PUTRAJAYA LIGHTING MASTERPLAN



PERBADANAN PUTRAJAYA

September 2002

PUTRAJAYA LIGHTING MASTERPLAN

Perbadanan Putrajaya
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This report has been prepared with the kind assistance and professionalism of various individuals from the following organisations through many rounds of close working sessions and may reviews for all of these help and more, we would like to take this opportunity to thank those involved.

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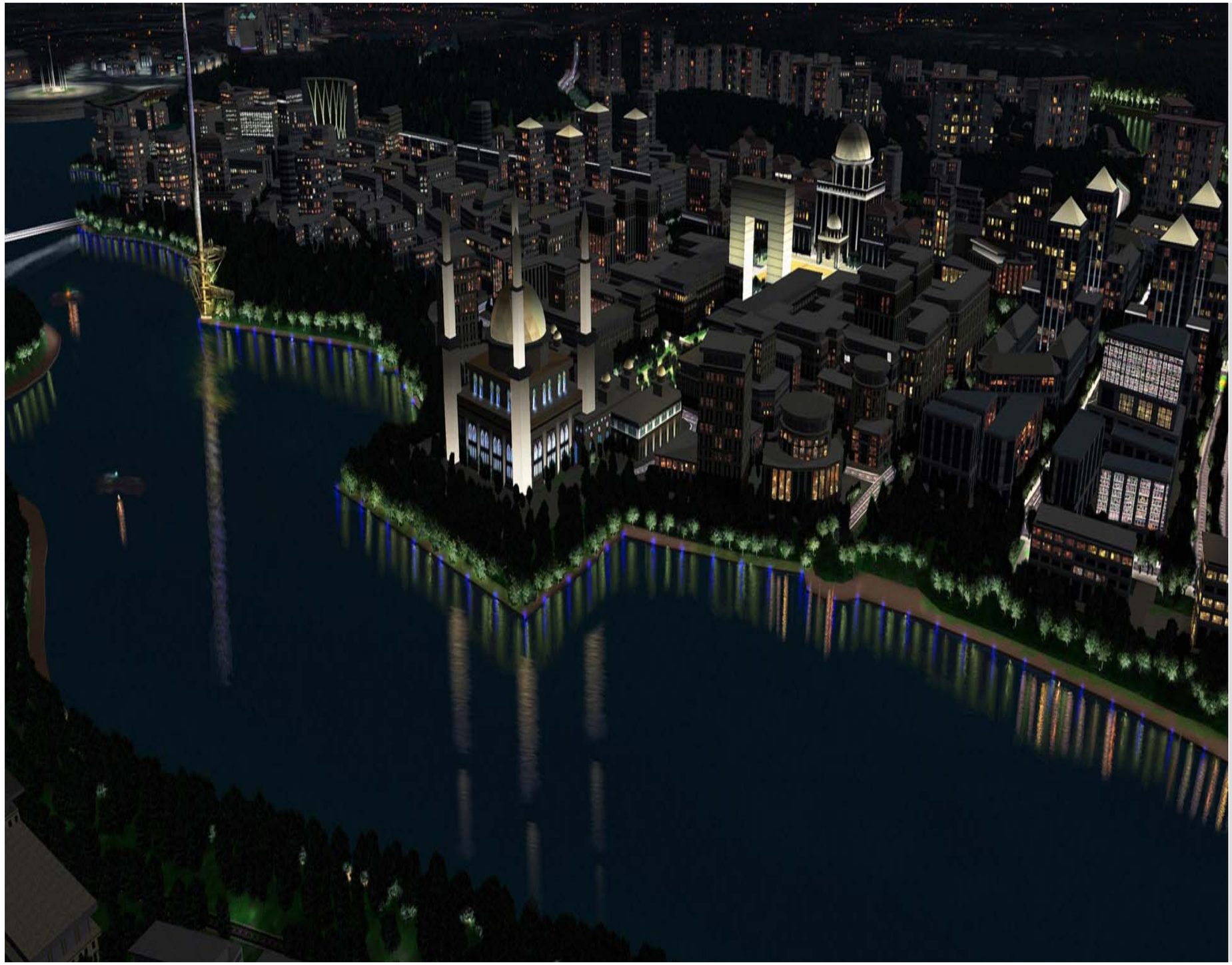
PREFACE

The purpose of this strategic Lighting Masterplan is to establish the visual and practical criteria that will ensure that the night time ambience of Putrajaya is attractive and appropriate to a city of its status and function. Additionally, the Lighting Masterplan considers the practical and functional aspects of exterior lighting and makes recommendations that will ensure that visual aesthetics are successfully balanced with the needs of public safety and amenity.

Whilst the Lighting Masterplan makes detailed recommendations in many areas, it is important that the reader respects the strategic and philosophical nature of the document. Lighting planning and design is, by its very nature, a blend of art and science and is most successful when neither one of these compromises the other. The observations, recommendations and technical guidelines in this document are therefore designed to provide a framework for design decisions. Whilst they are intended to steer the city towards a cogent night time image, they are not intended to be restrictive or unduly prescriptive and should be used constructively by those with the necessary lighting experience.

"…ensure that the night time ambience of Putrajaya is attractive and appropriate to a city of its status and function…"

"…it is important that the reader respects the strategic and philosophical nature of the document…"



Core Island by Night

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SECTION 1 - BACKGROUND

1.1 GENERATION AND CONTEXT OF THE LIGHTING MASTERPLAN

1.1.1 General

The Lighting Masterplan (refer to drawing 1.1.1) draws on and reflects the urban design principles applied to the city to date. Urban design and lighting design objectives are similar. These include creating a sense of visual unity to the overall lit composition. The opposite of visual unity is monotony. This is relieved by the use of contrast. However, excessive use of contrast can also create its own form of monotony and therefore requires to be relieved by visual punctuation.

In planning the lighting for Putrajaya, account must be taken of the texture and colour of local materials since it is the interface between these and the light that will substantially create the required sense of unity.

The revelation of the urban massing, through the use of planned artificial lighting, has to take into account human scale and human perception. In the context of the nightscape the main urban design elements include:

- Vista & climax
- Terminal features
- Landmark & landmark buildings

The appropriate use of light can create a strong sense of enclosure; this is a factor that must be borne in mind when planning the perception of individual areas and spaces, particularly those that are subject to a high degree of usage. In these instances the visual strength of composition will come from the relationship of floor and wall planes and their appropriate lighting treatments.

The foregoing are considerations that will assist in uniting the physical city with the lighting planning that will determine its night time presentation.

1.1.2 Contextual Elements

The lighting design must develop the main themes of simplicity, unity and dignity that underpin the city's urban statement.

Limited topography indicates that the city's 'visual cognisance' by both resident and visitor will be dominated by the lake. The water creates a variety of inter-related spaces and offers the opportunity to use light to form the main element of the nightscape. The urban plan indicates the contextual use of a development of the 'Padang'/Garden City as a core generator. The importance of landscape to the plan therefore cannot be underestimated. The climate will quickly produce a mature feel to the urban backdrop and this must be considered and emphasised through well-designed landscape lighting.

The night time image of Putrajaya should emphasise these main urban generators to give immediate cognisance of the simplicity, unity and dignity that is Putrajaya. The nightscape 'postcard' image will be largely determined by the lighting design quality that is applied to the waterscape, landscape and major buildings.

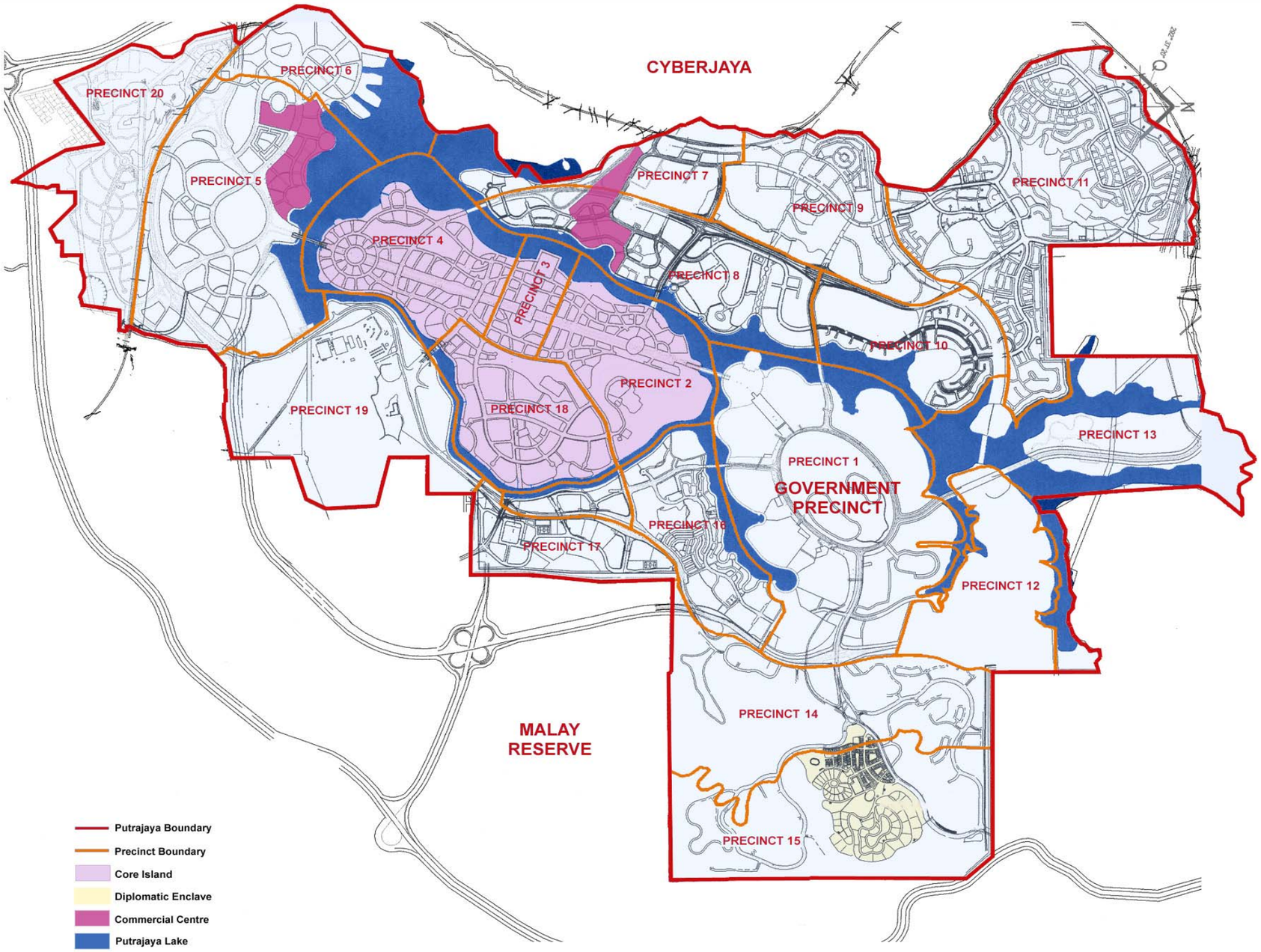
"…the opposite of visual unity is monotony…"

"…the appropriate use of light can create a strong sense of enclosure…"

"…lighting design must develop the main themes of simplicity, unity and dignity that underpin the city's urban statement…"

"…the nightscape 'postcard' image will be largely determined by the lighting design quality…"

Precinct Masterplan



Final Report
September 2002-11-27 Drawing 1.1.1

1.2 INTRODUCTION

The layout, design and quality of the city, as completed to date, express formality and monumentalism. The city's image is that of a serious place with a clearly defined function – to house the processes of government. The message is unambiguous. The Core Island Central Boulevard and its bounding buildings will become expressions of great magnitude that command attention and create a sense of immense substance and scale. This is supported and extended to the north by the Precinct 1 government buildings and to the south by the presence of the Convention Centre.

This daytime image can be extended into night time through a use of light that moves beyond the purely practical or ornamental.

In addition to fulfilling functions associated with safety, security and amenity, lighting should clearly reveal the city structure and its components. Lighting should not draw attention to itself and should not be frivolous. Terms that evoke the night time quality of the city include elegance, restraint, tranquillity and visual comfort. Strongly coloured or animated lighting will have a minor permanent role to play in Putrajaya's nightscape. However, such lighting can add an appropriate quality to temporary special or festive events.

Four existing buildings are good examples of primary visual anchors. The Prime Minister's Office, Prime Minister's Residence, Foreign Ministry and the Masjid Putra (refer to Figure 1.2.1 and 1.2.2) are indicative of the scale and magnitude of buildings yet to be built and of the importance that the lighting of these will have in shaping the image of the city at night.



Fig 1.2.1
Perdana Putra
Prime Minister Department



Fig 1.2.2
Masjid Putra

The significance and value of the lake system was, not fully evident at mid 2002. However, when the inundation programme is complete, numerous lighting opportunities will develop to express the relationship between land and water. The existence of a continuous pathway, that follows the shoreline both in the built up and the undeveloped areas, invites the use of light as a form of visual punctuation that marks the lake shore in certain areas and, literally, reflects the city at night.

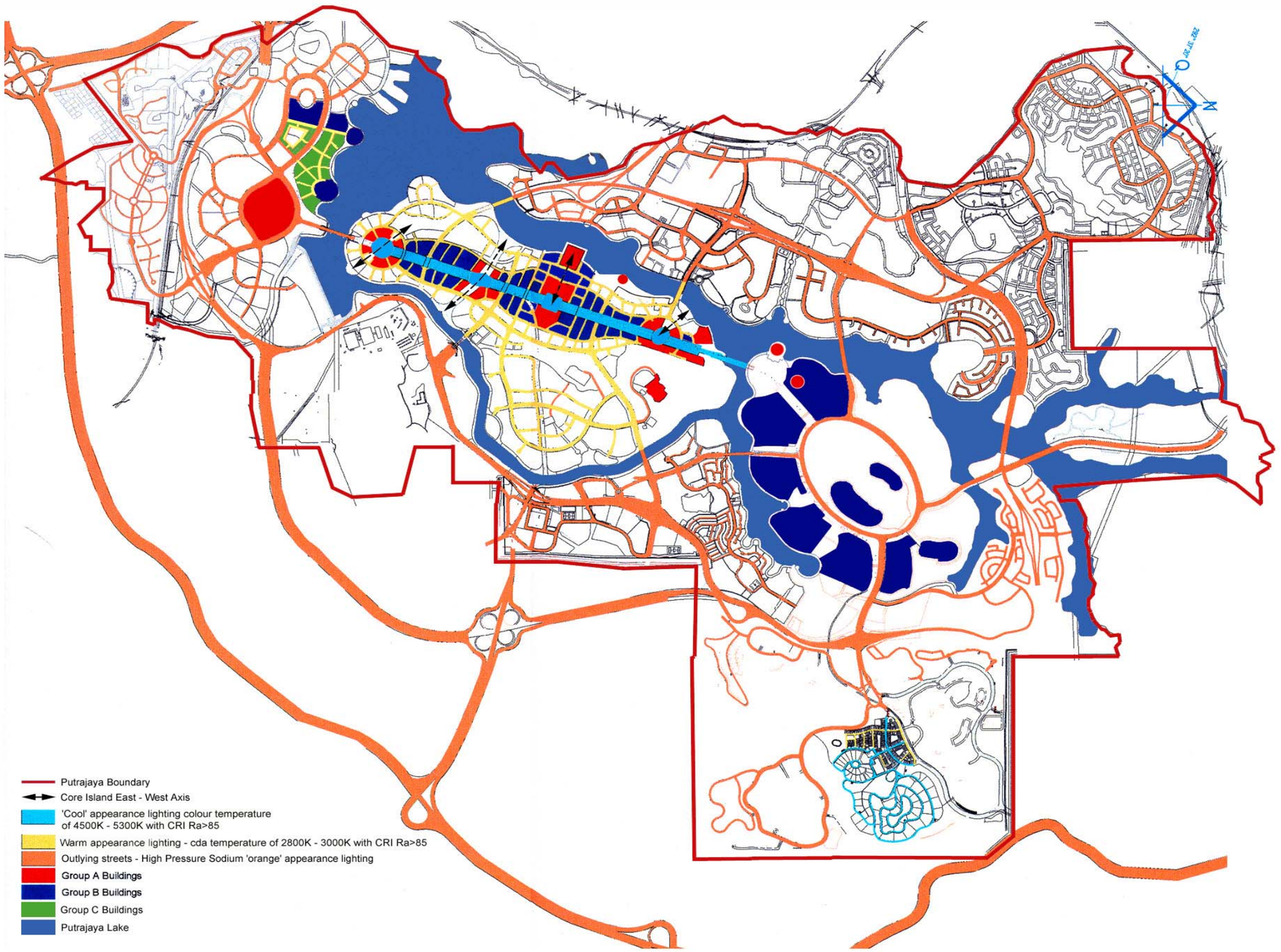
"…this daytime image can be extended into night time through a use of light that moves beyond the purely practical or ornamental…"

"…lighting should not draw attention to itself and should not be frivolous…"

"…strongly coloured or animated lighting will have a minor permanent role to play in Putrajaya's nightscape…"

"…numerous lighting opportunities will develop to express the relationship between land and water…"

Light Plan



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Drawing 1.2.1

1.3 PUTRAJAYA - THE URBAN CONTEXT

1.3.1 UDG & DUD

The Urban Design Guidelines for the city as a whole and the Detailed Urban Design for individual precincts have determined a series of urban characteristics and area functions that should be underpinned and emphasised at night through varying qualities of lighting. Additionally, the UDG and DUD documents provide analyses of the viewpoints and corridors of view that will evolve as the construction of the city develops.

Within the core island the DUD documents identify 5 main uses for individual precincts in the Core Island:

- Mixed Use Development (such as P2)
- Civic & Cultural (such as P3)
- High Intensity Commercial (such as P4)
- Sports & Recreational (such as P5)
- Residential (such as P6)
- Residential (such as P18)

Outside the Core Island subcentres have been identified which include

- Precinct 1 - Parcel Z - Commercial Development
- Precinct 5 - Festival Place
- Precinct 7 & 8 – Sub-Commercial Centre
- Precinct 11 & 18 – Neighbourhood Commercial Centre
- Precinct 14 - Diplomatic Enclave

Each of these requires a widely differing lighting response in order to emphasise their distinctive characters at night.

1.3.2 Topography

The topography of the city lends itself to the creation of nightscape vistas and distant viewpoints. The elevation of the land to the east and the south of the Core Island indicates that the potential exists for east-west through views in addition to the axial views north-south up and down the Central Boulevard and the western part of the lake.

This is an important issue since the availability of distant views establishes the opportunity to create a visual hierarchy at night. The macro view comprises a series of lit elements that are also the subject of micro or local views. The brightness of the lighting to buildings and structures is partially determined by the distance from which these are visible. Those that are viewed only locally will not benefit from higher intensities of lighting whilst those that are visible from a distance will require to be more brightly lit. A balance is recommended in terms of brightness ranges as determined by distance of visibility of key buildings and structures as well as the recommended ‘district brightness’ of a given area of the city.

“…the availability of distant views establishes the opportunity to create a visual hierarchy at night…”

“…balance is recommended in terms of brightness ranges as determined by distance of visibility of key buildings and structures as well as the recommended ‘district brightness’ of a given area…”

1.3.3 Night time visual hierarchy

An analysis suggests that the following would be an appropriate nightscape hierarchy in terms of relative brightness values with the Central Boulevard and its associated buildings becoming the key night time visual element:

- Central Boulevard
- Key buildings on Central Boulevard, Precinct 1 and Precinct 5
- Commercial buildings comprising the CBD at the southern end of the Core Island
- Bridges connecting to Core Island
- Lakeside promenades
- Secondary roads and streets
- Buildings on secondary roads and streets
- Parks
- Residential precincts

1.3.4 City Gateways

Arrival into Putrajaya is as yet **not** well defined with clear points of entry and exit other than highway signages. This supports the concept of developing 'gateways' that are distinct by day and become prominent at night through the use of light. The concept of a series of gateways is proposed, with suggested locations around the perimeter boundaries of Putrajaya. Gateways that are solely devised around the use of light, such as powerful vertical beams of light from equipment recessed within the ground, will not have the same degree of impact as those that are composed of a physical element that incorporates the innovative use of light. As the premier Garden City of Malaysia it is possible to create gateways through key landscaped elements. Accordingly, it is proposed that the physical design of gateway features be developed and complemented by appropriate lighting.

1.3.5 Waterways

The lake is a central component of the city's character. Its revelation at night is possibly more important than by day since it is both the city's visual anchor and guiding map. It also comprises a major proportion of the city's surface area. Its presence will be revealed at night by reflection of the lighting of surrounding buildings, roads, streets, promenades and the bridges that span it. However, there are opportunities to create further night time features that reflect the large expanse of water. Such features might include floating light sculptures, illuminated fountains and water jets or Sound and Light displays. Additionally, it is proposed that the lighting of the bridges is designed to provide a normal level of basic lighting with further lighting being brought into play for celebratory days thereby creating heightened reflections in the lake surface.

"… a series of gateways is proposed with suggested locations around the perimeter boundaries of Putrajaya…"

"…its presence will be revealed at night by reflection of the lighting of surrounding buildings, roads, street, promenades and the bridges …"

"…(the lake's) revelation at night is possible more important than by day since it is both the city's visual anchor and guiding map…"

1.4 APPRAISAL OF PUTRAJAYA AS CONSTRUCTED TO DATE

1.4.1 General

Putrajaya has taken the opportunity to ensure that lighting plays a highly visible role in the overall presentation of the emerging city. The majority of completed roads, buildings, structures and landscapes are lit. This has created an initial impression that there is an abundance of light (refer to Figure 1.4.1). Much of this impression is created by the fact that many of the external lighting fixtures are of a type that emit light in all directions such as 'globe' fixtures or other dispersive types of decorative lantern. This is demonstrated by Figure 1.4.2 and 1.4.3. These create a plethora of light points when viewed at a distance and frequently detract from the main object of regard such as a building façade, bridge or landscaped area. Much of the light dispersal is to the sky and adds only to night sky pollution.

There is a fine balance between creating a visual sense of night time liveliness and creating a scene that lacks clarity and legibility. The existing lighting of individual projects appears to have been designed and installed on a unilateral basis i.e. each project has been lit without regard to the contribution it will make to the complete nightscape. The overall result is the genesis of the type of night time visual disorder that characterises most existing urban environments throughout the world.



Fig 1.4.1
Abundance of Light



Fig 1.4.2
Day view of globe fixtures at Botanic Garden Carpark



Fig 1.4.3
Overall view of Botanic Garden carpark with globe fixtures which contribute to night sky pollution and reduced night ambience

"…Putrajaya has taken the opportunity to ensure that lighting plays a highly visible role in the overall presentation of the emerging city…"

"…There is a fine balance between creating a visual sense of night time liveliness and creating a scene that lacks clarity and legibility…"

1.4.2 Road & Street Lighting

The lighting of the major roads and streets is almost universally based on the use of high-pressure sodium light sources of a warm appearance with an orange hue. Some of the existing street lighting installed at Putrajaya is shown in Figure 1.4.4 and 1.4.5. The lighting levels at the road surface appear to be in general accordance with the standards that are normal for the various road categories. It is however noted that the uniformity of the lighting at the surface of the major roads in Precinct 1 appears to be compromised by the design of the decorative enclosure of the luminaire. This appears to slightly restrict the lateral distribution of the light from the luminaire with a resultant reduction in uniformity of light distribution at road surface level.

Currently the Standards and Codes of Practice for road and street lighting commonly quoted by the Putrajaya local authority is British Standards (BS) 5489. A limited survey has identified that the installed systems, in some instance, fail to provide the required level of uniformity. It is recommended that the adoption of the CIE (Commission Internationale de l'Éclairage) standard should be adopted as the standard for Putrajaya road and street lighting design.

A number of key access and trunk roads are designated as 'Protocol Roads'. A form of lighting different from that used on other roads should identify these. This could take the form of increased lighting levels or a lighting provision based on a light source other than high-pressure sodium.

See Appendix A for the details of a survey of the road and street lighting as existing in late 2001.



Fig 1.4.4
Existing Street Lighting



Fig 1.4.5
Existing Street Lighting

"…recommended that the adoption of the CIE (Commission International de L'Eclarage) standard should be adopted as the standard for Putrajaya…"

"…Protocal roads. A form of lighting different from that used on other roads should identify these…"

1.4.3 Building And Structure Lighting

The overriding impression is that the existing lighting of buildings merges with that of the surrounding roads and streets. In many instances, the same light source is used to light both elements and this results in a lost opportunity to distinguish and contrast the buildings from their surroundings. A major example of this is the Prime Minister's Office; the elevations are illuminated by high-pressure sodium light sources with only the coolly lit roofs becoming a dominant feature.

The existing illumination of most buildings is based on the use of high-pressure sodium light sources. This is an unfortunate development and a major policy recommendation is that the lighting of building elevations should be contrasted with that of the lighting of the surrounding roads and streets. This recommendation will also raise the question of whether the existing lighting of some of the most important buildings should be reconsidered.

1.4.4 Night Sky Light Pollution

A number of examples of night sky light pollution are evident. A high proportion of the lighting to the roofs and the dome of the Prime Minister's Office is clearly seen (from the shore of Precinct 8) to ' miss' the targeted surfaces and project upwards into the sky, illustrated in Figure 1.4.6. Similar examples can be seen in the lighting of the ministry buildings in Parcels C and D and the Masjid Putra.

The lighting of the Dataran Putra is based on a series of decorative columns, located in a circle, each with four road lighting lanterns directed at an upward angle of some 45° to the horizontal.

The decision to tilt the lanterns upward has been partially motivated by the need to project the light over the greatest possible distance. This lighting method results in an exceptionally high level of glare, particularly to those who are viewing either the Masjid Putra or the Prime Minister's Office at a distance, as illustrated in Figure 1.4.7. Additionally, since a major proportion of light is not directed downward, the contribution to sky glow or night sky light pollution is substantial.



Fig 1.4.6
Prime Minister Office
- night sky pollution



Fig 1.4.7
Dataran Putra

"…The overriding impression is that the existing lighting of buildings merges with that of the surrounding roads and streets…"

"…a major policy recommendation is that the lighting of building elevations should be contrasted with that of the lighting of the surrounding roads and streets…"

"…This lighting method results in an exceptionally high level of glare…"

"…The view, on a hazy night, of the partially completed northern end of the city from the roadway system at the south end demonstrates the degree of sky glow that already exists…"

A further small, but significant, example of glare and the associated reduction in visual comfort relates to the Masjid Putra minaret at the top of which there appears to be a powerful light source directed to the north west. The glare created by this unshielded source is a good example of how only one misdirected light source can detract substantially from the night time view of a building and its surroundings.

The view, on a hazy night, of the partially completed northern end of the city from the roadway system at the south end demonstrates the degree of sky glow that already exists. Inevitably some of this is by reflection but most of it emanates from inaccurate building and structure lighting and roadway lighting that directs part of its light above the horizontal plane. An additional and notable contribution to both the sky glow as well as the lack of visual legibility relates to the widespread use of globe lights mounted in many locations including perimeter walls and lake edge situations.

2.1 LIGHTING POLICIES

In order to overcome the problems that have been identified with aspects of the existing lighting in Putrajaya and to prevent a repetition of these in the future, a number of foundational lighting policies have been drawn up. The following 9 lighting policies are the foundations that enable Putrajaya to develop a nightscape that is cogent, attractive, environmentally successful and economic. Beyond purely visual considerations, the policies also include those that deal with the establishment of the necessary personnel structure and lighting design vetting procedures to ensure that the visual objectives are achieved and sustained.

2.1.1 Lighting Policies

POLICY 1: *Distinguish the Central Boulevard from all surrounding roads and streets on the Core Island and most other roads and streets throughout Putrajaya through the use of a distinct road lighting character. Limit this policy to situations where the use of differing colour values of 'white' light are used to distinguish specific areas e.g. the Chancery area within the Diplomatic Enclave.*

POLICY 2: *Limit the use of primary and saturated colour for the lighting of public and private buildings and structures throughout Putrajaya. Any such lighting should only be operated during state and/or festive occasions.*

POLICY 3: *Establish lit Gateways to the main entrances into Putrajaya from perimeter roadway system.*

POLICY 4: *Engage the necessary personnel to secure the comprehensive implementation of the lighting objectives of the Lighting Masterplan within Perbadanan Putrajaya.*

POLICY 5: *Ensure that Perbadanan Putrajaya maintains operational control of lighting throughout the city including lighting to roads and streets and public buildings, structures, landscapes and waterscapes. Additionally, establish a system to encourage the owners of private buildings to participate in the programme of external lighting.*

POLICY 6: *Extend the approvals process to embrace the requirement that all external lighting be submitted as a partial or separate approval application.*

POLICY 7: *Minimise night sky light pollution by requiring good lighting design practice, appropriate equipment specification and concise aiming of installed lighting.*

POLICY 8: *Establish maximum limits on the luminance of internally and externally illuminated advertising and signage.*

POLICY 9: *In residential areas street lighting columns should be of a height that is sympathetic to the scale of adjacent buildings but should not under any circumstances higher than the height of such buildings.*



Central Boulevard Looking South From Dataran Wawasan

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Figure 2.1.1

SECTION 2 – LIGHTING POLICIES

POLICY 1:

Distinguish the Central Boulevard from all surrounding roads and streets on the Core Island and most other roads and streets throughout Putrajaya through the use of a distinct road lighting character. Limit this policy to situations where the use of differing colour values of 'white' light are used to distinguish specific areas e.g. the Chancery area within the Diplomatic Enclave and the squares that mark the centre of regional residential areas.

Policy Objectives:

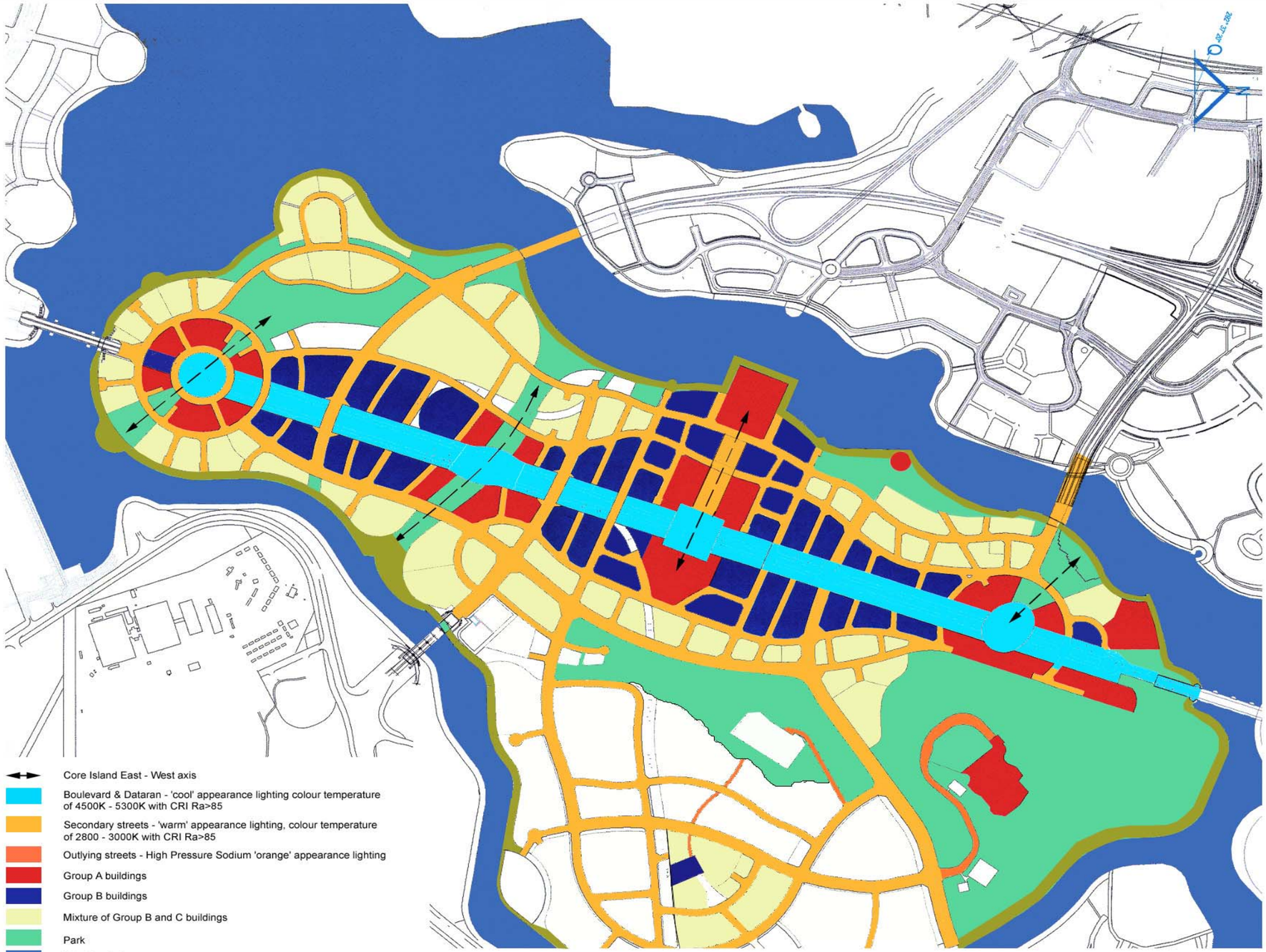
- Accentuate the special function of the Boulevard as a ceremonial route and venue for national celebration.
- Distinguish the night time experience of this key axial route from that of other roads.
- Use the powerful tool of 'white' light colour differentials to accentuate key areas outside the Core Island. This is illustrated in Drawing 2.1.1 and Figure 2.1.2.

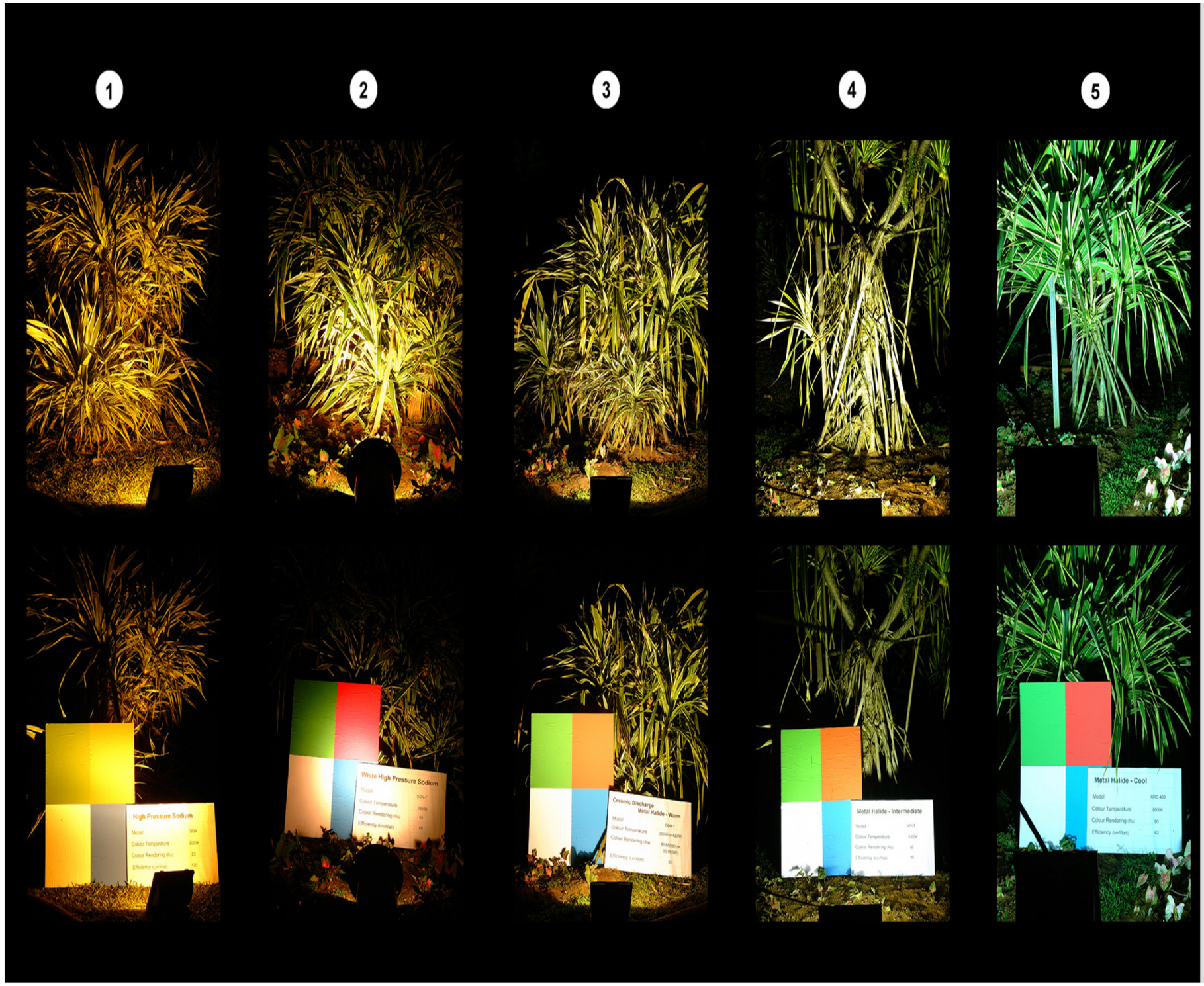
The Core Island lighting policy reinforces the objective of defining the Boulevard as one continuous open space that runs from Precinct 1 through Precincts 2 to 4 of the Core Island terminating at the Convention Centre in Precinct 5. Whilst the Boulevard passes through precincts of varying character, the lighting character of the road and adjacent pedestrian zone remains consistent, thereby establishing a sense of unity at night. Along the secondary axes that are characterised by more informal activities, an associated lighting quality is created to characterise particular areas and precincts.

Implementation Guideline:

See Section 3 - Design Guidelines for Individual Elements - Core Island Lighting Design Approach - Boulevard and Surrounding Buildings.

Hierachy of Boulevard Buildings





Demonstration of Colour Temperature Characteristics

1. Model – High Pressure Sodium (SON)
   Colour Temperature – 2000 Kelvin
   Colour Rendering (Ra) - 23
   Efficiency (lm/wwatt) - 120

2. Model – White High Presure Sodium (SON-T)
   Colour Temperature -2500 Kelvin
   Colour Rendering (Ra) -85
   Efficiency(lm/wwatt) -49

3. Model – Ceramic Discharge Metal Halide (CDM-T)
   Colour Temperature - 3000 or 4200 Kelvin
   Colour Rendering (Ra) - 81-85 (830) or 92-96 (942)
   Efficiency (lm/watt) - 95

4. Model – Metal Halide Intermediate (HPI-T)
   Colour Temperature -4300 Kelvin
   Colour Rendering (Ra) - 65
   Efficiency (lm/watt) - 95

5. Model- Metal Halide Cool (KRC-400)
   Colour Temperatre - 6000 Kelvin
   Colour Rendering (Ra) - 90
   Efficiency (lm/watt) - 62

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Drawing 2.1.1

POLICY 2:

Limit the use of primary and saturated colour for the lighting of public and private buildings and structure throughout Putrajaya.
Any such lighting should only be operated during state and/or festive occasions.

Policy Objectives:

To avoid the following undesirable visual responses:

1. Intense or saturated colour draws the eye and eclipses other aspects of what would otherwise be a well-balanced and perhaps subtle rendering of the building or structure.
2. The use of coloured light overwhelms the natural colour of the materials used in the architectural expression of the building and imposes a very different set of visual values from those originated by the architect.
3. The permanent presence of colour soon tires the eye of the beholder. The surprise factor wears thin and there is no other visual trick available to play, especially during festive occasions.
4. The maintenance of colour filters (where these are used to achieve a fixed saturated colour) adds a further burden to the demands of lighting maintenance in general. Missing or broken filters become extremely conspicuous.

Whilst the use of dense colour is not advocated on a permanent basis, it is recognised that coloured light is a valuable component in creating a sense of occasion and festivity. Examples of appropriate and inappropriate use of saturated colours to illuminate building are illustrated in Figure 2.1.3 and 2.1.4.

Implementation Guideline:

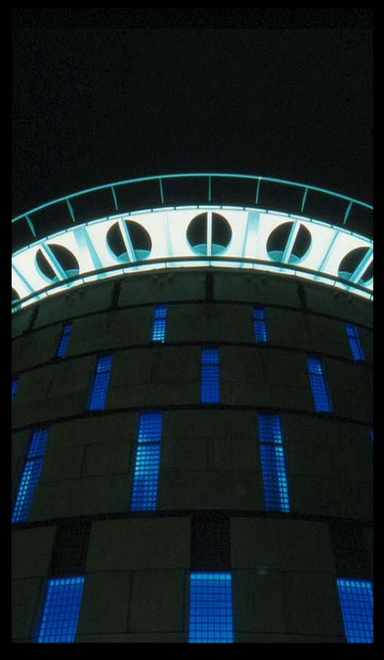
See Section 3 - Design Guidelines for Individual Elements - Festive Lighting

Limit the use of primary and saturated colour for the lighting of public and private buildings and structures throughout Putrajaya.











Putrajaya Lighting Masterplan
Use of Saturated Colour to Illuminate Buildings - Good/Appropriate Usage

Saturated Colour
Appropiate Usage

1. Composition of coloured lighting scheme has been well thought through, and focal point been highlighted with contrasting coloured light. Temporary installation for light and sound festival.

2. Coloured light enhances architectural form of building, and creates calm serene night time image.
(Note colonnade lit with blue light, as per proposed festive lighting scene in Putrajaya Lighting Masterplan)

3. Lighting scheme is installed within building. Colour of façade materials unaffected by lighting.

4. Again, light fittings are resticted to the internal of the building, so materiality of architecture is unaffected by coloured light. Contrasting white light highlights roofline feature, enhancing architectural statement.

5. Coloured ligt utilised as advertising for upmarket hotel. Normal scene utilises white light. At certain times of day/for festive days lighting ‘show’ is run. Permanent ‘temporary’ installation.

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Drawing 2.1.1



Saturated Colour
Inappropriate Usage

1. Sources creates point of glare. Choice of colour shows lack of sensitivity in urban situation.

2. Form of building os distorted by prominence of colour. Use of colour overwhelms natural colour of material.

3. Spotlights have been utilised to project colour onto façade of building, creating a lack ofuniformity.Eye is drwan to the spots of colour,resulting in the architectural legibility of the building being lost.

4. Lighting scheme shows lack of composition in terms of choice of colour. No building hierarchy set up so no one building is focus of festive scene.

5. Coloured lighting inappropiate inappropiate in historic and ecclesiastical situation. Natural colour of the building material is overwhelmed.

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Drawing 2.1.1











Gateway Imagery.

1. **Milho Museum Entrance, Shigaraki , Japan**
   Visibly expressive gateway

2. **Light Columns, Cardiff, Wales**
   Subtle expression of pedestrian and vehicular level, announcing an entry point.

3. **Erasmus Bridge, Rotterdam, The Netherlands.**
   Creating a monumental gateway visible from great, distances.

4. **Wstern Link, Melbourne, Australia.**
   Bridge design highlighted throgh lighting.

5. **Western Link, Melbourne, Australia.**
   Experience of gateway as a journey through archways.

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Drawing 2.1.1

POLICY 3:

Establish lit Gateways to the main entrances into Putrajaya from perimeter roadway system.

Policy Objectives:

- Enhance the entry to the city of Putrajaya by day with structures or landscape feature at major points of introduction to the city. Some examples are illustrated in Figure 2.1.5
- Accentuate the visual entry to the city of Putrajaya by night through the use of light to the structure or landscape features.

Arrival into Putrajaya from surrounding areas should be well defined with clear points of entry both by day and by night. The concept of creating significant gateways that become pronouncements at night through the use of lighting of structures or landscaped features, rather than merely of signposts, will clearly distinguish these major arterial intersections as entrances to Putrajaya - the Garden City. Currently the major entrance from Kuala Lumpur, KLIA, and Cyberjaya are marked by ring roads and junctions with highway signage to mark *exits* rather than *entries* into Putrajaya. Since lighting alone cannot create a full Gateway image it will be necessary to design and construct a physical form that can be lit at night.

The Gateway design might take the form of a landscape feature, major signage structure, or a full or partial portal. The lighting design for the Gateways should take account of the fact that since Putrajaya is located beneath the flight path to KLIA, the plan view at night will be striking.

Putrajaya Gateways

A series of 6 Putrajaya Gateway locations have been identified reflecting the north, south, east and western entries into Putrajaya. These Gateways are:

- **Persiaran Persekutuan Gateway:**

The main Northern Gateway from Kuala Lumpur and Seremban. A Protocol Road leads commuters into this main entry to Precinct 1 Government offices.

- **Persiaran Utara-Timur Gateway:**

The main Eastern Gateway from Bangi to Putrajaya. A Protocol Road leads in into Precinct 1 Government offices and the Prime Minister's Residence. To the south it links into the Diplomatic Enclave and the Northern Region District (Precinct 2).

- **Persiaran Utara-Barat Gateway:**

Marks one of three entries from the western and links directly into the northern Protocol Roads.

- **Persiaran Barat Gateway:**

The main Western Gateway that links across directly in to the Core Island through Bridge 8. The Western Terminal and the Western Region District (Precinct 7 & Precinct 8) will also be connected directly to Persiaran Barat. Other important features are the links out to Cyberjaya.

Recommendations:

1. ***Establish 6 Putrajaya gateways to identify the main points of entry into Putrajaya.***
2. ***Consider design competitions to create the 6 major gateways.***
3. ***Acknowledge that the majority of bridges in Putrajaya form Core Island gateways to the city centre and light them accordingly.***

- **Persiaran Selatan Gateway:**

Marks the main Gateway that leads to the Convention Centre from the Northern Highway. Currently the intersection is not under construction but it is recognised that, at a much later stage, this will become a significant entry from the south into Putrajaya.

- **Lebuh Ehsan Gateway:**

The main entry from the east that leads to the Core Island through to Bridge 4 and Bridge 2.

Each of these 6 locations provides a major opportunity to establish a night time landmark through the placement of a physical gateway feature that is lit both attractively and sufficiently strongly to be visible from a considerable distance – at least one kilometre. The Policy 3 recommendation includes the proposal that the gateways become the subject of a design competition and the Brief for such a competition should strongly emphasise the role of lighting.

The 6 major gateways entering into the Core Administrative Centre are highlighted in Drawing 2.1.1.

Core Island Gateways

Additional Core Island gateways to the centre of the city include:

- Jambatan Putra
- Bridge 1 – Jambatan Seri Bakti
- Bridge 2 – Jambatan Seri Bestari
- Bridge 4 – Jambatan Seri Setia
- Bridge 6 – Jambatan Seri Gemilang
- Bridge 8 – Jambatan Seri Saujana
- Bridge 9 – Jambatan Seri Wawasan
- Bridge 10 – Jambatan Seri Perdana
- Bridge 11 – Monorail Bridge
- Bridge 12 – Monorail Bridge

(refer to Drawing 2.1.2)

In considering these bridges as minor or secondary gateways, attention should be given to their lighting in terms of ensuring that all bridges are lit throughout hours of darkness and that each bridge has a normal mode of lighting in addition to a possible festive mode.

Implementation Guideline:

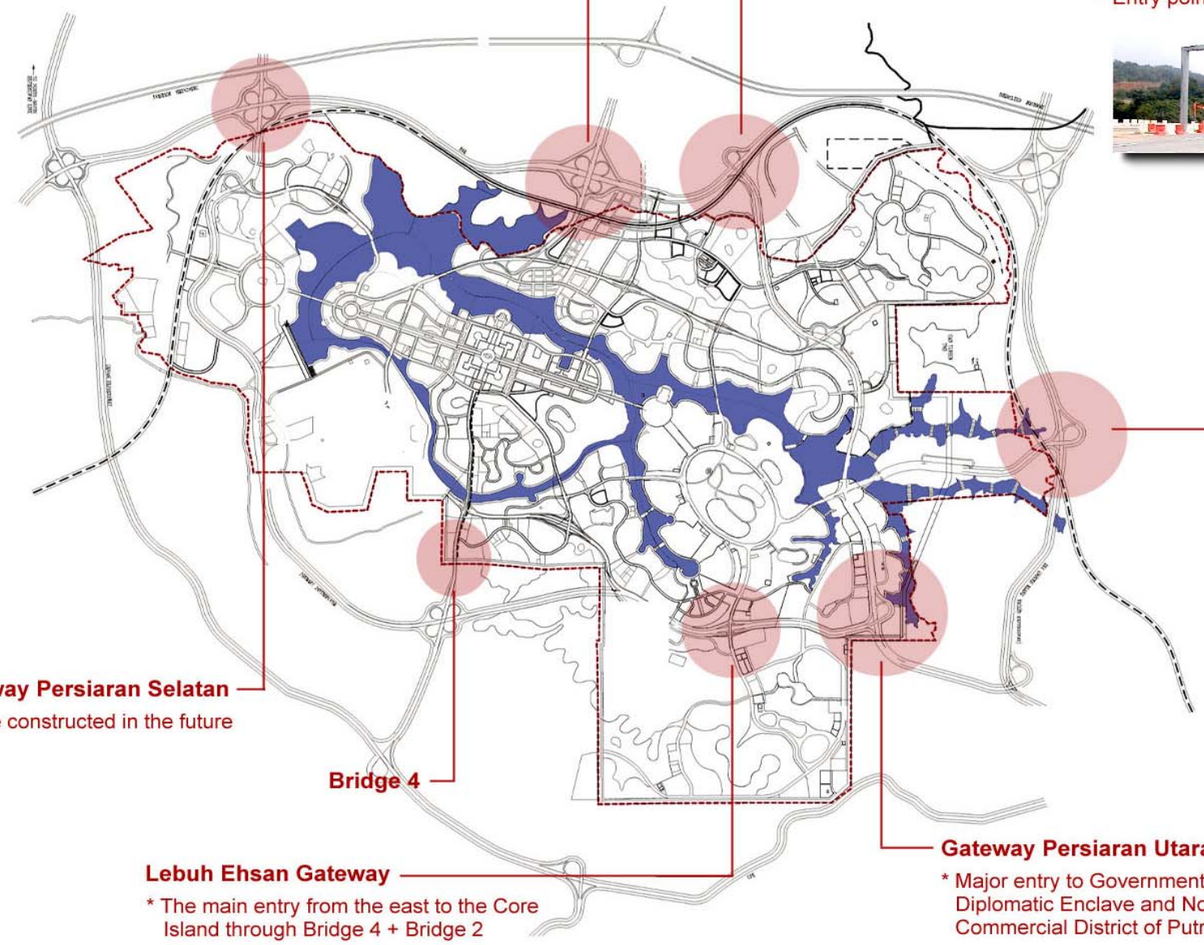
See Section 3 - Design Guidelines for Individual Elements – Gateways



Gateway Persiaran Barat
* Western + Southern gateway
* Cyberjaya link
* Western terminal link
* Connects to R2A

Gateway Persiaran Utara (Barat)
* Major entry to Government Precinct + protocol roads
* Entry point from LDP





Gateway Persiaran Persekutuan
* Major entry to Government Precinct
* Entry point from KL-Seremban Highway



Gateway Persiaran Selatan
* To be constructed in the future

Bridge 4

Lebuh Ehsan Gateway
* The main entry from the east to the Core Island through Bridge 4 + Bridge 2



Gateway Persiaran Utara (Timur)
* Major entry to Government Precinct, Diplomatic Enclave and Northern Commercial District of Putrajaya



Putrajaya Gateways:

-Gateway Persiaran Persekutuan

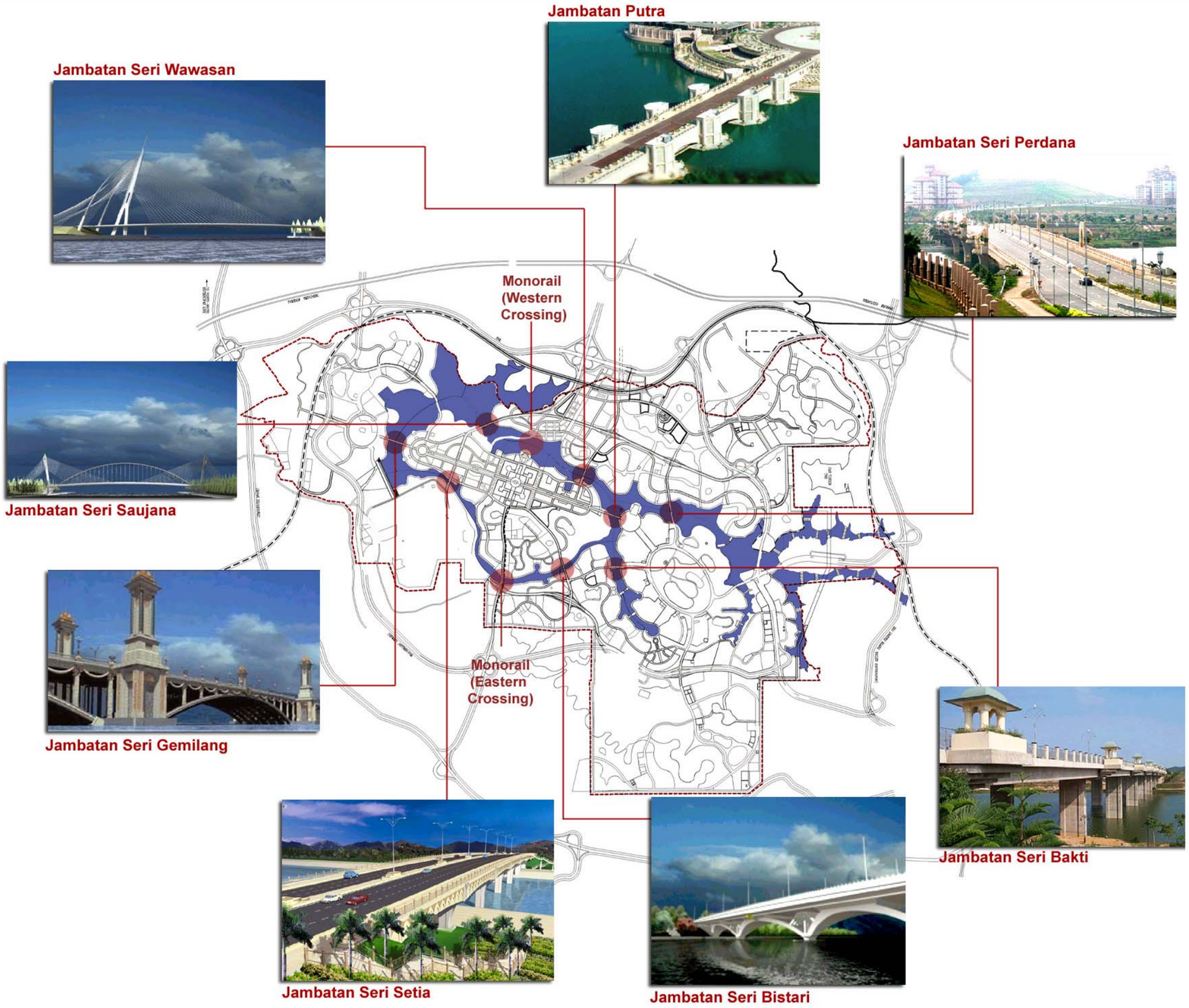
-Gateway Persiaran Utara

-Gateway Persiaran Barat

-Gateway Persiaran Selatan

-Lebuh Ehsan Gateway

-Gateway Persiaran Utara (Timur)



Core Island

-Jambatan Seri Perdana

-jambatan Seri Putra

-Jambatan Seri Wawasan

-Jambatan Seri Gemilang

-Jambatan Seri Setia

-Jambatan Seri Bistari

-Jambatan Seri Bakti

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September 2002
Drawing 2.1.1

POLICY 4:

Engage the necessary personnel to secure the comprehensive implementation of the lighting objectives of the Lighting Masterplan within Perbadanan Putrajaya.

