Technical Note

Project Name: Helikopterutredning Västerviks sjukus	Author: Helen Makewell
Project Reference: 30013655-001	Date: 06 October 2022
Project Manager: Helen Makewell	Document Reference: 30013655-001-SWE-XX-XX-T-U-0001 Revision: C01

Rev.	Date	Reason for issue	Prepared		Reviewed		Approved	
C01	06.10.22	S2 – For Information	HM	04.10.22	JW	04.10.22	SL	04.10.22

Helicopter Noise and the Acoustic Design of the Building Envelope

1 Introduction

Sweco UK Ltd have been commissioned to undertake a desk-based assessment to determine the noise impacts on the surrounding new and proposed buildings of the new helipad proposed to be located on the top of Building B at Västerviks sjukhus.

This technical note sets out the findings of the desk-based assessment.

2 Desk Based Study

2.1 Background

The development of Västerviks sjukhus proposes the construction of new buildings and the location of a new helipad on top of Building B.

It is understood that the use of the proposed helipad will be occasional and for the purposes of this study, helicopter movements are assumed to occur two times during the daytime (07:00-23:00) and two times during the night-time period (23:00-07:00).

The room uses for the buildings have not been specified as part of this assessment. The new proposed layout of Västerviks sjukhus is shown in Figure 1.

The labelling of the results follows the convention indicated in Figure 1.

Reg. Office Address:
Sweco UK Limited
Grove House
Mansion Gate Drive
Leeds, LS7 4DN
+44 113 262 0000

Reg. No.: 2888385
Reg. Office: Leeds

www.sweco.co.uk

Sweco UK Limited
4th Floor, Radcliffe House
Blenheim Court
Solihull
B91 2AA
+44 (0) 121 711 6600

Helen Makewell
Principal Acoustic Consultant
Mobile 07721 599152
helen.makewell@sweco.co.uk

