APPENDIX U – ELECTRICAL SERVICES ASSESSMENT

Ashburner Francis Consulting Engineers

PROJECT NUMBER

21-0469

ISSUE

A

Report

Electrical Services

For **Toowoomba Sports Precinct**

At **Corner Toowoomba Bypass and Warrego Hwy**

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P1	2 December 2021	Preliminary Issue	LW
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1. INTRODUCTION

1.1 Purpose of Report

This report was commissioned to:

- Review the requirements of the project in terms of electrical supply from the Ergon Network – Access, availability and required capacity.
- Review the requirements of the project in terms of on-site electrical power generation and storage options including solar PV, battery storage and hydrogen production.
- Review the requirements of the project in terms of communication links to the site from the NBN network and Council's private communication network – access, availability and required capacity.
- Review the requirements of the project in terms of internal electrical and communications infrastructure. Provide concept level designs.
- Review the requirements of the project in terms of Site outdoor and sports lighting in accordance with the relevant Australian Standards: AS 1158 series for Category P (pedestrian) lighting and the AS 2560 Series for sports lighting. Provide concept level designs.
- Review the requirements of the project in terms of compliance with the relevant Australian Standard for obtrusive lighting: AS 4282 Control of the obtrusive effects of outdoor lighting.

1.2 Referenced Standards

Certain standards were referenced in the assessment of this installation. They have been nominated in the relevant sections. This is by no means an indication that an exhaustive analysis of each referenced standard's relevance to the installation has been made. This type of in-depth analysis is generally made during design and documentation of works. While all due care has been taken to highlight the main relevant requirements, certain requirements may have been omitted from this document that would become apparent during future design and documentation of works.

1.3 Referenced Documents

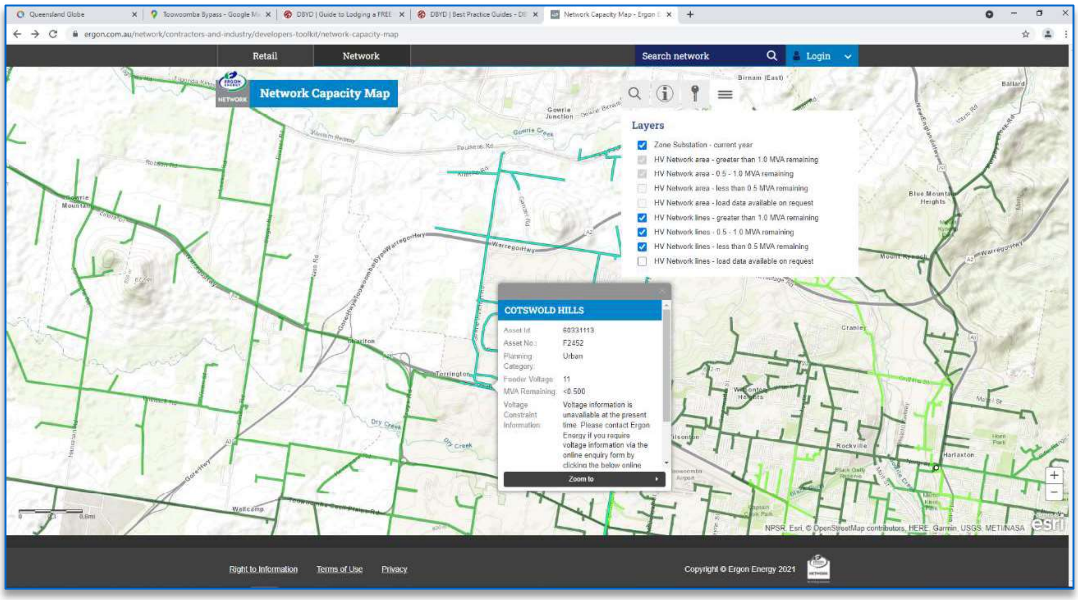
The documents referenced generally in this report are:

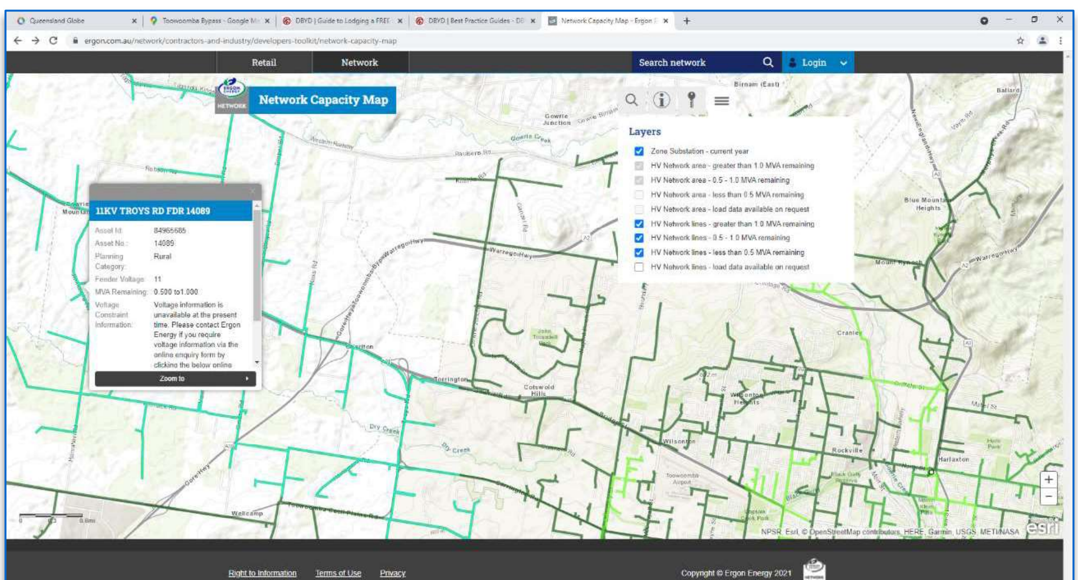
1. Toowoomba Region Sports Precinct 2020 Master Plan prepared by Greenedge Design
2. Toowoomba Region Sports Precinct Lighting Design (16-11-21) by Austube-Schreder (Designer: Gerard Bowtell-Harris)

2. ELECTRICAL SUPPLY

2.1 General

Ergon is the Network Service Provider in this case. The online Ergon Network Capacity Map provided on the Ergon website indicates that a number of High Voltage network lines exist in the area. The closest two feeders include the 11 kV Cotswold Hills feeder and the 11KV Troys Rd FDR 14089.





2.2 Access

The closest of the two available feeders is the 11KV Troys Rd FDR 14089. This runs along the Toowoomba Connection Road. The Cotswold Hills feeder runs along Gowrie Junction Road.

2.3 Availability

The Network Capacity Map indicates that 0.5 to 1 MVA remain available on the 11KV Troys Rd FDR 14089 feeder at the time of writing this report. The Network Capacity Map indicates that less than 0.5 MVA remain available on the Cotswold Hills feeder. This existing capacity will not be sufficient to cater to the needs of the site and will require an Ergon network services upgrade.

2.4 Required Capacity

Buildings and Air Conditioning Loads:

Based on initial energy demand method maximum demand calculations for the buildings and indoor sports facilities shown on the current plans, we estimate that these will require approximately 2,10 0 A or 1,500 kVA in terms of electrical supply.

Sports lighting, carpark lighting, road lighting and pathway lighting:

Based on initial maximum demand calculations with reference to the Austube-Schreder indicative lighting design for the Toowoomba Region Sports Precinct, we estimate that the site lighting will require approximately 1,400 A or 1,010 kVA in terms of electrical supply.

Total site power requirements:

The total estimated site power requirement along with 35% spare capacity would thus amount to approximately 4,700 A or 3,400 kVA.

3. ON-SITE ELECTRICAL POWER GENERATION AND STORAGE

3.1 General

The predicted usage patterns of the site should be fully assessed as part of the detailed design process. However, it can be assumed that the site will only be fully utilized during relatively rare major sporting events that occur over full day/night cycles. During normal use, it can be assumed that specific sports or events will be active during the daytime and at night. This type of usage pattern will result in localized electrical loads at the local clubhouses and amenities associated with those specific sports and events. At night, the specific fields in use will require the requisite sports lighting to be engaged, leading to a localised lighting electrical load in addition to electrical loads for the clubhouses and amenities associated with those fields and events. Whereas during the daytime, the electrical load will be made up primarily of electrical loads for the clubhouses and amenities with no additional external lighting load.

It can also be assumed that the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre will likely be in use much of the time, being a centralized hub for activities on the site. As such, this will represent a fairly regular electrical load.

3.2 Solar PV

3.2.1 Solar PV Module Installation Sites

Based on the Master Plan drawings, there are a number of buildings that may be appropriate installation sites for PV Modules. These include various clubhouses, the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre and the Indoor Shooting Range.

Based on the current drawings, the roof area of the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre may represent an area of approximately 14,000 m² and the attached amenities may represent an area of approximately 5,000 m².

The various other remaining buildings may represent a combined roof area of approximately 6,000 m².

Of this area, it is assumed that only approximately 40% will practically be used for solar PV. The most appropriate site being the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre.

