GNW Developments Limited

GREAT NORTHERN

Ventilation, Extraction and Odour Statement



GNW-WSP-Z0-XX-RP-M-570101
NOVEMBER 2022

PUBLIC

GNW Developments Limited

GREAT NORTHERN

Ventilation, Extraction and Odour Statement

TYPE OF DOCUMENT (VERSION) PUBLIC

PROJECT NO. 70087845
OUR REF. NO. GNW-WSP-Z0-XX-RP-M-570101

DATE: NOVEMBER 2022

WSP
8 First Street
Manchester
M15 4RP
Phone: +44 161 200 5000

WSP.com

QUALITY CONTROL

Issue/revision	Draft Issue	Formal Issue	Rev 02	Rev 03
Remarks	Planning Issue	Client comments incorporated	Further client comments incorporated	Development description updated
Date	31/10/2022	11/11/2022	16/11/2022	23/11/2022
Prepared by	Simon Graham	Simon Graham	Simon Graham	Alistair Lambert
Signature				
Checked by	Alistair Lambert	Alistair Lambert	Alistair Lambert	Alistair Lambert
Signature				
Authorised by	Craig Smith	Craig Smith	Craig Smith	Craig Smith
Signature				
Project number	70087845	70087845	70087845	70087845
Report number	GNW-WSP-Z0-XX-RP-M-570101	GNW-WSP-Z0-XX-RP-M-570101	GNW-WSP-Z0-XX-RP-M-570101	GNW-WSP-Z0-XX-RP-M-570101

1 VENTILATION, EXTRACTION AND ODOUR STATEMENT 1

1.1 INTRODUCTION 1

2 DESIGN 3

3 VENTILATION RATES 4

3.1 VENTILATION FRESH AIR RATES 4
3.1.1 ZONE 2 - GREAT NORTHERN WAREHOUSE (PHASE A) 4
3.1.2 ZONE 3A & 3B - DEANSGATE TERRACE (PHASE A & C) 4
3.1.3 ZONE 4 LEISUREBOX (PHASE B) 5

4 SYSTEMS 6

4.1 ZONE 2 GREAT NORTHERN WAREHOUSE (PHASE A) 6
4.1.1 OFFICES 6
4.1.2 KITCHENETTE EXTRACT 8
4.1.3 WCS/ CHANGING ROOMS 8
4.1.4 ENTRANCE & RECEPTION 9
4.1.5 MECHANICAL AND ELECTRICAL PLANT ROOMS 10
4.1.6 SMOKE VENTILATION 10
Escape Stairs 10
4.1.7 BASEMENT 11
4.1.8 ATRIUM 11
4.1.9 NEW COMMERCIAL UNITS 12
4.1.10 EXISTING TENANTS 12
4.2 ZONE 3A AND 3B DEANSGATE TERRACE (PHASE A & C) 14
4.2.1 NEW CAT-A OFFICE 14
4.2.2 MECHANICAL VENTILATION 14
4.2.3 NATURAL VENTILATION 14
4.2.4 WCS 15
4.2.5 ENTRANCE & RECEPTION 15
4.2.6 MECHANICAL AND ELECTRICAL PLANT ROOMS 15
4.2.7 NEW COMMERCIAL UNITS 16
4.2.8 EXISTING TENANTS 16
4.3 ZONE 4 LEISUREBOX (PHASE B) 17
4.3.1 APARTMENTS 17

	Kitchen Extract System	17
	Façade Opening Detail for Ventilation Requirement	17
	Purge Requirements	18
	Natural Purge Ventilation	18
	Interaction with Approved Document Part O	19
	Minimum Ventilation Rates	19
4.3.2	CORRIDOR SMOKE VENTILATION	20
4.3.3	CAR PARK	21
	Air Movement Throughout the Car Park	22
	Basement Car Park Ventilation Modes of Operation	22
	CO/ NO2 Monitoring System	22
4.3.4	STAFF/ MANAGERS OFFICE/ PARCEL STORE	23
4.3.5	STAFF CHANGE AND WCS	23
4.3.6	COMMS ROOMS	23
4.3.7	ENTRANCE & RECEPTION	23
4.3.8	REFUSE	24
4.3.9	MECHANICAL AND ELECTRICAL PLANT ROOMS	24
4.3.10	RESIDENTS LOUNGE & MEETING ROOMS	24
4.3.11	RESIDENTS GYM AND STUDIOS	24
4.3.12	PRIVATE KITCHEN	25
4.3.13	NEW COMMERCIAL UNITS	25

VENTILATION, EXTRACTION AND ODOUR STATEMENT

PUBLIC

1 VENTILATION, EXTRACTION AND ODOUR STATEMENT

1.1 INTRODUCTION

This statement has been prepared in support of the planning application for the development of the Great Northern site, including the Great Northern Warehouse, Leisure Box and Deansgate Terrace and surrounding public realm.

The Site is located adjacent to Deansgate and can be broadly divided into four components comprising:

- Great Northern Square – located to the north of the application boundary, the square is an area of public realm with a mix of soft and hard landscaping with an amphitheatre-style seating arrangement in its centre, which currently acts as barrier to movement across the space;
- Great Northern Warehouse and the modern atrium – a Graded II* Listed former railway goods warehouse built between 1896 and 1899, which was refurbished in 1999 to provide retail, commercial and car parking spaces (519 spaces);
- Leisure Box – a modern addition to the Warehouse following the 1999 refurbishments. The Leisure Box contains an Odeon cinema, the Gym and car parking (721 spaces); and Deansgate Terrace –covers the length of Deansgate from Peter Street to Great Bridgewater Street;
- The 3 to 4 storey length of terraces is Grade II Listed and currently comprises a mix of retail, food & drink and commercial.

Development Details

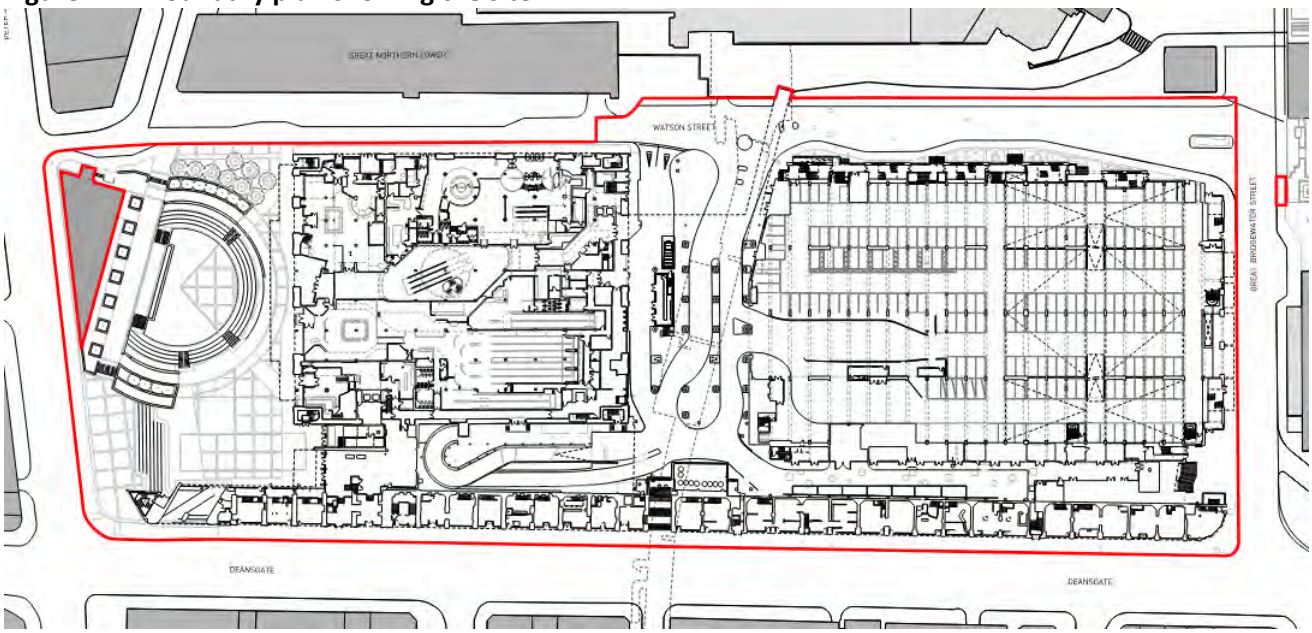
Phased redevelopment of the Great Northern Warehouse (GNW), Deansgate Terrace and Leisure Box, including areas of public realm, comprising:

