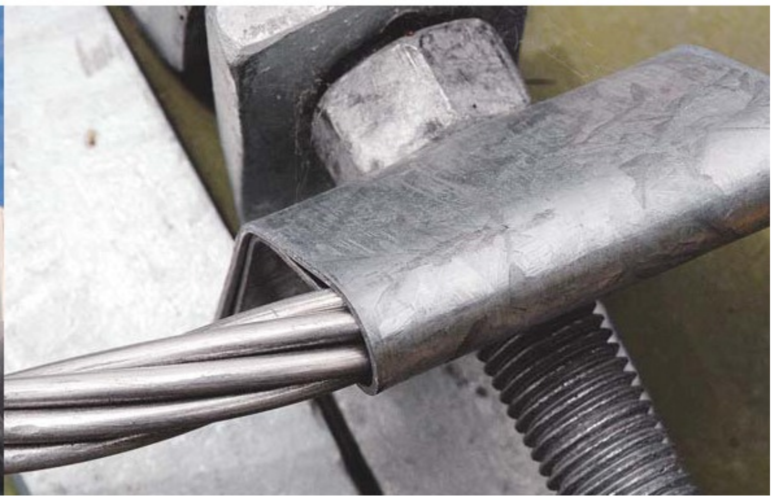
EnergyAustralia

Submission on the AER's public lighting supplementary draft decision

April 2009


BEWARE
NO.1
TRANSFORMER
132/11KV



Contents

CONTENTS **1**

1. PROCESS TO DATE **2**

1.1 Law and Rule requirements 2

1.2 Our June 2008 proposal 2

1.3 AER's draft determination 3

1.4 Our response to the draft determination with respect to public lighting 3

1.5 AER's supplementary draft determination 4

1.6 Our response to the March 2009 draft decision 4

2. ENERGYAUSTRALIA'S RESPONSE **6**

2.1 Representation of EnergyAustralia's information 6

2.2 EnergyAustralia's annuity approach 6

2.3 Reasonable opportunity to recover costs 9

2.4 Assumptions 12

2.5 New problems as a result of AER decision to use asset roll forward 16

2.6 Inconsistencies and errors 19

ATTACHMENTS **21**

1. Process to date

- EnergyAustralia has not revised its June 2008 proposal with respect to the control mechanism for the construction and maintenance of public lighting (referred to here in this submission as public lighting services) but it has updated some inputs into the control mechanism.
- In addition to setting out EnergyAustralia's updated inputs for the purposes of its proposed control mechanism, this Chapter is EnergyAustralia's submission in relation to the AER's draft decision NSW Draft Distribution Determination 2009-2010 to 2013-14 Alternative Control (public lighting) services, published by the AER on 17 March 2009
- This Chapter together with Chapter 7 of Part II of the June 2008 proposal is EnergyAustralia's current proposal in relation to public lighting services and should be considered in conjunction with EnergyAustralia's submission in Chapter 7 of Part II of EnergyAustralia's January 2009 Revised Regulatory Proposal and Interim Submission

1.1 Law and Rule requirements

Making a distribution determination

Transitional Rules require the AER to make its determination with respect to public lighting services[1] in accordance with clause 6.2.5 (c)(2) and (d) and clause 6.2.6 of the Transitional Rules. Clause 6.2.5 specifies what a control mechanism for alternative control services may consist of and the matters the AER must have regard to when deciding on such a control mechanism.

As an alternative control service, the public lighting component of the AER's distribution determination is predicated on a decision on the control mechanism for alternative control services and a decision on how compliance with that control mechanism is to be demonstrated.[2] It may also be predicated upon a decision in which the AER decides any other appropriate amounts, values or inputs.[3] The AER's discretion in making its distribution determination on public lighting is subject to clause 6.12.3 of the Transitional Rules and must set out the basis and rationale for the decision in accordance with clause 6.12.2 of the Transitional Rules.

The AER must also take into account the revenue and pricing Principles set out in section 7A of the NEL when it is exercising discretion in making those parts of a distribution determination relating to alternative control services[4].

1.2 Our June 2008 proposal

In June 2008, EnergyAustralia proposed a control mechanism which consisted of a schedule of prices for each type of public lighting asset used to provide public lighting services. EnergyAustralia also proposed that the control mechanism inflate prices annually based on the most recent inflation information.

Our proposed control mechanism was consistent with the control mechanism set out in the AER's Statement on Control Mechanisms for alternative control services ACT and NSW published in February 2008. EnergyAustralia's proposal did however differ from the AER's statement of approach in that it put forward a different methodology for establishing the asset (investment) returns on which the control mechanism was to be based. EnergyAustralia's 'cost of service' approach used an annuity approach to derive investment returns on the annual value of the replacement cost in 2008, and an allocation of EnergyAustralia's forecast public lighting operating and maintenance expenditure.

In contrast the approach outlined in the AER's guideline calculated asset returns using a roll forward regulated asset based (RAB), similar to what is currently provided for standard control services.

EnergyAustralia's approach to allocating EnergyAustralia's forecast public lighting operating and maintenance expenditure was consistent with the AER's guideline.

[1] Clause 6.2.3B(b)(1) deems public lighting services to be a direct control service and further an alternative control service.
[2] Clauses 6.12.1(12) & (13)
[3] Clause 6.12.1(10)
[4] Section 16 National Electricity Law.

Since June 2008, the AER has requested a lot of detailed information about EnergyAustralia's public lighting business. The AER has also requested that EnergyAustralia calculate public lighting prices under various scenarios. We have fully complied with all requests for information and tried to assist the AER where possible, while always maintaining that we see no reason or evidence that would justify a move away from the approach that we originally proposed in June 2008.

This submission maintains the annuity method that we proposed in June 2008. However, EnergyAustralia has updated the model to include the most up to date information, including updated:

- Customer information
- Asset inventory
- CPI and labour escalation
- Discount rate consistent with that used in our revised proposal
- Updated historic operating expenditure and bulk maintenance program costs

These updates are contained in the annuity model, which is Attachment 3 and is submitted to the AER in confidence.

1.3 AER's draft determination

In November 2008, the AER published its draft decision *New South Wales draft distribution determination 2009-10 to 2013-14 and a Draft Distribution Determination* ("the AER's November Decision").

The AER's November Decision rejected EnergyAustralia's proposed control mechanism but it did not include a substitute control mechanism in a form required by clause 6.5.2 of the Transitional Rules.

Instead of imposing an alternative control mechanism on prices or revenues, the AER's November 2008 draft decision proposed only the preferred "form" of control mechanism for alternative control services. That being:

- A schedule of fixed prices in the first year of the next regulatory control period for assets constructed before 1 July 2009 and a schedule of fixed prices in the first year of the next regulatory control period for assets constructed after 30 June 2009
- A price path, such as CPI, for the remaining years of the regulatory control period.

The AER's draft decision set out the following process before it would make a decision on the actual prices to form the schedule of fixed prices:

- 16 February 2009 – DNSPs to calculate prices as specified by the AER's draft decision.
- 9 March 2009 – The AER would publish its proposed price schedules and seek submissions.
- 23 March 2009 – Interested parties would make submissions to the AER.
- April 2009 – The AER would make its final determination.[5]

1.4 Our response to the draft determination with respect to public lighting

EnergyAustralia did not revise its June 2008 proposal with respect to public lighting in response to the AER's Draft Determination as permitted by clause 6.10.3 of the Transitional Rules. This was because the AER had not completed its Draft Determination in relation to alternative control services. Without the actual control mechanism, EnergyAustralia could not assess the impact of the AER's Draft Determination. However, EnergyAustralia responded to the AER's Draft Determination in its *Revised Regulatory Proposal and Interim Submission* dated 14 January 2009 ("the Interim Submission").

In the Interim Submission, EnergyAustralia raised concerns regarding the incompleteness of the AER's November draft decision and requested that the AER "formally proceed to make a draft determination with respect to the control mechanism for public lighting".[6] We noted that this affected

---

[5] Page 345 of AER draft determination, Nov 2008.

[6] Page 172 of the revised proposal and interim submission.

our ability to make a submission on the draft decision and further restricted our ability to formally revise our proposal.[7]

Also the Interim Submission included additional information for the AER to take into account when completing its draft decision.

After receiving EnergyAustralia's Interim Submission, the AER requested further detailed information about EnergyAustralia's public lighting pricing model and the public lighting business. This information request included a specific request to calculate prices for public lighting services under certain assumptions. EnergyAustralia provided[8] this information to the AER on 9 March, 2009.

1.5 AER's supplementary draft determination

On 17 March 2009, the AER published its draft decision in relation to alternative control services ("the March 2009 draft decision"). In contrast to the AER's November 2008 draft decision, the March 2009 draft decision imposed controls on the price of public lighting services. This control mechanism was set out as follows:

For assets constructed before 1 June 2009:

- A schedule of fixed prices for the first year of the next regulatory control period for assets constructed before 1 July 2009 as set out in Appendix B to the draft decision; and
- A price path for the remaining years of the next regulatory period, calculated by applying 60 per cent of the NSW EGW real labour growth rates to maintenance costs and the draft decision forecast inflation rates used in table 3.11 of the draft decision.

For assets constructed after 30 June 2009:

- A schedule of fixed prices for the first year of the next regulatory control period for assets constructed after 30 June 20099, as set out in appendix B
- A price path for the remaining years of the next regulatory control period, calculated using the AER's draft decision on forecast inflation rates set out in table 3.11.

The effect of the AER's decision is that it rejected EnergyAustralia's proposed schedule of fixed prices and the underlying annuity model for assets constructed before 1 July 2009. The March 2009 draft decision substituted a schedule of fixed prices based on an approach using a regulatory asset base (RAB) roll forward.

With respect to assets constructed after 30 June 2009, the AER rejected EnergyAustralia's proposed schedule of fixed prices but not the underlying annuity model. The March 2009 draft decision adopted the annuity model but it substituted certain assumptions regarding construction costs and amended certain inputs.

1.6 Our response to the March 2009 draft decision

EnergyAustralia has previously raised concerns with the process leading up to, and including, the AER's March 2009 draft decision. These concerns are outlined in the Interim Submission and a letter from EnergyAustralia to the AER[10].

The AER's process which has only allowed EnergyAustralia ten business days to consider the AER's decision has severely compromised EnergyAustralia's ability to fully consider and respond to the AER's decision.

EnergyAustralia is also concerned with the way in which the AER has represented information that EnergyAustralia has

7 Page 172 of our revised proposal and interim submission.
8 EnergyAustralia also provided further public lighting information to the AER on January 20th, March 2nd, 10th and 11th

9 (Note: The AER's decision at page 49 appears to be incorrect as it refers to assets constructed *before* 30 June 2009 rather than *after* 30 June 2009)
10 Attachment 2: Letter from EnergyAustralia dated 26 March 2009). This letter is confidential and should not be made public without EnergyAustralia's consent.

provided the AER in response to the requirements of the AER's November 2008 draft decision and further requests received since that time. The information provided in response to the AER's information requests is presented incorrectly in the March 2009 draft decision as being part of EnergyAustralia's proposal.

EnergyAustralia does not agree with the AER's November 2008 draft decision or its March 2009 draft decision. EnergyAustralia's reasons for not agreeing with the AER's Complete Draft Determination[11] are explained in detail in this submission and include:

- the AER has not given adequate consideration to the information provided by EnergyAustralia and has unreasonably substituted its own inputs and assumptions
- the AER has not properly taken into account the revenue and pricing principles and in particular has not given consideration to whether it has provided EnergyAustralia with a reasonable opportunity to recover at least the efficient costs

Section 2.1 clarifies the status of EnergyAustralia's proposal and the information that EnergyAustralia has provided to the AER.

Section 2.2 addresses why the AER has incorrectly rejected EnergyAustralia's proposed control mechanism for assets constructed before 1 July 2009 and why the annuity model (with some amended inputs to address issues raised by the AER's complete draft determination) should be applied to all assets used to provide public lighting services.

Section 2.3 addresses the AER's failure to give consideration to whether its complete draft determination provides EnergyAustralia with a reasonable opportunity to recover at least the efficient costs incurred in providing public lighting services and that for this reason the AER has not correctly exercised its discretion.

Section 2.4 addresses why the AER has incorrectly rejected EnergyAustralia's proposed assumptions and inputs with respect to:

- Bulk lamp replacement cycle
- Luminaire maintenance cost recovery
- Spot lamp replacement rate
- RAB allocation
- Economic life of supports and lamps

In most cases the AER has not provided robust analysis or evidence to support its approach.

Section 2.5 addresses issues arising in relation to the AER's proposed approach to the pricing of assets which are replaced early and new assets introduced during the next regulatory control period.

Section 2.6 sets out some minor errors in the AER's March 2009 draft decision which should be addressed during finalisation of this decision.

[11] "AER's Complete Draft Determination" is used to refer to the combination of the "AER's November 2008 draft decision" and the "March 2009 draft decision"

2. EnergyAustralia's response

2.1 Representation of EnergyAustralia's information

EnergyAustralia has provided a large amount of information to the AER, both in response to the AER's November 2008 draft decision, and in response to subsequent information requests. To date, EnergyAustralia has not revised its June 2008 Regulatory Proposal in relation to alternative control services. We are therefore concerned that the AER's March 2009 draft decision in some places infers, and in other places represents that EnergyAustralia has revised its regulatory proposal. Specifically, the AER requested that EnergyAustralia calculate certain prices using specific modelling assumptions and the AER's March 2009 draft decision incorrectly represents the resulting prices as EnergyAustralia's revised prices.

For example, page 5 of the March 2009 draft decision, states.

> This supplementary draft decision considers the charges proposed by the NSW DNSPs for alternative control services for 2009-2010, as well as their proposed price paths for the remaining years.

This statement is misleading. Prices and price paths considered in the March 2009 draft decision were not proposed by EnergyAustralia as part of its regulatory proposal. Those lists of charges and the price paths were prepared by EnergyAustralia in response to the requirements in the AER's November 2008 draft decision and subsequent information requests from the AER. Similarly, page 8 of the March 2009 draft decision indicates that EnergyAustralia has revised its proposal. This is not the case.

Similar issues arise in relation to the limited roll forward model, including the RAB prepared by EnergyAustralia in response to the November 2008 draft decision.[12] The AER states at page 8 of the March 2009 draft decision that:

> EnergyAustralia has determined its closing RAB as at 2008-2009 by applying IPART's opening RAB of $98 million as at 1 July 2004.

EnergyAustralia has not "determined" a closing RAB value as part of its proposal. The use of a limited roll forward model or RAB are not part of EnergyAustralia's proposal as neither are required when using an annuity approach. Again, the March 2009 draft decision incorrectly represents information provided in response to the AER's requests as being part of EnergyAustralia's proposal. Similar incorrect representations are made at pages 13, 15, 16 and 46. EnergyAustralia requests that these representations be withdrawn and corrected.

2.2 EnergyAustralia's annuity approach

This section addresses why the AER incorrectly rejected EnergyAustralia's proposed control mechanism for assets constructed before 1 July 2009 and why the annuity model should be applied to all assets used to provide public lighting services. This section also illustrates that the AER has not had sufficient regard to the factors set out in clause 6.2.5(d) which it must have regard to when deciding on a control mechanism for alternative control mechanism.

EnergyAustralia developed and proposed an annuity method using a price list, based on replacement cost, to calculate prices for public lighting assets because it:

- was relatively simple to apply,
- avoided the need for detailed asset age information (which is not available),
- results in a single price list for all assets,
- allows easy comparison of services provided by new technology with those provided by older, less efficient technology,
- establishes a platform to move to more energy efficient outcomes for the community
- supports future competition in the provision of public lighting services.

The annuity approach is also relatively simple to apply to a large asset base, and can be applied in the absence of detailed asset age information without the use of broad assumptions to recreate asset age data. This was particularly important as EnergyAustralia's asset systems do not contain full age information. The annuity model enabled EnergyAustralia to generate a detailed price list that we are confident will allow us to recover revenues sufficient to cover our forecast costs.

[12] Page 339 of the AER's Draft Determination required that EnergyAustralia calculate a RAB value.

These costs (capital & operating) were developed using approved forecasting methods. The forecasting method for developing costs is outlined below.

Recovery of efficient operating costs

EnergyAustralia forecast its maintenance costs for public lighting in the same manner it forecast its maintenance for the distribution network, using similar techniques to establish optimum maintenance and asset replacement cycles including FMECA[13] and RCM[14]. These techniques have been accepted by the AER and its consultant Wilson Cook & Co, as being representative of good business practice. SAHA, in their report in relation to EnergyAustralia's standard control services remarked that EnergyAustralia's asset management practices were in line with best practice, that produce efficient maintenance costs over time.

EnergyAustralia observed the costs of public lighting maintenance over time based on the four categories of maintenance cost reporting – inspection, corrective, breakdown and nature induced breakdown – to determine the efficient cost of maintenance going forward. This cost was subject to real cost escalation using the same escalators that were applied to the maintenance cost forecast for standard control services.

Having established the total value of forecast operating cost, EnergyAustralia created a model to allocate those costs to public lighting assets. There are 1.26 million separate asset components that make up the public lighting asset base, and it is not possible to allocate specific tasks and costs to individual assets. Therefore, an allocation of costs is undertaken. Again, this is similar to how costs are allocated to prices for our standard control services.

EnergyAustralia's cost allocation method has been approved by the AER. The method stipulates that costs are to be allocated on a causal basis where possible, and otherwise via non-causal allocation using certain business rules. This same methodology has been applied within EnergyAustralia's public lighting model.

13 Failure Modes Effects Critical Analysis.
14 Reliability Centred Maintenance.

EnergyAustralia's pricing lighting model allocates total operating costs by first allocating the cost of the bulk lamp replacement program to each lamp, and then allocates the remaining operating costs, which it attributes to spot replacement.[15]

In step 1, the cost of the bulk lamp replacement is allocated evenly across all lamps. In step 2, the remaining operating cost (assumed to be spot lamp replacement) is allocated using the cost of lamps, cost of lamp installation, and the location of the lamps (in residential areas or along traffic route) as weights.

The relative cost of the large scale programs do not necessarily represent the relative cost per unit of a bulk replacement task and a spot replacement task. This is because spot lamp replacements includes all other operating costs including operating cost related to general business overheads. This clouds the comparison of the bulk versus the spot replacement rate. If a comparison was required, other costs would need to be separated out to allow comparison of like with like.

The per unit cost of spot and bulk lamp replacement is considered when establishing the appropriate bulk lamp replacement rate (see section 2.4). Once established, the costs of bulk lamp and spot lamp replacement programs are allocated in the model using weights as described above.

Recovery of efficient capital costs

EnergyAustralia's public lighting model calculates costs for capital expenditure for each asset based on the total installed cost of the asset, plus the return on and of capital over the life of the asset, and divides the total into 20 equal annual payments. The model uses replacement cost for all assets and therefore produces a single price list.

All materials used in construction of public lights are sourced via competitive procurement arrangements. Labour used to construct assets is charged at a labour rate commensurate with labour charges for EnergyAustralia's standard control services. These costs have been separately assessed by the AER's consultant Wilson Cook.

15 The spot lamp replacement category includes other costs not directly attributed to spot lamp replacement such as vehicle costs

2. EnergyAustralia's response
(continued)

The assumptions of time taken to construct assets is based on field observations, and the effective labour rate is cheaper, on average, than other service providers in NSW.

The cost of capital used in the public lighting model is the same as that used for the distribution business.

EnergyAustralia's public lighting annuity model combines the operating and capital costs and allocates it according to the allocation method. It has been built to recover no more than the efficient costs of providing public lighting services to customers within our franchise area.

AER's rejection of annuity model for pre-1 July 2009 assets

The AER accepted EnergyAustralia's annuity method for assets installed after 1 July 2009 but rejected this method for assets installed before that date. The reason put forward to support its rejection of the annuity method was that the model used asset values that were based on replacement cost rather than a depreciated cost.

The AER noted that it was "aware that many of the assets in the DNSP's asset bases were constructed some time ago and therefore have a much lower value than that developed through a replacement cost approach."[16] The AER therefore based its rejection of an entire annuity model methodology on the basis that it objected to an input used in that methodology, rather than an objection to the methodology itself, which it in fact accepted for all new assets. EnergyAustralia considers that this decision was in error and has led to an incorrect exercise of discretion on the part of the AER.

The AER is limited in its discretion when it refuses to approve a methodology such as that which underpins the control mechanism for alternative control services or a value or amount reflected in that methodology. If the AER refuses to approve a methodology, value or amount, the substitute must be determined on the basis of the current regulatory proposal and amended from that basis only to the extent necessary to enable it to be approved in accordance with the Rules.[17] By not addressing itself to the input in the model i.e. the use of replacement cost, and rejecting the model itself, the AER has moved beyond its mandated use of discretion.

The AER's introduction of a new model has brought with it unnecessary complexity and created additional problems that cannot easily be solved without detailed asset and age related information, which the AER is aware does not exist. The AER's approach unnecessarily requires EnergyAustralia to develop a different price list based on a different methodology for the same service. The AER did not have regard to the impact of its decision which demonstrates that the AER has not had sufficient regard to the factors listed in clause 6.2.5 (d) when making its decision. Many of the AER's assumptions that were within the March 2008 draft decision did not regard for actual business practices. For example the AER recommended a bulk lamp replacement programme of 3 years when EnergyAustralia undertakes 2.5 years and has carried out a rigorous analysis to support this programme length[18]. This is further discussed in section 2.4.

To implement this new model, the AER has had to make a number of broad assumptions such as the average age of assets. This question is avoided entirely by the use of an annuity approach and was one of the primary drivers of EnergyAustralia's selection of an annuity approach.

Use of replacement cost rather than historic cost

The use of replacement cost for determining investment in the annuity model is entirely appropriate for a public lighting business. The age of the asset is irrelevant to the service, provided that the asset that delivers the service meet certain performance criteria. This means that as long as the asset delivers services that meet those criteria, the age of the asset providing the service is irrelevant.

EnergyAustralia's public lighting annuity model calculates all prices for assets on the basis that the *service* is purchased by customers. The cost of this service is based on the market

16 AER draft determination, Nov 2008, p330
17 Clauses 6.12.1 and 6.12.3 of the Transitional Rules.

18 Other examples includes the AER's assertion that supports and lamps should have a 35 and 3 year economic life respectively.

price of providing new services and is not related to the age of the asset providing the service.

Applying a roll forward of asset values used in the regulation of standard control services does not address the fundamental concept that customers are buying a unit based service. Our customers do not pay for the asset in isolation. The AER's application of a roll forward model in the context of limited asset information creates additional problems discussed in section 2.5 below.

2.3 Reasonable opportunity to recover costs

The AER is required to take into account the revenue and pricing principles, one of which is that a provider of direct control services (such as public lighting services) should be given a reasonable opportunity to recover at least the efficient costs incurred in providing these services. EnergyAustralia considers that the AER's March 2009 decision has failed to consider the efficient costs, and has failed to ensure we have an opportunity to recover such costs.

At no point within the March decision does the AER explicitly consider the concept of efficient cost. In fact, the AER attempts to reduce the cost of providing public lighting services by comparing providers, and selecting parameters from various proposals that delivers the lowest price to customers, without consideration of whether the resulting prices are sufficient to cover the efficient costs of each provider.

It is clear from the AER's own analysis that there is a wide variety of costs faced by each of the three NSW providers. However, the analysis has not been undertaken at a sufficiently detailed level to demonstrate what costs are captured in each category by each provider. By selecting the lowest price in all categories, the AER has effectively removed the ability of providers to recover their own costs which vary for legitimate reasons.

"Cherry picking" assumptions

The AER has materially changed the proposal that EnergyAustralia put forward to calculate public lighting prices. In creating its own framework using two models, the AER has reviewed the costs of the three NSW DNSPs, and has deliberately chosen parameters at the lowest common denominator (ie that deliver the lowest prices for customers) without sufficient regard to the costs of each provider in providing the service. This selection has been made regardless of whether those parameters are inconsistent with each other when applied to an individual DNSP.

Where an assumption has been used for EnergyAustralia that results in a higher price, the AER has changed the assumption to reduce prices. For example, the cycle of bulk lamp replacements has been extended from 2.5 years to 3 years. However, where EnergyAustralia has used an assumption that gives a lower cost than the proposals from Integral and Country Energy, the AER has not asked that the assumption be changed. In Table 4.3 of its March 2009 draft decision[19], the AER compares the capital costs for a constructed streetlight. EnergyAustralia's component costs are cheaper compared to Country Energy and compare favourably to Integral Energy's costs. In this case, the AER has not allowed EnergyAustralia to increase these costs to be comparable to the other DNSPs.

EnergyAustralia considers the comparisons the AER has undertaken to be relatively unsophisticated and not sufficient to take account of the costing methodologies used between the three providers that drive variations in costs. The AER's selection of the least cost assumptions to drive down public lighting prices does not appear to consider whether those changes impact the ability of providers to recover efficient costs.

This is in direct contrast to the AER's proposed approach set out in its February 2008 Statement on NSW Alternative Control Services, which asserted that it would "determine the initial price levels and the price path with reference to the efficient costs of providing public lighting services." Further, the AER stated in its November 2008 draft decision that "The AER considers it appropriate to allow the NSW DNSPs to charge prices which reflect the efficient costs of providing public lighting services."

EnergyAustralia has undertaken analysis of the assumptions used by the AER, and has calculated the impact of adopting those parameters. While mandating the use of consistent parameters appears to be a good approach, it must be done

[19] Supplementary draft determination, page 37.

2. EnergyAustralia's response
(continued)

with an understanding of the different models used by the businesses and the different ways in which these models account for costs.

If EnergyAustralia's parameters for labour rates, the bulk lamp replacement cycle, time taken to install lights, overheads, and reductions in spot replacement are included in EnergyAustralia's public lighting model, the prices recover $14.8 million in operating costs and $35.3 million in revenue in FY10. However, these outcomes change if the parameters are changed to those used by the AER or made consistent with the parameters used by Integral Energy. The results of the three scenarios are shown in Table 1.

Table 1 – Scenarios using different parameters in EnergyAustralia's public lighting model (FY10)

Parameters	EnergyAustralia's parameters	AER parameters	Integral Energy parameters
Labour rate	$93.64	$93.64	$127.51
Opex:			
Reduction in SPR due to BLR	1.13%	20%	20%
Target opex	$15.0m		
Opex recovered	**$14.78m**	**13.9m**	**$16.28m**
Capex:			
Overheads on capital	20%	20%	0%
BLR cycle	2.5	3	3
Time to install light - standard - traffic	 2 4	 2 2	 1.39 1.39
EWP rate	-	-	$44.86
Revenue recovered	**$35.31m**	**$33.46m**	**$35.33m**
Variance	**-**	**-$1.85m**	**$0.02m**

Table 1 shows that by changing various assumptions, the AER has materially reduced the amount of revenue received by EnergyAustralia in 2010. However, we note that Integral Energy was not required to make the same changes, despite the fact that, if EnergyAustralia used the parameters that Integral used, the revenue (including operating costs) recovered in prices would be higher than that put forward by EnergyAustralia.

This analysis demonstrates the importance of using assumptions mindful of the way in which the models use those parameters to generate revenue. Failure to take account of this will lead to outcomes where a provider of public lighting services will not be able to recover its costs.

EnergyAustralia does not consider the AER to have made a decision consistent with the National Electricity Objective.

The National Electricity Objective is to promote efficient investment in and efficient operation and use of electricity services for the long term interest of consumers of electricity. The decision does not promote efficient investment in electricity services as it has materially reduced the revenues that will be earned by EnergyAustralia to a point where we do not have a reasonable opportunity to recover efficient costs. Furthermore, it does not provide prices that are cost reflective and that are likely to lead to efficient consumption decisions in future.

The specific assumptions that the AER has proposed are discussed in the Section 2.4. EnergyAustralia strongly asserts that our assumptions from the June 2008 proposal should be reinstated.

Deferred depreciation

Not only has the AER failed to consider actual costs going forward, the AER has failed to take account of the lack of cost reflectivity of past prices. This is a further matter to which the AER must have regard under clause 6.2.5(d) when deciding on a control mechanism.

The AER is aware that IPART, when making its determination for public lighting in 2005, set prices based on a deferral of depreciation charges. IPART rejected EnergyAustralia's original proposal for depreciation and instead accepted a significant downward revision of the depreciation allowance. By doing so, the prices set by IPART were lower than the true cost of providing the service and would lead to higher prices in future years to recover this cost.

Allen Consulting Group in its 2003 report to IPART on depreciation, stated that "a change to the current depreciation method[20] for existing assets (i.e. to back end depreciation) may imply much lower prices than would have occurred under the alternative regime – and higher prices in the future."[21]

IPART itself admitted in its August 2005 public lighting price determination[22] that its decision would mean that cross subsidies will still exist between customers in 2009.

EnergyAustralia considers it important that the AER take account of prices for the 2009-2014 period when determining, the deferred depreciation that resulted from IPART's decision in 2004 to back end depreciation.

The AER acknowledged on page 2 of the March 2009 draft decision that prices set by IPART were not cost reflective and did not result in recovery of efficient cost. Despite this acknowledgement, the AER has not taken into account the value of depreciation that was deferred from the 2004-09 period that should be recovered and has set prices for existing assets that do not cover the efficient costs of providing public lighting services over time.

Table 2 shows the RAB as calculated by the AER using straight line depreciation. The decision to establish an asset base using straight line depreciation under values the true value of EnergyAustralia's public lighting asset base, in that it assumes a higher return of capital has been received than has actually been received. Using the AER's March 2009 draft decision, prices for assets installed prior to 1 July 2009 do not reflect the correct RAB value and are inappropriately low.

To correct this, the AER must establish the RAB using actual depreciation over the 2004-09 period rather than use an assumption of straight line depreciation.

Table 3 shows the derivation of the RAB using actual depreciation (as per IPART's decision) for the 2004-09 period[23].

Table 2 AER RAB roll forward ($ million, nominal)

	FY05	FY06	FY07	FY08	FY09
Opening value	97.8	99.6	102.9	107.4	106.8
Depreciation	10.9	11.8	12.8	14.0	14.9
Capex	9.7	12.1	13.8	11.2	16.9
Indexation	2.9	2.9	3.5	2.1	2.5
Closing value	99.6	102.9	107.4	106.8	111.3

Table 3 RAB consistent with previous IPART approval ($ million, nominal)

	FY05	FY06	FY07	FY08	FY09
Opening value	97.8	105.0	113.8	124.6	130.8
Depreciation	5.4	6.4	7.0	7.5	8.0
Capex	9.7	12.1	13.8	11.2	16.9
Indexation	2.9	3.1	3.9	2.5	3.1
Closing value	105.0	113.8	124.6	130.8	142.8

When actual depreciation is used in the roll forward model, the regulatory asset base for EnergyAustralia's public lighting business is higher than forecast by the AER in its March 2009 draft decision. Using the AER's roll-forward approach with the actual RAB, revenue for the next regulatory period will increase by an additional $23 million.

[20] Straight line depreciation

[21] Allen Consulting Group, *Principles for determining regulatory depreciation allowances - Note to the Independent Pricing and Regulatory Tribunal,* Sept 2003.

[22] IPART Statement of Reasons for Decision *EnergyAustralia application for proposed price increase of public lighting charges* August 2005 p4

[23] EnergyAustralia provided a simple RAB calculation in its original June 2008 proposal. However, the RAB roll-forward was done at a high level. Subsequent analysis has resulted in a more accurate RAB calculation as shown in Table 3.

2. EnergyAustralia's response
(continued)

2.4 Assumptions

The AER has made a number of changes to input assumptions as part of its March 2009 draft decision. These changes lack substantiation and all but one change has the effect of reducing required revenues below that required to meet the efficient costs of providing public lighting services in the 2009-14 period. In most cases the AER has not provided robust analysis or evidence to support its approach.

This section addresses each of the assumptions that the AER has changed and presents arguments and further material in support of EnergyAustralia's original assumptions.

Bulk lamp replacement cycle

In its March 2009 draft decision, the AER determined that EnergyAustralia's bulk lamp replacement programme should be extended from a 2.5 year cycle to a 3 year cycle. The AER provided no technical justification for this change but based its change on a high level comparison of bulk lamp cycle rates applied in other network areas.

