

## 12 AIR (NOISE AND VIBRATION)

### 12.1 Introduction

This section of the EIAR has been prepared by AWN Consulting Limited to identify and assess the potential noise and vibrational impacts associated with a proposed residential development at Woodbrook, Shankill, Co Dublin, during both the Construction and Operational Phases of the development.

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This chapter includes a description of the receiving ambient noise climate in the vicinity of the subject site, an assessment of the potential noise and vibration impact associated with the proposed development during both the short-term construction phase and the long term operational phase on its surrounding environment. The assessment of direct, indirect and cumulative noise and vibration impacts on the surrounding environment have been considered as part of the assessment.

Mitigation measures are included, where relevant, to ensure the proposed development is constructed and operated in an environmentally sustainable manner in order to ensure its minimal impact on the receiving noise climate.

The assessment has been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration which are set out within the relevant sections of this chapter and included in the references section. In addition to specific noise guidance documents, the following guidelines were considered and consulted for the purposes of this chapter: -

- EPA *Guidelines on the Information to be contained in Environmental Impact Statements*, (EPA, 2002).
- EPA *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements)*, (EPA, 2003).
- EPA *Guidelines on the Information to be contained in Environmental Impact Assessment Reports Draft August 2017*.
- EPA *Advice Notes for Preparing Environmental Impact Statements*, (Draft, September 2015).

### 12.2 Assessment Methodology

The following methodology has been prepared based on the requirements of the EPA document *Guidelines on the information to be contained in Environmental Impact Assessment Reports DRAFT August 2017* and on our experience of preparing the noise & vibration chapters for similar developments.

The assessment was be undertaken using the following methodology: -

- Baseline noise monitoring has been undertaken in the vicinity of the proposed development site in order to characterise the existing noise environment.
- A review of the most applicable standards and guidelines was be carried out in order to set a range of acceptable noise and vibration criteria for the construction and operational phases of the proposed development.
- Predictive calculations relating to construction phase impacts will be undertaken at the nearest sensitive locations to the development site in accordance with ISO 9613-2, 1996 *Acoustics – Attenuation of Sound During Propagation Outdoors* and BS 5228 2009 + A1 2014: *Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1 – Noise & Part 2 – Vibration*.

- Predictive calculations will be performed to assess the potential impacts associated with the operation of the development at the most sensitive locations surrounding the proposed development using guidance from ISO 9613-2, 1996, UK's *Calculation of Road Traffic Noise (CRTN), 1988*.
- A schedule of mitigation measures and monitoring proposals will be incorporated where required, to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed development.

### 12.3 Receiving Environment

The site under consideration is located north of Bray town and south of Shankill on lands currently occupied by open agricultural fields and part of the Woodbrook Golf Course. The lands in question are generally bounded to the north by Shanganagh Cemetery and Shanganagh Park, to the east by Woodbrook Golf Course and Dublin – Rosslare railway line, to the south by Corke Lodge and Woodbrook House both protected buildings and Woodbrook Glen residential area. The west of the site is bound by the Old Dublin Road (R119), St. James' Church and an adjacent residential dwelling with a small number of individual properties further west.

#### 12.3.1 Baseline Noise Environment

An environmental noise survey has been conducted at the site in order to quantify the existing noise environment. The survey was conducted in general accordance with ISO 1996: 2017: *Acoustics – Description, measurement and assessment of environmental noise*. Specific details are set out below.

##### 12.3.1.1 Measurement Locations

Four measurement locations, three attended (ATT01 – ATT03) and one unattended (UTT01), were selected as shown in Figure 12.1 and described below.



**Figure 12.1:** Baseline Noise Monitoring Locations.

- ATT01** This monitoring location located to the south of the proposed development within Woodbrook Glen residential development at the 'The Woods' cul de sac area. The position was chosen to represent baseline noise levels associated with existing residential properties to the south of the proposed development.
- ATT02** This monitoring position was located to the north of the site within the grounds of St. James cemetery. This location was chosen in order to obtain representative noise levels in the vicinity of noise sensitive of the cemetery, church and residential properties along this boundary of the proposed development.
- ATT02** This monitoring position was located to the north of the site within a green area in proximity to Castle Farm residential area. This location was chosen in order to obtain representative noise levels in the vicinity of noise sensitive buildings located north of the proposed development
- UTT01** This monitoring position was located within the grounds of the Woodbrook Golf Course at a position representative of the proposed residential dwellings from the adjacent to the Dublin to Rosslare Railway line.

#### 12.3.1.2 Survey Periods

Measurements were conducted over the course of the following survey periods: -

##### **Attended Measurements**

- 9.05 to 13:00hrs on 10 October 2018.

### Unattended Measurements

- 09:50 on 3 October 2018 to 08:55 on 5 October 2018.

#### 12.3.1.3 Measurement Parameters

The survey results are presented in terms of the following three parameters: -

$L_{Aeq}$  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 sample period.

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

$L_{A90}$  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.

#### 12.3.1.4 Measurement Results

##### ATT01

Survey results for monitoring position ATT01 are presented in Table 12.1.

Start Time	$L_{Aeq}$	$L_{AFmax}$	$L_{AF90}$
10:05	47	63	42
11:27	52	65	47
12:44	52	70	46

**Table 12.1:** Baseline Noise Levels Recorded at ATT01.

During the daytime survey, the noise climate at the location was influenced by intermittent vehicular activity within the residential area, wind generated noise within foliage and aircraft overhead. Ambient noise levels were measured in the range of 47 to 52dB  $L_{Aeq}$ . Background noise levels were in the range 42 to 46dB  $L_{A90}$ .  $L_{AFmax}$  levels were due to passing vehicles and distant aircraft.

##### ATT02

Survey results for monitoring position ATT02 are presented in Table 12.2.