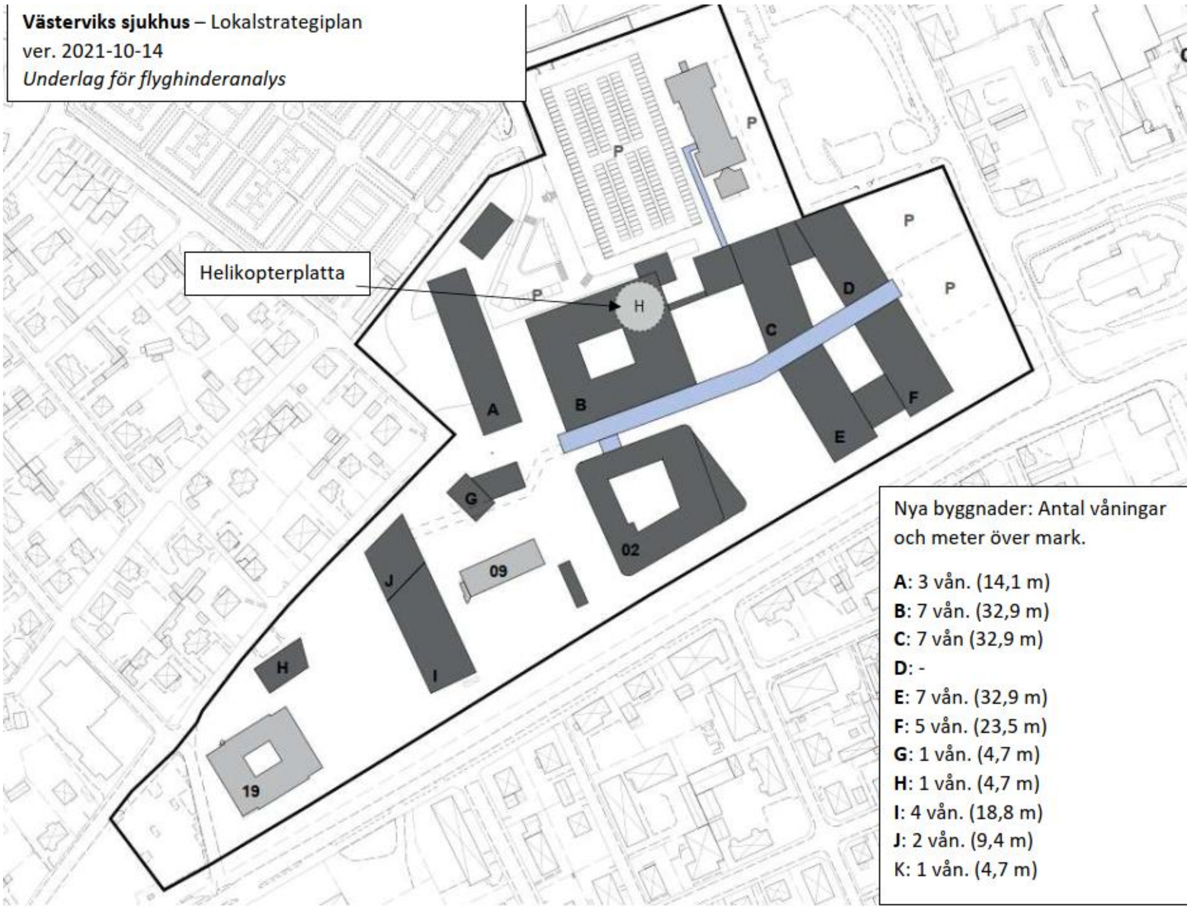


Figure 1: Building B and the proposed helipad.

2.1.1 Indoor Noise Levels Targets

As room uses within the buildings are unclear, indoor noise level targets have been defined considering the potential effects that could occur due to helicopter noise and are shown in Table 1. It is noted that these indoor noise level criteria apply only where helicopter movements are occasional – lower indoor noise targets would be appropriate where more helicopter movements occur.

Table 1: Recommended indoor noise targets assuming helicopter movements are occasional

Type of room	Potential effects due to helicopter noise	Recommended indoor helicopter noise level target	Justification
Wardrooms (rooms used for rest and recovery or sleeping)	Disruption of rest and/or sleep, annoyance.	Limit of ≤60 dB $L_{AFmax,event}$ with a target of ≤55 dB $L_{AFmax,event}$ where feasible.	Aircraft noise and sleep research indicates that aircraft events resulting in indoor maximum sound levels of <65 dB $L_{AFmax,event}$ are not likely to result in awakenings that can be recalled. Awakenings due to sound of this

Table 1: Recommended indoor noise targets assuming helicopter movements are occasional			
Type of room	Potential effects due to helicopter noise	Recommended indoor helicopter noise level target	Justification
			level were indistinguishable from spontaneous awakenings.
Examination rooms, consultation rooms, offices	Interference with speech communication, interference with activities requiring concentration, annoyance.	Limit of ≤60 dB $L_{AFmax,event}$ with a target of ≤55 dB $L_{AFmax,event}$ where feasible	It is good practice to apply indoor noise of 50 to 55 dB $L_{AFmax, event}$ for regular events. A relaxation of 5 to 10 dB is considered appropriate given the occasional nature of helicopter movements.
Back-of-house (ancillary rooms that are not permanently occupied)	Interference with speech communication, masking of sound from important sources (such as alarms)	≤70 dB $L_{AFmax,event}$	Considered sufficient to avoid masking of alarms, but likely to require occupants to raise voices/shout above the sound of the helicopter

3 Assessment Approach

A sound propagation model of Västerviks sjukhus, the helipad, and the surrounding area has been created in order to evaluate maximum sound pressure levels during helicopter movements. This three-dimensional model was constructed using the Datakustik Cadna/A sound propagation modelling software. The software carries out sound propagation predictions in accordance with ISO 9613-2 '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation'* (1996).

The model has been used to estimate the maximum sound pressure level from the helicopter along any point of the flightpath at each part of the building. In reality the maximum sound pressure level will vary, depending on the flight direction of the helicopter.

The following assumptions were incorporated into the assessment.

- Initially, the worst case noise output shown in Table 2 was used within the model.
- The maximum sound pressure level was then predicted considering helicopter arrivals/departures on any of the four routes shown in Figure 2.
- The helicopter movement was represented by point sources along the flightpath corridor spaced 50 metres apart, as shown in **Error! Reference source not found.**.
- The predicted sound pressure levels outside the building are facade levels and include second order reflections from surrounding buildings.