EnergyAustralia considers that the AER's decision is unreasonable and is an example of the limitations and errors that can result from reliance on high level benchmarking without any further analysis.

The AER's findings are based on a 2005 report prepared for the Australian Greenhouse Office on energy efficiency. This report states that the majority of lamps in Australia are replaced every four years. However in this report the authors admitted that "Little information about end of life batch changeovers was provided by distribution businesses as input to this project."[24] The report also stated that "Lamp data varies between distributors and manufacturers – and there is a considerable amount of conflicting information in the marketplace." The report relied on by the AER did not cite any cost benefit analyses used by utilities upon which the four year cycle assumption was based. The report therefore cannot be relied upon as a sound technical basis for setting the cycle for bulk lamp replacement.

The report has ignored information provided by EnergyAustralia in its previous submissions that demonstrates the efficiency of the assumption used within our public lighting model.

EnergyAustralia's bulk lamp replacement programme results in efficient costs. The bulk lamp replacement programme is used to reduce the total number of required spot lamp replacements. Instead of changing lamps when they fail on a case by case basis, the bulk lamp replacement programme is designed to optimise costs of replacement by undertaking replacement of all lamps in a location at the same time. By undertaking lamp replacements in bulk, the number of calls to replace assets in a particular location is reduced and the costs associated with travel time and resources is optimised to achieve cost effective replacement of assets within their design life. For bulk lamp replacement to be effective, it is critical that lamps are replaced before they fail. Therefore the cycle of bulk lamp replacement is a critical factor in determining the cost effectiveness of the bulk lamp replacement programme and the efficiency of costs overall.

EnergyAustralia has based its programme cycle of 2.5 years on an extensive technical review of lamp failure rates and costs, conducted using Weibull probability distribution analysis. The conclusion of this detailed analysis (provided as Attachment 1) is that the bulk lamp replacement programme should be conducted over a 2.5 year time frame[25]. This conclusion was on the basis that a 2.5 year timeframe provides the most efficient cost outcome between spot lamp replacements and bulk lamp replacements. Any extension of this time frame will increase the frequency with which spot lamp replacements occur, and consequently decrease the cost effectiveness of the bulk lamp replacement program.

The AER's change to the bulk lamp replacement cycle from 2.5 to 3 years will result in less efficient operating costs for public lighting customers in EnergyAustralia's area. Not only will costs increase, the resources required to manage higher rates of spot lamp replacement will also increase. This is not an efficient outcome for EnergyAustralia, its customers, or the

[24] Public Lighting in Australia – Energy Efficiency Challenges and Opportunities Final Report 2005

[25] Network Maintenance Standards - Street Lighting Analysis Report, 9th January 2004

community and will not contribute to the achievement of the national electricity objective.

For these reasons, EnergyAustralia submits that the AER must change its assumption for bulk lamp replacement for EnergyAustralia's network area. If it does not do so, it must increase operating costs to cater for the higher total costs resulting from the longer cycle of bulk lamp replacement and consequent higher spot lamp replacement rate.

EnergyAustralia notes that the replacement cycle appropriate for each network may be different due to the different characteristics of the assets being used, the maintenance policies in place, different operating and performance standards and varying environmental conditions that apply. For example, the Victorian Public Lighting Code (in addition to four year replacements at non-major roads) has a minimum standard that requires the DNSP to "routinely patrol at night to inspect, replace or repair luminaires at least three times a year"[26]. This requirement is significantly more stringent than a bulk lamp replacement programme of 2.5 years used by EnergyAustralia.

In making its decision, the AER must consider the operating conditions, asset type and environmental factors relevant to each provider before applying assumptions to other networks. Failure to do so demonstrates a lack of technical understanding of assets and their life cycle costs.

Recovering the costs of bulk lamp replacement

The total cost of the bulk lamp replacement programme is $3 million per annum. Luminaire maintenance is carried out in conjunction with lamp replacement and includes the labour associated with the cleaning and refitting of luminaires. EnergyAustralia's public lighting economic model allocates this maintenance cost on the basis of the number of luminaires serviced under the bulk lamp replacement programme. The number of luminaires serviced per year decreases as the length of the bulk lamp replacement programme cycle increases.

In its March 2009 draft decision, the AER changed the formula in EnergyAustralia's model that allocates the luminaire maintenance cost. We assume that this change has been made to make the allocation basis consistent with the cycle of the bulk lamp replacement programme which the AER considers should be carried out over 3 years. The AER purported that the effect of this change is to decrease total operating costs over the five year period by $3.8 million. This reduction in expenditure is totally unjustified because a lengthening of the cycle of bulk lamp replacement from an optimal length of 2.5 years to a sub-optimal cycle of 3 years (as discussed above) would lead to an increase in total operating costs driven by a higher number of more expensive spot lamp replacements.

By over-riding the formula in EnergyAustralia's model, the AER has not only misunderstood the model (see section 2.2), but has penalised EnergyAustralia two fold by increasing the overall forecast costs due to the sub-optimal replacement cycle, but has decreased allowed operating expenditure. This means that the gap between forecast efficient costs and allowed costs has increased. This further demonstrates that the AER's decision does not allow EnergyAustralia a reasonable opportunity to recover efficient costs.

The AER's decision demonstrates it has failed to acknowledge that an extension of the bulk lamp replacement cycle will in turn increase the spot lamp replacement rate, and that operating costs will need to increase to cover costs, rather than fall as the AER has proposed.

EnergyAustralia reiterates the fact that the most cost effective and efficient programme length for bulk lamp replacement for EnergyAustralia's network is 2.5 years.

Spot lamp replacement rate

In its March 2009 draft decision, the AER recommended that the spot lamp replacement rate be changed to show the improvement in the spot replacement rate as a result of the bulk lamp replacement being introduced in other networks. The AER considered this would result in prices being more cost reflective.

EnergyAustralia is concerned that this request shows a lack of understanding of what is included in the costs categorised as 'spot replacement' and a lack of understanding of how we have allocated these costs using its public lighting model.

[26] Victorian Public Lighting Code, Office of the Regulator General, September 2001

2. EnergyAustralia's response
(continued)

There are two key issues that should be understood:

1. Spot lamp replacement rate is directly related to the cycle of the bulk lamp replacement program.
2. Spot lamp replacement program includes all operating costs other than the costs associated with the bulk lamp replacement program.

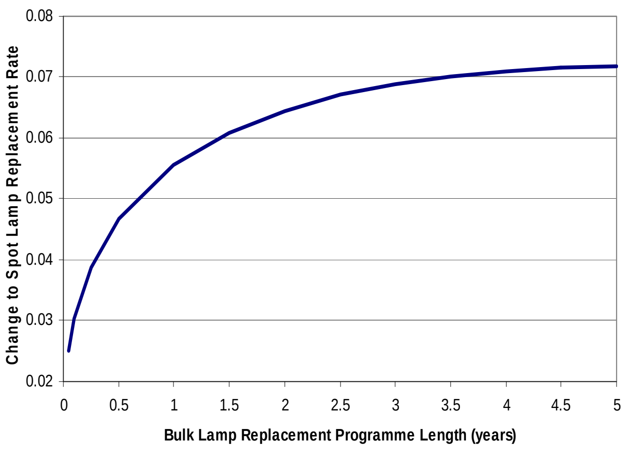
Relationship between bulk and spot

The rate of spot lamp replacement is directly related to the presence of a bulk lamp replacement program and the program's cycle.

EnergyAustralia has set its bulk lamp replacement cycle at 2.5 years following detailed assessment of asset types and failure rates. Our analysis has shown a clear relationship between rates of bulk and spot lamp replacement. If the bulk lamp replacement programme cycle is extended, the spot lamp replacement rate will increase.

This is illustrated in Figure 1 below which shows how the spot lamp replacement rate is influenced by a change in the bulk lamp replacement rate. For a SON1*150 the spot lamp rate increases from 6.7% to 6.9% per year as a result of the change from a 2.5 year bulk lamp replacement programme to a 3 year programme.

Figure 1: Spot Lamp Replacement Rate as a result of Bulk Lamp Replacement (for a SON1*150 lamp)



EnergyAustralia introduced its bulk lamp replacement programme for the Sydney region in 2006. The Sydney region, which accounts for the majority of EnergyAustralia public lighting network, has already completed a cycle of bulk lamp replacement. The total maintenance costs therefore already reflect the introduction of the bulk lamp replacement and any savings that have been forthcoming as a result of its introduction. EnergyAustralia has a tender for a similar programme to be established in the Newcastle region in 2009. The forecast costs for the Newcastle region take account of the forecast bulk lamp replacement program and therefore reflect efficient costs.

The relativity of the cost of bulk and spot replacement is important when undertaking the analysis to determine the optimal cycle for bulk replacement. However, once established, the total operating costs that result with a bulk replacement lamp replacement program of optimal length in place can be considered as being efficient. The allocation of the total costs to prices is a separate consideration.

Cost allocation methodology

As set out in section 2.2, EnergyAustralia's public lighting model allocates the efficient operating costs to individual assets by first, allocating the cost of the bulk lamp replacement program equally to each lamp, and then allocates the cost of the spot lamp replacement program (i.e. all other operating expenditure) to lamps based on lamp locations and lamp type. The cost of the spot lamp replacement program has reduced over time as bulk lamp replacement program has been introduced across the network (i.e. costs have moved out of spot lamp replacement and into the bulk lamp replacement program).

EnergyAustralia considers its allocation method to be reasonable as it evenly spreads the costs of the bulk lamp program across all lamps, but attributes a higher proportion of costs of the spot replacement program to lamps that are typically more difficult to access (i.e. on traffic routes) or more expensive.

The spot lamp replacement program includes all non-bulk lamp replacement operating costs, including costs that would normally be called 'other' costs. These costs include reconstruction of a light where a car hits a pole and typically are do not change as a result of the introduction of the bulk lamp replacement program.

The AER has proposed that the spot lamp replacement cost should fall by 20% as a result of the bulk lamp replacement program being introduced. However, for this to be the case, a comparison must be made between the costs of spot lamp replacement with and without bulk replacement. As EnergyAustralia already has the cost of the bulk replacement incorporated in its actual costs, and therefore in its forecast costs, the comparison is irrelevant. Furthermore, as EnergyAustralia's public lighting model captures all non-bulk replacement operating expenditure in the spot lamp replacement category, the comparison is not valid unless all 'other' operating costs are removed from the category and all spot lamp replacement operating costs vary as a result of the bulk program.

The AER should reconsider its statement that EnergyAustralia's current allocation methodology is not cost reflective, and reconsider its proposal that the spot lamp replacement rate be reduced.

RAB allocation to components

The AER's March 2009 draft determination applies a limited RAB roll forward method to calculate prices for assets installed prior to 1 July 2009. In establishing this model, the AER has set a regulatory assets base (RAB) of $111 million and requires this to be allocated to public lighting components on the basis of its written down value rather than on a replacement cost basis. The effect of allocating the RAB on a written down basis is that older components (with a shorter than average remaining economic life) will not be allocated as much of the $111 million asset base. Components that have been installed more recently (which have a longer than average remaining economic life) will be allocated more of the $111 million than they would under the replacement cost valuation. The effect of this change is that less depreciation (and hence less revenue) is recovered under the limited RAB roll forward approach.

It should be noted that the limited RAB methodology was not proposed by EnergyAustralia but proposed by the AER in its November 2008 draft decision. Despite its significant variation to the annuity method, EnergyAustralia prepared a second set of prices that specifically met the approach detailed in the November 2008 decision. EnergyAustralia considers that the recommendation to construct a limited RAB price model using written down RAB values has no sound economic basis, but has been proposed as a means by which the AER can lower the revenue that EnergyAustralia is otherwise entitled to recover through prices.

EnergyAustralia considers that the allocation of the RAB on the basis of replacement costs is entirely reasonable, given the widespread use of replacement cost valuations across a range of industries. Furthermore, EnergyAustralia considers that the allocation on the basis of replacement cost is more consistent with an annuity approach proposed by EnergyAustralia in the first instance. Allocation of the RAB using replacement cost means that all assets have an equal share of the RAB attributed to them regardless of the assets age which we argue is appropriate given that those assets provide the same service. EnergyAustralia does not consider the age of the asset to be relevant to the cost of the service provided by that asset if the service meets established performance criteria.

EnergyAustralia considers that the AER has imposed its own methodology of a roll forward approach without addressing itself to the methodology put forward by EnergyAustralia or the basis behind it. EnergyAustralia considers that the AER, by mandating the use of a limited roll forward model and mandating the allocation of the RAB on the basis of a written down value is not providing EnergyAustralia with an opportunity to recover efficient costs of providing public lighting services.

Economic life of supports

In its November 2008 draft decision, the AER noted that 35 years was the appropriate age for public lighting supports on the basis that this was consistent with the lives of similar assets in other jurisdictions. EnergyAustralia considers this decision to be unreasonable and again caused by applying high level benchmarking without an appropriate understanding of the technical issues involved in establishing an asset's life.

EnergyAustralia considers 20 years is the appropriate technical life for supports as this is a widely held industry standard for galvanised steel. The galvanising of support brackets is consumed over time, particularly in coastal areas where salt air wears the galvanisation and then corrodes the steel used for the supports. EnergyAustralia's network area is located along the coast from the Royal National Park in Sydney's south to

Nelson Bay north of Newcastle and therefore has a large proportion of assets in coastal areas which are more susceptible to salt corrosion.

The comparison with asset lives in other jurisdictions is not particularly relevant given the factors that drive asset condition are not consistent amongst the jurisdictions (i.e. not all networks are located predominantly on the coast).

Given the likelihood of corrosion, EnergyAustralia considers that supports should have a useful life that aligns with the luminaire (i.e. 20 years) in recognition of the industry standard and so that replacement of the luminaire and the support can be undertaken together.

To further demonstrate that the asset's life is approximately 20 years, EnergyAustralia carried out a bottom up analysis of public lighting capital expenditure over the last 10 years. Two scenarios were carried out for supports; one with an economic life of 20 years, and one with an economic life of 35 years. Capital expenditure under the bottom up analysis more closely matches actual expenditure where supports are assumed to have an economic life of 20 years.

EnergyAustralia maintains that a 20 year economic life on supports will deliver more cost reflective prices than would be generated with a 35 year assumption.

If the life of supports is extended from 20 years to 35 years, further operating expenditure must be added to our proposed operating costs to pay for the costs of maintaining aging galvanised steel supports for an additional 15 years.

As part of its January 2009 interim submission EnergyAustralia prepared prices with supports at a 35 year economic life[27]. This was in response to the AER's request and should not be viewed as an acceptance of this assumption by EnergyAustralia.

[27] This information was provided to the AER in response to a modelling request, and only took account of the impact of the change on depreciation. It did not incorporate the increase in operating expenditure that would be required if this assumption were applied.

Economic life of lamps

In its March 2009 determination, the AER recommended that economic life of 3 years be assigned to lamps rather than 2.5 years. We assume this change was made to match the economic life of the asset (based on bulk lamp replacement) with its technical life.

EnergyAustralia considers that it is appropriate for the economic life and technical life to be aligned. EnergyAustralia has demonstrated that the technical life of lamps is 2.5 years. It is therefore inappropriate for the economic life to be changed from 2.5 years to 3 years.

EnergyAustralia considers that the economic life should be consistent with the bulk lamp replacement cycle of 2.5 years.

2.5 New problems as a result of AER decision to use asset roll forward

This section identifies issues which arise in relation to AER's proposed approach to the pricing of retrofitted and new assets introduced during the next regulatory control period and demonstrates how these issues are resolved if an annuity approach is applied.

Inconsistent consideration of asset age

The arguments used by the AER in favour of using written down value of assets for allocation of the RAB to assets was that using replacement cost results in the allocation of the RAB being higher on older assets and lower on newer assets than it should.[28]

For this to be true, the AER must consider that replacement cost would overvalue past investment. This would only occur where prices have risen by more than just CPI over time. If this is the case, and this concern was extended into the future, the AER must also conclude that materials prices will increase in real terms. In a similar fashion, the 2008 replacement cost is likely to undervalue future investment. The AER has addressed its concern about past assets by requiring service providers to

[28] March decision, p17.

use the written down value of capital costs. However, the AER has not done enough to ensure the future value of capital is similarly protected.

The AER has not proposed to use a materials escalator within its model, and in fact, by separating out the assets that have been installed before and after 1 July 2009, the AER has effectively reduced the prices paid for past investment at the same time as it has under valued future investment. This inconsistency of approach over time, and the use of different assumptions in each model creates opportunities for real value to be lost or gained. In this decision, the AER's application of two models using different assumptions has led to a loss in value for EnergyAustralia and other NSW public lighting service providers.

If asset age is seen as an important allocating factor of cost for the RAB, it would be consistent for asset age to be is an equally important factor in the allocation of operating expenditure. This would be consistent with the view that older assets are more likely to fail and are typically more expensive to maintain compared to newer assets. Therefore, a higher proportion of maintenance costs should be allocated to older assets than newer assets.

The AER has not proposed that operating costs be allocated on the basis of age, and has instead, agreed to a smearing of operating costs across assets regardless of age. In doing so, the AER has shown its approach to be internally inconsistent in that it has used asset age as a primary driver of capital costs, but has ignored age in the allocation of operating costs. EnergyAustralia does not consider this inconsistency to be appropriate in the context of a roll-forward approach.

In contrast, the annuity approach does not explicitly consider age for either capital or operating costs. Instead, it calculates an equal annual charge for both considering the life cycle cost of the asset.

The AER's introduction of a roll-forward model in parallel to an annuity model is inherently inconsistent and does not consistently address the issue of asset age as an allocating factor for costs.

Use of historic costs within annuity model

The AER did not consider measures that might have been implemented within the annuity model to remedy the problem it perceived with the use of replacement costs. The AER did not consider using an historic value for assets within the model despite the fact that historic values could be derived in a similar way to developing an asset roll-forward. Instead, the AER rejected the entire model in favour of its own model.

EnergyAustralia considers the use of replacement cost as being appropriate, but we note that historic asset values could be used within an annuity model. The use of historic values for assets already installed would lead to more than one price list – one for assets installed before 1 July 2009, and one for assets installed after this date. While EnergyAustralia does not favour two price lists, two price lists using a similar model (the annuity approach) is preferable to deriving two price lists from two different models, particularly when one is a roll forward model.

The use of an annuity approach for pre- 1 July 2009 assets and one for post- 1 July 2009 assets was not considered by the AER. Had it done so, the number of issues outstanding, the internal inconsistency and the complexity of the outcome would be significantly reduced. EnergyAustralia considers that the use of an annuity approach with historic costs for pre- 1 July 2009 assets would be more likely to represent a legitimate exercise of discretion on the basis of concern about replacement cost. The outright rejection of an annuity approach and substitution of a roll-forward model is not.

Historic cost prevents competition

EnergyAustralia considers that the use of depreciated costs and an asset roll forward approach ensures that the cost of public lighting services provided by existing assets will always be lower than the cost of services provided by new assets (assuming costs of service increase over time). This means that customers have an incentive to stay with the current provider of public lighting services and effectively prevents competition for services in areas where public lighting assets already exist.

If prices for public lighting services were set using replacement cost, the cost to the customer of choosing another lighting provider would be equivalent, and is therefore more likely to encourage wider competition in the market for public lighting services.

EnergyAustralia notes that the Rules require the AER to explicitly consider the scope for competition in the market for alternate control services. The draft decision made by the AER actively discourages competition in the market for public lighting services, and also reduces incentives for customers to move to energy efficient lighting. This issue is discussed further in section 2.2.

Retrofit rate

In its January 2009 revised proposal EnergyAustralia reviewed its calculation of the retrofit rate, tariff class 6 (now tariff class 5). This is the rate that would be charged to customers that require components to be replaced before the end of their economic life. In the March 2009 draft decision the AER provided a response to this revised calculation. The AER rejected the method proposed by EnergyAustralia on the basis that using a replacement cost valuation would not encourage customers to select an alternative component before the end of the existing component's useful life.

EnergyAustralia has considered the AER's arguments and believes that it has some merit in the context of a framework that results in two price lists, one for assets installed before 1 July 2009, and those that are installed after that date. However, if all public lighting components are priced under the annuity method using the replacement cost as proposed by EnergyAustralia, this problem would not occur. Customers would be able to select new components (such as energy efficient lights) without seeing a significant price differential between existing prices and the corresponding retrofit price. A single price list based on replacement cost creates the right incentives for customers to choose public lighting assets that are more energy efficient.

The March 2009 draft decision proposes that retrofit prices will be approved on a case by case basis by the AER, which states that "these tariffs should be calculated at the time of the agreement with the customer based on an agreed method for determining residual asset value."[29]

EnergyAustralia does not consider a case by case assessment of retrofit prices to be consistent with the Rules, which requires a form of control to be specified, nor is it generally consistent form of regulation contemplated for alternative control services.

EnergyAustralia has raised concerns about the AER not having established a form of control in its November 2008 draft decision, which have now been largely remedied in its supplementary draft decision released in March 2009. The exception is for retrofit prices which have not been established either by way of a price schedule or a cap on the price of the service.

While the exact price may not be able to be established because new assets/technologies may not be available yet, we consider the AER could meet its obligations with respect to imposing a control mechanism by establishing a formula by which retrofit rates could be calculated in future. A formula would result in a clear mechanism by which customers could determine the value of retrofitting assets. Without an established mechanism, the retrofit value proposition is unknown to customers and is subject to dispute. EnergyAustralia considers the lack of guidance to be likely to lead to difficult negotiations and delays as has been seen during 2008/09.

If EnergyAustralia cannot reach agreement directly with customers for retrofit rates, we assume that the matter will be referred to the AER and that customers will be required to wait for a formal process to take place. The AER stated that its process for approving new components would take up to 6 months[30] and we therefore expect a similar length process to determine retrofit prices given the relationship to new products. EnergyAustralia does not consider the proposed process to be an efficient form of regulation that will result in timely outcomes for EnergyAustralia or its customers. We are concerned that in the absence of a control mechanism or an agreed timeframe within which the AER will make its case by case assessment, customers will avoid replacing equipment early even where there are energy efficiency benefits of doing so. This will essentially delay the uptake of new technologies at the expense of rate payers who seek energy and financial

[29] Draft Distribution Determination 2009-10 to 2013-14 Alternative control (public lighting) services p46

[30] Supplementary draft determination for alternative control services, p53.

efficiency. EnergyAustralia seeks clarification of the process with which the AER proposes to monitor the application of retrofit prices to customers who request the early removal of public lighting components.

The AER has further complicated matters by requiring that customers being charged the retrofit rate (tariff class 5) will revert to the corresponding residual free rate (tariff class 3 or 4) "once the residual value of the asset has been returned to the DNSP". EnergyAustralia also seeks clarification from the AER as to how it considers DNSPs will be able to determine that a customer has paid the residual value of a component removed before the end of its economic life given the limitations of current asset systems and the lack of asset age information. EnergyAustralia considers that this requirement relies on a detailed asset base for public lighting including asset age, and requires prices to be calculated for each asset to determine the retrofit prices specific to the date of installation and replacement of each asset. Such a system does not currently exist within EnergyAustralia. A system like this would be administratively complex and expensive to develop and would be used to calculate prices for a relatively small number of assets, particularly if the AER set prices that did not have sufficient incentive to encourage retrofitting.

The costs of developing pricing capability of producing these prices, as well as an asset system that records detailed age information for each component has not been factored in to EnergyAustralia's future operating costs for the 2009-14 regulatory period. Given the time available to comment on the AER's draft decision, EnergyAustralia has not been able to forecast the costs of making these system changes. However, the AER must consider the scope and detailed costing of such system changes if it intends to mandate these requirements in its final determination. Failure to do so will result in the AER not providing EnergyAustralia with sufficient opportunity to recover efficient costs as the Rules require.

EnergyAustralia does not consider the costs of these system changes to be outweighed by the benefits of asset specific retrofit prices. Furthermore, EnergyAustralia regards this issue as one of several problems that has been created by the AER's decision to change the framework to a asset roll forward model away from an annuity approach using replacement cost (as proposed by EnergyAustralia) in which these issues are avoided.

2.6 Inconsistencies and errors

This section briefly sets out inconsistencies and errors that have been identified within the AER's March 2009 draft decision. The purpose of raising these matters is to enable them to be addressed during the finalisation of this decision.

Allocation of capital costs

EnergyAustralia has reviewed the AER's model used in its March 2009 draft decision and has identified a modelling error in the allocation of capital costs to components for the purpose of generating prices under the roll forward method.

Prices under this method are generated by allocating allowable revenue across components by using a weighting of capital and operating costs. These weightings are taken from the annuity model. However EnergyAustralia believes that the weightings used by the AER for capital costs come from an out of date version of model.

As the AER has revised other assumptions relating to capital costs in the annuity model, the AER must also recalculate the prices in the draft decision for the limited RAB roll forward price list using the correct weightings for capital and operating costs.

Total cost of bulk lamp replacement

Figures in Table 3.7 on page 26 of the March 2009 Draft Decision do not show the total cost of a bulk lamp replacement. The $31.46 figure corresponds to the cost of servicing a lamp and luminaire during a bulk lamp replacement programme of 2.5 years, and therefore only relates to the capital cost (i.e. does not include the capital cost of the lamp). Similarly, the AER appears to have derived the "cost of bulk replacement per lamp per annum" of $12.58 by dividing $31.46 (as above) by the cycle of the bulk lamp replacement programme (i.e by 2.5). Again, EnergyAustralia notes that the capital cost of the lamp is not included in this figure.

If the AER is seeking to compare the cost of the bulk lamp replacement program per lamp with other providers, it must include the capital and operating costs associated with the program to ensure a like for like comparison.

2. EnergyAustralia's response
(continued)

Price change for FY2010

The AER calculated that prices for public lighting services in EnergyAustralia's area will decrease by 6% in FY 2010. This calculation is based on a simple average of price movements and does not consider the relative volumes of assets of each type. EnergyAustralia considers the AER's simple average to misrepresent the outcome of its decision to customers. EnergyAustralia has reviewed the impact of the AER's decision and has calculated that the average price increase for next year will be -1.2% under the new draft decision (or -0.8% when the AER's error relating to price weighting under the limited RAB roll forward is removed).

Attachments

Attachments

Attachment 1:	Network Maintenance Standards, Street Lighting Analysis Report, prepared by J. Hardwick & G. Winsor (9 January 2004)
Attachment 2:	Letter from EnergyAustralia dated 26 March 2009 (CONFIDENTIAL document)
Attachment 3:	Update EnergyAustralia annuity model (CONFIDENTIAL document)

570 George Street
Sydney NSW 2000
Telephone 12 15 35
Facsimile 02 9269 2830

Postal Address:
GPO Box 4009
Sydney NSW 2001

EnergyAustralia offices are open between 8.30am and 5.00pm Monday to Friday
Emergency Services are available 24 hours a day Telephone 13 13 88
Internet Address: www.energy.com.au

Network Maintenance Standards

Street Lighting Analysis Report

Prepared and presented by

John Hardwick & Gary Winsor

Revision: 04

Date: 09 January 2004

Contents

BACKGROUND **3**

APPROACH **3**

LAMP LIFE ANALYSIS **4**

STREET LIGHTING STRATEGIES **6**

RECOMMENDATION **8**

APPENDIX 1 – WEIBULL ANALYSIS **9**

APPENDIX 2 – SUMMARY DATA AND WEIBULL DISTRIBUTION PLOTS **22**

APPENDIX 3 – COST CURVES **26**

APPENDIX 4 – MAINTENANCE REQUIREMENTS ANALYSIS REPORT **34**

Maintenance Standards - Street Lighting

Background

A maintenance requirements analysis has been undertaken as part of the Maintenance Standards Project to review the current disparate street lighting maintenance strategies existing across the energy Australia.

The analysis was undertaken using the current procedures documented in the Maintenance Requirements Analysis Manual and implemented using the MIMIR software.

The Newcastle/Maitland and Chatswood areas were selected to participate in the analysis as dedicated street lighting teams existed in these areas. In addition the Chatswood team operated with a Bulk lamp Replacement strategy and the Newcastle team operated with a spot replacement strategy which allowed the two different approaches to be considered.

The Analysis Team comprised a mixture of engineering and field staff included:

Keith Newland, Don Wijayasinghe, John Hardwick, Peter Power

Part Time – Peter Edwards, Bob Sloan

Newcastle: Cindy Newman, Robert , Dale

Chatswood: Col, Col, Craig

Gary Winsor (Facilitator)

Approach

The street lighting FMECA and RCM analysis was performed by the team to identify failure modes and used to capture data against the failure modes to identify valid maintenance tasks using the MIMIR software.

The failure modes associated with the lamp includes a presumption of an age related degradation characteristic for both lamp failure and light output.

The selection of a proposed maintenance task to manage *lamp failure due to age degradation* and *reduction of lumen output to less than 70% of design due to age degradation* as assumed to be a scheduled discard of the lamp.

To determine the validity of a scheduled discard task, failure data from the start of life for each lamp type would be required. The benefit of the Newcastle area having a spot replacement strategy only operating was that the data from start of life was available and would lend itself to a Weibull analysis to determine the wear out characteristic of the various lamp types.

The Weibull analysis was performed using the Isograph AVSIM+ software. Over 70,000 lamp failure and replacement records from the Newcastle data would be analysed to establish if there is a clear wearout characteristic associated with the lamps age degradation failure mode and where it occurs. This would then be compared with the manufacturer's data to establish whether the lamp mortality or the reduction of lumen output was the replacement driver. The task costs of lamp replacement using the two strategies would then be compared to determine if a theoretical optimum bulk lamp replacement period existed. A NPV would then be performed to compare the total value of the task costs and any additional supporting tasks required to make each into a strategy viable from and engineering and performance perspective.

Lamp life Analysis

The lamp life data was collected from the NAMS Public Lighting Database for the Newcastle region with a start date of 1/1/98. This data was sorted by lamp type and in ascending order of failure dates. Failures of lamps at a life of shorter than 10 days were removed from the analysis as these were considered to be due to installation / handling / transport issues and not associated with the inherent reliability of the lamp.

The results of the Weibull analysis for each lamp type are attached in Appendix 1 – Weibull Analysis. The summary of Weibull distributions for the various sized lamps within a technological family are attached in Appendix 2 – Summary Data and Weibull Distribution Plots.

This is summarised in the table 1 below.

