Chapter 12
Noise and Vibration

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Chapter 12 Noise and Vibration

12.1 Introduction

This chapter, prepared by AWN Consulting, presents an assessment of the impacts of the proposed River Suir Sustainable Transport Bridge in terms of noise and vibration of the local environment as defined in the following Environmental Protection Agency guidance documents:

- Advice Notes on Current Practice in the Preparation of EIS (2003);
- Guidelines on the Information to be Contained in Environmental Impact Assessment Reports Draft August 2017; and
- Guidelines on the Information to be Contained in Environmental Impact Statements, 2002

The study has been undertaken using the following methodology:

- Baseline noise monitoring has been undertaken in the vicinity of the proposed Sustainable Transport Bridge in order to characterise the existing noise environment;
- A review of the most applicable standards and guidelines has been conducted in order to set a range of acceptable noise and vibration criteria for the construction and operational phases of the proposed Sustainable Transport Bridge;
- Predictive calculations have been performed for the construction phase of the project at the nearest sensitive locations to the development site;
- Predictive calculations have been performed to assess the potential impacts associated with the operation of the development at the most sensitive locations surrounding the Sustainable Transport Bridge. A schedule of mitigation measures has been proposed to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed Sustainable Transport Bridge.

The following British Standards were also consulted when carrying out this assessment:

- BS 4142:2014 *Methods for Rating and Assessing Industrial and Commercial Sound*;
- BS 5228 (2009 +A1 2014) Code of Practice for Noise and Vibration Control on Construction and Open Sites Parts 1 and 2; and
- BS 8233:2014 *Guidance on Sound Insulation and Noise Reduction for Buildings*.

This chapter of the Environmental Impact Assessment Report (EIAR) has been prepared by Alistair Maclaurin from AWN Consulting. Alistair Maclaurin (Senior Acoustic Consultant) holds a B.Sc. and has completed the Institute of Acoustics Diploma. Alistair has some 6 years' experience as an acoustic consultant and is a Member of the Institute of Acoustics. He has extensive knowledge in construction noise having worked as a noise specialist on major infrastructure projects such as Dublin Airport Expansion, Bolands Quay redevelopment, Crossrail and Thames Tideway Tunnel. Additionally, he has undertaken various other environmental noise assessments for infrastructure developments and planning reports.

12.2 Description of the Receiving Environment

A baseline environmental noise survey was conducted in the vicinity of the proposed Sustainable Transport Bridge and within Waterford City in order to quantify the existing noise environment in the vicinity of the noise-sensitive locations that may be affected by the proposed development.

A baseline survey of vibration along the proposed development was not undertaken as existing levels in the vicinity of the proposed development are not expected to be of a magnitude sufficient to cause disturbance to people or structural damage to property. Furthermore, vibration was not perceptible at any of the noise survey locations.

12.2.1 Survey Periods

An attended noise survey was conducted at 3 locations on 15 March 2017 between 13:20 and 17:30 hours.

12.2.2 Measurement Locations

The measurement location descriptions are presented in Table 12.1 below and illustrated in Plate 12.1.

Table 12.1 Baseline Noise Monitoring Locations

Survey Location	Description
AN1	Outside the rear of residential property at Bishopsgrove
AN2	Outside rear of residential property at Sion Row (overlooking the River Suir)
AN3	Outside mixed commercial and residential property on Meagher's Quay

