Review of irrigation prices

Asset Management Planning Methodology Paper

October 2010

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1. Background

SunWater owns 23 water supply schemes across Queensland which are subdivided into 40 Service Contracts consisting of the following types:

- 23 Bulk Supply
- 8 Irrigation Distribution and Drainage
- 6 Commercial Pipelines
- 2 Potable water treatment and distribution networks
- 1 Hydroelectric generator

SunWater also provides facility management services to 3 wholly owned subsidiary companies as well as other water infrastructure owners across Australia.

Overall SunWater has a portfolio of over 50,000 individual water infrastructure assets under management with a replacement value in the order of $7b just for that part of the portfolio owned by SunWater.

The portfolio includes numerous asset classes such as:

- Dams and Weirs
- Offstream and balancing storages
- Fishways
- Pump stations
- Hydroelectric generators
- Pipelines (trunk mains)
- Pipeline reticulation networks
- Open channel distribution networks
- Drainage networks
- High Voltage Switchyards and equipment
- Communication and control equipment
- Flow measurement equipment
- Cranes and lifting equipment
- Hydraulic and Pneumatic systems
- Buildings

The majority of the assets managed by SunWater are managed to maintain a specific standard of service in perpetuity. This means that while assets when considered at a higher level have indefinite lives, individual components need to be progressively replaced as they reach the end of their service life. It also means that individual assets are refurbished throughout their service lives in order to maintain the service potential of the bulk water scheme or distribution system..

There are three fundamental facets to SunWater's asset management approach:

- Replace assets as required to maintain overall system service standards;

- Refurbish assets through their service lives as necessary to maintain service potential;
- Service, monitor and maintain assets to maintain the ongoing operational performance and service capacity of assets as close as possible to the designed standard.

The purpose of this paper is to clearly articulate the process, decision making criteria and scheduling of planned asset maintenance activities.

2. Customer Service Standards

The objective of SunWater's asset management plans is to ensure that customer service standards are satisfied at minimum whole of life costs

SunWater is required to prepare and publish service targets under its customer contracts.

Table 2-1 gives an overview of these adopted Customer Service Targets for each Water Supply Scheme.

The delivery of service to customers is a key aspect to the assessment of asset risk (refer sections 4.1.5, 4.1.8, and 4.2.2). The greater the risk of not satisfying service standards the earlier an asset is refurbished or replaced. This process is explained in the following sections of this paper.

Table 2-1: Water Supply Scheme Service Targets

Water Supply Scheme		Planned Shutdowns - Notification					Unplanned Shutdown - Duration			Unplanned Shutdown - Notification			Meter Repairs and max no. of Interrupts		Complaints & Enquiries	
		For shutdowns planned to exceed 2 weeks	For shutdowns planned to exceed 3 days	For shutdowns planned to exceed 5 days	For shutdowns planned to be less than 3 days	For shutdowns planned to be less than 4 days	Unplanned shutdowns will be fixed so that at least partial supply is resumed	During Peak Demand Period	Outside Peak Demand Period	SunWater will notify affected customers verbally or by telephone, radio, or fax within	SunWater will notify customers in writing before the scheduled release	When the timing of the release varies from the notice, SunWater will notify customer council members within	Faults causing restrictions to supply will be repaired within	Planned or Unplanned interruptions per water year	Initial Response/Acknowledgement	Resolve or Provide Written Response
1	Barker Barambah	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
2	Bowen-Broken Rivers	8 w	3 w	-	5 d	-	7 d	-	-	24 h	-	-	2 wd	6	5 wd	21 d
3	Boyne River & Tarong	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
4	Bundaberg	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
5	Burdekin Haughton	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	2 wd	10	5 wd	21 d
6	Callide Valley	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
7	Chinchilla	8 w	2 w	-	5 d	-				24 h	-	-	1 wd	6	5 wd	21 d
8	Cunnamulla Weir	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
9	Dawson Valley	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
10	Eton	8 w		3 w	2 d	-	-	72 h	5 wd	24 h	-	-	1 wd	10	5 wd	21 d
11	Julius Dam	Not relevant for irrigation pricing														
12	Lower Fitzroy	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
13	Lower Mary River	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
14	Maranoa River	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
15	Mareeba Dimbulah	6 m	4 w	-	-	5 d	-	72 h	5 wd	24 h	-	-	1 wd	10	5 wd	21 d
16	McIntyre Brook	8 w	2 w	-	5 d			48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
17	Nogoa Mackenzie	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
18	Pioneer	Subject to separate arrangements with Pioneer Valley Water Board														
19	Proserpine	8 w		3 w	7 d	-	-	-	-	24 h	-	-	2 wd	6	5 wd	21 d
20	St George	8 w	2 w	-	5 d	-	-	48 h	5 wd	24 h	-	-	1 wd	6	5 wd	21 d
21	Three Moon Creek	-					-	-	-	-	2 w	2 wd	1 wd		5 wd	21 d
22	Upper Burnett	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d
23	Upper Condamine	8 w	2 w	-	5 d	-	48 h	-	-	24 h	-	-	1 wd	6	5 wd	21 d

3. The Asset Management Planning Methodology

There are three broad activities in the asset management planning methodology:

1. The development of standards, processes and methodologies;
2. The development of whole of life asset maintenance strategies for each asset type (Object Type) and risk exposure;
3. The scheduling of maintenance and replacement works based on risk and condition knowledge.

Section 4 of this paper explores the interrelationship of these activities in developing whole of life plans for water infrastructure assets and scheduling of necessary work. Figure 3-1 provides an overview of SunWater's Whole of Life Asset Management Planning Methodology.

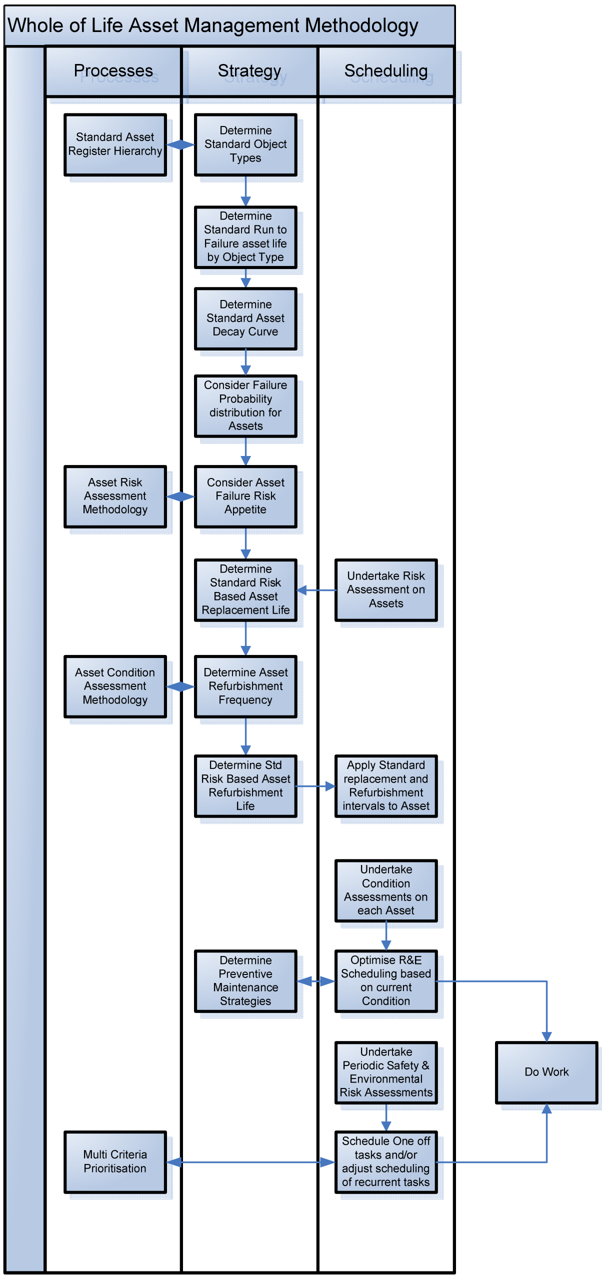

Figure 3-1 - Asset Management Methodology Process Flow

4. Explanatory Notes to the Planning Process

4.1 Developing Whole of Life Strategies

In managing its water infrastructure asset portfolio, SunWater takes a long term whole of life view. The development of whole of life strategies is based around each asset or object type.

