Environmental Impact Assessment Report

Chapter 8 Noise and Vibration

Grangemouth Flood Protection Scheme 2024
Falkirk Council

GRANGEMOUTH
Flood Protection Scheme
Protecting the heart of our communities

Grangemouth Flood Protection Scheme

Environmental Impact Assessment Report

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Contents

Tables

Appendices

Acronyms

AAWT	Annual Average Weekday Traffic
BPM	Best Practicable Means
BS	British Standard
BSI	British Standards Institution
CoPA	Control of Pollution Act
CEMP	Construction Environmental Management Plan
dB	Decibel (unit)
dB(A)	A-Weighted Decibel (unit)
DMRB	Design Manual for Roads and Bridges
DoE AL 72	The Department of the Environment Advisory Leaflet 72
EIA	Environmental Impact Assessment
EHO	Environmental Health Officer
EPA	Environmental Protection Act
FLDP2	Falkirk Local Development Plan 2
H	Hertz (unit)
IEMA	Institute of Environmental Management and Assessment
ISO	International Organisation for Standardisation
$L_{Aeq,T}$	A-weighted Equivalent Continuous Sound Pressure Level over a period of time T
m	Metres (unit)
m/s	Metres per second (unit)
mm/s	Millimetres per second (unit)
NPF4	National Planning Framework 4
PPV	Peak Particle Velocity
s	Seconds (unit)
VDV	Vibration Dose Value

8. Noise and Vibration

8.1 Introduction

This chapter presents the results of the noise and vibration assessment undertaken for the Scheme.

The assessment considers the potential noise and vibration effects from construction on sensitive receptors located within the vicinity of the Scheme. The operational activities associated with the Scheme will consist of maintenance works and, as such, are not expected to generate noise and vibration impacts that would result in significant effects. The assessment of operational noise and vibration has therefore been scoped out of this assessment, as stated in the Scoping Report (Appendix C3.1) and agreed by Falkirk Council. Table 8-1 summarises the elements covered.

Table 8-1: Noise and vibration assessment elements scoped in (✓) or scoped out (x)

Element	Scoped in / out
Construction noise	✓
Construction vibration	✓
Construction road traffic noise	✓
Operational noise	x
Operational vibration	x
Operational road traffic noise	x

Sensitive receptors identified in this assessment include residential buildings, educational facilities, hospitals, hotels, community facilities and places of worship.

Baseline noise levels were measured in February 2018 at locations representative of sensitive receptors. It is considered that this baseline still provides a valid representation of the noise climate in the area since there have been no major developments that could have influenced the baseline by a noticeable amount. Representative sensitive receptor locations have been selected as the closest to the proposed construction works, representing the worst-case locations.

As part of this assessment, calculations of the likely noise and vibration levels expected during construction have been undertaken to identify any potential impacts and associated mitigation measures. The effects of noise and vibration on ecological receptors are not considered as part of this assessment and are provided separately in Chapter 7: Biodiversity.

8.2 Policy and legislative framework

This Section presents the key legislation, policies and guidance that are relevant to the noise and vibration assessment.

8.2.1 Planning Policy

The Development Plan relevant to the Falkirk Council area is comprised of the National Planning Framework 4 (NPF4) (The Scottish Government, 2023) and the Falkirk Local Development Plan 2 (FLDP2) (Falkirk Council, 2020). NPF4 is the more recent publication, adopted by the Scottish Ministers in February 2023. FLDP2 was adopted by Falkirk Council in 2020. Both plans are read together, however where there is any difference in policy content the more recent publication takes precedence, in this case NPF4. There are no policies specifically relating to Noise and Vibration in FLDP2. The policy in NPF4 which is of key relevance to the topic of Noise and Vibration is summarised below:

Policy 23 Health and Safety: the intention of this policy is: *"To protect people and places from environmental harm, mitigate risks arising from safety hazards and encourage, promote and facilitate development that improves health and wellbeing."*

In relation to noise assessment, Policy 23 also states that: *"Development proposals that are likely to raise unacceptable noise issues will not be supported. The agent of change principle applies to noise sensitive development. A Noise Impact Assessment may be required where the nature of the proposal or its location suggests that significant effects are likely."*

8.2.2 Planning Advice Note (PAN) 1/2011 Planning and Noise

PAN1/2011 Planning and Noise was published in March 2011 (PAN1/2011), replacing PAN56 and Circular 10/1999, to provide guidance on the role of the planning system to control and limit the adverse effects of noise. Paragraph 2 of PAN1/2011 states that it:

"promotes the principles of good acoustic design and a sensitive approach to the location of new development. It promotes the appropriate location of new potentially noisy development, and a pragmatic approach to the location of new development within the vicinity of existing noise generating uses, to ensure that quality of life is not unreasonably affected, and that new development continues to support sustainable economic growth".

(PAN) 1/2011 promotes the principles of good acoustic design and a sensitive approach to the location of new development.

Technical Advice Note (TAN) 'Assessment of Noise' is supplementary guidance to PAN1/2011 on the technical evaluation of noise assessment. It is of relevance in this assessment as it explains the methods to be employed to assess the potential noise impacts that could arise during construction of the Scheme.

TAN states that the assessment should provide a full understanding of the existing acoustic environment, identify where the likely receptors are deemed sensitive and consider the nature of the development in order to assess the impacts. The document then sets out the stages for the assessment process.

8.2.3 Environmental Protection Act 1990

Part III, Section 79, of the Environmental Protection Act 1990 (EPA) (HMSO, 1990) defines what activities may constitute a Statutory Nuisance, and what activities are specifically exempt. Section 79 imposes a duty on local authorities to cause its area to be inspected from time to time to detect any statutory nuisance which ought to be dealt with such as environmental noise levels and to investigate noise complaints.

The EPA also requires local authorities to serve notice when a noise nuisance exists. Under these statutory nuisance provisions, the operators of a site or facility could be required to adopt best practicable means to abate noise nuisance at any time once operations have commenced.

8.3 Methodology

This assessment has considered the temporary increases in noise and vibration associated with the construction activities proposed as part of the Scheme. In addition, the assessment of temporary noise level increases due to road traffic during construction has been undertaken.

Each factor within the scope of this chapter has its own basis for methodology as summarised in Table 8-2.

Table 8-2: Assessment methodology

Factor	Methodology
Baseline data collection	BS 7445-1:2003 (description and measurement of environmental noise)
Construction noise	ISO 9613- 2:1996 (method for propagation of noise outdoors) BS 5228-1:2009+A1:2014 (Part 1) (method for calculating construction noise and data source of noise emission levels for plant and equipment) Design Manual for Roads and Bridges (DMRB) LA 111 Noise and Vibration, 2020 (criteria for assessing the significance of effect). Although LA 111 is primarily for assessing the impact from the construction and operation of road schemes, it contains guidance for using the duration of construction activities to determine whether a significant adverse effect exists. This is utilised during this assessment to take account of activity duration. Department of the Environment - Noise Control on Building Sites: Advisory Leaflet 72 1976 (noise limit criteria)
Construction vibration	BS 5228-2:2009+A1:2014 (Part 2) (methods for calculating construction vibration and vibration limit criteria) BS 7385-2:1993 and BS 6472-1:2008 (supporting information for vibration limit criteria) DMRB LA 111 Noise and Vibration, 2020 (criteria for assessing the significance of effect)
Road traffic noise during construction	Design Manual for Roads and Bridges (DMRB) LA 111 Noise and Vibration, 2020 (method and criteria for assessing the impact from road traffic)

8.3.1 BS 7445-1:2003 Description and measurement of environmental noise - Part 1: Guide to quantities and procedures

Part 1 of BS 7445:2003 defines the basic quantities to be used for the description of noise in community environments and describes basic procedures for the determination of these quantities. It is used for guidance when undertaking environmental noise surveys.

8.3.2 British Standard BS 5228:2009+A1:2014 - Code of practice for noise and vibration control on construction and open sites – Part 1: Noise

Part 1 of BS 5228:2009+A1:2014, hereafter BS 5228-1, provides guidance and recommendations on methods for assessing the potential impacts from construction noise on sensitive receptors in proximity to the activities. It also makes reference to the legislative background to noise control on construction sites and gives recommendations for basic methods of noise control.

BS 5228-1 provides suitable methods for the calculation of noise from construction activities, including basic information regarding noise levels from a range of construction equipment. For the calculation of construction noise at a receptor location, the selected A-weighted sound power levels of the plant and equipment are corrected to consider: the "Percentage On-time" (portion of time in which the equipment is operating at its maximum power); "Duration of Activity" (amount of time in relation to the "Shift Duration" in which the equipment is expected to operate); distance between sound sources and receptors; percentage of soft ground; and any screening corrections from obstacles between the sound propagation path.

8.3.3 British Standard BS 5228:2009+A1:2014: Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration

Part 2 of BS 5228:2009+A1:2014, hereafter BS 5228-2, provides guidance for assessing the potential effects from construction vibration upon the surroundings and provides recommendations for basic

methods of vibration control for construction sites where work activities have the potential to generate vibration levels. BS 5228-2 sets out significance criteria of vibration effects. The criteria are defined separately for human response and buildings response. For human response BS 5228-2 refers to the criteria set out in BS 6472-1:2008 – *'Guide to evaluation of human exposure to vibration in buildings - Part 1: Vibration sources other than blasting'*. For building response BS 5228-2 refers to the criteria set out in BS 7385-2:1993 – *'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration'*.

Annexes C and D of BS 5228-2 contain measured vibration levels for different methods of piling and ancillary operations, which can be used for the estimation of vibration levels at a construction site. Annex E of the standard provides derived empirical formulae which can be used to predict the resultant Peak Particle Velocity (PPV) from certain construction vibration activities. The formulae include a number of parameters specific for calculating vibratory compaction, percussive and vibratory piling, dynamic compaction and the vibration of stone columns and tunnel boring operations.

8.3.4 Department of the Environment - Noise Control on Building Sites: Advisory Leaflet 72 1976

The Department of the Environment (DoE) - Noise Control on Building Sites: Advisory Leaflet (AL) 72 1976 (now out of print) provides guidance to local authorities and developers for noise control on building sites. This assessment considers the provisions in BS 5228-1 and also the advice in the DoE Advisory Leaflet (AL) 72 which provides guidance on levels of noise that may be acceptable. In line with AL 72, the daytime (between 07:00 and 19:00) noise level in terms of $L_{Aeq,T}$ [1]from construction outside the nearest window of an occupied sensitive room closest to the site boundary, should not exceed:

- 70 dB(A) in rural, suburban and urban areas away from main road traffic and industrial noise or;
- 75 dB(A) in urban areas near main roads in heavy industrial areas.

The guidance also states that when working outside the normal daytime hours, the allowable noise levels from building sites will be less. For example, during the evening period (19:00 to 22:00); such as the reduced values given in the contract specification or as advised by the Environmental Health Officer (EHO) where a reduction of 10 dB(A) may be often appropriate. Noisy work likely to cause annoyance locally should not be permitted during the night-time period (22:00 to 07:00).

8.3.5 Guidance from Falkirk Council

When consulted during a site visit on 11 January 2018, the Falkirk Council EHO directed the surveyor to the advice from their website regarding working hours and Best Practicable Means. This advice is *"In terms of construction and demolition sites; the permitted hours of work for construction and demolition activities within the Falkirk Council area are:*

- *Monday-Friday: 8:00am to 7:00pm*
- *Saturday: 8:00am to 1:00pm*
- *Sunday/Bank Holidays: No noise to be audible at the site boundary*

There may be exceptional circumstances where construction and demolition work need to be conducted outside of the above noted hours. Contractors must liaise with the Environmental Protection Team at Falkirk Council in advance of works taking place to discuss proposals and obtain consent.

