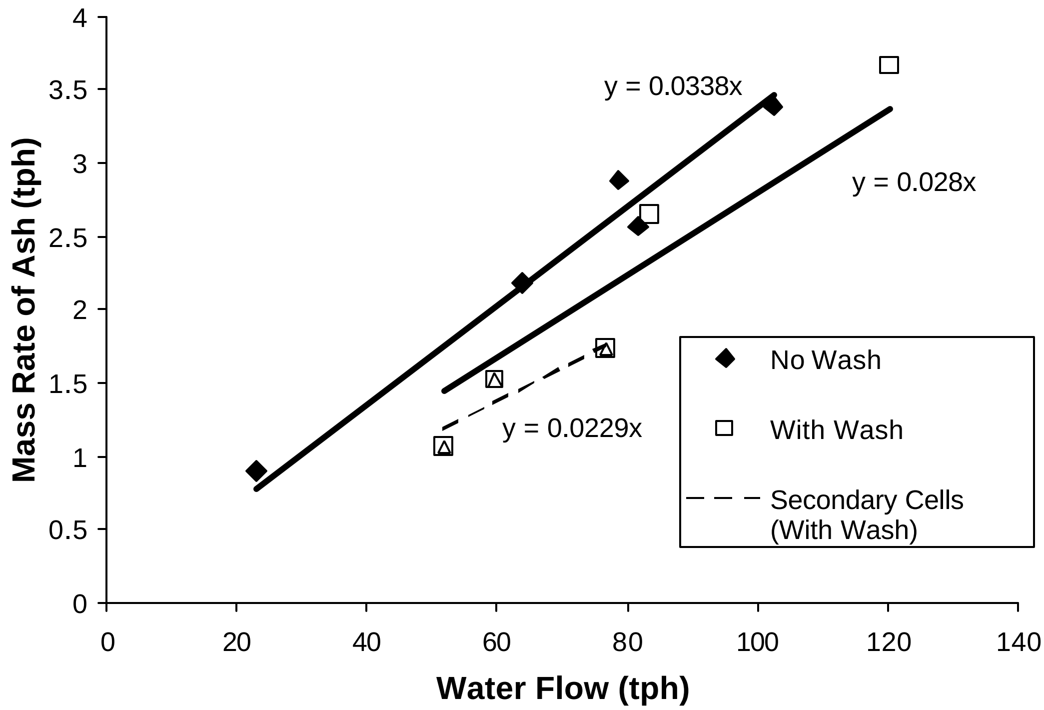


Figure 3.15 - Water ash relationship for test series 2, 80% Eagle / 20% Powellton coal blend.

For tests 3-A and 3-B, Figure 3.16 shows the difference that wash water made to all of the cells not just the last three. This shows that the effectiveness of the wash water was not limited to the last three cells but that all of the cells could benefit from froth washing. The biggest difference between test series 2 and series 3 are the amount of water that was recovered. Comparing the last point of each plot, for test 2, the most water recovered from any one cell was 120tph, whereas for test 3, the highest water recovery rate was 178 tph. Therefore even though the tons of ash recovered are less on a per ton of water basis, test 3 recovered more water and with it more tons of ash.

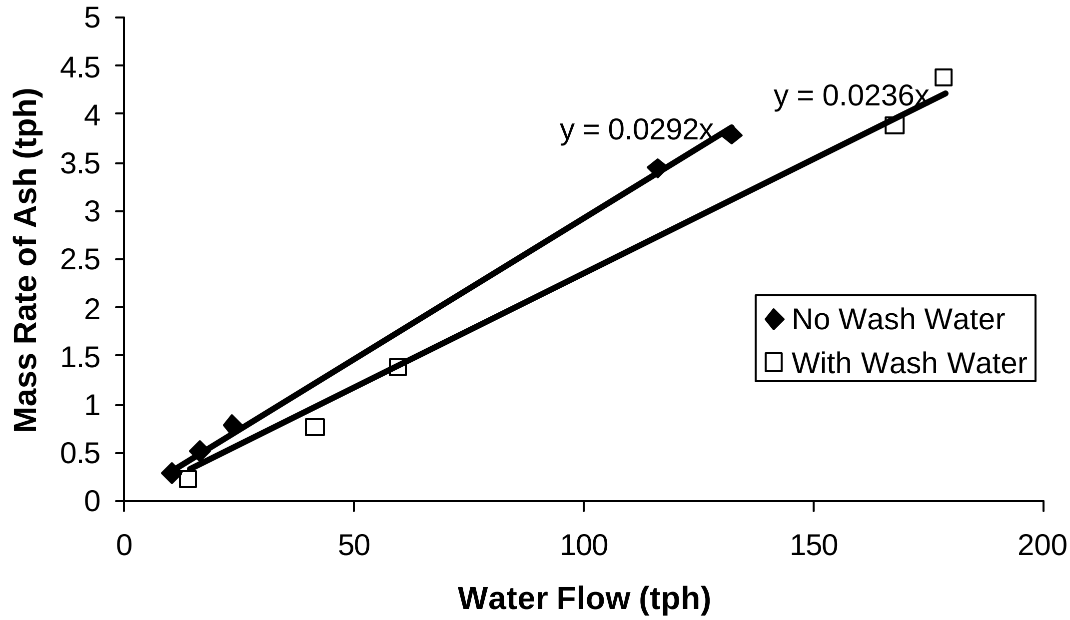


Figure 3.16 - Water ash relationship for tests 3-A and 3-B, Tunnel Eagle coal.

For test series 4 one of the chief goals of the test work was to see if a better balance of coal recovery to wash water addition could be achieved. When comparing the concentrate produced from each of the froth cells, during the test with paddles and without paddles the concentrate ash as well as the mass percentage stayed relatively constant, Tables 3.12 and 3.13 respectively. Both the Low Level (3-D) and the Very Low Level (3-E) tests had very little visual difference in flow rates for any of the cells. For these two tests (3-D, E) it looked like all but the last cell were recovering about the same amount of coal. Only the last cell looked a little less loaded. Usually, it is possible to determine visually which cells are recovering more coal; often the difference is dramatic. The tailings looked darker than usual; however they were not at an unacceptable level. The results of these tests confirmed the visual assessment, clearly that the recovery of coal was shifted down the bank of cells. Shifting the coal also increased the effectiveness of the froth washing. This is mirrored by the ratio of the liquid recovered in the concentrate to the amount of wash water added to the cell. As the ratio approaches 1, the amount of water being recovered equals the amount of wash water being added. Ratios over 1 indicate a net flow downward increasing the likelihood that the wash water completely rinsed the froth. Comparing the results of the five tests, it is clear that the very low level test (4-E) best approached this wash water bias, Table 3.14. None of the tests ever fully even reached equal amounts of water recovered to water added.

Table 3.12 - Concentrate ash comparison by cell for series 4 tests.

	Concentrate Ash				
Cell	With Paddles	No Paddles	Low Level	Very Low	No Wash
1	8.89	8.92	6.57	6.58	9.86
2	7.83	7.39	6.21	7.02	9.22
3	10.55	10.08	9.07	8.88	12.56
4	13.57	13.49	12.59	11.73	16.25
5	19.55	19.30	13.09	12.01	20.89

Table 3.13 - Concentrate mass comparison by cell for series 4 tests.

	Mass % of Concentrate				
Cell	With Paddles	No Paddles	Low Level	Very Low	No Wash
1	43.45	43.48	22.97	31.54	56.90
2	27.86	24.07	19.71	21.76	36.04
3	18.59	18.05	30.17	28.05	4.72
4	6.63	9.52	18.28	13.19	1.45
5	3.46	4.88	8.85	5.46	0.90

Table 3.14 - Concentrate water/wash water ratio by cell for series 4 tests.

Cell	Concentrate gallons/Wash water gallons (dilution washes) With Paddles (B)	No Paddles (C)	Low Level (D)	Very Low (E)	No Wash (A)
1	0.44	0.37	0.75	0.73	0
2	0.69	0.67	0.88	0.97	0
3	0.52	0.44	0.29	0.32	0
4	1.45	0.84	0.47	0.53	0
5	2.77	1.64	0.98	1.20	0
Weighted	0.51	0.50	0.61	0.67	

The last line of Table 3.14 shows the weighted average of the wash water bias. This wash water bias was weighted using the tons of concentrate produced by each cell. As you can see the bias never fully approached 1 for the entire bank, although it exceeded it for individual cells. The first two tests (4-B, 4-C) comparing with paddles and without paddles show almost the same bias 0.51 vs. 0.5. This is understandable because no shift in recovery was made by removing the paddles. However, for tests 4-D and 4-E (low level and very low level respectively), the difference was made by reducing the pulp level in each cell.

When compared at an equivalent combustible recovery of 90% for the tests on Eagle Coal (series 4 tests), the addition of wash water reduced the ash content of clean coal product from 9.6% to 8.2% (1.4 percentage points) for the low and very low pulp levels. This reduction allowed this particular flotation circuit to reject an additional 1.3 tph of ash. A lower reduction of only 0.8 percentage points (9.6% to 8.8%) was observed when the high pulp level was used.

The data shown in Figure 3.17 provides a partial explanation for the limited effectiveness of froth washing for the conventional cells. In this figure, the mass rate of ash reporting to clean coal was plotted as a function of the mass rate of liquid (water) reporting with the froth. As expected, the slope of the curve was reduced by the addition of wash water. This change is a good indication that the wash water is stripping a portion of the entrained high-ash material (fine clay) from the froth product. However, variations in the pulp level did not produce corresponding changes in the slope of the curve. Instead, lower pulp levels shifted points down the curve, while higher pulp levels shifted points up the curve. This finding suggests that the effectiveness of the wash water was not greatly altered by the range of froth depths evaluated in this study (i.e., 12-22 inches). However, the effect of froth depth on the system did increase froth residence time, increasing drainage, contributing to lower product ash.

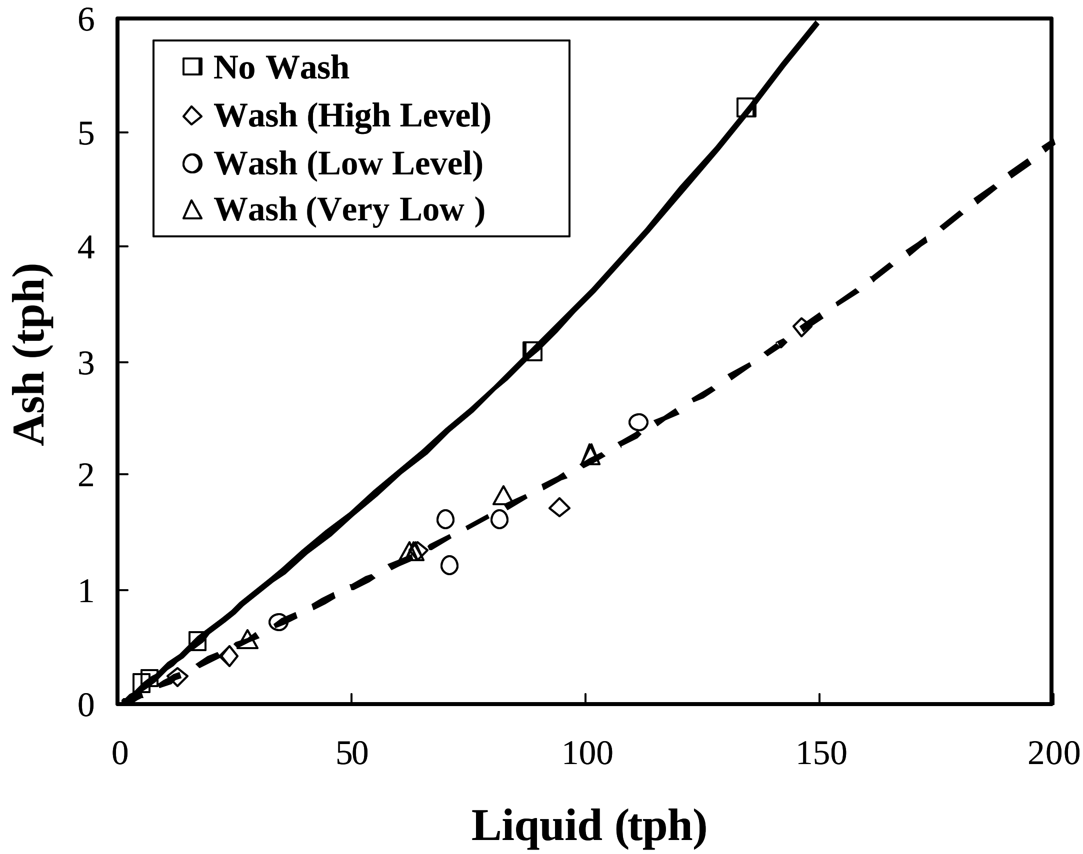


Figure 3.17 – Relationship between ash and liquid recovery rates for different operating conditions.

Another reason for the limited effectiveness of froth washing was the significant increase in the volumetric flow rate of froth that occurred when wash water was added. The wash water reduced bubble coalescence and stabilized the froth bed. In fact, the solids content of the froth decreased from approximately 27.0% to 19.7% for the overall bank (see Figure 3.18). As a result, the demand by the froth for wash water was significantly higher than originally estimated. Note: for comparisons of level test B was chosen to represent the high pulp level tests.

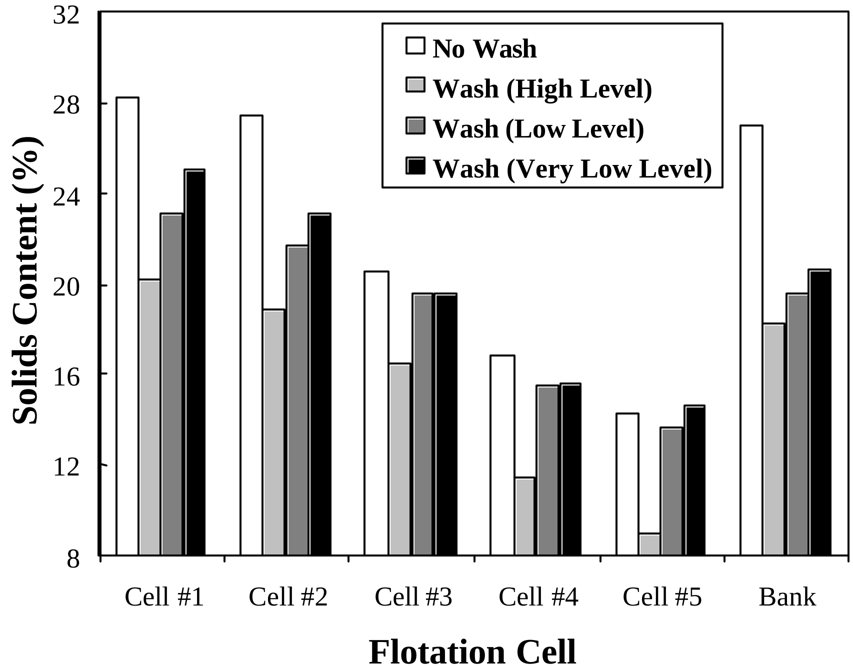


Figure 3.18 - Clean coal solids content obtained for each cell under different operating conditions for Eagle coal test (series 4).

In order to be effective, sufficient wash water must be added to completely replace the pulp reporting to the froth launder. The number of dilution washes (defined as the ratio of the volumetric flow of wash water to concentrate pulp) must be greater than unity. Table 3.14 (shown earlier) provides these values for the existing circuit. As shown, the dilution washes for the overall bank ranged from 0.51-0.67. In particular, cells #1, #3 and #4 were operated with too little wash water. A back-calculation shows that the wash water flow rate for the overall circuit would need to be increased from 1050 gpm to approximately 1800 gpm to achieve one dilution wash. Although this number could be increased depending on how much carry over of wash water the froth has. At some point the froth would no longer be able to hold any more water and any additional wash water added would not dilute the froth.

Figure 3.19 shows the effect of having the wash water ratio of water input to water recovery approach 1. This plot took the wash water ratio and ash of the primary cells for the Eagle coal series of tests (series 4). Notice that if the trend line is continued to the ratio of 1, shown here by the square, the theoretical limit for this wash water system would produce a primary ash of 5.4% significantly lower than 6.6% but still not as good as the release analysis.

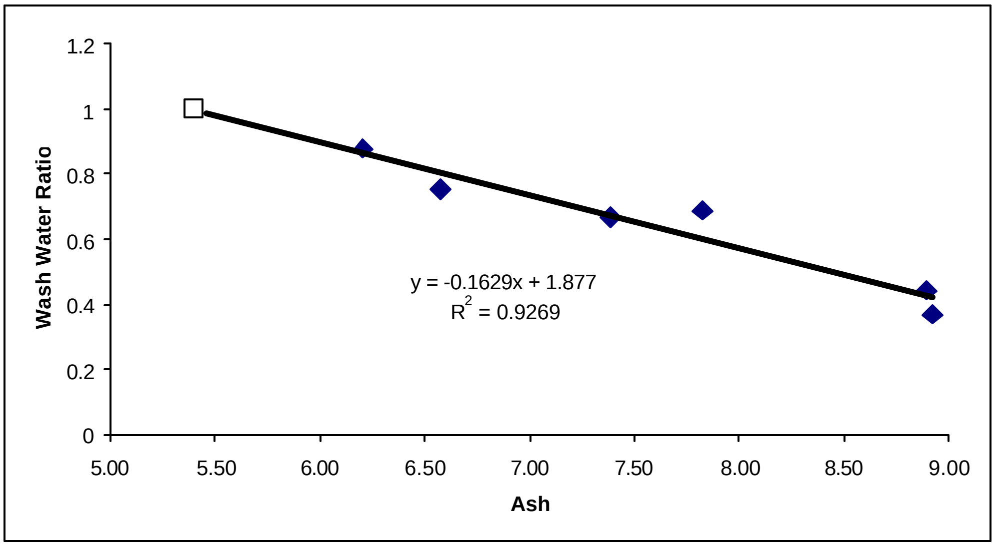


Figure 3.19 - Primary cell product ash for series 4 tests compared to wash water addition ratio.

Using the 1800 gpm figure, the unit wash water flow rate would need to be increased to more than 4.5 gpm/ft^2 for the first three cells and to 2.0 gpm/ft^2 for the last two cells. Typically, column cells are operated with less than 3.5 gpm/ft^2. However, column cells are operated with a much deeper froth (3-4 ft). The deeper froth allows for additional drainage and reduces the water demand. In most cases, conventional cells cannot be operated with such a deep froth since this would substantially reduce the pulp volume. For a fixed volumetric flow, a smaller pulp volume reduces residence time and lowers recovery. As was shown in section 3.1.2 the bank originally had a mean residence time of 8.7 minutes, but was reduced to 6.3 minutes when wash water was added to all of the cells. If the cells were operated with much deeper froths, the reduction in residence time made by adding wash water would be more pronounced.

3.3.2 - Residence Time Predictions

In order to evaluate the effects of higher wash water additions on residence time, mathematical calculations were performed as a function of froth depth and number of dilution washes for the existing flotation bank. The results of these calculations are summarized in Figure 3.21, with the plant results in Figure 3.20. As shown, the maximum residence time that can be maintained with one dilution wash is 8.7 minutes with ½ ft of froth depth, compared to 3.8 minutes for a froth depth of 4.0 feet. The 3.8 minutes is very close to the minimum residence time that would be required to maintain acceptable coal recoveries. In addition, the data from the in-plant test work indicates that water addition rates are very difficult to balance along the length of the bank. Normal fluctuations in feed tonnage to the flotation bank create shifts in the volumetric demand for wash water along the bank length. Therefore, higher wash water rates (e.g., 1.2-1.4 dilution washes) would probably be required in actual practice to compensate for these fluctuations. These higher rates would further shorten the available residence time and not allow acceptable coal recoveries to be obtained.

More importantly, the data obtained to date suggest that froth washing is not a practical solution for most of the existing flotation circuits in the coal industry. For example, most industrial flotation circuits are designed with 3.5-4.0 minutes of residence time when no wash water is utilized. As a result, the mean residence time for these existing circuits would fall below 1.0-1.5 minutes when proper wash water rates and froth depths are used, see Figure 3.22. Therefore, the use of froth washing in conventional flotation cells appears to be reasonable only for banks having considerable excess volumetric capacity (i.e., >8 minutes of available residence time) prior to the addition of wash water.

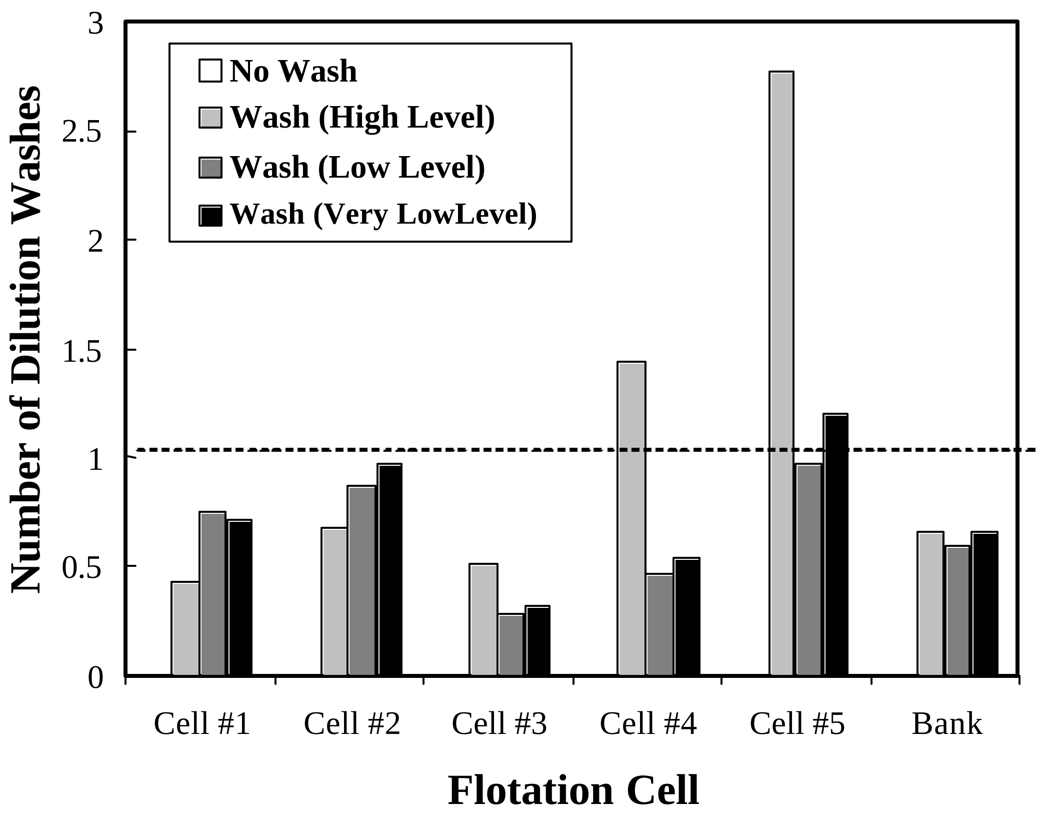


Figure 3.20 – Number of dilution washes obtained for each cell under different operating conditions.

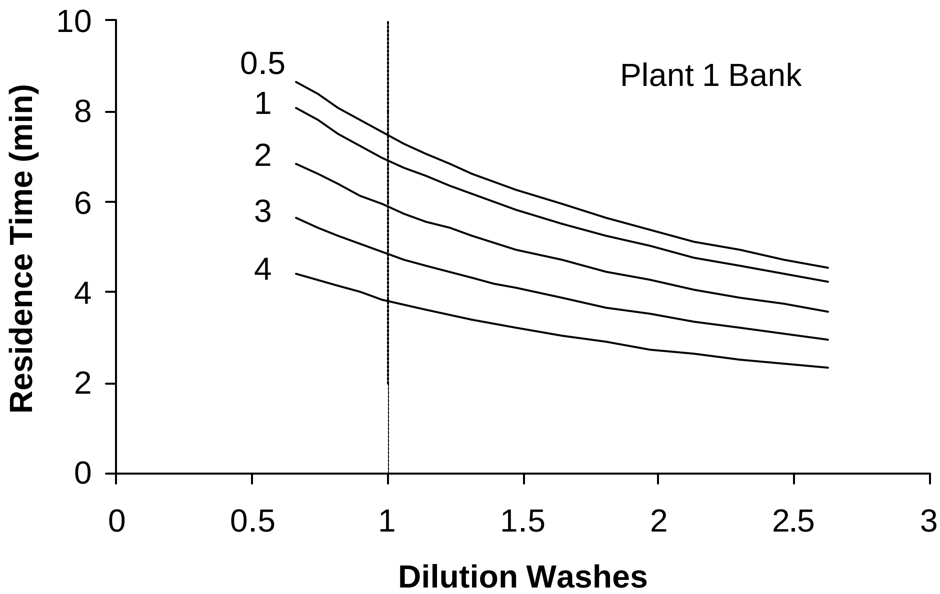


Figure 3.21 – Calculated pulp residence as a function of froth depth (ft) and number of dilution washes for the tested system.

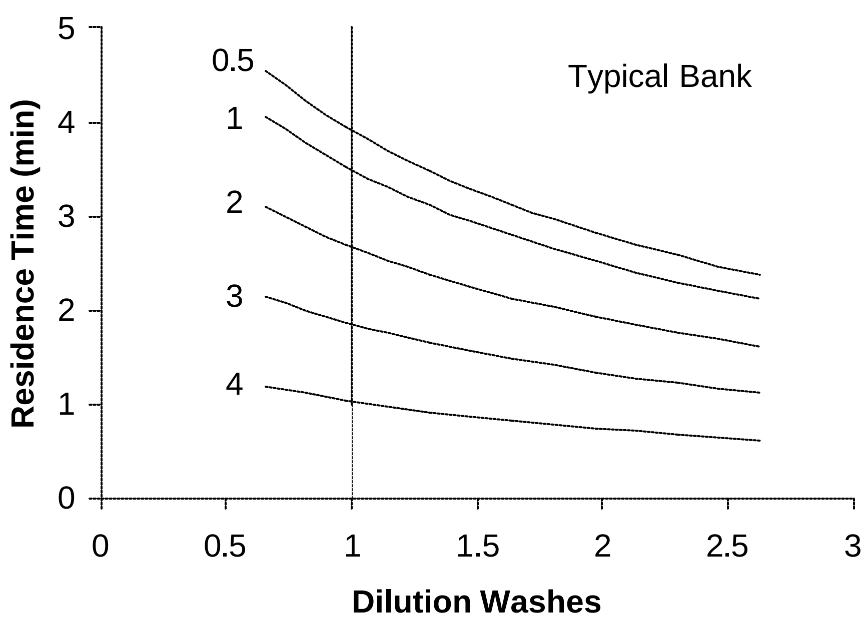


Figure 3.22 – Calculated pulp residence as a function of froth depth (ft) and number of dilution washes for a typical flotation bank.

3.3.3 - Effects of Staged Frother

Staged frother addition was chosen in the hopes of both moving the froth to the secondary cells and allowing for less frother addition due to more efficient placement. At first the frother was added in a transfer tank from the first cells to the second. Due to a lack of mixing in this tank the addition of frother seemed to produce almost no results. The frother addition was transferred to the air intake of the third cell. This is the recommended point of introduction according to Wemco. The theory was that the frother would be added at the point where the most mixing and shearing action of the water would occur. With the frother being added at a point of high shear for the water air mixture, the frother should have created a very fine froth. When the frother was added at first the effect was immediate. The froth became extremely fine and very loaded, and the froth level dropped. But as time went on the froth went back to normal, and eventually more frother was needed to maintain performance. Once the system reached equilibrium, the frother needed to maintain the recovery was much greater than if the frother was not added in stages. Thus, no frother savings could be achieved.

The placement as well as amount of frother, should have produced and maintained a much more dramatic effect on the froth cell performance. This raises the question as to why the savings to frother addition were not realized. One theory at the plant was that the frother was not actually making its way to the air water mixture, but was somehow going into the internal workings of the rotor assembly. When the frother was added to the cell the first time, it was fed through the air intake port. In subsequent tests the frother was added to a pipe that was supposed to connect to the air intake. The only explanation for the frother changing the froth initially is that the cell saw a large dose of it quickly. As of yet no explanation of why the frother was not being as effective has been shown. Other methods of adding the frother were tried but with no better results.

