Raul Alvarez

Subject: FW: Request for approximate Waste Volumes - ASB Integration Project
Attachments: Waste specs for buildings.pdf

From: Raymond Galway <r.galway@unsw.edu.au>
Sent: Wednesday, 16 January 2019 4:38 PM
To: Raul Alvarez <r.alvarez@unsw.edu.au>
Cc: John MacLeod <john.macleod@unsw.edu.au>
Subject: RE: Request for approximate Waste Volumes - ASB Integration Project

Hi,

The ASB/UNSW East Integration Building space (5,252² mts) appears to have similar activities and space usage (wet labs and teaching space) to the UNSW Campus Lowy Building.

I have based estimate volumes of hazardous waste (Biological and Chemical) on the current Lowy Building volumes produced.

Radiological waste is managed by the UNSW RSO – John McCleod. I have cc'ed John into this email as a point of contact for potential ongoing discussions.

See table for estimates.

Waste type	Volume per month ASB/UNSW East (estimate)	Comments
Chemical	764.9 kgs	Based on total weight of all chemical disposals per annum
Biological	1,470.19 kgs	Based on 1362 x 240L bins @ 1.36kgs per bin & 434 x C64 Clinismart bins @ 5kgs per bin. • 240L bins = 1362 bins per annum. • C64 Clinismart bins = 434 bins per annum.
Paper/cardboard	5,286.6 kgs	Based on 16 x 240L@ 50kgs. 3 x 660L @100kgs. 1 x 1100 @120kgs Total 1,220kgs disposed per week x 4 =5,286.6kgs
Polystyrene	16²mts per month	Best estimate in square metres.
Confidential	720L per month	Best estimate. 6 x 120L bins/month
General	9,103.46L per month	Based on 40L/100²mts/day
Mixed recyclables	4,551.8L per month	Based on 20L/100²mts/day

I have attached a document that may help for calculating waste for this and other buildings.

regards

Raymond Galway
Manager, Waste
Estate Management

We are entrusted and empowered to create outstanding campus environments and experiences.

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UNSW Biosciences South Project

Dangerous Goods

Revision 6

24th of April, 2017

Prepared for Brookfield Multiplex

Report Details

Project: Biosciences Renewal Project, High Street, Randwick

Document: Dangerous Goods Assessment

Report No.: 20018_UNSW_FinalDGReport_24Apr17_Rev(6)

Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY	VERIFIED BY
A	17 Mar 15	Draft Issue for comment	**Renton Parker** BEng.(Chem. Hons) MAIDGC GradMIEAust	**Steve Sylvester** BEng.(mech.hons) MAIDGC FS Engineer (TUV 2203/10) EEHA CT0984a&b	-
B	22 Apr 15	Incorporated BMX Comments			
C	13 Jul 15				
D	18 Aug 15	Incorporated CI comments			
1	19 Aug 15	Issued Final			
2	25 Sep 15	Incorporated BMX Comments			
3	11 Dec 15				
4	24 May 16	Incorporated minor changes	**Renton Parker** BEng.(Chem. Hons) VPAIDGC MIEAust CPEng NER		
5	29 Nov 16	Incorporated BMX Changes			
6	24 Apr 17				

EXECUTIVE SUMMARY

INTRODUCTION

Brookfield Multiplex Constructions (BMC) has been commissioned by the University of New South Wales (UNSW) to design additional facilities for the Biological Sciences precinct, known as the Biological Sciences Project. As part of the Biological Sciences operations, it will be necessary to store and handle a number of Dangerous Goods (DGs), the storage of which must comply with the requirements of the NSW Work Health and Safety Regulation – 2011 (the Regulation). To assist in reviewing the proposed DG storage and handling facilities, BMC has engaged RAWRiSK Engineering Pty Ltd (RAWRiSK) to provide advice on compliance of the proposed design with the Regulation.

This report has been developed to detail the design requirements for the Design Development (DD) of the Biological Sciences building.

METHODOLOGY

The following methodology was used for the DG review and compliance assessment of the Biological Sciences Project at the University of New South Wales:

- Meetings were held with BMC and Architects, Woods Bagot, to discuss the proposed building design plan, storage materials and quantities, and potential requirements of stores;
- details collected during the meetings were then collated and the results compared to the requirements of AS1940 (Ref. 1), AS3780 (Ref. 2), AS4452 (Ref. 3), AS2252.2 (Ref. 4), AS2647 (Ref. 5), and the particular requirements of UNSW to determine the compliance of the proposed storages with the standards;
- a draft report was then compiled detailing the study results and any additional requirements for each storage area to ensure that the storages are compliant with the relevant codes, standards and regulations; and
- a final draft report was developed incorporating comments from BMC for points of fact detailed that may have arisen within the report from the review.

CONCLUSIONS AND RECOMMENDATIONS

The bio-medical precinct at UNSW is currently in the design phase to be redeveloped to upgrade the building in line with UNSW's building renewal schedule. The building will consist of laboratories which may store and handle Dangerous Goods. To ensure the proposed storage locations comply with the relevant standards and the Work Health and Safety Regulation each DG store was assessed for compliance.

The results of the analysis indicate the major areas of concern are the storage location of cabinets and the potential formation of hazardous atmospheres. The following general recommendations have been made for these areas. It is noted that specific design guidelines for each room are within the body of the report.

Cabinets not stored in designated Chemical Stores: Storage of 30 L flammable liquid cabinet and corrosive cabinets are ventilated by the fume hoods and are considered to be permissible for use in this configuration.

Cabinets Stored in designated Chemical Stores**:** Rooms storing flammable liquid cabinets in a quantity exceeding 850 L should be designed as follows;

- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Floor with a FRL of 180/180/180;
- Bunding capable of containing 600 L;
- Doors with a FRL of -/120/30; and
- Appropriate placarding and signage.

Flammable liquid cabinets should be ventilated to eliminate the requirement for a 3m hazardous zone surrounding the cabinet.

Rooms fitted with gas outlets: Rooms fitted with gas outlets should have a fan fault/failure device alarming within the BMCS.

Storage of liquefied gases, cylinders or tanks: Rooms storing liquefied gases, cylinders or tanks should be fitted with oxygen monitoring and local alarms. The oxygen monitoring should be linked to the building management system. If oxygen concentrations are less than 18% or exceed 22.5% the local alarms should activate. The local alarms should consist of an audible alarm within the room and a visual alarm at each entrance to the room.

RECOMMENDATIONS SUMMARY

The design requirements specified in this report have been incorporated into the Design Development of the UNSW Biological Sciences building.

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AFFL	Above Fixed Floor Level
BCA	Building Code of Australia
BMC	Brookfield Multiplex Constructions
BMCS	Building Management Control System
CBD	Central Business District
CO_2	Carbon Dioxide
DG	Dangerous Goods
LPG	Liquefied Petroleum Gas
N_2	Nitrogen
O_2	Oxygen
UNSW	University of New South Wales

1 INTRODUCTION

1.1 BACKGROUND

Brookfield Multiplex Constructions (BMC) has been commissioned by the University of New South Wales (UNSW) to design additional facilities for the Biological Sciences precinct, known as the Biological Sciences Project. As part of the Biological Sciences operations, it will be necessary to store and handle a number of Dangerous Goods (DGs), the storage of which must comply with the requirements of the NSW Work Health and Safety Regulation – 2011 (the Regulation). To assist in reviewing the proposed DG storage and handling facilities, BMC has engaged RAWRiSK Engineering Pty Ltd (RAWRiSK) to provide advice on compliance of the proposed design with the Regulation.

1.2 OBJECTIVES

The objective of the review is to confirm to BMC that the proposed DG storage facilities configuration can achieve compliance with the regulation.

1.3 SCOPE OF WORK

The scope of work for this report/study is for a review of the proposed DG storage facilities configuration at the Biological Sciences project, UNSW. The study involves the assessment of the conceptual designs, layouts and configurations for the proposed DG storage areas within the Biological Sciences project only and does not include any other DG storage facilities within the Biological Sciences precinct.

2 METHODOLOGY

2.1 METHODOLOGY

The following methodology was used for the DG review and compliance assessment of the Biological Sciences Project at the University of New South Wales:

- Meetings were held with BMC and Architects, Woods Bagot, to discuss the proposed building design plan, storage materials and quantities, and potential requirements of stores;
- details collected during the meetings were then collated and the results compared to the requirements of AS1940 (Ref. 1), AS3780 (Ref. 2), AS4452 (Ref. 3), AS2252.2 (Ref. 4), AS2647 (Ref. 5), and the particular requirements of UNSW to determine the compliance of the proposed storages with the standards;
- a draft report was then compiled detailing the study results and any additional requirements for each storage area to ensure that the storages are compliant with the relevant codes, standards and regulations; and
- a final draft report was developed incorporating comments from BMC for points of fact detailed that may have arisen within the report from the review.

2.2 LIMITATIONS AND ASSUMPTIONS

In this instance the DG Report is developed based on applicable limitations and assumptions for the development which are listed as follows:

- the report is specifically limited to the project described in Section 3;
- the report is based on the information provided by BMC and Woods Bagot relating to the project;
- DG storage design details are based on the information provided by BMC and Woods Bagot;
- the assessment is limited to the requirements for compliance with the Regulation, including comments on compliance with the relevant codes and standards;
- malicious acts or arson with respect to fire ignition and safety systems compliance are limited in nature and are outside the scope of the assessment;
- this report is prepared in good faith and with due care for information purposes only, and should not be relied upon as providing any warranty or guarantee that spills, vapour release, ignition or fire/explosion will not occur;
- the assessment has only been conducted to demonstrate compliance with the Regulation, where the University has additional life safety system requirements (e.g. gas detection and alarm for rooms containing reticulated nitrogen systems, the assessment of these requirements is outside the scope of the study; and
- the DG Report is only applicable to the completed building. This report is not suitable for use in any other buildings or laboratories at the University of New South Wales or similar DG storages.

2.3 OXYGEN CONCENTRATION CALCUATIONS

To estimate the concentration of oxygen remaining in a room following a gas release, the following calculation has been used (Ref. 6).

$$C = \frac{V_r \times 0.21 \times n}{L + (V_r \times n)}$$

Where:

- L = gas release (m3/h)
- Vr = room volume (m3)
- n = air changes per hour

3 SITE DESCRIPTION

3.1 FACILITY LOCATION

The Biological Sciences precinct is located in the Kensington Campus of UNSW, NSW. **Figure 3-1** shows the regional location of the site of the Kensington Campus of UNSW, which is 5.5 km south of the Sydney CBD, while **Figure 3-2** shows the location of the Biological Sciences precinct in the UNSW Kensington Campus.

The Biological Sciences precinct is rectangular in shape and is accessed via Library Walk on the South or the Michael Birt Lawn on the North. It is a multi-storey facility consisting of laboratories, offices, teaching spaces and rooms, meeting rooms, open spaces, DG rooms and amenities. The facility has 9 floors including a ground and lower ground floor (both accessible via street level).

The lower ground floor will contain some laboratory spaces, but will mainly comprise of DG storage and waste. The ground floor and level 1 will contain mainly teaching labs. Level 2 will contain offices, a kitchen, work spaces and DG storage areas. Levels 3, 4, and 5 will consist mainly of offices and open laboratories. Levels 6 and 7 will consist primarily of holding areas. The floor layouts which will store/handle DGs (Lower Ground – Level 6) are shown in **Figure 3-3 - Figure 3-10** respectively**.**