Table 2: Sound power levels of helicopters										
Helicopter Type	Assumed sound power level of helicopter [dB L_W], per octave band [Hz]									A-weighted sound power level [dB L_{WA}]
	31.5	63	125	250	500	1000	2000	4000	8000	
Worst-case helicopter	141	137	133	133	134	130	125	116	104	135
EC-145	131	132	130	131	132	128	123	113	112	133
"Twin Squirrel"	-	132	131	135	132	129	125	118	122	133

AW-169 (fly-over)	144	135	134	131	131	127	121	114	94	132

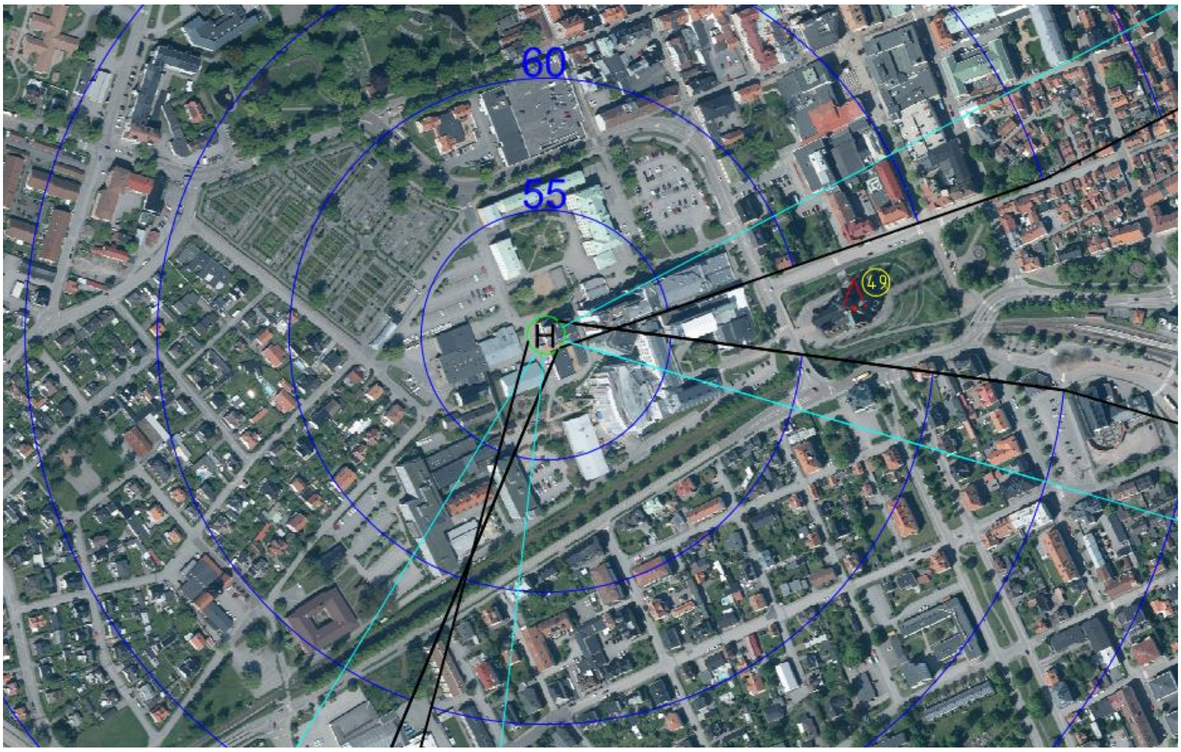


Figure 2: Assumed flight-paths

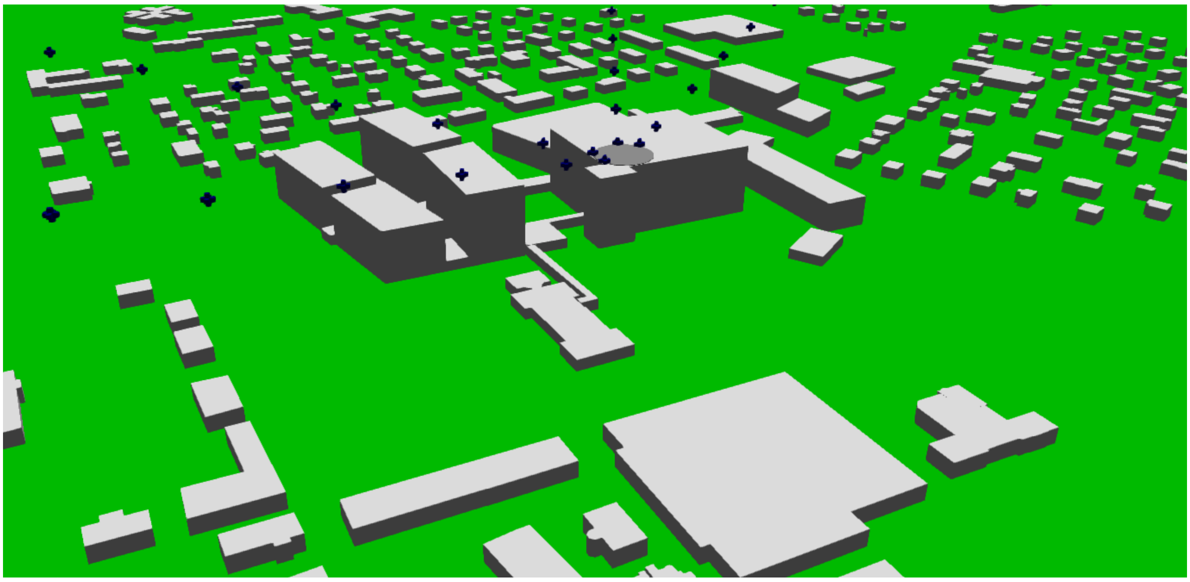


Figure 3: Sound propagation model

4 Outdoor Noise Level Predictions: Worst-Case Helicopter

Predicted outdoor maximum sound pressure levels during the worst-case helicopter movement outside Building B are shown in **Error! Reference source not found.**4.

Row Labels	2	3	4	5	6	7	8
Floor	dB LAFMax at North Façade						
Level 10	84	82	84	83	83	82	81
Level 9	80	78	77	78	77	78	77
Level 8	78	77	76	75	76	76	76
Level 7	76	76	76	75	74	74	75
Level 6	75	76	75	74	74	72	72
Level 5	74	75	75	74	73	72	72
Level 4	74	75	74	74	72	72	71
Level 3	73	74	74	73	72	71	71
Level 2	73	73	73	73	72	71	71
Level 1	72	73	73	72	71	71	71
Level 0	72	72	72	72	71	71	71

Row Labels	24	25	26	27	28	29
Floor	dB LAFMax at East Façade					
Level 10	98	100	102	102	102	103