- Demolition of the central atrium, GNW car park ramps, and other modern elements, alongside removal of 519 car parking spaces from the GNW, retention of casino (Sui Generis), bowling alley and existing food and drink unit (Use Class E) alongside the refurbishment, restoration, and re-use of the Grade II* Listed Great Northern Warehouse to provide office, retail and / or food and drink use (Use Class E) and ancillary areas;
- The refurbishment, restoration, partial demolition and 3-storey extension of the Grade II Listed Deansgate Terrace (northern section) and Goods Yard Entrance to form office, retail and / or food and drink use (Use Class E) and drinking establishments / hot food takeaway (Sui Generis), with associated public realm works comprising the reconfiguration of Great Northern Square and the introduction of additional public realm with associated hard and soft landscaping, together with highways works, access and servicing facilities, rooftop plant and other associated works;
- Partial demolition of the existing leisure box prior to conversion; reconfiguration and extension of existing car parking to provide 929 parking spaces and associated plant, followed by construction of three residential buildings to provide 746 no. apartments (Use Class C3) above the retained car park comprising ground floor plus 16, 27 and 34 storeys respectively including 753 cycle parking spaces, with office, retail and / or food and drink use (Use Class E), or Sui Generis (drinking establishments / hot food takeaway) at ground floor and level 3, hard and soft landscaping, together with highways works, access and servicing facilities, rooftop plant and other associated works; and,
- External alterations and restoration of Deansgate Terrace (southern section) to provide office, retail or food and drink use (Use Class E) or Sui Generis (drinking establishments / hot food takeaway / live music venue), along with delivery of associated public realm, highways works, plant, and associated works.

For clarity WSP documentation breaks the site buildings down into the following zone, for clarity in how these align to propose planning zoning:

- Zone 2 – Great Northern Warehouse (part of Phase A - Simpson Haugh Zoning Plan)
- Zone 3 A & B – Deansgate Terrace North & South (part of Phase A & C - Simpson Haugh Zoning Plan)
- Zone 4 – Leisure Box (part of Phase A - Simpson Haugh Zoning Plan)

Figure 1-1 - Boundary plan showing the site



2 DESIGN

The ventilation design shall comply with the following building regulation approved documents and standards:

Design Standards

The ventilation systems will be designed in accordance with recognised UK and industry best practice.

Design will be based on standards and guidelines, including:

- British and European Standards (BSI);
- Chartered Institution of Building Services Engineers (CIBSE);
- Building Services Research and Information Association (BSRIA);
- Building Research Establishment (BRE);
- Heating & Ventilating Contractors Association (HVCA);
- Control of Odour and Noise from Commercial Kitchen Exhaust Systems (EMAQ).

Statutory Requirements

Ventilation systems design will also be based on the following Statutory Requirements:

- The Building Regulations;
- Clean Air Act 1993;
- The Control of Pollution Act 1974 and Amendment Acts;
- The Construction (Design and Management) Regulations 2015;
- British Standards and Codes of Practice;
- Manchester City Council Planning Conditions & Requirements.

3 VENTILATION RATES

3.1 VENTILATION FRESH AIR RATES

Mechanical ventilation will comply with the following design criteria:

3.1.1 ZONE 2 - GREAT NORTHERN WAREHOUSE (PHASE A)

Table 3-1 - Ventilation Rates for the Warehouse

Space	System	Criteria
Retail	Fresh air ventilation	5 l/s/p
Kiosk	Fresh air ventilation	5 l/s/p
Offices	Fresh air ventilation	12 l/s/p
Meeting Rooms	Fresh air ventilation	12 l/s/p
Office Reception	Fresh air ventilation	12 l/s/p
Kitchen	Extract Air Changes	10 AC/H
WC/Showers	Extract Air Changes	10 AC/H
Gym	Mechanical Supply & Extract	10 AC/H
MEP Plant Rooms	Supply / Exhaust Ventilation	2 AC/H (normal), 10 AC/H (basement smoke over 200m^2)
Co-working Events	Fresh air ventilation	12 l/s/p
Co-working Mezzanine Entrance	Fresh air ventilation	10 l/s/p
Atrium	Natural Stack Effect Extract from louvres at roof level	
Comms Room	Unvented	n/a
Cleaners Store	Extract Air Changes	10 AC/H
Escape Corridors	Smoke Ventilation	Dedicated smoke extract subject to Fire Engineer requirements.

3.1.2 ZONE 3A & 3B - DEANSGATE TERRACE (PHASE A & C)

Table 3-2 - Ventilation Rates for the Terraces

Space	System	Criteria
Retail	Fresh air ventilation	5 l/s/p
Offices	Fresh air ventilation	12 l/s/p

Office Reception	Fresh air ventilation	10 l/s/p
WC/Showers	Extract Air Changes	10 AC/H

3.1.3 ZONE 4 LEISUREBOX (PHASE B)

Table 3-3 - Ventilation Rates for the Leisurebox

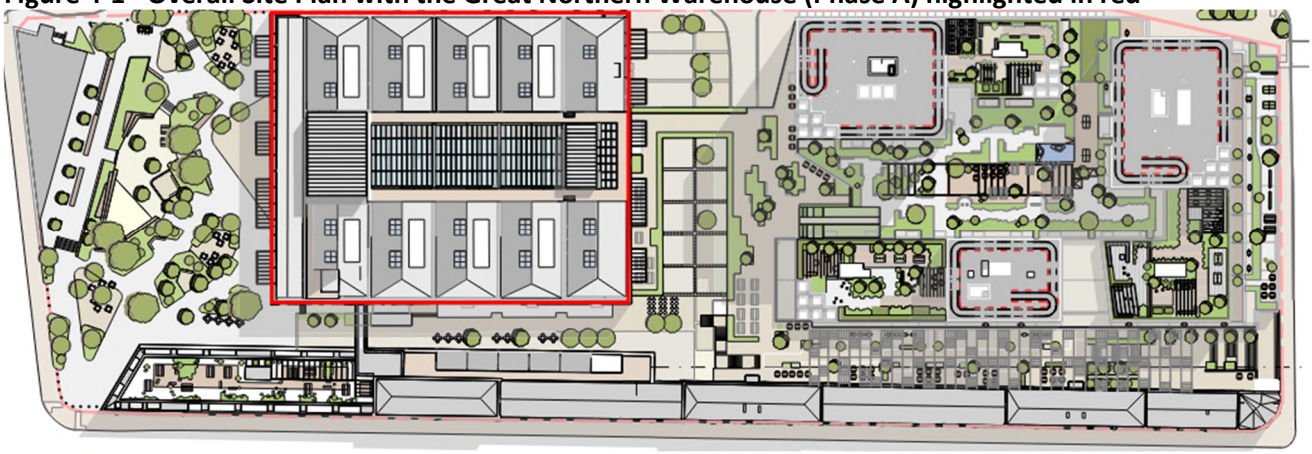
Space	System	Criteria
Apartments	Mechanical Ventilation Heat Recovery (MVHR)	To Building Regulations, Part F requirements and CIBSE Guide A **Area** — **Continuous Extract (l/s)** Kitchen — 13 Utility Room — 8 Bathroom — 8 Sanitary — 6
	Purge ventilation	Passive/ natural via openable windows (to Building Regulations, Part F requirements).
Residential Corridors	Smoke Ventilation	Push / Pull Arrangement subject to Fire Engineer requirements.
Residential BOH	Waste Storage	5 l/s/m^2
Retail	Fresh air ventilation	5 l/s/p
Gym	Fresh air ventilation	10 l/s/p
MEP Plant Rooms	Supply / Exhaust Ventilation	2 AC/H (normal)
Car Park Areas	Supply / Exhaust Ventilation	6 AC/H (Carbon Monoxide CO control), 10 AC/H (smoke)
Cycle Store	Supply / Exhaust Ventilation	2 AC/H
Entrance	Fresh air ventilation	10 l/s/p
Amenity	Fresh air ventilation	5 l/s/p

4 SYSTEMS

4.1 ZONE 2 GREAT NORTHERN WAREHOUSE (PHASE A)

The Great Northern Warehouse is highlighted below on the site plan.