Throughout the world, lighting design and specification is undertaken by a wide variety of persons. These include architects, electrical engineers, landscape architects, interior designers, electrical contractors, lighting equipment manufacturers and specialist lighting design consultants. Only a few of these have formal qualifications in pure lighting. This is particularly the case in Malaysia where there appears to be no current (2002) opportunity to gain formal training in lighting. Much of Putrajaya lighting will therefore be designed and specified by persons who are qualified professionals in related disciplines such as architecture and electrical engineering and therefore rely on considerable support from the lighting manufacturing industry. Currently there is no possibility that qualified lighting specialists will submit the majority of lighting design for Putrajaya. Therefore, the development of a Lighting Masterplan introduces a requirement for Perbadanan Putrajaya (PJC) to include professional lighting skill and experience within its personnel structure.

Additionally, an absence of professional lighting staff within PJC is likely to lead to inadequate maintenance of installed lighting with a resulting deterioration of the night time visual quality.

Implementation Guideline:

See Appendix C – Lighting Personnel

Recommendations:

1. ***Secure the objectives and policies of the Lighting Masterplan.***
2. ***Ensure that lighting quality is sustained in the long term.***

POLICY 5:

Ensure that Perbadanan Putrajaya maintains operational control of lighting throughout the city including lighting to roads and streets, publicly and privately owned buildings, structures, landscapes and waterscapes. Additionally, establish a system to encourage the owners of private buildings to participate in the programme of external lighting.

Policy Objectives:

- Develop a nightscape that includes all the lit components necessary to create a comprehensive and legible presentation of the city, through the lighting of all appropriate buildings and structures and the assured operation such lighting.
- Enable the variation of the presentation of the nightscape through the selective lighting of various elements at varying times and occasions.

During the early and current (2002) stages of the development of Putrajaya, Perbadanan Putrajaya (PJC) and Putrajaya Holdings (PJH) have managed lighting control on a joint basis. The operational control of lighting has not been considered as an issue that either PJC or PJH includes in determining the overall image and presentation of the city at night. This means that the existing lighting of buildings, bridges, landscapes and waterside areas is operated on a relatively *ad hoc* basis on an installation-by-installation basis.

This, non centralised, control arrangement results in a situation where the co-ordinated operation of lighting becomes inconvenient and cumbersome, in that requests have to be made in advance to the various ministries and their building managers to switch on the lighting at a pre-agreed time for a pre-agreed period. It also means that it is not possible to conveniently make co-ordinated changes in the lit presentation of the city during the course of an evening.

Implementation Guideline:

See Section 3 – Lighting Planning, Control and Maintenance.

This summary Approval Checklist indicates the proposed technical requirements for lighting submissions at the various building and landscape application stages.

POLICY 6:

Extend the approvals process to embrace the requirement that all external lighting including Road and Street Lighting be submitted as a partial or separate approval application

Policy Objectives:

The statutory application recognises 3 category of submissions - building, landscape and infrastructure. The procedure is similar for each of the submission. The following stages of planning and approval process are identified as those that are appropriate to include lighting design and planning considerations (refer to summary statutory checklist in the next page for details):

- Layout Submission (SA)
- Planning Submission (PB)
- Building Plan (MB)
- Landscape Approval (KL)
- Certificate of Fitness (TF or TCF)
- Fitting certification (IP, EMC) only for property under PJC management

- **Layout Submission (SA)**

  Preliminary and outline statement of exterior elevation lighting principles where submission relates to a building. No lighting related requirements for landscape submissions at this stage.

- **Planning Submission (PB)**

  It is proposed that the technical checklist, submitted in support of the concept stage lighting design approach for a building exterior or a landscape, should include:

  – Range of typical luminance values to be used, expressed in candela/metre².
  – Range of light sources to be used.
  – Colour temperature values of light sources
  – Colour rendering characteristics of light sources
  – Number of anticipated programmed scenes or variations (Normal use, after hours, high days and holidays)
  – Initial visualisation(s) showing, as accurately as possible, the proposed image(s) of the building at night

- **Building Plan or Landscape Approval Submission**.

  At the next stage, Building Plan (MB) or Landscape Approval (KL) Submission a more detailed level of information will be required to evidence the quality of the proposed lighting. This should be described in terms of:

  – Developed visualisation(s) showing, as accurately as possible, the proposed image(s) of the building at night
  – General description of anticipated locations for luminaires
  – General description of luminaire fixing or mounting methods to be adopted

Recommendations:

1. ***Ensure that all aspects external lighting design and implementation are developed within the context of the policies of the Lighting Masterplan.***

2. ***Ensure that Perbadanan Putrajaya has the degree of detailed control required to ensure that proposed lighting installations comply with the visual and technical objectives of the Lighting Masterplan.***

   Ensure a coordinated approach to the lighting design for buildings, landscapes and other elements.

3. ***The statutory application recognises 3 categories of submissions – Building, Landscape and Infrastructure. For each of the submission the procedure is more or less the same.***

- Methods to be adopted to prevent stray light projecting above the horizontal and to prevent glare from public viewing angles (reduction of night sky light pollution)
- Description of light sources detailing type, wattage, colour rendering index, colour temperature and lamp life
- Description of the lighting control methodology and the final number of different lighting scenes to be incorporated within the programme
- A clear description of the intended maintenance methodology

- **Technical Detail Submission**

The external building and landscape Technical Detail Submission checklist will include:

- Full Detail circuiting of lighting sources
- Full description of luminaires, including IP rating, complete with plan showing their proposed location and fixing /mounting methods
- Full description of lighting control
- Equipment certification (Only for public buildings and street lighting)
- Photometric calculations (Only for Roads and Parks)
- Luminance mapping of the proposed lighting shown as an iso-candela overlay of the elevations and any other lit elements to clearly show the maximum anticipated luminance in candela/metre². Example given in Figure 2.1.7.

- **Certificate of Fitness**

Lastly, at the final stage of the completion of the project, the application of Certificate of Fitness is applied for (TF or TCF maybe given) A request follows for a visual inspection of the project. The visual inspection is carried out with statutory officers and the following will comprise the technical checklist:

Through inspection, confirm that all the building elevation lighting has been installed in accordance with Planning and Building Plan submissions

Implementation Guideline:

See Section 3 – Lighting Planning, Control and Maintenance

POLICY 6: SUMMARY OF GUIDELINES CHECKLIST

SUBMISSION PROCEDURE	BUILDING APPLICATION	PARKS	INFRASTRUCTURE	SIGNAGE
1 SUSUNATUR (SA)	1 SUSUNATUR (S.A.)	1 SUSUNATUR (S.A.)	1 Layout Planning Information	
(Layout Submission)	1.1 Lighting principle Lighting principle for development to tie back to overall objective of Lighting Masterplan.	1.1 Lighting principle Lighting principle for development to tie back to overall objective of Lighting Masterplan.	1.1 Lighting principle	
2 PENDIRIAN BANGUNAN (PB)	2 PENDIRIAN BANGUNAN (P.B.)	2 PENDIRIAN BANGUNAN (P.B.)	2 MENDIRIKAN INFRASTRUKTUR	1 PEMASANGAN PAPAN TANDA
(Planning Submission) **MENDIRIKAN INFRASTRUKTUR** **(Infrastructure Approval)**	2.1 Luminance Range Range of typical luminance values to be used in the design 2.2 Range of Light Source Range of light sources to be used. 2.3 Colour Rendering Range of colour rendering index **and** colour temperature of light sources to be used in the design. 2.4 Lighting Scenes Number of anticipated programmed scenes or variations in lighting. 2.5 Initial Lighting Images Images showing as accurately as possible proposed lighting scenes of the building at night. 2.6 Mounting Methods Fixing or mounting method adopted for luminaire (how light is concealed or integrated to building façade)	2.1 Luminance Range Range of typical luminance values to be used in the design. 2.2 Range of Light Source Range of light sources to be used. 2.3 Colour Rendering Range of colour rendering index **and** colour temperature of llight sources to be used in the design. 2.4 Lighting Scenes Number of anticipated programmed scenes or variations in lighting. 2.5 Initial Lighting Images Images showing as accurately as possible proposed lighting scenes of the building at night. 2.6 Mounting Methods Fixing or mounting method adopted to luminaire (how light is concealed or integrated to monuments or façade classed under Group A)	2.1 Luminance Range Range of typical luminance values to be used in the design (Only for monuments/ structures class as group A). 2.2 Colour Rendering Range of colour rendering index **and** colour temperature of light sources to be used in the design. 2.3 Lighting Scenes Number of anticipated programmed scenes or variations in lighting. 2.4 Lighting Images Images showing as accurately as possible proposed lighting scenes of the façade (for structure classed as Group A) at night.	1.1 Limitation to Luminance Maximum luminance values to be used in the design. 1.2 Construction Drawing Construction drawing of proposed signage showing lighting in or on signage.

SUBMISSION PROCEDURE	BUILDING APPLICATION	PARKS	INFRASTRUCTURE	SIGNAGE
		3 KELULUSAN LANSKAP (K.L.)	2 MENDIRIKAN INFRASTRUKTUR	1 PEMASANGAN PAPAN TANDA
	2.7 Final Lighting Images Images showing as accurately as possible proposed lighting scenes of the building at night.	3.1 Final Lighting Images Images showing as accurately as possible proposed lighting scenes of the building at night.		
	2.8 Luminance Prediction Luminance prediction for building facade is iso-candela and/or other graphic method of showing levels of luminance.	3.2 Luminance Prediction Luminance prediction for building facade is iso-candela and/or other graphic method of showing levels of luminance.	2.5 Luminance Prediction Luminance prediction for façade for structure (classed under Group A) and for motorways or roads; iso-candela and/or other methods of showing graphic levels of luminance.	1.3 Luminance Prediction Luminance prediction (maximum & average) of signage façade in iso-candela (for large signage).
	2.9 Mounting Methods Fixing or mounting method adopted for luminaire (how light fixtures are concealed or integrated to building façade), follow up to 2.6.	3.3 Mounting Methods Fixing or mounting method adopted to luminaire (how light fixtures are concealed or integrated to monuments or façade classed under Group A) as follow up to 2.6.	2.6 Mounting Methods Fixing or mounting method adopted to for luminaire (how light fixtures are concealed or integrated into structures classed under Group A).	
	2.10 Night Sky Light Pollution Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare.	3.4 Night Sky Light Pollution Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare.	2.7 Night Sky Light Pollution Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare.	1.4 Night Sky Light Pollution Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare (for large signage only – exceeding 4m²).
	2.11 Listing of Light Source Listing and description of light sources.	3.5 Listing of Light Source Listing and description of light sources.	2.8 Listing of Light Source Listing and description of light sources.	
	2.12 Lighting Control Description of lighting control method and the number of different lighting scenes.	3.6 Lighting Control Description of lighting control method and the number of different lighting scenes.	2.9 Lighting Control Description of lighting control method and the number of different lighting scenes.	
	2.13 Maintenance Method A general description of the intended maintenance method (only applicable for public maintained building)	3.7 Maintenance Method A general description of the intended maintenance method (only applicable for publicly maintained monuments or structure).	2.10 Maintenance Method A general description of the intended maintenance method (only applicable for public maintained monuments or structure).	

SUBMISSION PROCEDURE	BUILDING APPLICATION	PARKS	INFRASTRUCTURE	SIGNAGE
3 KELULUSAN TEKNIKAL (KT) **(Technical Approval))**	**3 KELULUSAN TEKNIKAL (K.T.)** 3.1 Circuit Diagram Only applicable for public maintained lighting; full details of circuit of lighting system. 3.2 Lighting Layout Details of lighting layout. 3.3 Luminaire Certification Only applicable for publicly maintained lighting; full description of luminaire including submission of ratings, standards and certificates 3.4 Detail Lighting Controls Applicable only for public maintained lighting; a follow up to 3.6.	**4 KELULUSAN TEKNIKAL (K.T.)** 4.1 Circuit Diagram Only applicable for public maintained lighting; full details of circuit of lighting system 4.2 Lighting Layout Details of lighting layout. 4.3 Luminaire Certification Only applicable for publicly maintained lighting; full description of luminaire including submission of ratings, standards and certificates 4.4 Detail Lighting Controls Applicable only for public maintained lighting; a follow up to 3.6.	**3 KELULUSAN TEKNIKAL (K.T.)** 3.1 Circuit Diagram Only applicable for public maintained lighting; full details of circuit of lighting system 3.2 Lighting Layout Details of lighting layout. 3.3 Luminaire Certification Only applicable for publicly maintained lighting; full description of luminaire including submission of ratings, standards and certificates 3.4 Detail Lighting Controls Applicable only for public maintained lighting; a follow up to 2.9.	
4 CERTIFICATE OF FITNESS (CF) **MENGAMBIL ALIH** **(Handing Over)**	**4 CERTIFCATE OF FITNESS (C.F.)** 4.1 Pre-Inspection Checklist Checklist of submission before initiating C.F. inspection. 4.2 C.F. Inspection Checklist for C.F. inspection. 4.3 Recommendations for C.F. Checklist for recommendations of C.F.	**5 CERTIFCATE OF FITNESS (C.F.)** 5.1 Pre-Inspection Checklist Checklist of submission before initiating C.F. inspection. 5.2 C.F. Inspection Checklist for C.F. inspection. 5.3 Recommendations for C.F. Checklist for recommendations of C.F.	**4 MENGAMBIL ALIH** 4.1 Pre-Inspection Checklist Checklist of submission before initiating hand-over inspection. 4.2 Hand-Over Inspection Checklist for hand-over inspection. 4.3 Acceptance Checklist Checklist before official acceptance or taking over.	**2 KELULUSAN PAPAN TANDA** 2.1 Pre-Inspection Checklist Checklist of submission before initiating hand-over inspection. 2.2 Approval Inspection Checklist for inspection. Inspection may only be carried out on large signage and unipole 2.3 Pre Approval Checklist Post inspection checklist before official approval.

POLICY 6:GUIDELINES CHECKLIST FOR BUILDING APPLICATION

Item	Description			Objective of Submission	Submission Check List		
						From Developer	Responsible person
1	**SUSUNATUR (SA)**			**Layout Planning Information**			
1.1	**Lighting Principle** Lighting principle for development to tie back to overall objective of Lighting Masterplan.		1.1	Simple commitment from developer that lighting system listed will be implemented and in accordance with the Lighting Masterplan.	1.1	Simple statement of lighting concept (a) Confirmation that the Building façade will be lit. (b) Landscape will be lit in appropriate areas. (c) Pedestrian areas will be lit in appropriate levels.	Planner Architect Electrical Engineer
2	**PENDIRIAN BANGUNAN (PB)**			**Building Concept Information**			
				Notes Buildings referred in procedures 2.1 to 2.5 shall only pertain to building or structures defined in the Lighting Masterplan as Group A, B or C. Submission procedure where applicable where landscape areas are included will however still be required.			
2.1	**Luminance Range** Range of typical luminance values to be used in the design.		2.1	Indication of lighting concept and to check it matches with the Lighting Masterplan.	2.1	Simple statement listing the range of luminance or illuminance levels to be applied in the lighting design: (a) Building façade – cd/m² to match category and lighting zone. (b) Landscape. parks, and pedestrian areas – lux levels in accordance with CIE codes for pedestrian traffic.	Architect Electrical Engineer Landscape Architect Lighting Specialist
2.2	**Range of Light Source** Range of light source to be used.		2.2	To ensure streetlights fit in with overall street furniture.	2.2	General statement listing the type of light fitting; e.g. (a) Building façade – high intensity narrow beam/ medium/ wide beam or focused flood lights, feature lights etc. (b) Landscape and pedestrian areas – lantern tops, bollards, feature lights etc.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.3	**Colour Rendering**		2.3	To ensure colour rendering and colour temperature fits in with the ambience prescribed by the Lighting Master plan.	2.3	General statement on colour rendering index and colour temperature to be used in the lighting design.	Architect

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
	Range of colour rendering index **and** colour temperature of light sources to be used in the design.						Landscape Architect Electrical Engineer Lighting Specialist
2.4	**Lighting Scenes** Number of anticipated programmed scenes or variations in lighting.		2.4	Ensure coordination with overall programmed lighting scenes in planning.	2.4	General statement listing the programmed scenes such as Normal /After Office Hours/ Festive / High Days /Security etc.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.5	**Initial Lighting Images** Images showing as accurately as possible proposed lighting scenes of the building at night.		2.5	Image of lighting concept similar to the architectural perspective. Lighting image for landscape pertain to general ambience and location of lighting. Special features for landscape lighting should be indicated (e.g. water feature etc).	2.5	Rendered drawings showing perspective or artist's concept of the night lighting scene(s). For landscape, drawings similar to landscape layout showing general location of light fixtures and perspective or artist's concept of night lighting scene(s) where special feature are included.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.6	**Mounting Methods** Fixing or mounting method adopted for luminaire (how light is concealed or integrated to building façade)		2.6	To ascertain that light fittings as building fixtures or street furniture are not mounted in an obtrusive manner with negative impact on the general visual façade or landscape.	2.6	Statement or drawing describing or showing location of light fixtures. Mounting methods are as follows (a) Conceal or integrated into onto building façade or structure; (b) Surface mounted onto building surface or structure; and/or (c) Planted in ground on pole or plinth or on mounting base planted below-ground.	Architect Landscape architect Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
				Design Development Information			
2.7	**Final Lighting Images** Images showing as accurately as possible proposed lighting scenes of the building at night.		3.1	Update to 2.5 above.	3.1	Submission of images including rendered perspective drawings, artist's concept, computer generated drawing of colour images of the night lighting scene(s). (a) Building façade – rendered images or artist's perspective. (b) Landscape – images of feature lighting and concept similar to landscape images.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.8	**Iso-Luminance Mapping** Luminance forecast of building facade iso-candela /lux and/or colour banding (levels of luminance)		3.2	To ascertain compliance with design intent described in 3.2 above.	3.2	Submission for luminance or illuminance prediction to comprise computer generated iso-candela or iso-lux mapping or manually calculated maximum, minimum and average luminance values. (a) Building elevations – Luminance prediction is preferred in the form of iso-candela mapping across the complete elevations or other graphic techniques that show the gradation and peaks of luminance. Alternatively, manually calculated 'spot' maximum and minimum luminance values with an average may be submitted. (b) Landscape areas – iso-candela for monuments and iso-lux for pedestrian areas where applicable.	Architect Electrical Engineer Lighting Specialist
2.9	**Mounting Methods** Fixing or mounting method adopted for luminaire (how light is concealed or integrated to building façade)/ Follow up to 2.6.		3.3	Follow up details from 2.6.	3.3	Follow up details from 2.6 if available or applicable. Details will include drawings showing location of prominent luminaries and mounting methods:	Architect Landscape architect Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
2.10	**Night Sky Pollution** Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare.		3.4	To minimise night sky light pollution (refer Appendix C) Table C2.4 (shielding standard - good practice guide to minimise sky glow and glare) Table C2.6 (lumens limitation per acre – benchmark to check that landscape lighting design allowance is not exceeded). Images in last 3 pages of Appendix C (Good Lighting Practice Guide).	3.4	Concept statement on methods adopted to minimise night time sky light pollution. Methods include: (a) Shielding standard (b) Limits to lumens per acre ('lumen cap') (c) Specific statement or drawing showing lamp shielding or focusing especially globe lights or flood lights. Drawings to back-up statement may be submitted if appropriate.	Architect Landscape architect Electrical Engineer Lighting Specialist
2.11	**Listing of Light Source** Listing and description of light sources		3.5	Ascertain compliance to good engineering practice. Fixtures under private maintenance will only require a general listing; whilst fixtures to be handed over for public maintenance should be have detail description and listing.	3.5	For private maintained fixture a general listing on the type of light source. For public maintained fixture (public roads, parks facilities etc) a detail listing with detailed engineering description or specification (details required to be specified by Perbadandan, Engineering Department) should be submitted.	Electrical Engineer Lighting Specialist
2.12	**Lighting Control** Description of lighting control method and the number of different lighting scenes.		3.6	Ascertain degree of lighting control and coordinate with public switched lighting where applicable.	3.6	For private maintained fixture statement on lighting control: (a) Manual/ time switch / photo-cell or computer-automated time switching. (b) Provision for connection of façade lighting on separate circuits for possible future connection of separate electrical meter. For public maintained fixture (a) Manual/ time switch / light sensor or computer-automated time switching. (b) Provision of automated control and monitoring. Future detail and liaison with I.T. department of Perbadanan required.	Electrical Engineer Electrical Engineer

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
2.13	**Maintenance Method** A general description of the intended maintenance method (only applicable for public maintained building).		3.7	Ensure compliance to Perbadanan maintenance methodology.	3.7	Only for public maintained lighting; a statement listing maintenance methodology: (a) Lamp cleaning interval factor used in calculating luminance or illuminance level. (b) Relamping cycle. (c) Other information required by Perbadanan.	Electrical Engineer Lighting Specialist
3	**KELULUSAN TEKNIKAL (KL)**			**Detail Design Information**			
3.1	**Circuit Diagram** Only applicable for public maintained lighting; full details of circuit of lighting system.		4.1	Integrity of engineering design.	4.1	Submission only applicable for public maintained lighting system: (a) Circuit diagram (b) Feeder pillar design.	Electrical Engineer
3.2	**Lighting Layout** Details of lighting layout.		4.2	Technical compliance with design and to check coordination with façade fixture or street furniture.	4.2	For private maintained light fixture; a simple layout as a follow up to procedure 3.3 above. For public maintained light fixture; details (with drawings where applicable) to be submitted (a) Lighting location and layout; (b) Mounting details; (c) Other details required by Perbadanan	Electrical Engineer Lighting Specialist
3.3	**Luminaire Certification** Only applicable for public maintained lighting; full description of luminaire including submission of ratings, standards and certificates.		4.3	Good engineering practice and technical compliance.	4.3	Only required for public maintained lighting fixtures. Detail engineering submission include (a) Engineering ratings (IP, EMC standards, ballast losses, shielding standard etc) (b) Certification by independent testing laboratory of engineering standards. Components under the control of the Suruhanjaya Tenaga (Jabatan Elektrik) should also be approved.	Electrical Engineer

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
3.4	**Detail Lighting Controls** Applicable only for public maintained lighting; a follow up to 3.6.		4.4	To check for coordination with public maintained control and switching.	4.4	Only required for public maintained lighting system; details of lighting controls (if not already described in 4.1). If automation controls are implemented liaison and approval should be sought from Perbadanan (IT department)	Electrical Engineer
4	**CERTIFICATION OF FITNESS (C.F.)**			**Issuance of C.F.**			
4.1	**Pre-Inspection Checklist** Checklist of submission before initiating C.F. inspection.		5.1	To ensure all items complied with before C.F. inspection.	5.1	To compile and submit checklist of approvals before inspection: (a) Building (b) Landscape (c) Engineering (d) Certification by Electrical Engineer responsible.	Architect as part of overall CF checklist and application for inspection. Electrical Engineer
4.2	**C.F. Inspection** Checklist for C.F. inspection.		5.2	Inspection to ensure compliance to lighting approved plans, design concept and Lighting Masterplan. A checklist of inspection for Perbadanan include: (a) Visual inspection. (b) Types of luminaire. (c) Check for obvious case of light trespass, glare and sky pollution. (d) Witness luminance (cd/m²) or illuminance (lux) measurements. (e) Witness operation check.	5.2	Conduct the following: (a) Visual inspection (b) Luminance measurement (using luminance meter) or illuminance measurement (using illuminance meter) (c) Operation check (switch on all lights, switch on programmed scenes, operational check of controls etc).	Electrical Engineer Lighting Specialist Lighting Supplier or Contractor

Item	Description			Objective of Submission	Submission Check List		
						From Developer	Responsible person
4.3	**Recommendations for C.F.** Checklist for recommendations of C.F.		5.3	Final checklist before issuance of C.F.	5.3	For private maintained lighting system: (a) Report of C.F. inspection. For public maintained lighting system: (a) Report of C.F. inspection. (c) Compilation of As Built Drawings, Inventory list, Maintenance manuals (manual applicable only for automated controls or new engineering systems) and other engineering details requested by Perbananan. (d) Handing over of keys (feeder pillars) and spare parts.	Architect as part of C.F. submission. Electrical Engineer Lighting Supplier

POLICY 6 – DETAIL STATUTORY CHECKLIST FOR PARKS

Item	Description			Objective of Submission	Submission Check List		
						From Developer	Responsible person
1	**SUSUNATUR (SA)**			**Layout Planning Information**			
1.1	**Lighting Principle** Lighting principle for development to tie back to overall objective of Lighting Masterplan		1.1	Simple commitment from developer that lighting system listed will be implemented and in accordance with the Lighting Masterplan.	1.1	Simple statement of lighting concept (a) Landscape will be lit in appropriate areas. (b) Pedestrian areas will be lit to appropriate levels. (c) Monuments or large structure will be considered under 'Building Application.'	Planner Architect Electrical Engineer
2	**PENDIRIAN BANGUNAN (PB)**			**Design Concept Information**			
				Notes All monuments or structures referred herein this section and classed under Group A in the Masterplan will require lighting façade submission under 2.1 to 2.5.			
2.1	**Luminance Range** Range of typical luminance values to be used in the design (Only for monuments/ structures class as group A).		2.1	Indication of lighting concept and to check it matches with the Lighting Masterplan.	2.1	Simple statement listing the range of lighting levels to be applied in the lighting design: (a) Monuments or large structure classed as Group A – cd/m² to match category and lighting zone. (b) Landscape. parks, and pedestrian areas – lux levels in accordance with CIE codes for pedestrian traffic.	Architect Electrical Engineer Landscape Architect Lighting Specialist
2.2	**Range of Light Sources** Range of light sources to be used.		2.2	To ensure streetlights fit in with overall street furniture.	2.2	General statement listing the type of light fitting; e.g. (a) Monuments or structure classed as Group A– high intensity narrow beam/ medium/ wide beam or focused flood lights, feature lights etc. (b) Landscape and pedestrian areas – lantern tops, bollards, feature lights etc.	Architect Landscape Architect Electrical Engineer

Item	Description		Objective of Submission	Submission Check List		
					From Developer	Responsible person
						Lighting Specialist
2.3	**Colour Rendering** Range of colour rendering index **and** colour temperature of light sources to be used in the design.	2.3	To ensure colour rendering and colour temperature fits in with the ambience prescribed by the Lighting Master plan/	2.3	General statement on colour rendering index and colour temperature to be used in the lighting design.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.4	**Lighting Scenes** Number of anticipated programmed scenes or variations in lighting.	2.4	Ensure coordination with overall programmed lighting scenes in planning.	2.4	General statement listing the programmed scenes such as Normal /After Office Hours/ Festive / High Days /Security etc.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.5	**Initial Lighting Images** Images showing as accurately as possible proposed lighting scenes of the building at night.	2.5	Image of lighting concept similar to the architectural perspective. Lighting image for landscape pertain to general ambience and location of lighting fixtures. Special features for landscape lights should be indicated (e.g. water feature etc).	2.5	Rendered drawings showing perspective or artist concept of the night lighting scene(s). For landscape, drawings similar to landscape layout showing general location of lights and perspective or artist concept of night lighting scene(s) where special feature are included.	Architect Landscape Architect Electrical Engineer Lighting Specialist
2.6	**Mounting Methods** Fixing or mounting method adopted to luminaire (how light is concealed or integrated to monuments or façade classed under Group A)	2.6	To ascertain that light fittings as fixtures or street furniture are not mounted in an obtrusive manner with negative impact on the general visual façade or landscape.	2.6	Statement or drawing describing or location of light fixtures. Mounting methods are as follows (a) Conceal or integrated into onto monuments/structure façade. (b) Surface mounted onto building surface or structure; and/or (c) Planted in ground on pole or plinth or on mounting base planted below-ground.	Architect Landscape architect Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List From Developer	Responsible person
3	**KELULUSAN LANSKANP (KL)**			**Design Development Information**			
3.1	**Final Lighting Images** Images showing as accurately as possible proposed lighting scenes of the monuments or structures (classed as Group A) at night.		3.1	Update to 2.5 above.	3.1	Submission of images include rendered perspective drawings, artist concept, computer generated drawing of colour images of the night lighting scene(s). (a) Monuments or large structure class as Group A – rendered images or artist perspective. (b) Landscape – images on feature lighting and concept similar to landscape images.	Architect Landscape Architect Electrical Engineer Lighting Specialist
3.2	**Luminance Prediction** Luminance prediction for building facade as iso-candela and/or other graphic method of showing levels of luminance.		3.2	To ascertain compliance with design intent described in 3.2 above.	3.2	Submission for luminance or illuminance prediction to comprise computer generated iso-candela or iso-lux mapping or manually calculated maximum, minimum and average luminance values. (a) Elevations of monuments or structure (classed as Group A) – Luminance prediction is preferred in the form of iso-candela mapping across the complete elevations or other graphic techniques that show the gradation and peaks of luminance. Alternatively, manually calculated 'spot' maximum and minimum luminance values with an average may be submitted. (b) Landscape areas – iso-candela for monuments and iso-lux for pedestrian areas where applicable.	Architect Electrical Engineer Lighting Specialist
3.3	**Mounting Methods** Fixing or mounting method adopted to luminaire (how light fixtures are concealed or integrated to monuments or façade classed under Group A) as follow up to 2.6.		3.3	Follow up and update to 2.6 above.	3.3	Follow up details from 2.6 if available or applicable. Details will include drawings showing location of prominent luminaries and mounting methods:	Architect Landscape architect Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
3.4	**Night Sky Light Pollution** Method adopted to prevent stray lights from projecting above horizon and contributing to discomfort glare.		3.4	To minimise night sky light pollution (refer Appendix C) Table C2.4 (shielding standard - good practice guide to minimise sky glow and glare) Table C2.6 (lumens limitation per acre – benchmark to check that landscape lighting design allowance is not exceeded). Images in last 3 pages of Appendix C (good lighting practice guide).	3.4	Concept statement on methods adopted to minimise night light sky pollution. Methods include: (a) Shielding standard (b) Limits to lumens per acre ('lumen cap') (c) Specific statement or drawing showing lamp shielding or focusing especially globe lights or flood lights. Drawings to back-up statement may be submitted if appropriate.	Architect Landscape architect Electrical Engineer Lighting Specialist
3.5	**Listing of Light Source** Listing and description of light sources		3.5	Ascertain compliance to good engineering practice. Fixtures under private maintenance will only require a general listing; whilst fixtures to be handed over for public maintenance should be have detail description and listing.	3.5	For private maintained fixture a general listing on the type of light source. For public maintained fixture (public roads, parks facilities etc) a detail listing with detailed engineering description or specification (details required to be specified by Perbadandan, Engineering Department) should be submitted.	Electrical Engineer Lighting Specialist
3.6	**Lighting Control** Description of lighting control method and the number of different lighting scenes.		3.6	Ascertain degree of lighting control and coordinate with public switched lighting where applicable.	3.6	For private maintained fixture statement on lighting control: (a) Manual/ time switch / light sensor or computer-automated time switching. (b) Provision for connection of façade lighting on separate circuits for possible future connection of separate electrical meter. For public maintained fixture (a) Manual/ time switch / light sensor or computer-automated time switching.	Electrical Engineer Electrical Engineer

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
						(b) Provision of automated control and monitoring. Future detail and liaison with I.T. department of Perbadanan required.	
3.7	**Maintenance Method** A general description of the intended maintenance method (only applicable for public maintained monuments or structure).		3.7	Ensure compliance to Perbadanan maintenance methodology.	3.7	Only for public maintained lighting; a statement listing maintenance methodology: (a) Lamp cleaning interval factor used in calculating luminance or illuminance level. (b) Relamping cycle. (c) Other information required by Perbadanan.	Electrical Engineer Lighting Specialist
4	**KELULUSAN TEKNIKAL (KL)**			**Detail Design Information**			
4.1	**Circuit Diagram** Only applicable for public maintained lighting; full details of circuit of lighting system.		4.1	Integrity of engineering design.	4.1	Submission only applicable for public maintained lighting system: (a) Circuit diagram (b) Feeder pillar design.	Electrical Engineer
4.2	**Lighting Layout** Details of lighting layout.		4.2	Technical compliance with design and to check coordination with façade fixture or street furniture.	4.2	For private maintained light fixture; a simple layout as a follow up to procedure 3.3 above. For public maintained light fixture; details (with drawings where applicable) to be submitted (a) Lighting location and layout; (b) Mounting details; (c) Other details required by Perbadanan	Electrical Engineer Lighting Specialist
4.3	**Luminaire Certification** Only applicable for public maintained lighting; full description of luminaire including submission of ratings, standards and certificates.		4.3	Good engineering practice and technical compliance.	4.3	Only required for public maintained lighting fixtures. Detail engineering submission include (a) Engineering ratings (IP, EMC standards, ballast losses, shielding standard etc)	Electrical Engineer

Item	Description			Objective of Submission	Submission Check List		
						From Developer	Responsible person
						(b) Certification by independent testing laboratory of engineering standards. Components under the control of the Suruhanjaya Tenaga (Jabatan Elektrik) should also be approved.	
4.4	**Detail Lighting Controls** Applicable only for public maintained lighting; a follow up to 3.6.		4.4	To check for coordination with public maintained control and switching.	4.4	Only required for public maintained lighting system; details of lighting controls (if not already described in 4.1). If automation controls are implemented liaison and approval should be sought from Perbadanan (IT department)	Electrical Engineer
5	**CERTIFICATION OF FITNESS (C.F.)**			**Issuance of C.F.**			
5.1	**Pre-Inspection Checklist** Checklist of submission before initiating C.F. inspection.		5.1	To ensure all items complied with before C.F. inspection.	5.1	To compile and submit checklist of approvals before inspection: (a) Landscape (b) Engineering (c) Certification by Electrical Engineer responsible.	Architect as part of overall CF checklist and application for inspection. Electrical Engineer
5.2	**C.F. Inspection** Checklist for C.F. inspection.		5.2	Inspection to ensure compliance to lighting approved plans, design concept and Lighting Masterplan. A checklist of inspection for Perbadanan include: (a) Visual inspection. (b) Types of luminaire. (c) Check for obvious case of light trespass, glare and sky pollution. (d) Witness luminance (cd/m²) or illuminance (lux) measurements. (e) Witness operation check.	5.2	Conduct the following: (a) Visual inspection (b) Luminance measurement (using luminance meter) or illuminance measurement (using illuminance meter) (c) Operation check (switch on all lights, switch on programmed scenes, operational check of controls etc).	Electrical Engineer Lighting Specialist Lighting Supplier or Contractor
5.3	**Recommendation for C.F.** Checklist for recommendation of C.F.		5.3	Final checklist before issuance of C.F.	5.3	For private maintained lighting system: (a) Report of C.F. inspection. For public maintained lighting system: (a) Report of C.F. inspection.	Architect as part of C.F. submission. Electrical Engineer

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
						(c) Compilation of As Built Drawings, Inventory list, Maintenance manuals (manual applicable only for automated controls or new engineering systems) and other engineering details requested by Perbananan. (d) Handing over of keys (feeder pillars) and spare parts.	Lighting Supplier

POLICY 6 – GUIDELINES CHECKLIST FOR: INFRASTRUCTURE APPLICATION

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
1	**SUSUNATUR (SA)**			**Layout Planning Information**			
1.1	**Lighting Principle** Lighting principle for development to tie back to overall objective of Lighting Masterplan		1.1	Simple commitment from developer that lighting system listed will be implemented and in accordance with the Lighting Masterplan.	1.1	Simple statement of lighting concept (a) Large structure (e.g. bridge) is classified as building; in such case (and if structure is also classed as Group A under the Lighting Masterplan) façade lighting submission will be required. (b) Motorways to be lit to appropriate CIE standards. (c) Roads to be handed as public roads (e.g. roads to residential areas) to be lit to appropriate CIE standards.	Planner Architect Civil Engineer Electrical Engineer
2	**MENDIRIKAN INFRASTRUKTUR (MI)**			**Design Development Information**			
				Notes All monuments or large structures referred in this section and classed under Group A will required façade lighting submission under 2.1 to 2.5.			
2.1	**Luminance Range** Range of typical luminance values to be used in the design (Only for monuments/ structures class as group A).		2.1	Indication of lighting concept and to check it match with the Lighting Masterplan.	2.1	Simple statement listing the range of lighting levels to be applied in the lighting design: (a) Large structure classed as Group A – cd/m² to match category and lighting zone.	Architect Civil Engineer Electrical Engineer

Item	Description			Objective of Submission		Submission Check List From Developer	Responsible person
						(b) Roads and motorways – cd/m² in accordance with CIE codes for roads and motorways. (c) Pedestrian areas – lux levels in accordance with CIE codes for pedestrian traffic.	Lighting Specialist
2.2	**Colour Rendering** Range of colour rendering index **and** colour temperature of light source to be used in the design.		2.2	To ensure colour rendering and colour temperature fits in with the ambience prescribed by the Lighting Master plan.	2.2	General statement on colour rendering index and colour temperature to be used in the lighting design.	Architect Electrical Engineer Lighting Specialist
2.3	**Lighting Scenes** Number of anticipated programmed scenes or variations in lighting.		2.3	Ensure coordination with overall programmed lighting scenes in planning.	2.3	General statement listing the programmed scenes such as Normal /After Office Hours/ Festive / High Days /Security etc.	Architect Civil Engineer Electrical Engineer Lighting Specialist
2.4	**Lighting Images** Images showing as accurately as possible proposed lighting scenes of the façade (for structure classed as Group A) at night.		2.5	Image of lighting concept similar to the architectural perspective (only for structure classed as Group A). Lighting image for landscape pertain to general ambience and location of lighting. Special features for landscape lighting should be indicated (e.g. water feature etc).	2.5	Rendered drawings showing perspective or artist concept of the night lighting scene(s). For landscape, drawings similar to landscape layout showing general location of light fixtures and perspective or artist concept of night lighting scene(s) where special feature are included. No images required for roads or motorways.	Architect for structure Civil Engineer Electrical Engineer Lighting Specialist
2.5	**Initial Lighting Images** Images showing as accurately as possible proposed lighting scenes of the building at night.		2.6	To ascertain compliance with design intent described in 2.5 above.	2.6	Submission for luminance or illuminance prediction to comprise computer generated iso-candela or iso-lux mapping or manually calculated maximum, minimum and average luminance values. (a) Elevations of structure (classed as Group A) – Luminance prediction is preferred in the form of iso-candela mapping across the complete elevations or other graphic techniques that show the gradation and peaks of luminance. Alternatively, manually calculated 'spot' maximum and minimum luminance values with an average may be submitted.	Architect for structure Civil Engineer Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
						(b) Landscape areas – iso-candela for monuments and iso-lux for pedestrian areas where applicable. (c) Motorways and roads – iso-candela based on CIE recommendations.	
2.6	**<u>Mounting Methods</u>** Fixing or mounting method adopted to for luminaire (how light fixtures are concealed or integrated into structures classed under Group A)		2.7	To ascertain that light fittings as fixtures or street furniture are not mounted in an obtrusive manner with negative impact on the general visual façade or landscape.	2.7	Statement or drawing describing or location of light fixtures. Mounting methods are as follows (a) Conceal or integrated into onto large structure façade. (b) Surface mounted onto building surface or structure (c) Planted in ground on pole or plinth or on mounting base planted below-ground.	Architect for structure Civil Engineer Electrical Engineer Lighting Specialist
2.7	**<u>Night Sky Light Pollution</u>** Method adopted to prevent stray light from projecting above horizon and contributing to discomfort glare.		2.8	To minimise night sky light pollution (refer Appendix C) Table C2.4 (shielding standard - good practice guide to minimise sky glow and glare) Table C2.6 (lumens limitation per acre – benchmark to check that landscape lighting design allowance is not exceeded). Images in last 3 pages of Appendix C (Good Lighting Practice Guide).	2.8	Concept statement on methods adopted to minimise night time sky light pollution. Methods include: (a) Shielding standard (b) Specific statement or drawing showing lamp shielding or focusing especially globe lights or flood lights. Drawings to back-up statement may be submitted if appropriate.	Architect for structure Electrical Engineer Lighting Specialist
2.8	**<u>Listing of Light Source</u>** Listing and description of light sources		2.9	Ascertain compliance to good engineering practice. Fixtures under private maintenance will only require a general listing; whilst fixtures to be handed over for public maintenance should be have detail description and listing.	2.9	<u>For public maintained facilities</u> (public roads, public facilities etc) a detail listing with detailed engineering description or specification (details required to be specified by Perbadanan, Engineering Department) should be submitted.	Electrical Engineer Lighting Specialist

Item	Description			Objective of Submission		Submission Check List From Developer	Responsible person
2.9	**Lighting Control** Description of lighting control method and the number of different lighting scenes.		2.10	Ascertain degree of lighting control and coordinate with public switched lighting where applicable.	2.10	For public maintained fixture (a) Manual/ time switch / photo cell or computer-automated time switching. (b) Provision of automated control and monitoring. Future detail and liaison with I.T. department of Perbadanan required.	 Electrical Engineer Lighting Specialist
2.10	**Maintenance Method** A general description of the intended maintenance method (only applicable for public maintained monuments or structure).		2.11	Ensure compliance to Perbadanan maintenance methodology.	3.7	For public maintained lighting; a statement listing maintenance methodology: (a) Lamp cleaning interval factor used in calculating luminance or illuminance level. (b) Relamping cycle. (c) Other information required by Perbadanan.	 Electrical Engineer Lighting Specialist
3	**KELULUSAN TEKNIKAL (KL)**			**Detail Design & Installation**			
3.1	**Circuit Diagram** For public maintained lighting; full details of circuit of lighting system.		3.1	Integrity of engineering design.	3.1	For public maintained lightings: (a) Circuit diagram (b) Feeder pillar design.	 Electrical Engineer
3.2	**Lighting Layout** Details of lighting layout.		3.2	Technical compliance with design and to check coordination with façade fixture or street furniture.	3.2	For public maintained light fixture; details (with drawings where applicable) to be submitted (a) Lighting location and layout; (b) Mounting details; (c) Other details required by Perbadanan	 Electrical Engineer Lighting Specialist

Item	Description		Objective of Submission		Submission Check List	
					From Developer	Responsible person
3.3	**Luminaire Certification** For public maintained lighting; full description of luminaire including submission of ratings, standards and certificates.		3.3 Good engineering practice and technical compliance.	3.3	For public maintained lighting fixtures. Detail engineering submission include (a) Engineering ratings (IP, EMC standards, ballast losses, shielding standard etc) (b) Certification by independent testing laboratory of engineering standards. Components under the control of the Suruhanjaya Tenaga (Jabatan Elektrik) should also be approved.	Electrical Engineer
3.4	**Detail Lighting Controls** For public maintained lighting; as follow up to 2.10		3.4 To check for coordination with public maintained control and switching.	3.4	For public maintained lighting system; details of lighting controls (if not already described in 3.1). If automation controls are implemented liaison and approval should be sought from Perbadanan (IT department)	Electrical Engineer
4	**MENGAMBIL ALIH (M.A.)**		**Handing Over Infrastructure**			
4.1	**Pre-Inspection Checklist**		4.1 To ensure all items complied with before handing over inspection.	4.1	To compile and submit checklist of approvals before inspection: (a) Landscape (b) Engineering (c) Certification by Electrical Engineer responsible.	Engineer concerned as part of overall handover checklist and application for inspection. Electrical Engineer
4.2	**Handing Over Inspection** Checklist for handing over inspection.		4.2 Inspection to ensure compliance to lighting approved plans, design concept and Masterplan. A checklist of inspection for Perbadanan include: (a) Visual inspection. (b) Types of luminaire. (c) Check for obvious case of light trespass, glare and night sky light pollution. (d) Witness luminance (cd/m²) or illuminance (lux) measurements.	4.2	Conduct the following: (a) Visual inspection (b) Luminance measurement (using luminance meter) or illuminance measurement (using illuminance meter) (c) Operation check (switch on all lights, switch on programmed scenes, operational check of controls etc).	Electrical Engineer Lighting Specialist Lighting Supplier or Contractor

Item	Description			Objective of Submission		Submission Check List From Developer	Responsible person
				(e) Witness operation check.			
4.3	**Acceptance Checklist** Checklist before official acceptance or taking over.		4.3	Final checklist before acceptance or taking over.	4.3	For public maintained lighting system: (a) Report of Handing Over inspection. (b) Compilation of As Built Drawings, inventory list, Maintenance manuals and other engineering details requested by Perbananan. (c) Handing over of keys (feeder pillars) and spare parts.	Engineer concerned as part of taking over submission. Electrical Engineer Lighting Supplier

POLICY 6 – DETAIL GUIDELINES CHECKLIST FOR: SIGNAGE

Item	Description			Objective of Submission	Submission Check List		
						From Developer	Responsible person
1	**MENDIRIKAN PAPAN TANDA (MS)**			**Design Information**			
1.1	**Limitation to Luminance** Maximum luminance values to be used in the design		1.1	Indication to confirm lighting level (luminance) do not exceed recommended level in Lighting Masterplan.	1.1	Simple statement confirming that luminance level will not exceed the maximum value prescribed in the Lighting Masterplan.	Signage Contractor Lighting Specialist
1.2	**Construction Drawing** Construction drawing of proposed signage showing lighting in or on signage.		1.2	Mounting and type of lights do not contribute to night sky light pollution, glare and light trespass (especially for large signage)	1.2	Construction drawing(s) of signage showing including details of light fixtures (mounting and types).	Signage Contractor Lighting Specialist
1.3	**Luminance Forecast** Luminance forecast (maximum & average) of signage façade in iso-candela (for large signage).		1.3	Maximum luminance do not exceed prescribed limit	1.3	For large signage only (exceeding $4m^2$ (a) Elevations of structure – Luminance prediction is preferred in the form of iso-candela mapping across the complete elevations or other graphic techniques that show the gradation and peaks of luminance. Alternatively, manually calculated 'sport' maximum and minimum luminance values with an average may be submitted.	Signage Contractor Lighting Specialist
1.4	**Night Sky Light Pollution** Method adopted to prevent stray light from projecting above horizon and contributing to discomfort glare (for large signage only – exceeding $4m^2$		1.4	To minimize night sky light pollution (refer Appendix C) Table C2.4 (shielding standard – good practice guide to minimize sky glow and glare) Images in last 3 pages of Appendix C (good lighting practice guide).	1.4	For large signage only (exceeding $4m^2$), concept statement on methods adopted to minimize night sky light pollution. Methods include :- (a) Shielding standard (b) Specific statement or drawing showing lamp shielding or focusing flood lights. Drawings to back-up statement may be submitted if appropriate.	Signage Contractor Lighting Specialist

Item	Description			Objective of Submission		Submission Check List	
						From Developer	Responsible person
2	**APPROVAL**			**Issuance of Approval**			
2.1	**Pre-Inspection Checklist** Checklist of submission before initiating hand-over inspection.		2.1	To ensure all times complied with before handing over inspection.	2.1	To compile and submit checklist of approvals before inspection. (a) Planning approval (b) Request for inspection.	 Signage Contractor Lighting Specialist
2.2	**Approval Inspection** Checklist for inspection. Inspection may only be carried out on large signage and unipole.		2.2	Inspection to ensure compliance to lighting approved plans, design concept and Lighting Masterplan. A checklist of inspection for Perbadanan include : (a) Visual inspection. (b) Types of luminaire (c) Check for obvious case of light trespass, glare and sky pollution. (d) Measure luminance (cd/m^2) for large signage. Smaller signage may not require inspection.	2.2	Conduct the following : (a) Visual inspection (b) Operation check (switch on all lights, switch on programmed scenes, operational check of controls etc). © Operation check (switch on all lights, switch on programmed scenes, operational check of controls etc).	 Signage Supplier Lighting Specialist Lighting Supplier or Contractor
2.3	**Pre Approval Check List** Post inspection checklist before official approval.		2.3	Final checklist before approval.	2.3	Report of Approval inspection for large signage.	Owner Lighting Supplier

POLICY 7:

Minimise night sky light pollution by requiring good lighting design practice, accurate equipment specification and concise aiming of installed lighting.

In the international arena there is a growing realisation that outdoors lighting which are not well designed (and especially over-designed) and properly installed is harmful to the nighttime environment. The nighttime skies of cities are increasing being suffused with a glow, which degrade the clarity of the night sky and the stars. Badly designed light fixtures and lighting design contribute to the spillage of lights into the nighttime sky. Associated issues include glare (which cause visual discomfort), light trespass (which intrude into the privacy of neighbouring lots) and wastage of energy which are environmental concerns.

As noted in section 1.4.4 and Appendix A (Preliminary Lighting Survey) of night time sky pollution, glare and poor lighting design are already cause for concern in Putrajaya.

Appendix C contains guidelines on good practice in minimising night time sky pollution.

Recommendations:

1. ***To comply with internationally established environmental guidelines to eliminate or limit the escape of light directed to the sky.***
2. ***To minimise the creation of glare.***
3. ***To achieve optimum lighting design quality through the appropriate selection of lighting equipment.***

POLICY 8:

Establish maximum limits on the luminance of internally and externally illuminated advertising and signage.

The Signage and Advertisement Design Guidelines for Putrajaya whole of Putrajaya are assumed to be typical for all other areas. This document defines the type of luminaires that are recommended for internal and external lighting of signage. These range from 21-watt T5 linear fluorescent lamps for internally illuminated signs to 400-watt metal halide lamps with a colour temperature of 6000 K. No indication of target surface luminance is provided.

