Contents

9 AIR QUALITY / NOISE & VIBRATION

This section of the Environmental Impact Assessment Report (EIAR) assesses the impact of the Limerick City Greenway (UL to NTP) on

(i) Air quality, and

(ii) Noise and vibration, in the context of current relevant standards and guidance, and identifies any requirements or possibilities for mitigation.

Where negative effects are anticipated, mitigation measures and monitoring are set out. Any residual effects of the proposed development on air quality, noise and/or vibration are assessed. The cumulative effects of the development and the cumulative effects in-combination with other plans and projects are also presented in this Chapter.

One of the key objectives of the proposed works is to increase the number of users availing of sustainable transport infrastructure between Limerick City Centre and the University of Limerick (Limerick Smarter Travel – Route 2 Planning Report, April 2014). The proposed development will therefore, have a positive impact on air quality during the operational phase as discussed in further detail in Sections 9.1.4.4.

Impacts on air quality, noise and vibration may occur during the construction phase of the Limerick City Greenway (UL to NTP). Construction activities such as excavation, material handling and operation of construction plant and machinery and can lead to emissions of pollutants such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter ($PM_{2.5}$ & PM_{10}) and carbon monoxide (CO), all of which can impact on air quality. The impact of the proposed works on air quality is presented in Section 9.1 of the EIAR.

Noise and vibration impact assessments have been prepared for the construction phase of the proposed works in relation to the nearest noise sensitive locations (NSLs) and are presented in Section 9.2.

The Limerick City Greenway (UL to NTP) has an indefinite operational duration; therefore, it is not considered necessary to assess the impacts of decommissioning.

A description of the proposed works is provided in Chapter 4 of the EIAR.

The air quality, noise and vibration impact assessments presented in this section of the EIAR have been completed in accordance with the 'EIA Directive' as amended by Directive 2014/52/EU and the relevant guidance listed in Chapter 1.

9.1 AIR QUALITY STANDARDS

9.1.1 Ambient Air Quality Standards

The Air Quality Framework Directive (96/62/EC) was published in 1996 and sets out the principles of the European Commission's approach to monitoring, assessing and managing ambient air quality in order to reduce the risk to human health from poor air quality. Following this, four "daughter" directives were published which set out limits for specific pollutants:

- 1st Daughter Directive (1999/30/EC): Sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead.
- 2nd Daughter Directive (2000/69/EC): Carbon monoxide and benzene.
- 3rd Daughter Directive (2002/3/EC): Ozone.

- 4th Daughter Directive (2004/107/EC): Polyaromatic hydrocarbons, arsenic, nickel, cadmium and mercury in ambient air.

In May 2008, the Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive (2008/50/EC) was published which replaced the Air Quality Framework Directive and Daughter Directives 1-3 listed above. The CAFE Directive was transposed into Irish legislation by the Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011) and the 4th Daughter Directive was transposed into Irish legislation by the Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations 2009 (S.I. No. 58 of 2009). The Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011) was revoked on 31 December 2022 and has been replaced by the Ambient Air Quality Standards Regulations 2022 (S.I. No. 739/2022).

On December 2024, the revised EU Ambient Air Quality Directive (AAQD) (EU 2024/2881) entered into force. The Directive is an important milestone in achieving the European Union's zero pollution ambition, particularly the reduction of air pollution to levels no longer considered harmful to humans and the environment by 2050.

The EU Directive 2024/2881 merges and updates the two previous ambient air quality directives and brings 2030 EU air quality standards closer to the World Health Organisation's (WHO) Global Air Quality Guidelines (2021). EU members have until 11th of December 2026 to transpose the AAQD into national law and are required to meet updated air quality standards by 2030. The measures introduced in the Directive include:

- Reducing by more than half the allowed annual limit value for fine particulate matter (PM2.5).
- Updating air quality standards for allowed levels in ambient air for a total of twelve air pollutants.
- Reviewing air quality standards frequently.

Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland include the Air Quality Standards Regulations 2022 (S.I. No. 739/2022), which incorporate EU Directive 2008/50/EC which combines the previous air quality framework and subsequent daughter directives. Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions (see Tables 9.1 – 9.3).

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 (DEHLG, 2004). These can be implemented with regard to dust emissions from the proposed construction site. The German TA-Luft standard for dust deposition (non-hazardous dust) (German VDI, 2002) sets a maximum permissible 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, apply the Bergerhoff limit of 350 mg/m2/day to the site boundary of quarries (DEHLG, 2004).

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 impact. The Directive also sets an ambient standard for PM2.5 (particles less than 2.5 microns) which came into force in 2015. The European Environment Agency report Air Quality in Europe – 2022 indicated that in 2020, 610 deaths in Ireland were attributed to exposure to pollutants including fine particulate matter (PM2.5), nitrogen oxides (NOx) and Ozone (O3) (EEA, 2022).

Table 9.1 Air Quality Standards Regulations 2022 (Based on Directive 2008/50/EC as amended and S.I. 739 of 2022)

Pollutant	Regulation Note 1	Limit Type	Margin of Tolerance	Value
Nitrogen Dioxide (NO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	40% until 2003 reducing linearly to 0% by 2010	200 µg/m³ NO_2
		Annual limit for protection of human health	40% until 2003 reducing linearly to 0% by 2010	40 µg/m³ NO_2
		Annual limit for protection of vegetation	None	30 µg/m³ NO + NO_2
Lead (Pb)	2008/50/EC	Annual limit for protection of human health	100%	0.5 µg/m³
Sulphur Dioxide (SO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	150 µg/m³	350 µg/m³
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 µg/m³
		Annual & Winter limit for the protection of ecosystems	None	20 µg/m³
Particulate Matter (as PM_{10})	2008/50/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50%	50 µg/m³ PM_{10}
		Annual limit for protection of human health	20%	40 µg/m³ PM_{10}
$PM_{2.5}$ (Stage 1)	2008/50/EC	Annual limit for protection of human health	20% from June 2008. Decreasing linearly to 0% by 2015	25 µg/m³ $PM_{2.5}$
$PM_{2.5}$ (Stage 2)Note 2	-	Annual limit for protection of human health	None	20 µg/m³ $PM_{2.5}$
Benzene (C_6H_6)	2008/50/EC	Annual limit for protection of human health	100% until 2006 reducing linearly to 0% by 2010	5 µg/m³
Carbon Monoxide (CO)	2008/50/EC	8-hour limit (on a rolling basis) for protection of human health	60%	10 mg/m³ (8.6 ppm)

Note 1 EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC

Note 2 EU 2008/50/EC states - 'Stage 2 — indicative limit value to be reviewed by the Commission in 2013 in the light of further information on health and environmental effects, technical feasibility and experience of the target value in Member States'.

Table 9.2 US National Ambient Air Quality Standards (NAAQS) & PSD Increments

Pollutant	Averaging Period	Primary / Secondary Note 1	*Level*
$PM_{2.5}$	1 Year – annual mean, averaged over 3 years	Primary	12 (µg/m^3)
	1 Year – annual mean, averaged over 3 years	Secondary	15 (µg/m^3)
	24 Hour - 98th Percentile, averaged over 3 years	Primary & Secondary	35 (µg/m^3)
PM_{10}	24-Hour – not to be exceeded more than once per year on average over 3 years	Primary & Secondary	150 (µg/m^3)
NO_2	1 hour – 98th Percentile of 1-hour daily maximum values, averaged over 3 years	Primary	100 (µg/m^3)
	1 Year – Annual Mean	Primary & Secondary	53 (µg/m^3)
CO	8 Hour – not to be exceeded more than once per year	Primary	9 ppm
	1-Hour – not to be exceeded more than once per year	Primary	35 ppm
Hydrocarbon (Benzene)	3 Hours (6-9 AM) (corrected for methane)		160

Note 1 Primary standards to protect public health whilst secondary standards are set to protect public welfare

Table 9. 3 WHO Air Quality Guidelines 2005 and 2021

Pollutant	AQGs 2005	AQGs 2021	Averaging Time
Nitrogen dioxide (NO_2)	- µg/m^3 40 µg/m^3	25 µg/m^3 10 µg/m^3	24 hour Annual
Sulphur Dioxide (SO_2)	20 µg/m	40 µg/m^3	24 hour

Carbon monoxide	- mg/m^3	4 mg/m^3	24 hour
Ozone (O_3)	- µg/m^3 100 µg/m^3	60 µg/m^3 100 µg/m^3	Peak season 8-hour
Benzene	Note 1		
Particulate matter ($PM_{2.5}$)	25 µg/m^3 10 µg/m^3	15 µg/m^3 5 µg/m^3	24 hour Annual
Particulate matter (PM_{10})	50 µg/m^3 20 µg/m^3	45 µg/m^3 15 µg/m^3	24 hour Annual

Note 1 No safe level recommended owing to carcinogenicity.

9.1.2 Air Quality - Existing Environment

9.1.2.1 Meteorological Data

A key factor in assessing temporal and spatial variations in air quality is the prevailing meteorological conditions. Depending on wind speed and direction, individual receptors may experience very significant variations in pollutant levels under the same source strength (i.e. traffic levels) (World Health Organisation, 2006). 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 PM_{10}, the situation is more complex due to the range of sources of this pollutant. Smaller particles (less than $PM_{2.5}$) from traffic sources will be dispersed more rapidly at higher wind speeds. However, fugitive emissions of coarse particles ($PM_{2.5}$ – PM_{10}) will actually increase at higher wind speeds. Thus, measured levels of PM_{10} will be a non-linear function of wind speed.

The nearest weather station collating detailed weather wind rose records is Shannon Airport which is location approximately 20 km north of the proposed Greenway. Data collated by Met Eireann for the 30-year average (1991 – 2020) indicates that the mean windspeed at Shannon Airport is 9.1 knots. The predominant wind direction is south-southwest.

Based on the above, the mean windspeed at Limerick is likely to be in the region of 9.1 knots with a predominant south-southwest wind direction.

9.1.2.2 Background Air Quality Monitoring Data

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities. The *National Ambient Air Quality Network* is a series of air quality monitoring stations across the country. Air quality data from the stations is assessed against the European legal limit values and World Health Organisation (WHO) guideline values, as detailed in Section 9.1.1.

The most recent annual report on air quality "*Air Quality in Ireland 2023*" (EPA, 2024), details the range and scope of monitoring undertaken as part of the National Ambient Monitoring Programme (AAMP) which

commenced at the end of 2017. Nine new EU Level monitoring sites were brought online by the end of 2023. Ireland met all of its EU legal requirements in 2023 but failed to meet WHO[1] guideline levels for health. Achieving WHO Aire Quality Guidelines (AQG) in the future will be a major challenge for Ireland and all Europe. The report identifies two main pollutants in Ireland responsible for reducing air quality: particulate matter and nitrogen dioxide. The use of coal, peat and wood as solid fuel for home heating is noted to be the largest problem for air quality in Ireland. Along with traffic in major town and cities. Levels above the WHO air quality guideline (AQG) values were observed in 2023 for particulate matter (PM_{10} and PM_{25}), ozone, nitrogen dioxide and sulphur dioxide.

