TAB V

Access Statement (BHA)

Access Statement

The Access report prepared for Goulburn Performing Arts Centre addresses the following aspects of this project:

1.1 Accessible access to and within the building

The provision of external accessible path of travel are achieved from the southern side of the site where a new entry to the Performing Arts Centre is provided. The new entry includes both 1:14 ramp and stair access leading to the entry doors of the theatre and Box office.

Functionally there are two (2) pedestrian entry points for patrons to the Goulburn Performing Arts Centre where an automatic door will be provided to comply with AS1428.1:2009.

1.2 Vertical Transport (Lifts, Ramps and Stairs)

Connectivity between the levels within the building is via lifts or by stairs.
The plan proposes a lift service within the Foyer space connecting the basement and theatre levels. A lift is also proposed for the back of house area connecting the basement, stage area and change room facilities.

1.3 Box Office and Foyer space

The Goulburn Performing Arts Centre will rely on ongoing usher function to provide seating assistance for patrons to and within the Theatre

The doors to the Theatre seating areas are operated by the ushers. These doors will be acoustic doors and as a result will be heavy to operate. As a result, there is no requirement to satisfy the latchside clearances to doors or the maximum 20N force requirement to operate these doors required by AS1428.1:2009.

In the event of an emergency the ushers will be responsible for aiding those with mobility needs as part of the evacuation strategy.

1.4 Theatre

The architectural documentation identifies the strategies to be adopted in the provision of wheelchair seating positions within the Theatre.
The total number of seats within the Theatre is 440 seats:

- Stalls 291
- Circle 134
- Total 425

Applying the rate for accessible seating locations noted at NCC Table D3.9 the following number of Accessible seating locations will to be provided within the Stalls and the Circle:

- Stalls 6 accessible locations
- Circle 3 accessible locations
- Total 9 accessible locations

Clause 18 of AS1428.1:2009 indicates that accessible seating locations may be provided by the removal of fixed seating.

In each instance in this design the approach to the accessible seating location is from the rear of the allocated space.

The design proposal proposes a total of 9 wheelchair locations made up of 6 accessible wheelchair positions as part of the stalls and 3 accessible seating locations provided within the Dress Circle area. In both instances compliance is achieved by the removal of fixed seating and the installation of platform.

Consideration will be given to the allocation of companion seating positions when all seating positions are allocated

1.5 Dressing rooms

The design proposes the following:

• The provision of an accessible change room including an accessible WC/shower facility

• An accessible WC is provided at the Green Room level

The plan also proposes accessible dressing rooms as part of the Back of House areas. Accessible WC facilities have been provided.

1.6 WC Facilities

A compliant ambulant WC cubicle will be provide within the male and female WC facilities. The detailing of the ambulant WC facilities will satisfy the provisions of Clause 6 of AS1428.1:2009.

An accessible WC facility will be provided as part of the public WC facilities. The detailing of these facilities satisfies the requirements of Clause 15 of AS1428.1:2009.

1.7 Hearing augmentation

Hearing augmentation systems will be provided within this facility to satisfy the requirements of NCC clause D3.7 and the provisions of AS1428.5

TAB W

Amenities Calculations

GPAC Amenities Numbers - 10 November 2017

Gender	USAT	Ambulant	WC Pan	Urinal	Basin
Male (Basement)		1	2	3	3
Female (Basement)		1	10		3
Chrous Room L3			1		1
Dressing Room L3			1		1
Chorus Room L4			1		1
Dressing Room L4			1		1
USAT Public (Basement)	1				
USAT BOH (Basement)	1				
USAT Dressing Room L1	1				
USAT BOH (L2)	1				
USAT BOH (L3)	1				
USAT BOH (L4)	1				
USAT BOH (L5)					
Total	6	2	16	3	10

TAB X

Acoustic Report

MARSHALL DAY Acoustics

GOULBURN PERFORMING ARTS CENTRE
CONCEPT DESIGN REPORT

Rp 002 2016346SY | 14 December 2016

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Project:	**GOULBURN PERFORMING ARTS CENTRE**
Prepared for:	**Brewster Hjorth Architects** **Level 1, 4-14 Foster Street** **Surry Hills NSW 2010**
Attention:	**Ian Brewster**
Report No.:	**Rp 002 2016346SY**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Issued	-		14 Dec 2016	S. Marshall	M. Ottley

MARSHALL DAY Acoustics

TABLE OF CONTENTS

1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been commissioned by Brewster Hjorth Architects to provide acoustic advice for the new Goulburn Performing Arts Centre (the Project).

This report covers the acoustic design for the concept design stage. This report is not a comprehensive or highly detailed document that specifies precise acoustic treatment details required for construction, but rather provides high level advice and recommendations for acoustic treatment allowances at this early stage of the project. The details of acoustic treatment required will need to be further developed by the design team as the Project progresses.

This report has been prepared on the basis of Revision B of the architectural drawings, dated 22 November 2016.

Technical terms used throughout this report are described in Appendix A.

2.0 PROJECT AND SITE DESCRIPTION

2.1 Site location

The project site is located at 163 Auburn Street Goulburn. It is bounded by Auburn Street to the north west, Post Office Lane and commercial receivers to the north east, Goulburn Local Court to the south east and commercial receivers to the south west. The Goulburn Railway Station is approximately 250m to the south east of the site.

An aerial view of the site, nearest noise sensitive receivers and surrounding area is located in Figure 1.

Figure 1: Aerial view of the site

The nearest affected residential receivers have been identified as:

- The Alpine Heritage Motel at 248 Sloane Street and;
- The Goulburn Central Motor Lodge on the corner of Auburn & Verner Steets.

We note that these locations are the nearest affected receivers as the standard Liquor & Gaming consent conditions are applicable at short term accommodation as well as permanent residences.

2.2 Project description

The Project consists of the restoration and extension of the former Town Hall into a modern performing arts centre. The proposal involves creation of a performing arts venue and back of house facilities within a new building extension at the rear of the site. The restoration and re-fit of the original 1889 heritage building at the front of the site will form the front of house facilities. A foyer will connect the heritage building to the new 400 seat Theatre.

The main components of the Project are summarised in Table 1.

Table 1: Components of the Project

Level	Room
Heritage building	
G	Box office /cloak room
	Kitchen
	Bar / Café
	Foyer
L2	Theatre Groups / Support offices
	Theatre Managers office
	Waiting area
L3	Plantroom
Building extension	
B	Band Room
	Musical instrument store
	Equipment store
	Equipment workshop
	Basement (understage)
	Orchestra pit
	Seat store
	Wardrobe and laundry
	Backstage Access Control Office
	Bar / Foyer Store
	Basement Foyer
	Plant rooms
	Toilets
G	Foyer
	Sound locks
	Control room
	Theatre Stalls

Level	Room
G cont.	Stage
	Dressing room
	Technician office
	Loading dock
L2	Green room
	Touring office
	Fly tower – stage high level
	Theatre balcony
	Foyer void
L3	Dressing rooms and ensuite
	Chorus room and ensuite
	Bathroom
	Fly tower – Fly gallery
	Lighting bridges
	Follow spot room
	Foyer void
L4	Chorus room and ensuite
	Dressing room and ensuite
	Bathroom
	Fly tower – Fly gallery void
L5	Fly tower - loading gallery
	Plantroom
	Plant deck

2.3 Existing noise environment

For design purposes attended ambient and background noise levels were measured during a site survey on 15 October 2016. Measurements were taken on Sloane Street near the Alpine Heritage Motel and on the corner of Auburn and Verner Street. The measured octave band noise levels are provided in Table 1.

Table 2: Ambient and background noise levels, dB

	Octave Band Centre Frequency (Hz)								
Item	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**
Sloane St L_{eq}	65	58	57	57	59	56	48	39	62
Sloane St L_{90}	52	48	43	39	37	30	19	13	43

	Octave Band Centre Frequency (Hz)								
Item	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**
Cnr Auburn and Verner L_{eq}	70	66	57	54	53	48	42	34	58
Cnr Auburn and Verner L_{90}	52	56	48	42	39	33	26	16	46

The measurements on Sloane Street were dominated by the natural noise environment, with occasional local traffic. Distant road traffic was audible occasionally and distant mechanical plant audible for the duration of the measurement period.

Local road traffic dominated noise measurements on the corner of Auburn and Verner Street. Distant road traffic and mechanical plant were audible.

3.0 ACOUSTIC DESIGN CRITERIA

3.1 Client requirements

There are no briefing requirements relating to specific acoustic performance standards for the Project. We have developed acoustic criteria for the Project based on feedback from the user groups, relevant reference standards, guidelines and previous experience.

3.2 Acoustic parameters

The acoustic parameters used for assessment purposes are summarised in Table 3.

Table 3: Description of acoustic parameters used for assessment purposes

Acoustic parameter	Explanation	Descriptor
Noise Ingress	External noise intrusion from outdoor noise sources such as motor vehicle traffic	$L_{Aeq, 15min}$ Equivalent continuous sound level, measured over a representative 15 minute period
Sound Insulation	Internal sound insulation between adjacent spaces within the building	R_w Note that this is a laboratory acoustic rating. On-site performance Is measured by the D_w rating, which is commonly up to 5dB below the laboratory figure
Services Noise	Noise from building services plant and equipment such as mechanical, hydraulic, lifts, etc	NR Services noise must be free of any significant tonal or spectral content that may increase annoyance and should be measured at 1.5m from any room surface or noise source
Reverberation Time	A measure of how long a sound takes to decay within a space. A long Reverberation Time (RT) sounds “live” and has a high degree of “echo” or reverberation, whereas a short RT sounds “dead” or “dry”	RT, seconds

Acoustic parameter	Explanation	Descriptor
Objective clarity	A measure of the energy within 80 ms of the direct sound includes that of the direct sound and early reflections. Relates to the balance between the perceived clarity and reverberance.	C_{80} milliseconds
Speech Transmission Index	A single number rating system to quantify the intelligibility of speech, or the ease with which speech can be understood.	STI A value between 0.0 and 1.0, where 0.0 is completely unintelligible and 1.0 is perfectly intelligible.
Environmental noise	Environmental noise from the Project to the surrounding area	$L_{Aeq, period}$
Rain Noise	Noise from rainfall on roof and gutters etc.	NR $L_{eq, 1min}$
Floor impact sound insulation	Noise in a space due to impact on the floor above	$L'_{nT,w}$ Weighted, standardised impact sound pressure level, measured under site conditions

3.3 Acoustic standards and guidelines

The following acoustic standards and guidelines have been referenced in the development of acoustic criteria for the Project:

- Australian Standard 2107: 2016 – *Recommended design sound levels and reverberation times for building interiors* (AS2107)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers 2015 *ASHRAE Handbook - HVAC Applications*
- Norwegian Standard NS 8178:2014 *Acoustic criteria for rooms and spaces for music rehearsal and performance*
- Liquor & Gaming NSW (L&G) standard noise conditions.

3.4 Environmental noise criteria

All environmental noise generated by the Project during operation and construction are to comply with all local government and state environmental noise regulations and standards. .

Given the close proximity of noise sensitive receivers to the Project, environmental noise will require analysis. It is expected that equipment such as mechanical plant, chillers, boilers, pumps and other equipment will require noise control treatment to limit environmental noise emissions. Noise control measures would likely include sound attenuators, acoustic lining in ductwork, acoustic enclosures, etc.

Environmental noise at adjacent outdoor areas to the Project must also be considered. To achieve an appropriate level of acoustic amenity in outdoor areas, it is recommended that the noise level in any outdoor area that is a usual place of congregation for people should not exceed **55dB L_{Aeq}** from any plant equipment.

Activity noise from performances and practice within the Project must also comply with relevant environmental noise criteria from the L&G, which will require acoustic assessment of the building envelope. An octave band criterion has been developed for use in our assessment based on achieving L_{A90} + 5dB, in accordance with the L&G standard noise conditions for licensed premises. The criterion used in our assessment is provided in Table 4.

Table 4: L&G noise criterion, dB $L_{10,\,15min}$

	Octave Band Centre Frequency (Hz)								
Period	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**
Night-time	57	53	48	44	42	35	24	18	45

3.5 Internal acoustic criteria

Table 5 summarises the recommended internal acoustic criteria for the Project. Note that there are two values nominated for sound insulation in Table 5, the first being applicable to any adjacent space via a partition without a door, the second being applicable to any corridor or open plan space such as a general office area or lobby via a door. We note the following in regard to the criteria:

- Where rooms adjacent to one another have different sound insulation criteria, the higher of the two sound insulation ratings shall apply
- Where a room is not listed, the criteria for a room of the closest similar usage shall apply
- Hydraulic services must not be chased into masonry walls. Cavity plumbing walls must be used to run water pipes so as to control the transfer of structure borne plumbing noise
- Wall ratings apply to an adjacent occupied space. Walls to non-occupied space can be reduced by 5-10dB
- Door ratings apply to an adjacent occupied space. Doors to non-sensitive areas can be reduced by 10dB.

