University of Southern Queensland

Faculty of Engineering and Surveying

Management of Physical Assets at Purga Quarry

A dissertation submitted by

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Abstract

South East Queensland is growing at an average of 55,300 people a year, with the majority of this growth occurring in the Western Corridor. The Western Corridor is referred to as the areas surrounding Ipswich and the Lockyer and Fassifern Valleys including the growth suburbs of Springfield, Ripley, Ebenezer and Amberley. (SEQRP 2005-2026, 2005).

Purga Quarry is the only quarry operated by Boral that services the Western Corridor of South East Queensland. The quarry supplies roadbase and aggregates to road and infrastructure projects currently under construction is this region. Boral's SEQ Quarry Division acknowledged that the current production output needed to be increased to meet the current and future demands, so it therefore enlisted the quarry as part of its first wave of the 'Operational Excellence' project. Along with this project, a more efficient asset management method was needed for the current equipment at the quarry.

In this project, research was carried out on the way that the current assets such as the plant and load and haul equipment on the site are managed. From this research, varies recommendations were introduced including prestart checklists to be filled out every morning for both plants as well as the load and haul equipment, fortnightly scheduled maintenance days for both plants to be undertaken on Saturdays so that the downtime is minimised, introducing scheduled maintenance plans and plans to replace parts on the assets as well as inputting these asset management plans into an asset management program as the program will automatically show when an item has been changed.

Some of these recommendations have been implemented and their also has been an addition in tonnes being produced as well as a decrease in unscheduled equipment downtime. All of the other recommendations have been planned to be implemented over the next few months. As these ideas are implemented they will have to be continually monitored to determine if unscheduled equipment downtime has decreased with the amount of tonnes produced, increasing

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Certification

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31/10/2007

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Staff of Purga Quarry – Purga

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1. Introduction

This chapter outlines the outcome expected from this project as well as the risks involved if the quarry does not complete this project. It also includes details of the processes involved in solving the problems at hand and of the information included in this dissertation.

1.1 The Problem

South East Queensland is growing at an average of 55,300 people each year, with the majority of this growth occurring in the Western Corridor. The Western Corridor is referred to as the areas surrounding Ipswich and the Lockyer and Fassifern Valleys including the growth suburbs of Springfield, Ripley, Ebenezer and Amberley. (SEQRP 2005-2026, 2005). This area is shown in figure 1.1 below.

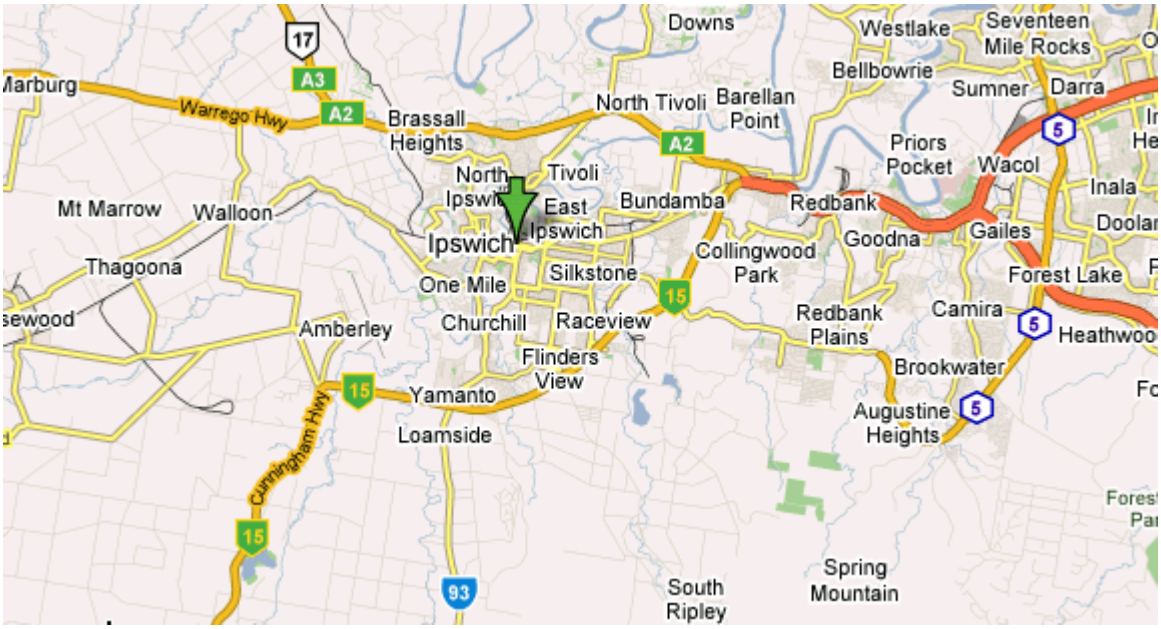

Figure 1.1: Map of Western Corridor of South East Queensland
(Google Maps, 2007)

Purga Quarry is the only quarry operated by Boral that services the Western Corridor of South East Queensland. (Pyne S 2007, pers. comm., 8 January) The quarry supplies

roadbase and aggregates to road and infrastructure projects currently under construction is this region. (Carroll J 2007, pers. comm., 18 January) Boral's SEQ Quarry Division acknowledged that the current production output needed to be increased to meet the current and future demands, so therefore enlisted the quarry as part of its first wave of the 'Operational Excellence' project. Along with this project, a more efficient asset management method is needed for the current equipment at the quarry. (Boral Operational Excellence Diagnostic Report, 2006)

Further background analysis can be found in Chapter 2 of this dissertation.

1.2 Research Objectives

Assets of companies such as Boral are made up of social and economic infrastructure which enables the provision of services to the public as well as to business. These assets play a vital role in the economy of the business with a key requirement being to secure a sustainable increase in the provision and management of infrastructure and other assets. (New Zealand Treasury, 2007)

The primary objective of this project was to identify a more efficient way to manage the assets that are currently at the quarry as well as the assets arriving via the 'Operational Excellence' project. With the help from the management and staff at Purga quarry, research was conducted on how the assets on the site were managed and maintained. From this research and research from the manufacturers of the assets on what their most effective way to maintain the assets are, an asset management plan was drawn up. This includes maintenance policies of current assets and identifying a time when replacing assets would be more effective than continuing to maintain the current assets. This asset management plan would then be implemented to meet the production target set out to meet the 'Operational Excellence' project to double production of the financial year 2005/06. (Boral Operational Excellence Diagnostic Report, 2006)

1.3 Project Methodology

A project of this magnitude needs to be conducted in a manner that all aspects of the research and development in this project are conducted in a satisfactory and timely manner.

The first task in this project is to research the current unscheduled downtime on both the plants as well as the load and haul equipment. This downtime would be mainly because of equipment failures that occur on the assets. This information is found on Boral's Quarry Database that only a selected few people have access to as well as information received from the staff working at the site operating the plants and load and haul equipment. After researching the downtime, it is essential to examine the current methods of maintenance that is conducted on both the plants as well as the load and haul equipment. This research is also conducted thanks to the staff at Purga Quarry as well as manuals that carry this information located at the quarry. It is then essential to find out what the manufactures recommend for maintenance on their equipment. By reading the manuals for the equipment as well as contacting the manufacturers, this information is easily found.

From this research conducted, new preventive maintenance policies can be then drawn up for both the plant and load and haul equipment. These policies can then be implemented and monitored for the improvements and the cost and production benefits can then be determined.

1.4 Risk Analysis

The 'Operational Excellence' project is set out to double the production of the financial year 2005/06. An efficient asset management program is needed to meet this projects demand. (Boral Operational Excellence Diagnostic Report, 2006)

By not outlining an effective asset management plan for Purga quarry, the assets are likely to fail causing downtime. (Pyne S 2007, pers. comm., 8 January) Downtime results in no production and as increased downtime periods occur, the production of the quarry

will be unable to meet the production targets set out by 'Operational Excellence'. If these targets are not met by the quarry, Boral will not be able to meet the demands of the consumers who will then therefore go to other companies such as Hanson and smaller local quarries. Consumers will also lose confidence in Boral as a supplier of quarrying material, therefore losing business. (Carroll J 2007, pers. comm., 18 January)

1.5 Dissertation Overview

This dissertation begins with an introduction, outlining the objectives of the project and the methodology undertaken to meet these objectives. The second chapter provides a background to the problem including, how a quarry operates as well as some background information on Purga quarry and an explanation of the South East Queensland Regional Plan and Operational Excellence. Chapter 3 provides more background information in the form of a literature review, outlining financial terms such as assets, different types of assets, asset management and different types of asset management. The fourth chapter gives a description of the main assets at Purga Quarry including the major load and haul equipment such as front end loaders and dump trucks as well as plant equipment such as crushers, screens and conveyor belts. Chapter 5 gives a critical assessment of the way the equipment is currently managed and maintained. It describes how the current prestart checks work and how the current equipment at the quarry is maintained. Chapter 6 outlines the new strategy for prestart checks for the plant and load and haul equipment, as well as the new preventive maintenance schedules that have been drawn up from the research carried out in the previous chapters. Also included in this chapter is the explanation of inputting these maintenance schedules in an asset maintenance program such as MEX which automatically flag up when maintenance is due on the equipment. The seventh chapter outlines the different methods of valuating the equipment at the quarry as well as the different methods of calculating depreciation of these assets as well as the need for replacement and when to do so. Chapter 8 gives a cost and production benefit of the improvements undertaken at Purga Quarry due to the introduction of these new methods with Chapter 9 describing what ideas have been implemented at the quarry to date. The final chapter, Chapter 10, is a conclusion to the project.

1.6 Conclusion

By identifying a more effective way to manage assets at the quarry, the production target outlined by the 'Operational Excellence' project of doubling the production of the quarry compared to the financial 2005/06 year will be met. (Boral Operational Excellence Diagnostic Report, 2006) Understanding how the equipment operates on the site as well as maintenance schedules and what parts of the assets regularly fail, will help the process of drawing up maintenance policies. Identifying when to replace equipment rather than continually maintaining them is also an important factor in drawing up an asset management plan.

2. Background

The background information on how a quarry operates as well as safety at a quarry and the background of Purga Quarry, South East Queensland Regional Plan 2005-2026 and Boral's Operational Excellence projects are found in this chapter. The information was sourced using various books, journals and other online resources as well as information provided by Boral and Queensland Government.

2.1 How a quarry operates

A quarry is an open cut pit where rock is being extracted. There are different types of quarries situated in and around South East Queensland extracting products such as aggregates, used for concrete, sealing materials and drainage; road base material; material used for fill and sand. (Boral SEQ Quarries, 2006)

Quarries usually operate for a period of 30 years but this depends on how much rock is being extracted. They are developed in steps or benches on hills or in pits underground, as shown in figure 2.1. (Wikipedia, 2007)

Figure 2.1 – Examples of Quarry Benches at Purga Quarry
(Boral SEQ Quarries, 2006)

To retrieve the final material from a quarry it goes through a number of processes. These include:

- Drilling
- Blasting
- Loading into Dump Trucks
- Hauling to the Crushing Plant
- Crushing and Screening
- Stockpiling
- Selling

(Rieck, D 2007, pers comm., 25 February)

2.1.1 Drilling

The first process of quarries is drilling. Drilling is usually done by drilling a series of holes in strategic places on the rock bench using a drill rig. If the holes are too close

together when blasted, the material is too fine therefore will not go through the crushing plant effectively. If the holes are too far apart, the material is too big and lumpy and will take longer to process through the crushing plant, resulting in a reduction in tonnes being produced for the day. (Rieck, D 2007, pers comm., 25 February)

2.1.2 Blasting

The second process is blasting. Blasting is a series of controlled shots where explosives are placed into the holes that have been previously drilled. These explosives are fired with the material falling neatly into piles onto the bench. One shot is fired at a time with a delay before the following shots are fired. (Rieck, D 2007, pers comm., 25 February)

2.1.3 Loading into Dump trucks

After the shots have been fired, an excavator or front end loader is driven up to the bench where the rock has been piled. The loading tool is used to load the material onto the dump trucks as well as removing material that is not of a standard to put through the crushing plant. This allows the loading tool to move to gain access to the quality material. This machine is also used to scrape off the loose material from the edge of the bench. (Rieck, D 2007, pers comm., 25 February)

2.1.4 Hauling to the Crushing Plant

The material is then transported in dump trucks to the crushing plant. The dump trucks travel along specially designated haul roads on which no other traffic is permitted. (Rieck, D 2007, pers comm., 25 February)

2.1.5 Crushing and Screening

The dump truck tips the raw material into the crushing plant jaw shown in figure 2.2.

Figure 2.2 – Picture of Purga Crushing Plant 1 taken from the control box

The first section of the crushing plant is the feeder which consists of a jaw and a primary crusher where it is crushed using powerful hammers or a cone system. An operator oversees this process from a dust tight and air conditioned control room usually located near the feeder. If the operator's sight of the feeder is impaired, a camera is placed at the feeder so that the operator can monitor the rate at which the material goes through the feeder. The operator has control of the speed at which the material goes through the jaw. If the material is fine, the speed of the jaw is slowed because the material will overload the conveyor after the feeder. If the material is lumpy or oversize, a hammer situated next to the jaw is used to push the material into the jaw. When the hammer is being used, the feeder is turned off therefore causing downtime. (Rieck, D 2007, pers comm., 25 February)

When making roadbase a dust is added to the material. The dust comes from an add bin which is situated after the primary jaw. (Rieck, D 2007, pers comm., 25 February)

The material is transported from the feeder to the first screen via a conveyor belt. This conveyor belt is the largest conveyor belt on the plant as it has to carry the largest size material. (Rieck, D 2007, pers comm., 25 February)

The material is then put through a screen which sieves the material into different sizes depending on how many different decks the screen has. Usually the first screen is a double deck screen with each deck splitting the material out into 40 mm in diameter material and above, material between 20 and 40 mm and anything less than 20 mm. (Rieck, D 2007, pers comm., 25 February)

The material above 20 mm is then transferred via conveyor belt to the second crusher then onto the second screen. If making aggregates, this screen is a triple deck screen splitting the material out into material above 20 mm, material between 20 and 10 mm, material between 10 and 5 mm and material less than 5 mm which is referred to as dust. The material above 20 mm is recirculated through the previous crusher before going through the screen again. If making roadbase, the screen is a triple deck screen splitting the material into material above 40 mm, material between 40 and 20 mm, material between 20 and 10 mm and material less than 10 mm. The material above 20 mm then goes though the recirculation process as described above. The material less than 20 mm is sent to a special crusher called a Barmac. A Barmac is designed to make the rock more round in shape as customers prefer rocks with a round shape rather than a rock with jagged edges. (Rieck, D 2007, pers comm., 25 February)

The material is then piled into heaps of different material sizes for aggregates or into a pile under the conveyor belt for the roadbase. (Rieck, D 2007, pers comm., 25 February)

2.1.6 Stockpiling

The material that is stocked in piles under the conveyor belts is then loaded onto dump trucks by a front end loader and is transported to a special stockpiling area. (Rieck, D 2007, pers comm., 25 February)

2.1.7 Selling

After the material has been dumped at its specific stockpile, it is then available to sell. Semi-trailers, trucks and dogs and B-Doubles are loaded by front-end loaders which transport the material to the project site. (Rieck, D 2007, pers comm., 25 February)

At some quarries the general public can bring in their utilities and trailers to be loaded with the material by the front end loaders. (Rieck, D 2007, pers comm., 25 February)

2.2 Safety at the Quarry

Quarry sites can be very dangerous places with large heavy machinery operating, hauling material to crushers and to stockpiles as well as loaders loading the dump trucks and sales trucks. (Webber, S 2007, pers comm., 18 January) With this in mind, safety is paramount. A number of safety measures are in place to keep the staff and visitors at the site as safe as possible. These include:

- New staff and visitors entering the quarry site must have a site induction. This induction includes a site tour, showing the emergency assembly areas as well as the site traffic routes and reading a manual of the do and don’ts of what to do at the quarry. (Boral Site Induction Book, 2006)

- Every visitor that enters the site must sign in, in the visitor’s book and notify the quarry manager or a quarry foreman that they are on site. (Webber, S 2007, pers comm., 18 January)

- Everyone at the quarry must wear personal protection equipment such as helmets, steel cap boots and high visible shirts or high visible vests to be highly visible to the other people and vehicles operating at the site. Along with the helmets, it is highly recommended that if working in the sun, a wide brim be placed on the helmet for sun protection. (Boral Site Induction Book, 2006)

- Light vehicles such as sedans, four wheel drives and utilities, that enter the quarry must have a flashing yellow light put onto the top of the roof as well as a four metre high pole consisting of a florescent flag for easy vision. (Boral Site Induction Book, 2006)

- Each vehicle on site being light or heavy must have a UHF radio on board and must let everyone know their location. (Webber, S 2007, pers comm., 18 January)

- Pedestrian traffic on the site is not permitted in the quarry unless the quarry manager is notified and a UHF radio is carried. (Boral Site Induction Book, 2006)

- Permits are required if a staff member or a visitor enters and works in a hot area, such as a warm crusher motor or a confined space such as screen decks. (Boral Site Induction Book, 2006)

- At all times the Workplace Health and Safety and the Mine Safety Acts are to be obeyed and if they are not, the quarry manager can ask the offender to leave. Fines and other penalties could apply if the acts are not followed. (Boral Site Induction Book, 2006)

If these safety rules are followed, every one who works or visits the quarry site will remain safe and injuries or fatalities will be minimal.

2.3 Purga Quarry

One of Boral's subsidiaries, Australian Construction Materials (ACM), operate the Purga Quarry on T Morrows Road off the Ipswich-Boonah Road. The quarry is located north of the township of Peak Crossing which is situated approximately 15 km south of the interchange with the Cunningham Highway (Southern Ipswich Bypass) at Yamanto and approximately 50 km south west of Brisbane. (Boral Operational Excellence Purga Wave 1 Report, 2007)

A map of the location of the site is shown in figure 2.3.

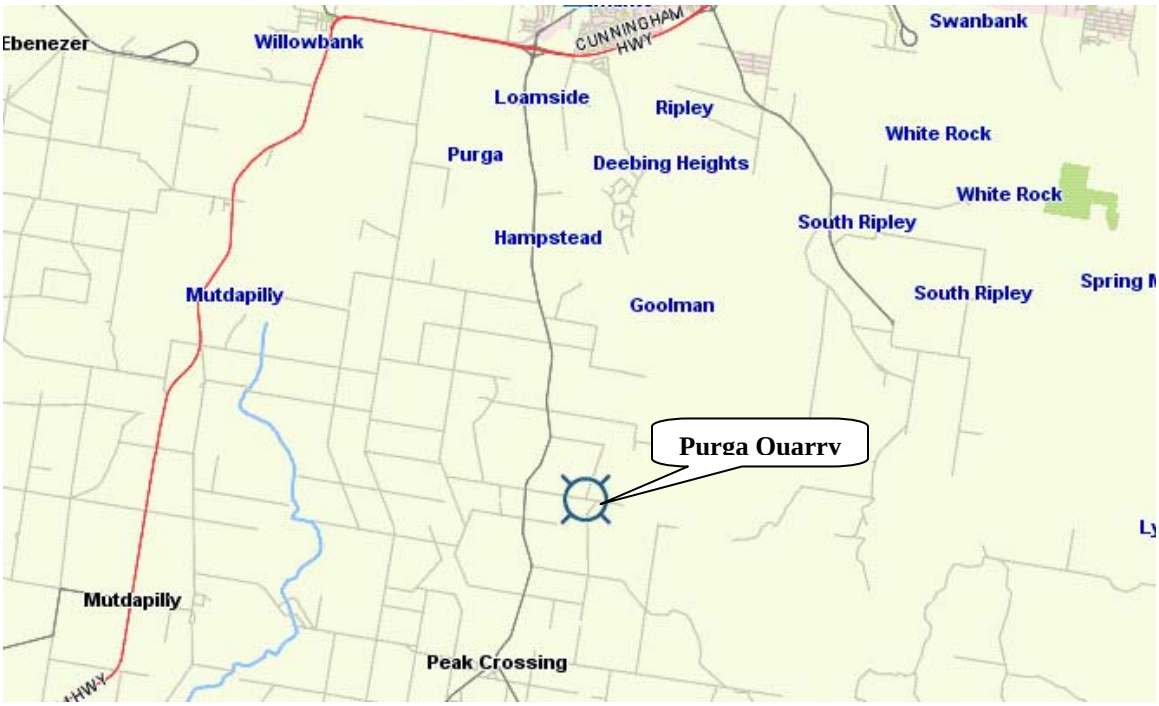

Figure 2.3: Map showing the location of the Purga Quarry
<http://www.whereis.com/whereis/confirmedMap.do?nref=homeMap>

The Purga quarry was opened in the early 1990's with a single plant and a second plant was commissioned at the site in 2005. The quarry services the rapidly growing western corridor of South East Queensland. Purga produced 565,000 tonnes of material in the financial year 2005/06, consisting of 40% aggregates and 60% roadbase.
(Boral Operational Excellence Purga Wave 1 Report, 2007)

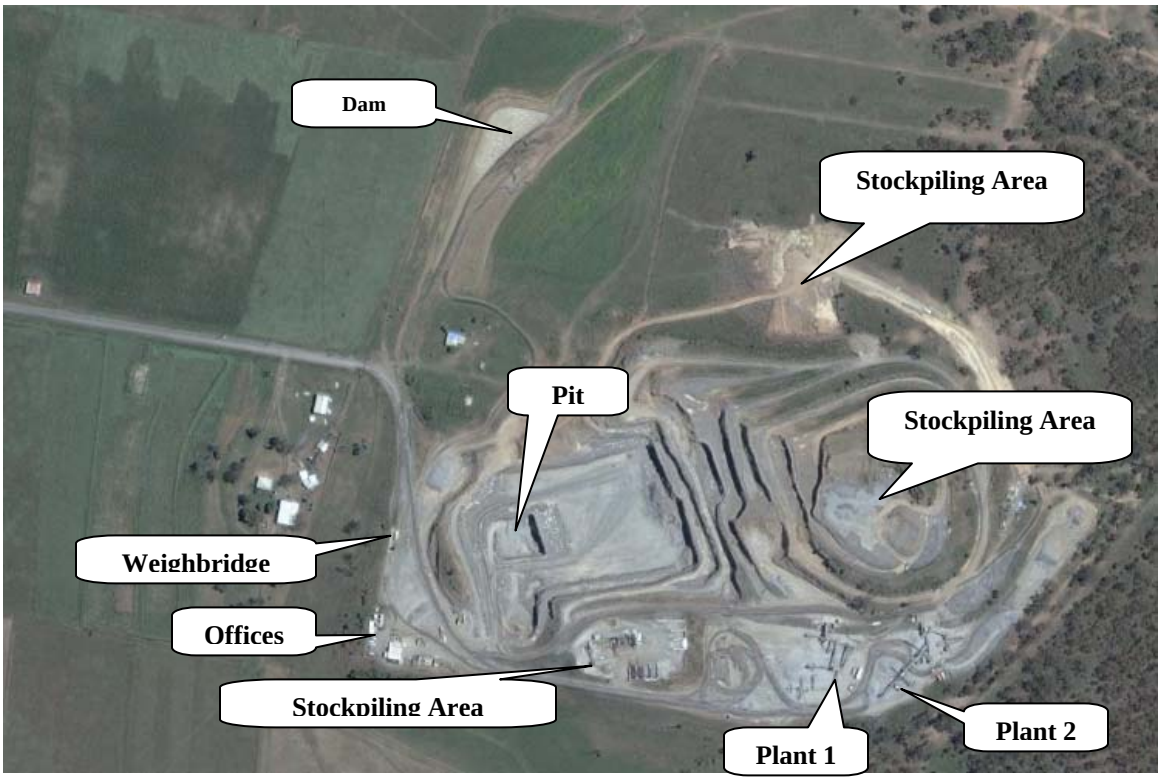

Figure 2.4: Aerial Photo of Purga Quarry
(Boral SEQ Quarries, 2006)

2.3.1 Purga Plant 1

Plant 1 is the new plant at Purga commissioned in 2005. This plant was moved to the site from a decommissioned quarry in the Northern Territory. The plant produced an average of 5569 tonnes/week in financial year 2005/06 producing B and C grade roadbase and aggregates from blue and brown rock. (Boral Quarry Database, 2007)

2.3.2 Purga Plant 2

Plant 2 is the original plant at Purga commissioned in the early 1990's. The plant was moved to the site with screens and crushers coming from different quarries in the South East Queensland region. (Boral Operational Excellence Purga Wave 1 Report, 2007) The plant produced an average of 4272 tonnes/week in financial year 2005/06 producing B and C grade roadbase and aggregates from blue and brown rock. (Boral Quarry Database, 2007)

2.3.3 Purga Quarry Life

Boral geologists predict that the site has approximately 5.8 million tonne of useful resource material, as shown in figure 2.5, which accounts to having a resource life of 10-11 years at its current annual production. This value would decrease to 5-6 years after the 'Operational Excellence' project which is currently taking place and will be explained in section 2.4 below. (Boral Operational Excellence Purga Wave 1 Report, 2007)

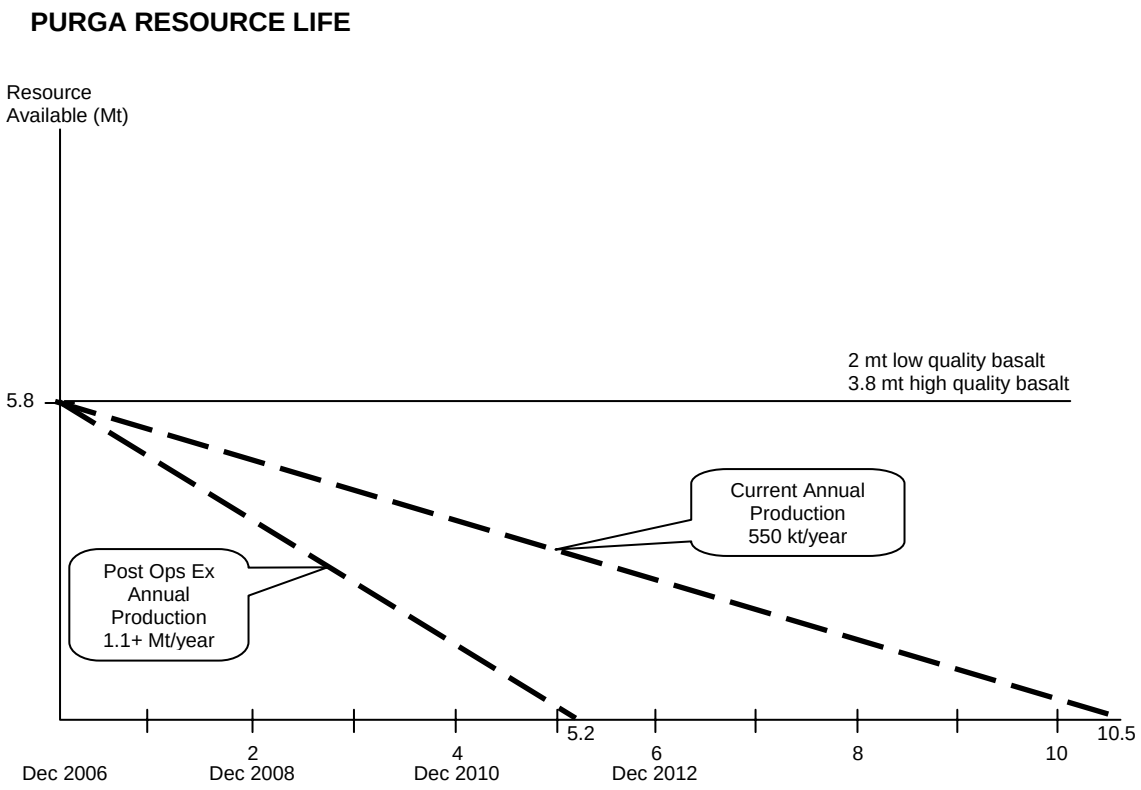

Figure 2.5: Purga Resource Life
(Boral SEQ Quarries, 2007)

2.4 Growth in the South East Queensland and the South East Queensland Regional Plan 2005-2026

According to the Queensland Government's South East Queensland Regional Plan 2005-2026, the population in South East Queensland has experienced a high population growth since the 1980's. An average of 55,300 people between 1986 and 2004 (SEQRP 2005-2026, 2005) moved to South East Queensland, resulting in an estimated population of 2,666,600 people in 2004.

The greatest growth area in the last decade has been the Western Corridor. The Western Corridor is the Greater Ipswich area, extending from Wacol through Ipswich City to Amberley and including Ebenezer, Swanbank, Ripley Valley and Springfield. (SEQRP 2005-2026, 2005)

In 2005 the Queensland Government along with the councils of South East Queensland, outlined a twenty year plan to guide regional growth and development in South East Queensland. (SEQRP 2005-2026, 2005)

The key proposals of the Western Corridor in the plan include the upgrading of the existing Ipswich Motorway or the Federal Government's proposed Goodna Bypass, deliver public transport networks to major population areas such as Springfield and Ripley, support employment and industry growth in the area with road and rail enhancements and to improve the connectivity of the Western Corridor with the rest of the region by additional and enhanced public transport and road connections such as the Centenary Highway extension through Ripley to Yamanto. (SEQRP 2005-2026, 2005)

As Purga Quarry is the only Boral quarry in the Western Corridor and with Boral continuing to win contracts for the ever increasing projects in the region, more material had to be extracted from the quarry in a more efficient and effective way. With the help of the 'Operational Excellence' project this is hoped to be achieved. (Pyne S 2007, pers. comm., 8 January)

2.5 Boral's 'Operational Excellence' Project

In response to the rapid growth in South East Queensland and the infrastructure planned for this growth, Boral South East Queensland introduced a step change project called 'Operational Excellence', with the help of Sydney based consulting firm Performance Essentials. This project was established to take advantage of this growth by having the infrastructure in place to meet the current and future demands. (Boral Operational Excellence Purga Wave 1 Report, 2007)

The diagnostic stage of the project took place from September 2006 through to December 2006 and looked at each aspect of the business, determining what parts could gain the most out of the project. The parts of the business that were chosen for Wave 1, running from January through to April, were the Transport, Network and Asphalt sectors of the business as well as the quarries of Stapylton and Purga. Wave 2, which began in early May and ran through to July, was Concrete, Coolum Quarry, the design and programming functions of a new quarry database along with the implementation of the findings and recommendations of Wave 1. (Boral Operational Excellence Diagnostic Report, 2007)

The team at Purga included John Carroll who is a Quarry Manager and Leader of the Purga OE team, Dale Rieck a dump truck driver who has an extraordinary knowledge of the Purga quarry as well as previous quarries that he has worked at, Lee Hughes a consultant with Performance Essentials and myself as the engineer. The objective of the Purga team was to develop improvement ideas to increase the production throughput to double the production volume of the financial year 2005-06 to approximately one million tonne. This had to be achieved without compromising the quality of the material to be sold to the consumer. The areas that the team were looking at were through new or upgraded equipment and also plant debottlenecking by removing and replacing the insufficient pieces of equipment with that of a higher productive rate. (Boral Operational Excellence Purga Wave 1 Report, 2007)

2.6 Conclusion

Purga Quarry is and will become an even more important quarry for Boral in the Western Corridor of South East Queensland. With the ‘Operational Excellence’ project in place, which is expected to double the production of the quarry compared to the financial year 2005/06, it is hoped that Boral can meet the demands of material requirement to supply the ever increasing number of projects in place to meet the population growth with adequate infrastructure.

3. Literature Review

A detailed literature review was carried out to fully understand the financial terms of asset, asset management and different types of assets and asset management strategies that different businesses and organisations implement. Along with the background chapter of this dissertation, various books, journals and online sources were used for research and information.

3.1 Asset

An asset is a financial term that describes the resources that an organisation controls as a result of a past transaction or events from which future economic benefits could be obtained. (New Zealand Treasury, 2007)

Assets have essentially three characteristics:

- Assets embody a future benefit either by itself or with a combination of other assets. In the case of profit oriented organisations, to contribute directly or indirectly to future net cash flows and in the case of non profit organisations they contribute by providing services to the community.
- The company that controls the asset can control it to gain the benefit
- The transaction or event giving rise to the entity's right to, or control of , the benefit has already occurred

(New Zealand Treasury, 2007)

Assets fall into two categories, current assets and fixed assets.

3.1.1 Current Assets

A current asset refers to an asset that is expected to be sold or used up in a short term period, namely twelve months or one business cycle whichever is longer. Examples of current assets include cash, cash equivalents, accounts receivable, inventory, the portion

of pre-paid accounts used within a year as well as short term investments. (New Zealand Treasury, 2007)

Current assets contained at a quarry would include the material that is produced from the crushing plants along with the oil, grease and other replenishables used to make the quarry operate to an adequate standard. (New Zealand Treasury, 2007)

This project will look more at fixed assets rather than current assets.

