University of Southern Queensland

Faculty of Engineering and Surveying

Cost Effectiveness of Suburban Street Lighting

A dissertation submitted by

Ricky Luke

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Abstract

Street lighting is a major concern for all Authorities that are required to provide this public service. Concerns about safety, crime reduction, and amenity need to be balanced against operation and maintenance costs, and reduction in greenhouse gas emissions. This project examined if the current lighting in a selected area of Castlemaine, Victoria met the Australian Standard AS/NZS1158, and what expenditure would be required to bring it up to this standard. Also, the project looked at energy efficient lamps to determine if it was cost effective to replace the existing items.

The Australian Standard has two sections – AS1158.1.1 for high vehicle traffic, and AS1158.3.1 for minor roads and pedestrian areas. After the sample area was broken up into lighting zones, computer modelling indicated that the highways were over-lit, and the minor roads were under-lit. The infrastructure required to bring lighting up to the relevant Standard is substantial. For the minor roads, an extra 28 luminaires will be required at an estimated cost of $174,000. The replacement of the current luminaires with more energy efficient items ahead of the proposed change over date is not warranted because the life of the energy efficient lamps are significantly less than the current items, and the annual maintenance charge for these “non standard” luminaires is three times the cost of the current item.

The recommendation is that Mount Alexander Shire Council, through the CVGA, lobby PowerCor to include energy efficient lighting in their standard luminaires, and that Council refrains from installing extra luminaires unless there is a well defined need. One aspect that was of interest is that AS 1158 is an advisory standard, and there is no requirement for an Authority who is responsible for Public Lighting to meet this Standard.

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Certification

I certify that the ideas, designs and experimental work, results, analysis and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicted and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

Ricky Luke

Student Number: 50029159

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Signature

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Date

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Glossary

Colour rendering – The degree to which the colours of objects illuminated by a given lamp conform to those of the same objects illuminated by the appropriate reference light source for that lamp.

Illuminance (E) – The physical measure of illumination is illuminance. It is the luminous flux arriving at a surface divided by the area of the illuminated surface.
Unit: lux (lx); (1 lx = 1 lm/m^2)

Lamp – The generic term for the light source in a luminaire.

Longitudinal Uniformity (U_L) – The ratio of the minimum to the maximum luminance along a specified length of the carriageway, along the longitudinal line passing though a specified observer position.

Luminaire - apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except for the lamp themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply.

Luminance (L) - The physical quantity corresponding to the brightness of a surface (eg a lamp, luminaire, or reflecting material such as the road surface) when viewed from a specified direction. Unit: candela per square metre (cd/m^2)

Luminous Flux (Φ) - The measure of the quantity of light. For a lamp or luminaire it normally refers to the total light emitted irrespective of the directions in which it is distributed. Unit: lumen (lm)

Luminous Intensity (I) - The concentration of luminous flux emitted in a specified direction. Unit: candela (cd)

Maintenance Factor - Ratio of the light flux emitted from a luminaire at a given time to that emitted initially.

Mounting Height (H) - The vertical distance between the centre of a luminaire and the surface which is to illuminated, eg the road surface.

Outreach – The distance, measured horizontally, from the centre of the luminaire to the supporting pole or fitting.

Overall uniformity (U_O) – The ratio of the minimum to the average luminance within the specified section of the carriageway, viewed from a specified observer position.

Overhang – the distance, measured horizontally between the centre of a luminaire and the adjacent kerb or carriageway edge. The distance is taken to be positive if the luminaire is in front of the kerb or carriageway edge and negative if it is behind.

Spacing (S) – the distance between successive luminaires in a road lighting installation measured along the line of luminaires.

Surround (verge) Illuminance (E_S) – The ratio of the average illuminance on a 3m wide strip of the verge to the average illuminance on a contiguous like strip of the carriageway, both strips extending for one span of lighting.

Threshold Increment (TI) – The measure of disability glare expressed as the percentage increase in contrast required between a standard object and its background (the carriageway) for it to be seen equally well with the source of glare present as with it absent, derived in the specified manner.

Upcast Angle – The angle by which the axis of the fixing spigot entry is tilted above the horizontal when the luminaire is installed.

(Source: AS/NZS 1158.0:2005 Road Lighting Part 0: Introduction – Definitions)

1.0 Introduction

1.1 Project Aims

The aim of the project was to assess a portion of Mount Alexander Shire Councils current lighting stock against the relevant Australian Standard and to suggest improvements that considers whole of life costs and sustainability issues.

The project considered five objectives.

1) Determine a suitable study area that encompasses late night pedestrian utilisation, open space, residential areas, and major roads. Usage zones were then defined.
2) Review AS1158 "Lighting for Roads and Public Spaces" and determine what standard is appropriate for each zone.
3) Develop an inventory of Council's current public lighting stock, and prepare location map, highlighting deficiencies against AS1158.
4) Select the most viable sustainable public lighting options for Council considering whole of life costs of luminaires and lamps, and compliance with AS1158.
5) Carry out a cost benefit analysis of the most viable sustainable public lighting options for the existing network, and the alterations to comply with AS1158 (if applicable).

1.2 Mount Alexander Shire Council

Mount Alexander Shire Council (MASC) is a member of the Central Victorian Greenhouse Alliance (CVGA), and is part of the Public Lighting Action Plan (PLAP). Council has committed itself to meeting greenhouse gas reduction targets set by the CVGA, and is looking at the efficiency of its public lighting assets to help meet these targets. This may have the benefit of reducing power consumption with a resultant reduction in electricity charges, but the installation of low power lamps may be not be cost effective when the whole of life costs are considered.

It was considered by the Council that the current lighting stock is not up to the current Australian Standard AS1158 for public lighting, but anecdotal evidence from complaints received by Council indicates that a lighting level to the relevant standard may be too bright for some areas. The decision was made to investigate a sample area of Castlemaine and to report on the current status of lamp type, and light intensity for pedestrians and vehicles. The study area needed to incorporate a mix of usage zones e.g. commercial, premises with late night patronage, well trafficked roads, and residential zones. These sample areas gave what is considered a reasonable model that can be expanded for use throughout the Shire.

It is also worth noting here that the first Australian Standard for street lighting (AS CA19-1939) was published in 1939, and that many of the older areas in the Shire may have had lighting installed to this standard. This was not investigated.

2.0 Background

Mount Alexander Shire Council is based in Castlemaine, Victoria, and is located about 150km NW of Melbourne. It was the major town at the centre of a large goldfield from the middle of the 19^{th} century, and as a result of this status, have a significant number of 30 m wide road reserves. These roads are also lined with deciduous trees, mainly elms, and this has affected the location and type of street lighting. There are 2 State Highways that pass through Castlemaine; the Pyrenees Highway and the Midland Highway. These are maintained by the State Roads Authority – VicRoads. For many years Castlemaine had a stagnant population size, but recent transport improvements to Melbourne and Bendigo have seen its population start to grow. The Shire also has a significant aging population (Australian Bureau of Statistics Census, 2003). Some of the older (60+) residents are retirees who have moved from larger towns for the more relaxed lifestyle, or off farms to be closer to medical and other care facilities. Both these groups find the relative lack of street lighting in Castlemaine disconcerting. These groups, and some long term residents, feel that their after dark activities are hindered by the lack of public lighting as they cannot see what or who is outside. Castlemaine is a relatively low crime area, and there is more of a fear of perceived crime rather than a fear of actual crime – that is, fear that a crime may happened compared with the likelihood of one actually occurring. It is mainly from these groups that MASC is being pressured to bring the street lighting up to the relevant Australian Standard.

One other organisation that would prefer that Councils street lighting meet the relevant Australian Standard is its insurer. Council has a significant network of footpaths, and is required to undertake reasonable steps to eliminate, reduce the severity, or make visible hazards along the footpath network. One aspect that is taken into consideration if a night time insurance claim is made against Council is the lighting of the area at the time the incident occurred. It is considered by the insurer, and indeed most other insurers that deal with Local Government, that Councils should implement best practise for public lighting, and this having a network that complies with the relevant Australian Standard.

The Shire is a member of the Central Victoria Greenhouse Alliance (CVGA) whose aim is, by 2010, to reduce the amount of CO_2 greenhouse gas emitted by 30% from the amount produced in 2000. Part of the plan is to reduce the amount of electricity used by street lights. This aim would improve lighting quality while significantly reducing energy costs and greenhouse gas emissions. The Alliance is looking at a number of options that members can implement to reduce their street lighting energy costs. These include turning off or dimming luminaires after a certain time, installing better quality photoelectric cells on luminaires that will ensure lights are on only through the night, using modern high efficiency electronic lighting control apparatus, and finally and most obviously, changing lamps to a more energy efficient item.

Council has an annual budget of $67,000 for the OMR (Operation, Maintenance and Repair) for existing street lighting, and a $5,000 annual budget for new lighting fixtures. Each new luminare and associated works costs in the order of $1,200 to install onto an existing pole. If a light is required away from the existing network the cost could be up to $10,000, which includes the pole, mounting bracket, luminaire, lamp, and electrical cabling. As the street lighting network is not metered, the OMR charge includes electricity consumed by the lamp,

2.1 Shared Cost Lighting

A portion of the street lighting network has its OMR costs shared with VicRoads. These are the lights located along the State Highways. As these luminaires have been installed mainly for the benefit of the wider travelling public, not just Shire residents, VicRoads pays for 2/3 of the OMR charges, and Council picks up the remaining 1/3. As of August 2006 though, VicRoads are looking at their responsibility regarding street lighting. They have undertaken an audit of their street lighting assets and have discovered that there are roads that are no longer under their jurisdiction that they are paying OMR for lighting, and conversely, some lights that should be their responsibility are not on their asset listing. This matter was raised at a recent meeting of all Victorian Councils through the Municipal Association of Victoria (MAV) (Minutes of State-wide meeting of the MAV, 26 July 2006, Flemington). A number of Councils around the outer developing fringe of Melbourne, (Shire of Hume, Shire of Whittlesea, City of Casey) reported that their seems to be a push from VicRoads to reduce the number of luminaires they are responsible for. The general impression is, and it must be stated that there is currently no formal correspondence regarding this matter, that VicRoads is trying to become responsible only for lighting at areas of road conflict in urban areas – intersections and pedestrian crossings, and the Local Council would be wholly responsible for all other lighting assets. The MAV will be vigorously pushing to reject any such change as this will have a significant detrimental financial impact to many Local Councils. While this aspect was not specifically considered when this project originated, the above has made it a priority to examine the potential financial impact any alteration to the current cost sharing regime may have on Councils resources, and to mount a convincing argument to the State Government against any proposals that VicRoads may put forward that alters the funding ratio.

2.2 Street Lighting and the Australian Standard

Similar to many small Local Government authorities, Mount Alexander Shire Council does not have a specialist public lighting officer on staff but are still required to professionally administer a substantial public asset. As previously mentioned Council has an annual budget of $67,000 for OMR on street lights (Mount Alexander Shire Council Annual Report 2005-06). This does not take into consideration Council officers time spent on lighting related issues. Councils Infrastructure Department consists of 4 staff, all of whom have a Civil Engineering background – one with roads experience, one with a stormwater background, one with water and wastewater background, and a Technical Officer who has only recently graduated. A fifth position is currently vacant, but it is another civil design position. The experience all members have regarding public lighting is minimal, and the Council has previously relied on advice from PowerCor (the electrical infrastructure provider), or from luminaire suppliers. This is not always satisfactory or impartial, as highlighted in a recent project. Council's development guidelines state that street lighting for a subdivision needs to be provided to PowerCor's satisfaction, even though the asset will become Councils responsibility. This particular subdivision in question is in a newly zoned residential area, but has approximately 1 km of unlit rural road before the development. The developer was instructed by PowerCor to install lighting to the Australian Standard, which appeared to the Shire engineer checking the plans to be excessive for the area. A driver travelling along this road would move from a dark roadway to a very bright area, and in 400 m, back to a dark roadway with a sharp bend 500 m away from the development. From a road safety perspective this was deemed to be less than desirable, and discussions were held with PowerCor and the developer to come up with a solution. The lack of knowledge concerning the Australian Standard for street lighting was a distinct disadvantage in these talks. In general, it was noted that the installation of any new luminaires in the Shire did not consider the Standard at all, and a working knowledge of the Standard by a member of the Department would be useful for any future street lighting projects.

After discussion with other staff in the Infrastructure Department, it was decided that this project would examine the current lighting infrastructure in a section of Castlemaine and compare it with the requirements of the relevant Australian Standard. Once a benchmark was set with the existing lighting types, the project would then look at replacing the current lighting with more energy efficient items and run a cost benefit analysis over the results to determine if it was worthwhile altering the lighting network.

2.3 Luminaire Description and identification

The Local Government Energy Toolbox website (www.energy-toolbox.vic.gov.au/publiclighting) notes that a street light consists of four basic elements, other than the pole itself. These are listed below, and are illustrated in Figure 2-1:

- The luminaire, or light fitting, attached to the pole.
- The lamp.
- The ballast/control gear.
- The on-off switching control, usually a photoelectric (PE) cell.

According to section 1.6.3 of AS/NZS1158.6 the luminaire shall be indelibly marked with a code corresponding to the lamp type and rating, diffuser style, and the year of manufacture. These markings are to be clearly visible from beneath the luminaire.

