MARSHALL DAY Acoustics

RYMAN KOHIMARAMA CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

Rp 001 20200185 | 16 April 2020

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Report No.: **Rp 001 20200185**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	-	For client review	20 Mar 2020	M Yang	S Wilkening
	01	Updated method	9 April 2020	M Yang	S King
	02	Minor comments from planner	15 April 2020	M Yang	-
Final	03	Minor comments from lawyer	16 April 2020	M Yang	-

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1.0 SUMMARY

Ryman Healthcare is proposing to construct a new comprehensive care retirement village (**Proposed Village**) at 223 Kohimarama Road and 7 John Rymer Place (**Site**). Ryman has engaged Marshall Day Acoustics to evaluate the Proposed Village's ability to comply with the Auckland Unitary Plan (**AUP**) permitted activity standards for construction noise and vibration and to make recommendations for construction management. This report details our assessment and conclusions.

To summarise, our findings are:

- Stage 1 works are predicted to comply with the 70 dB L_{Aeq} noise limit and the cosmetic and amenity vibration limits in the AUP.
- Stage 2 works are predicted to comply with the 70 dB L_{Aeq} noise limit and with the cosmetic and amenity vibration limits. During earthworks in close proximity to receivers, exceedances of the noise, cosmetic, and amenity vibration limits are possible, although these will be transient in nature. Noise barriers to the northwest and northeast receivers may not be practicable to mitigate the exceedances given the uneven terrain.
- Stage 3 works are predicted to comply with the 70 dB L_{Aeq} noise limit and the cosmetic and amenity vibration limits if auger piling is used. If vibro piling is required, compliance with the noise limit can be achieved with mitigation in place. However, an exceedance is predicted for the northern most elevator shaft even with a 3m noise barrier in place. Vibro piling can comply with both the cosmetic and amenity vibration limits.
- Stage 4 works are predicted to comply with the noise and vibration limits but have the potential to exceed during the works closest to receivers southeast of the site. Noise barriers are recommended to ensure these exceedances do not occur.
- To ensure ongoing compliance with the AUP and so noise and vibration effects are appropriately managed throughout the construction works, a Construction Noise and Vibration Management Plan (**CNVMP**) is recommended. A draft is appended to this report. The draft sets out the "best practicable options" (s2, RMA) to avoid, remedy, or mitigate potential noise and vibration effects, as well as communication/consultation and complaints procedures which are the most critical to managing potentially adverse effects.
- Although the AUP has two sets of vibration limits (cosmetic building damage limit and the amenity limits), we consider that for construction management, the cosmetic building damage limit should be used. The amenity limit should be used to inform consultation procedures.
- We consider that with the implementation of a CNVMP, construction noise and vibration effects can be managed to be reasonable and generally within the AUP permitted standards.

A glossary of terminology is attached in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Proposal

The proposal seeks to construct a new comprehensive care retirement village on the Site. The Proposed Village would cater for a variety of residents from independent living to full rest home care and include:

- 98 care rooms
- 75 assisted living suites
- 123 independent living units

Figure 1 overleaf presents the layout of the site.

Figure 1: Proposed Village

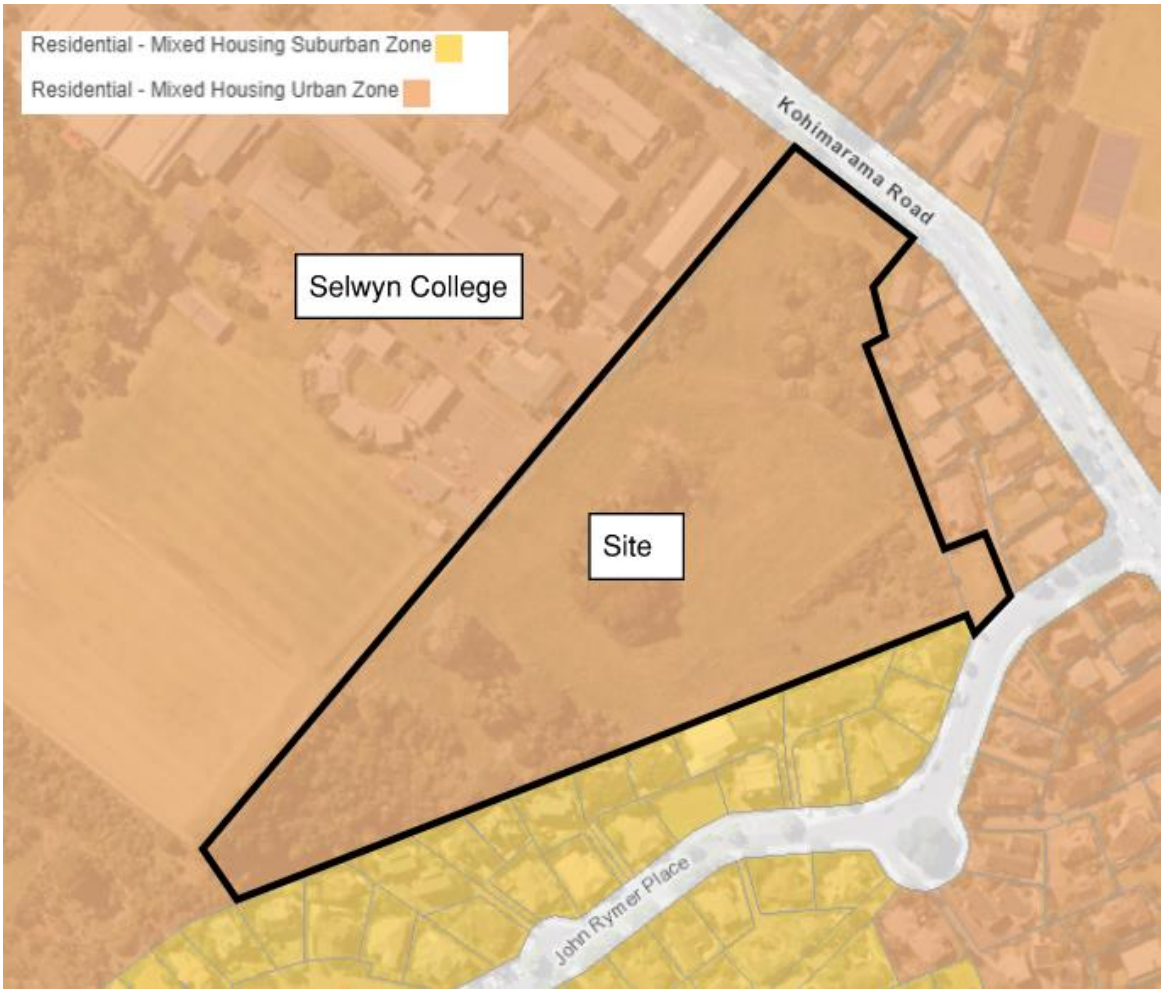
2.2 Nearby Receivers

The Site is zoned *Residential – Mixed Housing Urban* in the Auckland Unitary Plan (**AUP**) as are the immediate receivers to the northwest and northeast. To the south/southeast are receivers zoned *Residential – Mixed Housing Suburban*.