Table 5: Internal acoustic criteria

Room	Noise ingress, dB L_{Aeq}	Services noise, NR	Mid frequency reverberation time, T_{60}	Internal sound insulation ratings, R_w		
				Partition to enclosed space, no door	Partition to corridor/ circulation, with door	Door
Theatre / Stage / Orchestra Pit	30	25	1.0 ± 20%[1]	65	65	45[2]
Control Room	35	30	0.4	60	60	45[2]
Follow Spot Room	35	30	<0.8	60	60	45[2]
Back of House Corridors	40	35	<1.0	-	-	-
Loading Dock	40	35	<1.0	60	60	45[3]
Chorus Room	40	35	0.6	45	40	30
Dressing Rooms	40	35	0.6	45	40	30
Musician Change Room	40	35	0.6	45	40	30
Green Room	40	35	0.8	45	40	30
Private offices	40	35	0.6	45	40	30
Support Offices	45	40	0.6	45	35	30
Foyer / Box office / Cloak	45	40	<1.2	-	-	-
Office waiting area	45	40	<0.8	-	-	-
Bar / café	45	40	<0.8	-	-	-
Wardrobe & Laundry Room	45	40	0.8	55	50	40
General Corridors	45	40	<1.0	-	-	-
Basement (understage)[5]	40	35	<1.0	40	40	35
Toilets	50	45	-	55	45	30

Room	Noise ingress, dB L_{Aeq}	Services noise, NR	Mid frequency reverberation time, T_{60}	Internal sound insulation ratings, R_w		
				Partition to enclosed space, no door	Partition to corridor/ circulation, with door	Door
Storerooms	50	45	-	40	35	20
Equipment workshop	50	45	Min[4]	40	35	20
Kitchen	50	45	Min[4]	55	35	20
Plant rooms	-	-	-	60	50	45
Lift shafts & Riser shafts	-	-	-	60	-	-

Note 1: Refer Section 7.1.2 for additional room acoustic parameters

Note 2: Soundlocks with two sets of R_w30 doors are recommended for all entrances to the Theatre.

Note 3: Specialist high acoustic performance sliding door required

Note 4: Minimise as far as practicable for noise control

Note 5: The Basement (understage) area will not be accessed during performances and will be utilised for storage

4.0 BUILDING ENVELOPE DESIGN

The external structure of the building must minimise noise intrusion and noise breakout from day to day operations and performances. Noise intrusion from external ambient noise sources including road and rail traffic noise impacts on the site are not expected to be significant. Rainfall noise and operational noise emissions are considered below.

The design of the walls and the roof should result in a structure that is easy to construct and minimise the need for special acoustic treatment.

4.1 Design considerations

4.1.1 Rainfall noise

Rainfall has the potential increase internal noise levels within the building. Noise intrusion from rainfall has been calculated in occupied areas based on an Annual Exceedance Probability of 10% for 1 hour. For Goulburn, this equates to a rainfall depth of 30mm. It is recommended that rain noise intrusion to critical areas be equal to the services noise criterion. For all other affected areas, an allowance of 5dB above the services noise level design criterion is recommended for rain noise intrusion.

4.1.2 Theatre usage

As a worst case assessment, we have assumed an amplified rock/pop band may perform within the Theatre. The data provided in Table 6 has been used to assess an amplified rock band within the Theatre. The data is based on measurements from the MDA Noise Source Database of previous measurements.

Table 6: Reverberant noise level, dB

	Octave Band Centre Frequency (Hz)							
Source	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**dBA**
Amplified band	100	105	104	102	101	97	93	105

4.2 Roof constructions

The roof of the new building is to be of lightweight construction, utilising Ortech Durra Panel for sound insulation and reverberation control. The existing roof of the heritage building is to be confirmed. Preliminary allowances are provided based on a metal deck roof.

The following roof constructions in Table 7 will allow the reduction of noise ingress from rain noise intrusion and compliance with the design criteria in Tables 4 and 5.

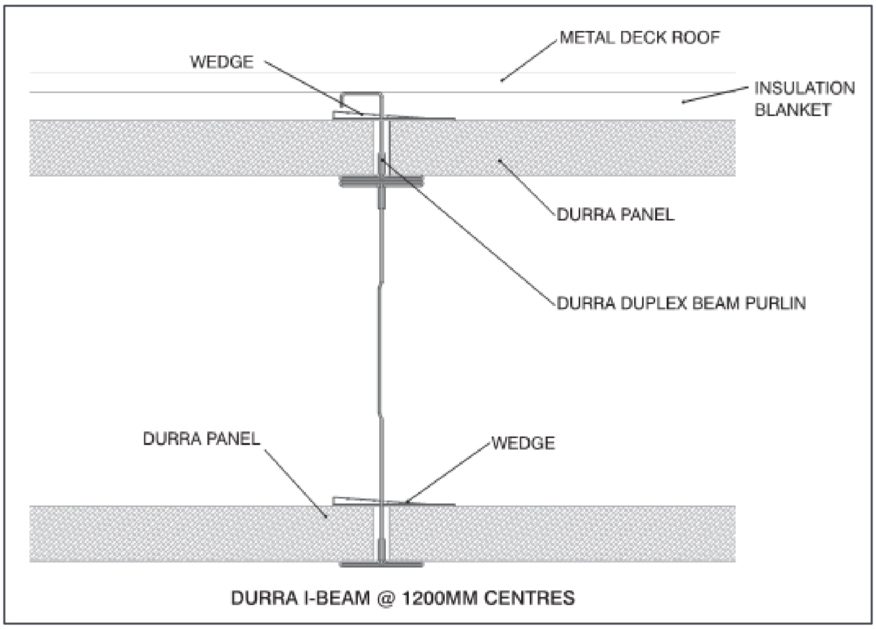
Table 7: Roof/ceiling constructions

Location	Construction
Theatre/Fly tower	– Minimum 0.48mm metal deck roof – 30mm air cavity with 50mm Anticon roofing blanket insulation (80mm Durra Duplex Beam with upper mass layer sitting within Duplex Beam) – 1 x layer of S50 Durra Panel – 344mm air cavity (400mm Durra I Beam with lower mass layers sitting within I Beam) with 100mm insulation, minimum density 20kg/m^3 in cavity – 1 x layer of S50 Durra Panel – 1 x layer of 6mm fibre cement sheet

Location	Construction
Foyer – new building	– Minimum 0.48mm metal deck roof – 19mm plywood – Cavity insulation (thickness and density TBC) – Acoustic ceiling
Foyer - heritage	Existing roof structure to be confirmed Allow for suspended 13mm plasterboard ceiling with insulation below metal deck roof

A conceptual sketch of the Theatre and Fly Tower roof/ceiling system is shown in Figure 2.

Figure 2: Theatre and Fly Tower roof/ceiling sketch



4.3 External walls

The following wall constructions in Table 8 will allow compliance with the design criteria in Tables 4 and 5. Further consideration of spaces will made as the design progresses.

Table 8: External wall constructions

Location	Construction
Theatre/Fly tower	– 150mm masonry (e.g. concrete, core filled blockwork etc.) – 64mm steel stud with 50mm cavity insulation, minimum density 20kg/m3 – 1 x layer of 13mm plasterboard
BOH	Non critical. Masonry wall acceptable. Internal lining as required. To be reviewed as design progresses.
Foyer	Masonry wall with glazing element expected. To be reviewed as design progresses

5.0 INTERNAL SOUND INSULATION

5.1 Partition acoustic ratings and constructions

Table 5 nominates the partition acoustic rating for the Project. Preliminary partition constructions and acoustic detailing requirements to achieve the nominated sound reduction ratings are shown in Table 9. Note that these constructions are provided at this stage primarily for spatial allowances and to indicate which walls will require masonry elements.

Table 9: Proposed wall types

Wall Rating	Wall Construction	Comment
R_w 65	Masonry wall leaf (100mm solid concrete or 110mm brick) 64mm steel stud separated by min. 20mm air-gap, with 60mm thick 14kg/m^3 acoustic insulation to cavity 1x 13mm fire-rated plasterboard	Discontinuous construction. Minimum 20mm clear between masonry and stud Partitions to extend full height slab to slab
R_w 60	2x 13mm fire-rated plasterboard 2x 92mm steel studs separated by min. 20mm air-gap. 60mm thick 14kg/m^3 acoustic insulation to both studs 1x 13mm fire-rated plasterboard	Discontinuous construction. Minimum 20mm clear between masonry and stud Partitions to extend full height slab to slab
R_w 55	2x 13mm fire-rated plasterboard 2x 92mm steel studs separated by min. 20mm air-gap. 60mm thick 14kg/m^3 acoustic insulation to both studs 1x 13mm fire-rated plasterboard	Discontinuous construction. Minimum 20mm clear between masonry and stud Partitions to extend full height slab to slab
R_w 50	2x 13mm fire-rated plasterboard 64mm staggered steel studs in 92mm track with 60mm thick 14kg/m^3 acoustic insulation 1x 13mm fire-rated plasterboard	Partitions to extend full height slab to slab
R_w 45	1x 13mm fire-rated plasterboard 64mm staggered steel studs in 92mm track with 60mm thick 14kg/m^3 acoustic insulation 1x 13mm fire-rated plasterboard	Build partitions to 100mm above flush plasterboard ceiling, or Build at least one leaf of the wall to the underside of the slab above mineral fibre tile, or Build full height wall s to underside of slab where above perforated ceiling
R_w 40	1x 13mm fire-rated plasterboard 64mm steel stud with 60mm thick 14kg/m^3 acoustic insulation 1x 13mm fire-rated plasterboard	Build partitions to 100mm above flush plasterboard ceiling, or Build at least one leaf of the wall to the underside of the slab above mineral fibre tile, or Build full height wall s to underside of slab where above perforated ceiling

Wall Rating	Wall Construction	Comment
R_w 35	1x 13mm fire-rated plasterboard 64mm steel stud with 60mm thick 14kg/m^3 acoustic insulation 1x 13mm fire-rated plasterboard	Partition can terminate at the underside of a plasterboard or mineral fibre tile ceiling, or Build at least one leaf of the wall to the underside of the slab where above perforated ceiling

The specific requirements of the Control Room window in the Theatre have not been determined at this stage. To maintain flexibility, it is suggested at this stage that the window be openable and have an acoustic rating of not less than R_w 35, which would be achievable with 10.38mm laminated glass. A heavy frame with high quality compression type acoustic seals will be required around this window.

Any glazing in acoustic rated walls must be coordinated with MDA.

5.2 Door constructions

Door constructions to achieve the nominated acoustic ratings from Table 5 are shown in Table 10.

Table 10: Recommended door construction

Door Rating	Door Construction
R_w 20	38mm solid core door (no seals) Door grills not permitted
R_w 30	38mm solid core door fitted with acoustic seals to the frame and bottom Door grilles not permitted
R_w 35	Proprietary acoustic door with integrated frame, hardware and acoustic seals - acoustic rating R_w 35, <u>or</u> Sound lock with two R_w 20 doors separated by 1m
R_w 40	Proprietary acoustic door with integrated frame, hardware and acoustic seals - acoustic rating R_w 40. Allow for 50-70mm solid core door with multiple sets of seals; <u>or</u> Sound lock with one R_w 30 door and one R_w 20 door separated by 1m
R_w 45	Proprietary acoustic door with integrated frame, hardware and acoustic seals - acoustic rating R_w 45. Allow for 50-70mm solid core door with multiple sets of seals; <u>or</u> Sound lock with two R_w 30 doors separated by 1m
R_w 50	Proprietary acoustic door with integrated frame, hardware and acoustic seals - acoustic rating R_w 50; <u>or</u> Sound lock with one R_w 35 door and one R_w 30 door separated by 1m
R_w 55	Proprietary acoustic door with integrated frame, hardware and acoustic seals - acoustic rating R_w 55; <u>or</u> Sound lock with two R_w 35 doors separated by 1m

5.3 Sound transfer over ceilings

Where partitions are not full height slab-to-slab or slab-to-roof walls, i.e. where they do not extend above ceiling level to block the ceiling void, then noise transfer over ceilings is a critical transfer path. The level of acoustic treatment to ceilings and the practicality of achieving high sound insulation figures must be considered on a case-by-case basis and often requires site testing of sound insulation performance.

The following general guidance is provided for the on-site sound insulation ratings that can typically be achieved by over ceiling noise transfer, for a range of ceiling types:

Table 11: Typical ceiling sound transfer ratings

Ceiling type	Typical on-site rating, D_w
Solid plasterboard ceiling with no openings	35-40
Plasterboard ceiling with penetrations	30-35
Acoustic ceiling tiles	30-35
Perforated ceiling	15-25

The acoustic performance of over-ceiling noise transfer must be carefully considered when selecting the partition types, ceiling types and the treatment of the void above ceiling level.

5.4 Lift shafts

Wherever a lift shaft is located next to an occupied space, a cavity wall of discontinuous construction is required between the lift shaft and the occupied space. There must be no contact between the lift shaft and the wall leaf.

5.5 Wet area walls

Wherever a wet area is located next to an occupied space, a cavity wall of discontinuous construction is required between the wet area and the occupied space. There must be no contact between the wet area and the other wall leaf. Plumbing services must only be fixed to the wall leaf on the wet area side of the partition.

