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Hillingdon

Outline Fire Strategy – Rev E

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Quality Assurance

| Revision | Date | Prepared by | Authorised by | Reason |
|----------|------------|-------------|---------------|--|
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| Rev A | 13/09/2019 | Tom Gibbins | Dane Owen | Update to incorporate New Drawings |
| Rev B | 10/10/2019 | Tom Gibbins | Dane Owen | Site Description updated as per GL Hearn’s Request |
| Rev C | 15/11/2019 | Tom Gibbins | Dane Owen | New Drawings |
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1 Introduction

- 1.1.1
- This report is to outline the fire safety aspects of the proposed Inland Homes Hillingdon development Scheme. The paragraphs below outline the major fire engineering considerations within the design as a basis to support the design team for the proposed site in the planning application.
- 1.1.2
- This document is not intended as a full Fire Strategy for the development as this will be prepared in due course to fully resolve and justify all aspects of the fire strategy design.

2 Important Information

- 2.1.1
- The layout of the development is not strictly compliant with the recommendations of the prescriptive guidance document BS 9991. Therefore, where the design deviates from the prescriptive guidance, a fire engineered approach has been adopted to demonstrate compliance with the functional requirements of Building Regulations. Where fire engineering has been used this will be justified through quantitative analysis and qualitative discussions on the performance of the solutions. The final objective is to produce a level of life safety commensurate with prescriptive guidance documents. It should be noted that all recommendations made in this report are of equal critical importance for life safety and compliance and the report should be read in its entirety. If you have any queries or don't understand anything within this report please contact us.
- 2.1.2
- Any proprietary systems or product used should be confirmed by the manufacturer and installer as appropriate for the use in the application to meet the performance specification of this report. This report is developed on the basis of either conventional steel or concrete structure being used, if the scheme is to be Timber frame of lightweight steel this report is not valid, and a detailed update will be required.
- 2.1.3
- The report has not yet been approved and should not be relied upon for design until it has been agreed with the relevant approval bodies.
- 2.1.4
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3 Legislation

- 3.1.1
- Under the Building Regulations a building owner is required to provide an adequate level of life safety to the building by providing suitable means of escape, means of warning occupants of a fire, limiting internal fire spread, protecting adjacent property from fire, and facilitating Fire Service operations. This can be achieved by the adoption of standard guidance as documented within Approved Document B (ADB Volume 1 & 2) 2019 Edition. However, ADB further recognises that alternative solutions may provide a more appropriate design. The use of an alternative approach is detailed in ADB, Use of Guidance page 3/4:

“The fire safety requirements of the Building Regulations will probably be satisfied by following the relevant guidance in this approved document. However, approved documents provide guidance for some common building situations and there may be alternative methods of complying with the Building Regulations’ requirements.

If alternative methods are adopted, the overall level of safety should not be lower than the approved document provides. It is the responsibility of those undertaking the work to demonstrate compliance.

If other standards or guidance documents are adopted, the relevant fire safety recommendations in those publications should be followed in their entirety. However, in some circumstances it may be necessary to use one publication to supplement another. Care must be taken when using supplementary guidance to ensure that an integrated approach is used in anyone building.”

- 3.1.2
- The building will adopt “BS 9991 – Fire safety in the design, management and use of residential buildings” will be used as the basis of the fire safety design of the residential accommodation.
- 3.1.3
- Where BS 9991 is not applicable, such as in the non-residential areas, ADB will be used as guidance.
- 3.1.4
- It should be noted that this report considers the requirements of the Building Regulations only. There may be additional fire safety featured requested by the end-user or operator. The relevant parties should be consulted to confirm if there are any additional non-Building Regulations requirements of the scheme.

4 Site Description

- 4.1.1
- The proposed Hillingdon development comprises of 12 buildings providing residential accommodation.
- 4.1.2
- The proposed scheme is to be the construction of a residential-led, mixed-use development comprising buildings of between 2 and 11 storeys containing 514 units (Use Class C3); flexible commercial units (Use Class B1/A1/A3/D1); associated car (164 spaces) and cycle parking spaces; refuse and bicycle stores; hard and soft landscaping including a new central space, greenspaces, new pedestrian links; biodiversity enhancement; associated highways infrastructure; plant; and other associated ancillary development.
- 4.1.3
- All residential buildings are served by a single stair core and has been assessed in accordance with the recommendations for a single stair building on all levels.
- 4.1.4
- The ground floor area between buildings 2 to 8 will also provide residential car parking. There are also commercial spaces located within the ground floor of building 1, between buildings 2/4, the commercial unit within buildings 2/4 is also on the first floor.
- 4.1.5
- Additionally, each building will also contain the following ancillary areas on ground level:
 - Plant Rooms
 - Bin Stores
 - Cycle Stores
 - Substation (Building 5 only)
- 4.1.6
- Buildings 2 through 9 have a landscaped terrace located on the First floor which can be accessed via some of the apartments located on the first floor and from the common corridors. Confirmation will be needed whether these terraces are open to the public or for the use of residents only.
- 4.1.7
- Currently, the height of each building when measured from the lowest adjacent ground to the topmost occupied storey is unknown. Detailed section/elevation drawings should be provided to confirm the height of each building as this will have a significant impact on the structural fire resistance of the buildings. The number of storeys of each building has been listed below:

| | | |
|---------------------------|---|---------------|
| Building 1, 2, 3, 6, 7, 8 | - | G + 7 Floors |
| Building 4, 10 | - | G + 6 Floors |
| Building 5 | - | G + 10 Floors |
| Building 9, 11, 12 | - | G + 4 Floors |



Figure 1: Site Plan

5 Automatic Fire Detection and Alarm (AFDA)

- 5.1.1 A minimum of Grade D1 LD2 alarm system should be provided to standard apartments designed and installed in accordance with BS 5839-6.
- 5.1.2 To operate the smoke ventilation in the corridor, a Category L5 detection and alarm system should be provided to the common corridors and stairs of each block on all levels. The system is provided to actuate the smoke ventilation only and will not act as a means of warning occupants of a fire.
- 5.1.3 To operate the mechanical smoke ventilation in the car park, a minimum Category L3 detection and alarm system should be provided.
- 5.1.4 The ancillary areas to the residential accommodation are to be provided with Category L3 coverage which will include sounders and manual call points. However, the alarm within such areas should be programmed such that fire detection in the ancillary areas does not trigger evacuation of the residential areas and vice versa.
- 5.1.5 The commercial spaces located on the ground floor of building 1, between buildings 2/4 and in building 13 are understood to be independent from the residential areas above and is to be design on a shell and core basis. This would require a minimum coverage of Category M to meet Building Regulations. However, the tenant is to provide the alarm system as appropriate for the fit-out of the unit.

- 5.1.6 Manual call-points are to be located in the non-residential areas on escape routes and at all storey exits. All doors to fresh air should be provided with manual call points, including where exits are not specifically designed as fire exits. The distribution of the manual call points should be such that no occupant has to travel more than 45m to reach the nearest one. It should be noted that the activation of a manual call point should not trigger any sounders on the residential levels to facilitate the stay-put evacuation policy.
- 5.1.7 The Landscaped terraces will be required to be provided with sounders and beacons which are connected to the common corridor detection system.
- 5.1.8 The fire alarm is to interface with a number of other systems such as plant shut down etc; these interfaces should be designed in accordance with BS 7273. In particular door release mechanisms and hold open devices should be interfaced in accordance with BS 7273-4.
- 5.1.9 The position of the fire alarm panel is to be determined by the design team; however, it is recommended that it is located in such a place that it can be monitored constantly by management and is visible from the external such the Fire Service can assess the panel before entering the building. Fire alarm repeater panels should be provided at all fire service entry points (not all entry points to the building).

6 Means of Escape

6.1 Means of Escape – Non-Residential/Ancillary Areas

- 6.1.1 The travel distance limitations in the non-residential/ancillary areas have been provided in Table 1.

Table 1: Travel Distance Limitations – Non-Residential/Ancillary Areas

| Location | One Direction | More than One Direction |
|------------------------------|---------------|-------------------------|
| Covered Residential Car Park | 18m | 45m |
| Commercial | 18m | 45m |
| Bin Stores | 9m | 45m |
| Cycle Storage | 25m | 45m |
| Plant Room | 9m | 35m |

- 6.1.2 If a storey has two or more storey exits it should be assumed that a fire might prevent occupants from using one of them. The remaining exits(s) should be wide enough to allow all occupants to leave quickly. Therefore, the largest/worst case exits should be discounted for the purpose of the assessment.
- 6.1.3 Where a single escape route is provided or the exit opens against the direction of escape, the occupancy will be limited to a maximum of 60 through that exit.
- 6.1.4 The escape widths should be in accordance with Table 2.

Table 2: Widths of Escape Routes and Exits

| Maximum Number of Occupants | Minimum Escape Width (mm) |
|-----------------------------|---------------------------|
| 60 | 750 |
| 110 | 850 |
| 220 | 1050 |
| More than 220 | 5mm per person |

- Commercial Spaces
- 6.1.5

The commercial spaces located on the ground floor of building 1 and between buildings 2/4 are understood to be independent from the residential areas above and is to be design on a shell and core basis. It is also assumed that the ground floor commercial unit between buildings 2 and 4 is connected to the commercial unit on the first floor via an independent staircase.
- 6.1.6

The maximum potential occupancy of the commercial spaces should be confirmed by the client. If the occupancy exceeds 60, there should be a minimum of two exits provided (allowing for one to be discounted). Providing two 850mm clear width exits would allow for an occupancy up to 110 and providing two 1050mm clear width exits would allow for an occupancy up to 220. A larger occupancy would be assessed based on 5mm per person.
- 6.1.7

The maximum occupancy of each landscaped terrace should be limited to 60 occupants.
- 6.1.8

Currently, the exits are not shown. It should be ensured that exits are also provided so that travel distances in Table 1 are met.

Ground Floor Car Parks

- 6.1.9

A means of smoke and heat ventilation system should be provided from every car park storey having the objective of clear smoke during a fire and/or after a fire has been suppressed. This has been discussed in Section 7.
- Car Park between Buildings 2/3/4

6.1.10

The car park between buildings 2/3/4 has 60 parking spaces. Based on 2 persons per parking space, the car park will have an occupancy of 120.

6.1.11

The car park is provided with the following exits:
 - 850mm clear width exit into building 2 (opening against the direction of escape) – limited to 60-occupants;
 - 850mm clear width exit into building 3 (opening against the direction of escape) – limited to 60-occupants;
 - 850mm clear width exit into building 4 (opening against the direction of escape) – limited to 60-occupants;
 - Vehicular Access Entrance (largest exit assumed to be discounted).

6.1.12

The exits provide a capacity for 180-occupants. Therefore, considered sufficient.

Car Park between Buildings 5/6, 6/7, 7/8

6.1.13

The car park between buildings 5/6 and 6/7 has 23 parking spaces. Based on 2 persons per parking space, the car park will have an occupancy of 46. The car park between buildings 7/8 has 26 parking spaces. Based on 2 persons per parking space, the car park will have an occupancy of 52.

6.1.14

Each car park is provided with a single exit via the vehicular access entrance. As a single escape route is provided, the occupancy will be limited to a maximum of 60 through that exit. This is considered sufficient.
- Ancillary Areas
- 6.1.15

Areas such as plant, storage, refuse stores etc. are considered unoccupied spaces; where occupants would only be present for a limited period of time. Thus, it is deemed acceptable additional occupancy is not accounted for in these areas.

6.1.16

Ancillary areas should not share the same escape routes as the residential accommodation’s stair which provides the only escape out of the building for the residential occupants.

6.1.17

Within the scheme there are several plant rooms etc. that share egress with the residential final exit (See Appendix A). The lobbies between the plant room and residential final exit should be provided with a minimum
- 1.5m² natural ventilation or a minimum 0.8m² mechanical ventilation with pressure sensors in the lobby. As neither are achievable due to the lobbies limited size, it is to be confirmed if escape can be achieved via a protected corridor around the back of the plant room.

6.1.18

Alternatively, a fire and smoke curtain could be provided which would descend on local detection, this deviation would be subject to agreement with Building Control.

6.1.19

Where bin stores are accessed internally, they should be separated by a protected lobby provided with not less than 0.2m² permanent ventilation.
- 6.2 Means of Escape – Residential Buildings
- 6.2.1

The travel distance limitations in the residential areas have been provided in Table 1.
- Table 3: Travel Distance Limitations – Residential
- | Location | One Direction | More than One Direction |
|---------------------|---------------|-------------------------|
| Standard Apartments | 9m | N/A |
| Common Corridor | 7.5m* | 30m* |
- Note: * Where sprinklers (Category 2 BS 9251) are fitted in all apartments on the floor, the maximum single direction corridor travel distances are permitted up to 15m and 60m where there is more than one direction of escape.
- Apartments
- 6.2.2

Travel distances in standard apartments should be limited to 9m from the furthest point in the room to the apartment entrance door. If this travel distance is exceeded, the entrance hall to the apartment must achieve the requirements of a protected entrance hall, i.e. 30 minutes fire-resistance and FD 30 fire doors.

Common Residential Areas

6.2.1

The recommendations of BS 9991 permit a single direction travel distance of up to 7.5m in an unventilated corridor on the basis that the corridor then provides access into a dedicated ventilated lobby then into a protected stair. Alternatively, BS 9991 also permits a 7.5m single direction travel distance within a ventilated corridor from an apartment entrance door to the protected stair.

6.2.2

Where the common corridors/lobbies have travel distances within the recommendation in BS 9991, the ventilation is achieved by either:
 - An AOV of 1.5m² direct to the external; or
 - An AOV of 1.0m² in area which discharges into a vertical natural smoke shaft with a clear internal area of 1.5m²; or
 - A 0.8m² mechanical ventilation shaft with a pressure sensor in the corridor/lobby to prevent excessive depressurisation. (Smoke ventilation contractor should confirm the size of the shaft is acceptable).

6.2.3

It should be noted that BS 9991 states that natural smoke ventilation via AOVs should not be utilised in buildings with height of more than 30m to the topmost occupied storey (i.e. Building 5).

6.2.4

There are extended single direction travel distances in buildings 4 & 10 up to 20m from the furthest apartment door to the protected staircase, therefore either:
 - Provide an enhanced mechanical ventilation system is to be provided to the corridor (with a minimum 0.8m² mechanical smoke shaft located at the remote end of the corridor which is served by a minimum 0.8m² natural inlet shaft at the opposite end. CFD modelling would be required to be provided as justification in the detailed design stage; or
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- A minimum Category 3 sprinkler system is required to be provided to the apartments in accordance with BS 9251, and it is to be ensured that the maximum distance from the furthest apartment to the staircase door is within 15m.
- 6.2.5 If the sprinkler option is to be provided, the residential corridor is to be ventilated by either:
- A minimum 1.0m² AOV, serving a 1.5m² natural smoke shaft; or
 - A minimum 0.8m² smoke shaft with pressure sensors in the lobby.
- 6.2.6 Recommendations for corridor smoke ventilation arrangement for each building has been provided in Appendix A.
- Egress from Residential Stairs**
- 6.2.7 In full accordance with BS 9991, egress from the stairs should be direct to the external at the lowest adjacent ground level as per Figure 34a and 34b of BS 9991. Every protected stairway should discharge direct to the external or by way of a protected corridor to the external.
- 6.2.8 Currently, the final exit from some buildings discharge into the common corridor/entrance lobbies. A protected route should be provided direct to the external. This has been highlighted in Appendix A.
- 6.2.9 Any final exit doors from the stairs would need to provide an equivalent clear width of the stair they serve.

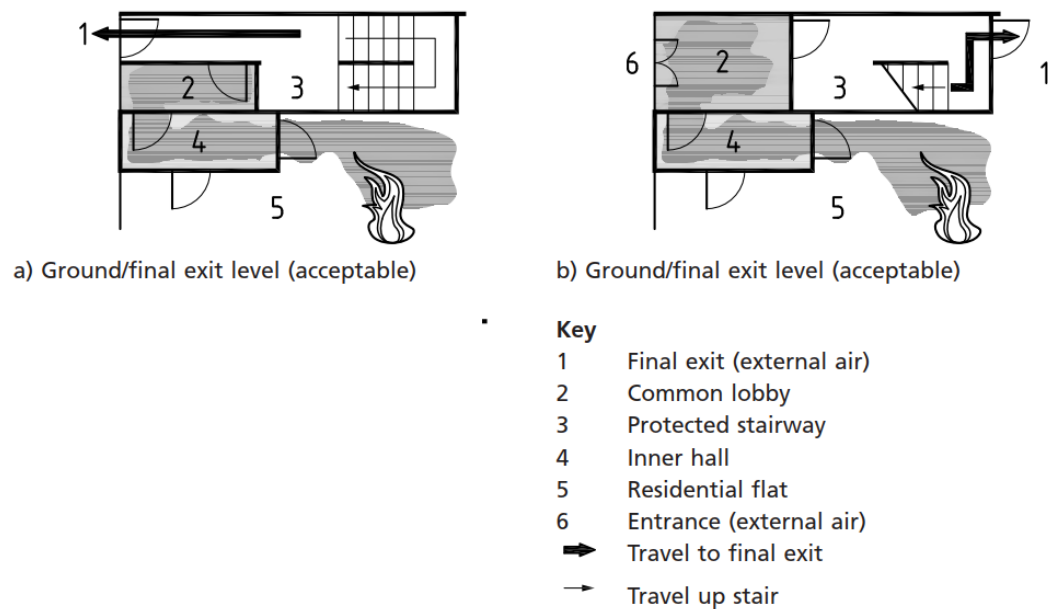


Figure 2: Lobby Protection to Final Exit from Stairway – BS 9991 Figure 34a & 34b

7 Ventilation Provisions

Car Park - Venting of Smoke and Heat

- 7.1.1 In accordance with ADB, a smoke and heat ventilation system should be provided from every car park storey having the objective of clear smoke during a fire and/or after a fire has been suppressed.

- 7.1.2 As the car park is enclosed, it is not possible to obtain the minimum standard of natural ventilation on opposing walls set out in ADB. Therefore, the ventilation will be achieved by a combination of natural inlets and jet fans which should be provided as follow:
- The system should be independent of any other ventilation system (other than any system provide normal ventilation to the car park) and be designed to operate at 10 air changes per hour in fire condition;
 - The system should be designed to run in two parts, each part capable of extracting 50% of the rates set out above and designed so that each part may operate singly or simultaneously;
 - Each part of the should have an independent power supply which would operate in the event of failure of the main supply;
- 7.1.3 CFD modelling demonstrating compliance will be required to be carried out in RIBA Stage 3.
- Automatic Openable Vents**
- 7.1.4 All stairs are required to be provided with a 1.0m² AOV at the head of the stairs.
- 7.1.5 The method to calculate the free area of the Automatic Openable Vents (AOV's) is highlighted in Figure 3.

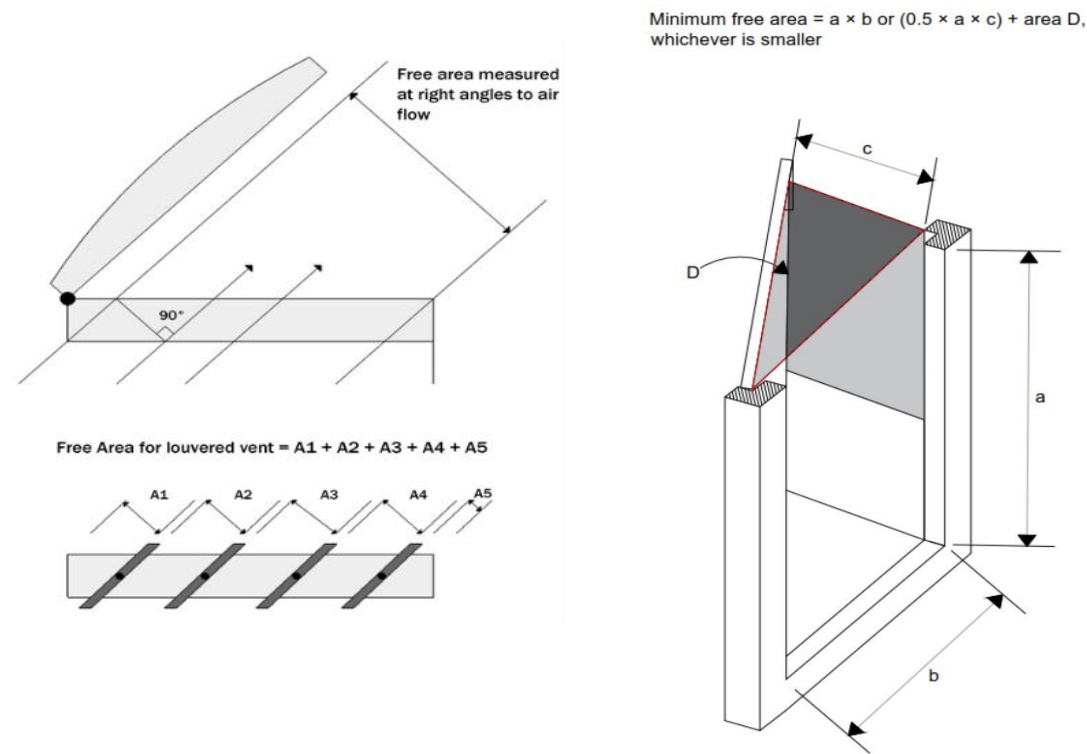


Figure 3: Free Area of Smoke Ventilation

Natural Smoke Shaft

- 7.1.6 Where a natural smoke shaft is adopted it will be designed to meet the following criteria:
- Minimum cross-sectional area 1.5m² (minimum dimension 0.85m in any direction), opening at roof level at least 0.5m above any surrounding structures that fall within a 2.0m radius on a horizontal plane so that it is not subject to adverse wind effects (i.e. it should always have negative wind pressure coefficients).
 - The shaft should extend at least 2.5m above the ceiling of the highest storey served by the shaft. If desired the 2.5m extension of the smoke shaft above the highest storey served can be omitted given the

recommendations of BCA Guidance Note 8 are followed as per paragraphs 7.1.7. (i.e. a 1.5m² rooflight can be provided in the corridor of the highest occupied floor and therefore it will prevent a chimney. The 1.5m² AOV would be located adjacent the staircase, near the natural smoke shaft which is to not serve the highest occupied floor.)

- The minimum free area of the vent from the corridor into the shaft and at the head of the shaft and all internal location within the shaft (e.g. safety grilles) should be at least 1.0m².
- The top of the lobby or corridor vent should be located as close to the ceiling of the lobby or corridor as is practicable and should be at least as high as the top of the door connecting the lobby or corridor to the stairwell.
- The lobby or corridor vents, in the closed position, should have a minimum fire and smoke resistance performance of 60 min and integrity (leakage) no greater than 360³/h/m² when tested in accordance with BS EN 1366-2.
- The smoke shaft should be constructed of materials classified as A1 in accordance with BS EN 13501-1, or of materials determined to be non-combustible when tested in accordance with BS 476-4, or of any material which when tested in accordance with BS 476-11 does not flame or cause any rise in the temperature on either the centre of the specimen or the furnace thermocouples. It should be noted that the non-combustibility requirement also applies to grilles at floor level, and so GRP Grilles cannot be used in the smoke shafts.
- As the smoke shaft penetrates compartment floors, it should achieve the fire-resistance of the floor that it passes through.
- No services other than those relating to the smoke shaft should be contained within the smoke shaft.
- The shaft will be no more than 4m at an inclined (maximum 30°) from the base to head.

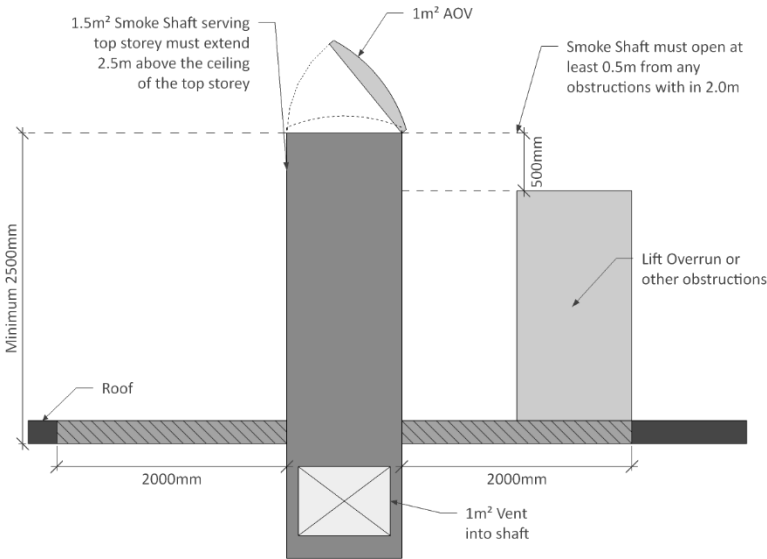


Figure 4: Natural Smoke Shaft

BCA Guidance Note 8

7.1.7 Where the smoke shaft penetrates the roof, it must be located such that any nearby projections/obstructions through the roof will not have an adverse effect on the smoke escaping and, at worse, will not prevent the smoke from escaping.

7.1.8 The natural smoke shaft must terminate at least 0.5m above the surrounding structure and extended 2.5m above highest storey served by the smoke shaft. This creates a “chimney” that extended somewhere in the region of 2m above the roof level. Therefore, even where there are no obstructions within 2m of the shaft that shaft termination will protrude above the roof line (something that most architects/planners would not prefer). As such, BCA Guidance suggests two potential solutions which can be adopted to omit the extension of the smoke shaft.

Option 1

7.1.9 This solution is based on a principle of increasing the size of AOV between the corridor and smoke shaft (top level only) and the AOV at the head of the stair. Both will need to achieve a cross-sectional free area of 1.5m². This combined with the effective clear free area of the smoke shaft of 1.5m², effectively creates a direct opening to the outside air from the top storey and does not rely on the smoke shaft as a chimney. The solution is intended to minimise the number of penetrations through the roof.

7.1.10 A typical arrangement of Option 1 can be seen on Figure 5.

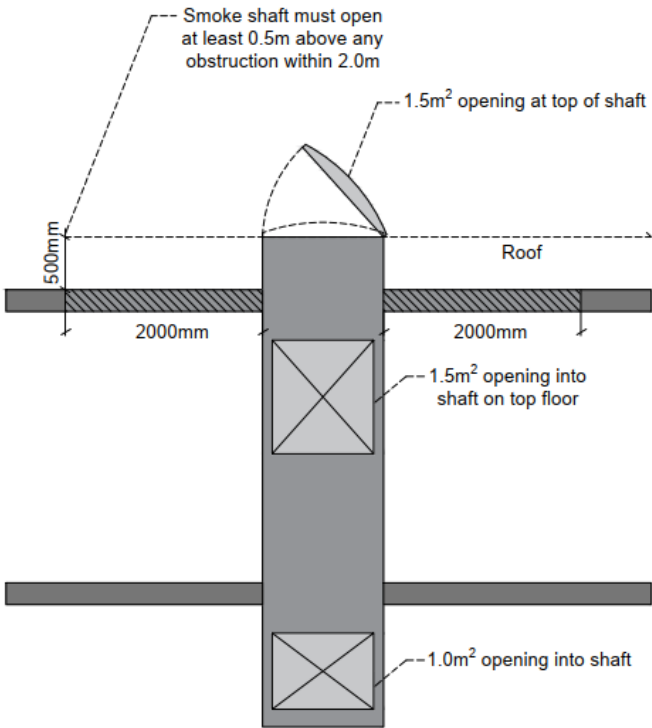


Figure 5: Natural Smoke Shaft Extension Omission – Option 1

7.1.11 Note, given the limitations and restrictions set out by BS 9991 on the use of AOVs as primary means of ventilation for buildings over 30m in height. This has been discussed and agreed in principle with Building Control (subject to implementation of BCA Guidance Note 8 in full). This should be further consulted with the Fire Authority for completeness of the approval process.

Option 2

7.1.12 This solution is based on a principle of omitting the AOV from the smoke shaft on the top storey, and instead provision of a roof mounted AOV, achieving 1.5m² cross-sectional area. By separating the ventilation provisions

to another opening in the roof construction and allowing for the extension of the smoke shaft to be counted from the lower level. Thus, the extension of the smoke shaft would be internal in the building.

7.1.13 The it should be noted however the smoke shaft, when penetrating through the roof will need to be extended 0.5m above any surrounding structure within 2m radius. Additionally, the shaft termination and the AOV vent in the roof will need to be minimum 2m apart.

7.1.14 A typical arrangement of Option 2 can be seen on Figure 5.

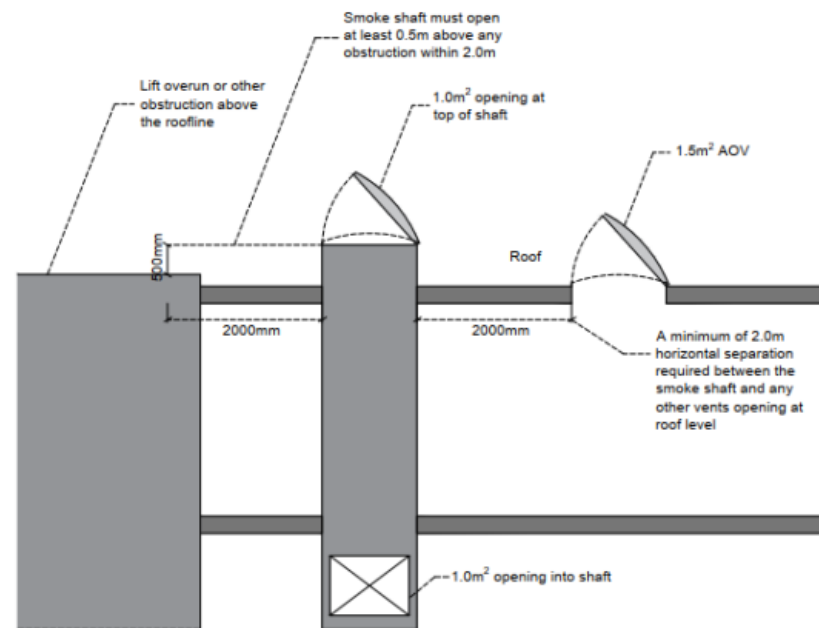


Figure 6: Natural Smoke Shaft Extension Omission – Option 2

Mechanical Smoke Shaft

7.1.15 The mechanically smoke shaft will have a cross sectional area of 0.8m². (Smoke ventilation contractor should confirm the size of the shaft). The operation of the mechanical shaft would be upon a smoke detector activating in the apartment. The smoke shaft is to include duplicate fans (duty and standby) with alternative power supplies. The fans in extract shaft are to be in line with BS EN 12101-6.