The receiver to the northwest is Selwyn College. We understand Ryman has received written approvals to its resource consent application from this receiver.

Nearby dwellings are generally two-storey with some dwellings being one storey. This means that upper floor receivers may be able to look over any noise barrier into the work site (and thus receive no shielding benefit). This is more pronounced if the work site is at an elevation below the receiver which appears to be the case for the north-east receivers. As such, effects at these receivers would also require careful management.

Figure 2: Site zoning and nearby receivers



3.0 CONSTRUCTION PERFORMANCE STANDARDS

3.1 Noise

Construction works are expected to be approximately 36 to 42 months and occur at various levels of intensity during this time. The main work hours will generally be 0700 – 1800 Monday to Saturday with no work on Sunday and Public Holidays. Noise limits that apply based on this duration and work hours can be found in AUP Standard E25.6.27 (1) and (4). They are presented in Table 1:

Table 1: Construction noise limits for long duration works (>20 weeks)

Time of week	Time Period	Noise limit	
		dB L_{Aeq}	dB L_{AFmax}
Monday to Friday	0700 – 0730	55	70
	0730 – 1800	70	85
Saturday	0700 – 0730	40	70
	0730 – 1800	70	85

The noise limits apply at 1m from the façade of any occupied building that contains an activity sensitive to noise. Construction noise must be measured and assessed in accordance with New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*.

The early morning time period has lower noise limits than during the day. This precludes any noisy works. However, from experience, this time would typically be used for pre-start toolbox meetings/site preparation which are generally quiet activities.

When the building is complete, other quiet works, such as painting and plastering, can also be carried out indoors during the more stringent time periods (i.e. early morning and night-time).

Given the spread-out nature of the site and the proposed staging of the construction works, we consider that any one receiver would not be exposed to high noise activities for the entire 36 to 42 months. In addition, once fitout works begin, any high noise source would typically be confined within the buildings.

3.2 Vibration

3.2.1 Cosmetic Building Damage

The applicable vibration performance standards are given in Standard E25.6.3 of the AUP. Standard E25.6.30 (1)(a) refers to DIN 4150-3 (1999) *"Structural Vibration – Part 3 Effects of vibration on structures"* which sets vibration limits to avoid cosmetic damage, such as cracking plaster, to buildings. The relevant limits are reproduced in Table 2.

Table 2: Building damage vibration limits

Type of Structure	Short-term vibration				Long-term vibration[1]
	PPV at the foundation at a frequency of			PPV at horizontal plane of highest floor (mm/s)	PPV at horizontal plane of highest floor (mm/s)
	1 - 10Hz (mm/s)	1 - 50Hz (mm/s)	50 - 100Hz (mm/s)		
Residential	5	5 – 15	15 – 20	15	5

Note:

1. Short-term vibration is defined as "vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated". Long-term vibration is defined as all other vibration types not covered by the short-term vibration definition.

DIN 4150 states *"Experience has shown that if these values are complied with, damage will not occur".* Note that we have adopted the Residential vibration limits for Selwyn College.

3.2.2 Amenity

Standard E25.6.30 (1)(b) provides vibration amenity limits reproduced in Table 3, which should be used as a trigger for consultation with building occupants and should not be used as the construction vibration limits which are given in Table 2.

Table 3: Vibration amenity limits

Receiver	Period	Peak Particle Velocity limit (mm/s)
Occupied activity sensitive to noise	Night-time 2200 – 0700 hrs Daytime 0700 – 2200 hrs	0.3 mm/s 2 mm/s

Standard E25.6.30 (1)(b) also states vibration may exceed 2mm/s between 0700 to 1800 hrs for up to three days provided that all occupied buildings within 50m of the works extent is communicated about the works at least three days in advance. They should be communicated to about the work locations, duration, and contact details for a person on site.

4.0 CONSTRUCTION ASSESSMENT

We have predicted noise (Section 4.2) and vibration (Section 4.3) levels for various equipment likely to be used for the project. Additionally, we have provided a high-level assessment of each stage based on the noisiest activity for that stage. To summarise, we recommend the following based on our assessment:

- Noise barriers to be used for Stages 2, 3, and 4 (minimum height 2.4m). A boundary noise barrier along the boundary with Selwyn College may also be appropriate. Noise barriers would be difficult to implement along the north-eastern and south-eastern boundaries given the terrain. In addition, little to no benefit would be provided:
  - along the north-eastern boundary because the receivers (generally 2 storey) are elevated above the work site; and,
  - along the south-eastern boundary as the work site is elevated above the receivers (also generally 2 storey).

  Therefore, localised barriers should be used where required and practicable
- Sheet piling should be avoided for the northern most elevator shaft if practicable
- A CNVMP be prepared and implemented throughout the construction period. This will contain communication procedures which would be the most important tool to managing construction noise and vibration effects.

4.1 Indicative construction method

The indicative construction methods have been provided by Ryman, recognising that the construction methodology will be finalised with the construction contractors closer to the time of construction. We understand that there would be no rock breaking or impact piling. Some sheet piling may be required for the lift shafts but and the need will be determined on a case by case basis.

The indicative construction programme is given below in Table 4.

Table 4: Proposed construction programme

Stage	Activity	Hours of Operation	Approximate Duration (weeks)	Estimated no. of Truck Movements per Hour
1	Initial site works	0700 – 1800 hrs	4 weeks	2
2	Earthworks / removal of existing buildings	0700 – 1800 hrs	3 seasons (30 weeks each)	6 – 8
3	Construction and Fitting out	0700 – 1800 hrs	Staged over 156 weeks	18 – 34
4	Vehicle Crossings	0700 – 1800 hrs	6 weeks	12 – 26

The closest receiver distances to the site boundary varies from 4m to 12m. Distances to actual working areas are still to be confirmed as part of the final construction methodology. Therefore, our assessment has been carried out on a high level.

4.2 Noise

4.2.1 Indicative equipment list

Indicative noise levels for the equipment likely to be used are given in Table 5. We have sourced these from BS 5228-1:2009 "*Code of practice for noise and vibration control on construction and open sites Part 1: Noise"* or from measurements previous carried out by us. Note that we have predicted noise levels based on a conservative worst-case scenario of 100% on time with no mitigation.