When comparing the total amount of frother used to the effectiveness of the wash water at reducing ash, a loose correlation becomes apparent. Table 3.15 lists all of the frother dosages as well as intake air and diesel addition for all of the tests conducted. If you compare the total frother amount used the test series 3 stands out for having very high frother addition rates. Notice also that the ash reduction was only 0.4 percentage points, whereas the series 2 tests reduced the overall ash by over 1 percentage point. Test 3-B had wash water on all of the cells while 2-B test only had wash water on the last three cells. This brings us back to water recovery. Looking at Table 3.16, one can see that the 3-B test had better wash water distribution (liquid flow/wash water); however the tph of liquid flowing from the cell was higher. With this higher recovery of water came a higher recovery of entrained clays. High water recovery is more a function of frother dosage than wash water effectiveness. With higher frother dosages, more froth is produced for the same amount of air. Also a more stable froth is produced. Taking a look at diesel addition, the series 3 tests also had the least amount added, in the low 200's (ml) vs. upper 300s (ml) for the series 4 tests. For metallurgical coals, the coal needs very little diesel to act as a collector. The diesel is often used to aid in reducing water recovery by matting the froth, i.e. diesel and frother work against each for froth stability. Series 3 tests not only had the most frother, but also the least amount of diesel, translating to very high water recovery, reducing the effectiveness of the wash water.

Table 3.15 - Comparison of frother addition for all tests.

Test Date	1-B	1-A	2-B	2-A	3-B	3-A	3-C
Coal Type	Powellton	Powellton	80E/20P	80E/20P	100% Tunnel Eagle	100% Tunnel Eagle	100% Tunnel Eagle
Air (P)	0.25	0.25	0.25	0.25	0.25	0.25	0.125
Frother (P)	260	260	170	170	206	206	206
Air (S)	0.5	0.5	0.5	0.5	0.625	0.625	0.625
Frother (S)	0	0	120	120	210	210	170
Total frother	260	260	290	290	416	416	376
Diesel	320	320	320	320	232	232	232
Wash Water	Y	N	Y	N	Y	N	Y

Test Date	4-B	4-C	4-D	4-E	4-A
	W P	N P	L L	V L L	N W
Coal Type	100% Eagle	100% Eagle	100% Eagle	100% Eagle	100% Eagle
Air (P)	0.25	0.25	0.25	0.25	0.25
Frother (P)	192	192	192	205	200
Air (S)	0.5	0.5	0.5	0.5	0.5
Frother (S)	160	160	160	132	0
Total frother	352	352	352	337	200
Diesel	380	380	380	335	335
Wash Water	Y	Y	Y	Y	N

Table 3.16 - Water recovery effect on concentrate ash for 2-B and 3-B tests.

	Liquid flow rate from cell tph		Tons of ash/ton of concentrate		Liquid flow/ wash water	
	2-B	3-B	2-B	3-B	2-B	3-B
1	83	168	0.073	0.073	0.00	0.45
2	120	179	0.082	0.088	0.13	0.42
3	52	60	0.063	0.101	0.72	0.63
4	77	42	0.084	0.127	0.49	0.90
5	60	14	0.119	0.165	0.63	2.68
total	392	462	0.081	0.086	0.33	0.57

3.4 - Release Analysis

3.4.1 - Overview

Several series of laboratory release analysis tests were conducted to evaluate the "ultimate" cleanability of the flotation feed. A second series of tests was performed on the combined concentrates for each test. This testing used release analysis methods to separate the coal from the recovered entrained particles. In a similar manner release analysis techniques were used to confirm the quality and quantity of floatable coal left in the tailings stream.

3.4.2 - Experimental

Release analysis is a commonly used technique for separating coal into fractions for froth flotation feed. This technique is similar to washability testing used for coarse coal fractions. The procedure used has been described in detail elsewhere (Killmeyer et al., 2000), but a brief outline of the procedure will be made.

If the feed is in slurry form then enough slurry is used to ensure ~ 200 grams of solids are tested. The slurry is added to a one-liter lab froth cell and the remainder of the cell is filled with fresh water to increase the level of the cell. Diesel and frother are added to the cell, and the entire amount of coal is floated out. The first stages of the procedure can be time consuming the last coal to float is often hard to float and requires a long residence time to be floated. The froth product is reslurried and diluted with fresh water to fill the cell and refloated. This procedure is repeated three to five times until a complete separation of coal and non-coal particles are made. From this point there are two methods of separating the coal into fractions: the standard or forward method, or the reverse method. Although the forward method is quicker, this method can entrain less floatable coals with the more floatable coals, which can shift the results. For all release analysis performed in this study the reverse method was used.

Once all of the products have been split into their respective fractions, non-floatable material, slightly floatable, to increasing floatable products, then the products are filtered and dried. The products are then weighed and ashed. This gives the weight percentages of the different qualities present. Then the results are plotted as combustible recovery vs. cumulative ash.

For the product release tests performed, the feed for the test had already been dried to determine the percent solids in the froth. The dried product was split to 50 grams and reslurried in enough water to fill a one liter froth cell. The coal was mixed with diesel in a mixer for several minutes to ensure that all of the particles were re-wetted. Then the coal was floated in the same manner as the first steps of a normal release analysis. The amount of diesel and frother used to make this separation were double to triple what a normal release analysis would take; this was because the product was not still in a slurried form. Because the release analysis of the feed had already been done, the product coal did not need to be split into its components; rather the composite was all that was needed.

For some of the tests a tailings release was also conducted. This was conducted in the same manner as a normal release analysis would be, only instead of feed, the plant tailings were used. This test work was used to show what quality of coal was being left by the circuit and what was the quantity of that coal.

3.4.3 - Results (Run-of-Mine Feeds)

For this section the release analysis will be discussed in the same order as the plant testing was conducted. Also as a reference to the work in the plant, the coal recovery vs. ash was plotted along with the release analysis.

3.4.3.1 - Powellton Coal (1-A, 1-B)

For the first test series using Powellton coal, the release analysis of the feed shows that at a 90% combustible recovery the total product ash would be 6.0% quite a difference from 10.48% actually recovered. Several observations can be made about the two tests. The first is that the two tests varied little in the recovery and ash from each cell. Looking at the two tests in the plant, Figure 3.23 shows that about 90% of the coal was recovered in the first two cells. One other unique difference is that in this case the curve with the wash water is further from the release analysis curve than the curve without wash water. This is probably from slight differences in the feed between the two tests. It is unlikely that the wash water played any significant role in this shift because the wash water was only used on the last three cells for 6% of the total product.

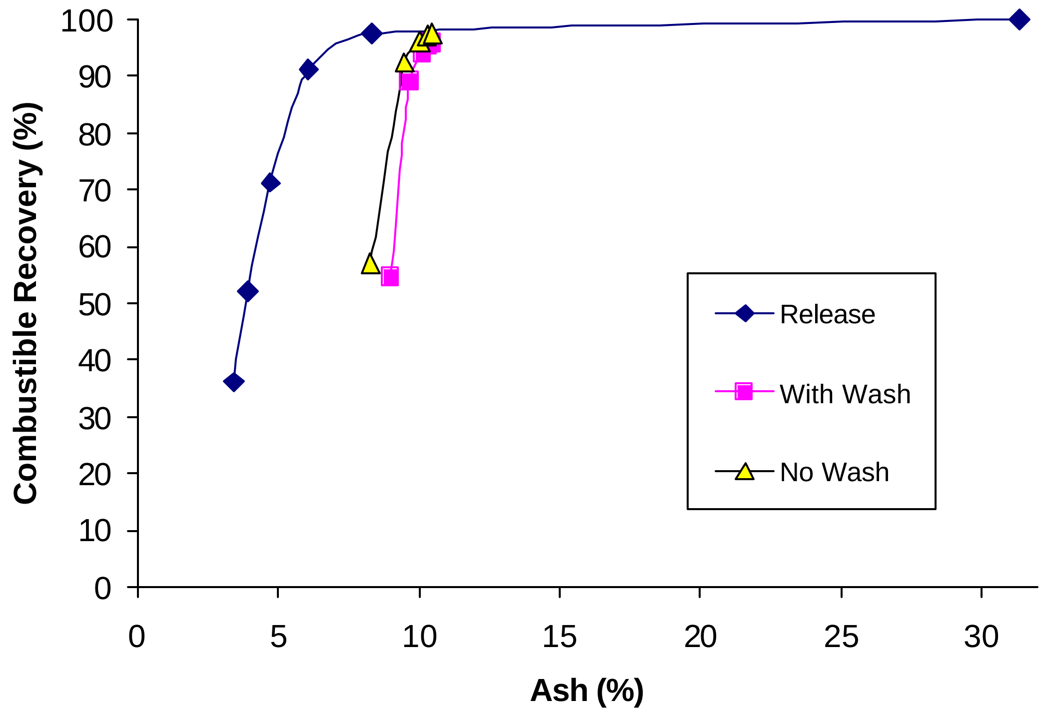


Figure 3.23 - Comparison of plant performance to release analysis for series 1.

3.4.3.2 – 80% Eagle 20% Powellton Coal Blend (2-A, 2-B)

For series 2 tests the plant feed was 80% Eagle-20% Powellton coal blend. The release analysis shows that for a 90% combustible recovery the product ash would be 3.5% ash (Figure 3.24). As with the first series of tests the plant was clearly not performing very close to what the release analysis shows was possible; however this time there was a distinction between the test with wash water and without. The distinction becomes more apparent in the third cell, (shown by the numbered points) and is emphasized with each additional cell's recovery.

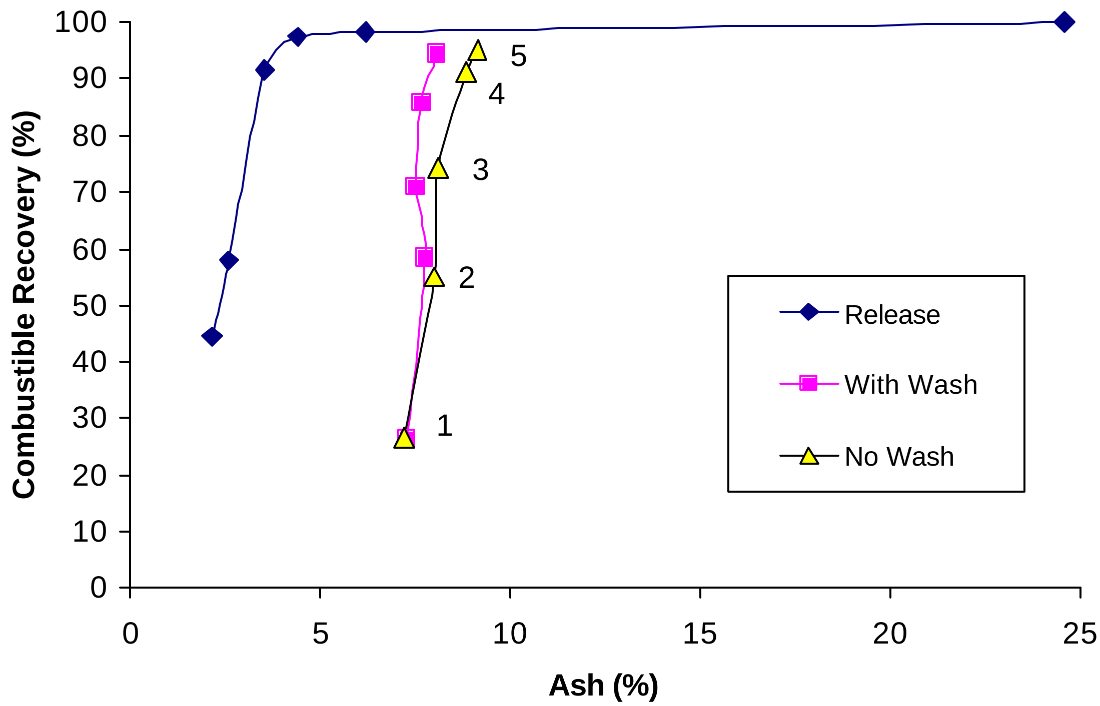


Figure 3.24 - Comparison of plant performance to release analysis for series 2 tests.

3.4.3.3 – Tunnel Eagle Coal (3-A, 3-B)

For the series 3, with Tunnel Eagle coal as plant feed, a 90% combustible recovery would produce a 3.75% ash product. As was discussed earlier in previous sections, the difference between the two tests with and with out wash water was minimal. This is clearly seen in Figure 3.25 by the close spacing of these two lines.

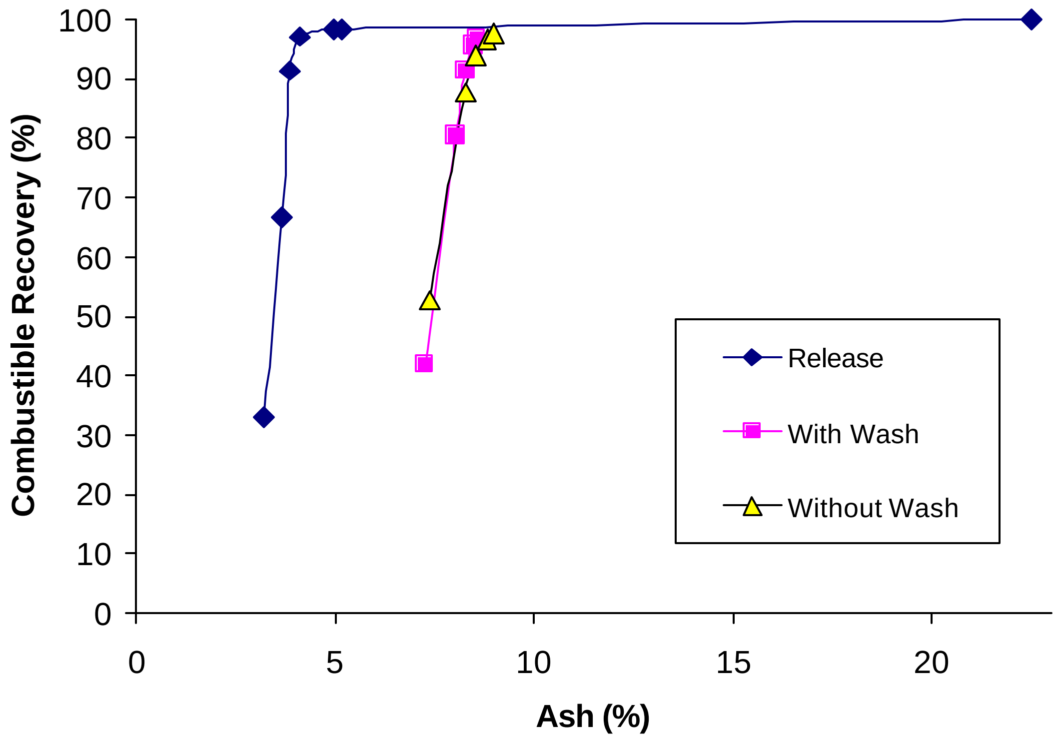


Figure 3.25 - Comparison of plant performance to release analysis for series 3 tests.

3.4.3.4 – Eagle Coal (4-A, B, C, D, E)

For the Eagle coal tests, the release analysis showed that a 4% ash could be achieved with a 90% coal recovery. See Figure 3.26 for a graphical summary. Although the final concentrate ash of the very low pulp level test was 8.3%, much closer than all of the other tests in approaching release analysis, the product ash was still more than 100% higher than it should be. In this series of tests the difference in pulp level, in concert with the wash water, was made evident. Both the low level (4-D) and very low level (4-E) tests were significantly better than the tests where only wash water was added. This was the first series of tests where the entire curve shifted from the curve without wash water. Also note the shift in the first few cells downward in recovery. This is attributed to the increase in froth depth, which the weir bars as well as the low pulp level in the first two cells created.

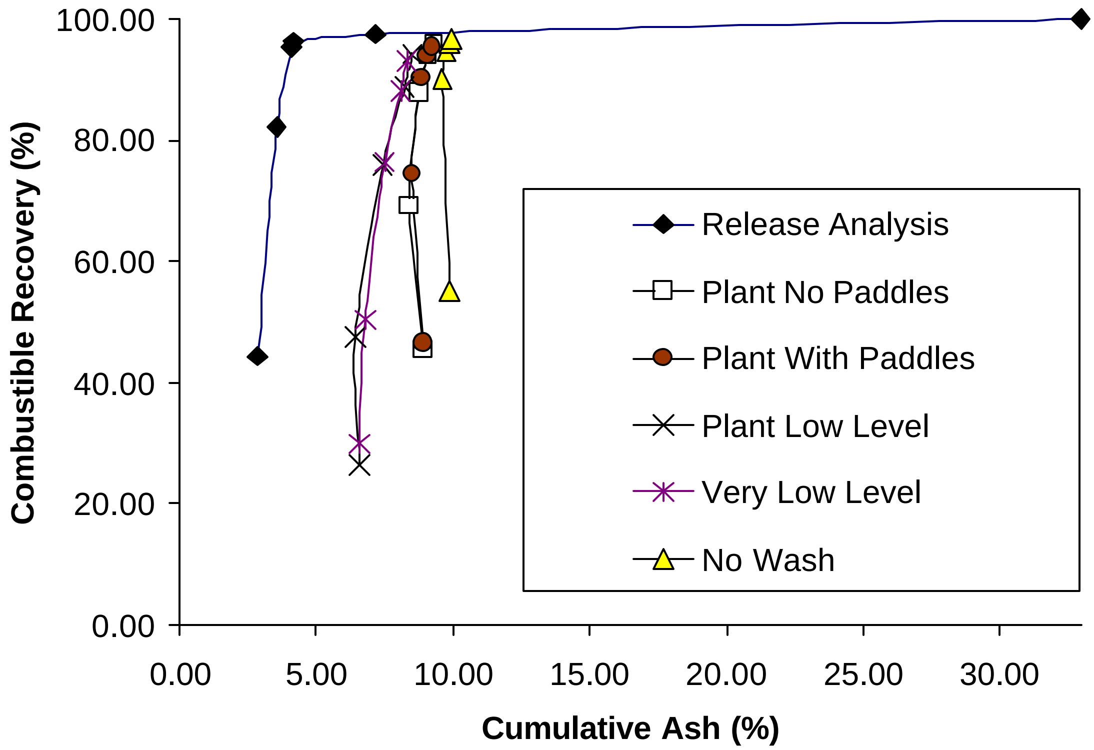


Figure 3.26 - Comparison of Plant Performance to Release Analysis for series 4 tests.

3.4.4 - Results (Floated Products)

The following charts, Figures 3.27-3.30, are a graphical representation of how much pure coal was recovered in each test. For each test, the coal ash for the tests with wash water was lower than the coal ash without wash water. This indicates that the wash water is slowing the coal recovery process. This is due in part to the wash water itself detaching coal from the air bubbles as well as decreasing the residence time that a coal particle has to be recovered. Some test work showed a very drastic shift between the coal ash with wash water vs. without, in particular the Tunnel Eagle test (3). Because the release analysis curve is very steep in the areas where the product coal ash lies, any shift in product coal ash translates into a large shift in recovery.

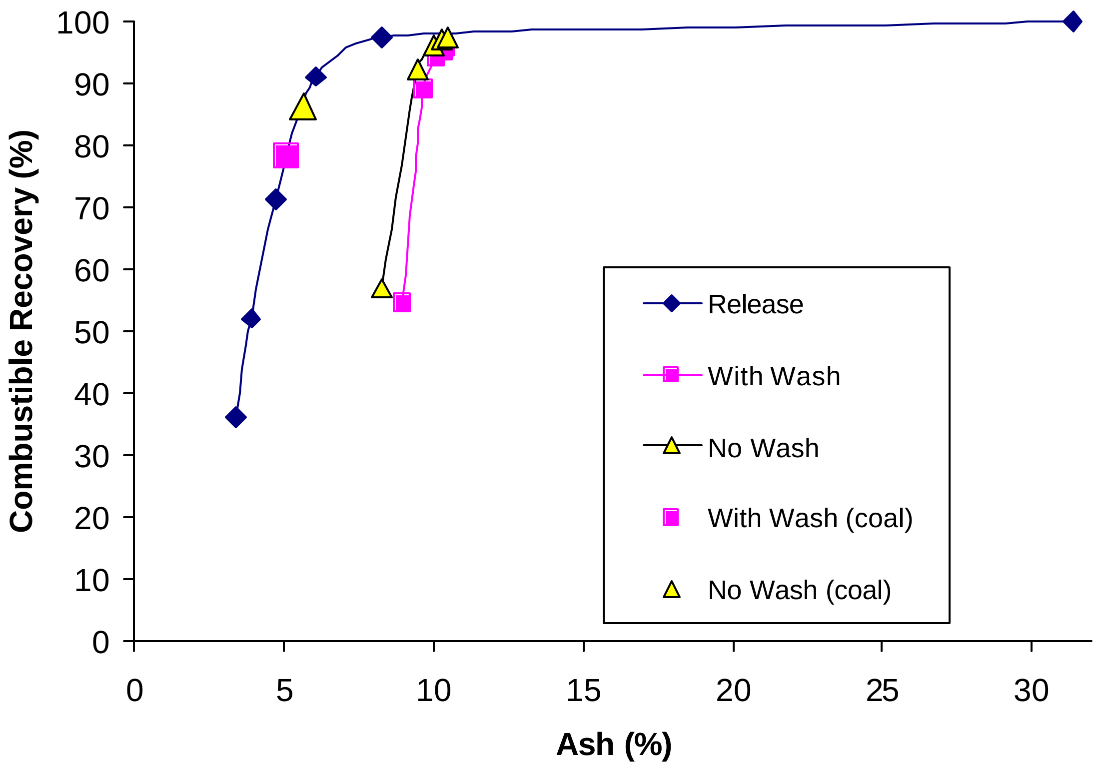


Figure 3.27 - Concentrate coal ash values for series 1.

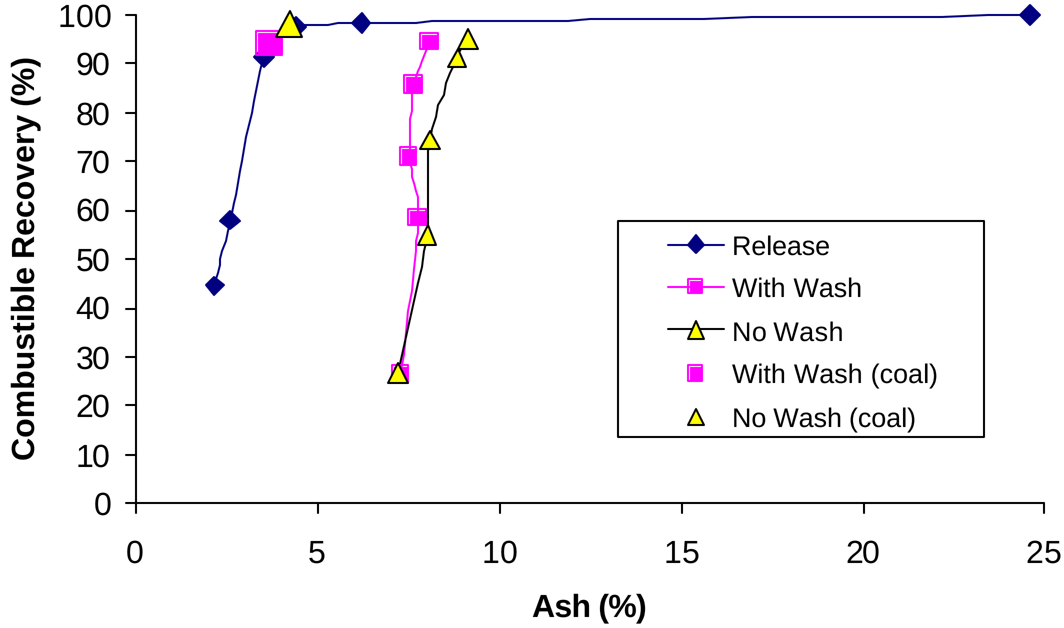


Figure 3.28 - Concentrate coal values for series 2.

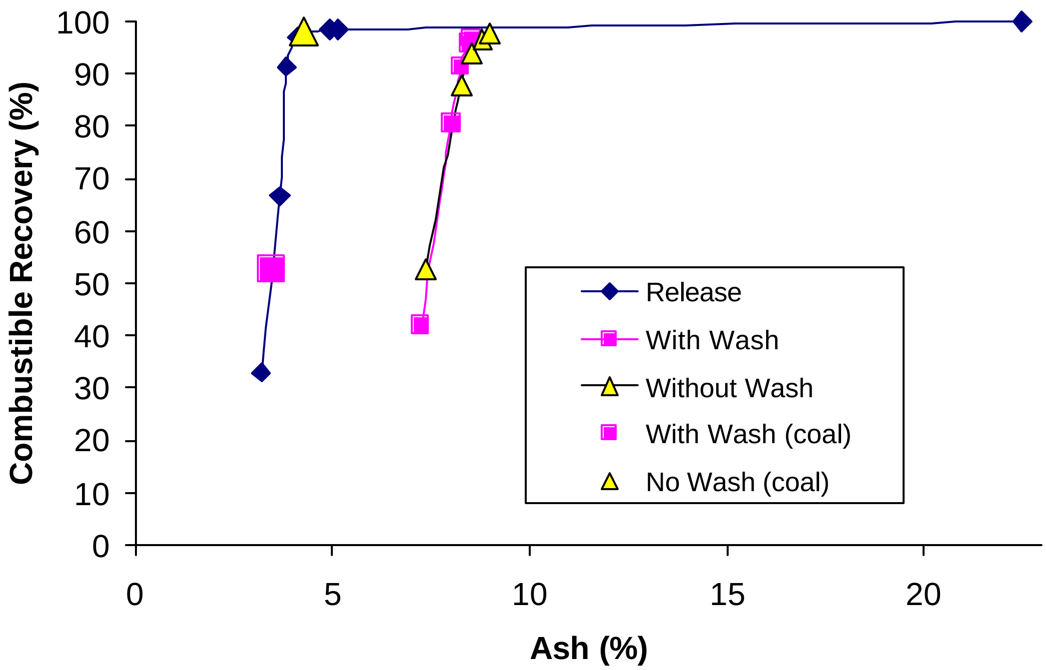


Figure 3.29 - Concentrate coal ash values for series 3.

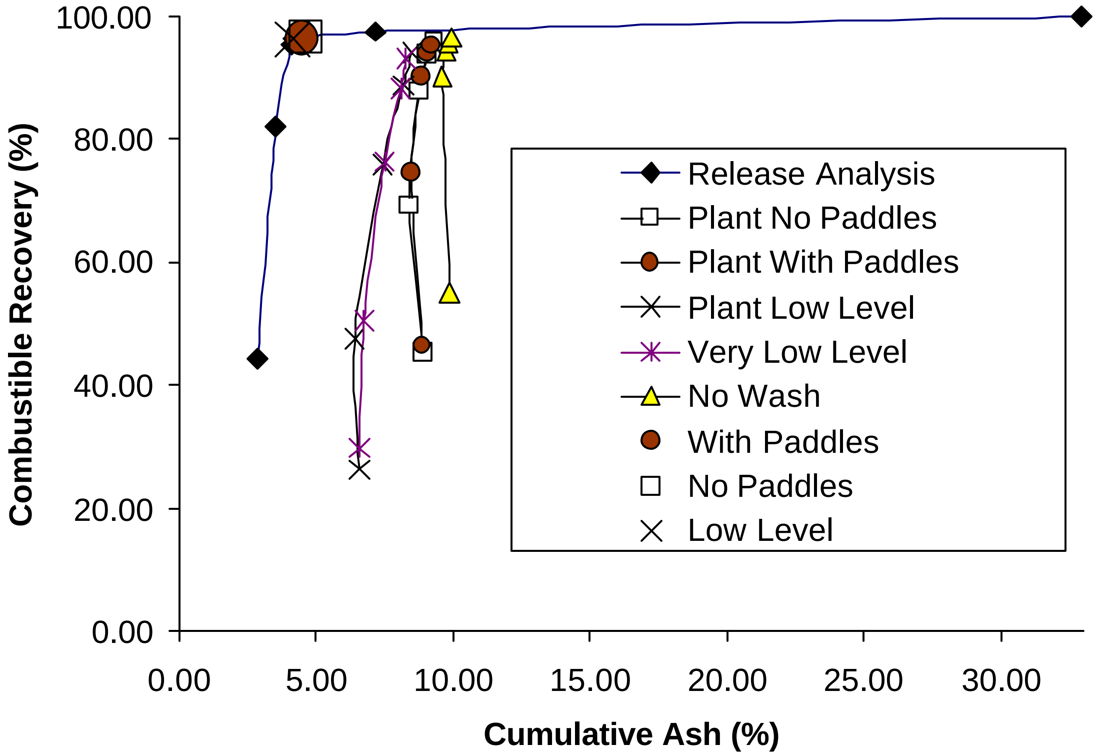


Figure 3.30 - Concentrate coal ash values for series 4.

3.4.5. - Discussion

Each of these series of tests was performed on the each of the different combinations of coal that are processed through Plant 1. Each of these coal seams is of metallurgical value and is considered high quality coals. This is shown by the previously described release analysis where each of the seams at a 90% combustible recovery and the highest product ash is only 6.0% yet the lowest test product was a 8.3% ash over double the corresponding release analysis values. This leads to the conclusion that froth washing is very limited in its effectiveness.