Lamp Type	Population	Comment	η Characteristic Life (days)	β 1=Random, >1 wearout	γ location parameter	Days to 10% of units failed	Days to 15% of units failed
INC1*50	1	Insufficent Failure Data	-	-	0	-	-
INC1*300	1	Insufficent Failure Data	-	-	0	-	-
MBF1*50	28738		5,144.3	1.345	0	965.7	1,332.8
MBF1*80	11303		4,178.5	1.404	0	840.9	1,145.1
MBF1*125	112		5,985.5	1.055	0	709.0	
MBF1*250	1544		3,701.7	1.310	0	664.5	925.0
MBF1*400	1270		3,372.2	1.635	0	851.8	1,110.2
MBF1*500	21	Insufficent Failure Data	-	-	0	-	-
MBF1*700	4	Insufficent Failure Data	-	-	0	-	-
MBF1*800	2	Insufficent Failure Data	-	-	0	-	-
MBF3*250			1,645.7	0.492	0	17.0	41.1
MBI1*1000	1	Insufficent Failure Data	-	-	0	-	-
MBI1*150	4	Insufficent Failure Data	-	-	0	-	-
MBI1*250	9	2 failures only	16,892.4	0.488	0	167.5	407.4
MBI1*70	1	Insufficent Failure Data	-	-	0	-	-
SON1*100	1	Insufficent Failure Data	-	-	0	-	-
SON1*150	4567		3,448.3	1.275	0	590.2	829.1
SON1*220	29		2,498.5	1.091	0	317.8	472.7
SON1*250	6240		2,422.1	1.437	0	505.7	683.8
SON1*310	154		2,204.5	2.751	0	972.9	1,138.9
SON1*360	13	Insufficent Failure Data	-	-	0	-	-
SON1*400	172		2,763.6	1.300	0	489.7	683.4
SON1*1000	3		-	-	0	-	-
SON1*50	10	2 failures only	822.6	37.201	0	774.3	783.3
SON1*70	504		2,167.0	1.440	0	454.1	613.5
SON2*250	7	Insufficent Failure Data	-	-	0	-	-
SON4*250	12	4 failures only	2,521.3	0.965	0	244.9	383.7
SON4*600	14		889.0	1.141	0	123.6	180.7
SOX1*135	663		1,811.2	3.338	0	922.9	1,050.8
SOX1*180	4	Insufficent Failure Data	-	-	0	-	-
SOX1*90	253		1,686.2	3.374	0	865.4	984.0
TF1*20	12	3 failures only	1,458.0	3.524	0	769.9	870.6
TF1*40	4070		2,318.0	1.512	0	523.0	696.7
TF1*80	2413		2,032.2	1.561	0	480.6	634.4
TF2*20	8490		2,069.7	2.303	0	778.8	940.2
TF2*40	23	5 failures only	1,865.3	2.047	0	621.2	767.7
TF4*20	7	Insufficent Failure Data	-	-	0	-	-
TF4*40	10	Insufficent Failure Data	-	-	0	-	-
TH1*1000	8	3 failures only	766.4	2.059	0	256.9	317.1
TH1*1500	2	Insufficent Failure Data	-	-	0	-	-
TH1*500	11	3 failures only	1,602.7	1.587	0	388.2	510.1
TH1*750	41		1,059.7	1.153	0	150.4	219.1

Table 1 – Full Weibull Results

This data was then reduced by the analysis team for further analysis to lamp types which had a population of 100 or more lamps in the sample.

The reduced set of lamps was then analysed against cost of BLR and spot replacement strategies to evaluate if there was a valid bulk lamp replacement period associated with the lamp type. The results of this analysis is included at Appendix 3 – Cost Curves.

The lamp life with calculated as documented in table 1 above at the 10 and 15% of population failed period is included on the graphs in Appendix 3 for comparison against the minimum cost.

The manufacturer data for the lumen output depreciation and periods to 10 and 15% of population failed period is summarised in Table 2 – Manufacturer lamp data summary below. This was produced from Charts and Datasheets provided to Energy Australia by the manufacturers, but the data was incomplete for a number of manufacturers.

Lumen Depreciation: Manufacturer Data Sheet Extracts

Lamp Type	Manufacturer	Model	Initial Lumens	Calculated 70%	Estimated Hrs to 70 %	Estimated days to 10% failed	Estimated days to 15% Failed
MBF1*50	Osram	HQL50W	1,800	1,260		-	-
MBF1*80	Osram	HQL80W	3,800	2,660		-	-
MBF1*125	Sylvania	HSL-BW125	6,300	4,410	10,250	1,062.50	1,312.50
MBF1*250	Osram	HQL250W	22,000	15,400		-	-
MBF1*400	Osram	HQL400W	40,000	28,000		-	-
SON1*70	Philips	SON70WI	5,600	3,920	23,500	1,125.00	1,416.67
SON1*150	Osram	NAV-E150W	14,000	9,800		-	-
SON1*250	Osram	NAV-T250W	27,000	18,900		-	-
SON1*310				-		-	-
SON1*400	Osram	NAV-T400	48,000	33,600		-	-
SOX1*90	Osram	SOX90W	13,500	9,450		-	-
SOX1*135	Osram	SOX135W	22,500	15,750		-	-
TF1*40	Osram	L36W/20	2,900	2,030	<8000	666.67	-
TF1*80	Osram	L65W/20	48,500	33,950	<8000	-	-

Table 2 – Manufacturer lamp data summary

When comparing the manufacturer's estimated time to 10% of the population failed (table 2 above) against that generated by the Newcastle statistics in Table 1 there is evidence that the manufacturer mortality data is significantly more optimistic than the actual field performance data.

The comparison of available manufacturer lumen depreciation against the Newcastle area generated data on lamp mortality and approximate cost optimum periods are summarised in table 3 below. This appears to indicate that lumen depreciation may not be the driver for lamp replacement, but rather the costs associated with replacement of lamps.

Lamp Type	Manufacturer days to 70% Lumen output	BLR Cost Optimum (~Days)	Days to 10% of units failed
MBF1*50	-	900	966
MBF1*80	-	720	841
MBF1*125	932	800	709
MBF1*250	-	800	664
MBF1*400	-	850	852
SON1*150	2,136	990	590
SON1*250	-	750	506
SON1*310		800	973
SON1*400	-	720	490
SON1*70	-	630	454
SOX1*135	-	800	923
SOX1*90	-	800	865
TF1*40		600	523
TF1*80		540	481

Table 3 – Manufacturer lamp data and analysis data summary

One of the anomalies identified as part of the analysis is the higher failure rate of the fluorescent tubes in the Newcastle sample area compared to the preliminary data from the Mosman street lighting trial. The data from the Mosman trial is as yet incomplete and needs to be further investigated with respect to the failure rates of the fluorescent tube installations.

Street Lighting Tasks and Strategies

The bundling of the proposed maintenance tasks on other street lighting components identified as part of the FMECA/RCM will be dependant upon the strategies developed to handle the lamp life.

The FMECA/RCM condition monitoring data algorithm (using the available data) was able to determine valid task intervals for one task, with two intervals depending upon the method used to execute the task. These are

270 days +/- 60 days	Examine SLP contactor connections for overheating (Kiosk SS installations). (Visual – 50% task effectiveness) or
511days +/- 100 days	Examine SLP contactor connections for overheating using Thermography (Kiosk SS installations). (Task effectiveness 80%)

The FMECA has identified the following one off examination task to identify and remove a type of defective lighting assembly.

Within 1 yr	Examine Sylvania B2229/B3000 fitting for cracks.

To ensure that the availability of the street lighting system remained above 95% as per *AS/NZS 1158.1.3:1997 Road lighting - Vehicular traffic (Category V) lighting - Guide to design, installation, operation and maintenance*, a strategy of BLR alone at the optimum periods identified in table 3 would not meet the requirements of the standard. The introduction of a condition monitoring and failure finding patrol would be required to increase the availability of the street lighting through the detection and resulting removal of defects. This system would be required to operate in addition to the current system where the public advise of defects, as analysis team advised the public appear to only report about 1/3 of the lamp failures.

The reliability of the various lamp types is included at Table 4 below. A potential annual patrol appears possible to maintain the number of failed lamps at less than 5% These periods are based on using a bulk lamp strategy. If a Continuous Spot Replacement (CSR) strategy is adopted a higher patrol frequency will be required as the effective rate of failure of the population of lamps will be higher.

Lamp Type	Days to 3 % failed	Days to 5 % failed	Days to 7 % failed	Days to 10 % failed	Days to 12 % failed	Days to 15 % failed
MBF1*50	383.9	565.5	731.9	965.7	1114.9	1,332.8
MBF1*80	347.3	503.5	644.7	840.9	965.1	1,145.1
MBF1*125	218.6	358.3	497.9	709.0	851.6	1,069.2
MBF1*250	257.5	383.6	499.9	664.5	770.1	925.0
MBF1*400	398.8	548.5	678.1	851.8	958.7	1,110.2
SON1*150	222.9	335.5	440.5	590.2	686.8	829.1
SON1*250	213.2	306.4	390.1	505.7	578.6	683.8
SON1*310	619.7	748.9	849.6	972.9	1043.8	1,138.9
SON1*400	188.6	281.5	367.6	489.7	568.2	683.4
SON1*70	191.8	275.4	350.4	454.1	519.3	613.5
TF1*40	230.1	324.9	408.7	523.0	594.4	696.7
TF1*80	217	303	378.5	480.6	544	634.4
	average	411.25				

Table 4 – Patrol interval to achieve 95% availability.

In order to select the appropriate strategy, the choice of the Bulk Lamping strategy or the Continuous Spot Replacement strategy will be based on which solution presents the best

NPV. This has been assessed based on a 4500 day cycle, with a discount rate of 7%. The result of this NPV analysis is shown at table 5 below. The costs have been calculated based on the entire Energy Australia populations of each lamp type, using mortality rates calculated from Weibull parameters generated from the data sets, and Energy Australia unit rates for BRL and CSR activity.

Lamp type	EA Total Population	BLR NPV	CSR NPV	Recommended Strategy
MBF1*50	22,279	$923,435	$1,102,113	BLR
MBF1*80	29,000	$1,207,060	$1,469,278	BLR
MBF1*125	6,050	$386,363	$326,806	CSR
MBF1*250	30,600	$2,005,769	$2,349,392	BLR
MBF1*400	16,163	$1,067,248	$1,023,878	BLR
SON1*150	474	$55,164	$55,595	either
SON1*250	14,989	$1,802,483	$2,484,774	BLR
SON1*400	1,690	$202,546	$232,369	BLR
SON1*70	2,921	$297,355	$485,510	BLR
TF1*40	8,755	$539,626	$1,000,410	BLR
TF1*80	749	$49,604	103,728	BLR

Table 5 – NPV Calculation Results

The difficulty in reaching a final strategy for the management of street lighting is due to the variety of street lights currently in service, and the fact that these do not exist in large areas of homogeneous populations, except possibly at intersections and along portions of the Traffic Route Lighting (TRL). At March 2003 Energy Australia has 53,724 lamps designated as TRL and 186,320 lamps designated as non TRL, each with a large variety of types.

This is further complicated by the variety of 'optimum' BLR periods based on the analysis of each lamp type. However all the data suggests that the current BLR cycle , where used, of 18months (approx 550 days) is too short. The possibility of using a common BLR period may be considered. If all types are considered, then an average of the optimum periods around 760 days results. If the SON 1x70 and TF types are excluded than the average of the optimums is extended out to around 815 days results.

Failures of photocells were also identified in the analysis as a component of concern. Some problems were easily attributable, such as photocells manufactured in the northern hemisphere had instructions on the box stating install facing north. For use in Australia this must be changed to install facing south to prevent early failure of the photocell. Another concern was that the modern photocell housings are plastic rather than metal, and anecdotal responses indicated that these housings were degrading over time. The provision of a BLR strategy would potentially allow the scheduled discard of the photocell at every second BLR action, although the analysis group had not firm objective data to support this conclusion.

Recommendation

The following recommendations are made with respect to the analysis performed on the street lighting system.

- Bulk Lamp Replacement is a viable maintenance strategy, and the programme should be executed on a cycle period of 30 months.
- An annual lighting failure finding patrol is required to manage random lamp outages and corrective action in the form of spot replacements will be essential to maintain the 95% average availability as required by *AS/NZS 1158.1.3:1997.*
- Photocell replacements every 2nd BLR cycle (ie at 60 Months).
- Implement Design Change: Replace mechanical timer for lighting on the Stockton side of the Stockton Bridge with a photo-electrically operated scheme.
- Examine SLP contactor connections for overheating using Thermography (Kiosk SS installations) every 18 months.
- Examine Sylvania B2229/B3000 fitting for cracks to identify and remove defective fittings as a one off task.

Appendix 1 – Weibull Analysis

Notes

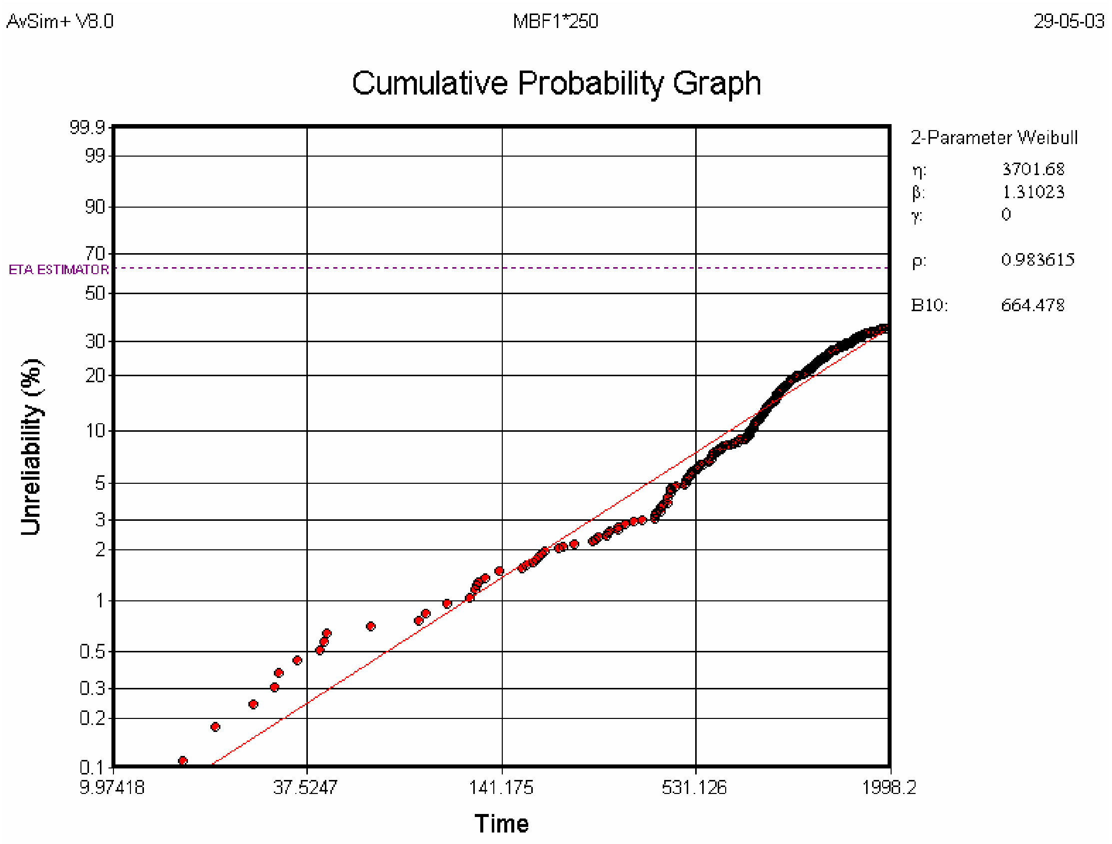
- Data for lamps with status of censored or in service from Newcastle database are considered as 'suspended' for the Weibull analysis
- B10 = days by which 10% of the population is expected to have failed

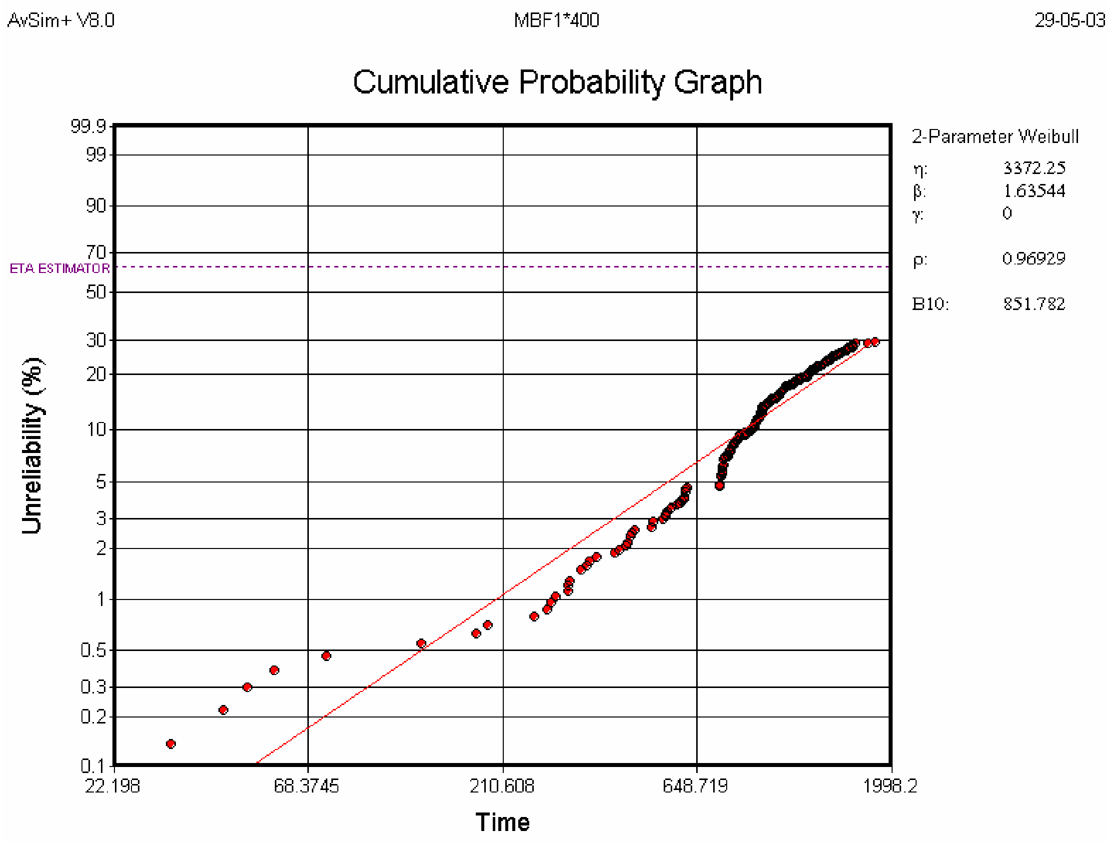
    β = 1 = Random Failure

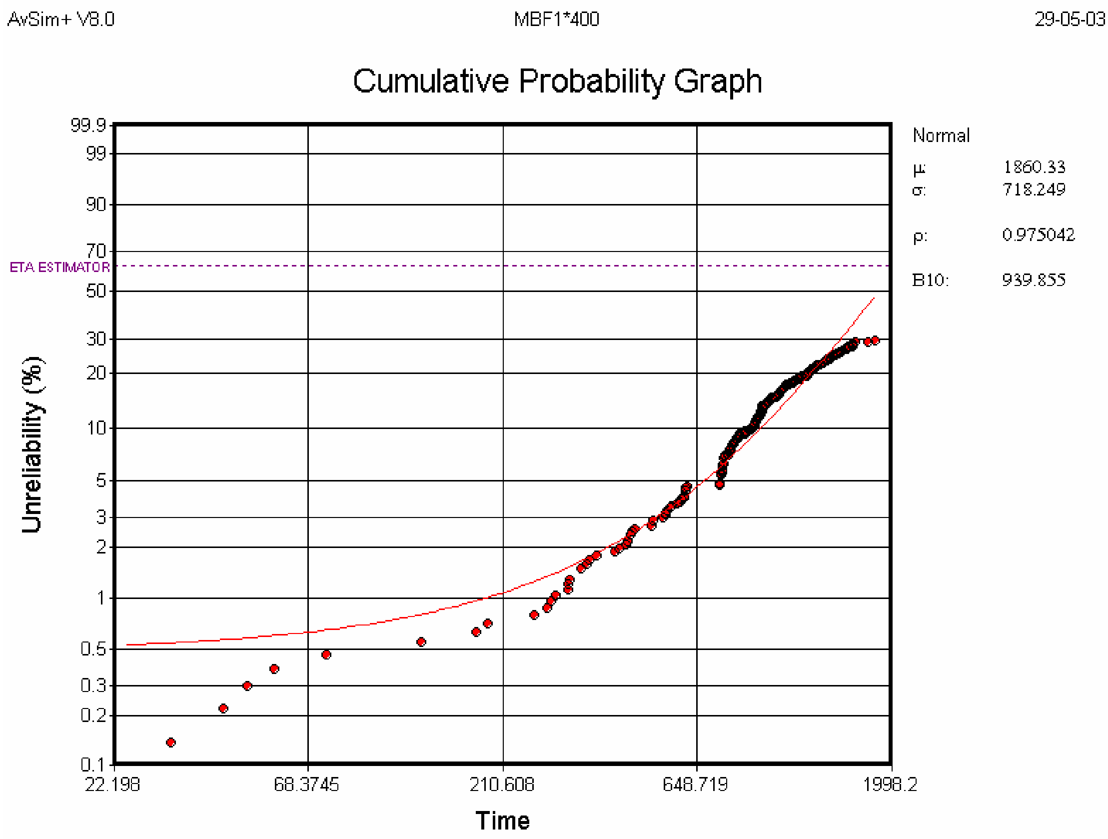
    β ~ 1.3 – wearout

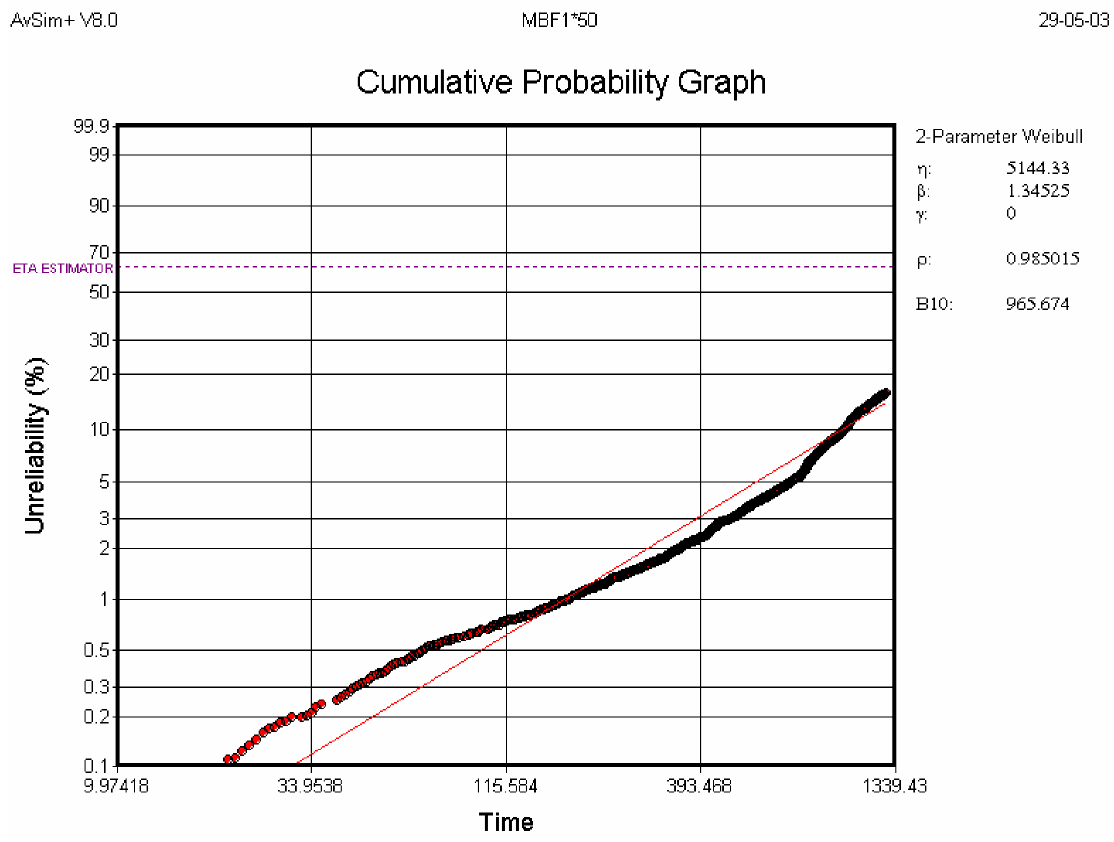
    β ~ 2.5 or more – rapid wearout

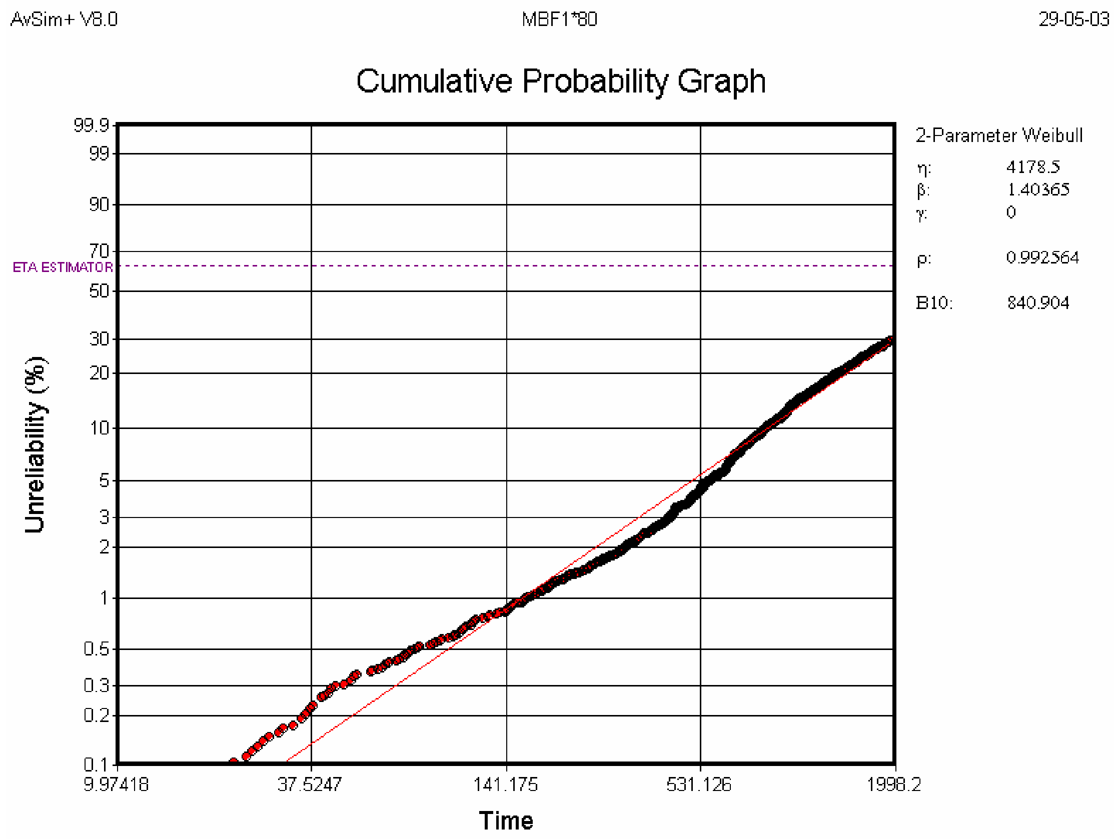
- Some distributions may be closer to normal than weibull. In these cases two graphs for the same data set are presented on the same page

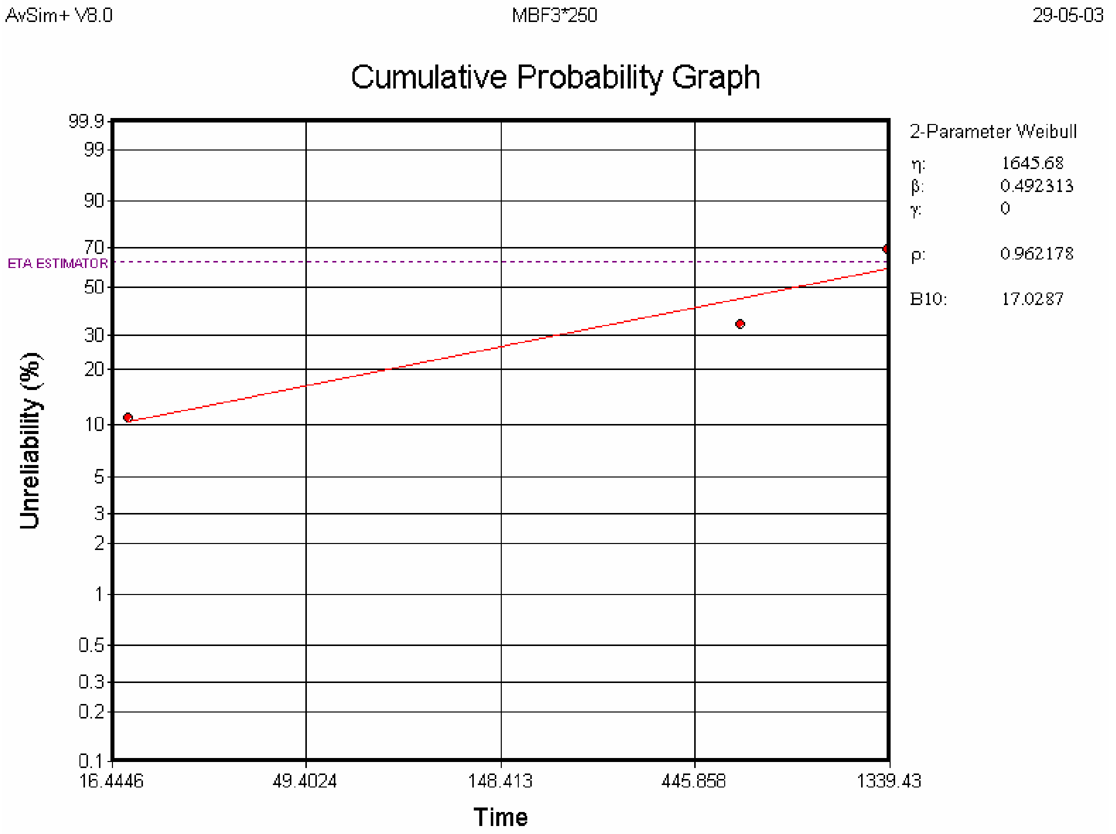


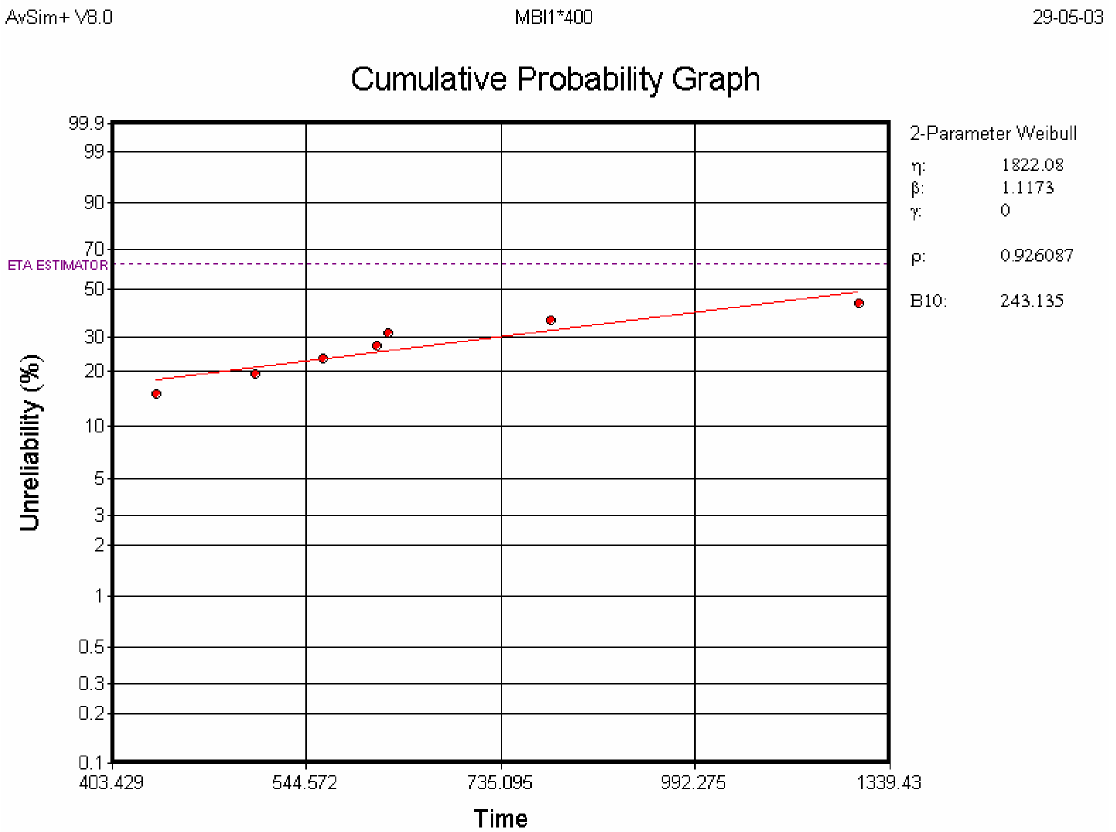

AvSim+ V8.0
MBF1*400
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 3372.25
β: 1.63544
γ: 0
ρ: 0.96929
B10: 851.782
ETA ESTIMATOR
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
Unreliability (%)
22.198
68.3745
210.608
648.719
1998.2
Time