The (Advertising) Control Policies and Guidelines – (Planning and Design Performance Requirement section – Paragraph 2.10.1 (iv) states:

'Illumination
The method of illumination of all types of signs is as an important design element. The intensity of illumination may cause visual distraction, nuisance glare or hazard. Perbadanan Putrajaya shall determine from time to time any required measures necessary to reduce possible negative impacts on adjacent building, roads or surrounding land uses.

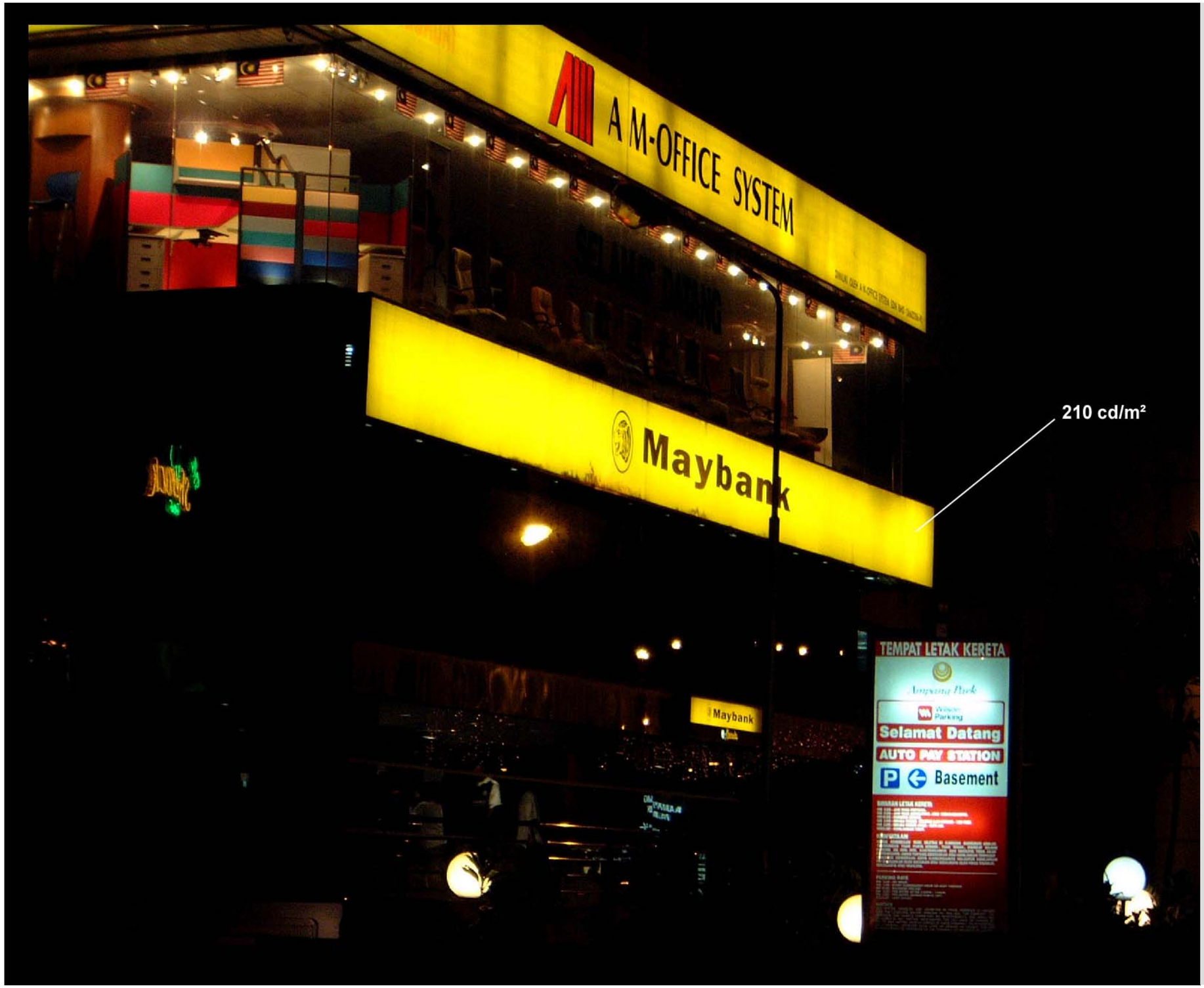
It is recommended that the maximum luminance is for internally and externally illuminated advertising and signage is as follows: -

- 200 cd/m² for Core Island (Precinct 2, 3 & 4) and Precinct 5 & 6
- 150 cd/m² for all other areas

The foregoing luminance value are the maximum value. This should be considered within the context of the lighting levels relating to the surround of the signage. A sensitive approach should be adopted to achieve a satisfactory balance between the brightness of the signage and that of its surrounding.

Recommendations:

1. ***To ensure that the brightness of illuminated advertising is controlled in relation to the brightness of surrounding lighting elements.***



Advertising Signage – Good Example

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Figure 2.1.8



Advertising Signage –Bad Example

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Figure 2.1.8

POLICY 9:

In residential areas street lighting columns should be of a height that is sympathetic to the scale of adjacent buildings but should not, under any circumstance, be higher than the height of such buildings.

Policy Objectives:

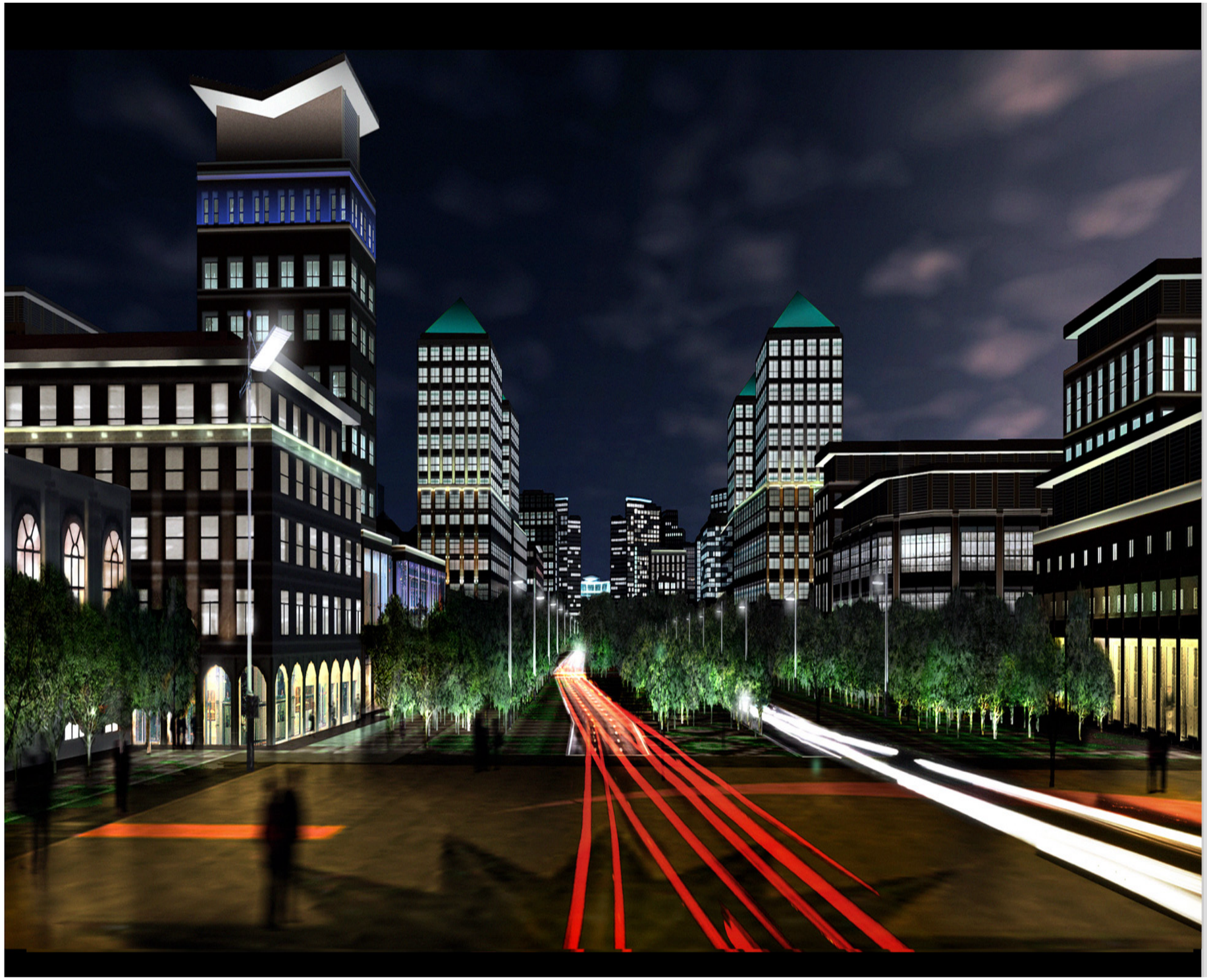
1. To minimise light trespass to the interior areas of private residences that bound the street. This is particularly aimed at ensuring that street lighting does not excessively intrude into the upper windows of residences which are normally those associated with bedrooms.

2. To create a sense of domestic residential scale in areas of low rise dwellings

3. To minimise glare created by street lighting.

It is recognised that the use of lower height columns is commensurate with tighter centre-to-centre spacing of columns. It is also commensurate with the use of lower wattage light sources at each column position. The increase in the number of columns within a given length of street is justified in relation to achieving the foregoing objectives.

Generally, streets in low-rise residential areas should be lit from 6 - 9 metre columns whilst those in high-rise residential areas can continue to be lit from 12 metre columns, as is the case throughout the initially established residential areas.



Central Boulevard Looking South From Dataran Putrajaya

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Figure 2.1.8



Typical Luminance Prediction

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Figure 2.1.8

SECTION 3 – DESIGN GUIDELINES FOR INDIVIDUAL ELEMENTS

3.1 DESIGN GUIDELINES FOR INDIVIDUAL ELEMENTS

3.1.1 Introduction

The following is a guideline to the lighting design opportunities that are offered by the design of the physical city as currently mid 2002 defined. These opportunities represent what is possible and desirable; they should be considered as benchmarks for the future lighting design opportunities that will continue to arise as the detailed design of the remainder of the city emerges.

3.1.2 Core Island Lighting Design Approach – Central Boulevard and Surrounding Buildings

- In order to achieve the objectives of Policy 1 it is recommended that the lighting to the vehicle surface of the Central Boulevard be based on the use of a light source with a high colour temperature and good colour-rendering characteristic. Typically, the source should have a colour-rendering index of not less than R^a 85 and colour temperature range of 4500K to 5300K. The use of this type of source will produce light of a cool white appearance that will contrast strongly with the lighting of the roads and streets that feed into the Central Boulevard. These should lit by light sources of warmer colour appearance with a colour temperature of 2800K to 3500K with a colour- rendering index of not less than R^a85. Correspondingly, the Central Boulevard will be strongly identified and characterised at night in relation to the network of surrounding roads and streets. Drawing 1.2.1 illustrates the overall roads and street lighting of the Core Island in relation to the lighting of roads and streets in surrounding Putrajaya. It is acknowledged that conventional roadway illuminating engineering practice favours the use of the high-pressure sodium light source. This is evidenced by its nearly universal application throughout the roads and streets of Putrajaya as constructed to date (April 2002) and its wholesale use in cities worldwide. However, being a new city, Putrajaya requires to examine cutting edge technology and the thinking that lies behind it. In the case of metal halide (HQI or British nomenclature: MH) versus high-pressure sodium (NAV or SON) there are two factors to be considered: colour characteristics and the performance of the human eye. These factors are examined in detail in Appendix D.

- Contrast the 'cool' character of the lighting of the Central Boulevard roadway lighting with the pedestrian lighting of a warmer appearance. Pedestrian lighting sources are recommended to be of warmer colour appearance with a colour temperature of 2800K to 3500K and a colour- rendering index of not less than R^a85.

- Increase Central Boulevard roadway luminance by approximately 50% to mark festive and ceremonial nights i.e. from 2 to 3 cd/m^2

- Use colour Luminous Emitting Diode (LED) clusters located at the top of the main roadway lighting columns to identify the Central Boulevard as a Protocol Road.

- The series of colonnades at ground level provides a unifying element to the Central Boulevard. In the case of those buildings that include such collonading, the lighting of the interior of these should be designed on a consistent basis from one building to the next. A luminance of between 10 and 15 cd/m^2 should be established. The light source colour temperature to be approximately 3000K with good colour rendering of not less than R^a 80.

Recommendations:

1. ***Light Central Boulevard roadway with 4500K-5300K, >R^a85 light sources***
2. ***Light Central Boulevard pedestrian lighting with 2800K-3500K, R^a85 light sources***
3. ***Increase Central Boulevard roadway lighting levels by 50% from normal code levels for festive and state occasions from 2 – 3 cd/42***
4. ***Mark Boulevard as Protocol Road by use of colour LED on road columns***
5. ***Light colonnades with c.3000K, R^a85 light sources to 10-15cd/m^2***
6. ***Light roof cornices where appropriate and possible***
7. ***Main Dataran Putrajaya Plaza level increase up to 10-12 cd/m^2 for Processional Events.***

- The rooflines of a number of the planned buildings and those under construction provide a further opportunity for visual unification.

- Linear uplighting to the cornices will emphasise the linear axial nature of the Central Boulevard at night. Such uplighting should be included wherever the opportunity occurs.

- The more intimate nature of the smaller east-west cross streets and other minor streets should be characterised at night by street lighting that is based on the use of a warm appearance light source with a colour temperature of 2800K to 3500K with a colour-rendering index of not less than R^a85.

- During state and festive periods:
  - Introduce colour to Central Boulevard colonnades – to provide pedestrian level awareness.
  - Introduce colour to Central Boulevard roofline punctuation – to provide distant/long view awareness.
  - Illuminate temporary structures.
  - Increase Central Boulevard road lighting light levels by 50% in relation to normal levels i.e. from 2 cd/42 to 3 cd/42

- Trees and other landscape planting should be contrasted with their surroundings through the use of good colour rendering metal halide light sources. The colour temperature of such sources should be selected to emphasise the colour of the planting e.g. green/blue-green foliage will benefit from high colour temperature light (4000K+) whilst planting that displays yellow/orange/red colouration will be optimised by the use of lower colour temperature light at not more than 3000K. If fluorescent light sources are used in preference to metal halide sources, the same colour temperature considerations apply.

- Light sources used to light building elevations on the Central Boulevard should include low colour temperature metal halide, fluorescent (compact and linear), mercury vapour and 'white high pressure sodium'. The use of high-pressure sodium should be avoided due to its lack of good colour rendering properties and its major use in the lighting of roadways. Lighting should distinguish buildings from their surroundings at night both in terms of local and distant views. Many will view the Core Island and the distant Central Boulevard buildings from remote locations where the ambient lighting is based on high-pressure sodium light sources. The combined use of high-pressure sodium and cool metal halide light sources directed at a common surface is acceptable.

- The Central Boulevard node points or Datarans (as shown in Figure 3.1.1, 3.1.2 and 3.1.3) present a major challenge in road and plaza lighting terms. The main requirement is to provide the requisite level of road lighting across the full extent of the plaza that each Dataran represents without imposing the presence of numerous lighting columns that would effectively bisect the Dataran in visual terms.

It is proposed that the illumination of **Dataran Putrajaya** be based on the use of a cellular mirror reflector system. The illustration of the illumination is demonstrated in Figure 3.1.4 and 3.1.5. This is an established technology that has the key advantage of providing sufficient levels of lighting without creating high levels of glare. The system was originated for the lighting of airport airside apron areas without creating disability glare to flight deck crews at night.

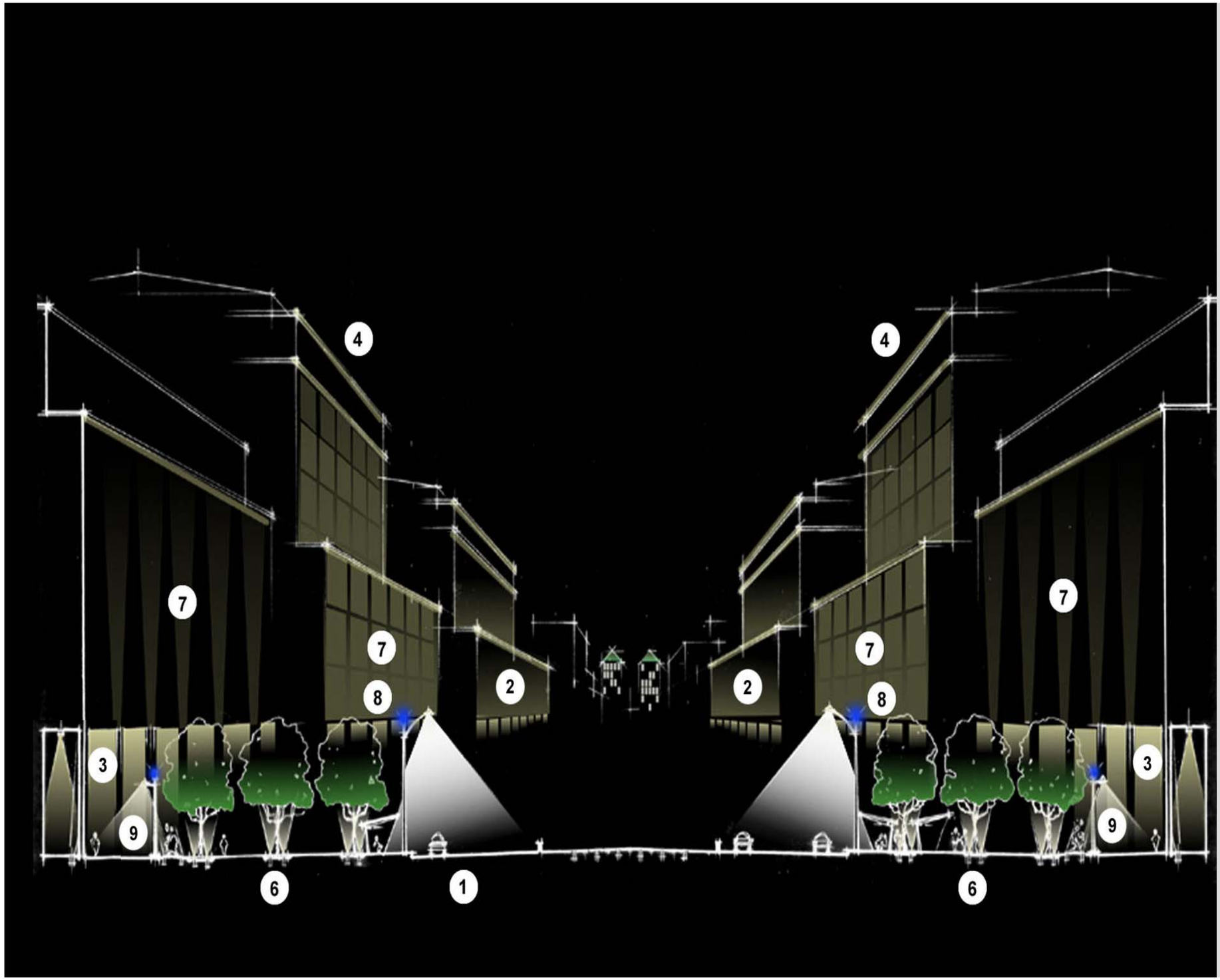
Recommendations:

1. ***Secondary roads to be illuminated with 2800k – 3500k, $>R^a85$ light source.***
2. ***Trees and other landscaped planting to emphasise green/blue-green foliage with 4000 k+ and planting with yellow/orange/red colouration with less then 3000k.***
3. ***High pressure sodium to light building elevations to be avoided.***
4. ***Dataran lighting to provide illumination across the full extent of the plaza.***
5. ***Dataran Putrajaya illumination to use cellular mirror reflector system.***

The current (2002) lighting of **Dataran Putra** creates a considerable level of glare and night sky light pollution. It is proposed that this problem be overcome through the re-engineering and re-design of the existing luminaires to ensure that these direct light to angles only below horizontal, which is illustrated in Appendix E (see appendix E: Example of photometric study using cellular mirror reflector system). The resulting lack of adequate lighting levels to the outer part of the Dataran could be resolved through the introduction of a second, outer, circle of road lighting columns and luminaires of a similar design to those in the central area.

Recommendations:

1. ***Dataran Putra to consider reengineering and redesign to existing luminaires.***



Central Boulevard Normal Operation

1. Central Boulevard illuminated utilisiing lamps within range 4500 K – 5300 K with CRI Ra > 85

2. Buildings lit according to hierarchy- Group A Buildings to be brightest (to be categorised as buidings or groups of buildings, structures or other elements that form vista terminations, landmarks when viewed from major distances, or are categorised as landmarks buildings in DUD documents.)

   Group B buildings to be lit less brightly (to be categorised as buildings that form thestreetwall between Group A buildings on Central Boulevard)
3. Colonnade unified with a consistency of colour and source.

4. Roofline punctuation zone unified with consistency of colour and space.

5. Trees and landscape features illuminated utilising green/blue green – 4000K and yellow/orange/red – 3000K

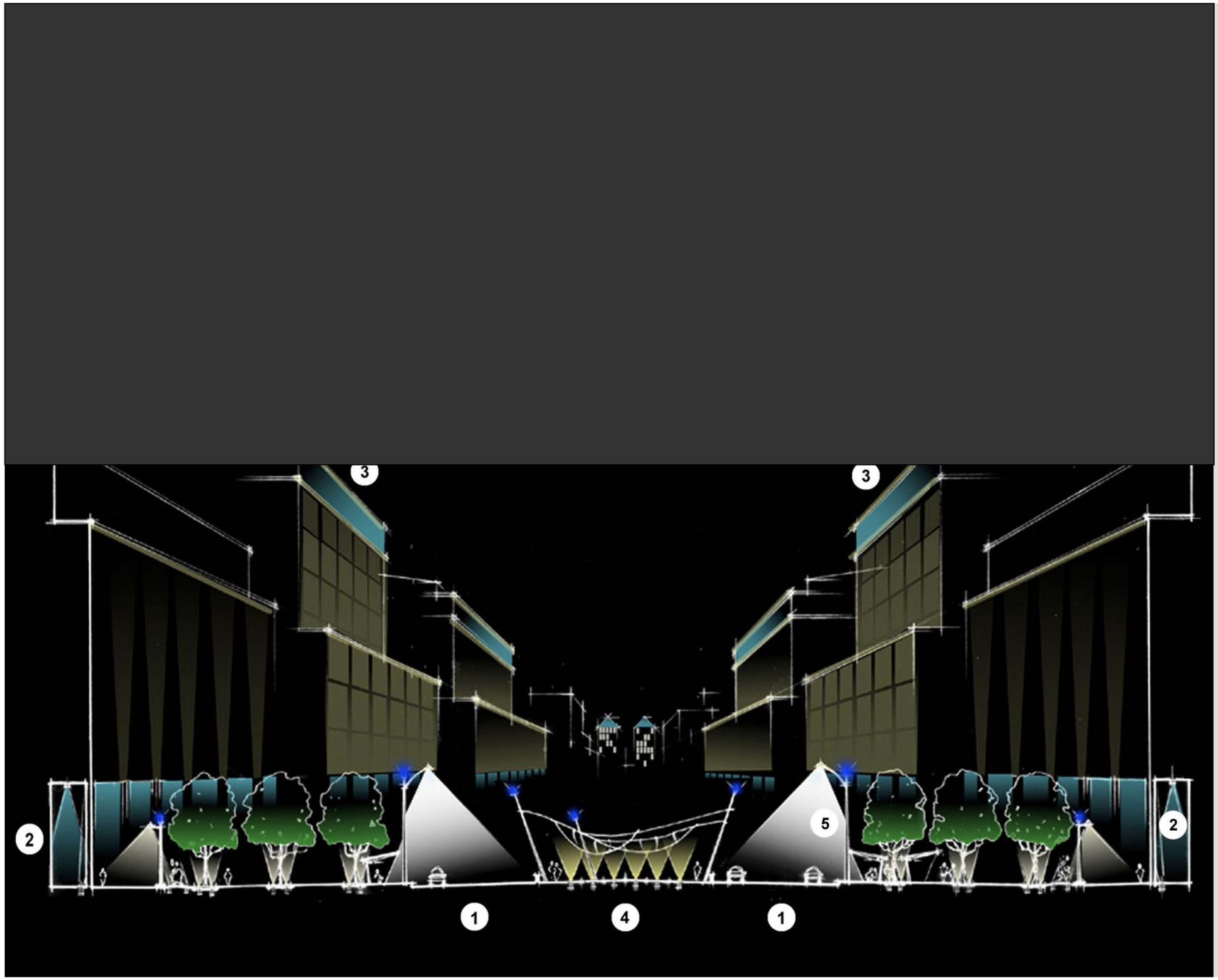
6. Metal Halide, Fluorescent, mercury vapour, white high pressure sodium to be utilised for illuminating building facades.

7. Beacons mounted to top of streetlight columns denoting ‘protocol road’ status.

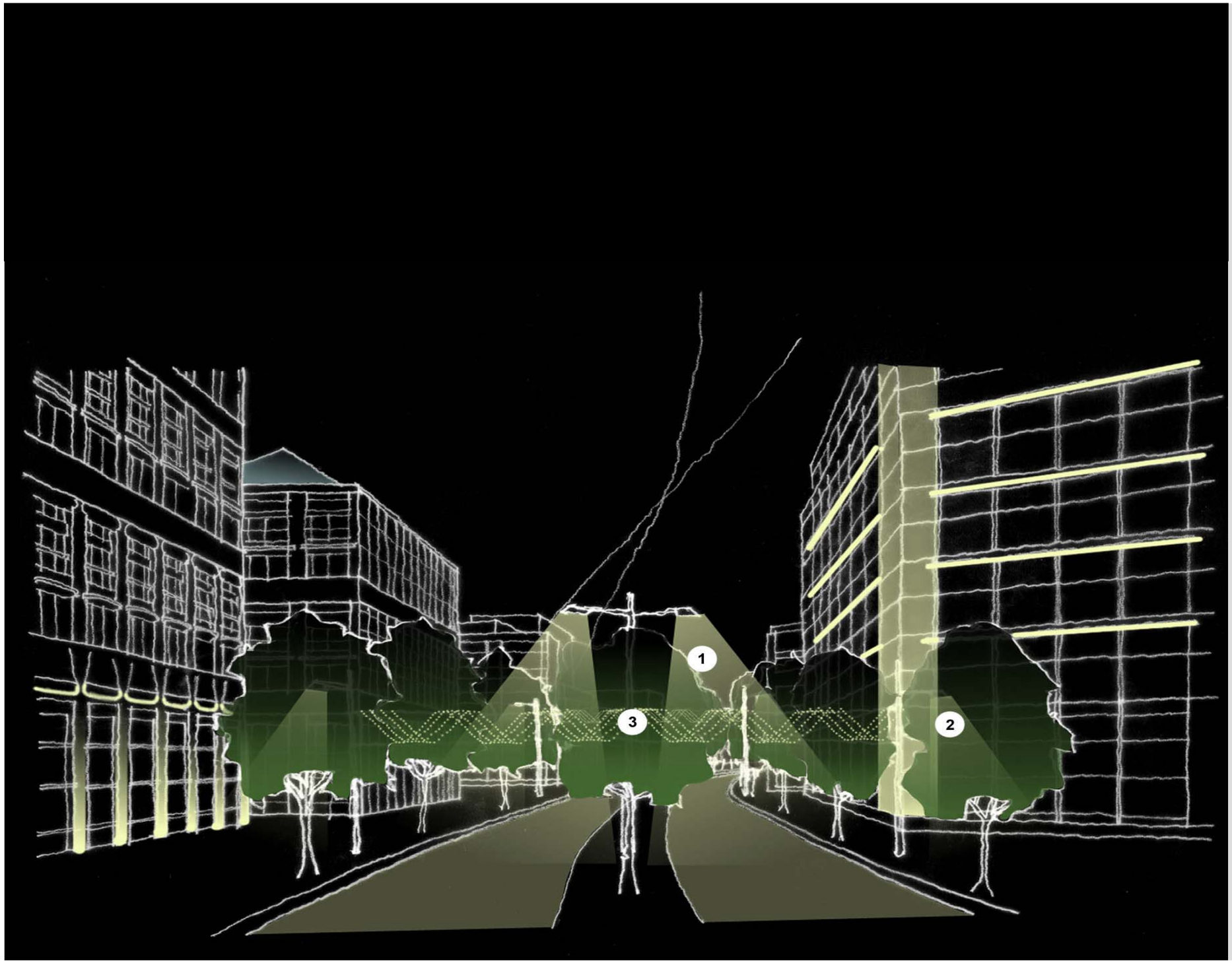
8. Safe lighting levels to pedestrian areas.

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Figure 2.1.8

Central Boulevard Festive Operation



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Figure 2.1.8



Secondary Streets

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Figure 2.1.8

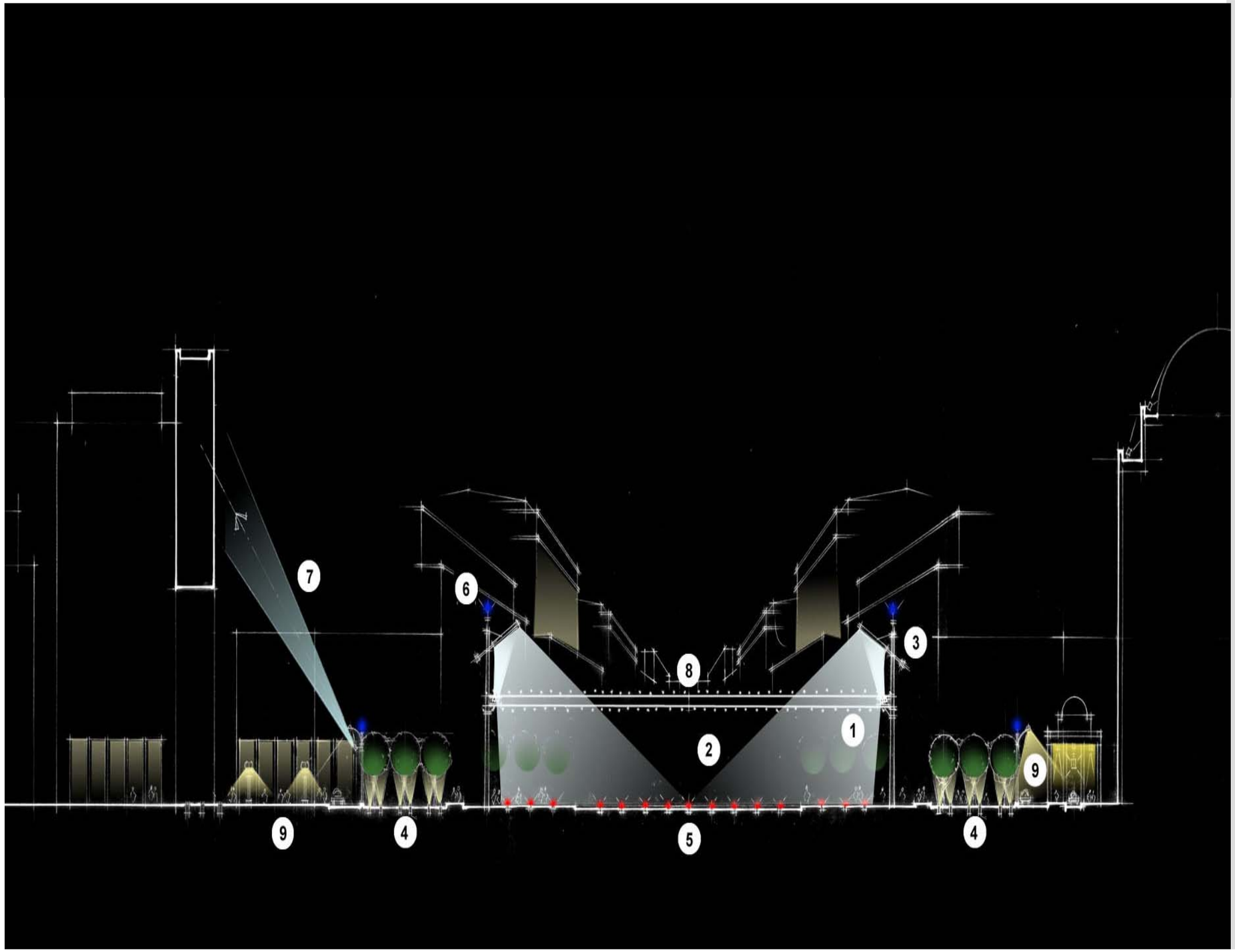
- **Dataran Wawasan** (refer to Figure 3.1.6) is designed in a manner that ensures that gathering and assemblies will take place in the landscaped plaza area to the west of the vehicular Boulevard. In view of this, the current (April 2002) design of the carriage way lighting comprising a total of 9, 12 metre, columns of the same design as is being used throughout the entire length of the central Boulevard, should be adopted.

- **Dataran Rakyat** (refer to Figure 3.1.7)

- **Dataran Gemilang** (refer to Figure 3.1.8)

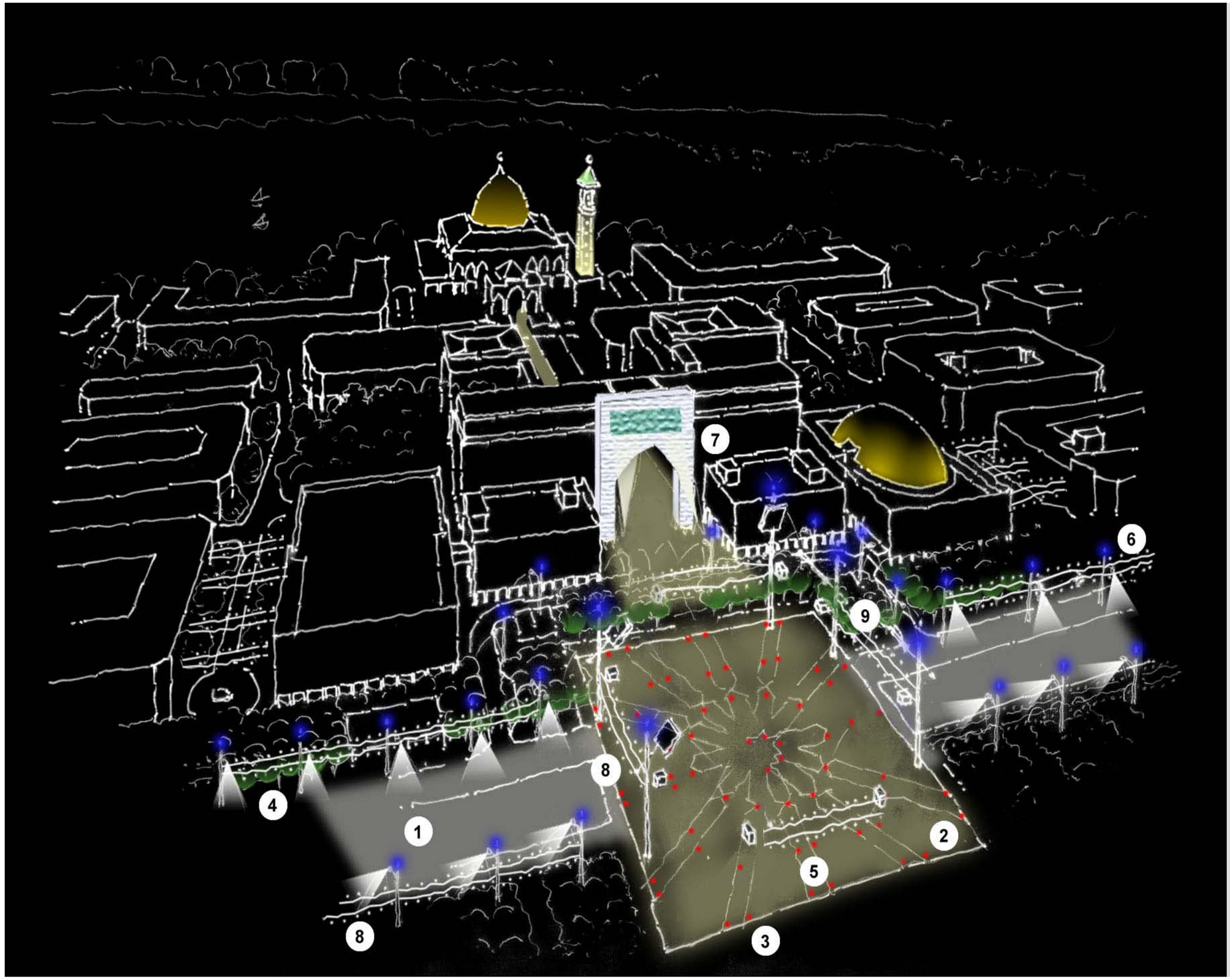
Recommendations:

1. ***Light Dataran Wawasan carriageway with conventional column mounted luminaires in normal kerbside locations***
2. ***Dataran Rakyat***
3. ***Dataran Gemilang***



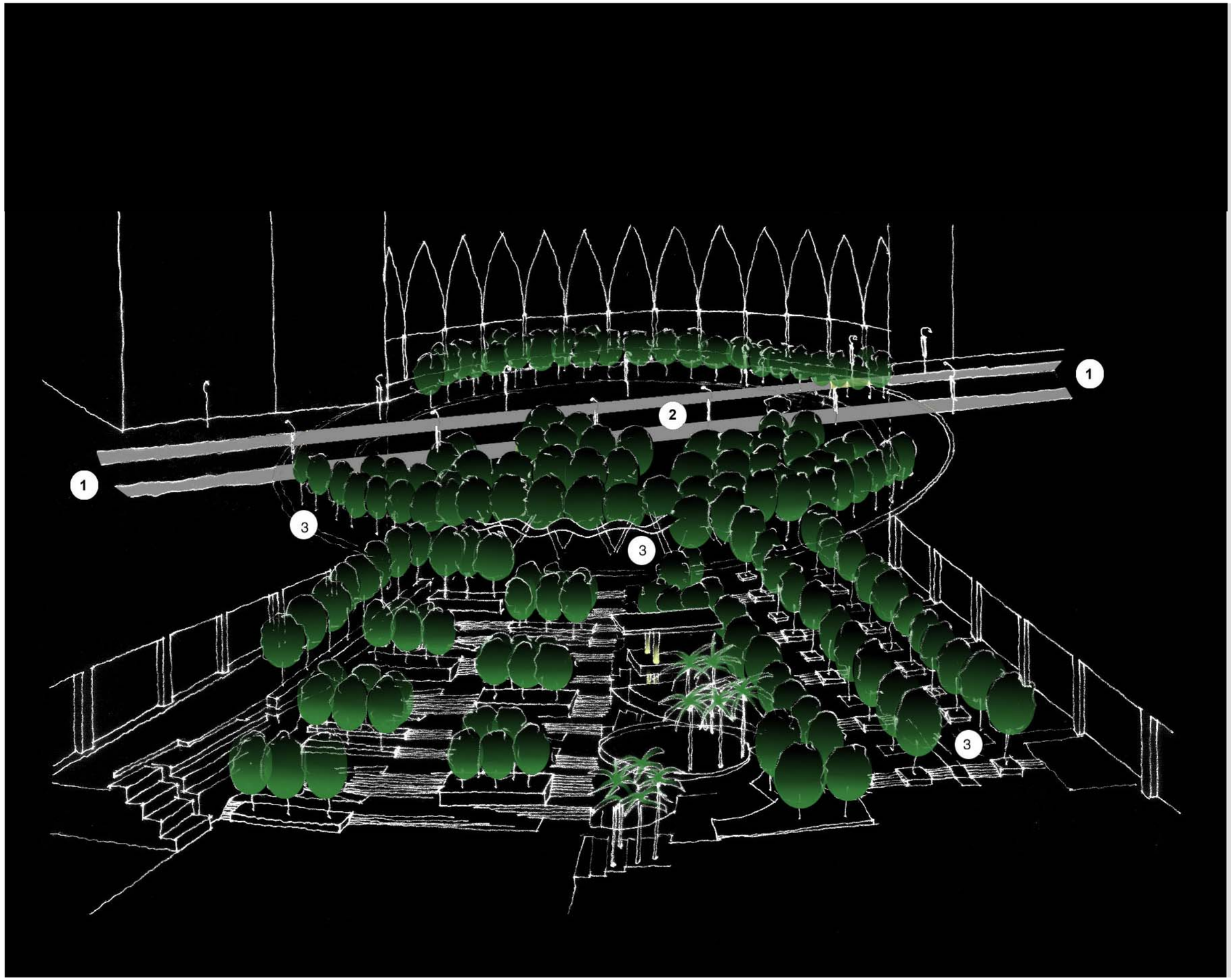
Dataran Putrajaya Section

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Figure 2.1.8



Dataran Putrajaya

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Figure 2.1.8



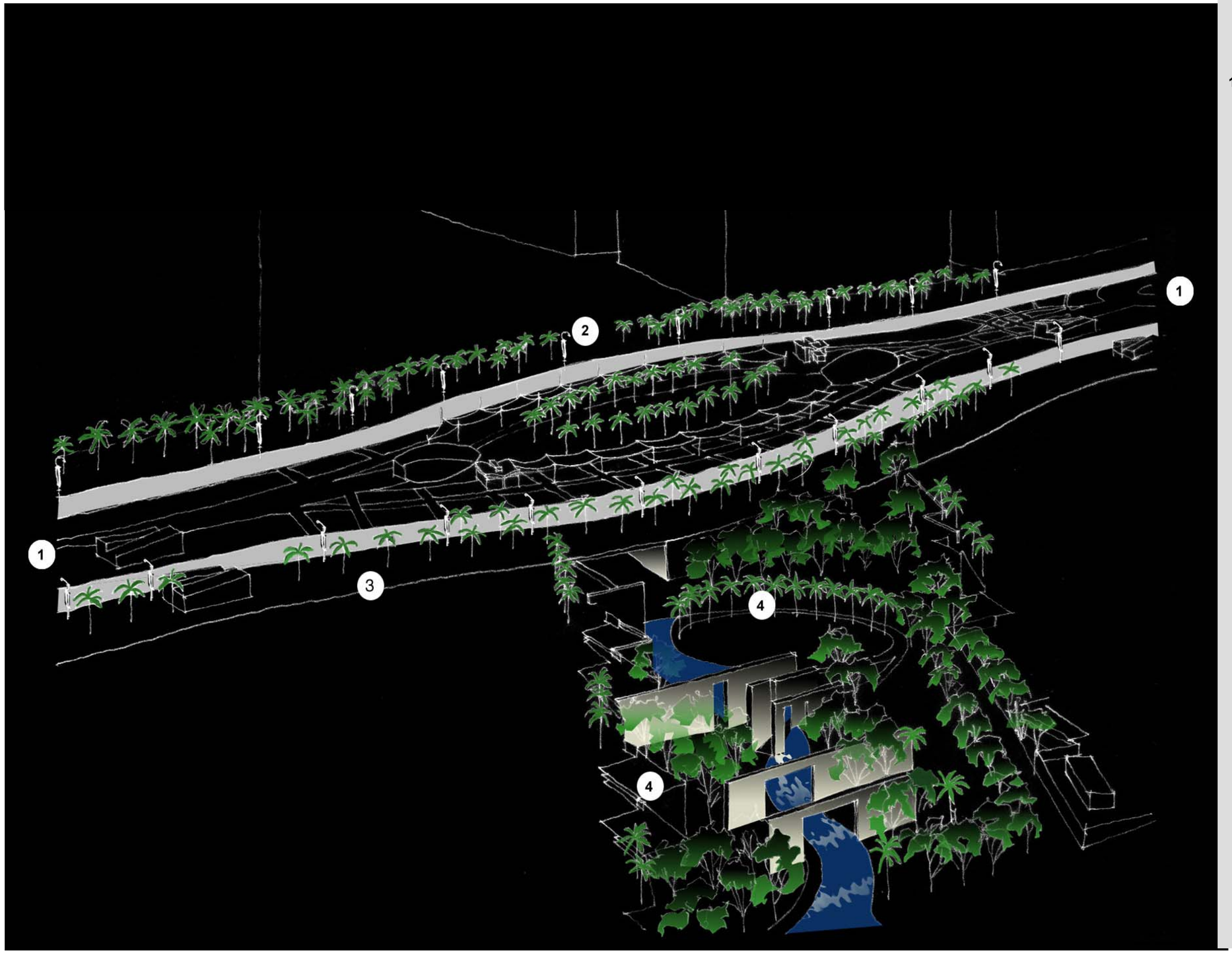
Dataran Wawasan

2. Central Boulevard Illuminated utilising lamps within range 4500 K – 5300 K with CRI Ra > 85

3. Streetlighting columns continue through dataran illuminating streets below

4. Trees and landscape features illuminated utilising lamps within range 4500 K-6000K with CRI Ra > 85

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Figure 2.1.8



Dataran Rakyat

1.

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Figure 2.1.8

3.2 LIGHTING TO BUILDINGS THROUGHOUT PUTRAJAYA

- Establish a hierarchy of buildings in terms of lighting 'brightness' or luminance to exemplify their relative importance and stature at night, as illustrated in Drawing 3.2.1: This hierarchy applies to buildings, structures, monuments and other lit elements throughout Putrajaya. Luminance is the product of incident lighting levels, or illuminance measured in lux, and the reflection factor of the surface upon which the incident light falls. Luminance, expressed in candela/m² is a more important measure than illuminance since it is a metric of what the eye actually sees.

- The following recommended luminance values are based on British work carried out in the mid 1990's and published by the Institution of Lighting Engineers (ILE) and the Chartered Institute of Building Engineers (CIBSE) Lighting Division (now the Society of Light & Lighting). The values have been increased in the case of Group A buildings to take account of differing cultural attitudes to brightness between Europe and Malaysia.

Group A – Buildings, groups of buildings, structures or other elements that form vista terminations, landmarks when viewed from major distances, nodal points, or are categorised as landmark buildings in DUD documents. The majority of Group A buildings will be located on the Core Island and within Precinct 1.

Lit to average luminance of 20-50 cd/m^2 with a maximum of 200cd/m² (refer to Figure 3.2.1)

Group B – Buildings that form the 'street wall' between Group A buildings on Central Boulevard, buildings of particular architectural note, structures, landmarks, key buildings in regional centres and other elements.

Lit to average luminance of 10-25 cd/m^2 with a maximum of 150cd/m² (refer to Figure 3.2.2)

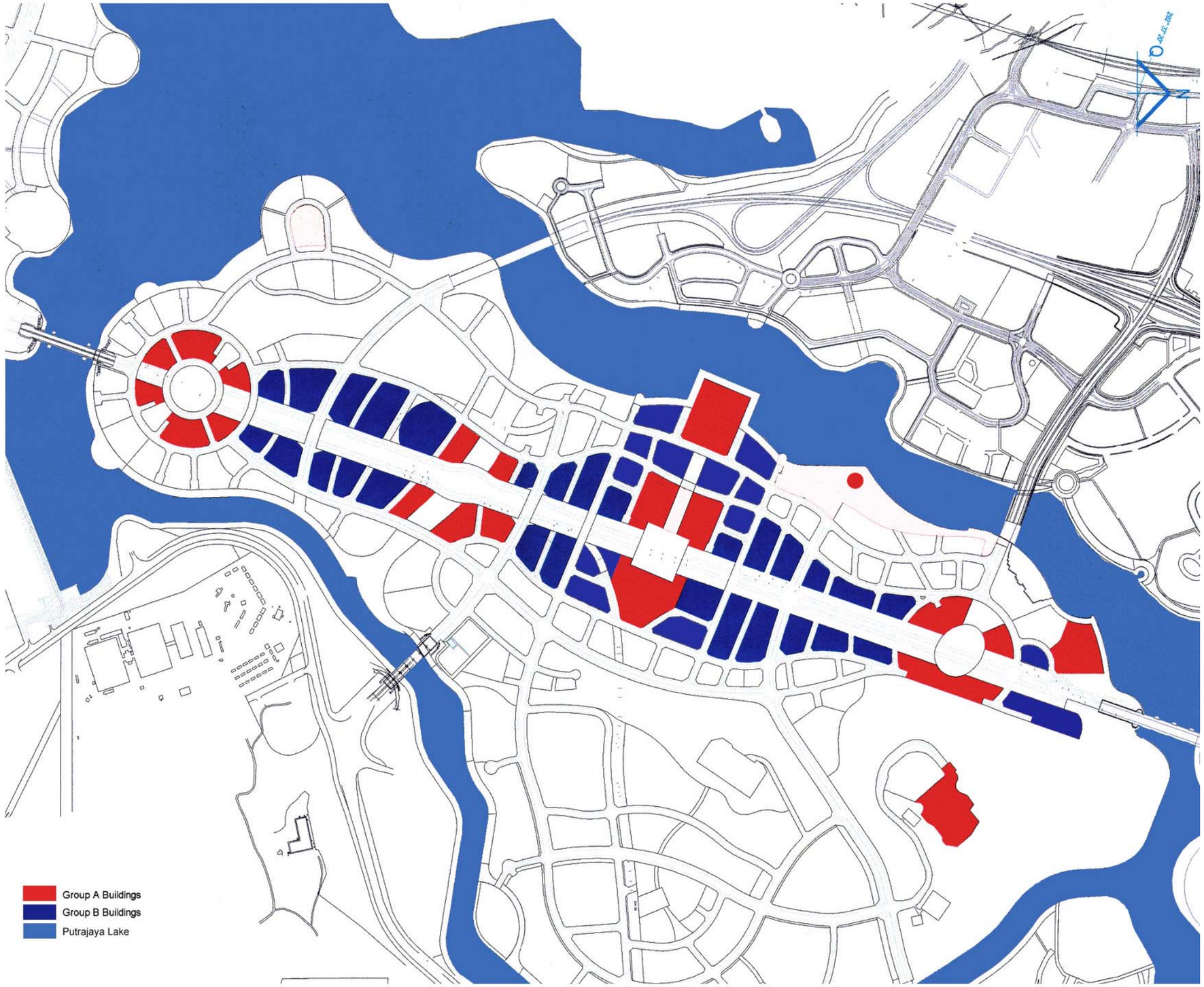
Group C – All remaining buildings, structures and elements that justify lighting for civic, architectural or commercial reasons.

Lit to average luminance of 5-10 cd/m^2 with a maximum of 60 cd/m^2 (refer to Figure 3.2.3)

Figure 3.2.4, 3.2.5, 3.2.6, 3.2.7 and 3.2.8 illustrate some examples of good lighting practice.