The Clean Air For Europe Directive (Directive 2008/50/EC on ambient air quality and cleaner air for Europe) requires that areas are divided into zones for the assessment and management of air quality. In Ireland, Zone A is the Dublin Conurbation, Zone B is the Cork Conurbation, Zone C is all large towns in Ireland with a population >15,000 and Zone D is all remaining area. Limerick City is categorised as Zone C.

Nitrogen Dioxide (NO_2)

The operation of construction plant and machinery has the potential to produce oxides of nitrogen (NOx). Nitrogen dioxide (NO_2) is of most concern due to its impact on health. The WHO has reported that epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long term exposure to NO_2 (WHO, 2006). The primary source of NO_2 in Ireland is from road transport, particularly diesel engine vehicles (EPA, 2024). Other sources identified by the EPA as contributing to NO_2 emissions are off road machinery, industrial and construction activities as well as electricity and heat production equipment (EPA, 2024).

NO_2 monitoring was carried out at 36. No stations in Ireland in 2023. All concentrations observed were below the annual limit values. From 2005 there was a reduction in approximately 22% in NO_2 levels considering all Zones.

Monitoring of NO_2 levels in Zone C locations which was carried out by the EPA from 2005 to 2021 indicates that levels were consistently below the EU annual limit and WHO guideline value (40 µg/m^3) for NO_2 **(Figure 9. 1**). Hence long-term average concentrations measured at Zone C locations, including Limerick, were significantly lower than the EU annual average limit value for the protection of human health of 40 µg/m^3.

[1] WHO Air Quality Guidelines are not legally binding however Ireland and Europe should move towards achieving them.

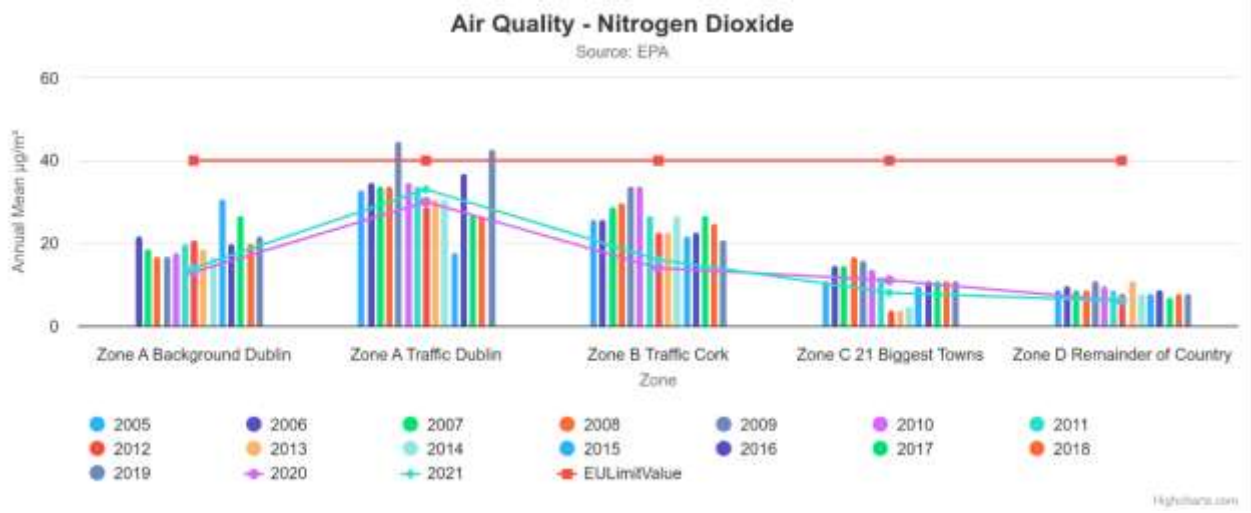

Figure 9. 1 EPA Air Quality - Nitrogen Dioxide (Source : EPA 2022, https://www.epa.ie/resources/charts--data/air/air-quality---nitrogen-dioxide.php

In addition to the above, real time air quality monitoring (January 2023) at three Limerick City and County Council air quality monitoring stations, located in O'Connell Street, Castletroy and Mungret, indicate that the measured long term mean NO_2 from Mar 2023 – Mar 2024 was 22 µg/m³, 12 µg/m³ and 10 µg/m³, respectively (LCCC, March 2024). The maximum recorded short-term mean values for NO_2 in March 2024 are presented in **Table 9. 4** below and indicate that there were no exceedances of the EU limit value or WHO Guideline Values (LCCC, March 2024).

Table 9. 4 Maximum Recorded Short-Term Mean Values for NO2 at Local Air Monitoring Sites in Limerick (LCCC, March 2024)

Location	Date	Pollutant	Averaging Period	WHO Guideline Value	Maximum Value Registered
O'Connell St, Limerick	Mar 2024	NO_2	1 hour	200 µg/m3	71 µg/m³
Castletroy, Limerick					10 µg/m³
Mungret, Limerick					29 µg/m³

Additionally, nitrogen dioxide (NO2) concentrations are currently been monitored at a number of locations within the Limerick urban area through the joint EPA/local authority diffusion tube monitoring programme using passive diffusion tube samplers (A. Finn - LCCC, per comm, Oct 2022). Indicative results show low level concentrations <10 µg/m³ (i.e good air quality) along the route of the proposed Greenway at Limerick Boathouse.

Based on the above information and baseline EPA monitoring data, the expected background concentration for Limerick City is below the EU annual mean and WHO annual mean guideline limit values of 40 µg/m³ and the WHO guideline 1-Hour limit value of 200 µg/m³.

Particulate Matter (PM_{10})

PM_{10} is defined as particulate matter with a particle size of 10 microns or less. Exposure to PM_{10} is a concern from a health perspective as particles of this size can penetrate and lodge inside the lungs causing adverse health impacts, predominantly to respiratory and cardiovascular systems (WHO, 2006). The main source of particulate matter (particularly fine particulate matter) is from burning of solid fuels. In addition, natural sources such as pollen can contribute to PM_{10} (EPA, 2024). Construction activities have also been identified as a source of PM_{10} (EPA, 2024). PM_{10} is generated on construction sites during activities such as resuspension of road dust, excavation, handling and stockpiling of soil and aggregates and from cutting of materials.

PM_{10} monitoring was carried out at 106. No monitoring stations in Ireland in 2023. No exceedance of the EU limit values (annual and daily) were recorded. However, WHO limit values were exceeded as they are more challenging to comply with.

Monitoring of PM_{10} levels in Zone C locations which was carried out by the EPA from 2005 to 2021 indicates that levels were consistently below the EU limit value for PM_{10} (**Figure 9. 2**). Hence long-term average concentrations measured at Zone C locations, including Limerick, were significantly lower than the EU annual average limit value for the protection of human health of 40 µg/m³. Although the WHO limit value of 20 µg/m³ was exceeded some years, it wasn't the case for 2021, with higher levels recorded in Zone C with 19 µg/m³ .

Figure 9. 2 EPA Air Quality - Particulate Matter 10 (Source : EPA 2022, https://www.epa.ie/resources/charts--data/air/air-quality---pm10.php)

Real time air quality monitoring (March 2024) at three Limerick City and County Council air quality monitoring stations, located in O'Connell Street, Castletroy and Mungret, indicate that the measured long term mean PM_{10} from March 2023 – March 2024 was 12 µg/m³, 7 µg/m³ and 11 µg/m³, respectively (LCCC, March 2024). The maximum daily mean values for PM_{10} in January 2024 are presented in **Table 9. 5** below and indicate that there were no exceedances of the EU limit value or WHO Guideline Values (LCCC, January 2024).

Table 9. 5 Maximum Daily Mean Values for PM10 in March 2024 at Local Air Monitoring Sites in Limerick (LCCC, March 2024)

Location	Date	Pollutant	Averaging Period	WHO Guideline Value	Maximum Value Registered
O'Connell St, Limerick	March 2024	PM_{10}	24-hour	45 µg/m³	22 µg/m³
Castletroy, Limerick					19 µg/m³
Mungret, Limerick					39 µg/m³

Based on the above information and baseline EPA monitoring data, the expected background concentration for Limerick City is below the EU annual limit value of 40 µg/m³. WHO guideline 24-hours limit value of 45 µg/m³ was not exceeded.

Fine Particulate Matter ($PM_{2.5}$)

$PM_{2.5}$ is classed as fine particulate matter with a particle size of 2.5 microns or less. Exposure to $PM_{2.5}$ is more health-damaging than PM_{10} as fine particulate matter can penetrate the lung barrier and enter the bloodstream leading to adverse health impacts (WHO,2006). Fine Particulate Matter is generated from construction activities such as excavation, handling and stockpiling of soil and aggregates, and from cutting of materials as well as emissions from diesel fuel combustion by construction plant and machinery and haulage heavy goods vehicles (HGVs).

$PM_{2.5}$ monitoring was carried out at 101. No monitoring stations in Ireland in 2023. No exceedances of the EU annual limit value were recorded. WHO limit values were not exceeded in 2021 but reached the 10 µg/m³ Zone D.

Monitoring of $PM_{2.5}$ levels in Zone C locations which was carried out by the EPA from 2005 to 2021 indicates that levels were consistently below the EU limit value for $PM_{2.5}$ (**Figure 9. 3**) however exceedances of the WHO guideline value (10 µg/m³) was observed. Long-term average concentrations measured at Zone C locations, including Limerick, were lower than the EU annual average limit value for the protection of human health of 20 µg/m³.