Contractors should ensure that the Best Practicable Means are employed to minimise noise as far as reasonably practicable."

[1] A-weighted Equivalent Continuous Sound Pressure Level. This is the steady sound level which, over a stated period of time T, would contain the same amount of acoustical energy as the fluctuating sound measured over that period.

As part of the assessment methodology, the noise limit criteria and locations for baseline noise monitoring have been agreed with Falkirk Council after consultation with the EHO (refer to Section 8.3.10 for the limit criteria and Section 8.4 for the baseline monitored locations).

8.3.6 National Highways - Design Manual for Roads and Bridges (DMRB), LA 111 Noise and Vibration, 2020

The magnitude of change outlined within the Design Manual for Roads and Bridges (DMRB) LA 111 Noise and Vibration 2020, issued by National Highways (formerly Highways England), has been used for defining the assessment methodology criteria for the increase in road traffic noise during construction of the Scheme. Although DMRB LA 111 is primarily intended for the assessment of impacts from the construction and operation of large road projects, it provides guidance in assessing the magnitude of impact and significance of effect for noise and vibration during construction that is also considered applicable to the Scheme.

The potential noise level increase from road traffic during the construction period has been assessed following a qualitative high-level approach, based on the guidance criteria provided in DMRB LA 111 to derive the magnitude of impact for this assessment. The method in the guidance requires a comparison of the existing road traffic noise levels against the anticipated road traffic noise levels on the access roads to be used during construction.

8.3.7 Study Area

For each of the Working Areas within each Flood Cell, construction noise and vibration levels have been assessed within a 300 m radius of the proposed construction works and construction compounds.

The study area has been selected following the guidance provided in BS 5228-1 for assessing construction noise, where it is stated that calculations of construction noise over 300 m become less accurate due to increases in the influence of meteorological effects. In addition, beyond 300 m construction noise and vibration levels are attenuated to a level that is not likely to cause a complaint due to the distance of separation. Therefore, the study area used in this assessment is limited to 300 m as illustrated in Figure B8.1.

8.3.8 Baseline Data Collection

In order to understand the baseline noise environment within each Flood Cell, a noise survey of the existing noise levels in the vicinity of construction works for the Scheme was undertaken in February 2018. The survey consisted of a series of non-consecutive noise level measurements during the daytime period at locations representative of the existing sensitive receptors, which were agreed with the Falkirk Council EHO. At the time of finalising this noise assessment, the results from these surveys are six years old. This is not considered to be a constraint to the assessment since there has been very little change in the area concerning major sources of noise.

Baseline noise measurements were undertaken at ten locations in the proximity of the proposed construction works as shown in Figure B8.1. The noise survey results are presented in Section 8.4 of this chapter.

For the measurement of environmental noise, the methodology contained in BS 7445-1:2003 – '*Description and measurement of environmental noise: Guide to quantities and procedures*', was followed. This standard sets out the requirements of the noise measurement equipment for environmental noise surveys, the type of location to be used for environmental measurements and the requirement to record the environmental conditions under which measurements are taken. The noise survey undertaken for the Scheme followed the guidance given in this standard.

8.3.9 Calculation Method for Noise and Vibration Levels

For the calculation of the noise levels during construction, the assessment has followed the methodology contained in BS 5228-1 which covers construction noise. The calculated construction noise levels have been corrected for the closest separation distances to the respective sensitive receptors in line with the method for calculating the noise propagation outdoors contained in ISO 9613-2:1996 - '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*'.

The noise levels emitted from the construction plant used for a specific construction activity have been combined with the measured baseline noise level at the relevant sensitive receptor location to present the overall noise level during construction at each sensitive receptor location. Where applicable, the attenuation provided by existing screening obstacles such as topographical features or existing buildings has been considered in the calculations.

In relation to the calculation of vibration levels, given the proposed types and methods of work anticipated to be employed, the relevant construction activities relate to vibratory piling and vibratory compaction. Prediction of vibration levels for these activities has been undertaken following the methods and formulae contained in Annex E of BS 5228- 2, which allow for the prediction of vibration in terms of the Peak Particle Velocity (PPV).

The list of plant and equipment, together with the associated acoustic data considered to be used for the construction of the Scheme, is presented in Appendix C8.1: Noise emission database of construction plant equipment.

8.3.10 Noise Limit Criteria

8.3.10.1 Construction Noise

It was agreed with the Falkirk Council EHO that a daytime noise limit of 75 dB $L_{Aeq,\ day}$ during construction would be applied at 'urban locations next to main roads and industrial sites' and that a noise limit of 70 dB $L_{Aeq,\ day}$ during construction would be applied to 'rural, suburban and urban areas away from main road traffic and industrial'. The noise limits have been agreed following guidance contained within DoE LA72. Below these limits it is considered that the construction activities would have no significant impact upon sensitive receptors within the respective area designations. Receptors in proximity to Flood Cells that are located within industrial land uses are not considered to be sensitive for the assessment of construction noise and construction noise limits at these locations are not defined. The applicable construction noise limits adopted for Flood Cell Working Areas are presented in Table 8-3.

Table 8-3: Applicable construction noise limit adopted at each working area

Flood Cell No.	Working Area No.	Location	Applicable construction daytime noise limit
1	1-1	Stirling Road	70 dB(A)
	1-2	Carron Bridges	70 dB(A)
	1-3	Chapel Burn	70 dB(A)
	1-4	Dock Street	70 dB(A)
2	2-1	Forth and Clyde Canal Lock	70 dB(A)
	2-2	Jarvie Plant	70 dB(A)
3	3-1	Mouth of the River Carron	n/a (industrial land use)
	3-2	West Coast of the Port	n/a (industrial land use)
	3-3	West Lock Gate to the Port	n/a (industrial land use)

Flood Cell No.	Working Area No.	Location	Applicable construction daytime noise limit
	3-4	East Lock Gate to the Port	n/a (industrial land use)
	3-5	Mouth of the Grange Burn	n/a (industrial land use)
4	4-1	Upstream of M9	75 dB(A)
	4-2	Flood relief channel – Rannoch Park	75 dB(A)
	4-3	Flood relief channel – Inchyra Road	75 dB(A)
	4-4	Flood relief channel – Wholeflats Road	75 dB(A)
	4-5	Grange Burn – Zetland Park	75 dB(A)
	4-6	Grange Burn – Dalgrain to Bo'Ness Road	75 dB(A)
	4-7	Grange Burn – Grangeburn Road	75 dB(A)
	4-8	Grange Burn – Petroineos	75 dB(A)
	4-9	Grange Burn – Mouth of Grange Burn	n/a (industrial land use)
5	5-1	Smiddy Brae and Avondale Road	70 dB(A)
	5-2	Flare Road and Road 33	n/a (industrial land use)
	5-3	Grangemouth Road	n/a (industrial land use)
	5-4	Mouth of the River Avon	n/a (industrial land use)
6	6-1	Beach Road	n/a (industrial land use)
	6-2	Petroineos Mouth of River Avon	n/a (industrial land use)
Notes: n/a when the identified receptors at the locations of the works correspond to industrial land uses with low sensitivity for noise.			

8.3.10.2 Construction vibration

Vibration effects are frequently associated with the assumption that, if vibration can be felt, then damage is inevitable. However, considerably greater levels of vibration are required to cause damage to buildings and structures, as indicated in BS 7385-2:1993. In any neighbourhood, some individuals will be more sensitive to vibration than others. For this reason, different criteria are used for assessing the impacts from vibration on humans and on buildings/structures.

8.3.10.2.1 Vibration annoyance (human response)

The effect of ground-borne vibration on people inside buildings is often assessed using the Vibration Dose Value (VDV) index, as described in BS 6472-1:2008: '*Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*'. However, BS 5228-2 recommends that in relation to construction activities, it is often more appropriate to utilise Peak Particle Velocity (PPV) levels, and therefore BS 5228-2 provides guidance criteria based on BS 6472-1:2008. This guidance is reproduced in Table 8-4.

Table 8-4: Impact for vibration annoyance (human response)

Vibration Level, PPV [1]	Definition
< 0.14 mm/s	Vibration is not perceptible.
0.14 – 0.29 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 - 0.99 mm/s	Vibration might just be perceptible in residential environments.
1.00 - 9.99 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
> 10.00 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure of this level.
[1] PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal. It is specified in millimetres per second (mm/s). It is important to note that the PPV refers to the movement within the ground of molecular particles and not surface movement.	

The vibration level for annoyance (human response) utilised in the assessment based upon Table 8-4 from BS 5228-2 is applicable to residential receptors of high sensitivity. It is considered suitable to apply to other sensitive receptors of high and medium sensitivities including educational facilities, medical facilities, hotels, community and leisure facilities and places of worship.

8.3.10.2.2 Vibration on buildings

BS 7385-2:1993: '*Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration*' provides guidance on vibration levels likely to result in cosmetic damage to buildings and is referenced in BS 5228-2. Guide values for transient vibration, above which cosmetic damage could occur, are frequency dependant measured in Hertz (Hz). Table 8-5 defines the impact criteria for groundborne vibration with regards to risk of building damage.

Table 8-5: Transient vibration guide values for cosmetic damage to buildings

Type of Building	Peak component of particle velocity in frequency range of predominant pulse (Threshold criteria)	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures	50 mm/s at 4 Hz and above	
Industrial and heavy commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Note 1: Values referred to are at the base of the building. Note 2: For un-reinforced or light framed structures and residential or light commercial buildings, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded.		

The limit criterion adopted for cosmetic damage to residential or light commercial buildings due to vibration utilised in this assessment has been set to 7.5 mm/s which is half of the lowest value from Table 8-5. This criterion is, conservatively, considered in the assessment to be applicable for all types of buildings identified within the study area.

8.3.11 Assessment of Sensitivity of Receptors, Magnitude of Impact and Significance of Effect

This section outlines the sensitivity of receptors and defines the magnitude of impact and significance of effect for construction noise, construction vibration (human response and on buildings), and road traffic noise during construction.

8.3.11.1 Determining the Sensitivity of Receptors

The determination of the sensitivity of the receptors in proximity to the construction works is set out in Table 8-6, and this based on the guidance within the Technical Advice Note which accompanies Planning Advice Note 1/2011 (PAN, 2011).

Table 8-6: Criteria for classifying the sensitivity of receptors

Receptor sensitivity	Receptor type definition
High	Residential, including private gardens where appropriate, quiet outdoor areas used for recreation, theatres/auditoria/studios, schools during the daytime, hospitals/residential care homes, places of worship.
Medium	Commercial, offices, bars/cafes/restaurants where external noise may be intrusive. Leisure facilities and hotels.
Low	Buildings not occupied during working hours, factories and working environments with existing high noise level, industrial land.

This classification is only relevant with regards to construction noise and vibration impacts in terms of human response / annoyance where a building is occupied. However, when assessing vibration impacts in terms of building damage, these are considered to be of high sensitivity even if unoccupied. Sensitive structures are considered to be buildings with delicate equipment such as nanotechnology laboratories, sound recording, broadcast studios, large auditoria, theatres or concert halls.

The representative noise and vibration sensitive receptors have been identified in relation to the location of the construction activities. Representative sensitive receptor locations have been identified as the closest to the proposed construction works, representing the worst-case locations.

8.3.11.2 Determining the classification of changes in noise and vibration

Potential changes in noise and vibration are always categorised as adverse, as positive changes from construction noise or vibration are not considered possible. The general criteria adopted for determining the change from noise and vibration during construction are defined in Table 8-7. These have been derived from threshold values for annoyance, changes in attitude or building damage criteria provided within the standards and guidance documents described in Section 8.3.