Level 9	97	100	101	102	100	100
Level 8	97	99	101	101	100	100
Level 7	97	99	100	100	99	99
Level 6	96	98	99	99	98	99
Level 5	96	97	98	99	98	98
Level 4	96	97	98	98	97	97
Level 3	95	96	97	97	97	97
Level 2	95	96	96	96	96	96
Level 1	94	95	96	96	95	96
Level 0	94	95	95	95	95	95

Row Labels	16	17	18	19	20	21	22	23
Floor	dB LAFMax at South Façade							
Level 10	98	96	99	104	105	100	96	93
Level 9	98	95	99	102	103	99	96	93
Level 8	97	95	96	99	100	97	94	92
Level 7	96	94	95	97	97	95	93	91
Level 6	95	93	93	95	95	93	91	90
Level 5	94	93	92	93	93	92	90	90
Level 4	94	92	91	92	92	91	90	90
Level 3	93	92	91	91	91	90	89	90
Level 2	92	91	90	90	90	89	89	90
Level 1	92	91	90	89	89	88	89	90
Level 0								

Row Labels	9	10	11	12	13	14	15
Floor	dB LAFMax at West Façade						
Level 10	91	92	94	95	98	100	103
Level 9	91	92	93	95	97	100	102
Level 8	91	92	93	95	97	99	101
Level 7	90	92	93	95	96	98	100
Level 6	90	92	93	94	96	97	99
Level 5	90	91	93	94	95	97	98
Level 4	90	91	92	94	95	96	97
Level 3	90	91	92	93	95	96	96
Level 2	90	91	92	93	94	95	96
Level 1	90	91	92	93	94	94	95
Level 0	89	90	91	92	93	94	94

Figure 4: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building B)

The predicted outdoor maximum noise level for the nearest buildings to Building B are displayed in the figures below.