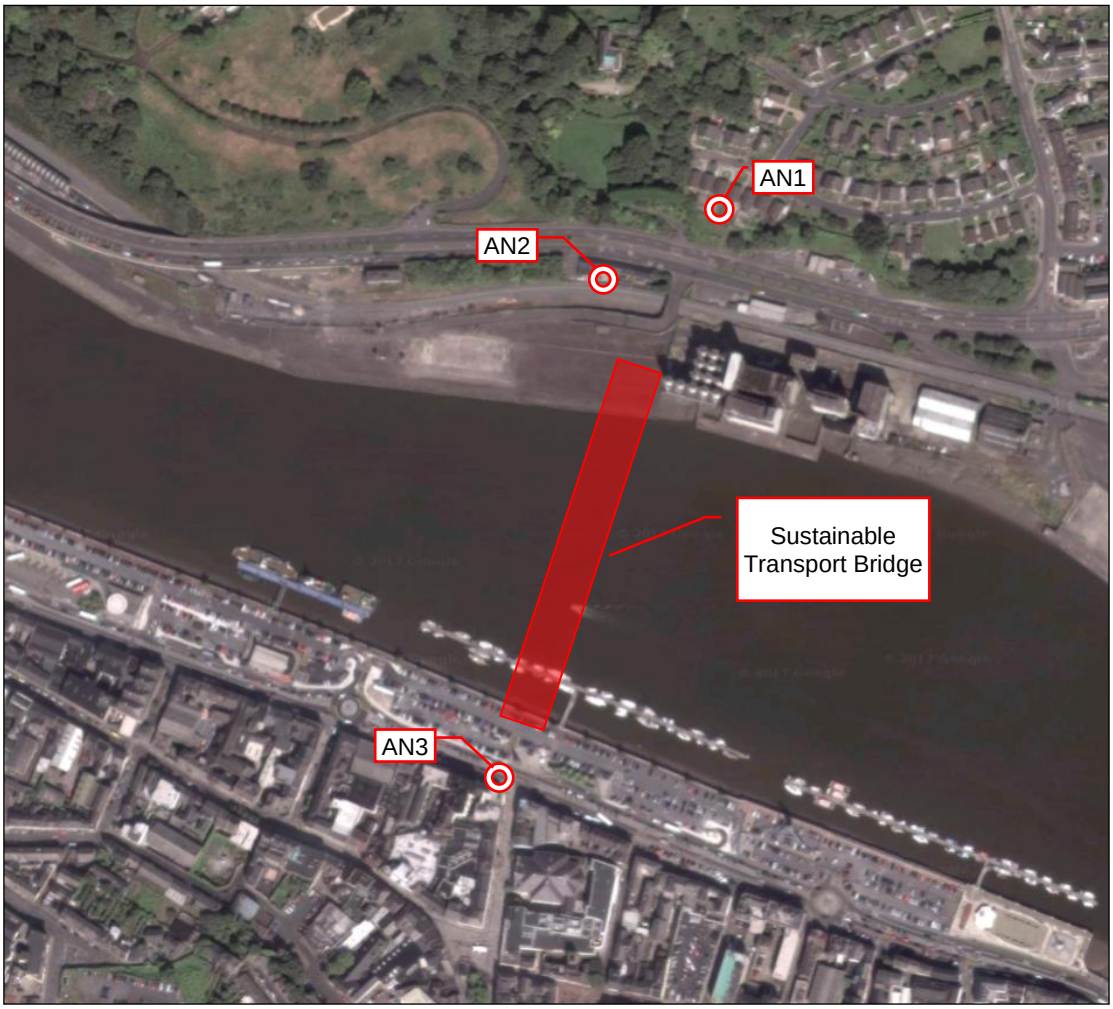

Plate 12.1 Baseline Noise Monitoring Locations

12.2.3 Instrumentation

The measurements were performed using a Brüel & Kjær Type 2250 Sound Level Meter. Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator.

12.2.4 Procedure

Measurements were conducted on a cyclical basis at the locations noted above. Sample periods for the noise measurements were 15 minutes at each location with each location sampled three times. The results were noted onto an Environmental Noise Survey Record Sheet immediately following each sample, and were also saved to the instrument memory for later analysis where required. Survey personnel noted the primary noise sources contributing to noise build-up.

12.2.5 Weather

The weather during the survey period was mainly dry with mild temperatures in the range of 10 to 12°C for the duration of the survey and light winds. Towards the end of the survey, the sky became overcast and precipitation commenced at approximately 17:30 when measurements were halted.

12.2.6 Measurement Parameters

The noise survey results are presented in terms of the following five parameters:

$L_{Aeq, T}$ is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the period T. It is typically used as a descriptor for ambient noise.

L_{Amax} is the instantaneous maximum sound level measured during the sample period.

L_{Amin} is the instantaneous minimum sound level measured during the sample period.

L_{A10} is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for traffic noise.

L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to 2×10^{-5} Pa.

12.2.7 Results of Noise Surveys

Table 12.2 presents the results of the attended measured noise levels for each of the three survey locations.

The results of the survey have indicated that baseline noise levels at all locations assessed are dominated by existing traffic flows along the roads within Waterford City.

At location AN1 the noise climate was dominated by road traffic movements on Dock Road. Ambient noise levels were measured consistently at 71 dB L_{Aeq}. Background noise levels were in the range of 63 to 66 dB L_{A90}.

At location AN2 the noise climate was also dominated by road traffic movements on Dock Road. Ambient noise levels ranged from 59 to 61 dB L_{Aeq}. Background noise levels were in the range of 51 to 53 dB L_{A90}.

At location AN3 the noise climate was dominated by road traffic movements on Meagher's Quay. It was noted that there were regular movements of emergency vehicles with sirens on the road throughout the day. Ambient noise levels ranged from 67 to 74 dB L_{Aeq}. Background noise levels were in the range of 58 to 61 dB L_{A90}.