The steps adopted by SunWater in the development of whole of life strategies are:

1. Determine Standard Object Types
2. Determine Standard Run to Failure asset life by Object Type
3. Determine Standard Asset Decay Curve
4. Consider Failure Probability distribution for Assets

5. Consider Asset Failure Risk Appetite
6. Determine Standard Risk Based Asset Replacement Life
7. Determine Asset Refurbishment Frequency
8. Determine Standard Risk Based Asset Refurbishment Life
9. Determine Preventive Maintenance Strategies

The whole of life maintenance plan for each asset is based on Reliability Centred Maintenance (RCM) techniques. Each plan includes specific types of maintenance tasks to manage failure based on risk. The types of tasks include:

- Survey
- Inspection
- Condition assessment
- Servicing
- Condition monitoring
- Failure finding
- Validation
- Refurbishment
- Replacement
- Corrective

These tasks are detailed in ***Appendix A-Maintenance Task Types***. The type of task performed on an asset will depend on the asset risk.

4.1.1 Determine Standard Object Types

An object type is a sub-class of asset which has specific characteristics and maintenance requirements. For example each type of pump (such as submersible, mixed flow and axial) would be considered as a separate object types. In some cases the size or manufacturing standard will impact on the life or maintenance needs of an asset and hence determine the object type. An example of this would be a large (>150mm) centrifugal pump versus a small centrifugal pump. These are separate object types.

The first step in developing whole of life plans across SunWater's portfolio was to define a standard set of object types that fully defined the assets in the portfolio. SunWater uses SAP-PM to store technical asset information and to plan both Opex and Capex work. The SAP-PM object code is used to identify the type of asset, e.g. Air Valve-VLVAIR. This code is used to inform refurbishments and replacements frequencies and as the basis for maintenance strategies and other specific tasks to be carried out to reduce or eliminate asset failure based on risk.

All technical assets have been assigned an object code in the asset register component of SAP-PM. The listing of standard object types is regularly reviewed and updated to reflect corporate learnings, changes in technology or additions to the portfolio.

4.1.2 Determine Standard Run to Failure asset life by Object Type

Each object type has a standard life. This is defined as the mean time to failure for the particular object type installed and operated in typical (or average) conditions.

Ideally the standard life would be defined from an extensive history of recorded failures drawn from a large sample size and statistically analysed. However the reality is that SunWater has a limited data set of failures and the portfolio has only a statistically small number of most object types. Also most utility organisations do not publish asset failure data. Consequently SunWater has adopted a standard life for each object type based on the available maintenance histories, literature review of public domain information and the collective engineering and technical experience of staff and consultants.

The standard life is also called the low risk life of an asset.

An important concept in the development of whole of life plans is an understanding that, by definition, there is a 50% probability that a particular asset will fail before it reaches its standard life.

4.1.3 Determine Standard Asset Condition Decay Curve

The condition of each asset will deteriorate over its service life. Depending on the object type, service life can be defined in terms of age, number of operations, time in operations, number of loading cycles etc. Figure 4-1 shows the standard asset condition decay curve adopted by SunWater. The asset life has been standardised and is expressed as a percentage. The condition is based on SunWater's condition assessment rating on a scale of 1 to 6 with 1 being an as new condition whilst 6 is a failed condition (refer section 4.2.3.)

The standard asset condition decay curve was developed in about 2006 as part of the Asset Management Process Improvement Program (AMPIP) with the aid of Indec Consulting Pty Ltd. The program developed a standard decay curve formula that is applied across the organisation's assets.

Although it could be argued that different object types would decay in different ways the standardised curve has been found to be reliable in most circumstances. As a future improvement opportunity SunWater will undertake detailed analysis of historic condition and maintenance data to develop a family of standardised decay curves for different asset classes.

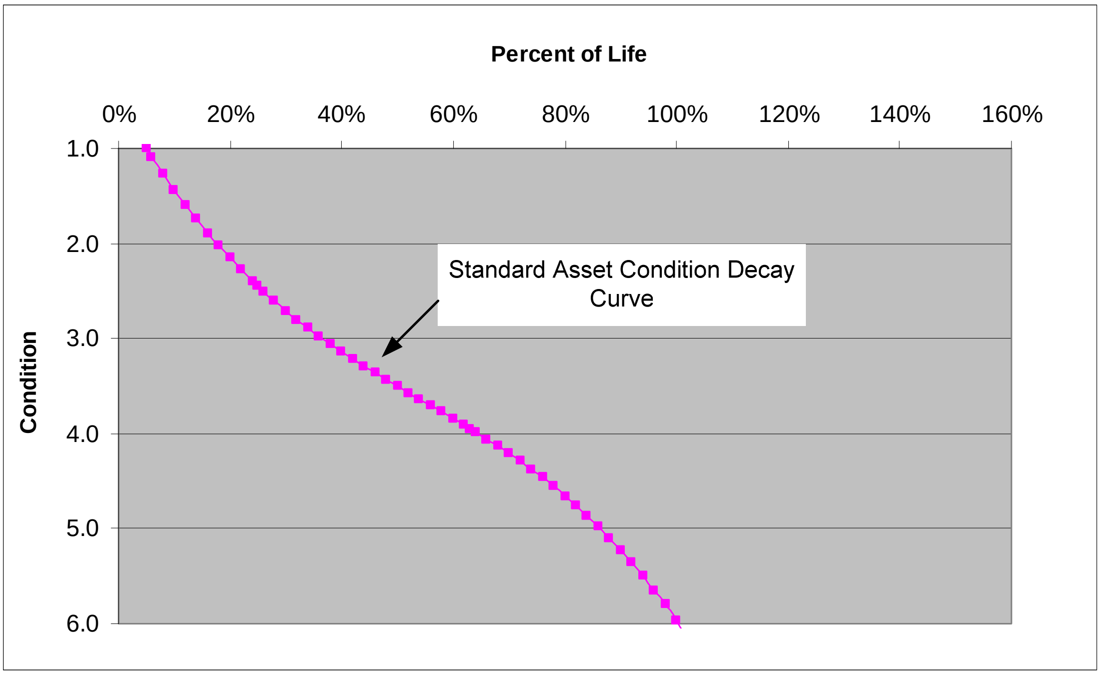

Figure 4-1: Standard Asset Condition Decay Curve

4.1.4 Consider Failure Probability distribution for Assets

As discussed in section 4.1.2 the standard low risk life of an asset is the average life expectancy. In reality across a sample of the same object type some individual assets will fail prior to the average life and some after. If there were a sufficiently large sample of a particular object type it would be possible to plot a failure distribution as shown in Figure 4-2. The actual shape of the failure distribution for a particular object type may or may not be a normal distribution, however it will have a spread of failures either side of the mean. One of the characteristics of a failure distribution is that the greater the standard distribution of the distribution the less the certainty that exists over the predicted life of a particular asset. However what is certain is that the closer an asset gets to its standard life the greater the probability that the asset will fail as demonstrated in Figure 4-3.

