WESTERN AUSTRALIA'S
WATER CORPORATION

RELIABILITY IMPROVEMENT
FOR THE
NEW MILLENIUM

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In an increasingly litigious world, providers of utilities and services must do everything they can to ensure uninterrupted provision of water, sewerage, electric power or gas.

In an increasingly competitive world, a world of corporatisation, privatisation and even greater regulation, we must also supply customers with products and services at the lowest possible cost, without exposing our businesses (and the public) to unacceptable risk.

Within many large scale plant based industries, maintenance costs can account for as much as 40% of an operational budget. The maintenance effort is therefore **easily identified** at a corporate level as a source of savings.

Costs in maintenance can be cut in either a beneficial, or a detrimental manner. The best business outcome would be to both reduce costs and optimise current maintenance effort to increase reliability.

It is in this environment that Western Australia’s Water Corporation (covering the vast State of Western Australia), has embarked on a project-based reliability improvement initiative.

Enlightened management at Water Corporation saw that the advertised benefits of an implementation of the principles of reliability centred maintenance could satisfy its business requirements as they related to the Corporation's expensive assets.

Increased equipment reliability, decreased overall maintenance costs, improved service and decreased corporate risk, were naturally seen as attractive outcomes from a business point of view.

Water Corporation Background

Servicing almost the entire State of Western Australia with its Water, Sewerage and Drainage requirements, the territory covered represents an area of 2.5 Million square kilometres.

230 cities and towns including over 1.7 million people throughout the state of Western Australia rely on the Water Corporation and its assets to provide reliable utility services.

Fig 1 *Map of Western Australia Showing the Water Corporation Business Regions.*

The Water Corporation presides over $8.7 Billion worth of assets.

These assets are a diverse mix which includes 243 Water treatment Plants, 73 Dams and Reservoirs, 11 Artesian Bores and 779 Ground Bores located in 106 Bore-fields, 635 Water Tanks & Towers, 28,000 Km of Water Mains, 91 Water Treatment Plants and 10,900 kilometres of sewers.

The reliability improvement initiative commenced in 1997. While it was recognised that reliability centred maintenance represented a logical and appropriate methodology, like many other organisations, the Corporation had reservations about embracing RCM in its 'textbook' associated format.

Recognising that a successful RCM implementation revolves around making the best possible decisions within the RCM framework, the Australian expert decision support system RCM *Turbo* was identified and selected as the platform through which to develop strategies and implement results.

The Analysis

The RCM methodology is an approach to establish a scheduled maintenance program, which will realise the inherent reliability of equipment at optimal cost.

The Water Corporation Asset Management Strategy Development initiative had business goals to improve maintenance policies, procedures, instructions and techniques. The initiative will have long term effects on all operating practices throughout the Water Corporation.

A major objective of the Water Corporation’s maintenance initiative is to better align maintenance policy and maintenance plans with Water Corporation's business needs, eliminating non value adding maintenance and implementing maintenance practices that maximise business returns in a safe operating environment. This objective will be achieved by upgrading all documentation concerning maintenance to a higher quality standard and by adopting new techniques for monitoring, diagnosis and systematic analysis of asset condition. The Water Corporation’s reliability initiative uses the structured decision support methodology encapsulated within the RCM *Turbo* approach.

The involvement of a broad range of Water Corporation staff was a fundamental issue that management saw as integral to the success of the initiative. Successful introduction of an RCM program requires a good understanding of the underlying methodology and a realisation from all concerned that their input would determine the project outcomes. A great deal of effort was therefore involved in providing introductory training and support to personnel State-wide.

Essential for any maintenance plan is an asset register. Therefore to facilitate the establishment of an effective RCM analysis program the first hierarchical structures required to be established were the productive units or processes within each of the target areas.

The functions and performance standards of the target area systems were documented and quantified , then the Maintainable Items for each system identified. As maintenance effort is directly linked to failure consequence, the Business Loss rates for each major plant area were analysed and documented.

To ensure that an RCM approach within the Corporation would produce tangible results and identify benefits, a pilot program was applied in two locations. One of these was the small coastal town of Jurien Bay.

Fig 2 *A Typical Bore site at Jurien Bay*

A post implementation review which included benefit realisation confirmed the potential benefits of implementing an RCM program. Based upon this evaluation, other major Water Corporation assets were programmed for analysis.

The Corporation's assets vary greatly in age. In some cases, the plant under analysis was over 30 years old and as a result had undergone numerous modifications over its life. One of the major issues was to take a step back and ensure the correct *functional requirements* for the various systems were clearly understood and where possible quantified. This simple concept resulted in a number of relatively inexpensive modifications and process improvements that resulted in increase in plant operational reliability and reduction in operating costs.

RCM *Turbo* Features

RCM *Turbo* documents the decision logic used in the structured RCM process for challenge and future review. It also assembles additional information to assist in the determination of an optimum maintenance program.

The first consideration in evaluating any failure possibility is safety. In instances where safety is involved, a conservative approach should normally be adopted when establishing task frequencies.