7.1.16 Where specified the mechanically smoke shafts will meet the following criteria:

- Where travel distances are within the compliant limit. A single mechanical shaft with pressure sensors in the corridor will be provided on those levels. This is to ensure the excess smoke is not drawn from the fire affected apartment into the stair.
- The smoke shafts are to include duplicate fans (duty and standby) with alternative power supplies. The fans in extract shaft are to be in line with BS EN 12101-6.
- Upon detection of smoke in the apartment, the vents on the fire floor, the vent at the top of the smoke shaft and the stair are to open simultaneously. The vents from the corridors/lobbies on all other storeys will remain closed.
- The top of the lobby vent should be located as close to the ceiling of the lobby as is practicable, and should be at least as high as the top of the door connecting the lobby to the stairwell) The lobby vents, in the closed position, should either:

- have a minimum fire and smoke resistance performance of 60 min and a leakage rate no greater than 200 m³/h/m² when tested in accordance with BS EN 1366-2; or
- be in accordance with BS EN 12101-8.

- The smoke shaft should be constructed of materials classified as A1 in accordance with BS EN 13501-1:2007+A1, or of materials determined to be non-combustible when tested in accordance with BS 476-4, or of any material which when tested in accordance with BS 476-11 does not flame or cause any rise in the temperature on either the centre of the specimen or the furnace thermocouples. It should be noted that the non-combustibility requirement also applies to grilles at floor level, and so GRP Grilles cannot be used in the smoke shafts.
- As the smoke shaft penetrates fire compartments should, as a minimum, maintain the same separation of the floors.
- No services other than those relating to the smoke shaft should be contained within the smoke shaft.
- Fans should be capable of handling gas temperatures of 300 °C for a continuous period of not less than 60 min and tested in accordance with BS EN 12101-3.
- Exhaust points outlets should be located at least 5m from the inlet vent to ensure it does not create recirculation with the stair.
- Smoke dampers configured to vent smoke from only one level at a time.

7.1.17

Where a mechanical extract shaft is provided with no dedicated inlet shaft, a pressure sensor should be provided within the protected lobby or corridor served such that the extract rate ramps down when no inlet air is available to prevent excessive depressurisation of the lobby. When inlet air is available (i.e. when the stair door is open) the extract rate should increase to its full rate. The extract rate for a single shaft system should be determined by the smoke control subcontractor, but this would typically be 3.5m³/s.

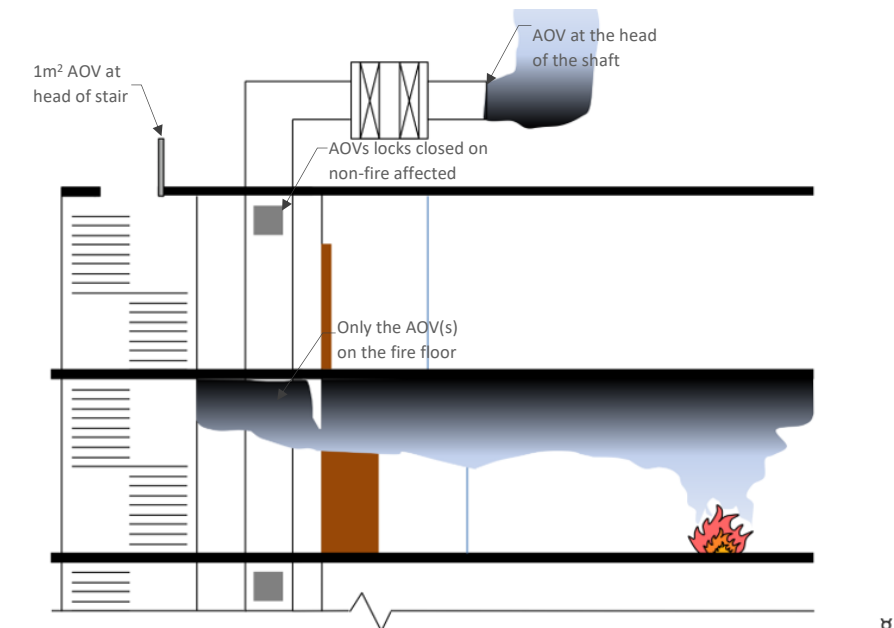


Figure 7: Mechanical Smoke Shaft

8 Emergency Escape Signage & Lighting

- 8.1.1
- Fire escape signs are to be provided to guide occupants from any point in a building, via a place of relative safety (the escape route) to the place of ultimate safety (outside the building). Exit and directional signage should be provided in accordance with the requirements of:
 - BS ISO 3864-1.
 - BS 5499-4.
 - BS 5499-5.
- 8.1.2
- Emergency lighting will be provided in accordance with BS EN 1838.

9 Limiting Fire Spread

Structural

- 9.1.1
- Buildings between 5m to 18m in height, when measured from ground level to the topmost habitable storey should be afforded with 60-minute fire resistance to all elements of structure when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure.
- 9.1.2
- Buildings between 18m to 30mm in height, when measured from ground level to the topmost habitable storey should be afforded with 90-minute fire resistance to all elements of structure when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure.
- 9.1.3
- Buildings more than 30m in height, when measured from ground level to the topmost habitable storey should be afforded with 120-minute fire resistance to all elements of structure when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure.
- 9.1.4
- The Architect should confirm the exact height of each block as this may have a significant impact on the structural fire resistance of the buildings.
- 9.1.5
- Where a building shares a party wall with a building with a higher structural fire protection, the party wall should achieve the higher protection. The party wall should also be protected to full height in a continuous vertical plane.

Sprinkler Suppression

- 9.1.6
- Based off the current Building Regulations requirements, sprinkler suppression should be provided in residential buildings over 30m in height. The sprinkler system is required as part of the structural fire protection for the building. Therefore, it includes all areas providing support to the towers (such that a lesser protected structural element does not provide support to elements requiring a higher level of protection).
- 9.1.7
- Building 5 is 11 stories in height. Based on a typical floor to slab height of 3m, the building is likely to be more than 30m in height and sprinkler protection would be required. The sprinkler suppression should be in accordance to BS EN 12845 or BS 9251 throughout.
- 9.1.8
- There is also a car park located on the ground level of building 5. As the car park forms part of the structure supporting the upper levels of the building, sprinkler protection in accordance to BS EN 12845 would be required. However, to omit the provision of sprinklers to the car park, a time equivalence assessment can be undertaken in the detailed design stage. This is a deviation from guidance and will be subject to agreement with Building Control.

Future Building Regulations Changes

- 9.1.9
- To be noted in May 2020, the government will publish an update to Approved Document B that will include increased fire safety measures in high-rise residential buildings, including the provision of sprinkler systems and consistent signage in all new high-rise blocks of flats over 11 metres tall. As such, each building of the scheme will be required to be provided with sprinkler suppression throughout.
- 9.1.10
- Therefore, the sprinkler suppression should be in accordance to BS EN 12845 or BS 9251 throughout. As the buildings are provided with ancillary accommodation at the ground level, it is proposed to provide a minimum Category 3 system throughout the buildings in accordance with BS 9251.
- 9.1.11
- There is also a number of car parks and commercial units located on the ground level of the scheme. As both areas form part of the structure supporting the upper levels of the building, sprinkler protection in accordance to BS EN 12845 would be required, at this stage of the design BB7 would recommend that costing for the system is allowed. However, it is proposed to omit the provision of sprinklers to the car park and commercial units, by undertaking a time equivalence assessment in the detailed design stage. This is a deviation from guidance and will be subject to agreement with Building Control.

Compartmentation

- 9.1.12
- The buildings provided residential accommodation; therefore, all floors will be required to be compartment floors achieving the same structural fire resistance period.
- 9.1.13
- Where any building shares a party wall between another, the wall should be provided with fire resisting protection achieving the rating of the taller structure. Fire resisting protection should be provided from both sides and the protection should run full height.
- 9.1.14
- Additional compartmentation requirements have been provided below in Table 4 to Table 7.

Table 4: Compartmentation Summary – Residential Buildings General

| Area of Building | Fire Resistance (minutes) | Fire Resistance (European Class) |
|--|---|----------------------------------|
| Plant Rooms | 60 | REI 60 |
| Bin Stores/Cycle Stores | 60 | REI 60 |
| Substations | 120* | REI 120* |
| Protected Residential Common Corridors | 60 | REI 60 |
| Protected Entrance Halls | 30 | REI 30 |
| Separating Apartments | 60 | REI 60 |
| Service Shafts (Fire stopped at floor level) | As per the surrounding compartment boundaries | |

*Substation fire-resistance may be increased to 240-minutes dependent on the energy provider’s requirements.

Table 5: Compartmentation Summary – Residential Buildings between 5m to 18m in height

| Area of Building | Fire Resistance (minutes) | Fire Resistance (European Class) |
|-----------------------------|---------------------------|----------------------------------|
| Protected Stairs | 60 | REI 60 |
| Lifts | 60 | REI 60 |
| Separating Commercial Space | 60 | REI 60 |
| Compartment Floors | 60 | REI 60 |

| Area of Building | Fire Resistance (minutes) | Fire Resistance (European Class) |
|--|---|----------------------------------|
| Service Shafts (Not fire stopped at floor level) | 60 | REI 60 |
| External Walls within 1m of the Boundary | 60 | REI 60 (from both sides) |
| Protected areas of external walls more than 1m from the boundary | 60 to loadbearing capacity and integrity, 15 minutes to insulation (from the inside only) | RE 60, REI 15 from the inside |

Table 6: Compartmentation Summary – Residential Buildings between 18m to 30m in height

| Area of Building | Fire Resistance (minutes) | Fire Resistance (European Class) |
|--|---|----------------------------------|
| Fire Fighting Stairs | 120 | REI 120 |
| Lifts | 90 | REI 90 |
| Fire Fighting Lifts | 120 | REI 120 |
| Service Shafts (Not fire stopped at floor level) | 90 | REI 90 |
| Separating Commercial Space | 90 | REI 90 |
| Separating Car Park | 90 | REI 90 |
| Compartment Floors | 90 | REI 90 |
| External Walls within 1m of the Boundary | 90 | REI 90 (from both sides) |
| Protected areas of external walls more than 1m from the boundary | 90 to loadbearing capacity and integrity, 15 minutes to insulation (from the inside only) | RE 90, REI 15 from the inside |

Table 7: Compartmentation Summary – Residential Buildings more than 30m in height

| Area of Building | Fire Resistance (minutes) | Fire Resistance (European Class) |
|--|--|----------------------------------|
| Fire Fighting Stairs | 120 | REI 120 |
| Lifts | 120 | REI 120 |
| Fire Fighting Lifts | 120 | REI 120 |
| Service Shafts (Not fire stopped at floor level) | 120 | REI 120 |
| Separating Car Park | 120 | REI 120 |
| Compartment Floors | 120 | REI 120 |
| External Walls within 1m of the Boundary | 120 | REI 120 (from both sides) |
| Protected areas of external walls more than 1m from the boundary | 120 to loadbearing capacity and integrity, 15 minutes to insulation (from the inside only) | RE 120, REI 15 from the inside |

- 9.1.15Cavity barriers are to be provided in accordance with Section 19 of BS 9991. Cavity barriers are required at all floors, compartment walls and openings (e.g. windows and doors). Additional cavity barriers are required where a compartment wall meets an external wall of the building. Cavity barriers are to also to be provided to ensure there is no void in the external wall exceeding 20m in any direction in the ancillary areas.
- 9.1.16Fire/fire and smoke dampers to be provided in accordance with the recommendations of BS 9991. Where a ductwork system serves more than one part of a compartment or fire-separated protected escape route, smoke detector operated fire dampers should be provided where ductwork enters each fire-separated or smoke-separated section of the escape route.
- 9.1.17The integrity of compartment walls within roof voids that are continuous with the compartment walls between flats on the top storey, is essential to prevent fire spread between flats.
- 9.1.18The lines of compartmentation between flats, and between flats and the common area located on the top floor of a building should extend through the roof void in a continuous vertical plane to the underside of the roof and be fire stopped at the wall/roof junction to afford a minimum of 60 minutes fire resistance. This will ensure that the fire resisting ‘box’ principle extends into the common roof voids, to prevent fire spread between flats and fire spread from a flat into other areas of the building, via the common roof void.
- 9.1.19The provision of fire resisting ceilings within top floors would not normally provide an alternative means of achieving an equivalent standard of safety as it would fail to address, for example, the possibility of a fire that starts within the roof void or one that enters the roof void externally (e.g. as a result of flames projecting from a top storey window). A fire resisting ceiling will afford protection against the spread of fire from a flat into the roof void, but not normally vice versa.

10 External Fire Spread

- 10.1.1A detailed assessment of external fire spread will be completed during the detailed fire strategy once compartment sizes are fixed and the detailed site plan information is received.
- External Walls

Balconies

10.1.2It should be noted, following the recent update from the government pertaining to the use of combustible materials on balconies (released 24th June), any balconies must be constructed of materials achieving at least a Class A2-s1, d0 rating.

10.1.3The ban of the use of combustible materials on residential balconies regardless of building height differs from both the pre-December 2018 Building Regulations and the post-December 2018 Building Regulations. For older projects, there was no restriction on combustible materials on balconies. For projects that are subject to the post-December regulations, combustible material was only restricted on buildings over 18m. This advice note overrules both sets of regulations.

10.1.4The government have announced that this advice note should be applied retrospectively, therefore, regardless of compliance with Building Regulations or not, any balconies must be constructed of materials achieving at least a Class A2-s1,d0 rating. The government have also advised building owners to strip any combustible materials from their existing balconies and this will apply to any projects currently on site regardless of whether they have received their certificate of compliance for Building Regulations or not.

- Insulation, Materials and Products Combustible

10.1.5

Following recent Government Circulars Omega advises for buildings under 18m in height that any cladding, insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction should achieve a rating of A2-s1,d0 unless a BR 135 assessment has been undertaken or the cladding suppliers can demonstrate how the risk of fire spread is mitigated within their products.

10.1.6

In a building with a storey 18m or more in height (when measured from the lowest adjacent side of the building to the upper floor surface of the topmost storey, excluding any floors consisting exclusively of plant), any insulation product, filler material (not including gaskets, sealants and similar) etc, used in the construction of an external wall should be of European Class A2-s1, d0 or better. Note, due to the use of the proposed building, Regulation 7(2) and 7(3) would be applicable and it prevails over the provisions stated within this paragraph.

Note 1: Whilst the guidance above applies to any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the construction of an external wall, consideration should be given to the choice of material used for any other parts of an external wall or attachments to the wall which could impact on the risk of fire spread over the wall.

Note 2: Best practice guidance for green walls (also called living walls) can be found in Fire Performance of Green Roofs and Walls, published by the DCLG.

- Roof Covering

10.1.7

Following recent Government Circulars Omega advises that all roof coverings should achieve a minimum of AA, AB, AC.

11 Firefighting Access

- 11.1.1

The specification for the pump appliance route access is provided in Table 8.

Table 8: Fire Appliance Access Route Specification

| Appliance Type | Minimum width of road between kerbs (m) | Minimum width of gateways (m) | Minimum turning circle between kerbs (m) | Minimum turning circle between walls (m) | Minimum clearance height (m) | Minimum carrying capacity (tonnes) |
|----------------|---|-------------------------------|--|--|------------------------------|------------------------------------|
| Pump | 3.7 | 3.1 | 16.8 | 19.2 | 3.7 | 12.5 |

Notes: This table is subject to agreement with the fire service as some fire services have appliances of greater weight or different sizes.

- 11.1.2

There should be pump appliance to at least 15% of the perimeter of the commercial/car park or 45m within every part of the projected floor plan whichever is more onerous.
- 11.1.3

The terrace houses would require a 45m pump appliance access to within every part of the projected floor plan.
- 11.1.4

A dry rising main should be provided in the stair core of all residential buildings.

Fire Main – Residential Buildings

- 11.1.5

The dry riser inlet is required to be visible and within 18m of the dry riser access point. The outlet is required to located within the residential staircase. Signage may be required to be provided to direct to the firefighters to the staircase from the riser inlet. This deviation is subject to agreement with the approval authorities.

Fire Hydrants

- 11.1.6

A fire hydrant should be provided within 90m of the dry fire main inlet to the residential blocks.
- 11.1.7

A fire hydrant should be provided within 90m of an entry point to the commercial/car park and not more than 90m apart.

12 Secondary Power

- 12.1.1

Fire Protection systems designed to operate in a fire require enhanced provisions to ensure a secure supply is available. Specific recommendations are detailed within BS 9999 Section 37.2.3.3, but the main aspects are detailed below.
- 12.1.2

To reduce the risk of loss the electrical supply to the fire protection systems that are required to operate continuously during a fire, a secondary supply is needed.
- 12.1.3

The secondary power supplies will be provided to the following systems:
 - Sprinkler Suppression System;
 - Mechanical Ventilation System
 - Firefighting intercommunications systems.
- 12.1.4

Emergency lighting and detection will be via local battery backup power

13 Conclusion

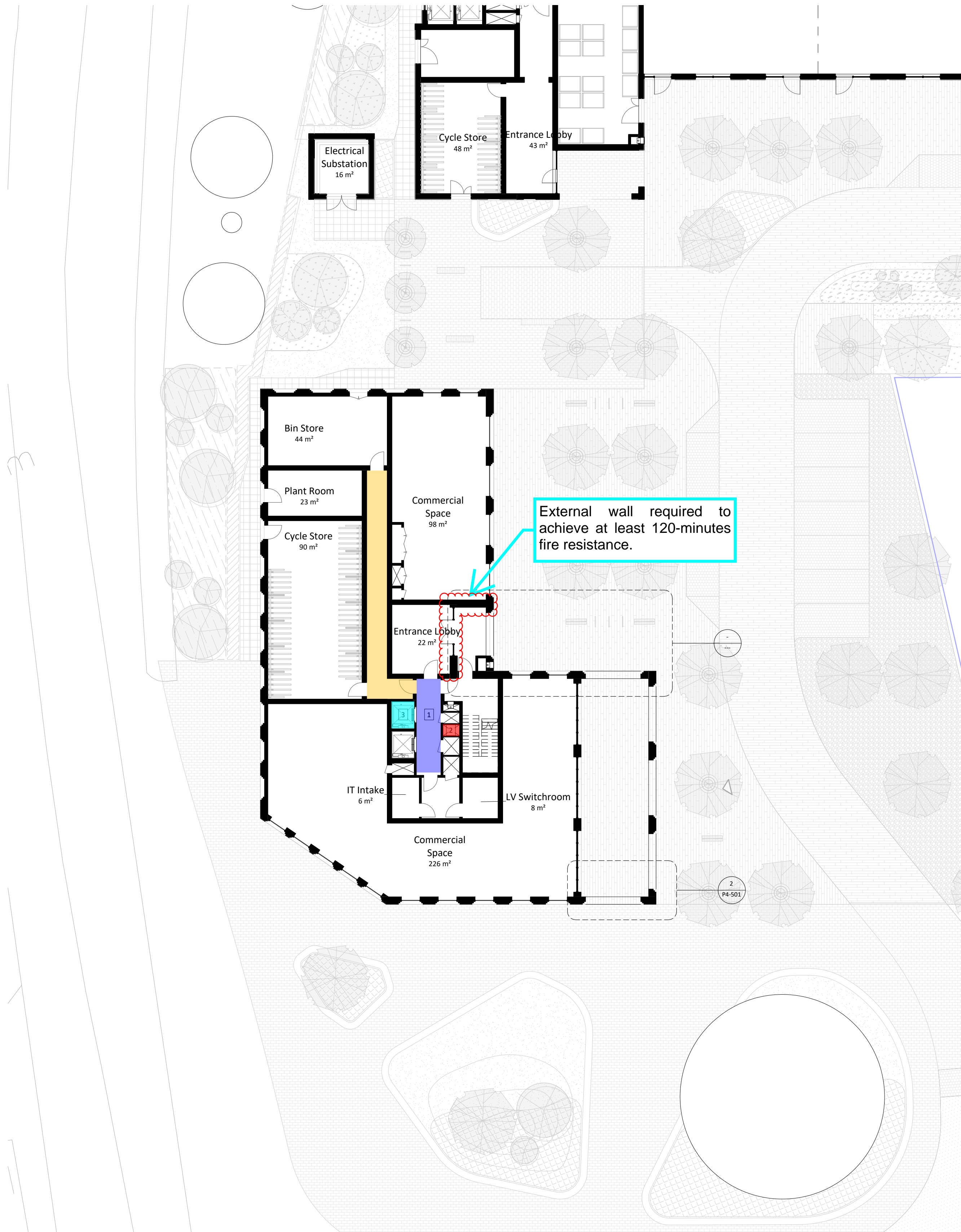
- 13.1.1

The outline design of the scheme, in general meets with prescriptive requirements of BS 9991. If the recommendations given in this report are followed, then it is considered that the building will meet the functional requirement of the Building Regulations. As this report provides recommendations for meeting the minimum requirement of the Building Regulations, any deviation may result in a fundamentally non-compliant building. The prescriptive requirements have been stated within this report and will be adhered to. Where codes of practise are restrictive to the design, an alternative (fire engineering solution) has been considered.
- 13.1.2

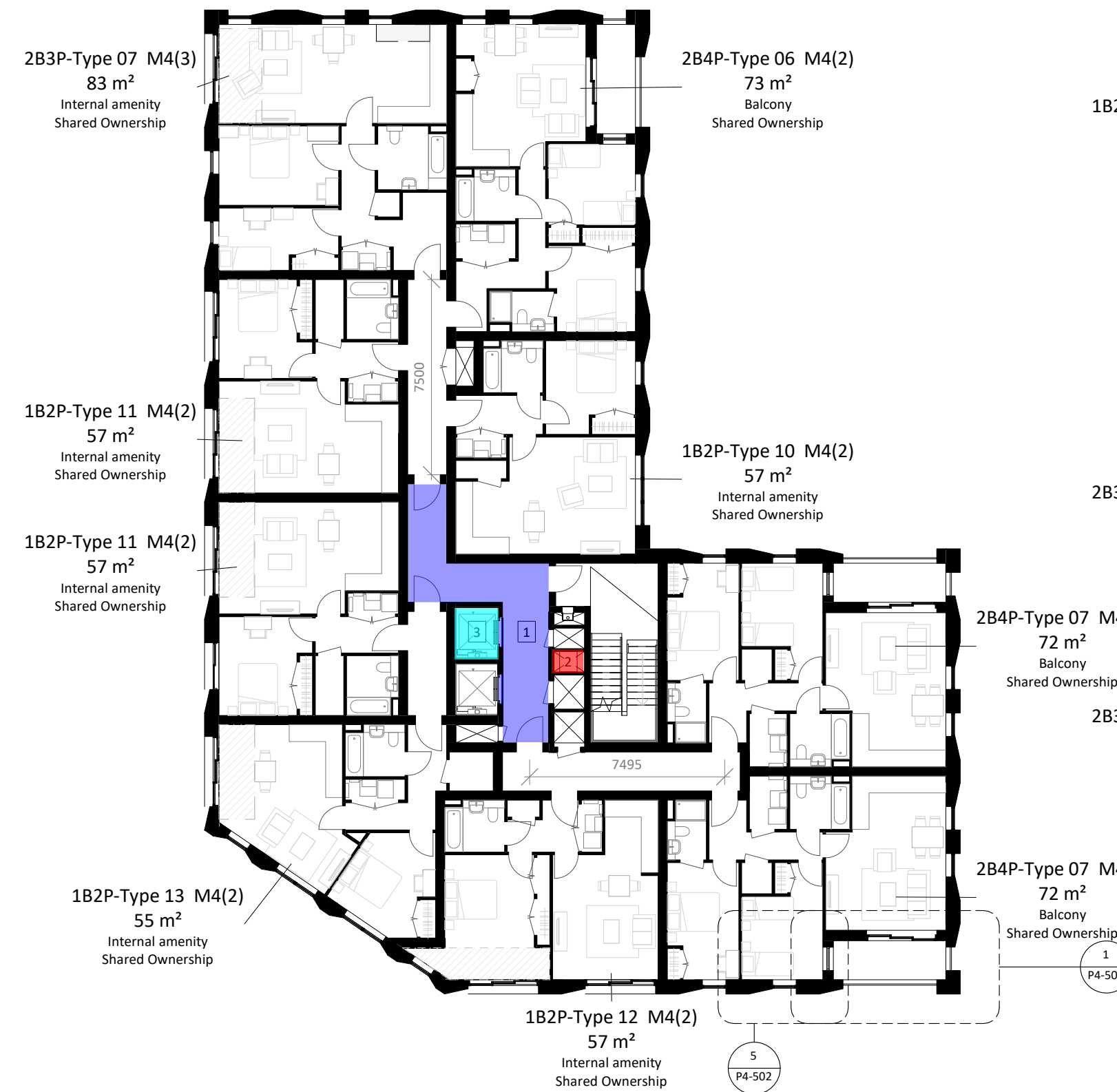
It is considered that between a culmination of the prescriptive requirements and fire engineering, a solution will be provided adequate to the prevailing risk.
- 13.1.3

The principles outlined in this strategy should be discussed internally with design team and agreed before being subsequently sent to Building Control for a formal approval of the design principle. This report will be updated as additional information is available and a Detailed Fire Strategy will be developed in the detailed design stage to support the Building Regulations application for the scheme.

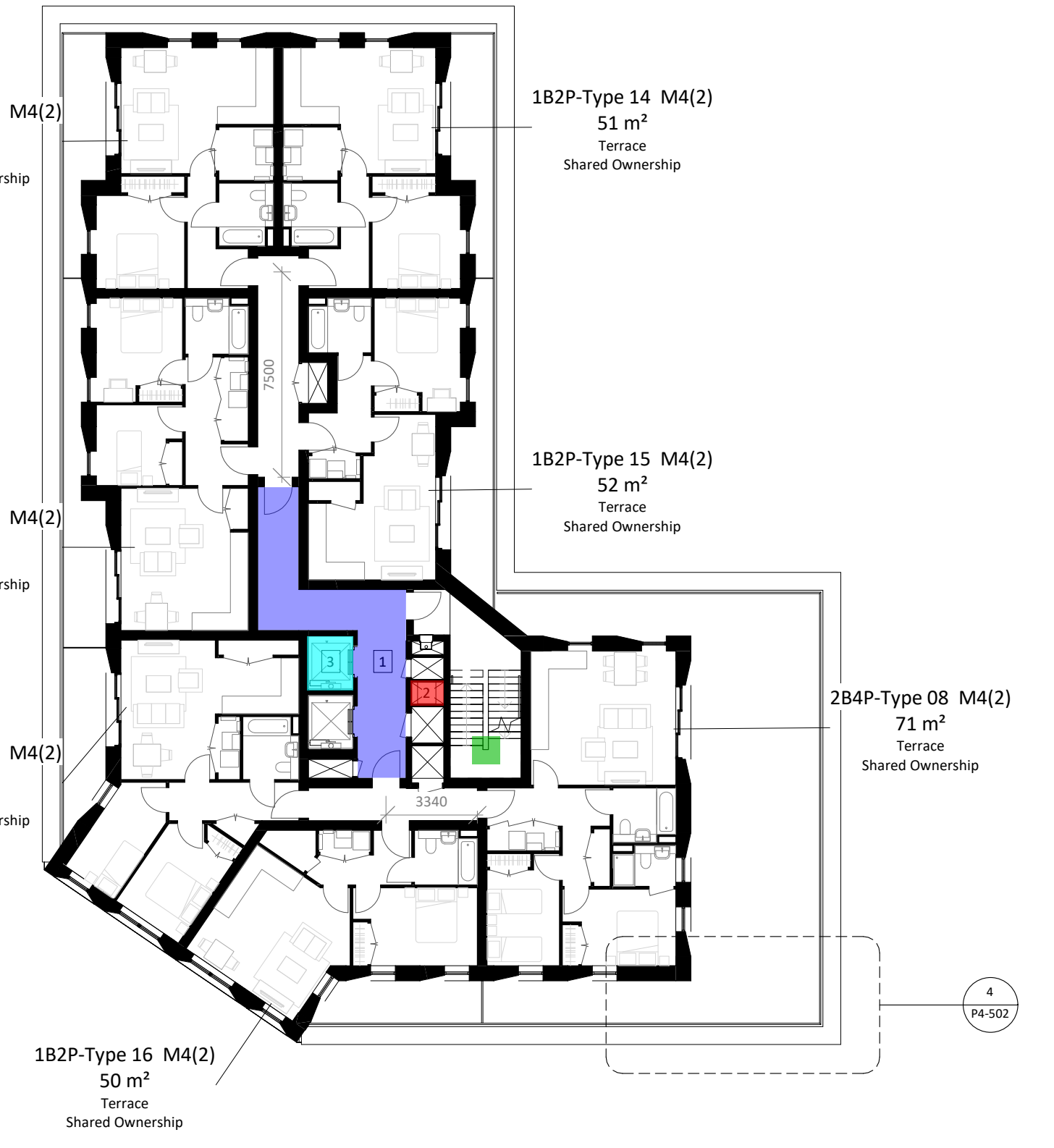
Appendix A – Drawing Comments



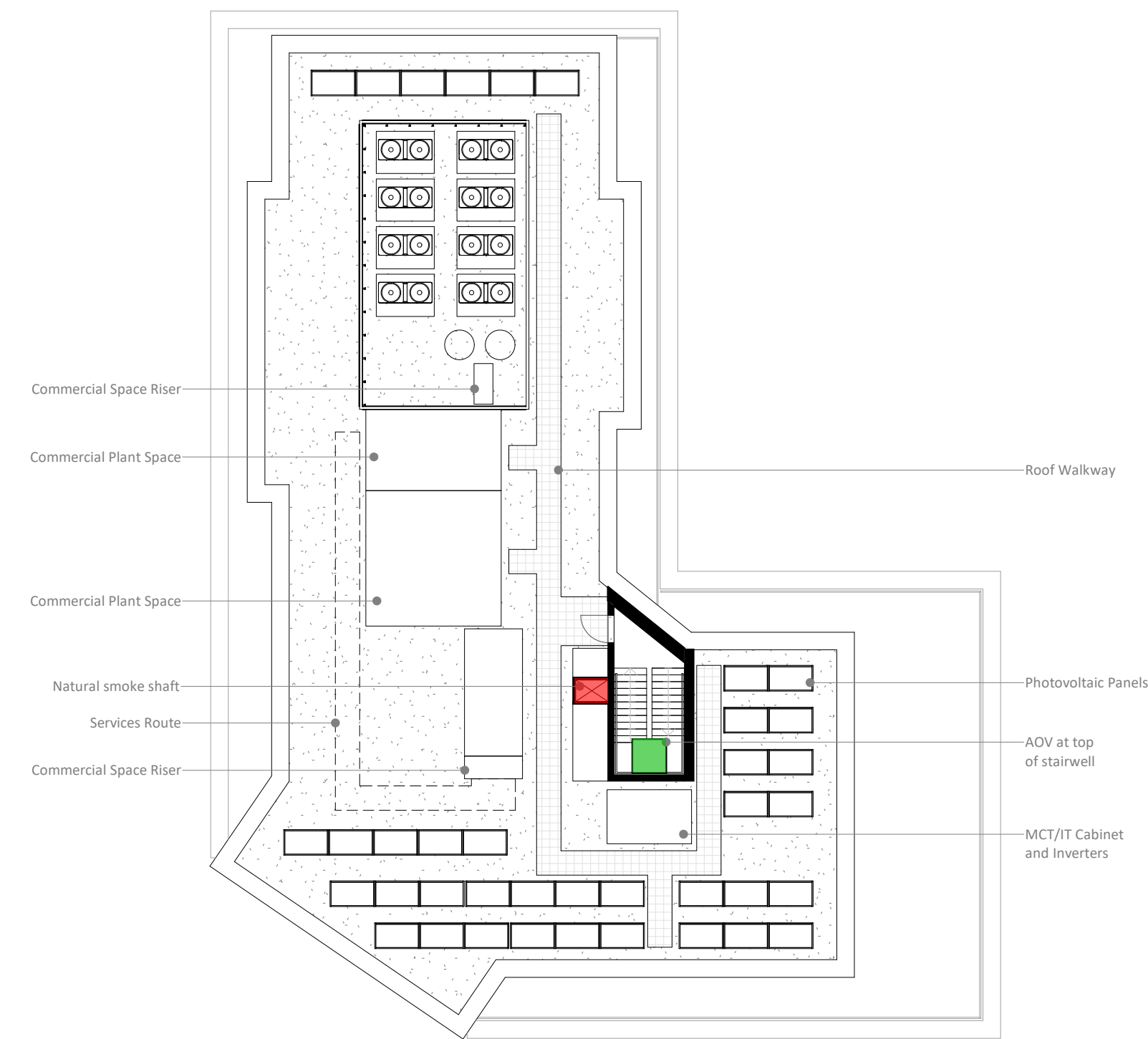
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2 Building 1 - First to Sixth Floor Plan
1 : 200



