13. Noise and Vibration

13.1. Introduction

This chapter considers the noise and vibration impact due to both the construction and operation of the proposed scheme. The purpose of the study was to:

- Establish the existing background noise and vibration levels at representative, sensitive locations,
- Assess the noise and vibration impacts of the construction work associated with the new branch line and the third mainline track,
- Assess the noise and vibration impacts of the operation of the new branch line and the third mainline track,
- Assess the impact of any changes in road traffic noise from the M8 as a consequence of the scheme, and,
- Provide recommendations on the mitigation of any construction and operational noise and vibration.

13.1.1. Terminology, Guidance and Criteria

Noise and vibration terminology, guidance and criteria are discussed in greater detail in Appendix 13, along with the relevant standards and criteria applicable to this scheme, the consequences of which are outlined below.

13.2. Noise & Vibration Prediction Methodology & Assessment Criteria

13.2.1. Demolition and Construction Noise

The main prediction method used in this assessment for construction and fixed plant noise sources is based on those outlined in BS 5228: 1997, used to predict noise as a free-field equivalent continuous level averaged over a one-hour period ($L_{Aeq,1h}$).

For short-term daytime construction noise a limit of 70 dB $L_{Aeq,1h}$ (free-field) is considered appropriate in the vicinity of the nearest noise-sensitive developments (i.e. local residential properties) – this should prove acceptable for up to 8 weeks per year at any single receptor throughout the course of the railway construction. For longer term demolition and construction activities a limit of 65dB $L_{Aeq,1h}$ (free-field) is appropriate.

13.2.2. Fixed Plant

For any new permanent fixed plant (substations, pumps, generators etc.) a limit of up to 5 dB(A) in excess of the existing ambient background noise level at nearest noise-sensitive developments is appropriate. On the basis that such plant could operate on a 24-hour basis, comparison of predicted levels with the existing minimum reasonable ambient background noise level throughout a 24-hour period measured at the respective property is considered appropriate.

13.2.3. Scheme Operational Noise

The prediction method for rail traffic has been undertaken to the requirements of the 'Calculation of Railway Noise' (CRN) issued by the Department of Transport, 1995. This prediction method is used to predict the 18-hour L_{Aeq} level ($L_{Aeq,18h}$) for daytime (06.00-24.00) and a 6-hour L_{Aeq} level ($L_{Aeq,6h}$) for night-time at (24.00-06.00) 1 metre from the most exposed façade.

For operational noise due to the passage of passenger and freight trains, the daytime, evening (19.00-24.00) and night-time L_{Aeq} due to the operation of the line is appropriate for assessing the impact of the scheme by comparison with existing ambient noise levels for short-term impact, and with reference to social studies reporting public perception of railway noise for long-term impact. Additionally, the occurrence of $L_{Amax,\ fast}$ values above 60 dB at the facades of residential properties during night-time (23:00-07:00) is appropriate for assessing the impact of the railway movements specific to sleep disturbance.

The advice given in GoMMMS (DETR, 2000) and Guidelines For Noise Impact Assessment (IOA/IEMA, draft, 2002) has been followed and the criteria in Table 13.1 have been employed, comparing predicted noise levels for the 'Do Minimum' and 'Do Something' scenarios:

Table 13.1: Categorisation of the Significance of Noise Impact

Façade $L_{Aeq,18h}$ (from railway)	Increase in L_{Aeq} (day, evening, night periods)			
	1 < 3	3<5	5<10	>10
< 55	negligible	negligible	minor	minor
55 < 60	negligible	minor	moderate	moderate
60 < 65	negligible	minor	moderate	substantial
> 65	negligible	moderate	substantial	substantial

These results were used to assess the need for mitigation in the form of lineside barriers. Applying the methodology discussed previously, all properties subject to a façade noise level (due to railway noise) equal to or greater than 55 dB $L_{Aeq,18h}$ (approximately 52 dB $L_{Aeq,18h}$ free-field) and subject to an increase in free-field noise level equal to or greater than 5 dB(A) were considered in need of mitigation. Planning Advice Note 56 (PAN 56) and the World Health Organisation suggest an onset of community annoyance at daytime 55 dB $L_{Aeq,18h}$ and GoMMMs confirms that 'Therefore 55 dB $L_{Aeq,18h}$ is the recommended cut-off level to use in estimating the total population annoyed' (GoMMMs, Volume 2 paragraph 4.3.14). A 5 dB(A) or greater increase was chosen on the basis that increases of up to 3 dB(A) (in steady noise) generally goes unnoticed to the human ear.

