Chapter 8:

Air Quality & Climate / Noise & Vibration

8 AIR QUALITY & CLIMATE / NOISE & VIBRATION

This section, prepared by McCarthy Keville O'Sullivan Ltd. with Damian Brosnan Acoustics, assesses both the air quality & climate and the likely noise & vibration impact of the proposed works, in the context of current relevant standards and guidance, and identifies any requirements or possibilities for mitigation.

The proposed works will not have any air quality or noise and vibration impact during its operational phase. As a result, it is only considered necessary to assess the potential noise and vibration impact on the surroundings during the construction phase.

The construction phase will be temporary in nature and will generally comprise of the following works:

- A new Fluvial Flood Forecasting system based on both predictive and real time rainfall, and real time river flows and reservoir level data, to be utilised in combination with the existing harbour tidal flood forecasting system.
- A new flood warning system to more effectively disseminate warnings and information to landowners and river users during major flood events.
- Designation of floodplains (washlands) upstream of Cork City. This along with the Flood Forecasting system will facilitate the use of revised dam operation procedures resulting in a more aggressive lowering of reservoir levels in advance of a predicted flood event to maximise available reservoir storage and thus provide increased attenuation to reduce the peak flow during major flood events
- Direct defences (walls and embankments) from downstream of Inniscarra Dam through to Cork Harbour to defend against the design flood event
- Flow Control chamber at the upstream end of the South Channel to divert a greater proportion of flood flow along the higher capacity North Channel, thus minimising the extent of required direct defences on the Curraheen River and western end of the South Channel
- Demountable flood gates (tidal) at a limited number of key bridges and critical locations within the eastern part of Cork City.
- Re-grading of ground and road ramping at a number of locations
- Associated groundwater cut off walls and back-of-defence drainage infrastructure to intercept and manage groundwater seepage
- Associated drainage infrastructure (including non-return valves on drainage outlets) and pumping stations to manage surface water/groundwater at back of defences
- Associated services/utility diversions

8.1 AIR QUALITY & CLIMATE – EXISTING ENVIRONMENT

Meteorological Data

A key factor in assessing temporal and spatial variations in air quality is the prevailing meteorological conditions. Depending on factors such as wind speed, individual receptors may experience very significant variations in pollutant levels under the same source strength (i.e. traffic levels)(12). Wind is of key importance in dispersing air pollutants and for ground level sources, such as traffic emissions, pollutant concentrations are generally inversely related to wind speed. Thus, concentrations of pollutants derived from traffic sources will generally be greatest under very calm conditions and low wind speeds when the movement of air is restricted. In relation to PM10, the situation is more complex due to the range of sources of this pollutant. Smaller particles (less than PM2.5) from traffic sources will be dispersed more rapidly at higher wind speeds. However, fugitive emissions of coarse particles (PM2.5 – PM10) will actually increase at higher wind speeds. Thus, measured levels of PM10 will be a non-linear function of wind speed.

County Cork has a temperate oceanic climate, resulting in mild winters and cool summers. The Met Éireann weather station at Cork Airport is the nearest weather and climate monitoring station to the proposed development site located approximately 4.4 kilometres south of the site. Meteorological data recorded at Cork Airport over the 30-year period from 1981-2010 is shown in Table 8.1 overleaf. The wettest months are October and December, and July is usually the driest. July is also the warmest month with an average temperature of 18.7° Celsius.

Table 8.1 Data from Met Éireann Weather Station at Cork Airport, 1981 to 2010

	Monthly and Annual Mean and Extreme Values												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE (degrees Celsius)													
Mean daily max	8.2	8.3	9.9	11.8	14.4	17	18.7	18.5	16.5	13.2	10.3	8.5	12.9
Mean daily min	3	3.1	4	4.9	7.4	10	11.8	11.8	10.2	7.7	5.2	3.7	6.9
Mean temperature	5.6	5.7	6.9	8.4	10.9	13.5	15.3	15.2	13.3	10.5	7.8	6.1	9.9
Absolute max.	16.1	14	15.7	21.2	23.6	27.5	28.7	28	24.7	21.4	16.2	13.8	28.7
Absolute Min.	-4.3	-1.6	1.4	5	7.6	10.7	12.8	11.9	10.4	6	0.6	-3.2	-4.3
Mean No. of Days With Air Frost	10.6	10.6	10.9	11.4	15.1	16.2	19	18.4	17.3	15.4	12.8	11.6	19
Mean No. of Days With Ground Frost	-8	-4.7	-4.3	-2.3	-0.9	3.7	6.7	5.3	2.3	-0.9	-3.3	-7.2	-8
RELATIVE HUMIDITY (%)													
Mean at 0900UTC	89.8	89.4	87.8	83.1	80.6	81.3	83.2	85.4	88.4	90.1	90.7	90.5	86.7
Mean at 1500UTC	83.7	78.9	75.5	71.3	70.9	71.5	72.9	72.8	75.4	80.4	83.4	85.4	76.8
SUNSHINE (Hours)													
Mean daily duration	1.8	2.4	3.3	5.3	6.2	5.8	5.4	5.2	4.3	3	2.3	1.7	3.9
Greatest daily duration	8.5	10	11.5	13.6	15.5	16	15.3	14.4	11.9	10.3	8.7	7.6	16
Mean no. of days with no sun	10.1	7.9	6.3	3.1	2.1	2.5	2	2.6	3.6	6.4	8.6	11.9	67.1
RAINFALL (mm)													
Mean monthly total	131.4	97.8	97.6	76.5	82.3	80.9	78.8	96.8	94.6	138.2	120	133.1	1227.9
Greatest daily total	45.7	49.9	55.2	34.2	34.9	59.7	73.2	60.9	58.9	52.1	47.9	41.9	73.2
Mean num. of days with >= 0.2mm	20	17	19	16	15	14	15	15	16	19	19	19	204
Mean num. of days with >= 1.0mm	16	13	14	11	12	10	10	11	11	15	14	15	152
Mean num. of days with >= 5.0mm	9	6	5	5	5	5	5	5	5	8	7	8	73
WIND (knots)													
Mean monthly speed	12.1	12	11.6	10.3	10.1	9.4	9	9	9.4	10.7	10.9	11.6	10.5
Max. gust	78	83	70	62	59	49	57	54	58	75	66	80	65.9
Max. mean 10-minute speed	52	54	43	40	40	33	40	38	39	48	46	56	44.1
Mean num. of days with gales	2.3	1.8	1.3	0.3	0.3	0	0.1	0.2	0.3	1	1.2	1.9	10.8
WEATHER (Mean No. of Days With:)													
Snow or sleet	3.1	3.1	2	0.7	0	0	0	0	0	0	0.3	2.2	11.3
Snow lying at 0900UTC	0.7	0.5	0.2	0.1	0	0	0	0	0	0	0	0.5	2
Hail	1	1.1	1.4	1.9	0.7	0.2	0.1	0	0.1	0.3	0.2	0.4	7.4
Thunder	0.2	0.1	0.1	0.1	0.6	0.5	0.8	0.3	0	0.4	0.1	0.1	3.3
Fog	7.8	6.8	8.5	7.5	7.6	7.6	8.4	8.8	9.1	8.7	7.6	8.4	96.8

Available Background Data

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities. The most recent annual report on air quality "Air Quality Monitoring Report 2010"(10), details the range and scope of monitoring undertaken throughout Ireland. The Environmental Protection Agency (EPA) has designated four Air Quality Zones for Ireland:

- Zone A: Dublin City and environs
- Zone B: Cork City and environs
- Zone C: 16 urban areas with population greater than 15,000
- Zone D: Remainder of the country.

These zones were defined to meet the criteria for air quality monitoring, assessment and management described in the Framework Directive and Daughter Directives. The site of the proposed development lies within Zone B, which represents Cork city and its environs.

The EPA publishes Air Monitoring Station Reports for monitoring locations in all four Air Quality Zones. The ambient air quality monitoring carried out closest to the proposed development site is at Blackpool, Co. Cork, located adjacent to the proposed development site. EPA air quality data is available for Blackpool in the report '*Ambient Air Monitoring at Blackpool, Cork City 19th January 2000 to 31st May 2000*', as detailed below. This monitoring location also lies within Zone B. Similar measurement values for all air quality parameters would be expected for the proposed development site as it lies 1 kilometre south of this monitoring location.

Sulphur Dioxide (SO2)

Sulphur dioxide data for the 2000 monitoring period in Blackpool is presented in Table 8.2. A technical problem with the monitor meant that no data was collected between 29th March and 18th May 2000.

Table 8.2 Sulphur Dioxide Data Blackpool January to May 2000

Parameter	Measurement
No. of hours	3,188
No. of measured values	1,952
Percentage Coverage	61.2%
Maximum hourly value	161.3 µg/m3
98 percentile for hourly values	96.1 µg/m3
Mean hourly value	25.3 µg/m3
Maximum 24-hour mean	58.3 µg/m3
98 percentile for 24-hour mean	47.3 µg/m3

During the period of operation there were no exceedences of the 350 µg/m3 hourly limit for the protection of human health. There were two exceedences of the 50 µg.m-3 lower assessment threshold. The directive stipulates that the lower assessment threshold should not be exceeded more than three times in the calendar year. The mean hourly value of 25.1 µg/m3 exceeds the limit value for the protection of ecosystems. However, the report states that this limit may not be relevant to monitoring in an urban environment. It would be expected that SO2 values at the proposed development site (1 kilometre south of this monitoring location) would be similar to those recorded at the Blackpool monitoring site.

Particulate Matter (PM10)

Particulate matter (PM_{10}) data for the 2000 monitoring period in Blackpool is presented in Table 8.3.

Table 8.3 Particulate Matter (PM10) Data Blackpool January to May 2000

Parameter	Measurement
No. of days	133
No. of measured values	117
Percentage Coverage	87.9%
Maximum daily value	239.4 µg/m3
98 percentile for daily values	111.5 µg/m3
Mean daily value	49.1 µg/m3

The 24-hour limit for the protection of human health was breached 46 times during the measurement period; the Directive permits the limit value to be exceeded only 35 times in a calendar year. The mean of the daily values during the measurement period (49.1 µg/m3) also exceeds the annual limit value for the protection of human health (40.0 µg/m3). It would be expected that PM_{10} values at the proposed development site would be similar to those recorded during the 2000 Blackpool monitoring period.

Nitrogen Dioxide (NO2)

Nitrogen dioxide and oxides of nitrogen (NOx) data for the 2000 monitoring period in Blackpool is presented in Table 8.4. No data was collected between 29th February and 18th May because of a technical problem with the monitor.

Table 8.4 Nitrogen Dioxide and Oxides of Nitrogen Data Blackpool January to May 2000

Parameter	Measurement
No. of hours	3,188
No. of measured values	1,254
Percentage Coverage	39.3%
Maximum hourly value (NO2)	107.1 µg/m3
98 percentile for hourly values (NO2)	72.9 µg/m3
Mean hourly value (NO2)	26.8 µg/m3
Mean hourly value (NOx)	55.4 µg/m3 NO2

All hourly mean NO2 values were below the lower assessment threshold (100 µg/m3) except for one exceedence. The Directive stipulates that the lower assessment threshold should not be exceeded more than 18 times in a calendar year. The mean hourly NO2 value (26.9 µg/m3) during the period of measurement was below the annual limit for the protection of human health (40 µg/m3) but just above the annual lower assessment threshold for the protection of human health (26 µg/m3). The mean hourly value of NOX (55.1 µg/m3 NO2) during the measurement period exceeds the annual limit value for the protection of vegetation (30 µg/m3 NOX). However, the report states that the applicability of this limit to urban air pollution monitoring is questionable. It would be expected that NO2 and NOx values at the proposed development site would be similar to those recorded during the 2000 Blackpool monitoring period.

Carbon Monoxide (CO)

Carbon monoxide data for the 2000 monitoring period in Blackpool is presented in Table 8.5. A limited dataset from 19th January until 13th February is available due to a technical problem with the carbon dioxide monitor.

Table 8.5 Carbon Monoxide Data Blackpool January to February 2000

Hourly Values	Result
No. of hours	3,188
No. of measured values	601
Percentage Coverage	18.8%
Maximum hourly value	21.8 mg/m3
98 percentile for hourly values	2.9 mg/m3
Mean hourly value	0.9 mg/m3
Maximum 8-hour mean	10.9 mg/m3
98 percentile for 8-hour mean	3.8 mg/m3

During the monitoring period there was an exceedence of the 10 mg/m3 limit. This was an isolated result and may have been attributable to a local impact at the sampling location. Otherwise, all data is below the lower assessment threshold for the protection of human health. It would be expected that carbon monoxide values at the proposed development site would be similar to those recorded during the 2000 Blackpool monitoring period.

Dust

A study by the UK ODPM(13) gives estimates of likely dust deposition levels in specific types of environments. In open country a level of 39 mg/(m2*day) is typical, rising to 59 mg/(m2*day) on the outskirts of town and peaking at 127 mg/(m2*day) for a purely industrial area. As a worst-case, a level of 127 mg/(m2*day) can be estimated as the existing dust deposition level for the current location.