For example column flotation cells that are well maintained are generally capable of producing products at acceptable recoveries at or close to the release analysis.

3.5 - Parametric Study

Throughout the testing, several questions were raised about how the wash water should be added. How should the wash water system be used? What are the critical X's controlling washing out clay? Here are some of the specific questions that the parametric study attempted to answer: What does stopping the paddles so that all of the froth must pass under the paddle do? What is the effect of running the paddles vs. not using paddles do? How does froth depth affect product ash? And are the wash boxes too high above the froth etc.

The testing was broken up into three days. The first two days dealt primarily with the effect of paddles and froth depth, while the last day dealt with wash box height and addition method as well as froth depth. Statistical methods of analyzing means and distributions were used to determine the critical X's. Throughout the testing, only cell #2 was used, and the comparison was between the two sides. This method was chosen because it reduced the number of samples required, and it increased the clarity of the effects.

3.5.1 - Parametric Study Results

3.5.1.1 - Paddle Usage at Various Froth Height (5-A)

Purpose was to test the difference in wash water effectiveness for different froth height levels. Also, the effects of having the paddles stopped versus running were tested.

Six tests were completed with two tests comparing paddles stopped. For all of the tests, only two froth depths were used. For each of the three test series, a blank indicates a test condition that has the same settings for each sample. This was used to see if the differences observed were from the varied conditions or the normal plant variation (Table 3.17).

Table 3.17 – 5-A test summary.

Description	Coal Tunnel Eagle				
Paddles on and running	tph 2000			Diesel	220
Description	Test order / Cell set point	Sample	Ash	% Solids	TPH Solids
no wash low level blank	4	T1R	7.75	28.76	19.2
no wash low level blank	sp 14.15	T1H	7.43	28.25	18.6
w/ wash low level	3	T2R	5.98	22.44	9.5
no wash low level	sp 14.15	T2H	8.11	26.51	17.6
w/ wash high level	1	T3R	8.09	19.50	11.8
no wash high level	sp 12.00	T3H	9.66	22.45	20.1
no wash high level blank	2	T4R	9.48	26.09	15.8
no wash high level blank	sp 12.00	T4H	9.84	24.69	15.6
w/ wash low level paddles stopped	5	T5R	6.64	20.75	12.7
no wash low level paddles stopped	sp 14.15	T5H	7.44	29.63	12.4
no wash low level paddles stopped	6	T6R	7.51	29.67	13.9
no wash low level paddles stopped	sp 14.15	T6H	7.39	29.76	16.1

3.5.1.2 – Paddles vs. No Paddles at Various Froth Heights (5-B)

The purpose of this test series was to find the effect a running paddle had on froth washing. For this test, a paddle was removed on one side of cell 2, while the on the other side, the paddle remained. Samples were taken simultaneously on both sides at different conditions. The tests were repeated at several froth heights to see how froth height might vary any differences between the two sides (Table 3.18).

Table 3.18 – 5-B test summary.

Description	Coal Eagle				
paddles cut off right side	tph	2000		Diesel	272
				Frother (Primary)	224
Description	Test order and Cell set point	Sample	Ash	% Solids	TPH Solids
w/wash low level no paddle on	7	T7R	6.165	23.14	10.48
w/ wash low level paddle running	ı 11.6 = 10	T7H	7.93	21.99	22.13
no wash low level l lank no paddle on	9	T8R	7.745	28.59	25.21
no wash low level blank paddle flat	ı 11.6 = 10	T8H	7.965	27.54	28.07
w/ wash low level no paddle on	8	T9R	6.705	23.15	13.90
no wash low level paddle flat	ı 11.6 = 10	T9H	8.14	27.58	24.30
w/wash high level no paddle on	10	T10R	8.635	19.90	15.20
no wash high level paddle flat	) 13.25 = 8	T10H	10.19	23.19	30.71
no wash high level blank no paddle on	11	T11R	9.88	24.89	22.45
no wash high level blank paddle flat	) 13.25 = 8	T11H	10.005	24.58	19.61
w/ wash high level no paddle on	12	T12R	8.345	19.44	14.44
w/ wash high level paddle running	) 13.25 = 8	T12H	9.285	19.42	21.52

3.5.1.3 – Wash Box Position at Various Froth Heights (5-C)

This test was conducted to check various froth water addition methods (Table 3.19). Should the wash boxes be right over top of the froth, or kept in original positions? For one test, a wash box was tipped on its side to simulate water weiring over in a sheet like fashion. This was to see if there was a better way to distribute the wash water. The thought was that by making a sheet of water all of the bubbles would have to pass through the clean water. This idea may work, but the way that it was implemented was not very good. Unfortunately, laminar flow conditions could not be achieved; the flow was also intermittent and not very well distributed across the whole bed. It ended up not washing the froth, but more or less diluting it. A second attempt of changing the wash water addition method was made by one of the operators. The operator added a sheet of hard plastic at an angle to the wash boxes. The wash water would hit the plastic and slide off the end of the sheet. This provided much better distribution than the first attempt but didn't seem to have any better results. The results seemed to be sporadic at best. The water flow in the downward direction was not enough for the amount of water being carried up and over the weir, and so the effect was more of dilution than washing. (See Figure 3.33)

Table 3.19 – 5-C test summary.

Paddles off Water addition methods						
Description	Sample	Ash	% Solids	TPH Solids	Cell set point	Froth height
Low level wash box	T13H	5.44	23.28	6.73	8.10	9.0
High level wash box	T13R	5.18	25.59	2.87	8.10	9.0
Low level wash box	T14H	9.55	17.13	16.23	10.00	4.5
High level wash box	T14R	9.54	14.92	10.71	10.00	4.5
Low level wash box	T15H	8.77	17.34	12.50	9.05	6.5
High level wash box	T15R	8.83	17.46	10.37	9.05	6.5
High level wash box with weir water	T16H	7.33	20.03	14.08	8.75	7.0
High level wash box normal	T16R	7.27	20.48	8.13	8.75	7.0

3.5.2 - Discussion

For the first set of tests, the effect of stopped paddles verses paddles running contributed vary little to the overall effectiveness of the system. Froth depth had a much greater effect on the whole system. Comparing the populations of stopped paddles to running paddles, tests 1,2,5, and 6 (T 1,2,5,6) the means are 7.24% and 7.31% ash respectively. A two-sample T test was conducted to see if this difference was significant, and the difference is not statistically significant for the sample size taken.

Tests T1-4 were combined with T7-12 for statistical analysis of the effects of running paddles vs. no paddles. In this case, the means between both data sets were

8.35% and 8.38% ash with paddles on and no paddles respectively. A two sample T test proved that there was no statistically significance between the two populations, for the given sample size. This was also shown with the tests conducted on 6/16 with the primary cells with and without paddles test. In that case the two tests acted almost the same, showing no difference in performance.

Similarly, the differences between the addition methods, high and low wash boxes, as well as weiring or sheeting of the wash water are very slight in comparison between other variables (T13-17). Their means are 7.70% for the high wash box and 7.77% ash for the low wash box. Of the X's controlling product ash, froth depth, and adding wash water had the greatest effect on lowering product ash. Tons per hour of concentrate also played a significant contributor but was really more of a result of other variables than a contributor. As the froth depth increased so the points on a water ash curve shifted downward, as in Figure 3.31. This is due to letting more froth water drain back into the pulp. Also as the froth depth increases, the tons per hour of product decrease increasing the number of dilution washes. Note: for the tests with the low wash boxes, the greatest effect seen was the amount of water recovery and not the over all ash. This is due to less bubble coalescence by adding the water more gently, but not increasing the froth depth to allow for better drainage. So the net affect is more water carryover.

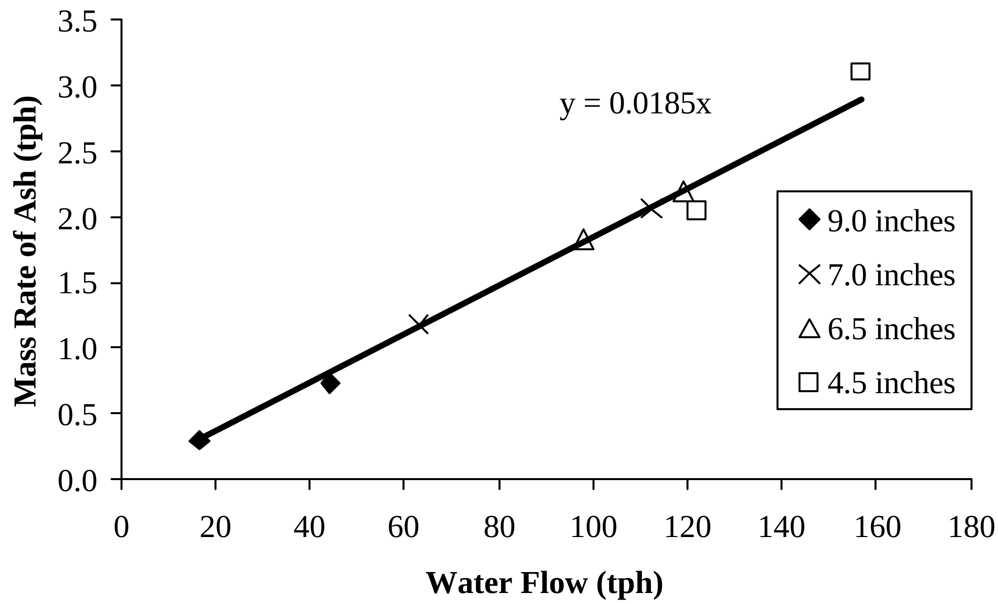


Figure 3.31 - Effect of froth depth on water ash plot for 5-C tests.

3.5.2.1 - Explanation to Effectiveness of Froth Washing.

During the parametric study, the critical X's were discussed. Both froth depth and the number of dilution washes were determined to be the controlling factors in the process. Other questions, such as how wash water can be added, why its effects seem to be minimized, and why a deeper froth works better, are answered in this section.

For all of the tests in this study, the froth washing always took place at the cell lip. This was to ensure that all of the froth would be washed. However, looking back a better placement might have been further back from the edge of the cell. This is due to the short residence time of the froth leaving the cell after the wash water was added between 0.25 seconds and 2 seconds (deeper froths). This is not enough time for the wash water to effectively wash and drain the pulp water out of froth. So rather than washing the clays out of the froth, the clays are only diluted. As froth depth increases, product ash decreases. This is due to froth water draining back into the pulp, carrying entrained clays with it. Deeper froths not only allow for more drain back of the clays, but the flow past the wash water is much slower. This increases the froth's residence time, allowing the wash water to drain rather than absorbing the extra water.

One of the differences of wash water systems for columns is that the wash water is distributed evenly across the entire area of the cell. This allows the froth more time to drain as it travels to the lip and into the launder, Figure 3.32.

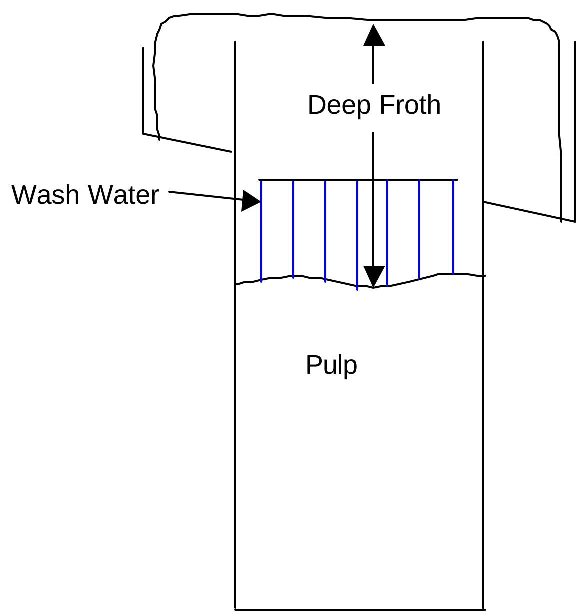


Figure 3.32 - Column cell arrangement.

Froth residence time is dictated by the time it takes for a bubble to rise to the top of the froth and travel to the lip. Because froth cell geometry is fixed, the time for the froth to travel to the cell lip is dictated by the length that bubble must travel. Therefore, the way to increase the residence time is to increase the froth depth. Froth that has formed in the center of the cell will have a longer distance to the cell lip; therefore, it will have a longer residence time, and a greater froth liquid drain-back.

Weir bars are an effective way to increase the froth depth, especially when greater cell residence time is needed to increase recovery. Weir bars increase the froth depth without changing the cell volume that the pulp is occupying. Lowering the pulp level in the froth cell also increases the froth depth; however, the volume that the pulp now has to fill is smaller, which decreases pulp residence time and adversely effects recovery.

The following Figures 3.33 and 3.34 are graphic illustrations of the effects of time and depth of froth on wash water effectiveness. With shallow, fast-flowing froths, the wash water does not have time to adequately drain and effectively remove the clays, Figure 3.33. Instead, the froth water is merely diluted and clays are swept over the cell lip with the product. Figure 3.34 shows that deep, slow-moving froth increases the natural froth drain-back, allowing better separation of froth from entrained water, and reduces the amount of water carryover. The reduction in hydraulic entrained clays is enhanced when a deep froth is used in combination with wash water; in this case, this reduction is greater than that which could be achieved by the sum of its parts (the effects of deep froth and wash water).

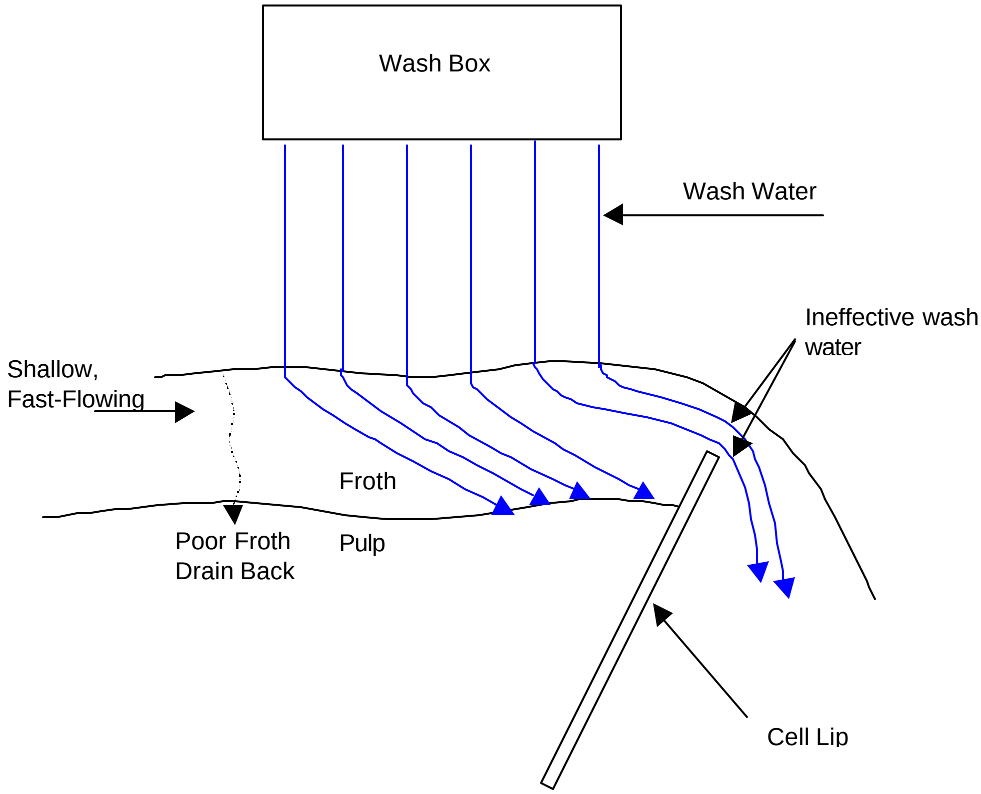


Figure 3.33 - Ineffective wash water from shallow froth.

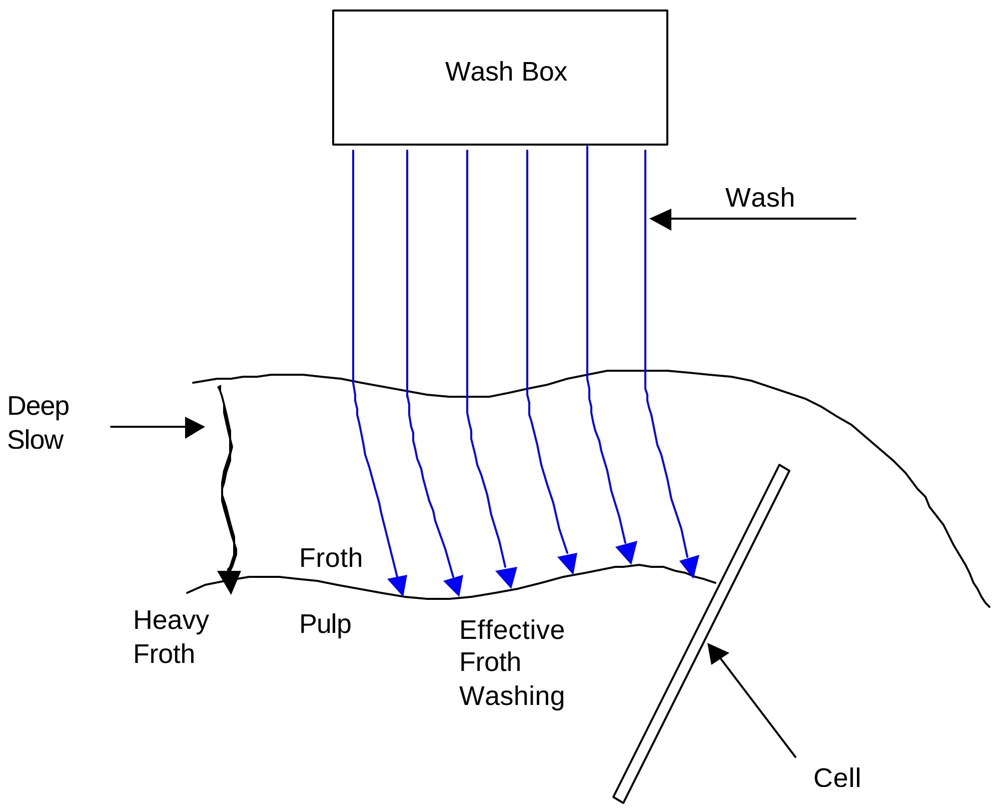


Figure 3.34 - Effective froth washing with slow deep froth.

The effect of one hole in the wash box is to produce a single stream of water pouring onto the froth. This stream of water is deflected around the various froth bubbles. As the water is deflected, the natural shape of this stream becomes a cone, whose base widens as depth increases. The spacing of the cones is dictated by the hole spacing of the wash box. The desired effect is to have the froth pass through the overlapping sections of the cones, where the washing would be the most complete (Figure 3.35). If the froth is too shallow and the cones do not overlap, parts of the froth will not pass through the area of wash water influence. Deeper froths increase the overlap; however, if the froth is too deep, it will become unstable. Froth that has wash water added can support deeper froths; unfortunately, this system adds wash water at the cell lip so the total froth does not benefit from this stabilizing effect. Column cells are able to take advantage of this effect because the wash water is added over the entire froth, rather than only at the cell lip.

A secondary cause of reduced water effectiveness is the velocity at which the wash water is added. If the wash water is added too forcefully, then the area of effective washing will be greatly diminished, i.e. the cone of effective washing does not start at the surface, but at a point in the froth where the water velocity is slow enough to be dispersed. Heavier-laden froths tend to spread wash water out faster than lightly loaded froths, thus wash water needs to be added more gently to lightly loaded froths. If wash water is added too forcefully, a jet of water will penetrate the froth rather than dispersing within the froth and replacing the pulp water that makes up the bubbles. When this happens, the effectiveness of the wash water is mostly due to the increased bubble coalescence from the forceful water. As a general guideline, wash water needs to be added as gently as possible; however, as water is added more gently, the froth residence time needed for adequate water drainage increases. Hence, adding wash water over the entire cell is preferential to adding it only to the lip.

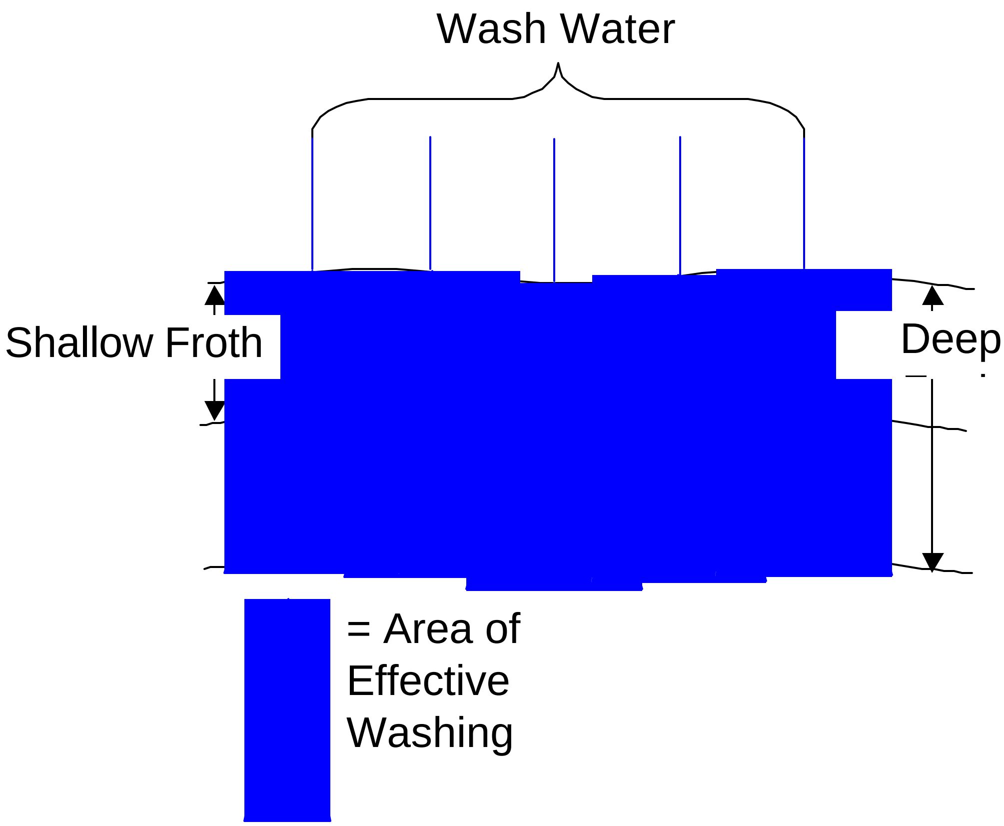


Figure 3.35 - Area of effective froth washing.

<u>3.6 - Plant 2</u>

3.6.1 - Background

At Plant 2 the flotation system includes two five cell banks. The feed is split into two fractions by a T in the piping. The feed to the system is fed at very high percent solids (45%) and is diluted with plant water to bring the feed to below 20 percent. The amount of dilution water added is controlled by valves entering each feed box. The two banks do not seem to have the same feed amounts or characteristics. The recovery from each bank tends to be different as well. The froth characteristics are different from cell to cell as well as bank to bank. Some cells will be heavily loaded on one side, while the corresponding cells on the other bank will have different froth loading. When the two sides were tested to quantify the residence time the two banks showed a lack of balance in flow as well as high variability in residence time.

Besides the distribution and residence time problems, the banks had various mechanical problems. Other problems included a lack of response to frother and diesel addition rates. All of these problems indicated that the froth cells were overloaded and adding a wash water system would have a far greater impact on recovery than on cleaning the froth product. Because the froth product ash ranged between 9 and 18%, even though previous release analysis showed a >90% recovery at ash values less than 5%, there was great incentive to find a solution. For this reason a two staged flotation system study was conducted.

3.6.2 - Plant Conventional

The following tests were conducted to see what kind of effects various chemical addition rates had on the recovery of the system. The tests are summarized here in Table 3.20. Due to the location of the feed sample port, the effects of dilution water are not seen in the feed percent solids. The actual feed percent solids for all of the tests with dilution water added are lower than reported, no good method for collecting feed percent solids information was available. Unfortunately, no corresponding residence time data is available for the two test conditions, with and without dilution water.

Table 3.20 – Effects of reagent dosage and dilution water for Plant 2 froth cells.

Test #	Description	Chemicals	ml		Feed	Con	Tails
1	Normal reagen dosage	Frother	110	Ash	42.86	17.85	50.38
	Dilution water added	Kerosene	150	% Solids	24.34	31.46	9.35
2		Frother	110	Ash	42.25	17.68	50.72
	Dilution water added	Kerosene	196	% Solids	24.12	30.61	9.38
3		Frother	132	Ash	43.36	17.94	47.89
	Dilution water added	Kerosene	150	% Solids	23.61	30.2	10.35
4		Frother	150	Ash	42.4	17.36	75.84
	No dilution water added	Kerosene	150	% Solids	24.09	33.87	10.33

Test #	Description	Yeild	Cumbustible Recovery	Froth depth (in.)
1	Normal reagent dosage	23.12	33.24	3
	Dilution water added			
2	Dilution water added	25.64	36.54	3
3	Dilution water added	15.13	21.91	3
4	No dilution water added	57.18	82.04	8

As mentioned earlier in section 3.5.1, the froth cells at Plant 2 are very unreactive to variation in frother and kerosene addition for certain feed conditions. This information coupled with the fourth test where the dilution water was eliminated, indicates that the froth cells are overloaded. Often the first cell would be unreactive to any changes made to the system, and no froth would form, indicating that the first cell was acting more like a conditioner than a froth cell greatly reducing the effective residence time. Normally reducing the amount of dilution water would decrease the recovery of the system, as well increase the product ash; however, in this case the opposite effect was seen.

3.6.3 - Two Stage Float

3.6.3.1 - Two Stage Float Experimental

For this study a combined concentrate sample was collected Table 3.21. All work was done from this sample, rather than from fresh feed. This was done to keep from biasing the first stage results. The froth product sample was split via a slurry splitter into five equal samples. Each sample was then diluted with water and floated using a two-liter laboratory flotation cell. The target dilution rates were 5, 10, 15, and 20% solids, however actual tests produce feeds of the following percent solid ratios: 4.2, 8.8, 13.1, and 17.3. The purpose of this testing was to show what kind of product could be obtained while maintaining good recovery.

Table 3.21 – Plant performance for corresponding test samples.

USX Product Run

	Ash	% Solids	Yield	Combustible Recovery
Feed	47.03	37.78	51.5	87.9
Con.	9.535	22.31		
Tails	86.81	9.9		

The tests conducted as follows: Each sample was conditioned for one minute after one drop of frother was added, and before any air was added to the system. The air was then added to the cell and product was paddled off as rapidly as it was produced. Care was taken that the froth paddled off of the cell did not contain any pulp; this was to minimize any clay entrainment. The product sample was divided by how much time was used in making the product. For all samples other than the 4.2 percent solids dilution, times of 1, 2, 3, and 5 minutes were used as the demarcation times. For the 4.2 percent solids dilution product was grouped by half-minute intervals, through one and a half minutes and the final product sample at 3 minutes.

3.6.3.2 - Two Stage Float Results

All of the tests produced recoveries above 93% by three minutes of residence time, and over 99% by 5 minutes as shown in Figure 3.36. Because all of the coal in this second stage of flotation had already been floated, the coal floated quickly. This also explains the high recovery in the second stage of flotation.

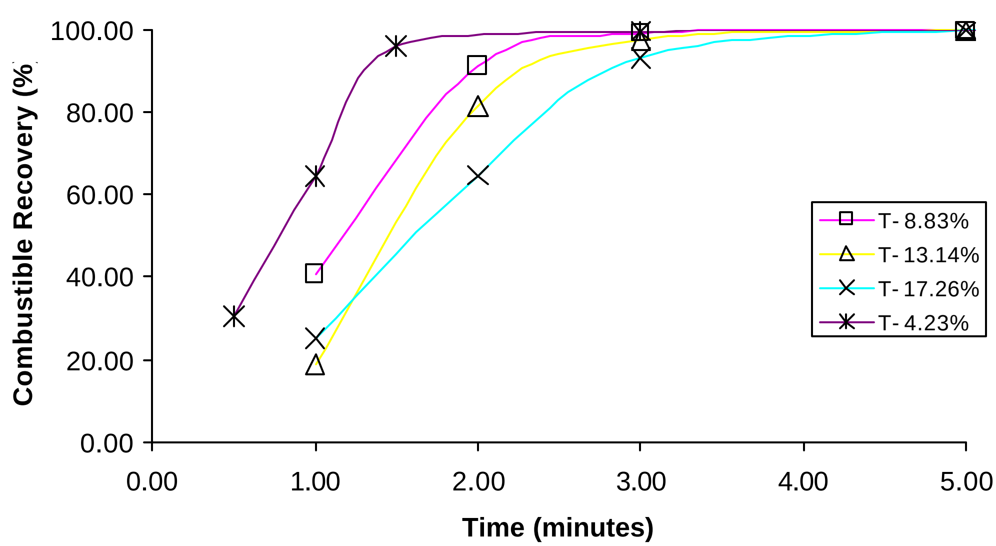


Figure 3.36 - Effect of time on recovery for various repulped % solids.