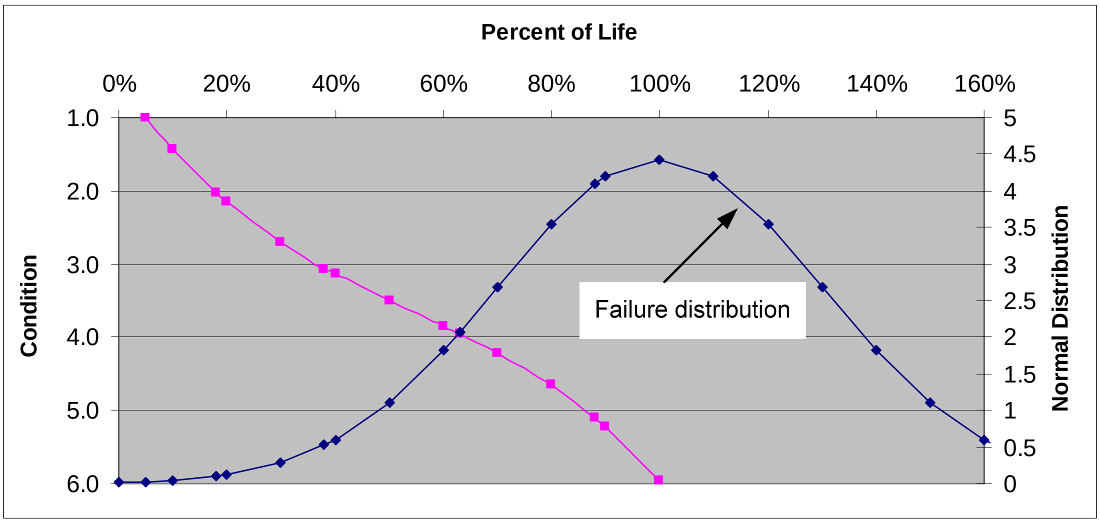

Figure 4-2: Asset Failure Distribution

The actual failure distribution for most object types is unknown however research has identified, for example the standard deviation for failures of centrifugal pumps can be as high as 40%. An important concept for SunWater's approach is that there is a relationship between life, condition and probability of failure. As the condition of an asset can be measured and monitored it is possible to predict failure probability from the condition of a particular asset. Figure 4-4 demonstrates that based on the standard asset condition decay curve, an asset can be expected to reach condition 3 by the time it has reached 38% of its standard life. Table 4-1 demonstrates how the probability of failure increases the higher the standard deviation of the failure distribution. If, for example, a pump was deemed to be of high risk to supply continuity and it was planned to replace the centrifugal pump (standard deviation 40%) when it was just at 38% of the standard life at condition 3 so as to avoid a failure, the pump still has a 6% probability of failing prior to planned replacement.

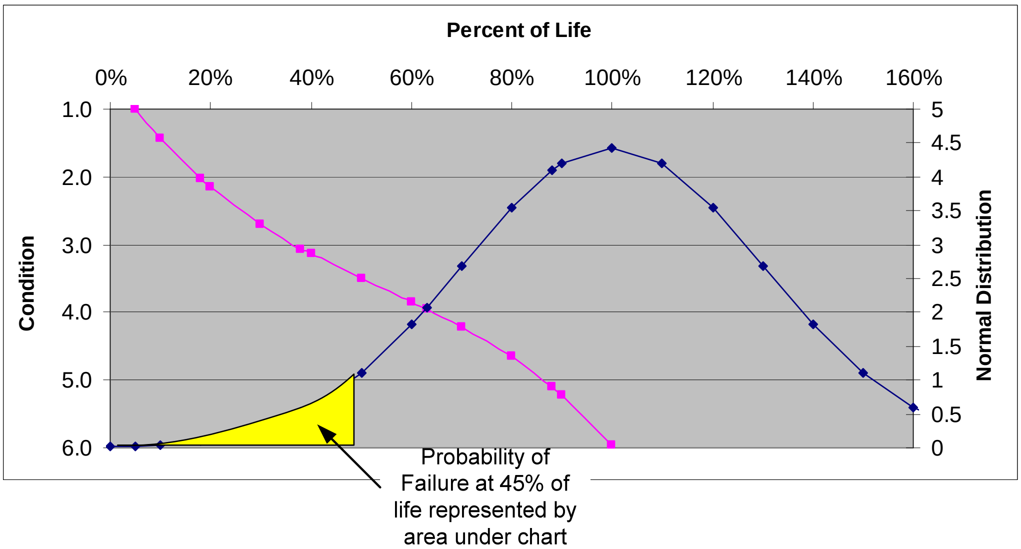

Figure 4-3: Asset Probability of Failure

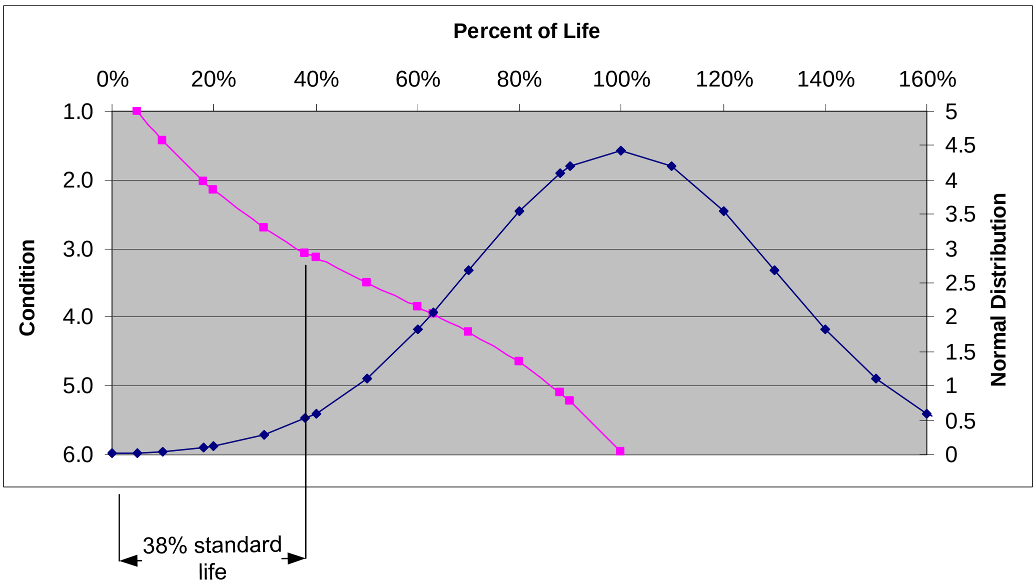

Figure 4-4: Relationship between Age and Condition

Table 4-1: Varying Probability of Failure at 38% of Life with Standard Deviation of failure distribution

Std Deviation	20%	30%	40%	50%	60%
Probability of Failure at 38% of life	0.1%	1.9%	6%	11%	15%

4.1.5 Consider Asset Failure Risk Appetite

As discussed in section 4.1.4 above, the older an asset, the further the condition of that asset will decay, and the greater the probability that that asset will fail. SunWater considers the consequences if a particular asset were to fail. In many cases the consequences of a failure will be minor in terms of supply continuity and other business risks due to the nature of the asset (eg a customer meter) or built in redundancy (eg a standby pump within a pumpstation), or ease of repair. Where the consequences of failure are minor SunWater will accept the risk of the asset failing in service and will replace or repair the asset once it fails. However as the consequences of a particular failure increases the less acceptable that failure becomes. This section outlines how SunWater has defined the approach for accepting the risk of asset failures.

As outlined in section 4.2.2 SunWater has adopted a semi-quantitative approach to asset risk assessments.

Risks have been assessed for each asset across five categories namely:

- Workplace Health & Safety
- Environment
- Financial
- Production/Operations
- Stakeholder Relations

Risk scores are recorded for each asset in the Work Management System (WMS) of SAP-PM.

It should be noted that the risk category of Production/Operations relates directly to the impact on SunWater's ability to supply water to customers and meet service standards. The consideration of this risk category as part of the planning methodology ensures that delivery against agreed customer service is a key driver in the asset plans adopted. For example if an asset was assessed as posing a high risk of SunWater not being able to meet service standards then it would attract a high priority in the maintenance program.

It is also important to understand that the financial risk category considers the cost of repairs and replacements.

Figure 4-5 shows how SunWater has determined generic strategies based on where that asset plots on the risk curve. There are 3 generic strategies that can be adopted:

1. Run to Failure – repair or replace when necessary
2. Condition monitor – schedule maintenance based on assessed condition
3. Condition Monitor and Risk Mitigation (avoidance) - schedule maintenance based on assessed condition plus adopt additional measures to mitigate against (avoid) failure

The first strategy is adopted for assets that are assessed as low or medium risk where the consequence score is less than or equal to 8 (refer section 4.2.3). The second strategy above applies where the asset has been assessed as medium or low but where the consequence of failure is higher at a score greater than 8. The third strategy applies to assets assessed as high or extreme risk.