8.2 NOISE & VIBRATION - EXISTING ENVIRONMENT

8.2.1 Noise receptors

The study site follows the course of the River Lee from Inniscarra, near Classes Lake, to Horgan's Quay and Victoria Road in Cork City. The noise environment graduates from rural to urban over the approximately 12 km length of the study site. From west to east, the noise environment consists of the following zones:

- NOISE ZONE 1. At the western end of the study site, the Lee passes to the north of the Classes Lake area at the western end of Ballincollig. Residential estates across Classes Lake are separated from the river by steep wooded inclines. The noise environment along the river does not impact on the residential estates, and vice versa. To the north, regional route R618 runs parallel to the river, with a separation distance varying from 10 to 380 m. A number of dwellings lie along the R618 at this end of the study area, many of them on elevated inclines overlooking the valley floor. A small number of commercial premises are also scattered across this zone, including a former block making facility opposite Inniscarra graveyard. None of the commercial premises constitutes a significant noise source in the local environment, and noise arises chiefly from R618 traffic, and traffic using Wood Road along the southern side of the river. This zone measures approximately 1 km in length (river course length).

- NOISE ZONE 2. Inniscarra Bridge links the R618 to Ballincollig, and it is at this point that the Lee valley begins to widen. This is the second longest zone in the study area, measuring approximately 3 km in length, and extending from Inniscarra Bridge to Leemount Cross. The R618 runs parallel to the river along its northern side. Several dwellings lie between the river and road, a number of which are located within 10 m of the river bank. Ballincollig town lies on the southern side of the river. While the main town thoroughfare lies approximately 500 m from the river, a number of residential estates extend north towards the river, particularly at Powdermills. The western end of NOISE ZONE 2 includes Ballincollig Regional Park, adjacent to Inniscarra Bridge. A cluster of dwellings lies north of the bridge, close to the R618 junction. A service station is located adjacent to this junction. The soundscape throughout NOISE ZONE 2 is dominated by traffic noise arising from the R618 and from the network of access roads serving residential estates between the river and Ballincollig. Traffic using Inniscarra Bridge represents a significant noise source at the western end of this zone.
- NOISE ZONE 3. As the river approaches Leemount Cross, it begins to meander significantly. The chief characteristic of this zone is the busy traffic environment, with the R618 meeting the R579 and Lee Road at the cross. A second junction, Carrigrohane Cross, lies 650 m southeast of Leemount Cross, and here the R618 meets Carrigrohane Road. Both junctions see significant traffic throughout the day, and queues may form during peak periods. Several clusters of dwellings lie in proximity to Leemount Cross, while a number of residential estates lie to the immediate south of Carrigrohane Cross. This zone, approximately 1.1 km in length, marks the end of the rural character of the study site, and may be classed as semi-rural.
- NOISE ZONE 4. This is the longest zone. Over a distance of 3.4 km, the Lee flows along the northern side of Carrigrohane Road, a busy arterial route linking Cork City to Ballincollig and the northwest. Traffic using the road dominates the noise environment, due to a combination of high speed (due to the straight road alignment), high volume, and absence of screening features. A single cluster of eight dwellings lies between the river and the road. However, a larger number of dwellings lies along Lee Road, which runs along the northern side of the river. Several of these occupy elevated sites overlooking the valley floor.
- NOISE ZONE 5. At the eastern end of Carrigrohane Road, the study area quickly becomes urban, and the dominance of high speed Carrigrohane traffic is replaced by lower speed traffic noise arising from Carrigrohane Road and Lee Road as they converge near Victoria Cross, in addition to traffic using Western Road, Sunday's Well, Victoria Cross Road and Wellington Bridge. Over the 700 m length of NOISE ZONE 5, noise receptors change from detached rural dwellings to terraces and student accommodation blocks. This zone includes the Kingsley Hotel, located adjacent to the divergence of the northern and southern channels of the river.
- NOISE ZONE 6. This zone consists of the 1.5 km of northern channel which flows from Wellington Bridge to Grenville Place, between Sunday's Well and The Mardyke. Throughout this stretch, the northern bank is occupied by long gardens which extend down from Sunday's Well dwellings to the river bank. In contrast, the southern bank of the river is occupied by external amenity spaces including sports grounds and Fitzgerald Park. As the river approaches Grenville Place, both banks become dominated by former industrial buildings now used by university-related facilities. A primary and secondary school are also located here. At Grenville Place, the Mercy Hospital overlooks the river. Although traffic noise remains the dominant source throughout NOISE ZONE 6,

the soundscape along the river is afforded a temporary respite due to the setback of the road network.

- NOISE ZONE 7. After rounding Grenville Place, the northern channel flows through the city centre over a distance of 1.5 km to its convergence with the southern channel. Throughout this distance, the river is bordered by busy quays which separate the river from surrounding buildings. These buildings are occupied by a combination of commercial space, modern apartment complexes, and older dwellings converted to apartments. The noise environment is dominated by quay traffic which is audible up and down the river.
- NOISE ZONE 8. This short zone extends northwards away from the northern channel of the river, up Carroll's Quay towards Murphy's Brewery. As Carroll's Quay marks the southern end of the North Ring Road, the quay sees busy traffic throughout the day, and Christy Ring Bridge at this location is one of the busiest bridges on the Lee. Carroll's Quay itself is surrounded by old and new commercial buildings including the brewery and a multi-storey carpark. The quay's junction with Pope's Quay and Camden Quay is marked by apartment complexes.
- NOISE ZONE 9. This zone consists of the southern channel of the Lee as it flows from Victoria Cross to Western Road, a distance of approximately 1.4 km. The noise environment is dominated by Western Road traffic which remains busy throughout the day. However, the channel's course takes it slightly away from the road through most of this zone, through the somewhat quieter grounds of UCC and Gaol Walk. A number of apartment complexes in this zone are used chiefly as student accommodation. A cluster of dwellings to the west of the main gates of UCC lies directly adjacent to the river bank. To the east of the gates, several former dwellings backing onto the river are gradually becoming subsumed into university ownership. At this location, a small residential estate on O'Donovan Rossa Road lies close to the river.
- NOISE ZONE 10. As the southern channel returns to meet Western Road, the built environment changes from the slightly more tranquil surroundings of NOISE ZONE 9 to the busier environs of the city centre. Over a distance of approximately 2 km, the channel follows a convoluted route through the city centre to its confluence with the northern channel. The western end of this zone is dominated by traffic on Lancaster and Wandesford Quays. After a short reprieve through the Crosses Green area, the river meets French's Quay where traffic coming from George's and Sullivan's Quays is consistently busy. The built environment along the channel throughout this zone consists of a mixture of commercial space, apartment complexes and older dwellings. Several apartment complexes at the western end of the zone lie immediately adjacent to the river, where the channel is narrower.

The noise zones described above are shown in Figures 8.1 and 8.2. The zones are defined by their respective soundscapes rather than by their physical characteristics, although the former is inherently determined by the latter.

Descriptions of the various noise environments above relate to daytime hours, as the proposed works will chiefly be carried out during the daytime. The descriptions are based on site inspections, and particularly on a noise survey undertaken across the study site as described below. The evening noise environment in each zone is likely to be similar to the daytime environment, as traffic noise is likely to continue into evening hours.

Traffic is the chief noise source present across the study site. At the western end of the study site, traffic on the R618 dominates due to its proximity to the river corridor. This is joined by traffic on Wood Road, Inniscarra Bridge Road, and traffic throughout the northern environs of Ballincollig. Traffic noise increases at Leemount Cross due to the R618's junction with the R579, Lee Road and Carrigrohane Road. At the eastern end of Carrigrohane Road, falling traffic speeds and increasing volumes alter the noise regime which becomes decidedly urban in character. Across the city, the soundscape is dominated by urban traffic patterns, with typical features such as lower tyre rolling noise, higher engine/transmission noise, movement in waves due to light sequencing, and clearly audible traffic on distant streets during local lulls.

Apart from traffic, there are no other noise sources of major significance across the study site. Other sources noted in the rural environment, none of which dominates, include bird song/calls, dog barking and agricultural machinery. In urban areas, sources such as pedestrian voices, playing school-children, alarms and construction noise is evident. A Cork Airport flight path crosses the western end of the city, resulting in occasional low altitude aircraft noise throughout the day. Certain positions are influenced by water flow over weirs in the river channel, particularly apartments overlooking Wandesford Quay.

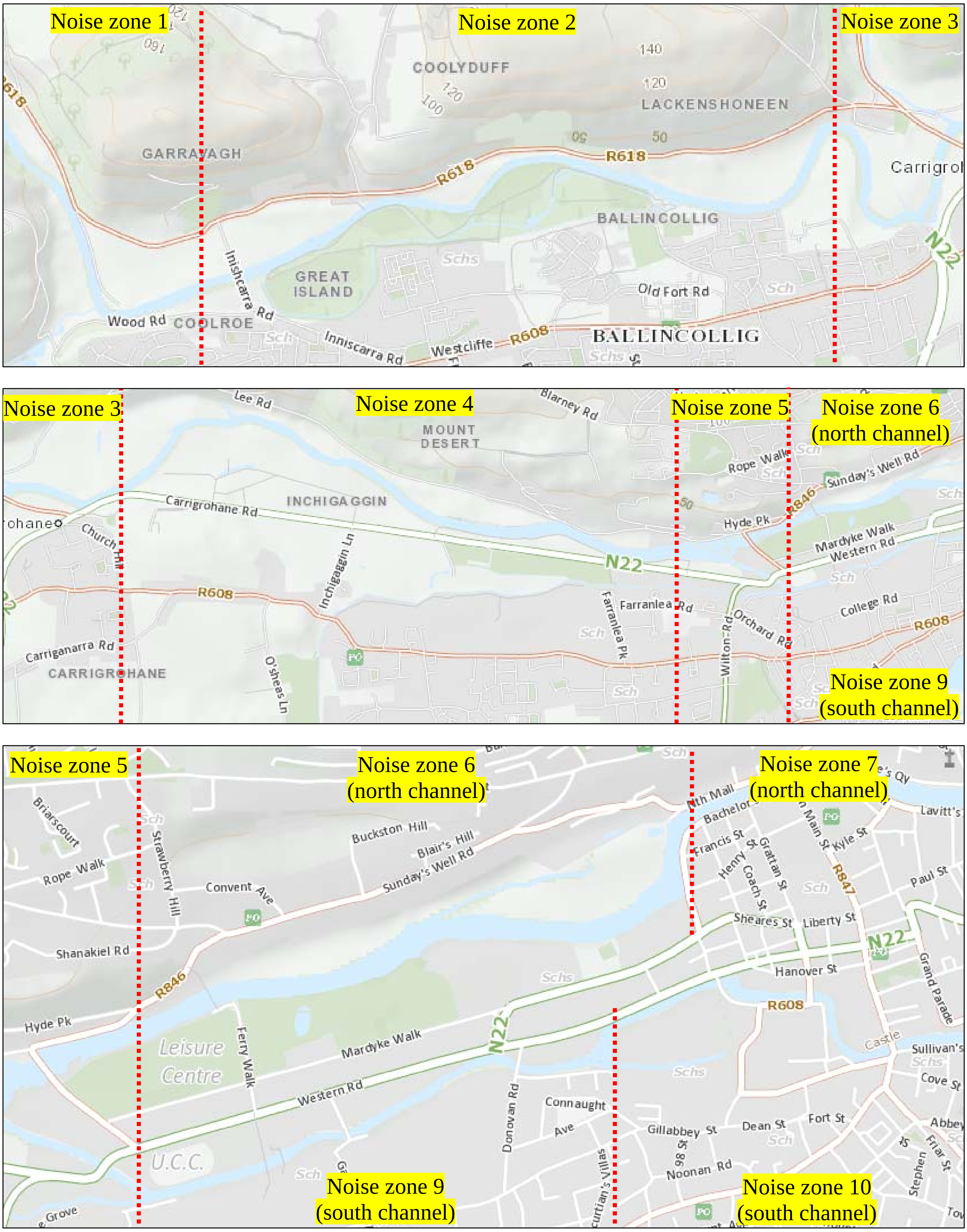


Figure 8.1: Noise zones upstream of city centre. N

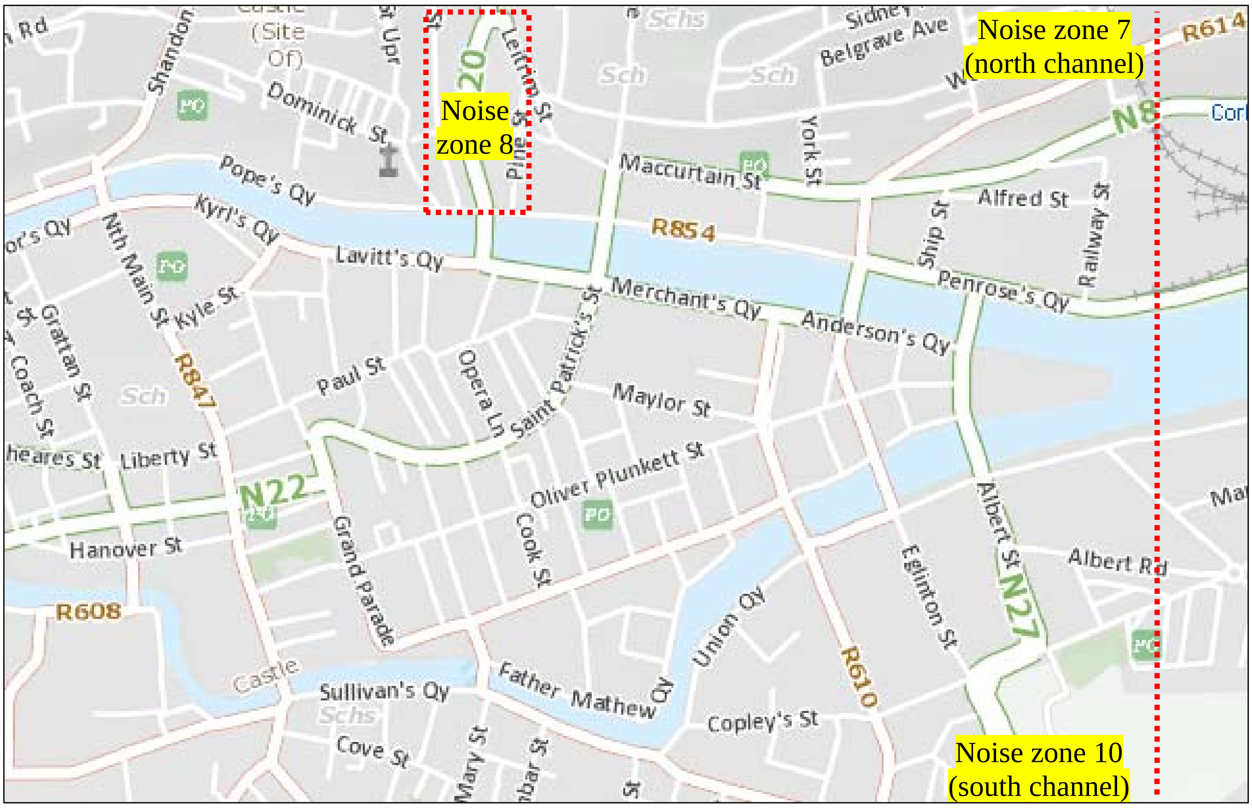


Figure 8.2: Noise zones in city centre. N

The EPA defines a noise sensitive location (NSL) as:

> '*Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or area of high amenity which for its proper enjoyment requires absence of noise at nuisance levels.*'

NSLs across the western half of the study site consist entirely of residential dwellings. Within city zones, NSLs include dwellings, dwellings converted to apartments, overhead living spaces, apartment complexes, student accommodation, hotels, bed & breakfast premises, schools, university/college facilities, a hospital, and places of worship. In the city, NSLs extend to a height of 5-6 storeys. Rather than attempting to identify every individual NSL along the study site within the city, it is considered more practical to assume that the quays are flanked by NSLs on both sides of each river channel.

While the NSL definition does not include any reference to office spaces, it is noted that a number of office developments lie along the quays, including recently constructed developments at the eastern end of the study site. Being located in a busy urban environment adjacent to quays which see traffic throughout the day, such developments are likely to include acoustic-grade glazing.

8.2.2 Noise survey methodology

Existing daytime ambient noise levels (see glossary in Appendix 8A) across the study site were quantified through a noise survey undertaken Wednesday November 2 2016. Survey methodology, equipment specifications and weather conditions are listed in Appendix 8B. Monitoring was undertaken at 19 stations, designated N1-N19, as described in Table 8.6, shown in Figures 8.3-8.14, and shown in Photographs 8.1-8.19.

In rural zones, noise stations were selected on the basis of the following criteria:

- Flood relief works are proposed locally.
- Dwellings are located in proximity.
- The noise environment is likely to be different to those at other stations, due to geography, terrain, road layout, screening, etc.

In urban noise zones, stations were selected to represent the typical noise environment within each zone, at positions close to NSLs, with additional stations selected where locally warranted.

Table 8.6: Noise station locations.

Station	ITM NGR	Location
N1	557129 571301	Field gate 20 m NE of N-most dwelling in cluster N of Inniscarra Br.
N2	558519 571705	R618 entrance to unfinished dwelling 1450 m ENE of Inniscara Br.
N3	560991 571961	80 m E of house at Bannow Br.
N4	562200 571771	Near farm buildings 300 m W of dwelling cluster at Inchigaggin
N5	565097 571406	NE corner of Kingsley Hotel carpark
N6	565174 571591	Adjacent to terrace on Lee Road, 40 m W of Thomas Davis Br.
N7	565701 571706	Outside NW corner of Fitzgerald Park
N8	566569 571842	Presentation College, 20 m W of school building NW corner
N9	566744 572047	Grenville place, 10 m NW of Mercy Hospital NW corner
N10	566729 572161	North Mall, N of pedestrian bridge
N11	567113 572280	Popes Quay, 100 m NW of pedestrian bridge
N12	567453 572307	North City Link Road junction with Devonshire St., at NE corner of apartment block
N13	566205 571563	Dwellings on Western Road, on N bank of S channel, W of UCC main entrance, front yard of 2nd dwelling from E end (no access to rear of dwellings)
N14	566491 571548	O'Donovan Rossa Road, opposite most E of dwellings on Western Road E of UCC main entrance (no direct access from dwellings)
N15	566861 571607	St Aloysius School, Sharman Crawford St, school carpark, adjacent to E and of channel
N16	566838 571737	N end of St Finbarre's Bridge, to represent apartments overlooking river (direct access not possible), also representative of Lancaster Lodge and nearby hotel
N17	567071 571671	Crosses Green, 30 m S of bend
N18	567713 571629	Fr. Matthew Quay, at NE corner of College of Commerce
N19	568128 571870	Albert Quay East, 10 m E of junction with Eamon de Valera Br.

