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24th March 2020

Independent Planning Commission
Level 3, 201 Elizabeth St,
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Dear Independent Planning Commission,

Subject: **Daylight Study for the Santa Sophia Catholic College Project**

Steensen Varming prepared a daylight study for the Santa Sophia Catholic College project as part of the Response to Submissions following a request on the daylight amenity to outdoor learning / play areas from the GANSW. The results from this initial modelling showed that the current design provided high levels of daylight to all outdoor learning / play areas throughout the year.

Following receipt of the DPIE Assessment report and the draft conditions of consent, the use of the daylight assessment has been incorporated as supporting evidence for the inclusion of design alterations, particularly to level 04 and 05 of the design. As such the daylight assessment has been updated to provide a clearer picture of the initial modelling and responds to the concerns surrounding daylight amenity to each level and through each season throughout the school term that was raised in DPIE's assessment report.

The revised modelling demonstrates that the current design provides high levels of daylight to the outdoor decks throughout the year and school year.

Alterations have been proposed to the current design in the aim of achieving greater daylight through reduced shade coverage, we note this report shows the proposed alteration would provide minimal benefit as levels 4 and 5 are already achieving appropriate daylight levels. Instead the proposed changes would impact on the use of spaces as learning and play areas due to over exposure of daylight and exposure to extreme weather conditions such as wind, rain and direct solar.

This daylight study supports the design as it is currently documented, as it ensures that outdoor spaces receive sufficient natural light for educational activities.

Yours faithfully,

Kenny Lim

Project Manager, TSA Management Pty Ltd

Attachments: Steensen Varming Outdoor Decks Daylight Study Rev 03 Date 23-03-2020

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SUSTAINABLE DESIGN

STEENSEN VARMING

Santa Sophia Catholic College
Outdoor Decks Daylight Study

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Document Revision and Status

Date	Rev	Status	Notes	Checked	Approved
20-08-2019	00	Draft	For review	BAJ	BAJ
22-08-2019	01	Final	For review	GL	BAJ
12-09-2019	02	Final	TSA and Urbis updates	GL	BAJ
23-03-2020	03	Final	Response to DPIE concerns	GL/BAJ	BAJ

Sydney March 23th, 2020
Ref. No. 187153 S03

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1.0 Executive Summary

This report has been prepared by Steensen Varming on behalf of the Catholic Education Diocese of Paramatta (CEDP) (the Applicant). This accompanies a Response to the Submissions Report, in support of State Significant Development Application (SSD_9772) for the proposed Santa Sophia Catholic College (the Proposal), located on the corner of Fontana Drive and the future road 'B', between Red Gables Road and Fontana Drive, in Box Hill North (the site).

This is a continuation of the previous report (in response to concerns raised by the Government Architects Office on the daylight amenity to outdoor spaces of the Santa Sophia Catholic College, to address new queries from DPIE. Specifically, regarding a lack of daylight on the lower levels and a concern of seasonal fluctuation in the results.

1.1 Approach

An annual assessment was performed and included in the previous report (see Appendix B). This determined that all levels, received high lux levels, when averaged across the year.

In further refining this study, this report assesses light levels across each season (Winter, Spring, Summer and Autumn), in confirming that all spaces receive high quantities of continuous daylight, without detrimental gaps of limited or restricted exposure. All four seasons have been reviewed independently (comparative results are included in Section 2.0 of this report) and referred to as **Study 1**.

Furthermore, a secondary study **(Study 2)** was performed, which accessed light levels during the identified worst-case season, via a single point in time lux level calculation (lux levels is a single unit within the sDA calculation). Plotted lux levels are presented in Section 3.0. of this report. This calculation was performed for the external play hours of: 10am, 12pm and 2pm (late morning, midday and early afternoon sun position). These times coincided with periods of expected outdoor play.

For details on the modelling methodology and the approach refer to Appendix A of this report.

1.2 Methodology

Spatial Daylight Autonomy (sDA) is the daylighting metric used to evaluate daylight availability across the outdoor areas. sDA was utilised for the assessment. Australian Environmental benchmark Standard: Green Star requires between 40-60% of occupied spaces to achieve at least (for 80% of the time) 160 lux (160/80). While LEED (the principle sustainable certification from the United States) sets the criteria for 50% of the occupied time to achieve 300 lux (300/50), with a similar 40-55% of the tested area to comply. If 75% or more of the spaces achieve the required threshold the results are awarded with exemplary performance.

CEDP set their own light level threshold of 400 lux, which is more stringent than in any of certifications or standards. For SSCC the following measure was selected: sDA (400/50) for at least 40-60% of tested areas. Approaching the study in this manner, ensures the results address the high standards of both certifications methods.

Floor Area (%) sDA 400lux / 50%

Floor Area (%):	*The percentage of floor area achieving the sDA criteria*
sDA:	*Spatial Daylight Autonomy*
400lux:	*The daylighting illuminance (lux) criteria*
50%:	*Percentage of time a minimum of 400 lux is achieved during the assessment period*

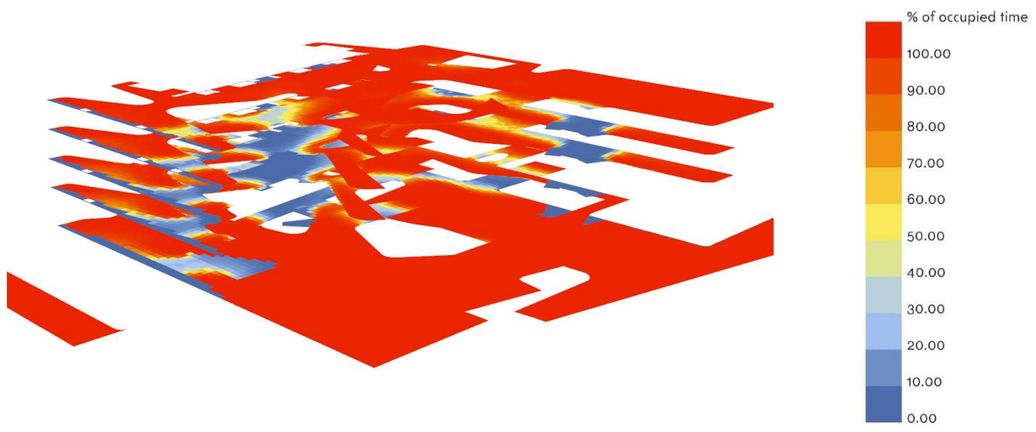
1.3 Results Summary

The DPIE's assessment report identified their concern with daylight levels to the lower floors. A direction was given to the consider the removal of shade/making them retractable on Level 4 (surrounding fitness centre) & Level 5 (roof to walkway decks), to compensate for less daylight to play areas on the lower levels.

Our revised modelling demonstrates that the current design provides high levels of daylight to the outdoor decks throughout the year. This daylight study supports the current design, in ensuring outdoor spaces receive sufficient natural light for study-based activities.

Specifically, the current design performs well in:

- Seasonally, like the annual results (see below), show high levels of daylight throughout the year. The outdoor spaces on most school levels are exceeding the set target requirements.