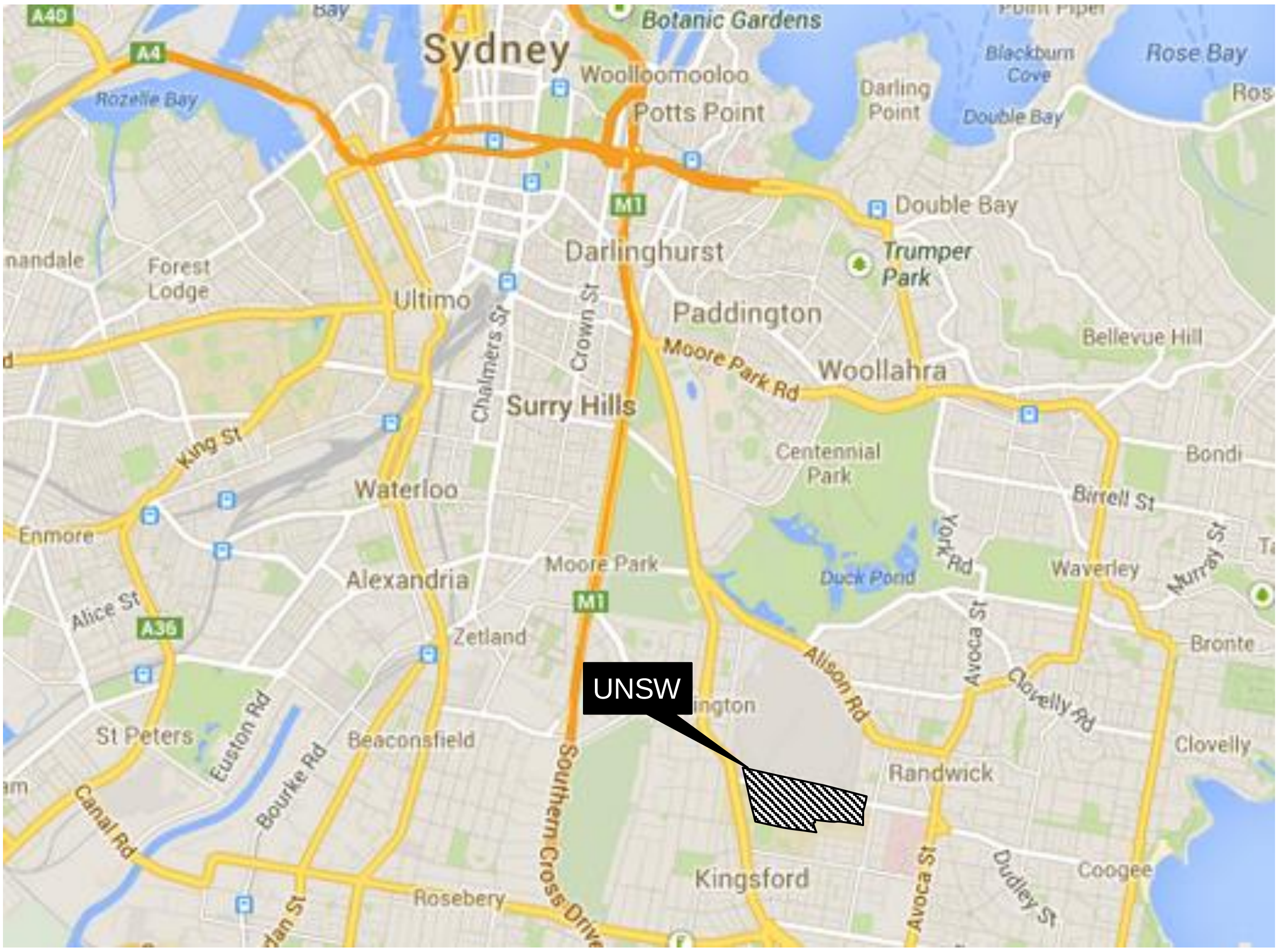

Figure 3-1: Site Location

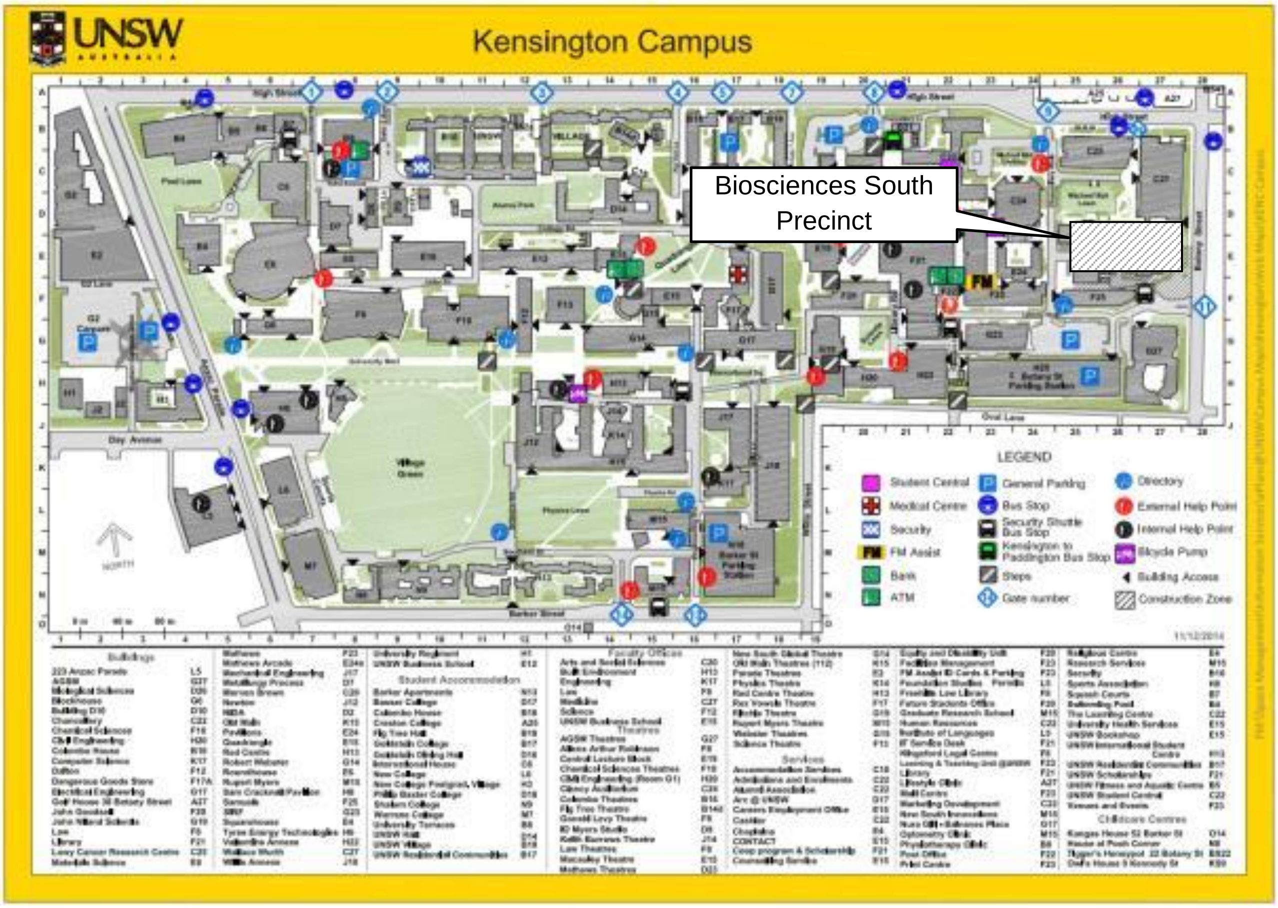

Figure 3-2: UNSW Kensington Campus Map Showing Location of the Biosciences South Precinct

3.2 PROJECT OVERVIEW

The project will strive to meet the objectives listed below.

- Provide a contemporary, world class research and teaching environment as part of the Biomedical Precinct
- Provide modern infrastructure for training the next generation of researchers and technically qualified graduates who will help maintain Australia's connectivity and competitiveness in a rapidly advancing world
- Create flexible and adaptable space for strategic recruitment, taking into account trends in technology, research infrastructure, and national and UNSW priority areas
- Enhance effectiveness and interdisciplinary teamwork by efficiently connecting biologists, environmental, earth and biomedical scientists and reinforcing research synergies between the research groups, schools and faculties.

3.3 BUILDING OVERVIEW

The building is designed to accommodate research and teaching of undergraduate and postgraduate students. The space is designed to be flexible, supporting current research and teaching needs as well as providing infrastructure to support future technological advances. The facilities to be built within the facility are:

- Large loading dock, stores, workshop and utilities

- Biomedical teaching facilities
- Flexible research laboratory spaces
- Specialised research equipment

3.4 DGS STORED

Provided in **Table 3-1** is a summary of the classes of DGs stored for each level. It is noted these are the accumulated storages throughout each level with storage predominantly occurring in cabinets.

Table 3-1: Quantities of Dangerous Goods (L)

LEVEL	CLASS 2			CLASS 3	CLASS 6.1	CLASS 8	C2
	Gases	LN_2	LCO_2				
Lower Ground	4,000	7,260	1,200	3,060	100	1,190	10,000
Ground	-	-	-	1,340	-	90	-
Level 1	-	200	-	560	-	340	-
Level 2	350	-	-	340	-	150	-
Level 3	300	500	-	340	-	340	-
Level 4	300	300	-	1120	-	620	-
Level 5	300	-	-	1840	-	1090	-
Level 6	300	-	-	-	-	-	1,000