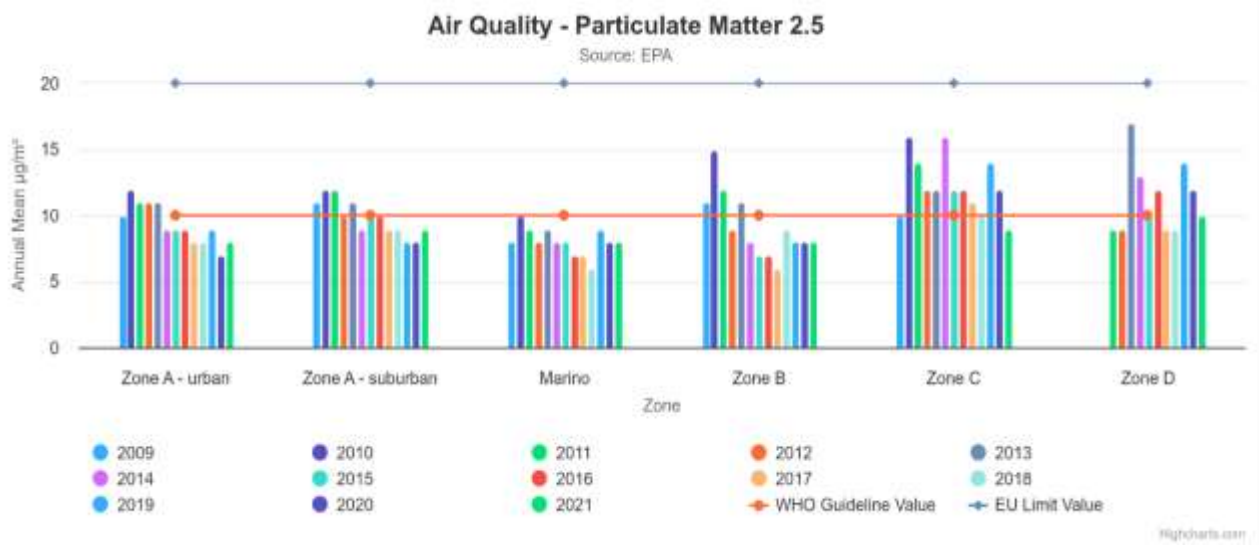

Figure 9. 3 EPA Air Quality - Particulate Matter 2.5 (Source : EPA 2022, https://www.epa.ie/resources/charts--data/air/air-quality---particulate-matter-25.php)

Real time air quality monitoring (March 2024) at three Limerick City and County Council air quality monitoring stations, located in O'Connell Street, Castletroy and Mungret, indicate that the measured long term mean $PM_{2.5}$ from March 2023 – March 2024 was 8 µg/m³, 6 µg/m³ and 6 µg/m³, respectively (LCCC, March 2024). The maximum recorded daily mean values for $PM_{2.5}$ in March 2024 are presented in Table 9.6 and indicate that there were no exceedances of the EU limit value but WHO Guideline Values were exceeded at all three stations (LCCC, March 2024).

Table 9. 6 Maximum Daily Mean Values for PM2.5 in March 2024 at Local Air Monitoring Sites in Limerick (LCCC, March 2024)

Location	Date	Pollutant	Averaging Period	WHO Guideline Value	Maximum Value Registered
O'Connell St, Limerick	January 2023	$PM_{2.5}$	24-hour	15 µg/m³	19 µg/m³
Castletroy, Limerick					17 µg/m³
Mungret, Limerick					14 µg/m³

Based on this information, the anticipated background $PM_{2.5}$ concentration for Limerick is below the EU annual mean limit value for protection of human health of 20 µg/m³. But above WHO guideline values for O'Connell St., and Castletroy stations.

Benzene (C_6H_6)

The WHO has reported that exposure to Benzene is associated with a range of acute and long-term adverse health effects and diseases (WHO, 2010). Benzene emissions from the construction of the Greenway may

arise from exhaust emissions and evaporation losses from construction machinery, and evaporation losses during the handling, distribution and storage of petrol.

With regard to benzene, continuous monitoring was carried out at Kilkenny Seville Lodge (Zone C), and Rathmines (Zone A) in 2019, with annual averages of 0.12 µg/m^3 and 0.26 µg/m^3 respectively (EPA, 2019). Monitoring of Benzene in Dublin, Cork and Kilkenny from 2007 – 2017 indicates that levels were consistently below the EU limit value over the time period (EPA, 2018).

Based on the above information a conservative estimate of the background benzene concentration for the region of the proposed development is below 1.0 µg/m^3. This is below then EU annual limit for protection of human health of 5 µg/m^3.

Carbon Monoxide (CO)

Carbon monoxide (CO) plays a role in air pollution. CO affects the abundance of methane, carbon dioxide and ozone in the atmosphere. CO emissions from the construction of the proposed development may arise from exhaust emissions from construction plant.

In terms of CO, results for the Zone C location of Portlaoise was 0.1mg/m^3 annual mean for the rolling 8-hour CO concentration in 2019, while Enniscorthy (Zone D) was 0.06 mg/m^3 for the annual average in 2016. Monitoring of CO in Dublin and Cork from 2007 – 2017 indicates that levels were consistently below the EU limit value and WHO guideline value have been recorded over the time period (EPA, 2018).

Real time air quality monitoring (January 2024) at three Limerick City and County Council air quality monitoring stations, located in O'Connell Street, Castletroy and Mungret, indicate that the measured long term mean CO from March 2023 – March 2024 was 0.22 µg/m^3, 0.11 µg/m^3 and 0.25 µg/m^3, respectively (LCCC, March 2024). There are no WHO or EU CAFÉ Directive annual mean limits established for this gas.

The EU maximum 8-hour limit value for the protection of human health is set at 10 mg/m^3. Based on the above information the background CO concentration for the region of the proposed development is expected to be significantly lower than the EU limit value.

In summary, based on a review of extensive long-term data from the EPA and real time monitoring at three air quality monitoring stations in Limerick City, existing baseline levels of NO_2, PM_{10}, $PM_{2.5}$, CO and C_6H_6 are likely to be below ambient air quality limit values in the vicinity of the proposed development. In addition, the EPA's Air Quality Index for Health (AQIH) is a rating which indicates the current air quality in a region in terms of potential impact on human health and is based on five air quality pollutants: Ozone gas, nitrogen dioxide gas, sulphur dioxide gas and particulate matter (PM_{10} and $PM_{2.5}$). The AQIH for Limerick (People's Park and Henry Street Stations) is currently 2 – Good (Index calculated 12th March, EPA, 2024, https://airquality.ie/)

Ammonia (NH_3)

The agricultural sector accounts for mostly all (99%) of ammonia emissions in Ireland. Emissions are 14.4% higher than in 1990 (EPA, 2021). National emissions of ammonia are tightly linked to cattle population and nitrogen fertilizer use. Road transport accounts for <1% of national ammonia emissions as a result of three-way catalysts in passenger cars.

The Ambient Air Quality Standards Regulations 2022 (S.I. No. 739/2022) which transpose EU Directive 2008/50/EC does not include limit values for ammonia.

The Air Pollution Information System (APIS) developed in partnership by the UK and Ireland conservation agencies and regulatory agencies and the UK Centre for Ecology and Hydrology. The latest available data of ammonia dates from 2018. Results show a 2.53 ug m-3 of NH_3. According to APIS Ammonia critical levels

range from 1 to 3 ug m-3. Most of ammonia levels in Ireland are closer to the upper-level threshold, surpassing levels that might be recommended to protect certain habitats.

9.1.3 Potential Impacts – Air Quality

A full detail on the description of the potential impact is given in Chapter 1 of this EIAR.

9.1.3.1 Do Nothing' Scenario

One of the key objectives of the proposed Greenway is providing an alternative, more sustainable mode of transport which minimises the negative impacts of unsustainable transport modes on the environment through the reduction of localised air pollutants and greenhouse gas emissions. If the proposed development were not to proceed, this opportunity to reduce air pollutants and greenhouse gas emissions would be lost.

9.1.3.2 Air Quality – Dust and Particulate Matter (PM_{10} & $PM_{2.5}$) Generation

Construction Phase - Potential Temporary Slight Negative Impact

Dust particles can be defined as those that are easily deposited (coarse fraction of particulates) and airborne particles that remain suspended in air for longer periods. The size of deposited and suspended particles therefore affects their distribution.

Currently there are no EU, WHO or Irish Statutory standards or limits for the assessment of dust deposition. The German TA Luft Air Quality Standard sets a guideline limit value for total dust deposition of 350 $mg/m^2/day$ (averaged over a 30 +/- 2 day period).

A study by the UK ODPM (2000) gives estimates of likely dust deposition levels in specific types of environments. In open country a level of 39 $mg/m^2/day$ is typical, rising to 59 $mg/m^2/day$ on the outskirts of town and peaking at 127 $mg/m^2/day$ for a purely industrial area. As a worst-case, a level of 127 $mg/m^2/day$ can be estimated as the existing dust deposition level for the current location which is below the TA Luft guidelines of 350 $mg/m^2/day$. The German TA Luft Regulations set criteria for 'possible nuisance' of 350 $mg/m^2/day$ and 'very likely nuisance' of 650 $mg/m^2/day$.

Construction activities may lead to the emission of dust. Dust is classified as matter with a particle size of between 1 and 75 microns (1-75 µm). As dust particles fall out of suspension in the air, dust deposition typically occurs in close proximity to the site and potential impacts generally occur within 500 metres of the dust generating activity. Deposition rates decrease with distance from the generating source and larger particles deposit closer to 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 expected to stop.

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. Assuming worst case scenario, dust deposition may impact on properties within 500 m of the works during the construction phase of the development.

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. 30-year average data (1981 - 2010) from Shannon Airport meteorological station identified that typically 211 days per

annum are "wet", respectively. Therefore, for greater than 58% of the time no significant dust generation will be likely due to meteorological conditions.

Large particles which are greater than 75 microns in size fall out of atmospheric suspension and are therefore deposited in close proximity to the source. Smaller particles which are less than 75 microns can remain in atmospheric suspension for a greater distance and therefore give rise to potential dust nuisance. Particles which are less than 75 microns in size are referred to as silt. Emission rates are normally predicted on a site-specific particle size distribution for each dust emission source. A proportion of generated $PM_{2.5}$ will be owing to diesel particulate matters are typically spheres about 15–40 nm in diameter, and approximately more than 90 % of PM is smaller than 1 μm in diameter. The formation process of PM emissions is dependent on many factors as the combustion and expansion process, fuel quality (sulfur and ash content), lubrication oil quality, and consumption, combustion temperature, exhaust gas cooling (Burtscher 2005)

The majority of dust produced during the construction period will be deposited in close proximity to the source and any impacts from dust will generally be within several hundred meters of the construction area (UK ODPM, 2000).

Construction activities such as excavating and earth moving are likely to produce some level of dust during the construction phase of the project. These activities will mainly produce particles of dust greater than 10 microns, these particles are considered a nuisance but do not have the potential to cause significant health impacts. Given that background levels of PM_{10} and $PM_{2.5}$ are likely to be below the ambient air quality limit values and as the construction phase of the proposed Greenway is temporary, the potential for dust nuisance and significant levels of PM_{10} and $PM_{2.5}$ will be temporary and will vary spatially during the construction phase, constituting a temporary slight negative impact. Mitigation measures relating to dust generation are detailed in Section 9.3.4.

Operational Phase - Potential Permanent Slight Positive Impact

The proposed Greenway will increase the number of people using sustainable transport to commute between Limerick City Centre, University of Limerick, NTP, and Annacotty due to connections with existing active travel infrastructure links which extend to Dublin Road (R445). This will result in a long term slight positive impact in terms of air quality by reducing the amount of air pollutants that would otherwise have been emitted from transport vehicles if the Greenway was not available.