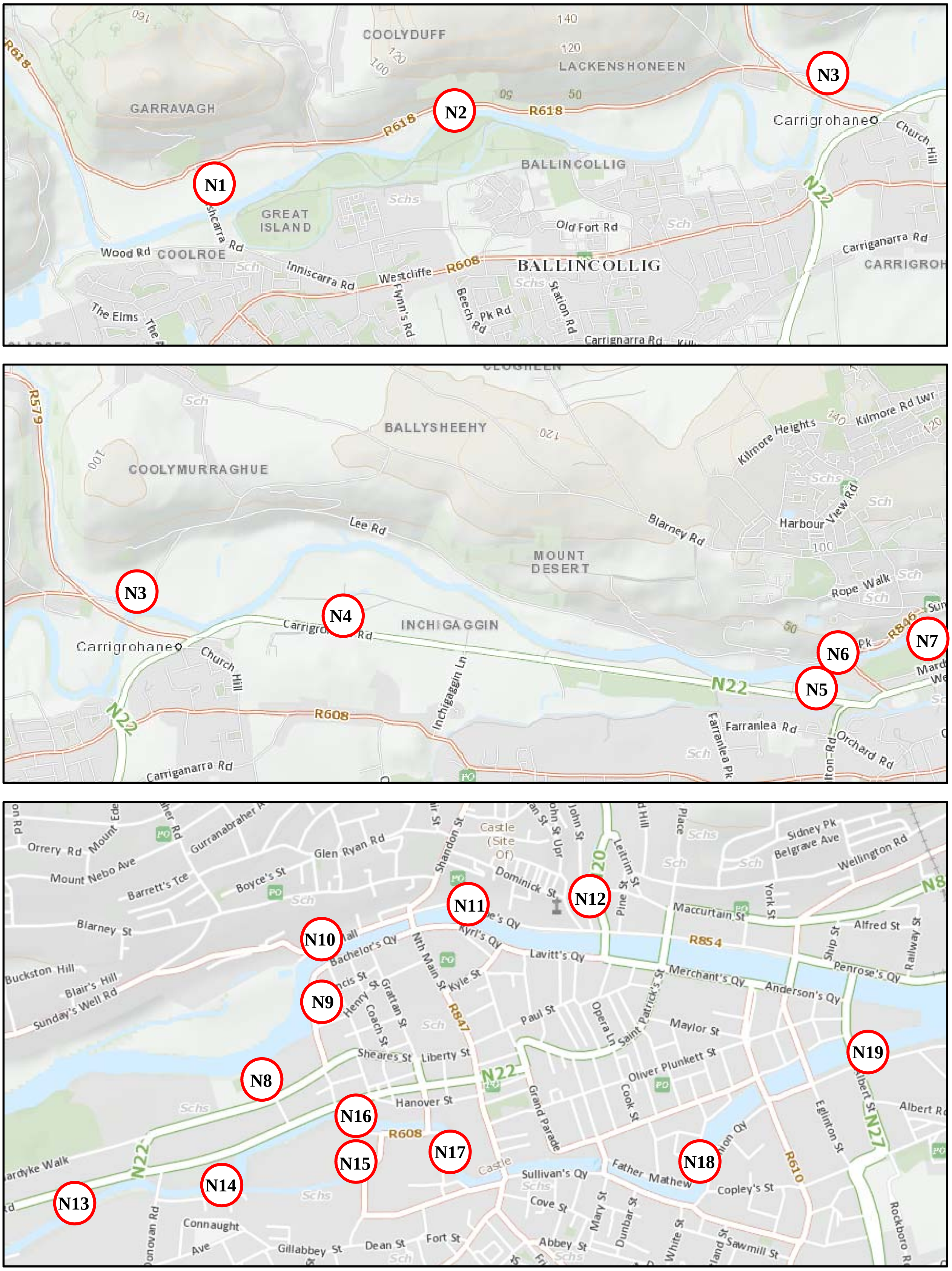


Figure 8.3: Noise station locations. N

Figure 8.4: Station N1 location.N

Figure 8.5: Station N2 location. N

Figure 8.6: Station N3 location. N↑

Figure 8.7: Station N4 location. N↑

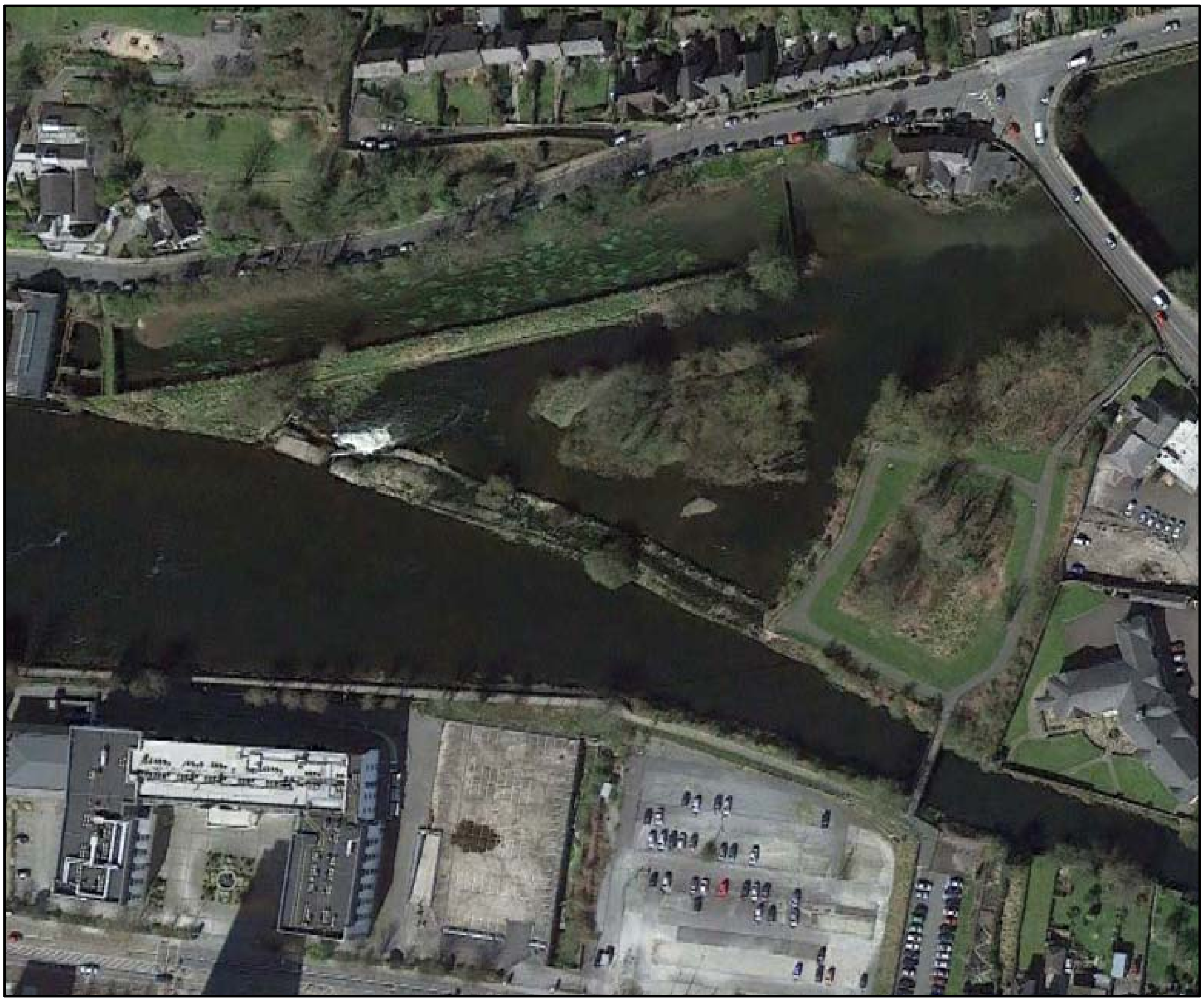


Figure 8.8: Location of stations N5 and N6. N↑

Figure 8.9: Station N7 location. N

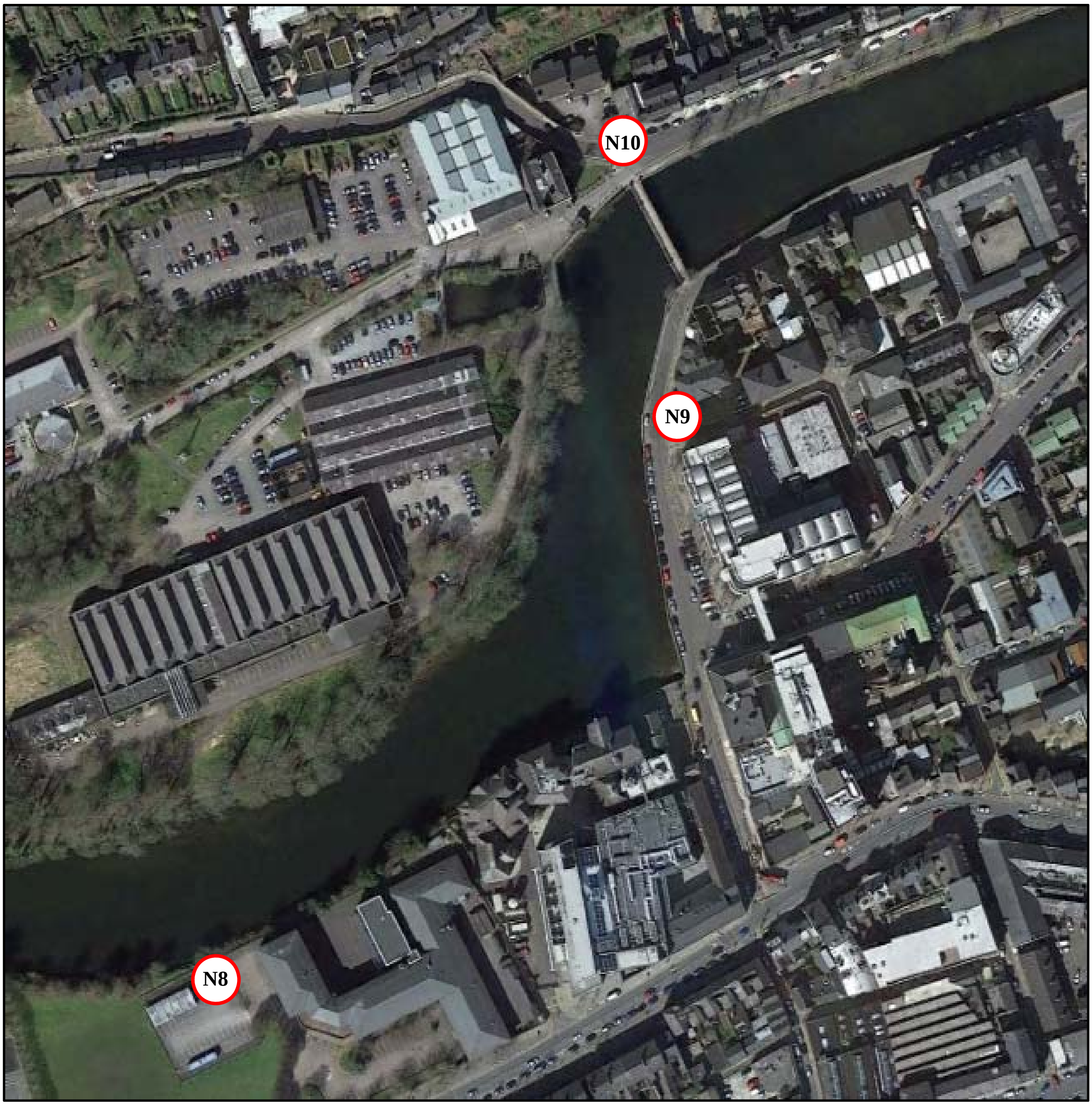


Figure 8.10: Location of stations N8, N9 and N10. N

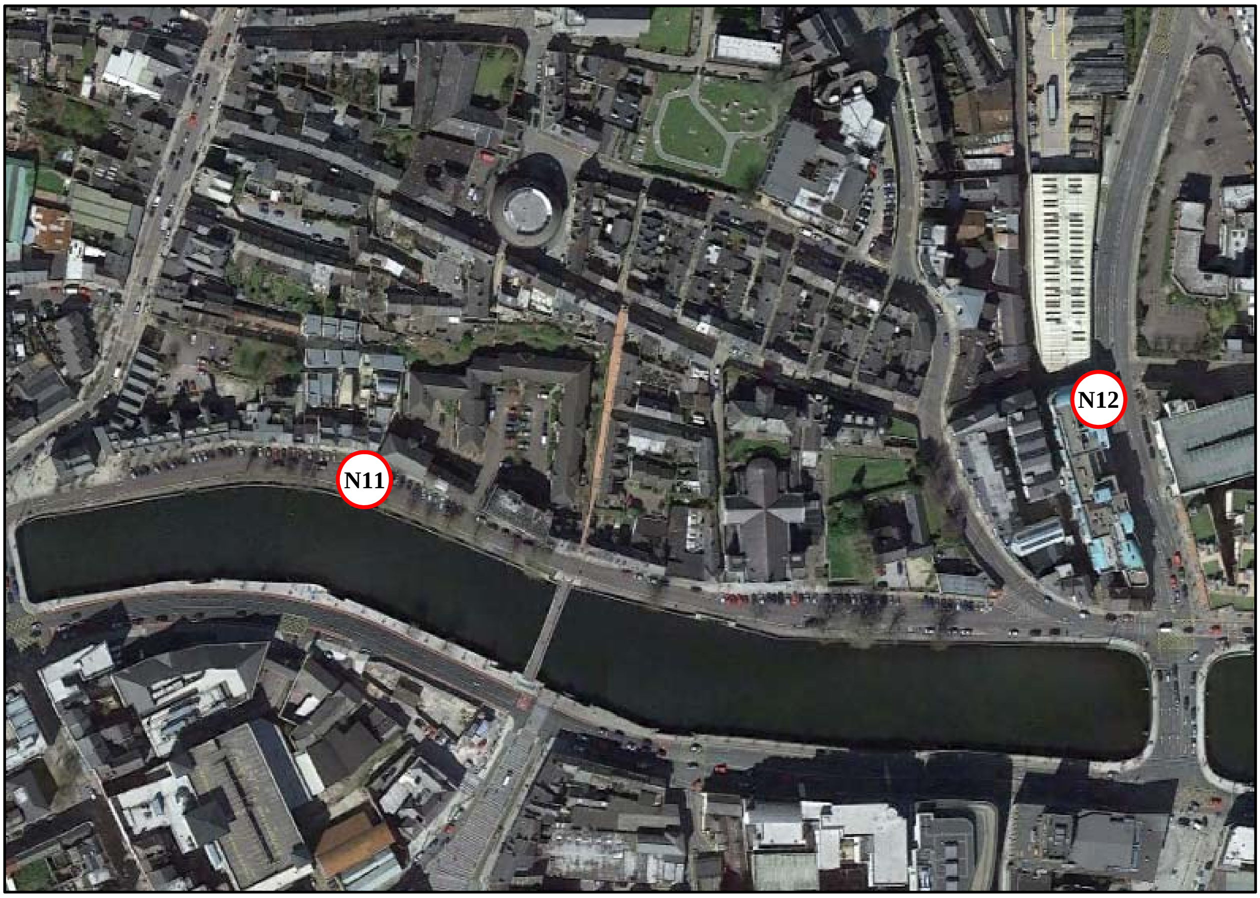


Figure 8.11: Location of stations N11 and N12. N

Figure 8.12: Location of stations N13 and N14. N

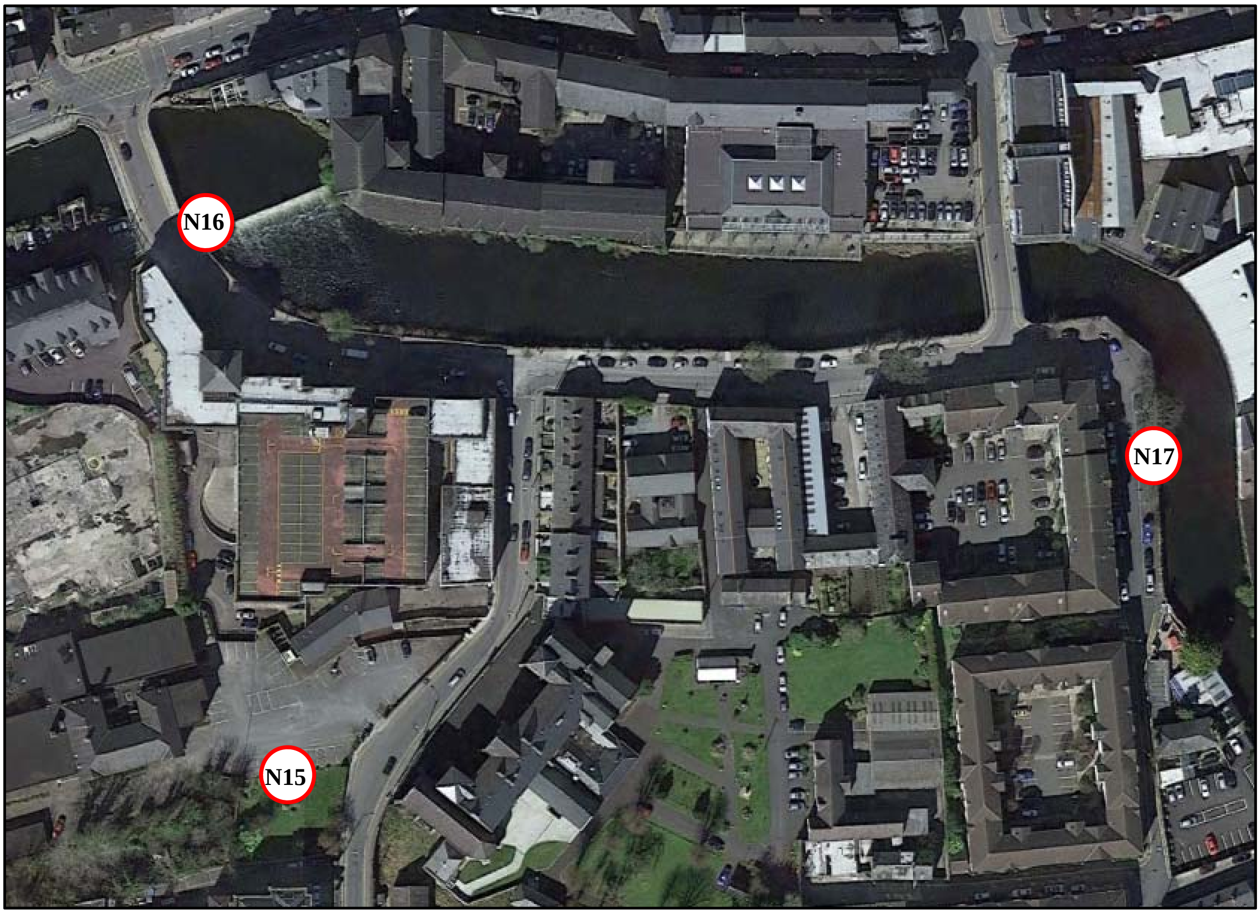


Figure 8.13: Location of stations N15, N16 and N17. N↑

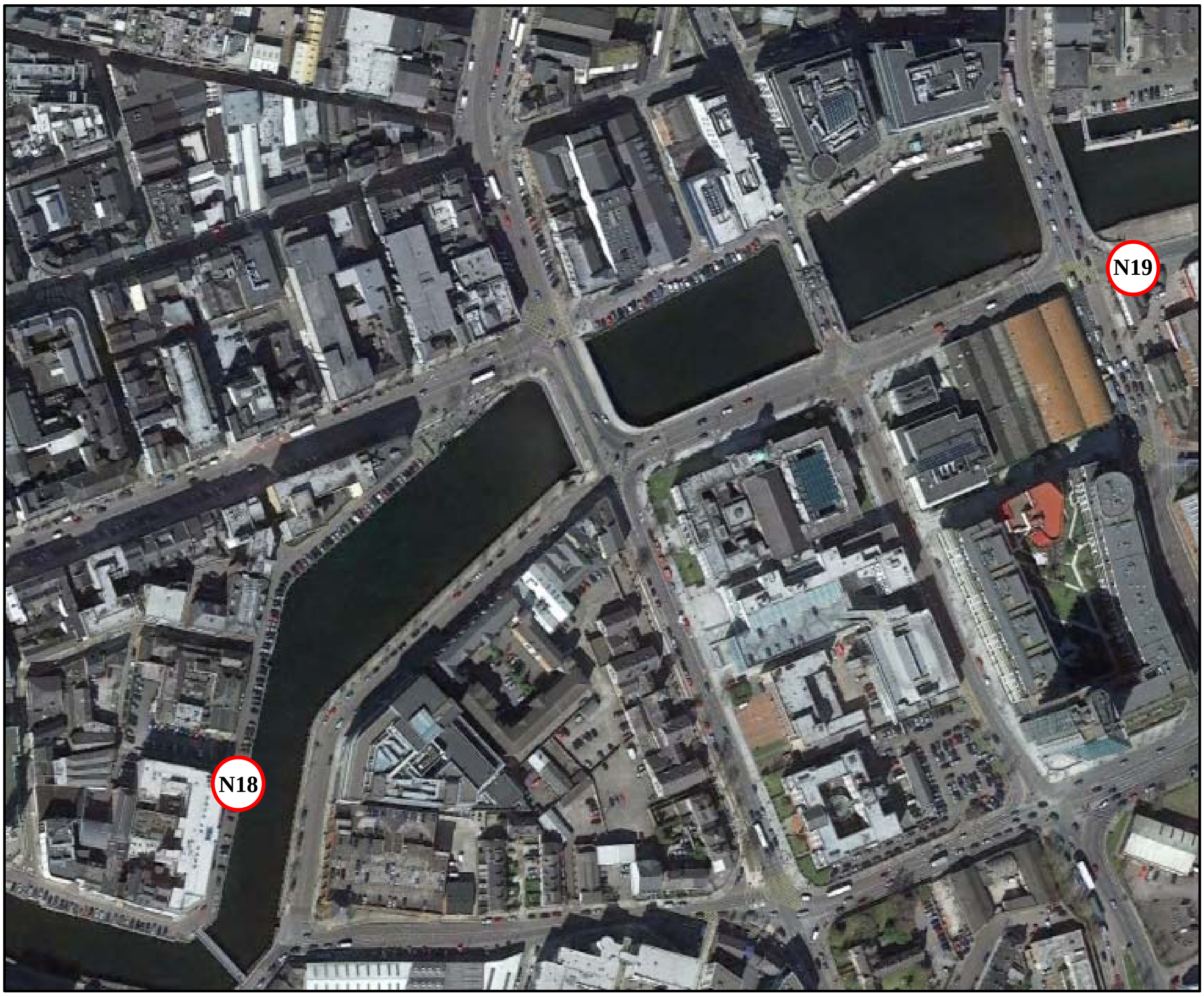
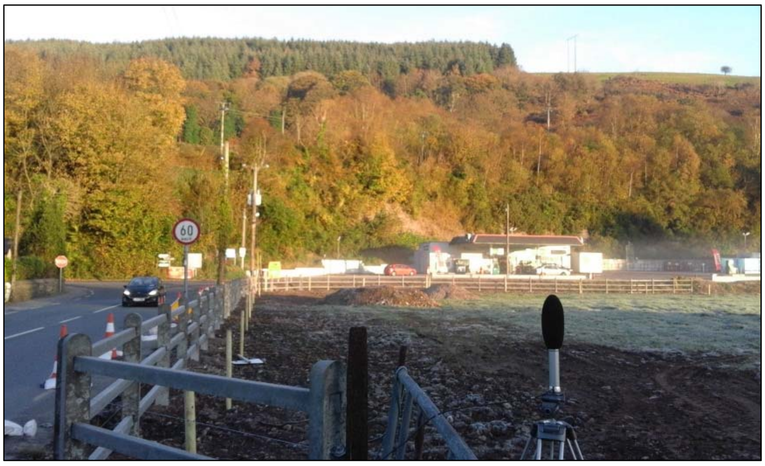


Figure 8.14: Location of stations N18 and N19. N



Photograph 8.1: N1
Adjacent to dwellings N of Inniscarra Bridge, with R618 junction visible in distance, looking N.

Photograph 8.2: N2
Adjacent to dwelling cluster along R618, looking E.

Photograph 8.3: N3
Lee Road, looking W towards dwelling adjacent to Bannow Bridge.

Photograph 8.4: N4
Looking E towards dwelling cluster at Inchigaggin.

Photograph 8.5: N5
Carpark at Kingsley Hotel, looking NW.

Photograph 8.6: N6
Lee Road at Thomas Davis Bridge, looking WNW.

Photograph 8.7: N7
Outside NW corner of Fitzgerald Park, looking NW.

Photograph 8.8: N8
Presentation College on the Mardyke, looking E.

Photograph 8.9: N9
Grenville Place, looking SE towards Mercy Hospital.

Photograph 8.10: N10
North Mall, looking S to Bachelors' Quay.

Photograph 8.11: N11
Pope's Quay, looking NW.

Photograph 8.12: N12
Apartment complex at North City Link Road, looking SW.

Photograph 8.13: N13
Front car parking area of dwelling on Western Road, looking NE. It was not possible to gain access to the rear of this or adjacent dwellings.

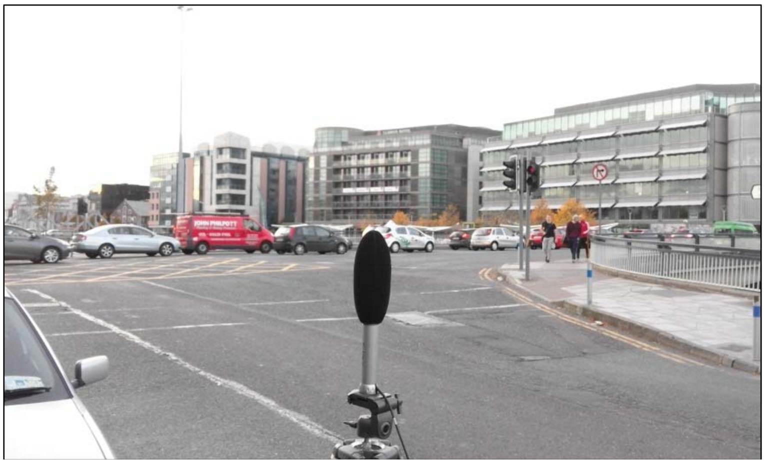
Photograph 8.14: N14
Overgrown area at O'Donovan Rossa Road, overlooking S channel of river behind rear of dwellings on Western Road. It was not possible to gain access to the rear of these dwellings. Looking NW.

Photograph 8.15: N15
Carpark of St. Aloysius School, Sharman Crawford St., looking NE.

Photograph 8.16: N16
Looking NE to rear of apartments overlooking Wandesford Quay.

Photograph 8.17: N17
Crosses Green, looking W.

Photograph 8.18: N18
Father Matthew Quay, looking E towards the School of Music.



Photograph 8.19: N19
Albert Quay, looking NW to Eamon de Valera Bridge.

8.2.3 Results

Noise data recorded are presented in Table 8.7 below. Frequency spectra and time history profiles are shown in Appendix 8C.

Rather than a clear divide in noise levels between rural and urban zones, a more apparent pattern is evident with respect to proximity to traffic, regardless of rural or urban setting. Thus, the lowest LAF90 15 min levels (typically used to describe the background noise environment) were measured alongside the R618, Bannow Bridge, St. Aloysius School and Fitzgerald Park. The defining feature of these environments is the absence of continuous traffic in close proximity. Despite its central location, one of the lowest LAF90 15 min levels was measured at St. Aloysius School.

The highest LAeq 15 min and LAF90 15 min levels were measured at stations which suffer from continuously intrusive traffic noise such as North City Link Road and Albert Quay. LAeq 15 min levels of 72 dB here contrast with levels of 55-57 dB in quieter city centre areas. Rural areas close to busy roads also showed elevated LAeq 15 min levels, including the most upstream station (N1) where passing traffic resulted in a LAeq 15 min level of 69 dB.

In summary, recorded noise data reflect traffic noise intrusion at all stations, including quieter stations where more removed traffic nonetheless dominated. No tones were noted at any station.

Table 8.7: Ambient noise data summary.

Station	Location	Start Time	$L_{Aeq\ 15\ min}$ dB	$L_{AF90\ 15\ min}$ dB	Dominant noise sources
N1	Inniscarra Br.	0813	69	52	Frequent local traffic dominant. During lulls, distant traffic continuously audible. Aircraft.
N2	R618	0842	67	45	Intermittent local traffic dominant. During lulls, distant traffic continuously audible. Bird song/calls along river corridor. Aircraft.
N3	Bannow Br.	0908	67	47	Intermittent local traffic dominant. During lulls, distant traffic continuously audible, particularly to S. Aircraft.

N4	Inchigaggin	0932	66	53	Carrigrohane Straight traffic noise continuously dominant locally and in distance. During lulls, distant traffic and aircraft audible.
N5	Kingsley Hotel	0954	53	50	Traffic on roads through surrounding area and across river continuously audible and dominating ambient environment. Bird song/calls along river corridor. Aircraft. Pedestrian voices.
N6	Thomas Davis Br.	1017	66	51	Intermittent local traffic dominant, with frequent traffic at nearby junction clearly audible. Distant traffic across river also audible. Continuous water flow over nearest weirs audible. Aircraft.