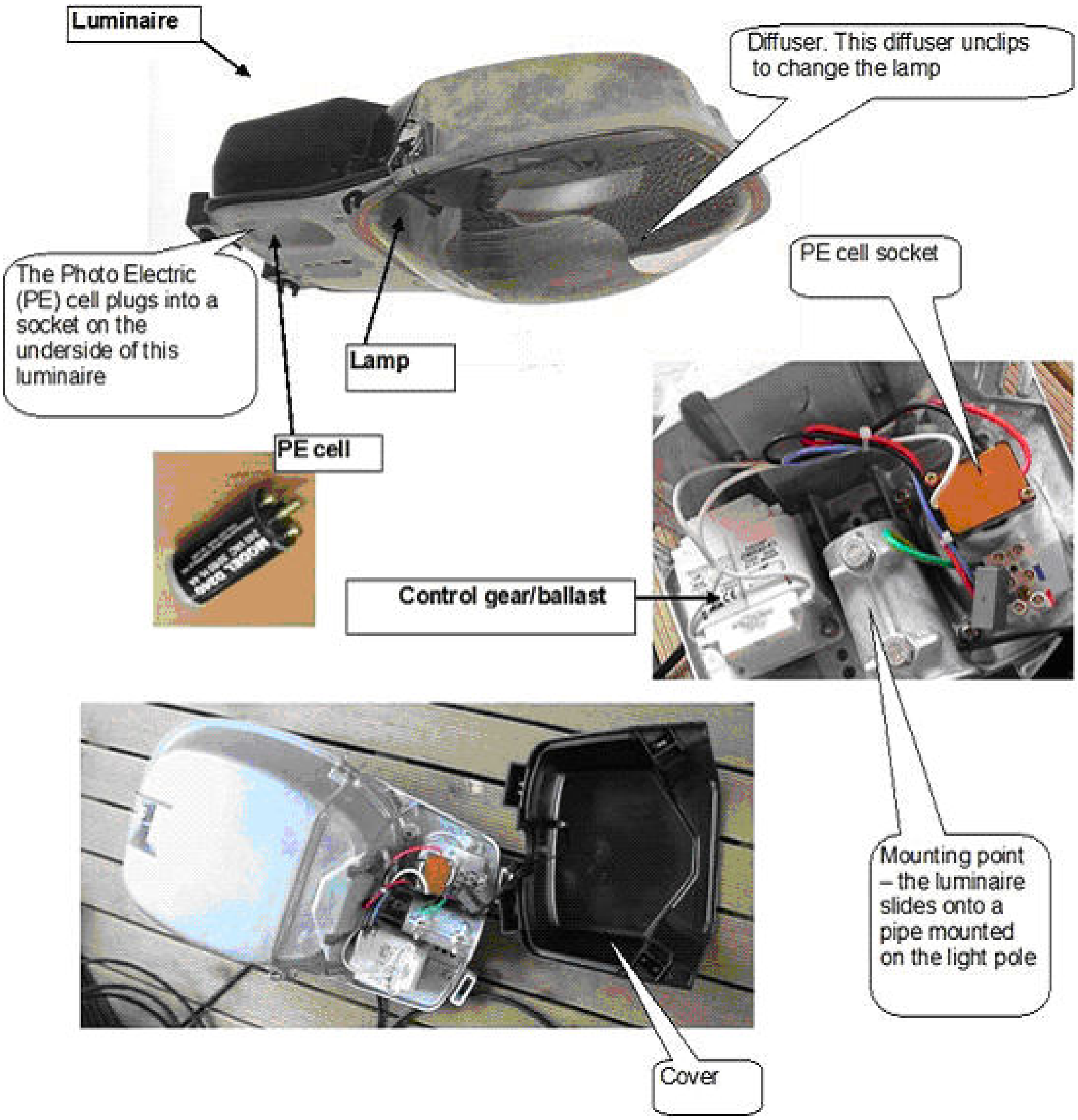


Figure 2-1 Outline of the basic elements of a street light luminaire (www.energy-toolbox.vic.gov.au/publiclighting)

3.0 Methodology

3.1 Model Area

As stated in the project aims, the first objective was to select a suitable area to examine. This was important to the overall project as too small an area would not have a wide enough range of vehicle and pedestrian movements to be considered as a satisfactory model for the Shire, but too large an area may have been too time consuming to calculate the required lighting. The area to be modelled needed to contain different levels of nocturnal pedestrian movements. The range of criteria that was decided on what was perceived to be the main items – high / low traffic volumes, high / low pedestrian movement, residential, commercial, late night entertainment venues, and pedestrian movement between these areas.

It was decided early in the project that the model area should be centred on the central business area of Castlemaine. This area has the main supermarket for the town, and is open to 10.00 pm most nights. The block also contains a cinema, 3 hotels and two takeaway shops. This block is also bounded on the west and south by the Midland Highway and Pyrenees Highway respectively. This was important as the lighting on these roads is a joint responsibility between VicRoads and Council, and luminaires on highways are generally more closely spaced and higher wattage than other roads.

An examination of Councils customer request system was undertaken to determine what requests or complaints Council had received concerning street lighting, and if the results could be used to help define the study area. The register covers the last 6 years, but no useful information was derived from it. The data had requests for the installation or the removal of street lights at various locations around the Shire, but generally all away from the Castlemaine CBD. The closest request would require an excessively large area to model, so other data was sought that would help define the area.

Council and other authorities have undertaken a number of pedestrian and traffic movement studies around the Castlemaine CBD for various reasons, such as off street parking locations, determining the locations for traffic lights and pedestrian crossings, possible bicycle paths and footpath upgrades. Most of these pedestrian surveys only considered daytime movements, but it was felt that the data could be interpolated for night time use. As a check on this assumption, staff members who have been with the Shire for these studies were asked for their professional opinion about after dark pedestrian movements, and in general they concurred with the theory. Traffic movements were easier to verify. VicRoads and MASC have vehicle classifier data that records the number and type of vehicle, and the time that vehicle moved over the traffic classifier. These classifiers were used in the above studies, and the results were extracted from the original raw data to determine the night time traffic movements. Again, MASC staff was consulted to determine the validity of the assumptions.

Using the above data, a model area was selected. This was the area bounded by the Railway on the west, Campbell Street to the north, Urquhart Street to the east, and the Pyrenees Highway / Forest Street to the south. A copy of the aerial photograph of the area is located in Figure 3-1.

Figure 3-1 Aerial photograph of model area

3.2 Literature Review

A review of various university libraries show that there are virtually no books published that focus solely on street or public lighting, especially from an Australian perspective. A search on the internet for books published on this subject produced only one relevant hit – "Outdoor Lighting Pattern Book" (Leslie & Rodgers, 1996). This does not appear to be available in Australia, and it's relevance to this project is questionable considering its North American origin. It appears by the description on various booksellers' internet sites that it is more focused towards lighting public places for effect, not safety. Most road and pedestrian lighting references are based around traffic engineering such as "Roadway Lighting" (Austroads, 2004), and "Highway Engineering Handbook" (Brockenbrough, Boedecker, 1996). Periodicals are a source of information, but a decision had to be made about the relevance of articles written before 2004. This is because the current Australian and New Zealand Standard "AS/NZS1158 Lighting for Roads and Public Spaces" was revised and published by Standards Australia in 2005, and according to the preface, has had its scope expanded from the 1999 version as well as incorporating many significant technical changes. These changes are listed in the preface to the Standard. Australian periodicals that have articles that may have articles relevant to this project are "Highway Engineering in Australia" (Klemzig), and "Municipal Engineering in Australia" (Klemzig) but examination of these journals published from January 2004 in the MASC Engineering library did not provide any useful information. Another article that was examined was "Guidance Notes for the Reduction of Light Pollution" (The Institution of Lighting Engineers, Rugby, United Kingdom, 2003). This short article considers obtrusive light a form of pollution that can have detrimental effects on the environment if not controlled properly. While English in its origin, it will still have some relevance when any change to the project areas lighting is considered. However, it was decided that he article was not relevant to this project.

As mentioned above, the current Australian and New Zealand Standard for lighting in public places is “AS/NZS1158 Lighting for Roads and Public Spaces”. The standard contains a number of sections that need to be examined to determine the relevance to the subject area, once chosen. The sections of the standard are:

- AS/NZS 1158.0: Introduction
- AS/NZS 1158.1.1: Vehicular traffic (Category V) lighting – Performance and design requirements.
- AS/NZS 1158.1.3: Vehicular traffic (Category V) lighting – Guide to design, installation, operation and maintenance.
- AS1158.2: Computer Procedures for the calculation of light technical parameters for Category V lighting
- AS/NZS 1158.3.1: Pedestrian Area (Category P) lighting – Performance and design requirements.
- AS 1158.4: Supplementary Lighting at Pedestrian Crossings.
- AS 1158.6: Luminaires.

The situation is different when looking at sustainability issues and cost benefits of Public Lighting. There is a significant amount of information published on various reputable websites, and much of this has been produced in Australia. The most relevant is a Victorian Government website “Local Government Energy Toolbox” (http://www.energy-toolbox.vic.gov.au/publiclighting/index.php) which contains much useful information that was relevant for this project. The purpose of the site (or hub as it is called) is “The aim of the sustainable public lighting information hub is to accelerate the uptake of sustainable public lighting in Victoria." The sustainable public lighting hub provides:

- guidance in getting started with strategies and action plans
- current information about the trial of different technologies and information sharing projects supported by the Sustainable Public Lighting Initiative in Victoria
- the various standards and regulations that govern public lighting in Victoria
- tools, resources, templates and guidelines to help implement sustainable public lighting
- information about the different technologies available
- lists of distribution businesses, suppliers, contacts and other web based resources, and
- news and events.

And a similar Federal Government site is http://www.greenhouse.gov.au/local/. It repeats much of what is in the Victorian Government website.

The final document examined was a previous project on street lighting "Cost Effectiveness of Suburban Street Lighting" (Jason Fowler, USQ, 2004). This examined street lighting in the City of Bunbury (COB) in Western Australia and looked at the costs for Council maintained lights compared with costs for the power authority to maintain these Council assets. While this project has similarities to the one currently undertaken here, the aim of the Fowler project was to establish the cost effectiveness of the provision of suburban street lighting within the City by their power utility Western Power, compared to the Council installing and maintaining its own networks to the

Australian Standard, and so is of no benefit to this project apart from some reference material.

It should be remembered that this project specifically looked at if the current lighting stock met the current Australian Standard, and sustainability issues surrounding the choice and location of luminaires. Hence many of these references are only of interest as background information and are not strictly relevant to this project. This really left the Australian Standard AS 1158 as the prime reference for this task.

3.2.1 Review of the Australian Standard

AS/NZS 1158 series was obtained and critically analysed for information to be utilised in this project. Below is a summary of findings from each section of the Standard.

1. AS/NZS1158.0:2005 Introduction contains a glossary of terms and definitions that are used in the Standard.
2. AS/NZS1158.1.1:2005 Vehicular traffic (Category V) lighting – Performance and design requirements, is used to determine what the design objectives and light technical parameters are for lighting along roads where the lighting is primarily for motorists. The Standard gives examples of how the road network should be further divided into subcategories, and the design methods to be used to determine the lighting required. It was noted that the only acceptable design method for straight sections of road and intersections are Luminance based computer calculations (table 3.1, AS/NZS1158.1.1:2005). The procedures are found in AS/NZS 1158.2.
3. AS/NZS 1158.1.3:1997 Vehicular traffic (Category V) lighting – guide to design, installation, operation, and maintenance is divided into three main

elements covering lighting fundamentals, design, and application. The publication is quite informative and is a useful background to why, how, and where street lights are installed. This version is due to be superseded, but as it is still the current standard, the general guidelines were utilised in the analysis of category V roads in this project.

4. AS/NZS 1158.2:2005 Computer procedures for the calculation of light technical parameters for Category V and Category P lighting details is used for the design or evaluation of road lighting in accordance with the requirements of the AS/NZS1158.1.1 and AS/NZS1158.3.1. This part also gives the general requirements for computer programs to calculate the light technical parameters (LTPs) for road and public space elements in both Category V and P lighting. Included with this part is a CD containing SAA STAN and STANSHELL. SAA STAN is a DOS based computer program that is used to calculate the LTPs on straight sections of Category V roads. STANSHELL is a shell program that runs SAA STAN under a Windows environment. Section 4.1 of this part notes that the use of SAA STAN is required to calculate the LTPs for Category V straight road elements. LTPs for category P roads cannot be calculated using STANSHELL (Section 4.4.1, AS/NZS 1158.2:2005), and another program needed to be sourced. It was noted in section A2 of Appendix ‘A’ that other programs from international sources use similar, but not identical algorithms to SAA STAN and so are likely to yield different values of LTPs. Appendix ‘C’ provided details of two commercial programs that are compatible with SAA STAN. As one of the requirements of this project is to assess the lighting against the relevant Australian Standard, some of the overseas software was examined to see if they could prepare a design based on AS/NZS 1158, but they did not

appear to comply. The providers of the software noted in Appendix 'C' were contacted, and a copy of Perfectlite (www.perfectlite.com) was obtained.

5. AS/NZS1158.1.1:2005 Pedestrian area (Category P) lighting – Performance and design requirements, is similar in scope to item 4 above, except that the safe movement of pedestrians is the main design criteria. Again, section 1.2 notes that the application of this Standard to public lighting design rests with the local Authority, as well as the decision of what sub category is used for the basis of the design. Section 2 and specifically Table 2.1 "Lighting Categories for Road Reserves in Local Areas" is used to determine these subcategories. Apart from type of road or pathway, the designer needs to consider pedestrian/cycle activity, risk of crime, and need to enhance prestige. The latter 3 items are given a high, medium, low, or N/A rating to determine the applicable lighting subcategory. The risk levels correspond to the classifications of the same names in HB436 Risk Management Guidelines (Standards Australia, 2004). Section 3.2.1 notes that subcategories P1 and P2 are to be used only to light the pathway, not the whole road reserve. This is due to the reasons for choosing this level of lighting – either because of high crime risk or enhanced prestige is required for the area, not for motorists.

6. AS/NZS1158.4:2005 Supplementary lighting at pedestrian crossings was not reviewed as there is only one crossing in the proposed area. This will be removed within 6 months when an intersection nearby has traffic signals installed.

7. AS/NZS 1158.6:2004 Luminaires is concerned with standards of manufacture and hence will not be referred to any further in this project.

Below is a summary of what was learned from the Standard that affects this project and what needs to be considered for any future lighting work.