5.6 Airborne sound transfer between floors

Airborne sound insulation ratings between floors must achieve the criteria nominated in Table 5 for the R_w acoustic ratings of a wall with no door. The following base floor/ceiling construction is recommended for the building extension:

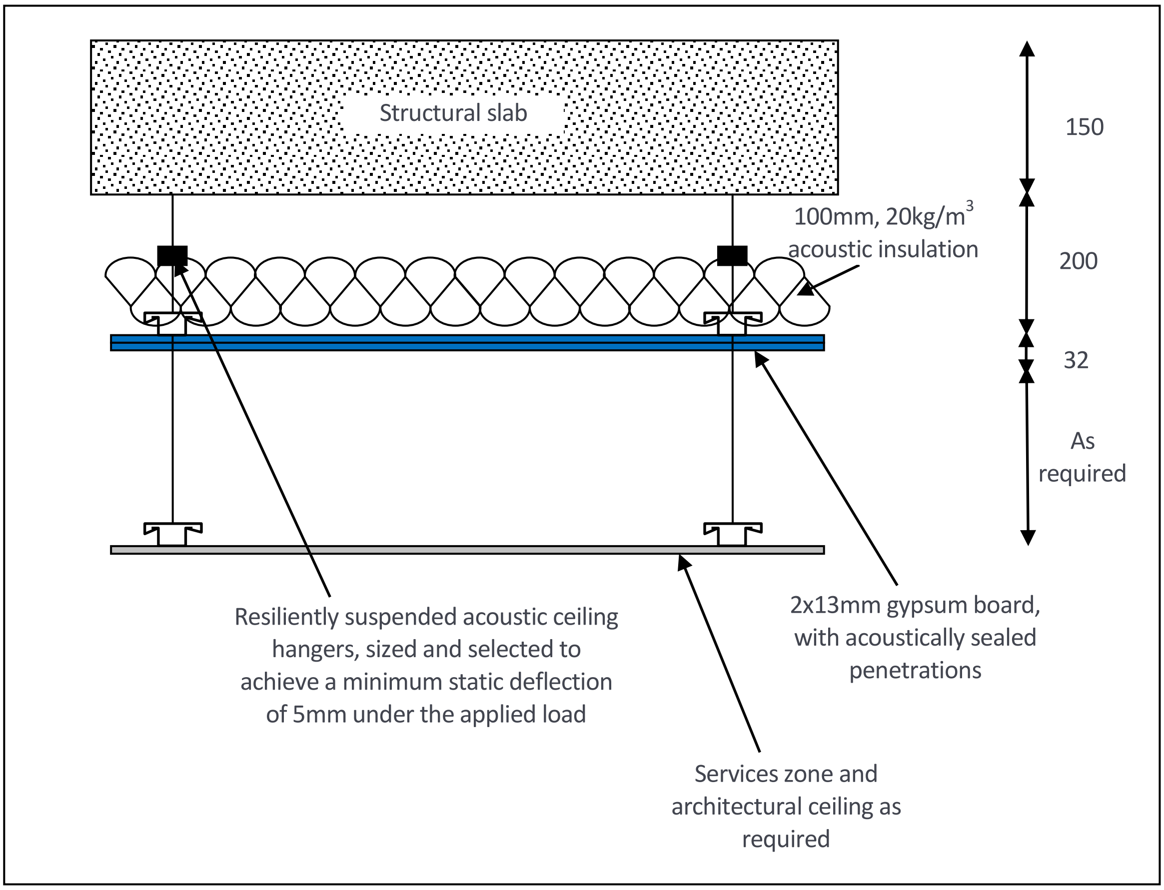
- 200mm concrete
- Metal suspension ceiling system with a minimum air space of 200mm
- Plasterboard or mineral fibre ceiling tile with a minimum acoustic rating of CAC35

The standard floor/ceiling construction detailed above is predicted to achieve an airborne sound insulation rating of R_w 60. This complies with the majority of the sound insulation ratings nominated in Table 5 and so would be acceptable in the majority of cases without further treatment. Note that any areas without a ceiling or with a perforated ceiling would require further review.

Where a sound insulation rating greater than R_w 60 is specified, additional acoustic treatment may be required. This may include installation of a resiliently suspended mass layer ceiling above or below the space in question.

A schematic detail of this upgrade of resiliently suspended mass layer ceiling treatment is shown in Figure 3.

Figure 3: Schematic detail of resiliently suspended mass layer ceiling



5.7 Floor impact sound isolation

5.7.1 Heritage building

Heritage building is assumed to have existing timber floors. The Level 2 offices are currently detailed as a carpet finish. The addition of a resilient suspended ceiling would further improve the floor impact sound insulation rating.

The Bar and Box office are located on Level 1 below the office areas on Level 2. These areas within the heritage building have a relatively low sensitivity. We note the preservation of heritage features may be of more value and would therefore take precedence over the acoustic requirements.

5.7.2 Building extension

The standard floor/ceiling construction detailed above is predicted to achieve a floor impact sound insulation rating of L_{nw} 62. Footfall noise will be audible in the space below.

The installation of resilient floor coverings such as carpet, cushioned vinyl or timber on resilient polyurethane adhesive (not rigid cement based adhesive) would improve the floor impact sound insulation rating, but a tiled or bare concrete finish would not.

If audible footfall is considered acceptable, then the base floor/ceiling system would be satisfactory. If better ratings are desired, then the floor finish would need to provide some resilience.

Note that the above floor impact sound insulation rating would not be achieved if ceilings are not provided, or if perforated ceilings were installed. In this case, the floor finish would need to be taken into consideration and modified if required to improve the performance.

It should be noted that the soundlock on Level 2 is located directly above the theatre. Carpet must be installed in this location so as to minimise floor impact noise transfer.

6.0 SPECIAL SOUND REDUCTION REQUIREMENTS

6.1 Theatre

Additional issues for consideration in the Theatre design include:

- The drawings identify a plant area underneath the Theatre seating. This will need to be acoustically isolated from the Theatre space and if any noisy plant is to be located in this area a highly acoustic rated enclosure will be required.
- The AHU plantroom requires a completely enclosed plantroom construction as per the R_w 65 specification. The plantroom must not be open to the plant area under the Theatre seating. Routes for cable trays and other services must be carefully managed.
- All access to the Theatre should be via a sound lock entry, because this provides a good balance between acoustic performance, ease of door operation and cost of installation (removing the need for expensive high performance acoustic doors). One set of doors can be held open when a high degree of acoustic separation is not required, then closed when the Theatre is in use, so as to maximise the sound reduction performance.

6.2 Control room

The control room window in the Theatre is to be openable. An acoustic rating of R_w 35 is recommended, which can be achieved with 10.38mm laminated glass. A heavy frame with high quality compression type acoustic seals will be required around this window. It is recommended the window be angled towards the ceiling by 5 degrees to eliminate the possibility of late reflections arriving at the stage, which can be disconcerting for performers.

The need for communication between the Theatre and the Control room may require open windows between the spaces at times. Therefore all noisy control equipment (including units fitted with intermittent cooling fans) shall be located external to the Theatre or in acoustic enclosures.

6.3 Follow spot

The heat build-up in the Follow spot room from the equipment will require mechanical ventilation and appropriate acoustic treatment to meet the internal noise design criteria. Fixed glazing is documented for the window to the Theatre. An acoustic rating of R_w 35 is recommended, which can be achieved with 10.38mm laminated glass.

6.4 Scenery door

Sound insulation of the scenery door requires careful consideration. The loading dock may be in use during a performance, as such noise breakout and break-in must be treated appropriately. An allowance for an acoustic door with a minimum sound reduction rating of R_w 50 should be made.

6.5 Theatre flying systems

The theatre flying systems is proposed to be a counter weight system, with the potential for future mechanical winches to be located at the Fly Gallery level. Any future winches installed for the flying system will need to be located within a room so as to reduce noise transfer to the stage and Theatre. The sound insulation of the winch room will need to be reviewed, and appropriate space and structural allowances should be considered.

6.6 Noise intrusion from control equipment

Audio Visual control systems, house and performance lighting systems can contribute to audible noise levels in the Theatre. Installation of these systems shall be in nominated locations selected to avoid noise intrusion into the performance space. Acoustic treatments such as acoustic enclosures or installation in dedicated spaces may be required for these items.

7.0 ROOM ACOUSTICS AND REVERBERATION CONTROL

The 400 seat Theatre requires special consideration of room acoustic conditions. A number of other areas within the Project will require relatively simple reverberation control. Preliminary recommendations for the various areas are discussed below.

Depending on the specific requirements of the room, a mix of broad band sound absorbers, tuned low frequency slotted or perforated sound absorbers and acoustic reflectors / diffusers will be necessary to achieve the required room acoustic conditions. A mix of sound absorptive and acoustically reflective ceilings will be required. Where acoustic wall panels are nominated, they will need to be evenly distributed around the room and located around the walls at a height of between 0.5m and 2m above floor level.

7.1 Theatre

7.1.1 Usage

We understand from client briefings that the Theatre will be used for:

- Spoken drama
- Musical theatre
- Amplified music
- Lectures and other spoken amplified events
- Orchestral choral recitals

The stage will be used by varying numbers of performers from small groups to full orchestral performances.

The Theatre will be used for both amplified and unamplified performances. It can be seen from the above that a range of different uses need to be accommodated in the Theatre which requires an appropriate balance between the ideal requirements of the different types of usage. It should be noted that by accommodating the various uses, the venue will not be capable of supporting a luscious room acoustic expected for traditional orchestral and choral performances.

7.1.2 Acoustic design criteria

Our proposed acoustic design criteria for the Theatre are shown in Table 12.

Table 12: Proposed acoustic design criteria

Parameter	Criteria
Reverberation time RT	1.0 seconds ± 20%
Clarity C80 (music)	0dB ± 2dB
Speech Intelligibility STI	≥ 0.5 at 90% of seats
Internal sound insulation	>R_w 65
Noise ingress	30dBA
Services Noise	NR25

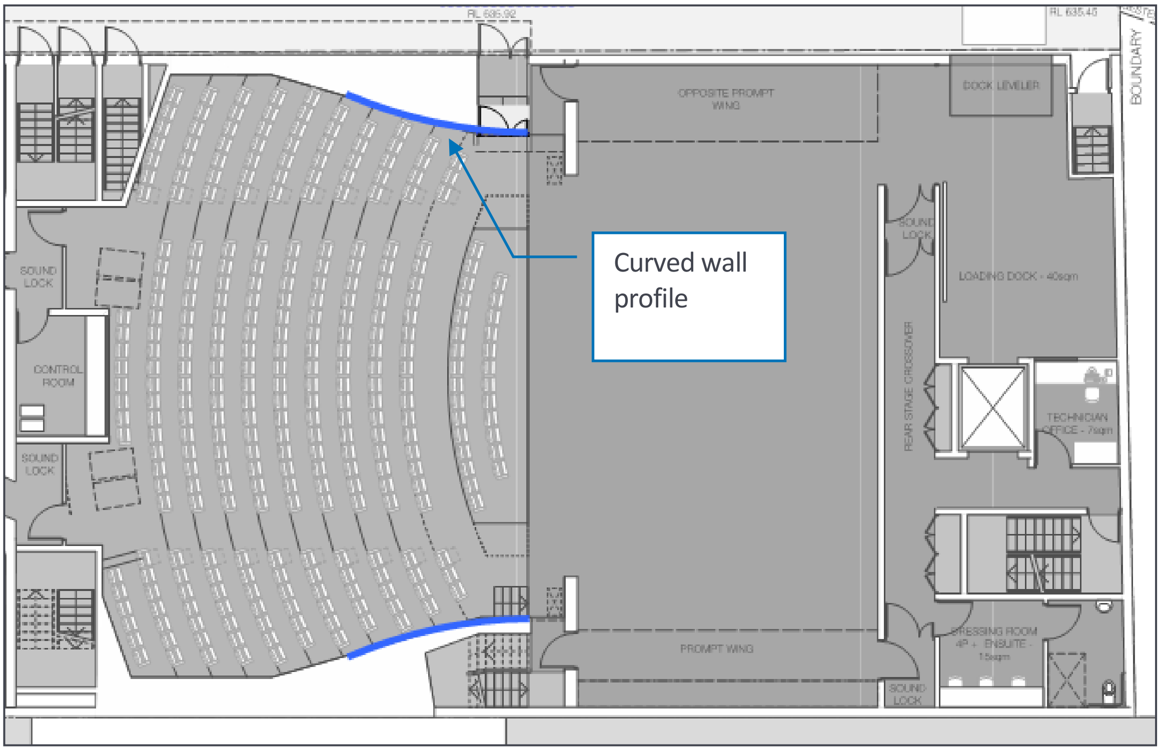
7.1.3 Volume and geometry

In general, the Theatre has a fan form with seating split between the stalls and balcony level with a maximum occupancy of 440 seats.

The room acoustic success of the Theatre depends on creating an appropriate volume for the room and installing surfaces that support the early reflections required for acoustic clarity and speech intelligibility. The approximate volume of Theatre is 2580m^3 equating to 5.8m3 per seat. This is considered to be within the recommended volume range for a multipurpose auditorium.

The wall profiles are important in promoting early lateral reflections to increase clarity, particularly in the mid stalls under the balcony where ceiling reflections will not reach. The current documented wall profiles will not promote reflections into the audience, and will therefore be detrimental to achieving the desired room acoustic. It is recommended the walls at the front of the audience area have a curved profile as indicated in Figure 5.

Figure 4: Theatre walls profile



The control room window should be angled up by 5 degrees to prevent unwanted reflections back to the stage which can be distracting for performers.

7.1.4 Surface finishes

Floor

The floor is to be timber on the stage and surrounding area, then carpet in the seating area.

Seating

Seating with an upholstered back, seat and arms will likely be required. The seating must be specified to achieve specific sound absorption values.