Figure 4-1 - Overall Site Plan with the Great Northern Warehouse (Phase A) highlighted in red



4.1.1 OFFICES

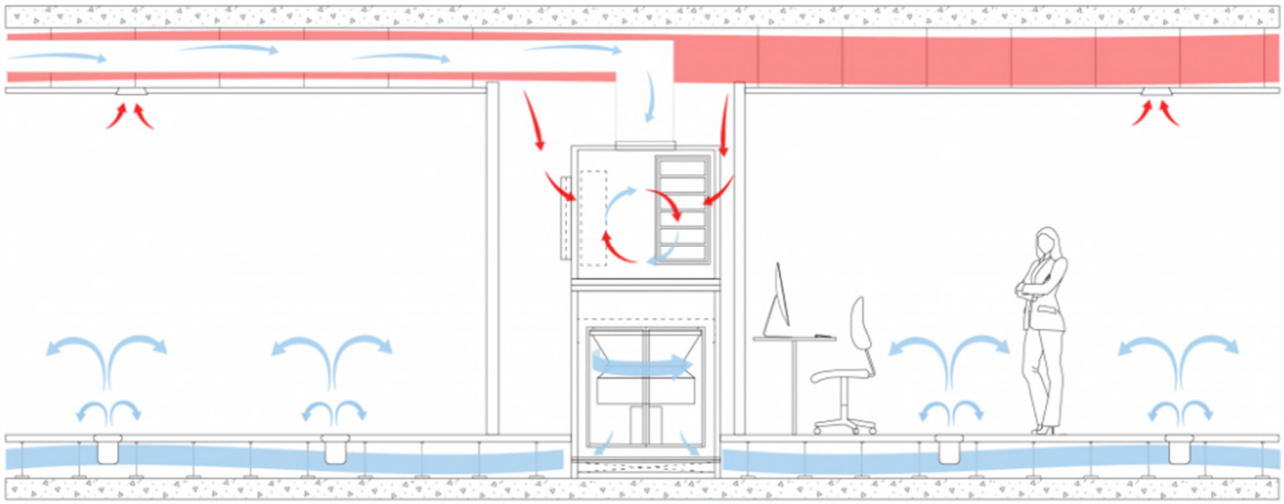
Underfloor Air Distribution (UFAD)

The proposed office spaces are currently used a multi-storey car park. Therefore, any existing ventilation equipment is to be removed and a new system installed which will be appropriate for serving an office space.

The offices are proposed to be heated and cooled via an underfloor air distribution system (UFAD) strategy.

This solution consists of a series of floor mounted heating/cooling downflow units located in risers or cupboards surrounding the office zones which blow cooled (or heated) air into the raised floor plenum. An example of the system in cooling mode can be seen in the diagram below. This system also provides ventilation to all areas/ zones of the office space.

Figure 4-2 - An Example Illustration of UFAD System



Outside air is introduced into the system via a plenum at the top of each downflow unit or from below where it is mixed with recirculated air from the space prior to being drawn through the unit and supplied into the floor void.

Air is introduced locally to the occupied zone via “fan-tiles” which are selected to operate at 30% of their maximum airflow to avoid discomfort to occupiers within the office space resulting from excessive air movement/ velocities. Each “fan tile” can incorporate a small electric heater (electronically controlled), which permits users to increase the supply air temperature to suit their local conditions/environmental preferences.

Return air is displaced out of the office space to the central atrium via high level return air grilles.

This strategy requires a 200mm floor void on each office level, although WSP are exploring a slimmer product with manufacturers.

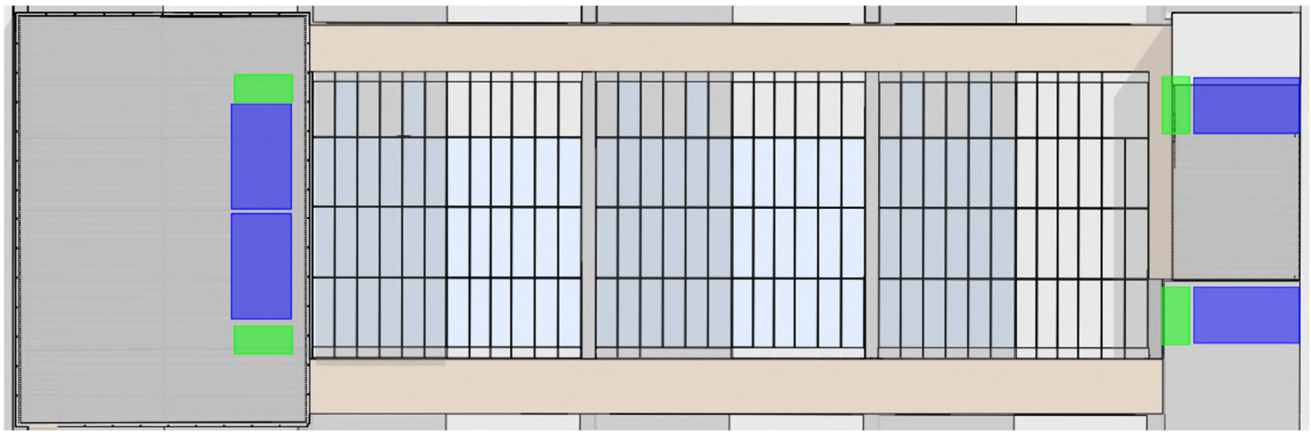
This system is very flexible as fan tiles can be moved around the office to suit future changes in individual tenant internal arrangements.

Main Plant

4 no. Air Handling Units (AHUs) with a duty of 5m^3/s each are proposed to be located at roof level to serve to the office levels, located within covered plant compounds. These units have been sized to meet the occupancy of the proposed floor plates at 1 person per 8m2, with a further 10% spare capacity for future tenant requirements and changes in internal arrangements.

The AHU and office fresh air riser locations are highlighted on the roof layout below. The new risers will drop adjacent to the Atrium and serve the office spaces at each level.

Figure 4-3 - Proposed Location of Roof Mounted AHUs highlighted in Blue, fresh air risers highlighted in Green



At floor plate level the ventilation shall route from the dedicated risers to provide fresh air adjacent to the Conditioned Air Module (CAM) units as described above. Where risers are remote from the CAM unit’s ductwork shall route via the perimeter of the flood void or via plenums at high level.

Incoming supply air will be filtered and tempered by the air handling unit and distributed through galvanised ductwork to the floor plates.

Extract air is allowed to displace into the atrium where it is extracted by the AHUs at high level from the top of the atrium and exhausted to atmosphere via the heat exchanger section of the unit, so that maximum use is made of “free” heating from the return air. Further, in summer the units shall make use of “free air cooling”, where at night colder air is delivered to the office spaces.

Fire dampers and smoke dampers shall be provided within the ventilation ductwork to maintain the integrity of fire compartmentation in accordance with the Fire Strategy and the requirements of Building Control.

Volume control dampers shall be installed within the ductwork system as indicated to aid correct regulation and air balancing of the systems.

All supply and extract ductwork will be thermally insulated where it passes through spaces that are at different temperatures to that of the transferred air, or where external to the building to negate condensation.

Fresh air inlets are to be positioned so that entrainment of exhaust air from either general extract, kitchen or the toilet extract systems is not possible.

The proposed installation shall be complete with ventilation to meet minimum requirements and system provides balanced supply and extract at a 12l/s/p based on design occupation density of 1 per 8m2.

The air handling unit controller shall sit on the Building Management System (BMS) network as an outstation and enable fault reporting, monitoring, operation and set point control via the BMS. The AHU shall run at all times to provide mechanical ventilation to all areas during occupation..

Variable Air Volume Dampers (VAVs) shall be installed within the system and located at each floor level. These shall be linked to CO2 sensors within occupied areas to always ensure efficient running of the ventilation system and ramp the air flow down to save energy based on occupancy.