Table 12.2 Baseline Noise Monitoring Results

Survey Location	Start time	Measured Noise Levels (dB re.2x10^{-5}Pa)					Notes
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}	
AN1	15/03/2017 13:22	71	80	56	74	63	Free-field
	15/03/2017 14:50	71	81	56	75	64	
	15/03/2017 16:15	71	80	58	74	66	
AN2	15/03/2017 13:44	61	74	47	64	51	Façade
	15/03/2017 15:08	60	75	48	64	53	
	15/03/2017 16:34	59	76	48	63	52	
AN3	15/03/2017 14:16	69	84	54	73	61	Façade
	15/03/2017 15:41	74	102	52	70	58	
	15/03/2017 17:06	67	86	53	70	61	

12.3 Methodology

12.3.1 Construction Assessment Criteria

Noise

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. In lieu of statutory guidance, an assessment of significance has been undertaken as per British Standard *BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise*.

The approach adopted here calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded at this location, indicates a significant noise impact is associated with the construction activities.

BS 5228-1:2009+A1:2014 sets out guidance on permissible noise levels relative to the existing noise environment. Table 12.3 sets out the values which, when exceeded, signify a significant effect at the façades of residential receptors.

Table 12.3 Example Threshold of Potential Significant Effect at Dwellings

Assessment category and threshold value period	Threshold value, in decibels (dB) ($L_{Aeq, T}$)		
	Category A[A]	Category B[B]	Category C[C]
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
Evenings and weekends [D]	55	60	65
Night-time (23:00 to 07:00hrs)	45	50	55

[A] Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

[B] Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

[C] Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

[D] 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

For the appropriate assessment period (i.e. daytime in this instance) the ambient noise level is determined through a logarithmic averaging of the measurements for each location and then rounded to the nearest 5dB. If the construction noise exceeds the appropriate category value, then a significant effect is deemed to occur. Table 12.4 presents the assigned *BS 5228-1:2009+A1:2014* categories and threshold values for each baseline location.

Table 12.4 Defined Construction Noise Thresholds

Survey Location	$L_{Aeq, 12\ hr}$	Ambient Noise Level Rounded to Nearest 5 dB L_{Aeq}	BS 5228-1:2009+A1:2014 Category	Construction Noise Threshold Value (dB) ($L_{Aeq, T}$)
AN1*	74	75	C	75
AN2	60	60	A	65

Survey Location	$L_{Aeq, 12\ hr}$	Ambient Noise Level Rounded to Nearest 5 dB L_{Aeq}	BS 5228-1:2009+A1:2014 Category	Construction Noise Threshold Value (dB) ($L_{Aeq, T}$)
AN3	71	70	C	75

*Note that the survey measurements for location AN1 were undertaken in free-field conditions. For the purpose of this assessment a 3 dB correction for façade reflections has been applied.

Vibration

In terms of vibration, *BS 5228-2:2009+A1:2014* recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak component particle velocity (PPV) (in frequency range of predominant pulse) of 15mm/s at 4Hz increasing to 20mm/s at 15Hz and 50mm/s at 40Hz and above. The standard also notes that below 12.5 mm/s PPV the risk of damage tends to zero. It is therefore common, on a cautious basis, to use this lower value. Taking the above into consideration the vibration criteria in Table 12.5 are recommended.

Table 12.5 Defined Construction Vibration Thresholds for Structurally Sound Buildings

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:-		
Less than 15Hz	**15 to 40Hz**	**40Hz and above**
15 mm/s	20 mm/s	50 mm/s

Note that the above thresholds are specified for transient or intermittent vibrations. Some construction activities, such as piling, may give rise to continuous vibrations. In these instances the guidance recommends that the previously defined thresholds are reduced by at least 50%.

Furthermore, the Clock Tower on Meagher's Quay has been identified as a potentially vulnerable building. *BS 5228-2:2009+A1:2014* recommends that vibration thresholds at this location are reduced by a further 50%. Table 12.6 defines the criteria for vulnerable buildings or structures.

Table 12.6 Defined Construction Vibration Thresholds for Vulnerable Buildings and Structures

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:-		
Less than 15Hz	**15 to 40Hz**	**40Hz and above**
7.5 mm/s	10 mm/s	25 mm/s

12.3.2 Operational Assessment Criteria

Noise Levels Generally

The World Health Organisation (WHO) have published in October 2018 *Environmental Noise Guidelines for the European Region*. The objective of these guidelines is to provide recommendations for protecting human health from exposure to environmental noise from transportation, wind farm and leisure sources of noise. The guidelines present recommendations for each noise source type in terms of L_{den} and L_{night} levels above which there is risk of adverse health risks.