Table 8-7: Criteria for determining the classification of change in noise and vibration

Topic	Criteria	Change in noise/vibration (extent and severity)				
		Negligible	Very small	Small	Medium	Large
Noise	Exceedance of predicted noise level above noise criteria (Refer to Table 8-3)	Less than 1.0 dB	Between 1.0 and 2.9 dB	Between 3.0 and 4.9 dB	Between 5.0 and 9.9 dB	More than 10.0 dB

Topic	Criteria	Change in noise/vibration (extent and severity)				
		Negligible	Very small	Small	Medium	Large
Vibration annoyance (human response)	Predicted vibration level in mm/s (refer to Table 8-4)	Less than 0.14 mm/s	Between 0.14 and 0.29 mm/s	Between 0.3 and 0.9 mm/s	Between 1.0 and 9.9 mm/s	More than 10.0 mm/s
Vibration on buildings	Predicted vibration level in mm/s (refer to Table 8-5)	No vibration	Between 0.0 and 7.4 mm/s	n/a	Between 7.5 and 14.9 mm/s	More than 15.0 mm/s
Construction road traffic noise on access routes	Qualitative assessment based on the increase in the existing road traffic flows. A 25% increase is the smallest noticeable increase (resulting in 1dB increase)	Increase of less than 25%	Increase between 25 and 49%	Increase between 50 and 74%	Increase between 75 and 99%	Increase larger than 100%

For the assessment of vibration on buildings, considering the adopted threshold criteria for building damage of 7.5 mm/s, four category bands are defined, with the 'Small' band being omitted since it is not possible to derive a fifth category band from the available criteria (as shown in Table 8-5).

8.3.11.3 Assessing the magnitude of impact

To determine the magnitude of impact, the change in noise or vibration is compared with the sensitivity of the receptor. This magnitude of impact is determined using the change criteria provided in Table 8-7 and the sensitivity of the receptor from Table 8-6.

Table 8-8: Criteria for determining magnitude of impact in relation to sensitivity

Change in noise / vibration	Sensitivity of receptor		
	High	Medium	Low
Large	Major	Major/Moderate	Moderate
Medium	Major/Moderate	Moderate	Moderate
Small	Moderate	Moderate	Minor
Very small	Minor	Minor	Minor
Negligible	Negligible	Negligible	Negligible

For this EIA, magnitudes of impact of Moderate, Major-Moderate and Major result in potentially significant adverse effects.

8.3.11.4 Determining significance of effect

To determine the significance of effects from noise and vibration associated with the construction of the Scheme, the DMRB LA 111 guidance is also considered along with that from Advisory Leaflet 72 (AL72). When the absolute noise level is above the criteria from AL72 (i.e. 70 and 75 dB(A)), the duration of the

works for which noise or vibration levels are expected to exceed the limit criteria is then considered as well as the magnitude and duration of impact in order to assess the likely significance of effects.

DMRB LA 111 states that: "*a significant adverse effect is likely to occur from construction noise, vibration and construction traffic where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:*

- *10 or more days or nights in any 15 consecutive days or nights*
- *a total number of days exceeding 40 in any 6 consecutive months*"

Therefore, based on DMRB LA 111, for the noise and vibration impacts resulting in Moderate, Major-Moderate and Major (in Table 8-8), the above listed durations are considered to determine whether the effect would be significant. The assessment uses the indicative duration of the works (refer to Appendix C4.2 Construction Methodology Report), to determine the likelihood of the noise and vibration levels being exceeded for a period exceeding the two above listed durations from DMRB LA 111.

Table 8-9 presents the definitions for the significance categories for noise and vibration.

Table 8-9: Definitions of significance of effects categories - noise and vibration

Significance effect category	Criteria for determination
Not significant	Negligible or Minor magnitude of impact. Moderate, Major-Moderate and Major magnitude of impact when the DMRB LA 111 duration criteria are not met.
Significant	Moderate, Major-Moderate and Major magnitude of impact when the DMRB LA 111 duration criteria are met and the overall noise level is above the criteria from AL72.

8.3.12 Consultation

Consultation was undertaken with the Falkirk Council EHO on 11 January 2018 with regard to the noise and vibration assessment methodology (refer to Appendix C3.2 Scoping Responses). This included consultation on the permitted hours of work for construction sites, construction noise limit criteria and locations for baseline noise monitoring, including agreement on site of the location for the baseline noise surveys (refer to Section 8.3.10 for the limit criteria and Section 8.4 for the baseline monitored locations).

8.3.13 Assumptions and Limitations

8.3.13.1 Calculation of construction noise

The plant and equipment list employed for the calculations is indicative and is based on the information available at this stage of design development (and as further discussed in Appendix C4.2 Construction Methodology Report). The acoustic 'on-time', which is defined as the period of time that the equipment operates at full power, has been defined based on professional experience of similar construction schemes. The Sound Power Levels considered for the plant and equipment have been derived either from manufacturer's specifications or measurement data available in Annex C of BS 5228-1. Refer to Appendix C8.1 for the list of plant and equipment considered for the purposes of this assessment. The calculations of construction noise have conservatively assumed a 50% ground absorption since the intervening ground surface is predominantly grass.

8.3.13.2 Time periods of construction

The daytime construction period is defined as between 07:00 and 19:00 in line with DoE Al 72 and BS 5228-1. However, the Scheme construction works are anticipated to be limited to the daytime period between 08:00 and 18:00 hours and during weekdays only, in line with the Falkirk Council permitted

hours of work. Therefore, for the purposes of this assessment, standard working hours for the calculations are assumed to be daytime (08:00–18:00) Monday to Friday. Apart from two exceptions that are explained below, no work activity has been considered during the evening nor the night-time period and at any other time during weekends or at all on bank holidays.

Night-time working will be required over short periods of time for the replacement of the existing lock gates located in Flood Cell 3 within the Port of Grangemouth and for the construction of flood defences in Flood Cell 6 along the coastal edge of the Grangemouth Refinery to allow works during the low tide periods. Since these works are required at a location where only industrial land uses exist, with no sensitive receptors present during the night-time period, noise or vibration impacts in this case are unlikely to occur and have therefore not been considered further in the assessment. The other works related to flood gates proposed will not require night-time working since these are associated with works outside of the water and therefore not tidally constrained.

8.3.13.3 Duration and phases of work

The assessment considers the construction activities at each Working Area to occur in consecutive order. Appendix C4.2: Construction Methodology Report provides indicative durations for the works. However, these are not defined per construction activity, but per Working Area. For the purposes of this assessment, the data available on durations in relation to the length of the flood defences works are reproduced in Table 8-10 alongside the estimated rate at which the transient works (i.e. construction of flood defences) would move in meters per week. A receptor within a Flood Cell would not be exposed to the noise and vibration from the works for the entire duration. Table 8-10 only lists the Flood Cells at which there are sensitive receptors identified within the study areas.

Table 8-10: Anticipated durations of the works per Flood Cell

Flood Cell	Working Area and location	Estimated overall length of flood defences (m)	Duration in months	Estimated construction of flood defences in meters per week
1	1-1 Stirling Road	1611	24	15
	1-2 Carron Bridges	1045	18	13
	1-3 Chapel Burn	685	12	13
	1-4 Dock Street	557	9	14
2	2-1 Forth and Clyde Canal Lock	662	9	17
	2-2 Jarvie Plant	840	9	22
4	4-1 Upstream of M9	1078	15	17
	4-2 Flood relief channel – Rannoch Park	559	9	14
	4-3 Flood relief channel – Inchyra Road	505	12	10
	4-4 Flood relief channel – Whole-flats Road	2359	27	20
	4-5 Grange Burn – Zetland Park	767	12	15
	4-6 Grange Burn – Dalgrain to Bo'Ness Road	804	12	15
	4-7 Grange Burn – Grangeburn Road	1250	18	16
	4-8 Grange Burn – Petroineos	1051	12	20
5	5-1 Smiddy Brae and Avondale Road	1786	18	23

The assessment calculates the noise and vibration levels from the construction of a flood defence when at the closest point to the receptors. The noise and vibration levels are expected to reduce with distance as the activity moves away from the receptors. Based on Table 8-10, calculations have been undertaken to determine at which distance from the receptors the construction activities would still be exceeding relevant limit criteria and the duration of the exceedance. This assumption is relevant for assessing the significance of effects in relation to the duration of the activity (refer to Section 8.3 for the DMRB LA 111 criteria adopted).

The assessment also considers the phasing of construction works, which is provided in Appendix C4.2: Construction Methodology Plan. Proposed construction activities are anticipated to occur in four phases, with some phasing of work occurring at different working areas in parallel. The locations of the works where phases are expected to overlap and are located within 300 m of the sensitive receptors have been considered for the assessment of cumulative effects. Where works at adjacent Working Areas are expected to overlap and the distances between the works at each site and the receptors is larger than 300 m, it is anticipated that these overlaps would not result in an increased noise or vibration level greater than the individual predicted level at the closest distance to the receptor. This is because at a distance greater than 300m the contribution of the noise from the works would be negligible compared to the noise from other, closer sources.

8.4 Baseline

A noise survey of the existing noise levels in the vicinity of the works was undertaken in February 2018 as outlined in Section 8.3. The results of the noise survey are provided in Sections 8.4.1 to 8.4.6 according to each Flood Cell. The measured baseline noise levels are presented in terms of the averaged L_{Aeq}, day noise level from four non-consecutive samples of 15 minutes each, measured within the daytime period (i.e. 07:00 to 19:00).

8.4.1 Flood Cell 1

The results from the baseline noise survey within Flood Cell 1 are presented in Table 8-11.

Table 8-11: Baseline noise measurement record, Flood Cell 1

Location	Description	Measured baseline noise level - L_{Aeq}, day (dB)
Stirling Road	In the vicinity of the residential receptor opposite the First Group Bus Depot, Stirling Road	57
Park Road	To the rear of residential property, Park Road, Bainsford	49
Carronside Street	On open land to the North of Carronside Street, Bainsford	59
Rae Court	On footpath to the South of Rae Court, Carronshore	49
South of Dock Street	On Riding for the Disabled land, south of Dock Street, Carronshore	51

8.4.2 Flood Cell 2

The results from the baseline noise survey within Flood Cell 2 are presented in Table 8-12.

Table 8-12: Baseline noise measurement record, Flood Cell 2

Location	Description	Measured baseline noise level - L_{Aeq}, day (dB)
Rear of Bank Street/ Devon Street	On footpath to the north of Bank Street/Devon Street, Grangemouth	55

8.4.3 Flood Cell 3

No measurements were undertaken within this Flood Cell as the proposed works are in an industrial area and in excess of 650 m from the closest receptor of medium or high sensitivity. Therefore, noise levels from construction have not been calculated for this Flood Cell since it is unlikely to result in any potential noise impact at the location of the closest sensitive receptors.

8.4.4 Flood Cell 4

The results from the baseline noise survey within Flood Cell 4 are presented in Table 8-13.

Table 8-13: Baseline noise measurement record, Flood Cell 4

Location	Description	Measured baseline noise level – L_{Aeq}, day (dB)
Zetland Park	To the eastern side of Abbots Road in Zetland Park, east of Grange Burn	62
Rannoch Road	At the west end of Rannoch Road, close to residential flats	64
Avonside House	Close to residential properties at the north end of Reddoch Road (Avonside House)	65
Grandsable Cemetery	Close to residential property at entrance to Grandsable Cemetery in the area of the upstream of M9 works.	60

8.4.5 Flood Cell 5

The majority of Flood Cell 5 is within an industrial area, with the only residential receptors being located south of the A905 at approximately 80 m from the closest Working Area. In discussion with the Falkirk Council EHO it was agreed that the baseline noise levels measured at Flood Cell 4, in the vicinity of Avonside House, would be utilised to represent the baseline environment of the residential receptors in this area. This is a representative baseline noise level of 65 dB(A) as shown in Table 8-13.