Façade Position	1	2	3	4	5	6	7	8	37
Floor	dB LAFMax at North Façade								
Level 10	96	95	97	98	97	96	94	94	97
Level 9	95	95	96	98	97	95	94	94	97
Level 8	95	94	96	97	96	95	94	93	96
Level 7	94	94	95	96	96	94	93	93	95
Level 6	94	93	95	95	95	94	93	93	95
Level 5	93	93	94	95	94	93	93	92	94
Level 4	93	92	94	94	94	93	92	92	93
Level 3	92	92	93	93	93	92	92	91	93
Level 2	92	92	92	93	93	92	91	91	92
Level 1	91	91	92	92	92	91	91	91	92
Level 0	91		91	92	91	91	90	90	91

Façade Position	9	10	11	12	13	14	15	16
Floor	dB LAFMax at East Façade							
Level 10	89	87	87	86	86	85	85	88
Level 9	88	87	86	86	86	85	85	88
Level 8	88	87	86	86	86	85	85	87
Level 7	88	87	86	86	85	85	85	87
Level 6	88	87	86	86	85	85	85	87
Level 5	88	87	86	86	85	85	85	87
Level 4	88	87	86	86	85	85	85	87
Level 3	88	87	86	85	85	85	85	87
Level 2	88	87	86	85	85	84	84	87
Level 1	87	87	86	85	84	84	84	87
Level 0	87	86	86	85	84	84	83	87

Façade Position	17	18	19	20	21	22	23	24	25	26	27
Floor	dB LAFMax at West Façade										
Level 10	88	88	89	90	92	93	95	97	99	99	100
Level 9	88	88	89	90	92	93	95	97	98	98	99
Level 8	88	88	89	90	91	93	95	96	97	98	98
Level 7	88	88	89	90	91	93	94	96	97	97	97
Level 6	87	88	89	90	91	92	94	95	96	96	96
Level 5	87	88	89	90	91	92	93	95	95	96	96
Level 4	87	88	89	90	91	92	93	94	95	95	95
Level 3	87	88	88	89	90	92	93	94	94	94	95
Level 2	87	88	88	89	90	91	92	93	94	94	94
Level 1	87	87	88	89	90	91	92	93	93	93	93
Level 0	87	87	88	89	90	91	92	92	93	93	93

Façade Position	28	29	30	31	32	33	34	35	36
Floor	dB LAFMax at South Façade								
Level 10	99	97	95	94	96	98	100	100	100
Level 9	98	97	95	93	95	98	99	100	100
Level 8	97	96	94	93	95	97	99	99	99
Level 7	97	96	94	93	95	97	98	98	98
Level 6	96	95	94	93	94	96	97	98	98
Level 5	95	95	93	93	94	96	97	97	97
Level 4	95	94	93	92	94	95	96	96	96
Level 3	94	94	93	92	93	95	95	96	96
Level 2	94	93	92	92	93	94	95	95	95
Level 1	93	93	92	91	93	94	94	94	95
Level 0	93	92	91	91	92	93	94	94	94

Figure 5: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building 02)

Façade Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Floor	dB LAFMax at North Façade						dB LAFMax at East Façade						dB LAFMax at South Façade			dB LAFMax at West Façade								
Level 4	78	78	79	86	87	88	89	90	91	93	94	96	96	95	94	90	89	87	86	85	84	83	82	82
Level 3	73	74	79	86	87	88	89	90	91	93	94	95	95	95	94	88	87	86	85	84	83	83	82	82
Level 2	72	74	79	86	87	88	89	90	91	92	93	95	95	94	93	87	86	85	85	84	83	83	82	82
Level 1	72	74	79	86	87	88	89	90	91	92	93	94	94	94	93	87	86	85	84	84	83	83	82	82
Level 0	71	74	78	86	87	88	89	90	91	92	93	94	94	93	93	87	86	85	84	83	83	82	82	82

Figure 6: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building A)