- The overall results indicate the outdoor areas achieve approximately 80% sDA (Study 1), which demonstrates exemplar performance;
- The outdoor spaces are transient, and occupants can freely move to favourable areas suitable to their comfort levels and preference for daylight;
- Seasonal fluctuation of daylight levels are considered marginal and subsequently have minimal effect on the quantity of daylight received;
- For the areas raised as a concern by the DIPE on Levels 4 and 5, sDA levels of 85% plus are recorded for each season;
- Most areas accessed, achieve very high lux levels of daylight during play time (10am-2pm) even in winter (See Study 2) and as per the table below;
- The removal of shading on Level 4 (surrounding fitness centre) & Level 5 (roof to walkway decks), is unlikely to provide meaningful daylighting benefits, but rather increase exposure to rain, wind and direct solar.

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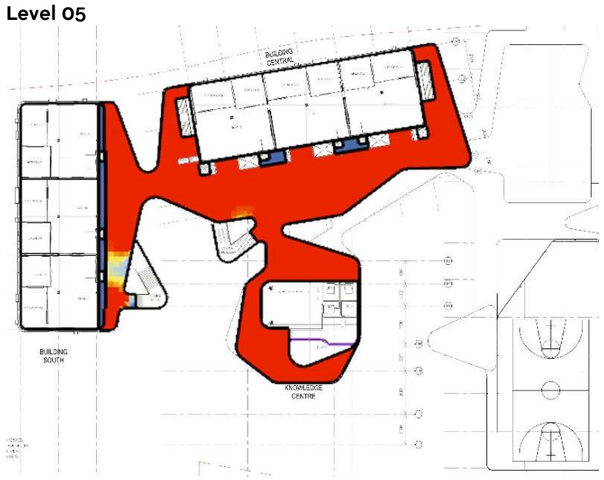
Daylight levels on June 2nd at 2pm for an overcast sky condition:

Level 04

Level 05



Lux

400+ 360 320 280 240 200 160 120 80 40 0

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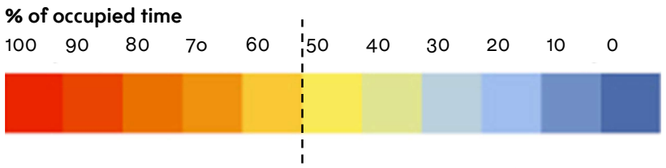
2.0 Study 1: Seasonal Results

DA (400 lux)

% of occupied time

100 90 80 70 60 50 40 30 20 10 0



Target: 40-60% of tested area to comply with sDA(400/50)

2.1 Level 00

Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun-Aug)	Spring (Sep-Nov)
83.7% complies with sDA (400/50)	**82.95%** complies with sDA (400/50)	**81.52%** complies with sDA (400/50)	**83.07%** complies with sDA (400/50)
			

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2.2 Level 01

Summer	Autumn	Winter	Spring
85.11% complies with sDA (400/50)	**84.1%** complies with sDA (400/50)	**83.03%** complies with sDA (400/50)	**84.99%** complies with sDA (400/50)

DA (400 lux)

% of occupied time

100 90 80 70 60 50 40 30 20 10 0

Target: 40-60% of tested area to comply with sDA(400/50)

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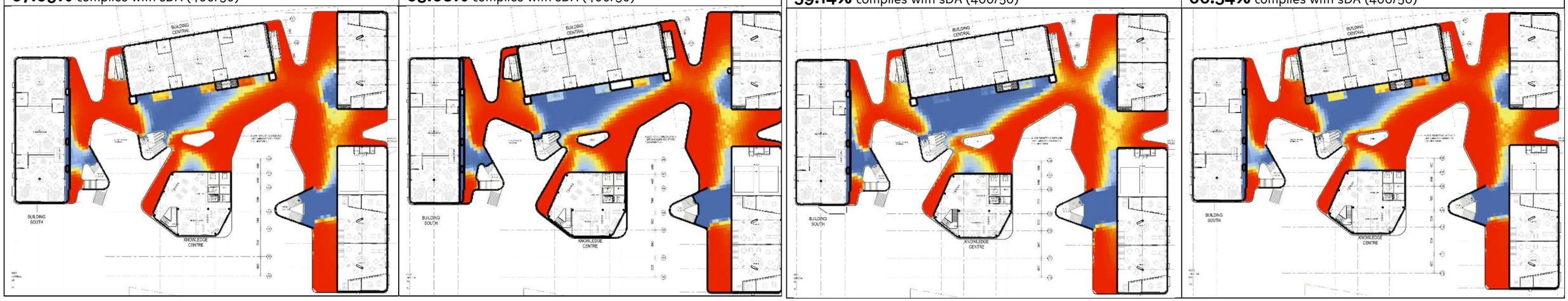
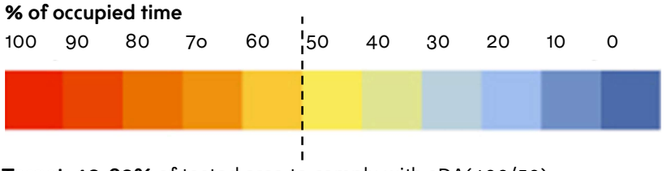
2.3 Level 02

Summer	Autumn	Winter	Spring
67.69% complies with sDA (400/50)	**63.68%** complies with sDA (400/50)	**59.14%** complies with sDA (400/50)	**66.54%** complies with sDA (400/50)



DA (400 lux)

% of occupied time



Target: 40-60% of tested area to comply with sDA(400/50)

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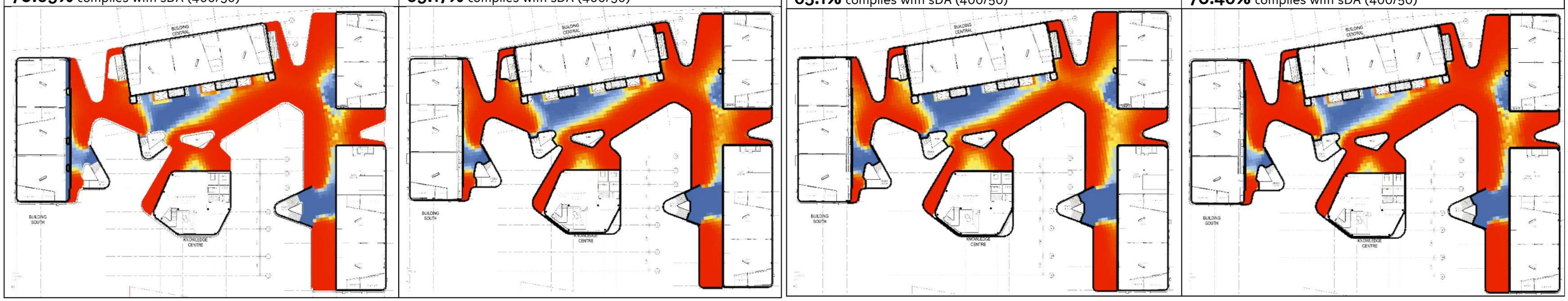
2.4 Level 03

Summer	Autumn	Winter	Spring
70.69% complies with sDA (400/50)	**69.17%** complies with sDA (400/50)	**65.1%** complies with sDA (400/50)	**70.46%** complies with sDA (400/50)



DA (400 lux)

% of occupied time

100 90 80 70 60 50 40 30 20 10 0

Target: 40-60% of tested area to comply with sDA(400/50)