Figure 3-3: Lower Ground Level Plan

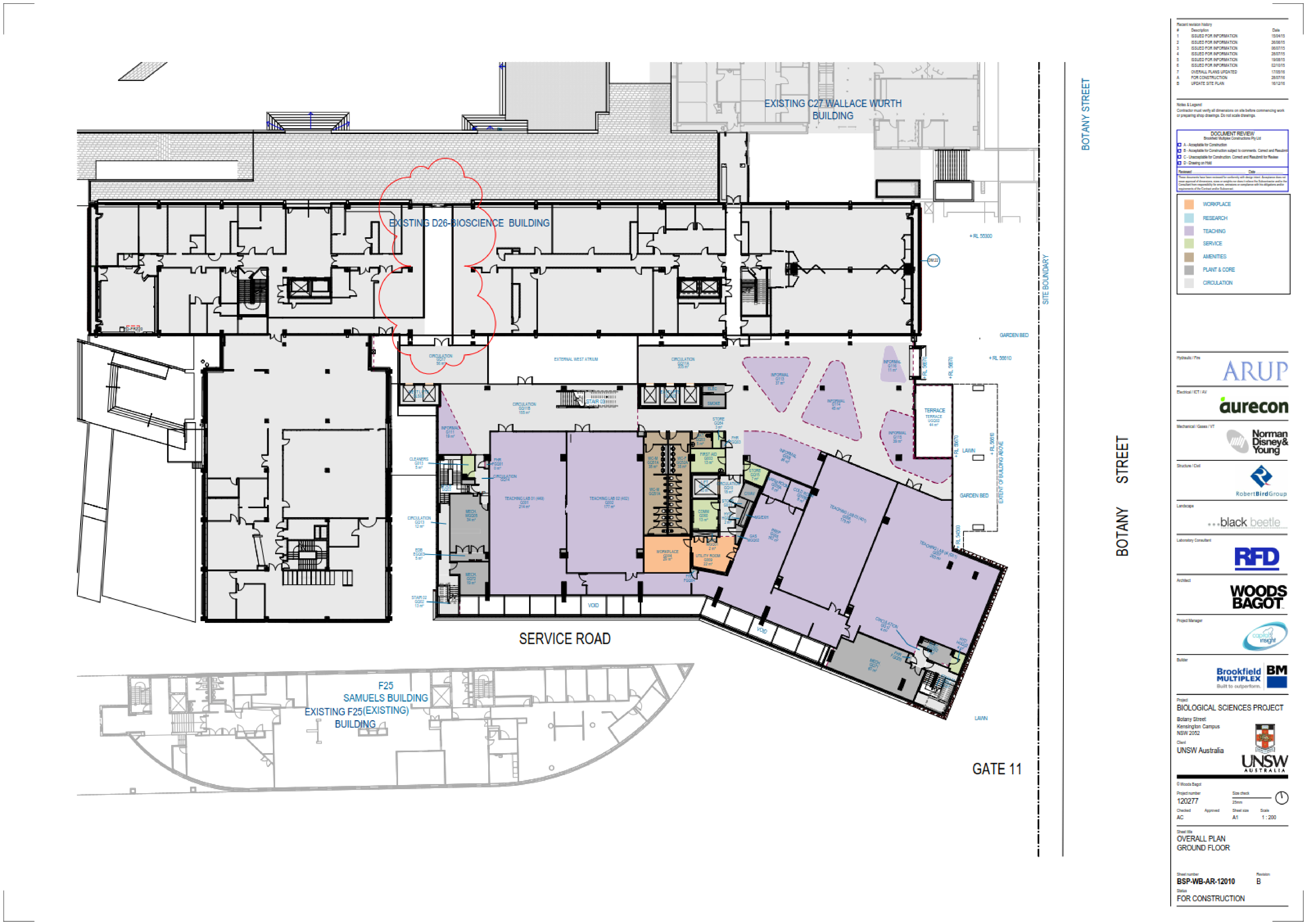

Figure 3-4: Ground Level Plan

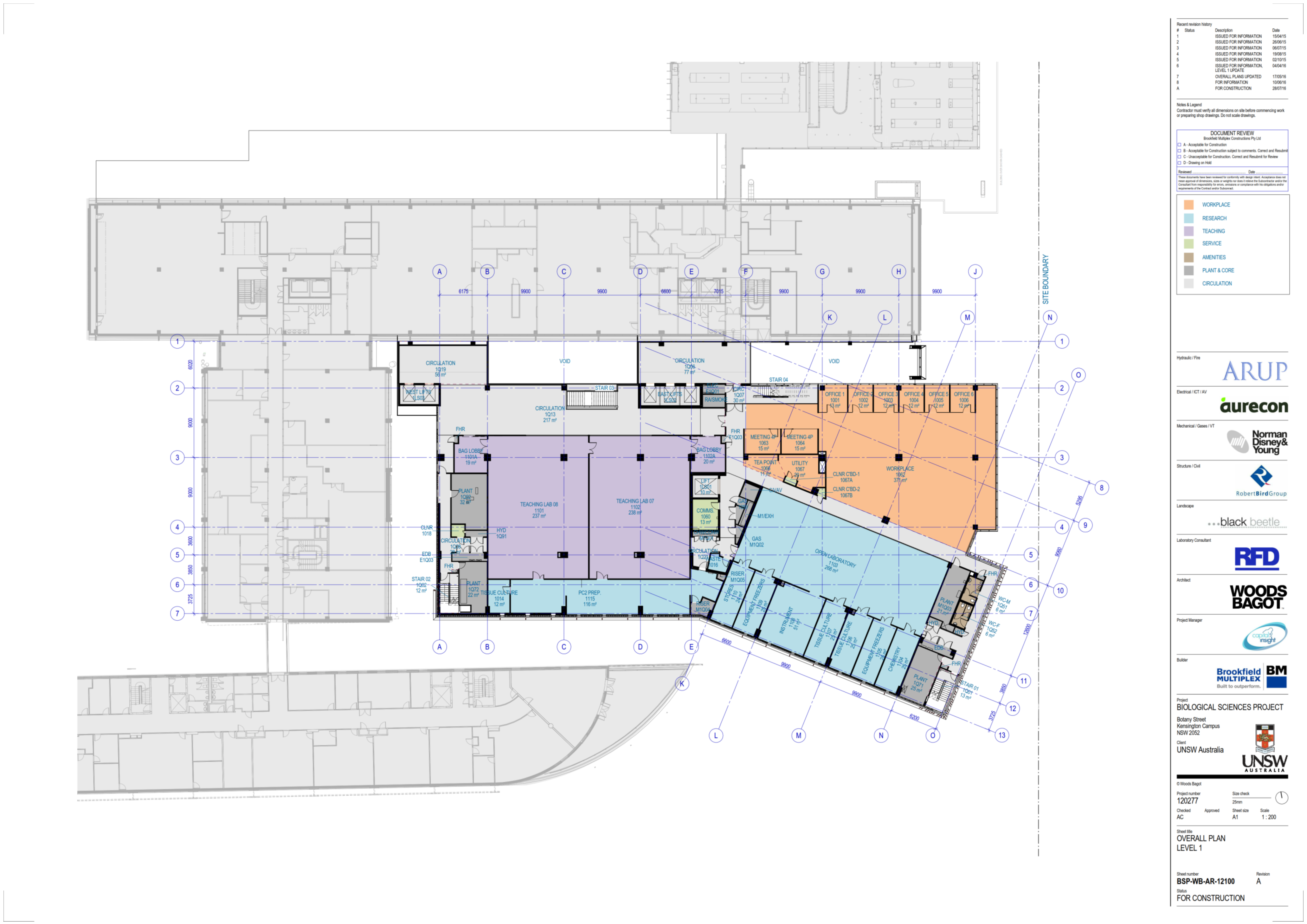

Figure 3-5: Level 1 Plan

Figure 3-6: Level 2 Plan

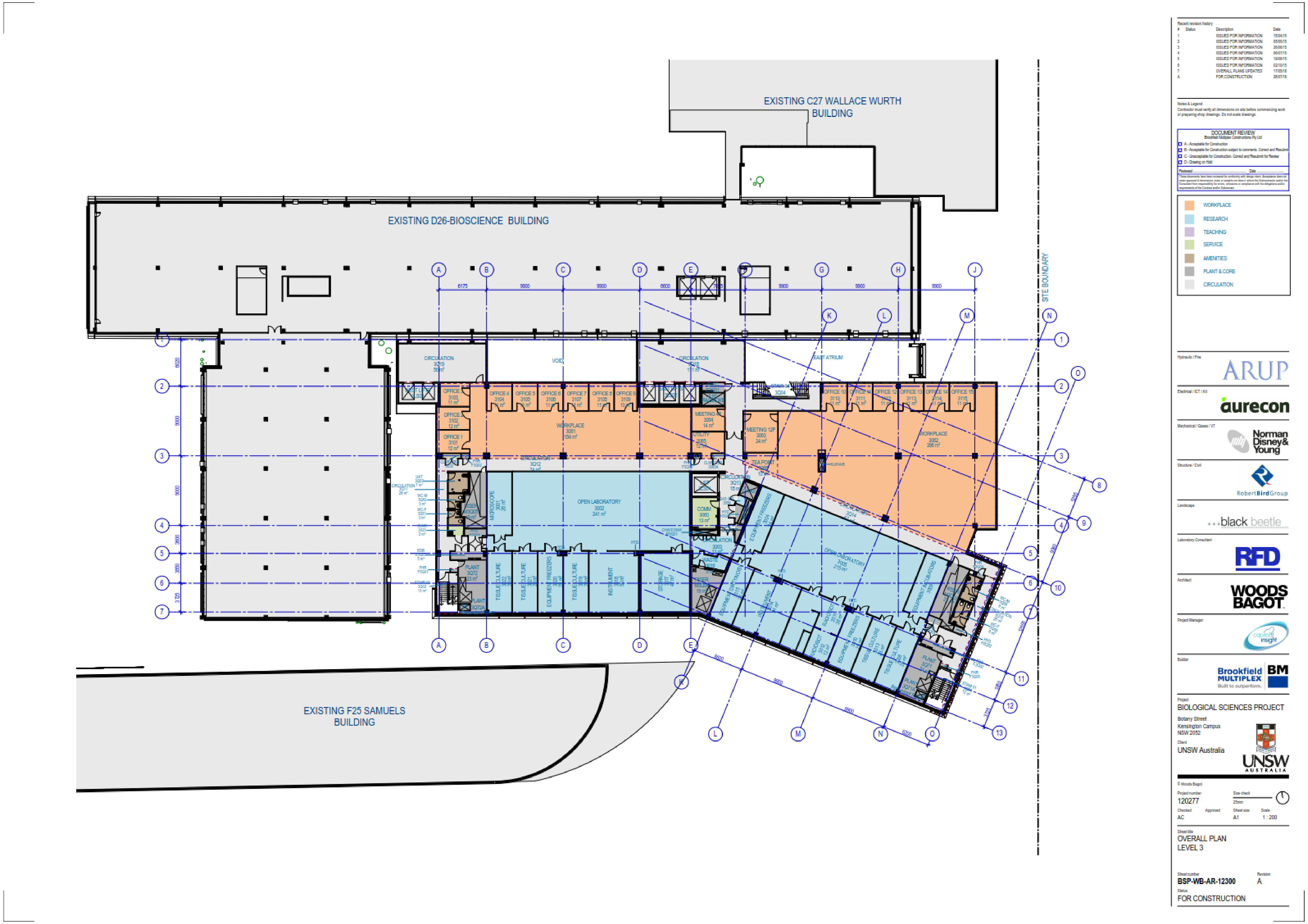

Figure 3-7: Level 3 Plan

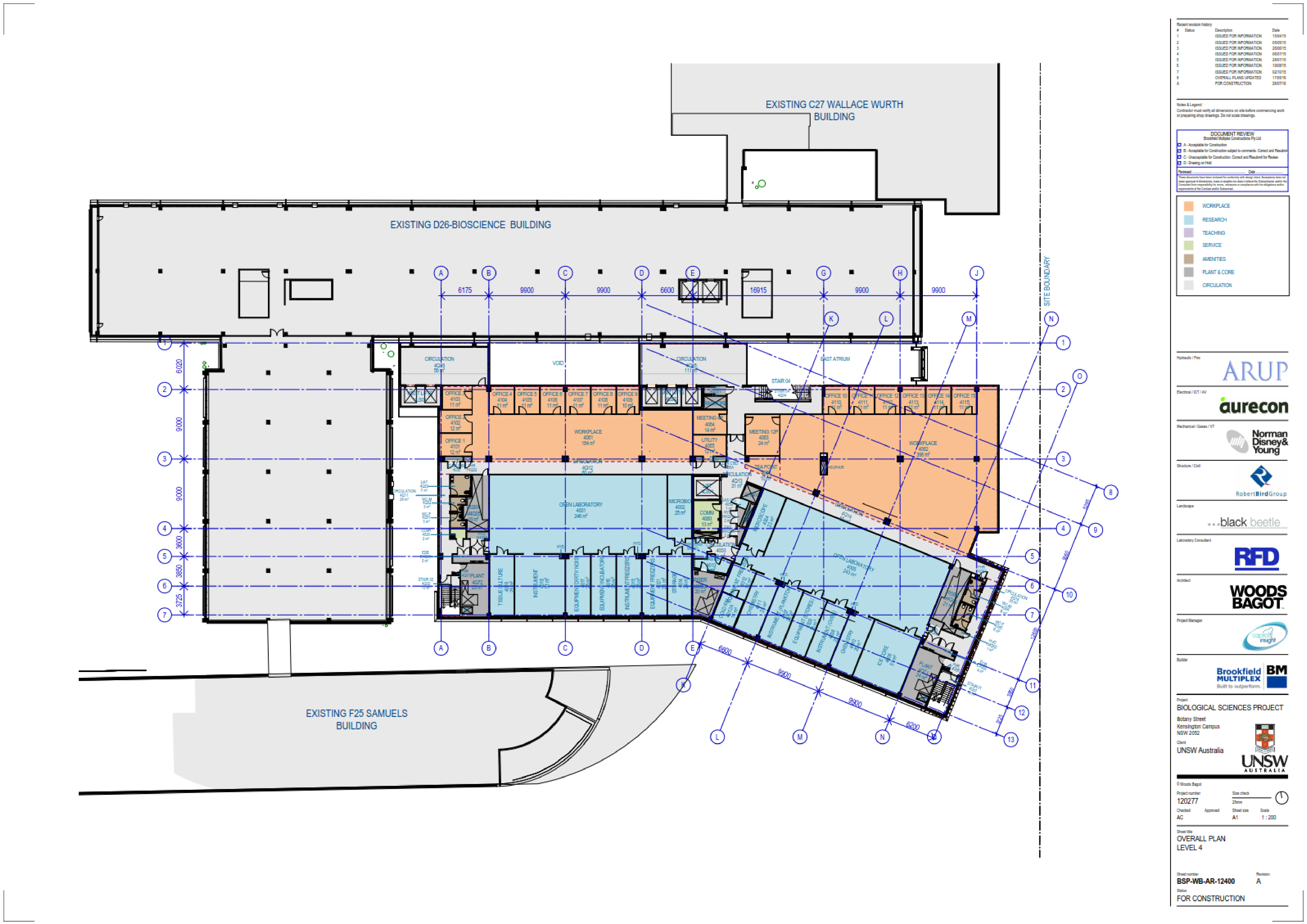

Figure 3-8: Level 4 Plan

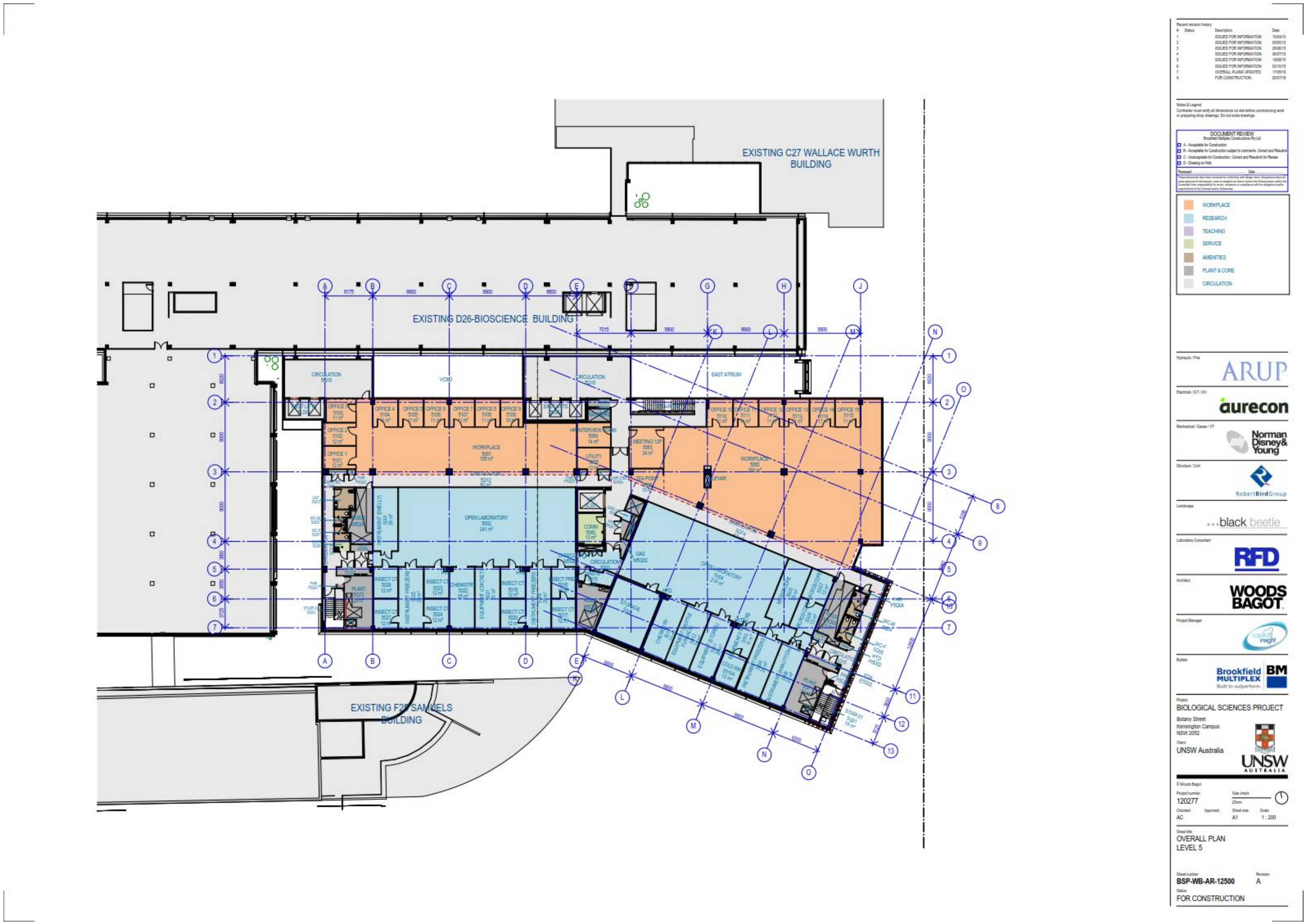

Figure 3-9: Level 5 Plan

Figure 3-10: Level 6 Plan

4 LOWER GROUND - DG STORAGE ASSESSMENT

4.1 INTRODUCTION

The following rooms are located on the Lower Ground Floor and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard based on that room. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 4.17**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

4.2 LGQ71 - BULK GAS

The bulk gas store contains a 6,000 L liquid nitrogen tank and a 1,200 L carbon dioxide tank. Tanks would be supplied by a 3rd party gas supply company. Gas tank certification and compliance is provided by the gas supply organisation. Decanting of gases may occur, although this is anticipated to occur infrequently.

AS1894-1997 (Ref. 8) requires an area storing cryogenic liquids to be ventilated by either mechanical or natural ventilation. The bulk gases room has been designed to incorporate an entirely open louvre along the face of the room. Clause 3.5.4.2(a) describes suitable natural ventilation as:

"*Siting the vessel against an external wall and incorporating into that wall a wire mesh, lattice or louvred opening equivalent in size to the width of the vessel being installed, and of a height from floor level to the vessel fill point. The opening shall not incorporate any means of being sealed, nor allow discharge to areas of public congregation or into any basements, pits or trenches.*"

The size of the openings exceeds the dimensions of the vessel' hence, natural ventilation would be achieved as indicated by the standard.

Notwithstanding this, in the event a leak occurs within either tank, oxygen will be excluded from the rooms. Due to the volume of the tanks and their location within the building it will be necessary to install oxygen monitoring sensors and visual and audible alarms.

In addition, CO_2 may have a toxic effect at concentrations below the point where oxygen is excluded. Therefore, it may be necessary to have a CO_2 sensor located at low level (300 mm AFFL) near the CO_2 tank to ensure CO_2 accumulation does not occur within the store.

The store should be fitted with the following;

- Three (3) oxygen monitoring sensors around the room, one (1) senor should be located at each of the tanks and one (1) near the room entrance. The sensor near the CO2 should be located at low level (300 mm AFFL) and the N2 tank should be located at mid-level (1400 mm AFFL). The sensors at the entrance should be located at mid-level (1400 mm AFFL). The sensors should be set to trigger the alarms at oxygen levels of 18%;
- One (1) CO2 sensor located near the CO2 tank at low level (300 mm AFFL) and should activate at 0.5%;
- An audible alarm within the store indicating low oxygen content in the room;
- A visual alarm should be located at each entrance to the store (i.e. one (1) visual alarm) indicating low oxygen content in the room;
- Signage and placarding;
- Fire Protection as per Building Code of Australia (BCA); and
- Door seal on bulk liquefied gases room.

4.3 LG001 – PALEO PREP-SAMPLE (ON HOLD)

The paleontological sample sort room contains the following;

- Class 3 – 1 x 250 L Ventilated Cabinet
- Class 8 – 1 x 30 L Cabinet

Each item has been assessed below:

Class 3: An aggregate capacity of flammable liquids cabinets is located within the herbarium area, the petro prep lab and the paleontological acid baths room which would require 10 m separation to the next aggregate capacity of cabinets. To ensure compliance, it would be necessary to ensure the flammable liquids cabinet in the paleontological sample sort room is located at least 10 m from either of these rooms.

Flammable liquid cabinets should be vented to eliminate the requirement for a 3m hazardous zone surrounding the cabinet. This may be achieved via flexible joint, flame arrestor and steel ducting connected to a manifold line. The manifold fan should have a fan fault/failure device which triggers an alarm within the Building Management Control System (BMCS).

One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: The corrosive cabinet is not located within 5 m of another corrosive cabinet; hence, there are no additional requirements.

Summary of equipment: Based on the analysis the following will be required within the room;

- Class 3 cabinet located to allow 10 m separation to other flammable cabinet stores;
- 1 x Flexible connection;
- 1 x Flame arrestor;
- 1 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher.

4.4 LG004 - HERBARIUM FREEZER (ON HOLD)

The herbarium contains 1 x 250 L flammable liquids cabinet. The lower ground floor is accessible from the ground level; hence, is permitted to store 850 L aggregate capacity of flammable liquids cabinets per 250 m^2; therefore, this storage complies with the standard.