Recommendations:

1. ***Categorise buildings into 3 lighting 'brightness' groups to signify status and function within urban plan.***
2. ***Plan lighting installations on the basis of using predicted luminance (cd/m²) values rather than illuminance (lux) values***



Hierarchy of Building in Luminance/' Brightness'

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Figure 2.1.8

Precinct 5 Building Category

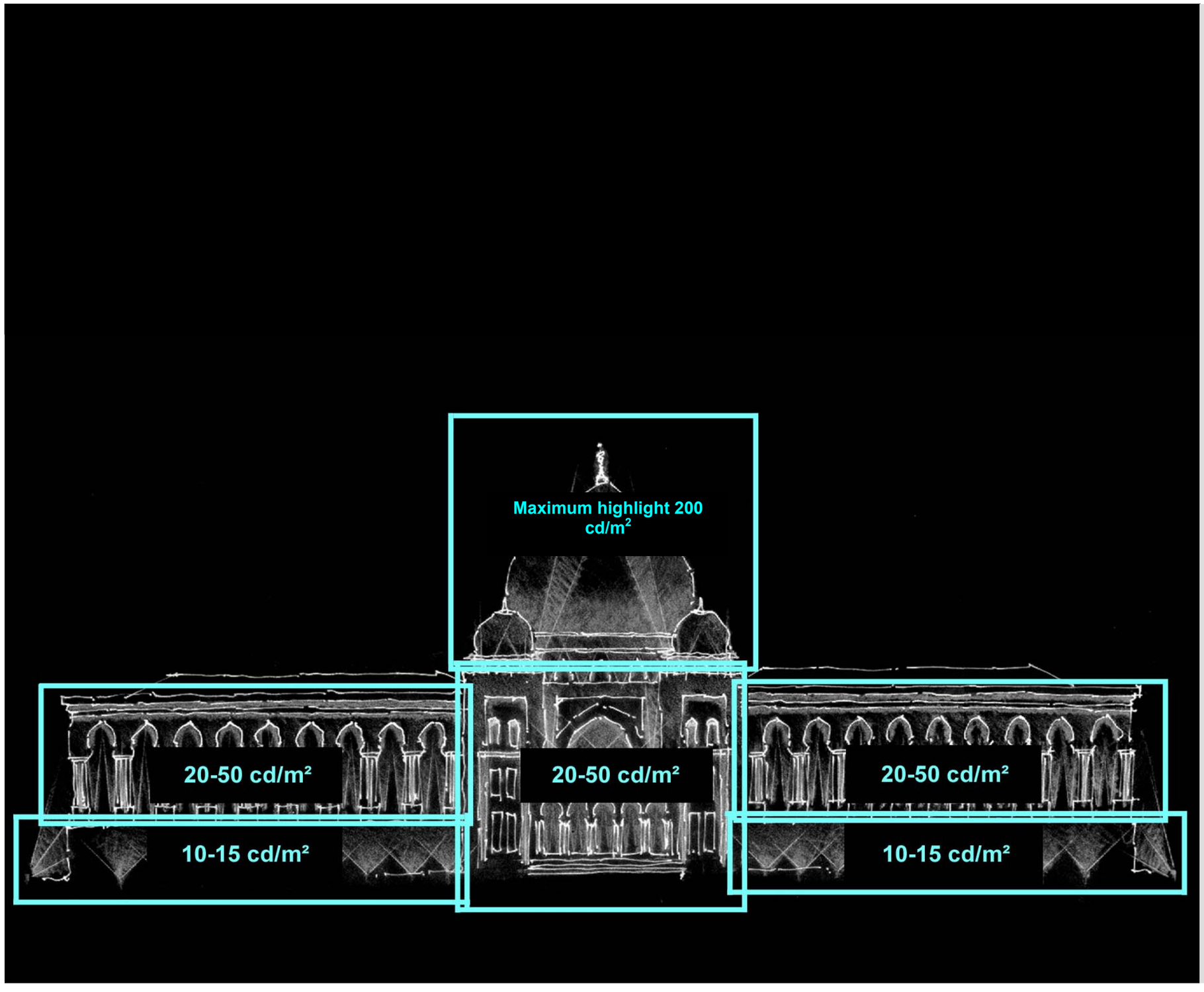


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Figure 2.1.8

Precinct 7 & 8 Building Category



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Figure 2.1.8

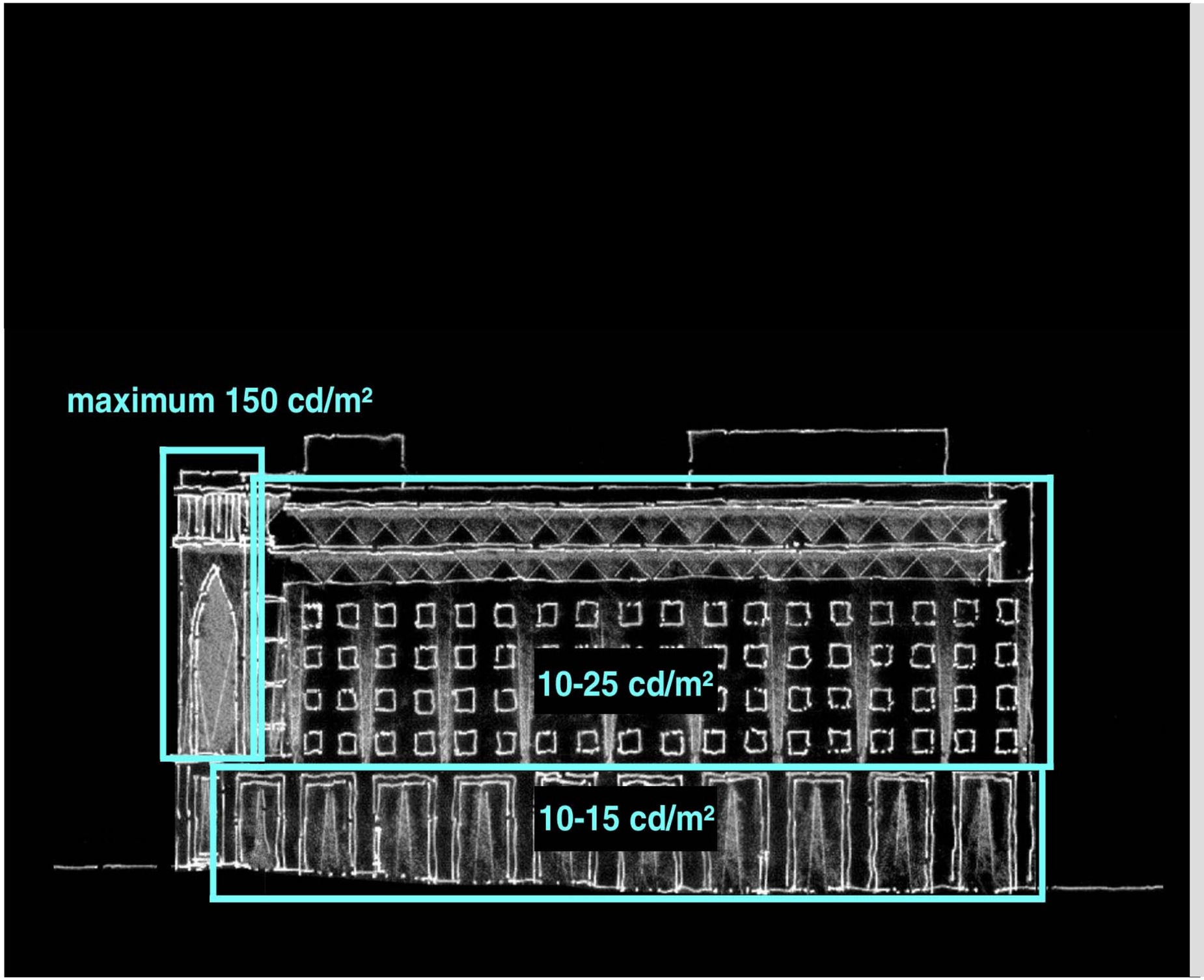


Group A Buildings

Buildings or groups of buildings that form landmarks when viewed from a major distance, vista terminations, nodal points or buildings which are categorised as landmark buildings in the DUD document, to be lit to an average luminance of 20 – 50 cd/m2 with a maximum of 200 cd/m2

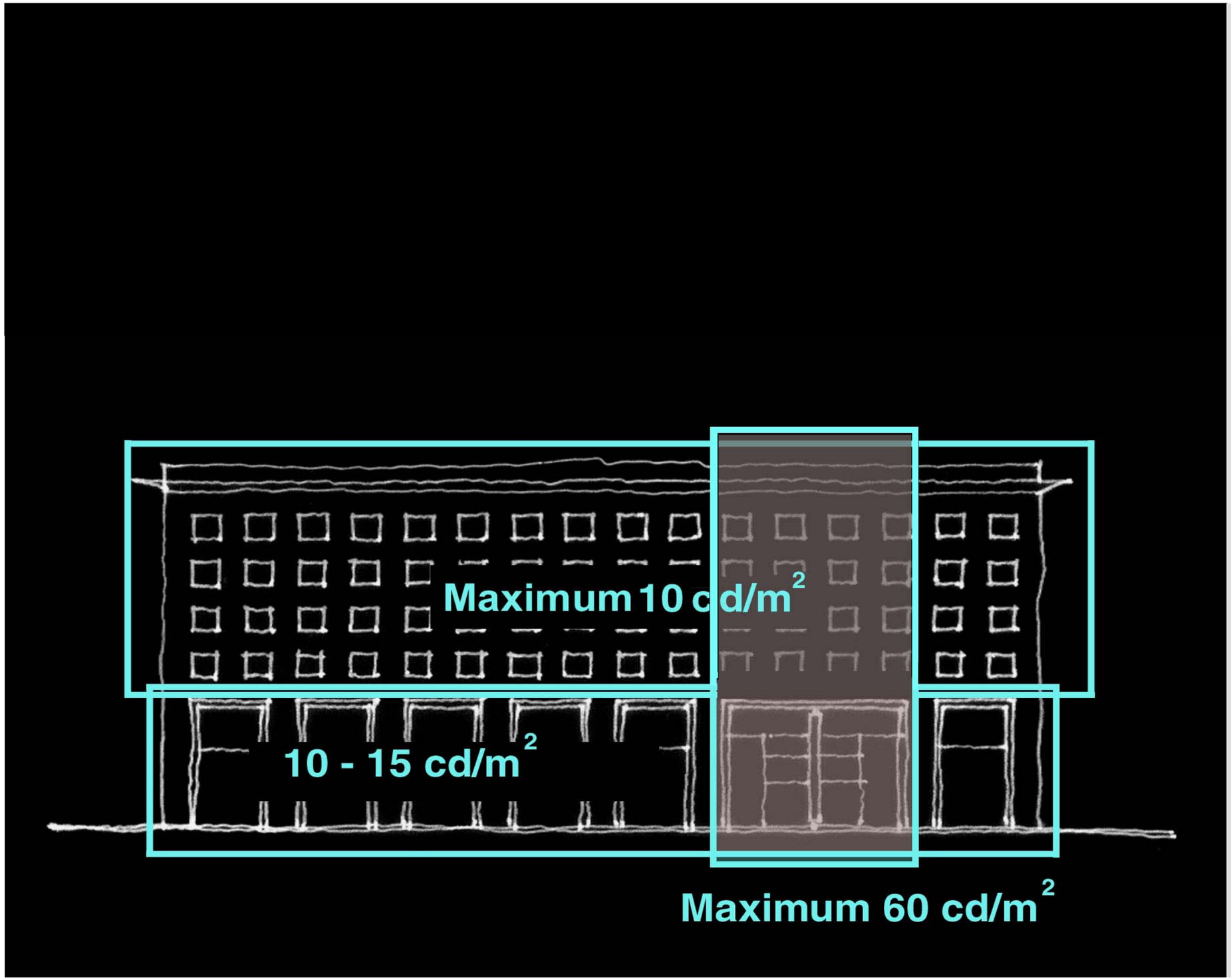
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Figure 2.1.8

Group B Buildings



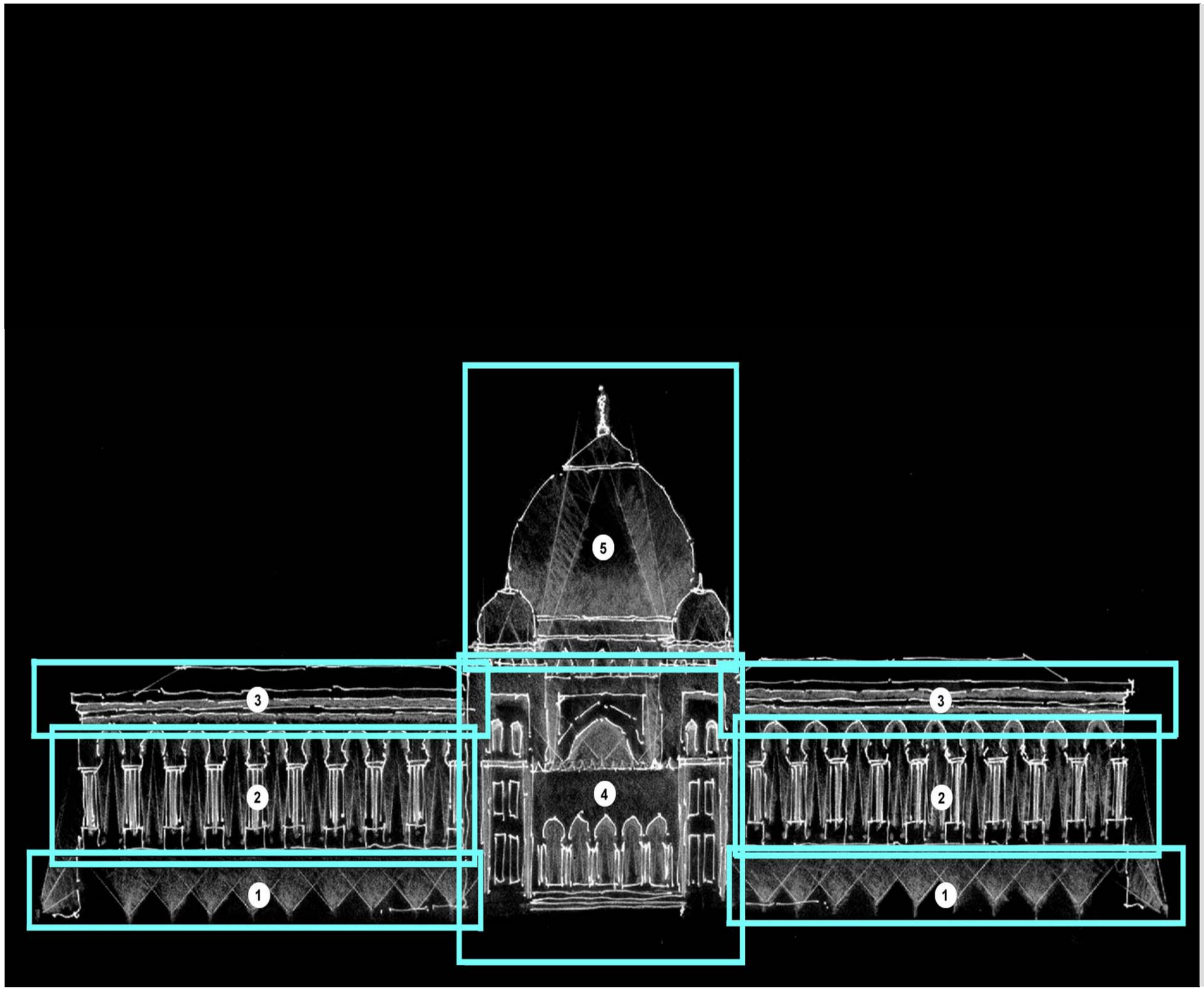
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Figure 2.1.8

Group C Buildings

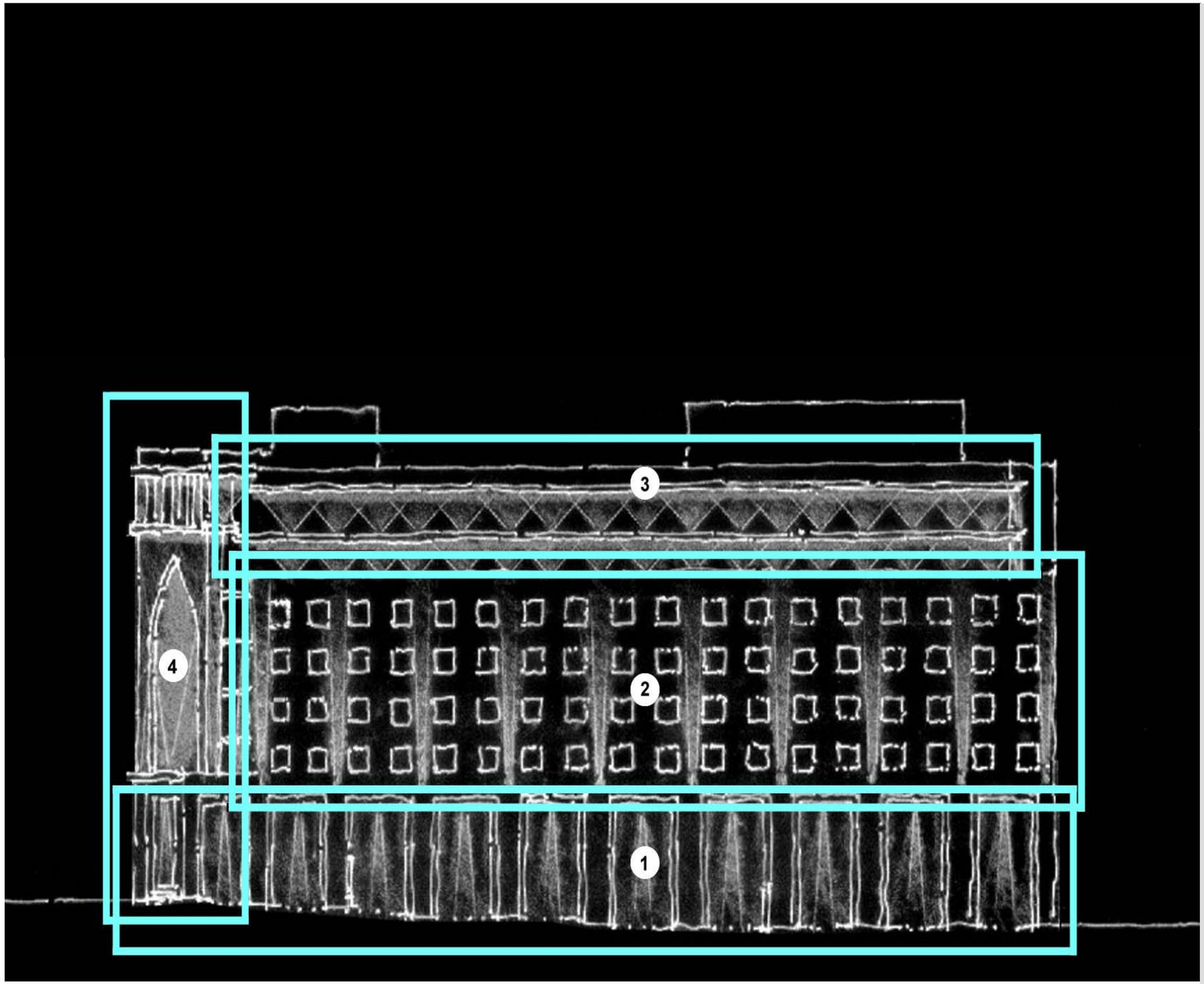


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Figure 2.1.8

Group A Buildings
Good Lighting Practice

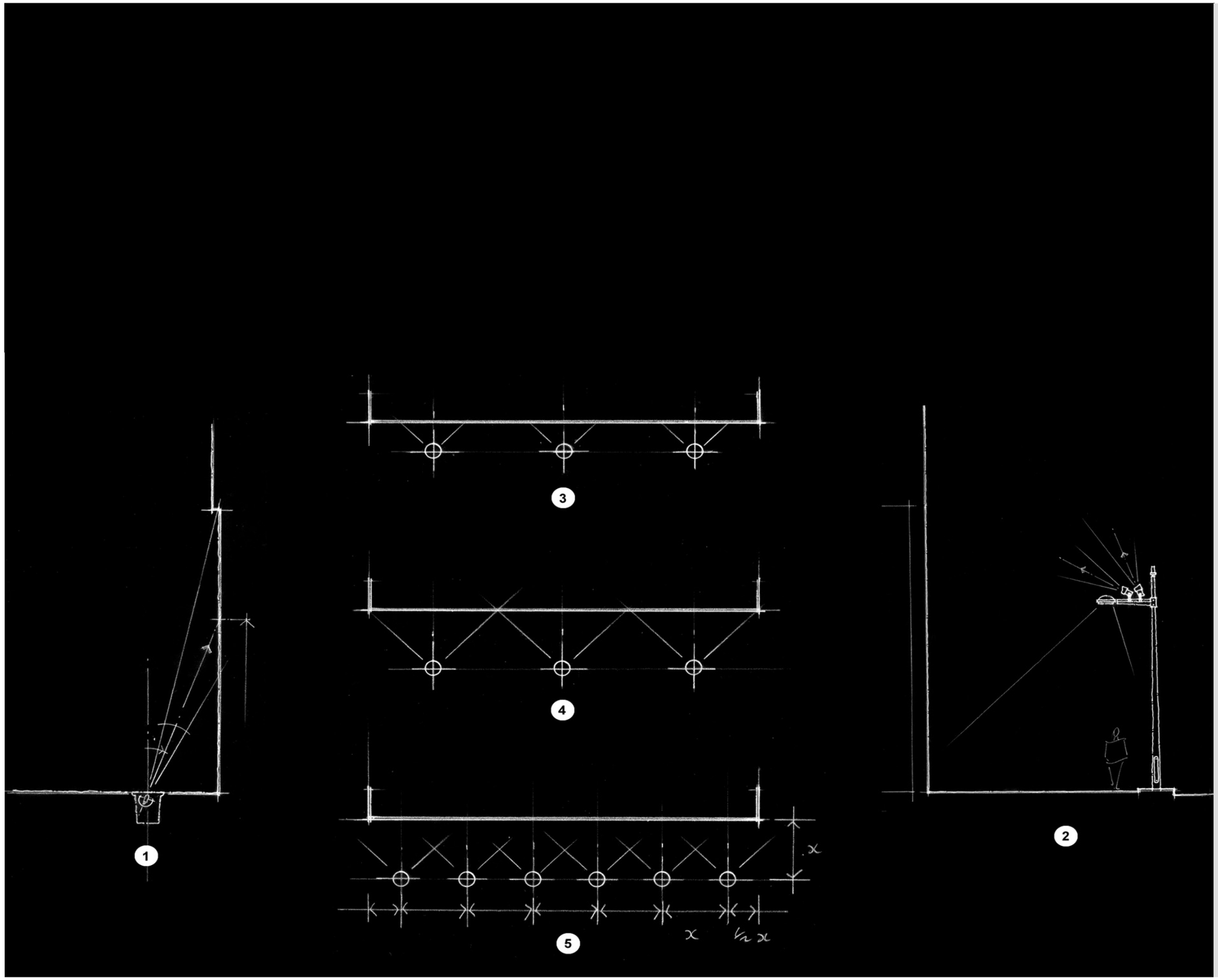


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Figure 2.1.8



Group B and C Buildings
Good Lighting Practice

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Figure 2.1.8



Good Lighting Practice
Building Lighting

1. **Inground uplights to have either wallwash reflector or a djustbale lamp position to ensure all light emitted from fitting hits the building /wall and does not cause stray light.**

2. **Fittings illuminating streetwalls should be located in concealed locations on building or mounted on streetlight columns to ensure fittings are not seen. Fittings on buildings should be painted in RAL colour to match building materiality. Wiring and conduit to fittings should be concealed as far as is practicable.**

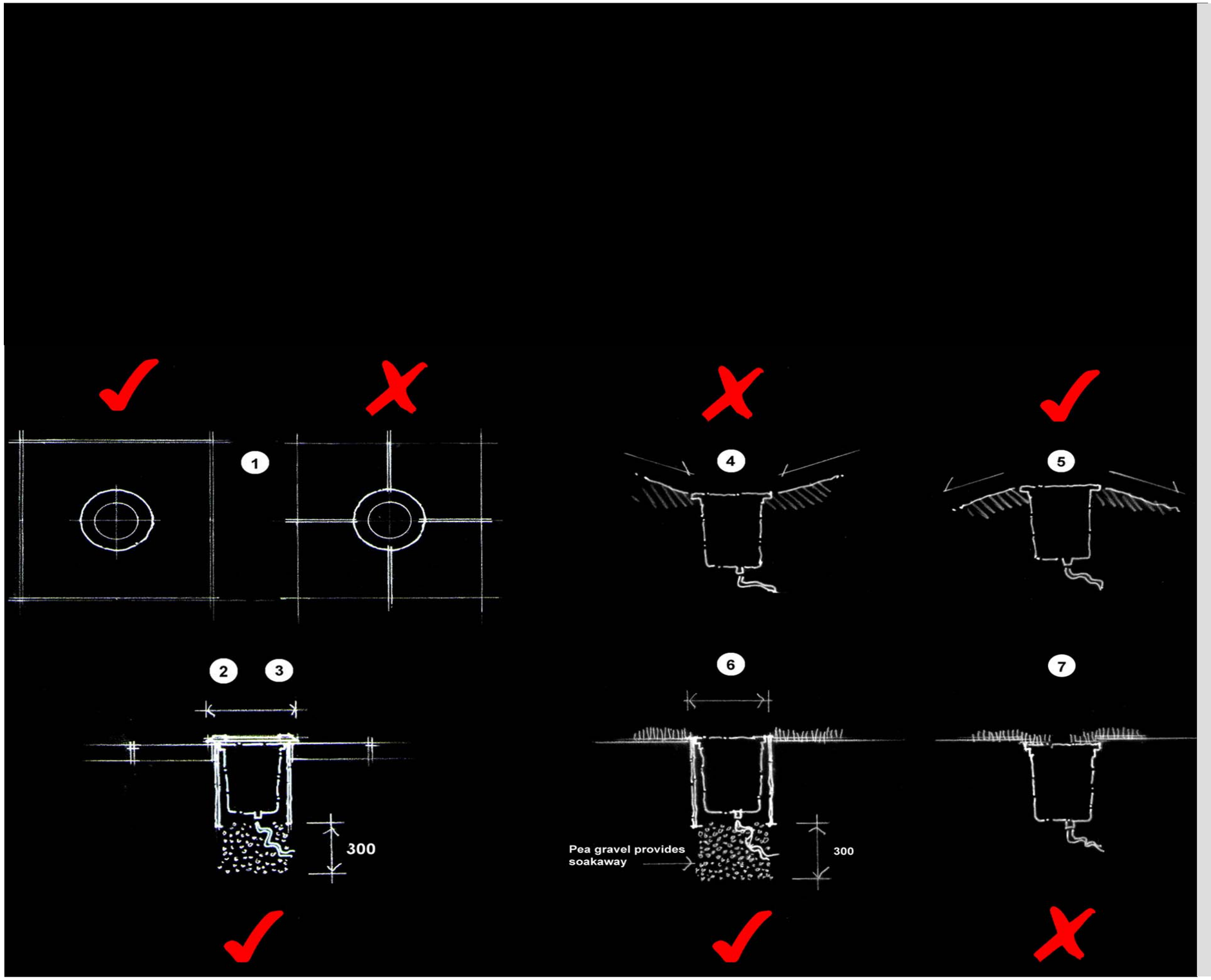
3. **Inground recessed uplights positioned close to walls create dramatic scalloping effect.**

4. **Inground recessed upligts positioned at greater distance from wall create a more uniform wallwash effect.**

5. **Inground recessed uplights positioned at optimum distance from wall create very uniform wallwash effect.**

6. **Ensure additional lighting on buildings or structures have been allowed for structurally.**

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Figure 2.1.8



Good Lighting Practice
Inground Recessed Uplights

1. Inground uplights should be centered on paving slabs to ensure levels beneath fitting are the same, avoiding differential compression of gasket seals.

2. Bevelled top plates can be used to cover discrepancies in slab core cutting.

3. Top plates used which extend above ground level should be bevelled to minimised the potential of trip hazards.

4. Ground levels to perimeter of inground recessed fittings should fall away from fittings to ensure ponding does not occur on fitting, encouraging seepage into fitting.

5. Ground levels fall away from fitting.

6. When appropriate e.g. when inground fittings are recessed into concrete slabs, recessing sleeves should be utilised with pea gravel to ensure free draining below fitting.

7. Maintenance should be carried out on a regular basis to ensure top plate glass is clean, and free from debris.

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Figure 2.1.8

3.3 LIGHTING OPPORTUNITIES FOR INDIVIDUAL DESIGN ELEMENTS

3.3.1 Waterfront Promenades

At night the visual relationship between the Lake and its surrounding land should be clarified in certain areas through the use of waterside marker lights that delineate the edge of the Lake and the Core Island. It is proposed that the Lakeside walkway which extends down the western side of the Core Island be marked, at the shoreline, with coloured (possibly blue) LED powered marker lights. It is recommended that a similar treatment be applied to the Lake edge in Precincts 5 and 6 and other locations where a high volume of pedestrian use is anticipated. It is not suggested that this treatment be applied to areas where wildlife conservation is being encouraged or where night time pedestrian traffic is to be discouraged.

3.3.2 Water

The Lake system divides into a number of areas of differing character that can be emphasised at night (refer to Figure 3.3.1 for water hierarchy):

- The water recreation in the southwest area of the Lake –zone for possible floating light sculptures, water jets, fountains and submerged lighting features. These features might be permanent or temporary (refer to Figure 3.3.4)

- The general navigation zone to the west and north of the Core Island– zone for feature lighting 'buoys' (refer to Figure 3.3.3)

- Canal to east of Core Island– zone for shore located marker and way finding lights (refer to Figure 3.3.2)

- Weir at extreme north end of Lake – submerged uplighting to 'catch' water as it falls into light.

- No lighting in wetlands areas

- No lighting in ecologically sensitive areas.

3.3.3 Parks

Parkland lighting is provided for amenity, security and delight. The range of lighting technique is wide but certain fundamentals should be observed:

- Avoid all forms of glare. In an otherwise well balanced lightscape it only requires one badly directed or overly bright light source to create a visual magnet that draws the eye from the remainder of the scene. Additionally, glare sources, through the processes of contrast, make areas that are lit to a relatively low level appear dark.

- Ensure that footpath lighting columns are maintained at centre to centre spacing that avoid glare being created by the use of luminaires that are designed to spread light over a considerable area at low mounting heights.

- Avoid the use of high-pressure sodium light sources. These will render, as a brown colour, the green and blue/green colours of foliage, grass and other forms of planting.

Recommendations:

1. ***Delineate the Lake shoreline with way-finding marker lights in selected areas on the Core Island and elsewhere***
2. ***Maximise the value of the relationship between light, water and reflections***
3. ***Do not light ecologically and environmentally sensitive areas***
4. ***Use reduced height street lighting columns in future low-rise residential areas.***
5. ***Avoid direct 'floodlighting' to residential buildings***
6. ***Consider the identification of high rise residential buildings through a roof top 'cap' lighting feature***
7. ***Characterise night time regional 'centres' through street lighting of a differing quality to that of surrounding roads.***
8. ***Light bridge decks with the same light source as used to light approach ways***
9. ***Light bridge superstructures with white light except during festive periods when colour can be introduced***

- Use saturated colour with care. Converting the natural colours of soft landscape foliage and planting is frequently inadvisable because it distorts the range of subtle colour variation that occurs in a landscape with multiple species of planting. Temporary use of saturated colour is advocated.

- Take advantage of the possibility of shadow play. Whilst uplighting into the crowns of trees and to lower level foliage is a well-established technique, thought should be given to lighting downwards through tree foliage to create interesting shadows at ground level. Projection of foliage shadow work on vertical surfaces is also an attractive technique.

- Use vertical surfaces such as walls and areas of dense vertical foliage to reflect light and to create a sense of boundary. This technique also provides for a sense of enhanced security by placing in silhouette any person between the observer and the vertical surface.

3.3.4 Residential Areas

- In the residential areas the use of high-pressure sodium light sources for road and street lighting is likely to continue for the foreseeable future.

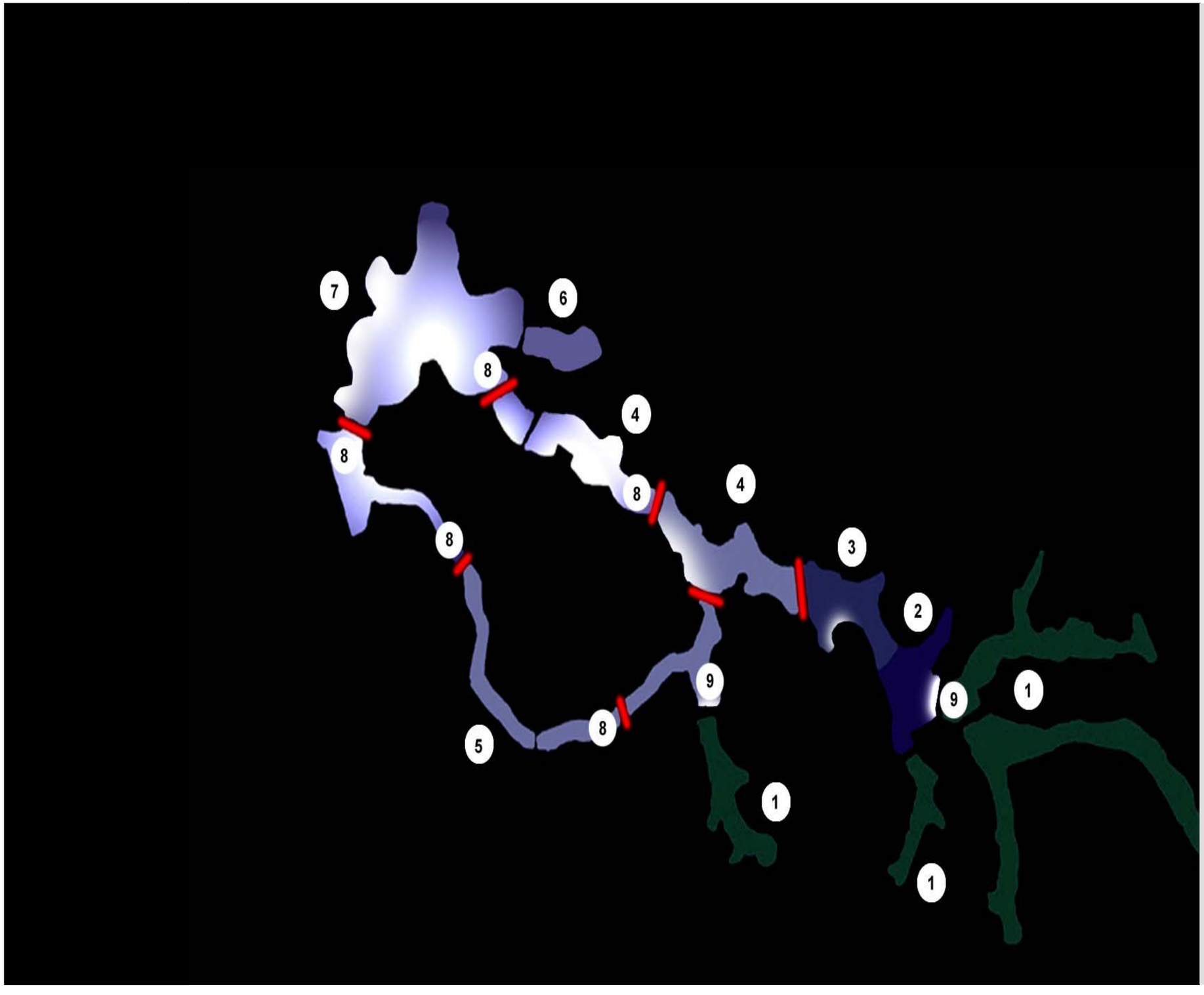
- Height of columns in existing lighting schemes (at April 2002) is 12 metres (Figure 3.3.7). This is acceptable for areas of high-rise residential building but, in future, consideration should be given to the use of 6 – 9 metre columns and increased centre-to-centre spacing in low-rise residential areas. Lighting mounting heights for luminaires located to the rear of low rise residential buildings should be lower yet, at some 4.5 metres.

- Residential building elevations should not be directly floodlit. However, consideration can be given to the creation of roof top 'cap' lighting features on high-rise residential buildings.

- Consideration should be given to identifying and characterising the regional 'centres ' in Precincts 7, 8 and 11 through the use of a higher colour temperature and better colour rendering light source for the street lighting within the immediate area that defines the communal centre of the region. Typically such a light source will have colour-rendering index of not less than R^a 85 and a colour temperature range of 4500K to 5300K.

Recommendations:

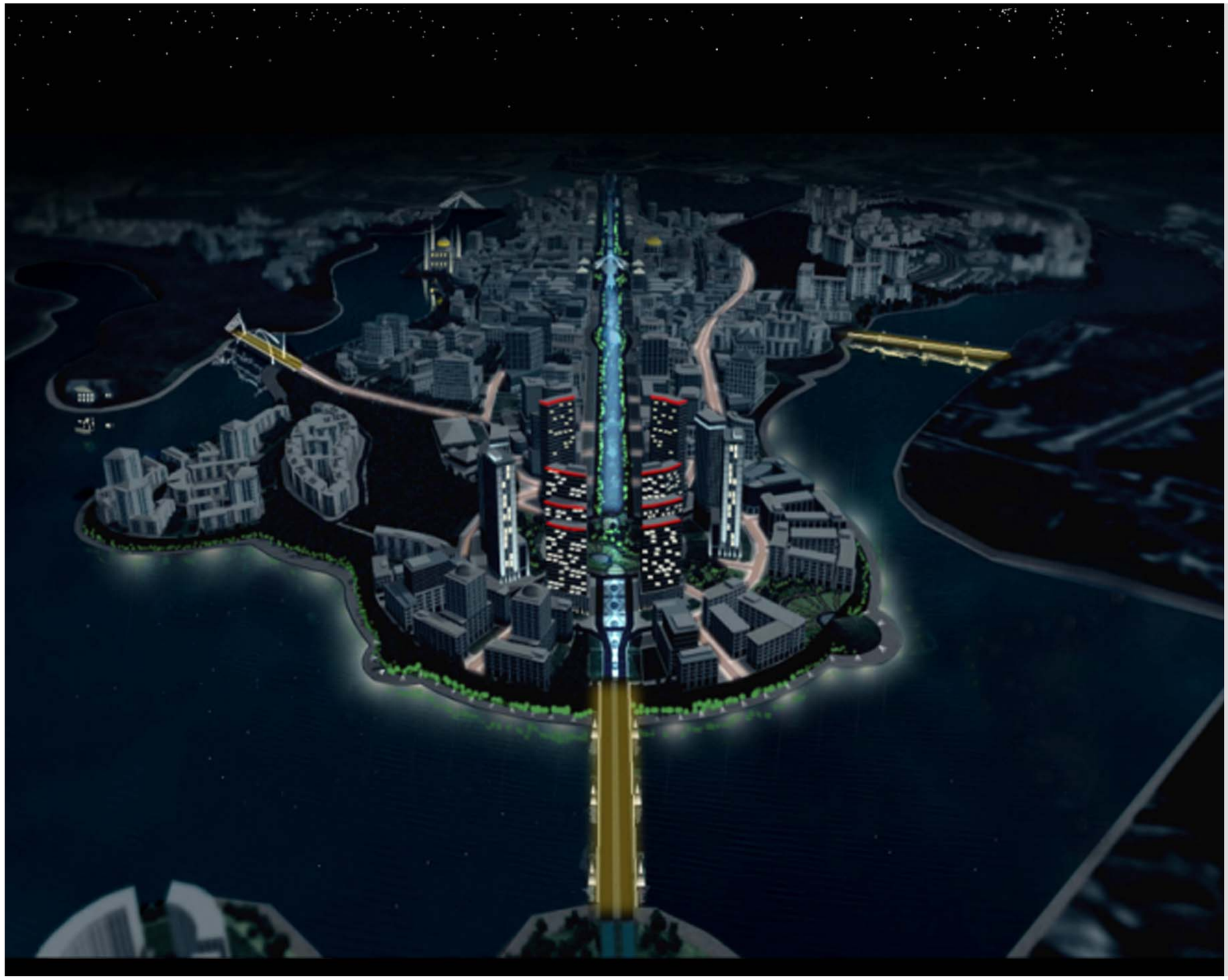
1. ***Future residential areas to lower height of poles to 6 – 9 metres.***
2. ***Residential building elevation should not be directly floodlit.***
3. ***Regional centres should use higher colour temperature and better colour rendering light source to define communal centre.***



Water Hierarchy

1. **Sensitive Ecological Area- no lighting opportunity.**
2. **Environmental Wetlands Reserve- no lighting opportunity.**
3. **Critical Security and Privacy Area- low levels of ligting opportunity.**
4. **General Navigation Zone- medium to high levels of lighting opportunity.**
5. **General Navigation Zone- (canal area)**
   Medium levels of lighting opportunity.
6. **Passive Recreation Zone – low medium levels of lighting opportunity.**
7. **Active Recreation Zone and General Navigation Zone- high levels of lighting opportunity.**
8. **Bridges illuminated as gateways to Core Island**
9. **Weirs illuminated.**

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Figure 2.1.8



Aerial View of Core Island Looking North

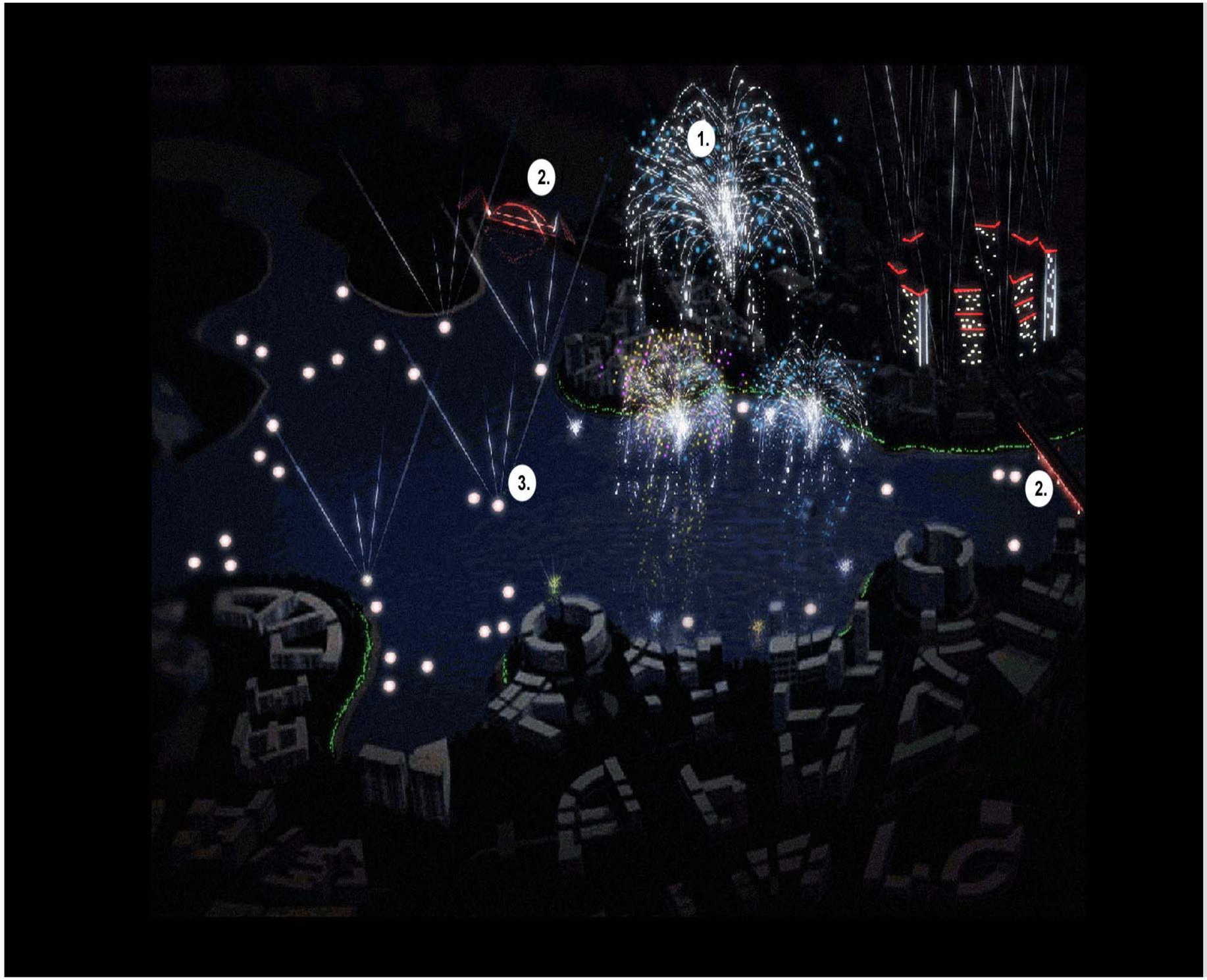
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Figure 2.1.8



Rowing / Sailing Festival

Illuminated buoys and light strings define rowing and sailing courses for competition opening ceremonies.

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Figure 2.1.8



Water High Days / Holidays Lighting

1. Sound and light shows encouraged at waterfront areas for bigger audience visibility.
2. Bridges can introduce colour during festive periods.
3. Navigational buoys during festive periods introduce laser or beam lights.

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Figure 2.1.8



Parks Hierarchy

1 Taman Wetlands – Sensitive Ecological area. Little/ no lighting opportunity.

2. Taman Putra Perdana
Medium to high levels
of illumination

3. Taman Botani
Little / No lighting opportunity

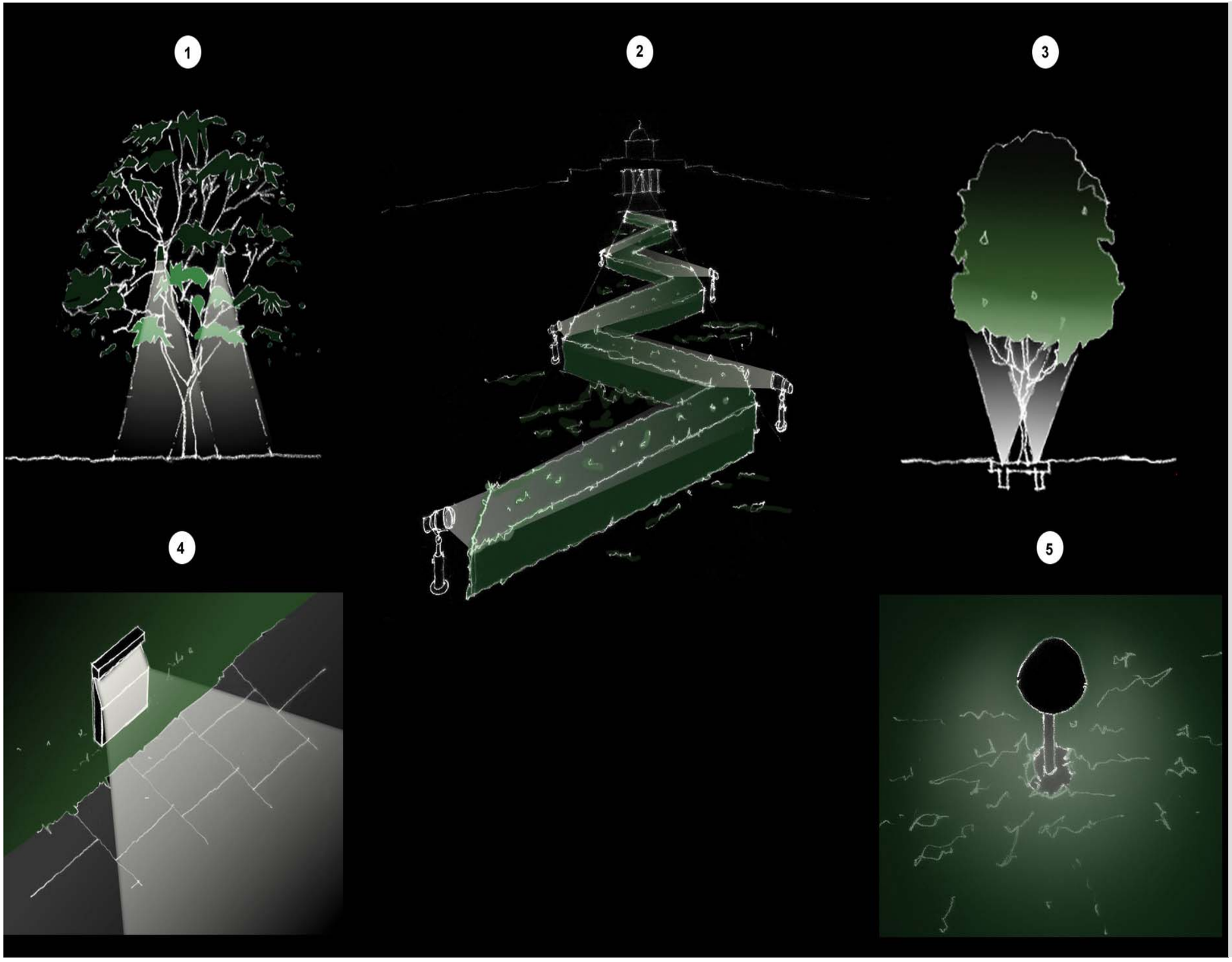
4. Core Island Central Boulevard
High levels of lighting

5. Core Island East – West Axis
Medium to high
Levels of lighting

6. Peripheral Waterfront
Promenande
Medim to high levels of lighting

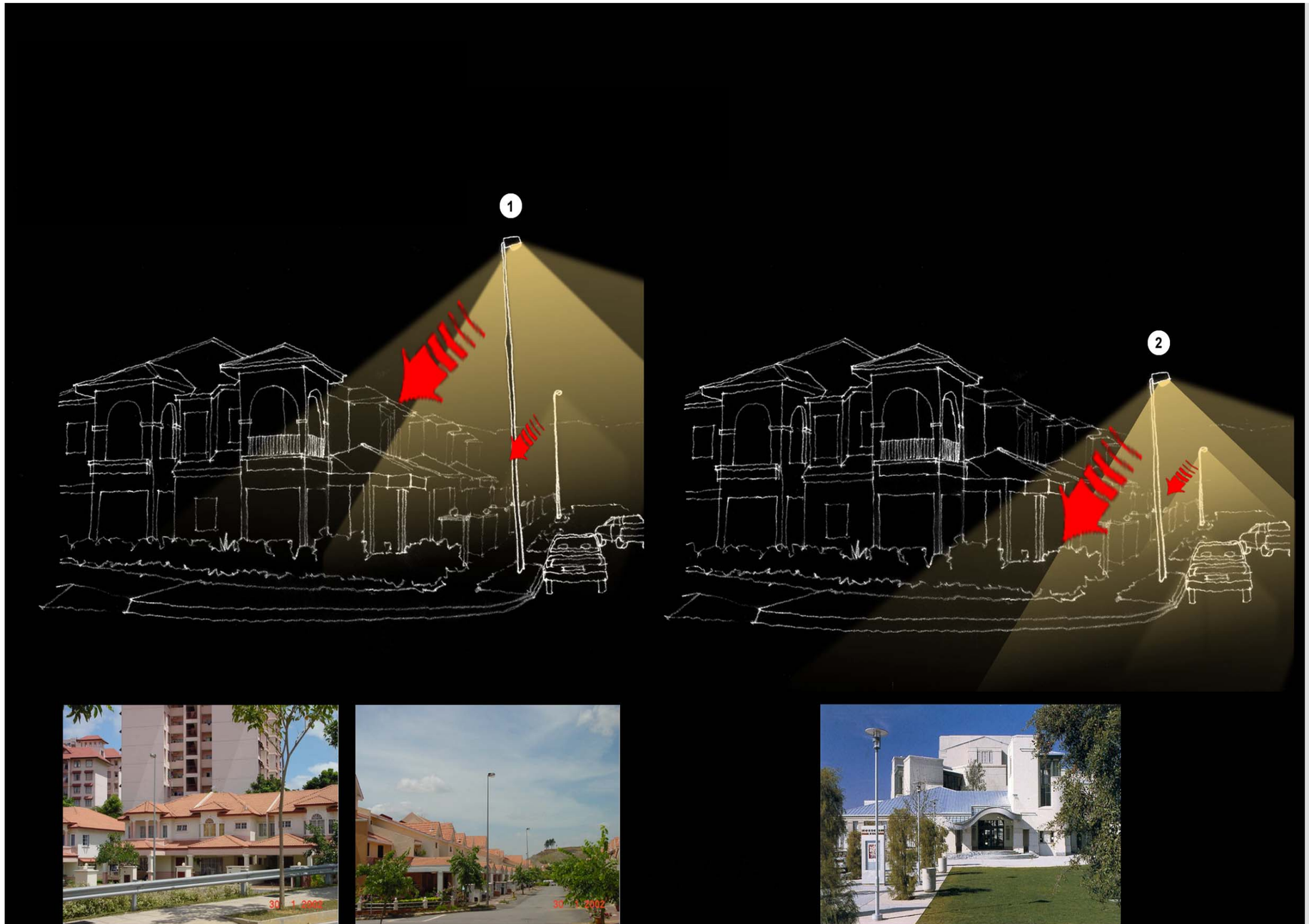
7. Core Island Waterfront
Promenade areas
Low to Medium levels of lighting.

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Figure 2.1.8



Parks - Soft Landscaping

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Figure 2.1.8



Residential Lighting

1. Existing Situation
   Column height 12m – stray light enters windows of low scale residential buildings. Columns out of proportion with housing, and can be seen from a distance projecting above roof line.

2. Proposed Situation
   Column height reduced between 6.0m and 9.0m. Light prevented from straying into residential buildings. Column in propotion with buildings and do not project above roof line.

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Figure 2.1.8

3.3.5 Bridges

- The bridges are considered as the gateways to the inner city. The high-pressure sodium light sources that are used to illuminate the roadways that lead to bridges from the outer city should continue to be the light source used to illuminate the vehicle deck of the bridges. Major and Minor gateways are discussed in Policy 3.

- The superstructures of the bridges should be lit with white light during normal use.

- Where possible and appropriate, coloured light should be introduced to the lighting of the superstructures to mark festive periods.

3.3.6 Diplomatic Enclave

Objectives

Security is the primary most important factor relevant to lighting Embassies. Illumination for security purposes will take priority over all other lighting issues. A second factor relates to the qualitative aspect associated with the concept of traditionalism created for this Diplomatic enclave.