Each one of the second stages of flotation tests provided excellent reduction in ash. The ash reduction ranged from 3.8 points (41%) for 17.3% solids, and 4.9 points (53%) for the 4.2% solids dilution, Figure 3.37. When compared to the ash reduction from froth washing, this method is far superior in effectiveness. The drawback from this method is the extra capital and floor space required to install two flotation banks. A second drawback is the overall coal recovery is lower for a two-stage flotation circuit than a single stage (Table 3.22).

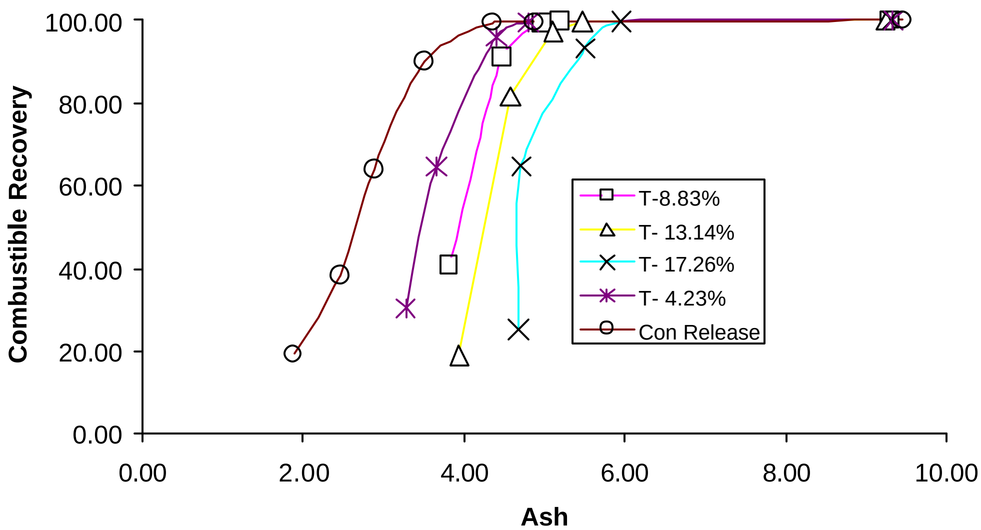


Figure 3.37 – Comparison of repulped % solids on ash and recovery.

Table 3.22 – Comparison of recovery and expected product ash

	Conventional	Conventional	Conventional	Collumn Cell
Number of Stages	1	2	2	1
Notes	existing cells	17% solids	8.8% solids	expected performance
Recovery per stage (%)	87	93	99	90
Total system recovery (%)	87	80.9	86.1	90
Expected product ash	9.5	4.9	4.7	4.2

3.6.3.3 - Two Stage Float Discussion.

Several conclusions can be drawn from this series of tests. The first conclusion is that as dilution water increases the product quality approaches that of release analysis. This is because the concentration of clays in the pulp decreases with increasing dilution. All of the clays recovered are from hydraulic entrainment.

The second conclusion that can be drawn is that as dilution is increased the time required to recover the same amount of coal decreases. This is partly due to increased air to coal particle ratio, increasing the probability of coal attaching to bubbles. However as dilution rate increases so does the volumetric flow rate through the cells. So there is a trade off between quicker recovery rates and decreased residence time.

The third conclusion that can be drawn from these tests is similar to the first: that the selectivity of the circuit increases with increasing dilution. This very simply put means that as dilution of clay in the pulp is increased, hydraulic entrainment is decreased, decreasing the recovery of clay. Selectivity is the recovery of desired material over recovery of gangue. Figure 3.38 shows that as residence time is increased selectivity is increased. This trend would continue only until all of the coal is recovered. Also the rate at which selectivity increases grows as dilution is increased. These effects are amplified when looking at the total system, as shown in Figure 3.39. Note that the expected selectivity for a column flotation cell is similar to the selectivity of the high dilution scenario, however it takes half of the residence time that the two-stage flotation system does.

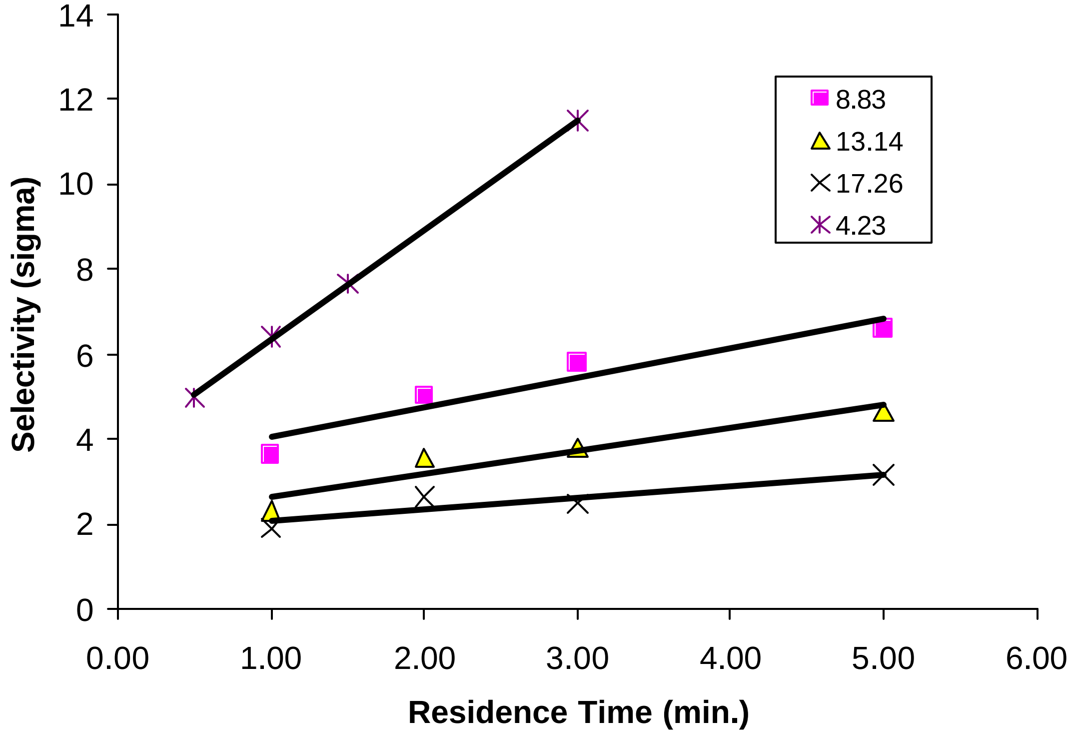


Figure 3.38 - The relationship of residence time and selectivity for various repulping % solids.

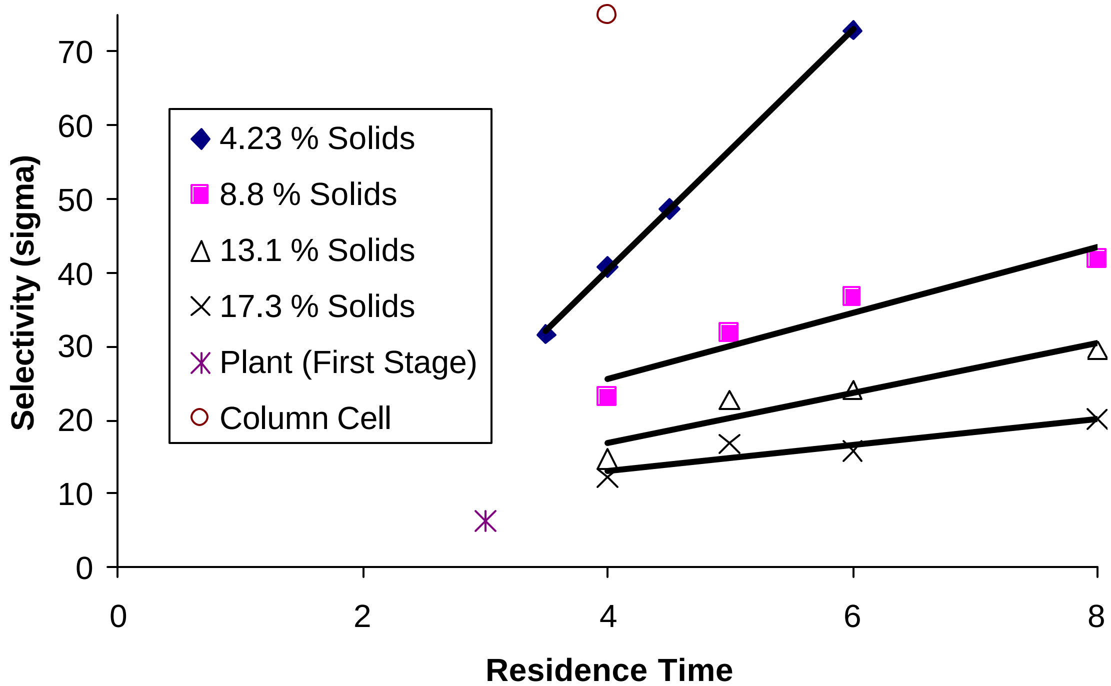


Figure 3.39 – Total system selectivity vs. cumulative residence time.

Chapter 4

CONCLUSIONS

Wash water systems like the system installed at Plant 1 provide an inexpensive solution to reducing hydraulic entrainment in conventional froth flotation systems. This study has shown that reductions in ash by one percentage point can be achieved through this system. Critical to the operation of these systems are the following:

Ample residence time (above 6 minutes)

Bias flow of wash water (1.2-1.4 preferred)

Wash water should be added in a gentle manner

Even wash water distribution

As deep a froth as can be run and still be stable enough for recovery over 90%

Only enough frother to produce a stable froth

Feed that does not have a high coarse fraction (>48 Mesh)

Even with all of the above parameters optimized, the wash water system **does not compete** with either two stages of flotation or column cell flotation for comparing performance to release analysis.

Two stage flotation systems can achieve high degrees of cleaning approaching that of column cells and even release analysis if the second stage is diluted to the five percent solids range. Drawbacks include potential loss of recovery when compared to column cells and a guaranteed loss of recovery to single stage conventional flotation.

Chapter 5

FUTURE WORK

Due to the high current capacity at Plant 1, a two-stage system should be investigated. Use the primary cells as roughers, add a sump and pump for the collection and redistribution of the first stage froth product to the secondary cells. This would provide greater cleaning capability than currently available with the wash water system.

A second area to be tested at the Plant 1 site is adding a wash water system that covers the entire froth cell coupled with a deeper froth, on the order of 2-3ft. Both of these modifications would be possible due to the excess capacity in that system.

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APPENDIX

Test	1-A		Description No wash water on cells				
Coal	100% Powellton						
Plant Feed	2000						

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	260	320	14.85	***	No
Secondary	0.5	0	0	10	***	No

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	30.30	13.2	126.9	3674	75.58	97.16
Con	10.39	26.5	95.9	1346		
Tails	91.89	3.8	31.0	3222		
Cell 1	8.46	29.2	54.0	685		
Cell 2	11.53	24.9	35.8	536		
Cell 3	21.68	18.4	4.4	90		
Cell 4	32.16	16.2	1.1	27		
Cell 5	44.73	14.7	0.5	14		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	29.54	11.5	126.4	4219	76.66	97.40
Con	10.48	26.5	96.9	1358		
Tails	92.14	4.0	29.5	2861		
Cell 1	8.28	29.3	55.3	698		
Cell 2	11.32	25.0	35.5	531		
Cell 3	21.59	18.4	4.4	89		
Cell 4	32.10	16.2	1.1	27		
Cell 5	44.69	14.7	0.5	14		

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water Measured or Calculated Value — 1/3

Test 1-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	30.30	10.39	91.89	8.46	11.53	21.68	32.16	44.73
Mass (tph):								
Total	126.91	95.91	31.00	54.04	35.79	4.39	1.15	0.55
Ash (tph):								
Total	38.45	9.97	28.48	4.57	4.13	0.95	0.37	0.25
Percent Solids:	13.17	26.50	3.76	29.19	24.92	18.37	16.18	14.74
Solid SG:	1.53	1.35	2.58	1.34	1.36	1.45	1.55	1.69
Flow Rate:								
Slurry (tph)	963.57	362.00	825.18	185.13	143.62	23.92	7.08	3.73
Liquid (tph)	836.66	266.09	794.19	131.09	107.83	19.53	5.93	3.18
Slurry (gpm)	3674.42	1346.29	3221.75	685.09	535.79	90.13	26.67	13.99
Liquid (gpm)	3346.63	1064.35	3176.74	524.38	431.32	78.10	23.74	12.71

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	29.54	10.48	92.14	8.28	11.32	21.59	32.10	44.69
Mass (tph):								
Total	126.36	96.87	29.49	55.28	35.55	4.35	1.14	0.55
Ash (tph):								
Total	37.32	10.15	27.17	4.58	4.02	0.94	0.37	0.24
Percent Solids:	11.49	26.52	4.02	29.31	25.00	18.38	16.19	14.74
Solid SG:	1.52	1.36	2.59	1.34	1.36	1.45	1.55	1.69
Flow Rate:								
Slurry (tph)	1099.33	365.25	734.08	188.61	142.21	23.68	7.04	3.71
Liquid (tph)	972.98	268.38	704.59	133.33	106.66	19.32	5.90	3.17
Slurry (gpm)	4219.39	1358.14	2861.26	697.90	530.54	89.22	26.53	13.94
Liquid (gpm)	3891.90	1073.53	2818.38	533.31	426.64	77.30	23.61	12.66

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water — Percentage Change in Measured or Calculated Value — 2/3

Test 1-A

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	-2.51	0.83	0.28	-2.11	-1.85	-0.43	-0.17	-0.09
Mass (tph):								
Total	-0.44	1.00	-4.87	2.31	-0.67	-0.95	-0.47	-0.35
Ash (tph):								
Total	-2.93	1.84	-4.60	0.15	-2.51	-1.37	-0.64	-0.44
Percent Solids:	-12.73	0.10	6.94	0.42	0.31	0.07	0.04	0.01
Solid SG:	-0.50	0.05	0.29	-0.10	-0.12	-0.06	-0.04	-0.03
Flow Rate:								
Slurry (tph)	14.09	0.90	-11.04	1.88	-0.98	-1.01	-0.51	-0.36
Liquid (tph)	*16.29*	0.86	-11.28	1.70	-1.08	-1.03	-0.52	-0.36
Slurry (gpm)	14.83	0.88	-11.19	1.87	-0.98	-1.01	-0.51	-0.36
Liquid (gpm)	*16.29*	0.86	-11.28	1.70	-1.08	-1.03	-0.52	-0.36

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00
Mass (tph):								
Total	***	***	***	2.00	2.00	2.00	2.00	2.00
Ash (tph):								
Total	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water | Weighted Sum-of-Squares | 3/3

Test 1-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Total WSSQ
Ash (% stream):									
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):									
Total	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):									
Total	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Solid SG:	***	***	***	***	***	***	***	***	***
Flow Rate:									
Slurry (tph)	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***	***
									0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Total	46.07	80.85	89.12	91.28	92.14	***	***	
Mass (tph):								
Total	71.08	35.53	31.18	30.04	29.49	0.00	0.00	
Ash (tph):								
Total	32.75	28.72	27.78	27.42	27.17	0.00	0.00	
Percent Solids:	7.80	4.62	4.19	4.07	4.02	***	***	
Solid SG:	1.71	2.30	2.50	2.56	2.59	***	***	
Flow Rate:								
Slurry (tph)	910.73	768.52	744.84	737.80	734.08	0.00	0.00	
Liquid (tph)	839.65	732.99	713.66	707.76	704.59	0.00	0.00	
Slurry (gpm)	3521.50	2990.95	2901.73	2875.20	2861.26	0.00	0.00	*
Liquid (gpm)	3358.60	2931.95	2854.65	2831.04	2818.38	0.00	0.00	*

Mass Balance For Froth Cells By Size								
Plant 1	Measured or Calculated Value							1/6
No Wash Water	Feed	Clean	Reject	Clean #1	Clean #2	Clean #3	Clean #4	Clean #5
Test 1-A	F1	C1-C5	R5	C1	C2	C3	C4	C5
Mass (% stream):								
Plus 48 M	2.80	3.08	0.34	2.66	2.62	1.48	1.30	0.94
48 x 65 M	7.18	9.18	0.26	9.20	8.40	3.86	2.94	1.46
65 x 100 M	12.36	14.16	0.42	16.72	12.26	7.16	4.24	2.34
100 x 325 M	39.48	46.84	13.64	47.02	44.68	36.40	29.24	21.12
Minus 325 M	38.18	26.74	85.34	24.40	32.04	51.10	62.28	74.14
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ash (% stream):								
Plus 48 M	5.89	2.97	58.35	2.44	3.56	6.86	12.07	16.87
48 x 65 M	5.04	3.84	74.49	2.61	4.83	12.43	24.03	37.31
65 x 100 M	5.75	3.85	83.78	2.88	5.42	14.21	33.44	46.56
100 x 325 M	16.83	6.41	92.90	4.09	7.19	20.49	39.06	63.48
Minus 325 M	56.72	24.25	92.25	22.82	21.66	24.52	29.54	39.78
Total	29.54	10.48	92.14	8.28	11.32	21.59	32.10	44.69
Mass (tph):								
Plus 48 M	3.54	2.98	0.10	1.47	0.93	0.06	0.01	0.01
48 x 65 M	9.07	8.89	0.08	5.09	2.99	0.17	0.03	0.01
65 x 100 M	15.62	13.72	0.12	9.24	4.36	0.31	0.05	0.01
100 x 325 M	49.89	45.37	4.02	25.99	15.88	1.58	0.33	0.12
Minus 325 M	48.24	25.90	25.17	13.49	11.39	2.22	0.71	0.41
Total	126.36	96.87	29.49	55.28	35.55	4.35	1.14	0.55
Ash (tph):								
Plus 48 M	0.21	0.09	0.06	0.04	0.03	0.00	0.00	0.00
48 x 65 M	0.46	0.34	0.06	0.13	0.14	0.02	0.01	0.00
65 x 100 M	0.90	0.53	0.10	0.27	0.24	0.04	0.02	0.01
100 x 325 M	8.40	2.91	3.74	1.06	1.14	0.32	0.13	0.07
Minus 325 M	27.36	6.28	23.22	3.08	2.47	0.55	0.21	0.16
Total	37.32	10.15	27.17	4.58	4.02	0.94	0.37	0.24
Percent Solids:	11.49	26.52	4.02	29.31	25.00	18.38	16.19	14.74
Solid SG:	1.52	1.36	2.59	1.34	1.36	1.45	1.55	1.69
Flow Rate:								
Slurry (tph)	1099	365	734	188.6	142.2	23.7	7.0	3.7
Liquid (tph)	973	268	705	133.3	106.7	19.3	5.9	3.2
Slurry (gpm)	4219	1358	2861	697.9	530.5	89.2	26.5	13.9
Liquid (gpm)	3892	1074	2818	533.3	426.6	77.3	23.6	12.7

Mass Balance For Froth Cells By Size								
Plant 1	Estimated or Calculated Value							2/6
No Wash Water	Feed	Clean	Reject	Clean #1	Clean #2	Clean #3	Clean #4	Clean #5
Test 1-A	F1	C1-C5	R5	C1	C2	C3	C4	C5
Mass (% stream):								
Plus 48 M	2.27	2.82	0.46	2.97	2.81	1.66	1.34	0.95
48 x 65 M	6.82	8.80	0.33	9.47	8.66	3.88	2.95	1.48
65 x 100 M	11.33	14.60	0.58	16.96	12.36	7.18	4.24	2.34
100 x 325 M	37.95	45.09	14.52	46.51	44.79	36.59	29.34	21.18
Minus 325 M	41.63	28.70	84.11	24.10	31.38	50.70	62.13	74.04
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ash (% stream):								
Plus 48 M	5.72	3.04	59.10	2.43	3.55	6.86	12.07	16.87
48 x 65 M	4.63	3.82	75.08	2.68	4.98	12.47	24.11	37.35
65 x 100 M	5.05	4.09	84.60	2.90	5.46	14.23	33.47	46.57
100 x 325 M	14.10	6.37	92.96	4.18	7.37	20.74	39.24	63.56
Minus 325 M	55.64	22.94	92.30	22.87	21.71	24.42	29.45	39.74
Total	29.54	10.48	92.14	8.28	11.32	21.59	32.10	44.69
Mass (tph):								
Plus 48 M	2.87	2.73	0.14	1.64	1.00	0.07	0.02	0.01
48 x 65 M	8.62	8.52	0.10	5.23	3.08	0.17	0.03	0.01
65 x 100 M	14.31	14.14	0.17	9.37	4.39	0.31	0.05	0.01
100 x 325 M	47.96	43.68	4.28	25.71	15.92	1.59	0.33	0.12
Minus 325 M	52.60	27.80	24.80	13.32	11.16	2.21	0.71	0.41
Total	126.36	96.87	29.49	55.28	35.55	4.35	1.14	0.55
Ash (tph):								
Plus 48 M	0.16	0.08	0.08	0.04	0.04	0.00	0.00	0.00
48 x 65 M	0.40	0.33	0.07	0.14	0.15	0.02	0.01	0.00
65 x 100 M	0.72	0.58	0.14	0.27	0.24	0.04	0.02	0.01
100 x 325 M	6.76	2.78	3.98	1.08	1.17	0.33	0.13	0.07
Minus 325 M	29.27	6.38	22.89	3.05	2.42	0.54	0.21	0.16
Total	37.32	10.15	27.17	4.58	4.02	0.94	0.37	0.24
Percent Solids:	11.49	26.52	4.02	29.31	25.00	18.38	16.19	14.74
Solid SG:	1.52	1.36	2.59	1.34	1.36	1.45	1.55	1.69
Flow Rate:								
Slurry (tph)	1099	365	734	188.6	142.2	23.7	7.0	3.7
Liquid (tph)	973	268	705	133.3	106.7	19.3	5.9	3.2
Slurry (gpm)	4219	1358	2861	697.9	530.5	89.2	26.5	13.9
Liquid (gpm)	3892	1074	2818	533.3	426.6	77.3	23.6	12.7

Mass Balance For Froth Cells By Size								
Plant 1	Percentage Change in Measured or Calculated Value							3/6
No Wash Water	Feed	Clean	Reject	Clean #1	Clean #2	Clean #3	Clean #4	Clean #5
Test 1-A	F1	C1-C5	R5	C1	C2	C3	C4	C5
Mass (% stream):								
Plus 48 M	*-18.98*	-8.51	*36.62*	11.48	7.14	11.86	3.17	1.33
48 x 65 M	-5.02	-4.18	*26.89*	2.88	3.07	0.41	0.30	1.60
65 x 100 M	-8.36	3.10	*38.01*	1.41	0.84	0.29	0.01	0.10
100 x 325 M	-3.86	-3.73	6.43	-1.07	0.25	0.51	0.34	0.30
Minus 325 M	9.04	7.32	-1.44	-1.23	-2.06	-0.78	-0.24	-0.14
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash (% stream):								
Plus 48 M	-2.96	2.24	1.28	-0.42	-0.37	-0.04	-0.01	-0.01
48 x 65 M	-8.18	-0.44	0.79	2.76	3.08	0.35	0.35	0.10
65 x 100 M	-12.10	6.29	0.98	0.84	0.72	0.12	0.09	0.02
100 x 325 M	*-16.20*	-0.57	0.07	2.30	2.45	1.20	0.45	0.13
Minus 325 M	-1.89	-5.40	0.06	0.25	0.20	-0.40	-0.31	-0.10
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):								
Plus 48 M	*-18.98*	-8.51	*36.62*	11.48	7.14	11.86	3.17	1.33
48 x 65 M	-5.02	-4.18	*26.89*	2.88	3.07	0.41	0.30	1.60
65 x 100 M	-8.36	3.10	*38.01*	1.41	0.84	0.29	0.01	0.10
100 x 325 M	-3.86	-3.73	6.43	-1.07	0.25	0.51	0.34	0.30
Minus 325 M	9.04	7.32	-1.44	-1.23	-2.06	-0.78	-0.24	-0.14
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):								
Plus 48 M	*-21.37*	-6.46	*38.37*	11.01	6.75	11.81	3.16	1.32
48 x 65 M	-12.79	-4.61	*27.90*	5.72	6.24	0.76	0.64	1.71
65 x 100 M	*-19.45*	9.59	*39.36*	2.26	1.56	0.41	0.11	0.13
100 x 325 M	*-19.43*	-4.28	6.50	1.20	2.71	1.72	0.79	0.43
Minus 325 M	6.98	1.52	-1.39	-0.98	-1.86	-1.18	-0.55	-0.24
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Solids:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid SG:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate:								
Slurry (tph)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (tph)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slurry (gpm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mass Balance For Froth Cells By Size								
Plant 1	Relative Error in Measured Value							4/6
No Wash Water	Feed	Clean	Reject	Clean #1	Clean #2	Clean #3	Clean #4	Clean #5
Test 1-A	F1	C1-C5	R5	C1	C2	C3	C4	C5
Mass (% stream):								
Plus 48 M	1.00	1.00	5.00	1.00	1.00	5.00	5.00	5.00
48 x 65 M	1.00	1.00	5.00	1.00	1.00	1.00	1.00	5.00
65 x 100 M	1.00	1.00	5.00	1.00	1.00	1.00	1.00	1.00
100 x 325 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Minus 325 M	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total	***	***	***	***	***	***	***	***
Ash (% stream):								
Plus 48 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
48 x 65 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
65 x 100 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100 x 325 M	1.00	1.00	0.10	1.00	1.00	1.00	1.00	1.00
Minus 325 M	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total	***	***	***	***	***	***	***	***
Mass (tph):								
Plus 48 M	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***
Total	***	***	***	1.00	1.00	1.00	1.00	1.00
Ash (tph):								
Plus 48 M	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***
Total	***	***	***	***	***	***	***	***
Percent Solids:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells By Size								
Plant 1	Weighted Sum-of-Squares							5/6
No Wash Water	Feed	Clean	Reject	Clean #1	Clean #2	Clean #3	Clean #4	Clean #5
Test 1-A	F1	C1-C5	R5	C1	C2	C3	C4	C5
Mass (% stream):								
Plus 48 M	0.04	0.01	0.01	0.01	0.01	0.00	0.00	0.00
48 x 65 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65 x 100 M	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
100 x 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	***	***	***	***	***	***	***	***
Ash (% stream):								
Plus 48 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48 x 65 M	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65 x 100 M	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100 x 325 M	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	***	***	***	***	***	***	***	***
Mass (tph):								
Plus 48 M	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***
Total	***	***	***	0.00	0.00	0.00	0.00	0.00
Ash (tph):								
Plus 48 M	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***
Total	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells By Size
Plant 1

6/6

No Wash Water Test 1-A	Total WSSQ	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B
Mass (% stream):								
Plus 48 M	0.07	1.73	0.65	0.50	0.47	0.46	***	***
48 x 65 M	0.01	4.76	0.86	0.44	0.35	0.33	***	***
65 x 100 M	0.01	6.95	1.53	0.74	0.61	0.58	***	***
100 x 325 M	0.01	31.30	17.79	15.17	14.63	14.51	***	***
Minus 325 M	0.00	55.27	79.17	83.14	83.94	84.12	***	***
Total	***	100.00	100.00	100.00	100.00	100.00	***	***
Ash (% stream):								
Plus 48 M	0.00	10.11	38.64	53.18	57.61	59.16	***	***
48 x 65 M	0.01	7.64	34.25	60.75	72.48	75.43	***	***
65 x 100 M	0.02	9.13	38.85	72.11	82.32	85.02	***	***
100 x 325 M	0.03	25.57	71.43	88.49	92.23	93.01	***	***
Minus 325 M	0.00	66.76	84.63	89.75	91.45	92.29	***	***
Total	***	46.07	80.85	89.12	91.28	92.14	***	***
Mass (tph):								
Plus 48 M	***	1.23	0.23	0.16	0.14	0.14	0.00	0.00
48 x 65 M	***	3.38	0.31	0.14	0.10	0.10	0.00	0.00
65 x 100 M	***	4.94	0.54	0.23	0.18	0.17	0.00	0.00
100 x 325 M	***	22.24	6.32	4.73	4.40	4.28	0.00	0.00
Minus 325 M	***	39.28	28.13	25.92	25.21	24.81	0.00	0.00
Total	0.00	71.08	35.53	31.18	30.04	29.49	0.00	0.00
Ash (tph):								
Plus 48 M	***	0.12	0.09	0.08	0.08	0.08	0.00	0.00
48 x 65 M	***	0.26	0.11	0.08	0.08	0.07	0.00	0.00
65 x 100 M	***	0.45	0.21	0.17	0.15	0.14	0.00	0.00
100 x 325 M	***	5.69	4.52	4.19	4.05	3.98	0.00	0.00
Minus 325 M	***	26.22	23.80	23.26	23.05	22.89	0.00	0.00
Total	***	32.75	28.72	27.78	27.42	27.17	0.00	0.00
Percent Solids:	0.00	7.80	4.62	4.19	4.07	4.02	***	***
Solid SG:	***	1.71	2.30	2.50	2.56	2.59	***	***
Flow Rate:								
Slurry (tph)	***	911	769	745	738	734	0.00	0.00
Liquid (tph)	***	840	733	714	708	705	0.00	0.00
Slurry (gpm)	0.00	3521	2991	2902	2875	2861	0.00	0.00
Liquid (gpm)	***	3359	2932	2855	2831	2818	0.00	0.00
	0.15							