Start Time	$L_{Aeq}$	$L_{AFmax}$	$L_{AF90}$
09:37	54	69	50
11:01	55	67	49
12:20	56	68	53

**Table 12.2:** Baseline Noise Levels Recorded at ATT02.

During the daytime survey, the noise climate at this location was dominated by road traffic along the old Dublin Road (R119), rustling foliage and birdsong. Ambient noise levels were measured in the range of 54 to 56dB  $L_{Aeq}$ . Background noise levels were in the range 49 to 53dB  $L_{A90}$ .  $L_{AFmax}$  levels were due to passing vehicles and some works within adjacent cemetery area.

**ATT03**

Survey results for monitoring position ATT03 are presented in Table 12.3.

Start Time	L <sub>Aeq</sub>	L <sub>AFmax</sub>	L <sub>AF90</sub>
09:05	52	60	51
10:37	53	64	52
09:05	52	60	51

**Table 12.3:** Baseline Noise Levels Recorded at ATT03.

During the daytime survey, the noise climate at this location was dominated by road traffic along the surrounding road network in the background. Additional activities from intermittent vehicle movements from residential areas and birdsong. Ambient noise levels were measured in the range of 52 to 53dB L<sub>Aeq</sub>. Background noise levels were in the range 51 to 52dB L<sub>A90</sub>. L<sub>AFmax</sub> levels were due predominately to birdsong.

**UTT01**

Survey results for the logged monitoring position UTT01 are summarised in Table 12.4 for daytime periods (07:00 to 23:00hrs).

Date	Scenario	L <sub>Aeq</sub>	L <sub>AFmax</sub>	L <sub>AF90</sub>
3 October (09:50 – 23:00hrs)	Highest	73	93	50
	Lowest	44	49	35
	Average	68	82	46
4 October (07:00 – 23:00hrs)	Highest	74	94	52
	Lowest	38	42	36
	Average	68	82	45
5 October (07:00 – 08:54hrs)	Highest	72	91	50
	Lowest	48	52	47
	Average	67	79	48

**Table 12.4:** Daytime Baseline Noise Levels Recorded at UTT01.

The baseline noise monitoring results at this position were influenced by activities within the golf club grounds, passing trains along the Dublin to Rosslare rail line, overhead aircraft and rustling foliage. Average daytime noise levels were measured in the range of 67 to 68dB L<sub>Aeq</sub>. Due to the proximity of the monitoring equipment immediately along the rail line boundary, noise levels measured represent worst case noise levels influenced by passing DART, Intercity and commuter trains.

Survey results for the logged monitoring position UTT01 are summarised in Table 12.5 for night-time periods (23:00 to 07:00hrs).

Date	Scenario	L <sub>Aeq</sub>	L <sub>AFmax</sub>	L <sub>AF90</sub>
4 October (23:00 – 07:00hrs)	Highest	74	95	45
	Lowest	31	34	29
	Average	62	50	35
5 October (23:00 – 07:00hrs)	Highest	70	91	47
	Lowest	36	44	35
	Average	59	55	40

**Table 12.5:** Night-time Baseline Noise Levels Recorded at UTT01.

The baseline noise monitoring results at this position were influenced by golf club grounds, passing trains along the Dublin to Rosslare rail line, overhead aircraft and rustling foliage. Average night-time noise levels were measured in the range of 59 to 62dB L<sub>Aeq</sub>. Highest noise levels were recorded during periods of passing trains, commencing from 05.30hrs and up until 23:30hrs at night. Between 23:30 and 05:30hrs, ambient noise levels were typically between 32 to 40dB L<sub>Aeq</sub>.

#### 12.3.1.5 Summary of the Noise Environment

The proposed site for the mixed-use and residential development is primarily located within zoned development lands on a greenfield site between the suburbs of Bray town to the south and Shankill to the north. There are a small number of noise sensitive properties located in close proximity to the development, predominately located along the western boundary. The noise environment at the off-site noise monitoring locations was noted to be influenced by road traffic along the Old Dublin Road, rustling foliage, birdsong and intermittent local sources from vehicles in residential areas. Overhead aircraft was also audible in the distance.

Along the eastern boundary of the proposed development site immediately against the rail line, passing rail dominated the ambient noise environment.

#### 12.3.2 Proposed Development

The site is generally bounded by the Old Dublin Road (R119) and St. James (Crinken) Church to the west, Shanganagh Public Park and Shanganagh Cemetery to the north, Woodbrook Golf Course to the east and Corke Lodge and woodlands and Woodbrook Golf Clubhouse and car park to the south. The replacement golf hole lands are generally bounded by the existing train line to the west, Shanganagh Public Park to the north and Woodbrook Golf Course to the east and south. The proposed development is within the townlands of Cork Little and Shanganagh, Shankill, Co. Dublin.

In summary, the proposed Strategic Housing Development broadly comprises: -

- 685no. residential units (207no. houses, 48no. duplex and 430no. apartments) in buildings ranging from 2 to 8-storeys.
- 1no. childcare facilities (c. 429 sq. m gross floor area).
- Provision of Woodbrook Distributor Road / Woodbrook Avenue from the Old Dublin Road (R119) to the future Woodbrook DART Station, including the provision of a temporary surface car park (164no. parking spaces including set down areas and ancillary bicycle parking and storage) adjacent the future Woodbrook DART Station in northeast of site.
- Provision of a series of linear parks and green links (Coastal Park and Corridor Park), including 2no. pedestrian / cycle links to Shanganagh Public Park and provision of interim landscaping of future public plaza to serve future Local Centre to allow full north / south connection, supplemented by smaller pocket parks.
- Provision of SuDS infrastructure and connection to existing surface water culvert on Old Dublin Road (R119).