3 Building 1 - Seventh Floor Plan
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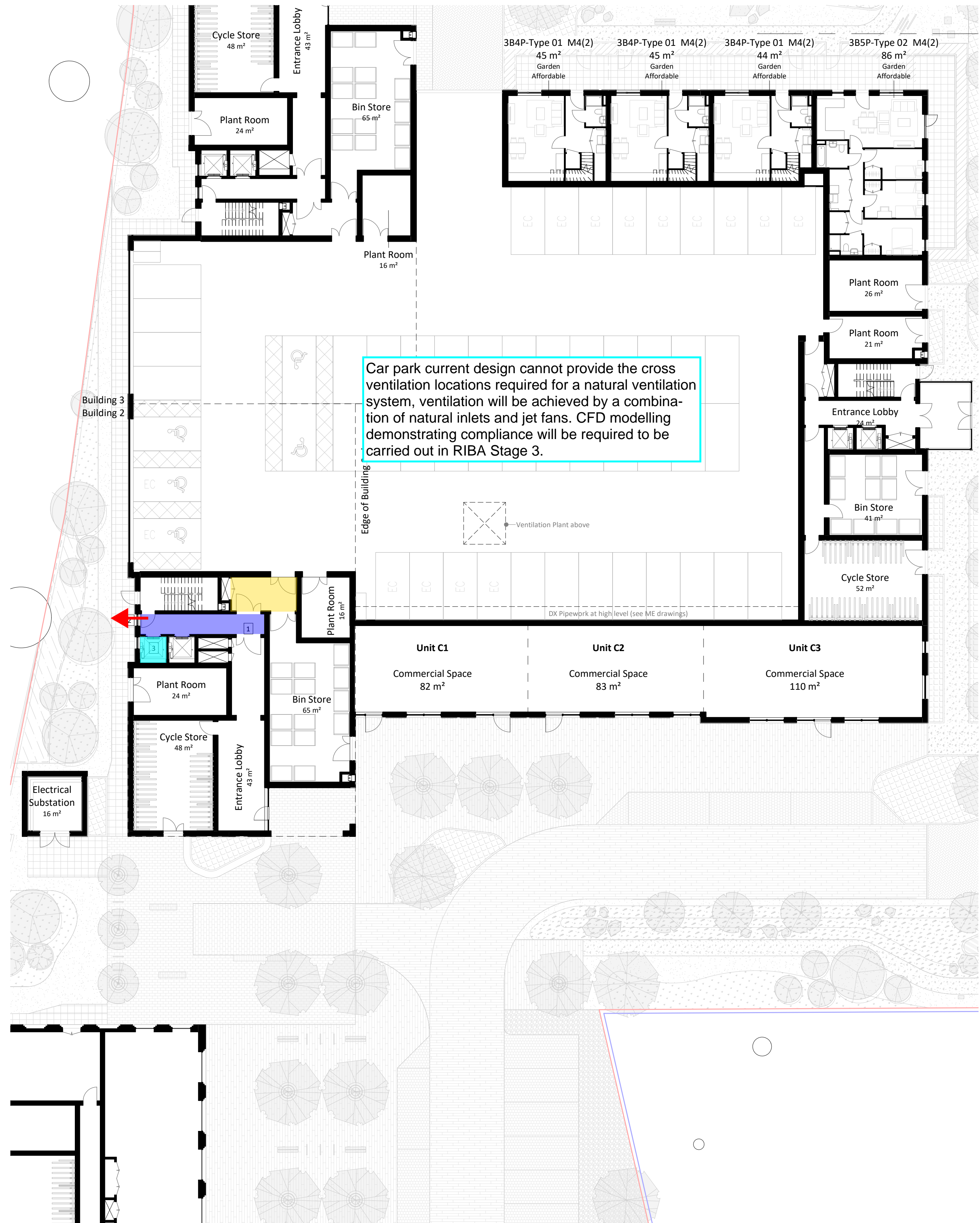
4 Building 1 - Roof Plan

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

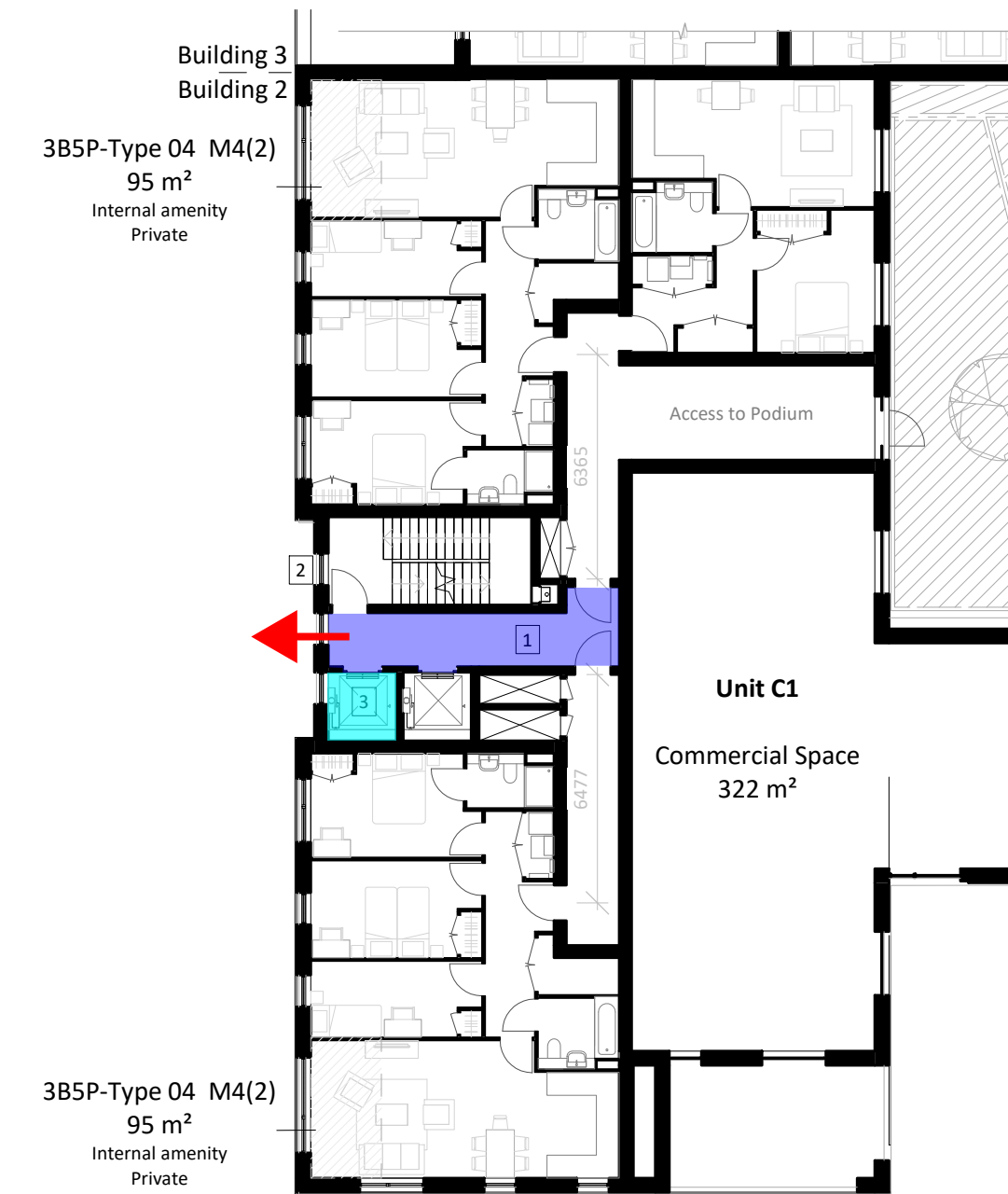
To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

| Key - | |
|--|--|
| | Minimum 0.2m² permanently ventilated lobby |
| | Sterile ventilated staircase lobby |
| | Minimum 1.5m² natural smoke shaft |
| | Minimum 1.0m² AOV at head of staircase |
| | Firefighting Lift |

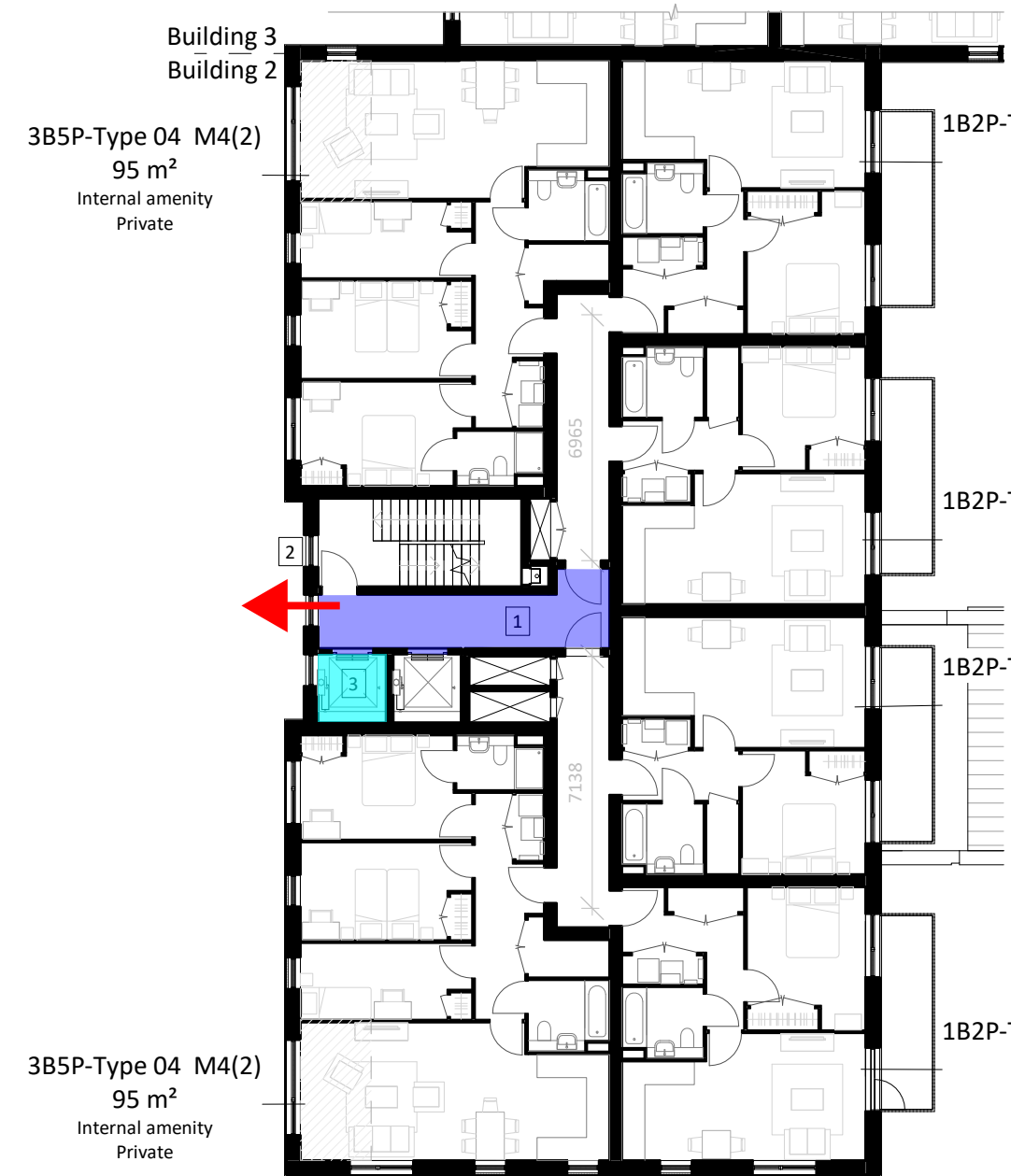
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22nd April 2020
Review by: Thomas Gibbins
Authorised by: Dane Owen



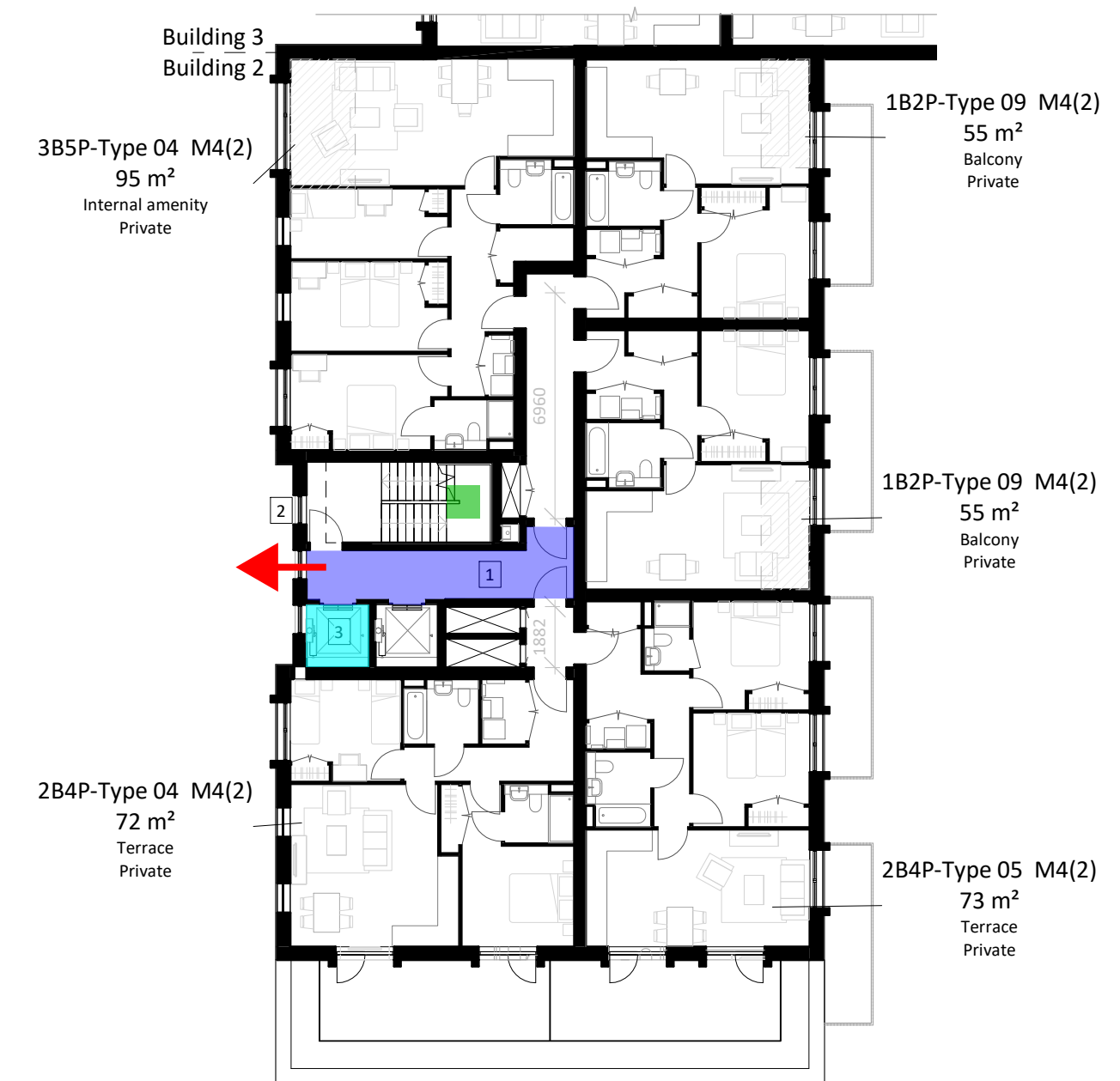
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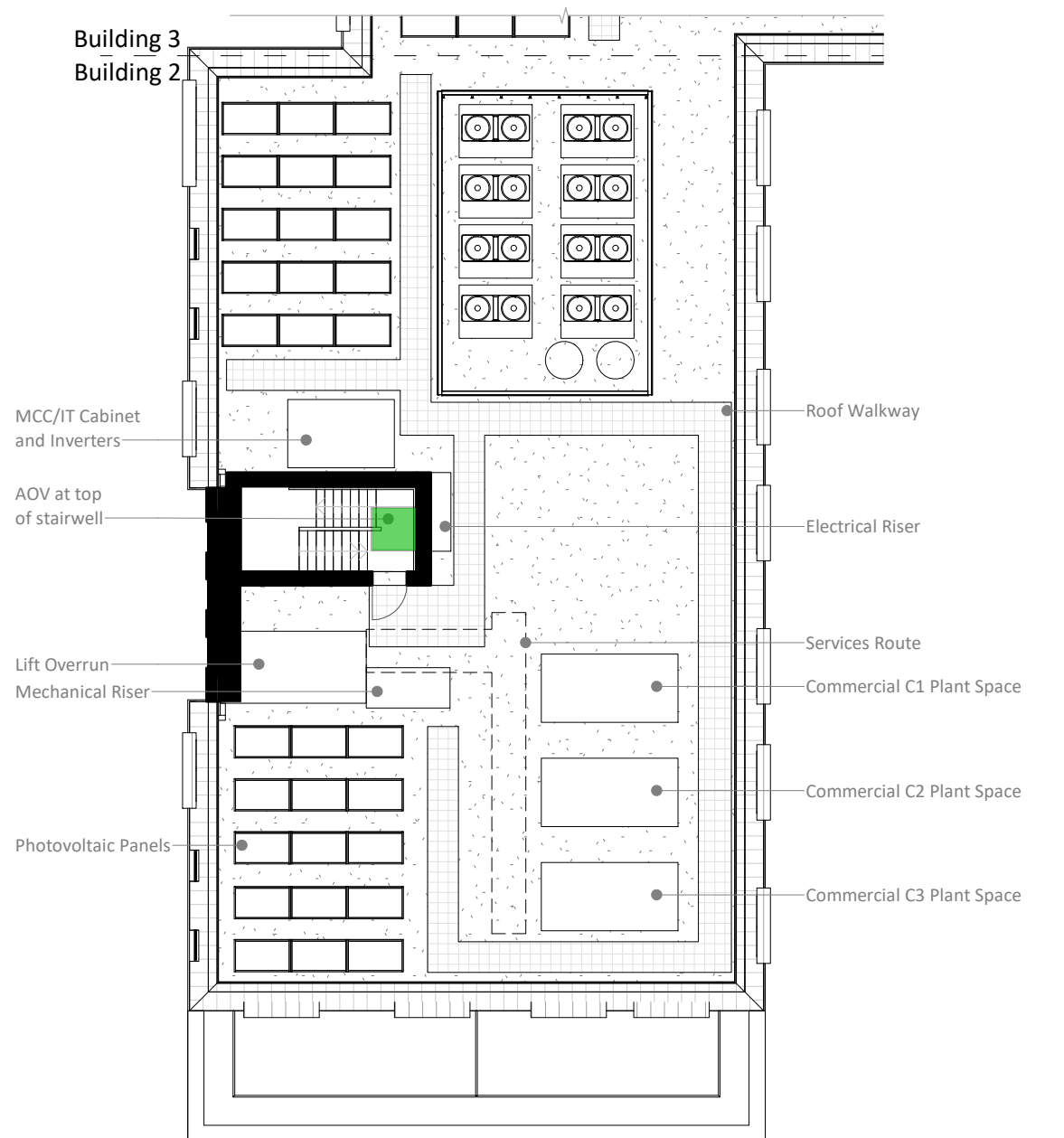
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3 Building 2 - Second to Sixth Floor Plan
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4 Building 2 - Seventh Floor Plan
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5 Building 2 - Roof Plan
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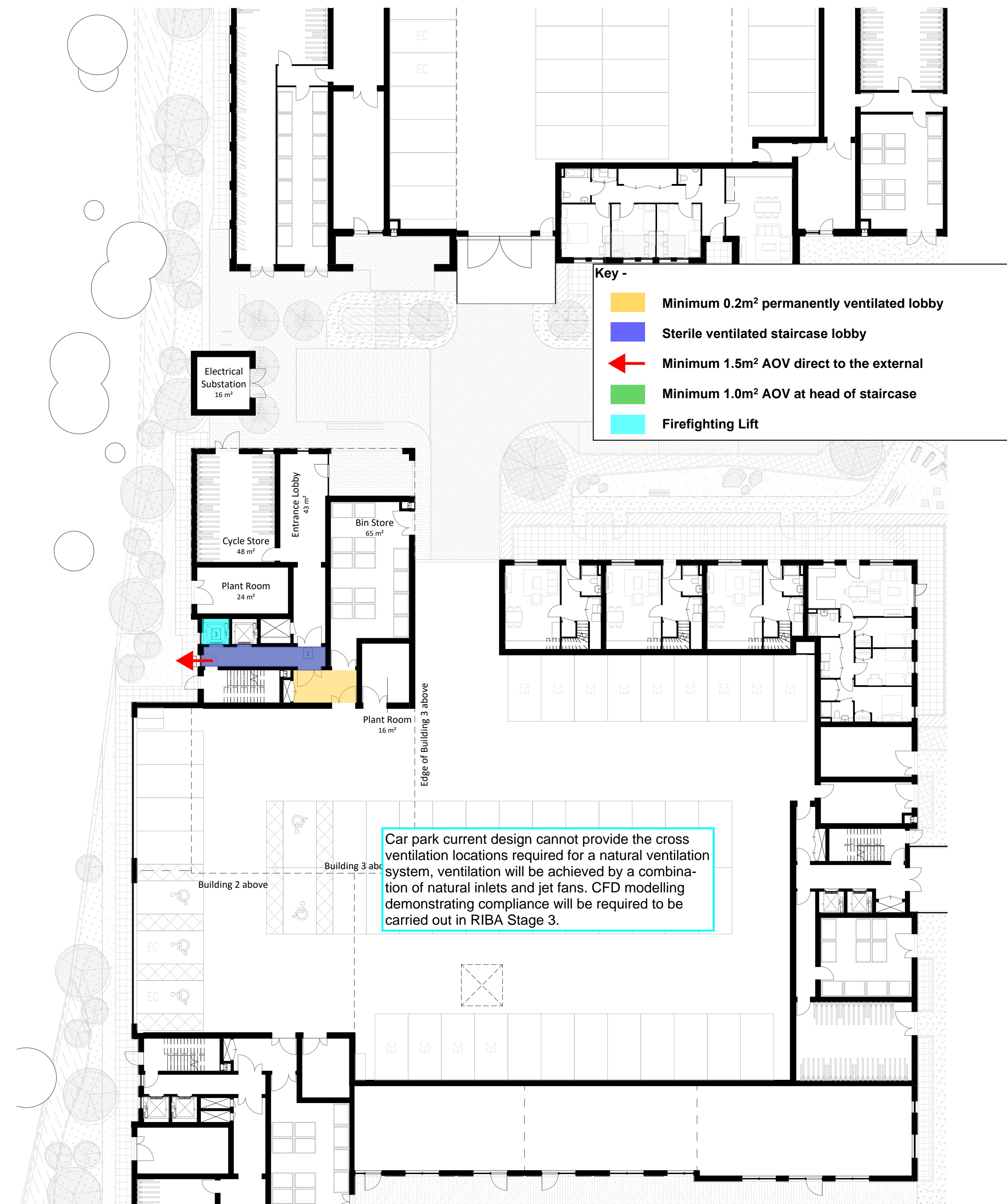
To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

Key -

- Minimum 0.2m² permanently ventilated lobby
- Sterile ventilated staircase lobby
- Minimum 1.5m² AOV direct to the external
- Minimum 1.0m² AOV at head of staircase
- Firefighting Lift
- Alternative escape route required to be provided

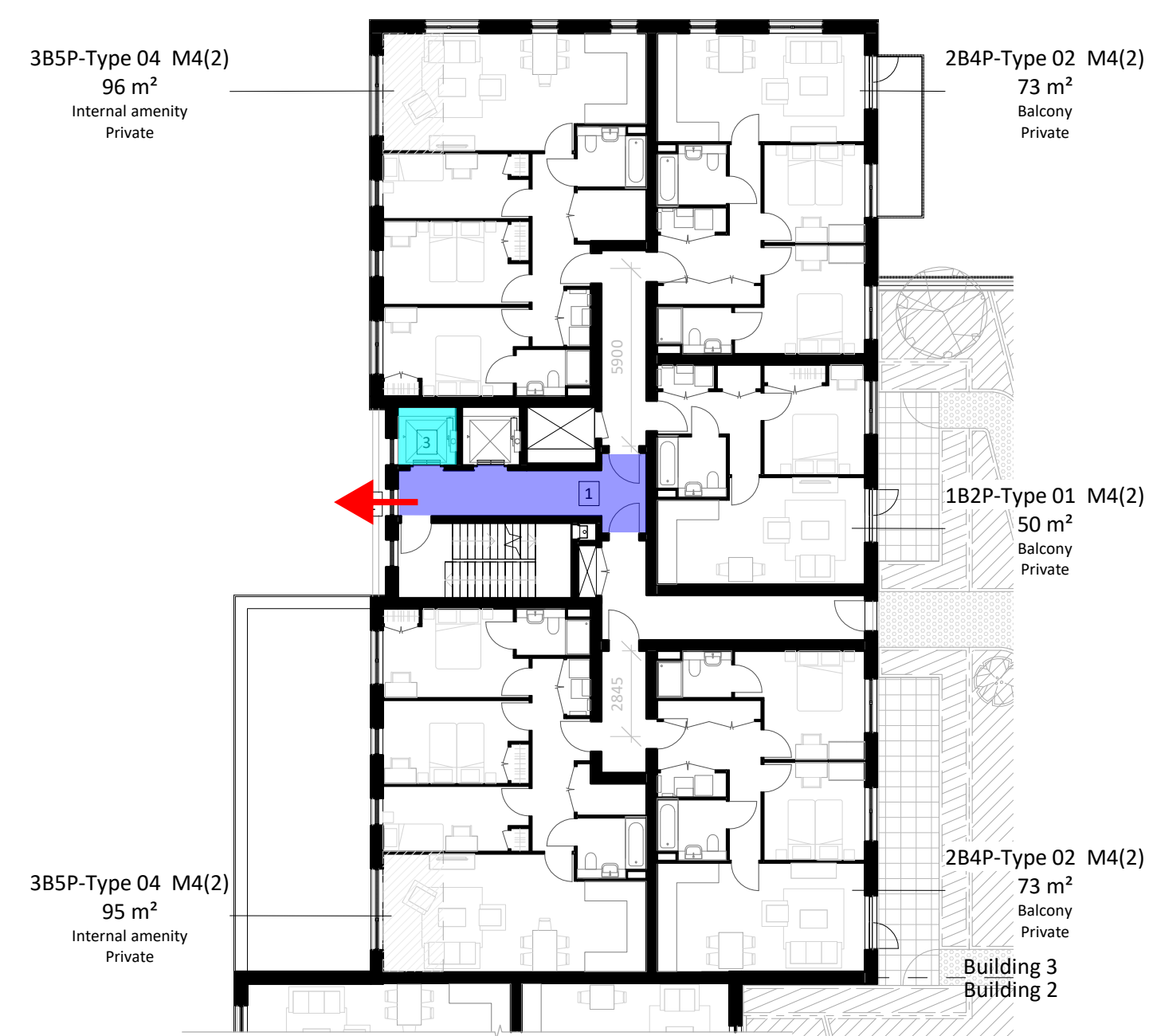
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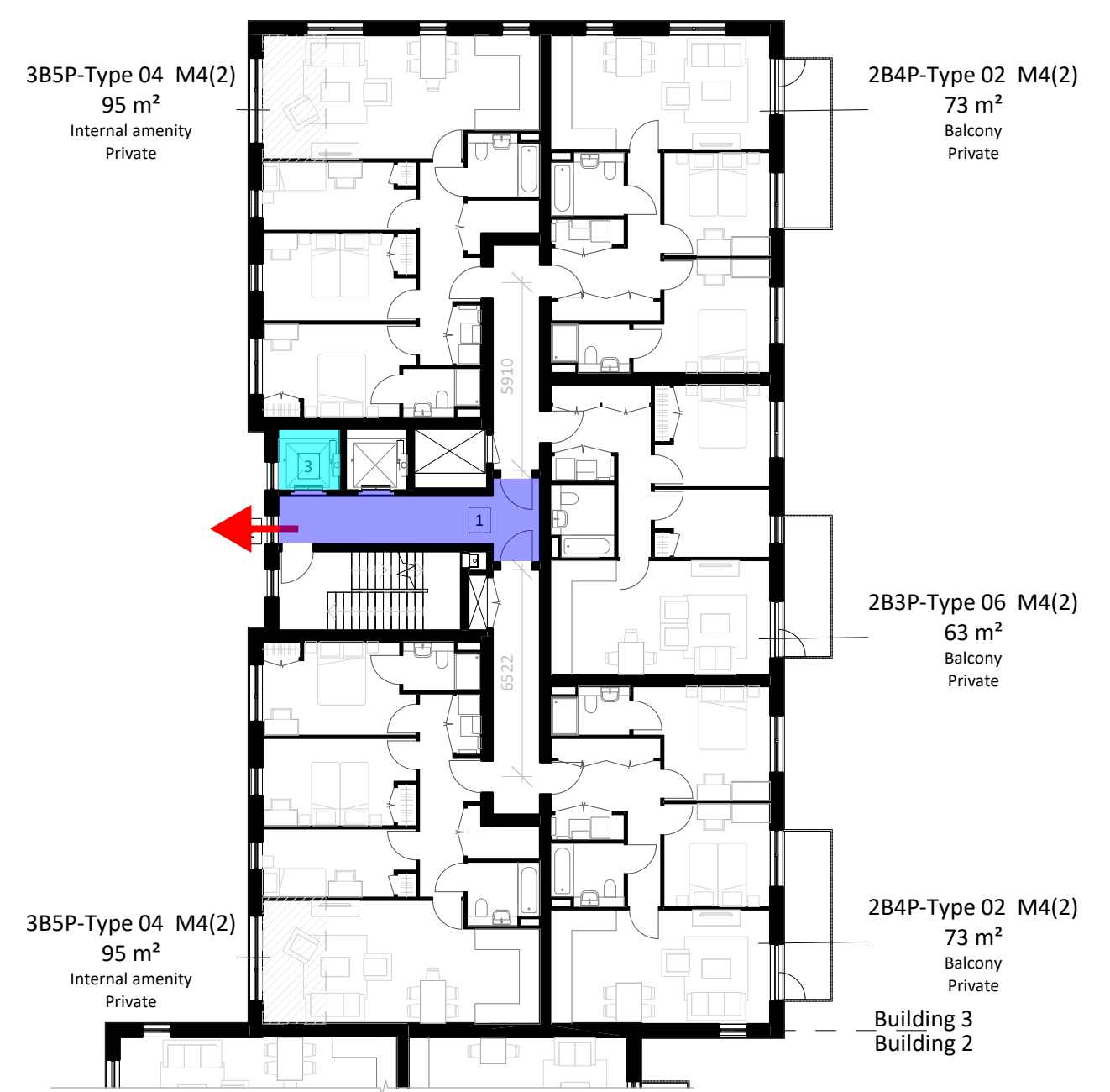
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To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