N7	Fitzgerald Park	1042	57	48	Leaf blower in park and grass mower at sports pitch at 100 m both significant to 1050. Intermittent local traffic. Pedestrian voices. Bird song/calls. Distant traffic, including across river. Aircraft.
N8	Presentation College	1151	58	52	Mardyke Road traffic almost continuously clearly audible. Distant traffic also audible. Water flow over nearby weir continuously audible in background. Aircraft. Construction plant at 100 m clearly audible 1154-1158 and from 1201.
N9	Grenville Pl.	1213	66	51	Regular passing traffic dominant. During lulls, distant traffic audible in several directions. Intermittent vehicle activity near hospital entrance. Passing pedestrian voices. Aircraft.
N10	North Mall	1234	69	53	Regular passing traffic dominant. Distant traffic on opposite quay and further E audible in background. Pedestrian voices. Aircraft. Bird calls on river. Construction noise at dwelling across river.
N11	Pope's Quay	1300	64	53	Intermittent passing traffic dominant. Distant traffic audible along quays on both sides of river. Pedestrian voices. Aircraft.
N12	North City Link Rd.	1328	72	63	North City Link Road traffic continuously dominant, masking all other noise apart from passing pedestrian voices.
N13	Western Rd.	1125	69	53	Western Road traffic almost continuously dominant, moving in waves due to traffic light sequencing. During lulls, distant traffic audible, bird song/calls along river, and aircraft. Levels in rear gardens likely to be slightly lower due to screening of Western Road traffic.
N14	O'Donovan Rossa Rd.	1507	57	56	Water flow over nearby weir continuously audible in background. Traffic on Western Road audible at low level continuously. Construction noise regularly audible at

					dwellings on Western Road. Sporadic local traffic. Bird calls and aircraft.
N15	St. Aloysius Sch.	1354	55	46	Intermittent traffic on Sharman Crawford St. dominant. Distant traffic in several directions audible during lulls. Bird song/calls, aircraft, and construction activity in several directions. Several car movements in adjacent carpark.
N16	St. Finbarre's Br.	1415	63	59	Regular traffic on Wandesford Quay dominant. All other noise apart from pedestrian voices and loudest vehicles on Western Road masked by water flow over nearby weir.
N17	Crosses Green	1439	66	56	Ambient environment dominated by Beamish & Crawford demolition activity, particularly concrete breakers. During breaker lulls, distant traffic audible in several directions. Intermittent local traffic.
N18	Fr. Matthew Quay	1542	56	50	Intermittent quay traffic and traffic on opposite quays dominant. Distant traffic and pedestrian voices.
N19	Albert Quay	1611	72	61	Road traffic through adjacent junction continuously dominant. No other noise audible apart from engine hum from vessel docked at quay.

8.3 ASSESSMENT CRITERIA

8.3.1 Air Quality & Climate

8.3.1.2 Air Quality

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health or environmental-based levels for which additional factors may be considered. For example, natural background levels, environmental conditions and socio-economic factors may all play a part in the limit value which is set. Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values.

In 1996, the Air Quality Framework Directive (96/62/EC) was published. This Directive was transposed into Irish law by the Environmental Protection Agency Act 1992 (Ambient Air Quality Assessment and Management) Regulations 1999. The Directive was followed by four Daughter Directives, which set out limit values for specific pollutants:

- The first Daughter Directive (1999/30/EC) deals with sulphur dioxide, oxides of nitrogen, particulate matter and lead.
- The second Daughter Directive (2000/69/EC) addresses carbon monoxide and benzene. The first two Daughter Directives were transposed into Irish law by the Air Quality Standards Regulations 2002 (SI No. 271 of 2002).
- A third Daughter Directive, Council Directive (2002/3/EC) relating to ozone was published in 2002 and was transposed into Irish law by the Ozone in Ambient Air Regulations 2004 (SI No. 53 of 2004).
- The fourth Daughter Directive, published in 2007, deals with polyaromatic hydrocarbons (PAHs), arsenic, nickel, cadmium and mercury in ambient air.

The Air Quality Framework Directive and the first three Daughter Directives have been replaced by the Clean Air for Europe (CAFE) Directive (Directive 2008/50/EC on ambient air quality), which encompasses the following elements:

- The merging of most of the existing legislation into a single Directive (except for the Fourth Daughter Directive) with no change to existing air quality objectives.
- New air quality objectives for PM2.5 (fine particles) including the limit value and exposure concentration reduction target.
- The possibility to discount natural sources of pollution when assessing compliance against limit values.
- The possibility for time extensions of three years (for particulate matter PM10) or up to five years (nitrogen dioxide, benzene) for complying with limit values, based on conditions and the assessment by the European Commission.