3.1.2 Fixed Assets

A fixed asset refers to assets which possess a physical form and is intended to have a useful life which exceeds one year in order to earn an income or to produce outputs. According to the New Zealand Treasury (<http://www.treasury.govt.nz/publicsector/>), a fixed asset should possess the following characteristics:

- It should be able to provide services or benefits to the entity that uses it
- It should have an estimated useful life of greater than one year
- It should be used by the entity in pursuit of its objectives
- And it should be under the control of the entity so that the entity benefits from it.

Examples of fixed assets include property, buildings, vehicles, machinery and equipment which a company or organisation own and use. In most cases assets that are tangible are referred to as a fixed asset. (New Zealand Treasury, 2007)

Fixed assets are the major assets that will be included in this project. Major examples found at a quarry include plant equipment such as, crushers, screens and conveyor belts, as well as load and haul equipment including, dump trucks, excavators and front end loaders.

When a new piece of equipment has been purchased, the general rule to determine between expenditure and an asset is that when an item is expended, the total value of an item is treated as an expense for the period and is offset against the revenue for the period. When an item is capitalised, the cost of the item is then shown as an asset. (New Zealand Treasury, 2007)

3.2 Fixed Asset Management

Asset management is the process of tracking and managing assets. As this project is only concentrating on fixed assets an explanation of fixed asset management will be given.

Fixed asset management is the process of tracking and managing fixed assets for the purposes of financial accounting, preventive maintenance and theft deterrence. (New Zealand Treasury, 2007)

Asset management is important even when a company or organisation has limited investment into fixed assets. Careful specification of asset requirement helps companies and organisations to avoid the purchase of unsuitable assets, even when the value of the asset maybe low. Poor asset management may result in high operating or maintenance costs or the purchase of the equipment does not meet the business's needs. (New Zealand Treasury, 2007)

There are two major methods of fixed asset management, either centralised or decentralised.

3.2.1 Centralised Fixed Asset Management Method

The centralised asset management method is when a business manages its assets from a central location or head office.

Centralised asset management has several advantages. By managing the assets from a head office, it helps obtain the best discounts on purchases, to replace the plant at the

right time, to monitor operating costs, to undertake appropriate maintenance and servicing and to control overheads. (New Zealand Treasury, 2007)

3.2.2 Decentralised Fixed Asset Management Method

The decentralised asset management method is where the people responsible for the asset are the people who use it. This could be different sites within a business or different parts of the business. Before people can be accountable for assets, they must have the authority to manage them. The site management can influence the asset costs by deciding what and when to purchase and from whom to purchase it from. (New Zealand Treasury, 2007)

Advantages of this method would be that the people who are continually working with the assets are familiar with their operation and condition therefore can monitor their ongoing maintenance schedules and replacement. (New Zealand Treasury, 2007)

Disadvantages using this method would be that asset management at different sites within a business would not conform resulting in increased downtime in a location if it is more productivity driven compared to a location where asset management is more of a priority, therefore resulting in reduced downtime and in the long run increased production. (New Zealand Treasury, 2007)

3.3 Conclusion

Fixed assets can be conveniently visualised as sets of services with a useful economic life. Determining what type of method the assets of a company are being managed, either centralised or decentralised, along with the advantages and disadvantages of each method is essential when determining a new asset management plan.

4. Assets at Purga Quarry

Purga Quarry consists of physical assets both on the plant and load and haul. The following chapter has a description of the major assets that is at the quarry and what they are used for. These will be the equipment that will be critically assessed and complete maintenance policies on. Also included is a brief description of some of the other assets that are at the quarry but due to time restraints will not be assessed or have maintenance policies written about.

4.1 Load and Haul

Load and Haul equipment is used to get the material up to and from the plants. The load equipment, also called Stock, Pick and Load, refers to the front end loaders that load the material into the dump trucks. Haul equipment includes the dump trucks that bring the material from the face to the plants as well as from the plants to the stockpiling areas. (Rieck, D 2007, pers comm., 25 February)

The machine hours from June 2007 for all of the load and haul equipment can be found in Appendix F.

4.1.1 Front End Loaders

Purga quarry has five front end loaders of which two of these are used to supply the plants with dust when making roadbase as well as removing the material from under the conveyor belts by loading the dump trucks with the raw material after it has gone though the plant. These loaders are also used to feed the plants from the stockpile located beside the plants, called the boot, when the dump truck drivers are on either meal break, lunch or when they are working on another job. (Rieck, D 2007, pers comm., 25 February)

Another two loaders are used to load the haul trucks or sales trucks that deliver the material to the project site. Sales are only conducted within specific times throughout the day depending on the hours that project site is working or the material that has been ordered. Outside of these hours, these front end loaders are either used to move the

material within the stockpile to make more room for the material that has just processed in the plant. They also put material through the pugmill which is designed to grind the aggregate and blend it with a liquid used to make the aggregate a blacker colour for the customers to use for the blue metal used on roads for surfacing. This is only done when requested by a customer and is not performed every day as the pugmill is transferred from quarry to quarry where needed. The final task that the sales loaders can perform is to help the plant loaders out by feeding the plant with material off the boot, filling the add bin with dust when producing roadbase or loading the dump trucks with material from under the conveyor belts when full. (Rieck, D 2007, pers comm., 25 February)

A fifth loader has been despatched to the quarry site and is planned to replace the current excavator as the machine to load the dump trucks with the raw material to take to the plant. A front end loader is preferred over an excavator for this job as it has a bucket with a bigger capacity therefore can load the trucks with less bucket loads. It can also be moved between destinations easier and quicker. The only main disadvantage is that the benches must be wider to accommodate the turning circle of the loader. The excavator will remain on site until the benches have been widened by different methods of blasting to the current method and by using the excavator to get remove the initial material that the loader would not reach. The excavator has reached the end of its useful life and will be removed from the current fleet and sold. (Bavdek, M 2007, pers comm., 24 August)

Note – Due to time constraints, pictures of the front end loaders at the site were not able to be taken. As a substitute, pictures of front end loaders made in the same year as the ones that on site have been added and referenced as to the web sites they have come from.

4.1.1.1 CAT 988H

Figure 4.1: CAT 988H Front End Loader
(Emeco Sales, www.emeco.com.au)

The CAT 988H front end loader is the newest heavy machine at the quarry having being commissioned on the 1st July 2007. This loader is proposed to replace the current excavator as the main loading tool. It is used in this manner where the benches have been widened with different blasting techniques as well as a plant loader. This loader is the largest loader at Purga Quarry. (Bavdek, M 2007, pers comm., 24 August)

The main specifications for the CAT 988H front end loader are:

- Engine Model – CAT C18 ACERT
    - Producing 414 kW power
    - Rated speed of 1800 rpm
- Operating weight - 49546 kg
- Payload capacity - 11000 kg
- Bucket capacity - 6.3 m^3 - 7 m^3 depending on the material type
- Fuel tank capacity - 712 L
- Wheel base length – 4550 mm

- Overall length - 11765 mm

(Hastings Deering, 2007)

All of the specifications for the CAT 988H can be found in Appendix C

4.1.1.2 Komatsu WA500

Figure 4.2: Komatsu WA500 Front End Loader

(Machinery Trader, www.machinerytrader.com)

The Komatsu WA500 was commissioned on the 31st December 2004. As of November 2006, this machine had clocked up a total of 6021 hours with operating hours averaging 50.77 hours a week over the first six months of 2007. This front end loader is smaller than the CAT 988H as described in the main specifications below. It is used as a sales loader and averages eight truck and dog trailers per hour. (Bavdek, M 2007, pers comm., 24 August)

The main specifications for the Komatsu WA500 front end loader are:

- Engine Model – Komatsu SAA6D1
    - Producing 261 kW power
    - Rated speed of 1900 rpm
- Operating weight - 33305 kg
- Bucket capacity - 4.5 m^3 – 5.6 m^3 depending on the material type
- Wheel base length – 3780 mm
- Overall length - 9815 mm

(Komatsu Australia, 2007)

All of the specifications for the Komatsu WA500 can be found in Appendix C

4.1.1.3 CAT 970F

Figure 4.3: CAT 970F Front End Loader

(Machinery Trader, www.machinerytrader.com)

The CAT 970F was commissioned on the 31st October 1994. This front end loader is one of the oldest on site clocking up 26234 hours as of June 2007 averaging 50.33 hours a week over the first six months of 2007. (Boral Quarry Database, 2007) It is used as the plant loader on Plant 1, loading the dump trucks with material that has been processed through the plant and loading the add bin with dust when making roadbase. (Bavdek, M 2007, pers comm., 24 August)

The main specifications for the CAT 970F front end loader are:

- Engine Model – CAT C13 ACERT
    - Producing 214 kW power
    - Rated speed of 1400 rpm
- Operating weight - 25148 kg
- Bucket capacity - 3.8 m^3 – 4.6 m^3 depending on the material type
- Wheel base length – 3450 mm
- Overall length - 9815 mm

(Komatsu Australia, 2007)

All of the specifications for the CAT 970F can be found in Appendix C

4.1.1.4 CAT 980F

Figure 4.4: CAT 980F Front End Loader
(Machinery Trader, www.machinerytrader.com)

Another front end loader on site is the CAT 980F. This front end loader is used as a plant loader for Plant 2, loading the dump trucks with material which has been processed by the plant as well loading the add bin with dust when producing roadbase. It was originally from Boral's Ormeau Quarry and arrived at Purga in late November 2006 to replace the aging CAT 980C. (Bavdek, M 2007, pers comm., 24 August)

The main specifications for the CAT 980F front end loader are:

- Engine Model – CAT C15 ACERT
  - Producing 264 kW power
  - Rated speed of 1200 rpm
- Operating weight - 30519 kg
- Bucket capacity – 3.8 m^3 – 6.1 m^3 depending on the material type

- Wheel base length – 3700 mm
- Overall length - 9010 mm

(Hastings Deering, 2007)

All of the specifications for the CAT 980F can be found in Appendix C

4.1.1.5 CAT 980C

Figure 4.5: CAT 980C Front End Loader

(Machinery Trader, www.machinerytrader.com)

The CAT 980C is the oldest front end loader in the fleet, commissioned in 31st October 1983. This loader is primarily used as a sales loader but is also used as a spare if one of the loaders on the plants breaks down. (Bavdek, M 2007, pers comm., 24 August) It has worked 55707 hours by November 2006, at an average of 23 hours per week. (Boral Quarry Database, 2007)

The main specifications for the CAT 980F front end loader are:

- Engine Model – CAT C15 ACERT
    - Producing 264 kW power
    - Rated speed of 1200 rpm
- Operating weight - 30519 kg
- Bucket capacity – 3.8 m^3 – 6.1 m^3 depending on the material type
- Wheel base length – 3700 mm
- Overall length - 9010 mm

(Hastings Deering, 2007)

All of the specifications for the Komatsu WA500 can be found in Appendix C

4.1.2 Dump Trucks

At Purga quarry there are three dump trucks on site. Two trucks are used to deliver raw material to the plants with the other one used to move the processed material to the stockpiles on the other side of the quarry. When there is excess material around the plants, the plant dump trucks can also be used to deliver material to the stockpiles. (Bavdek, M 2007, pers comm., 24 August)

4.1.2.1 Komatsu HD325

Figure 4.6: Komatsu HD325 Dump Truck

The Komatsu HD325 dump truck is the newest of the dump truck fleet at Purga Quarry. It was commissioned on site on the 3rd May 2006. This truck is used mainly to deliver the raw material to Plant 2. It can also be used to move material from the plant to the stockpiling area. (Bavdek, M 2007, pers comm., 24 August) This truck has clocked up 4825 hours work by the end of November 2006 averaging approximately 53 hours per week. (Boral Quarry Database, 2007)

The main specifications for the Komatsu HD325 dump truck are:

- Engine Model – Komatsu SAA6D1
    - Producing 386 kW power
    - Rated speed of 2000 rpm
- Payload capacity – 36500 kg
- Wheel base length – 3700 mm
- Overall length - 8465 mm

(Komatsu Australia, 2007)

All of the specifications for the Komatsu HD325 can be found in Appendix D

4.1.2.2 CAT 769D

Figure 4.7: CAT 769D Dump Truck

The CAT 769D is a plant truck delivering raw material to Plant 1. This truck is also used to move the material from the plant to the stockpiling area. (Bavdek, M 2007, pers comm., 24 August) It was commissioned on the 31st May 2004 and has worked a total of 10291 hours by the end of November 2006 averaging approximately 53 hours per week. (Boral Quarry Database, 2007)

The main specifications for the CAT 769D dump truck are:

- Engine Model – CAT 3408E
    - Producing 386 kW power
    - Rated speed of 2000 rpm
- Payload capacity 36400 kg
- Wheel base length – 3713 mm
- Overall length - 8039 mm

(Hastings Deering, 2007)

All of the specifications for the CAT 769D can be found in Appendix D

4.1.2.3 CAT 769C

Figure 4.8: CAT 769C Dump truck

The CAT 769C is the oldest dump truck in the fleet, commissioned in 30 June 1980. This dump truck is primarily used to move the material from the plant to the stockpiling areas but is also used as a spare if one of the trucks on the plants breaks down. It has worked 42503 hours by November 2006, at an average of 33 hours per week.

The main specifications for the CAT 769C dump truck are:

- Engine Model – CAT 3408E
    - Producing 386 kW power
    - Rated speed of 2000 rpm
- Payload capacity 36400 kg
- Wheel base length – 3713 mm
- Overall length - 8039 mm

(Hastings Deering, 2007)

All of the specifications for the CAT 769C can be found in Appendix D

4.1.3 Other Mobile Equipment

There is other mobile equipment used at the quarry but will not be included in this project due to time constraints. They include:

- Toyota Landcruiser Utility – This vehicle is used by the boiler maker on site who uses it to transport equipment from the equipment shed, near the site office, to the plant. It was commissioned on the 2nd April 1993.
- Hino Water Truck – The water truck is needed on site to water down the haul and access roads. This is done to reduce the dust after the vehicles drive over the roads. The water truck was commissioned on the 30th September 1982.
- Liebherr R952 Excavator – The excavator was the primary loading tool before the CAT 988H arrived. It is still used as a loading tool where the benches are narrower and a loader cannot turn around in. This excavator was commissioned on the 31st March 1993.
- Atlas Copco drill rig – The drill rig is used to drill the rock for the explosives when blasting. It was commissioned at on the 31st October 2004.

4.2 Plant Equipment

As described in Chapter 2, the plants crush the raw material to make aggregates, used to make concrete and to seal roads, as well as roadbase. The plants consist of crushers, screens, conveyor belts and an add bin for the dust. Some of the equipment has been previously used on other sites before being moved to Purga to build the plants.

4.2.1 Equipment on Plant 1

The following is a table of equipment on the plant; it includes the piece of equipment with the date it was commissioned. The equipment included below is only the major equipment on the plants. Other equipment such as water pumps and water lines have not been included.

Crushers

Equipment	Commission Date
Barmac 9000 Duopactor	30 June 2005
Portec Feeder	30 June 2005
Secondary Crusher	30 June 2005
Tertiary Crusher	30 June 2005

Table 4.1 Crushers on Plant 1 (Boral Quarry Database, 2007)

Screens

Equipment	Commission Date
16x6 Screen	28 August 2002
16x5 Screen	30 June 2005
12x5 Screen	30 June 2005
12x6 Screen	30 June 2005

Table 4.2 Screens on Plant 1 (Boral Quarry Database, 2007)

Conveyor Belts

Equipment	Commission Date
Conveyor C1	30 June 2005
Conveyor C2	30 June 2005
Conveyor C3	30 June 2005
Conveyor C4	30 June 2005
Conveyor C5	30 June 2005
Conveyor C6	30 June 2005
Conveyor C7	30 June 2005
Conveyor C8	30 June 2005
Conveyor C9	30 June 2005
Conveyor C10	30 June 2005
Conveyor C11	30 June 2005
Conveyor C12	30 June 2005

Table 4.3 Conveyor Belts on Plant 1 (Boral Quarry Database, 2007)

4.2.3 Equipment on Plant 2

The following is a table of equipment on the plant; it includes the piece of equipment with the date it was commissioned. The equipment included below is only the major equipment on the plants. Other equipment such as water pumps and water lines have not been included.

Crushers

Equipment	Commission Date
Jaw Crusher	1 March 1997
Primary Feeder	30 June 1981
Jaques Impactor	28 February 1991
Barmac Rotopactor	4 January 1987

Table 4.4 Crushers on Plant 2 (Boral Quarry Database, 2007)

Screens

Equipment	Commission Date
Malco 12x6 2 Deck Screen	4 January 1987
12x5 Jaques 2 Deck Screen	30 April 1989
Vibrating Grizzly Screen	1 June 1997
16x6 Screen	1 December 1996

Table 4.5 Screens on Plant 2 (Boral Quarry Database, 2007)

Conveyor Belts

Equipment	Commission Date
Conveyor C1	28 February 1991
Conveyor C2	28 February 1991
Conveyor C3	28 February 1991
Conveyor C4	28 February 1991
Conveyor C5	28 February 1991
Conveyor C6	28 February 1991
Conveyor C7	28 February 1991
Conveyor C8	28 February 1991
Conveyor C9	28 February 1991
Conveyor C10	28 February 1991
Conveyor C11	28 February 1991
Conveyor C12	28 February 1991

Table 4.6 Conveyor Belts on Plant 2 (Boral Quarry Database, 2007)

4.3 Conclusion

These are the assets that will be assessed for this project. Maintenance policies will then be written from this assessment and which is included in a further chapter. To optimise the production at the quarry, these assets will have to be more reliable resulting in less downtime. This will result in producing more tonnes, meeting the 'Operational Excellence' production target.

5. Critical Assessment of Current Asset Management

To improve the method that the quarry manages its assets, it is essential that we critically assess the methods that the assets are currently managed. By researching manuals provided by the manufacturers and other manuals relating to crushing and screening of rock material, as well as working on site at the quarry conducting research by observing and asking how the staff currently manage the assets.

The main assets on the quarry consist of the load and haul equipment, such as dump trucks and front end loaders as well as plant equipment such as crushers, screens and conveyor belts used to crush the raw material.

5.1 Purga Quarry Asset Management Structure

Earlier in this project the different asset management methods such as centralised and decentralised were discussed. Boral's asset management structure includes both these methods. The general day to day running of the plant and load and haul equipment is the responsibility of the quarry. The major changes to the plants and load and haul equipment are the responsibility of the asset manager. (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

The responsibility of the quarry includes the prestart checks, the servicing and any minor maintenance that is involved. This could include assigning specialists of specific areas to repair various parts that the operators are not trained to repair. (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

The purchasing of new equipment as well as organising the installation, commissioning of the new equipment along with major maintenance, is included in the asset manager's responsibility. The asset manager of Boral SEQ Quarries is based at Boral's head office at Milton and is responsible for all of the quarries that Boral operate in South East Queensland. (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

5.2 Load and Haul

As discussed in earlier chapters, load and haul is to transport the raw material to the plant and away from it after it is processed. The load and haul equipment are worth hundreds of thousands of dollars and needs to be maintained in an adequate fashion to continue to be a valuable asset for the company. (Bavdek, M 2007, pers comm., 24 August)

Currently the load and haul equipment at the quarry undergo a prestart check in the morning along with an adequate maintenance schedule to that which is effective. This is outlined below.

5.2.1 Current Load and Haul Prestart Checks

Prestarts on the load and haul equipment is completed first up in the morning before the equipment has started. It involves a series of checks on the piece of equipment to make sure that is working to its potential. Prestart checks are a form of preventive maintenance as these checks are performed to verify if any mechanical fault is evident. (Bavdek, M 2007, pers comm., 24 August)

Prestart checks include visual checks of any damage to the machines structure such as guards and body, as well as visual checks of whether there are any leaks of liquids such as water, coolant or oil. The fluid levels, such as coolant, engine oil, transmission oil and hydraulic oil are checked and if they are below the required levels they are filled. The fuel tank is usually filled with diesel in the morning for that day. Other things such as two-way radios, the horn and lights are also checked. (Bavdek, M 2007, pers comm., 24 August)

Currently prestart checks are conducted on the load and haul equipment. These checks are generally done between 6am and 7am before any equipment can start at the quarry. When there are problems with the crushing plant, the prestart checks on the load and haul equipment are generally ignored in order to prioritise repairng the crushing plant. When completed, the load and haul equipment is just refuelled, started and set to work in its various capacities. (Bavdek, M 2007, pers comm., 24 August)

The operator of the front end loader or dump truck is responsible for the prestart checks on their piece of equipment. There is currently no checklist or any other forms that are filled out and handed to the site foreman/supervisor or site manager before beginning to operate the machinery. Operators have been known to skip morning prestart checks to either attend to the plant needs or other matters that have arisen. (Bavdek, M 2007, pers comm., 24 August)

5.2.2 Current Load and Haul Maintenance

Compared to the plant equipment, the load and haul maintenance is more efficient and therefore effective. (Boral Quarry Database, 2007) Because of this, the failures on the dump truck and the front end loaders are less common to those on the crushing plants.

All of the new load and haul equipment go through a 250, 500, 750, 1000 and 2000 hour preventive maintenance services with every machine having their services performed every 2000 hours. (CAT Handbook, 2005), (Komatsu Manual, 2005)

The activities that are performed during the 250 hour service are usually checking various parts of the machine after it has been in use for a short while. These include checks on the air conditioner, lights, batteries, the condition of the transmission, hydraulics, final drive and the coolant. The activities that are conducted in this service are also done on the 750 hour service. (CAT Handbook, 2005), (Komatsu Manual, 2005)

The 500 hour service includes changing filters and oils as well as checking various parts of the machine. The original oil, air and fuel filters are changed in this service along with the original engine, transmission and hydraulic oils and fluids. Various checks are also carried out in this service to look at the condition of items including the air conditioner, alternator, batteries, transmission, hydraulics and final drives. (CAT Handbook, 2005), (Komatsu Manual, 2005)

The major services such as the 1000 hour, the 2000 hour and every service after that, include changing the engine oil, the transmission fluid and the hydraulic fluid and left

and right final drive oils. The radiator is also cleaned along with the air conditioner filters. Many filters are changed including the oil filter, the fuel filter, the air filter and the hydraulic fluid filter. A various amount of checks are also carried out in this service to look at the condition of items including the air conditioner, alternator, batteries, transmission, hydraulics and final drives. (CAT Handbook, 2005), (Komatsu Manual, 2005)

Other major services are carried out on the equipment throughout its life. A list of these can be found in Appendix E with the major changes including engine changes for the CAT dump trucks at 15400 hours with the Komatsu dump trucks changing them later at 16800 hours. The engines of the front end loaders are also changed with CAT changing theirs at 15400 hours and Komatsu at 16800 hours. The transmission is changed for the CAT dump truck at 13200 hours with the Komatsu at 16800 hours. The CAT front end loaders have their transmissions changed at 13200 hours while the Komatsu front end loaders get theirs changed at 16800 hours. (CAT Handbook, 2005), (Komatsu Manual, 2005)

These services have been up to 3 months late at times but they do get completed. The quarry enlist mechanics from either Hastings Deering or other diesel mechanics from around the Ipswich area to complete these tasks as the workers at the quarry do not have the training to do these tasks. (Bavdek, M 2007, pers comm., 24 August)

Oil samples are also sent regularly to Hastings Deering's Archerfield Laboratory for testing. According to Hasting Deering (Hastings Deering Lab Staff, 2006, pers comm., 10 December), their SOS Fluid Analysis is one of the most useful and important maintenance support programs available. The samples are scientifically analysed to determine if there is any metal or other material in the oil of the machine which would lead to a catastrophic failure.

5.2.3 Common Failures on Load and Haul

The load and haul equipment at the site is reasonably reliable. The only common problem for the load and haul equipment is tyre failures. These failures are caused by the dump trucks and front end loaders running over exposed sharp rocks which puncture the tyres. One dump truck or front end loader on average accumulates this problem at least once per month with the machine being down sometimes for the duration of a week. (Bavdek, M 2007, pers comm., 24 August)

5.3 Plant Equipment

As discussed in earlier chapters, the plant is used to crush the raw material into either roadbase or aggregates. The plants are the major part of the quarry if they were down, no production will be occurring. The crushers, screens and conveyor belts that make up the plant are worth millions of dollars and need to be maintained adequately. (Murphy, S 2007, pers comm., 2 April)

Currently the plants at the quarry undergo a prestart check every morning along with an adequate maintenance schedule to that which is effective. (Murphy, S 2007, pers comm., 2 April) The method that the plants are currently being managed is outlined below.

5.3.1 Plant Maintenance Characteristics

CHARACTERISTICS	I FIREFIGHTER	II CONTROLLER	III INNOVATOR	IV BEST OF BEST
General description	▪ Fire fighting ▪ Little structure ▪ Technical skills are paramount ▪ Production and equipment drive maintenance	▪ More fire fighting than planned work	▪ Organisation/planning becomes critical ▪ Structure becomes more rigid ▪ Management skills are developed ▪ Discipline is learned	▪ Work is performed according to plan ▪ Maintenance takes leadership role ▪ Greater individual responsibility ▪ Technical/management development is ongoing
Organisation	▪ People = machines ▪ No accountability ▪ Excess reporting levels ▪ Narrow spans of control	▪ Site manager accountability only ▪ Confusion ▪ Limited employee involvement	▪ Direct line supervision accountability ▪ Functional excellence ▪ Wider spans of control	▪ Self managed teams ▪ Multi-functional integration ▪ Total productive maintenance
Practices **–Planning** **–Scheduling** **–Quality** **–Training**	▪ No formal planning ▪ No formal scheduling ▪ No quality emphasis ▪ Safety training only	▪ Overhaul work order planning only ▪ Informal daily scheduling ▪ Little quality emphasis ▪ Some management training	▪ Planned work exceeds 60% of man hours ▪ Weekly scheduling ▪ Quality materials, more planned work ▪ Frequent management training	▪ Trades assist in planning and estimating jobs ▪ Operations drive schedules ▪ Quality audits of repair & PM work ▪ Frequent hourly training
Preventive maintenance	▪ Fragmented, limited PM ▪ PM lacks credibility	▪ PM program ▪ No dedicated effort	▪ PM compliance 95+% ▪ PM quality program to maximise options	▪ Dedicated effort, problems prevented ▪ Operations participate in PM function
Cost control	▪ Costs not formally controlled	▪ Cost reduction programs ▪ No formal cost reporting	▪ Realise costs are high	Operations active in cost decisions External focus – industry
Stores management	▪ Abundance of storeroom management practices	▪ Some stores control ▪ Lack of performance measures ▪ Turns less than 1 ▪ Computerised inventory control system	▪ Alliances developed with vendors ▪ Streamlined procurement process	Online maintenance system integrated with business system
Maintenance management systems	▪ Basic PM Program on system ▪ Cost reporting	▪ Computerised work order maintenance management system	▪ Maintenance system used by maintenance and operations	Maintenance management system central to preventive maintenance& failure reporting.
Equipment Improvement	▪ Failures repaired but not investigated	▪ Tradesmen develop one-off fixes for recurring failures	▪ Equipment improvement occurs routinely as part of maintenance role	▪ Equipment improvement is core to maintenance strategy ▪ Executed rigorously

Table 5.1: Maintenance Characteristics (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

As described in Table 5.1, there are many different characteristics of maintenance. These range from Firefighter – being the maintenance characteristic with the least controlled – to the Best of the Best which involves following maintenance plans and scheduling maintenance before it is needed. (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

By following the above table it can be determined that Purga Quarry can be described to have a Firefighter maintenance characteristic. (Bavdek, M 2007, pers comm., 2 April)

The reasons for this are stated in the following subsections with increasing downtime and decreasing maintenance being conducted on the plant.

5.3.2 Plant Downtime for Financial Year 2005/2006

When the plants are not operating therefore not producing, it is referred to as downtime. Downtime can be due to maintenance, equipment failure or for any reason that the plant is not operating. There are two different types of downtime, scheduled and unscheduled. Scheduled downtime is referred to as downtime that is scheduled or planned. The major scheduled downtimes includes screen changes for changing the product that is produced that day, prestart checks that run over the scheduled start time of 7 am and maintenance days. (Bavdek, M 2007, pers comm., 2 April)

As shown in figure 5.1, during the financial year 2005/2006 Plant 1 accumulated 177.59 hours of scheduled downtime of which 120.4 hours is general plant maintenance including screen changes due to product change. The remainder of the 52.69 hours is equipment maintenance on crushers, screens and conveyors. (Boral Quarry Database, 2007)

For Plant 2, as shown in figure 5.2 during financial year 2005/2006, the scheduled downtime accumulates to 182.13 hours which includes 78.72 hours of equipment maintenance with the remainder 103.35 hours coming from general plant maintenance. (Boral Quarry Database, 2007)

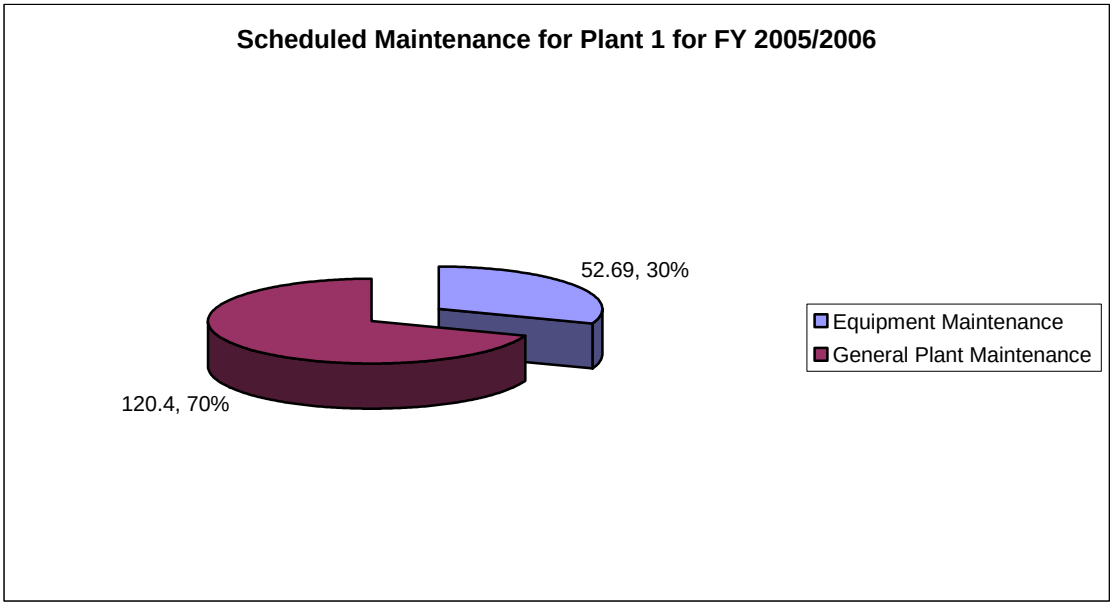

Figure 5.1: Pie Chart of the Scheduled Maintenance for Plant 1 for Financial Year 2005/2006. (Boral Quarry Database, 2007)

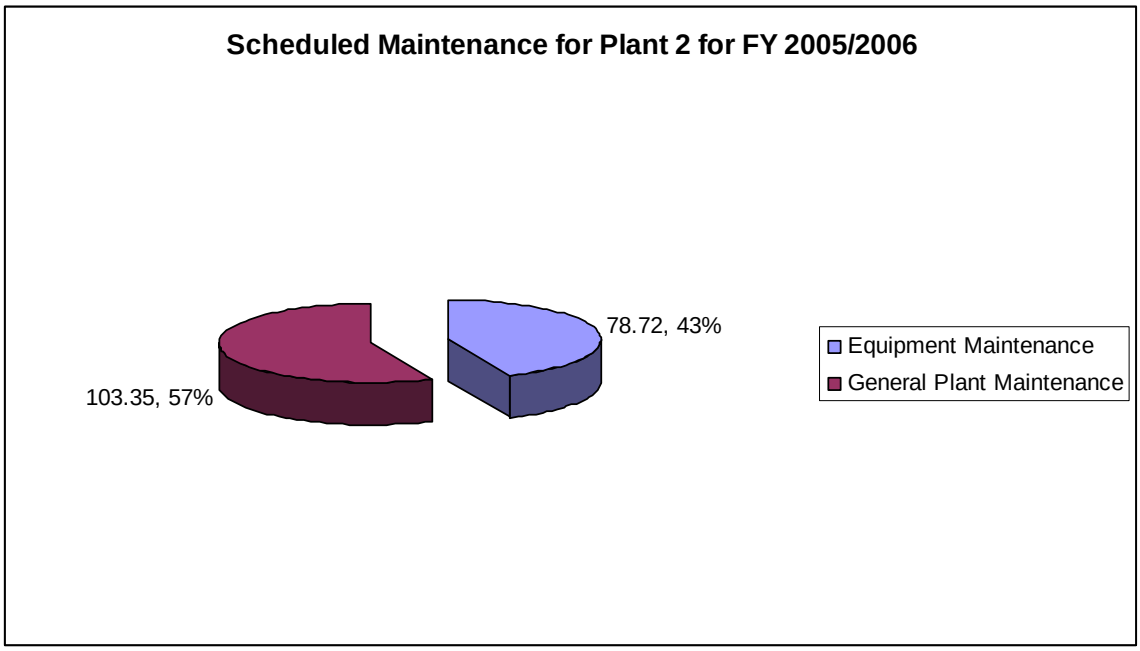

Figure 5.2: Pie Chart of the Scheduled Maintenance for Plant 2 for Financial Year 2005/2006. (Boral Quarry Database, 2007)

