

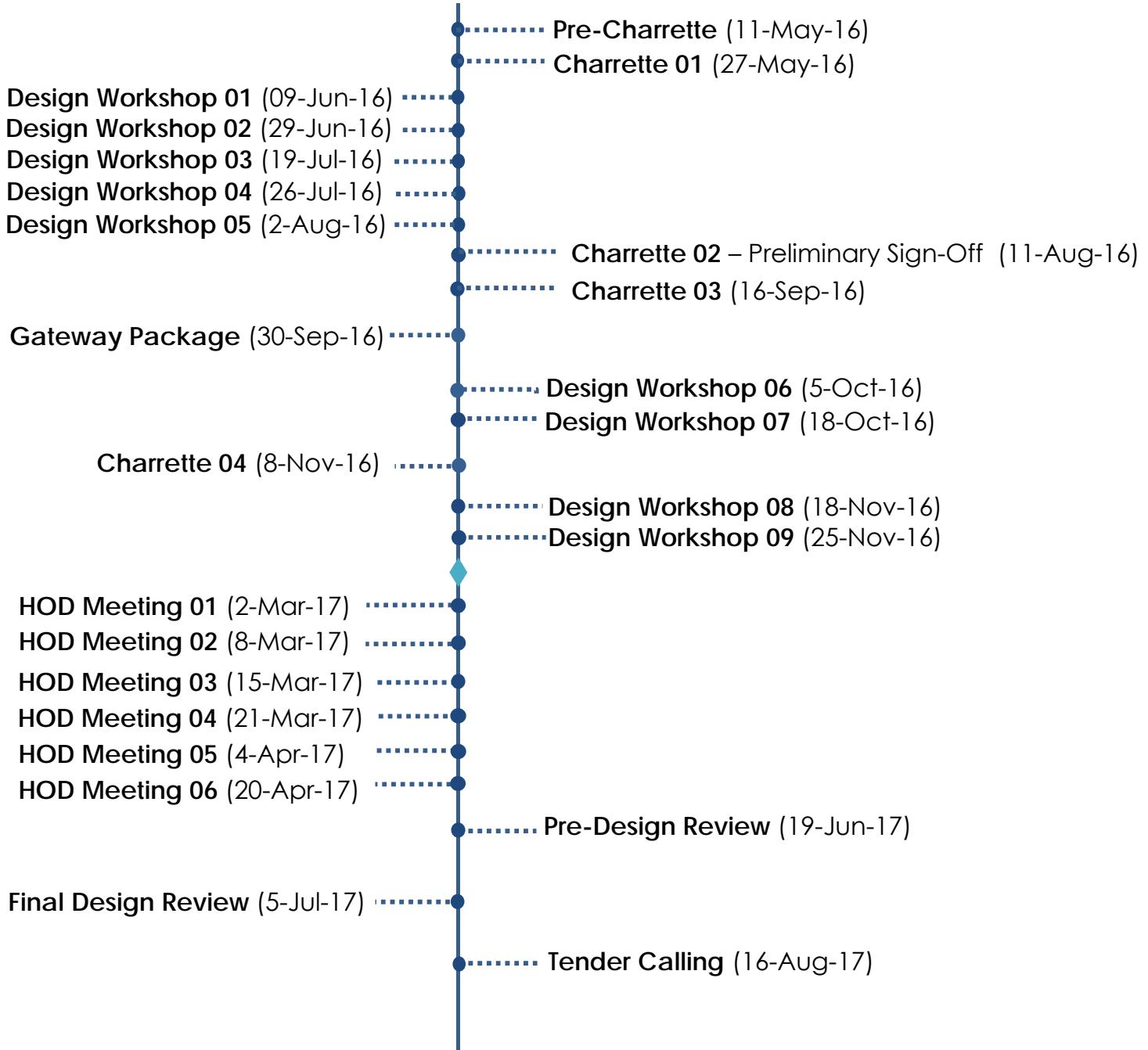


# A&A and Facility Renewal to NUS SDE 3 & 1

Final Design Review with SDE, 19-Jun-17

# SDE Design Values

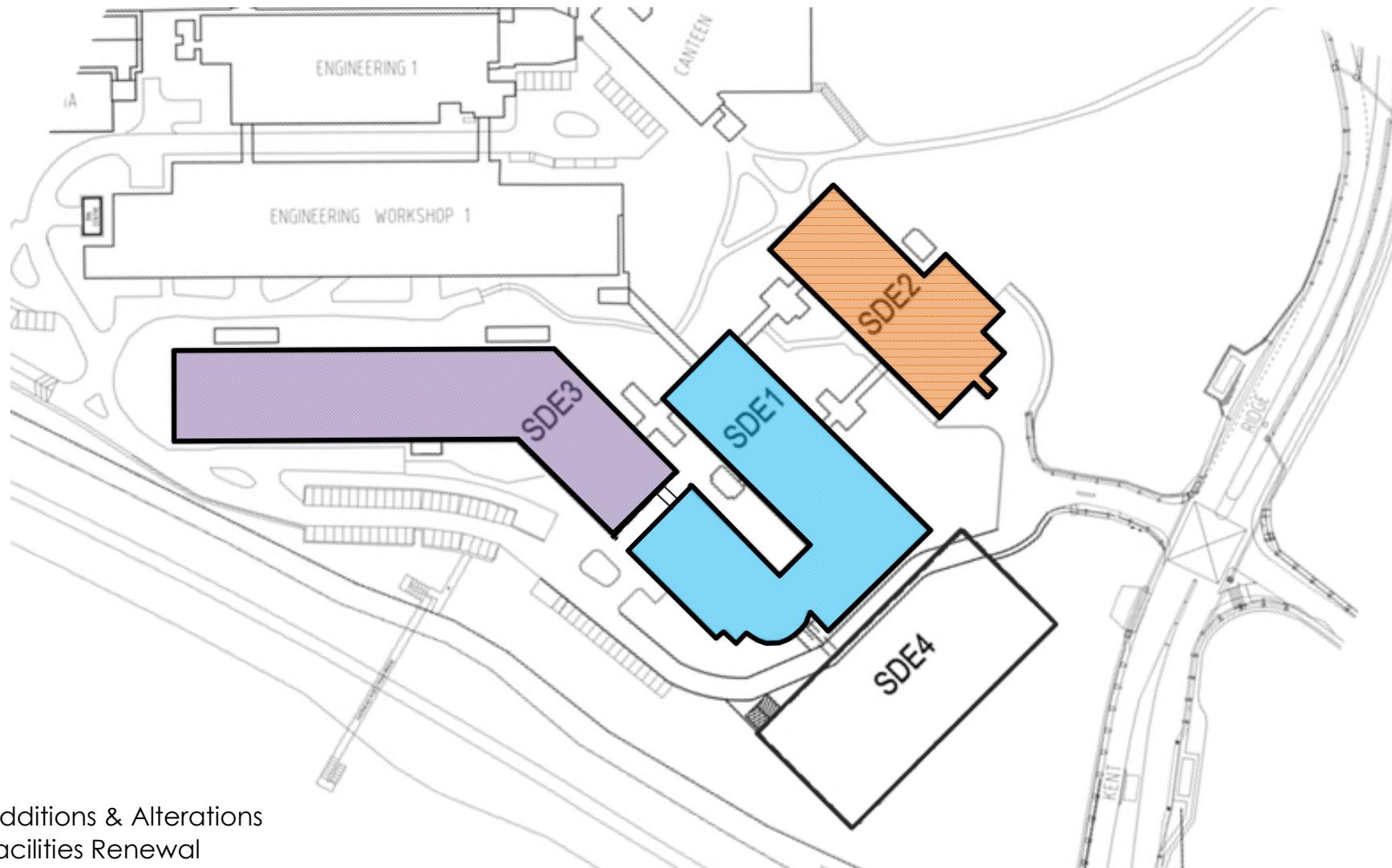
- Symbolic/strategic positioning
- Spatial quality and integration
- Spatial continuity
- Efficient and adaptable space planning
- Pedagogical value
- Material innovation
- Safety
- Schedule



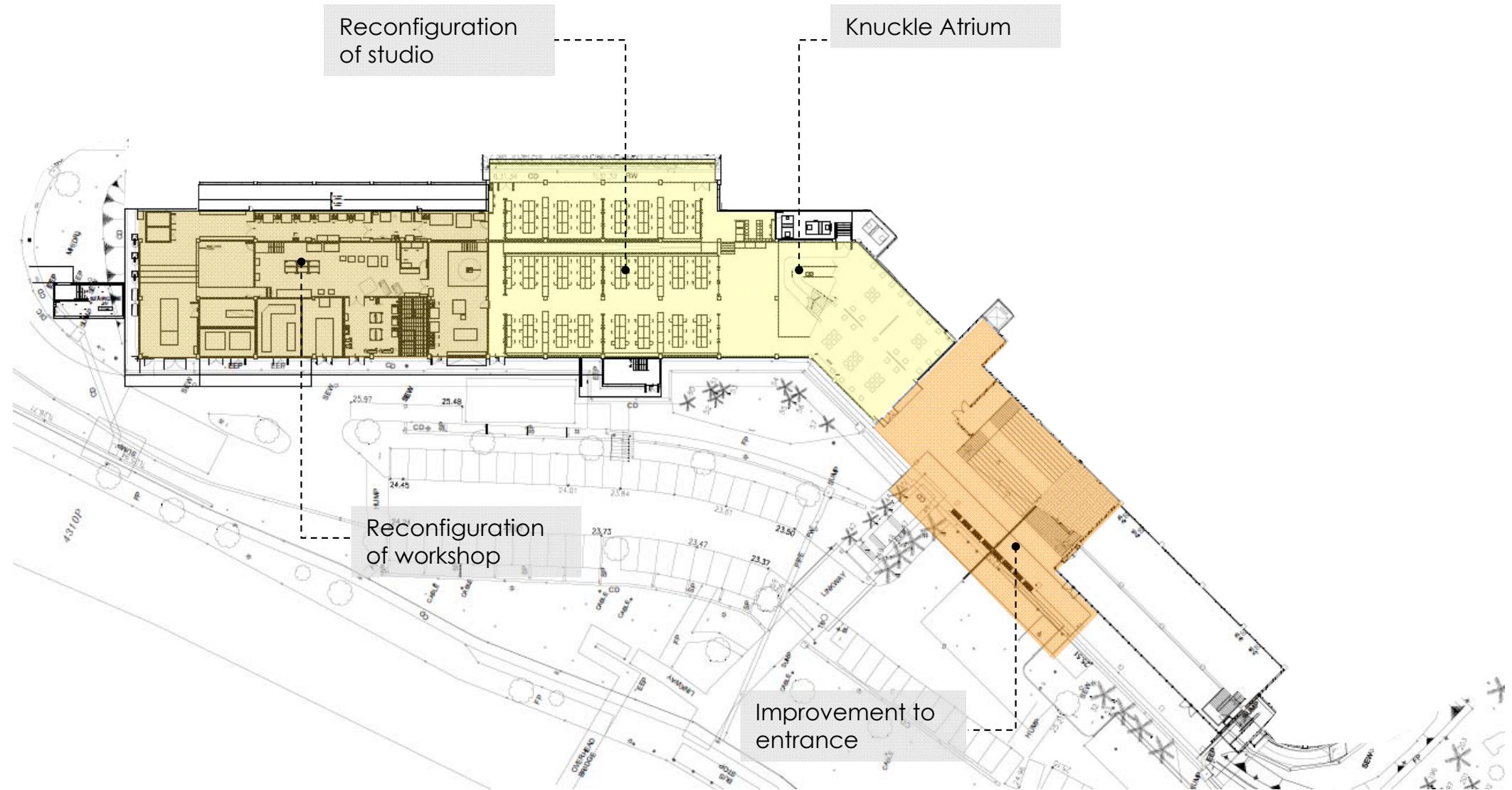
Timeline

# Project Orientation

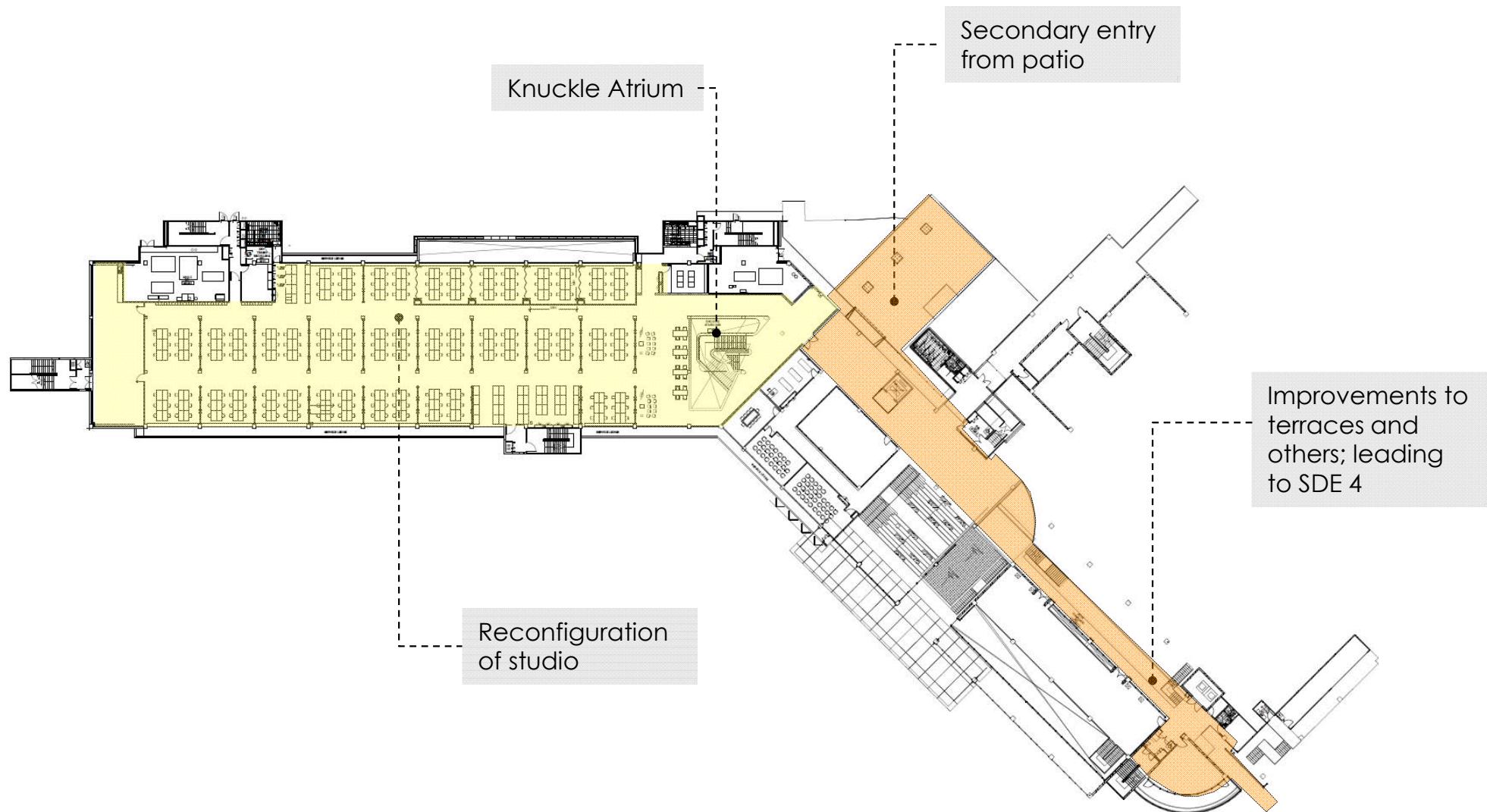
## SDE 3 & 1



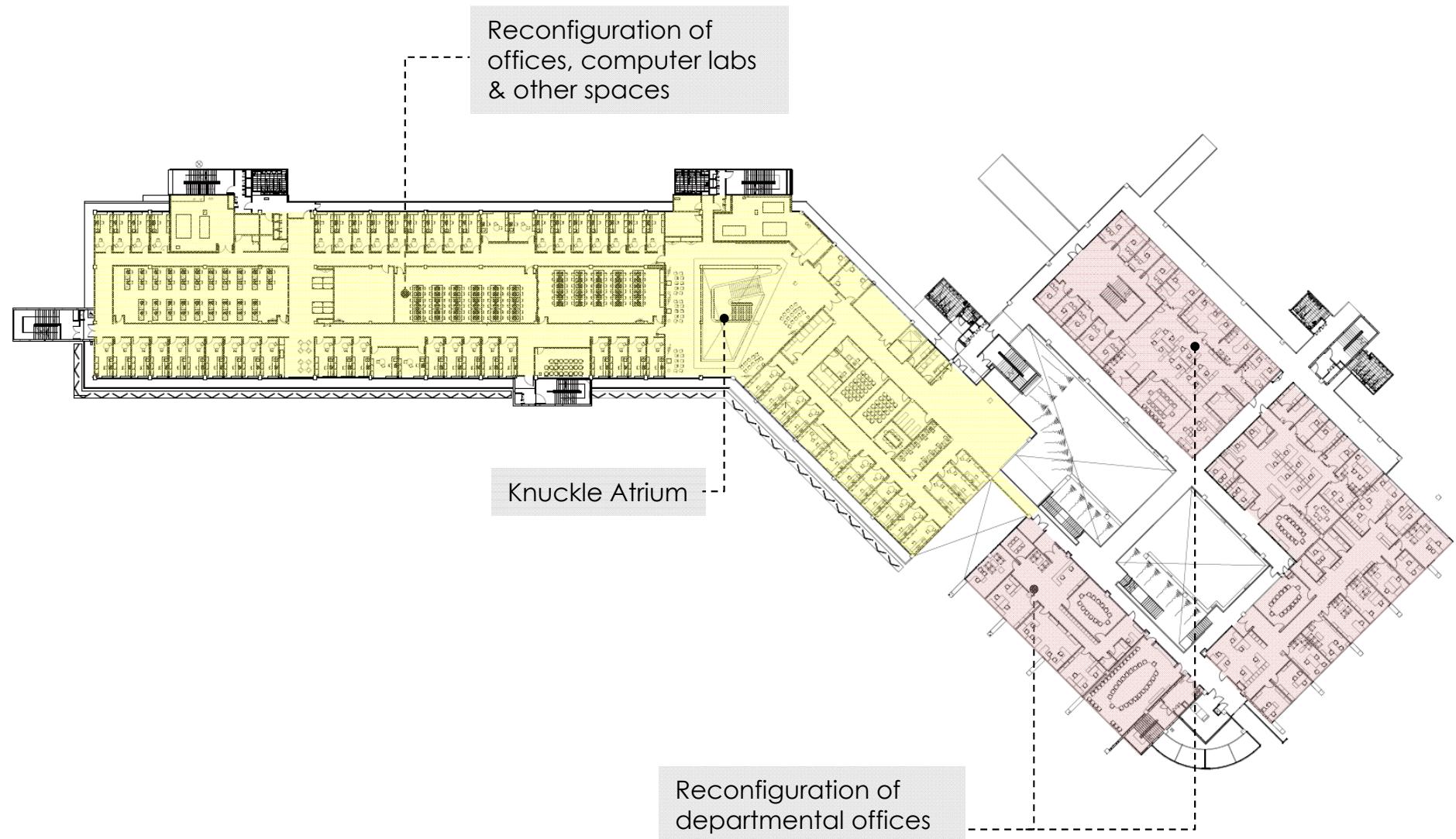
## Overall Key Plan



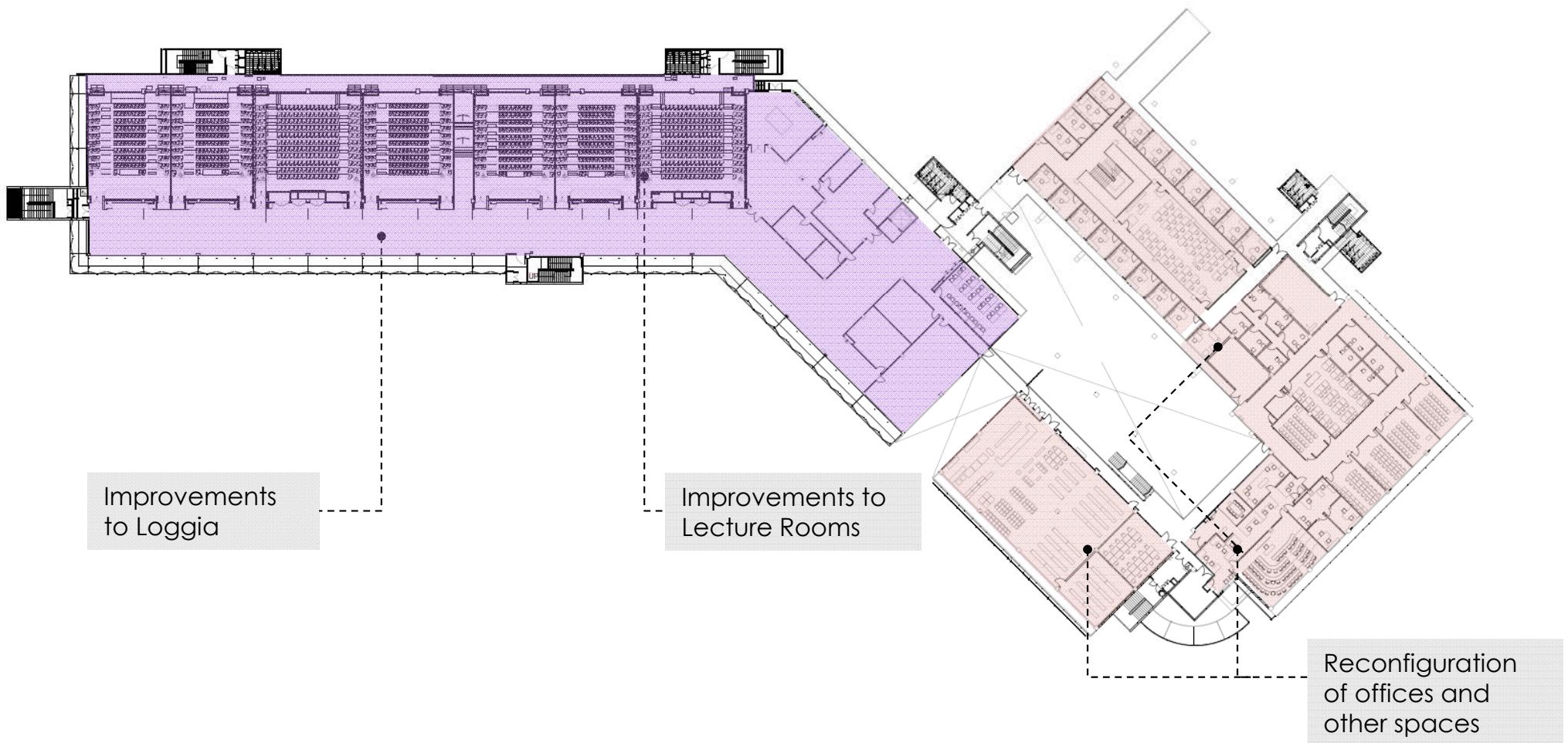
**Level 1**  
Floor Plan



**Level 2**  
Floor Plan

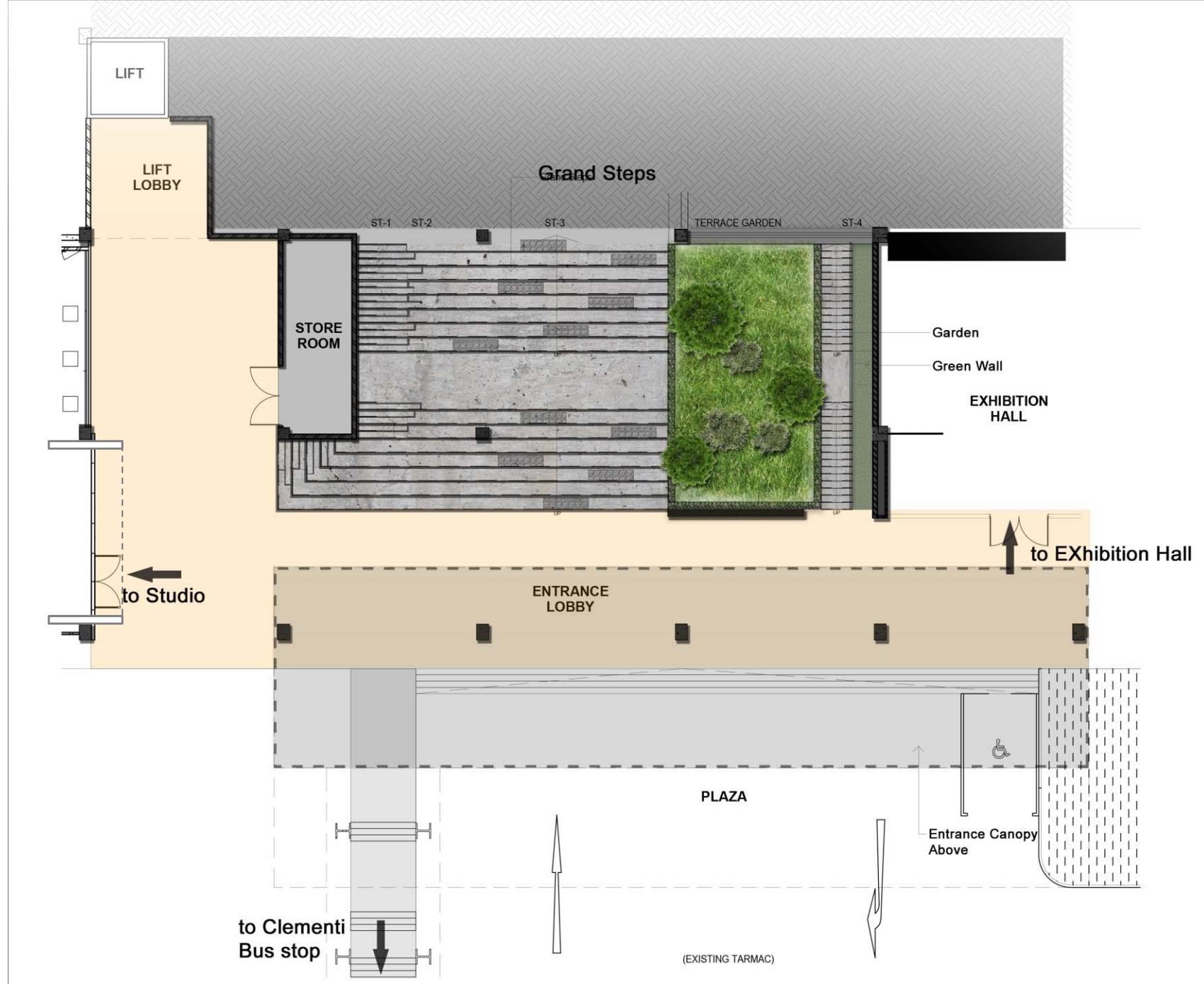


**Level 3**  
Floor Plan



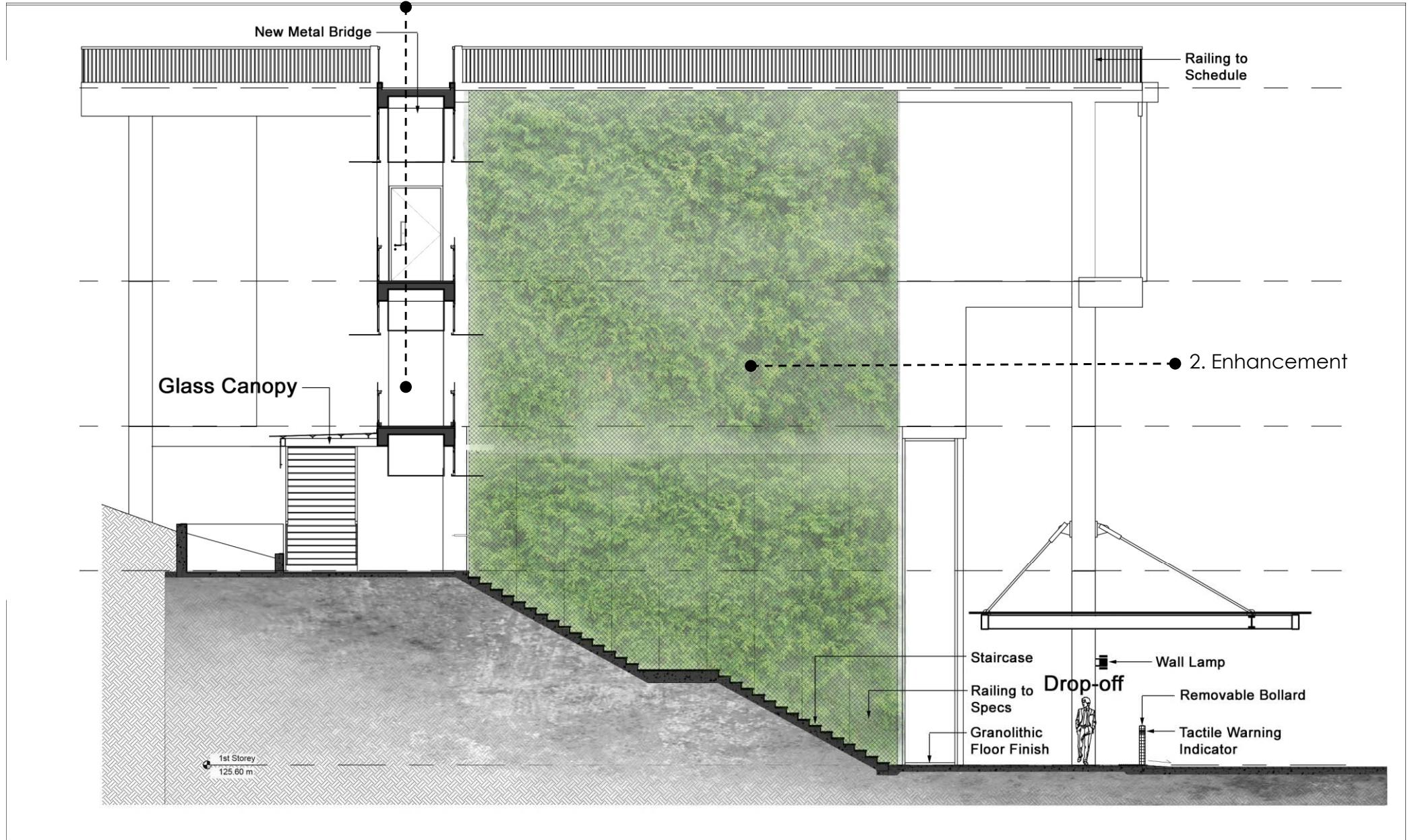
**Level 4**  
Floor Plan

# Entrance

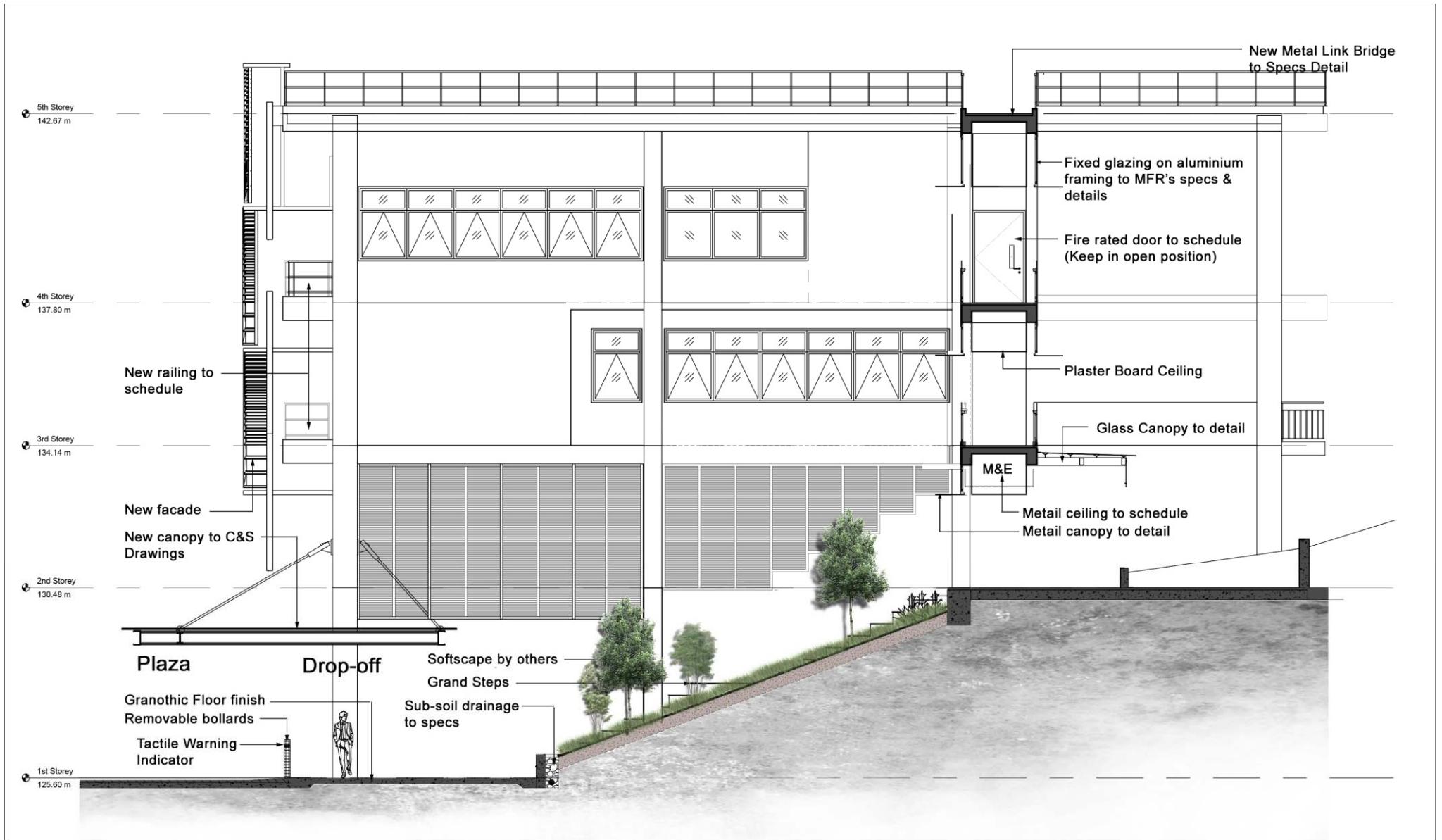


**Entrance**  
Part Plan

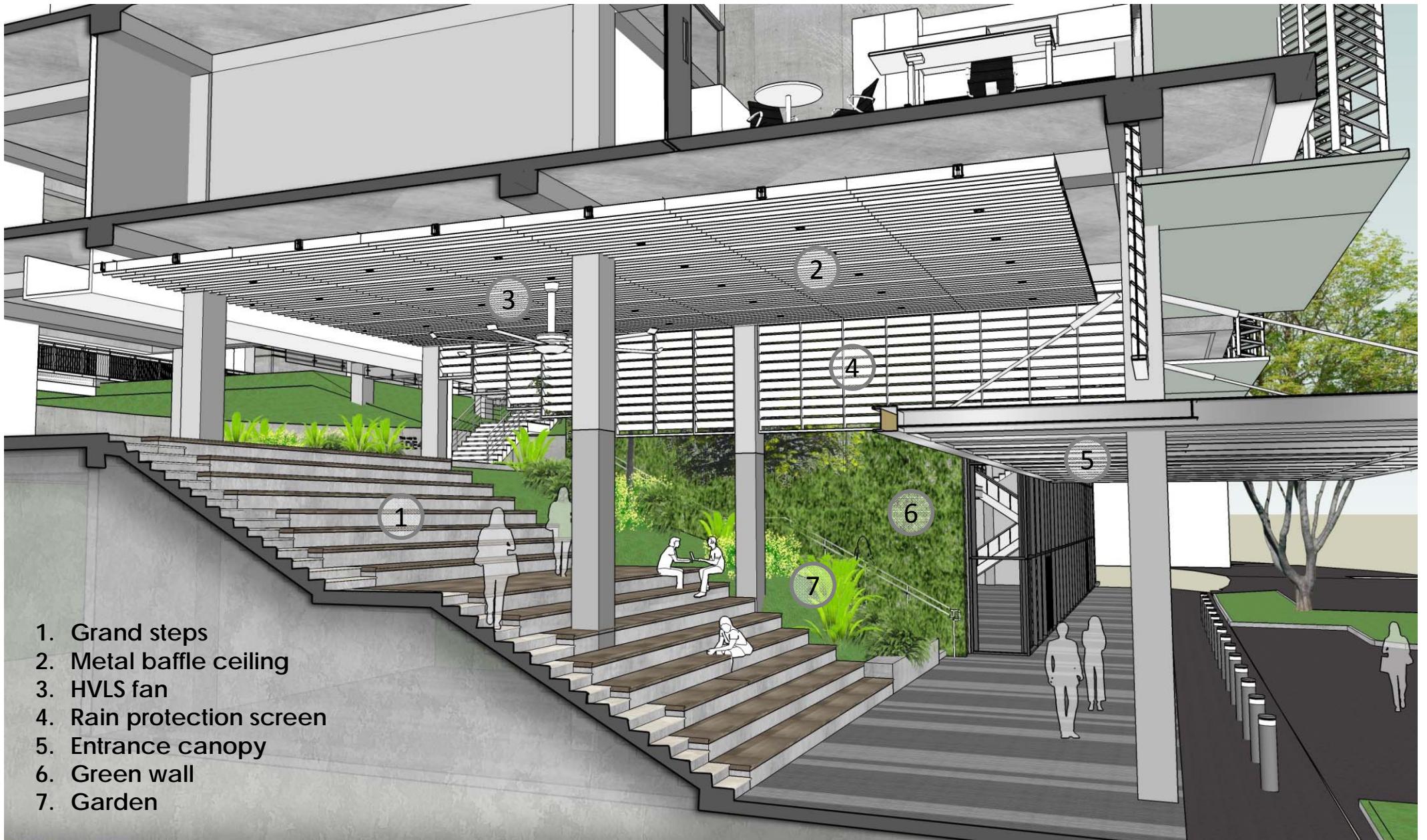
## Linkway @ L3 and L4



**Entrance**  
Section A



**Entrance**  
Section B



1. Grand steps
2. Metal baffle ceiling
3. HVLS fan
4. Rain protection screen
5. Entrance canopy
6. Green wall
7. Garden

## Entrance

View from Grand Steps

## View of entrance from driveway

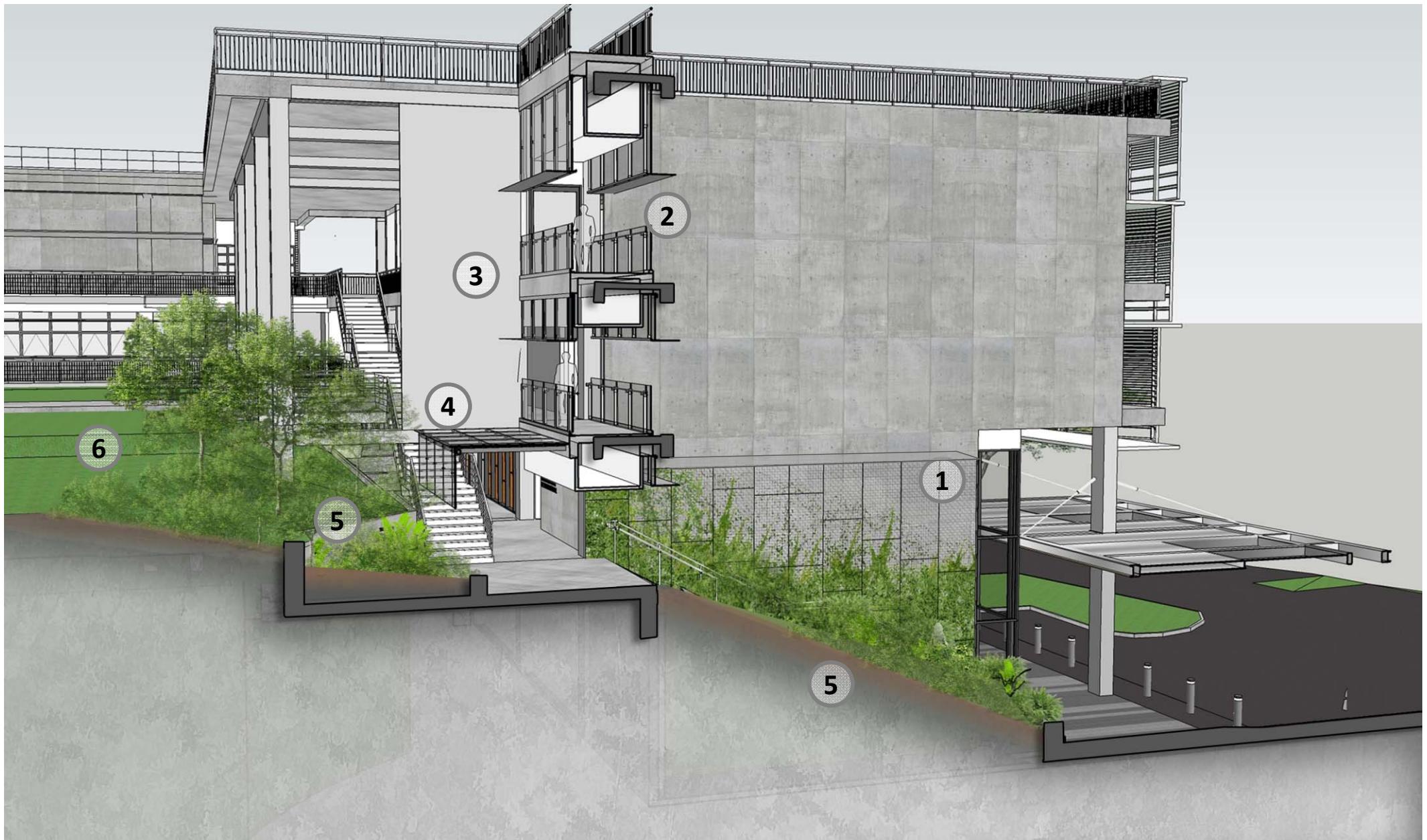


**Entrance  
Section A**

- 1. Entrance Canopy
- 2. Grand steps
- 3. Garden

- 4. Green wall (enhanced)
- 5. Butterfly façade screen
- 6. Butterfly façade screen (enhanced)

- 7. Linkways at L3/L4
- 8. Entry plaza



**Entrance**  
Cross sectional view

1. Green wall (base)
2. Linkways at L3/L4
3. Fire wall / building signage

4. Glass canopy
5. Garden
6. Courtyard



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**Entrance**  
To Knuckle Foyer / Studio

**WIP**

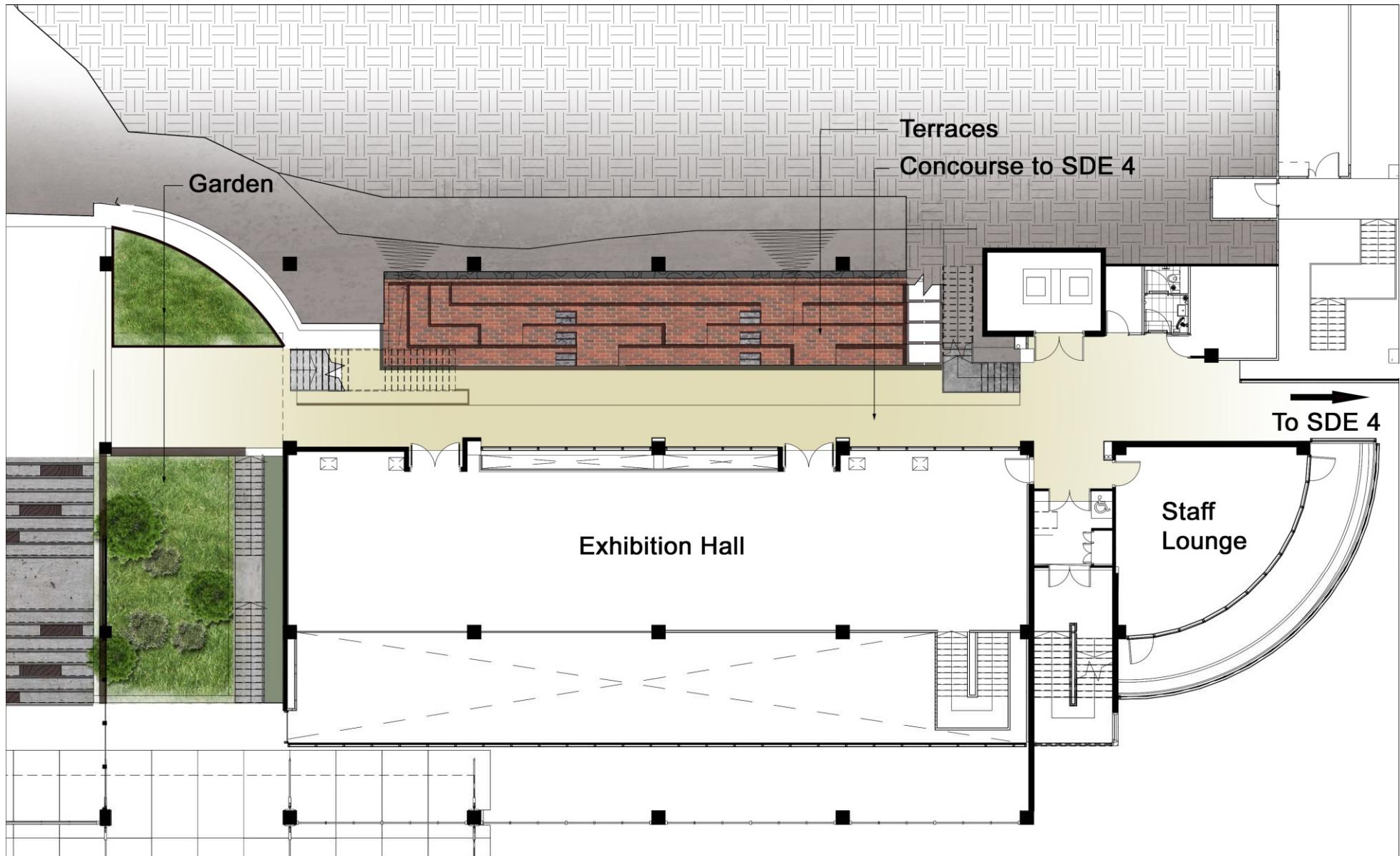
*View to be updated*



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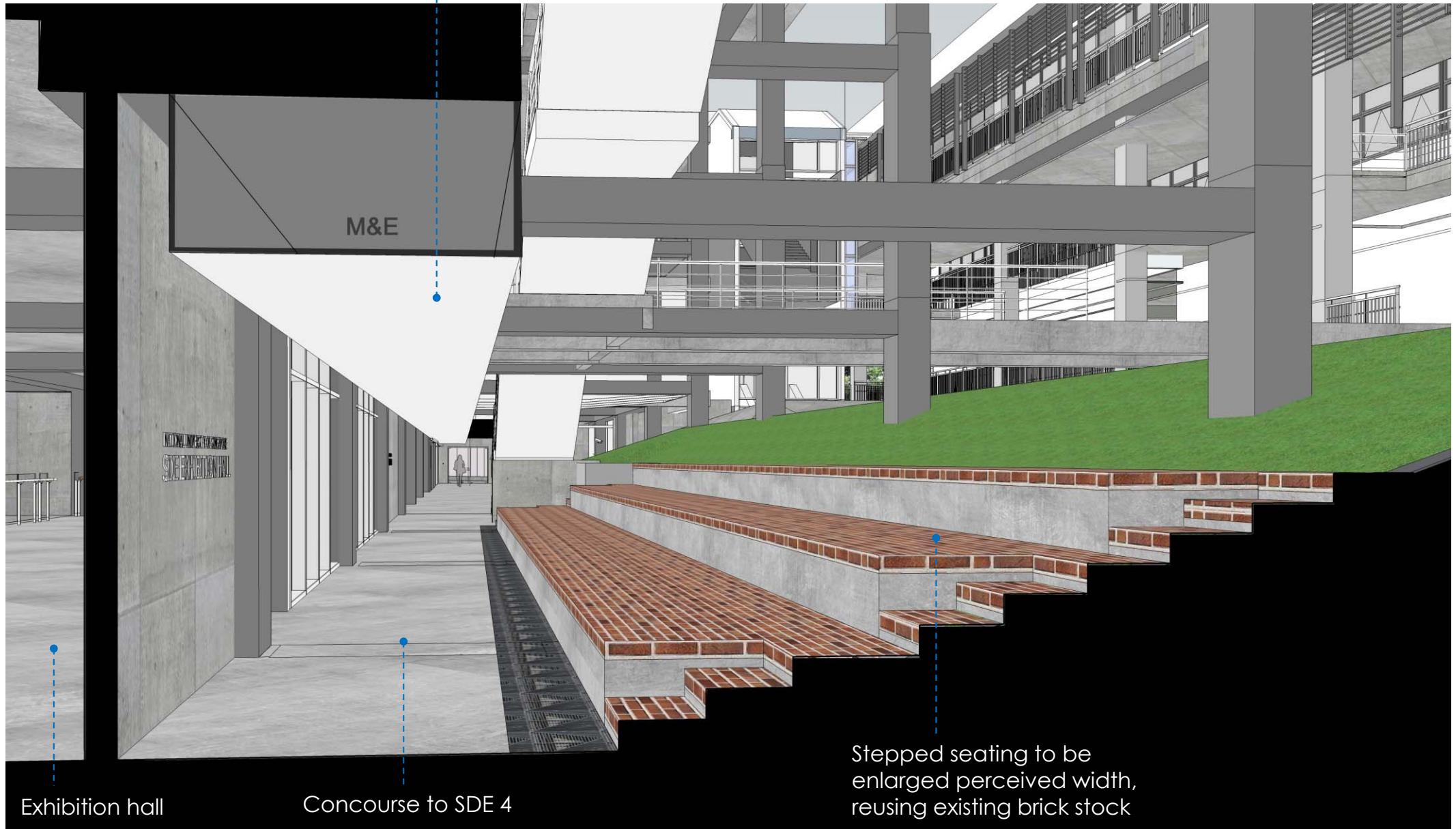
**Entrance**  
To Knuckle Foyer / Studio

# Terraces & Courtyard

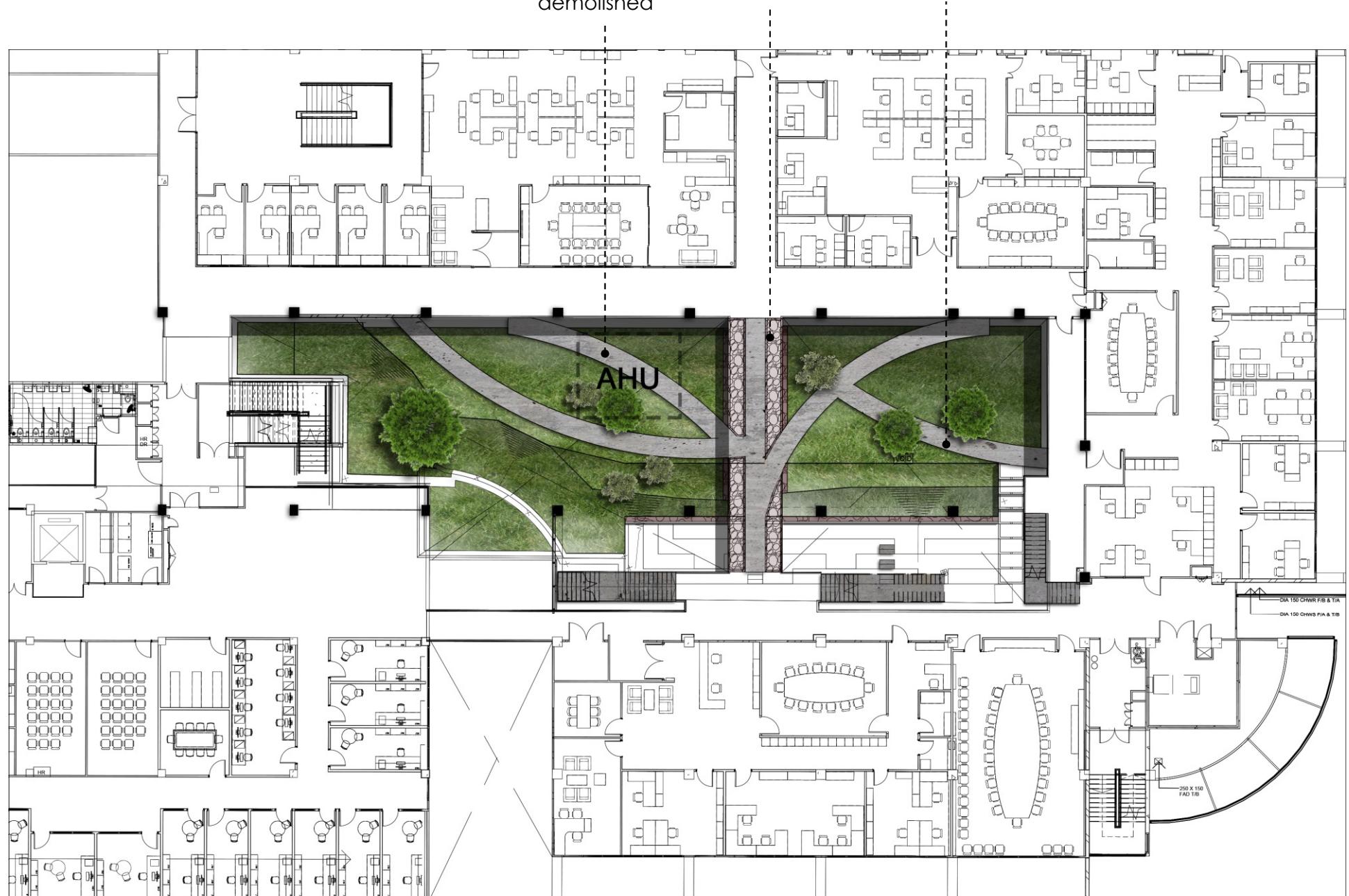


**Concourse @ L2**  
Plan

Painted plaster ceiling board



**Concourse @ L2**  
View

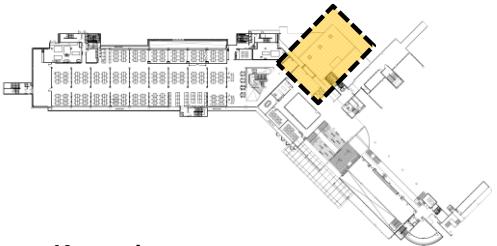


**Courtyard**  
Part Plan

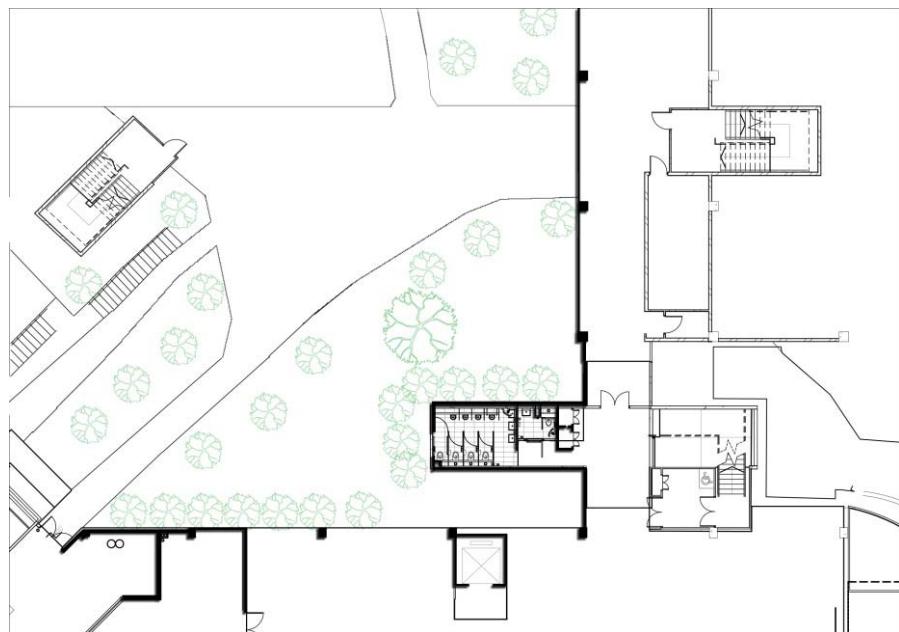


Courtyard  
View

# Patio



Key plan



L2 Part Plan (Existing)



L2 Part Plan (New)

Patio  
Plan

Bodhi tree retained

Entry Portal

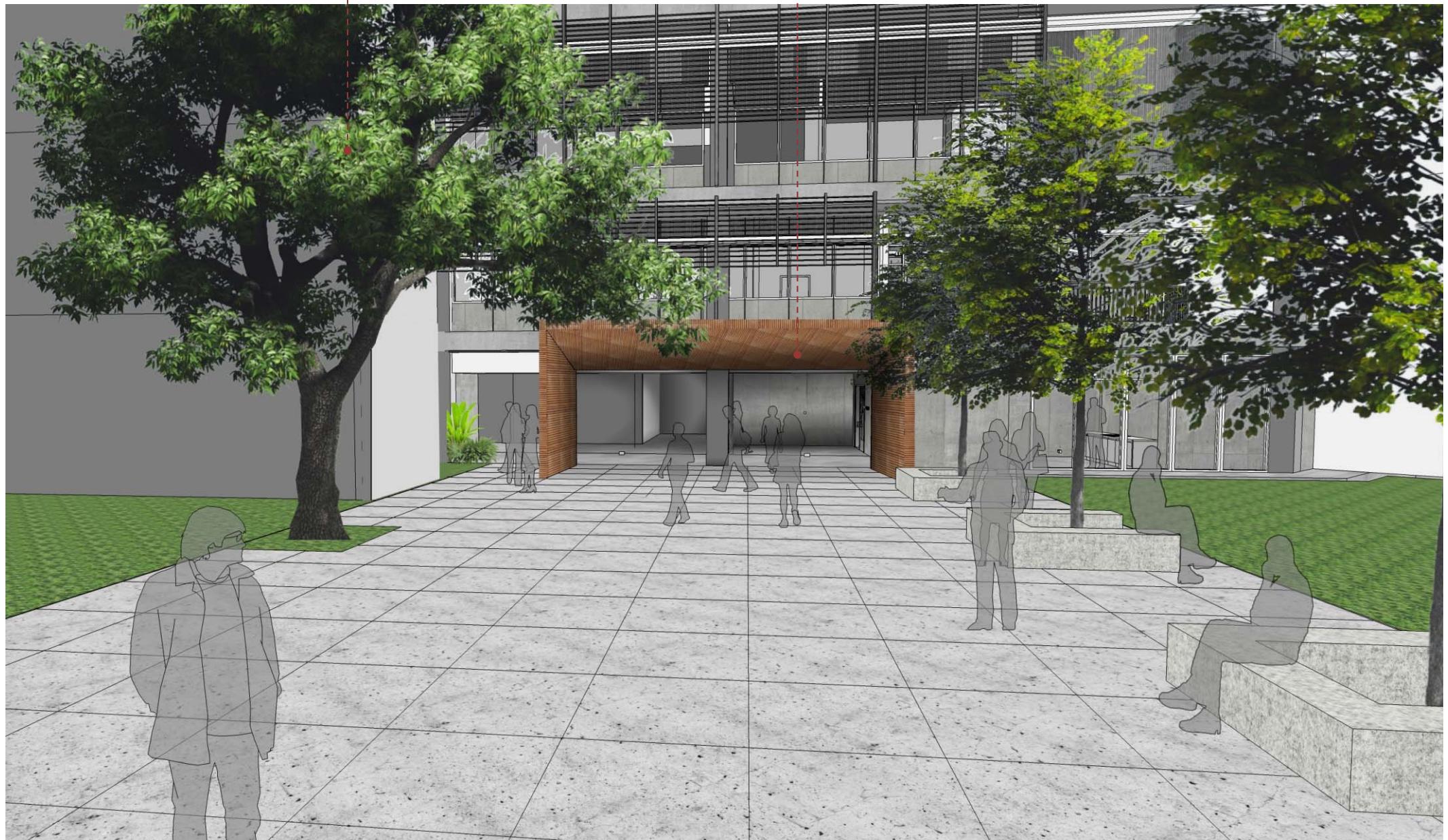


## Patio

Sectional perspective

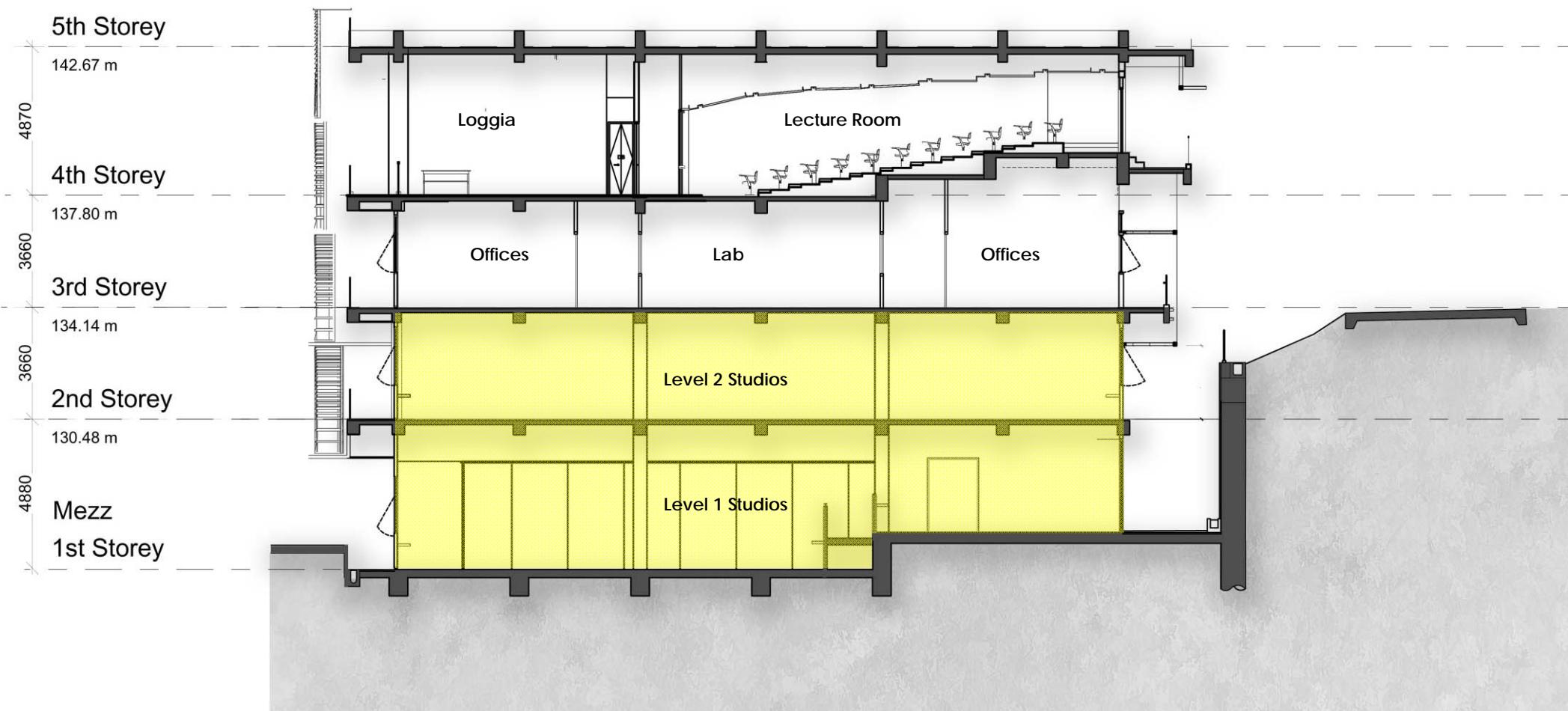
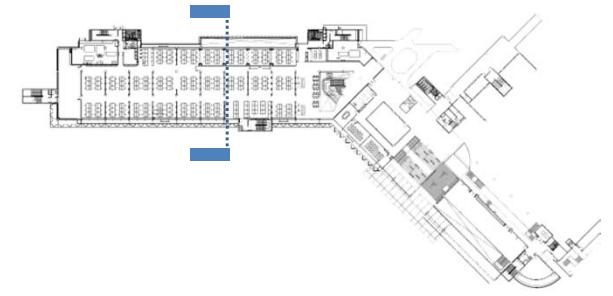
Bodhi tree retained