For the purposes of this report, we have assumed that 50% of the available Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre roof area will be used for solar PV installation, representing an area of 7,000 m². We have also assumed that the remaining buildings will contribute approximately 3,000 m² of roof space to solar PV generation.

In addition to the available roof area, there are a number of large carparks shown near to the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre. It may be possible to provide covered parking for all or some of these carpark areas and install PV Modules on the covered carparks. However, this is not shown on the drawings and has not been taken into the approximations presented in this report.

3.2.2 Roof Orientation and Tilt

Within this region, a north-facing roof with a 27° pitch would be optimal for PV generation. The type of roof structure, roof orientations and tilts will impact the generation capability of any installed solar PV systems. However, at this stage in the project it is difficult to confirm what these will be. It appears as though most buildings shown on the Master Plan drawings will not have their longitudinal axes running east-west. Their roofs will thus not allow for optimal north-facing solar exposure. However, the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre appears to be optimally oriented for solar generation.

3.2.3 Roof Area

The average size of a 250W solar module is approximately 1650X992. Based on this size, a conservative estimate of the number of panels that can be installed on the available roof area can be calculated. It is estimated that approximately 4,200 panels can be installed on the available Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre roof space. The remaining roof space would be able to accommodate approximately 1,800 panels. In ideal conditions, this would amount to a total power output of approximately 1,050 kW generated by the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre and 450 kW generated by the remaining buildings. This represents a total of approximately 1,500 kW of solar PV generation for the site.

3.2.4 Roof Structure

The roof structure should be assessed and designed accordingly to support the load represented by the solar PV modules. In addition, maintenance access should be provided around the solar modules (ie. Contractors should not walk on top of the solar panels). In addition, panels should not be stacked on the roof prior to installation.

3.2.5 PV Inverter locations

Due to the ring distribution network providing power to the site, the solar PV generation will also have to be distributed in nature. Local grid-connected inverters should feed into local main switchboards. However, the main generation potential on site is the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre. Hence, although generation potential is distributed, the main solar PV generation centre can be located at the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre.

3.2.6 Average Daily Production of PV System

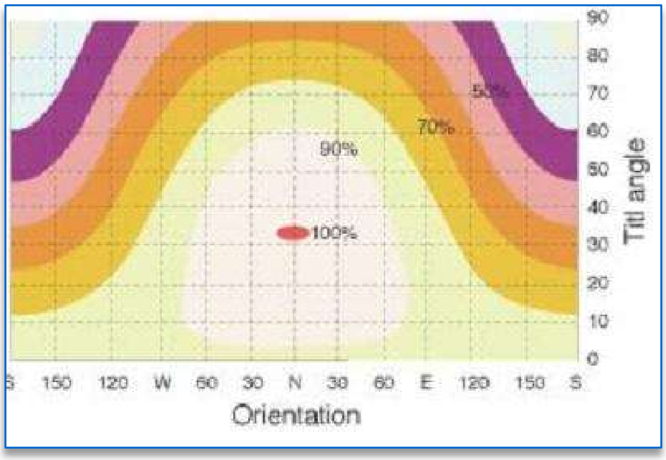
The CEC publication “Guide to Installing Solar PV for Business and Industry” includes a table of average daily production (in kWh) of various sizes of solar PV systems based on area and associated sun hours. It should be noted that these values are for ideal conditions and do not take into account factors such as variable tilt, orientation and sources of shadowing.

The average daily production (in kWh) for the Toowoomba Sports Centre based on a 1,500 kW solar PV system can be extrapolated from the table as 6,700 kWh per day.

Based on a 30-day month, the average monthly production should be 201,000 kWh under ideal conditions.

3.2.7 Effect of Tilt, Orientation and Shading

The Your Home Technical Manual provides a graphic which indicates percentage efficiency based on orientation and tilt angle. The highest percentage efficiency of the solar PV system installed at the Toowoomba Region Sports Precinct cannot be expected to be higher than approximately 70%-8o% due to limitations imposed by potential sub-optimal tilt angles and orientations.



It is thus expected that the actual monthly production would be closer to 150,000 kWh.

When the system produces the predicted 1,500 kW of power (or 1,500 kVA at a power factor of 1), the solar PV system may be capable of offsetting the daytime electrical site load imposed by AC and internal building lighting. The full site maximum demand will not be supported by this generation capacity. However, the full site maximum demand would only be incurred at night or during poor lighting conditions when the site external lighting is switched on. At these times, solar PV generation would not be possible or would at least be sub-optimal. The site's usage patterns will dictate whether offsetting its electrical loads with the solar PV system is feasible.