4.1.2 KITCHENETTE EXTRACT

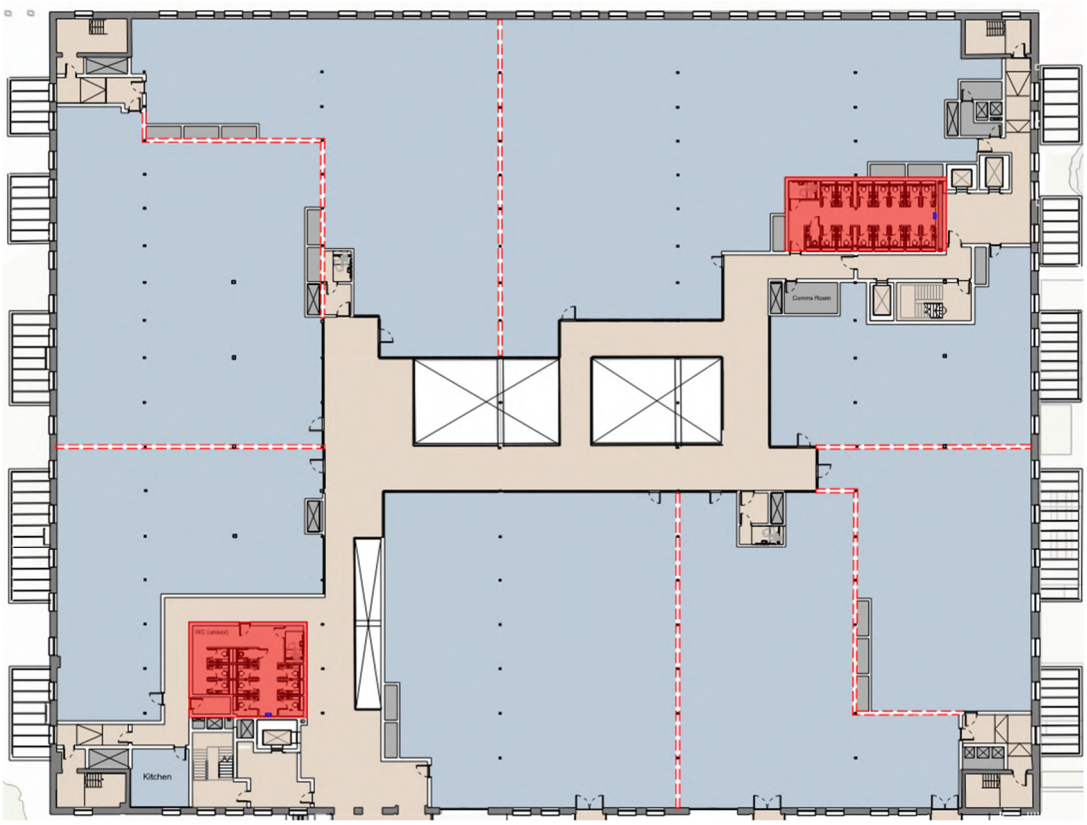
Riser space shall be coordinated to provide future kitchenette extract routes for tenants to roof level. Any kitchenette fans shall be located within the office tenant demise and installed by the tenant. Ductwork which routes to the roof shall exhaust away from any fresh air intakes of the office ventilation system.

These future systems shall be designed in line with Approved Document F.

4.1.3 WCS/ CHANGING ROOMS

WC and Changing Room extract systems shall provide dedicated extract in line with best practice as advised in the design criteria section at the front of the document. This is to limit moisture build up and foul smells.

Figure 4-4 - Proposed Office floor layout showing Toilet Blocks highlighted in Red with Dirty Extract Risers in Blue.



Mechanical extract ventilation shall be provided from fans located at roof level with distribution via galvanised ductwork installed to the requirements of DW144 through to ceiling mounted grilles in enclosed spaces.

Replacement make-up air will be drawn from adjacent rooms and corridors via door undercuts or transfer grilles mounted directly in the door to prevent door slamming due to pressurisation issues.

Silencers are fitted before and after the fan to ensure noise levels within the space are within acceptable limits.

4.1.4 ENTRANCE & RECEPTION

The entrance and reception areas will be provided with a dedicated ventilation system. Outside air will be provided at 10 l/s per person as per the CIBSE guide recommendation. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground floor façade. These shall be located at a suitable distance from each other to ensure that recirculation of intake and exhaust air flows is minimised.

Communal areas are likely to be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would

benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

4.1.5 MECHANICAL AND ELECTRICAL PLANT ROOMS

All plant rooms shall be provided with ventilation as appropriate to their use, either natural via louvred doors such as electrical substation or minimum 2 ACHs if basement wet plantrooms are at risk from stagnation.

Where basement plant rooms are larger than 200m², they are to be provided with 10 ACHs for smoke ventilation, this is required in the external basement plant room only.

4.1.6 SMOKE VENTILATION

Escape Stairs

Smoke extract shall be required within the escape stair lobbies at office levels, in order to meet the fire strategy set out by the fire consultant.

A specialist contractor shall be responsible for designing, supplying, installing, testing and commissioning a new corridor smoke clearance system that will operate automatically in the event of a fire and in line with Fire Engineer's report, it is expected that the system will be along the brief outlined below.

A grille complete with fire damper (lobby ventilator) located at high level within the corridor shall open automatically at the dictates of the fire control panel to allow the passage of smoke from the affected corridor, into the smoke shaft formed within the core area.

The system shall provide an automatic opening vent (AOV) at the head of stair. This shall open automatically at the dictates of the fire control panel to provide make-up air for the clearance system. The stair door shall open into the corridor via the pressure of the system to provide this make-up air path during operation.

A dedicated corridor smoke detector located at all levels shall be used to actuate the fire damper at the affected floor.

Fans at roof level, controlled automatically by the fire control panel, once energised shall extract smoke from the building through an automatic opening vent. The fans shall be run in duty/ standby mode to ensure operation when required and be controlled automatically by the fire control panel. The fans shall also be complete with supply and discharge attenuation.

The system shall be designed to operate on only one level at a time, on first activation.

All plant items associated with the system shall also be fed by the Generator to ensure operation when the electricity supply is interrupted.

The control panel for each system shall be located at the foot of the stair core adjacent to the fire personnel entry point.

The smoke exhaust systems will comprise of the following:

- Duty and standby variable speed extract fans with inverter drive, linked to pressure sensors within the lobby and corridor at each level via a control panel;
- Extract fans (3 kW nominal) rated at 300 °C for 2 hours;
- Motorised smoke and fire dampers between the shaft and the lobby at each level;
- A builder's work shaft in each lobby;

- Fire alarm interfaces and essential power supplies as required;
- Builders work shaft that is substantially straight & vertical and will connect to the lobbies at each level via a 1-hour fire rated damper and grille; and
- The construction of the builder's work shaft is to have a smooth internal face and minimum air leakage.

Roof fans shall be concealed behind architectural visual screens. The necessary free area louvre and plant access shall be provided.

All on-floor smoke exhaust connections will be provided with localised diffusers and motorised smoke dampers. The motorised smoke damper will be controlled by the fire alarm system.

Automatic opening vents (AOVs) will be provided at the top of each stair with a minimum opening of 1.0 m^2, subject to confirmation in the next revision of the Fire Strategy.

4.1.7 BASEMENT

The Public Health (PH) sprinkler plant room located in the basement will require smoke ventilation at 10 ACHs as it is greater than 200m2, as advised by the Fire Engineer.

The system shall consist of 1 no. extract fan located within the store at basement level with ductwork extracting from all room/ spaces and rising to exhaust within the public realm. Make up air is then drawn from outside via natural shafts from the public realm above with automatic opening vent (AOV) ensuring they are weather tight outside use.

The fan is controlled automatically by the fire control panel and shall also be complete with supply and discharge attenuation.

The fan shall also be fed by the Generator to ensure operation when the electricity supply is interrupted.

All smoke exhaust connections will be provided with localised diffusers and motorised smoke dampers. The motorised smoke dampers will be controlled by the fire alarm system.

The smoke exhaust systems will comprise of the following:

- Duty and standby variable speed extract fans with inverter drive, linked to pressure sensors within the lobby and corridor at each level via a control panel;
- Extract fan (3 kW nominal) rated at 300 °C for 2 hours;
- Motorised smoke and fire dampers between the shaft and the lobby at each level;
- A builder's work shaft up to the external ground floor;
- Fire alarm interfaces and essential power supplies as required;

4.1.8 ATRIUM

The atrium will require smoke ventilation to comply with the recommendations in BS 9999 and a smoke clearance system will be provided at the head of the atrium roof. Natural exhaust vents with a total geometric free area, of not less than 10% of the maximum plan area of the atrium, have been coordinated into roof.

A specialist contractor shall be responsible for designing, supplying, installing, testing and commissioning the atrium louvres within the atrium roof that will operate automatically in the event of a fire and in line with Fire Engineer's report.

This shall open automatically at the dictates of the fire control panel.

Heat sensors will also be installed within the atrium space at each level, so that the louvres can be used to control excessive heat gain within the space during summer. This shall be linked and controlled by the BMS.

4.1.9 NEW COMMERCIAL UNITS

All new retail units are being constructed as “shell and core” only. As such sufficient plant allocation and louvres shall be provided to enable a flexible tenant fit out and ensure that such fit out is able to comply with all relevant standards.

Services serving the proposed retail units shall be designed, procured and installed by the individual tenants with appropriate power and water supplies provided only as an interface.