1. The choice of whether to install a scheme of road or public lighting in compliance with this Standard rests with the lighting authority. (AS/NZS 1158.3.1:2005, section 1.2). This is contrary to what seems to be general public perception. That is, if a Standard exists, it should be complied with.
2. If the decision is to light an area to the Standard, it is up to the lighting authority to determine what Category (V or P) and subcategory that area is to be lit to. This is subject to any overriding legislation.
3. Computer software that is written for the requirements of AS/NZS 1158 is required to properly assess the lighting requirements for an area. The software supplied, SAA STAN and STANSHELL is not suitable to assess the majority of the lighting network (Category P).

3.3 Lighting subcategories

It was known that the lighting requirements for different areas required different lighting. However the method of determining how these areas were categorised was unknown. Following the review of the Australian Standard the subject area was re-examined and divided into the relevant categories defined in AS/NZS1158.0 Section 5. The highways were deemed to be in Category V, and the remaining areas Category P. The relevant parts of the Standard were examined, and the applicable subcategories were determined.

For Category V roads table 2.1 “Category V lighting and typical applications” of AS/NZS1158.1.1 was used to determine the subcategory. From that table it was decided that the subcategory all sections of both highways should be V3. Both highways are arterial roads that predominately carry through traffic from one region to another. They have mixed vehicle and pedestrian traffic, moderate through and local traffic volumes, but low (50km/h) vehicle speeds, parking alongside the carriageway, and traffic entering from abutting properties.

For Category P roads table 2.1 "Lighting categories for road reserves in local areas" of AS/NZS 1158.3.1 was used. Each block of the roads that were determined to be Category P was assessed against the criteria in the table and a subcategory determined. The decision as to what constitutes "high", "medium" or "low' in the selection criteria of table 2.1 is left to the designer to quantify. With no basis in the Standard for comparison it was decided that the criteria should be set in relation to each other. For example, Mechanics Lane is a narrow road that contains a Senior Citizens centre and a theatre. It also is used as a short cut between two shopping precincts and the surrounding residential areas for high school aged pedestrians. As a result of these two facts, it has high night time pedestrian counts and there are higher concerns about the possibility of crime in this area compared with other areas of Castlemaine. This places Mechanics Lane in subcategory P1. Other roads were categorised in relation to this determination. The results are in table 3-1 below. The zones were then mapped on Councils GIS over the aerial photography of the zone. The map is in Appendix "B".

Table 3-1 Zone Assessment of Road Network

Road	From	To	Table (see notes)	Road Type (see notes)	Pedestrian / Cycle activity	Risk / Fear of Crime	Prestige	Lighting category
Forest St	Kennedy St	Midland Hwy	P2.1	C	M	M	N/A	P2
Forest St	Midland Hwy	Hargraves St	V2.1	LSA	N/A	N/A	N/A	V3
Forest St	Hargraves St	Union St	V2.1	LSA	N/A	N/A	N/A	V3
Forest St	Union St	Urquhart St	V2.1	LSA	N/A	N/A	N/A	V3
Mostyn St	Kennedy St	Midland Hwy	P2.1	C	M	M	N/A	P2
Mostyn St	Midland Hwy	Frederick St	P2.1	C	H	M	N/A	P2
Mostyn St	Frederick St	Hargraves St	P2.1	C	H	M	N/A	P2
Mostyn St	Hargraves St	Union St	P2.1	C	H	M	N/A	P2
Mostyn St	Union St	Urquhart St	P2.1	C	M	L	N/A	P3
Lyttleton St	Kennedy St	Midland Hwy	P2.1	C	M	M	N/A	P2
Lyttleton St	Midland Hwy	Frederick St	P2.1	C	H	M	N/A	P2
Lyttleton St	Frederick St	Hargraves St	P2.1	C	H	M	N/A	P2
Lyttleton St	Hargraves St	Urquhart St	P2.1	C	M	L	N/A	P3
Mechanics Lane	Midland Hwy	Frederick St	P2.1	L	M	H	N/A	P1
Templeton St	Kennedy St	Midland Hwy	P2.1	C	M	M	N/A	P2
Templeton St	Midland Hwy	Hargraves St	P2.1	C	L	M	N/A	P2
Templeton St	Hargraves St	End of Road	P2.1	L	L	L	N/A	P4
Campbell St	Kennedy St	Midland Hwy	P2.1	L	L	M	N/A	P3
Campbell St	Midland Hwy	Hargraves St	P2.1	L	L	M	N/A	P3
Campbell St	Hargraves St	Urquhart St	P2.1	L	L	L	N/A	P4
Kennedy St	Forest St	Mostyn St	P2.1	C	M	M	N/A	P2
Kennedy St	Mostyn St	Lyttleton St	P2.1	C	M	M	N/A	P2
Kennedy St	Lyttleton St	Templeton St	P2.1	C	M	M	N/A	P2
Kennedy St	Templeton St	Campbell St	P2.1	C	M	M	N/A	P2
Midland Hwy	Forest St	Mostyn St	V2.1	LSA	N/A	N/A	N/A	V3
Midland Hwy	Mostyn St	Lyttleton St	V2.1	LSA	N/A	N/A	N/A	V3
Midland Hwy	Lyttleton St	Templeton St	V2.1	LSA	N/A	N/A	N/A	V3
Midland Hwy	Templeton St	Campbell St	V2.1	LSA	N/A	N/A	N/A	V3
Frederick St	Mostyn St	Lyttleton St	P2.1	L	H	H	N/A	P1
Frederick St	Lyttleton St	Templeton St	P2.1	L	M	H	N/A	P1
Hargraves St	Forest St	Mostyn St	P2.1	C	H	M	N/A	P2
Hargraves St	Mostyn St	Lyttleton St	P2.1	C	H	M	N/A	P2
Hargraves St	Lyttleton St	Templeton St	P2.1	C	M	M	N/A	P2
Hargraves St	Templeton St	Campbell St	P2.1	C	L	M	N/A	P2
Union St	Forest St	Mostyn St	P2.1	L	L	M	N/A	P3
Urquhart St	Forest St	Mostyn St	P2.1	L	L	L	N/A	P4
Urquhart St	Mostyn St	Lyttleton St	P2.1	L	L	L	N/A	P4
Urquhart St	Lyttleton St	Campbell St	P2.1	L	L	L	N/A	P4
NOTES								
LSA	Low Speed Arterial							
C	Collector Road							
L	Local road							
V2.1	Table 2.1	AS/NZS1158.1.1						
P2.1	Table 2.1	AS/NZS1158.3.1						

3.4 Street lighting details

The commercial relationship between the electricity distributor and the public lighting customer is overseen by the Essential Services Commission, Victoria. The Commission produces a Public Lighting Code (Essential Services Commission, Victoria, April 2005) which all parties must comply with. Section 5 of the code deals with the provision of information, and a request was made to PowerCor for the street lighting data in the model area. PowerCor supplied a spreadsheet containing a street lighting schedule for all of Castlemaine. This schedule is dated 2003, and contains lamp type, height, location, and other data not relevant to this project. A plan was also received showing the location of the luminaires, along with the type. This was placed in the GIS for the project as a layer over the subcategory zones. Apart from the age of the data, it was noted that there were anomalies that needed to be assessed before proceeding. The plan supplied had more luminaires than what was listed in the spreadsheet, so this needed to be reviewed. A night inspection showed that a number of luminaires were spot lights used to highlight historic buildings or commercial properties. Other luminaires were in parking areas, or used for decorative purposes. These luminaires are connected to the street lighting circuit, but are not considered part of the public street lighting network. It was also noted that the total number of luminaires on the plan appeared to match the spreadsheet, but along the highways the lamp type did not appear to match.

After discussion with PowerCor it appeared that some older mercury vapour lamps (MV) had been replaced with high pressure sodium lamps (HPS) of the same wattage. The plans were amended accordingly.

3.5 Computer modelling

Compliance with the requirements of AS/NZS 1158 is based on a lighting scheme achieving prescribed values of quantities known as LTPs (lighting technical parameters). These LTPs and the values required for compliance are given in AS/NZS1158.1.1:2005 for Category V lighting and AS/NZS1158.3.1:2005 for Category P lighting.

3.5.1 Category V lighting schemes

SAA STAN and the shell program STANSHELL is the software that must be used to determine the LTPs for straight Category V roads. Light Technical Parameters (LTP) for Category V lighting include

- Minimum average carriageway luminance (Ĺ) – units (cd/m^2)
- Minimum overall luminance uniformity (U_O)
- Minimum longitudinal uniformity (U_L)
- Maximum threshold increment (TI)
- Minimum surround illuminance ratio (E_s)

The designer then needs to select a photometric file for use by the program. A photometric file is a specially written text file that the luminaire manufacture creates that describes how the light is distributed from the luminaire. Each file is unique to the luminaire type and lamp combination. All luminaires along the highways are Sylvania Roadster models with either 250W HPS or MV lamps. There are some luminaires that are listed as Sylvania Roadster models with 150W HPS lamps, but it was difficult to see from the ground if this was the case (due to the luminaires overhanging the traffic lanes). As these were isolated an assumption was made that all luminaires were 250W, and a further simplification made that the 5 mercury vapour lamps were to be modelled as high pressure sodium. This is valid as PowerCor are replacing all MV lamps on arterial roads with HPS lamps, as HPS are the most cost effective of the commonly used high wattage lamps (table 5.1, AS/NZS118.1.3:1997).

The relevant Sylvania photometric files were obtained from the manufacturer and data from PowerCor and the GIS input into STANSHELL. The program was initially run for spacings from 30m (current spacing) to 60m, in 10m increments. Figure 3-1 shows the data input of STANSHELL and Table 3-2 shows the output results. The arrangement box refers to the way the lights are installed on the roadway and is shown in table 5.1 AS/NZS1158.2 (reproduced in figure 3-2 below)

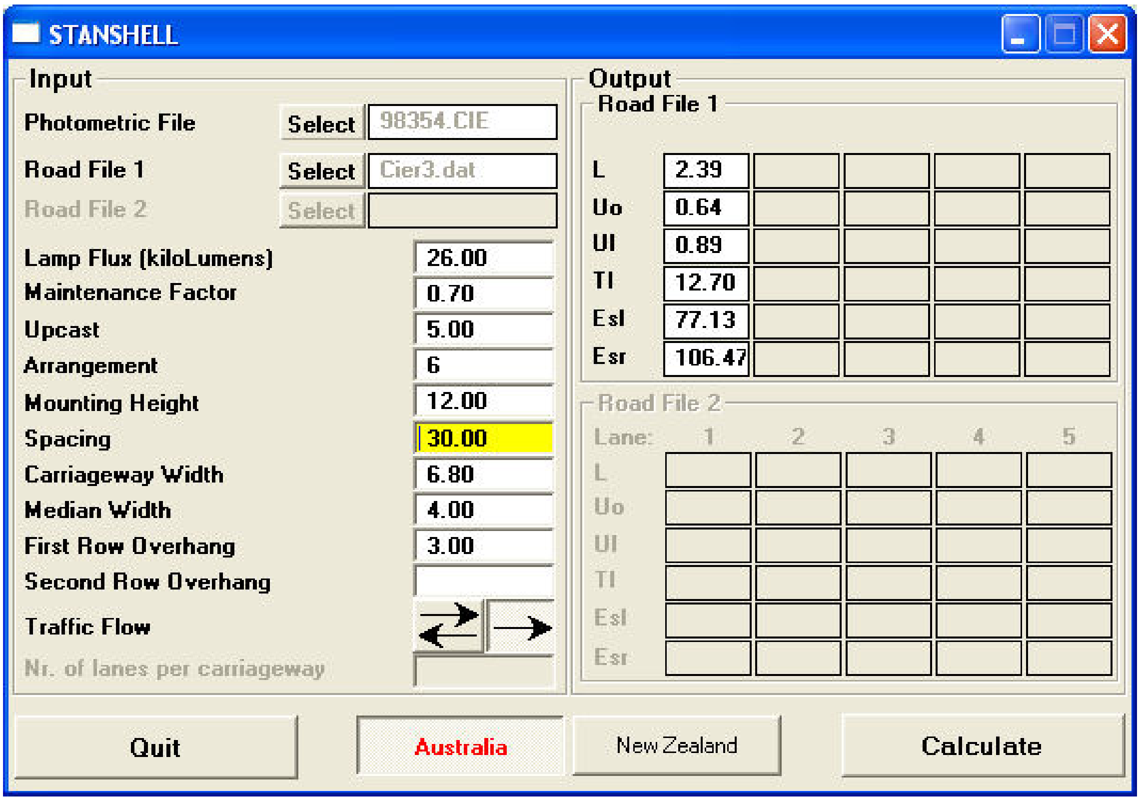


Figure 3-2 STANSHELL data calculation screen

Parameter	Required LTP for Cat V (table 2.2 AS/NZS 1158.1.1)	30m	40m	50m	60m
L	>=0.75	2.39	1.80	1.44	1.21
Uo	>=0.33	0.64	0.64	0.61	0.56
UL	>=0.5	0.89	0.88	0.89	0.74
TI	<=20	12.7	13.21	14.00	14.56
Esl	>=50	77.13	76.58	77.43	77.44
Esr	>=50	106.47	106.90	106.26	106.26

Table 3-2 LTPs for various luminaire spacings

The calculations show that for the current luminaires a spacing of at least 60m could be used and meet the LTPs for the V3 subcategory. As it was unclear what the maximum spacing was to be allowed using STANSHELL, a copy of Perfectlite Vcat lighting design software was utilised to determine the maximum spacings. Running the same parameters in Perfectlite yielded a maximum spacing of 80m.