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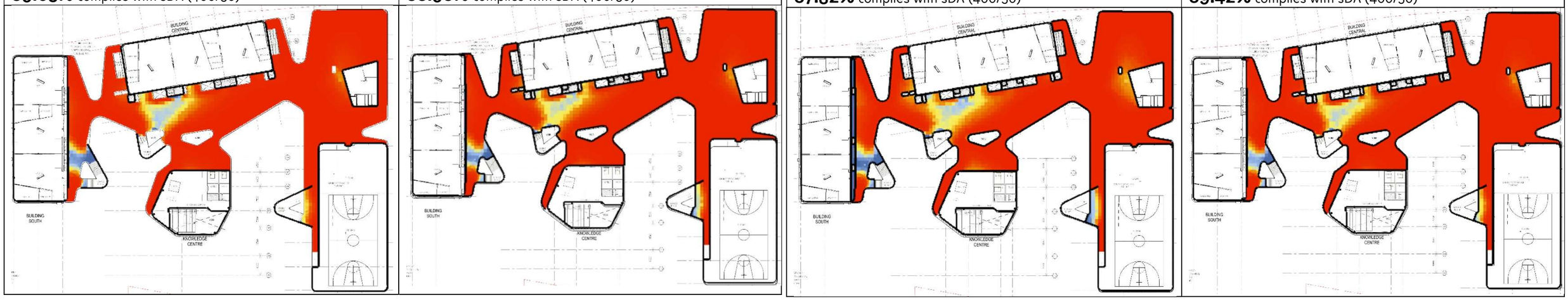
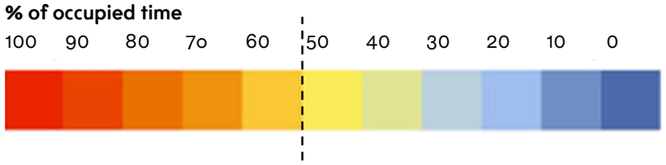
2.5 Level 04

Summer	Autumn	Winter	Spring
89.63% complies with sDA (400/50)	**88.98%** complies with sDA (400/50)	**87.32%** complies with sDA (400/50)	**89.42%** complies with sDA (400/50)



DA (400 lux)

% of occupied time



Target: 40-60% of tested area to comply with sDA(400/50)

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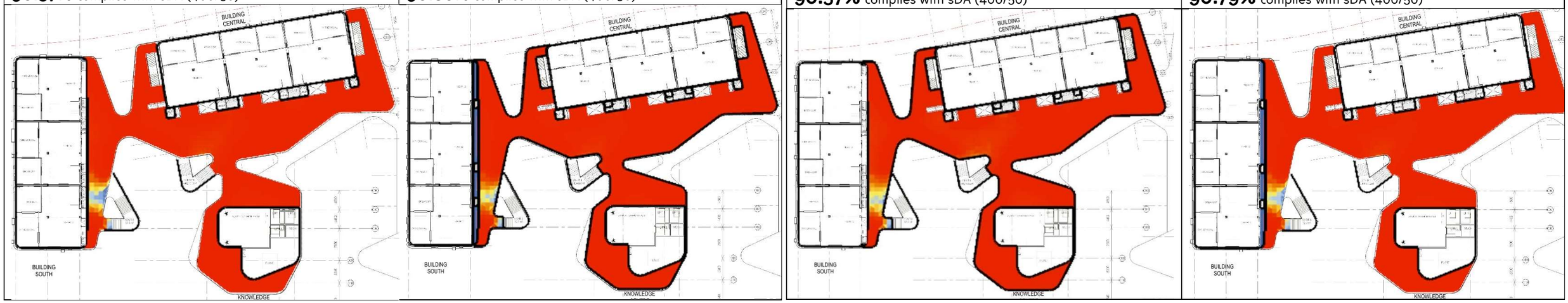
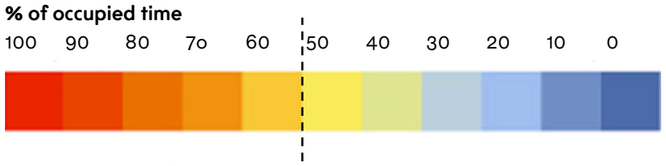
2.6 Level 05

Summer	Autumn	Winter	Spring
90.57% complies with sDA (400/50)	**90.86%** complies with sDA (400/50)	**90.57%** complies with sDA (400/50)	**90.79%** complies with sDA (400/50)



DA (400 lux)

% of occupied time



Target: 40-60% of tested area to comply with sDA(400/50)

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3.0 Study 2: Winter Play Time Hours

Over the period of a year, winter naturally receives fewer hours of daylight when compared to the other seasons. In response to a concern raised by the DPIE, over the potential of reduced daylight levels to decks during this period, this section reviews daylight levels during play hours (10am-2pm) during the winter equinox.

Results for 10am, 12pm and 2pm are presented as a point in time lux level calculation (see below). The selected times are described as mostly cloudy (60% coverage of the sky dome by clouds). A fully overcast day (June 2nd) at 2pm, was also included, to ensure all worst-case scenarios were accounted for. The threshold remains at 400 lux, with exceeding lux levels shown in red. Maximum values reaching 31,000 lux in some instances.

Lux

400+ 360 320 280 240 200 160 120 80 40 0

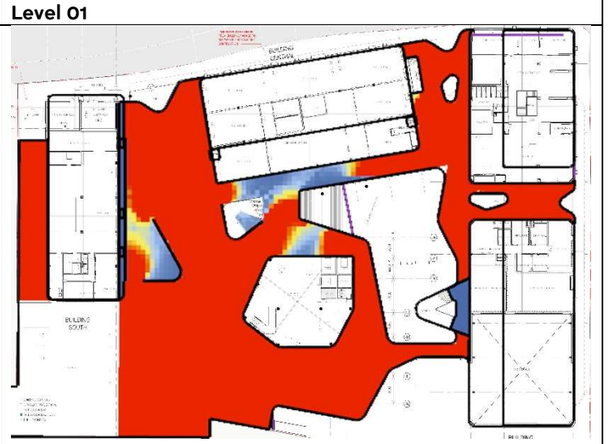
The following sections review lux levels to play hours during winter equinox.

3.1 June 21st 10 am

60% coverage of the sky dome by clouds.