Flammable liquid cabinets should be vented to eliminate the requirement for a 3m hazardous zone surrounding the cabinet. This may be achieved via flexible joint, flame arrestor and steel ducting connected to a manifold line. The manifold fan should have a fan fault/failure device which triggers an alarm within the Building Management Control System (BMCS).

One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Class 3 cabinet located to allow 10 m separation to other flammable cabinet stores;
- 1 x Flexible connection;
- 1 x Flame arrestor;
- 1 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher.

4.5 LG010 – PALEO PREP – ACID BATH (ON HOLD)

The paleontological acid baths room contains the following;

- Class 3 – 1 x 250 L
- Class 3 – 1 x 30 L
- Class 8 – 1 x 30 L
- 1x Natural Gas (NG) Outlet
- Compressed Air
- Acid bath.

Each item has been assessed below:

Class 3: An aggregate capacity of flammable liquids cabinets is located within the herbarium area and the petro prep lab which would require 10 m separation to the next aggregate capacity of cabinets. To ensure compliance, it would be necessary to ensure the flammable liquids cabinets in the paleontological acid baths rooms are located at least 10 m from either of these rooms.

Flammable liquid cabinets should be vented to eliminate the requirement for a 3m hazardous zone surrounding the cabinet. This may be achieved via flexible joint, flame arrestor and steel ducting connected to a manifold line. The manifold fan should have a fan fault/failure device which triggers an alarm within the BMCS.

One (1) 4.5 kg dry powder extinguishers should be located within the store.

Class 8: The corrosive cabinet is not located within 5 m of another corrosive cabinet; hence, there are no additional requirements.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Acid Baths: The acid baths require a bund which extends at least 0.5 x the height of the acid baths away from the acid baths to ensure spill containment. The bund should be required to hold at least the volume of the largest vessel within the bund with an additional 10% for emergencies. The bund should be made of material that will not be corroded by the acid being stored.

Summary of equipment: Based on the analysis the following will be required within the room;

- Class 3 cabinets located to allow 10 m separation to other flammable cabinet stores;
- Fan fault/failure alarming within the BMCS;
- Local visual alarm, indicating fan flow failure, at the entrance to the room and audible alarm, indicating fan flow failure, within the room;
- 3 x Flexible connection;
- 3 x Flame arrestor;
- 3 x steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguishers.

4.6 LG011 – ROCKCUT (ON HOLD)

LG011 contains 2 x compressed air outlets which do not pose any hazards; hence, have not been assessed.

4.7 LG012 – PETRO PREP (ON HOLD)

The petrological specialist space 2 will contain;

Class 3 - 1 x 30 L cabinet.

Class 8 – 1 x 30 L cabinet.

There are no corrosive cabinets within 5 m; hence, there are no additional compliance requirements. These cabinets would be considered within the aggregate capacity of the area which is 850 L per 250 m^2; therefore, the store would comply with AS1940-2004. The area would require one (1) 4.5 kg dry chemical powder extinguisher.

4.8 LG014 – ROCK CRUSHING (ON HOLD)

LG014 contains 4 x compressed air outlets which do not pose any hazards; hence, have not been assessed.

4.9 LG020 - CHEMICAL STORE

The chemical store will store Class 3 and Class 8 DGs. Based on the storage quantities the following will be required;

- Bunding to contain approximately 500 L (no automatic sprinkler system);
- Electrical sources within the room are to comply with AS60079 series (Ref. 7) within 3 m of the storage area;
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Door with a FRL of -/120/30;
- Dampers with a minimum FRL of -/180/180 for any ductwork passing through the chemical store.
- One (1) 4.5 kg dry powder and one (1) foam extinguisher.

Review of the bund design indicates that it will have a 35 mm bund resulting in a total containment of 2.065 m^3 exceeding the specified requirement.

4.10 LG021 – COMPACTUS CHEMICAL STORE

The compactus chemical store will store

- Class 3 - 4 x 250 L cabinets
- Class 8 - 1 x 250 L cabinet.

Based on the storage quantities the following will be required;

- Bunding to contain approximately 500 L (no automatic sprinkler system);
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Door with a FRL of -/120/30;
- 4 x Flexible connection;
- 4 x Flame arrestor;
- 4 x steel cabinet ventilation duct work;
- Fan fault/failure alarming within the BMCS;
- A 3 m exclusion zone for ignition sources around the door of the compactus chemical; and
- Two (2) 4.5 kg dry powder extinguishers.

Review of the bund design indicates that it will have a 35 mm bund resulting in a total containment of 1.015 m^3 exceeding the specified requirement.

4.11 LG023 – GAS CYLINDER ROOM

The cylinder store contains approximately 80 'G' sized cylinders of various classes of gases including liquefied petroleum gas (LPG), hydrogen, oxygen and inert gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released, 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 59.4 m^3; hence, the volume of oxygen within the room is normally 0.21 x 59.4 = 12.5 m^3. Exclusion of the oxygen results in a concentration of (12.5-1.9)/59.4 = 17.8%. Therefore, it would be necessary to install oxygen monitoring sensors and visual and audible alarms within the store.

In addition, oxygen cylinders may be stored within the room which could release resulting in excessive oxygen within the room. The release of 9 m^3 of oxygen within the room would increase the concentration to (12.5+9)/59.4 = 36.2%.

The store should be fitted with the following;

- 2 oxygen monitoring sensors around the room, one (1) sensor should be located on the back wall opposite the entrance and one (1) located next to the entrance. The sensors should be located at mid-level (1400 mm AFFL) and should trigger the alarms at an oxygen concentration of 18% or 22.5%.
- An audible alarm within the store indicating low oxygen content in the room;
- Fan fault/failure alarming within the BMCS;
- A visual alarm should be located at each entrance to the store (i.e. one (1) visual alarm) indicating low oxygen content in the room;
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Ceiling with a FRL of 180/180/180;
- Door with a FRL of -/120/30;
- Mechanical ventilation;
- Electrical equipment to comply with AS60079 series (Ref. 7);
- Cylinder restraints; and
- At least one (1) hose reel and one (1) 4.5 kg fire extinguisher.

4.12 LG026 - CHEMICAL WASTE

This store will hold

- Class 3 - 1 x 250 L cabinets
- Class 8 - 1 x 250 L cabinet
- Class 6.1 – 1 x 100 L cabinet

Based on the storage quantities and operations that may occur within the room, the following will be required;

- Bunding to contain approximately 500 L (no automatic sprinkler system);

- Electrical sources within the room are to comply with AS60079 series (Ref. 7) within 3 m of the storage area;
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Door with a FRL of -/120/30; and
- One (1) 4.5 kg dry powder and one (1) foam extinguisher.

Review of the bund design indicates that it will have a 35 mm bund resulting in a total containment of 1.225 m^3 exceeding the specified requirement.

4.13 LG028 - CRYO STORE

This store will house a range of liquid nitrogen Dewars as follows;

- 1 x 800 L tank
- 6 x 20 L
- 2 x 40 L
- 2 x 80 L
- N_2 pipework

Liquid nitrogen will evaporate forming nitrogen gas which expands significantly from the liquid volume. As nitrogen gas is formed it may exclude oxygen within the store resulting in an oxygen deficient atmosphere. Liquid nitrogen has an expansion ratio of approximately 1:682 at 15^{o}C (Ref. 6).

If an 80 L Dewar was to spill, the gas generated from the evaporation of the liquid nitrogen would be 54.6 m^3. The cryo store has a volume of 108 m^3; hence, nitrogen would exclude oxygen from the room. Therefore, the cryo store would be required to be fitted with oxygen monitoring sensors and visual and audible alarms. The visual alarm should be located external to the room.

The store should be fitted with the following;

- 2 oxygen monitoring sensors located at mid-level (1400 mm Above Fixed Floor Level (AFFL)) around the room and within the vicinity of the Dewars and close to entrances. The sensors should be set to trigger the alarms at oxygen levels of 18%;
- Fan fault/failure alarming within the BMCS;
- An audible alarm within the store;
- A visual alarm should be located at each entrance to the store (i.e. 2 visual alarms);
- Solenoid valve on N2 supply line interlocked with the ventilation flow detection.
- Signage and placarding; and
- Fire Protection as per Building Code of Australia (BCA).

4.14 LG030 – FIELD GEAR PREP

LG030 contains a compressed air outlet which do not pose any hazards; hence, have not been assessed.

4.15 LG031 – DIVE GEAR

The Scuba room contains the following;

- 12 x Scuba Cylinders

Each item has been assessed below:

Scuba: Scuba cylinders contain air and do not pose significant hazard within the store. There are no further requirements for this room.

4.16 LGQ75 - DIESEL TANK ROOM

A 2 x 5,000 L diesel tank will be stored on the ground floor. The following items are required for the installation;

- A tank with integral secondary containment with a FRL of 240/240/240;
- Liquid level indication;
- Overfill protection;
- Overfill alarm;
- One (1) dry powder extinguisher;
- Any venting to be vented to the outdoors;
- Vent piping shall fall consistently back to the tank at a slope of at least 1 in 100;
- Vent pipe shall not pass through building foundations but may be embedded in concrete that is part of the other building construction;
- Where vent piping penetrates a fire-rated wall, it shall be installed so as to ensure that the fire resistance of the wall is maintained;
- Joints in vent piping shall be sealed to prevent liquid or vapour release and tested to a minimum hydrostatic pressure of 35 kPa;
- The vent discharge point shall be located laterally at least 2 m from any opening into a building;
- The vent discharge point shall be located at least 4 m above ground level;
- Where the tank is to be filled by gravity flow from a tank vehicle, the vent discharge point for the tank shall be at least 4 m above ground level at the fill point and in all circumstances shall be higher than the tank vehicle; and
- The discharge end of the vent shall be protected from the ingress of foreign material by means of protected cage or fitting.

4.17 DESIGN SUMMARY

Each of the design requirements for the Lower Ground Level are summarised in the following subsections.

4.17.1 LGR01 - Bulk Gases

LGR01 (Bulk Gases) will be fitted with 3 oxygen monitoring sensors around the room which are located at the entrance to the room and one at each of the tanks. The sensors at the entrance and the nitrogen tank will be located at 1400 mm AFFL while the sensor near the carbon dioxide tank will be located at 300 mm AFFL. A carbon dioxide sensor will be located near the carbon dioxide tank at 300 mm AFFL.

In the event that oxygen deficiency is detected with the room the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- Audible alarm activated at the gas alarm panel; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

4.17.2 LG023 - Cylinder Store

LG023 will be fitted with 2 oxygen monitoring sensors around the room each located at 1400 mm AFFL. In the event that oxygen deficiency is detected with the room the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- Audible alarm activated at the gas alarm panel; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

The store is constructed of walls with a FRL of 240/240/240.

4.17.3 LG028 - Cryo Store

LG028 will be fitted with 2 oxygen monitoring sensors around the room each located at 1400 mm AFFL. In the event that oxygen deficiency is detected with the room the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- Audible alarm activated at the gas alarm panel;
- N_2 gas supply will be isolated to the zone via a solenoid; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

4.17.4 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

4.17.5 Flammable Liquids Cabinets and Chemical Stores

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

LG020, LG021 and LG026 will be designed with walls with an FRL of 240/240/240 and doors with a FRL of -/120/30. The potential for spills or potentially contaminated liquid will be managed via bunding of these spaces. Bunding is achieved via a 35 mm set down which allows containment of spills from the cabinets and a portion of liquid from an emergency response. The minimum containment of these three rooms is 1.015 m^3 which exceeds the specified requirement for all stores.

5 GROUND FLOOR - DG STORAGE ASSESSMENT

5.1 INTRODUCTION

The following rooms are located on the Ground Floor and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 5.4**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

5.2 G001, G002, G006, G007 – TEACING LABS 01 TO 04

G001, G002, G006 and G007 contain the following;

- Class 8 – 1 x 30 L Cabinet (G002 & G006)
- Class 3 – 2 x 250 L Cabinet (G001)
- Class 3 – 1 x 30 L Cabinet (G002 & G006)
- 1-12 x NG Gas Outlet
- 1 x CO_2 Gas Outlet
- 5 x Compressed Air Outlet

Each item has been assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with a ventilation system that will not operate after hours. The longest period that the system will not be operating is between 6 pm on a Friday until 7 am on a Monday morning totalling 61 hours. Natural gas is released at a rate of 0.288 m^3/h which results in a total release of 61 x 0.288 = 17.6 m^3. The room has an area of 213 m^3; hence, a NG atmosphere 17.6/213 = 80 mm deep will occur in the event of NG release and the ventilation system is not in operation.

Accumulation may result in the formation of a hazardous atmosphere at ceiling height; therefore, the ventilation system should be designed to operate once every 5 hours for 20 minutes to exhaust any NG that may accumulate in the event of an opened tap.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. It is noted that the system is not in operation after hours; hence, the system should operate every 5 hours for 20 minutes to exhaust any accumulated gases that may have occurred in a tap failure/opened scenario.

CO_2: CO_2 may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 575.1 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{575.1 \times 0.21 \times 6}{1.2 + (575.1 \times 6)} = 21\%$$

The room is fitted with a ventilation system that will not operate after hours. The longest period that the system will not be operating is between 6 pm on a Friday until 7 am on a Monday morning totalling 61 hours. CO_2 is released at a rate of 1.2 m^3/h which results in a total release of 61 x 1.2 = 73.2 m^3. The room has an area of 213 m^3; hence, a CO_2 atmosphere 73.2/213 = 340 mm deep will occur in the event of CO_2 release and the ventilation system is not in operation. Accumulation may result in the formation of a hazardous atmosphere at floor level; therefore, the ventilation system should be designed to operate once every 5 hours for 20 minutes to exhaust any CO_2 that may accumulate in the event of an opened tap.

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 575.1 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{575.1 \times 0.0004 \times 6 + 1.2}{1.2 + (575.1 \times 6)} = 0.075\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.075% resulting in a volume of CO_2 within the lab of 0.4 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.002 m deep and would not pose a risk to personnel within the laboratory.

Compressed Air: No hazards are posed by compressed air.

Class 8: There are no other requirements for the storage of this cabinet.

Class 3: The class 3 cabinets are located on the ground floor and so are able to be stored in an aggregate capacity of 850 L per 250 m^2. This complies with the standard; hence, there are no additional requirements.

One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- Audio and visual alarms which are activated upon detection of fan fault/failure. The audio alarms should be located within the laboratory while the visual alarm should be located at the entrances to the laboratory; and
- Ventilation system to operate once every 5 hours for 20 minutes.
- One (1) 4.5 kg dry powdered extinguisher located within the store.

5.3 G005 - WET TEACHING PREP

Wet teaching prep contains the following;

- Class 8 – 1 x 30 L Cabinet
- Class 3 – 3 x 250 L Cabinet
- Class 3 – 1 x 30 L Cabinet
- 1 x CO2 Gas Outlet
- 1 x NG Gas Outlet

Each item has been assessed below:

Class 8: There are no other requirements for the storage of this cabinet.