9.1.3.3 Air Quality – Exhaust Emissions (NO_2, C_6H_6 & CO)

Construction Phase - Potential Temporary Slight Negative Impact

Construction related traffic originating from the delivery of materials to the site, the removal of surplus excavated material from the site and the transport of workforce to, from and within the site will give rise to emissions of nitrogen dioxide, sulphur dioxide, benzene and carbon monoxide within the site boundary (set out in Chapter 1 Figure 1.1) and along the anticipated transport routes presented in Chapter 12 Material Assets. This has the potential to impact on health and the environment as discussed in Sections 9.1.1, 9.1.2 and 9.1.3. Given that background levels of nitrogen dioxide, sulphur dioxide, benzene and carbon monoxide are likely to be below ambient air quality limit values as discussed in Section 9.1.3 and emissions will be temporary in nature, this constitutes a potential temporary slight negative impact in terms of air quality during the construction phase of the Greenway. Mitigation measures relating to exhaust emissions are detailed in Section 9.1.5.

Operation Phase - Potential Permanent Slight Positive Impact

The proposed Greenway will provide an alternative and sustainable transport option for cyclists and pedestrians undertaking recreational and/or commuting trips between Limerick City Centre, University of Limerick, NTP, and Annacotty due to connections with existing active travel infrastructure links which extend to Dublin Road (R445). Users will benefit from the higher quality air in comparison to alternative urban routes as well as making a positive contribution to urban air quality.

This will result in a long term slight positive impact in terms of air quality due to exhaust emissions during the operation phase of the development by reducing the amount of exhaust emissions that would otherwise have been emitted from transport vehicles if the Greenway was not available.

9.1.4 Mitigation Measures – Air Quality

9.1.4.1 Air Quality - Dust and Particulate Matter (PM_{10} & $PM_{2.5}$) Generation

The generation of dust and particulate matter is dependent on the construction activity being carried out and environmental factors such as rainfall, wind speed and wind direction. A worst-case scenario has been assumed in the assessment. In order to predict and reduce the volume of dust emissions pertaining to the construction phase of the proposed development, a dust minimisation plan has been developed and is included in the Construction Environmental Management Plan (CEMP) (Appendix 4C). Any measures specified in the plan that are to be carried out by third parties will be contractual obligations.

The following measures will be implemented in order to minimise dust impact:

- All site roads within the construction works boundary shall be regularly inspected, cleaned and maintained during the construction phase. The construction works boundary is shown in Chapter 4,
- Hard surface roads within the construction site boundary shall be regularly cleaned and dampened down to prevent the generation of dust;
- Any road that has the potential to give rise to dust emissions must be regularly inspected and watered during periods of dry and/or windy weather to minimise the movement of dust particles to the air and ensure that dust does not cause a nuisance;
- Speeds shall be restricted on hard surface roads and vehicles transporting materials with dust potential must ensure that the material is enclose or covered with tarpaulin at all times;
- The construction traffic routes identified in Chapter 12, shall be regularly inspected for cleanliness and cleaned as necessary to minimise the movement of dust particles to the air, as detailed in the CEMP;
- The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure that best practice and procedures are in place to minimise dust emissions;
- All plant and materials shall be stored in dedicated compound areas on site;
- Stockpiling of material will be minimised and stockpiles will be covered or fenced to prevent wind whipping. Materials which have the potential to produce dust will be removed from site as soon as possible;
- In the event of dust nuisance occurring outside the site boundary, movement of materials must be terminated immediately and procedures implements to rectify the problem; and

- A record of all dust and air quality complaints will be maintained, along with details of the cause of emissions and the measures implemented to reduce emissions. All records will be made available to Limerick City and County Council.

9.1.4.2 Air Quality - Exhaust Emissions (NO_2, C_6H_6 & CO)

A number of mitigation measure will be implemented in relation to exhaust emissions during the construction phase:

- Machinery will be switched off when not in use;
- All construction vehicles and plant will be maintained in good operational order;
- Aggregate materials used in construction shall be sourced locally where possible to reduce potential exhaust emissions; and
- Where possible, mains electricity or battery power equipment will be used in lieu of diesel or petrol-powered generators.

9.1.4.3 Monitoring

The dust mitigation measures put in place will be strictly monitored and assessed throughout the construction phase to ensure their effectiveness as identified in the CEMP (Appendix 4C).

Dust monitoring will be carried out as follows:

- Daily inspections shall be carried out to monitor dust within and in the vicinity of the Study Area, including roads. Monitoring shall include regular dust soiling checks of surfaces within 100 m of the site boundary.
- Regular site inspections shall be carried out and logged with all the relevant information (responsible staff, time, site, weather condition) by the site engineer in order to ensure that the measures specified in the dust minimisation plan are being implemented effectively.
- The frequency of site inspections shall be increased when activities with a high potential to produce dust are being carried out (e.g. excavation) or during prolonged dry or windy conditions.
- Dust deposition, dust flux or PM_{10} monitoring locations shall be agreed with the Local Authority. Baseline monitoring shall be carried out a minimum of 3 months in advance of works commencing on site. The purpose of the monitoring is to ascertain that the dust levels would comply with the 1-hour average and 24-hour average. Dust monitoring methodology can range from active samplers (powered) to measure specific dust fractions to passive samplers (unpowered) that measure dust flux, dust deposition and soiling. Baseline monitoring allows to define existing conditions more accurately and help with the interpretation of "trigger threshold". The site engineer will ensure data is collected and registered.
- Inspection results shall be recorded and made available to the Local Authority on request.

9.1.5 Residual Impact – Air Quality

Temporary Not Significant Negative Impact and Permanent Slight Positive Impact

The implementation of the mitigation measures set out above will minimise impacts associated with dust generation and air pollutant emissions during the construction phase, therefore the proposed development will have a temporary negligible impact on air quality during the construction phase.

The proposed development will have a permanent positive impact on air quality once operational by providing a sustainable alternative mode of transport.

9.2 NOISE AND VIBRATION

The noise and vibration assessment has been undertaken in accordance with the overarching EIA guidance and in accordance with:

- EPA (2016) Guidance Note for Noise: License Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4).
- Transport Infrastructure Ireland (TII) (NRA) (2004) Guidelines for the Treatment of Noise and Vibration in National Road Schemes.
- Transport Infrastructure Ireland (TII) (2014) Good Practice Guidance for the Treatment of Noise and Vibration during the Planning of National Road Schemes.
- British Standard Institution (BSI) 7385-2 (1993) Evaluation and measurement of vibration in buildings Part 2: Guide to damage levels from ground borne vibration.
- British Standard Institution (BSI) (2014) 5228-1 and 2:2009+A1:2014 Code od practice for noise and vibration control on construction and open sites. Noise and Vibration.
- World Health Organisation (2018) Environmental Noise Guidelines for the European Region.

9.2.1 Construction Noise Level Criteria

The potential noise impact of the proposed development on the surroundings will occur during the construction phase, much of which will be generated by construction plant and machinery.

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. Local authorities normally control construction activities by imposing limits on the hours of operation and consider noise limits at their discretion. The majority of the construction activity is expected to occur during normal working hours.

The following documents contain guidance in relation to acceptable noise control on construction sites:

- British Standard BS 5228 – 1: 2009+A1:2014: *Code of Practice for Noise and Vibration Control on Construction and Open Sites: Noise.*
- NRA *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (2004)

In the absence of specific noise limits, criteria relating to permissible construction noise levels for a development of this type may be found in the abovementioned documents and is summarised below.

BS 5228-1:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites: Noise* sets out a procedure for determining the impacts of construction noise on surrounding receptors. **Table 9.7** sets out the threshold noise levels (L_{AEQ}) as set out in the Standard. The Standard recommends that total noise levels during construction should not exceed the threshold levels.

Table 9.7 Noise Threshold Levels determined in accordance with BS 5228-1:2009+A1:2014

Assessment Category and Threshold Value Period (L_{AEQ})	Threshold Value (dB)		
	Category A	Category B	Category C
Monday to Friday 07:00 to 19:00hrs Saturdays (07:00 – 13:00)	65	70	75

Assessment Category and Threshold Value Period (L_{AEQ})	Threshold Value (dB)		
	Category A	Category B	Category C
Monday to Friday 19:00 to 23:00hrs Saturday (13:00 – 23:00) Sunday (07:00-23:00)	55	60	65
Monday – Sunday (23:00 – 07:00)	45	50	55

Note:

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

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

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

The NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes (2004) also recommends threshold noise levels for the construction phase of road projects. **Table 9.8** indicates the maximum permissible noise levels at the facade of dwellings during the construction period as recommended by the NRA (Now TII). These limits are widely applied in Ireland to construction projects.

Table 9.8 Maximum permissible noise levels at the facade of dwellings during construction

Days and Times	Noise Levels (dB re. $2x10^{-5}$ Pa)	
	$L_{Aeq(1hr)}$	L_{Amax}
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 22:00hrs	60*	65*
Saturdays 08:00 to 16:30hrs	65	75
Sundays & Bank Holidays 08:00 to 16:30hrs	60*	65*

***Note:** Construction activity at these times, other than that required for emergency works, will normally require the explicit permission of the relevant local authority.

Based on the above, **Table 9.9** suggests limits considered suitable for the construction of the proposed development. Given that the majority of receptors are located adjacent to streets/ roads, the Category B levels from **Table 9.7** have been applied along with the NRA guidance levels. The threshold values specified in **Table 9.9** will be adopted as the noise criteria in the assessment of noise impacts on receptors in Section 9.2.5.

Table 9.9 Suggested noise levels at receptors during construction based on BS 5228:2009 and NRA Guidance

Days and Times	Noise Levels (dB re. $2x10^{-5}$ Pa)	
	$L_{Aeq(1hr)}$	L_{Amax}
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 23:00hrs	60	65
Saturdays 07:00 to 16:30hrs	65	75
Sundays & Bank Holidays 07:00 to 23:00hrs	60	65
Night-time 23:00 to 07:00	50	60

9.2.2 Vibration Criteria

Any potential vibration impact associated with the proposed works on the surroundings will occur during the construction phase. No vibration impacts will occur following construction.

Vibration standards are divided into two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. In both instances, the magnitude of vibration is considered in terms of Peak Particle Velocity (PPV).

Humans are particularly sensitive to vibration stimuli and any perception of vibration may lead to concern. In the case of road traffic, vibration greater than 0.5 mm/s may be disturbing. Higher levels of vibration are typically tolerated for events of short duration or single events.

The following documents contain guidance in relation to acceptable vibration within buildings:

British Standard BS 7385 - 2 (1993): *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration*, and;

British Standard BS 5228 – 2 (2009)+A1:2014: *Code of Practice for Noise and Vibration Control on Construction and Open Sites: Vibration.*

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15mm/s at low frequencies rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical buildings.

BS 5228 recommends that, for 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 particle velocity of 15mm/s for transient vibration at frequencies below 15Hz and 20mm/s at frequencies above than 15Hz. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is such that resonances are excited within structures the limits discussed above may need to be reduced by 50%.

NRA, 2004 details the permissible vibration levels during construction phase for national road schemes. These are listed in Table 9.10.