For the ground floor retail units, ventilation systems will be provided by individual tenants to suit their requirements (tenant fit out). Louvred areas on the façade will be provided at high level to enable tenants’ air intake and exhaust ductwork connections. These intake and exhaust louvres shall be separate at a suitable distance from each other (as described in the previous sections). The tenant shall design a ventilation system to draw outdoor air and discharge vitiated air via this louvre arrangement.

In all cases where cooking processes will occur, fire rated kitchen extract ventilation plant will be provided by the tenant and must incorporate grease, ultra-violet, activated-carbon and electrostatic precipitator filtration systems to eliminate the build-up of grease, smoke and odours. Access to the kitchen extract ductwork and plant must be provided for regular cleaning and maintenance. This duct work will raise up to high level of the unit where it will be discharged out of the louvres along the elevation and away from any supply louvres.

The kitchen extract systems shall be designed and installed in accordance with DEFRA Guidance on the Control of Odour and Noise from Kitchen Exhaust Systems. This shall include provisions for access at each level in line with HVCA 171 – Kitchen Ventilation Systems and approval by the EHO at Manchester City Council shall be sort prior to installation.

A plant/ Back of House (BOH) area will be provided centrally for the retail units. This is to be used by retail units that have fitted kitchens that require large plant space for ventilation systems, including AHU and supply and extract fans in an unheated area.

Defra has published a document entitled: ‘Guidance on the Control of Odour and Noise from Commercial Kitchen Exhaust Systems’. It describes a method of risk assessment for odour, guidance on minimum requirements for odour and noise control, and advice on equipment selection. It is recommended that the proposed commercial unit (should there be a prospect of that coming forward for commercial use) should refer to this document (particularly Annex B). Details should also be provided in relation to replacement air.

4.1.10 EXISTING TENANTS

The existing tenants of the Warehouse have a mixture of naturally ventilated and mechanical systems.

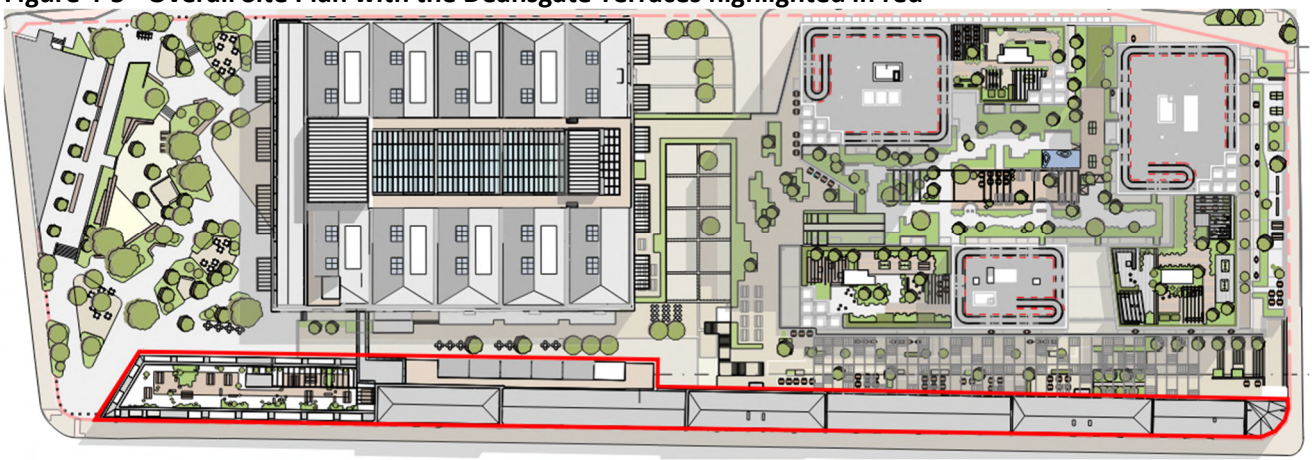
The overall strategy is to retain the existing tenant systems as they are currently installed. However, there will be some amending of existing kitchen extract ductwork at roof level to suit the proposed offices scheme requirements. This involves pulling back existing ductwork at roof level to the top of retained tenant risers and amending roof cowls/ exhausts to suit the proposed scheme.

Further, all existing tenant extract systems will be checked to ensure they comply with the DEFRA and EMAQ requirements of the council as per the above for all new commercial units.

4.2 ZONE 3A AND 3B DEANSGATE TERRACE (PHASE A & C)

The location of the Deansgate Terraces is highlighted on the site plan below.

Figure 4-5 - Overall Site Plan with the Deansgate Terraces highlighted in red



4.2.1 NEW CAT-A OFFICE

All new CAT-A office at the higher levels of the terraces shall be ventilated either by natural ventilation or mechanical ventilation, with the intention to use as much natural ventilation as possible..

4.2.2 MECHANICAL VENTILATION

Mechanically ventilated offices, will be provided with a dedicated supply and extract ventilation system. Outdoor air will be provided at 12 l/s per person in line with CIBSE guidance. These areas will be served by local filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level at each floor in the rear façade, as the front façade is listed there is no potential for new louvres. The air intake and exhaust points will be required to be an adequate distance from each other so as to minimise the risk of recirculation.

Communal areas may be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

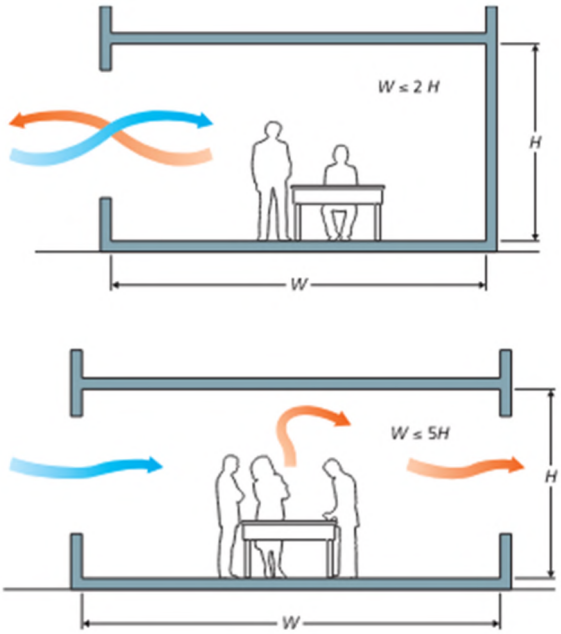
4.2.3 NATURAL VENTILATION

The intention is to naturally ventilate the smaller office spaces via openable windows to reduce the requirement for plant equipment. The Hilson Moran air quality report indicates that openable windows are acceptable on all elevations of the terraces.

The limitations of natural ventilation are laid out in CIBSE AM10. The floor to ceiling heights varies but are between 2.45m and 3.25m, which gives a limitation of approximately 6m deep room for single sided openable windows and 15m deep room for double sided openable windows. This is shown in the diagram below.

The intention is that all office spaces will where suitable shall make use of natural ventilation, where spaces are too deep mechanical ventilation shall be provided as per above.

Figure 4-6 - CIBSE AM10 Natural Ventilation Guidance



4.2.4 WCS

Toilets associated with all office areas will be provided with dedicated twin extract fans with replacement air make-up drawn from adjacent rooms and corridors via door undercuts or transfer grilles mounted directly in the door.

Exhaust louvres will be formed at high level in the east façade. The exhaust points will be required to be an adequate distance from any intake louvre so as to minimise the risk of recirculation.

4.2.5 ENTRANCE & RECEPTION

The entrance and reception areas will be provided with a dedicated ventilation system. Outside air will be provided at 10 l/s per person as per the CIBSE guide recommendation. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground floor façade. These shall be located at a suitable distance from each other to ensure that recirculation of intake and exhaust air flows is minimised.

Communal areas are likely to be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

4.2.6 MECHANICAL AND ELECTRICAL PLANT ROOMS

All plant rooms shall be provided with ventilation as appropriate to their use either natural via louvred doors such as electrical substation or minimum 2 ACHs if basement wet plantrooms are at risk from stagnation.

4.2.7 NEW COMMERCIAL UNITS

All new retail units are being constructed as “shell and core” only. As such sufficient plant allocation and louvre shall be provided to enable a flexible tenant to fit out and ensure that such fit out is able to comply with all relevant standards.

Services serving the proposed retail units shall be designed, procured and installed by the individual tenants with appropriate power, water and drainage provided only as an interface.