The nature of the site and its expected usage patterns would have to be assessed in order to ascertain whether the site would be dormant for much of the optimal daytime solar PV generation. If the site is predominantly underutilized or dormant during the day, the solar PV generation capacity may lend itself to being coupled with an energy storage solution such as battery storage or hydrogen generation.

3.3 Energy Storage

Due to the type of electrical distribution network recommended for the site, a centralized power generation and energy storage solution incorporating all of the distributed solar PV generation is not possible. The site will be fed by a network of transformers that are in turn fed by a hybrid ring-type HV network.

The transformers will feed local main switchboards which in turn will feed smaller local distribution switchboards. As such, PV generation and energy storage will have to be distributed across the site and associated with local main switchboards that are near to the primary points of generation. This approach will of course also lend itself well to the site staging. However, the complexity and thus cost for energy storage approaches may be negatively impacted due to the need for multiple installations across the site. More conventional battery-based energy storage options would lend themselves more to the distributed nature of the site. Most battery storage options are modular in nature and can easily be expanded or distributed on a site without having as much of a significant negative impact on the cost or system complexity as other less conventional systems, such as hydrogen generation, may exert.

However, as mentioned previously, the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre represents the site's main single electrical load and could also represent the site's main solar PV generation centre. Locating an energy storage facility at the Premier Hub/Multi-Purpose Indoor

Sports Centre & Aquatic Centre may thus be a logical and efficient application of technology instead of multiple energy storage facilities located at satellite stations across the site.

3.3.1 Battery Storage

Battery storage is a maturing, competitive, conventional and modular approach to energy storage when coupled with a solar PV system. There are a number of solutions that are currently available, such as the Tesla Powerwall II, which are typically aimed at the domestic market.

An example of a system that is geared more towards larger industrial or commercial sites such as the Toowoomba Region Sports Precinct, is the scalable ZBM2 battery system by Redflow.

ZBM2 - where power meets intelligence, delivering sustained energy storage from the world's smallest zinc-bromine flow battery, monitored and managed online.

This battery storage system could be scaled to meet the local demand, integrated with the local PV generation and installed in a dedicated plant room near to the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre. The system could then be used to offset usage peaks during night-time use or increased AC loads during the day.

3.3.2 Hydrogen Production

Hydrogen production typically makes use of surplus renewable electrical generation capacity to separate water into hydrogen and oxygen through an electrolysis process. The gas produced in this reaction is then used as an energy store. Hydrogen generation is occasionally used at sites that employ a modified fleet of vehicles that run off hydrogen fuel cells fuelled by gas generated by the central plant. In addition, some sites may use hydrogen to power modified electrical generators. The Wikipedia entry on Hydrogen indicates the following: “The energy density per unit *volume* of both liquid hydrogen and compressed hydrogen gas at any practicable pressure is significantly less than that of traditional fuel sources, although the energy density per unit fuel *mass* is higher. Nevertheless, elemental hydrogen has been widely discussed in the context of energy, as a possible future *carrier* of energy on an economy-wide scale.” The energy density of Hydrogen per unit volume is thus relatively low.

Hydrogen generation plant would typically be located at a central location on site and would require several pieces of equipment. As an example, Australian Hydrogen Generation (a subsidiary of Amtronics) has a short video on their website showing several stages of the generation, purification and storage of nitrogen. They also produce plant equipment for hydrogen generation, purification and storage that is similar to the equipment shown in the demonstration video. This equipment could be located within a dedicated plant room near to the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre.

In addition to the hydrogen generation, purification and storage plant equipment, some means of utilizing the stored energy represented in the hydrogen gas is also required. This could take the form of banks of hydrogen fuel cells or a hydrogen power generator such as the GEH2 Blue Diamond Hydrogen Power Generator.

Self-contained hydrogen generation and fuel cell storage batteries designed to integrate with rooftop solar systems have begun to be available on the market. An example of one of these systems is the Lavo Hydrogen Battery System.