Façade Position	16	17	18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Floor	dB LAFMax at North Façade			dB LAFMax at East Façade						dB LAFMax at South Façade			dB LAFMax at West Façade					
Level 7	94	93	91	89	90	91	92	94	95	95	95	94	94	95	96	95	93	92
Level 6	94	93	91	89	90	91	92	93	94	95	94	93	94	94	95	94	93	91
Level 5	94	92	91	89	90	91	92	93	94	94	94	93	93	94	94	93	92	91
Level 4	93	92	91	89	89	90	91	93	93	94	93	92	92	93	93	93	92	90
Level 3	93	92	91	88	89	90	91	92	93	93	93	92	92	92	92	92	91	90
Level 2	93	92	90	88	89	90	91	92	93	93	92	92	91	92	91	91	91	90
Level 1	92	91	90	88	89	90	91	91	92	92	92	91	91	91	90	91	90	89
Level 0				88	89	89	90	91	92	92	92	91	84			90	90	89

Figure 7: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building F)

Façade Position	10	11	12	4	5	6	7	8	9	1	2	3	13	14	15	16	17	18
Floor	dB LAFMax at North Façade			dB LAFMax at East Façade						dB LAFMax at South Façade			dB LAFMax at West Façade					
Level 10	102	99	96	89	91	93	96	102	105	103	104	103	97	96	98	99	98	97
Level 9	100	98	95	89	91	93	95	101	104	101	103	102	97	96	98	99	98	96
Level 8	98	97	95	89	91	93	95	100	102	100	101	101	96	96	98	98	98	96
Level 7	94	95	94	89	91	92	94	99	101	99	100	100	96	95	97	98	97	96
Level 6	92	91	92	89	90	92	94	98	100	99	99	99	95	95	97	97	97	96
Level 5	95	94	93	89	90	92	93	98	99	98	98	98	94	94	97	97	96	95
Level 4	94	93	92	88	90	91	93	97	98	97	97	97	94	94	96	96	96	95
Level 3	93	92	91	88	89	91	92	96	97	96	97	96	93	93	96	96	95	95
Level 2	92	91	90	88	89	90	92	96	96	96	96	96	93	92	95	95	95	94
Level 1	92	90	89	88	89	90	91	95	95	95	95	95	92	92	95	95	95	94
Level 0	91	90	89	88	89	90	90								94	94	94	93

Figure 8: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building C)

Façade Position	7	8	9	10	11	12	13	14	15	16	17	1	2	3	4	5	6
Floor	dB LAFMax at North Façade			dB LAFMax at East Façade					dB LAFMax at South Façade			dB LAFMax at West Façade					
Level 7	96	95	97	97	96	95	93	92	91	93	94	92	91	92	94	99	100
Level 6	95	95	96	97	96	95	93	92	91	92	94	91	91	92	93	98	99
Level 5	95	94	95	96	95	94	93	92	91	92	93	91	90	91	93	97	98
Level 4	94	94	95	95	95	94	93	91	91	92	93	91	90	91	92	97	97
Level 3	93	93	94	95	94	93	92	91	91	92	93	90	89	91	92	96	97
Level 2	93	93	94	94	94	93	92	91	90	91	93	90	89	90	91	95	96
Level 1	92	93	93	94	93	92	92	91	90	91	92	90	89	90	91	95	95
Level 0	91	92	93	93	93	92	91	90				89	89	90	85		

Figure 9: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building D)

Façade Position	16	17	18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Floor	dB LAFMax at North Façade					dB LAFMax at East Façade				dB LAFMax at South Façade			dB LAFMax at West Façade					
Level 10	103	106	104	92	93	95	95	95	94	90	89	88	84	85	86	87	88	90
Level 9	102	104	102	91	93	94	95	95	94	90	89	88	84	85	86	87	88	90
Level 8	101	102	101	91	92	94	94	94	93	90	89	88	84	85	86	87	88	90
Level 7	100	101	100	91	92	93	94	93	93	90	89	88	84	85	86	87	88	90
Level 6	99	100	99	90	92	92	93	93	92	90	89	88	84	85	86	87	88	89
Level 5	98	99	98	90	91	92	92	92	92	90	89	88	84	85	86	87	88	89
Level 4	97	98	97	90	91	91	92	92	91	89	89	88	84	85	86	87	88	89
Level 3	96	97	97	89	90	91	91	91	91	89	88	88	84	85	86	87	88	89
Level 2	96	96	96	89	90	90	91	91	90	89	88	88	84	85	85	86	88	89
Level 1	95	95	95	89	89	90	90	90	90	89	88	87	84	84	85	86	87	88
Level 0				88	89	90			89	89	88	87	84	84	85	86	87	88