Entry Portal

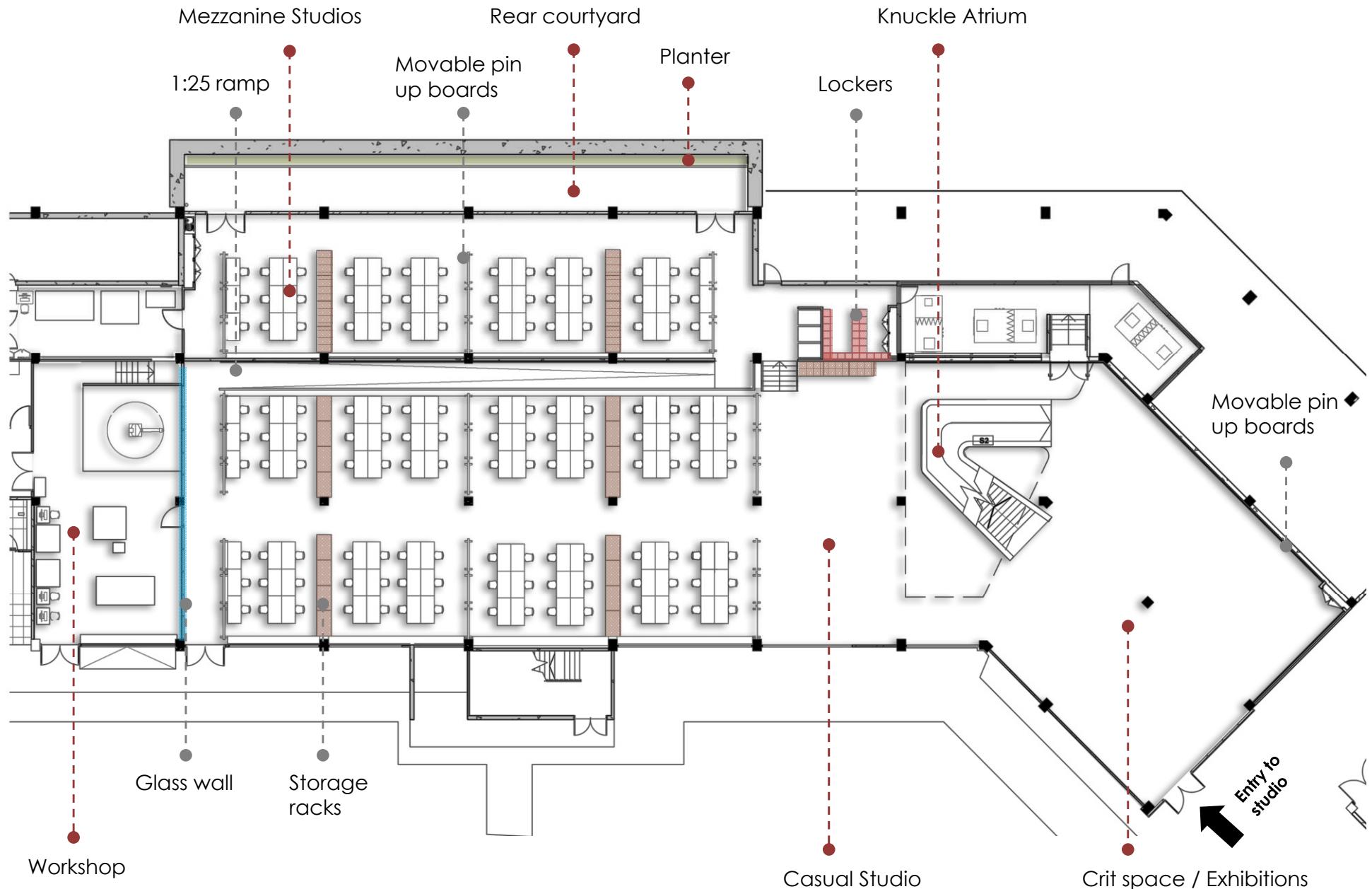


Patio  
View

# Studios



**Studios**  
Cross Section



**Studios**  
Part Plan L1

7 clusters : 12 students  
5 clusters : 9 students

Total clusters : 12  
Total students : 129

Lockers : 108  
Storage racks : 27

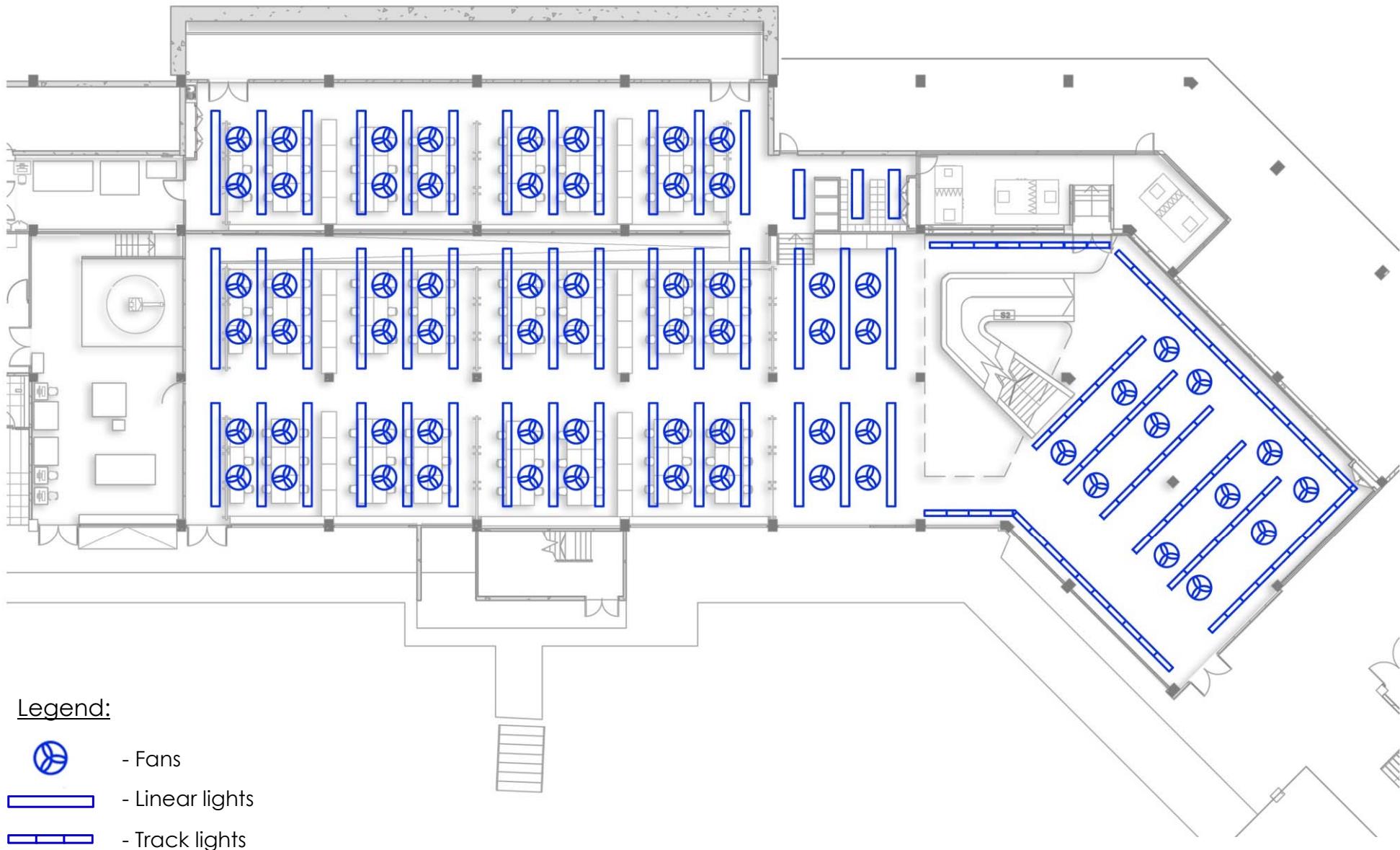


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**Studios**  
Interior

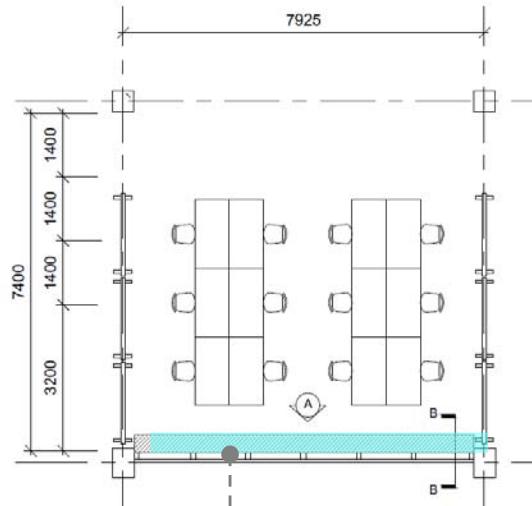


**Studios**  
Rear Courtyard

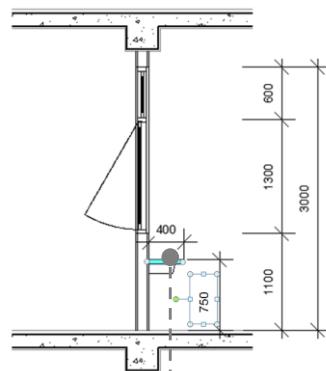


## Studios

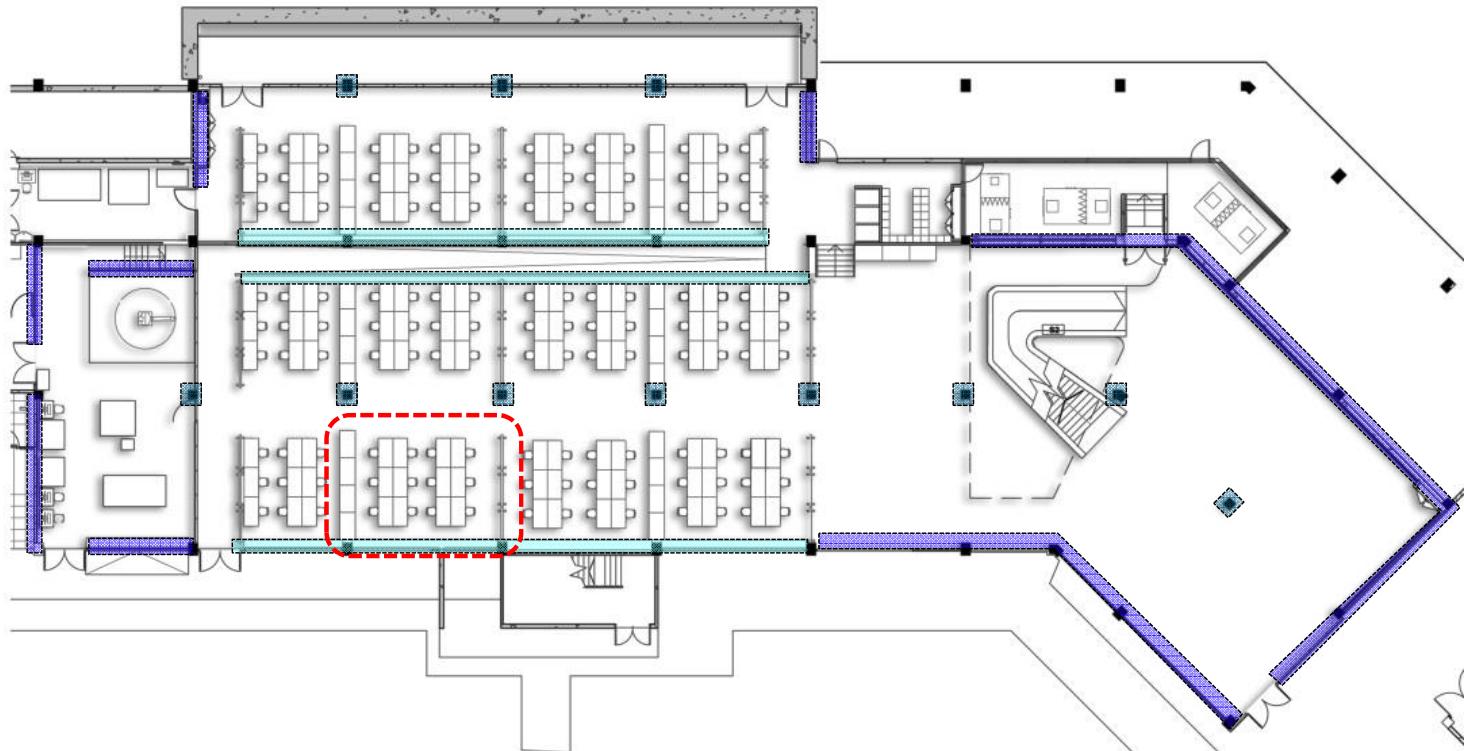
Lights and Fans L1



Wire ledge



Wire ledge

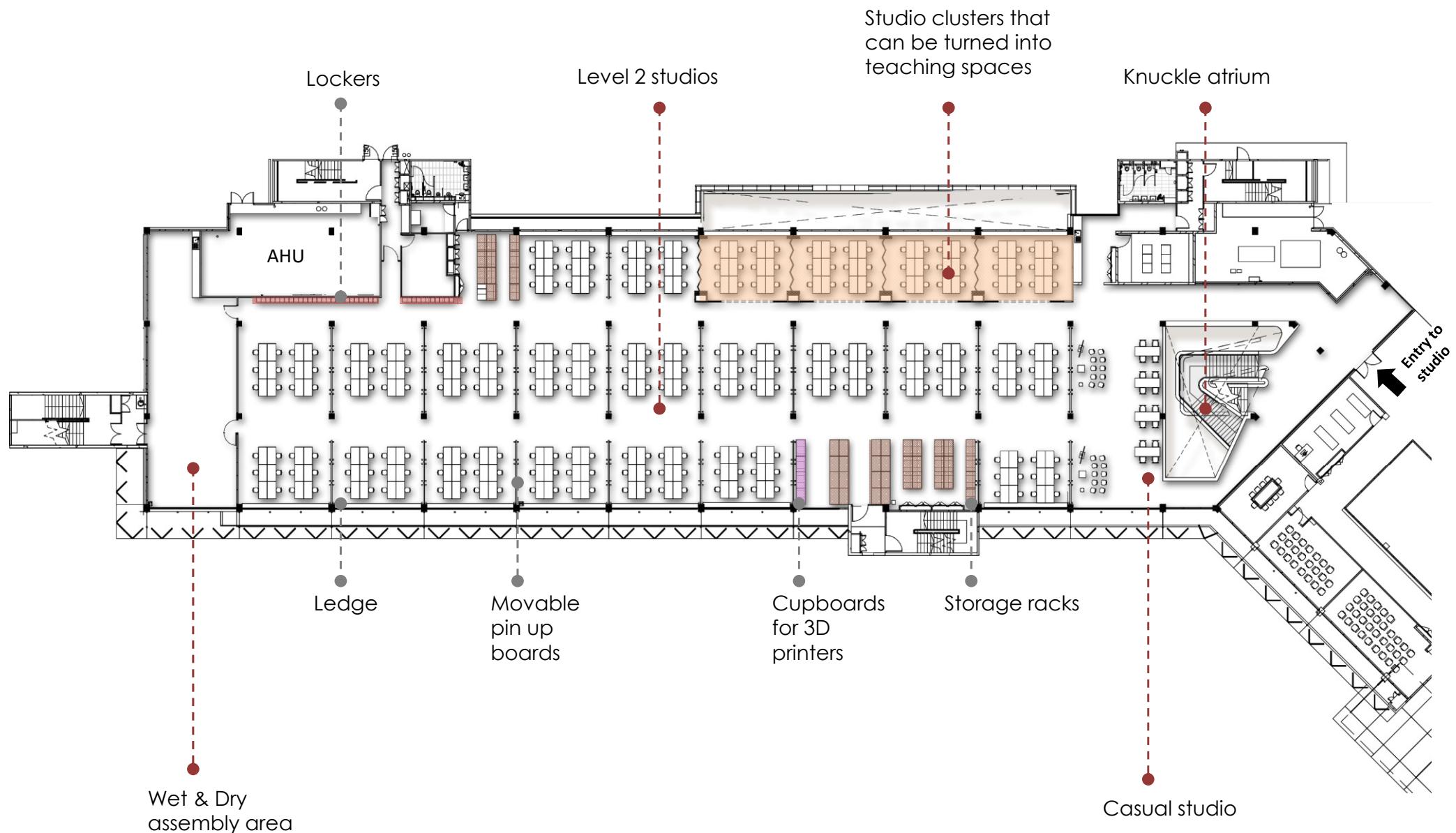


#### Legend:

- [Dark Blue Square] - Outlets at columns
- [Light Blue Square] - Outlets along work ledges
- [Purple Square] - Outlets along walls

## Studios

### Electrical Power Points – L1



**Studios**  
SDE3 L2

**22 clusters : 12 students**  
**Number of students : 264**

**No. of casual studio students : 50**  
**Total number of students : 314**

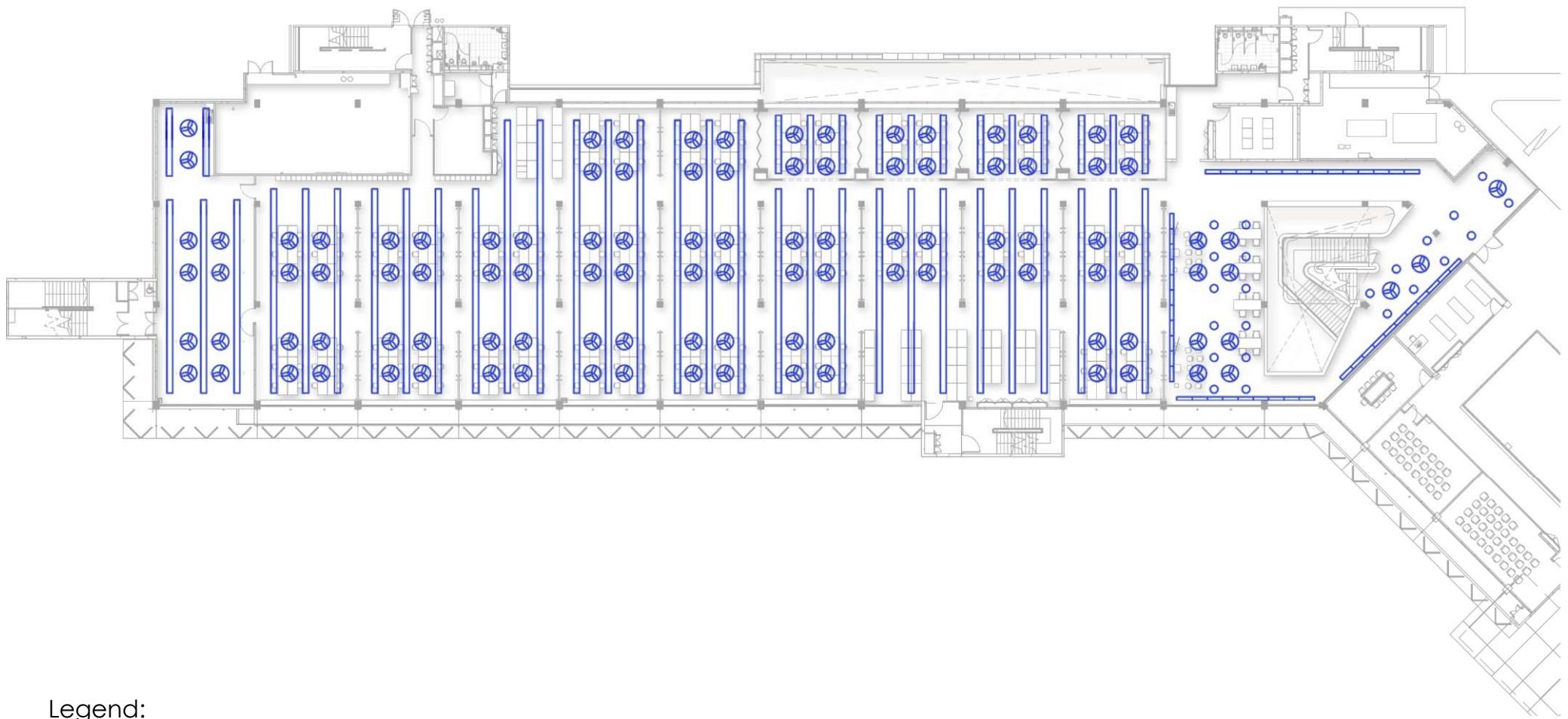
**Lockers : 185**  
**Storage racks : 43**



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## Studios

View of L2 Studio clusters (convertible to teaching spaces)



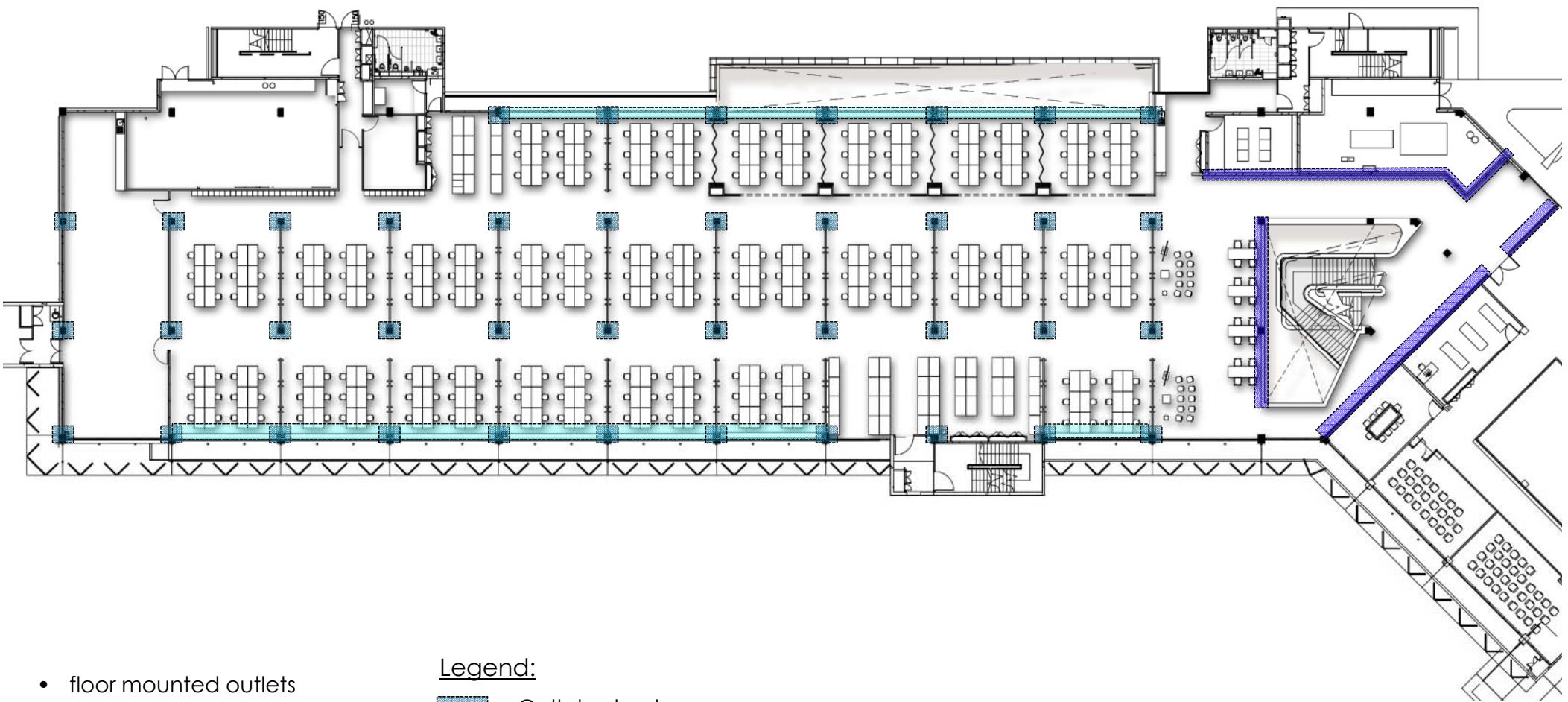
Legend:

-  - Fans
-  - Linear lights
-  - Track lights
-  - Downlights

---

## Studios

Lights & Fans L2



- floor mounted outlets replaced with column/wall mounted electrical outlets. Additional points provided along work ledges.

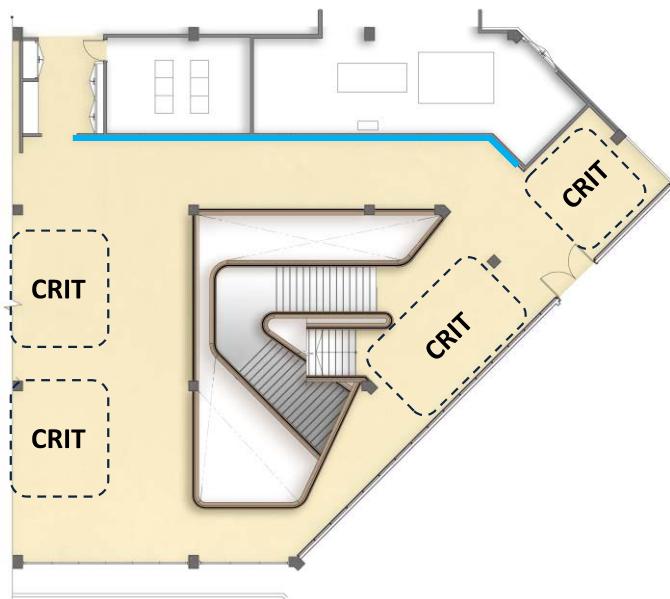
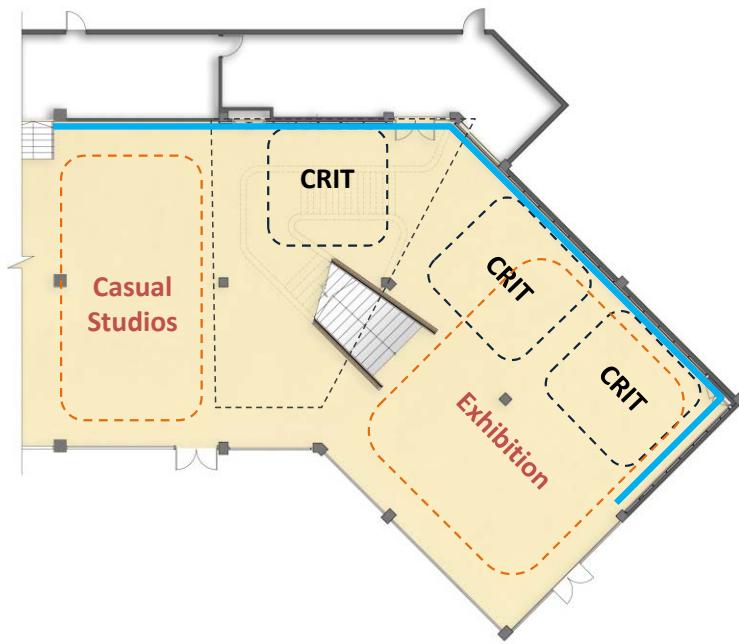
#### Legend:

- [Dotted Pattern] - Outlets at columns
- [Solid Light Blue] - Outlets along work ledges
- [Solid Dark Blue] - Outlets along walls

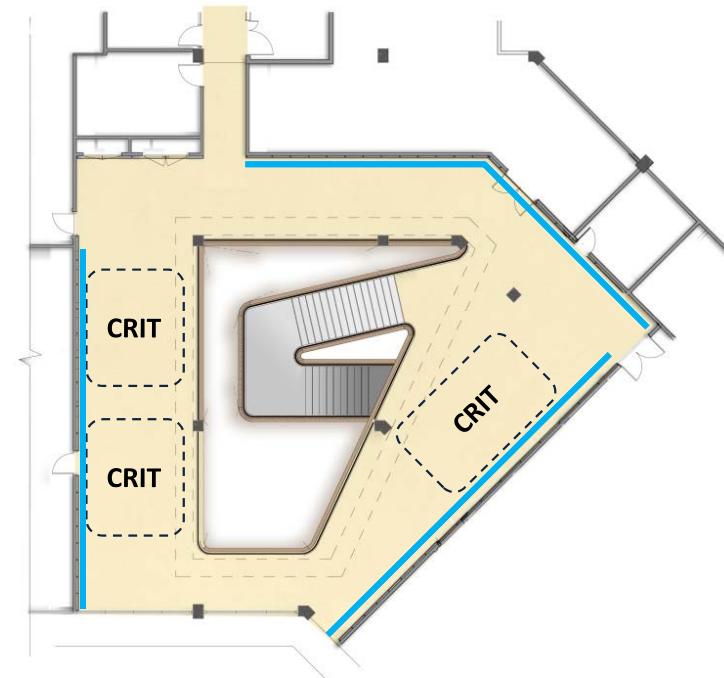
## Studios

Electrical power points - L2

Knuckle Foyer



L3



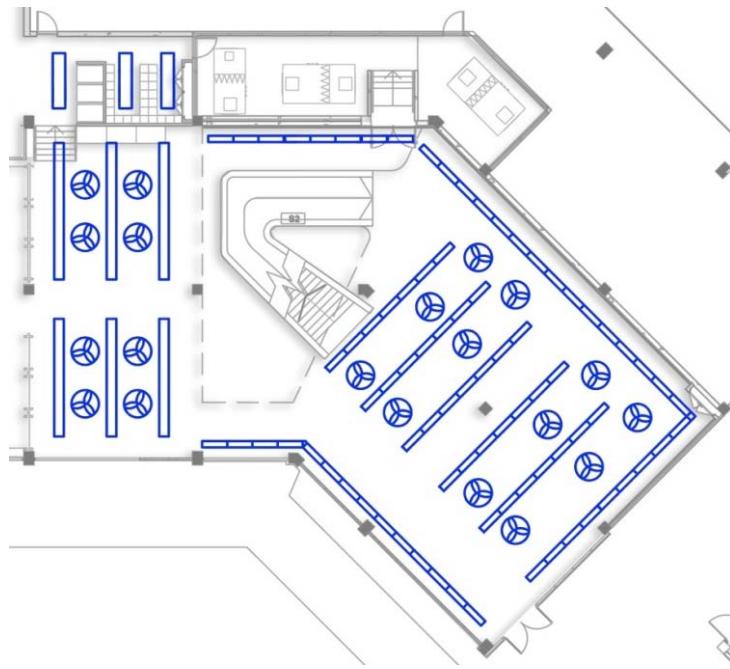
**Knuckle Foyer**  
Plans (L1, L2, L3)

— Wall display



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**Knuckle Foyer**  
Sectional Perspective

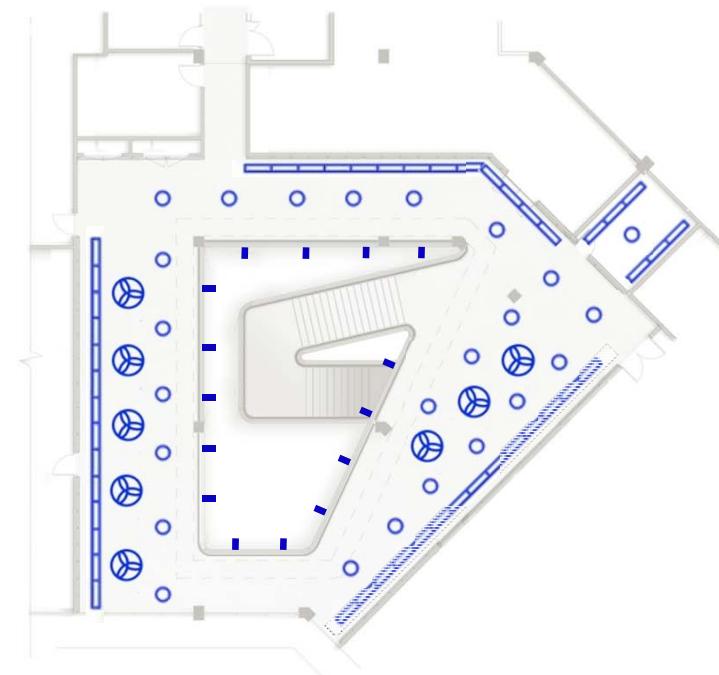


L1



L2

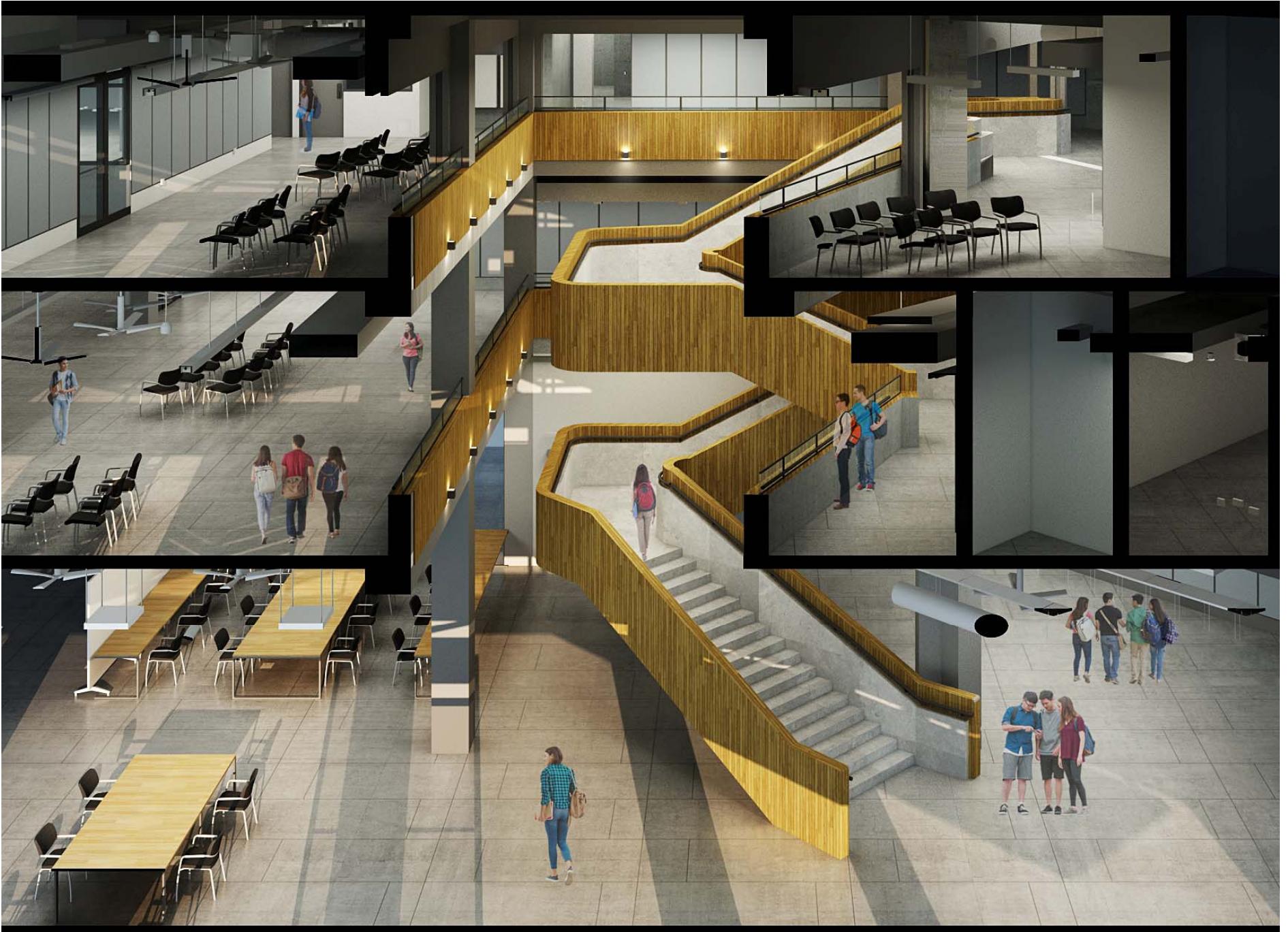
L3



**Knuckle Foyer**  
Lights and Fans

Legend:

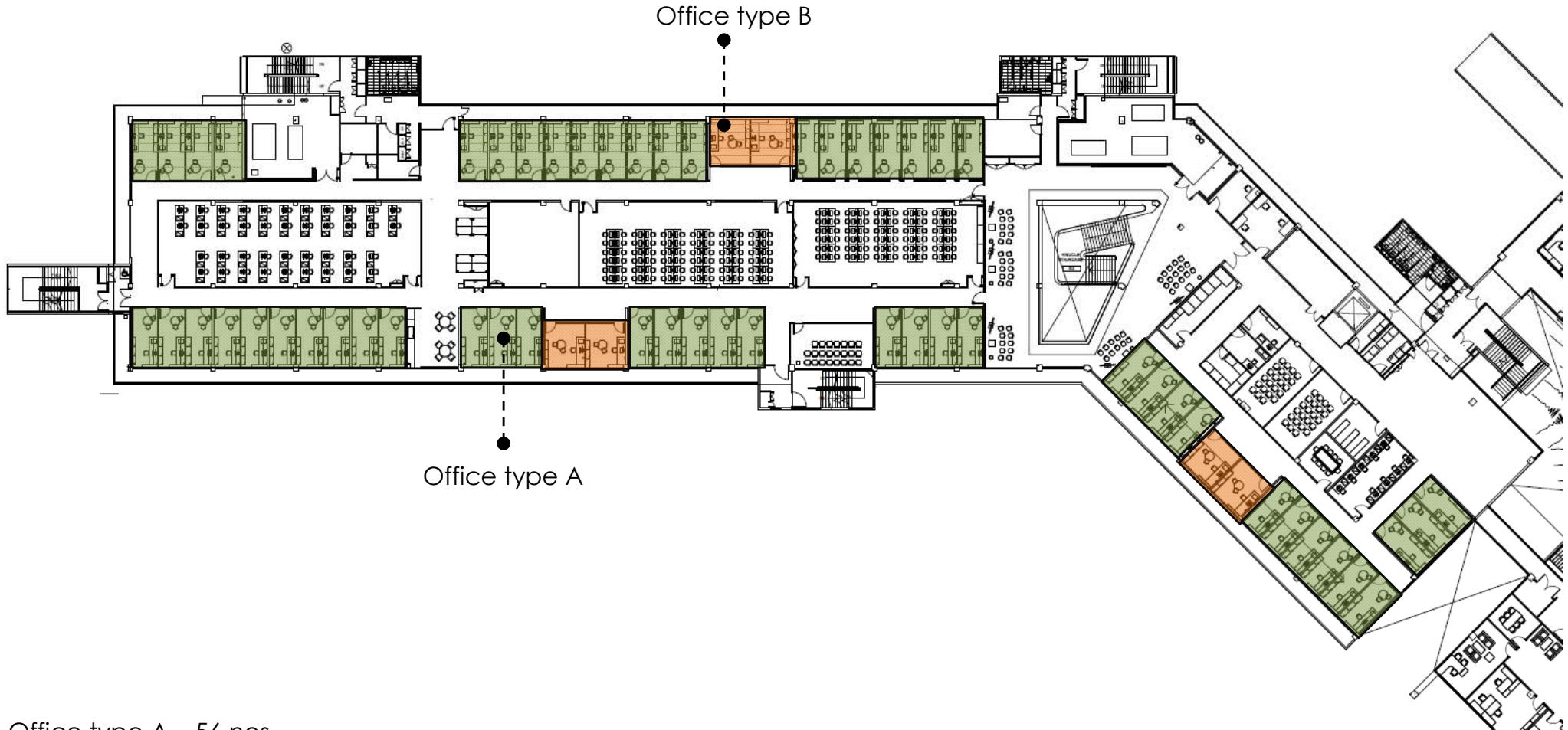
-  - Fans
-  - Linear lights
-  - Track lights
-  - Downlights
-  - Knuckle atrium light



**Knuckle Foyer**  
View

**Offices @ L3**

# Offices @ L3

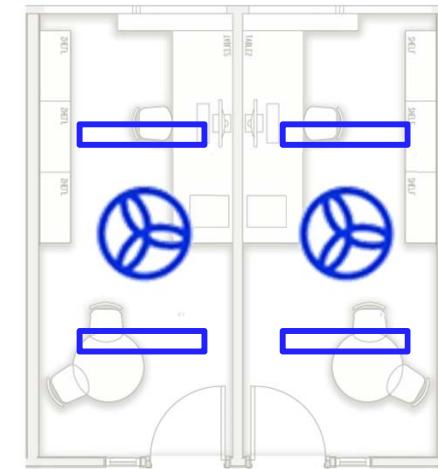
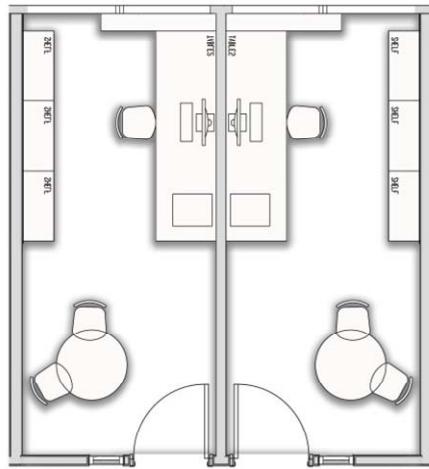


**L3 OFFICES**  
SDE3 L3

## Office Type 1

Plan

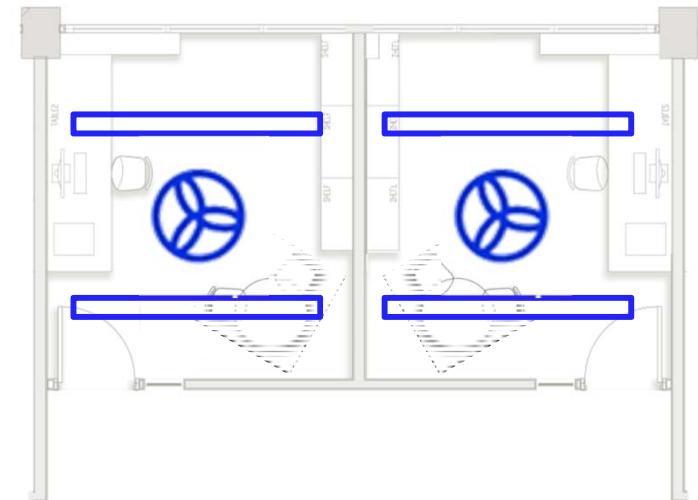
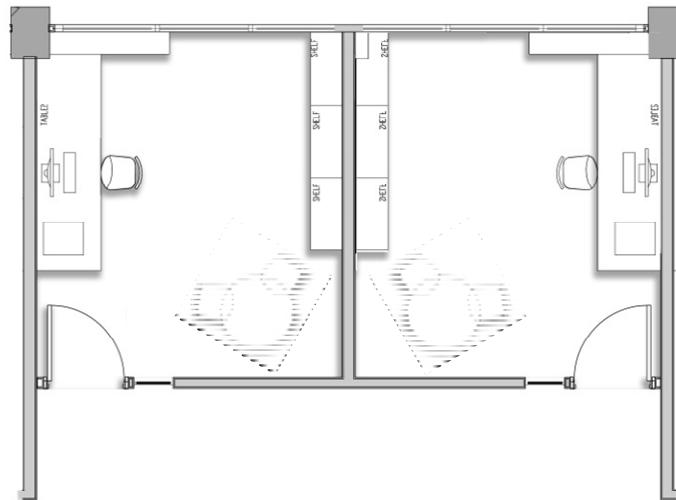
RCP



## Office Type 2

Plan

RCP

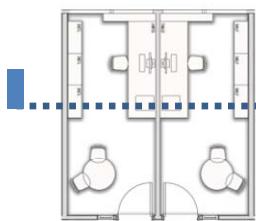


**L3 OFFICES**  
Type 1 & 2

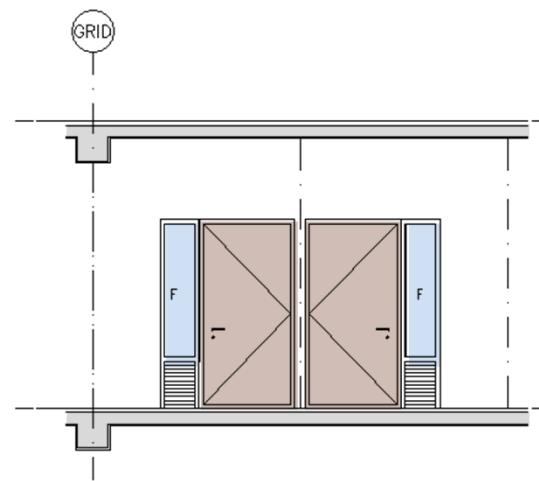
Legend:



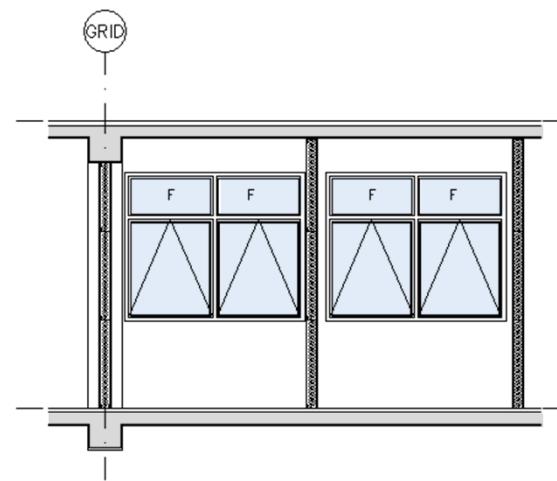
- Fans
- Linear lights



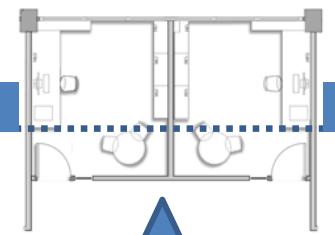
Type 1



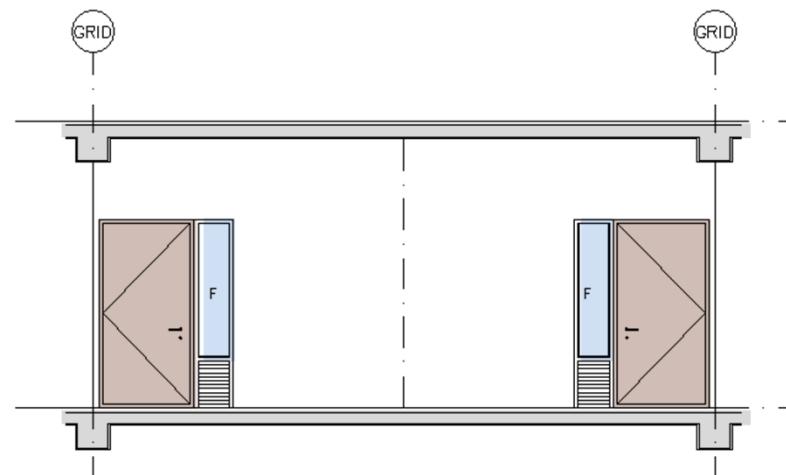
Elevation (from corridor)



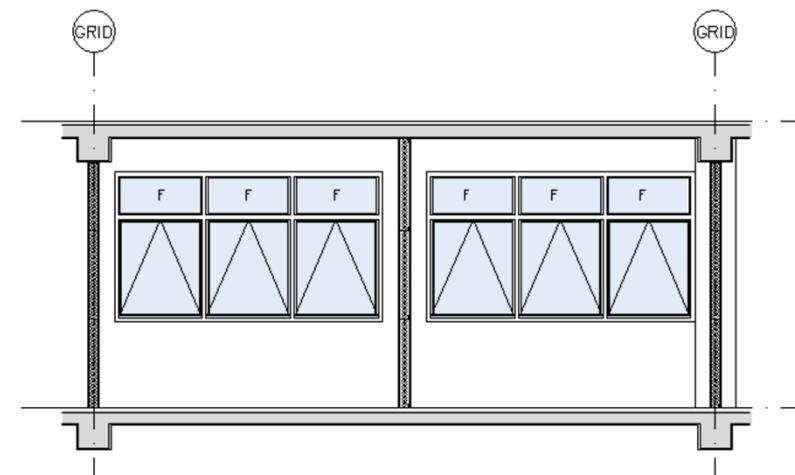
Section



Type 2

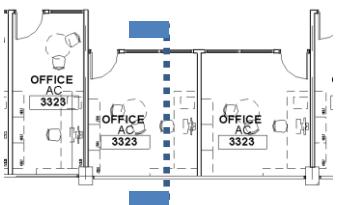


Elevation (from corridor)



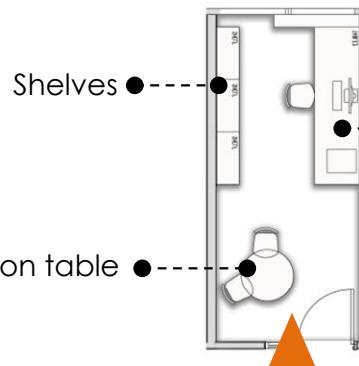
Section

**L3 OFFICES**  
Type 1 & 2

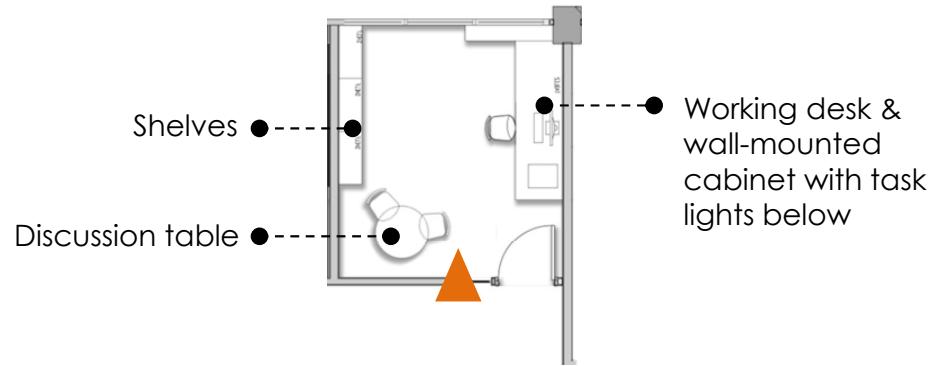


**L3 OFFICES**  
Sectional Perspective

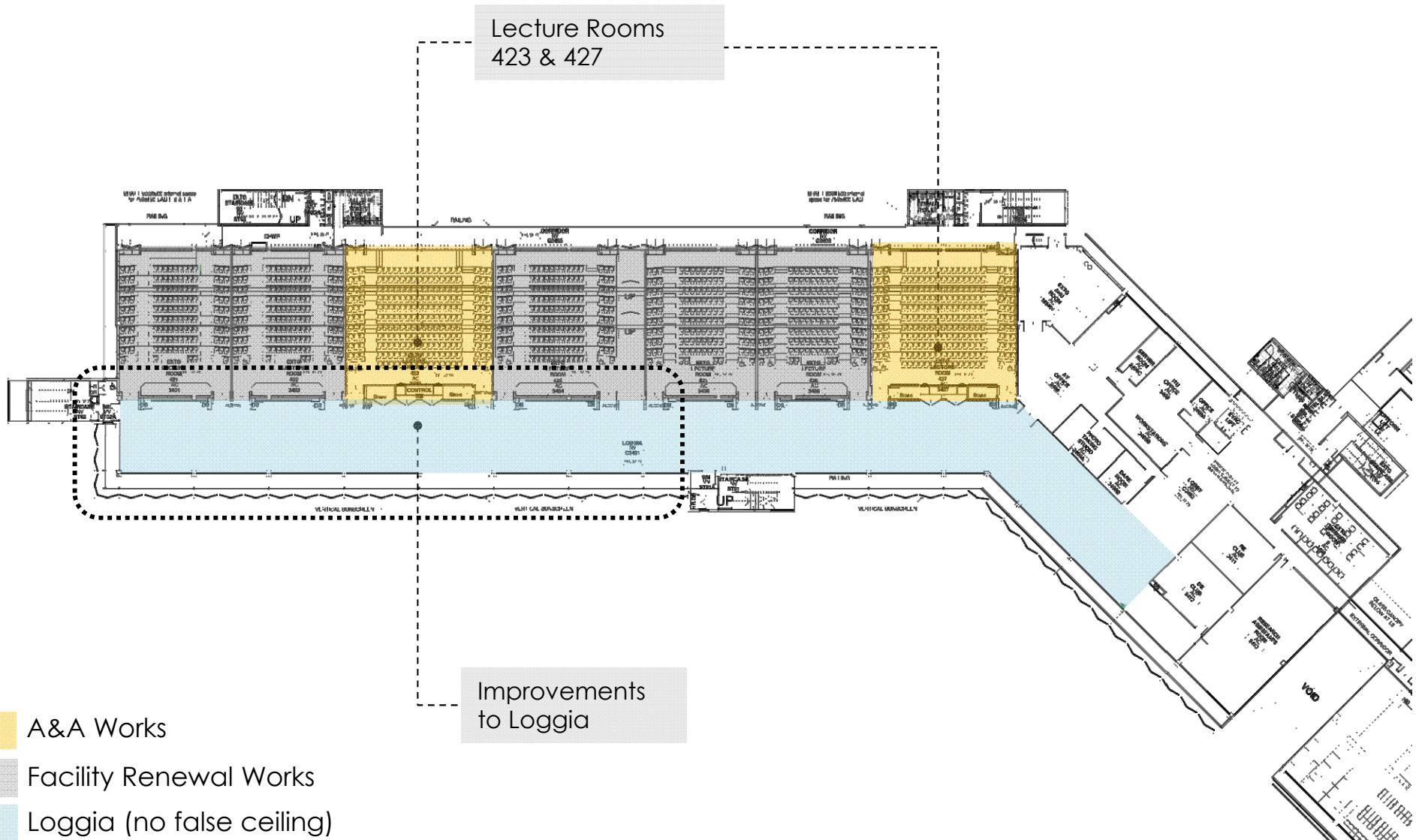
## Office Type 1



## Office Type 2

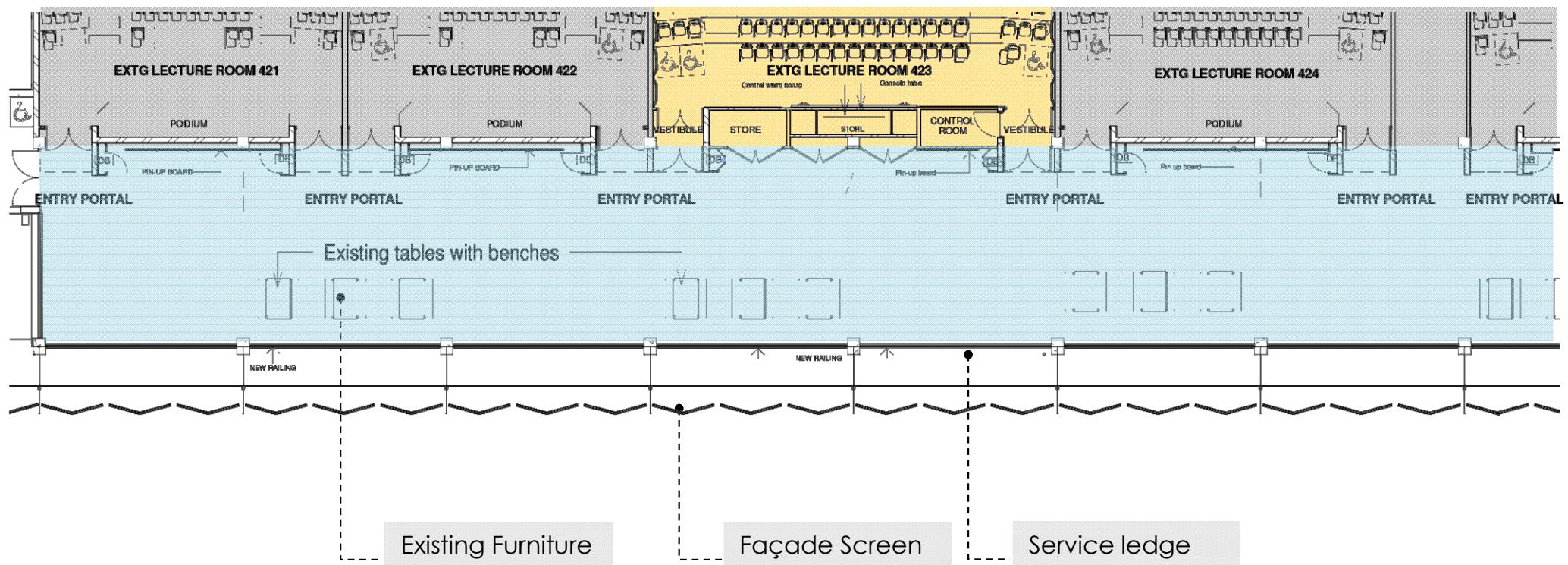


# Loggia & Lecture Rooms



**Loggia**  
SDE3 L4

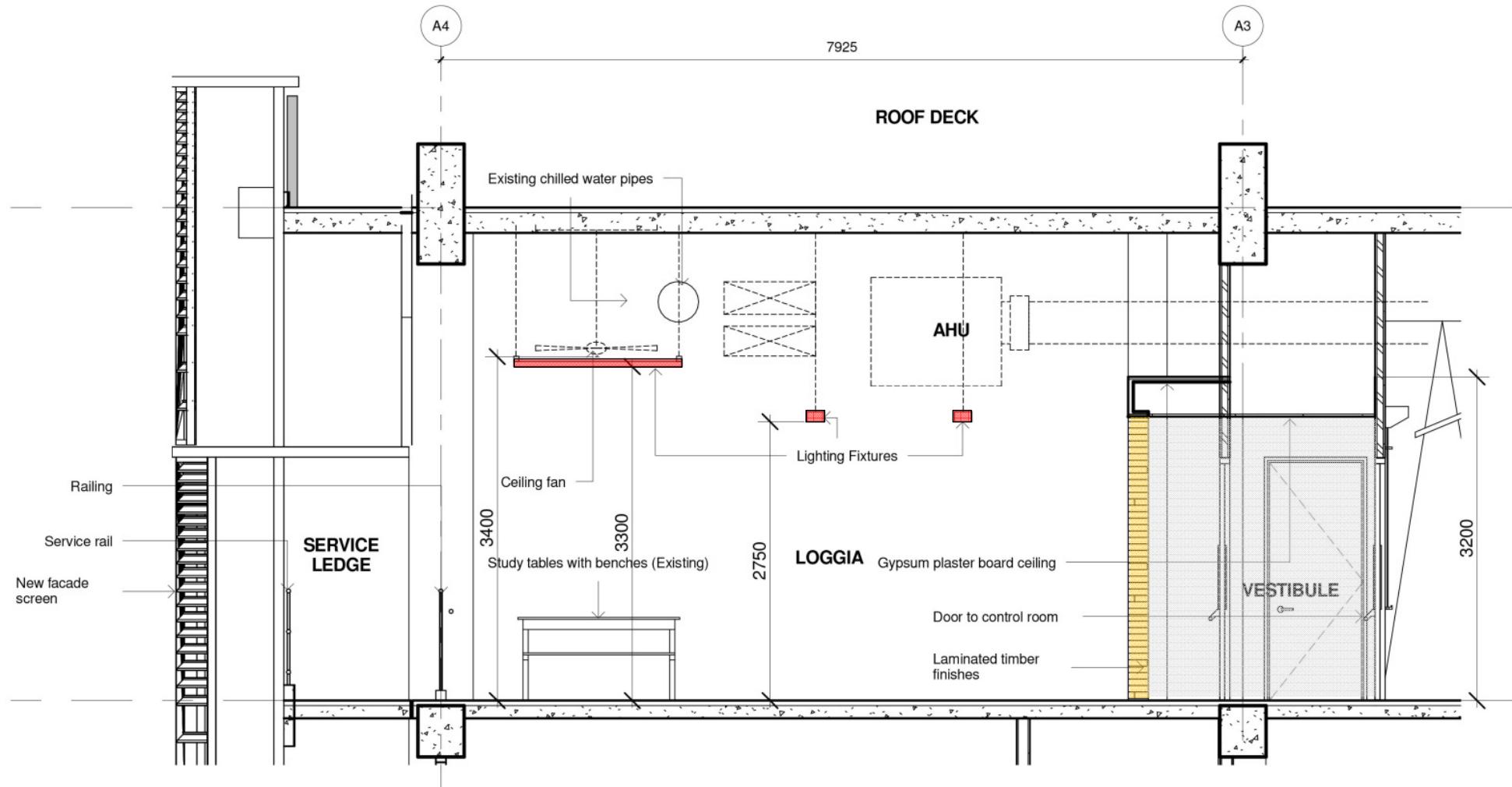
# Loggia & Lecture Rooms



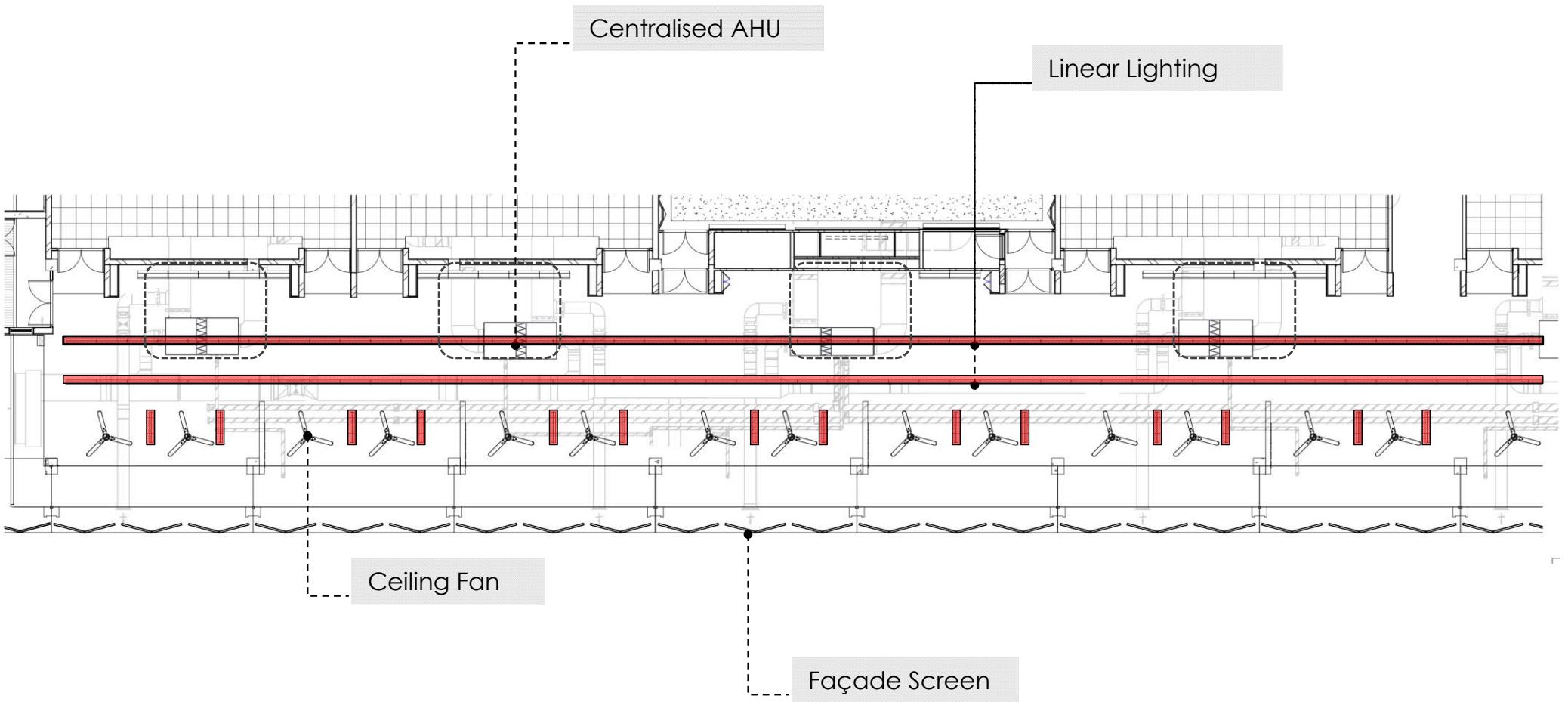


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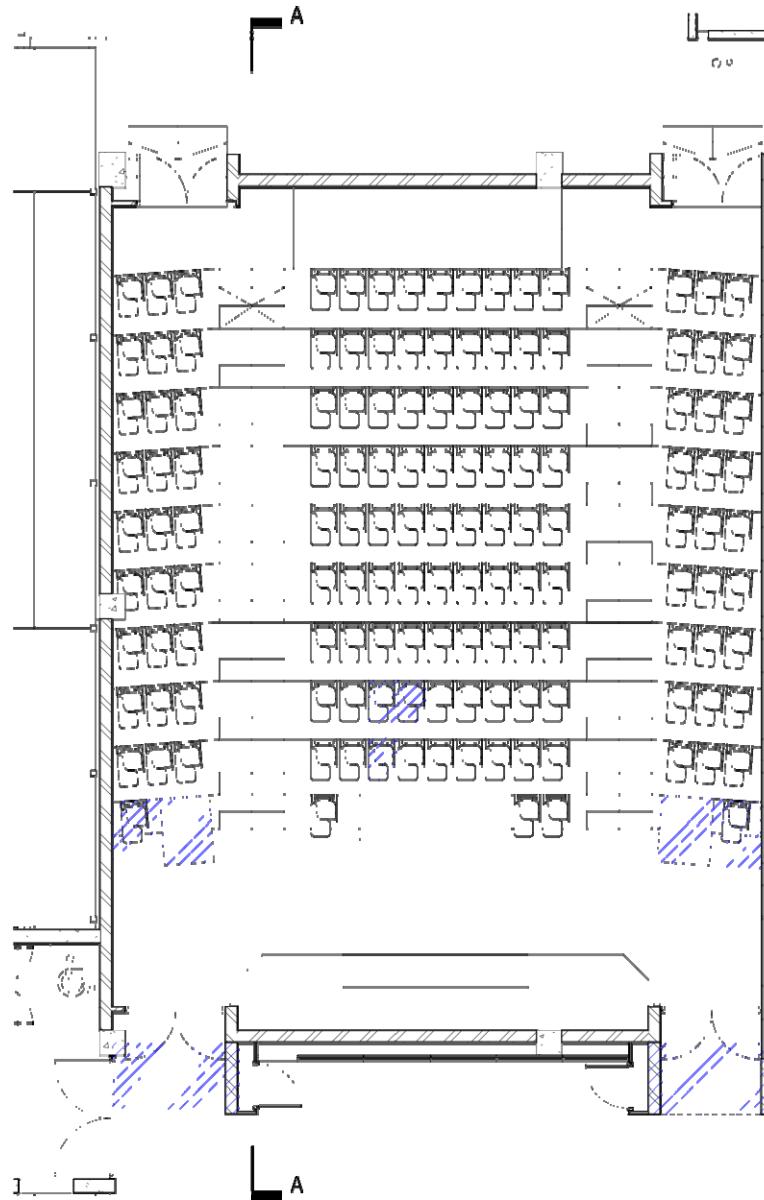
**Loggia**  
View