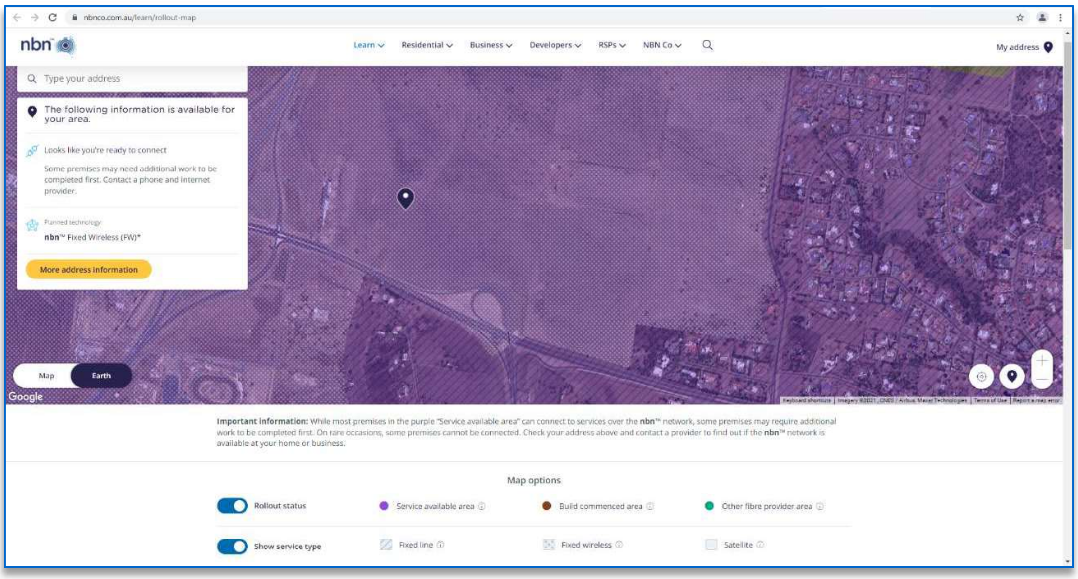
This system appears specifically designed for the domestic market, but up-scaled systems may become available from various other producers over the next few months, some of which may be applicable to the site.