Both carriageway and associated pedestrian areas that are bounded by Embassies and Residences should be lit by high colour temperature light sources with high colour rendering characteristics. Typically, such sources will increase the sense of brightness and provide better lighting conditions for visual recognition and perception of distances. Such a source is also particularly suitable for CCTV coverage that will be utilised throughout all external areas of both Embassies and Residences.

The lighting of the village area of the Diplomatic Enclave should be contrasted with the 'business' area represented by the Chanceries and Embassy buildings through the use of lighting with a lower colour temperature of 2800K to 3500K with a colour- rendering index of not less than Ra 85.

Common areas of landscaping and tree planting should be illuminated to minimise shadowing and pockets of darkness thereby further aiding the question of security.

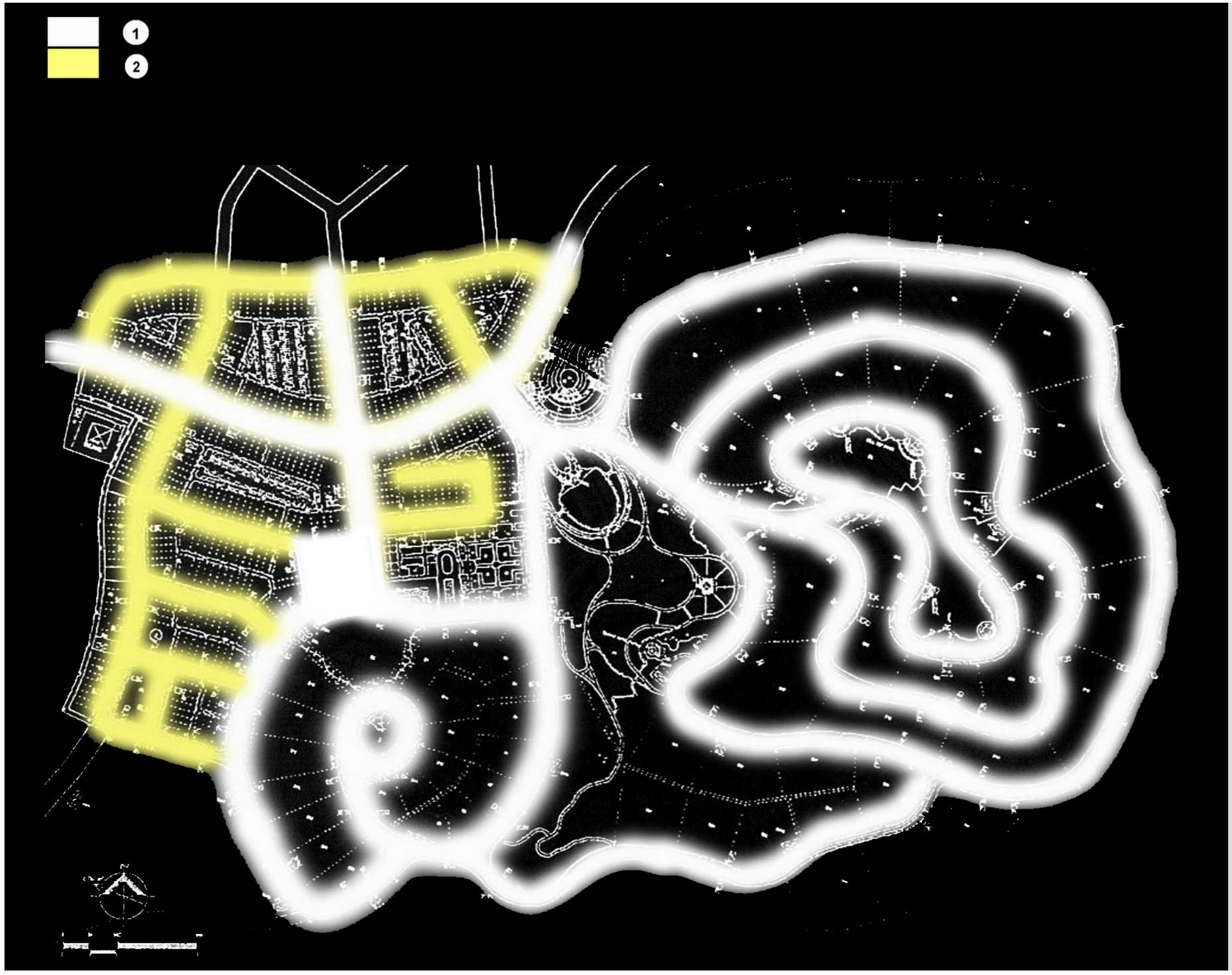
It should be presumed that it is likely that all Embassies and Residences will wish to illuminate their buildings and probably their grounds as well. It should also be presumed that such illumination will include all elevations, entrances, driveways etc. (Figure 3.3.8). High levels of illumination will be sought at areas where cars will be alighted and disembarked. It should also be assumed that there will be a requirement for functional illumination to large areas including the parking of numerous vehicles. During the planning approvals process particular attentions should be given to the avoidance of the levels of glare that indiscriminately located security and amenity lighting can frequently create.

Architectural and landscape Illumination of the both the buildings and associated grounds should be encouraged to have schemes designed which include the security and functional illumination. Such schemes should be designed to include security illumination as part of a co-ordinated lighting design approach and not as an ad hoc feature to be further added as a separate element. Appropriate design and usage of circuitry can easily accommodate this.

Recommendations:

- ***High pressure sodium maintained on the vehicle deck to Bridges***
- ***Superstructures of bridges to be lit with white light***
- ***Security is the primary most important factor relevant to the lighting of Embassies***
- ***Qualitative aspect associated with the concept of traditionalism created for the Diplomatic Enclave should be respected***
- ***Low pressure sodium light sources should not be allowed for security illumination***
- ***The town area of Diplomatic Enclave should be lit with lower colour temperature of 2800k to 3500k , <R^a85***

The use of low-pressure sodium light sources should not be allowed for security illumination. The lighting concept for the Diplomatic Enclave divides the area into two distinct sub-areas. The first is dedicated exclusively to the diplomatic enclave and the chancelleries, the other to a mixed-use centre that includes some diplomatic uses. The two street axes and the main street including the focus on the Town. Square and Visitors Centre are characterised through the use of warm metal halide light sources thereby contrasting these areas with the cooler visual quality of the Chancellery areas.



Diplomatic Enclave Streetlighting Colour Temperature Diagram

1. Good quality high colour temperature lamps within range 4500 – 5300 K with CRI Ra > 85
2. Good quality high colour temperature lamps within range 2800 – 3500 K with CRI Ra > 85

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Figure 2.1.8

3.3.7 Monorail

- The Monorail system is a unifying element that is a predominant feature within the city. A major opportunity exists to reinforce its presence by night through the use of a colour-coded form of feature lighting. This should be a two-colour system that signals and distinguishes the two lines - possibly blue and red.

- The light signals should take the form of colour LED clusters located on the concrete support pillars for the over-ground sections of the monorail and at platform locations for the underground sections. Consideration should also be given to the possibility of continuing the way-marking within the tunnel sections.

3.3.8 Non-Residential Areas

- In the non-residential areas the use of high-pressure sodium light sources is likely to continue for the foreseeable future.

- In low-rise areas it is recommended that the road and street lighting be provided from columns of 6 to 9 metre height at appropriate centres. In high-rise areas the continued use of 12 metre columns is advocated.

- Small-scale local community buildings such as markets, sports facilities and small retail outlets should be identified by night through the lighting of external elevations and features.

- Small-scale pockets of soft and hard landscape areas should be supported at night through lighting that provides character as well as amenity and security.

3.3.9 Festive Lighting

Festive lighting is the subject of either:

a) Permanently installed lighting that is switched on only during festive periods; and/or

b) Temporarily installed lighting that is specifically designed for a particular occasion.

It is proposed that some permanently installed coloured lighting be included in the design of the lighting to the elevations of the major buildings on the central Boulevard. This should be located at ground level within the colonnades that are a largely consistent feature and at high level where, again, a largely consistent feature comprises the cornices. Lighting these two elements in colour will create a high and low level visual datum that will be significantly different in character from that seen on normal days.

Further permanent additionally installed coloured lighting can be considered for Jambatan Seri Gemilang (Bridge 6) for the festive expression of its superstructure. Additionally, consideration should be given to the possibility of temporary colour filtration of aspects of the lighting to other bridges.

Other festive lighting elements could include:

a) Temporary colouration to the lighting of the roof caps of the major buildings on the central Boulevard and, possibly, to those in Precincts 1 & 5.

b) Large-scale image or pattern projection to the elevations of selected buildings on the central Boulevard.

Recommendations:

- ***The monorail system should introduce a two colour lighting system signaling the two lines using LED light sources.***

- ***In non-residential areas road and street lighting pole heights should be reduced***

- ***Permanently installed coloured lighting to be included in the design of lighting to the elevations of major buildings***

c) White light sources forming a continuous chain of 'sparkle' down the entire length of the central Boulevard through the use of clear festoon lamps hung between the main roadway lighting columns.

d) Laser projections between rooftops forming an overhead web of laser lines.

e) Colouration to the uplighting of trees that line the central Boulevard.

f) Use of the colour element designed as part of the Millennium Monument.

The lighting infrastructure required to enable the foregoing is considerable in view of the 4.2 km length of the central Boulevard. It is proposed that a detailed study be carried out that identifies:

a) The potential locations for permanently installed festive lighting within those buildings already designed and/or constructed.

b) Guidelines to those responsible for the future lighting design for the exterior of buildings for the inclusion of permanent festive lighting elements.

c) Optimum locations for specialist equipment such as laser or image projectors.

d) Costs associated with the provision and installation of festoon lighting throughout the length of the central Boulevard.

The festive lighting design should be based upon the provision of a permanently available, civically funded, base level infrastructure that is supplemented by the creative initiative associated with each major celebratory event. Repetitive festive lighting themes will quickly fade from prominence and Perbadanan Putrajaya should therefore precipitate new design on a regular basis. This could be achieved either by running a design competition (as was the case for the annual Christmas decorative lighting in Regent Street, London) or by commissioning appropriately skilled designers.

3.4 ROADS AND STREET LIGHTINGS

3.4.1 Appraisal of Existing Roads and Street Lights

- **Scope of Survey**

A survey on existing road lighting was carried out in core precincts of Putrajaya. (Appendix A) This survey analyses the quality of roads and street lights by measuring the lighting levels using an illuminance (lux) meter. The scope of survey conducted in October and November 2001 covers the measurements of lighting levels at Protocol roads within core precinct of Putrajaya, and visual inspection to identify problem areas impacting sky glow, light trespass and discomfort glare. The aesthetic impact of lighting (which include issues of colour and visual coordination) is not covered in this survey.

- **Conclusion**

From the survey the following conclusion can be drawn.

a. All existing roads and streetlights are designed to uniform colour standard using high pressure sodium lamps.
b. Most roads and streetlights are provided with lighting levels which exceed the BS and CIE recommendations (Luminance recommended by CIE 2cd/72)
c. In some cases (suburban and core island), lighting levels are high (compared to recommended levels).
d. Despite the abundance of lighting levels, light distribution and uniformity (especially at main Protocol roads) are poor. The degradation in light distribution and uniformity and inconsistency is due to the poor photometric characteristics of the luminaire where aesthetic consideration is given primacy over the technical.
e. Some problem area in discomfort glare (Dataran Putrajaya, decorative highway luminaire) and sky glow (flood lighting of PM's complex and Grand Mosque) is also identified.

Recommendations:

The survey report recommends the following:

- ***A detail comprehensive and survey of lighting level and performance to be executed by a specialist company.***
- ***Remedial work be carried out to correct non-uniform road lighting (non-uniformity of lighting luminance in Protocol Roads identified in the Survey)***
- ***Remedial works to correct quality of lights issues identified in this survey (discomfort glare and sky glow)***

3.5 LIGHTING CONTROL AND MAINTENANCE

3.5.1 Lighting Control and Maintenance

Cognisant of Policy 5, it is recommended that all external lighting to buildings, structures, landscapes, road and street lighting and any other lit elements owned and/or operated by Perbadanan Putrajaya be controlled through a centralised system. This will enable effective co-ordination of the overall lighting settings throughout a substantial number of the elements that comprise the built city. It will also enable the lighting to be programmed to respond to differing presentations of the city at night for conditions such as:

- National Day, religious holidays and other festive days
- Normal day-to-day conditions – dusk to mid evening
- Normal day-to-day conditions – late evening
- Late night to morning conditions

This network of centrally operated lighting could be known as the City Lighting Network (CLN). The owners of private buildings should be required or encouraged to include the operation of their lighting within the CLN. The justification for this proposal lies in the fact that, in the overall visual context, there is little or no distinction in the eye of the beholder of the city as to what is a publicly or privately owned building. Inclusion of all lit elements, whether private or publicly owned will enable a comprehensive and co-ordinated presentation of the city at night.

It is acknowledged that Perbadanan Putrajaya may meet with resistance from private building owners to participate in the CLN on the basis that they do not materially gain from lighting their buildings at night. In the face of such objection, PJC has two choices:

- To publicise the inclusion of external lighting, it's consistent maintenance and its operation through the CLN as a desirable and publicly spirited act that would be welcomed by PJC as a non-mandatory inclusion within a building planning submission.

- To establish a non-mandatory programme that provides financial assistance to private building owners to offset the costs of designing, installing, maintaining and operating the lighting. Such financial assistance could be offered on the basis that the completed installation must comply with the aims of the Lighting Masterplan, be maintained and be operated through the CLN. Appendix F is a brief technical discussion with some policy proposals for consideration in the implementation of the CLN.

The CLN must interface the requirements of Perbadanan's IT Network System (Putra.Net). The connectivity and integration guidelines are as follows:

a. The CLN components must support the TCP/IP transmission protocol for data transmission.
b. The CLN components must support the SN/IP management protocol for managing the components of the CLN.
c. The CLN data structure must support the ORALLE data structure and requirement for database compatibility.

The CLN must be integrated into the City Management Centre and also be integrated into the Disaster Recovery Centre.

Recommendations:

- ***All external lighting of public building, structure & landscape road and street lighting be centrally controlled by Perbadanan Putrajaya***
- ***Encourage private owners to include the operation of their lighting within the CLN***
- ***CLN to interface with Perbadanan's IT Network System Putra.Net and integrated into the City Management Centre and Disaster Recovery Centre***

3.5.2 Maintenance of Street Lights

In formulating a maintenance policy for road street and public lighting main factors complicating the issue include the wide geographical dispersion of street lights (which present logistical problems) and the perception that street lights are an essential service (in maintaining vehicular safety and pedestrian security).

Methodologies in the maintenance of street luminaire include preventive maintenance where regular and scheduled maintenance are carried out (this also include regular cleaning and the monitoring abnormal operating conditions) and non-scheduled maintenance (damage before their scheduled lifetime usually resulting from accident or vandalism). Regular maintenance of street lamps include relamping and/or changing of ancillary equipment (light switches/contactors etc) in accordance with its designed operating life and cleaning of lamp. Table 3.2 of CIE 92 shows recommended lamp cleaning intervals (see Appendix G). As shown in the table cleaning intervals is a function of IP rating, maintenance factor during design and pollution index.

Maintenance by a municipal department may involve one or all of the following method:

- Subletting part or all maintenance procedure to a private company.
- Maintaining a street lights crew, in this case the man-power allocation may be a problem, and
- The installation of a city wide monitoring and automation network for streetlights.

The CLN management system shall provide the following data but not limited to

- Location and time of lamp power failures
- Statistics on lamp lift
- Automatic generated maintenance schedules
- Lamp on and burn times
- Lamp failure
- Open lamp circuit
- Alternative switching of the lamps
- Real time mapping of the lamp layout

3.6 LIGHTING CODES AND STANDARDS

3.6.1 General Overview of Codes and Standards

- **BS and CIE Standards**

In Malaysia the design and practice of roads and streetlights generally follow British Standards (B.S.) and Codes of Practice (C.P.). The current choice for most design professionals (in roads and street lighting) is BS 5489 published in ten parts (see Appendix G for a detail of BS 5489). Standards for roads and street lightings adopted by CENELEC (the European body for harmonisation of standards) are the standards published by the '*Commission Internationale de L'Ėclairage*' (CIE or International Commission on Illumination). With the harmonisation of British Standards to European ('EN') Standards and in light of current trend towards globalisation, and Malaysia's membership and growing active participation in the Internation Standard Organisation (ISO); the ISO/CIE standards will become important. Appendix G has a listing of CIE publication relevant to roads and street lighting.

- **Local Standards**

No Malaysian codes or standards exist as yet in Malaysia. A working group under S.I.R.I.M., ISC-E ("*Industry Standard Committee – designation 'E' for electrotechnical*') is currently drafting a Malaysian Standard for roads and street lighting.

3.6.2 Regulatory Standards

- **Legal Framework**

In Malaysia, the submission of public road and street lights falls under the purview of the '*Local Council Act*' This Act in conjunction with the '*Street, Drainage and Buildings Act (1974)*' and its accompanying by-law the '*Uniform Building By-Laws (1984)*' empowers local city halls, municipal or district councils, and/or authorities having jurisdiction over public roads and street lights to regulate and approve design of roads and street lights. Submission procedures for (public) roads and street lights are usually subsumed under submission for 'Development Order' and 'Planning Approval' of the councils or authorities concerned. Other authorities/agencies having jurisdiction (and significant influence) on the design and definition of standards are the '*Jabatan Kerja Raya*' ('*JKR*' - or Public Works Department) and the '*Malaysian Highway Authority*' (MHA).

- **Submitting Professionals**

Under the purview of the '*Street, Drainage and Buildings Act (1974)*', the '*Uniform Building By-Laws (1984)*', and the relevant Act governing registration of professionals, submission of road and street lighting planning falls under the responsibility of the electrical engineer.

Legality of Standards

In Malaysia, Standards are governed by the '*Standards of Malaysia Act, 1996*'. The regulatory agency for standards is the Department of Standards Malaysia (DSM). DSM in turn has appointed SIRIM as the coordinator of standards development in Malaysia. Thus any standards adopted as a Malaysian Standards will have status as a legal document under Malaysian law. However, given the absence of a substantial body of standards and Malaysia's membership of the ISO, the relevant ISO standards may have some legal standing in lieu of any non-existing Malaysian standards.

Recommendations:

- ***It is recommended that CIE Standards be adopted by Putrajaya***
- ***The Electrical Engineer is the submitting professionals Under Street, Drainage and Building Act.***

3.6.3 Existing Procedures and Submission Standards

- General

Apart from the two agencies listed in 3.6.2 above, most local authorities in Malaysia do not have firm and written guidelines for approvals of (public) road and street lighting beyond a. delegation of professional responsibilities to the submitting person. Some municipal councils and city halls issue simple guidelines (‘*garispanduan*’) for street lighting submission. Where no guidelines are published or issued, conditions for approval are usually imposed (on an ad-hoc basis) by the district engineer responsible for the district, municipal or city roads.

- **Common Guidelines**

Some common requirement listed in the guidelines issued by most local authorities relate to simple installation standards. The last section of Appendix G has more detail description of approving guidelines and Putrajaya’s existing guidelines on approval of streetlights.

3.7 ENVIRONMENTAL AND ECOLOGICAL CONSIDERATIONS

3.7.1 Energy Efficiency Codes

- **MS 5025:2001**
  'Energy Efficiency in Buildings' (a Malaysian Standard) do not deal with street lighting However a section on general lighting in building advocate:
  a. Use of low loss ballast (this recommendation is now a law under the jurisdiction of the '*Jabatan Elektrik, Suruhanjaya Tenaga*' (Electricity Department of the Energy Commission – previously known as the *Jabatan Bekalan Elektrik Dan Gas*).
  b. Use of energy saving lamps, and
  c. Optimal lighting design based on recommended lighting (lux) levels,

- **Electricity Efficiency Regulations**
  Authored by the 'Energy Commission' these are currently in draft stage. Proposal for labelling of energy efficiency is included in these regulations but however as yet no provision is included for the inclusion of 'energy labels' for street lighting equipment.

3.7.2 Night Sky Pollution

- **Sky Glow and The International Dark Sky Association**
  In the international arena there is a growing realisation that outdoor lighting which is not well-designed (and especially over-designed) and properly installed is harmful to the night time environment. The night time skies above cities are increasing being suffused with a glow, which degrade the clarity of the stars. Due to this, observatories have to be sited increasing further from cities and even towns. It is therefore not surprising that astronomical societies are in the forefront for a growing campaign against night sky pollution. In the U.K. this is represented by the B.A.A. (British Astronomical Association) Campaign for Dark Skies and internationally 'The International Dark Sky Association' (IDA) is the forefront of against night sky pollution.

- **Issues**
  In outdoor lighting design include the following:
  – Glare is the result of poorly-designed or installed lighting which can severely hamper the vision of pedestrians, cyclists, and drivers, creating a hazard rather than increasing safety.
  – Light Trespass is the result of outdoor lighting intruding into or shining onto neighbouring properties and into bedroom windows, reducing privacy, hindering sleep, and creating an unattractive look to the area.
  – Energy Waste Over-design and/or poor outdoor lighting wastes energy due to poor light distribution or over lighting without enhancing security, safety or aesthetic consideration.

- **Sky Glow**
  Occurs where a large proportion of poor designed lighting shines directly upwards. Thereby creating the adverse sky glow above cities. Sky glow obscure our view of the dark night sky, taking away an important natural resource (the beauty if the stars). The IDA in their campaign proclaims their aim of 'bringing back the stars to our children'.

- **International Trends in Lighting Codes**
  Recognising the above, cities in the U.K. and the U.S.A. are increasing adopting codes addressing the concerns listed above. In the 'US pattern codes' (a generic code published by the IDA for the guidance of cities wishing to adopt a good Code Practice for outdoor lighting, are increasing being adapted by cities to regulate outdoor lighting.

Recommendations:

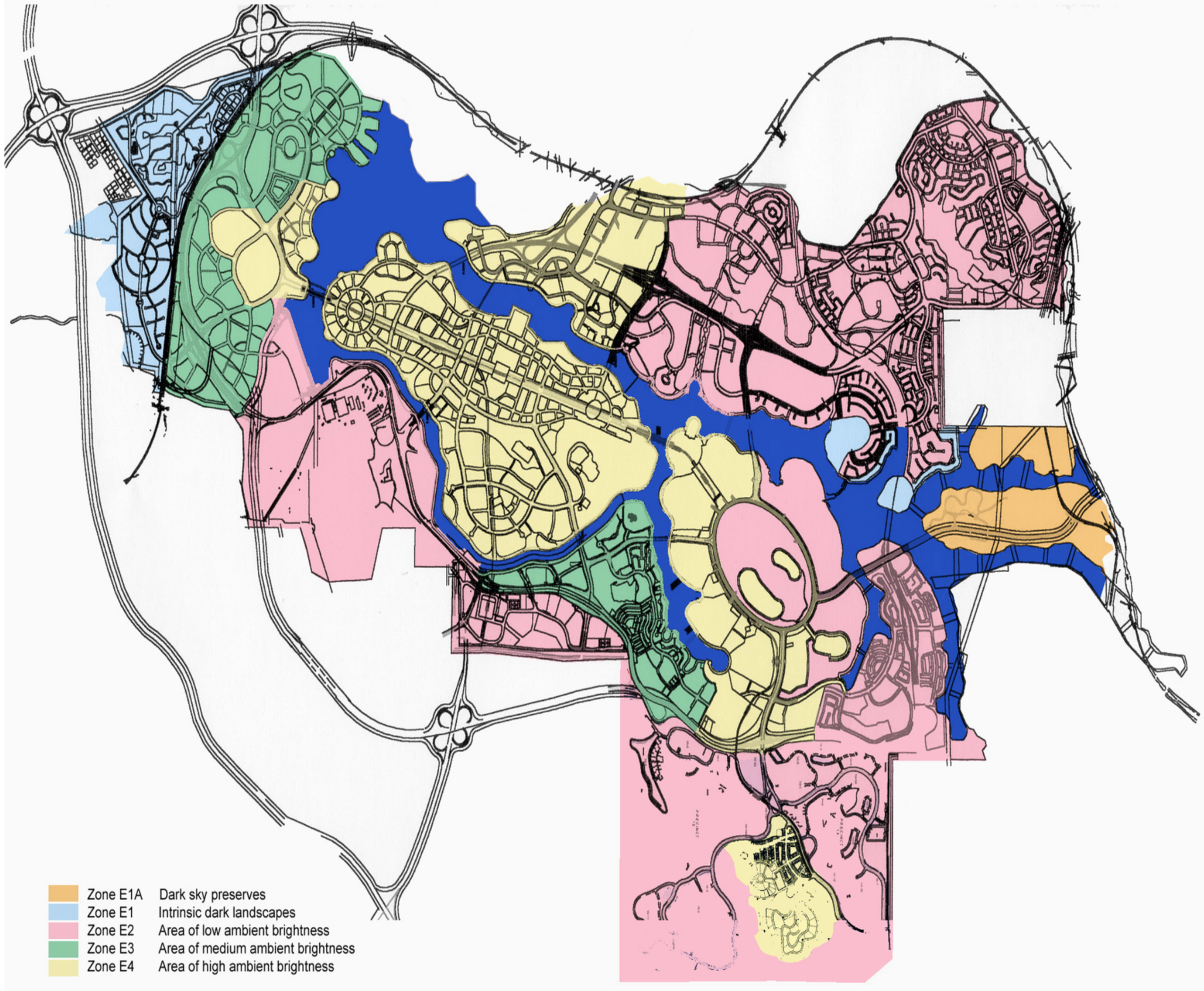
1. ***Adopting international code as a guideline.***
2. ***Ecological consideration by establishing efficient lighting.***

3.7.3 Ecological Considerations

Ecological considerations are addressed as follows:

- Efficient design including considerations of light wastage due to sky glow, light trespass etc contributes to lower energy cost, and
- In ecological enclave (e.g. Wetlands) lighting should be absent or kept to a minimum and where required (for security purpose or pedestrian safety) monochromatic lights (especially low pressure sodium) should not be used. It has been found that monochromatic light sources (LPS etc) has adverse effect on insect and avian ecology.

Environmental Mapping for Lighting Zones



APPENDIX A: SURVEY OF EXISTING ROAD AND STREET LIGHTING IN PUTRAJAYA

September 2002

APPENDIX A – SURVEY ON EXISTING ROADS

1 INTRODUCTION

A survey on existing road lighting was carried out on existing roads in Putrajaya. This survey attempts to analyse the quality of road lightings by measuring the lighting levels using an illuminance (lux) meter. Despite the technical impediment of the measurements, the following conclusion can be drawn from the survey:

(a) All Protocol roads within Putrajaya generally comply with and usually exceed the minimum luminance level specified in the BS and CIE standards.

(b) Despite the abundance in lighting, a serious problem in lighting uniformity exists in most Protocol roads. This deficiency (in road lighting uniformity) can perhaps be attributed to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

(c) This REPORT recommends that a detail and accurate survey using proper luminance meter be conducted by a specialist company for accurate identification and assessment of the (technical aspect) of the (Protocol) road lighting in Putrajaya.

(d) Problems in lighting issues are also identified in this REPORT; problems include sky glow (PM's complex and Grand Mosque) and discomfort glare (Dataran Putra).

Due to the scope and nature of investigation, this REPORT and attendant survey is not meant to be an exhaustive analysis of streets and public lighting in Putrajaya and should only be treated as a 'Preliminary Assessment REPORT'. A separate survey employing specialist company (conclusion (c) above) should be commissioned if such detailed and exhaustive survey is required.

2.0 SCOPE AND METHODOLOGY

2.1 Scope of Survey

The scope of survey conducted in October and November 2001 covers the following inspections at core precinct of Putrajaya:

(a) Measurement of lighting level at Protocol roads within core precinct of Putrajaya, and

(b) Visual inspection to identify problem areas impacting sky glow, light trespass and discomfort glare.

2.1 Scope of Survey
(a) Measurement of lighting level in core precinct; and
(b) Visual inspection to identify areas of sky glow, light trespass and discomfort glare.

2.2 Illuminance Measurement

Luminance Meter Measurement of lighting level was conducted using a (cosine corrected) illuminance (E – lux) meter. The light sensor was placed on the surface of the road and illuminance (lux) was read off the attached meter. Care was taken to ensure that accuracy of reading is not affected by stray shadows.

Efficacy of Parameters In the specification of road lighting, luminance (L – cd/m²) is an oft-used parameter, as it describes more accurately the perception of brightness and visualisation for a motorist looking ahead at the azimuth (of the road). Where pedestrian intrusion is a criteria (residential access, pedestrian crossing, park/vehicular access etc) illuminance (E – lux) is specified for pedestrian comfort.
The assessment of road lighting adequacy utilising illuminance measurement is therefore not an accurate indicator.

Cd/m^2 to Lux To provide some assessment of road lighting adequacy, the illuminance data obtained is converted to luminance. Conversion of illuminance to luminance is another approximation based on the following:

(1) $E_{Lambertian} = L \times \pi$

Equation (1) is inferred from the definition of the candela, steradian and the assumption that the surface is Lambertian (a Lambertian surface is an ideal diffusing surface reflecting light equally in all directions). Road surfaces however are not Lambertian and have a specular component depending on the directions of light source and observer. BS 5489 and CIE30.2 describe the following:

'…this REPORT and attendant survey should only be treated as a 'Preliminary Assessment REPORT'.
A separate survey employing specialist company should be commissioned …'

(2) $E = q \times L$ (CIE 30.2; where q the luminance coefficient is a factor dependent on the vertical angle of throw of the luminaire and 'r' – a 'reduced coefficient' which is a function of the specular property of the road).

(3) $E = \sigma \times L$ (BS 5489; where σ the average luminance coefficient is obtained by consulting tabulation of road types and properties).

BS 5489 avers that 'the great majority of British roads' have an average luminance coefficient of **0.07**. CIE 30.2 list q_o (the average luminance coefficient) as between **0.07 and 0.1**. This REPORT assumes an average luminance coefficient of 0.07.

Margin of Errors The estimation of luminance data in this REPORT should be taken as a guide, as the following will contribute to margin of errors in the assessment:

(a) The error intrinsic in the illuminance meter,

(b) Error arising from field measurements,

(c) The assumption of 0.07 as an average luminance coefficient (theoretically each road type should be considered on its own characteristics), and

(d) Field measurements are not complete (a complete field data would require measurement on a recommended grid between at least two to three columns of luminaire) to determine accurate average and uniformity values.

However despite the margin of errors, estimates of luminance values obtained are reasonably useful to provide a preliminary technical assessment.

2.3 Visual Survey

Visual survey of lighting in core precinct attempts to identify the following luminaire or lighting system:

(a) Contribution to sky glow,

(b) Contribution to light trespass, and

(c) Discomfort glare.

2.4 Sky glow

Sky Glow refers to the wasteful throw of lights into the night sky contributing to light pollution. It is usually a result of:

(a) Misdirected light which throws more light onto the sky than at the intended area.

(b) Wasteful use of wide angle projection in an attempt to 'flood' or 'wash' a façade or monument (instead up to 80% of the light is lost skyward).

(c) Luminaire with a significant portion of lights escaping above the horizontal plane. Luminaire with shields or reflector to limit this upward throw of lights is termed fully or semi 'cut-off' (an exact definition of cut-off differs between BS, CIE and the IESNA and is beyond the scope of this REPORT). Non 'cut-off' luminaire under certain conditions also contributes to discomfort glare.

2.5 Light trespass

Light trespass refers to the intrusion of light into a neighbouring lot. Light trespass is usually a result of:

(a) Misdirected light trespassing onto a neighbouring lot,

(b) Wide angled projected light trespassing onto a neighbouring lot,

(c) Unshielded Luminaire.

Margin of Errors Estimation of luminance data in this REPORT should only be taken as a guide:

- ***The error intrinsic in the illuminance meter,***
- ***Error arising from field measurements,***
- ***Assumption of 0.07 as an average luminance coefficient, and***
- ***Field measurements are incomplete (a complete field data would require measurement on a recommended grid between at least two to three columns of luminaire) to determine accurate average and uniformity values.***

However despite the margin of errors, estimates of luminance values obtained are reasonably useful to provide a preliminary technical assessment.

2.6 Glare

Glare is a complex issue is treated in both CIE 31 and BS 5489:Part 1. Two types of glare are classified:

Disability Glare refers to loss of visibility cause by the disability glare of a source of bright light. An object that is just visible (i.e. at the threshold of visibility) in the absence of glare will merge into the background in the presence of disability glare.

Discomfort Glare refers to the response of the eye to varying and contrasting levels of lights. The contrast of glare source to background lighting, though not causing visibility loss causes a certain amount of discomfort.

The quantification of glare especially disability glare is treated in motorway lighting by the calculation of 'threshold increment' (TI). Formulation of TI is based on the percentage increase in luminance difference required to make an object visible in the presence of disability glare. The appraisal of discomfort glare is subjective and various guidelines are given. Appraisal of discomfort glare include the distinction between 'sparkle' and glare and the effect of 'cut-off' (shielded) lamp source and even mounting height of luminaire on glare restriction formula.

This report will not discourse on the details of glare calculation but will focus on the subject of discomfort glare.

2.7 Out of Scope

This REPORT/SURVEY will not touch on the following subject:

(a) The visual impact of lighting and the coordination of visual lighting impact in the core precincts of Putrajaya,

(b) The impact of colour rendering on architecture and landscape, and

(c) The aesthetic aspect of lighting and light fixture.

3 SURVEY OF LIGHTING LEVELS

3.1 Benchmarks

Before tabulating the data obtain in the survey, recommended values of luminance and uniformity is tabulated in table A3.1 for comparison with measured values. The tabulation in table A3.1 is simplified to consider only the types of roads treated in this SURVEY.

	BS 5489				CIE 115 and 136			
Motorways								
Description	**Class**	**L cd/m²**	**U_o**	**U_L**	**Class**	**L cd/m²**	**U_o**	**U_L**
Main high speed ring and access roads (separate carriageway).	Part 10	2	0.4	0.7	M1	2	0.4	0.7
Secondary high speed access roads (dual carriageway)	Part 2 2/1	1.5	0.4	0.7	M2	1.5	0.4	0.7
Important urban roads precinct distributor.	Part 2 2/2	1.0	0.4	0.5	M3	1.0	0.4	0.5
Local distributor, residential access	Part 2 2/3	0.5	0.4	0.5	M4	0.75	0.4	NR

Table A3.1a – Recommended Lighting Levels

1.2 Out of Scope

This REPORT/SURVEY will not touch on the following subject:

(a) The visual impact of lighting and the coordination of visual lighting impact in the core precincts of Putrajaya,

(b) The impact of colour rendering on architecture and landscape, and

The aesthetic aspect of lighting and light fixture.

Table A3.1a Recommended luminance for motorways (in cd/m²) BS 5489 and CIE 115 & 136.

	BS 5489				CIE 115 and 136			
Urban Centres								
Class	**Class**	**L cd/m²**	**U_o**	**E (lux)**	**Class**	**L cd/m²**	**U_o**	**E (lux)**
City Centre primarily vehicular		1.5	0.4	NA	Classification M1 to M5			
City centre mixed pedestrian /vehicular		NA	NA	30		NA	NA	25
City Centre wholly pedestrian		NA	NA	25		NA	NA	15
Suburbs primarily vehicular		1.5	0.4	MA	Classification M1 to M5			
Suburbs mixed pedestrian /vehicular		NA	NA	25		NA	NA	20
Suburbs wholly pedestrian		NA	NA	15		NA	NA	10

Table A3.1b – Recommended Lighting Levels

1.2 Tabulation of Data

The section at the back of this REPORT illustrate the locality of measurement and visual presentation of lighting types.

	Protocol Road	L cd/m²	U_o	U_L	E lux	Comments
1	Fauna single arm dual carriageway	1.7	0.33	0.5	-	Uniformity problem
	Fauna double arm, 4 lanes separate carriageway	2.4	0.4	0.5	-	Uniformity problem
2	Wau Bulan 6 lanes separate carriageway	2.5	0.4	0.3	-	Uniformity problem
3	Obor 6 lanes separate carriageway	1.1	0.6	0.7	-	Uniformity and uneven light distribution.
4	Persiaran Seri Perdana Flora – 4 lanes, separate carriageway	3 to 6	0.3	0.4	-	Uniformity problem exceeds BS & CIE recommendations
5	Core island ring road –Wau Bulan – 5 lanes single carriageway	3	0.5 – 0.6	0.5 – 0.6		Exceeds BS & CIE recommendations
6	Taman Putra Perdana Mixed pedestrian vehicular (2 lanes)	1	-		14	Comply with recommended values
7	Precinct 9 housing:-					
	(a) Main approach	3	0.45	0.4	45	Exceed BS & CIE recommendations
	(b) Secondary	2	0.75	0.6	40	

Table A3.2 – Tabulation of Lighting Assessment

***Table A3.1b* Recommended illuminance for pedestrian traffic (in lux) BS 5489 and CIE 115 & 136.**

***Table A3.2* Tabulation of Lighting Levels of core precinct from preliminary lighting survey.**

3.3 Detail Visual Assessment

Sky glow is a problem at core precinct area especially at:

(a) Grand mosque,

(b) Prime Minister's complex and

Sky glow in these areas are principally due to the usage of wide angle flood light in 'washing' architectural features (especially domes).

Discomfort glare are identified in the following areas:

I. Dataran Purajaya; where the street lights mounted on decorative columns are tilted upwards allowing lights to be directed above the horizontal plane,

II. Certain street lights (Obor and Flora) where the decorative luminaire has poor photometric characteristics, and

III. Wide spread use of globe lights (parks and Wisma Putra).

Light Trespass is not (yet) significant as the level of development Putrajaya has not reached a built-up and density sufficient to warrant such concern.

(e) Some problem area in discomfort glare (Dataran Putrajaya, decorative highway luminaire) and sky glow (flood lighting of PM's complex and grand mosque) is also identified.

(f) This REPORT is a preliminary assessment and is not meant to be an exhaustive or detail technical treatment of the subject.

4 CONCLUSION

From the survey the following conclusion can be drawn.

(a) Most roads and street lights are provided with lighting levels which exceed the BS and CIE recommendation.

(b) In some cases (suburban and core island), lighting levels are high (compared to recommended levels).

(c) Despite the abundance of lighting levels, light distribution and uniformity (especially at main Protocol roads) are poor. The degradation in light distribution and uniformity and inconsistency is due to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

(d) In view of the above, it is recommended that a detail survey of lighting level and performance be commissioned to be executed by a specialist company with the proper luminance meter.

… from the survey the following conclusion can be drawn:

(a) Lighting levels at most roads exceed the BS & CIE recommendation.

(b) In some cases (suburban and core island), levels are relatively high (compared to recommended values).

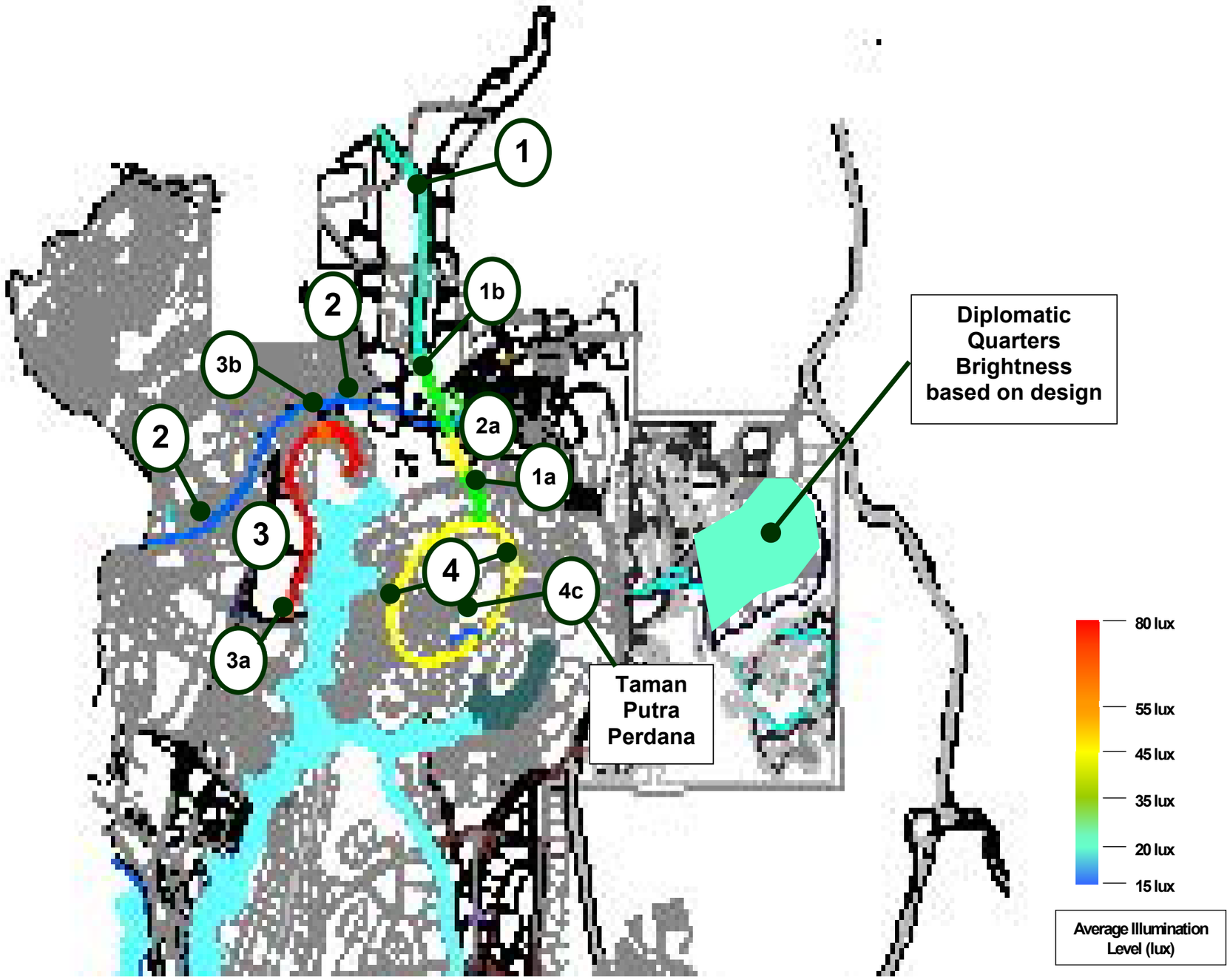
(c) Despite the abundance of lighting, light. The degradation in light distribution, uniformity and consistency is due to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

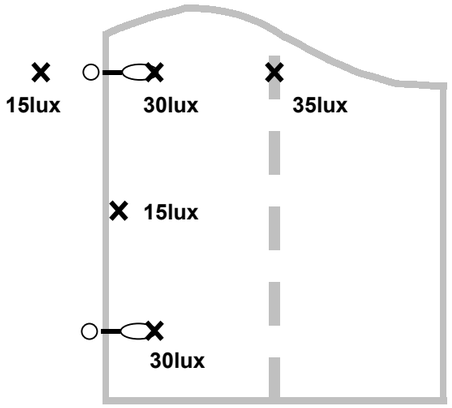
(d) It is recommended that a detail survey of lighting level and performance be executed by a specialist company with the proper luminance meter.

SECTION 2 – SURVEY OF EXISTING ROADS

Mapping of illuminance level

A6

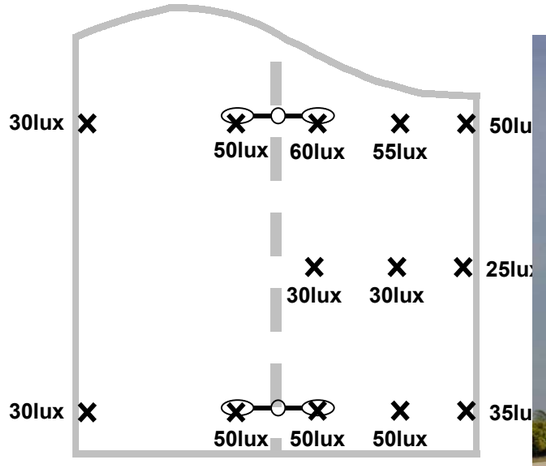




Road width – 2 lanes
Lamp height – 12m;
type - 250W SON

Protocol No. 1 – Fauna





Road width – 4 lanes
Lamp height – 12m;
type - 250W SON

Persiaran Persekutuan - Fauna





***Type Fauna** – estimate of luminance uniformity values falls below recommended values.*

Average luminance falls from 1.7cd/m² to 2.4cd/m² (CIE recommendations 2 cd/m²)

Location 1 - - Type Fauna

Estimate of overall Uniformity; $U_o \simeq 0.33$
Estimate of longitudinal Uniformity; $U_L \simeq 0.5$
Estimate of Average Luminance; $L_{av} \simeq 1.7$ cd/m²

The uniformity figures falls below the recommended values of
$U_o \simeq 0.4$
$U_L \simeq 0.5$

Location 1b - - Type Fauna

Estimate of overall Uniformity; $U_o \simeq 0.4$
Estimate of longitudinal Uniformity; $U_L \simeq 0.5$
Estimate of Average Luminance; $L_{av} \simeq 2.4$ cd/m²

Note:
Glare thresh-hold of fittings seems high.



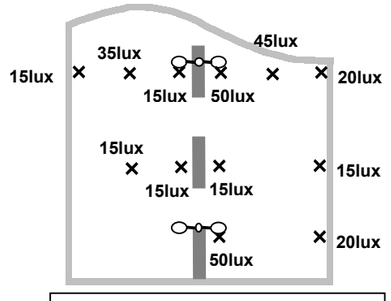






***Type Wau Bulan** – estimate of longitudinal uniformity values is below recommended values.*

Luminance averages 2.5cd/m² (CIE recommendations 2 cd/m²)



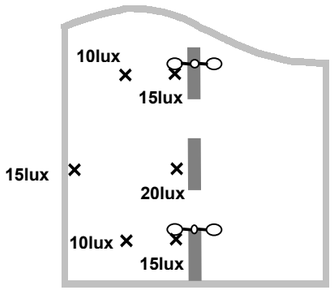
No of Lanes: 6
Lamp: 250W SON
Pole Height: 12m

Protocol No. 1 – Wau Bulan

Location 1a - - Type Wau Bulan

Estimate of overall Uniformity; $U_o \simeq 0.4$
Estimate of longitudinal Uniformity; $U_L \simeq 0.3$
Estimate of Average Luminance; $L_{av} \simeq 2.5$ cd/m²

Note:
Non-uniformity along longitudinal (parallel to road) axis is very obvious.



No of Lanes: 6
Lamp: 400W SON
Pole Height: 12m

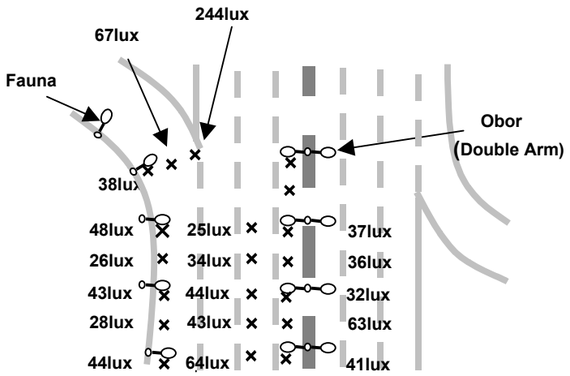
Persiaran Utara - Obor

Location 2 - - Type Obor

Estimates of

overall Uniformity; $U_o \simeq 0.6$
longitudinal Uniformity; $U_L \simeq 0.75$
Average Luminance; $L_{av} \simeq 1.1$ cd/m²

Note:
Despite the estimated values shown, uniformity of lighting level seems to be pronounced from visual inspection.



No of Lanes:
Lamp:
Pole Height:

Protocol No. 2 Obor-Double Arm

Location 2a - Type Obor

Estimates of

overall Uniformity; $U_o \simeq 0.65$
longitudinal Uniformity; $U_L \simeq 0.5$
Average Luminance; $L_{av} \simeq 2.5$ cd/m²

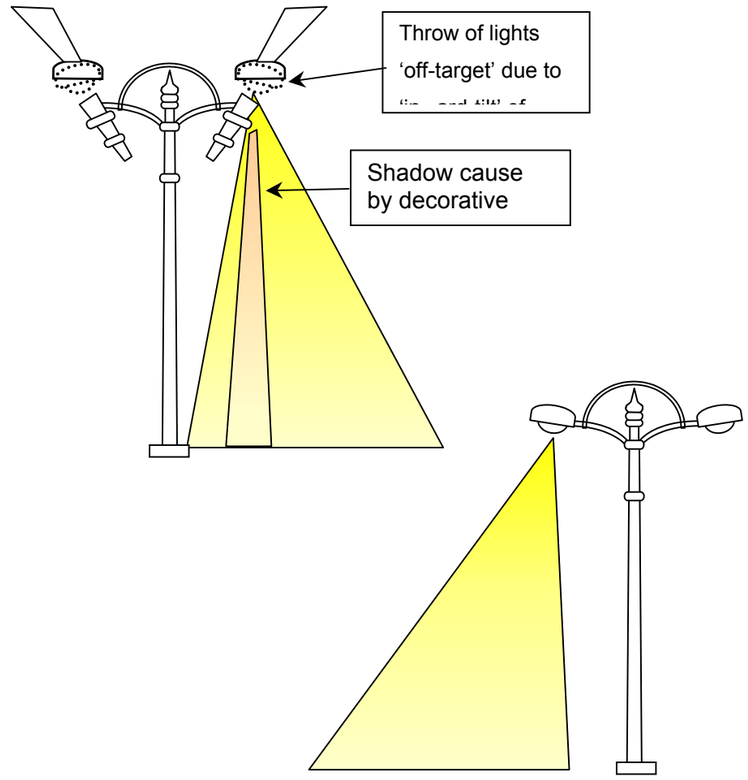


Figure AS2-1 – Poor Photometric Characteristics of Luminaire Type Obor

Luminaire type Obor has poor photometric characteristics due to the following:-

(a) The street luminaire is tilted 'inwards' instead of 'outwards' which is the usual manufacturer recommendation. Due to this the throw of lights onto the road is not distributed evenly onto the road.

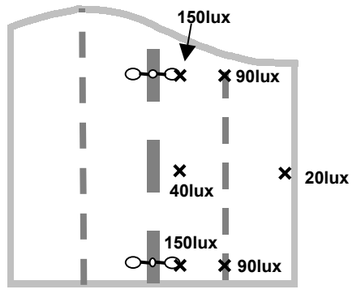
(b) The decorative fixture gets into the way of the lights causing shadow and degrading light spread.
The figure on the right shows the correct (and usual designed) configuration of light throw and lamp installation.

Type Obor –uniformity values measure reasonable but has problem over longer stretch of the road.

Average luminance falls from 1.1cd/m² to 2.5cd/m² (CIE recommendations 2 cd/m²)

Poor photometric characteristics of luminaire type Obor due to:
(a) 'inward' tilt of lamp (instead of 'outward' tilt);
(b) decorative fixture interfering with light spread causing shadows …





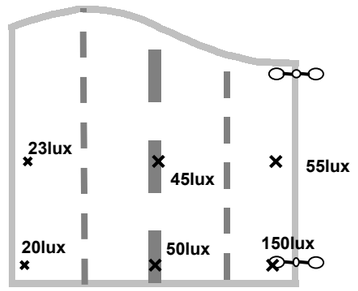
No of Lanes: 4
Lamp: 250W SON
Pole Height: 9m

Persiaran Seri Perdana - Flora

Location 3 - - Type Flora

Estimates of

overall Uniformity; $U_o \simeq 0.2$
longitudinal Uniformity; $U_L \simeq 0.3$
Average Luminance; $L_{av} \simeq 6$ cd/m²
Note: Non-uniformity very high probably due to unsatisfactory photometric characteristics.



No of Lanes: 4
Lamp: 250W SON
Pole Height: 9m

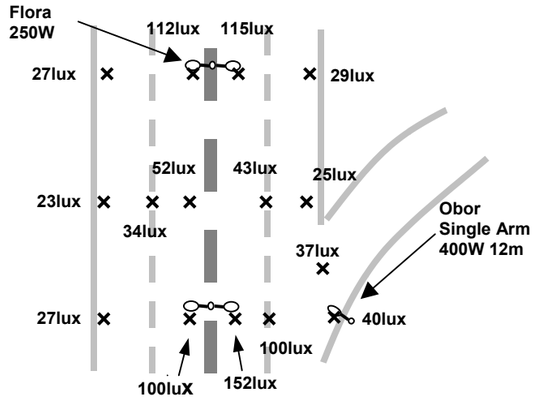
Persiaran Seri Perdana - Flora

Location 3a - - Flora

Estimates of

overall Uniformity; $U_o \simeq 0.34$
longitudinal Uniformity; $U_L \simeq 0.36$
Average Luminance; $L_{av} \simeq 4$ cd/m²
Note: Non-uniformity very high probably due to unsatisfactory photometric characteristics.