Level 00

Level 01



Level 02

Level 03

Level 04

Level 05

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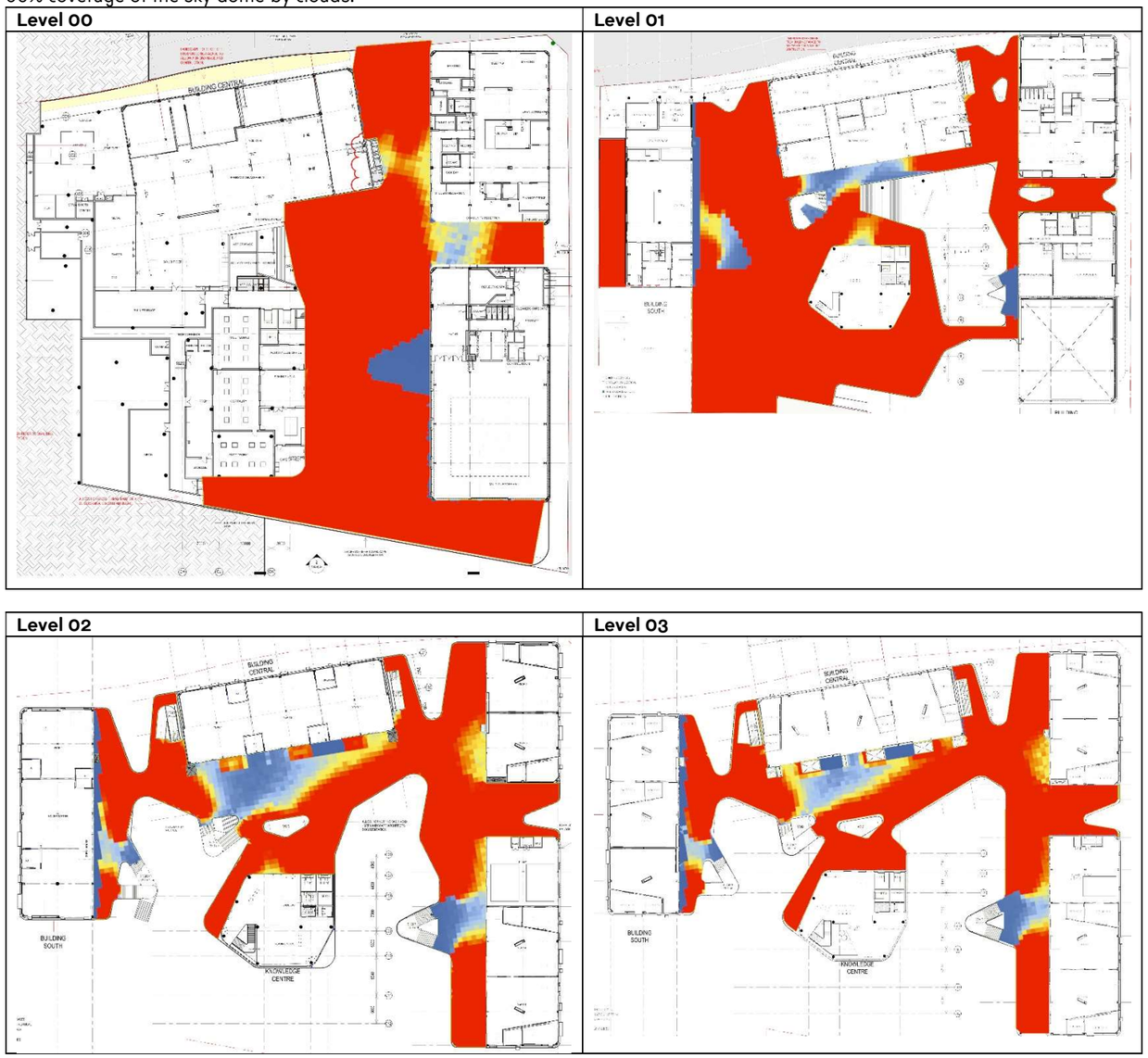
3.2 June 21st 12 pm

60% coverage of the sky dome by clouds.



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3.3 June 21st 2 pm

60% coverage of the sky dome by clouds.

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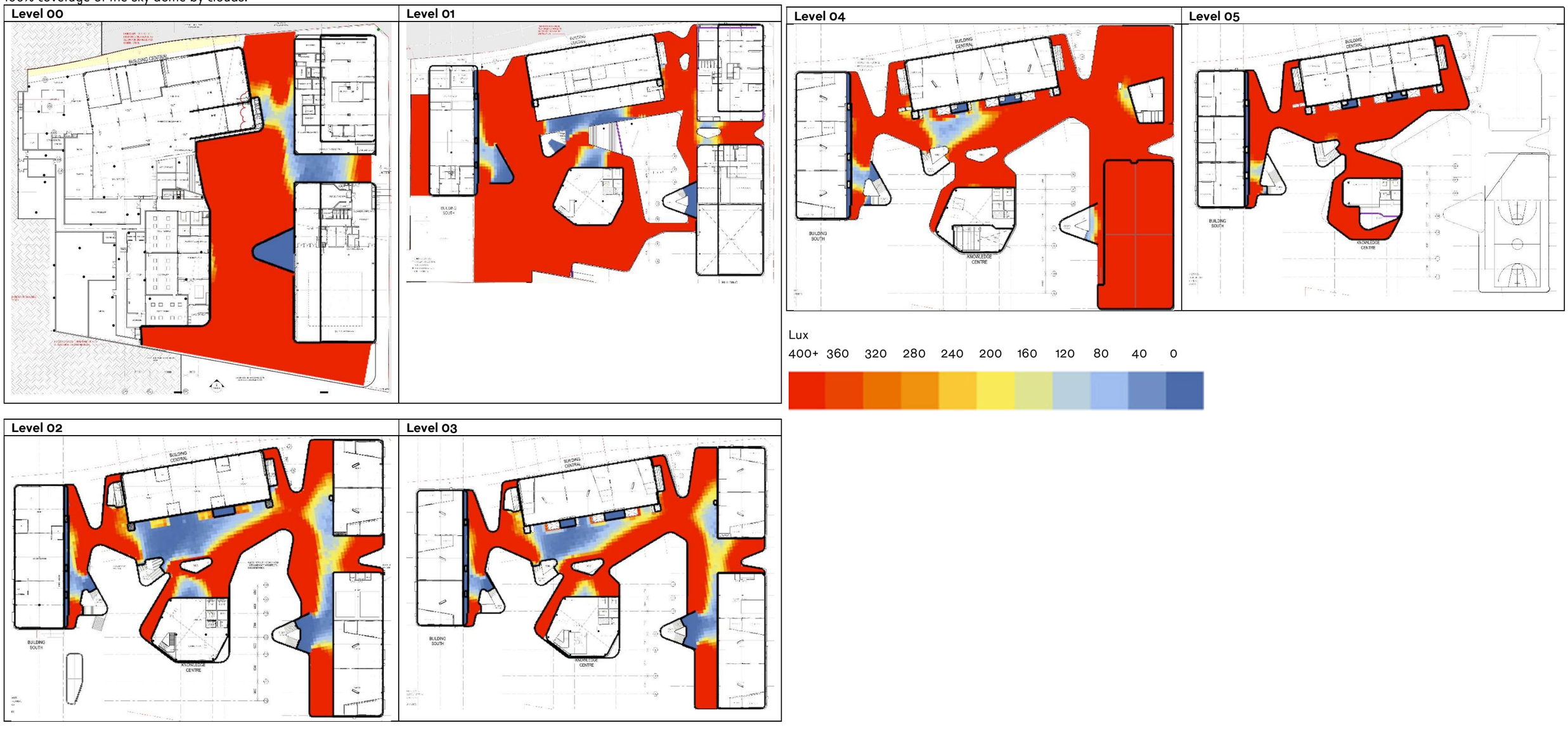
3.4 June 2nd 2 pm

100% coverage of the sky dome by clouds.



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4.0 Conclusion

The results demonstrate good levels of daylight in the outdoor spaces, i.e. 400 lux or more across >60% of the area for at least 50% of the occupied time (as per best practice standards).

The analysis shows that approximately 80% of the outdoor areas receive 400 lux or more for 50% of the occupied time.

Throughout all levels, only 9.4% of the outdoor area receives less than 400 lux at any given time and could be considered underlit for tasks that require higher levels of light, e.g. reading or seeing fine details.

Artificial lighting has been designed and documented for the covered outdoor areas to supplement the daylight ingress to these areas and provide a comfortable well-lit environment for circulation, movements, intermittent study and similar tasks. Artificial lighting will be balanced with the incoming daylight with the use of photoelectric cells to maintain a consistent level of illumination throughout these outdoor areas.