The additional louvres required will be mounted on the Great Northern Warehouse side of the Terraces as to not require builders work to the listed Deansgate façade. Any intake or exhaust ductwork can be taken from this louvre to mechanically ventilate the space.

Services serving the proposed retail units shall be designed, procured and installed by the individual tenants.

For the ground floor retail units, ventilation systems will be provided by individual tenants to suit their requirements (tenant fit out). Louvred areas on the façade will be provided at high level to enable tenants’ air intake and exhaust ductwork connections. These intake and exhaust louvres shall be separate at a suitable distance from each other (as described in the previous sections). The tenant shall design a ventilation system to draw outdoor air and discharge vitiated air via this louvre arrangement.

In all cases where cooking processes will occur, fire rated kitchen extract ventilation plant will be provided by the tenant and must incorporate grease, ultra-violet, activated-carbon and electrostatic precipitator filtration systems to eliminate the build-up of grease, smoke and odours. Access to the kitchen extract ductwork and plant must be provided for regular cleaning and maintenance. This duct work will raise up to high level of the unit where it will be discharged out of the louvres along the elevation and away from any supply louvres.

The kitchen extract systems shall be designed and installed in accordance with DEFRA Guidance on the Control of Odour and Noise from Kitchen Exhaust Systems. This shall include provisions for access at each level in line with HVCA 171 – Kitchen Ventilation Systems.

Defra has published a document entitled: ‘Guidance on the Control of Odour and Noise from Commercial Kitchen Exhaust Systems’. It describes a method of risk assessment for odour, guidance on minimum requirements for odour and noise control, and advice on equipment selection. It is recommended that the proposed commercial unit (should there be a prospect of that coming forward for commercial use) should refer to this document (particularly Annex B). Details should also be provided in relation to replacement air.

4.2.8 EXISTING TENANTS

The existing tenants of the Terraces have a mixture of natural ventilated and mechanical systems.

The overall strategy is to retain the existing tenant systems as they are currently installed.

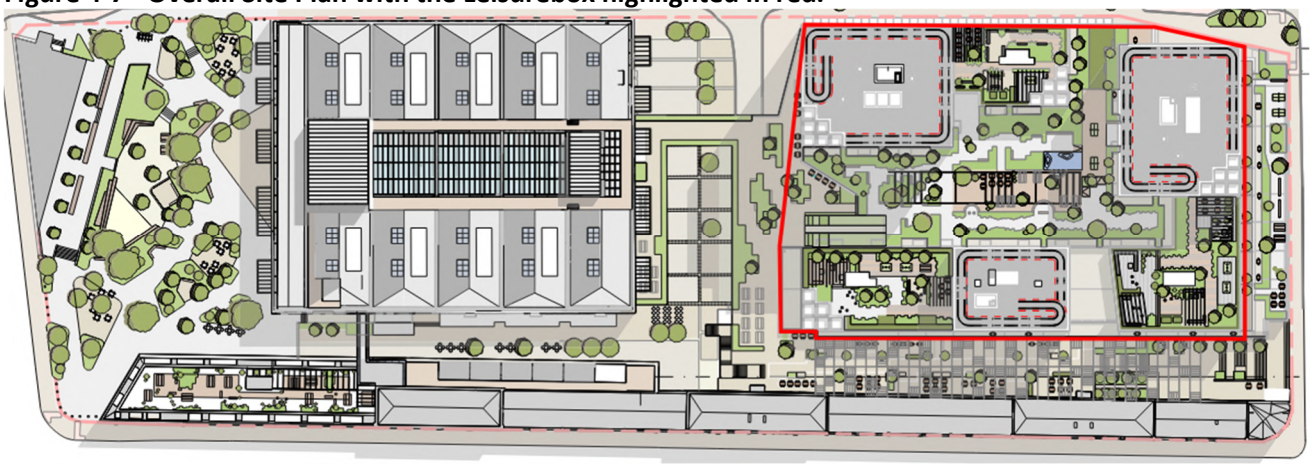
Where units currently run ductwork through to exhaust on the east side of the terraces, these will need be rerouted to above their entrance door and internal modifications made by the tenants to make use of existing louvre. The proposal of these changes shall be detailed and conditioned prior to occupation.

Further, all existing tenant extract systems will be checked to ensure they comply with the DEFRA and EMAQ requirements of the council as per the above for all new commercial units.

4.3 ZONE 4 LEISUREBOX (PHASE B)

The location of the Leisure Box is highlighted on the site plan below.

Figure 4-7 - Overall Site Plan with the Leisurebox highlighted in red.



4.3.1 APARTMENTS

Mechanical ventilation shall be provided to all apartments via dedicated Mechanical Ventilation & Heat Recovery (MVHR) in line with the requirements of "Building Regulations 2010, Approved Document Part F, Volume 1: Dwellings" – 2021 edition .

Each apartment will be provided with a Mechanical Ventilation Heat Recovery (MVHR) unit. This will be in the utility cupboard within each apartment and ducted at ceiling void level.

Ductwork carrying air between the external supply/discharge terminals and the MVHR will be insulated, and wrapped with a vapour barrier outside the insulation, to prevent condensation occurring within the insulation material. Insulation with the equivalent of 25mm of a material having a thermal conductivity of 0.04W/(m.K) or less will be used for condensation prevention. Pre-insulated ductwork compliant with this performance criterion will be considered for ease of installation.

The MVHR will operate continuously by supplying outside air to occupied rooms and extracting via the kitchen and wet rooms.

The final intake and discharge terminal locations shall be located above the rapid ventilators integrated within the façade.

The apartments have been designed to comply with Acoustic, Ventilation and Overheating requirements as part of the Manchester City Council guidance and are complaint with the new Approved Document Part O.

Kitchen Extract System

The kitchens will be equipped with an over hob recirculating extract fan complete with carbon filtration to minimise odours. There will be a short-term increase in internal noise levels when in use.

Façade Opening Detail for Ventilation Requirement

All the apartments have rapid vent openings that will satisfy the Building Regulations to purge ventilate the apartments.

The MVHR system will draw air into the apartment and discharge air via formed louvres over the rapid ventilators. The louvres are separated as to not recirculate vitiated air back into the apartment.

Purge Requirements

A system for purge ventilation will be provided in each habitable room – which is classed as "A room used for dwelling purposes, but which is not solely a kitchen, utility room, bathroom, cellar or sanitary accommodation." Hence, bedrooms and living rooms only. Where open plan kitchen/ living rooms exist it is reasonable to assume that they are split 50/50 and purge ventilation is applied to the living room only.

Purge ventilation should be capable of extracting at least four air changes per hour (ACH) per room directly to the outside and can be delivered by either natural "openings" (windows or doors) or by mechanical means, which is set out below.

Natural Purge Ventilation

Where purge ventilation is delivered through openings in a habitable room, the minimum opening areas in the table below should be achieved. The values in the table below are based on BS 5925, which assumes all of the following:

- Single-sided ventilation;
- An urban environment;
- A wind speed of 2.1 metres per second (m/s); and
- A temperature difference of 3°C between the air inside and outside the building.

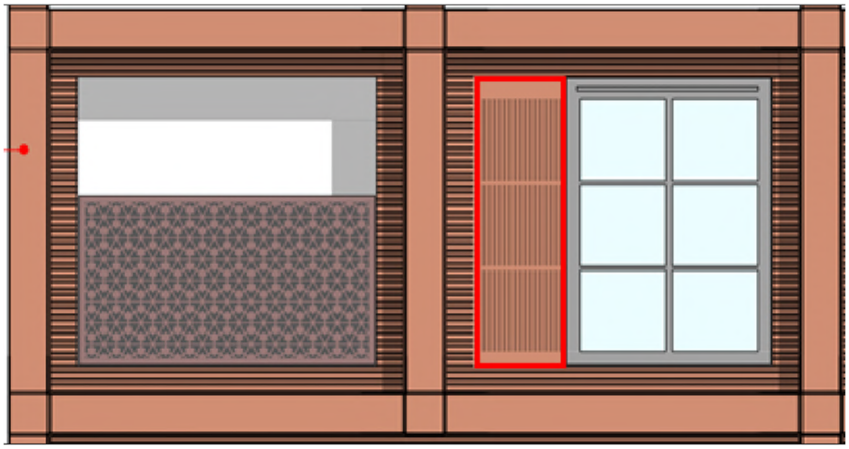
Table 1.4 Purge ventilation openings

Opening type	Minimum total area of openings
Hinged or pivot windows with an opening angle of 15 to 30 degrees	1/10 of the floor area of the room
Hinged or pivot windows with an opening angle of greater than or equal to 30 degrees	1/20 of the floor area of the room
Opening sash windows	
External doors	

Figure 4-8 - Table 1.4 from Building Regulations Part F

This purge ventilation strategy has been coordinated into all apartment types. The purge panel can be seen adjacent to the glazing in the image below.