No of Lanes:
Lamp:
Pole Height:

Persiaran Seri Perdana

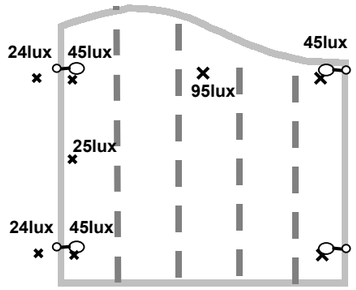
Location 3b – Type Flora

Estimates of

overall Uniformity; $U_o \simeq 0.45$
longitudinal Uniformity; $U_o \simeq 0.4$
Average Luminance; $L_{av} \simeq 3.5$ cd/m²
Note:

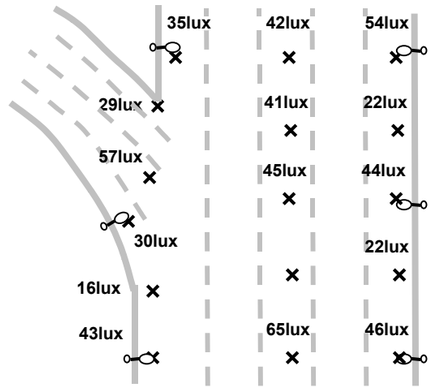
***Type Flora** (Persiaran Seri Perdana) – luminance uniformity values falls below recommended values.*

Average luminance falls from 4cd/m² to 6cd/m² is very high (CIE recommendations 2 cd/m²)



No of Lanes: 5
Lamp: 250W SON
Pole Height: 12m

Persiaran Perdana – Wau Bulan



No of Lanes: 5 lanes
Lamp: 250W SON
Pole Height: 12m

Persiaran Perdana





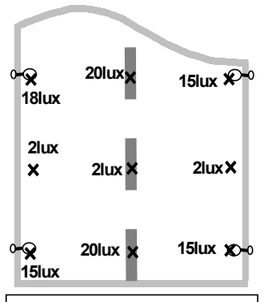
Locations 4a & 4b – Wau Bulan

***Taman Putra Perdana** – Where pedestrian traffic predominate illuminance values are more important.*

Average illuminance generally exceed 40 lux (about 3 cd/m²) which is slightly high (CIE recommendations for mixed pedestrian/vehicular roads at city centre is 25lux).

Location 4a - - Wau Bulan
(Photos in previous page)
Estimates of
overall Uniformity; $U_o \simeq 0.62$
longitudinal Uniformity; $U_L \simeq 0.6$
Average Luminance; $L_{av} \simeq 3.2$ cd/m²

Location 4b
(Photos in previous page)
Estimates of
overall Uniformity; $U_o \simeq 0.55$
longitudinal Uniformity; $U_L \simeq 0.5$
Average Luminance; $L_{av} \simeq 3.1$ cd/m²



No of Lanes: 2 (mixed)
Lamp: 70W SON
Pole Height: 6m

Taman Putra Perdana

Location 4c - - Taman Putra Perdana
(Photo on the right.)

Estimate of
overall Uniformity; $U_o \simeq 0.14$
longitudinal Uniformity; $U_L \simeq 0.1$
Average Luminance; $L_{av} \simeq 1.0$ cd/m²

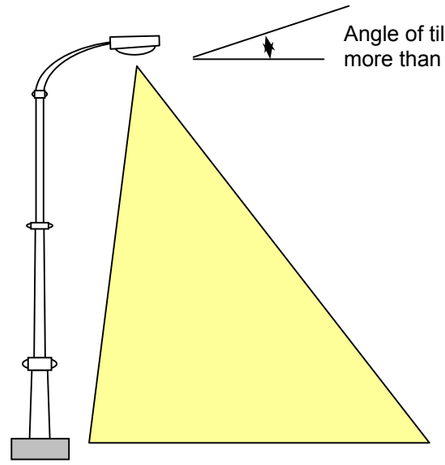
Note:
Mixed pedestrian/vehicle roads. Recommended uniformity (U_o) more than 0.4. However illuminance is more important and recommended minimum level (for mixed pedestrian/vehicular, city centre) is 25lux. The unsatisfactory uniformity is probably due to the photometric characteristics of the lamps.



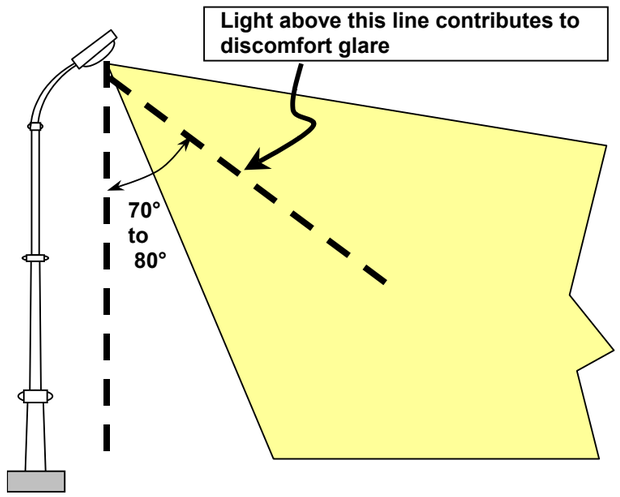
Locations 4c – Taman Putra Perdana







✔ **Normal Mounting Method**



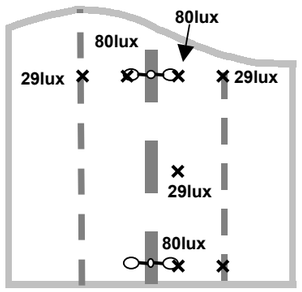
✘ **High Angle of Tilt Contributes to Discomfort Glare**

Dataran Putrajaya

No meaningful measurement of lighting level can be made without proper luminance meter.

Note:
The luminaire (which is a normal street light) is up-tilted contributing to significant glare (see figure below)

***Dataran Putrajaya* Upward tilt of luminaire in square contributes to discomfort glare and detract from the night scene.**



No of Lanes: 4
Lamp: 250W SON
Pole Height: 12m

Precinct 9 – Main Approach Road

Precinct 9 - -Housing Area

Estimates of

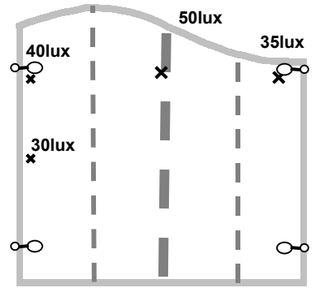
overall Uniformity; $U_o \simeq 0.45$
longitudinal Uniformity; $U_L \simeq 0.4$
Average Luminance; $I_{av} \simeq 3.1$ cd/m²

Note: CIE classification for residential access roads M5/C5 recommends:-
$I_{av} \simeq 0.5$ cd/m² $E_{av} \simeq 7.5$ lux
$U_o \simeq$

Location 9 - -Housing Area

Estimates of

overall Uniformity; $U_o \simeq 0.75$



No of Lanes: 4
Lamp: 250W SON
Pole Height: 12m

Precinct 9 Housing – Secondary Road

Location 9 - -Housing Area

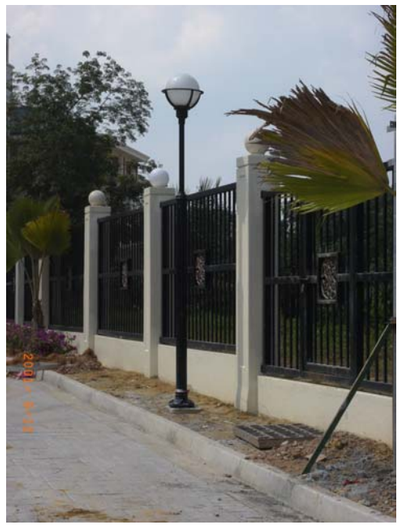
Estimates of

overall Uniformity; $U_o \simeq 0.75$
longitudinal Uniformity; $U_L \simeq 0.6$
Average Luminance; $L_{av} \simeq 2.0$ cd/m²

Note: CIE classification for residential access roads M4/C4 recommends:-
$I_{av} \simeq 0.75$ cd/m² $E_{av} \simeq 10$ lux
$U_o \simeq 0.4$



Wisma Putra
Predominance of Globe Light

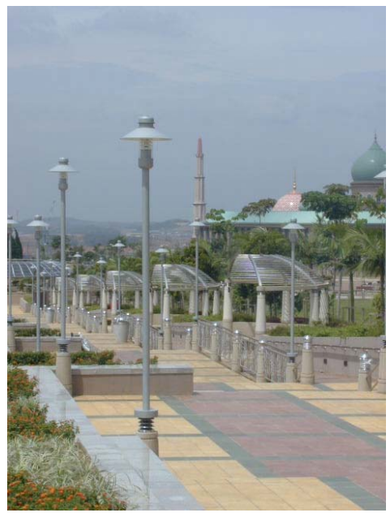


Residential ***The estimated average luminance/ illuminance exceed 3cd/m² / 40 lux (about 3 cd/m²).***
The recommended value under CIE Standard is around 0.75cd/m² / 20lux (lux value is more appropriate for mixed pedestrian/vehicular traffic.

Predominance of globe light at Wisma Putra (contributes towards light pollution).



Botanical Garden
Predominance of Lantern Tops



(END OF SURVEY REPORT)

APPENDIX B: LIGHTING PERSONNEL

APPENDIX B: LIGHTING PERSONNEL

1. The functions and duties of the lighting specialist(s)

It is proposed that two persons be recruited:

- City Lighting Manager
- Assistant City Lighting Manager

City Lighting Manager

This senior post will include the following duties:

- Advise on the modification, amendment or extension of the planning approval structure, and its associated legislation, to embrace any form of external lighting as a part of the Planning Approval Application.

- Establish and maintain a comprehensive system to ensure that the detailed design for all external lighting is submitted, reviewed and approved as a part of the overall planning approval process.

- Advise on the establishment of an advisory or mandatory structure that requires all external lighting that is subject of to a Planning Approval Application to be maintained and operated at agreed times.

- Advise and educate PJC personnel in the Development Control Unit, the Urban Design Unit, the Infrastructure & Utilities Unit, the Parks Unit, the Environmental Unit and, within the Urban Development Department, the Development Co-ordination Division, the Building Control Division and the Infrastructure Control Division. Lighting issues prevail in all these units and divisions and it is the responsibility of the City Lighting Manager to ensure that all personnel who have contact with external lighting and related issues are made, and kept aware, of the Lighting Masterplan objectives and value.

- Review and comment on all external lighting design proposals submitted to PJC to ensure compliance with the objectives of the Lighting Masterplan and any other applicable lighting directives or standards. These will include the external lighting of buildings, bridges, structures, landscapes, waterscapes, roads, streets, pedestrian precincts, advertising, security requirements and the permanently installed lighting of any other external element.

- Establish and maintain a system that reviews completed external lighting installations to ensure that these are in compliance with the designs submitted for, and approved through, the Planning Approval Application.

- Establish and maintain a system that encourages and, where possible, ensures the effective and comprehensive maintenance of all installed external lighting in the ownership of public authorities or the private sector.

- Prepare and submit regular reports on the progress towards, or deviation from, the attainment of the Lighting Masterplan objectives.

- Ensure that external lighting is placed and maintained on all relevant planning and development agendas. This to include road and street lighting, advertising lighting and temporary festive lighting.

- Advise and educate external designers, architects, engineers and contractors on the objectives of the Lighting Masterplan to assist such persons to achieve designs that are in compliance with its aims and directives. This will include responsibility for ensuring the appropriate distribution of the Good Lighting Practice guide document.

- Pro-actively encourage high quality external lighting to buildings and structures where this is appropriate and supportive of the aims of the Lighting Masterplan.

- Initiate and participate in appropriate public relations exercises to promote the values of quality external lighting.

- Maintain awareness and knowledge of international developments in lighting design trends, techniques and technology.

- Prepare, or direct preparation by external consultants, lighting design for property owned by PJC.

Assistant City Lighting Manager

This junior post will include the following duties:

- Assist the City Lighting Manager is in his or her full range of duties but with particular emphasis on the following:

- Maintain routine examination of all installed external lighting throughout Putrajaya to ensure comprehensive and effective maintenance and operation at agreed times.

- Liase with private property owners to ensure effective maintenance and operation of external lighting of properties not owned by PJC.

- Instruct and oversee the timely maintenance of external lighting to property owned and/or operated by PJC.

- Examine newly installed external lighting to ensure compliance with the submitted Planning Approval Application.
- Assist in advising and guiding lighting planning and design to conform to the aims of the Lighting Masterplan.

2. The experience and qualifications of the selected personnel.

It is acknowledged that PJC will possibly be establishing a unique precedent in engaging professional lighting personnel to ensure the successful implementation of the Lighting Masterplan. Selected personnel will, ideally, require to be experienced in and appreciative of the:

- Art of lighting design in the architectural and urban environment.

- Science of illuminating engineering in general and road/street lighting in particular.

- Role of lighting in urban society and the night time economy.

- Relationship of artificial light to the natural environment.

- Latest developments in lighting technology.

- Various methods by which lighting design and installation is achieved.

Additionally, the City Lighting Manager will require excellent interpersonal and communication skills. He or she will possess a high level of enthusiasm for the subject of lighting and will appreciate the unique opportunity to influence and shape the perception and image of a new city at night.

The question of lighting qualification and education is complex and perhaps particularly so in Malaysia.

Overview on lighting education and qualification

Lighting does not yet conform to recognised and certifiable standards. Many successful designers have achieved their status through the 'experience track' method. This is because lighting design is a young developing profession that is still establishing educational and qualification criteria on a national and international basis. Many designers enter architectural and urban lighting design from architectural, interior design, industrial design, stage lighting design, electrical engineering and pure illuminating engineering. The routes by which people arrive in architectural lighting are various. They include background experience in the lighting manufacturing industry, lighting sales organisations, the consulting engineering community and the arts. A number of lighting training courses exist internationally but it is understood that no specific lighting training is currently available in Malaysia.

Internationally available lighting education comprises courses at technical college, under-graduate and postgraduate levels aimed at providing specific training in lighting and related issues. The long established postgraduate courses are those provided at:

- The University of Sydney
- The Bartlett School of the Built Environment, University College London
- The Lighting Research Centre, Rensselaer Polytechnic Institute, New York State
- The Parsons School of Design, New York.

These courses produce graduates who are considered to be the most highly trained in the art and science of lighting. It is known that a number of Malaysian nationals have completed the postgraduate course at the Bartlett, London. Research is required to determine if other Malaysian or, possibly, Asian nationals have completed courses at the other establishments.

At undergraduate level lighting is frequently included as a subject within a wider curriculum such as architecture or electrical engineering. It is unusual for graduates to specialise in lighting unless they have attended an architectural or building sciences course that includes a strong lighting element. At technical college level or other tertiary education establishments, lighting courses are available in most western countries.

In addition to formal courses, the major lighting and lamp manufacturing organisations such as GE, Philips and iGuzzini teach aspects of lighting coupled to familiarisation with their products.

The PJC requirement – City Lighting Manager

It should be noted that even those who have completed a postgraduate degree in lighting still require their education to be tempered by experience. It is proposed that PJC requires a City Lighting Manager who has ideally completed a postgraduate course in lighting but who also has at least 5 years experience in lighting design and planning. Such experience will ideally have been obtained as an independent lighting design professional working either in a specialist lighting design practice or within an architectural or consulting engineering firm. An acceptable but lesser alternative would be experience obtained in one of the major lighting manufacturing companies that include external lighting within their operation. Exceptionally, a candidate may present who does not have a formal qualification but can demonstrate lengthy (at least 10 years) and in-depth experience in lighting design and planning – such a person should merit equal consideration. An additional consideration is that the successful applicant is likely to have senior grade membership of one or more of the following:

- Illuminating Engineering Society of Australia & New Zealand (IESANZ)
- Illuminating Engineering Society of North America (IESNA)
- International Association of Lighting Designers (IALD)
- Society of Light & Lighting – UK
- European Lighting Designers Association (ELDA)

It is anticipated that a combination of national and international advertising for the post of City Lighting Manager would draw much attention and yield a worthwhile degree of choice. International journals in which to advertise include:

- Lighting (Australia)
- Lighting Equipment News (UK)
- The Lighting Journal (UK)
- Light & Lighting (UK)
- Light (UK)
- Professional Lighting Design (Germany)
- Lighting Design & Application (USA)
- Architectural Lighting (USA)

The PJC requirement – Assistant City Lighting Manager

This post will ideally attract persons with similar levels of qualification as the candidate for City Lighting Manager but is unlikely to attract the same degree of experience.

The level of experience to successfully fulfil the Assistant City Lighting Manager role will have been gained within the lighting manufacturing industry as an in-house designer/specifier or in a junior position within a specialist lighting design group. Alternatively, a young electrical engineer with a keen interest and considerable experience in lighting would be suitable.

3. The department or unit of PJC within which the lighting personnel should be located.

It is proposed that lighting be identified within PJC as an issue that relates particularly to the Town Planning Division, to some degree to the Environmental Division and to a minor degree to divisions within the Urban Development Department. This is because lighting should be considered as a visual and amenity issue. Since much of the work to be done by the City Lighting Manager and his or her Assistant relates to the planning approval system, its enforcement and reviewing the resulting visual outcome, it is proposed that a lighting sub-division be created within the Town Planning Division. It is not currently known how the various divisions and units within PJC communicate. However, it will be important to ensure that effective communication is established and maintained between the lighting sub-division and those :

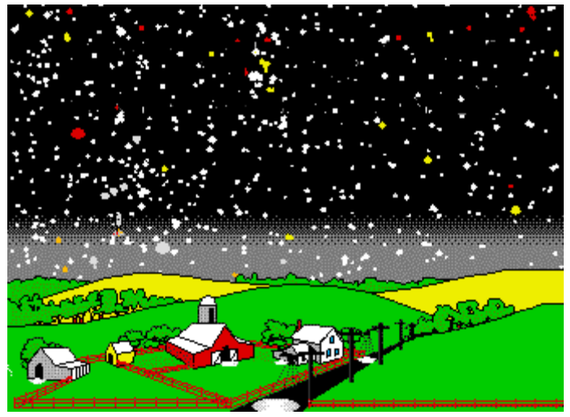
- Responsible for calling for and reviewing information upon which to base a Planning Application Approval.
- Engaged in drawing up strategies, planning and development policies.
- Responsible for co-ordinating infrastructure and utilities. Responsible for enforcing planning law. Managing the development of parklands and water areas
- Engaged in co-ordinating standard regulations, guidelines, plans and research into environmental aspects.
- Responsible for road and street lighting maintenance.
- Who are responsible for enforcing laws relating to infrastructure works such as road lighting and related issues.

From the foregoing it will be appreciated that lighting personnel will require to be involved in a wide range of issues. This reflects the ubiquity of the subject.

APPENDIX C: NIGHT SKY POLLUTION

APPENDIX C – SKY GLOW AND THE NIGHT TIME SKY

INTRODUCTION



In the international arena there is a growing realisation that outdoor lighting which is not well-designed (and especially over-designed) and properly installed is harmful to the night time environment. The nighttime skies of cities are increasing being suffused with a glow, which degrade the clarity of the stars. Due to this, observatories have to be sited increasing further from cities and even towns. In is therefore not surprising that astronomical societies are in the forefront for a growing campaign against night sky pollution. In the U.K. this is represented by the B.A.A. (British Astronomical Association) Campaign for Dark Skies and internationally 'The International Dark Sky Association' (IDA) is in the forefront against night sky pollution.

This section identifies the problem associated with sky pollution and suggests some good practice methods to mitigate against night sky polluion.

1.0 ISSUES IN OUTDOOR LIGHTING

1.1 The Positive Influence of Outdoor Lighting

The introduction of outdoor lighting has contributed immensely to the greater productivity, quality of life and general benefits to humankind. Outdoor lighting is generally associated with roadway lightings. Since the 20th Century, outdoor lighting has increasingly being introduced for purposes other than functional (roadways) and safety. Initial usage of outdoor lightings has progressed from recreational lightings to present day lightings for advertising purposes.

It has been recognised that poorly-designed lighting and especially over-designed lighting scheme is contributing to a growing problem in night time **light pollution**.

1.2 Light Pollution Issues

General Light pollution refers to the general wastage of poorly designed lighting scheme or light fixture. The type of light pollution generally recognised by most standards (U.S.A. Pattern Codes, CIE Publication 1 etc.) are listed in this sub-section.

Sky Glow refers to the wasteful throw of lights into the night sky contributing to light pollution. It is usually a result of:

(a) Misdirected light which throws more light onto the sky than at the intended area.

(b) Wasteful use of wide angle projection in an attempt to 'flood' or 'wash' a façade or monument (instead up to 80% of the light is lost skyward).

(c) Luminaire with a significant portion of lights escaping above the horizontal plane. Luminaire with shields or reflector to limit this upward throw of lights is termed fully or semi 'cut-off'. Non 'cut-off' luminaire under certain conditions also contributes to discomfort glare.

Light Trespass refers to the intrusion of light into a neighbouring lot. Light trespass cause a loss of privacy (such as street lights intruding into the bedroom and is usually a result of:

i. Misdirected light trespassing onto a neighbouring lot,
ii. Wide angled projected light trespassing onto a neighbouring lot,
iii. Unshielded Luminaire.

The nighttime skies of cities are increasing being suffused with a glow, which degrade the clarity of the skies and stars

Poorly designed lighting and especially over designed lighting scheme contribute to a growing problem in light pollution.

1.2 Light Pollution Issues

(a) Poor lighting Scheme – due to poor design or over design or design in the wrong context.
(b) Sky Glow - wasteful throw of lights into the night sky;
(c) Light Trespass – intrusion of light into neighbouring lot; and
(d) Glare – comprising 'Disability Glare ' (loss in visibility) and discomfort glare (distraction from the surrounding scene).

Glare is a complex issue which is treated in both CIE 31 and BS 5489:Part 1. Two types of glare are classified:

- Disability Glare refers to loss of visibility cause by the disability glare of a source of bright light. An object that is just visible (i.e. at the threshold of visibility) in the absence of glare will merge into the background in the presence of disability glare.
- Discomfort Glare refers to the response of the eye to varying and contrasting levels of lights. The contrast of glare source to background lighting, though not causing visibility loss causes a certain amount of discomfort.

The quantification of glare especially disability glare is treated in motorway lighting by the calculation of 'threshold increment' (TI). Formulation of TI is based on the percentage increase in luminance difference required to make an object visible in the presence of disability glare. The appraisal of discomfort glare is subjective and various guidelines are given. Appraisal of discomfort glare include the distinction between 'sparkle' and glare and the effect of 'cut-off' (shielded) lamp source and even mounting height of luminaire on glare restriction formula. Discomfort glare is usually considered in most publication on minimising Night time light pollution.

1.3 Ecological Concerns

Issues related to light pollution include the following:

Energy Waste Over-design and/or poor outdoor lighting wastes energy due to poor light distribution or over lighting without enhancing security, safety or aesthetic consideration.

Ecological considerations become an issue in ecological enclave (e.g. Wetlands). The wrong usage or even usage itself of lightings should be carefully considered, as artificial lighting will have adverse impact on the bio-ecology of such enclaves. It has also being found that monochromatic lights (i.e. lights with predominantly a single colour such as low pressure sodium) has a higher impact on insect and avian ecology.

2.0 STANDARDS FOR MINIMISING LIGHT POLLUTION

2.2 Publications

In addressing the concerns of light pollution various publication by the B.A.A. (British Astronomical Association) 'Campaign for Night Sky' and the 'International Dark Sky Association' (IDA) has been issued. The IDA's 'U.S.A. Pattern Code' in particular is a generic code which can be modified to the needs of a particular community and is popularly adapted by many cities and municipal authorities in the U.S.A. Some 'good practices' and standard procedures for minimising light pollution included in the following sub-sections are gleaned from the publication listed.

2.3 Lighting Zones

General In lighting codes, it is recognised that different zoned development has differing developed and natural conditions, with differing levels and sensitivities to appropriate outdoor light usage. Because of this, five Lighting Zones are usually defined based on the Environmental Zones defined by the *Commission Internationale de l'Éclairage (CIE)*, and also used by the IESNA:

Zone E1A Dark-Sky Preserves. These are areas close to major active astronomical research facilities, and within and near dark-sky preserves or parks that have identified the preservation of the darkest nighttime environment as a priority. In Putrajaya the inner sanctum of the Wetland enclave would qualify for this classification.

Zone E1 Intrinsic Dark Landscapes Examples are national parks, areas of outstanding natural beauty, areas surrounding major astronomical observatories. In Putrajaya buffer areas

1.3 Ecological concerns

(a) Energy Waste – over design of lights; and

(b) Ecological considerations – principally in ecological enclave (e.g. Wetlands).

2.3 Lighting Zones

Codes recognised that different zoned development require differing levels and sensitivities to outdoor light usage…

(a) Zone E1A – Dark Sky Preserve (Astronomy enclave, Wetlands);

(b) Zone E1 -Intrinsic Dark Landscapes (Buffer around E1A, parks);

(c) Zone E2 – Areas of low ambient brightness (rural residential/ city parks);

(d) Zone E3 – Areas of medium ambient brightness (urban residential); and

(e) Zone E4 – Areas of high ambient brightness (urban areas, commercial, city centres).

surrounding the Wetland enclaves and certain parks may qualify for this classification.

Zone E2 Areas of low ambient brightness. These are suburban and rural residential areas and may include some city parks or car park and pedestrian areas of city parks. Some 'low-rise' residential areas or 'private' residential areas may fall under this classification.

Zone E3 Areas of medium ambient brightness. These will generally be urban residential areas. Most residential district of Putrajaya will fall under this classifcation.

Zone E4 Areas of high ambient brightness. Normally these are urban areas that have both residential and commercial use and experience high levels of nighttime activity. This include the core business district and

1.2 Lamp Type and Shielding Standards

Shielding of lamps is a common practice to minimise light pollution. Shielding refers to the spillage of lights above the horizontal axis of the light fixture. A detail discussions of shielding (or its technical equivalent 'cut-off' or 'semi-cut-off' is in section 2.5 below): Table C2.4 is extracted from the 'U.S.A. Pattern Code ('IDA') in the regulation of shielding and light pollution. The benchmark described in the said standard, if adopted as a mandatory standard may however be difficult to enforce in some instance (e.g. requirement for shielding of lamp at residential homes – last row of table). The benchmarks should therefore be consulted by lighting designer as an indication of 'good-lighting practice'.

The legends used in the table are as follows:

A = all types of fixtures allowed; shielding not required but highly recommended, except that any spot or flood-light must be aimed no higher than 45 degrees above straight down

F = only fully shielded fixtures allowed

X = not allowed

Class and Lamp Type	Lighting Zones				
	E4	E3	E2	E1	E1A
Class 1 Lighting (Colour Rendition)					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	F	F
Class 2 Lighting (General Illumination)					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	F	F
Class 3 Lighting (Decorative)					
Output ≥ 2,000 lumens	F	F	X	X	X
Output < 2,000 lumens	A	A	F	F	F
Residential Lighting (All Classes)					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	A	F

Table C2.4 – Lamp Type and Shielding Standards

Notes to the above are as follows:

1) Output refers to the initial designed output of the luminaire.
2) In all cases flood or spot lamps must be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side) when the source is visible from any off-site residential property or public roadway.
3) Exceptions to shielding may be allowed in case of seasonal (festive occasions) decorations using typical unshielded low-wattage incandescent lamps.
4) In some cases a 'curfew' on lighting especially Class 3 may be imposed. Curfew hours for lighting may depends on the lighting zone (E1 areas will

C3

Table C2.4 – Lamp Shielding Standards
Shielding standards of lumiaire for different zones.

Note (1) For Class 3 lighting (lights for decorative purposes) lamp types of more than 2,000 lumens is not recommended in lighting zones EA1, E1 and E2.

(2) Generally lamps with output of more than 2,000 lumens require some form of shielding.

have longer curfew hours compared to E4 zones) and are typically from 2.00pm to 8.00am and/or even 12.00pm midnight to 7.00am.

2.5 Shielding and Cut-Off

In defining lamp shielding, the technical terms used are 'cut-off' and 'semi-cut-off'. The definition of cut-off under CIE publication 12 is shown in table C2.5.

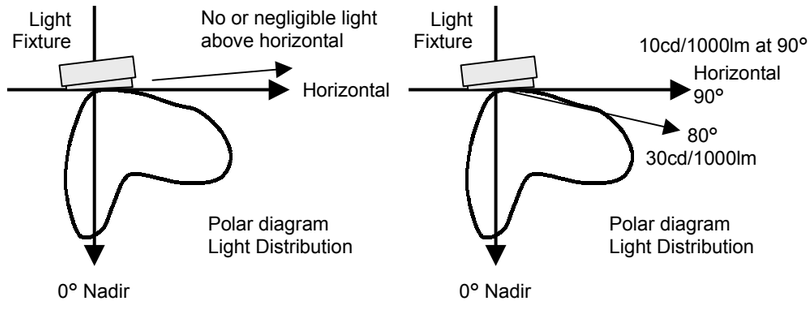
Type of Luminaire	Direction of Max Intensity	Maximum Permissible Value at Intensity emitted At	
		90°	80°
a. Full Cut-Off	0 –68°	*10cd/1000lm	30cd/1000lm
b. Semi Cut-Off	0 –75°	*500cd/1000lm	100cd/lm
c. No Cut-Off	-	1000cd	-
Note * - Up to a maximum value of 1000cd whatever is the luminous flux.			

Table C2.5 - Definition of Cut-Off (CIE 12:1995)

Due to the technical nature of the above, most lighting codes adopt a simplified definition of shielding. For the layman and the non-technical personal:-

A fully shielded fixtures is defined as light fixture with no (or negligible) light output at and above the horizontal axes of the lowest light emitting part of the fixture.

Figures C2.5.1 illustrates the principal of shielding and cut-off.



Simple Definition of Fully-Shielded **CIE-12 Definition of 'Cut-Off'**

Figure C2.5 – Definitions of Shielding and 'Cut-Off'

2.6 Limitations of Lumens Per Acre (Lumens Cap)

Over lighting is a common problem where the over-zealous application of lights contributes to energy wastage and a pervasive over-powering of the night time scene. To regulate over lighting and promote efficient lighting design, some measures adopted by outdoor lighting ordinances include:

- Broad limitation on Lumens per Acre (or 'lumens cap') generally based on 80,000 lumens per net acre with full cut-off (fco) lighting. Parcels of less than one acre are allowed fco lumens proportionate to the one acre limitations.
- A more sophisticated lumens cap based on lighting zones is proposed under the IDA's pattern code (table C2.6)

LUMEN CAPS (Initial Lamp Lumens Per Net Acre)	Lighting Zones				
	E4	E3	E2	E1	E1A
Commercial and Industrial zoning (1)					
Total (fully shielded + unshielded)	20,000	100,000	50,000	25,000	12,500
Unshielded only	10,000	10,000	4,000	2,000	1,000
Residential zoning (2)					
Total (fully shielded + unshielded)	20,000	10,000	10,000	1,0000	5,000
Unshielded only	5,000	5,000	1,000	1,000	0

Table C2.6 Lumens Cap Based on Zoning (extracted from 'IDA's U.S Pattern Code')

C4

Simple definition of 'Fully-Shielded': No or negligible light throw at or above the horizontal axis of the lowest light emitting part of the luminaire.

2.6 Limitation of Lumens Per Acre (Lumens Cap)

A declared limitation on lumens per acre (lumens cap) places a broad guide or benchmark on lighting design forcing efficient design.

A broad base 'lumens cap' may generally be quoted at 80,000 lumens per acre (with fully shielded luminaire).

Table C2.6 is a more sophisticated categorising of lumens cap based on lighting zones based on the IDA's US 'Pattern Code'.

Some notes to lumens cap are as follows:

- Seasonal variations (festive occasions etc) to the above are permitted.
- The values in table C2.6 are upper limits and not design goals; design goals should be the lowest levels that meet the requirements of the task.
- Calculation of 'lumens cap' exclude signage lights, internally lit signs, internal building lights, neon lights, temporary lights, festive occasion lights and lights which provide 'sparkle'.
- Footnote (1) refers to all land-use zoning classifications for multiple families, commercial and industrial uses.
- Footnote (2) refers to all residential land-use zoning classifications, including all densities and types of housing such as single-family detached and duplexes.

2.7 Pole Heights

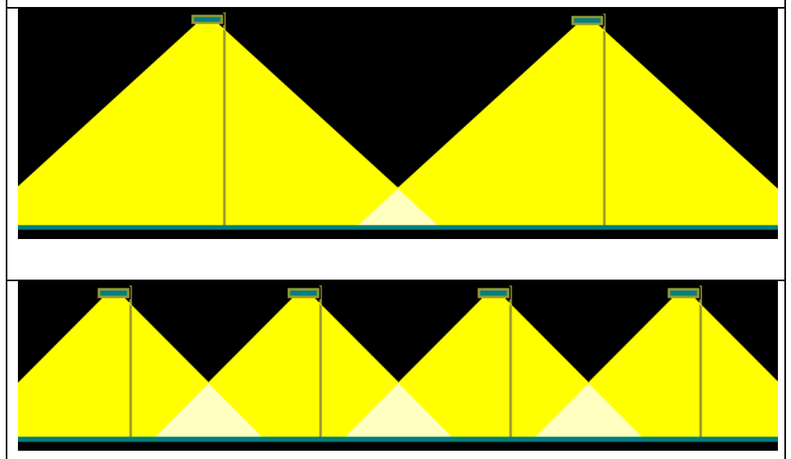
Should Pole Heights be limited Concerns have sometimes being raised with regards to pole height, and call for the inclusion of pole height restrictions be included in a lighting code. However, recent industry findings conclude that restriction on pole heights may not be as intended and restriction of pole heights should not be included in any lighting codes.

Pole Heights in Design In the design of streets and roadway lightings, pole height considerations impact lighting design as follows:

- Uniformity of Lighting. Taller poles will have greater uniformity problems which can be off-set by choosing the luminaire with the correct light distribution,
- Cost, Shorter poles requires more poles increasing cost, and
- Visual impact. Tall poles may not be visually desirable in areas of low rise and generally street lights bears some visual coordination with the surrounding buildings.

Figure C2.7 is a series of diagram explaining pole height issues:

In attempting to limit the daytime visual impact of tall light poles against landscape views, shorter poles may help but lighting uniformity goals may offset the gains from shorter poles by causing an increase in the number of poles. More poles will result in higher capital and operating cost.



Pole height restrictions may cause more poles to maintain uniformity

If attempting to limit the night time visual impact of lights, in particular the spread of light from high luminaires into surrounding areas (light trespass), pole restrictions may be much less than hoped. Since most area lighting has certain target uniformity levels, shorter poles will mean that more must be used, which may increase the visual impact at night as well as in the daytime. While these poles will be shorter the trade-off of more poles may compromise the original intent to reduce visual clutter.



Pole height restrictions may cause more glare with higher angle candlepower distributions. Some designer in an attempt to avoid increasing the number of

2.7 Issues Concerning Pole Height

A lower visual impact due to shorter poles be off-set by the increase in number of poles causing higher capital and operating cost.

Restricting pole heights to control light spread and ultimately light trespass may be less than hoped for. The trade-off in shorter poles and lower visual impact may cause an increase in the number of poles and increase visual clutter

Pole height restriction may cause more glare. In attempting to avoid increasing the number of poles by using luminaire with wide angle luminance spread, achieving uniformity goals will be at the expense of increase glare.

poles by using luminaries with wide angle luminance, may achieve luminance and uniformity goals at the expense of increased glare.
Figure C2.6 – Consequence of Pole Height Restrictions

In general, it is not recommended that a lighting code limit pole heights. With good designs using fully shielded luminaires, poles with standard heights (up to about 11 meters or 35 feet) are in most situations minimally obtrusive.

2.8 Obtrusive Light Limitations

A proposal to limit luminance level and intensity may be based on table C2.7 below:

Environmental Zones	Sky Glow UWLR [Max.%]	Source Instensity I [kcd]		Building Luminance*** L [cd/m2]
		Before curfew**	After curfew	Average Before curfew
E1	0	0	0	0
E2	5	50	0.5	5
E3	15	100	1.0	10
E4	25	100	2.5	25

Table C2.8 - Obtrusive Light Limitations for Exterior Lighting Installations

Guidance to table C2.7 is as follows:

- **I** = Light intensity in kcd or kilo-candelas
- L = Luminance in Candelas per square metre
- ** **Source Intensity** - applies to each source in the potentially obtrusive direction, *outside* of the area lit. The figures given are for general guidance only and for some medium to large sports lighting applications with limited mounting heights, may be difficult to achieve. However, if the recommendations are followed then it should be possible to lower these figures to under 10 kcd (kilocandela).
- *** **Building Luminance** - This should be limited to avoid overlighting, and relate to the general district brightness.
- **UWLR** – Upward Waste Light Ratio (maximum allowable percentage of luminaire flux escaping directly sky wards.

3 PRACTICAL ISSUES IN MINIMISING LIGHT POLLUTION

3.2 Four Characteristics to Good Lighting Practice

C6

Good lighting design aims for an efficient design with minimal impact on the environment. The four characteristics of a good design can be summarised below:

Adequacy of Lights The level of lighting provided is adequate for the intended context and usage and is never over or under provided. Luminance tables provided in codes and standards are guides towards this aim but in 'contextual' lighting luminance guide may not be sufficient and experience may be necessary.

Efficient Positioning and Installation of Light Fixtures aims to maximise the usage in the intended property and minimise the impact onto adjacent properties. Positioning and correct 'aiming' of light fixtures are also important to maintain the intended contextual design element.

Colour Rendering and Energy Efficient Lamps High efficiency lamps are preferred for its lower environmental impact and operating cost. Balanced against this however is the need to maintain the 'quality' of lights. Quality of lights represented by colour rendering is an important element in the design of contextual lighting scheme.

Proper shielding of Lights to reduce glare, light trespass and sky glow are important in maintaining a safe and visually pleasant lit environment.

Table C2.8 proposes benchmarking values ps source intensity (kilocandela) and average building luminance value; e.g. for zone E4 – maximum lamp source kilo-cd Average building luminance less than 25cd/m²; average luminance value (calculated over the total building surface) should not be confused with spot values which is usually much higher.

3.2 Four Characteristics of Good Lighting Practice

(a) Adequacy of Lights (right amount and in the right context)

(b) Efficient Positioning and Installation of Fixtures;

(c) Colour Rendering and Energy Efficient Lamps; and

(d) Proper Shielding of Lights

Figure C3.3- Examples of Effective Signage Lights

3.3 Outdoor Advertising Signs

General In the modern environment, outdoor advertising signs are becoming an important and ubiquitous feature of the urban and suburban landscape (and increasing even in the rural landscape). Unfortunately the trend in lighting for advertising signs have been one of increasing visual (and lighting) impact which are frequently obtrusive. Some guides to the regulation of outdoor advertising signs are listed in this sub-section.

Internally Illuminated Sign are signs with light fixture mounted within the signage structure or enclosure. Guidelines for internally illuminated signs are as follows:

(a) Advertising signs must be either constructed with an opaque background and translucent text and symbols, or with coloured background and generally lighter text and symbols.

Signs with white background or other bright background produce the greatest amount of light and such internally lit signs are by nature unshielded light source.

Colour background with lighter text and symbols often convey information more effectively and attractively at a reduced light output compared to signs with bright or white background.





Externally Illuminated Signs have fixtures mounted externally to the signage structure or enclosure.

I. External light fixtures in this instances is classified as Class 1 lighting in table C2.4 (i.e. all luminaire more than 2,000 lumens are to be fully shielded).

II. Light fixtures should preferably be mounted to shine down. However in case where this is not possible, then careful choice of luminaire with asymmetrical luminance distribution, proper positioning and targeting of luminaire should be implemented to minimise glare and sky glow.

Other Consideration which may be included in regulating advertising signs may be as follows:

- Lamps used for internal illumination shall not be counted towards lumen caps calculation.
- A curfew may be imposed on the lighting of advertising signs.

The following sub-sections illustrates some example of good lighting practice.

C7

Outdoor Advertising Signs; Some Guides

(a) Internally-Lit Signs:

Either constructed with an opaque background and translucent text and symbols, or with coloured background and generally lighter text and symbols.

Signs with white background or other bright background produce the greatest amount of light and are by nature unshielded light source.

Colour background with lighter text and symbols often convey information more effectively and attractively at a reduced light output compared to signs with bright or white background.

(b) Externally Lit Signs:
Luminaire to be fully shielded; and
Light fixture preferably mounted to shine downwards

Figure C3.4.3 For road lighting, light near to or above the horizon should be minimised

3.4 Examples of Good Light Practice

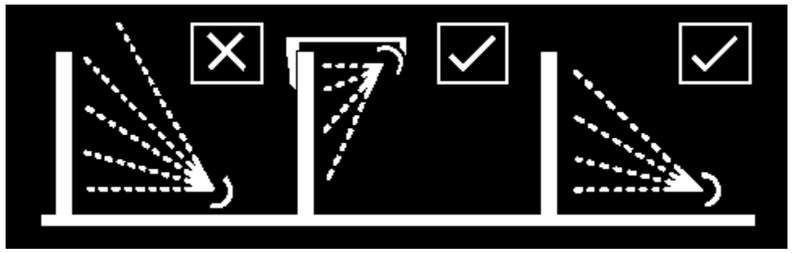


Figure C3.4.1 Use specifically designed lighting equipment that once installed minimises the spread of light near to, or above the horizontal.

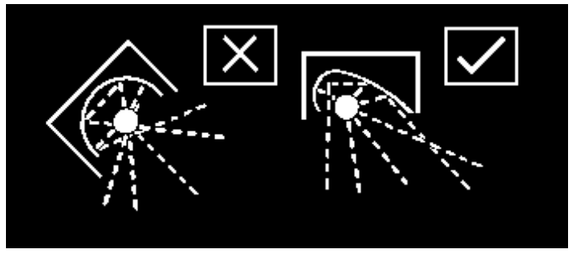
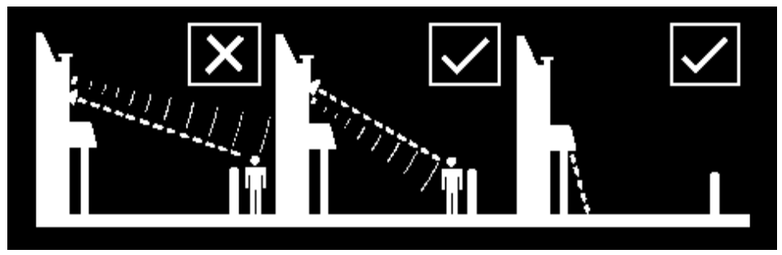


Figure C3.4.2 Wherever flood lights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit should be used. For proper targeting of objects or slim monument, narrow beam lights (as opposed to generic flood lights) should be used.



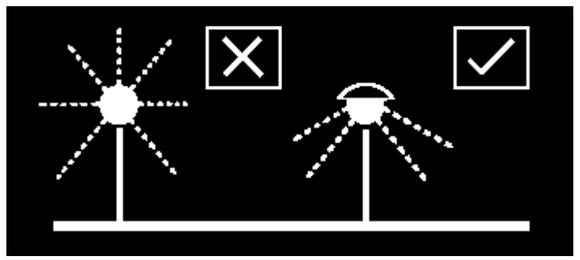


Figure C3.4.4 Proper shielding of luminaire minimise wastage and sky glow.

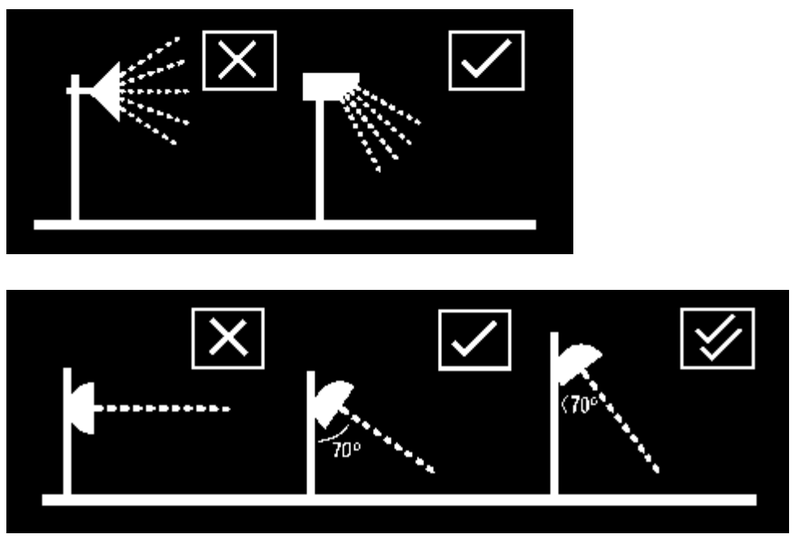


Figure C3.4.5 To keep glare to a minimum, ensure that the main beam angle of all lights directed towards any potential observer is kept below 70 degrees. It should be noted that the higher the mounting height, the

lower can be the main beam angle. In places with low ambient light, glare can be very obtrusive and extra care should be taken in positioning and aiming.

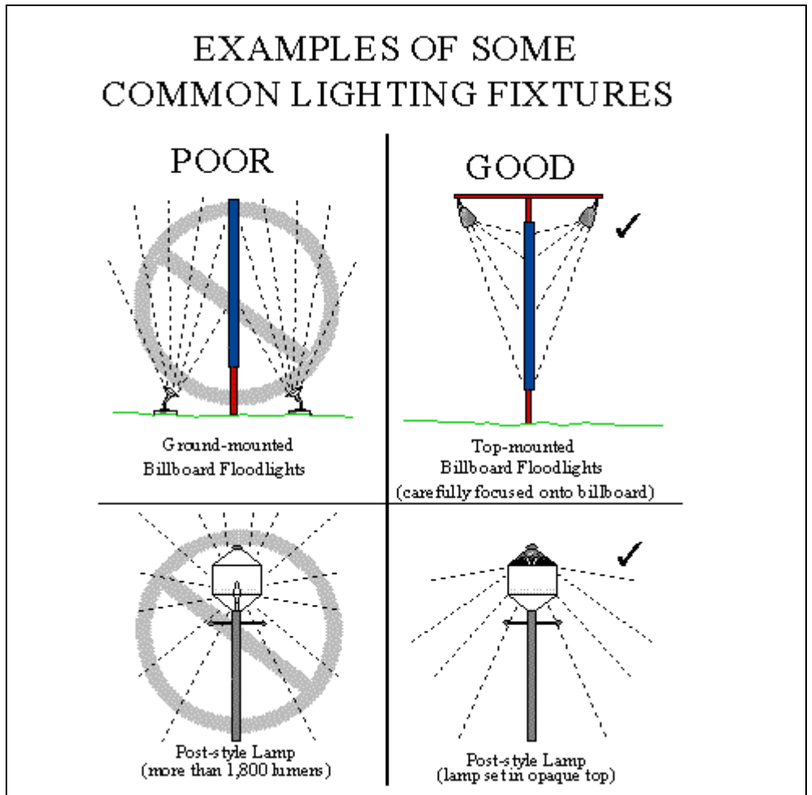


Figure C3.4.6 – Good Lighting Fixture (Outdoor)

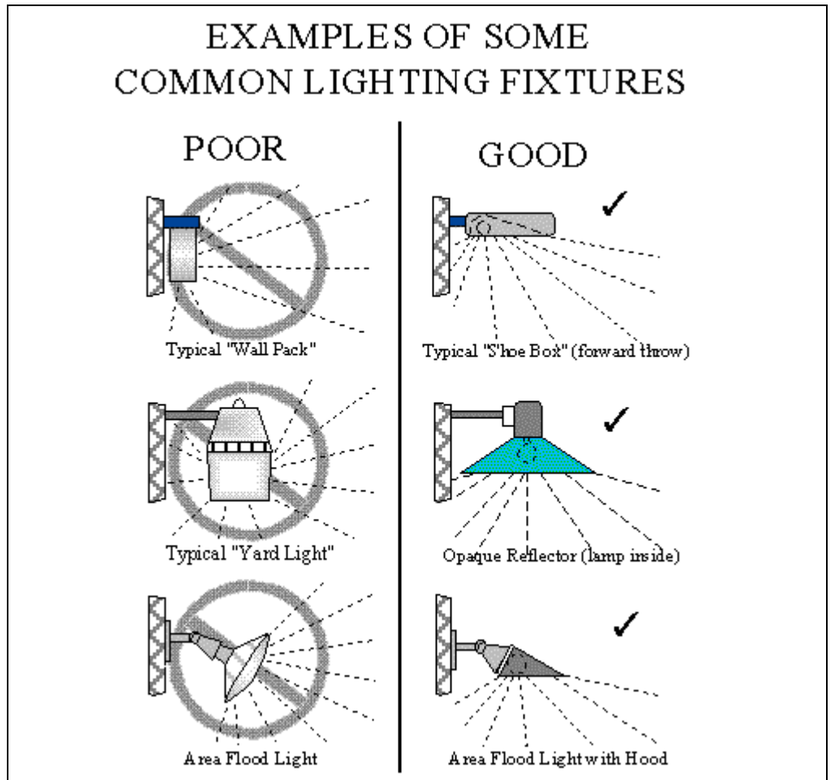


Figure C3.4.7 – Good Lighting Fixture (Wall Mount)

Examples of good lighting practice.

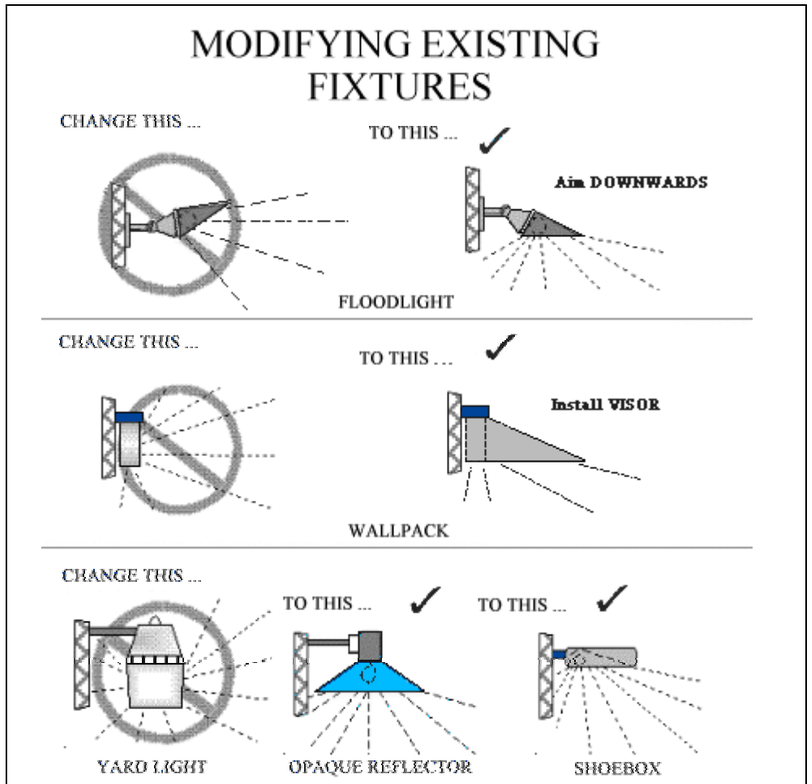


Figure C3.4.8 – Good Lighting Fixture (Modifications)

2 REFERENCE

(a) '*Outdoor Lighting Code Handbook*' Version 1.12, by the 'International Dark Sky Association' October 2001, http://www.darksky.org

(b) '*Guidance Notes for the Reduction of Light Pollution"* by the B.A.A. Campaign for dark skies http://www.dark-skies.freeserve.co.uk

(c) '*Good Neighbour Outdoor Lighting*' compiled by the 'New England Light Pollution Advisory Group' (NELPAG) and the International Dark-Sky Association, May 1995

(d) '*White Paper on Outdoor Lighting Code Issues*' by 'National Electrical Manufacturer's Association' (NEMA, U.S.A.) Luminaire Section, Aug 1, 2000

(e) 'Framework for Outdoor Lighting Improvement Ordinances' by The Indiana Council on Outdoor Lighting Education, ICOLE http://home.att.net/~icole

(f) '*Supplementary Planning Guidance; External Artificial Lighting*' by the Huntingdonshire District Council, U.K.

(g) 'CIE Publications:1. 'Guide lines for minimizing Urban Sky Glow near Astronomical Observatories'.