- Provision of waste water infrastructure (pumping station including 24 hour emergency storage and rising foul main through Shanganagh Public Park to tie-in to existing services at St. Anne's Park Residential Estate).
- 2no. replacement golf holes on eastern side of railway line.
- All associated and ancillary site development and infrastructural works, hard and soft landscaping and boundary treatment works.

A full project description is provided in Chapter 3: Description of Proposed Development.

### **12.3.3 Cumulative – Woodbrook**

The overall masterplan development for the Woodbrook development will be completed over 2 phases which involves a minimum of 1,400no. homes within the full development lands along with a neighbourhood centre and plaza and the required infrastructure of internal roads, streets and public open areas. Specific detail on the breakdown of the various elements within the overall Woodbrook Masterplan development and phasing is included within Chapter 3: Description of Development.

## **12.4 Characteristics of the Proposed Development**

### **12.4.1 Proposed Development**

When considering a development of this nature, the potential noise and vibration impacts on the surroundings are considered for each of two distinct stages, the short-term construction phase and the long term operational phase.

#### **12.4.1.1 Construction Stage**

During the construction phase, the main site activities will include site clearance and bulk excavation, foundations, building construction, road works, and landscaping. This phase has the greatest potential noise and vibration impacts on its surrounding environment, however this phase will be of short-term impact.

#### **12.4.1.2 Operational Stage**

During the operational phase of the development, no significant sources of noise or vibration are expected with the development. The primary source of outward noise in the operational context relates to any changes in traffic flows along the local road network and any operational plant noise used to serve the ancillary elements within the apartment buildings and amenity spaces.

### **12.4.2 Cumulative – Woodbrook**

Due to the nature of the proposed development under consideration, the same characteristics apply to both the proposed development (Phase 1) and the Woodbrook Masterplan development.

#### **12.4.2.1 Construction Stage**

As discussed in Section 12.4.1.1, main site activities will include, site clearance and bulk excavation, foundations, building construction, road works, and landscaping. These activities will have the greatest potential noise and vibration impacts on the surrounding environment, however the construction phase will be of short-term impact. The phasing of construction works over the masterplan development will need to consider potential impacts on noise sensitive locations external to the development site and those within the earlier part of Phase 1.

### 12.4.2.2 Operational Stage

As discussed in Section 12.4.1.2, no significant sources of noise or vibration are expected with the development once operational. The primary source of outward noise in the operational context relates to any changes in traffic flows along the local road network and any operational plant noise used to serve the ancillary elements within the apartment buildings and amenity spaces.

## 12.5 Potential Impact of the Proposed Development

### 12.5.1 Relevant Criteria

#### 12.5.1.1 Construction Phase – 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. Wicklow County Council typically controls construction activities by imposing limits on the hours of operation and consider noise limits at their discretion.

In order to set appropriate construction noise limits for the development site, reference has been made to BS 5228 2009 +A1 2014 *Code of practice for noise and vibration control on construction and open sites*. Part 1 of this document *Noise* provides guidance on selecting appropriate noise criteria relating construction works.

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 12.6 sets out the values which, when exceeded, signify a significant effect at the facades of residential receptors.

Assessment category and threshold value period (L <sub>Aeq</sub> )	Threshold value, in decibels (dB)		
	Category A <sup>A</sup>	Category B <sup>B</sup>	Category C <sup>C</sup>
Daytime (08:00 – 19:00) and Saturdays (08:00 – 14:00)	65	70	75
Evenings and weekends <sup>D</sup>	55	60	65
Night-time (23:00 to 07:00hrs)	45	50	55

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

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

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

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

**Table 12.6:** Example Threshold of Significant Effect at Dwellings

For the appropriate assessment period (i.e. daytime in this instance) the ambient noise level is determined and rounded to the nearest 5dB. If the construction noise exceeds the appropriate category value, then a significant effect is deemed to occur.



The closest neighbouring residential properties to the proposed development are the dwellings to the west of the site along the Old Dublin Road and St James Church, located within 20m to 50m of the Phase 1 boundary.

To the south of the site development boundary, Corke Lodge is located within approximately 70m and Woodbrook Glen residential area the, some 380m from the Phase 1 boundary. To the north of the site, the Castle Farm / St Anne's park residential areas area at distances of approximately 650m from the northern boundary of Phase 1.

Taking into account the construction noise criteria threshold values detailed in Table 5.5.6, and the measured baseline noise levels on the proposed site described in Section 5.5.5, the Category A value (i.e. 65dB) is deemed appropriate for all the assessed noise sensitive receivers and other receivers in their respective vicinities.

### 12.5.1.2 Construction Phase – Vibration

#### Building Response

In terms of vibration, BS 5228-2:2009+A1:2014 Part 2 *Vibration* 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.

The standard notes that important buildings that are difficult to repair might require special consideration on a case by case basis but building of historical importance should not (unless it is structurally unsound) be assumed to be more sensitive. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other groundborne disturbance. Where adjacent buildings with the potential to be more vulnerable than other adjacent modern structures, on a precautionary basis, the guidance values for structurally sound buildings are reduced by 50% in line with the guidance documents referred to above.

Taking the above into consideration the vibration criteria in Table 12.7 are recommended.

<b>Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:-</b>			
	<b>Less than 15Hz</b>	<b>15 to 40Hz</b>	<b>40Hz and above</b>
Structurally Sound Buildings	15mm/s	20mm/s	50mm/s
Protected Buildings	6mm/s	10mm/s	25mm/s

**Table 12.7:** Recommended Construction Vibration Threshold for Control of Building Damage.

#### Human Perception

People are sensitive to vibration stimuli at levels orders of magnitude below those which have the potential to cause any cosmetic damage to buildings. Vibration typically becomes perceptible at around 0.15 to 0.3 mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short-term duration, particularly during construction projects and when the origin and or the duration of vibration is known. For example, piling can typically be tolerated at vibration levels up to 2.5mm/s if adequate public relations are in place and timeframes are known. These values refer to the day-time periods only.