Figure 4-9 - Typical Elevation of Purge Panel (highlighted in red) and Ventilation Louvre Above Glazing



Interaction with Approved Document Part O

Approved Document Part F sets minimum standards for purge ventilation for rapidly diluting indoor air pollutants and extracting water vapour where necessary in habitable rooms in dwellings. For domestic-type buildings, Approved Document Part O may require a higher standard than the guidance given in this document for purge ventilation to remove excess heat. In this case, the higher of the two standards should be followed.

WSP have undertaken a CIBSE TM59 study and all sample apartments are compliant with Table 1.4 above for the proposed purge ventilation panel.

Minimum Ventilation Rates

Minimum extract ventilation rates for continuous extract systems are specified in the table below. A continuous rate is given for the general operation of the fan and a high rate for when additional extraction is required.

Table 1.2 Minimum extract ventilation rates for continuous extract systems[1]

Room	High rate (l/s)	Continuous rate
Kitchen	13	The sum of all extract ventilation in the dwelling on its continuous rate should be at least the whole dwelling ventilation rate given in Table 1.3
Utility room	8	
Bathroom	8	
Sanitary accommodation	6	

NOTE:

1. If the continuous rate of ventilation provided in a room is equal to or higher than the minimum high rate specified in the table, no extra ventilation is needed.

Figure 4-10 - Table 1.2 from Building Regulations Part F

The minimum whole dwelling ventilation rate for the supply of air to the habitable rooms in a dwelling should meet both of the following conditions:

- A minimum rate of 0.3 litres per second per m2 of internal floor area (this includes all floors, e.g. for a two-storey building, add the ground-floor and first-floor areas); and
- A minimum rate determined by the number of bedrooms, as specified in the table below.

Table 1.3 Minimum whole dwelling ventilation rates determined by the number of bedrooms

Number of bedrooms[1][2]	Minimum ventilation rate by number of bedrooms (l/s)
1	19
2	25
3	31
4	37
5	43

NOTES:

1. If the dwelling only has one habitable room, a minimum ventilation rate of 13l/s should be used.
2. For each additional bedroom, add 6l/s to the values in Table 1.3.

Figure 4-11 - Table 1.3 from Building Regulations, 2021 Part F1

Service Void Requirements

The services installations and distribution within the apartments will generally be routed through the ceiling voids and stud walls.

Apartment ceiling void depths will typically be as follows:

Table 4-1 - Apartment Service Void Requirements

Area	Clear Dimension mm
Bulkhead areas	300 mm clear void
Non bulkhead areas	100 mm clear void

4.3.2 CORRIDOR SMOKE VENTILATION

Smoke extract shall be required from the stair and lobby areas of residential floors, as set out by the fire engineer. It is expected that the system will be along the brief outlined below.

A specialist contractor shall be responsible for designing, supplying, installing, testing and commissioning a new corridor smoke clearance system that will operate automatically in the event of a fire and in line with Fire Engineer's report.

A grille complete with fire damper (lobby ventilator) located at high level within the corridor shall open automatically at the dictates of the fire control panel to allow the passage of smoke from the affected corridor, into the smoke shaft formed within the core area.

The system shall provide an automatic opening vent (AOV) at the head of stair. This shall open automatically at the dictates of the fire control panel to provide make-up air for the clearance system. The stair door shall open into the corridor via the pressure of the system to provide this make-up air path during operation.

A dedicated corridor smoke detector located at all levels shall be used to actuate the fire damper at the affected floor.

Fans at roof level, controlled automatically by the fire control panel, once energised shall extract smoke from the building through an automatic opening vent. The fans shall be run in duty/ standby mode to ensure

operation when required and be controlled automatically by the fire control panel. The fans shall also be complete with supply and discharge attenuation.

The system shall be designed to operate on only one level at a time, on first activation.

All plant items associated with the system shall also be fed by the Generator to ensure operation when the electricity supply is interrupted.

The control panel for each system shall be located at the foot of the stair core adjacent to the fire personnel entry point.
The smoke exhaust systems will comprise of the following:

- Duty and standby variable speed extract fans with inverter drive, linked to pressure sensors within the lobby and corridor at each level via a control panel;
- Extract fans (3 kW nominal) rated at 300 °C for 2 hours;
- Motorised smoke and fire dampers between the shaft and the lobby at each level;
- A builder's work shaft in each lobby;
- Fire alarm interfaces and essential power supplies as required;
- Builders work shaft that is substantially straight & vertical and will connect to the lobbies at each level via a 1-hour fire rated damper and grille; and
- The construction of the builder's work shaft is to have a smooth internal face and minimum air leakage.

Roof fans shall be concealed behind architectural visual screens. The necessary free area louvre and plant access shall be provided.

All on-floor smoke exhaust connections will be provided with localised diffusers and motorised smoke dampers. The motorised smoke damper will be controlled by the fire alarm system.

Automatic opening vents (AOVs) will be provided at the top of each stair with a minimum opening of 1.0 m^2, subject to confirmation in the next revision of the Fire Strategy.

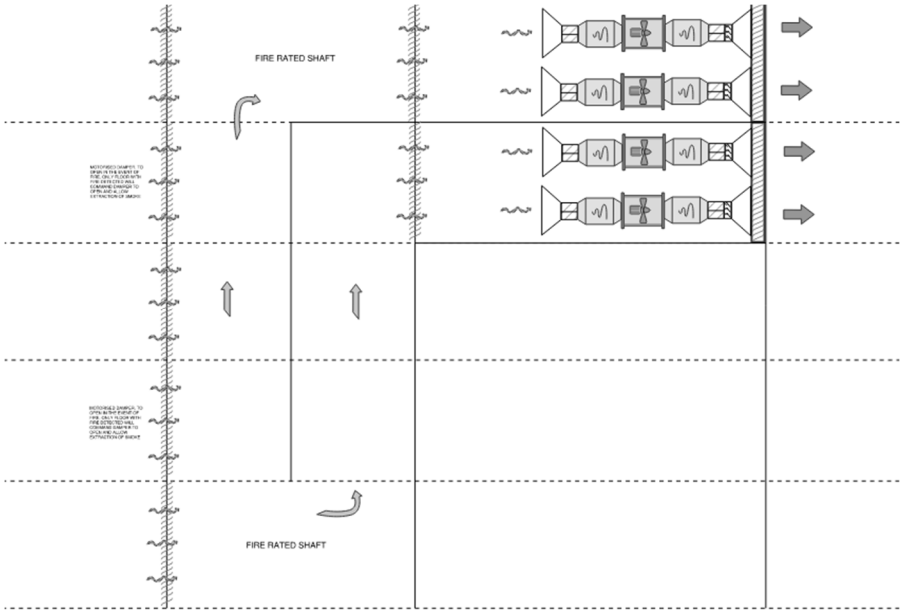
4.3.3 CAR PARK

The car park ventilation system will be capable of providing the required air change rates under either a normal day-to-day operation fume extract profile, or to meet the extraction rates required for smoke removal following a fire event of 10 air changes per hour.

Make up air is supplied via the car park ramps.

There will be 2 No. plant rooms housing 2 extract fans each (4 in total). These plant rooms will be located on level 02 and 03 and have immediate access to external louvres to discharge to atmosphere. A common smoke shaft will be located adjacent to the plant room with access to all car park levels. This arrangement can be seen below.

Figure 4-12 - Imagre below shows the schematic detail of the car park extract system



An additional plant room will be required on level 02 to house the control panel for the extract fans.

As the level 01 car park does not have access to external louvres, 12m^2 of free area is required between level 00 and the level 01 to enable air flow through the lowest car park level. This free area is to be located at the northern end of the car park (away from the car park ramps) to enable sufficient air flow.

Induction fans will be introduced where required to prevent stagnant areas of air and promote good air quality throughout.

Air Movement Throughout the Car Park

To ensure air within the car park is directed towards the extract fans, the system will rely upon several ceiling mounted air movement impulse/ jet fans strategically placed within the car park. These units will be located in accordance with a CFD model provided by the car park ventilation specialist.

Under a fire condition all air quality sensors would be disabled and the ventilation system should extract smoke from the area. All fans associated with the air movement and extraction systems will require to be operated under fire conditions and will be suitably rated to meet the requirements of all relevant codes of practice.