We have also predicted noise levels for selected high noise activities using 3D sound modelling software SoundPLAN to account for the terrain. Figures showing the predicted noise levels (refer Appendix B) provide an insight into the potential noise levels at the nearby receivers from works at potential worst-case locations. However, as we have only modelled a limited number of scenarios, we recommend that Table 5 should be used to determine potential for noise exceedances. This will inform what measures may need to be implemented to mitigate or manage potential exceedances to ensure general compliance with the AUP standards.

Table 5: Indicative noise levels at 1m from a building facade with no mitigation

Equipment	Sound Power (dB L_{WA})	Façade Noise Level (dB L_{Aeq})				Setback distance (m)
		5	10	15	20	
Vibratory sheet piling	116	97	91	85	76	83
Plate compactor	108	89	83	77	68	40
Grinder (hand tools)	108	89	83	77	68	40
Loader	107	88	82	76	67	36
Hydrovac excavation	107	88	82	76	67	36
Excavator (30T)	105	86	80	74	65	30
Directional drilling	105	86	80	74	65	30
Auger piling rig	103	84	78	72	63	25
Excavator (20T)	103	84	78	72	63	25
Concrete truck and pump	103	84	78	72	63	25
Static or vibratory roller	103	84	78	72	63	25
Excavator (5T)	102	83	77	71	62	22
Mobile Crane (35T) operating	98	79	73	67	58	14
Hydraulic power pack	97	78	72	66	57	13
Generator (150kVA)	93	74	68	62	53	8
Pump (150mm dia)	93	74	68	62	53	8
Compressor	93	74	68	62	53	8
Truck Idling	91	72	66	60	51	6
Mobile Crane (35T) idling	88	69	63	57	48	4

Shaded cells show an exceedance of the daytime noise limit of 70 dB L_{Aeq}.

4.2.2 Stage 1 Assessment

The Stage 1 works would be relatively quiet and would involve establishing the site office and other associated initial site works. The main noisy equipment anticipated are:

- Excavator
- Mobile crane
- Truck movements

We consider that activities carried out for Stage 1 can comply with the noise limit of 70 dB L_{Aeq}, provided our recommended mitigation is put in place. As shown in Table 5, a setback distance of at least 30m is required to a receiver to enable compliance from an excavator without mitigation. If stationary excavator use is required within 30m of a receiver, we recommend that a minimum 2.4m noise barrier is constructed in close proximity to the excavator to block line of sight to receivers. A properly constructed and maintained noise barrier reduces noise levels by up to 10 decibels and would enable compliance at setback distances of 10m for a 30T excavator.

In general, we consider that the Stage 1 works would be relatively benign and would be similar to a typical residential development. This means that the impact of noise to adjacent receivers would be comply with the AUP, and likely be low provided the nearby receivers are informed of the relevant Stage 1 works.

4.2.3 Stage 2 Assessment

Stage 2 involves earthworks. We understand that approximately 52,874m^3 of cut and approximately 5,750m^3 of fill is required over the entire site with the exception of the south western vegetated area. These works are needed to create the foundations and basement of each building as well as to install services and establish the roading network. As earthworks are required over the entire site (i.e. a transient source), a receiver will only be exposed to high noise for a limited duration when the earthworks are directly adjacent to them. The main noisy equipment anticipated are:

- Excavators
- Loader
- Trucks
- Rollers (vibratory or static)
- Plate compactor

Earthworks would be able to comply with 70 dB L_{Aeq} at Selwyn College with construction noise barriers established along the boundary. Refer figures in Appendix B to see our recommendation.

However, exceedances are predicted for receivers to the north-east and south-east of the Site (front row of houses facing the site along Kohimarama Road and John Rymer Place) and boundary barriers to mitigate this exceedance may not be practicable given the terrain. The transient nature of these works may also mean that localised barriers for this Stage may not be practicable. At this stage, the duration of the exceedances is difficult to quantify given the exact construction method is unknown. However, based on experience, we estimate that no receiver would be exposed to high noise for more than two weeks during Stage 2.

During times when equipment is in close proximity to receivers (i.e. 40m to a receiver for plate compaction) exceedances would potentially arise. This will depend on the work location.

Where practicable, earthworks within 40m should be scheduled so that noise effects are minimised at the nearest receivers (this may include limiting work hours for those receivers in a day or workdays in a week). If consultation finds that the dwellings would be empty during the daytime, then earthworks can be carried out at the closest location to a receiver and not give rise to noise effects. However, consultation may reveal that other scheduling measures need to be considered.

Localised barriers for this Stage can also be considered if practicable as an alternative to these restrictions. It also needs to be acknowledged that scheduling will need to consider all potentially affected residents, meaning some disruption may be inevitable (eg for people working from home during weekdays or shift workers).

4.2.4 Stage 3 Assessment

During Stage 3, the building foundation construction period will be the noisiest period. Once construction is complete, fit out will be a quiet construction activity as the majority of the works will be within the building. In addition, receivers will be most affected during the period when the building that is closest to them is being constructed. This means that a receiver will not be exposed to high construction noise for the entire 156 weeks for this Stage. If practicable, we recommend scheduling the works so that they begin east to west – although it is recognised that this will need to be determined at the time of construction. This approach would mean that the south-eastern buildings can be used to provide shielding as works move towards the west. The main noisy equipment anticipated are:

- Auger/sheet piling rigs and associated auxiliaries
- Small excavators
- Trucks

We have predicted likely piling noise levels to the nearby receivers based on three potential worst-case positions. Refer Appendix B.

Based on our predictions, we conclude that:

- Auger piling would be able to comply at all receivers.
- Sheet piling can comply with mitigation in place at the south-eastern receivers.
- Sheet piling adjacent to Selwyn College can comply provided the boundary noise barrier is constructed.
- Sheet piling at the northern most elevator shaft would exceed by up to 7 decibel at 245, 247, and 247A Kohimarama Road. The duration of exceedance would be the duration to construct the elevator shaft. We estimate that this would be no more than one week. Further details can be provided once this method is confirmed to be required for this shaft.

Note that, the noise source height of a vibro hammer is high (3m +), which means a 3m structural barrier would provide little to no benefit. Such barrier would become more beneficial once the source height falls below 3m. This change in height has not been accounted for in the model which means the figures are conservative.

If sheet piling is required, then we recommend that receivers within the setback distance to compliance (refer Table 5) are consulted to understand their sensitivities. Where practicable, piling should be scheduled to minimise noise effects.