Table 8.8 below sets out the limit values of the CAFE Directive, as derived from the Air Quality Framework Daughter Directives. Limit values are presented in micrograms per cubic metre (µg/m3) and parts per billion (ppb). The notation PM10 is used to describe particulate matter or particles of ten micrometres or less in aerodynamic diameter. PM2.5 represents particles measuring less than 2.5 micrometres in aerodynamic diameter.

Table 8.8 Limit values of Directive 2008/50/EC, 1999/30/EC and 2000/69/EC (Source: EPA)

Pollutant	Limit Value Objective	Averaging Period	Limit Value (µg/m^3)	Limit Value (ppb)	Basis of Application of Limit Value	Attainment Date
Sulphur dioxide (SO2)	Protection of Human Health	1 hour	350	132	Not to be exceeded more than 24 times in a calendar year	1st Jan 2005
Sulphur dioxide (SO2)	Protection of human health	24 hours	125	47	Not to be exceeded more than 3 times in a calendar year	1st Jan 2005
Sulphur dioxide (SO2)	Protection of vegetation	Calendar year	20	7.5	Annual mean	19th Jul 2001
Sulphur dioxide (SO2)	Protection of vegetation	1st Oct to 31st Mar	20	7.5	Winter mean	19th Jul 2001
Nitrogen dioxide (NO2)	Protection of human health	1 hour	200	105	Not to be exceeded more than 18 times in a calendar year	1st Jan 2010
Nitrogen dioxide (NO2)	Protection of human health	Calendar year	40	21	Annual mean	1st Jan 2010
Nitrogen monoxide (NO) and nitrogen dioxide (NO2)	Protection of ecosystems	Calendar year	30	16	Annual mean	19th Jul 2001
Particulate matter 10 (PM10)	Protection of human health	24 hours	50	-	Not to be exceeded more than 35 times in a calendar year	1st Jan 2005
Particulate matter 2.5 (PM2.5)	Protection of human health	Calendar year	40	-	Annual mean	1st Jan 2005
Particulate matter 2.5 (PM2.5) Stage 1	Protection of human health	Calendar year	25	-	Annual mean	1st Jan 2015
Particulate matter 2.5 (PM2.5) Stage 2	Protection of human health	Calendar year	20	-	Annual mean	1st Jan 2020
Lead (Pb)	Protection of human health	Calendar year	0.5	-	Annual mean	1st Jan 2005
Carbon Monoxide (CO)	Protection of human health	8 hours	10,000	8,620	-	1st Jan 2005
Benzene (C6H6)	Protection of human health	Calendar Year	5	1.5	-	1st Jan 2010

The Ozone Daughter Directive 2002/3/EC is different from the other Daughter Directives in that it sets target values and long-term objectives for ozone rather than limit values. Table 8.9 presents the limit and target values for ozone.

Table 8.9 Target values for Ozone Defined in Directive 2008/50/EC

Objective	Parameter	Target Value for 2010	Target Value for 2020
Protection of human health	Maximum daily 8 hour mean	120 mg/m3 not to be exceeded more than 25 days per calendar year averaged over 3 years	120 mg/m3
Protection of vegetation	AOT40 calculated from 1 hour values from May to July	18,000 mg/m3.h averaged over 5 years	6,000 mg/m3.h
Information Threshold	1 hour average	180 mg/m3	-
Alert Threshold	1 hour average	240 mg/m3	-

There are no statutory guidelines regarding the maximum dust deposition levels that may be generated during the construction phase of a development in Ireland. Furthermore, no specific criteria have been set in respect of this development. However, guidelines from the Department of the Environment, Heritage and Local Government currently exist for dust emissions from quarrying and ancillary activities(1). These can be implemented with regard to dust emissions from the proposed construction sites.

With regard to dust deposition, the German TA-Luft standard for dust deposition (non-hazardous dust)(2) sets a maximum permissible immission level for dust deposition of 350 mg/(m2*day) averaged over a one year period at any receptors outside the site boundary. Recommendations outlined by the Department of the Environment, Health & Local Government(1), apply the Bergerhoff limit of 350 mg/(m2*day) to the site boundary of quarries.

The concern from a health perspective is focused on particles of dust which are less than 10 microns. EU ambient air quality standards (Council Directive 2008/50/EC transposed into Irish law as S.I. 180 of 2011) centres on PM10 (particles less than 10 microns) as it is these particles which have the potential to be inhaled into the lungs and cause some adverse health impacts. The Directive also sets an ambient standard for PM2.5 (particles less than 2.5 microns) which will come into force in 2015 (see Table 8.8).

8.3.1.2 Climate Agreements

Ireland is a Party to the Kyoto Protocol, which is an international agreement that sets limitations and reduction targets for greenhouse gases for developed countries. It is a protocol to the United Nations Framework for the Convention on Climate Change. The Kyoto Protocol came into effect in 2005, as a result of which, emission reduction targets agreed by developed countries, including Ireland, are binding.

At Kyoto in 2007, the European Union committed to an average annual greenhouse gas (GHG) emission reduction of 8% below the 1990 levels, over the five year period 2008-2012, with the reductions to be shared between EU Member States. Ireland negotiated an increase of 13% above the 1990 level for the period 2008-2012. Other Member States committed to a reduction of more than 8% to facilitate Ireland's increase in emissions.

In Doha, Qatar, on 8th December 2012, the 'Doha Amendment to the Kyoto Protocol' was adopted. The amendment includes:

- New commitments for Annex I Parties (including Ireland) to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
- A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period; and
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

During the first commitment period, 37 industrialised countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first. Under the protocol, countries must meet their targets primarily through national measures, although market based mechanisms (such as international emissions trading can also be utilised.)

COP21 was the 21st session of the Conference of the Parties (COP) to the United Nations Convention. Every year since 1995, the COP has gathered the 196 Parties (195 countries and the European Union) that have ratified the Convention in a different country, to evaluate its implementation and negotiate new commitments. COP21 was organised by the United Nations in Paris and held from 30th November to 12th December 2015.

COP21 closed on 12th December 2015 with the adoption of the first international climate agreement (concluded by 195 countries and applicable to all). The twelve-page text, made up of a preamble and 29 articles, provides for a limitation of the temperature rise to below 2°C and even to tend towards 1.5°C. It is flexible and takes into account the needs and capacities of each country. It is balanced as regards adaptation and mitigation, and durable, with a periodical ratcheting-up of ambitions. Ireland formally ratified the agreement on the 27th October 2016, and it entered into force on the 4th November 2016.

Research Methodology

The assessment of air quality has been carried out using a phased approach as recommended by the UK DEFRA(7, 8). The phased approach recommends that the complexity of an air quality assessment be consistent with the risk of failing to achieve the air quality standards. In the current assessment, an initial scoping of possible key pollutants was carried out and the likely location of air pollution "hot-spots" identified. An examination of recent EPA data (9–11) has indicated that SO2, smoke and CO are unlikely to be exceeded at locations such as the current one and thus these pollutants do not require detailed monitoring or assessment to be carried out. Nevertheless, CO was included in the impact assessment. The initial scoping of pollutants did, however, indicate potential problems in regards to nitrogen dioxide (NO2) and PM10 at busy junctions in urban centres(9–11). Benzene, although previously reported at quite high levels in urban centres(9), has recently been measured at several city centre locations to be well below the EU limit value(10-11).

The current assessment thus focused firstly on identifying the existing baseline levels of NO2, PM10 and benzene in the region of the proposed development by an assessment of EPA monitoring data. Thereafter, the impact of the development during the construction phase of the project on air quality at the neighbouring sensitive receptors was determined by an assessment of the dust generating construction activities associated with the proposed development.

8.3.2 Noise criteria

The proposed flood relief works will not give rise to any noise emissions following commissioning. While the current draft proposal includes several underground pumping stations, noise emissions from installed pumps at these are expected to be entirely negligible. Operational noise emissions may therefore be discounted. In contrast, construction phase emissions are of greater significance.

There are no mandatory noise limits applicable to the construction phase of projects in Ireland. In granting permission for projects, regulatory authorities may specify maximum noise limits at receptors which construction works are required to meet. In selecting suitable limits, authorities may refer to two guidance documents.

British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 1: Noise (2009) sets out a procedure which may be used to determine the impacts of construction noise at surrounding receptors. The procedure involves setting threshold values based on ambient LAeq T levels. Table 8.10 lists threshold levels determined using the methodology set out in the standard, taking into account ambient noise levels measured across the study site. The standard recommends that, during the construction phase, total noise levels including construction emissions should not exceed these threshold levels.

The National Roads Authority (NRA) document Guidelines for the treatment of noise and vibration in national road schemes (2004) also recommends limits applicable to the construction phase of projects. Although the guidance is applicable specifically to road construction projects, the limits are widely applied in Ireland to other construction projects. The limits are presented in Table 8.11.

Table 8.10: Noise threshold levels ($L_{Aeq\ T}$) determined in accordance with BS 5228:2009.

Period	Rural receptors adjacent to roads	Rural receptors set back from roads	Urban receptors adjacent to streets	Urban receptors in quieter positions
Weekdays 0700-1900 h	70 dB	65 dB	75 dB	65 dB
Weekdays 1900-2300 h	60 dB	55 dB	65 dB	55 dB
Saturdays 0700-1300 h	70 dB	65 dB	75 dB	65 dB
Saturdays 1300-2300 h	60 dB	55 dB	65 dB	55 dB
Sundays 0700-2300 h	60 dB	55 dB	65 dB	55 dB
Night-time 2300-0700 h	50 dB	45 dB	65 dB	45 dB

Table 8.11: Noise limits recommended by the NRA (2004).

Period	LAeq 1 h	LASmax
Weekdays 0700-1900 h	70 dB	80 dB
Weekdays 1900-2200 h	60 dB	65 dB
Saturdays 0700-1630 h	65 dB	75 dB
Sundays & bank holidays 0800-1630 h	60 dB	65 dB

BS 5228:2009 and NRA guidance differs in several ways:

- The NRA document does not include night-time or weekend evening limits.
- The NRA document includes LAmax criteria. It is noted that the LASmax parameter is specified rather than the more common LAFmax.
- Evening cut-off times differ by one hour (2200 h v 2300 h).
- BS 5228:2009 specifies standard Saturday limits up to 1300 h. In contrast, the NRA document specifies a standard limit up to 1630 h.
- BS 5228:2009 guidance relates to free field levels (measured more than 3.5 m from any wall), whereas NRA limits are façade levels (usually measured at 1 m from the façade). Due to reflections, façade levels are typically 3 dB higher than free field levels.

On the basis of the foregoing, Table 8.12 suggests limits considered suitable for the proposed project. Given the importance of the project, and the long term benefit which will accrue to all receptors, including those in more secluded positions, the midrange criteria determined in Table 8.10 are applied. In the absence of any NRA LASmax criteria for night-time hours, LASmax limits are adopted from LAFmax limits included in the World Health Organisation document Guidelines for community noise (1999).

Table 8.12: Suggested noise limits at all receptors, based on BS 5228:2009 and NRA guidance.

Period	LAeq 1 h	LASmax
Weekdays 0700-1900 h	70 dB	80 dB
Weekdays 1900-2300 h	60 dB	65 dB
Saturdays 0700-1630 h	65 dB	75 dB
Saturdays 1630-2300 h	60 dB	60 dB
Sundays & bank holidays 0700-2300 h	60 dB	65 dB
Night-time 2300-0700 h	50 dB	60 dB

Given the project's importance to the long term welfare of residents across the study site, it is suggested that limits proposed in Table 8.12 should be free field rather than façade levels. On this basis, levels measured at facades may be up to 3 dB higher than Table 8.12 limits.

It is expected that most construction activity will be undertaken during daytime hours Monday-Saturday. Construction activities outside of these times, other than emergency works, will require the agreement of the relevant local authority.

8.3.3 Vibration criteria

The proposed flood relief works are not expected to give rise to ground borne vibration post-commissioning. Vibration emissions, however, may arise during the construction phase. As with noise, there are no mandatory vibration limits, and reference may instead be made to a number of standards, all of which refer to peak particle velocity (PPV, measured in mm/s) which is usually used to quantify ground borne vibration

British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 2: Vibration (2009) notes that human beings are highly sensitive to vibration, and will detect vibration at levels far lower than those which may cause building damage. Examples of human reactions described by the standard are summarised in Table 8.13.

Table 8.13: Human reactions to vibration, from BS 5228:2009.

PPV	Effect
0.14 mm/s	Just about perceptible in the most sensitive situations for typical construction frequencies.
0.3 mm/s	Just perceptible in residential environments.
1 mm/s	Likely to cause complaint in residential environments, although will be tolerated id prior warning and explanation is given.
10 mm/s	Likely to be intolerable for any more than a very brief exposure.

In contrast to the markedly low levels presented in Table 8.13, PPV levels which may cause cosmetic or structural damage to buildings are considerably higher. On the basis of extensive studies, limits recommended by the two most respected international authorities are presented in Table 8.14. The limits are those below which cosmetic damage (hairline cracking, etc.) to buildings is unlikely to occur. Limits relating to structural damage are significantly higher.

Table 8.14: Recommended vibration limits.