13.2.4. Changes in Road Traffic Use

The prediction method for road traffic has been undertaken to the requirements of the 'Calculation of Road Traffic Noise' (CRTN) issued by the Department of Environment and the Welsh Office, 1988. This is used to predict road traffic noise as an 18-hour L_{A10} daytime level ($L_{A10,18h}$) at 1m from the most exposed façade.

For any potential change in local road traffic as a consequence of the scheme the Design Manual for Road and Bridges provides a method of evaluating both the immediate and long term impact of abrupt changes in the 18-hour daytime traffic flow (06.00-24.00) in terms of the effects on occupiers of residential property. The inference from recognised literature is that a change of up to 1dB(A), equivalent to road traffic flow changes of greater than –20% or +25%, is not significant in terms of noise.

13.2.5. Demolition and Construction and Operational Vibration

A full discussion of construction and operational vibration is included in the Appendix to Chapter 13.

There are no nationally accepted formulae for the prediction of passage of vibration through ground due to the non-uniform effects of different ground conditions, although some empirical formulae have been proposed for known ground conditions based on previously measured data.

Operational vibration has been calculated at a set of receptors using measured source data from another site and by making appropriate adjustments for distance and ground conditions.

Vibration due to construction has been calculated using measured source data and the propagation relationship taken from BS 5228: 1992: part 4. The Standard suggests that attenuation with distance should be calculated as the reciprocal of the source-receiver distance.

Both predicted operational and construction vibration can then be compared to building damage criteria described in BS 5228: Part 4 :1992 and BS 7385: Part 2: 1993 from derived peak particle velocities (ppvs).

Vibration associated with the construction and operation of the railway having the potential to cause human annoyance data has been assessed using British Standard BS 6472: 1992 (as discussed in detail in Appendix 13). This may be used to assess the likelihood of adverse comment arising from local residents due to vibration associated with the construction and operation of the railway using derived vibration dose values (VDVs).

13.3. Consultations

Telephone discussions were held with Environmental Health Officers from Renfrewshire Council (Russell Anderson) and Glasgow City Council (Vincent McInally). From these discussions, and with reference to site maps and their local knowledge, locations for baseline noise monitoring were discussed and a set of monitoring positions was agreed.

The agreed ambient noise monitoring locations are shown on Figure 12.1.

13.4. Baseline Measurements

13.4.1. Noise

Ambient noise levels were monitored at four locations over short-term periods (1 hour) throughout a 24-hour period along the corridor of the proposed railway. Due to the new airport spur line required and the associated construction works, monitoring has been focused to the affected area (Paisley). The monitoring procedures adopted were in conformance with the requirements of BS 7445:1991 'Description and measurement of environmental noise' and all meters were checked for calibration before, during and after use. Measurements at all locations were made 'free field' (no vertical reflective surfaces within 3m of the microphone). The microphone was positioned at a height of 1.5m above ground level at all locations.

The sound level meters were programmed to measure a range of noise parameters including L_{Aeq}, L_{A90} and $L_{Amax,fast}$ values.

The full ambient measurements recorded are reported in the Appendix. Typical day (06:00-19:00), evening (19:00-00:00) and night (00:00-06:00) L_{Aeq} and L_{A90} values are presented in Table 13.2.

Table 13.2 Summary of Ambient Noise Measurements

Ref	Location (see also Figure 12.1)	07.00-19.00 Day		19.00-23.00 Evening		23.00-07.00 Night		
		L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	$L_{Amax,fast}$
A	Adjacent to 168 Greenock Road beside St James' Park	63	60	62	59	55	52	73
B	Adjacent to 74 Clark Street, opposite Airlink parking	64	53	61	50	43	42	49
C	Opposite 70 Murray Street, adjacent to railway line	64	46	62	43	53	39	79
D	Rear of 46 Queen Elizabeth Ave, adjacent to Hillington West Station	57	48	54	45	41	37	46

The area in the vicinity of Greenock Road and St James Park (Position A) is dominated at all time periods by road traffic noise from the M8. Other noise sources include aircraft noise (except night-time) from the airport nearby and road traffic noise from the A726 (Greenock Road). Noise sensitive receptors to the area are mainly traditional single and 2-storey detached and semi-detached residential houses.