Walls

Late reflections that are heard as anomalies in the space shall be avoided by installing wall panels of acoustic absorption and diffusion. Preliminary acoustic treatment zones with a depth of 300mm shall be reserved on the rear wall and lower half of the side walls of the Theatre to allow scope for wall profiling and acoustic treatments to be incorporated into the design.

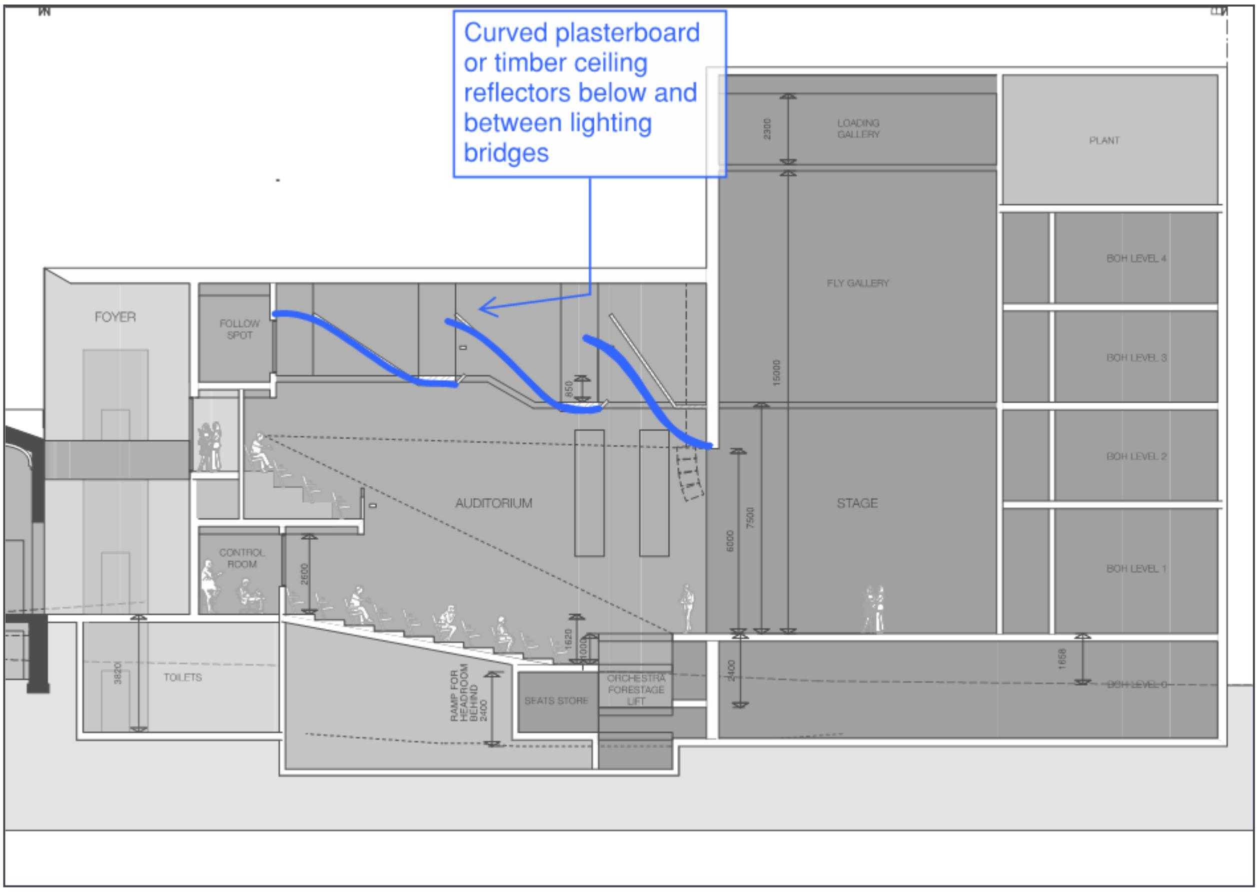
These profiles and treatments will need to be developed in consultation with the architects to establish a unified acoustic and architectural design that accommodates the theatrical requirements of the venue. The area and performance requirements of these panels shall be determined as the design proceeds.

Ceiling

Reflecting surfaces shall be installed in the ceiling plane to assist speech clarity. These surfaces will need to be co-ordinated with the lighting bridges and with the suspension rigging system and may be flown or attached to the lighting bridges.

The surfaces shall be shaped to promote reflections from the stage into the audience seating areas and may be constructed from 12mm plywood attached to a frame. Details of the overhead reflectors shall be developed with the Architect to achieve a seamless incorporation into the functionality of the Theatre. An indicative reflector location and profile is provided in Figure 6.

Figure 5: Theatre reflectors



7.1.5 Sound system

The Theatre will be used for both amplified and unamplified performance types. The room acoustic conditions will allow for both these performance modes. The sound system design will require coordination with the placement of the room acoustic treatments to allow seamless integration for amplified performances.

7.2 Orchestra pit

The design of the orchestra pit must prioritise the acoustic comfort of the musicians and have good sightlines for all musicians to the conductor at the front of the pit. In particular, consideration must be given to standing musicians at the rear who are often subject to higher noise levels from rear facing instruments.

A curtain will be required against the rear wall of the orchestra pit. The curtain should be divided into 2m wide strips to allow musicians to adjust the room acoustic as required for the performance.

7.3 Stagehouse

7.3.1 Acoustic design criteria

The stagehouse will need to achieve a reverberation time similar to the Theatre in order to ensure there are no anomalies associated with the acoustic coupling of the two spaces.

7.3.2 Surface finishes

Walls

Fixed acoustic absorption in the form of 100mm thick 32kg/m^3 insulation will be required to 50% of the wall surface area up to a height of 5m.

Ceiling

The entire ceiling area of the stagehouse should be lined with acoustic absorption in the form of 50mm thick 32kg/m^3 insulation.

7.4 Ancillary spaces

To control internal noise levels within the ancillary spaces, it is recommended that sound absorptive ceilings and wall panels be used. The typical layout for acoustic treatment in a room is as follows:

- The ceiling treatment should be mineral fibre ceiling tiles or a perforated (> 20% OA) plasterboard ceiling achieving a sound absorption rating of at least NRC 0.70. Note that in some spaces a ceiling layer with high transmission loss (such as solid plasterboard) may also be required above the absorbent layer to control noise breakout to adjacent spaces.
- Wall panels should achieve a sound absorption rating of at least NRC 0.7. Panels should be mounted on two adjacent walls so as to avoid walls with hard finishes from facing one another. Refer Figure 5.
- Carpeted floor wherever recommended.

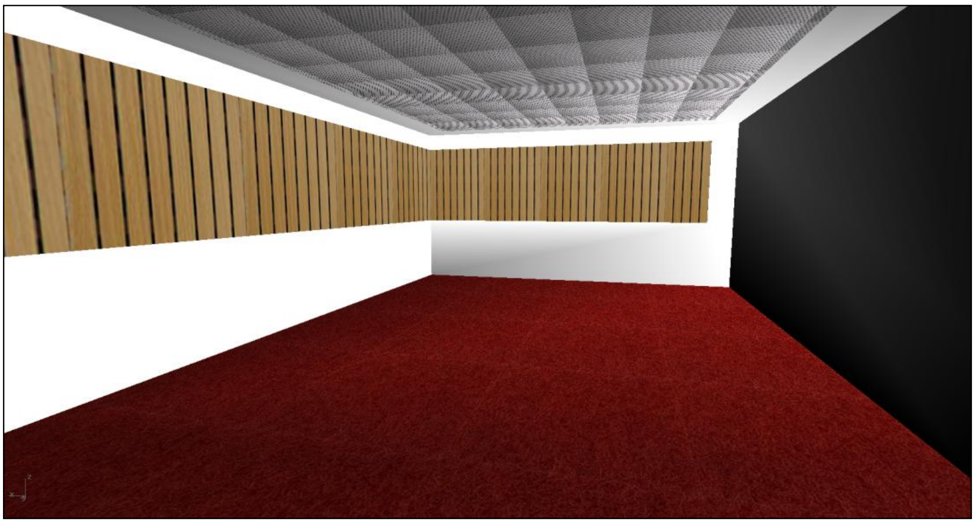
The recommended acoustic treatment for ancillary spaces is summarised in **Table 13** below.

Table 13: Recommended extent of acoustic treatment

Space	Floor	Wall Panels	Acoustic Ceiling
Foyers	-	15%	100%
Bar areas	-	-	✓
Green Room	Carpet	✓	✓
Dressing/Change Rooms	Carpet	-	✓
Control Room	✓	-	✓
Follow Spot Room	✓	-	✓
Back of House Corridors	-	-	✓

Space	Floor	Wall Panels	Acoustic Ceiling
Loading Dock	-	-	✓
Private offices	Carpet	✓	-
Support Offices	Carpet	✓	90%
Office waiting area	-	-	70%
Wardrobe & Laundry Room	-	-	-
General Corridors	-	-	✓
Kitchen	-	-	✓

Figure 6: Typical acoustic treatment: carpet, panels on adjacent walls and ceiling tiles.



Of particular importance is the control of reverberation in the Foyer where excessive reverberation can result in high crowd noise levels and poor privacy.

8.0 MECHANICAL SERVICES NOISE CONTROL

8.1 Recommended internal noise levels

Recommendations for internal noise level targets are listed in Table 5 applicable to building services systems. Noise from mechanical services must be free of tonal and spectral content and not exceed the levels stated in Table 5 when measured no closer than 1.5m from any diffuser or plantroom wall.

8.2 Mechanical services preliminary allowances for noise control

The following preliminary allowances should be made for the mechanical services noise control design:

- Internally lined ductwork to all acoustically sensitive spaces is expected to be required to achieve nominated noise level targets
- All access panels in mass layer acoustic ceilings will require acoustically rated access panels
- Where practicable, ducts should not penetrate full height acoustic rated partitions
- Acoustic rated transfer ducts will be required for relief air for high rated acoustic partitions
- Air velocities in ducts must not exceed the levels recommended in Table 14.

Table 14: Maximum duct velocities

Design criteria	Duct velocity limits, m/s				
NR	Main riser	Main duct	Branch duct	Run-out duct	Flexible duct
25	8	5	4	2.5	2.0*
30	9.5	6	4.5	3.5	2.5*
35	11	7.5	5.5	4	3
40	13	8.5	6.5	5	3.5
45	15.0	9.0	7.5	6.0	4.5

Definitions:

Main riser	Ducts not in the criteria space. Ducts in plant rooms or masonry risers which are followed by main ducts.
Main duct	Ducts within the criteria space followed by at least one lined elbow and run-out ducting, or at least 3 duct diameters of branch duct and run-out ducting.
Branch duct	All ducts connected directly to the run-out ducting.
Run-out duct	All ducts connected directly to the terminal register, or within 5 duct diameters of the register.
*	Caution must be exercised when installing flexible duct to ensure that airflow generated noise does not occur due to airflow restrictions.

8.3 Provisions for sensitive spaces

Suggested allowances for sensitive spaces (with criteria NR25) are:

- Allow to provide supply and return air attenuators and internal acoustic insulation to all ductwork
- Allow to provide cross-talk attenuation between the noisy and/or sensitive spaces if required (ideally common duct runs should not occur between these spaces).
- Allow to provide sufficiently large supply diffusers and return air grilles to minimise air velocities
- Allow to acoustically treat all ductwork penetrations through ceilings and full height walls
- Allow to provide an acoustic enclosure around the ductwork to control breakout noise from the air-handling unit

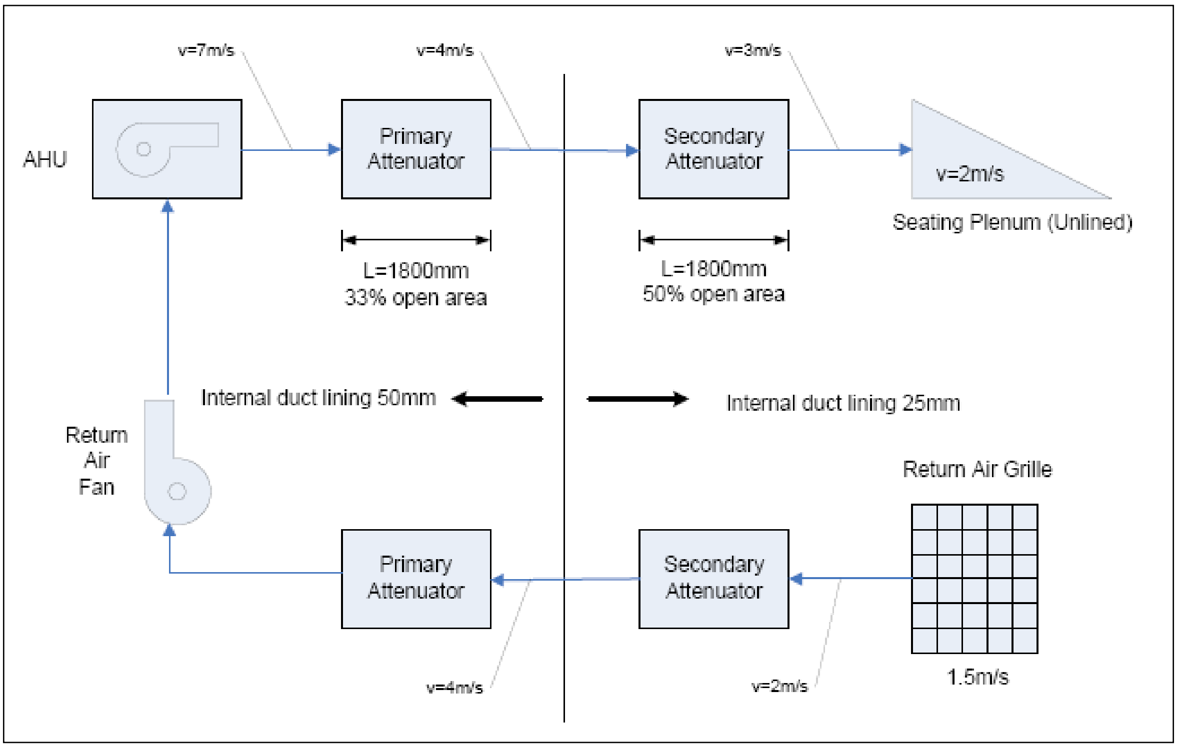
Detailed analysis of the mechanical services design will be required as the design progresses. To achieve low air velocities within sensitive spaces, large supply and return air plenums may be required with large air grilles.