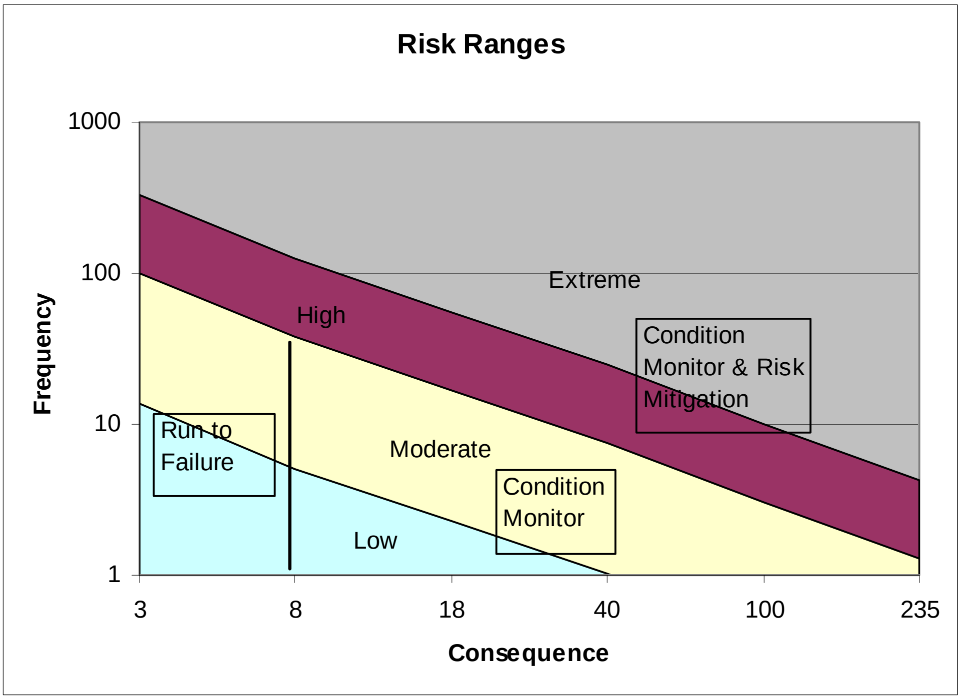

Figure 4-5: Asset Risks and Generic Strategies

Risk is the potential to incur cost (tangible or intangible). As the risk of an asset increases the annualised cost of failure also increases. The higher the risk the greater the desire to avoid the failure. This desire is manifest in two key approaches to SunWater's asset management planning methodology. The first approach is the higher the risk posed by an asset the earlier refurbishment or replacement will be scheduled to avoid the incurrence of the failure cost. The second approach is that the higher the risk the higher the priority afforded to the scheduling of the intervention work (refurbishment or replacement). Figure 4-6 shows the SunWater risk matrix with the asset strategies and priorities overlayed.

		Minor	Moderate	Significant	Major	Critical	Catastrophic
		$ 100,000	$ 1,000,000	$ 5,000,000	$ 15,000,000	$ 50,000,000	$ 100,000,000
Almost Certain	1.000	$ 100,000	$ 1,000,000	$ 5,000,000	$ 15,000,000	$ 50,000,000	$ 100,000,000
Likely	0.500	$ 50,000	$ 500,000	$ 2,500,000	$ 7,500,000	$ 25,000,000	$ 50,000,000
Possible	0.200	$ 20,000	$ 200,000	$ 1,000,000	$ 3,000,000	$ 10,000,000	$ 20,000,000
Unlikely	0.050	$ 5,000	$ 50,000	$ 250,000	$ 750,000	$ 2,500,000	$ 5,000,000
Rare	0.015	$ 1,538	$ 15,385	$ 76,923	$ 230,769	$ 769,231	$ 1,538,462
Very Rare	0.002	$ 200	$ 2,000	$ 10,000	$ 30,000	$ 100,000	$ 200,000
Extremely Rare	0.001	$ 50	$ 500	$ 2,500	$ 7,500	$ 25,000	$ 50,000

Asset Management Strategy Planning Priority	
A (Extreme)	
B (High)	
C (Medium)	
D (Low)	

Figure 4-6: Asset Strategies and Risk Matrix Zones

Table 4-2 below summarises SunWater's policy for scheduling intervention work (refurbishment or replacement) to reduce the probability of unacceptable asset failures. This table is interpreted, for example, for an asset assessed as high risk, refurbishment or replacement will be scheduled when the condition is forecast to decay beyond condition 4.

Table 4-2: Asset Risk and Condition Intervention Policy

Asset/Business Risk	Maximum Condition Score
Extreme	3
High	4
Low to Medium (Consequence >8)	5
Low to Medium (Consequence <=8)	Run to Fail

4.1.6 Determine Standard Risk Based Asset Replacement Life

SunWater has combined the standard asset decay curve, standard low risk life and the above risk policies to determine a standard replacement life for planning purposes for each object type based on the installed risk at a particular site. The standard replacement lives are detailed in Table 4-3, Figure 4-7, Figure 4-8, Figure 4-9, and Figure 4-10 below.

The adoption of these standard replacement intervals allows SunWater to produce replacement expenditure forecasts over an extended period.

Table 4-3: Standard Replacement Lives

Asset/Business Risk	Replacement Life (% of Standard Low risk life)
Extreme	38%
High	63%
Low to Medium (Consequence >8)	88%
Low to Medium (Consequence <=8)	100%