**Loggia**  
Typical section



**Loggia**  
Lights and Fans



**Typical Lecture Room**  
Facilities Renewal (FR)

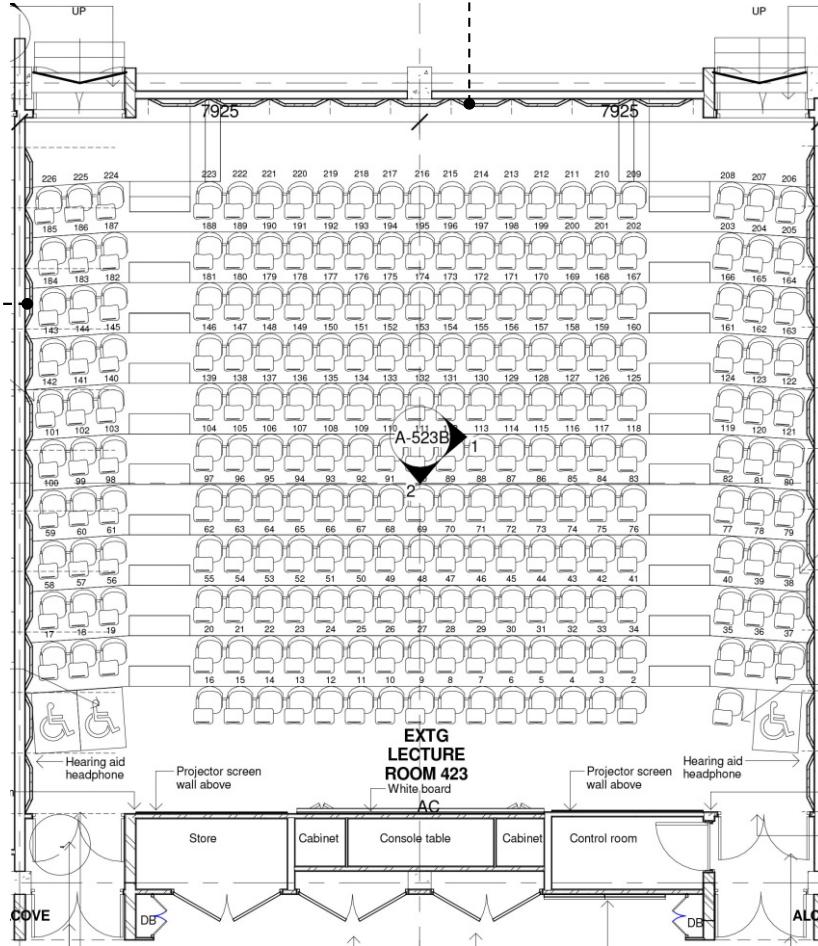
### **Facilities Renewal (FR)**

Minor modifications made:

- i. New entrance doors
- ii. Free area for handicapped users
- iii. Provision of high power supply for projector
- iv. Provision of additional seats in previous projector area
- v. Provision of Hearing Enhancement System (portable receiver & neckband)
- vi. New ACMV & Electrical system
- vii. New ceiling

Acoustic wall  
panels

Acoustic  
wall  
panels

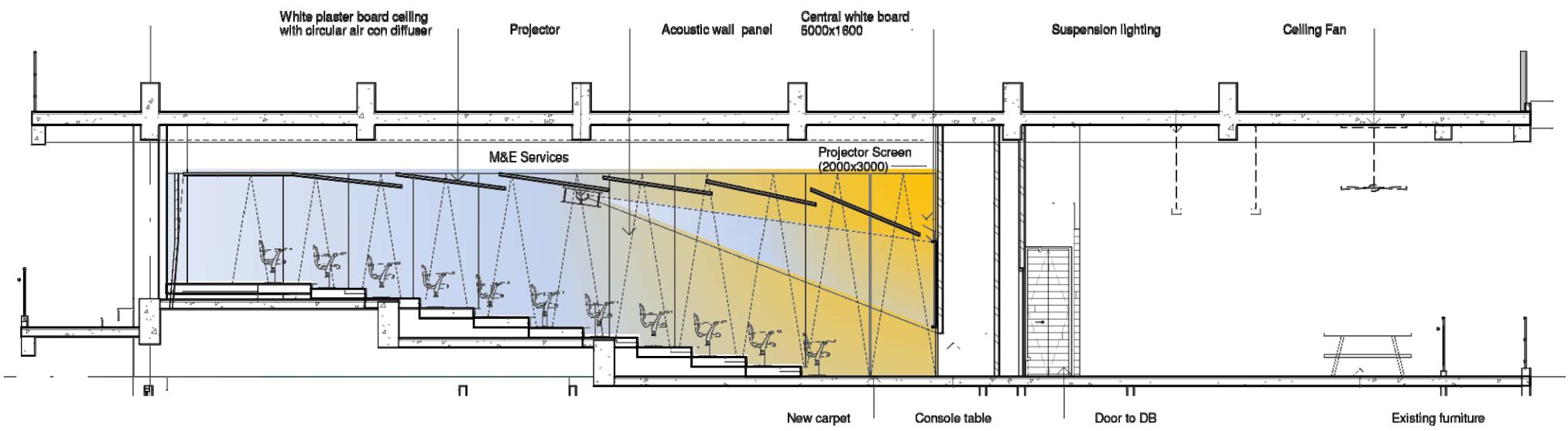


## Typical Lecture Room Additions & Alterations (A&A)

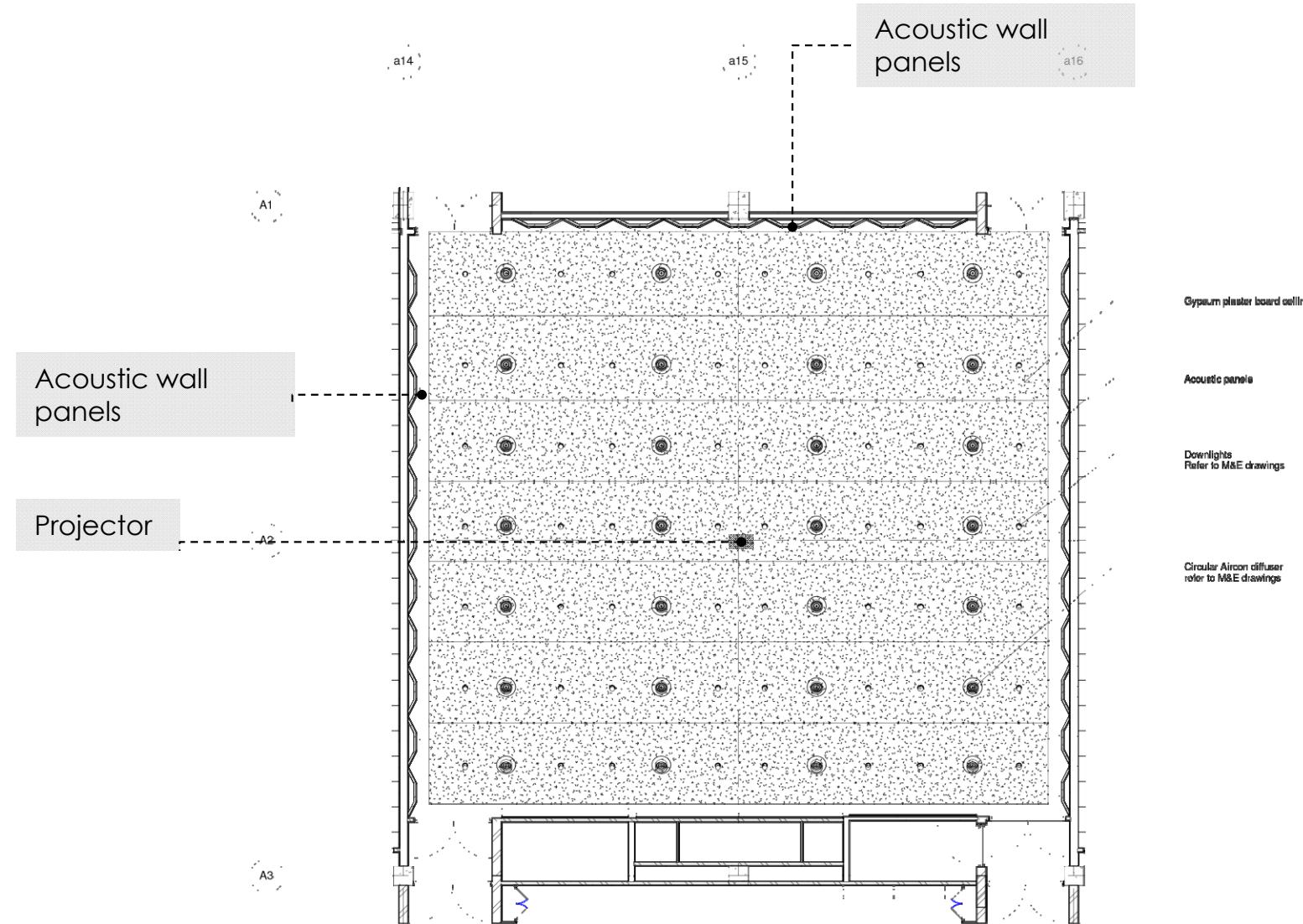
### Additions & Alterations (A&A)

Major modifications made:

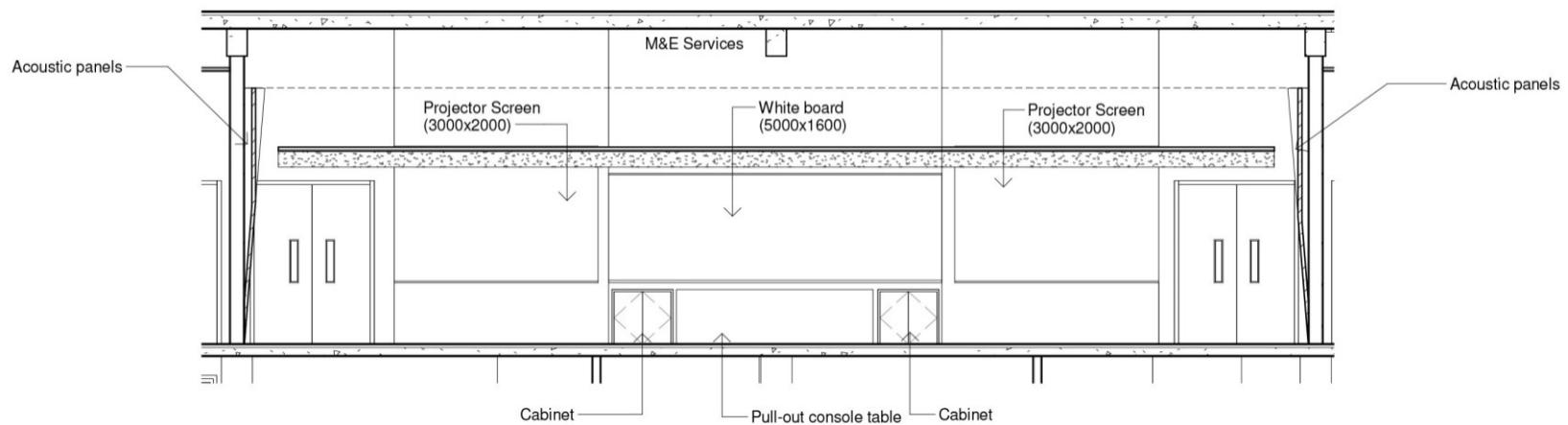
- i. New platform & seats for 15 inch laptops
- ii. New interior finishes
- iii. New entrance doors
- iv. Free area for handicapped users
- v. Provision of high power supply for projector
- vi. Provision of Hearing Enhancement System (induction loop system)
- vii. New console table
- viii. New Control Room
- ix. New Store
- x. New ACMV & Electrical system
- xi. New ceiling



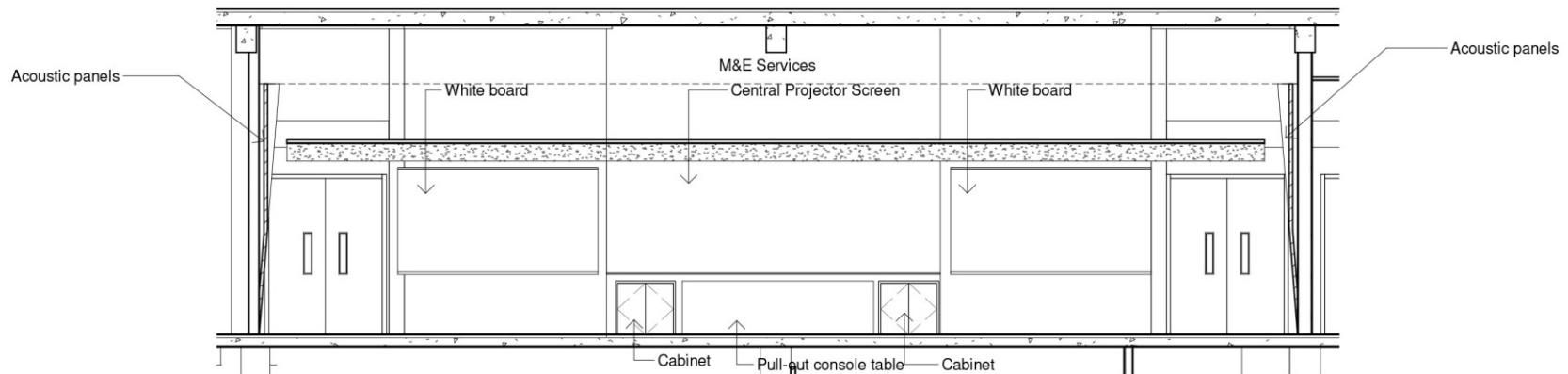
Typical LR 423/427  
Section



Typical LR 423/427  
RCP



**LR 423**  
Provision of 1 whiteboard, 2 projector screens



**LR 427**  
Provision of 2 whiteboards, 1 projector screen

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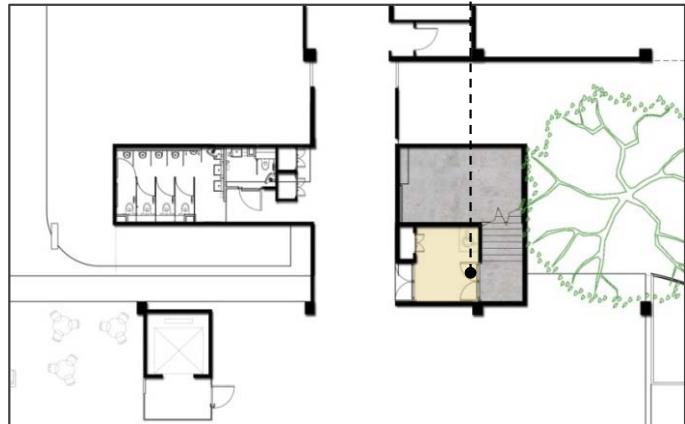
**Typical LR 423/427  
Elevations**



Typical LR 423/427  
View

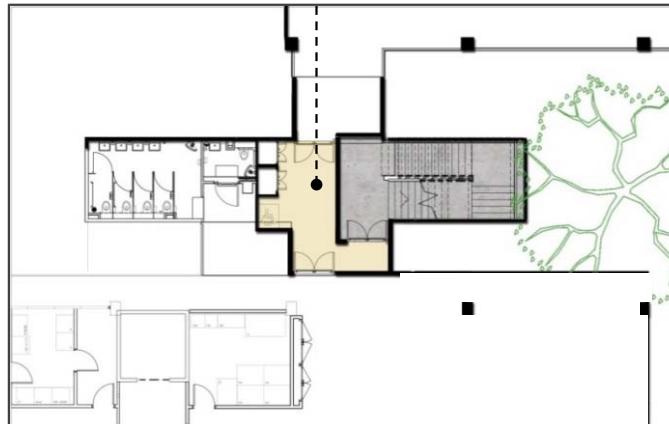
# Reconfiguration of Staircase 05

Reconstruction of  
lower staircase



ST05 – Level 2

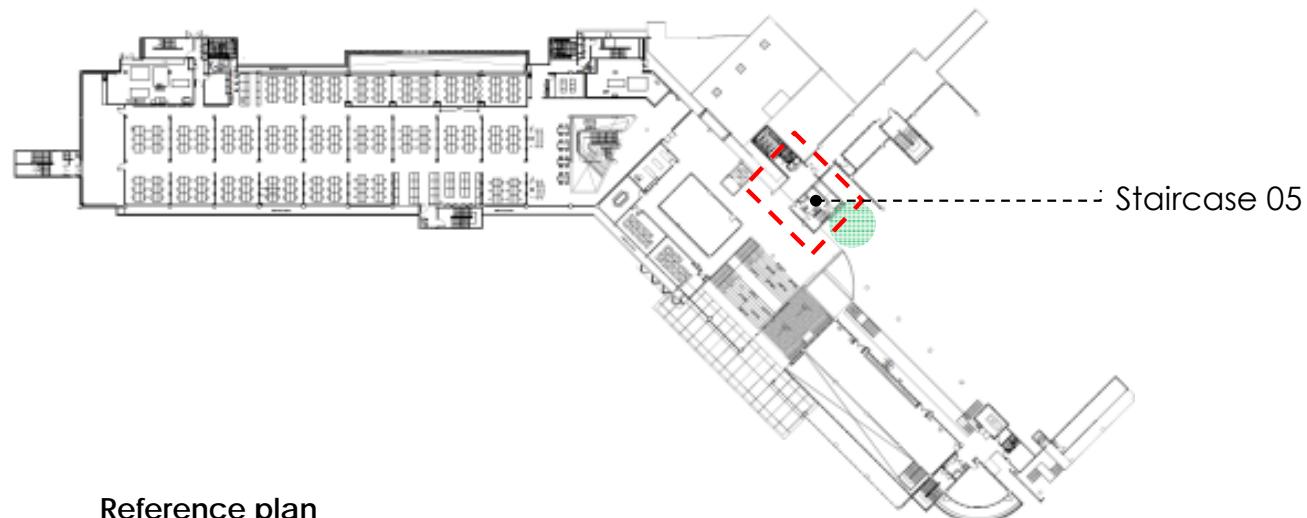
Narrowed passageway



ST05 – Level 3



ST05 – Level 4



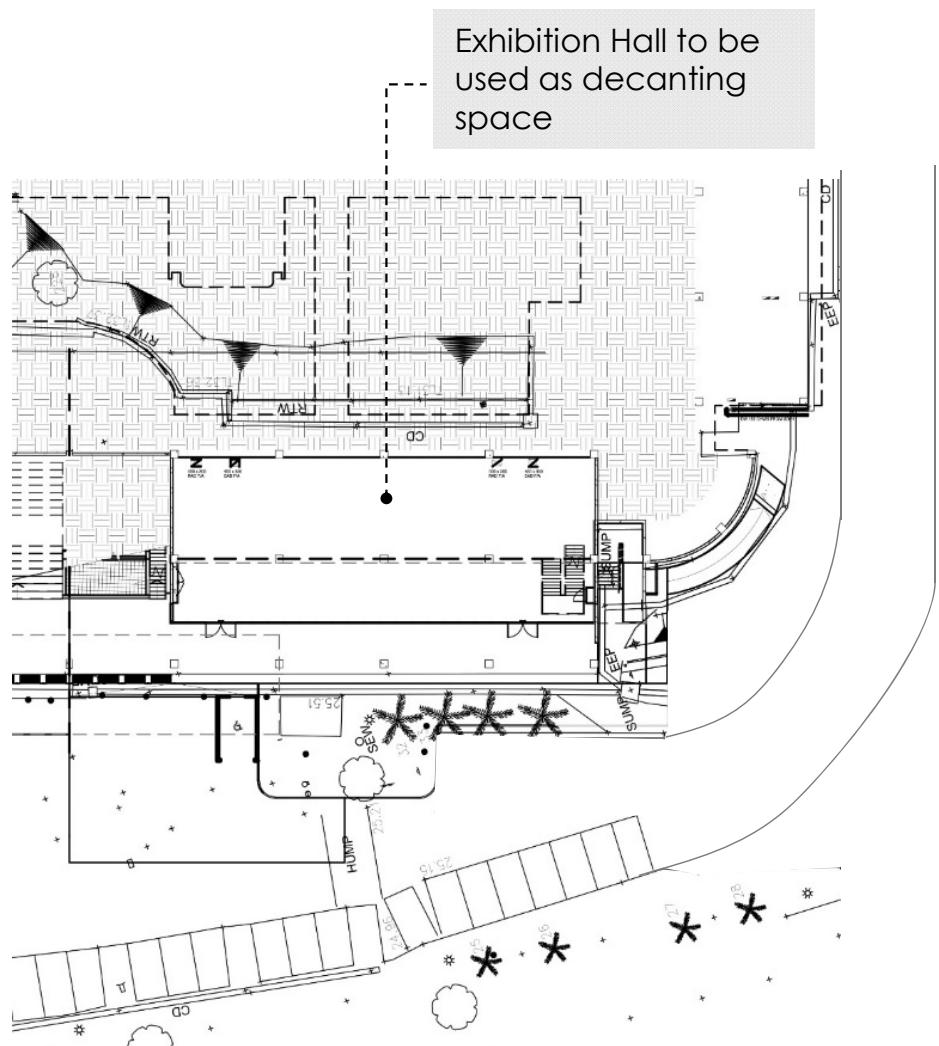
Reference plan

## Reconfiguration of ST05

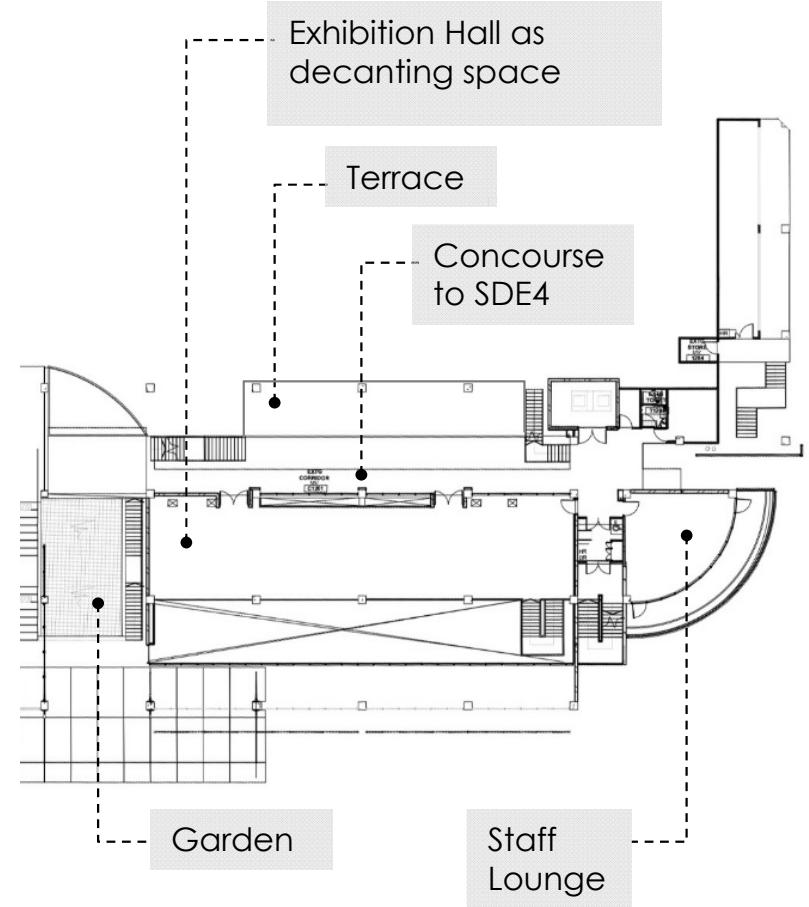
Compartmentation based on existing layout

**SDE 1**

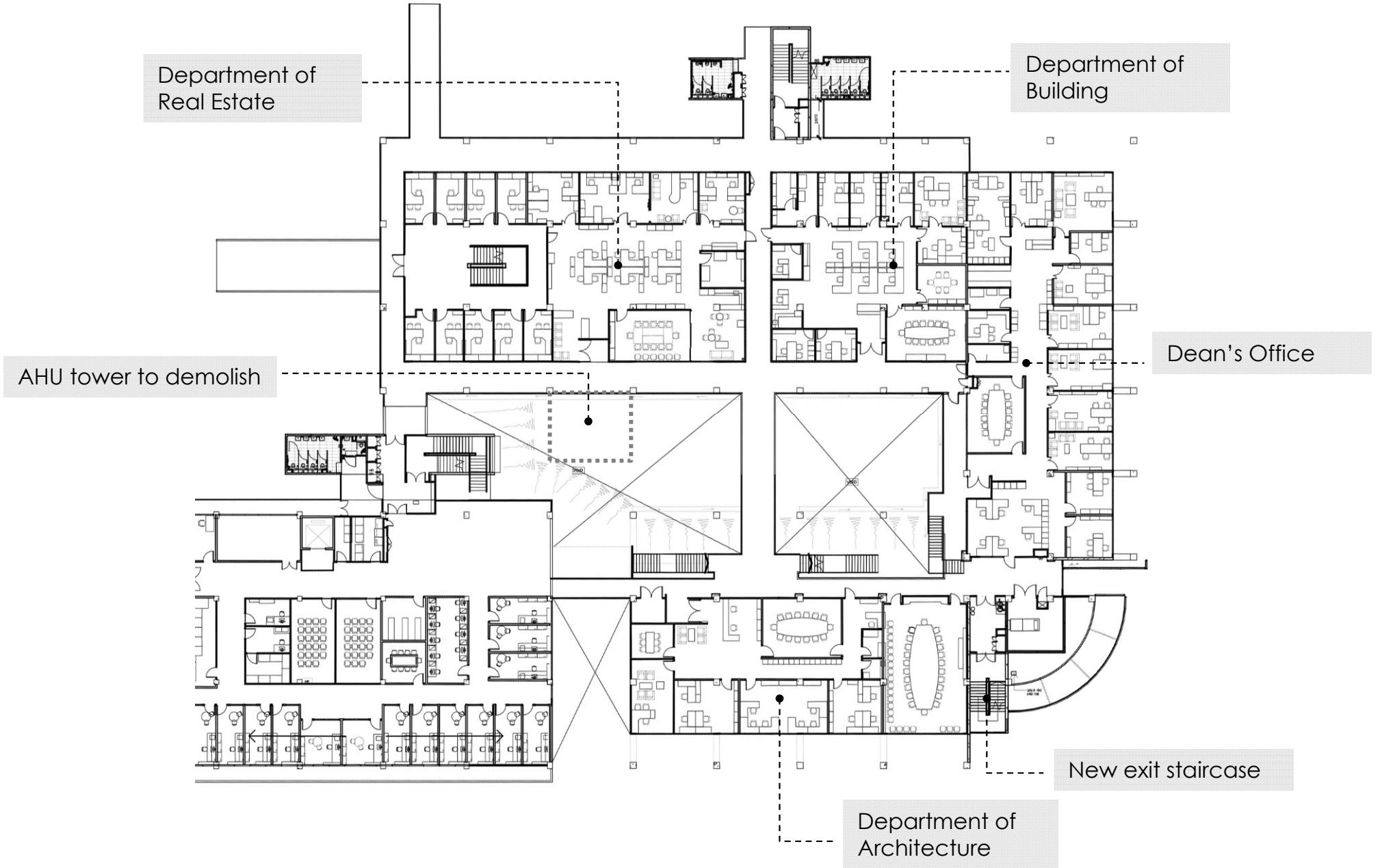
# SDE 1

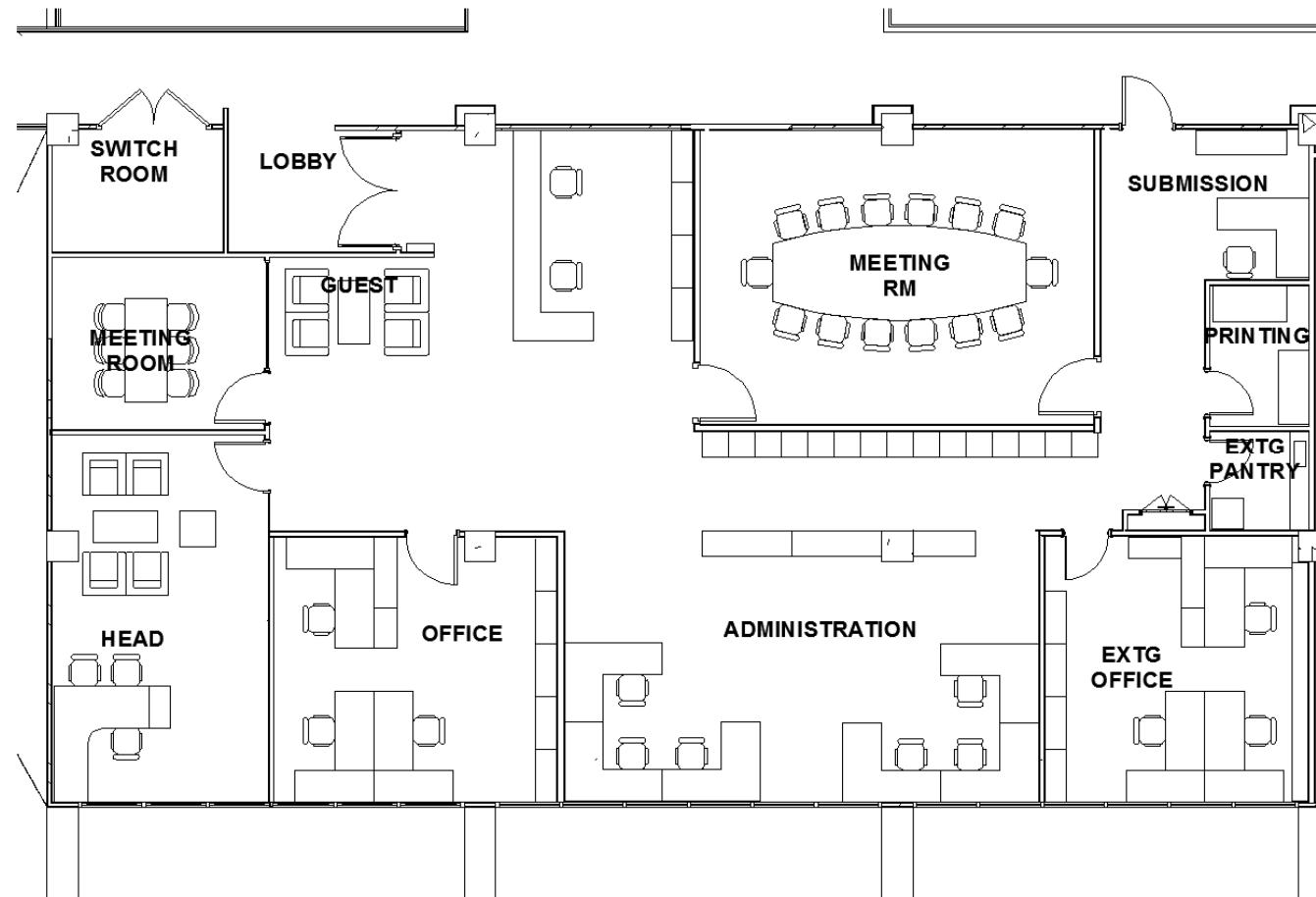


SDE1 – L1 Plan

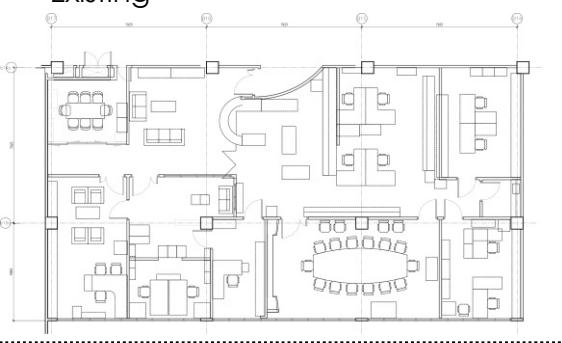


SDE1 – L2 Plan

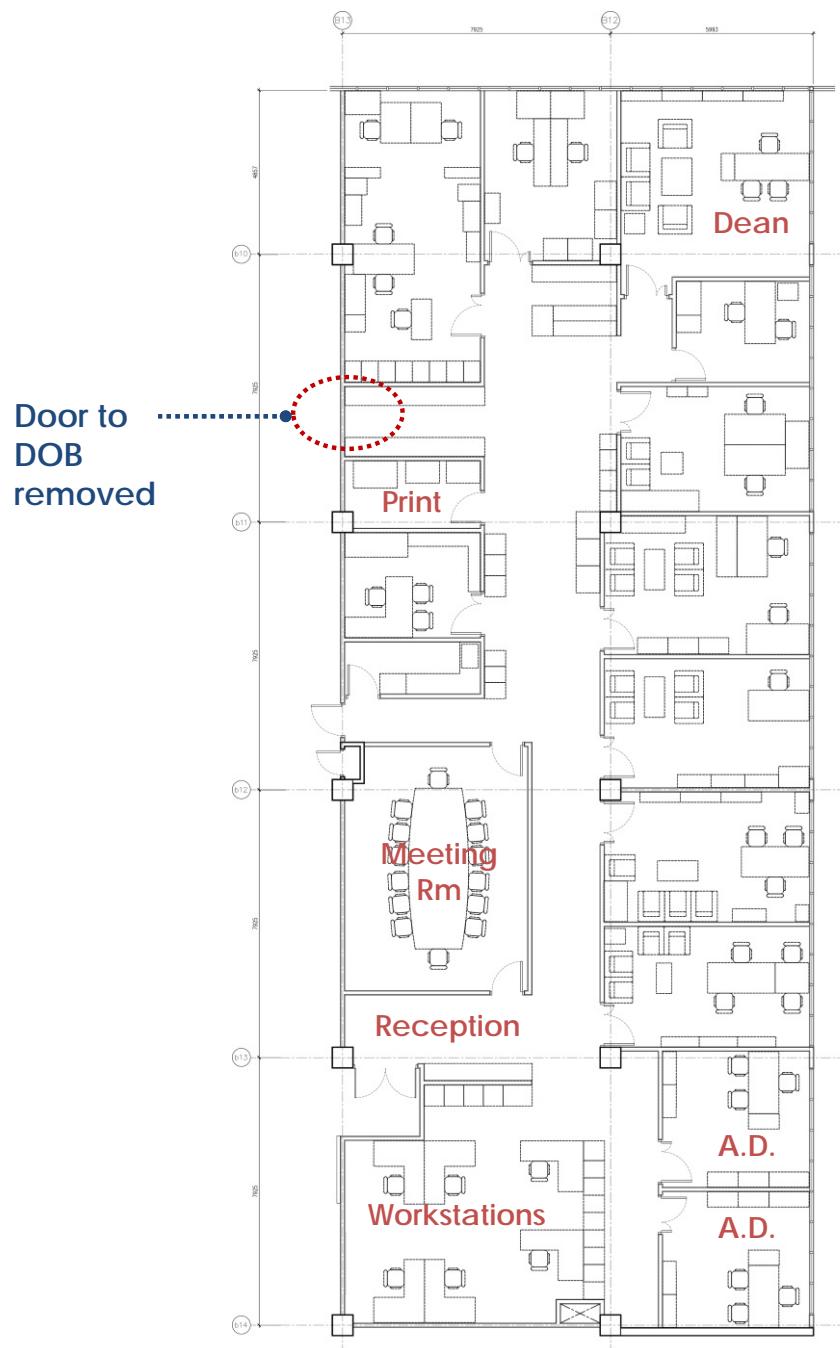
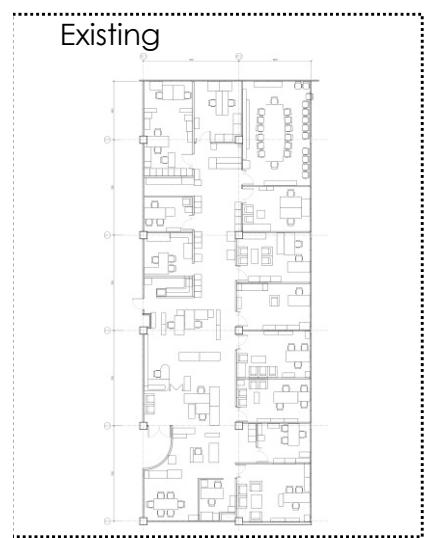




Existing

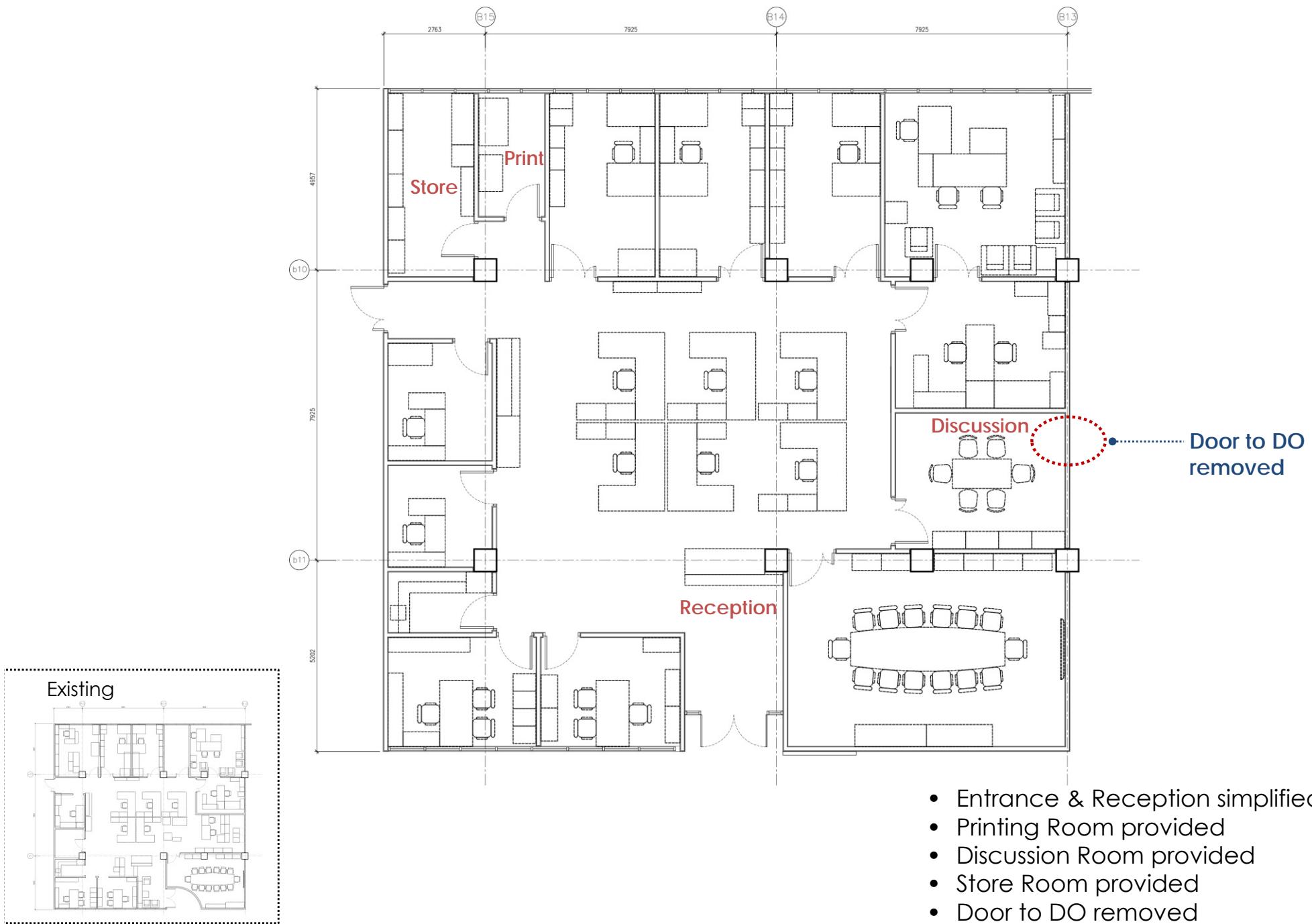


- Entrance & Reception simplified
- Meeting Room relocated to the front
- Workstations relocated with external view
- Printing Room provided
- Submission window provided



- Entrance & Reception simplified
- Meeting Room relocated to the front
- Dean's Office relocated
- Workstations relocated
- Printing Room provided
- Associate Director Office provided
- Door to DOB removed

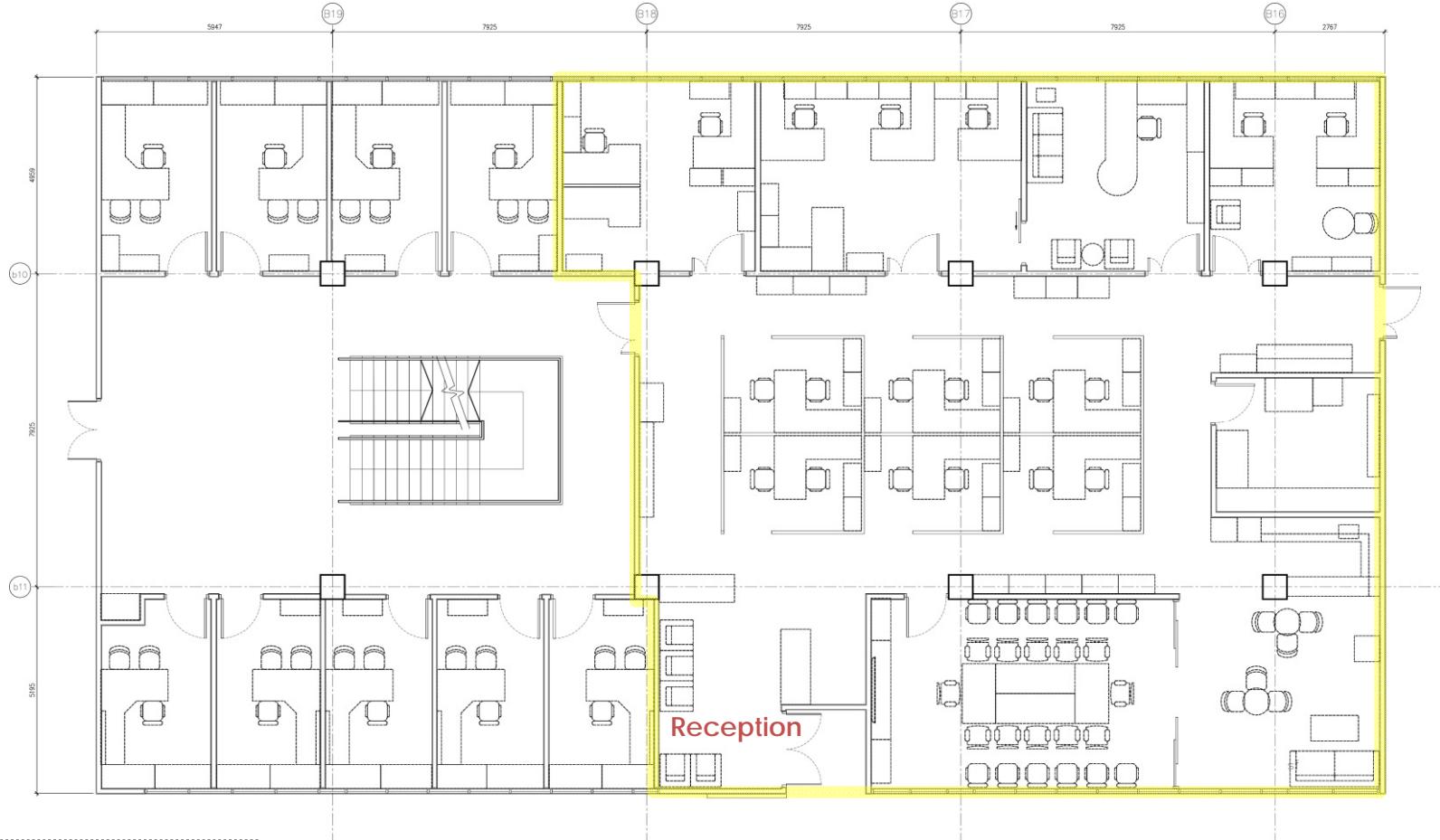
**SDE1**  
L3 – Dean's Office



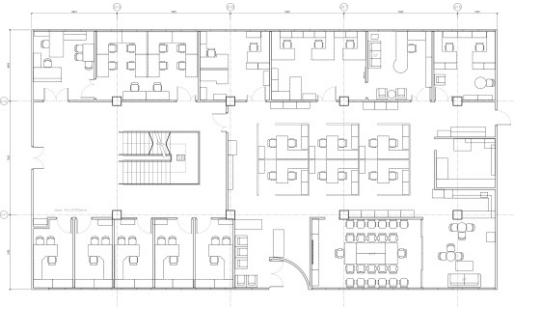
- Entrance & Reception simplified
- Printing Room provided
- Discussion Room provided
- Store Room provided
- Door to DO removed

## SDE1

L3 – Department of Building



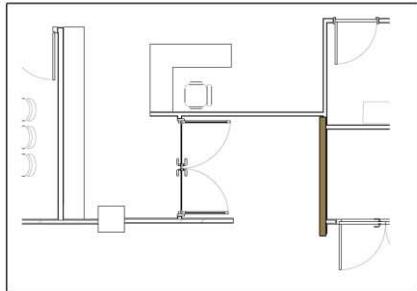
Existing



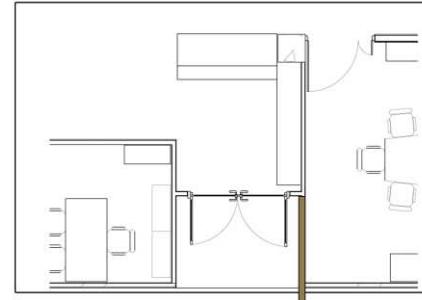
- Entrance & Reception simplified
- Signage relocated

## SDE1

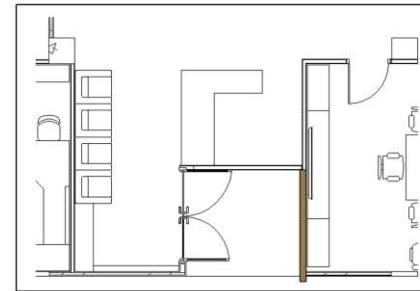
L3 – Department of Real Estate



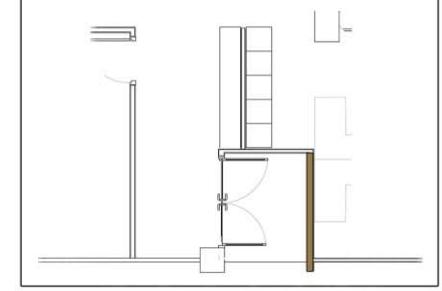
Department of Architecture



Department of Building



Department of Real Estate



Dean's Office



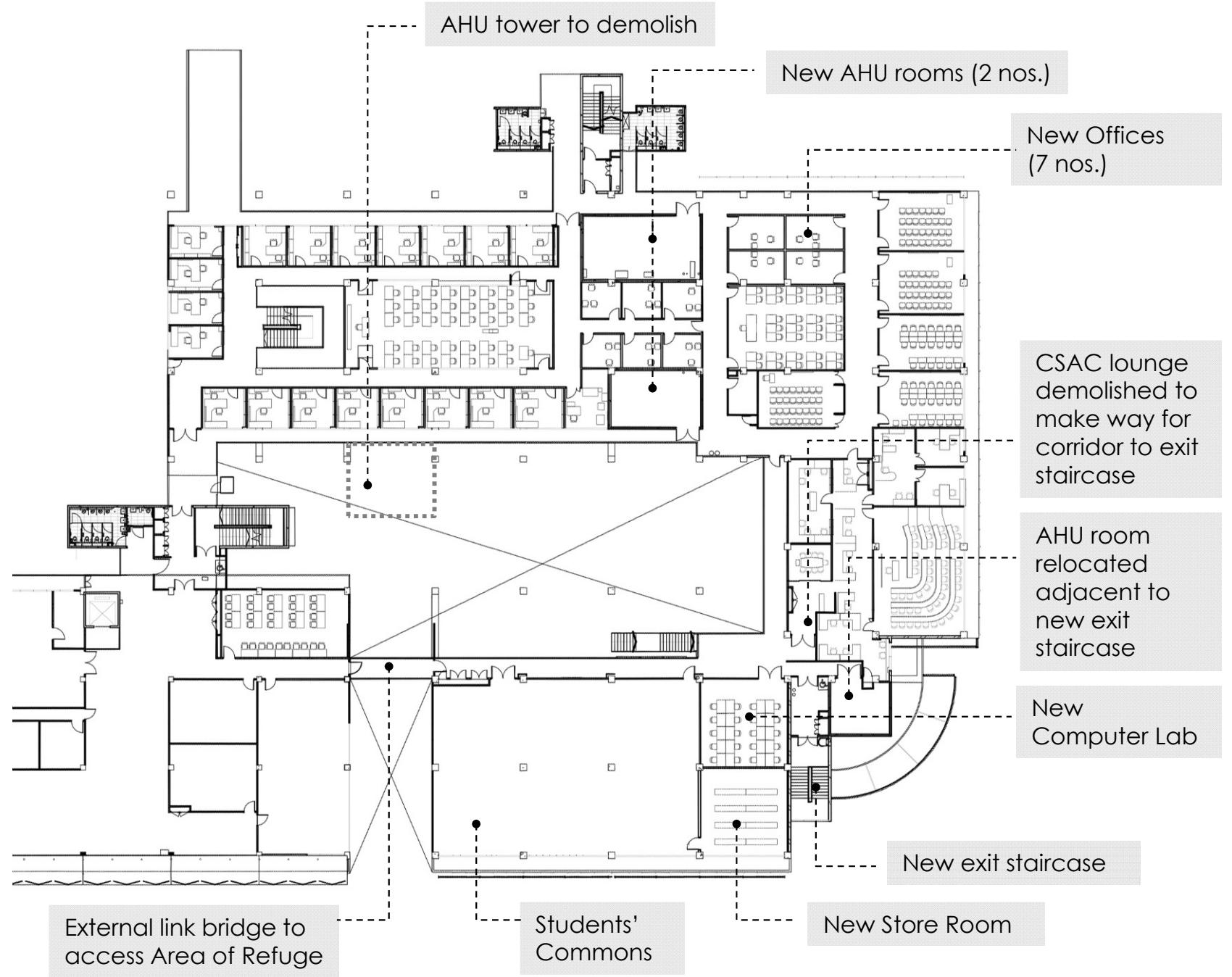
SDE1

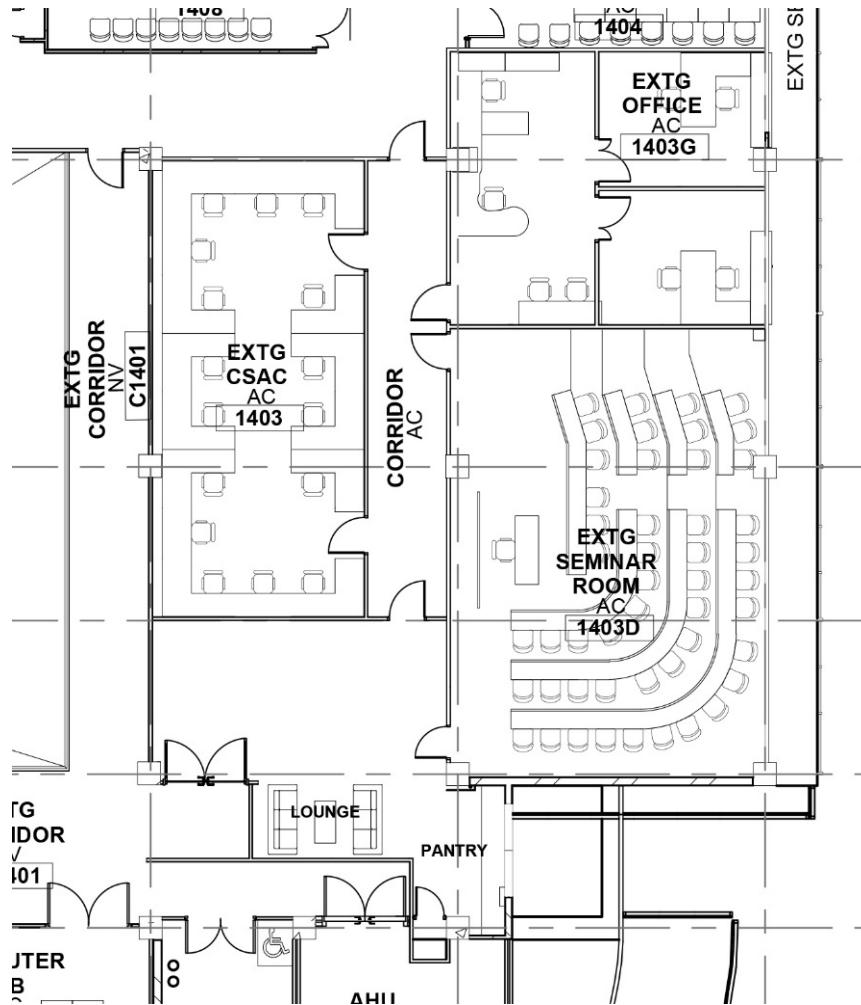
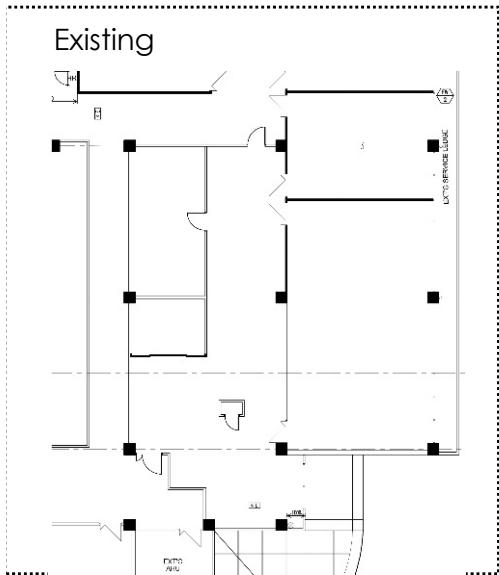
L3 – Entry treatment to Department Offices