8.4.6 Flood Cell 6

No measurements were undertaken within this Flood Cell as the proposed works are within an industrial area and in excess of 1,000 m from the nearest sensitive receptor. Therefore, noise levels from construction have not been calculated for this Flood Cell since it is unlikely to result in any potential noise impact at the location of the closest sensitive receptors.

8.5 Impact assessment

8.5.1 Construction phase

8.5.1.1 Construction activities and locations

Construction activities have the potential to result in increased noise and vibration levels at sensitive receptor locations throughout the construction period. Table 8-14 presents the construction activities considered for the calculations of construction noise and vibration for each of the Flood Cells and the worst case representative sensitive receptors and distances to these construction activities.

Table 8-14: Construction activities and sensitive receptor distances to works

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
1	1-1 Stirling Road	Residential - Stirling Road	n/a		9	9	290		50										65
		Residential - Beech Crescent, Falkirk Road and Lade Drive	n/a		110	110	n/a		270										100
		Commercial buildings on Stirling Road	185		10	10	185		15										30
	1-2 Carron Bridges	Residential - Burder Park	87*	105	10	10			15			105		30		40	20		
		Residential - Beaumont Drive	200*	160*	5	5			125			170*		20		150	130		
		Residential - Park and Carron Roads	80	15	35	35			60			5		105		70	65		
		Residential - Farm Street	220*	125*	10	10			125			130*		110		190*	190*		
		Residential - Mulloch Avenue	n/a	30	n/a	n/a			n/a			n/a		n/a		n/a	n/a		
		Dawson Mission Church	140	45	25	25			45			65		60		95	90		
	1-3 Chapel Burn	Residential - Waters End and Bryce Avenue			6	6													
		Residential - Duncan Avenue			6	6													
		Carronshore community Centre			25	25													

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
		Residential - Halket Crescent and Rae Court			10	10													
		Residential - Blackmill Crescent			45	45													
	1-4 Dock Street	Residential- Dock street, Wardlaw Place and Gilfillan Place			10	10			35		10					27			
		Residential - The Avenue (including Carron House Lodge)			6	6			210*		135					135			
		Residential - Main Street, Westerton Terrace and Bothkennar Road			205	205			n/a		n/a					n/a			
		Residential - Halket Crescent and Inglis Drive			40*	40*			140*		90					95*			
		Commercial (containing Stables) - end of Dock Street			5	5			22		60					5			
2	2-1 Forth and Clyde Canal Lock	Residential - West Church Drive and Clyde Street	n/a		80*	80*			n/a							75*			
		Industrial buildings	30		25	25			35							210			

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	2-2 Jarvie Plant	Residential - West Church Drive and Clyde Street	n/a		n/a	90			n/a										
		Industrial buildings	30		5	5			15										
3	3-1 Mouth of the River Carron	Industrial buildings	30		5	5					5		5			5			
	3-2 West Coast of the Port	Industrial buildings			10	10					10		20						
	3-3 West Lock Gate to the Port	Industrial buildings			5	5							10						
	3-4 East Lock Gate to the Port	Industrial buildings	10		5	5			20	30			25						
	3-5 Mouth of the Grange Burn	Industrial buildings		10	35	35			60										
4		Cherry Tree nursery			5	5					85*								

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																	
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	4-1 Upstream of M9	Hotels to the north of A9			5	5					5								
		Residential - Grandsable Road			5	5					200*								
		Hotel to the south of A9 (Premier Inn - Beancross Road)			5	5					5								
	4-2 Flood relief channel – Rannoch Park	Residential - Rannoch Road	40		20	20									55	55			30
		Residential – Burnbank and Portal Road	20		65	65									60	250			75
		Residential - Fintry Road	n/a		185*	185*									n/a	n/a			190
	4-3 Flood relief channel – Inchyra Road	Residential - Moriston Court	n/a	n/a	45	45													55
		Residential - Fintry Road	220	275	35	35													55
		Residential - Cuiling Place	210	n/a	45	45													55
		Inchyra Hotel	45	15	110	110													220
		Leisure Centre (Grange Road)	60	50	40	40													110
	4-4 Flood	Residential - Redddoch Road	30		8	8		95						40		20	n/a		10

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	relief channel – Whole-flats Road	Residential - Smiddy Brae	17		16	16		200						50		195	n/a		205
		Leisure Centre - Grange Road	150		115	115		30						210		300	90		35
	4-5 Grange Burn – Zetland Park	Residential - Abbots Road		45	15	15					55					40		130	
		Residential Drummond Place		170	80	80					25					65		60	
		Educational & Leisure facility - Grangemouth Community Education Unit		135	105	105					300					300		n/a	
	4-6 Grange Burn – Dalgrain to Bo'Ness Road	Residential - Abbots Road			17	17								30					
		Residential - Park Road			15	15								25					
	4-7 Grange Burn – Grangeburn Road	Residential - Grangeburn Road			12	12					35								
	4-8 Grange	Residential - Albert Avenue			60	60			65		95								

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)															
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	Burn – Petroineos	Residential - Grangeburn Road			20	20			30		45							
	4-9 Grange Burn – Mouth of Grange Burn	Industrial buildings			5	5			110							45		
5	5-1 Smiddy Brae and Avondale Road	Residential - Avondale Road	n/a		260	260			290									
		Residential - Polmonthill Cottage	n/a		275	275			275									
		Residential - Reddoch Road	130		80	80			n/a									
	5-2 Flare Road & Road 33	Industrial buildings			30	30	80											
	5-3 Grangemouth Road	Industrial buildings	70		20	20			20									
	5-4 Mouth of the River Avon	Industrial buildings			35	35			55				50					
6	6-1 & 6-2 West of River	Industrial buildings			35	35			120			105	115					

Flood Cell No.	Working Area	Representative noise sensitive receptors	Distance from sensitive receptor location to construction activity in metres (m)																
			Site compound	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary Culverts	Coastal Revetment	Bridge Works	Flow Control Structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	Avon: Beach Road and Mouth of River Avon																		
	6-3 & 6-4 East of River Avon: Chemical Works at River Avon and Chemical Works	Industrial buildings	12		18	18					5								

Notes:
n/a: when noise and/or vibration levels are not calculated as the construction activity is located at a distance greater than 300 m and therefore outside the assessment study area.
* Location of the works partially screened by intervening obstacles such as existing buildings.

8.5.1.2 Construction noise

The calculation methodology set out in BS 5228-1 has been employed to estimate the noise level from each of the proposed construction activities on the worst-case representative noise sensitive receptors indicated in Table 8-15. Appendix C8.1 contains the list of plant, equipment and associated acoustic data for the construction activities considered for the assessment, as listed in Table 8-15.

Table 8-15 presents the estimated noise level at the location of the closest sensitive receptor façade from each construction activity. Baseline noise levels (reported in Section 8.4) have been added to the predicted construction noise levels reported in Table 8-15. Construction noise levels calculated to be above the daytime construction noise limit criteria are highlighted (in red text) in Table 8-15.

Table 8-15: Estimated construction noise level at representative noise sensitive receptors

Flood Cell	Working Area	Representative noise sensitive receptors	Calculated noise level from construction activities in A-weighted decibels (dBA)																	
			Site compound - set up	Site compound - operation	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary culverts	Coastal revetment	Bridge works	Flow control structure	Building demolition	Footpath construction	Kiosk construction	Relining works
1	1-1 Stirling Road	Residential - Stirling Road	n/a	n/a		83	76	58		64										58
		Residential - Beech Crescent, Falkirk Road and Lade Drive	n/a	n/a		62	59	n/a		57										57
		Commercial buildings on Sterling Road	58	58		83	76	59		74										61
	1-2 Carron Bridges	Residential - Burder Park	60	60	64	83	76			74			61		67		62	68		
		Residential - Beaumont Drive	59	59	60	83	76			60			59		70		59	59		
		Residential - Park and Carron Roads	59	57	80	71	65			61			78		55		55	56		
		Residential - Farm Street	59	59	61	83	76			60			60		60		59	59		
		Residential - Mulloch Avenue	n/a	n/a	74	n/a	n/a			n/a			n/a		n/a		n/a	n/a		
		Dawson Mission Church	60	60	70	75	69			65			63		62		60	60		
	1-3 Chapel Burn	Residential - Waters End and Bryce Avenue				83	76													
		Residential - Duncan Avenue				83	76													

Flood Cell	Working Area	Representative noise sensitive receptors	Calculated noise level from construction activities in A-weighted decibels (dBA)																	
			Site compound - set up	Site compound - operation	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary culverts	Coastal revetment	Bridge works	Flow control structure	Building demolition	Footpath construction	Kiosk construction	Relining works
		Carronshore community centre				75	68													
		Residential - Halket Crescent and Rae Court				83	76													
		Residential - Blackmill Crescent				69	62													
	1-4 Dock Street	Residential -Dock Street, Wardlaw Place and Gilfillan Place				83	76			66		81					63			
		Residential - The Avenue (including Carron House Lodge)				83	76			52		57					52			
		Residential - Main Street, Westerton Terrace and Bothkennar Road				56	53			n/a		n/a					n/a			
		Residential - Halket Crescent and Inglis Drive				66	60			53		61					52			
		Commercial (containing Stables) - end of Dock Street				83	76			71		64					72			
2	2-1 Forth and Clyde Canal Lock	Residential - West Church Drive / Clyde Street	n/a	n/a		61	57			n/a							64			

Flood Cell	Working Area	Representative noise sensitive receptors	Calculated noise level from construction activities in A-weighted decibels (dBA)																	
			Site compound - set up	Site compound - operation	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary culverts	Coastal revetment	Bridge works	Flow control structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	2-2 Jarvie Plant	Residential - West Church Drive / Clyde Street	55	55		55	55			n/a										
3		Industrial buildings. No assessment undertaken.																		
4	4-1 Upstream of M9	Cherry Tree nursery				83	76					62								
		Hotels to the north of A9				83	76					81								
		Residential - Grandsable Road				83	76					60								
		Hotel to the south of A9 (Premier Inn - Beancross Road)				83	76					81								
	4-2 Flood relief channel – Rannoch Park	Residential - Rannoch Road	68	67		77	71									66	65			66
		Residential – Burnbank and Portal Road	73	71		68	65									66	64			64
		Residential - Fintry Road	n/a	n/a		64	64									n/a	n/a			64
	4-3 Flood relief channel – Inchyra Road	Residential - Moriston Court	n/a	n/a	n/a	70	66													64
		Residential - Fintry Road	64	64	64	72	67													64
		Residential - Cuiling Place	64	64	n/a	70	66													64

Flood Cell	Working Area	Representative noise sensitive receptors	Calculated noise level from construction activities in A-weighted decibels (dBA)																
			Site compound - set up	Site compound - operation	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary culverts	Coastal revetment	Bridge works	Flow control structure	Building demolition	Footpath construction	Kiosk construction	Relining works
		Inchyra Hotel	67	66	80	66	64													64
		Leisure Centre (Grange Road)	66	65	70	71	67													64
	4-4 Flood relief channel – Whole-flats Road	Residential - Reddoch Road	70	69		83	76		65						67		69	n/a		71
		Residential - Smiddy Brae	74	72		79	73		64						66		64	n/a		64
		Leisure Centre (Grange Road)	64	64		65	64		68						64		64	64		65
	4-5 Grange Burn – Zetland Park	Residential - Abbots Road			71	79	73					67					64		62	
		Residential Drummond Place			63	66	63					73					63		62	
		Educational and Leisure facility - Grangemouth Community Education Unit			64	64	63					62					62		n/a	
	4-6 Grange Burn – Dalgrain to Bo'Ness Road	Residential - Abbots Road				78	72								68					
		Residential - Park Road				79	73								69					
	4-7 Grange Burn – Grangeburn Road	Residential - Grangeburn Road				81	75					70								

Flood Cell	Working Area	Representative noise sensitive receptors	Calculated noise level from construction activities in A-weighted decibels (dBA)																	
			Site compound - set up	Site compound - operation	Embankment	Piled walls	Walls formwork reinforcement & concrete	Seepage barrier	Ground level raising	Flood gates	Lock gate (Port)	Road works	Temporary culverts	Coastal revetment	Bridge works	Flow control structure	Building demolition	Footpath construction	Kiosk construction	Relining works
	4-8 Grange Burn – Petroineos	Residential - Albert Avenue				68	64			64		64								
		Residential - Grangeburn Road				77	71			69		68								
5	5-4 Smiddy Brae and Avondale Road	Residential - Avondale Road	n/a	n/a		65	65			65										
		Residential - Polmonthill Cottage	n/a	n/a		65	65			65										
		Residential - Reddoch Road	65	65		67	66			n/a										
6	No calculations undertaken (see paragraph 8.4.6).						n/a			n/a										

Notes:

n/a: when noise levels are not calculated as the construction activity is located at a distance greater than 300 m and therefore outside the assessment study area.