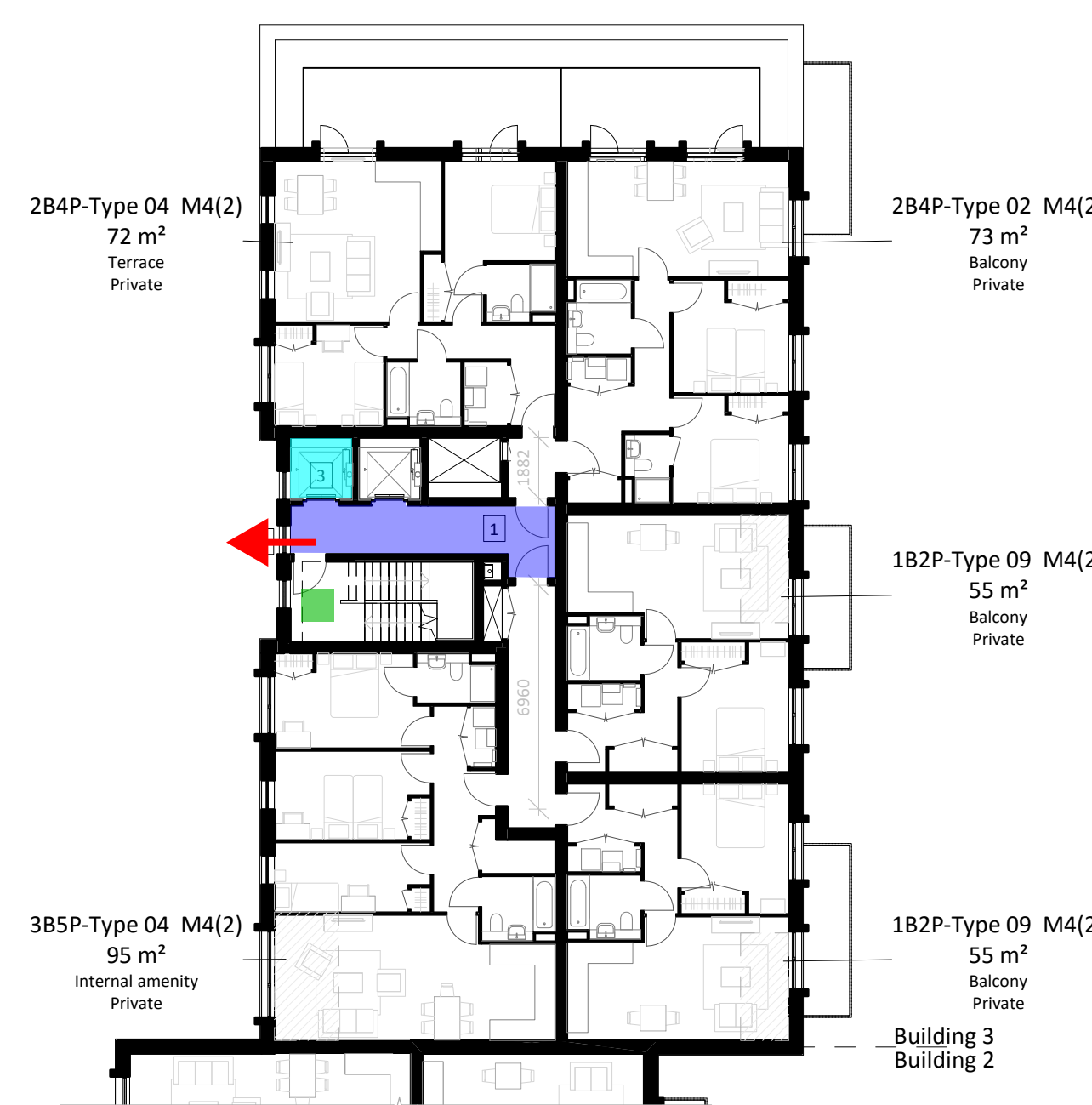
To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.



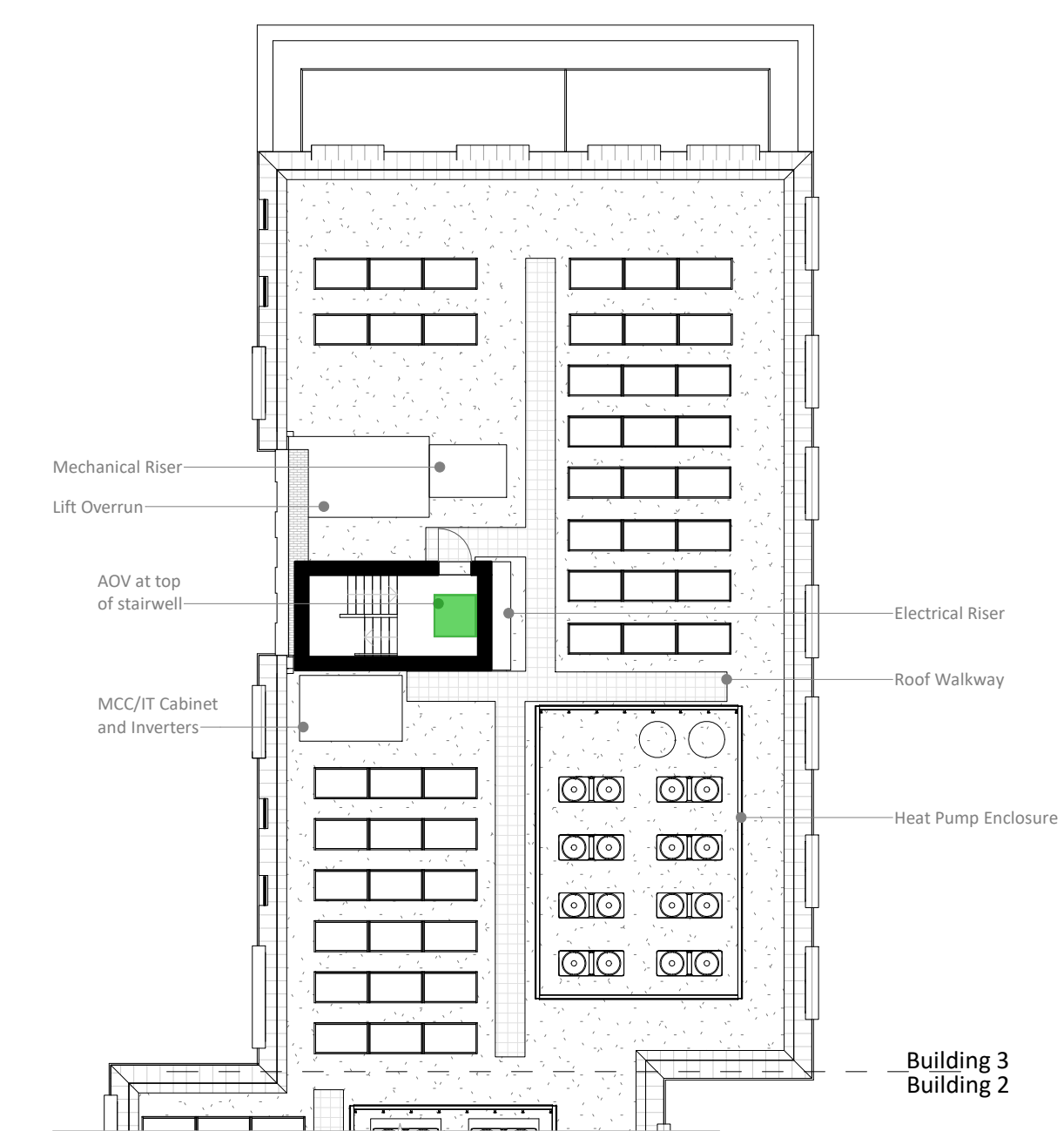
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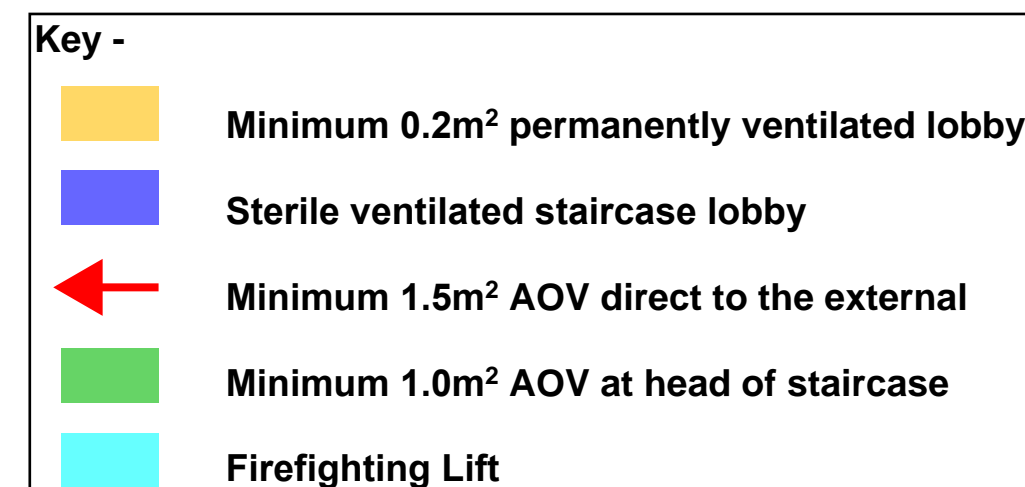
3 Building 3 - Second to Sixth Floor Plan
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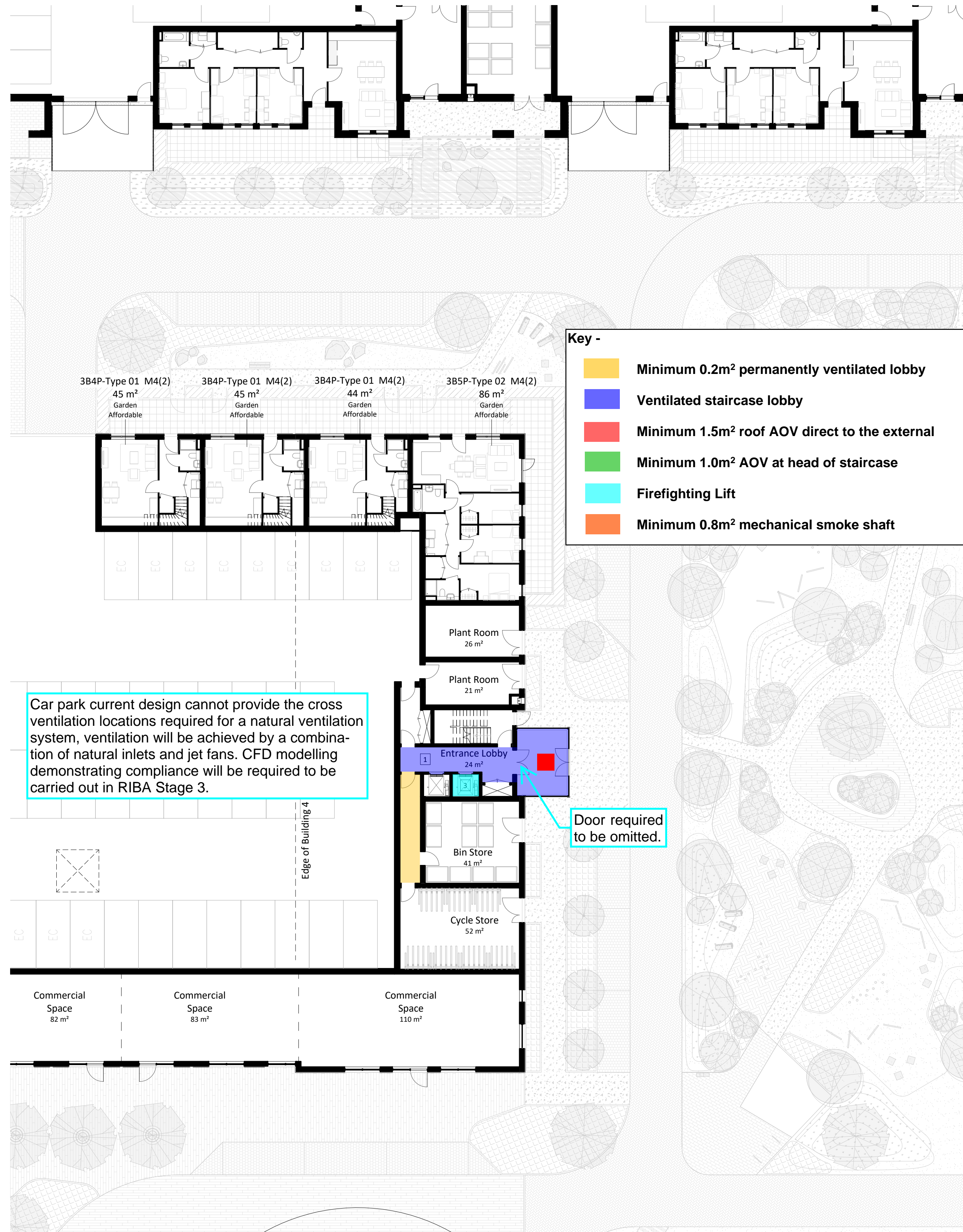
4 Building 3 - Seventh Floor Plan
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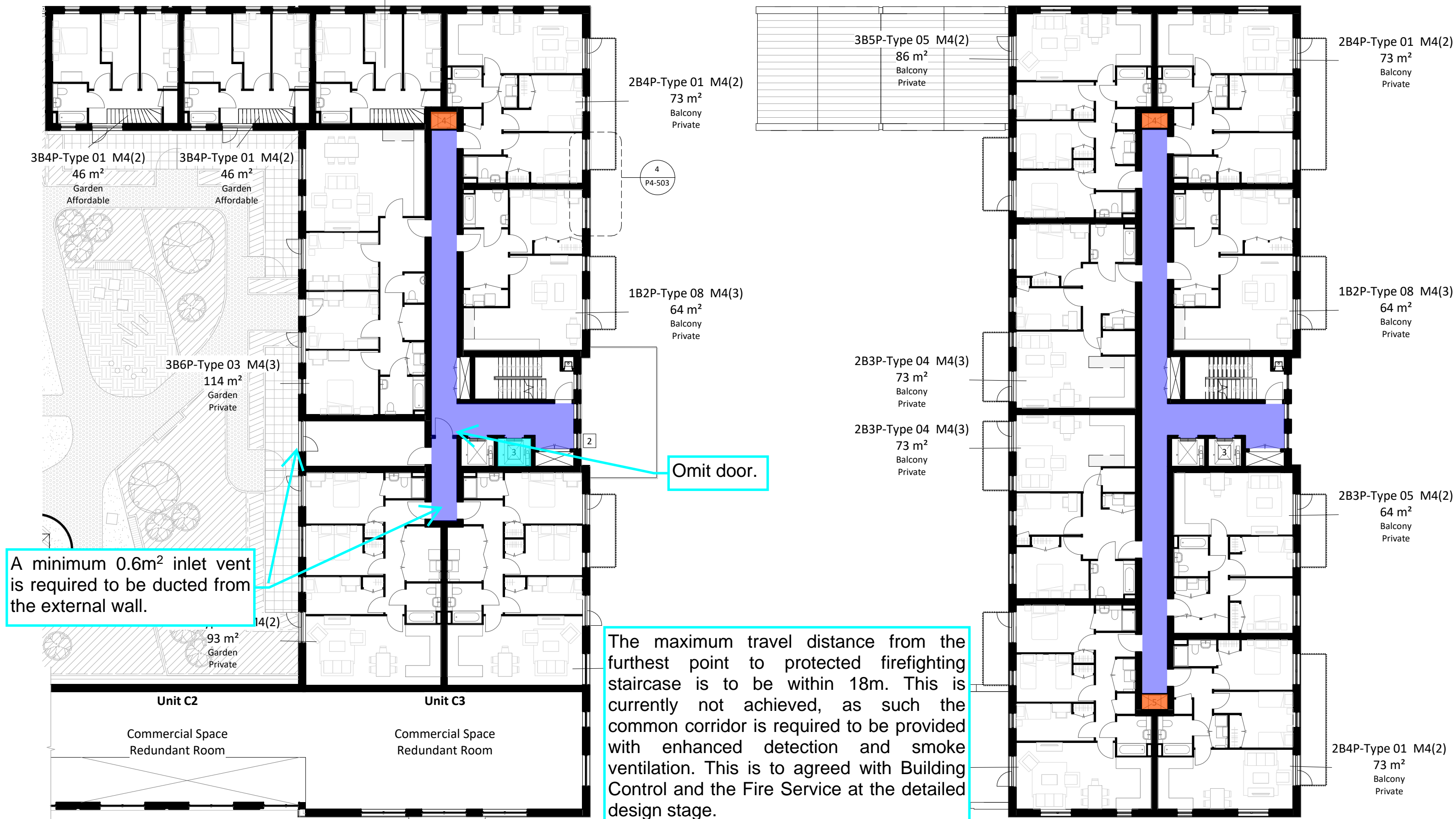
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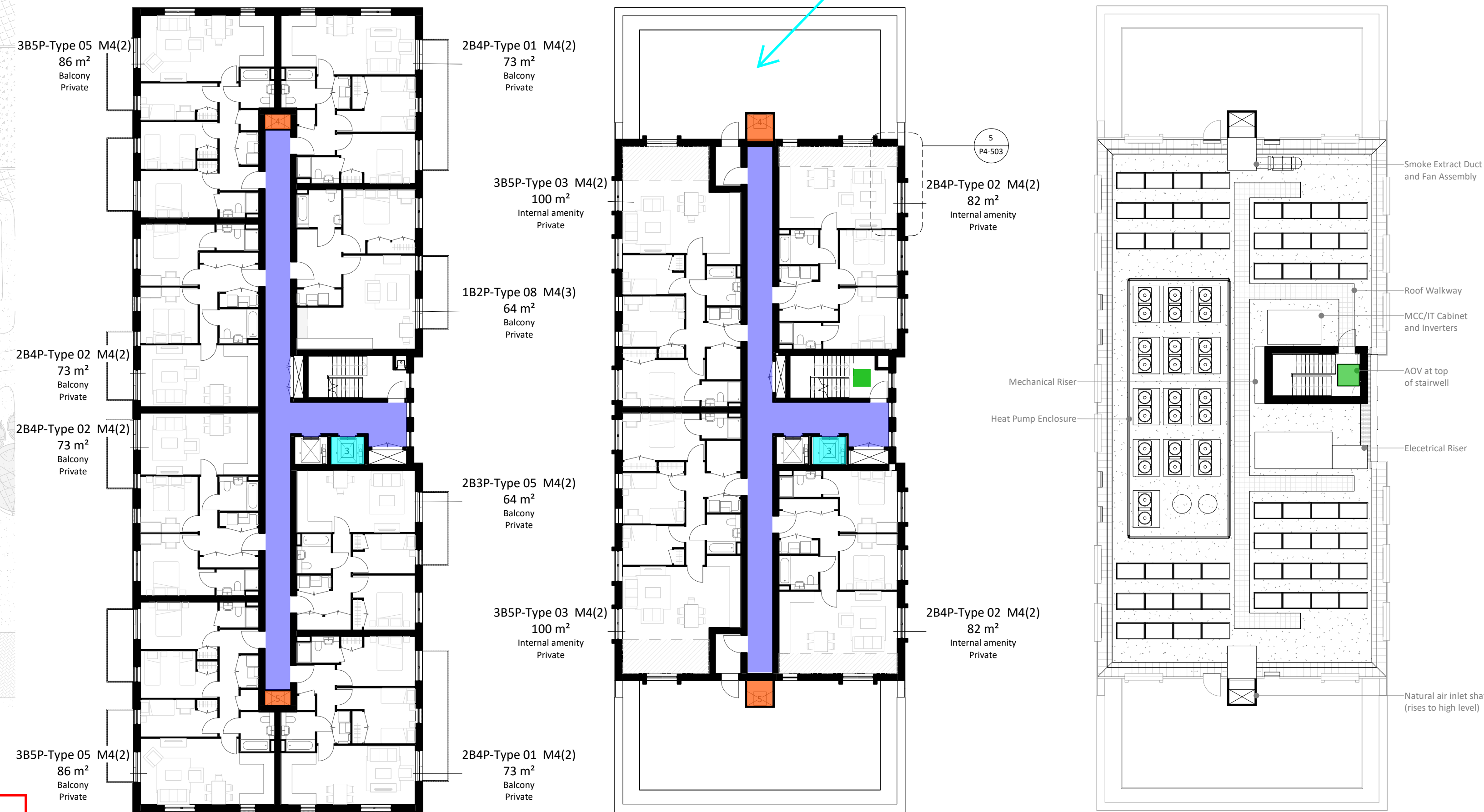


1 Building 4 - Ground Floor Plan
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2 Building 4 - First Floor Plan
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3 Building 4 - Second Floor Plan
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4 Building 4 - Third to Fifth Floor Plan 5 Building 4 - Sixth Floor Plan

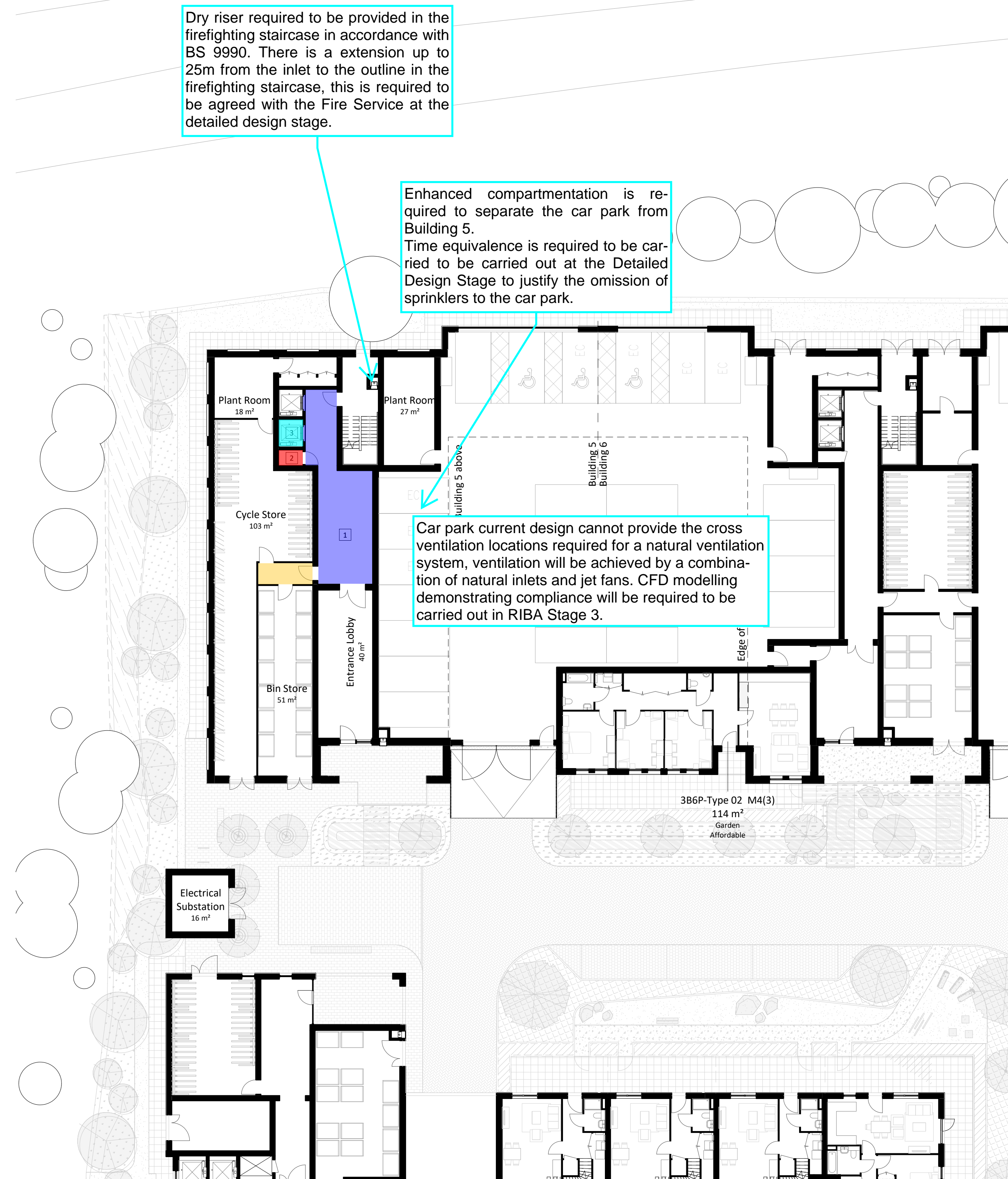
6 Building 4 - Roof Plan

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Authorised by: Dane Owen

The cross-corridor doors and the lobby AOV's direct to the external are to be omitted, allowing for 2x 0.8m² mechanical smoke shafts are to be provided at the remote ends of the corridors (one at each end). CFD modelling would be required to justify this deviation. However, considering that the travel distance isn't excessive and that the apartments are not impeding the vertical escape route, it is considered that this proposed solution has limited design risk.

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.



1 Building 5 - Ground Floor Plan
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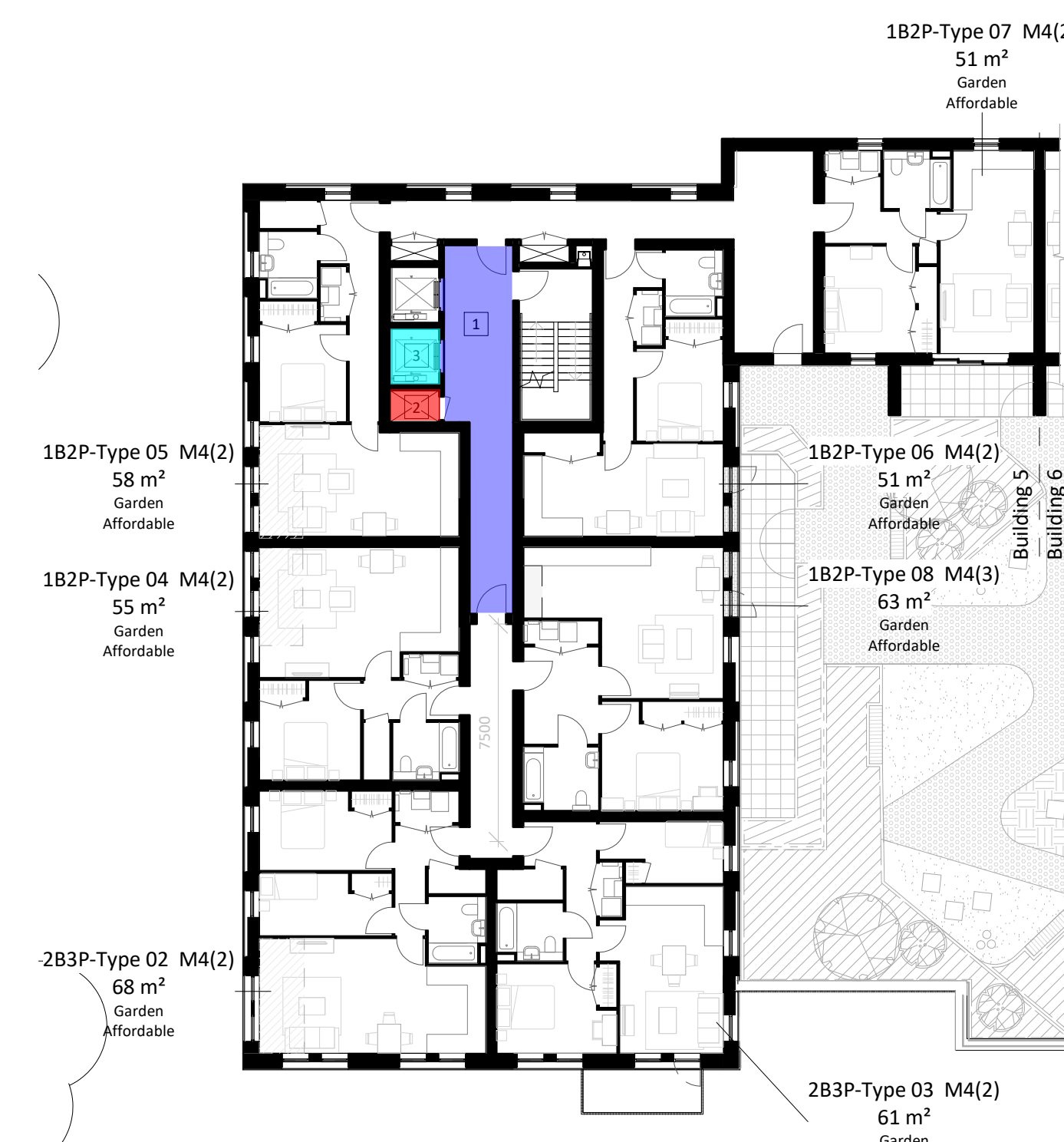
As Building 5 exceeds 30m in height from lowest external level to topmost occupied floor, a minimum Category 2 sprinkler system with a discharge density in accordance with Table 2 - Footnote b of BS 9251, is to be provided throughout the building.