### 12.5.1.3 Operational Phase - Noise

The main potential source of outward noise impact associated with the proposed development relates to additional traffic flows on the surrounding road network. Given that traffic from the development will make use of existing roads already carrying traffic volumes, it is appropriate to consider the increase in traffic noise level that arises as a result of vehicular movements associated with the development.

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

Change in Sound Level (dB A)	Subjective Reaction	DMRB Magnitude of Impact	Impact Guidelines on the Information to be contained in EIAR (EPA)
0	Inaudible	No Impact	Imperceptible
0.1 – 2.9	Barely Perceptible	Negligible	Not Significant
3 – 4.9	Perceptible	Minor	Slight, Moderate
5 – 9.9	Up to a doubling of loudness	Moderate	Significant
10+	Doubling of loudness and above	Major	Very Significant

**Table 12.8:** Likely Impact Associated with Change in Traffic Noise Level.

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 for consistency in wording and terminology for the assessment of impact significance.

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.

For other non-traffic related sources 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 summarised in Table 12.9.

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

**Table 12.9:** Recommended indoor Ambient Noise Levels for Dwellings

For the purposes of this study, it is appropriate to derive external limits based on the internal criteria noted in the paragraph above. This is done by factoring in the degree of noise reduction afforded by a partially open window and typical 15dB attenuation is noted in this British Standard. Using this correction value across an open window, the following external noise levels would achieve the internal noise levels noted in Table 12.9 above.

- Daytime / Evening (07:00 to 23:00 hours) 50 - 55dB  $L_{Aeq,1hr}$
- Night-time (23:00 to 07:00 hours) 45dB  $L_{Aeq,15min}$

#### 12.5.1.4 Mechanical and Electrical Services

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.

There are no expected sources of vibration associated with the proposed development, hence no vibration criteria are set for this phase.

### 12.5.2 Proposed Development

#### 12.5.2.1 Construction Stage

##### Construction Noise

A variety of items of plant will be in use for the purposes of site preparation, construction of buildings and road works. There will be vehicular movements to and from the site that will make use of existing and temporary roads.

The impact at nearby noise sensitive buildings will depend upon a number of variables, the most notable of which are: -

- the amount of noise generated by plant and equipment being used at any one time, expressed in terms of sound pressure or sound power.
- the periods of operation of the plant at the development site, known as the "on-time".
- the distance between the noise source and the receptor.
- the attenuation due to ground absorption or barrier screening effects from walls, buildings, site hoarding etc.

The construction phase will be controlled through the use of construction noise limits which the contractor will be required to work within. In this regard, the choice of plant, scheduling of works on site, provision of localised screening and other best practice control measures will be employed in order to ensure noise limits are not exceeded. Given the construction phase involves a number of various phases which will encompass a range of different activities on a day to day and week to week basis, it is not possible to calculate with a high degree of accuracy the specific levels of noise associated with each phase. It is possible, however, to determine a range of likely scenarios which represent the key construction phases. These can be used to identify potential phases which will require noise mitigation.

The Phase 1 works will be undertaken over a number of staged phases which include development of the temporary haul road, child care facility and initial residential phased buildings within the south western portion of the site. The works will then progress from west to east in different zoned areas which will include development of the residential buildings, green corridor and the northern link road.

Using guidance set out in BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1 – Noise*, calculations have been made at distance of 20m, 50m, 380m and 600m from construction activities representing noise levels at the nearest noise sensitive locations to the site boundaries. It must be stated that for most of the time, plant and equipment will be a greater distance from the nearest noise sensitive locations than those used within the calculations in Table 12.10 and consequently will have lower impact. Our assessment is therefore representative of a “worst-case” scenario representing construction activities at a minimum distance from the noise sensitive areas. For the purposes of the calculation, it is assumed that equipment will operate for 66% of the 12-hour working day (i.e. 8 hours).

It has been assumed that a standard 2.4m high solid site hoarding will be erected along the boundary of the site for the duration of the construction programme. Table 12.10 summarises the construction noise prediction calculations.

Phase	Plant Item (BS 5228 Ref.)	Plant Noise Level at 10m (dB L <sub>Aeq</sub> )	Predicted Noise Level, (dB L <sub>Aeq,1hr</sub> ) at varying distances			
			20m	50m	380m	600m
Site Preparation	Wheeled loader x1 (C3.51)	74	69	61	45	40
	Dozer x2 (C.3.30)	76				
	Tracked excavator x1 (C3.92)	76				
	Dumper x2 (C3.98)	77				
Foundation Laying	Compressor x2 (C6.19)	72	67	59	42	37
	Poker Vibrator x2 (C6.40)	73				
	Cement Mixers x2 (C6.6)	71				
Steel Erection	Crane x1 (C7.120)	76	65	57	40	35
	Lorry x2 (C7.121)	70				
General Construction	Compressor x2 (C7.70)	70	71	63	46	42
	Diesel Hoist x1 (C7.97)	73				
	Hand Tools x3	75				
	Generator x2 (C7.51)	72				
Roadworks/ Landscaping	Surfacing (C8.26)	80	67	59	42	38

**Table 12.10:** Indicative Construction Noise Levels at distances from the works.

Highest noise levels are calculated at a distance of 20m from construction activities assuming all works are taking place at this distance. The distance of 20m has been calculated to represent the closest distance of construction works to the residential dwelling to the west of the development site. The calculations have indicated the recommended construction noise level of 65dB  $L_{Aeq,1hr}$  is likely to be exceeded when activities are taking place at this distance.

