SHORT, NON-REFEREED PAPER

THE DEVELOPMENT AND APPLICATION OF A STOCKPILING MODEL AT THE UMFOLOZI SUGAR MILL

BOOTE G L N, BEZUIDENHOUT C N AND LYNE P W L

School of Bioresources Engineering and Environmental Hydrology,
University of KwaZulu-Natal, P/Bag X01, Scottsville, 3209, South Africa
beeh@ukzn.ac.za gordonboote@gmail.com
bezuidenhoutc@ukzn.ac.za lynep@ukzn.ac.za

Abstract

The co-owned Umfolozi mill area has developed as an integrated supply chain. The objective of this study was to create a tool which would unlock one systemic problem and thus increase the productivity of the mill. Cane supply reliability was identified as a vulnerable area at Umfolozi. It was found that low cane supply reliability was as a result of wet weather conditions preventing harvesting on the Umfolozi flats and thus inducing a mill stop. To address the problem, a stochastic model was created to assess the effectiveness of an enlarged cane stockpile outside the mill. The stockpile will be maintained on the current tram system outside the mill and be crushed when wet weather prevents further harvesting. The model was then used to conduct a series of Monte Carlo simulations on which sensitivity analyses and economic feasibility assessments were conducted.

Keywords: supply chain, stockpiling, integrated systems, network, no-cane stops, cane yard

Introduction

After conducting complex systems analysis at the Umfolozi mill it was found that the mill experienced frequent no-cane stops as a result of wet conditions preventing harvesting teams from entering fields on the Umfolozi Flats. As outlined by Bartlett (1974), a possible solution to this is to create a stockpile of cane. The stockpile would ensure a continuous supply of cane to the mill when harvesting is not possible. It would be operated on a first-in-first-out basis and be in continuous motion, i.e. all cane would pass through the stockpile before being crushed.

This short paper focuses on the development of a stockpiling model, which was then used to determine the feasibility of the solution. The model conducts capital budgeting methods to establish the number of years it would take to repay the investment of additional tram trucks required to maintain the stockpile.

Materials and Methods

Model overview

The mill is supplied by the Umfolozi flats (70%) and other outlying areas (30%). Due to the high concentration of the flats and the localised climate the area tends to experience similar rainfall patterns, therefore, after a rainfall event, 70% of the cane supply to the mill is put on hold until the fields are dry enough for harvesting to resume. This inevitably results in a no-cane stop at the mill. The cane from the flats is transported to the mill on a narrow gauge tram system. The tram system has sidings that are ideally suited for creating a stockpile and therefore formed the basis of this stockpiling model.

It was proposed that 614 additional tram trucks, each with a capacity of 5.2 tons per truck, be purchased or built in-house at the mill at an estimated cost of R11 million. These additional trucks would be used to store the stockpile. The savings achieved by implementing the stockpile should then be able to repay the capital investment. In order to analyse the implications and the effectiveness of the stockpile, it was decided to create a model which would simulate a 24-hour stockpile of cane.

Rainfall

The driver of the model is a stochastic rainfall generator based on 53 years of rainfall data. Receiver Operating Characteristics outlined by Fawcett (2006) were used in the analysis of the previous three years of mill data. It was determined that harvesting was typically affected by rainfall at three different thresholds. For 5-10 mm of rainfall infield harvesting is not possible for one day, for 10-30 mm of rainfall harvesting is not possible for two days and for rainfall events above 30 mm harvesting cannot take place for three or more days. The limits and stochastic rainfall generator were combined to simulate wet field conditions.

Mill no-cane stop costs

The cost of a no-cane stop had to be calculated in order to determine that cost benefit of the stockpile. It was estimated that a single no-cane stop would cost the mill approximately R115 000.

RV % cane

In addition to the benefits generated as a result of fewer no-cane stops, the amount saved is also a function of the recoverable value (RV) of the cane. Towards the end of the season the RV decreases. It is thus advantageous to everyone that a majority of the cane is crushed mid-season. The length of milling season (LOMS) is extended with an increase in rainfall events as a result of wet field conditions. The stockpile attempts to mitigate the effect of an increased LOMS. In order to calculate the benefit of a shorter season, a RV curve for the Umfolozi cane was created. Using the current price per ton RV (R2500) daily revenue for the mill was calculated.