Covered outdoor areas are not exposed to direct sunlight, assisting to limit issues associated with glare, overheating, thermal discomfort and risk of sun / UV overexposure. However, it is important to note that due to the nature of the space, it will be exposed to the direct sun more than the typical indoor environment. It will be desirable if users of the outdoor spaces will be able to adjust their location, outwear and activities to suit the daily conditions.

Appendix A illustrates sDA with threshold of 2000 lux, i.e. percentage of occupied time where illumination levels are 2000 lux or more. These areas may be considered over-exposed and uncomfortable for extended periods, in a similar manner to any other outdoor unshaded space.

The tables below demonstrate that all levels received high lux levels, cumulatively throughout the year.

sDA results			
Level	**Outdoor Floor Area (m^2)**	**(m^2) sDA $_{400lux / 50\%}$ at 100mm above FFL**	**(%) sDA $_{400lux / 50\%}$ at 100mm above FFL**
00	2489.23	2058.10	82.68
01	3831.05	3250.29	84.84
02	2557.71	1622.36	63.43
03	2424.32	1663.33	68.61
04	3459.50	3062.35	88.52
05	1438.80	1300.53	90.39
Total	**16200.6**	**12956.95**	**79.98**

The percentage of outdoor areas that receive less than 400 lux for 100% of the time are as follows:

Areas receiving less than 400 lux			
Level	**Evaluated Area (m^2)**	**Area m^2**	**% of area**
L 00	2489.23	158.47	7.7
L 01	3831.05	224.27	6.9
L 02	2557.71	282.02	18.0
L 03	2424.32	267.80	16.1
L 04	3459.50	208.82	6.9
L 05	1438.80	63.73	4.9
Total	**16200.6**	**1215.11**	**9.4**

Our revised modelling demonstrates that the current design provides high levels of daylight to the outdoor decks throughout the year. This daylight study supports the current design, in ensuring outdoor spaces receive sufficient natural light for study-based activities.

Specifically, the current design performs well in:

- Seasonally, like the annual results (see below), show high levels of daylight throughout the year. The outdoor spaces on most school levels are exceeding the set target requirements.
- The overall results indicate the outdoor areas achieve approximately 80% sDA (Study 1), which demonstrates exemplar performance;
- The outdoor spaces are transient, and occupants can freely move to favourable areas suitable to their comfort levels and preference for daylight;
- Seasonal fluctuation of daylight levels are considered marginal and subsequently have minimal effect on the quantity of daylight received;
- For the areas raised as a concern by the DIPE on Levels 4 and 5, sDA levels of 85% plus are recorded for each season;
- Most areas accessed, achieve very high lux levels of daylight during play time (10am-2pm) even in winter (See Study 2);
- The removal of shading on Level 4 (surrounding fitness centre) & Level 5 (roof to walkway decks), is unlikely to provide meaningful daylighting benefits, but rather increase exposure to rain, wind and direct solar.

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Appendix A - Approach

4.1 Spatial Daylight Autonomy

Spatial Daylight Autonomy (sDA) is a metric that evaluates the percentage of floor area where the target illuminance level is achieved for at least a given percentage of the time. An sDA criteria is expressed as follows:

Floor Area (%) sDA $_{400lux\ /\ 50\%}$

Floor Area (%):	*The percentage of floor area achieving the sDA criteria*
sDA:	*Spatial Daylight Autonomy*
400lux:	*The daylighting illuminance (lux) criteria*
50%:	*Percentage of time a minimum of 400 lux is achieved during the assessment period*

For example, an sDA value of 60% (60% sDA $_{400lux\ /\ 50\%}$) means that 60 % of the space receives more than 400 lux for at least 50% of the occupied time. A higher sDA value indicates a larger percentage of floor area achieves the criteria, which means greater levels of daylight.

There are several daylight evaluation metrics, however, sDA has become one of the most commonly used due to its inclusion in various sustainability ratings such as LEED, WELL, Green Star, etc.

sDA is calculated using a daylight simulation tool that computes the daylight levels in the space for every hour of the defined occupied time.

This calculation is based on *'IES LM-83-12 Approved Method IES sDA and ASE'*, which is an internationally approved standard for Spatial Daylight Autonomy calculations.

We note that ASE (Annual Solar Exposure) is generally undertaken in parallel with sDA calculation. ASE calculations have not been undertaken, due to the tested areas being outdoor space and they will not need to comply with the requirement established for indoor spaces. From our professional experience and industry discussions, the requirement for ASE 1000 lux / 10% of the occupied time is not feasible and the threshold is too low. Even 2000 lux level is considered to be usable light, however, the ASE threshold is still defined as 1000 lux.

4.2 Assessment Method

Due to the absence of available metrics for assessing natural daylight to outdoor spaces, the Spatial Daylight Autonomy (sDA) metric has been utilised to assess the uncovered spaces. While there no metrics available, the use of sDA is relevant as it allows the estimation of natural illuminance levels, percentage of area and amount of time.

Figure 2 provides the recommended illumination levels (lux levels) for specific activities. The tasks associated with the outdoor covered areas are outlined in green and falls within the range of 150 – 400 lux. Based on this range, an illuminance threshold of 400 lux has been utilised in this daylighting assessment.

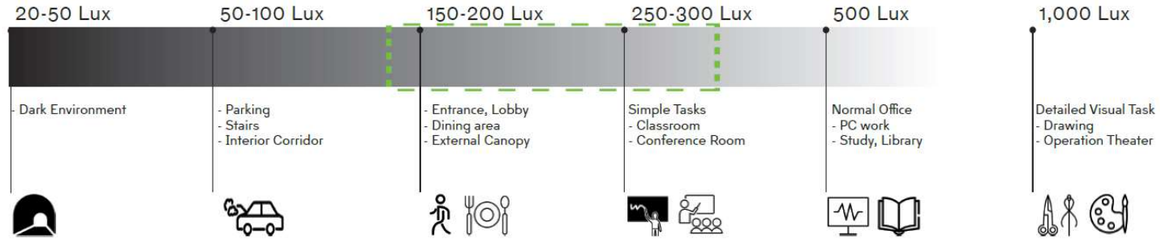

Figure 2: Recommended illuminance (lux levels) for specific tasks.

CEDP have requested 400 lux for the lighting of indoor spaces as well as outdoor assessed areas. Good practice* would be to achieve a target illumination level of 300 lux across 40-60% of the regularly occupied indoor area for at least 50% of operating hours.
* The information is sourced from multiple resources and professional experience, including CIEBSE guidelines, LEED, WELL and GS certifications.

4.3 Modelling Software

To accurately predict and assess the daylight of the proposed spaces, a computer program was utilised, namely Rhino with additional plug-ins: Grasshopper, Ladybug and Honeybee tools.

- Rhino is a highly accurate modelling software package.
- Ladybug and Honeybee (LB&HB) are environmental design tools for architects and building designers. LB&HB are complete building design and environmental analysis tools that cover the broad range of simulation and analysis functions required to understand how a building design will operate and perform.

LB&HB analyses Daylight Autonomy (DA), which is used for determining sDA by measuring lux levels at each test point during every hour of the assessed period of a year. The sky models include the standard CIE overcast sky used in DA calculations.

The simulation engine used is Radiance. LB&HB take as input the three-dimensional geometric model of the physical environment and produces a map of spectral radiance values as a colour image based on a weather file data. These resultant images can be used to accurately visualise and quantify the levels of illumination.