Given the variation of on-site activities and number of plant items during any one phase and the likelihood of works operating along the closest boundaries for a limited duration of the works, the calculated noise levels presented are considered to present a worst-case scenario.

When works are occurring at distances of 50m and beyond, construction noise levels are reduced to within the recommended criteria.

At the remaining distances of 350m and beyond representative of the closest residential dwellings, the construction noise levels are well below the adopted limit value of 65dB  $L_{Aeq,1h}$  and result in noise levels in line with or below the prevailing noise environment such that the noise impact at these distances will be not significant.

### Construction Vibration

Potential for vibration impacts during the construction phase programme are likely to be limited given the minimal level of ground-breaking or excavations required. Piling will to be used for building and basement foundations. For the purposes of this assessment the expected vibration levels during piling assuming augured or bored piles have been determined through reference to published empirical data. The British Standard BS 5228 – Part 2: *Vibration*, publishes the measured magnitude of vibration of rotary bored piling using a 600mm pile diameter for bored piling into soft ground over rock, (Table D.6, Ref. No. 106): -

- 0.54mm/s at a distance of 5m, for auguring.
- 0.22mm/s at a distance of 5m, for twisting in casing.
- 0.42mm/s at a distance of 5m, for spinning off.
- 0.43mm/s at a distance of 5m, for boring with rock auger.

Considering the low vibration levels at very close distances to the piling rigs, vibration levels at the nearest buildings at further distances will be further reduced such that vibration levels are significantly below those set to prevent any cosmetic damage to protected or standard light framed buildings (Refer to Table 12.7) and hence are not expected to pose any significance in terms of cosmetic or structural damage. In addition, the range of vibration levels is typically below a level which would cause any disturbance to occupants of nearby buildings.

In this instance, taking account of the distance to the nearest sensitive off-site buildings, vibration levels at the closest neighbouring buildings are expected to be orders of magnitude below the limits set out in Table 12.7.

The potential vibration impact during the construction phase if of short-term, neutral and imperceptible impact.

#### 12.5.2.2 Operational Stage

##### Additional Vehicle Movements on Public Roads

A traffic impact assessment relating to the proposed development has been prepared by Atkins as part of this EIAR. Information provided by the traffic engineers has been used to determine the predicted change in noise levels in the vicinity of a number of roads in the area surrounding the proposed development. The traffic links assessed are illustrated in Figure 12.2.

Forecast traffic growth has been provided for the opening year of opening 2020 which assumes Phase 1 of the Woodbrook development lands are fully developed and that the proposed DART station is not yet operational. The design year of year of 2035 includes for Phase 1 and Phase 2 of the Woodbrook development lands (to include residential units, creche, school and retail elements).

The traffic flows are provided in terms of the Annual Average Daily Traffic (AADT) in addition to the percentage of Heavy Goods Vehicles (HGVs) for each assessment scenario.



Figure 12.2: Traffic Links Assessment Locations.

Table 12.11 summarises the calculated change in noise levels along the assessed road links associated with the addition of development related traffic.

Road Link	2020 Do Minimum		2020 Base Plus Development (Phase 1)		Calculated Change in Noise Levels
	AADT	%HGV	AADT	%HGV	
A	10,562	0.9	11,364	0.9	+0.3
B	13,651	0.8	14,300	0.8	+0.2
C	11,821	1.0	12,102	1.0	+0.1
D	12,626	3.9	13,140	3.9	+0.1
E	78,841	4.0	79,227	4.1	+0.1
Road Link	2035 Do Minimum		2035 Base Plus Development (Phase 1 & 2)		Calculated Change in Noise Levels
A	12,317	1.1	14,070	0.9	
B	15,916	0.9	17,434	0.9	+0.5
C	13,789	1.2	14,438	1.2	+0.2
D	14,807	4.6	16,312	4.5	+0.4
E	92,462	4.7	93,259	6.1	+0.7

**Table 12.11:** Operational Traffic Noise Levels along surrounding road network

The assessment has indicated that due to existing traffic volumes along the local road network, the addition of development related traffic results in a negligible increase in noise level when added to the existing road network. The calculated change in traffic noise is less than 1dB(A) along all link roads in the vicinity of the development site.

Reference to Table 12.8 confirms that a change in noise level of less than 1dB(A) is negligible and not significant.

In summary, the predicted increase in noise levels associated with the addition of development related traffic is neutral, negligible and long term.

### Mechanical and Electrical Services

Due to the nature of the building types across the development being predominately residential, there are minimal fixed noise sources in terms of mechanical or electrical plant items associated with the Phase 1 development. Within the apartment buildings, there are a small number of plant areas which will be located at basement areas. Due to the enclosed nature of the plant room areas below ground level, the noise breakout from these areas will be minimal.

Similarly, for the creche facility, there is likely to be minimal plant items serving this facility with the potential to generate noise levels to the external noise environment.

The site layout and selection of plant will be designed so that there is no negative impact on noise sensitive locations within the development itself. During the detailed design stage of the apartment buildings, the key noise control considerations from this area of the building will relate to controlling airborne and structure borne noise transfer within the residential apartments from plant areas. This will be undertaken as part of the building design. Operational plant noise levels at the residential dwellings within the development itself will be controlled to ensure the internal noise levels included within Table 12.9 will be achieved.

Noise levels associated with services plant at the existing noise sensitive locations outside the development boundary will be controlled to ensure compliance with BS 4142 (2014) such that adverse impacts are avoided. The results of baseline surveys of the prevailing background sound level will be used to set appropriate operational limit values.

### Residential Amenity Areas

There will be residential tenant amenity spaces will be located within the apartment buildings at ground floor level. There is no expected noise impact associated with these areas to noise sensitive locations outside the development boundary given these areas are internally located within the buildings and the low noise sources associated with these spaces. During the detailed design stage, sound insulation control measures will be suitably incorporated into the building design to control potential noise transfer from amenity areas to residential apartments within the development buildings.