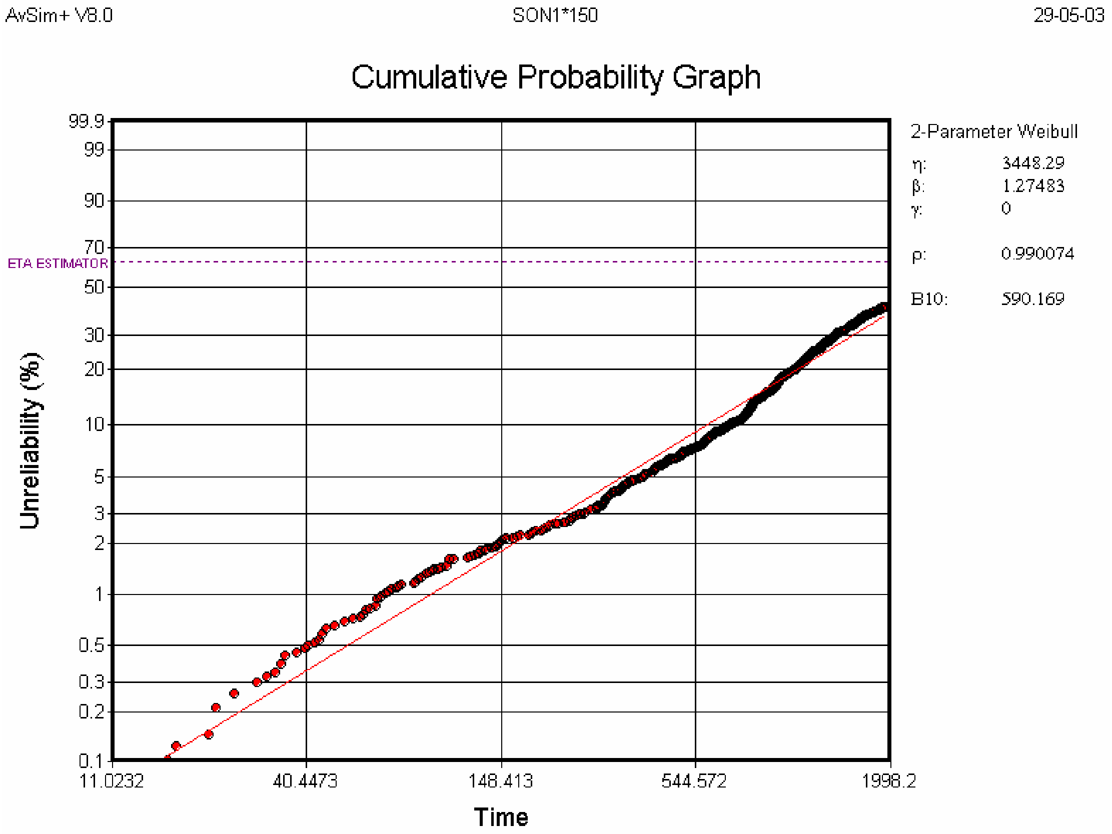

AvSim+ V8.0
MBF1*400
29-05-03
Cumulative Probability Graph
Normal
μ: 1860.33
σ: 718.249
ρ: 0.975042
B10: 939.855
ETA ESTIMATOR
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
Unreliability (%)
22.198
68.3745
210.608
648.719
1998.2
Time


AvSim+ V8.0
MBF1*50
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 5144.33
β: 1.34525
γ: 0
ρ: 0.985015
B10: 965.674
ETA ESTIMATOR
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
Unreliability (%)
9.97418
33.9538
115.584
393.468
1339.43
Time

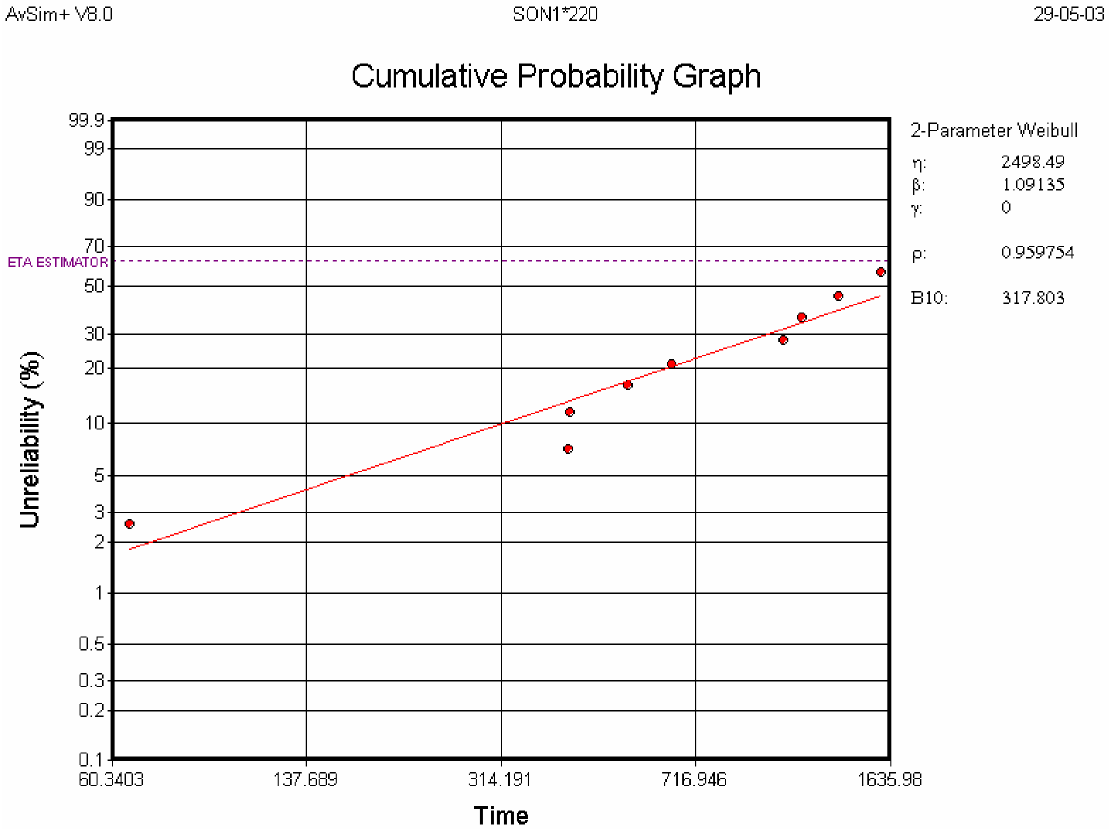

AvSim+ V8.0
MBF1*80
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 4178.5
β: 1.40365
γ: 0
ρ: 0.992564
B10: 840.904
ETA ESTIMATOR
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
Unreliability (%)
9.97418
37.5247
141.175
531.126
1998.2
Time


AvSim+ V8.0
MBF3*250
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 1645.68
β: 0.492313
γ: 0
ρ: 0.962178
B10: 17.0287
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
16.4446
49.4024
148.413
445.858
1339.43
Time

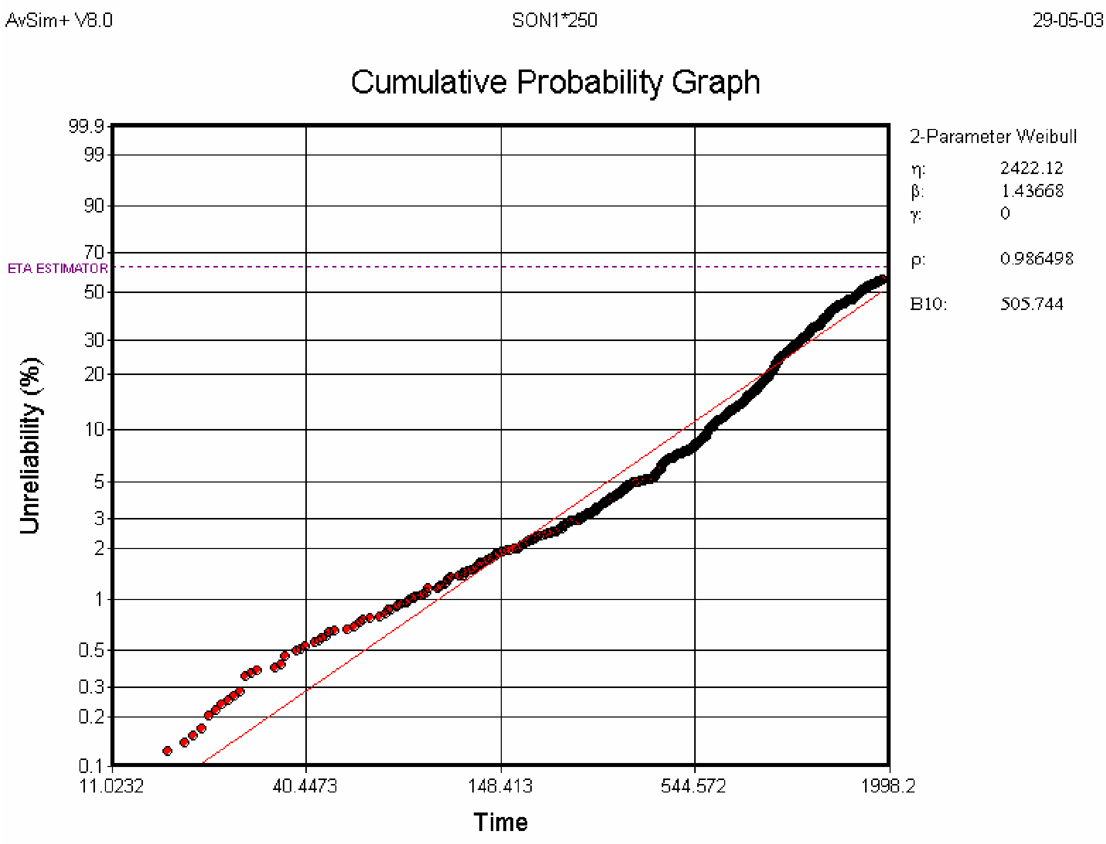

AvSim+ V8.0
MBI1*400
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 1822.08
β: 1.1173
γ: 0
ρ: 0.926087
B10: 243.135
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
403.429
544.572
735.095
992.275
1339.43
Time

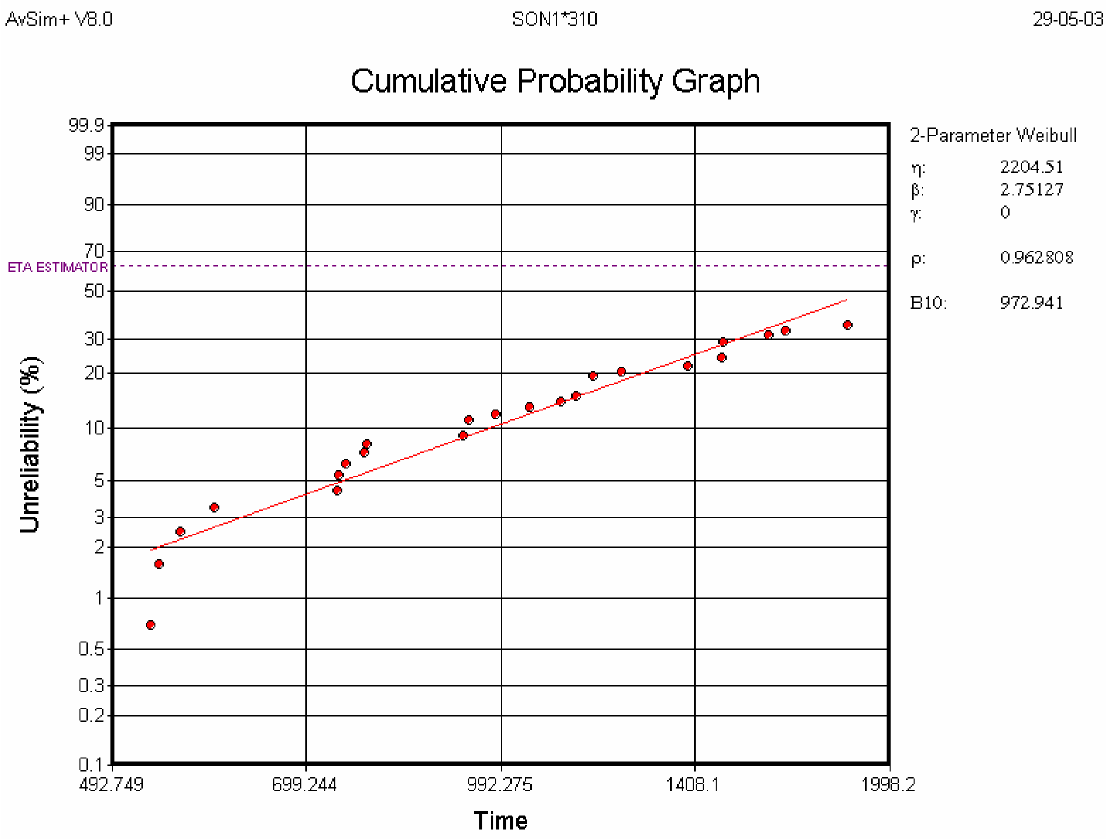


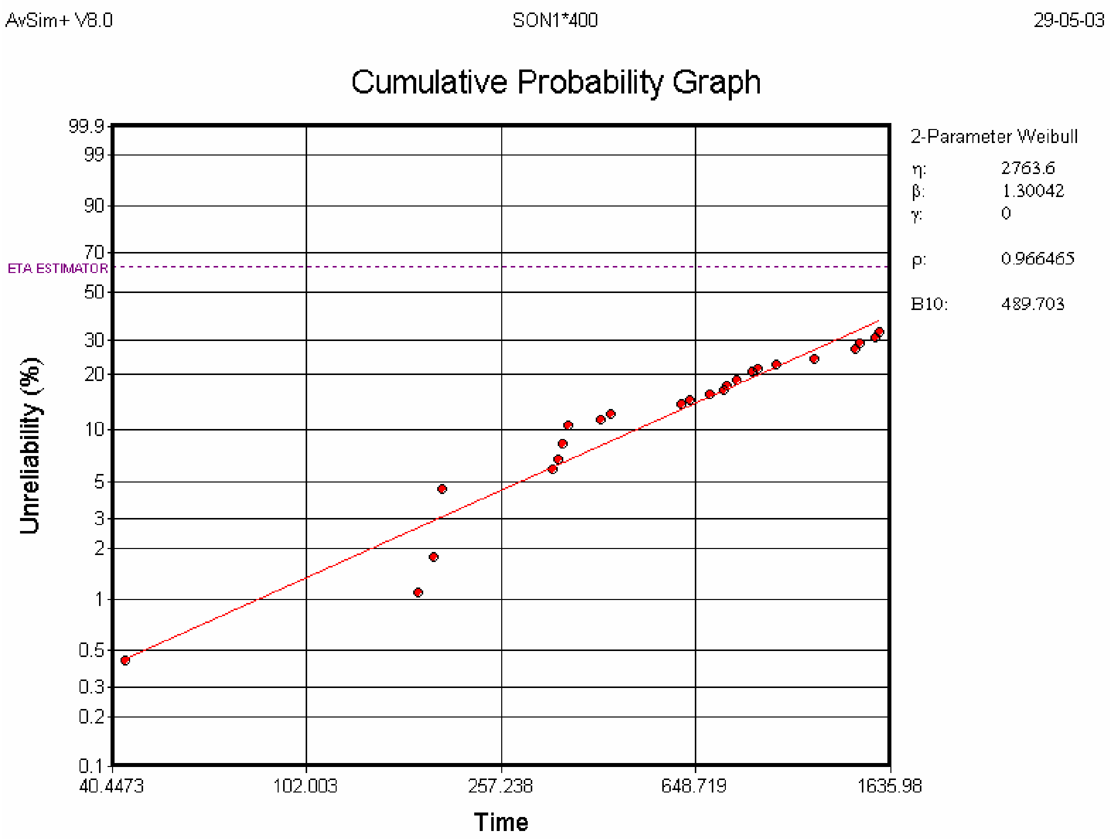
AvSim+ V8.0
SON1*150
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 3448.29
β: 1.27483
γ: 0
ρ: 0.990074
B10: 590.169
ETA ESTIMATOR
Unreliability (%)
Time

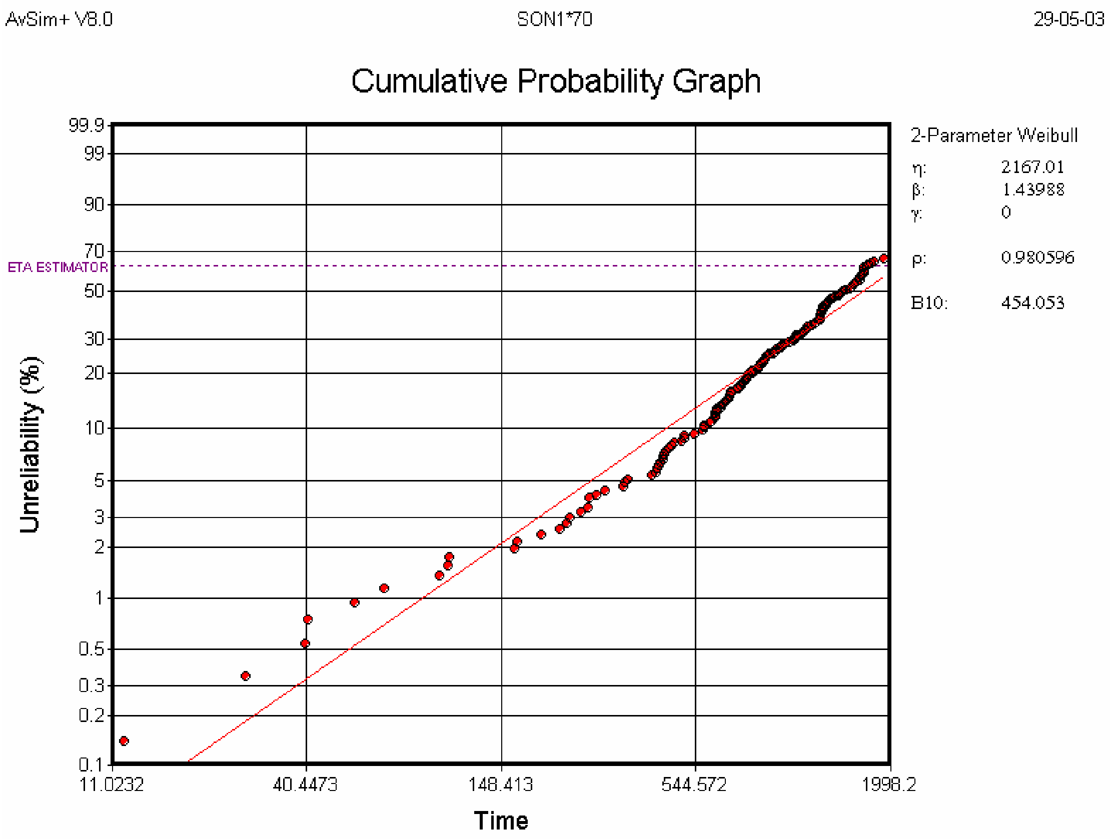


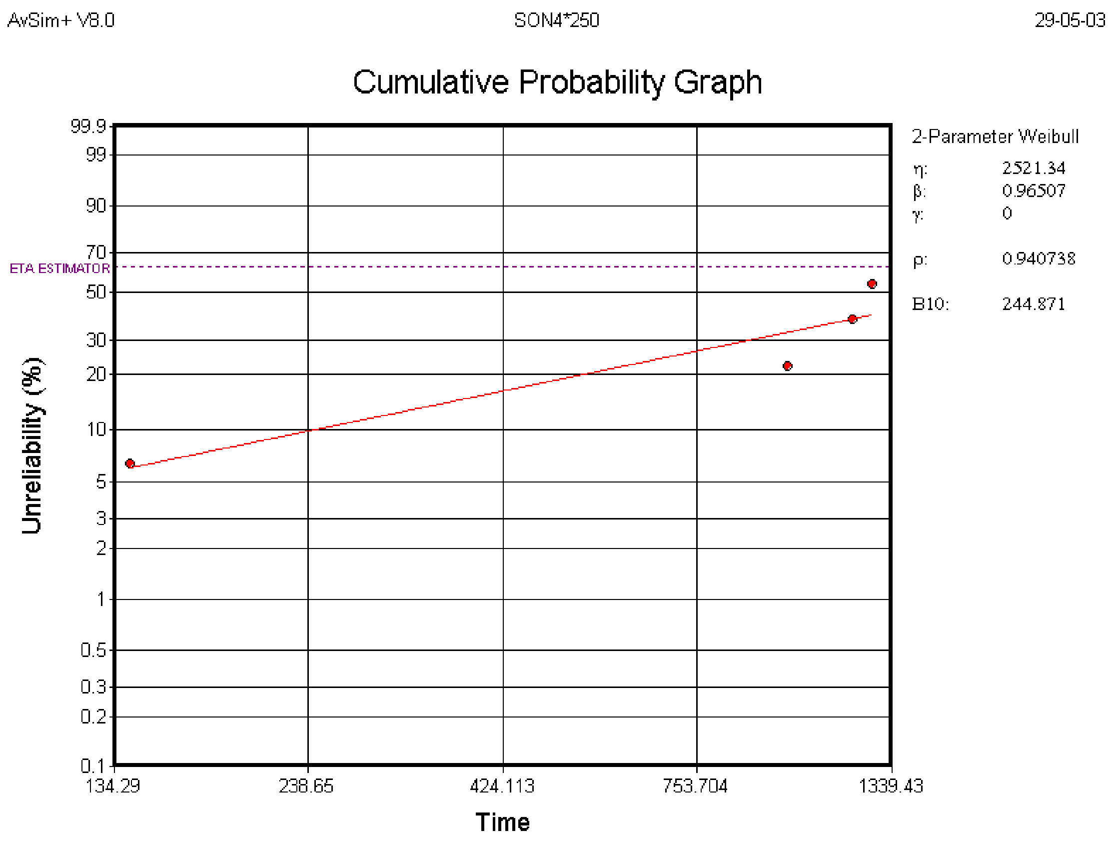
AvSim+ V8.0
SON1*220
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2498.49
β: 1.09135
γ: 0
ρ: 0.959754
B10: 317.803
ETA ESTIMATOR
Unreliability (%)
Time

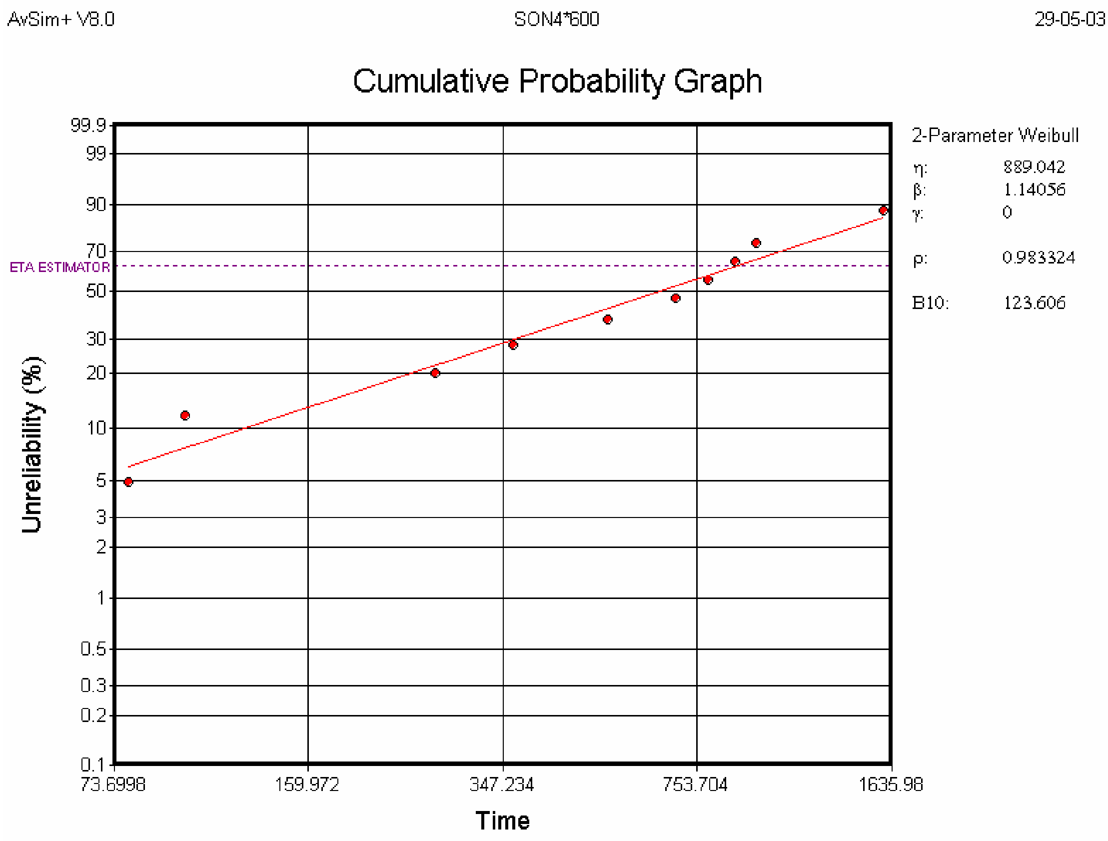

AvSim+ V8.0
SON1*250
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2422.12
β: 1.43668
γ: 0
ρ: 0.986498
B10: 505.744
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
11.0232
40.4473
148.413
544.572
1998.2
Time

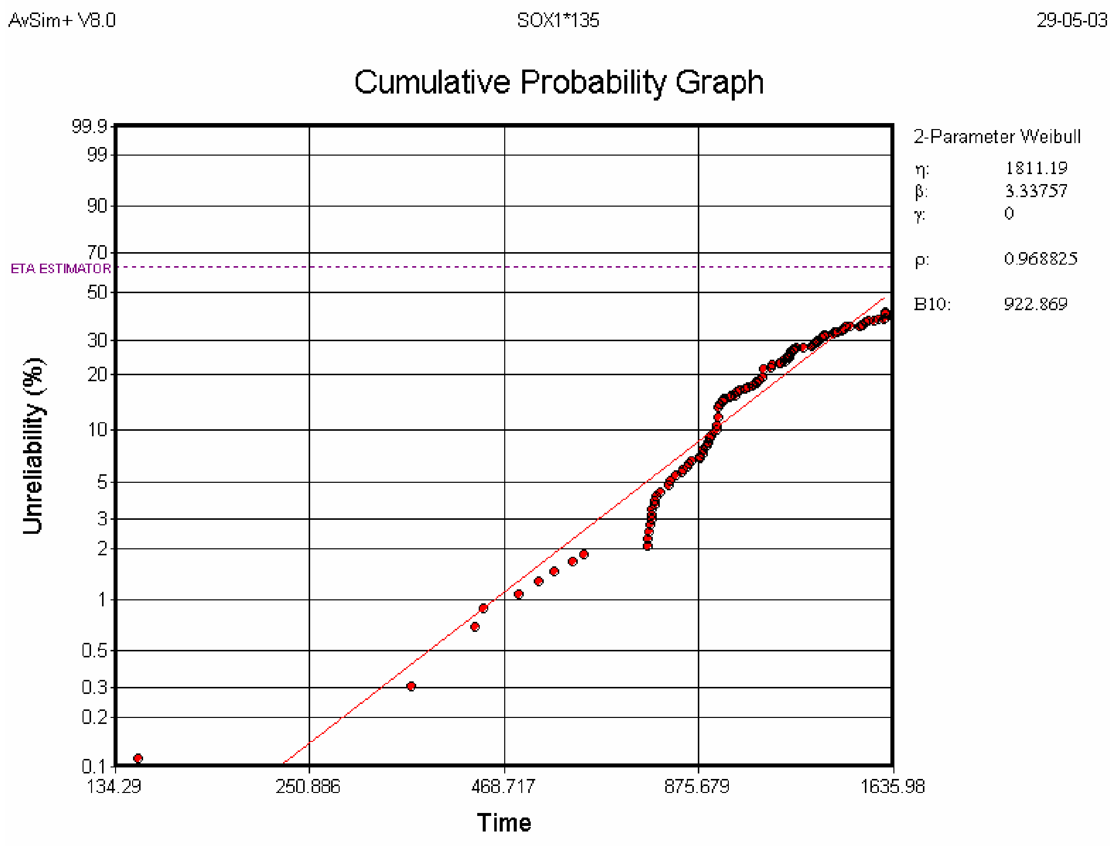

AvSim+ V8.0
SON1*310
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2204.51
β: 2.75127
γ: 0
ρ: 0.962808
B10: 972.941
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
492.749
699.244
992.275
1408.1
1998.2
Time

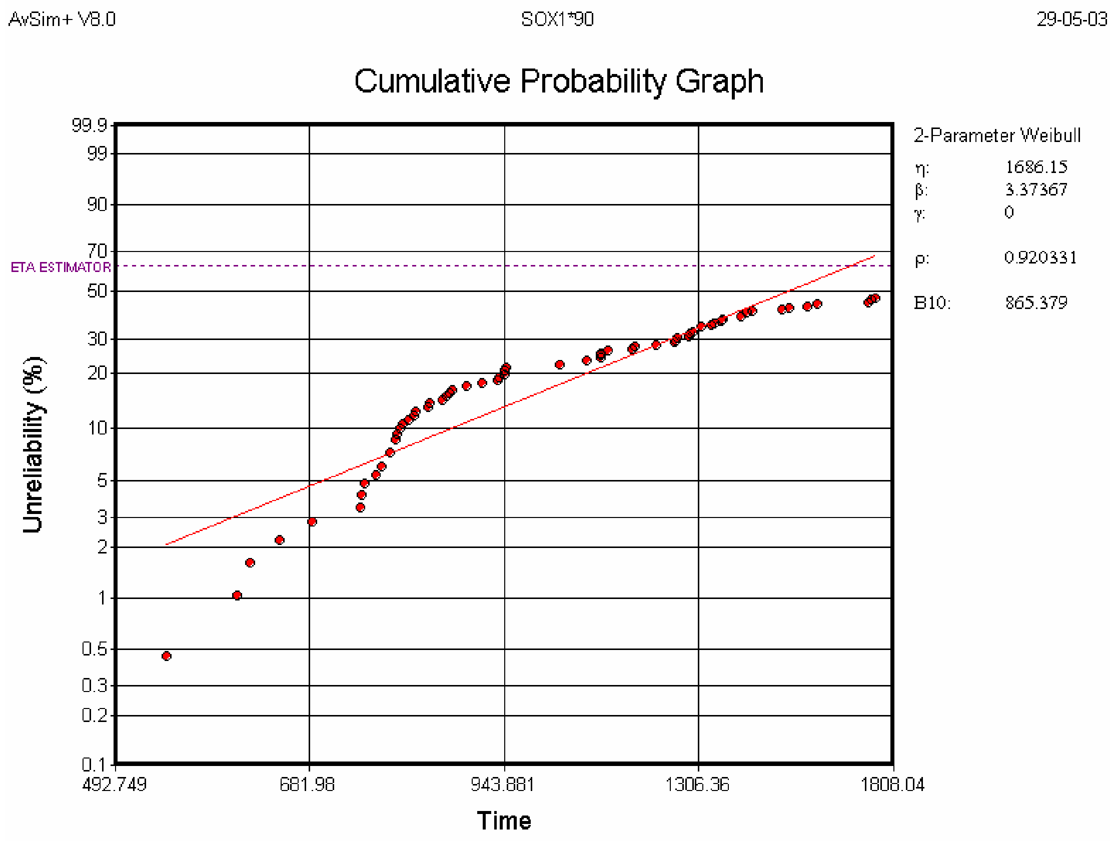

AvSim+ V8.0
SON1*400
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2763.6
β: 1.30042
γ: 0
ρ: 0.966465
B10: 489.703
ETA ESTIMATOR
Unreliability (%)
Time
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
40.4473
102.003
257.238
648.719
1635.98