(END OF APPENDIX C)

Modifying existing light fixture – figure C3.4.8

References

APPENDIX D: POLICY #1 COLOUR & THE HUMAN EYE

APPENDIX D: POLICY #1 COLOUR & THE HUMAN EYE

1. Colour Characteristics

In an environment such as a 'garden city', predominated by green landscaping and natural surroundings, the spectral characteristics of metal halide light sources are particularly suitable. This is because, unlike the high-pressure sodium source, the energy output has peaks in the 400 to 500 nanometre range (the blue green end of the visible spectrum) and a reasonable degree of continuum across the entire 400 to 700 nanometre visible light range. Typically, a high-pressure sodium source peaks in the 550 to 600-nanometre range (the yellow/orange/red range). Correspondingly, the colour and vibrancy of green and blue objects and surfaces appear suppressed under high-pressure sodium light whilst appearing bright and natural under metal halide lighting.

This increased colour quality is further assisted in the case of metal halide sources because these have a higher colour-rendering index (Ra) than high-pressure sodium.

Colour rendering index is defined as:

- A measure of the correspondence between the colour of an object (its "self luminous colour") and its appearance under a reference light source. To determine the Ra values, eight test colours defined in accordance with DIN 6169 are illuminated with the reference light source of the same colour temperature as the source under test and the test light source. The smaller the discrepancy between the two sources, the better the colour rendering property of the lamp being tested.
- A light source with a Ra value of 100 displays all colours exactly as they appear under the reference light source. The lower the Ra value, the worse the colours are rendered.' (courtesy of OSRAM)

Typical **high-pressure sodium** lamps have a colour-rendering index of **Ra 20 – 39**
Typical **metal halide** lamps have a colour-rendering index of **Ra 80 – 90**

2. The Human Eye

The reason that high-pressure sodium is highly favoured is because the human eye response is at its most efficient when operating under light in the 560 nanometre (yellow) region. However, this only holds true when light levels are in the higher range with luminance (in broad terms: "brightness") values above 3.0 candela/m².

At this higher light level, the retina of the eye is operating through its cone receptors. Cone vision is referred to as *photopic vision* and is activated under normal levels of daylight and higher levels of artificial light. At the opposite end of the range of human vision, the eye operates through its rod receptors; these come into operation under very low levels of light such as starlight, measured in the region of 0.001 candela/m²; such vision is referred to as *scotopic vision.* Under these conditions the eye's overall sensitivity changes substantially with response to the yellow/red spectral range dropping in favour of the blue end of the spectrum in the region of 500 nanometres. Cone receptors operate optimally in the yellow light region whilst rod receptors operate optimally in the blue light region. In the light level range that lies between the levels that enable *photopic and scotopic visio*n, the eye operates through both its cones and its rod receptors. This range of vision is referred to as *mesopic vision* and is applicable under levels experienced at twilight and under most *road and street lighting conditions* e.g. 0.3 – 2.00 candela/m².

The cone receptors (operating optimally under yellow light) are concentrated in the foveal area of the retina that enables the narrow central part, (approximately 2 º) of the field to be viewed. The rod receptors (blue light optimised) are located to enable wide, peripheral, vision. This means that broad peripheral (or 'off-axis') vision in roads and streets, illuminated to conventional standards, by high-pressure sodium light sources is less efficient than under those conditions where roads and streets are illuminated by metal halide light sources. The research that lead to this realisation has resulted in the concept of the ' Effective Lamp Lumen Rating. This challenges the precept, established in 1924, that the lumen output of a lamp should be measured under photopic vision conditions. Alternatively, in recognising that the eye's spectral response varies under differing light levels (a recognition based on 100 + year old work by Purkinje) it becomes justifiable to consider the use of Lumen Effectiveness Multipliers. These essentially enable roadway lighting to be designed and calculated on a basis that takes account of the function of the eye when operating under realistic mesopic light conditions provided by sources other than high pressure sodium, in particular, metal halide.

Current research indicates that metal halide lighting could be as much as 80% more effective than high pressure sodium when evaluated under specific conditions relating to reaction times and brightness matching. In practical terms, tests indicate that an average roadway lighting level of 1.0 candela/m² provided by a metal halide light source would require to be equated with 3.9 candela/m² derived from a high-pressure sodium source in order to achieve the same reaction time from a vehicle driver.

Conclusion

Considerable research work has been carried out and continues in this field – see references. However, there is no doubt that the use of metal halide light sources is now wholly justified. Large-scale road lighting applications of this source can be designed to reduced light levels, based on conventional photopic vision calculations and compared to historic light values calculated on the use of high-pressure sodium sources. In the case of the Central Boulevard it is proposed that the use of metal halide lighting be justified on the basis that:

a) There is a requirement, at night, to distinguish this key boulevard from its surrounding streets and approach roads as well from the buildings that bound it.
b) The colour characteristics of metal halide are such that they complement and enhance soft landscape elements.
(c) If economics are to be a consideration for this, the most prestigious axis of Putrajaya, the lighting levels can be reduced (as can electrical loads) in comparison to those that would be expected under high-pressure sodium.

It is proposed that the Central Boulevard lighting be designed to achieve a level of approximately 3.0 candela/m² when used for parades and special occasions, reducing to 2.0 candela/m² under normal conditions. The presently designed luminance value is not currently known.

References

The foregoing is drawn from material published and presented in the following:

1. Dr Ian Lewin. Lamp Spectral Effects at Roadway Lighting Levels. *The Lighting Journal (UK)* March/April 1999.

2. Dr Ian Lewin. Visibility Factors in Outdoor Lighting Design. *The Lighting Journal (UK)* November/December 1999 & January/ February 2000.

3. Lewis, Alan L. ' Visual Performance as a Function of Spectral Power Distribution of Light Sources at Illuminances Use for General Outdoor Lighting'. Submitted for publication in the *Journal of the Illuminating Engineering Society (USA).*

4. Lewis, Alan L. 'Equating Light Sources for Visual Performances at Low Illuminances'. *Journal of the Illuminating Engineering Society (USA).* Vol.27 no.1, Winter 1998 IESNA New York

5. *American National Standard Practice for Roadway Lighting, RP-8* (Proposed). Submitted by the IESNA Roadway Lighting Committee to the IESNA Technical Review Board, September 1998.

In addition to the above, attention is drawn to the following:

- The Long and Lighted Road: Lighting and Driving. *Lighting Futures (USA).* Vol.5 No.1
- The Lighting Research Center (www.lrc.rpi.edu/Futures/LF-Auto/main5.htm)
- Night Vision. LRC Research. (www.lrc.rpi.edu\Projects\night.html)
- Applying Research on Night Vision. LRC Research.

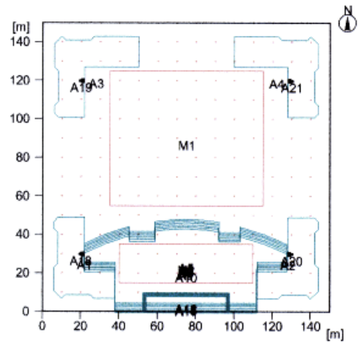
  (www.lrc.rpi.edu\Projects\nvp.html)

APPENDIX E: DATARAN PUTRAJAYA

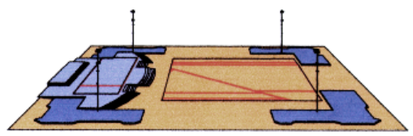
APPENDIX E – DATARAN PUTRAJAYA

1. Project description

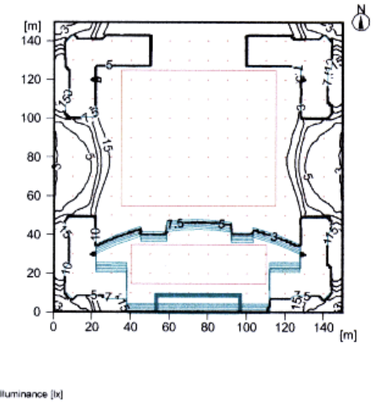
1.1 Overview



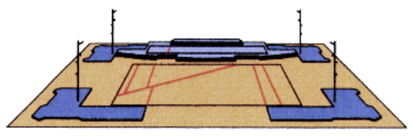
Floor plan



Internal room, sightline 1

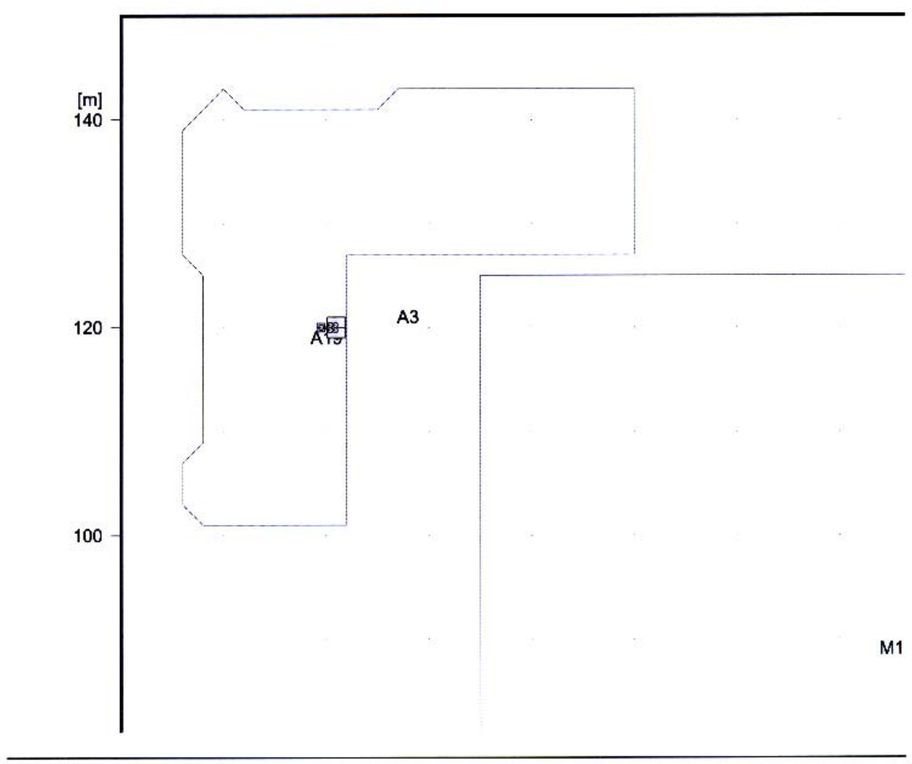


Calculation results



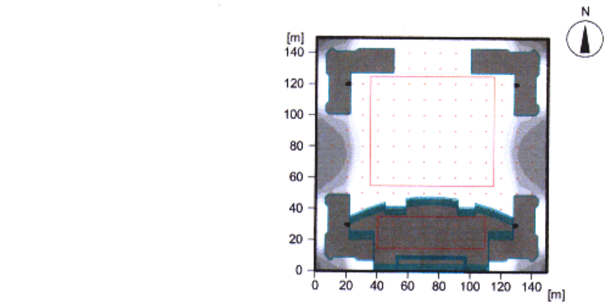
Internal room, sightline 2

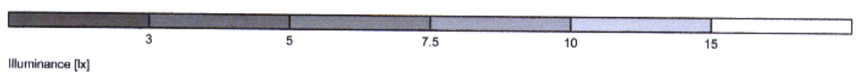
1.2 Floor plan



2. Summary

2.1 Result overview





Illuminance [lx]

Specifications:

Maintenance factor:	: 0.80
Number of calculation points in x/y direct.	: 151 / 151
Calculation algorithm used	: Direct part
Height reference plane	: 0.20 m

Result reference plane:

Average illuminance	Eav	: 13 lx
Minimum illuminance	Emin	: 0 lx
Maximum illuminance	Emax	: 39 lx
Uniformity g1	Emin/Em	: ---
Uniformity g2	Emin/Emax	: ---

Total luminous flux of all lamps	: 838400 lm
Total power	: 0 W
Total power per area	: 0.00 W/m²/100 lx

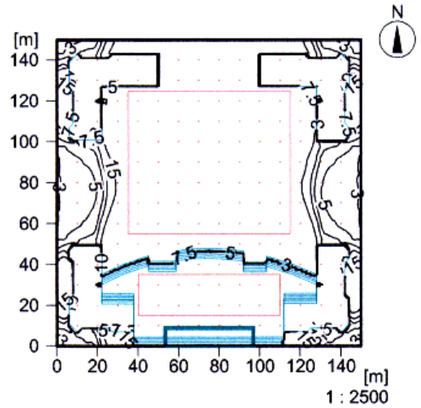
Type No.\Manuf.

		Siteco Fremd	
1	2	Order no.	: !VOR5x5
		Luminaire name	: Secondary Reflector 2000 x 2000mm
		Equipment	: 1 x 0 W / 150000 lm
3	4	Order no.	: !VOR2x2
		Luminaire name	: Secondary Reflector 800 x 800mm
		Equipment	: 1 x 0 W / 20000 lm
4	2	Order no.	: !VOR5x5
		Luminaire name	: Secondary Reflector 2000 x 2000mm
		Equipment	: 1 x 0 W / 228000 lm

2.1 Result overview

		Siteco Innen1
2	24	Order no. : !5NA 726 0-1 VS 11C
		Luminaire name : Projector
		Equipment : 1 x HIT-DE 1000W 0 W / 100 lm

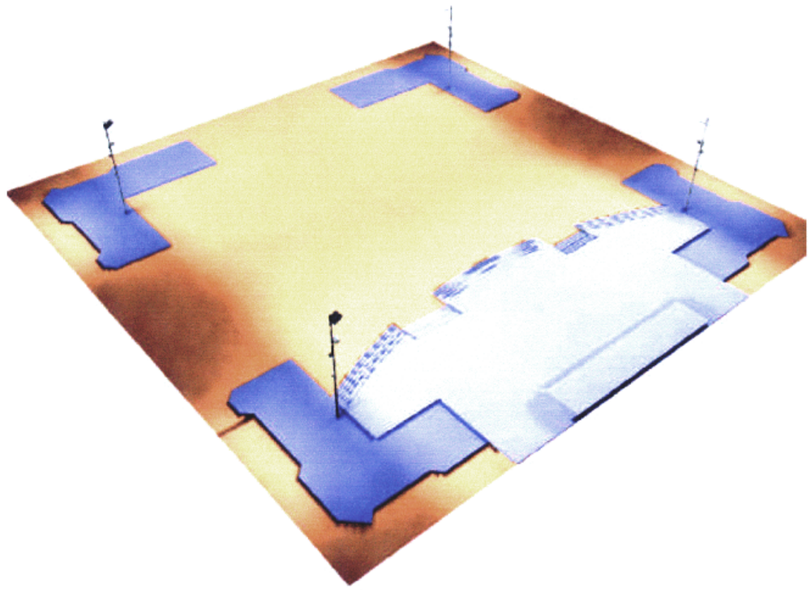
3.2 Isolines representation, Illuminance, Reference plane



Illuminance [lx]

Height of the reference plane		: 0.20 m
Average illuminance	Eav	: 13 lx
Minimum illuminance	Emin	: 0 lx
Maximum illuminance	Emax	: 39 lx
Uniformity g1	Emin/Em	: ---
Uniformity g2	Emin/Emax	: ---

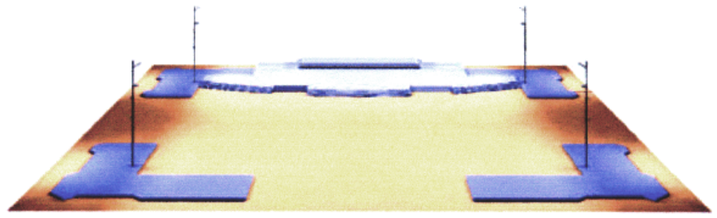
3.3 3D luminance distribution, Variable view



Luminance on the room-surrounding surfaces:

Minimum: 0 cd/m²
Maximum: 8 cd/m²

3.4 3D luminance distribution, View from rear



Luminance on the room-surrounding surfaces:

Minimum: 0 cd/m²
Maximum: 8 cd/m²

APPENDIX F: AUTOMATED MONITORING AND CONTROL ON STREET LIGHTING

APPENDIX F – AUTOMATED MONITORING AND CONTROL ON STREET LIGHTING

1.0 INTRODUCTION

This Section presents a brief overview of automated monitoring system for Street and Public Lighting. The Section lists the issues which need to be addressed in the implementation of a Metropolitan-wide automation system.

Putrajaya's present implementation of an automated 'Street and Public Lighting' monitoring system is touched on and the Section concludes by offering some suggestions and recommendations for policy adoption by Putrajaya.

2.0 AUTOMATED MONITORING AND CONTROL OF STREET AND PUBLIC LIGHTINGS

2.1 Automation Systems – A Brief Historical Perspective

2.1.1 Since the widespread adoption of direct digital control ('DDC') in automation systems in the commercial and industrial environment from the 1970s, automation systems has undergone a steady evolution in cost (decreasing) and capability (increasing). DDC automated system can be differentiated from its earlier technological predecessor which has actuator and sensor systems essentially rooted in mechanical systems (pneumatic and hydraulic).

2.1.2 The industry wide adoption of DDC systems can perhaps be attributed to the followings

(a) Decreasing cost in computer chips (Moore's law).

(b) Successful adoption of industry-wide standards in the computer industry (International Standard Organisation) engenders a Thriving market in computer technology allowing easy market entry to new players and encouraging innovation.

(c) The popularity of the **NET** (internet) which encourages the wide spread development of **computer networking** technology.

2.1.3 DDC automation systems can be classified into the following based on its separate evolution within its industry niche:

(a) Industrial systems generally include 'Programmable Logic Controllers' (PLC) and plant-wide automation. This sector is the largest sector in the DDC automation market. Early and active players in this field include 'Elsag Bailley', 'Foxboro', 'Honeywell', 'Johnson Controls', 'Siemens' etc.

(b) Equipment automation and specific process automation. The HVAC (heating, ventilation and air conditioning) industry was the earliest adherent to the DDC automation movement. Other specific automation sector under this category include the automotive sector ('CAN in Automation'; **CAN** – Controller Area Network). This sector taken as a whole is as large (or perhaps larger) than the industrial plant wide system described in (a) above. Players in this niche include Modicon (a German company), Rockwell International (USA), ASi (Actuator Sensor Interface), Allen Bradley etc.

(c) SCADA (System Control and Automated Data Acquisition) systems originally developed for the electrical power industry saw wide spread adoption from the early 1980s. SCADA technology has since been adopted for other application especially SCADA in monitoring networks (gas piping, utility networks etc). Industry players include 'Foxboro', 'Johnson Controls', 'Siemens', 'Allen Bradley' etc

Widespread adoption of DDC in automation system:
(a) Decreasing cost in chips;
(b) Adoption of industry wide standards;
(c) Growth of the 'NET'.

Classification of DDC-based automation systems:
(a) Industrial systems; 'Programmable Logic Controllers' (PLC), plant-wide automation etc;
(b) Equipment automation; HVAC sector, CAN in car sector;
(c) SCADA; system control and automated data acquisition;
(d) Building automation system

(d) Building Automation Systems / Building Management Systems (BAS or BMS) pertains to the implementation of automation in buildings. This sector started later and was hobbled by cost issues and fragmentary standards in its early days (the 1980s).

(e) BAS/BMS is at present experiencing a resurgence and players in this sector include 'Honeywell', 'Landis & Gyr', and

2.2 Open Standards in Automation

2.2.1 Open standards are industry wide adoption of a common technological platform and implies universal availability, public-domain knowledge-base and vendor neutrality. Open standards are important for further progress of the automation industry:

(a) It allows easier entry for new market players (proprietary standards in contrast restrict new entrant with technological and legal barriers).

(b) Innovation and new products can be developed at lower cost and easier adoption by the market.

(c) Open standards ultimately drive cost downwards and at the same time deliver increasing system capability and innovation for the consumer.

2.2.2 Open Standards are also coloured by the reality of existing installed-base and vendor-driven standards development (which requires funding). Open standards are also viewed by market players as the 'holy grail' of market domination (witness the VHF/Betamax tussle of the video industry during the late 1970s/early 1980s). Since the 1980s, development of industry-wide open standards in automation systems has been fragmentary, sometimes acrimonious and coloured by national pride (principally intra-European and European versus North American).

2.2.3 Movements towards global standards are principally driven by the following bodies:

(a) Standard organisations listed below adopts standards drafted by standard writing organisation (SWO).

(b) European Standard Organisation (CENELEC),

I. International Standard Organisation (ISO),

II. International Electrotechnical Commission (IEC),

(c) American National Standard Organisation (ANSI).

Open Standards' under the above organisations are however compromised by industry clout of market players. Due to this the CENELEC, ISO/IEC and ANSI standards virtually include description of all systems of major industry player. Instead of uniformity, a diversity of standards is officially sanctioned leading to fragmentation of the industry. The 'mother' of all standards for automation is the **ISO/IEC 61158:2001**.

2.2.4 **Convergence Initiatives** are voluntary industry-driven initiatives which perhaps can be more ideally termed as 'global open standard' movement:

(a) **BACnet** (principally centred around North America) for the home and building automation market,

(b) **Fieldbus Foundation** which encompass a multitude of vendors principally centred around North America for the industrial automation sector.

(c) **Konnex** (European) comprising the technologies of EIB ('European Installation Bus'), EHSA ('European Home System Association'), and BatiBus (France).

(d) Vendor Specific Standards driven by the de-facto reality of 'installed base' (this may in fact be the over-riding factor leading to a true global standard; 'Windows' operating system became a world standard principally on the marketing success of Microsoft). Main vendor system include:

(e) In Europe – the Profibus system (Siemens) dominate,

(f) In North America – LonWorks (Echelon Corp) and Fieldbus Foundation dominate.

(g) **Nascent Open standards** (in the sense that they are touted as widely accepted, in reality are not yet 'de-facto' but have the **possibility** of becoming widely accepted in the long term) include:-

I. CEBus, EIA-6000 (USA) incorporates 'plug-and-play' capability into common electrical appliances (systems which have device-intensive standard such as in the fire alarm industry are ideal users),

II. 'X-10' defines standards for power-line carrier,

III. 'Blue-tooth' defines standards for incorporating networking capability into electrical appliances using principally wireless (R.F. in the ISM band) technology.

2.2.5 Open Standards or industry wide standards should be **important consideration** in the implementation of any automation system:

(a) Proprietary systems are frequently touted by vendors as the most optimal system neglecting to mention its drawback:

I. Support, back-up and spares are proprietary i.e. the vendor is locked into a captive market for support, back-ups and spares,

II. The 'Optimal' designation is controversial, as proprietary system does not encourage innovation and multiple party development.

III. Proprietary systems can and will be overwhelm by industry wide standard system leading to its probable future demise. In Malaysia, automation system implemented since the 1980s has already experience the problem of obsolescence due to discontinued product, discontinued support, and discontinued market presence.

(b) Open standards in contrast:

I. Allow a wider option for industry support and spare parts,

II. Scalability (up grades and expansion) issues are easier to address, and implement.

III. Obsolescence is less of a concern.

3.0 AUTOMATION SYSTEM FOR STREET AND PUBLIC LIGHTINGS (SPL)

3.1 System Design

3.1.1 System design for automation of street and public lighting can be depicted (on a generic basis – i.e. non-vendor specific) in the following series of diagrams (tables F3.1.1, F3.1.2, and figure 3.1.1.3). Thefunctions listed in tables 1 and 2 are only indicative and may be implemented in full or partially.

TABLE F3.1.1- ACTIVE CONTROLS

Function	Actuator	Device	Comments
1 Switching of Lamps	Contactor	Lamps	Can be implemented:- (a) Individual contactor with intelligent addressable capability at each individual lamps. (b) Individual contactor without intelligent capability at each individual lamps. (c) Contactor switching per circuit
2 Dimming of Lighting level	Contactor Intrinsic thyristor	Multi-tap wound ballast Electronic ballast	Recommended solution. Not recommended.
3 Switching of circuits	Contactor	Circuits in switch boards.	This would be a redundant function if function 1 above is implemented.
4 Switching of Switch Boards	Contactor	Main Circuit Breaker in Switch Board	Remote active switching of switch board should only be implemented with a set of on-site safety procedure, otherwise this can be a potential for hazard and dangerous accidents.

TABLE F3.1.2- MONITORING FUNCTIONS			
Function	**Sensor**	**Device**	**Comments**
1 Lamp Status	Current and/or Voltage transducers.	Lamps	The current and/or voltage input into lamps can infer lamp performance, operating hours etc. Can be implemented together with the individual intelligent device-level controller described in table 1-1(a) above.
2 Lamp component status	Current and/or voltage or circuit break transducer	Lamp component (ballast)	Depending on the sophistication of the sensor, component sensing can infer component failure or impending failure.
3 Circuit status	Current and/or voltage or circuit break transducer	Lamp circuit	Depending on the sophistication of the sensor, circuit sensing can infer circuit break, operation hours etc.
4 Switch Board status	Current, voltage transducers, auxiliary contact etc.	Main Breaker and Switch Board	Depending on the sophistication of the sensors provided, switch board status and energy consumption can be log for management analysis and 'data mining'.

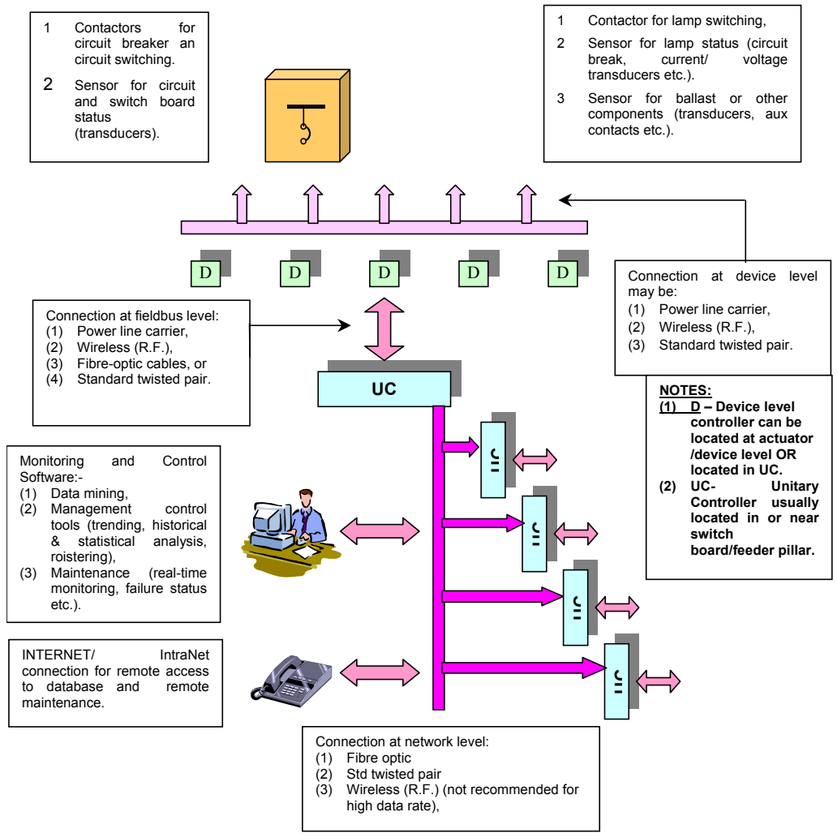


Figure F3.1.3 – Generic Network Architecture of SPL Automation and Monitoring System

Table F3.1.2 – Possible Monitoring Functions implemented in Street Lighting System Automation System.

Figure F3.1.3 – Generic Architecture of SPL Automation and Monitoring System.

3.2 Dimming of Street Lights

3.2.1 Due to the proposal to maintain multi level lighting at the Main Boulevard/Protocol roads, the issues of dimming of street lights are discussed in this section. Two main technologies are currently available for dimming of street lamps:-

(a) **Electronic ballast** and solid state thyristor switching to control current levels in lamps. and

(b) Multi-tap wound ballast with step dimming levels (typically only two).

3.2.2 Electronic Ballast has a long history and was first commercially available in the 1970s. Traditionally dimming of lights for filament lamps are easily implemented by voltage /current limiting transformers/resistors (which are technologically simple and cheap to manufacture). However discharge lamps (of which fluorescent and SON/HBI street lamps fall under this category) cannot be dimmed using this technology. Early solid state dimmers were only designed for filament lamps. Solid state dimmers designed for discharge lamps were first commercially available for fluorescent lamps (from the late 1980s). The early dimmers (for fluorescent lamps) suffers from serious setback:

(a) Prone to failure,

(b) Harmonics generation which cause secondary problem to the electrical network,

(c) Unsatisfactory performance (early dimmers for fluorescent lamps can only dim from 50% and its dimming capability diminishes rapidly with age).

(d) Very high capital cost which (despite the denial of vendors) off-set any savings in energy.

The above concerns are still valid to-date. Quality and harmonics problems have been ameliorated to a certain extent by the use of better quality components and design standard **but** at substantial capital cost increase. Implementation of electronic ballast by the electrical engineer should proceed with **caution** (even for fluorescent lamps) and care should be taken to evaluate the quality and reliability of such ballast.

Unfortunately in choosing a quality and reliable dimmable ballast, the energy savings gains may be off-set from the significantly higher cost.

3.2.3 Multi-tap wound ballast with step dimming levels is recommended. However implementation of multi-tap wound ballast should be proceeded with caution with care taken to evaluate the quality and reliability if said ballast.

3.3 Existing Street and Public Lighting (SPL) Automation System in Putrajaya

3.3.1 Two pilot projects on monitoring and control system are currently being implemented in Purajaya. The SPL monitoring aims to provide monitoring of lamp, circuit and (some) component failures, and dimming of lamps to achieve energy savings.

(a) Protocol roads, monitoring right down to individual lamps and circuits.

(b) Both projects used hybrid multi-wound type ballast with capability for step dimming (via multiple taps).

3.3.2 The basic system configuration of the SPL Automation system as shown in figure G3.3.2, is generally made up as follows:

(a) At Device Level; Basic Signalling Module (BSM) located at each street lights. The BSM is a device-level semi-intelligent unit. It will monitor lamp status data and probably has capability to implement active control. Possibility of active control of dimmable ballast is also mentioned. The BSM is connected (at device level network) to the next level of control (fieldbus level) using power line carrier technology (the cost savings in additional cables at device level is however translated to higher device level (BSM) unit cost).

(b) At the Fieldbus Level; data loggers located in feeder pillars arbitrate between device level BSM and higher level networking. Fieldbus data loggers can be stand alone or connected (via twisted pair cables) to other data loggers.

Dimming of Discharge Lamps can be implemented using 2 technologies:
(a) Electronic Ballast;
(b) Multi-tap wound ballast

Implementation of electronic ballast by the electrical engineer should proceed with caution (even for fluorescent lamps) and care should be taken to evaluate the quality and reliability of such ballast

Unfortunately in choosing a quality and reliable dimmable ballast, the energy savings gains may be off-set by significant higher capital cost.

(c) At the Net-Work Level data loggers are connected to central command centres with any of the following or combination depending on site conditions:

I. Wireless using Radio modem (private radio channel),
II. Wireless using GSM modem (via cell-phone service provider),
III. Telephone cable connection (via telecom service provider),
IV. Fibre optic cables, or twisted pair.

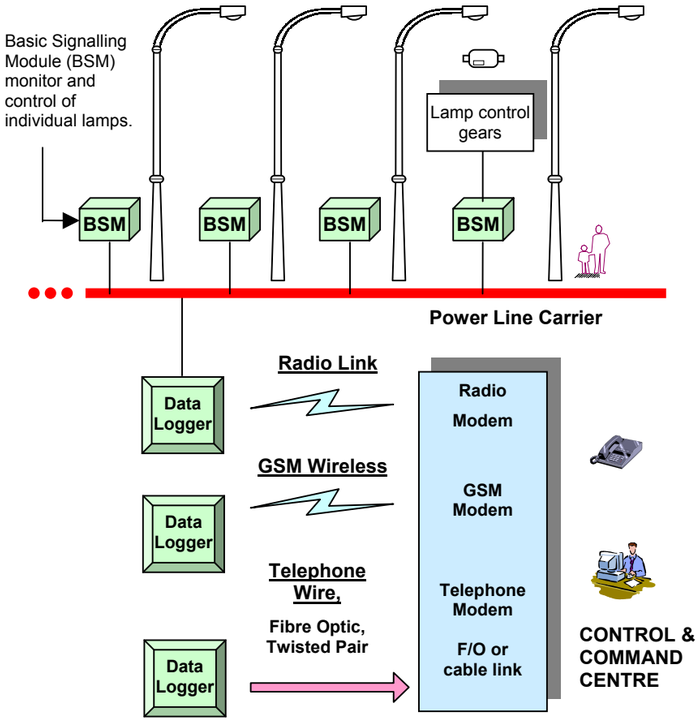


Figure F3.3.2 – Configuration of SPL Automation System (Pilot Scheme)

4.0 ISSUES IN THE IMPLEMENTATION OF A CITY-WIDE SPL AUTOMATION SYSTEM

4.1 General

In the implementation of a SPL automation system (and any automation system), the issues listed in this sub-section must be addressed:

4.2 Readiness of Facilities Managers

Facility managers (in this case Putrajaya) must be ready for the operation and maintenance of automation based management system. Sub-issues include:

(a) Availability of maintenance staff with knowledge and awareness of automation system.
(b) Commitment from management for implementation and **continued operation** of automation system.
(c) Facility managers must have management staff with knowledge and awareness of automation system and in particular data analysis.
(d) Maintenance, management and work procedures will have to be changed to make them compatible with the automation system.

4.3 Commitment of Management

Commitment at management level is also important for the continuous operation and evolution of automation system. Operation of automation systems are frequently not static and by right should evolve from its inception at physical completion. Evolution issues include:

(a) Up-grades of system hardware and software to make it more effective,
(b) Evolution of work procedures in the integration of automation system in the maintenance and management procedure (new procedures may even be evolved as new benefits are discovered).

Issues in implementing a City Lighting Network (CLN):

4.2 Readiness of facilities managers:

(a) Availability of staff with expertise and/or knowledge of automation;
(b) Commitment from management for implementation and continued operation of automation system;
(c) Management staff with knowledge and/or awareness of automation system.
(d) Maintenance, management and work procedures to fit in with and be compatible with automation system.

4.3 Commitments of Management

(a) Upgrades of hardware and software;
(b) Evolution of work procedure and integration of automation system into maintenance and management procedures.

4.4 Adopt Open Standards in Automation System.

4.5 Include Surge Protection.

4.4 Adoption of Open standards

Open Standard or industry wide standard system should be adopted early during implementation stage to minimise the possibility of future system obsolescence, product obsolescence and/or bad technical support.

4.5 Include Surge Protection

The electronics in automation equipment are sensitive and where cables linking systems are exposed to atmospheric originated electromagnetic activities (electric thunderstorm etc) equipment failure due to electric surge and transient are common problems. A complete and integrated surge protection system should be included in the design during inception.

4.6 Common Failures

The Malaysian automation scene is littered with automation system which suffers from the following common problems:

(a) Automation becoming 'white elephant' due to product obsolescence, poor technical support and discontinued market presence.

(b) Management indifference to automation after practical completion of system. Most facility managers adopt a commitment only during implementation stage but during operation and maintenance, automation issues are side-lined. This creeping side-lining ultimately lead to the 'slow-death' of the automation system.

(c) Poor technical support. A serious shortage at the technician level on automation system is an obstacle to most facility managers which can only be overcome with staff training.

(d) Indifferent and expensive back up and support from the automation vendor after practical completion.

5.0 POLICY RECOMMENDATIONS FOR IMPLEMENTATION OF A CITYWIDE LIGHTING NETWORK (CLN)

5.1 Benefits of SPL Automation

Present Putrajaya policy on implementation of SPL automation system at district levels (but not yet on a CLN level) is laudable and on the right track. Benefits of automation system include:

5.1.1 Data Analysis and Data Mining Proper analysis of data (data mining) provides critical management information for optimal performance; e.g.

(a) The stocking of spares and inventory is optimised by analysing historical data. Trending analysis also provides insight on (year-round) time-related consumption of spares and inventory. Traditional management of stock and inventory suffers from over-stocking and poor inventory keeping.

(b) Trending analysis on failures provides information useful for preventive maintenance. Defective models and spares (which are not obviously defective) can be spotted based on trending analysis.

(c) Analysis of 'abnormal' data points to impending failure or faulty maintenance procedure.

(d) Analysis of energy consumption, consumption of spares and staff deployment provides valuable data on cost appraisal, and budget allocation etc.

(e) Other nuggets of management (or commercial) information are waiting to be discovered from analysis of data ('**data mining**' is a relatively new field in information technology).

5.1.2 Faster Response to Equipment Failure A faster response time to SPL failure and shorter down time of equipment. Effective utilisation of automation system also reduces staff deployment and monitoring of lamp failure.

Common Failures of Automation Systes:

(a) System becoming 'white elephant' due to product obsolescence, poor technical support & discontinue market presence;

(b) Management indifference especially after practical completion leads to creeping side-lining and ultimate demise of the automation system;

(c) Poor in-house technical support; and

(d) Indifferent and/or expensive back-up from vendors after practical completion.

Benefits of a SPL automation include:

(a) Data analysis and data mining – provides critical management information for optimal performance;

(b) Faster response to equipment failure including reduction of staff deployment.

For the effective maintenance of metropolitan-wide street and public lighting system, the highest man-power allocation is frequently spent on monitoring and repair of faulty equipment. Due to the wide geographical dispersion of equipment, common methods of monitoring include:

(a) Full time monitoring crew making regular patrols (this method is cumbersome and not practical where manpower is an issue),

(b) Reliance on the public to report equipment failure. A public hot-line on SPL is commonly adopted as the reporting avenue.

5.2 Policy Recommendation

5.2.1 Further and expanded Implementation of SPL Automation System

(a) Putrajaya should further the implementation of SPL automation system in the city of Putrajaya.

(b) This policy should be expanded to include the bulk of the Central Boulevard and Core Precinct area (which will become the focal point of Putrajaya).

(c) Expanded automation may even include active switching of lightings in certain core and critical areas (this 'sub-policy' should however be adopted after careful consideration of the 'readiness' of Putrajaya to maintain and operate a sophisticated automation system).

5.2.2 Consistent Policy

A consistent policy on automation system should be adopted in the implementation of automation system. Though it is not the scope of this REPORT to propose detail policies, some broad policy statements are suggested as follows:

(a) Open-Standard A strong statement on adoption of open-standard (with reference to the ISO/IEC 61158) should be included.

(b) Registration of Vendors Any vendor proposing automation system for Putrajaya should be properly pre-qualified:

I. Submit conformance certification to any of the systems named in the ISO/IEC 61158,

II. Should provide commitment that their system can interoperate with existing system (without hidden cost to ensure interoperability),

III. Commitment to provide back-up, spares and up grade (a certain amount of consumable spares should always be provided at the local premise of the vendor), and

IV. Should be domiciled in Peninsular Malaysia.

5.2.3 Design Masterplan A broad masterplan on SPL automation may be included in the I.C.T. masterplan (if available). The Masterplan for automation may include the following:

(a) Hierarchy of control:

I. Full monitoring and active control (switching and dimming) of lights in Central Boulevard and precincts considered focal areas,

II. Full monitoring (without active control) of 'non-focal' core precincts (protocol roads), and

III. Group monitoring in outlying district (monitoring at feeder pillars only).

The hierarchy of controls are only suggestions and should be debated with engineering and ICT department (PJc) before adoption.

(b) Design standards include the following:

I. Conformance to open-standard (ISO/IEC 61158 is suggested as a base reference),

II. Inclusion of surge protection equipment as an integral component in the design. Surge protection should be hierarchy based protection class.

III. Compatibility of components (especially dimmable ballast) supplied by other vendors.

(c) Integration with other automation system and I.C.T. networks maintained by PJc. This include the following possibilities:

I. The SPL automation cable at the network level can be integrated with existing city-wide I.C.T. cabling infrastructure.

POLICY RECOMMENDATIONS

5.2.1 Further expansion in implementing automation system;

5.2.2 Adopt consistent policies:
(a) Adopt Open Standards;
(b) Register Vendors in Automation Systems.

5.2.3 Draft a CLN Masterplan, which may be included in the I.C.T. Masterplan (if available), issues include;
(a) Hierarchy of controls;
(b) Design standards (open standards, surge protection etc);
(c) Integration with other automation system and ICT networks.

5.2.4 Commitment of Management:
(a) Inclusion of automation as an agenda in management procedures especially in ISO9000 procedures.
(b) Maintain a strong culture in information technology; and
(c) Maintain and sustain continuing education and training for administrative and maintenance staff in automation and I.C.T.

II. Integration with existing city-wide automation system (if available). Automation systems include city-wide information board messaging, traffic control and monitoring and building automation systems,

III. Integration of SPL automation to the Internet or (city-wide intranet).

IV. Integration above will usually be implemented at the sub-net level.

5.2.4 Commitment of Management

Strong statement of management to automation policies and procedures should be included and sub-policies are as follows:

(a) Inclusion of automation as an agenda in the management procedure (especially the ISO9000 procedure),

(b) Maintain a strong culture in information technology; this can be monitored by efficiency targets or improvements gleaned from analysis of utilisation of automation, and

(c) A continuing and sustain education and training of administrative and maintenance staff in automation (and I.C.T.).

(END OF APPENDIX F)

APPENDIX G: ENGINEERING STANDARDS & SUBMISSION PROCEDURES

APPENDIX G – ENGINEERING STANDARDS

1.0 INTRODUCTION

The section Is a review of existing standards and procedures commonly applicable in Peninsular Malaysia for the design and submission of street lightings. Putrajaya standards and procedures pertaining to street and urban lightings are also listed. Some preliminary recommendation to present approval and procedures are then listed in this section.

2.0 LEGAL FRAMEWORK FOR SUBMISSION

2.1 Statutory Framework

2.1.1 In Malaysia roads and highway falls under the purview of the National Land Code. Two broad areas of existing responsibilities can be delineated:-

(a) Roads under the jurisdiction of local district councils and state authorities,

(b) Tolled expressways and highways under the jurisdiction of the ***Malaysian Highway Authority*** (MHA was set up under an act of parliament, Act 231; 1980 has legal jurisdiction over interurban highways.

2.1.2 In the promotion of standards and guidelines, the authorities responsible are therefore the legal entities listed above. As Putrajaya falls under the definition of a local council, this report will only concentrate on the situation named under (a) above.

2.2 Responsible Approving Authorities

I2.2.1 In the construction of local and district roads (and therefore the implementation of design standards including road lighting standards), two procedures are normally applicable:

(a) Where roads are implemented by the state or federal Government as infrastructure development, such roads are usually constructed by the JKR (***Jabatan Kerja Raya*** also known as the Public Works Department). In such case the JKR is the responsible authority approving standards for road constructions.

(b) Where roads are implemented by private developer under the purview of the '*Roads, Buildings and Drainage Act*', the local district, municipal or city council is the responsible authority approving standards.

2.3 Responsibility for Maintenance

2.3.1 In the maintenance of roads and road fixtures and lightings, the local authorities (which is the local district/town/city councils) are responsible for upkeep of the lighting fixtures. In reality the following cases are applicable:-

(a) All city halls have their own maintenance departments responsible for road lighting.

(b) Most municipal (towns) councils and some district councils have their own maintenance departments responsible for road lighting.

(c) Most district councils and some municipal councils sub-let the maintenance of road lighting to a third party:-

I. usually TNBD Sdn Bhd (a subsidiary company of Tenaga Nasional Berhad responsible for maintenance works),

II. sometimes the district JKR (JKR role in maintaining public street lights has been diminishing for the past ten years and only in remote district is the JKR still playing this traditional role).

2.1 Statutory Framework

In Malaysia, roads and highway falls under the purview of the National Land Code. Two areas of responsibility can be delineated:

(a) Road under the jurisdiction of local district councils and state authorities;

(b) Interurban highways and expressways under the jurisdiction of the Malaysian Highway Authority (MHA).

3.0 DESIGN STANDARDS

3.1 Codes, Standards and Practice

3.1.1 Standards and Codes of Practice commonly quoted by local authorities (and the highway/road engineering design fraternity in Malaysia) in the application and design of road lighting are as follows:-

(a) British Standards (BS) and code of practice (CP) 5489 published in ten parts is by far the more popular standards;

I. BS 5489 Part 1 – *Guide to the general principals,*

II. BS 5489 Part 2 – Code of practice for lighting for traffic routes,

III. BS 5489 Part 3 – Code of practice for Lighting of subsidiary roads and associated pedestrian areas,

IV. BS 5489 Part 4 – *Code of practice for single-level road junctions including roundabouts,*

V. BS 5489 Part 5 - *Code of practice for grade-separated junctions,*

VI. BS 5489 Part 6 – *Code of practice for Lighting for bridges and elevated roads,*

VII. BS 5489 Part 7 – *Code of practice for the lighting of tunnels and underpass,*

VIII. BS 5489 Part 8 – *Code of practice for lighting that may affect aerodromes, railways, harbours and navigable inland waterways,*

IX. *BS 5489 Part 9 – Code of practice for urban centres and public amenity areas,*

X. BS 5489 Part 10 - *Code of practice for lighting for motorways*.

(b) Commission Internationale de L'Ėclairage (CIE or International Commission on Illumination); CIE publications:-

I. 115-1995, 12.2-1977 *Recommendations for the Lighting of Roads for Motor and Pedestrian Traffic*,

II. 12.2-1977, *Recommendations for the Lighting of Roads for Motorised Traffic,*

III. 30.2-1982, *Calculations and Measurement of Illuminance in Road Lighting,*

IV. 31-1076, *Glare and Uniformity in Road Lighting Installations,*

V. 47-1979, *Road Lighting for Wet Conditions,*

VI. 91-1992, *Guide to the Lighting of Urban Areas,*

VII. *92 – 1992, Guide to the Lighting of Urban Areas*.

3.1.2 Procedures adopted by most local authorities for approval of road and street lightings usually fall under the purview of the '*Roads, Buildings and Drainage Act*'. In most cases, submission procedure for streetlights are included as part of submission procedures for roads and drainage which is a subset of D.O. application (D.O. – Development Order).

3.2 Local Standards in Submission of Street Lighting Installations

3.2.1 Most local authorities **do not** have firm and written guidelines for street lighting approvals beyond a delegation of professional responsibilities to the submitting professional (submitting professional defined under the '*Roads, Buildings and Drainage Act*' in this case refers to the professional engineer). Some municipal councils and city halls have simple written guidelines (***garispanduan***) for compliance by the submitting professional. Municipal councils and city halls publishing written guidelines for street lighting submission include DBKL, Majlis Perbandaran Shah Alam.

3.2.2 Where no written guidelines are published, conditions for approval are usually imposed (on an ad-hoc basis) by the district engineer responsible at the district or municipal level.

3.2.3 Common requirements quoted by most local authorities in approval of streetlights are as follows:-

(a) **Poles** The type of poles are specified (hot dipped galvanised octagonal). with height depending on road type and width. The hinged cover for service compartment is sometimes specified (top hinged etc.).

3.1 Codes and Standards

Standards commonly quoted by local authorities in the application and design of road lighting are as follows:-

(a) British Standards (BS) 5489 published in ten parts is by far the more popular standards;

(b) Commission Internationale de L'Ėclairage (CIE or International Commission on Illumination); CIE publications

Submission procedures for streetlights are included as part of submission procedures as a subset of D.O. application.

(b) **Lamps** specified are usually SON for highways and motorways and MBF (mercury) lamps in housing estates. Some city halls and municipal authorities limit the brands of street lamps citing maintenance constraint in storage of spares (e.g. DBKL and MPSA). Common brand names quoted include '*Philips*', '*Schreder*', and '*Thorn*'.

(c) **Electrics** Most council (including DBKL) require a minimum cable size of 16mm² copper with no requirement on laying 4 core cables. MPSA however has a requirement insisting that 4-core cables be laid in all cases irrespective of the number of lights or circuits.

(d) **Controls** Most council specify time switch and/or light sensor. DBKL insist only on timer switch (since mid-1980s, DBKL decided that photocells are more troublesome in maintenance compared with timer switch as photocells persistently loses their sensitivity due to dust coating). However some municipal council (e.g. Penang) still insist on photocells only.

(e) **Spares** Some municipal councils and city halls insist that spares be provided by the developer on handing over to the said council. Spares include lamps and lanterns (15% to 25%), components such as ballast, igniters (10% 60 15%), and poles (10%).

(f) **Feeder Pillars** for streetlights are usually left to the discretion of the professional engineer responsible.

4.0 EXISTING PROCEDURES AND STANDARDS IN PUTRA JAYA

4.1 Existing Lighting Design

The lighting designed in Putra Jaya can generally be delineated into the following areas:

(a) Non-core areas of residential and commercial district which generally employs functional street luminaires in general compliance with the specifications listed in 3.2.3. above.

(b) Non-core areas still to be developed or under development, this include the Diplomatic enclave. It is expected that the ambient and signature of the lighting in these areas will be commented by the specialist consultant (LDP).

(c) Lighting in most roads (protocol and non-protocol roads) is generally designed to CIE standards. The average luminance level of **2 cd/m²** is an oft quoted figure. Site measurements of road lighting is reported in appendix A.

(d) SON lamps are generally used in all roads including residential road lighting.

4.2 Putra Jaya Design and Submission Guidelines

4.2.1 Special guidelines for street lighting submission published by the *Jabatan Bangunan*, Putrajaya are listed as follows:-

(a) Street Lighting Poles:-

I. (Service) door to be provided with latch.

II. Able to withstand a wind speed of at least 35m2sec.

III. The use of cut-out fuse and neutral must be changed to terminal block (?) approved by PPj.

IV. The value of fuse must be 6A.

(b) **Luminaire**

I. Must be built and constructed for easy maintenance such as changing of lamp, control gear, reflector and lamp-holder without requirement of special tools.

(c) **Feeder Pillar**

I. methods of lamp control must be provided i.e. photocell, bypass and timer.

II. Miniature Circuit Breaker (MCB) must be at least 6kA (short circuit rating)

(d) **System of Electrical Circuit**

I. Use 4c –PVCSSWAPVC copper cables where the minimum size is 16mm².

II. (The) circuit must be installed in sequence (of) RYB.

III. Cables must be run in duct.

(e) **Earthing System**

I. The feeder pillar must be supplied (with) earth chamber for purpose of testing (?).

II. Earth (impedance) readings of at least 1 ohms (must be obtained).

(f) **Luminance** must comply with the following parameters:-

I. Average luminance (L_{av}) $\geq$ 2 cd/m²

II. Overall Uniformity (U_o) > 0.4

III. Longitudinal Uniformity (U_L) > 0.75

IV. Threshold Increment (T_I) < 10%

(g) Spares

I. Amount of spares to be at least 5% of the total quantity installed.

II. Spares include igniters, capacitors, bulbs, ballast and poles.

4.3 Maintenance

From information provided by Perbandanan Putrajaya (municipal authority) maintenance of street lights in Putrajaya is at present undertaken by a private company (TNBD).

4.4. Automated Controls of Street Lights

4.4.1 Special design features include the following:-

(a) Implementation of hybrid multai-wound type electronic ballast for all street luminaire in protocol roads.

(b) Implementation of a special electronic and computer based 'Street and Public Light' (SPL) monitoring system for protocol roads

4.4.2 A pilot project is currently being implemented at the Central Boulevard. This pilot project include the use of hybrid type (multi-tap wound with electronic control) ballast for dimming of street lamps and the connection of street and public lightings in an automated network. Appendix **F** has a more detail treatment of this subject.

5.0 RECOMMENDATIONS FOR ENGINEERING STANDARDS

5.1 General Approval Requirements

Two aspect are important in the approving procedure for street and public lighting:

(a) Design Approval include the approval of luminance or illuminance levels, maintenance factor etc., and

(b) Components Approval include the physical quality and standards of luminaire and lamps. Components approval however are only applicable where street luminaries falls under the maintenance of Putrajaya (i.e. luminaire on private property and under the maintenance jurisdiction of private owners should not be subject to component approval).

Components Standards

5.2.1 Ballast are components which though unseen contribute to energy wastage. Electronic ballasts are one means of energy savings. However due to reasons (which are discussed elsewhere by the author) electronic ballast despite its more than 15 years technology is still not popularly accepted by the electrical engineering fraternity. A more realistic solution for energy efficiency (and which is adopted by most energy efficiency codes world wide including the Malaysian Energy Codes) is to specify 'low loss' conventional ballast. However as 'low loss' ballast for SON, MBF and HBI lamps are still not popular industry standards, a first step should be made by including loss figures in the proposed Putra Jaya lighting codes. Recommended values are as follows:-

5 RECOMMENDATIONS

5.1 General Approval Requirement

(a) Design approval; and

(b) Components approval.