8.4 Theatre mechanical design

As an example of appropriate mechanical services noise control design, Figure 7 provides a simplified duct layout for a fan system serving a critical space such as the Theatre. Note attenuator lengths are nominal allowances as the mechanical design is not yet available for acoustic review.

In addition to duct attenuators, it may be necessary to lag or enclose items of plant or ductwork in close proximity to noise sensitive spaces, to control case radiated or breakout noise from the systems. The mechanical consultant will need to take such issues into account in their noise control design.

Figure 7: Schematic layout of sound attenuation for critical spaces



8.5 Internal duct lining

Where ductwork is internally lined with acoustic insulation, the lining must achieve the minimum sound absorption performance as detailed in Table 16, including the effect of any facing material such as perforated metal or foil.

Table 15: Sound absorption performance specification for internal duct lining

	Random incidence sound absorption coefficient at octave band centre frequency (Hz)					
Thickness	**125**	**250**	**500**	**1k**	**2k**	**4k**
25mm	0.10	0.25	0.65	0.80	0.90	0.95
50mm	0.25	0.60	0.95	0.95	0.95	0.95

8.6 System balancing

For spaces with services noise criteria of NR35 or less, system balancing must be achieved using splitter dampers located remote from the terminal devices, grilles or diffusers. There must be no balancing dampers behind the diffusers or air grilles.

The supply and return air systems for these spaces must be designed such that they are naturally balanced and have low duct velocities.

A balanced duct system will branch out into a similar number of sub-ducts with similar length and dimensions, such that the air pressure is evenly distributed.

8.7 Flexible ductwork

All flexible duct must be the perforated acoustic type and must achieve a minimum insertion loss per metre as detailed in Table 17.

Table 16: Acoustic performance specification for flexible ductwork

Frequency	63	125	250	500	1k	2k	4k	Hz
Insertion loss	6	7	8	8	8	8	8	dB/m

8.8 Air diffusers, grilles and registers

For spaces with services noise criteria of NR30 or less, laboratory tested air regenerated sound power level data measured in a reverberation chamber in accordance with a recognised standard will be required for all grilles and diffusers. Manufacturers' noise ratings shall not be used as a selection guide.

Air diffusers, slot diffusers, return air grilles and supply air registers shall be quiet in operation and shall produce no objectionable tones or hissing noise.

8.9 Smoke exhaust fans

Smoke exhaust fans are to be located on the roof above the Theatre and the Stage. Unless treated appropriately, noise breakout from the Theatre through the smoke exhaust fans will exceed the environmental noise criteria.

Provision must be made to attenuate the smoke exhaust fan path during normal Theatre operation, in addition to when the fans are operational.

8.10 Environmental noise

To control environmental noise from significant external plant such as chillers, condensers, cooling towers, exhaust fans, pumps, etc. allowance should be made for the following:

- Acoustic screens around major plant equipment
- Acoustic louvres to major plantrooms
- Duct mounted sound attenuators to significant fans that exhaust to outside
- Acoustic doors to plantrooms.

The mechanical engineer will need to consider these issues and incorporate appropriate acoustic treatment into the mechanical systems as the design progresses.

8.11 Noise from electrical services

Noise-generating electrical equipment should, wherever possible, be located outside the Theatre. Fluorescent lighting can produce buzzing noise and should generally be avoided within the Theatre.

Electrical hum caused by low voltage lighting or dimmers should likewise be avoided. Fittings should be carefully selected and potentially noisy items (such as dimmer transformers) installed in a separate location away from noise sensitive spaces, e.g. within the ceiling space in the hallway.

9.0 VIBRATION AND STRUCTURE BORNE NOISE

The mechanical contractor must limit vibration levels arising from the operation of the building plant and associated equipment to prevent undue disturbance to occupants by designing to the requirements of the *2015 ASHRAE Handbook - HVAC Applications*.

There are various sources of vibration that require consideration in terms of compliance with the above requirements, including equipment such as pumps, fans, condensers, chillers, cooling towers, generators, air handling units, fan coil units, boilers, lifts, etc.

The mechanical contractor must provide equipment vibration isolation mounts, hangers and associated treatment such as flexible connections in ducts and pipes, etc. as required to achieve compliance with the ASHRAE requirements.

Dynamic sources of vibration such as that generated by people walking will need to be considered by the structural engineer to assess compliance with the ASHRAE vibration limits.

10.0 FURTHER CONSIDERATIONS FOR DETAILED DESIGN

Further analysis and design reviews required to complete the detailed design are required including:

- Detailed review of the mechanical services design to control services noise and ensure that the acoustic separation between spaces is not compromised
- Detailed review and specification of doors and glazing systems
- Detailed modelling and specification of surface finishes
- Noise emissions from HVAC plant
- Noise breakout from on site operations for Council compliance

APPENDIX A GLOSSARY OF TERMINOLOGY

dBA The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.

D_w Weighted sound reduction index, which is a measure of the acoustic effectiveness of a building partition, door or other building element in blocking noise transmission from one side of the element to the other. This value is the result of measurements on-site in accordance with the relevant Australian Standards. The higher the D_w, the better the acoustic performance.

$L_{Aeq\ (t)}$ The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.

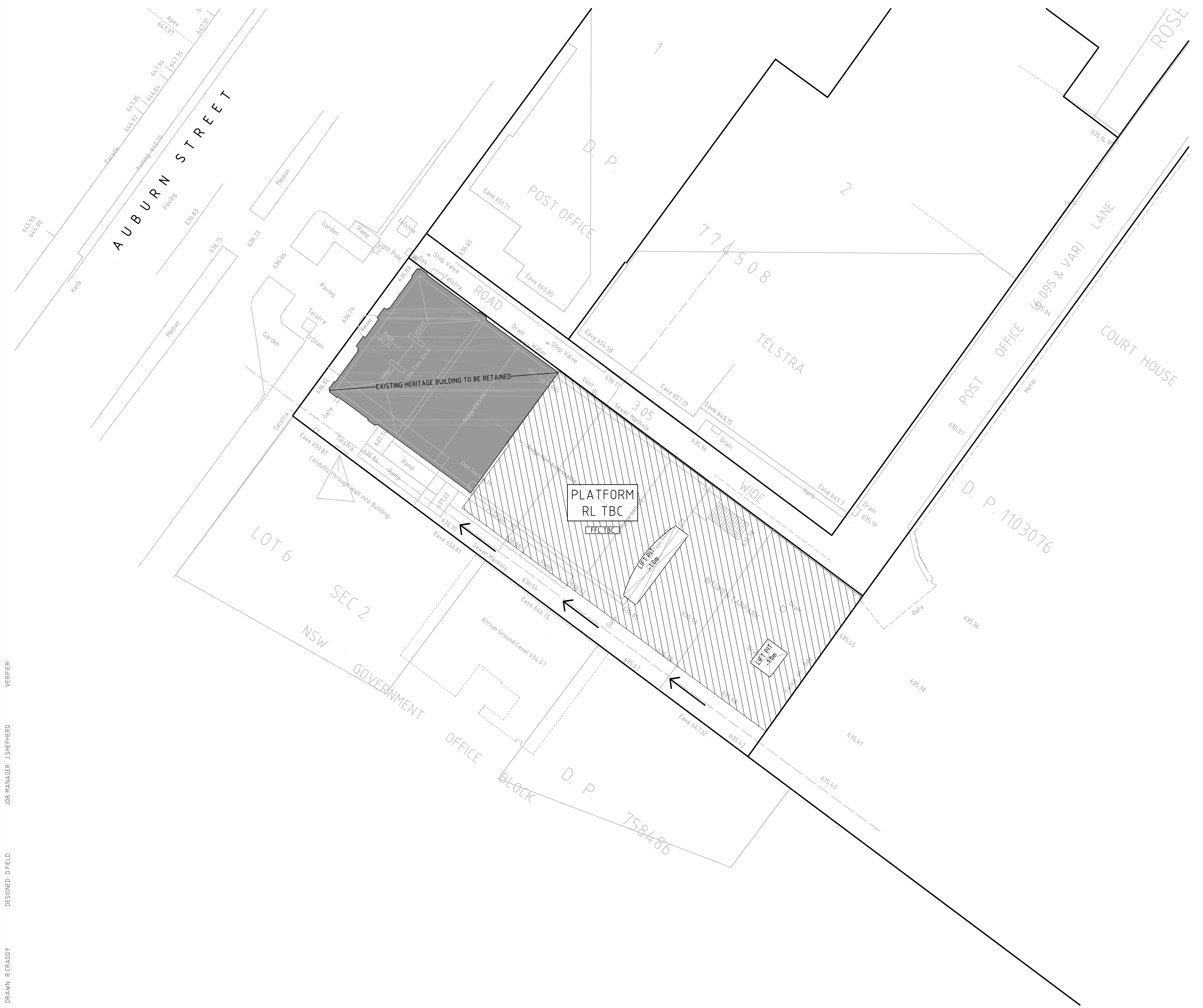
R_w Weighted Sound Reduction Index
A single number rating of the sound insulation performance of a specific building element. R_w is measured in a laboratory. R_w is commonly used by manufacturers to describe the sound insulation performance of building elements such as plasterboard and concrete.

RT or T_{60} Reverberation Time
The time (in seconds) taken for the sound pressure level generated by a particular noise incident to decay by 60 decibels following the conclusion of the noise event (hence T_{60} abbreviation).

Reverberation Time is used for assessing the acoustic qualities of a space, describing how quickly sound decays within a space. The reverberation time is related to the room volume and total absorption.

TAB Y

Bulk Earthworks Plan



LEGEND:

✳ REFER ARCHITECTURAL DRAWINGS FOR SETOUT

FLAT PLATFORM

DIRECTION OF FALL

NOTES:

A. BULK EARTHWORKS & CIVIL WORKS

- UNLESS OTHERWISE NOTED, CARRY OUT ALL WORK IN ACCORDANCE WITH GOULBURN MULWAREE COUNCIL SPECIFICATIONS AND REQUIREMENTS.
- CONTRACTOR TO OBTAIN SERVICES CLEARANCES FROM ALL RELEVANT AUTHORITIES PRIOR TO COMMENCING WORKS. UNDERTAKE ALL NECESSARY TEMPORARY WORKS TO PROTECT & MAINTAIN EXISTING SERVICES DURING CONSTRUCTION. RESTORE ALL SERVICES AT THE COMPLETION OF THE WORKS.
- RESTORE ALL PAVED, GRASSED AND LANDSCAPED AREAS OUTSIDE THE BOUNDARY DAMAGED BY THE WORK TO THEIR ORIGINAL CONDITION ON COMPLETION OF WORKS.
- CONFIRM LEVELS ON SITE. IF ANY DISCREPANCIES, CHECK WITH THE SUPERINTENDENT.

B. POLLUTION CONTROL

- CONTRACTOR TO COMPLY WITH ENVIRONMENTAL PROTECTION ACT & TAKE OUT ANY REQUIRED ENVIRONMENT PROTECTION AGREEMENT WITH GOULBURN MULWAREE COUNCIL PRIOR TO COMMENCING WORKS.
- ALL EROSION & SEDIMENT CONTROL TO BE CONSTRUCTED IN ACCORDANCE WITH 'THE BLUE BOOK'.
- EROSION & SEDIMENT CONTROL MEASURES ARE TO BE MAINTAINED, ADJUSTED AND/OR SUPPLEMENTED THROUGHOUT THE CONSTRUCTION PERIOD AS NECESSARY.