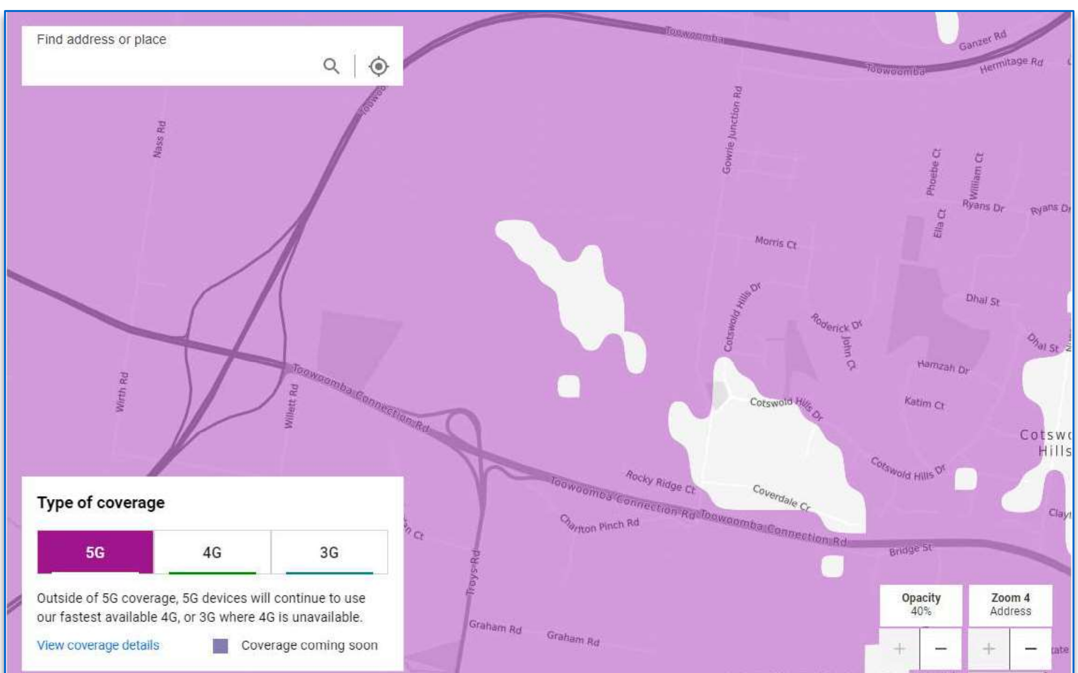
4. COMMUNICATIONS

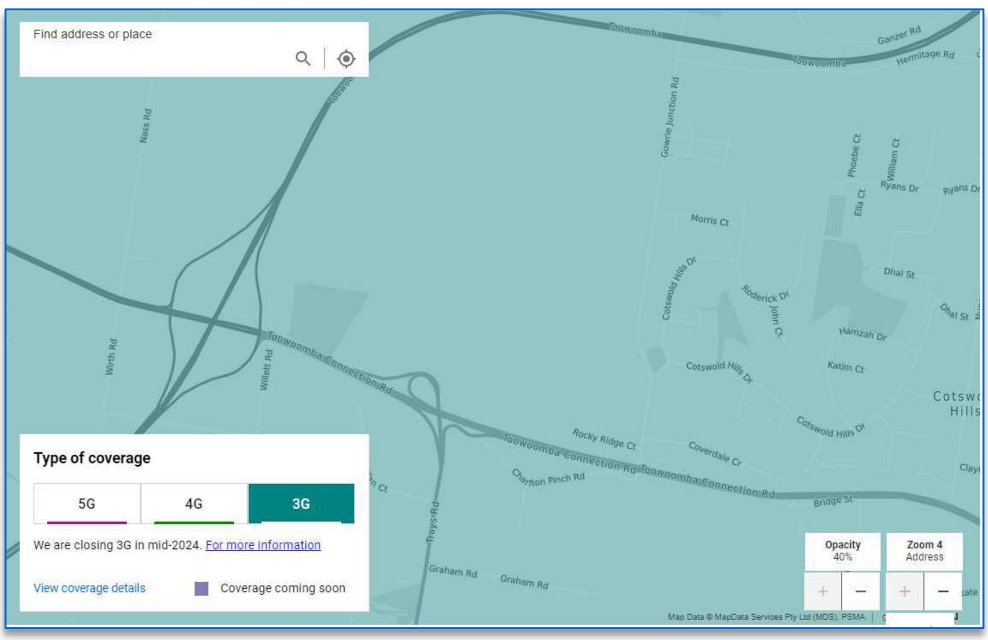
4.1 General

Telstra and NBN services are available in the area of works. According to the online NBN rollout map, fixed line service is not currently available for the site although fixed wireless service is available. However, fixed line service is available along the Toowoomba Connection Road and along Gowrie Junction Road, allowing this to be extended to the site.

According to the online Telstra coverage map, 5G, 4G and 3G services are available on the site although it is important to note that there appear to be holes in the 5G coverage that may affect the site overall coverage.







In addition, it is important to note that the Toowoomba Regional Council Principal Depot is located at 24 Nass Road, which is in close proximity to the site. The TRC communications network could thus be extended to incorporate the new Sports Precinct.

4.2 Access

Access to the NBN fixed line service would be possible by extending pit and conduit network from Gowrie Junction Road. In addition, a pit and conduit network could be extended directly from the TRC Principal Depot or via a dedicated microwave link to extend the existing TRC data network to the new site. Alternatively, depending on the location of other TRC communication infrastructure, service could be extended from the Toowoomba Connection Road, following Gowrie Junction Road and then alongside the NBN pit and conduit network.

5. INTERNAL ELECTRICAL AND COMMUNICATIONS INFRASTRUCTURE

5.1 General

Concept level designs were prepared for the site internal electrical and communications infrastructure. In both cases, the pit and conduit network will follow the hybrid ring-type HV network due to the staging for the site.

5.2 Electrical Backbone Staging and Indicative design

The site staging will affect the design of the electrical reticulation and supply. The proposed design is based on a ring-type HV distribution network feeding a number of distributed local transformers which in turn feed local main switchboards and satellite distribution switchboards. Ring-type distribution networks are inherently more resistant to local failures in the network. However, due to the staging, a simple ring-type distribution network is not possible in this case. As such, multiple, interconnected ring distribution networks have been incorporated in the indicative design to ensure that maintenance can be carried out on the final network arrangement without shutting down large sections of the precinct.

The ring-type distribution network has been designed to be implemented in stages to facilitate the expansion of the project over time. Typically, this will involve the installation of a HV network along with ring main units at specific locations that may remain dormant until the project progresses to further stages that are fed from those ring main units.

5.3 Communications Backbone Staging and Indicative Design

The internal site communications infrastructure will require staging in much the same way as the electrical HV and associated LV network. It can follow a similar path to the internal site electrical reticulation network and use the site internal eastern and southern roads as a backbone.

5.4 Wifi, PA, Security/CCTV, EV charging

Aside from typical conventional services provided within buildings, the Austube-Schreder design can offer the following services to lighting poles within carpark areas and other ares such as pathways or parks as necessary:

- In-built security cameras
- Indicator light rings
- Wifi routers
- PA speaker system
- EV charging options
- Help button and call out for safety and security

These services can be distributed across the site as required as part of the lighting layout.

5.5 Integrated Lighting/Power Control

In terms of controlling of power across the site, a distributed system of smart meters and control options can be incorporated into the design. This can be simple in nature or take the form of a full site-wide management system. We would recommend that this be considered for a project of this scale and would lead to improved control and reduced energy consumption. If a site management system is incorporated, it should be capable of interfacing with the site lighting control system.