It should be noted that for all the images generated, illuminance is provided by only natural daylight, and as per the climate-based sky model. A climate-based sky model has been used for determining the daylight autonomy. The luminance of the sky changes according to the weather file.

The following weather file has been utilised in this assessment:
AUS_NSW.Richmond.RAAF.957530_RMY.epw

It is important to note that weather file used is the closest based on the recent NatHERs weather files. NatHERs weather files have been utilised because they have been compiled with statistical climate data recorded by BOM.

4.4 Modelling Methodology

The sDA assessment has been based on the documentation and information available as outlined in Table 3.

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Basis of Analysis			
Date Received	**Description**	**Doc. Ref**	**Provided by**
29/07/2019	3D Model	SantaSophia_DWG_Export_Daylight Study_V2.dwg	BVN
13/08/2019	Test Area	AR-DD-A10-00-00.PDF-04-GA KEY PLAN - LEVEL 00.pdf - AR-DD-A10-06-00.PDF-03-GA KEY PLAN - LEVEL 06.pdf	BVN
14/08/2019	True North direction	1803009-000_AR_BLD_RVT19_amehr - Floor Plan - SD_OVERALL SITE PLAN.dwg	BVN

The following assumptions have been utilised in this assessment:

- LRV (light reflectance value) of 50% for all surfaces – it is understood that not all finishes will be exactly LRV 50%, however, an average between ceiling, floor and walls will be approx. 50.
- Occupied time used is 8am - 5pm to cover school and teacher working hours;
- Assessed areas include outdoor terraces/decks connecting the buildings, ground courtyard areas;
- The assessed area utilises an analysis grid located 100mm above FFL for all studies.

4.5 Building Model & Overshadowing

The following images represent the 3D Geometric model that has been utilised for the daylighting analysis. Due to the unresolved masterplan, no surrounding buildings were taken into consideration. However, this is not considered to be a limitation of the study, as the building self-shadows the tested area and only a minor direct light blockage is expected from the future neighbouring buildings and structures. In addition, the restriction of the direct light does not necessarily reduce compliance with sDA $400_{lux\,/\,50}$ %, because the intensity of direct sunlight can generally range between 2,000-10,000 lux (or more).

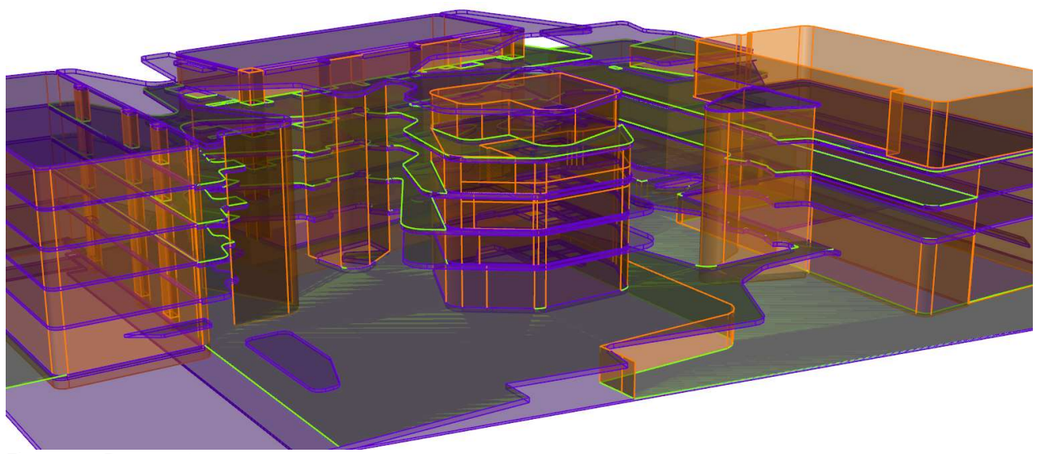

Figure 3: 3D geometry

True North is 34.19 degrees West of project North.

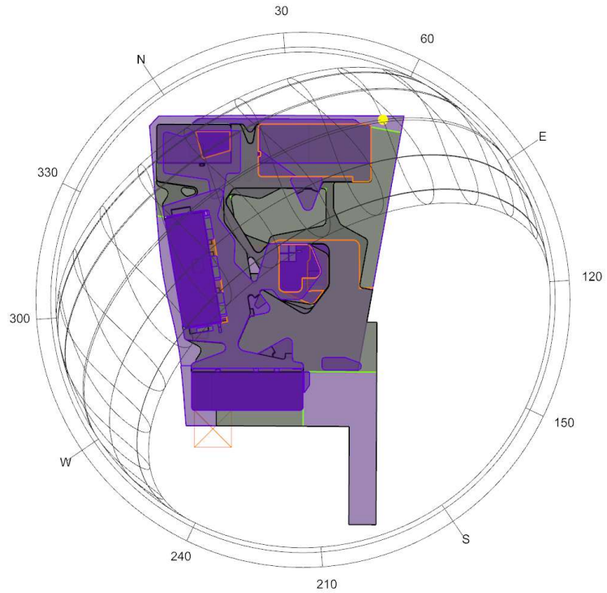

Figure 4: True North

4.6 Nominated Area

The assessed floor area applied to the daylighting analysis is in accordance with the BVN mark-ups of all outdoor learning spaces. This responds to CEDP's pedagogy which utilises external spaces as potential learning environment.

Generally, all outdoor spaces are included, and plant rooms, staircases and lifts have been excluded from the calculation. Figure 5 below shows the nominated area throughout all levels.

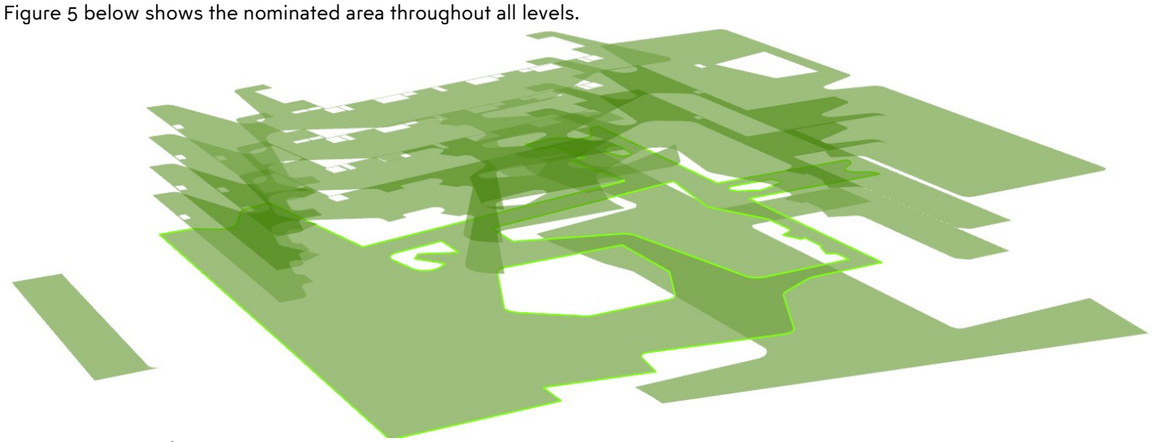

Figure 5: Assessed area.