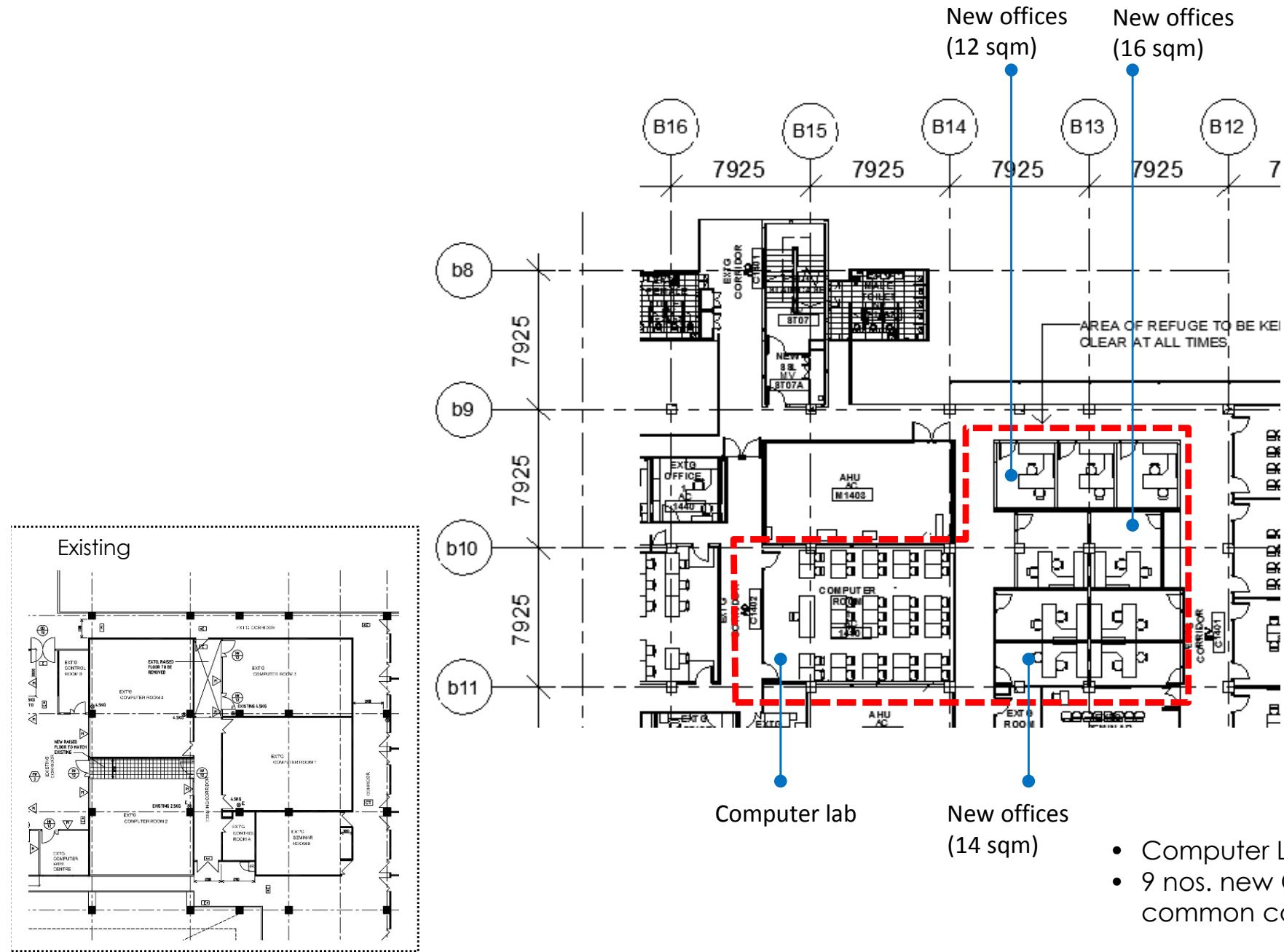
**SDE1**

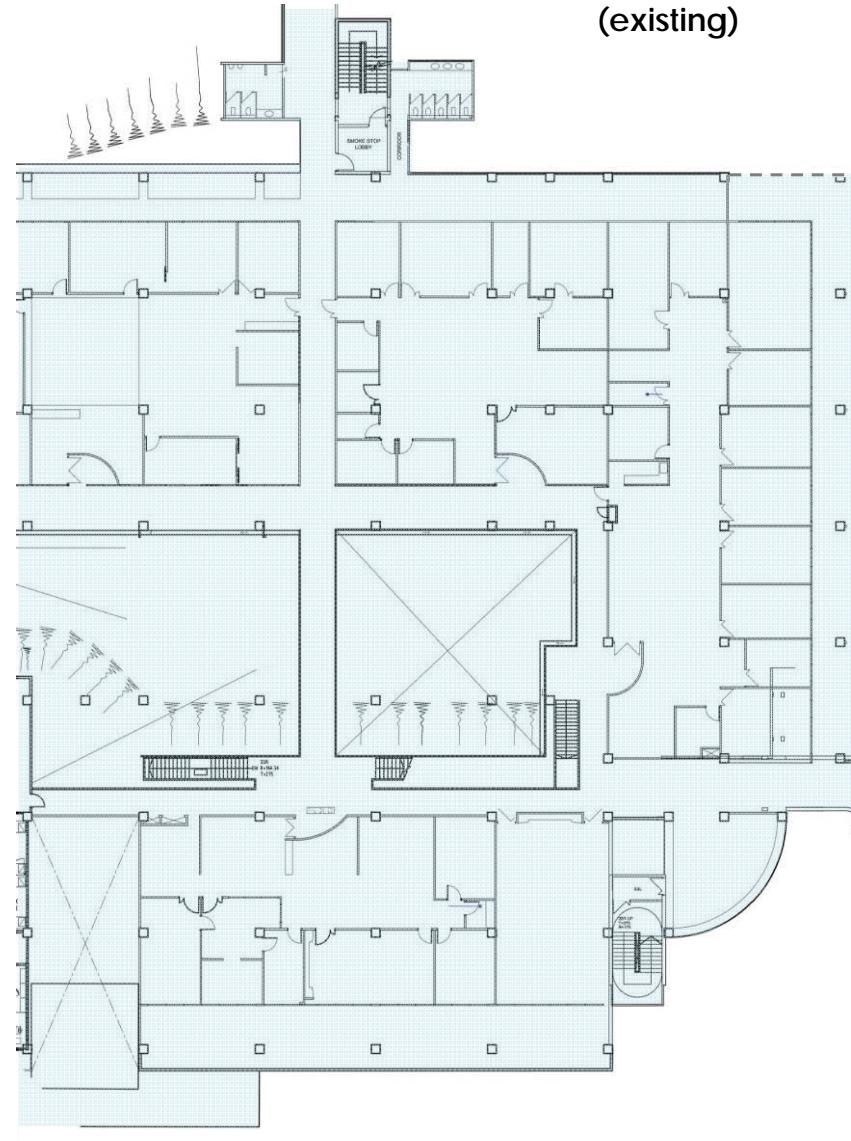
L3 – Entry treatment along corridor



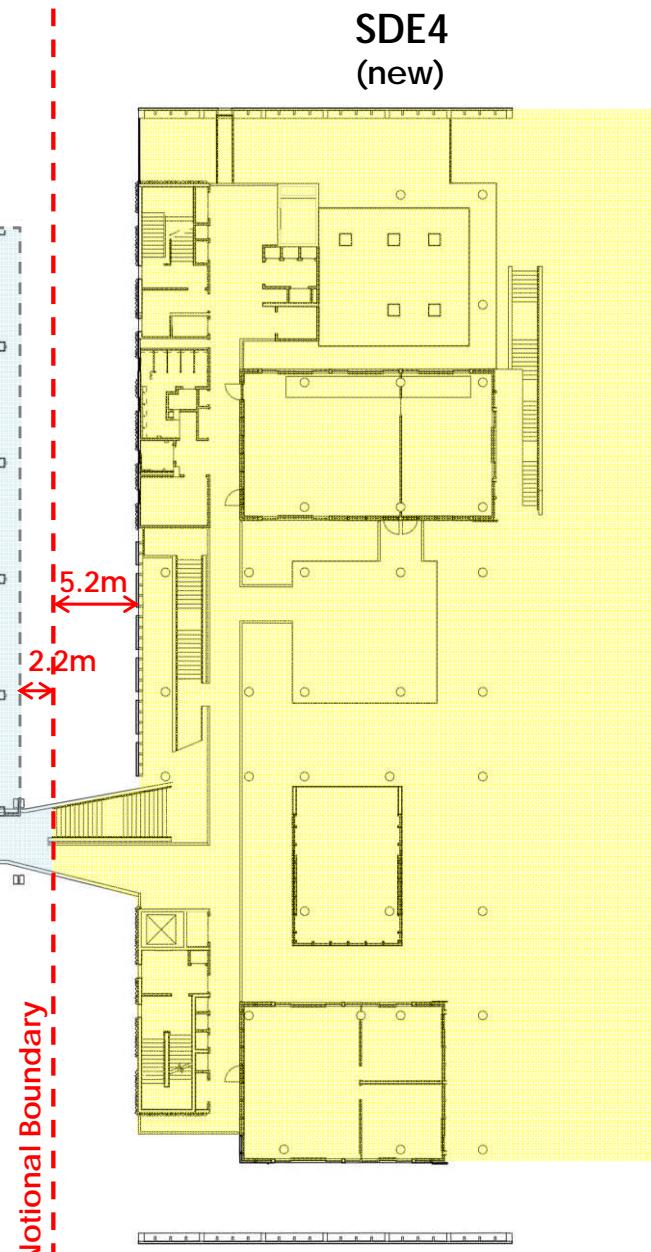


- Separate access to CSAC / Seminar Room created
- Lounge / Pantry reconfigured to make way for new corridor to exit staircase & AHU
- Discussion room removed





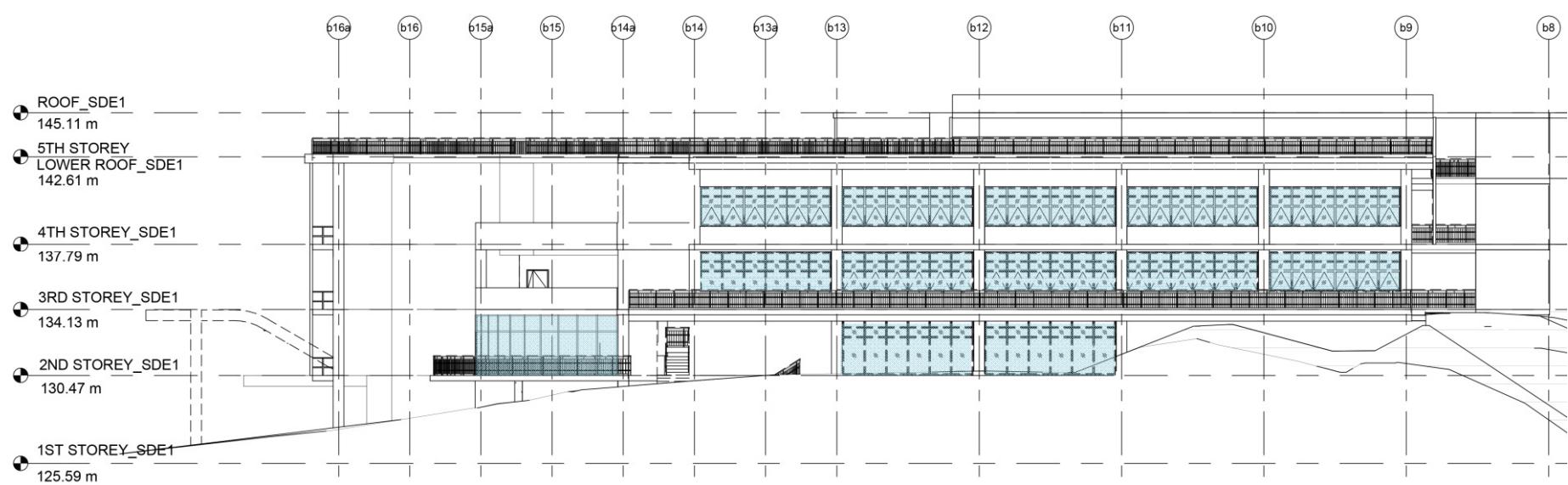
SDE1  
(existing)



SDE4  
(new)

## SDE1

Notional Boundary & Unprotected Openings



**Existing Unprotected Openings**  
Require 3.25m setback



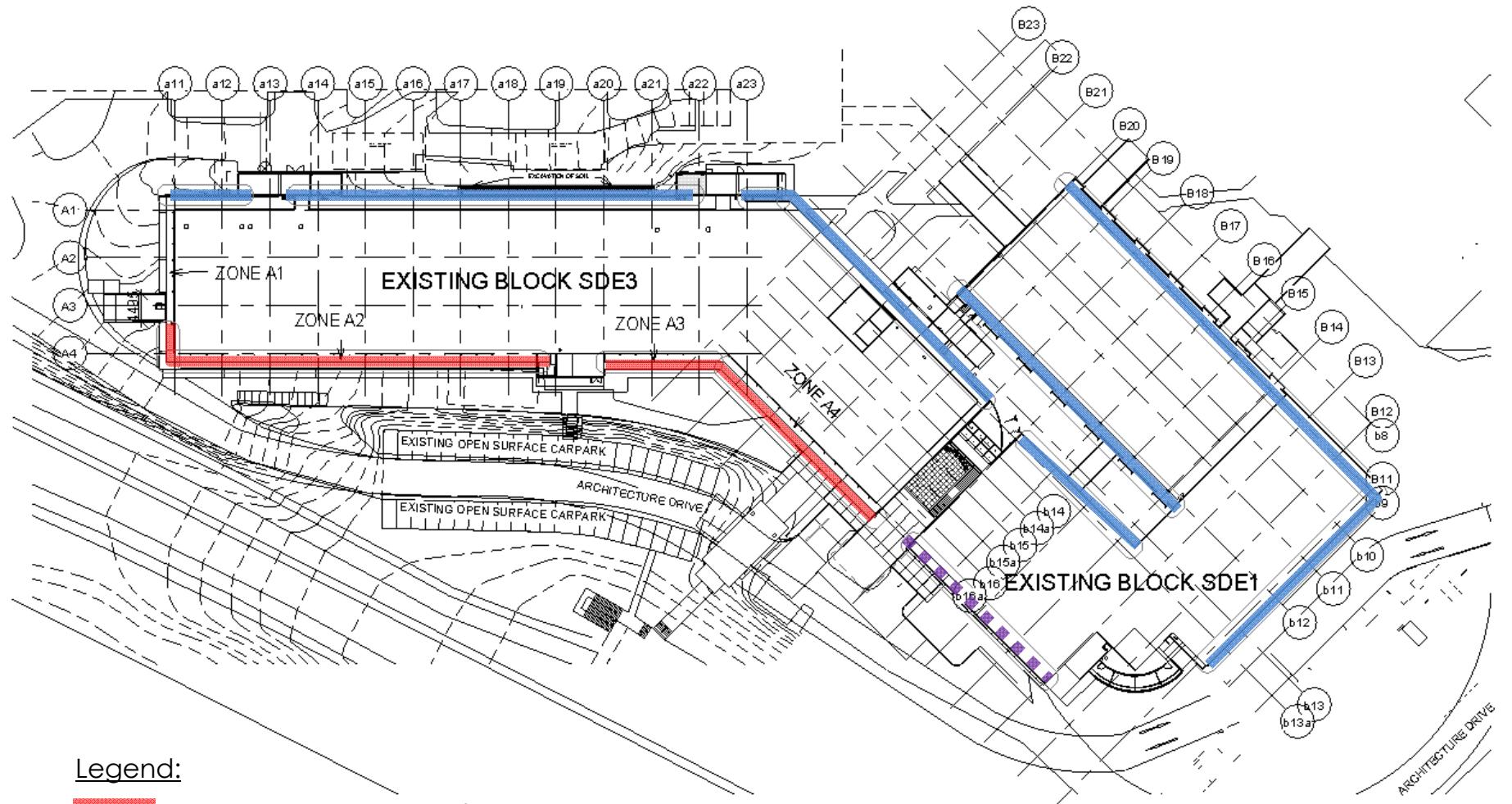
**Proposed Unprotected Openings**  
Complied with 2.2m setback

Reduction in window openings; top glazing removed

**SDE1**

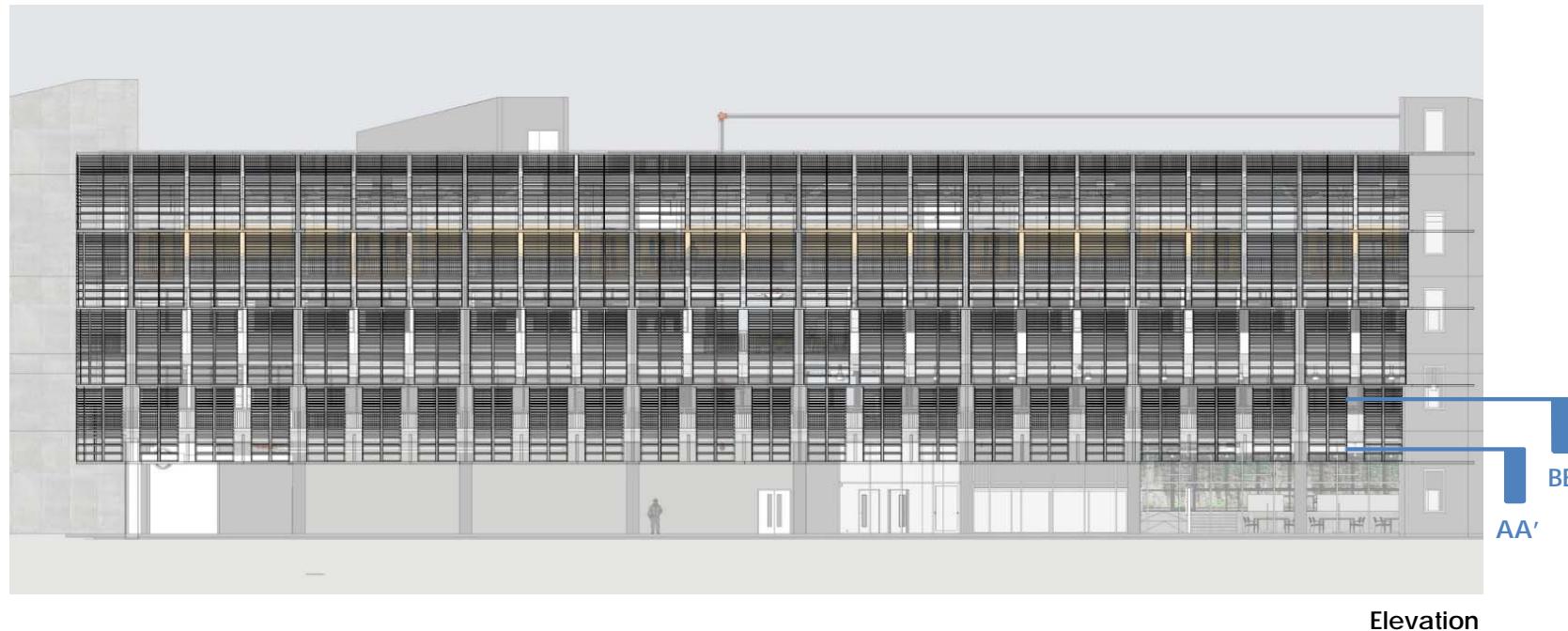
Notional Boundary & Unprotected Openings

# Facade

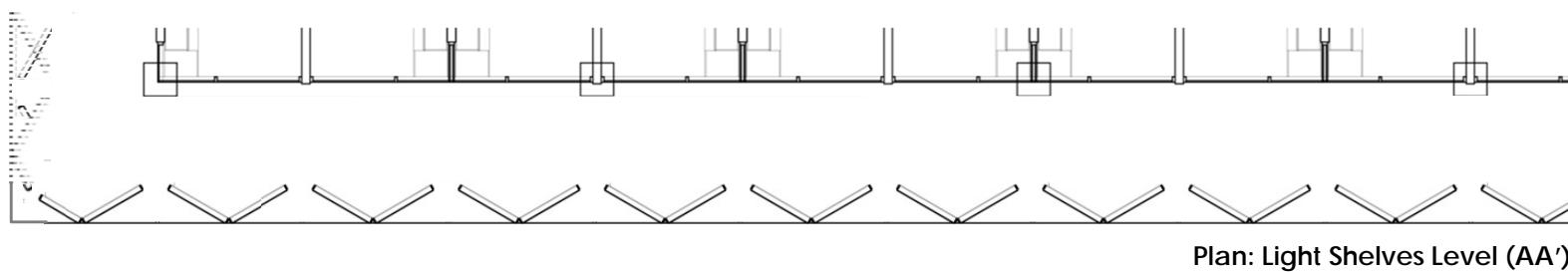


Legend:

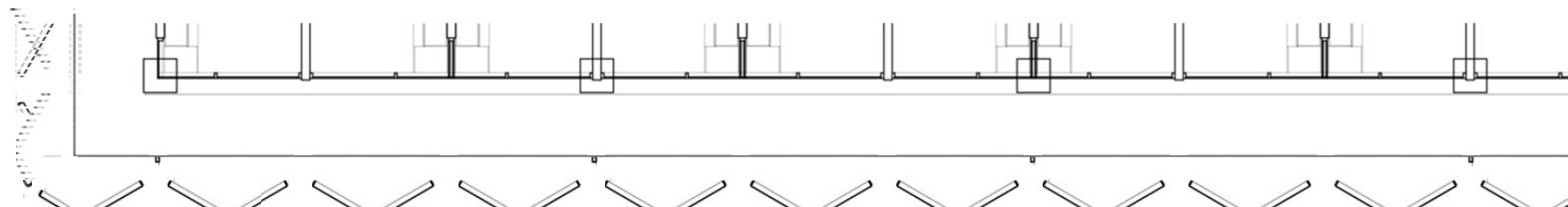
- Western Façade Butterfly screens
- Selective replacement / removal of existing screens
- Extension of Butterfly screens (Enhancement)



Elevation



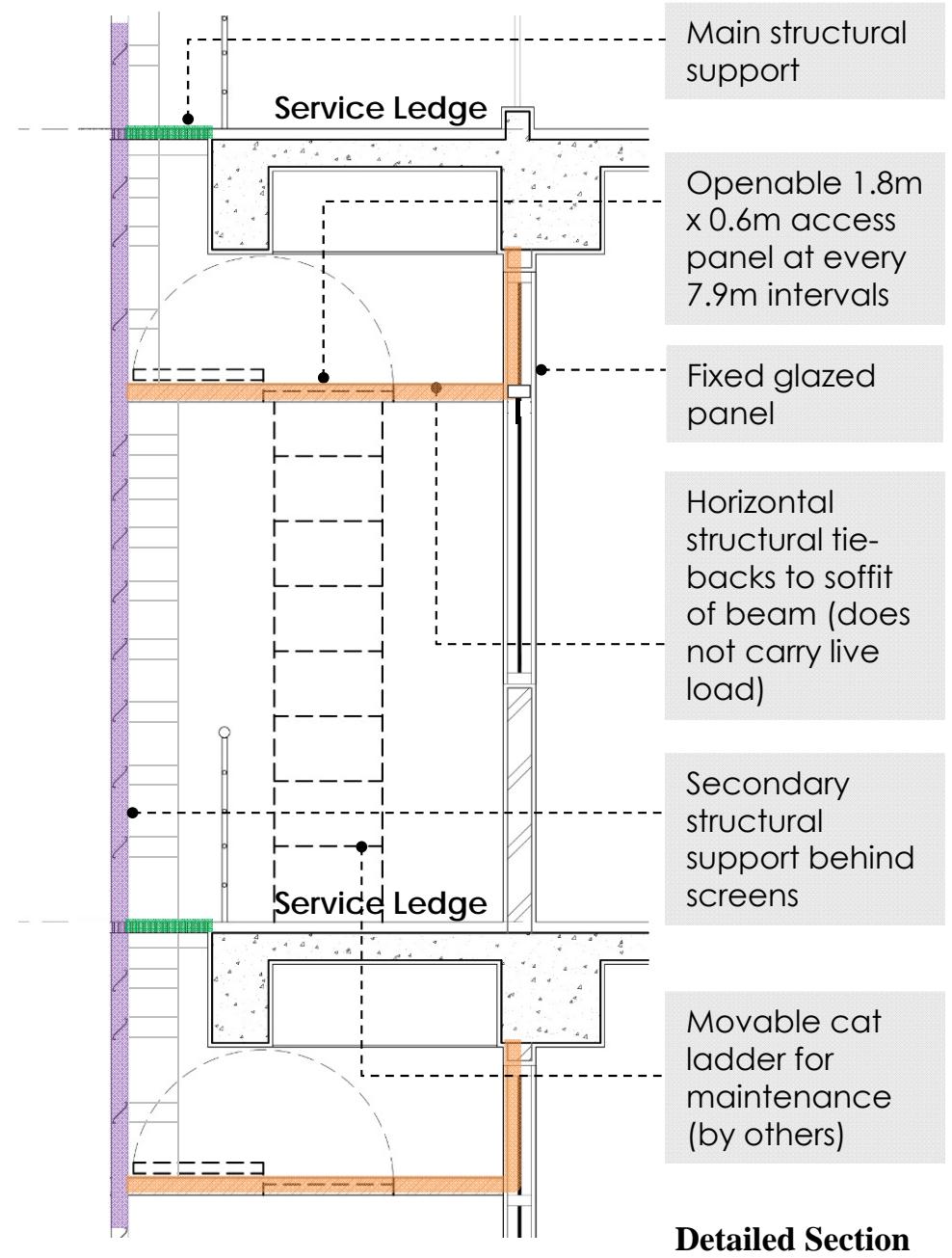
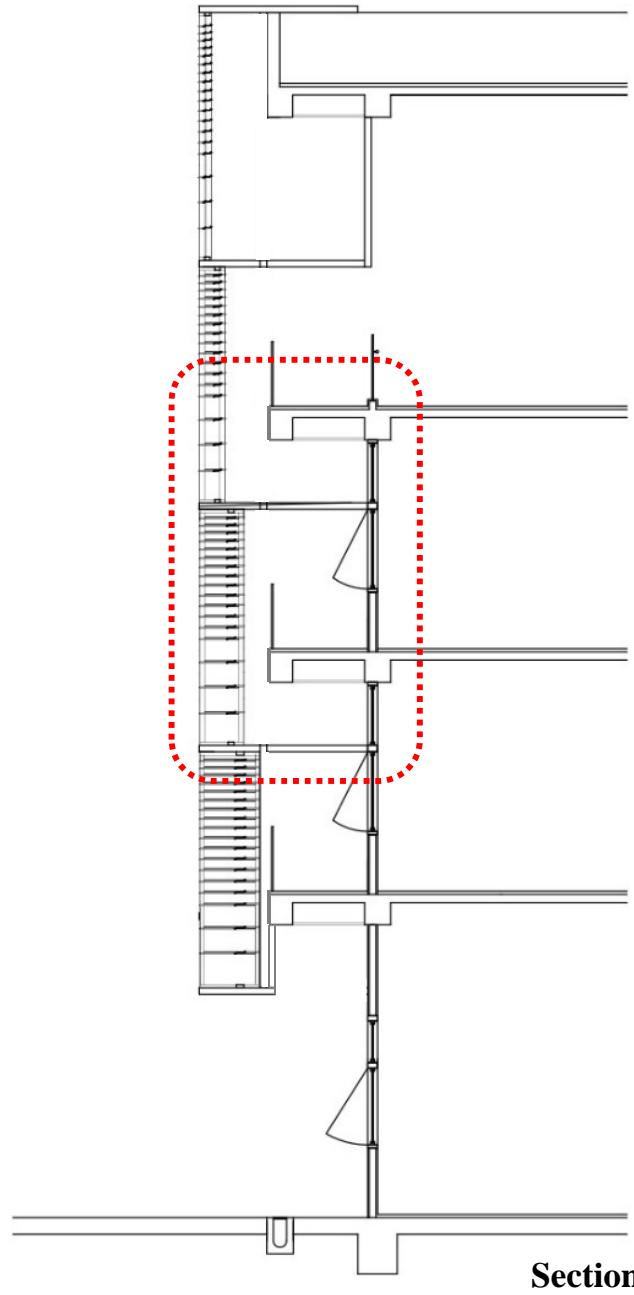
Plan: Light Shelves Level (AA')



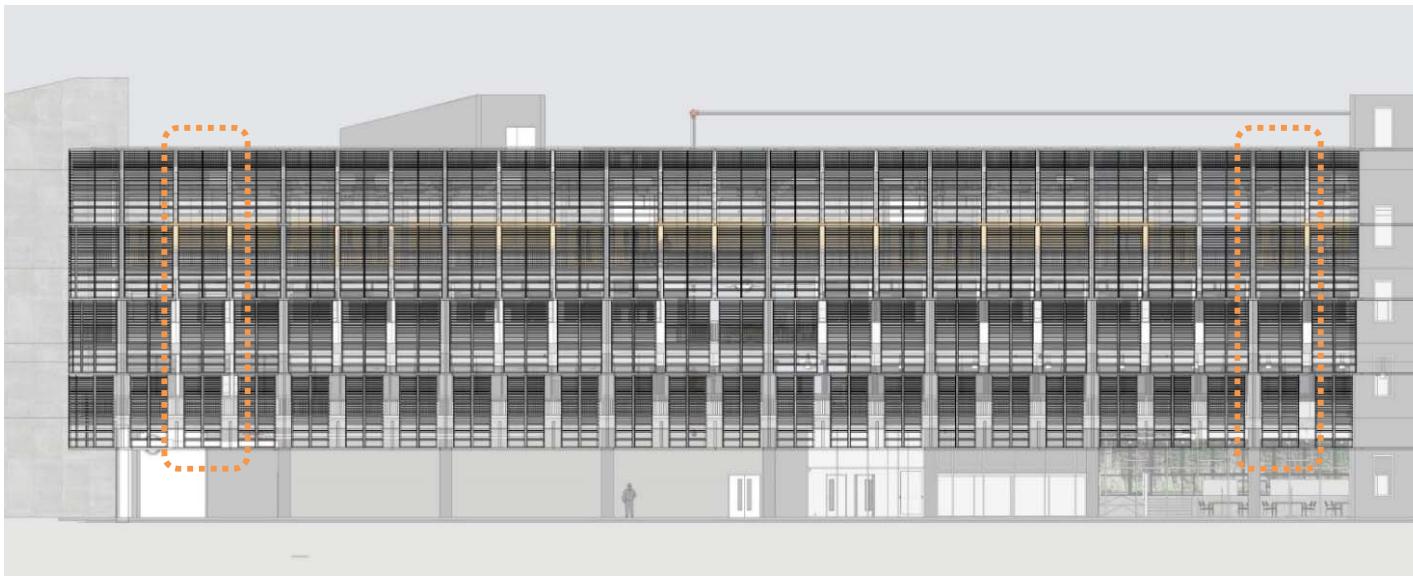
Plan: Service Ledge Level (BB')

## Facade

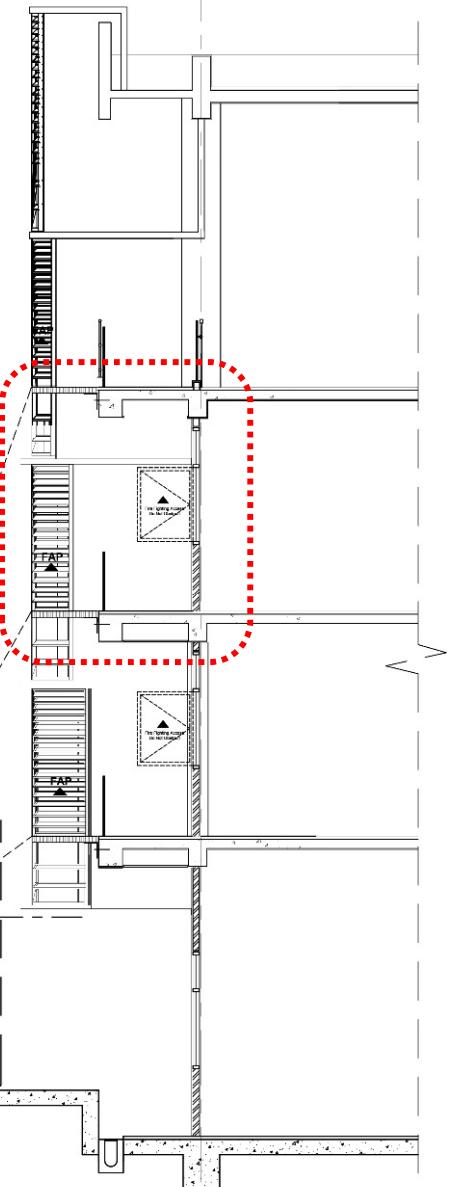
West Elevation



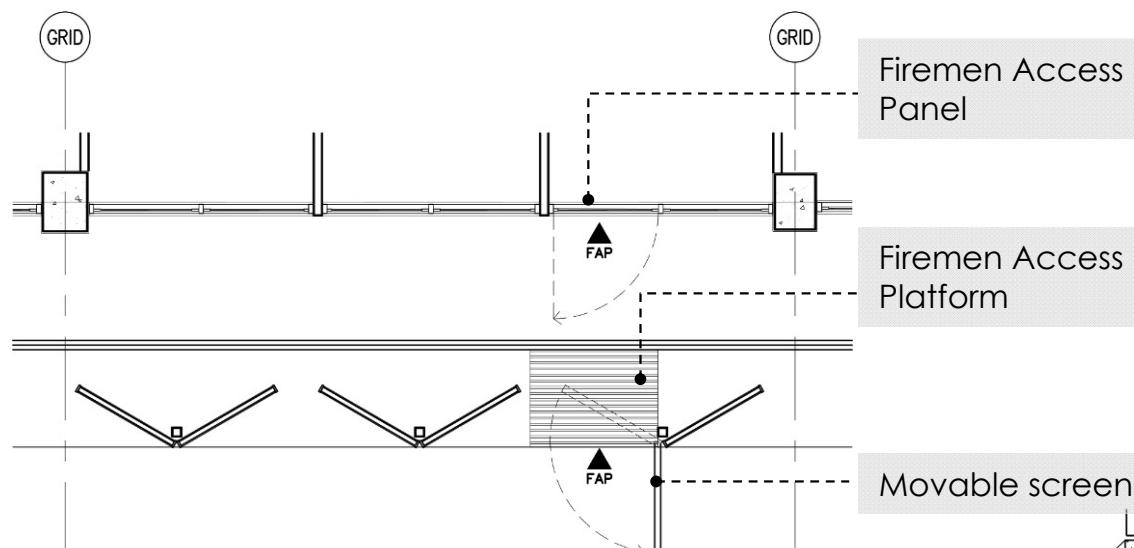
**Facade**  
Access & Maintenance Provisions



A4



Section



Detailed Part Plan

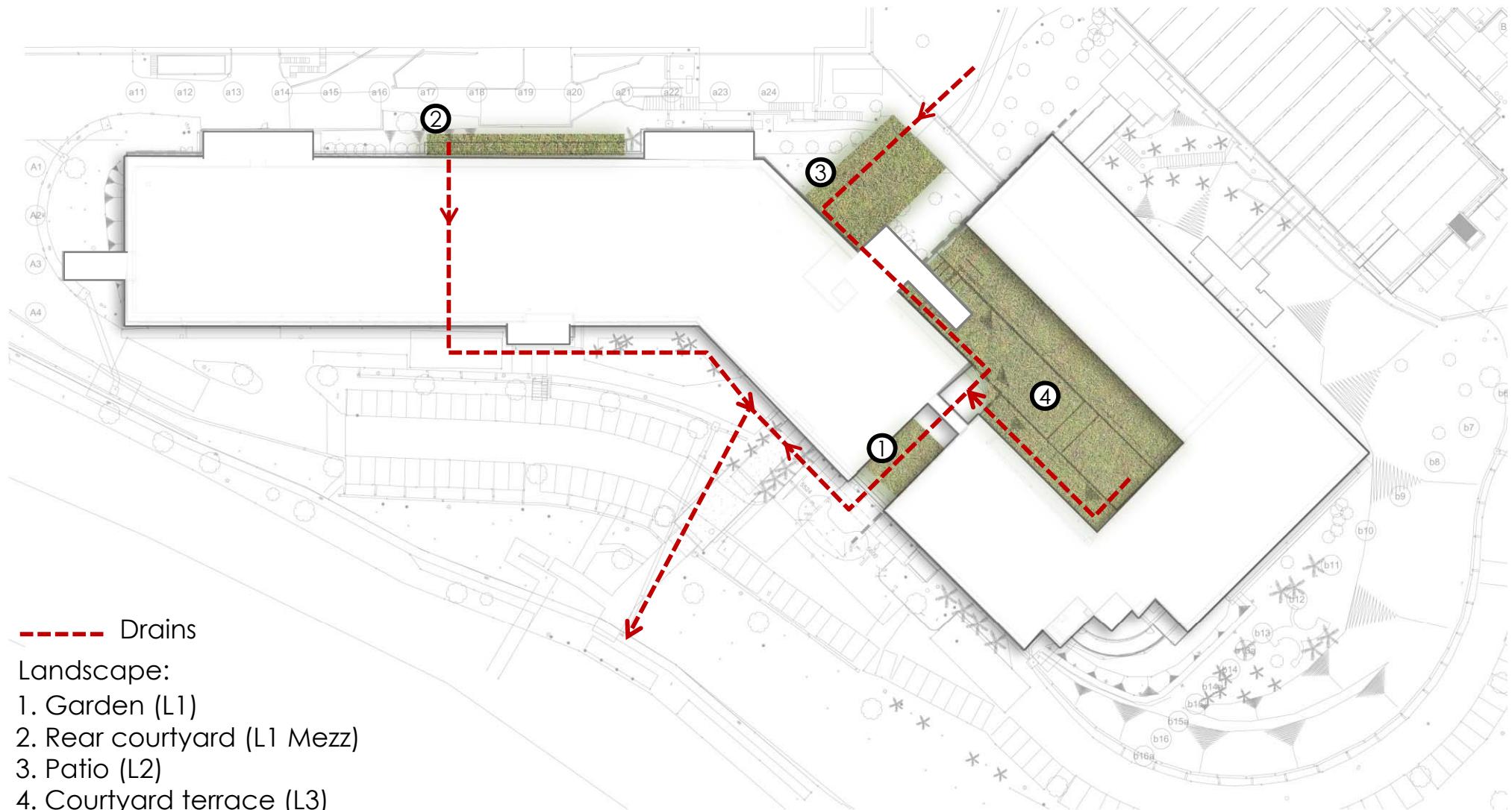
**Facade**

Firemen Access Provisions



**Facade**  
View (West façade)

# Hydrology



## Hydrology

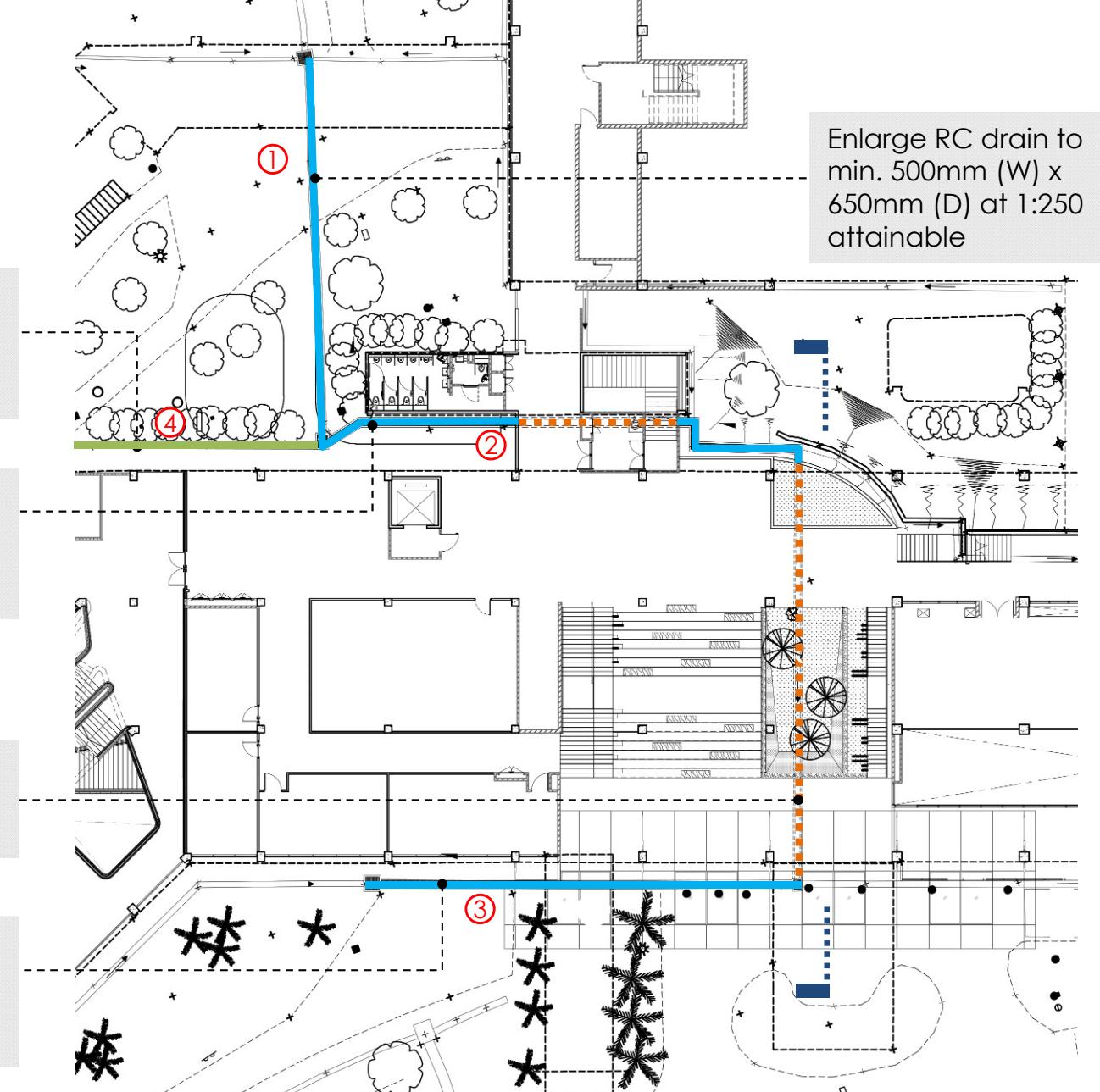
### Drains & Landscape

Existing RC drain  
acceptable; 300mm  
(W) x 800mm (D) at  
1:175 attainable

Enlarge RC drain to  
min. 600mm (W) x  
700mm (D) at 1:175  
attainable

Enlarge RC drain to  
min. 500mm dia. at  
1:10 attainable

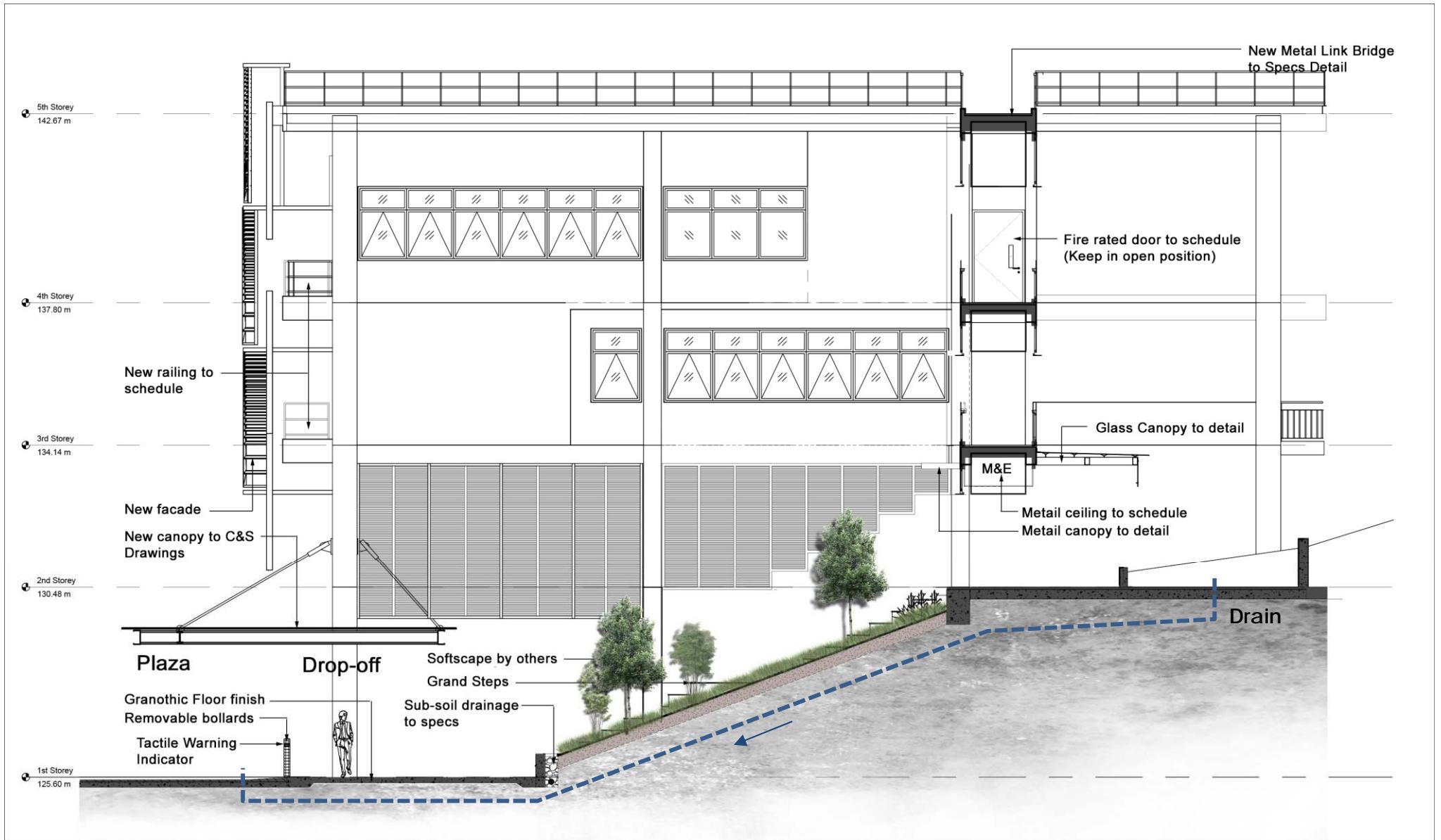
Enlarge RC drain to  
min. 600mm (W) x  
600mm (D) at 1:100  
attainable



Enlarge RC drain to  
min. 500mm (W) x  
650mm (D) at 1:250  
attainable

## Hydrology

### Drain Enlargement

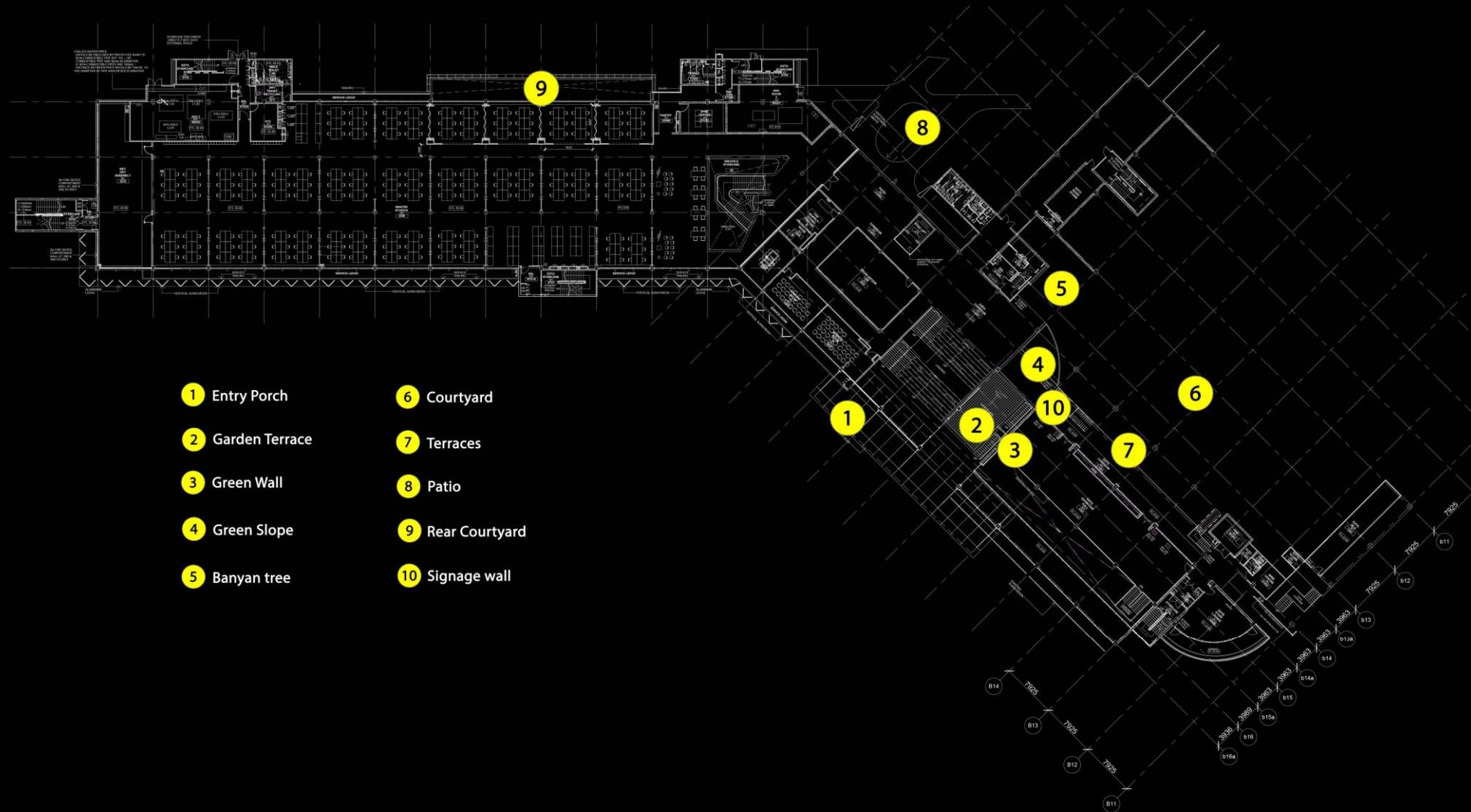


## Hydrology

Drain across the Garden

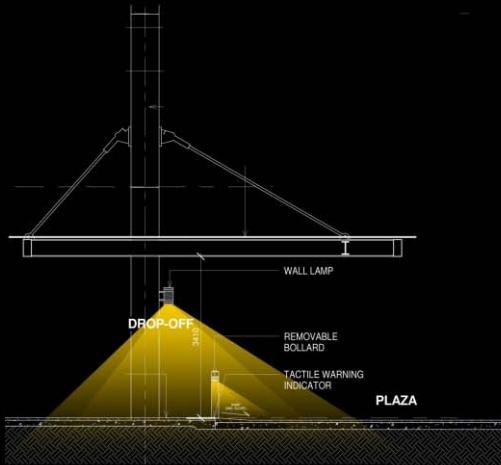
# Night Lighting

# Night Lighting



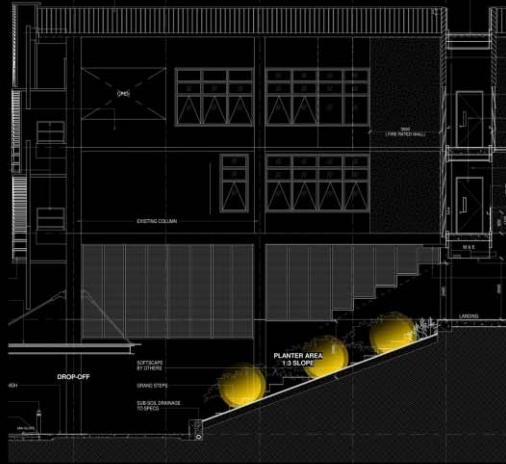
# Entrance canopy / garden terrace / green wall

1 Entry Porch



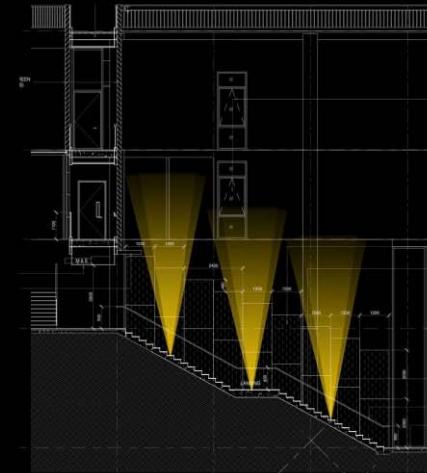
Downlights mounted at every column to light up drop-off area

2 Garden Terrace



Low level uplights to light up planted area

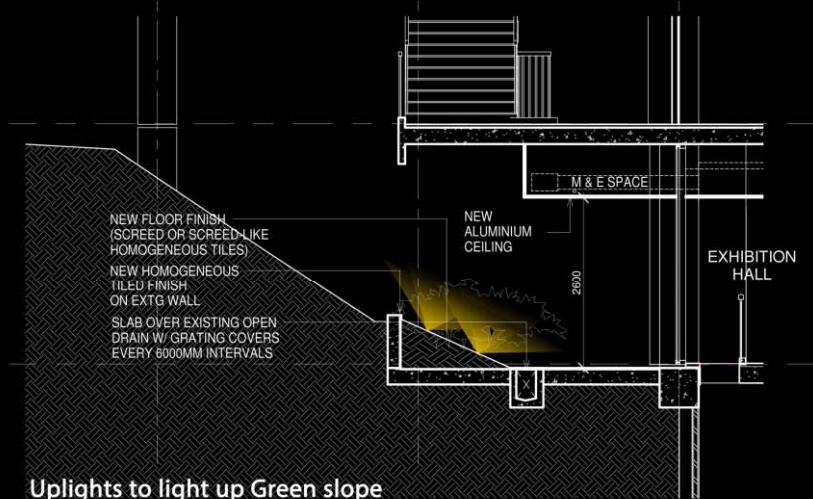
3 Green Wall



Uplights to light up Green wall

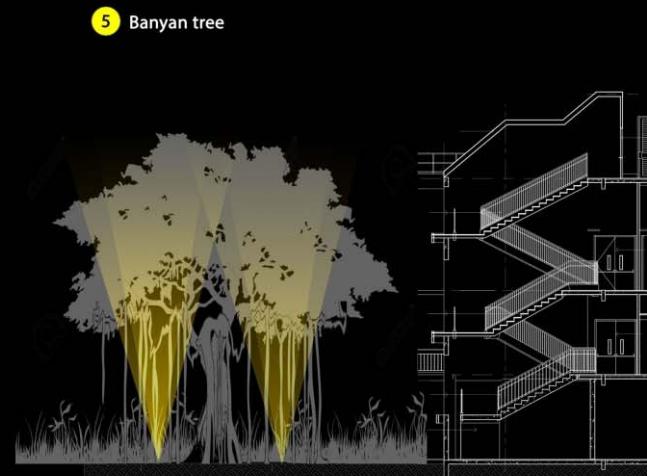


4 Green Slope

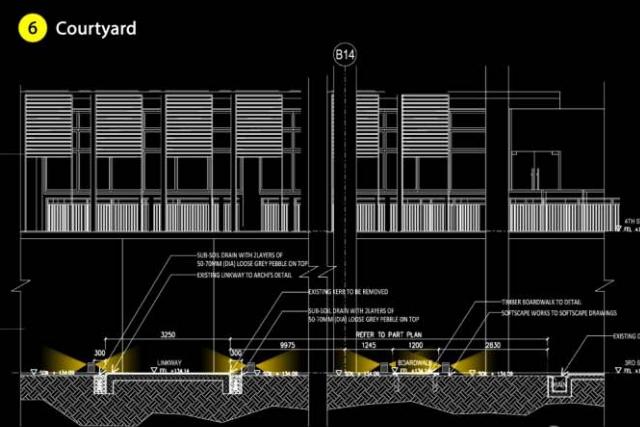


Uplights to light up Green slope

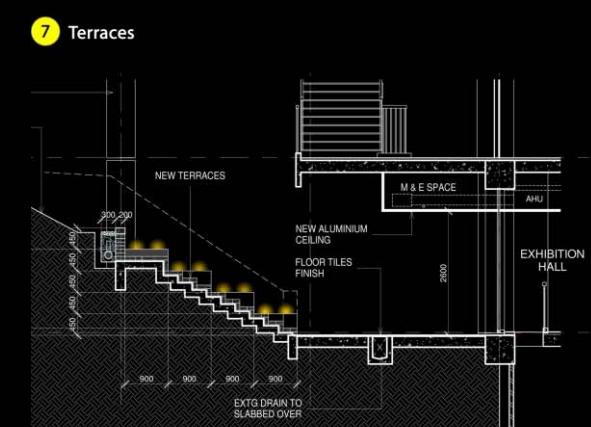
# Patio, courtyard, banyan tree



**Uplights to highlight banyan tree**



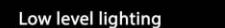
Low level bollard lights along pathway at courtyard



#### Fairy lights embedded in terrace steps

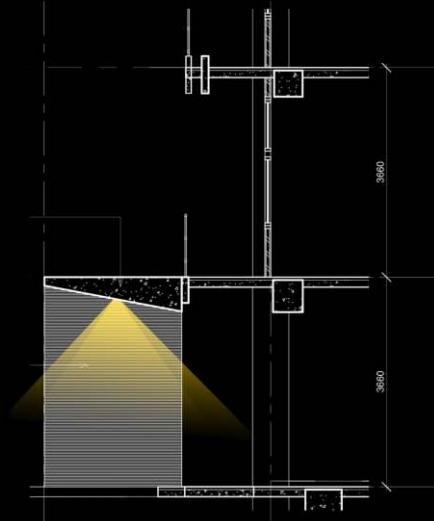


### **Uplighting to light up bodhi tree**



# Entry portal, rear courtyard

8 Patio



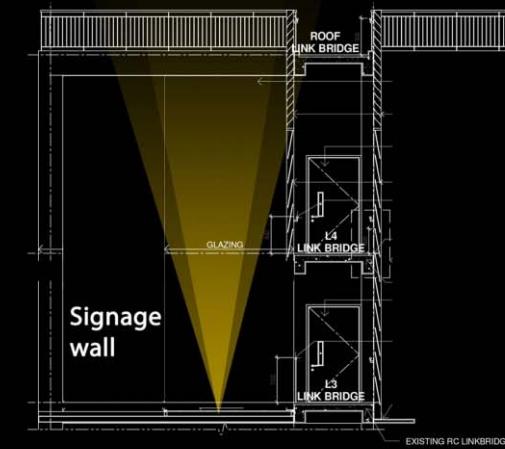
Downlight from patio canopy to light up secondary entry at L2

9 Rear Courtyard



Rear courtyard uplighting to light up planted wall

10 Signage wall



Uplighting to light up signage wall



1 Entry Porch

2 Garden Terrace

3 Green Wall

4 Green Slope

5 Banyan tree

6 Courtyard

7 Terraces

8 Patio

9 Rear Courtyard

10 Signage wall

## LEGEND

- 1. Entry porch
- 2. Garden Terrace
- 3. Green wall
- 4. Green Slope
- 5. Banyan tree
- 6. Courtyard
- 7. Fibre Optic lighting
- 8. Patio
- 9. Rear courtyard
- 10. Signage wall



**Night Lighting  
Examples**

No .	Light fitting type at designate areas	Images	Light Specification	Number of fittings	Cost
1	Downlight at drop – off area		Krislite KRISLEDZ STARLIGHT/ LED Aisle light C31015 LED 10W, Colour temperature: 3000K Dimension: 82x70x138	5	Waiting for input from Krislite
2	Low level uplights at planted area		Krislite KRISLEDZ EXPLORE C10965 LED 19W	10	Waiting for input from Krislite
3	Uplights to light up green wall		Krislite KRISLEDZ SPOT C70280 LED 25W	5	Waiting for input from Krislite
4	Uplights to light up green slope		Krislite KRISLEDZ EXPLORE C10965 LED 19W	5	Waiting for input from Krislite
5	Uplight to highlight banyan trees		Krislite KRISLEDZ EXPLORE C11000 LED 18W	2	Waiting for input from Krislite
6	Low level bollard light along pathway at courtyard		Krislite Fibre Optic lighting	12-15	Waiting for input from Krislite
7	Fairy light embedded in terraced steps		Krislite Fibre Optic lighting	88 m2	Waiting for input from Krislite
8	1. Patio: Uplighting to light up bodhi tree 2. and low lighting 3. Patio Canopy: Downlight from Patio Canopy		1. Krislite KRISLEDZ EXPLORE C11000 LED 18W 2. Krislite KRISLEDZ EXPLORE C10965 LED 19W 3. Patio Canopy: Krislite KRISLEDZ WIND C70217 LED 60W	2 2 5	Waiting for input from Krislite
9	Rear courtyard: Uplighting to light up planted wall		Krislite KRISLEDZ SPOT C70280 LED 25W	5	Waiting for input from Krislite
10	Uplighting to light up signage wall		Krislite KRISLEDZ SPOT C70280 LED 25W	2	Waiting for input from Krislite