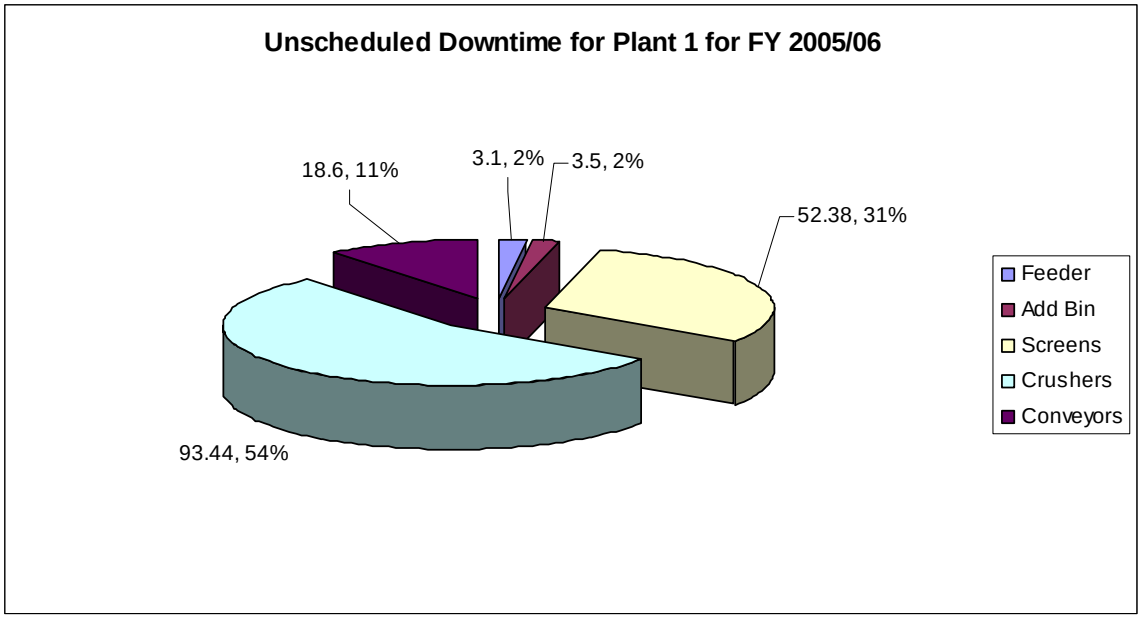

Figure 5.3: Pie Chart of the Unscheduled Equipment Failures for Plant 1 for Financial Year 2005/2006. (Boral Quarry Database, 2007)

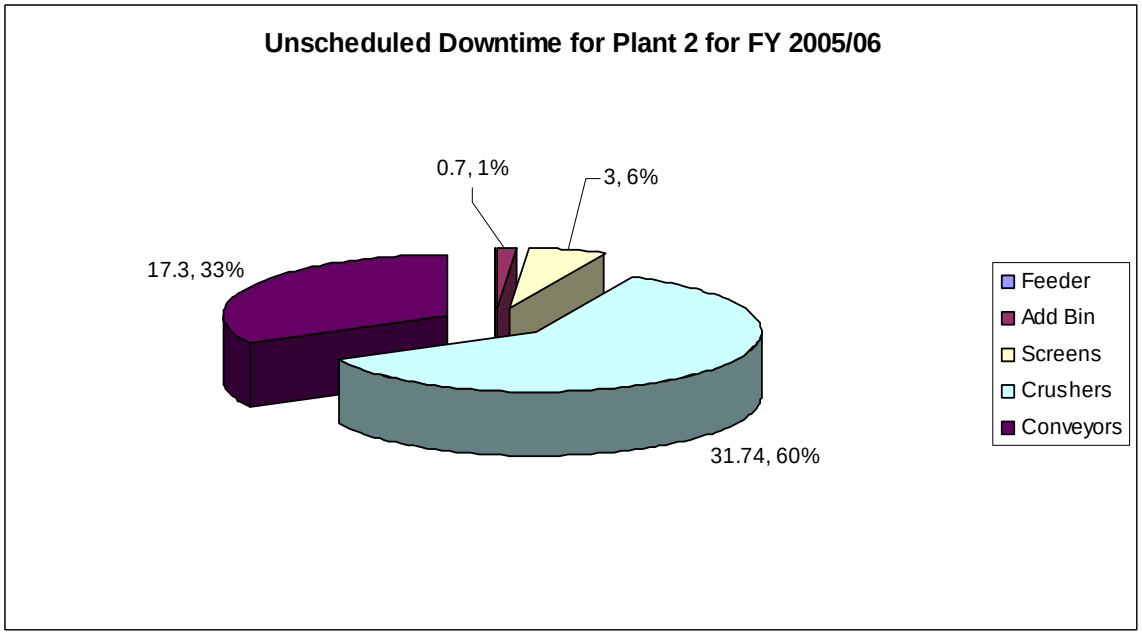

Figure 5.4: Pie Chart of the Unscheduled Equipment Failures for Plant 2 for Financial Year 2005/2006. (Boral Quarry Database, 2007)

Unscheduled downtime is referred to as downtime that is unscheduled or unplanned. The major cause of unscheduled downtime is equipment failures but may also include meetings, oversize rocks, no rock or dust at the plant or any other event that causes the plant to not be working and therefore causing downtime. (Bavdek, M 2007, pers comm., 2 April)

For the financial year 2005/2006, as shown in figure 5.3, the total of the equipment failures accumulated to 171.02 hours for Plant 1. The major downtime is 93.44 hours for crusher failures including 46.16 hours in electrical faults. Other downtime on the plant results in 52.38 hours of screen failures including 18.48 hours of it from bearing failures, 18.6 hours for conveyor failures, 3.1 hours for failures for the feeder and 3.5 hours for failures due to the add bin. (Boral Quarry Database, 2007)

For Plant 2, as shown in figure 5.4 during financial year 2005/2006, there is reduced downtime compared to Plant 1 for the same period. The unscheduled downtime shows that it totals to 52.74 hours which includes 31.74 hours for crusher failures which includes 19.46 hours for the failures of the hydraulics on the crushers. Other downtime on the plant results in 3 hours of screen failures, 17.3 hours for conveyor failures and 0.7 hours for failures due to the add bin. (Boral Quarry Database, 2007)

5.3.3 Current Plant Prestart Checks

Prestart checks on the plants, like prestart checks on the load and haul equipment, are completed every morning before it is started. Just like load and haul, the prestart checks on the plants consist of a series of checks to make sure the equipment is working to its potential. Prestart checks are a form of preventive maintenance as these checks are performed to verify if any mechanical fault is evident. (Murphy, S 2007, pers comm., 2 April)

Prestart checks involve a series of visual checks on the crushers, screens and conveyor belts, for damage that might have been missed the previous day as well as damage that

might have occurred over night. Oil checks on the crushers, feeder and rockbreaker is conducted and if necessary filled. Safety items such as the emergency button as well as lanyards that stop the plant when in an emergency are checked along with the condition of the screen material, commonly known as the media. Whilst checking the screens, the drive is checked to make sure that it is working at an efficient rate. (Murphy, S 2007, pers comm., 2 April)

Prestart checks are conducted on the plant are currently being conducted between 6am and 7am before it is permitted to start at the quarry. Prestart checks are where the majority of problems on the plant can be found. When a problem has been found, the problem is rectified by the plant operator as well as the dump truck operator and the front end loader operator. If a problem has been found fixing the problem is a priority with the other prestart checks ignored. Some days these checks are not carried out with the plant starting as soon as the problem has been fixed. (Murphy, S 2007, pers comm., 2 April)

The plant operator as well as the dump truck driver and the loader operator for that particular plant are responsible for the prestart checks on the plant. There is currently no checklist or any other forms that are filled out and handed to the site foreman/supervisor or site manager before beginning to operate the machinery. The plant operator usually begins the prestart checks while the truck and loader operators complete the prestart checks on their truck or loader and then complete the prestart check of the plant with the plant operator. This can sometimes leave the plant operator to check the plant by himself as attention is required for a truck or a loader. The prestart check therefore might not be conducted adequately as the plant operator is rushed to get it done in time to commence crushing at 7am. (Murphy, S 2007, pers comm., 2 April)

5.3.4 Current Plant Maintenance

By comparing the plant downtime due to equipment failure it shows that the downtime due to maintenance on the plants is a lot less. Maintenance is usually conducted on a plant when a failure has occurred on that plant. This was done so to reduce the time when the plant is down. It only was done during the period when the failure was being repaired

to have the ability to reduce downtime. This is not the case as more equipment failures occur due to the plants not receiving adequate maintenance. (Bavdek, M 2007, pers comm., 2 April)

When maintenance is conducted, it involves a series of visual checks for oil levels and the condition of the equipment. If any item is in need of a replacement, the repair is carried out. A series of spares are stored on site to make these repairs. Improvements to the plants are also done on a maintenance day but no improvements have been made over the financial year of 2005/2006. (Murphy, S 2007, pers comm., 2 April)

Maintenance also includes changing the screen media when new products are being made. This is usually done the morning that the new product starts to be produced. (Bavdek, M 2007, pers comm., 2 April)

Some equipment failures have been recorded in the downtime database as maintenance so that the manager of the quarry does not get into trouble for not maintaining the plant properly by the asset manager or any other manager that might look at the downtime data. (Bavdek, M 2007, pers comm., 2 April)

5.3.5 Common Failures on the Plants

Both plants at Purga Quarry have failures that come about regularly causing breakdown. These failures can occur anything from daily, weekly to monthly.

The dust produced from the crushers and screens of Plant 1 can cause the plant to shut down as it is it in excess of Environmental regulations. By screening the material dry on a dry day, causes dust to become airborne resulting in an excess of dust floating around the local area causing complaints from nearby neighbours. When this occurs the plant must be stopped for a period of time so that the dust settles and does not get out of control. (Bavdek, M 2007, pers comm., 2 April)

Spillage from screen 2 on Plant 1 can build up under the tail of conveyors seven, eight, four and five, causing these conveyors to trip out resulting in downtime. This spillage is caused by an uneven distribution of material on the screen as well as excess material built up in the sump of the screen. (Murphy, S 2007, pers comm., 2 April)

Both plants suffer from chute and skirt wear on the conveyors caused by the impact of the material as it passes over the conveyors. This results in cracks and openings occurring on the chutes or skirts causing spillage. The plant must be shut down when that occurs as more material will escape through this section causing excess spillage. This is mainly a result of poor maintenance as these had not been replaced during scheduled maintenance. (Bavdek, M 2007, pers comm., 2 April)

5.3.6 Major Failures that have Occurred Recently

Major failures can occur to the plants causing major downtime as the problem is rectified. These failures can occur at anytime but can be minimised with regular maintenance. Purga has suffered a major failure over the past six months with the shaft of Crusher 3 on Plant 1 failing. (Bavdek, M 2007, pers comm., 2 April)

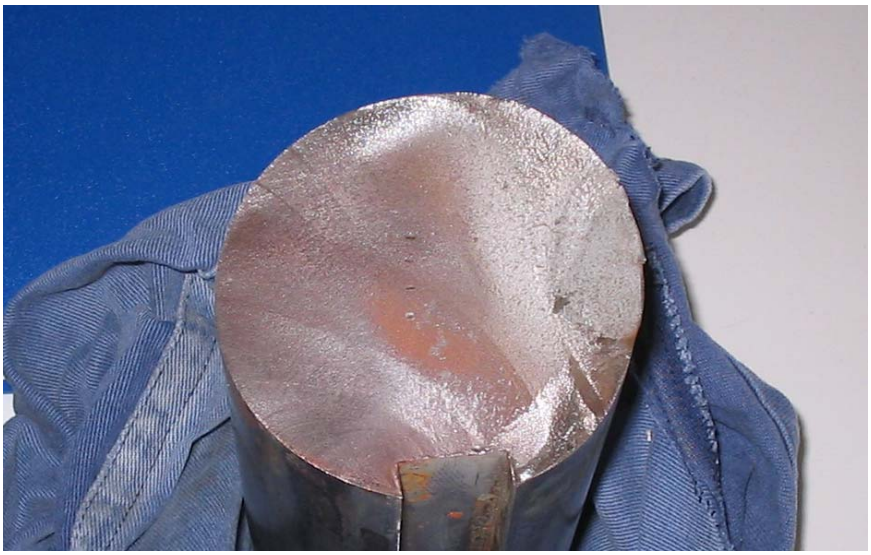

Figure 5.5: Cross Section view of broken shaft

The failure of the shaft in crusher 3, shown in figure 5.5, was caused by the vibrations of the platform on which it sits. With these vibrations, the shaft is under alternate tensile and

compressive stresses as it spins. This causes the shaft to bend in both directions, weakening it until it begins to crack. The crack grows to a point of complete failure where it snaps, just off the side of the motor. (Cooper, N 2007, pers comm., 25 March) This failure has been a regular occurrence, with the previous time being in September 2006. (Bavdek, M 2007, pers comm., 25 March)

The platform consists of two platforms joined by 25 mm diameter bolts. On each end of the platform there are motors of the similar age. The vibration that occurs also causes the bolts to loosen which regularly have to be retightened by plant operators or the operators of machines at the site. (Cooper, N 2007, pers comm., 25 March)

Figure 5.6: Platform that motor sits on at present

The end of the platform of which this failure occurred, shown in figure 5.6, is braced to the concrete base with a column which is situated behind the motor. A diagonal cross beam is braced from a beam at the front of the motor to this column. When the motor is operating, the platform excessively vibrates as there is no support with the concrete base to the front of the motor. (Cooper, N 2007, pers comm., 25 March)

Figure 5.7: The opposite end of the platform

The opposite end of the platform is sturdily braced with a column connecting it to the concrete base, shown in figure 5.7. This platform does not vibrate to the extent of the other end, with the motor containing its original shaft. (Cooper, N 2007, pers comm., 25 March)

5.4 Conclusion

To improve the efficiency of the plant and load and haul equipment based at the quarry, it is essential to review the way that the maintenance of the assets is conducted. From there a preventive maintenance plan for the assets can be drawn up and implemented.

6. Improvement Recommendations

As discussed in Chapter 5, Purga Quarry's current maintenance characteristic can be described as having a firefighter characteristic with little structure and no formal planning. To improve this characteristic to become a controller, innovator or best of the best a number of recommendations need to be implemented. These recommendations are explained below.

6.1 Preventive Maintenance

To improve the plant maintenance characteristic is to improve the preventive maintenance. To reduce the downtime it is important that preventive maintenance is carried out so that problems can be found early before failures can occur.

Preventive Maintenance is a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include equipment checks, partial or complete overhauls at specified periods, oil changes, lubrication and so on. In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. Recent technological advantages in tools for inspection and diagnosis have enabled even more accurate and effective equipment maintenance. The ideal preventive maintenance would prevent all equipment failures before they occur. (Weibull, 2007)

6.1.1 Value of Preventive Maintenance

There are multiple misconceptions about preventive maintenance. One such misconception is that preventive maintenance is unduly costly. This logic dictates that it would cost more for regularly scheduled downtime and maintenance than it would normally cost to operate equipment until repair is absolutely necessary. This may be true

for some components, however one should compare not only the costs but the long term benefits and savings associated with preventive maintenance. Without preventive maintenance, costs for lost production time from unscheduled equipment breakdown will be incurred. Also preventive maintenance will result in savings due to an increase of effective system service life. (Weibull, 2007)

Long term benefits of preventive maintenance include:

- Improved system reliability
- Decreased cost of replacement
- Decreased system downtime
- Better spares inventory management

(Weibull, 2007)

6.1.2 When Does Preventive Maintenance Make Sense

Preventive maintenance is logical choice if the following two conditions are met:

- The component in question has an increasing failure rate. In other words, the failure rate of the component increases with time, thus implying wear out. Preventive maintenance of a component that is assumed to have an exponential distribution (which implies a constant failure rate) does not make sense.
- The overall cost of the preventive maintenance action must be less than the overall cost of corrective action.

(Weibull, 2007)

Long term effects and cost comparisons usually favour preventive maintenance over performing maintenance only when the system fails. (Weibull, 2007)

6.2 Introducing Prestart Checklists on Load and Haul and Plant Equipment

The first recommendation to improve the efficiency of the plants as well as the load and haul equipment is to introduce prestart checklists on the load and haul equipment as well as both of the plants. This is a list that is to be completed by the operators of the plants as

well as the load and haul equipment every morning before starting to operate at 7 am and handed to a supervisor. This ensures that prestart checks are completed each morning.

Prestart checks are part of preventive maintenance which checks many items to make sure that each item is working efficiently and effectively. (Bavdek, M 2007, pers comm., 24 August) The new prestart checklists that are to be introduced include what item needs to be checked or completed, a tick box to indicate that the item has been checked is then next to these instructions. A comments box for the operator to make comments on particular parts of their equipment is to the right of the page.

Prestart checks for the load and haul equipment include visual checks of any damage to the machines structure such as guards and body, as well as visual checks of whether there are any leaks of liquids such as water, coolant or oil. The fluid levels such as coolant, engine oil, transmission oil and hydraulic oil is checked and if they are below the required levels they are filled. The fuel tank is usually filled with diesel in the morning for that day. Other things such as two-way radios, the horn and lights are checked. (Bavdek, M 2007, pers comm., 24 August)

Prestart checks for the plants involve a series of visual checks on the crushers, screens and conveyor belts, for damage that might have been missed the previous day as well as damage that might have occurred over night. Oil checks on the crushers, feeder and rockbreaker is conducted and if necessary filled. Safety items such as the emergency button as well as lanyards that stop the plant when in an emergency are checked along with the condition of the screen material, commonly known as the media. Whilst checking the screens, the drive is checked to make sure that it is working at an efficient rate. (Murphy, S 2007, pers comm., 2 April)
The proposed prestart checklists for Load and Haul Equipment can be found in Figure 6.1, Plant 1 in Figure 6.2 and the Plant 2 in Figure 6.3.

LOAD & HAUL CHECK LIST		CHECKED	COMMENTS
DATE :			
1. Machine Visual Checks			
- Structural Damage	Ok		
- Guard Damage	Ok		
- Fluid Leaks	Ok		
2. Check Fluid Levels			
- Engine Oil	Ok		
- Coolant	Ok		
- Transmission Fluid	Ok		
- Hydraulic Fluid	Ok		
3. Cabin Checks			
- Two Way Radio	Ok		
- Horn	Ok		
- Lights	Ok		
- Fire Extingusher	Ok		
Inspection completed by :			
Print name :			15 minutes to complete

Figure 6.1: Proposed Prestart Checklist for Load and Haul

PLANT 1 PRE START CHECK LIST		CHECKED	COMMENTS
DATE :			
1. Check Crusher lube oil levels	Ok		
2. Check HCU on Cr2 - 'E' Stop	Reset		
- oil level	Ok		
- crusher chamber	Ok		
3. Check HCU on Cr3 - 'E' Stop	Reset		
- oil level	Ok		
- crusher chamber	Ok		
4. Check Scr 1 - media	ok		
- isolator	Ok		
5. Check Jaw - Crush chamber	Clear		
- drive	Ok		
6. Check Feeder - isolator	Ok		
- lanyard	Reset		
- drive	Ok		
7. Start Crusher lube oil Pp's	Ok		
8. Scr 2 - media	Ok		
- drive	Ok		
9. Scr 4 - media	Ok		
- drive	Ok		
10. Check Barmac - isolator	Ok		
- drives	Ok		
- 'E' Stops	Reset		
11. Scr 3 - media	Ok		
- drive	Ok		
12. Check switch room - area clean	Ok		
- all cabinets locked	Ok		
- a/c on	Ok		
13. Ready to start Plant			
Inspection completed by :			
Print name :			30 minutes to complete

Figure 6.2: Proposed Prestart Checklist for Plant 1

PLANT 2 PRE START CHECK LIST		CHECKED	COMMENTS
DATE :			
1. Check Crusher - lube oil level	Ok		
- 'E' stop	Reset		
- crushing chamber	Ok		
2. Check Feeder - lube oil level	Ok		
- 'E' stop	Reset		
3. Check Rock breaker - Oil level	Ok		
4. Check C3a/4 & 5 - Junction	Clear		
5. Check Screen 1 -Isolator	Ok		
- Drive	Ok		
6. Check Cr3 - drive	Clear		
- Isolator	Reset		
7. Check Cr2 - drive	Clear		
- Isolator	Ok		
8. Scr 1a - media	Ok		
- drive	Ok		
9. Scr 2 - media	Ok		
- drive	Ok		
10. Check air compressor - Oil level	Ok		
- Turn off bleed Vv	Ok		
11. Check switch room - area clean	Ok		
- all cabinets locked	Ok		
- a/c on	Ok		
Inspection completed by :			
Print name :			30 minutes to complete

Figure 6.3: Proposed Prestart Checklist for Plant 1

6.3 Introduce Fortnightly Maintenance on Both Plants

The second recommendation made in this project is to introduce fortnightly maintenance days on both of the plants. This maintenance conducted on the plants would be preventive maintenance to prevent major failures occurring. Failures can still occur but with the recommended maintenance strategy in place it will minimise this dramatically from what the previous unscheduled equipment downtime figures were.

As a result of the investigation into the unscheduled plant downtime and the reasons for this occurring, it was determined that the main reason was inadequate maintenance conducted on the plants over the last few years. It was the main reason that the amount of maintenance had to be increased and if measures were not put in place to rectify this, the unscheduled equipment downtime would continue to increase at a rapid rate. (Bavdek, M 2007, pers comm., 24 August)

Maintenance would be completed every week on Saturdays alternating between the plants on a weekly basis. It is planned to be conducted on Saturdays as the plants are only scheduled to crush from 7 am to 11:30 am, therefore minimal time would be lost compared to a day during the week when the plants are scheduled to crush from 7 am to 6 pm.

The activities conducted on a maintenance day are explained in the next recommendation and will require external resources such as electricians, boiler makers, fitter and turners and belt weigher calibrators.

6.4 Introduce Maintenance Plans on the Plants

As fortnightly maintenance for each plant is introduced, a number of plans should be introduced to determine what work is done on maintenance days. This work includes a more thorough check than what is conducted on the prestart checks each morning when the plant can be stopped and also be checked when it is running. This maintenance conducted on the plants would be preventive maintenance to prevent major failures occurring. Failures will still occur but with the recommended maintenance strategy in place it will minimise this dramatically from what the previous unscheduled equipment downtime figures were.

It is important to introduce plans on what is undertaken on maintenance day as items that have to be accomplished will be listed and therefore will not be relying on the memory of the manager, supervisor or the plant operator. A checklist could be made from these lists, similar to what has been proposed to the prestart checklists to make sure that each task has been completed.

Appendix G Table G.1 shows the activities that are required when conducting a maintenance day for Plant 1 with Table G.2 for Plant 2. The lists include the machine, the machine component which requires to be maintained along with the component item, the activity to be performed on the component, the time that is required to be taken to check the item and the time needed to replace the item if required. The activities conducted on a maintenance day will require external resources such as electricians, boiler makers, fitter and turners and belt weigher calibrators for conducting activities that the on site staff are not trained to perform. Other activities such as plant upgrades are also usually conducted

on maintenance days when the plant is not crushing to take full advantage of the scheduled downtime.

As described in the next recommendation, these plans are to be inputted into an asset management program but before these items are imputed, they can be printed out and bound into a book to be used when out on site conducting maintenance.

6.5 Input Preventive Maintenance Plans into an Asset Management Program

Rather than relying on calendars and excel spreadsheets to determine when parts are to be changed, it is easier to input these maintenance plans into an asset management program which automatically brings up what is required to be changed or what requires to be done on a maintenance day. To input these maintenance plans into the asset management program will also reduce the problems of forgetting to change parts when they require to be changed.

The program that has been chosen for this application is MEX which was created by a Brisbane company called Maintenance Experts. The reason that this program was chosen was that Boral already obtained a copy of this program and the outlaying expense is minimal. If required, training and assistance is offered by Maintenance Experts in Brisbane therefore it is not required to travel or phone interstate to obtain assistance.

6.5.1 MEX Asset Management Program

MEX is a computerised maintenance management system (CMMS) that delivers simplicity and functionality to any maintenance environment. MEX helps to track the value of plant and equipment and analyse and improve performance.
(MEX, 2007)

The MEX system enables the company to ensure that all of the assets are monitored and maintained. The MEX system will let the quarry take control of maintenance and ensure

that work progresses smoothly and that the maintenance is done when it is due. (MEX, 2007)

6.5.2 Key Modules of MEX

Included in the MEX Asset Management Program is a number of modules including the Asset Register, Work Orders, History, Maintenance Policies, Regions, Readings, Invoicing, Permits, Control Files, Security, Reports, Stores, Easytime, Key Registers, Downtime, Drawings, Requests, Inspections and KPIs. Some of these modules are not required for this project but could be used to record the history of the asset. An explanation of each of the modules can be found in Appendix H.

6.5.3 Implementation of MEX

The implementation of the MEX program will be the last recommendation to be implemented. The reason for the delay in inputting the data for the scheduled maintenance plans into an asset management program is that it takes time to set up the program as well as to input the data into a computer system. As quarry personnel are required on other activities around the quarry, it will require an outside resource to complete this task or will only be completed when time permits.

6.6 Conclusion

The recommendations are, to introduce a number of measures including prestart checklists to be filled out every morning for both plants as well as the load and haul equipment, fortnightly scheduled maintenance days for both plants to be undertaken on Saturdays so that the downtime is minimised, introducing scheduled maintenance plans and plans to replace parts on the assets as well as inputting these asset management plans into an asset management program as the program will automatically show when an item has been changed.

7. Valuation and Replacement of Assets

After producing asset management strategies it is also essential to determine when the items should be replaced. It is essential to value the item, then work out the annual depreciation of the item as well as determining if the item needs replacing. The information was sourced using various books and other online resources as well as information provided by Boral and the USQ library.

7.1 Valuation of Assets

Historical cost or some estimate thereof is the usual way to value equipment. Appraised and market values are occasionally found and in a few isolated cases there have been attempts to adjust the historical costs for changes in the accountants measuring unit. Other valuation schemes for plant assets such as opportunity costs, current market values and replacement costs have seldom been used in practise although theoretical arguments are common. (Dyckman, 'Long Lived Assets', 1967)

Cost is the primary basis for the valuation of assets, however assets can be valued in other methods other than cost. Two such circumstances arise when the cost of replacing items is below the recorded cost and when the asset is not saleable at normal sales prices due to imperfections or wear. (Fess and Warren, 'Accounting Principles', 1990)

7.1.1 Valuation at Lower of Cost

If the market price of an item in inventory is lower than its cost, the lower of cost or market method is used to value the item. It should be noted that regardless of the method used (cost or lower of cost or market), it is first necessary to determine the cost of the item. The term market is interpreted to mean cost to replace the item on the inventory date based on qualities typically purchased from the usual source of supply. (Fess and Warren, 'Accounting Principles', 1990)

If the replacement price of an item is lower than its cost, the use of the lower of cost method provides two advantages. These include the gross profit is reduced for the period in which the decline occurred and an approximately normal gross profit is realised during the period of which the item is sold. To illustrate the lower of cost method, assume a product with a unit cost of $70 was sold at $100 during the period, yielding a profit of 30%. Also assume that at the end of the year, there is a single item that its replacement cost has declined to $63. Under these circumstances it would be reasonable to expect that the selling price would also decline. Assuming a reduction in the selling price to $90, the gross profit based on replacement cost of $63 would be $27, which is also 30% of the selling price. Accordingly, valuation of the unit at $63 reduced the gross profit of the past by $7 and permits a normal gross profit of $27 to be realised on its sale in the following period. If the item had been valued at $70, the gross profit determined for the past year would be $7 greater and the gross profit attributed to the sale of the item would be $7 less. (Fess and Warren, 'Accounting Principles', 1990)

7.1.2 Valuation at Net Realisable Value

Obsolete, spoiled or damaged items and other items that can be sold at prices below cost should be valued at net realisable value. The net realisable value is the estimated selling price less any direct cost of disposition, such as sales commissions. (Fess and Warren, 'Accounting Principles', 1990)

7.1.3 Depreciation

The term depreciation in its most common usage designates the gradual expiration of the cost or other value of certain long lived assets through time and use. Depreciation accounting is an attempt to recognise, in some orderly fashion, the periodic extent of this cost of operation so that a more meaningful statement of both company asset values and periodic extent to the cost of operations so that a more meaningful statement of both company asset value and periodic income can be made. (Dyckman, 'Long Lived Assets', 1967)

7.1.3.1 What Causes Depreciation

Because plant assets do not physically become part of the product, as is true of raw materials, for example, some indirect means must be found of associating depreciation with periodic revenues. This objective is accomplished by procedures associated with the causes of depreciation. (Dyckman, 'Long Lived Assets', 1967)

The most obvious cause of the decline in asset service potential is physical deterioration. Use, improper maintenance, and the action of the elements all contribute to the decline of the asset's economical and efficient use. Increased maintenance costs and reduced reliability result in ultimately causing retirement. (Dyckman, 'Long Lived Assets', 1967)

A more subtle though equally relevant cause of the loss of an asset's capacity to render service is obsolescence. An asset may become inadequate to meet the needs for service required by a firm. This condition can develop independently of the physical condition of the asset. For example, increased sales may require a larger machine capacity. Alternatively, a road built to facilitate the extraction of rock from the quarry can lose its service potential when the rock is exhausted, even if the road is still in good condition at that time. (Dyckman, 'Long Lived Assets', 1967)

However, generally the obsolescence factor is most closely associated with the technological change which results in new and improved methods of accomplishing specific objectives. For a particular firm or for a specific asset, technological obsolescence is usually the result of sudden change which can even cause the immediate extinction of an assets economic life. Therefore while physical deterioration, considered together with maintenance policies, establishes the maximum life of an asset, obsolescence dictates the shorter useful life. (Dyckman, 'Long Lived Assets', 1967)

7.1.3.2 Methods of Depreciation

When determining the depreciation of a piece of equipment there are four methods which are used most often. These include the straight line method, the units of production,

declining balance and sum of the years digit. The extent of the use of these methods is shown in figure 7.1. (Fess and Warren, 'Accounting Principles', 1990)

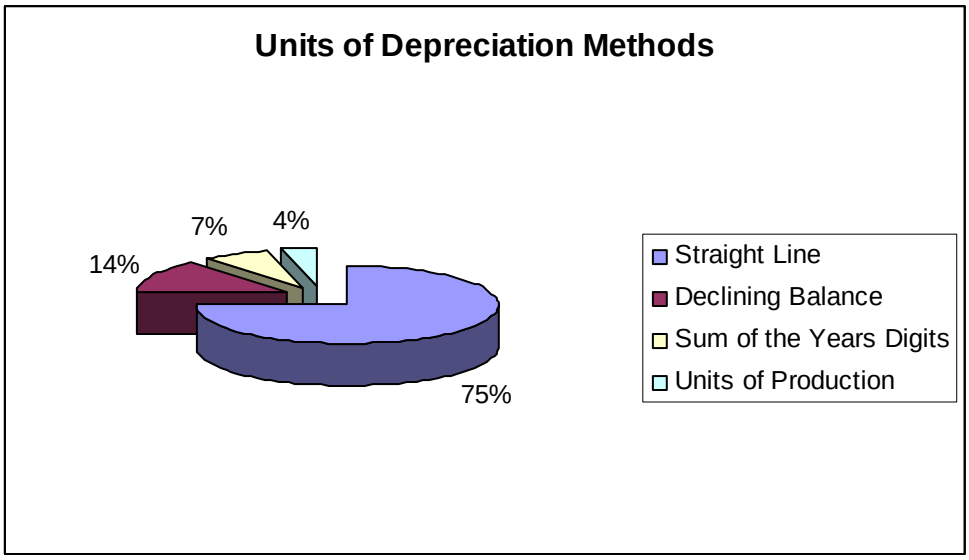

Figure 7.1 – Percentages of Depreciation Methods
(Fess and Warren, 'Accounting Principles', 1990)

Straight Line Method

The straight line method of determining depreciation provides for equal periodic charges to expense over the estimated life of the equipment. The annual straight line depreciation is calculated as follows: (Fess and Warren, 'Accounting Principles', 1990)

$$\frac{\text{Cost} - \text{Estimated Residual Value}}{\text{Estimated Life}} = \text{Annual Depreciation}$$

The straight line method is widely used because of its simplicity. In addition, it provides a reasonable allocation of costs to periodic revenue when usage is relatively the same from period to period. (Fess and Warren, 'Accounting Principles', 1990)

Units of Production Method

The units of production method yields a depreciation charge that varies with the amount of equipment usage. To apply this method, the length of life is expressed in terms of productive capacity, such as hours, kilometres or another value of units. The depreciation

for a unit of one hour is calculated as follows: (Fess and Warren, 'Accounting Principles', 1990)

$$\frac{\text{Cost} - \text{Estimated Residual Value}}{\text{Estimated Hours}} = \text{Hourly Depreciation}$$

When the amount if usage of a piece of equipment varies from year to year, this method is more logical than the straight line method. It may yield fairer allocations of cost against periodic revenue. (Fess and Warren, 'Accounting Principles', 1990)

Declining Balance Method

The declining balance method yields a declining periodic depreciation charge over the estimated life of the asset. The most common technique is to double the straight line depreciation rate, as described above and apply the resulting rate to the cost of the equipment less its accumulated depreciation. For example, the declining balance rate for an asset with an estimated life of five years would double the straight line rate of 20% or 40%. This rate is then applied to the cost of the asset for the first year of its use and thereafter to the declining book value (cost minus accumulated appreciation). (Fess and Warren, 'Accounting Principles', 1990)

Sum of the Years Digits Method

The sum of the years digit method yields results like those obtained from using the declining balance method. The periodic charge for depreciation declines steadily over the estimated life of the asset because a successively smaller fractions is applied each year to the original cost of the asset less the estimated residual value. The denominator of the fraction, which remains the same, is the sum of the digits representing the years of life. The numerator of the fraction which changes each year is the number of years of life remaining at the beginning of the year for which depreciation is being computed. (Fess and Warren, 'Accounting Principles', 1990)

7.1.4 Valuation and Depreciation of Major Items at Purga Quarry

As described above, to complete a valuation of the items at Purga Quarry it is essential to determine the cost to replace them. This is completed by finding the costs of the same items of the approximately same hours that is currently at Purga Quarry, via mining and quarry equipment websites.