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Appendix B - Annual Results

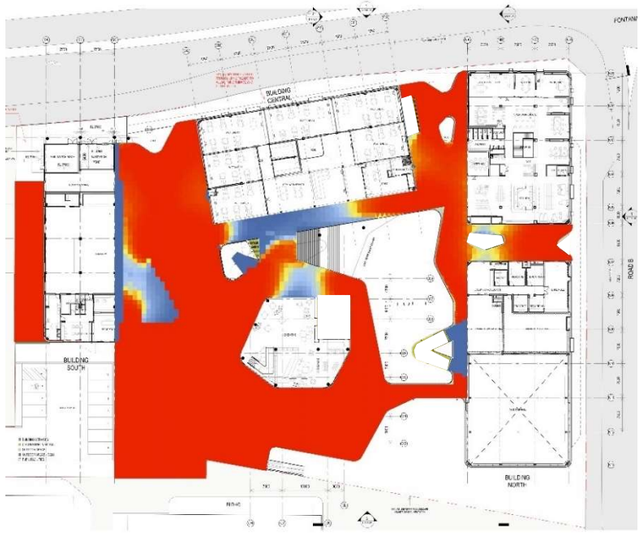
The sDA value expresses the percentage of floor area, that achieves a minimum of 400 lux for at least 50% of operating hours (8am - 5pm) throughout the year for each working day (Monday-Friday). This approach has been taken to account for student and teacher usage. School terms and holiday hours have also been included in this assessment.

Below are results of the Spatial Daylight Autonomy (sDA) analysis and visualisations of light levels across individual floors. All levels achieved an sDA >63%, i.e. more than 63% of the assessed area complies with the target of 400 lux for a minimum 50% of the occupied time. Floors that are more exposed to the sky, including levels 00, 01, 04 and 05 achieved higher sDA levels of ~80-90%.

The dark blue colour indicates areas that receive less than 400 lux at any given time during occupied hours. Areas other than blue can be a subject to much higher light levels than 400 lux, especially if they receive direct sunlight. Please refer to Appendix C for visualisations of light levels above 2000 lux. Red colour indicates high light levels.

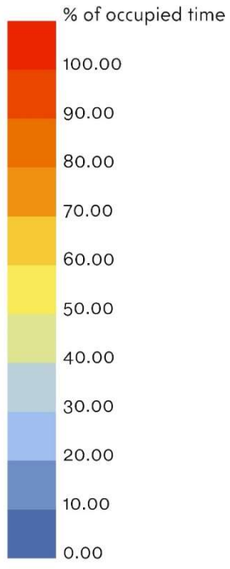
All levels reached an sDA of >63% with an overall total of sDA ~80%. It can be concluded that the general daylight amenity to the outdoor spaces of Santa Sofia is good.

Level 00



Level 01

Level 02



- Red - 400 lux or more for 100% of the time;
- Yellow - 400 lux or more for 50% of the time;
- Blue - less than 400 lux for 100% of the time.

Nominated Floor Area with minimum 400 lux for a minimum 50% of school hours (100mm above FFL):		
2058.10m²	3250.29m²	1622.36m²
82.68%	84.84%	63.43%
Nominated Floor Area with less than 400 lux for 100% of school hours (100mm above FFL):		
158.47m2	224.27m2	282.02m2
7.7%	6.9%	18.0%

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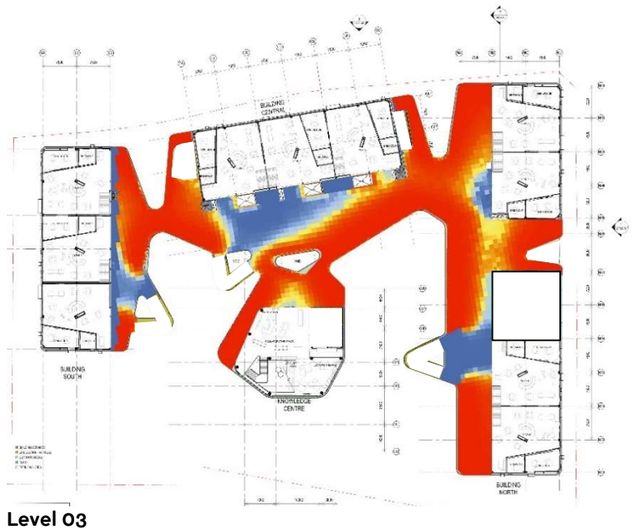
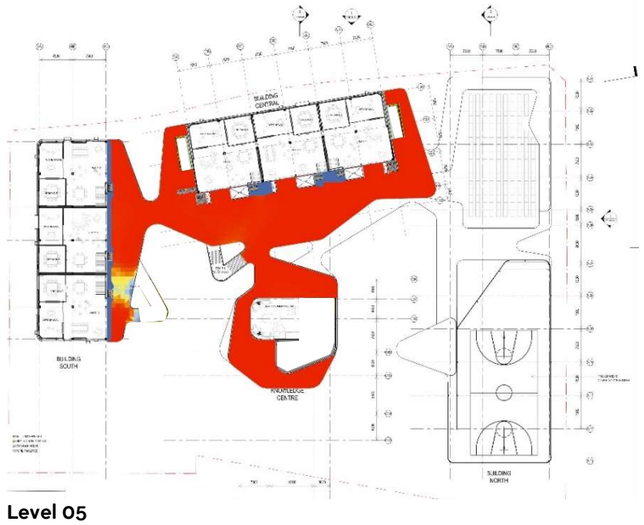
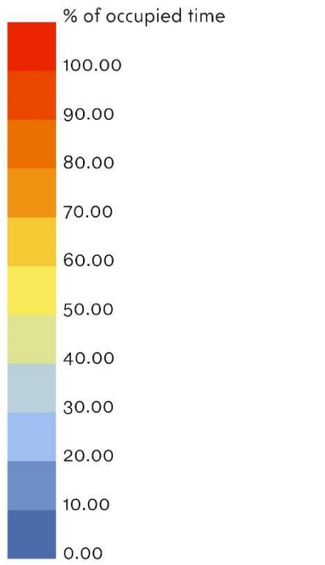