However, it should be noted that the WHO guideline values referred to here are recommended to serve as the basis for a policy-making process to allow evidence based public health orientated recommendations. They are not intended to be noise limits and the WHO document states the following regarding the implementation of the guidelines,

> *"The WHO guideline values are evidence-based public health-oriented recommendations. As such, they are recommended to serve as the basis for a policy-making process in which policy options are considered. In the policy decisions on reference values, such as noise limits for a possible standard or legislation, additional considerations – such as feasibility, costs, preferences and so on – feature in and can influence the ultimate value chosen as a noise limit. WHO acknowledges that implementing the guideline recommendations will require coordinated effort from ministries, public and private sectors and nongovernmental organizations, as well as possible input from international development and finance organizations. WHO will work with Member States and support the implementation process through its regional and country offices."*

It is therefore not intended to refer to the WHO guidelines in an absolute sense as part of this assessment and it will be a decision for national and local policy makers to adopt the WHO guidelines and propose noise limits for use.

The main potential source of outward noise is the operation of the bridge whilst opening and any further mechanical services that may be associated with it. Appropriate guidance on internal noise levels for dwellings is contained within BS 8233:2014 *Guidance on Sound Insulation and Noise Reduction for Buildings*. This British Standard sets out recommended noise limits for indoor ambient noise levels in dwellings as presented in Table 12.7:

Table 12.7 Recommended Indoor Ambient Noise Levels from BS 8233:2014

Typical situations	Design Range, $L_{Aeq,T}$ dB	
	Daytime LAeq,16hr (07:00 to 23:00hrs)	Night-time LAeq, 8hr (23:00 to 07:00hrs)
Living / Dining Rooms	35 - 40	n/a
Bedrooms	35	30

Plant Noise

In relation to external services plant noise, reference is made to BS 4142:2014 *Methods for Rating and Assessing Industrial and Commercial Sound*. This document describes methods for rating and assessing sound of an industrial and/or commercial nature to a residential receptor. The methods described in this standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident. The results of baseline surveys of the prevailing background sound level allow for the noise impact associated with proposed new external plant items to be assessed. With reference to BS 4142:2014, it is noted that, depending on context, adverse impacts are likely to occur when rated plant sound level exceeds the prevailing background sound level by +5dB, with a significant adverse impact occurring at +10dB or more. Where the rating level does not exceed the background sound level, BS 4142 comments that this is an indication of the specific sound source having a low impact, again depending on the context.

Vehicular Traffic

In order to assist with the interpretation of the noise associated with vehicular traffic on existing public roads, Table 12.8 offers guidance as to the likely impact associated with any particular change in traffic noise level (Source Design Manual for Roads and Bridges (DMRB), 2011).

Table 12.8 Likely Impact Associated with Change in Traffic Noise Level

Change in Sound Level (dB L_{A10})	Subjective Reaction	Magnitude of Impact
0	Inaudible	No Impact
0.1 – 2.9	Barely Perceptible	Negligible
3 – 4.9	Perceptible	Minor
5 – 9.9	Up to a doubling of loudness	Moderate
10+	Doubling of loudness and above	Major

Table 12.8 presents the DMRB (2011) likely impacts associated with change in traffic noise level. The corresponding significance of impact presented in the '*EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports* (EIAR), Draft, August 2017 is presented in Table 12.9 for consistency in wording and terminology for the assessment of impact significance.

Table 12.9 Likely Impact Associated with Change in Traffic Noise Level

Change in Sound Level DMRB, 2011 (dB L_{A10})	Subjective Reaction DMRB, 2011	Impact Guidelines for Noise Impact Assessment Significance (Institute of Acoustics)	Impact Guidelines on the Information to be contained in EIAR (EPA)
0	No change	None	Imperceptible
0.1 – 2.9	Barely perceptible	Minor	Not Significant
3.0 – 4.9	Noticeable	Moderate	Slight, Moderate
5.0 – 9.9	Up to a doubling or halving of loudness	Substantial	Significant
10.0 or more	More than a doubling or halving of loudness	Major	Very Significant, Profound

The criteria above reflect the key benchmarks that relate to human perception of sound. A change of 3 dB(A) is generally considered to be the smallest change in environmental noise that is perceptible to the human ear. A 10 dB(A) change in noise represents a doubling or halving of the noise level. The difference between the minimum perceptible change and the doubling or halving of the noise level is split to provide greater definition to the assessment of changes in noise level.