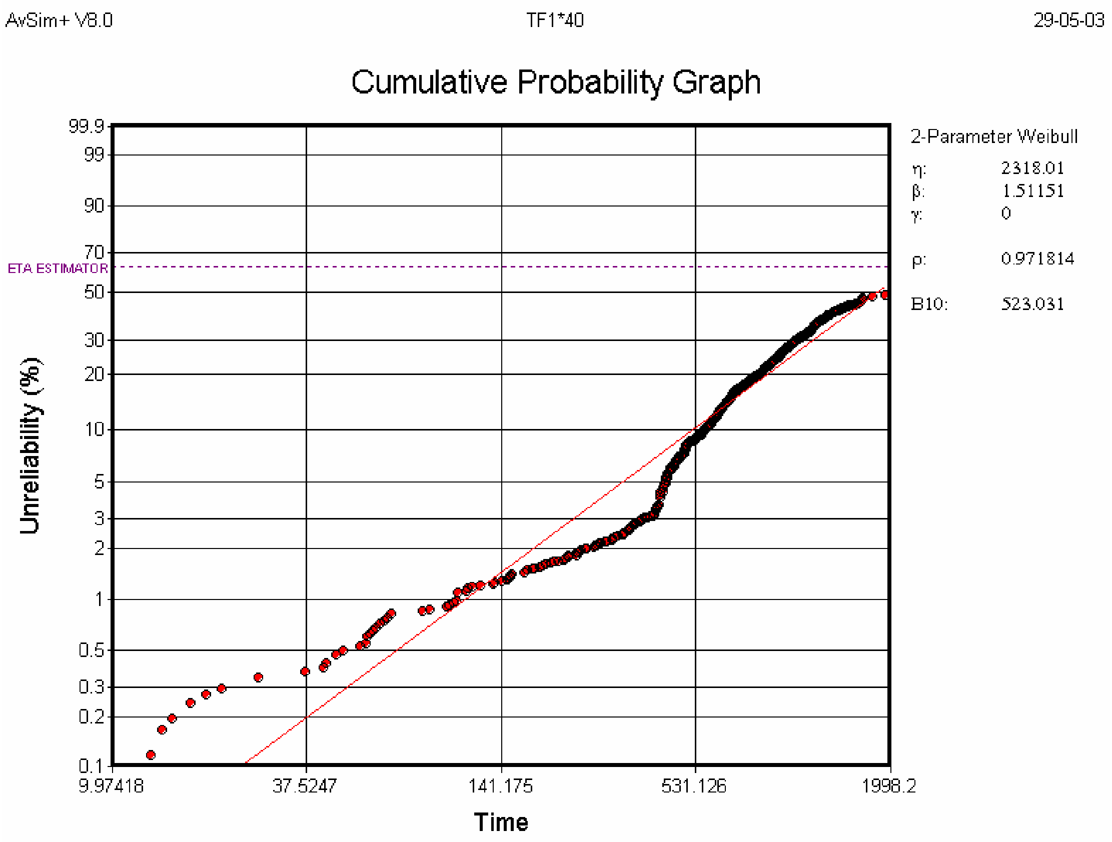

AvSim+ V8.0
SON1*70
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2167.01
β: 1.43988
γ: 0
ρ: 0.980596
B10: 454.053
ETA ESTIMATOR
Unreliability (%)
Time
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
11.0232
40.4473
148.413
544.572
1998.2

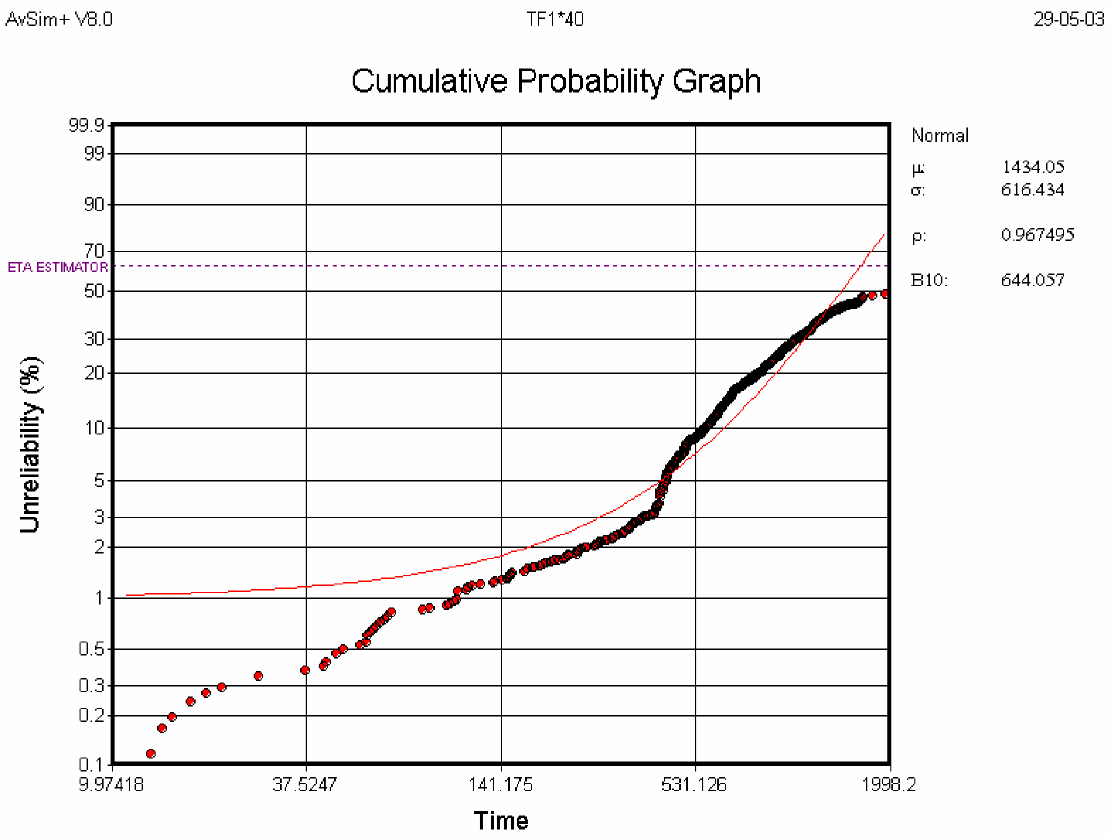

AvSim+ V8.0
SON4*250
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2521.34
β: 0.96507
γ: 0
ρ: 0.940738
B10: 244.871
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
134.29
238.65
424.113
753.704
1339.43
Time

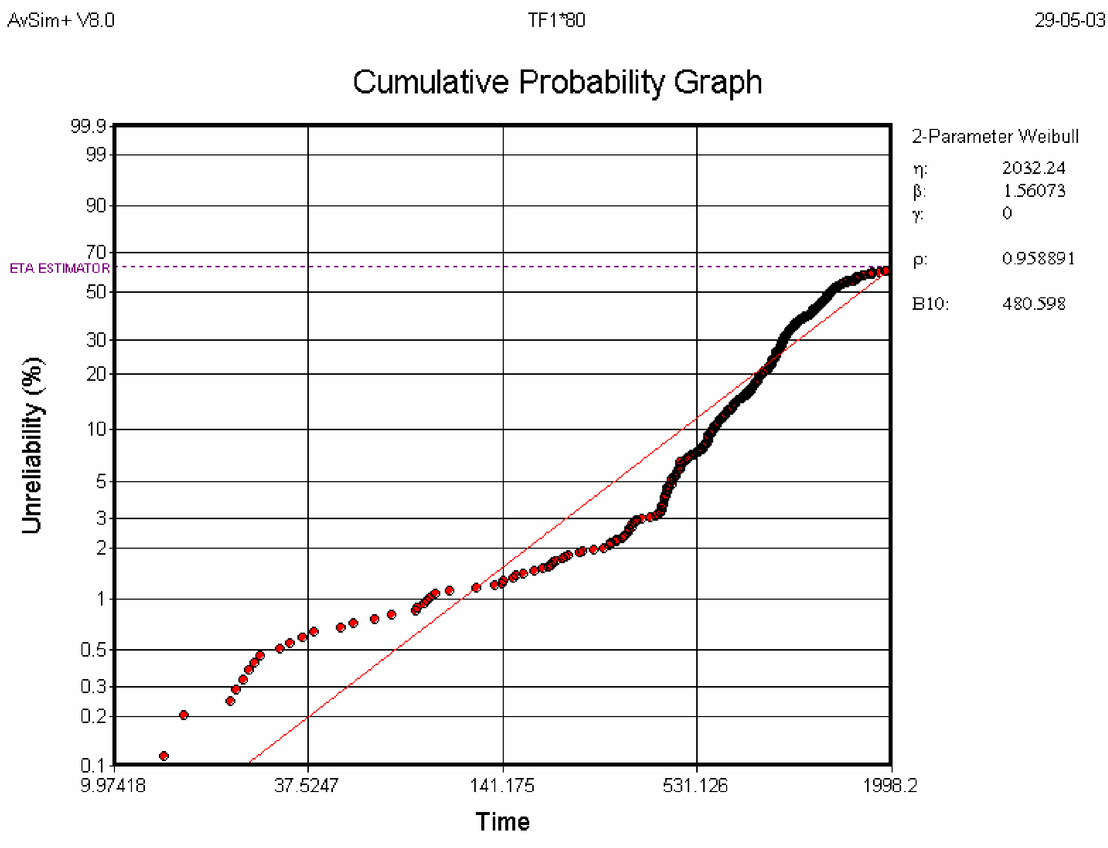

AvSim+ V8.0
SON4*600
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 889.042
β: 1.14056
γ: 0
ρ: 0.983324
B10: 123.606
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
73.6998
159.972
347.234
753.704
1635.98
Time

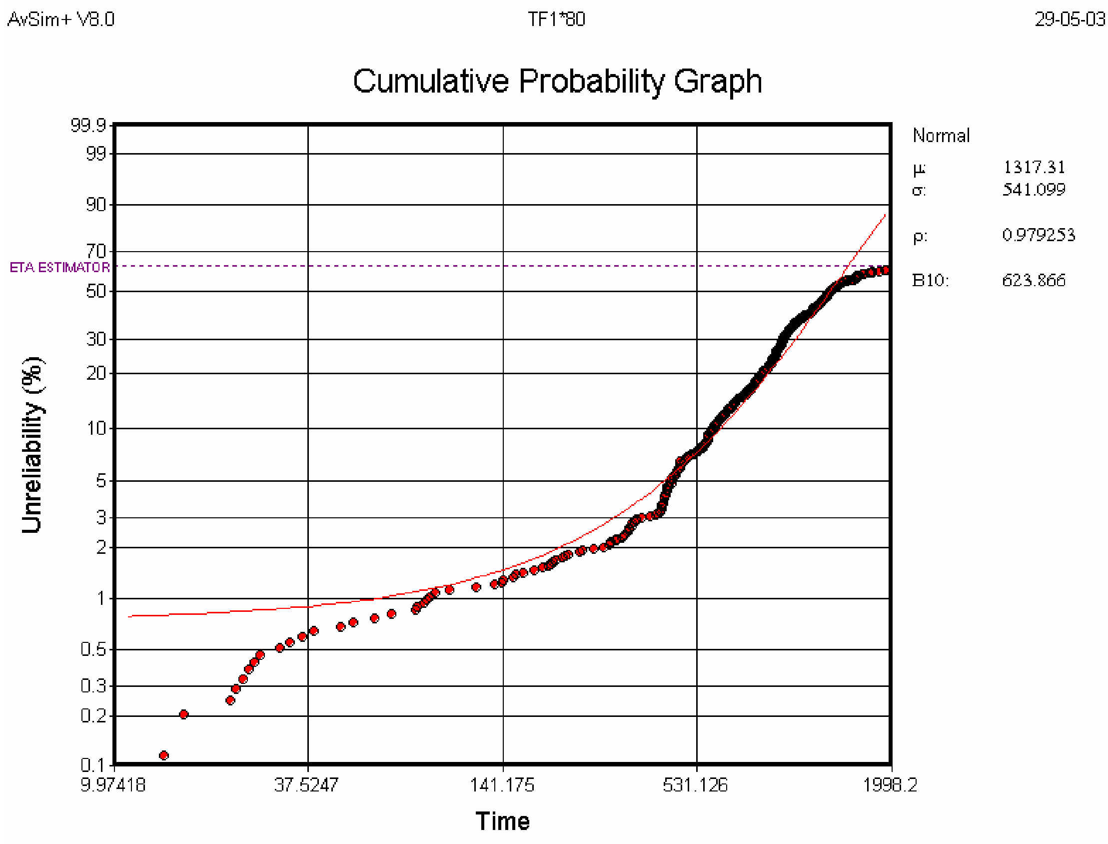

AvSim+ V8.0
SOX1*135
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 1811.19
β: 3.33757
γ: 0
ρ: 0.968825
B10: 922.869
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
134.29
250.886
468.717
875.679
1635.98
Time

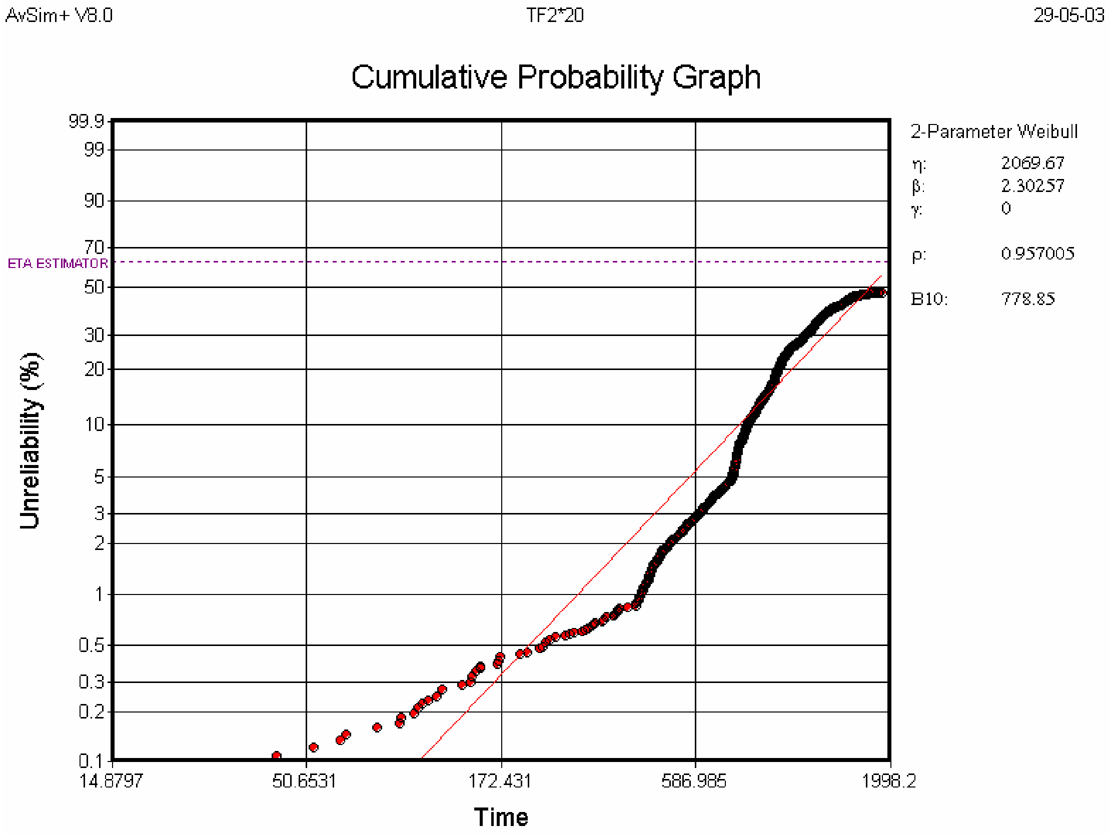

AvSim+ V8.0
SOX1*90
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 1686.15
β: 3.37367
γ: 0
ρ: 0.920331
B10: 865.379
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
492.749
681.98
943.881
1306.36
1808.04
Time

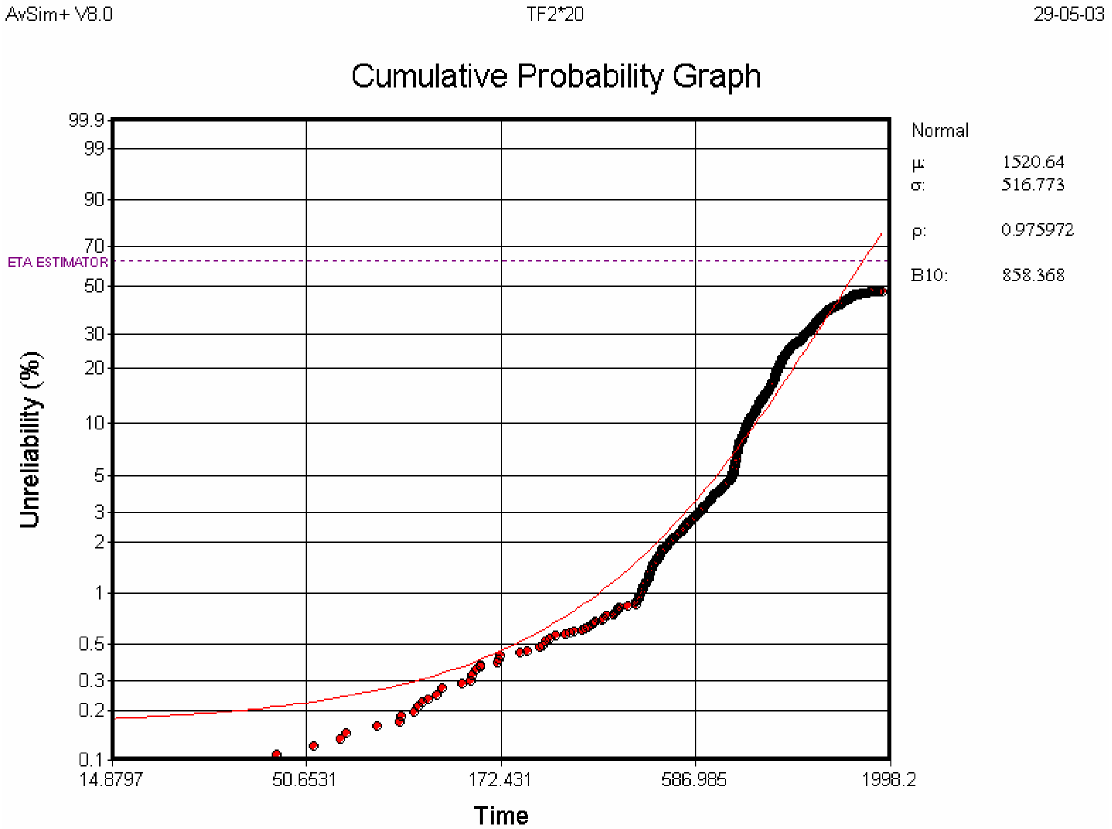

AvSim+ V8.0
TF1*40
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2318.01
β: 1.51151
γ: 0
ρ: 0.971814
B10: 523.031
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
9.97418
37.5247
141.175
531.126
1998.2
Time

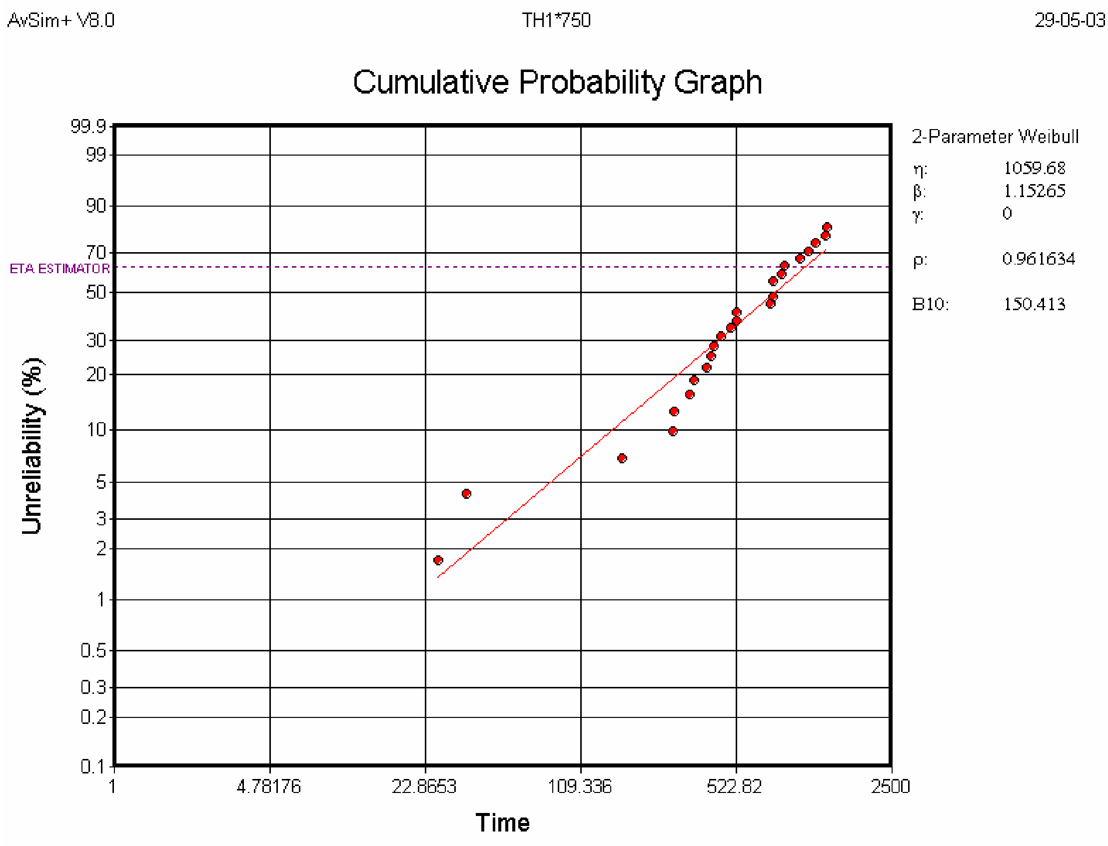

AvSim+ V8.0
TF1*40
29-05-03
Cumulative Probability Graph
Normal
μ: 1434.05
σ: 616.434
ρ: 0.967495
B10: 644.057
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
9.97418
37.5247
141.175
531.126
1998.2
Time

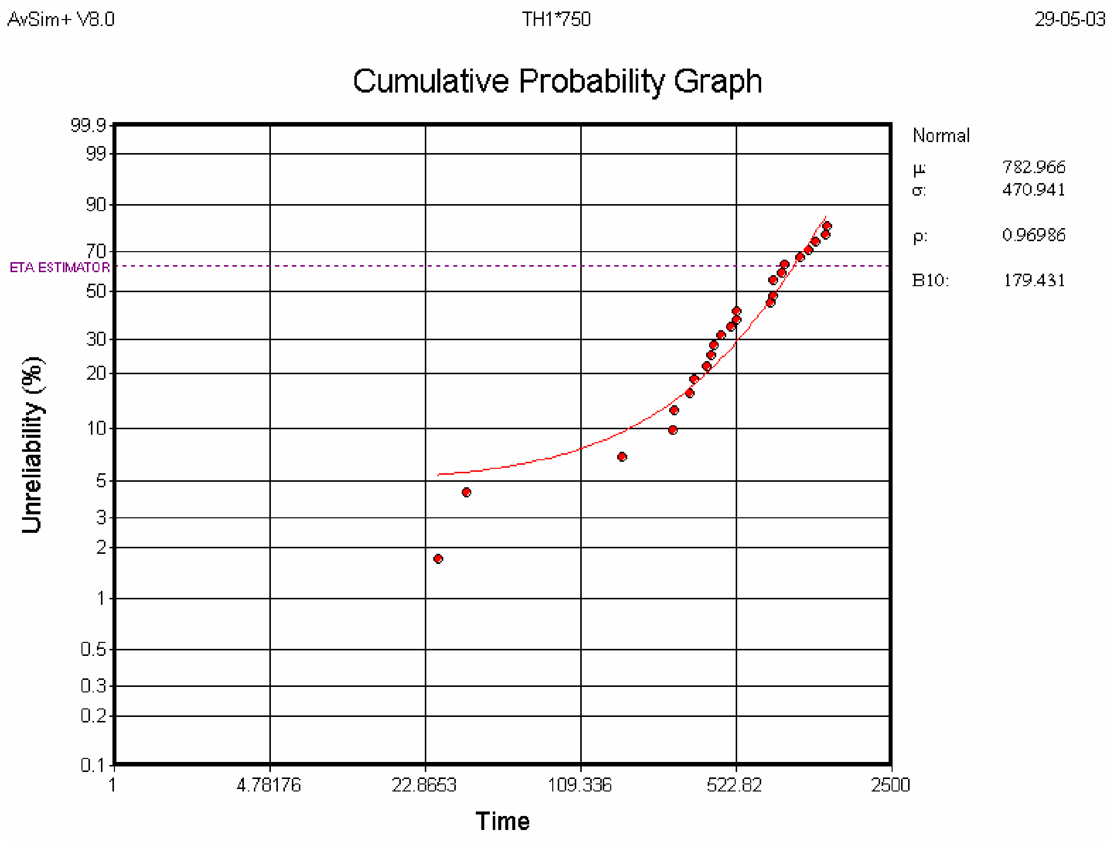

AvSim+ V8.0
TF1*80
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2032.24
β: 1.56073
γ: 0
ρ: 0.958891
B10: 480.598
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
9.97418
37.5247
141.175
531.126
1998.2
Time


AvSim+ V8.0
TF1*80
29-05-03
Cumulative Probability Graph
Normal
μ: 1317.31
σ: 541.099
ρ: 0.979253
B10: 623.866
ETA ESTIMATOR
Unreliability (%)
99.9
99
90
70
50
30
20
10
5
3
2
1
0.5
0.3
0.2
0.1
9.97418
37.5247
141.175
531.126
1998.2
Time

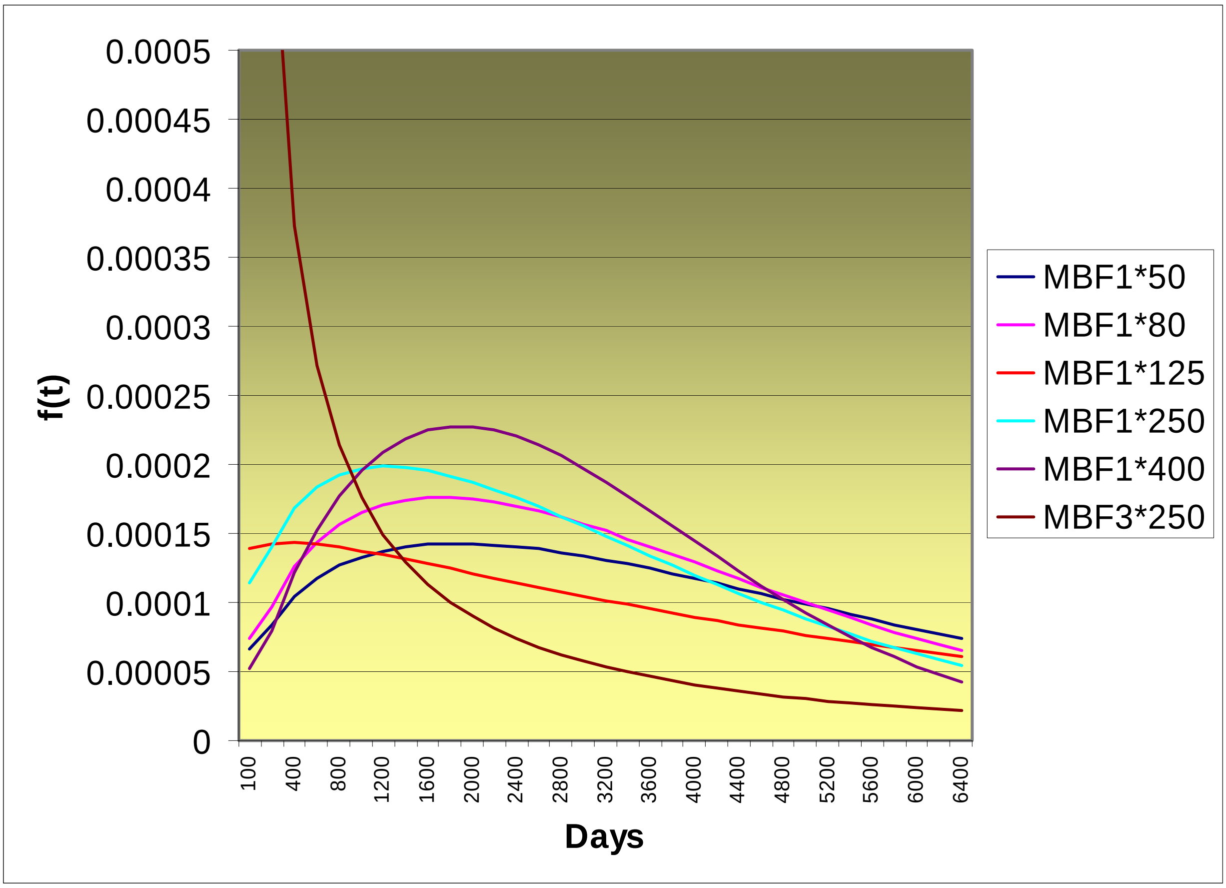

AvSim+ V8.0
TF2*20
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 2069.67
β: 2.30257
γ: 0
ρ: 0.957005
B10: 778.85
ETA ESTIMATOR
Unreliability (%)
Time
14.8797
50.6531
172.431
586.985
1998.2

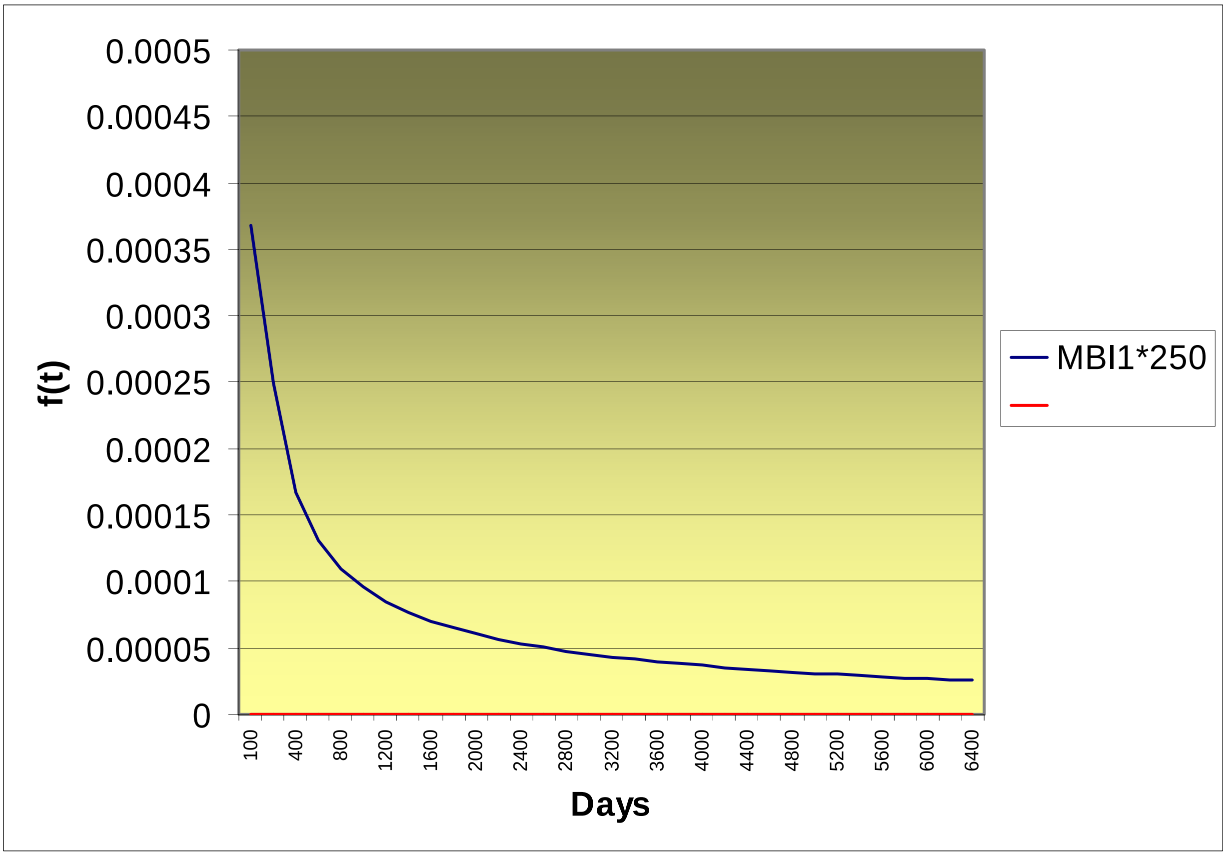

AvSim+ V8.0
TF2*20
29-05-03
Cumulative Probability Graph
Normal
μ: 1520.64
σ: 516.773
ρ: 0.975972
B10: 858.368
ETA ESTIMATOR
Unreliability (%)
Time
14.8797
50.6531
172.431
586.985
1998.2