Class 3: The class 3 cabinets are located on the ground floor and so are able to be stored in an aggregate capacity of 850 L per 250 m^2. This complies with the standard; hence, there are no additional requirements.

Flammable liquid cabinets should be ventilated to eliminate the requirement for a 3 m hazardous zone surrounding the cabinet. This may be achieved via flexible joint, flame arrestor and steel ducting connected to a manifold line. The manifold fan should have a fan fault/failure device which trigger an alarm within the BMCS.

One (1) 4.5 kg dry powdered extinguisher should be located within the store.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with a ventilation system that will not operate after hours. The longest period that the system will not be operating is between 6 pm on a Friday until 7 am on a Monday morning totalling 61 hours. Natural gas is released at a rate of 0.288 m^3/h which results in a total release of 61 x 0.288 = 17.6 m^3. The room has an area of 213 m^3; hence, a NG atmosphere 17.6/213 = 80 mm deep will occur in the event of NG release and the ventilation system is not in operation. Accumulation may result in the formation of a hazardous atmosphere at ceiling height; therefore, the ventilation system should be designed to operate once every 5 hours for 20 minutes to exhaust any NG that may accumulate in the event of an opened tap.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. It is noted that the system is not in operation after hours; hence, the system should operate every 5 hours for 20 minutes to exhaust any accumulated gases that may have occurred in a tap failure/opened scenario.

CO_2: CO_2 may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 575.1 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{575.1 \times 0.21 \times 6}{1.2 + (575.1 \times 6)} = 21\%$$

The room is fitted with a ventilation system that will not operate after hours. The longest period that the system will not be operating is between 6 pm on a Friday until 7 am on a Monday morning totalling 61 hours. CO_2 is released at a rate of 1.2 m^3/h which results in a total release of 61 x 1.2 = 73.2 m^3. The room has an area of 213 m^3; hence, a CO_2 atmosphere 73.2/213 = 340 mm deep will occur in the event of CO_2 release and the ventilation system is not in operation. Accumulation may result in the formation of a hazardous atmosphere at floor level; therefore, the ventilation system should be designed to operate once every 5 hours for 20 minutes to exhaust any CO_2 that may accumulate in the event of an opened tap.

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 575.1 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{575.1 \times 0.0004 \times 6 + 1.2}{1.2 + (575.1 \times 6)} = 0.075\ \%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.075% resulting in a volume of CO_2 within the lab of 0.4 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.002 m deep and would not pose a risk to personnel within the laboratory.

Compressed Air: No hazards are posed by compressed air.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- Audio and visual alarms which are activated upon detection of fan fault/failure. The audio alarms should be located within the laboratory while the visual alarm should be located at the entrances to the laboratory; and
- CO_2 supply line solenoid valve interlocked with ventilation flow detection;
- 2 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) dry powder extinguisher.

5.4 DESIGN SUMMARY

Each of the design requirements for the Ground Level are summarised in the following subsections.

5.4.1 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

5.4.2 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be

fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

6 LEVEL 1 - DG STORAGE ASSESSMENT

6.1 INTRODUCTION

Level 1 has not been assessed as the design has not been finalised.

6.2 1101 – TEACHING LAB 08

1101 contains the following;

- 65 x NG Gas Outlet
- 2 x N_2 Gas Outlet
- 2 x Compressed Air Outlet
- Class 8 – 1 x 30 L cabinet

Each item has been assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

N_2: Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3.** The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 640 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{640 \times 0.21 \times 6}{2.4 + (640 \times 6)} = 21\%$$

Provided the ventilation system is operating, N_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of N_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 is supplied from bulk gases which provides a large reservoir; hence, the N_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Class 8: There are no other requirements for the storage of this cabinet.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.

6.3 1102 – TEACHING LAB 07

1102 contains the following;

- 64 x NG Gas Outlet
- 4 x CO_2 Gas Outlet

Each item has been assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. It is noted that the system is not in operation after hours; hence, the system should operate every 5 hours for 20 minutes to exhaust any accumulated gases that may have occurred in a tap failure/opened scenario.

CO_2: CO_2 may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 643 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 4 x 20 x 60 = 4800 L/h = 4.8 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{643 \times 0.21 \times 6}{4.8 + (643 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 643 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 4 x 20 x 60 = 4800 L/h = 4.8 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{643 \times 0.0004 \times 6 + 4.8}{4.8 + (643 \times 6)} = 0.5\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.5% resulting in a volume of CO_2 within the lab of 3.2 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.013 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

6.4 1103 – OPEN LABORATORY

1103 contains the following;

- 24 x NG Gas Outlet
- 3 x Compressed Air Outlet

Each item has been assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS.

6.5 1104 – CHEMISTRY

1104 contains the following;

- 24 x NG Gas Outlet
- 3 x Compressed Air Outlet
- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet

Each item has been assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Class 8: This cabinet is located >5 m from another corrosive substance cabinet; hence, there is no further compliance requirements.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS.

6.6 1106/1107 – TISSUE CULTURE

Each tissue culture room contains;

- 1 x 100 L Liquid Nitrogen Dewar
- 6 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet

Each item has been assessed below:

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15°C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.1 x 682 = 68.2 m^3 of gas which exceeds the volume within the room (67.5 m^3) resulting in the exclusion of oxygen. Therefore, oxygen monitoring and visual and audible alarms would be required.

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 8 x 20 L/min x 60 = 9600L/h = 9.6 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5\times 0.21\times 6}{9.6 + (67.5\times 6)} = 20.4\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 x 60 = 7200 L/h = 7.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5\times 0.0004\times 6 + 7.2}{7.2 + (67.5\times 6)} = 1.78\ \%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.78% resulting in a volume of CO_2 within the lab of 1.2 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.05 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: The room should be fitted with the following;

- One (1) oxygen monitoring sensor located at mid-level (1400 mm AFFL) within the vicinity of the Dewar. The sensors should be set to trigger the alarms at oxygen levels of 18%;
- Fan fault/failure alarming within the BMCS;
- A visual alarm, indicating low oxygen levels, should be located at each entrance to the store (i.e. one (1) visual alarm);
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.

6.7 1108 – INSTRUMENT

1108 contains;

- 1 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet
- 1 x NG Gas Outlet
- 2 x Compressed Air Outlet
- Class 8 – 1 x 250 L Cabinet
- Class 3 – 2 x 250 L Cabinet
- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet

Each item is assessed below:

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 138 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 3 x 20 L/min x 60 = 3600L/h = 3.6 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{138 \times 0.21 \times 6}{3.6 + (138 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 138 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{138 \times 0.0004 \times 6 + 1.2}{1.2 + (138 \times 6)} = 0.5\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.5% resulting in a volume of CO_2 within the lab of 0.75 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.015 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 8: This cabinet is located >5 m from another corrosive substance cabinet; hence, there is no further compliance requirements.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinet is 250 L and is vented to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards. The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure alarming within the BMCS; and

- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- Solenoid valve on N_2 supply line interlocked with the ventilation system 1 x Flexible connection;
- 1 x Flame arrestor;
- 1 x Steel cabinet ventilation duct work;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher.

6.8 1114 – TISSUE CULTURE

1114 contains;

- 1 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet
- 2 x Compressed Air Outlet

Each item is assessed below:

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \times 0.21 \times 6}{1.2 + (32.4 \times 6)} = 20.6\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{32.4 \times 0.0004 \times 6 + 1.2}{1.2 + (32.4 \times 6)} = 1.0\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1% resulting in a volume of CO_2 within the lab of 0.32 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.03 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

6.9 1115 – PC2 PREP

1115 contains;

- 8 x NG Gas Outlet
- 2 x Compressed Air Outlet
- Class 3 – 1 x 250 L Cabinet

Each item is assessed below:

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in **Appendix A** to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinet is 250 L and is vented to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards. The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- 1 x Flame arrestor;
- 1 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher.

6.10 DESIGN SUMMARY

Each of the design requirements for Level 1 are summarised in the following subsections.

6.10.1 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel;
- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- N_2 or CO_2 gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;
  - 1101
  - 1106
  - 1107
  - 1108
  - 1114

6.10.2 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

7 LEVEL 2 - DG STORAGE ASSESSMENT

7.1 INTRODUCTION

The following rooms are located on Level 2 and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 7.16**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

7.2 2022 - GAS MANIFOLD

The cylinder store contains approximately 7 'G' sized cylinders including;

- 1 x argon
- 1 x compressed air
- 1 x CO_2
- 1 x N_2
- 3 x nitrogen manifold
- 1 x helium
- 1 x N_2/Helium mix

A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released, 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 30 m^3; hence, the volume of oxygen within the room is normally 0.21 x 30 = 6.3 m^3. Exclusion of the oxygen results in a concentration of (6.3-1.9)/30 = 14.7%. Therefore, it would be necessary to install oxygen monitoring sensors and visual and audible alarms within the store.

The store should be fitted with the following:

- One (1) oxygen monitoring sensor should be located in the room. The sensor should be located at mid-level (1400 mm AFFL) and should trigger the alarms at an oxygen concentration of 18%.
- An audible alarm within the store;

- A visual alarm should be located at each entrance to the store (i.e. one (1) visual alarm); and
- Cylinder restraints.

7.3 2000 – CELL SPEC

The prep lab spec room contains the following;

- 2 x N_2 Gas Outlet
- 1 x Compressed Air Gas Outlet
- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet
- 1 x 100 L Liquid Nitrogen Dewar

Each item has been assessed below:

N_2: Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3.** The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{2.4 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, N_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of N_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 is supplied from bulk gases which provides a large reservoir; hence, the N_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Class 8: This cabinet is located >5 m from another corrosive substance cabinet; hence, there is no further compliance requirements.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15°C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.x 682 = 68.2 m^3 of gas which exceeds the volume within the room resulting in the exclusion of oxygen. Therefore, oxygen monitoring and visual and audible alarms would be required.

Summary of equipment: The store should be fitted with the following;

- One (1) oxygen monitoring sensor located at mid-level (1400 mm AFFL) within the vicinity of the Dewar. The sensors should be set to trigger the alarms at oxygen levels of 18%;
- Fan fault/failure alarming within the BMCS;
- An audible alarm within the store indicating low oxygen concentration in the room;
- A visual alarm should be located at each entrance to the store (i.e. one (1) visual alarm) indicating low oxygen concentration in the room;
- Solenoid valve on N_2 supply line interlocked with the ventilation system; and
- One (1) dry powder extinguisher.

7.4 2001 - CELL ANALYSERS

The cell analysers contain

- 1 x CO_2 Gas Outlet
- 3 x CA Outlet

Each item has been assessed below:

Class 2 Cabinet: a review of AS2647-2000 (Ref. 5) indicates there are no additional requirements for these cabinets other than the appropriate biohazard signage.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 214 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200 L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{213\times0.21\times6}{1.2+(213\times6)} = 0.13\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 213 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2:

$$C_{CO2} = \frac{213 \times 0.0004 \times 6 + 1.2}{1.2 + (213 \times 6)} = 0.13\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.13% resulting in a volume of CO_2 within the lab of 0.4 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.0035 m deep and would not pose a risk to personnel within the laboratory.

Summary of equipment: The store should be fitted with the following;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on CO_2 supply line interlocked with the ventilation system.

7.5 2002 - PREP AND BPA

The prep and analysis room contains the following;

- 6 x N_2 Gas Outlet
- 6 x Compressed Air Gas Outlet
- 3 x NG Gas Outlet
- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet

Each item has been assessed below:

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

N_2: Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 407.7 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 L/min x 60 = 7200 L/h = 7.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{407.7 \times 0.21 \times 6}{7.2 + (407.7 \times 6)} = 21\%$$

Provided the ventilation system is operating, N_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of

N_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 is supplied from bulk gases which provides a large reservoir; hence, the N_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 8: A review of AS3780-2008 (Ref. 2) indicates there are no other specific requirements for this storage.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- Solenoid valve on N_2 supply line interlocked with the ventilation system.
- Biohazard symbol signage; and
- One (1) 4.5 kg dry powder extinguisher.

7.6 2003 - PRE AMP

The pre prep amp contains the following;

- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet

Each item has been assessed below:

Class 8: This cabinet is located >5 m from another corrosive substance cabinet; hence, there is no further compliance requirements.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- One (1) dry powder extinguisher.

7.7 2005 - POST AMP

The post prep amp contains the following;

- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet

Each item has been assessed below:

Class 8: This cabinet is located >5 m from another corrosive substance cabinet; hence, there is no further compliance requirements.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- One (1) dry powder extinguisher.

7.8 2006 - RPRL ROOM

The SSBA Room contains the following;

- 6 x CO_2 Gas Outlet

Each item has been assessed below:

CO_2: carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 140.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 L/min x 60 = 7200 L/h = 7.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{140.4 \times 0.21 \times 6}{7.2 + (140.4 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with a single fan for air supply and exhaust; however, an additional exhaust system is provided which yields air exchange rates of 4 air changes per hour. Substituting this reduced extraction system into the oxygen concentration calculation yields;

$$C_{Oxygen} = \frac{140.4 \times 0.21 \times 4}{7.2 + (140.4 \times 4)} = 20.7\%$$

The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 140.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 x 60 = 7200 L/h = 7.2 m^3/h

Concentration of CO_2:

$$C_{CO2} = \frac{140.4 \times 0.0004 \times 6 + 7.2}{7.2 + (140.4 \times 6)} = 0.89\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.89% resulting in a volume of CO_2 within the lab of 1.25 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.024 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation flow detection; and
- Biohazard symbol signage.

7.9 2008 – INSTRUMENTATION ARRAYS AND ROBOTICS

2008 contains 5 x compressed air outlets which do not pose any hazards; hence, have not been assessed.

7.10 2010 - CHEM STORE

The chem store contains the following;

- Class 8 – 2 x 30 L
- Class 3 – 1 x 250 L

Each item is assessed below:

Class 8: The corrosive cabinet is not located with 5 m of another corrosive store; hence, there is no further requirement for this store.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinet is 250 L and is vented to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards. The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Summary of equipment: Based on the analysis the following will be required within the room;

- 1 x Flexible connection;
- 1 x Flame arrestor;
- 1 x Steel cabinet ventilation duct work;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher.

7.11 2012 - MASS SPEC

The cell sorter room contains the following;

- 10 x N_2 Gas Outlet
- 8 x Helium/N_2 Gas Outlet
- 4 x Argon Gas Outlet

Each item has been assessed below:

Class 2.2 Gases: Nitrogen, argon, and helium may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 210.6 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 22 x 20 L/min x 60 = 26400L/h = 26.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{210.6 \times 0.21 \times 6}{26.4 + (210.6 \times 6)} = 20.5\%$$

Provided the ventilation system is operating, N_2, Helium and Argon will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 is supplied from bulk gases which provides a large reservoir; hence, the N_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on N_2 supply line interlocked with the ventilation flow detection.