12.4 Description of Potential Impacts

During the construction phase the main site activities will include site clearance, demolition, substructure and super structure construction. This phase will involve the use of various mobile plant, excavators, cranes, piling rigs, and other standard

construction machinery throughout most of the site. Although it is expected that the demolition and substructure works are likely to give rise to noise and vibration emissions, the impact is considered relatively short-term in nature and is assessed in Section 12.4.1.

During the operational phase of the development, the potential sources of noise and vibration are limited to occasional use of mechanical plant required to operate the bridge opening mechanism and the movement of cyclists, pedestrians and an electric bus across the bridge. It is proposed to use plant rooms located on the north and south quays to open the bridge. These plant rooms will provide for a hydraulic power unit, a generator, a standby generator drive and programmable logic controller (PLC) units. The plant room required to open the southern bascule leaf will be located in a small building which will be located on the proposed footprint of the future building (west side of plaza). For the north quays, the plant room will be located in a room(s) located within the proposed future developments for the north quays. This building will be delivered as part of the SDZ development and is therefore not considered as part of this EIAR.

12.4.1 Construction Phase

Noise

The construction phase is expected to last a total of 18 – 24 months. Construction noise has been predicted at four noise sensitive locations. The locations are defined in Table 12.10 along with their associated baseline location and construction noise threshold. The receptor locations are presented in Plate 12.2.

Table 12.10 Defined Construction Noise Thresholds

Receptor	Receptor Address	Residential / Commercial	Applicable Baseline Ref	Construction Noise Threshold Value (dB) ($L_{Aeq, 12\ hr}$)
R1	12 Bishopsgrove	Residential	AN1	75
R2	8 Sion Row	Residential	AN2	65
R3	72-73 Meagher's Quay	Commercial	AN3	75
R4	79 Meagher's Quay	Residential	AN3	75

Plate 12.2 Noise Sensitive Receptor Locations

A variety of items of plant will be in use for the purposes of site clearance and construction. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for the generation of elevated levels of noise.

During the construction phase, excavator mounted breakers will be employed to remove existing concrete and rock and then standard construction tools and methods will be employed for general construction and landscaping.

It is possible to predict indicative noise levels using guidance set out in *BS 5228-1:2009+A1:2014* for the main phases of the proposed construction works. The calculations assume common equipment used for each activity along with estimates of percentage on times for which the equipment will operate during the 12-hour working day. Table 12.11 summarises the construction noise prediction calculations at the nearest residences using the assumptions set out above for the worst-case day during each phase of construction.

Note that the predicted noise levels referred to in this section are indicative only and present the worst-case noise levels when construction works are occurring in close proximity to the sensitive locations. Construction noise levels will be lower than these levels for the majority of the time at the majority of properties in the vicinity of the proposed development.

Table 12.11 Indicative construction noise calculations at closest properties to works

Construction Plant	Data Source	Plant SWL dB	Percentage on Time	Calculated Construction Noise Levels, dB $L_{Aeq,12hr}$			
				R1	R2	R3	R4
Site Clearance & Removal of Glass Panels							
Excavator	BS 5228 (C2-21)	99	66	40	42	61	55
Excavator (loading)	BS 5228 (C2-30)	107	10	40	42	60	55
Lorry	BS 5228 (C2-34)	108	20	44	46	64	59
Generator	BS 5228 (C4-76)	89	100	32	34	52	47
Angle Grinder	BS 5228 (C4-93)	108	20	44	46	64	59
Hand-Tools (Based on Circular Saw)	BS 5228 (C4-72)	107	20	43	45	63	58
Total				50	51	70	65
Demolish North Site							
Excavator with Breaker	BS 5228 (C1-1)	120	66	70	75	64	64
Dumper	BS 5228 (C4-3)	104	66	54	59	48	48
Lorry	BS 5228 (C2-34)	108	20	53	58	47	47
Excavator (Loading)	BS 5228 (C2-30)	107	10	49	54	43	43
Total				70	75	64	64
Breakout Concrete South Bank							
Excavator with Breaker	BS 5228 (C1-1)	120	66	61	63	81	77
Dumper	BS 5228 (C4-3)	104	66	45	47	65	61
Lorry	BS 5228 (C2-34)	108	20	44	46	64	60
Excavator (Loading)	BS 5228 (C2-30)	107	66	48	50	68	64
Excavator	BS 5228 (C2-21)	99	66	40	42	60	56
Total				62	63	81	78
Driven Piles for South Quay Wall							
Bored Piling Rig	BS 5228 (C3-14)	111	66	53	54	70	67
Excavator	BS 5228 (C2-21)	99	66	41	42	58	55
Concrete Truck & Pump	BS 5228 (C4-28)	103	25	40	42	57	55