Figure 10: Outdoor maximum sound pressure levels during worst-case helicopter movement (Building E)

These values allow for a helicopter movement along any point of each flightpath. In reality the maximum sound pressure level will vary with event, depending on the flight direction of the helicopter.

5 Assessment of Noise Ingress

5.1 Methodology and Assumptions

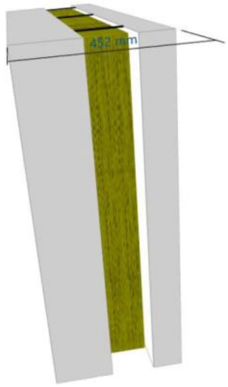
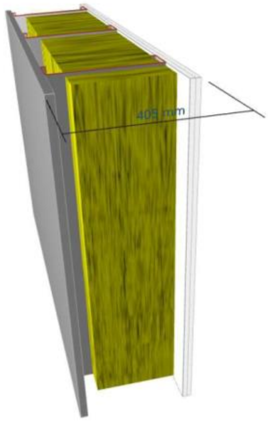
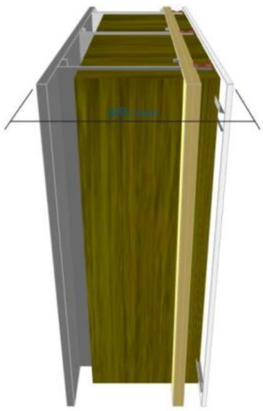
Noise ingress calculations have been carried out through applying the approach with ISO 12354-3:2017: *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 3: Airborne sound insulation against outdoor sound*. The assessment has considered the worst affected point on the worst affected façade of Buildings B and 02 on floors 10, 8 and 6, and on Buildings D and F on floors 7 and 5.

The following assumptions were incorporated into the assessment for the purposes of this initial study:

- The room is assumed to be reasonably small (4 m by 4 m by 2.8 m).
- The building envelope is assumed to contain two windows (total area of 4.4 m^2), and it is assumed that these are triple glazed systems with a very stringent sound insulation requirement. The type of glazing under consideration is shown in Appendix A.
- The room is assumed to be ventilated mechanically with no passive vents within the building envelope (and any ductwork opening to outdoors attenuated sufficiently so that it is not an important noise ingress route).
- The room is assumed to include a suspended ceiling system that achieves sound absorption class A over at 80% of the ceiling area, and it is assumed that a reverberation time criterion of 0.6 seconds T_{mf} is achieved within sensitive rooms.
- It is assumed that back of house rooms of the same size will have a reverberation time of around 1 second T_{mf}.

The effect of varying the construction of the non-glazed elements within the building enveloped has been investigated. This included consideration of the façade systems shown in Table 3.

In addition to these systems, a comparison with a simple Brick/Block with cavity wall (as seen in Table E1.A of British Standard 8233:2014) has been made. This additional system considers the potential construction of already constructed buildings that are remaining on site.

Table 3: Façade systems considered		
Type of Façade System	Construction	Construction details
Heavy masonry system		200 mm pre-cast concrete, cavity of 150 mm depth containing 150 mm depth of mineral wool insulation (min. 22 kg/m^3), 102 mm concrete layer. Point connections between masonry layers spaced every 600 mm.
Lightweight façade system with rigid connections		25 mm fibre cement panel (40 kg/m^2), cavity of 350 mm depth containing 300 mm depth of mineral wool insulation (min. 22 kg/m^3), 2 layers of 15 mm acoustic plasterboard (12.6 kg/m^2 per layer). Both layers supported on steel studwork (max gauge 1.6 mm) with studworks spaced every 600 mm.
Lightweight façade system with resilient connections and additional dense boards		25 mm fibre cement panel (40 kg/m^2), cavity of 350 mm depth containing 300 mm depth of mineral wool insulation (min. 22 kg/m^3), 2 layers of 18 mm dense cementitious board (22.9 kg/m^2 per layer), cavity of 63 mm with 60 mm depth of mineral wool insulation (min. 22 kg/m^3), 1 layer of 15 mm acoustic plasterboard (12.6 kg/m^2 per layer). Fibre cement and cementitious board supported on steel studwork (max gauge 1.6 mm) with studworks spaced every 600 mm. Additional acoustic plasterboard layer supported on narrow studwork with a resilient rail connection.