The Austube-Schreder design offers a lighting control network, allowing flexibility in the control of lighting across the entire site.

6. SITE LIGHTING

6.1 General

6.1.1 Envisioned use of the Facility

According to the Master Plan document, a variety of sports are set to be played at the facility in the future. These sports and activities include but are not limited to:

1. Archery
2. Athletics
3. Baseball
4. Shooting (skeet and long-range)
5. AFL
6. Aquatic Sports
7. Cricket
8. Football
9. Netball
10. Rugby

This is an extensive list of sports and activities which have associated standards setting out recommended lighting levels and parameters.

In addition to these sports, the Master Plan shows an extensive network of roadways, pathways, parks and carparks that all require lighting.

6.2 The Austube-Schreder Design

6.2.1 Referenced Standards

The standards that are applicable to the design process include but are not limited to:

1. AS/NZS 2560 series
2. AS/NZS 1158 series

6.2.2 General

Austube-Schreder prepared an indicative lighting design for the Toowoomba Region Sports Precinct on the 16th November 2021. At this stage in the design process, only indicative concept-level designs have been prepared for the Toowoomba Region Sports Precinct. The main focus of the design work to date has predominantly been on the sports fields because this represents a significant portion of the site electrical load.

The Austube-Schreder design includes suggestions and recommendations for elements such as roadway lighting, pathway lighting, park lighting and carpark lighting. However, no detailed design has been prepared for these elements yet because of the early stage in the design process. At this stage, only notional fitting numbers have been associated with elements such as the roadways, pathways and carparks in order to estimate the site maximum demand. As such, detailed designs are not presented in this report for these elements of the site.

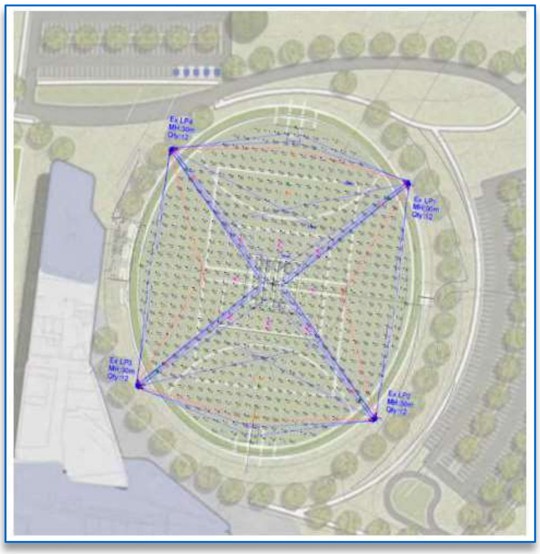
In addition, the lighting within the Premier Hub/Multi-Purpose Indoor Sports Centre & Aquatic Centre has only been incorporated as an estimated electrical lighting load within the energy demand method maximum demand calculation for the site. A detailed design has thus not been presented in this report.

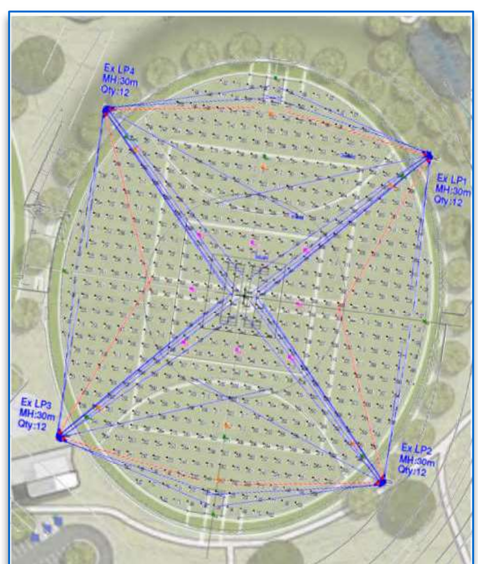
The sports lighting designs provided by Austube-Schreder should be seen as very much concept-level designs and will require further work and modification as the design progresses.

6.2.3 Sports Field Lighting Design

The Austube-Schreder indicative lighting design for the Toowoomba Region Sports Precinct incorporated the requirements of the relevant standards from the AS/NZS series of sports lighting standards. Certain assumptions were made in terms of the type and level of activities that would occur on the fields. These are noted in their design documents, and all appeared reasonable based on the available information and the early stage of the design process. These assumptions will be confirmed as part of the detailed design for the site.

The design incorporated pole and lighting layouts for all the sports fields currently shown on the Master Plan document.