The predominant daytime noise source in the Murray Business Area (Positions B and C) is from road traffic. During the survey, the proportion of heavy goods vehicles and minibuses appeared to be relatively high due to the numerous industrial units and airport parking facilities. Railway noise from the Bishopton to Paisley Gilmour Street line and aircraft noise (except night-time) are also clearly audible. There are few residential dwellings in this area, apart from a short row of houses on Clark Street and Murray Street. It is understood that the Carlton Die Casting works located at the junction of Clark Street and Greenhill Road contains vibration sensitive equipment, although this building is currently as close to the existing mainline as it would be from the new branch line.

In the Penilee/Hillington areas (Position D) railway noise from the mainline is the dominant noise source in the vicinity of the railway corridor. Road traffic noise from Sandwood Road and Queen Elizabeth Avenue was also occasionally audible. These areas are predominantly residential.

To the east of Hillington, the area is generally less residential and runs closely to the M8 motorway. Road traffic noise therefore predominates over railway noise.

The range of day, evening and night-time ambient noise levels monitored is not unusual for suburban and semi-suburban areas. The most recent National Noise Incidence survey found that 54% of the population of the UK live in dwellings exposed to daytime (07:00-23:00) noise levels above 55 dB L_{Aeq} and 67% to night-time noise levels above 45dB L_{Aeq}.

13.4.2. Vibration

Ambient vibration levels were monitored at the same locations as for the noise survey over short-term periods (1-hour) throughout a 24-hour period. Additional measurements were recorded at the Junction of Clark Street and Greenhill Road. The detailed ambient measurements are reported in the Appendix 13. Typical day (06:00-19:00), evening (19:00-00:00) and night (00:00-07:00) Vibration Dose Values (VDV, units m/s1.75) and peak particle velocity (PPV, units m/s) are presented in Table 13.3.

Table 13.3: Summary of Ambient Vibration Measurements

Ref	Location (see also Figure 12.1)	06.00-19.00 Day		19.00-00.00 Evening		00.00-06.00 Night	
		VDV 1hr	ppv	VDV 1hr	ppv	VDV 1hr	ppv
A	Adjacent to 168 Greenock Road beside St James' Park	0.03	0.34	-	-	0.01	0.14
B1	Adjacent to 74 Clark Street, opposite. Airlink parking, 138 metres from nearest rail	0.02	0.26	-	-	0.01	0.14
B2	Junction of Clark Street and Greenhill Road, 43 metres from nearest rail	0.06	0.86	0.04	0.46	-	-
C	Opposite 70 Murray Street, adjacent to railway line, 20 metres from nearest rail	0.10	0.86	0.10	0.82	0.01	0.22
D	Rear of 46 Queen Elizabeth Ave, adjacent to Hillington West Station, 40 metres from nearest rail	0.04	0.32	0.03	0.30	0.01	0.14

13.5. Environmental Effects

13.5.1. Effects of Construction

13.5.1.1 Railway Construction Noise

In order to evaluate construction noise it is necessary to define the various activities that will be undertaken. Until the construction contractor has been appointed, this can only be assumed based on previous experience since, unless contractually obliged to use a particular method, different contractors tend to use different approaches to achieve the same ends.

Based on previous experience with railway development a range of typical construction routines has been used to enable calculation of likely noise levels at nearest existing noise-sensitive receptors. The prediction routines assumed and tabulated calculation routines, to the requirements of BS 5228, are shown in the Appendix to Chapter 13.

Worst case free-field $L_{Aeq,1h}$ levels have been calculated at the nearest sensitive receptors for each phase of the work. The receptor locations are given in Table 4, chosen as representative of worst-case receptors (i.e. closest position to the line in a particular area or closest position to a construction compound). Where considered practicable (around the construction compound and for the majority of ground level works, for example) it was assumed that a 2 metre high temporary or permanent barrier was in place to the works perimeter. Erection of such boarding is not uncommon at construction sites, to provide security and restrict line-of-sight, vandalism, litter, noise etc., and this boarding provides useful noise attenuation. The predicted free-field $L_{Aeq,1h}$ levels are reported in the Appendix 13.

