MineMAX Planner vs Whittle Four-X
An Open Pit Optimisation Software Evaluation and Comparison

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1 Introduction

MineMAX Pty. Ltd approached SRK Consulting, as an independent consultant, to test and evaluate its *MineMAX Planner* open pit optimization software and make the results publicly available. SRK was not paid for this work but did receive discounted copies of the MineMAX Planner software.

2 Objectives

The prime objective of the comparison exercise is to test MineMAX Planner's performance, in terms of its ability to correctly calculate an optimal pit, against the current industry standard pit optimization software, *Whittle Four-X*.

3 Whittle Four-X – Overview

3.1 Background

Whittle Four-X (Four-X) is the core module of what is now known as *Four-X Analyser*, a suite of open pit optimization, scheduling and analysis tools written originally by Whittle Programming Pty Ltd, [www.whittle.com.au/] and now wholly owned by Gemcom Software International [www.gemcom.bc.ca/]. Four-X is based on the Lerchs-Grossmann algorithm (1) that determines the exact optimum shape, in terms of cash flow, for an open pit in three dimensions. Four-X has been in use in the mining industry for many years and is accepted as the standard benchmark tool for open cut optimization and analysis. This paper will focus on the *Foundation* and *Multi Element* optimization modules from within the total Four-X Analyser suite.

3.2 Capabilities

- Optimal pit calculation
    - Single element, single process streams (Foundation module)
    - Multiple elements, multiple process streams (Multi Element module)
    - Optimisation by cutoff or cash flow
    - Ability to use formulas and expressions to create complex variations of costs, revenues and recoveries with depth and with time

- Nested pits calculation
- Re-Blocking utility
- Basic scheduling (non optimal)
- Basic Analysis

4 MineMAX Planner – Overview

4.1 Background

MineMAX Planner (MMP) is a new software tool from MineMAX Pty Ltd [www.MineMAX.com/] that is focused solely on open pit optimization. It is based on an algorithm called push-relabel (2,3) that is also an exact optimization algorithm. It's output is designed to be integrated into MineMAX Scheduler, an exactly optimal scheduling and blending package.

4.2 Capabilities

- Optimal pit calculation
    - Single and multiple element
    - Single process stream
    - Simple revenues and costs
- Nested pits calculation
- Simple analysis

5 Models Used

A real data set from a multi element metalliferous open pit operation was used to carry out the comparison. It features a massive style copper-gold-silver-zinc orebody that is reasonably continuous along strike and down dip.

6 Scenarios

Two scenarios were run. The first assuming a single rock type and a single element and single processing stream, in this case the gold was used and all other elements ignored. The second case used three rock types and all four elements, again with a single processing stream.

The processing decision method for MMP is by cash flow only. The option to control the processing selection by a specific element and cut off grade is not currently available but is planned for inclusion in future versions. Four-X has the option to control processing selection by cut offs or cash flow and the Four-X optimisation runs were set to control by cash flow to match MMP.

Parameters used for both optimizers were selected arbitrarily but approximate current industry conditions. The parameters are as listed in Table 1. No Cost adjustment factors for depth or throughput factors were used for mining or processing.

Parameter	Value	Comment
Block Size	10 x 5 x 2.5	Multi element re-blocked to 10 x 10 x 5
Copper Price	2204.6 $/t	Process recovery 90 %
Zinc Price	1000 $/t	Process recovery 80 %
Gold Price	500 $/oz	Process recovery 85 %
Silver Price	4.75 $/oz	Process recovery 95 %
Mining Recovery	100%	(assumes already built into block model as
Mining Dilution	None (100%)	MMP has no capability to set these values)
Processing Cost	50 $/t	
Mining Cost	1.5 $/t	
Overall pit slope	60 degrees	
# of benched for slope calculation	20	

Table 1: Optimisation parameters

7 Results

In both the single and multi element cases tested using identical parameters for both optimizers MMP and Four-X produce ore tonnes, grade, metal and waste tonnes are all within 0.02% of each other over a range of nested pits. These very small differences occur at the 4th or 5th significant figure and are most likely due to precision and rounding errors to do with unit conversions and internal reporting rather than any difference in the algorithms. While 0.02% is a significant difference mathematically it is negligible as far as pit optimisation is concerned as the optimisations produce theoretical optimal shells only. The optimal shells have yet to have a realistic pit designed around them and the order of accuracy of this process is far less than 0.02%. The packages in effect produce exactly the same optimal pits. The exact numbers for a single optimal pit for each method for the multiple element case are shown in Table 2.

That the two packages produce effectively the same result is to be expected given that both optimisation algorithms theoretically converge to an optimal solution to the optimisation problem. It shows that, assuming that Four-X is the accepted standard, MMP has correctly implemented the underlying algorithms for optimisation and slope precedence generation.

Examination in section and 3D visualisation of the pit shells exported from both packages in a separate mine planning package confirms that the results are the same. A slice at a selected elevation through both pit shells is shown in Figure 1. The differences in styles of the plan outlines shown in Figure 1 are due to the export and import routines and smoothing functions of the various software packages rather than differences in optimisation.