Secondly, where the failure consequences are economic, total cost depends on the frequency with which these consequences are likely to occur. The first question in evaluating the cost effectiveness of prevention therefore concerns the frequency of functional failures.

For failures with economic consequences the *cost effectiveness* of any maintenance strategy is of paramount importance. The cost effectiveness of preventive maintenance strategies is determined by simultaneously considering maintenance costs against plant availability, reliability and risk, and totals these costs against the frequency of the maintenance task. The optimum maintenance frequency is where the total cost is lowest. This optimum cost is then compared against the annualised Operate-To-Failure (OTF) cost to determine whether the maintenance effort is cost effective.

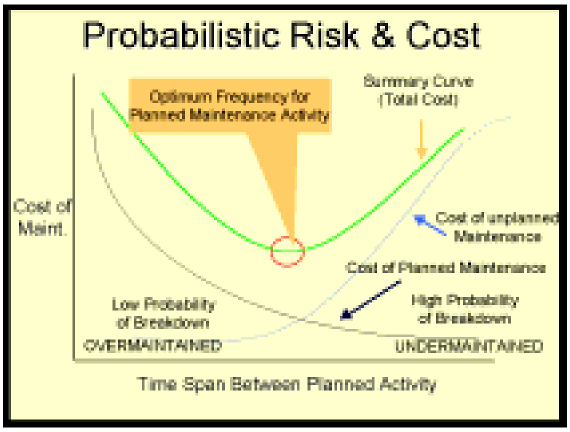
Optimisation of maintenance *task frequencies* is completed by simultaneously considering existing plant configuration and dependencies within a complex plant.

RCM *Turbo* allowed us the selection of three different types of maintenance strategies for evident failure modes, *fixed time maintenance* (FTM), *conditioned based maintenance* (CBM) and *operate-to-failure* (OTF). The maintenance action is described in two parts: *Primary Action* and *Secondary Action*. The initial maintenance task is the primary action and for a FTM strategy the primary action would include lubrication, greasing, component change-out, overhauls, etc carried out on a purely fixed time basis, regardless of equipment condition or performance. In the case of CBM strategies the primary action is intended to determine condition or health of the equipment and therefore primary actions would include inspection, testing or measurement to detect the onset of failure and to prevent the full consequences of an unplanned failure.

The *Secondary Action*, is the necessary task to maintain the functionality of the equipment if degradation of performance is detected during the course of completing the primary action. In general terms this secondary action is a repair, replacement of component, adjustment etc. To ensure consistency in approach, a *secondary action initiator* (S/A initiator) needs to be detailed. This parameter is the quantification of the level of degradation necessary to trigger the secondary action.

Resources required to complete the individual maintenance actions are entered from a resource pick list established at the commencement of the project with the appropriate hourly rates. Defining the task duration permits calculation of the maintenance costs once a frequency is established and facilitates the preparation of a zero based maintenance planning budget.

The optimisation process for complex plant begins at the individual failure mode level. Each *credible and likely* failure mode needs to be considered independently. The outcome from this process is to determine whether a maintenance task is *cost effective* and to establish the optimum frequency for each of these primary actions. The simplified graph below shows the theory behind this concept.



We modelled each of the costs to the business (preventive maintenance costs *and* the cost of breakdown) against different time periods for the primary maintenance action.

The annualised total cost of maintenance actions is calculated from a number of input parameters:

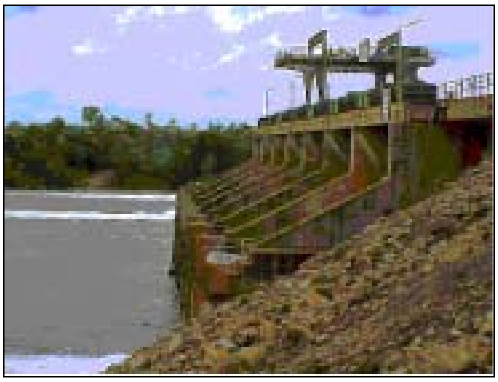
- Cost of actual failure or breakdown,
- Cost of the primary maintenance action,
- Cost of the secondary maintenance action, (this is the corrective repair that is done as a result of an observation or warning condition observed as a result of conducting the primary action)
- Frequency of the primary action
- Probability of failure for the equipment being maintained, based upon its life characteristic.
- Probability of detecting and completing the secondary action within the warning time distribution

In addition to the optimum frequency for the primary maintenance action and groups of primary actions, we are able to determine two additional outcomes for each failure mode. The *reliability* and *availability* at the optimum frequency is established and the total annualised cost calculated.

RCM *Turbo* was acquired from Strategic Corporate Assessment Systems Pty Ltd.

http://www.strategicorp.com - Contact is Chris Kelly 03 9455 2211

KUNUNURRA DAM PROJECT



The purpose of the Kununurra Diversion Dam is to maintain water levels in Lake Kununurra to allow water to be diverted for irrigation.