Test	1-B		Description With Wash Water on last 3 cells				
Coal	Powellton						
Plant Feed	2000						

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	260	320	14.85	***	Yes
Secondary	0.5	0	0	10	***	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	31.23	13.2	137.4	3972	***	73.81	96.37
Con	10.21	24.0	101.4	1586	450		
Tails	90.46	3.5	36.0	4003	***		
Cell 1	9.68	27.1	55.5	760	0		
Cell 2	11.30	23.5	37.7	599	0		
Cell 3	17.79	13.8	6.1	168	150		
Cell 4	24.24	10.3	1.7	62	150		
Cell 5	30.02	6.4	0.6	34	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	30.08	11.2	135.9	4657	***	74.80	95.80
Con	10.45	23.7	101.6	1610	450		
Tails	88.36	3.8	34.3	3497	***		
Cell 1	8.97	27.4	56.1	760	0		
Cell 2	10.66	23.7	37.5	592	0		
Cell 3	17.52	13.8	5.9	163	150		
Cell 4	24.06	10.3	1.6	61	150		
Cell 5	29.92	6.4	0.6	34	150		

Mass Balance for Froth Cells Using Complete Streams

Plant 1 Measured or Calculated Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	31.23	10.21	90.46	85.00	9.68	11.30	17.79	24.24	30.02	0.00	0.00	85.00	85.00	85.00
Mass (tph):														
Total	137.42	101.43	36.02	0.03	55.51	37.65	6.05	1.66	0.56	0.000	0.000	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	42.91	10.36	32.58	0.03	5.37	4.25	1.08	0.40	0.17	0.00	0.00	0.01	0.01	0.01
Percent Solids:	13.18	23.96	3.52	0.027	27.13	23.54	13.77	10.33	6.43	0.000	0.000	0.027	0.027	0.027
Solid SG:	1.54	1.35	2.54	2.40	1.35	1.36	1.42	1.47	1.53	1.28	1.28	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	1042	423	1023	113	204.61	159.93	43.93	16.07	8.72	0.00	0.00	37.54	37.54	37.54
Liquid (tph)	905	322	987	113	149.10	122.28	37.88	14.41	8.16	0.00	0.00	37.53	37.53	37.53
Slurry (gpm)	3972	1586	4003	450	760.29	599.16	168.46	62.08	34.08	0.00	0.00	150.00	150.00	150.00
Liquid (gpm)	3619	1288	3950	450	596.42	489.14	151.52	57.63	32.65	0.00	0.00	150.12	150.12	150.12

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	30.08	10.45	88.36	88.36	8.97	10.66	17.52	24.06	29.92	88.36	88.36	88.36	88.36	88.36
Mass (tph):														
Total	135.88	101.64	34.27	0.03	56.08	37.48	5.88	1.64	0.56	0.000	0.000	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	40.87	10.62	30.28	0.03	5.03	3.99	1.03	0.39	0.17	0.000	0.000	0.009	0.009	0.009
Percent Solids:	11.21	23.66	3.83	0.027	27.43	23.72	13.81	10.34	6.44	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.36	2.48	2.48	1.34	1.36	1.41	1.47	1.53	2.48	2.48	2.48	2.48	2.48
Flow Rate:														
Slurry (tph)	1213	430	896	113	204.41	158.05	42.59	15.83	8.64	0.00	0.00	37.54	37.54	37.54
Liquid (tph)	1077	328	861	113	148.33	120.57	36.71	14.19	8.09	0.00	0.00	37.53	37.53	37.53
Slurry (gpm)	4657	1610	3497	450	759.55	592.22	163.34	61.16	33.78	0.00	0.00	149.99	149.99	150.01
Liquid (gpm)	4307	1312	3446	450	593.31	482.27	146.84	56.77	32.35	0.00	0.00	150.12	150.12	150.13

Mass Balance for Froth Cells Using Complete Streams

Plant 1 Percentage Change in Measured or Calculated Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-3.66	2.32	-2.32	3.95	-7.25	-5.64	-1.48	-0.74	-0.32	0.00	0.00	3.95	3.95	3.95
Mass (tph):														
Total	-1.12	0.21	-4.84	0.00	1.03	-0.44	-2.76	-1.41	-0.68	0.00	0.00	-0.01	-0.01	0.00
Ash (tph):														
Minus 325 M	-4.74	2.53	-7.05	3.95	-6.30	-6.06	-4.20	-2.14	-1.00	0.00	0.00	3.94	3.94	3.95
Percent Solids:	*-15.01*	-1.24	8.73	0.00	1.13	0.74	0.29	0.08	0.22	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.75	0.14	-2.24	3.59	-0.41	-0.37	-0.16	-0.11	-0.06	*94.50*	*94.50*	3.59	3.59	3.59
Flow Rate:														
Slurry (tph)	*16.34*	1.46	-12.49	0.00	-0.10	-1.18	-3.04	-1.49	-0.90	0.00	0.00	-0.01	-0.01	0.00
Liquid (tph)	*18.99*	1.85	-12.76	0.00	-0.52	-1.40	-3.09	-1.50	-0.92	0.00	0.00	-0.01	-0.01	0.00
Slurry (gpm)	*17.26*	1.52	-12.62	0.00	-0.10	-1.16	-3.04	-1.49	-0.90	0.00	0.00	-0.01	-0.01	0.00
Liquid (gpm)	*18.99*	1.85	-12.76	0.00	-0.52	-1.40	-3.09	-1.50	-0.92	0.00	0.00	-0.01	-0.01	0.00

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	2.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.01	0.01	50.00	50.00	50.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance for Froth Cells Using Complete Streams
Plant 1 Weighted Sum-of-Squares

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	***	***	***	***	***	0.02
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.02

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	44.91	75.25	84.58	87.42	88.36	***	***	
Mass (tph):								
Total	79.80	42.32	36.45	34.82	34.27	0.00	0.00	
Ash (tph):								
Minus 325 M	35.84	31.85	30.82	30.44	30.28	0.00	0.00	
Percent Solids:	7.92	4.98	4.31	4.02	3.83	***	***	
Solid SG:	1.70	2.18	2.39	2.46	2.48	***	***	
Flow Rate:								
Slurry (tph)	1008	850	845	867	896	0.00	0.00	
Liquid (tph)	928	808	809	832	861	0.00	0.00	
Slurry (gpm)	3898	3306	3292	3381	3497	0.00	0.00	x
Liquid (gpm)	3713	3231	3234	3328	3446	0.00	0.00	x

Mass Balance for Froth Cells By Size
Plant 1

Measured or Calculated Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Mass (% stream):														
Plus 48 M	2.34	3.08	0.56	0.00	2.62	2.68	1.50	1.50	1.26	0.00	0.00	0.00	0.00	0.00
48 x 65 M	7.28	9.04	0.36	0.00	9.30	7.60	4.50	2.72	1.58	0.00	0.00	0.00	0.00	0.00
65 x 100 M	10.20	12.68	0.68	0.00	16.56	13.72	7.50	4.76	2.66	0.00	0.00	0.00	0.00	0.00
100 x 325 M	39.30	45.90	14.32	1.00	45.60	40.36	36.90	29.72	36.54	0.00	0.00	1.00	1.00	1.00
Minus 325 M	40.88	29.30	84.08	99.00	25.92	35.64	49.60	61.30	57.96	0.00	0.00	99.00	99.00	99.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00
Ash (% stream):														
Plus 48 M	10.49	2.78	53.02	0.00	2.19	3.31	6.84	9.02	12.83	0.00	0.00	0.00	0.00	0.00
48 x 65 M	5.90	3.62	63.85	0.00	2.56	4.39	10.67	17.12	26.59	0.00	0.00	0.00	0.00	0.00
65 x 100 M	6.45	3.80	78.40	0.00	2.89	4.55	13.03	24.27	34.25	0.00	0.00	0.00	0.00	0.00
100 x 325 M	17.57	6.01	91.86	78.51	4.38	6.01	21.45	31.35	43.78	0.00	0.00	78.51	78.51	78.51
Minus 325 M	53.43	23.19	88.18	88.46	23.94	20.16	16.23	21.19	21.44	0.00	0.00	88.46	88.46	88.46
Total	30.08	10.45	88.36	88.36	8.97	10.66	17.52	24.06	29.92	0.00	0.00	88.36	88.36	88.36
Mass (tph):														
Plus 48 M	3.18	3.13	0.19	0.00	1.47	1.00	0.09	0.02	0.01	0.000	0.000	0.000	0.000	0.000
48 x 65 M	9.89	9.19	0.12	0.00	5.22	2.85	0.26	0.04	0.01	0.000	0.000	0.000	0.000	0.000
65 x 100 M	13.86	12.89	0.23	0.00	9.29	5.14	0.44	0.08	0.01	0.000	0.000	0.000	0.000	0.000
100 x 325 M	53.40	46.65	4.91	0.00	25.57	15.13	2.17	0.49	0.20	0.000	0.000	0.000	0.000	0.000
Minus 325 M	55.55	29.78	28.82	0.03	14.54	13.36	2.92	1.00	0.32	0.000	0.000	0.010	0.010	0.010
Total	135.88	101.64	34.27	0.03	56.08	37.48	5.88	1.64	0.56	0.000	0.000	0.010	0.010	0.010
Ash (tph):														
Plus 48 M	0.33	0.09	0.10	0.00	0.03	0.03	0.01	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48 x 65 M	0.58	0.33	0.08	0.00	0.13	0.13	0.03	0.01	0.00	0.000	0.000	0.000	0.000	0.000
65 x 100 M	0.89	0.49	0.18	0.00	0.27	0.23	0.06	0.02	0.01	0.000	0.000	0.000	0.000	0.000
100 x 325 M	9.38	2.80	4.51	0.00	1.12	0.91	0.47	0.15	0.09	0.000	0.000	0.000	0.000	0.000
Minus 325 M	29.68	6.91	25.41	0.03	3.48	2.69	0.47	0.21	0.07	0.000	0.000	0.009	0.009	0.009
Total	40.87	10.62	30.28	0.03	5.03	3.99	1.03	0.39	0.17	0.000	0.000	0.009	0.009	0.009
Percent Solids:	11.21	23.66	3.83	0.027	27.43	23.72	13.81	10.34	6.44	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.36	2.48	2.48	1.34	1.36	1.41	1.47	1.53	1.28	1.28	2.48	2.48	2.48
Flow Rate:														
Slurry (tph)	1213	430	896	113	204	158	43	16	9	0	0	38	38	38
Liquid (tph)	1077	328	861	113	148	121	37	14	8	0	0	38	38	38
Slurry (gpm)	4657	1610	3497	450	760	592	163	61	34	0	0	150	150	150
Liquid (gpm)	4307	1312	3446	450	593	482	147	57	32	0	0	150	150	150

Mass Balance for Froth Cells By Size

Plant 1 Estimated or Calculated Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Mass (% stream):														
Plus 48 M	2.76	3.16	1.60	0.04	3.13	3.57	1.53	1.50	1.26	0.00	0.00	0.04	0.04	0.04
48 x 65 M	6.44	8.38	0.80	-0.13	9.44	7.71	4.53	2.73	1.58	0.00	0.00	-0.13	-0.13	-0.13
65 x 100 M	11.07	14.68	0.59	1.15	16.47	13.66	7.49	4.76	2.66	0.00	0.00	1.15	1.15	1.15
100 x 325 M	35.70	43.23	13.87	0.91	46.00	40.62	36.96	29.74	36.55	0.00	0.00	0.91	0.91	0.91
Minus 325 M	44.03	30.55	83.14	98.04	24.96	34.44	49.50	61.27	57.95	0.00	0.00	98.04	98.04	98.04
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00
Ash (% stream):														
Plus 48 M	10.35	2.87	53.04	0.00	2.21	3.32	6.84	9.02	12.83	0.00	0.00	0.00	0.00	0.00
48 x 65 M	5.58	3.66	63.86	0.00	2.73	4.48	10.68	17.12	26.59	0.00	0.00	0.00	0.00	0.00
65 x 100 M	5.17	4.14	78.40	0.00	5.45	0.53	13.03	24.27	34.25	0.00	0.00	0.00	0.00	0.00
100 x 325 M	15.20	6.69	92.04	78.51	4.94	6.33	21.49	31.36	43.78	0.00	0.00	78.51	78.51	78.51
Minus 325 M	53.22	21.45	88.73	89.39	21.95	21.92	16.19	21.18	21.44	0.00	0.00	89.39	89.39	89.39
Total	30.08	10.45	88.36	88.36	8.97	10.66	17.52	24.06	29.92	0.00	0.00	88.36	88.36	88.36
Mass (tph):														
Plus 48 M	3.75	3.21	0.55	0.00	1.75	1.34	0.09	0.02	0.01	0.000	0.000	0.000	0.000	0.000
48 x 65 M	8.75	8.52	0.27	0.00	5.29	2.89	0.27	0.04	0.01	0.000	0.000	0.000	0.000	0.000
65 x 100 M	15.04	14.92	0.20	0.00	9.24	5.12	0.44	0.08	0.01	0.000	0.000	0.000	0.000	0.000
100 x 325 M	48.51	43.94	4.75	0.00	25.79	15.23	2.17	0.49	0.20	0.000	0.000	0.000	0.000	0.000
Minus 325 M	59.83	31.05	28.49	0.03	14.00	12.91	2.91	1.00	0.32	0.000	0.000	0.010	0.010	0.010
Total	135.88	101.64	34.27	0.03	56.08	37.48	5.88	1.64	0.56	0.000	0.000	0.010	0.010	0.010
Ash (tph):														
Plus 48 M	0.39	0.09	0.29	0.00	0.04	0.04	0.01	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48 x 65 M	0.49	0.31	0.18	0.00	0.14	0.13	0.03	0.01	0.00	0.000	0.000	0.000	0.000	0.000
65 x 100 M	0.78	0.62	0.16	0.00	0.50	0.03	0.06	0.02	0.01	0.000	0.000	0.000	0.000	0.000
100 x 325 M	7.38	2.94	4.37	0.00	1.27	0.96	0.47	0.15	0.09	0.000	0.000	0.000	0.000	0.000
Minus 325 M	31.84	6.66	25.28	0.03	3.07	2.83	0.47	0.21	0.07	0.000	0.000	0.009	0.009	0.009
Total	40.87	10.62	30.28	0.03	5.03	3.99	1.03	0.39	0.17	0.000	0.000	0.009	0.009	0.009
Percent Solids:	11.21	23.66	3.83	0.03	27.43	23.72	13.81	10.34	6.44	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.36	2.48	2.48	1.34	1.36	1.41	1.47	1.53	1.28	1.28	2.48	2.48	2.48
Flow Rate:														
Slurry (tph)	1213	430	896	113	204	158	43	16	9	0	0	38	38	38
Liquid (tph)	1077	328	861	113	148	121	37	14	8	0	0	38	38	38
Slurry (gpm)	4657	1610	3497	450	760	592	163	61	34	0	0	150	150	150
Liquid (gpm)	4307	1312	3446	450	593	482	147	57	32	0	0	150	150	150

Mass Balance for Froth Cells By Size
Plant 1

Percentage Change in Measured or Calculated Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Mass (% stream):														
Plus 48 M	*18.00*	2.60	*186.19*	0.00	*19.41*	*33.14*	2.01	0.23	-0.07	0.00	0.00	0.00	0.00	0.00
48 x 65 M	-11.57	-7.27	*122.28*	0.00	1.51	1.39	0.57	0.36	0.30	0.00	0.00	0.00	0.00	0.00
65 x 100 M	8.50	*15.79*	-12.59	0.00	-0.52	-0.43	-0.16	-0.08	-0.06	0.00	0.00	0.00	0.00	0.00
100 x 325 M	-9.16	-5.82	-3.17	-8.56	0.87	0.65	0.16	0.06	0.02	0.00	0.00	-8.56	-8.56	-8.56
Minus 325 M	7.71	4.26	-1.12	-0.97	-3.70	-3.36	-0.20	-0.05	-0.02	0.00	0.00	-0.97	-0.97	-0.97
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash (% stream):														
Plus 48 M	-1.33	3.09	0.03	0.00	0.79	0.42	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48 x 65 M	-5.45	0.97	0.01	0.00	6.62	2.03	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00
65 x 100 M	*-19.86*	9.06	0.00	0.00	*88.66*	*-88.30*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100 x 325 M	-13.46	11.24	0.20	0.00	12.81	5.32	0.22	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Minus 325 M	-0.39	-7.50	0.62	1.06	-8.31	8.73	-0.21	-0.03	-0.03	0.00	0.00	1.06	1.06	1.06
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):														
Plus 48 M	*18.00*	2.60	*186.19*	0.00	*19.41*	*33.14*	2.01	0.23	-0.07	0.00	0.00	0.00	0.00	0.00
48 x 65 M	-11.57	-7.27	*122.28*	0.00	1.51	1.39	0.57	0.36	0.30	0.00	0.00	0.00	0.00	0.00
65 x 100 M	8.50	*15.79*	-12.59	0.00	-0.52	-0.43	-0.16	-0.08	-0.06	0.00	0.00	0.00	0.00	0.00
100 x 325 M	-9.16	-5.82	-3.17	-8.56	0.87	0.65	0.16	0.06	0.02	0.00	0.00	-8.56	-8.56	-8.56
Minus 325 M	7.71	4.26	-1.12	-0.97	-3.70	-3.36	-0.20	-0.05	-0.02	0.00	0.00	-0.97	-0.97	-0.97
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):														
Plus 48 M	*16.42*	5.77	*186.29*	0.00	*20.36*	*33.70*	2.02	0.23	-0.07	0.00	0.00	0.00	0.00	0.00
48 x 65 M	*-16.39*	-6.37	*122.31*	0.00	8.23	3.45	0.65	0.37	0.30	0.00	0.00	0.00	0.00	0.00
65 x 100 M	-13.04	*26.28*	-12.59	0.00	*87.68*	*-88.36*	-0.16	-0.08	-0.06	0.00	0.00	0.00	0.00	0.00
100 x 325 M	*-21.39*	4.77	-2.98	-8.56	13.79	6.00	0.37	0.10	0.03	0.00	0.00	-8.56	-8.56	-8.56
Minus 325 M	7.29	-3.56	-0.51	0.08	-11.70	5.07	-0.41	-0.08	-0.04	0.00	0.00	0.08	0.08	0.08
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Solids:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid SG:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate:														
Slurry (tph)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (tph)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slurry (gpm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mass Balance for Froth Cells By Size
Plant 1 Relative Error in Measured Value

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Mass (% stream):														
Plus 48 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
48 x 65 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
65 x 100 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
100 x 325 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Minus 325 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Ash (% stream):														
Plus 48 M	1.00	1.00	1.00	1.00	1.00	1.00	5.00	5.00	5.00	***	***	***	***	***
48 x 65 M	1.00	1.00	1.00	1.00	1.00	1.00	5.00	5.00	5.00	***	***	***	***	***
65 x 100 M	1.00	1.00	1.00	1.00	1.00	1.00	5.00	5.00	5.00	***	***	***	***	***
100 x 325 M	1.00	1.00	1.00	1.00	1.00	1.00	5.00	5.00	5.00	***	***	***	***	***
Minus 325 M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Mass (tph):														
Plus 48 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Total	***	***	***	***	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Ash (tph):														
Plus 48 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance for Froth Cells By Size

Plant 1 Weighted Sum-of-Squares

With Wash water Test 1-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Mass (% stream):															
Plus 48 M	0.03	0.00	3.47	0.00	0.04	0.11	0.00	0.00	0.00	***	***	***	***	***	3.65
48 x 65 M	0.01	0.01	1.50	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	1.51
65 x 100 M	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.05
100 x 325 M	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.02
Minus 325 M	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Ash (% stream):															
Plus 48 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
48 x 65 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
65 x 100 M	0.04	0.01	0.00	0.00	0.79	0.78	0.00	0.00	0.00	***	***	***	***	***	1.61
100 x 325 M	0.02	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	***	***	***	***	***	0.05
Minus 325 M	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	***	***	***	***	***	0.02
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Mass (tph):															
Plus 48 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Plus 48 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
48 x 65 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
65 x 100 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
100 x 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Total	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															6.93

Mass Balance for Froth Cells By Size Plant 1

With Wash water Test 1-B	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Mass (% stream):								
Plus 48 M	2.50	1.56	1.56	1.57	1.57	***	***	
48 x 65 M	4.33	1.34	0.82	0.73	0.72	***	***	
65 x 100 M	7.27	1.61	0.66	0.46	0.43	***	***	
100 x 325 M	28.46	17.70	14.58	13.87	13.49	***	***	
Minus 325 M	57.44	77.80	82.38	83.37	83.79	***	***	
Total	100.00	100.00	100.00	100.00	100.00	***	***	
Ash (% stream):								
Plus 48 M	17.50	46.24	52.46	54.42	54.96	***	***	
48 x 65 M	9.94	37.85	62.03	69.91	71.47	***	***	
65 x 100 M	4.72	36.26	79.02	105.34	112.42	***	***	
100 x 325 M	26.87	68.62	87.91	93.61	95.80	***	***	
Minus 325 M	62.77	78.79	84.87	87.07	87.81	***	***	
Total	44.91	75.25	84.58	87.42	88.36	***	***	
Mass (tph):								
Plus 48 M	2.00	0.66	0.57	0.55	0.54	-0.01	0.01	
48 x 65 M	3.45	0.57	0.30	0.25	0.25	-0.05	0.03	
65 x 100 M	5.80	0.68	0.24	0.16	0.15	-0.09	0.06	
100 x 325 M	22.72	7.49	5.31	4.83	4.62	-0.18	0.13	
Minus 325 M	45.84	32.93	30.02	29.03	28.72	0.32	-0.22	
Total	79.80	42.32	36.45	34.82	34.27	0.00	0.00	
Ash (tph):								
Plus 48 M	0.35	0.31	0.30	0.30	0.30	0.00	0.00	
48 x 65 M	0.34	0.21	0.19	0.18	0.18	0.00	0.00	
65 x 100 M	0.27	0.25	0.19	0.17	0.17	0.00	-0.01	
100 x 325 M	6.10	5.14	4.67	4.52	4.43	0.06	-0.06	
Minus 325 M	28.77	25.94	25.48	25.28	25.22	-0.07	0.07	
Total	35.84	31.85	30.82	30.44	30.28	0.00	0.00	
Percent Solids:	7.92	4.98	4.31	4.02	3.83	***	***	
Solid SG:	1.70	2.18	2.39	2.46	2.48	***	***	
Flow Rate:								
Slurry (tph)	1008	850	845	867	896	0.00	0.00	
Liquid (tph)	928	808	809	832	861	0.00	0.00	
Slurry (gpm)	3898	3306	3292	3381	3497	0.00	0.00	x
Liquid (gpm)	3713	3231	3234	3328	3446	0.00	0.00	x

Test	2-A		Description	No wash water on cells			
Coal	80 E/20P						
Plant Feed	2000						

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	170	320	14.27	***	No
Secondary	0.5	120	0	12.38	***	No

Unbalanced

Stream	Ash %	% Solids	Mass Flow Tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	26.19	17.3	169.5	3687	76.81	94.59
Con	9.10	28.8	130.2	1674		
Tails	82.78	4.2	39.3	3627		
Cell 1	7.23	29.9	35.2	435		
Cell 2	8.82	26.9	38.7	536		
Cell 3	8.33	28.8	26.1	336		
Cell 4	12.12	23.0	24.3	396		
Cell 5	15.59	20.0	5.8	109		

Balanced

Stream	Ash %	% Solids	Mass Flow Tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	25.20	13.2	166.5	4806	78.29	95.10
Con	9.14	27.2	130.4	1784		
Tails	83.10	4.7	36.1	3023		
Cell 1	7.20	30.4	35.7	433		
Cell 2	8.76	27.4	38.7	525		
Cell 3	8.29	29.2	26.3	334		
Cell 4	12.05	23.3	23.9	385		
Cell 5	15.56	20.1	5.8	108		

Mass Balance For Froth Cells Using complete streams
Plant 1

No Wash Water — Measured or Calculated Value

Test 2-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	26.19	9.10	82.78	7.23	8.82	8.33	12.12	15.59
Mass (tph):								
Total	169.46	130.16	39.30	35.24	38.71	26.15	24.26	5.80
Ash (tph):								
Total	44.37	11.84	32.54	2.55	3.41	2.18	2.94	0.90
Percent Solids:	17.32	28.78	4.23	29.94	26.88	28.82	22.95	20.03
Solid SG:	1.49	1.34	2.34	1.33	1.34	1.34	1.37	1.40
Flow Rate:								
Slurry (tph)	979	452	930	118	144	91	106	29
Liquid (tph)	809	322	891	82	105	65	81	23
Slurry (gpm)	3687	1674	3627	435	536	336	396	109
Liquid (gpm)	3237	1289	3564	330	421	258	326	93

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	25.20	9.14	83.10	7.20	8.76	8.29	12.05	15.56
Mass (tph):								
Total	166.51	130.37	36.15	35.70	38.70	26.30	23.90	5.76
Ash (tph):								
Total	41.96	11.92	30.04	2.57	3.39	2.18	2.88	0.90
Percent Solids:	13.25	27.17	4.65	30.44	27.42	29.19	23.28	20.12
Solid SG:	1.48	1.34	2.35	1.33	1.34	1.34	1.37	1.40
Flow Rate:								
Slurry (tph)	1257	480	777	117	141	90	103	29
Liquid (tph)	1090	349	741	82	102	64	79	23
Slurry (gpm)	4806	1784	3023	433	525	334	385	108
Liquid (gpm)	4362	1398	2964	326	410	255	315	91

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water — Percentage Change in Measured or Calculated Value

Test 2-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	-3.77	0.52	0.39	-0.47	-0.62	-0.36	-0.51	-0.20
Mass (tph):								
Total	-1.74	0.16	-8.03	1.32	-0.02	0.60	-1.48	-0.77
Ash (tph):								
Total	-5.45	0.68	-7.67	0.84	-0.64	0.24	-1.99	-0.97
Percent Solids:	*-23.50*	-5.58	10.08	1.68	2.01	1.29	1.45	0.44
Solid SG:	-0.63	0.03	0.33	-0.02	-0.03	-0.02	-0.04	-0.02
Flow Rate:								
Slurry (tph)	*28.44*	6.08	*-16.46*	-0.35	-1.99	-0.68	-2.88	-1.20
Liquid (tph)	*34.76*	8.48	*-16.83*	-1.07	-2.71	-1.20	-3.30	-1.31
Slurry (gpm)	*30.35*	6.55	*-16.67*	-0.48	-2.13	-0.78	-2.97	-1.23
Liquid (gpm)	*34.76*	8.48	*-16.83*	-1.07	-2.71	-1.20	-3.30	-1.31

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00
Mass (tph):								
Total	***	***	***	2.00	2.00	2.00	2.00	2.00
Ash (tph):								
Total	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams
Plant 1

No Wash Water Weighted Sum-of-Squares

Test 2-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Total WSSQ
Ash (% stream):									
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):									
Total	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):									
Total	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Solid SG:	***	***	***	***	***	***	***	***	***
Flow Rate:									
Slurry (tph)	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***	***
									0.02

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Total	30.11	39.08	51.38	73.82	83.10	***	***	
Mass (tph):								
Total	130.81	92.11	65.81	41.91	36.15	0.00	0.00	
Ash (tph):								
Total	39.39	36.00	33.82	30.94	30.04	0.00	0.00	
Percent Solids:	11.48	9.23	7.24	5.20	4.65	***	***	
Solid SG:	1.53	1.63	1.78	2.15	2.35	***	***	
Flow Rate:								
Slurry (tph)	1140	999	908	806	777	0.00	0.00	
Liquid (tph)	1009	906	843	764	741	0.00	0.00	
Slurry (gpm)	4373	3848	3515	3130	3023	0.00	0.00	*
Liquid (gpm)	4035	3626	3370	3055	2964	0.00	0.00	*