C. BULK EARTHWORKS PROCEDURE

- INSTALL AGREED POLLUTION CONTROL MEASURES IN ACCORDANCE WITH ANY REQUIRED ENVIRONMENTAL PROTECTION AGREEMENT REQUIREMENTS.
- REMOVE ANY VEGETATION, GRASSING, BUILDERS DEBRIS AND CONCRETE & BITUMEN PAVING. STRIP TOPSOIL FROM VEGETATED AREAS AND SPOIL ALL MATERIALS OFF SITE.
- REMOVE ANY TREES AND ROOTS EXCEPTING THOSE INTENDED FOR RETENTION.
  GRUB OUT ROOTS AND STUMPS OVER 75mm DIAMETER TO MINIMUM DEPTH OF 500mm BELOW THE PLATFORM LEVEL.
  FILL GRUB HOLES AND OTHER VOIDS WITH GENERAL FILL AND COMPACT IN 150mm COMPACTED THICKNESS LAYERS TO THE LEVELS SHOWN ON THE DRAWINGS.
- PROOF ROLL THE EXPOSED SURFACE WITH AT LEAST A 10 TONNE ROLLER IN THE PRESENCE OF THE ENGINEER TO DETERMINE THE INTEGRITY OF THE EXPOSED SURFACE. CARRY OUT REPLACEMENT AS NECESSARY TO ACHIEVE THE REQUIRED COMPACTION.
- EXCAVATE AND REPLACE UNSUITABLE SUBGRADE IN SELECT MATERIAL FROM EXCAVATION, PLACED IN 200mm LAYERS, WITH EACH LAYER COMPACTED TO 100% MMDD. UNSUITABLE MATERIAL TO BE SPOILED FROM SITE.
- UNDERTAKE CUT/FILL OPERATIONS TO ESTABLISH THE BUILDING PLATFORM LEVELS NOMINATED.
- COMPACT THE EXPOSED SURFACE TO THE FOLLOWING CONDITIONS
  UNDER FUTURE BUILDINGS
  COMPACT TO 100% STDD

  UNDER FUTURE ROADS/CARPARKING/PAVING
  COMPACT TO 90% STDD IF GREATER THAN 600mm BELOW NOMINATED PAVEMENT SUBGRADE LEVEL, OTHERWISE 95%MMDD.

  OMC -1%/+3% DURING COMPACTION
- MATERIALS WON FROM EXCAVATION CAN BE USED FOR ENGINEERING FILL ON THE FOLLOWING CONDITIONS:

  TOPSOIL IS EXCLUDED TOPSOIL MAY BE USED IN LANDSCAPE BATTERS.
  FILL MATERIALS MAY BE USED PROVIDED DELETERIOUS MATERIALS ARE REMOVED.
  MEDIUM/HIGH PLASTICITY SANDY CLAYS (RESIDUAL SOILS) ARE THOROUGHLY MIXED WITH GRANULAR SOILS.
  HIGHLY WEATHERED ROCK/MODERATELY WEATHERED ROCK IS BROKEN DOWN TO PARTICLES WITH A SIZE NO GREATER THAN 100mm BIGGER PARTICLES MUST BE EXCLUDED.
- FILL MATERIALS TO BE PLACED IN MAXIMUM 200mm LAYERS, EACH LAYER COMPACTED TO THE NOMINATED DENSITY AND MOISTURE CONTENT.

  IMPORT FILL TO MAKE UP ANY SHORTFALL. IMPORTED FILL TO COMPLY WITH FOLLOWING SPECIFICATION.
  MAXIMUM SIZE 75mm
  PASSING 75 MICRON SIEVE - NOT GREATER THAN 25%
  PLASTICITY INDEX - LESS THAN 15%
  CBR - NO LESS THAN 8.
  FREE OF ORGANIC MATTER AND LUMPS OF CLAY.

TESTING:

- UNDERTAKE THE FOLLOWING TESTS BY NATA REGISTERED LABORATORY
  COMPACTION TESTS - NOT LESS THAN 1 TEST PER 1000m² FOR EACH SUCCESSIVE ODD LAYER
  TESTS TO BE TAKEN ON EXPOSED SURFACE
  LAYERS No. 1, 3, 5 & EACH SUCCESSIVE ODD LAYER TO OBTAIN REPRESENTATIVE CROSSSECTION
  CBR TESTS TO CONFIRM IN-SITU CBR STRENGTH OF CUT & FILL SUBGRADES.
- ANY FILL TO BE CERTIFIED BY AN APPROPRIATELY QUALIFIED ENGINEER TO LEVEL 1 STANDARD AS DEFINED IN AS 3798.
  STOCKPILED TOPSOIL TO BE SPREAD IN LANDSCAPE BATTERS TO FINISH LEVEL.
  ALL EXCESS TOPSOIL & FILL MATERIAL TO BE SPOILED FROM SITE IN AN LEGAL MANNER.
- STABILISE ALL EXCAVATION FACES IN ACCORDANCE WITH DETAILS SPECIFIED ON STRUCTURAL ENGINEERS DRAWING.
- CONTROL ALL RAINWATER & GROUNDWATER SEEPAGE BY PUMPING. COMPLY WITH ALL PROVISIONS OF THE ENVIRONMENT PROTECTION AGREEMENT RELATING TO DISPOSAL OF SITE WATER.
- TOLERANCES: LEVEL: = +25mm -10mm

NOT FOR CONSTRUCTION

DRAWN: R.CRADDY
DESIGNED: D FIELD
JOB MANAGER: J SHEPHERD
VERIFIER:

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	PRELIMINARY	RC		DF	18.10.2016

CLIENT
GOULBURN MULWAREE COUNCIL

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT
BREWSTER HJORTH ARCHITECTS

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

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PLAN
SCALE 1:200 @ A1

NORTHROP
Canberra
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Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT
GOULBURN PERFORMING ARTS CENTRE
LOT 17 SECTION 2
AUBURN STREET, GOULBURN NSW

DRAWING TITLE
CIVIL WORKS
CONCEPT BULK EARTHWORKS PLAN

JOB NUMBER
CR161849

DRAWING NUMBER
C100

REVISION
1

DRAWING SHEET SIZE = A1

TAB Z

Geotechnical Report Investigation

ACT Geotechnical Engineers Pty Ltd

NORTHROP CONSULTING ENGINEERS

PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW

GEOTECHNICAL INVESTIGATION REPORT

SEPTEMBER 2016

Geotechnical Engineers ACT

ACT Geotechnical Engineers Pty Ltd
ACN 063 673 530

5/9 Beaconsfield Street, Fyshwick ACT 2609
PO Box 9225, Deakin ACT 2600
Ph: (02) 6285 1547 & 0419 249 686
Email: hermann.retief@actgeoeng.com.au

15 September 2016
Our ref: HR/C8315

Northrop Consulting Engineers
2 – 4 Shea Street
PHILLIP ACT 2606

Attention: Mr Bryan Cossart

Dear Sir

PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW

GEOTECHNICAL INVESTIGATION REPORT

We are pleased to present our geotechnical investigation for the proposed performing arts centre at 163 Auburn Street, in Goulburn, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions, and provides recommendations for site earthworks and building footing design.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

HRetief

Hermann Retief
Senior Geotechnical Engineer

NORTHROP CONSULTING ENGINEERS

PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW

GEOTECHNICAL INVESTIGATION REPORT

SEPTEMBER 2016

NORTHROP CONSULTING ENGINEERS

PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW

GEOTECHNICAL INVESTIGATION REPORT

TABLE OF CONTENTS

NORTHROP CONSULTING ENGINEERS

PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW

GEOTECHNICAL INVESTIGATION REPORT

1 INTRODUCTION

In response to a request by Northrop Consulting Engineers, ACT Geotechnical Engineers Pty Ltd conducted a geotechnical investigation for the performing arts centre at 163 Auburn Street, in Goulburn, NSW.

The project involves the demolition of the later additions of the existing building at 163 Auburn Street, and an extension to the rear.

The aim of the investigation was to:

(i) Provide the site classification to AS2870 "Residential Slabs & Footings".

(ii) Identify subsurface conditions, including the extent and nature of any fill materials, natural soil profile, bedrock type and depth, and groundwater presence.

(iii) Recommend suitable footing systems for the proposed extension including founding depths and recommended allowable bearing pressures.

(iv) Advise on preparation of subgrades for building slabs and pavements.

(v) Advise on excavation conditions, suitability of excavated material for use in controlled fill platforms, and advice for construction of controlled fill platforms.

(vi) Advise on stability of cut and fill batters.

(vii) Advise on pavement subgrade preparation and provide indicative design CBR values.

(viii) Provide the Earthquake Site Factor.

(ix) Advise on site drainage and other relevant geotechnical issues.

2 SITE DESCRIPTION & GEOLOGY

The site is located at 163 Auburn Street and is bounded by a post office to the north, Post Office Place to the north-east, Goulburn Law Court to the east, developed lots to the south, and Auburn Street to the north-west. Figure 1 shows the site locality.

The site is presently occupied by the heritage-listed McDermott Centre building on the front two-thirds, and bitumen carparking at the rear third of the site. The groundsurface is relatively flat. A recent aerial photograph is presented as Figure 2 that also shows the locations of the auger holes and Figure 3 is a site plan provided by the client showing the proposed development and also shows the location of the auger holes.

The Geological Survey of New South Wales 1:250,000 Goulburn Geology map (Reference 1) documents the site to be underlain by Quaternary age alluvial deposits of sand, gravel and clay, associated with the Mulwaree Ponds River, underlain by Silurian age undifferentiated sedimentary bedrock including limestone, shale, chert, quartzite and tuff. Previous investigations in this area of Goulburn have found the bedrock to be as deep as 10m.

3 INVESTIGATION METHODS

To establish the subsurface conditions, a Yanmar excavator with an auger attachment was used to drill two investigation auger holes, designated 1A and 2A on the site on 8 September, 2016. The borehole logs are included in Appendix A.

The subsurface profiles were logged in terms of the Unified Soil Classification System (USCS). Definitions of geotechnical engineering terms used on the auger hole logs, including a copy of the USCS chart, are provided in Appendix B.

4 INVESTIGATION RESULTS

4.1 Subsurface Conditions

Investigation boreholes 1A and 2A found a similar subsurface profile of the site, comprising:

Geological Profile	Typical Depth Interval	Description
ASPHALTIC CONCRETE	0m to 0.05m/0.14m	ASPHALTIC CONCRETE.
UNCONTROLLED FILL	0.05m/0.14m to 0.7m/1.0m	SANDY CLAY, GRAVELLY CLAY, SAND & CLAYEY SAND; low and low to medium plasticity clay, fine to coarse sand, some sub-rounded gravels up to 5mm size, dark brown, yellow-brown, dark grey, some brick and concrete fragments up to 50mm size, trace ceramic and glass fragments, trace sub-angular quartz gravels up to 30mm size, dry to moist and moist to wet, soft to firm, loose and medium dense.
SLOPEWASH	0.7m to 0.9m	GRAVELLY CLAY; low to medium plasticity clay, ferruginous nodules up to 10mm size, pale grey, some fine to coarse sand, moist to wet, soft to firm. Only encountered in auger hole 1A.
ALLUVIUM	below 0.9m/1.0m	SANDY CLAY & GRAVELLY CLAY; medium to high plasticity clay, fine to medium sand, sub-angular gravels up to 5mm size, yellow-brown, some red-brown, pale grey, some fine to coarse sand, some sub-angular and sub-rounded gravels up to 5mm size, dry to moist, moist, very stiff.

Uncontrolled fill was encountered in all auger holes, extending to 0.7m/1.0m depth. Bedrock was was not encountered in any of the auger holes within the 3m investigation depth. Previous investigations in this area of Goulburn have found the bedrock to be as deep as 10m.

4.2 Groundwater

Permanent groundwater was not encountered during the investigation. Temporary, seasonal seepages could occur following rainfall, particularly at the interface in-between the uncontrolled fill and natural soil.

5 DISCUSSION & RECOMMENDATIONS

5.1 Site Classification

Due to the presence of uncontrolled fill of up to 1.0m depth in the area of the proposed extension, the site must be designated a Class "P" (problem) site according to AS2870 "Residential Slabs & Footings" (Reference 2).

If the fill is removed footings are founded in the very stiff to hard alluvial soils, or the existing fill is replaced by controlled fill, based on the expected thicknesses and shrink-swell propertied of the natural soils, we estimate the characteristic ground surface movement "y_s", as defined by AS2870 "Residential Slabs & Footings" (Reference 2) for the range of extreme dry to extreme wet ground moisture conditions to be between 40mm and 60mm. Footings could then be proportioned for a Class "H1" (highly reactive) site. It is recommended that the site classification is re-assessed after cut/fill works have been carried out.

Deemed-to-comply footing designs provided by AS2870 are applicable specifically to residential-style one and two-storey structures, or buildings with similar loads and superstructure stiffness.

5.2 Building Footings & Ground Slabs

The project involves the demolition of the later additions of the existing building at 163 Auburn Street, and an extension to the rear.

Suitable footings for the structure include pads/strips founding in newly placed controlled fill (Section 5.5) or very stiff to hard alluvial soil. Alternatively, bored piers founding in the very stiff to hard alluvial soils below 0.9m/1.0m depth can be used. All footings should be taken below any asphaltic concrete, uncontrolled fill, moisture-softened slopewash or disturbed ground. A founding depth of 0.9m/1.0m is expected.

Recommended allowable end-bearing pressures for various footing systems are provided in Table 1.

TABLE 1

Recommended Allowable End-Bearing Pressures for Footings

Foundation Material Type	Depth Below Existing Surface	Allowable End-Bearing Pressure		
		Strips	Pads	Piers
Newly Constructed Controlled Fill	-	100kPa	125kPa	N/A
Very Stiff to Hard Alluvial Soil	0.9m/1.0m	125kPa	150kPa	200kPa

All footing excavations should be inspected and approved by an experienced geotechnical engineer to confirm the foundation material and design values, and to ensure the excavations are clean and stable.

Groundslabs can be constructed on newly constructed controlled fill, natural alluvial/residual soil or weathered bedrock, following the removal of any silty topsoil and uncontrolled fill, and disturbed ground. Following excavation to required level, slab areas on soil should be proof-rolled by a pad-foot roller to check for any weak, wet or deforming soils that may require replacement. Suitable replacement fill should be compacted at about OMC in not thicker than 150mm layers to not less than 98%StdMDD.