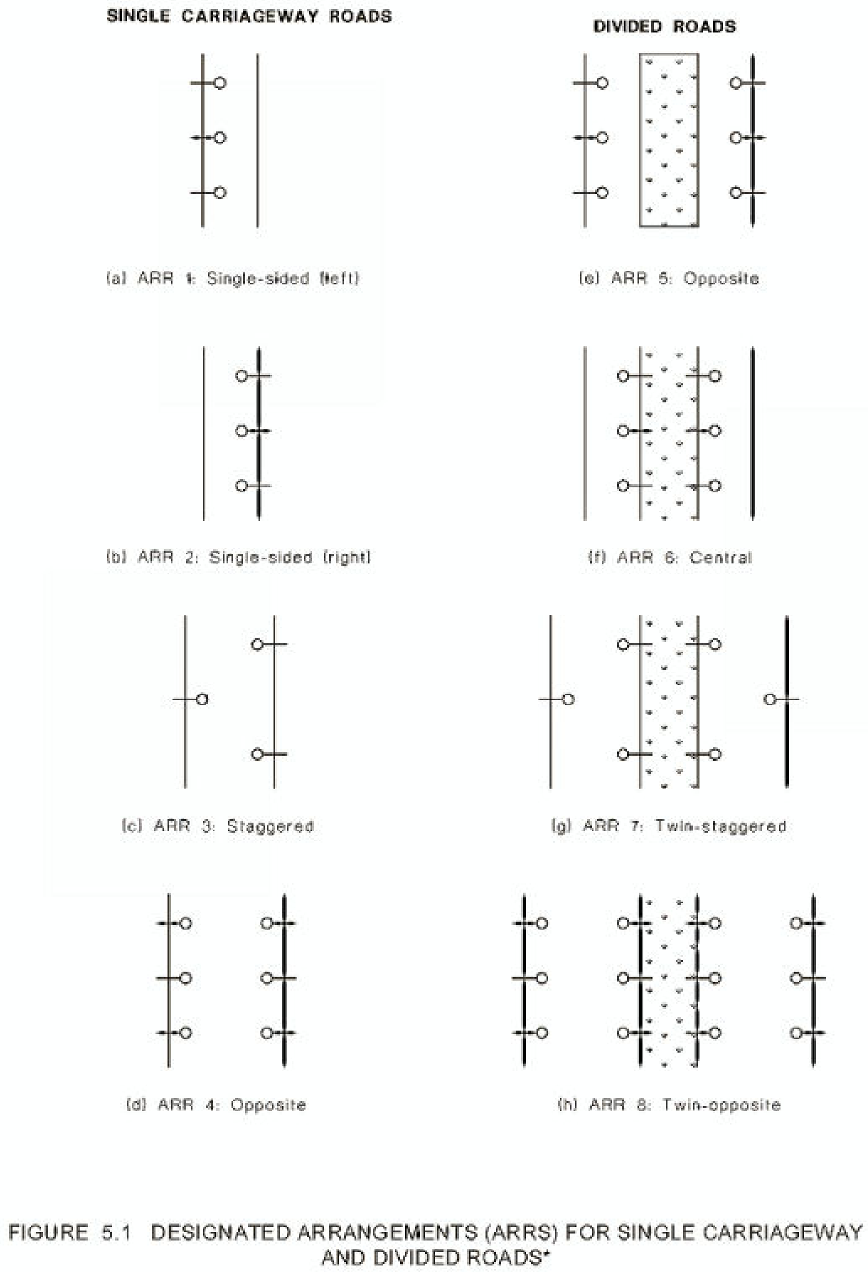


Figure 3-3 Luminaire arrangements AS/NZS 1158.2

3.5.2 Category P lighting zones

SAA STAN and the associated shell program STANSHELL cannot be used for determining Category P LTPs. An attempt was considered to model the area using a spreadsheet but an examination of the requirements of Section 3.3 of AS/NZS1158.2 made such an attempt unlikely to succeed. To model the lighting network on a straight section of road, the LTPs are calculated at each point of a grid. The grid has to be created between two adjacent luminaires (S) in the longitudinal direction and between the two property boundaries in the transverse direction (Figure 3-3).

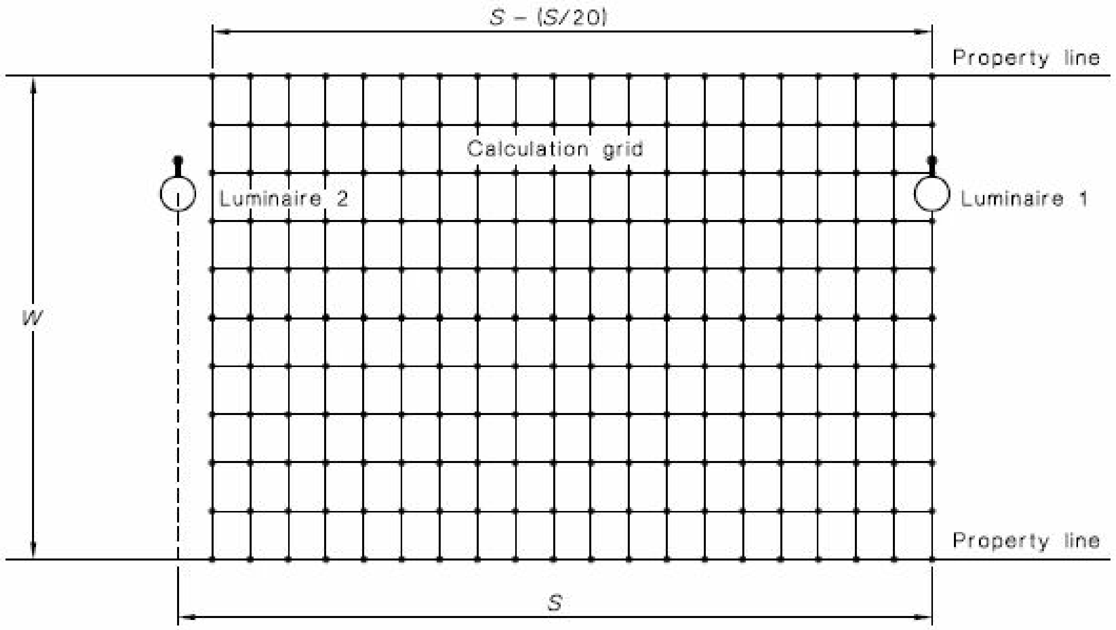


FIGURE 3.7 THE CALCULATION FIELD FOR THE CALCULATION OF ILLUMINANCE BASED LTPs FOR A STRAIGHT ROAD ELEMENT FOR CATEGORY P LIGHTING

Figure 3-4 Calculation field from Figure 3-7 AS/NZS1158.3.1

The spacing of the calculation points is not to be less than S/20 in the longitudinal direction and at least 11 points across the road reserve. This could require up to 44 points required to be assessed for a spacing of 80m. This was deemed to be impractical, and Perfectlite Pcat lighting design software was sourced for the analysis.

The Perfectlite Pcat software is similar to the Vcat software. The designer selects the photometric file that matches the lamp/luminaire combination and completes the data input screen (Figure 3-4) from information supplied by the luminaire and lamp manufacturer. The designer then completes the relevant details from the roads tab on the spacing table menu (Figure 3-5).

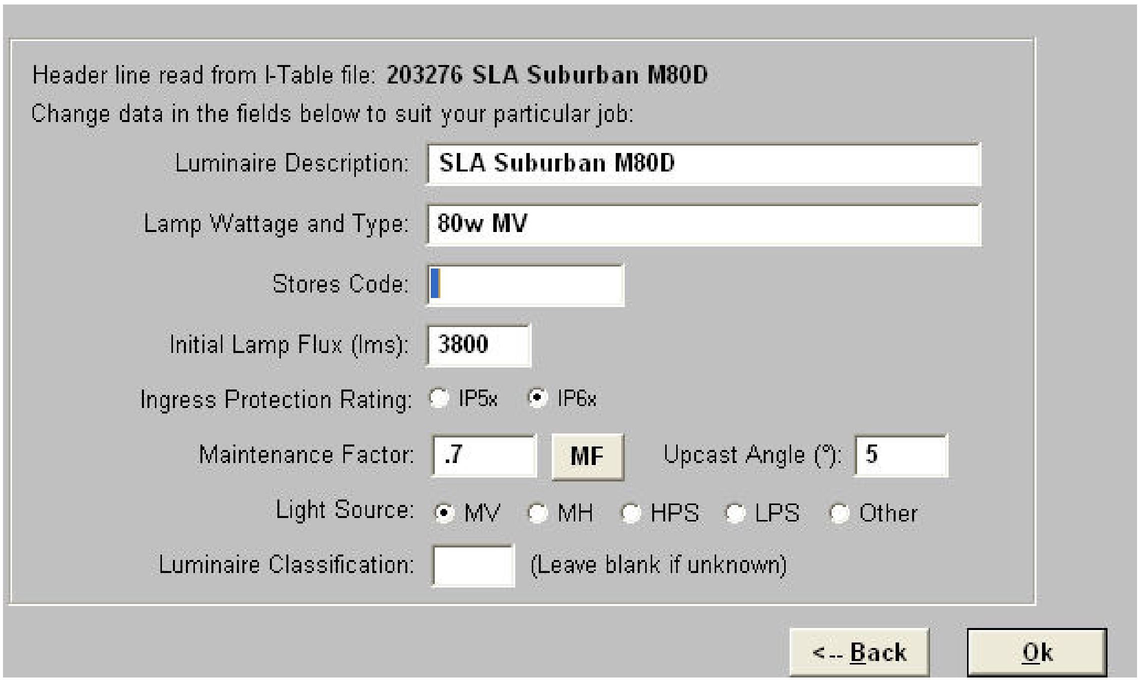


Figure 3-5 Lamp / luminaire data input screen

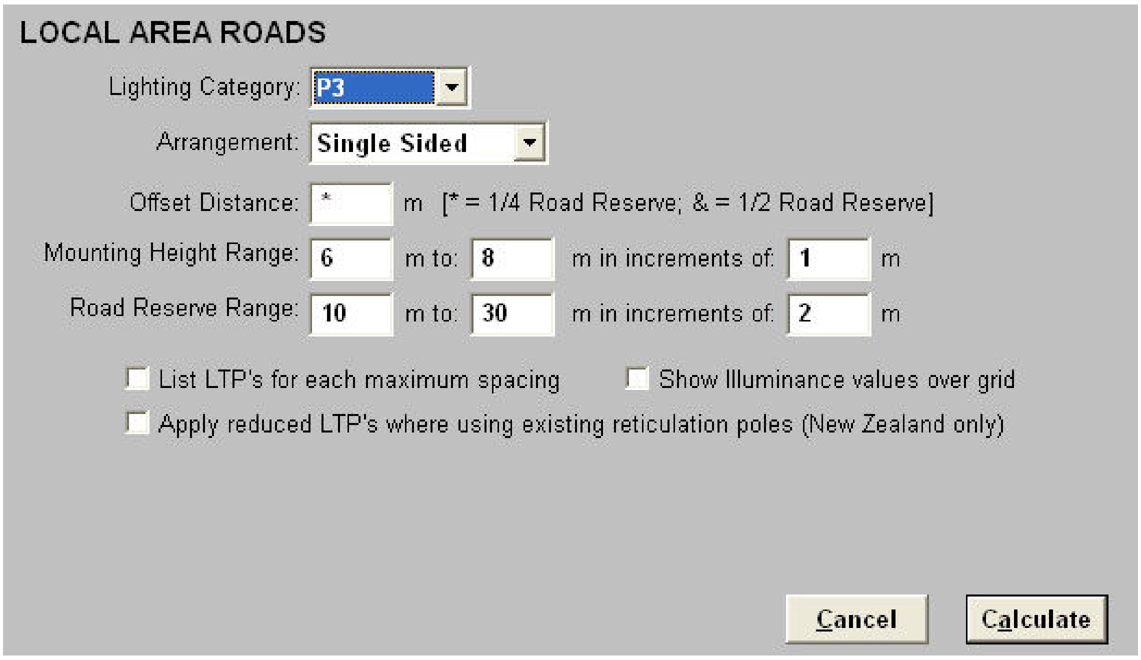


Figure 3-6 Roadway data screen

This will then calculate the LTPs for each combination of roadway width and luminaire height, and present the data in a table that specifies the required spacing.

For the model area it was decided to only model subcategory P1 and P2 areas using luminaires on a single side of the roadway, but P3 and P4 areas were modelled using single sided, staggered, and opposite luminaires as shown in figure 3-2 (above). As noted in section 3.2.1 of AS/NZS1158.3.1, subcategory P1 or P2 lighting is to be designed to only illuminate the pedestrian pathway, not the full width of the road reserve. However, many of the roads in the model area have paths on both sides of the road so the lighting design will be mirrored.

3.5.3 Category P Calculations

The category P zones were divided into 2 groups for modelling purposes. The first group contained roads that were predominately lit by 80W mercury vapour lamps usually mounted at 6m height on existing power poles. This group will be labelled PMV. The second group were those predominately lit by high pressure sodium lamps mounted on 12m poles. These areas are around the central business district of Castlemaine and have been placed in subcategory P2. This group will be labelled PHPS.

Table 3-3 lists the spacing required for the PMV group. The proposed configuration considers whether there is a path on both sides of the road. Luminaires at intersections with Cat V roads are included in the Cat V luminaire counts.

Road	Cat.	Width to be lit (m)	Configuration Proposed	Current Spacing (m)	Proposed Spacing (m)	Current No Luminaires	Proposed No Luminaires
Kennedy St	P2	3	Single	irregular	40	7	14
Campbell St	P3	30	Opposite	irregular	55	1	12
Campbell St	P4	30	Single	irregular	33	0	4
Templeton St	P2	5	Opposite	irregular	40	7	16
Templeton St	P4	30	Single	irregular	33	0	4
Mechanics Lane	P1	10	Single	40	14	1	5
Mostyn St	P2	5	Opposite	irregular	40	2	8
Lyttleton St	P2	5	Opposite	irregular	40	3	16
Lyttleton St	P3	30	Opposite	irregular	55	3	6
Frederick St	P1	10	Single	50	14	4	13
Hargraves St	P2	5	Opposite	irregular	40	3	12
Union St	P3	10	Single	irregular	53	1	1
Urquhart St	P4	30	Single	irregular	33	3	15
TOTAL						**35**	**126**

Table 3-3 PMV group luminaire spacing and numbers using MV lamps

Calculations show that subcategory P3 roads of 30m width cannot be lit to the Standard from a line of luminaires on a single side. The opposite configuration is the most effective solution in this situation. The spacings have been rounded to the nearest metre. Section 3.1.2 of AS/NZS1158:3.1 allow the actual spacing to exceed the design spacing by up to 10%. For this project the extra spacing of a luminaire by up to 0.5m is not considered significant. If the design was to be implemented an onsite inspection to determine the best luminaire location is likely to change the design spacings more significantly and Section 3.1.2 would need to be considered.