# Materiality/ Finishes/ Detailing

# Materiality/ Finishes/ Detailing

WIP

*Views to be added*



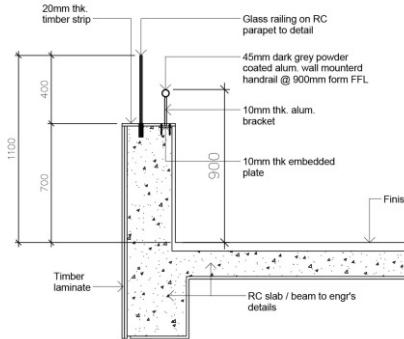
Render of the  
Grand Steps



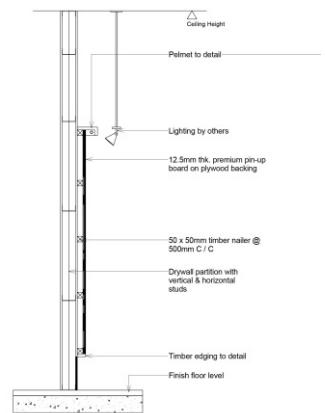
Render of the  
Studio



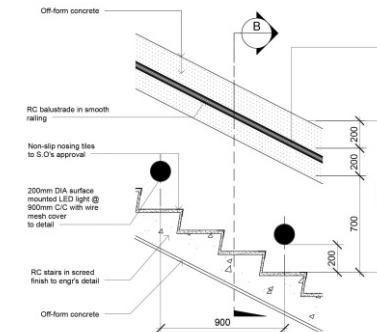
## Details



Balustrade with top glazed panel



Pin-up boards



Staircase detail with embedded light fitting

## Materials



Timber laminate staircase



Parapet Lighting



Open-atrium

Pin-up board for crit areas around knuckle foyer

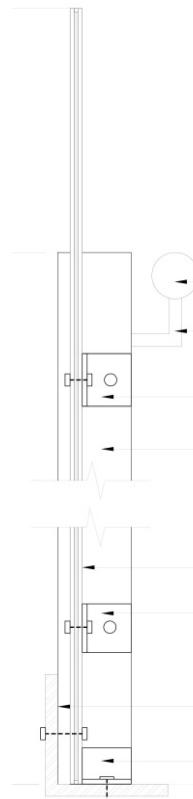
## Knuckle Foyer

Achieving warm accents via use of timber laminate

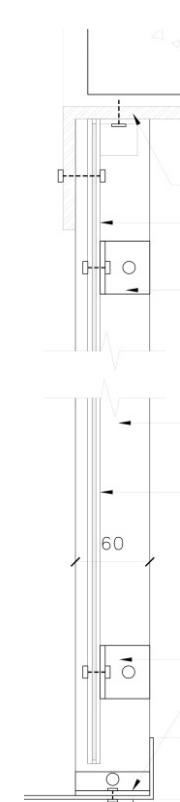


## Entrance

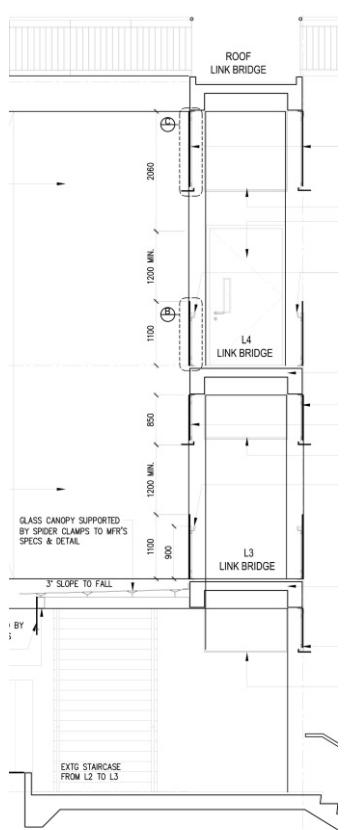
Achieving transparency through use of glass for balustrades & canopy



Glazed Balustrade detail



Fixed glazing on alum framing detail



Linkway details with glazed canopy



Baffle ceiling



Slate stone for seating



Glass railing



Bollards with lights



Green wall with mesh



Linear lighting

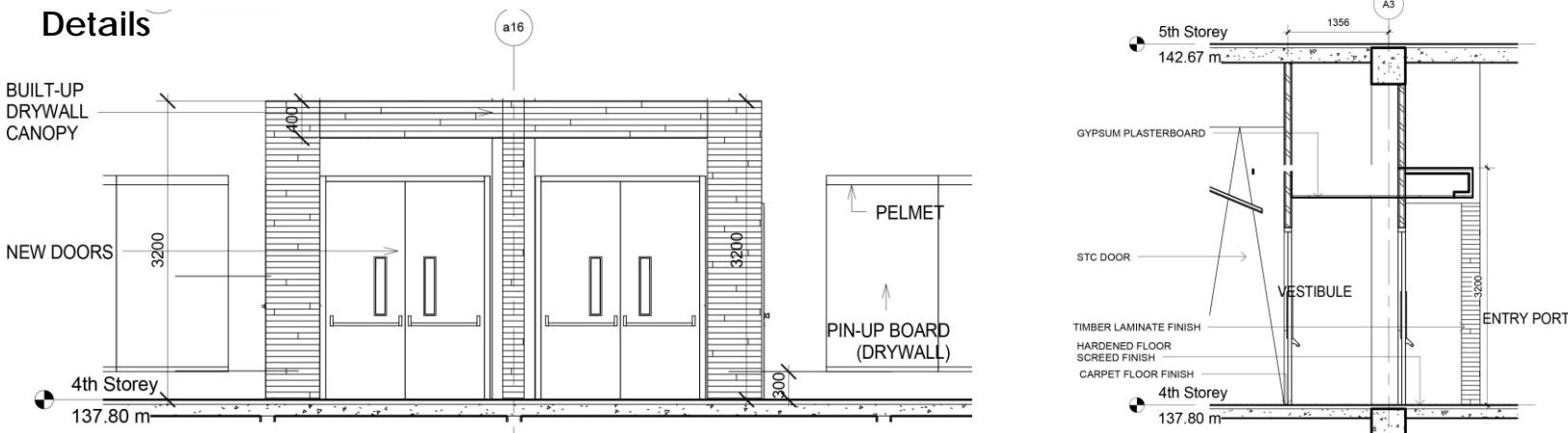


Screed floor



Timber laminate portal

## Details



Entry Portal detail

Pin-up boards

## Loggia

Timber laminate panels used as accents and for wayfinding



Pin-up board



Signage



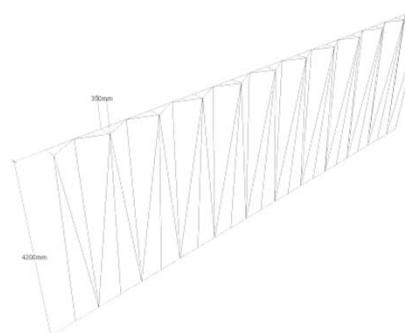
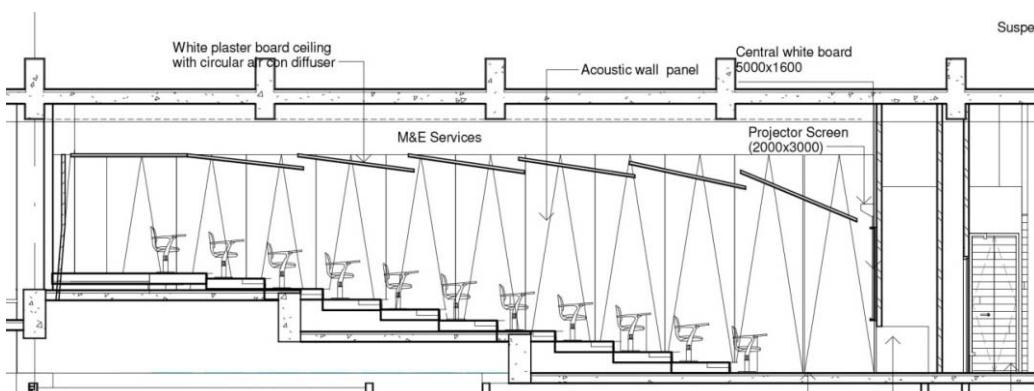
Carpet



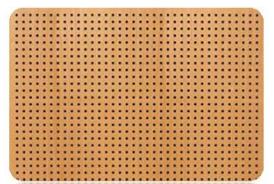
Ceiling\_Calcium silicate board



PRIMA One beam seatings with folding writing table



Faceted acoustic wall panels



Acoustic panel



Faceted timber laminate panels

## Lecture Room

Use of faceted timber laminate panels against a neutral setting

# Acoustics

## SDE 3 & 1

# **ACOUSTICS**

## **Summary of Recommendations**

---

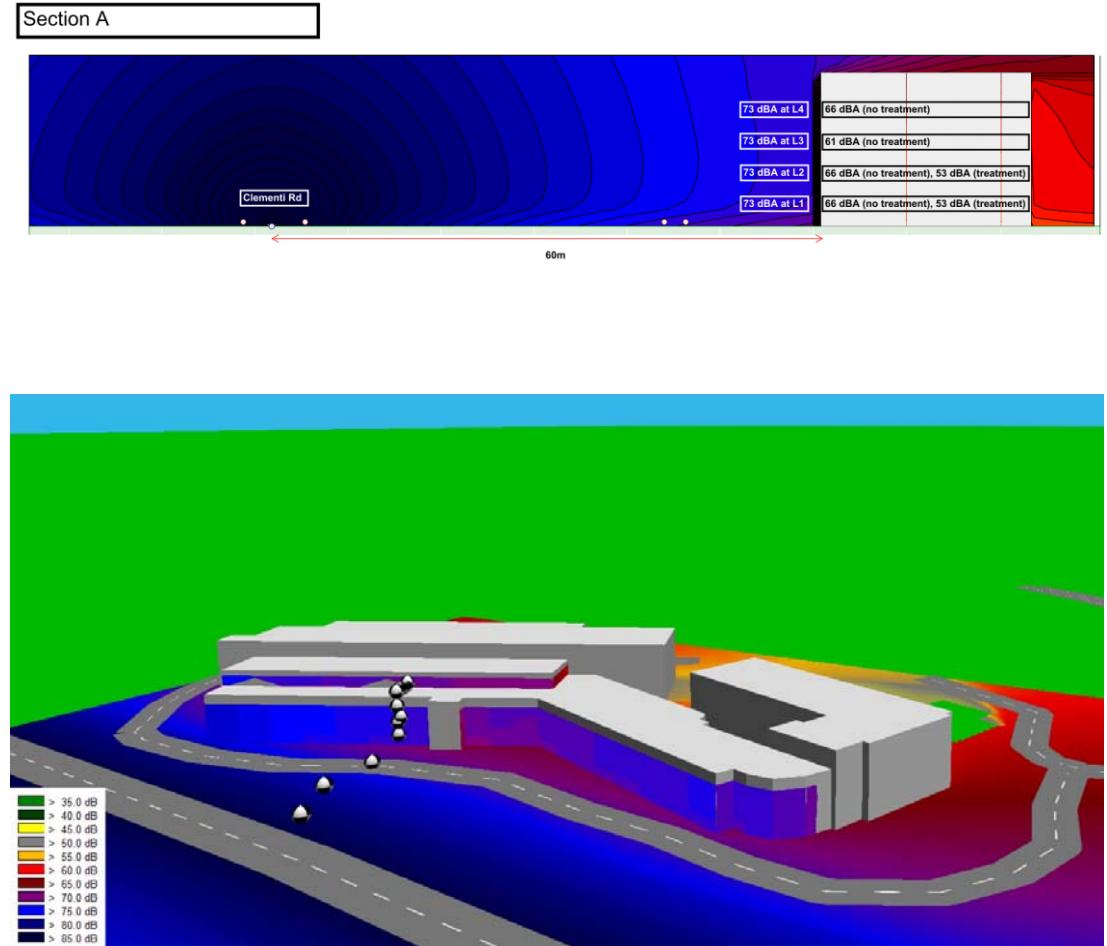
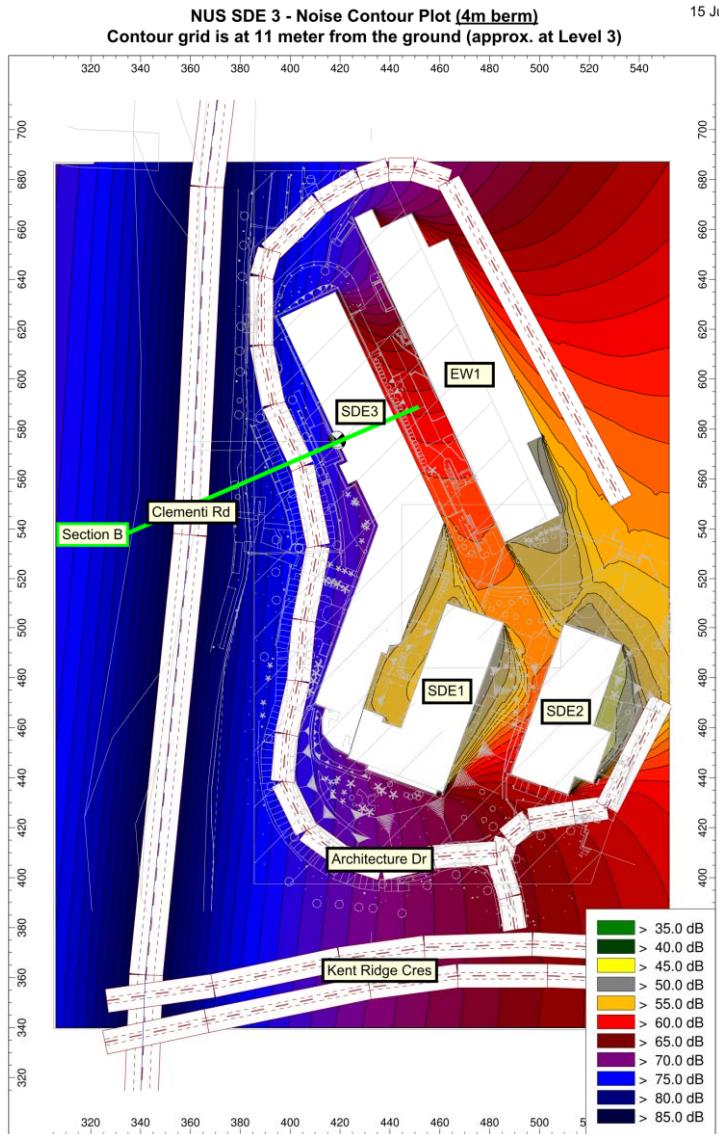
## DESIGN CRITERIA

Space/Area	NC	Approx. Level in dB(A)	Reverberation time (RT) in second
Lecture Rooms	35	40	0.5 - 0.7
Studios	35	40	0.6 – 1.2

# ACOUSTIC SURVEY AT EXISTING NUS SDE 3

Space	Date of Survey	Condition	Surveyed noise level (dBA)	Criteria (dBA)	Remarks
Façade (external)	14 – 15 July 2016	1m from façade at external space	West (facing Clementi Rd) – 72 dBA North (facing Clementi Rd) – 70 dBA East (facing Engineering Blk) – 55- 60 dBA Southeast (near SDE 1) – 55 dBA		
Studio	21 – 22 June 2016	Windows open	4m from façade – 60 dBA 9m from façade – 55 dBA 16m from façade – 50 dBA	40 dBA	Does not comply
Level 4 Lecture Theatres #424 and #427	11 November 2016	Inside theatres	Lecture Theatre #424 – 40 dBA Lecture Theatre #427 – 42-43 dBA	40 dBA	Does not comply for Lecture Theatre #427

# DESIGN STRATEGIES – FAÇADE STUDY



# DESIGN STRATEGIES – FAÇADE RECOMMENDATION

Direction	Façade STC	Façade Build Up	Predicted noise level dBA L10, 1 hr	Remarks
North	38 (glass only)	8mm monolithic – 13mm air gap – 6mm monolithic		
West	38 (glass only)	8mm monolithic – 13mm air gap – 6mm monolithic		
South	38 (glass only)	8mm monolithic – 13mm air gap – 6mm monolithic	43.2 dBA	Does not comply with criteria.
East	38 (glass only)	8mm monolithic – 13mm air gap – 6mm monolithic		

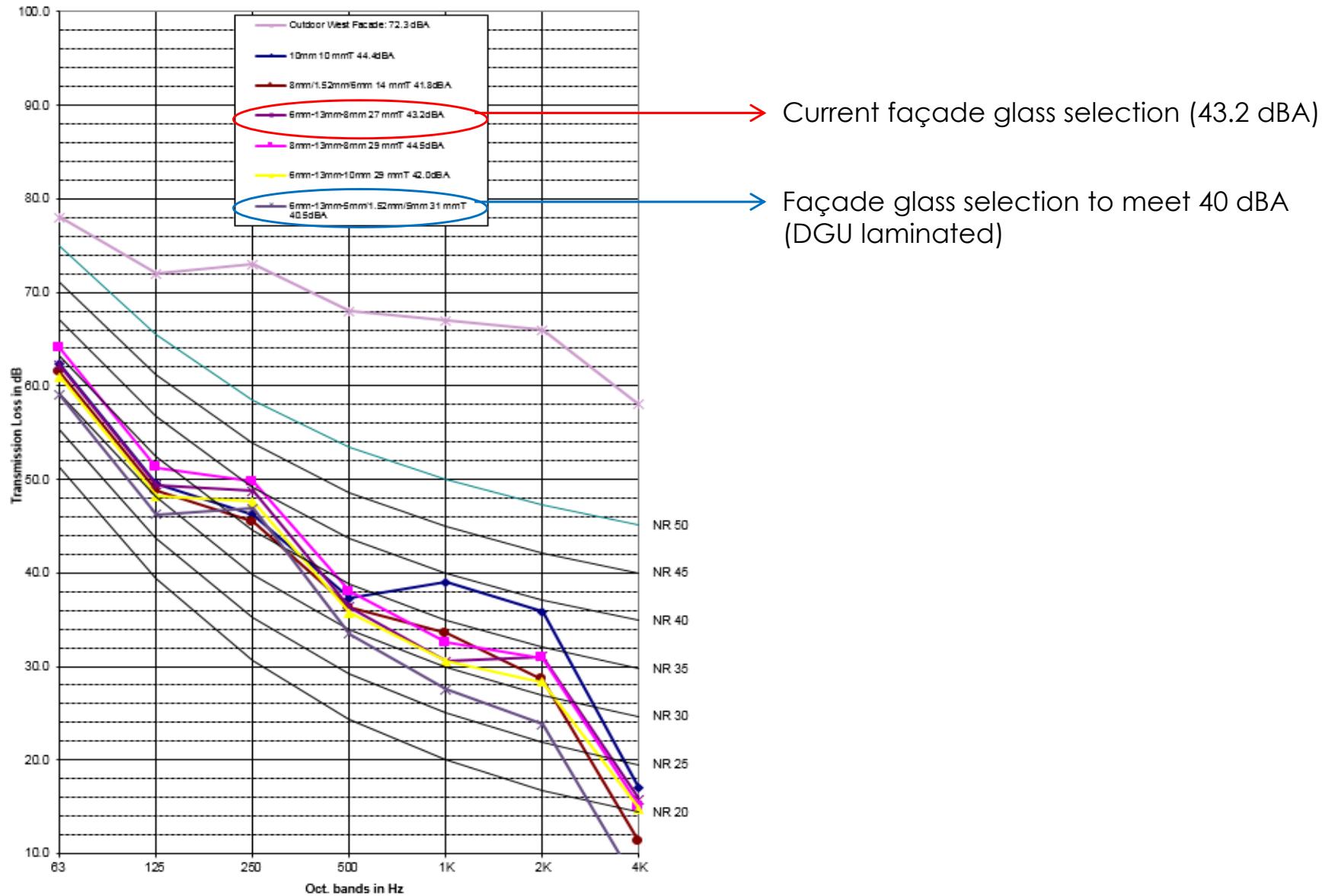
Façade STC recommendation is for glass STC only, as a guideline for glass selection.

When put into frame, the STC of the system usually becomes 3 points lower. When installed on site, there is additional 3 – 5 points reduction.

Contractor to submit laboratory test data of the selected glass and to conduct field test.

**To comply with criteria, north and west glass façade thicknesses to be increased to DGU laminated of 6mm monolithic – 13mm air gap – 11.52mm laminated.**

# DESIGN STRATEGIES – FAÇADE GLASS THICKNESS COMPARISON



## DESIGN STRATEGIES – WALLS AND DOORS RECOMMENDATION

Area	Location	Cross wall STC	Front wall STC	Door STC
Studio	SDE 3 – Level 2 and Level 3  (see adjacent space)		50	35
Lecture Rooms	SDE 3 – Level 4	60	52	2xSTC 40 doors with minimum 1.5m vestibule

## DESIGN STRATEGIES – WALLS AND DOORS BUILD UP

STC	Door	Wall (new construction)	Wall (improvement to existing)
35	50mm solid core door with perimeter and drop seals	-	-
40	Proprietary acoustic door with laboratory certificate	-	-
50	-	2x16mm gypsumboard on both sides with 64mm steel studs (total <u>128mm</u> )	Alternative 1: Existing wall + 25mm clear gap infilled with rockwool + 50mm studs infilled with rockwool  Alternative 2 ( <u>masonry</u> ): Existing wall + 50mm cavity infilled with rockwool + 100mm ALC with 15mm plaster
52	-	2x16mm gypsumboard on both sides with 92mm steel studs (total <u>156mm</u> )	Existing wall + 25mm clear gap infilled with rockwool + 50mm studs infilled with rockwool

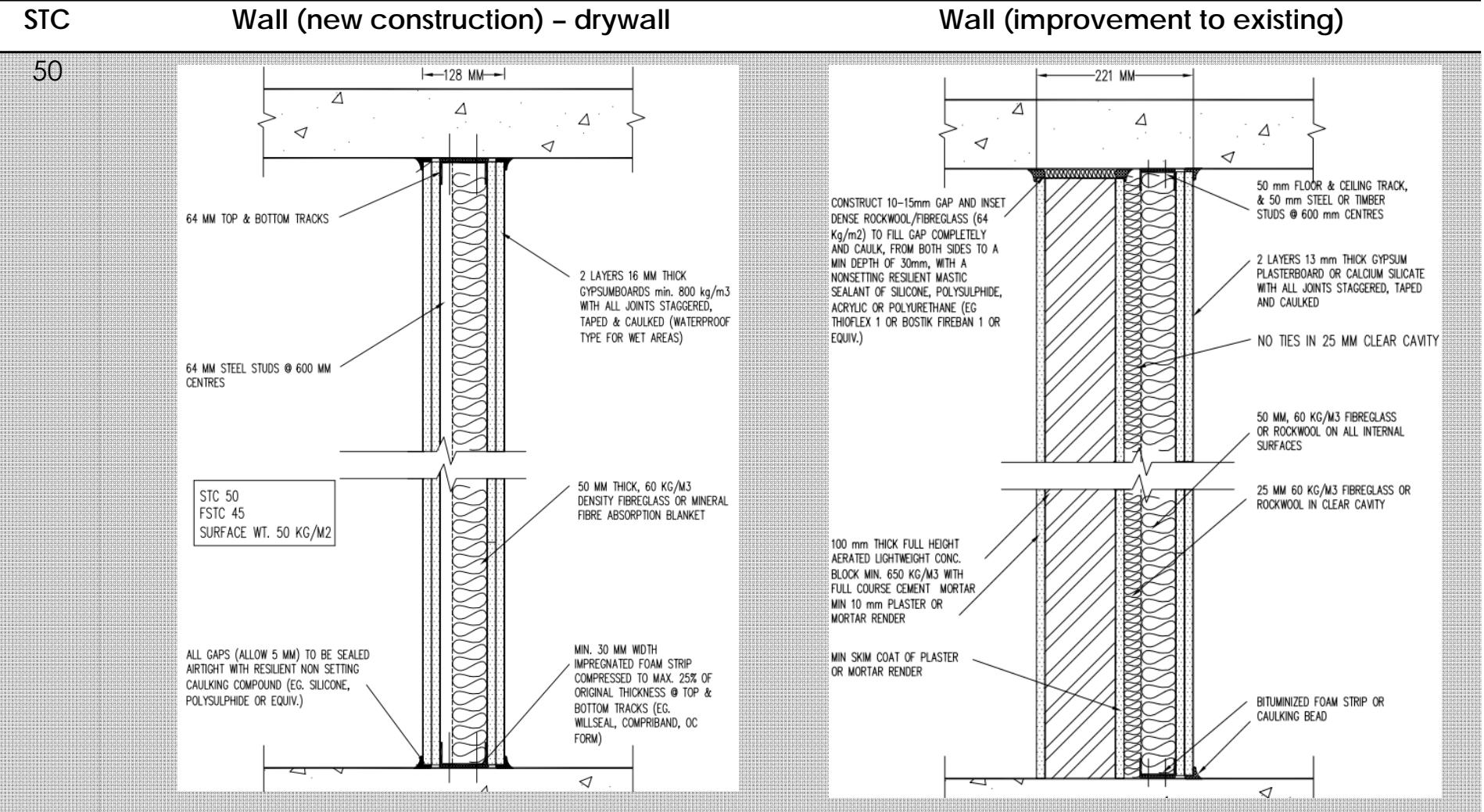
Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

## DESIGN STRATEGIES – WALLS AND DOORS BUILD UP

STC	Door	Wall (new construction)	Wall (improvement to existing)
60	-	2x16mm gypsumboard on both sides with 2x64mm independent twin studs with 20mm clear gap (total <b>212mm</b> )	Existing wall + 50mm studs infilled with rockwool and 2x16mm gypsumboard on each side. One side to have additional clear gap of 20mm.

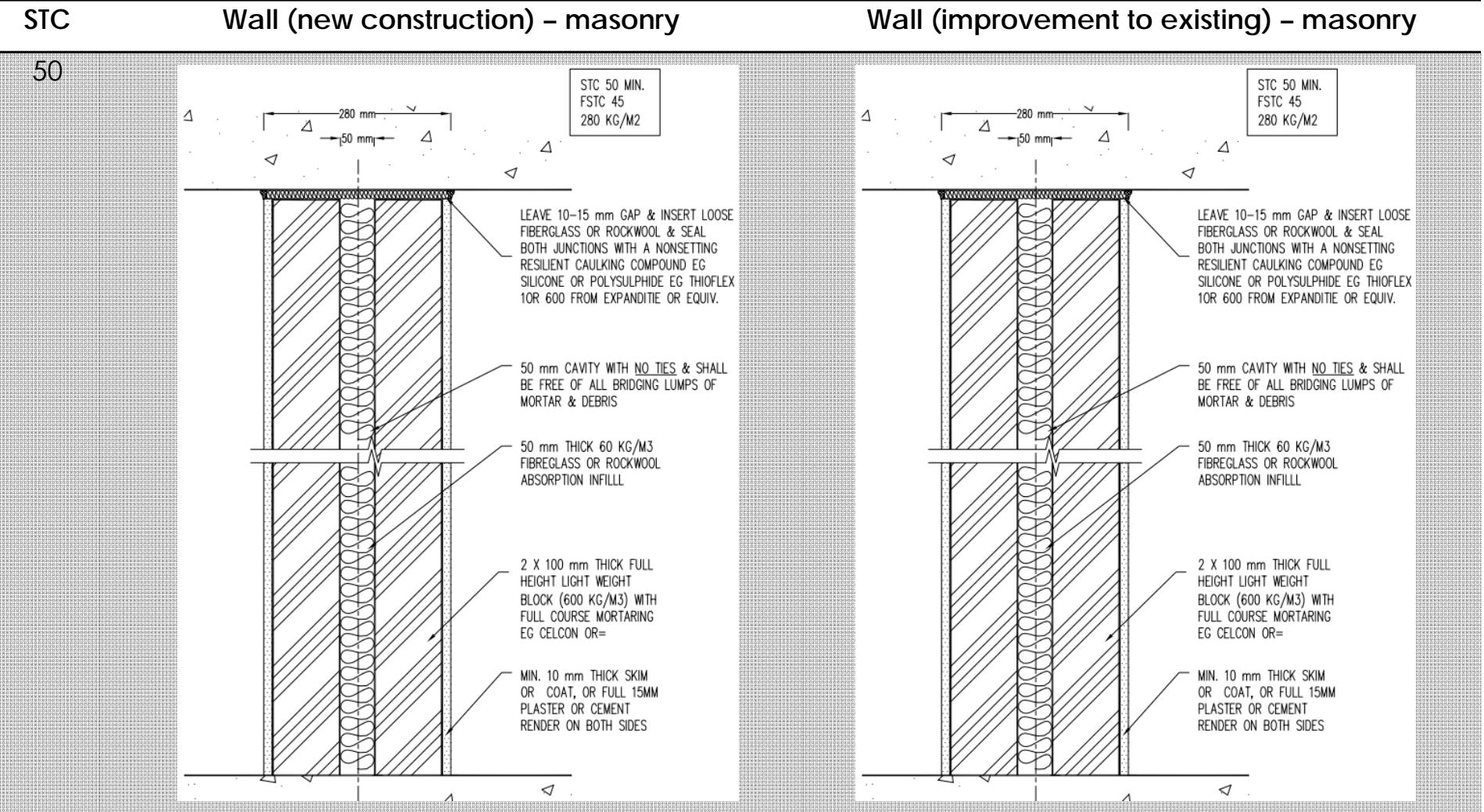
Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

# DESIGN STRATEGIES – WALLS TYPICAL DETAILS



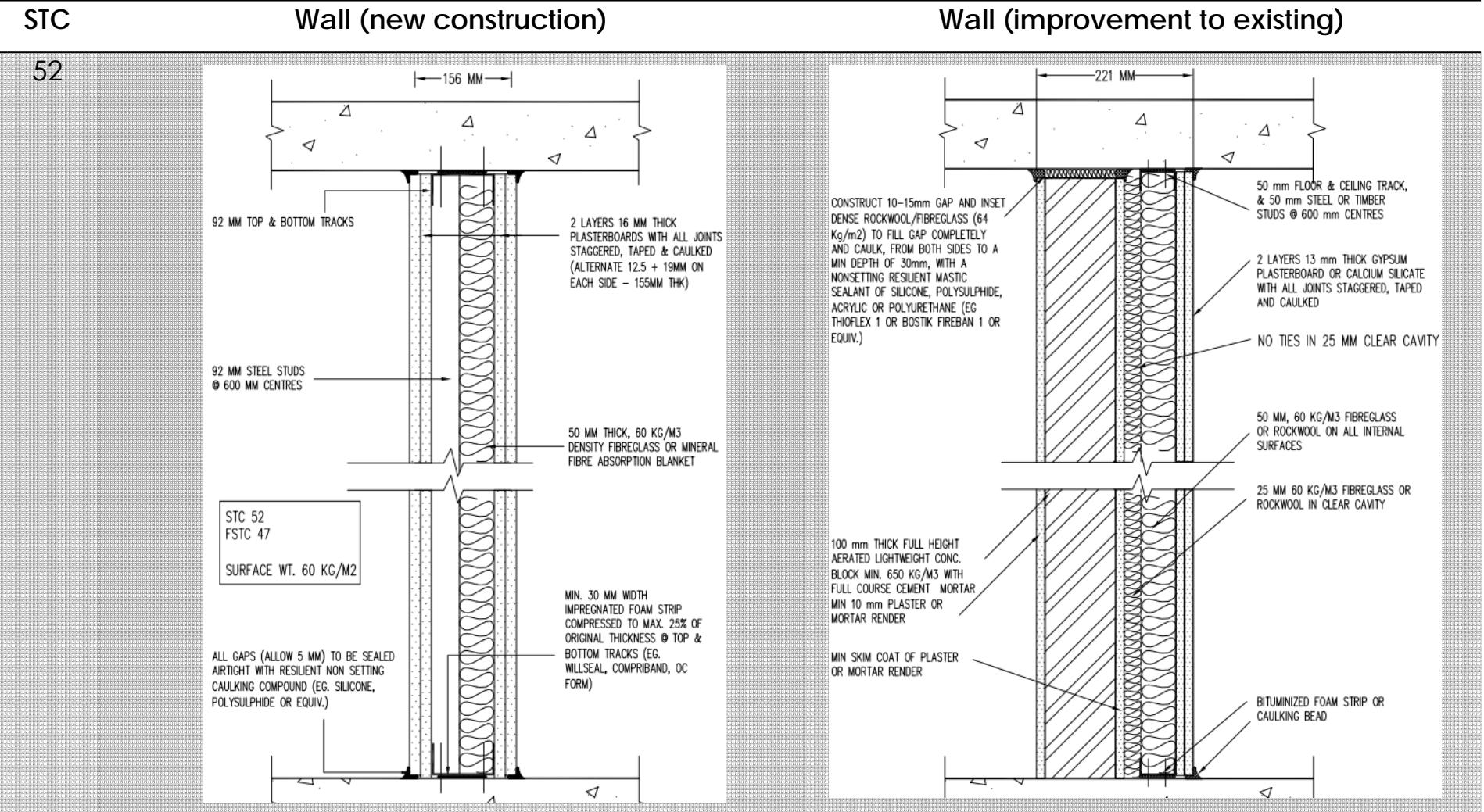
Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

# DESIGN STRATEGIES – WALLS TYPICAL DETAILS



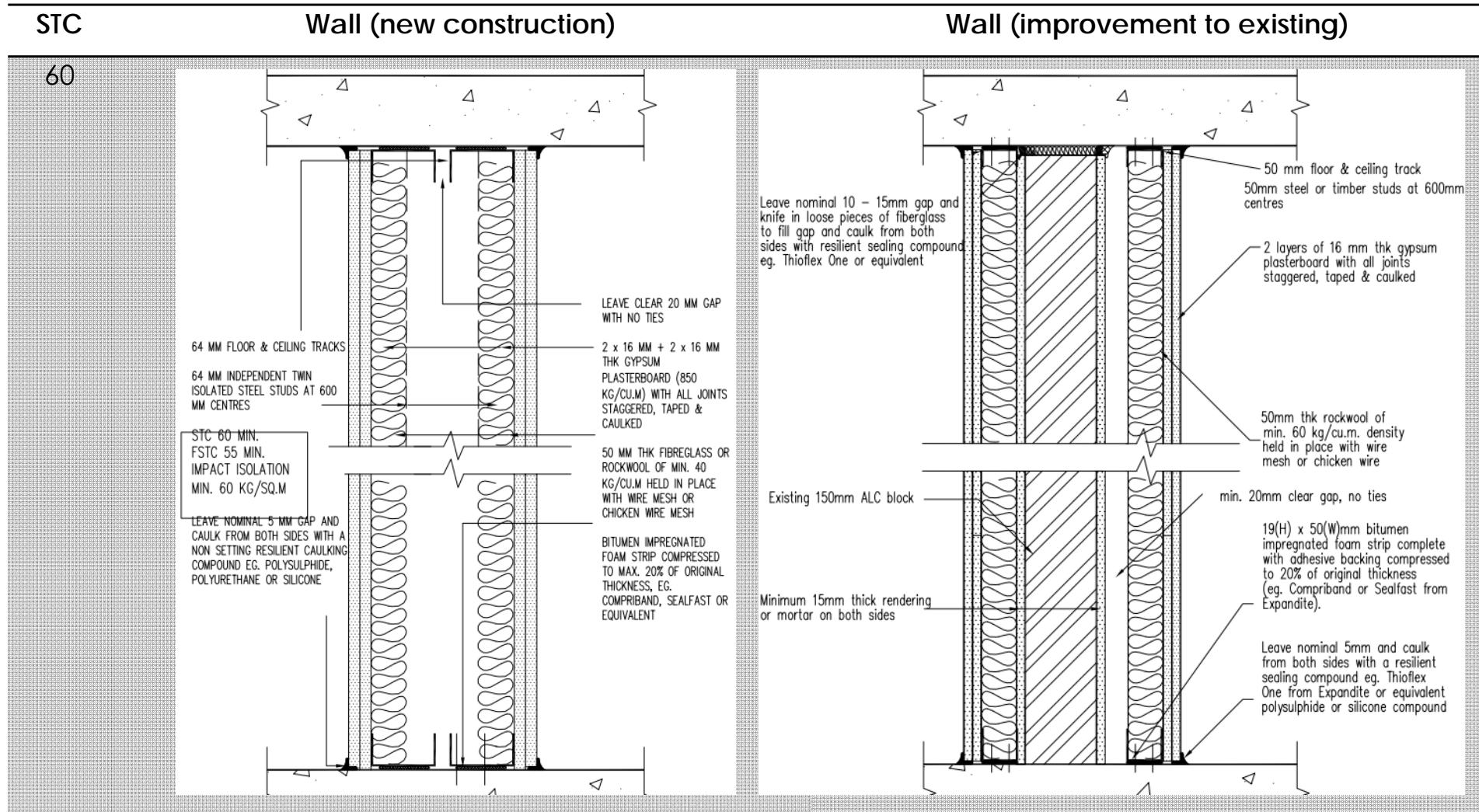
Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

# DESIGN STRATEGIES – WALLS TYPICAL DETAILS



Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

# DESIGN STRATEGIES – WALLS TYPICAL DETAILS



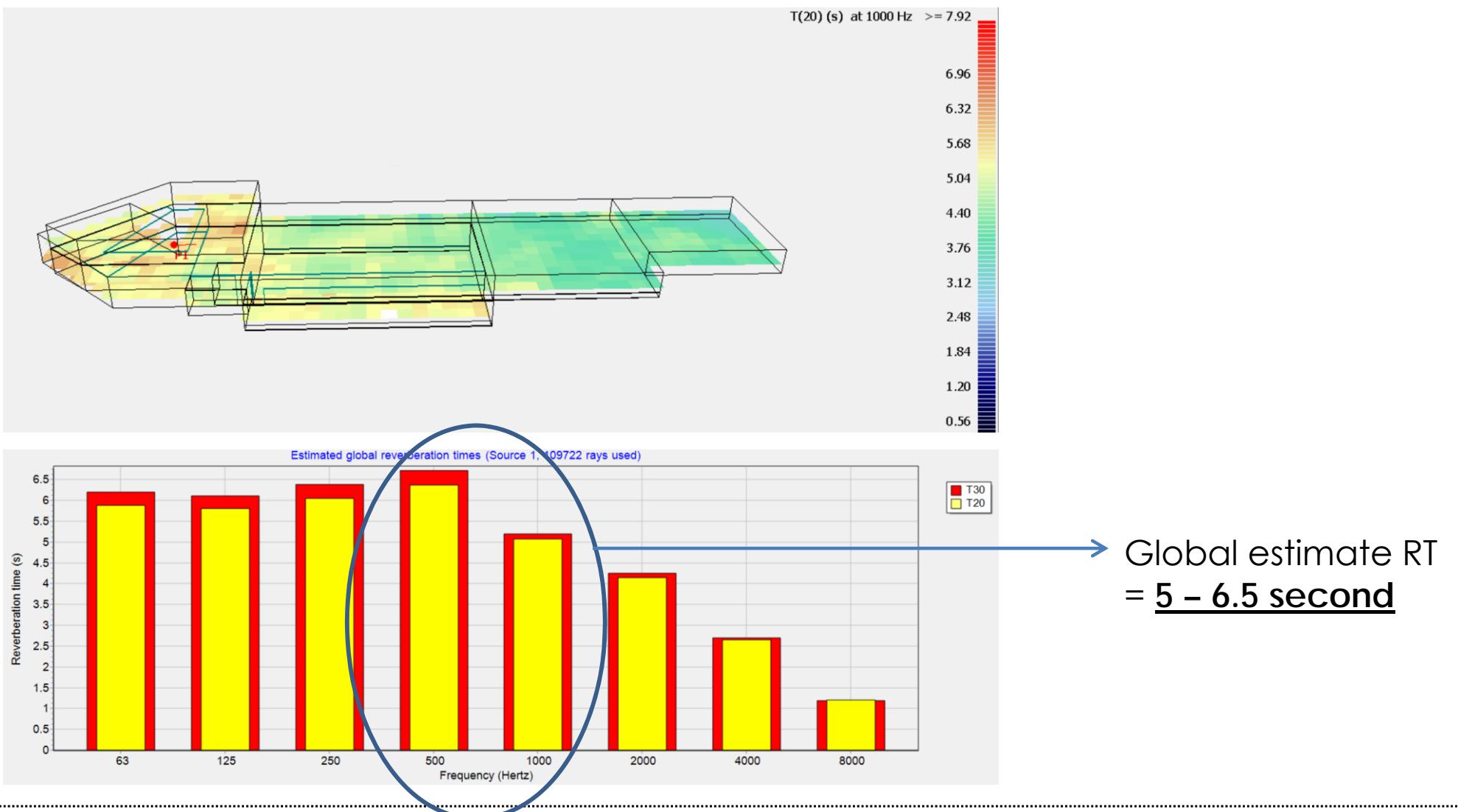
Note: existing wall is assumed to be 100 – 150mm thick brick wall (1300 kg/m<sup>3</sup>)

# DESIGN STRATEGIES – INTERIOR ACOUSTICS

Area	Location	NRC Ceiling & %area	NRC Wall & %area	NRC Floor & %area
Studio	SDE 3 – Level 2 and Level 3	NRC 0.8, 80%	NRC 0.5 to applicable perimeter wall	
Lecture Rooms	SDE 3 – Level 4	NRC 0.05, 100% (normal gypsumboard)	NRC 0.8, 100% rear wall, 70% side walls, 50% side walls from 1-3m FFL	NRC 0.35, 100% (carpet)
Loggia	SDE 3 – Level 4	NRC 0.8, 80%		

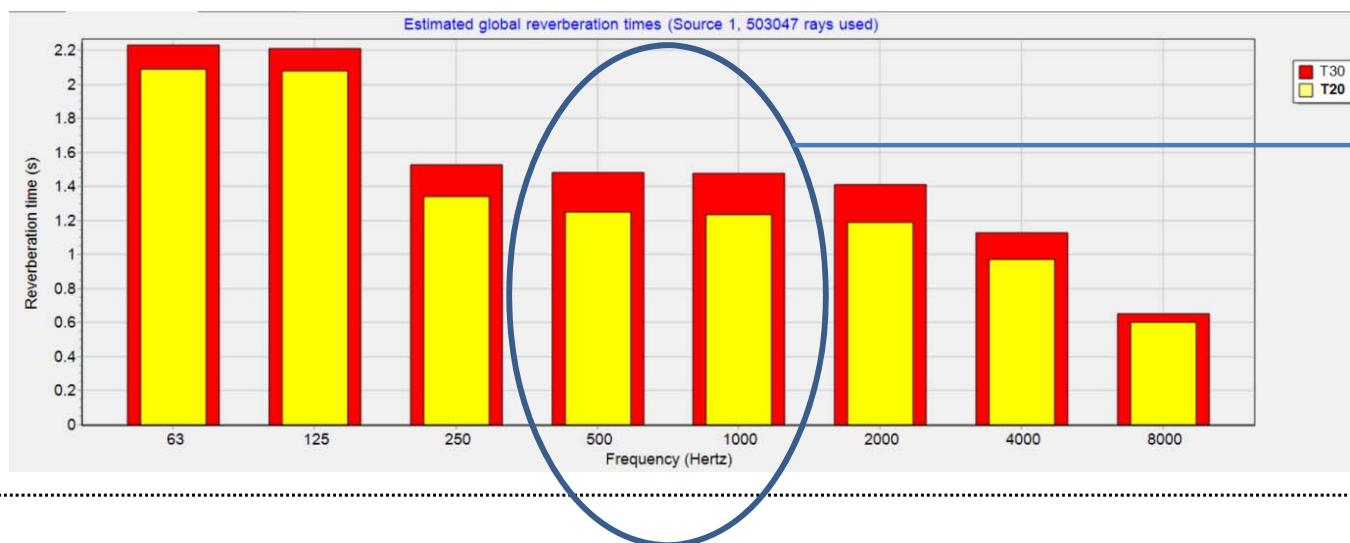
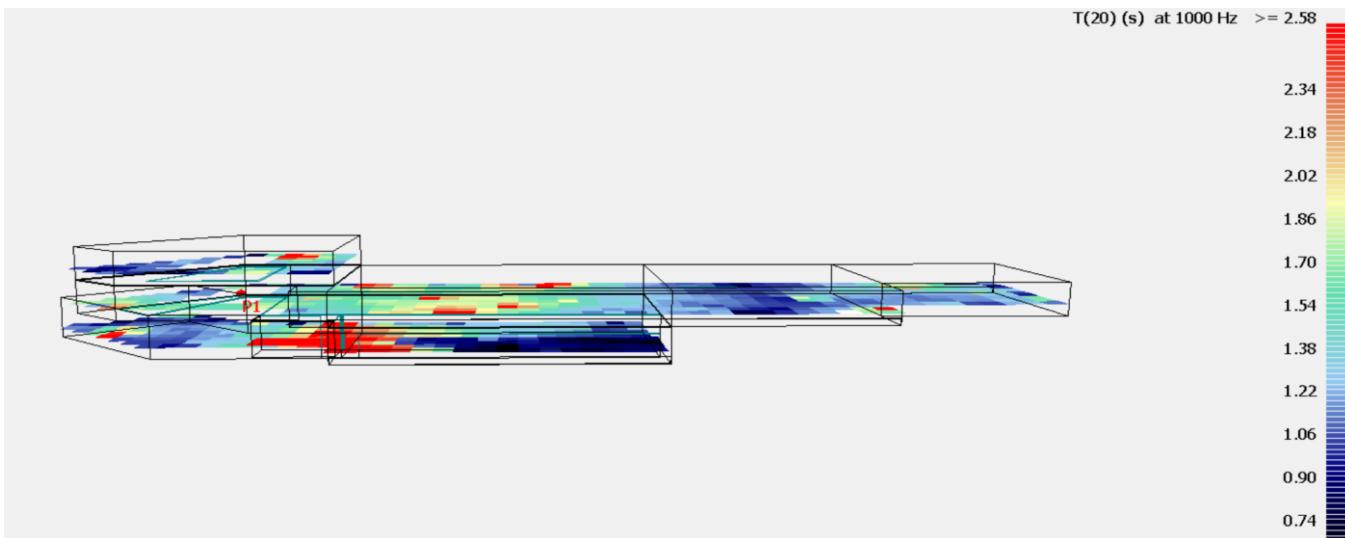
# DESIGN STRATEGIES – INTERIOR ACOUSTICS STUDIO&CRIT SPACE SIMULATION

Without acoustic treatment



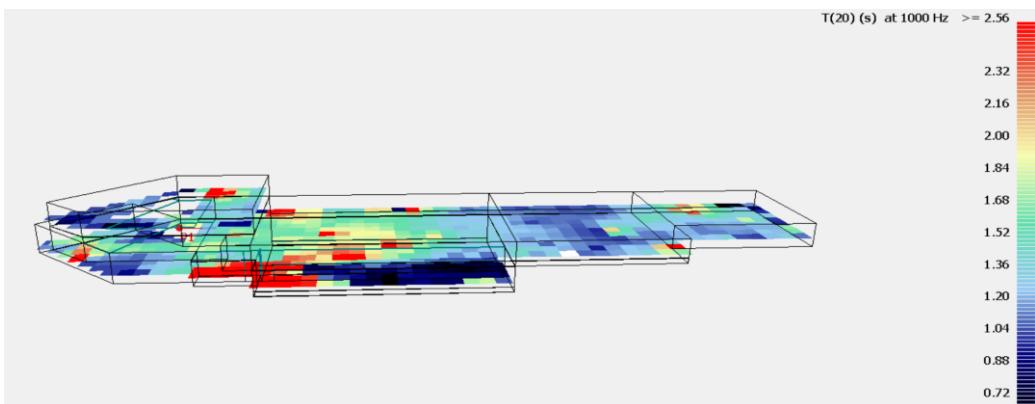
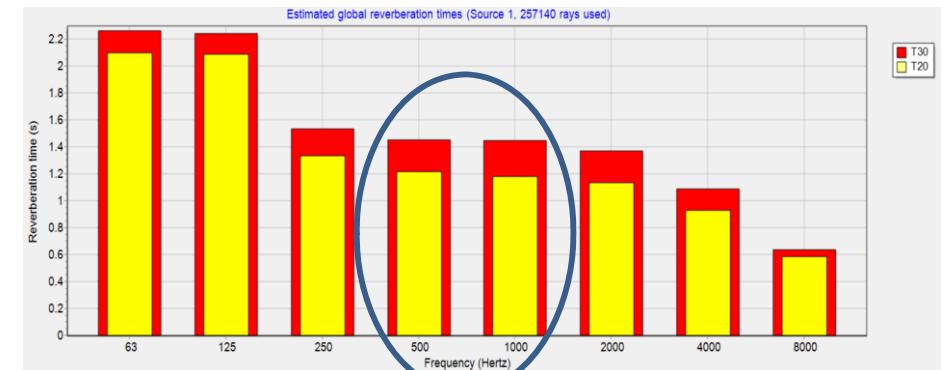
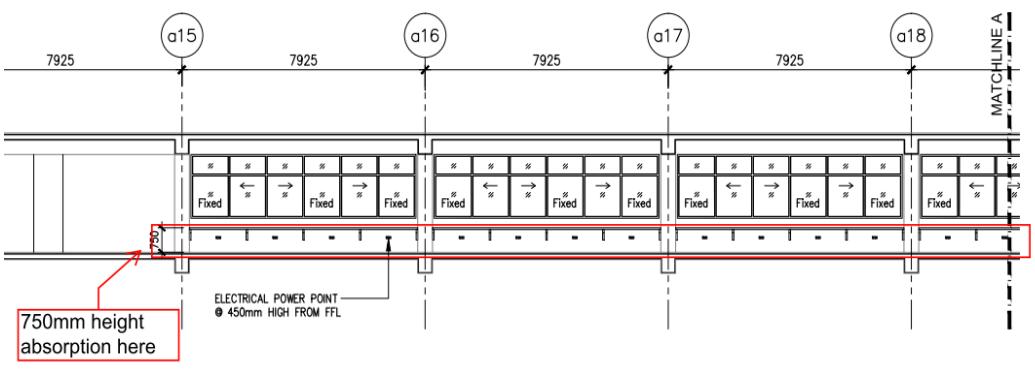
# DESIGN STRATEGIES – INTERIOR ACOUSTICS STUDIO&CRIT SPACE SIMULATION

Treatment 1: acoustic ceiling spray NRC 0.85, applied to 100% ceiling area



# DESIGN STRATEGIES – INTERIOR ACOUSTICS STUDIO&CRIT SPACE SIMULATION

Treatment 2: acoustic ceiling spray NRC 0.85, applied to 100% ceiling area  
wall absorption NRC 0.5, applied to applicable wall area (750mm)



Global estimate RT  
= 1.2 – 1.4 second

# DESIGN STRATEGIES – INTERIOR ACOUSTICS STUDIO&CRIT SPACE SIMULATION SUMMARY

Treatment	RT Result (Global estimate)	RT Criteria	Remarks
None	5 – 6.5 seconds	0.6 – 1.2	Does not comply. Space will be too reverberant and very bad for speech intelligibility.
Ceiling: NRC 0.85 acoustic spray to 100% ceiling space	1.2 – 1.4 second	0.6 – 1.2	Marginally complies with criteria.
Ceiling: NRC 0.85 acoustic spray to 100% ceiling space	1.2 – 1.4 second	0.6 – 1.2	Marginally complies with criteria.
Wall: NRC 0.5 absorptive wall panel at 0 - 750mm height FFL to applicable perimeter wall space			

Conclusion:

- Acoustic spray ceiling significantly reduces RT thus provides better speech intelligibility within the space.
- Effect of absorptive wall panel is negligible.

# DESIGN STRATEGIES – INTERIOR ACOUSTICS MATERIAL

Area	NRC	Description	Typical example/product
Ceiling	NRC 0.8	Acoustic ceiling spray (50mm) or suspended acoustic sub-ceiling or StoSilent seamless acoustic ceiling (expensive)	<p>K13 Spray System (spray)</p>  <p>Armstrong Optra (suspended ceiling)</p> 

# DESIGN STRATEGIES – INTERIOR ACOUSTICS MATERIAL

Area	NRC	Description	Typical example/product
Wall (Lecture Room)	NRC 0.8	Typically 50mm acoustic wall panel	Autex QuietSpace  A photograph showing a large, light-colored acoustic panel installed on a wall. The panel has a subtle texture and is part of a larger room setup. The brand name 'QuietSpace' and 'Panel' is visible in the bottom right corner of the panel itself.

# DESIGN STRATEGIES – ACMV NOISE CONTROL

Area	Location	Noise Control Strategies to get NC 35/40 dBA
Lecture Rooms and Loggia	SDE 3 – Level 4	<p>AHU at loggia ceiling space:</p> <ul style="list-style-type: none"> <li>• Enclose with STC 35 enclosure OR to provide double skin AHU to meet 60 dBA at 1 meter</li> <li>• Provide attenuator of 1.8m length upstream and downstream</li> <li>• Lag the duct with 25mm rockwool + 2mm lagging (5 kg/m<sup>3</sup>) for at least 6 meters upstream and downstream</li> </ul>

## DESIGN STRATEGIES – ACMV NOISE CONTROL

Area	Location	Noise Control Strategies
Other areas	All floors	Refer to ACMV Noise & Control specification and schedule of sound attenuation requirement.

Break Time...