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

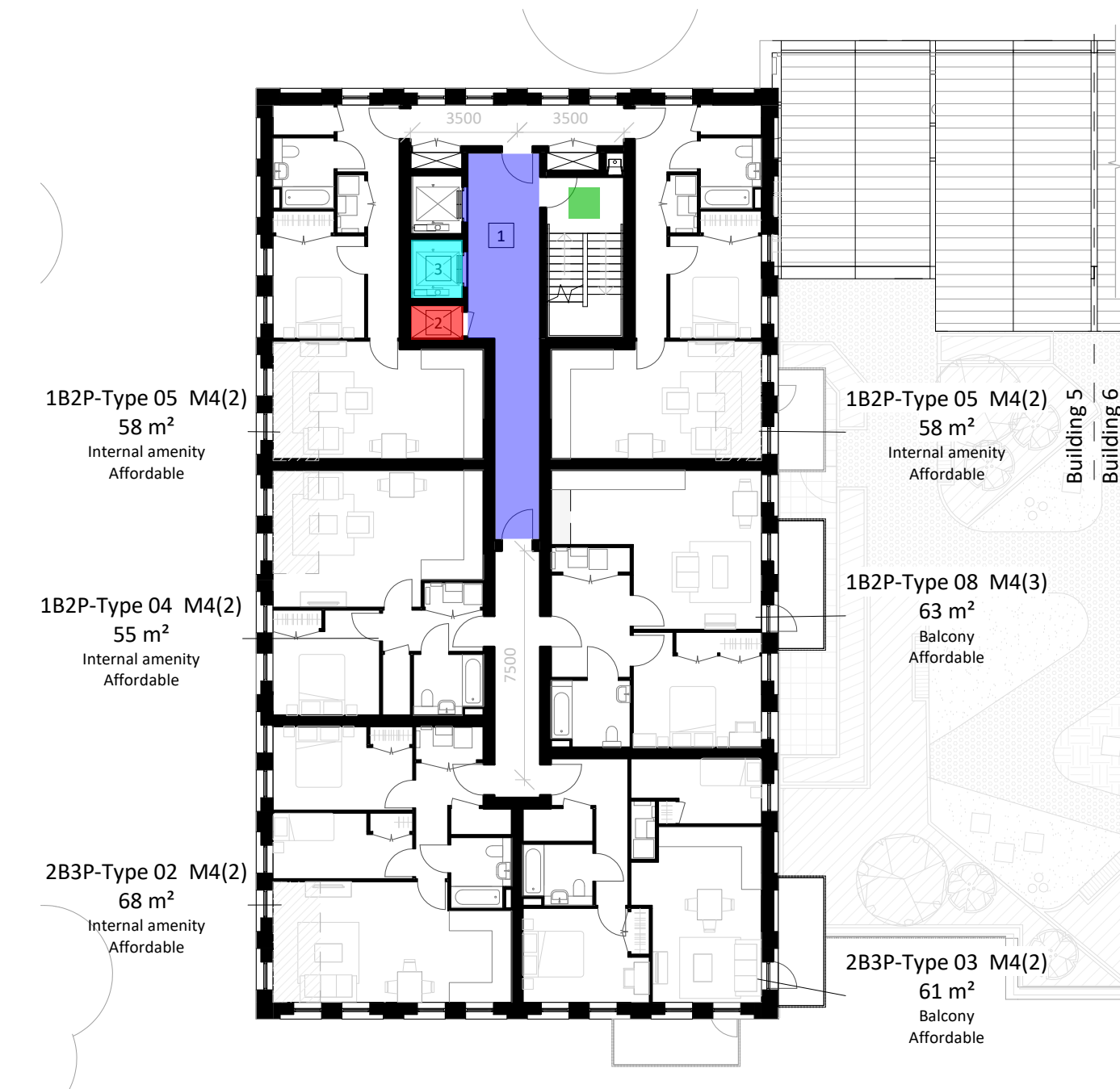
To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

Key -

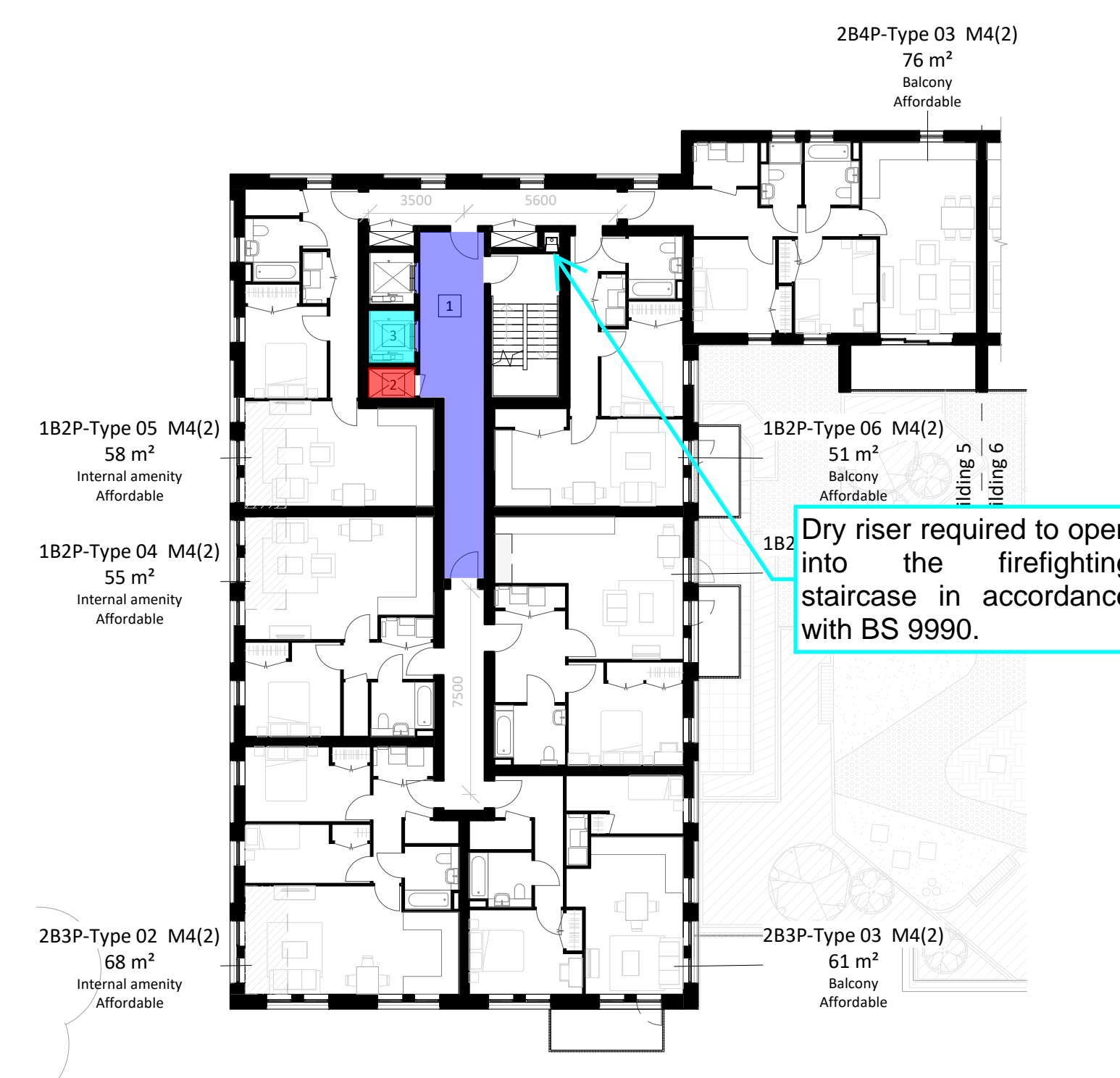
- Minimum 0.2m² permanently ventilated lobby
- Sterile ventilated staircase lobby
- Minimum 1.5m² natural smoke shaft
- Minimum 1.0m² AOV at head of staircase
- Firefighting Lift



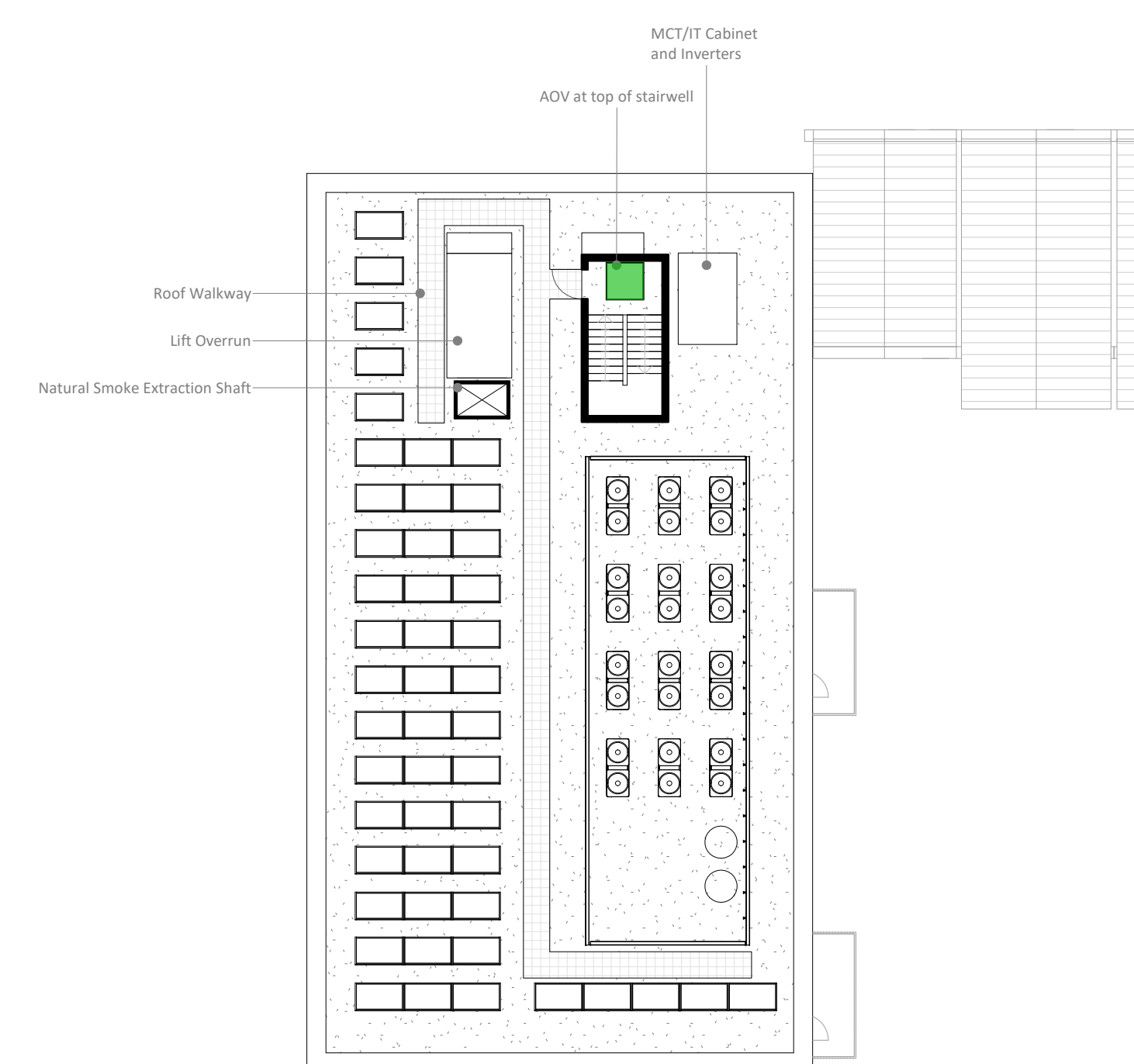
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4 Building 5 - Fifth to Tenth Floor Plan
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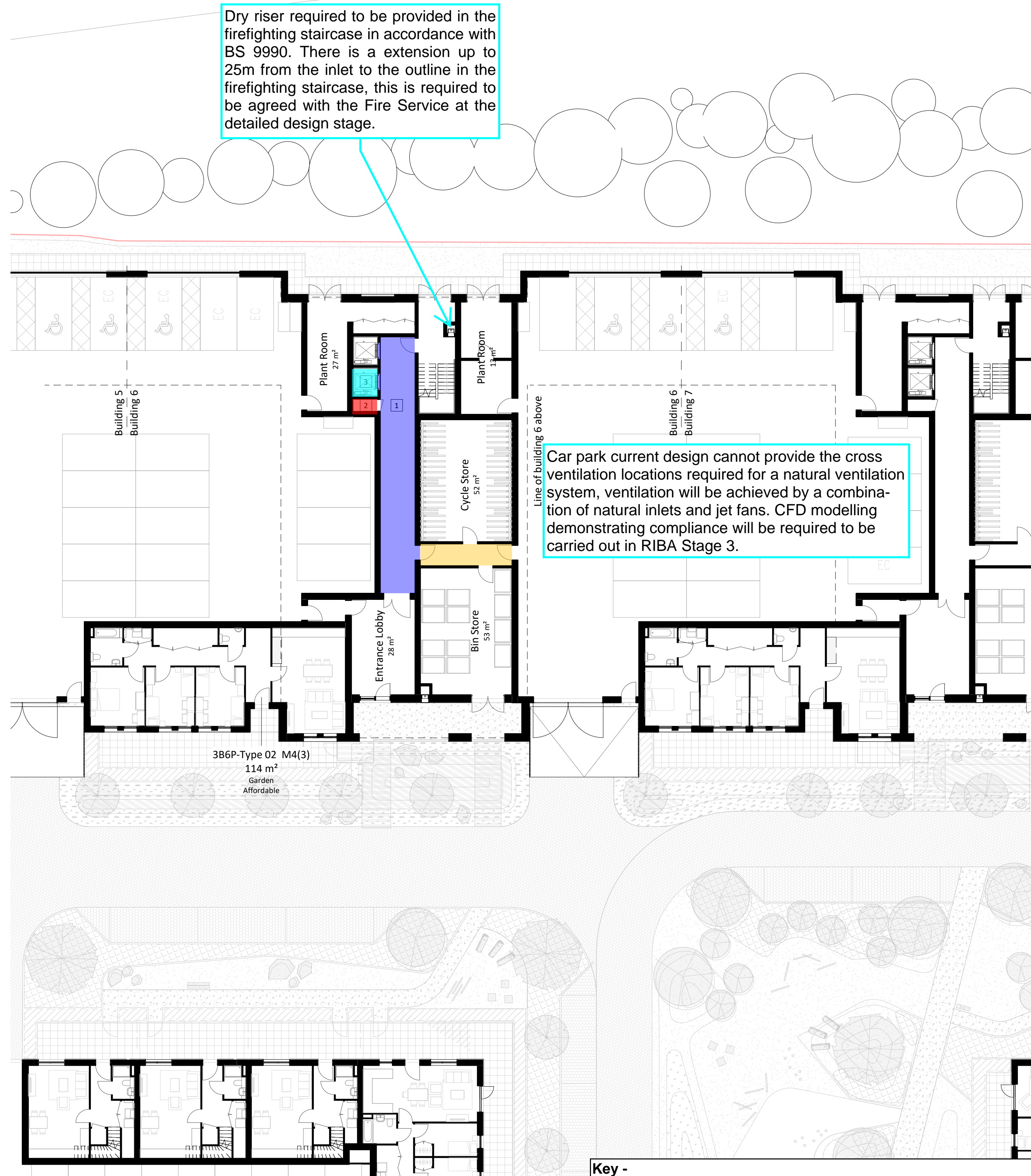


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5 Building 5 - Roof Plan
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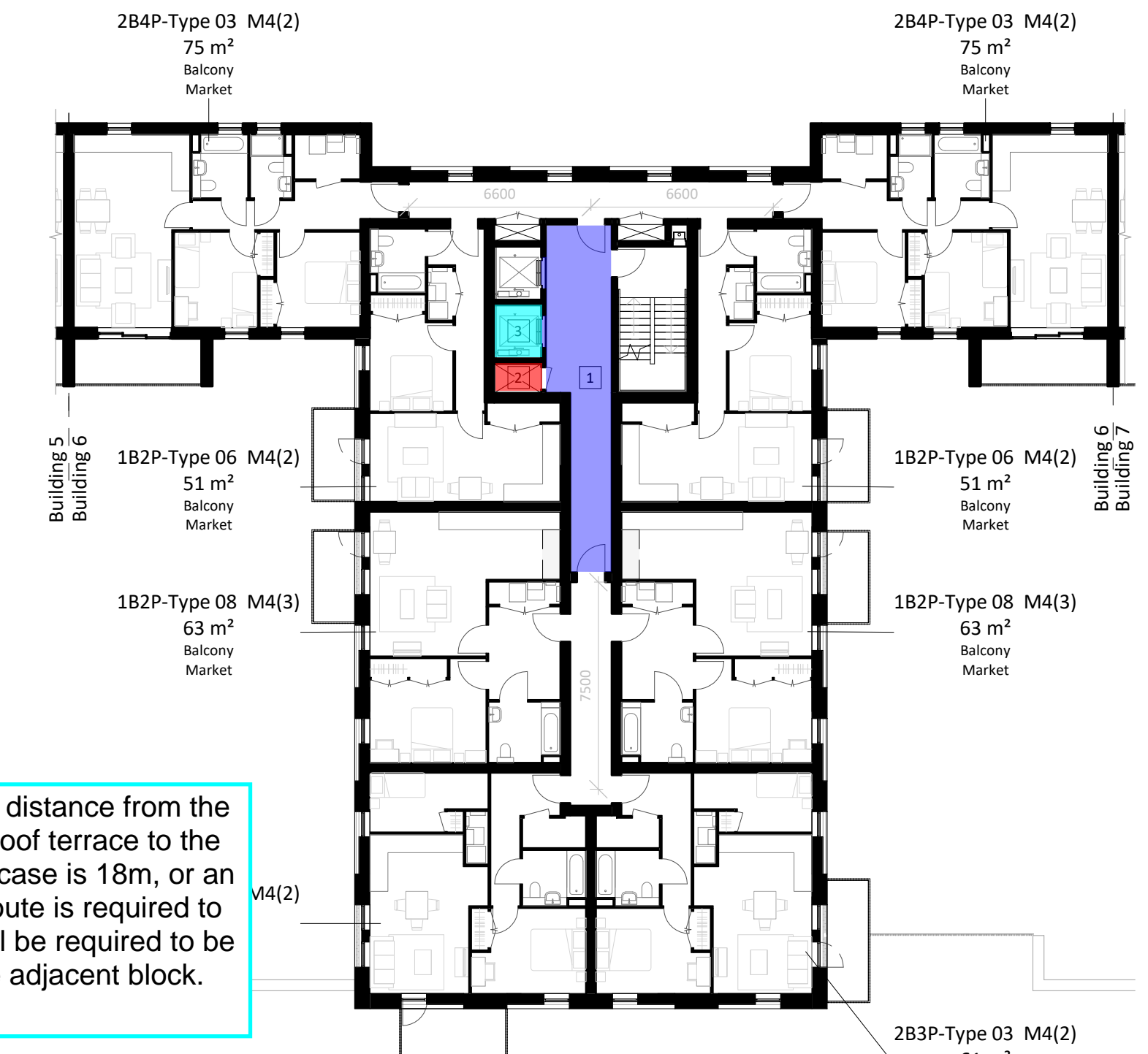
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22nd April 2020
Review by: Thomas Gibbins
Authorised by: Dane Owen



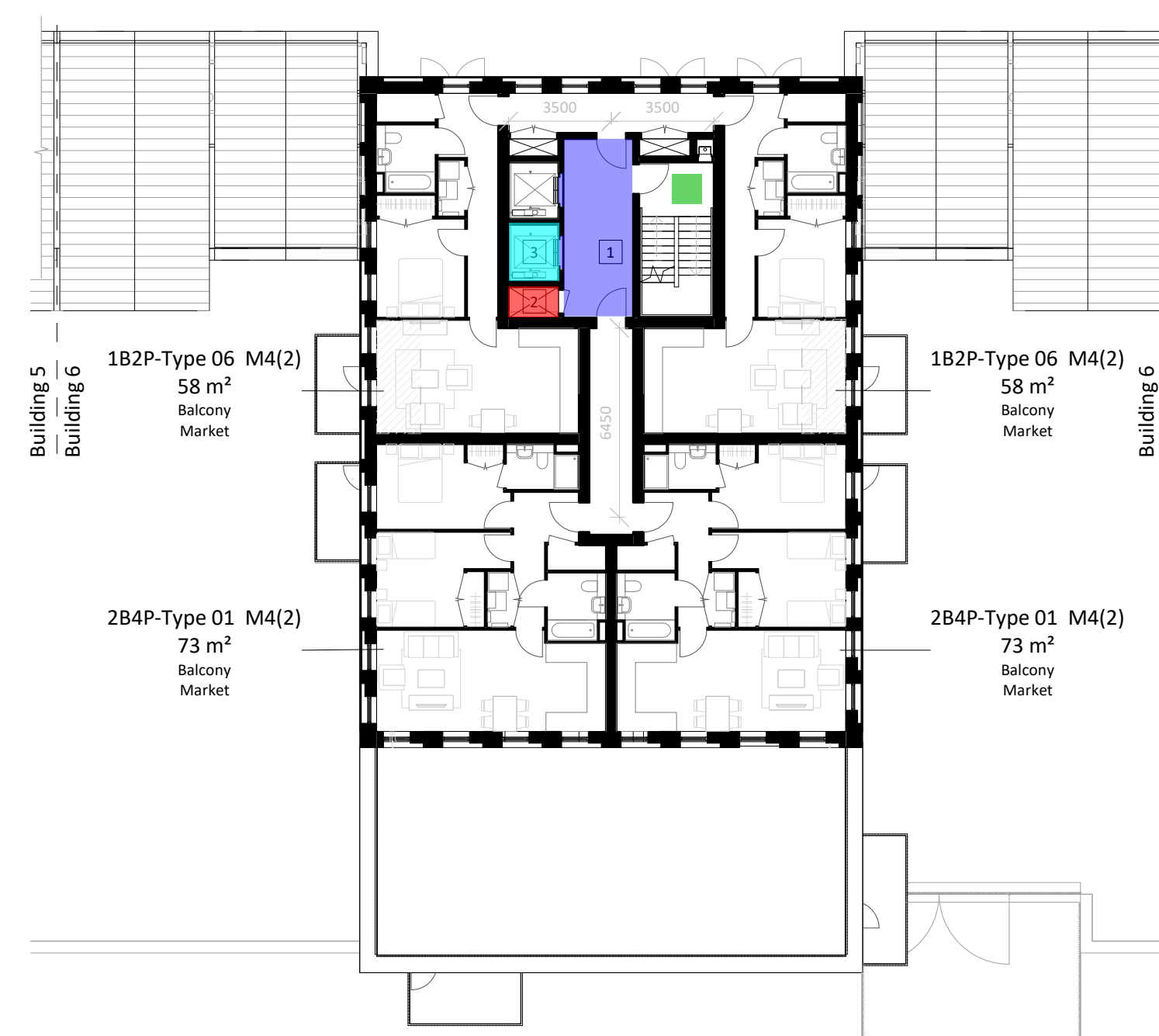
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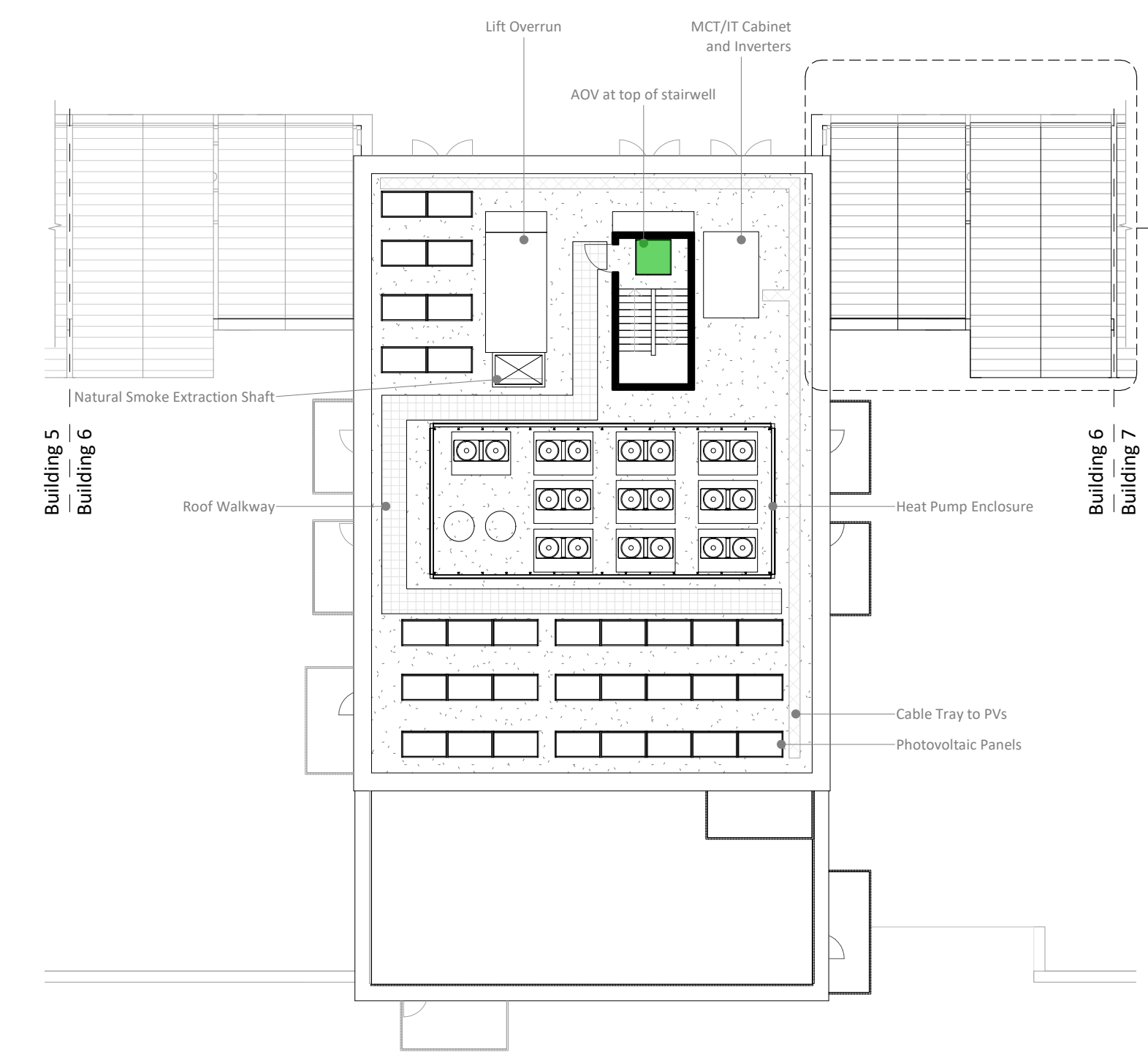
2 Building 6 - First Floor Plan



3 Building 6 - Second to Fourth Floor Plan



4 Building 6 - Fifth to Seventh Floor Plan



5 Building 6 - Roof Plan

1 : 200

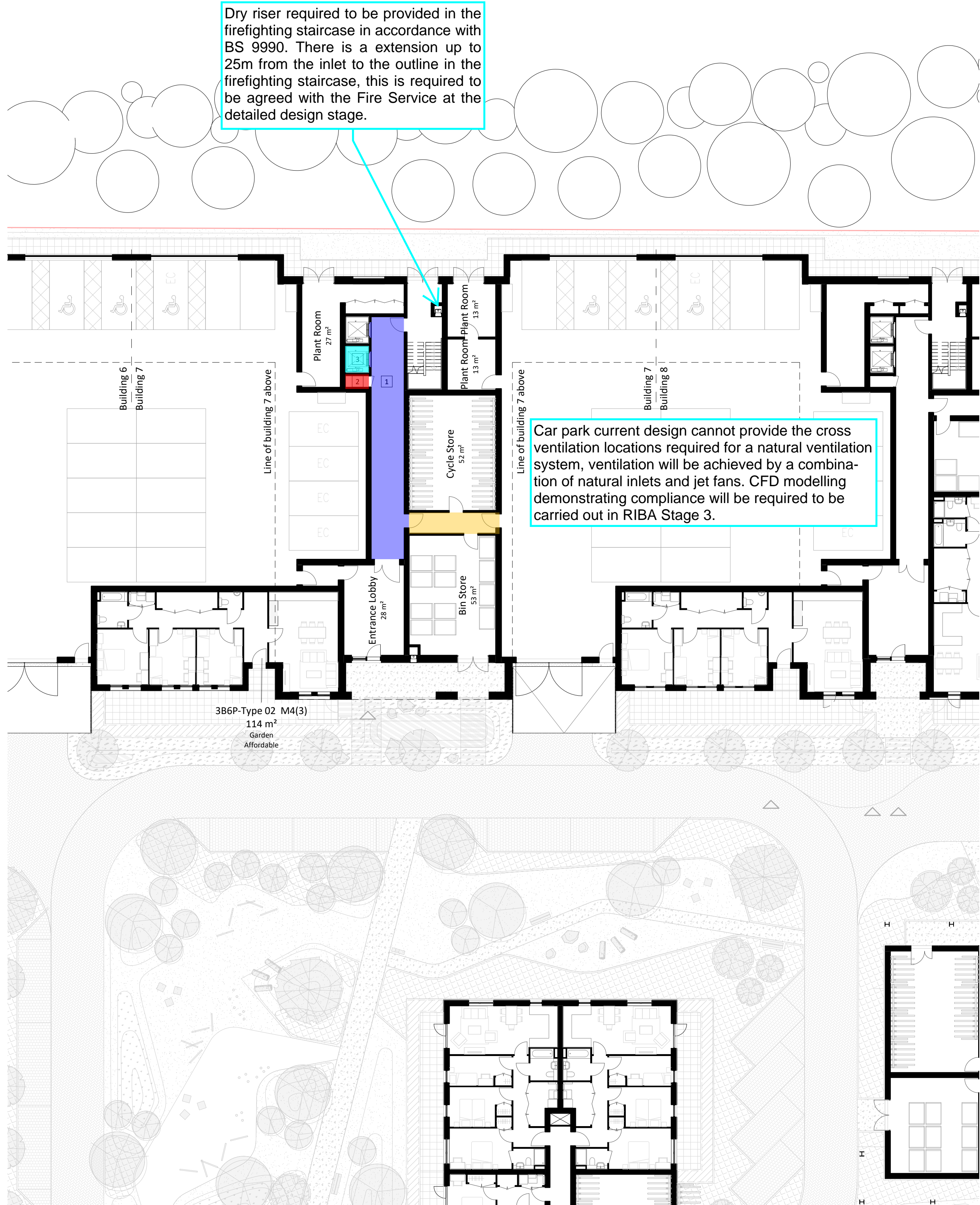
Key -

- Minimum 0.2m² permanently ventilated lobby
- Sterile ventilated staircase lobby
- Minimum 1.5m² natural smoke shaft
- Minimum 1.0m² AOV at head of staircase
- Firefighting Lift
- Alternative escape route required to be provided