The following tables show the current valuation of the load and haul equipment as well as the major items on the plants as of 27 September 2007. To value the items properly it is essential to value the items of the same currency. For this project, everything has been valued in Australian Dollars which equates to $US0.87 As found on the Travelex Australia web site on the 27 September 2007.

7.1.4.1 Load and Haul Valuations and Depreciation

The following tables are the current valuations of the load and haul equipment:

Dump Trucks

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
Komatsu HD325	1 May 2006	$500,200.00	$235,767.39	$13,221.63
CAT 769D	31 May 2004	$398,695.00	$326,000.00	$18,173.75
CAT 769C	30 June 1980	$175,700.00	$138,765.00	$2172.65

Table 7.1 Valuations and Depreciation of Dump Trucks

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

Front End Loaders

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
CAT 988H	1 July 2007	N/A	N/A	N/A
Komatsu WA500	31 December 2004	$500,200.00	$195,000.00	$76,300.00
CAT 970F	31 October 1994	$342,472.00	$95,000.00	$17,676.57
CAT 980F	N/A	N/A	$129,709.00	N/A
CAT 980C	30 September 1980	$238,390.00	$85,000	$9022.94

Table 7.2 Valuations and Depreciation of Front End Loaders

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

7.1.4.2 Plant 1 Equipment Valuations and Depreciation

The following tables are the current valuations of the equipment on Plant 1:

Plant 1 Crushers

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
Barmac 9000 Duopactor	30 June 2005	$118,043.54	$92,345.00	$8566.18
Portec Feeder	30 June 2005	$27,513.16	$15,854.00	$3886.39
Secondary Crusher	30 June 2005	$666,859.00	$387,427.35	$93,143.88
Tertiary Crusher	30 June 2005	$666,859.00	$387,427.35	$93,143.88

Table 7.3 Valuation and Depreciation of Crushers on Plant 1

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

Plant 1 Screens

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
16x6 Screen	28 August 2002	$11,613.61	$9765.45	$1848.16
16x5 Screen	30 June 2005	$70,731.72	$48,972.12	$7253.20
12x5 Screen	30 June 2005	$55,382.26	$32,902.00	$7493.42
12x6 Screen	30 June 2005	$62,749.63	$36,865.00	$8628.21

Table 7.4 Valuation and Depreciation of Screens on Plant 1

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

7.1.4.3 Plant 2 Equipment Valuations and Depreciation

The following tables are the current valuations of the equipment on Plant 2:

Plant 2 Crushers

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
Jaw Crusher	1 March 1997	$175,584.00	$56,872.00	$11,571.20
Primary Feeder	30 June 1981	$16,401.00	$6542.00	$579.94
Jaques Impactor	28 February 1991	$34,826.00	$20,734.00	$1281.10
Barmac Rotopactor	4 January 1987	$40,000.00	$15,862.00	$1206.90

Table 7.5 Valuation and Depreciation of Crushers on Plant 2

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

Plant 2 Screens

Item	Purchased Date	Purchased Cost	Current Replacement Cost	Annual Straight Line Depreciation
Malco 12x6 2 Deck Screen	4 January 1987	$7000.00	$2984.00	$200.80
12x5 Jaques 2 Deck Screen	30 April 1989	$6400.00	$2875.00	$195.83
Vibrating Grizzly Screen	1 June 1997	$117,466.76	$84,213.00	$3325.37
16x6 Screen	1 December 1996	$81,823.00	$42,987.00	$3530.55

Table 7.6 Valuation and Depreciation of Screens on Plant 2

(Boral Quarry Database, 2007), (Machinery Trader, 2007)

7.2 Replacement of Assets

In this era of rapid technological change, a piece of equipment purchased today is likely to be better following in a very brief time by a new generation of equipment that will do the same job better, faster and more economically. It is a certainty that the people who sell the equipment would have us believe that 'new and improved' model is essential if we are to continue operating efficiently. People are told what they are using now is obsolete, but there are different kinds of obsolescence and the equipment that is obsolete in one sense is may remain perfectly appropriate in another sense. (Charles R McConnell, 'Old Equipment: When to Replace, When to Keep', 2004)

Rapid technological change ensures that much equipment we buy becomes technologically obsolete in a short time, meaning there is now something available that is superior in some respects to what we are presently using. But if an equipment replacement decision is made on the basis of technological obsolescence, the organisation is shelling out good money that the company could avoid spending. For equipment to be truly obsolete and a candidate of replacement, it should be functionally obsolete, that means that it will no longer do the job that it was meant to do. (Charles R McConnell, 'Old Equipment: When to Replace, When to Keep', 2004)

Functional obsolescence is true obsolescence. When a particular piece of equipment can no longer serve its intended purpose, this is either because the equipment has deteriorated or the function has changed. Consider this example. Say a company bought Machine X a year ago and today a friendly sales representative arrives with the news that Machine X is obsolete because Machine NIX (New and Improved X) is now available. Machine NIX will work 25% faster than Machine X, so therefore Machine X is indeed technologically obsolete. But a closer look at Machine X reveals that the volume that it is producing has not changed much and that only 50% of Machine X's capacity is being used. Copy quality remains consistent and quality requirements have not changed. So Machine X is not functionally obsolete because it will still do the job it was intended to perform at essentially the same cost. (Charles R McConnell, 'Old Equipment: When to Replace, When to Keep', 2004)

Another example is that if the present piece of equipment is broken down and cannot be repaired at a reasonable cost, a replacement decision is likely in order. But otherwise, what has to be thoroughly considered first is the application. If the application remains such as the old equipment will still do the job, the equipment, although technologically obsolete, is not functionally obsolete and can continue to do its job. If the application has changed such that the old equipment can not perform at all, or, more likely, can not perform fast enough or economically enough, then the old equipment is functionally obsolete and replacement is indicated. (Charles R McConnell, 'Old Equipment: When to Replace, When to Keep', 2004)

There are at times when it makes sense to go for the up to date bells and whistles, all of the fancy features of the newest model. This is usually the case when the new technology means a bankable cost saving. (Charles R McConnell, 'Old Equipment: When to Replace, When to Keep', 2004)

As part of this project I have been asked to explain when it is appropriate to replace equipment but not to determine which equipment needs to be replaced. This was undertaken in the 'Operational Excellence' project that this project is comes from.

7.3 Conclusion

After producing asset management strategies it is also essential to determine when the items should be replaced. The first thing is to value the piece of equipment by finding out the market value of the equipment and to determine the annual depreciation of it, then to determine if the equipment needs to be replaced or kept. There are two steps involved in deciding to replace or keep a piece of equipment. This is determining whether a piece of equipment is functionally obsolete or if it remains appropriate for the application and to determine a comparison of all the costs associated with owning and operating the new and old equipment.

8. Project Benefits

When undertaking a project it is important to determine the benefits that will be achieved. For this project the benefits come in the form of production benefits which is the additional amount of material that will be produced as well as the cost reductions because of the more effective and efficient equipment at the quarry.

8.1 Production Benefits

The object of this project is to decrease the unscheduled equipment downtime that currently occurs on both of the plants. This decrease in downtime should result in an increase in production.

For Plant 1, the unscheduled equipment downtime over the financial year of 2005/2006 was recorded as 171.02 hours with the scheduled downtime recorded as 177.59 hours. This equates to 348.61 hours of downtime recorded during this period. (Boral Quarry Database, 2007)

For Plant 2, the unscheduled equipment downtime over the financial year of 2005/2006 was recorded as 52.74 hours with the scheduled downtime recorded as 182.13 hours. This equates to 234.87 hours of downtime recorded during this period. (Boral Quarry Database, 2007)

Fortnightly maintenance is to be conducted on a Saturday, when the plant only operates from 7 am to 11:30 am, therefore only resulting in four and a half hours of downtime. It is assumed that the staff on site operates 50 weeks a year which includes the time off for public holidays such as Christmas, New Year, Easter, Australia Day, ANZAC Day, Queens Birthday Holiday and Ipswich Show Holiday. The amount of downtime taken due to fortnightly maintenance is shown below. (Boral Quarry Database, 2007)

4.5 hours of scheduled operation on a Saturday between 7 am and 11:30 am
50 operating weeks per year
50/2 = 25 fortnightly maintenance days per year
4.5 x 25 = 112.5 hours of downtime for scheduled maintenance per year

As mentioned earlier, it is impossible to eradicate all equipment failures but if they are looked after more effectively, the risk of failures are lower. It is for this reason that an additional 50 hours is added to the assumed downtime for the year. This downtime is assumed to include prestart check overruns as well as scheduled maintenance for screen changes and any other maintenance that is also supposed to be done in the morning before the plant starts at 7 am. The addition of these hours is shown below.

112.5 hours of downtime for scheduled maintenance per year
50 additional hours for unexpected equipment failures
112.5 + 50 = 162.5 hours of assumed downtime in a year after this project is implemented

This assumed figure of 162.5 hours of downtime is the assumed total equipment downtime for a year after this project is fully implemented. It includes all of the unscheduled and scheduled equipment downtime but not any of the process downtime such as no rock being fed into the crushing plant or large rock going through the plant which needs to be broken up by the rockhammer. The process downtime is difficult to assume for a year as it varies from day to day, depending on many factors. For this exercise it is assumed that there is no process downtime therefore assuming that the feed is perfect and there is always rock going through the feeder during crushing hours.

This assumed total downtime is lower than the equipment downtime recorded for both of the plants by a significant amount as shown below.

Plant 1

348.61 hours of equipment downtime for Plant 1 for FY2005/2006

162.5 hours of assumed downtime in a year after this project is implemented

348.61 – 162.5 = 186.11 hours difference

Plant 2

234.87 hours of equipment downtime for Plant 2 for FY2005/2006

162.5 hours of assumed downtime in a year after this project is implemented

234.87 – 162.5 = 72.37 hours difference

To determine the amount of material that is additionally produced due to this project, it is essential to determine what rates the plants run at per hour. This rate can change due to the material that is produced as well as the size of the rock that is fed into the plants. To produce aggregates it is slower than producing roadbase due to the increasing crushing and screening that is involved making the aggregates at a certain size. Therefore to assume a standard tonnage rate is to determine the average of both the rate for producing aggregates as well as the average to produce roadbase. From the Boral Quarry Database, this figure can be assumed to be 242 TPH for Plant 1 and 183 TPH for Plant 2.

Therefore to determine the benefit in production:

Plant 1

186.11 hours difference between assumed and FY2005/2006

242 TPH average production rate for Plant 1

186.11 x 242 = 45038.62 tonnes benefit for Plant 1

Plant 2

72.37 hours difference between assumed and FY2005/2006

183 TPH average production rate for Plant 2

72.37 x 183 = 13243.71 tonnes benefit for Plant 2

Total Benefit

45038.62 tonnes benefit for Plant 1

13243.71 tonnes benefit for Plant 2

45038.62 + 13243.71 = 58282.33 tonnes

Therefore the benefit of this project is 58282.33 tonnes. Of course this figure does not include the downtime for the process downtime therefore this figure is the maximum that can be achieved using these rates. With other improvements being made to the plants, the rate will improve therefore the advantage could be more.

8.2 Cost Benefits

Cost benefit analysis is a term that refers both to

- A formal discipline used to help appraise or assess the case for a project of proposal which itself is a process known as project appraisal
- An informal approach to making decisions of any kind.

(Wikipedia, *Cost Benefit Analysis*, 2007)

Cost benefit analysis is an economic tool to aid social decision making and is typically used to the desirability of a given intervention in a market. The aim is to gauge the efficiency of the impacts of an intervention which are evaluated on terms of the willingness to pay for benefits or the willingness to pay to avoid the costs. Inputs are measured in terms of opportunity costs – the value in their best alternative use.
(Wikipedia, *Cost Benefit Analysis*, 2007)

The process involves monetary value of initial and ongoing expenses verses the expected return. Constructing plausible measures of the costs and benefits of specific actions is often very difficult. In practice, analysts try to estimate costs and benefits either by using survey methods or by drawing inferences from market behaviour. The cost benefit analysis attempts to put all relevant costs and benefits on a common footing. A discount rate is chosen, which is then used to compute all relevant future costs and benefits in present-value terms. (Wikipedia, *Cost Benefit Analysis*, 2007)

Maintenance expenses can vary from maintenance day to maintenance day depending on what needs to be performed when undertaking the maintenance. The major task on a maintenance day would involve lubrication as well as checking various parts of the plants. The expense in undertaking maintenance includes lubricant for which Boral have a national agreement with a major oil company to supply. Any other equipment needed on the plants are either stored on site or ordered when needed. This equipment is either installed by the staff on site or by using external resources. The costs of these external resources are in an agreement between the quarry and the company that offers the resources and cannot be given. (Bavdek, M 2007, pers comm., 12 September)

For this exercise, it will be assumed that a normal maintenance day costs $2500. The calculation of the expenses is shown below. Maintenance days are performed every Saturday so therefore there are fifty maintenance days that are done throughout the duration of the year.

50 maintenance days per year
$2500 assumed maintenance day costs
50 x $2500 = $125000 costs for performing maintenance for a year

The price per tonne of rock varies depending on the expenses that it takes to produce the material depending on drill and blast as well as maintenance and any other costs that are associated. (Bavdek, M 2007, pers comm., 12 September) For this exercise, it will be

assumed that the price of the material is $6 per tonne. The amount of money that is made when selling the material out the gate is shown below.

$6 assumed price of material per tonne
58282.33 tonnes is the benefit of undertaking this project
$6 x 58282.33 = $349693.98 amount made when the additional material is sold

The profit made is the difference between the costs and the amount that is sold. This is determined in the calculation below.

$125000 costs for performing maintenance for a year on both plants
$349693.98 amount made when the additional material is sold
$349693.98 - $125000 = $224693.98 profit

The cost benefit of this project is then determined as $224693.98. This is not of course an accurate figure due to information that cannot be supplied but is sufficient for this activity.

8.3 Conclusion

Therefore from determining the benefits associated with this project, it shows that a benefit can be achieved with less downtime which leads to an additional 58282.33 tonnes of material. From assuming costs associated with maintaining the plants as well as the price of material, it shows that there is a significant cost benefit of $224693.98.

9. Implementation and Future Work

Whenever a project is introduced it has to be implemented and goes through an implementation plan. This plan includes a specific start date which usually coincides with the beginning of a month, year or financial year, as well as a monitoring process to make sure that the targets set by the project are being met or that an increase in production is being achieved. It was decided that some of the ideas that came from this project were to be implemented earlier as it was believed that the benefits from those proposals were required as soon as possible.

9.1 Current Implementations

Throughout the duration of undertaking this project, a couple of the proposed items were implemented. These items include the introduction of fortnightly maintenance days for each plant as well as the introduction of a prestart checklist for each plant to be conducted each morning.

9.1.1 Fortnightly Maintenance for Each Plant

As a result of the investigation into the unscheduled plant downtime and the reasons for this happening, it was shown that the main reason this occurred was because of the inadequate maintenance that has been conducted on the plants over the last few years. It was for this reason that the amount of maintenance had to be increased.

It was therefore determined that it would be more effective to introduce more maintenance days as soon as possible. Fortnightly maintenance began in the beginning of April 2007. The maintenance was scheduled so that it would occur on Plant 1 one week and Plant 2 the other, alternating between the plants each week. It was also determined that the best time to conduct the maintenance on the plants was to be a Saturday because the plants are only scheduled to work until 11:30 am and therefore minimal time would be lost compared to if it was a day during the week where the plants crush from 7 am to 6 pm. (Bavdek, M 2007, pers comm., 24 August)

On some occasions, external resources such as electricians, boiler makers, fitter and turners and belt weigher calibrators are required. These external resources may not be available when required so other planned maintenance days are required during the week. If this is the case, although this happens rarely as these resources are booked weeks in advance, the plant which requires the maintenance crushes on the Saturday that the maintenance was originally scheduled on and the maintenance is then scheduled to a day during the week when all of the external resources are available. (Bavdek, M 2007, pers comm., 24 August)

From implementing this new change, the unscheduled downtime has reduced from an average of 18.65 hours per month on both plants in financial year 2005/2006 to an average of 9.6 hours per month in August 2007. A breakdown of the unscheduled downtime for each piece of equipment is shown in the Figures 9.1 and 9.2 below for the months following the introduction of this idea with the unscheduled downtime for each piece of equipment for financial year of 2005/2006. (Boral Quarry Database) There have been some exceptions when screens have to be cleaned more often in wet weather due to the material sticking to the screen media. There was also a feeder failure on Plant 2 during July 2007. (Bavdek, M 2007, pers comm., 24 August)

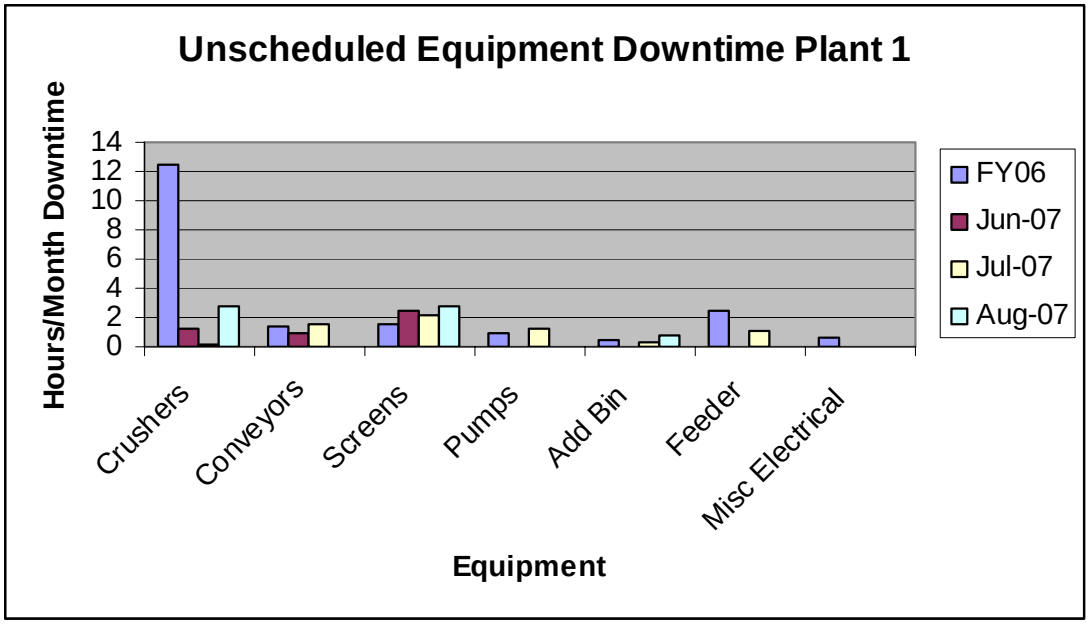

Figure 9.1: Comparison of Unscheduled Downtime for Equipment for Plant 1 (Boral Quarry Database)

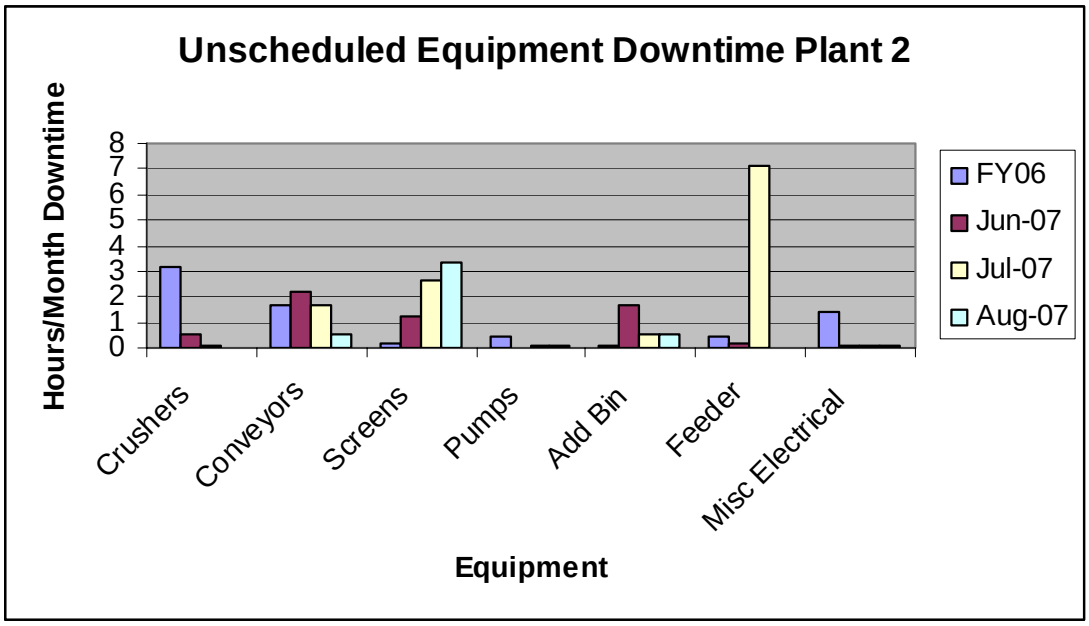

Figure 9.2: Comparison of Unscheduled Downtime for Equipment for Plant 2 (Boral Quarry Database)

9.1.2 Prestart Checklists for Plants

Along with the introduction of fortnightly maintenance to each plant it was recommended that a prestart checklist which would be handed to the site manager or the supervisor, for both of the plants would be implemented. It was shown when investigating the current way the assets are managed, that there were no checklists when conducting prestart checks on the plants. This therefore was another reason that there was an increasing amount of unscheduled equipment downtime as these items were not properly checked.

It was therefore determined that prestart checklists be introduced to the plants after the introduction of fortnightly scheduled maintenance for each plant. It was important to find the benefits of the fortnightly scheduled maintenance for each plant before introducing the prestart checklists. Therefore the introduction of the prestart checklists began in the beginning of August 2007.

The prestart checks are conducted when the staff start at 6 am through to 7 am when crushing is scheduled to commence. With the introduction of these prestart checks, on some occasions it has to be noted that prestart check overruns have occurred as problems have been found because of the thorough checking and when fixed the rest of the plant must be continued to be checked. This time overrun is then put into Boral's Quarry Database as Scheduled Downtime as prestart checks are scheduled to occur but the plant is not operating. (Bavdek, M 2007, pers comm., 24 August)

From implementing this new change, along with the introduction of fortnightly maintenance being undertaken on the plants, the unscheduled downtime has reduced from an average of 18.65 hours per month in financial year 2005/2006 to an average of 9.6 hours per month in August 2007. A breakdown of the unscheduled downtime for each piece of equipment is shown in the Figure 9.1 below for the months following the introduction of this idea with the unscheduled downtime for each piece of equipment for financial year of 2005/2006. (Boral Quarry Database, 2007)

9.2 Implementation Timetable

Along with the ideas already implemented there are other ideas that require to be implemented to maximise potential benefits. These ideas are scheduled to be implemented at the beginning of the following months.

- Introduce Prestart Checklists for Load and Haul Equipment – November 2007
- Introducing a scheduled maintenance and replacement plan – January 2008
- To input these scheduled maintenance plans into an asset management program – Not available at this time, See Future Work.

9.3 Future Work

Along with the implementation of the above ideas there is some future work that is needed to be undertaken on this project after this dissertation is to be handed in for marking. This includes inputting the data for the scheduled maintenance plans into an asset management program as well as continual monitoring of the other ideas.

The reason for the delay in inputting the data for the scheduled maintenance plans into an asset management program is that it takes time to set up the program as well as to input the data into a computer system. As quarry personnel are required on other activities around the quarry, it will require an outside resource to complete this task or will only be completed when time permits.

Continual monitoring of the project is required to make sure that the targets determined for this project is continually met and that the production is increased with the downtime decreasing. This monitoring will coincide with the monitoring conducted for the "Operational Excellence" project with will continue until March 2009.

9.4 Conclusion

When completing a project it is important to have an implementation plan to implement the ideas to the particular project that is to be completed. This project has a stepped out

implementation plan to determine if a particular idea is delivering the results that is targeted.

10. Conclusion

Purga Quarry is the only quarry operated by Boral that services the Western Corridor of South East Queensland. The quarry supplies roadbase and aggregates to road and infrastructure projects currently under construction is this region. (Pyne S 2007, pers. comm., 8 January) Boral's SEQ Quarry Division acknowledged that the current production output needed to be increased to meet the current and future demands. This project aimed to identify ways to develop a more efficient and effective asset management and maintenance method to meet the future demands of this quarry. (Boral Operational Excellence Diagnostic Report, 2007)

A review of the background information showed that a quarry is an open cut pit where rock is extracted. To retrieve the material from a quarry, the material goes through a number of processes. These are:

- Drilling
- Blasting
- Loading into Dump Trucks
- Hauling to the Crushing Plant
- Crushing and Screening
- Stockpiling
- Selling

(Rieck, D 2007, pers comm., 25 February)

Different ways that assets are managed were obtained from relevant literature. These were the Centralised Asset Management Method and the Decentralised Asset Management Method. The Centralised Asset Management Method is a method where the assets are managed from a central location with the Decentralised Asset Management Method being where assets are managed by the people who use it. (New Zealand Treasury, 2007)

Purga Quarry, along with all of the other Boral Quarries, is responsible for the day to day running of the plant and load and haul equipment with the major changes the responsibility of the asset manager whom is based at the head office in Milton. (Boral Operational Excellence Technical Team Wave 1 Report, 2007)

Currently the load and haul equipment at the site undergo a prestart check in the morning between 6 am and 7 am as well as regular maintenance. When there is problem with the plants, the prestart checks on the load and haul equipment is generally ignored in favour of repairing the plants. There is currently no prestart checklist for the load and haul equipment to be given to the foreman/supervisor every morning. (Bavdek, M 2007, pers comm., 24 August)

The plants also currently undergo prestart checks every morning but only undertake the minimum amount of maintenance in favour of production. (Murphy, S 2007, pers comm., 2 April) Plant 1 only accumulated 177.59 hours of scheduled downtime in financial 2005/06 with Plant 2 only accumulating 182.13 hours. The majority of this scheduled downtime was for screen changes when different products are being produced. The total amount of downtime for equipment failures over this same period was 171.02 hours for Plant 1 and 52.74 hours for Plant 2. The majority of this was in crusher failures with 93.44 hours for Plant 1 and 31.74 hours for Plant 2. This amount of downtime would only increase in the future if the maintenance problems were not addressed, so something had to be done. (Boral Quarry Database, 2007)

The recommendations were, to introduce an number of measures including prestart checklists to be filled out every morning for both plants as well as the load and haul equipment, fortnightly scheduled maintenance days for both plants to be undertaken on Saturdays so that the downtime is minimised, introducing scheduled maintenance plans and plans to replace parts on the assets as well as inputting these asset management plans into an asset management program as the program will automatically show when an item has been changed.

Some of these recommendations have been implemented and there has also been an addition in tonnes being produced as well as a decrease in unscheduled equipment downtime. All of the other recommendations are planned to be implemented over the next few months. As these ideas are implemented, they will have to be continually monitored to determine if unscheduled equipment downtime has decreased with a marked increase of amount of tonnes produced.

These recommendations as well as the recommendations from the 'Operational Excellence' Project should therefore meet the targets of doubling the production of material than the financial year of 2005/2006 by the two year allocation period so that the quarry can produce the material needed to meet the demands of the growing Western Corridor of South East Queensland.

10.1 Summary of Changes

There were a number of changes to the current way that the physical assets on the site were maintained to improve the efficiency of the equipment. These include:

- Introducing Prestart Checklists for both the plants as well as the load and haul equipment
- Introducing more scheduled preventive maintenance days than what there currently is
- Introducing a scheduled maintenance plan and plans to replace parts of these assets
- To input these scheduled maintenance plans into an asset management program

With these changes to the management of the equipment on site along with the changes made to the plants and load and haul equipment via the 'Operational Excellence' Project, it is forecast that the quarry should double its production compared to the 2005/2006 financial year.

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Appendix A – Project Specification

University of Southern Queensland
Faculty of Engineering and Surveying

ENG4111/2 Research Project
PROJECT SPECIFICATION

FOR:	Daniel Crowe
TOPIC:	Management of Physical Assets
SUPERVISOR:	Professor David Ross
SPONSORSHIP:	University of Southern Queensland
PROJECT AIM:	This project aims to manage, monitor and develop maintenance policies and replacement strategies of physical assets contained at a quarry.
PROGRAMME:	**Issue A, 18 March 2007**

1. Research the background of the problems that occurs when managing assets and developing strategies for managing assets.
2. Critically evaluate the current asset management processes conducted by the quarry
3. Investigate failures and reasons for failures of assets
4. Develop and write up maintenance policies for selected parts of the assets from the failure analysis previously conducted
5. Define the time when replacement of assets would be more effective than being continually maintained
6. Define the cost and production benefit of improvements undertaken from this project
7. Present a progress report to my peers and prepare a dissertation in the required format

As time permits:

8. Report on the implementation of the recommendations of this project

AGREED:

_____ (Student)	20/3/07
_____ (Supervisor)	20/3/07
_____ (Co-examiner)	26/3/07

Appendix B – Purga Asset Register

Below is a table of the assets that are at Purga Quarry as of February 2007.