Construction Plant	Data Source	Plant SWL dB	Percentage on Time	Calculated Construction Noise Levels, dB $L_{Aeq,12hr}$			
				R1	R2	R3	R4
Generator	BS 5228 (C4-76)	89	100	33	34	49	47
Total				53	55	70	68
Pile Caps for South Quay Wall							
Angle Grinder	BS 5228 (C4-93)	108	25	45	47	62	60
Excavator With Breaker	BS 5228 (C1-1)	120	66	62	63	79	76
Concrete Truck & Pump	BS 5228 (C4-28)	103	25	40	42	57	55
Excavator	BS 5228 (C2-21)	99	66	41	42	58	55
Generator	BS 5228 (C4-76)	89	100	33	34	49	47
Total				62	64	79	76
Driven Piles North Abutment							
Bored Piling Rig	BS 5228 (C3-14)	111	66	61	66	55	55
Excavator	BS 5228 (C2-21)	99	66	49	54	43	43
Dumper	BS 5228 (C4-3)	104	66	54	59	48	48
Concrete Truck & Pump	BS 5228 (C4-28)	103	25	49	54	43	43
Generator	BS 5228 (C4-76)	89	100	41	46	35	35
Total				62	67	56	56
Pile Caps North Abutment							
Angle Grinder	BS 5228 (C4-93)	108	20	53	58	47	47
Excavator With Breaker	BS 5228 (C1-1)	120	66	70	75	64	64
Concrete Truck & Pump	BS 5228 (C4-28)	103	66	53	58	47	47
Excavator	BS 5228 (C2-21)	99	66	49	54	43	43
Dumper	BS 5228 (C4-3)	104	66	54	59	48	48
Total				70	75	64	64
Cofferdams Construction							
Vibratory Piling Rig	BS 5228 (C3-8)	116	66	62	65	66	65
Total				62	65	66	65

Construction Plant	Data Source	Plant SWL dB	Percentage on Time	Calculated Construction Noise Levels, dB $L_{Aeq,12hr}$			
				R1	R2	R3	R4
Driven Piles in River							
Driven Piles	BS 5228 (C3-3)	116	66	64	67	69	67
300T Crane	BS 5228 (C4-38)	106	66	54	57	59	57
Total				64	68	69	68
Pile Caps Construction In River							
Angle Grinder	BS 5228 (C4-93)	108	20	51	54	55	54
Excavator With Breaker	BS 5228 (C1-1)	120	66	59	62	64	62
Concrete Truck & Pump	BS 5228 (C4-28)	103	66	47	50	51	50
Excavator	BS 5228 (C2-21)	99	66	47	50	52	50
Dumper	BS 5228 (C4-3)	104	66	39	42	43	42
Total				60	63	65	64
Install Deck							
Angle Grinder	BS 5228 (C4-93)	108	20	51	54	55	54
Hand-Tools (Based on Circular Saw)	BS 5228 (C4-72)	107	20	50	53	54	53
300T Crane	BS 5228 (C4-38)	106	66	54	57	59	57
Driven Piles	BS 5228 (C3-3)	116	66	64	67	69	67
Concrete Truck & Pump	BS 5228 (C4-28)	103	25	47	50	51	50
Total				65	68	69	68
Install South Plaza							
Angle Grinder	BS 5228 (C4-93)	108	20	45	46	61	58
Hand-Tools (Based on Circular Saw)	BS 5228 (C4-72)	107	20	44	45	60	57
300T Crane	BS 5228 (C4-38)	106	66	48	49	64	61
Excavator	BS 5228 (C2-21)	99	66	41	42	57	54
Lorry	BS 5228 (C2-34)	108	66	50	51	66	63
Concrete Truck & Pump	BS 5228 (C4-28)	103	25	41	42	57	54
Total				54	55	70	67

The results of the assessment indicate that daytime construction thresholds are likely to be exceeded at locations R2, R3 and R4. The predicted exceedances are due to noise emissions from concrete breaking and piling activities. Note that whilst the entire programme of works is expected to last 18 – 24 months, individual activities such as breaking and piling will likely last for a smaller percentage of the entire programme (approximately 2-3 months) and as such these exceedances will not be occurring continuously throughout the construction phase. Piling is expected to take place at a range of distances from the sensitive receptors with the noisiest part of the piling process only occurring for a relatively short period in comparison with the entire programme.

Giving consideration to the predicted construction noise levels, it is recommended that the various best practice working methods used to control noise and vibration are adopted by the contractor during all works.

Vibration

The potential for vibration at neighbouring sensitive locations during construction is typically limited to excavation works, piling activities, breaking operations and lorry movements on uneven road surfaces. The more significant of these is the vibration from piling and breaking operations; the method of which will be selected and controlled to ensure there is no likelihood of structural or even cosmetic damage to existing neighbouring dwellings.