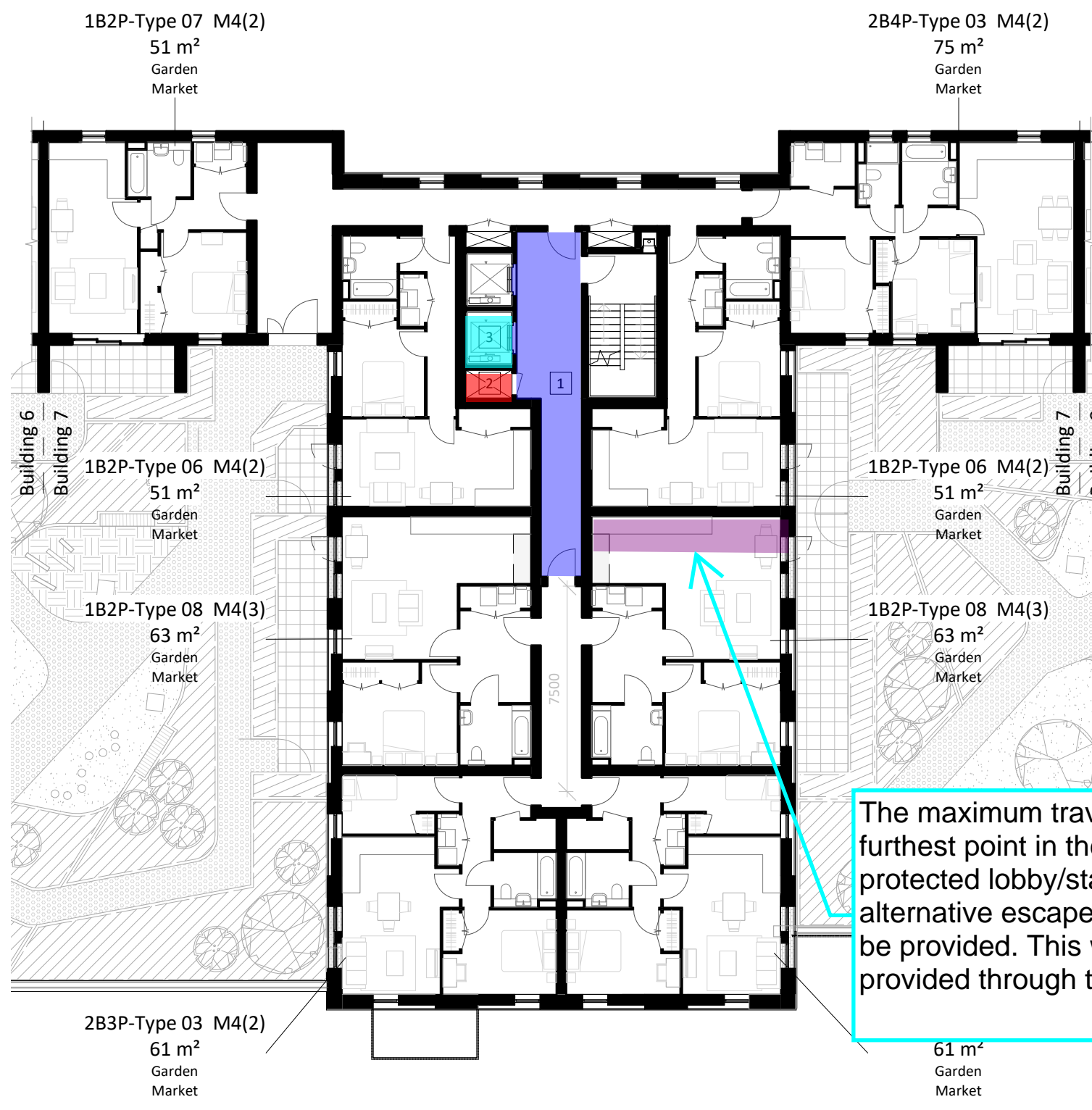
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To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

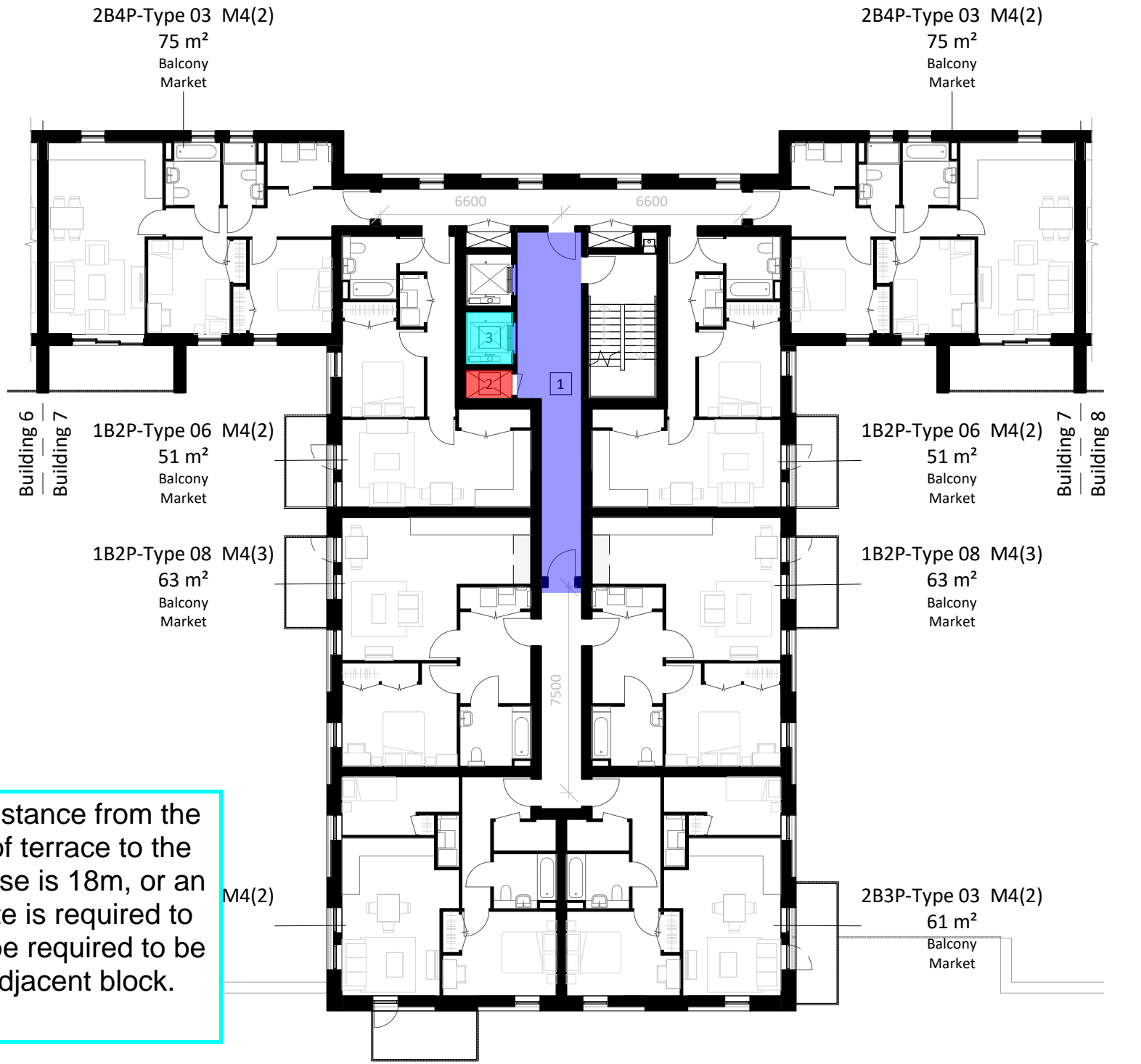
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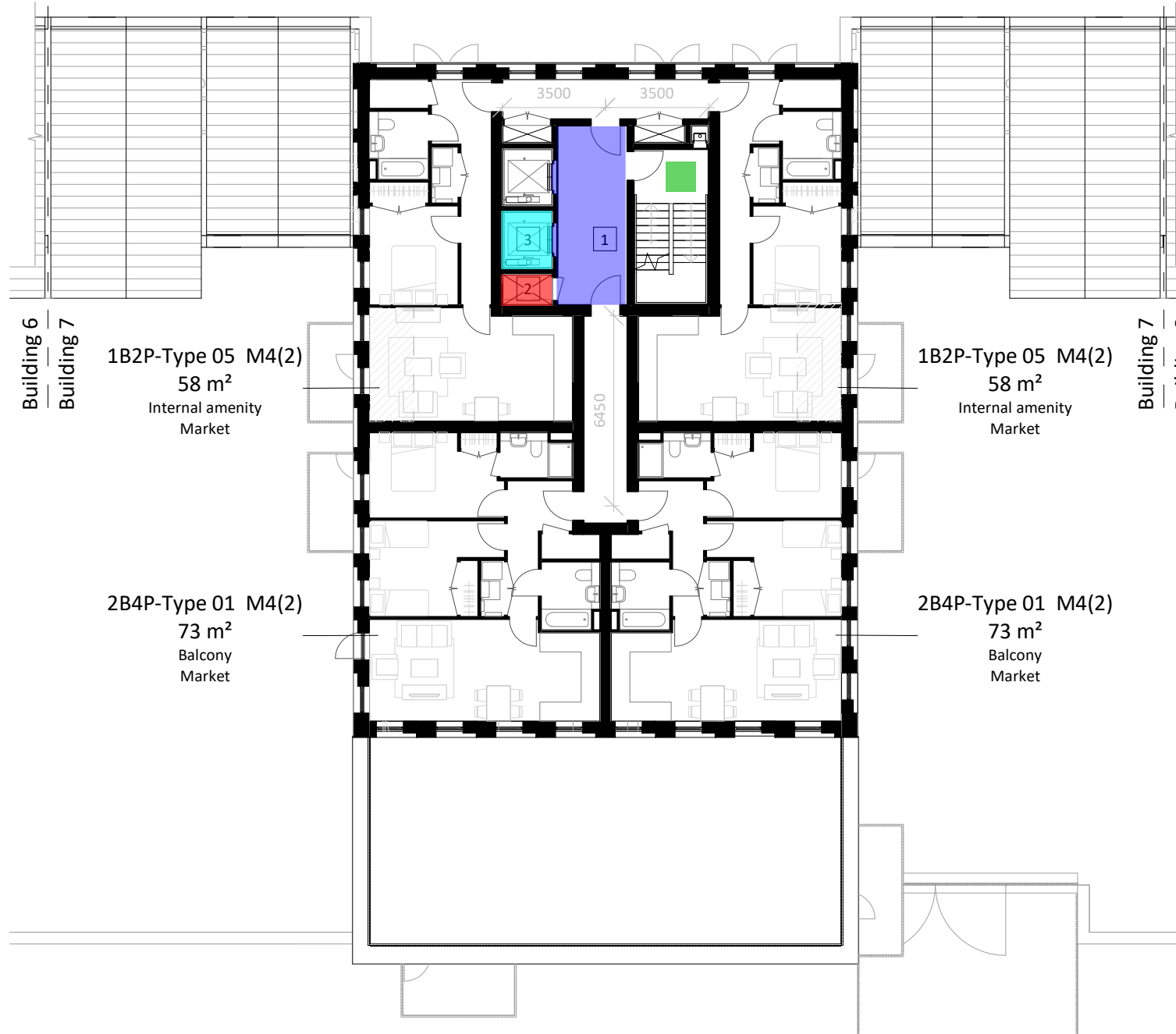
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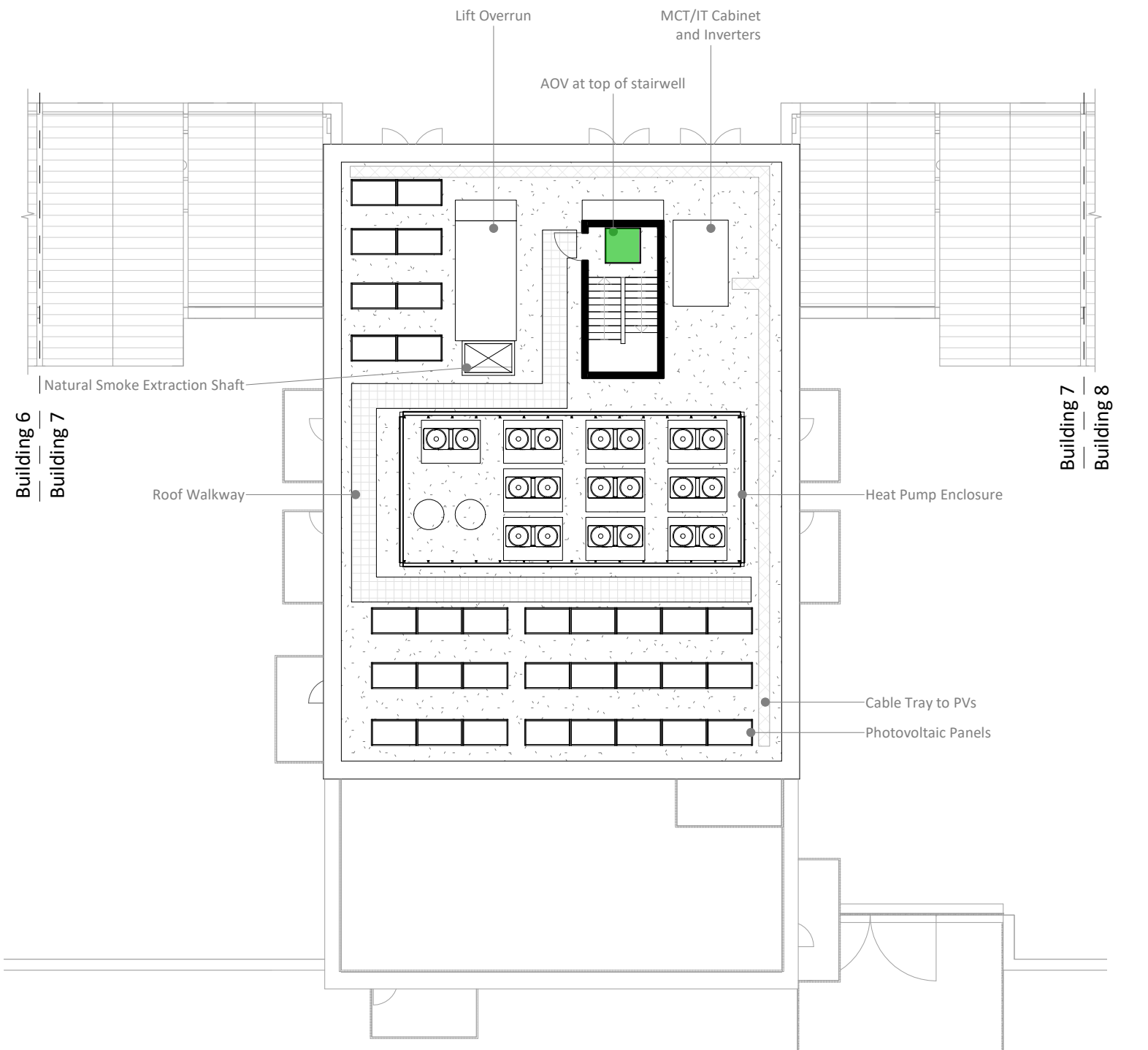
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3 Building 7 - Second to Fourth Floor Plan
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4 Building 7 - Fifth to Seventh Floor Plan
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5 Building 7 - Roof Plan
1 : 200

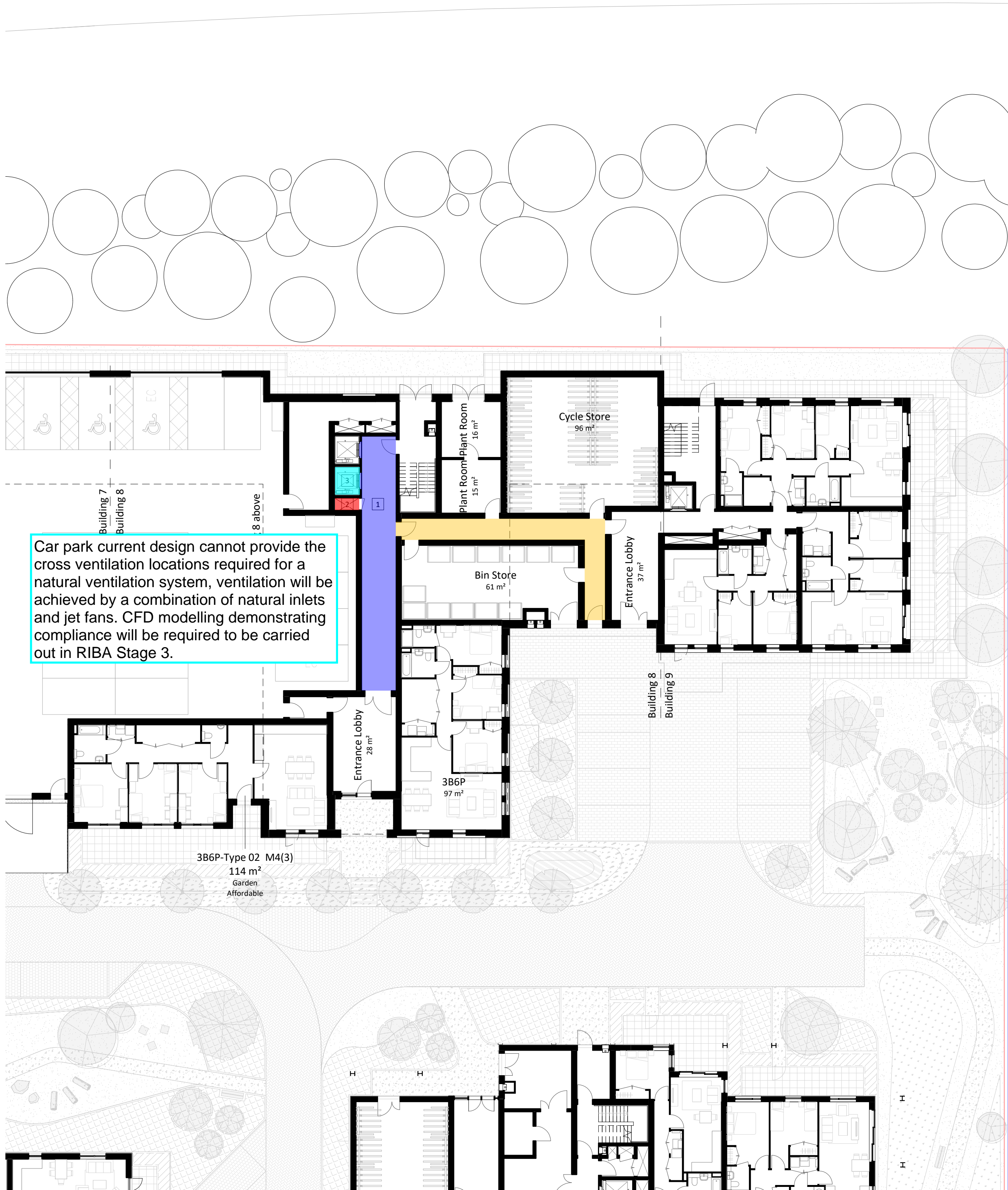
Key -

- Minimum 0.2m² permanently ventilated lobby
- Sterile ventilated staircase lobby
- Minimum 1.5m² natural smoke shaft
- Minimum 1.0m² AOV at head of staircase
- Firefighting Lift

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

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22nd April 2020
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Authorised by: Dane Owen

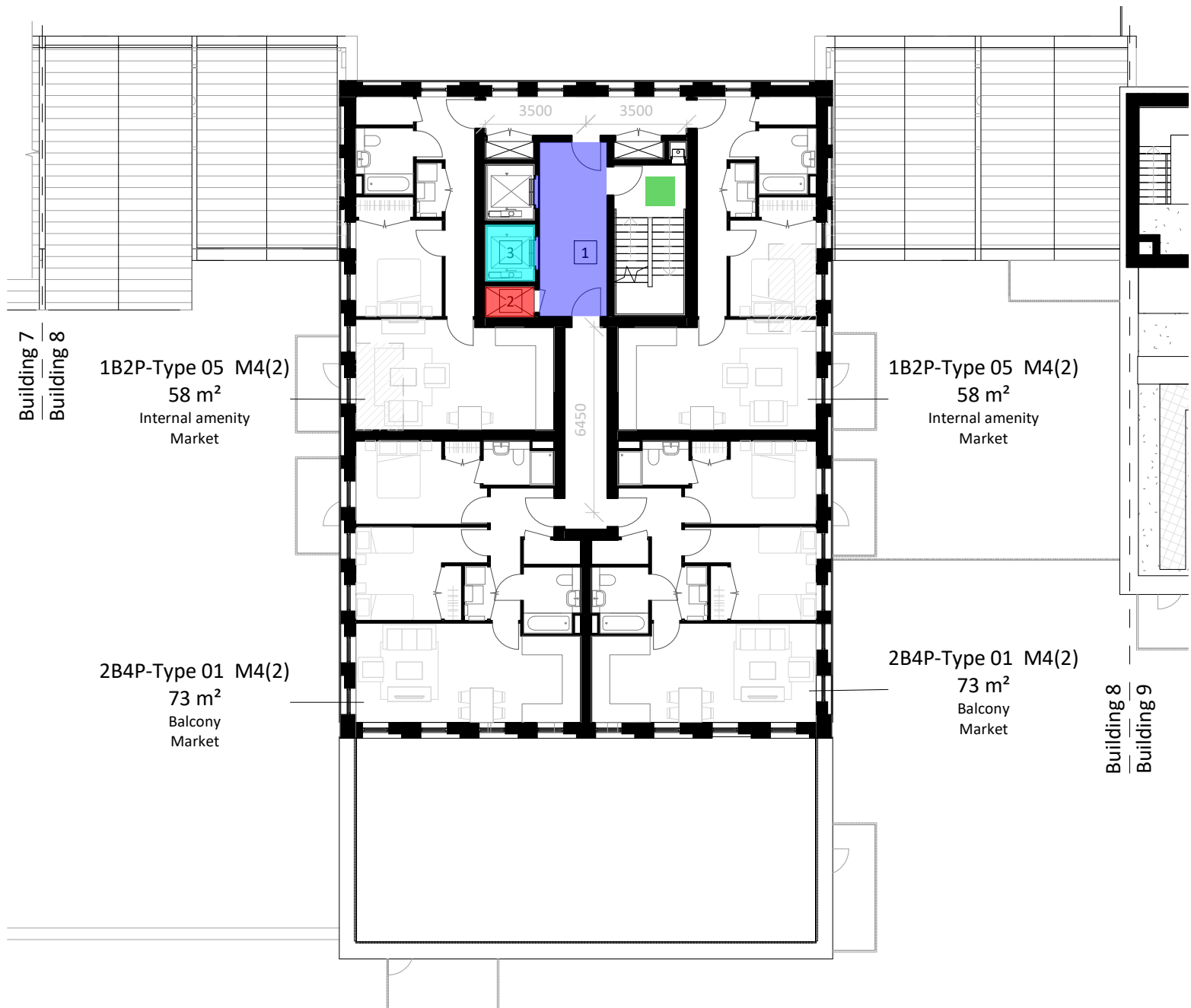


1 Building 8 - Ground Floor Plan
1 : 200

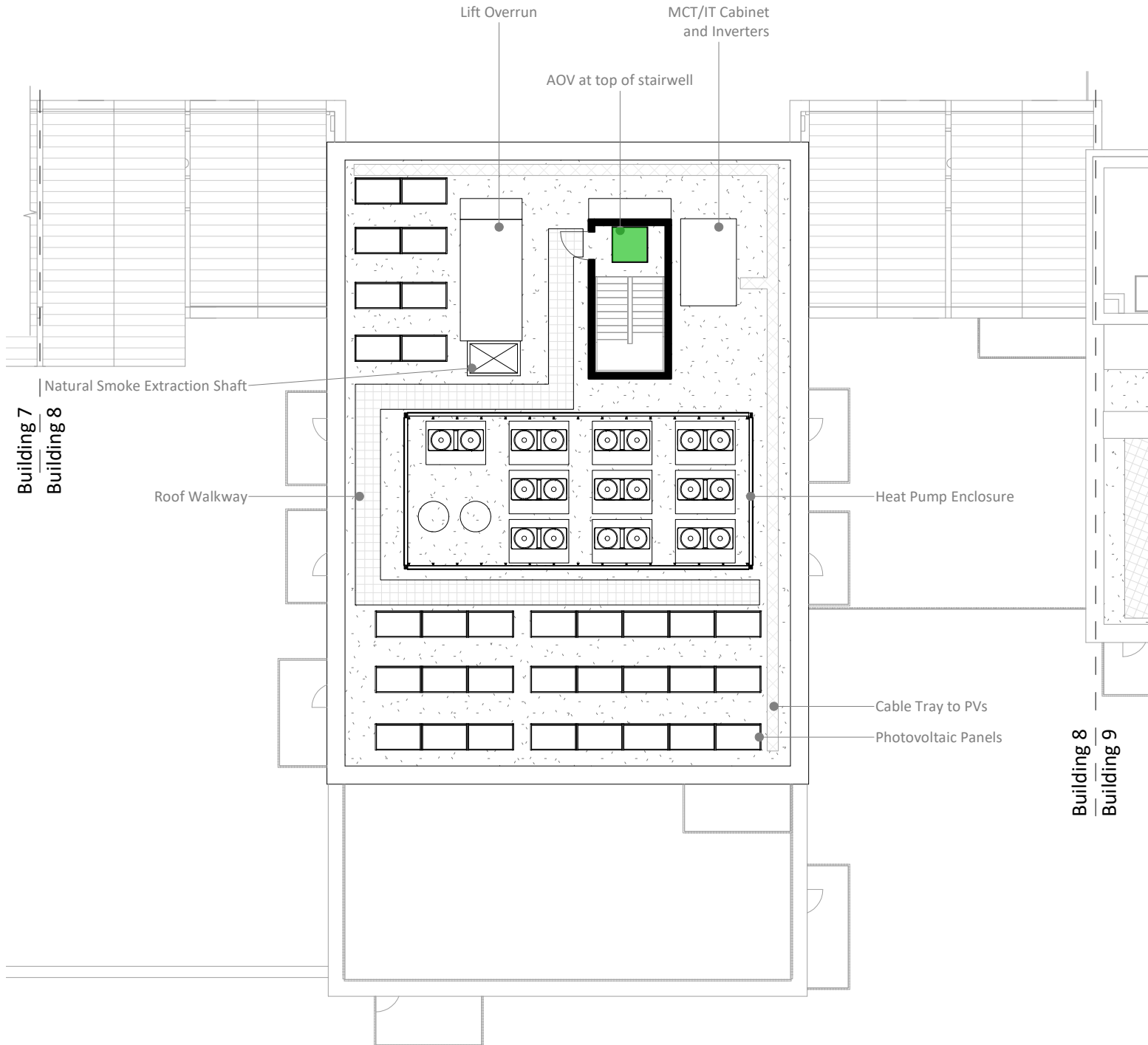


2 Building 8 - First Floor Plan
1 : 200

3 Building 8 - Second to Fourth Floor Plan
1 : 200



4 Building 8 - Fifth to Seventh Floor Plan
1 : 200



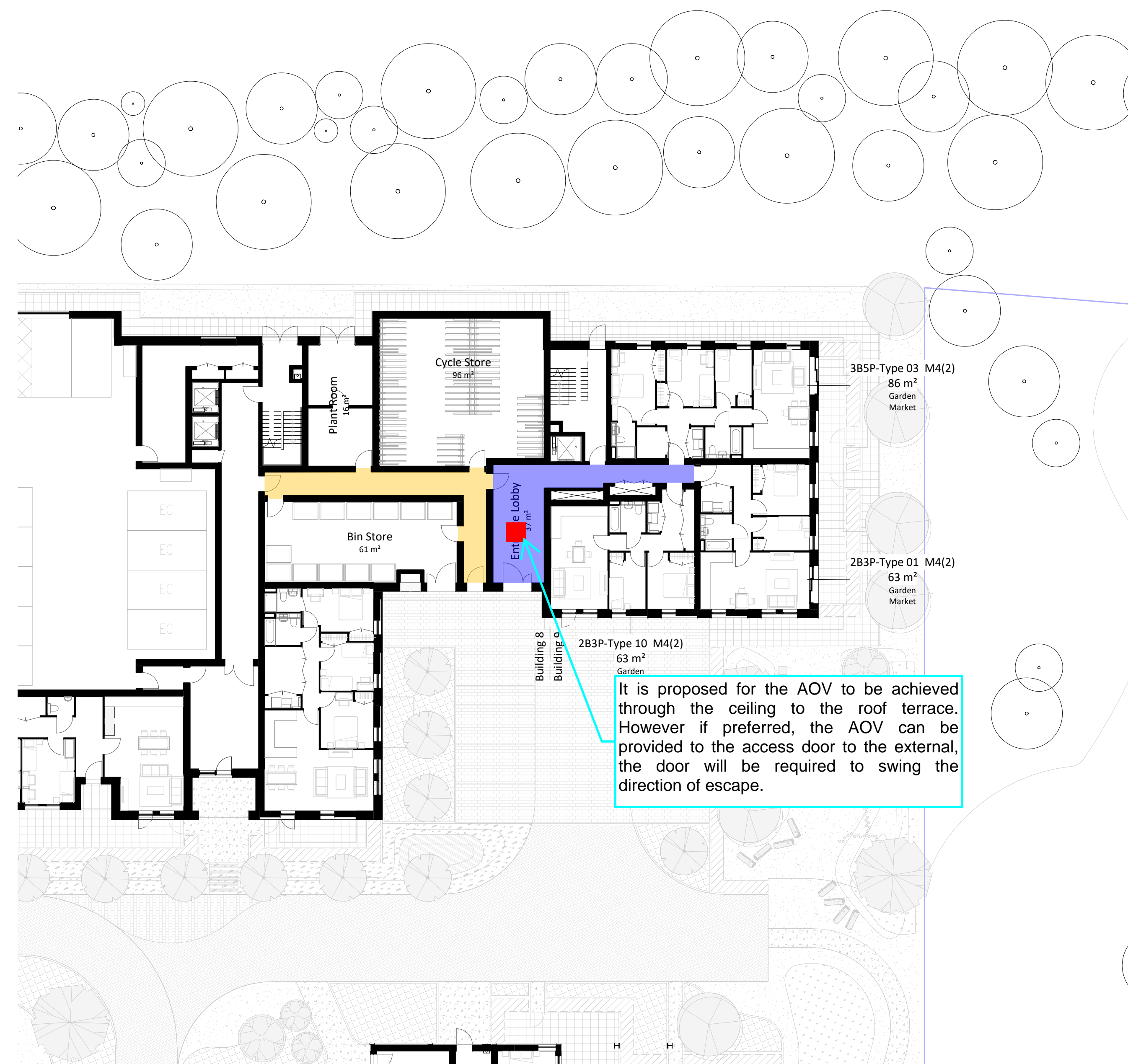
5 Building 8 - Roof Plan
1 : 200

| Key - | |
|-------|--|
| | Minimum 0.2m² permanently ventilated lobby |
| | Sterile ventilated staircase lobby |
| | Minimum 1.5m² natural smoke shaft |
| | Minimum 1.0m² AOV at head of staircase |
| | Firefighting Lift |