5.2 Components Standards

*(c) **Ballast** – specify standard loss ballast (low loss ballast for discharge lamps is as yet not available). Publication of loss figures at least filters out sub-standard and high loss (inefficient) ballast.*

	Lamp Type	Maximum Allowable Losses
(i)	Sodium 70W	15W
(ii)	Sodium 100W	20W
(iii)	Sodium 150W	22W
(iv)	Sodium 250W	30W
(v)	Sodium 400W	45W
(vi)	Metal Halide 70W	16W
(vii)	Metal Halide 100W	16W
(viii)	Metal Halide 150W	20W
(ix)	Metal Halide 250W	34W
(x)	Metal Halide 400W	40W
(xi)	Metal Halide 1000W	60W
(xii)	Mercury 80W	12W
(xiii)	Mercury 125W	15W
(xiv)	Mercury 250W	18W
(xv)	Mercury 400W	28W

Table G5.2.1 – Recommended Loss Values for Ballast

5.2.2 IP Rating All luminaire should be certified to comply with the appropriate IP ratings (IP rating refers to the degree of water-tightness of a luminaire). Luminaire especially decorative and luminaries usually faces problems of water tightness. This will contribute to maintenance problem and fitting and electrical failure. IP ratings to be specified should be as follows:-

	Installation Conditions	IP Rating
(i)	Exposed to weather but located under roofing, awning or rain shield.	IP53
(ii)	Exposed to general weather.	IP 55
(iii)	Buried in ground	IP 65
(iv)	Underwater light (fountain, swimming pool etc)	IP 66

Table G5.2.2 – Recommended IP Ratings

5.2.3 Certification procedures to ensure that lamps and luminaire supplied are to the rating and quality as claimed should be included. The following certification procedures are recommended:-

(a) Electrical integrity Certification include Jabatan Elektrik,Suruhanjaya Tenaga (formerly known as the 'Jabatan Bekalan Elektrik & Gas') approval (which usually requires SIRIM certification of compliance to the relevant safety standards).

(b) Ballast Loss Values Certification authority include SIRIM and internationally recognised certification authorities (such as KEMA and UL).

(c) IP Rating To confirm compliance to IP rating certification authority includes SIRIM and internationally recognised certification authorities (UL).

Table G5.2.3 is a list of standards applicable for certification for components approval.

	Components	Standards	Comments
1	**Inductive ballast for discharge lamps**:		
	(a) Safety requirements	IEC 61347-2-9	Replace IEC60922
	(b) Performance Requirements	IEC 60923	
	(c) Ballast losses	Table G5.2.1.	
2	**Tubular fluorescent lamps:**		
	(a) Inductive ballast - safety requirements	IEC 61347-2-8 MS 141 Pt 1	replace IEC60920
	(b) Inductive ballast - performance Requirements	IEC 60921 MS 141 Pt 2	Prescribed item under the jurisdiction of the *Jabatan Elektrik,* Suruhanjaya Tenaga.
	(c) Inductive ballast losses	6W maximum	
	(d) Starters for fluorescent lamps	IEC 60155	
	(e) Electronic ballast - Safety Requirements	IEC 61347-2-3	replace IEC60928
	(f) Electronic ballast - performance Requirements	IEC 60929	
4	**Transformer for neon lamps - General safety requirements**	IEC 61050	
5	**Luminaire (light fittings)**		
	(a) Luminaires - general requirement and tests	IEC 60598-1	
	(b) Particular requirements	IEC 60598-2	
	(i) Fixed general purpose luminaires	IEC 60598-2-1	
	(ii) Recessed luminaires	IEC 60598-2-2	
	(iii) Roads and street lightings	IEC 60598-2-3	
	(iv) Floodlights	IEC 60598-2-5	
	(v) Luminaire with built-in transformers for filament lamps	IEC 60598-2-6	
	(vii) Luminaires for swim-ming pool and similar applications.	IEC 60598-2-18	
	(c) Degree of protection (IP rating) of luminaires	IEC 529 and table G5.2.2.	
	(d) Luminaire photometric data	Verification of photometric data claimed by vendor.	
6	**Lamps**		
	(a) Self-ballasted lamps – safety requirement	IEC 60968	
	(b) High pressure mercury	IEC 60188	
	(c) Low pressure sodium	IEC 60192	
	(d) High pressure sodium	IEC 60662	
	(e) Double-capped fluorescent lamps - performance requirements	IEC 60081	Prescribed item under the jurisdiction of the *Jabatan Elektrik,* Suruhanjaya Tenaga.
	(f) Single-capped fluorescent lamps – safety and performance requirements	IEC 60901	
	(g) Tungsten filament lamps - Performance requirements	IEC 60064	
7	**Feeder Pillars**		
	(a) Manufacturer license	Jabatan Elektrik (S.T.)	Licensing under the Electricity Act
	(b) Assembly standard	IEC 60439-1	Type tests may not be specified
	(c) Degree of protection	IP55 for outdoor feeder pillars IP42 for indoor feeder pillars	

Notes: Test certificates shall be from nationally and internationally recognised testing laboratories.

Table G5.2.3 – Applicable Standards for Components Certification

Table G5.2.3 – List of Standards for components certification and approval.

5.3 **Standardisation**

5.3.1 A more detail standardisation of design for street lighting poles especially in non-core areas where standard galvanised poles will predominate.

5.3.2 Some standardisation generalities to non-standard type lightings poles in core/protocol areas. Issues include:-

(a) Extent, type and construction of banner protrusion along poles for mounting of buntings, flags and banners.

(b) Standardisation of cable entry and service compartment.

5.3.3 Standardisation issues impacting maintenance of street luminaire to be addressed. This include the requirement for specifying or limiting the brands and types of components.

5.4 Design Standards

5.4.1 CIE Standards Given Malaysia's membership in the International Standard Organisation (ISO) and the eventual phasing out of British Standards (BS) in favour of European Standards (EN), it is recommended that all design should be in accordance with CIE Standards; unless and until a Malaysian Standard become current (a technical committee under SIRIM ISC-E is currently attempting to draft a code/standard for Road Lightings – late 2001 to-date).

5.4.2 Luminance / Illuminace Level should generally be in accordance with the recommended values listed in CIE publication 115. Special requirement are however for special Protocol roads and Central Boulevard such as the requirement of lighting controlled to (perhaps) two levels:

(a) 50% for normal usage,

(b) 100% during special occasions.

5.4.3 Energy savings measures using multiple lamps on a pole and multi-circuit switching (though technically inelegant) may be a more practical solution towards the same end. Statement requiring such multiple lamps and, alternate circuiting of luminaire may be included. Dimming if cannot be avoided should be implemented with care taking into considerations:

(a) Multi-wound hybrid-electronic ballasts are preferred over pure electronic ballast (this may however change in the future when cost, reliability and technology improve).

(b) Quality ballast issues are important, as many system fail due to the cheap electronic ballast. Unfortunately in keeping to rigorous standards and maintaining reliable components, the energy savings gains are off-set from the high capital cost.

5.4.4 Night Time Sky Pollution; mitigating factors include:

(a) For monument and façade-feature lighting use narrow beam and proper positioning of lights.

(b) Where unipole or advertising boards are to be lit, 'top down' flooding rather than bottom-up flooding to be used, and careful selection of beam spread and luminaire position to be considered.

(c) Appendic C has a detail treatment on this subject.

5.4.5 Maintenance In the design of street lights the various factors affecting the design goals of average luminance levels and uniformity are listed in table G5.4.5. As can be noted from the table, the cleaning intervals for lamps is a factor set during design calculations. It is therefore imperative that Putrajaya should specify a standard cleaning intervals for designers in their luminance level submission.

5 RECOMMENDATIONS

5.3 Standardisation

Standardisation of poles, and pole details (banner protrusion, cable entry door etc) and perhaps limitation to luminaire type.

5.4 Design Standards

***CIE standards** is recommended over BS as the CIE will be part of the ISO and given Malaysia's membership in the ISO.*

***Energy Saving** measures to be included in design standards include use of energy savings lamps.*

***Night Time Sky Pollution –** mitigating factor required.*

***Maintenance** – design factor affecting maintenance factor listed in table G5.4.5.*

Table G5.4.5 – Luminaire depreciation factor (table 3.2 of CIE Publication 92).

Cleaning intervals (months)	Degree of protection of lamp housing					
	IP 23 minimum			IP 54 minimum		
	Pollution category					
	High	Medium	Low	High	Medium	Low
6	0.61	0.69	0.96	0.91	0.92	0.96
12	0.53	0.62	0.94	0.86	0.88	0.94
18	0.48	0.58	0.92	0.83	0.85	0.92
24	0.45	0.56	0.91	0.81	0.83	0.91
36	0.42	0.53	0.90	0.79	0.82	0.90
(1) High pollution occurs in the middle of large urban areas in heavy industrial areas.						
(2) Medium pollution occurs in semi-urban, residential, and light industrial areas.						
(3) Low pollution occurs in rural aeas.						

Table G5.4.5. Luminaire Depreciation Factors (table 3.2 of CIE 92)

(END OF APPENDIX G)

APPENDIX H: FREQUENTLY ASKED QUESTIONS

APPENDIX H – FREQUENTLY ASKED QUESTION

1.0 INTRODUCTION

In the course of preparing the "Putrajaya Urban Lighting Masterplan" and its key policies, various questions were raised by developers and consultants. This section is a reply to 'Frequently-Asked-Questions' (FAQ) to the Masterplan and its key policies.

2.0 POWER SUPPLY RELATED ISSUES

2.1 Upgrade to power supply and even substation required if street lights are upgraded from 250W SON (high pressure sodium) to 400W metal halide (MH)

Policy 1 of the Masterplan advocate the distinction of the Central Boulevard from its surrounding areas by the use of high colour rendering lamps (MH) instead of relatively 'monochromatic lamp' (SON). Vigorous objections to this policy include the opinion that usage of 400W MH over 250W SON will increase power requirement to street lightings by 100% thereby necessitating **major** cost increase in power supply cables and even upgrading of power station to cater for this increase.

(a) Upgrading of Substation

In the planning of any development, the calculation of load demand is an essential exercise which determines the number, size and capacity of (electrical power) substation space allocated within the development. Street lightings usually constitute a very small percentage (typically 5% or less) of the total load demand in any development. The reasons for this are:

Road lighting lamps at 250W or 400W are relatively small loads (at the micro level) compared to building services loads such as pumps and air conditioning motors.

I. Due to the relatively low level demand of road lightings (2cd/m² or about 20lux etc) compared to lightings in internal building (typically 300lux or more), the watts per m² for road lightings is very much less compared to internal building lights.

Thus an increase from 250W SON to 400W road should not in typical case require major expansion or upgrade to existing power station unless in **exceptional** case where existing substation is already overloaded (usually in very old city centre substation). It should also be noted that power station capacities are usually sized with spare capacity of about 15% to 30%.

(b) Power supply require upgrading

Street lighting 'feeder pillars' are typically designed at capacities of 60Amps, 100Amps, 120Amps, 150Amps and 200Amps rating. Cable ratings to feeder pillars are sized at standard 70mm² (aluminium) irrespective of the feeder pillar rating. Street lighting circuits are also designed with 16mm² -3 phase cables (present Putrajaya requirement). Due to the 'highly dispersed' nature of street lighting loads (refer also 2.1 (a) ii above), an increase of 400W MH lamps over 250W SON will not (unless in **very exceptional** case) impact on or have any effect on power supply cables to street lightings. Even a doubling of road lighting level (say from 2cd/m² to 3cd/m²) which may require additional 400W lamp circuits **will not** (unless in very exceptional ase) require the upgrading of power supply cables. Figure H2.1.1 illustrates this.

2.1 Upgrade to power supply and even substation required if street lights are upgraded from 250W SON (high pressure sodium) to 400W metal halide (MH)

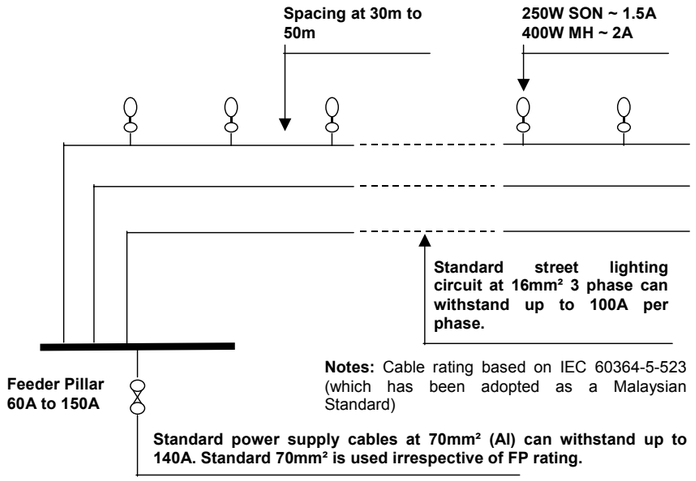
Upgrading of substation

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Thus an increase from 250W SON to 400W road should not in typical case requires major expansion or upgrade to existing power station. It should also be noted that power station capacities are usually sized with spare capacity of about 15% to 30%.

Power supply require upgrading

Due to the 'highly dispersed' nature of street lighting loads, an increase of 400W MH lamps over 250W SON will not impact on or have any effect on power supply cables to street lightings.



The number of lamps per circuit and even per feeder pillar is usually restricted by the highly dispersed nature of street lights. Thus most street lighting feeder pillars and street lighting circuits are usually 'under-loaded' and lamps can be safely upgraded from 250W to 400W without major upgrade to cables.

Figure H2.1.1 – Typical Circuiting For Street Lights

3.0 METAL HALIDE VERSUS HIGH PRESSURE SODIUM

Objections raised include safety of metal halide, unsuitability of metal halide and the high cost of metal halide. An opinion has even been voiced that metal-halide is dangerous ('will-explode'), is not well suited for street lights and present a 'sterile' white ambience. Champs Elysées, Paris has been quoted as opting for SON rather than white metal halide.

In the advocacy of metal halide and 'white SON' for the Central Boulevard, the principle of a high colour rendering (CR) lamp is the basic thrust of the policy. High pressure sodium (SON) has a typical colour rendering index (CRI) of 20-39 while metal halide has a CRI of 80 – 90. White SON has typical colour rendering of around 80.

3.1 Unsuitability of 'white' metal halide

CIE 12 and BS 5489 made no reference to lamp source or colour rendering beyond a recommendation of average luminance, uniformity and glare thresh-hold levels. It is therefore **not correct** to assert that metal-halide is unsuitable and unsafe in the design of street light. However latest research and recommendation recognise the efficacy of high CRI lamp source particularly in scotopic (night time) vision. As is well known (refer 'Glossary of Technical Terms' – subsection 4), visual acuity during daytime (photopic) peaks at around 555nm (yellowish-green). However visual acuity at night (scotopic) shifts the peak sensitivity of human perception to around 480nm (bluish-green). Thus monochromatic SON will suffer a lower efficiency in perception at night. Table H3.1 compares the 'brightness' efficacy of various lamps based on 'Mesopic' (gloomy evening) conditions.

Table H3.1

Lumens Effectiveness Multipliers (High Pressure Sodium = 1,00)
From Brightness Matching Mesopic Functions

Luminance (cd/m²)	0.01	.01	0.1	1	3	10
Metal Halide	2.25	2.11	1.82	1.35	1.13	1.00
High Pressure Sodium	1.00	1.00	1.00	1.00	1.00	1.00
Clear Mercury	1.48	1.43	1.38	1.22	1.09	1.00
Low Pressure Sodium	0.47	0.51	0.61	0.82	0.95	1.00

From Adrian, Werner "The Influence of Spectral Power Distribution for Equal Visual Performance in Roadway Lighting Levels." Proceedings of the 4th International Lighting Research Symposium, Orlando, 1998. Lighting Research Office of the Electrical Producers Institute, Pleasant Hill, California

The Champs Elysées, Paris (a central boulevard in the heart of Paris) has been quoted as opting for sodium lamps. However it should be noted that the Champs Elysée in their latest street lights up-grade selected 'white' sodium with a CRI of 80 for pavement lightings ('Screder Group News Report No 21'). The use of high CRI light source (such as metal-halide) is gaining international recognition as a concept for inner city lighting. In Petaling Jaya the streets at the overhead bridge ('Matshusita junction', Petaling Jaya) uses metal-halide without apparent diminishing of lighting performance.

3.1 *Unsuitability of 'white' metal halide*

CIE 12 and BS 5489 made no reference to lamp source or colour rendering beyond a recommendation of average luminance, uniformity and glare thresh-hold levels. It is therefore not correct to assert that metal-halide is unsuitable and unsafe in the design of streetlight.

Latest research and recommendation recognise the efficacy of high CRI lamp source particularly in scotopic (night time) vision.

In Petaling Jaya the streets at the overhead bridge ('Matshusita junction', Petaling Jaya) uses metal-halide without apparent diminishing of lighting performance.

3.2 Higher glare due to metal halide

It has also been claimed that metal-halide or high colour rendering lamp source will present glare control problems in street light. This is again a **not correct** as glare control is suitably covered in CIE12 and BS5489 by the 'Threshold Increment' (TI) index. The T.I. index is a function of lamp design, lamp spacing, pole height etc and do not depend on lamp source or CRI of lamp. The subject of glare is a highly technical subject and previous recommendations based on 'glare control marls' has been found to be unsuitable. CIE 31 has a detail treatment on this subject.

3.3 High Cost of Metal Halide

It has also been asserted that metal halide will cost exceptionally higher than SON with figures of 150% been quoted. From a survey of market in December 2001 it was found that the cost comparison between metal halide and SON lamps are not exceptionally higher (see table H3.3). The cost comparison assumes the complete fittings to be changed. However depending on the selection of luminaire housing, change-over to metal halide may involve only a change of lamp and lamp control (not the housing). In this case, cost incurred for changing over to metal halide will be lower. From the quotations we note that the cost of metal-halide lamps with luminaire **is not significantly** higher as claimed.

A summary of average cost from the three suppliers are as follows:

Fittings	**Unit Cost in Ringgit**	
	Metal Halide	**SON**
(a) 400W with gears	RM280	285
(b) 250W with gears	RM250	230
(c) 150W with gears	-	185
(d) 400W with housing	RM1,800	RM1,700
(e) 250W with housing	RM1,700	RM1,600

Table H3.3 – Comparison of cost

3.4 Safety Issues

Metal halide belongs to the category of lamps known as **gas discharge** lamps. In gas-discharge lamp, an electric current is discharged into a gas-filled glass or translucent container. The ionisation of the gas molecules or atoms results in the generation of light. The colour of light emitted depends both on the mixture of gases and the material coating inside the gas tube. In fluorescent lamps, ionisation of the gas produces invisible light in the ultraviolet range. The 'excitation' of the phosphor coating on the inside of the tube converts the UV light into visible light.

In low pressure sodium or mercury lamp, the active ingredient is sodium or mercury vapour mixed with an inert gas (often neon or argon). The vapour pressure is usually very low (at a millionth of one atmosphere). In high pressure lamps or high intensity discharge (HID) lamps, the energy of the electron discharge into the gas is at relatively higher energy level. Metal halide is similar to mercury vapour except that it has small amount of additive comprising various metallic halides.

High pressure sodium (HPS) operates at relatively lower pressure (about ¼ atmosphere) whilst metal halide (MH) operate at higher pressures of 2 to 4 times atmosphere. MH lamps pressurised at above atmospheric pressure leads to the perception that it is explosive. However as in most 'engineered' system for consumer usage, MH lamps are designed for safe operation within statistical limits of hazard. An example would be the NGV canister used in cars powered by natural gas and which is pressured at about 1000psi. Despite concerns raised by layman of 'potential bombs' on the highway, thousands of cars fitted with NGV canisters are currently cruising the highway without higher statistical hazard and neither has there been reported instances of NGV canisters exploding even in an accident involving natural gas powered vehicle. It should however also be noted that high pressure sodium (if not handled properly) is just as dangerous (hot sodium is a highly reactive chemical and metallic sodium reacts with water to produce hydrogen gas which is highly explosive). Both HPS and MH lamps are designed with an inner arc tube (hard quartz for MH and

3.2 Higher glare due to metal halide

Glare control is suitably covered in CIE12 and BS5489 by the 'Threshold Increment' (TI) index. The T.I. index is a function of lamp design, lamp spacing, pole height etc and do not depend on lamp source or CRI of lamp. The subject of glare is a highly technical subject and previous recommendations based on 'glare control marls' has been found to be unsuitable. CIE 31 has a detail treatment on this subject.

3.3 High Cost of Metal Halode

From a survey of market in December 2001 it was found that the cost comparison between metal halide and SON lamps are **not exceptionally higher**. The cost comparison assumes the complete fittings to be changed. However depending on the selection of luminaire housing, change-over to metal halide may involve only a change of lamp and lamp control (not the housing). In this case, cost incurred for changing over to metal halide will be lower.

3.4 Safety Issues

MH lamps pressurised at above atmospheric pressure leads to the perception that it is explosive. However as in most 'engineered' system for consumer usage, MH lamps are designed for safe operation within statistical limits of hazard.

translucent ceramic for HPS) sealed within an outer glass envelope. MH lamps are widely used in installation requiring high CRI such as sports stadium, auditorium and even factories without any perceptible increase in hazard.

The only real issue pertains to the hazard from the disposal of lamps and leaching of toxic chemicals into the environment. Mercury which is added into most gas discharge lamp (including sodium lamps) improve the efficiency of lamps (lower arc temperature etc). Mercury however has a high toxic potential to the environment. This issue is addressed by the industry with the following approach:

(a) Proper disposal of lamps Proper disposal of lamps include a central disposal agency. In some countries proper disposal is enforced by legislation (come states in the U.S.A.). In Malaysia there is at yet no legislative support for the proper disposal of lamps.

(b) Low mercury lamp Industry experts are working towards lamps with less mercury additive.

3.5 Comparative cost of maintenance for MH and HPS

Table H3.5.1 is a comparison listing the differences in the lamp types for the most common sizes.

Table H3.5.1 - A Summary of Lamp Type

Factor	Incand-escent	Fluorescent	MH	HPS	LPS
Wattage	25-150	18-95	50-400	50-400	18-180
Output (lumens)	210-2700	1000-7500	1900-30000	3600-4600	1800-33000
Efficiency (lumens/watt)	8-18	55-79	38-75	72-115	100-183
Lumen Main-tenance	90 (85)	85 (80)	75 (65)	90 (70)	100 (100)
Lamp Life (hours)	750-2000	10000 - 20000	10000 - 20000	18000 - 24000	16000
CRI	90-95	30 - 90	80-90	20-39	

Notes: **Wattage** and **output** refers to the common available lamp rating for outdoor lightings.
Efficiency refers to luminous efficiency taken at 50% mean lifetime and do not include ballast loss.
Lumen Maintenance refers to percent of initial lamp putput at 50% of mean lifetime at at end of lifetime (parenthesis).
Lamp life refers to the approximate mean lifetime of lamp.

From the perspective of maintenance, we can conclude from the table above as follows:

(a) MH is less efficient than HPS The efficiency of a lamp translate from the lamp flux output (lumens) to the power input (watts). MH lamps are about 50% less efficient than LPS lamps. Thus to maintain a certain lighting level using (say) 250W HPS, 400W will be required if MH lamps are used. A lower lamp efficiency translate to higher electricity cost.

This view should however be tempered by the perspective of brightness efficacy based on CRI (refer section 3.1 and table H3.1 preceding; remember that the 'lumens' is defined to be weighted at 555nm).

3.4 Safety Issues

Safety issue pertains to the hazard from the disposal of lamps and leaching of toxic chemicals into the environment (especially Mercury which is added into discharge lamps to improve the efficiency of lamps. This following are approach adopted by industry:

(a) Proper disposal of lamps Proper disposal of lamps include a central disposal agency. In Malaysia there is at yet no legislative support for the proper disposal of lamps.

(b) Low mercury lamp Industry experts are working towards lamps with lower mercury content.

3.6 Comparative cost of maintenance for MH and HPS

(a) MH is less efficient than HPS
A lower lamp efficiency tramslate to higher electricity cost.

(b) Lument maintenance and Lamp Life

MH has a lower lumen maintenance and life (about 30% lower). A lower lamp life will require a shorter 're-lamping' period.

(b) Lumen Maintenance and Lamp Life

MH has a lower lumen maintenance and life (about 30% lower). A lower lamp life will require a shorter 're-lamping' period.

A quick calculation of maintenance cost for energy consumption and relamping yields the result in table H3.5.2.

Table H3.5.2
Maintenance Cost – Annual Energy & Relamping Cost (5000 lamps)

	250W HPS	400W MH	
i. Annual electricity cost 400 hours per month Tariff G	RM 120,000.00	RM 192,000.00	
ii. Annual Re Lamping 80% for HPS 110% for MH Inclusive of ballast	RM 1,000,000.00	RM 1,650,000.00	
Total Cost	RM 1,120,000.00	RM 1,842,000.00	
	100%	164%	

(END OF FAQ)

3.6 Comparative cost of maintenance for MH and HPS

A quick calculation of maintenance cost (energy and relamping) confirms that annual maintenance cost for MH is about 60% higher than HPS (Malaysian context only) (Table H3.5.2).

APPENDIX I: GLOSSARY OF TEHNICAL TERMS

APPENDIX I – GLOSSORY OF TECHNICAL TERMS

This section is a glossary of basic terms and concepts in the physics of lighting including measurement concepts in lighting. The subjective response of the human eye to colours and brightness are some issues impacting design and choice of lights.

1.0 THE PHYSICAL NATURE OF LIGHT

1.1 Electromagnetic Radiation Light is a form of radiation similar to radio waves and X-rays known collectively as **electromagnetic radiation**. Electromagnetic radiation is also a form of energy which is all around us

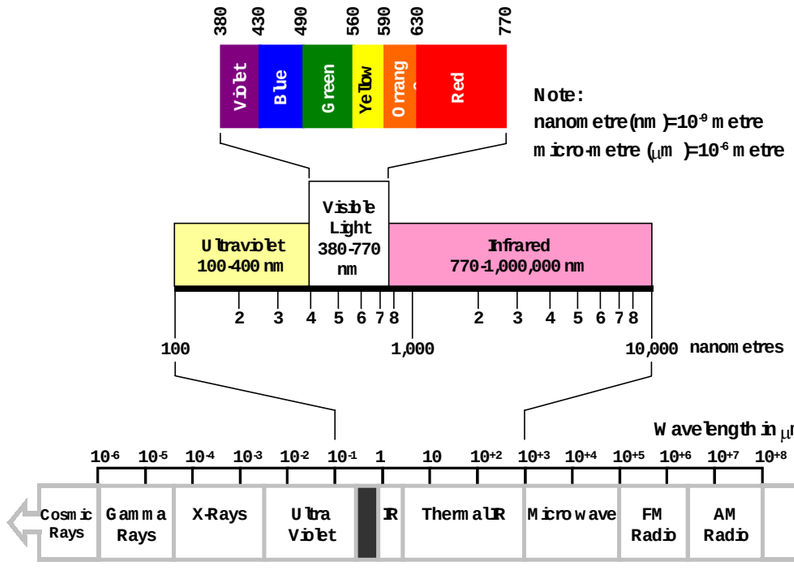
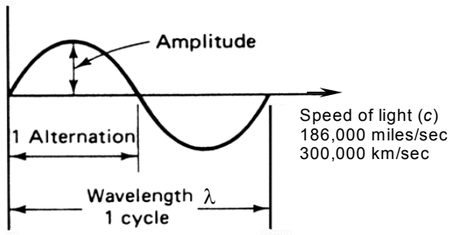


Figure I1.1 – The Electromagnetic & Visible Light Spectrum

and travels at the speed of light (186,000 miles/seconds or 300,000 km/seconds). The electromagnetic spectrum encompasses a diversity of energy from radio waves at one end to X-ray at the other end with the visible light spectrum falling somewhere in the middle (**figure I1.1**).

Wavelength, Frequency and Energy of Light The energy of electromagnetic radiation is directly related to its frequency. **Figure I1.2** shows the relationship between wavelength and frequency of a wave propagation. Ultraviolet light at the lower wavelength band (or higher frequency) has higher energy level compared to infrared at the higher wavelength band. For this reason ultraviolet rays are more harmful due to its higher energy level and higher penetration power on living tissue cells



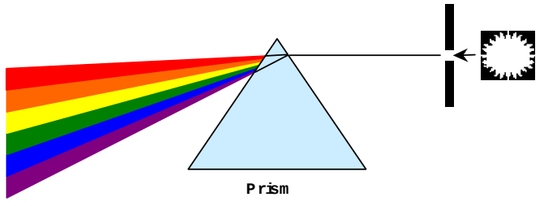
Electromagnetic wave travels at the speed of light (*c*), Frequency is the number of cycles per sec (*f*). Thus the relation ship between *c*, *f* and λ is as follows:

$\lambda = c / f$

Figure I1.2 – Wavelength and Frequency

2.0 SPECTRAL ENERGY OF LIGHTS

2.1 Colours As can be seen in figure 1, the visible light spectrum spans a range of wavelength, which the eyes perceive as colours. Typical 'white light' source (such as sun-light) has a mixture of all lights within the six colours bandwidth (**figure I2.1** shows a narrow beam of white light being split into the colour spectrum).



Light at different wavelength (or energy) when refracted in glass travels at (slightly) different speed. Due to this a beam of white light refracted in a glass prism is split up into its component colours.

Figure I2.1 – The colour of white light

1.1 Electromagnetic Radiation

*Electromagnetic radiation is a form of energy which is all around us and travels at the speed of light (186,000 miles/seconds or 300,000 km/seconds). The electromagnetic spectrum encompasses a diversity of energy from radio waves at one end to X-ray at the other end with the visible light spectrum falling somewhere in the middle (**figure I1.1**).*

1.2 Wavelength, Frequency and Energy of Light

Frequency (f) is the number of cycles per sec. Wavelength (λ) is the distance travelled in one cycle.

$\lambda = c / f;$

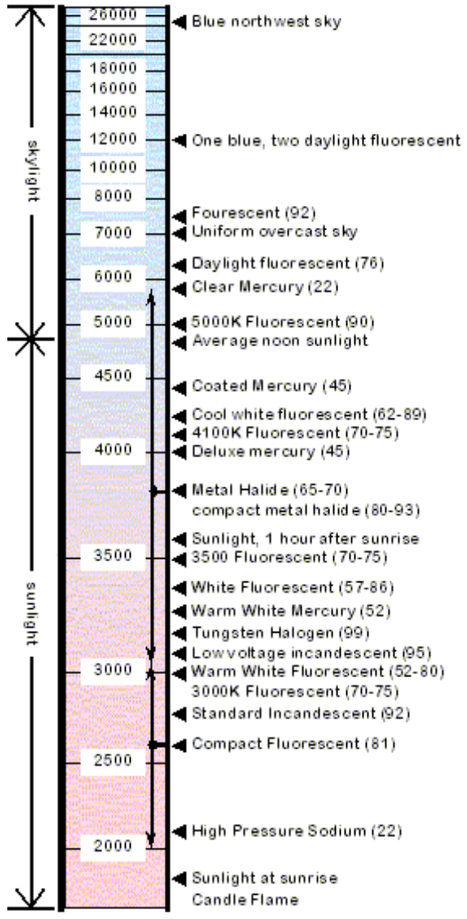
c = speed of light (300,000km/sec)

2.1 Colours

The visible light spectrum spans a range of wavelength which the eyes perceive as colours. Typical 'white light' source (e.g. sun-light) has a mixture of all lights within the six colour band. Figure I2.1 shows a beam of white light being split into the colour spectrum.

2.2 **Colour Temperature** The variation in the amount of colours within a light mixture affects the appearance of the light in terms of its relative 'warmness' or 'coolness'. To describe this variation in relative 'warmness' and 'coolness' or the colour of light sources, the term '**colour temperature**' is used.

Colour temperature or Correlated Colour Temperature (CCT) due to its theoretical basis in the study of 'black body' radiation should apply only to sources with a **continuous spectrum** (such as incandescent lamps and natural light). However for light sources with non-continuous spectral distribution (such as fluorescent lamps and discharge lamps where the spectrum consist of peaks of energy), CCT is used mainly on an empirical sense (i.e. in a very 'near approximate' sense) to describe the degree of 'whiteness' of the said light source. **Figures I2.2** shows the colour temperature chart of various light sources.



The Colour Temperature of light is correlated to the temperature of a laboratory 'black body' and its corresponding colour as it is heated through the various stages of incandescent from red to blue white. The Correlated Colour Temperature (CCT) is in Kelvin . The colour rendering index (CRI) for each source is shown in brackets

Figure I2.2 - The correlated colour temperature of various light sources (in Kelvin

2.3 **Colour Rendering** A more common method of characterising light sources by its colour is the **Colour Rendering Index (CRI)**. The **CRI** compares the spectral energy content of a light source to that of a standard reference source with full-spectrum. The CRI value is a numerical value and is 100 for full-spectrum natural white light. Incandescent lights are considered nearly white and has CRI close to 100. Most lights have CRI typically in the range 20 to 80.

The CRI model is not a perfect model and should only be used to compare light source with the same colour temperature. For example (about) 6000K daylight fluorescent and clear mercury has CRI of 76 and 22 respectively. The daylight fluorescent will therefore render colours better than clear mercury. The difference between a 3400K tungsten halogen with CRI 99 and an ordinary 2800K incandescent with CRI 92 can usually also be differentiated by most observers. Despite the small difference in CRI values, the tungsten halogen will render colours more vividly compared to the ordinary incandescent.

Colour rendering is a very important concept in the selection of lights for visual impact especially in the case of (building) façade and monument lighting.

3.0 THE POWER AND INTENSITY OF LIGHT

3.1 **Optical watt** The fundamental unit of optical power is defined as the watt (W) which is equivalent to a rate of energy of 1 Joules (**J**) per second.

1 watt (optical power) = 1 Joule per second

3.2 **Luminous Flux, Lumen (lm)** The photometric equivalent of the optical power for visible light is the **lumens (lm)**, which has to take into account the sensitivity of the human eyes by weighting it towards yellowish-green light (at 555nm). The average human eyes have the greatest response at 555nm. The lumens is also referred to as the **luminous flux**.

1 watt at 555nm = 683.0 lumens

2.2 Correlated Colour Temperature (CCT)

The variation in the amount of colours within a light mixture affects the appearance of the light in terms of its relative 'warmness' or 'coolness' and this variation in relative 'warmness' and 'coolness' is term '**colour temperature**'. Theoretically CCT is defined as light colour correlated (or compared) to the temperature of a laboratory 'black body' as it is heated through the various stages of incandescent from red to blue white. The Correlated Colour Temperature (CCT) is in Kelvin.

2.3 Colour Rendering Index (CRI)

The **CRI** compares the spectral energy content of a light source to that of a standard reference source with full-spectrum. The CRI value is a numerical value and is 100 for full-spectrum natural white light. Incandescent lights are considered nearly white and has CRI close to 100.

3.1 Optical Watt

The fundamental unit of optical power is defined as the watt (W)[

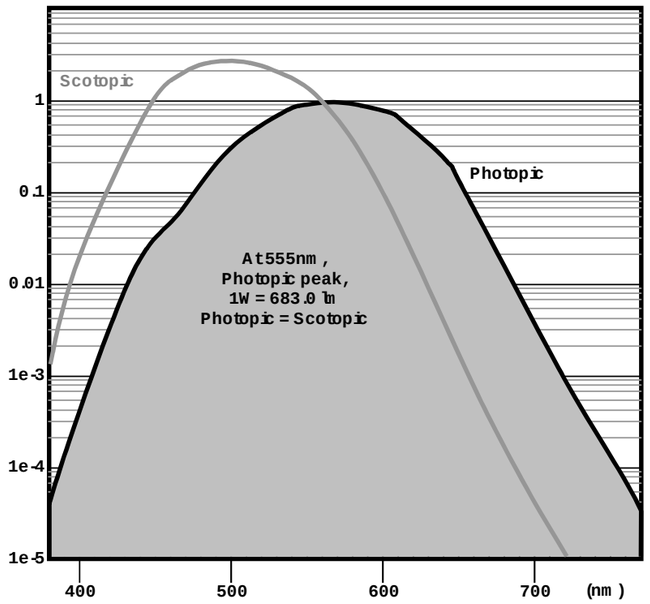
1 watt optical = 1 Joule per second

3.2 Luminous Flux, Lumen (lm)

1 watt at 555nm = 683 luments

The watt take into account the optical sensitivity of the human eye by weighting ut towards yellowish-green light at 555nm.

The CIE (*Commission Internationale De L'Éclairage* or International Commission on Illumination) has defined the responsiveness of the human eye in terms of **Photopic** (daytime) and **Scotopic** (night time) vision. **Figure I3.2** shows the CIE photopic and scotopic response curve.



The vertical scale measures the relative sensitivity with maximum response at 555nm (relative sensitivity 1) for photopic response. Note that scotopic sensitivity is enhanced.

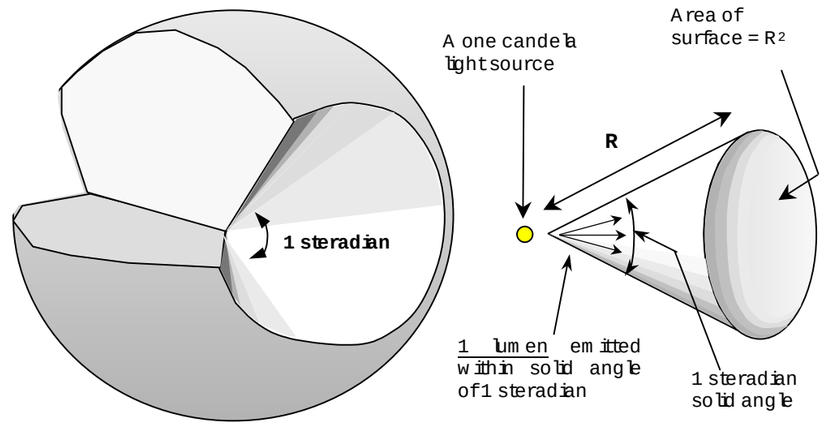
Figure I3.2 – CIE Photopic and Scotopic Sensitivity curves

3.3 **Luminous Intensity (I)** As light is dispersed from a point source quantification of light power has to take into account the geometry of space. The standard geometrical projection for luminous flux is a cone with a solid angle of one steradian (see **figure I3.3**). The basic unit of irradiance or luminous intensity is the **candela** (**cd**).

1 candela is a light source which emits

1 lumen per steradian, isotropically in all directions.

Due to the definition of a steradian, one candela (or 1 lm per steradian) will project a luminous flux of 1 lumens per sq. ft. at one foot from the point source or 1 lumens per sq. metre at one metre from the point source (see **figure I3.3**).



A one steradian solid angle is when the area of the surface cut by the solid angle is equal to the square of the radius. A solid sphere has a total solid angle of 4π steradian.

The **Candela** is a light source which emits (isotropically or equally in all directions) an intensity of **1 lumen within a 1 steradian** solid angle. A one candela source will project 1 lumen/ft² for a 1 feet radius and 1 lumen/m² for a 1 metre radius.

Figure I3.3 – Geometries, Steradian and the Candela

3.4 **Luminance (L)** is the luminous intensity per unit area projected in a given direction. The unit of luminance is the candela per sq. metre (cd/m²) which is also called the **nit**. The footlambert (fL) is also in common use. Luminance is a common quoted parameter in the specification of lighting performance and it is commonly represented by the designation '**L**'.

1 cd/m² = 1 nit

1 fL=3.426cd/m²

3.5 **Illuminance (E)** is the luminous flux incident on a surface per unit area or the photometric flux density. It is expressed in lumens per unit area. The units of illuminance which is also commonly represented by the designation '**E**' is as follows:

1 lux (lx) = 1 lumen /m²

1 foot-candle (fc) = 1 lumen /ft²

***Photopic** – daytime visual response (peaks at 555nm);*
***Scotopic** – night time visual response (sensitivity peaks shifts from photopic). Scotopic response is also enhanced compared to photopic.*

3.3 Luminous Intensity (I)

*The basic unit of irradiance or luminous intensity is the **candela** (**cd**).*
*A **1 candela** light source emits **1 lumen per steradian** isotropically in all directions.*

*One **Steradian** solid angle is when the area of the surface cut by the solid angle is equal to the square of the radius (a solid sphere has 4π Steradian).*

3.4 Luminance (L)

L is the luminous intensity per unit area projected in a given direction (in candela per sq. metre – cd/m² or footLambert)

1 cd/m² = 1 nit

1 footLambert (fL) = 3.426 cd/m²

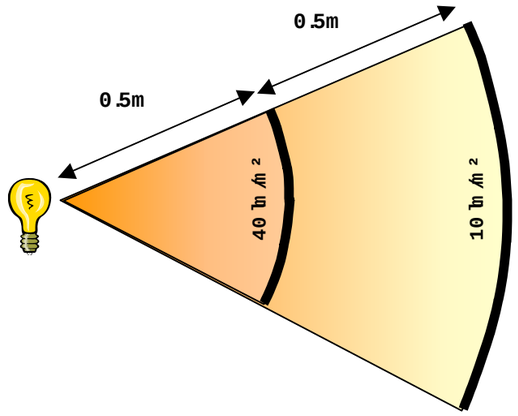
3.5 Illuminance (E)

E is the luminous flux incident on a surface per unit area or the photometric flux density (in lumens per unit area):

1 lux (lx) =1 lumen / m²

1 footcandle (fc) = 1 lumen / ft²

3.6 **Inverse Square Law** Lighting intensity as for all electromagnetic radiation follows the inverse square law. Lighting intensity per unit area falls inversely with the square of the distance (**figure I3.6**).



The inverse square law states that the intensity per unit area of light is inversely proportional to the square of the distance.

$E \propto 1/d^2$ OR $E_1 \times d_1^2 = E_2 \times d_2^2$

Figure I3.6 – The Inverse Square Law

4.0 PHOTOMETRY

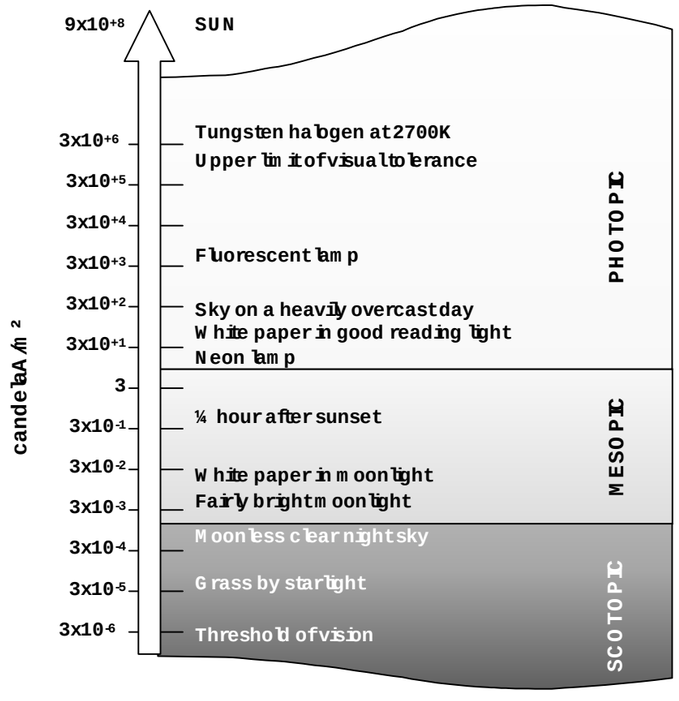
4.1 **Brightness and the Luminance/Illuminance Confusion** Both luminance (*L*) and illuminance (*E*) are quantities measuring the density of light energy falling on a surface.

Luminance (*L* in cd/m²) measures the intensity per unit area **projected** in a given direction. Luminance is therefore sensitive to the direction of projection (or perception) and perhaps can be perceived as a '**perception**' measurement. Some experts also aver that luminance is a quantity which is most akin with '**brightness**'. It should however be cautioned that luminance is a measurable quantity whilst '**brightness**' is a subjective value and both terms are **not** interchangeable. **Figure I4.1** charts human perception over a range of luminance value.

Brightness is a subjective value which can be perceived differently by different people and under different circumstances. The response of the human eye to the magnitude of lights is complex, non-linear and depends on the sensitivity of the retina (age), the colour of the light, the uniform background lighting level (photopic/mesopic/scotopic conditions) and the presence of glare.

Illuminance (*E* in footcandle or lux) measures the luminous flux **incident** on a surface.

In codes and standards, luminance (*L* – *cd/m²*) is more commonly specified for roads and highway lightings while illuminance (*E* – fc/lux) is preferred for interior lightings.



Luminance levels perceived by the human eye. The sensitivity of the human eyes respond logarithmically to the luminance level. The range of human perception ranges over a luminance level of 12 orders magnitude.

Figure I4.1 – Luminance Chart

3.6 The Inverse Square Law

Lighting intensity per unit area falls inversely with the square of the distance.

4.1 Brightness and the Luminance/ Illuminance Confusion

Both luminance (L) and illuminance (E) measure the density of light energy falling on a surface.

*Luminance (L in cd/m²) measures the intensity per unit area **projected** in a given direction. L is therefore sensitive to direction of perception.*

*Illuminance (E in footcandle or lux) measures the luminous flux **incident** on a surface.*

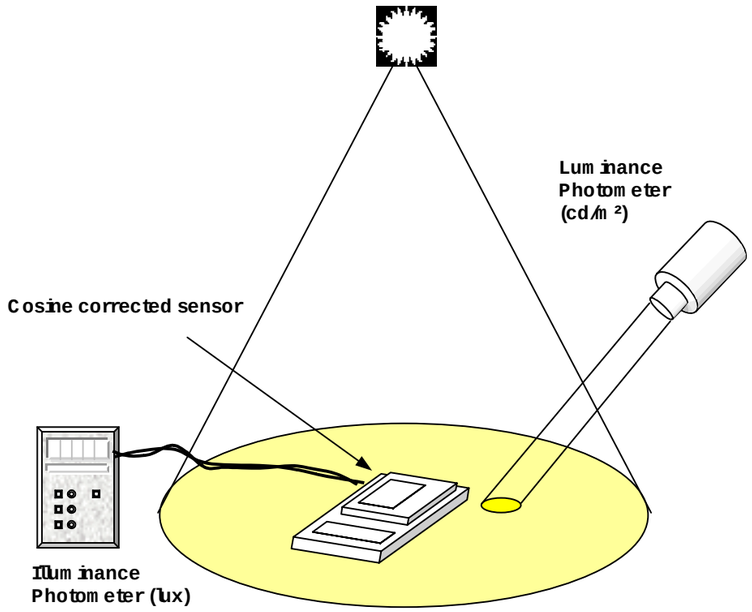
Brightness is a subjective value. Luminance is sometimes quoted as most akin to 'brightness'.

In codes and standards, luminance (L – cd/m²) is more commonly specified for motorways whilst illuminance (E – fc or lux) is preferred for interior lightings and/or pedestrian traffic.

4.2 **Photometry** The difference between luminance (*L*) and Illuminance (*E*) is best illustrated by the different methods employed by both types of photometers.

Luminance photometer mimics the human eyes. The luminance photometer is aimed at a lighted surface or light source and brought to focus. The luminous flux captured through the aperture and focusing lens of the photometer falls onto a photo-detector permitting a measurement of luminance.

In contrast, the illuminance photometer is placed directly under a light source or onto the surface to be measure. The illuminance measured is irrespective of the direction of the light source. **Figure I4.2** illustrate the fundamental difference between the luminance and the illuminance photometers.

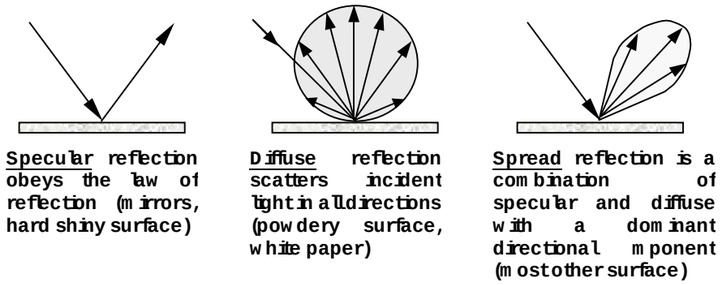


Luminance and Illuminance Photometry illustrates the difference between Luminance and Illuminance

Figure I4.2 – Photometers

5.0 REFLECTION ON A SURFACE

5.1 **Specular, Diffuse and Spread Reflection** Light reflected off a mirror obeys the law of reflection. In such case, the reflection is said to be specular. Hard shiny surfaces are primary specular. Diffuse reflection occurs when the light is scattered in all directions when reflected. Fine granulated surfaces (such as powders) present a uniformly bright (instead of shiny) surface in all directions. Reflections which are a combination of both specular and diffuse is termed spread reflection. Spread reflection usually has a dominant directional component which is partially diffused by surface irregularities. **Figure I5.1** illustrates the difference between specular, diffuse and spread reflection.



Specular reflection obeys the law of reflection (mirrors, hard shiny surface)

Diffuse reflection scatters incident light in all directions (powdery surface, white paper)

Spread reflection is a combination of specular and diffuse with a dominant directional mponent (most other surface)

Figure I5.1 – Specular, Diffuse and Spread Reflection

5.2 **Lambert's Cosine Law and the Lambertian Surface** Lambert's Cosine law states that the irradiance or luminous intensity falling on a surface varies as the cosine of the incident angle (see **figure I5.3**).

5.3 **Lambertian Surfaces** are perfectly diffusing surfaces which obeys Lambert's Cosine Law. Light falling onto a Lambertian surface provides a uniform diffusion of luminance when viewed from all directions. Prefect Lambertian surface is a theoretical ideal but most every day objects with a matte surface (such as paper, towel, carpets etc) approximate Lambertian surface closely. In calculation of interior lighting, all surface are assumed to be Lambertian to simplify calculations. For outdoor

I5

4.2 Photometry

Luminance photometer mimics the human eyes. The luminance photometer is aimed at a lighted surface or light source and brought to focus. The luminous flux captured through the aperture and focusing lens of the photometer falls onto a photo-detector permitting a measurement of luminance.

The illuminance photometer is placed directly under a light source or onto the surface to be measure. The illuminance measured is irrespective of the direction of the light source.

5.1 Specular, Diffuse and Spread Reflection

***Specular reflection** – obeys the law of reflection (highly reflective surface such as mirrors and hard shiny surfaces);*

***Diffuse reflection** – scatters incident light in all directions (powdery surface, white paper);*

***Spread reflection** – is a combination of specular and diffuse reflection with a dominant directional component (most surfaces).*

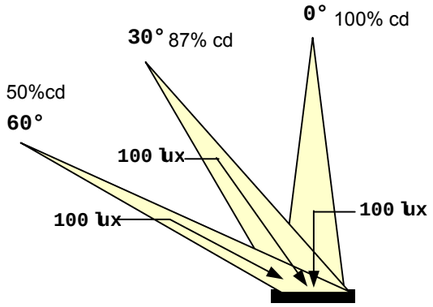
5.2 Lambert's Cosine Law

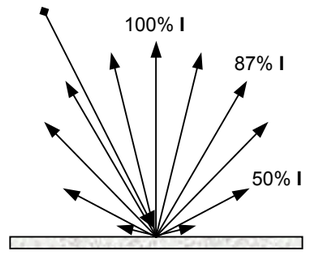
Irradiance or luminous intensity falling on a surface varies with the cosine of the incident angle.

5.3 Lambertian Surface

A perfectly diffusing surface which obeys Lambert's Cosine Law. A Lambertian surface provides a uniform diffusion of luminance viewed from all directions.

façade and monument lighting however this may be an over-simplification. **Figure I5.3** illustrates the property of a Lambertian surface.





Lambert's Cosine Law states that the luminous intensity of a light incident on a surface is proportional to the cosine of the incident angle.

$I_\alpha \cos(\gamma)$ OR $I_\gamma = I\cos(\gamma)$

Lambertian Surface is a perfectly diffusing surface which obeys Lambert's Consine Law. As the luminous intensity falls in proportion to the cosine of its incident angle, the area spread by the incident beam increases. Thus luminance viewed at any angle for a Lambertian surface is equal.

Figure I5.3 – Lambert's Cosine Law and Lambertian Surface

6.0 REFERENCE

(a) '*Lectures on Physics*' by Richard P. Feynman, Addison-Wesley 1995

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(c) '*Light Measurement Handbook*', Alex Ryer http://www.intl-light.com

(d) '*Introduction to Light and Colour, Part I and II*', Sam Mills, AIA, IES, Oct 1987 and Nov 1987 of Architectural Lighting Magazine

(e) '*Brightness, Luminance, and Confusion*' 1993 by Charles P. Halsted