# **Environmentally Sustainable Design**

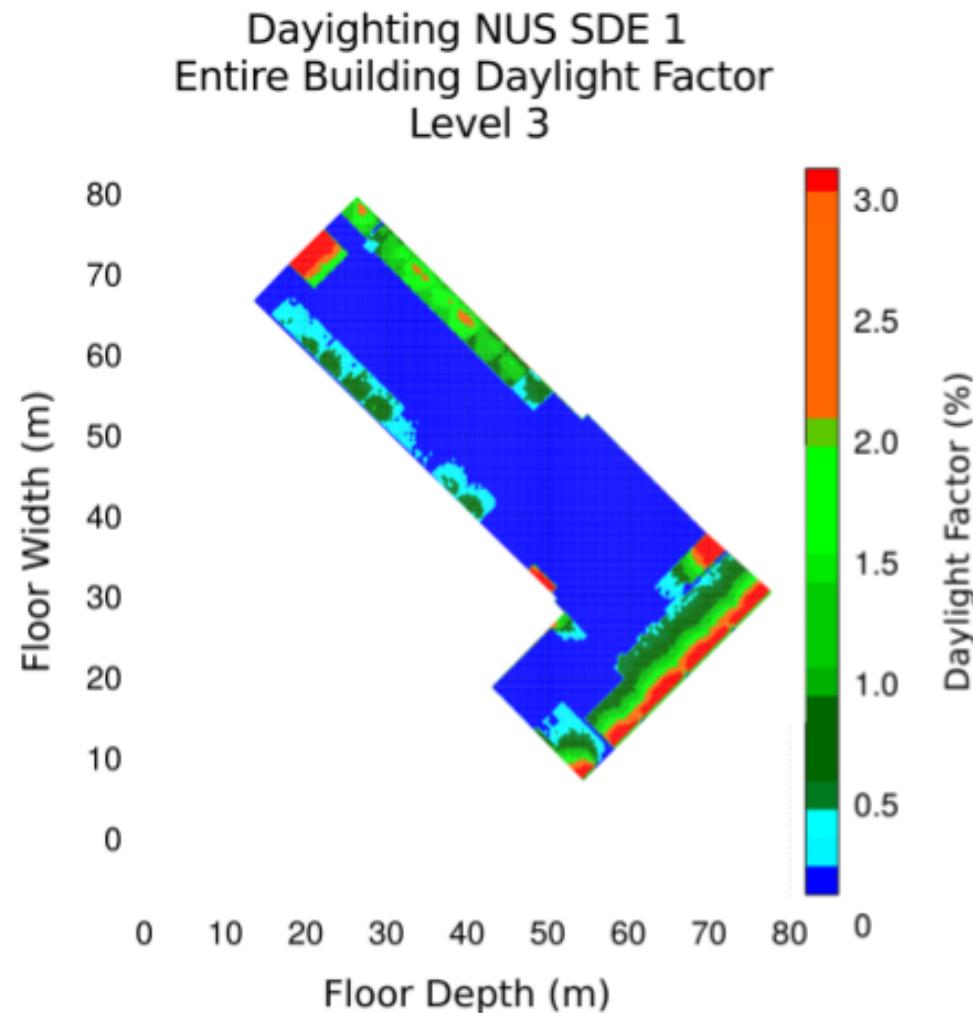
## **SDE 3 & 1**

DAYLIGHT

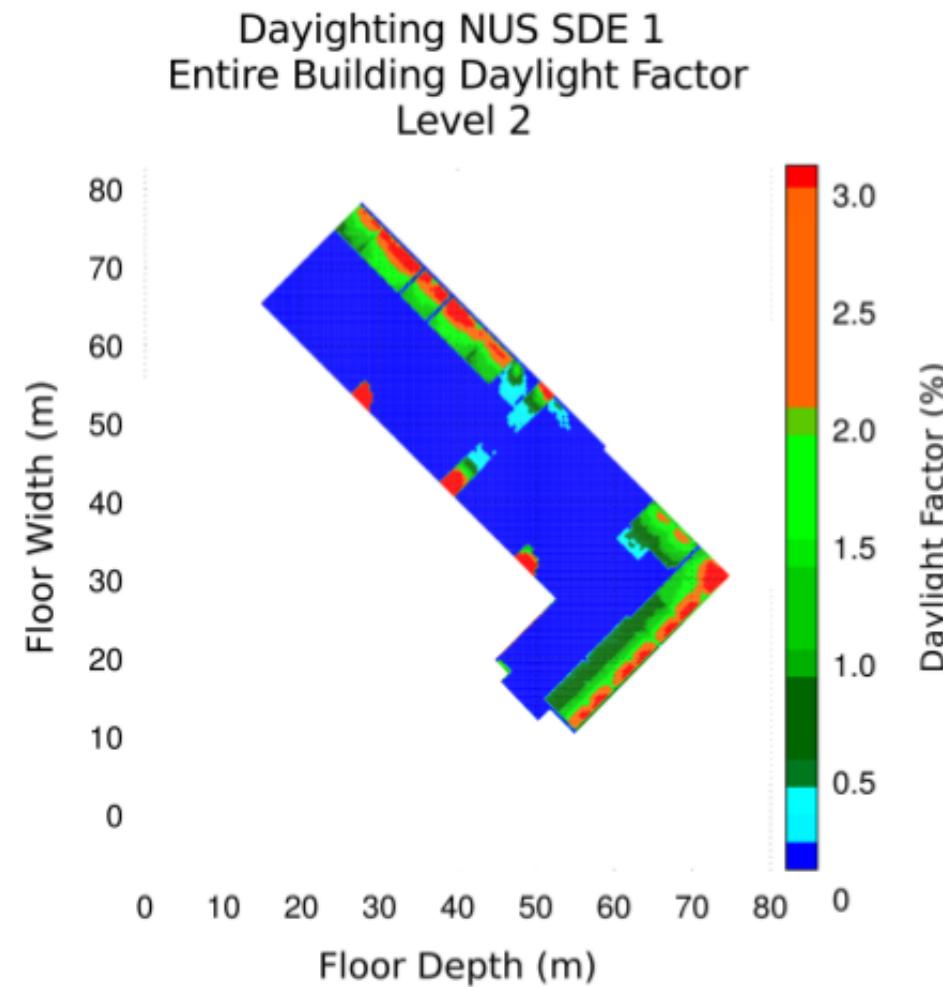
DAYLIGHT

SDE 1

# Daylight Penetration SDE1



# Daylight Penetration SDE1

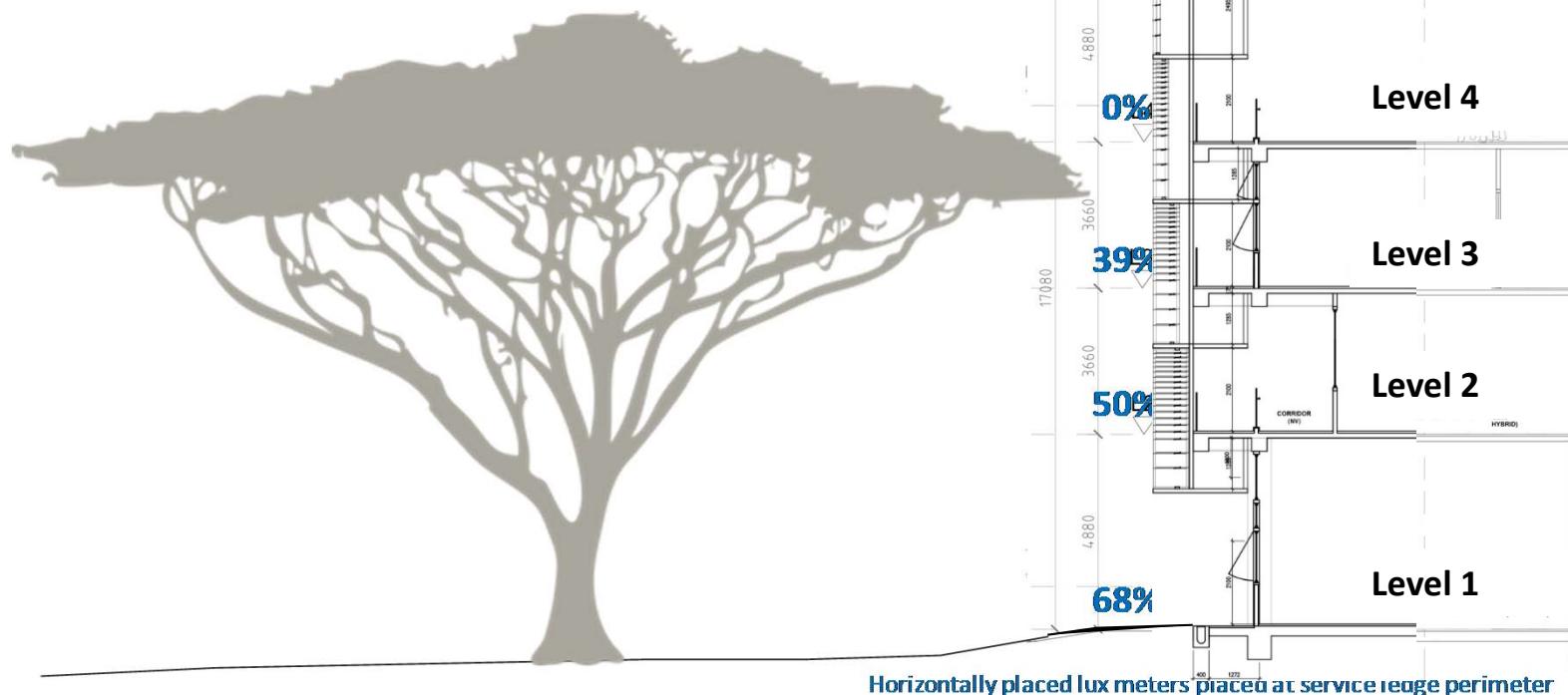


DAYLIGHT

SDE 3

# SDE3 West Façade

Shading from trees measured with lux meters



# SDE3

## Section



SDE3\_5th Storey

142.67 m



ALL\_FPS\_4TH  
STOREY Mezzanine

138.71 m



SDE3\_4th Storey

137.80 m



SDE3\_3rd Storey

134.14 m



SDE3\_2nd Storey

130.48 m



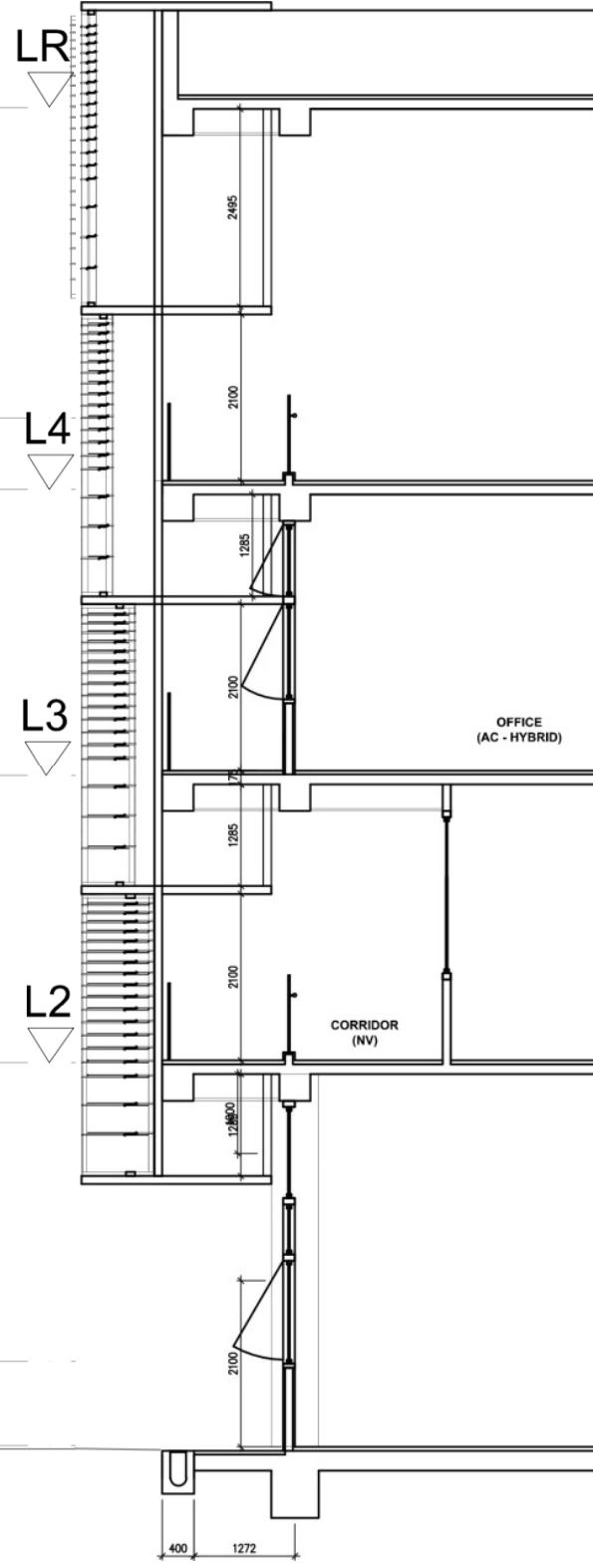
ALL\_FP\_1ST  
STOREY Mezzanine

126.67 m



SDE3\_1st Storey

125.60 m



# Daylight Penetration SDE3

## Simulation Parameters

### *Light Reflectances:*

Floor 40% / Walls 70% / Ceiling 80%

Lightshelf Topside 94% / Lightshelf Underside 60%

### *Visible Light Transmittances (VLT):*

Lower Glazing 50% / Upper Glazing 80% / Internal

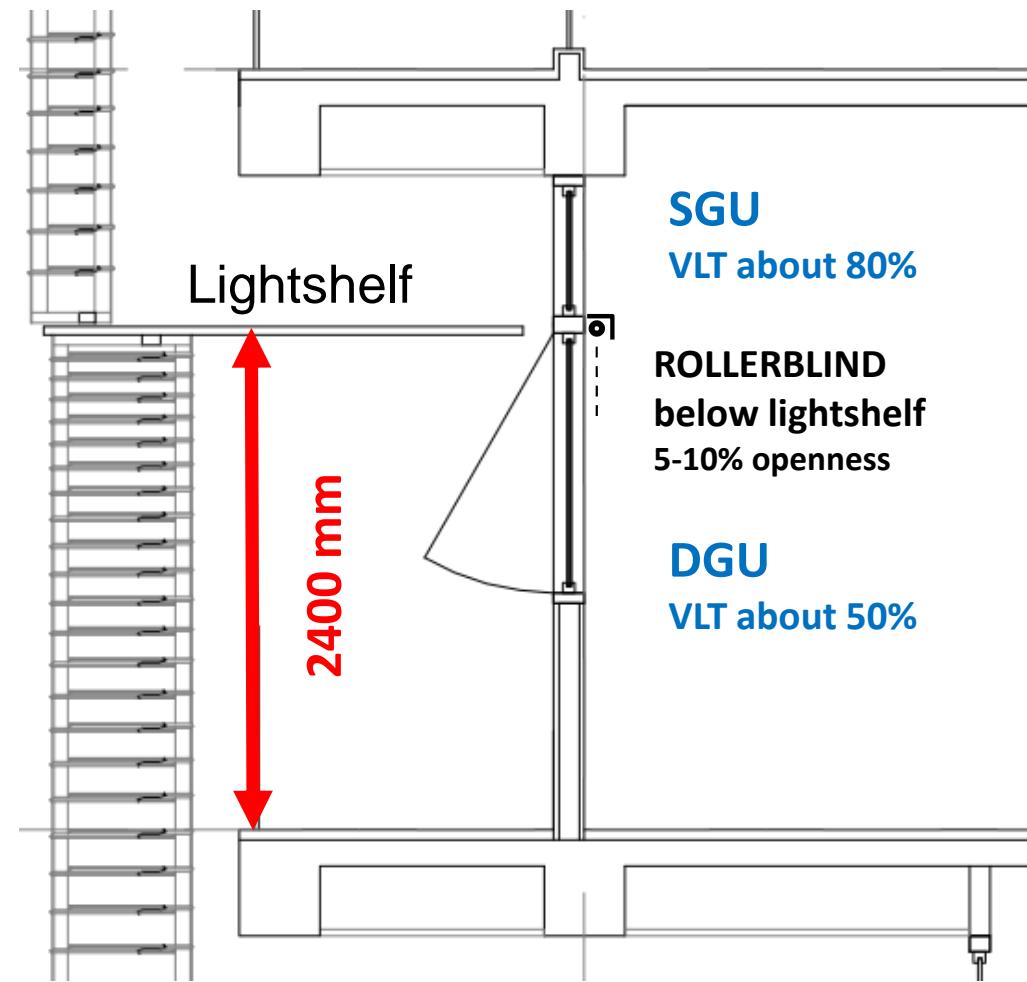
Glazing 90%

### *Sky:*

CIE Overcast + Tree shading (refer to previous slide)

## West Façade SDE 3

Light indoor colour scheme: Light reflectance of floor (40%), Walls (70%) and Ceiling (80%)



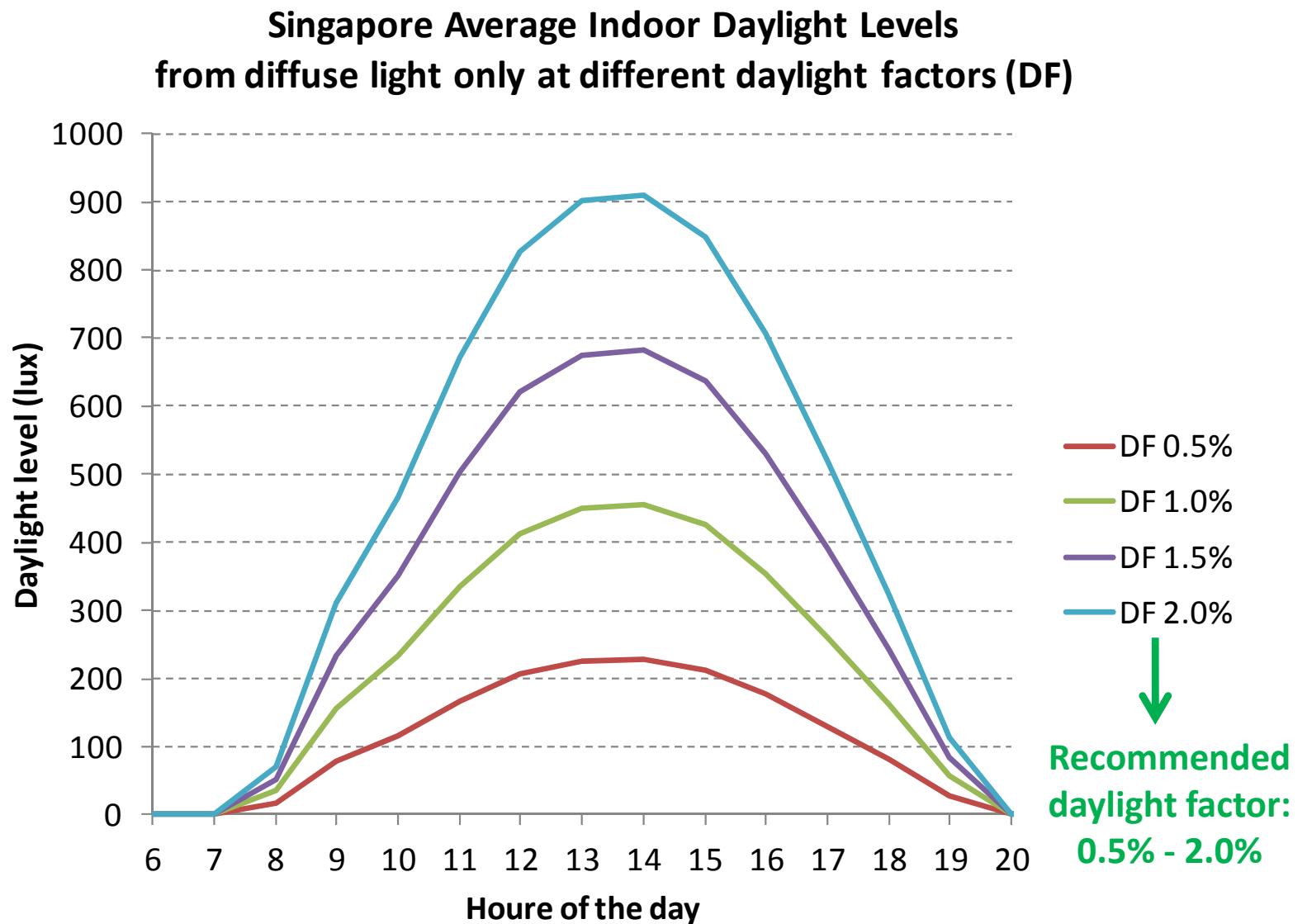
## What Daylight Factor To Design For?

# LIGHT levels

500 lux (offices)  
Singapore code

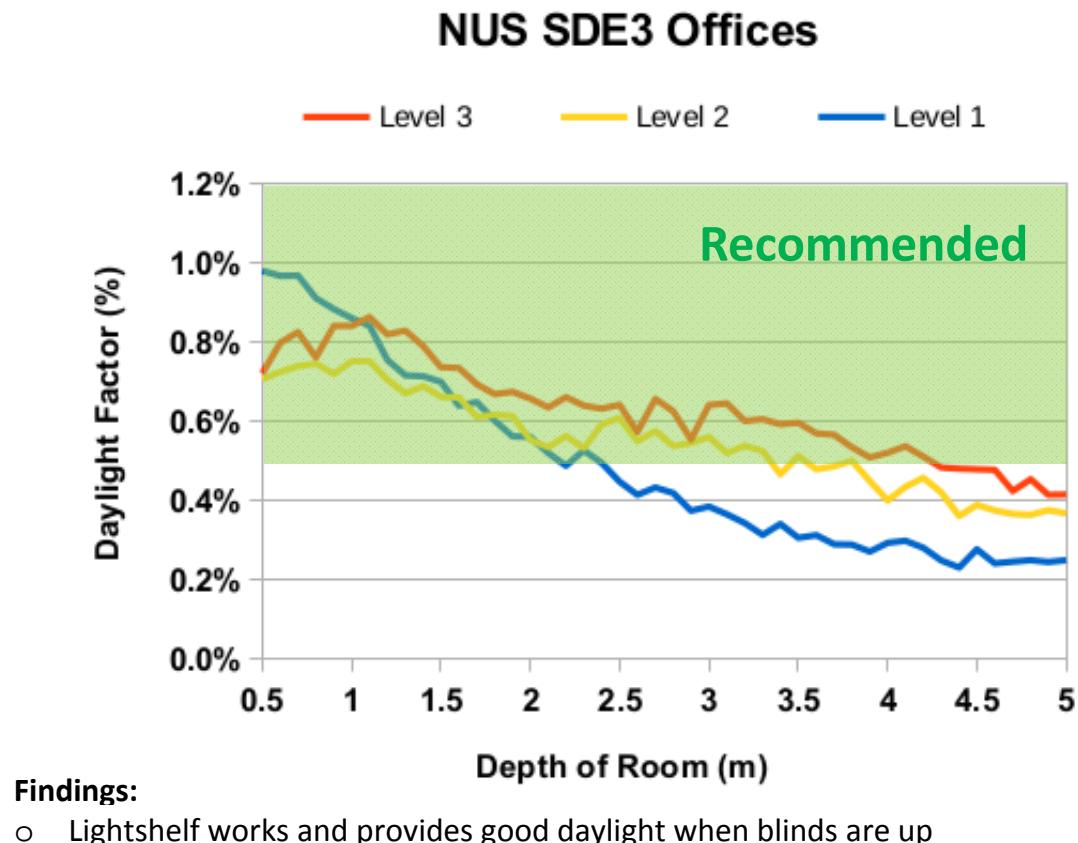
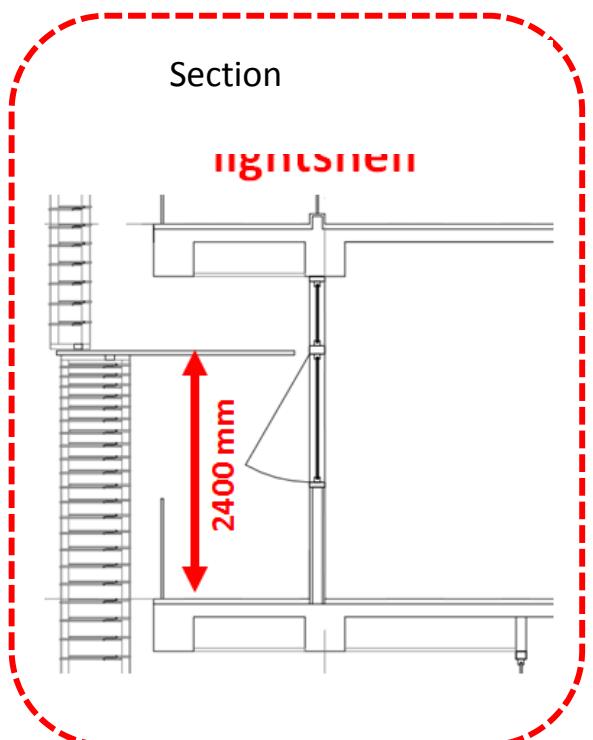
300 lux (offices  
general lighting) +  
task lights  
Singapore code

50 – 100 lux  
(computer work)  
Illuminating  
Engineers Society



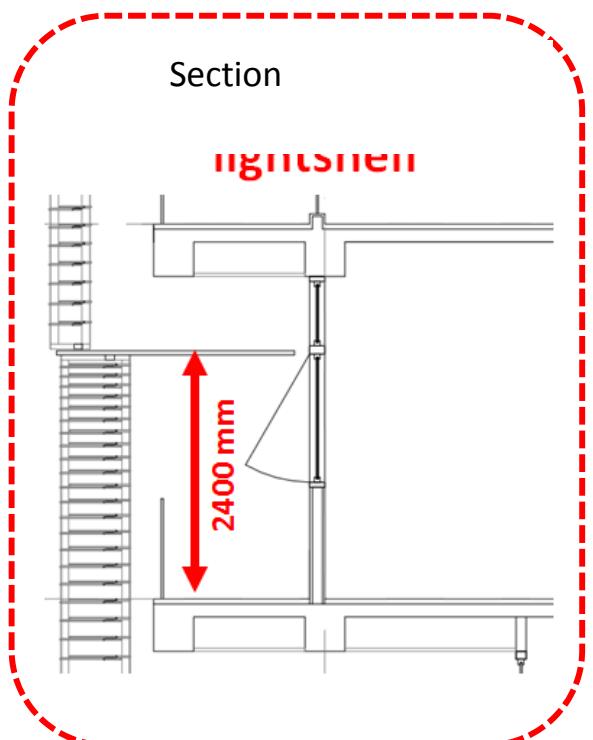
# Daylight Factor & Daylight Distribution

Glazing above below lightshelf 50% vlt,  
Above lightshelf 80% vlt



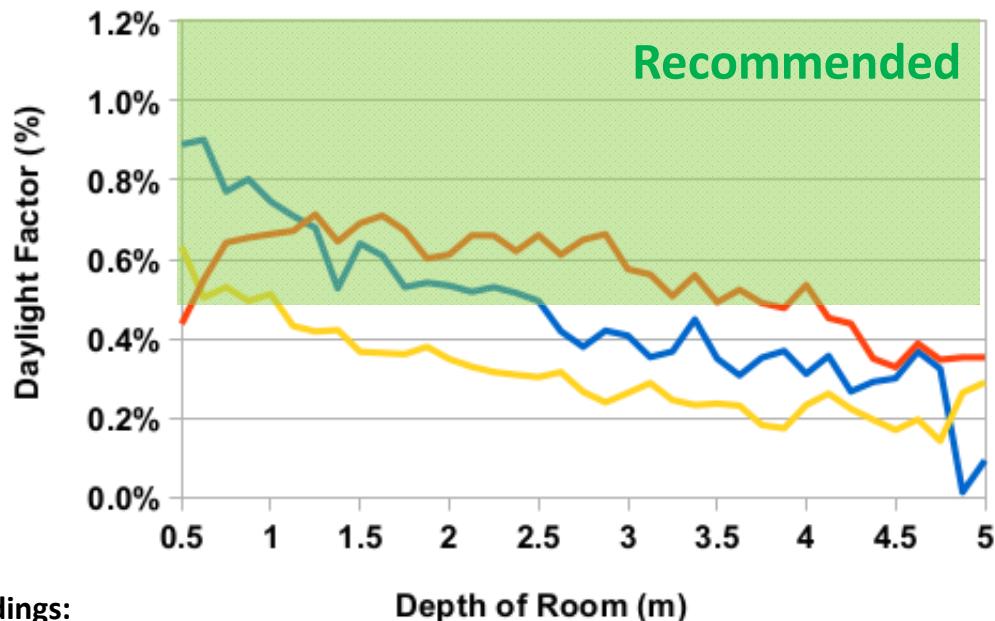
# Daylight Factor & Daylight Distribution

Glazing above below lightshelf 50% vlt,  
Above lightshelf 80% vlt



## NUS SDE3 Spaces

— Knuckle Level 2 — Studio Level 2 — Office Level 3

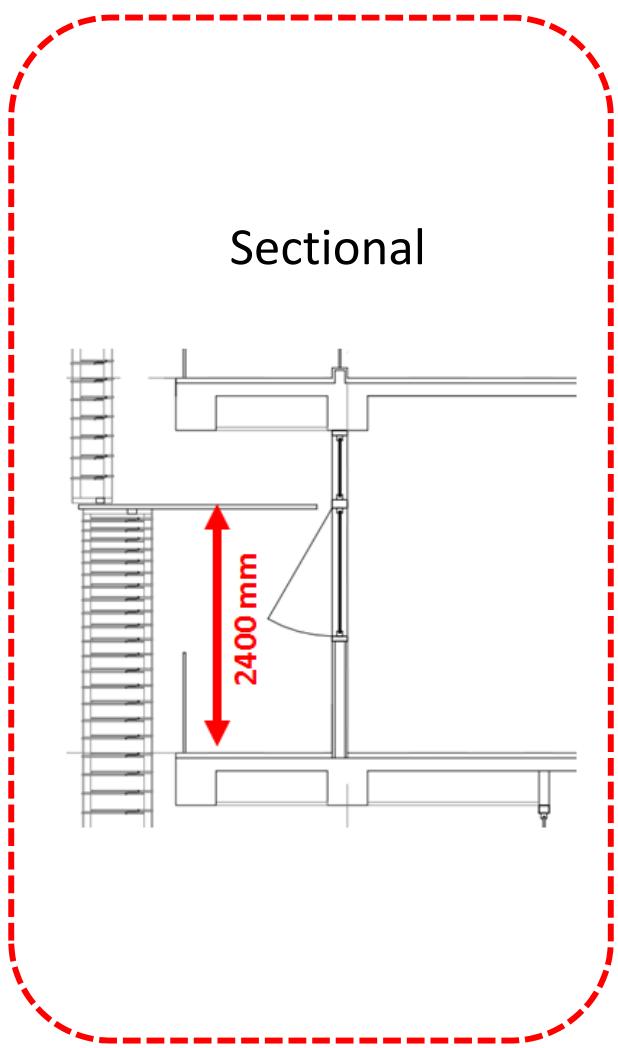


### Findings:

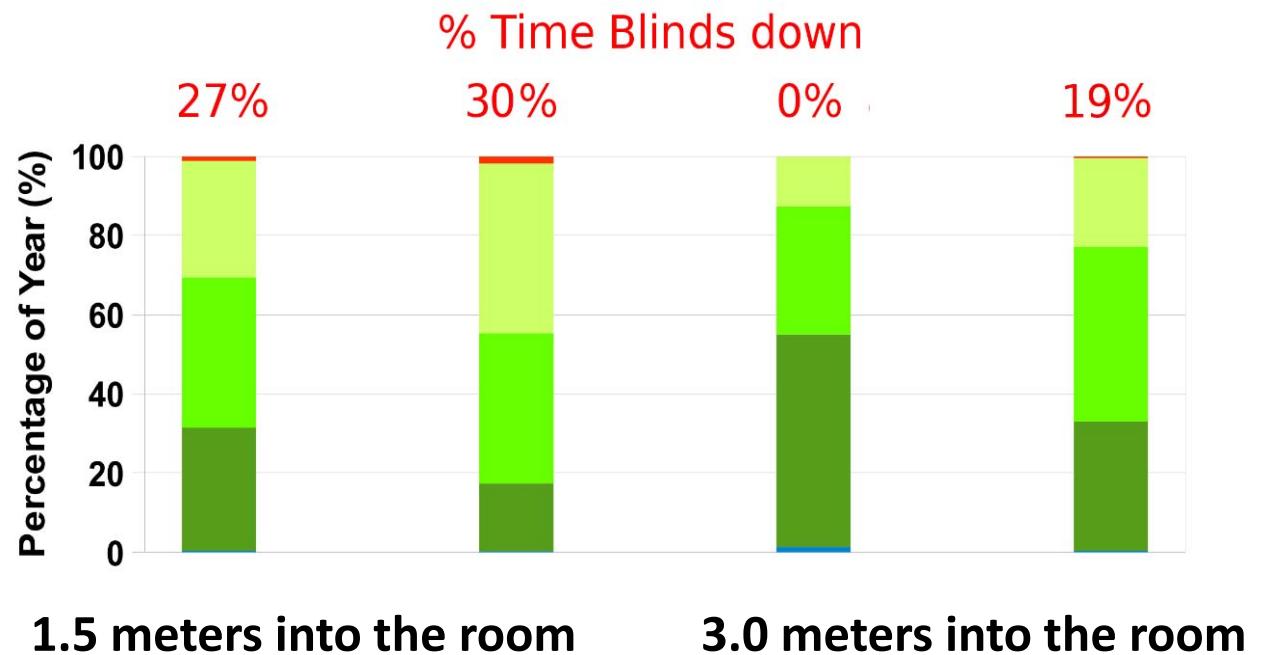
- Good daylight provided in knuckle and offices

## Annual Daylight Levels & Glare

Between the hours of 9 am – 6 pm



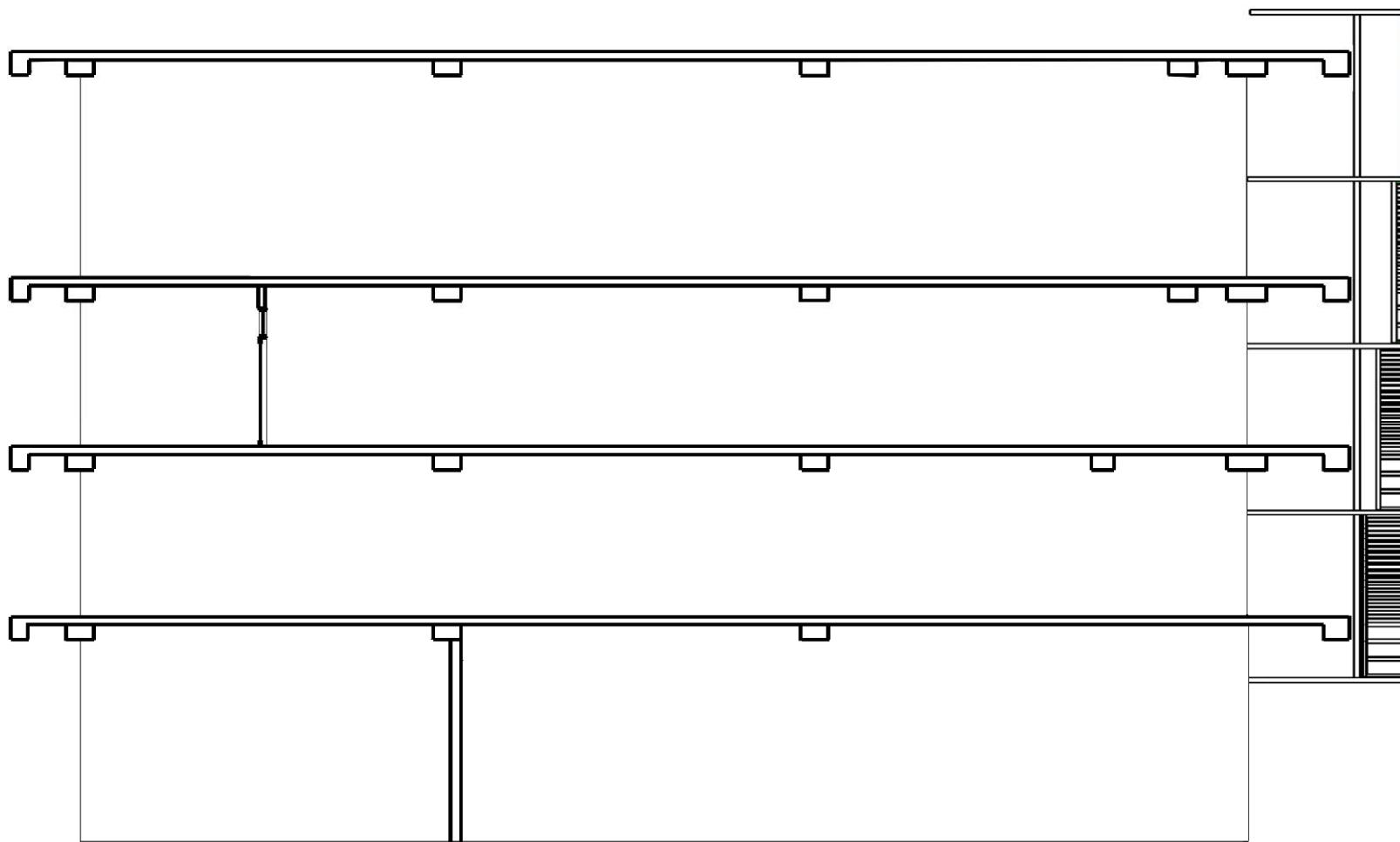
- Extreme Glare (>10000 lux)
- Brightly Daylit (500-1000 lux)
- Daylit (100-300 lux)
- Glare (1000-10000 lux)
- Well Daylit (300-500 lux)
- Dim (0-100 lux)



\* If glare occurs, the blinds are assumed to remain down for the next 1 week

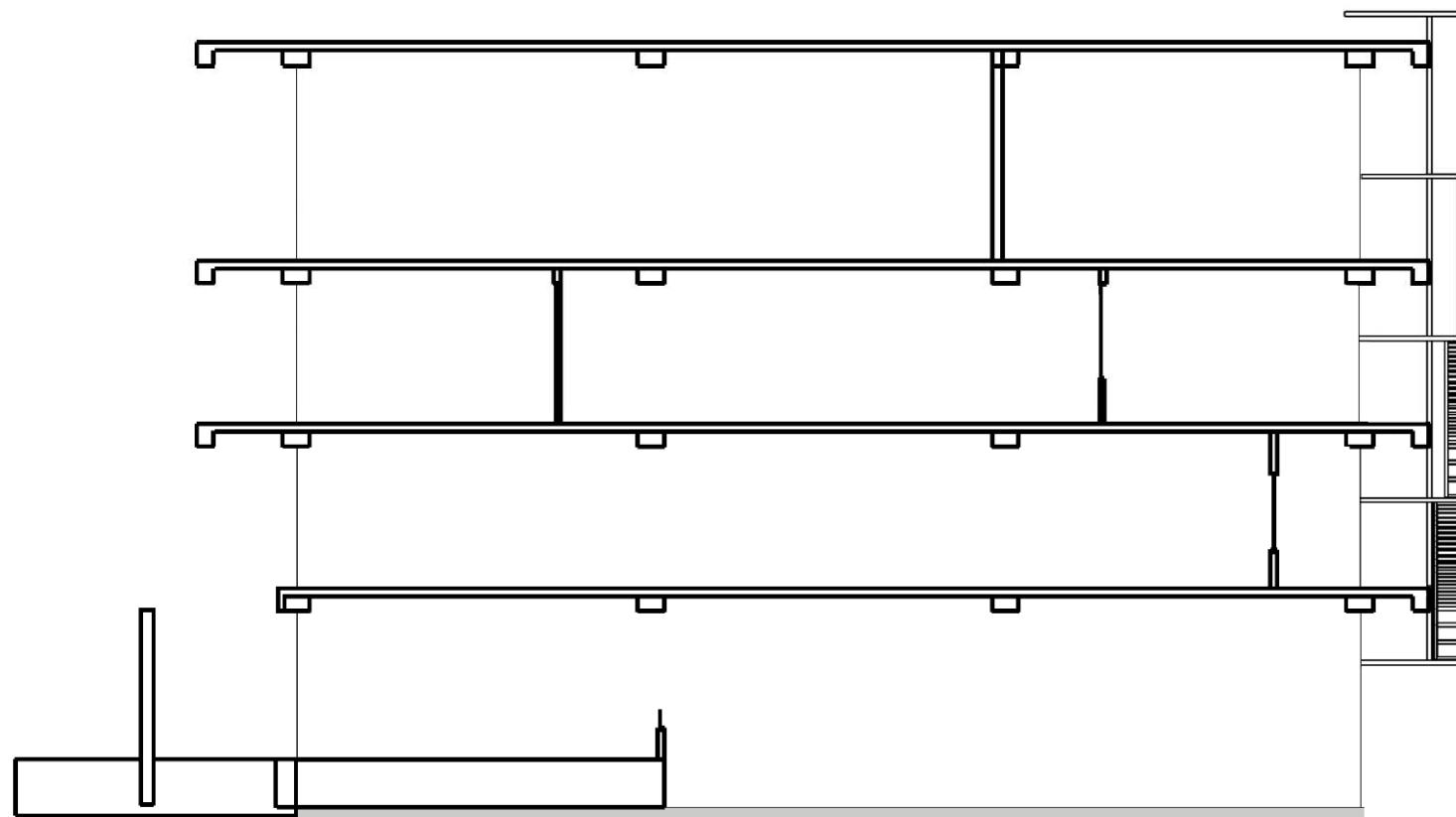
# Daylight Penetration SDE3

Sectional – Knuckle Space

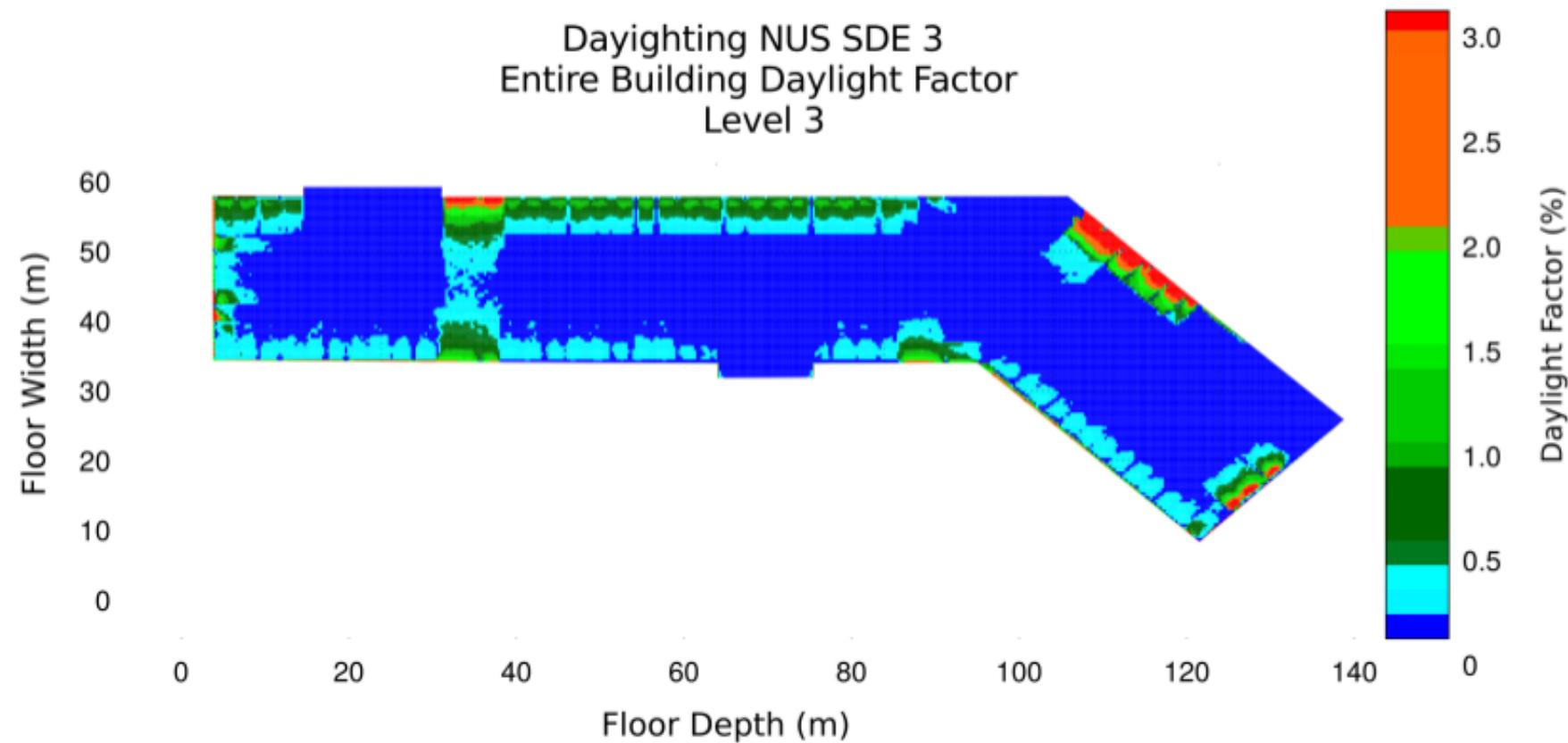


# Daylight Penetration SDE3

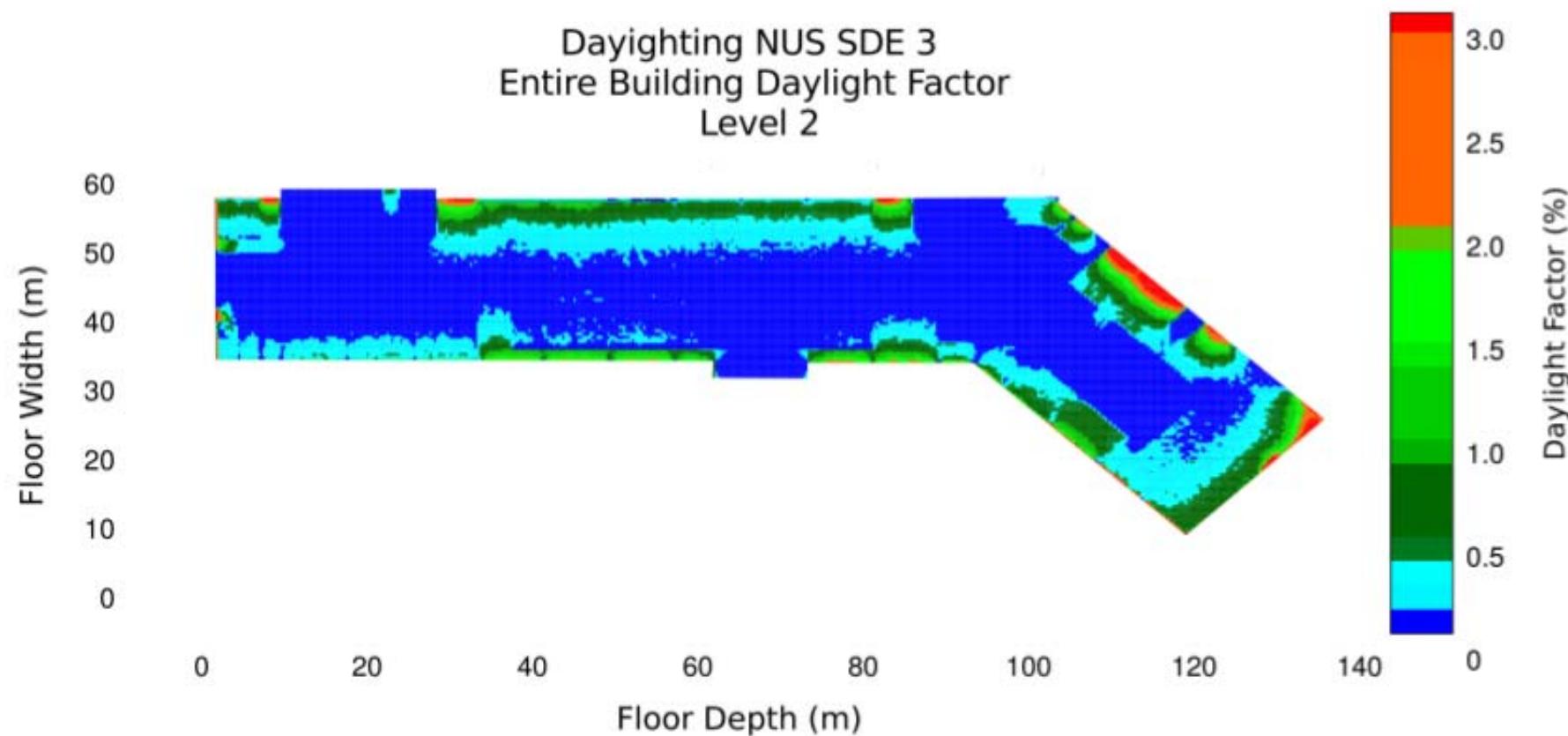
Sectional – SDE Design Studio



## Daylight Penetration SDE3



## Daylight Penetration SDE3



# HYBRID VENTILATION

# Hybrid Ventilation

Hybrid Ventilation aims to provide thermal comfort by following the PMV thermal comfort model in ASHRAE 55-2013 which allows for elevated airspeeds.

By elevating the air speed through the use of ceiling fans, thermal comfort can be achieved at higher air temperature and humidity levels than for conventional air-conditioned (AC) spaces:

System	Operative Temperature, °C	Air Speed, m/s	Thermal Comfort , PMV
AC	24 – 26	0.15	-0.5 < PMV < 0.5
Hybrid	27 - 29	0.3 – 1.2	-0.5 < PMV < 0.5

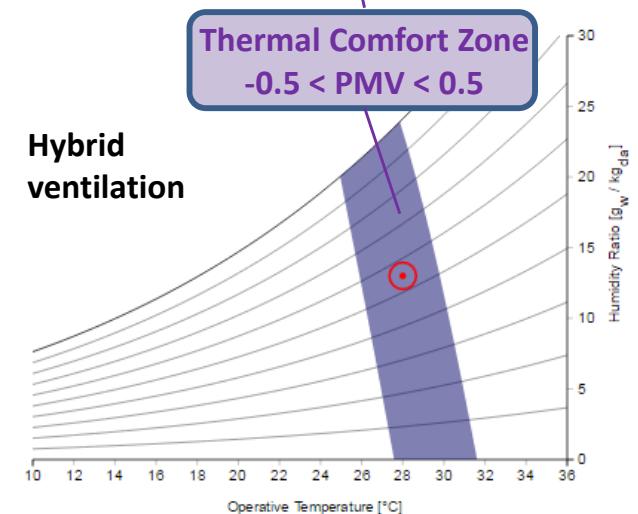
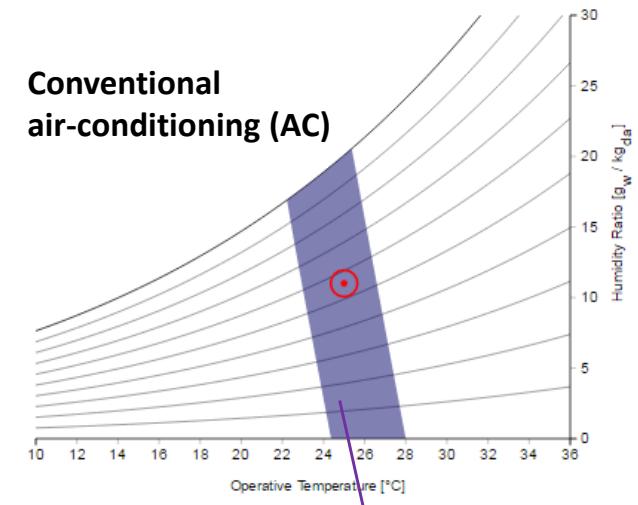
## Spaces Served by Hybrid Ventilation

### SDE 1

- Office

### SDE 3

- Office
- Studio
- Knuckle
- Crit



# Illustration of Hybrid Operation Schedules

## Normal Operation

## After Hours Operation (Mechanical Ventilation)

ENERGY

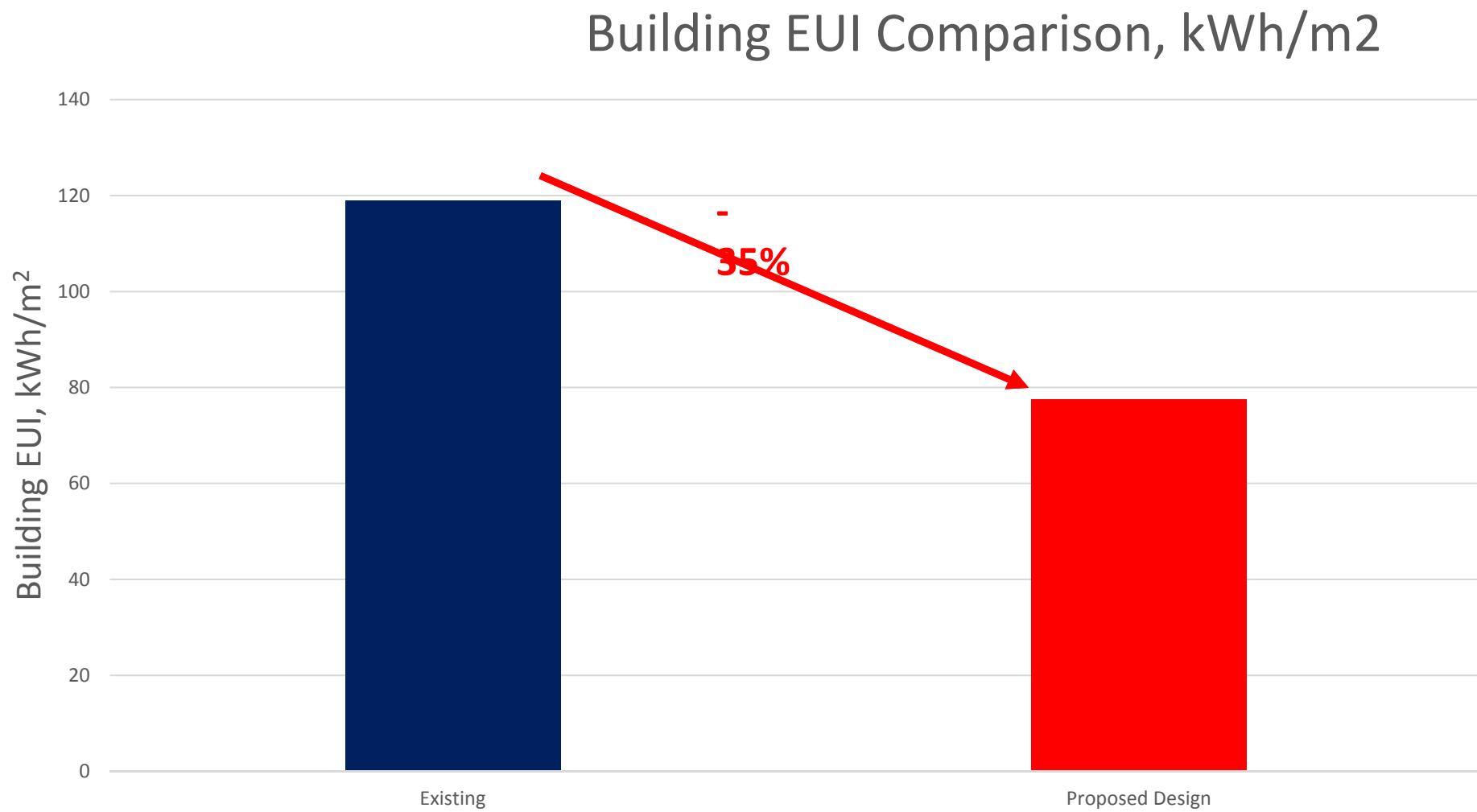
ENERGY

SDE 1

## Space Category

SDE1			
Space	AC System	Occupancy Schedule	Internal Loads
Offices	Hybrid	Scheduled use throughout the year	Low Loads
Exhibition Hall	AC	Non-scheduled use throughout the year	Medium – High Loads
Staff Lounge	AC	Non-scheduled use throughout the year	Low Loads
Lecture Theatres	AC	Scheduled use. Not in use during semester break	Medium – High Loads
Computer Labs	AC	Scheduled use. Not in use during semester break	High Loads
Crit Spaces	Hybrid	Non-scheduled use. Not in use during semester break	Low Loads

## SDE 1 Energy Use Intensity



\*Results are NOT final

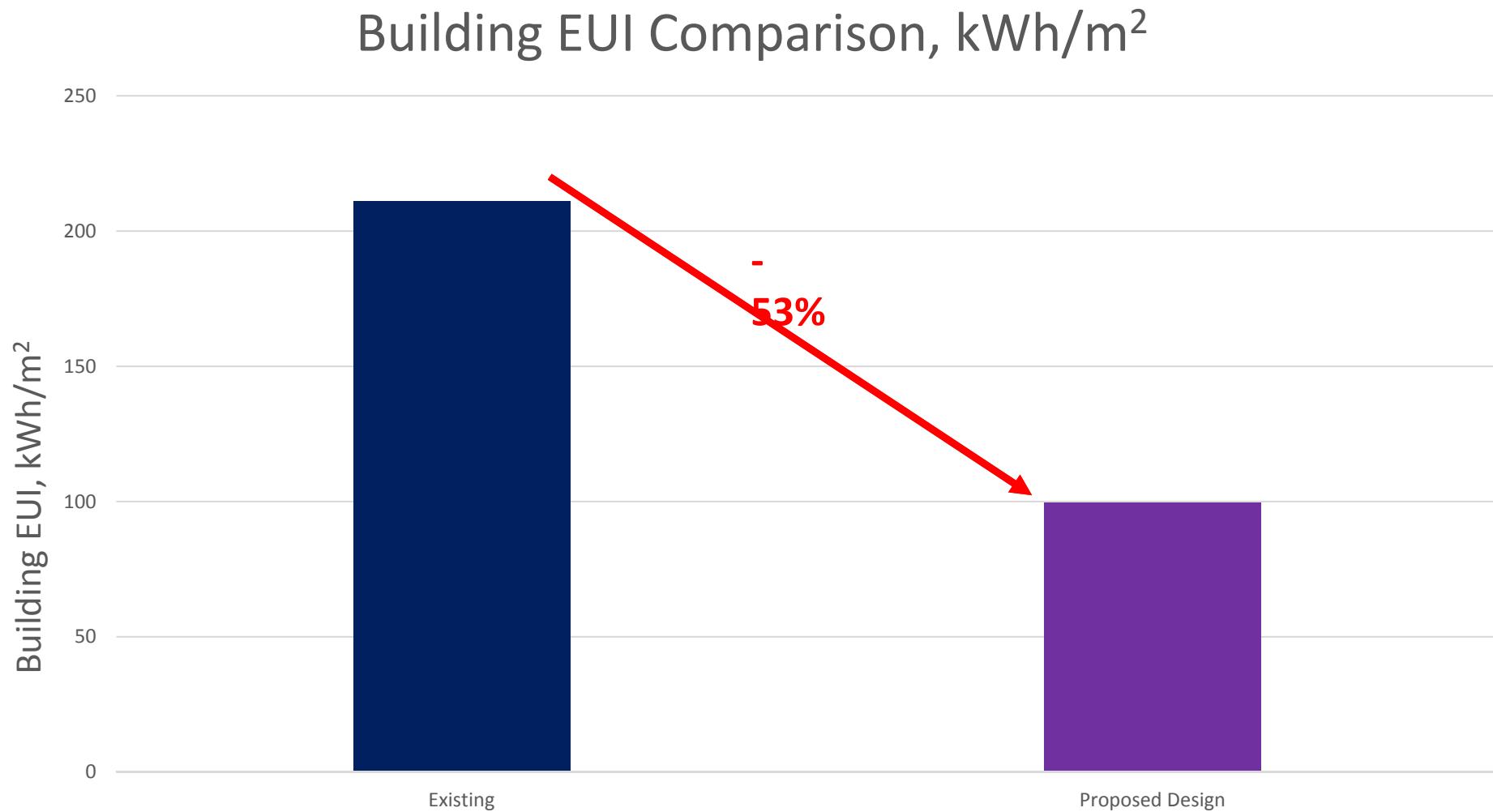
ENERGY

SDE 3

## Space Category

SDE1			
Space	AC System	Occupancy Schedule	Internal Loads
Individual Offices	Hybrid	Non-scheduled use. 85% of rooms not used during semester break	Low Loads
General Offices	Hybrid	Scheduled use throughout the year	Medium Loads
Studios	Hybrid	Scheduled and non-scheduled use. Not in use during semester break	Medium – High Loads
Lecture Theatres	AC	Scheduled use. Not in use during semester break	Medium – High Loads
Computer Labs	AC	Scheduled use. Not in use during semester break	High Loads
Crit Spaces	Hybrid	Non-scheduled use. Not in use during semester break	Low Loads

## SDE 3 Energy Use Intensity



\*Results are NOT final

# ENERGY

Summary

## **Summary**

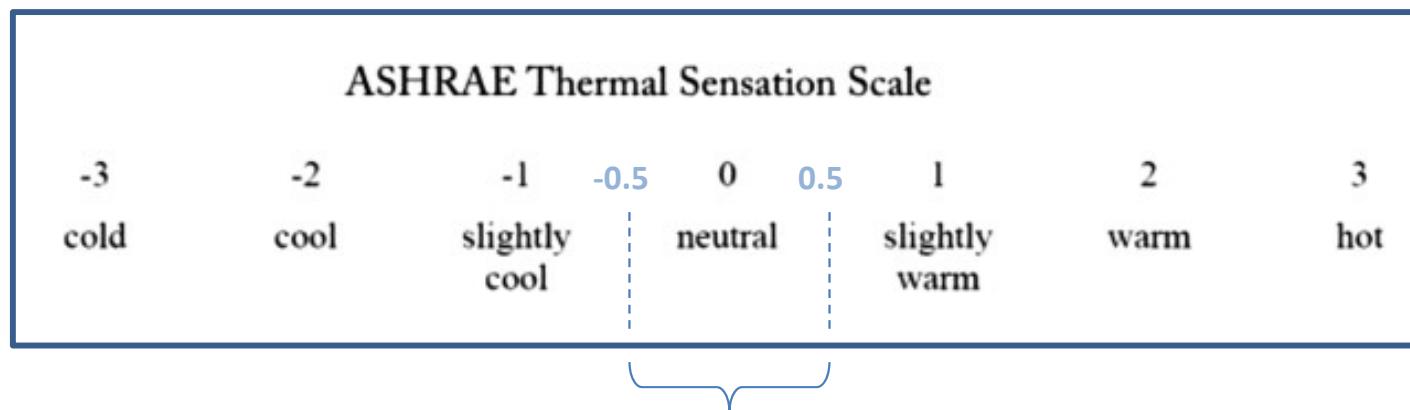
- Both SDE 1 & 3's EUI below 100 kWh/m<sup>2</sup>
- Combined EUI ~43 kWh/m<sup>2</sup>

**\*Results are NOT final**

Thermal Comfort

# Thermal Comfort

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation according to the Predicted Mean Vote (PMV) scale in the ASHRAE 55 standard (2013).



Thermal comfort:  
 $-0.5 < \text{PMV} < 0.5$

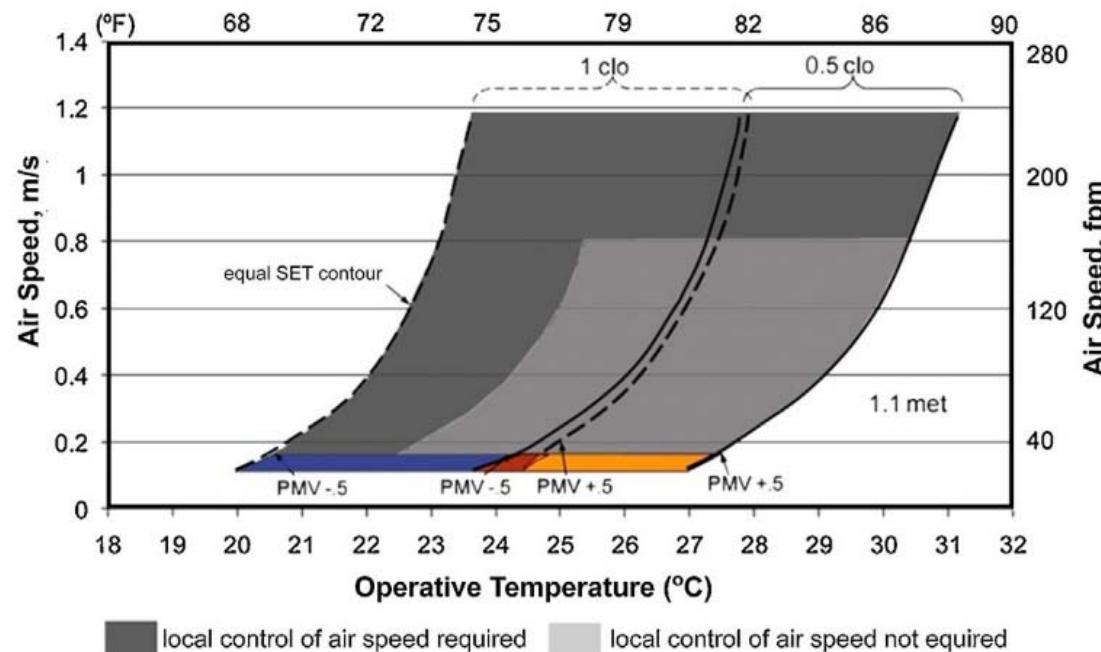
# Predicted Mean Vote (PMV)

## 6 Factors

- Garment Insulation
- Activity Metabolic Rate
- Air Velocity
- Air Temperature
- Radiant Temperature
- Humidity

\*Air and Radiant Temperature can be represented by a single value called Operative Temperature.