Major/Minor	Description	Commission Date	Cost
Front End Loader	CAT 970F FEL	31 October 1994	$342,472.00
Weighbridge	Weighbridge Qld Weighing Machine	28 February 1991	$41,222.00
Front End Loader	CAT 980C FEL	30 September 1980	$238,390.00
Front End Loader	Komatsu WA500 FEL	31 December 2004	$500,200.00
Dump Truck	Komatsu HD325 RDT	1 May 2006	$500,465.00
Welding Units Portable	Lincoln 400AS Welder	2 April 1993	$3,232.00
Pump	Water Supply Pump CR16 Webster 140H	30 April 1995	$3,070.00
Motor Vehicle General	Landcruiser Ute Unregistered	2 April 1993	Unknown
Crushers	Jaques 536 Impactor	28 February 1991	$34,826.00
Crushers	Barmac Rotopactor	4 January 1987	$40,000.00
Crushing Bin	12 sqm Tipping Bin	4 January 1987	$4,000.00
Crushing Bin	Tipping Bin	28 February 1991	$4,092.00
Screens	Malco 12x6 2 deck	4 January 1987	$7,000.00
Conveyors	Conveyor C1 12m x 750 mm	28 February 1991	$3,726.00
Conveyors	Conveyor C2 11.5m x 600 mm	28 February 1991	$3,571.00
Conveyors	Conveyor C3 14.5m x 600 mm	28 February 1991	$4,502.00
Conveyors	Conveyor C4 17.7m	28 February 1991	$5,496.00

	x 750 mm		
Conveyors	Conveyor C5 23.5m x 750 mm	28 February 1991	$7,297.00
Conveyors	Conveyor C6 18.4m x 600 mm	28 February 1991	$5,713.00
Conveyors	Conveyor C7 6.8m x 750 mm	28 February 1991	$2,111.00
Conveyors	Conveyor C8 20m x 600 mm	28 February 1991	$6,210.00
Conveyors	Conveyor C9 5.8m x 450 mm	28 February 1991	$1,801.00
Conveyors	Conveyor C10 26m x 450 mm	28 February 1991	$7,980.00
Conveyors	Conveyor C11 23m x 600 mm	28 February 1991	$6,986.00
Conveyors	Conveyor C12 17m x 450 mm	28 February 1991	$5,341.00
Conveyors	Conveyor C13 18m x 450 mm	28 February 1991	$5,682.00
Conveyors	Conveyor C1A 18m x 600 mm	28 February 1991	$5,589.00
Conveyors	Conveyor C2A 19m x 450 mm	28 February 1991	$5,899.00
Conveyors	Conveyor C3A 19m x 600 mm	28 February 1991	$5,744.00
Conveyors	Conveyor C13 7.5m x 600 mm	28 February 1991	$2,329.00
Crushing Bin	Additive Bin	4 January 1987	$15,000.00
Screens	12x5 Jaques 2 Deck Screen	30 April 1989	$6,400.00
Crushers	AC Hydrocone 36	31 October 1974	$33,797.00

	inch		
Crushers	42 inch x 30 inch SD Jaw Crusher	30 June 1984	$70,000.00
Crushers	42x30 inch Jaw Crusher	30 June 1984	$18,654.00
Crushers	36x24 Kue Ken Jaw	31 July 1984	$24,000.00
Crushers	Primary Feeder 42x30	30 June 1981	$16,401.00
Crushers	Duopactor	1 August 1996	$81,823.24
Screens	Screen Vibrating Grizzly	1 June 1997	$175,584.34
Crushers	Rockbreaker over Jaw Crusher	30 April 1999	$35,210.00
Screens	16x6 Screen	28 August 2002	$11,613.61
Crushers	Portec Feeder	30 April 2005	$27,513.16
Crushers	Secondary and Tertiary Crushers	30 June 2005	$666,859.65
Crushers	Barmac 9000 Duopactor	30 June 2005	$118,043.54
Screens	Final Screen 16x5	30 June 2005	$70,731.72
Crushers	Additive Bin and Feeder	30 June 2005	$117, 466.76
Pumps/Pipes	Water Spray System	30 June 2005	$32,361.03
Motor Vehicles >1 Tonne	Hino Water Truck	30 September 1982	$25,103.00
Dump Truck	CAT 769C RDT	30 June 1980	$201,400.00
Excavator	Liebherr Excavator R952HD	31 March 1993	$175,700.00
Dump Truck	CAT 769D RDT	31 May 2004	$398,695.00
Drill Rig	Atlas Copco ROC F9-2	31 October 2004	$604,513.00

Table B.1: Purga Quarry Asset Register (Boral Quarry Database, 2007)

Appendix C - Front End Loader Specifications

The following is a list of the full specifications for the Front End Loaders located at Purga Quarry.

CAT 988H

Engine	
Net Power	373 kW
Engine Model	Cat C18 ACERT
Gross Power	414 kW
Net Power – EEC 80/1269	373 kW
Net Power – ISO 9249	373 kW
Gross Power – ISO 3046-2	388 kW
Bore	145 mm
Stroke	183 mm
Displacement	18.1 L
Rated Speed	1800 RPM
Operating Specifications	
Operating Weight	49546 kg
Rated Payload	11.4 Tonnes
Rated Payload - Standard	11.4 Tonnes
Static Tipping Load, Full Turn	29368 kg
Static Tipping Load, Full Turn - HL	27191 kg
Dump Clearance	3742 mm
Breakout Force	378.4 kN
CAT Truck Match - Standard	769D
Operating Weight - HL	50429 kg
Bucket Capacity - HL	$7m^3$
Breakout Force - HL	468.3 kN
Articulation Angle	43 degrees

Transmission	
Converter Drive – Forward 1	6.7 km/hr
Converter Drive – Forward 2	11.8 km/hr
Converter Drive – Forward 3	20.8 km/hr
Converter Drive – Forward 4	36 km/hr
Converter Drive – Reverse 1	7.6 km/hr
Converter Drive – Reverse 2	13.5 km/hr
Converter Drive – Reverse 3	23.7 km/hr
Direct Drive – Forward 1	Lock-up disabled
Direct Drive – Forward 2	12.3 km/hr
Direct Drive – Forward 3	21.9 km/hr
Direct Drive – Forward 4	38.6 km/hr
Direct Drive – Reverse 1	7.9 km/hr
Direct Drive – Reverse 2	14.1 km/hr
Direct Drive – Reverse 3	25.1 km/hr
Hydraulic Cycle Time	
Raise	9.4 sec
Dump	2.4 sec
Lower Float Down (Empty)	3.8 sec
Total Hydraulic Time	15.6 sec
Service Refill Capacities	
Fuel Tank	712 L
Cooling System	103 L
Crankcase	60 L
Transmission	70 L
Differentials and Final Drives - Front	186 L
Differentials and Final Drives - Rear	186 L
Hydraulic System (Factory Fill)	470 L
Hydraulic System (Tank Only)	267 L

Dimensions	
Height to top of exhaust stacks	4128 mm
Height to top of ROPS/FOPS	4128 mm
Height to top of hood	3156 mm
Ground Clearance	549 mm
Reach at Max Lift/Dump – Standard	1720 mm
Reach at Max Lift/Dump - HL	1818 mm
Clearance at Max Lift/Dump - Standard	3790 mm
Clearance at Max Lift /Dump - HL	4203 mm
Bucket Pivot at Max Lift - Standard	5440 mm
Bucket Pivot at Max Lift - HL	5853 mm
Overall Height Bucket Raised - Standard	7699 mm
Overall Height Bucket Raised - HL	8111 mm
Length – Rear Axle to Bumper	3132 mm
Wheel Base Length	4550 mm
Overall Length - Standard	11765 mm
Overall Length - HL	12209 mm
Full Turn Static Tipping Load at 43^{o}	29568 kg
Dump Clearance at Full Lift and 45^{o} Dump - Standard	3790 mm
Reach at Full Lift and 45^{o} Dump - Standard	1720 mm
Dump Clearance at Full Lift and 45^{o} Dump - HL	4203 mm
Reach at Full Lift and 45^{o} Dump - HL	1818 mm
Straight Static Tipping Load - Standard	35026 kg
Straight Static Tipping Load - HL	32650 kg
Hinge Pin Height at Full Lift - Standard	5440 mm
Hinge Pin Height at Full Lift - HL	5853 mm
Height to top of cab	4128 mm
Height to top of Air Cleaner	3382 mm

Centre Line of Rear Axle to Edge of Rear Bumper	3132 mm
Centre Line of Front Axle to Hitch	2275 mm
Length with Bucket on Ground	11765 mm
Height to Centre of Wheel	978 mm
C-Pin Height	1009 mm
Rack Back Angle at Ground	47.8 degrees
Rack Back Angle at Carry	56.5 mm
Height to Spillguard	5432 mm
B-Pin Height	5853 mm
Rack Back Angle at Maximum Lift	65 degrees
Dump Angle at Maximum Lift	45 degrees
Buckets	
Bucket Capacities	6.3 m^3 – 7.0 m^3
Maximum Bucket Capacity	7m^3
Bucket Width	3695 mm
Axles	
Maximum Single – Wheel Rise and Fall	568 mm
Front	Fixed
Rear	Oscillating
Oscillation Angle	13
Brakes	
Brakes	Meet SAE ISO 3450:1996
Cab	
Air Conditioning	Standard
Cab – ROPS/FOPS	Meets SAE and ISO Standards
Sound Performance	Meets ANSI, SAE and ISO Standards

Steering	
Steering	Meets ANSI, SAE and ISO Standards
Total Steering Angle	86 degrees
Loader Hydraulic System	
Main Hydraulic System Output at 2010 RPM and 6900 kPa	492 L/min
Relief Valve Setting	31000 kPa
Cylinders, Double Acting: Lift, Bore and Stroke	220 x 911 mm
Cylinders Double Acting: Tilt, Bore and Stroke	220 x 1770 mm
Pilot System, Gear – Type Pump Output at 2010 RPM and 2500 kPa	76 L/min
Relief Valve Setting (Low Idle)	2400 kPa

Table C.1: Specifications for CAT 988H

(Hastings Deering, 2007)

CAT 980F

Engine	
Net Power – ISO 9249	237 kW
Net Power – SAE J1349	235 kW
Engine Model	CAT C15 ACERT
Gross Power – SAE J1995	264 kW
Net Power – 80/1269/EEC	237 kW
Flywheel Power	237 kW
Peak Torque (Net) at 1200 RPM	1615 Nm
Bore	137 mm
Stroke	171.5 mm
Displacement	15.2 L
Weights	
Operating Weight	30519 kg
Buckets	
Bucket Capacities	3.8 – 6.1 m^3
Max Bucket Capacity	6.1m^3
Bucket Width	3533 mm
Capacity – Reference Bucket	4.2 m^3
Type – Reference Bucket	GP with teeth
Breakout Force of Reference Bucket	273 kN
Operating Specifications	
Dump Clearance	3.305 m
Static Tipping Load, Full Turn	19496 kg
Breakout Force	199 kN
Transmission	
Forward 1	6.6 km/hr

Forward 2	11.8 km/hr
Forward 3	20.7 km/hr
Forward 4	36.3 km/hr
Reverse 1	7.6 km/hr
Reverse 2	13.5 km/hr
Reverse 3	23.6 km/hr
Reverse 4	41.5 km/hr
Hydraulic System	
Bucket/Work Tool System – Pump Output	464 L/min
Bucket/Work Tool System – Relief Valve Setting	20700 kPa
Hydraulic Cycle Time - Raise	6 sec
Hydraulic Cycle Time - Dump	2.1 sec
Hydraulic Cycle Time – Lower, Empty, Float Down	3.4 sec
Hydraulic Cycle Time - Total	11.5 sec
Pilot System – Pump Output	464 L/min
Brakes	
Brakes	Meets required standards
Axles	
Front	Fixed front
Rear	Oscillating +/- 13 degrees
Maximum Single-Wheel Rise and Fall	550 mm
Tyres	
Tyres	Choose from a variety of tyres to match your application

Cab	
ROPS/FOPS	Meets SAE and ISO standards
Service Refill Capacities	
Fuel Tank - Standard	479 L
Cooling System	83 L
Crankcase	34 L
Transmission	62 L
Differentials and Final Drives - Front	87 L
Differentials and Final Drives - Rear	87 L
Hydraulic System (Including Tank)	250 L
Hydraulic Tank	125 L
Dimensions	
Height to top of ROPS	3765 mm
Height to top of exhaust pipe	3716 mm
Height to top of hood	2716 mm
Ground Clearance	442 mm
B-Pin height - Standard	4505 mm
Centre line rear axle to edge of counterweight	2493 mm
Wheelbase	3700 mm
Centre line rear axle to hitch	1850 mm

Table C.2: Specifications for CAT 980F

(Hastings Deering, 2007)

CAT 970F

Engine	
Net Power – ISO 9249	214 kW
Net Power – SAE J1349	212 kW
Gross Power – SAE J1995	232 kW
Engine Model	CAT C13 ACERT
Net Power – 80/1269/EEC	214 kW
Flywheel Power	214 kW
Peak Torque (Net) at 1400 RPM	1332 Nm
Bore	130 mm
Stroke	157 mm
Displacement	12.5 L
Weights	
Operating Weight	25148 kg
Buckets	
Bucket Capacities	3.8 – 4.6 m^3
Maximum Bucket Capacity	4.6 m^3
Bucket Width	3145 mm
Transmission	
Forward 1	7.2 km/hr
Forward 2	12.6 km/hr
Forward 3	21.4 km/hr
Forward 4	36.9 km/hr
Reverse 1	8.2 km/hr
Reverse 2	14.2 km/hr
Reverse 3	24.3 km/hr
Reverse 4	38.8 km/hr
Axles	

Front	Fixed Front
Rear	Oscillating +/- 13^{o}
Maximum Single-Wheel Rise and Fall	502 mm
Brakes	
Brakes	Meets required standards
Hydraulic System	
Bucket/Work Tool System – Pump Output	305 L/min
Steering System Pump Type	Piston
Hydraulic Cycle Time - Raise	5.9 sec
Hydraulic Cycle Time - Dump	2.1 sec
Hydraulic Cycle Time – Lower, Empty, Float Down	2.4 sec
Hydraulic Cycle Time - Total	10.4 sec
Service Refill Capacities	
Fuel Tank - Standard	380 L
Cooling System	39 L
Crankcase	35 L
Transmission	35 L
Differentials and Final Drives - Front	64 L
Differentials and Final Drives - Rear	64 L
Hydraulic Tank	110 L
Cab	
ROPS/FOPS	Meets SAE and ISO standards
Tyres	
Tyres	Choose from a variety of tyres to match your application

Operating Specifications	
Dump Clearance	3.157 m
Static Tipping Load, Full Turn	16903 kg
Breakout Force	230 kN
Dimensions	
Height to top of ROPS	3606 mm
Height to top of exhaust pipe	3557 mm
Height to top of hood	2683 mm
Ground Clearance	496 mm
B-Pin Height - Standard	4466 mm
Centre Line Rear Axle to Edge of Counterweight	2461 mm
Wheelbase	3450 mm
Centre Line Rear Axle to Hitch	1725 mm

Table C.3: Specifications for CAT 970F

(Hastings Deering, 2007)

Komatsu WA500

Engine	
Engine Make and Model	Komatsu SAA6D1
Engine Classifying Power	263 kW
Net Power – SAE Rated	263 kW at 1900 RPM
Engine Displacement	15.2 lit
Number of Cylinders	6
Transmission	
Transmission Type	P'tory Auto
Gears - Forward	4
Gears - Reverse	4
Maximum Speed – Forward	34.9 km/hr
Maximum Speed - Reverse	37.5 km/hr
Ride Control System	Standard
Brake Types	Wet Disc
Loader	
Operating Weight	33,305 kg
Breakout Force	25,000 kgf
Static Tip Load	22,141
Dump height, bucket at 45^{o} discharge	3,295 mm
Dump reach, bucket at 45^{o} discharge	1,500 mm
Bucket Width	3,400 mm
Bucket Link Type	Z-bar
Dimensions	
Length – including bucket	9,815 mm
Wheelbase	3,780 mm
Width without bucket	3,190 mm
Height to top of cab	3,785 mm

Ground Clearance	450 mm
Turning Circle Diameter, Outside Bucket Corner	7,650 mm
Tyres	29.5-25-28PR(L3)

Table C.4: Specifications for Komatsu WA500

(Komatsu Australia, 2007)

CAT 980C

Engine	
Net Power – ISO 9249	237 kW
Net Power – SAE J1349	235 kW
Engine Model	CAT C15 ACERT
Gross Power – SAE J1995	264 kW
Net Power – 80/1269/EEC	237 kW
Flywheel Power	237 kW
Peak Torque (Net) at 1200 RPM	1615 Nm
Bore	137 mm
Stroke	171.5 mm
Displacement	15.2 L
Weights	
Operating Weight	30519 kg
Buckets	
Bucket Capacities	3.8 – 6.1 m^3
Max Bucket Capacity	6.1m^3
Bucket Width	3533 mm
Capacity – Reference Bucket	4.2 m^3
Type – Reference Bucket	GP with teeth
Breakout Force of Reference Bucket	273 kN
Operating Specifications	
Dump Clearance	3.305 m
Static Tipping Load, Full Turn	19496 kg
Breakout Force	199 kN
Transmission	
Forward 1	6.6 km/hr

Forward 2	11.8 km/hr
Forward 3	20.7 km/hr
Forward 4	36.3 km/hr
Reverse 1	7.6 km/hr
Reverse 2	13.5 km/hr
Reverse 3	23.6 km/hr
Reverse 4	41.5 km/hr
Hydraulic System	
Bucket/Work Tool System – Pump Output	464 L/min
Bucket/Work Tool System – Relief Valve Setting	20700 kPa
Hydraulic Cycle Time - Raise	6 sec
Hydraulic Cycle Time - Dump	2.1 sec
Hydraulic Cycle Time – Lower, Empty, Float Down	3.4 sec
Hydraulic Cycle Time - Total	11.5 sec
Pilot System – Pump Output	464 L/min
Brakes	
Brakes	Meets required standards
Axles	
Front	Fixed front
Rear	Oscillating +/- 13 degrees
Maximum Single-Wheel Rise and Fall	550 mm
Tyres	
Tyres	Choose from a variety of tyres to match your application

Cab	
ROPS/FOPS	Meets SAE and ISO standards
Service Refill Capacities	
Fuel Tank - Standard	479 L
Cooling System	83 L
Crankcase	34 L
Transmission	62 L
Differentials and Final Drives - Front	87 L
Differentials and Final Drives - Rear	87 L
Hydraulic System (Including Tank)	250 L
Hydraulic Tank	125 L
Dimensions	
Height to top of ROPS	3765 mm
Height to top of exhaust pipe	3716 mm
Height to top of hood	2716 mm
Ground Clearance	442 mm
B-Pin height - Standard	4505 mm
Centre line rear axle to edge of counterweight	2493 mm
Wheelbase	3700 mm
Centre line rear axle to hitch	1850 mm

Table C.5: Specifications for CAT 980C

(Hastings Deering, 2007)

Appendix D – Dump Truck Specifications

The following is a list of the full specifications for the Dump Trucks located at Purga Quarry.

CAT 769D

Engine	
Engine Model	CAT 3408E
Gross Power – SAE J1995	386 kW
Net Power – SAE J1349	359 kW
Net Power - Cat	363 kW
Flywheel Power	363 kW
Net Power – ISO 9249	363 kW
Net Power – 80/1269/EEC	363 kW
Torque Rise	27 %
Bore	137 mm
Stroke	152 mm
Displacement	18 L
Weights - Approximate	
Target Gross Machine Operating Weight	71400 kg
Operating Weight - Empty	11100 kg
Operating Specifications	
Nominal Payload Class	36.4 Tonnes
Top Speed - Loaded	77.7 km/hr
Body Capacity - Struck	17 m^3
Body Capacity – SAE 2:1	24.2 m^3
Maximum Capacity	36.58 Tonnes
Transmission	

Forward 1	12.6 km/hr
Forward 2	17.2 km/hr
Forward 3	23.3 km/hr
Forward 4	31.4 km/hr
Forward 5	57.7 km/hr
Forward 6	57.3 km/hr
Forward 7	77.7 km/hr
Reverse	16.6 km/hr
Final Drives	
Differential Ratio	2.74:1
Planetary Ratio	4.80:1
Total Reduction Ratio	13.15:1
Brakes	
Brake Surface – Front	1 395 cm^2
Brake Surface - Rear	54 999 cm^2
Body Hoists	
Pump Flow – High Idle	417 L/min
Relief Valve Setting - Raise	17225 kPa
Relief Valve Setting - Lower	3445 kPa
Body Raise Time – High Idle	7.5 sec
Body Lower Time - Float	8.3 sec
Body Power Down – High Idle	8.3 sec
Capacity – Dual Slope – 100 % Fill Factor	
Struck	17 m^3
Heaped 2:1 (SAE)	24.2 m^3
Heaped 3:1	21.7 m^3

Heaped 1:1	40.6 m^3
Weight Distributions – Approximate	
Front Axle - Empty	49.8 %
Front Axle - Loaded	33.3 %
Rear Axle - Empty	50.2 %
Rear Axle - Loaded	66.7 %
Suspension	
Effective Cylinder Stroke - Front	234 mm
Effective Cylinder Stroke - Rear	149 mm
Rear Axle Oscillation	8.5 degrees
Approximate Weights – Quarry Flat Floor	
Chassis	23000 kg
Body	7800 kg
Standard Liner	3300 kg
Front Axle - Empty	49.7 %
Front Axle - Loaded	33.3 %
Rear Axle - Empty	50.3 %
Rear Axle - Loaded	66.7 %
Approximate Weights – Dual Slope	
Chassis	23000 kg
Body	7300 kg
Standard Liner	3200 kg
Front Axle - Empty	49.8 %
Front Axle - Loaded	33.3 %
Rear Axle - Empty	50.2 %
Rear Axle - Loaded	66.7 %

Capacity – Quarry Flat Floor – 100 % Fill Factor	
Struck	16.5 m^3
Heaped 3:1	21.6 m^3
Heaped 2:1 (SAE)	24.2 m^3
Heaped 1:1	31.7 m^3
Service Refill Capacities	
Fuel Tank	530 L
Cooling System	113.5 L
Differentials and Final Drives	83 L
Steering Tank	34 L
Steering System (Includes Tank)	56 L
Torque Converter/Brake/Hoist Hydraulic Tank	155 L
Brake/Hoist System (Includes Tank)	277 L
Torque Converter/Transmission System	53 L
Torque Converter/Transmission System (Includes Sump)	72 L
Tyres	
Standard Tyre	Standard 18.00-R33 (E4)
ROPS	
ROPS/FOPS Standards	Meets SAE J1040 MAY94 and ISO 3741:1994
Sound	
Sound Standards	Meets ISO,ANSI/SAE standards

Steering	
Steering Standards	Meets SAE J1511 FEB94 and ISO 5010 – 1992
Dimensions	
Height to Top of ROPS	3690 mm
Overall Body Length	7615 mm
Inside Body Length	5275 mm
Overall Length	8039 mm
Wheelbase	3713 mm
Rear Axle to Tail	2541 mm
Ground Clearance	627 mm
Dump Clearance	465 mm
Loading Height - Empty	3143 mm
Inside Body Depth - Maximum	1390 mm
Overall Height – Body Raised	7709 mm
Operating Width	5069 mm
Centreline Front Tyre Width	3102 mm
Engine Guard Clearance	627 mm
Overall Canopy Width	4398 mm
Inside Body Width	3658 mm
Front Canopy Height	3952 mm
Rear Axle Clearance	615 mm
Centreline Rear Dual Tyre Width	2470 mm
Overall Tyre Width	3584 mm

Table D.1: Specifications for the CAT 769D Rear Dump Truck

(Hastings Deering, 2007)

Komatsu HD325

Engine	
Engine Make and Model	Komatsu SAA6D1
Engine Power	386 kW at 2000 RPM
Engine Displacement	15.24 lit
Number of Cylinders	6
Transmission	
Transmission Type	Auto p'tary
Drive	4 x 2
Speeds F/R:	7/1
Maximum Speed	70 km/hr
Gradeability	35 %
Body	
Payload Capacity	36500 kg
Unladen Weight	31600 kg
Heaped Capacity	24 m^3
Loading Height	3220 mm
Dump Speed, Up/Down	20 kg
Dump Angle	48 degrees
Dump Cycle Time – Full Cycle	20 sec
Weight Distribution, Dimensions, etc	
Operating Weight	31600 kg
Weight distribution, full, F/R	33%/67%
Length	8465 mm
Height	4150 mm
Turning Circle, diameter, outside corner	14400 mm

Tyres F/R	18-33-28PR

Table D.2: Specifications for the Komatsu HD325 Rear Dump Truck

(Komatsu Australia, 2007)

CAT 769C

Engine	
Engine Model	CAT 3408E
Gross Power – SAE J1995	386 kW
Net Power – SAE J1349	359 kW
Net Power - Cat	363 kW
Flywheel Power	363 kW
Net Power – ISO 9249	363 kW
Net Power – 80/1269/EEC	363 kW
Torque Rise	27 %
Bore	137 mm
Stroke	152 mm
Displacement	18 L
Weights - Approximate	
Target Gross Machine Operating Weight	71400 kg
Operating Weight - Empty	11100 kg
Operating Specifications	
Nominal Payload Class	36.4 Tonnes
Top Speed - Loaded	77.7 km/hr
Body Capacity - Struck	17 m^3
Body Capacity – SAE 2:1	24.2 m^3
Maximum Capacity	36.58 Tonnes
Transmission	
Forward 1	12.6 km/hr
Forward 2	17.2 km/hr
Forward 3	23.3 km/hr
Forward 4	31.4 km/hr
Forward 5	57.7 km/hr

Forward 6	57.3 km/hr
Forward 7	77.7 km/hr
Reverse	16.6 km/hr
Final Drives	
Differential Ratio	2.74:1
Planetary Ratio	4.80:1
Total Reduction Ratio	13.15:1
Brakes	
Brake Surface – Front	1 395 cm^2
Brake Surface - Rear	54 999 cm^2
Body Hoists	
Pump Flow – High Idle	417 L/min
Relief Valve Setting - Raise	17225 kPa
Relief Valve Setting - Lower	3445 kPa
Body Raise Time – High Idle	7.5 sec
Body Lower Time - Float	8.3 sec
Body Power Down – High Idle	8.3 sec
Capacity – Dual Slope – 100 % Fill Factor	
Struck	17 m^3
Heaped 2:1 (SAE)	24.2 m^3
Heaped 3:1	21.7 m^3
Heaped 1:1	40.6 m^3
Weight Distributions – Approximate	
Front Axle - Empty	49.8 %
Front Axle - Loaded	33.3 %

Rear Axle - Empty	50.2 %
Rear Axle - Loaded	66.7 %
Suspension	
Effective Cylinder Stroke - Front	234 mm
Effective Cylinder Stroke - Rear	149 mm
Rear Axle Oscillation	8.5 degrees
Approximate Weights – Quarry Flat Floor	
Chassis	23000 kg
Body	7800 kg
Standard Liner	3300 kg
Front Axle - Empty	49.7 %
Front Axle - Loaded	33.3 %
Rear Axle - Empty	50.3 %
Rear Axle - Loaded	66.7 %
Approximate Weights – Dual Slope	
Chassis	23000 kg
Body	7300 kg
Standard Liner	3200 kg
Front Axle - Empty	49.8 %
Front Axle - Loaded	33.3 %
Rear Axle - Empty	50.2 %
Rear Axle - Loaded	66.7 %
Capacity – Quarry Flat Floor – 100 % Fill Factor	
Struck	16.5 m^3
Heaped 3:1	21.6 m^3

Heaped 2:1 (SAE)	24.2 m^3
Heaped 1:1	31.7 m^3
Service Refill Capacities	
Fuel Tank	530 L
Cooling System	113.5 L
Differentials and Final Drives	83 L
Steering Tank	34 L
Steering System (Includes Tank)	56 L
Torque Converter/Brake/Hoist Hydraulic Tank	155 L
Brake/Hoist System (Includes Tank)	277 L
Torque Converter/Transmission System	53 L
Torque Converter/Transmission System (Includes Sump)	72 L
Tyres	
Standard Tyre	Standard 18.00-R33 (E4)
ROPS	
ROPS/FOPS Standards	Meets SAE J1040 MAY94 and ISO 3741:1994
Sound	
Sound Standards	Meets ISO,ANSI/SAE standards
Steering	
Steering Standards	Meets SAE J1511 FEB94 and ISO 5010 – 1992
Dimensions	

Height to Top of ROPS	3690 mm
Overall Body Length	7615 mm
Inside Body Length	5275 mm
Overall Length	8039 mm
Wheelbase	3713 mm
Rear Axle to Tail	2541 mm
Ground Clearance	627 mm
Dump Clearance	465 mm
Loading Height - Empty	3143 mm
Inside Body Depth - Maximum	1390 mm
Overall Height – Body Raised	7709 mm
Operating Width	5069 mm
Centreline Front Tyre Width	3102 mm
Engine Guard Clearance	627 mm
Overall Canopy Width	4398 mm
Inside Body Width	3658 mm
Front Canopy Height	3952 mm
Rear Axle Clearance	615 mm
Centreline Rear Dual Tyre Width	2470 mm
Overall Tyre Width	3584 mm

Table D.3: Specifications for the CAT 769C Rear Dump Truck

(Hastings Deering, 2007)

Appendix E – Machinery Hours for June 2007

The following table is the machinery hours recorded from June 2007.

Machine Description	Open Reading	Close Reading	Total Hours	Total Litres	Litres/Hour
CAT 988H FEL*	0	0	0	0	0
CAT 769C RDT	42559	42647	88	1299	14.76
CAT 769D RDT	10461	10663	202	3267	16.17
Komatsu HD325 RDT	4972	5182	210	3985	18.98
Excavator Liebherr R952	28858	28916	58	4884	84.21
CAT 970F FEL	26018	26234	216	4486	20.77
CAT 980C FEL	5840	5897	57	188	3.3
CAT 980F FEL	N/A	N/A	N/A	3854	N/A
Komatsu WA500 FEL	5800	6021	221	5700	25.79

Table E.1: Machinery Hours for June 2007 (Boral Quarry Database)

* - CAT 988H FEL was commissioned in the beginning of July 2007

Appendix F – Manufacture Recommendations for Changing Specific Parts for Load and Haul Equipment

Dump Trucks

The following is a list of the manufacture recommendations for changing specific parts for the Dump Trucks located at Purga Quarry.

CAT 769C/769D Dump Trucks

Component	Quantity	Hours
Engine Overhaul	1	15400
Turbo Charger	1	7700
Muffler	1	15400
After Cooler	1	15400
Fuel Pump	1	7700
Unit Injectors	6	7700
Radiator	1	15400
Thermostat	1	7700
Fan	1	33000
Belt Tensioner	1	7700
Fan Drive	1	7700
Water Pump	1	7700
Alternator	1	7700
Starter Motor	1	7700
Air Conditioning	1	7700
Transmission	1	13200
Torque Converter	1	15400
Drive Axle	2	30800
Uni Joint Front	1	8800
Drive Shaft	2	26400
Diff Re-race/Set	1	13200
Diff Replace	1	39600

Final Drive	2	13200
Wheel Hub	2	13200
Front Brake	2	6600
Rear Brake	2	13200
Brake Pressure intensifiers	2	6600
Steer Cylinders	2	8800
Steering Links	6	13200
Steering Pump	1	13200
Steering Metering Unit	1	11000
Secondary Steer Pump	1	13200
Secondary Steer Motor	1	13200
Hydraulic Control Valve	1	15400
Hydraulic Hoist Pump	1	13200
Hoist Valve	1	15400
Suspension Cylinder Front	2	15400
Suspension Cylinder Rear	2	15400
Dump Body Minor	1	7700
Dump Body Major	1	23100
Dump Body Mounting	1	19800
Seat	1	6600

Table F.1: Manufacture Recommendations for Changing Specific Parts for CAT 769C/769D Dump Trucks (CAT Handbook, 2005)

Komatsu HD465-7, HD605, HD405, HD325

Component	Quantity	Hours
Engine	1	16800
Turbocharger	1	7000
Fuel Injector	6	7000
Fuel Injection Pump	1	7000
Water Pump	1	8400
Starter Motor	1	7200
Alternator 24V	1	6000
Engine Radiator	1	16800
Fuel Cooler	1	16800
Torque Converter	1	16800
Transmission	1	16800
Rear Differential	1	19200
Rear Final Drive	2	19200
Rear Brake	2	19200
Front Brake	2	7200
Front Spindle and Hub	2	14400
Final Drive Seal	2	9600
Park Brake	1	12000
Transmission Pump	1	8400
Brake Cooling Pump	1	8400
Brake Cooler	1	16800
Uni Joint Front	2	21600
Uni Joint Rear	4	7200
Shift Electrics	1	16800
Shift Control Valve	1	16800
Transmission Oil Cooler	1	16800
Main Frame	1	20000
Cylinder Mounts	2	12000
Hoist Pump	1	12000
Steering Pump	1	7200

Hoist Cylinder	2	14400
Steering Cylinder	2	9600
Main Control Valve	1	16800
Steering Valve	1	12000
Steering Accumulator	1	9600
Front Suspension	2	14400
Rear Suspension	2	14400
Suspension Control	1	7200
Vessel Repairs	0	6000
Body Hinge and Bush	1	9600

Komatsu project a life for a rear dump truck of 40000

Table F.2: Manufacture Recommendations for Changing Specific Parts for Komatsu HD465-7, HD605, HD405, HD325 Dump Trucks (Komatsu HD465-7, HD605, HD405, HD325 Manual, 2005)

Front End Loaders

The following is a list of the manufacture recommendations for changing specific parts for the Front End Loaders located at Purga Quarry.