Table 9. 10 Allowable Vibration During Construction Phase

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:		
Less than 10Hz	**10 to 50Hz**	**50 to 100Hz (and above)**
8 mm/s	12.5 mm/s	20 mm/s

It is suggested that the NRA criteria be applied in the assessment of vibration impacts in Section 9.2.9.

9.2.3 Existing Environment

The Agglomeration of Limerick Noise Action Plan 2024-2028 (NAP) provides significant baseline data on the levels of noise in the Limerick area and its environs.

The Plan includes the two main noise indicators for developing strategic noise maps:

- L_{den} – the annual average noise level for the day, evening and night periods and is designed to indicate overall annoyance; and
- L_{night} – the annual average noise level for the night-time periods from 23:00 to 07:00 hourse, and it is designed to indicate sleep disturbance.

Supplementary noise indicators are also included in the plan, namely $L_{Aeq,16hr}$ (the annual average noise level for the daytime/evening periods from 07:00 to 23:00 hours) which has been approved by the EPA as the appropriate noise indicator to inform candidates for Quiet Areas.

Quiet Areas in the Limerick Agglomeration are monitored by the Council through fixed monitoring at the principal park in the city, The People's Park and began monitoring at the Castletroy Greenway in January 2023. The results of monitoring are shown below.

Table 9. 11 Results of monitoring at Castletroy Greenway in 2023 (Limerick Agglomeration - Noise Action Plan 2024-2028)

Monitoring results (2023)					Strategic Noise Mapping 2021	
$L_{Aeq,\ 16hr}$	L_{den} (dB)	L_{day} (dB)	$L_{evening}$ (dB)	L_{night} (dB)	L_{den} (dB)	L_{night} (dB)
55.2	55.6	56.1	49.6	45.1	<55	<50

The noise exposure assessment undertook as part of the Plan, indicates that noise exposure is mostly associated with road traffic. The following table shows the percentage of people exposed to different noise source within the Limerick agglomeration.

Table 9.12 Percentage of total population exposed to noise sources (Limerick Agglomeration - Noise Action Plan 2024-2028)

Noise exposure (dB Lden)	All Roads	All Railway	All Industry
55-59	24%	1%	0%
60-64	13%	1%	0%
65-69	5%	0%	0%
70-74	1%	0%	0%
>= 75	0%	0%	0%

Noise exposure (dB Lnight)	All Roads	All Railway	All Industry
55-59	10%	0%	0%
60-64	1%	0%	0%
65-69	0%	0%	0%
70-74	0%	0%	0%
>= 75	0%	0%	0%

The Environmental Noise (Amendment) Regulations 2021 set out the assessment methods for harmful effects, which considers ischaemic heart disease (IHD), high annoyance (HA) and high sleep disturbance (HSD).

For the Limerick agglomeration area, with a total population of 101,028 persons, around 9% might be affected by road noise and display health effects (ischaemic heart disease, highly annoyed, highly sleep disturbed). While a 0.4% might be affected by railway noise and display harmful effects such as high annoyance and sleep disturbance (NAP 2024-2028).

The most relevant source of environmental noise within the Limerick Agglomeration is road traffic, where there is a total 42,900 people in dwellings exposed to road traffic noise greater or equal to 55 dB L_{den}, in comparison to 1,600 people exposed to railway source and 0 from industry sources.

The following figures show the strategic noise maps for road traffic and industry, included in the Limerick Agglomeration NAP 2024-2028, highlighting the location where the proposed greenway will be located.

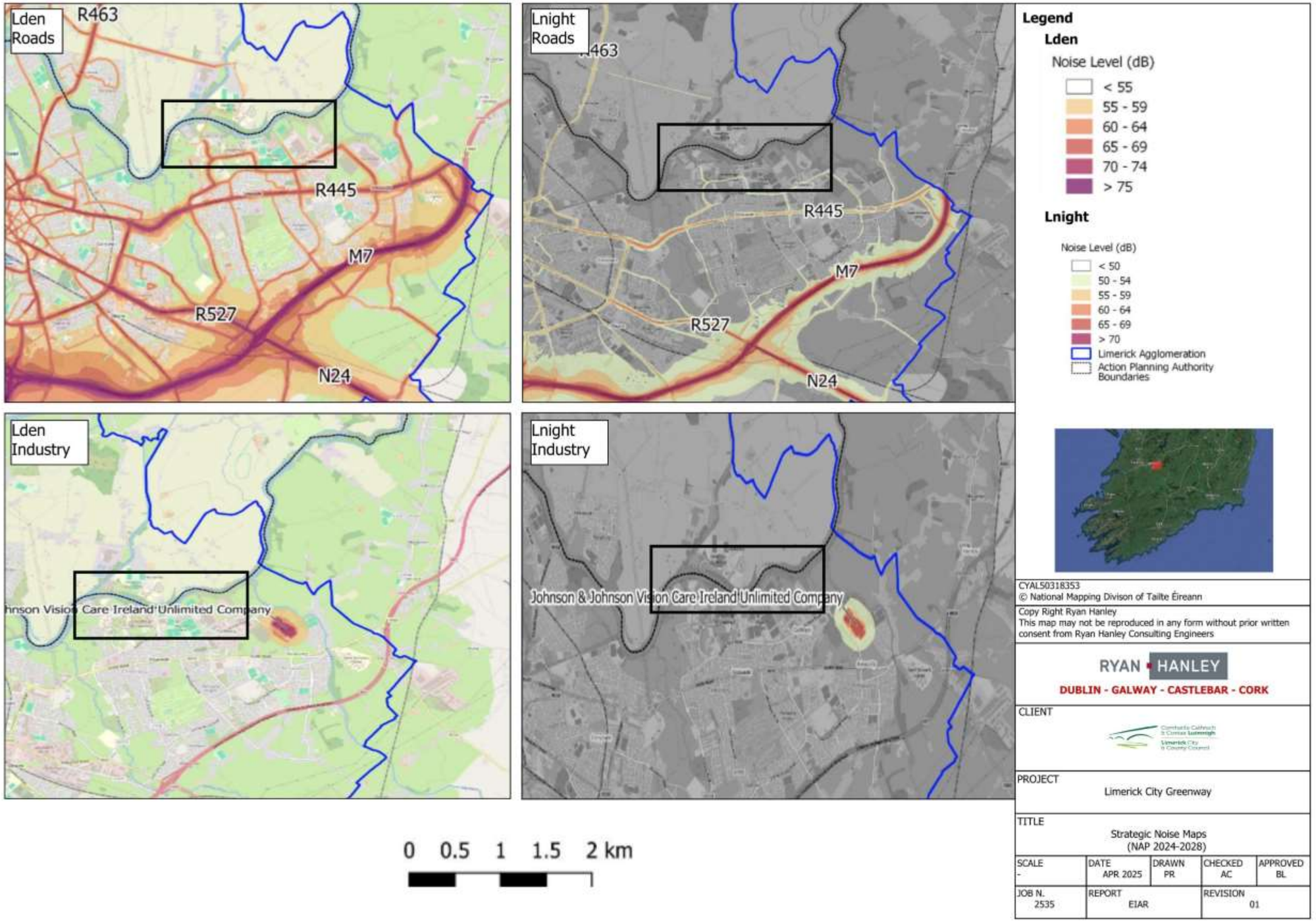

Figure 9.1 Strategic Noise Map for Road and Industry (Limerick Agglomeration NAP 2024-2028)

9.2.4 Potential Impacts – Noise

9.2.4.1 'Do Nothing' Scenario

If the proposed development were not to proceed, the existing noise and vibration environment would remain unchanged.

9.2.4.2 Noise Sensitive Receptors

Sensitive receptor locations are defined by TII[2] guidance as *residential housing, schools, hospitals, places of worship, sport centres and shopping areas i.e. locations where members of the public are likely to be regularly present*. Sensitive receptors were identified along the greenway route considering the path, temporary working areas and construction compounds. **Figure 9.4** shows the location of the noise sensitive receptors that have been identified as being in close proximity to the proposed works areas. **Table 9.13** provides further details relating to the Noise Sensitive Locations (NSLs).

Table 9.13 Distance from Works Noise Emission to Nearest NSLs

NSL	Location	Works Section/s
NSL1	Dromroe Student Village and UL Language Centre	Temporary working area 1 / Compound 2
NSL2	UL Physical Education and Sport Sciences (PESS) Building	Compound 2 and 3
NSL3	Kilmurry Student Village (Western Block)	Compound 3
NSL4	Kilmurry Student Village (Eastern Block)	Compound 3

[2] 'Air Quality Assessment of Specified Infrastructure Projects – Overarching Technical Document' (TII, 2022), and 'Air Quality Assessment of Proposed National Roads-Standard' (TII, 2022)