LTPs for the PHPS group have to be calculated slightly different to the PMV group. As these areas have HPS lamps, it is believed that the original lighting scheme designers intention was to light this area to the cat V standard, or what was applicable at the time of installation. However, as the area fits into the Cat P criteria, this was used for the analysis. Mostyn St has centre car parking with the luminaires mounted along the parking areas. It is doubtful if sufficient light would fall onto the footpath under the shop awnings to meet the standard, but the model was run using a road width of 15m to simulate the luminaire in the middle of the road. Hargraves St does not have centre of the road parking, and the existing luminaires are located opposite shops with awnings so the path should be able to be lit from one side. As per section 3.2.1 of AS/NZS1158.3.1, the full road width should not be lit to this level, however as the luminaires are in place it was decided to proceed with the modelling to determine if the lighting was up to the required Standard. The results are shown in table 3-4.

Road	Cat.	Width to be lit (m)	Configuration Proposed	Current Spacing (m)	Proposed Spacing (m)	Current No. Luminaires	Proposed No. Luminaires
Mostyn St	P2	15	Centre twin	70, 126	106	7	8
Hargraves St	P2	30	single	50 +/- 5m	53	6	6
Forest St	P2	30	single	75, 115	53	2	2

Table 3-4 PHPS group luminaire spacing and numbers

3.6 Calculation results

The modelling results indicate that the Category V areas are over illuminated and that replacing the existing 250W HPS lamp with 150W HPS lamps will meet the requirements set out in AS/NZS 1158.1.1. Category P lights in the areas currently illuminated by mercury vapour lamps (group PMV) are under illuminated and that additional luminaires are required to meet the requirements set out in AS/NZS 1158.3.1. Category P lights in areas that are currently illuminated by high pressure sodium lamps (group PHPS) vary. Hargraves Street meets the requirements of the Standard but the whole roadway is lit to the P2 category. This may be over lighting the roadway and creating a nuisance to the surrounding properties (section 2.5.3.4 AS/NZS1158.3.1), and further investigation is warranted. Mostyn St between Midland Highway and Hargraves St has a centrally 12m pole with 2 x 250W HPS luminaires mounted on it. This is nearly sufficient to comply with the Standard, but the shop awnings are likely to limit the effectiveness of the luminaire. Forest Street requires relocation of the existing luminaires to comply with the standard.

3.7 Energy efficient options

Many luminaire manufacturers are currently selling energy efficient luminaire / lamp combinations. The more common alternatives include T5 tube fluorescent lamps, low wattage high pressure sodium lamps, compact fluorescent lamps, and light emitting diodes. Many of these technologies have been used in Europe, and are now undergoing trials in various parts of Australia to determine their suitability. The Victorian Government produces a web site for energy efficiency that has a section devoted to public lighting (www.energy-toolbox.vic.gov.au/publiclighting/index). This site provides information on lighting that can be used to determine what technologies are appropriate for various lighting tasks. Below is a selection of lamp types and their relative merits.

Mercury vapour lamps have been around since the 1930's and have been successfully employed in the street light arena since that time. Mercury vapour lamps employ mercury as the primary light-producing element. They emit a white light with an efficiency of 55 lumens per watt (lm/W). The useful life of such a light is in the order of 12,000 hours or 2 years and 9 months based on 11 hours per day lit. These lamps are cheap, robust, reliable and pedestrian friendly as the white light gives a clear outline of objects. Their downside is that they possess a low efficiency rating, display rapid lumen depreciation and are not environmentally friendly on disposal due to the high amount of mercury present. Mercury vapour lights are used extensively in category P streets in Australia. However due to the above disadvantages of this type of luminaire their use in Europe and most of America has been discontinued. (www.energy-toolbox.vic.gov.au /publiclighting/index)

Metal halide lamps were first developed in the 1960s (www.greenhouse.gov.au, Department of the Environment and Heritage – Australian Greenhouse Office). Like mercury vapour lamps, they emit a crisp blue/white tone light. (www.greenhouse.gov.au/lgmodules/wep/streetlighting/training) Mercury is added to halide additives to create the light producing element. Their useful life is less than mercury vapour with only 8,000 hours but produce an efficiency of 80 lm/W. (Sylvania price list 2006). Although metal halide technology has been around for some 40 years, there isn't a significant number of luminaires installed in Australia. Europe and America installed metal halide luminaires as a replacement to the superseded mercury vapour luminaires. (www.energy-toolbox.vic.gov.au /publiclighting/index)

Metal halide lamps are not in common use mainly due to the initial higher costs for installation and lamp replacement costs. (www.energy-toolbox.vic.gov.au /publiclighting/index) The major advantage of metal halide lamps is their good colour rendering ability, due to their predominantly white light appearance and the enhanced efficiency of the luminaire. (www.energy-toolbox.vic.gov.au /publiclighting/index)

High Pressure Sodium lamps emit a golden yellow/orange colour light through the use of sodium vapour in a high pressure arc tube. These lights have a typical useful life of 14,000 hours and possess an efficiency rating of 100 lm/W. (www.energy-toolbox.vic.gov.au /publiclighting/index) The orange colour of the lamp is absorbed by foliage along a carriageway and not reflected making it harder to distinguish details. Due to their high efficiency but poor colour rendition index they are utilised on category V roads where the vehicular movement is considered the predominant movement along the carriageway. HPS lamps can be purchased with a double arc. These lamps have a second arc path which is only used as a backup to the first. Manufacturers claim a life of up to 50,000 hours can be expected. (Sylvania lighting fact sheet Lamp_136)

Light Emitting Diodes are a long life lamp. These lamps are relatively new to the market but they have very poor colour rendition - typically only 15 lumens/watt. (www.energy-toolbox.vic.gov.au /publiclighting/index) The low colour rendition means that these lamps are unlikely to replace proven street light lamps, but they are suitable for bollards and the like.

Incandescent street lamps are similar to normal household lamps. They have a poor efficiency standard and a relatively short operating life. (www.energy-toolbox.vic.gov.au /publiclighting/index) These two factors combined result in a high operating cost and as such are not commonly used for street lighting.

Fluorescent lights are available in either monophosphor lamp or as a triphosphor lamp. The mono and tri use either one or three coatings of phosphor on the inside of the lamp tube to provide visible light respectively. Triphosphor lamps are available in either compact or traditional tubular formation. Compact fluorescent (CF) technology has been used in public lighting, especially in solar public lighting applications. It offers reasonable price and good efficacy. However its short life means greater replacements. Their expected lamp life is about 8,000 hours. The newer triphosphor lamps are available in 42W lamps that have an equivalent efficiency of an 80W mercury vapour and exhibit good colour rendition.

(www.energy-toolbox.vic.gov.au /publiclighting/index).

It should be noted that the choice of ballast/ control gear can also make a significant difference to the efficiency of the luminaire. The choice depends upon the type of lamp to be controlled, but some gain in efficiency can be expected over older types.

Currently PowerCor does not include any of the energy efficient lamps in its schedule of standard services (www.powercor.com.au/customercharges/Pcor_SchedExcludSerCharges.pdf). If the lamp / luminaire is not included on the list of standard items, the annual operation, maintenance, and repair (OMR) charge is set at the maximum charge of $86.53 per luminaire. The OMR rate for an 80W MV lamp is $31.45. There is pressure being applied by State and Local Government to the power authorities to include such items on their schedule at a rate that reflects actual costs.

Discussions with Sylvania Lighting indicate that they are at an advanced stage of getting their 42W Lynx Compact Fluorescent lamps approved by PowerCor for inclusion onto the schedule of standard lamps. These lamps produce a similar output (3200 lm) to the existing 80W MV lamps (3800 lm) used in the majority of the

Category P areas, so the decision was made to model the test area with the Sylvania Suburban luminaire fitted with the 42W Lynx –TE compact fluorescent lamp.

3.7.1 Energy efficient lamp model

The Perfectlite model was run with the photometric data for the compact fluorescent lamp. The results are in table 3-5.

Road	Cat.	Width to be lit (m)	Config. Proposed	Current Spacing (m)	Proposed Spacing (m)	Current No Luminaires	Proposed No Luminaires
Kennedy St	P2	3	Single	irregular	33	7	16
Campbell St	P3	30	Opposite	irregular	47	1	14
Campbell St	P4	30	Opposite	irregular	65	0	4
Templeton St	P2	5	Opposite	irregular	30	7	20
Templeton St	P4	30	Opposite	irregular	65	0	4
Mechanics Lane	P1	10	Single	40	9	1	8
Mostyn St	P2	5	Opposite	irregular	30	2	12
Lyttleton St	P2	5	Opposite	irregular	30	3	20
Lyttleton St	P3	30	Opposite	irregular	47	3	8
Frederick St	P1	10	Single	50	9	4	16
Hargraves St	P2	5	Opposite	irregular	30	3	14
Union St	P3	10	Single	irregular	50	1	2
Urquhart St	P4	30	Opposite	irregular	65	3	16
TOTAL						**35**	**154**

Table 3-5 PMV group luminaire spacing and numbers using CF lamps

Due to the lower output of the Compact Fluorescent lamp, more luminaires need to be installed to produce the same level of light to comply with the Standard.

For roads that are currently lit by high pressure sodium lamps, there does not appear to be any better lamp currently available. (Table 5.1 AS/NZS1158.3.1, reproduced in figure 3-6)

TABLE 5.1

COMPARISON OF DISCHARGE LAMPS USED FOR CATEGORY V LIGHTING

1	2	3	4	5	6	7
Lamp type	Approx. average luminous efficacy (see Notes) (lm/W)	Typical average useful life (see Notes) (h)	Commonly used ratings W	Source appearance	Colour rendering	Comments
High pressure sodium vapour	100	14 000	100 150 250 400	Golden yellow	Fair/good	Most cost-effective light source due to high efficiency, long life and high lumen maintenance. Most widely used lamp for Category V lighting
High pressure mercury vapour (coated)	55	12 000	250 400 700	White	Good	Superseded by high pressure sodium. Now used mostly in extensions of existing installations
Low pressure sodium vapour	140	10 000	90 135 180	Monochromatic yellow	Poor	Not widely used in new installations mainly due to overall cost. Some road safety problems in vicinity of traffic signals. Use favoured near astronomical observatories
Metal halide	80	8 000	250 400	White	Excellent	Not favoured on overall economic grounds. Some variations in colour appearance may be observed between individual lamps. Used mainly in specialty installations

Figure 3-7 Lamp comparison from AS/NZS1158.3.1

As a comparison, the 250W lamps were changed in the Perfectlite Cat V model to recreate a 150W HPS installation. The maximum spacing derived was 45m. This was interesting as it could be feasible to replace the existing 250W luminaires with 150W items and save 100 watts per hour of energy for each luminaire. As the operation, maintenance, and replacement of Category V lights are a shared cost between Council and VicRoads, this point was noted for future discussions between the parties.

3.7.2 Cost Benefit Analysis – Category V zones

Under the Public Lighting Code issued by the Essential Services Commission, Victoria the Distributor (PowerCor) must inspect major road luminaires at least three times per year at night and replace or repair any defective items. They are also must replace luminaires at the end of their economical life. (Section 2.3.1, Public Lighting Code, Essential Services Commission, Victoria, 2005). These costs are built into the operation, maintenance, and repair (OMR) charges that PowerCor charges its Public Lighting customers. If a customer wishes to alter the lighting ahead of the proposed changeover date, then the distributor must allow the change but the cost will be borne by the customer. The replacement date for the majority of luminaires in the Category V zone is 2015. With this in mind the following analysis has been performed comparing the cost of replacing the existing 250W HPS Sylvania Roadster luminaires with 150W items in the same location. PowerCor charges $170.20 per a service truck to install a single luminaire. The replacement project would be quoted as a single job, but the total cost comprising 64 single charges for a total of $10,892 is included as an estimate. As there is no extra purchase cost involved in moving from the 250W HPS to the 150W HPS luminaire, PowerCor would consider not charging, or only applying a minimal charge for the capital upgrade. This would need to be discussed with them at the time of proposed changeover as the OMR charges that have been paid would contribute to the eventual replacement.

Lamp	Number of Luminaires	OMR charge per luminaire/annum(1)	Energy Consumption per hour (Wh)(2)	Luminaire life(3)	Luminaire Purchase cost(4)
250W HPS	64	$86.53	273	20	$496
150W HPS	64	$74.40	173	20	$496

Figure 3-8 Comparison of HPS lamps for Cat V areas

Notes
(1) PowerCor Standard Service Prices effective 6 March 2002, PowerCor, 2002
(2) Public Lighting Load Table, Essential Services Commission, Victoria, 2004
(3) Sylvania Lighting Australia reports that their current Roadster model luminaires have an expected life of twenty years.
(4) Sylvania Lighting Australia price list 2006

The OMR savings for the replacement of each luminaire is $12.13 per annum or $109.17 over the 9 years remaining life. This is only 22% of the purchase price of the replacement luminaire. From an asset management view there is no justification in replacing a luminaire that has nearly 50% of its expected life remaining. From energy saving and greenhouse gas abatement perspective there is a reason to alter the existing infrastructure ahead of the expected replacement date. Assuming the street lights are lit for 11 hours per night; the energy saved is 401kW per year which equates to 562kg of CO_2 not emitted per luminare. For the 64 luminaires the reduction in CO_2 is 36 tonnes per annum. The calculation is based on 1 MWh of electricity producing 1.44 tonne of CO_2. (Northern Alliance for Greenhouse Action (NAGA) Public lighting worksheet, www.energy-toolbox.vic.gov.au/publiclighting, 2005). Replacement of the luminaires would require that an elevated platform truck travel from Bendigo to Castlemaine each day for 4 days. This is a total trip of 320km for the task, consuming approximately 64 litres of fuel and producing 154kg of CO_2 emissions. (http://www.hcdoes.org/airquality/Anti-Idling/idle.htm, Hamilton County Environmental services, 2006). Replacement of the 250W luminaires would significantly decrease the amount of CO_2 emitted by electricity production by 34.8 tonnes or 36.6%. This meets the 30% reduction of CO_2 goal that CVGA has set for its members at a gross outlay of $42,637; however as the OMR charges for these luminaires are shared with VicRoads discussions would need to be held with them.