4.2.5 Stage 4 Assessment

To construct the vehicle crossings/internal roads, typical roading equipment is anticipated. The noise sources would typically be transient in nature. The main noisy equipment for this work includes:

- Roller (vibratory or static)
- Concrete truck and pump
- Excavator

We consider that compliance with 70 dB L_{Aeq} can be achieved provided our recommendations are put in place. During construction of the internal road directly adjacent to 17 and 17A John Rymer Place, noise has the potential to exceed the limits for brief periods. The highest predicted unmitigated noise level is 76 dB L_{Aeq} at 17A John Rymer Place. We recommend that a temporary noise barrier is constructed to enable compliance to be achieved. Refer Appendix B.

4.3 Vibration

We have identified that sources of high vibration would be limited to Stage 2 to Stage 4. They are:

- Vibratory sheet piling rig
- Vibratory roller

Table 6 presents setback distances required to comply with the cosmetic building damage limit and the amenity limit. These are sourced from databases or measurements that we have previously carried out for other projects. We have also shown the vibratory rolling setback distances on an aerial image in Appendix C as a horizontal setback with no consideration for elevation changes. Additionally, because we do not know where rolling would be, the figure is conservative. It serves to indicate who may be potentially affected until more details are known.

Table 6: Vibration emission radii

	Emission Radius (m)	
Vibration Source	**Cosmetic Damage 5mm/s**	**Daytime Amenity 2mm/s***
Sheet piling	11	30
Vibratory roller	14	38

* Vibration amenity setback distances should be used as a prompt to implement a management response – see Section 3.2.2

There are no buildings within 30m of any sheet piling location. Therefore, sheet piling will not exceed the cosmetic damage, or the amenity vibration limits in the AUP.

Vibratory rolling will exceed the amenity limits if carried out within 38m of a dwelling. Therefore, consultation measures must be implemented. Where practicable, we recommend that only static rollers be used within 14m of a dwelling. If vibratory rolling cannot be avoided within the cosmetic damage setback distances to a receiver, then we recommend:

- Consultation be carried out with those receivers to understand their sensitivities
- A pre-construction building condition survey is carried out prior to high vibration work commencing
- Vibration monitoring should be carried out in the first instance of rolling

If measurements confirm an exceedance, then the works must stop, and a condition survey carried out. If no new damage has been found, then the vibration limit at that receiver can be increased. If there has been damage found and that it was confirmed to be due to high construction vibration, then the contractor must commit to repairing the damage to a condition that is equal or better to what it was prior to the construction works commencing. A post-construction building condition survey should also be carried out to ensure all potential damage due to vibration has been identified.

Any receiver within the amenity setback distances should be communicated to before work causing high vibration levels starts. They should be informed that vibration may be perceived and given contact details (mobile phone number and email) for a contact person on site.

4.4 Discussion

Where practicable and effective we recommend that temporary noise barriers be utilised to mitigate construction noise. Indicative barrier locations have been shown in Appendix B. An effective noise barrier would provide up to 10 decibels of construction noise mitigation. We note that temporary noise barriers might not be practicable or effective in certain locations due to the terrain. Therefore, some exceedances during Stage 2 works may not be able to be practicable mitigated.

We recommend that construction noise and vibration effects be managed through a CNVMP. The CNVMP should be implemented throughout the construction period of the project. A draft CNVMP has been appended to this report.

Communication during all stages with neighbours will be critical to successfully managing and mitigating adverse noise and vibration effects. We recommend that written communication (e.g. newsletter) is provided to occupiers of buildings within 50m of the extent of works at least 2 weeks prior to construction commencing in that area. The communication should acknowledge that some activities are predicted to generate high noise levels that may result in disturbance for short periods. It should include details of the overall works, its timing, duration and contact details where complaints and enquiries should be directed.

5.0 CONCLUSION

Marshall Day Acoustics has assessed construction noise and vibration related to the establishment of a new Comprehensive Care Retirement Village in Kohimarama, Auckland. The works would include four distinct stages from the initial site preparation stage to the final roading network completion stage.

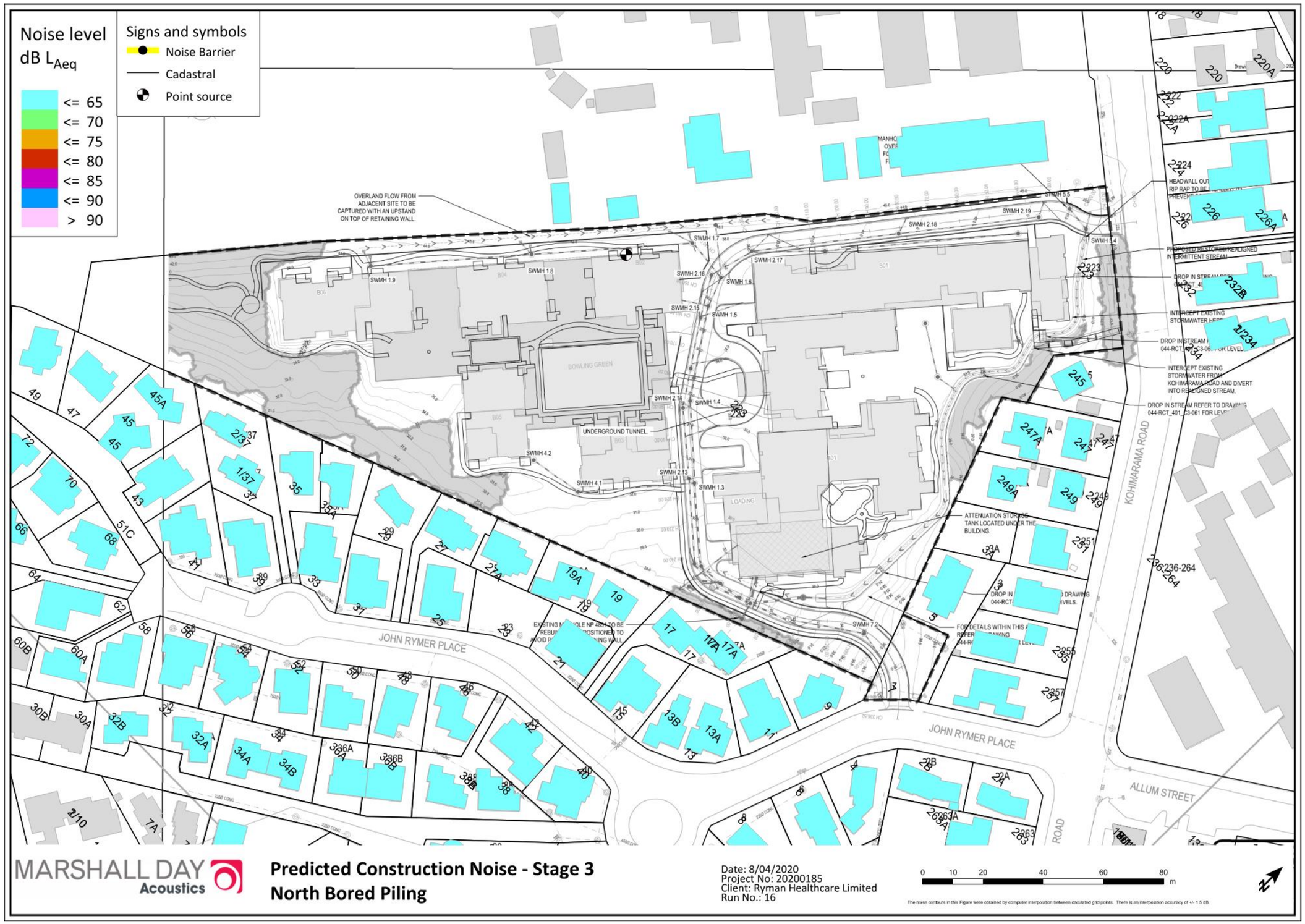
We conclude that:

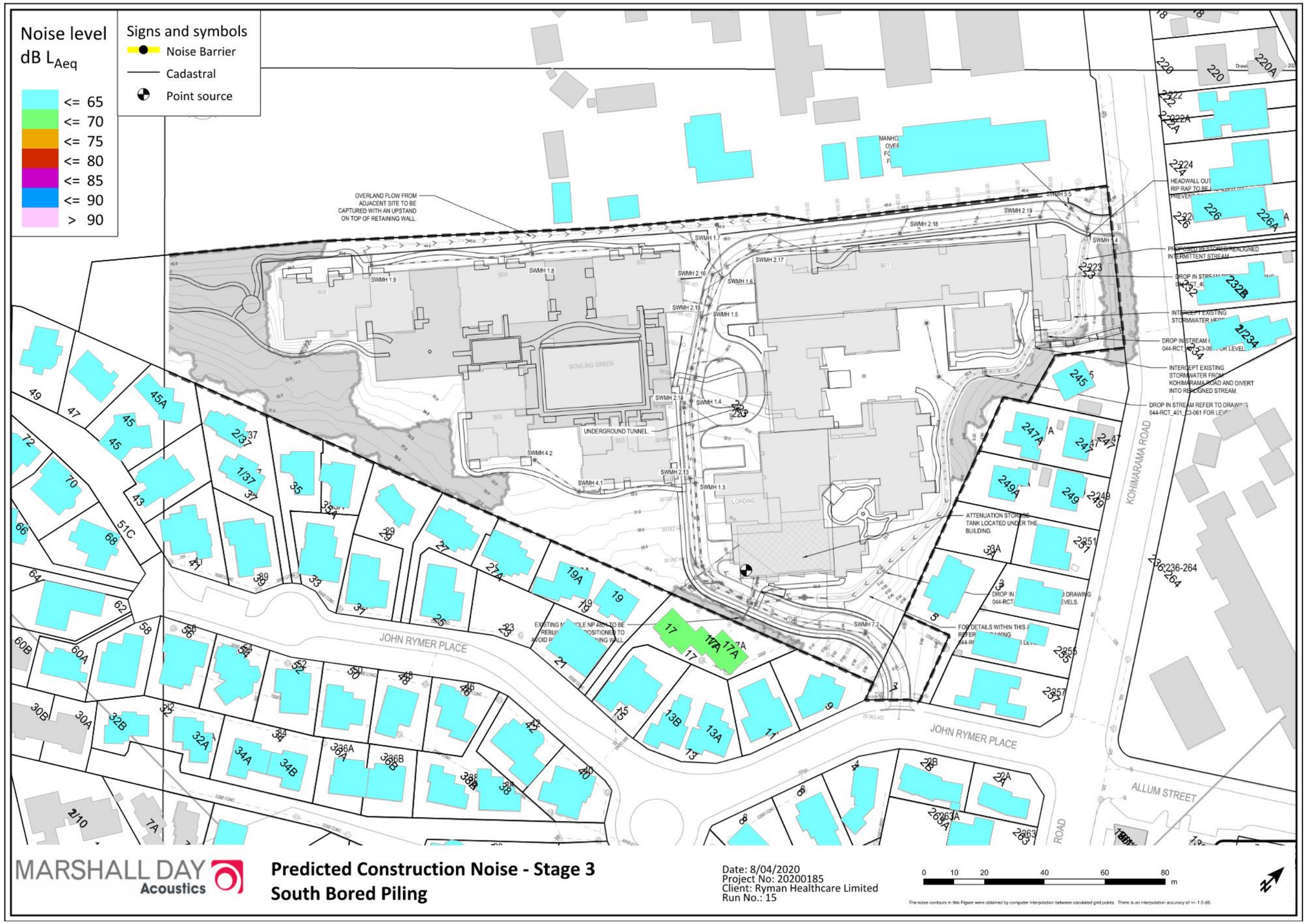
- Stage 1 works are predicted to comply with the 70 dB LAeq noise limit and the cosmetic and amenity vibration limits in the AUP.
- Stage 2 works are predicted to comply with the 70 dB LAeq noise limit and with the cosmetic and amenity vibration limits. During earthworks in close proximity to receivers, exceedances of the noise, cosmetic, and amenity vibration limits are possible, although these will be transient in nature. Noise barriers to the northwest and northeast receivers may not be practicable to mitigate the exceedances given the uneven terrain.
- Stage 3 works are predicted to comply with the 70 dB LAeq noise limit and the cosmetic and amenity vibration limits if auger piling is used. If vibro piling is required, compliance with the noise limit can be achieved with mitigation in place. However, an exceedance is predicted for the northern most elevator shaft even with a 3m noise barrier in place. Vibro piling can comply with both the cosmetic and amenity vibration limits.
- Stage 4 works are predicted to comply with the noise and vibration limits but have the potential to exceed during the works closest to receivers southeast of the site. Noise barriers are recommended to ensure these exceedances do not occur.
- To ensure ongoing compliance with the AUP and so noise and vibration effects are appropriately managed throughout the construction works, a Construction Noise and Vibration Management Plan (CNVMP) is recommended. A draft is appended to this report. The draft sets out the “best practicable options” (s2, RMA) to avoid, remedy, or mitigate potential noise and vibration effects, as well as communication/consultation and complaints procedures which are the most critical to managing potentially adverse effects.
- Although the AUP has two sets of vibration limits (cosmetic building damage limit and the amenity limits), we consider that for construction management, the cosmetic building damage limit should be used. The amenity limit should be used to inform consultation procedures.
- We consider that with the implementation of a CNVMP, construction noise and vibration effects can be managed to be reasonable and generally within the AUP permitted standards.