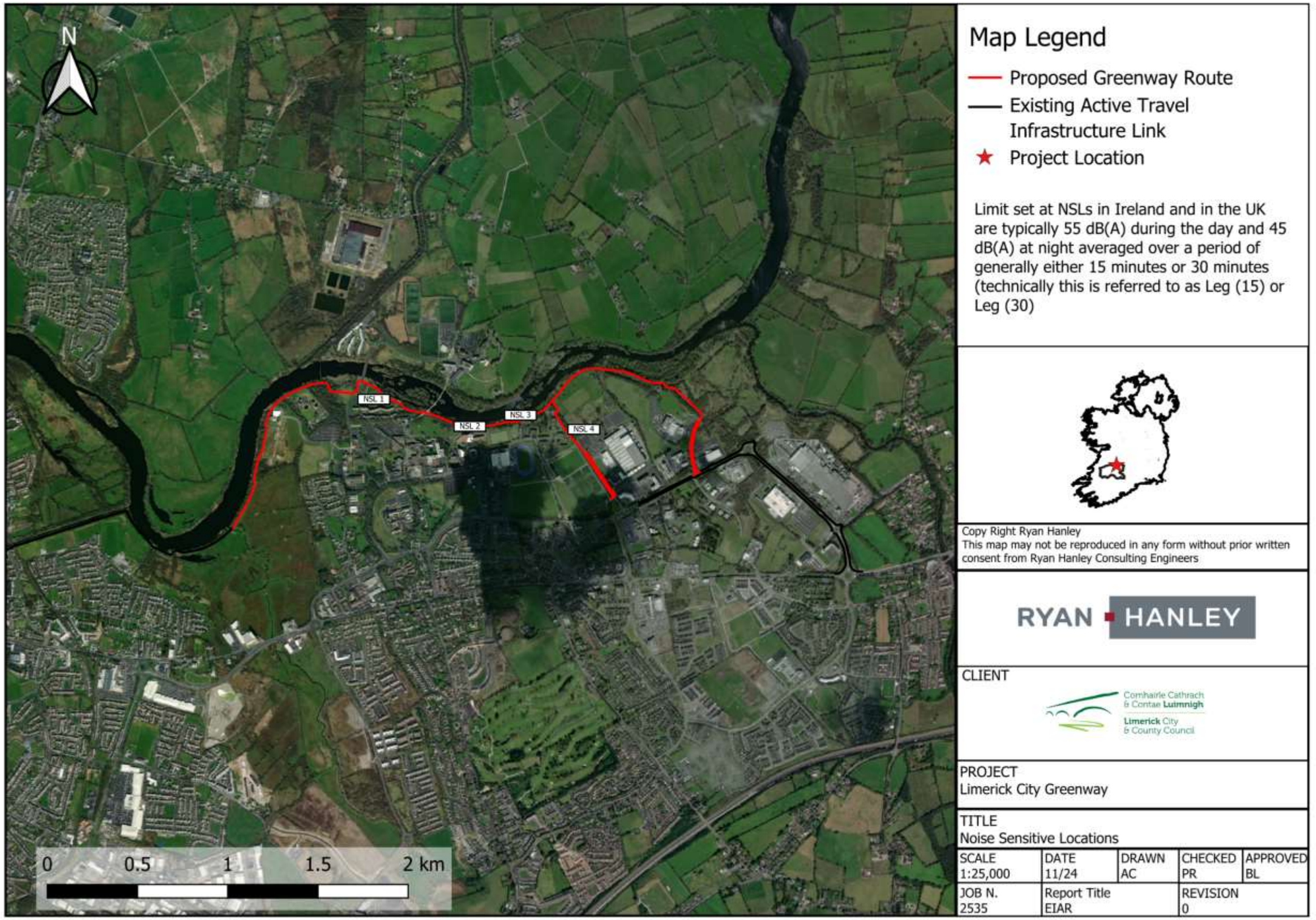

Figure 9.4 Noise Sensitive Locations (NSL) Map

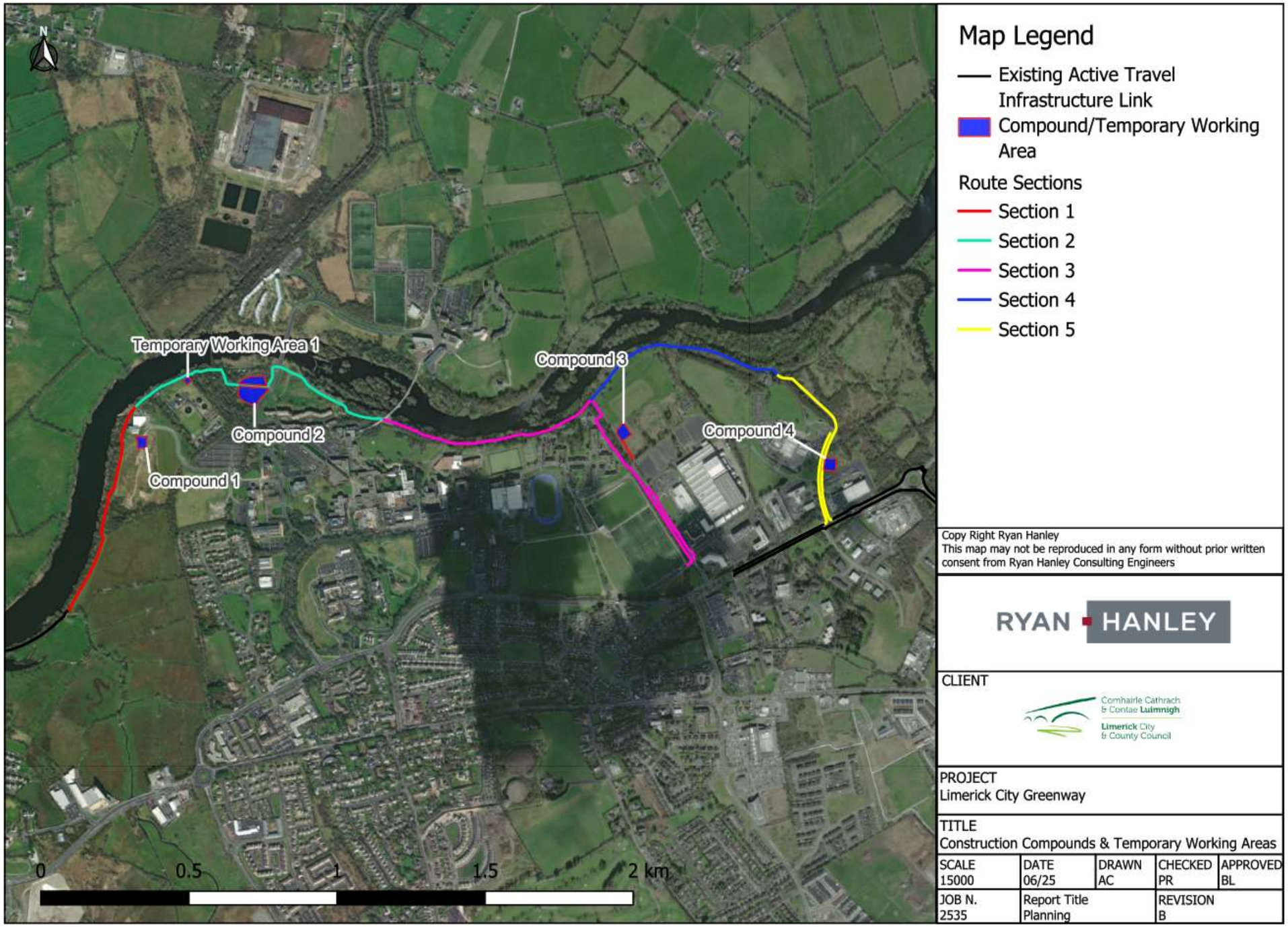

Figure 9.5 Site compounds and temporary working areas locations

9.2.4.3 Potential Impact - Noise

Works associated with the proposed development that may contribute to noise impact during the construction phase are as follows:

- Site compound set up;
- Compound operations;
- Site clearance and installation of temporary access roads;
- Installation of tree root protector;
- Installation of utilities/ services, construction of drainage infrastructure including open drains, installation of lighting;
- Construction of haul roads, and Greenway;
- Construction of bridges and stream crossings by culverts/concrete beams;
- Landscaping, reinstatement, and surfacing, and
- HGV movements delivering to construction compounds.

9.2.4.3.1 Construction Works

A variety of items of plant will be in use for each of these work activities, such as excavators, lifting equipment and dump trucks, as set out in **Table 9.14**. Site clearance and installation of temporary access road works are expected to have the highest noise emissions.

The following factors are noted in relation to the prediction of noise impacts associated with the construction of the proposed Greenway;

- The construction programme has been established in outline form only and is presented in Chapter 4;
- The timing, duration and amplitude of noise emissions associated with each activity will vary considerably;
- Construction details and plant and machinery requirements are likely to change on a regular basis during construction. In additional each individual noise source will be relocated frequently e.g. excavators, dumper trucks etc; and
- There will be extended periods when little or no noise emissions arise.

Due to the above factors, it is not possible to calculate the actual magnitude of noise emissions to the local environment. However, the following section presents calculations of indicative noise levels for typical noise sources associated with each of the identified activity types.

Table 9.14 presents the expected sound pressure level (SPL) in the works areas based on typical plant sound pressure levels at 10 m as specified in BS 5228: 2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.*

Table 9.14 Expected sound pressure level (SPL) at 10m

Activity	Equipment	SPL at 10 m	Total SPL at 10 m
Compound Set Up	14T Excavator x1 (C.2.25)	69 dB	83 dB
	Dump Truck x 1 (C.2.30)	79 dB	

Activity	Equipment	SPL at 10 m	Total SPL at 10 m
	Truck x 1 (C.2.34)	80 dB	
Compound Operations	Generator x 1 (C.6.39) Truck x 2 (C.2.34) 25T Excavator x1 (C.2.19)	65 dB 80 dB 77 dB	84 dB
Site clearance & installation of temporary access road	14T Excavator x1 (C.2.25) Dump Truck x1(C.2.30) Truck x 1(C.2.34) Chainsaw x 2 (D.2.14)	69 dB 79 dB 80 dB 86 dB	90 dB
Construction of Greenway and surfacing	14T Excavator x1 (C.2.25) Dump Truck x2 (C.2.30)	69 dB 79 dB	82 dB
Installation of utilities/ services, Construction of drainage infrastructure including French drains, Installation of Lighting / CCTV	14T Excavator x1 (C.2.25) Dump Truck x1 (C.2.30)	69 dB 79 dB	80 dB
Installation of tree root protector	Tractor and Flat-bed trailer x 1(C.4.75)	79 dB	79 dB
Construction of bridges and stream crossings by culverts/ concrete beams	25T Excavator x 1 (C.2.19) Tractor and Flat-bed trailer x1 (C.4.75) 50T Crane x 1(C.4.46)	77 dB 79 dB 67 dB	81 dB

The calculated noise impacts at the NSLs illustrated in Figure 9.4 are presented in Table 9.13Error! Reference s ource not found., based on the distance from the relevant works area to the closest point at each of the NSLs.

A worst-case scenario has been assumed whereby the listed plant items are assumed to be in operation cumulatively at the closest point to each of the noise sensitive locations. The assessment does not take account of any screening. In each instance, source information was obtained from BS 5228: 2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise* which sets out typical noise levels for items of construction plant.

A summary of the impacts presented in Table 9.13 is provided below in light of the 70 dB $L_{AEQ\ (1hr)}$ criterion discussed in Section 9.2.1.

Table 9.15 Predicted Noise Levels at NSLs

Works Element	Predicted Noise Level at NSL Locations (dB $L_{Aeq, 1hr}$)			
	1	2	3	4
Site Compound Set Up	**73**	59	59	59
Compound Operations	**76**	60	60	60
Site Clearance and Installation of Temporary Access Road	**82**	66	66	66
Construction of Greenway and surfacing	**73**	**71**	**78**	**78**
Installation of utilities/ services, Construction of drainage infrastructure including French drains, Installation of Lighting	**72**	69	**72**	**74**
Installation of tree root protector	**71**	69	**74**	**74**
Construction of bridges and stream crossings by culverts/ concrete beams	57	57	65	57

As specified above, the calculated levels listed above are commensurate with a worst-case condition, that would only occur during the short span of time, that the listed plant items are at the closest point to each of the noise sensitive locations and assuming that no screening is in place. The worst-case scenario is unlikely to occur routinely, if at all.

Site Compound Set Up

Potential Temporary Imperceptible to Significant Negative Impact

four temporary compounds are proposed at the locations shown in Figure 9.5. The site compound set up will involve site clearance and the removal and delivery of materials to and from the works area. Based on the assessment, a number of dwellings at NSL 1 (Dromroe Student Village) within 25 m of Site Compound 2 may be subject to LAEQ (1h) levels above 70 dB in the absence of mitigation. Works to set up each of the compounds will be carried out over a short duration and are anticipated to last for approximately 10 days. This constitutes a potential temporary significant negative impact at NSL1 for receptors within 25m of site Compound 2, in the absence of mitigation measures. Noise impacts are expected to be imperceptible to not significant at NSL 2, 3 and 4.