Mill crush rate and LOMS

Based on the previous three years' data the mill crushes at a rate of between 150 t/h and 406 t/h. The average crush rate was 300 t/h. It was found that in a season with a total crush of 1.1 million tons, a crush rate of 220 t/h was required to ensure that the season finished before 25 December.

Stockpile cane deterioration

An important factor that challenges the stockpiling proposal is cane deterioration that occurs from the moment the cane is burnt or cut (Barnes *et al.*, 2000). With a stockpile the cane would be delayed by an extra 24 hours before being crushed. The equation for deterioration as stated in Wynne and van Antwerpen (2004) was used to determine the amount of deterioration that would occur. It was assumed that the RV% cane in the stockpile would deteriorate by a constant of 1% RV.

Simulations
A series of Monte Carlo simulations were carried out. Each scenario was conducted by simulating 1000 seasons. The different scenarios included:

1. No stockpile
2. A 24 hour stockpile
3. Varying the amount of cane deterioration.

Results and Discussion

Figure 1 demonstrates how the stockpile successfully shortened the LOMS. The shorter LOMS generated more income for the mill as a result of crushing cane with a higher RV.

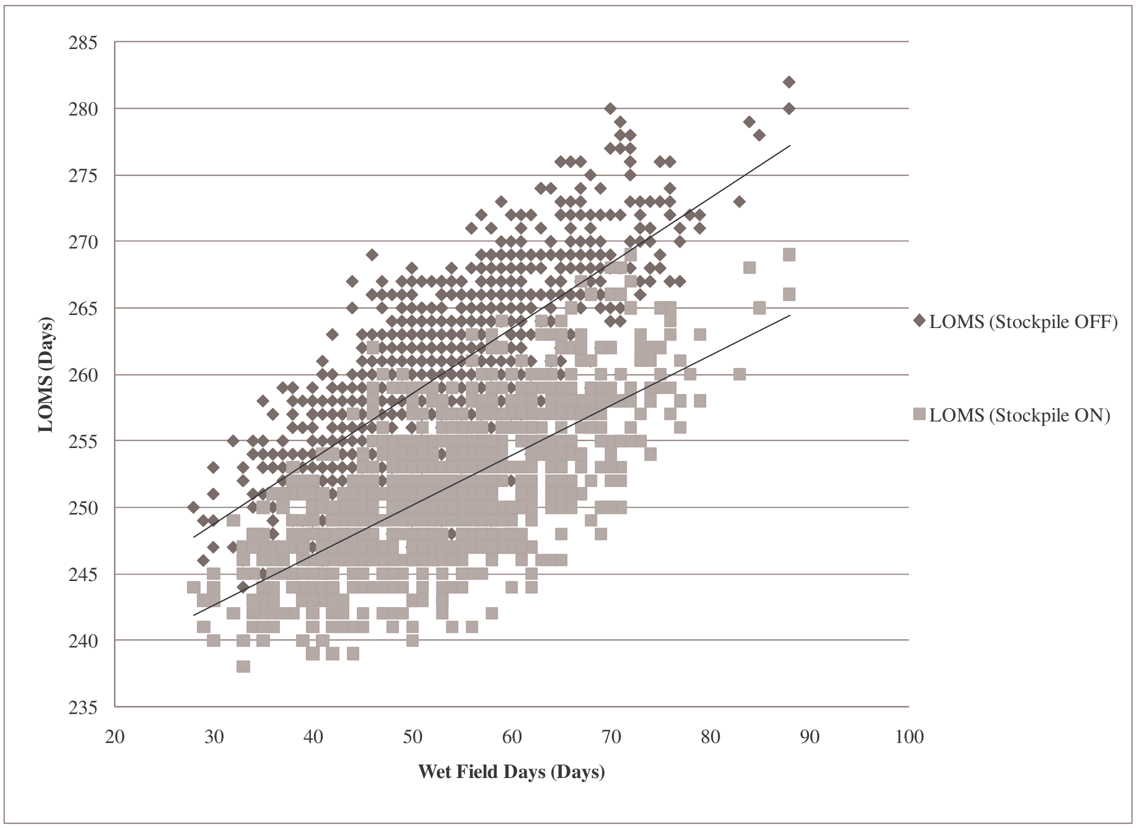

Figure 1. Effect of the stockpile on LOMS.