#### 12.5.2.3 Do-Nothing Impact

In the absence of the proposed development being constructed, the noise environment at the nearest noise sensitive locations and within the development site are expected to remain unchanged. The noise levels recorded during the baseline noise environment are considered representative of the Do-Nothing scenario.

### 12.5.3 Cumulative – Woodbrook

#### 12.5.3.1 Construction Stage

The construction stages of the Woodbrook masterplan will occur on a phased basis. It is expected that Phase 1 will be largely completed before Phase 2 works commence on site. The indicative noise calculations presented in Table 12.9 are considered valid for works occurring during Stage 2 works at the nearest noise sensitive locations external to the site.

#### 12.5.3.2 Operational Stage

The overall cumulative impacts associated with the proposed development will be similar to those associated with Phase 1. The key potential sources are discussed in the following headings: -

#### Additional Vehicle Movements on Public Roads

Forecast traffic growth provided by Atkins have been provided for the design year of 2035 to account of the full potential cumulative impacts associated with all of the Woodbrook development lands, the DART station car park in addition to the proposed future Shanganagh Castle development to the north (assumed to consist of 630 units). The traffic links assessed are illustrated in Figure 12.2. Table 12.12 summarises the calculated increase in noise level along the assessed road links.

Road Link	2035 Do Minimum		2035 Base Plus Cumulative Developments		Calculated Change in Noise Levels
A	12,317	1.1	14,070	0.9	+0.4
B	15,916	0.9	17,434	0.9	+0.5
C	13,789	1.2	14,438	1.2	+0.2
D	14,807	4.6	16,312	4.5	+0.4
E	92,462	4.7	93,259	6.1	+0.7

**Table 12.12:** Cumulative Operational Traffic Noise Levels along Surrounding Road Network.

The assessment has indicated that due to existing traffic volumes along the local road network, the addition of development related traffic results in a negligible increase in noise level when added to the existing road network. The calculated change in traffic noise is less than 1dB(A) along all link roads in the vicinity of the development site.



Reference to Table 12.8 confirms that a change in noise level of less than 1dB(A) is negligible and not significant.

In summary, the predicted increase in noise levels associated with the addition of development related traffic and other cumulative developments is neutral, negligible and long term.

### **Mechanical and Electrical Services**

Following the development of the childcare facility within Phase 1, the remainder of the neighbourhood centre and plaza will be developed as part of the overall Masterplan. This will include a mixed use building with an element of ground floor retail and commercial space, with residential on the upper floors, and a low rise pavilion building with café at ground floor and residential above. There will be an element of mechanical and electrical plant required to service the retail and commercial units within the neighbourhood centre.

The specific requirements for mechanical and electrical plant items for the neighbourhood areas has not yet been progressed at this stage of the design. The closest off-site noise sensitive locations to operational on-site sources are residential properties along the Old Dublin Road at a minimum distance of 50m. Depending on the operational phasing, there will be a requirement for operational items of plant to operate over day and night-time periods.

The site layout and selection of plant will be designed so that the operation of cumulative elements across the development will not give rise to negative impacts on noise sensitive locations within the development itself (i.e. residential properties within the Neighbourhood Centre). Operational plant noise levels at the residential dwellings within the development itself will be controlled to ensure the internal noise levels included within Table 12.9 will be achieved.

Cumulative noise levels associated with services plant at the existing noise sensitive locations outside the development boundary will be controlled to ensure compliance with BS 4142 (2014) such that adverse impacts are avoided. The results of baseline surveys of the prevailing background sound level will be used to set appropriate operational limit values.

There are no significant vibration sources associated with the full Woodbrook operational phase.

### **Inward Impact of External Sources to Development Buildings**

As part of the proposed Phase 2 of the Woodbrook Masterplan, there is potential for apartment buildings to be developed along the north eastern boundary of the site within the *Dart Gateway* zone of the development lands. Given the proximity of these buildings to the operational rail line, control of noise the rail line will be required to ensure acceptable internal noise levels are achieved within the residential units.

As part of the detailed design of these buildings, the specific sound insulation requirements of the building facades (glazing, walls, vents etc) will be determined taking account of the rail noise levels, orientation of noise sensitive facades towards the rail line, the surface areas of the façade, internal room dimensions etc. Internal noise levels will be designed to achieve internal noise levels not exceeding those included in BS 8233:2014 *Guidance on Sound Insulation and Noise Reduction for Buildings*.

The results of the baseline survey have determined the noise climate along the eastern site boundary bordering the rail line has highest noise levels recorded during the baseline study (UTT1). The measured noise levels indicate that an enhanced glazing system over and above a standard thermal double glazed system will be required along the eastern facades in addition to acoustic vents, where relevant.

## 12.6 Ameliorative, Remedial or Reductive Measures

### 12.6.1 Proposed Development

Mitigation measures for the construction phase are set out below in order to reduce potential impacts as far as practicable to within the adopted design goals for noise and vibration.

#### 12.6.1.1 Construction Stage

The contract documents will clearly specify the construction noise criteria included in this chapter which the construction works must operate within. The Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of *BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise* and the European Communities (Noise Emission by Equipment for Use Outdoors) Regulations, 2001. These measures will ensure that: -

- 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.
- Any plant, such as generators or pumps that is required to operate outside of normal permitted working hours will be surrounded by an acoustic enclosure or portable screen.

*BS 5228 -1:2009+A1 2014* includes guidance on several aspects of construction site practices, which include, but are not limited to: -

- Selection of quiet plant.
- Control of noise sources.
- Screening.
- Hours of work.
- Liaison with the public.