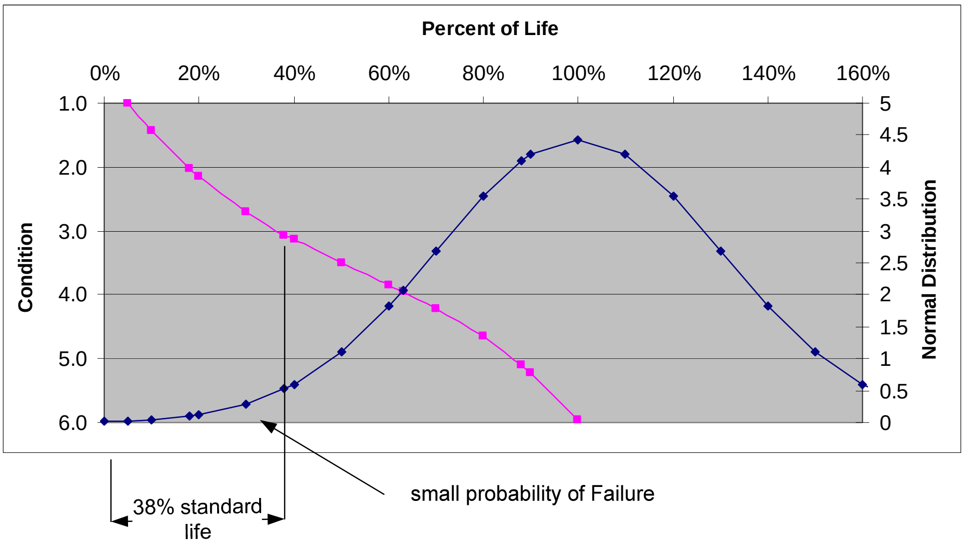

Figure 4-7: Extreme Risk Replacement Life

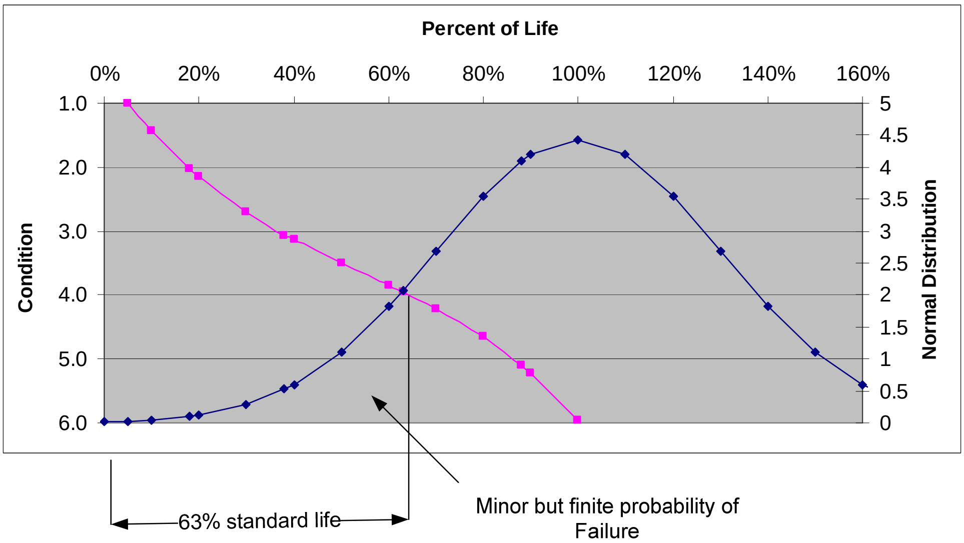

Figure 4-8: High Risk Replacement Life

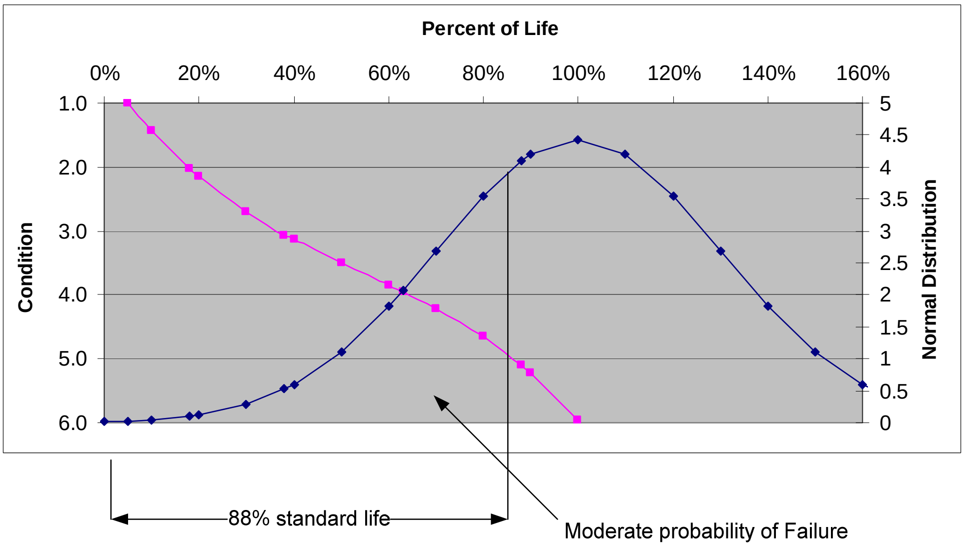

Figure 4-9: Medium Risk Replacement Life

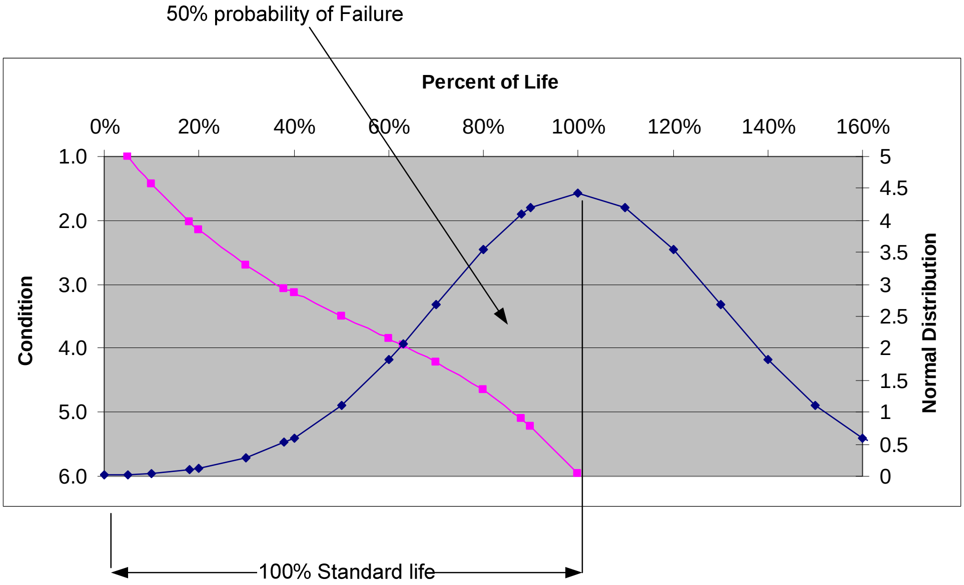

Figure 4-10: Low Risk Replacement Life

Cost Optimisation

In the determination of standard asset lives and refurbishment frequency SunWater has considered the optimisation of the cost of repair versus the cost of replacement. As discussed in section 4.1.7 below, the refurbishment frequency is the optimised frequency that will ensure that the asset meets service expectation over the standard life. Generally this assessment is based on experience and engineering judgement for setting the standard frequency. However, as discussed in section 4.3.4, prior to scheduling any major work a full options study in undertaken to ensure the most cost effective decision (repair or replace) is taken.

4.1.7 Determine Asset Refurbishment Frequency

So that assets remain in a serviceable condition and are able to deliver the required customer service standards throughout the adopted service life it is necessary on many object types to undertake significant periodic maintenance or refurbishment work. For example for a centrifugal pump to meet the necessary performance standards throughout its planned 60 year life it is necessary to refurbish that pump, on average 3 times (refurbishment frequency) during its life (refer Figure 4-11). Refurbishment will include repairs or replacement of major components such as impellors and bearings, corrosion protection etc.

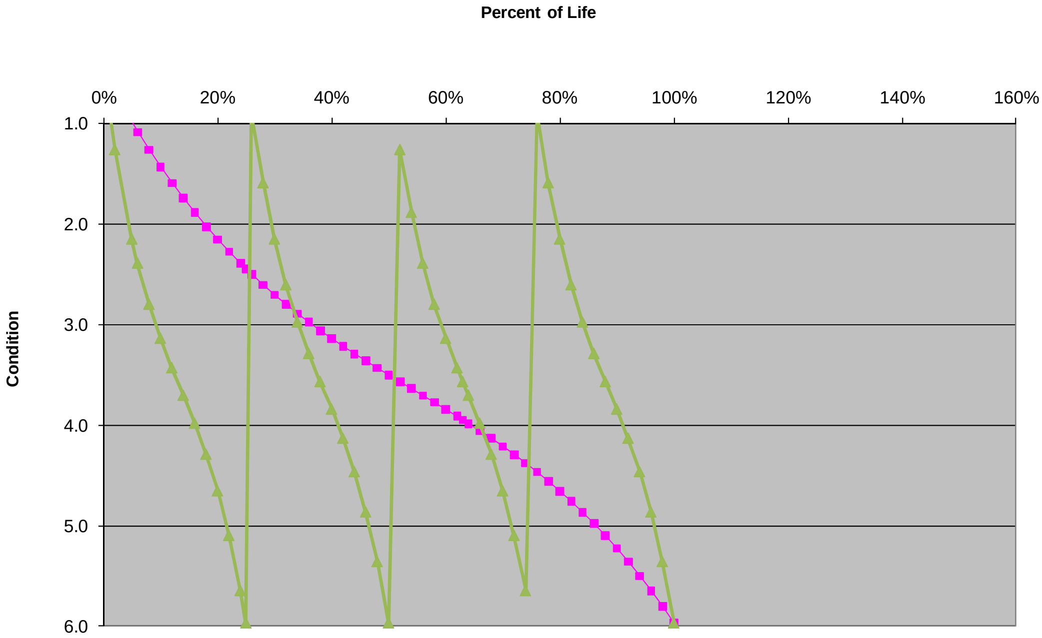

Figure 4-11: Asset Condition Decay between refurbishments

Similarly to the determination of standard lives, ideally the refurbishment frequency would be defined from an extensive history of recorded maintenance drawn from a large sample size and statistically analysed. However the reality is that SunWater has a limited data set and the portfolio has only a statistically small number of most object types. Consequently SunWater has adopted a refurbishment frequency for each object type based on the available maintenance histories and the collective engineering and technical experience of staff and consultants.