Test	2-B	Description With Wash Water Last Three Cells			
Coal	80e/20p				
Plant Feed	2000				

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	170	320	14.85	***	Yes
Secondary	0.5	120	0	10	***	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	24.79	17.2	174.3	3827	***	75.59	92.26
Con	8.21	26.0	131.8	1895	515		
Tails	76.15	4.0	42.6	4165	***		
Cell 1	7.10	30.0	36.4	449	0		
Cell 2	7.88	26.7	44.9	626	65		
Cell 3	6.22	24.4	17.1	264	150		
Cell 4	8.26	21.0	20.7	374	150		
Cell 5	11.78	17.1	12.6	281	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	23.88	13.7	167.7	4672	***	78.34	94.60
Con	8.08	25.1	131.4	1960	515		
Tails	81.01	4.4	36.4	3227	***		
Cell 1	7.28	30.3	36.3	442	0		
Cell 2	8.16	27.1	44.9	616	65		
Cell 3	6.29	24.6	16.9	258	150		
Cell 4	8.40	21.2	20.6	368	150		
Cell 5	11.95	17.5	12.7	276	150		

Mass Balance For Froth Cells Using Complete Streams

Plant 1

Measured or Calculated Value

With Wash Test 2-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	24.79	8.21	76.15	85.00	7.10	7.88	6.22	8.26	11.78	0.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	174.30	131.76	42.57	0.03	36.41	44.90	17.14	20.74	12.57	0.000	0.004	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	43.21	10.82	32.42	0.03	2.58	3.54	1.07	1.71	1.48	0.00	0.00	0.01	0.01	0.01
Percent Solids:	17.19	25.97	4.00	0.027	29.98	26.73	24.42	20.97	17.09	0.000	0.027	0.027	0.027	0.027
Solid SG:	1.48	1.34	2.20	2.40	1.33	1.34	1.32	1.34	1.37	1.28	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	1014	507	1065	129	121	168	70	99	74	0	16	38	38	38
Liquid (tph)	840	376	1023	129	85	123	53	78	61	0	16	38	38	38
Slurry (gpm)	3827	1895	4165	515	449	626	264	374	281	0	65	150	150	150
Liquid (gpm)	3359	1502	4091	515	340	492	212	313	244	0	65	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	23.88	8.08	81.01	81.01	7.28	8.16	6.29	8.40	11.95	0.00	81.01	81.01	81.01	81.01
Mass (tph):														
Total	167.73	131.40	36.37	0.03	36.31	44.88	16.90	20.61	12.70	0.000	0.004	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	40.05	10.62	29.46	0.03	2.64	3.66	1.06	1.73	1.52	0.000	0.003	0.008	0.008	0.008
Percent Solids:	13.72	25.10	4.39	0.027	30.32	27.14	24.58	21.17	17.54	0.000	0.027	0.027	0.027	0.027
Solid SG:	1.47	1.34	2.30	2.30	1.33	1.34	1.32	1.34	1.37	1.28	2.30	2.30	2.30	2.30
Flow Rate:														
Slurry (tph)	1223	524	828	129	120	165	69	97	72	0	16	38	38	38
Liquid (tph)	1055	392	792	129	83	120	52	77	60	0	16	38	38	38
Slurry (gpm)	4672	1960	3227	515	442	616	258	368	276	0	65	150	150	150
Liquid (gpm)	4220	1569	3167	515	334	482	208	307	239	0	65	150	150	150

Mass Balance For Froth Cells Using Complete Streams

Plant 1 Percentage Change in Measured or Calculated Value

With Wash Test 2-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-3.68	-1.58	6.39	-4.69	2.59	3.55	1.05	1.71	1.49	0.00	-4.69	-4.69	-4.69	-4.69
Mass (tph):														
Total	-3.77	-0.27	-14.58	-0.07	-0.27	-0.05	-1.38	-0.63	1.03	0.00	-0.37	-0.03	-0.03	-0.03
Ash (tph):														
Minus 325 M	-7.31	-1.85	-9.12	-4.76	2.31	3.50	-0.34	1.07	2.53	0.00	-5.04	-4.72	-4.72	-4.72
Percent Solids:	*-20.19*	-3.37	9.90	0.00	1.14	1.55	0.65	0.97	2.65	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.58	-0.07	4.83	-3.95	0.11	0.16	0.04	0.08	0.10	0.00	-3.95	-3.95	-3.95	-3.95
Flow Rate:														
Slurry (tph)	*20.58*	3.21	*-22.27*	-0.07	-1.39	-1.57	-2.02	-1.59	-1.57	0.00	-0.37	-0.03	-0.03	-0.03
Liquid (tph)	*25.63*	4.43	*-22.59*	-0.07	-1.88	-2.13	-2.22	-1.84	-2.11	0.00	-0.37	-0.03	-0.03	-0.03
Slurry (gpm)	*22.08*	3.46	*-22.52*	-0.07	-1.51	-1.72	-2.06	-1.65	-1.71	0.00	-0.37	-0.03	-0.03	-0.03
Liquid (gpm)	*25.63*	4.43	*-22.59*	-0.07	-1.88	-2.13	-2.22	-1.84	-2.11	0.00	-0.37	-0.03	-0.03	-0.03

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	2.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	50.00	50.00	50.00	50.00	50.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Ce lls Using Complete Streams
Plant 1 Weighted Sum-of-Squares

With Wash Test 2-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.03

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	28.46	38.99	46.94	63.13	81.01	***	***	
Mass (tph):								
Total	131.43	86.55	69.66	49.06	36.37	0.00	0.00	
Ash (tph):								
Minus 325 M	37.41	33.75	32.69	30.97	29.46	0.00	0.00	
Percent Solids:	11.91	9.07	7.55	5.69	4.39	***	***	
Solid SG:	1.51	1.63	1.72	1.96	2.30	***	***	
Flow Rate:								
Slurry (tph)	1103.12	953.99	922.73	862.94	828.05	0.00	0.00	
Liquid (tph)	971.69	867.44	853.08	813.88	791.68	0.00	0.00	
Slurry (gpm)	4229.97	3679.23	3570.81	3352.70	3226.86	0.00	0.00	x
Liquid (gpm)	3886.77	3469.74	3412.31	3255.53	3166.72	0.00	0.00	x

Test	3-A	Description	No Wash Water
Coal	100% tunnel eagle		
Plant Feed	2000		

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	206	232	14.15	***	No
Secondary	0.625	210	0	14.51	***	No

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	22.67	15.3	118.6	2944	82.69	97.36
Con	8.94	25.5	98.1	1439		
Tails	88.23	3.0	20.5	2689		
Cell 1	7.41	27.5	51.6	698		
Cell 2	9.66	23.2	35.8	578		
Cell 3	12.31	21.1	6.4	114		
Cell 4	17.04	15.7	3.1	74		
Cell 5	22.34	11.2	1.3	45		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	21.79	12.0	116.9	3740	83.90	97.64
Con	8.98	24.7	98.1	1484		
Tails	88.54	3.3	18.8	2256		
Cell 1	7.35	28.0	51.5	683		
Cell 2	9.58	23.6	35.9	570		
Cell 3	12.29	21.2	6.4	113		
Cell 4	17.02	15.7	3.0	74		
Cell 5	22.32	11.2	1.3	45		

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water — Test 3-A — Measured or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	22.67	8.94	88.23	7.41	9.66	12.31	17.04	22.34
Mass (tph):								
Total	118.59	98.06	20.53	51.57	35.76	6.38	3.06	1.30
Ash (tph):								
Total	26.88	8.77	18.11	3.82	3.45	0.78	0.52	0.29
Percent Solids:	15.32	25.46	3.00	27.49	23.23	21.13	15.67	11.17
Solid SG:	1.46	1.34	2.48	1.33	1.35	1.37	1.41	1.46
Flow Rate:								
Slurry (tph)	774	385	685	188	154	30	20	12
Liquid (tph)	655	287	665	136	118	24	16	10
Slurry (gpm)	2944	1439	2689	698	578	114	74	45
Liquid (gpm)	2622	1148	2659	544	473	95	66	41

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	21.79	8.98	88.54	7.35	9.58	12.29	17.02	22.32
Mass (tph):								
Total	116.93	98.10	18.83	51.54	35.88	6.35	3.04	1.29
Ash (tph):								
Total	25.48	8.81	16.67	3.79	3.44	0.78	0.52	0.29
Percent Solids:	12.03	24.74	3.27	28.05	23.62	21.21	15.71	11.18
Solid SG:	1.45	1.34	2.49	1.33	1.35	1.37	1.41	1.46
Flow Rate:								
Slurry (tph)	972	397	576	184	152	30	19	12
Liquid (tph)	855	298	557	132	116	24	16	10
Slurry (gpm)	3740	1484	2256	683	570	113	74	45
Liquid (gpm)	3422	1194	2228	529	464	94	65	41

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water — Percentage Change in Measured or Calculated Value

Test 3-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	-3.85	0.50	0.36	-0.69	-0.76	-0.17	-0.11	-0.06
Mass (tph):								
Total	-1.40	0.05	-8.30	-0.05	0.34	-0.37	-0.69	-0.48
Ash (tph):								
Total	-5.19	0.54	-7.97	-0.74	-0.42	-0.54	-0.80	-0.54
Percent Solids:	*-21.51*	-2.82	9.14	2.03	1.66	0.34	0.22	0.05
Solid SG:	-0.54	0.03	0.34	-0.03	-0.04	-0.01	-0.01	-0.01
Flow Rate:								
Slurry (tph)	*25.62*	2.95	*-15.97*	-2.04	-1.31	-0.71	-0.91	-0.53
Liquid (tph)	*30.51*	3.94	*-16.21*	-2.79	-1.80	-0.80	-0.95	-0.53
Slurry (gpm)	*27.05*	3.15	*-16.12*	-2.18	-1.40	-0.73	-0.92	-0.53
Liquid (gpm)	*30.51*	3.94	*-16.21*	-2.79	-1.80	-0.80	-0.95	-0.53

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00
Mass (tph):								
Total	***	***	***	2.00	2.00	2.00	2.00	2.00
Ash (tph):								
Total	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells
Using complete streams
Plant 1

No Wash Water — Weighted Sum-of-Squares

Test 3-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Total WSSQ
Ash (% stream):									
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):									
Total	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):									
Total	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Solid SG:	***	***	***	***	***	***	***	***	***
Flow Rate:									
Slurry (tph)	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***	***
									0.02

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Total	33.18	61.87	75.47	84.30	88.54	***	***	
Mass (tph):								
Total	65.39	29.51	23.15	20.12	18.83	0.00	0.00	
Ash (tph):								
Total	21.69	18.25	17.47	16.96	16.67	0.00	0.00	
Percent Solids:	8.29	4.63	3.82	3.42	3.27	***	***	
Solid SG:	1.56	1.94	2.18	2.38	2.49	***	***	
Flow Rate:								
Slurry (tph)	789	637	607	587	576	0.00	0.00	
Liquid (tph)	723	607	584	567	557	0.00	0.00	
Slurry (gpm)	3057	2487	2374	2301	2256	0.00	0.00	*
Liquid (gpm)	2893	2428	2334	2269	2228	0.00	0.00	*

Test	3-B		Description With Wash Water on **All** cells				
Coal	100% tunnel eagle						
Plant Feed	2000						

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	206	232	14.15	***	Yes
Secondary	0.625	210	0	14.51	***	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	22.19	15.7	150.8	3660	***	82.31	96.83
Con	8.47	27.2	124.1	1697	1050		
Tails	86.06	3.1	26.7	3421	***		
Cell 1	7.45	22.6	50.9	851	300		
Cell 2	9.09	20.3	49.7	928	300		
Cell 3	10.43	18.1	16.0	336	150		
Cell 4	12.73	12.3	6.1	193	150		
Cell 5	16.52	8.3	1.4	68	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	21.54	13.7	148.2	4127	***	83.29	97.07
Con	8.56	21.1	123.4	2213	1050		
Tails	86.26	3.3	24.8	2965	***		
Cell 1	7.27	24.1	53.2	830	300		
Cell 2	8.84	21.7	49.4	861	300		
Cell 3	10.07	18.6	13.6	279	150		
Cell 4	12.67	12.5	5.9	184	150		
Cell 5	16.46	8.5	1.3	60	150		

Mass Balance For Froth Cells Using complete streams

Plant 1 Measured or Calculated Value

With Wash Water Test 3-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	22.19	8.47	86.06	85.00	7.45	9.09	10.43	12.73	16.52	85.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	150.81	124.14	26.75	0.07	50.87	49.68	16.00	6.14	1.45	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	33.47	10.51	23.02	0.06	3.79	4.52	1.67	0.78	0.24	0.02	0.02	0.01	0.01	0.01
Percent Solids:	15.66	27.22	3.07	0.027	22.55	20.27	18.15	12.30	8.32	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.45	1.34	2.42	2.40	1.33	1.34	1.35	1.37	1.40	2.40	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	963	456	872	263	226	245	88	50	17	75	75	38	38	38
Liquid (tph)	812	332	845	263	175	195	72	44	16	75	75	38	38	38
Slurry (gpm)	3660	1697	3421	1050	851	928	336	193	68	300	300	150	150	150
Liquid (gpm)	3249	1328	3380	1051	699	781	289	175	64	300	300	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	21.54	8.56	86.26	86.26	7.27	8.84	10.07	12.67	16.46	86.26	86.26	86.26	86.26	86.26
Mass (tph):														
Total	148.21	123.45	24.83	0.07	53.21	49.38	13.62	5.94	1.30	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	31.93	10.57	21.42	0.06	3.87	4.37	1.37	0.75	0.21	0.017	0.017	0.009	0.009	0.009
Percent Solids:	13.74	21.10	3.28	0.027	24.07	21.66	18.57	12.49	8.48	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.45	1.34	2.43	2.43	1.33	1.34	1.35	1.37	1.40	2.43	2.43	2.43	2.43	2.43
Flow Rate:														
Slurry (tph)	1079	585	756	263	221	228	73	48	15	75	75	38	38	38
Liquid (tph)	931	462	732	263	168	179	60	42	14	75	75	38	38	38
Slurry (gpm)	4127	2213	2965	1050	830	861	279	184	60	300	300	150	150	150
Liquid (gpm)	3722	1847	2926	1051	671	714	239	166	56	300	300	150	150	150

Mass Balance For Froth Cells Using complete streams

Plant 1

Percentage Change in Measured or Calculated Value

With Wash Water Test 3-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-2.91	1.17	0.24	1.49	-2.40	-2.70	-3.43	-0.46	-0.31	1.49	1.49	1.49	1.49	1.49
Mass (tph):														
Total	-1.73	-0.56	-7.17	0.03	4.59	-0.60	-14.85	-3.35	-10.17	0.02	0.03	0.05	0.05	0.05
Ash (tph):														
Minus 325 M	-4.59	0.60	-6.95	1.52	2.08	-3.28	*-17.78*	-3.79	-10.45	1.50	1.51	1.53	1.53	1.53
Percent Solids:	-12.26	*-22.50*	6.99	0.00	6.74	6.85	2.34	1.53	1.89	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.40	0.06	0.21	1.32	-0.10	-0.14	-0.21	-0.03	-0.03	1.32	1.32	1.32	1.32	1.32
Flow Rate:														
Slurry (tph)	12.01	*28.31*	-13.23	0.03	-2.02	-6.97	*-16.80*	-4.80	-11.83	0.02	0.03	0.05	0.05	0.05
Liquid (tph)	14.56	*39.10*	-13.42	0.03	-3.94	-8.59	*-17.24*	-5.01	-11.98	0.02	0.03	0.05	0.05	0.05
Slurry (gpm)	12.76	*30.43*	-13.35	0.03	-2.39	-7.30	*-16.88*	-4.85	-11.87	0.02	0.03	0.05	0.05	0.05
Liquid (gpm)	14.56	*39.10*	-13.42	0.03	-3.94	-8.59	*-17.24*	-5.01	-11.98	0.02	0.03	0.05	0.05	0.05

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	1.00	1.00	1.00	1.00	2.00	1.00	2.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	5.00	2.00	5.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams

Plant 1 Weighted Sum-of-Squares

With Wash Water Test 3-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.05	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.07
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.07

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	29.55	51.97	69.80	82.79	86.26	***	***	
Mass (tph):								
Total	95.02	45.66	32.05	26.12	24.83	0.00	0.00	
Ash (tph):								
Minus 325 M	28.08	23.73	22.37	21.62	21.42	0.00	0.00	
Percent Solids:	10.19	5.85	4.31	3.56	3.28	***	***	
Solid SG:	1.53	1.79	2.07	2.34	2.43	***	***	
Flow Rate:								
Slurry (tph)	932.83	779.97	744.19	734.19	756.44	0.00	0.00	
Liquid (tph)	837.81	734.31	712.14	708.08	731.61	0.00	0.00	
Slurry (gpm)	3597.07	3036.52	2907.68	2874.17	2964.53	0.00	0.00	x
Liquid (gpm)	3351.23	2937.25	2848.56	2832.31	2926.43	0.00	0.00	x

Test	4 - A	Description	No Wash Water
Coal	100% eagle		
Plant Feed	2000		

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	200	335	0	***	No
Secondary	0.5	0	0	0	***	No

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	31.88	12.5	127.6	3899	72.71	96.12
Con	9.95	27.0	92.8	1277		
Tails	90.32	3.9	34.8	3502		
Cell 1	9.86	28.2	52.8	694		
Cell 2	9.22	27.4	33.4	454		
Cell 3	12.56	20.5	4.4	81		
Cell 4	16.25	16.8	1.3	30		
Cell 5	20.89	14.2	0.8	22		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Yield %	Combustible Recovery %
Feed	31.13	11.0	125.8	4377	73.73	96.40
Con	9.95	27.1	92.8	1269		
Tails	90.56	4.1	33.1	3108		
Cell 1	9.87	28.5	52.8	686		
Cell 2	9.22	27.6	33.4	450		
Cell 3	12.56	20.5	4.4	80		
Cell 4	16.25	16.8	1.3	30		
Cell 5	20.89	14.2	0.8	22		

Mass Balance For Froth Cells Using complete streams

Plant 1

No Wash Water Test 4-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	31.88	9.95	90.32	9.86	9.22	12.56	16.25	20.89
Mass (tph):								
Total	127.60	92.78	34.82	52.79	33.43	4.37	1.35	0.83
Ash (tph):								
Total	40.68	9.23	31.45	5.21	3.08	0.55	0.22	0.17
Percent Solids:	12.50	27.00	3.88	28.18	27.37	20.49	16.80	14.20
Solid SG:	1.55	1.35	2.54	1.35	1.35	1.37	1.40	1.44
Flow Rate:								
Slurry (tph)	1021	344	897	187	122	21	8	6
Liquid (tph)	893	251	863	135	89	17	7	5
Slurry (gpm)	3899	1277	3502	694	454	81	30	22
Liquid (gpm)	3573	1003	3450	538	355	68	27	20

Measured or Calculated Value

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	31.13	9.95	90.56	9.87	9.22	12.56	16.25	20.89
Mass (tph):								
Total	125.82	92.77	33.05	52.79	33.43	4.37	1.35	0.83
Ash (tph):								
Total	39.17	9.23	29.93	5.21	3.08	0.55	0.22	0.17
Percent Solids:	11.04	27.15	4.14	28.48	27.57	20.54	16.82	14.22
Solid SG:	1.54	1.35	2.54	1.35	1.35	1.37	1.40	1.44
Flow Rate:								
Slurry (tph)	1140	342	798	185	121	21	8	6
Liquid (tph)	1014	249	765	133	88	17	7	5
Slurry (gpm)	4377	1269	3108	686	450	80	30	22
Liquid (gpm)	4055	996	3059	530	351	68	27	20

Mass Balance For Froth Cells Using complete streams

Plant 1 Percentage Change in Measured or Calculated Value

No Wash Water Test 4-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	-2.36	0.05	0.27	0.07	0.03	0.01	0.01	0.00
Mass (tph):								
Total	-1.39	-0.01	-5.07	0.00	-0.01	-0.02	0.01	0.02
Ash (tph):								
Total	-3.72	0.04	-4.82	0.07	0.01	-0.02	0.01	0.03
Percent Solids:	-11.67	0.55	6.77	1.08	0.75	0.22	0.12	0.11
Solid SG:	-0.50	0.00	0.26	0.00	0.00	0.00	0.00	0.00
Flow Rate:								
Slurry (tph)	11.64	-0.55	-11.10	-1.08	-0.76	-0.25	-0.11	-0.09
Liquid (tph)	13.50	-0.75	-11.34	-1.50	-1.04	-0.31	-0.14	-0.11
Slurry (gpm)	12.28	-0.59	-11.24	-1.16	-0.81	-0.26	-0.12	-0.10
Liquid (gpm)	13.50	-0.75	-11.34	-1.50	-1.04	-0.31	-0.14	-0.11

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5
Ash (% stream):								
Total	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00
Mass (tph):								
Total	***	***	***	2.00	2.00	2.00	2.00	2.00
Ash (tph):								
Total	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	5.00	5.00	5.00	5.00	5.00
Solid SG:	***	***	***	***	***	***	***	***
Flow Rate:								
Slurry (tph)	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams

Plant 1 Weighted Sum-of-Squares

No Wash Water Test 4-A	Feed F1	Clean C1-C5	Reject R5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Total WSSQ
Ash (% stream):									
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass (tph):									
Total	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Ash (tph):									
Total	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid SG:	***	***	***	***	***	***	***	***	***
Flow Rate:									
Slurry (tph)	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***
Liquid (gpm)	***	***	***	***	***	***	***	***	***
									0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Total	46.50	77.96	86.08	88.85	90.56	***	***	
Mass (tph):								
Total	73.03	39.60	35.23	33.88	33.05	0.00	0.00	
Ash (tph):								
Total	33.96	30.87	30.32	30.11	29.93	0.00	0.00	
Percent Solids:	7.65	4.75	4.34	4.22	4.14	***	***	
Solid SG:	1.72	2.24	2.43	2.50	2.54	***	***	
Flow Rate:								
Slurry (tph)	954	833	812	804	798	0.00	0.00	
Liquid (tph)	881	793	776	770	765	0.00	0.00	
Slurry (gpm)	3691	3241	3161	3130	3108	0.00	0.00	*
Liquid (gpm)	3525	3173	3106	3079	3059	0.00	0.00	*

Test	4-B	Description	With Paddles on Primary Cells Wash Water on all cells
Coal	100% Eagle		
Plant Feed	2000		

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	192	380	14.55	14	Yes
Secondary	0.5	160	0	13.25	12	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	33.63	12.7	108.6	3268	***	69.53	95.11
Con	9.22	19.0	75.5	1512	1050		
Tails	89.35	3.6	33.1	3562	***		
Cell 1	8.91	20.0	36.6	696	300		
Cell 2	7.84	18.7	21.8	444	300		
Cell 3	10.57	16.4	12.7	296	150		
Cell 4	13.58	11.5	3.1	105	150		
Cell 5	19.55	9.0	1.2	54	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	32.45	10.9	105.9	3748	***	70.90	95.27
Con	9.23	18.3	75.1	1562	1050		
Tails	89.02	3.7	30.9	3235	***		
Cell 1	8.89	20.4	36.5	679	300		
Cell 2	7.83	19.0	21.7	435	300		
Cell 3	10.55	16.5	12.6	290	150		
Cell 4	13.57	11.6	3.1	104	150		
Cell 5	19.55	9.0	1.2	54	150		

Mass Balance For Froth Cells Using complete streams

Plant 1 Measured or Calculated Value

With Wash Water Test 4-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	33.63	9.22	89.35	85.00	8.91	7.84	10.57	13.58	19.55	85.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	108.56	75.49	33.15	0.07	36.62	21.83	12.68	3.12	1.25	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	36.51	6.96	29.62	0.06	3.26	1.71	1.34	0.42	0.24	0.02	0.02	0.01	0.01	0.01
Percent Solids:	12.67	18.97	3.64	0.027	19.95	18.72	16.38	11.52	8.96	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.57	1.35	2.51	2.40	1.34	1.33	1.36	1.38	1.43	2.40	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	857	398	911	263	184	117	77	27	14	75	75	38	38	38
Liquid (tph)	748	322	878	263	147	95	65	24	13	75	75	38	38	38
Slurry (gpm)	3268	1512	3562	1050	696	444	296	105	54	300	300	150	150	150
Liquid (gpm)	2994	1289	3512	1051	588	379	259	96	51	300	300	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	32.45	9.23	89.02	89.02	8.89	7.83	10.55	13.57	19.55	89.02	89.02	89.02	89.02	89.02
Mass (tph):														
Total	105.89	75.07	30.89	0.07	36.48	21.69	12.56	3.10	1.25	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	34.37	6.93	27.50	0.06	3.24	1.70	1.33	0.42	0.24	0.018	0.018	0.009	0.009	0.009
Percent Solids:	10.85	18.30	3.73	0.027	20.36	18.97	16.53	11.55	8.98	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.55	1.35	2.50	2.50	1.34	1.33	1.36	1.38	1.43	2.50	2.50	2.50	2.50	2.50
Flow Rate:														
Slurry (tph)	976	410	828	263	179	114	76	27	14	75	75	38	38	38
Liquid (tph)	870	335	797	263	143	93	63	24	13	75	75	38	38	38
Slurry (gpm)	3748	1562	3235	1050	679	435	290	104	54	300	300	150	150	150
Liquid (gpm)	3479	1341	3189	1051	571	371	254	95	51	300	300	150	150	150

Mass Balance For Froth Cells Using complete streams

Plant 1

Percentage Change in Measured or Calculated Value

With Wash Water Test 4-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-3.50	0.19	-0.37	4.73	-0.21	-0.11	-0.10	-0.03	-0.02	4.73	4.73	4.73	4.73	4.73
Mass (tph):														
Total	-2.46	-0.55	-6.81	0.01	-0.38	-0.64	-0.93	-0.63	-0.09	0.01	0.01	0.01	0.01	0.01
Ash (tph):														
Minus 325 M	-5.87	-0.37	-7.15	4.74	-0.59	-0.74	-1.03	-0.66	-0.11	4.74	4.74	4.74	4.74	4.74
Percent Solids:	-14.32	-3.56	2.54	0.00	2.02	1.30	0.86	0.31	0.16	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.79	0.01	-0.35	4.33	-0.01	0.00	-0.01	0.00	0.00	4.33	4.33	4.33	4.33	4.33
Flow Rate:														
Slurry (tph)	13.84	3.12	-9.12	0.01	-2.36	-1.91	-1.78	-0.94	-0.25	0.01	0.01	0.01	0.01	0.01
Liquid (tph)	*16.21*	3.97	-9.21	0.01	-2.85	-2.21	-1.94	-0.98	-0.26	0.01	0.01	0.01	0.01	0.01
Slurry (gpm)	14.69	3.30	-9.17	0.01	-2.46	-1.98	-1.82	-0.95	-0.25	0.01	0.01	0.01	0.01	0.01
Liquid (gpm)	*16.21*	3.97	-9.21	0.01	-2.85	-2.21	-1.94	-0.98	-0.26	0.01	0.01	0.01	0.01	0.01

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	1.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams

Plant 1 Weighted Sum-of-Squares

With Wash Water Test 4-B	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	44.85	61.68	79.92	86.32	89.02	***	***	
Mass (tph):								
Total	69.43	47.76	35.21	32.13	30.89	0.00	0.00	
Ash (tph):								
Minus 325 M	31.14	29.46	28.14	27.73	27.50	0.00	0.00	
Percent Solids:	7.97	5.74	4.44	3.99	3.73	***	***	
Solid SG:	1.70	1.93	2.28	2.43	2.50	***	***	
Flow Rate:								
Slurry (tph)	871	832	794	804	828	0.00	0.00	
Liquid (tph)	802	784	759	772	797	0.00	0.00	
Slurry (gpm)	3369	3234	3093	3139	3235	0.00	0.00	x
Liquid (gpm)	3208	3138	3034	3089	3189	0.00	0.00	x

Test 4 - C Description No Paddles on Primary Cells

Coal 100% Eagle

Plant Feed 2000

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	192	380	14.55	14	Yes
Secondary	0.5	160	0	13.25	12	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	31.20	13.3	120.9	3467	***	72.60	95.80
Con	9.20	19.0	87.7	1758	1050		
Tails	89.47	3.8	33.2	3398	***		
Cell 1	9.26	18.8	41.3	835	300		
Cell 2	7.50	17.9	21.2	453	300		
Cell 3	10.25	19.2	17.3	343	150		
Cell 4	13.59	12.4	5.9	182	150		
Cell 5	19.37	8.8	2.1	93	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	30.44	11.9	119.4	3850	***	73.50	95.82
Con	9.32	17.9	87.7	1868	1050		
Tails	89.03	4.1	31.7	3032	***		
Cell 1	8.92	19.3	41.3	812	300		
Cell 2	7.39	18.1	21.4	450	300		
Cell 3	10.08	19.4	17.2	337	150		
Cell 4	13.49	12.5	5.8	178	150		
Cell 5	19.30	8.9	2.1	91	150		