Basement Car Park Ventilation Modes of Operation

Under the dictates of the system, under everyday use the CO/ NO2 detectors will ensure that car exhaust fumes are diluted and forced towards the main extract points. More importantly, the jet impulse fans will also prevent the build-up of fuel vapours. When an increase in CO/NO2 is detected, the system will provide boosted ventilation to ensure the noxious gasses are drawn towards the exhaust points.

CO/ NO2 Monitoring System

There shall be a complete system of CO/ NO2 monitoring in the car park to provide information to the specialist control system to allow speed control of the extract fans in accordance with the conditions.

A mechanical ventilation system shall provide up to 6 air changes per hour under normal operation or ensure carbon monoxide levels do not exceed: 30ppm over an 8-hour period and 90ppm over a 15-minute period.

4.3.4 STAFF/ MANAGERS OFFICE/ PARCEL STORE

Staff areas are located at ground floor level and include parcel room and staff room. These areas will be provided with a dedicated supply and extract ventilation system. Outdoor air will be provided at 10 l/s per person in line with CIBSE guidance. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground and mezzanine level façade. The air intake and exhaust points will be required to be an adequate distance from each other so as to minimise the risk of recirculation.

Communal areas may be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

Toilets associated with these spaces will be provided with dedicated twin extract fans with replacement air make-up drawn from adjacent rooms and corridors and designed in line with best practice and CIBSE guidance.

The staffroom kitchen will be provided with dedicated kitchen extract fan with replacement air make-up drawn from adjacent rooms and corridors.

4.3.5 STAFF CHANGE AND WCS

Toilets associated with all front of house and staff areas will be provided with dedicated twin extract fans with replacement air make-up drawn from adjacent rooms and corridors via door undercuts or transfer grilles mounted directly in the door.

Exhaust louvres will be formed at high level in the ground and mezzanine level façade. The air intake and exhaust points will be required to be an adequate distance from each other so as to minimise the risk of recirculation.

4.3.6 COMMS ROOMS

The comms rooms shall have no ventilation as treated as an unoccupied space.

4.3.7 ENTRANCE & RECEPTION

The entrance and reception areas will be provided with a dedicated ventilation system. Outside air will be provided at 10 l/s per person as per the CIBSE guide recommendation. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground floor façade. These shall be located at a suitable distance from each other to ensure that recirculation of intake and exhaust air flows is minimised.

Communal areas are likely to be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

4.3.8 REFUSE

All proposed tenant and retail refuse areas are to be provided with appropriate dedicated extract ventilation. Refuse store extract ventilation shall be provided via an extract fan and ducting system that shall exhaust foul air to atmosphere at ground floor level, away from public spaces and air intakes.

A refuse holding area/ refuse store is located at the ground floor of each tower core to serve each tower. There is also a large shared refuse store which is used by the retails units located in the Leisurebox, the Great Northern Warehouse and the Deansgate Terraces. All refuse areas will have mechanical extract ventilation which will be provided in line with current industry standard practice levels as set out in BS 5906:2005 - Waste management in buildings - Code of practice. A localised extract air fan will be located at high level (soffit mounted), within each refuse store, to provide 5 l/s-m2 of mechanical extract ventilation.

This is in accordance with ASHRAE, Ventilation for Acceptable Indoor Air Quality, 62.1-2004, TABLE 6-4 Minimum Exhaust Rates. This extract ventilation will be ducted to the louvered façade. Supply air make-up will be drawn from the adjacent areas and via infiltration through intake louvres along the elevation to external.

Refuse store extract ventilation shall be provided via an extract fan and ducting system that shall exhaust foul air to atmosphere at ground floor level, away from public spaces and air intakes.

Bin stores shall be ventilated at 5l/s /m² via a fire rated fan. All ductwork external to the bin store shall be fire rated.

The bin chute lobby shall be provided with dedicated ventilation on each residential floor. This shall be 6 ACH and the extract duct shall run adjacent to the bin chute itself within the dedicated riser.

4.3.9 MECHANICAL AND ELECTRICAL PLANT ROOMS

All plant rooms shall be provided with ventilation as appropriate to their use; either natural via louvred doors such as electrical substations or a minimum of 2 ACHs in the case of wet plantrooms located in the basements.

4.3.10 RESIDENTS LOUNGE & MEETING ROOMS

These areas will be provided with a dedicated ventilation system. Outside air will be provided at 10 l/s per person as per the CIBSE guide recommendation. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground floor façade. These shall be separate at a distance from each other to minimise recirculation of intake and exhaust air flows.

Communal areas are likely to be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

4.3.11 RESIDENTS GYM AND STUDIOS

The gym and studio areas will be provided with a dedicated ventilation system. Outside air will be provided at 10 ACH as per the CIBSE guide recommendation. These areas will be served by a filtered heat recovery supply and extract units located within ceiling voids of each space.

Outdoor air intake and exhaust louvres will be formed at high level in the ground floor façade. These shall be separate at a distance from each other to minimise recirculation of intake and exhaust air flows.

Communal areas are likely to be provided with a false ceiling, or no ceiling, to suit the required aesthetic. A false ceiling solution would be equipped with supply and return air grilles. A solution with no ceilings would benefit from a higher apparent ceiling with all services exposed and finished to suit the interior design. In this case, grilles would be duct mounted.

4.3.12 PRIVATE KITCHEN

A new mechanical supply and extract system shall be designed following the guidance outlined in DW172 (Building Engineering Services Association – Specification for: Kitchen Ventilation Systems). The extract air volumes shall be calculated based on the kitchen equipment proposed by the kitchen design specialist.

A dedicated AHU is proposed to be provided within the ceiling void adjacent to the kitchen. Air shall be extracted from the kitchen via the kitchen canopy. Ultraviolet (UV) filtration shall also be provided. Mechanical supply make up air shall be provided to the kitchen via the AHU.

In addition to the UV filters, Electrostatic Precipitator (ESP) filters shall be provided within the extract ductwork system prior to exhausting at out of the adjacent elevation. The combination of the UV and ESP filters shall mitigate the risk of grease build up within the extract system and odours exhausted to atmosphere.

The kitchen extract systems shall be designed and installed in accordance with DEFRA Guidance on the Control of Odour and Noise from Kitchen Exhaust Systems. This shall include provisions for access at each level in line with HVCA 171 – Kitchen Ventilation Systems.

The exhaust air from the system shall be exhausted away from residential elements such as openable windows or intake louvres for apartments.

4.3.13 NEW COMMERCIAL UNITS

All new retail units are being constructed as “shell and core” only. As such sufficient plant allocation and louvre shall be provided to enable a flexible tenant to fit out and ensure that such fit out is able to comply with all relevant standards.

Services serving the proposed retail units shall be designed, procured and installed by the individual tenants with appropriate power, water and drainage provided only as an interface.

For the ground floor retail units, ventilation systems will be provided by individual tenants to suit their requirements (tenant fit out). Louvred areas on the façade will be provided at high level to enable tenants’ air intake and exhaust ductwork connections. These intake and exhaust louvres shall be separate at a suitable distance from each other (as described in the previous sections). The tenant shall design a ventilation system to draw outdoor air and discharge vitiated air via this louvre arrangement.

In all cases where cooking processes will occur, fire rated kitchen extract ventilation plant will be provided by the tenant and must incorporate grease, ultra-violet, activated-carbon and electrostatic precipitator filtration systems to eliminate the build-up of grease, smoke and odours. Access to the kitchen extract ductwork and plant must be provided for regular cleaning and maintenance. This duct work will raise up to high level of the unit where it will be discharged out of the louvres along the elevation and away from any supply louvres.

The kitchen extract systems shall be designed and installed in accordance with DEFRA Guidance on the Control of Odour and Noise from Kitchen Exhaust Systems. This shall include provisions for access at each level in line with HVCA 171 – Kitchen Ventilation Systems.

Defra has published a document entitled: 'Guidance on the Control of Odour and Noise from Commercial Kitchen Exhaust Systems'. It describes a method of risk assessment for odour, guidance on minimum requirements for odour and noise control, and advice on equipment selection. It is recommended that the proposed commercial unit (should there be a prospect of that coming forward for commercial use) should refer to this document (particularly Annex B). Details should also be provided in relation to replacement air.

Consideration shall be made regarding the coordination of tenant extract locations and openable residential windows during the tenant fit out process.



8 First Street
Manchester
M15 4RP

wsp.com

PUBLIC