* Location of the works partially screened by intervening obstacles such as existing buildings.

At receptor locations where construction activities are located at less than 10 m distance, the calculations have considered a distance of 10m as a minimum, since these are based on a worst case which considers the location of all items of plant, listed per each activity (in Appendix C8.1), operating at the same time, at a single position and the closest point to the receptor. Thus, for distances of less than 10 m this is not realistic to assume.

The exceedances reported in Table 8-15 are mainly associated with the construction of the flood defences due to their proximity to the sensitive receptor locations. The resultant magnitude of the impact and significance of the effect due to construction noise is presented in Section 8.5.1.5. This is based on the noisiest construction activity at each sensitive receptor location, as reported in Table 8-16.

For locations with only industrial land uses, calculations of construction noise are not reported in Table 8-15 since these have a low sensitivity for noise.

In addition to the activities shown in Table 8-15, some of the sites for construction of the flood defences will require vegetation clearance to enable access.

Utility diversion works will also need to be carried out before the construction of the flood defences. Grangemouth contains numerous buried services (electricity, gas, telecommunications, water and waste), as well as overhead services (telecommunications, electricity and lighting). Service providers are being consulted to determine which services can be diverted and which will have to be protected.

Calculations of noise levels from vegetation clearance and service diversion works have been made at generic distance bands to provide indication of the likely noise levels generated from these activities (refer to Table 8-16).

Table 8-16: Estimated noise level from vegetation clearance and service diversion works at generic distance bands

Construction activity	Calculated noise level from construction activities in dB(A) at generic distance bands in metres (m)					
	10 m	20 m	50 m	100 m	200 m	300 m
Vegetation clearance	86	80	71	64	57	53
Service diversion	82	76	67	61	54	50

Estimated construction noise levels for vegetation clearance and service diversions reported above the daytime construction noise limit of 70 dB(A) are indicated in red text in Table 8-16. Any sensitive receptors within 50 m of the vegetation clearance and within approximately 40 m of the service diversion works are anticipated to exceed the noise limit criteria of 70 dB(A).

8.5.1.3 Construction vibration

Vibration levels from vibratory compaction and piling activities taking place during some of the construction phases have been calculated using the method contained in BS 5228-2. To assess the potential for worst case for vibratory compaction, the formulae during start up and run down of the equipment has been used. Vibratory piling method has been assumed to be employed for the construction of sheet pile walls and embankments. Table 8-17 shows the input parameters used for the vibration level calculations.

Table 8-17: Input parameters for calculation of vibration levels

Parameter	Variable Input [1]	Definition
Vibratory compaction during start up and run down [2]		
K_s	65	scaling factor (50% probability of predicted value being exceeded)
n_d	2	number of vibrating drums

Parameter	Variable Input [1]	Definition
A	0.5	maximum amplitude of drum vibration (mm)
x	Refer to Table 8-14	distance to representative receptor (m)
L_d	1.5	width of vibrating roller drum (m)
Vibratory Piling		
K_v	60	scaling factor for 50% probability of predicted value being exceeded
δ	1.3	constant associated with all types of operation (steady state and start up and run down)
x	Refer to Table 8-14	distance to representative receptor (m)
[1] Note that the variable inputs are conservatively selected based on the anticipated size and specifications of the considered plant and equipment to be used for the activities. [2] This is considered to be the worst case when compared with the steady state cycle.		

Table 8-18 presents the estimated vibration levels from vibratory compaction and vibratory piling at the locations of the vibration sensitive receptors and buildings identified within the study area. The locations at which the human vibration criteria in BS 5228-2 (reproduced in Table 8-4) are likely to give raise to complaint are indicated in red text. For the avoidance of doubt, this is where the estimated vibration level would be more than 1.0 mm/s at occupied buildings with sensitive receptors. Note that industrial buildings are included to assess the potential for cosmetic damage only, considering conservatively a threshold of 7.5 mm/s, which is half of the lowest criteria value from BS 5228-2 (as set out in Table 8-5).

Table 8-18: Estimated vibration level at representative vibration sensitive receptors / buildings

Flood Cell	Working Area	Representative vibration sensitive receptors	Calculated vibration level in terms of PPV (mm/s)							
			Vibratory compaction					Vibratory piling		
			Site compound set up	Ground level raising	Road works	Temporary culverts	Footpath construction	Embankment	Piled walls	Seepage barrier
1	1-1 Stirling Road	Residential - Stirling Road	n/a						3.45	0.04
		Residential - Beech Crescent / Falkirk Road / Lade Drive	n/a						0.13	n/a
		Commercial buildings on Sterling Road	0.04						3.01	0.07
	1-2 Carron Bridges	Residential- Burder Park	0.10			0.08	0.60	0.14	3.01	
		Residential - Beaumont Drive	0.03			0.04	0.06	0.08	7.40	
		Residential - Park Road and Carron Road	0.11			2.85	0.13	1.78	0.59	
		Residential - Farm Street	0.03			0.06	0.04	0.11	3.01	
		Residential - Mulloch Avenue	n/a			n/a	n/a	0.72	n/a	

Flood Cell	Working Area	Representative vibration sensitive receptors	Calculated vibration level in terms of PPV (mm/s)							
			Vibratory compaction					Vibratory piling		
			Site compound set up	Ground level raising	Road works	Temporary culverts	Footpath construction	Embankment	Piled walls	Seepage barrier
		Dawson Mission Church	0.05			0.14	0.09	0.43	0.91	
	1-3 Chapel Burn	Residential - Waters End and Bryce Avenue							5.84	
		Residential - Duncan Avenue							5.84	
		Carronshore Community Centre							0.91	
		Residential - Halket Crescent							3.01	
		Residential - Blackmill Crescent							0.43	
	1-4 Dock Street	Residential - Dock Street / Wardlaw Place / Gilfillan Place			1.36				3.01	
		Residential - The Avenue (incl. Carron House Lodge)			0.05				5.84	
		Residential - Main Street / Westerton Terrace / Bothkennar Road			n/a				0.06	
		Residential - Halket Crescent / Inglis Drive			0.09				0.50	
		Commercial (containing Stables) - end of Dock Street			0.15				7.40	
2	2-1 Forth & Clyde Canal Lock	Residential - West Church Drive / Clyde Street	n/a						0.20	
		Industrial buildings	0.37						0.91	
	2-2 Jarvie Plant	Residential - West Church Drive / Clyde Street	n/a						n/a	
		Industrial buildings	0.37						7.40	
3	3-1 Mouth of the River Carron	Industrial buildings	0.37		2.85				7.40	
	3-2 West Coast of the Port	Industrial buildings			1.36				3.01	
	3-3 West Lock Gate to the Port	Industrial buildings							7.40	
	3-4 East Lock Gate to the Port	Industrial buildings	1.36						7.40	

Flood Cell	Working Area	Representative vibration sensitive receptors	Calculated vibration level in terms of PPV (mm/s)							
			Vibratory compaction					Vibratory piling		
			Site compound set up	Ground level raising	Road works	Temporary culverts	Footpath construction	Embankment	Piled walls	Seepage barrier
	3-5 Mouth of the Grange Burn	Industrial buildings						3.01	0.15	
4	4-1 Upstream of M9	Cherry Tree Nursery			0.10				7.40	
		Hotels to the north of A9			2.85				7.40	
		Residential - Grandsable Road			0.03				7.40	
		Hotel to the south of A9 (Beancross Road)			2.85				7.40	
	4-2 Flood relief channel – Rannoch Park	Residential - Rannoch Road	0.26						1.22	
		Residential - Burnbank Road & Portal Road	0.60						0.26	
		Residential - Fintry Road	n/a						0.07	
	4-3 Flood relief channel –Inchyra Road	Residential - Moriston Court	n/a					n/a	0.29	
		residential - Fintry Road	0.03					0.04	0.59	
		Residential - Cuiling Place	0.03					n/a	0.43	
		Inchyra Hotel	0.22					1.78	0.13	
		Leisure Centre (Grange Road)	0.15					0.37	0.50	
	4-4 Flood relief channel – Whole- flats Road	Residential & Milnholm Manor hotel - Redddoch Road	0.37	0.09			n/a		4.02	
		Residential - Smiddy Brae	0.73	0.03			n/a		1.63	
		Leisure Centre (Grange Road)	0.05	0.37			0.09		0.13	
	4-5 Grange Burn – Zetland Park	Residential - Abbots Road			0.17			0.43	1.78	
		Residential Drummond Place			0.46			0.08	0.20	
		Educational & Leisure facility - Grangemouth Community Education Unit			0.02			0.10	0.14	
	4-6 Grange Burn – Dalgrain to Bo'Ness Road	Residential - Abbots Road							1.51	
		Residential - Park Road							1.78	
	4-7 Grange Burn – Grangeburn Road	Residential - Grangeburn Road			0.30				2.37	
		Residential - Albert Avenue			0.09				0.29	

Flood Cell	Working Area	Representative vibration sensitive receptors	Calculated vibration level in terms of PPV (mm/s)							
			Vibratory compaction					Vibratory piling		
			Site compound set up	Ground level raising	Road works	Temporary culverts	Footpath construction	Embankment	Piled walls	Seepage barrier
	4-8 Grange Burn – Petroineos	Residential - Grangeburn Road			0.22				1.22	
	4-9 Grange Burn – Mouth of Grange Burn	Industrial buildings							7.40	
5	5-1 Smiddy Brae and Avondale Road	Residential - Avondale Road	n/a						0.04	
		Residential - Polmonthill Cottage	n/a						0.04	
		Residential - Reddoch Road	0.06						0.20	
	5-2 Flare Road and Road 33	Industrial buildings							0.72	0.20
	5-3 Grangemouth Road	Industrial buildings	0.13						1.22	
	5-4 Mouth of the River Avon	Industrial buildings							0.59	
6	6-1 & 6-2 West of River Avon: Beach Road and Mouth of River Avon	Industrial buildings				0.08			0.59	
	6-3 & 6-4 East of River Avon: Chemical Works at River Avon and Chemical Works	Industrial buildings	1.10		2.85				1.40	
Notes: n/a when vibration levels are calculated as the construction activity is located at a distance greater than 300 m and therefore outside the assessment study area.										