7.12 2013 - MICROSCOPE 1

The microscope 1 room contains the following;

- 4 x N_2 Gas Outlet
- 5 x CO_2 Gas Outlet
- 5 x Compressed Air Gas Outlet

Each item has been assessed below:

CO_2 & N_2: Nitrogen and carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 140.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 9 x 20 L/min x 60 = 10800L/h = 10.8 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{140.4 \times 0.21 \times 6}{10.8 + (140.4 \times 6)} = 20.7\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 140.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 5 x 20 x 60 = 6000 L/h = 6 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{140.4 \times 0.0004 \times 6 + 6}{6 + (140.4 \times 6)} = 0.75\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.75% resulting in a volume of CO_2 within the lab of 1.05 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.02 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.

7.13 2014 - MICROSCOPE 1

The microscope 1 room contains the following;

- 2 x N_2 Gas Outlet
- 2 x CO_2 Gas Outlet
- 2 x Compressed Air Gas Outlet

Each item has been assessed below:

CO_2 & N_2: Nitrogen and carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 4 x 20 L/min x 60 = 4800L/h = 4.8m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \times 0.21 \times 6}{4.8 + (32.4 \times 6)} = 20.5\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{32.4\times0.0004\times6 + 2.4}{2.4 + (32.4\times6)} = 1.26\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.26% resulting in a volume of CO_2 within the lab of 0.41 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.03 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.

7.14 2015 - CELL SORTER

The cell sorter room contains the following;

- 1 x Compressed Air Outlet
- 1 x Argon Gas Outlet

Each item has been assessed below:

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Argon: Argon may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \times 0.21 \times 6}{1.2 + (32.4 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, argon will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with an argon release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS.

7.15 DESIGN SUMMARY

Each of the design requirements for the Level 2 are summarised in the following subsections.

7.15.1 2000 – Prep Lab

Laboratory 2000 will be fitted with one oxygen monitoring sensor which will be located 1400 mm AFFL. In the event that oxygen deficiency is detected, an audible alarm within the room will activate in addition to a visual alarm at the entrance. The nitrogen supply to the laboratory will be isolated.

7.15.2 2022 – Gas Manifold

The gas manifold room will be fitted with an oxygen monitoring sensor which will be located 1400 mm AFFL. In the event that oxygen deficiency is detected with the rooms the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- BMCS alarm signal sent to head end to notify laboratory managers and security;
- Cylinder restraints.

7.15.3 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel;
- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- N2 or CO2 gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;
    - 2000
    - 2002
    - 2006
    - 2010

- 2012
- 2013
- 2014

7.15.4 Isolation

Each wing will be fitted with an emergency push button. The push button will deactivate the following services within laboratories within the designated zone;

- Power (non-essential and essential);
- Laboratory gases (all lab gases – not including vacuum or compressed air);
- Natural Gas (in labs where applicable); and
- BMCS alarm single sent to head end to notify laboratory managers and security.

7.15.5 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

8 LEVEL 3 - DG STORAGE ASSESSMENT

8.1 INTRODUCTION

The following rooms are located on Level 3 and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 8.11**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

8.2 3059 - GAS MANIFOLD

The cylinder store contains approximately 6 ‘G’ sized cylinders of various classes predominately Class 2.2 gases. A ‘G’ sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released, 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 6 m^3; hence, the volume of oxygen within the room is normally 0.21 x 6 = 1.3 m^3. The oxygen cylinder would therefore exclude all oxygen within the room.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. Therefore, if the gas can be discharged out of the room, oxygen depletion will not occur. Therefore, if the doors of the store are fitted with louvred grilles at the base and the top of the doors, the gas will be able to be discharged from the store preventing accumulation.

The store should be fitted with the following:

- Louvred grilles in the base and top of the access door.
- Cylinder restraints.

8.3 3001 – MICROSCOPE ROOM

The microscope room contains;

- 1 x Compressed Air Outlet
- 2 x CO_2 Gas Outlet

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{2.4 + (67.5 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{6735 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on CO2 supply interlocked with the ventilation system.

8.4 3002, 3005 – OPEN LABORATORY

Each molecular/cell room contains the following;

- 1 x Compressed Air Outlet
- 1 x CO_2 Gas Outlet
- 14 x NG Gas Outlet (3002), 12 x NG Gas Outlet (3005)

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on CO_2 supply interlocked with the ventilation system.

8.5 3006, 3007 - MICROSCOPE

Each microscope room contains;

The microscope room contains;

- 2 x Compressed Air Outlet
- 2 x CO_2 Gas Outlet

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{2.4 + (67.5 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- Solenoid valve on CO_2 supply interlocked with the ventilation system.

8.6 3008, 3013, 3019, 3021, 3022 – TISSUE CULTURE

Each tissue culture room contains;

- 1 x 100 L Liquid Nitrogen Dewar
- 6 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet

Each item has been assessed below:

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15°C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.1 x 682 = 68.2 m^3 of gas which exceeds the volume within the room (67.5 m^3) resulting in the exclusion of oxygen. Therefore oxygen monitoring and visual and audible alarms would be required.

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 8 x 20 L/min x 60 = 9600L/h = 9.6 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{9.6 + (67.5 \times 6)} = 20.4\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 x 60 = 7200 L/h = 7.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 7.2}{7.2 + (67.5 \times 6)} = 1.78\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.78% resulting in a volume of CO_2 within the lab of 1.2 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.05 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: The store should be fitted with the following;

- One (1) oxygen monitoring sensor located at mid-level (1400 mm AFFL) within the vicinity of the Dewar. The sensors should be set to trigger the alarms at oxygen levels of 18%;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.
- Biohazard symbol signage;
- One (1) 4.5 kg dry powder extinguisher.

8.7 3009 – EQUIPMENT ROOM

Each equipment rooms contain the following;

- 1 x CO_2 Gas Outlet
- 1 x Compressed Air Outlet

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- Solenoid valve on CO_2 supply interlocked with the ventilation system.

8.8 3011/3012 – RADIOISOT

3012 contains;

- Class 8 – 1 x 30 L cabinet
- Class 3 – 1 x 30 L cabinet

Each item is assessed below:

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{2.4 + (67.5 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 3: AS1940-2004 (Ref. 1) indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: AS3780-2008 (Ref. 2) indicates that no more than 250 L of corrosive substances cabinets can be stored per floor. A review of the corrosive substance cabinets on the level indicates this requirement may be exceeded; however, the cabinets are stored beneath fume cupboards which prevents accumulation of corrosive vapours around the cabinets; hence, it is considered that exceedance of the 250 L is permissible due to the additional safety controls.

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system.
- One (1) x dry powder fire extinguisher.

8.9 3014, 3018 - EQUIPMENT ROOM INSTRUMENTS

Each equipment room contains the following;

- 1 x CO_2 Gas Outlet

- 2 x N_2 Gas Outlet
- 2 x Compressed Air Outlet
- 1 x NG Outlet (3014)
- Class 3 – 1 x 30 L Cabinet (Only 3014)
- Class 8 – 1 x 30 L Cabinet (Only 3014)
- 4 x G sized Gas Cylinders (3014)

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 3 x 20 L/min x 60 = 3600L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{3.6 + (67.5 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33%

resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 3: AS1940-2004 (Ref. 1) indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provide continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: AS3780-2008 (Ref. 2) indicates that no more than 250 L of corrosive substances cabinets can be stored per floor. A review of the corrosive substance cabinets on the level indicates this requirement may be exceeded; however, the cabinets are stored beneath fume cupboards which prevents accumulation of corrosive vapours around the cabinets; hence, it is considered that exceedance of the 250 L is permissible due to the additional safety controls.

Gas Cylinders: The room contains 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 62.5 m^3; hence, the volume of oxygen within the room is normally 0.21 x 62.5 = 6.8 m^3. The oxygen cylinder would therefore reduce the oxygen concentration to 18% which would not result in any injuries.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. The rooms are ventilated; hence, excluded oxygen would be rapidly replaced preventing a critical oxygen levels from occurring.

The store should be fitted with the following:

- Cylinder restraints.

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- Solenoid valve on N_2 supply line interlocked with the ventilation system;
- One (1) dry powder extinguisher; and

- Cylinder restraints.

8.10 3017 - STORAGE

The chemical store contains the following;

- 1 x CO_2 Gas Outlet
- 1 x Compressed Air
- Class 3 – 2 x 250 L Cabinet
- Class 8 - 2 x 250 L Cabinet
- Class 3 – 1 x 30 L cabinet
- Class 8 – 1 x 30 L cabinet
- 1 x NG Gas Outlet

Each item has been assessed below;

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 130 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{130 \times 0.21 \times 6}{1.2 + (130 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 130 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{130 \times 0.0004 \times 6 + 1.2}{1.2 + (130 \times 6)} = 0.19\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.19% resulting in a volume of CO_2 within the lab of 0.25 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.005 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 3: This store contains 1000 L of flammable liquid cabinets which exceeds the aggregate capacity. To comply with the standard, it would be necessary to construct this incorporating the following;

- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Floor with a FRL of 180/180/180;
- Bunding capable of containing 500 L;
- Doors with a FRL of -/120/30;
- Appropriate placarding and signage; Flexible connection;
- 2 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguishers not located within 3 m and not further than 10 m from the cabinets.

Review of the bund design indicates that it will have a 35 mm bund resulting in a total containment of 1.645 m^3 exceeding the specified requirement.

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- Solenoid valve on CO_2 supply interlocked with the ventilation system.
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;

- Floor with a FRL of 180/180/180;
- Bunding capable of containing 500 L;
- Doors with a FRL of -/120/30;
- Appropriate placarding and signage;
- 2 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguishers not located within 3 m and not further than 10 m from the cabinets.

8.11 DESIGN SUMMARY

Each of the design requirements for the Level 3 are summarised in the following subsections.

8.11.1 3059 – Gas Manifold

The gas manifold room will be fitted with louvred grilles at the base and top of the access door to allow gas dispersion should a release occur within the store. Cylinders shall be restrained.

8.11.2 3008, 3013, 3019 3021, 3022

Each room will be fitted with an oxygen sensor located 1400 mm AFFL within the vicinity of the liquid nitrogen Dewars. In the event that oxygen deficiency is detected with the rooms the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- Audible alarm activated at the gas alarm panel;
- Gas supply will be isolated to the zone via a solenoid; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

8.11.3 3017 – Chemical Store

3017 will be designed with walls with an FRL of 240/240/240 and doors with a FRL of -/120/30. The potential for spills or potentially contaminated liquid will be managed via bunding of these spaces. Bunding is achieved via a 35 mm set down which allows containment of 1.645 m^3 of spills from the cabinets and a portion of liquid from an emergency response.

8.11.4 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel;
- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- Gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;

  - 3002
  - 3005
  - 3006
  - 3007
  - 3008
  - 3009
  - 3011/3012
  - 3013
  - 3014
  - 3017
  - 3018
  - 3019
  - 3021
  - 3022

8.11.5 Isolation

Each wing will be fitted with an emergency push button. The push button will deactivate the following services within laboratories within the designated zone;

- Power (non-essential and essential);
- Laboratory gases (all lab gases – not including vacuum or compressed air);
- Natural Gas (in labs where applicable); and
- BMCS alarm single sent to head end to notify laboratory managers and security.

8.11.6 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

9 LEVEL 4 - DG STORAGE ASSESSMENT

9.1 INTRODUCTION

The following rooms are located on Level 4 and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 9.11**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

9.2 4059 - GAS MANIFOLD

The cylinder store contains approximately 6 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 6 m^3; hence, the volume of oxygen within the room is normally 0.21 x 6 = 1.3 m^3. The oxygen cylinder would therefore exclude all oxygen within the room. Therefore, it would be necessary to install oxygen monitoring sensors and visual and audible alarms within the store.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. Therefore, if the gas can be discharged out of the room, oxygen depletion will not occur. Therefore, if the doors of the store are fitted with louvred grilles at the base and the top of the doors, the gas will be able to be discharged from the store preventing accumulation.

The store should be fitted with the following:

- Louvred grilles in the base and top of the access door.
- Cylinder restraints.

9.3 4001, 4004, 4005 – OPEN LABORATORY

Each of these rooms contain the following;

- 1 x Compressed Air Outlet

- 1 x CO_2 Gas Outlet
- 14 x NG Gas Outlet (4001 & 4005)

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air; hence, it has not been assessed.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

9.4 4002 - MICROBIO

The negative pressure micro room contains the following;

- 2 x CO_2 Gas Outlet
- 2 x NG Gas Outlet
- 1 x 100 L Liquid Nitrogen Dewar

Each item is assessed below:

CO_2: Carbon dioxide and methane may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 64.8 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400 L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{64.8 \times 0.21 \times 6}{2.4 + (64.8 \times 6)} = 20.8\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 64.8 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 24200 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{64.8 \times 0.0004 \times 6 + 2.4}{2.4 + (64.8 \times 6)} = 0.65\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.65% resulting in a volume of CO_2 within the lab of 0.42 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.018 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15^{o}C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.1 x 682 = 68.2 m^3 of gas. The room has a volume of 64.8 m^3; hence, the nitrogen will exclude the full volume of air within the room. Therefore, oxygen monitoring and visual and audible alarms would be required for the room.

Summary of equipment: The store should be fitted with the following;

- One (1) oxygen monitoring sensor located at mid-level (1400 mm AFFL) within the vicinity of the Dewar. The sensors should be set to trigger the alarms at oxygen levels of 18%;
- Fan fault/failure alarming within the BMCS;
- An audible alarm within the store indicating low oxygen concentration in the room; and
- A visual alarm, indicating low oxygen concentration in the room, should be located at each entrance to the store (i.e. one (1) visual alarm);
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Biohazard symbol signage.

9.5 4006 - ICE CORE

The ice lab room contains the following;

- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet
- Liquid Nitrogen Dewar (100 L)
- 2 x G sized Gas Cylinders (O_2 and CO_2)

Each item has been assessed below;

Class 3: AS1940-2004 (Ref. 1) indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provides continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: AS3780-2008 (Ref. 2) indicates that no more than 250 L of corrosive substances cabinets can be stored per floor. A review of the corrosive substance cabinets on the level indicates this requirement may be exceeded; however, the cabinets are stored beneath fume cupboards which prevents accumulation of corrosive vapours around the cabinets; hence, it is considered that exceedance of the 250 L is permissible due to the additional safety controls.