Source	Structure	Lower frequencies	Higher frequencies
1	Modern dwellings	<40 Hz: 19 mm/s	>40 Hz: 51 mm/s
	Older dwellings	<40 Hz: 12.7 mm/s	>40 Hz: 51 mm/s
2 & 3	Industrial & heavy commercial	4-15 Hz: 50 mm/s	>15 Hz: 50 mm/s
	Residential & light commercial	4-15 Hz: 15-20 mm/s	>15 Hz: 20-50 mm/s

Sources:

[1]US Bureau Of Mines report RI 8507: Structural response and damage produced by ground vibration from surface mines blasting (1980).

[2]British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (2009).

[3]British Standard BS 7385:1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (1993).

The strictest limit included in Table 8.14 is 12.7 mm/s reported by the US Bureau Of Mines with respect to older dwellings (typically plaster on wood lath in the US). Limits reported for newer buildings by both US and British authorities are 15 mm/s or higher. With respect to older buildings, such as period dwellings across the study site, British Standard BS 7385:1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (1993) states that 'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive'.

The NRA's 2004 guidance document includes vibration criteria relevant to the construction phase of road projects, reproduced in Table 8.15. The NRA limits were drawn up taking international guidance into account, and appear to incorporate significant safety margins. It is suggested that the NRA criteria be applied to the proposed development.

Table 8.15: Construction phase vibration criteria recommended by the NRA (2004).

Frequency	<8 Hz	10-50 Hz	>50 Hz
PPV limit	8 mm/s	12.5 mm/s	20 mm/s

8.4 POTENTIAL IMPACTS

8.4.1 Air Quality & Climate

Air Quality

Material handling activities on site may typically emit dust. Dust is characterised as encompassing particulate matter with a particle size of between 1 and 75 microns (1-75 µm). Deposition typically occurs in close proximity to each site and potential impacts generally occur within 500 metres of the dust generating activity as dust particles fall out of suspension in the air. Larger particles deposit closer to the generating source and deposition rates will decrease with distance from the source. Sensitivity to dust depends on the duration of the dust deposition, the dust generating activity, and the nature of the deposit. Therefore, a higher tolerance of dust deposition is likely to be shown if only short periods of dust deposition are expected and the dust generating activity is either expected to stop or move on.

The potential for dust to be emitted will depend on the type of activity being carried out in conjunction with environmental factors including levels of rainfall, wind speed and wind direction.

As indicated, dust generation rates depend on the site activity, particle size (in particular the silt content, defined as particles smaller than 75 microns in size), the moisture content of the material and weather conditions. Dust emissions are dramatically reduced where rainfall has occurred due to the cohesion created between dust particles and water and the removal of suspended dust from the air. It is typical to assume no dust is generated under "wet day" conditions where rainfall greater than 0.2 mm has fallen. Information collected from Cork Airport Meteorological Station (1962-1991) identified that typically 204 days per annum are "wet". Thus for greater than 55% of the time no significant dust generation will be likely due to meteorological conditions.

Large particle sizes (greater than 75 microns) fall rapidly out of atmospheric suspension and are subsequently deposited in close proximity to the source. Particle sizes of less than 75 microns are of interest as they can remain airborne for greater distances and give rise to the potential dust nuisance at the sensitive receptors. This size range would broadly be described as silt. Emission rates are normally predicted on a site-specific particle size distribution for each dust emission source.

Whilst construction activities are likely to produce some level of dust during earth moving and excavating phases of the project, these activities will mainly be confined to particles of dust greater than 10 microns. Particles of dust greater than 10 microns are considered a nuisance but do not have the potential to cause significant health impacts. For instance, bulldozing and compacting operations release 84% of particles which are greater than PM10 with only 16% of particles being less than 10 microns(14).

It is envisaged that the construction of the development will occur in distinct phases. As such, the potential for dust nuisance and significant levels of PM10 & PM2.5 concentrations will vary both temporally and spatially as the construction advances.

Worst-case truck movements during the peak construction period would be about 4 inward and 4 outward / hour for concrete works in the city, while for the embankemnts to the west of the city this is likely to increase to between 10-20 truck movements per hour. Construction traffic of this level will lead to dust emissions of the order of 3 g/m2 each hour along the haul roads based on no mitigation being implemented(14). However, provided vehicle speeds are restricted to less than 40 km/hr, this level of construction traffic will lead to dust emissions of the order of 2 g/m2 each hour along the haul roads(14). Thus, it is unlikely that the emissions of this magnitude will lead to dust deposition levels at the site boundary which exceed the TA Luft limit value for dust nuisance of 350 mg/(m2*day).

With effective implementation of a dust minimisation plan, the proposed development is expected to have a negligible impact on air quality during the construction phase. Due to the size, nature and location of the development, which will lead to no increase in road traffic emissions, the proposed development is expected to have an imperceptible impact on air quality once it is operational.

Hence the impact on air quality of the proposed development will be insignificant.

Climate

Construction traffic would be expected to be the dominant source of greenhouse gas emissions as a result of the development. Vehicles will give rise to CO_2 and N_2O emissions during construction of the proposed development. This activity will result in a temporary negligible impact on climate.

8.4.2 Noise sources

The proposed development will not give rise to audible noise emissions following commissioning. While underground pumping stations will include pumps which will operate during high flow events, noise emissions from these are expected to be entirely negligible at the nearest receptors. Occasional maintenance works following commissioning will not be audible beyond their immediate vicinity due to masking by road traffic noise. Accordingly, operational noise emissions may be discounted.

Construction phase emissions, albeit occurring over a confined period, have greater potential to cause local noise intrusion. The construction phase will involve installation of a number of flood defence measures, the final design and positioning of which will be determined at detailed design stage. The measures will include the following, proposed at various positions:

- Construction of new walls in city centre locations.
- Installation of glass walls at certain positions.
- Installation of sheet pile walls at certain locations.
- Construction of flood embankments, chiefly to the west of the city, but also along the Mardyke area.
- Installation of demountable flood gates at certain bridges at the eastern end of the city.
- Installation of a flow control structure at the western end of the south channel.
- Installation of pumping stations at a small number of locations at the eastern end of the city.
- Improvements to existing drainage infrastructure.

Implementation of the above works is likely to require the following activities:

- Embankment construction works, involving use of 1-2 midsized tracked excavators, and possibly a small number of dumpers or dump trucks. Such works will be required at several points upstream of the city, and along the Mardyke area.
- Concrete breaking may be required at several locations, involving either hydraulic breakers on tracked excavators, or handheld pneumatic breakers powered by compressors. Concrete saws may also be required.
- Wall and parapet wall construction works, proposed along city centre quays, are likely to involve a number of activities, including blockwork and concrete pours. Plant such as telescopic handlers and mini-excavators may be required. Various activities are likely to require mobile generators to power equipment, lights and pumps. Larger works areas are likely to be surrounded by temporary hoarding to a height of 2.4 m.
- Sheet pile walling will be required at a number of locations. The selection of piling method, will not be determined until site specific investigations are undertaken in due course. Sheet piling may involve use of driven or pressed-in piles, or use of vibratory techniques. For the puposes of this noise impact assessment, it will assumed that any of these methods could be used at any location, therefore all will be assessed
- Installation of underground pumping stations will require use of one or more excavators, in addition to ancillary plant such as pumps, compressors and lifting equipment. Removal of excavated material, and deliveries of concrete and other materials, will require a number of HGV movements throughout the project. These will be concentrated at specific areas where easements are available.
- Installation of the flow control structure on the southern channel will require use of one or more excavators and associated plant within the river channel itself.

The overall duration of the construction phase is expected to be approximately 6-7 years, depending on how the various elements are divided among contracts. Activities at each of the proposed works zones are expected to last no more than several months, depending on the works involved.

8.4.3 Noise impacts

The noise impacts of the proposed construction works have been assessed on the basis of the scheme as it currently proposed, notwithstanding the fact that further minor alterations may be made following public exhibition detailed site inspections and detailed engineering design.. Although the works required at each location are unlikely to change significantly, the methodologies, plant and timeframes used in this assessment have been selected based on knowledge of construction practices followed during the implementation of similar flood defence schemes, and may change further based on the appointed contractor(s) suggested construction methods. Moreover, prediction of noise impacts associated with the construction phase of any project is complicated by several additional factors:

- The timing, duration and amplitude of emissions associated with activity in each works zone will vary considerably.
- Construction details and plant requirements will alter on a daily basis as construction progresses.
- Plant requirements and activities may vary considerably due to unforeseen changes in the construction program.
- There will be extended periods when little or no construction noise emissions arise e.g. during concrete drying periods.
- Each individual source may be relocated frequently e.g. excavators.

Due to the foregoing, it is not possible to accurately calculate the noise output which will arise onsite throughout the construction phase at every noise sensitive receptor (individual house, buildings, etc.) within the study site. An alternative approach here is to calculate likely noise levels expected to arise in the vicinity of work zones. The calculation is presented in Table 8.16, based on typical plant sound pressure levels at 10 m provided by British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 1: Noise (2009). The worst case scenario assumed in each zone is unlikely to occur routinely, if at all. With respect to sheet piling, where conditions allow, it is possible that pressed-in piling could be a considered methodology.

Table 8.16: Expected sound pressure level (SPL) in work zones.

Activity	Worst case scenario	SPL at 10 m	Total SPL at 10 m
Embankment construction	Tracked excavators x2 Dump trucks x2	75 dB (134 kW) 78 dB (187 kW)	83 dB
Concrete breaking	Hydraulic breaker x1 Consaw x1	72 dB (143 kW) 91 dB (3 kW)	72-91 dB
Wall construction	Telescopic handler x1 Discharging mixer truck x1 Generator x1	71 dB (60 kW) 75 dB 65 dB	77 dB
Sheet piling 1	Pressed-in piling rig x1 Mobile crane x1 Ancillary activities	60-70 dB 70 dB 60-70 dB	60-75 dB
Sheet piling 2	Driven piling rig x1 Mobile crane x1 Ancillary activities	80-88 dB 70 dB 60-70 dB	80-88 dB
Sheet piling 3	Vibratory piling rig x1 Mobile crane x1 Ancillary activities	88 dB 70 dB 60-70 dB	88 dB
Underground pumping station excavation	Tracked excavator x1 Pump x1 Generator x1	75 dB (134 kW) 65 dB (150 mm) 65 dB	76 dB
Flow control structure construction	Tracked excavators x2	75 dB (134 kW)	78 dB

Noise impacts at receptors associated with emissions presented in Table 8.16 are assessed in Table 8.17 in light of the 70 dB daytime $L_{Aeq\ 1\ h}$ criterion discussed above. The table does not take into account screening provided by possible hoarding panels around each work zone.

Table 8.17: Noise impacts at receptors.

Activity	Total SPL at 10 m	Impacts
Embankment construction	83 dB	Proposed at former block yard upstream of Inniscarra Br., at locations upstream and downstream of Inniscarra Br., adjacent to the R618, at Bannow Br., along the Carrigrohane Straight, at Fitzgerald Park, and behind premises along the Mardyke. Approx. 20 dwellings upstream of the city will lie within 10 m of proposed embankments, and will thus be subject to $L_{Aeq\ 1\ h}$ levels which exceed 70 dB.
Concrete breaking	72-91 dB	Where required, concrete breaking is unlikely to exceed the 70 dB criterion. Cutting of concrete using a consaw will reach 91 dB $L_{Aeq\ 1\ h}$ at 10 m when undertaken continuously over 1 h. Any NSLs within approximately 100 m of consaw operations will receive emissions over 70 dB.
Wall construction	77 dB	Proposed at several dwellings along the R618, at Bannow Br., along Carrigrohane Road, and at a large number of points along city quays. NSLs in proximity include dwellings, apartments and schools. $L_{Aeq\ 1\ h}$ levels at NSLs within 20 m may exceed 70 dB on occasion. In the city centre, there are few NSLs within 20 m of such walls, and ambient noise levels will in any case partially mask such emissions. At R618 and Bannow Br., several dwellings lie within 20 m. Two rows of dwellings upstream and downstream of the UCC main gates on Western Road lie within 20 m of proposed walls. Presentation College also lies within 20 m, as do dwellings at the north end of Thomas Davis Bridge and apartments east of St. Finbarre's Bridge.
Sheet piling	60-88 dB	Sheet piling will not give rise to levels which exceed the 70 dB criterion at any receptor where pressed-in piles are used. Where other methods are proposed, noise levels are likely to exceed the 70 dB criterion at local receptors, depending on proximity and piling method. Where driven or vibratory piles are used, the criterion is likely to be exceeded at receptors out to approximately 80 m. Driven piling emissions will be impulsive.
Underground pumping station excavation	76 dB	Locations of pumping stations have not yet been identified. Most such stations are expected to be located near open quays at the eastern end of the city. There are few NSLs located close to such quays, and certainly very few within 20 m. Receptors outside 20 m are unlikely to see noise levels exceed the 70 dB. criterion.
Flow control structure construction	78 dB	This structure will be installed at the upstream end of the southern channel, close to the rear of several dwellings and a religious premises at Victoria Cross. However, none of these receptors lies within 30 m, beyond which $L_{Aeq\ 1\ h}$ levels are expected to reduce to below 70 dB.

On the basis of the foregoing, the 70 dB criterion may be exceeded in the following cases:

- Any dwelling within approximately 100 m of consaw operations, and with a direct line of sight, may be exposed to levels above 70 dB.
- During construction of embankments, dwellings adjacent to Inniscarra Bridge and Bannow Bridge, dwellings along the R618, and dwellings at Inchigaggin may receive LAeq 1 h levels which exceed 70 dB.
- During construction of flood defence walls, dwellings along the R618, at Bannow Bridge, at Thomas Davis Bridge, and on the Western Road close to the UCC main gates may receive LAeq 1 h levels

above 70 dB during certain operations. Presentation College and apartments at St. Finbarre's Bridge may be similarly exposed.