Further comment is offered on these items in the following paragraphs.

Noise control measures that will be considered include the selection of quiet plant, enclosures and screens around noise sources, limiting the hours of work and noise monitoring. The contractor will be required to conduct construction noise predictions prior to works taking place and put in place the most appropriate noise control measures depending on the level of noise reduction required at any one location.

#### **Selection of Quiet Plant**

The potential for any item of plant to generate noise will be assessed prior to the item being brought onto the site. The least noisy item of plant will be selected wherever possible. Should a particular item of plant already on the site be found to generate high noise levels, the first action will be to identify whether or not said item can be replaced with a quieter alternative.

For static plant such as compressors and generators used at work areas such as construction compounds etc., the units will be supplied with manufacturers' proprietary acoustic enclosures where possible.

### **General Comments on Noise Control at Source**

If replacing a noisy item of plant is not a viable or practical option, consideration will be given to noise control "at source". This refers to the modification of an item of plant, or the application of improved sound reduction methods in consultation with the supplier or the best practice use of equipment and materials handling to reduce noise.

In practice, a balance may need to be struck between the use of all available techniques and the resulting costs of doing so. It is therefore proposed to adopt the concept of "*Best Available Techniques*". as defined in EC Directive 96/61. In this context "*best*" means "*the most effective in achieving a high general level of protection of the environment as a whole*".

Proposed techniques will also be evaluated in light of their potential effect on occupational health and safety. The following outline guidance relates to practical noise control at source techniques which relate to specific site considerations: -

- For mobile plant items such as cranes, dump trucks, excavators and loaders, the installation of an acoustic exhaust and/or maintaining enclosure panels closed during operation can reduce noise levels by up to 10dB. Mobile plant will be switched off when not in use and not left idling;
- For piling plant, noise reduction can be achieved by enclosing the driving system in an acoustic shroud. For steady continuous noise, such as that generated by diesel engines, it is possible to reduce the noise emitted by fitting a more effective exhaust silencer system or utilising an acoustic canopy to replace the normal engine cover.
- For all materials handling, the contractor will ensure that best practice site noise control measures are implemented including ensuring that materials are not dropped from excessive heights and drop chutes/dump trucks are lined with resilient materials, where relevant.
- Where compressors, generators and pumps are located in areas in close proximity to noise sensitive properties/ areas and have potential to exceed noise criterion, these will be surrounded by acoustic lagging or enclosed within acoustic enclosures providing air ventilation.
- Resonance effects in panel work or cover plates can be reduced through stiffening or application of damping compounds; rattling and grinding noises can be controlled by fixing resilient materials in between the surfaces in contact.
- Demountable enclosures can also be used to screen operatives using hand tools and may be moved around site as necessary.
- 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.

### **Screening**

Typically screening is an effective method of reducing the noise level at a receiver location and can be used successfully as an additional measure to other forms of noise control. The effectiveness of a noise screen will depend on the height and length of the screen, its mass, and its position relative to both the source and receiver.

The length of the screen should in practice be at least five times the height, however, if shorter sections are necessary then the ends of the screen will be wrapped around the source. BS 5228 - 1:2009+A1 states that on level sites the screen should be placed as close as possible to either the source or the receiver. The construction of the barrier will be such that there are no gaps or openings at joints in the screen material. In most practical situations the effectiveness of the screen is limited by the sound transmission over the top of the barrier rather than the transmission through the barrier itself. In practice, screens constructed of materials with a mass per unit of surface area greater than 10kg/m<sup>2</sup> will give adequate sound insulation performance.

Construction noise calculations have assumed a partial line of sight (-5dB) is achieved using a solid 2.4m high standard construction site hoarding. It will be a requirement for works occurring immediately in proximity to the closest noise sensitive locations along the Old Dublin Road, that the line of sight is further blocked such that a reduction of at least 10dB is achieved between the noise sensitive façade and construction activities. A reduction of this order can be achieved using a higher perimeter screen or using localised screening around specific items of plant.

Annex B of BS 5228-1:2009+A1:2014 (Figures B1, B2 and B3) provide typical details for temporary and mobile acoustic screens, sheds and enclosures that can be constructed on site from standard materials.

In addition, careful planning of the site layout will also be considered. The placement of temporary site buildings such as offices and stores between the site and sensitive locations can provide a good level of noise screening during the phasing of works.

### **Hours of Work**

Construction noise impacts will be controlled through strict working hours.

Construction activity will only be carried out between the hours of 0700 to 1900 Mondays to Fridays inclusive and between 0800 and 1400 hours on Saturdays. There will be no construction works carried out on Sundays or public holidays. Deviation from these times will only take place when written approval is granted by DLRCC in exceptional circumstances.

Consideration will be given to the scheduling of activities in a manner that reflects the location of the site and the nature of neighbouring properties. Each potentially noisy event/activity will be considered on its individual merits and scheduled according to its noise level, proximity to sensitive locations and possible options for noise control.

### **Liaison with the Public**

Clear forms of communication will be established between the contractor and noise sensitive areas in proximity so that residents or building occupants are aware of the likely duration of activities likely to generate higher noise or vibration.

The duration of piling, excavation and other high noise or vibration activities works is usually short in relation to the length of construction work as a whole, and the amount of time spent working near to sensitive areas can represent only a part of the overall period. Subjective impacts during these phases can be significantly reduced if timelines and potential impacts are known in advance.

### **Vibration**

On review of the likely vibration levels associated with construction activities, it may be concluded that the construction of the proposed development is not expected to give rise to vibration that is either significantly intrusive or capable of giving rise to structural or cosmetic damage to adjacent buildings.