At some residential locations the vibration levels estimated at the closest point to the receptor in Table 8-18 are likely to be above the recommended vibration limit criteria of 1.0 mm/s and are estimated to reach up to 7.4 mm/s, in the worst-case scenario during the vibratory piling works required for the construction of the flood defences. This is due to the short distance between the works and the receptors, which in some cases is approximately 5 m. However, this activity is of transient nature and the vibration levels are expected to reduce as the works progress and move away from the receptors, limiting the duration of the impact. Exceedances are also anticipated at some locations during some of the vibratory compaction works required for the road works, also considered to be a transient activity. Non-

transient activities such as the site compound set up and construction of temporary culverts will generate vibration levels in excess of the limit criteria, but these are only expected to last for a limited period when certain items of vibration generating plant are being used.

In terms of cosmetic damage to structures, including industrial buildings, the lowest level at which cosmetic damage may occur to buildings is considered in this assessment to be 7.5 mm/s, which is half of the lowest value from the criteria in BS 7385-2 (reproduced in Table 8-5). The predicted levels of vibration in Table 8-18 are below 7.5 mm/s for all the occupied and unoccupied buildings and therefore no cosmetic damage to buildings is anticipated, including the industrial buildings identified in the proximity of the works which have been indicated in grey shading in Table 8-18.

8.5.1.4 Road traffic noise during construction

The assessment of construction noise has included the potential Heavy Goods Vehicles (HGV) movements required to undertake the construction activities. This does not include the impact from the increase in road traffic during construction on access routes to the sites which run close to a number of sensitive receptors. A qualitative high-level approach has been adopted to assess these potential impacts, based on the data contained in Chapter 14: Traffic and Transportation.

The most likely routes for construction vehicles to and from the Flood Cell areas are shown in Figure B14.2 in Appendix B14 of Chapter 14: Traffic and Transportation and are listed for each Flood Cell in Section 14.4.1. The access routes, together with the baseline Annual Average Weekday Traffic (AAWT) flows, were used for the assessment of potential impacts and are listed in Table 8-19.

Table 8-19: Existing traffic flow on likely access routes

Access route	Approximate two-way AAWT flow[1]	Percentage HGV
A88 Bellsdyke Road between A9 Stirling Road and A905	10,500	Unknown
A9 Stirling Road between A88 Bellsdyke Road and M9 J5	4,000 to 19,000	4 to 5
B906 Ronades Road between B902 Carron Road and A9	13,500	7
B902 Carron Road between B906 Ronades Road and A88 Bellsdyke Road	12,500	3
A904 Falkirk Road between A9 and M9 J6	28,000	14
M9 between J5 to J7	42,500 to 60,000	8
A904 Earls Road east of M9 J6	12,000	17
A904 Bo'ness Road between A904 Earls Road and A905	3,800 to 4,500	16 to 19
Inchyra Road between M6 J5 and A904 Bo'ness Road	17,000	11
A905, Wholeflats Road between Inchyra Road and A904	14,300	11
[1] A range is provided where the sections of road are split by one or more junctions.		

The indicative construction traffic for the Scheme in terms of daily HGVs for construction materials and light vehicles for the workforce to the sites is presented in Table 8-20.

Table 8-20: Estimated two-way daily construction traffic

Flood Cell No.	Indicative construction traffic – Number of two-way movements per day		
	HGVs	Light vehicles (for work force)	Total
1	56	74	130
2	40	36	76
3	52	94	146
4	68	146	214
5	58	120	178
6	36	80	116

An increase of 25% in the existing traffic would result in an increase of 1 dB(A) in the emission level from the road traffic noise, which is the smallest increase that could be noticeable by a human receptor. Taking the likely access route with the lowest traffic flow shown in Table 8-19 (i.e. an AAWT of 3,800) and adding in the highest estimated level of construction traffic (i.e. 214 two-way movements per day), the increase is 6 %. This comparison would be worst case since a road with an existing low traffic flow would be more sensitive to an increase in traffic. In line with the criteria in Table 8-7, the magnitude of the impact from increased road traffic noise on access roads used during construction of 6 % is a Negligible change in noise.

8.5.1.5 Assessment of impact and significance of effects

The assessment of significance considers the absolute noise level, the magnitude of the impact and the duration of the construction activity. Receptors of low sensitivity and unoccupied buildings are not included. Industrial buildings are considered to be of low sensitivity and therefore no significant effects are anticipated. No cosmetic damage to buildings or structures is anticipated based on the predicted levels of vibration in Table 8-18.

In line with the methodology, Moderate, Major-Moderate and Major impacts are only considered as significant effects when the absolute noise level is above the noise criteria and the construction noise and/or vibration is likely to occur for a period exceeding 10 or more days or nights (or 2 weeks) in any 15 consecutive days or nights or a total number of days exceeding 40 in any 6 consecutive months. The construction activities that are considered to exceed the temporal scope are the embankment works and the sheet piled walls.

The duration of the works assumed at each Working Area has been used to guide the assessment of the significance of effects to determine the likely duration of the impacts. Based on the highest noise and vibration levels, calculations have been undertaken to determine at which distance and duration the relevant criteria are likely to be exceeded.

Based on the results reported in Table 8-15 for noise and Table 8-18 for vibration, and the duration of the works (in Table 8-10), the resultant magnitude of impacts and significance of effects are presented in Table 8-21.

Table 8-21: Significance of effect from construction noise and vibration

Flood Cell	Working Area	Representative noise sensitive receptor	Sensitivity of receptor	Construction noise			Construction vibration (human response)		
				Change in noise (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect	Change in vibration (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect
1	1-1 Stirling Road	Residential – Stirling Road	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not Significant [2]
		Residential - Beech Crescent / Falkirk Road / Lade Drive	High	Negligible	Negligible	Not significant	Negligible	Negligible	Not significant
		Commercial buildings on Stirling Road	Low	Large	Moderate adverse	Significant [1]	Medium	Minor adverse	Not significant
	1-2 Carron Bridges	Residential - Burder Park	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Beaumont Drive	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Park Road and Carron Road	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Farm Street	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Mulloch Avenue	High	Small	Moderate adverse	Not Significant [2]	Small	Moderate adverse	Not significant [2]
		Dawson Mission Church	Medium	Medium	Moderate adverse	Not Significant [2]	Medium	Moderate adverse	Not significant [2]
	1-3 Chapel Burn	Residential - Waters End and Bryce Avenue	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]

Flood Cell	Working Area	Representative noise sensitive receptor	Sensitivity of receptor	Construction noise			Construction vibration (human response)		
				Change in noise (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect	Change in vibration (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect
		Residential - Duncan Avenue	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Carronshore community Centre	Medium	Medium	Moderate adverse	Not Significant [2]	Medium	Moderate adverse	Not significant [2]
		Residential - Halket Crescent	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Blackmill Crescent	High	Negligible	Negligible	Not Significant	Small	Moderate adverse	Not significant [2]
	1-4 Dock Street	Residential-Dock Street/ Wardlaw Place / Gilfillan Place	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - The Avenue (incl. Carron House Lodge)	High	Large	Major-moderate adverse	Significant [1]	Medium	Major-moderate adverse	Not significant [2]
		Residential - Main Street / Westerton Terrace / Bothkennar Road	High	Negligible	Negligible	Not Significant	Negligible	Negligible	Not significant
		Residential - Halket Crescent / Inglis Drive	High	Negligible	Negligible	Not Significant	Small	Moderate adverse	Not significant [2]

Flood Cell	Working Area	Representative noise sensitive receptor	Sensitivity of receptor	Construction noise			Construction vibration (human response)		
				Change in noise (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect	Change in vibration (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect
		Commercial - Stables at the end of Dock Street	Medium	Large	Major-moderate adverse	Significant [1]	Medium	Moderate adverse	Not significant [2]
2	2-1 Forth & Clyde Canal Lock	Residential - West Church Drive / Clyde Street	High	Negligible	Negligible	Not Significant	Negligible	Negligible	Not significant
	2-2 Jarvie Plant	Residential - West Church drive / Clyde Street	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
4	4-1 Upstream of M9	Cherry tree nursery	High	Medium	Major-moderate adverse	Not Significant [2]	Very Small	Minor adverse	Not significant [2]
		Hotels to the north of A9	Medium	Medium	Moderate adverse	Not Significant [2]	Medium	Moderate adverse	Not significant [2]
		Residential - Grandsable Road	High	Medium	Major-moderate adverse	Not Significant [2]	Medium	Major-moderate adverse	Not significant [2]
		Hotel to the south of A9 (Beancross Road)	Medium	Medium	Moderate adverse	Not Significant [2]	Medium	Moderate adverse	Not significant [2]
	4-2 Flood relief channel – Rannoch Park	Residential - Rannoch Road	High	Very Small	Minor adverse	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		Residential - Burnbank and Portal Road	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		residential - Fintry Road	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]

Flood Cell	Working Area	Representative noise sensitive receptor	Sensitivity of receptor	Construction noise			Construction vibration (human response)		
				Change in noise (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect	Change in vibration (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect
	4-3 Flood relief channel – Inchyra Road	Residential - Moriston Court	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		Residential - Fintry Road	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		Residential - Cuiling Place	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		Inchyra Hotel	Medium	Medium	Moderate adverse	Not Significant [2]	Medium	Moderate adverse	Not significant [2]
		Leisure Centre (Grange Road)	Medium	Negligible	Negligible	Not Significant	Medium	Moderate adverse	Not significant [2]
	4-4 Flood relief channel – Whole-flats Road	Residential - Reddoch Road	High	Medium	Major-moderate adverse	Not Significant [2]	Small	Moderate adverse	Not significant [2]
		Residential - Smiddy Brae	High	Small	Moderate adverse	Not Significant [2]	Negligible	Negligible	Not significant
		Leisure Centre (Grange Road)	Medium	Negligible	Negligible	Not Significant	Small	Minor adverse	Not significant
	4-5 Grange Burn – Zetland Park	Residential - Abbots Road	High	Small	Moderate adverse	Not Significant [2]	Small	Moderate adverse	Not significant [2]
		Residential Drummond Place	High	Negligible	Negligible	Not Significant	Small	Moderate adverse	Not significant [2]
		Grangemouth Community Education Unit	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]
		Residential - Abbots Road	High	Small	Moderate adverse	Not Significant [2]	Small	Moderate adverse	Not significant [2]

Flood Cell	Working Area	Representative noise sensitive receptor	Sensitivity of receptor	Construction noise			Construction vibration (human response)		
				Change in noise (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect	Change in vibration (Table 8-7)	Magnitude of impact (Table 8-8)	Significance of effect
	4-6 Grange Burn – Dalgrain to Bo'Ness Road	Residential - Park Road	High	Small	Moderate adverse	Not Significant [2]	Medium	Major-moderate adverse	Not significant [2]
	4-7 Grange Burn – Grangeburn Road	Residential - Grangeburn Road	High	Medium	Major-moderate adverse	Not Significant [2]	Medium	Major-moderate adverse	Not significant [2]
	4-8 Grange Burn – Petroineos	Residential - Albert Avenue	High	Negligible	Negligible	Not Significant	Small	Moderate adverse	Not significant [2]
		Residential - Grangeburn Road	High	Very Small	Minor adverse	Not Significant	Medium	Major-moderate adverse	Not significant [2]
5	5-1 Smiddy Brae and Avondale Road	Residential - Avondale Road	High	Negligible	Negligible	Not Significant	Small	Moderate adverse	Not significant [2]
		Residential - Polmonthill Cottage	High	Negligible	Negligible	Not Significant	Very Small	Minor adverse	Not significant
		Residential - Reddoch Road	High	Negligible	Negligible	Not Significant	Medium	Major-moderate adverse	Not significant [2]

[1] Impacts of Moderate, Major-Moderate and Major adverse are considered to result in significant adverse effects when the duration of exceedances above the applicable criteria is anticipated to exceed the period of *'10 days in any 15 consecutive days or a total number of days exceeding 40 in any 6 consecutive months'*, as set out in DMRB LA 111.