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15^{o}C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.1 x 682 = 68.2 m^3 of gas. The room has a volume of 140.4 m^3; hence, the nitrogen will exclude 0.21 x 68.2 = 14.3 m^3 of oxygen. The room has an oxygen concentration of 0.21 x 140.4 = 29.5 m^3. Hence the release of nitrogen into the room will reduce the oxygen concentration to (29.5-14.3)/140.4 = 10.8%. Therefore, oxygen monitoring and visual and audible alarms would be required for the room.

Gas Cylinders: The room contains 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 62.5 m^3; hence, the volume of oxygen within the room is normally 0.21 x 140.4 = 6.8 m^3. The oxygen cylinder would therefore reduce the oxygen concentration to 19.6% which would not result in any injuries.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. The rooms are ventilated; hence, excluded oxygen would be rapidly replaced preventing a critical oxygen levels from occurring.

The store should be fitted with the following:

- Cylinder restraints.

Summary of Equipment: The store should be fitted with the following;

- One (1) oxygen monitoring sensors around the room adjacent to the Dewar storage;
- An audible alarm within the store indicating low oxygen levels in the room;

- A visual alarm, indicating low oxygen levels in the room, should be located at each entrance to the store (i.e. one (1) visual alarm);
- Signage and placarding;
- One (1) dry powder extinguisher; and
- Cylinder restraints.

9.6 4010, 4011

Room 401 contains the following;

- Class 8 – 1 x 30 L Cabinet
- Class 3 – 1 x 30 L Cabinet
- Class 3 – 2 x 250 L Cabinet
- 1 x CO_2 Gas Outlet
- 1 x Compressed Air
- 1 x NG Gas Outlet

Each item has been assessed below:

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the 30 L cabinets are vented by the fume hood and the 250 L and has a dedicated venting system to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards.

The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: There are 11 x 30 L corrosive cabinets totally 330 L on this level spread over the two wings. Assuming PGII acids are stored; AS3780 allows multiple stores containing a maximum quantity of 250 L provided they are separated by at least 5 m (Ref. 2). The two wings are separated by >5 m; if viewed as the aggregate capacity residing in each wing then there is two aggregate capacities each with <250 L. This arrangement would comply with AS3780 (Ref. 2).

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: No hazards identified for compressed air; hence, it has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- 2 x Flexible connection;
- 2 x Flame arrestor;

- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher.

9.7 4014 - STORAGE

The chemical store contains the following;

- Class 3 – 2 x 250 L Cabinet
- Class 8 – 2 x 250 L Cabinet
- Class 3 – 1 x 30 L Cabinet
- Class 8 – 1 x 30 L Cabinet
- 1 x CO_2 Gas Outlet
- 1 x Compressed Air Outlet
- 1 x NG Gas Outlet

Each item has been assessed below;

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the 250 L and has a dedicated venting system to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards.

The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: No hazards identified for compressed air; hence, it has not been assessed.

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system.
- Appropriate placarding and signage;
- 2 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on the cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher not located within 3 m and not further than 10 m from the cabinets.

9.8 4016, 4017

These rooms contain the following;

- 1 x Compressed Air Outlet
- 1 x CO_2 Gas Outlet
- 1 x NG Gas Outlet

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

9.9 4018 – INSTRUMENT

Room 4016 contains the following;

- 2 x Compressed Air Outlet
- 1 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet
- Class 3 – 1 x 30 L Cabinet
- Class 8 – 1 x 30 L Cabinet
- 4 x G sized cylinders

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2 & N_2: Carbon dioxide and nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 3 x 20 L/min x 60 = 3600L/h = 3.6 m^3/h

Concentration of Oxygen:

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 3.6}{3.6 + (67.5 \times 6)} = 0.9\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

Class 3: AS1940-2004 (Ref. 1) indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the cabinets are 30 L cabinets and are stored beneath fume hoods which provides continuous ventilation to the cabinets. This reduces the risk as there is a reduced potential for accumulation of vapours. One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: AS3780-2008 (Ref. 2) indicates that no more than 250 L of corrosive substances cabinets can be stored per floor. A review of the corrosive substance cabinets on the level indicates this requirement may be exceeded; however, the cabinets are stored beneath fume cupboards which prevents accumulation of corrosive vapours around the cabinets; hence, it is considered that exceedance of the 250 L is permissible due to the additional safety controls.

Gas Cylinders: The room contains 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 62.5 m^3; hence, the volume of oxygen within the room is normally 0.21 x 62.5 = 6.8 m^3. The oxygen cylinder would therefore reduce the oxygen concentration to 18% which would not result in any injuries.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. The rooms are ventilated; hence, excluded oxygen would be rapidly replaced preventing a critical oxygen levels from occurring.

The store should be fitted with the following:

- Cylinder restraints.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- Solenoid valve on N_2 supply line interlocked with the ventilation system; and
- Cylinder restraints.

9.10 4019 - TISSUE CULTURE

Each tissue culture room contains;

- 1 x 100 L Liquid Nitrogen Dewar
- 6 x CO_2 Gas Outlet
- 2 x N_2 Gas Outlet

Each item has been assessed below:

Liquid N_2: Liquid nitrogen has an expansion ratio of 682 at 15°C (Ref. 6); hence, if 100 L of liquid nitrogen were to be spilled it would evaporate forming 0.1 x 682 = 68.2 m^3 of gas which exceeds the volume within the room (67.5 m^3) resulting in the exclusion of oxygen. Therefore, oxygen monitoring and visual and audible alarms would be required.

CO_2 & N_2: Carbon dioxide and Nitrogen may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 8 x 20 L/min x 60 = 9600L/h = 9.6 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{9.6 + (67.5 \times 6)} = 20.4\%$$

Provided the ventilation system is operating, N_2 and CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a gas release is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS. The N_2 and CO_2 are supplied from bulk gases which provides a large reservoir; hence, the N_2 and CO_2 supply should be fitted with a solenoid valve which is interlocked to the ventilation system.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5m^3

Ventilation: 6 air changes/hour

Gas Release rate: 6 x 20 x 60 = 7200 L/h = 7.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 7.2}{7.2 + (67.5 \times 6)} = 1.78\ \%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.78% resulting in a volume of CO_2 within the lab of 1.2 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.05 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: The store should be fitted with the following;

- One (1) oxygen monitoring sensor located at mid-level (1400 mm AFFL) within the vicinity of the Dewar. The sensors should be set to trigger the alarms at oxygen levels of 18%;
- Fan fault/failure alarming within the BMCS;
- An audible alarm within the store indicating low oxygen levels; and
- A visual alarm, indicating low oxygen levels, should be located at each entrance to the store (i.e. one (1) visual alarm);
- CO_2 supply line solenoid valve interlocked with ventilation system; and
- Solenoid valve on N_2 supply line interlocked with the ventilation system;
- Biohazard symbol signage;

9.11 DESIGN SUMMARY

Each of the design requirements for the Level 4 are summarised in the following subsections.

9.11.1 4059 – Gas Manifold

The gas manifold room will be fitted with louvred grilles at the base and top of the access door to allow gas dispersion should a release occur within the store. Cylinders shall be restrained.

9.11.2 4002, 4006, 4019

Each room will be fitted with an oxygen sensor located 1400 mm AFFL within the vicinity of the liquid nitrogen Dewars. In the event that oxygen deficiency is detected with the rooms the following will occur;

- Audible alarm activated within the room;
- Visual alarm activated at the entrance;
- Audible alarm activated at the gas alarm panel;
- Gas supply will be isolated to the zone via a solenoid; and
- BMCS alarm signal sent to head end to notify laboratory managers and security.

9.11.3 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel;
- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- Gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;
    - 4001
    - 4002
    - 4004
    - 4005
    - 4010
    - 4011
    - 4014
    - 4016
    - 4018
    - 4019

9.11.4 Isolation

Each wing will be fitted with an emergency push button. The push button will deactivate the following services within laboratories within the designated zone;

- Power (non-essential and essential);
- Laboratory gases (all lab gases – not including vacuum or compressed air);
- Natural Gas (in labs where applicable); and
- BMCS alarm single sent to head end to notify laboratory managers and security.

9.11.5 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

10 LEVEL 5 - DG STORAGE ASSESSMENT

10.1 INTRODUCTION

The following rooms are located on Level 5 and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 10.10**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

10.2 5059 - GAS MANIFOLD

The cylinder store contains approximately 6 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 6 m^3; hence, the volume of oxygen within the room is normally 0.21 x 6 = 1.3 m^3. The oxygen cylinder would therefore exclude all oxygen within the room.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. Therefore, if the gas can be discharged out of the room, oxygen depletion will not occur. Therefore, if the doors of the store are fitted with louvred grilles at the base and the top of the doors, the gas will be able to be discharged from the store preventing accumulation.

The store should be fitted with the following:

- Louvred grilles in the base and top of the access door.
- Cylinder restraints.

10.3 5001 – INSTRUMENT SMALL (SMELLY)

The instrument small room contains the following;

- 1 x NG Gas Outlet
- Class 3 – 1 x 250 L Cabinet

- Class 3 – 1 x 30 L Cabinet
- Class 8 – 1 x 30 L Cabinet
- 1 x CO_2 Gas Outlet

Each item has been assessed below;

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the 30 L cabinets are vented by the fume hood and the 250 L and has a dedicated venting system to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards.

The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8 – The cabinets are located > 5 m from the nearest cabinet; hence, complies with the standard

CO_2: CO_2 may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- 1 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) dry powder extinguisher.

10.4 5002, 5004, 5005 – OPEN LABORATORY

Each of these rooms contain the following;

- 2 x Compressed Air Outlet
- 2 x CO_2 Gas Outlet
- 14 x NG Gas Outlet (5002), 12 x NG Gas Outlet (5005)

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 2.4}{2.4 + (67.5 \times 6)} = 0.63\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.63% resulting in a volume of CO_2 within the lab of 0.43 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.01 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

10.5 5006, 5007 – MICROSCOPE

Each of these rooms contain the following;

- 2 x Compressed Air Outlet
- 2 x CO_2 Gas Outlet

Each item has been assessed below:

Compressed Air: No hazards identified for compressed air.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \ \times 0.21 \times 6}{2.4 + (32.4 \ \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2: CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{32.4 \times 0.0004 \times 6 + 2.4}{2.4 + (32.4 \times 6)} = 1.26\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.26% resulting in a volume of CO_2 within the lab of 0.41 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.03 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

10.6 5008, 5012

The room contains 'G' sized cylinders of various classes predominately Class 2.2 gases. A 'G' sized cylinder typically holds approximately 9 m^3 of pressurised gas. Each room contains the following number of cylinders;

- 5 cylinders (5008)
- 2 x Oxygen cylinders (5012)

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 32.4 m^3; hence, the volume of oxygen within the room is normally 0.21 x 32.4 = 6.8 m^3. The oxygen cylinder would therefore reduce the oxygen concentration to 15%.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. The rooms are ventilated; hence, excluded oxygen would be rapidly replaced preventing a critical oxygen levels from occurring.

The store should be fitted with the following:

- Cylinder restraints.

10.7 5013, 5022 - CHEMISTRY

Each of the chemistry rooms contains the following;

- Class 3 – 1 x 30 L Cabinet
- Class 3 – 1 x 250 L Cabinet
- 1 x CO_2 Gas Outlet
- 1 x Compressed Air Outlet
- 1 x NG Gas Outlet

Each item has been assessed below:

Class 3: AS1940-2004 indicates that no more than 250 L of flammable liquid cabinets can be stored per 250 m^2 of floor area. A review of the number of the cabinets on the floor indicates this is likely to be exceeded; however, this is considered permissible as the 30 L cabinets are vented by the fume hood and the 250 L and has a dedicated venting system to extract vapours from within the cabinet reducing the potential for accumulation of vapours and the associated hazards.

The venting of the cabinet should include;

- Flame arrestor;
- Flexible connection;
- Steel cabinet venting ductwork;
- Fan fault/failure alarming within the BMCS; and
- One (1) 4.5 kg dry powdered extinguisher should be located within the store.

Class 8: There are 11 x 30 L corrosive cabinets totally 330 L on this level spread over the two wings. Assuming PGII acids are stored; AS3780 allows multiple stores containing a maximum quantity of 250 L provided they are separated by at least 5 m (Ref. 2). The two wings are separated by >5 m; if viewed as the aggregate capacity residing in each wing then there is two aggregate capacities each with <250 L. This arrangement would comply with AS3780 (Ref. 2).

CO_2: CO_2 may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Compressed Air: No hazards identified for compressed air; hence, it has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- 2 x Flexible connection;
- 2 x Flame arrestor;
- 2 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) dry powder extinguisher.

10.8 5014 - STORAGE

The chemical store contains the following;

- Class 3 – 2 x 250 L Cabinet
- Class 8 - 4 x 250 L Cabinet
- 1 x CO_2 Gas Outlet
- 1 x Compressed Air Outlet
- 1 x NG Gas Outlet

Each item has been assessed below;

Class 3: This store contains 1000 L of flammable liquid cabinets which exceeds the aggregate capacity. To comply with the standard, it would be necessary to construct this incorporating the following;

- Bunding to contain approximately 500 L (no automatic sprinkler system);
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Door with a FRL of -/120/30;
- 4 x Flexible connection;
- 4 x Flame arrestor;
- 4 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher not located within 3 m and not further than 10 m from the cabinets.

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{67.5 \times 0.21 \times 6}{1.2 + (67.5 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 67.5 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{67.5 \times 0.0004 \times 6 + 1.2}{1.2 + (67.5 \times 6)} = 0.33\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.33% resulting in a volume of CO_2 within the lab of 0.22 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

Compressed Air: No hazards identified for compressed air; hence, it has not been assessed.

NG: NG is a flammable gas which may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. A conservative calculation has been performed in Appendix A to assess the potential for oxygen exclusion and hazardous atmosphere development. The results of this analysis indicate that, provided the ventilation system is operating, oxygen concentrations will remain at 20.2% and the maximum gas concentration will be 3.74% resulting in no hazardous zone being present, noting that the lower explosive limit of NG is 4.4%.

The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of NG is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

Summary of equipment: Based on the analysis these rooms would require the following;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system;
- Bunding to contain approximately 500 L (no automatic sprinkler system);
- Electrical sources within the room are to comply with AS60079 series (Ref. 7) within 3 m of the storage area;
- Signage and placarding;
- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Door with a FRL of -/120/30;
- 4 x Flexible connection;
- 4 x Flame arrestor;
- 4 x Steel cabinet ventilation duct work;
- Fan fault/failure on cabinet fan alarming within the BMCS; and
- One (1) 4.5 kg dry powder extinguisher not located within 3 m and not further than 10 m from the cabinets.

Review of the bund design indicates that it will have a 35 mm bund resulting in a total containment of 0.84 m^3 exceeding the specified requirement.