Site Compound Operations

Potential Temporary Imperceptible to Significant Negative Impact

The primary sources of noise emission from the site compounds will include the transport of materials to and from the compounds, and the running of a generator. Based on the assessment, a number of dwellings at NSL1 (Dromroe Student Village) that are within 25 m of Site Compound 2 may be subject to LAEQ (1h) levels above 70 dB in the absence of mitigation. Operations at Site Compound 2 are anticipated to last for 120 days. In the absence of mitigation, this constitutes a potential temporary significant negative impact for receptors at NSL1 that are in close proximity of Site Compound 2. Noise impacts due to site compound operations are anticipated to be imperceptible to slight negative at NSLs 2, 3 and 4.

Site Clearance and Installation of Temporary Access Road

Potential Temporary Not Significant to Significant Negative Impact

Site clearance will be required within the temporary works areas. Works will include the removal of topsoil, vegetation clearance and removal of existing infrastructure items which are obstacles to the proposed Greenway. Temporary access roads will be installed to facilitate the construction of the Greenway and will subsequently form the subbase layers of the Greenway. Works will include vegetation cutting/clearance with a chainsaw, excavation, and delivery and placing of subbase layers. Based on the assessment, receptors within 90 m of the proposed site clearance and temporary access road works areas may be subject to $L_{AEQ\ (1h)}$ levels above 70 dB in the absence of mitigation. These include NSLs 1; Dromore Student Village. The works will be ongoing for a short duration and are anticipated to take 1-5 days depending on the construction compound or haul route. This constitutes a potential temporary significant negative impact for receptors within 90 m of the site clearance and temporary access road works areas. Noise impacts at NSL2, 3 and 4 are expected to be not significant.

Construction of Greenway and Surfacing

Potential Temporary Moderate to Significant Negative Impact

Works to construct the Greenway will include excavation, earthmoving and delivery of materials to the works areas. Based on the assessment, receptors within 40 m of the proposed Greenway works areas may be subject to $L_{AEQ\ (1h)}$ levels above 70 dB in the absence of mitigation. These include all the Noise Sensitive Locations given their proximity to the proposed greenway route. The works will be ongoing for a temporary period and are anticipated to take 90-150 days for different sections. In the absence of mitigation, this constitutes a potential temporary moderate to significant negative impact for receptors within 40 m of the Greenway construction and surfacing works.

Installation of utilities/services, construction of drainage infrastructure, installation of lighting

Potential Temporary Not Significant to Significant Negative Impact

The installation of utilities/services, construction of drainage infrastructure and installation of lighting along the Greenway will require excavation and delivery of materials to the site. Based on the assessment, receptors within 30 m of the proposed Greenway works areas may be subject to $L_{AEQ\ (1h)}$ levels equal to or above 70 dB in the absence of mitigation. These include Dromroe village (NSL1), Kilmurray village -west (NSL3), Kilmurray village – east (NSL4) that are within 30m of the works. Utility, drainage and lighting works are anticipated to take 20-30 days in each section. This constitutes a potential temporary significant negative impact for receptors within 30m of the works in Section 3. Noise impacts at NSL2 are anticipated to be not significant.

Installation of Tree Root Protector

Potential Temporary Imperceptible to Significant Negative Impact

The installation of tree root protector will require the use of a mini digger, dump truck, and utility vehicle.

Based on the assessment, receptors within 29 m of the proposed works areas may be subject to $L_{AEQ\ (1h)}$ levels above 70 dB in the absence of mitigation. These include dwellings at Dromroe Village (NSL1), Kilmurray village – west (NSL3) and Kilmurray village – east (NSL4) that are within 29 m of the works area. Tree root protection works are anticipated to take 2-5 days in each of these works areas. This constitutes a potential temporary significant negative impact for receptors within 29 m of tree root protection works at NSL1, NSL3 and NSL4. in the absence of mitigation. Noise impacts at NSL2 are anticipated to be imperceptible to not significant.

Construction of Bridges and Stream Crossings by Culverts/Concrete Beams

Potential Temporary Not Significant

5 no. new bridges and stream crossings will be constructed along the route of the Greenway as detailed in Chapter 4, Section 4.1.8. Works will include excavation works, delivery of materials the works areas and installation of prefabricated or precast units. Based on the assessment, the noise impacts associated with the construction of bridges and stream crossings are anticipated to be a temporary not significant impact at NSLs 1, 2, 3 and 4 as the proposed bridge works will be at a greater distance of 34 m from the NSLs.

9.2.4.3.2 HGV Movements

Potential Temporary Not Significant Impact

The construction phase of the proposed Greenway will give rise to additional traffic which may incur a noise impact on the adjacent noise sensitive locations. Construction traffic will access the works areas along the existing roads and temporary access roads shown on the planning drawings.

The noise level associated with an event of short duration, such as a passing vehicle movement, may be expressed in terms of its Sound Exposure Level (L_{AX}). The Sound Exposure Level can be used to calculate the contribution of an event or series of events to the overall noise level in a given period.

The appropriate formula is given below:

$$L_{Aeq,T} = L_{AX} + 10\log_{10}(N) - 10\log_{10}(T) - 20\log_{10}(r_2/r_1)dB$$

where:

$L_{Aeq,T}$ is the equivalent continuous sound level over the time period T (in seconds);

L_{AX} is the "A-weighted" Sound Exposure Level of the event considered (dB);

N is the number of events over the course of time period T;

r_1 is the distance at which L_{AX} is expressed;

r_2 is the distance to the assessment location.

The mean value of Sound Exposure Level for truck moving at low to moderate speeds (i.e. 15 to 45km/hr) is in the order of 82 dB L_{AX} at a distance of 5 metres from the vehicle. This figure is based on a series of measurements conducted under controlled conditions.

As specified in Chapter 13, the average daily construction traffic ranges is estimated to be between 4 to 24 round trips per day while works are being carried out at each works section. Assuming a worst-case scenario, whereby all HGV movements required for completion of each section work are assumed to take place on the same day, the maximum daily number of HGV round trips during the construction phase of the Greenway in each works section is anticipated to be 28 round trips. Using the equation detailed above and taking into account the attenuation due to distance, and assuming a worst-case scenario that all trips take place within one hour, the predicted noise levels at each of the noise sensitive locations (NSLs) to the main haulage routes are listed in Table 9.16.

Table 9.16 Predicted construction traffic noise emission at nearest NSLs

Location	Distance From Roadway / Easement (m)	HGV Sound Exposure Level at 5 metres (dB,L_{AX})	Predicted Noise Level (dB, $L_{Aeq,1hr}$)
NSL1	20	82	41

Location	Distance From Roadway / Easement (m)	HGV Sound Exposure Level at 5 metres (dB,L_{AX})	Predicted Noise Level (dB, $L_{Aeq,1hr}$)
NSL2	400		15
NSL3	180		22
NSL4	20		41

The predicted noise emission levels range between 15 dB and 53 dB $L_{Aeq,1hr}$ with 53 dB $L_{Aeq,1hr}$ being the expected maximum at the any remaining noise sensitive locations along construction traffic routes that are located immediately adjacent to the road (i.e. < 10 m away). These predicted noise levels are within the minimum design criterion of 70dB L_{Aeq}. Therefore, the impact of construction traffic on the local environment is expected to be a temporary not significant impact.

9.2.4.4 Mitigation Measures – Noise

In order to sufficiently ameliorate the likely noise impacts from the construction of the proposed works, a schedule of noise and vibration control measures has been formulated for the construction phase and are further detailed in the Construction Environmental Management Plan (CEMP) (Appendix 4C). Any measures to be carried out by third parties will be contractual obligations.

Reference will be made to BS 5228-1: 2009+A1:2014: *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise*, which offers detailed guidance on the control of noise & vibration from demolition and construction activities.

In particular, it is proposed that various practices be adopted during construction, including:

- where noise levels at NSLs are anticipated to exceed the daytime noise criteria, hoarding extending to a height of 2.4 m will be erected at the works boundary between the works area and the NSL. If such measures are installed, the construction operations are expected to meet or be less than the 70 dB $L_{Aeq(1hr)}$ criterion in the majority of cases as shown in Table 9.13.
- limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- establishing channels of communication between the contractor/developer, Local Authority and residents;
- appointing a site representative responsible for matters relating to noise;
- monitoring typical levels of noise during critical periods and at sensitive locations

Furthermore, a variety of practicable noise control measures will be employed. These will include:

- selection of plant with low inherent potential for generation of noise;
- erection of enclosures as necessary around noisy processes and items such as generators and heavy mechanical plant;
- placing of noisy plant as far away from sensitive properties as permitted by site constraints.

If noise levels are non-compliant during the construction activities, the below should be followed:

- Reschedule specific activities: temporarily halt and reschedule works that are causing exceedances.
- Additional barriers: install more robust noise shielding solutions.

- Set up a community liaison and complaint mechanism. Investigate and address noise complaints promptly.

Noise disturbance to fauna is addressed in detail in Chapter 6 – Biodiversity of this EIAR. Noise thresholds will be complied with as specified in Table 9.7 to avoid any potential impacts to the environment and the population in the area.

9.2.4.5 Monitoring – Noise

During the proposed works, noise monitoring will be conducted during construction activities that have been identified as potentially exceeding the 70 dB $L_{Aeq(1hr)}$ criterion at NSLs. It is considered that short term attended noise measurements would be appropriate to ensure that the project design criteria are being met. The Construction Environmental Management Plan (CEMP) defines the critical periods, persons responsible for monitoring and the noise sensitive locations that will be monitored and is provided in Appendix 4C.

The following survey methodology will be employed for attended noise monitoring:

- measure LAeq, LAMax, LAMin, LA10 and LA90 over a sample period of 15 minutes;
- detailed notes will be taken in relation to primary noise sources, weather and prevailing winds;
- measurements will be conducted at various locations on a cyclical basis over the course of a typical day.

Noise monitoring will be conducted in accordance with ISO 1996: 2007: *Acoustics – Description, measurement and assessment of environmental noise*.

9.2.4.6 Residual Impact – Noise

Temporary Imperceptible to Moderate Negative Impact

During the construction phase, noise impacts at all receptors will be temporary and localised. With the mitigation measures specified in Section 9.2.6 in place, impacts will be imperceptible at the majority of receptors, as detailed in Table 9.15. The assessment assumes a worst-case scenario that would only occur during the short span of time, that the listed plant items are at the closest point to each of the noise sensitive locations. The worst-case scenario is unlikely to occur routinely, if at all.

Table 9. 17 Residual noise levels at NSLs with screening in place (worst case scenario)

Works Element	Predicted Noise Level at NSL Locations (dB $L_{Aeq, 1hr}$)			
	1	2	3	4
Site Compound Set Up	69	54	54	54
Compound Operations	67	50	50	50
Site Clearance and Installation of Temporary Access Road	**72**	56	56	56
Construction of Greenway and surfacing	65	65	67	67

Installation of utilities/ services, Construction of drainage infrastructure including French drains, Installation of Lighting	63	59	65	65
Installation of tree root protector	60	59	63	65
Construction of bridges and stream crossings by culverts/ concrete beams	47	47	55	47

At a number of dwellings, impacts will range from temporary slight negative to moderate negative. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise control measures such as screening will ensure that noise impact is kept to a minimum. The residual impact will be a temporary imperceptible to moderate negative impact.