[2] Impacts of Moderate, Major-Moderate and Major are not considered to result in significant adverse effects when the duration of the construction activities exceeding the applicable criteria are not expected to exceed the period of *'10 days in any 15 consecutive days or a total number of days exceeding 40 in any 6 consecutive months'*, as set out in DMRB LA 111.

For most of the receptors, it is anticipated that impacts would not result in significant adverse effects since the duration of the construction activity is shorter than the DMRB LA 111 duration criteria. Based on the duration of the activity, significant adverse effects are expected during the construction works at Flood Cell 1, at the locations indicated in Table 8-21, without mitigation.

With regards to construction vibration in terms of human annoyance, no significant adverse effects are anticipated at sensitive receptor locations since the duration is shorter than the DMRB LA 111 duration criteria.

In relation to the additional road traffic during construction, no significant effects are anticipated as the change in noise is negligible.

Where significant adverse effects have been identified in Table 8-21, these require mitigation measures to minimise and/or mitigate the anticipated construction noise and vibration levels. Mitigation measures are discussed in Section 8.6.

8.5.2 Operation phase

Operational and maintenance activities are not expected to result in adverse impacts at any sensitive receptor location. Operational impacts have therefore been scoped out of this assessment as stated in Table 8-1.

8.5.3 Cumulative effects

Cumulative effects are discussed considering the effects across the Scheme (between Flood Cells and Working Areas) and the effects of the Scheme with other relevant developments in the area.

8.5.3.1 Same project cumulative effects

Due to the extent of the proposed flood defences, it is anticipated that the construction works will be divided into four phases / contracts and indicative phases of work have been assumed. Works that overlap are considered for the cumulative effects across the Scheme.

The following overlapping works are not likely to result in cumulative effects since either the receptors are of industrial land-use with negligible sensitivity or the distance separation between the sensitive receptors and the works, at each site, is of more than 300 m and therefore, not likely to result in cumulative construction noise impacts:

- Phase 1:
  - Works overlapping at Cell 1 between Working Areas 1-1, 1-2 and 1-3
  - Works overlapping at Cell 2 between Working Areas 2-1 and 2-2
  - All Working Areas at Cell 2 overlap with Cell 4 Working Areas 4-1, 4-2, 4-6 and 4-7
  - Cell 4 Working Areas 4-1, 4-2, 4-3, 4-5, 4-6 and 4-7 overlap with Cell 5 Working Areas 5-2 and 5-3
  - Works overlapping at Cell 5 between Working Areas 5-1, 5-2 and 5-3
- Phase 2: Cell 3 lock gates works overlap with works at Cell 4 Working Area 4-4 and Cell 5 Working Areas 5-2 and 5-3.
- Phase 3:
  - Works overlapping at Cell 3 between all Working Areas of Cell 3

  - Works overlapping at Cell 3 Working Area 3-1 with Cell 1 all Working Areas
  - Cell 3 Working Area 3-2 overlaps with Cell 1 all Working Area 1-1
  - Cell 3 all Working Areas (except for 3-1) overlap with works at 5-4, 6-1, 6-2
- Phase 4:
  - Works overlapping at Cell 6 between all Working Areas of Cell 6
  - Works overlapping at Cell 4 between Working Areas 4-8 and 4-9
  - Cell 4 Working Areas 4-8 and 4-9 overlap with Cell 6 Working Areas 6-3 and 6-4
  - Cell 5 Working Area 5-4 overlaps with Cell 3 Working Areas 3-2, 3-4 and 3-5
  - Cell 6 Working Areas 6-1 and 6-2 overlap with Cell 3 Working Areas 3-2, 3-3 and 3-4

Cumulative impacts may occur at some of the indicative phases of work when these are forecast to overlap within 300 m of the sensitive receptors. For these cases, the assessment considers the construction noise levels which have been calculated, as worst case, at the closest point to the receptors (as reported in Table 8-16) and, the distance and noise level from the adjacent (overlapping) activity to assess the potential for cumulative effects. This is presented in Table 8-22, with the predicted cumulative levels above the relevant noise level criteria indicated in red text.

Table 8-22: Same project potential for cumulative effects – Predicted cumulative noise levels during construction

Phase	Works forecast to overlap	Receptor	Worst case distances from the works	Predicted cumulative noise level [1]	Noise level greater than predicted in Table 8-16? Y/N
Phase 4	Cell 1: Working Areas 1-3 and 1-4	Residential - Halket Crescent and Rae Court	10 m (1-3) 250 m (1-4)	83 dB(A)	No
	Cell 4: Working Areas 4-1 and 4-2	Hotels to the north of A9	5 m (4-1) 140 m (4-2)	89 dB(A)	No
		Residential - Burnbank and Portal Road	20 m (4-1) 120 m (4-2)	73 dB(A)	No
	Cell 4: Working Areas 4-2 and 4-3	Residential - Moriston Court	45 m (4-3) 105 m (4-2)	71 dB(A)	Yes (+1dB increase)
		Residential - Fintry Road	35 m (4-3) 185 m (4-2)	72 dB(A)	No
	Cell 4: Working Areas 4-3 and 4-4	Leisure Centre (Grange Road)	10 m (4-3) 115 m (4-4)	71 dB(A)	No
	Cell 4 & 5: Working Areas 4-4 and 5-1	Residential - Reddoch Road	8 m (4-4) 80 m (5-1)	85 dB(A)	No

[1] Worst case predicted cumulative noise level considering the closest distance between the highest noise level activity at each site and the distance to the adjacent working area.

For the residential receptor at Moriston Court, with works overlapping at Working Areas 4-2 and 4-3, it is predicted that the cumulative noise level would be 1 dB(A) higher than that predicted in the individual worst case activities. However, this increase would not result in a higher magnitude of impact or significance of effect since the resultant cumulative noise level would still be below the applicable noise threshold (i.e. 75dB(A)). At the remaining locations it is not expected that the construction activities

occurring at the same time would cumulatively result in noise levels greater than that already predicted for the assessment (Table 8-16). This includes the sensitive receptors where the noise levels are already exceeding the criteria (in red text in Table 8-22). Therefore, same project cumulative effects from noise are not anticipated during the construction of the Scheme.

Vibration levels quickly attenuate with distance and at a distance of 100 m from the works the vibration level is estimated to be below the criteria for human annoyance (i.e. of 1.0 mm/s). It is considered unlikely that vibration levels from works occurring at the same time at two different Working Areas would both be within 100 m from a receptor. Therefore, same project cumulative effects from construction vibration on human response are not anticipated.

With regard to vibration on nearby buildings/structures, the predicted levels of vibration (refer to Table 8-18) are below the threshold criteria for cosmetic damage from BS 5228-2 (of 15 mm/s) and below that adopted for this assessment, (of 7.5 mm/s, half of the value). As such, it is considered that no identified receptors will experience cumulative effects from vibration.

The potential cumulative effects on noise and vibration sensitive receptors, when considered in-combination with any other impacts identified in the other factor specific assessments that form part of the EIA, are discussed in Chapter 15: Cumulative Effects.

8.5.3.2 Other projects cumulative effects

There are not expected to be any cumulative effects from other projects within the area. This is because the activities associated with other projects are either too distant from any Working Area or are of a low noise generating nature.

8.6 Mitigation

8.6.1 Construction phase

8.6.1.1 Secondary mitigation

A noise and vibration monitoring plan shall be prepared in consultation with Falkirk Council and implemented during the construction phase to determine whether the noise and/or vibration levels arising from the works would exceed or are likely to exceed the agreed limits. This is commitment **NV1** This monitoring plan would include the locations of the adversely affected residents identified in this assessment (i.e. at representative receptor locations and during the construction activities indicated in Table 8-15 in red text, predicted to exceed the appliable noise limit criteria, in particular at the locations which have been identified with significant residual adverse effects in Section 8.7.1.). The monitoring methodology and plan would be defined and undertaken by the appointed contractor, in line with these assessment outcomes and the recommendations in this Section.

Noise levels must be monitored according to the methods set out in Annex G of BS 5228-1. All measurements must be made on a sound level meter complying Class 1 as defined within BS EN 61672-1:2013 (British Standards Institution, 2013). While vibration monitoring should be undertaken following the guidance contained in BS 6472-1:2008 on measurement of vibration for assessing human disturbance and for building damage in BS ISO 4866:2010.

For the noise monitoring, measurements should be undertaken at the façade of the closest adversely affected residential properties facing the construction works. The microphone should sit between 1.2 and 1.5 m above the ground and in a façade position (i.e. 1 m from the closest building to the works). The noise monitoring should record the $L_{Aeq,T}$ (in A-frequency weighting and Fast-time weighting setting) and the L_{AFmax} (in A-frequency weighting and Fast-time weighting setting). Both indices should be with a sampling time of 1s or smaller.

For vibration monitoring, the closest sensitive occupied building should be chosen as the monitoring location. The most suitable location for vibration monitoring is on a hard surface, at ground floor level, and inside the building. If access is not available inside the closest sensitive building, then an alternative representative location will be sought or a location near the foundation of the closest building to the outside may be selected. Based on the outcomes of the assessment undertaken this chapter, the buildings which have been predicted to exceed the applicable vibration limit criteria for human annoyance during the vibratory compaction and vibratory piling works as indicated in Table 8-18 in red text, are recommended to be monitored for vibration. The vibration monitoring should continuously measure the maximum PPV in all the orthogonal directions.

The time period of monitoring for noise and vibration will vary depending upon the works activity being undertaken but this is preferably to be continuous noise and vibration monitoring. This will allow instantaneous mitigation measures to be implemented once any exceedances in noise and/or vibration are registered.

The locations for noise and vibration monitoring need to be selected prior to commencement of the works when further details access are known and accordingly agreed with the relevant EHO at Falkirk Council. The monitors could be linked to an alert system that would provide visual and audible alarm in times when threshold levels are being exceeded. The results from the monitoring would be made available to Falkirk Council if requested or in the case of any complaints these need to be accordingly logged in a register.

8.6.1.2 Tertiary mitigation

Tertiary mitigation measures across the Scheme are discussed below. These will be incorporated into the Construction Environmental Management Plan (CEMP) to manage the noise on-site during the construction phase and reduce the magnitude of predicted impacts.

NV2 – Adopt Best Practicable Means (BPM) under Section 72 of Control of Pollution Act (CoPA) 1974 (HMSO, 1974) and good practice under BS 5228 Part 1: Noise and Part 2: Vibration throughout the construction period.