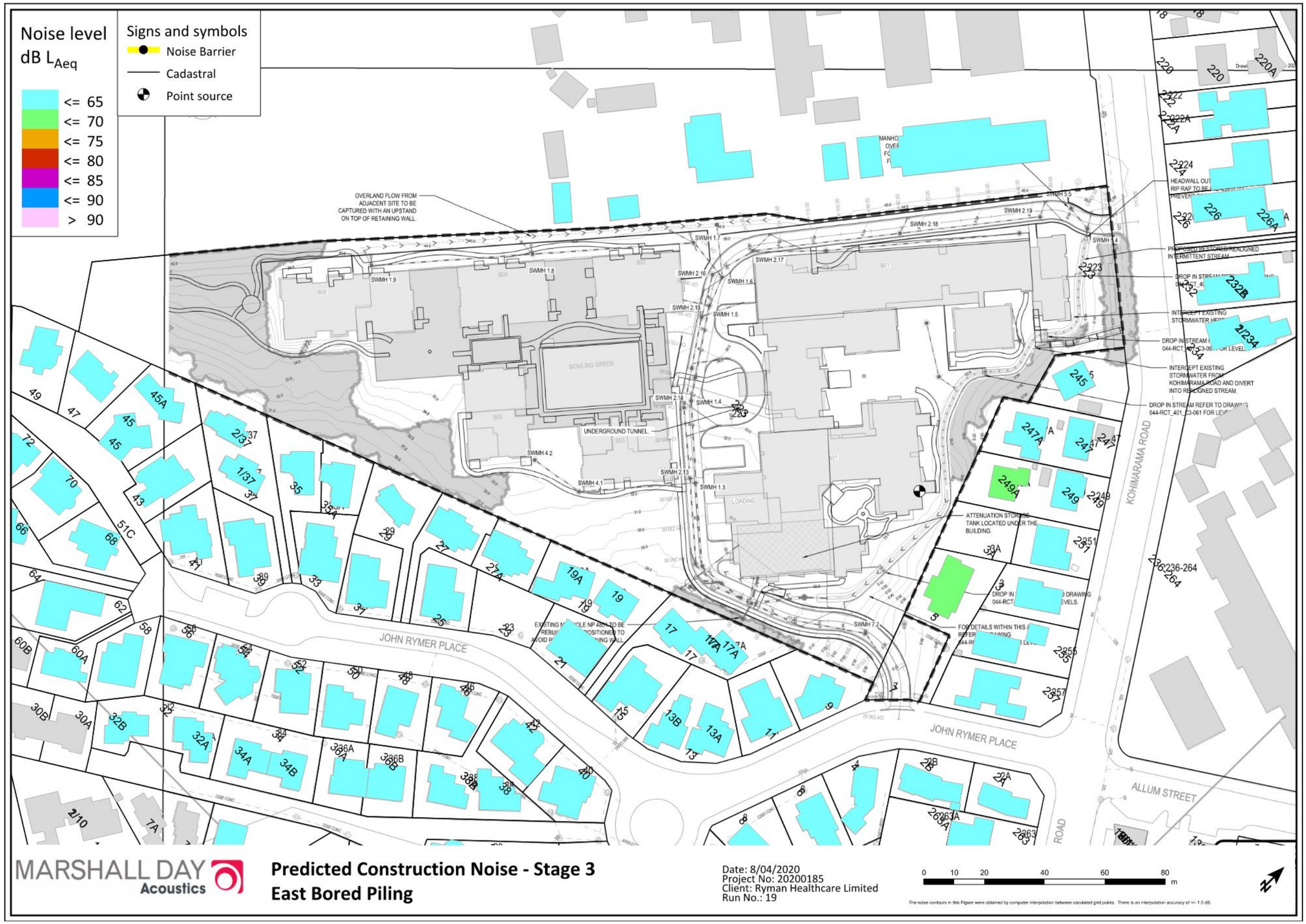
APPENDIX A GLOSSARY OF TERMINOLOGY

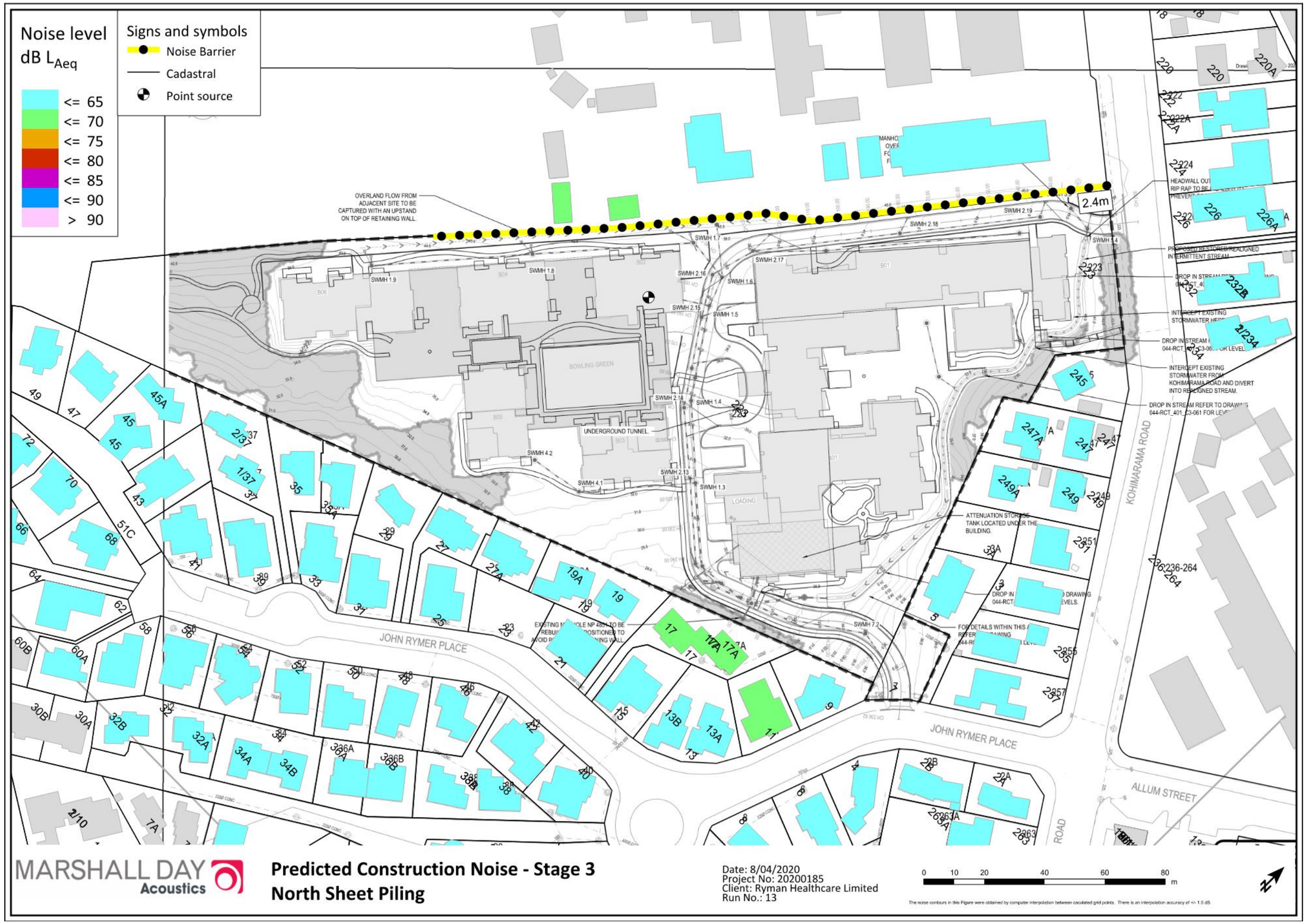
Noise	A sound that is unwanted by, or distracting to, the receiver.
SPL or L_P	Sound Pressure Level A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 µPa RMS) and expressed in decibels.
SWL or L_W	Sound Power Level A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 µPa i.e. dB = 20 x log(P/Pr)
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
$L_{Aeq\,(t)}$	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.
L_{AFmax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).
PPV	Peak Particle Velocity For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.