3.7.3 Cost Benefit Analysis – Category P zones

Item four of the Project specification states "Select the most viable sustainable public lighting options for Council considering whole of life costs of fixtures and luminaires, and compliance with AS1158." Item five states "Carry out a cost benefit analysis of the most viable sustainable public lighting options for the existing network, and the alterations to comply with AS1158 (if applicable)." It is apparent from the calculations performed in Section 3.5.3 that the existing Category P lighting network lit by MV lamps does not comply with the Standard, and so the calculation for item four of the project specification shall be to examine the benefits of immediately replacing the existing 80W mercury vapour luminaires with a similar 42W compact fluorescent luminaire.

The markings on the mercury vapour category P luminaires in the model area indicate that they were installed as a batch around 1991 (figure 3-8). This means they nominally have 5 years left in service before PowerCor would replace them as part of the OMR charge.

Figure 3-9 Existing Sylvania 80W MV luminaire manufactured in 1989

As there is a strong push by public lighting authorities to have energy efficient luminaires included in the standard service charges, a cost benefit analysis was performed looking at whether to replace the MV luminaires with energy efficient luminaires now or wait until the bulk changeover in 2011 assuming that the energy efficient items will have made it onto the standard service charge list. Table 3-6

Lamp	OMR charge per luminaire/annum(1)	Energy Consumption per hour (Wh)(2)	Luminaire life(3)	Lamp Life (hours) (4)	Luminaire Purchase cost(4)
80W MV	$31.45	95.8	20	12,000	$194
42W CFL	$86.53	50	20	8,000	$270

Table 3-6 Comparison of MV and CFL lamps for Cat P areas

Notes
(1) PowerCor Standard Service Prices effective 6 March 2002, PowerCor, 2002
(2) Public Lighting Load Table, Essential Services Commission, Victoria, 2004
(3) Sylvania Lighting Australia reports that the current installed MV luminaires have been superseded by the Suburban model luminaires and have an expected life of twenty years.
(4) Sylvania Lighting Australia price list 2006

Estimate to install 42W CFL luminaire	
Suburban CFL Luminaire purchase cost	$270.00
LESS	
75% of Suburban MV luminaire purchase cost	$145.50
Subtotal	$124.50
Installation cost	$170.20
Total Installation cost per 42W CFL luminaire	**$294.70**
Extra OMR per year	$55.08

Table 3-7 MV lamp replacement costs

The above table 3-7 is the expected cost to replace one Sylvania Suburban 80W MV luminaire with a Sylvania Suburban 42W CFL luminaire. As MASC has paid for 15 years of OMR on the existing luminaires, it is expected that PowerCor would deduct this money from any alternative replacement. Therefore 75% of the purchase price of a replacement MV luminaire should be deducted from an energy efficient replacement. As with the Cat V calculations, if MASC requires the luminaires to be changed over prior to the bulk changeover by PowerCor then an installation charge of no more than $170.20 will be charged for the work. As the CFL luminaires are not on the service charge list, an extra $55.08 over the $31.45 OMR charge needs to be budgeted for.

Currently there are 35 80W mercury vapour luminaires in the trail area. The total estimated replacement cost (assuming 5 years life remaining for the current luminaires) is $10,314. Extra OMR charges will be $1927.80 per annum.

For energy efficiency calculations, the 42W CFL is not listed on the Essential Services Commission's official public lighting load table, so the assumption was made that the listing for a standard 40W fluorescent lamp would be suitable for the calculations.

	80W	**42W**
Power used per luminaire (Wh)	95.8	50
Annual power usage (assuming 11 hours lit) kW	384.64	200.75
Total annual power usage for 35 no. 80W MV luminaires (kW)	13462.4	7026.25
Greenhouse gas produced (tonnes CO_2)	19.4	10.1
Total energy savings per annum for replacing 35 no. 80W luminaires (kW)		6436.15
Total greenhouse gas savings (tonnes CO_2)		9.3
Percentage reduction in greenhouse gas produced		48%

Table 3-8 CFL vs. MV lamp energy savings

This exceeds the proposed 30% reduction in greenhouse gas emissions CVGA expects of its members.

For the network to meet the Standard, an extra 28 luminaires will need to be installed, along with the relocation of 38 others. It was initially thought that more luminaires would be required, however re-examination of AS/NZS 1158.3.1 highlighted an error in the decision making process. This was trying to light the whole road to a P2 level, not just the pedestrian pathway. However, each new luminaire will cost approximately $1200 to install on an existing electricity supply pole and up to $10,000 if a new pole and cabling is required. Initial estimates are that 16 new poles will be required, and the remaining luminaires can be fitted to existing poles. The total estimated cost for this exercise is $174,000.

4.0 Discussion of Results

The purpose of this project is to determine if the lighting in a trial area of Castlemaine met the relevant Australian Standard, and if energy efficient lighting could replace the existing luminaires in a cost effective way. It was apparent early in the decision making process that the lighting subcategories are based on arbitrary decisions, and that the final design could well have been different if another designer looked at the initial zone qualifications. For instance, Mechanics Lane received a P1 zoning based on high “fear of crime”. In reality, this may only have needed a P2 rating, as the crime problem in Castlemaine is very low. Roads that were given “high” pedestrian counts actually have low numbers when compared to major centres, and so may have rated a P3 zoning instead of the higher P2. The descriptions for Category V zones are more precise, however discussions late in the project with Highway engineers indicates that subcategory V4 is usually sufficient in urban areas instead of the V3 the Standard proposes.

While the use of the Perfectlite software and MapInfo GIS would have made such changes relatively easy to calculate, it was felt that the original decision represents the worst case scenario and as such it will be a valid report for the Mount Alexander Shire Council to consider.

5.0 Conclusion

The divided highways that pass through the Castlemaine CBD test area are over lit when compared with the Category V3 lighting technical parameters from AS/NZS1158.1.3. The 250W high pressure sodium lamps that are installed are currently the most efficient type available for this purpose, but calculations indicate that a reduction to 150W HPS lamps will achieve the required level of lighting and reduce the energy required by 36%. While this would allow Council to meet the greenhouse gas reduction targets set by the Central Victorian Greenhouse Alliance (CVGA), the capital outlay required of $42,637 is well above the budget allocated for new works. Council should consider entering into discussions with VicRoads to determine their policy on such alterations, and commit to altering the luminaires by 2010.

The areas nominated Category P are under lit when compared to the lighting technical parameters that were allocated to the zones chosen. The zones selected are derived from tables in AS/NZS1158.3.1 but the decision is left to the designer to allocate what is thought to be correct. While further work should be carried out to validate the assumptions made in deciding the zones, the cost required to bring the area up to the chosen level is $174,000. As the standard AS/NZS1158 is an advisory standard only, it is recommended that no substantial extension to the network is made to comply with the standard, but any minor extension to the existing lighting network be in accordance with the standard. It is also noted that CVGA and other similar bodies are attempting to have energy efficient luminaires included in PowerCor's list of standard luminaires. It is recommended that Council commits to replacing all existing 80W mercury vapour lamps with energy efficient items by 2010 as part of the expected bulk replacement due in 2011 by PowerCor, and any new luminaires installed until then be an energy efficient item.

6.0 REFERENCES

1. Australian Bureau of Statistics, (1991) *Year Book 2003 - Population Distribution*
2. Australian/New Zealand Standard 2005, *Road lighting: Part 0: Introduction. AS/NZ 1158.0:2005,* Sydney, Standards Australia.
3. Australian/New Zealand Standard 2005, *Road lighting: Part 1.1: Vehicular traffic (Category V) lighting - Performance and installation design requirements, AS/NZS 1158.1.1:2005,* Sydney, Standards Australia.
4. Australian/New Zealand Standard 2005, *Road lighting: Part 3.1: Pedestrian area (Category P) lighting - Performance and installation design requirements AS/NZS 1158.3.1:2005,* Sydney, Standards Australia.
5. Australian/ New Zealand Standard 2005, Lighting for roads and public spaces*: Part 2 Computer procedures for the calculation of lighting technical parameters for Category V and Category P lighting. AS/NZS 1158.2:2005*, Sydney, Standards Australia.
6. Australian/New Zealand Standard 1997, Road lighting: *Part 1.3: Vehicular traffic (Category V) lighting - Guide to design, installation, operation and maintenance, AS/NZ 1158.1.3:1997*, Sydney, Standards Australia
7. Australian/New Zealand Standard 2004, Lighting for roads and public spaces: Part 6: Luminaires, AS/NZ 1158.6:2004, Sydney, Standards Australia.
8. Local Government Energy Toolbox viewed on 15 May 2006 www.energy-toolbox.vic.gov.au/publiclighting
9. Mount Alexander Shire Council Annual Report 2005-06 (September 2006)
10. Sylvania Fixtures 2005/2006 - Technical Information
11. Sylvania Lighting Price List 2006

7.0 BIBLIOGRAPHY

1. Australian Standard 2005, Lighting for roads and public spaces, part 4- Supplementary Lighting at Pedestrian Crossings*, AS/NZS 1158.4:2005,* Homebush, Standards Australia
2. City of Melbourne. *Lighting Strategy (2002).* City of Melbourne
3. Cost Effectiveness of Suburban Street Lighting (January 2006), Jason Fowler, USQ.
4. Guidance Notes for the Reduction of Light Pollution (The Institution of Lighting Engineers, Rugby, United Kingdom, 2003)
5. Highway Engineering Handbook (Brockenbrough, Boedecker, 1996)
6. Highway Engineering in Australia (Klemzig, various dates)
7. http://www.greenhouse.gov.au/local/ (Australian Government, viewed 24 May 2006)
8. Municipal Engineering in Australia (Klemzig, various dates)
9. Outdoor Lighting Pattern Book (Leslie & Rodgers, 1996).
10. Roadway Lighting (Austroads, 2004)

8.0 APPENDICES

Appendix A: Project Specification

Appendix B: Maps of the area

Appendix C: Review and Analysis of the 2001 Western Power and City of Bunbury Service Agreement

Appendix D: City of Bunbury Owned Street Lighting Network Asset Data (Data Collected by OPUS International Consulting Firm)

Appendix E: Western Power Tariff and Street Lighting Asset Data

Appendix F:

APPENDIX A:

PROJECT SPECIFICATION

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/2 Research Project
PROJECT SPECIFICATION

For: **RICKY LUKE**

Topic: Cost Effectiveness of Suburban Street Lighting in the Castlemaine CBD

Supervisors: Dr. R Merrifield, Dr. Sanithikumar
M Kenealy – Mount Alexander Shire

Aim: The aim of the project is to assess Councils current lighting stock against the relevant Australian Standard and to suggest improvements that considers whole of life costs and sustainability issues.

Sponsorship: Mount Alexander Shire Council

PROGRAM: Issue 'A' 7th April 2006

1. Determine suitable study area that encompasses late night pedestrian utilisation, open space, residential areas, and major roads. Define usage zones. 3.1

2. Review AS1158 "Lighting for Roads and Public Spaces" and determine what standard is appropriate for each zone. 3.2

3. Develop an inventory of Council's current public lighting stock, and prepare location map, highlighting deficiencies against AS1158. 3.3

4. Select the most viable sustainable public lighting options for Council considering whole of life costs of fixtures and luminaires, and compliance with AS1158. 3.4, 3.5,

5. Carry out a cost benefit analysis of the most viable sustainable public lighting options for the existing network, and the alterations to comply with AS1158 (if applicable).