Particular attention should be given to those items of equipment that may give rise to continuous vibrations. In the case of this project, those items are likely to be piling equipment. To this end empirical data has been selected from BS-5228-2 in order to identify whether there is potential for vibration emissions to impact on local receptors.

The sensitive receptor locations remain as defined in the construction noise assessment, however an additional receptor has been added to account for the Clock Tower on the South Quay which has been assumed to be a vulnerable building, in which case BS 5228-2 recommends that any vibration thresholds at this location are reduced by 50%. Plate 12.3 presents the location of the Clock Tower.

Plate 12.3 Clock Tower Location

It should be noted that the closest sensitive receptor (R3 in Plate 12.2) to the steel driven piling works is estimated to be at 50m distance, with the Clock Tower estimated to be approximately 25m distance from the steel driven piles located at the south abutment. In case a piling option is selected to prevent the settlements under the south plaza, Continuous Flight Auger (CFA) piles at suitable depth and spacing will be specified in order to avoid the excessive noise and vibrations in close proximity to the surrounding sensitive receptors. The advantage of selecting CFA piles is they are virtually vibration free and suitable for the soils and the type of development proposed on the South Quays.

Vibratory piling works will be carried out at the south abutment and at the sheet piling for the temporary cofferdams. The closest receptor to the vibratory piling works is estimated to be approximately 50m distance and the Clock Tower is estimated to be approximately 30m from the vibratory piling works.

Table 12.12 BS 5228-2 Empirical Vibration Data

BS 5228-2 Empirical Vibration Data		
Piling Type	**Distance (m)**	**Range of PPV**
Rotary Bored (BS 5228-2 D.6)	10	0.3 – 3.2 mm/s
Vibratory (BS 5228-2 D.10)	25	2.9 mm/s
Vibratory (BS 5228-2 D.10)	40	2.0 mm/s

As can be seen in Table 12.12, piling is not expected to emit vibrations that may cause building damage.

12.4.2 Operational Phase

Noise

There are four primary sources of operational noise that may be associated with the bridge:

- Plant servicing the bridge;
- Traffic on the bridge (electric shuttle bus);
- The bridge opening; and
- Plant room on the South Plaza.

The mechanical plant required to open the bridge will be controlled in accordance with BS 4142 such that the existing noise environment is not increased. Note that this applies to the plant required for normal operations, emergency or back-up plant such as the generator and related equipment will not be subject to the same noise limits.

Regarding traffic noise, a calculation has been undertaken to predict noise levels emitted by the electric bus that is proposed to run across the proposed bridge. For assessment purposes in calculating the noise emissions from the bus, it has been assumed that the bus will run approximately every 20 minutes between 8 am and 7 pm. To calculate the noise levels associated with this element of the proposed development a source SEL (sound exposure level) for a diesel bus has been taken from AWN's database of measured source noise levels to inform a road traffic calculation. It should be noted that a diesel bus is considered to emit a higher magnitude of noise than an electric bus. An electric bus will only generate tyre noise and there will be no engine noise associated with the proposed operation, therefore, this is a worst case assessment. The SEL has been used to calculate a 11 hour noise

level at the closest receptors as a result of the bus operation alone. The results of the assessment are presented in Table 12.13.

Table 12.13 Baseline Noise Monitoring Locations

Receptor Ref	Bus SEL (dB)	Approximate Distance (m)	Calculated Noise Level (dB)	Baseline Noise Level (dB)	Resultant Change in Noise Level
R1	90	90	28	74	0
R2		25	33	59 - 61	0
R3		18	47	67 - 74	0

The results indicate that noise emissions due to the bus operation are multiple orders of magnitude below the existing baseline noise levels. It is predicted that the operation of the electric bus will be imperceptible.

Considering the measured existing noise levels and the perceived character of the existing noise environment (traffic related noise) it is expected that the operation of the Sustainable Transport Bridge will not generate noise or vibration emissions of significance such that the existing environment will be altered, this includes the movements of cyclists, the electric bus, pedestrians and the opening of the bridge.

It is considered that there will be a minor/not significant increase in noise levels at the receptors R3 and R4 however the as indicated previously as this is predicted to be of the order of 3 dB(A) it will be barely perceptible in the busy and receiving environment where the baseline noise levels of 67-74dB is dominated by vehicular traffic on the South Quays.

Vibration

It is considered vibration emissions from the operation of the Sustainable Transport Bridge will be imperceptible at all receptor locations.