Table 13.4: Receptor Positions for Principal Construction Areas/ Tasks

Ref.	Location	Closest Representative Sensitive Receptor
C1	Airport Station Construction Compound	Holiday Inn
C2	Airport Fuel Farm Construction Compound	176 Greenock Road
C3	St James' Park Construction Compound	176 Greenock Road
C4	Paisley Viaduct Construction Compound (Wallneuk Junction)	3 Lawn Street
C5	Barshaw Golf Course Construction Compound (Arkleston)	16 Arkleston Crescent
C6	Third Track, Main Line	184 Linburn Road
C8	Glasgow Central Station	32 Oswald Street
C9	Elderslie Loop	Main Road, Elderslie
C10	Arkleston Branch Construction Compound (Wallneuk Junction)	223 Gallowhill Road

The BS 5228 prediction Tables in the Appendix 13 show that the short term limit of 70 $dBL_{Aeq,1h}$ would be exceeded at various locations for some operations that may be associated with construction, particularly during welding, jointing and rail stressing work necessitating the use of rail saws, even after allowing for noise reduction due to the use of barriers.

Construction compound noise is predicted to be considerably lower than the 70 $dBL_{Aeq,1h}$ short term limit (approximately 60 $dBL_{Aeq,1h}$ at 30 metres), although this is of course dependent on the precise activities that will be undertaken. It is understood in addition to the Arkleston Branch Construction Compound, there will be five other compounds located along the main line and three associated with the branch line and Central Station works.

A full demolition and construction noise impact assessment is recommended once the contractor has been appointed and the preferred method of working made available (to include timetable, plant, location of plant compound etc.). This will enable an accurate assessment of potential construction noise and liaison with the contractor would allow specific noise mitigation measures to be identified where necessary. These measures may include erection of additional noise barriers, changes to originally proposed methods of work, restrictions on working times, and liaison with local residents.

13.5.1.2 Haul Routes

For works on the main railway line, the majority of materials will be transported to each construction compound by rail, as these are all adjacent to the railway. However, road access will be required for personnel to enter these sites and the local road network will be utilised in each case.

Defined haul routes will be used for transporting men and materials to the construction compounds. For the branch line compounds these routes will all be by road, predominantly via the M8 (see Figure 2.2). North of the motorway, compounds will be accessed via the local road north of the M8 heading east from Junction 29 (St James' Interchange) and the airport roads, returning to the M8 via Junction 28 and/or 29.

For compounds south of the M8, vehicles will exit the M8 at Junction 29 southwards onto the A726. From this point vehicles will either turn left at the temporary signalised junction into the compound at St James' Park or right, into McFarlane Road. From McFarlane Road, vehicles will use North Greenhill Road to access Clark Street and Murray Street (via McKean Street).

During construction periods when significant numbers of HGV movements will be necessary, careful consideration should be given to their timing to avoid convoys of vehicles, especially through residential areas. Attention should be given to the quality of road surfaces, in particular on smaller, local roads, to minimise the effects of ground-borne vibration (which is negligible for a HGV passing by on a good road surface). This is particularly relevant for Greenhill Road where at 108/110 a property is suffering from structural defects and also Carlton Die Castings Ltd are located at the Clark Street junction.

13.5.1.3 Railway Construction Vibration

With the exception of certain types of piling construction plant, the equipment listed in the Appendix 13 is not recognised as sources of high levels of environmental vibration.

Vibration from any necessary piling work on the elevated sections of the Airport branch line would depend upon local ground conditions and the type of equipment used, but small diameter (150 – 200 mm) rotary bored piling equipment is expected to be used and would result in generally lower noise and vibration levels than other types of piling equipment.

As discussed in the Appendix 13, rotary bored piling would result in vibration levels well below the limits of human annoyance and structural damage at the nearest properties to the viaduct and consequently complaints regarding vibration from piling work are highly unlikely. There are various other low vibration (and low noise) piling options available.

It is understood that Carlton Die Castings Limited at the Four Square Tobacco Building at Greenhill Road undertake foundry casting and metal machining work, utilising various traditional metalworking machines including lathes, turners and millers manufactured by Matsuura, Daewoo and Cincinnati. Information from Matsuura indicates a vibration tolerance of 4.9 ms^{-2} or less for a CNC milling machine. (This is a relatively moderate vibration tolerance and much more stringent tolerances exist for proprietary computer and other sensitive equipment).

The nearest point of the property is 48m from the existing railway lines, and would be 10m from the proposed GARL railway. From Appendix 13 it can be seen that rotary bored piling would be unlikely to generate a ppv exceeding the suggested tolerance of 4.9 m/s. Furthermore, it is assumed that the relevant machines are located at the closest point of the building to the proposed GARL railway. Consequently it is considered unlikely that the use of rotary bored piling (or a similar low vibration piling method) would give rise to machine errors at the Carlton Die Casting Limited's premises.