- Where driven or vibratory piling is undertaken, the 70 dB criterion is likely to be exceeded at local receptors, extending out to a distance approaching 80 metres. Piling is proposed at several locations along the study site, including north of Ballincollig, Bannow Bridge, east and west of Thomas Davis Bridge, the Mardyke area including Presentation College and UCC-related facilities, Wandesford Quay, Crosses Green, Parnell Bridge and Donovan's Road. Most of these locations have receptors within 80 metres. In particular, a large number of apartments and student accomodation buildings overlook the proposed sheet piling zones at Wandesford Quay and Crosses Green. School and college facilities between the Mardyke and Grenville Place also lie close to proposed piling zones. Piling may also result in exceedance of LAmax criteria included in Table 8.11.

With respect to 70 dB exceedances identified above, consaw operations may be readily controlled by erecting a hoarding around the cutting area. In addition, wall construction works at Bannow Bridge, the R618, Presentation College, and close to UCC may be similarly treated by erecting a hoarding along the boundary of the works zone. In each case, the hoarding should extend to a height of 2.4 m, and should consist of plywood boarding on both sides of timber framework, with waterproofed cavity to be filled with mineral wool or similar. Gaps at partition interfaces should be boarded. If such measures are installed, consaw and wall construction operations are expected to meet the 70 dB LAeq 1 h criterion.

Use of hoarding may also be beneficial with respect to receptors close to sheet piling operations, particularly where driven or vibratory piling is required. However, such hoarding will be of limited value where receptors overlook the proposed piling zone, such as at Wandesford Quay, Crosses Green, and between the Mardyke and Grenville Place. Here, use of acoustic enclosures around the pile hammer will be beneficial, as recommended by British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 1: Noise (2009). It is noted that such operations will be confined to a limited period.

Given the size of plant associated with embankment construction, and the proximity of receptors at certain locations, use of hoarding to screen noise emissions is unlikely to be practical. In this case, it is considered more suitable to notify residents in advance of operations. The affected NSLs consist of dwellings at Iniscarra Bridge, along the R618, at Bannow Bridge and at Inchigaggin.

In addition to the sources discussed above, noise emissions will also arise from HGV movements across the study area associated with import of materials and export of soils, etc. HGV access to work zones will be facilitated using the local road network, and through privately owned access points by agreement. The number of HGV movements required has not been accurately quantified at this point. On the basis of experience with other large scale construction projects, the number of movements at most concrete work zones is unlikely to exceed about 4 inward and 4 outward per hour. Where larger civil engineering works are required, such as embankment construction, this may increase to 10-20 movements per hour.

Noise levels attributable to HGV movements may be determined using:

$L_{Aeq\ 1\ h} = L_{AE} + 10\log N - 10\log T$

L_{AE} Sound exposure level from vehicle pass. Truck L_{AE} will vary. Typical L_{AE} value of 83 dB at 5 m is assumed, based on experience at other sites.

N: Number of passes.

T: 1 hour.

On this basis, $L_{Aeq\ 1\ h}$ levels associated with up to five movements per hour will be 54 dB at 5 m. It follows that $L_{Aeq\ 1\ h}$ levels will be significantly lower than the 70 dB criterion at all receptors. Given the dominance of existing traffic noise in the local environment, HGV movements are highly unlikely to alter existing traffic noise levels.

During the construction phase, noise impacts at all receptors will be temporary and localised. At most of these, impacts will be imperceptible. At a small number of dwellings, particularly those immediately adjacent to wall or embankment construction works, impacts will range from slight negative to noticeable negative. Given the benefit which will accrue to these dwellings in particular, the overall long term impact is expected to be positive.

8.4.4 Vibration impacts

Three potential sources of ground borne vibration may arise during the construction phase: vibratory compaction, concrete breaking, and sheet piling.

Vibratory compaction of infill may be required over small areas prior to the laying of finished surfaces. This source is unlikely to be significant offsite due to the small areas involved and the limited time present. Moreover, the fluidic nature of infill when vibrated tends to attenuate ground vibration; most of the vibration energy is lost through particle settlement before reaching underlying strata. Low peak particle velocity (PPV) levels in the order of 1.5 mm/s have been reported at a distance of 25 m at some sites. At the nearest receptors, PPV levels are therefore likely to be significantly lower than criteria presented in Tables 8.11 and 8.12.

Concrete breaking, where required, will involve hydraulic breaker units fitted to tracked excavators, or pneumatic handheld units. Although this activity may give rise to high levels of ground vibration in proximity to the breaking area, the vibration tends to contain relatively little energy in the lower frequencies at which buildings and occupants are most vulnerable. In addition, higher frequencies attenuate more rapidly than low frequencies, thus minimising the impact zone. For this reason, most vibration guidance documents such as British Standard BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (2009) ignore concrete breaking vibration. Table 8.18 lists various PPV levels reported in literature at sites where hydraulic rock breaking has been undertaken. The range in levels noted reflects variations in equipment power and rock type.

Table 8.18: Reported rock breaking vibration levels.

Distance	5 m	10 m	20 m	50 m
PPV	0.2-4.5 mm/s	0.06-3.0 mm/s	0.02-1.5 mm/s	0.1-0.3 mm/s

The highest PPV level presented in Table 8.18 is 4.5 mm/s, measured at 5 m from the breaking operation. This level is considerably lower than criteria presented in Tables 8.11 and 8.12. It should be noted that levels presented in Table 8.18 relate to rock breaking. PPV levels associated with concrete breaking are likely to be lower.

Sheet piling will be required in multiple locations, with the type of sheet piling (installation method) to be confirmed at detailed design stage. Traditional piling methods such as driven piling may generate high levels of ground borne vibration. Vibratory piling may also give rise to elevated PPV levels. If either of these is deemed necessary, it is recommended that real time monitoring of PPV levels is undertaken at surrounding receptors. It is also recommended that prior test piling be undertaken, with concurrent PPV measurement, to determine piling parameters required to meet criteria presented in Tables 8.11 and 8.12.

Where ground conditions allow, it is possible that pressed-in piling could be a considered methodology. British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 2: Vibration (2009) notes that vibration levels associated with pressed-in piling are minimal. The document refers to PPV levels measured in the vicinity of two separate pressed-in piling projects where the following levels were measured: 2.5-4.3 mm/s at 4.5 m, 0.3-0.7 mm/s at 7.1 m, and <0.5 mm/s at 24 m.

In summary, vibration impacts are expected to be imperceptible where pressed-in piles are used. Any other piling methods are likely to result in temporary community-wide impacts, ranging from noticeable negative to substantial negative depending on separation distance.

8.5 MITIGATION MEASURES

8.5.1 Air Quality & Climate

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within several hundred metres of the construction area(13).

In order to ensure that no dust nuisance occurs, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Speeds shall be restricted on hard surfaced roads as site management dictates. Vehicles delivering material with dust potential shall be enclosed or covered with tarpaulin at all times to restrict the escape of dust.

Public roads in the vicinity of the site shall be regularly inspected for cleanliness, and cleaned as necessary.

At all times, the dust mitigation measures put in place will be strictly monitored and assessed. In the event of dust nuisance occurring outside the site boundary, movement of materials will be immediately terminated and satisfactory procedures implemented to rectify the problem before the resumption of the operations.

The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practice and procedures.

8.5.2 Noise & Vibration

Following completion of the proposed flood relief works, noise emissions are expected to be satisfactory, and no specific mitigation measures are required.

Noise emissions associated with the construction phase will in general be satisfactory at most receptors. Underground pumping station chambers are unlikely to be excavated close to NSLs. At each work zone along the entire study area, operations will be confined to a relatively short period, extending to several months at most. Apart from a small number of exceptions, noise emissions at each zone will comply with the daytime 70 dB LAeq 1 h criterion. Exceptions to this are as follows:

- Any dwelling within approximately 100 m of consaw operations, and with a direct line of sight, may be exposed to levels above 70 dB. This may be readily mitigated by erecting hoarding between the operations area and nearby receptors.
- During construction of embankments, dwellings adjacent to Inniscarra Bridge and Bannow Bridge, dwellings along the R618, and dwellings at Inchigaggin may receive LAeq 1 h levels which exceed 70 dB. While every effort will be made to limit and reduce construction noise levels, where an exceedance of the 70dB level is likely, the appointed constractor shall notify the occupants of these noise sensitive receptors of the period and duration of works likely to exceed the noise threshold. During construction of flood defence walls, dwellings along the R618, at Bannow Bridge, at Thomas Davis Bridge, and on the Western Road close to the UCC main gates may receive LAeq 1 h levels above 70 dB during certain operations. Presentation College and apartments at St. Finbarre's Bridge may be similarly exposed. The appointed constractor shall notify the occupants of these noise sensitive receptors of the period and duration of works likely to exceed the noise threshold, while making every effort will be made to limit and reduce construction noise levels. Hoarding may also be used at these locations to screen receptors.
- Where driven or vibratory piling is undertaken, receptors out to a distance of approximately 80 m may receive noise levels which exceed the 70 dB criterion. LAMax criteria set out in Table 8.11 may also be exceeded. Use of hoarding will benefit receptors located at or close to ground level. At more elevated receptors, including those at the Mardyke, Wandesford Quay and Crosses Green, use of an acoustic enclosure around the hammer will assist in curtailing emissions from driven piling. The appointed constractor shall provide advance notification to the occupants of receptors within 100 m where driven or vibratory piling is required.

Where hoarding is required, it is recommended that hoarding panels should extend to a height of 2.4 m, and should consist of plywood boarding on both sides of timber framework, with waterproofed cavity to be filled with mineral wool or similar. Gaps at panel interfaces should be boarded. If such measures are installed, consaw and wall construction operations are expected to meet the 70 dB LAeq 1 h criterion at receptors.

Installation of hoarding will be less suitable for control of embankment construction works. It is noted that the dwellings in question lie in close proximity to the channel, and are therefore vulnerable to flooding. The proposed works will eliminate the possibility of flooding at these receptors. In this light, temporary construction works are likely to be considered acceptable.

It is recommended that appointed contractor(s) be required to adopt practices set out in British Standard BS 5228:2009 Code of practice for noise and vibration control on construction and open sites Part 1: Noise and Part 2: Vibration (2009). Measures recommended in the standard include:

- Appointing a project representative responsible for noise and vibration issues, and for liaising with local representatives. A clear communication channel should be established between all parties prior to project commencement.
- Requiring that contractors ensure that site personnel are familiar with potential noise and vibration issues, and that personnel apply a common-sense approach to eliminating unnecessary noise emissions.

- Use of quieter plant and methods where possible.
- Installation of temporary barriers or enclosures around local sources such as compressors and generators.
- Limiting times of activities which may generate elevated noise or vibration emissions.

With respect to sheet piling, no mitigation measures are considered necessary where pressed-in piles are used. If ground conditions require an alternative piling method, it is recommended that real-time monitoring of PPV levels is undertaken at surrounding receptors. It is also recommended that prior test piling be undertaken, with concurrent PPV measurement, to determine piling parameters required to meet criteria presented in Tables 8.11 and 8.12.

The assessment above relates to daytime operations. Where evening or night-time operations are required, it is recommended that noise impacts associated with proposed works be assessed in advance.

8.6 Residual Impact

8.6.1 Air Quality & Climate

There are no residual impacts expected on air quality and climate from the proposed development

8.6.2 Noise & Vibration

Noise and vibration impacts during the construction phase, inclusive of mitigation, are expected to be temporary, localised and imperceptible at most locations. At dwellings close to proposed works zones, particularly adjacent to wall and embankment construction areas, impacts are likely to be slight negative to noticeable negative. Impacts may increase to noticeable negative or substantial negative where piling methods other than pressed-in piles are used. However, it should be noted that these impacts will be entirely temporary in nature, lasting several days or weeks locally in most cases. Implementation of mitigation measures described above will further reduce impacts. Moreover, the long term impact is expected to be positive, given the elimination of flood risk in these areas.

8.7 Monitoring

8.7.1 Air Quality & Climate

The dust mitigation measures put in place will be strictly monitored and assessed throughout the construction phase to ensure their effectiveness. If a dust minimisation plan is effectively implemented there will be no need for dust monitoring during the construction phase.

8.7.2 Noise and Vibration

Monitoring of noise and vibration levels at receptors may be undertaken at specified locations across the study site while certain operations are in progress. The following monitoring criteria are suggested:

- Noise monitoring in accordance with International Standard ISO 1996-2 Acoustics – Description, measurement and assessment of environmental noise, Part 2: Determination of environmental noise levels (2007). Attended measurement of LAeq 15 min, LAF10 15 min, LAF90 15 min, and LAFmax (and, if possible, LASmax to assess compliance with NRA criteria). Monitoring locations should be selected to represent the nearest receptors to work zones at the time of the survey.

Vibration monitoring in accordance with British Standard BS 7385:1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (1993). Maximum PPV levels to be measured over 15 min at each location. Monitoring locations should be selected to represent the nearest and/or most vulnerable receptors to work zones at the time of the survey.