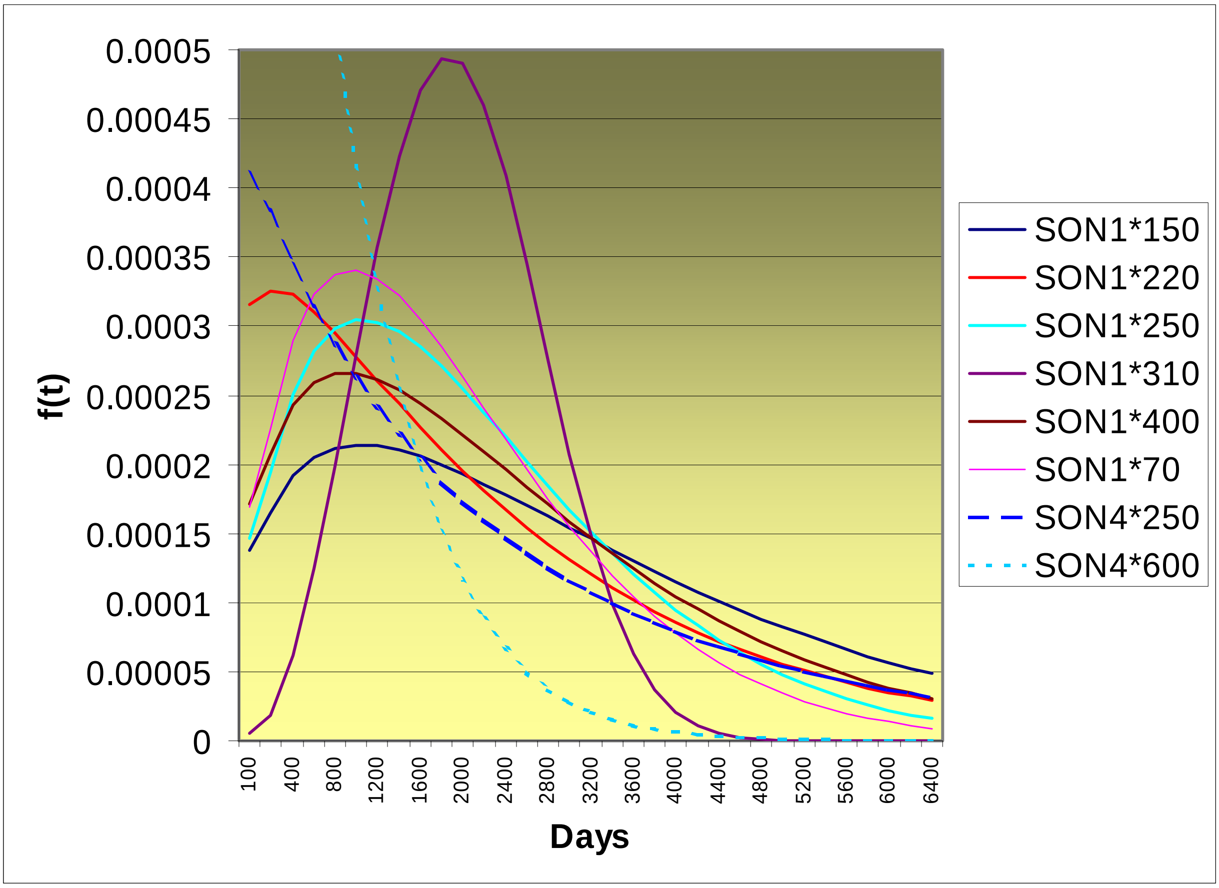

AvSim+ V8.0
TH1*750
29-05-03
Cumulative Probability Graph
2-Parameter Weibull
η: 1059.68
β: 1.15265
γ: 0
ρ: 0.961634
B10: 150.413
ETA ESTIMATOR
Unreliability (%)
99.9 99 90 70 50 30 20 10 5 3 2 1 0.5 0.3 0.2 0.1
1 4.78176 22.8653 109.336 522.82 2500
Time


AvSim+ V8.0
TH1*750
29-05-03
Cumulative Probability Graph
Normal
μ: 782.966
σ: 470.941
ρ: 0.96986
B10: 179.431
ETA ESTIMATOR
Unreliability (%)
99.9 99 90 70 50 30 20 10 5 3 2 1 0.5 0.3 0.2 0.1
1 4.78176 22.8653 109.336 522.82 2500
Time

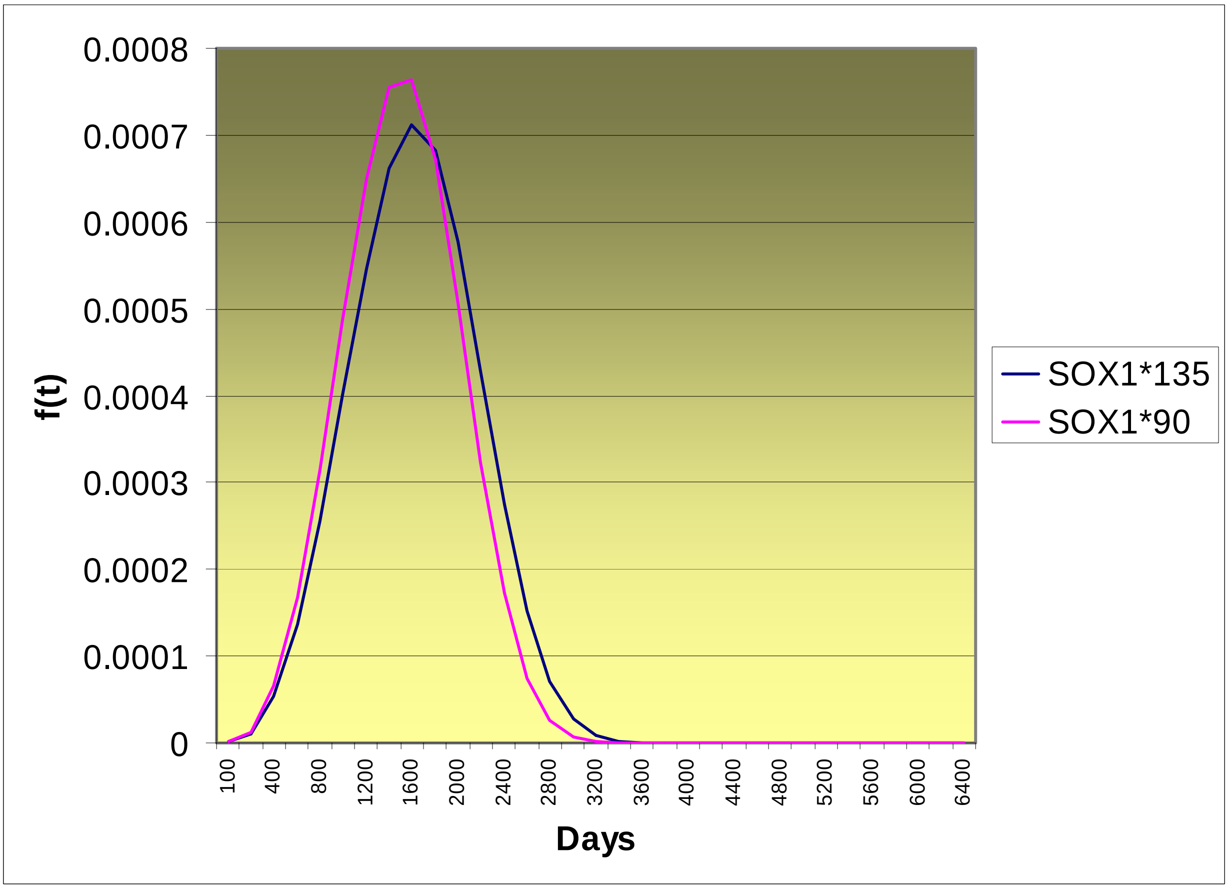
Appendix 2 – Summary Data and Weibull Distribution Plots



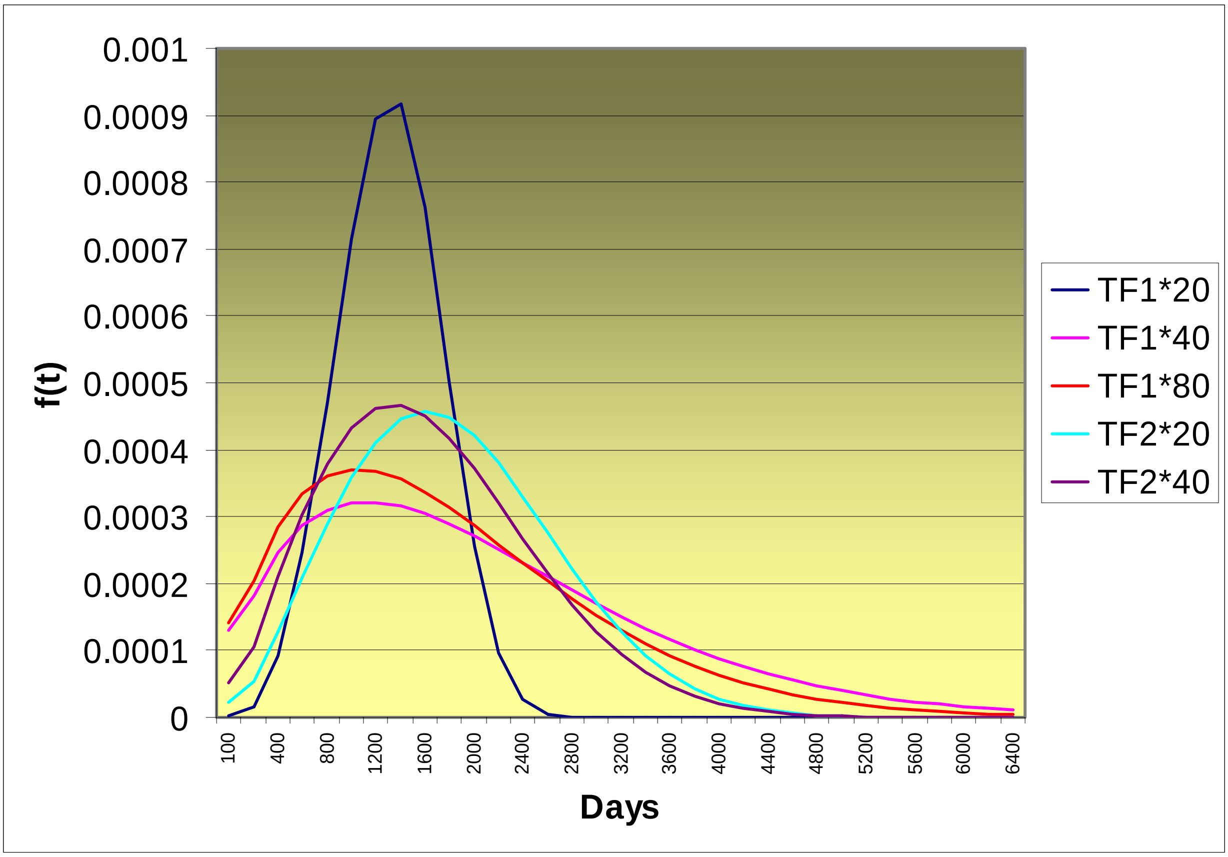


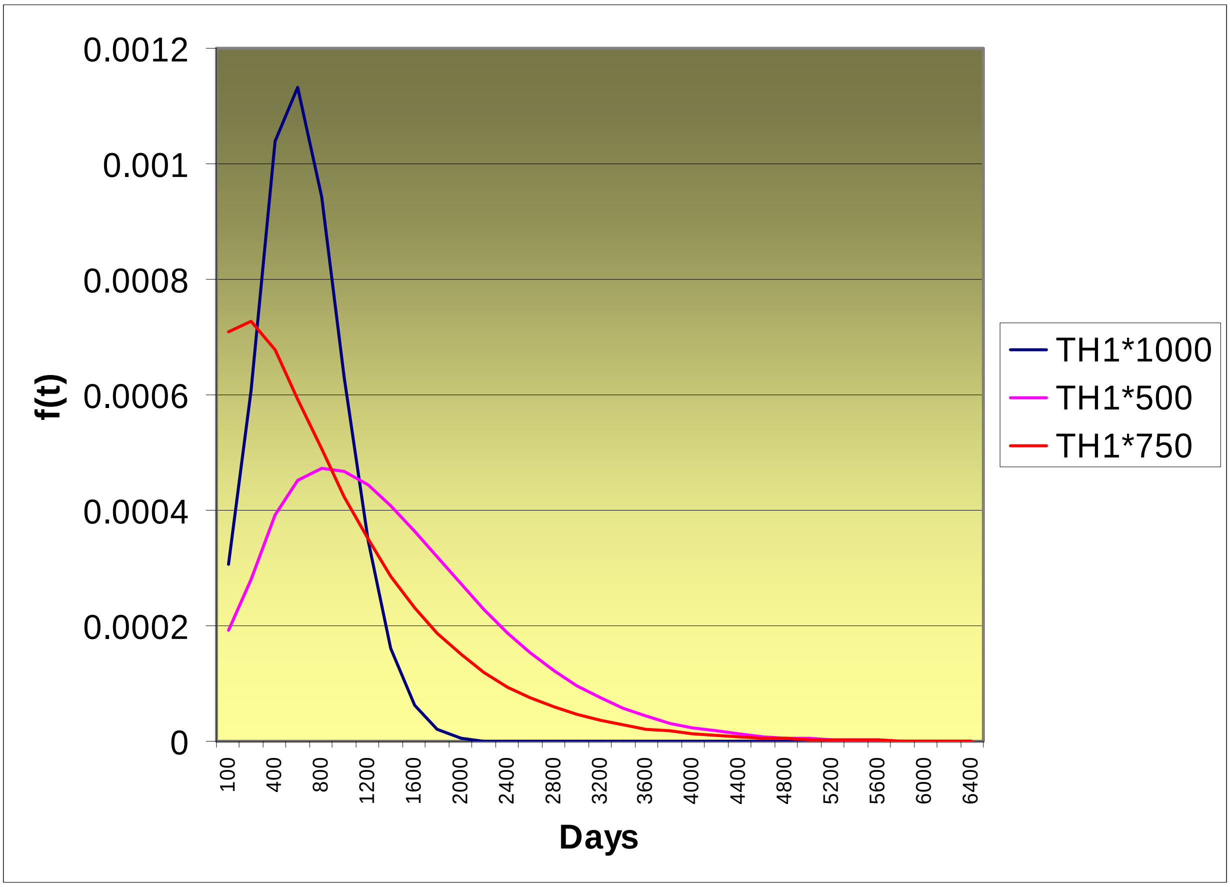


0.0005
0.00045
0.0004
0.00035
0.0003
0.00025
0.0002
0.00015
0.0001
0.00005
0
f(t)
100
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
Days
SON1*150
SON1*220
SON1*250
SON1*310
SON1*400
SON1*70
SON4*250
SON4*600

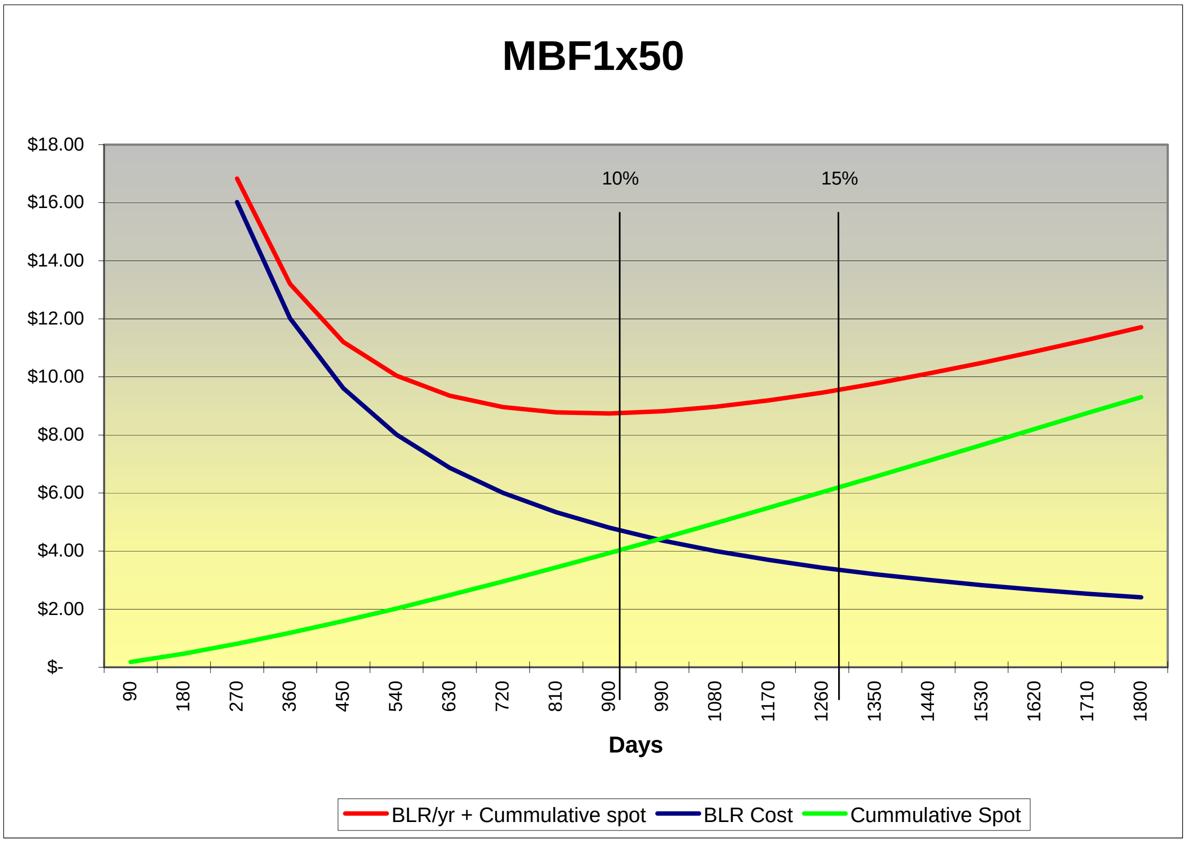


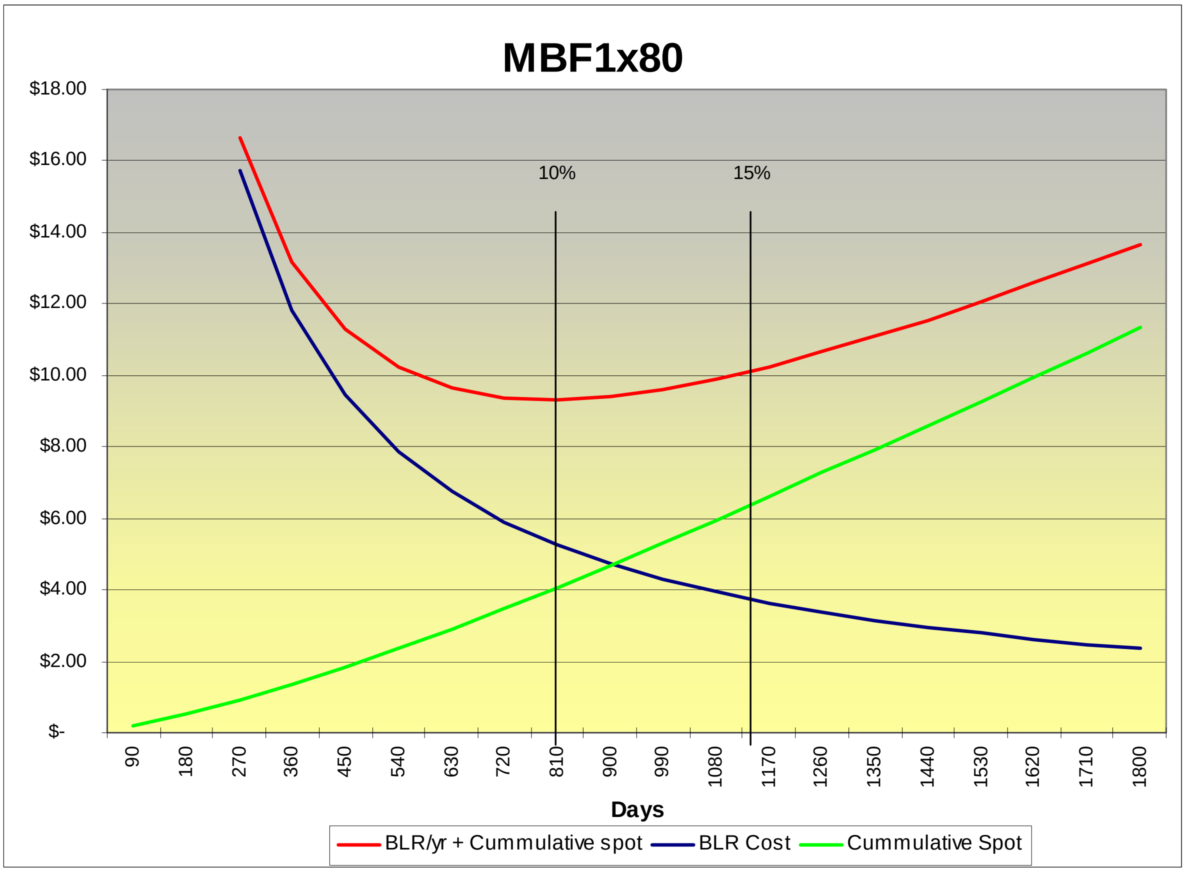
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
f(t)
100
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
Days
SOX1*135
SOX1*90

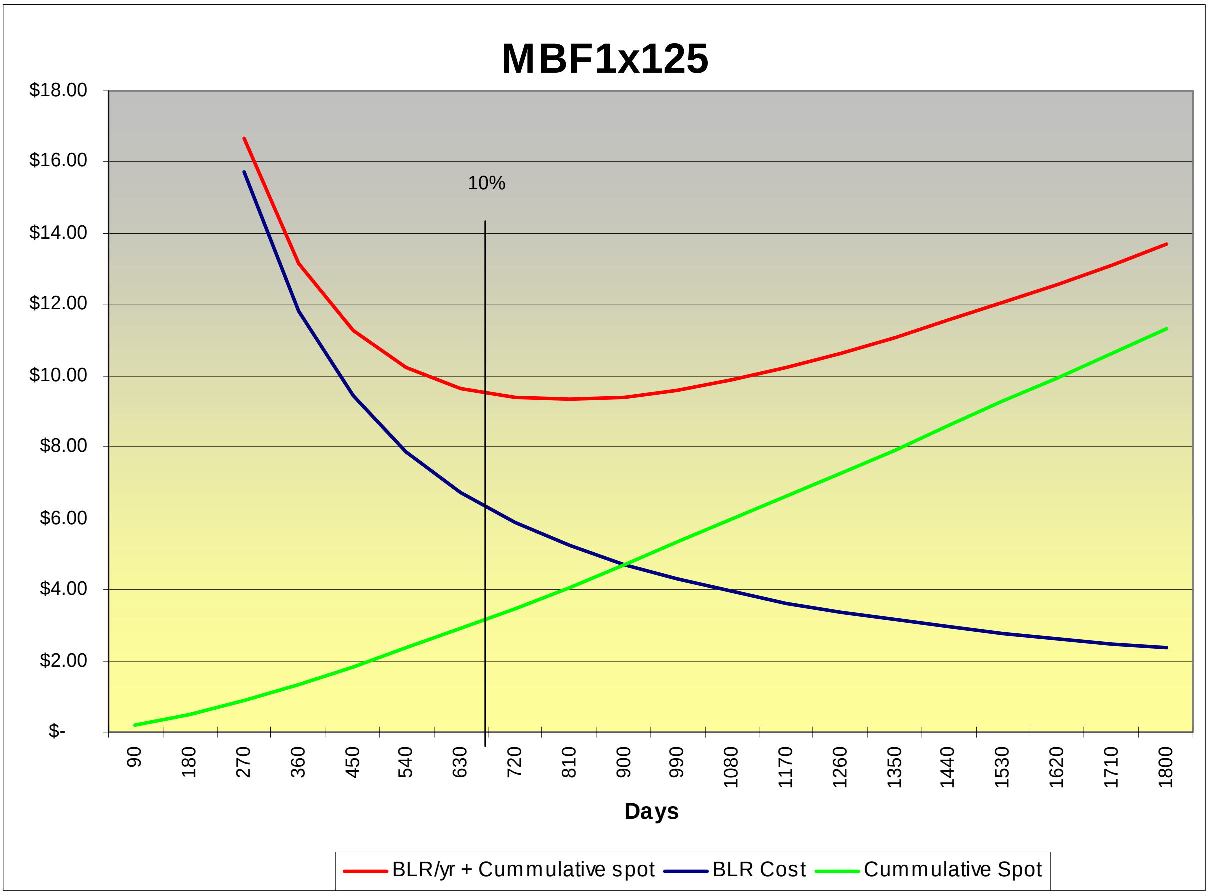

0.001
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
f(t)
100
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
Days
TF1*20
TF1*40
TF1*80
TF2*20
TF2*40

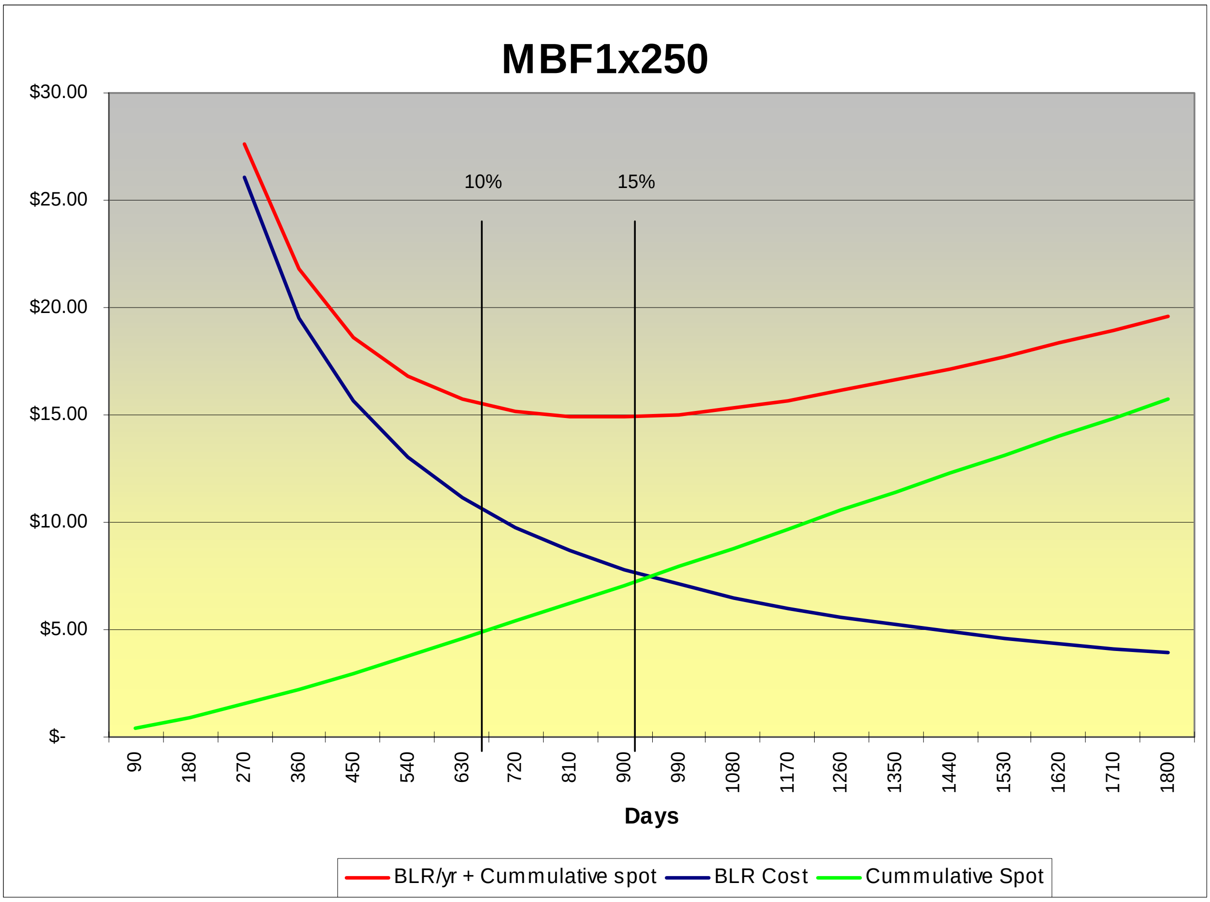

0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
f(t)
100
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
Days
TH1*1000
TH1*500
TH1*750