# Thermal Comfort at Hybrid Spaces

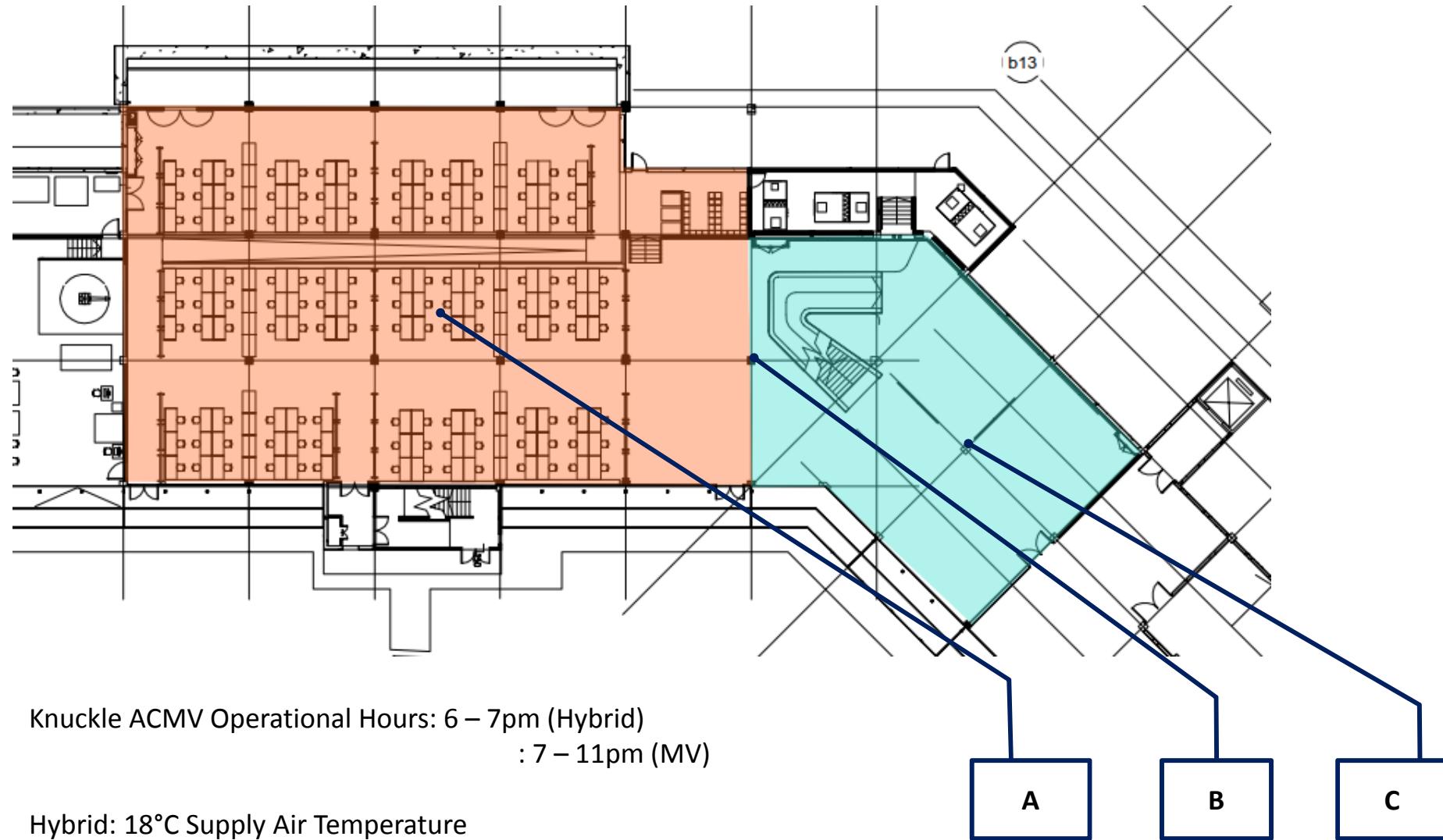


**Fig. 5.** Acceptable ranges of operative temperature and air speeds, reproduced from [24].

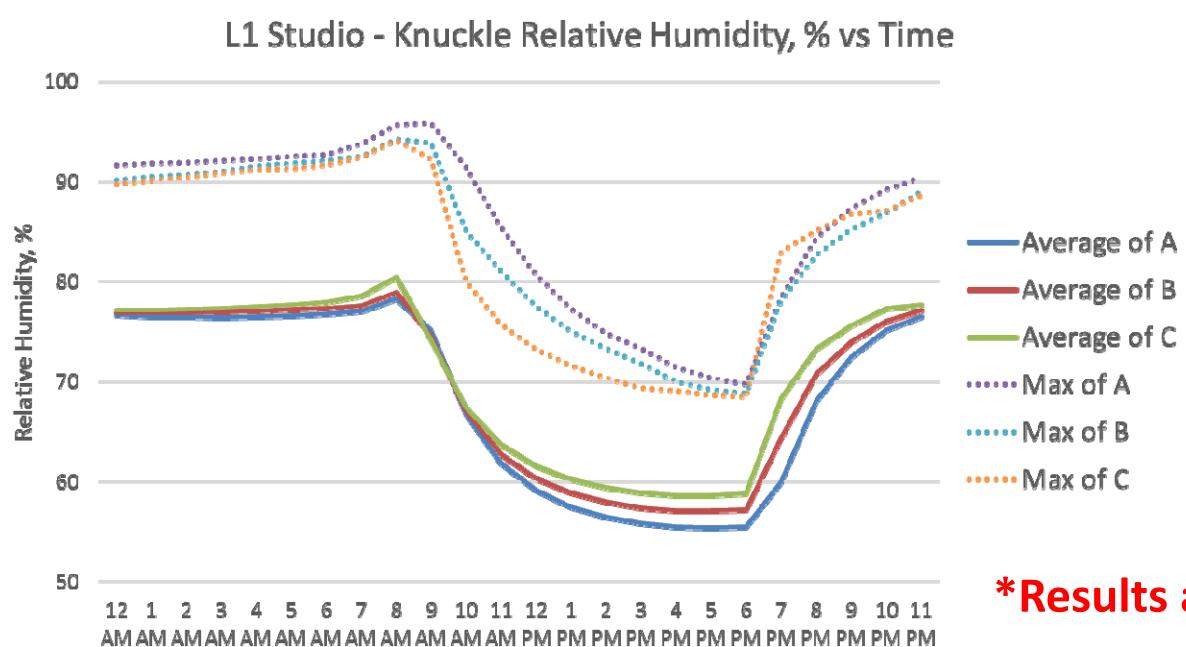
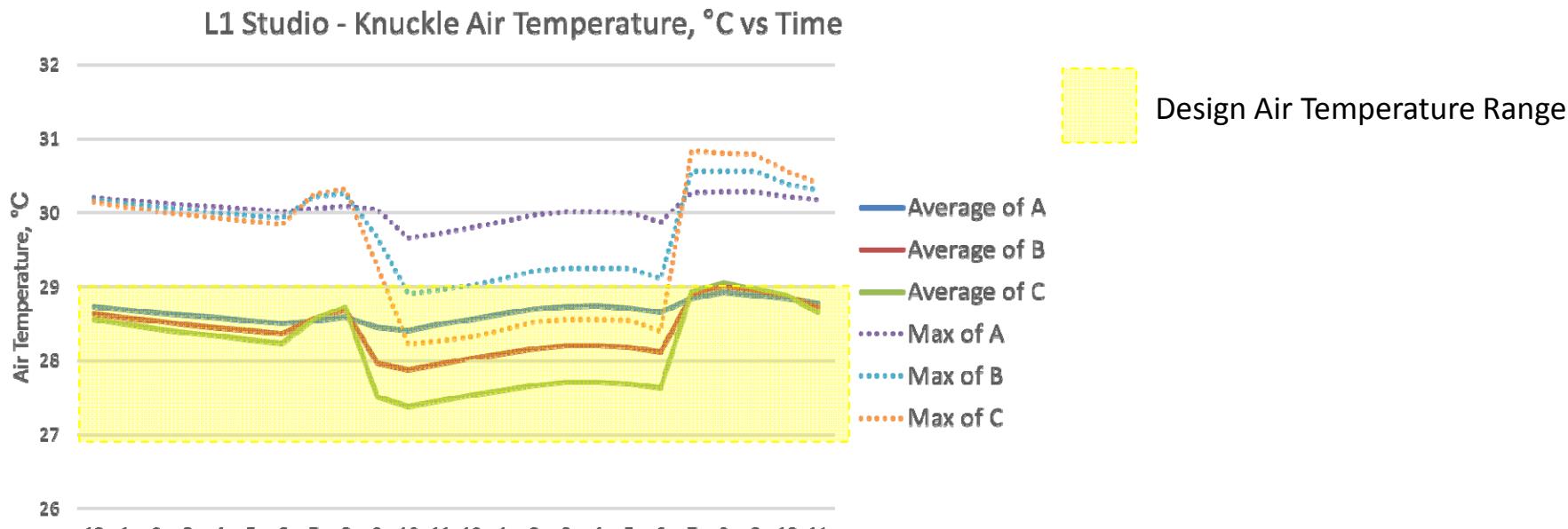
# Thermal Comfort

## Hybrid Ventilation Spaces

## Level 1 Studio-Knuckle

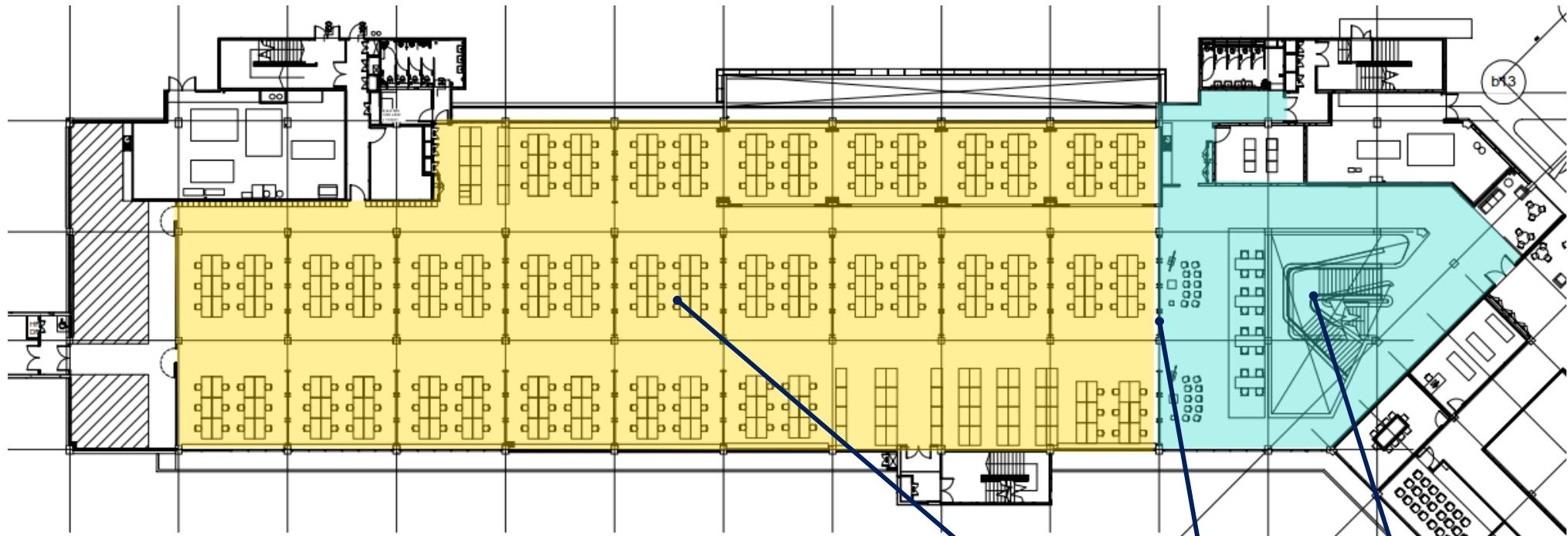


# **Level 1 Studio–Knuckle – Daily Air Profile (Term Break)**



**\*Results are NOT final**

## Level 2 Studio – Knuckle



Knuckle ACMV Operational Hours: 6 – 7pm (Hybrid)  
: 7 – 11pm (MV)

A

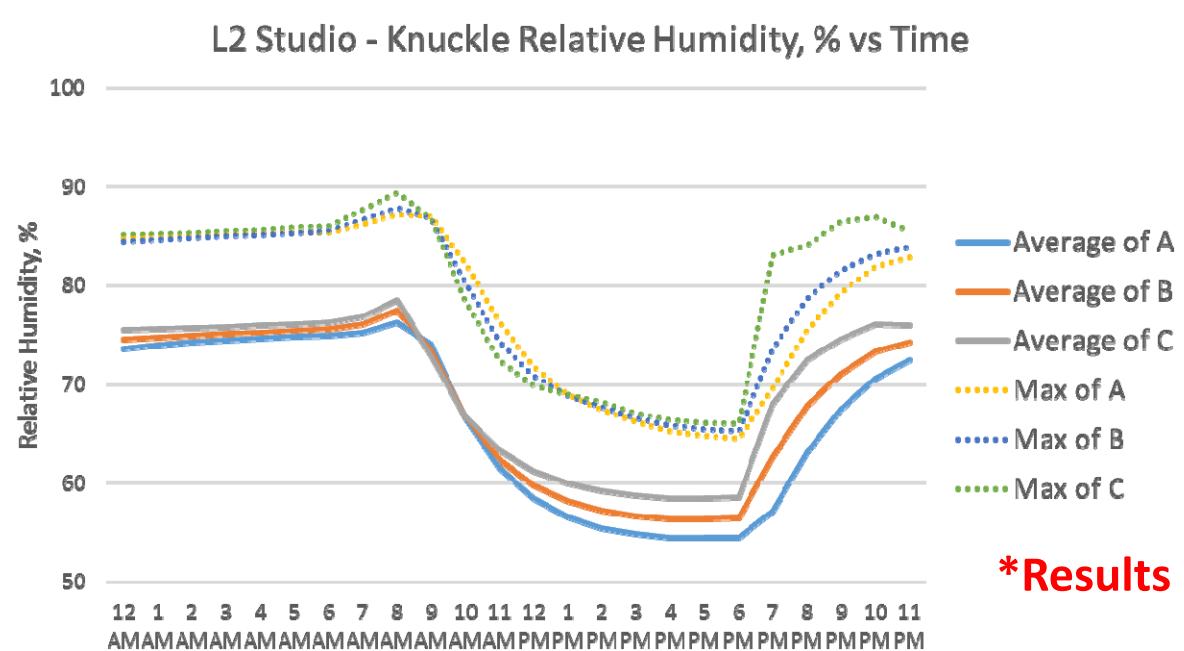
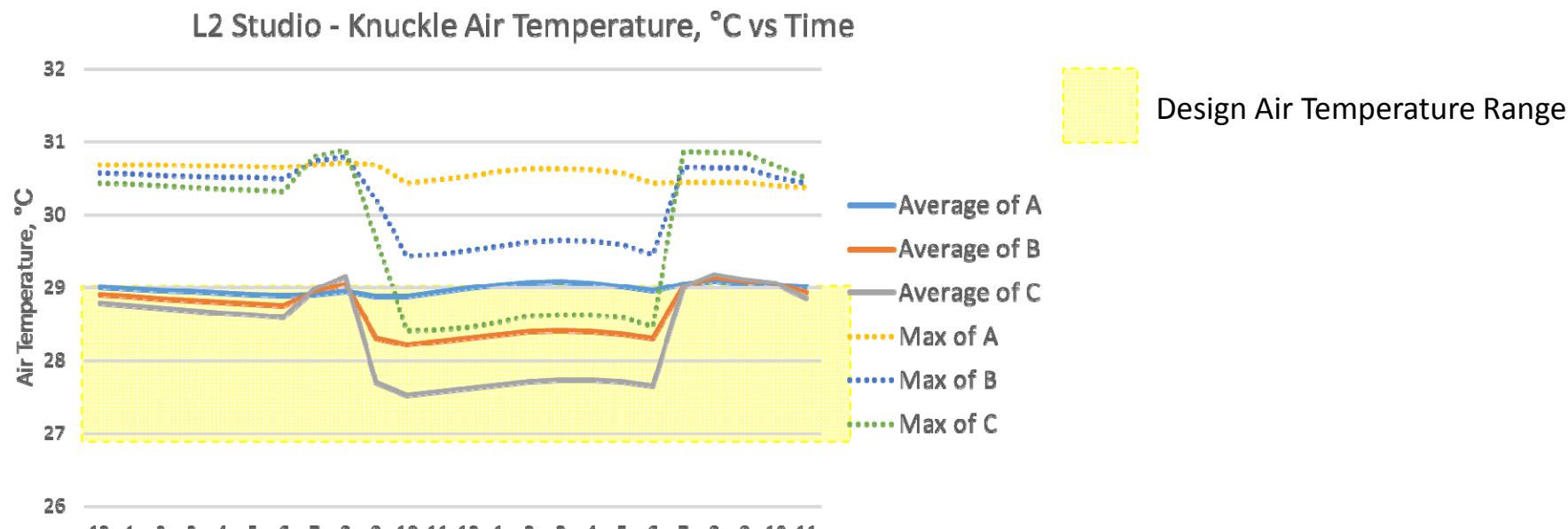
B

C

Hybrid: 18°C Supply Air Temperature

MV: 4 ach

## **Level 2 Studio–Knuckle – Daily Air Profile (Term Break)**



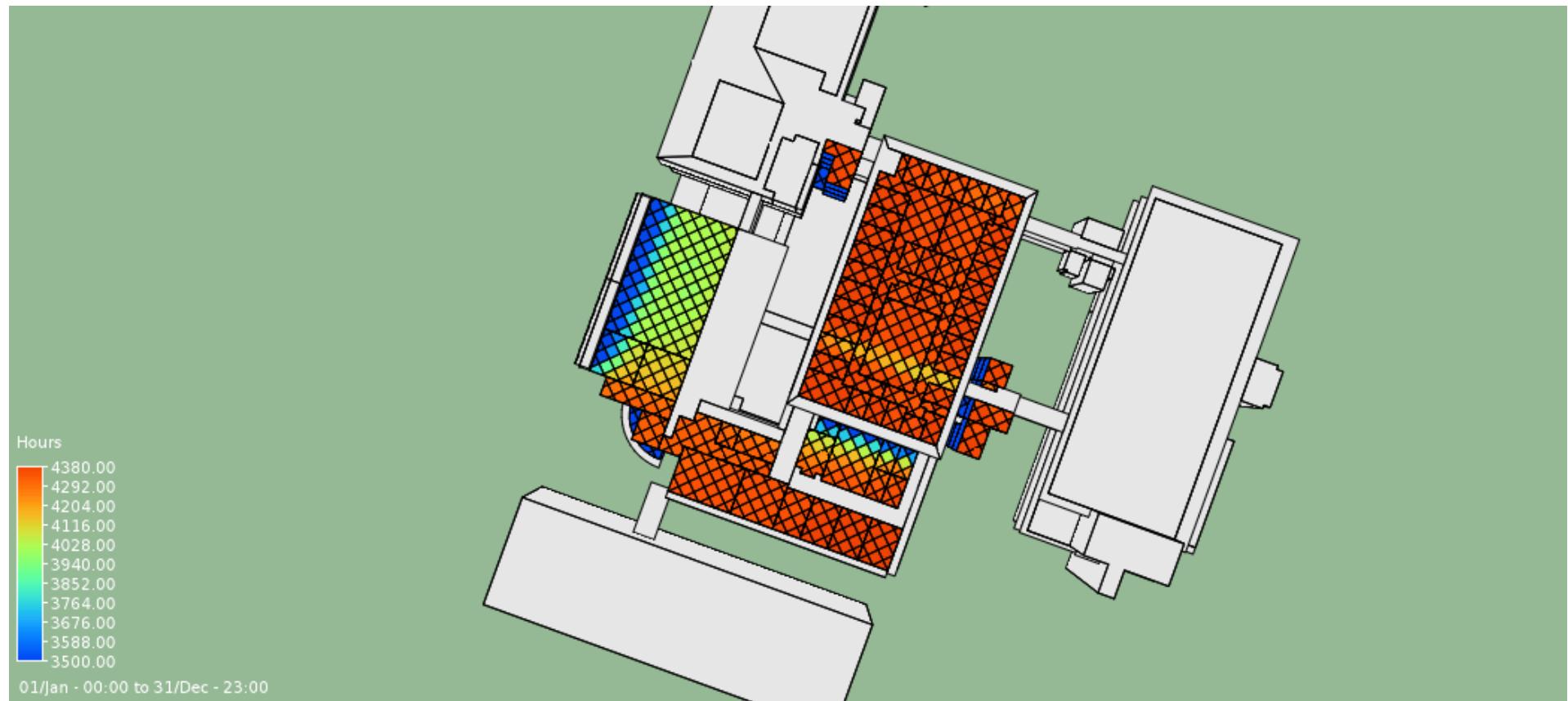
**\*Results are NOT final**

# APPENDIX

# APPENDIX

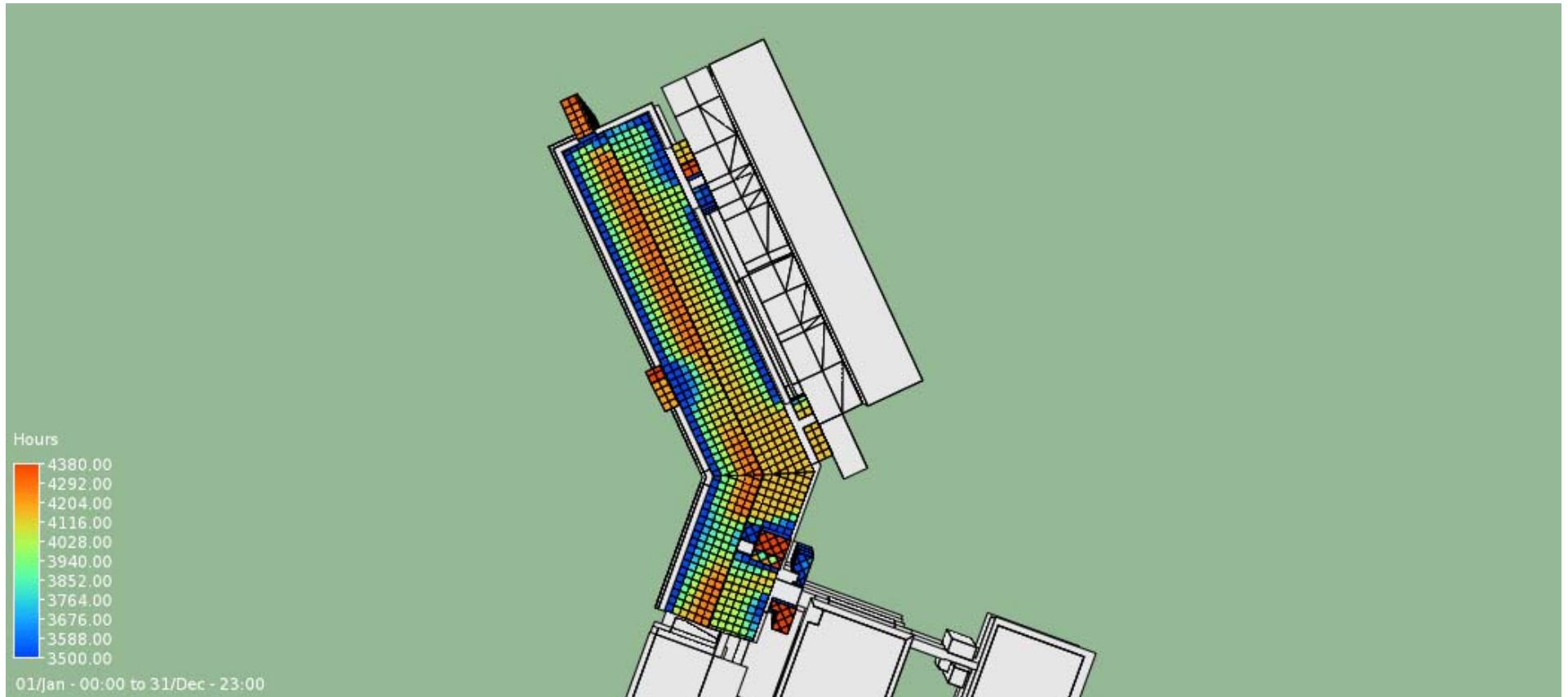
PV

## Hours of Direct Sun per Year – SDE 1



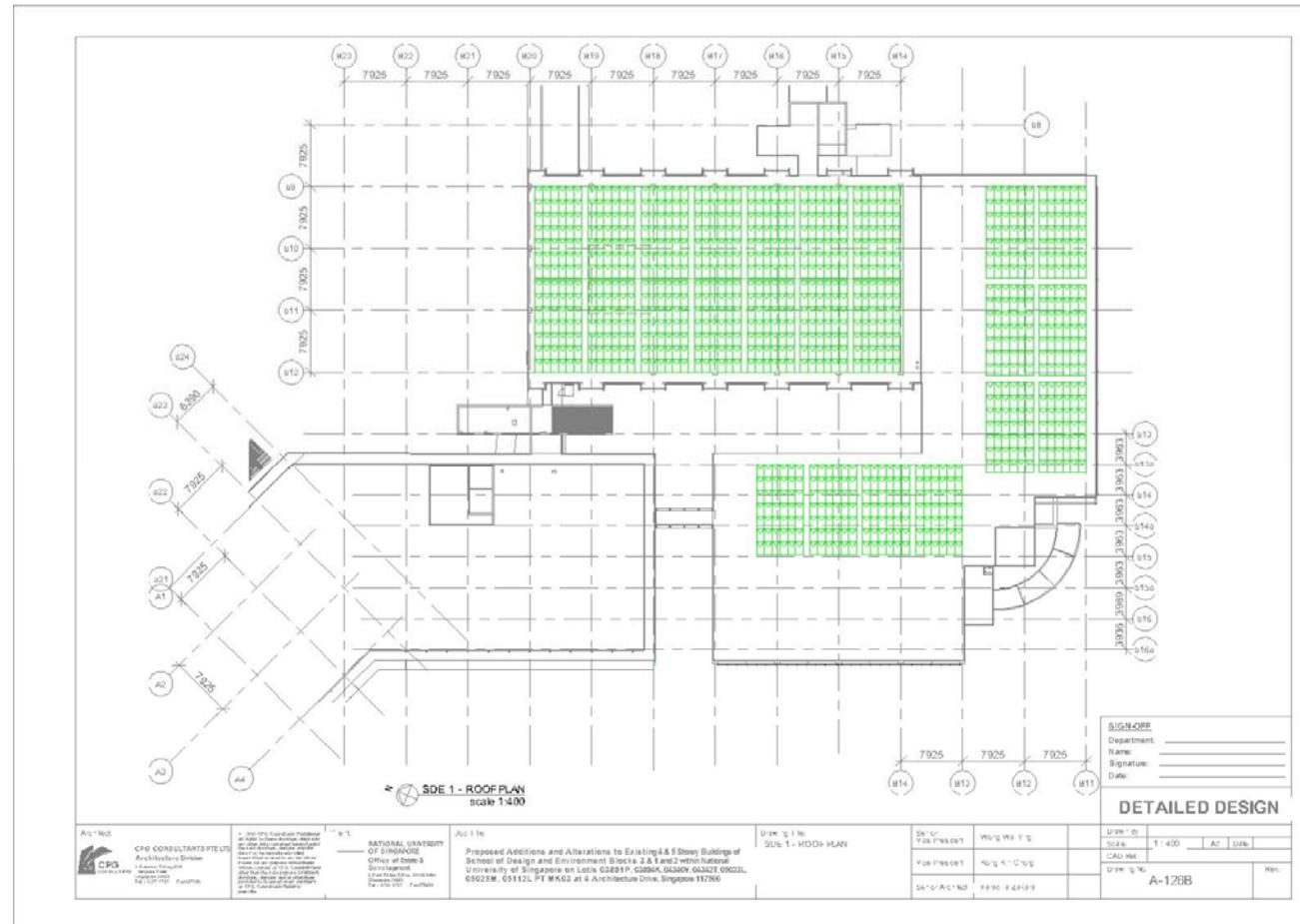
\*Results are NOT final

## Hours of Direct Sun per Year – SDE 3



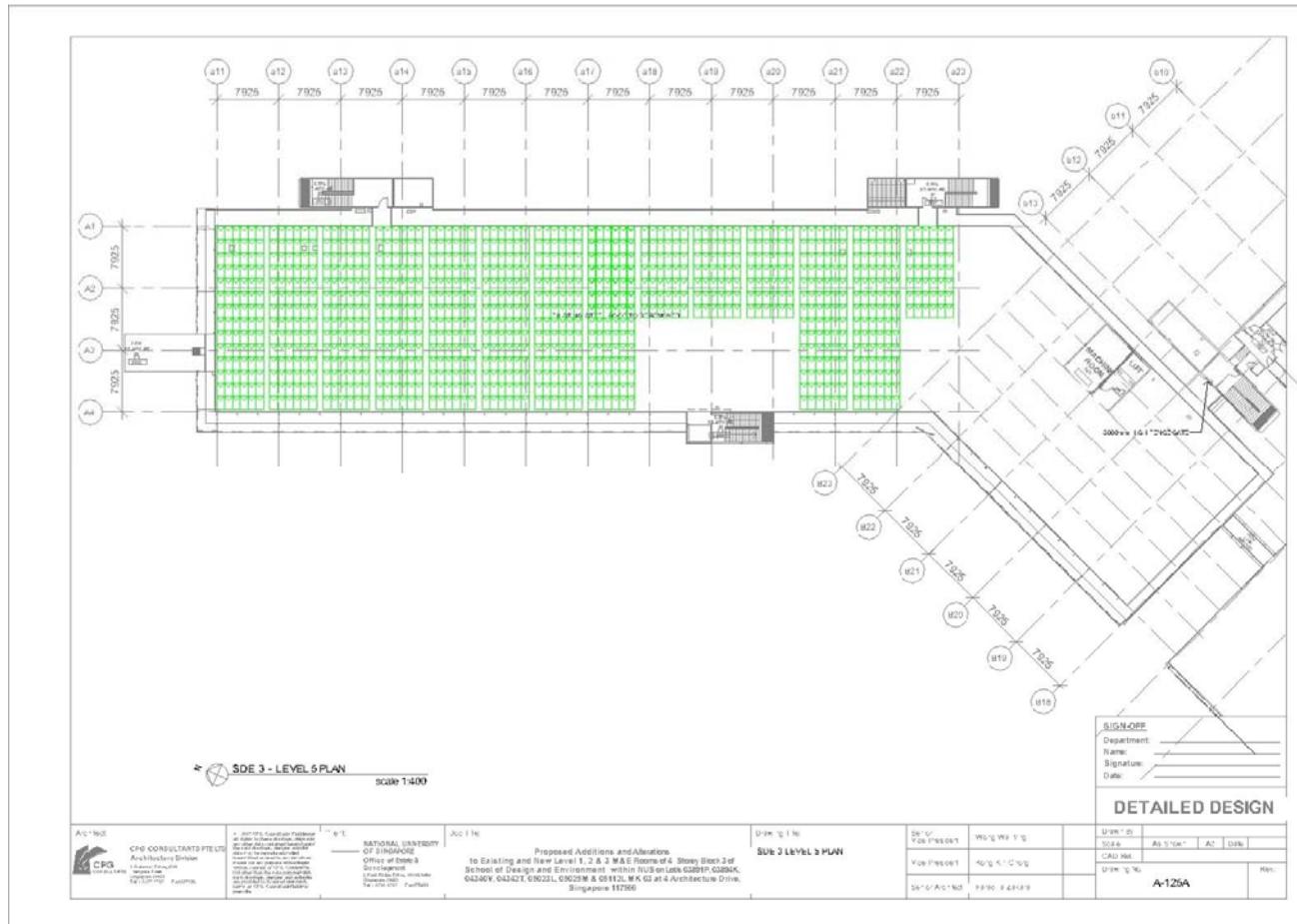
\*Results are NOT final

## PV Layout – SDE 1



**\*Results are NOT final**

# PV Layout – SDE 3



**\*Results are NOT final**

## **Summary**

- Proposed 1008 nos of PV panels on SDE 1&3 providing a total capacity of 252kWp.
- Estimated production of
- Estimated nett EUI of

**\*Results are NOT final**

# APPENDIX

## WELLS

# APPENDIX

Living Building Challenge

# Mechanical & Electrical

## SDE 3 & 1

# Air Conditioning & Mechanical Ventilation

## SDE 3 & 1

- Concept
- Ventilation Zoning
- Thermal Comfort
- Indoor Air Quality

	Fully AC	Hybrid Ventilation
Standard Reference	SS553	ASHRAE 55
Operative temperature	24°C – 26°C	27°C – 29°C
Relative humidity	65% ± 5%	65% - 75%
Air movement speed	< 0.3m/s	0.1m/s - 1.3m/s with local control
Ventilation type	Recirculated ventilation	One-pass ventilation with ceiling fans
Thermal comfort	Stipulated	$-0.5 \leq PMV \leq +0.5$

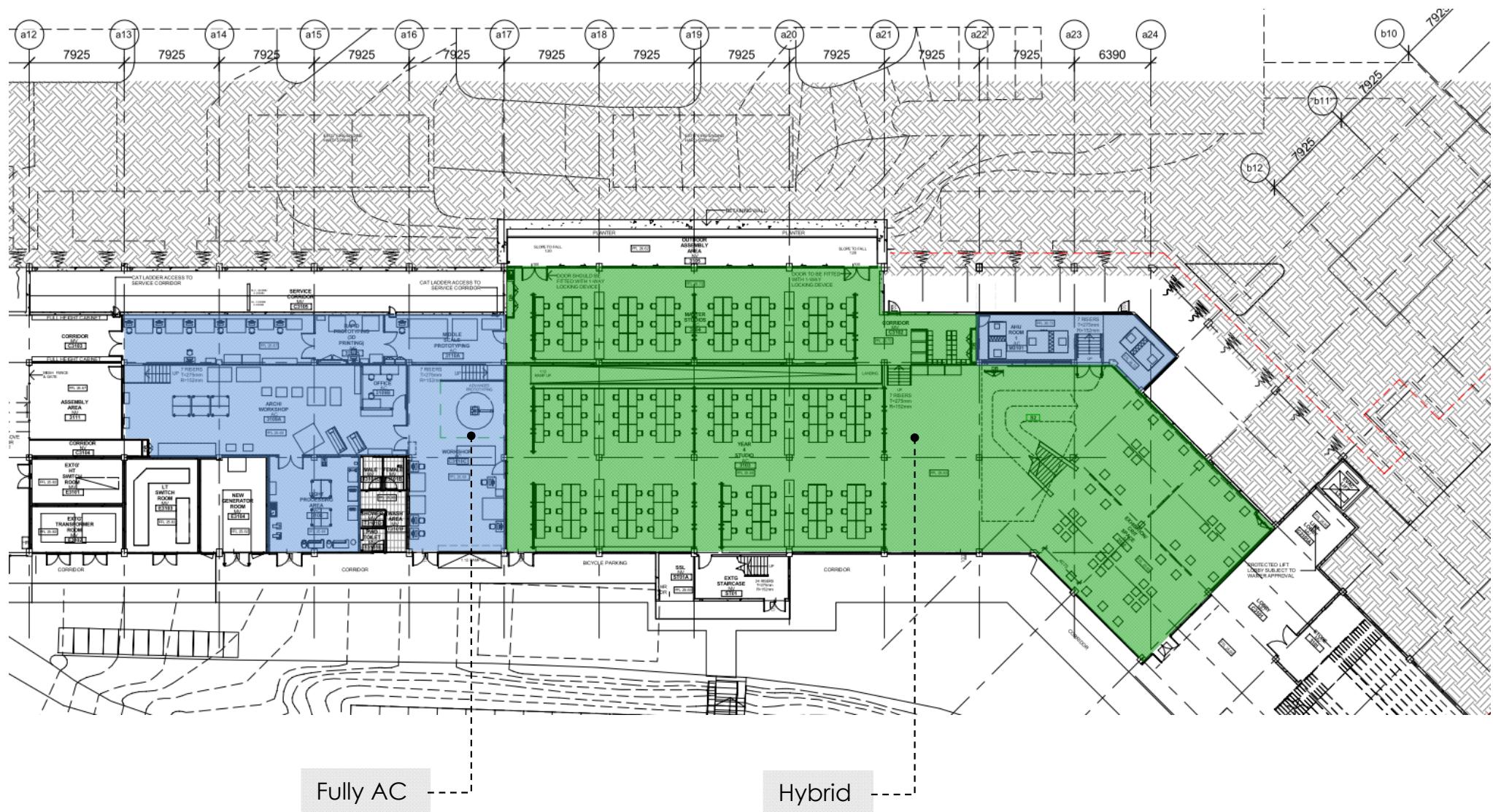
AC SPACE

CORRIDOR

STUDIO

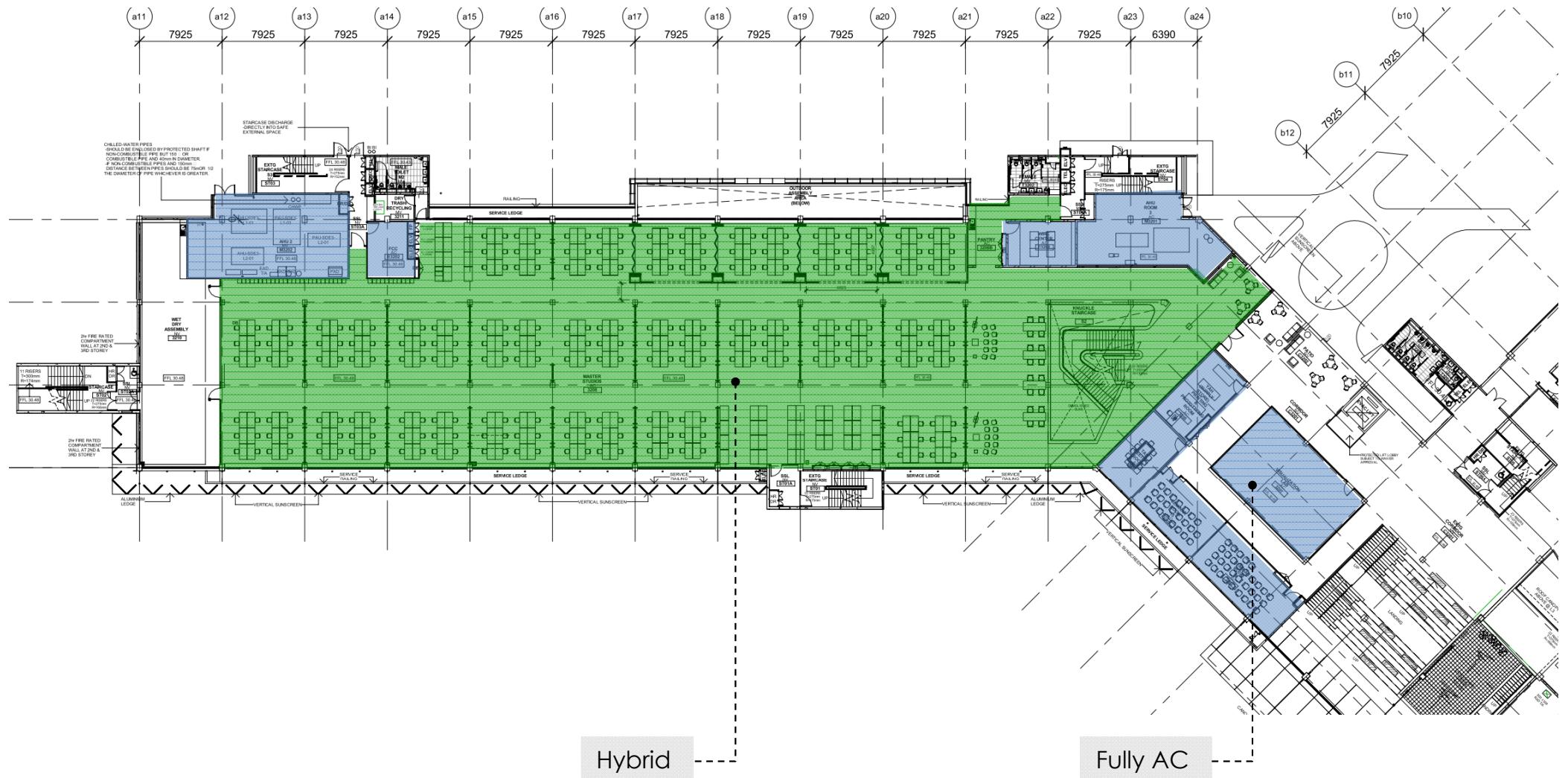
## Concept

ACMV – SDE – Fully AC & Hybrid Ventilation

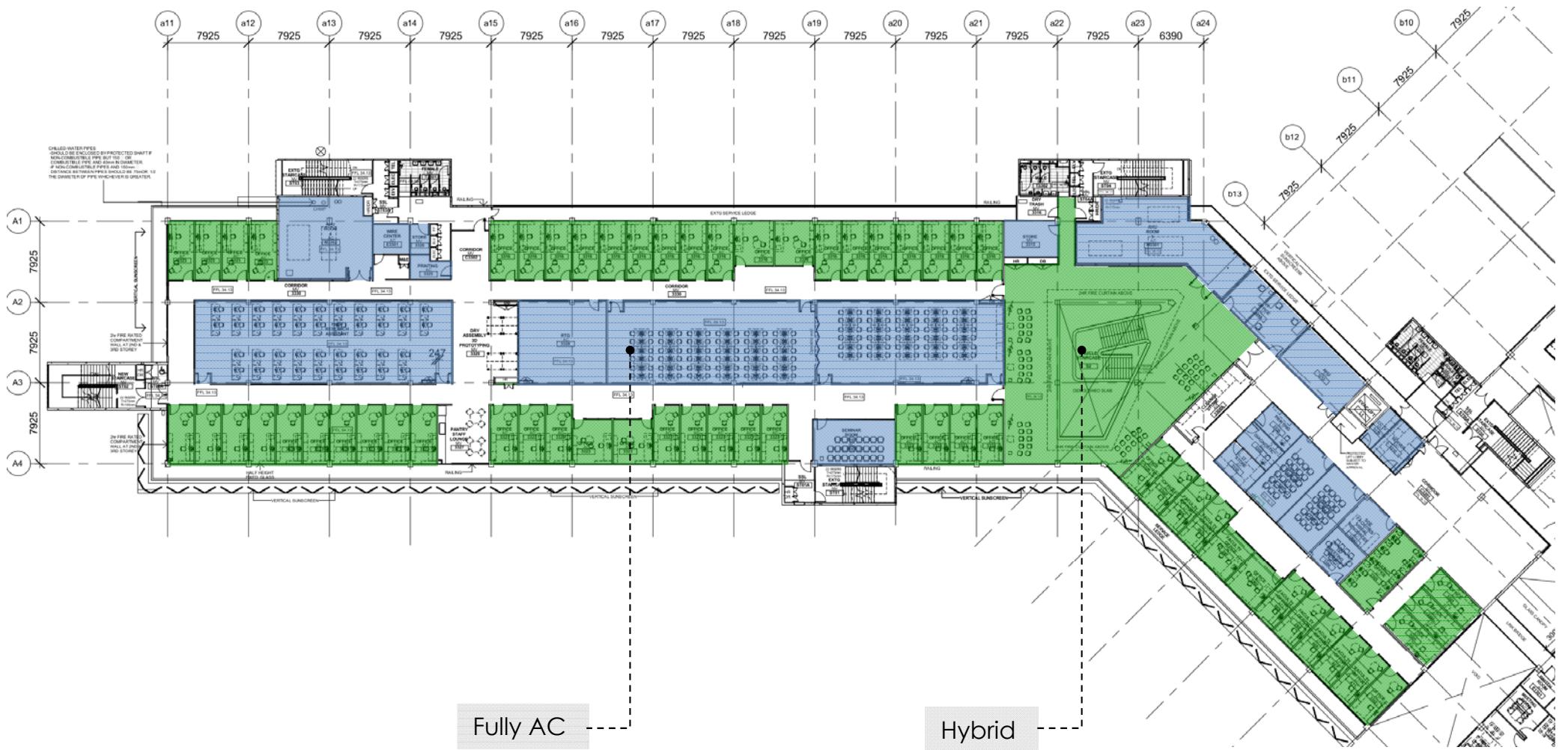


# Ventilation Zoning

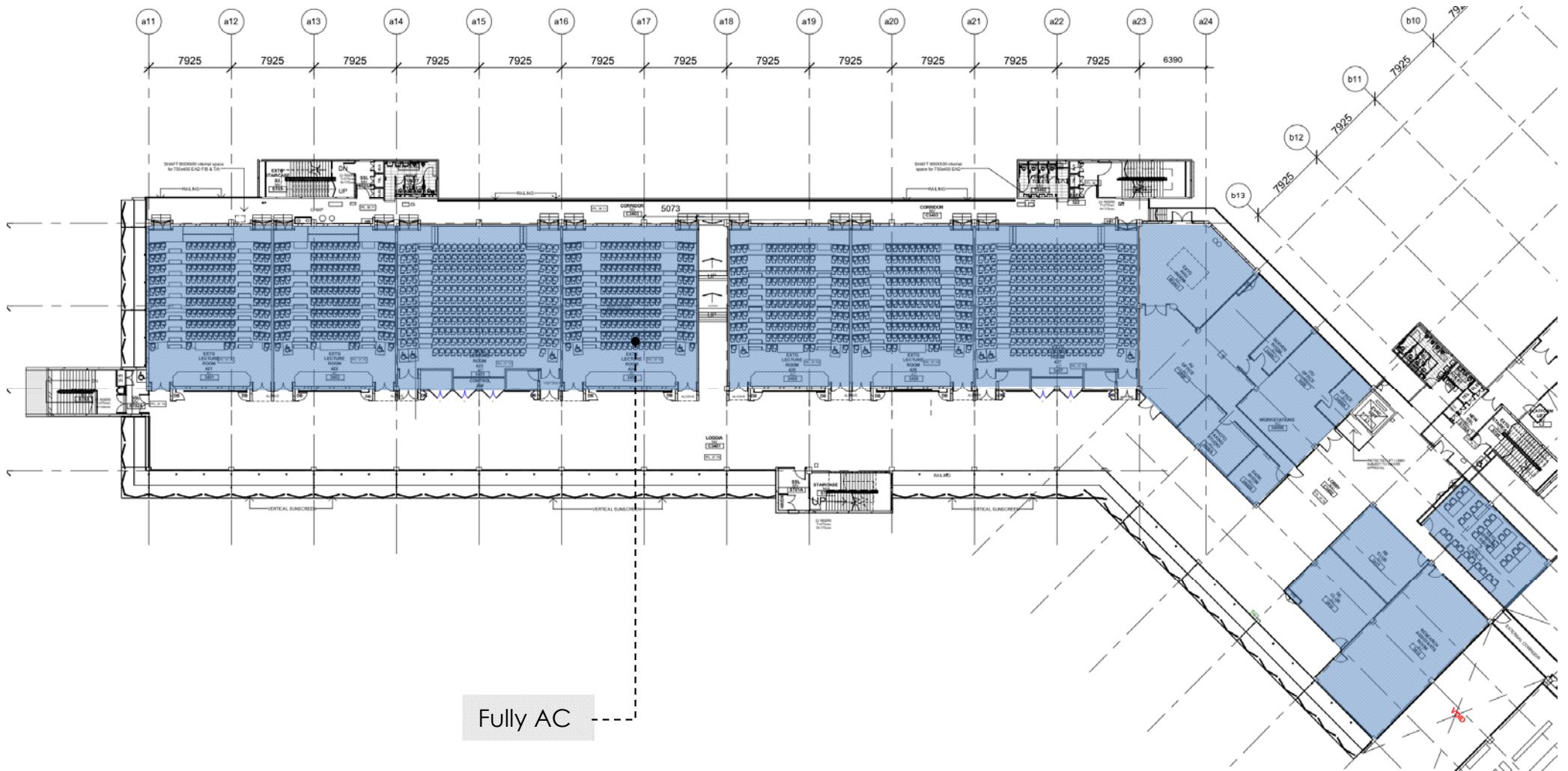
## ACMV – SDE3 – Level 1



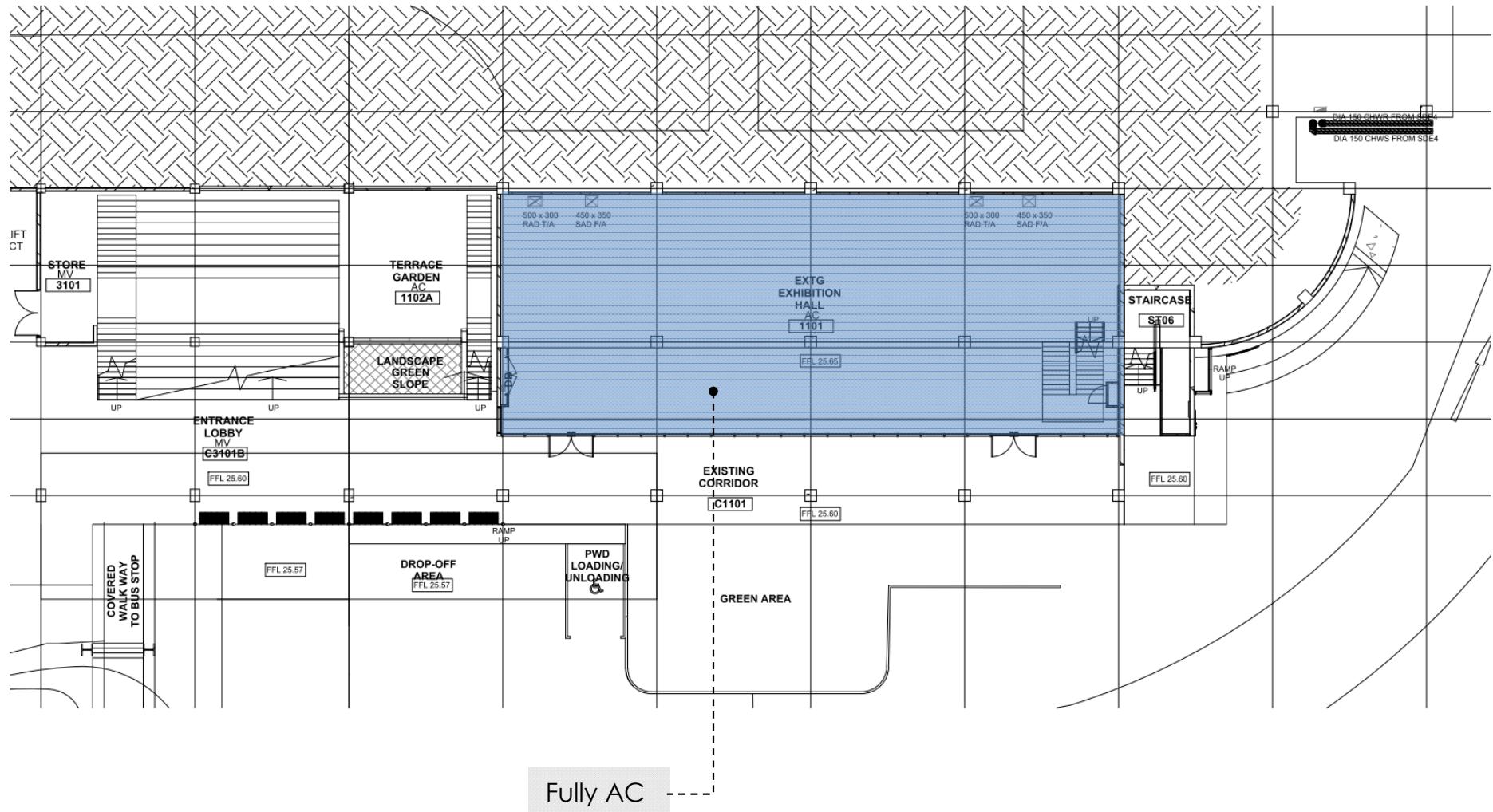
**Ventilation Zoning**  
ACMV – SDE3 – Level 2



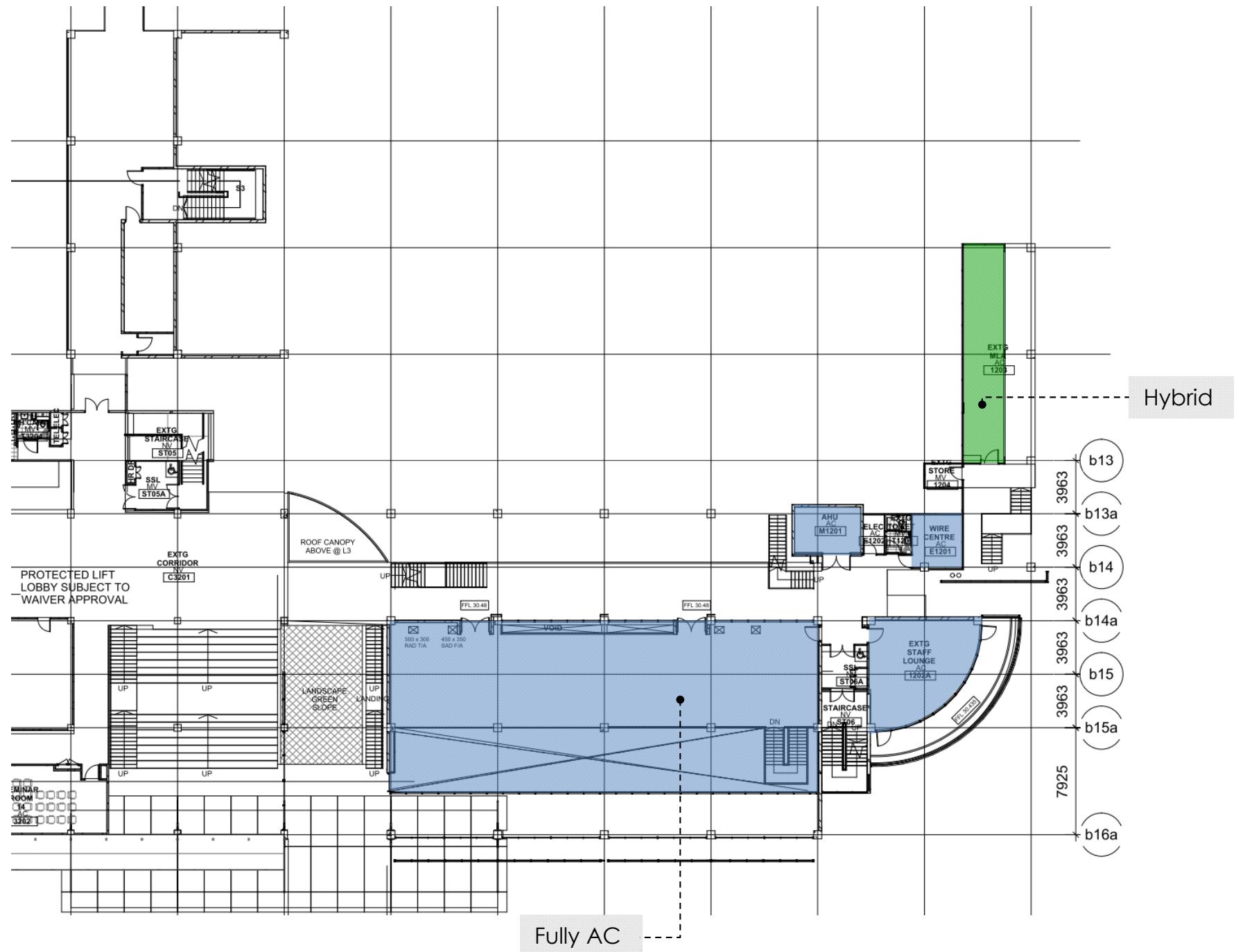
**Ventilation Zoning**  
ACMV – SDE3 – Level 3



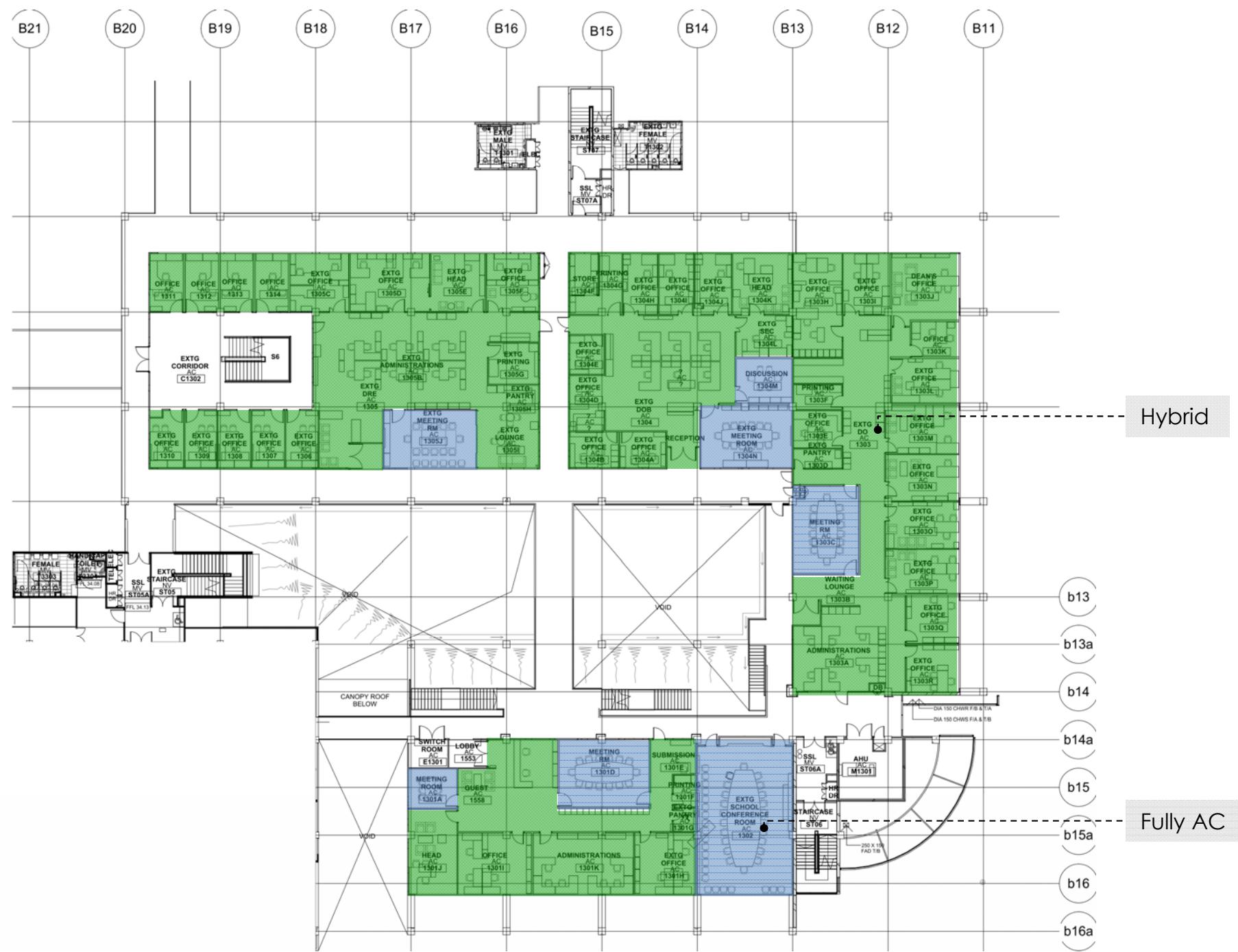
**Ventilation Zoning**  
ACMV – SDE3 – Level 4



**Ventilation Zoning**  
ACMV – SDE1 – Level 1

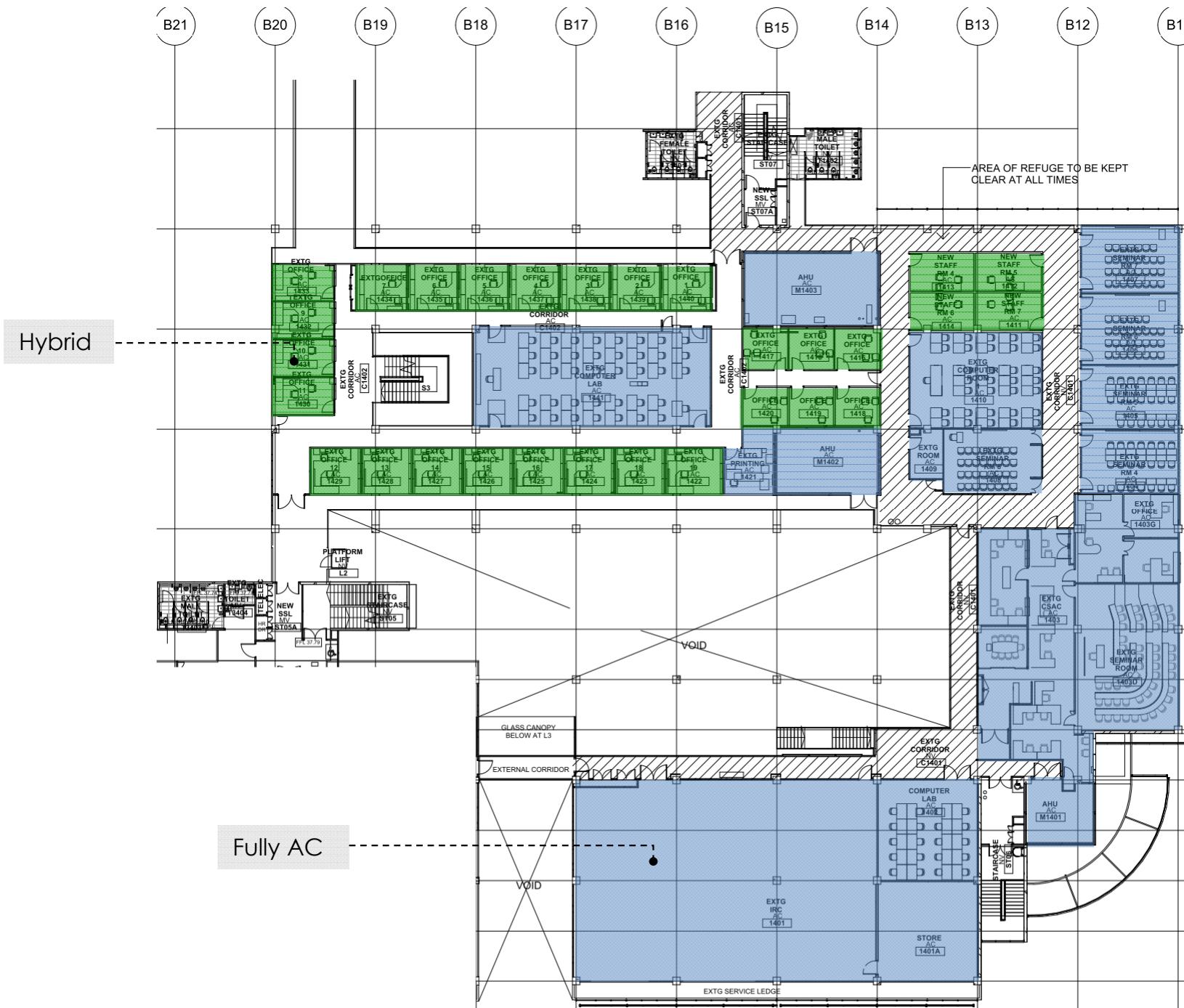


**Ventilation Zoning**  
ACMV – SDE1 – Level 2



# Ventilation Zoning

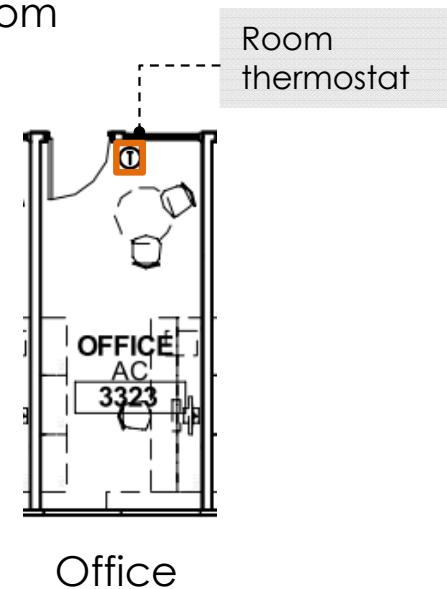
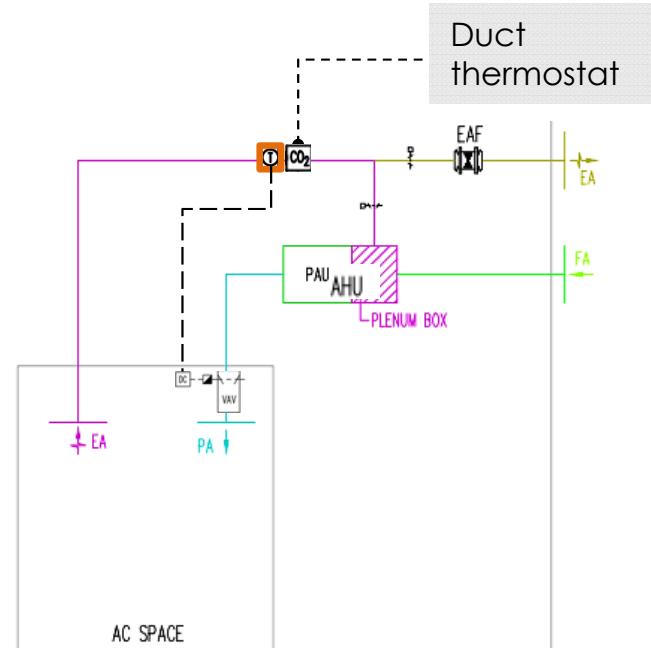
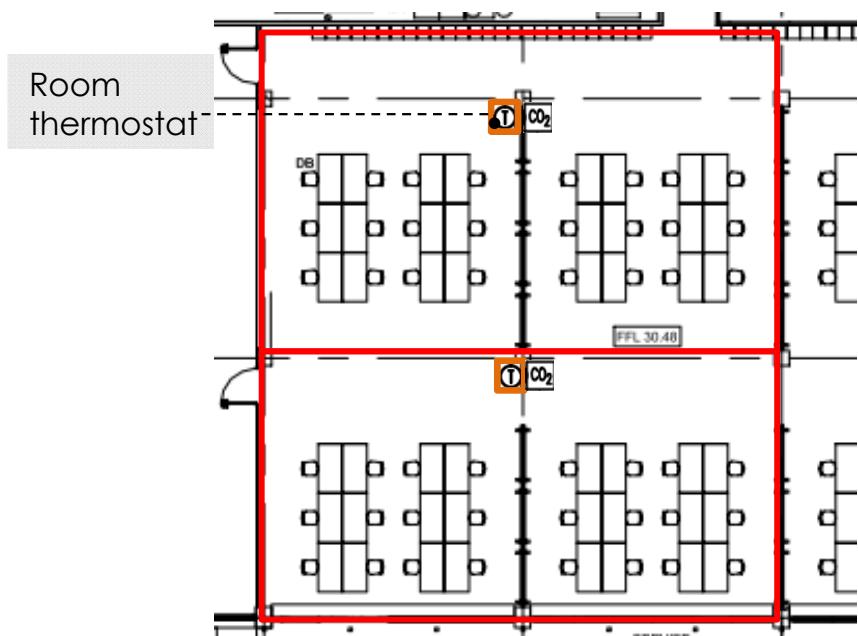
## ACMV – SDE1 – Level 3



**Ventilation Zoning**  
ACMV – SDE1 – Level 4



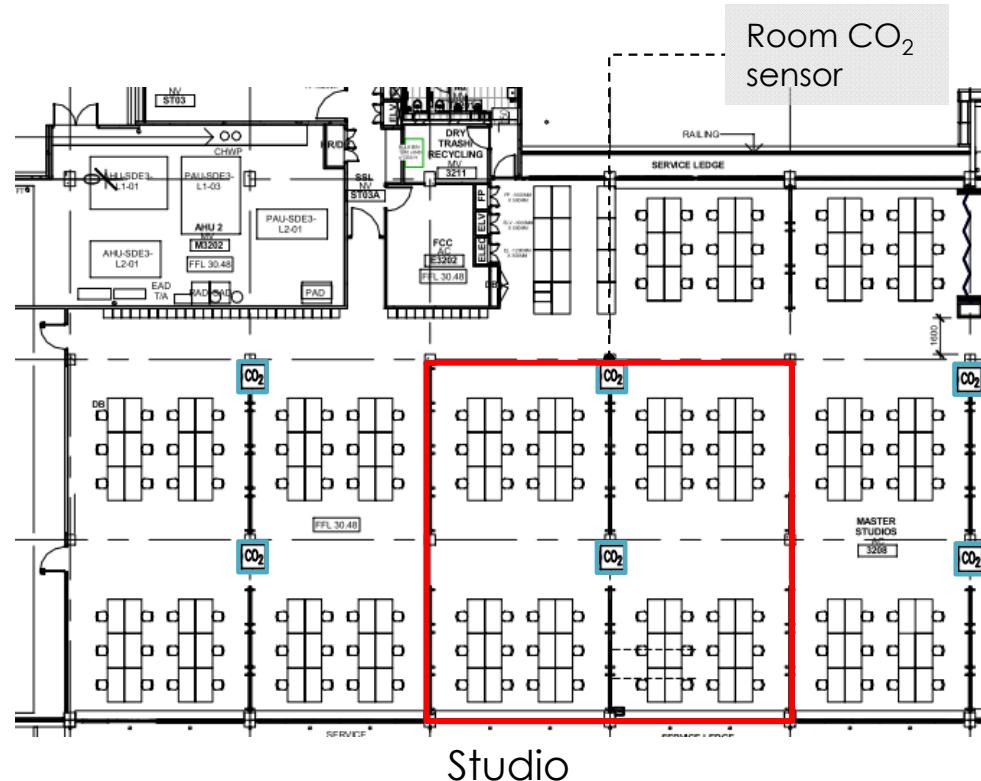
**Ventilation Zoning**  
ACMV – SDE1 – Level 5



- General Spaces – Dedicated space thermostat is provided per room
- Studios/ Knuckle – Dedicated space thermostat is provided per 2 bays
- Lecture Rooms – Dedicated ducted thermostat is provided per lecture room

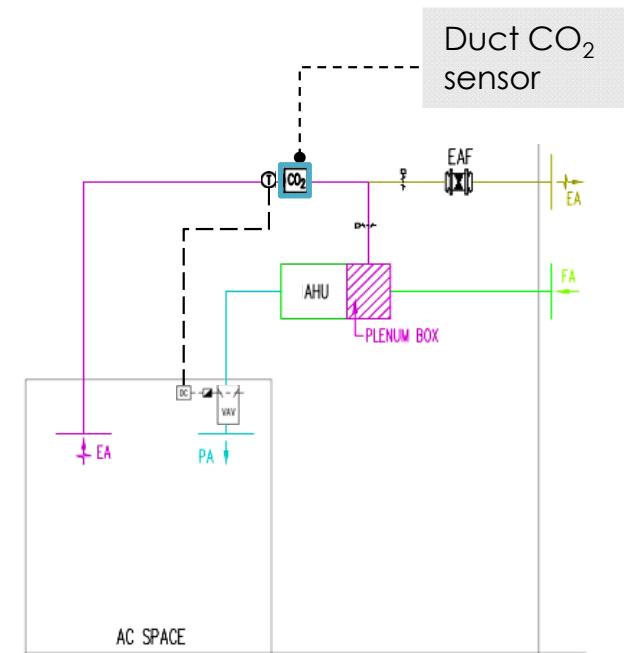
## Thermal Comfort

ACMV – SDE – IAQ (Temperature Feedback)

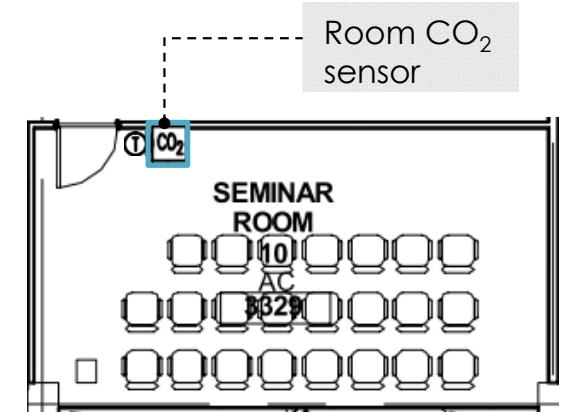


Studio

- CO<sub>2</sub> sensors are provided in high occupancy spaces to minimize surplus fresh air intake.
- High occupancy spaces:
  - Seminar / Meeting rooms / Computer Labs,
  - Studio / Knuckle
  - Lecture rooms
- Min. 50% of fresh air requirement specified in SS553 need to be kept when the space is occupied.