CAT 988

Component Name	Nominated Frequency Quarry Application
Engine	17500
Turbo	8750
Muffler	17500
Fuel Transfer Pump	8750
Unit Injectors	8750
Radiator	17500
Thermostat	7500
Fan	35000
Water Pump	8750
Hyd Oil Cooler	15000
Fan Motor	10000
Fan Pump	10000
Alternator	8750
Starter Motor	8750
Transmission	15000
Transmission Oil Pump	12500
Torque Convertor	17500
Pump Drive	17500
Drive Lines Front and Rear	30000
Uni's Input	8750
Uni's Main	8750
Diff's Front	15000
Diff's Rear	15000
Final Drive F & R	15000

Brakes Front	15000
Brakes Rear	15000
Park Brake	10000
Steer Pump	15000
Steer Cylinder	10000
Steer Valve	15000
Secondary Steer Pump	15000
Secondary Steer Motor	15000
Hyd Control Valve	15000
Gear Motor	10000
Gear Pump	10000
Implement Pump	10000
Pilot Pump	10000
Lift Cylinder	10000
Crowd Cylinder	10000
Articulation	15000
Bucket Pims	10000
Seat	7500

Table F.3: Manufacture Recommendations for Changing Specific Parts for CAT 988 Front End Loaders (CAT Handbook, 2005)

CAT 980

Component Name	Qty	Quarry Application
Park Brake	1	6250
Turbo Charger Replacement	1	10000
Fuel Injectors/Nozzles	6	10000
Thermostat	2	10000
Fan Motor	1	10000
Fan Pump	1	10000
Water Pump	1	10000
Alternator	1	10000
Starter Motor	1	10000
Air Conditioner	1	10000
Steer Cylinders	2	10000
Steering Metering Unit	1	10000
Lift Cylinders	2	10000
Crowd Cylinders	2	10000
Drive Axle Rear/Trunnions	1	12500
Diff Re-race/Set Front	1	12500
Final Drive Front	2	12500
Front Brake	1	12500
Steering Pump	1	12500
Hydraulic Control Valve	1	12500
Hydraulic Implement Pump	1	12500
Bucket Rebuild	1	12500
Pilot Pump	1	12500
Seat	1	12500
Secondary Steer Pump	1	15000
Secondary Steer Motor	1	15000
Drive Axle Front	1	15000
Uni Joint Front	1	15000
Diff Re-race/Set Rear	1	15000
Final Drive Rear	1	15000

Rear Brake	2	15000
Transmission	1	17500
Torque Convertor	1	17500
Transfer Gear Set	1	17500
Engine Overhaul	1	20000
Muffler Replacement	1	20000
Radiator	1	20000
Loader Frame	1	20000
Articulation	1	20000
Fan	1	37500

Table F.4: Manufacture Recommendations for Changing Specific Parts for CAT 980 Front End Loaders (CAT Handbook, 2005)

Appendix G – Activities to be performed on Maintenance Days for Both Plants

Machine	Machine Component	Component item	Activity	Hours	Time req'd
Barmac	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Barmac	Drive	Bearings	Grease	0.15	5 min
Barmac	Mechanism	Chamber inspection	Condition inspection	0.5	30 min
Barmac	Electrics	Circuit breaker	Test operation	0.1	1 min
Barmac	Mechanism	Distributor plate	Condition inspection	3	3 hours to replace
Barmac	Electrics	Emergency stop	Test operation	0.1	1 min
Barmac	Mechanism	Feed tube	Condition inspection	1.5	1.5 hours to replace
Barmac	Mechanism	Feed tube holder	Condition inspection	1.5	1.5 hours to replace
Barmac	Mechanism	Feeder plate	Condition inspection	1.5	1.5 hours to replace
Barmac	Drive	Guarding	Condition inspection		
Barmac	Electrics	isolator	Test operation	0.1	1 min
Barmac	Drive	Motor x 2	Condition inspection		30 min (electrical)
Barmac	Drive	Pulleys	Condition inspection		
Barmac	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Barmac	Mechanism	Rotor tips	Condition inspection	3	replace rotor
Barmac	Mechanism	Rotor wear plate	Condition inspection		replace rotor
Barmac	Structure	Subframe	Condiition inspection	0.5	30 min
Barmac	Drive	V-Belts	Condition inspection		
Barmac	Drive	V-Belts tension	Check tension	0.15	5 min
Barmac	Chute work	Wear materials	Condition inspection	0.25	15 min
Conveyor 1 Scalps	Drive	Bearing	Grease	0.15	5 min
Conveyor 1 Scalps	Belt	Belt	Condition inspection		4 hours to replace
Conveyor 1 Scalps	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 1 Scalps	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 1 Scalps	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 1 Scalps	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 1 Scalps	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 1 Scalps	Drive	Guarding	Condition inspection		
Conveyor 1 Scalps	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 1 Scalps	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 1 Scalps	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 1 Scalps	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 1 Scalps	Drive	Oil seals	Seal condition		
Conveyor 1 Scalps	Drive	Pulleys	Condition inspection		
Conveyor 1 Scalps	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 1 Scalps	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 1 Scalps	Scraper	Scraper	Condition / Adjust as required	0.5	30 min to replace
Conveyor 1 Scalps	Skirts	Skirts	Condition / Adjust as required	0.5	30 min
Conveyor 1 Scalps	Drive	V-Belts	Condition inspection		
Conveyor 1 Scalps	Drive	V-Belts tension	Check tension	0.15	5 min
Conveyor 10	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 10	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 10	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 10	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 10	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 10	Drive	Guarding	Condition inspection		
Conveyor 10	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 10	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 10	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 10	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 10	Drive	Oil seals	Seal condition		
Conveyor 10	Drive	Pulleys	Condition inspection		
Conveyor 10	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 10	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 10	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 10	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 10	Drive	V-Belts	Condition inspection		
Conveyor 10	Drive	V-Belts tension	Check tension	0.15	5 min
Conveyor 10	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 10	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 11	Drive	Bearings	Grease	0.15	5 min
Conveyor 11	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 11	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 11	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 11	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 11	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 11	Drive	Guarding	Condition inspection		
Conveyor 11	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 11	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 11	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 11	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 11	Drive	Oil seals	Seal condition		
Conveyor 11	Drive	Pulleys	Condition inspection		
Conveyor 11	Belt	Replace	Condition inspection		4 hours to replace

Conveyor 11	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 11	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 11	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 11	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 11	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 11	Drive	V-Belts	Condition inspection		
Conveyor 11	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 12	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 12	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 12	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 12	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 12	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 12	Drive	Guarding	Condition inspection		
Conveyor 12	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 12	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 12	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 12	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 12	Drive	Oil seals	Seal condition		
Conveyor 12	Drive	Pulleys	Condition inspection		
Conveyor 12	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 12	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 12	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 12	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 12	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 12	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 12	Drive	V-Belts	Condition inspection		
Conveyor 12	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 13	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 13	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 13	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 13	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 13	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 13	Drive	Guarding	Condition inspection		
Conveyor 13	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 13	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 13	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 13	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 13	Drive	Oil seals	Seal condition		
Conveyor 13	Drive	Pulleys	Condition inspection		
Conveyor 13	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 13	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 13	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 13	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 13	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 13	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 13	Drive	V-Belts	Condition inspection		
Conveyor 13	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 14	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 14	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 14	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 14	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 14	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 14	Drive	Guarding	Condition inspection		
Conveyor 14	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 14	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 14	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 14	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 14	Drive	Oil seals	Seal condition		
Conveyor 14	Drive	Pulleys	Condition inspection		
Conveyor 14	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 14	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 14	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 14	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 14	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 14	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 14	Drive	V-Belts	Condition inspection		
Conveyor 14	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 15 Recovery	Drive	Bearing	Grease	0.15	5 min
Conveyor 15 Recovery	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 15 Recovery	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 15 Recovery	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 15 Recovery	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 15 Recovery	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 15 Recovery	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 15 Recovery	Electrics	Isolator	Test operation	0.1	1 min

Conveyor 15 Recovery	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 15 Recovery	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 15 Recovery	Drive	Oil seals	Seal condition		
Conveyor 15 Recovery	Drive	Pulleys	Condition inspection		
Conveyor 15 Recovery	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 15 Recovery	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 15 Recovery	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 15 Recovery	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 15 Recovery	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 15 Recovery	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 15 Recovery	Drive	V-Belts	Condition inspection		
Conveyor 15 Recovery	Chute work	Wear Materials	Condition inspection	0.25	15 min
Conveyor 16 Add Bin	Drive	Bearing	Grease	0.15	5 min
Conveyor 16 Add Bin	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 16 Add Bin	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 16 Add Bin	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 16 Add Bin	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 16 Add Bin	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 16 Add Bin	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 16 Add Bin	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 16 Add Bin	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 16 Add Bin	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 16 Add Bin	Drive	Oil seals	Seal condition		
Conveyor 16 Add Bin	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 16 Add Bin	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 16 Add Bin	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 16 Add Bin	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 16 Add Bin	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 16 Add Bin	Bin condition	Structure	Condition inspection		
Conveyor 16 Add Bin	Bin condition	Wear Materials	Condition inspection		
Conveyor 17	Drive	Bearings	Grease	0.15	5 min
Conveyor 17	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 17	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 17	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 17	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 17	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 17	Drive	Guarding	Condition inspection		
Conveyor 17	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 17	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 17	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 17	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 17	Drive	Oil seals	Seal condition		
Conveyor 17	Drive	Pulleys	Condition inspection		
Conveyor 17	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 17	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 17	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 17	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 17	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 17	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 17	Drive	V-Belts	Condition inspection		
Conveyor 17	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 18	Drive	Bearings	Grease	0.15	5 min
Conveyor 18	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 18	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 18	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 18	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 18	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 18	Drive	Guarding	Condition inspection		
Conveyor 18	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 18	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 18	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 18	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 18	Drive	Oil seals	Seal condition		
Conveyor 18	Drive	Pulleys	Condition inspection		
Conveyor 18	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 18	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 18	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 18	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 18	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 18	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 18	Drive	V-Belts	Condition inspection		
Conveyor 18	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 2	Drive	Bearing	Grease	0.15	5 min
Conveyor 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 2	Structure	Conveyor support structure	Condition inspection	0.5	30 min

Conveyor 2	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 2	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 2	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 2	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 2	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 2	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 2	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 2	Drive	Oil seals	Seal condition		
Conveyor 2	Drive	Pulleys	Condition inspection		
Conveyor 2	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 2	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 2	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 2	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 2	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 2	Drive	V-Belts	Condition inspection		
Conveyor 2	Transfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 3	Drive	Bearing	Grease	0.15	5 min
Conveyor 3	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 3	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 3	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 3	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 3	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 3	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 3	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 3	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 3	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 3	Drive	Oil seals	Seal condition		
Conveyor 3	Drive	Pulleys	Condition inspection		
Conveyor 3	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 3	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 3	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 3	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 3	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 3	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 3	Drive	V-Belts	Condition inspection		
Conveyor 3	Transfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 4	Drive	Bearings	Grease	0.15	5 min
Conveyor 4	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 4	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 4	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 4	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 4	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 4	Drive	Guarding	Condition inspection		
Conveyor 4	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 4	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 4	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 4	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 4	Drive	Oil seals	Seal condition		
Conveyor 4	Drive	Pulleys	Condition inspection		
Conveyor 4	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 4	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 4	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 4	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 4	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 4	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 4	Drive	V-Belts	Condition inspection		
Conveyor 4	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 5	Drive	Bearings	Grease	0.15	5 min
Conveyor 5	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 5	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 5	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 5	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 5	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 5	Drive	Guarding	Condition inspection		
Conveyor 5	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 5	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 5	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 5	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 5	Drive	Oil seals	Seal condition		
Conveyor 5	Drive	Pulleys	Condition inspection		
Conveyor 5	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 5	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 5	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 5	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace

Conveyor 5	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 5	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 5	Drive	V-Belts	Condition inspection		
Conveyor 5	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 6	Drive	Bearings	Grease	0.15	5 min
Conveyor 6	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 6	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 6	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 6	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 6	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 6	Drive	Guarding	Condition inspection		
Conveyor 6	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 6	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 6	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 6	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 6	Drive	Oil seals	Seal condition		
Conveyor 6	Drive	Pulleys	Condition inspection		
Conveyor 6	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 6	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 6	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 6	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 6	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 6	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 6	Drive	V-Belts	Condition inspection		
Conveyor 6	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 7	Drive	Bearings	Grease	0.15	5 min
Conveyor 7	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 7	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 7	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 7	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 7	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 7	Drive	Guarding	Condition inspection		
Conveyor 7	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 7	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 7	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 7	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 7	Drive	Oil seals	Seal condition		
Conveyor 7	Drive	Pulleys	Condition inspection		
Conveyor 7	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 7	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 7	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 7	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 7	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 7	Head box	Structure	Condition inspection	0.15	5 min
Conveyor 7	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 7	Drive	V-Belts	Condition inspection		
Conveyor 7	Head box	Wear Materials	Condition inspection		
Conveyor 8	Drive	Bearings	Grease	0.15	5 min
Conveyor 8	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 8	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 8	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 8	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 8	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 8	Drive	Guarding	Condition inspection		
Conveyor 8	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Conveyor 8	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 8	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 8	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 8	Drive	Oil seals	Seal condition		
Conveyor 8	Drive	Pulleys	Condition inspection		
Conveyor 8	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 8	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 8	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 8	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 8	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 8	Drive	V-Belt Tension	Check tension	0.5	5 min
Conveyor 8	Drive	V-Belts	Condition inspection		
Conveyor 8	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Conveyor 9	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 9	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 9	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 9	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 9	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Conveyor 9	Drive	Guarding	Condition inspection		
Conveyor 9	Pulleys	Head / Tail	Condition inspection		2 hours to replace

Conveyor 9	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 9	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 9	Drive	Motor	Condition inspection	0	30 min (electrical)
Conveyor 9	Drive	Oil seals	Seal condition		
Conveyor 9	Drive	Pulleys	Condition inspection		
Conveyor 9	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 9	Frames	Replace / Service	Condition inspection	0.5	30 min to replace
Conveyor 9	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 9	Scraper	Replace / Service	Condition / Adjust as required	0.5	30 min to replace
Conveyor 9	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Conveyor 9	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 9	Drive	V-Belts	Condition inspection		
Conveyor 9	Tansfer chute	Wear Materials	Condition inspection	0.15	5 min
Crusher 2	Closed Side Setting	Adjustment	Measure in line with production	0.25	15 min lead / adj
Crusher 2	Hydraulic adjustment unit	Adjustment ram condition	Condition inspection		
Crusher 2	Mechanism	Bearing temperature	Monitor temperature	0.15	5 min
Crusher 2	Drive	Bearings	Grease	0.15	5 min
Crusher 2	Mechanism	Bearings	Grease	0.15	5 min
Crusher 2	Mechanism	Chamber inspection	Condition inspection	0.5	30 min
Crusher 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Crusher 2	Liners	Concave	Condition inspection	0.25	15 min
Crusher 2	Mechanism	Counter shaft	Oil leak / Seal condition	0.15	5 min
Crusher 2	Mechanism	Eccentric bush	Condition inspection		
Crusher 2	Electrics	Emergency stop	Test operation	0.1	1 min
Crusher 2	Drive	Guarding	Condition inspection		
Crusher 2	Hydraulic adjustment unit	Hose condition	Condition inspection	1	1 hour to replace
Crusher 2	Lubrication	Hose condition	Condition inspection	1	1 hour to replace
Crusher 2	Hydraulic adjustment unit	Hydraulic filter change	Condition inspection	0.25	15 min
Crusher 2	Hydraulic adjustment unit	Hydraulic Pp	Condition inspection		
Crusher 2	Electrics	isolator	Test operation	0.1	1 min
Crusher 2	Hydraulic adjustment unit	Isolator	Test operation	0.1	1 min
Crusher 2	Closed Side Setting	Lead Result	Product req'd	0.25	15 min lead / adj
Crusher 2	Lubrication	Lube oil cooler	Condition inspection	0.15	5 min
Crusher 2	Lubrication	Lube oil filter change	Condition inspection	0.5	30 min
Crusher 2	Lubrication	Lube oil Pp	Condition inspection	.	
Crusher 2	Lubrication	Lube oil pressure	Monitor pressure	0.1	1 min
Crusher 2	Liners	Mantle	Condition inspection	0.25	15 min
Crusher 2	Drive	Motor	Condition inspection	0	30 min (electrical)
Crusher 2	Hydraulic adjustment unit	Oil Leaks	Condition inspection		
Crusher 2	Lubrication	Oil Leaks	Condition inspection		
Crusher 2	Hydraulic adjustment unit	Oil level	Oil level / Add if req'd	0.15	5 min
Crusher 2	Lubrication	Oil level	Oil level / Add if req'd	0.25	15 min
Crusher 2	Hydraulic adjustment unit	Oil Pressure	Monitor pressure	0.1	1 min
Crusher 2	Mechanism	Pinion Gear & Crown	Condition inspection		
Crusher 2	Mechanism	Plungers	Condition inspection		
Crusher 2	Drive	Pulleys	Condition inspection		
Crusher 2	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Crusher 2	Mechanism	Socket sealing ring	Condition inspection		
Crusher 2	Structure	Subframe	Condiition inspection	0.5	30 min
Crusher 2	Hydraulic adjustment unit	Unit control function	Test operation	0.15	5 min
Crusher 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Crusher 2	Drive	V-Belts	Condition inspection		
Crusher 3	Closed Side Setting	Adjustment	Measure in line with production	0.25	15 min lead / adj
Crusher 3	Hydraulic adjustment unit	Adjustment ram condition	Condition inspection		
Crusher 3	Mechanism	Bearing temperature	Monitor temperature	0.15	5 min
Crusher 3	Drive	Bearings	Grease	0.15	5 min
Crusher 3	Mechanism	Bearings	Grease	0.15	5 min
Crusher 3	Mechanism	Chamber inspection	Condition inspection	0.5	30 min
Crusher 3	Electrics	Circuit breaker	Test operation	0.1	1 min
Crusher 3	Liners	Concave	Condition inspection	0.25	15 min
Crusher 3	Mechanism	Counter shaft	Oil leak / Seal condition	0.15	5 min
Crusher 3	Mechanism	Eccentric bush	Condition inspection		
Crusher 3	Electrics	Emergency stop	Test operation	0.1	1 min
Crusher 3	Drive	Guarding	Condition inspection		
Crusher 3	Hydraulic adjustment unit	Hose condition	Condition inspection	1	1 hour to replace
Crusher 3	Lubrication	Hose condition	Condition inspection	1	1 hour to replace
Crusher 3	Hydraulic adjustment unit	Hydraulic filter change	Condition inspection	0.25	15 min
Crusher 3	Hydraulic adjustment unit	Hydraulic Pp	Condition inspection		
Crusher 3	Electrics	isolator	Test operation	0.1	1 min
Crusher 3	Hydraulic adjustment unit	Isolator	Test operation	0.1	1 min
Crusher 3	Closed Side Setting	Lead Result	Product req'd	0.25	15 min lead / adj
Crusher 3	Lubrication	Lube oil cooler	Condition inspection	0.15	5 min
Crusher 3	Lubrication	Lube oil filter change	Condition inspection	0.5	30 min
Crusher 3	Lubrication	Lube oil Pp	Condition inspection		
Crusher 3	Lubrication	Lube oil pressure	Monitor pressure	0.1	1 min

Crusher 3	Liners	Mantle	Condition inspection	0.25	15 min
Crusher 3	Drive	Motor	Condition inspection	0	30 min (electrical)
Crusher 3	Hydraulic adjustment unit	Oil Leaks	Condition inspection		
Crusher 3	Lubrication	Oil Leaks	Condition inspection		
Crusher 3	Hydraulic adjustment unit	Oil level	Oil level / Add if req'd	0.15	5 min
Crusher 3	Lubrication	Oil level	Oil level / Add if req'd	0.25	15 min
Crusher 3	Hydraulic adjustment unit	Oil Pressure	Monitor pressure	0.1	1 min
Crusher 3	Mechanism	Pinion Gear & Crown	Condition inspection		
Crusher 3	Mechanism	Plungers	Condition inspection		
Crusher 3	Drive	Pulleys	Condition inspection		
Crusher 3	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Crusher 3	Mechanism	Socket sealing ring	Condition inspection		
Crusher 3	Structure	Subframe	Condiition inspection	0.5	30 min
Crusher 3	Hydraulic adjustment unit	Unit control function	Test operation	0.15	5 min
Crusher 3	Drive	V-Belt Tension	Check tension	0.15	5 min
Crusher 3	Drive	V-Belts	Condition inspection		
Jaw Crusher	Jaw Shim Setting	Amount of shim (mm)	Condition inspection		
Jaw Crusher	Jaw Shim Setting	Amount required	Add or remove shim	2	2 hours to replace
Jaw Crusher	Drive	Bearing	Grease	0.15	5 min
Jaw Crusher	Mechanism	Cheek plate bolts	Condition inspection	0.25	15 min
Jaw Crusher	Mechanism	Cheek plates	Condition inspection	0.25	15 min
Jaw Crusher	Electrics	Circuit breaker	Test operation	0.1	1 min
Jaw Crusher	Electrics	Emergency stop	Test operation	0.1	1 min
Jaw Crusher	Mechanism	Fixed Jaw Plate wear	Condition inspection	3	3 hours to replace
Jaw Crusher	Drive	Guarding	Condition inspection		
Jaw Crusher	Electrics	Isolator	Test operation	0.1	1 min
Jaw Crusher	Mechanism	Jaw bolts	Condition inspection	0.15	5 min
Jaw Crusher	Mechanism	Jaw shim tensioner springs	Condition inspection	0.15	5 min
Jaw Crusher	Drive	Motor	Condition inspection	0	30 min (electrical)
Jaw Crusher	Drive	Pulleys	Condition inspection		
Jaw Crusher	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Jaw Crusher	Structure	Subframe	Condition inspection	0.5	30 min
Jaw Crusher	Mechanism	Swing Jaw bearing	Grease	0.15	5 min
Jaw Crusher	Mechanism	Swing Jaw bearing temp	Monitor temperature		
Jaw Crusher	Mechanism	Swing Jaw Plate wear	Condition inspection		
Jaw Crusher	Drive	V-Belt Tension	Check tension	0.15	5 min
Jaw Crusher	Drive	V-Belts	Condition inspection		
Jaw Crusher	Chute work	Wear Materials	Condition inspection	0.25	15 min
Portec Feeder	Impact rollers	Bearings	Grease	0.15	5 min
Portec Feeder	Pulleys	Bearings	Grease	0.15	5 min
Portec Feeder	Return rollers	Bearings	Grease	0.15	5 min
Portec Feeder	Rollers	Bearings	Grease	0.5	30 min
Portec Feeder	Feeder belt	Chains	Condition inspection	1	1 hour
Portec Feeder	Electrics	Circuit breaker	Test operation	0.1	1 min
Portec Feeder	Electrics	Emergency stop	Test operation	0.1	1 min
Portec Feeder	Feeder belt	Flights	Condition inspection	0.25	15 min per flight
Portec Feeder	Structure	Frame	Condition inspection		30 min
Portec Feeder	Drive	Gearbox	Oil level / Add if req'd	0.25	15 min
Portec Feeder	Structure	Guarding	Condition inspection		
Portec Feeder	Pulleys	Head / Tail	Condition inspection		2 hours to replace
Portec Feeder	Electrics	isolator	Test operation	0.1	1 min
Portec Feeder	Electrics	Lanyards	Test operation	0.1	1 min
Portec Feeder	Drive	Motor	Condition inspection	0	30 min (electrical)
Portec Feeder	Drive	Oil seals	Seal condition		
Portec Feeder	Drive	Pulleys	Condition inspection		
Portec Feeder	Scraper	Replace / Service	Condition inspection	0.5	30 min to replace
Portec Feeder	Impact rollers	Roller condition	Condition inspection	2	2 hours to replace
Portec Feeder	Return rollers	Shaft condition	Condition inspection		
Portec Feeder	Rollers	Shaft condition	Condition inspection		
Portec Feeder	Pulleys	Shafts	Visual inspection		
Portec Feeder	Structure	Skirts	Condition inspection		
Portec Feeder	Feeder belt	Sprocket sets	Condition inspection	0.25	15 min
Portec Feeder	Structure	Subframe	Condition inspection	0.5	30 min
Portec Feeder	Drive	V-Belt Tension	Check tension	0.15	5 min
Portec Feeder	Drive	V-Belts	Condition inspection		
Portec Feeder	Structure	Wear Materials	Condition inspection		
Rock Breaker	Structure	Base plate	Condition inspection		
Rock Breaker	Structure	Bracing	Condition inspection		
Rock Breaker	Hammer control mechanism	Cabling	Condition inspection		
Rock Breaker	Electrics	Circuit breaker	Test operation	0.1	1 min
Rock Breaker	Hammer	Hammer integrity(structural	Condition inspection	0.5	30 min
Rock Breaker	Hammer	Hammer tip condition	Condition inspection		1 hour to replace
Rock Breaker	Drive	Hose condition	Condition inspection	1	1 hour to replace
Rock Breaker	Hammer	Hose condition	Condition inspection	1	1 hour to replace
Rock Breaker	Drive	Hydraulic Pp	Condition inspection		

Rock Breaker	Electrics	Isolator	Test operation	0.1	1 min
Rock Breaker	Boom / Dipper arm	Leaking rams	Condition inspection		
Rock Breaker	Hammer control mechanism	Lever operation	Condition inspection		
Rock Breaker	Structure	Main post	Condition inspection		
Rock Breaker	Drive	Motor	Condition inspection	0	30 min (electrical)
Rock Breaker	Drive	Oil filter	Replace as req'd	0.25	15 min
Rock Breaker	Drive	Oil Leaks	Condition inspection		
Rock Breaker	Hammer	Oil Leaks	Condition inspection		
Rock Breaker	Drive	Oil level	Check level / add if req'd	0.15	5 min
Rock Breaker	Drive	Oil Pressure	Monitor pressure	0.1	1 min
Rock Breaker	Boom / Dipper arm	Pins and keepers	Grease	0.15	5 min
Screen 1	Counter weight	Bearing	Grease	0.15	5 min
Screen 1	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 1	Counter weight	Bearings	Grease	0.15	5 min
Screen 1	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 1	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 1	Counter weight	Guarding	Condition inspection		
Screen 1	Drive	Guarding	Condition inspection		
Screen 1	Electrics	isolator	Test operation	0.1	1 min
Screen 1	Media	Middle Deck	Condition inspection	1	1 hour to replace
Screen 1	Drive	Motor	Condition inspection	0	30 min (electrical)
Screen 1	Drive	Pulleys	Condition inspection		
Screen 1	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Screen 1	Structure	Side plate	Condition inspection		
Screen 1	Sump	Structure	Condition inspection	0.25	15 min
Screen 1	Structure	Subframe	Condition inspection	0.5	30 min
Screen 1	Media	Top Deck	Condition inspection	1	1 hour to replace
Screen 1	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 1	Drive	V-Belts	Condition inspection		
Screen 1	Sump	Vibrator	Condition inspection	0.5	30 min (electrical)
Screen 2	Counter weight	Bearing	Grease	0.15	5 min
Screen 2	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 2	Media	Bottom Deck	Condition inspection	1	1 hour to replace
Screen 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 2	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 2	Counter weight	Guarding	Condition inspection		
Screen 2	Drive	Guarding	Condition inspection		
Screen 2	Electrics	isolator	Test operation	0.1	1 min
Screen 2	Media	Middle Deck	Condition inspection	1	1 hour to replace
Screen 2	Drive	Pulleys	Condition inspection		
Screen 2	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Screen 2	Structures	Side plate	Condition inspection	0.25	15 min
Screen 2	Sump	Structure	Condition inspection	0.25	15 min
Screen 2	Structures	Subframe	Condition inspection	0.25	15 min
Screen 2	Media	Top Deck	Condition inspection	1	1 hour to replace
Screen 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 2	Sump	Vibrator	Condition inspection	0.5	30 min (electrical)
Screen 2	Drive	Motor	Condition inspection	0	30 min (electrical)
Screen 2	Drive	V-Belts	Condition inspection		
Screen 3	Counter weight	Bearing	Grease	0.15	5 min
Screen 3	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 3	Media	Bottom Deck	Condition inspection	1	1 hour to replace
Screen 3	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 3	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 3	Counter weight	Guarding	Condition inspection		
Screen 3	Drive	Guarding	Condition inspection		
Screen 3	Electrics	isolator	Test operation	0.1	1 min
Screen 3	Media	Middle Deck	Condition inspection	1	1 hour to replace
Screen 3	Drive	Motor	Condition inspection	0	30 min (electrical)
Screen 3	Drive	Pulleys	Condition inspection		
Screen 3	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Screen 3	Structures	Side plate	Condition inspection	0.25	15 min
Screen 3	Sump	Structure	Condition inspection	0.25	15 min
Screen 3	Structures	Subframe	Condition inspection	0.25	15 min
Screen 3	Media	Top Deck	Condition inspection	1	1 hour to replace
Screen 3	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 3	Drive	V-Belts	Condition inspection		
Screen 3	Drive	V-Belts	Condition inspection		
Screen 3	Sump	Vibrator	Condition inspection	0.5	30 min (electrical)
Screen 4	Counter weight	Bearing	Grease	0.15	5 min
Screen 4	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 4	Drive	Bearing temperature	Monitor temperature	0.1	5 min
Screen 4	Media	Bottom Deck	Condition inspection	1	1 hour to replace
Screen 4	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 4	Electrics	Emergency stop	Test operation	0.1	1 min

Screen 4	Counter weight	Guarding	Condition inspection		
Screen 4	Drive	Guarding	Condition inspection		
Screen 4	Electrics	isolator	Test operation	0.1	1 min
Screen 4	Media	Middle Deck	Condition inspection	1	1 hour to replace
Screen 4	Drive	Motor	Condition inspection	0	30 min (electrical)
Screen 4	Drive	Pulleys	Condition inspection		
Screen 4	Skirts	Replace / Service	Condition / Adjust as required	0.5	30 min
Screen 4	Structures	Side plate	Condition inspection	0.25	15 min
Screen 4	Sump	Structure	Condition inspection	0.25	15 min
Screen 4	Structures	Subframe	Condition inspection	0.25	15 min
Screen 4	Media	Top Deck	Condition inspection	1	1 hour to replace
Screen 4	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 4	Drive	V-Belts	Condition inspection		
Screen 4	Sump	Vibrator	Condition inspection	0.5	30 min (electrical)

Table G.1: Activities to be performed for maintenance on Plant 1

Machine	Machine Componer	Component	Activity	Hours	Time req'd
Air compressor	Electrics	isolator	Test operation	0.1	1 min
Air compressor	Drive	Motor	Condition inspection		30 min (electrical)
Air compressor	Drive	Bearing	Grease	0.15	5 min
Air compressor	Drive	Pulleys	Condition inspection	0.15	5 min
Air compressor	Drive	V-Belts	Condition inspection		30 min to replace
Air compressor	Drive	V-Belt Tension	Check tension	0.15	5 min
Air compressor	Drive	Guarding	Condition inspection		5 min to inspect
Air compressor	Drive	Air receiver	Condition inspection	0.5	30 min to inspect
Barmac Cr 3	Chute work	Wear materials	Condition inspection	0.5	30 min
Barmac Cr 3	Drive	Bearings	Grease	0.15	5 min
Barmac Cr 3	Drive	Guarding	Condition inspection		5 min to inspect
Barmac Cr 3	Drive	Pulleys	Condition inspection	0.15	5 min
Barmac Cr 3	Drive	V-Belts	Condition inspection		30 min to replace
Barmac Cr 3	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Barmac Cr 3	Drive	V-Belt tension	Check tension	0.15	5 min
Barmac Cr 3	Drive	Motor	Condition inspection		30 min (electrical)
Barmac Cr 3	Electrics	Emergency stop	Test operation	0.1	1 min
Barmac Cr 3	Electrics	Circuit breaker	Test operation	0.1	1 min
Barmac Cr 3	Electrics	Isolators	Test operation	0.1	1 min
Barmac Cr 3	Mechanism	Chamber inspection	Condition inspection	0.5	30 min to inspect
Barmac Cr 3	Mechanism	Distributor plate	Condition inspection		3 hours to replace
Barmac Cr 3	Mechanism	Feed tube	Condition inspection		
Barmac Cr 3	Mechanism	Feed tube holder	Condition inspection		
Barmac Cr 3	Mechanism	Feeder plate	Condition inspection		
Barmac Cr 3	Mechanism	Rotor tips	Condition inspection		3 hours to replace
Barmac Cr 3	Mechanism	Rotor wear plate	Condition inspection		3 hours to replace
Barmac Cr 3	Structure	Subframe	Condition inspection	0.5	30 min
Barmac Cr 3	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 1A	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 1A	Drive	Bearing	Grease	0.15	5 min
Conveyor 1A	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 1A	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 1A	Drive	V-Belt tension	Check tension	0.15	5 min
Conveyor 1A	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 1A	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 1A	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 1A	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 1A	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 1A	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 1A	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 1A	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 1A	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 1A	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 1A	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 1A	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 1A	Skirts	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 1A	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 1	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 1	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 1	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 1	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 1	Drive	V-Belt tension	Check tension	0.15	5 min
Conveyor 1	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 1	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 1	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 1	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 1	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 1	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 1	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 1	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 1	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 1	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 1	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 1	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 1	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 1	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 1	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 2	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 2	Drive	Bearings	Grease	0.15	5 min
Conveyor 2	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 2	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 2	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 2	Drive	Motor	Condition inspection		30 min (electrical)