The standard low risk asset refurbishment life is equal to the standard low risk replacement divided by the refurbishment frequency plus 1. In the example above 60 years/(3+1) equals 15 years.

4.1.8 Determine Standard Risk Based Asset Refurbishment Life

It should be noted from Figure 4-11 that each refurbishment will be targeted to address one or more aspects (refer section 4.2.3) of a particular asset the condition of which has deteriorated to an unacceptable level. The decay of each condition aspect is assumed to decay according to standard asset condition decay curve where 100% is the asset refurbishment life.

Similar risk policies have been applied to refurbishment lives as those applied to replacement lives and are outlined in Table 4-4 below.

Table 4-4: Standard Refurbishment Lives

Asset/Business Risk	Refurbishment Life (% of Standard Low risk Refurbishment life)
Extreme	38%
High	63%
Low to Medium (Consequence >8)	88%
Low to Medium (Consequence <=8)	100%

4.1.9 Determine Preventive Maintenance Strategies

In line with RCM approaches, SunWater has developed a program of preventive maintenance strategies for facilities in each service contract. The program consists of inspections, surveillance, condition monitoring and servicing of assets. The purpose of the program is to monitor the performance and condition of assets to ensure that they continue to meet the agreed service standards and to detect when assets are operating outside of acceptable parameters so that corrective action can be taken or scheduled.

The program is organised into maintenance schedules structured around facilities in similar geographic areas, planned frequency of task and crew skill sets required to undertake the tasks. For example there might be a maintenance schedule for servicing of mechanical equipment at the Haughton pump stations. This schedule will have different tasks scheduled on a monthly frequency and additional tasks scheduled on a quarterly or annual frequency. This will be a separate schedule to say condition monitoring of electrical equipment at the same pump stations due to the need to assign the work to a different maintenance crew with a different skill set.

The program is stored in SAP-PM. On a monthly basis a program called “Deadline Monitoring” is run in each area to produce the work orders for each maintenance item scheduled in the next planning period. The work orders are attached to detailed work instructions and assigned to individual crews. The work instructions detail the tasks to be undertaken. Work crews undertake the work defined in the work instructions and record any necessary readings, actions, observations or corrective actions undertaken or that need to be scheduled. The completed work order and work instructions are returned to the scheduler for capture of maintenance histories and close out.

The preventive maintenance program and detailed work instructions have been developed over time with the collective experience of operators, trade qualified maintenance staff, technical and engineering staff. The program has been critically reviewed by independent consultants Parsons Brinckerhoff and updated accordingly. The consultants findings are documented in a separate report.

Further refinement of the preventive maintenance program has been identified as an opportunity for further refinement. SunWater has plans in place to roll out formal RCM methodologies over the next two to three years. One of the outcomes of this roll out will be further improvement to the preventive maintenance program.

4.2 Policy and Standards

SunWater has developed and documented a number of policies and standards to provide guidance to staff and consultants as they apply the asset management planning methodology. These processes include but are not limited to:

1. Standard asset register hierarchy
2. Asset risk assessment methodology
3. Asset condition assessment methodology

The following sections provide an outline of these approaches

4.2.1 Standard Asset Register Hierarchy

SunWater uses the SAP-PM Technical Asset Hierarchy structure, i.e. parent-child relationship structure, and has developed its own standard for this structure. The structure can be drilled down to a final level representing the technical asset that is to be maintained. Although all levels in the structure are assigned an object code, maintenance strategies are only applied to the object code representing a planning asset.

SunWater uses the standard SAP objects of Functional Location and Equipment to identify the levels in the hierarchy structure. A functional location can be basically defined as a physical location and equipment as the equipment located at that address. However, SunWater has not used this concept holistically and in the majority of cases a functional location will be the planning asset. The functional location is therefore assigned an appropriate object code for a planning asset.

The hierarchy has developed to meet several business requirements in addition to whole of life planning. Although the existing hierarchy is a solid platform for developing and maintaining whole of life plans there are some inconsistencies and sub-optimal structures for planning. SunWater has an improvement program in place to refine the current data to ensure optimal planning outcomes.

4.2.2 Asset Risk Assessment Methodology

This risk assessment process is used to set priorities for expenditure for the SunWater replacement and refurbishment program as described above, and to categorise assets into maintenance strategy grouping (i.e. run to failure, condition monitor etc).

Risks are assessed for each asset across five categories namely:

- Workplace Health & Safety
- Environment
- Financial
- Production/Operations
- Stakeholder Relations

The latter 3 categories are termed Asset/Business risks and are the risks that are combined with condition to determine maintenance priorities as described in section 4.1 above. Asset/Business risk assessments are undertaken for all existing assets and for any new assets created or purchased. Risk assessments are required to be reviewed and/or redone when there is a material change in use such as an agreed change to service standards or when an asset is modified. The context or assumption when undertaking these assessments is that risk is assessed assuming the asset is in an as new condition and the approved maintenance program is being implemented.

Safety/Environmental risk assessments are undertaken at any time when a hazard has been identified or following the implementation of risk mitigation measures.

All risk assessment and condition assessment scores are recorded in the SAP-PM via the Work management system (WMS).

Personnel involved in the refurbishment planning and ongoing maintenance management processes are trained in the principles and methodology.

The following functional requirements are considered when undertaking a risk assessment of an asset within SunWater:

- maintenance of technical functionality to achieve required service performance outcomes – consider all relevant technical failure modes
- achievement of required service performance in the event of natural events such as flood, storm, lightning, bush fire, earthquake
- ability to meet dam safety requirements
- ability to meet ROP compliance requirements
- ability to comply with workplace health and safety (WH&S) including public safety and regulatory requirements
- ability to comply with environmental management and regulatory requirements

4.2.2.1 Asset/Business Risk

Risks assessed in the categories of Finance, Production/Operations and Stakeholder relations. Risks are assessed based on the assumptions of the asset being in an as new condition with current approved maintenance strategies fully implemented.

4.2.2.2 Safety/Environmental Risks

Risks assessed in the categories of Safety or Environment will be in accordance with the relevant standards in the WHS and/or EMS. Risks are assessed on the basis of the asset being in its current condition.

4.2.3 Asset Condition Assessment Methodology

SunWater uses asset condition information to adjust the frequencies for replacements and refurbishments of an asset. Condition assessment information, in the form of a numerical score, is recorded for a planning asset on a separate tab in the Work Management System (WMS) Planning component of SAP-PM.

The asset knowledge acquired through condition monitoring, condition assessment and risk assessments combine to provide a powerful tool for a formal means of prioritising expenditure that is consistent and transparent. It is generally recognised that a risk and condition based approach is an integral part of good management practice that promotes a responsible and informed decision-making means for prioritising expenditure on refurbishment and maintenance. The higher the risk and the poorer the condition, the more important it is to refurbish a particular asset (refer section 4.1).

The use of the risk score in combination with the condition assessment scores provides the necessary tools for prioritising work.

Each significant aspect of each asset is assigned a condition rating. The condition rating is a number in the range from 1 to 6, which provides a simple assessment of the condition of an asset. Condition rating 1 is “as new” whereas rating 6 is a “failed” condition. The Condition ratings refer to the condition of the asset with respect to safety, structural condition, performance (function), fitness for purpose etc. A valve, for example, may have a separate condition rating for each of the following aspects: structural integrity; metal work; mechanism, operability, and fitness for purpose. The scores are based on a criteria matrix developed for each asset type. Table 4-5 below provides a generic description of what these rating mean with respect to the broad life cycle of an asset.

Rating	Description of Condition
1	Perfect, as-new condition
2	Minor defects only
3	Moderate deterioration with minor refurbishment required to ensure ongoing reliable operation.
4	Significant deterioration with substantial refurbishment required to ensure ongoing reliable operation.
5	Major deterioration such that asset is virtually inoperable.
6	Asset has failed and is not operable.

Table 4-5: Condition Assessment Ratings

The condition scores for each asset in combination with the risk scores and mean time to failure give the asset manager a comprehensive picture for the planning of the refurbishment spend.