If required for design of ground slabs, a modulus of subgrade reaction of 30kPa/mm can be assumed for a controlled fill or natural soil foundation.

5.3 Excavation Conditions & Use of Excavated Material

Proposed excavation depths have not been indicated but may be up to 1.0m depth. Such excavations would be through asphaltic concrete, uncontrolled fill, slopewash soils and into alluvial soils. The overburden soils can be all dug by backhoe and excavator.

The low to medium plasticity clayey/sandy/gravelly, slopewash and uncontrolled fill soils could be used in controlled fill construction provided all particles are broken down to less than 75mm size. The medium to high plasticity alluvial clay is not typically suitable for controlled fill, but could be used in non-structural applications such as landscaping.

If imported fill is required, a suitable select fill material would include a low or medium plasticity soil such as clayey sand or gravelly clayey sand, containing between 25% and 50% fines less than 0.075mm size (silt and clay), and no particles greater than 75mm size.

Permanent groundwater is not expected within the proposed excavation depth. However, temporary perched seepages can be present at shallower depth following rain, but should be readily controllable during construction.

5.4 Stable Cut/Fill Batter Slopes

Temporary site excavations to 1.5m depth can be formed near-vertical, although the uncontrolled fill should be cut at 1(H):1(V). If required, deeper temporary cuts can be benched or formed at 1(H):1(V). Exposed temporary batters in soil should be protected from the weather by black plastic pinned to the face with link-wire mesh or similar, and should be inspected during construction by a geotechnical engineer.

Permanent cut and fill soil batters should be formed at no steeper than 2(H):1(V). All soil cut and fill surfaces should be protected against erosion by topsoiling and grassing, or other suitable means. It is advisable that permanent batters are inspected during excavation by an experienced geotechnical engineer to confirm stability.

5.5 Controlled Fill Construction

The following procedure is recommended for construction of controlled fill foundation platforms for buildings and pavements:

1) Areas be fully stripped of all asphaltic concrete, uncontrolled fill, moisture-softened slopewash or disturbed ground (a stripping depth of up to 1.0m may be required).
2) Stripped foundations be proof-rolled by a vibratory pad-foot roller of not less than 9 tonne static mass to check for any weak or wet areas that require replacement.
3) Replacement fill and platform fill of suitable materials (Section 5.3) be compacted to required level in not thicker than 150mm layers to not less than 98%StdMDD at about optimum moisture content.
4) Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 as defined in AS3798 - 1996 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 3).

5.6 Low Retaining Walls

Retaining walls constructed using cantilevered soldier piers or in open excavation, with the gap between the excavation face and the wall backfilled later, can be designed for a triangular earth/rock pressure distribution given by:

$\sigma_h = (K_a\gamma' h) + Kq$

where,

σ_h is the horizontal earth pressure acting on the back of the wall, in kPa

K_a is the dimensionless coefficient of earth pressure; this can be assumed to be 0.4 when the top of the wall is unrestrained horizontally, and 0.6 when the top of the wall is restrained (i.e. by building floor slabs etc.)

γ' is the effective unit weight of the backfill, and can be assumed to be 20kN/m^3 for a lightly compacted soil backfill

h is the height of the backfill, in metres

q is any uniform distributed vertical surcharge acting on the top of the backfill, in kPa

Apart from structural restraints such as floor slabs, resistance to overturning and sliding of retaining walls is provided by frictional and adhesive resistance on the base, and by passive resistance at the toe of the wall. For a natural soil or controlled fill foundation, an ultimate base friction factor (tanδ) of 0.4, base adhesion (c) of 30kPa, and passive earth pressure coefficient Kp=2.5 can be used for calculation of of sliding resistance.

Free-draining granular backfill or synthetic fabric drains should be installed behind all walls. These should connect to weep holes and/or a collector drain, and ultimately to the stormwater system. Granular backfill should be wrapped in a suitable filter fabric to minimise infiltration of silt/clay fines.

5.7 Pavement Subgrades

Pavement subgrades should be prepared as outlined in Section 5.5. Natural or controlled fill subgrades can be designed using a CBR value of 3%. Exposed subgrades should be inspected by a geotechnical engineer to check the recommended design CBR value.

5.8 Earthquake Site Factor

The Geoscience website (Reference 4) lists the earthquake acceleration coefficients for major centres to be considered in structural design. The Goulburn area has an acceleration coefficient of 0.06.

Section 4 of AS1170.4 "Minimum Design Loads on Structures - Part 4: Earthquake Loads" (Reference 5) summarises the Site Subsoil Class which depends on the subsurface conditions at the site in question. A Site Subsoil Class C_e is applicable for this development.

5.9 Site Drainage

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond against the buildings.

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REFERENCES

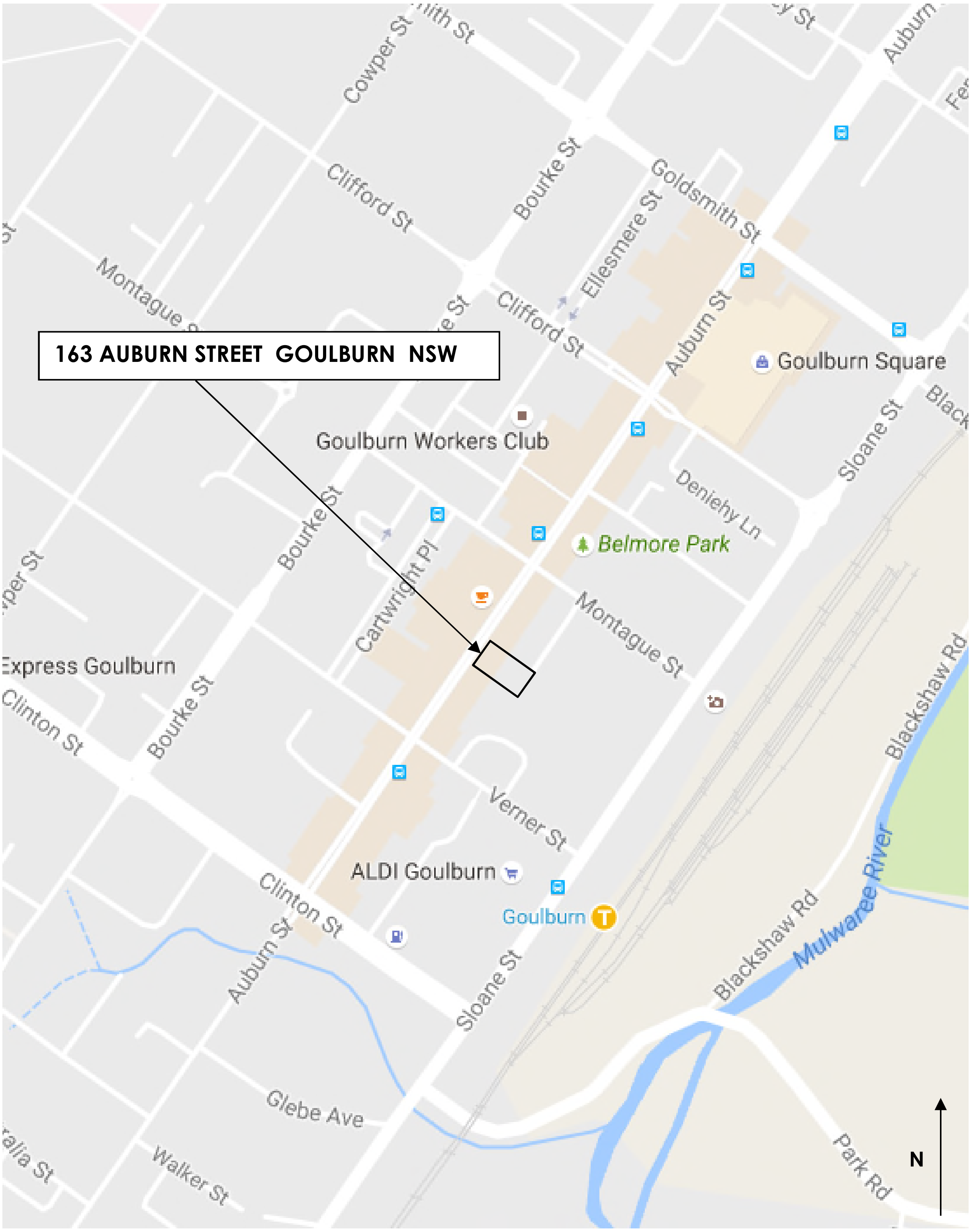
Reference 1 Geological Survey of New South Wales, "Geology of Goulburn - 1:50,000 Geological Series Sheet SI 55-12", 1970.

Reference 2 Standards Australia, "AS2870 - Residential slabs and footings - Construction", 2011.

Reference 3 Standards Australia, "AS3798 - Guidelines on Earthworks for Commercial & Residential Developments", 1996.

Reference 4 Geoscience Australia - http://www.ga.gov.au/darwin-view/hazards.xhtml# 14 September 2016.

Reference 5 Standards Australia, "AS1170.4 - 1993 - Minimum Design Loads on Structures Part 4: Earthquake Loads".

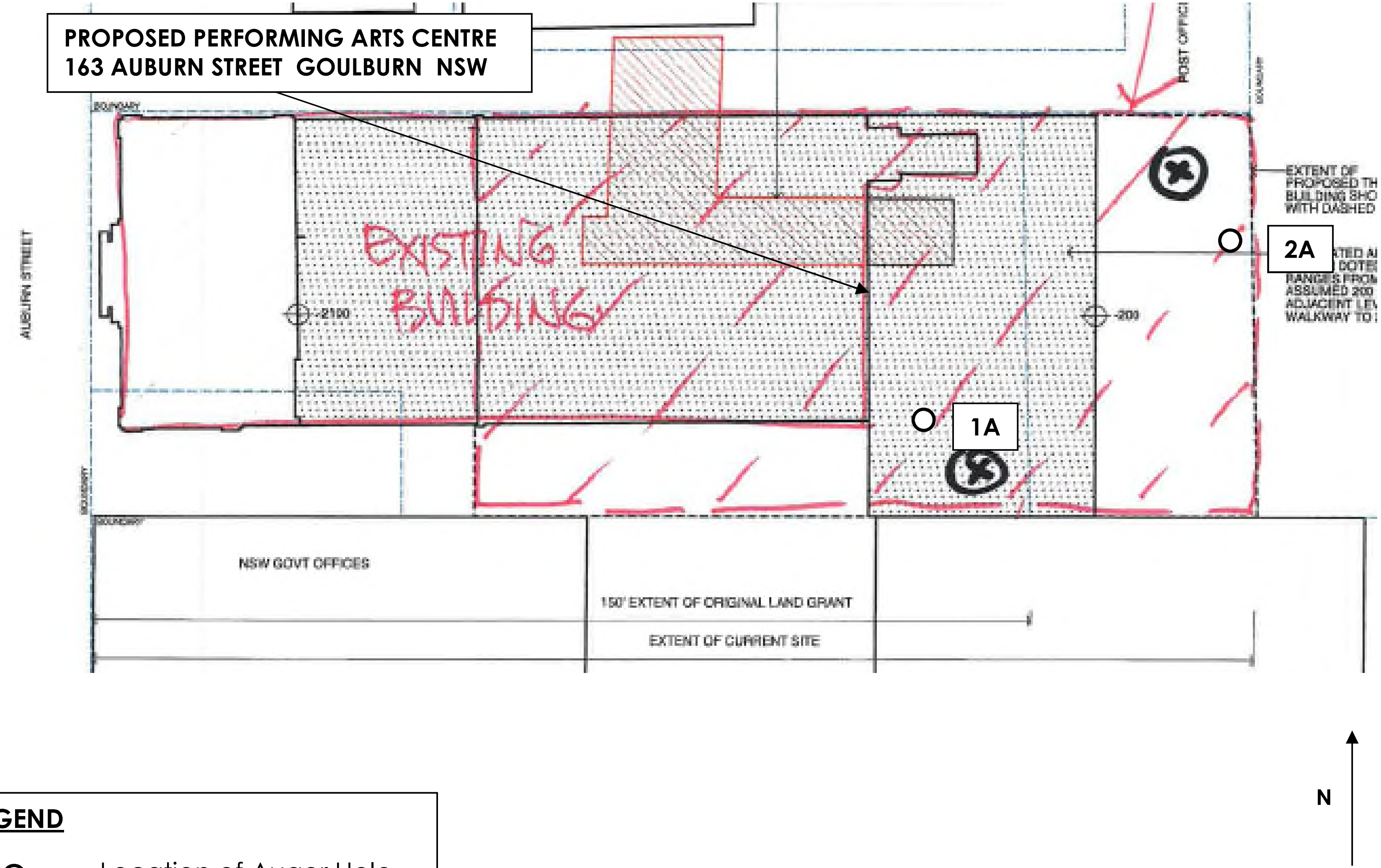


NORTHROP CONSULTING ENGINEERS
PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW
SITE LOCALITY

ACT Geotechnical Engineers Pty Ltd	C8315	FIGURE 1

NORTHROP CONSULTING ENGINEERS
PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW
RECENT AERIAL PHOTOGRAPH & LOCATIONS OF AUGER HOLES