Conveyor 2	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 2	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 2	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 2	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 2	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 2	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 2	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 2	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 2	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 2	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 2	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 2	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 2	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 3	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 3	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 3	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 3	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 3	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 3	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 3	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 3	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 3	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 3	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 3	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 3	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 3	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 3	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 3	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 3	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 3	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 3	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 3	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 3	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 3A	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 3A	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 3A	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 3A	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 3A	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 3A	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 3A	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 3A	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 3A	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 3A	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 3A	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 3A	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 3A	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 3A	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 3A	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 3A	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 3A	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 3A	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 3A	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 3A	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 4	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 4	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 4	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 4	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 4	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 4	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 4	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 4	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 4	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 4	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 4	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 4	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 4	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 4	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 4	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 4	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 4	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 4	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 4	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 4	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 5	Belt	Replace	Condition inspection		4 hours to replace

Conveyor 5	Chute work	Wear Materials	Condition inspection	0.5	30 min
Conveyor 5	Drive	Bearing	Grease	0.15	5 min
Conveyor 5	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 5	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 5	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 5	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 5	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 5	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 5	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 5	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 5	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 5	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 5	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 5	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 5	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 5	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 5	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 5	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 5	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 4a Add Bin	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 4a Add Bin	Bin condition	Structure	Condition inspection	0.5	30 min
Conveyor 4a Add Bin	Bin condition	Wear Materials	Condition inspection	0.5	30 min
Conveyor 4a Add Bin	Vibrator	Motor	Condition inspection		30 min (electrical)
Conveyor 4a Add Bin	Drive	Bearing	Grease	0.15	5 min
Conveyor 4a Add Bin	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 4a Add Bin	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 4a Add Bin	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 4a Add Bin	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 4a Add Bin	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 4a Add Bin	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 4a Add Bin	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 4a Add Bin	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 4a Add Bin	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 4a Add Bin	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 4a Add Bin	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 4a Add Bin	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 4a Add Bin	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 4a Add Bin	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 2a	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 2a	Drive	Bearings	Grease	0.15	5 min
Conveyor 2a	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 2a	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 2a	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 2a	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 2a	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 2a	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 2a	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 2a	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 2a	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 2a	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 2a	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 2a	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 2a	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 2a	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 2a	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 2a	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 2a	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 2a	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 2a	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 7	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 7	Drive	Bearings	Grease	0.15	5 min
Conveyor 7	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 7	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 7	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 7	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 7	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 7	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 7	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 7	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 7	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 7	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 7	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 7	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 7	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 7	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect

Conveyor 6	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 6	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 6	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 6	Transfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 6	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 8	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 8	Drive	Bearing	Grease	0.15	5 min
Conveyor 8	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 8	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 8	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 8	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 8	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 8	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 8	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 8	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 8	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 8	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 8	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 8	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 8	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 8	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 8	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 8	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 8	Transfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 8	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 9	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 9	Drive	Bearings	Grease	0.15	5 min
Conveyor 9	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 9	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 9	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 9	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 9	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 9	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 9	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 9	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 9	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 9	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 9	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 9	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 9	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 9	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 9	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 9	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 9	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 9	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 9	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 11	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 11	Drive	Bearings	Grease	0.15	5 min
Conveyor 11	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 11	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 11	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 11	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 11	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 11	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 11	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 11	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 11	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 11	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 11	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 11	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 11	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 11	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 11	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 11	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 11	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 11	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 11	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 12	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 12	Drive	Bearings	Grease	0.15	5 min
Conveyor 12	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 12	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 12	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 12	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 12	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 12	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min

Conveyor 12	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 12	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 12	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 12	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 12	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 12	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 12	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 12	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 12	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 12	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 12	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 12	Tansfer chute	Wear Materials	Condition inspection	0.5	30 min
Conveyor 12	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Conveyor 13	Belt	Replace	Condition inspection		4 hours to replace
Conveyor 13	Drive	Bearings	Grease	0.15	5 min
Conveyor 13	Drive	Guarding	Condition inspection		5 min to inspect
Conveyor 13	Drive	Pulleys	Condition inspection	0.15	5 min
Conveyor 13	Drive	V-Belts	Condition inspection		30 min to replace
Conveyor 13	Drive	V-Belt Tension	Check tension	0.15	5 min
Conveyor 13	Drive	Motor	Condition inspection		30 min (electrical)
Conveyor 13	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Conveyor 13	Drive	Oil seals	Seal condition	0.15	5 min
Conveyor 13	Electrics	Emergency stop	Test operation	0.1	1 min
Conveyor 13	Electrics	Lanyards	Test operation	0.1	1 min
Conveyor 13	Electrics	Circuit breaker	Test operation	0.1	1 min
Conveyor 13	Electrics	Isolator	Test operation	0.1	1 min
Conveyor 13	Frames	Replace / Service	Condition inspection		30 min to replace
Conveyor 13	Head box	Structure	Condition inspection	0.25	15 min
Conveyor 13	Head box	Wear Materials	Condition inspection	0.25	15 min
Conveyor 13	Pulleys	Drum Lagging	Condition inspection		4 hours to replace
Conveyor 13	Pulleys	Head / Tail	Condition inspection	0.25	15 min to inspect
Conveyor 13	Rollers	Replace / Service	Condition / Replace as req'd	0.25	15 min to replace
Conveyor 13	Scraper	Replace / Service	Condition / Adjust as required	0.15	30 min to replace
Conveyor 13	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Conveyor 13	Structure	Conveyor support structure	Condition inspection	0.5	30 min
Crusher 2	Drive	Bearings	Grease	0.15	5 min
Crusher 2	Drive	Guarding	Condition inspection		5 min to inspect
Crusher 2	Drive	Pulleys	Condition inspection	0.15	5 min
Crusher 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Crusher 2	Drive	Motor	Condition inspection		30 min (electrical)
Crusher 2	Drive	V-Belts	Condition inspection		30 min to replace
Crusher 2	Electrics	Emergency stop	Test operation	0.1	1 min
Crusher 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Crusher 2	Electrics	Isolators	Test operation	0.1	1 min
Crusher 2	Liners	Cabinet	Condition inspection	0.25	15 min
Crusher 2	Rotor	Hammer wear	Condition inspection	0.25	15 min
Crusher 2	Rotor	Rotor wear & balance	Condition inspection	0.25	15 min
Crusher 2	Liners	Chamber inspection	Condition inspection	0.5	30 min to inspect
Crusher 2	Mechanism	Bearings	Grease	0.15	5 min
Crusher 2	Mechanism	Bearing temperature	Condition inspection	0.15	5 min
Crusher 2	Mechanism	Chamber inspection	Condition inspection	0.5	30 min to inspect
Crusher 2	Structure	Subframe	Condiition inspection	0.5	30 min
Crusher 2	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Jaw Crusher	Lubrication	Lube oil pressure	Monitor pressure	0.15	5 min
Jaw Crusher	Lubrication	Oil level	Oil level / Add if req'd	0.5	30 min
Jaw Crusher	Lubrication	Hose condition	Condition inspection	0.15	5 min
Jaw Crusher	Lubrication	Lube oil cooler	Condition inspection	0.15	5 min
Jaw Crusher	Lubrication	Lube oil filter change	Condition inspection	0.25	15 min to change
Jaw Crusher	Lubrication	Lube oil Pp	Condition inspection	0.15	5 min
Jaw Crusher	Lubrication	Oil Leaks	Condition inspection	0.15	5 min
Jaw Crusher	Chute work	Wear Materials	Measure wear rate on plates	0.5	30 min
Jaw Crusher	Drive	Bearing	Grease	0.15	5 min
Jaw Crusher	Drive	Guarding	Condition inspection		5 min to inspect
Jaw Crusher	Drive	Pulleys	Condition inspection	0.15	5 min
Jaw Crusher	Drive	V-Belts	Condition inspection		30 min to replace
Jaw Crusher	Drive	V-Belt Tension	Check tension	0.15	5 min
Jaw Crusher	Drive	Motor	Condition inspection		30 min (electrical)
Jaw Crusher	Electrics	Emergency stop	Test operation	0.1	1 min
Jaw Crusher	Electrics	Circuit breaker	Test operation	0.1	1 min
Jaw Crusher	Electrics	Isolator	Test operation	0.1	1 min
Jaw Crusher	Jaw Shim Setting	Amount of shim (mm)	Condition inspection	0.15	5 min
Jaw Crusher	Jaw Shim Setting	Amount required	Add or remove shim in line with jaw wear and product requirements		
Jaw Crusher	Mechanism	Jaw bolts	Condition inspection	0.15	5 min
Jaw Crusher	Mechanism	Swing Jaw bearing	Grease	0.15	5 min
Jaw Crusher	Mechanism	Swing Jaw bearing temp	Monitor temperature	0.15	5 min

Jaw Crusher	Mechanism	Cheek plate bolts	Condition inspection	0.15	5 min
Jaw Crusher	Mechanism	Cheek plates	Condition inspection	0.15	5 min
Jaw Crusher	Mechanism	Fixed Jaw Plate wear	Condition inspection	0.15	5 min
Jaw Crusher	Mechanism	Jaw shim tensioner springs	Condition inspection	0.25	!5 min
Jaw Crusher	Mechanism	Swing Jaw Plate wear	Condition inspection	0.25	!5 min
Jaw Crusher	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Jaw Crusher	Structure	Subframe	Condition inspection	0.5	30 min
Vibratory Feeder	Drive	Pulleys	Condition inspection	0.15	5 min
Vibratory Feeder	Drive	V-Belts	Condition inspection		30 min to replace
Vibratory Feeder	Drive	V-Belt Tension	Check tension	0.15	5 min
Vibratory Feeder	Drive	Motor	Condition inspection		30 min (electrical)
Vibratory Feeder	Drive	Gearbox	Oil level / Add if req'd	0.5	30 min
Vibratory Feeder	Drive	Oil seals	Seal condition	0.15	5 min
Vibratory Feeder	Electrics	Emergency stop	Test operation	0.1	1 min
Vibratory Feeder	Electrics	Lanyards	Test operation	0.1	1 min
Vibratory Feeder	Electrics	Circuit breaker	Test operation	0.1	1 min
Vibratory Feeder	Electrics	Isolators	Test operation	0.1	1 min
Vibratory Feeder	Impact area	Monitor plate wear	Condition inspection	0.25	!5 min
Vibratory Feeder	Grizzly	Monitor wear	Condition inspection	0.25	!5 min
Vibratory Feeder	Tip bin	Monitor wear	Condition inspection	0.25	!5 min
Vibratory Feeder	Structure	Guarding	Condition inspection		5 min to inspect
Vibratory Feeder	Structure	Wear Materials	Measure wear rate on plates	0.5	30 min
Vibratory Feeder	Structure	Frame	Condition inspection	0.5	30 min
Vibratory Feeder	Structure	Subframe	Condition inspection	0.5	30 min
Vibratory Feeder	Structure	Skirts	Condition inspection	0.5	30 min
Rock Breaker	Boom / Dipper arm	Leaking rams	Condition inspection	0.15	5 min
Rock Breaker	Boom / Dipper arm	Pins and keepers	Grease	0.15	5 min
Rock Breaker	Drive	Oil filters	Replace as req'd	0.25	15 min to change
Rock Breaker	Drive	Oil Leaks	Condition inspection	0.15	5 min
Rock Breaker	Drive	Hose condition	Condition inspection	0.15	5 min
Rock Breaker	Drive	Hydraulic Pp	Condition inspection	0.15	5 min
Rock Breaker	Drive	Oil level	Check level / add if req'd	0.25	!5 min
Rock Breaker	Drive	Oil Pressure	Monitor pressure	0.15	5 min
Rock Breaker	Electrics	Motor	Condition inspection		30 min (electrical)
Rock Breaker	Electrics	Circuit breaker	Test operation	0.1	1 min
Rock Breaker	Electrics	Isolator	Test operation	0.1	1 min
Rock Breaker	Hammer	Hammer tip condition	Condition inspection	0.15	5 min
Rock Breaker	Hammer	Hose condition	Condition inspection	0.15	5 min
Rock Breaker	Hammer	Hammer integrity(structural)	Condition inspection	0.25	!5 min
Rock Breaker	Hammer	Oil Leaks	Condition inspection	0.15	5 min
Rock Breaker	Hammer control mec	Cabling	Condition inspection	0.25	!5 min
Rock Breaker	Hammer control mec	Lever operation	Condition inspection	0.15	5 min
Rock Breaker	Structure	Base plate	Condition inspection	0.5	30 min
Rock Breaker	Structure	Bracing	Condition inspection	0.5	30 min
Rock Breaker	Structure	Main post	Condition inspection	0.5	30 min
Screen 1a	Counter weight	Bearing	Grease	0.15	5 min
Screen 1a	Counter weight	Bearings	Grease	0.15	5 min
Screen 1a	Counter weight	Guarding	Condition inspection		5 min to inspect
Screen 1a	Drive	Guarding	Condition inspection		5 min to inspect
Screen 1a	Drive	Pulleys	Condition inspection	0.15	5 min
Screen 1a	Drive	V-Belts	Condition inspection		30 min to replace
Screen 1a	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 1a	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 1a	Drive	Motor	Condition inspection		30 min (electrical)
Screen 1a	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 1a	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 1a	Electrics	Isolators	Test operation	0.1	1 min
Screen 1a	Media	Middle Deck	Condition inspection	0.15	5 min
Screen 1a	Media	Top Deck	Condition inspection	0.15	5 min
Screen 1a	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Screen 1a	Structure	Side plate	Condition inspection	0.5	30 min
Screen 1a	Structure	Subframe	Condition inspection	0.5	30 min
Screen 1a	Sump	Structure	Condition inspection	0.25	15 min
Screen 1a	Sump	Vibrator	Condition inspection	0.15	5 min
Screen 1	Counter weight	Bearing	Grease	0.15	5 min
Screen 1	Counter weight	Guarding	Condition inspection		5 min to inspect
Screen 1	Drive	Guarding	Condition inspection		5 min to inspect
Screen 1	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 1	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 1	Drive	Pulleys	Condition inspection	0.15	5 min
Screen 1	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 1	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 1	Electrics	Isolators	Test operation	0.1	1 min
Screen 1	Media	Bottom Deck	Condition inspection	0.25	15 min
Screen 1	Media	Middle Deck	Condition inspection	0.25	15 min

Screen 1	Media	Top Deck	Condition inspection	0.25	15 min
Screen 1	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Screen 1	Structure	Side plate	Condition inspection	0.5	30 min
Screen 1	Structure	Subframe	Condition inspection	0.5	30 min
Screen 1	Sump	Structure	Condition inspection	0.25	15 min
Screen 1	Sump	Vibrator	Condition inspection	0.15	5 min
Screen 1	Drive	Motor	Condition inspection		30 min (electrical)
Screen 1	Drive	V-Belts	Condition inspection		30 min to replace
Screen 2	Counter weight	Bearing	Grease	0.15	5 min
Screen 2	Counter weight	Guarding	Condition inspection		5 min to inspect
Screen 2	Drive	Guarding	Condition inspection		5 min to inspect
Screen 2	Drive	V-Belts	Condition inspection		30 min to replace
Screen 2	Drive	Bearing temperature	Monitor temperature	0.15	5 min
Screen 2	Drive	V-Belt Tension	Check tension	0.15	5 min
Screen 2	Drive	Motor	Condition inspection		30 min (electrical)
Screen 2	Drive	Pulleys	Condition inspection	0.15	5 min
Screen 2	Drive	V-Belts	Condition inspection		30 min to replace
Screen 2	Electrics	Emergency stop	Test operation	0.1	1 min
Screen 2	Electrics	Circuit breaker	Test operation	0.1	1 min
Screen 2	Electrics	Isolators	Test operation	0.1	1 min
Screen 2	Media	Bottom Deck	Condition inspection	0.25	15 min
Screen 2	Media	Middle Deck	Condition inspection	0.25	15 min
Screen 2	Media	Top Deck	Condition inspection	0.25	15 min
Screen 2	Skirts	Replace / Service	Condition / Adjust as required	0.25	30 min to replace
Screen 2	Structure	Side plate	Condition inspection	0.5	30 min
Screen 2	Structure	Subframe	Condition inspection	0.5	30 min
Screen 2	Sump	Structure	Condition inspection	0.25	15 min
Screen 2	Sump	Vibrator	Condition inspection	0.15	5 min

Table G.2: Activities to be performed for maintenance on Plant 2

Appendix H – Features of MEX Asset Management Program

Asset Register

The Asset Register contains a record of all the equipment, assets and plants to be managed by MEX. Every record can contain as little or as much information as required. Information included is the equipment number and a brief description as well as information such as warranty dates, registration numbers, serial numbers, expected life, models, makes, colours etc. (MEX, 2007)

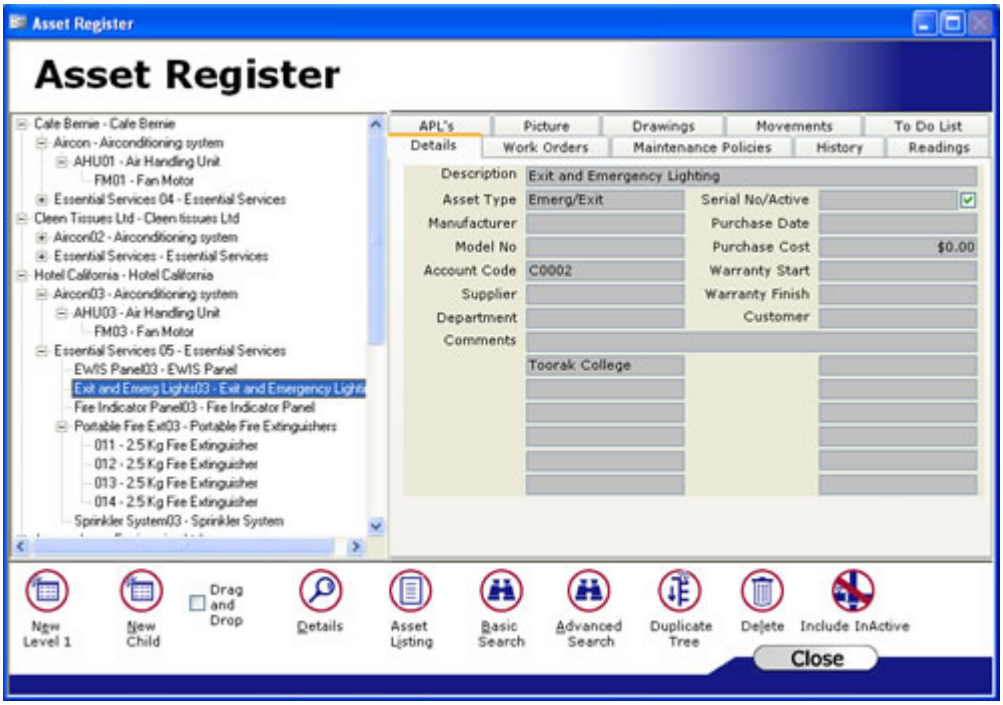

Figure H.1: Asset Register from the MEX Program (MEX, 2007)

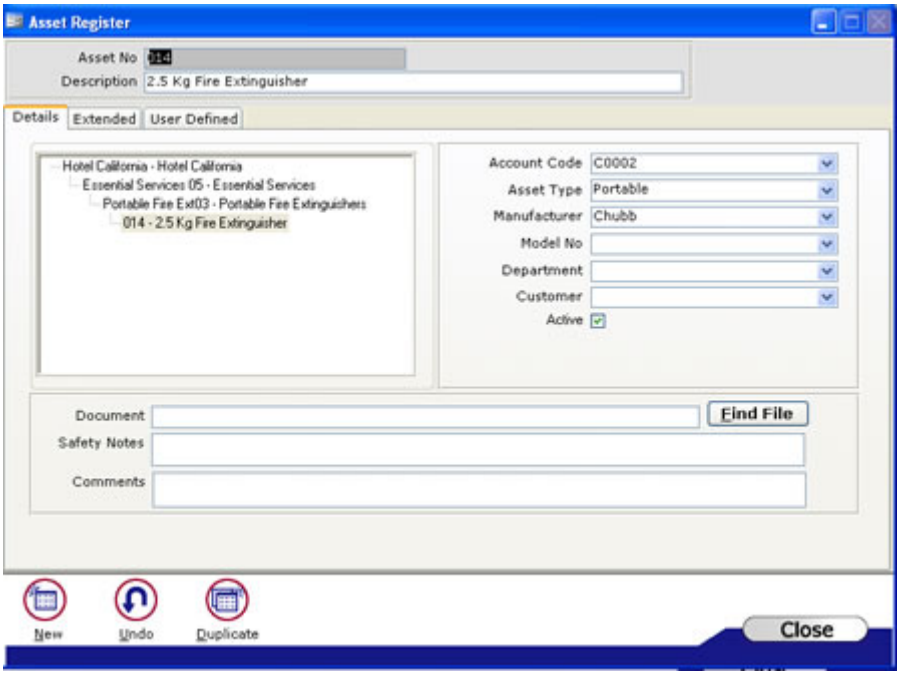

Figure H.2: Asset Register from the MEX Program (MEX, www.mex.com.au)

Work Orders

MEX makes planning and scheduling maintenance work simple. With an accurate up to date list of all outstanding work the manager has access to investigate, plan and report on jobs using detailed information on dates, status, trades equipment and job types. (MEX, 2007)

Work Orders have the capability to link directly with MS Project, allowing the manager to import the work orders into either a Project Gantt Chart or Calender. Data can be viewed, manipulated and modifies before being updated in the MEX system allowing accurate maintenance and efficient forecasts for resources and components. (MEX, 2007)

Work Orders can include all information relevant to a job including detailed work and safety instructions, tasks, labour and spare parts and all other associated costs. (MEX, 2007)

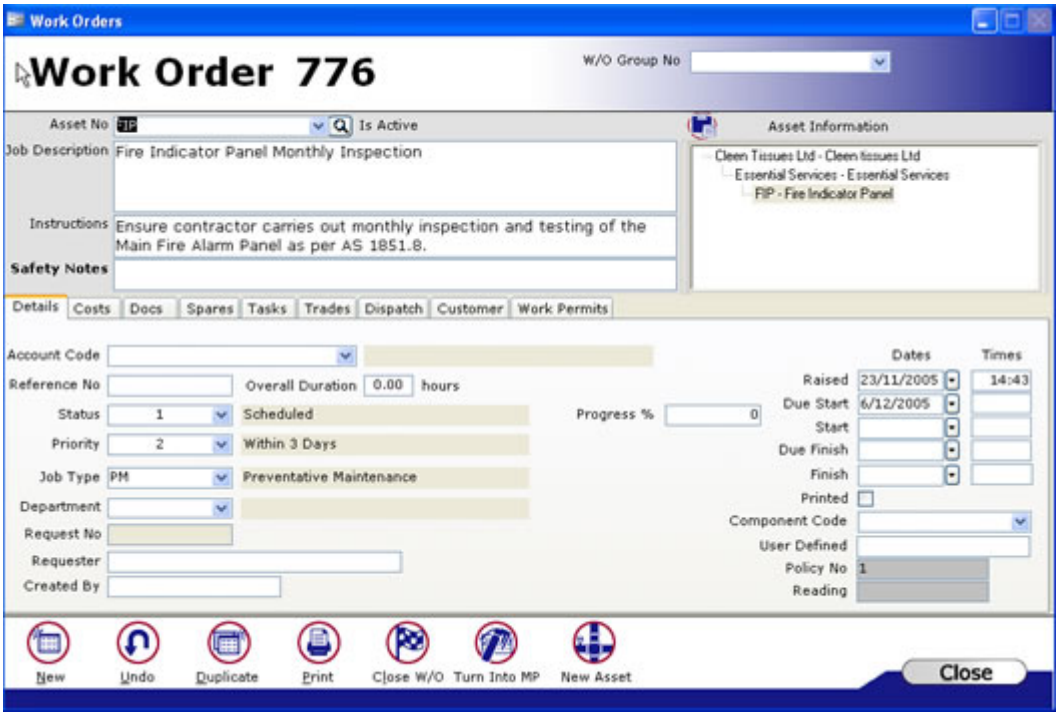

Figure H.3: Work Orders from the MEX Program (MEX, 2007)

History

The History module stores a record of all work that has been done on an asset registered within MEX. When a Work Order is closed off, the information from that Work Order is transferred to the History module. This historical information can then be recalled for analysis and reporting. (MEX, 2007)

MEX also has the capability of utilising Failure Analysys Codes, which produce reports to identify:

- Repetitive Failures
- Problems with the maintenance program not preventing failures
- What failures cost the most money and time
- What type of maintenance work is being done
- What are the symptoms that are not being picked up in inspections and services
- What are the delays on doing work

(MEX, 2007)

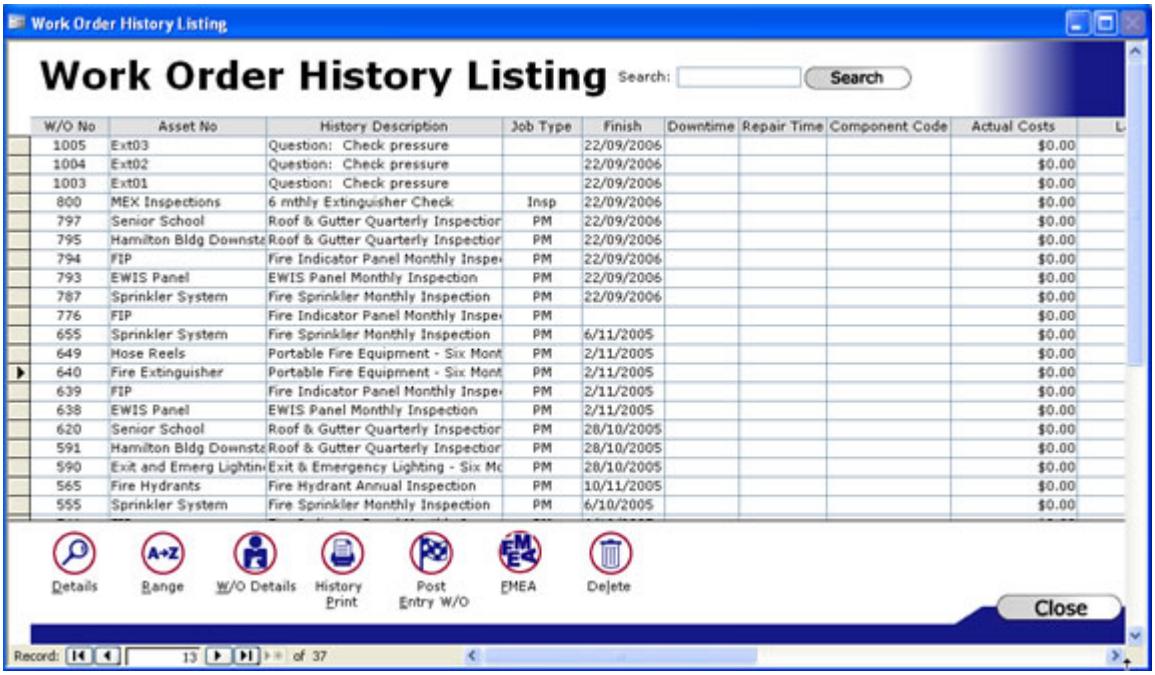

Figure H.4: Work Order History from the MEX Program (MEX, 2007)

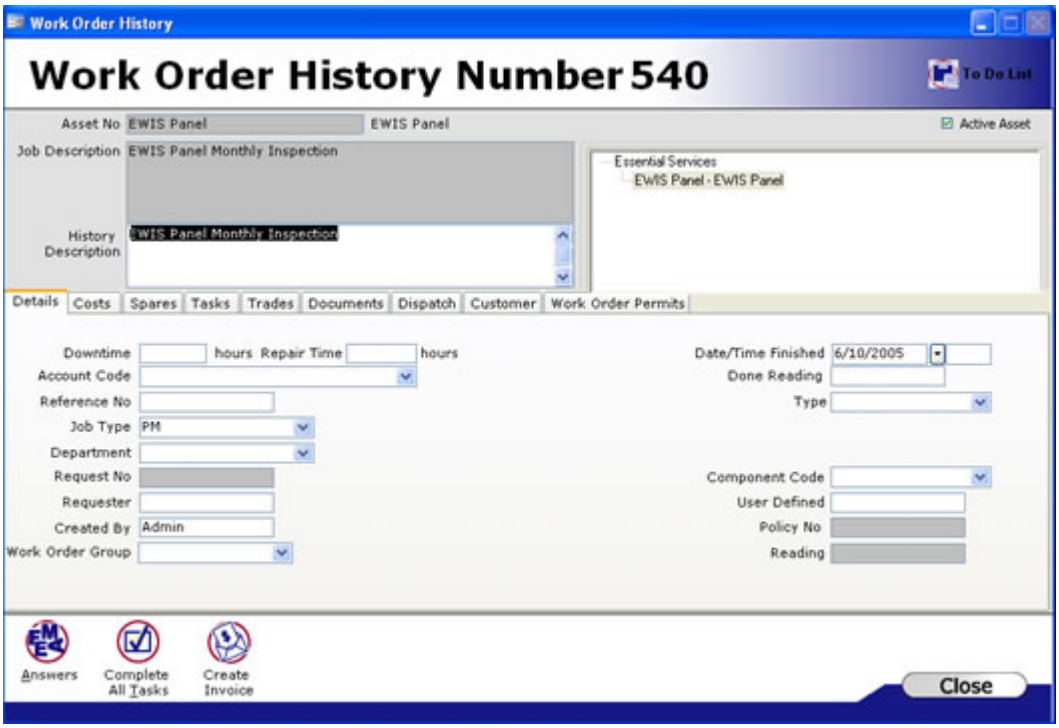

Figure H.5: Work Order History from the MEX Program (MEX, www.mex.com.au)

Maintenance Policies

Maintenance Policies is the module within MEX which is used to manage routine and repetitive jobs. The Maintenance Policy will contain all of the information required to complete the job including the piece of equipment, personnel, tools and spare parts, the frequency of the job and any required documentation. (MEX, 2007)

Once your Maintenance Policies have been created, MEX will automatically schedule the job to be done based on either last done dates or readings. Work Orders will be raised and spare parts, personnel and costs will be allocated to the job. Maintenance Policies ensure work is done before equipment can fail and this ultimately saves money. (MEX, 2007)

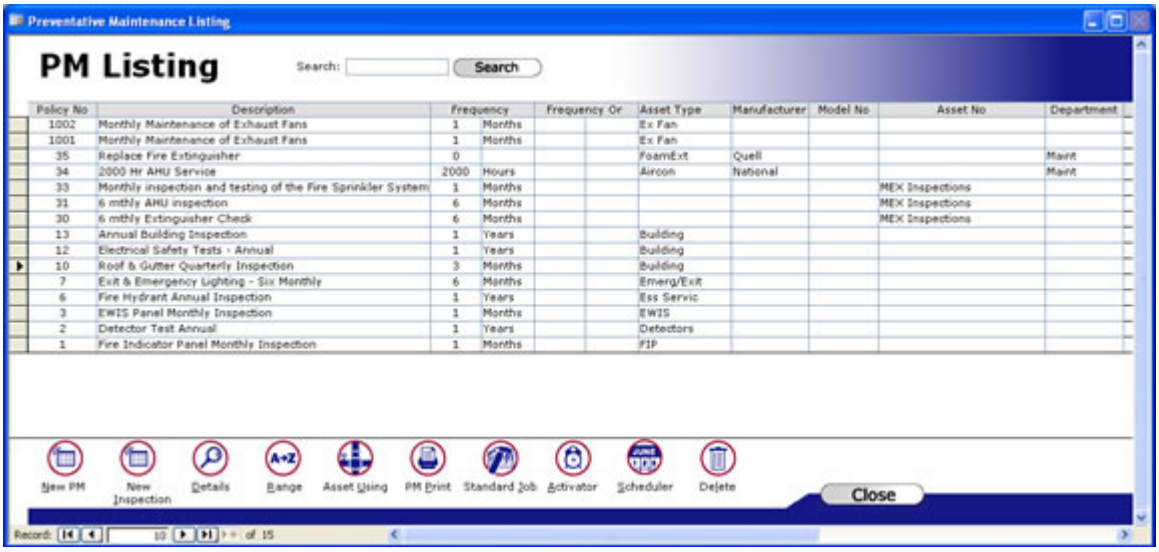

Figure H.6: Preventive Maintenance Listings from the MEX Program
(MEX, 2007)

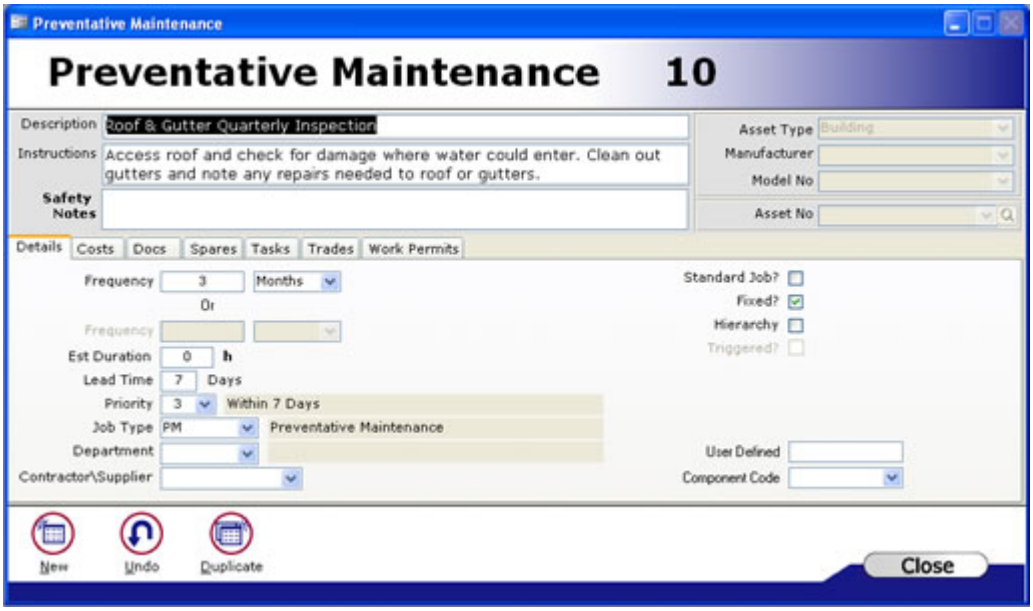

Figure H.7: Preventive Maintenance Listings from the MEX Program (MEX, 2007)

Regions

The MEX regions function allows the quarry manager to segregate the organisation within the software. The program has the flexibility to handle multiple sites within a single database. (MEX, 2007)

Features include:

- Restrict user access by location
- Customisable down to an individual user at a particular time
- Create regions for Assets, Spares, Work Orders, History, Readings, Maintenance Policies, Suppliers, Trades, Inspections, Request Keys, Drawings, Customers, Departments, Invoices and Purchase Orders.