Measures developed for construction sites should be implemented considering the use of BPM under Section 72 of CoPA 1974 (HMSO, 1974) and good practice under BS 5228 Part 1: Noise and Part 2: Vibration. These include, but are not limited to:

- Restriction of working hours to between 8:00 and 18:00 Monday to Friday, and no working on Saturday, Sunday or Public Holidays;
- Programming the works to restrict impacts to the minimum possible time;
- Keeping local residents and property owners fully informed about the nature and timing of the works, including traffic controls, via such means as newsletters or individual contact, where appropriate;
- Having a representative available on site during working hours to answer queries or address any concerns expressed;
- The quietest available plant or machinery should be used where practicable. For example, any compressors brought to site will be super-silenced or sound reduced models fitted with acoustic enclosures or any pneumatic tools fitted with silencers or mufflers, wherever practicable;
- Ensure that all plant and equipment is properly maintained and operated in accordance with manufacturers' recommendations and in such a manner as to avoid causing excessive noise;
- Start-up plant and equipment sequentially rather than all together;
- Ensure that equipment is shut down when not in use for a period longer than 5 minutes;

- Use of temporary construction noise screens / barriers around particularly noisy activities and stationary plant such as generators;
- Setting for vibration compaction plant to a low amplitude mode or using smaller plant items when operating in close proximity to sensitive receptors to minimise the vibration levels;
- Using rotary piling wherever possible to minimise the impact from vibratory piling;
- No vehicles will wait or queue on public highways with engines running and care will be taken when unloading deliveries, and
- The Contractor on site should carry out a risk assessment to determine the most appropriate mechanism of noise management for reversing alarms. The use of reversing alarms should not be considered as a default position in lieu of a proper risk assessment. The noise control for reversing alarms should consider; design traffic routing and vehicle selection to avoid / minimise the requirement for vehicle reversing, switch off alarms and introduce a banksman where feasible. Where vehicle reversing alarms are required, they should be designed to cause the lowest practical environmental impact; preferably these should be directional broadband noise emitters or automatically adjusted to ambient noise levels.

It is recognised that it will be challenging to reduce these levels through mitigation, in particular due to the small distance between some of the receptors and activities, which, in the worst cases is between 5 to 20 m from the construction works. The use of temporary noise screens can if positioned effectively provide noise reductions of between 5 and 10 dB(A).

8.6.2 Operation phase

No mitigation measures are proposed as there are no adverse effects anticipated during operation of the Scheme.

8.6.3 Cumulative effects

No mitigation measures are proposed as there are no significant cumulative effects in relation to noise and vibration.

8.7 Residual Effects

8.7.1 Construction phase

It is anticipated that the mitigation set out in Section 8.6 is likely to reduce the predicted adverse impacts from some of the activities. However, the efficacy of the measures cannot be fully quantified since they are dependent on the site-specific conditions and would be fully defined by the contractor, once appointed for the works.

In order to assess the likely residual effects, the assessment has assumed that noise mitigation measures are likely to provide at least 10 dB(A) reduction based on professional experience and the possible noise reductions provided within BS 5228-1. In locations where the predicted exceedance of the noise limit is below 10 dB(A), this will reduce the noise and vibration levels to a level below the relevant criteria. For locations where the construction noise levels are more than 10 dBA above the criteria, the magnitude of impact would be reduced but the significant effect would remain.

For construction vibration it is anticipated the levels of vibration would be reduced through use of a lower vibration setting or with the use of plant of smaller size when working in close proximity to the sensitive receptors.

Significant residual adverse effects from construction noise are expected to occur at the following locations within Flood Cell 1:

- 1-1 Stirling Road: Residential receptors on Stirling Road.
- 1-2 Carron Bridges: Residential receptors on Burder Park, Beaumont Drive, and Farm Street.
- 1-3 Chapel Burn: Residential receptors on Waters End, Bryce Avenue, Duncan Avenue, Halket Crescent and Rae Court.
- 1-4 Dock Street: Residential receptors on Dock Street, Wardlaw Place, Gilfillan Place, The Avenue (including Carron House Lodge).

Residual significant adverse effects are not anticipated at the remaining sensitive receptors within Flood Cell 1 or within any other Flood Cells. There are predicted to be no significant residual adverse effects from vibration or construction traffic. Similarly, there are not predicted to be any cumulative effects from noise or vibration.

Residual effects after mitigation in each Working Area are shown in Table 8-23, with reference to the unmitigated impacts reported in Table 8-21. Table 8-23 refers to construction vibration effects on human annoyance only as the assessment has showed there is no potential for cosmetic damage to buildings.

The assessment has estimated that vibration levels would not exceed the recommended criteria for a period exceeding '*10 or more days or nights in any 15 consecutive days or nights or, a total number of days exceeding 40 in any 6 consecutive months*'. Therefore, there are no significant residual adverse effects expected at any sensitive receptor location due to vibration during construction.

During construction, vibration levels would be perceptible at some locations. The duration of the vibratory compaction and piling works is expected to be short and therefore these would not result in significant adverse effects.

No significant residual effects are anticipated from the additional road traffic during construction of the Scheme.

Table 8-23: Residual impacts and effects in each Working Area – Construction noise and vibration

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
1-1 Stirling Road	Residential – Stirling Road	Elevated noise and/or vibration levels during the construction phase of the Scheme, with works limited to weekdays and daytime only. These impacts are of temporary nature and limited to the duration of the works.	Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]	Tertiary mitigation measures anticipated to result in 10 dB(A) reduction in construction noise. No specific mitigation measures are possible for vibration. However, the duration of the activity is short which results in no significant effects.	Moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Beech Crescent / Falkirk Road / Lade Drive		Negligible - Not significant [3]	Negligible- Not significant [3]		Negligible- Not significant [3]	Negligible- Not significant [3]
	Commercial buildings on Stirling Road		Moderate adverse - Significant [1]	Minor adverse - Not significant [3]		Minor adverse- Not significant [3]	Minor adverse - Not significant [3]
1-2 Carron Bridges	Residential - Burder Park		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Beaumont Drive		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Park Road and Carron Road		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Farm Street		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Mulloch Avenue		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
	Dawson Mission Church		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
1-3 Chapel Burn	Residential - Waters End and Bryce Avenue		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Duncan Ave		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Carronshore community Centre		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Residential - Halket Crescent and Rae Court		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - Blackmill Crescent		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
1-4 Dock Street	Residential-Dock Street/ Wardlaw Place / Gilfillan Place		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]
	Residential - The Avenue (incl. Carron House Lodge)		Major-moderate adverse - Significant [1]	Major-moderate adverse - Not significant [2]		Moderate adverse- Significant [1]	Major-moderate adverse - Not significant [2]

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
	Residential - Main Street / Westerton Terrace / Bothkennar Road		Negligible - Not significant [3]	Negligible - Not significant [3]		Negligible- Not significant [3]	Negligible - Not significant [3]
	Residential - Halket Crescent / Inglis Drive		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Commercial - Stables at the end of Dock Street		Major-moderate adverse- Significant [1]	Moderate adverse - Not significant [2]		Minor adverse- Not significant [3]	Moderate adverse - Not significant [2]
2-1 Forth & Clyde Canal Lock	Residential - West Church Drive / Clyde Street		Negligible - Not significant [3]	Minor adverse - Not significant [3]		Negligible- Not significant [3]	Minor adverse - Not significant [3]
2-2 Jarvie Plant	Residential - West Church Drive / Clyde Street		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
4-1 Upstream of M9	Cherry tree nursery		Major-moderate adverse - Not significant [2]	Negligible - Not significant [3]		Negligible- Not significant [3]	Negligible - Not significant [3]
	Hotels to the north of A9		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
	Residential - Grandsable Road		Major-moderate adverse - Not significant [2]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Hotel to the south of A9 (Beancross Road)		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
4-2 Flood relief channel – Rannoch Park	Residential - Rannoch Road		Minor adverse - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Burnbank and Portal Road		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Fintry Road		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
4-3 Flood relief channel – Inchyra Road	Residential - Moriston Court		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Fintry Road		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Cuiling Place		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Inchyra Hotel		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
	Leisure Centre (Grange Road)		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
4-4 Flood relief channel – Whole-flats Road	Residential - Reddoch Road		Major-moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Residential - Smiddy Brae		Moderate adverse - Not significant [2]	Negligible - Not significant [3]		Negligible- Not significant [3]	Negligible - Not significant [3]
	Leisure Centre (Grange Road)		Negligible - Not significant [3]	Minor adverse - Not significant [3]		Negligible- Not significant [3]	Minor adverse - Not significant [3]
4-5 Grange Burn – Zetland Park	Residential - Abbots Road		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Residential Drummond Place		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Grangemouth Community Education Unit		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
4-6 Grange Burn – Dalgrain to Bo'Ness Road	Residential - Abbots Road		Moderate adverse - Not significant [2]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Residential - Park Road		Moderate adverse - Not significant [2]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
4-7 Grange Burn – Grangeburn Road	Residential - Grangeburn Road		Major-moderate adverse - Not significant [2]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
	Residential - Albert Ave		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]

Working Area	Representative noise sensitive receptor	Impact	Predicted significance of effect without mitigation (as reported in Table 8-21)		Mitigation[1]	Residual significance of effect considering mitigation	
			Construction noise	Construction vibration (Human response)		Construction noise	Construction vibration (Human response)
4-8 Grange Burn – Petroineos	Residential - Grangeburn Road		Minor adverse - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]
5-1 Smiddy Brae and Avondale Road	Residential - Avondale Road		Negligible - Not significant [3]	Moderate adverse - Not significant [2]		Negligible- Not significant [3]	Moderate adverse - Not significant [2]
	Residential - Polmonthill Cottage		Negligible - Not significant [3]	Minor adverse - Not significant [3]		Negligible- Not significant [3]	Minor adverse - Not significant [3]
	Residential - Reddoch Road		Negligible - Not significant [3]	Major-moderate adverse - Not significant [2]		Negligible- Not significant [3]	Major-moderate adverse - Not significant [2]

[1] Impacts of Moderate, Major-Moderate and Major are considered to result in significant adverse effects as the duration of exceedances above the applicable criteria is anticipated to exceed the period of *'10 days in any 15 consecutive days or a total number of days exceeding 40 in any 6 consecutive months'*, as set out in DMRB LA 111 and in consideration of the Construction Methodology Report which provides indicative durations for the works (as set out in Table 8-10).

[2] Impacts of Moderate, Major-Moderate and Major are not considered to result in significant adverse effects when the duration of the construction activities exceeding the applicable criteria are not expected to exceed the period of *'10 days in any 15 consecutive days or a total number of days exceeding 40 in any 6 consecutive months'*, as set out in DMRB LA 111 and in consideration of the of the Construction Methodology Report which provides indicative durations for the works (as set out in Table 8-10).

[3] Impacts of Minor and Negligible are not considered to result in significant adverse effects, in line with the EIA methodology.

8.7.2 Operation phase

No residual significant effects from operation are anticipated.

8.7.3 Interaction with other environmental disciplines

Changes in road traffic due to the construction phase of the Scheme have been assessed based on the data in Chapter 14: Traffic and Transportation. Vibration levels from construction activities involving compaction and vibratory piling have been calculated at the location of cultural heritage assets and it was concluded that no risk of cosmetic damage is likely to occur (refer to Chapter 13: Cultural Heritage). The noise and vibration assessment of ecologically designated sites and ecology receptors has been provided separately in the Habitats Regulations Appraisal Report and in Chapter 7: Biodiversity.

8.7.4 Cumulative effects

As discussed in Section 8.5.3 and Chapter 15: Cumulative Effects, no significant 'Same Project' or 'Other Project' cumulative effects on noise and vibration sensitive receptors are anticipated or require specific mitigation and therefore no significant cumulative effects are anticipated.

8.8 Monitoring

8.8.1 Construction phase

A noise and vibration monitoring plan shall be prepared in consultation with Falkirk Council and implemented during the construction phase (**NV1**; see Section 8.6.1 for details).

8.8.2 Operation phase

No monitoring would be required for noise and vibration during operation as there are no impacts and effects associated with this phase.

8.8.3 Cumulative effects

Although no cumulative effects are anticipated due to noise and vibration based on current understanding of the phases of work for the Scheme and current information available from other projects in the area, the noise and vibration monitoring plan should consider the potential for cumulative effects with the same project or other projects. Noise and/or vibration monitoring will help to keep a record of the construction noise and vibration levels from the Scheme and if construction noise or vibration from other developments in the area are contributing further to an increase in the levels at the nearest sensitive receptors.

8.9 References

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