5.2 Predicted Indoor Levels

Based on the above assumptions, estimated indoor helicopter noise levels based on the predicted worst-case helicopter noise levels (Table 2) are shown in Tables 4 and 5 below.

Table 4: Estimated indoor maximum sound levels, Brick/Block construction with cavity wall			
Building	Floor	Predicted External Noise Level (dBA $L_{AF,Max,event}$)	Predicted Internal Noise Level (dBA)
B	10	105	60
B	8	101	57
B	6	99	55
02	10	101	57
02	8	100	56
02	6	99	55
D	7	100	56
D	5	98	54
F	7	97	53
F	5	95	50

Table 5: Estimated indoor maximum sound levels, lightweight façade system with rigid connections			
Building	Floor	Predicted External Noise Level (dBA $L_{AF,Max,event}$)	Predicted Internal Noise Level (dBA)
B	10	105	59
B	8	101	55
B	6	99	54
02	10	101	56
02	8	100	54
02	6	99	53
D	7	100	54
D	5	98	52
F	7	97	51
F	5	95	49

The above results demonstrate the following:

- There is only marginal difference between the façade types considered. This is due to the fact that, even with a triple glazed system, the glazing remains the dominant noise ingress path. This accounts for the expected frequency characteristics of helicopter noise with a moderate to high level of low-frequency sound.
- With a façade that has a minimum R_w of at least 50dB, plus the triple glazing system, the indoor noise level targets are likely to be achieved at the floors closest to the

helipad when considering “typical” helicopter movements that vary with direction of approach and also helicopter type.

- Within the lower floors, the indoor target of 55 dB $L_{AFmax,event}$ is achievable.

It is noted that for all of the above predictions, the sound insulation performance of the building envelope at low frequency (i.e. the 63 Hz octave band) is very important. Unfortunately, the level of uncertainty within the source data, sound insulation data and sound absorption data at low frequency is also greater. This uncertainty can be reduced by ensuring that the acoustic performance of elements at low frequency is tested, using a representative sample element with the same construction and geometry that will be used within the building.

5.3 Outline Façade Sound Insulation Specification

Based on above assessment, it is recommended that the following outline sound insulation requirements for the building envelope is incorporated into the building specifications.

Table 6: Outline sound insulation specification for external glazing

Minimum sound reduction index of triple glazing system [dB R], per octave band [Hz]							Single-figure sound insulation rating [dB $R_w + C_{tr}$)]
63	125	250	500	1000	2000	4000	
23	33	41	47	54	57	54	45

Nominal suitable construction:
Triple glazed system. Nominal construction of 8.8 mm laminated glass, 175 mm cavity, 4 mm glass, 16 mm cavity, 6 mm glass.

Table 7: Outline sound insulation specification for the external facade

Minimum sound reduction index of the external façade [dB R], per octave band [Hz]							Single-figure sound insulation rating [dB $R_w + C_{tr}$]
63	125	250	500	1000	2000	4000	
34	40	46	52	53	57	61	50

Nominal suitable construction:
Achievable with the lightweight façade system with rigid connections shown in Table 3, subject to the provision of an additional layer of acoustic plasterboard on the inner face. Achievable with the heavy masonry construction as shown in Table 3.

6 Conclusion

Prediction of noise levels from the proposed helicopter landing pad at Västerviks sjukhus was undertaken in order to determine potential noise implications within the hospital building. The predicted noise levels were then compared against façade constructions and internal noise levels calculated, which were then compared against the limit levels set out in Table 1.

Based on the assumptions made within the memo, and the constructions detailed in Table 6 and Table 7, the internal noise levels within rooms on the worst affected floors and facades should still meet the limit levels with the occasional use of the helicopter landing pad.