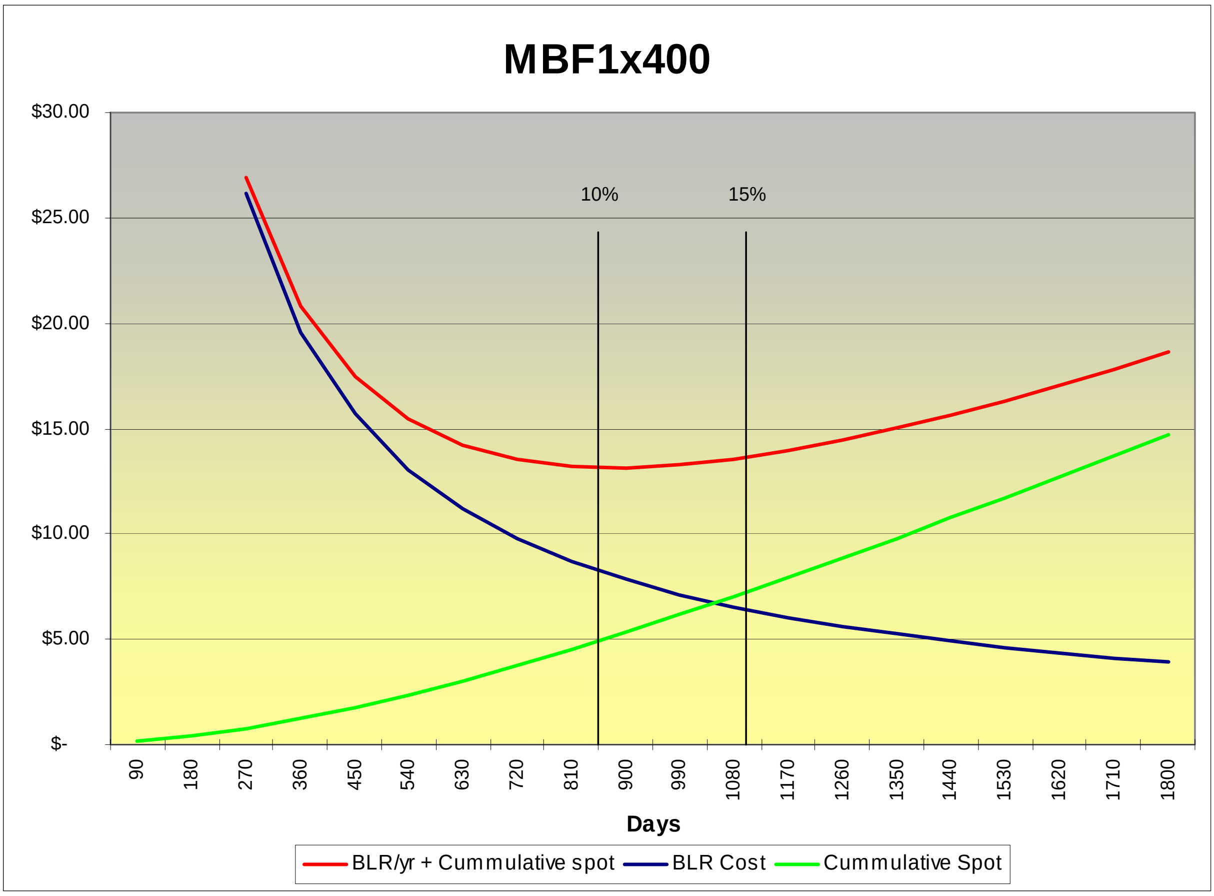
Appendix 3 – Cost Curves

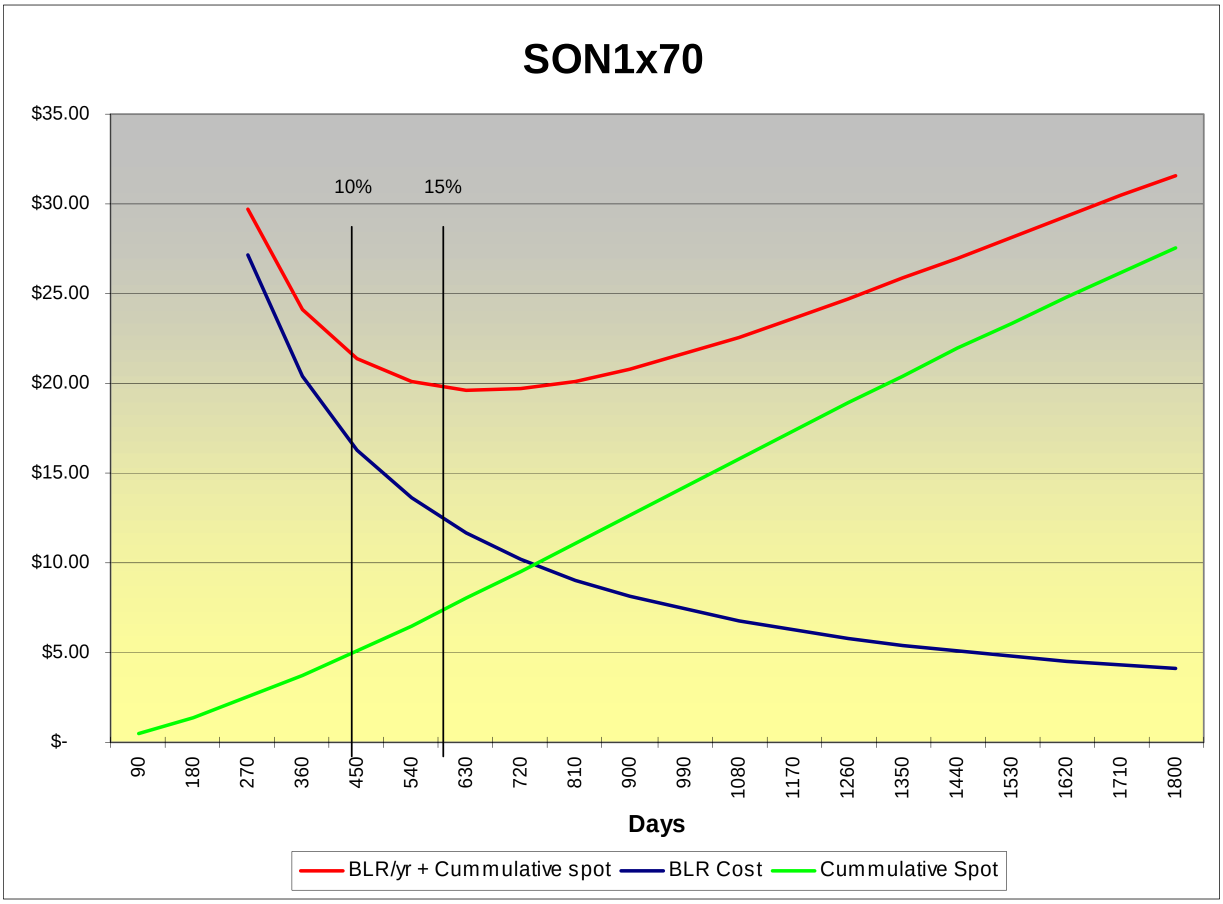


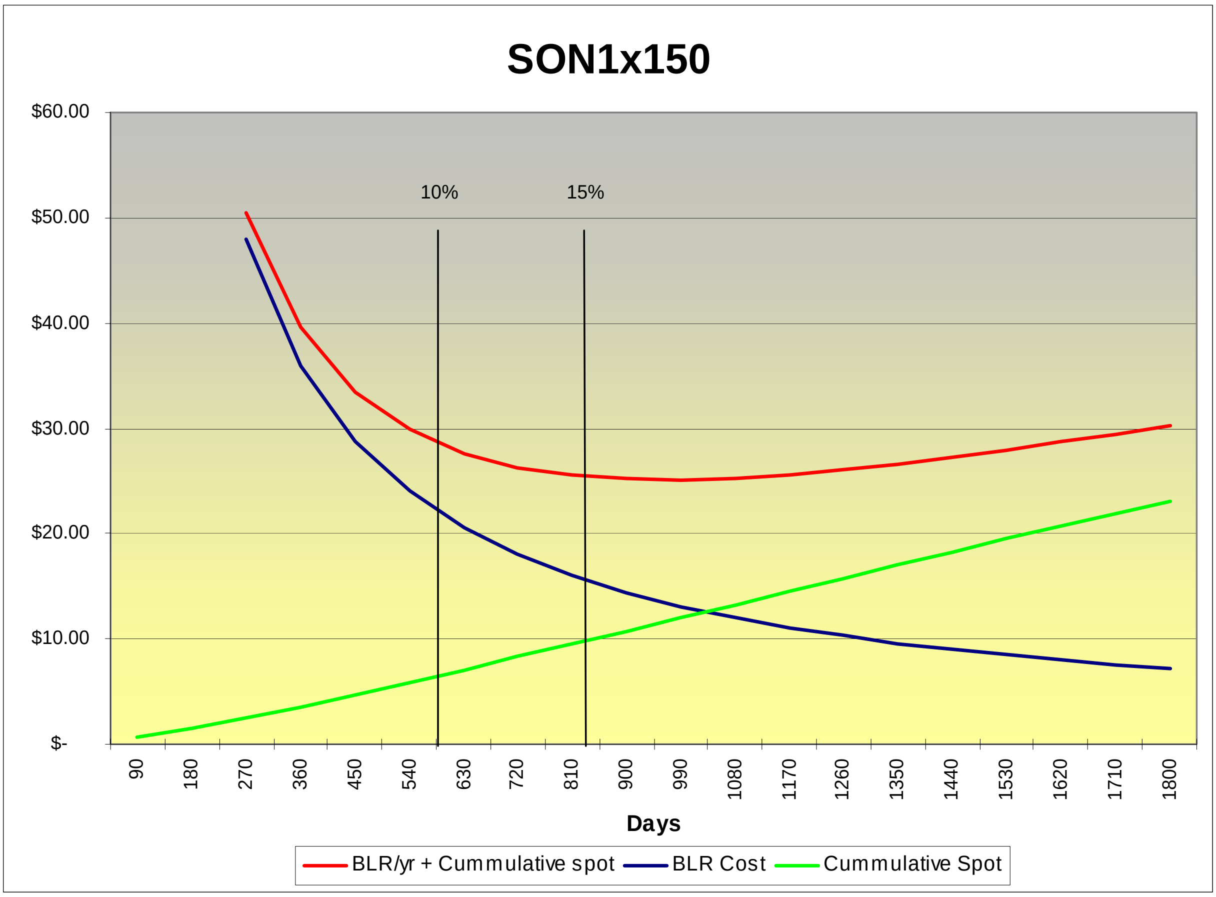

MBF1x80
$18.00
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

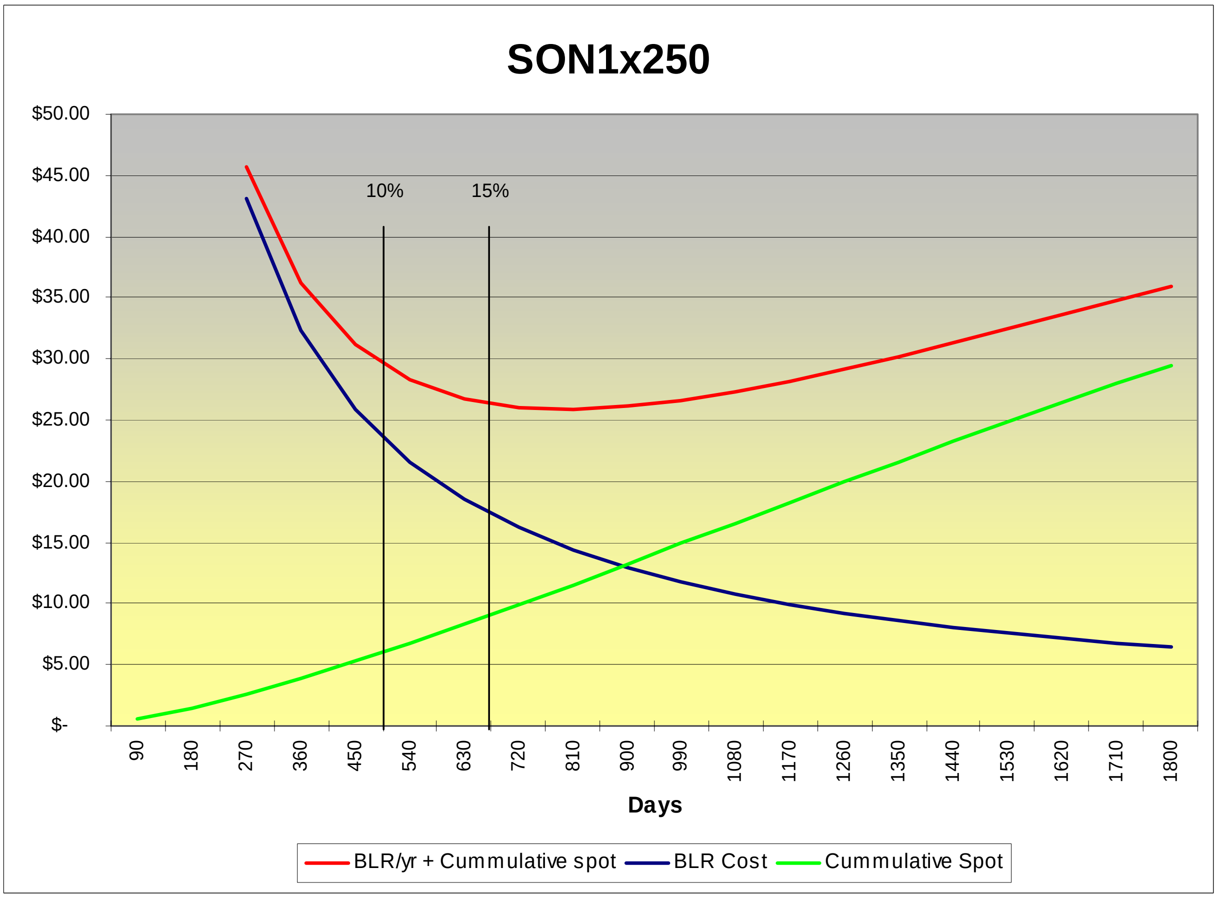

MBF1x125
$18.00
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$-
10%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

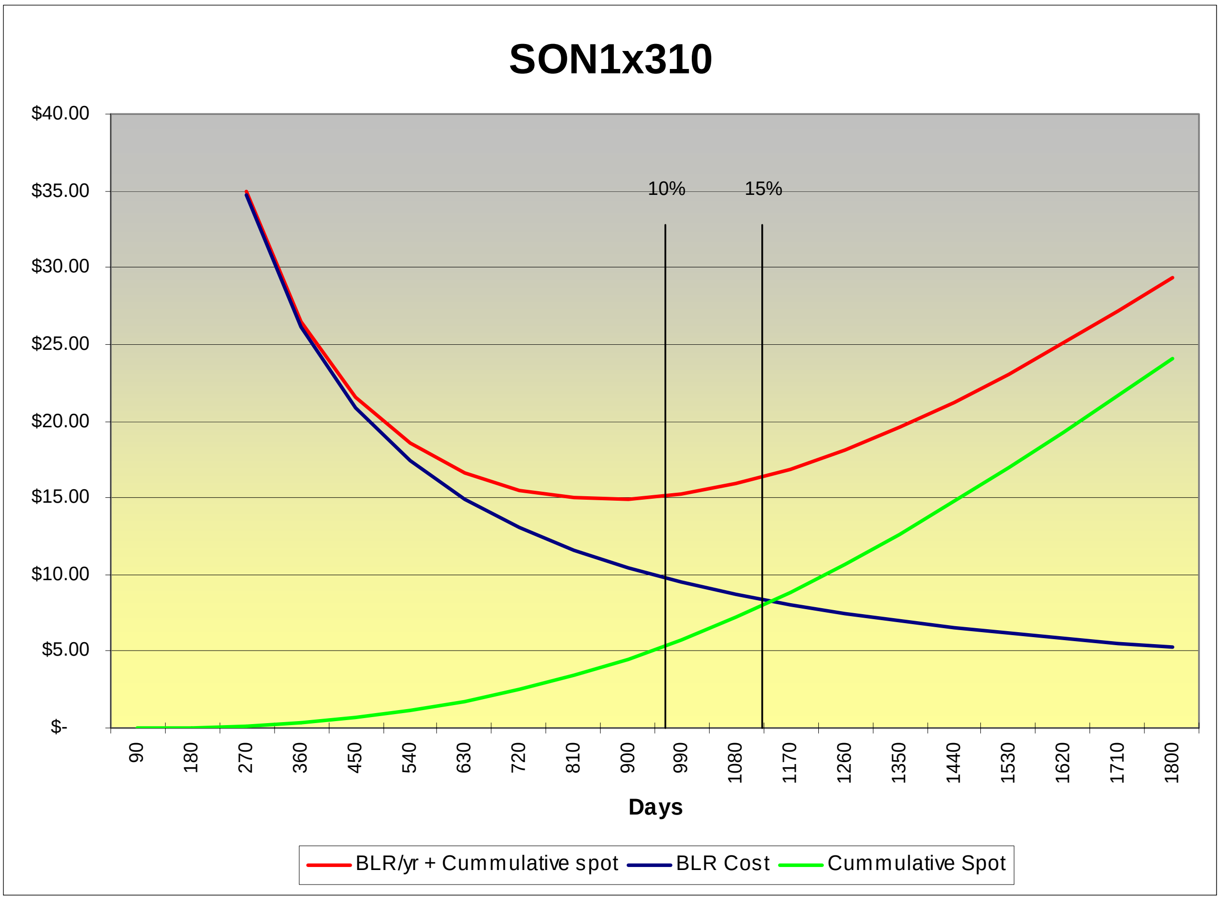

MBF1x250
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

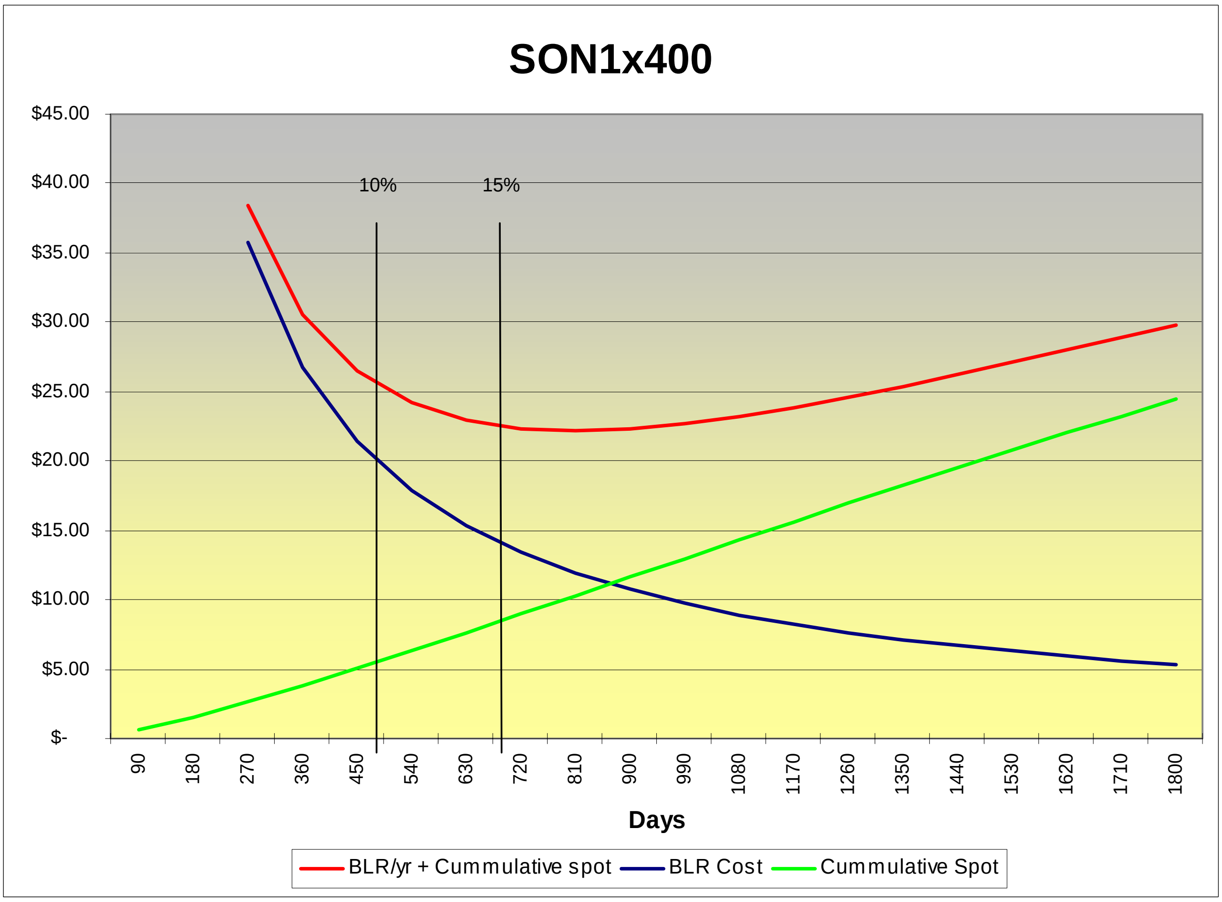

MBF1x400
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

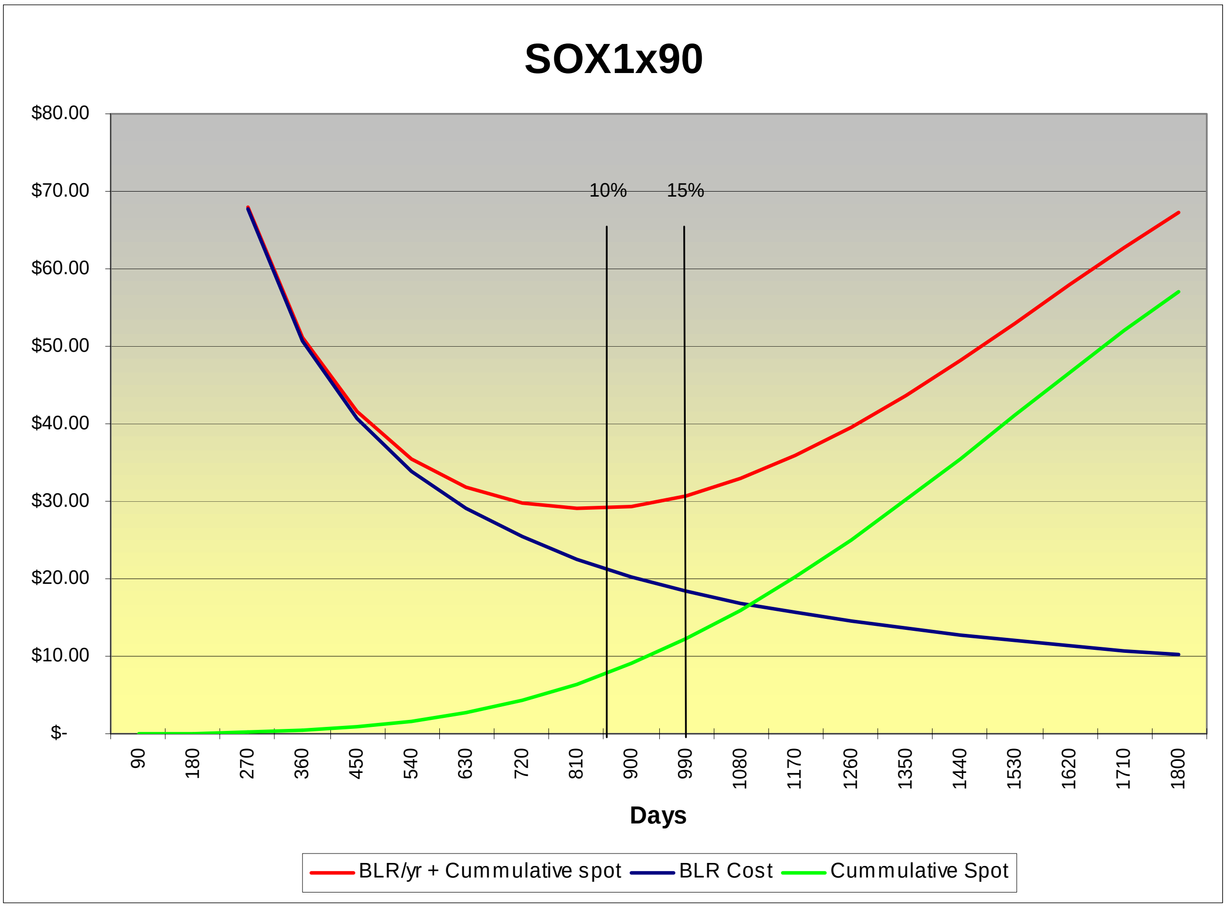

SON1x70
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

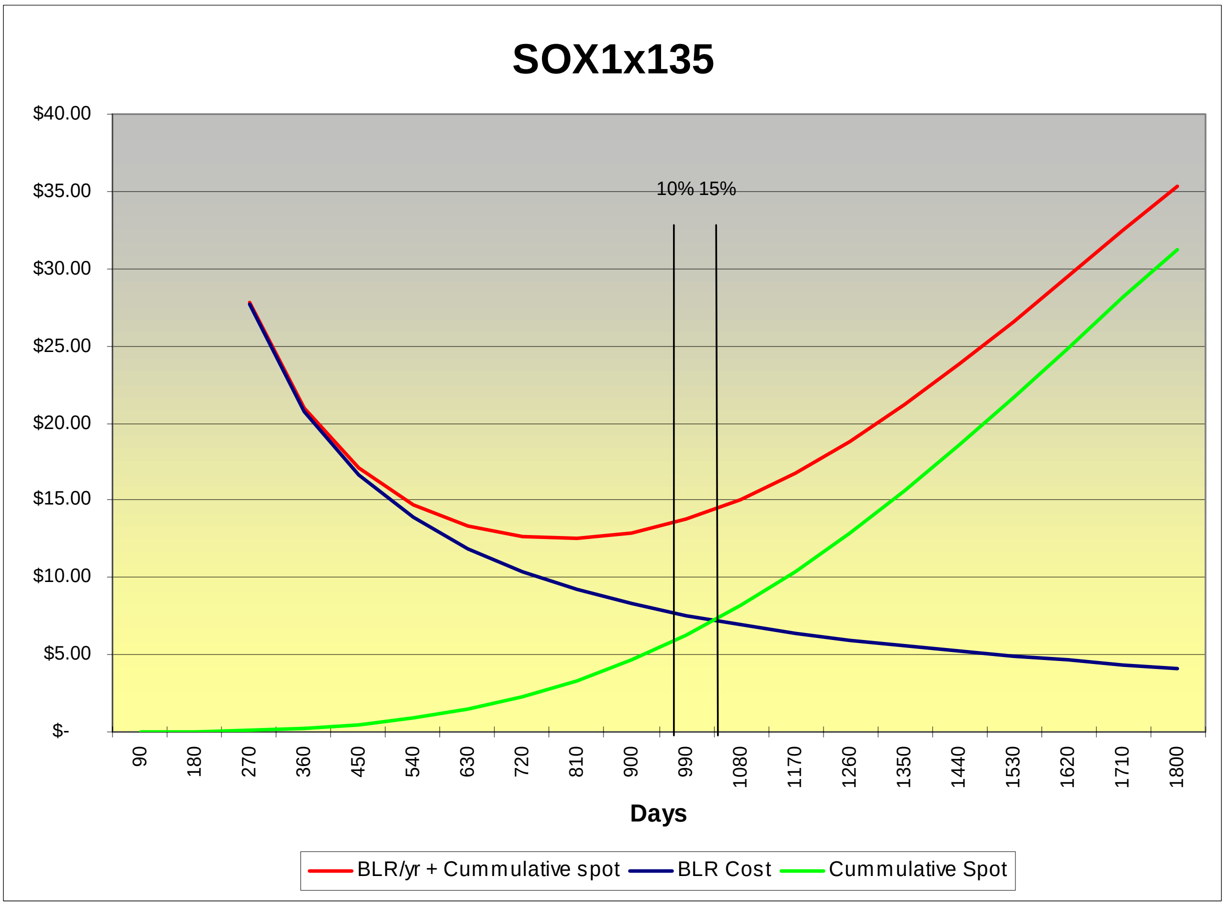

SON1x150
$60.00
$50.00
$40.00
$30.00
$20.00
$10.00
$-
10%
15%
90 180 270 360 450 540 630 720 810 900 990 1080 1170 1260 1350 1440 1530 1620 1710 1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

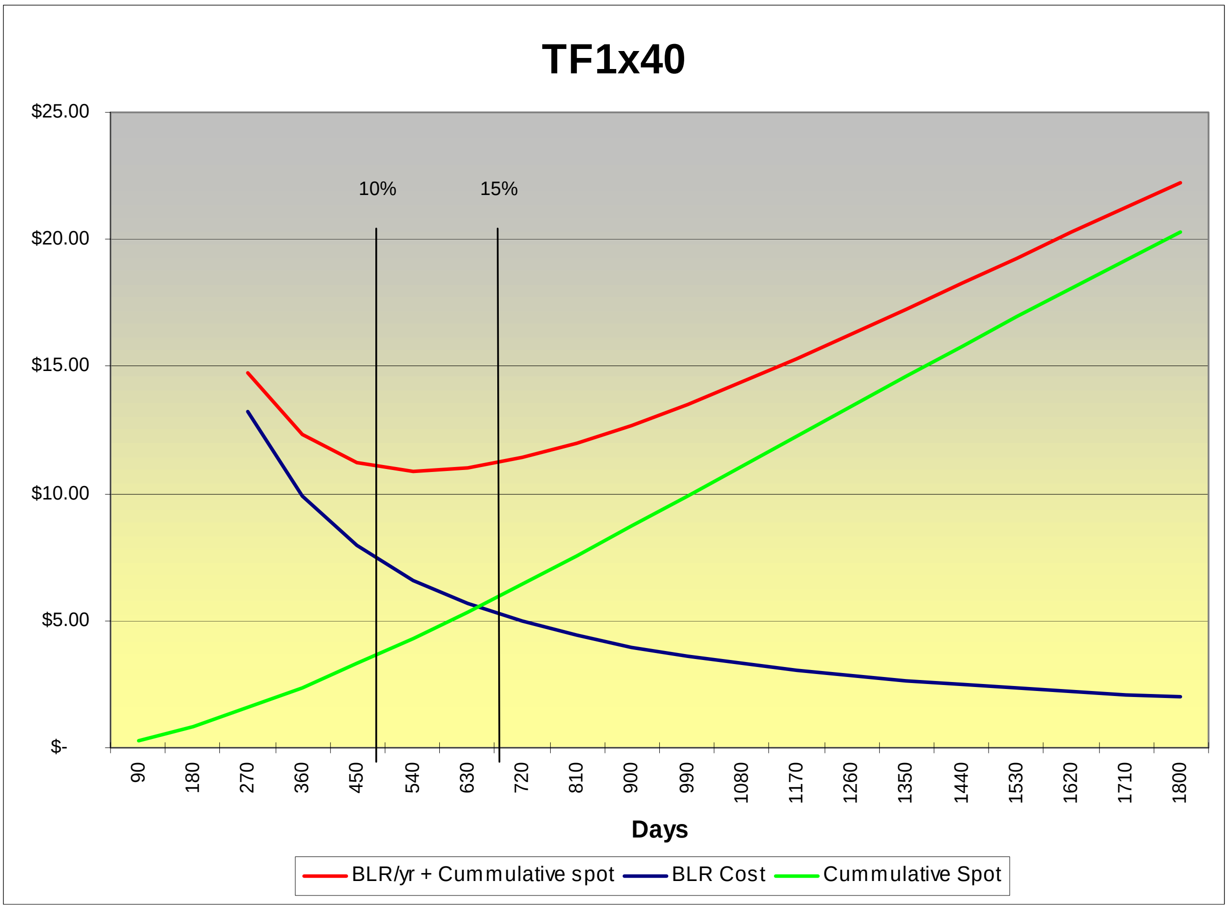

SON1x250
$50.00
$45.00
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90 180 270 360 450 540 630 720 810 900 990 1080 1170 1260 1350 1440 1530 1620 1710 1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot


SON1x310
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

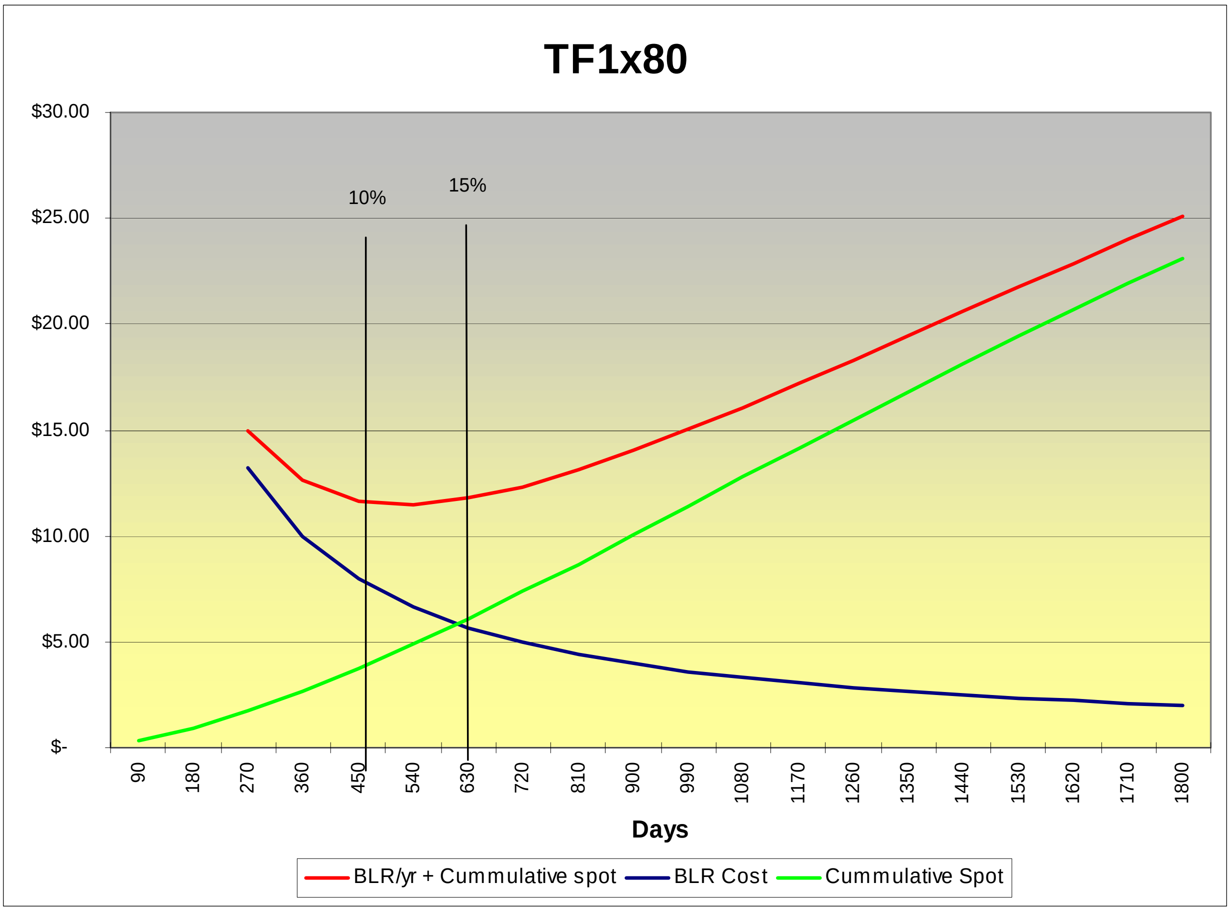

SON1x400
$45.00
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot


SOX1x90
$80.00
$70.00
$60.00
$50.00
$40.00
$30.00
$20.00
$10.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot


SOX1x135
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot



TF1x40
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot



TF1x80
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$-
10%
15%
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
Days
BLR/yr + Cummulative spot
BLR Cost
Cummulative Spot

Appendix 4 – Maintenance Requirements Analysis Report

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
11	**AF Relays does not switch off due to AF Signal not received.**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	N	–	N	N		N.S.M.	Excessive capacitance from customer equipment (lighting or UPS Units). Estimate from North area - 1 per week. Nctle 4000, Nth 100 population.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	100.00	100.00	14,965	4,100	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
13	**AF Relays does not switch off due to bypass (external bridge fitted).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	N	–	N	N		N.S.M. Remove external bridge when found and repair location.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	22.00	22.00	68,023	4,100	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
31 **AF Relays does not switch off due to electrical surge.**		N	N	Y	–	N	N	N	N	–	N	N		N.S.M.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	86.00	86.00	17,401	4,100	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
14 **AF Relays does not switch off due to internal fault (black boxed).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	N	–	N	N		N.S.M.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	76.00	76.00	19,691	4,100	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
12	**AF Relays does not switch on due to AF Signal not received.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M.	Patrol ?
															Replace AF installation with PE Controlled SLP.	Excessive capacitance from customer equipment (lighting or UPS Units).