4.2.3.1 Assessment Criteria

Each asset type has up to six assessment aspects that relate to the asset (eg structural integrity, erosion, metal work, etc). Assessment Criteria Sheets give a guideline as to what score different asset aspects should be given depending on the condition. The criteria are a mix of subjective and objective measures. SunWater’s continuous improvement program as seen a progressive increase in objective measures and corresponding reduction in subjective measures. Shown below is an example of the assessment criteria sheet for a pump.

M1: PUMP

Pumps
Cooling Water Pumps, Main Supply Pumps, Submersible Pumps in a non submersible application (i.e. Clare B, Millaroo B and Dalbeg B)

Aspect	Assessment Parameter	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Rating 6
External Coating / Surface / Bolts	Cracking / Flaking / Corrosion as per AS/NZS 2312:2002	Coating as new, no defects.	Coating showing no signs of any visible deterioration.	Coating showing signs of aging, but no visible defects.	Coating loss / deterioration exposing steel. Steel surface corroding / rusting. Surface area affected less than 0.5%	Coating loss / deterioration exposing steel. Steel corroding / rusting. Surface area affected is between 0.5% and 2%.	Coating or surface failure. Surface area affected is greater than 2%
Foundation and/or Baseplate	Physical condition	As new condition	No visible deterioration	Some parts showing minor signs of deterioration.	Obvious signs of deterioration such as cracking and/or spalling of concrete; corrosion and/or cracking of steel. Requires attention	Deterioration advanced, requires immediate attention to restore structural support	Components have failed and no longer offer structural support
Pump	Vibration (based on AS 2625.1-2003)	Overall is < 1.4 mm/s, Brg Conditon < 1 G's	Overall is < 2.8 mm/s, Brg Conditon < 1 G's	Overall is > 2.8 mm/s, Brg Cond > 2 G's	Overall is > 4.5 mm/s, Brg Cond > 4 G's	Overall is > 7.1 mm/s, Brg Cond > 6 G's	Overall is > 11 mm/s, Brg Cond > 6 G's
Flow and Discharge Pressure	Comparison to rated values	As new condition	Performing as per nameplate data	> 1% drop in performance compared to nameplate data.	> 2.5 % drop in performance compared to nameplate data.	> 5 % drop in performance compared to nameplate data.	> 7.5 % drop in performance compared to nameplate data. Pump no longer fulfilling required performance.
Casing Internals & Gland	Physical condition	As new condition	No visible deterioration	Some parts showing minor signs of deterioration, such as leakage.	Obvious signs of deterioration such as leakage and/or corrosion. Requires attention	Deterioration advanced, requires immediate attention to restore operational function.	Components have failed and pump unit no longer able to be used.
Pump Unit	Age (% Of Refurbishment Life)	< 10%	< 25%	< 50%	< 75%	> 75%	Failed / Unrepairable / Obsolete

Table 4-6: Example Assessment Criteria Sheet

Ratings

For condition assessments, each criterion can be rated from one (1) to six (6), one (1) being near new and six (6) being totally failed and not functional. A rating is given to each assessment aspect where relevant.

The individual higher scores will be used in determining planned refurbishments.

4.3 Scheduling

The methodology described in section 4.1 provides the long term forward program of work based on standard risk based replacement and refurbishment lives. In the near term the scheduling of work is adjusted based on the current condition of the asset. The scheduling methodology is outlined in the following sections.

4.3.1 Undertake Risk Assessment on Assets

Asset Management staff have been trained on how to undertake asset risk assessments in accordance with the methodology described in section 4.2.2. During the period 2006 to 2008 SunWater undertook portfolio wide risk assessments which were stored in SAP WMS. Since 2008 additional risk assessments have been undertaken to address specific issues or when risk mitigation strategies are altered or when new potential risks are identified.

4.3.2 Apply Standard replacement and Refurbishment intervals to Asset

SunWater recently changed the delivery model for asset management across the organisation to be a centre lead model as compared to the old regional model. As a result of this change SunWater undertook a portfolio wide review of the standard replacement and refurbishment lives described in section 4.1. Upon completion of this review the scheduled replacement and refurbishment dates were updated across the portfolio to reflect the new standard. The updated program was loaded into SAP WMS.

4.3.3 Undertake Condition Assessments on each Asset

Condition assessments of assets are undertaken at the completion of any corrective maintenance or refurbishment work or in accordance with a predefined schedule. The scheduled frequency of assessments is set by object type based on the risks and potential rate of decay of the object type and compliance requirements. For example a minor civil structure may have an assessment frequency of 10 years where as pump may be 2 years due to the greater potential for change over a shorter period. Lifts and dams however have an annual frequency due to risk and compliance requirements.

4.3.4 Optimise R&E Scheduling based on current Condition

Section 4.1.3 describes SunWater's standard asset condition decay curve. Sections 4.1.6 and 4.1.8 describe the adopted policies with respect to how far the condition of a particular asset needs to decay to prior to replacement or refurbishment. Following these procedures ensures that the planned maintenance program is a "Just in Time" and cost optimised program.

It is quite probable that the actual assessed condition of a particular asset will vary from the predicted condition from the standard decay curve (Figure 4-12). When this variation occurs the decay curve is effectively transposed to match the assessed condition (Figure 4-13). The replacement or refurbishment task is then rescheduled based on when the condition is predicted to meet the condition criteria based on the adjusted curve for the asset (Figure 4-14).