Mass Balance For Froth Cells Using complete streams
Plant 1

Measured or Calculated Value

With Wash Water Test 4-C	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	31.20	9.20	89.47	85.00	9.26	7.50	10.25	13.59	19.37	85.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	120.87	87.75	33.19	0.07	41.27	21.16	17.34	5.87	2.11	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	37.70	8.07	29.69	0.06	3.82	1.59	1.78	0.80	0.41	0.02	0.02	0.01	0.01	0.01
Percent Solids:	13.28	18.97	3.81	0.027	18.80	17.85	19.17	12.43	8.82	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.54	1.35	2.51	2.40	1.35	1.33	1.35	1.38	1.43	2.40	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	910	462	870	263	220	119	90	47	24	75	75	38	38	38
Liquid (tph)	789	375	837	263	178	97	73	41	22	75	75	38	38	38
Slurry (gpm)	3467	1758	3398	1050	835	453	343	182	93	300	300	150	150	150
Liquid (gpm)	3156	1499	3349	1051	713	390	292	165	87	300	300	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	30.44	9.32	89.03	89.03	8.92	7.39	10.08	13.49	19.30	89.03	89.03	89.03	89.03	89.03
Mass (tph):														
Total	119.36	87.73	31.70	0.07	41.30	21.36	17.23	5.77	2.08	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	36.33	8.18	28.22	0.06	3.68	1.58	1.74	0.78	0.40	0.018	0.018	0.009	0.009	0.009
Percent Solids:	11.88	17.90	4.08	0.027	19.31	18.12	19.39	12.51	8.85	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.35	2.50	2.50	1.34	1.33	1.35	1.38	1.43	2.50	2.50	2.50	2.50	2.50
Flow Rate:														
Slurry (tph)	1005	490	778	263	214	118	89	46	23	75	75	38	38	38
Liquid (tph)	886	402	746	263	173	97	72	40	21	75	75	38	38	38
Slurry (gpm)	3850	1868	3032	1050	812	450	337	178	91	300	300	150	150	150
Liquid (gpm)	3543	1609	2984	1051	690	386	287	161	85	300	300	150	150	150

Mass Balance For Froth Cells Using complete streams
Plant 1

Percentage Change in Measured or Calculated Value

With Wash Water Test 4-C	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-2.42	1.31	-0.49	4.74	-3.65	-1.53	-1.67	-0.74	-0.37	4.74	4.74	4.74	4.74	4.74
Mass (tph):														
Total	-1.25	-0.02	-4.51	0.01	0.06	0.95	-0.59	-1.80	-1.50	0.01	0.01	0.01	0.01	0.01
Ash (tph):														
Minus 325 M	-3.64	1.29	-4.97	4.75	-3.60	-0.60	-2.25	-2.53	-1.86	4.75	4.75	4.75	4.75	4.75
Percent Solids:	-10.59	-5.65	6.86	0.00	2.75	1.53	1.17	0.61	0.31	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.50	0.07	-0.47	4.34	-0.20	-0.07	-0.10	-0.06	-0.04	4.34	4.34	4.34	4.34	4.34
Flow Rate:														
Slurry (tph)	10.45	5.97	-10.64	0.01	-2.62	-0.57	-1.74	-2.39	-1.80	0.01	0.01	0.01	0.01	0.01
Liquid (tph)	12.24	7.37	-10.88	0.01	-3.24	-0.90	-2.01	-2.48	-1.83	0.01	0.01	0.01	0.01	0.01
Slurry (gpm)	11.07	6.27	-10.78	0.01	-2.73	-0.63	-1.79	-2.41	-1.81	0.01	0.01	0.01	0.01	0.01
Liquid (gpm)	12.24	7.37	-10.88	0.01	-3.24	-0.90	-2.01	-2.48	-1.83	0.01	0.01	0.01	0.01	0.01

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	2.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams
Plant 1 Weighted Sum-of-Squares

With Wash Water Test 4-C	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	41.84	54.82	74.35	84.74	89.03	***	***	
Mass (tph):								
Total	78.08	56.74	39.52	33.76	31.70	0.00	0.00	
Ash (tph):								
Minus 325 M	32.67	31.11	29.38	28.61	28.22	0.00	0.00	
Percent Solids:	9.01	6.89	5.12	4.42	4.08	***	***	
Solid SG:	1.66	1.83	2.16	2.39	2.50	***	***	
Flow Rate:								
Slurry (tph)	866	824	772	764	778	0.00	0.00	
Liquid (tph)	788	767	733	730	746	0.00	0.00	
Slurry (gpm)	3338	3188	3001	2973	3032	0.00	0.00	x
Liquid (gpm)	3153	3067	2931	2920	2984	0.00	0.00	x

Test	4 - D	Description	Low Level in all cells No paddles on primary cells
Coal	100% Eagle		
Plant Feed	2000		

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	192	380	10.79	18	Yes
Secondary	0.5	160	0	10.06	16	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	31.44	12.5	128.7	3928	***	69.82	93.14
Con	8.53	20.1	89.8	1692	1050		
Tails	84.42	3.4	38.9	4466	***		
Cell 1	6.55	23.0	24.6	404	300		
Cell 2	6.19	21.5	19.7	347	300		
Cell 3	9.01	19.4	27.2	532	150		
Cell 4	12.54	15.4	12.8	320	150		
Cell 5	13.07	13.5	5.4	156	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	30.45	10.9	124.7	4419	***	71.59	94.17
Con	8.51	19.6	89.3	1731	1050		
Tails	85.73	3.7	35.5	3738	***		
Cell 1	6.57	23.2	24.5	398	300		
Cell 2	6.21	21.7	19.6	341	300		
Cell 3	9.07	19.6	27.0	522	150		
Cell 4	12.59	15.5	12.8	316	150		
Cell 5	13.09	13.6	5.4	153	150		

Mass Balance For Froth Cells Using complete streams

Plant 1

Measured or Calculated Value

With Wash Water Test 4-D	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	31.44	8.53	84.42	85.00	6.55	6.19	9.01	12.54	13.07	85.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	128.67	89.83	38.91	0.07	24.64	19.72	27.19	12.83	5.45	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	40.45	7.66	32.84	0.06	1.61	1.22	2.45	1.61	0.71	0.02	0.02	0.01	0.01	0.01
Percent Solids:	12.51	20.13	3.41	0.027	23.00	21.54	19.42	15.38	13.47	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.54	1.34	2.38	2.40	1.32	1.32	1.34	1.37	1.38	2.40	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	1028	446	1140	263	107	92	140	83	40	75	75	38	38	38
Liquid (tph)	900	356	1101	263	82	72	113	71	35	75	75	38	38	38
Slurry (gpm)	3928	1692	4466	1050	404	347	532	320	156	300	300	150	150	150
Liquid (gpm)	3599	1426	4405	1051	330	287	451	282	140	300	300	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	30.45	8.51	85.73	85.73	6.57	6.21	9.07	12.59	13.09	85.73	85.73	85.73	85.73	85.73
Mass (tph):														
Total	124.70	89.27	35.50	0.07	24.47	19.55	27.02	12.79	5.43	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	37.97	7.60	30.44	0.06	1.61	1.21	2.45	1.61	0.71	0.017	0.017	0.009	0.009	0.009
Percent Solids:	10.85	19.59	3.71	0.027	23.20	21.69	19.64	15.48	13.64	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.34	2.42	2.42	1.33	1.32	1.34	1.37	1.38	2.42	2.42	2.42	2.42	2.42
Flow Rate:														
Slurry (tph)	1149	456	956	263	105	90	138	83	40	75	75	38	38	38
Liquid (tph)	1024	366	921	263	81	71	111	70	34	75	75	38	38	38
Slurry (gpm)	4419	1731	3738	1050	398	341	522	316	153	300	300	150	150	150
Liquid (gpm)	4098	1466	3683	1051	324	282	442	279	138	300	300	150	150	150

Mass Balance For Froth Cells Using complete streams

Plant 1

Percentage Change in Measured or Calculated Value

With Wash Water Test 4-D	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-3.14	-0.26	1.56	0.86	0.46	0.35	0.70	0.46	0.20	0.86	0.86	0.86	0.86	0.86
Mass (tph):														
Total	-3.08	-0.62	-8.75	0.03	-0.67	-0.86	-0.63	-0.29	-0.27	0.02	0.02	0.04	0.05	0.05
Ash (tph):														
Minus 325 M	-6.12	-0.88	-7.33	0.89	-0.22	-0.52	0.07	0.17	-0.07	0.88	0.87	0.90	0.90	0.90
Percent Solids:	-13.27	-2.68	8.78	0.00	0.87	0.73	1.12	0.67	1.31	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.65	-0.01	1.37	0.76	0.02	0.01	0.04	0.03	0.02	0.76	0.76	0.76	0.76	0.76
Flow Rate:														
Slurry (tph)	11.75	2.12	*-16.12*	0.03	-1.53	-1.58	-1.73	-0.95	-1.56	0.02	0.02	0.04	0.05	0.05
Liquid (tph)	13.87	2.81	*-16.38*	0.03	-1.78	-1.77	-1.99	-1.07	-1.76	0.02	0.02	0.04	0.05	0.05
Slurry (gpm)	12.49	2.27	*-16.28*	0.03	-1.58	-1.62	-1.79	-0.98	-1.61	0.02	0.02	0.04	0.05	0.05
Liquid (gpm)	13.87	2.81	*-16.38*	0.03	-1.78	-1.77	-1.99	-1.07	-1.76	0.02	0.02	0.04	0.05	0.05

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	2.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams

Plant 1 Weighted Sum-of-Squares

With Wash Water Test 4-D	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	36.29	43.58	60.96	76.08	85.73	***	***	
Mass (tph):								
Total	100.26	80.72	53.71	40.93	35.50	0.00	0.00	
Ash (tph):								
Minus 325 M	36.38	35.18	32.74	31.14	30.44	0.00	0.00	
Percent Solids:	8.96	7.31	5.35	4.27	3.71	***	***	
Solid SG:	1.60	1.68	1.92	2.20	2.42	***	***	
Flow Rate:								
Slurry (tph)	1119	1104	1004	959	956	0.00	0.00	
Liquid (tph)	1018	1023	950	918	921	0.00	0.00	
Slurry (gpm)	4321	4280	3908	3742	3738	0.00	0.00	x
Liquid (gpm)	4074	4092	3800	3671	3683	0.00	0.00	x

Test	4 - E		Description	Very Low Level Wash Water on all cells
Coal	100% Eagle			
Plant Feed	2000			

	Air	Frother (ml/min)	Diesel (ml/min)	Cell Set Point	Froth height (in.)	Wash Water
Primary	0.25	205	335	0	22	Yes
Secondary	0.5	132	0	0	18	Yes

Unbalanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	31.33	12.4	126.9	3912	***	69.09	92.27
Con	8.29	20.6	87.7	1612	1050		
Tails	82.83	3.5	39.3	4372	***		
Cell 1	6.58	25.1	27.7	413	300		
Cell 2	7.02	23.1	19.1	311	300		
Cell 3	8.87	19.6	24.6	478	150		
Cell 4	11.72	15.6	11.5	283	150		
Cell 5	12.01	14.6	4.8	125	150		

Balanced

Stream	Ash %	% Solids	Mass Flow tph	Slurry Flow gpm	Wash Water gpm	Yield %	Combustible Recovery %
Feed	30.23	10.6	123.0	4448	***	70.80	93.07
Con	8.30	20.7	87.1	1597	1050		
Tails	83.43	3.6	36.0	3901	***		
Cell 1	6.58	25.2	27.5	409	300		
Cell 2	7.02	23.1	19.0	309	300		
Cell 3	8.88	19.6	24.4	473	150		
Cell 4	11.73	15.6	11.5	282	150		
Cell 5	12.01	14.6	4.8	125	150		

Mass Balance For Froth Cells Using complete streams

Plant 1 Measured or Calculated Value

With Wash Water Test 4-E	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	31.33	8.29	82.83	85.00	6.58	7.02	8.87	11.72	12.01	85.00	85.00	85.00	85.00	85.00
Mass (tph):														
Total	126.92	87.69	39.30	0.07	27.67	19.07	24.65	11.54	4.76	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	39.76	7.27	32.55	0.06	1.82	1.34	2.19	1.35	0.57	0.02	0.02	0.01	0.01	0.01
Percent Solids:	12.40	20.60	3.52	0.027	25.10	23.10	19.56	15.60	14.64	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.54	1.34	2.35	2.40	1.33	1.33	1.34	1.37	1.37	2.40	2.40	2.40	2.40	2.40
Flow Rate:														
Slurry (tph)	1024	426	1116	263	110	83	126	74	32	75	75	38	38	38
Liquid (tph)	897	338	1077	263	83	63	101	62	28	75	75	38	38	38
Slurry (gpm)	3912	1612	4372	1050	413	311	478	283	125	300	300	150	150	150
Liquid (gpm)	3586	1352	4309	1051	330	254	405	250	111	300	300	150	150	150

Estimated or Calculated Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	30.23	8.30	83.43	83.43	6.58	7.02	8.88	11.73	12.01	83.43	83.43	83.43	83.43	83.43
Mass (tph):														
Total	123.01	87.10	35.98	0.07	27.47	18.96	24.43	11.49	4.75	0.020	0.020	0.010	0.010	0.010
Ash (tph):														
Minus 325 M	37.19	7.23	30.02	0.06	1.81	1.33	2.17	1.35	0.57	0.017	0.017	0.008	0.008	0.008
Percent Solids:	10.64	20.65	3.61	0.027	25.16	23.14	19.61	15.62	14.65	0.027	0.027	0.027	0.027	0.027
Solid SG:	1.53	1.34	2.36	2.36	1.33	1.33	1.34	1.37	1.37	2.36	2.36	2.36	2.36	2.36
Flow Rate:														
Slurry (tph)	1156	422	997	263	109	82	125	74	32	75	75	38	38	38
Liquid (tph)	1033	335	961	263	82	63	100	62	28	75	75	38	38	38
Slurry (gpm)	4448	1597	3901	1050	409	309	473	282	125	300	300	150	150	150
Liquid (gpm)	4131	1338	3843	1051	327	252	401	248	111	300	300	150	150	150

Mass Balance For Froth Cells Using complete streams

Plant 1

Percentage Change in Measured or Calculated Value

With Wash Water Test 4-E	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	-3.50	0.07	0.72	-1.85	0.05	0.04	0.06	0.04	0.01	-1.85	-1.85	-1.85	-1.85	-1.85
Mass (tph):														
Total	-3.08	-0.67	-8.43	0.03	-0.74	-0.59	-0.86	-0.49	-0.05	0.02	0.02	0.03	0.04	0.04
Ash (tph):														
Minus 325 M	-6.47	-0.60	-7.77	-1.82	-0.69	-0.55	-0.80	-0.45	-0.04	-1.83	-1.83	-1.81	-1.81	-1.81
Percent Solids:	-14.16	0.26	2.56	0.00	0.23	0.17	0.25	0.16	0.05	0.00	0.00	0.00	0.00	0.00
Solid SG:	-0.72	0.00	0.61	-1.59	0.00	0.00	0.00	0.00	0.00	-1.59	-1.59	-1.59	-1.59	-1.59
Flow Rate:														
Slurry (tph)	12.91	-0.93	-10.72	0.03	-0.97	-0.76	-1.11	-0.65	-0.10	0.02	0.02	0.03	0.04	0.04
Liquid (tph)	*15.17*	-1.00	-10.80	0.03	-1.04	-0.81	-1.17	-0.68	-0.11	0.02	0.02	0.03	0.04	0.04
Slurry (gpm)	13.70	-0.95	-10.77	0.03	-0.98	-0.77	-1.12	-0.65	-0.10	0.02	0.02	0.03	0.04	0.04
Liquid (gpm)	*15.17*	-1.00	-10.80	0.03	-1.04	-0.81	-1.17	-0.68	-0.11	0.02	0.02	0.03	0.04	0.04

Relative Error in Measured Value

	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5
Ash (% stream):														
Minus 325 M	1.00	0.40	0.40	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Mass (tph):														
Total	***	***	***	***	2.00	2.00	2.00	2.00	1.00	***	***	***	***	***
Ash (tph):														
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***	***	***	***	***
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:														
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	5.00	5.00	5.00	5.00	5.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***

Mass Balance For Froth Cells Using complete streams

Plant 1 Weighted Sum-of-Squares

With Wash Water Test 4-E	Feed F1	Clean C1-C5	Reject R5	Wash W1-W5	Clean #1 C1	Clean #2 C2	Clean #3 C3	Clean #4 C4	Clean #5 C5	Wash #1 W1	Wash #2 W2	Wash #3 W3	Wash #4 W4	Wash #5 W5	Total WSSQ
Ash (% stream):															
Minus 325 M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Mass (tph):															
Total	***	***	***	***	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.00
Ash (tph):															
Minus 325 M	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Percent Solids:	0.01	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	***	***	***	***	***	0.01
Solid SG:	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Flow Rate:															
Slurry (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Liquid (tph)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Slurry (gpm)	***	***	***	***	***	***	***	***	***	0.00	0.00	0.00	0.00	0.00	0.00
Liquid (gpm)	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
															0.01

	Reject #1 R1	Reject #2 R2	Reject #3 R3	Reject #4 R4	Reject #5 R5	Cnstrt A	Cnstrt B	Use Cnstrt?
Ash (% stream):								
Minus 325 M	37.04	44.48	61.15	75.09	83.43	***	***	
Mass (tph):								
Total	95.57	76.63	52.21	40.73	35.98	0.00	0.00	
Ash (tph):								
Minus 325 M	35.40	34.08	31.92	30.58	30.02	0.00	0.00	
Percent Solids:	8.52	6.87	5.08	4.11	3.61	***	***	
Solid SG:	1.60	1.69	1.92	2.18	2.36	***	***	
Flow Rate:								
Slurry (tph)	1122	1115	1028	992	997	0.00	0.00	
Liquid (tph)	1026	1038	975	951	961	0.00	0.00	
Slurry (gpm)	4338	4330	4007	3875	3901	0.00	0.00	x
Liquid (gpm)	4104	4152	3902	3804	3843	0.00	0.00	x

Mass Balance		coal		tails		total	measured total	Estimated or calculated values coal		tails		total	Relative change coal		tails	
		ash	wt%	ash	wt%	ash	ash	ash	wt%	ash	wt%	ash	ash	wt%	ash	wt%
1- A	Powellton	5.50	94.93	91.97	5.07	9.88	10.48	5.63	94.51	94.09	5.49	10.48	-2.38	0.44	-2.31	-8.19
1 - B	Powellton	5.07	93.92	90.94	6.08	10.29	10.44	5.09	93.80	91.40	6.20	10.44	-0.44	0.12	-0.51	-1.88
2 - A	80E 20P	4.25	94.02	88.31	5.98	9.28	9.14	4.23	94.13	87.86	5.87	9.14	0.39	-0.12	0.51	1.93
2- B	80E 20P	3.71	94.73	90.80	5.27	8.29	8.08	3.68	94.91	90.04	5.09	8.08	0.64	-0.18	0.84	3.29
3 - A	Tunnel Eagle	4.28	94.44	87.86	5.56	8.93	8.98	4.29	94.40	88.04	5.60	8.98	-0.18	0.05	-0.21	-0.77
3 - B	Tunnel Eagle	3.47	93.77	91.64	6.23	8.96	8.55	3.44	94.12	90.36	5.88	8.55	0.84	-0.37	1.39	5.61
4 - B	Eagle	4.55	94.04	89.47	5.96	9.61	9.22	4.50	94.36	88.25	5.64	9.22	1.16	-0.34	1.37	5.35
4 - C	Eagle	4.63	94.41	88.08	5.59	9.30	9.31	4.63	94.40	88.13	5.60	9.31	-0.03	0.01	-0.06	-0.22
4 - D	Eagle	4.18	94.61	85.39	5.39	8.55	8.50	4.17	94.65	85.21	5.35	8.50	0.16	-0.05	0.22	0.82

		Relative Error coal		tails		Weighted Sum-of-Squares coal		tails		Total WSSE	Constraints	
		ash	wt%	ash	wt%	ash	wt%	ash	wt%			
1- A	Powellton	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
1 - B	Powellton	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
2 - A	80E 20P	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
2- B	80E 20P	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
3 - A	Tunnel Eagle	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
3 - B	Tunnel Eagle	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
4 - B	Eagle	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
4 - C	Eagle	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
4 - D	Eagle	1.00	2.00	1.00	2.00	0.0	0.0	0.0	0.0	0.0	0.00	100
										0.0		

Release analysis

Powellton Test 1

Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery	ash of all coal	ash of all clay
	Feed Individual								
P1	25.71	3.405	0.88	3.41	25.71	0.88	36.2	8.29	93.79
T5	11.55	5.02	0.58	3.91	37.27	1.46	52.2	wt % of all coal	wt % of all clay
T4	14.10	6.905	0.97	4.73	51.37	2.43	71.3	73.03	26.97
T3	15.23	10.58	1.61	6.07	66.60	4.04	91.1		
T2	6.43	31.31	2.01	8.29	73.03	6.05	97.6		
T1	26.97	93.79	25.29	31.35	100.00	31.35	100.0		

80E 20P Test 2

Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery	ash of all coal	ash of all clay
	Feed Individual								
P1	34.31	2.165	0.74	2.17	34.31	0.74	44.5	4.41	91.93
T5	10.50	3.98	0.42	2.59	44.81	1.16	57.9	wt % of all coal	wt % of all clay
T4	26.71	5.13	1.37	3.54	71.52	2.53	91.5	76.94	23.06
T3	5.42	15.88	0.86	4.41	76.94	3.39	97.5		
T2	2.10	71.615	1.50	6.19	79.04	4.89	98.3		
T1	20.96	93.96	19.70	24.59	100.00	24.59	100.0		

Release analysis
Tunnel Eagle Feed
Test 3

Sample	Individual								
Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery	ash of all coal	ash of all clay
P1	26.41	3.195	0.84	3.20	26.41	0.84	33.0	4.95	93.68
P2	27.20	4.12	1.12	3.66	53.61	1.96	66.6	wt % of all coal	wt % of all clay
P3	20.04	4.355	0.87	3.85	73.65	2.84	91.4	80.23	19.77
P4	4.86	8.185	0.40	4.12	78.51	3.24	97.1		
P5	1.72	42.855	0.74	4.95	80.23	3.97	98.4		
T2	0.20	89.1	0.18	5.16	80.43	4.15	98.4		
T1	19.57	93.725	18.34	22.49	100.00	22.49	100.0		

Eagle Feed
Test 4

Sample	Individual								
Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery	ash of all coal	ash of all clay
P1	30.67	2.865	0.88	2.87	30.67	0.88	44.4	4.16	92.29
T5	26.42	4.315	1.14	3.54	57.09	2.02	82.1	wt % of all coal	wt % of all clay
T4	9.55	7.39	0.71	4.09	66.65	2.72	95.3	67.34	32.66
T3	0.70	11.44	0.08	4.16	67.34	2.80	96.2		
T2	3.06	73.29	2.24	7.17	70.40	5.05	97.5		
T1	29.60	94.26	27.90	32.95	100.00	32.95	100.0		

Tunnel Eagle Concentrate Release

3 - B	Individual						
Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery
P1	40.97	1.76	0.72	1.76	40.97	0.72	44.2
P2	21.69	3.36	0.73	2.31	62.65	1.45	67.2
P3	26.50	4.14	1.10	2.86	89.15	2.55	95.1
P4	4.09	11.55	0.47	3.24	93.24	3.02	99.1
P5	0.53	44.26	0.23	3.47	93.77	3.25	99.4
T2	0.70	87.63	0.62	4.09	94.47	3.87	99.5
T1	5.53	92.145	5.09	8.96	100.00	8.96	100.0

Tunnel Eagle Tailings Release

3 - B	Individual			Cumulative			
Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery
P1	10.55	27.945	2.95	27.95	10.55	2.95	51.6
P2	4.53	59.78	2.71	37.51	15.08	5.65	64.0
T1	84.92	93.76	79.62	85.28	100.00	85.28	100.0

Plant 2	Usx						
Feed	Individual						
Sample	% Wt	Ave Ash	product	Ash	Yield	product	Combustible Recovery
P1	19.91	2.10	0.42	2.10	19.91	0.42	23.33
T6	43.52	2.42	1.05	2.31	63.43	1.47	74.18
T5	16.88	2.95	0.50	2.45	80.30	1.97	93.79
T4	3.79	9.45	0.36	2.76	84.10	2.32	97.91
T3	1.21	45.78	0.55	3.37	85.31	2.88	98.69
T2	1.32	86.70	1.14	4.64	86.63	4.02	98.90
T1	13.37	93.14	12.46	16.48	100.00	16.48	100.00

Plant 2 Concentrate Dilution Tests

USX Feed blend

			Individual			Cumulative					
Test	Sample	(% solids of feed)	Wt %	Ave. Ash	product	Ash	Yeild	product	Combustible Recovery	Time	
1	P1	5	28.47	3.28	0.93	3.28	28.47	0.93	30.38	0.50	% Solids
	P2	5	32.21	4.00	1.29	3.66	60.68	2.22	64.48	1.00	4.23
	P3	5	30.35	5.90	1.79	4.41	91.04	4.01	95.99	1.50	
	P4	5	3.75	14.51	0.54	4.81	94.79	4.56	99.53	3.00	ash reduction
	TAILS	5	5.21	91.75	4.78	9.34	100.00	9.34	100.00	10.00	4.93
	+28M	5	0.95	2.38	***	9.27	***	***	***	***	
2	P1	10	38.31	3.82	1.46	3.82	38.31	1.46	40.63	1.00	% Solids
	P2	10	48.04	5.01	2.40	4.48	86.35	3.87	90.94	2.00	8.83
	P3	10	8.16	10.23	0.83	4.97	94.50	4.70	99.02	3.00	
	P4	10	0.81	31.80	0.26	5.20	95.31	4.96	99.63	5.00	ash reduction
	TAILS	10	4.69	92.80	4.35	9.31	100.00	9.31	100.00	10.00	4.33
	+28M	10	0.94	2.53	***	9.24	***	***	***	***	
3	P1	15	17.80	3.95	0.70	3.95	17.80	0.70	18.84	1.00	% Solids
	P2	15	59.79	4.76	2.85	4.57	77.60	3.55	81.59	2.00	13.14
	P3	15	15.60	7.79	1.22	5.11	93.20	4.76	97.44	3.00	
	P4	15	2.48	19.19	0.48	5.48	95.67	5.24	99.64	5.00	ash reduction
	TAILS	15	4.33	92.55	4.00	9.24	100.00	9.24	100.00	10.00	4.13
	+28M	15	0.89	2.49	***	9.18	***	***	***	***	
4	P1	20	23.80	4.69	1.12	4.69	23.80	1.12	25.02	1.00	% Solids
	P2	20	37.70	4.74	1.79	4.72	61.50	2.90	64.64	2.00	17.26
	P3	20	27.89	7.28	2.03	5.52	89.39	4.93	93.16	3.00	
	P4	20	6.68	11.88	0.79	5.96	96.07	5.72	99.65	5.00	ash reduction
	TAILS	20	3.93	91.89	3.61	9.33	100.00	9.33	100.00	10.00	3.82
	+28M	20	1.07	2.58	***	9.26	***	***	***	***	