Level 03

Level 04

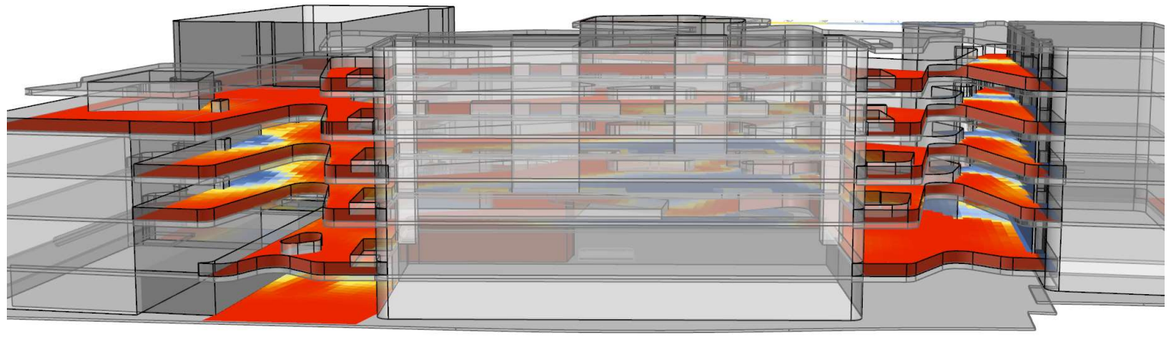


Level 05

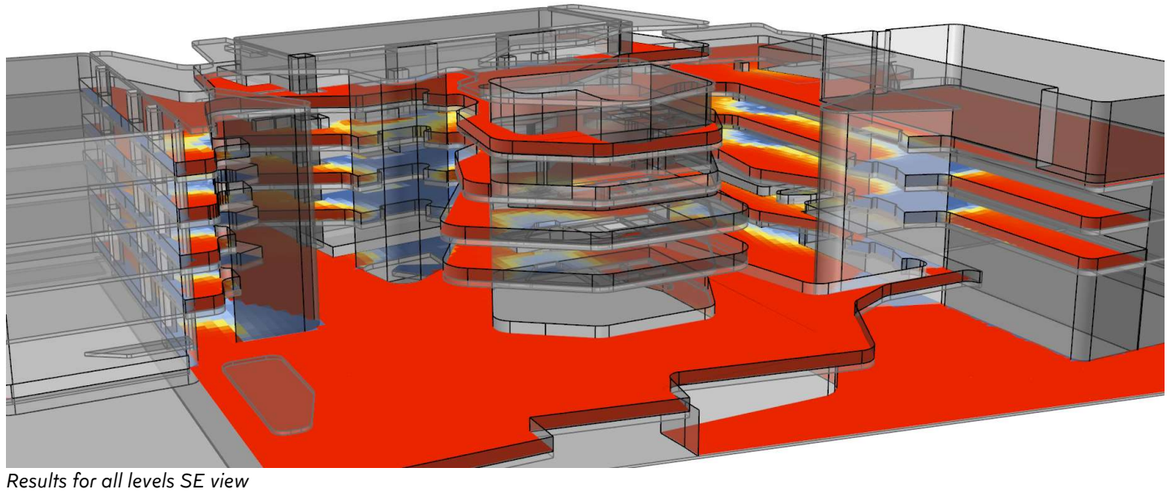


- Red - 400 lux or more for 100% of the time;
- Yellow - 400 lux or more for 50% of the time;
- Blue - less than 400 lux for 100% of the time.

Nominated Floor Area with minimum 400 lux for a minimum 50% of school hours (100mm above FFL):		
1663.33m^2	3062.35m^2	1300.53m^2
68.61%	88.52%	90.39%
Nominated Floor Area with less than 400 lux for 100% of school hours (100mm above FFL):		
267.80m2	208.82m2	63.73m2
16.1%	6.9%	4.9%



Results for all levels NW view



Results for all levels SE view

The engineer in his own way is an artist too - and not just a dead fish with a slide rule.
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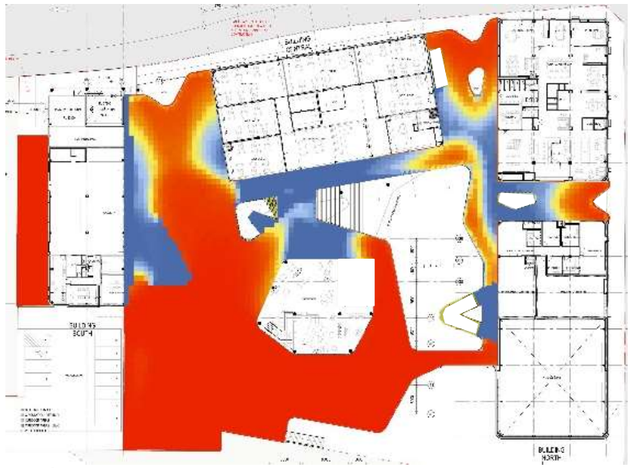
Appendix C – High Lux Levels

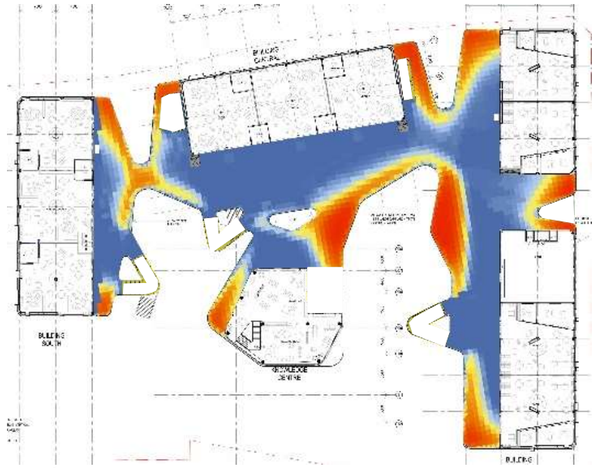
The illustrations below show sDA for 2000 lux. The dark blue colour indicates areas that never receive 2000 lux at any given time. Light blue to red colour indicates the percentage of time when areas receive 2000 lux or more. These areas are likely to be uncomfortable at these times, in terms of glare, heat and other aspects related to exposure to direct sunlight.

It is not recommended to remove any of shading elements, including roofs, due to the direct solar exposure. Climatic conditions in the area predominantly require heat and solar control. Therefore, removal of roof will cause detrimental impact to the usability of the spaces.

Level 00



Level 01



Level 02

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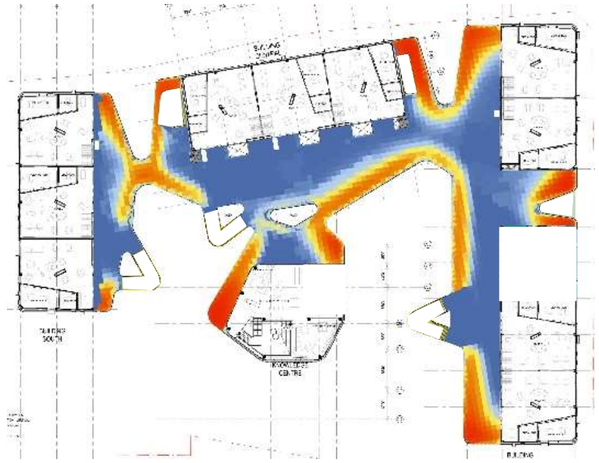
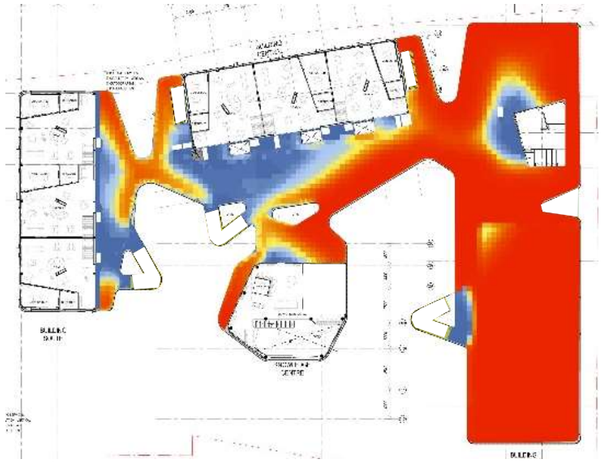
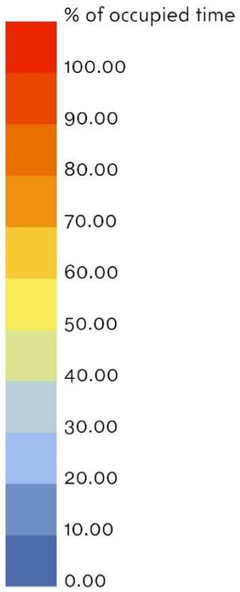


Level 03



Level 04

Level 05



- Red - 2000 lux or more for 100% of the time;
- Yellow - 2000 lux or more for 50% of the time;
- Blue - less than 2000 lux for 100% of the time.