History

- Boral shifted to the Lean Continuous Improvement system four years ago
- Seaham Quarry had experienced a few Continuous Improvement Systems over the years
  - Six Sigma, Fast track
- Initial wins with LEAN principles in previous years included
  - Sorting out graveyards and bringing up the standard of the site
  - Awareness of continuous improvement processes
- Management developed an understanding of the value in the Continuous Improvement tools
  - First year focussed on how the site looked - Painted lines and tidied areas
  - Second year we understand the range of tools, trained and trialled some examples
  - Third year we filled in an action plan with targeted projects, more than ever before
  - Fourth year, we have continued to plan and deliver on projects to improve our key metrics
Previous Action Plan

Previous action plans had been filled with minor aesthetic improvements to raise the standard of the site. With a new manager, Seaham was determined to focus on more targeted projects that had an impact on operations.

- For the past 2 years the site management team spend 2 days each new year planning several projects that, when competed, would improve the OEE (Overall Equipment Effectiveness) of the Quarry.

- The team focussed on projects to reduce downtime, speed up time to repair/replace, increase wear life, and improve quality.

- We have included a selection of projects on the following slides, including:
  - Drill and Blast Improvements
  - Wear Rate Improvement on G.E.T.
  - Monitoring for Critical temperatures
  - Reducing changeover times for Liner Changes
  - Safety and time saving improvements for crusher changes
  - Wear life improvements on Liner Profiles
  - TPM improvements on major areas of plant (e.g. Tunnel)
  - R&M improvements on chutes and transfer points
  - Wear life improvements on sales loader buckets and crusher components
  - Environmental Improvements for surface water
  - Focus on increasing our employees knowledge
Planning Projects

A water fall diagram was created to define how we can improve our OEE, using real downtime data from our reporting system.

Our goal for July 2015 is 85%
Drill and Blast
The drill and blast practice at Seaham was the biggest gripe of operators at the face, on-going issues with undulating unbroken toe, floors and oversize

- The team of 6 people over 2 months consisted of completed a bottleneck analysis to identify issues and solutions to the different stages in the process.

- The following issues were found as a result
  - The driller had a different means of lining up the azimuth compared to the blast contractor
  - The undulation in the floor was being transferred to the next level as the laser profiler had no designated floor
  - The blasting site rules had been “optimised” years earlier to improve drill costs and were using 102mm holes by opening up the drill pattern – at the detriment to production throughput
  - Reviewing the dip sheet and shot information was done on the day with no time to implement any changes

Unbroken Toe
High proportion of oversize in shot
Drill and Blast Solutions

The solutions were often simple

- **Understanding how blast contractors set the bench face angle**
  - Train the Drillers to use the Laser sight on the drill to improve accuracy
  - Record a measureable score for Driller accuracy for the front row and random selection of middle and back rows

- **Setting the correct floor level to work from**
  - Surveyor to Stake out Pit and mark levels for each bench
  - Painted 1m² concrete blocks with the RL as the mark for Setting floor level when laser profiling
  - Renamed the benches to use the agreed Relative Level e.g. RL 75 instead of level 3, 4 etc

- **Trialled new design patterns and initiation methods**
  - Closed up the pattern to trial 89mm drill holes - Very successful, able to reduce C.S.S. in Primary Jaw which allowed for lesser crusher reduction ratio in 2 other crushers down the line
  - Trialled electronic detonation in multiple shots – not as cost efficient with higher associated cost

- **Set administration control points in place to review drill and blast information**
  - Cannot drill without manager reviewing and signing off the potential mark out
  - Drill not to leave without reviewing and signing off all bore track data days before

When Everything comes together you see good faces and level floor
Better wear on Ground Engaging tools (G.E.T.)

Seaham has 5 loaders on site, with each one requires the GET component to be replaced periodically. Team conducted a PDCA Project (Plan, Do, Check, Act) involving site and supplier, over the course of 6 months

- Review the cost of the current G.E.T. (Example - Face Loader)
  - Were using KVX teeth – Supplier estimated 2000 hrs before change out
  - Cost to change was $22k for 500 hours that was actually received

- Arrange for a trail of best few options
  - A.R.M. (Abrasive resistant material) KVX with hardened edges – Tungsten Carbide tipped
  - KVX pick design – new design for teeth that sharpened into a pick
  - Caterpillar modular teeth – Brought in a different loader with different lip configuration
  - Proclaw tooth system
  - Used our own stud Welder to fit studs onto KVX Teeth

- Implement the change - Trialled over 6 months

- Measure the success
  - Photos on regular basis measuring wear
  - Cost for solution

Solution implemented is the KVX Teeth with the wedge and the use of Stud welder. This has seen a 75% increase in wear life on our face loaders GET
Example of the Trials on G.E.T

Original bucket
Designing new teeth

Abrasive Resistance Material
ARM KVX design

KVX Pick Teeth studded

KVX Pick Teeth

Modular teeth
Able to be changed by operator
Most cost effective per hour
Critical Asset Temperature board

Within Seaham some of the bearing monitoring had been overlooked. Often failing at the most inconvenient time, a system had to be established to improve our awareness and planning of replacement of critical bearings.