12.5 Mitigation Measures

12.5.1 Construction Phase

Noise

With regard to construction activities, best practice control measures for noise and vibration from construction sites are found within BS 5228 (2009 +A1 2014) Code of Practice for Noise and Vibration Control on Construction and Open Sites Parts 1 and 2. It is expected that the contractor will ensure that all best practice noise and vibration control methods will be used as necessary in order to ensure impacts to nearby residential noise sensitive locations are not significant. This will be particularly important during concrete breaking which is the activity forecast to have the highest potential noise impact. During concrete breaking, it is typical to screen the hydraulics with localised temporary barriers in order to break line of sight to the sensitive receptors. This may give up to a 10 dB reduction in noise levels which would bring noise levels into line with the previously defined thresholds for these activities.

Noise-related mitigation methods are described below and will be implemented for the project in accordance with best practice. These methods include:

- No plant used on site will be permitted to cause an ongoing public nuisance due to noise;

- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations;
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract;
- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers;
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use;
- During construction, the contractor will manage the works to comply with noise limits outlined in *BS 5228-1:2009+A1 2014. Part 1 – Noise*;
- All items of plant will be subject to regular maintenance. Such maintenance can prevent unnecessary increases in plant noise and can serve to prolong the effectiveness of noise control measures;
- Limiting the hours during which site activities which are likely to create high levels of noise or vibration are permitted;
- Monitoring levels of noise and vibration during critical periods and at sensitive locations;
- Establishing channels of communication between the contractor/developer, Waterford City and County Council and residents so that receptors are aware of the likely duration of activities likely to generate higher noise or vibration;
- The Contractor appointing a Site Environmental Manager (SEM) responsible for matters relating to noise and vibration; and
- Hydroacoustic monitoring will be undertaken for the full duration of the construction of the proposed development. This monitoring will establish the ambient underwater noise levels in the estuary (and the rate of sound attenuation) and more accurately characterise the sound outputs in terms of SPL and SEL at different frequencies arising from the different methods of pile driving and different types and sizes of piles. This monitoring shall be undertaken on a continuous basis for the duration of construction and the results will be frequently reviewed (at least fortnightly) by the Ecological Clerk of Works.

Furthermore, it is envisaged that a variety of practicable noise control measures will be employed. These may include:

- Selection of plant with low inherent potential for generation of noise and/ or vibration;
- Erection of good quality, printed site hoarding around the South Quays which will act as a noise barrier to general construction activity at ground level;
- Erection of barriers as necessary around items such as generators or high duty compressors; and
- Situate any noisy plant as far away from sensitive properties as permitted by site constraints.

Working Hours

Normal working times will be 07:00 to 19:00hrs Monday to Friday and 08:00 to 16:30hrs Saturday and Sunday. Works will not be undertaken outside these working hours without the written permission of Waterford City and County Council. Piling works will only be permitted between 08:00 to 18:00hrs Monday to Friday during the months of June, July, August, November, December and January.

Vibration

The Clock Tower will be equipped with the suitable monitoring equipment and instrumentation to closely monitor vibration levels in real-time during construction works in order to ensure compliance with the thresholds defined in Section 12.3.1 and Table 12.6. Should the specified vibration levels be exceeded works swill cease until an appropriate solution has been identified.

12.5.2 Operation Phase

No mitigation measures related to noise and vibration will be necessary during the operation of the proposed bridge and South Plaza as it is expected that it will not generate noise or vibration emissions of significance such that the existing noise or vibration environment will be altered. Furthermore, best practice guidelines will be adhered to by plant servicing the bridge. However, noise monitoring will be undertaken during the initial 6 month period following the opening of the bridge in accordance with the methodology outlined in BS4142 to determine that the existing baseline noise environment has not increased as a result of mechanical plant serving the development. In the event that an increase is measured, additional noise mitigation measures will be adopted.

12.6 Residual Impacts

12.6.1 Construction Phase

During the construction phase of the project there is the potential for impacts on nearby noise sensitive properties due to noise emissions from site activities. The application of binding noise limits, hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration impacts will be reduced as far as is reasonably practicable. The resultant residual noise impact from this source will be of negative, moderate, short-term impact.

Table 12.14 Description of Construction Phase Effects

Quality	Significance	Duration
Negative	Moderate	Short-term

12.6.2 Operational Phase

During the operational phase it is expected that noise emissions from the Sustainable Transport Bridge will not be perceptible above the existing noise environment resulting in a neutral, imperceptible, long-term impact.

Table 12.15 Description of Construction Phase Effects

Quality	Significance	Duration
Neutral	Imperceptible	Long-term

12.7 Do-Nothing Scenario

In the event that the proposed development does not take place, the existing noise and vibration climate will remain unchanged on site and at nearby noise sensitive locations.