ACT Geotechnical Engineers Pty Ltd	C8315	FIGURE 2



LEGEND

○ - Location of Auger Hole

NORTHROP CONSULTING ENGINEERS
PROPOSED PERFORMING ARTS CENTRE
163 AUBURN STREET GOULBURN NSW
SITE PLAN & LOCATIONS OF AUGER HOLES

ACT Geotechnical Engineers Pty Ltd	**C8315**	**FIGURE 3**

APPENDIX A

Auger Hole Logs 1A & 2A

Excavation Log

Excavation No.	1A
Sheet	1 of 1
Job No.	C8315

CLIENT: Northrop Consulting Engineers

PROJECT Proposed Performing Arts Centre - Geo. Inv.
163 Auburn Street Goulburn NSW

Location : See Figures 2 & 3

Surface Level : Not Known

Equipment Type : Yanmar Excavator
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.14			ASPHALTIC CONCRETE			ASPHALTIC CONCRETE
			0.35		SW	SAND; fine to coarse sand, yellow-brown, some low plasticity clay, some brick and concrete fragments up to 50mm size, dry to moist.	MEDIUM DENSE		FILL
			0.7		CL	GRAVELLY CLAY; low to medium plasticity clay, sub-rounded gravels up to 5mm size, dark grey, some fine to coarse sand, moist to wet.	SOFT/ FIRM		FILL?
			0.9		CL	GRAVELLY CLAY; low to medium plasticity clay, ferruginous nodules up to 10mm size, pale grey, some fine to coarse sand, moist to wet.	SOFT/ FIRM		SLOPEWASH
			1.0 2.0 3.0 3		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to medium sand, yellow-brown, some red-brown, some pale grey, trace sub-rounded gravels up to 5mm size, moist.	VERY STIFF		ALLUVIUM
			4.0 5.0			EXCAVATION TERMINATED AT 3m			

Logged By : HR Date : 8/9/16 Checked By : Date :

BOREHOLE/EXCAVATION LOG C8315.GPJ ACT GEO.GDT 14/9/16

Excavation Log

Excavation No.	2A
Sheet	1 of 1
Job No.	C8315
Location	See Figures 2 & 3
Surface Level	Not Known

CLIENT: Northrop Consulting Engineers

PROJECT: Proposed Performing Arts Centre - Geo. Inv.
163 Auburn Street Goulburn NSW

Equipment Type : Yanmar Excavator
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.05			ASPHALTIC CONCRETE			ASPHALTIC CONCRETE
					SC/ CL	CLAYEY SAND/SANDY CLAY; fine to coarse sand, low plasticity clay, dark brown, some brick fragments up to 40mm size, trace ceramic and glass fragments, trace sub-angular quartz gravels up to 30mm size, moist to wet.	LOOSE or SOFT/ FIRM		FILL
			1.0		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to medium sand, yellow-brown, some red-brown, some pale grey, some sub-angular sedimentary gravels up to 5mm size, moist.	VERY STIFF		ALLUVIUM
			2.0						
			2.7		CL-CH	GRAVELLY CLAY; medium to high plasticity clay, sub-angular gravels up to 5mm size, yellow-brown, pale grey, some red-brown, some fine to coarse sand, dry to moist.	VERY STIFF		
			2.8		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to medium sand, yellow-brown, some red-brown, some pale grey, moist.	VERY STIFF		
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

Logged By : HR Date : 8/9/16 Checked By : Date :

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APPENDIX B

Definitions of Geotechnical Engineering Terms

UNIFIED SOIL CLASSIFICATION SYSTEM (METRICATED)
DATA FOR DESCRIPTION IDENTIFICATION AND CLASSIFICATION OF SOILS

Coarse grained soils

MAJOR DIVISIONS	GROUP SYMBOL	TYPICAL NAME (DESCRIPTION)	DESCRIPTIVE DATA	FIELD IDENTIFICATION: GRADATIONS	NATURE OF FINES	DRY STRENGTH	GROUP SYMBOL	% (2) < 0.06mm	PLASTICITY OF FINE FRACTION	$C_u = \frac{D_{60}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{D_{10}D_{60}}$	NOTES
COARSE GRAINED SOILS — More than 50% by dry mass, less than 60mm is greater than 0.06mm — GRAVELS (More than 50% of coarse grains are greater than 2.0mm)	GW	Well graded gravels and gravel-sand mixtures, little or no fines.	Give typical name, indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition and hardness of the coarse grains, local or geological name and other pertinent descriptive information; symbols in parenthesis.	GOOD — Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	GW	0-5	-	>4	between 1 and 3	1 Identify fines by the method given for fine grained soils.
GRAVELS	GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.		POOR — Predominantly one size or range of sizes			GP	0-5	-	Fails to comply with above		2 Borderline classifications occur when the percentage of fines (fraction smaller than 0.06mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
GRAVELLY SOILS	GM	Silty gravels, gravel-sand-silt mixtures.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	GOOD to FAIR — "Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	GM	12-50	Below 'A' line or $I_p < 4$	-	-	
GRAVELLY SOILS	GC	Clayey gravels, gravel-sand-clay mixtures.	EXAMPLE: Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size; rounded and sub angular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; light brown alluvial sand, (SM)		Fines are plastic (1)	Medium to high	GC	12-50	Above 'A' line and $I_p > 7$	-	-	
SANDS (More than 50% of coarse grains are less than 2.0mm)	SW	Well graded sands and gravelly sands, little or no fines.		GOOD — Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	SW	0-5	-	>6	between 1 and 3	
SANDS	SP	Poorly graded sands and gravelly sands, little or no fines.		POOR — Predominately one size or range of sizes.			SP	0-5	-	Fails to comply with above		
SANDY SOILS	SM	Silty sand, sand-silt mixtures.		GOOD to FAIR — "Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	SM	12-50	Below 'A' line or $I_p < 4$	-	-	
SANDY SOILS	SC	Clayey sands, sand-clay mixtures.			Fines are plastic (1)	Medium to high	SC	12-50	Above 'A' line and $I_p > 7$	-	-	

Field identification: Determine approximate percentages of material over 60mm in size, maximum size, shape, surface texture, hardness of material, geological description. Identify on estimated percentage mass of the various fractions.

COARSE GRAINED SOILS: More than half of the material less than 60 mm is larger than 0.06mm.

0.06mm is about the smallest particle visible to the naked eye.

Laboratory classification: Use the gradation curve of material passing 60 mm for classification of fractions according to the criteria given under "Major Divisions".

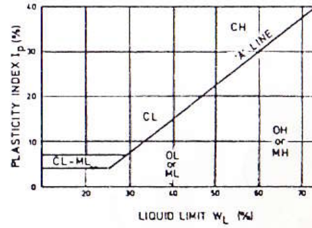
Fine grained soils

SILT AND CLAY FRACTION — Fraction smaller than 0.20mm AS sieve size

MAJOR DIVISIONS	GROUP SYMBOL	TYPICAL NAME	DESCRIPTIVE DATA	DRY STRENGTH	DILATANCY	TOUGHNESS	GROUP SYMBOL	PLASTICITY
FINE GRAINED SOILS — More than 50% by dry mass, less than 60mm is less than 0.06mm — Liquid Limit less than 50%	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any; local or geological name and other pertinent descriptive information; symbols in parenthesis.	None to low	Quick to slow	None	ML	Below 'A' line
Liquid Limit less than 50%	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	For undisturbed soil add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions.	Medium to high	None to very slow	Medium	CL	Above 'A' line
Liquid Limit less than 50%	OL	Organic silts and organic silty clays of low plasticity.	EXAMPLE: Clayey Silt, brown; low plasticity, small percentage of fine sand; numerous vertical root-holes; firm and dry in place, fill, (ML)	Low to medium	Slow	Low	OL*	Below 'A' line
Liquid Limit more than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.		Low to medium	Slow to none	Low to medium	MH	Below 'A' line
Liquid Limit more than 50%	CH	Inorganic clays of high plasticity, fat clays.		High to very high	None	High	CH	Above 'A' line
Liquid Limit more than 50%	OH	Organic clays of medium to high plasticity.		Medium to high	None to very slow	Low to medium	OH*	Below 'A' line
	Pt	Peat muck and other highly organic soils.		Readily identified by colour, odour, spongy feel and generally by fibrous texture			Pt*	*Effervesces with H_2O_2

FINE GRAINED SOILS: More than half of the material less than 60 mm is smaller than 0.06mm.

More than 50% passing 0.06mm.



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAIN SOILS OR FRACTIONS

These proceedures are to be performed on the minus 0.6mm size particles. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to Shaking)

After removing particles larger than 0.6mm size, prepare a pat of moist soil with a volume of about 10 cm³. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assists in identifying the character of the fines in the soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than 0.6 mm size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic of clays in the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength but can be distinguished by feel when powdering the dry specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency Near Plastic Limit)

After removing particles larger than 0.6 mm size, a specimen of soil, about 10 cm³ in size, is moulded to the consistency of putty. If too dry, water must be add and, if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Notes

1. *The above follows the original Unified Classification System (U.S.B.R. Earth Manual) and ASTM Designation D2487-69 except that it adopts the particle size limits given in AS 1289 and other standards, viz*

Gravel	2 - 60mm
Sand	0.06 - 2mm
Silt and Clay	less than 0.06mm

The system excludes the boulder and cobble fractions of the soil and classifies only the material less than 60mm in size.

2. *As 60mm, 2mm and 0.06mm sieve sizes are not normally used, the percentages passing these sizes can be obtained from a particle size distribution curve determined from a laboratory test. Alternatively, the percentages passing maybe estimated in the field.*
3. *Australian Standard Code of Practice for Site Investigation, Appendix D, and ASTM Designation D2488-69, Tables 1 to 4, contain standard terms and manual tests for describing and identifying soils.*

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ACN 063 673 530

DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on Australian Standard 1726 - 1981, the SAA Site Investigation Code. In general, descriptions cover the following properties - soil type, colour, secondary grain size, structure, inclusions, strength or density and geological description.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following basis:

Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00 to 60.00mm

Soils are also classified according to the Unified Soil Classifications System which is included in this Appendix.

Rock types are classified by their geological names.

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The terms are defined as follows:

Classification	Shear Strength kPa
Very soft	less than 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of insitu standard penetration tests as below:

Relative Density	"N" Value blows/300mm
Very loose	less than 5
Loose	5 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	greater than 50

SAMPLING

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are generally taken by one of two methods:

(i) driving or pushing a thinwalled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state.

(ii) Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in addition to that obtained from disturbed samples and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

PENETRATION TESTING

The relative density of non-cohesive soils is generally assessed by insitu penetration tests, the most common of which is the standard penetration test. The test procedure is described in Australian Standard 1289 "Testing Soils for Engineering Purposes" - Test No. F3.1.

The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63 kg hammer having a free fall of 750mm.

The "N" value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

The test is also used to provide useful information in cohesive soils under certain conditions, a good quality disturbed sample being recovered with each test.

Other forms of insitu testing are used under certain conditions and where this occurs, details are given in the report.

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

(A) GENERAL DEFINITIONS — ROCK AND SOIL

ROCK In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since "strong" and "permanent" are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System. Three principal classes of soil recognised are:

(a) Residual soils: soils which have been formed insitu by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

(b) Transported soils: soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind and gravity. Two important types of transported soil in engineering geology and materials investigations are:

(i) Colluvium - a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principal forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances

(ii) Alluvium - a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

(c) Lateritic soils: soils which have formed insitu under the effects of tropical weathering and include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clays to sesquioxide rich crusts. The term does not necessarily imply any compositional, textural or morphological definition; all distinctions useful for engineering purposes are based on the differences in geotechnical characteristics.

(B) ROCK WEATHERING DEFINITIONS

Extremely Weathered (EW)

Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.

Highly Weathered (HW)

Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.

Moderately Weathered (MW)

Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.

Slightly Weathered (SW)

Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance, usually by limonite, has taken place. The colour and texture of the fresh rock is recognisable.

Fresh (Fr)

Rock substance unaffected by weathering.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the prominent degree of weathering first (e.g. EW-HW).

The various degrees of weathering do not necessarily define strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric, and some rocks may increase in strength during the weathering process.

Fresh drill cores of some rock types, such as basalt and shale may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS

This classification system provides a standardized terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. Where other rock types are encountered, such as in dykes, standard geological descriptions are used for rock types and the same descriptions as below are used for strength, fracturing and weathering.

Under this system rocks are classified by Rock Type, Strength, Stratification Spacing, Degree of Fracturing and Degree of Weathering. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc) where these are relevant.

ROCK TYPE DEFINITIONS

ROCK TYPE	DEFINITION
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than .06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly laminated	< 6mm
Laminated	6mm to 20mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 0.2m
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2m
Very thickly bedded	> 2m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

Term	Description
Fragmented:	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter.
Highly Fractured:	Core lengths are generally less than 20mm - 40mm with occasional fragments.
Fractured:	Core lengths are mainly 30mm - 100mm with occasional shorter and longer section.
Slightly Fractured:	Core lengths are generally 300mm - 1000mm with occasional longer sections and occasional sections of 100mm - 300mm.
Unbroken:	The core does not contain any fracture.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is(50) MPa	Field Guide	Approx. qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium Strong:	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
Strong:	3	A piece of core 150mm long x 50mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very Strong	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely Strong:		A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	

The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ratio to the point load index of 24:1. This ratio may vary widely.

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