AGREED

Ricky Luke	R Merrifield
7/4/2006	/ /

APPENDIX B:

Maps of the model area

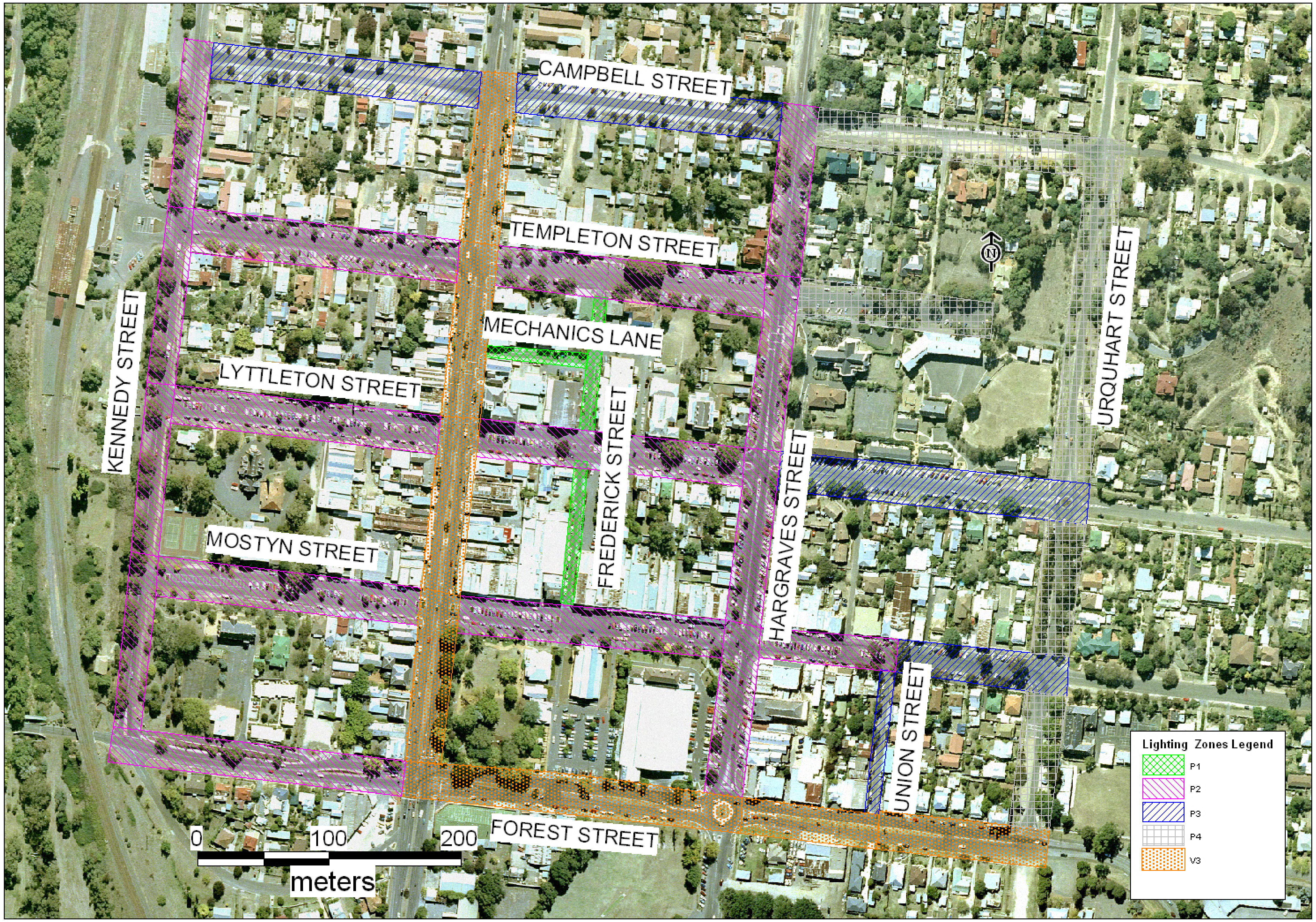


Figure B-1Lighting zones

Figure B-2 Existing Luminaires

APPENDIX C:

Sample Perfectlite output sheets

```
@B                   P Category Lighting - AS/NZS 1158.3.1-2005
@B                   ******************************************
 @B      Road Lighting Workshop / Training Course - Student Edition
@B           ----------------------------------------------------------
I-table Filename: C:\Program Files\Perfect lite\Workshop\98370.CIE
    Luminaire Description: 98370 ROADSTER S150C
     Lamp Wattage & Type: 150w HPS
       Initial Lamp Flux: 14500 lms
      Maintenance Factor: 0.7
             Stores Code:
            Upcast Angle: 5 degrees
             Arrangement: Single Side
         Offset Distance: 1/4 Road Reserve
Upward Waste Light Ratio: 1.7 %
            Light Source: HPS - High Pressure Sodium
Luminaire Classification: Not specified

@B       Lighting Category: P2 (Local Area Roads - Tables 2.1 & 2.6)

    Illuminance Criteria:  Minimum Illuminance (Eph) >= 0.70 lux
    (Maintained values)    Average Illuminance (Eav) >= 3.50 lux
                         Illuminance Uniformity (Up) <= 10.0

        Calculation Grid: 20 x 11 points - Figure 3.7 of AS/NZS1158.2

@B Mounting     Maximum Spacing at different
@B Height         Road Reserve Widths
         10.0  15.0  20.0  25.0  30.0
      +-------------------------------+
  6.0 |  53.2  49.7  45.1  22.2    -  |
  7.0 |  58.3  54.2  49.9  31.0    -  |
```

```
  8.0 |  62.1  58.3  54.7  48.4   4.8 |
  9.0 |  65.6  63.0  60.5  55.9  24.5 |
 10.0 |  70.6  68.4  66.0  61.7  37.2 |
 11.0 |  75.5  73.5  70.7  62.3  45.1 |
 12.0 |  80.2  75.5  67.4  59.9  53.1 |
      +-------------------------------+
```

Value/s in above table are all in metres.

The table contains maximum spacings which, for the specified luminaire and lamp combination, provide compliance with the light technical parameters (LTPs) of Table 2.6 of AS/NZS 1158.3.1-2005.

@IPlePcat - Vers 3.00 (Built: 19/9/05)   Run: 29/10/2006 at 15:30:59

@B P Category Lighting - AS/NZS 1158.3.1-2005

**@B **

@B Road Lighting Workshop / Training Course - Student Edition

@B ---

I-table Filename: C:\Program Files\Perfect Lite\Workshop\203276.CIE

Luminaire Description: SLA Suburban M80D

Lamp Wattage & Type: 80w MV

Initial Lamp Flux: 3800 lms

Maintenance Factor: 0.7

Stores Code:

Upcast Angle: 5 degrees

Arrangement: Single Side

Offset Distance: 1/4 Road Reserve

Upward Waste Light Ratio: 5.4 %

Light Source: MV - Mercury Vapour

Luminaire Classification: Not specified

@B Lighting Category: P2 (Local Area Roads - Tables 2.1 & 2.6)

Illuminance Criteria: Minimum Illuminance (Eph) >= 0.70 lux

(Maintained values) Average Illuminance (Eav) >= 3.50 lux

Illuminance Uniformity (Up) <= 10.0

Calculation Grid: 20 x 11 points - Figure 3.7 of AS/NZS1158.2

```
@B Mounting                Maximum Spacing at different
@B Height                       Road Reserve Widths
@B --------                ----------------------------

          3.0   5.0   7.0   9.0  11.0  13.0  15.0
      +--------------------------------------------+
  6.0 |  41.3  39.2  35.8  32.5  29.5  26.7  24.2 |
  7.0 |  36.6  34.3  31.6  29.1  26.6  24.2  22.1 |
  8.0 |  31.8  30.1  28.0  25.9  23.8  21.7  19.8 |
  9.0 |  27.7  26.4  24.7  22.9  21.0  19.2  17.4 |
      +--------------------------------------------+

  Value/s in above table are all in metres.
  The table contains maximum spacings which, for the specified
luminaire
  and lamp combination, provide compliance with the light technical
  parameters (LTPs) of Table 2.6 of AS/NZS 1158.3.1-2005.



----------------------------------------------------------------------
-----
@IPlePcat - Vers 3.00 (Built: 19/9/05)          Run: 29/10/2006 at
14:22:50
```

APPENDIX D:

Sylvania Lighting Data Sheets

Bright White Standard Mercury

Universal use mercury vapour discharge lamps, combining good efficacy and long life.

Features

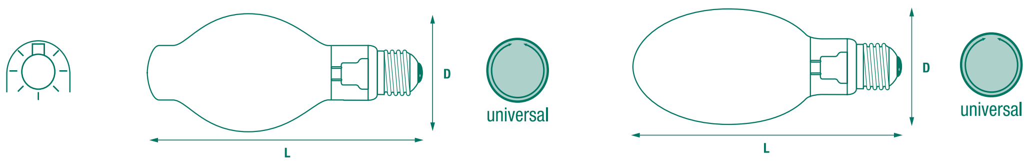
- Colour rendering (Ra 42)
- Operates on simple choke circuits
- Excellent starting characteristics
- Rugged construction to withstand shocks and vibration
- Efficacies: up to 60 lm/W
- Envelope shape/finish: elliptical/coated
- Average rated life: up to 29000 hours

Applications

- Road lighting
- Dock, rail-yard and industrial lighting
- Park and garden lighting

Directions For Use

- Burning position: universal
- Technical data: p. 146
- Circuit diagrams: p. 155 N° 1



Item description	Watt	Volt	Current	Cap	Dimensions (mm) L	Dimensions (mm) D	Bulb finish	Colour temp. temp. K	Light output lm	Packing Quantity	Ordering Code
HSL-BW 50W E27	50	95	0.61	E27	130	56	coated	4000	1800	40	645001
HSL-BW 80W E27	80	115	0.80	E27	166	71	coated	4000	3800	40	645002
HSL-BW 80W B22-3 PIN	80	115	0.80	B22d-3	166	71	coated	4000	3800	40	620518
H38AV-100DX	100	130	0.85	E26	138	54	coated	4000	8400	20	679670
HSL-BW 125W E27	125	125	1.15	E27	178	76	coated	4000	6300	40	654600
HSL-BW 125W B22-3 PIN	125	125	1.15	B22d-3	178	76	coated	4000	6300	40	204470
H37KC-175DX	175	130	1.55	E39	211	90	coated	4000	8400	6	688090
HSL-BW 250W E40	250	130	2.13	E40	228	91	coated	4000	13000	12	645003
HSL-BW 400W E40	400	135	3.25	E40	292	122	coated	3800	22000	12	654822
HSL-BW 700W E40	700	140	5.40	E40	357	152	coated	4000	40000	6	645004
H34GW-1000DX	1000	135	8.00	E39	391	178	coated	4000	55000	6	692720
H36GW-1000DX	1000	265	4.00	E39	391	178	coated	4000	60500	6	693180

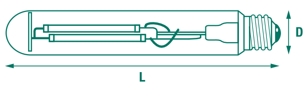
SHP & SHP-T Standby

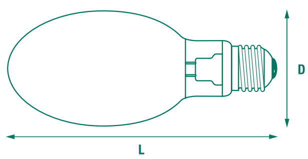
Standard high-pressure sodium lamps with a double arc tube, guaranteeing immediate re-strike after a power cut and doubling lamp life.

Features
- Double arc tube lamp
- Standby arc tube restarts immediately after mains failure
- Improved lumen maintenance throughout life
- Average rated life: up to 55000 hours

Applications
- Where access and maintenance is difficult or expensive
- Security floodlighting at airports, military installations, sports arenas, tunnels,
  harbours and industrial sites
- Street lighting

Directions For Use
- Burning position: universal
- Equipped with standard high pressure sodium arc tubes
- Technical data: p. 146
- Circuit diagrams: p. 155 N° 2/5





Item description	Watt	Volt	Current	Cap	Dimensions (mm) L	Dimensions (mm) D	Bulb finish	Colour temp. temp. K	Light output lm	Packing Quantity	Ordering Code
Elliptical coated											
SHP 70W SBY	70	90	0.98	E27	165	72	coated	2050	5800	40	673270
SHP 150W SBY	150	100	1.8	E40	227	91	coated	2050	14000	12	673132
SHP 250W SBY	250	100	3.0	E40	227	91	coated	2050	26000	12	672065
SHP 400W SBY	400	105	4.45	E40	292	122	coated	2050	47000	12	672030
Tubular clear											
SHP-T 150W SBY	150	100	1.8	E40	211	48	clear	2050	14500	12	673135
SHP-T 250W SBY	250	100	3.0	E40	260	48	clear	2050	28000	12	673138
SHP-T 400W SBY	392	100	4.6	E40	292	48	clear	2050	48000	12	672035
LU1000WSBY	1000	250	4.70	E39	383	80	clear	2050	130000	6	675430

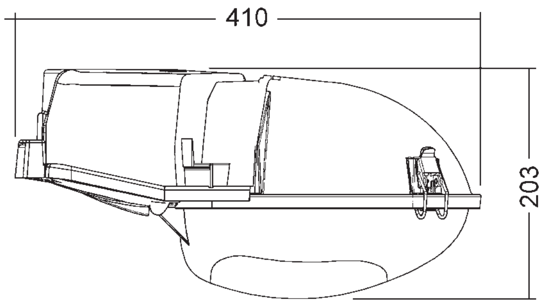
Suburban

Building upon the success of the Urban Series, the Suburban delivers superior optical performance, which is supported by a precision, high pressure die-cast body and optical assembly complying with AS1158-1 Category P and AS1158.6 / AS3771 road lighting requirements. The high performance aluminium reflector system incorporates a house side reflector which dramatically reduces the obtrusive lighting behind the Suburban. Combined with the injection moulded acrylic visor, the Suburban produces a typical light distribution pattern for precise street lighting requirements for lamps up to 70W High Pressure Sodium, Metal Halide and 42W Compact Fluorescent.

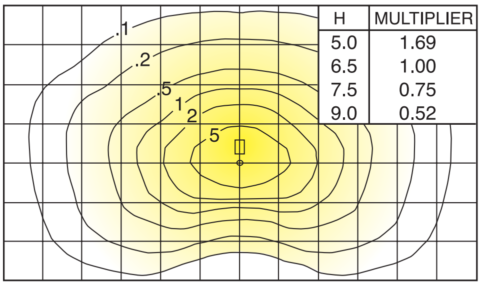
The HPF, 240V/250V control gear is mounted direct to the body chamber or on a removable gear cassette, as required, which is easily accessed by removing the top cover assembly. The cover is 100% compatible with the Urban and is uniquely retained by four patented non corrosive, quick release retention clips, which are of course captive to the cover assembly.

Both the lantern head and gear chamber form two discrete weatherproof compartments IP64 Optical, IP24 Gear. The visor which is sealed by a silicon gasket is retained by two secure, stainless steel toggles. Photo electric cell control is available in D2. Fixing mounting is via a 34mm O.D. spigot assembly.

Applications
Category P Minor Road, Security areas, Pathways, Car Parks, Conveyor, Catwalk lighting.



Suburban 80MV
H = 6.5m U = 5



H	MULTIPLIER
5.0	1.69
6.5	1.00
7.5	0.75
9.0	0.52

SLA Cat No.	Type	Lamp	Mass
Suburban/50MV	Mercury Vapour	HSL BW 80	3.6kg
Suburban/80MV	Mercury Vapour	HSL BW 80	3.7kg
Suburban/50HPS	High Pressure Sodium	SHP 50/CO/I	4.0kg
Suburban/70HPS	High Pressure Sodium	SHP 70/CO/I	4.2kg
Suburban/70MA	Metal Halide	M70/CO/U	4.2kg
Suburban/42CFL	Compact Fluorescent	Lynx-TE	4.2kg

Roadster Series

The Roadster series caters specifically for 100/150/250/400 watt clear sodium lamp sources and 250 watt Mercury Vapour coated lamps complying with AS1158-1 Category V and AS1158.6 / AS3771, main road requirements. Metal Halide 100/150/250 watt clear and coated lamp sources are available combined with standard IR control gear.