- The team consisting of the maintenance supervisor, fitter, leading hand and plant room operator reviewed the process and frequency as part of an error proofing event.
  - Frequency of all automatically generated work orders
  - How accurate was the data collection
  - What means for bearing analysis used
  - The process for collection including where did the information go
  - Improving awareness – who on site was aware of potential issues

23 Critical Bearings Monitored Daily, Trends can be Identified, Placed along main corridor
- Reviewed the frequency of data collection
  - Head office required a weekly check with data emailed back
  - We increased the site only frequency to be a daily check of critical assets

- Reviewing the current method
  - Temperature monitoring was being conducted however the information was only seen by a handful of people
  - Not easy to compare over time or identify a trend in data
  - Vibration analysis is now used as a regular analysis

- The accuracy of the data
  - Found that different fitters recorded the temperature in different places
  - Painted dot on each crusher or screen to ensure temperature recordings are consistent

- A board was created to track the temperature readings
  - Fitter is required to update the board daily
  - Accountability of inspection being done
  - Can be seen by all with simple visual representation
  - Anyone can see trends or issues
  - Clear upper and lower limits
Liner change procedure
Seaham has 3 Gyro-cone crushers and highly abrasive rock Required 26 liner changes a year for 1Mt production year

- With production occurring during the week the only time for maintenance is during the weekend
- The cost associated were high enough to justify a Quick Changeover (S.H.E.D) event
  - Two fitters, all maintenance team and leading hand were involved
- Review the current change out procedure
  - Reduced production time due to liner change over – Friday afternoons lost for liner change
  - Poor performance for days after liner change as new liners wear in
  - Lack of flexibility in options for liner change – sometimes having to change out earlier than desired
  - Potential for improving safety of the procedure

Each Stage of process mapped out and timed
Liner change procedure

- **Purchasing spare components**
  - The amount of work in a liner change was halved by purchasing a spare Top shell and Main shaft
    - Liners could be poured and set on spare components instead of using the same set
    - This allowed for most work to be done ahead of time and swapping components instead of having to squeeze 36 hours work in a weekend
    - Reduced fixed price for each change was negotiated due to simplicity of job

- **Swapping intermittently**
  - Instead of installing both components at once we spread the work by changing either the top shell or main shaft in a single event
  - This allows for a change in the liner design and increase liner life from 240hr to 380hrs
  - Offsetting the two components in a change out reduced the resulting “wear in” time by half as a new profile matches the worn in profile.
    - 2 days at reduced throughput from complete change become a half a day reduced throughput each change

- **Extend the Overhead crane and create a suitable working surface near the crushers**
  - Allowing for safer removal of crusher components by eliminating the need for franna crane
  - Pouring a concrete pad under new crane to allow for setting new liners at the crusher house
  - Eliminate the need for Crane movements to transport to the workshop and back
Liner Profile design

With the liners now able to be swap intermittently it gave opportunity to increase liner life

Working with the original equipment manufacturer, Designed an oversize concave that wouldn’t normally fit in the crusher
- Designed approximately 40% larger allows for fewer change outs
- When either half has worn below a certain point the opposite component can be changed out
- Increases the percentage of wear used before having to change out the concave

At the same time investigated the Mantle profile and opening to ensure a larger crush zone
- based on two rotations with our intended optimal feed
- Reduced bellowing out and premature change out

Changes extended the liner life by 90% with a reduced wasted proportion of wear material each change out – 200 hours to 380 hours before change required

- Concave made larger
- Components only swapped out when opposite is worn to a certain point
- There is always 30mm wasted wear material
  - Having a larger concave lowers the proportion of wasted concave approximately 1/3
The reclaim tunnel was a issue for many years from an event 10 years ago. A small incident became a catalyst for a TPM event – (Total Preventative Maintenance)

- A clean to inspect was completed, and then instead of applying a band aid solution the entire tunnel was dug out and rebuilt
The tunnel was completely cleaned out
- Clean to inspect conducted
- All material build up in the tunnel was removed by wheelbarrow
- Acro-props removed and everything was washed down

The tunnel was dug out by an excavator and man power

The defects in the existing tunnel structure were identified and repaired

The existing frame served as formwork for a stronger concrete tunnel designed by structural engineer

The reinforcement for the concrete was all constructed with operators
- Cut to length and bent into shape
- Welded to create a framework
- Installed into place

Formwork built was then built

Concrete was poured whilst material was packed around formwork

All Work completed using our own staff where possible
R&M Improvements on chutes and transfer points

The natural abrasiveness of the materials (> 30% silica) means our R&M cost is quite high per unit, with a lot spent (time & $) on chute and transfer point maintenance.