13.5.2. Effects of Operation

13.5.2.1 Railway Noise

The number of daytime (06:00-00:00) and night-time (00:00-06:00) movements in both directions used for the noise assessment is presented in Tables 13.5 and 13.6 respectively. The data is based on timetabling information supplied by the Transportation Division of Faber Maunsell. All GARL services will comprise Class 334 EMUs (Electric Multiple Units).

Table 13.5 Day Time Train Movements (both directions)

Stretch	EMU[1]		DMU[2]		Freight	
	Current	With GARL	Current	With GARL	Current	With GARL
Glasgow Central - Shields Junction	331	455	86	79	0	0
Shields Junction - Cardonald Junction	290	426	5	5	71	71
Cardonald Junction - Paisley Gilmour St	283	425	5	5	64	64
Paisley Gilmour St - Paisley St James	136	280	0	0	0	0
Airport Branch	0	142	0	0	0	0

[1]Electric Multiple Unit
[2]Diesel Multiple Unit

Table 13.6 Night-Time Train Movements (both directions)

Stretch	EMU[1]		DMU[2]		Freight	
	Current	With GARL	Current	With GARL	Current	With GARL
Glasgow Central - Shields Junction	8	20	7	0	0	0
Shields Junction - Cardonald Junction	0	5	0	0	1	1
Cardonald Junction - Paisley Gilmour St	0	3	0	0	1	1
Paisley Gilmour St - Paisley St James	0	3	0	0	0	0
Airport Branch	0	3	0	0	0	0

Typical daytime (06:00-midnight) increases along the mainline are in the order of 40% with night-time services increasing from 0 to around 5.

Representative properties have been chosen along the route fronting the railway corridor. From the supplied train schedule and speed profile, façade noise levels were calculated at first floor level (4.0m high) using the recommended 'Calculation of Railway Noise' publication methodology. Selected properties were chosen to reflect the worst-case noise impact for single properties or groups of properties along the complete length of the line from Glasgow Central Station to the Airport. At each location the $L_{Aeq,18h}$ daytime (06.00-00.00) and $L_{Aeq,6h}$ night-time (00.00-06.00) has been calculated, assuming no mitigation. Consideration has been given to track gradient. The following assumptions have been used:

1) No official data is available for the Class 334 EMU proposed for the GARL service, therefore the closest equivalent (Class 319) has been assumed.
2) All GARL services are composed of 4 carriages.
3) All other passenger services are composed of 6 carriages.
4) GARL service only is to use the 3rd (new) mainline. This has been assumed in the absence of detailed operational information (which is likely to change from day to day).
5) Freight trains are assumed to be travelling at a steady speed.
6) The length of freight trains and types of wagons is not available as this varies from day to day. A representative train has been assumed for all freight movements (Class 47/56/60 loco (all 3 classes produce same noise level) and 10 Coal Hopper HA wagons, travelling at 60 mph).

A summary of the daytime results is presented in Table 13.7, and the night-time results in Table 13.8.

The Do Minimum and Do Something scenarios represent the situation either without or with the scheme respectively, at the year of opening.

Table 13.7 Predicted existing daytime and future daytime railway noise levels

Stretch	Location	Predicted Current railway noise level	Predicted With GARL railway noise level (no mitigation)	Difference (dB increase)	Existing Measured Ambient noise (all sources)	Comments
		$L_{Aeq,18h}$	$L_{Aeq,18h}$		L_{Aeq} (measured)	
Branch line	172a Greenock Rd	(no railway)	55	-	63	Daytime ambient noise already exceeds predicted future railway noise
Branch line	74 Clark St	56	59	3	64	Minor increase. Daytime ambient noise already exceeds predicted future railway noise
Branch line	70 Murray St	66	67	1	64	Negligible increase
Mainline	184 Linburn Rd	68	70	2	57[a]	Negligible increase
Mainline	40 Fochabers Dr	70	72	2	-[b]	Negligible increase
Mainline	37 Nelson St	55	57	2	-[b]	Negligible increase

[a]Not possible to measure at same location as prediction location, hence discrepancy between measured noise level and predicted Do Minimum noise level
[b]No data

Table 13.8 Predicted existing night-time and future night-time railway noise levels

Stretch	Location	Predicted Current railway noise level	Predicted With GARL railway noise level (no mitigation)	Comments
		$L_{Aeq,6hr}$	$L_{Aeq,6hr}$	
Branch line	172a Greenock Rd	no night-time rail	43	Only 3 movements per night (midnight-06:00)
Branch line	74 Clark St	no night-time rail	46	Only 3 movements per night
Branch line	70 Murray St	no night-time rail	55	Only 3 movements per night
Mainline	184 Linburn Rd	49	53	Only 3 additional movements per night
Mainline	40 Fochabers Dr	52	57	Only 5 additional movements per night
Mainline	37 Nelson St	45	48	Only 5 additional movements per night

Increases in Daytime Operational Railway Noise

The results were used to assess the potential need for mitigation in the form of lineside barriers where the increase in railway noise might give rise to a noticeable increase in local noise annoyance.