9.2.5 Potential Impact – Vibration

Potential Temporary Slight to Moderate Negative Impact

The majority of the construction activities which will be employed during the construction phase of the Greenway with the exception of the installation of piles at proposed Bridge No. 2 and Bridge No. 5 are unlikely to generate perceptible vibrations at the sensitive locations.

Piling activity is generally one of the most significant sources of vibration on construction sites.

Assuming worst-case scenario and the use of traditional piling methods, this will likely result in a temporary negative impact ranging in severity depending on the distance from the sensitive receptor to the works location. Therefore, assuming the worst-case scenario, there is likely to be a slight to moderate amount of vibration impact at NSL 1, although it would occur over short durations.

9.2.5.1 Mitigation Measures – Vibration

In order to sufficiently ameliorate any likely vibration impacts from the proposed works, a schedule of noise and vibration control measures has been formulated for the construction phase and are detailed in the Construction Environmental Management Plan (CEMP) (Appendix 4C).

Reference will be made to BS 5228-1: 2009: *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 2: Vibration*, which offers detailed guidance on the control of vibration from demolition and construction activities. In particular, the following practices will be adopted during construction:

- establishing channels of communication between the contractor/developer, Local Authority and residents;
- appointing a site representative responsible for matters relating to vibration;
- monitoring typical levels of vibration during critical periods and at sensitive locations

Furthermore, a variety of practicable vibration control measures will be employed. These will include:

- selection of plant with low potential for generation of vibration;
- The vibration transmission associated with piling can be significantly reduced if piling operations are conducted using methods that are viable to reducing vibration impacts such as the 'press-in' method. Although the exact levels will depend on ground composition, research indicates that vibration levels

at a distance of 10m from the piling rig would be of the order of 1mm/s (White et al. 2002). This level is well below the BS 5228 guidance criteria limits. If traditional piling methods are employed, a test pile will be erected at the piling location closest to the nearest sensitive location. Vibration monitoring will then be conducted to confirm that ground borne vibration will be within the guidance criteria limits listed in Table 9.10 and that no structural damage will therefore occur to adjacent buildings.

- Vibration from construction activities will be limited to the values set out in Table 9.10.
- Table 9. 10 Vibration monitoring will also be conducted at locations along the bed of the mill race which is close to piling activities on Plassey Beach to ensure that vibration will not adversely affect the aquatic environment. Ensure the duration of piling activities is short and temporary;
- Placing of vibratory plant as far away from sensitive properties as permitted by site constraints and the use of vibration isolated support structures where necessary.

9.2.5.2 Monitoring – Vibration

During the proposed works, vibration monitoring will be conducted during construction activities that may give rise to vibration. It is considered that short term attended vibration measurements would be appropriate to ensure that the project design criteria are being met. The Construction Environmental Management Plan defines the critical periods, persons responsible for monitoring and the sensitive locations that will be monitored and is provided in Appendix 4C.

The following survey methodology will be employed for attended vibration monitoring or test pile measurements:

- measure the maximum PPV at each location over a sample period of 15 minutes;
- detailed notes will be taken in relation to primary vibration sources;
- measurements will be conducted at the locations on a cyclical basis over the course of a typical day (attended vibration monitoring only).

Vibration monitoring will be conducted in accordance with either BS 7385-1 (1990) *Evaluation and measurement for vibration in buildings — Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings* or BS 6841 (1987) *Guide to Measurement and Evaluation of Human Exposure to Whole-Body Mechanical Vibration and Repeated Shock* as appropriate.

9.2.5.3 Residual Impact – Vibration

Temporary Imperceptible Negative Impact

With the implementation of the above mitigation measures and monitoring, the likely impact of vibration from the proposed construction works on the local environment will be a temporary imperceptible negative impact.

9.3 CUMULATIVE AND IN-COMBINATION IMPACT ASSESSMENT

9.3.1 Cumulative Impact Assessment

All elements of the proposed development were assessed in order to identify any cumulative effects.

Site activity during the construction phase of the Greenway could give rise to noise that could cause potential disturbance to fauna. All construction activities will be temporary in nature with limited interaction on sensitive habitats and will progress across the four works sections, minimising the duration of works in any one area.

The movement of construction vehicles both within and to and from the works areas has the potential to give rise to noise and dust nuisance impacts during the construction phase. However, these effects and the measures that are in place to avoid any cumulative or interactive effects are fully described in this EIAR.

The operation of construction plant and machinery during the construction phase of the Greenway has the potential to give rise to emissions which can impact human health, air quality. However, these effects and the measures that are in place to avoid any cumulative or interactive effects are fully described in this EIAR.

Based on the assessment of all elements of the proposed development, no significant cumulative effects relating to air quality, noise and vibration are anticipated.

9.3.2 In-Combination Impact Assessment

The potential cumulative effects on air quality, noise and vibration between the proposed development and other plans and projects in the vicinity, as presented in Chapter 3, Section 3.5 of the EIAR, were also assessed.

Air Quality

The construction phase of the proposed Greenway, in combination with the construction phases of projects listed in Chapter 3 will have the potential to negatively impact on air quality of the area due to cumulative dust and construction plant emissions. The mitigation measures employed during the construction phase of the proposed development will minimise the contribution that it will make towards impacting on air quality. Given that existing baseline levels of NO_2, PM_{10}, $PM_{2.5}$, CO and benzene are likely to be below ambient air quality limit values in the vicinity of the proposed works, and with mitigation measures in place, there is the potential for a short-term negligible cumulative impact in terms of air quality. Overall, the proposed Greenway will constitute a permanent positive impact during the operation phase due in terms of air quality by reducing the amount of air pollutants that would otherwise have been emitted from transport vehicles if the Greenway was not available.

Noise & Vibration

In the unlikely event of all of the projects listed in Chapter 3 being constructed simultaneously, there is a potential for a short-term slight to moderate negative cumulative noise and vibration impact. With implementation of the mitigation measures listed in 9.2.6 and 9.2.10 above during the construction phase, the potential cumulative impact that this project will be minimised. Any impacts from the proposed Greenway will be temporary and transient in nature as the works progress along the four proposed works sections. Impacts will also differ between receptors, depending on distance to the works areas, and the type of works being carried out in the area. Given the mitigation measures being implemented for the construction phase of the Greenway, and depending on the receptor in question, there is potential for no impact or a temporary imperceptible to moderate negative cumulative impact.

Based on the assessment of the proposed development in combination with all other programmes and projects in the vicinity, no significant in-combinate cumulative effects relating to air quality, noise and vibration are anticipated.

REFERENCES

Aidan Finn – Limerick City and County Council (LCCC), personal communication, Oct 2022

BS 5228-1: 2009: Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1: Noise

BS 5228-2 (2009): Code of Practice for Noise and Vibration Control on Construction and Open Sites: Vibration

BS 6841 (1987) Guide to Measurement and Evaluation of Human Exposure to Whole-Body Mechanical Vibration and Repeated Shock

BS 7385-2 (1993): Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration

BS 7385-1 (1990) Evaluation and measurement for vibration in buildings — Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings

Burtscher H (2005) Physical characterization of particulate emissions from diesel engines: a review. Aerosol Sci 36:896–932

DOEHLG 2004, Quarries and Ancillary Activities, Guidelines for Planning Authorities

DoPHLG 2018, Guidelines for Planning Authorities and An Bord Pleanála on Carrying out Environmental Impact Assessment

EC 2017, Guidance on the Preparation of the Environmental Impact Assessment Report

EEA, 2019, Air Quality in Europe – 2019 Report, European Environment Agency, ISBN: 978-92-9480-088-6

EPA 2017, Guidelines on the information to be contained in Environmental Impact Assessment Reports (DRAFT August 2017)

EPA (2016) Guidance Note for Noise: License Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)

EPA, 2016, Ireland's Environment 2016 – An Assessment, ISBN 978-1-84095-679-5

EPA, 2017, Air Quality in Ireland 2016, Key Indicators of Ambient Air Quality. ISBN 978-1-84095-719-5

EPA, 2017, National Ambient Air Quality Monitoring Programme 2017- 2020. ISBN: 978-1-84095-807-2

EPA, 2019 Air Quality in Ireland 2018

EPA. 2018, Air Quality in Ireland 2017, Key Indicators of Ambient Air Quality. ISBN: 978-1-84095-807-2

EPA, 2020, Air Quality in Ireland 2019. IBSN: 978-1-84095-940-6

EPA, 2024, Air Quality in Ireland 2023, ISBN: 978-1-80009-194-8

EU Directive 2008/50/EC, Direction 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe

EU Directive 2024/2881 of the European Parliament and of the Council of 23 October 2024 on ambient air quality and cleaner air for Europe (recast) [2024] OJ L, 2024/2881 (AAQD)

IAQM U GUIDANCE, 2018. Construction Dust Monitoring Guidance on Monitoring in the Vicinity of Demolition and Construction Sites Institute of Air Quality Management.

ISO 1996: 2007: Acoustics – Description, measurement and assessment of environmental noise.

LCCC, March 2024. Limerick City and County Council. Air Quality Report for Limerick March 2024.

NRA 2004, Guidelines for the Treatment of Noise and Vibration in National Road Schemes, National Roads Authority, 2004

Reșitoğlu, İ.A., Altinișik, K. & Keskin, A. The pollutant emissions from diesel-engine vehicles and exhaust aftertreatment systems. Clean Techn Environ Policy 17, 15–27 (2015). https://doi.org/10.1007/s10098-014-0793-9

S.I. No. 180/2011 Air Quality Standards Regulations 2011

S.I. No. 739/2022 Ambient Air Quality Standards Regulations 2022

Sandanayake M. (&) G. Zhang S. Setunge C.M. Thomas. 2015. Environmental Emissions of Construction Equipment Usage in Pile Foundation Construction Process—A Case Study (in L. Shen et al. (eds.), Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate, DOI 10.1007/978-3-662-46994-1_28

Transport Infrastructure Ireland (TII) (NRA) (2004) Guidelines for the Treatment of Noise and Vibration in National Road Schemes.

Transport Infrastructure Ireland (TII) (2014) Good Practice Guidance for the Treatment of Noise and Vibration during the Planning of National Road Schemes.

White et al, 2002. Press-In Piling: Ground Vibration and Noise During Pile Installation. David Whit, Tim Finlay, Malcolm Bolton and Grant Beatss

WHO 2006, World Health Organisation, Air Quality Guidelines: Global Update-2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide

WHO 2010, Exposure to Benzene: A Major Public Health Concern, World Health Organisation, https://www.who.int/ipcs/features/benzene.pdf, 2010