Plant 1 Test 1

Mean Retention Time (min): 6.88 Total Concentration (ppt): 0.311

Initial Lag Time (min): 3.50 Base Concentration (ppt): 0.484

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.481	0.0000	0.0000	0.0000	0.0000	0.0000
0.500	0.000	0.000	0.479	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	0.000	0.000	0.480	0.0000	0.0000	0.0000	0.0000	0.0000
1.500	0.000	0.000	0.481	0.0000	0.0000	0.0000	0.0000	0.0000
2.000	0.000	0.000	0.482	0.0000	0.0000	0.0000	0.0000	0.0000
2.500	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
3.000	0.000	0.000	0.483	0.0000	0.0000	0.0000	0.0000	0.0000
3.500	0.000	0.000	0.482	0.0000	0.0000	0.0000	0.0000	0.0000
4.000	0.500	0.073	0.483	0.0000	0.0000	0.0000	0.0000	0.0000
4.500	1.000	0.145	0.489	0.0050	0.0161	0.0081	0.0025	0.0025
5.000	1.500	0.218	0.493	0.0090	0.0290	0.0145	0.0068	0.0045
5.500	2.000	0.291	0.497	0.0130	0.0419	0.0209	0.0130	0.0065
6.000	2.500	0.363	0.502	0.0180	0.0580	0.0290	0.0225	0.0090
6.500	3.000	0.436	0.503	0.0190	0.0612	0.0306	0.0285	0.0095
7.000	3.500	0.509	0.508	0.0240	0.0773	0.0386	0.0420	0.0120
7.500	4.000	0.581	0.513	0.0290	0.0934	0.0467	0.0580	0.0145
8.000	4.500	0.654	0.516	0.0320	0.1031	0.0515	0.0720	0.0160
8.500	5.000	0.727	0.517	0.0330	0.1063	0.0531	0.0825	0.0165
9.000	5.500	0.799	0.518	0.0340	0.1095	0.0547	0.0935	0.0170
9.500	6.000	0.872	0.518	0.0340	0.1095	0.0547	0.1020	0.0170
10.000	6.500	0.945	0.519	0.0350	0.1127	0.0564	0.1138	0.0175
10.500	7.000	1.017	0.516	0.0320	0.1031	0.0515	0.1120	0.0160
11.000	7.500	1.090	0.516	0.0320	0.1031	0.0515	0.1200	0.0160
11.500	8.000	1.163	0.513	0.0290	0.0934	0.0467	0.1160	0.0145
12.000	8.500	1.235	0.512	0.0280	0.0902	0.0451	0.1190	0.0140
12.500	9.000	1.308	0.510	0.0260	0.0837	0.0419	0.1170	0.0130
13.000	9.500	1.380	0.507	0.0230	0.0741	0.0370	0.1093	0.0115
13.500	10.000	1.453	0.506	0.0220	0.0709	0.0354	0.1100	0.0110
14.000	10.500	1.526	0.503	0.0190	0.0612	0.0306	0.0998	0.0095
14.500	11.000	1.598	0.502	0.0180	0.0580	0.0290	0.0990	0.0090
15.000	11.500	1.671	0.499	0.0150	0.0483	0.0242	0.0863	0.0075
15.500	12.000	1.744	0.498	0.0140	0.0451	0.0225	0.0840	0.0070
16.000	12.500	1.816	0.495	0.0110	0.0354	0.0177	0.0688	0.0055
16.500	13.000	1.889	0.495	0.0110	0.0354	0.0177	0.0715	0.0055
17.000	13.500	1.962	0.493	0.0090	0.0290	0.0145	0.0608	0.0045
17.500	14.000	2.034	0.492	0.0080	0.0258	0.0129	0.0560	0.0040
18.000	14.500	2.107	0.491	0.0070	0.0225	0.0113	0.0508	0.0035
18.500	15.000	2.180	0.490	0.0060	0.0193	0.0097	0.0450	0.0030
19.000	15.500	2.252	0.488	0.0040	0.0129	0.0097	0.0465	0.0030
20.000	16.500	2.398	0.487	0.0030	0.0097	0.0097	0.0495	0.0030
21.000	17.500	2.543	0.486	0.0020	0.0064	0.0064	0.0350	0.0020
22.000	18.500	2.688	0.485	0.0010	0.0032	0.0032	0.0185	0.0010
23.000	19.500	2.834	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
24.000	20.500	2.979	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
25.000	21.500	3.124	0.485	0.0010	0.0032	0.0032	0.0215	0.0010
26.000	22.500	3.270	0.485	0.0010	0.0032	0.0032	0.0225	0.0010
27.000	23.500	3.415	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
28.000	24.500	3.560	0.485	0.0010	0.0032	0.0032	0.0245	0.0010
29.000	25.500	3.706	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
30.000	26.500	3.851	0.485	0.0010	0.0032	0.0032	-0.3379	-0.0128
31.000								
						1.000	2.042	0.297

Plant 1 Test 2

Mean Retention Time (min):	7.92	Total Concentration (ppt):	0.293
Initial Lag Time (min):	9.00	Base Concentration (ppt):	0.438

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
6.500	0.000	0.000	0.434	0.0000	0.0000	0.0000	0.0000	0.0000
7.000	0.000	0.000	0.434	0.0000	0.0000	0.0000	0.0000	0.0000
7.500	0.000	0.000	0.434	0.0000	0.0000	0.0000	0.0000	0.0000
8.000	0.000	0.000	0.434	0.0000	0.0000	0.0000	0.0000	0.0000
8.500	0.000	0.000	0.434	0.0000	0.0000	0.0000	0.0000	0.0000
9.000	0.000	0.000	0.436	0.0000	0.0000	0.0000	0.0000	0.0000
9.500	0.500	0.063	0.444	0.0060	0.0205	0.0102	0.0015	0.0030
10.000	1.000	0.126	0.447	0.0090	0.0307	0.0154	0.0045	0.0045
10.500	1.500	0.189	0.450	0.0120	0.0410	0.0205	0.0090	0.0060
11.000	2.000	0.253	0.455	0.0170	0.0581	0.0290	0.0170	0.0085
11.500	2.500	0.316	0.459	0.0210	0.0717	0.0359	0.0263	0.0105
12.000	3.000	0.379	0.460	0.0220	0.0752	0.0376	0.0330	0.0110
12.500	3.500	0.442	0.463	0.0250	0.0854	0.0427	0.0438	0.0125
13.000	4.000	0.505	0.464	0.0260	0.0888	0.0444	0.0520	0.0130
13.500	4.500	0.568	0.469	0.0310	0.1059	0.0529	0.0697	0.0155
14.000	5.000	0.631	0.470	0.0320	0.1093	0.0547	0.0800	0.0160
14.500	5.500	0.694	0.470	0.0320	0.1093	0.0547	0.0880	0.0160
15.000	6.000	0.758	0.469	0.0310	0.1059	0.0529	0.0930	0.0155
15.500	6.500	0.821	0.469	0.0310	0.1059	0.0529	0.1008	0.0155
16.000	7.000	0.884	0.468	0.0300	0.1025	0.0512	0.1050	0.0150
16.500	7.500	0.947	0.460	0.0220	0.0752	0.0376	0.0825	0.0110
17.000	8.000	1.010	0.460	0.0220	0.0752	0.0376	0.0880	0.0110
17.500	8.500	1.073	0.460	0.0220	0.0752	0.0376	0.0935	0.0110
18.000	9.000	1.136	0.456	0.0180	0.0615	0.0307	0.0810	0.0090
18.500	9.500	1.200	0.455	0.0170	0.0581	0.0290	0.0808	0.0085
19.000	10.000	1.263	0.454	0.0160	0.0547	0.0273	0.0800	0.0080
19.500	10.500	1.326	0.453	0.0150	0.0512	0.0256	0.0788	0.0075
20.000	11.000	1.389	0.451	0.0130	0.0444	0.0222	0.0715	0.0065
20.500	11.500	1.452	0.449	0.0110	0.0376	0.0188	0.0633	0.0055
21.000	12.000	1.515	0.448	0.0100	0.0342	0.0171	0.0600	0.0050
21.500	12.500	1.578	0.448	0.0100	0.0342	0.0171	0.0625	0.0050
22.000	13.000	1.642	0.448	0.0100	0.0342	0.0171	0.0650	0.0050
22.500	13.500	1.705	0.448	0.0100	0.0342	0.0171	0.0675	0.0050
23.000	14.000	1.768	0.447	0.0090	0.0307	0.0231	0.0945	0.0068
24.000	15.000	1.894	0.444	0.0060	0.0205	0.0205	0.0900	0.0060
25.000	16.000	2.020	0.443	0.0050	0.0171	0.0171	0.0800	0.0050
26.000	17.000	2.147	0.441	0.0030	0.0102	0.0102	0.0510	0.0030
27.000	18.000	2.273	0.440	0.0020	0.0068	0.0068	0.0360	0.0020
28.000	19.000	2.399	0.439	0.0010	0.0034	0.0034	0.0190	0.0010
29.000	20.000	2.525	0.439	0.0010	0.0034	0.0034	0.0200	0.0010
30.000	21.000	2.652	0.440	0.0020	0.0068	0.0068	0.0420	0.0020
31.000	22.000	2.778	0.439	0.0010	0.0034	0.0034	0.0220	0.0010
32.000	23.000	2.904	0.439	0.0010	0.0034	0.0034	0.0230	0.0010
33.000	24.000	3.030	0.438	0.0000	0.0000	0.0000	0.0000	0.0000
34.000	25.000	3.157	0.439	0.0010	0.0034	0.0034	0.0250	0.0010
35.000	26.000	3.283	0.435	0.0000	0.0000	0.0000	0.0000	0.0000
36.000	27.000	3.409	0.440	0.0020	0.0068	0.0068	0.0540	0.0020
37.000	28.000	3.536	0.441	0.0030	0.0102	0.0102	0.0840	0.0030
38.000	29.000							
						1.009	2.338	0.295

Plant 1 Test 3

Mean Retention Time (min):	5.23	Total Concentration (ppt):	0.293
Initial Lag Time (min):	3.50	Base Concentration (ppt):	0.500

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
0.500	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
1.500	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
2.000	0.000	0.000	0.484	0.0000	0.0000	0.0000	0.0000	0.0000
2.500	0.000	0.000	0.491	0.0000	0.0000	0.0000	0.0000	0.0000
3.000	0.000	0.000	0.495	0.0000	0.0000	0.0000	0.0000	0.0000
3.500	0.000	0.000	0.494	0.0000	0.0000	0.0000	0.0000	0.0000
4.000	0.500	0.096	0.507	0.0070	0.0239	0.0120	0.0018	0.0035
4.500	1.000	0.191	0.515	0.0150	0.0512	0.0256	0.0075	0.0075
5.000	1.500	0.287	0.521	0.0210	0.0717	0.0359	0.0158	0.0105
5.500	2.000	0.382	0.532	0.0320	0.1093	0.0547	0.0320	0.0160
6.000	2.500	0.478	0.533	0.0330	0.1127	0.0564	0.0413	0.0165
6.500	3.000	0.573	0.534	0.0340	0.1161	0.0581	0.0510	0.0170
7.000	3.500	0.669	0.536	0.0360	0.1230	0.0615	0.0630	0.0180
7.500	4.000	0.764	0.536	0.0360	0.1230	0.0615	0.0720	0.0180
8.000	4.500	0.860	0.534	0.0340	0.1161	0.0581	0.0765	0.0170
8.500	5.000	0.955	0.530	0.0300	0.1025	0.0512	0.0750	0.0150
9.000	5.500	1.051	0.526	0.0260	0.0888	0.0444	0.0715	0.0130
9.500	6.000	1.146	0.520	0.0200	0.0683	0.0342	0.0600	0.0100
10.000	6.500	1.242	0.518	0.0180	0.0615	0.0307	0.0585	0.0090
10.500	7.000	1.337	0.515	0.0150	0.0512	0.0256	0.0525	0.0075
11.000	7.500	1.433	0.511	0.0110	0.0376	0.0188	0.0413	0.0055
11.500	8.000	1.528	0.509	0.0090	0.0307	0.0154	0.0360	0.0045
12.000	8.500	1.624	0.507	0.0070	0.0239	0.0120	0.0298	0.0035
12.500	9.000	1.719	0.507	0.0070	0.0239	0.0120	0.0315	0.0035
13.000	9.500	1.815	0.507	0.0070	0.0239	0.0120	0.0333	0.0035
13.500	10.000	1.910	0.506	0.0060	0.0205	0.0102	0.0300	0.0030
14.000	10.500	2.006	0.506	0.0060	0.0205	0.0102	0.0315	0.0030
14.500	11.000	2.101	0.505	0.0050	0.0171	0.0085	0.0275	0.0025
15.000	11.500	2.197	0.505	0.0050	0.0171	0.0085	0.0288	0.0025
15.500	12.000	2.292	0.504	0.0040	0.0137	0.0068	0.0240	0.0020
16.000	12.500	2.388	0.504	0.0040	0.0137	0.0068	0.0250	0.0020
16.500	13.000	2.483	0.503	0.0030	0.0102	0.0051	0.0195	0.0015
17.000	13.500	2.579	0.503	0.0030	0.0102	0.0051	0.0203	0.0015
17.500	14.000	2.674	0.502	0.0020	0.0068	0.0034	0.0140	0.0010
18.000	14.500	2.770	0.502	0.0020	0.0068	0.0034	0.0145	0.0010
18.500	15.000	2.865	0.502	0.0020	0.0068	0.0034	0.0150	0.0010
19.000	15.500	2.961	0.502	0.0020	0.0068	0.0034	0.0155	0.0010
19.500	16.000	3.056	0.502	0.0020	0.0068	0.0034	0.0160	0.0010
20.000	16.500	3.152	0.501	0.0010	0.0034	0.0017	0.0083	0.0005
20.500	17.000	3.247	0.501	0.0010	0.0034	0.0017	0.0085	0.0005
21.000	17.500	3.343	0.501	0.0010	0.0034	0.0017	0.0088	0.0005
21.500	18.000	3.438	0.501	0.0010	0.0034	0.0017	0.0090	0.0005
22.000	18.500	3.534	0.501	0.0010	0.0034	0.0017	0.0093	0.0005
22.500	19.000	3.629	0.500	0.0000	0.0000	0.0000	0.0000	0.0000
23.000	19.500	3.725	0.500	0.0000	0.0000	0.0000	0.0000	0.0000
24.000	20.500	3.916	0.500	0.0000	0.0000	0.0000	0.0000	0.0000
25.000	21.500	4.107	0.500	0.0000	0.0000	0.0000	0.0000	0.0000
26.000	22.500	4.298	0.500	0.0000	0.0000	0.0000	0.0000	0.0000
27.000	23.500							
						0.767	1.175	0.225

Plant 2 Test 1 Bank 1

Full Capacity

Mean Retention Time (min): 2.49

Initial Lag Time (min): 1.00

Total Concentration (ppt): 0.293

Base Concentration (ppt): 0.463

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
0.500	0.000	0.000	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	0.000	0.000	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
1.500	0.500	0.201	0.550	0.0870	0.2972	0.1486	0.0218	0.0435
2.000	1.000	0.402	0.643	0.1800	0.6149	0.3074	0.0900	0.0900
2.500	1.500	0.603	0.677	0.2140	0.7310	0.3655	0.1605	0.1070
3.000	2.000	0.804	0.669	0.2060	0.7037	0.3518	0.2060	0.1030
3.500	2.500	1.005	0.633	0.1700	0.5807	0.2904	0.2125	0.0850
4.000	3.000	1.206	0.594	0.1310	0.4475	0.2237	0.1965	0.0655
4.500	3.500	1.407	0.559	0.0960	0.3279	0.1640	0.1680	0.0480
5.000	4.000	1.608	0.535	0.0720	0.2459	0.1230	0.1440	0.0360
5.500	4.500	1.809	0.535	0.0720	0.2459	0.1230	0.1620	0.0360
6.000	5.000	2.010	0.503	0.0400	0.1366	0.0683	0.1000	0.0200
6.500	5.500	2.211	0.493	0.0300	0.1025	0.0512	0.0825	0.0150
7.000	6.000	2.412	0.480	0.0170	0.0581	0.0290	0.0510	0.0085
7.500	6.500	2.613	0.478	0.0150	0.0512	0.0256	0.0487	0.0075
8.000	7.000	2.814	0.462	0.0000	0.0000	0.0000	0.0000	0.0000
8.500	7.500	3.015	0.465	0.0020	0.0068	0.0034	0.0075	0.0010
9.000	8.000	3.216	0.465	0.0020	0.0068	0.0034	0.0080	0.0010
9.500	8.500	3.417	0.460	0.0000	0.0000	0.0000	0.0000	0.0000
10.000	9.000	3.618	0.454	0.0000	0.0000	0.0000	0.0000	0.0000
10.500	9.500	3.819	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
11.000	10.000	4.020	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
11.500	10.500	4.222	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
12.000	11.000	4.423	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
12.500	11.500	4.624	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
13.000	12.000	4.825	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
13.500	12.500	5.026	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
14.000	13.000	5.227	0.463	0.0000	0.0000	0.0000	0.0000	0.0000
15.000	14.000							
						2.278	1.659	0.667

Plant 2 Test 1 Bank 2

Full Capacity

Mean Retention Time (min):	3.00	Total Concentration (ppt):	0.293
Initial Lag Time (min):	2.00	Base Concentration (ppt):	0.443

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.445	0.0020	0.0068	0.0017	0.0000	0.0000
0.500	0.000	0.000	0.441	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	0.000	0.000	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
1.500	0.000	0.000	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
2.000	0.000	0.000	0.441	0.0000	0.0000	0.0000	0.0000	0.0000
2.500	0.500	0.167	0.470	0.0270	0.0922	0.0461	0.0067	0.0135
3.000	1.000	0.334	0.507	0.0640	0.2186	0.1093	0.0320	0.0320
3.500	1.500	0.500	0.540	0.0970	0.3313	0.1657	0.0728	0.0485
4.000	2.000	0.667	0.547	0.1040	0.3553	0.1776	0.1040	0.0520
4.500	2.500	0.834	0.543	0.1000	0.3416	0.1708	0.1250	0.0500
5.000	3.000	1.001	0.526	0.0830	0.2835	0.1418	0.1245	0.0415
5.500	3.500	1.168	0.514	0.0710	0.2425	0.1213	0.1243	0.0355
6.000	4.000	1.334	0.501	0.0580	0.1981	0.0991	0.1160	0.0290
6.500	4.500	1.501	0.491	0.0480	0.1640	0.0820	0.1080	0.0240
7.000	5.000	1.668	0.480	0.0370	0.1264	0.0632	0.0925	0.0185
7.500	5.500	1.835	0.470	0.0270	0.0922	0.0461	0.0742	0.0135
8.000	6.000	2.002	0.452	0.0090	0.0307	0.0154	0.0270	0.0045
8.500	6.500	2.169	0.459	0.0160	0.0547	0.0273	0.0520	0.0080
9.000	7.000	2.335	0.450	0.0070	0.0239	0.0120	0.0245	0.0035
9.500	7.500	2.502	0.448	0.0050	0.0171	0.0085	0.0188	0.0025
10.000	8.000	2.669	0.448	0.0050	0.0171	0.0085	0.0200	0.0025
10.500	8.500	2.836	0.448	0.0050	0.0171	0.0085	0.0213	0.0025
11.000	9.000	3.003	0.430	0.0000	0.0000	0.0000	0.0000	0.0000
11.500	9.500	3.169	0.438	0.0000	0.0000	0.0000	0.0000	0.0000
12.000	10.000	3.336	0.430	0.0000	0.0000	0.0000	0.0000	0.0000
12.500	10.500	3.503	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
13.000	11.000	3.670	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
13.500	11.500	3.837	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
14.000	12.000	4.003	0.443	0.0000	0.0000	0.0000	0.0000	0.0000
15.000	13.000							
						1.305	1.144	0.382

Plant 2 Test 2 Bank 1

Algoma Seam full capacity

Mean Retention Time (min):	4.32	Total Concentration (ppt):	0.293
Initial Lag Time (min):	4.00	Base Concentration (ppt):	0.558

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
2.833	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
3.000	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
3.500	0.000	0.000	0.556	0.0000	0.0000	0.0000	0.0000	0.0000
4.000	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
4.500	0.500	0.116	0.589	0.0310	0.1059	0.0529	0.0077	0.0155
5.000	1.000	0.232	0.614	0.0560	0.1913	0.0956	0.0280	0.0280
5.500	1.500	0.347	0.648	0.0900	0.3074	0.1537	0.0675	0.0450
6.000	2.000	0.463	0.665	0.1070	0.3655	0.1828	0.1070	0.0535
6.500	2.500	0.579	0.675	0.1170	0.3997	0.1998	0.1463	0.0585
7.000	3.000	0.695	0.676	0.1180	0.4031	0.2015	0.1770	0.0590
7.500	3.500	0.810	0.672	0.1140	0.3894	0.1947	0.1995	0.0570
8.000	4.000	0.926	0.665	0.1070	0.3655	0.1828	0.2140	0.0535
8.500	4.500	1.042	0.654	0.0960	0.3279	0.1640	0.2160	0.0480
9.000	5.000	1.158	0.644	0.0860	0.2938	0.1469	0.2150	0.0430
9.500	5.500	1.273	0.632	0.0740	0.2528	0.1264	0.2035	0.0370
10.000	6.000	1.389	0.620	0.0620	0.2118	0.1059	0.1860	0.0310
10.500	6.500	1.505	0.611	0.0530	0.1810	0.0905	0.1723	0.0265
11.000	7.000	1.621	0.602	0.0440	0.1503	0.0752	0.1540	0.0220
11.500	7.500	1.737	0.595	0.0370	0.1264	0.0632	0.1388	0.0185
12.000	8.000	1.852	0.587	0.0290	0.0991	0.0495	0.1160	0.0145
12.500	8.500	1.968	0.583	0.0250	0.0854	0.0427	0.1063	0.0125
13.000	9.000	2.084	0.576	0.0180	0.0615	0.0307	0.0810	0.0090
13.500	9.500	2.200	0.573	0.0150	0.0512	0.0256	0.0712	0.0075
14.000	10.000	2.315	0.570	0.0120	0.0410	0.0205	0.0600	0.0060
14.500	10.500	2.431	0.568	0.0100	0.0342	0.0171	0.0525	0.0050
15.000	11.000	2.547	0.566	0.0080	0.0273	0.0137	0.0440	0.0040
15.500	11.500	2.663	0.564	0.0060	0.0205	0.0102	0.0345	0.0030
16.000	12.000							
						2.263	2.861	0.662

Plant 2 Test 2 Bank 2

Algoma Seam full capacity

Mean Retention Time (min):	2.51	Total Concentration (ppt):	0.293
Initial Lag Time (min):	7.33	Base Concentration (ppt):	0.558

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
0.500	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
1.500	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
7.333	0.000	0.000	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
7.500	0.167	0.066	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
8.000	0.667	0.266	0.580	0.0220	0.0752	0.0376	0.0073	0.0110
8.500	1.167	0.465	0.673	0.1150	0.3928	0.1964	0.0671	0.0575
9.000	1.667	0.665	0.751	0.1930	0.6593	0.3296	0.1608	0.0965
9.500	2.167	0.864	0.745	0.1870	0.6388	0.3194	0.2026	0.0935
10.000	2.667	1.063	0.716	0.1580	0.5397	0.2699	0.2107	0.0790
10.500	3.167	1.263	0.671	0.1130	0.3860	0.1930	0.1789	0.0565
11.000	3.667	1.462	0.627	0.0690	0.2357	0.1179	0.1265	0.0345
11.500	4.167	1.662	0.597	0.0390	0.1332	0.0666	0.0812	0.0195
12.000	4.667	1.861	0.580	0.0220	0.0752	0.0376	0.0513	0.0110
12.500	5.167	2.060	0.574	0.0160	0.0547	0.0273	0.0413	0.0080
13.000	5.667	2.260	0.564	0.0060	0.0205	0.0102	0.0170	0.0030
13.500	6.167	2.459	0.564	0.0060	0.0205	0.0102	0.0185	0.0030
14.000	6.667	2.659	0.560	0.0020	0.0068	0.0034	0.0067	0.0010
14.500	7.167	2.858	0.566	0.0080	0.0273	0.0137	0.0287	0.0040
15.000	7.667	3.057	0.557	0.0000	0.0000	0.0000	0.0000	0.0000
15.500	8.167	3.257	0.556	0.0000	0.0000	0.0000	0.0000	0.0000
16.000	8.667	3.456	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
16.500	9.167	3.655	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
17.000	9.667	3.855	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
17.500	10.167	4.054	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
18.000	10.667	4.254	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
18.500	11.167	4.453	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
19.000	11.667	4.652	0.558	0.0000	0.0000	0.0000	0.0000	0.0000
20.000	12.667							
						1.633	1.199	0.478

Plant 1 Test 1

All impellers turning the same direction

Cedar grove 570 tph

Mean Retention Time (min): 3.63

Initial Lag Time (min): 8.00

Total Concentration (ppt): 0.293

Base Concentration (ppt): 0.321

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
8.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
8.583	0.583	0.161	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
9.083	1.083	0.298	0.322	0.0010	0.0034	0.0017	0.0005	0.0005
9.583	1.583	0.436	0.348	0.0270	0.0922	0.0576	0.0267	0.0169
10.333	2.333	0.642	0.381	0.0600	0.2050	0.1281	0.0875	0.0375
10.833	2.833	0.780	0.398	0.0770	0.2630	0.1315	0.1091	0.0385
11.333	3.333	0.918	0.402	0.0810	0.2767	0.1383	0.1350	0.0405
11.833	3.833	1.055	0.389	0.0680	0.2323	0.1258	0.1412	0.0368
12.417	4.417	1.216	0.365	0.0440	0.1503	0.0877	0.1134	0.0257
13.000	5.000	1.377	0.350	0.0290	0.0991	0.0619	0.0906	0.0181
13.667	5.667	1.560	0.337	0.0160	0.0547	0.0364	0.0605	0.0107
14.334	6.334	1.744	0.330	0.0090	0.0307	0.0205	0.0380	0.0060
15.000	7.000	1.927	0.326	0.0050	0.0171	0.0100	0.0204	0.0029
15.500	7.500	2.065	0.325	0.0040	0.0137	0.0068	0.0150	0.0020
16.000	8.000	2.203	0.324	0.0030	0.0102	0.0051	0.0120	0.0015
16.500	8.500	2.340	0.324	0.0030	0.0102	0.0066	0.0164	0.0019
17.283	9.283	2.556	0.322	0.0010	0.0034	0.0022	0.0060	0.0006
17.783	9.783	2.694	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
18.283	10.283	2.831	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
18.783	10.783	2.969	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
19.283	11.283	3.107	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
19.783	11.783	3.244	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
20.283	12.283	3.382	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
20.783	12.783	3.520	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
21.283	13.283	3.657	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
21.783	13.783	3.795	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
22.283	14.283	3.933	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
22.783	14.783	4.070	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
23.283	15.283							
						0.820	0.872	0.240

Plant 3 Test 2

All impellers turning the same direction

Cedar Grove 75 0 tph

Mean Retention Time (min):	5.18	Total Concentration (ppt):	0.293
Initial Lag Time (min):	0.00	Base Concentration (ppt):	0.321

Actual Time (min)	Correct Time (min)	Normal Time (---)	Actual Concn (ppt)	Correct Concn (ppt)	Normal Concn (---)	Unit Concn (---)	C(t)(dt) (---)	C(dt) (---)
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
0.000	0.000	0.000	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
1.000	1.000	0.193	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
2.000	2.000	0.386	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
2.667	2.667	0.514	0.322	0.0010	0.0034	0.0020	0.0016	0.0006
3.167	3.167	0.611	0.340	0.0190	0.0649	0.0325	0.0301	0.0095
3.667	3.667	0.707	0.360	0.0390	0.1332	0.0722	0.0775	0.0211
4.250	4.250	0.820	0.379	0.0580	0.1981	0.0991	0.1233	0.0290
4.667	4.667	0.900	0.378	0.0570	0.1947	0.0892	0.1219	0.0261
5.167	5.167	0.997	0.371	0.0500	0.1708	0.0854	0.1292	0.0250
5.667	5.667	1.093	0.360	0.0390	0.1332	0.0666	0.1105	0.0195
6.167	6.167	1.190	0.349	0.0280	0.0956	0.0478	0.0863	0.0140
6.667	6.667	1.286	0.340	0.0190	0.0649	0.0325	0.0633	0.0095
7.167	7.167	1.383	0.334	0.0130	0.0444	0.0222	0.0466	0.0065
7.667	7.667	1.479	0.329	0.0080	0.0273	0.0137	0.0307	0.0040
8.167	8.167	1.575	0.327	0.0060	0.0205	0.0102	0.0245	0.0030
8.667	8.667	1.672	0.325	0.0040	0.0137	0.0068	0.0173	0.0020
9.167	9.167	1.768	0.324	0.0030	0.0102	0.0051	0.0138	0.0015
9.667	9.667	1.865	0.324	0.0030	0.0102	0.0051	0.0145	0.0015
10.167	10.167	1.961	0.323	0.0020	0.0068	0.0034	0.0102	0.0010
10.667	10.667	2.058	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
11.167	11.167	2.154	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
11.667	11.667	2.251	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
12.167	12.167	2.347	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
12.667	12.667	2.444	0.321	0.0000	0.0000	0.0000	0.0000	0.0000
13.167	13.167							
						0.594	0.901	0.174

VITA

Timothy Josiah McKeon was born on February 25, 1976 in Montgomery County, Virginia. He graduated high school from Dayspring Christian Academy in 1994. From there he enrolled at Virginia Polytechnic and State University (Virginia Tech) for a Bachelor of Science degree in Mining and Minerals Engineering. There he successfully passed the EIT exam.

After graduating in December 1998, he continued his enrolment at VPI&SU for a Masters of Science in Mining and Minerals Engineering with a specialization in mineral processing. He and his wife, Cathy, currently live in Florida where Tim serves as a process engineer for E.I. DuPont.