Applying the methodology discussed previously, all properties subject to a façade noise level (due to railway noise) equal to or greater than 55 dB $L_{Aeq,18h}$ (approximately 52 dB $L_{Aeq,18h}$ free-field) and subject to an increase in free-field railway noise level equal to or greater than 5 dB(A) would be considered in need of mitigation. It can be seen from Table 13.7 that none of the calculated railway noise levels are predicted to increase by more than 3 dB(A), so it is considered that mitigation is not required.

Night-time operation
There are currently a number of night-time (midnight-06.00) rail movements, all around the 06.00 and 24.00 time periods. There may be other occasional unscheduled night-time rail movements. It is understood that implementation of the scheme will not alter the number of night-time freight rail movements.

The scheme would introduce few additional night-time rail movements and consequently the resulting night-time L_{Aeq} values will not significantly affect the existing night-time ambient noise conditions, apart from Fochabers Drive, where a 5 dB increase is predicted. It should be noted that the significance of noise impact criteria, specified in GoMMMS (reproduced in Table 13.1) applies to daytime only.

It is considered more appropriate to assess night-time noise disturbance based on L_{max}, rather than L_{Aeq} noise levels. Specific to night-time sleep disturbance, the $L_{Amax,fast}$ level can be estimated from the train sound exposure level (SEL) using the equation;

$$L_{Amax,fast} = 0.973\ SEL - 3.9\ log10(t)$$

where t is the time taken for the train to pass (in seconds). Calculations indicate that for an eight car unit travelling at 70 kph estimated façade noise levels would exceed the preferred limit of 75 dB $L_{Amax,fast}$ for most unshielded properties within at least 100m of the nearest rail. However, reference to the ambient noise levels indicates that this value, 75 dB $L_{Amax,fast}$, is already regularly exceeded (Table 13.2) at residential property in proximity to the line due to other local sources, mostly road traffic, and this is not uncommon at properties fronting on to roads. Given that the scheme would introduce only 3-5 passenger movements in the 24:00-06:00 period (all within either 24:00 and 00:30 or 05:30-06:00) it is considered that these additional, infrequent high levels of impulsive-type noise should prove acceptable. This is in agreement with The World Health Organisation's (WHO) 'Guidelines for Community Noise' reports, for external environmental noise levels, that;

"*For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10-15 times per night……"*

Using the 8 hour time period defined by the World Health Organisation (23.00-07.00) there are already a significant number of train movements, ranging from 60 in the Glasgow Central area to 38 on the mainline and 9 in the Paisley St James area. The introduction of the GARL service would add approximately 18 movements to these values. It is considered that the increases in the Glasgow Central and mainline areas are unlikely to be noticeable due to the significant number of existing movements. The greatest proportional increases are in the Paisley St James area. Due to the existing relatively high ambient noise conditions at the northerly end of the branch line caused by road traffic noise from the M8, the introduction of the GARL service is unlikely to cause sleep disturbance. The increased number of train movements in the Paisley St James area has the potential to cause some initial sleep disturbance; but since the train movements are all within either 23:00 and 00:30 or 05:30-07:00 periods and are not running throughout the night, the impact will be relatively minor.

It should also be noted, as has been stated elsewhere, that the predicted railway noise levels have been based on timetabling information which is likely to be subject to change.

Fixed Plant Noise
Ambient night-time noise levels indicate that the background noise falls to approximately 37 dB L_{A90} in the early hours of the morning at some residential properties along the proposed railway. This is a moderate minimum night-time noise level, not uncommon in suburban and urban areas.

It is proposed that a limit of 40 dB L_{Aeq} at nearest residential property is set for noise from fixed plant that would be introduced as a consequence of the scheme that may operate on a 24-hour basis. For plant that operates on a daytime only basis a relaxed criterion of 45 dB L_{Aeq} is appropriate (from an evening minimum ambient background noise level of 43 dB L_{A90} measured at Murray Street, Table 2).