In the case of vibration levels giving rise to human discomfort, in order to minimise such impacts, the following measures shall be implemented during the construction period: -

- A clear communication programme will be established to inform adjacent building occupants in advance of any potential intrusive works which may give rise to vibration levels likely to exceed perceptible levels. The nature and duration of the works will be clearly set out in all communication circulars.
- Appropriate vibration isolation shall be applied to plant, where feasible.
- Monitoring will be undertaken at identified sensitive buildings, where proposed works have the potential to be at or exceed the vibration limit values.

#### 12.6.1.2 Operational Stage

Noise levels associated with operational plant will be designed to ensure the prevailing background noise environment is not increased by a significant level such that potential adverse noise impacts are avoided. During the detail design stage, the prevailing background noise environment will be verified through updated baseline studies at the nearest noise sensitive locations in order to set appropriate noise limits in accordance with BS 4142 (2014). Once noise emissions from fixed plant items are designed in accordance with BS 4142 resultant residual noise impact from this source will be of neutral, minor, long term impact.

The use of low noise operational plant items, siting items of plant away from noise sensitive boundaries, screening and acoustic attenuation measures will all be considered, where relevant during this stage.

The development will be designed to ensure that the design goals outlined in Section 12.7 can also be achieved for occupants of the dwelling units within the proposed development.

#### 12.6.2 Cumulative – Woodbrook

The same design guidance applies to the first phase of the development and to the Woodlands masterplan as a whole. In this instance, there are no additional noise mitigation measures over and above those set out in Section 12.8.1 for the construction and operational phases.

### 12.7 Residual Impact of the Proposed Development

#### 12.7.1 Proposed Development

##### 12.7.1.1 Construction Stage

During the construction phase of the project there is the potential for a minor to major short term noise impact on nearby noise sensitive properties due to noise emissions from site activities. The application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration impact is kept to a minimum.

The residual impact of the proposed development during the construction phase will be of short-term minor to major short-term impact.

Similarly, vibration impacts during the construction phase will be well controlled through the use of low impact equipment and adherence to strict limit values which will be subject to monitoring at the nearest sensitive buildings. The overall residual impact will be short-term, neutral and imperceptible.

#### 12.7.1.2 Operational Stage

The predicted noise level associated with additional traffic is predicted to be of insignificant impact along the existing road network. In the context of the existing noise environment, the overall contribution of traffic is not considered to pose any significant impact to nearby residential locations. It can be concluded that, once operational, noise levels associated with the proposed development will not contribute any significant noise impact to its surrounding environment.

The resulting impact is of neutral, long-term and not-significant.

Noise levels associated with operational plant will be designed to ensure the prevailing background noise environment is not increased by a significant level such that potential adverse noise impacts are avoided. During the detail design stage, the prevailing background noise environment will be verified through updated baseline studies at the nearest noise sensitive locations in order to set appropriate noise limits in accordance with BS 4142 (2014). Once noise emissions from fixed plant items are designed in accordance with BS 4142 resultant residual noise impact from this source will be of neutral, minor, long term impact.

#### 12.7.1.3 Worst Case Impact

In terms of potential noise and vibration impacts, the assessment has considered a range of worst case scenarios to determine the potential impacts of the proposed development.

During the construction phase, a range of worst case scenarios have been assessed assuming all plant items are operating along the closest noise sensitive boundaries. The assessment has determined impacts associated with these scenarios can be controlled through the best practice measures outlined in Section 12.8.

During the operational phase, traffic noise calculations along the surrounding road network incorporate a range of worst case scenarios to include the various phasing of the development site. The assessment has determined the resultant impact is not significant.

### 12.7.2 Cumulative – Woodbrook

#### 12.7.2.1 Construction Stage

The similar magnitude of residual noise and vibration impacts discussed in Section 12.7.1.1 for the proposed development are relevant to the full Woodbrook masterplan development given the same construction noise and vibration criteria will apply to all phases.

#### 12.7.2.2 Operational Stage

The similar magnitude of residual noise and vibration impacts discussed in Section 12.7.1.2 for the proposed development are relevant to the full Woodbrook masterplan development given the same operational noise a criteria will apply to all phases.

#### 12.7.2.3 Worst Case Impact

In terms of potential noise and vibration impacts, the assessment has considered a range of worst case scenarios to determine the potential impacts of the proposed development.

During the operational phase, traffic noise calculations along the surrounding road network incorporate a range of worst case scenarios to include the various phasing of the development site in addition to other committed developments in the area. The assessment has determined the resultant impact is not significant.

## **12.8 Monitoring**

### **12.8.1 Proposed Development**

#### 12.8.1.1 Construction Stage

The contractor will be required to ensure construction activities operate within the noise limits set out within Table 12.6. The contractor will be required to undertake regular noise monitoring at locations representative of the closest sensitive locations to ensure the relevant criteria are not exceeded.

Noise monitoring should be conducted in accordance with the International Standard ISO 1996: 2017: *Acoustics – Description, measurement and assessment of environmental noise*.

#### 12.8.1.2 Operational Stage

Noise or vibration monitoring is not required once the development is operational.

### **12.8.2 Cumulative – Woodbrook**

#### 12.8.2.1 Construction Stage

The monitoring requirements for the proposed development will be the same as those for the Cumulative Woodbrook Masterplan development.

#### 12.8.2.2 Operational Stage

Noise or vibration monitoring is not required once the full masterplan development is operational.

## **12.9 Reinstatement**

### **12.9.1 Proposed Development**

#### 12.9.1.1 Construction Stage

Not applicable.

#### 12.9.1.2 Operational Stage

Not applicable.

### **12.9.2 Cumulative – Woodbrook**

#### 12.9.2.1 Construction Stage

Not applicable.

#### 12.9.2.2 Operational Stage

Not applicable.

## **12.10 Difficulties Encountered**

No difficulties were encountered in the preparation of this chapter.