The Roadster comprises of two main components, namely:

- The pressure die-cast single body providing for mounting capability via a single spigot mount.
- Integral HPF 240V/250V control gear, which is serviced via the rear cover assembly.

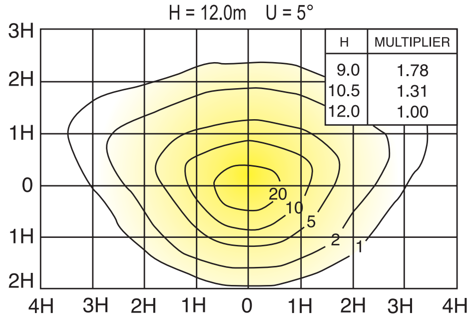
Mounting spigots are available up to 60mm maximum, 48mm standard. The Roadster complies with IP66 for the optical chamber and IP24 for the gear chamber. For areas requiring extra control or limits to upward light effects, an aeroscreen flat glass is available.

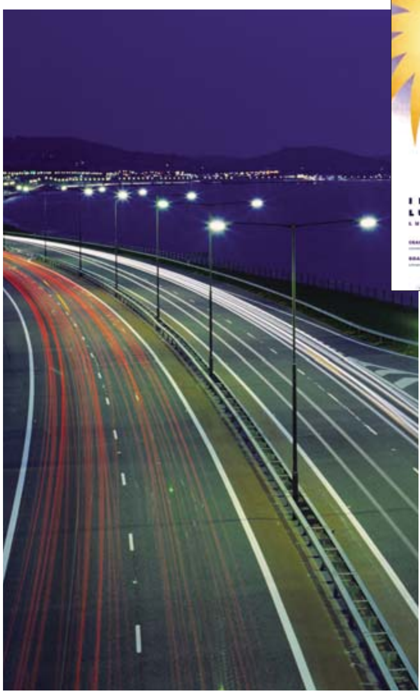
Applications
Category V major road, Freeway and interchange lighting, Car park and Security areas.

STANDARD CONFIGURATION

AEROSCREEN CONFIGURATION

Roadster 250HPS Coated
H = 12.0m U = 5°





SLA Cat No.	Type	Lamp	Mass
Roadster 250MV	Mercury Vapour	HSLBW 250	10.0kg
Roadster 100HPS	High Pressure Sodium	SHPT 100	10.0kg
Roadster 150HPS	High Pressure Sodium	SHPT 150	10.0kg
Roadster 250HPS	High Pressure Sodium	SHPT 250	10.5kg
Roadster 400HPS	High Pressure Sodium	SHPT 400	12.0kg
Roadster 150MA	Metal Halide	M 150/CO/U	10.0kg
Roadster 250MH	Metal Halide	HSIT SX 250	10.5kg

Options 1. Diffuse lamp configuration available.
2. For Aeroscreen specify 'AERO'.
3. 60mm diameter.

Sylvania Road Lighting
Photometric Index

Roadway / Security

File No.	Luminaire		Lamp
98358	Roadster S100C	SCO	SHP-TS100
98385	Roadster S100CA	AERO	SHP-TS100
98370	Roadster S150C	SCO	SHP-T150
99184	Roadster S150C FT	SCO	SHP-T150 (Forward Throw)
98373	Roadster S150CA	AERO	SHP-T150
202200	Roadster S150C + GS	SCO	SHP-T150 (Glare Shield)
98354	Roadster S250C	SCO	SHP-T250
99188	Roadster S250C FT	SCO	SHP-T250 (Forward Throw)
98376	Roadster S250CA	AERO	SHP-T250
200178	Roadster S250C + GS	SCO	SHP-T250 (Glare Shield)
98382	Roadster S400C	SCO	SHP-T400
98379	Roadster S400CA	AERO	SHP-T400
200179	Roadster S400C + GS	SCO	SHP-T400 (Glare Shield)
98347	Roadster M250D	SCO	HSL-BW250
201016	Roadster MH150D	SCO	MP150/CO/U 3K
201017	Roadster MH150DA	AERO	MP150/CO/U 3K
200016	Roadster MH250C	SCO	HSI-TSX250 or HSI-THX250
201022	Roadster MH250CA	AERO	HSI-TSX250 or HSI-THX250
201023	Roadster MH400CA	AERO	HSI-TSX400 or HSI-THX400
204004A	Suburban M50D	SCO	HSL-BW50
203276	Suburban M80D	SCO	HSL-BW80
203352A	Suburban S50D	SCO	SHP50/CO
203352	Suburban S70D	SCO	SHP70/CO
204004	Suburban MH75D	SCO	MP75/CO/U 3K
203306	Suburban CF42W	SCO	Lynx-CFTE 42W
201076	Urban M50D	SCO	HSL-BW50
95638	Urban M50DA	AERO	HSL-BW50
201045	Urban M80D	SCO	HSL-BW80
95635	Urban M80DA	AERO	HSL-BW80
203084	Urban M80D + GS	SCO + Glare Shield	HSL-BW80
95625	Urban M125D	SCO	HSL-BW125
95639	Urban M125DA	AERO	HSL-BW125
201145A	Urban S50D	SCO	SHP50/CO
95633A	Urban S50DA	AERO	SHP50/CO
201145	Urban S70D	SCO	SHP70/CO
95633	Urban S70DA	AERO	SHP70/CO
95641	Urban S100D	SCO	SHP-S100
95640	Urban S100DA	AERO	SHP-S100
95651	Urban ULX150CL	SCO	ULX150/CL
97526	Urban S100C HZL	SCO	SHP-TS100
201303A	Urban MH75D	SCO	MP75/CO/U 3K
201307A	Urban MH75DA	AERO	MP75/CO/U 3K
201303	Urban MH100D	SCO	MP100/CO/U 3K
201307	Urban MH100DA	AERO	MP100/CO/U 3K

APPENDIX E:

PowerCor Pricing schedules

Standard Service Prices

(GST inclusive)

Effective 6 March 2002

The following prices apply throughout the area served by Powercor Australia. After hours rates will apply for work performed outside of normal Powercor Australia business hours which includes weekends and public holidays. Charges for work performed after hours include award overtime and call back provisions. When a charge is recorded as recoverable works ("RW"), RW rates and award penalty rates apply. Major works on large commercial or industrial installations, blocks of flats, and CT operated metering are charged at recoverable work rates and award penalty rates apply. All listed prices have been approved by the Essential Services Commission.

	Normal Hours GST Inclusive	Product Code	After Hours GST Inclusive	Product Code
Connection				
New Premises – Residential [a]	$ 186.69	DCFE	$ 362.69	DCAH
New Premises – Non Residential	$ 274.57	BCFE	$ 395.57	BCAH
Existing Premises – Reconnection	$ 21.97	CTFE	$ 159.47	CTAH
Existing Premises – Customer Transfer	$ 21.97	CTFE	$ 159.47	CTAH
[a] Also applies to a Builders Supply Permanent Domestic Location (Partial Supply) and any Builders Supply Pole				
Field Office Visit				
Reconnect After Disconnection for Non Payment	$ 49.44	RECF	$ 159.45	AHRF
Adjust Time Switch – Tariff Change	$ 21.97	TSA	NA	
Fuse Removal/Insertion for Electrical Contractor Per Visit	$ 21.97	510025	$ 159.47	510026
Special Reader Visit	$ 21.97	FCFE	$ 159.47	SRAH
Underground Cable Location	$ 60.42	510027	$ 296.92	510028
Service Truck Visit				
Service Truck Visit	$ 170.20	510031	$ 340.70	510032
Wasted Service Truck Visit	$ 142.75	STV	$ 142.75	STV
Low Voltage Meter Conversion				
Low Voltage Meter Conversion – To Winner (New Installation)	$ 285.99	CONW	NA	WAHN
Low Voltage Meter Conversion – To Winner (Existing Installation)	$ 516.69	WBHE	$ 879.69	WAHE
Low Voltage Meter Conversion – To Time of Use (Existing Installation)	$ 676.13	TBHE	$ 1,017.13	TAHE
Installation of 5 Day Electric Time Switch	$ 313.24	TSBH	$ 362.74	TSAH
Meter Equipment Test				
Single Phase	$ 170.12	MT1P	NA	
Single Phase – Each Additional Meter	$ 65.81	MA1P	NA	
Multi Phase	$ 252.51	MTMP	NA	
Multi Phase – Each Additional Meter	$ 87.73	MAMP	NA	
Provision of Switching Service	$ 53.55	SS	RW	
Provision of Service Fuses				
160A 4 Pole	$ 404.67	510036	RW	
400A 3 Pole	$ 758.87	510037	RW	
400A 4 Pole	$ 885.37	510038	RW	
Hinged Fuses: 300A Group of 3	$ 417.74	Not Used	RW	

Issued by Manager Regulation & Pricing

Elective Underground Servicing				
Supply up to 100A (Existing Installation) [b]	$ 572.57	Not Used	RW	
Supply between 100A – 197A (Existing Installation) [b]	$ 707.83	Not Used	RW	
[b] Excludes all civil works, reinstatement, cable and conduits.				
Temporary Cover				
Temporary Cover of LV Mains – 2 Wire Cover	$ 461.26	510044	$ 648.26	510045
Material Rental for Additional Month – 2 Wire Cover	$ 38.50	Not Used	NA	
Temporary Cover of LV Mains – All Wire Cover	$ 626.02	510046	$ 879.02	510047
Material Rental for Additional Month – All Wire Cover	$82.50	Not Used	NA	
Temporary Cover for LV Mains – Service Cable	$ 296.51	510048	$ 417.51	510049
Material Rental for Additional Month – Service Cable	$ 9.90	Not Used	NA	
Meter Provision				
Existing Premise – Single Phase 1 Element Type 5 Meter (installation charge)	$ 120.42	MI1E	NA	
(annual meter charge)	$ 50.00	MA1E	NA	
Existing Premise – Single Phase 2 Element Type 5 Meter (installation charge)	$ 131.31	MI2E	NA	
(annual meter charge)	$ 67.39	MA2E	NA	
Existing Premise – 3 Phase Direct Connected Type 5 Meter (installation charge)	$ 175.26	MI3E	NA	
(annual meter charge)	$ 118.65	MA3E	NA	
Existing Premise – 3 Phase CT connected Type 5 Meter (installation charge)	$ 171.99	MICE	NA	
(annual meter charge)	$ 157.18	MACE	NA	
New Premise – Single Phase 1 Element Type 5 Meter (installation charge)	NA		NA	
(annual meter charge)	$ 45.50	MA1N	NA	
New Premise – Single Phase 2 Element Type 5 Meter (installation charge)	NA		NA	
(annual meter charge)	$ 67.39	MA2N	NA	
New Premise – 3 Phase Direct Connected Type 5 Meter (installation charge)	NA		NA	
(annual meter charge)	$ 101.49	MA3N	NA	
New Premise – 3 Phase CT connected Type 5 Meter (installation charge)	NA		NA	
(annual meter charge)	$ 157.18	MACN	NA	
Meter Data Services				
Type 5&6 Metering Data Services Quarterly Read (per annum)	$ 19.96	Tariff Element	NA	
Type 5&6 Metering Data Services Monthly Read (per annum)	$ 59.88	Tariff Element	NA	
Type 7 Metering Data Service Charges (per NMI per annum)	$ 145.88	Tariff Element	NA	
(per light)	$ 0.95	DSC tariff	NA	

Public lighting operation and maintenance				
50W CC Mercury Vapour (per annum)	$ 33.30	510071	NA	
80W CC Mercury Vapour (per annum)	$ 31.45	510072	NA	
125W CC Mercury Vapour (per annum)	$ 32.95	510073	NA	
250W CC Mercury Vapour (per annum)	$ 43.92	510074	NA	
400W CC Mercury Vapour (per annum)	$ 46.98	510075	NA	
150W HP Sodium (per annum)	$ 74.40	510076	NA	
250W HP Sodium (per annum)	$ 86.53	510077	NA	
400W HP Sodium (per annum)	$ 84.73	510078	NA	
Other (non-standard) (per annum)	$ 86.53	510079	NA	
Miscellaneous				
Copy of Codes and Licences	$ 2.20	510039	NA	
Reserve Feeder Supply (per kW per annum)	$ 12.54	Tariff Element	NA	
Service Cable Pulled Down by High Load – Single Phase	$ 245.80	510050	$ 377.79	510051
Service Cable Pulled Down by High Load – Multi Phase	$ 372.73	510052	$493.73	510053

PUBLIC LIGHTING LOAD TABLE

Version 3 – Effective 13 August 2004

Lamp Type	Normal Lamp Rating (W)	Energy Consumption per hour (Wh)
Mercury Vapour	50	65
	80	95.8
	125	142
	250	270
	400	430
	700	740
High Pressure Sodium	70	86.0
	100	120
	150	173
	220 (1)	242 (1)
	360 (1)	396 (1)
	250	273
	400	440
	1000 (1)	1055 (1)
Metal Halide (reactor control gear)	70	81.5
	100 (2)	113 (2)
	150	168
	175	191
	250	268
	400	425
	1000	1040
	1500	1560
Metal Halide - CW (constant wattage control gear)	150	173
	250	286
	400	449
Low Pressure Sodium	90	115
	150	186
	160	194
	180	212
High Pressure Sodium		
Fluorescent	20	29.0
	Twin 20	50.0
	3 x 20	77.0
	40	50.0
	80	90.0
Incandescent	100	100.0
	150	150.0
	200	200.0
	300	300.0
	500	500.0
	750	750.0
	1000	1000.0
	1500	1500.0

Notes to Table:

(1) Lamp type, nominal rating and energy consumption have only been approved for use by customers in the CitiPower network area

(2) Lamp type, nominal rating and energy consumption have only been approved for use by customers in the CitiPower network area and for the City of Monash in the United Energy network area