Lecture Room



Seminar Room

## Indoor Air Quality

ACMV – SDE – IAQ (CO<sub>2</sub> Feedback)



Location		Office				Studio				Crit					
Area (m2)		15		m2		970		m2		405		m2			
Height		3.6		m		3.6		m		3.6		m			
Design		SS 553	IESVE Simulated Hybrid Flowrates				SS 553	IESVE Simulated Hybrid Flowrates				SS 553	IESVE Simulated Hybrid Flowrates		
			26 degC	27 degC	28 degC	29 degC		26 degC	27 degC	28 degC	29 degC		26 degC	27 degC	
		4 CMH/m2	28.3	26.7	24.7	22.5	10	15.2	13.8	13.0	13.0	10	15.8	14.7	
Average Flowrates	CMH	60	425	400	370	338	9700	14752	13382	12568	12566	4050	6408	5942	
													5440	4963	
ACH		1.11	7.87	7.41	6.85	6.25	2.78	4.22	3.83	3.71	3.60	2.78	4.39	4.08	
Comparison to Code (%)		100%	708%	667%	617%	563%	100%	152%	138%	134%	130%	100%	158%	147%	
													134%	123%	

- Based on IEN's finding, fresh air supply exceeds minimum requirement stipulated in SS553

## Indoor Air Quality

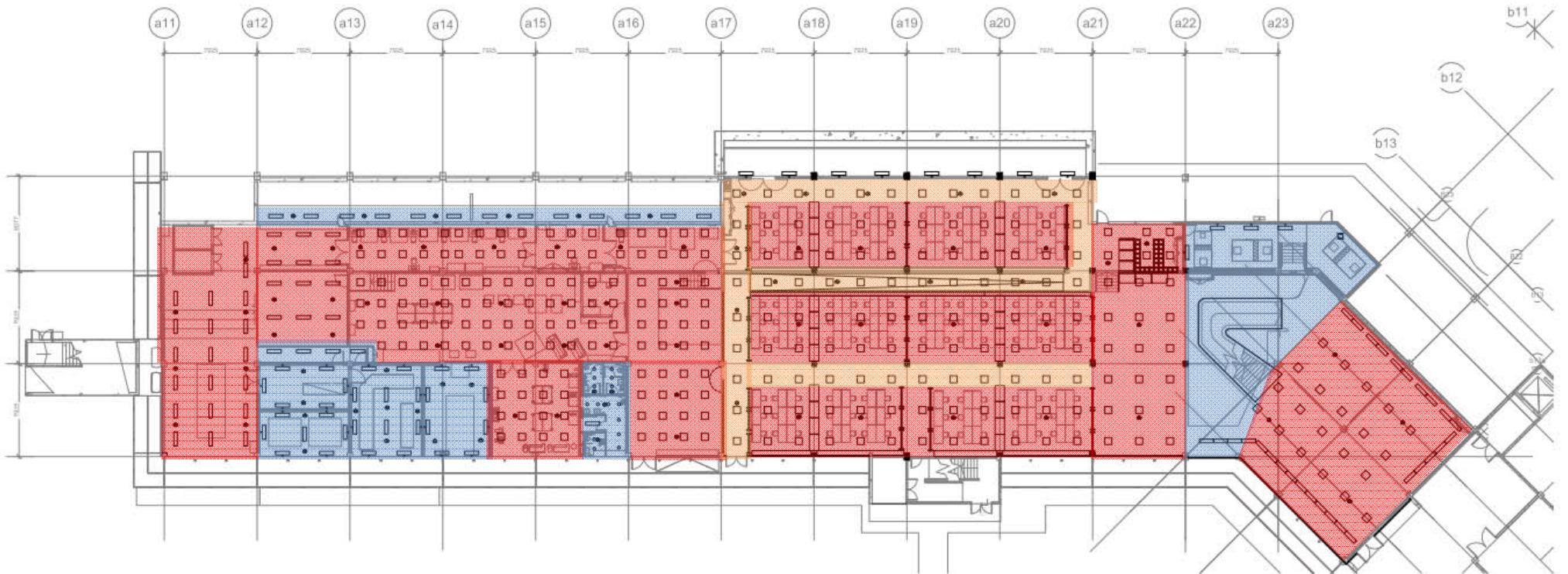
ACMV – SDE – IAQ (Outdoor Air)

# Electrical SDE 3 & 1

- Lighting Concept
- Lux Level Zoning
- Lighting Control
- Lighting Control Zoning

SS531 – Lighting of Work places	Recommended Lux Level
Circulation areas and corridors	100 lux
Stairs	150 lux
Plantroom, toilet	200 lux
Offices, Studios, Assembly Areas, Workshop - Circulation - Workstation	300 lux 500 lux

**Lighting Concept**  
EL – SDE – Lux Level

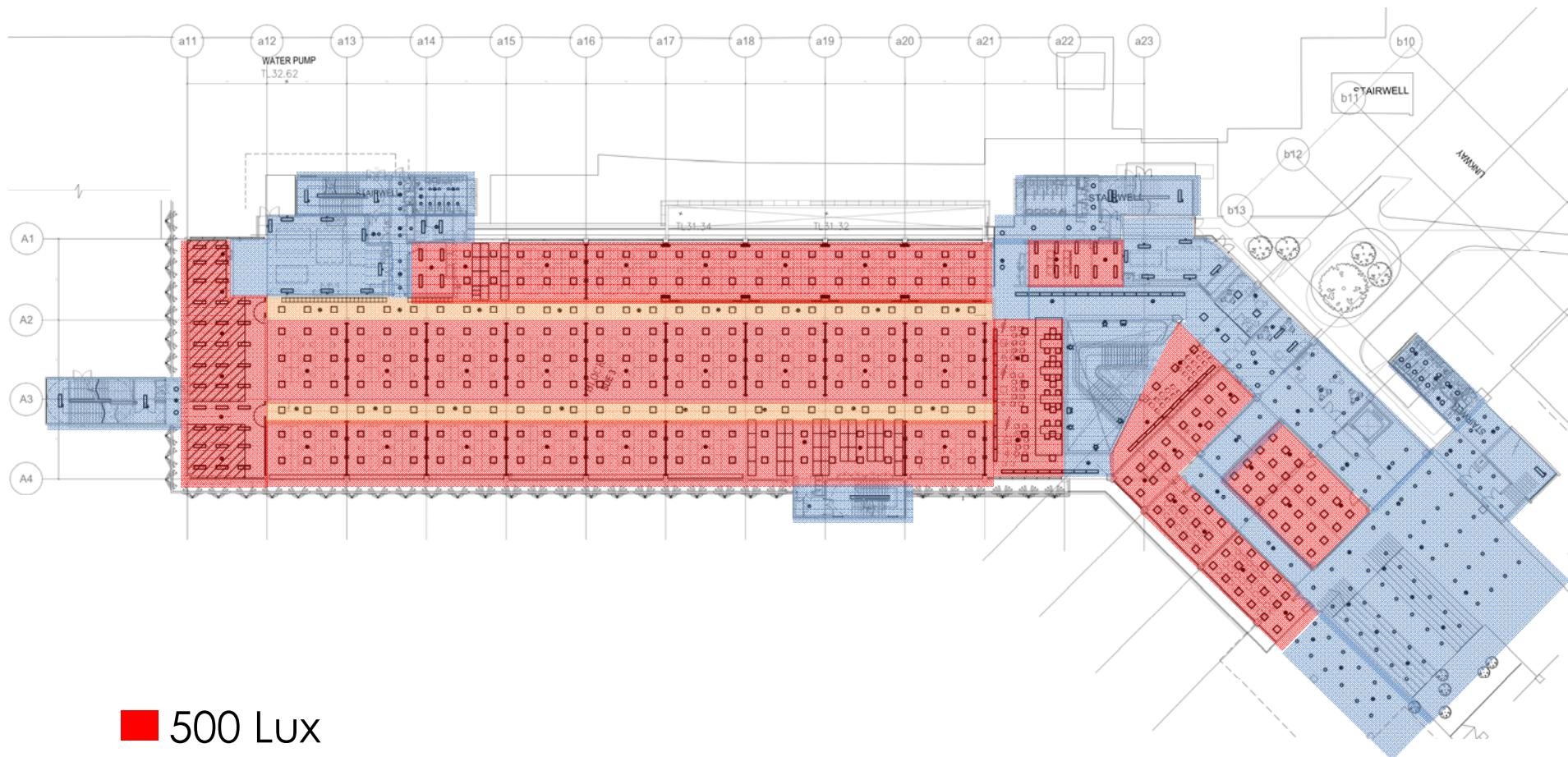


■ 500 Lux

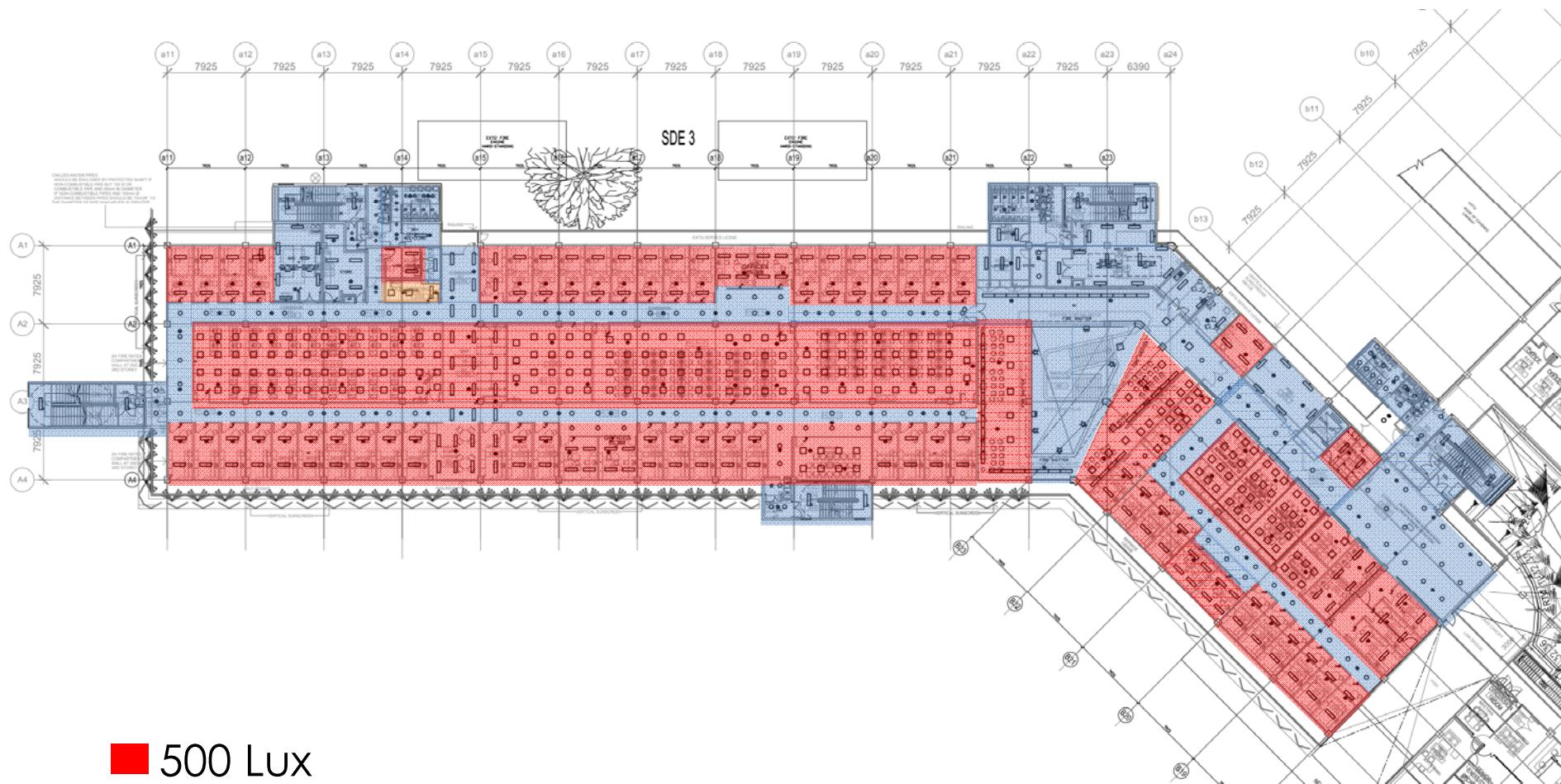
■ 300 Lux

■ 100 to 200 Lux

**Lighting Lux Level**  
EL – SDE3 – Level 1



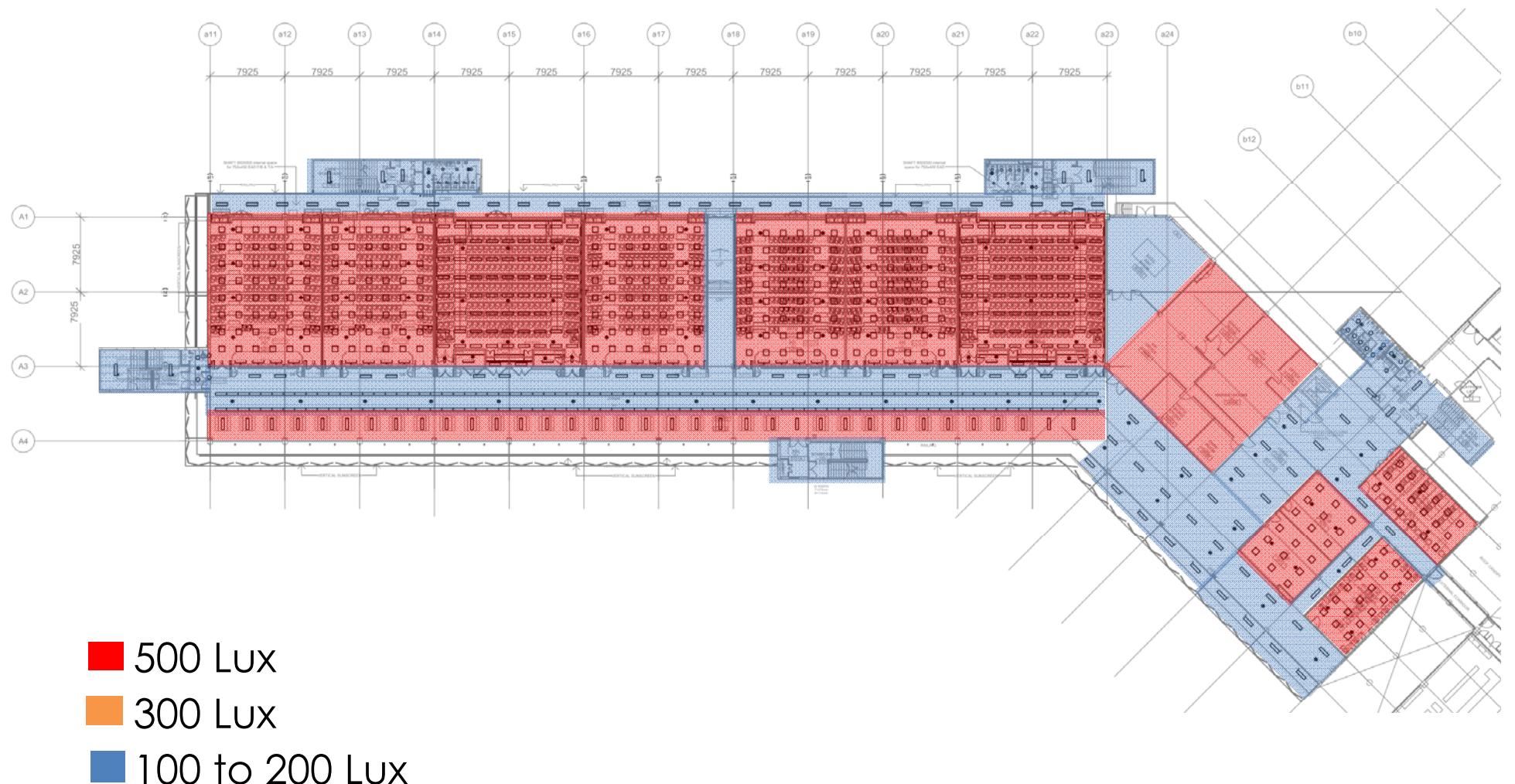
**Lighting Lux Level**  
EL – SDE3 – Level 2



- 500 Lux
  - 300 Lux
  - 100 to 200 Lux

# **Lighting Lux Level**

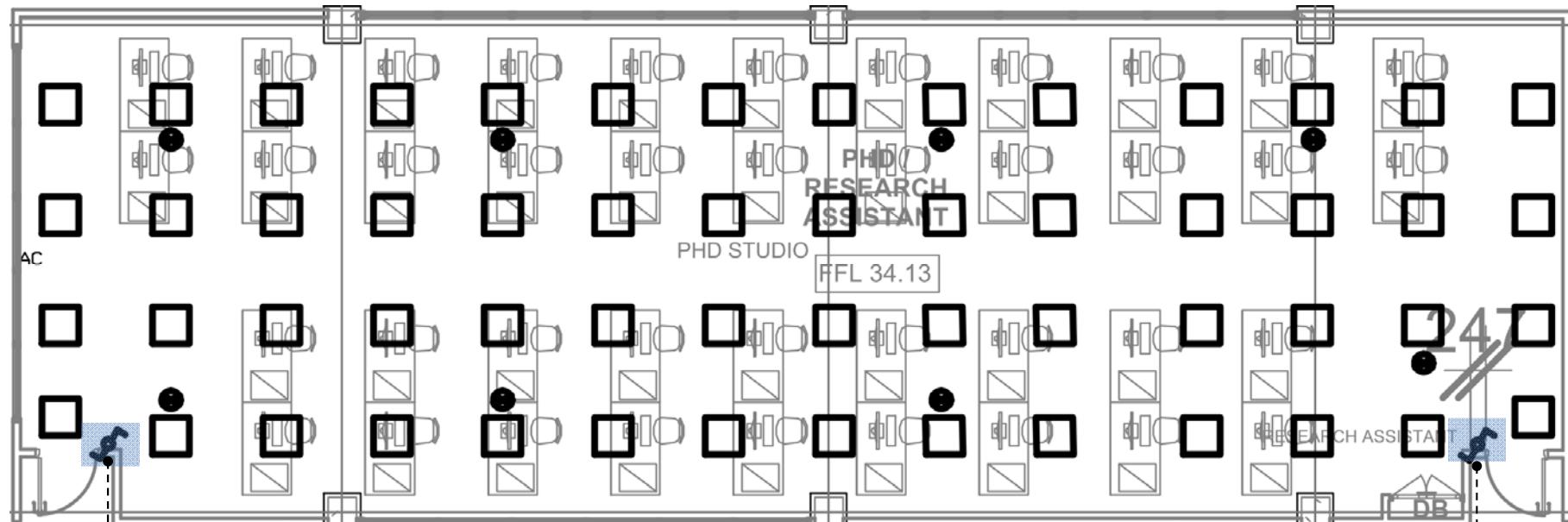
## **EL – SDE3 – Level 3**



**Lighting Lux Level**  
EL – SDE3 – Level 4

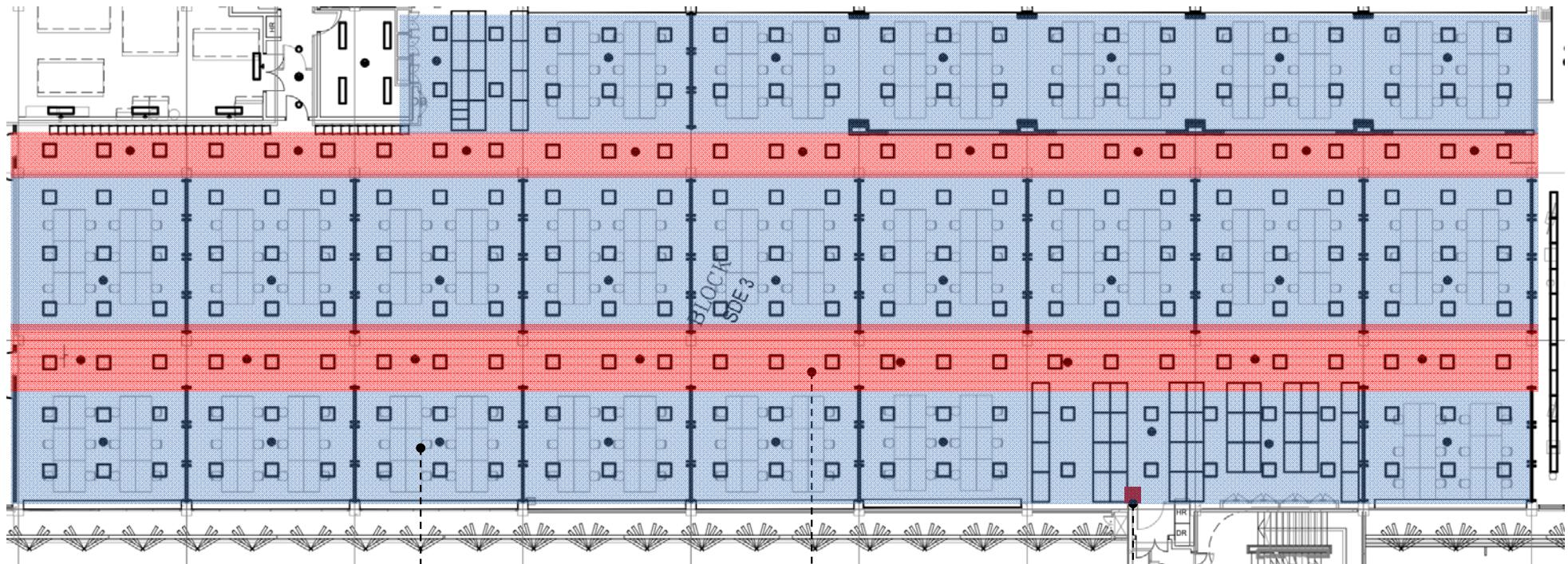
# Types of Controls

- User Control
- Timer control c/w master switch and user control (For Studios)
- Timer control c/w separate circuiting for 24hrs lightings (For Corridors)
- Timer control c/w motion sensor (For Toilets)



- User control

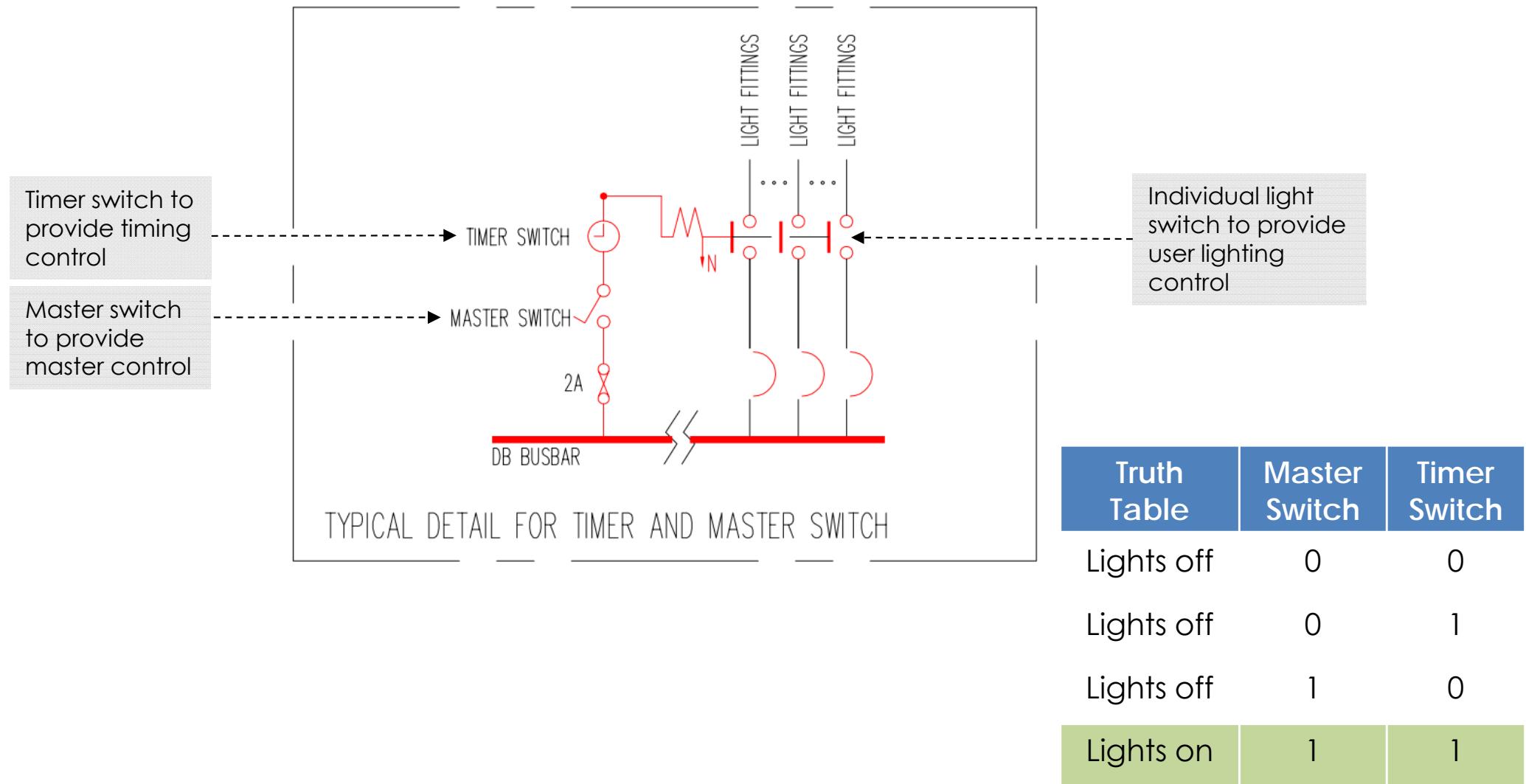
**Lighting Control**  
EL – SDE – Operation at User Spaces



- Timer control c/w master switch and user control

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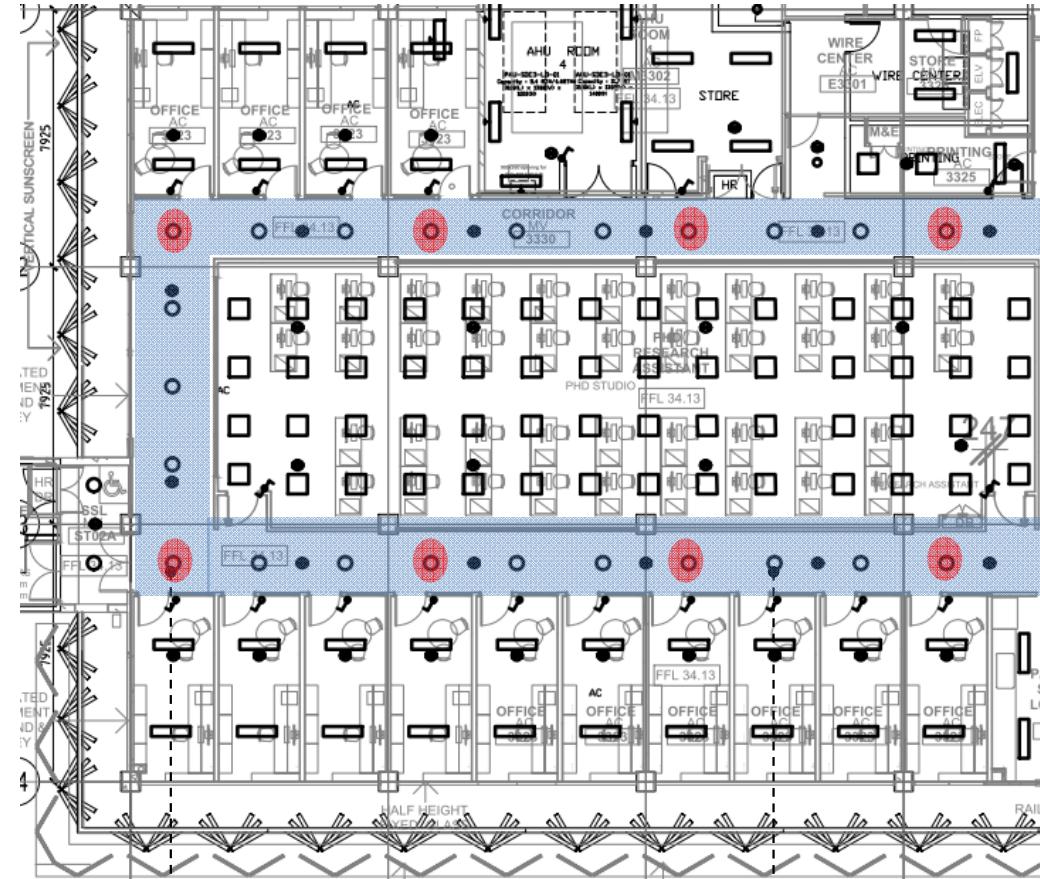
**Lighting Control**  
EL – SDE – Operation at Studio



- Timer control c/w master switch and user control

## Lighting Control

EL – SDE – Operation at Studio



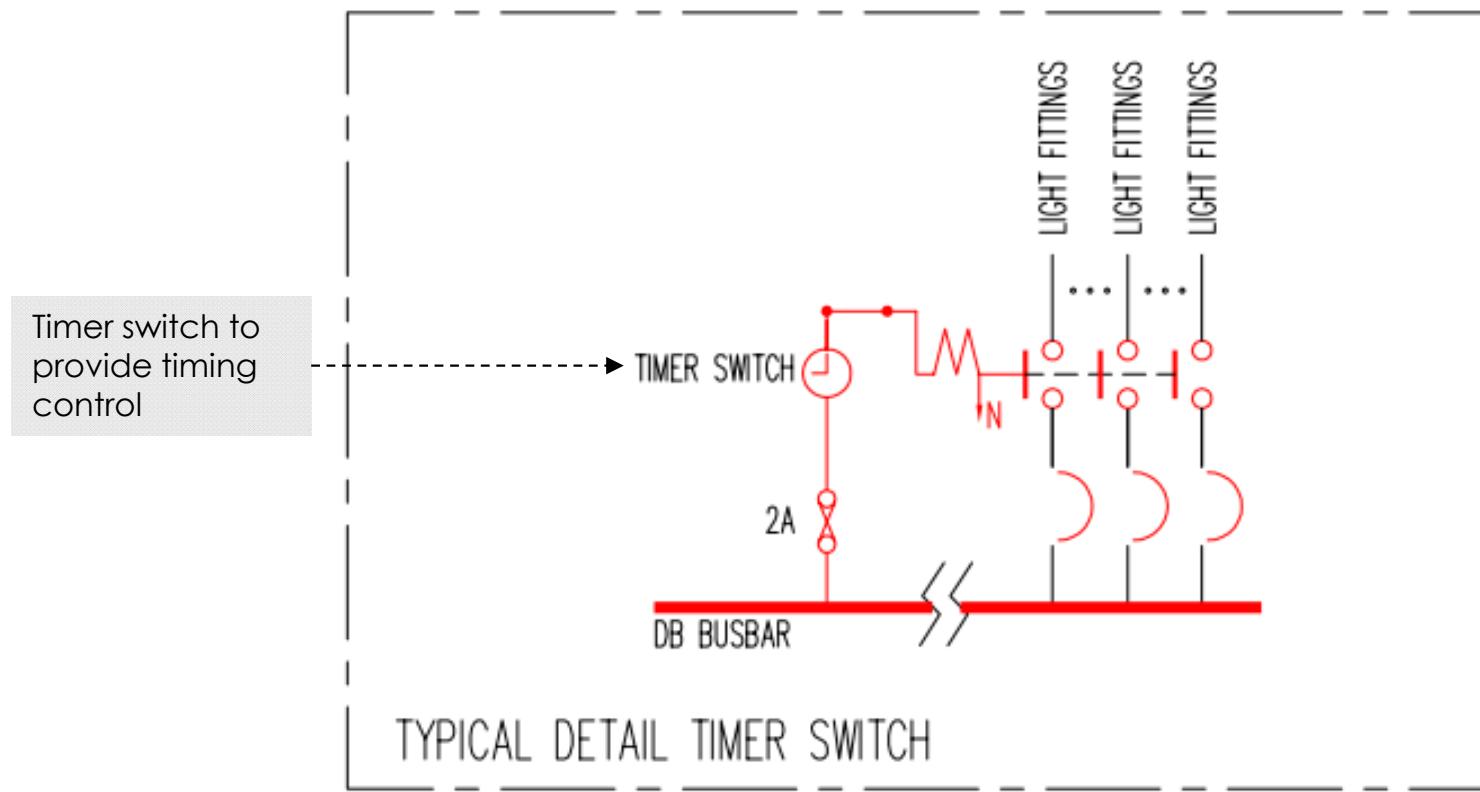
Separate circuiting  
at ~3-5m interval for  
after office hours or  
24hrs control

Timer Control on  
office hours for  
circulation spaces

- Timer control c/w separate circuiting for 24hrs lighting

## Lighting Control

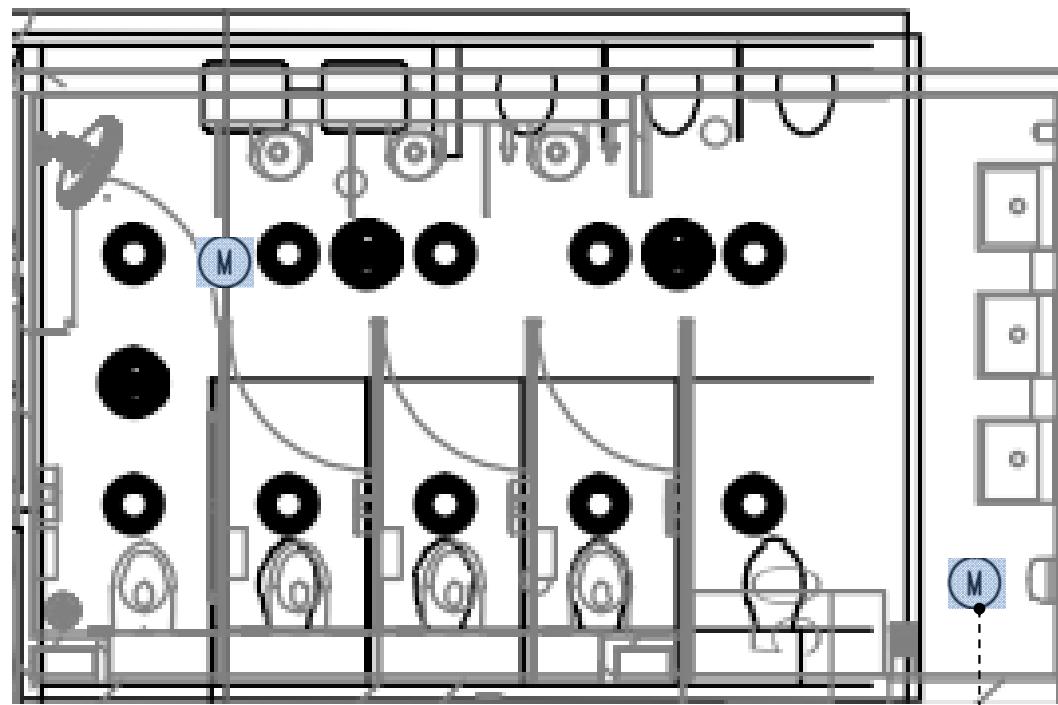
EL – SDE – Operation at Corridor



- Timer control c/w separate circuiting for 24hrs lighting

## Lighting Control

EL – SDE – Operation at Corridor



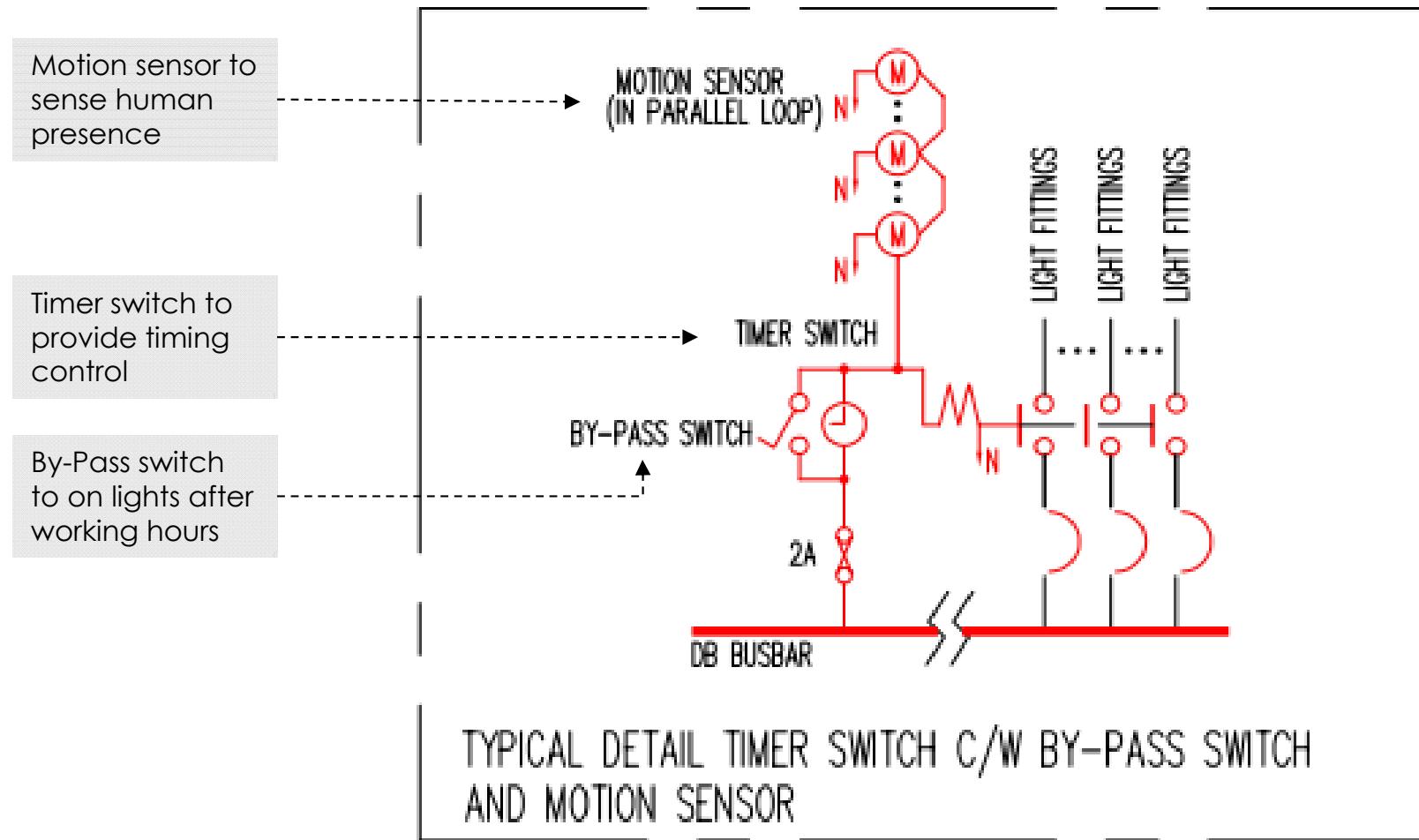
Motion sensor for  
presence sensing

- Timer control c/w motion sensor

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## Lighting Control

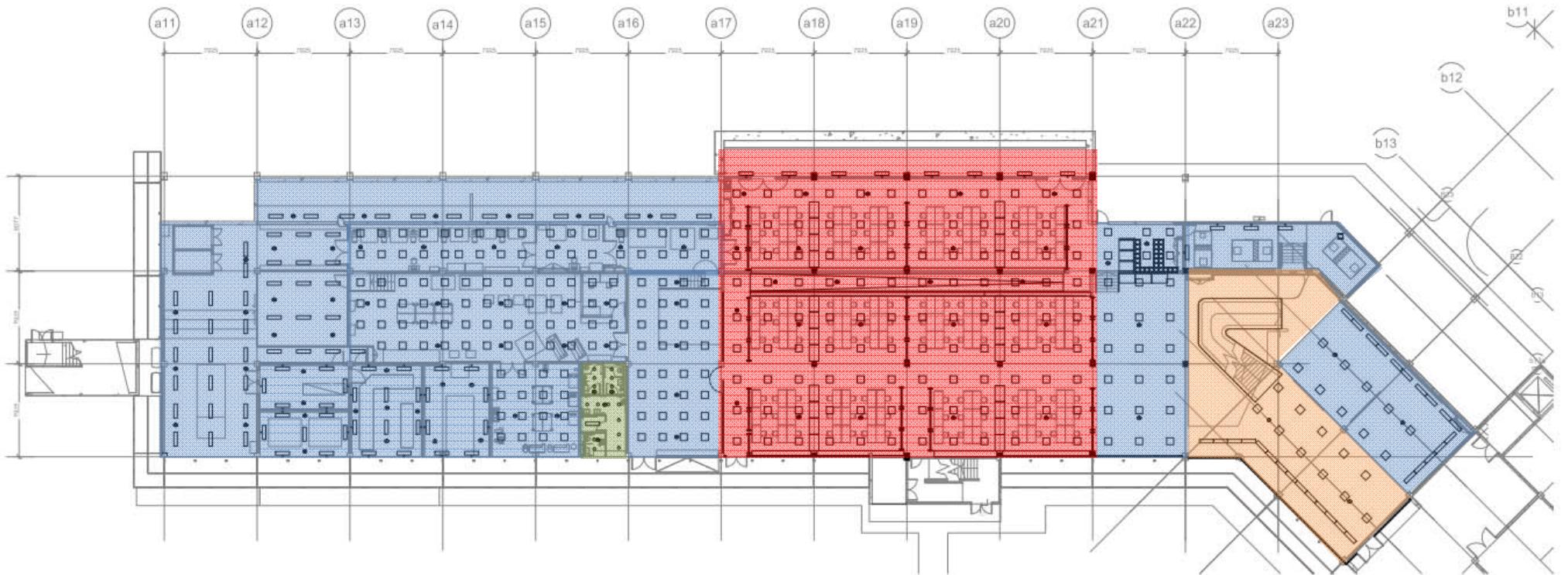
EL – SDE – Operation at Toilet / Staircase



- Timer control c/w motion sensor

## Lighting Control

EL – SDE – Operation at Toilet / Staircase



- █ User Control
- █ Timer control c/w master switch and user control
- █ Timer control c/w separate circuiting for 24hrs lightings
- █ Timer control c/w motion sensor

## Lighting Control Zoning

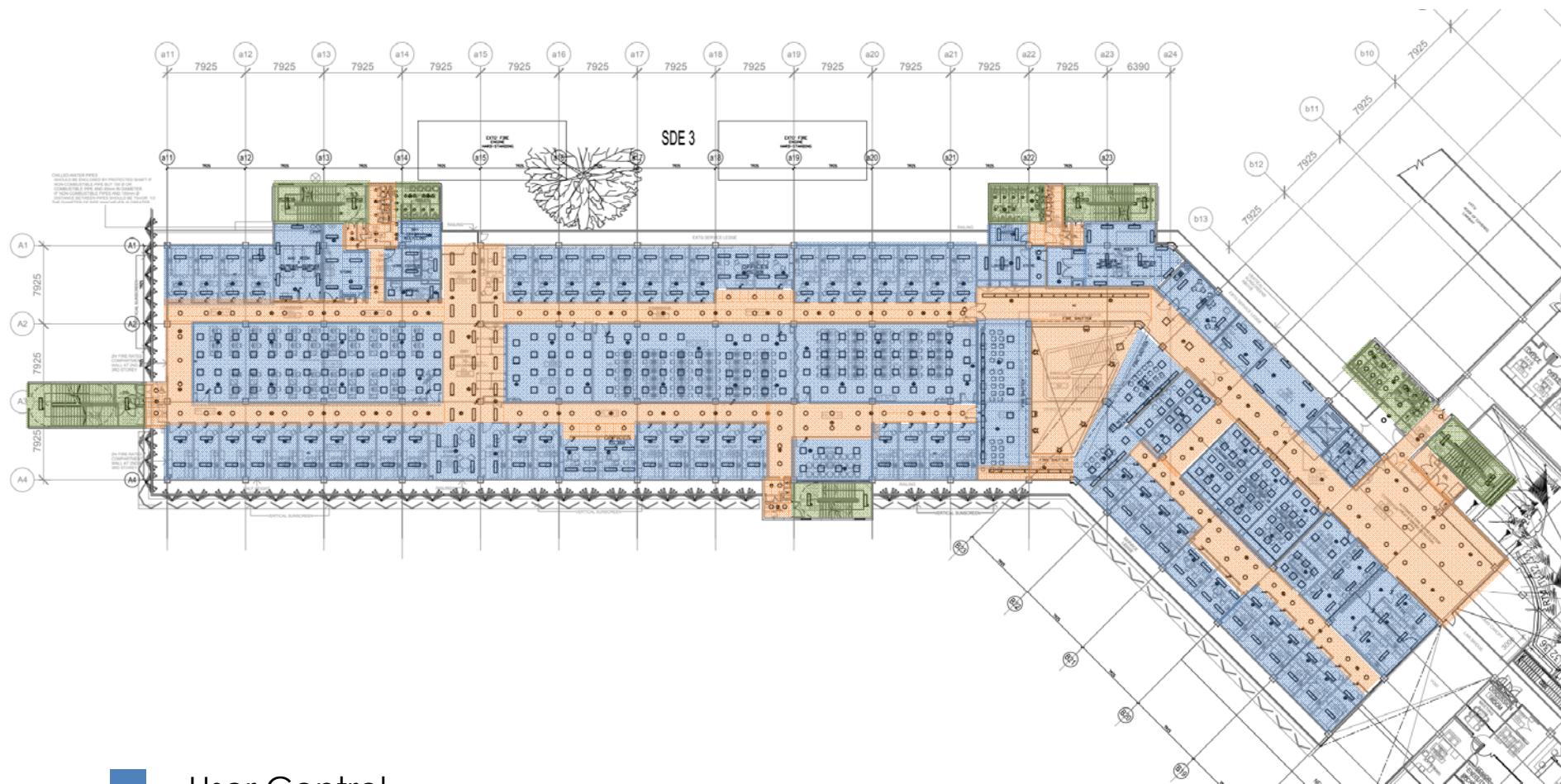
EL – SDE3 – Level 1



- █ User Control
- █ Timer control c/w master switch and user control
- █ Timer control c/w separate circuiting for 24hrs lightings
- █ Timer control c/w motion sensor

## Lighting Control Zoning

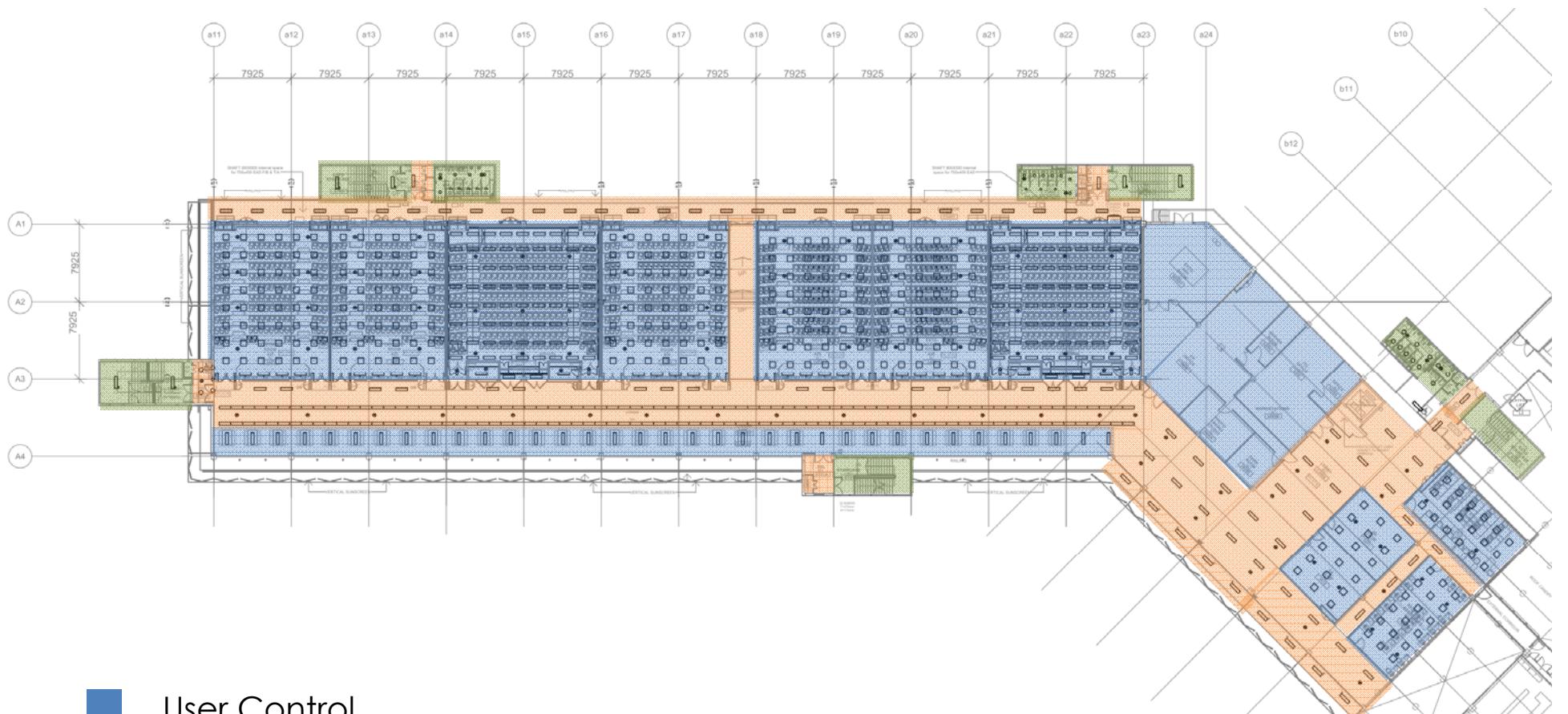
EL – SDE3 – Level 2



- User Control
  - Timer control c/w master switch and user control
  - Timer control c/w separate circuiting for 24hrs lightings
  - Timer control c/w motion sensor

# **Lighting Control Zoning**

## **EL – SDE3 – Level 3**



- █ User Control
- █ Timer control c/w master switch and user control
- █ Timer control c/w separate circuiting for 24hrs lightings
- █ Timer control c/w motion sensor

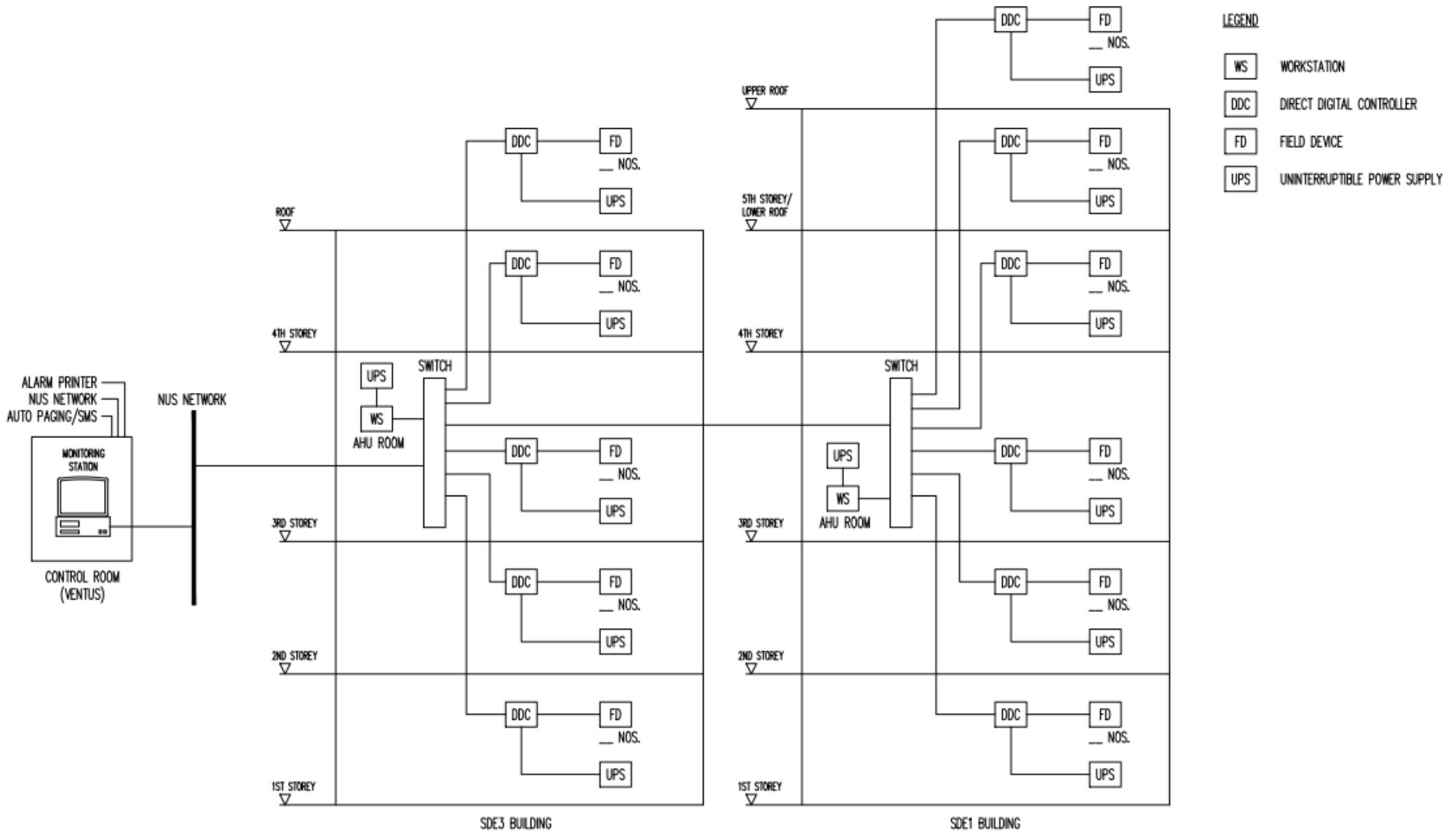
## Lighting Control Zoning

EL – SDE3 – Level 4

# **Building Intelligence**

## **SDE 3 & 1**

- **System Architecture**



## System Architecture

### BMS – SDE – BMS Schematic

# **Green Mark Overview**

## **SDE 3 & 1**

<b>Green Mark Criteria</b>	<b>Estimated Point</b>
Part 1 – Energy Efficiency	52
Part 2 - Water Efficiency	14
Part 3 - Sustainable Operation & Management	21
Part 4 - Indoor Environmental Quality	12
Part 5 – Other Green Features	0
<b>Total</b>	<b>99</b>

Target: Green Mark **Platinum** (NREB Version 3.0)

1. High chiller plant efficiency of **0.65 kW/RT** or better
2. Good ETTV of **40W/m<sup>2</sup>** and lower
3. Hybrid system
4. High efficient lighting system
5. Control and monitoring system
6. Integration design process
7. Campus wide sustainability effort and initiatives



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**Key Green Mark  
Features**

Thank You