Speed tests between the two packages have not specifically been quantified as yet but for the models involved (240 000 blocks) the time taken to run the optimisation in both packages on a computer with 900 MHz processor and 512Mb of RAM was negligible, in the order of seconds.

Optimal pit		Whittle Four-X	MineMAX Planner	% Difference
Total Tonnage		24 562 037	24 563 802	0.007%
Ore Tonnage		4 966 695	4 967 004	0.006%
Waste Tonnage		19 595 342	19 596 798	0.007%
Total Metal				
	Cu (kg)	7 224 245	7 222 996	-0.017%
	Zn(kg)	12 407 369	12 408 051	0.005%
	Au (g)	14 125 485	14 125 073	-0.003%
	Ag (g)	153 304 507	153 316 521	0.008%
Undiscounted Pit Value		172 666 495	172 625 187	-0.024%
Cu grade		1.4545	1.4542	-0.024%
Zn grade		2.4981	2.4981	-0.001%
Au grade		2.8440	2.8438	-0.009%
Ag grade		30.8665	30.8670	0.002%

Table 2 : Grade, tonnage and metal comparisons.

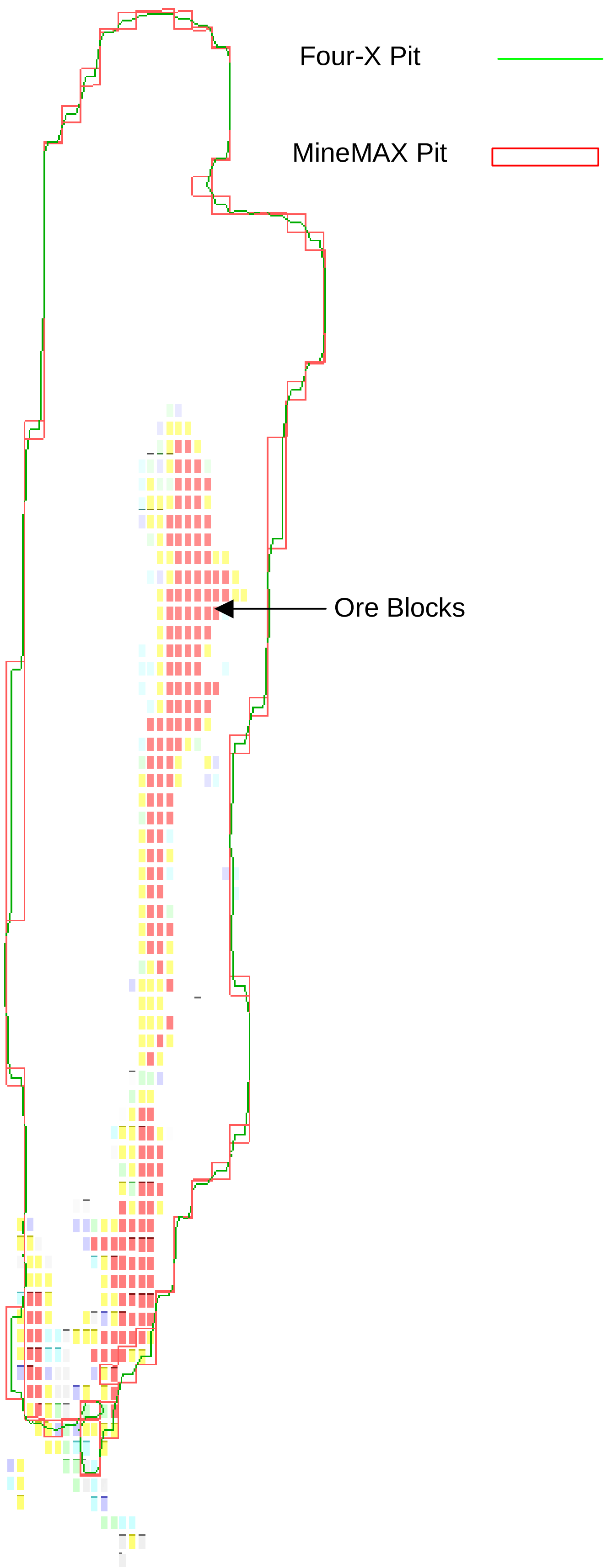

Figure 1: Plan view of optimal pit outlines at a selected elevation.

8 Discussion

Although both optimisation packages produce the same results for the actual optimal pit calculations they are very different packages. MMP is a relatively simple package that does not have the flexibility and functionality that is built into the basic Four-X options. It is not the purpose of this paper to itemise the various options and settings that each package has. The important conclusion is that the two algorithms produce the same result. The details of additional tools and user friendliness of each package are subjects for a separate paper.

In the authors opinion the main feature that needs to be added to MMP at this time is the ability to work with multiple process streams, for example and operation that runs both heap leach and a mill. It is understood that this option is currently under development and due for inclusion in the near future.

9 References

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