With the deterioration in the stockpile set to zero, there was more than a 60% chance that the number of years required to break even would range from 5 to 16 years. These results may seem satisfactory, but when an additional 1% deterioration caused by the delay in the stockpile was factored into the model, the savings were eroded and the mill began to lose large sums of money. The sensitivity to deterioration is demonstrated in Figure 2. At 0.025% deterioration there is a rapid decrease in the savings generated by the stockpile.

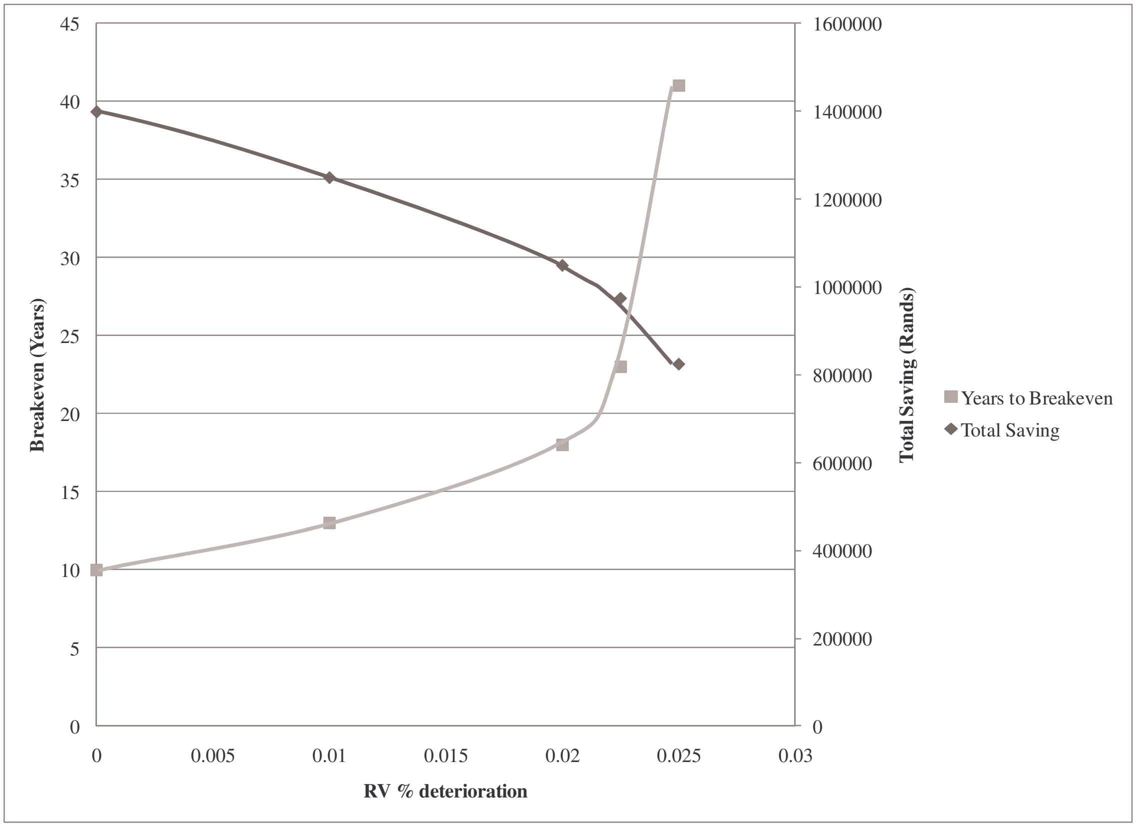

Figure 2. Deterioration and the negative effect it has on the additional revenue generated by the stockpile.

The Stockpile model successfully modelled the factors that affect cane supply at the Umfolozi sugar mill and has the potential to be adapted for other mills. The stockpile model supports the fact that stockpiling outside the mill would be a major disadvantage when cane deterioration is factored into the equation. The model, however, can serve as a foundation for other related cane supply modelling efforts, such as the assessment of the costs of mill breakdowns.

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