6.3 Obtrusive Effects of the Lighting Design

6.3.1 General

At this early stage of the design, an assessment of the obtrusive effects of the site external lighting is not possible. When the concept level lighting design is advanced to a more detailed stage, these obtrusive effects will have to be assessed. However, the current lighting layout has been designed to minimize obtrusive lighting effects through the use of light fittings that minimize glare and reduce or eliminate upward light spill.

6.3.2 Referenced Standards

The standards applicable to the obtrusive effects of the lighting design are:

1. AS 4282 2019 "Control of the obtrusive effects of outdoor lighting"

6.3.3 Recommendations of the Standard

AS 4282 contains a number of recommendations which are relevant to this lighting design. Some of these recommendations pertain to the type of luminaires used, aiming angles, height of poles and associated physical characteristics of the installation while others pertain to site operation and curfew hours.

The requirements of AS 4282 will need to be fully incorporated into the detailed design and installation.

AS 4282 recommends values for illuminance in the vertical plane, luminous intensity emitted by luminaires and threshold increment in order to minimize the obtrusive effects of lighting. The recommended values for illuminance in the vertical plane and luminous intensity emitted by luminaires vary based on whether the installation is being assessed pre-curfew or during curfew hours.

6.3.4 Curfew Hours

AS 4282 indicates that curfew hours are typically set by local government. We recommend that these curfew hours be considered and finalized based on the predicted usage patterns of the site. Curfew hours could be taken as being between 11 PM and 6 AM. During curfew hours, lighting should be significantly reduced in order to meet the requirements of AS 4282 for the environmental zone that applies to the site.

6.3.5 Environmental Zone

Based on AS 4282 Table 3.1, it could be assumed that the site could be considered an A2 zone (sparsely inhabited rural and semi-rural area) because of the street lighting along the major arterial roads that border the site. An A2 zone is described as possessing low district brightness. However, if it is intended that TV broadcasts are to be made from the site, the environmental zone could be seen as a TV zone (vicinity of major sports stadium during TV broadcasts). This would redefine the area as a high district brightness area. Note that AS 4282 indicates that the light technical parameters for TV code installations apply only while the installation is being used for broadcast. For training and at other times the installation shall conform to the requirements for the applicable environmental zone (A2 in this case). The usage and intent for the site will dictate whether this is going to be classed as an A2 or TV zone. The site's environmental zone will affect the required light technical parameters and the detailed lighting design.

6.3.6 Light Technical Parameters

AS 4282 calls for several light technical parameters to be assessed for the site. These include Vertical Illuminance, Average Luminance, Luminous Intensity, Upward Light Ratio and Threshold Increment. A vertical calculation grid will be set up either at the property boundary or at the window-line of abutting buildings in order to calculate the vertical illuminance. In the case of the Toowoomba Regional Sports Precinct, the vertical calculation grid may have to be set up at the property boundary due to the underdeveloped state of the site. The average luminance will calculated for any illuminated signs, facades or artworks. In addition, in this case, the maximum luminous intensity of luminaires may have to be assessed because there may be direct vision of light sources or the flashed areas of the reflectors of certain light fittings from certain directions. Upward light ratio will also be calculated for the site. In addition, threshold increment will have to be assessed for the site. Threshold increment is a measure of disability glare and applies to a set of calculations that will need to be performed for pedestrian and traffic corridors near to the site.

6.3.7 Required Light Technical Parameters

As mentioned previously, the site's environmental zone will affect the required light technical parameters as indicated below:

AS/NZS 4282:2019 Table 3.2 calls for the following light technical parameters for Zone A2:

Max. Vertical illuminance levels (non-curfew): 5 lx

Max. Vertical illuminance levels (curfew): 1 lx

Max. Threshold increment (TI): 20%

Max. Upward light ratio: 0.01

AS/NZS 4282:2019 Table 3.2 calls for the following light technical parameters for Zone TV:

Max. Vertical illuminance levels (non-curfew): Defined in Table 3.4 and affected by the camera placement and illumination.

Max. Vertical illuminance levels (curfew): N/A

Max. Threshold increment (TI): 20%

Max. Upward light ratio: 0.08

AS/NZS 4282:2019 Table 3.3 calls for the following light technical parameters for Zone A2:

Luminous intensity (non-curfew L1): 7,500 cd

Luminous intensity (curfew L1): 1,000 cd

AS/NZS 4282:2019 Table 3.3 calls for the following light technical parameters for Zone TV:

Luminous intensity (non-curfew L1): 100,000 cd

Luminous intensity (curfew L1): 0 cd

7. CONCLUSION

Each section of this report highlights conditions and options that should be considered. Please refer to each section individually for these points.