10.9 5016 – INSECT PREP

Each of the prep rooms contains the following;

- 2 x CO_2 Gas Outlet
- 2 x Compressed Air Gas Outlet

Each item has been assessed below:

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \times 0.21 \times 6}{2.4 + (32.4 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{32.4 \times 0.0004 \times 6 + 2.4}{2.4 + (32.4 \times 6)} = 1.26\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 1.26% resulting in a volume of CO_2 within the lab of 0.41 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.03 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and

- CO_2 supply line solenoid valve interlocked with ventilation system.

10.10 5017, 5019, 5020, 5023, 5024, 5026, 5027 - INSECT

The above rooms contain;

- 1x CO_2 Gas Outlet
- 1 x Compressed Air outlet

Each item has been assessed below:

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{32.4 \times 0.21 \times 6}{1.2 + (32.4 \times 6)} = 21\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 32.4 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{32.4 \times 0.0004 \times 6 + 1.2}{1.2 + (32.4 \times 6)} = 0.65\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, the worst case scenario in this office may result in concentrations exceeding the TWA concentration; however, it is substantially lower than the Immediately Dangerous to Life and Health (IDLH) of 40,000 ppm or 4%. In addition, the steady state concentration is 0.65% resulting in a volume of CO_2 within the lab of 0.21 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.02 m deep and would not pose a risk to personnel within the laboratory.

It is noted, that this scenario is based on all taps being left open; however, this is considered to be excessively conservative as personnel working within the laboratories are expected to be trained and competent operators. Therefore, the concentration within the laboratory is likely to be substantially lower than the TWA in a more realistic scenario (i.e. 1 tap left open).

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

10.11 DESIGN SUMMARY

Each of the design requirements for the Level 5 are summarised in the following subsections.

10.11.1 5059 – Gas Manifold

The gas manifold room will be fitted with louvred grilles at the base and top of the access door to allow gas dispersion should a release occur within the store. Cylinders shall be restrained.

10.11.2 5014 – Chemical Store

5014 will be designed with walls with an FRL of 240/240/240 and doors with a FRL of -/120/30. The potential for spills or potentially contaminated liquid will be managed via bunding of these spaces. Bunding is achieved via a 35 mm set down which allows containment of 0.84 m^3 of spills from the cabinets and a portion of liquid from an emergency response.

10.11.3 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- Audible alarm activated at the gas alarm panel;
- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- Gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;
    - 5001
    - 5002
    - 5004
    - 5005
    - 5006
    - 5007
    - 5013
    - 5014
    - 5016
    - 5017
    - 5019

- 5020
- 5022
- 5023
- 5024
- 5026
- 5027

10.11.4 Isolation

Each wing will be fitted with an emergency push button. The push button will deactivate the following services within laboratories within the designated zone;

- Power (non-essential and essential);
- Laboratory gases (all lab gases – not including vacuum or compressed air);
- Natural Gas (in labs where applicable); and
- BMCS alarm single sent to head end to notify laboratory managers and security.

10.11.5 Flammable Liquids Cabinets

250 L Flammable liquids cabinets and 30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

11 LEVEL 6 - DG STORAGE ASSESSMENT

11.1 INTRODUCTION

The following rooms are located on Level 6 and store and handle DGs. Each room has been assessed individually to determine the requirements necessary to store the DGs to comply with the applicable standard. Several recommendations are synergistic between laboratory spaces. A summary of all recommendations made for each space and how they are achieved in the building spaces is provided in **Section 11.6**.

It is noted that ventilation has not been included in the assessment as it is understood that each of the room spaces are ventilated at a minimum of 6 air changes per hour which would exceed the minimum ventilation requirements specified in the DG standards.

It is noted that where lab gases (nitrogen and carbon dioxide from bulk supply) are only supplied to a room via the fume hood, solenoid valve isolations (for the room) are not required as the fume hoods have independent isolation within the hood which will isolate on flow failure. Where lab gases are provided for bench taps, isolation of the supply to the room will be required to occur when room ventilation failure occurs. If a room only has gases supplied to a fume hood and bench top gases are added in the future, the isolation strategy will be required to be reviewed on a case by case basis. Furthermore, personnel will be required to be trained for the isolation regime adopted for each of the spaces to ensure appropriate response to an alarm occurs.

11.2 6059 - GAS MANIFOLD

The cylinder store contains approximately 6 ‘G’ sized cylinders of various classes predominately Class 2.2 gases. A ‘G’ sized cylinder typically holds approximately 9 m^3 of pressurised gas.

If the valve were to fail, the full volume of the cylinder would be released which would exclude 9 m^3 of air present in the room. Oxygen has a concentration in air of approximately 21%; hence, if a cylinder released, 9 x 0.21 = 1.9 m^3 of oxygen would be excluded. The room has a volume of 6 m^3; hence, the volume of oxygen within the room is normally 0.21 x 6 = 1.3 m^3. The oxygen cylinder would therefore exclude all oxygen within the room.

It is noted that gas cylinders do not spontaneously discharge all the gas at once but is from a release which may occur from a small crack in the valve stem. Therefore, if the gas can be discharged out of the room, oxygen depletion will not occur. Therefore, if the doors of the store are fitted with louvred grilles at the base and the top of the doors, the gas will be able to be discharged from the store preventing accumulation.

The store should be fitted with the following:

- Louvred grilles in the base and top of the access door.
- Cylinder restraints.

11.3 6001, 6015 - PREP

Each of the prep rooms contains the following;

- 1 x CO_2 Gas Outlet
- 2 x Compressed Air Gas Outlet

Each item has been assessed below:

CO_2: Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 65 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 L/min x 60 = 1200L/h = 1.2 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{65 \times 0.21 \times 6}{1.2 + (65 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 65 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 1 x 20 x 60 = 1200 L/h = 1.2 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{65 \times 0.0004 \times 6 + 1.2}{1.2 + (65 \times 6)} = 0.35\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.35% resulting in a volume of CO_2 within the lab of 0.23 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS; and
- CO_2 supply line solenoid valve interlocked with ventilation system.

11.4 6024, 6026

Each room will contain 2 x CO_2 gas outlets. Carbon dioxide may exclude oxygen resulting in an oxygen deficient environment. An analysis of a gas release from the outlet has been conducted to determine whether oxygen monitoring is required. The calculation has been conducted using the methodology outlined in **Section 2.3**. The assessment has been conducted in the worst case, i.e. if all valves are opened.

Room Volume: 65 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 L/min x 60 = 2400L/h = 2.4 m^3/h

Concentration of Oxygen:

$$C_{Oxygen} = \frac{65 \times 0.21 \times 6}{2.4 + (65 \times 6)} = 20.9\%$$

Provided the ventilation system is operating, CO_2 will be unable to accumulate thereby preventing the formation of a hazardous atmosphere. The room is fitted with an independent fan on the air supply side and the air exhaust side. The likelihood of both systems failing simultaneously with a release of CO_2 is considered negligible. Therefore, the ventilation system should be fitted with a fan fault/failure device that triggers an alarm back to the BMCS.

CO_2 may be toxic at levels which don't exclude oxygen. The CO_2 is piped into the laboratory from a bulk tank; hence, there is a large volume that can be released into the laboratory. Therefore, to ensure CO_2 can't accumulate to toxic levels in the laboratory the supply should be interlocked with the ventilation system. Therefore, if the ventilation system fails the supply is isolated. If the ventilation system is operating, the CO_2 cannot accumulate to toxic levels:

Room Volume: 65 m^3

Ventilation: 6 air changes/hour

Gas Release rate: 2 x 20 x 60 = 2400 L/h = 2.4 m^3/h

Concentration of CO_2

$$C_{CO2} = \frac{65 \times 0.0004 \times 6 + 1.2}{1.2 + (65 \times 6)} = 0.35\%$$

The TWA exposure limit for CO_2 is 5,000 ppm or 0.5%; hence, there is no potential for toxic exposure as a result of a CO_2 release in this laboratory. Furthermore, the steady state concentration is 0.35% resulting in a volume of CO_2 within the lab of 0.23 m^3. As CO_2 is a dense gas it will form a CO_2 layer approximately 0.009 m deep and would not pose a risk to personnel within the laboratory.

Compressed Air: Compressed air does not pose any hazards and has not been assessed.

Summary of equipment: Based on the analysis the following will be required within the room;

- Fan fault/failure alarming within the BMCS;
- CO_2 supply line solenoid valve interlocked with ventilation system.

11.5 DIESEL TANK

A 1 x 1,000 L diesel tank will be stored in Level 6. The following requirements are required to comply with AS1940-2004.

- Double walled construction (i.e. tank with integral secondary containment);
- Outer shell shall drain to a remote draining tank, sump or compound having a capacity at least equal to the tank capacity (i.e. 1,000 L);

- An over flow alarm shall be fitted, audible at the filling point;
- Fill point liquid level indication;
- Dry break connection at fill point;
- Manual shut off valve immediately upstream of coupling; and
- One-powder type extinguisher.

11.6 DESIGN SUMMARY

Each of the design requirements for the Level 6 are summarised in the following subsections.

11.6.1 6059 – Gas Manifold

The gas manifold room will be fitted with louvred grilles at the base and top of the access door to allow gas dispersion should a release occur within the store. Cylinders shall be restrained.

11.6.2 Ventilation

The ventilation system is fitted with a device to identify a fan fault/failure. In the event that a fan fault/failure is identified, the following will occur;

- BMCS alarm signal sent to head end to notify laboratory managers and security; and
- Gas supply to the zone containing activated alarm will be isolated via a solenoid. Specific laboratories affected include;
  - 6001
  - 6015
  - 6024
  - 6026

11.6.3 Isolation

Each wing will be fitted with an emergency push button. The push button will deactivate the following services within laboratories within the designated zone;

- Power (non-essential and essential);
- Laboratory gases (all lab gases – not including vacuum or compressed air);
- Natural Gas (in labs where applicable); and
- BMCS alarm single sent to head end to notify laboratory managers and security.

11.6.4 Flammable Liquids Cabinets

30 L flammable liquids cabinets not located under a fume hood will be ventilated to eliminate the 3 m exclusion zone around the cabinets. Each cabinet will be fitted with a flexible joint, arrestor and steel piping which are manifolded to the main ventilation duct. The ventilation fan is fitted with a device to detect fan fault/failure will alarm at the BMCS upon detection.

Flammable liquids cabinets located below a fume hood are considered to be adequately ventilated by the fume hood which will draw vapours away from the cabinet and into the fume hood. This is considered to eliminate the 3 m exclusion zone around 30 L cabinets below fume hoods.

11.6.5 Diesel Tank

- Double walled construction (i.e. tank with integral secondary containment);
- Outer shell shall drain to a remote draining tank, sump or compound having a capacity at least equal to the tank capacity (i.e. 1,000 L);
- An over flow alarm shall be fitted, audible at the filling point;
- Fill point liquid level indication;
- Dry break connection at fill point;
- Manual shut off valve immediately upstream of coupling; and
- One-powder type extinguisher.

12 CONCLUSIONS

12.1 CONCLUSIONS

The bio-medical precinct at UNSW is currently in the design phase to be redeveloped to upgrade the building in line with UNSW's building renewal schedule. The building will consist of laboratories which may store and handle Dangerous Goods. To ensure the proposed storage locations comply with the relevant standards and the Work Health and Safety Regulation each DG store was assessed for compliance.

The results of the analysis indicate the major areas of concern are the storage location of cabinets and the potential formation of hazardous atmospheres. The following general recommendations have been made for these areas. It is noted that specific design guidelines for each room are within the body of the report.

Cabinets not stored in designated Chemical Stores: Storage of 30 L flammable liquid cabinet and corrosive cabinets are ventilated by the fume hoods and are considered to be permissible for use in this configuration.

Cabinets Stored in designated Chemical Stores**:** Rooms storing flammable liquid cabinets in a quantity exceeding 850 L should be designed as follows;

- Walls with a FRL of 240/240/240;
- Roof with a FRL of 180/180/180;
- Floor with a FRL of 180/180/180;
- Bunding capable of containing 600 L;
- Doors with a FRL of -/120/30; and
- Appropriate placarding and signage.

Flammable liquid cabinets should be ventilated to eliminate the requirement for a 3m hazardous zone surrounding the cabinet.

Rooms fitted with gas outlets: Rooms fitted with gas outlets should have a fan fault/failure device alarming within the BMCS.

Storage of liquefied gases, cylinders or tanks: Rooms storing liquefied gases, cylinders or tanks should be fitted with oxygen monitoring and local alarms. The oxygen monitoring should be linked to the building management system. If oxygen concentrations are less than 18% or exceed 22.5% the local alarms should activate. The local alarms should consist of an audible alarm within the room and a visual alarm at each entrance to the room.

12.2 RECOMMENDATIONS SUMMARY

The design requirements specified in this report have been incorporated into the Design Development of the UNSW Biosciences South building.

13 REFERENCES

13.1 REFERENCES

1. AS1940-2004, “The Storage and Handling of Flammable and Combustible Liquids”, Standards Association of Australia, Sydney
2. AS3780-2008, “The Storage and Handling of Corrosive Substances”, Standards Association of Australia, Sydney
3. AS4452-1997, “The Storage and Handling of Toxic Substances”, Standards Association of Australia
4. AS2252.2-X, “Biological Safety Cabinets Class II – Design”, Standards Association of Australia., Sydney
5. AS2647, “Biological Safety Cabinets – Installation and Use”, Standards Association of Australia., Sydney
6. Code of Practice 30, “The Safe Use of Liquid Nitrogen Dewar’s up to 50 Litres’, British compressed Gases Association, 2008
7. AS60079 series, “Electrical Apparatus for Explosive Gas Atmospheres Set”, Standards Association of Australia, 2008
8. AS1894-1997, “The Storage and Handling of Non-Flammable Cryogenic and Refrigerated Liquids”, Standards Association of Australia, Sydney

APPENDIX A NATURAL GAS CALCULATION

A1. INTRODUCTION

The assessment of natural gas has been based on a conservative scenario assuming a small laboratory space with 24 natural gas tap open releasing gas into the space. This will provide sufficient conservatism such that the calculation can be applied to all spaces within the biosciences building.

A2. OXYGEN

Room volume: 30 m^3

Ventilation: 6 air changes/hour

Gas release: 0.08 L/s x 24 x 3600 = 6912 L/h = 6.912 m^3/h

$$C_{Oxygen} = \frac{30 \times 0.21 \times 6}{6.912 + (30 \times 6)} = 20.2\%$$

A3. HAZARDOUS AREAS

Room volume: 30 m^3

Ventilation: 6 air changes/hour

Atmospheric methane concentration: 0.000002

Gas release: 0.08 L/s x 24 x 3600 = 6912 L/h = 6.912 m^3/h

$$C_{Oxygen} = \frac{30 \times 0.000002 \times 6 + 6.912}{6.912 + (30 \times 6)} = 3.74\%$$