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

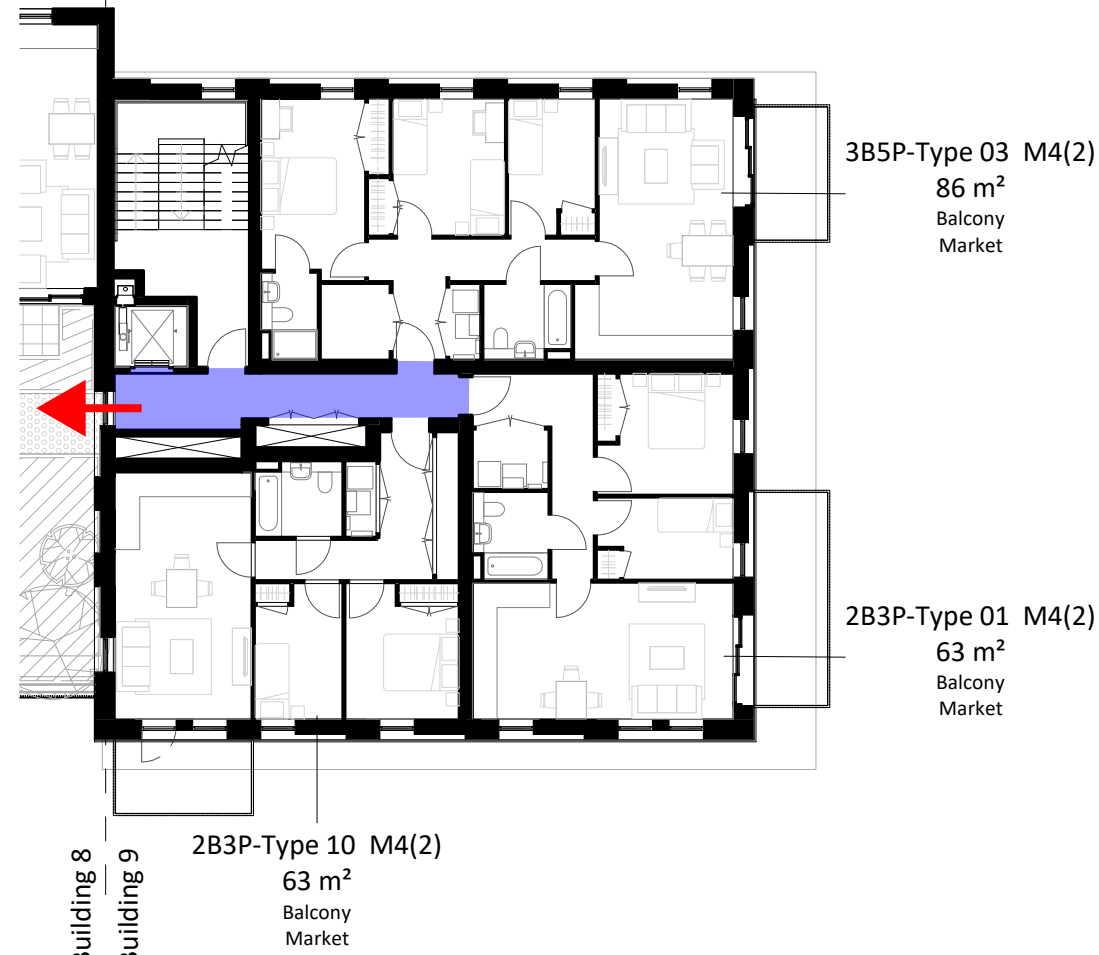
To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

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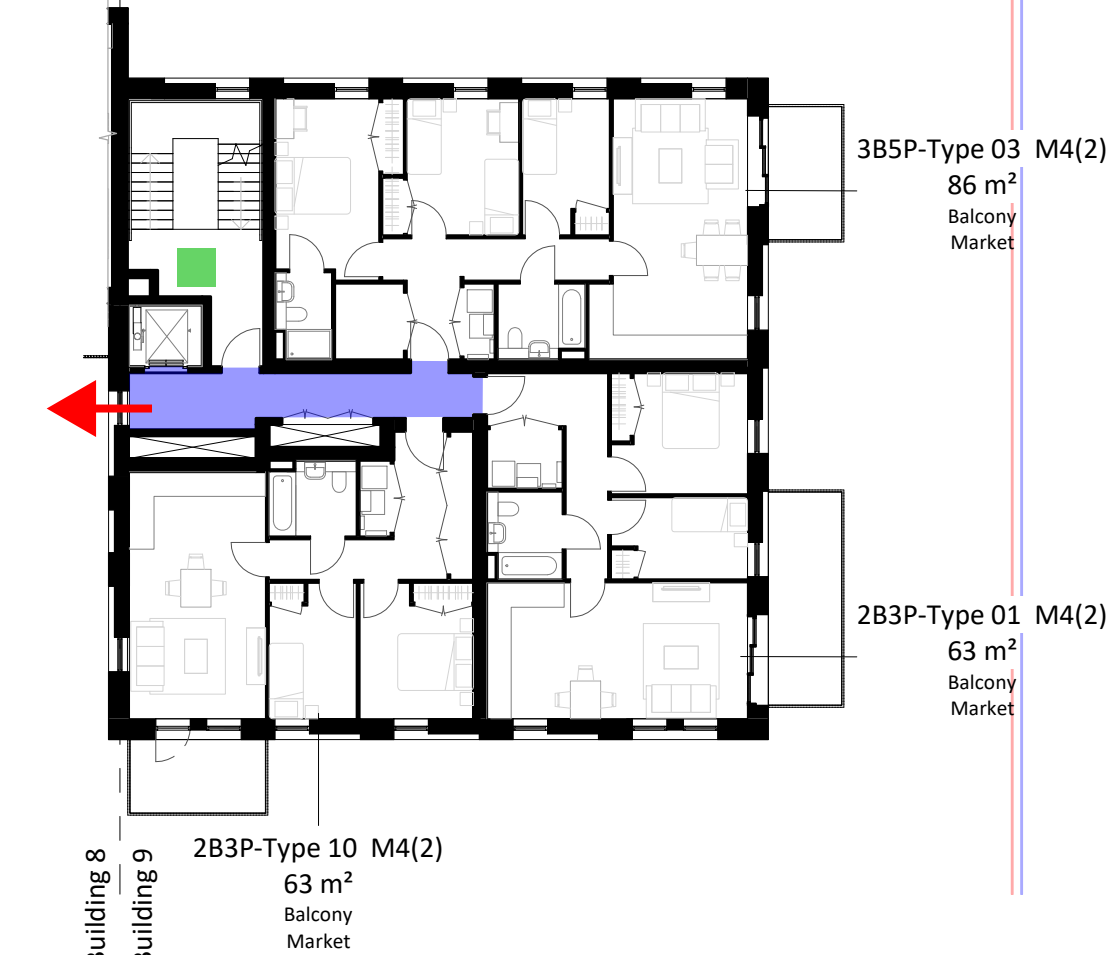


1 Building 9 - Ground Floor Plan
1 : 200

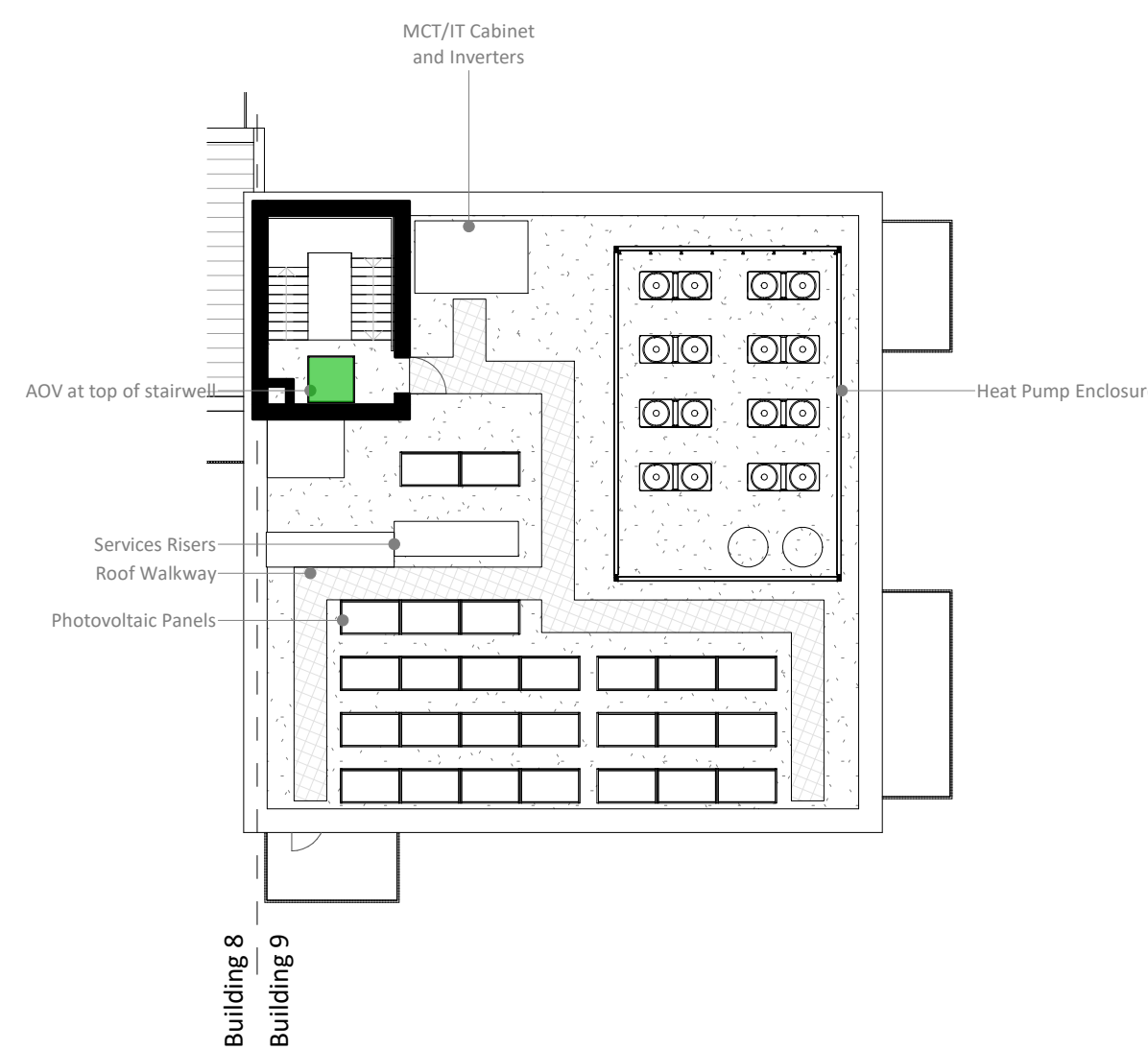
It is proposed for the AOV to be achieved through the ceiling to the roof terrace. However if preferred, the AOV can be provided to the access door to the external, the door will be required to swing the direction of escape.



2 Building 9 - First Floor Plan
1 : 200



3 Building 9 - Second to Fourth Floor Plan
1 : 200



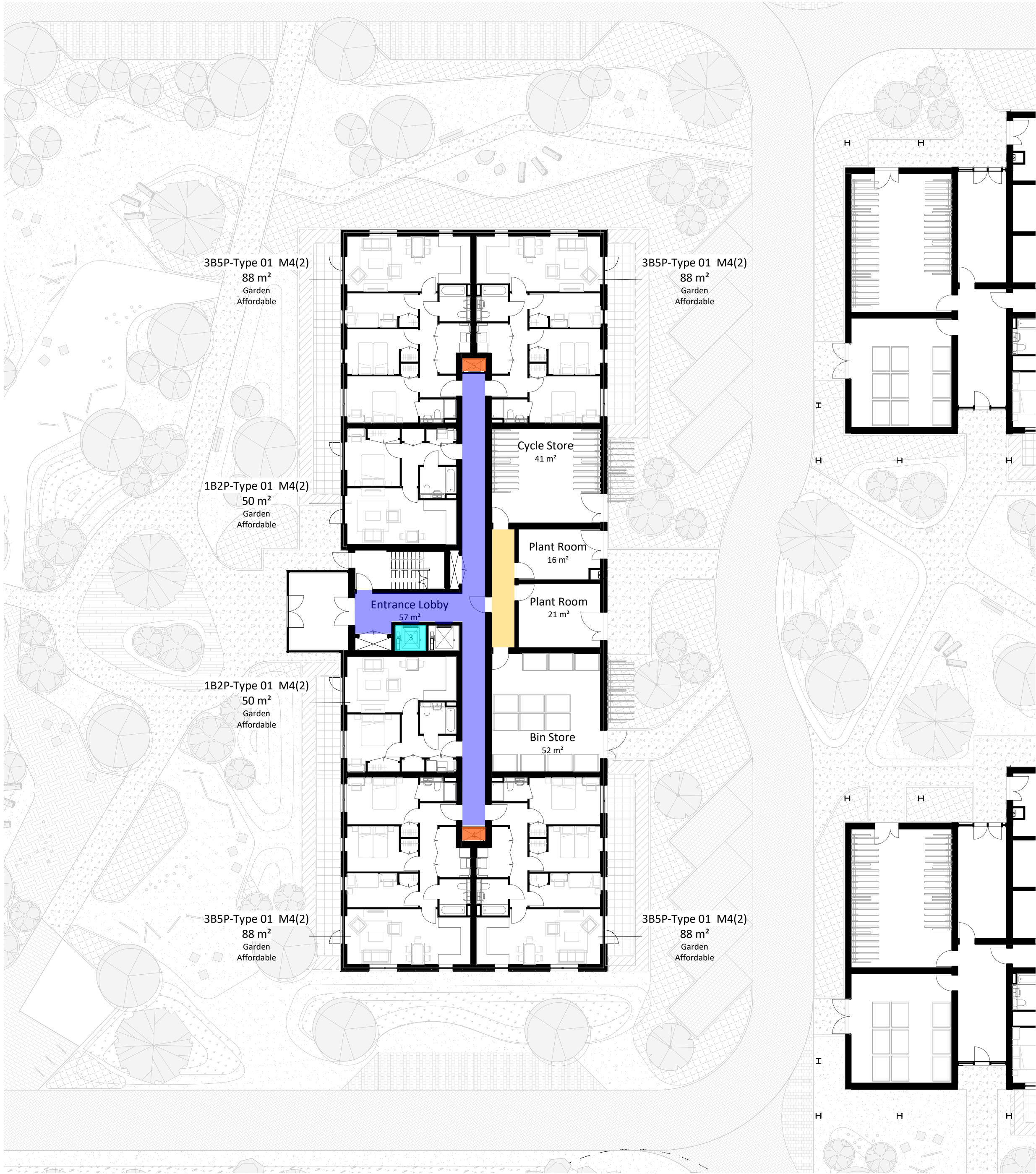
4 Building 9 - Fifth Floor Plan
1 : 200

| Key - | |
|-------|---|
| | Minimum 0.2m² permanently ventilated lobby |
| | Ventilated staircase lobby |
| | Minimum 1.5m² AOV direct to the external |
| | Minimum 1.5m² roof AOV direct to the external |
| | Minimum 1.0m² AOV at head of staircase |

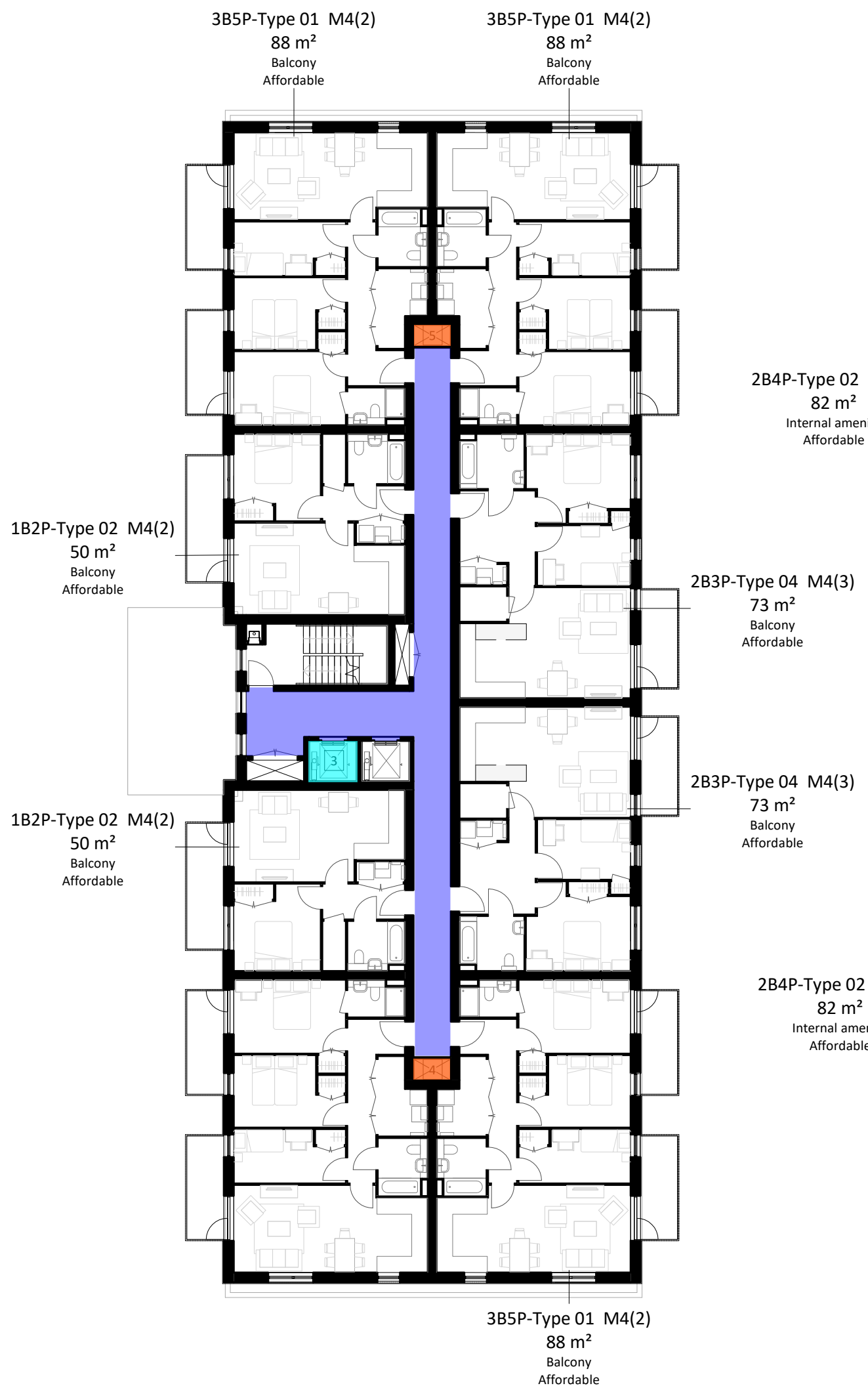
To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

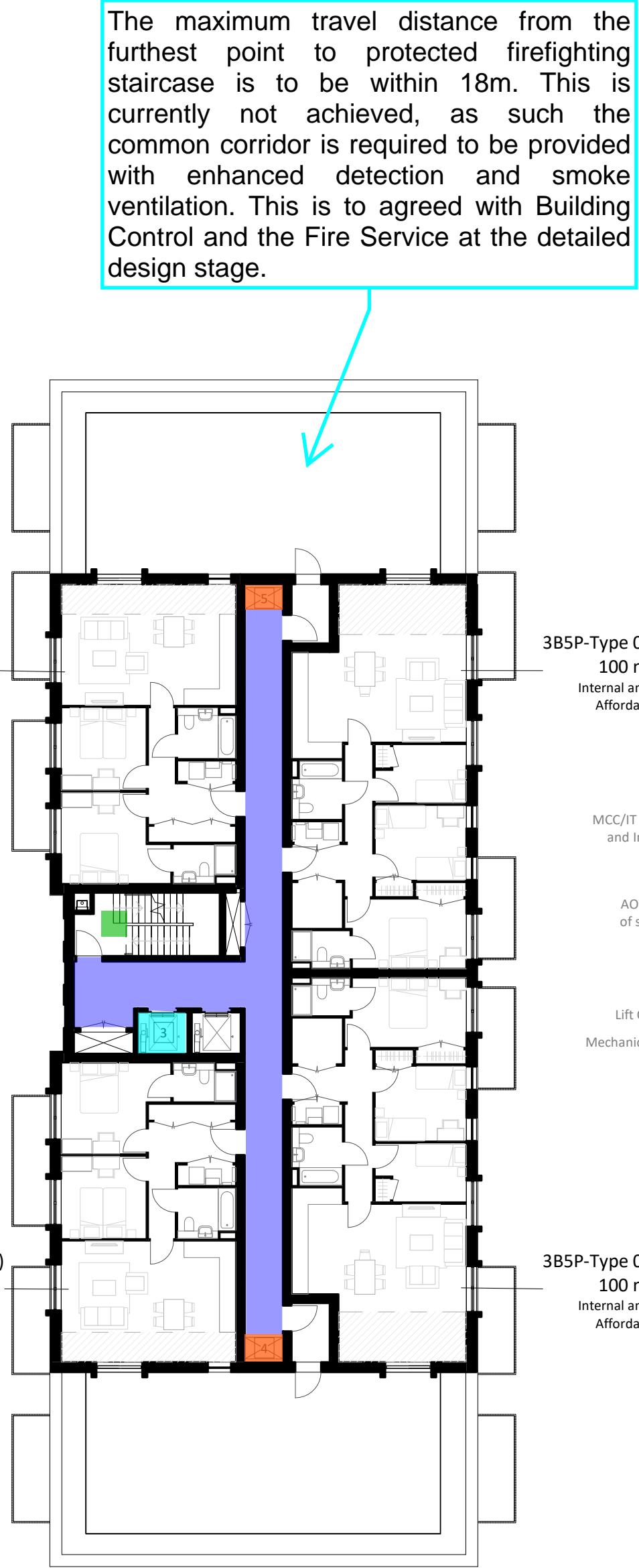
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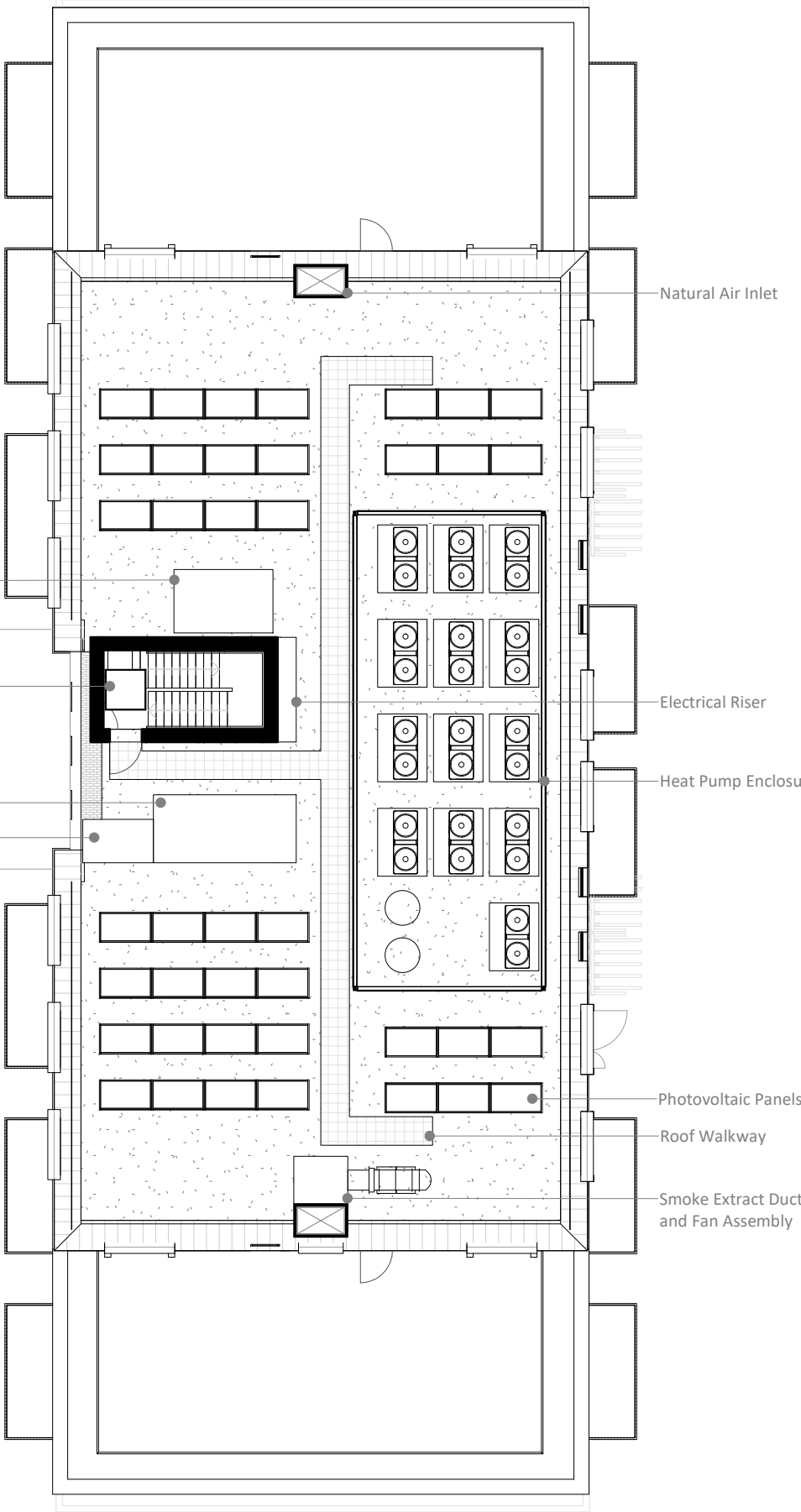
1 Building 10 - Ground Floor Plan
1 : 200



2 Building 10 First to Fifth Floor Plan
1 : 200



3 Building 10 - Sixth Floor Plan
1 : 200



4 Building 10 - Roof Plan
1 : 200

The maximum travel distance from the furthest point to protected firefighting staircase is to be within 18m. This is currently not achieved, as such the common corridor is required to be provided with enhanced detection and smoke ventilation. This is to agreed with Building Control and the Fire Service at the detailed design stage.