(MEX, 2007)

Benefits include:

- Users only view only what they need for their location
- Easy single database management for multiple sites
- Share information between locations by functions, eg. enables access to all stores
- Track equipment between sites
- Product reports on the entire organisation or any selected site

(MEX, 2007)

Readings

The readings module is where you enter your equipments readings taken from hour metres, odometers, pressure gauges, shock pulse metres or any other instrument that is required to record the performance of the equipment.

Typically, these readings are then used for two purposes:

- For the scheduling of maintenance policies that are usage based.
- For the recording and reporting on performance of a particular asset

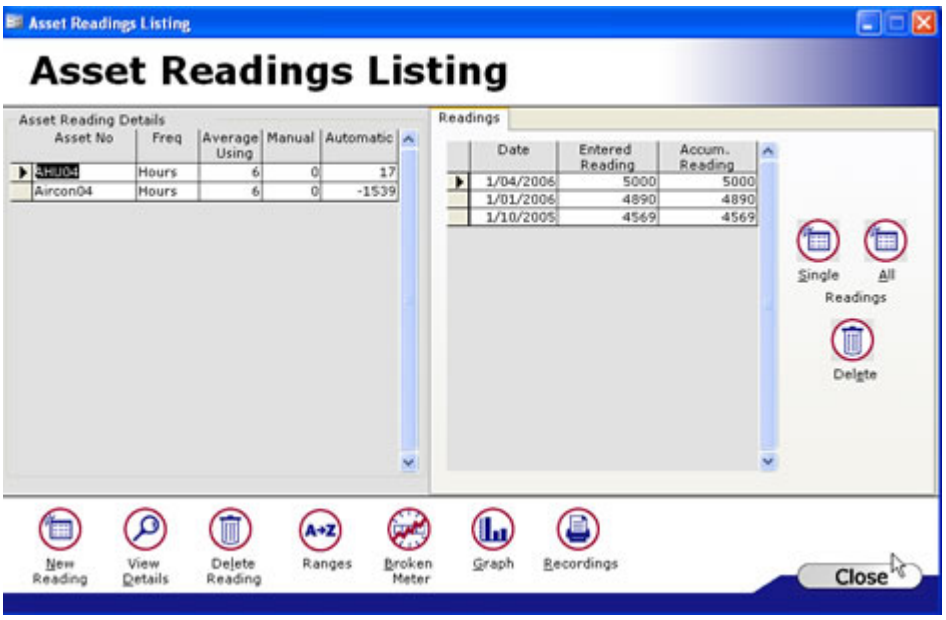

Figure H.8: Asset Readings from the MEX Program
(MEX, 2007)

Invoicing

The invoicing module within MEX allows invoicing for the work performed. Invoices can come directly from a closed Work Order by creating an ad hoc invoice or by using the invoice Wizard. Credit Notes can also be created against existing invoices. (MEX, 2007)

Some of the features of the Invoicing module are:

- Invoicing of work completed
- Create invoices directly from Work Orders
- Complete breakdown of costs, labour and parts
- Customer specific pricing

(MEX, 2007)

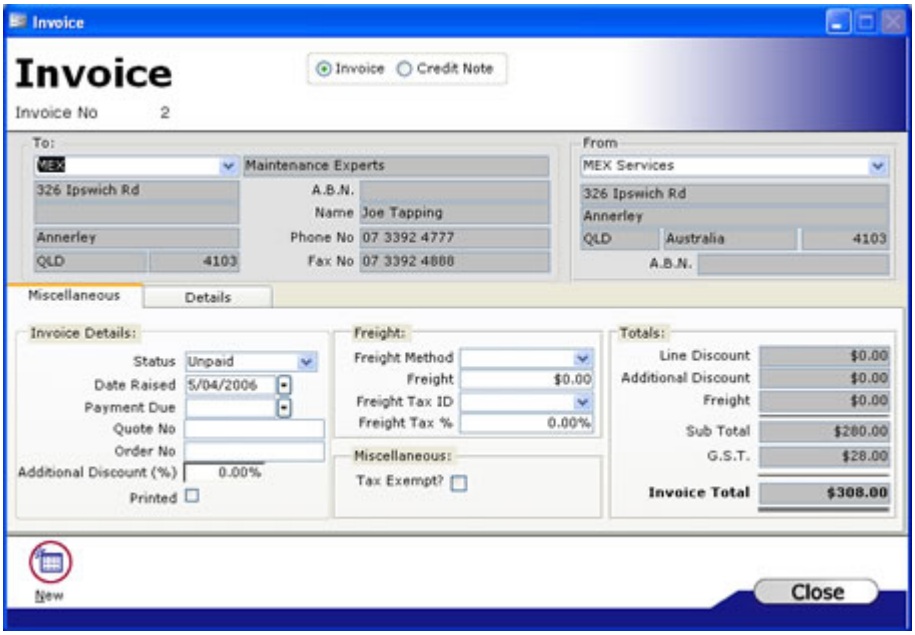

Figure H.9: Invoicing from the MEX Program

(MEX, 2007)

Permits

Permits will streamline the permit approvals notification and maintain necessary paperwork and certification. Permits can be stored as part of a work order or maintenance policy and release of work can be restricted until approved.

Some features of the Permits are:

- Work Permits are embedded with maintenance records
- Track all permit issues and approvals
- Electronic approval of permits
- Two levels of approval
- Permits are customisable or new permit templates can be created
- Restriction of work release enabling compliance control

(MEX, 2007)

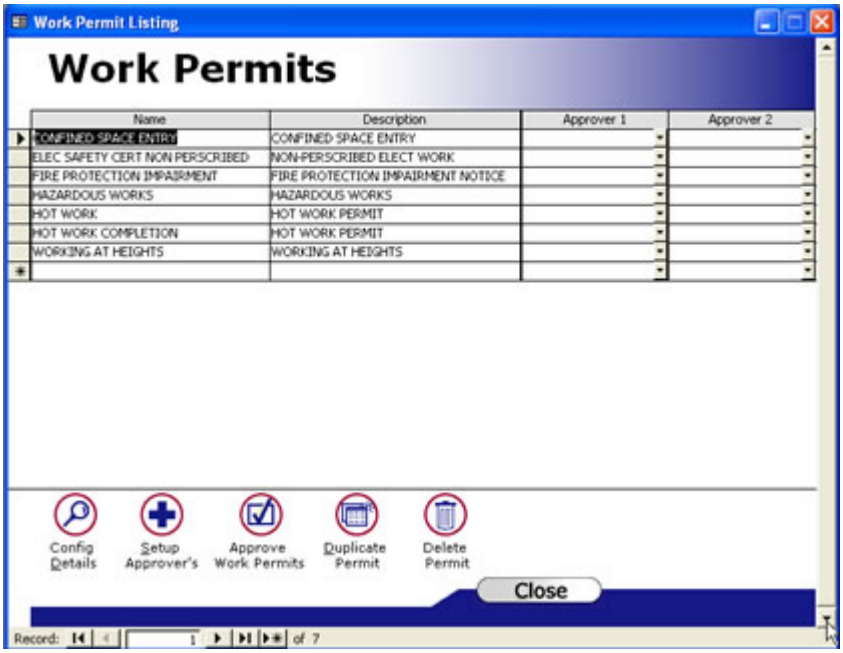

Figure H.10: Work Permits from the MEX Program

(MEX, 2007)

Control Files

The Control Files module of MEX is the administrative headquarters for the system. All the information that is specified within this module includes:

- Employees
- Trade Codes
- Equipment Types
- Account Codes
- Contractor and Supplier Details
- Freight Methods

(MEX, 2007)

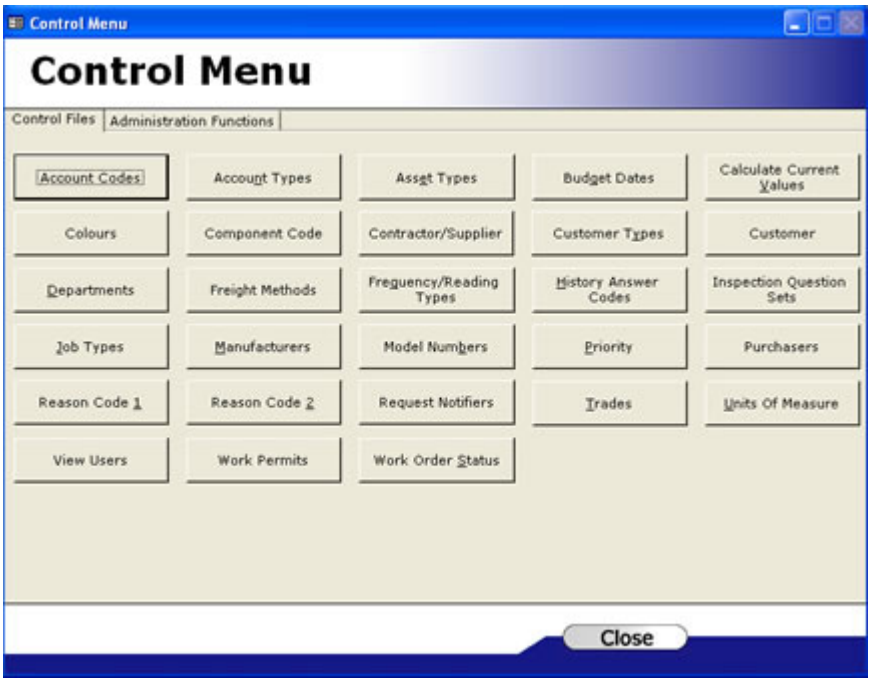

Figure H.11: Control Menu from the MEX Program

(MEX, 2007)

Security

Security will enable you to protect the system and data from unauthorised users. Limit access by application right down to form and field level or by individual where access can be determined down to ability to view, add or delete a field value.
(MEX, 2007)

Security gives you the flexibility when added Users to the MEX system. Choose to allocate passwords for users, adding users to pre-define or Modified Groups or create groups for specific users.

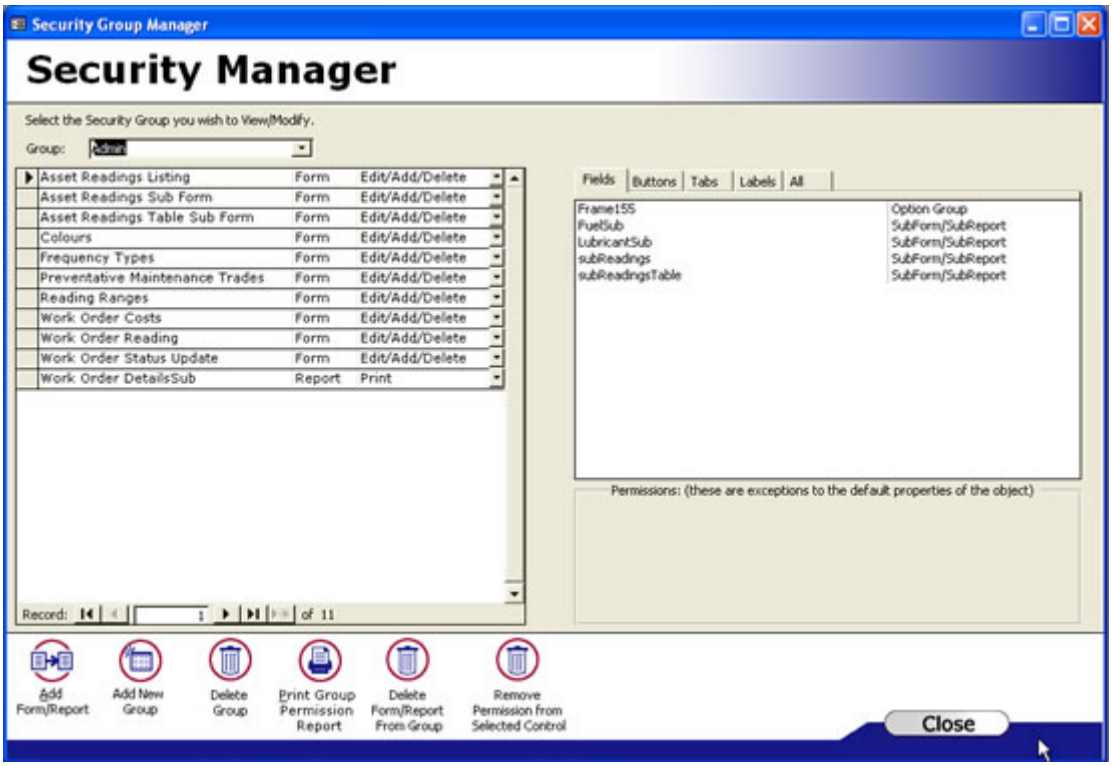

Figure H.12: Security Manager from the MEX Program
(MEX, 2007)

Reports

Reporting is a vital part of ensuring your maintenance operation is performing at its optimum level, and MEX's Reports module provides you with the ultimate tool. With access to such accurate data and statistics you can quickly identify areas for improvements and monitor your operations progress. At a mouse click, you will know for example: the history of all work done; how well both assets and staff are being utilised; how equipment and spare parts are performing and have an accurate indication of costs. (MEX, 2007)

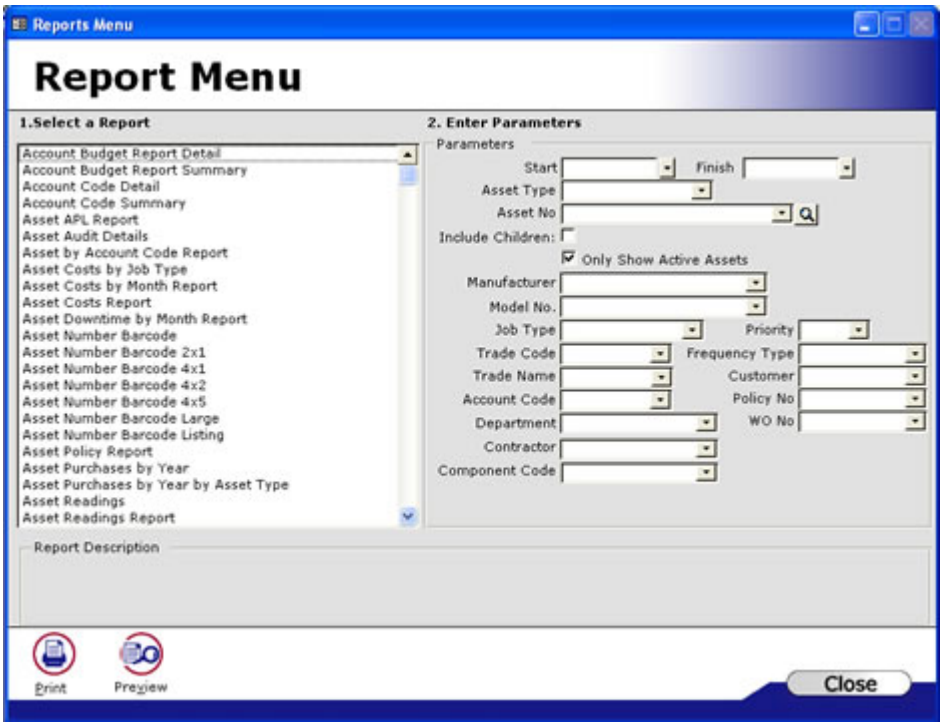

Figure H.13: Report Menu from the MEX Program
(MEX, 2007)

Stores

Central to the successful operation of your maintenance department is control of your inventory. You want to be able to maintain an appropriate balance between what you need on hand, while keeping the capital tied up in your Store to a minimum. (MEX, 2007)

The MEX Stores module will put you one step ahead. You will know exactly what parts have been used, what parts are needed and when they are needed by. (MEX, 2007)

Figure H.14: Stores Menu from the MEX Program
(MEX, 2007)

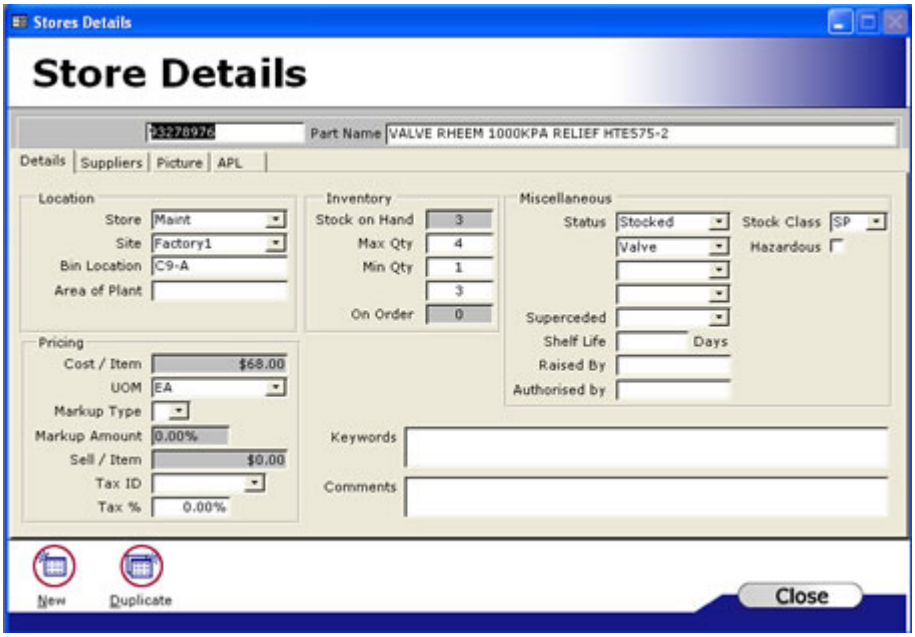

Figure H.15: Stores Details from the MEX Program

(MEX, 2007)

Easytime

The EasyTime module is used to create Timecards for each staff member for any given period. Timecards are raised, and time allocated against jobs carried out by the particular tradesperson. The information entered onto the Timecard is then automatically transferred to all associated Work Orders, keeping track of jobs that may otherwise go unnoticed. (MEX, 2007)

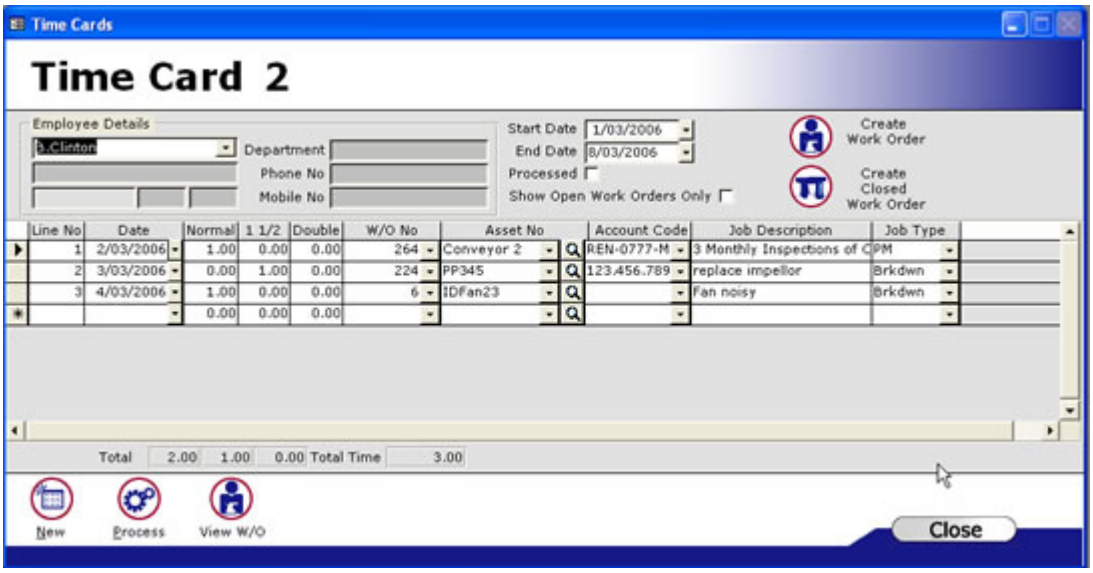

Figure H.16: Easytime Time Card from the MEX Program
(MEX, 2007)

Key Register

The Key Register is particularly useful for facility management. It is the area within MEX where you record the keys your company has, what they open, the status of the key and who currently has the key in their possession. (MEX, 2007)

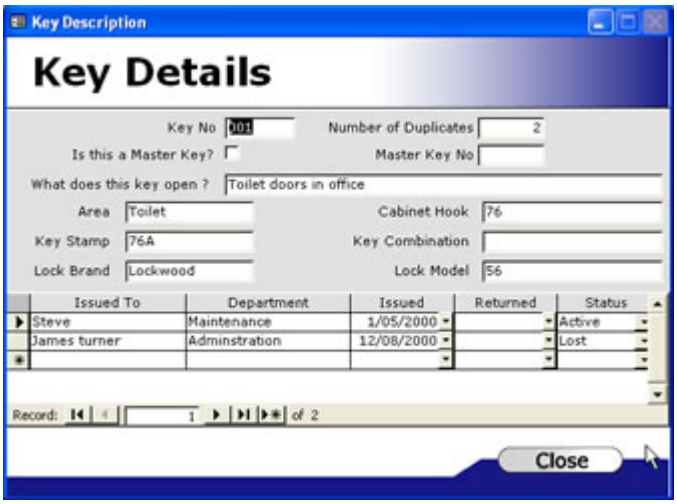

Figure H.17: Key Details from the MEX Program (MEX, 2007)

Downtime

The Downtime module of MEX is used to record the downtime of an asset when not in use. The module is useful for determining the amount of production downtime within your company, as opposed to maintenance downtime, when the machine is down due to scheduled maintenance. (MEX, 2007)

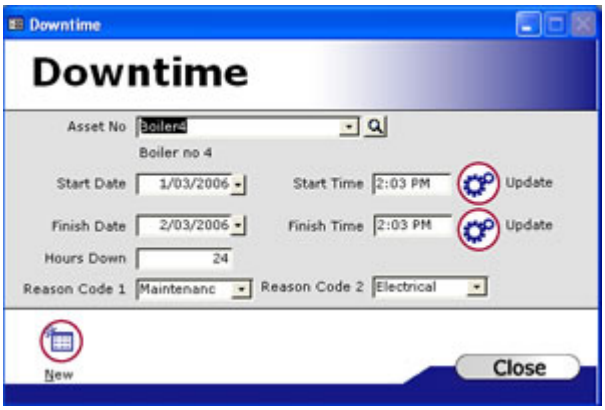

Figure H.18: Downtime Recorder from the MEX Program
(MEX, 2007)

Drawings

The Drawings module within MEX allows for printed or electronic documents to be catalogued and viewed (if electronic) from within the module. This feature gives you a comprehensive description of each drawing or document, including:

- a revision number
- a revision date
- file location
- physical location
- who authorised it
- comments.

(MEX, 2007)

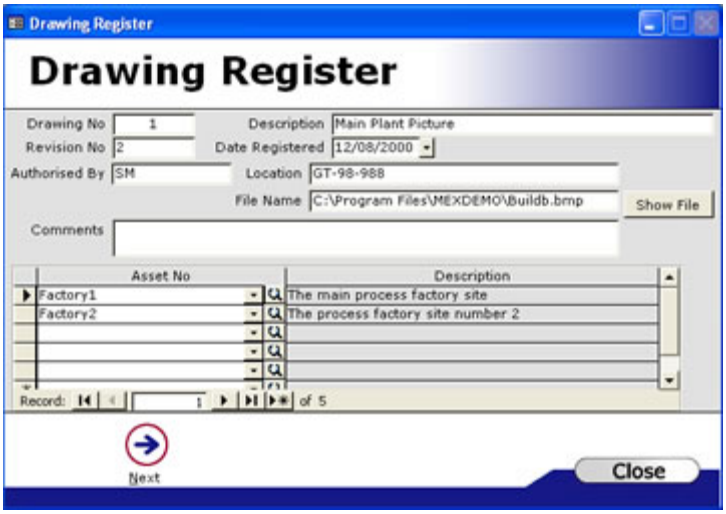

Figure H.19: Drawing Register from the MEX Program (MEX, 2007)

Request

The Job Requests module of MEX is used in conjunction with Work Orders. This module allows personnel to send requests to the Maintenance Department for work to be done. The Maintenance Department may then raise Work Orders for these requests, and subsequently the requester can check the status of his/her request.

Job requests are useful from a maintenance perspective as it allows the maintenance manager to determine which jobs are worthy of work orders, it also allows for authorisation before any maintenance work is to be done.

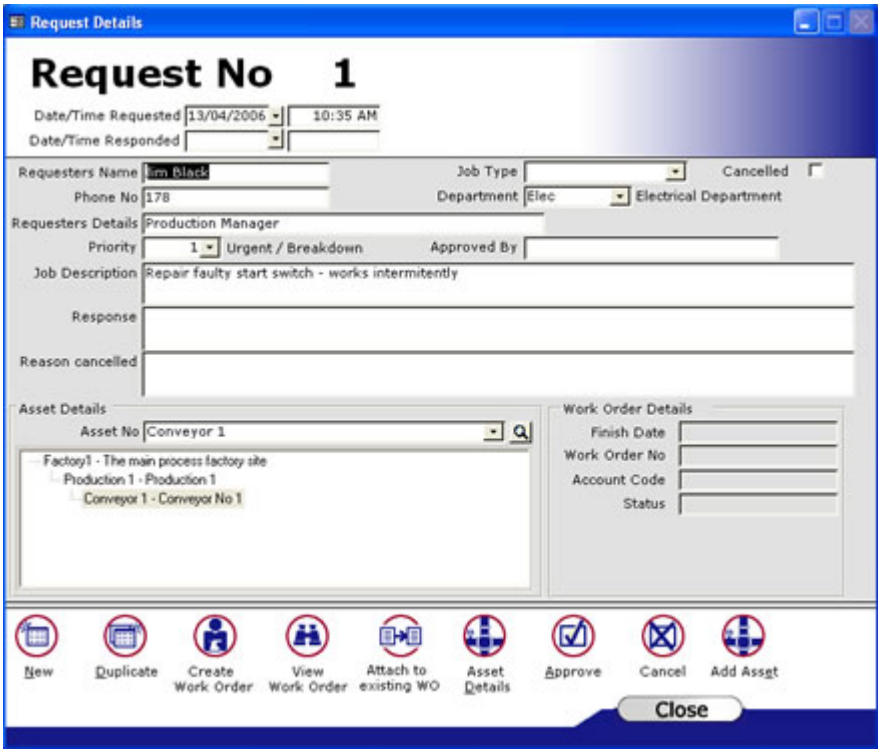

Figure H.20: Requests from the MEX Program
(MEX, 2007)

Inspections

Inspections are a key requirement for any maintenance operation. The MEX Inspections module has been developed to assist in making inspections easy to perform; easy to manage; easy to act on and easy to report on. Develop an inspection routine to include multiple assets on a single inspection. The MEX Inspections module can be used inconjunction with a hand-held device.

Inspections are Maintenance Policies that are created as Inspections. The following information can be associated with them:

- A time based frequency at which it is performed
- Labour costs
- Estimated duration
- A fixed timeframe between inspections

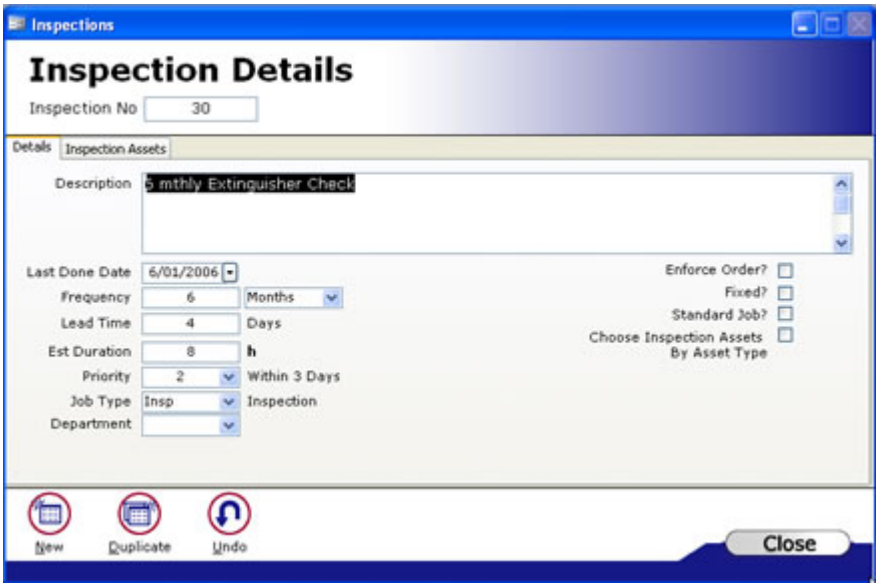

Figure H.21: Inspection Details from the MEX Program
(MEX, 2007)

KPI

The Key Performance Indicators (KPI"s) module is another way within MEX to view your data graphically. KPI graphs can be set up initially and then the same items graphed, with values refreshed each time the KPI module is opened.

KPI's are initially divided into categories and within each category are a number of items that can be graphed. The categories reflect the major modules contained within the MEX system including:

- Work Orders
- Asset Register
- Stores
- Maintenance Policies
- History.

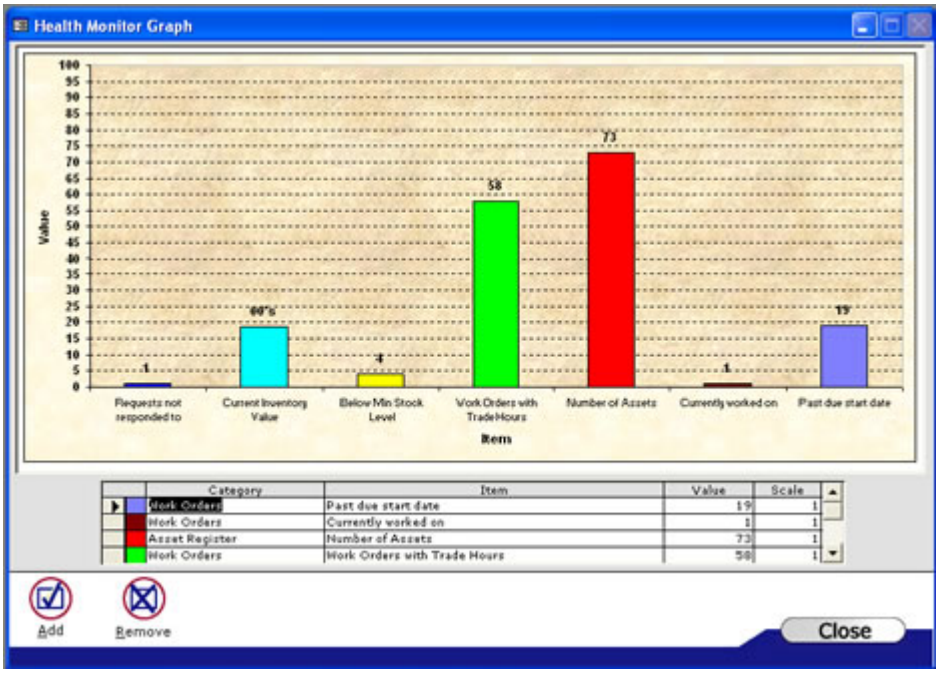

Figure H.22: KPI graphs from the MEX Program
(MEX, 2007)