The fixed plant schedule is not known and it is possible that there may be minimal fixed plant associated with the scheme. Items of plant may include power supply transformers and signalling equipment. Once the schedule is finalised it is recommended that a specific fixed plant noise impact prediction is undertaken to enable identification of any necessary noise mitigation measures.

Fixed plant is relatively easy to attenuate (specification of noise-reduced plant, in-duct silencers, lined cowls, screening, purpose built enclosures etc.) and there is no reason why noise from fixed plant should prove problematical for the development.

Airport Station
A new twin platform station is required for the airport. The operation of the station has the potential to cause noise nuisance due to station operations. However, due to the busy nature of the airport and the

consequent relatively high levels of ambient noise that currently exist in its vicinity, it is considered that the impact will be insignificant.

Fuel Farm
The fuel farm will comprise of 6 above ground storage tanks and associated ancillary equipment. The operation of the fuel farm could potentially involve approximately 50 tanker movements per day, gaining access from junction 29 of the M8. The proposed location of the fuel farm is directly adjacent to the M8, where existing ambient noise levels are already relatively high due to road traffic noise and aircraft noise. It is therefore considered that the operational impact is unlikely to be significant.

13.5.2.2 Railway Vibration

Human Perception
There is no standard prediction model for railway vibration. The transmission of vibration through ground is complex. Boundaries such as layers of soil, rock or building foundations can attenuate or enhance the transmission of vibration by refraction or interference. Furthermore, transmission into individual buildings will depend on the interface between the earth and foundations, and transmission through the building will depend on construction. Such effects are virtually impossible to predict. Therefore, vibration is commonly assessed by site measurements of the similar vehicles travelling over similar track formations, or by consideration of potential increases at a site already subject to vibration.

Ambient vibration measurements undertaken at locations close to the existing track and subject to vibration from existing railway use is shown in Table 3. It can be seen that, at a closest distance of 20m from the railway the 1-hour daytime VDV opposite Murray Street was measured at 0.10 m/s1.75. When converted to a 16-hour daytime exposure, as required by BS 6472, the equivalent daytime VDV becomes 0.20 m/s1.75. This is at the very lowest end of the range for which BS 6472 states there is 'low probability of adverse comment'.

Railway use would increase by up to 100% with the introduction of the scheme. Calculations show that this would increase the daytime measured VDV at the worst affected area, Murray Street, from 0.20 m/s1.75 to 0.24 m/s1.75. The perceived vibration there would therefore remain in the 'low probability of adverse comment' range shown in BS 6472 (see Appendix to Chapter 13 (Volume 4)).

Consequently it is considered unlikely that introduction of the scheme would result in justifiable complaint from local residents as a consequence of increased operational railway vibration.

Vibration Structural Damage
Potential for structural damage relies solely on the peak particle velocity generated by any given event. The number of events is not normally critical to the onset of building damage.

From Table 3 above it can be seen that the existing peak particle velocities (PPV) at the vibration monitoring positions due to passage of current trains, typically 0.14-0.86 m/s, are well below levels at which the onset of cosmetic building damage may commence, 5 m/s. An increase in railway use along the existing line or along the proposed viaduct will simply introduce more occurrences of similar levels of PPV.

It is consequently unlikely that the introduction of the scheme would give rise to structural damage, of even a cosmetic nature, at properties alongside the existing track or alongside the proposed branch line.

The Carlton Die Casting Limited's premises are currently 48m from the existing railway and would be 10 m from the proposed GARL railway. Vibration-sensitive metalworking equipment there (notwithstanding that casting and pressing operations may be undertaken at the premises) is subject to a relatively moderate ppv limit of 4.9 m/s. From ambient vibration measurements tabulated in table 13.3 above it can be seen that ppvs of no greater than 0.86 m/s currently occur at 43 m from the track (during the survey it was noted that HGVs passing along Clark Street (which has an uneven road surface in places) were also likely to be contributing to this measured level). At Murray Street, 20m from the current track, a maximum ppv of 0.86 m/s similarly occurred. Consequently, even at 10m from the proposed GARL track it is most unlikely that a ppv approaching the suggested machine limit of 4.9 m/s would be approached during normal operation of the railway.

13.5.2.3 Operational Noise – Road Traffic

The Design Manual for Road and Bridges (DMRB) Volume 11 Section 3 Part 7 'Traffic Noise and Vibration' 1994 provides a method of evaluating both the immediate and long term impact of abrupt changes in the 18-hour traffic flow (06.00-24.00) in terms of the effects on people and, principally, occupiers of residential property.