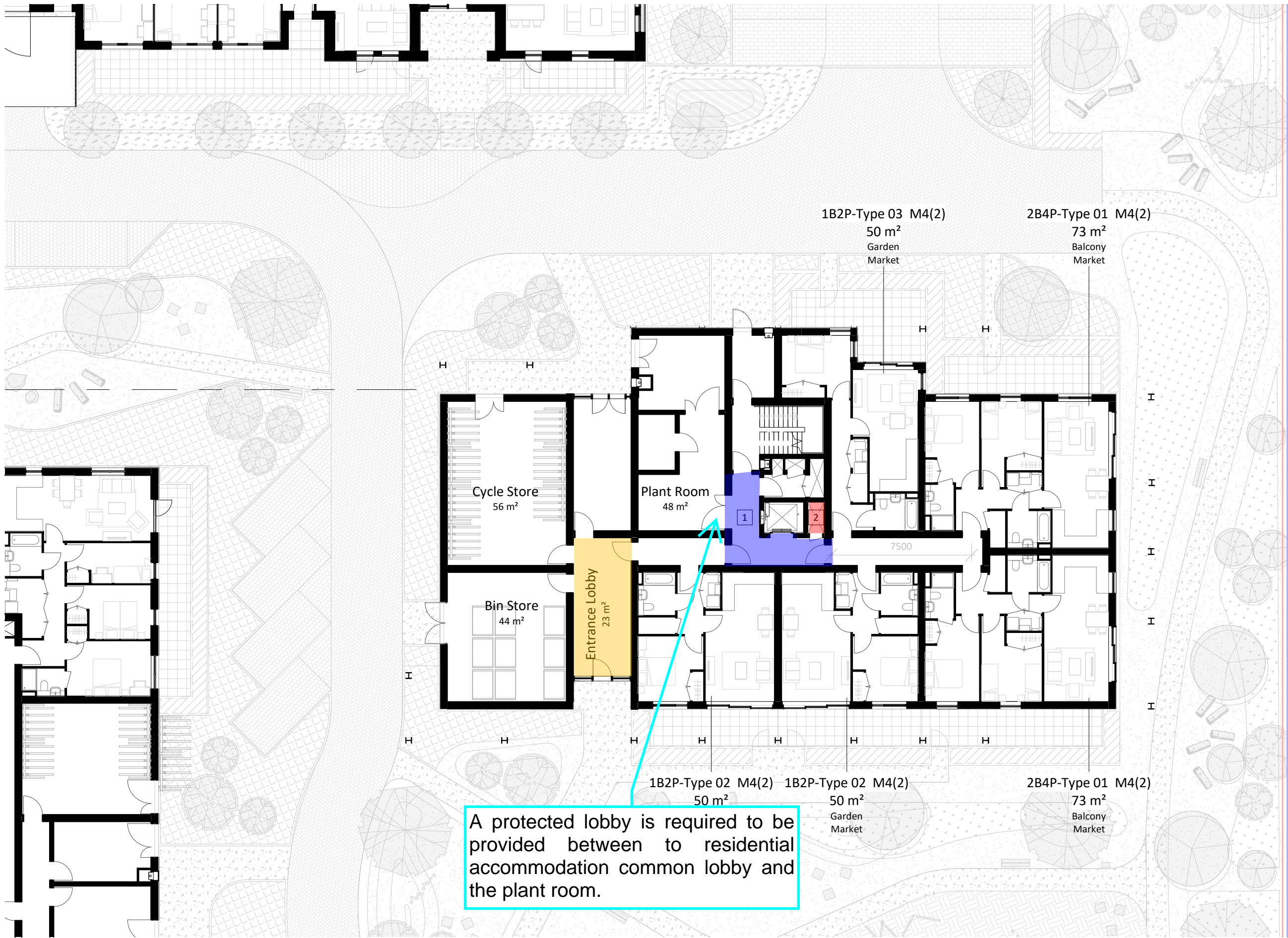
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To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

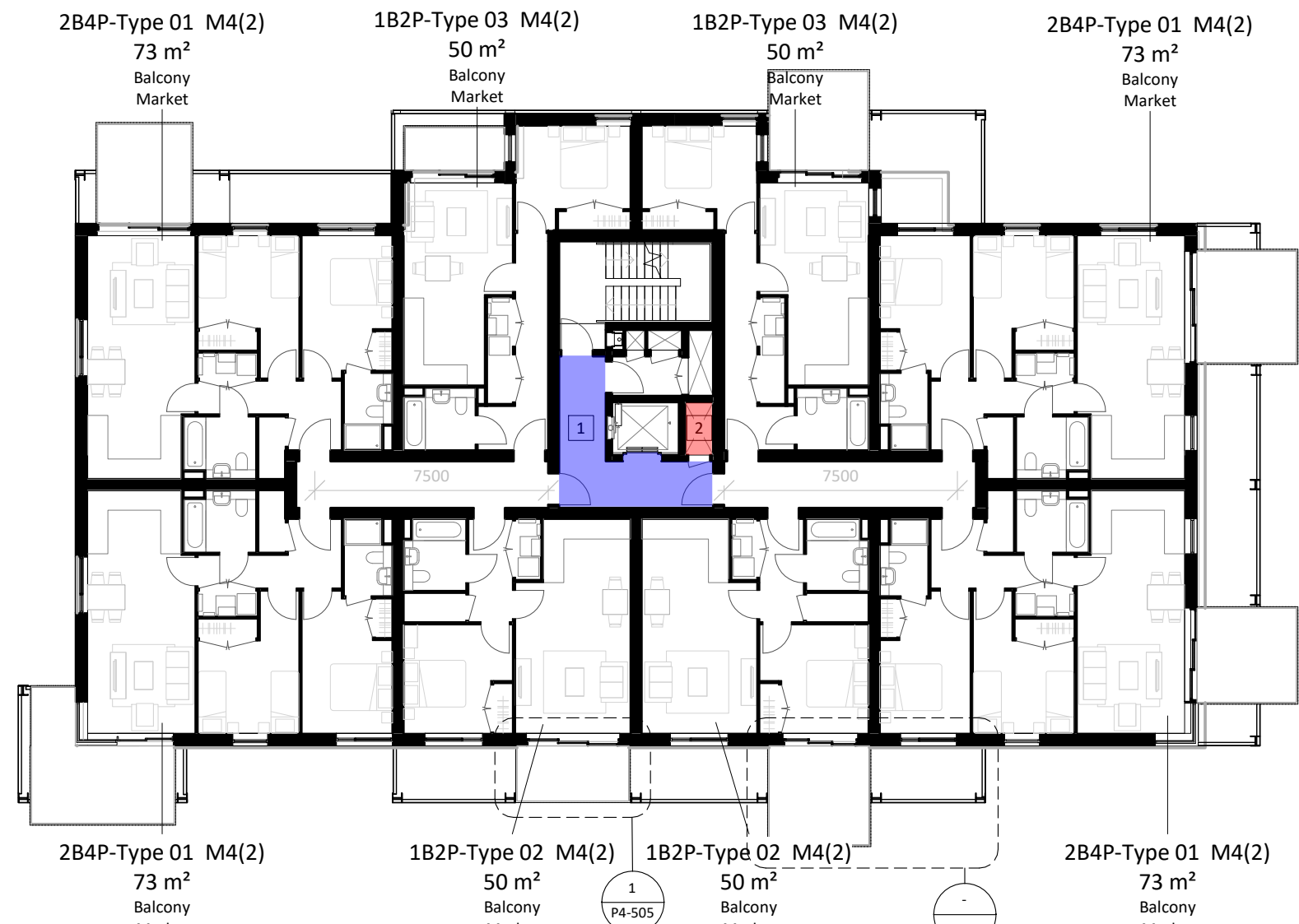
To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

- Key -
- Minimum 0.2m² permanently ventilated lobby
 - Sterile ventilated staircase lobby/ corridor
 - Minimum 0.8m² mechanical smoke shaft
 - Minimum 1.0m² AOV at head of staircase
 - Firefighting Lift

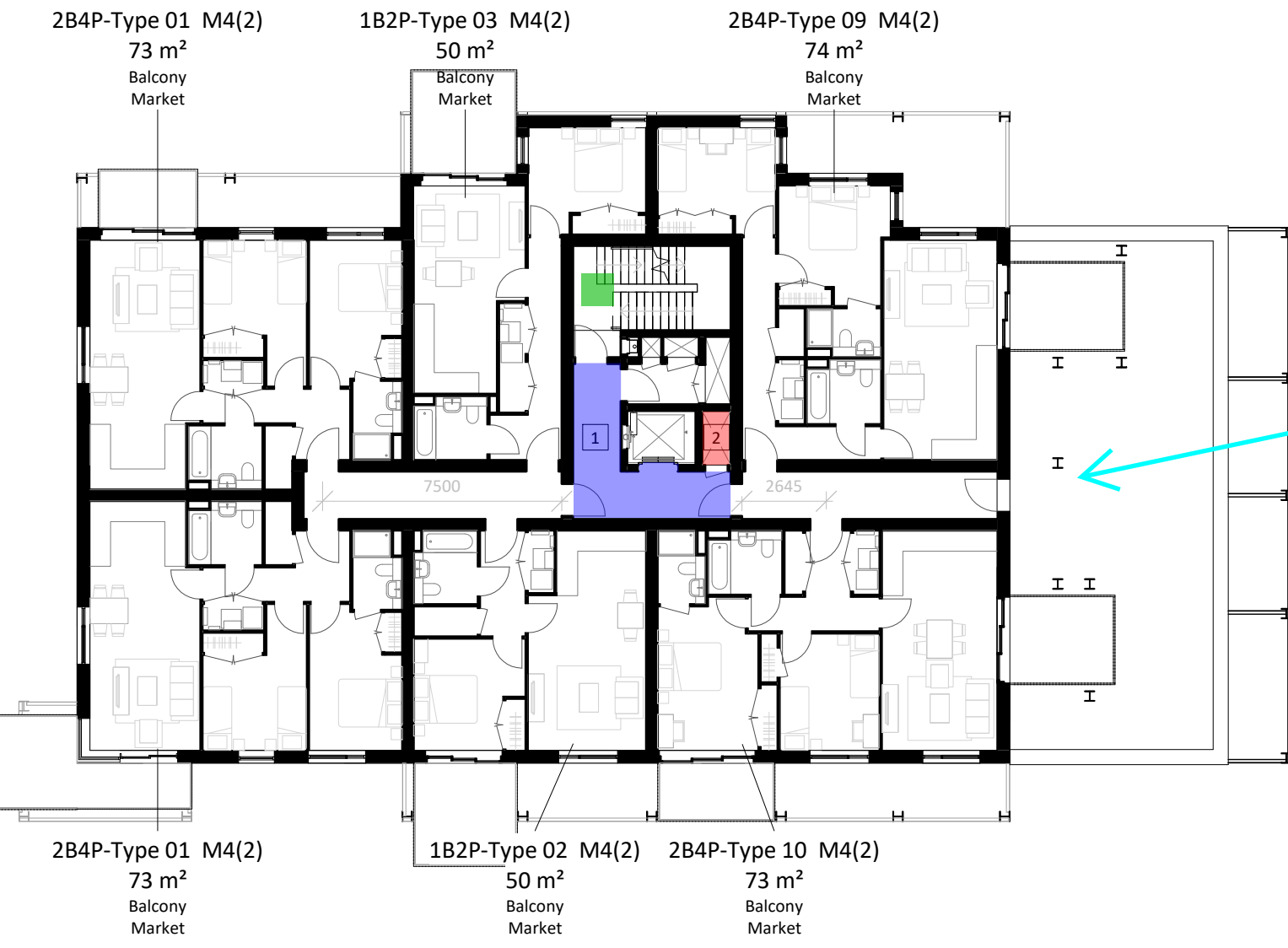
The cross-corridor doors and the lobby AOV's direct to the external are to be omitted, allowing for 2x 0.8m² mechanical smoke shafts are to be provided at the remote ends of the corridors (one at each end). CFD modelling would be required to justify this deviation. However, considering that the travel distance isn't excessive and that the apartments are not impeding the vertical escape route, it is considered that this proposed solution has limited design risk.



1 Building 11 - Ground Floor Plan
1 : 200

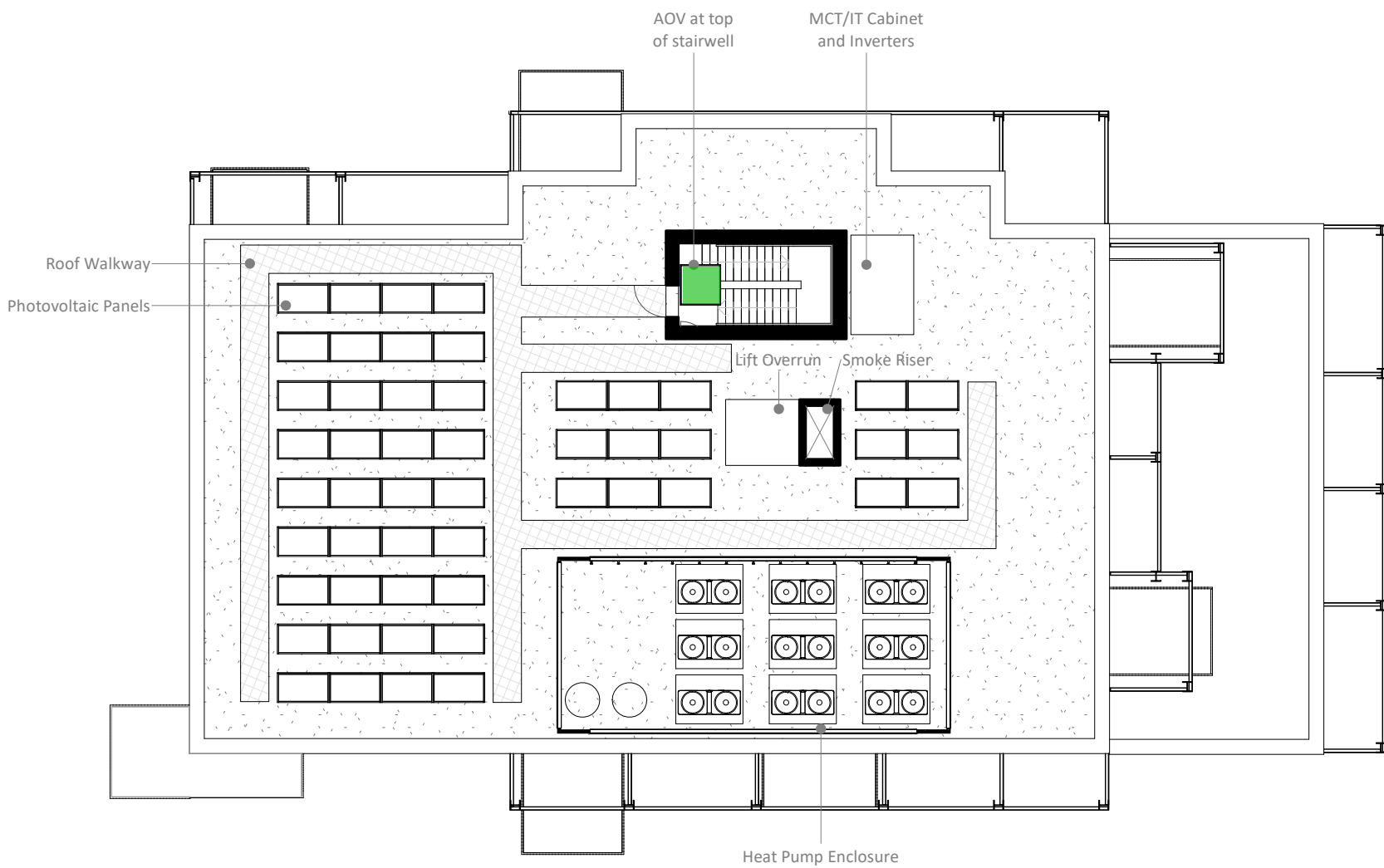


2 Building 11 - First to Third Floor Plan
1 : 200



3 Building 11 - Fourth Floor Plan
1 : 200

The maximum travel distance from the furthest point to protected firefighting staircase is to be within 18m. This is currently not achieved, as such the common corridor is required to be provided with enhanced detection and smoke ventilation. This is to agreed with Building Control and the Fire Service at the detailed design stage.



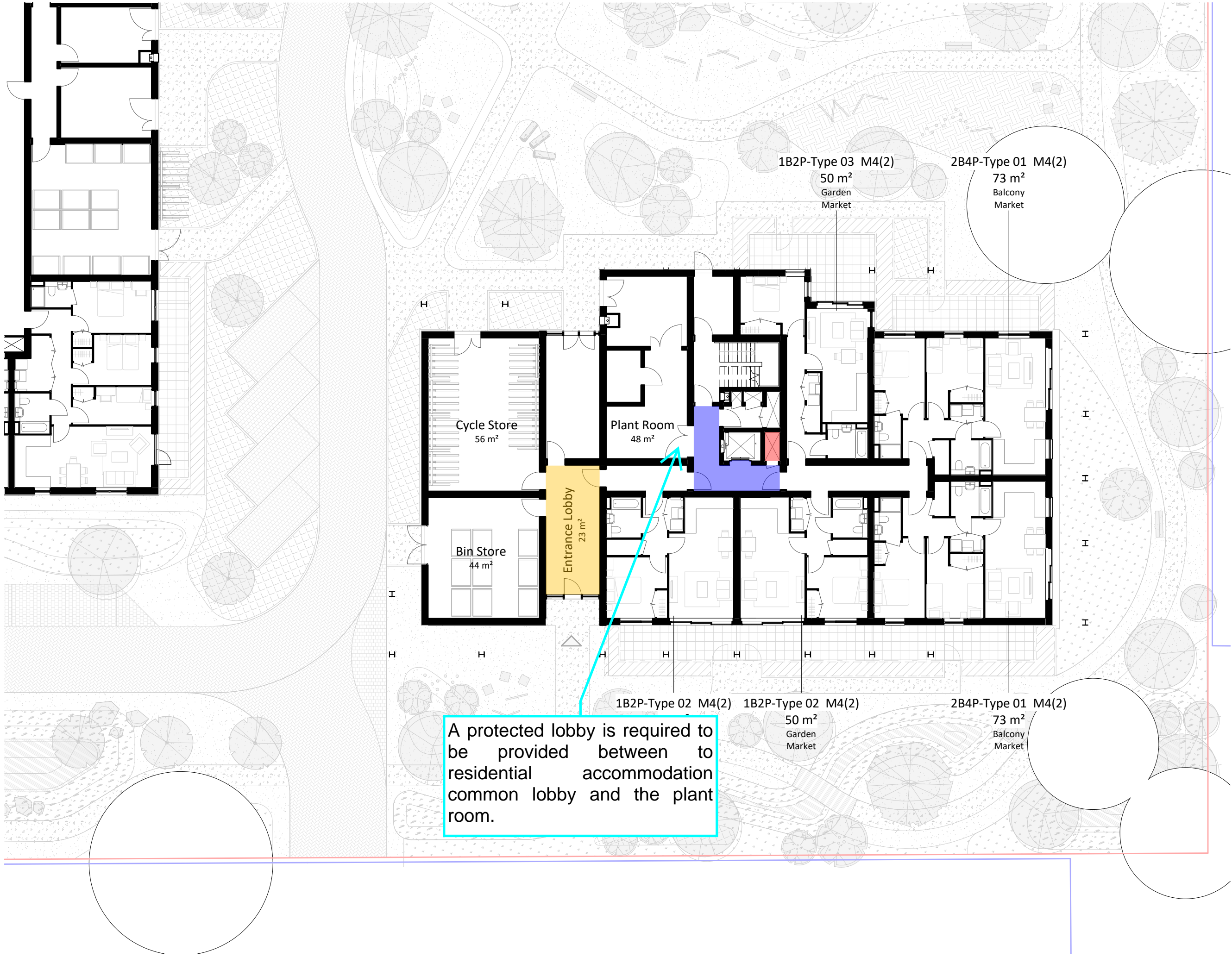
4 Building 11 - Roof Plan
1 : 200

| Key - | |
|--|--|
| | Minimum 0.2m² permanently ventilated lobby |
| | Sterile ventilated staircase lobby |
| | Minimum 1.5m² natural smoke shaft |
| | Minimum 1.0m² AOV at head of staircase |
| | Firefighting Lift |

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.

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1 Building 12 - Ground Floor Plan
1 : 200

Key -

Minimum 0.2m² permanently ventilated lobby

Sterile ventilated staircase lobby

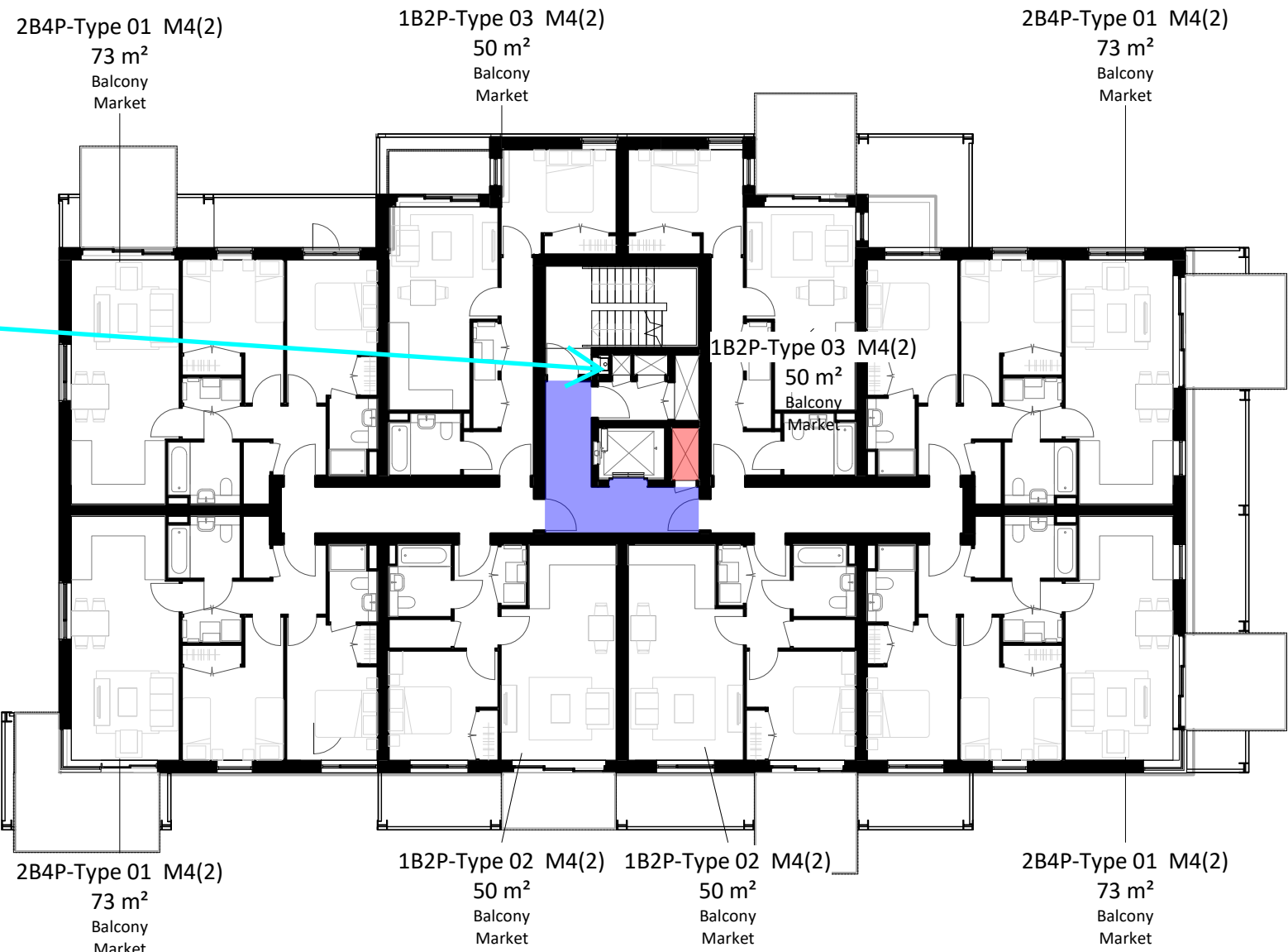
Minimum 1.5m² natural smoke shaft

Minimum 1.0m² AOV at head of staircase

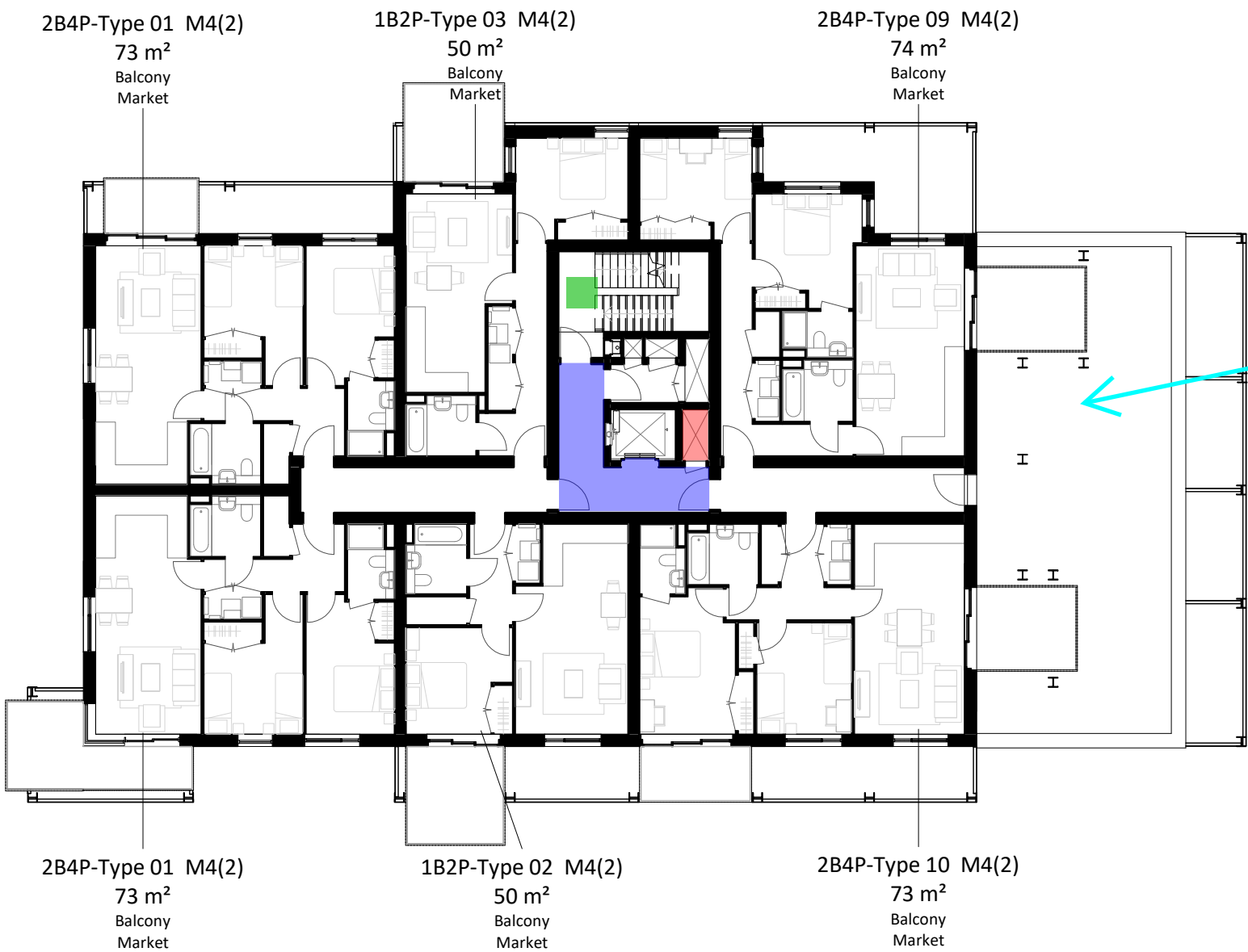
Firefighting Lift

To be noted, if the service riser is to only contain water services or metal ventilation ductwork from the ground floor, it is considered a limited fire hazard. As such, this riser shaft may be located in the staircase lobby.

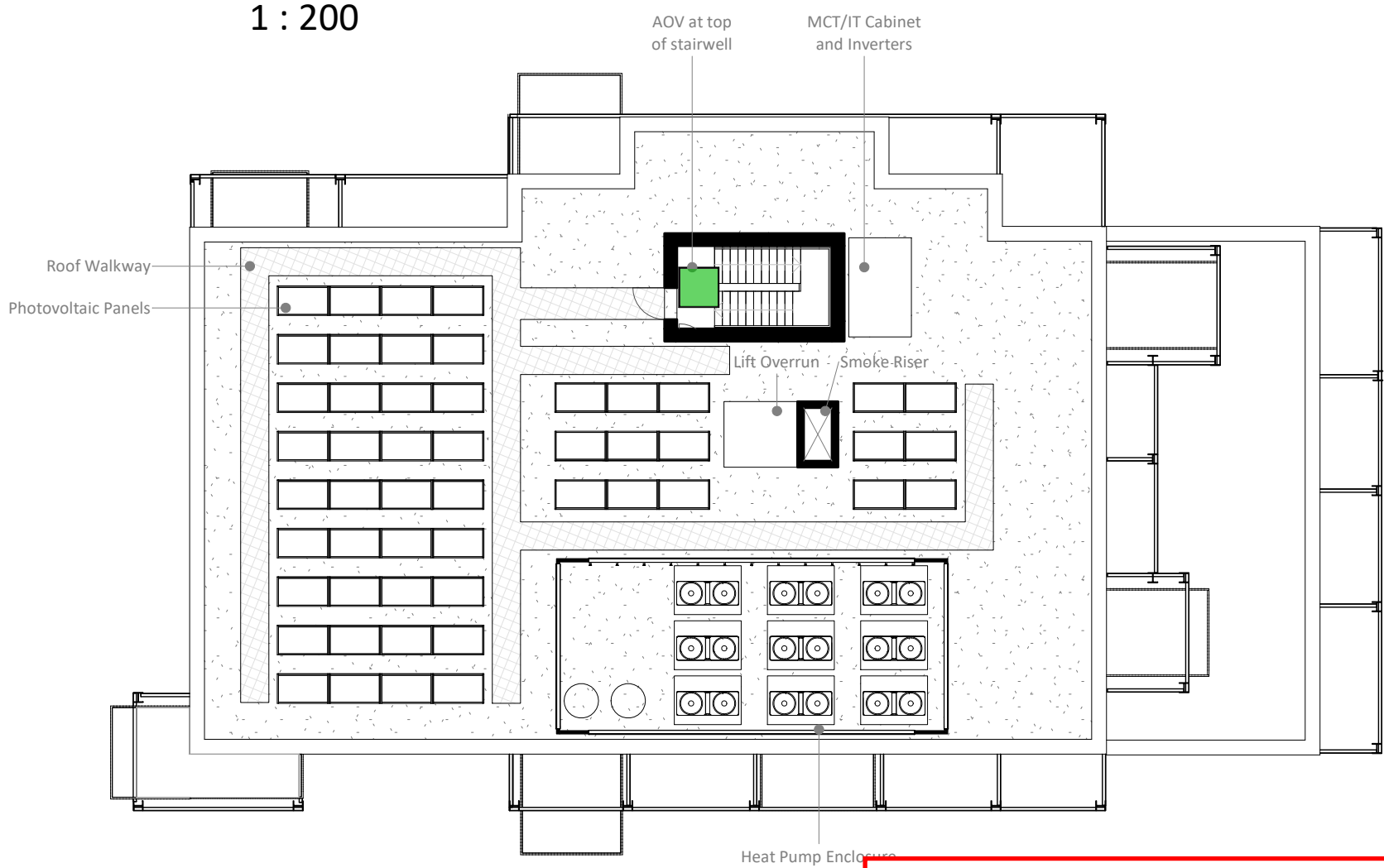
To be noted, the government have stated from May 2020, all new building's over 11m in height are required to be provided with sprinklers, see Section 9.



2 Building 12 - First to Third Floor Plan
1 : 200



3 Building 12 - Fourth Floor Plan
1 : 200



4 Building 12 - Roof Plan
1 : 200

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