APPENDIX B PREDICTED NOISE LEVELS









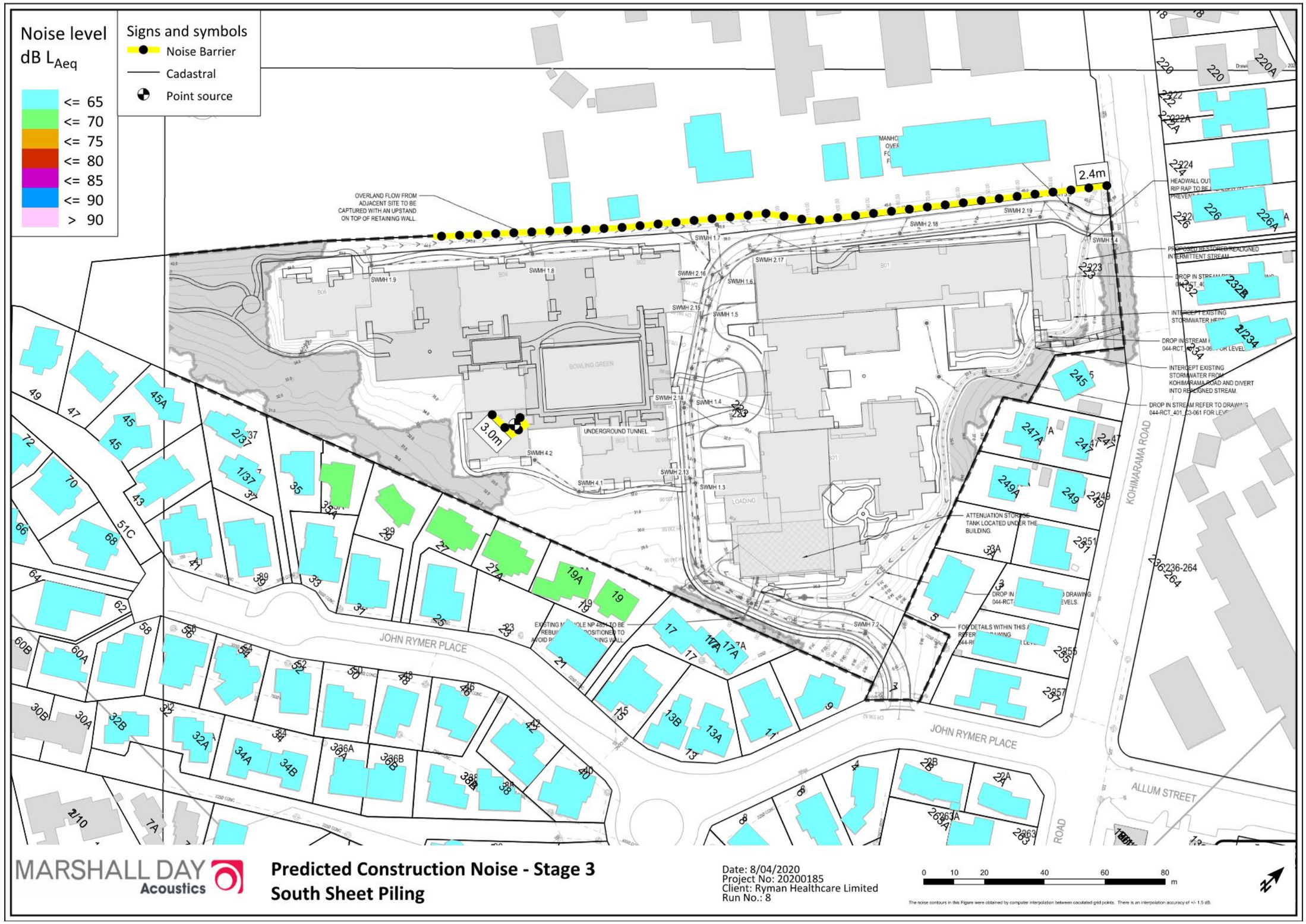
MARSHALL DAY Acoustics

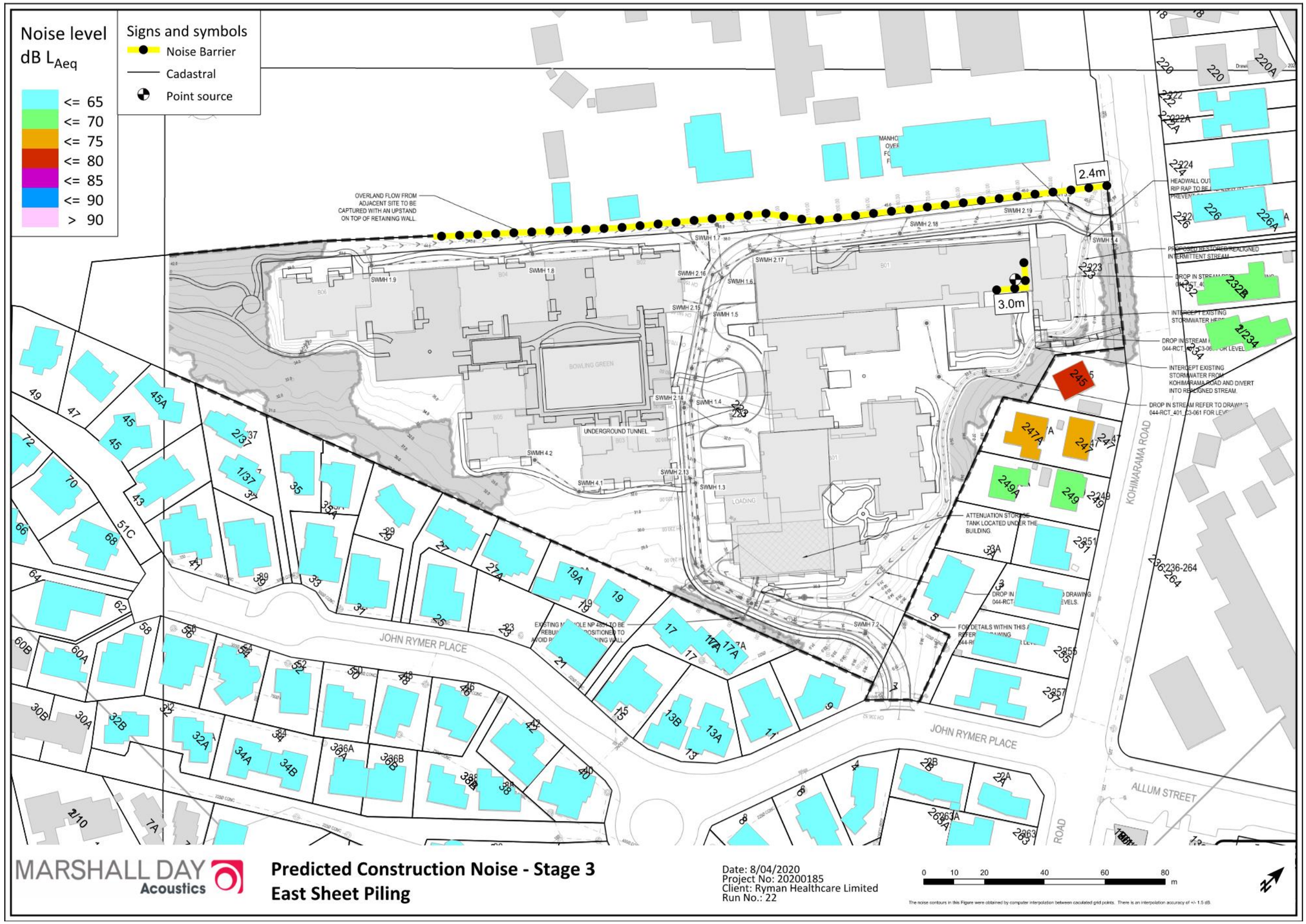
Predicted Construction Noise - Stage 3
North Sheet Piling

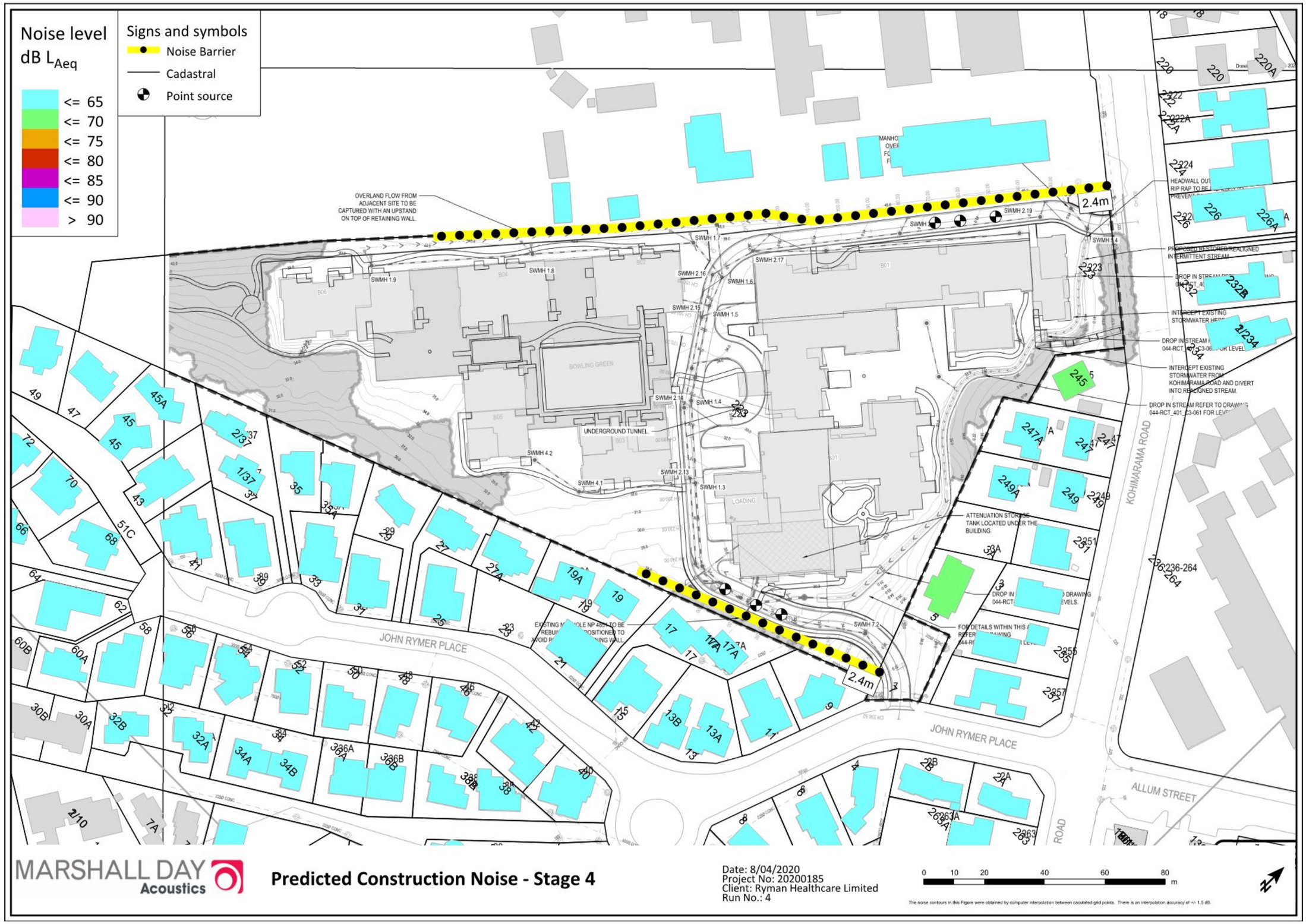
Date: 8/04/2020
Project No: 20200185
Client: Ryman Healthcare Limited
Run No.: 13

0 10 20 40 60 80 m

The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5 dB.







APPENDIX C VIBRATION SETBACK DISTANCES