DMRB requires that an assessment is undertaken where a change in road traffic flow of > -20%/+25% is predicted (equivalent to an increase or decrease in road traffic noise of approximately 1 dB(A)), implying that road traffic flow changes of up to 25% offer no significant impact in environmental noise terms.

Predicted road traffic data provided by Faber Maunsell indicates that on the proposed opening year, the proposed scheme would not cause any significant changes to road traffic flows on the M8, east and west of junction 28a. Typically flows are predicted to decrease by less than 1%, well below the 20% required to cause a perceivable change in road traffic noise.

Consequently it is concluded that road traffic flow changes that would arise as a consequence of the scheme are unlikely to prove noticeable to local residents or sensitive users.

13.5.3. Significance of Environmental Effects

The significance of the environmental effects, without mitigation, are summarised in Table 13.9, below. For railway operational noise, the short-term impact will decrease due to familiarisation.

Table 13.9: Significance of Effects

Feature	Potential Impact	Significance of Impact
Airport Station Construction Noise	Short-term direct impact	Moderate Adverse
Airport Station Construction Vibration	Short-term direct impact	Minor Adverse
Branch line Railway Construction Noise	Short-term direct impact	Moderate Adverse
Branch line Railway Construction Vibration	Short-term direct impact	Minor Adverse
Third Mainline Construction Noise	Short-term direct impact	Moderate Adverse (localised)
Third Mainline Construction Vibration	Short-term direct impact	Negligible/Minor Adverse (localised)
Branch line Operational Noise	Long-term direct impact	Minor Adverse
Branch line Operational Vibration	Long-term direct impact	Insignificant
Mainline Operational Noise	Long-term direct impact	Minor Adverse
Mainline Operational Vibration	Long-term direct impact	Insignificant
Reduction in Traffic on M8	Long-term indirect	Insignificant Beneficial

13.6. Mitigation

13.6.1. Construction Noise and Vibration Mitigation

From the above discussion it can be seen that the predicted worst-case construction noise levels may exceed the short-term recommended limit of 70 dB $L_{Aeq,1h}$ at specific locations and for assumed specific operations, even after provision of a site-boundary noise barrier at certain locations. It is therefore recommended that specific noise mitigation measures are employed, such as additional temporary noise barriers/enclosures (in particular for rail sawing/grinding operations), changes to proposed methods of working, restriction of working hours and liaison with local residents.

A Code of Construction Practice will be produced which will incorporate measures to manage construction noise. A full demolition and construction noise impact assessment would be undertaken once the contractor has been appointed and the preferred method of working defined (to include timetable, plant, location of plant compound etc.). This will assist the identification of the required specific noise mitigation measures, outlined above.

13.6.2. Railway Operational Noise Mitigation

On the basis of the CRN predicted noise levels it is considered that mitigation is not necessary due to the minor changes in railway noise levels predicted due to the scheme. The noise calculations have been undertaken with a number of assumptions that may affect the final calculated levels, namely:

1) No official data is available for the Class 334 EMU proposed for the GARL service, therefore the closest equivalent (Class 465) has been assumed.
2) All GARL services are composed of 4 carriages.
3) All other passenger services are composed of 6 carriages.
4) GARL service only is to use the 3rd (new) mainline . This has been assumed in the absence of detailed operational information (which is likely to change from day to day)..
5) Freight trains are assumed to be travelling at a steady speed
6) The length of freight trains and types of wagons is not available as this varies from day to day. A representative train has been assumed for all freight movements.

13.6.3. Railway Operational Vibration Mitigation

No vibration mitigation measures are considered necessary for the proposed scheme.

13.7. Summary

Ambient noise and vibration levels have been measured at locations agreed with local authority officers close to the existing and proposed railway lines. Existing and future railway noise prediction has been undertaken to the requirements of CRN, subject to limitations arising from the data available. The assessment predicts that the increase in noise during the operation of GARL would be negligible or minor and unlikely to give rise to justifiable complaint from local residents. No mitigation to control operational noise is therefore considered necessary. The assessment also concludes that vibration from increased railway movements would not give rise to justifiable complaints from local residents or result in any structural damage, of even a cosmetic nature, at residential property. At some locations high levels of construction noise are predicted. A Code of Construction Practice will be implemented which will incorporate measures to manage construction noise.