- Historically we have repaired using weld on components when relining chutes and dead box areas. This costs in terms of time (to remove old, fabricate and fit new) as well as cost to purchase materials and pay for labour

Team considered several techniques and they determined the best option was to:

- Developed custom rock ledges using grouser bar with standardised rotor broached holes to make them interchangeable
- Standardise sizes (700, 550, 400) were agreed upon
- All are rotatable, so can be flipped when one end worn, to wear other end down
- The rock ledges are proving to be very sturdy, lasting significantly longer than weld on components, in some places we have seen 50-70% increase in wear life
- An area of higher wear can have sectional replacements rather than replacing the whole

Rock Ledges now used in site, std sizes and bolt placement

Ability to replace small sections as required rather than the whole

Rock Ledges wearing well, and can be rotated to wear both ends before discarding
R&M Improvements on chutes and transfer points

Changes have reduced manual handling (nothing >12kg), changeover times and costs down by 80% as it’s quicker to replace, and staff can do it themselves. Also allowed for reduction in inventory.

Change to rock ledges began in April 2012.
All transfer points/chutes etc in site have been modified (completed May 2014)
Sales Loader Bucket Improvements

The lip plates were wearing, again due to the abrasive material, coupled with high utilisation and mixed materials.

- Similar to the Face Loader GET trails, the team trialled different strength lips and edges to determine the best option for the site.
- We were getting 3000hrs (1 years life) from a standard lip.
- By using the stud welder on the bucket lip and wearing faces (to protect the leading edge of the bucket skin) we have been able to increase our sales loaders bucket life.
- At 2000hrs we have experienced 10% wear (compared to 100% wear at 3000hrs previously).
- Gives us the opportunity to re-stud the lip when current wear studs are no longer viable.

Results have been so good, we have since retrofitted this solution to all sales loaders on site.
Protecting the crusher head from wear

Improvements to wear protection on our crusher spider arms and housings to not only decrease wear, but also reduce downtime from failures in wear protection.

- Historically we used chocolate blocks welded to the spider arms and housing to protect against wear.
- In the past we have suffered downtime from ineffective wear protection (cracks) and mechanical failures when choc blocks have come loose and jammed in the crusher as they are larger than crusher CSS.

Solution (In place 2.5yrs)
- Stud welding the spider arms and housing to provide the wear protection
- The studs allows material to build up between the voids, allowing rock on rock interaction to occur
- As these studs are smaller than our CSS, over time, if they break off they will not cause damage to the crusher.

Old way of using Chocolate Blocks

Studs in place for 2.5yrs at time of photo (June 2014), still no sign of significant wear, no failures.
Environmental
Completed a large amount of work on surface water and drainage to reduce the suspended solids. This also will help to maintain the integrity of our haul roads.

BEFORE: Large water Catchment with a fine material - the area allowed for water to build in large quantities and overwhelm the single dam

A proper water flow plan was instigated, with easy access for ongoing maintenance.

AFTER: The area was reshaped with a fold down the centre. This halves and diverts water into two separate dam holding systems

Dust was relocated to a less sensitive area

The area was seeded to prevent erosion
Additional Improvements

- Changed the culture on site from having 35% casual workforce to 5% casual workforce
  - Greater ownership of site and projects by all employees
  - Reduced the turnover of operators
  - Increased morale and site culture

- Focus on training staff
  - 78% staff on site have at least a cert 2 in extractive industries
  - 30% of the site has cert 3 and above in extractive industries
  - In the past year two of Seahams supervisors have moved into leadership roles in neighbouring Boral sites

- Installation of vibrators on critical chutes to reduce blockages

- Changed to poly screen cloths to get increased life where possible
  - Initial trail shows about 3 fold improvement in life replacement

- Smarter timings in the PLC to improve automation
  - Linking silo level of critical products to feed rate of crushers
Benefits of the Improvement Projects

The culture of continuous improvement has seen the whole team willing to question, trial and encourage further improvements in areas we may have not bothered before.

- OEE has improved steadily each year – with the team on target for their goal of 85% in July 2015
- Changes to wear life for critical kit, and improved monitoring of critical temps has improved our plant availability
- Many of the projects made it easier for us to replace/repair equipment - this has shown in our MTTR results