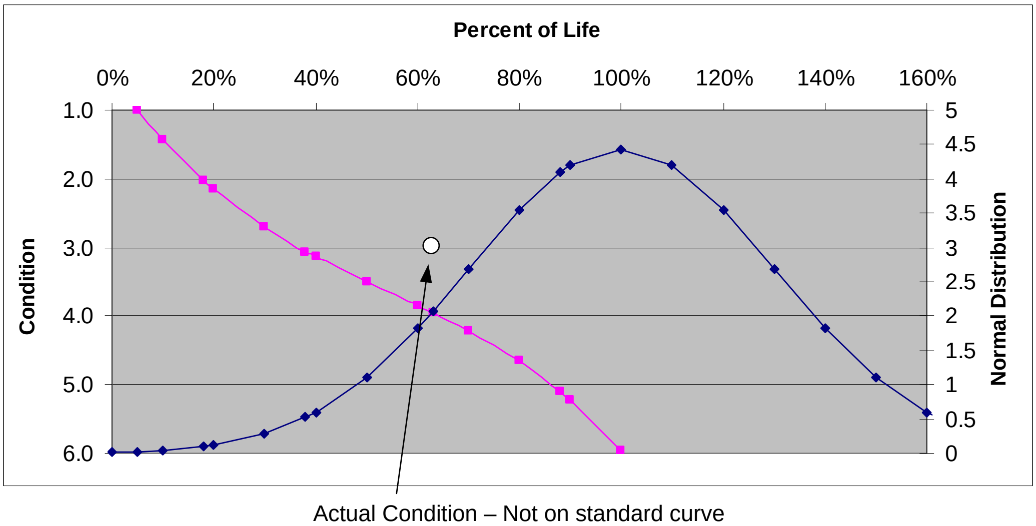

Figure 4-12: Actual Condition varies from standard curve

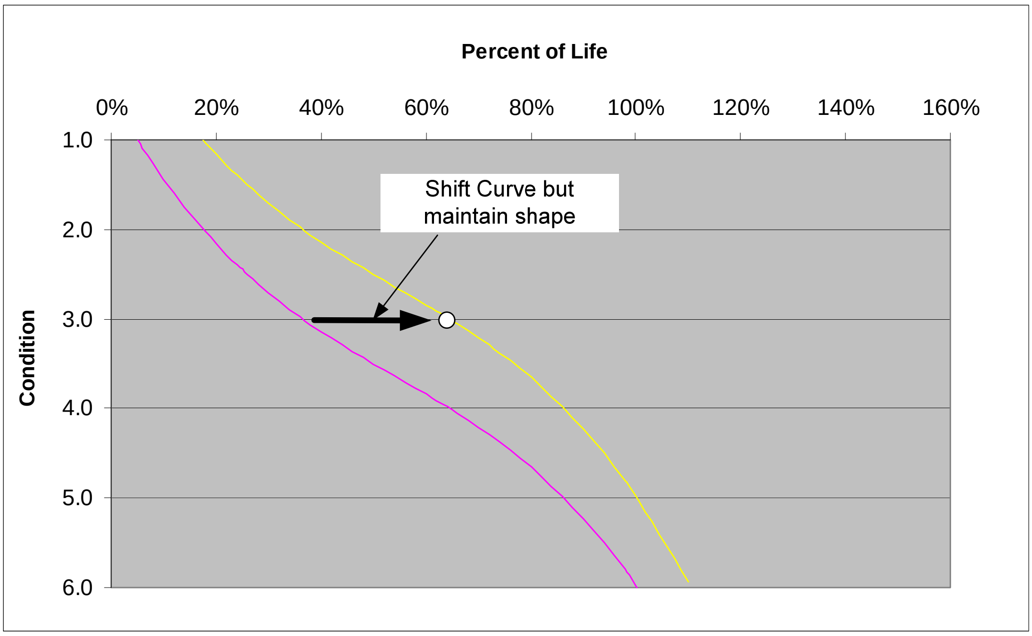

Figure 4-13: Shift decay curve to match actual condition

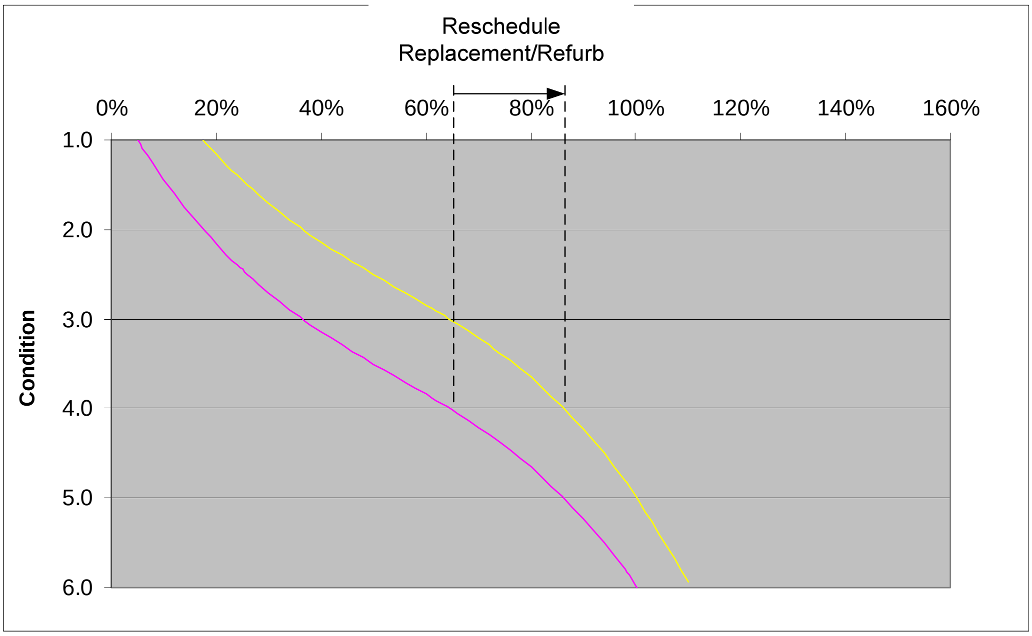

Figure 4-14: Reschedule Work to match adjusted curve

An important step in the process once a major task is scheduled is the undertaking of an options analysis. An options analysis considers all repair and replacement options, including "do nothing" and "decommission". The analysis is usually based on preliminary design engineering estimates and included an NPV analysis of the options. An options analysis is generally undertaken for all tasks that exceed $50,000. This process is designed to ensure that the costs are optimised.

4.3.5 Undertake Periodic Safety & Environmental Risk Assessments

SunWater undertakes regular safety and environmental risk assessments as part of site inspections, and audits the results of these assessments are stored in SAP-WMS and used in the annual review of the works program.

4.3.6 Schedule One off tasks and/or adjust scheduling of recurrent tasks

In addition to the condition based replacement or refurbishment works (refer section4.3.4) other identified risks (refer section 0) require additional work for adequate mitigation. An example might be where a safety risk has been identified whereby staff could fall from an unacceptable height. The mitigation strategy could be the installation of new handrails. On an annual basis risks stored in SAP-WMS are reviewed. Any high or extreme risk that does not have a maintenance item identified as a suitable mitigation is flagged. Asset Management planners undertake a review of suitable options and schedule the appropriate works.

Prioritising all of the work identified is not as simple as running a report in WMS. It is a process that involves multi criteria decisions and judgement calls. The Planner must balance the relative importance of doing work on a high business risk asset in moderate condition with a low risk asset in poor condition with a high safety risk asset. Which project comes first? To assist the following criteria has been developed and applied

Priority	Condition Based			Risk Based (Safety & Environment)		
	Condition Score	Asset Risk Rating	Consequence Score	Risk Rating	Consequence Score	Rectification Cost
A	>2	Extreme	NA	Extreme	NA	NA
B	>3	High	NA	High	NA	NA
C	>4	Low to Medium	>8	Medium	>8	<$100K*
D	6	Low to Medium	<=8			

Table 4-7: Multi Criteria Prioritisation

* Guide only

5. Storage and Maintenance of Asset Management Plans

The final output of the SunWater Asset Management planning process outlined in this document are Network Services Plans (NSPs) for each of the water infrastructure service contracts under management.

The inputs such as asset information, condition and risk, and the detailed work programs are all stored within the corporate SAP system. There are three key areas of SAP containing different aspects of the information and plans:

- SAP-PM Asset Register – The listing of assets information and key asset characteristics;
- SAP PM – Maintenance Planning – Detailed maintenance schedules and task lists for the routine preventive maintenance program; and,
- SAP WMS – A customised module for work management planning and governance.

The SAP WMS system has been developed by SunWater to support its approach to asset management. The system is developed on the philosophy that the asset planner should be able to access all relevant asset information from the one screen. The WMS system contains the risk assessments for the asset as well as the complete condition record. The planner updates the WMS system with the schedule for replacements and refurbishments for each asset. The system also provides a facility to develop cost estimates for the planned work.

The WMS system can produce numerous report including long term cash flow programs.

The WMS system is a dynamic system meaning that planners are continuously improving and updating the forward program as information becomes available.

6. Appendix A - Maintenance Task Types

As part of the maintenance strategies, SunWater uses the following specific types of maintenance tasks to manage technical assets:

- Survey
- Inspection
- Condition assessment
- Servicing
- Condition monitoring
- Failure finding
- Validation
- Refurbishment
- Replacement
- Corrective

Survey

A survey involves a brief check on an asset to identify any evident failures.

Examples:

A weekly pump station survey to identify any problems.

A pipeline survey to identify any leaks.

Inspection

A detailed inspection of an asset to determine if it is may fail and to determine a time when it should be repaired.

Examples:

Inspect specific equipment in a pump station for evidence of failure.

Condition Assessment

A condition assessment involves the recording of condition values to for entry in WMS Planning.

Servicing

Servicing involves the lubrication or servicing of assets for the purpose of maintaining the life of an asset.

Examples:

change oil in a gearbox.

grease a component.

replace packing.

Condition Monitoring

Condition monitoring involves checking equipment for potential failures.

Examples:

vibration analysis.

oil analysis.

thermographic checks.

Failure Finding

Failure finding involves the checking of specific types of assets to determine if they have failed.

Examples:

checking that a standby pump operates.

testing trip functions.

Validation

Involves carrying out tasks to determine the continued accuracy of a meter in accordance with AS 4747.

Refurbishment

Refurbishment involves the restoration of an asset to a standard that will prolong the life of an asset.

Examples:

overhaul of a pump.

rewinding of a motor.

Replacement

Replacement involves the replacement of an asset with a new asset.

Examples:

replace a pump.

replace a meter.

Corrective (run to failure)

Run to failure implies that the asset is used until it or part of it fails. It is then repaired through corrective maintenance.