There are 20 radial gates, which provide a barrier against which water is stored, and when required can be opened by lifting, in order to allow the high wet season floods to pass without interference. There is also a requirement to maintain environmental flows in accordance with regulatory requirements.

A 20-ton gantry crane straddles the roadway and is used to place stop logs in front of the radial gates to allow routine maintenance to be carried out on the gates.

The Kununurra Diversion Dam was constructed in 1963. This was prior to the construction of the Ord River Dam in 1971. In 1963 the Kununurra Diversion Dam was the *only* means by which the high wet season floods could pass and prevent flooding of the irrigation area. This was accomplished by opening the large radial gates.

The Ord River Dam now attenuates the river inflow into the Kununurra Diversion Dam during the wet season and this reduces the frequency of gate operation. During a normal dry season only two or three gates are required to be opened at a time and during an above average wet season there may be a requirement for up to 10 or more radial gates to be opened to control river flows and Lake Kununurra water levels.

Prior to the commissioning of the Ord River Dam the maintenance requirements for the Kununurra Diversion Dam were such that all gates had to be fully operational and available particularly in the wet season. This required a considerable amount of maintenance effort and cost as equipment was maintained at manufacturer and design recommendations.

Since commissioning of the Ord River Dam the probability of requiring all 20 gates to be operational at the same time is reduced. Due to the reduction of the frequency of use of some of the equipment items there was an opportunity to extend the maintenance interval from manufacturer and design recommendations.

In developing an appropriate maintenance strategy for this asset, it was obvious that a careful study of its current *functions and standards* needed to be conducted before the commencement of detailed analysis.

Once the business loss rates were agreed and quantified, the “Failure mode, Effects and Criticality analysis” (FMECA) commenced. The analysis proceeded for each maintainable item as follows:

- Each part or component of the maintainable items that had a realistic chance of failure was analysed.

- The Failure mode was described in three stages:

- What was the failure mechanism involved that caused the failure?

- What evidence, if any, is apparent as the asset's resistance to failure decreases?

- What impact does the failure have on the maintainable item, the productive unit and finally on the plant?

- Establish the root cause of failure

After the failure consequences were documented, the analysis team determined whether there was a technically feasible predictive or preventive maintenance action for each failure. During this process, the objective was to challenge the current maintenance practice and to employ new methods of condition monitoring where applicable. The analysis process showed that a considerable amount of resource hours for primary maintenance actions could be shifted to operational checks, which are carried out on running equipment. The operating crews rather than the maintenance team can perform the majority of these tasks. This has resulted in more flexible resource management and higher plant availability.

Completing the FMECA process resulted in the establishment of a group of failure modes and subsequent maintenance actions to predict or prevent them. Each of the failure modes resulted in one preventive maintenance strategy, (consisting of a primary action and a secondary action for CBM strategies) and one corrective maintenance action (breakdown action).

Improving the *maintainability* aspects of assets within the Corporation was recognised as an important issue. All team members made recommendations to assist in reducing repair and service times. Plant availability was recognised as a key performance indicator and methods to reduce downtime have been addressed . Recommendations to improve safe working conditions in the target sites, as identified during the analysis process, have also been implemented. These initial steps have reinforced management’s commitment to a safe working environment and reduced risk exposure to the public.

Project Outcomes

The Kununurra Dam assessment has now been completed.

The analysis resulted in a 70% reduction in overall maintenance costs against the originally recommended manufacturer/design schedules, annualised using a 10 year net present value calculation. The RCM process confirmed that reductions in maintenance costs were possible due to reduced operating frequency of the radial gates since the Ord River Dam was built and highlighted additional tasks which could have their maintenance intervals extended

At the same time, the Corporation's high risk areas have been identified and properly addressed through the maintenance analysis. A clear audit trail exists of the basis for each and every significant decision and the new maintenance schedules are defensible and justified from both a business and technical point of view.

Those involved in the assessment now have a very high level of ownership of the outcomes. The process of carefully examining the assets under assessment, their relative criticality and the clear definition of current equipment functions and standards has contributed to this local buy-in and will ensure that future equipment performance review will be easily carried out.

SUMMARY

A healthy Asset Management Program for Water Corporation Assets is essential to our business. This is required for the sound financial management of assets and to ensure their ability to provide the required level of service to our customers. The Water Corporation is also bound by *Duty of Care* to ensure that a well documented, auditable maintenance plan for its major assets is in place.

By using the RCM process in conjunction with the expertise of relevant personnel including trades persons in the East Kimberley district, it is believed that a more appropriate maintenance plan from manufacturer/Design recommendations for the Kununurra Diversion Dam has been developed.

The reliability process has been applied to many other assets within the Corporation to similar effect. We know that the application of reliability principles within a project based approach has a demonstrable return on investment. That said, organisations need to be prepared to make the investment in achieving such improvements.

Water Corporation has demonstrated its commitment to reliability improvement and community risk reduction through its RCM and other Asset Management initiatives. The results speak for themselves.