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*219.00*	*219.00*	*6,833*	*4,100*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
18	**AF Relays does not switch on due to circuit fuse (30A) blown.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–				N.S.M.	Patrol ?

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*130.00*	*130.00*	*11,512*	*4,100*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
32	**AF Relays does not switch on due to electrical surge.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–				N.S.M.	Patrol ?

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*91.00*	*91.00*	*16,445*	*4,100*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

17 **AF Relays does not switch on due to internal fault (black boxed).**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. Replace defective AF unit	Replace AF installation with PE Controlled SLP in long term?

Primary

Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
Staff/Public Injury	250,000	0.00	65.00	65.00	23,023	4,100	0	0			

Examination

Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
	0	0	0	0	0	250,000	System

Protective

Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
33	**AF Relays does not switch on due to open circuit neutral connection overheated.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–	N	Y		N.S.M.	Ex McKellar area problem mainly due to type of installation.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*12.00*	*12.00*	*124,708*	*4,100*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
15 **AF Relays false operation due to wrong channel / frequency.**	Light turns on or off when not expected. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–				N.S.M.	Commissioning Testing

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	18.00	18.00	83,139	4,100	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	250,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
20 **Contactor does not operate due to manufacturing defect.**	Failure evident when commissioning, requires immediate replacement.	Y	N	Y	–	N	N	N	N	–		N		N.S.M. Replace unit and re-commission.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	7.00	7.00	62,571	1,200	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
47	**Contactor noisy due to internal fault (black boxed).**	customer complaints.	N	N	N	–	N	N	N	N	–	N	N		N.S.M. Replace Contactor

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	12.00	0.00	12.00	36,500	1,200	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
21	**Contactor operating coil burnt out due to aged insulation.**	May cause circuit fuse to blow. Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–	N	Y		N.S.M. New designs are not include contactors.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	60.00	60.00	7,300	1,200	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	250,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
Street Lighting															
SL 01 00 00 Street Lighting Control Equipment															
To provide automatic switching of lighting assemblies based on daylight levels.															
Lighting not switched when required.															
22 **Contactor operating coil burnt out due to corrosion (salt based).**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M.	High failure rates indicate consideration of redesign.
														Replace Contactor	Nth estimate 2% of 1000 in salt effected areas

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*12.00*	*12.00*	*608*	*20*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
19 **Contactor operating coil burnt out due to electrical surge.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N		N.S.M. Replace Contactor	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	20.00	20.00	21,900	1,200	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	250,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
35	**Contactor overheated connections due to loose.**	Loose of phase supply to lighting. Loss of typically 1/3 of the lighting (depend on installed configuration). Customer complaints. Possible safety/security impacts.	N	Y	Y	–	N	Y			–				Examine SLP contactor connections for overheating using Thermography (Kiosk SS installations).	Part of Kiosk SS Mtce
															Replace Contactor	CF Interval to be checked.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	10.00	63.00	73.00	6,000	1,200	1,460	511	18 mth		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
	Mains Crew (2)	2	80	100	300	1,500	26,800	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
36 **Contactor overheated connections due to over current.**	Loss of phase supply to lighting. Loss of typically 1/3 of the lighting (depend on installed configuration). Customer complaints. Possible safety/security impacts.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. Replace Contactor and redistribute street lighting load.	Review of practices involving 'joining circuits' required.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*67.00*	*67.00*	*6,537*	*1,200*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System
Equipment
Function
Function Failure
Failure Mode | **Effect** | **E SE O – L OC SR SD – CB FF RD** | **Proposed Task / Corrective Task** | **Decision Basis MTBF Basis**

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
48	**Contactor slow operation due to internal fault (black boxed).**	Delays in pickup/release result in customer complaints.	N	N	Y	N	N	N	N		N	N	N.S.M. Replace Contactor	Needs further investigation

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	3.00	0.00	3.00	146,000	1,200	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
50	**PE Cell does not switch off due to age degradation (D2 type)**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	N	N	N	Y				Replace D2 tpye PE cell Replace PE Cell	when replacing lamp??? offline Weibull required. Total stores usage of D2 PE cells in Nctle and Chatswood ifor the last year is 3400 units

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	1,360.00	2,040.00	3,400.00	1,181	11,000	0	0	2 x bulk l		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
10	**PE Cell does not switch off due to age degradation (Nema).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	Y	–				Replace PE Cell	Align with every second bulk lamp replacement of larger lamp types????? offline Weibull required.
															Replace PE cell	Spot replacement counts only with no bulk changeout. Est PE cell life is 5 years. Total stores usage of Nema PE cells in Nctle and Chatswood ifor the last year is 3000 units

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	*0*	*800.00*	*2,200.00*	*3,000.00*	*2,555*	*21,000*	*0*	*0*	*2 x bulk l*		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	*0*	*0*	*10*	*0*	*10*	*System*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
8	**PE Cell does not switch off due to contacts welded (overcurrent).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	N	–		N	Y	N.S.M. Replace PE Cell

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	N/A	*0*	*0.00*	*10.00*	*10.00*	*1,168,000*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy System*
		0	*0*	*0*	*0*	*0*	*0*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
39	**PE Cell does not switch off due to impact damage (hail/storm).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	–	N	N	N	N	–		N	N	N.S.M. Replace PE Cell

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	N/A	*0*	*0.00*	*50.00*	*50.00*	*233,600*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy System*
		0	*0*	*0*	*0*	*0*	*0*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
49	**PE Cell does not switch off due to manfacturing defects (D2 type)**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	N	N	N	N		N	Y	N.S.M. Replace PE Cell	High failure rates not long after installation. Sensitivity to high ambient light? Estimate in Nctle & Nth is 25% of PE cells are D2 types. Failures are about 30% of the total uasge.. 1001 used in 1 yr in Nth, ?? in Nctle

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	1,001.00	1,001.00	4,011	11,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
6	**PE Cell does not switch off due to spider web / insects.**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	N	N	N	N		N	N	N.S.M. Remove web / insects.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	0.00	50.00	50.00	233,600	32,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	– L	OC	SR	SD	– CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	– L	OC	SR	SD	– CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
7 **PE Cell does not switch off due to UV exposure (cell facing north?).**	Wasted energy, shortened globe life. Customer complaints.	N	N	Y	N	N	N	N	–	N	Y	N.S.M. Refit PE Cell to face South.	Manufactured in nth Hemisphere, and box indicates to face cell north. Should be South?

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	N/A	*0*	*3.00*	*15.00*	*18.00*	*648,889*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*0*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
5 **PE Cell does not switch on due to age degradation.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N		–				Replace PE Cell	Chatswood 200/700 est in 21000 units

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*320.00*	*1,120.00*	*1,440.00*	*8,111*	*32,000*	*0*	*0*	*2 x bulk l*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy System*
		0	*0*	*0*	*0*	*0*	*250,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

2 **PE Cell does not switch on due to burnout from overcurrent (system design error).**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. Replace PE Cell and redistribute load.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*16.00*	*16.00*	*730,000*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System
Equipment
Function
Function Failure
Failure Mode

Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis
40	**PE Cell does not switch on due to contacts operate but open circuit.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N		N.S.M.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*0.00*	*0.00*	*7,300,000*	*20,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
	Mains Crew (2)	*0*	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
3 **PE Cell does not switch on due to electrical surge (lightning / mains clash). .**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–				N.S.M.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*160.00*	*160.00*	*73,000*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy System*
		0	*0*	*0*	*0*	*0*	*250,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 **Street Lighting Control Equipment**

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
37 **PE Cell does not switch on due to installation error - not rotated fully when replaced.**	Wasted energy, shortened globe life. Customer complaints.	N	Y	Y	–	N	N	N	N	–				N.S.M.	this needs a check at time of installation - High rate appears to be associated with BLR contract work. Chatswood figures - based on followup action on bulk lamp replacement Contractors.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*202.00*	*202.00*	*36,139*	*20,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
4	**PE Cell does not switch on due to UV exposure.**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	Y	–				Replace PE Cell

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	48.00	52.00	100.00	116,800	32,000	0	0	2 x bulk l		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	250,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
9	**PE Cell does not switch on due to vandalism - taped over cell.**	Wasted energy, shortened globe life. Customer complaints.	N	Y	Y	–	N	N	N	N	–	N			N.S.M.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	0.00	0.00	0	0	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	250,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task
16 **PE Cell false operation due to age degradation (drift).**	Cell operates earlier or later than expected. Lighting not available when required or operate when not required.	N	Y	Y	N	N	N	Y				Replace PE Cell

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*8.00*	*160.00*	*168.00*	*69,524*	*32,000*	*0*	*0*	*2 x bulk l*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task
30 **PE Cell false operation due to birds attack.**	Fails when it next rains. Cell does not operate as expected.	N	N	Y	N	N	N	N		N	N	N.S.M.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*8.00*	*160.00*	*168.00*	*69,524*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 **Street Lighting Control Equipment**

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
1	**PE Cell false operation due to external light source.**	Light turns off when still required. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. Realign PE Cell or fit cover/shield.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*61.00*	*61.00*	*191,475*	*32,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task
38	**PE Cell base broken due to excessive installation force. (GEC Astra Types)**	Works initially, but fails after any vibration causes internal base to drop. Local reduced lighting level. Customer complaints. Possible safety/security impacts.	Y	N	N	N	N	N	N			N	N.S.M. Replace PE cell base unit.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*10.00*	*100.00*	*110.00*	*66,364*	*20,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	– L	OC	SR	SD	– CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
29 **PE Cell base cracked insulation due to UV exposure.**	Corrosion of conductor. Possible electric shock hazard. Possible short circuit may burn down conductor.	N	Y	Y	N	N	N	Y				Replace PE Cell	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*2.00*	*37.00*	*39.00*	*299,487*	*32,000*	*0*	*0*	*2 x bulk l*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
46 **SL Circuit Fuses blown due to numerous random external events (trees, storms etc).**	Lighting will not turn on. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	N	Y	–	N	N	N	N	–	N	N		N.S.M.	est 300 in Nctle/Hunter, Est 6000 in Nth

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*6,300.00*	*6,300.00*	*87*	*1,500*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
Street Lighting													
SL 01 00 00 Street Lighting Control Equipment													
To provide automatic switching of lighting assemblies based on daylight levels.													
Lighting not switched when required.													
43 **SL Wiring (excluding mains) conduit strikes mains due to saddles missing.**	Local fuse blows, and group of lighting not operational. Customer complaints. Safety and security impacts	N	N	Y	N	N	N	N		N	Y	N.S.M. Replace missing saddles / clouts.	Problems with fastenings falling out as sapwood decays. Old poles have hard timber which are almost impossible to drive longer nails. Needs a longer stronger self driving fastener

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	55.00	30.00	85.00	253,353	59,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	25,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
41	**SL Wiring (excluding mains) corroded connection to aluminium cable due to electrolytic action.**	Lighting may not operate. Lighting standard may become energised.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. Repair to new standard configuration upon failure.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*20.00*	*50.00*	*70.00*	*307,643*	*59,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*25,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
23 **SL Wiring (excluding mains) cracked insulation due to UV exposure.**	Corrosion of conductor. Possible electric shock hazard. Possible short circuit may burn down conductor.	N	Y	Y	–	N	Y			–				Examine wiring insulation for excessive degradation/cracking.	Perform when making any corrective action on pole/ lighting circuit Est Nctle 8000 Standard and 32000 Overhead., Nth 6500 Standard and 52500 Overhead.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	40.00	229.00	269.00	115,335	85,000	0	0	Lamp re		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	250,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
45 **SL Wiring (excluding mains) damaged due to birds strip insulation within hollow spun concrete poles.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	Y	Y	–	N	N	N	N	–		N	Y	N.S.M. / Fill unused access points.	Needs more permanent solution to seal entry point into pole.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*52.00*	*52.00*	*2,106*	*300*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
26	**SL Wiring (excluding mains) damaged due to excavations / pegs /stakes.**	Light turns on or off when not expected. Customer complaints. Possible safety and security impacts where a group of lights are not operating.	N	Y	Y	–	N	N	N	N	–		N	Y	Advertise the "Dial Before You Dig service"	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*0.00*	*32.00*	*32.00*	*159,688*	*14,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System
Equipment
Function
Function Failure
Failure Mode | Effect | E SE O – L OC SR SD – CB FF RD | Proposed Task / Corrective Task | Decision Basis MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
27	**SL Wiring (excluding mains) damaged due to MVA - lighting column struck.**	Wiring insulation damaged. Fault on lighting circuit even after the lighting standard is replaced.	N	Y	Y	N	N	N	N		N		N.S.M.	Repaired after notification of accident and inspection of pole/lighting standard.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	*250,000*	*0.00*	*50.00*	*50.00*	*102,200*	*14,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	*0*	*0*	*0*	*0*	*250,000*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
42	**SL Wiring (excluding mains) damaged insulation due to corrosion of steel conduit.**	Local fuse blows, and group of lighting not operational. Customer complaints. Safety and security impacts	N	Y	Y	N	Y						See Overhead Line MRA	Covered by line examination. See Overhead Line MRA No Steel conduit in Newcastle

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*10.00*	*30.00*	*40.00*	*273,750*	*30,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
44	**SL Wiring (excluding mains) fatigued tail connections (Dee Why area) due to long tails not secured.**	Local light does not operate. Light head assembly make become active if neutral broken. Customer complaints. Public safety/security impacts.	N	Y	Y	N	N	N	N		N	Y	N.S.M. Refit wiring to current standard when luminairre is replaced.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Staff/Public Injury	*250,000*	*50.00*	*200.00*	*250.00*	*14,600*	*10,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy*
		0	*0*	*0*	*0*	*0*	*250,000*	*System*

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

No.	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
24	**SL Wiring (excluding mains) service broken due to bird strike.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	Y	Y	N	N	N	N				N.S.M.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	0.00	11.00	11.00	1,758,636	53,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	25,000	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

No.	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
25	**SL Wiring (excluding mains) service broken due to loose wiring - fixing clout works loose.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	Y	Y	N	N	N	N		N	Y	N.S.M. TBA	New design required for fasteners. Self drilling galvanised metal(?) screws? See code 43

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	3,655.00	490.00	4,145.00	7,485	85,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	0	0	0	0	0	System

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System
Equipment
Function
Function Failure
Failure Mode | **Effect** | **E SE O – L OC SR SD – CB FF RD** | **Proposed Task / Corrective Task** | **Decision Basis MTBF Basis**

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

To provide automatic switching of lighting assemblies based on daylight levels.

Lighting not switched when required.

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
28	**SL Wiring (excluding mains) wrong polarity/phasing due to installation / repair error.**	Lighting may not operate. Lighting standard may become energised.	N	Y	Y	N	N	N	N		N	Y	N.S.M. Phasing and polarity to be tested upon commissioning/repairing installation.	est 6 Nth, 12 N'ctle

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	18.00	18.00	2,007,500	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	250,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
51	**Time clock (1 unit only - to be replaced - no further analysis) maloperation due to various**	Unit to be replaced with a standard design.	N	Y	Y	N	N	N	N		N	Y	N.S.M.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			0.00	0.00	0.00	0	0	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy System
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System
Equipment
Function
Function Failure
Failure Mode | **Effect** | **E SE O – L OC SR SD – CB FF RD** | **Proposed Task / Corrective Task** | **Decision Basis MTBF Basis**

Street Lighting

SL 01 00 00 Street Lighting Control Equipment

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis
21	**Choke (separate unit) damaged due to door to choke box not secured.**	Allows water into choke box, damaging components. Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	N	N	N	N	N	N		N.S.M. Re-secure choke box door.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
			2.00	*91.00*	*93.00*	*80,065*	*20,400*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*0*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode | Effect | E SE O – L OC SR SD – CB FF RD | Proposed Task / Corrective Task | Decision Basis MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

No.	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task
20	**Choke (separate unit) damaged due to door to choke box open - vehicle clips pole.**	Allows water into choke box, damaging components. Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	N	N	N	N		N	N	N.S.M. Re-secure choke box door.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	0.00	30.00	30.00	248,200	20,400	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

No.	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task
19	**Choke (separate unit) fuse dislodged from carrier due to large vehicle vibration/impacts.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	N	Y	N	N	N	N		N	N	N.S.M. Re-secure choke box door.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			0.00	74.00	74.00	111,966	22,700	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 **Lamp Assemblies**

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
12	**Choke (separate unit) shorted due to water damage.**	Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	–	N	N	N	N	–		N	N	N.S.M. Replace choke box.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*0.00*	*37.00*	*37.00*	*223,932*	*22,700*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	*0*	*0*	*0*	*0*	*25,000*	*Equipment*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
23	**Choke / integral control gear access door open due to not secured.**	Increased aging of internal components. Customer complaints.	N	N	Y	–	N	N	N	N	–		N	N	N.S.M. Re-secure choke box door.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	*0*	*172.00*	*24.00*	*196.00*	*22,347*	*12,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	*0*	*0*	*0*	*0*	*0*	*Equipment*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
22	**Choke / integral control gear shorted due to design error - excessive connections in terminals.**	Overheating of terminals. Wiring fails and lamp does not work.	N	N	Y	–	N	N	N	N	–		N	Y	N.S.M.	Reduction in excess wire counts in terminals to reduce failure rate.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*0.00*	*20.00*	*20.00*	*219,000*	*12,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
11	**Choke / integral control gear shorted due to water damage.**	Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	–	N	N	N	N	–		N	N	N.S.M. Replace luminaire.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*4.00*	*141.00*	*145.00*	*30,207*	*12,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System
Equipment
Function
Function Failure
Failure Mode | **Effect** | **E SE O – L OC SR SD – CB FF RD** | **Proposed Task / Corrective Task** | **Decision Basis MTBF Basis**

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

#	Failure Mode	Effect	E SE O – L OC SR SD – CB FF RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis
18	**Internal wiring shorted due to heat damages insulation.**	Lamp not working. Reduced local light level with possible safety/security issues. Head may become live.	N N Y – N N N N – N N	N.S.M.	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*121.00*	*221.00*	*342.00*	*12,807*	*12,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

#	Failure Mode	Effect	E SE O – L OC SR SD – CB FF RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis
28	**Lamp no light output due to age degradation.**	Local light does not operate. Customer complaints. Safety/security impacts.	N Y Y – N N N Y –	Replace Lamp	See Offline Weibull analysis

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
			0.00	*0.00*	*0.00*	*0*	*0*	*0*	*0*	*30 mth b*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*0*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 **Lamp Assemblies**

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
26 **Lamp no light output due to electrical surge.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	N	Y	–	N	N	N	N	–		N	N	N.S.M. Replace Lamp	

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*1,800.00*	*1,800.00*	*20,075*	*99,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System
Equipment
Function
Function Failure
Failure Mode

Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

30 **Lamp no light output due to installation / repair error.**

Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
Local light does not operate. Customer complaints. Safety/security impacts.	N	Y	Y	N	N	N	N				N.S.M.	Needs a timely post work quality check?
											Replace Lamp	Problem evident in areas where bulk lamp replacement occurs. BLR Cycles 18mth/30mth.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	0.00	1,000.00	1,000.00	21,535	59,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

27 **Lamp no light output due to manufacturing error.**

Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis
Short life requiring replacements in early lamp life.	Y	Y	Y	N	N	N	N				N.S.M.	Check at time of installation
											Replace Lamp	Batch related problems?

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	0.00	256.00	256.00	141,152	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
25	**Lamp no light output due to random failure.**	Local light does not operate. Customer complaints. Safety/security impacts.	N	Y	Y	–	N	N	N	Y	–				Replace Lamp	See Offline Weibull Replacement. Only applicable to Nth as this area has bulk lamp replacement.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*500.00*	*500.00*	*43,070*	*59,000*	*0*	*0*	*30 mth b*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
14 **Lamp holder broken due to age/heat degradation.**	Unable to replace lamps and replacement of unit required. Reduced local light level with possible safety/security issues.	N	Y	Y	–	N	N	N	Y	–				Replace Lamp holder (when required) in conjunction with BLR.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*340.00*	*200.00*	*540.00*	*66,917*	*99,000*	*0*	*0*	*Lamp re*		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task
32 **Luminairre broken due to MVA - lighting column struck.**	Fitting may fall or be left hanging after impact. Repair as callout action.	Y	N	Y	–	N	N	N	N	–			N	N.S.M. Repair/Replace Upon notification

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			0.00	*0.00*	*0.00*	*36,135,000*	*99,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	*0*	*0*	*0*	*0*	*0*	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
8 **Luminairre broken due to vandalism.**	Lamp not working. Reduced local light level with possible safety/security issues.	N	Y	N	–	N	N	N	Y	–				N.S.M. Repair/Replace Upon notification	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			264.00	228.00	492.00	73,445	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
9 **Luminairre not working due to age degradation.**	Lamp not working. Reduced local light level with possible safety/security issues.				–					–					Generic. Needs to be split into types.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	200.00	1,460.00	1,660.00	21,768	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
10 **Luminairre not working due to end seal missing/misaligned/damaged.**	Luminairre fills with water and shorts out lamps or ballast. Loss of lighting with possible safety/security issues.				–					–					

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			301.00	605.00	906.00	39,884	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
33 **Luminairre not working due to local fuse blown.**	Local light does not operate. Customer complaints. Safety/security impacts.				–					–				N.S.M.	9000 nth, 1400 Nctle.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	0.00	10,400.00	10,400.00	3,510	100,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

Street lighting availability to be at least 95%.

Availability of lighting is less than 95%.

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
13 **Luminairre not working due to PE Cell base contacts deformed.**	Lamp remains illuminated after PE cell re-inserted. Wasted energy, shortened globe life. Customer complaints.	N	Y	Y	N	N	N	N		N		N.S.M.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	0.00	40.00	40.00	182,500	20,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	250,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
15 **Starter broken due to age/heat degradation.**	Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	N	N	N	N		N	N	N.S.M.	Should starters be replace in conjunction with BLR? Nth only

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Staff/Public Injury	250,000	150.00	200.00	350.00	20,857	20,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	250,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
Street Lighting													
SL 02 00 00 Lamp Assemblies													
Street lighting availability to be at least 95%.													
Availability of lighting is less than 95%.													
29 **Starter maloperation due to installation / repair error.**	Lamp not working. Reduced local light level with possible safety/security issues.	N	N	Y	N	N	N	N		N	N	N.S.M.	Needs a timely post work quality check

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			200.00	800.00	1,000.00	7,300	20,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
24	**Lamp low output due to age degradation.**	Reduced local light output. Possible customer complaints.	N	N	Y	–	N	N	N	Y	–				Replace Lamp	See Offline Weibull analysis. All lamps. data does not include BLR. See Street lighting database extracts for individual lamp data.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*100.00*	*300.00*	*400.00*	*90,338*	*99,000*	*0*	*0*	*30 mth b*		

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
4 **Light Bracket misaligned due to coach screw missing.**	Wind allows arm to rotate, light now no longer focused on roadway. Possible safety/security issues and customer complaints.	N	N	Y	N	N	N	N		N		N.S.M.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	4.00	10.00	14.00	1,173,214	45,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
34	**Light Bracket misaligned due to fasteners/bolts loose.**	Light now no longer focused on roadway. Possible safety/security issues and customer complaints.	N	Y	Y	N	N	N	N		N		N.S.M.	Nctle/Maitland use bolts. Majority are missing nuts

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*800.00*	*12.00*	*812.00*	*17,980*	*40,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

#	Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
3	**Light Bracket misaligned due to moved for high load.**	Light now no longer focused on roadway. Possible safety/security issues and customer complaints.	Y	Y	Y	N	N	N	N			Y	N.S.M.	Ensure work procedure restores and secures bracket after moving for high load passage.

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
	Minor Injury	*25,000*	*0.00*	*1.00*	*1.00*	*14,600,000*	*40,000*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*25,000*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	– L	OC	SR	SD	– CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

	Failure Mode	Effect	E	SE	O	– L	OC	SR	SD	– CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
17	**Luminairre cracked casing (2x20W plastic body) due to UV degradation.**	Hangs by wiring, lighting not over road. Lighting may drop, with injury/property damage.	N	N	Y	– N	N	N	N	–	N	Y	N.S.M. Replace if any repair work required.	No more plastic body units to be purchased

Primary	*Operation Loss Description*	*Operatonal Loss $*	*Cond Fail*	*Funct Fail*	*Total Failures*	*MTBF*	*Population*	*CF Interval*	*Optimal*	*Scheduled*	*TMP*	*Actual*
			0.00	*0.00*	*0.00*	*0*	*0*	*0*	*0*			

Examination	*Examination Crew*	*Time (m)*	*Success %*	*Setup $*	*Planned Repair Cost $*	*Call Out, Secondary Damage $*	*Unplanned Failure Cost*	*Redundancy Equipment*
		0	*0*	*0*	*0*	*0*	*0*	

Protective	*Failures*	*Population*	*MTBF*	*No Prot. S*	*Repair Cost $*	*Double Failure Cost $*
	0	*0*	*0*	*0*	*0*	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

No.	Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
16	**Luminairre cracked casing (B2229 type) fatigued due to vibration.**	Casing drops to ground. Injury to public and/or property.	N	Y	Y	–	N	Y			–				Examine Slyvania B2229/B3000 fitting for cracks.	Perform one off in initial inspection to prioritise replacement.
															Replace Luminairre	Removed from north. Est pop for Nctle/Hunter 1200. 0.3% found cracked in sample examination. Guess of CF is < 30 mths

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*0.00*	*24.00*	*24.00*	*18,250*	*1,200*	*365*	*405*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
	Mains Crew (2)	*1*	*95*	*100*	*700*	*500*	*26,200*	*Equipment*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	0

System
Equipment
Function
Function Failure
Failure Mode | Effect | E SE O – L OC SR SD – CB FF RD | Proposed Task / Corrective Task | Decision Basis MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

6 **Luminairre obstructed due to trees.**

Effect: Creation of shadow areas. Reduced lighting - possible safety/security issues and customer complaints.

E SE O – L OC SR SD – CB FF RD: – –

Decision Basis: Covered by task in Overhead Line analysis - Vegetation Mgmt programme

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
			0.00	30.00	30.00	60,833	5,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

5 **Luminairre rotated due to fastening screw lossened. (wind/vibration).**

Effect: Light now no longer focused on roadway. Possible safety/security issues and customer complaints.

E SE O – L OC SR SD – CB FF RD: N Y Y – N N N N –

Proposed Task / Corrective Task: N.S.M.

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	6.00	100.00	106.00	340,896	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	25,000	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	

MIMIR

Maintenance Requirements Analysis Detailed Report

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
7 **Twin Flourescent Lamps low output due to one tube failed.**	Reduced local light output. Possible customer complaints.	N	Y	Y	–	N	N	N	N	–		Y		Examine Street Lighting for adequate light level	Patrol Task
														Repair/Replace based on local Gov preference.	Total failure estimate based on Weibull parameter calculations for population Beta=2.3, neta=2070

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	25,000	100.00	1,764.00	5.00	1,825,000	25,000	0	767	365 Patr		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
	Mains Crew (2)	1	99	2	300	0	25,300	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	1,864	25,000	4,895	0	300	25,600

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
31 **Visors hanging down due to various.**	Lamp not protected.	N	N	N	–	N	N	N	N	–		N	N	N.S.M.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	N/A	0	100.00	420.00	520.00	69,490	99,000	0	0			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy Equipment
		0	0	0	0	0	0	

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	0	0	0	0	0

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies

The average lumen output to be not less than 70% of the original design output.

Average lumen output is less that 70% of original design output.

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
2 **Visors obstructed due to dirt/dust buildup.**	Reduced local light output. Possible customer complaints.	N	Y	Y	–	Y				–				Clean visor. Replace visor if aged.	(in conjunction with other work)

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*10.00*	*686.00*	*696.00*	*51,918*	*99,000*	*0*	*0*	*Lamp re*		

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	*0*	*0*	*0*	*0*	*25,000*	*Equipment*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

Failure Mode	Effect	E	SE	O	–	L	OC	SR	SD	–	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis
1 **Visors obstructed due to insects.**	Reduced local light output. Possible customer complaints.	N	Y	Y	–	Y				–				Clean visor.	

Primary	Operation Loss Description	Operatonal Loss $	Cond Fail	Funct Fail	Total Failures	MTBF	Population	CF Interval	Optimal	Scheduled	TMP	Actual
	Minor Injury	*25,000*	*2.00*	*696.00*	*698.00*	*51,769*	*99,000*	*0*	*0*			

Examination	Examination Crew	Time (m)	Success %	Setup $	Planned Repair Cost $	Call Out, Secondary Damage $	Unplanned Failure Cost	Redundancy
		0	*0*	*0*	*0*	*0*	*25,000*	*Equipment*

Protective	Failures	Population	MTBF	No Prot. S	Repair Cost $	Double Failure Cost $
	0	*0*	*0*	*0*	*0*	

System / Equipment / Function / Function Failure / Failure Mode	Effect	E	SE	O	L	OC	SR	SD	CB	FF	RD	Proposed Task / Corrective Task	Decision Basis / MTBF Basis

Street Lighting

SL 02 00 00 Lamp Assemblies